**COMMITTEE OF THE WHOLE (WS)**
**June 2, 2021**

Item # 2

ASSET MANAGEMENT PLAN – CORE ASSETS
Attachment #1

Attachment 1

# City of Vaughan
# Asset Management Plans

## (Core Assets)

City of Vaughan

Project number: 60641721

May 2021 (version 5)

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# 1. Introduction

The City of Vaughan ("the City") appointed AECOM Canada Ltd. ("AECOM") to assist in the renewal of the City's Asset Management (AM) Plans for its core infrastructure assets.

## 1.1 Overview

The City is one of nine area municipalities, located within the Regional Municipality of York. As a lower tier municipality, the City is responsible for providing such services as fire protection, public works, water distribution and wastewater collection, parks and recreation, building and planning and development control.

In 2018, by City Council approval, the Corporate AM Policy for the City came into effect; and, in 2013, the City's first Corporate AM Strategy was published. As identified in the Corporate AM Strategy, the City's first set of AM Plans (AMPs) were developed in 2014.

The purpose of this AMP is to capture new core infrastructure assets and any updates in the City's asset data, so as to provide the City with a comprehensive AMP. The objective is to deliver a financial and technical roadmap for the management of the City's core infrastructure assets, and to provide the means for the City to maximize value from its assets, at the lowest overall expense while, at the same time, providing enhanced service levels for its residents and promoting green initiatives.

Organizations that implement good AM practices will benefit from improved business and financial performance, effective investment decisions, and better risk management. Stakeholders can expect lower total asset life cycle costs, higher asset performance, and confidence in sustained future performance.

## 1.2 Asset Management Planning Provincial Requirements

The O. Reg. 588 / 17 came into effect in 2018 and stipulates specific AM requirements to be in place within Ontario municipalities by certain key dates (**Table 1-1**). The renewal of this AM Plan for the City is one of the steps towards meeting the July 1st, 2022 deadline.

**Table 1-1: O. Reg. 588 / 17: AM Planning for Municipal Infrastructure**

**Description:** A regulation made under the Infrastructure for Jobs and Prosperity Act, 2015, stating that every municipality shall prepare and update a Strategic AM Policy, and that every municipality shall prepare an AM Plan for its core infrastructure assets by July 1, 2022, and an AM Plan for all other infrastructure assets by July 1, 2024. The regulation outlines several requirements that each AM Plan must follow, such as including current and proposed level of service. Core municipal infrastructure assets include water, wastewater, stormwater, road, and bridge assets.

| Deadline Date | **Regulatory Requirement** |
|---|---|
| July 1st, 2019 | All municipalities are required to prepare their first Strategic AM Policy. |
| July 1st, 2022 | All municipalities are required to have an AM Plan for its entire core municipal infrastructure (i.e., water, sanitary, stormwater, and transportation). |
| July 1st, 2024 | All municipalities are required to have an AM Plan for infrastructure assets not included under their core assets. |
| July 1st, 2025 | All AM Plans must include information about the LoS that the municipality proposes to provide, the activities required to meet those level of service, and a strategy to fund activities. |

## 1.3 Asset Management Plan Scope

This AMP has been developed for the City's four core asset categories, owned and maintained by the City, as shown in **Table 1-1**. The renewal of the City's AM Plans is consistent with the guidelines laid out in the City's Corporate AM Policy and Section 5 of O. Reg. 588 / 17.

**Table 1-2: In-Scope Assets**

| Asset Category | Sub-Assets |
|---|---|
| Water Distribution System | Water mains, service connections, valves, hydrants, chambers, water meters, pump stations, and water filling stations. |
| Wastewater Collection System | Wastewater mains, laterals, manholes, flowmeters, pump stations, and generator stations. |
| Stormwater Management System | Stormwater mains, laterals, manholes, catch basins, stormwater culverts, inout structures, devices, pump stations, ditches, stormwater management ponds, lakes, rivers, and waterways. |
| Transportation | Roads, bridges, and culverts. |

The following elements are included within the scope of this AM Plan for each of the asset categories shown in **Table 1-2**.

- A summary of the asset inventory, including the replacement cost of the assets, the average age of the assets, the condition of the assets, and the City's approach to assessing the condition of the assets (**Section 3.1**, **3.2** & **3.3**);
- Current levels of service (LoS) based on data from 2018 to 2020 determined in accordance with the qualitative descriptions and technical metrics outlined in O. Reg 588 / 17 (**Section 3.4**); and
- Asset lifecycle management activities to maintain identified current LoS, minimize associated asset risks, and to optimize costs over the whole lifecycle of the asset (**Section 3.5**).

## 1.4 Growth Planning

The City is one of Canada's fastest growing cities, with a population of over 300,000. It is projected that the number of residents will increase to 430,000 by 2031. In addition to its rapidly growing population, the City is home to a well-diversified and expanding employment sector with over 8,000 businesses and 150,000 employees. The City has the largest supply of new employment lands in the Greater Toronto Area (GTA) and it is projected that the number of employees will increase to 278,000 by 2031.

show the development of the City's water network by decades, which is one of the most essential and critical assets indicating the City's development.

The next 25 years will see the City transition from a growing suburban municipality to a fully urban space. This type of transition will require long-term thinking about how best to accommodate and make the most of new opportunities. Planning for the future through strategic planning will position the City to deal with the many pressing issues impacting the organization such as community safety, access to health facilities, environment, traffic congestion and issues related to growth and the quality of municipal services.

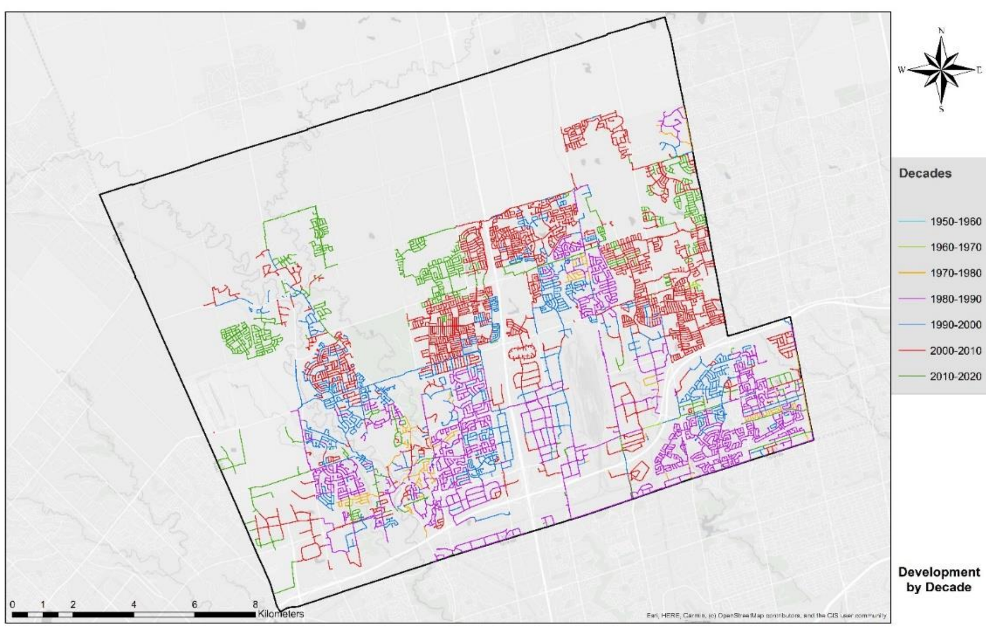



**Figure 1-1: City of Vaughan Development Map**

# 2. Approach for Asset Management Plan

The approach used in the renewal of this AM Plan is presented in **Figure 2-1**, and has been selected to ensure that the City can have the confidence to make fact-based and defensible business decisions from reliable and robust information.

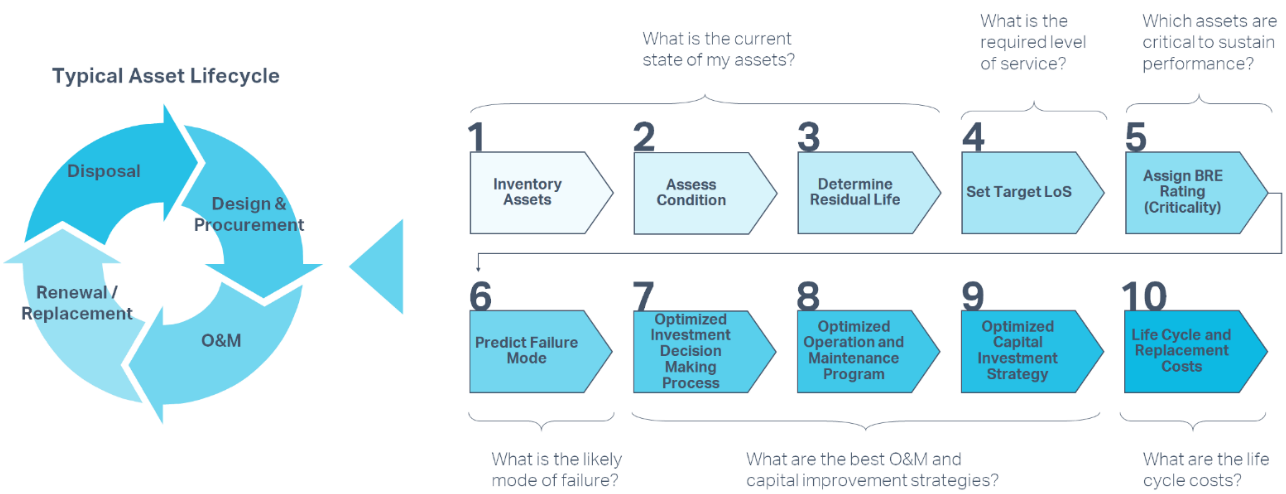



**Figure 2-1: AM Plan Approach**

## 2.1 State of Infrastructure

Defining the state of the infrastructure involves quantifying the assets owned, examining their age, replacement value, and condition. AECOM's approach to each of these asset characteristics is summarized below.

### 2.1.1 Expected Service Life & Remaining Service Life

The expected service life (ESL) is defined as the period over which an asset is available for use and able to provide the required level of service at an acceptable risk (i.e., without unforeseen costs of disruption for maintenance and repair). The ESL for this assignment will be based on discussions with City staff, information from previous studies, and any additional information that might inform the ESL. In terms of determining the Remaining Service Life (RSL), AECOM used the installation date together with the ESL.

In reality, different assets will deteriorate at different rates and not necessarily linearly over time, however, it is important to keep in mind the level of effort required to predict failure compared with the asset value. More sophisticated deterioration modelling may be warranted for very high value assets, whilst the cost of deterioration modeling for low-value assets may very well exceed the replacement cost of the asset. The actual service life can vary significantly from the ESL. In some instances, a variation in expected vs. actual service life is evident due to the following factors:

- **Operating conditions and demands:** Some equipment is operated intermittently or even infrequently, or is being operated a lower demand than its design capacity, thus the actual operating "age" of the asset is reduced.
- **Environment:** Some equipment is exposed to very aggressive environmental conditions (e.g., corrosive chemicals), while other assets are in relatively benign conditions, thus the deterioration of assets is affected differently.
- **Maintenance:** Equipment is maintained through refurbishment or replacement of components, which prolongs the service life of the asset.

- **Technological Obsolescence:** Some assets can theoretically be maintained indefinitely, although considerations such as maintenance cost, energy inefficiency and new technologies are likely to render this approach uneconomical.

### 2.1.2 Asset Replacement Cost

The estimated replacement value is the cost of replacing an existing asset in today's dollars, considering an inflation rate. These costs were developed based on the records used in the 2016 AECOM project titled "Integration of Underground Utilities with Pavement Management System", previous tenders and quotes, other municipalities similar in size to the City, and consultation with the City's staff. Where applicable, a 2% annual inflation rate was used to adjust the historical costs to 2021 values; this rate is representative of the average inflation rate in Canada for the past 5 to 10 years.

In the reinvestment need analysis for water, wastewater, and stormwater assets, the replacement costs are calculated considering the equation [1] and [2]:

$$Unit\ Cost\ (all - inclusive) = \{pipe\ unit\ rate, appurtenances/accessories\} \quad [1]$$

$$Total\ Replacement\ Value\ of\ Service\ Type\ (water, wastewater, storm) = \sum Unit\ Cost\ (all - inclusive) * Length + \sum Others \quad [2]$$

Where $Others$ refers to asset types that are not measured in the all-inclusive unit rate and can vary depending on the service type.

For example, in water, $Unit\ Cost\ (all - inclusive)$ is calculated by considering the total replacement values of pipes, hydrants, chambers, service connections, and valves. The total replacement value was proportionally distributed based on the total length of each pipe size in the network. $Others$ included meters, pressure reducing valves, and water facilities. Upon calculating the replacement costs, the values were rounded to the nearest thousand.

### 2.1.3 Asset Condition

All assets are expected to deteriorate over their lifetime, and their assigned condition reflects the physical state of the asset. No on-site condition assessments were carried out for this project; therefore, physical condition of the assets is based on consultations with City staff who have experience in managing the assets, combined with any existing condition data, and information from past studies.

Where empirical data is not available (i.e., previous condition assessments, inspections, and observations), Weibull three-parameter distribution was used to assess the current condition and project the future condition of the City's assets. The Weibull distribution has been used extensively in reliability studies and lifetime prediction models in industries ranging from the automotive to the oil and gas industries and provides a suitable distribution for this type of analysis.

The Weibull probability distribution provides a left-skewed distribution that rises slowly and diminishes quickly as the population is consumed. The underlying premise of the Weibull-shaped deterioration is that while some assets fail prematurely due to severe conditions or improper installation, other assets are very long-lived and function well beyond their theoretical expected service life. In order to perform a high order network-level analysis, it was assumed that assets would fail (and require replacement) within a deterioration envelope / curve approximated by a Weibull probability distribution. The Weibull probability distribution has three parameters for location, scale and shape, as set out in equation [3]:

$$f(x) = \frac{\beta}{\alpha}\left(\frac{x-\gamma}{\alpha}\right)^{\beta-1} e^{-\left(\frac{x-\gamma}{\alpha}\right)^{\beta}} \quad [3]$$

Where: $\alpha$ = scale parameter
$\beta$ = shape parameter (or slope)
$\gamma$ = location parameter

A set of Weibull cumulative distributions were created to depict a set of deterioration curves for assets with different expected service lives (ESLs).

Table 2-1 presents the condition score ranges and the corresponding range of ESL and total life consumed.

**Table 2-1: Age-Based Physical Condition Scale**

| Condition Score (minimum) | Condition Score (maximum) | Condition Rating | Range % of ESL Consumed | Range of % Operational Life Consumed * |
|---|---|---|---|---|
| 1 | 1.5 | Very Good | 0% – 71% | 0% – 47% |
| 1.5 | 2.2 | Good | 72% – 84% | 48% – 56% |
| 2.2 | 2.8 | Fair | 85% – 92% | 57% – 60% |
| 2.8 | >=3.5 | Poor | 93% – >100% | 61% – 100% |

* NOTE: WERF uses the term “operational life” to define the time period over which an asset remains operational irrespective of performance, risk or cost considerations.

## 2.2 Levels of Service

In AECOM’s experience, documenting LoS is a proven practice that will enable the City to:

- Link corporate strategic objectives to customer expectations and technical operations.
- Balance customer needs and expectations while evaluating the effectiveness of operations and whether the right LoS is being provided at the right cost.
- Transition from an “Asset Stewardship” approach that focuses on making decisions based on maintaining assets in an acceptable condition to a “Serviceability” approach that is geared towards making decisions based on balancing the costs, risks, and goals for the LoS being provided by the City’s assets.
- Communicate the physical nature of infrastructure that the City owns and is financially responsible for while promoting the use of LoS to enable effective consultation with stakeholders regarding alternative funding options according to desired LoS outcomes.
- Make recommendations on strategies that the City can take now to minimize future renewal costs while ensuring that adequate LoS can be delivered without burdening future generations.
- Assess internal (e.g., program changes) and external (e.g., climate change) factors that have the potential to impact the City’s ability to deliver services and how these factors may impact the LoS being provided.
- Implement a corporate continuous improvement program to further optimize asset management (AM) across all service areas.

The O. Reg. 588 / 17 requires all AM Plans to include information about LoS that the municipality proposes to provide, the activities required to meet those measures, and a strategy to fund activities. The deadline of the requirements for formalized LoS is July 1, 2025.

Successful AM programs aim to achieve targeted service levels through customer-based decision making. To achieve this, AECOM considered a customer-centric approach, where the customer is at the heart of every decision from development to implementation, consultation, and roll-out of the LoS Framework (Figure 2-2).

There are two types of LoS measures: Customer LoS (also called “Community” LoS) and Technical LoS. Customer LoS are recorded in a manner that attempts to describe the LoS in terms of what is actually being provided to the customer (i.e., the public) and how the customers experience the service. It is important to note that customers are not concerned with the specific operating requirements of the assets that provide the service, but rather the value they obtain from the operation of the assets. To achieve Customer LoS there needs to be line of sight between the value delivered and how that value is realized. This is the purpose of Technical LoS which attempts to describe how the City will provide and meet the expected Customer LoS.

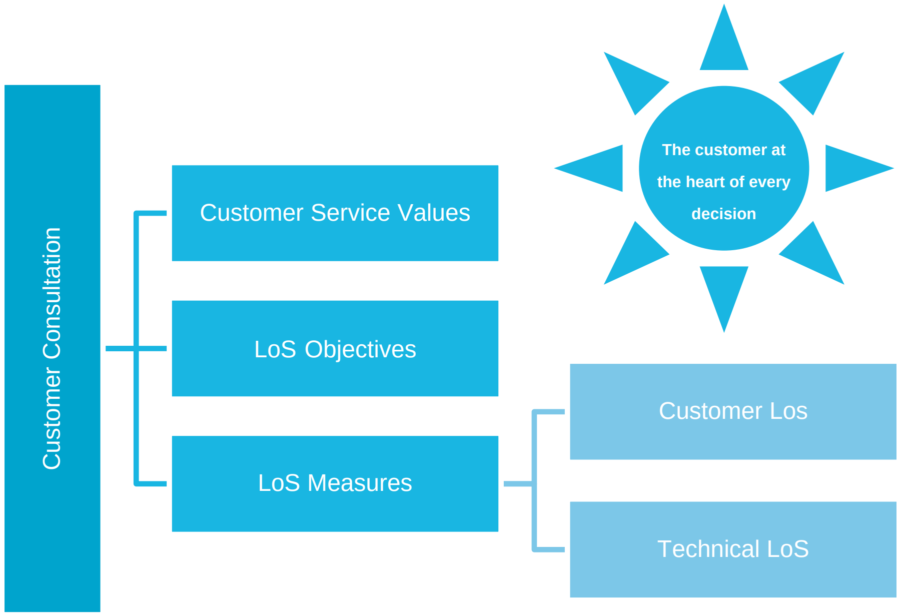



**Figure 2-2: The LoS Framework Customer-Centric Approach**

The LoS Framework was primarily conceived through a collaborative workshop process. In 2020, AECOM facilitated four workshops with City staff across each of the fourteen service areas. The following outcomes were achieved during each service area workshop:

- Staff were oriented as to the purpose and importance of establishing a consistent LoS Framework;
- Stakeholders were identified, including their expectations, interests, and any regulatory requirements;
- Customer service values were established and reviewed;
- LoS objectives were established for each customer service value;
- Staff provided several performance measures that are currently being tracked as well as those that the City would like to track in the future;
- Where information was available, current performance, targets, and data sources were documented; and
- Growth and shifts in future demand were discussed across the City's service areas.

## 2.3 Lifecycle Management Strategies

Life cycle management focuses on the specific activities we must undertake during all phases of the asset life cycle. Considering entire asset life cycles can ensure we make sound decisions that take into account present and future service delivery needs.

The overarching goal of life cycle management is to maximize the long-term benefits and services our assets deliver while minimizing the associated costs and risks in the long run. Every asset has a life cycle cost, which is the total cost of all the activities undertaken throughout its service life. The following sections describe activities across the life cycle of assets.

### 2.3.1 Life Cycle Activities

Any responsible owner of assets such as the City has a desire to preserve the condition of their existing assets for as long as possible, by maintaining or even extending their design lives through routine activities such as maintenance and active intervention. The City is continually acquiring infrastructure assets, but these assets require increased funding for operation and maintenance as they age. The City is also responsible for the replacement of deteriorated assets as long as the service is required. While individual assets may have a useful life that can be predicted in years or decades, the service that the asset provides could be for a substantially longer duration (perhaps in perpetuity).

Part of the purpose of the AM planning process is to fully understand and predict the long-range financial requirements for the City's infrastructure to facilitate planning and resource management in the most cost-effective manner possible. Figure 2-3 illustrates how costs typically accumulate over an asset's life. It is worth noting that the accumulation of the ongoing operations and maintenance, refurbishment and disposal / replacement costs is many multiples of the initial acquisition costs. A key and important take-away from Figure 2-3 is therefore for the City to fully understand the entire life cycle costs before proceeding with asset acquisition.

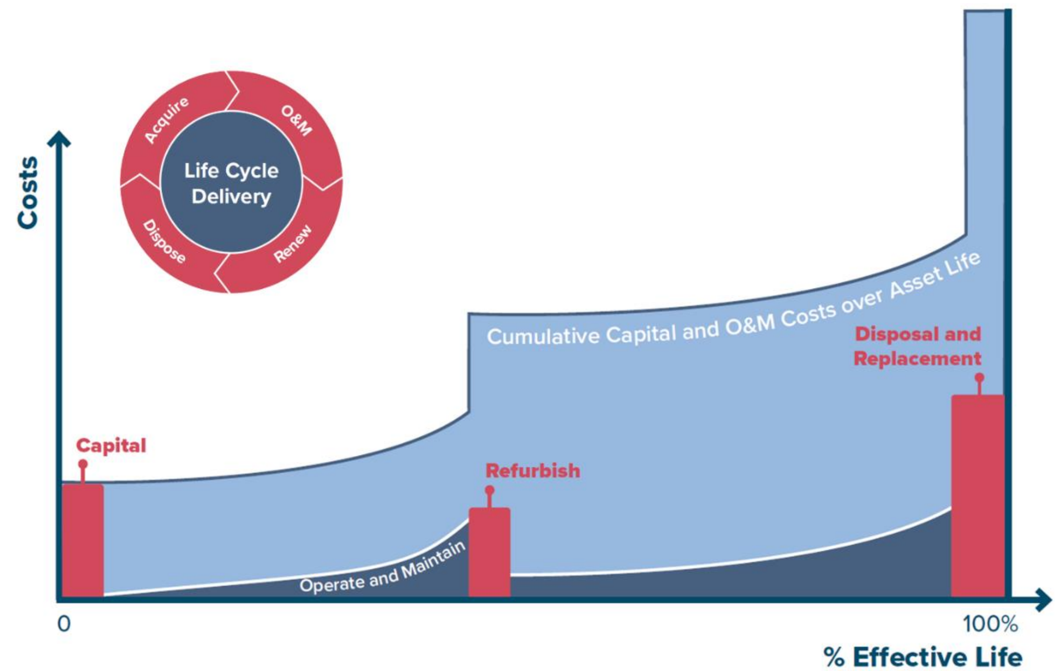
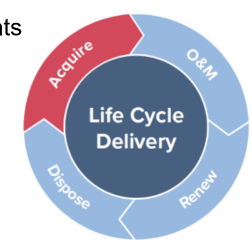
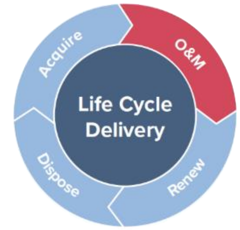



**Figure 2-3: Life Cycle Cost Accumulation Over Asset Life**

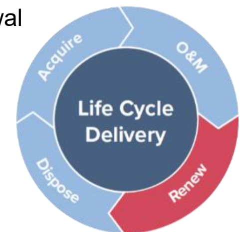
Expressed simply, full lifecycle cost of infrastructure can be accumulated under the following broad headings:



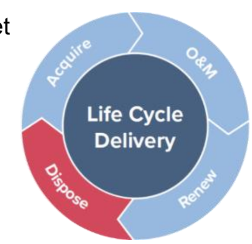

- **Asset Acquisition / Procurement / Construction**: The City has made significant investments in the design and acquisition of its municipal infrastructure assets. Added to City-purchased inventory is infrastructure that the City accepts (and takes immediate financial responsibility for) from developers as new neighborhoods are constructed. For example, as developers build new neighborhoods, the new local infrastructure (including local roads, water mains, sewer mains and storm mains) is paid for by the developer and then transferred to the City for operation, maintenance and ultimately replacement. The City's infrastructure inventory was therefore created over many decades through infrastructure paid for by the City or by developers Looking towards the future, when acquiring new assets, the City should evaluate credible alternative design solutions that consider how the asset is to be managed at each of its life cycle stages. Asset management and full life cycle considerations for the acquisition of new assets include, but are not limited to the following:
  - The asset's operability and maintainability;
  - Availability and management of spares;
  - Staff skill and availability to manage the asset;
  - The manner of the asset's eventual disposal.




- **Asset Operations and Maintenance (O&M)**: As new infrastructure is commissioned, the City accepts the responsibility of operating and maintaining the infrastructure according to O&M standards to ensure that the infrastructure is safe and reliable. Operations staff provide the day-to-day support required to operate infrastructure. In few cases, operation costs are minor, but for most there are significant increases. For example, underground pipes require almost no operational support while a facility such as a pump station requires full-time staff to operate the facility safely and efficiently. Maintenance expenses include periodic preventive maintenance to ensure that the infrastructure can provide reliable service throughout the life of the asset and corrective maintenance that is required to repair defective assets as and when needed. Inadequate funding for O&M will have an adverse impact on the lifespan of assets. The amount of O&M resources required in any period is a function of the current inventory of infrastructure and total O&M needs required for each asset. As the inventory of infrastructure grows, total O&M requirements will also grow.




- **Renewal and Replacement:** The third portion of full life cycle costing relates to the renewal and replacement of infrastructure that has deteriorated to the point where it no longer provides the required service. Renewal cost is sometimes incurred during the life of an asset where an investment is made to improve the condition and / or functionality of the asset e.g., re-lining of a pipe or resurfacing of a road. Disposal and replacement costs are incurred at the end of an asset's life when it is disposed of and replaced by a fully new asset. Canadian municipalities, including City of Vaughan, have not traditionally factored renewal or replacement costs into future budget projections, except for assets that have a relatively short life such as computer equipment and vehicles. The main reason behind this is the fact that large portions of this infrastructure inventory can have a very long life e.g., from 75 to 100 years for underground pipes. For growing communities like the City, there has not been a historical need to forecast expenses that are not anticipated for decades. However, based on the experiences of more established Canadian cities (where vast inventories of old assets are now in dire need of renewal or replacement), it is vital that communities fully understand the looming obligations of infrastructure renewal or replacement and develop a strategy to respond in a manner that is fair and affordable. The general life cycle activities of asset renewal, and replacement will be explored in more detail as these activities are to be reflected in the Deighton's Total Infrastructure Management System (dTIMs) analysis to determine when City assets are to be intervened upon, what type of intervention is needed and the associated cost (refer to **Section 2.3.2**).




- **Decommissioning and Disposal:** There will inevitably come a point in time when an asset must be removed from service and, depending on the type of asset, there may be significant costs associated with its decommissioning and disposal. Factors that may influence the decision to remove an asset from service include: changes to legislation that cause the asset to be in non-compliance, the inability of the asset to cope with increased service levels, technology advances that render the asset obsolete, the cost of retaining the asset is greater than the benefit gained, or the current risk associated with the asset's failure is not tolerable. Normally, major costs that may be incurred during disposal and decommissioning derive from the environmental impact of the disposal and, if required, the rehabilitation and decontamination of land. In some cases, there will be residual liabilities and risks to consider if a decision is made to partially abandon the asset as oppose to fully disposing of its components (e.g., leaving a non-functioning pipe in the ground, or an inactive building standing). However, some cost savings may be achieved through the residual value of the asset or by exploring alternative uses for the asset. In all cases, it is important to consider disposal and decommissioning as the strategy employed has the potential to attract significant stakeholder attention. For that reason, the costs and risks associated with disposal and decommissioning should be equally considered in the City's capital investment decision-making process.

The infrastructure AMPs present the City's strategy for responding to the full lifecycle costs of all its infrastructure assets. Long-range estimates were prepared together with the AMPs, based on industry best practices to ensure the financial sustainability of the City's infrastructure assets over their full life cycle, as discussed in the next Chapters.

### 2.3.2 Coordination of Infrastructure Works

Municipal infrastructure networks are comprised of complex interconnected systems including roads, water, sanitary and storm sewers, sidewalks, landscaping, signs and lighting systems, to name but a few. Decision makers are tasked with making the best use of available funding to manage these assets at an acceptable level of service. This means having to manage a broad range of assets within any road right-of-way, with each asset deteriorating at a different rate and requiring interventions that often times are not optimally coordinated to reduce cost and limit disruption to businesses and residents. Piecemeal or "silo-based" planning results in e.g., utility staff making cuts into newly paved roads to perform a utility pipe or service connection replacement, and an irate public that rightly questions whether their tax dollars are spent in the most efficient manner. The opportunity therefore exists to improve and optimize the coordination between the capital interventions on especially roads, water, wastewater and stormwater assets to minimize disruption and cost.

- **Work Coordination Decision Making Process:** Each of the service areas has a sequence of activities describing the decision-making process. For example, **Section 3.5.3.1** elaborated on the decision-making process of the water mains on the type and timing of interventions on the underground utilities. Inherent in the decision-making process used in this analysis is the coordination and optimization of the timing of interventions, as presented in **Figure 2-4**.

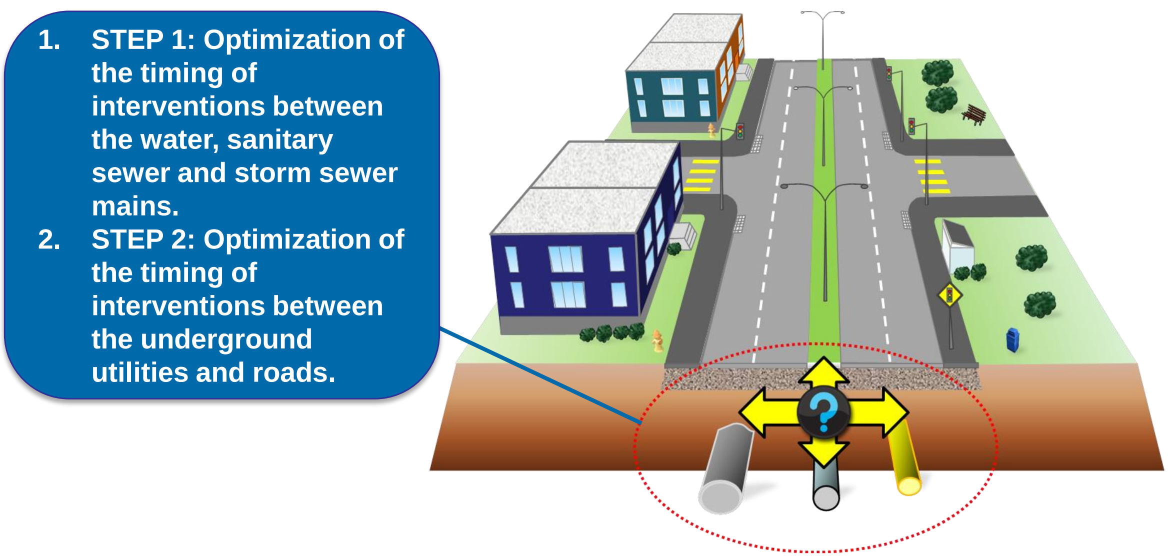



**Figure 2-4: Optimization of Utility and Road Interventions**

- **Utility GIS Linear Referencing to Road Routes**: The optimization of interventions could only occur by imbuing each asset within the analysis set with "spatial awareness" so that when an intervention is called for in a certain year, a check is performed in GIS whether any adjacent asset in the same right-of-way requires an intervention within ten years. When such events are triggered, dTIMS moves the dates of interventions to occur in the same year e.g., coordinating the open cut pipe replacement of one or more pipes in a roadway to occur in the same year, and where possible, in the same year as a roadway intervention such as a partial reconstruction or reclamation.

The groundwork for this optimization was laid within GIS, as the linear referencing for the utility "From" and "To" attributes for each pipe had to be aligned with the "From" and "To" attributes for the roadway within which it runs (where applicable). A layer of Thiessen polygons was created in GIS to form an analysis boundary for each road segment containing utility pipes, as well as utility pipe segments running outside of a roadway. **Figure 2-5** presents a screenshot from ArcMap for a typical neighborhood in the City showing the boundaries of the Thiessen polygons, depicted by the light green lines crossing diagonally through intersections and running along the parcel boundaries along each street.

**Figure 2-5: Thiessen Polygons Modeling- A Sample**

### 2.3.3 Capital Planning

Capital investment is to address community growth or changes, or to renew existing assets to maintain service levels. For the actual funding needs assessment, please refer to **Section 3.6**, **Section 4.6**, **Section 5.6**, and **Section 6.6** for Water, Wastewater, Stormwater, and Transportation service, respectively.

- **Life Cycle Cost Analysis Approach**. Deighton's Total Infrastructure Management System (dTIMS) is used in the infrastructure renewal and replacement forecasting. dTIMS analysis enables optimized decision making and mathematical deterioration modelling of infrastructure assets and the development of short, medium and long-term forecasts of renewal and replacement costs of a number of decision criteria and the ability to compare different intervention options to find the optimal solution in terms of timing and the intervention option chosen. **Section 2.3.4** presents the analytical logic to prioritize work in constrained funding scenarios.

- **Forecast Periods.** The City aims to develop Short- to Medium-Term and Long-Term capital plans. Typically, short to medium-term capital plan identifies the activities required to meet current and future demand, the cost of those activities and a financing approach. It is developed or renewed every three to five years and should coincide with regulations on short to medium-term expenditure planning. A long-term plan can serve as part of Strategic Asset Management Plan, which indicates what will be spent, by service areas, over a set period of time. Long-term plans tend to focus only on costs.

  According to the workshop discussion with the City, the analysis periods for funding need assessment are 20 years.

- **Budget scenarios:**

  – Do-Nothing Strategy: Each segment in the network that is being analyzed starts with the Do-Nothing strategy. This strategy assumes that no renewal and maintenance treatments will be performed.

  – Unlimited Budget: This budget scenario aims to provide optimized strategies with maximized benefits without the concern of budget constraints. dTIMS returns the highest benefit strategy for each element with the implementation of the coordination of assts in different service area.

– Optimal Budget: Multi-objective optimization provide feasible solutions for each element constrained by defined budgets, resources or restrictions as defined by the City. The analysis considers the current condition of assets, the rate that the condition is expected to degrade, and appropriate treatment triggers, costs and resets for asset renewal activities to forecast the condition profile into the future.

## 2.3.4 Asset Prioritization

### 2.3.4.1 Risk Assessment

Infrastructure-related risk exposure is assessed based on the combined consideration of probability and consequences of an asset failure, which is used to drive the selection and prioritization of appropriate action, based on risk tolerance thresholds and funding availability. Understanding the risk exposure for a given set of assets allows the City to identify where they are most exposed to risk, and to target their investments to most effectively reduce that exposure.

In addressing risk for infrastructure assets, the first step in the analysis is to identify assets that are most critical to the business. Critical assets are those that will potentially have the greatest impact on service delivery should they fail. It should be noted that the parameters, criteria and weighting factors area starting point, and should be reviewed and modified to reflect the priorities of the City on an ongoing basis.

The fundamental principle of consequence (or criticality) models is that they evaluate the relative importance of assets based on select criteria. The approach to risk analysis within this project utilizes a triple-bottom-line assessment approach utilizing the following four criticality indices:

- **Economic** – influence of the asset's failure on monetary resources
- **Operational** – influence of the asset's failure on operational ability
- **Social** – influence of the asset's failure on society
- **Environmental** – influence of the asset's failure on the environment

By applying specific indices, the risk assessment framework generates a risk (or priority) score for each asset. The risk score is a rating of the asset based on the detailed assessment of the likelihood and consequence of failure based on a number of key parameters. All parameters are then equated using equation [4].

$$\textit{Risk} = \textit{Likelihood of Failure} \times \textit{Consequence of Failure} \qquad [4]$$

Based on this principal, the risk associated with a given asset's failure can be managed by limiting the likelihood of this occurring, or the impact realized, should it occur.

Consequences of Failure (CoF) reflect the relative "impact" of a given asset's failure. While traditionally these have been looked at as purely economic terms (i.e. repair cost, loss of revenue, etc.), the truth is that investment decisions are often driven by non-economic factors. Understanding both the economic and non-economic impacts associated with loss or limitation of service help in categorizing an asset's "criticality" and justifying infrastructure decisions in a consistent, defensible manner.

### 2.3.4.2 Analytical Logic of dTIMS to Sequence Interventions

dTIMS recognizes that the imperative to implement an unfunded action increases in each subsequent year and that the imperative is greater for high-risk assets. dTIMS resets the order for allocating funds in each year of a funding scenario as a result of changes in the annual funding level available and the composite risk scores of the actions due. Several steps are to be undertaken for dTIMS to apply the logic correctly in each scenario. First, dTIMS generates annual needs ("actions") estimates such that every replacement is completed by the time an asset reaches its useful life according to the applicable Weibull deterioration curve or other trigger defined in the flow chart for each of the service area. dTIMS projects the timing and extent of annual spending required to address all actions based on the City's asset inventory, resulting in thousands of calculations based on service dates, useful lives and / or intervention triggers, and replacement costs given in each asset record.

With applied funding unlimited (at the outset of the analysis), composite scores and rank ordering of funding do not affect the outcome. Secondly, a budget constraint is developed to determine the capital funds available each year in the constrained funding scenarios. All actions for the first year of the analysis are ranked according to risk scores, and needs are funded in this order until the budget constraint is reached for that year. Funded needs become actions for that year, but all unfunded needs from that year age by one year (and generate a higher age score if the asset has exceeded its useful life and are rolled over into the set of needs for the next year.

The asset criticality score can be used to prioritize projects within a funding constrained environment. Figure 2-6 illustrates this logic of carrying unfunded needs to the next year in the period where they receive a higher probability of receiving funds based on their criticality score. According to the sequencing logic, dTIMS funds actions due in the same year in the order of highest to lowest criticality score, derived from the sum of each action's priority scores. If these assets had the same criticality score, then dTIMS funds the least expensive need first.

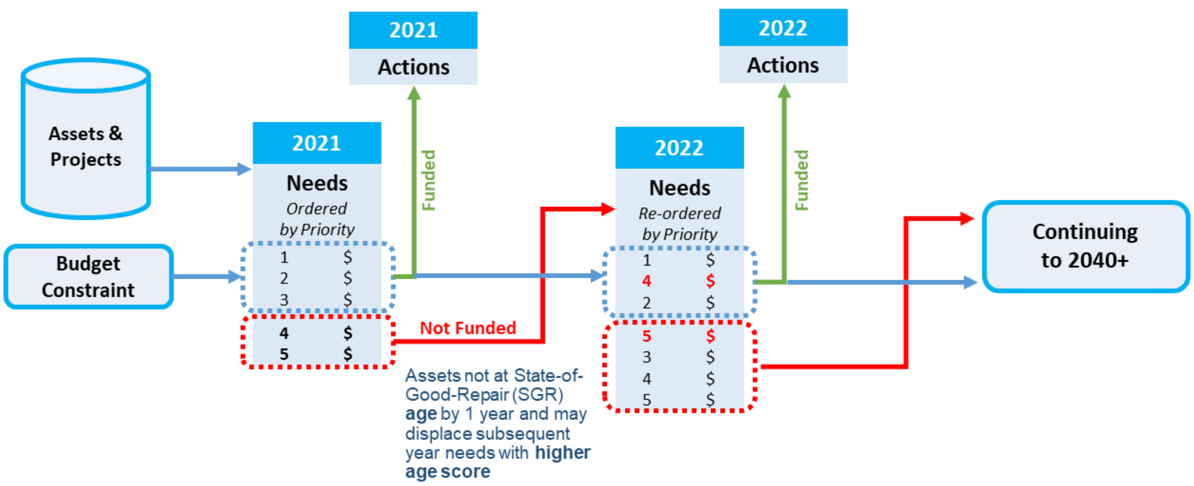



Figure 2-6: The Role of Criticality to Prioritize Projects Within A Funding Constrained Environment

## 2.4 Financial Planning

### 2.4.1 Financial Policies

The City has taken the initiative to establish financial asset management policies in 2018, which provides directions on how financial principles apply to assets to ensure that service goals are met. The policy aligns the business model of AM with the City's financial planning, financial reporting, cost management, treasury and taxation functions. The City will integrate findings from the AM Plans into its long-term financial planning and budgeting processes. Sound financial analysis will be encompassed in AM planning in order for the AM Plan to be a sought-after guide for employees in budgeting and financial planning.

### 2.4.2 Financial Analysis

Financial analysis activities for asset management is centered on two essential quantities: revenues and expenditures. Revenues can come from many sources. Through asset operations, the City generate its own source revenues from taxes, development charges, etc. Expenditures are all the direct and indirect costs associated with capital, operating and maintaining, and disposing of assets.

Assessing the financial implications supports in the decision-making when there are competing priorities and trade-offs between projects. Financial analysis provides a better picture of how to fund the capital plan and make critical decisions about service delivery while providing the greatest benefit for the community at the lowest cost.

### 2.4.3 Aligning the Financial and Non-Financial Functions of AM

ISO 55010[1] identifies the that the financial and non-financial functions of AM within organizations are generally inadequately aligned, as follows:

- **Financial Accounting Functions:** Focused on retrospective reporting of accounting / regulatory financial activities. However, there is a growing awareness in organizations of the need to focus on providing a managerial costing approach in order to support decision-making for the future.
- **Non-Financial Functions:** Have a limited understanding of financial accounting functions but are recognizing the need to improve their understanding of the financial implications of their activities.

The lack of alignment between financial and non-financial functions can be attributed to silos in an organization, including reporting structures, functional / operational business processes, and related technical data. Silos generally bring forth the necessary level of specialization. However, with a lack a communication between the silos, organizations are at risk of inefficiencies and errors in AM results, or AM failures due to a lack of alignment between AM staff and senior management. Financial and non-financial alignment needs to work both "vertically" and "horizontally", as follows:

- **Vertical Alignment:** Financial and non-financial asset-related directives by management are informed by accurate upward information flows, effectively implemented across the appropriate levels of the organization.
- **Horizontal alignment:** Financial and non-financial information that flows between departments (conducting functions such as operations, engineering, maintenance, financial accounting and management) uses the same terminology and refers to the assets identified in the same way.

Figure 2-7 presents the key elements in a framework to address the need to achieve the alignment.

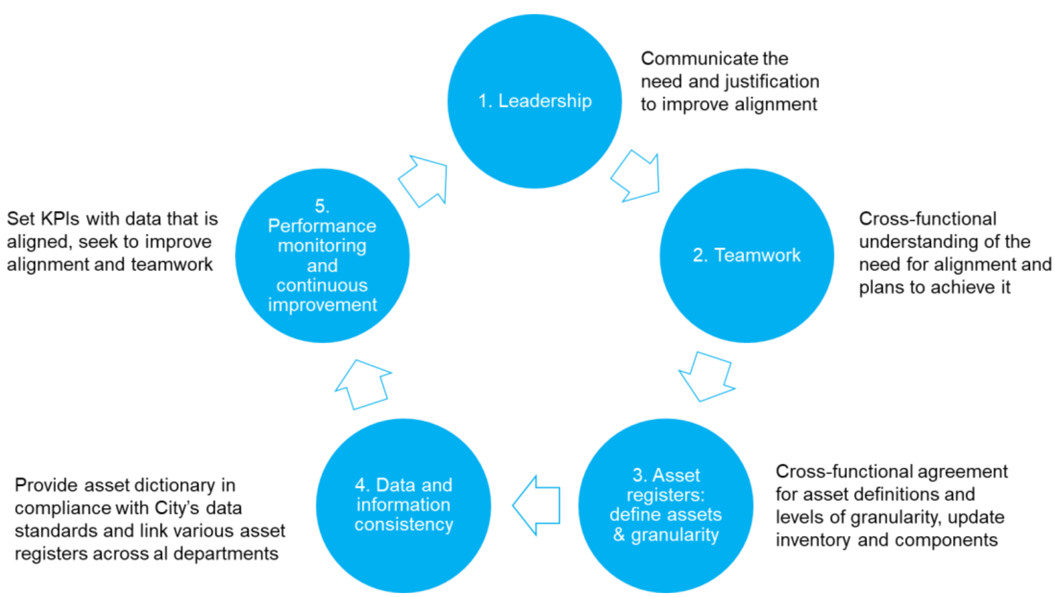



**Figure 2-7: Key Elements of a Framework to Achieve Financial and Non-Financial Alignment**

### 2.4.4 Long-Term Financial Planning

Strengthening the City's AM planning according to the recommendations in **Asset Management Strategy** will improve the City's long-term financial planning, by accounting for whole life cycle costs as presented in **Section 2.3.1**. This includes all capital, annual operation and maintenance, and disposal costs over the planning timeframe, thereby aligning financial requirements with long-term level of service objectives.

[1] International Organization for Standardization (2019): ISO 55010 - Asset management — Guidance on the alignment of financial and non-financial functions in asset management

The challenge is often one of agreeing on a timeframe for such planning, recognizing that the AM perspective is ideally focused on the asset life cycle, versus the political / election cycle that could be as short as a three to four-year Council term. Accordingly, financial and non-financial staff, as well as top management and politicians, should agree on a long enough timeframe to provide useful forward planning information that aligns the financial and non-financial perspectives, as presented in **Figure 2-8**.


**Figure 2-8: AM Planning Alignment Across the Organization**

The City should have an appropriate long-term financial planning process that achieves the following:

- Stimulates long-term strategic thinking and perspective for stakeholders and decision-makers.
- Can be used as a tool to prevent or predict future financial shocks and demonstrate financial sustainability.
- Demonstrates to internal and external stakeholders that the organization has a financial strategy in place to meet their demands, now and in the future.

The long-term financial planning process needs to involve financial and non-financial staff working together to combine the important elements of strategy development, asset management planning and financial forecasting (**Figure 2-7** and **Figure 2-8**).

# 3. Water

The City's Water service provides drinking water and fire protection service to approximately 335,000 residents. Supplying safe, drinkable water to all residential, industrial, commercial and institutional customers involves managing a reliable water system capable of providing sufficient quality, flow and pressure to satisfy business needs. Treated drinking water is purchased from the York Region. York Region purchases water from City of Toronto and the Region of Peel Water Supply Systems, which draw water from Lake Ontario. Drinking water is pumped from the treatment plants and distributed and metered to all water customers through 1,146 km of water distribution network, which is operated and maintained by the City.

## 3.1 Asset Inventory and Replacement Value

Water assets are managed and maintained to meet provincially issued system and facility operating permits, as well as the City's performance and reliability targets. Valued at approximately $1.5 Billion, the water assets can be grouped into two categories: Linear and Water Facilities (**Table 3-1**). They are further divided into five asset types ranging from water mains to water filling stations.

The City's core services including Water, Wastewater, Stormwater, and Transportation are coordinated with each other to ensure cost efficiencies to maintain the desired level of service while minimizing the risks. The core service areas are considered as a whole when considering the infrastructure lifecycle needs.

**Table 3-1: Asset Inventory & Valuation (Water Services)**

| Asset Category | Asset Type | | Number/ Length | Unit of Measure | Unit Replacement Cost ($/Unit) | Total Replacement Value |
|---|---|---|---|---|---|---|
| Water Linear | Water Mains | | 1,146 | km | $200,000 - $2,050,000 | $598,016,000 |
| | Appurtenances | Service Connections | 314 | km | $200,000 - $ 920,000 | $183,500,000 |
| | | Valves | 52,567 | Ea. | $4,500 - $18,700 | $460,012,000 |
| | | Hydrants | 10,210 | Ea. | $9,900 | $100,337,000 |
| | | Chambers | 10,370 | Ea. | $10,000 - $30,000 | $122,818,000 |
| | | Pressure Reducing Valves | 15 | Ea. | $10,700 | $160,000 |
| | Meters | Water Meters | 91,064 | Ea. | $400 - $18,000 | $45,451,000 |
| | | Fire Line Water Meter | 17 | Ea. | $8,800 - $18,000 | $191,000 |
| Water Facilities | Pump Stations | | 2 | Ea. | $1,281,000-$232,000 | $1,535,000 |
| | Water Filling Stations | | 5 | Ea. | $211,100 | $1,056,000 |
| **Total** | | | | | | **$1,513,076,000** |

NOTE: The replacement value for water mains and service connections exclude the asphalt cost, which is accounted for in the road AMP. Total replacement value of service connection includes estimation of missing records in GIS.

Water Linear assets are the largest of the inventory categories including water mains, appurtenances (service connections, valves, hydrants, and chambers) and water meters. Pressure Reducing Valves (PRVs) are tracked as their own category given the critical nature of these valves.

## 3.2 Age Summary

**Figure 3-1** shows the Water average asset age and average remaining service life as a proportion of average expected service life by asset type. Asset ages have been established using data from the City's GIS database and consultant reports. The expected service life (ESL) is developed using the City's Tangible Capital Asset database and through workshop discussions with City staff.

The water mains including transmission mains and distribution mains are approximately 28% through their ESL. Service connections are similar to water mains, approximately 29% through their ESL. Water meters are approximately three quarters through their ESL. Chambers and hydrants are in the middle of their ESL. Valves are about one third through their ESL. The pump stations' age indicates that the assets are approximately 60% through their asset life.

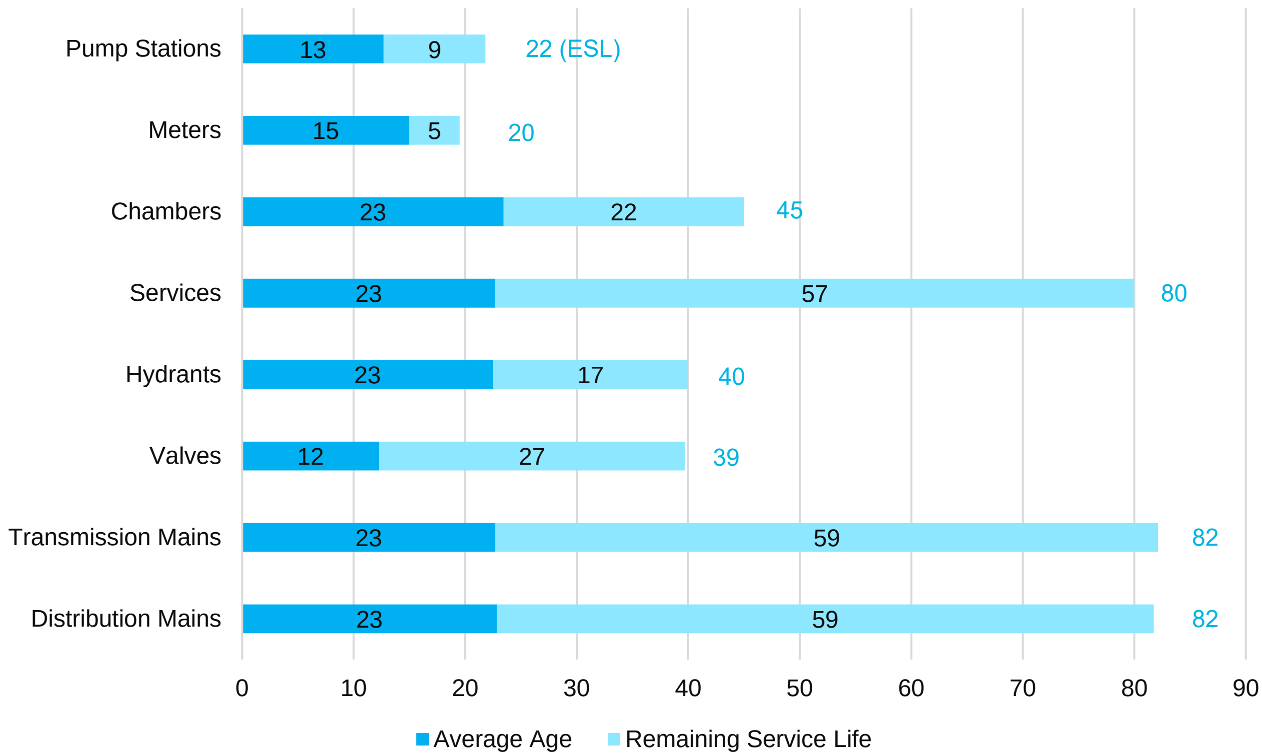



**Figure 3-1: Average Asset Age as a Proportion of Average Expected Service Life (Water Services)**

## 3.3 Asset Condition

The City's Water service assets are overall in very good condition with nearly 91% of assets in Very Good condition (**Figure 3-2**) weighted by replacement value. There are 4% of assets in Poor condition meaning that they are approaching or exceeded the end of their expected service lives, indicating a need for investment in the short to medium term. The remaining 5% of assets are in Good and Fair condition indicating that they are meeting current needs, but some are aging and may require attention.

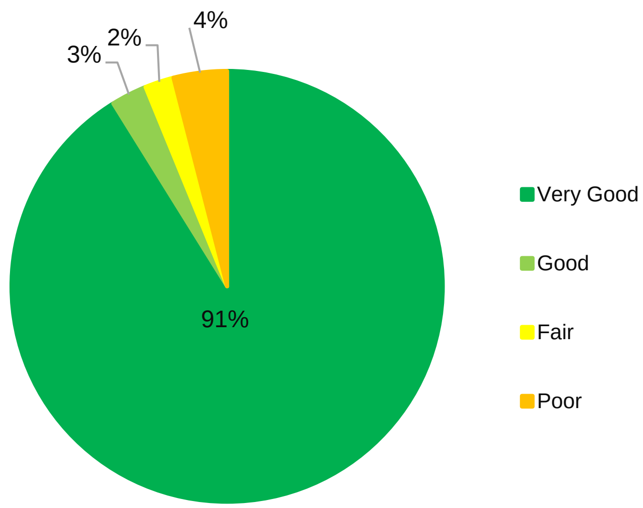



**Figure 3-2: Asset Condition Summary (Water Services)**

Asset conditions have been determined by using the data from the City' GIS database and consultant reports (**Figure 3-3**). The condition assessment of water mains, appurtenances and meters is based on the age and expected service life. For pump stations, condition information is adopted from consultant condition assessment reports in 2017.

There are 93% watermains by replacement value in very good condition. Only 5% are in Poor Condition which indicates the need for investment in the short to medium term. Continuing focusing on the renewal of cast iron and ductile iron mains is necessary to meet the City's service goals.

Service Connections and Valves are nearly in very good condition. The majority of hydrants is in Good or Very Good condition, and 11% of hydrant are in Poor condition which indicates a need for the short and medium team actions. Chambers are mostly in Very Good, Good, and Fair Condition. There are more than one third of water meters in Poor condition. Replacing aged meters would bring benefits over the years to come.

Approximately 55% of the water Facilities are in Very Good to Fair condition weighted by replacement value. The Poor condition water facility assets are in need for investment in the short to medium term. Pumping Stations, while currently in a Good condition, would deteriorate if the needs identified through consultant reports are not met since 2017. The condition assessment for water pump station is based on 2017 consultant reports. Water filling station condition was estimated based on age and estimated ESL.

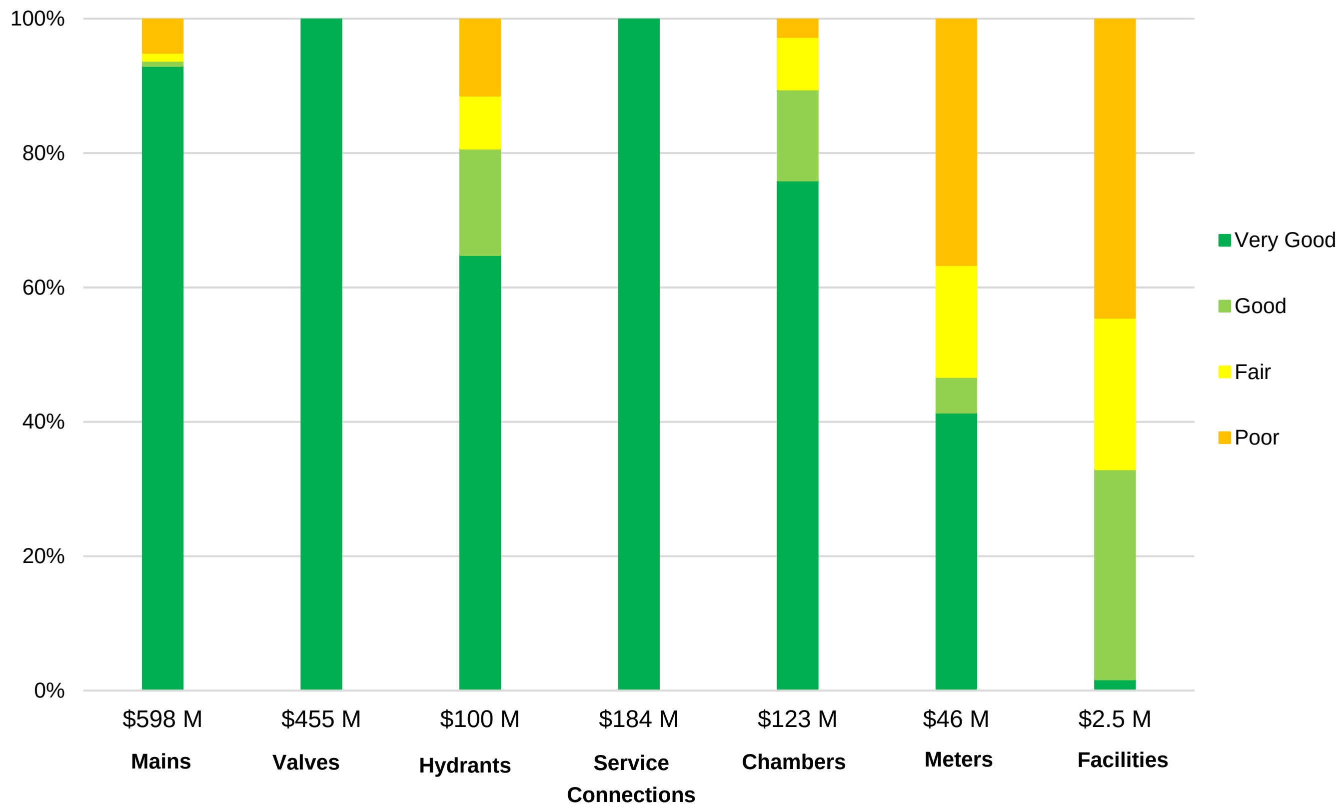



**Figure 3-3: Distribution of Asset Condition by Replacement Value (Water Services)**

## 3.4 Levels of Service

O. Reg. 588 / 17 requires legislated community levels of service for core assets. Community levels of service use qualitative descriptions to describe the scope or quality of service delivered by an asset category. O. Reg. 588 / 17 also requires legislated technical levels of service for core assets. Technical levels of service use metrics to measure the scope or quality of service being delivered by an asset category. **Table 3-2** presents a summary of the City's water service level for O. Reg 588 / 17 Metrics. References are provided to show where O. Reg 588/17 requirement has been attained.

**Table 3-2: O. Reg. 588 / 17 Levels of Service Metrics (Water Services)**

| Community Levels of Service | Technical Levels of Service |
|---|---|
| • Description, which may include maps, of the user groups or areas of the municipality that are connected to the municipal water system (**Figure 3-4**).<br>• Description, which may include maps, of the user groups or areas of the municipality that have fire flow (**Figure 3-5**). | • Percentage of properties connected to the municipal water system (94.4%).<br>• Percentage of properties where fire flow is available (96.4%). |
| • Description of boil water advisories and service interruptions (0 days of boil water advisory and service interruptions). | • The number of connection-days per year where a boil water advisory notice is in place compared to the total number of properties connected to the municipal water system (0 days).<br>• The number of connection-days per year due to water main breaks compared to the total number of properties connected to the municipal water system (0 days). |

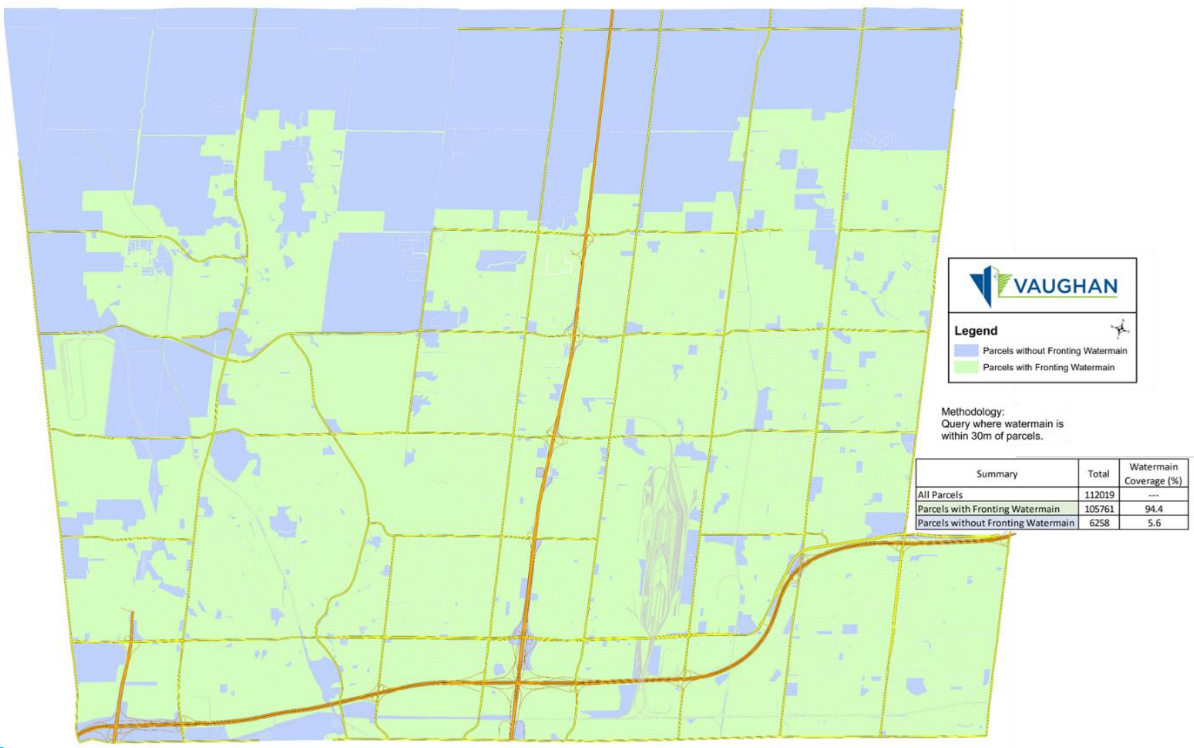



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**Figure 3-4: Map Outlining the City's Water Connectivity**

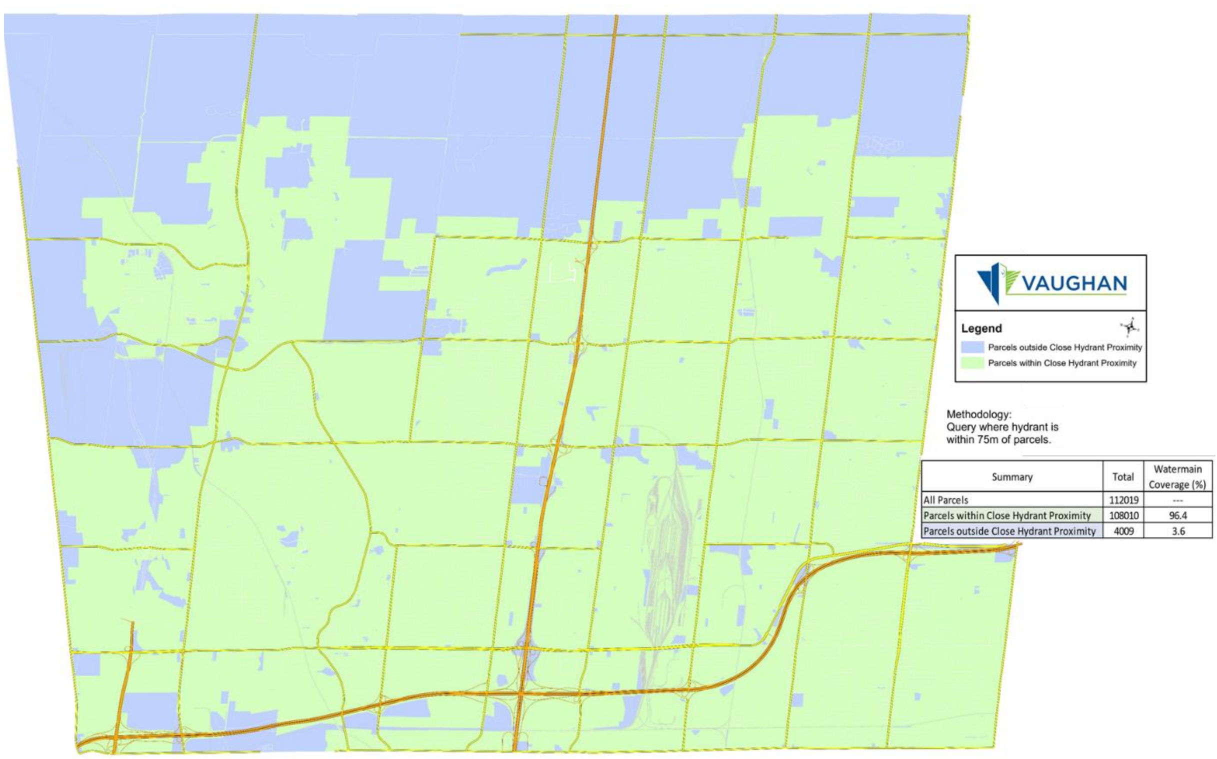


**Figure 3-5: Map Outlining the City's Fireflow Connectivity**

## 3.5 Life Cycle Strategies

### 3.5.1 Asset Acquisition / Procurement / Construction Strategies

Added to City-purchased inventory is water infrastructure that the City accepts (and takes immediate financial responsibility for) from developers as new neighborhoods are constructed.  For example, as developers build new neighborhoods, the new local infrastructure (including water mains) is paid for by the developer and then transferred to the City for operation, maintenance and ultimately replacement. The City's infrastructure inventory was therefore created over many decades through infrastructure paid for by the City or by developers.

Development Engineering will make sure water assets are up to standard for water operations. Regarding the water asset assumption process, the City has a standard process. Inspectors from Development Engineering firstly conduct asset inspections and update the GIS database. If there are any issues, Development Engineering will take the issue up with the contractor(s). The actual assumption process is fast. GIS will capture assets as assumed at the as-building drawings phase. For the assumption to happen it could take up to ten years due to a variety of reasons such as developer delays, which is not uncommon.

### 3.5.2 Asset Operations and Maintenance (O&M) Strategies

Water asset O&M cost consists of three major components: Water Purchase, Pure Water O&M Activities, and Overhead cost. **Table 3-3** presents the breakdown activities and five-year average cost for the City's Water assets.

A significant expenditure is for water purchase from York Region. The average annual water purchase cost is $42,916,000, which will be inflated considering water quality regulations and potential more water purchase in the future years. The five-year average annual pure water activity cost is $4,252,000 on of the last five years. The overhead cost is approximately half of the pure water activity cost.

Pure water activities refers to water assets related O&M activities including water operations, water leaking protection, backflow prevention program, material disposal, watermain repairs, watermain swabbing, flushing, flow tests, valve inspection, valve repairs/replace/inspect, chamber repairs, valve exercising, PRV inspection & maintenance, hydrant inspection/repair/maintenance/paint, hydrant winterizing, hydrant painting, hydrant daylighting, water service investigation, water service repairs, shutoff/turn-on service, water service swabbing, thawing, water service raise/lower, meter installations, meter reading, meter repairs/testing/replace, booster inspections, booster maintenance & repair, booster repair, water filling station maintenance, locates and stakeouts, sampling, stockpiling water/sewer gran, water connection services, and water AMI Program.

**Table 3-3: Water O&M Activities and Five-Year Average Costs**

| O&M Activities | Description | Five-year Average Cost |
|---|---|---|
| **Water Purchase** | Water Division - Admin. | $42,916,000 |
| **Overhead** | All overhead cost (e.g., compliance and training, business support, etc.) | $2,151,000 |
| **Pure Water O&M Activities** | Include water operations, watermain activities, valve activities, chamber activities, hydrant activities, water leaking protection, water service activities, thawing, meter activities, water filling station maintenance, shutoff/turn-on service, booster station activities, AMI program, etc. | $4,252,000 |
| **Total** | | **$49,319,000** |

### 3.5.3 Asset Renewal and Replacement Strategies

#### 3.5.3.1 Water Pipes

**Pipe renewal.** The following renewal activities were identified for the mains, assuming that the water, sewer and storm mains will be renewed with the same methods, as follows.

- Pipe Bursting. Pipe bursting can be applied to brittle materials, and pipe splitting to ductile materials. The old pipe is ruptured and pressed into the surrounding soil while a new pipe follows the cone-ended bursting tool to replace the old pipe. The bursting tool is hammered through the host pipe by pneumatic or hydraulic means. The benefit of pipe bursting is that it allows for trenchless upsizing of the original pipe. The typical length of pipe replaced by pipe bursting is approximately 110m, but greater lengths have been accomplished. Pipe depth, soil conditions, adjacent utilities and service connections will dictate whether pipe bursting is appropriate. Pipe bursting can be used on almost any type of existing pipe except ductile iron (DI) or heavily reinforced concrete.
- Cured-in-Place Pipe (CIPP) Liners. Cured-in-place pipe liners (CIPP; also known as “cast”-in-place liners) have been commercially available since 1971 and are used to seal and or structurally renew existing pipes without excavation of the pipe itself. The basic CIPP liner product is a tube, impregnated with a liquid thermoset resin, inserted into a pipeline, and cured. CIPP liners were developed as a modified coating system, delivering resins in a carrying tube (often described as a “sock”) that could hold the desired coating in place until the resin had time to cure. CIPP liners are either inverted, pulled in place, or manually inserted into the host pipe. All expand radially or are otherwise conformed tightly against the host pipe. Various resins are utilized including epoxy, polyester, silicate, and vinylester, and the most commonly used resins are styrene-based. Resins are either ambient cured, thermally cured (utilizing either hot water or steam), or ultraviolet light (UV) cured. The City indicated that CIPP liners will be an option for main renewal where open-cut intervention is not possible due to accessibility, and in particular where the existing pipe is located under the following assets or in close proximity to the following features:
  - Regional roads;
  - Easements;
  - Railways;
  - Pipelines;
  - Bridges;
  - Rivers;
  - Walkways.

The use of trenchless technologies for pipe renewal and replacement is increasing and is predicted to grow into the future, as these technologies provide many benefits over open-cut pipe replacement. In terms of indirect costs, traffic disruption as a result of an open-cut pipe trench appears to be the greatest social cost to the consumer. By using trenchless technologies, utilities can reduce the societal burden by keeping roads open and not blocking business and local traffic. Other benefits of trenchless projects include improved safety (i.e., by not having an open trench) and that trenchless work does not interfere with other utilities or underground obstacles. Trenchless work is generally more cost effective than open-cut e.g., WERF estimates that cured-in-place lining enables savings of at least 10% over open cut methods. Another benefit of trenchless work is the elimination of cuts and patches in pavement which leads to the accelerated deterioration of the road surface.

**Pipe replacement**. Pipe replacement through trench open-cut is still fairly common within most municipalities, although open-cut work is typically disruptive to the adjacent area and requires a great deal of traffic control if the trench is located in a roadway. It tends to be slower than trenchless methods and more dangerous as workers / residents risk cave-ins when in or near the trench. Finally, trench open-cut methods generally are more expensive than trenchless methods. However, trench-open could still be the best / only option when trenchless methods are not viable.

Open-cut replacement consists of the traditional method of pipe installation, where an excavation crew typically digs a trench along the existing trench line using a track excavator or backhoe. The new pipe is laid, bedded and the trench is backfilled, compacted and the surface is reinstated as necessary.

The unit cost of pipe replacement through open-cut excavation needs to include the cost of excavation, laying the new pipe, backfilling and reinstatement. Other factors impacting costs include the installation of appurtenances such as valves, manholes, catch basin leads and whether and how many service connections need to be re-connected. The cost of the surface reinstatement could vary significantly based on whether the excavation needs to be returned to the level of e.g., an arterial road or only a landscaped surface.

The Water asset intervention process flow that governs the decision-making on when and how to intervene on the pipes in the analysis are presented in Figure 3-6.

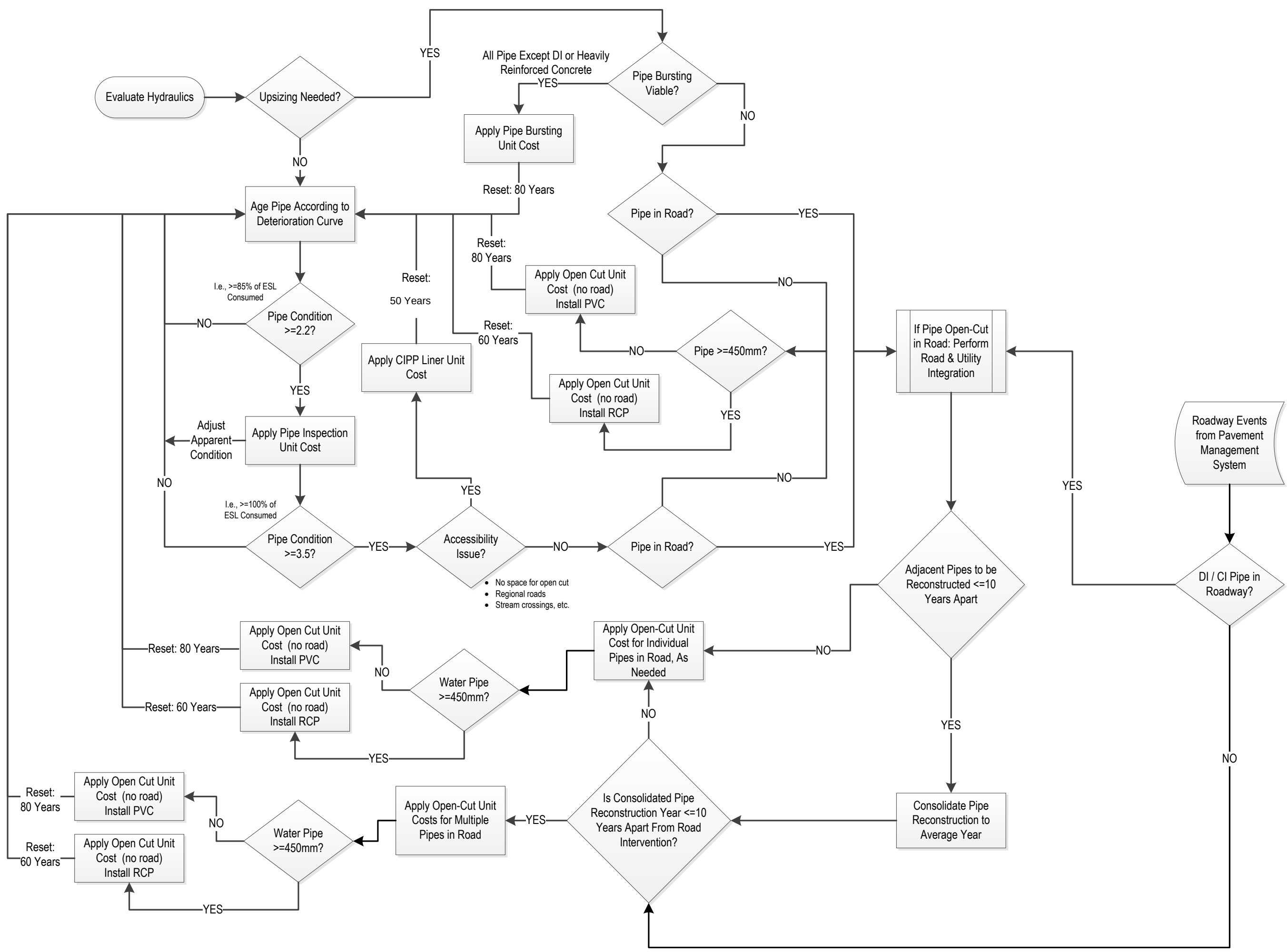


**Figure 3-6: Water Process Flow**

Table 3-4 presents a summary of the key decision-points within the pipe intervention process flow, and an explanation of the decisions programmed into dTIMS.

## Table 3-4: Pipe Intervention Process Decision Points & Explanations

| Decision Point | Decision & Explanation |
|---|---|
| **Upsizing Needed?** | YES: If a hydraulic constraint is identified (from elsewhere e.g., the City's hydraulic model) and the pipe is required to be up sized to the required pipe diameter, the next step is to consider whether pipe bursting is viable.<br>NO: If no hydraulic constraint is identified, no pipe upsizing is needed. |
| **Pipe Bursting Viable?** | YES: If pipe bursting is viable (i.e., viable for all pipes except for DI or heavily reinforced concrete pipes) then apply the pipe bursting unit cost to the length of pipe replaced. Reset pipe age to zero and apply an 80-year ESL to new pipe.<br>NO: If pipe bursting is not viable (i.e., pipe is DI or heavily reinforced concrete), the next step is to consider whether the pipe is in a road. |

| Decision Point | Decision & Explanation |
|---|---|
| **Pipe Condition >= 2.2?** | YES: If the pipe condition is equal or more than 2.2 (i.e., equal or more than 85% of the pipe ESL has been consumed), then trigger a pipe inspection and apply the inspection unit cost table.<br>NO: If the pipe has not yet reached a condition of 2.2 then dTIMS will “age” the pipe according to the applicable deterioration curve until it reaches a condition of 2.2 and then trigger an inspection. |
| **Pipe Condition >= 3.5?** | YES: If the pipe condition is equal to or greater than 3.5 (i.e., equal to or more than 100% of the pipe ESL has been consumed), then trigger a pipe renewal or replacement. The next step is to consider whether CIPP is a viable option for pipe renewal.<br>NO: If the pipe has not yet reached a condition of 3.5 then dTIMS will “age” the pipe according to the applicable deterioration curve until it reaches a condition of 3.5 and then trigger a pipe renewal or replacement. |
| **Accessibility Issue?** | YES: If the City flags the pipe as having an accessibility issue such as within / next to a Regional road, at a stream crossing, or where there is no space for an open cut intervention, then apply the CIPP unit cost to the length of pipe. Reset pipe age to zero and apply a 25-year ESL to the re-lined pipe.<br>NO: If accessibility is not an issue (i.e., the pipe is not within / next to a Regional road, at a stream crossing, or where there is no space for an open cut intervention), the next step is to consider whether the pipe is in a road. |
| **Is CIPP Viable?** | YES: If CIPP is viable (i.e., the pipe has not yet been re-lined or reached a condition of 3.5 in 2016 / is beyond its ESL in 2016), then apply the CIPP unit cost to the length of pipe. Reset pipe age to zero and apply a 25-year ESL to the re-lined pipe.<br>NO: If CIPP is not viable (i.e., the pipe has been re-lined once already or has reached a condition of 3.5 in 2016 / is beyond its ESL in 2016), the next step is to consider whether the pipe is in a road. |
| **Pipe in Road?** | YES: If an open-cut excavation pipe replacement is needed and the pipe is in a road, then the next step is to consider whether any adjacent pipes need to be replaced less than ten years apart.<br>NO: If an open-cut excavation pipe replacement is needed but the pipe is not in a road, then apply the basic open-cut unit cost to the length of pipe to be replaced. Reset pipe age to zero and apply an 80-year ESL to new pipe. |
| **Pipe => 450mm?** | YES: If the pipe diameter in equal or greater than 450mm, then replace pipe with reinforced concrete pipe (RCP), and apply a 60-year ESL to the new pipe.<br>NO: If the pipe diameter is less than 450mm, replace pipe with PVC pipe, and apply an 80-year ESL to the new pipe. |
| **Adjacent Pipes to be Reconstructed <10 Ten Years Apart.** | YES: If the years of open-cut reconstruction of two or more pipes in the same roadway are less than ten years apart, then calculate the average of the years and apply that as the year of reconstruction. Adjust the years of utility work to match the years of road work if it is within 10 years of one another. Apply the unit cost table for open-cut excavation in a roadway for two or three pipes, as needed, over the length of pipes reconstructed. Reset the pipes’ age to zero and apply an 80-year ESL to new pipes.<br>NO: If the years of open-cut reconstruction of two or more pipes in the same roadway are more ten years apart, do not adjust the reconstruction year. Adjust the years of utility work (one pipe) to match the year of road work if it is within 10 years of one another. Apply the unit cost table for open-cut exaction in a roadway for one pipe, over the length of pipe reconstructed. Reset the pipe age to zero and apply an 80-year ESL to new pipe. |
| **Risk Category = A** | YES: Pipe asset deemed critical and asset inspection & renewal should be prioritized based on risk rating;<br>NO; Assets are less critical, and repairs can be pushed out to align with pavement renewal program.<br>Note: Use when prioritizing within budget constraints. |

The capital planning applied a conservative principle in estimating pipe and appurtenance replacement. The capital budgeting forecasts for pipes will reflect the cost of replacing or renewal pipes and its adjacent appurtenances including service connections, chambers, valves, and hydrants. Oftentimes, the adjacent appurtenances’ condition is based on the liner asset condition, thus, the investment requirement timeline is similar.

#### 3.5.3.2 Water Meters

Aging makes water meters become less accurate, leading to a loss in revenues as water consumption is not accurately recorded. However, the premature replacement of water meters that are still reading consumption accurately is a waste of resources. Between these two economically opposing forces there is a point that economically justifies the cost of meter replacement. As such, the optimum service life of a meter depends on prevailing water rates, rate of meter wear (and loss of accurate registration), repair and maintenance costs, and inflation and discount rates. Ultimately, there's no standard time period for meter replacement that can be broadly applied to all utilities as local conditions such as chemical composition of the water, temperature and humidity all impact on meter life. Within Canada there is significant variability in meter replacement schedules between water utilities and a recent survey by the Canadian Infrastructure Benchmarking Initiative found that utilities generally change out between approximately 4% and 10% of their meters per year. Due to more water being sold and revenue generated through ICI meters, some utilities might even have a different replacement cycle for these meters e.g., changing 20% of their ICI meters out per year. With the latter numbers in mind and for the purpose of the Water AMP, AECOM has applied a 5% meter change-out cycle, which is equivalent to changing all meters out every 20 years.

#### 3.5.3.3 Water Pressure Reducing Valves

AECOM has applied a 4% PRV change-out cycle, which is equivalent to changing all PRVs out every 25 years.

#### 3.5.3.4 Water Facilities

In 2020, the City has performed Building Condition Assessment and generated facility inventories and 10-year capital renewal plan for North Maple Booster Station and Teston Water Filling Station. In 2017, the City has conducted condition assessment for Woodland Acres Pressure Elevation System and developed a renewal plan. The rest of the water filling stations are East Filling Station, Central Filling Station, West Filling Station, North Filling Station. AECOM has applied a flat rate based on the existing AM Plans for the capital planning analysis period.

### 3.5.4 Decommissioning and Disposal Strategies

Asset decommissioning and disposal activities are performed to decommission and dispose of assets due to ageing or changes in performance and capacity requirements. This decision process includes the consideration of costs and benefits of rationalization using a whole life approach, the impact of asset rationalisation on other infrastructure and the processes for disposal of assets. More specifically, the following factors need to be evaluated when considering the decommission and disposal of assets:

- Assets not required for the delivery of services, either currently, or over the longer planning period.
- Assets that have become uneconomical to maintain or operate.
- Assets that are not suitable for service delivery.
- Assets that have a negative impact on service delivery, the environment, or community.
- Assets that no longer support the City's service objectives due to a change in type of service being delivered or the delivery method.
- Assets where their use has become uneconomical due to the limited availability of spares or the cost of their replacement parts.
- Assets where their technology has been outdated.
- Assets which can no longer be used for the purpose originally intended.

Considerations for the City's asset decommissioning and disposal activities include, but are not limited to:

- Updates to the City's Statement of Tangible Capital Assets. Considerations related to the determination of residual value and the disposal of assets include:
  – Residual value and the useful life of an asset should be reviewed, at the very least, at each financial year-end and, if expectations differ from previous estimates, any change should be accounted for prospectively as a change in estimate.
  – The depreciation method used should reflect the pattern in which the asset's economic benefits are consumed.

- The depreciation method should be reviewed, at the very least, annually and, if the pattern of consumption of benefits has changed, the depreciation method should be changed prospectively as a change in estimate.

- Updates to asset databases such as the GIS and CMMS.
- Environmental impact of disposal and implications for land rehabilitation, where applicable.
- Continued service delivery while a new asset is being constructed / commissioned: overlap of the start-up of new assets / facilities and the decommissioning of existing assets / facilities being replaced.
- Cost of decommissioning and disposal.
- Disposing Asbestos Cement (AC) mains
  - In normal use, Asbestos fibers in drinking water will not affect public health since there is low concentration of asbestos in drinking water. However, when AC pipes are severely deteriorated, asbestos can be released into the drinking water.
  - While the City does not have extensive AC pipelines in its water distribution system (approximately 1.1 km), additional health and safety measures should be taken into considerations when attempting to repair, remove, or dispose such a material. These types of activities, if not well managed, may release asbestos fibers into the air causing risks to the public health. Work associated with assets made of AC material should be in accordance to the City's specifications related to hazardous material management (i.e. asbestos management) and in accordance to O. Reg. 278 / 05, which is made under the Occupational Health and Safety Act.

### 3.5.5 Risk Assessment

A detailed risk assessment has been performed as part of AECOM's 2016 project for the City. A risk score was calculated for each watermain using its Probability of Failure (PoF) and Consequence of Failure (CoF) score. PoF for watermains was estimated using a combination of the Weibull age deterioration and expected service life approach and the City's main break history. The age of mains contributed to 75% of the PoF score while the break history was responsible for the remaining 25%. The relative contributing percentage values of age versus main breaks are variable and can be adjusted, as applicable. The potential exists to incorporate soil corrosivity in the future assessment of PoF, once the City has a better idea of which soils contribute to the exterior corrosion of metallic mains. The CoF for the new developed assets after 2016 were determined by a multi-regression method.

Please refer to 2016 Risk Management Framework Report for more details.

**Figure 3-7** shows the risk map for water mains. As the City's assets are relatively young, most of the water mains fall in Low risk category.

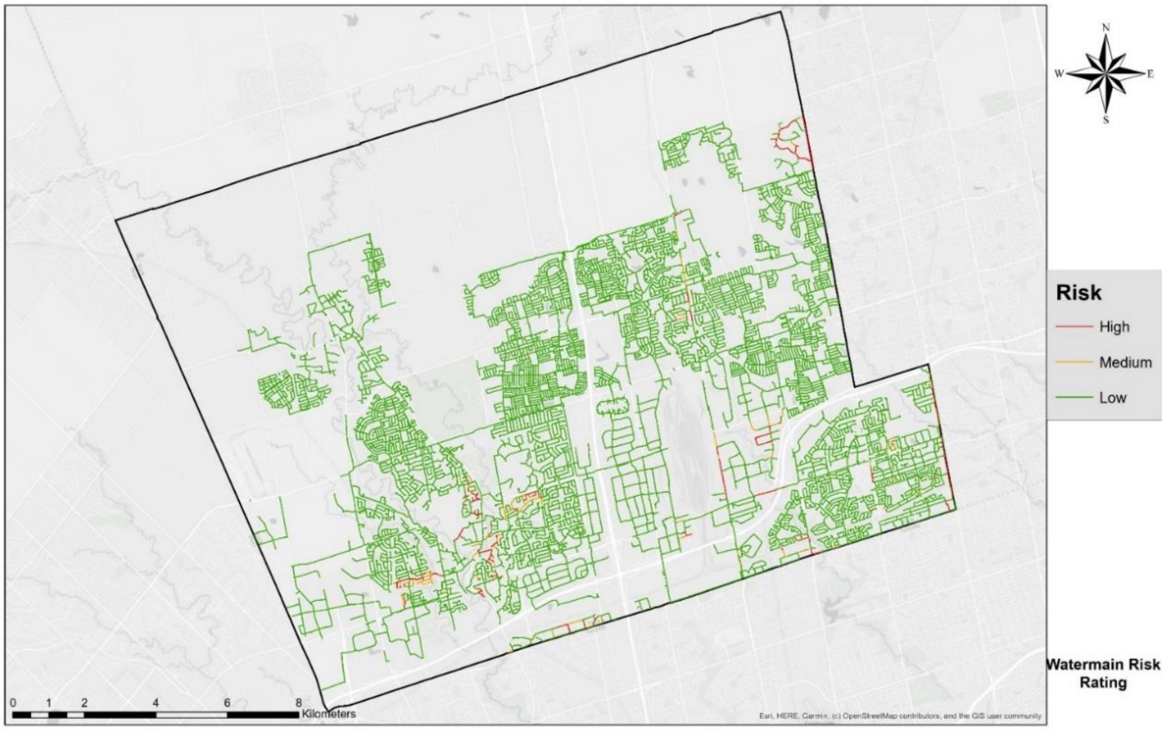


Figure 3-7: Water Main Risk Map

## 3.6 Funding Need Analysis

### 3.6.1 Water Linear Asset Condition Forecasts and Budget Scenarios

Three budget scenarios were performed for water linear assets reinvestment need analysis, which are Do-Nothing, Unlimited and $6M budget. Figure 3-8 shows the condition of water linear assets changing over the next 20 year for different budget scenarios. The gaps between Do-Nothing and the others are increasing over the next 20 years, while the condition of the $6M scenarios and unlimited budget nearly overlaps with each other at the end of the analysis period. The reinvestment needs for water non-linear assets were analyzed using the approaches illustrated in Section 3.5.3.2 to 3.5.3.4.

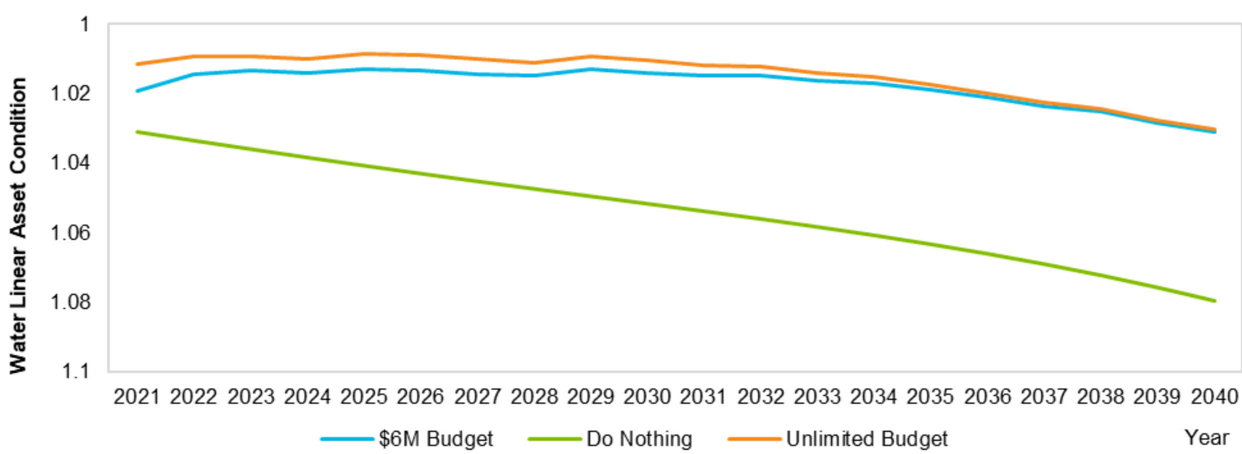


Figure 3-8: Water Linear Asset Condition Forecasts and Budget Scenarios

The $6M linear asset budget scenario will be carried forth in the Water 20-Year Funding Need Analysis in the next section.

### 3.6.2 Water 20-Year Funding Need Analysis

When the linear asset $6M budget scenario is added to the reinvestment required for meters and facilities, the average annual reinvestment rate for the City's entire water infrastructure assets is $10M over the next 20 years in inflated dollar values. This is equivalent to a total of approximately $200M over the next 20 year period, as presented in **Figure 3-9**.

It is important to note, as shown in **Figure 3-10**, there is significant reinvestment required for pipe open cut and trenchless replacement, as well as water meter replacement. Looking ahead to the decade between 2031 and 2040, the City should prepare for more reinvestment as pipes continue to age, especially as ductile iron and cast-iron pipes start to approach and exceed their respective ESLs.

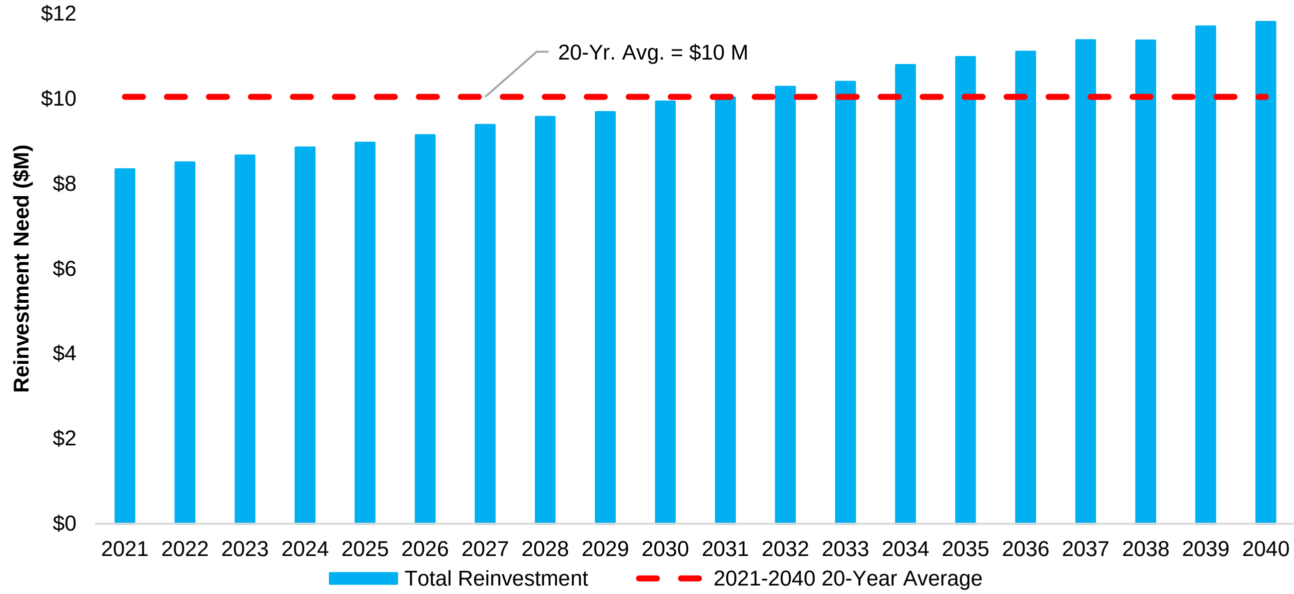


**Figure 3-9: Water 20-Year Total Reinvestment Need (Includes $6M Water Linear Asset Budget Scenario)**

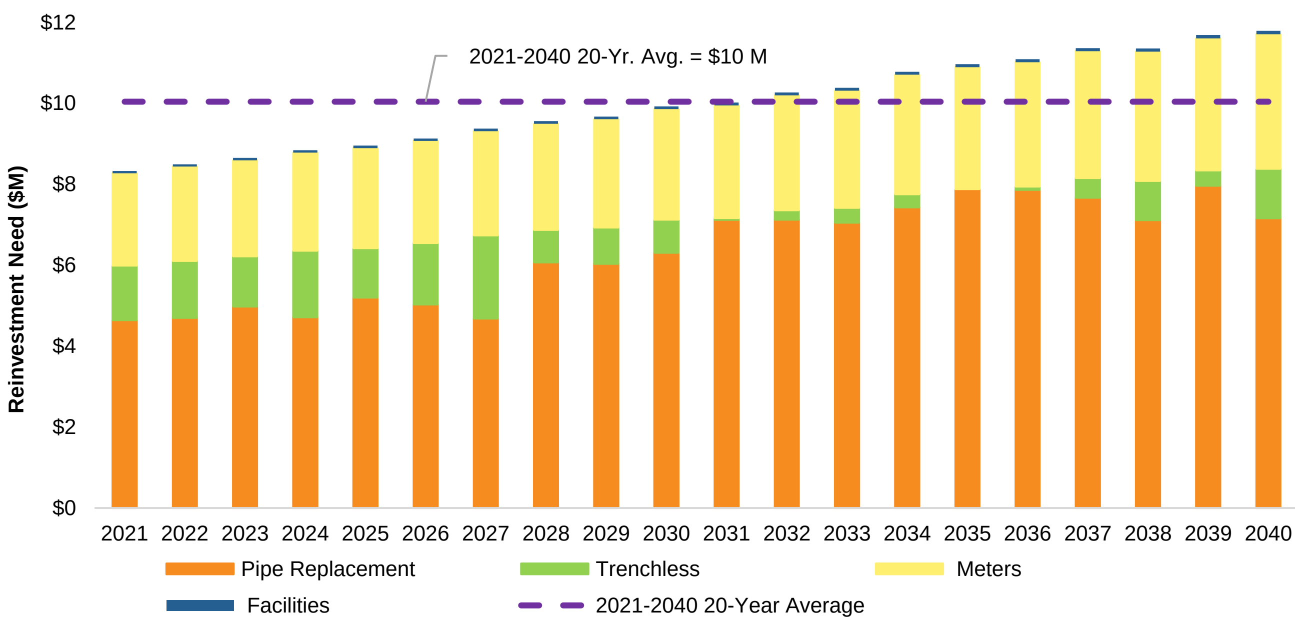


**Figure 3-10: Water 20-Year Reinvestment Need Details**

The detailed reinvestment needs for pipes and appurtenances, meters, facilities, and PRVs are presented in **Table 3-5.**

**Table 3-5: 20-Year Total and Annual Average Reinvestment Need**

| | Pipes and Appurtenances | Water Meters | Facilities | PRVs | Total |
|---|---|---|---|---|---|
| Annual Average Need | $7,190,000 | $2,774,000 | $68,000 | $7,800 | $10,040,000 |
| 20-Year Total | $143,790,000 | $55,471,000 | $1,361,000 | $156,000 | $200,778,000 |

The total annual reinvestment rate from **Figure 3-9** has been overlaid with an idealised / target O&M annual budget (based on National Benchmarking utility median values, inflated dollar value) and the Average Water Development Cost (DC), as presented in **Figure 3-11**.

Water assets requires approximately $245M O&M funding over the next 20 years, equivalent to $12.3M per year in inflated dollar value. The Water service development requires approximately $86M over the next 20 years, equivalent to roughly $4.3M annually. As such, with the addition of O&M and Water DC, the total average annual reinvestment rate for the City's water infrastructure assets increases to approximately $27M annually, for a total of $532M over the next 20-year period.

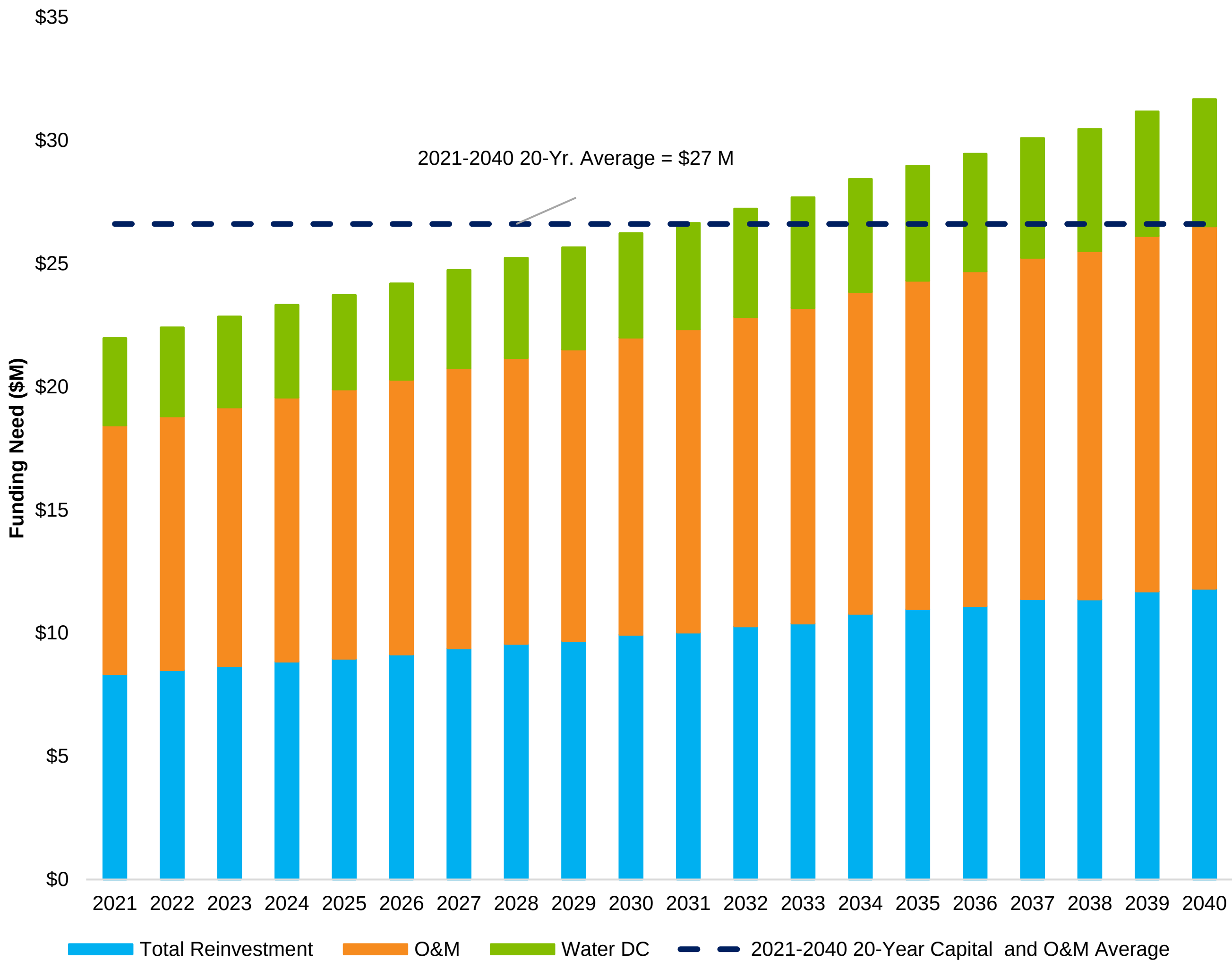


**Figure 3-11: Water 20-Year Capital Investment and O&M Cost Forecast**

### 3.6.3 Full Funding Need Profile

**Figure 3-12** shows a full picture of the City's Water Service funding need forecast over the next 20 years, which provides the City the full funding requirements in order to perform effective financial planning activities. The total annual reinvestment rate from **Figure 3-9** has been overlaid with the City's five-year annual average water purchase cost, O&M cost, and the annual average Water DC.

The City's water service funding requirement increases to approximately $1.6B over the next 20 years with additional funding requirement of water purchase, O&M and water DC, equivalent to $79M per year in inflated dollar value. It is noticeable that the funding requirement for water purchase is significant compared to capital requirement and O&M requirement, as presented in **Figure 3-12**.

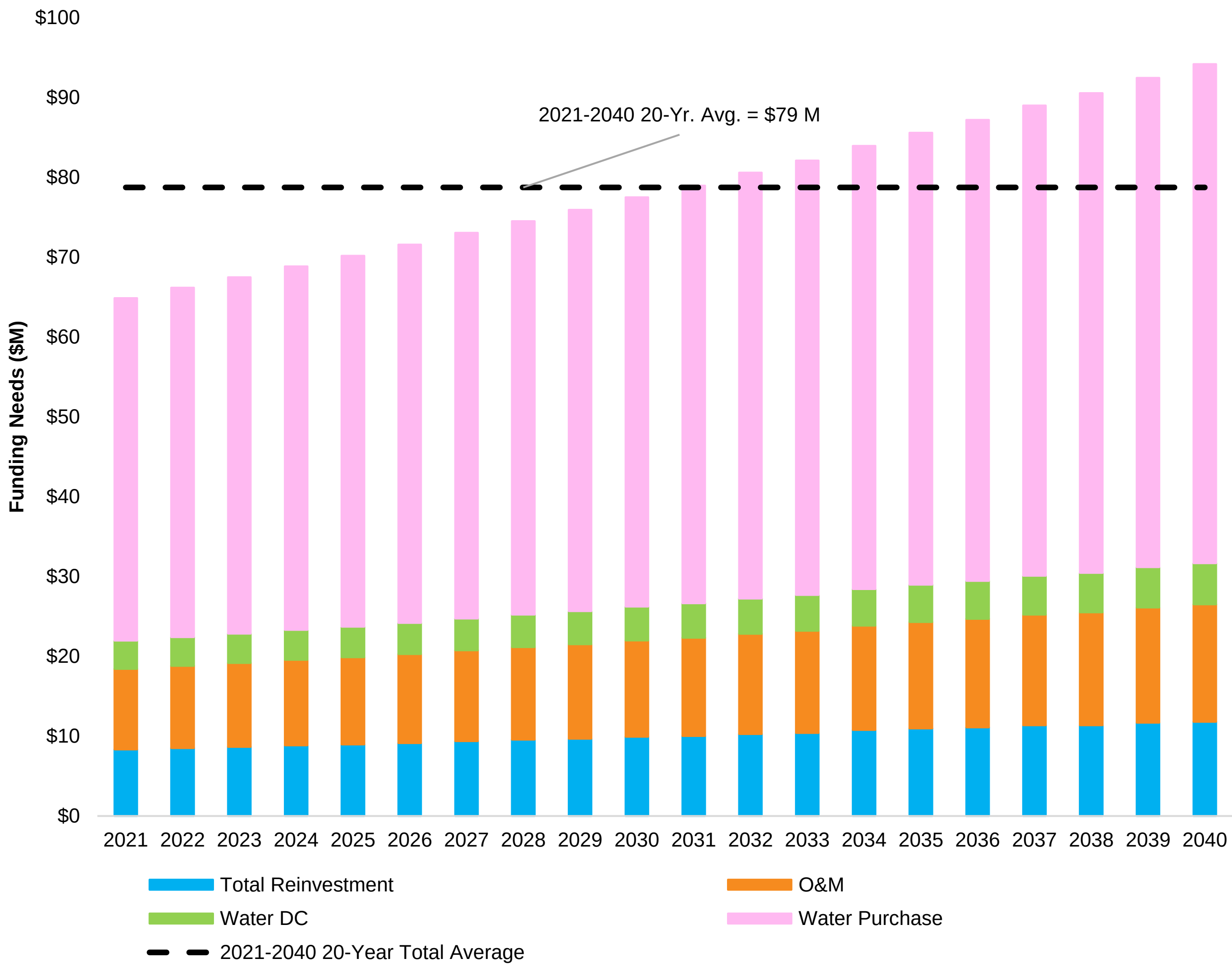


**Figure 3-12: Water Full Funding Need Profile**

## 3.7 Recommendations for Water AMP Continuous Improvement

Continuous improvement is an important component of any AM program and is achieved through the implementation of recommended improvement initiatives which support sustainable service delivery. While the City's water assets are in a fairly good condition, there are current and future challenges that must be contended with. It is important to address these challenges thoroughly and promptly to leave a positive legacy for future generations.

AECOM has identified a set of activities that represents the next stage of AM planning and implementation within the City.

- **Refine the asset data and close existing data gaps, so as to have a more accurate representation of the current state of the water infrastructure; and, ultimately, to make more informed and defensible decisions.**
  - Continue to collect data and fill gaps in the GIS inventory. The City should also prioritize collecting condition data across all water assets.
  - Assign a unique ID for each water asset and link the ID across data sources so that assets can be tracked throughout their whole lifecycle. Old legacy asset ID's from the GIS inventory should be removed.
  - Develop a consistent and structured condition assessment process across all Water assets.
  - Develop a Data Governance Framework to define clear roles on data ownership and accountability, improve confidence in decision-making, improve asset data integrity and streamline information workflows.
- **Refine the Levels of Service Framework to quantify the gaps between existing and target service levels.**
  - Collect current asset performance data for key performance indicators (KPIs) that are not currently being tracked, including associated costs.
  - Analyze asset performance data to determine trends and to establish annual performance benchmarks.
  - Engage in a discussion with key stakeholders (see **AM Strategy**) to establish service level targets and identify associated costs to meet those targets.
  - Once LoS targets have been decided upon, the City should develop strategies on how to meet service level targets considering its existing operating environment (i.e., staff availability, current funding, resources, etc.).
  - Develop a Customer Consultation Plan to engage the public and other stakeholders on the LoS framework and to better understand customers' willingness to pay for enhanced service levels.
- **Enhance the Water risk assessment for future iterations of the AM plan, and use the risk assessment results to drive future water condition assessments and financial needs forecasting.**
  - Update Risk model's Probability of Failure component to assess the ability of the asset to meet current and future operational requirements including capacity, regulatory, resilience and other LoS needs.
  - Continuing from previous bullet, incorporate hydraulic modeling data to combine pipe capacity limitations together with pipe condition / remaining service life information to better predict when pipes need to be replaced.
  - Assess criticality and risk comprehensively for new assets in the inventory;
  - Frequently revisit and revise probability of failure and criticality model as needed;
  - Review risk attribute values periodically to ensure alignment with business objective and appetite;
  - Overlay the risk models with the current state of the assets (i.e., condition), and the 20-year financial forecast. Using this approach, the City could focus its monitoring, maintenance, and renewal and replacement budget and activities on high risk water infrastructure. Medium risk infrastructure could be addressed through the mitigation of failure through regular monitoring, and the low risk infrastructure could be accepted with caution.

- **Establish a sustainable water funding model that fits the needs of the community.**
  - In light of the annual capital investment reinvestments outlined in **Figure 3-11**, the City should increase water expenditures on asset renewal, replacement, O&M, and new development to an average of $27M per year over the next 20 years.
  - Review financial modeling assumptions on ESL and replacement values and update the financial model with new information as it becomes available. The financial model is based on a number of key assumptions for asset ESL and replacement values that could have a significant impact on the outcomes of the model.
- **Continue to find ways to improve AM initiatives across the City by maintaining a high level of AM awareness through training, communication, and knowledge sharing.**
  - Conduct an AM Software Assessment to identify future system requirements that may include enhancing existing software, adding-on, or replacing.
  - Develop a Knowledge Retention Strategy & Internal Communications Plan to document staff AM knowledge and experience for reporting and succession planning purposes. Communicate AM improvement initiatives and enhance AM awareness internally through internal communication.
  - Aligning the Financial and Non-Financial Functions of AM. Refer to **Section 2.4.3** for the framework to address the need to achieve this alignment.

# 4. Wastewater

The City's wastewater infrastructure is a combination of linear sewers (pipes) and pumping stations that collect wastewater through gravity and force mains that discharges to Regional wastewater treatment plants, where it is cleaned and discharged into the environment. The wastewater system is designed to collect residential, commercial, and industrial wastewater.

Wastewater generated by the City flows through over 1,000 kilometres of sewers before it reaches the Duffin Creek Treatment Plant. The Regional Municipalities of York and Durham jointly own the Duffin Creek Water Pollution Control Plant, located on the shore of Lake Ontario in the City of Pickering, Ontario. Treated water outlets to Lake Ontario. The Kleinburg area is serviced by a treatment plant operated by York Region.

## 4.1 Asset Inventory and Replacement Value

The City's wastewater assets are managed and maintained to meet provincially issued system and facility operating permits, as well as the City's technical targets for performance and reliability. Valued at approximately $1.0 Billion, the extensive wastewater collection network of assets is categorized into Wastewater Linear and Wastewater Facilities; and further divided into six asset types ranging from wastewater mains and appurtenances to facilities (**Table 4-1**).

The City's core services including Water, Wastewater, Stormwater, and Transportation are coordinated with each other to ensure cost efficiencies to maintain the desired level of service while minimizing the risks. The core service areas are considered as a whole when considering the infrastructure lifecycle needs.

**Table 4-1: Asset Inventory & Valuation (Wastewater Services)**

| Asset Category | Asset Type | No. | Unit of Measure | Unit Replacement Cost ($/Unit) | Replacement Value |
|---|---|---|---|---|---|
| **Wastewater Linear** | Mains | 1,000 | km | $340,000 - $2,100,000 | $468,871,000 |
| | Laterals | 246 | km | $350,000 - $650,000 | $371,537,000 |
| | Manholes | 16,174 | Ea. | $11,010 - $33,140 | $180,158,000 |
| | Flow Meters | 45 | Ea. | $13,600 - $50,400 | $970,000 |
| **Wastewater Facilities** | Pump Stations | 12 | Ea. | $63,000 - $1,629,000 | $6,115,000 |
| | Generator Station | 1 | Ea. | $403,000 | $403,000 |
| **Total** | | | | | **$1,028,054,000** |

NOTE: The replacement value for wastewater mains and service connections exclude the asphalt cost, which is accounted for in the road AMP. Total replacement value of service connection includes estimation of missing records in GIS.

Wastewater linear assets represent the largest component of the wastewater system inventory, and include pipes, laterals, manholes, and flowmeters. Within the wastewater mains, there are 889 km local sewers (diameter < 450 mm) and 111 km trunk sewers (diameter >= 450 mm). There are approximately 4.8 km force mains that convey the City's wastewater under pressure.

Pumping stations are fixed facilities dispersed throughout the collection system. The City operates and maintains 12 wastewater pump stations and one generator station. The generator station provides hydro service and emergency power connected to two pump stations nearby and operates below grade pumping facilities.

## 4.2 Age Summary

**Figure 4-1** shows the Wastewater average asset age as a proportion of average expected service life by asset types. Asset ages have been established using data from the City's GIS database and consultant reports. The expected service life is developed using the City's Tangible Capital Asset database and workshop discussions.

The wastewater mains are approximately 28% through the expected service life. Service connections and manholes are similar to water mains, approximately 30% through the expected service life. Pump Stations are about 36% through their expected service life. The generator station is approximately in the middle of their expected service life (ESL).

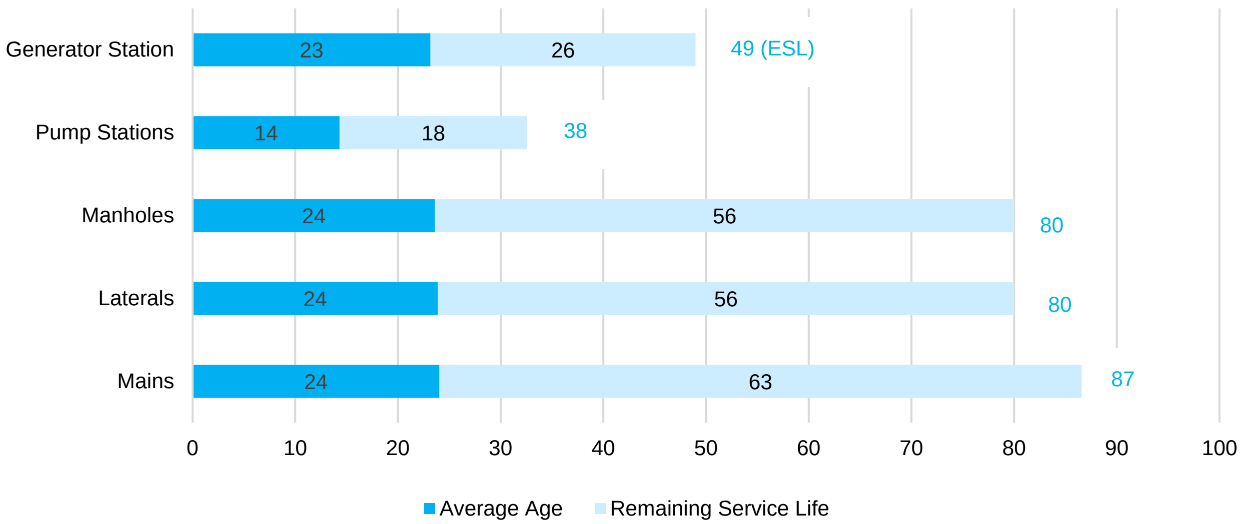


**Figure 4-1: Average Asset Age as a Proportion of Average Expected Service Life (Wastewater Services)**

## 4.3 Asset Condition

The City's Wastewater service assets are overall in very good condition with nearly 99.6% of assets in Very Good condition (**Figure 4-2**). There are only 0.01% of assets in Poor condition meaning that they are approaching the end of their expected service lives, indicating a need for investment in the short to medium term. The reminder assets are in Good and Fair condition indicating that they are meeting current needs but are aging and may require attention.

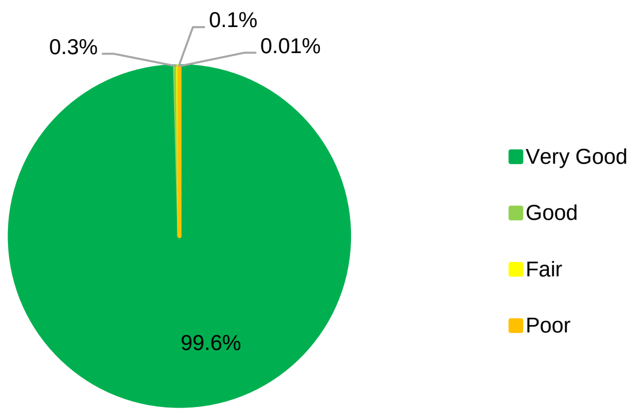


**Figure 4-2: Asset Condition Summary (Wastewater Services)**

Asset conditions have been determined by using the data from the City' GIS database and consultant reports. The condition assessment of wastewater mains, laterals and manholes is based on the age and expected service life. For facilities, condition information is adopted from consultant condition assessment reports in 2017 and 2020.

Wastewater mains, laterals and manholes are overall rated in Very Good condition (**Figure 4-3**). Facilities are nearly in Good to Fair condition. Pumping Stations, while currently in a Good condition, would deteriorate if the needs identified through consultant reports are not met since 2017.

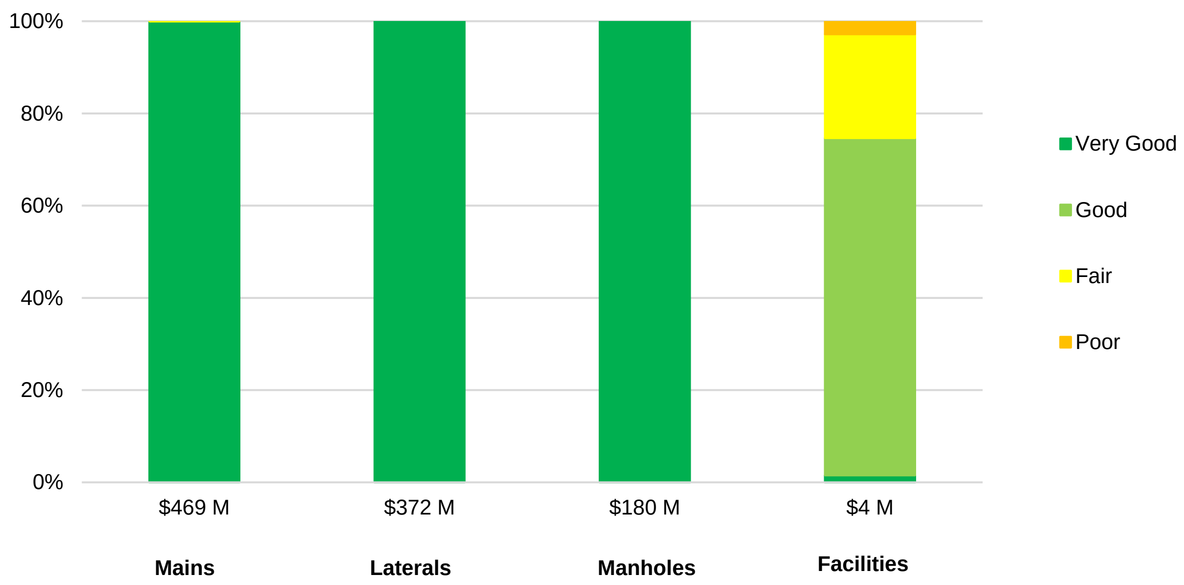


**Figure 4-3: Asset Condition Detail (Wastewater Services)**

## 4.4 Levels of Service

Ontario Regulation (O.Reg.) 588/17 requires legislated community levels of service for core assets. Community levels of service use qualitative descriptions to describe the scope or quality of service delivered by an asset category. O. Reg. 588/17 also requires legislated technical levels of service for core assets. Technical levels of service use metrics to measure the scope or quality of service being delivered by an asset category. Table 4-2 is a summary of the City's water service level for O.Reg. Metrics. References are provided to show where O. Reg 588/17 requirement has been attained.

**Table 4-2: O. Reg. 588/17 Levels of Service Metrics (Wastewater Services)**

| Community levels of service | Technical levels of service |
|---|---|
| • Description, which may include maps, of the user groups or areas of the municipality that are connected to the municipal wastewater system. (Figure 4-4) | • Percentage of properties connected to the municipal wastewater system. (93.7%). |
| • Description of how combined sewers in the municipal wastewater system are designed with overflow structures in place which allow overflow during storm events to prevent backups into homes (N/A, City of Vaughan does not operate combined wastewater/stormwater systems).<br>• Description of the frequency and volume of overflows in combined sewers in the municipal wastewater system that occur in habitable areas or beaches (N/A, City of Vaughan does not operate combined wastewater/stormwater systems).<br>• Description of the effluent that is discharged from sewage treatment plants in the municipal wastewater system (N/A, City of Vaughan does not operate sewage treatment facilites). | • The number of events per year where combined sewer flow in the municipal wastewater system exceeds system capacity compared to the total number of properties connected to the municipal wastewater system. (0 events).<br>• The number of connection-days per year due to wastewater backups compared to the total number of properties connected to the municipal wastewater system. (0 days).<br>• The number of effluent violations per year due to wastewater discharge compared to the total number of properties connected to the municipal wastewater system. (0 events). |

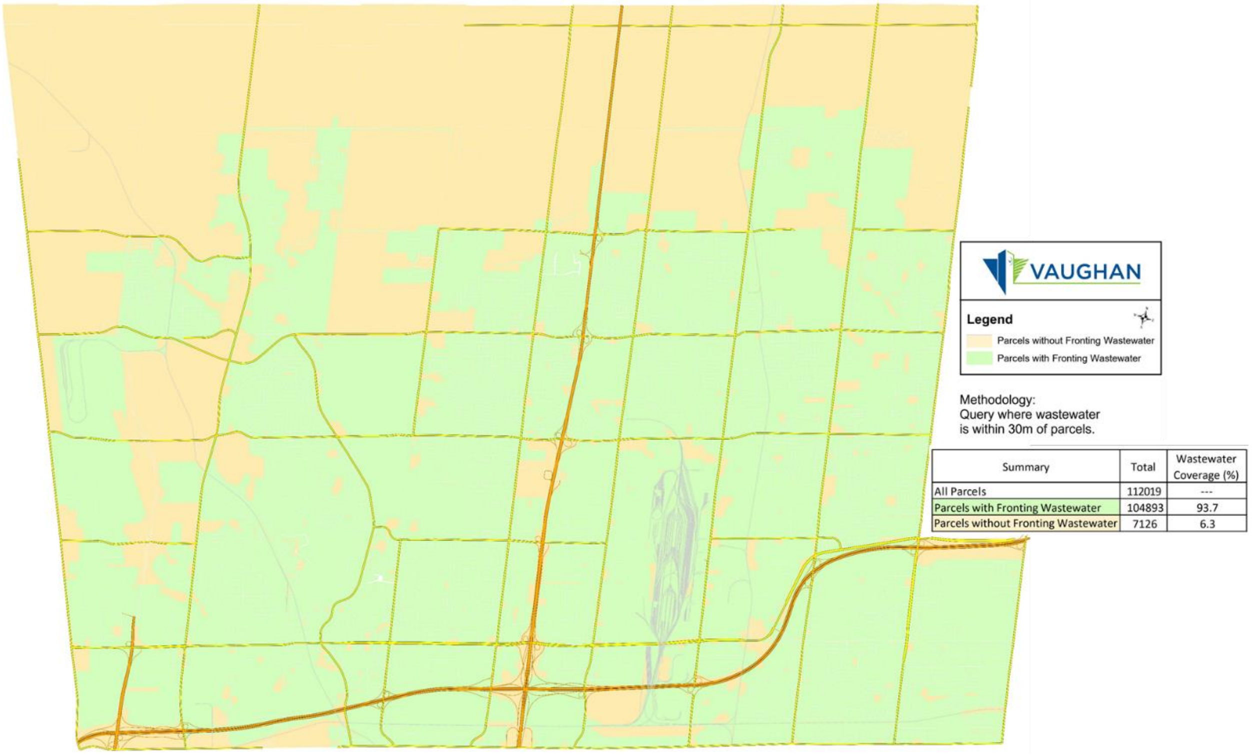


**Figure 4-4: Map Outlining the City's Wastewater Connectivity**

## 4.5 Life Cycle Strategies

### 4.5.1 Asset Acquisition / Procurement / Construction Strategies

Added to City-purchased inventory is wastewater infrastructure that the City accepts (and takes immediate financial responsibility for) from developers as new neighborhoods are constructed. For example, as developers build new neighborhoods, the new local infrastructure (including wastewater mains) is paid for by the developer and then transferred to the City to operate, maintain and ultimately replace. The City's infrastructure inventory was therefore created over many decades through infrastructure paid for by the City or by developers. Development Engineering will make sure that wastewater assets are up to standard for wastewater operations.

### 4.5.2 Asset Operations and Maintenance (O&M) Strategies

Wastewater asset operations and maintenance cost consist of three major components: wastewater service cost, pure wastewater O&M activities, and overhead. Table 4-3 presents the breakdown activities and five-year average cost for the City's Wastewater assets.

A significant portion of O&M cost is for wastewater service to Region of York. The five-year average Regional wastewater service cost is $60,554,000, which will be inflated considering wastewater regulations and potential more wastewater discharges in the future years. The five-year average annual wastewater activity cost is totally $4,094,000. The overhead cost is approximately one third of the pure wastewater activity cost.

The pure wastewater activities include all O&M activities related to wastewater assets including wastewater operations, main inspections, main repairs, material disposal, CCTV sewer program, flushing and cleaning, sanitary lateral installation, lateral repairs, lateral blockage, service investigations, manhole inspections, manhole repairs, methane gas inspections, sample/contamination inspections, spill and cleanups, flow monitoring, backwater valve installation, inflow & infiltration reduction, lift station inspection/repair/maintenance, and wastewater AMI program.

**Table 4-3: Wastewater O&M Activities and Five-year Average Costs**

| O&M Activities | Description | Five-year Average Cost |
|---|---|---|
| **Wastewater Service to Region of York** | Wastewater Division - Admin. | $60,554,000 |
| **Overhead** | All overhead cost (e.g., compliance and training, business support, etc.) | $1,367,000 |
| **Pure Wastewater O&M Activities** | Wastewater operations, wastewater main activities, lateral activities, manhole activities, flow monitoring, backwater valve installation, inflow & infiltration reduction, lift station activities, and wastewater AMI program | $4,094,000 |
| **Total** | | **$66,015,000** |

## 4.5.3 Asset Renewal and Replacement Strategies

### 4.5.3.1 Wastewater Pipes

Renewal and replacement activities were identified for the mains, assuming that the water, wastewater and stormwater mains will be renewed with the same methods, refer to **Section 3.5.3.1** for pipe trenchless technologies and pipe replacement approach**.**

The wastewater asset intervention process flow that governs the decision-making on when and how to intervene on the pipes in the analysis are presented in **Figure 4-5** and **Figure 4-6**.

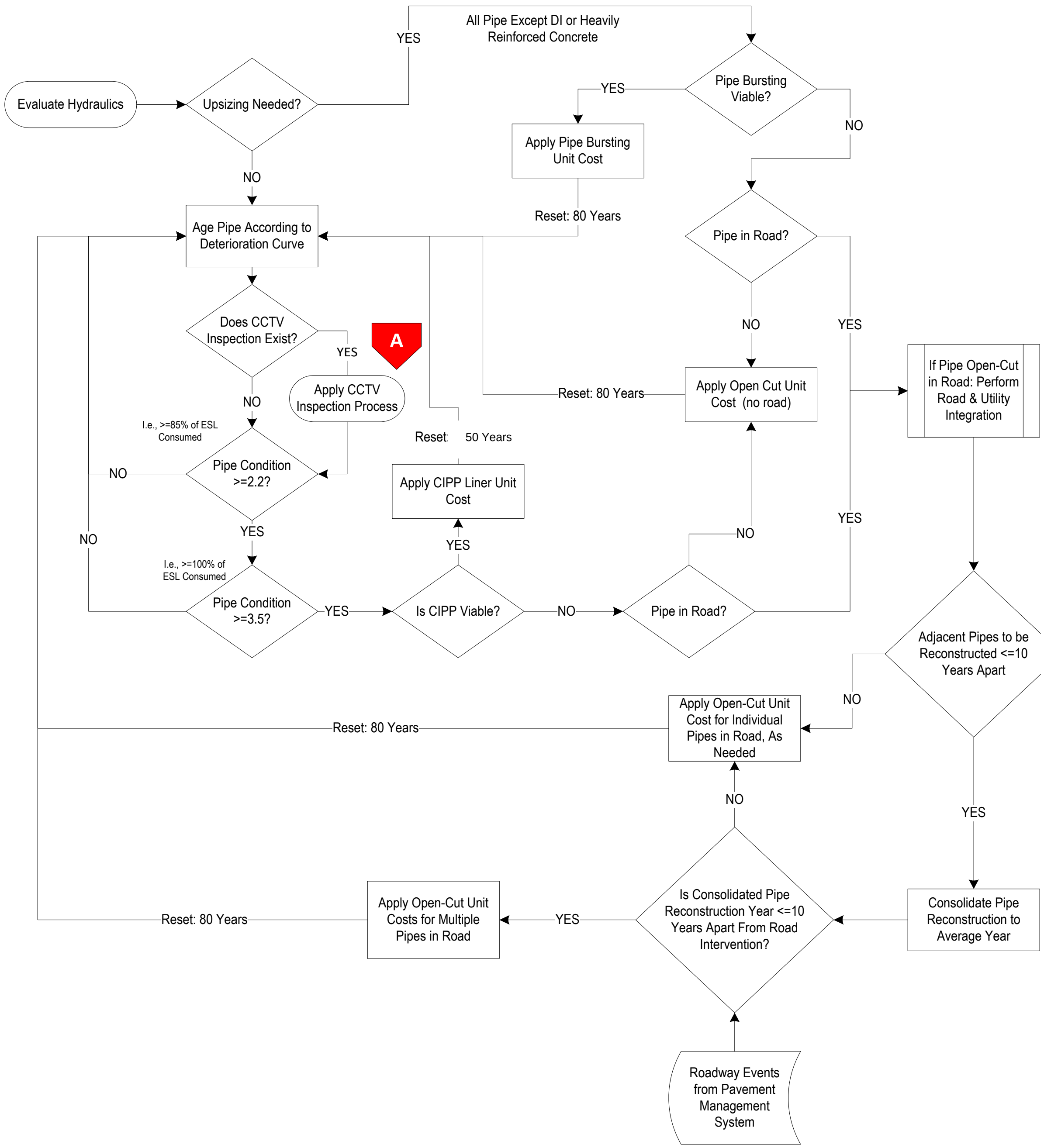


**Figure 4-5: Wastewater Process Flow**

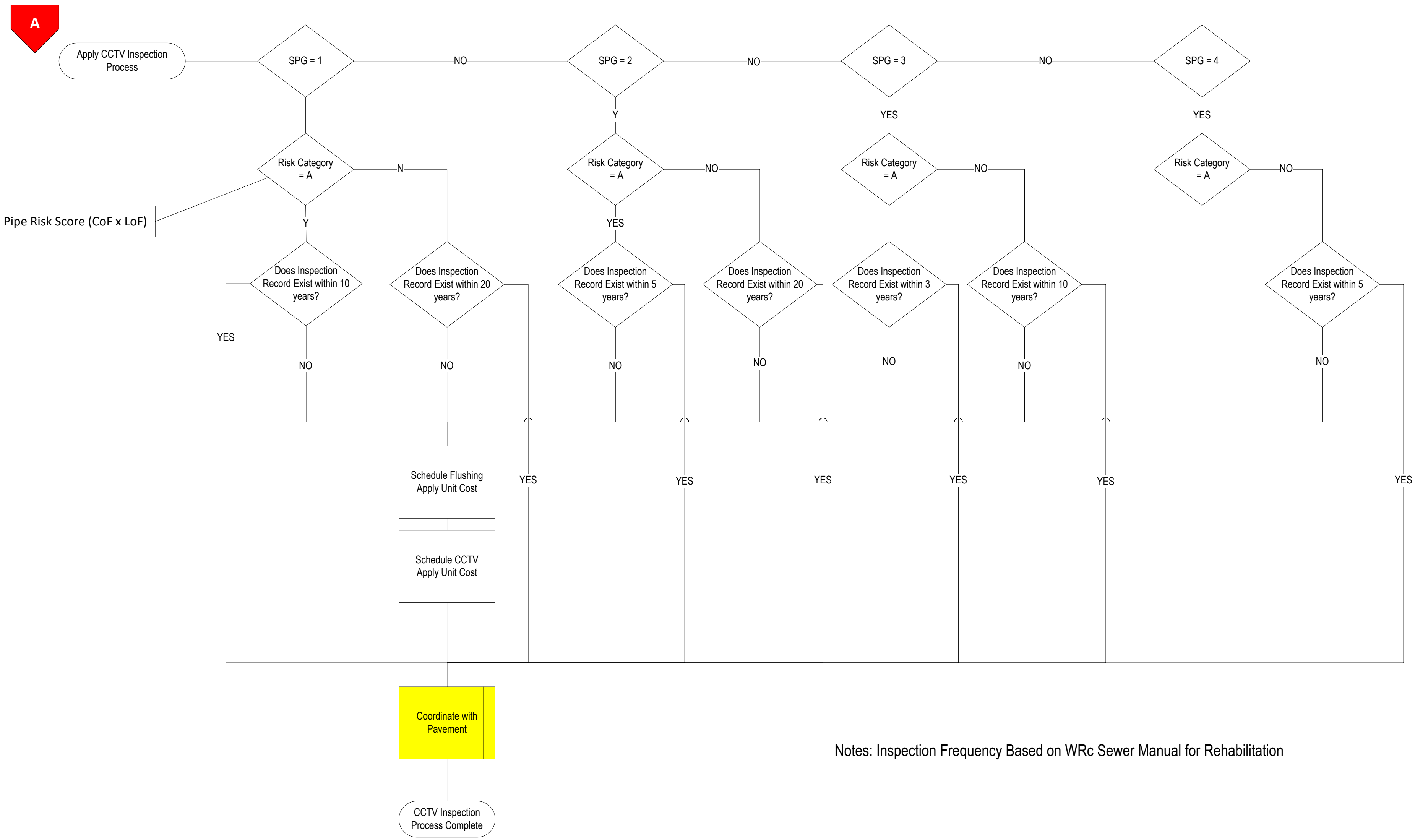


**Figure 4-6: CCTV Process Flow**

CCTV data and resultant structural grade scores were not available and not incorporated in this report but could be incorporated in the future iteration of AM plans. Table 4-4 presents a summary of the key decision-points within the pipe intervention process flow, and an explanation of the decisions programmed into dTIMS.

### Table 4-4: Pipe Intervention Process Decision Points & Explanations

| Decision Point | Decision & Explanation |
|---|---|
| **Upsizing Needed?** | YES: If a hydraulic constraint is identified (from elsewhere e.g., the City's hydraulic model) and the pipe is required to be up sized to the required pipe diameter, the next step is to consider whether pipe bursting is viable.<br>NO: If no hydraulic constraint is identified, no pipe upsizing is needed. |
| **Pipe Bursting Viable?** | YES: If pipe bursting is viable (i.e., viable for all pipes except for DI or heavily reinforced concrete pipes) then apply the pipe bursting unit cost to the length of pipe replaced. Reset pipe age to zero and apply an 80-year ESL to new pipe.<br>NO: If pipe bursting is not viable (i.e., pipe is DI or heavily reinforced concrete), the next step is to consider whether the pipe is in a road. |
| **Pipe Condition >= 2.2?** | YES: If the pipe condition is equal or more than 2.2 (i.e., equal or more than 85% of the pipe ESL has been consumed), then trigger a pipe inspection and apply the inspection unit cost table.<br>NO: If the pipe has not yet reached a condition of 2.2 then dTIMS will "age" the pipe according to the applicable deterioration curve until it reaches a condition of 2.2 and then trigger an inspection. |
| **Pipe Condition >= 3.5?** | YES: If the pipe condition is equal to or greater than 3.5 (i.e., equal to or more than 100% of the pipe ESL has been consumed), then trigger a pipe renewal or replacement. The next step is to consider whether CIPP is a viable option for pipe renewal.<br>NO: If the pipe has not yet reached a condition of 3.5 then dTIMS will "age" the pipe according to the applicable deterioration curve until it reaches a condition of 3.5 and then trigger a pipe renewal or replacement. |
| **Accessibility Issue?** | YES: If the City flags the pipe as having an accessibility issue such as within / next to a Regional road, at a stream crossing, or where there is no space for an open cut intervention, then apply the CIPP unit cost to the length of pipe. Reset pipe age to zero and apply a 25-year ESL to the re-lined pipe.<br>NO: If accessibility is not an issue (i.e., the pipe is not within / next to a Regional road, at a stream crossing, or where there is no space for an open cut intervention), the next step is to consider whether the pipe is in a road. |
| **Is CIPP Viable?** | YES: If CIPP is viable (i.e., the pipe has not yet been re-lined or reached a condition of 3.5 in 2016 / is beyond its ESL in 2016), then apply the CIPP unit cost to the length of pipe. Reset pipe age to zero and apply a 25-year ESL to the re-lined pipe.<br>NO: If CIPP is not viable (i.e., the pipe has been re-lined once already or has reached a condition of 3.5 in 2016 / is beyond its ESL in 2016), the next step is to consider whether the pipe is in a road. |
| **Pipe in Road?** | YES: If an open-cut excavation pipe replacement is needed and the pipe is in a road, then the next step is to consider whether any adjacent pipes need to be replaced less than ten years apart.<br>NO: If an open-cut excavation pipe replacement is needed but the pipe is not in a road, then apply the basic open-cut unit cost to the length of pipe to be replaced. Reset pipe age to zero and apply an 80-year ESL to new pipe. |
| **Pipe => 450mm?** | YES: If the pipe diameter in equal or greater than 450mm, then replace pipe with reinforced concrete pipe (RCP), and apply a 60-year ESL to the new pipe.<br>NO: If the pipe diameter is less than 450mm, replace pipe with PVC pipe, and apply an 80-year ESL to the new pipe. |
| **Adjacent Pipes to be Reconstructed <10 Ten Years Apart.** | YES: If the years of open-cut reconstruction of two or more pipes in the same roadway are less than ten years apart, then calculate the average of the years and apply that as the year of reconstruction. Adjust the years of utility work to match the years of road work if it is within 10 years of one another. Apply the unit cost table for open-cut excavation in a roadway for two or three |

| Decision Point | Decision & Explanation |
|---|---|
| | pipes, as needed, over the length of pipes reconstructed. Reset the pipes' age to zero and apply an 80-year ESL to new pipes.<br>NO: If the years of open-cut reconstruction of two or more pipes in the same roadway are more ten years apart, do not adjust the reconstruction year. Adjust the years of utility work (one pipe) to match the year of road work if it is within 10 years of one another. Apply the unit cost table for open-cut exaction in a roadway for one pipe, over the length of pipe reconstructed. Reset the pipe age to zero and apply an 80-year ESL to new pipe. |
| **Gravity Sewer SPG (Structural Performance Grade) > = 4** | YES: Align scheduled pipe rehabilitation with the Road program. Pipes with structural grades of 5 should be prioritized in the current planning year and pipes equal to 4 in the subsequent year<br>NO: Pipe with a structural grade of 3 and the pipe does not have a high-risk profile, a CCTV inspection should be scheduled with the next 10 year otherwise schedule CCTV inspection within the next 5 years. Pipe with a structural grade of 2 and the pipe does not have a high risk profile, a CCTV inspection should be scheduled with the next 15-20 years otherwise schedule CCTV inspection within the next 10 years with a structural grade of 2 and the pipe does not have a high risk profile, a CCTV inspection should be scheduled with the next 20 years otherwise schedule CCTV inspection within the next 10 year.<br>Note: Apply when structural grade available. |
| **Risk Category = A** | YES: Pipe asset deemed critical and asset inspection & renewal should be prioritized based on risk rating;<br>NO: Assets are less critical, and repairs can be pushed out to align with pavement renewal program.<br>Note: Use when prioritizing within budget constraints. |

The capital planning applied a conservative principle in estimating pipe and appurtenance replacement. The capital budgeting forecasts for pipes will reflect the cost of replacing or renewal pipes and its adjacent laterals and manholes. Often times, the adjacent appurtenances' condition are based on the liner asset condition, thus, the investment requirement timeline is similar.

#### 4.5.3.2 Wastewater Flowmeters

AECOM has applied a 6.7% flowmeter change-out cycle, which is equivalent to changing all flowmeters out every 15 years.

#### 4.5.3.3 Wastewater Facilities

In 2020, the City has performed Building Condition Assessment and generated facility inventories and 10-year capital renewal plan for 10 of the wastewater facilities (Pine Valley North SPS, Pine Grove SPS, Block 55 SPS, Block 39 SPS, Nashville SPS, Molise SPS, Vaughan Hospital SPS, Maplewood SPS, Camlaren Generating Station, and Kerrwood SPS). The City has also conducted condition assessment for five facilities and developed a renewal plan in 2017. A change out cycle of 30 years was assumed for capital planning of the wastewater facilities to achieve consistency between various consultant reports / data sources.

### 4.5.4 Decommissioning and Disposal Activities Strategies

Asset decommissioning and disposal activities are performed to decommission and dispose of assets due to ageing or changes in performance and capacity requirements. This decision process includes the consideration of costs and benefits of rationalization using a whole life approach, the impact of asset rationalisation on other infrastructure and the processes for disposal of assets. More specifically, the following factors need to be evaluated when considering the decommission and disposal of assets:

- Assets not required for the delivery of services, either currently, or over the longer planning period.
- Assets that have become uneconomical to maintain or operate.

- Assets that are not suitable for service delivery.
- Assets that have a negative impact on service delivery, the environment, or community.
- Assets that no longer support the City's service objectives due to a change in type of service being delivered or the delivery method.
- Assets where their use has become uneconomical due to the limited availability of spares or the cost of their replacement parts.
- Assets where their technology has been outdated.
- Assets which can no longer be used for the purpose originally intended.

Considerations for the City's asset decommissioning and disposal activities include, but are not limited to:

- Updates to the City's Statement of Tangible Capital Assets. Considerations related to the determination of residual value and the disposal of assets include:
  - Residual value and the useful life of an asset should be reviewed, at the very least, at each financial year-end and, if expectations differ from previous estimates, any change should be accounted for prospectively as a change in estimate.
  - The depreciation method used should reflect the pattern in which the asset's economic benefits are consumed.
  - The depreciation method should be reviewed, at the very least, annually and, if the pattern of consumption of benefits has changed, the depreciation method should be changed prospectively as a change in estimate.
- Updates to asset databases such as the GIS and CMMS.
- Environmental impact of disposal and implications for land rehabilitation, where applicable.
- Continued service delivery while a new asset is being constructed / commissioned: overlap of the start-up of new assets / facilities and the decommissioning of existing assets / facilities being replaced.
- Cost of decommissioning and disposal.

### 4.5.5 Risk Assessment

A detailed risk assessment was performed as part of AECOM's 2016 project for the City. A risk score was calculated for each wastewater main using its Probability of Failure (PoF) and Consequence of Failure (CoF) score. PoF for wastewater mains had two potential options based on whether Closed-Circuit Television (CCTV) condition data was available for the sewer segment or not. If a sewer segment was not visually inspected by CCTV, PoF was estimated using the Weibull age deterioration approach which allows determining where does the wastewater main segment sit on a deterioration curve relative to age and its expected service life. If a sewer had undergone CCTV inspection and its structural condition score ranged between 2 and 5, its age was adjusted by selecting an appropriate age value that corresponded with the sewer's structural condition on a deterioration score chart.

For example, the age of a sewer with a structural condition score equal to 5 was adjusted so that its apparent age was increased to reflect greater ageing close to or beyond its expected service life. In this way, a sewer with a relatively low age but which is in a poor structural condition will be triggered for replacement within the immediate future. In addition, if a pipe is located within a "Hotspot" area its PoF score was increased with the application of an adjustment factor. Base on the availability of the data, PoF was estimated using the Weibull age deterioration approach. The potential exists to incorporate CCTV condition data in the future assessment of PoF. The CoF for the new developed assets after 2016 were determined by a multi-regression method. Please refer to 2016 Risk Management Framework Report for more details.

Risk Score was calculated for each wastewater main asset using its Probability of Failure (PoF) and Consequence of Failure (CoF) scores. As the City's assets are relatively young with very low PoF score, most of the wastewater mains fall in low risk category. In this case, the City can prioritize wastewater work using the CoF (criticality) scores. **Figure**

4-7 shows the criticality map for wastewater mains demonstrating location of wastewater mains that are at high, medium, and low criticality level.

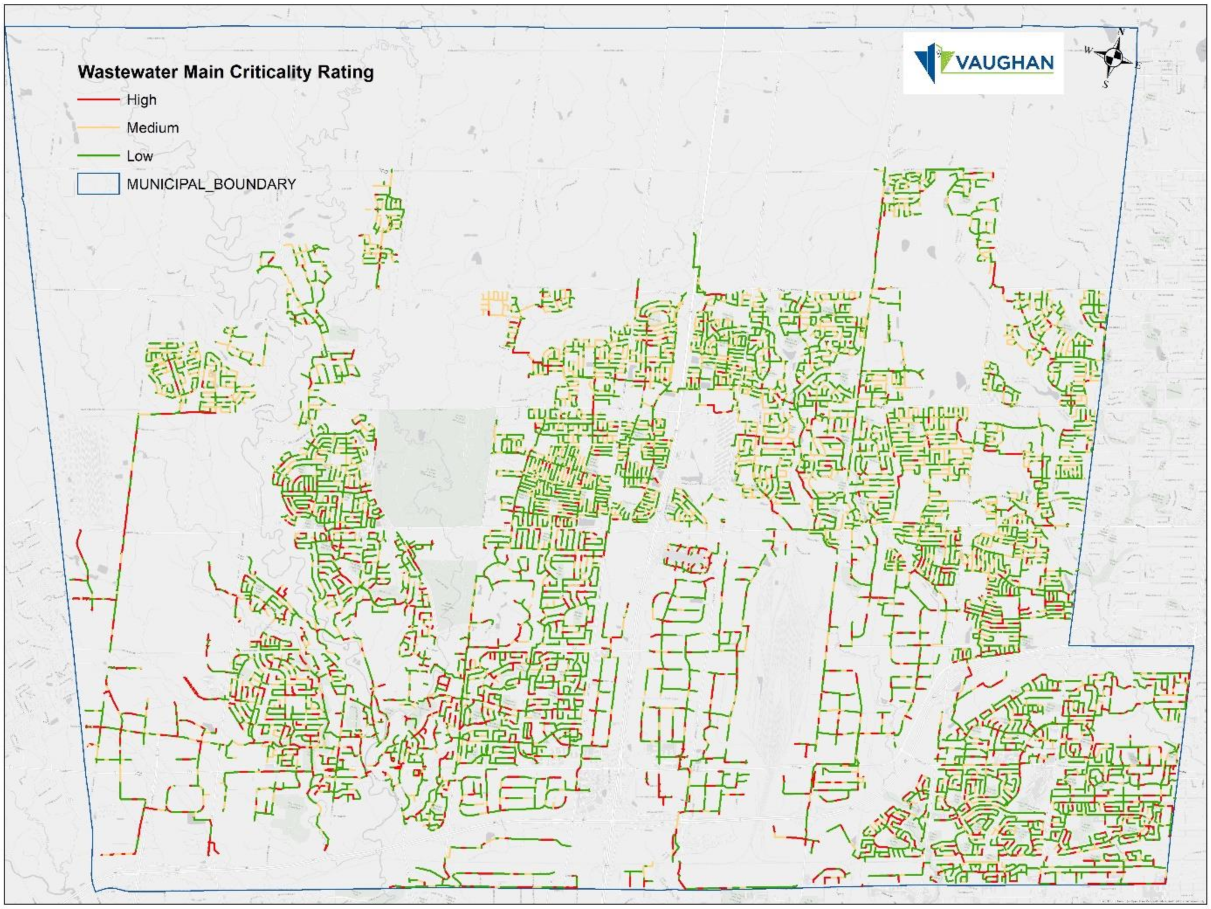


**Figure 4-7: Wastewater Main Criticality Map**

## 4.6 Funding Need Analysis

### 4.6.1 Wastewater Linear Asset Condition Forecasts and Budget Scenarios

The City's wastewater mains are still very young, and in the absence of any pipe condition scores from the CCTV program, dTIMS did not predict any significant asset renewal or replacement based purely on main age. Three budget scenarios were performed for wastewater linear assets reinvestment need analysis, which are Do-Nothing, Unlimited, and a minimal annual budget of $260,000. Figure 4-8 shows the condition of wastewater linear assets changing over the next 20 year for different budget scenarios. The condition trends of all budget scenarios overlap with each other. The capital funding needs developed in Section 4.6.2 were therefore based on a proposed combination of CCTV inspections at a ten-year cycle (i.e., annually inspecting 10% of the system) and renewals that would subsequently be required once the main condition is known. Therefore, as the three scenarios lead to the same trend in dTIMS's analysis, in the next sections, AECOM applied high level estimations for Wastewater 20-Year Funding Need Analysis, which considers CCTV inspection cost and capital project cost associated with the CCTV inspection results for linear assets. The reinvestment needs for wastewater non-linear assets were analyzed using the approaches illustrated in Section 4.5.3.2 and 4.5.3.3.

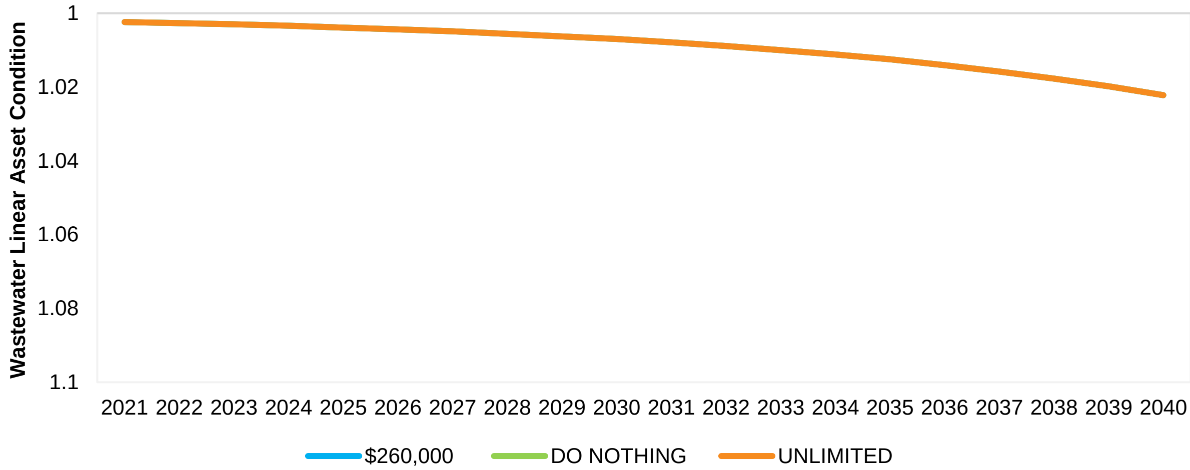


**Figure 4-8: Wastewater Linear Asset Condition Forecasts and Budget Scenarios (dTIMS Analysis)**

### 4.6.2 Wastewater 20-Year Funding Need Analysis

When the linear asset reinvestment need is added to the reinvestment required for meters and facilities, the average annual reinvestment rate for the City's entire wastewater infrastructure assets is $4.4M over the next 20 years in inflated dollar values. This is equivalent to a total of approximately $88M over the next 20 year period, as presented in **Figure 4-9**. Approximately $2.85M is annually required for main and appurtenance renewal, which was estimated by applying a capital reinvestment rate of 0.5% per year (based on National Benchmarking utility value for similar municipalities, inflated dollar value).

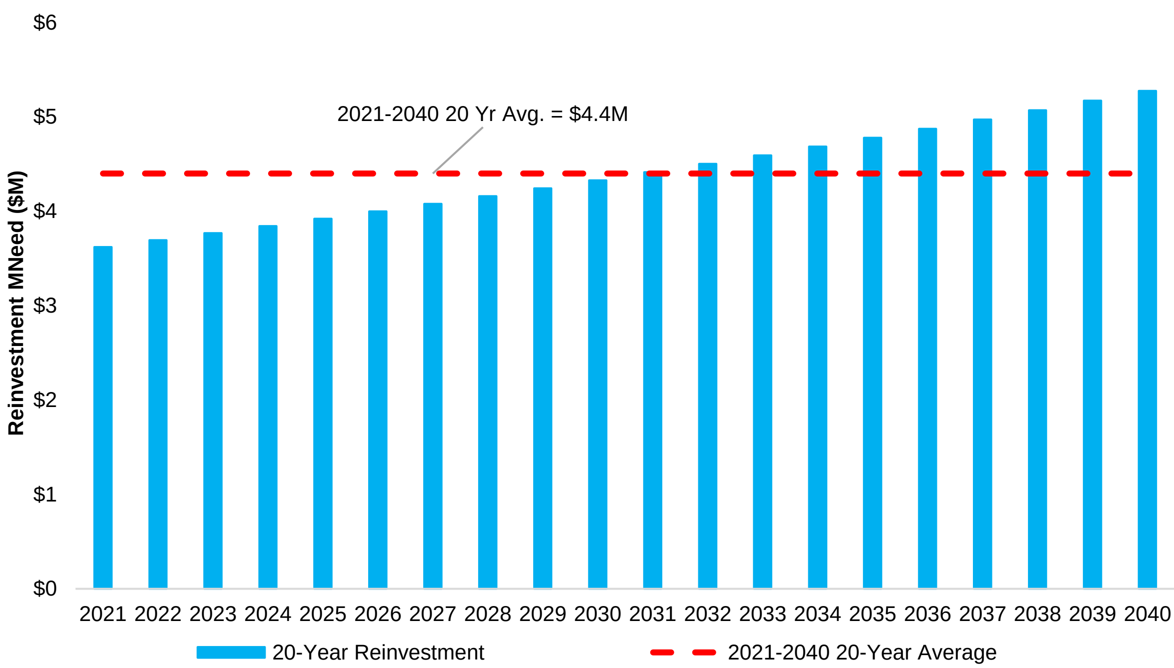


**Figure 4-9: Wastewater Linear 20-Year Reinvestment Need**

It is important to note, as shown in **Figure 4-10**, there is some annual reinvestment required for capital project costs for main and appurtenance renewal. For the City's 13 wastewater facilities, the annual average reinvestment need is noticeable. The need for a CCTV program is also noticeable, as the recommended annual percentage of length inspected by CCTV is targeted at 10% of the system. Looking ahead to the decade between 2031 and 2040 and beyond, the City should prepare for more reinvestment funding as pipes continue to age (see Error! Reference source not found.).

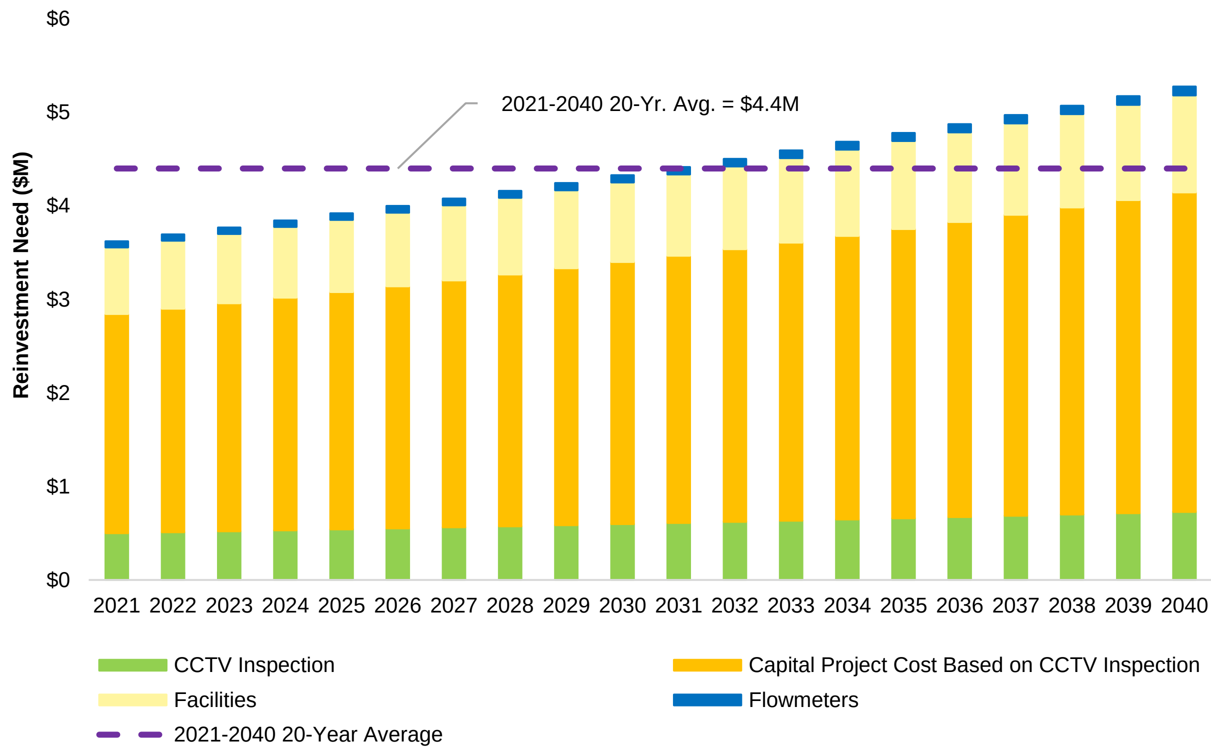


**Figure 4-10: Wastewater 20-Year Reinvestment Need Details**

The detailed reinvestment needs for pipes and appurtenances, flowmeters, and facilities are presented in **Table 4-5.**

**Table 4-5: 20-Year Total and Annual Average Reinvestment Need**

| | CCTV Program | Capital Renewal for Pipe and Appurtenance | Flowmeters | Facilities | Total |
|---|---|---|---|---|---|
| Annual Average Need | $608,000 | $2,849,000 | $79,000 | $866,000 | $4,402,000 |
| 20-Year Total | $12,160,000 | $56,980,000 | $1,580,000 | $17,320,000 | $88,040,000 |

The total annual reinvestment rate from **Figure 4-9** has been overlaid with an idealised / target O&M annual budget (based on National Benchmarking utility median values, inflated dollar value) and the Average Wastewater Development Cost (DC), as presented in **Figure 4-11**.

Wastewater assets requires approximately $141M O&M funding over the next 20 years, equivalent to approximately $7M per year in inflated dollar value. The Wastewater development cost requires approximately $36M over the next 20 years, equivalent to roughly $1.8M annually. As such, with the addition of O&M and Wastewater DC, the total average annual reinvestment rate for the City's wastewater infrastructure assets increases to approximately $13.2M annually, for a total of $264M over the next 20-year period, as presented in **Figure 4-11**.

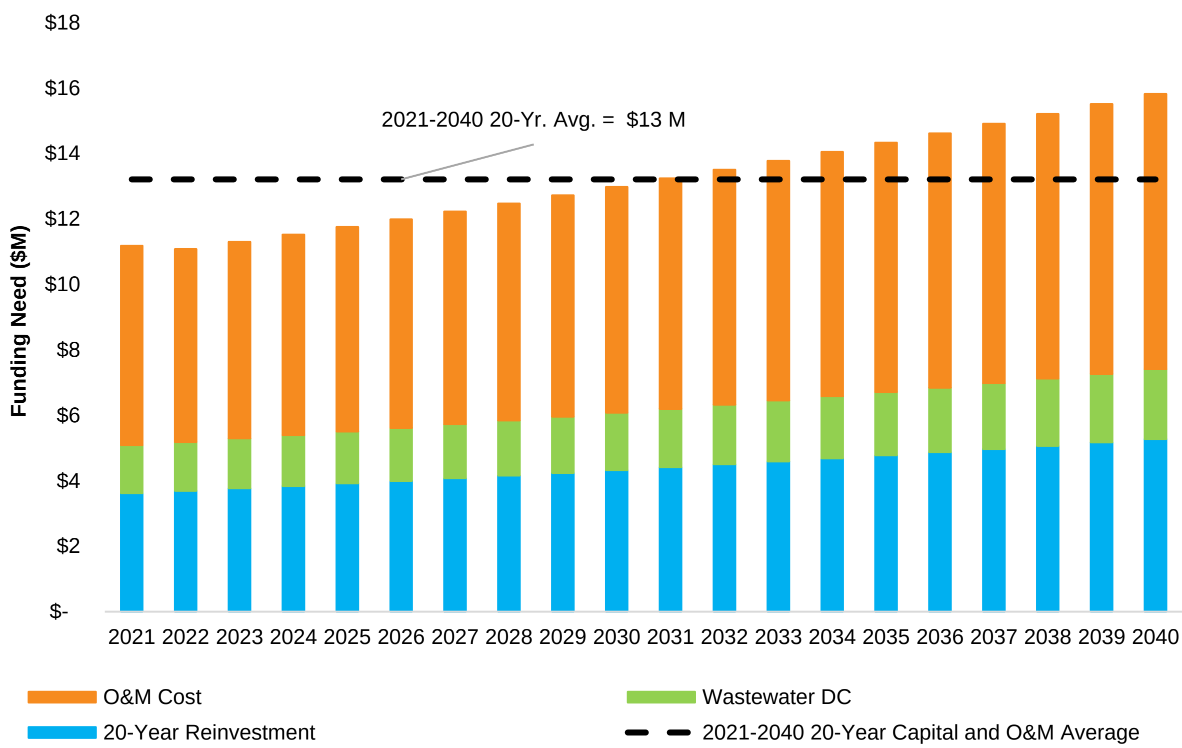


**Figure 4-11: Wastewater 20-Year Capital Investment and O&M Cost Forecast**

### 4.6.3 Full Funding Need Profile

**Figure 4-12** shows a full picture of the City's Wastewater Service funding need forecast over the next 20 years, which provides the City the full funding requirements in order to perform effective financial planning activities. The total annual reinvestment rate from **Figure 4-9** has been overlaid with the City's five-year annual average Wastewater service cost, O&M cost, and the annual average Wastewater DC.

The City's Wastewater service funding requirement increases to approximately $1.8B over the next 20 years with additional funding requirement of wastewater service to the Region, O&M and wastewater DC, equivalent to $88M per year in inflated dollar value. It is noticeable that the funding requirement for the Regional wastewater service cost is significant compared to capital requirement and O&M requirement, as presented in **Figure 4-12**.

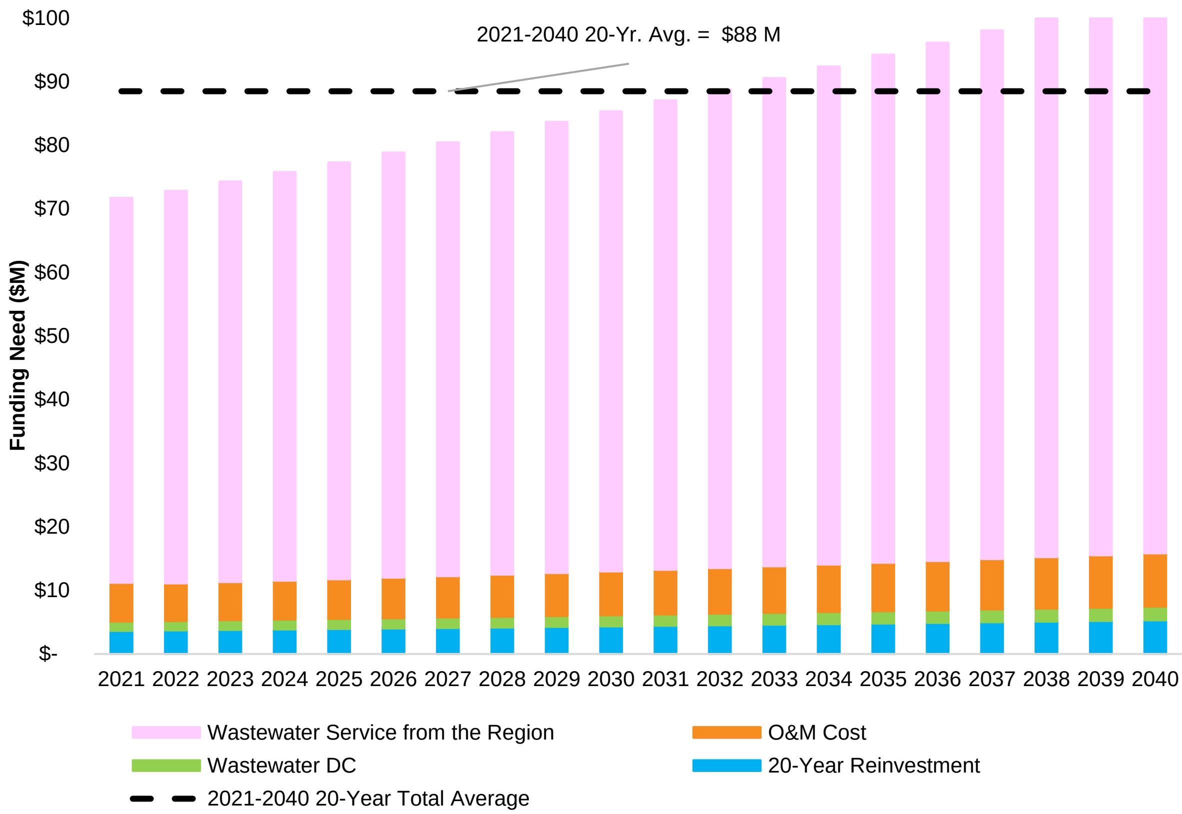


**Figure 4-12: Wastewater Full Funding Need Profile**

## 4.7 Recommendations for Wastewater AMP Continuous Improvement

Continuous improvement is an important component of any AM program and is achieved through the implementation of recommended improvement initiatives which support sustainable service delivery. While the City's wastewater assets are in a very good condition at the moment, there are future challenges that must be contended with. It is important to address these challenges thoroughly and promptly to leave a positive legacy for future generations.

AECOM has identified a set of activities that represents the next stage of AM planning and implementation within the City.

- **Refine the asset data and close existing data gaps, so as to have a more accurate representation of the current state of the wastewater infrastructure; and, ultimately, to make more informed and defensible decisions.**
  - Continue to collect data and fill gaps in the GIS inventory. For example, some of the pipe construction date and diameter information is shown as 0 in the GIS database. Pump stations inventory should be updated and incorporated in GIS record.
  - Develop a Data Governance Framework to define clear roles on data ownership and accountability, improve confidence in decision-making, improve asset data integrity and streamline information workflows.
- **Develop a regular wastewater sewer condition assessment program**. Condition assessment is one of the primary steps utilized prior to performing maintenance, rehabilitation, or replacement activities. In sewers, the most commonly used inspection technique is CCTV. The results from this inspection are used to evaluate the internal condition of the pipeline to determine the structural and operational condition. Establishing a program that would annually inspect mains and manholes basins will aid in accomplishing three main objectives. The first relates to structural condition deficiencies and forms the basis for updating overall system upgrading requirements (short- and long-term). The second identifies re-inspection frequencies associated with sewer infrastructure that has no short-term upgrading requirements. The third is to identify portions of the

infrastructure that have specialized cleaning requirements such as intruding lateral removal, root growth that cannot be removed by non-mechanical sewer cleaning equipment, etc. Overall, a CCTV program will allow the City to:

- Better forecast infrastructure renewal and rehabilitation needs.
- Avoid infrastructure failures and the resulting economic, social, and environmental costs.
- Leverage cost-effective methods to extend the life of assets before the asset becomes too deteriorated and must be replaced.

- **Update new standards when new types of wastewater assets are constructed within the City.**
  - Design requirements would help the City and developers determine the appropriate sizing for any new type of assets as well ensure proper access for maintenance.
  - Maintaining and continuing updating standard as the City introduce new asset will ensure wastewater assets are up to standard for wastewater operations.
- **Refine the Levels of Service Framework to quantify the gaps between existing and target service levels.**
  - Collect current asset performance data for key performance indicators (KPIs) that are not currently being tracked, including associated costs.
  - Analyze asset performance data to determine trends and to establish annual performance benchmarks.
  - Engage in a discussion with key stakeholders (see the **AM Strategy**) to establish service level targets and identify associated costs to meet those targets.
  - Once LoS targets have been decided upon, the City should develop strategies on how to meet service level targets considering its existing operating environment (i.e., staff availability, current funding, resources, etc.).
  - Develop a Customer Consultation Plan to engage the public and other stakeholders on the LoS framework and to better understand customers' willingness to pay for enhanced service levels.
- **Enhance the Wastewater risk assessment for future iterations of the AM plan, and use the risk assessment results to drive future wastewater condition assessments and financial needs forecasting.**
  - Update Risk model's Probability of Failure component to assess the ability of the asset to meet current and future operational requirements including capacity, regulatory, resilience and other LoS needs.
  - Continuing from previous bullet, incorporate hydraulic modeling data to combine pipe capacity limitations together with pipe condition / remaining service life information to better predict when pipes need to be replaced.
  - Assess criticality and risk comprehensively for new assets in the inventory.
  - Frequently revisit and revise probability of failure and criticality model as needed.
  - Review risk attribute values periodically to ensure alignment with business objective and appetite.
  - Overlay the risk models with the current state of the assets (i.e., condition), and the 20-year financial forecast. Using this approach, the City could focus its monitoring, maintenance, and renewal and replacement budget and activities on high risk wastewater infrastructure. Medium risk infrastructure could be addressed through the mitigation of failure through regular monitoring, and the low risk infrastructure could be accepted with caution.
- **Establish a sustainable Wastewater funding model that fits the needs of the community.**
  - In light of the annual capital investments and O&M outlined in **Figure 4-11**, the City should budget for wastewater expenditures on asset renewal, replacement, O&M, and new development to an average of $13M estimated per year over the next 20 years.
  - Review financial modeling assumptions on ESL and replacement values and update the financial model with new information as it becomes available (e.g., when the results from the CCTV inspection program

become available). The financial model is based on a number of key assumptions for asset ESL and replacement values that could have a significant impact on the outcomes of the model.

- **Continue to find ways to improve AM initiatives across the City by maintaining a high level of AM awareness through training, communication, and knowledge sharing.**
  - Conduct an AM Software Assessment to identify future system requirements that may include enhancing existing software, adding-on, or replacing.
  - Develop a Knowledge Retention Strategy & Internal Communications Plan to document staff AM knowledge and experience for reporting and succession planning purposes. Communicate AM improvement initiatives and enhance AM awareness internally through internal communication.
  - Aligning the Financial and Non-Financial Functions of AM. Refer to **Section 2.4.3** for the framework to address the need to achieve this alignment.

# 5. Stormwater

The City's stormwater management approach protects its citizen and the environment, property, and water quality. The City takes steps to lessen the impacts of climate change with a long-term plan to manage the potentially damaging effects of stormwater.

The City's stormwater management system is designed to limit flooding and minimize hazards under major storm events. The stormwater management system also provides a reasonable level of convenience and safety for pedestrians and traffic under more frequent storm events. In addition, the stormwater management system protects the environment by returning water into the ground wherever feasible and removal of pollutants prior to it entering receiving waters, thus minimizing the impact of development on water quality and aquatic life in the natural environment.

## 5.1 Asset Inventory and Replacement Value

An extensive stormwater network of assets is operated and maintained by the City to mange stormwater. Valued at $9.3 Billion, the City's stormwater system is categorized into three asset categories: Stormwater Conveyance, Stormwater Management, and Nature Assets, and is further divided into 17 asset types ranging from stormwater mains to waterways (see **Table 5-1** for a high-level asset breakdown).

**Table 5-1: Asset Inventory & Valuation (Stormwater Services)**

| Asset Category | Asset Type | | No. | Unit of Measure | Unit Replacement Cost ($/Unit) | Total Replacement Value |
|---|---|---|---|---|---|---|
| Stormwater Conveyance | Mains | Mains - Stormwater | 1,123 | km | $200,000 - $5,160,000 | $1,014,230,000 |
| | | Mains - Clean Water Collectors (CWC) | 5.5 | km | $250,000 - $14,280,000 | $4,324,000 |
| | | FDC Mains- Foundation Drain Collector (FDC) | 85 | km | $200,000 - $2,240,000 | $36,053,000 |
| | Laterals | | 226 | km | $260,000 - $1,840,000 | $283,713,000 |
| | Manholes | STM Manholes | 15,458 | No. | $11,100 - $33,200 | $195,696,000 |
| | | CWC Manholes | 35 | No. | $11,100 - $33,200 | $387,000 |
| | | FDC Manholes | 632 | No. | $11,100 - $33,200 | $7,094,000 |
| Stormwater Management | Open conveyance | Catch Basins | 21,375 | No. | $11,050 - $33,130 | $239,959,000 |
| | | Culverts | 177 | No. | $350 - $3,000 | $3,234,000 |
| | | In-out Structures | 756 | No. | $7,510 | $5,678,000 |
| | | Devices | 489 | No. | $9,210 | $4,504,000 |
| | | Ditches | 287 | km | $620 | $177,971,000 |
| | Facilities | Pump Stations | 1 | No. | $58,000 | $58,000 |
| | | Stormwater Management Ponds | 153 | No. | $200,000 - $500,000 | $67,500,000 |
| Natural Assets | Lakes | | 861,467 | $m^2$ | $100 | $86,147,000 |
| | Rivers | | 416,498 | m | $10,000 | $4,164,977,000 |
| | Waterways | | 606,272 | m | $5,000 | $3,031,360,000 |
| **Total** | | | | | | **$9,322,884,690** |

NOTE: The replacement value for stormwater mains and service connections exclude the asphalt cost, which is accounted for in the road AMP. Total replacement value of service connection includes estimation of missing records in GIS.

Stormwater Conveyance assets include 1,214 kilometers of stormwater mains with laterals, and manholes. The City identifies sub types for mains and manholes to indicate different sewer system and technologies, which are clean water collectors (CWC) and foundation drain collectors (FDC). The CWC system have significant environmental benefits beyond groundwater infiltration, which is different from other groundwater recharge methods because it uses only relatively clean water from roof areas and provides means to modify its operation and a direct access for maintenance. The foundation drainage systems infiltrate runoff generated from pervious and impervious surfaces after providing a measure of water quality treatment to remove suspended solids and other contaminants

The open conveyance linear systems include catch basins, culverts, in-out structures, devices, and ditches. The storm water management facilities include one pump station and 153 stormwater management ponds providing water quantity, quality and / or erosion control. The City's stormwater management natural assets include 0.9 $km^2$ lakes and over 1,022 kilometers of rivers and waterways.

The City's core services including Water, Wastewater, Stormwater, and Transportation are coordinated with each other to ensure cost efficiencies to maintain the desired level of service while minimizing the risks. The core service areas are considered as a whole when considering the infrastructure lifecycle needs.

For maintaining the assets in a desired service level, the City implements approximately 300 programs and initiatives including routine CCTV inspection of stormwater mains, catch basins cleaning, annual inspection and stormwater management ponds and critical pond cleaning, prevention of erosion and degradation of natural creek system, and proactive improvement and preventive repair of stormwater infrastructure.

## 5.2 Age Summary

**Figure 5-1** shows the stormwater management system average asset age as a proportion of average expected service life (ESL) by asset types. Asset ages have been established using data from the City's GIS database and consultant reports. The expected service life is developed using the City's Tangible Capital Asset database and workshop discussions.

The stormwater management system is overall considered to be in the early stages of its life. The stormwater FDC and STM mains are approximately one quarter through their expected service life. CWC mains are approximately only one twentieth through their expected useful life. The City's laterals and manholes' age are similar to their adjacent mains.

The City's catch basins are approximately 28% through the expected service life. The age of culverts indicates that the assets are approximately 16% through their service life. The in-out structures are approximately one quarter through their expected service life. It is noticeable that the age of devices is two third through their life. The stormwater pump station's age is approximately half of its expected service life.

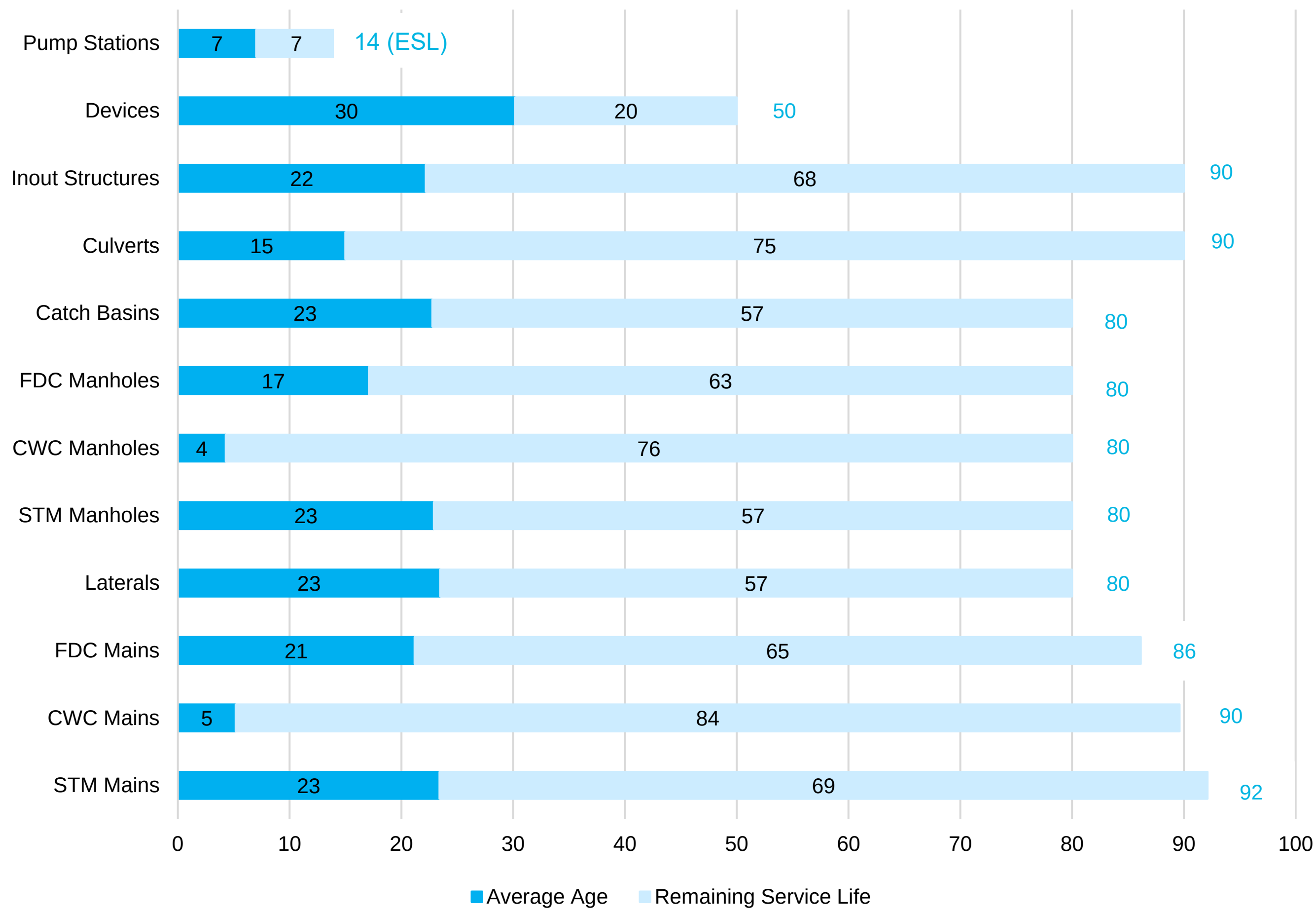


**Figure 5-1: Average Asset Age as a Proportion of Average Expected Service Life (Stormwater Services)**

The ages of ditches and stormwater management ponds have not been systematically documented or the information is not readily available. Generally, stormwater management ponds, like many other natural assets are considered to be non-traditional assets that is not necessarily to be replaced. There is no generally accepted accounting principles (GAAP) and some of them do not have an "end of life", assuming that these assets will essentially be maintained indefinitely.

## 5.3 Asset Condition

The stormwater service has 99.9% of assets in Very Good condition and 0.1% of assets in Good condition weighted by replacement value, which indicates the City's stormwater management system is very young and meet the current need. Attention may be required as these assets continue to age in future years.

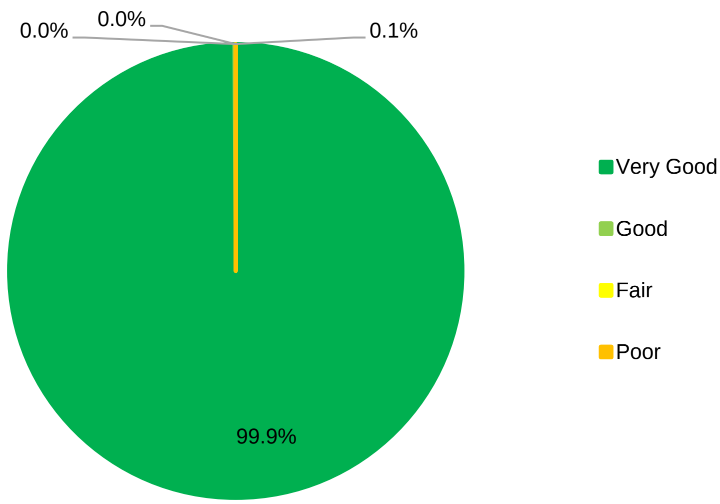


**Figure 5-2: Asset Condition Summary (Stormwater Services)**

Asset conditions have been determined by using the data from the City' GIS database and consultant reports. The condition assessment of stormwater mains, laterals, manholes, catch basins, culverts, in-out structures, and devices is based on the age and expected service life. For the pump station, condition information is adopted from consultant condition assessment reports in 2017.

As shown in the detailed condition profile in **Figure 5-3**, most of stormwater assets are in Very Good condition. Approximately 60% of the stormwater pump station assets is in Very Good to Fair Condition, and 40% in Poor condition weighted by replacement value. It is noted that pump station assets, while currently in a Good condition, would deteriorate if the needs identified in the 2017 condition assessment consultant reports are not met.

As the age information of natural assets such as stormwater management ponds, ditches, lake, rivers, waterways is not readily available and the deterioration of these assets is hard to predict, the condition of these assets is not presented in the condition details.

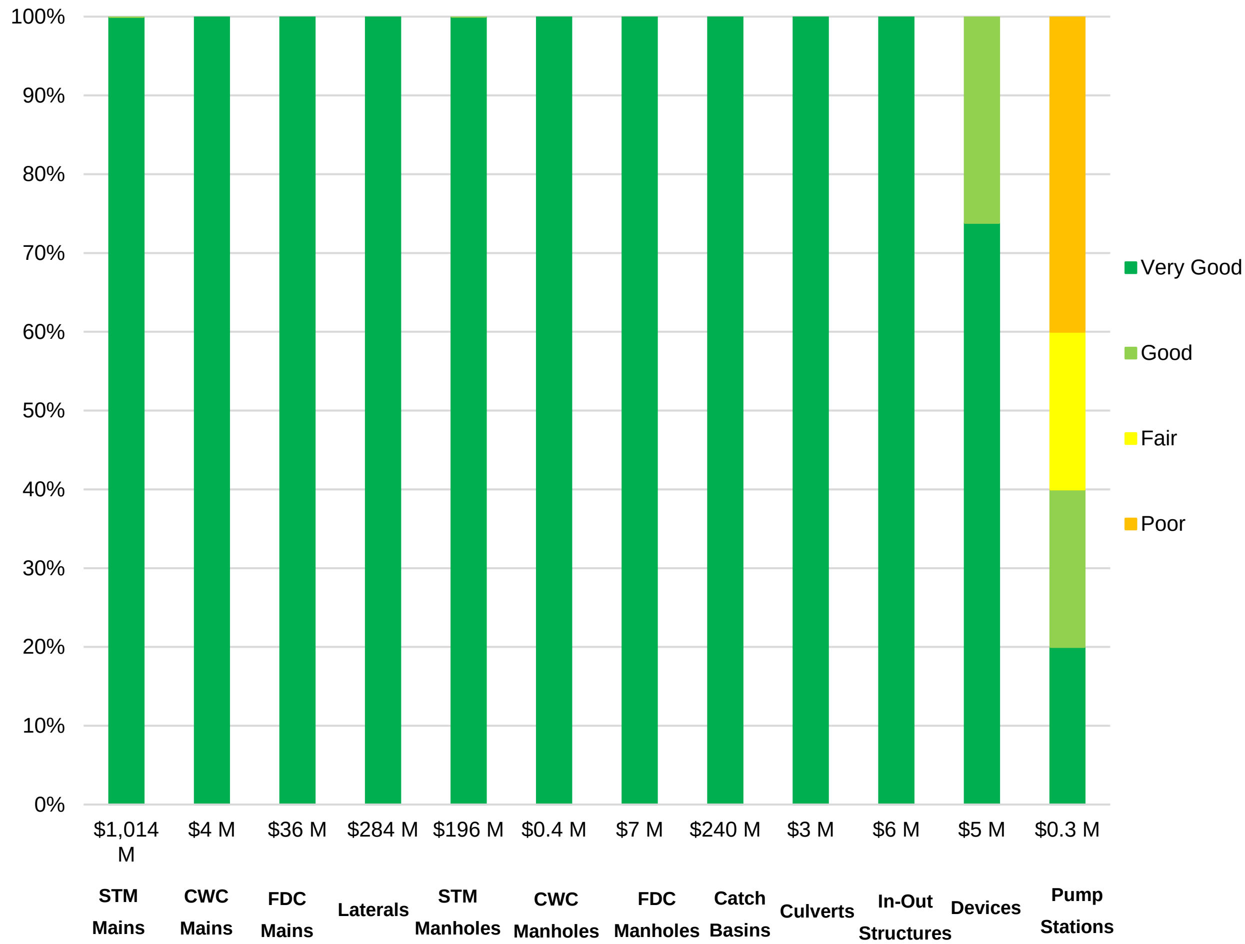


**Figure 5-3: Asset Condition Detail (Stormwater Services)**

## 5.4 Levels of Service

Ontario Regulation (O.Reg.) 588/17 requires legislated community levels of service for core assets. Community levels of service use qualitative descriptions to describe the scope or quality of service delivered by an asset category. O. Reg. 588/17 also requires legislated technical levels of service for core assets. Technical levels of service use metrics to
measure the scope or quality of service being delivered by an asset category. Table 5-2 is a summary of the City's stormwater service level for O..Reg. Metrics. References are provided to show where O. Reg. 588/17 requirement has been attained.

**Table 5-2: O. Reg. 588/17 Levels of Service Metrics (Stormwater Services)**

| Community levels of service | Technical levels of service |
|---|---|
| • Description, which may include maps, of the user groups or areas of the municipality that are protected from flooding, including the extent of the protection provided by the municipal stormwater management system. (Figure 5-4) | • Percentage of properties in municipality resilient to a 100-year storm (98.2%, only based on major system flooding).<br>• Percentage of the municipal stormwater management system resilient to a 5-year storm. (98.6%, only based on major system flooding). |

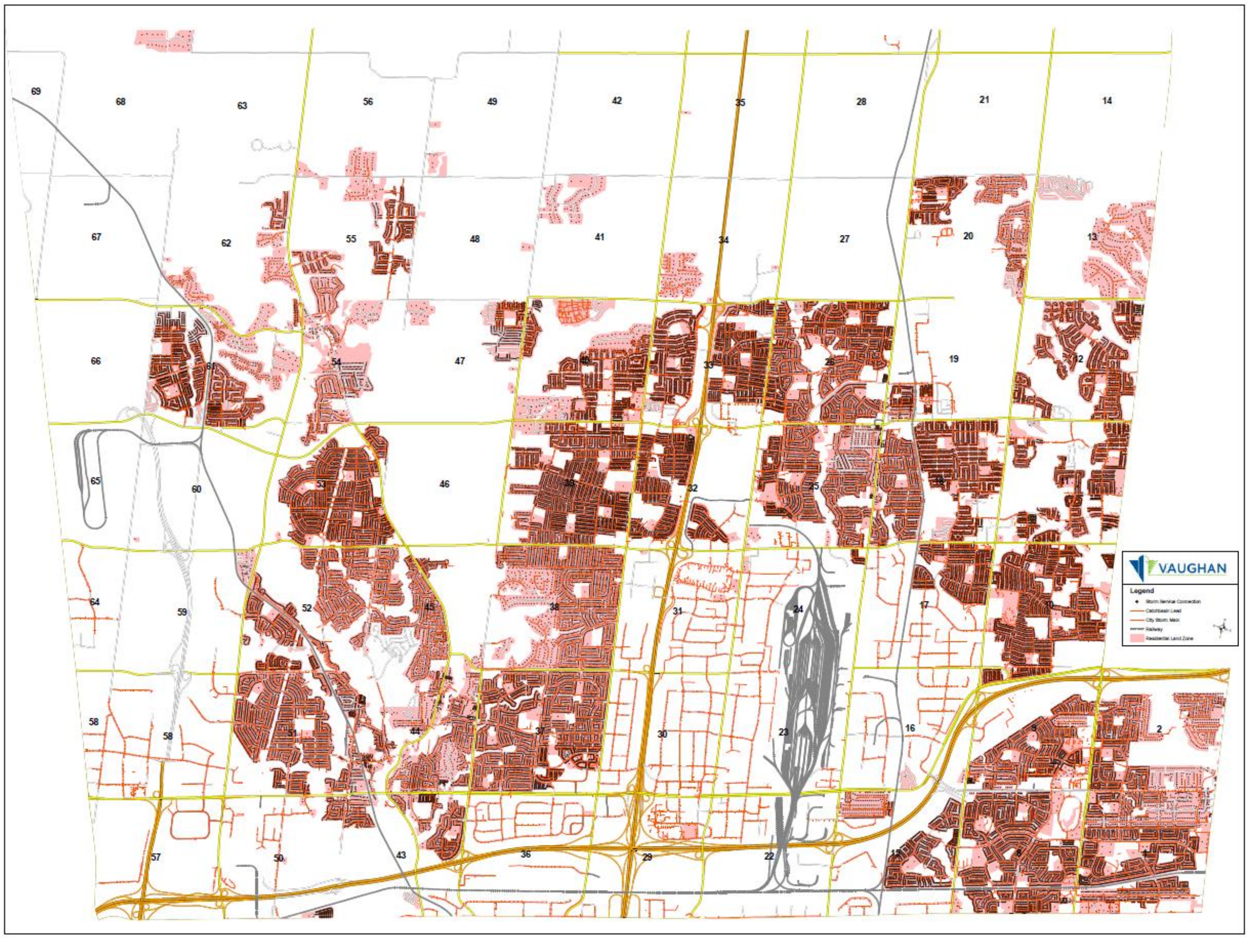


**Figure 5-4: Map Outlining the City's Stormwater Service Connectivity**

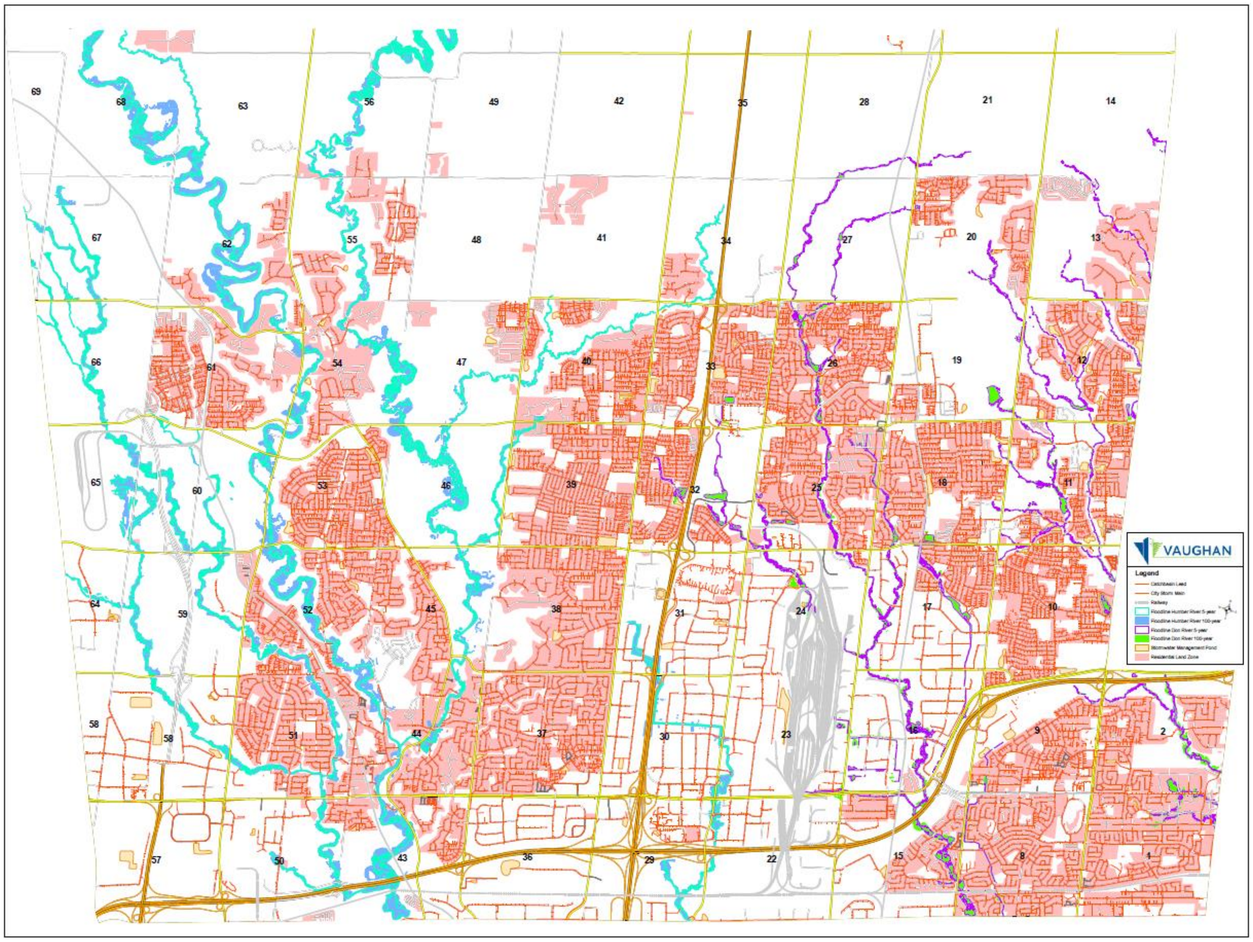


**Figure 5-5: Map Outlining the City' Floodlines**

## 5.5 Life Cycle Strategies

### 5.5.1 Asset Acquisition / Procurement / Construction Strategies

Added to City-purchased inventory is stormwater infrastructure that the City accepts (and takes immediate financial responsibility for) from developers as new neighborhoods are constructed. For example, as developers build new neighborhoods, the new local infrastructure (including stormwater mains) is paid for by the developer and then transferred to the City to operate, maintain, and ultimately replace. The City's infrastructure inventory was therefore created over many decades through infrastructure paid for by the City or by developers. Development Engineering will make sure that stormwater assets are up to standard for stormwater operations.

### 5.5.2 Asset Operations and Maintenance (O&M) Strategies

Stormwater asset operations and maintenance cost consist of three major components: pure stormwater O&M activities, overhead and street sweeping. Table 5-3 presents the breakdown activities and five-year average cost for the City's Stormwater assets. The five-year average annual pure stormwater activity cost is totally $1,873,000. The overhead cost is approximately more than half of pure stormwater O&M activities cost. It should be noted that street sweeping is partially funded by wastewater and stormwater service and performed by road service.

The pure stormwater activities include all O&M activities related to stormwater assets including inspections cleanings, repairs, disposal activities. The detailed activities include new development inspection, system inspections, main inspections, service investigations, manhole inspections, catch basin inspections, inlet/outlet inspections, ditch/watercourse inspections, ditch/watercourse inspections, sample/contamination inspection, cross connection investigation, storm sewer connect/disconnect, main repairs, lateral repairs, manhole repairs, catchbasin repairs, inlet/outlet repairs, subsurface drain repairs, curb and gutter repair, drainage channel repairs, pond management, main replacement material disposal, flushing and cleaning, catch basin cleaning, inlet/outlet cleaning, ditches / watercourse cleaning, spills and cleanup, storm flow monitoring, catchbasin grate cleaning, super catchbasin & oil/grit, storm pond sign installation, storm sewer CCTV program, etc.

**Table 5-3: Stormwater O&M Activities and Five-year Average Costs**

| O&M Activities | Description | Five-year Average Cost |
|---|---|---|
| **Overhead** | All overhead cost (e.g., Stormwater Division - Admin., compliance and training, business support, etc.) | $2,510,000 |
| **Pure Stormwater O&M Activities** | Storm sewer CCTV program, catch basin activities, pond management, lateral activities, main activities, manhole activities, inlet/outlet activities (stormwater management pond related), ditch/watercourse inspections (stormwater management pond related), storm flow monitoring, subsurface drain repairs, curb and gutter repair, and drainage channel repairs. | $1,873,000 |
| **Street Sweeping** | Funded by wastewater and stormwater services and performed by road service. | $633,000 |
| **Total** | | **$5,016,000** |

For stormwater management pond and ditches, O&M activities are the only life cycle activities identified.

Currently, the City performs sediment removal for stormwater ponds every 10 years instead of every 20 years as in previous years. This change in activity cycles has significant implications in the City's budgets and cash flows. On top of that, as there are new regulations for disposal and testing, an increasing trend for stormwater pond O&M cost is expected.

For ditches, the City's O&M activities involve erosion control, grass-cutting and garbage pickup.

## 5.5.3 Asset Renewal and Replacement Strategies

### 5.5.3.1 Stormwater Pipes

Renewal and replacement activities were identified for the mains, assuming that the water, wastewater and stormwater mains will be renewed with the same methods, refer to **Section 3.5.3.1** for pipe trenchless technologies and pipe replacement approach**.**

The analysis assume stormwater and wastewater has the same intervention process flow that governs the decision-making on when and how to intervene on the pipes. Refer to **Figure 4-5**, **Figure 4-6**, and **Table 4-4** for stormwater process flows and a summary of the key decision-points with explanations of the decisions programmed into dTIMS within the wastewater and stormwater pipe intervention process flow.

The capital planning applied a conservative principle in estimating pipe and appurtenance replacement. The capital budgeting forecasts of stormwater pipes reflect the cost of replacing or renewal the pipes and its adjacent laterals, manholes, and catch basins. Often times, the adjacent appurtenances' condition are based on the pipe asset condition, thus, the investment requirement timeline is similar.

### 5.5.3.2 Stormwater Open conveyance Assets

AECOM has applied a 1.1% devices change-out cycle for culverts and in-out structures, which is equivalent to changing all culverts and in-out structures out every 90 years. Similarly, 2% of change-out cycle has applied to devices, which is equivalent to changing all devices out every 50 years.

As mentioned in **Section 5.5.2**, the life cycle activities for ditches will only consist of O&M activities. Thus, there will be no renewal and replacement need identified for ditches in this report.

#### 5.5.3.3 Stormwater Pump Station

The City has performed Building Condition Assessment and generated facility inventory and capital renewal plan for the stormwater pump station in 2017. Reinvestment need analysis was performed based on the existing pump station inventory and ESL.

#### 5.5.3.4 Stormwater Management Ponds

As mentioned in **Section 5.5.2**, the life cycle activities for stormwater management ponds will be only O&M activities. Thus, there will be no renewal and replacement need identified in this report.

#### 5.5.3.5 Natural Assets

As mentioned in **Section 5.5.2**, the life cycle activities for natural assets such as lakes, rivers and waterways will be only O&M activities. Thus, there will be no renewal and replacement need identified in this report.

### 5.5.4 Decommissioning and Disposal Activities

Asset decommissioning and disposal activities are performed to decommission and dispose of assets due to ageing or changes in performance and capacity requirements. This decision process includes the consideration of costs and benefits of rationalization using a whole life approach, the impact of asset rationalisation on other infrastructure and the processes for disposal of assets. More specifically, the following factors need to be evaluated when considering the decommission and disposal of assets:

- Assets not required for the delivery of services, either currently, or over the longer planning period.
- Assets that have become uneconomical to maintain or operate.
- Assets that are not suitable for service delivery.
- Assets that have a negative impact on service delivery, the environment, or community.
- Assets that no longer support the City's service objectives due to a change in type of service being delivered or the delivery method.
- Assets where their use has become uneconomical due to the limited availability of spares or the cost of their replacement parts.
- Assets where their technology has been outdated.
- Assets which can no longer be used for the purpose originally intended.

Considerations for the City's asset decommissioning and disposal activities include, but are not limited to:

- Updates to the City's Statement of Tangible Capital Assets. Considerations related to the determination of residual value and the disposal of assets include:
  - Residual value and the useful life of an asset should be reviewed, at the very least, at each financial year-end and, if expectations differ from previous estimates, any change should be accounted for prospectively as a change in estimate.
  - The depreciation method used should reflect the pattern in which the asset's economic benefits are consumed.
  - The depreciation method should be reviewed, at the very least, annually and, if the pattern of consumption of benefits has changed, the depreciation method should be changed prospectively as a change in estimate.
- Updates to asset databases such as the GIS and CMMS.
- Environmental impact of disposal and implications for land rehabilitation, where applicable.

- Continued service delivery while a new asset is being constructed / commissioned: overlap of the start-up of new assets / facilities and the decommissioning of existing assets / facilities being replaced.
- Cost of decommissioning and disposal.

### 5.5.5 Risk Assessment

A detailed risk assessment was performed as part of AECOM's 2016 project for the City. A risk score was calculated for each stormwater main using its Probability of Failure (PoF) and Consequence of Failure (CoF) score. PoF was estimated using the Weibull age deterioration approach which allows determining where does the stormwater main segment sit on a deterioration curve relative to age and its expected service life. The potential exists to incorporate CCTV condition data in the future assessment of PoF. The CoF for the new developed assets after 2016 were determined by a multi-regression method. Please refer to 2016 Risk Management Framework Report for more details.

Risk Score was calculated for each stormwater main asset using its Probability of Failure (PoF) and Consequence of Failure (CoF) scores. As the City is relatively young, most of the stormwater main assets fall in the Low Risk category. It is recommended that the City to prioritize its work program by using the asset criticality or CoF score. **Figure 5-6** shows the criticality map for stormwater mains, indicating the location of the mains that are considered to be in the high, medium, and low criticality categories.

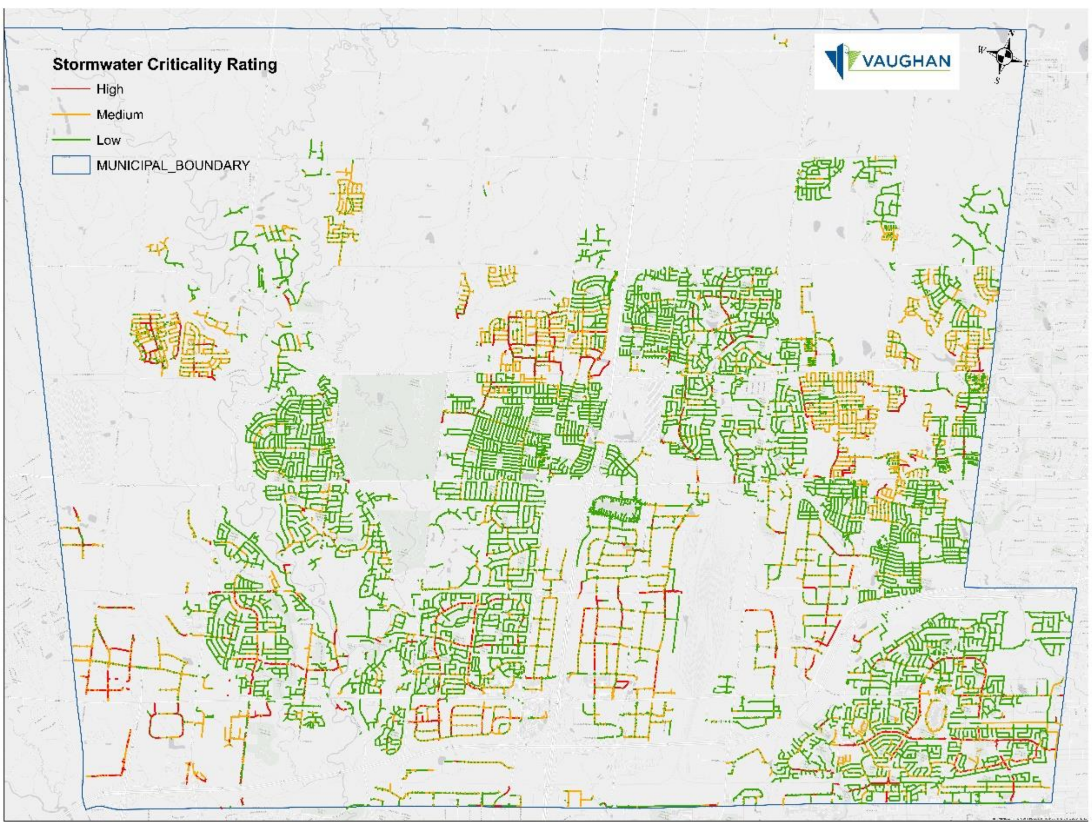


**Figure 5-6: Stormwater Main Criticality Map**

Beside the risk assessment initiative, the City took the initiative to perform a Stormwater Management Vulnerability Study[2] in 2015 where maps were generated for visualizing vulnerability assessment results.

[2] Ontario Climate Consortium (2014): TRCA Stormwater Management Vulnerability Study report

## 5.6 Funding Need Analysis

### 5.6.1 Stormwater Linear Asset Condition Forecasts and Budget Scenarios

The City's stormwater mains are still very young, and in the absence of any pipe condition scores from the CCTV program, dTIMS did not predict any significant asset renewal or replacement based purely on main age. Three budget scenarios were performed for stormwater linear assets reinvestment need analysis, which are Do-Nothing, Unlimited and minimal annual budget of $240,000. **Figure 4-8** shows the condition of stormwater linear assets changing over the next 20 year for different budget scenarios. The condition trends of all budget scenarios overlap with each other. The capital funding needs developed in **Section 5.6.2** were therefore based on a proposed combination of CCTV inspections at a ten-year cycle (i.e., annually inspecting 10% of the system) and renewals that would subsequently be required once the main condition is known.

Therefore, as the three scenarios lead to the same trend in dTIMS's analysis, in the next sections, AECOM applied high level estimations for Stormwater 20-Year Funding Need Analysis, which considers CCTV inspection cost and capital project cost associated with the CCTV inspection results for linear assets. The reinvestment needs for stormwater non-linear assets were analyzed using the approaches illustrated in **Section 5.5.3.2** to **5.5.3.5.**

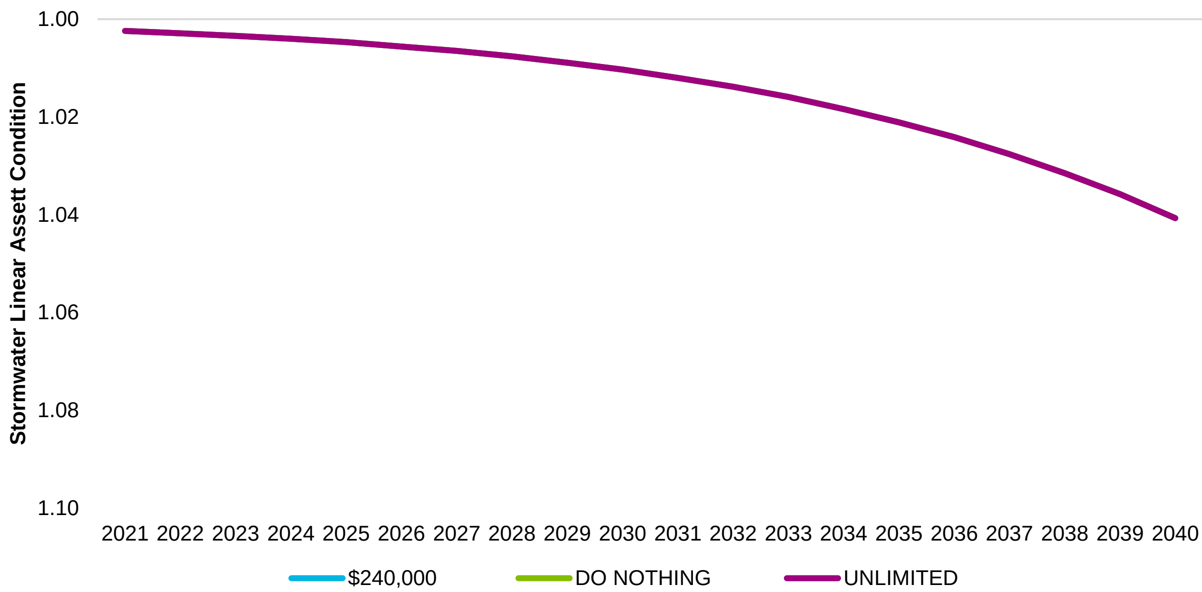


**Figure 5-7: Stormwater Linear Asset Condition Forecasts and Budget Scenarios (dTIMS Analysis)**

### 5.6.2 Stormwater 20-Year Funding Need Analysis

The average annual reinvestment rate for the City's entire stormwater service is $9.6M over the next 20 years in inflated dollar values. This is equivalent to a total of approximately $192M over the next 20 year period, as presented in **Figure 5-8**. Approximately $8.6M is annually required for main and appurtenance renewal, which was estimated by applying a capital reinvestment rate of 0.25% per year (based on National Benchmarking utility value for similar municipalities, inflated dollar value).

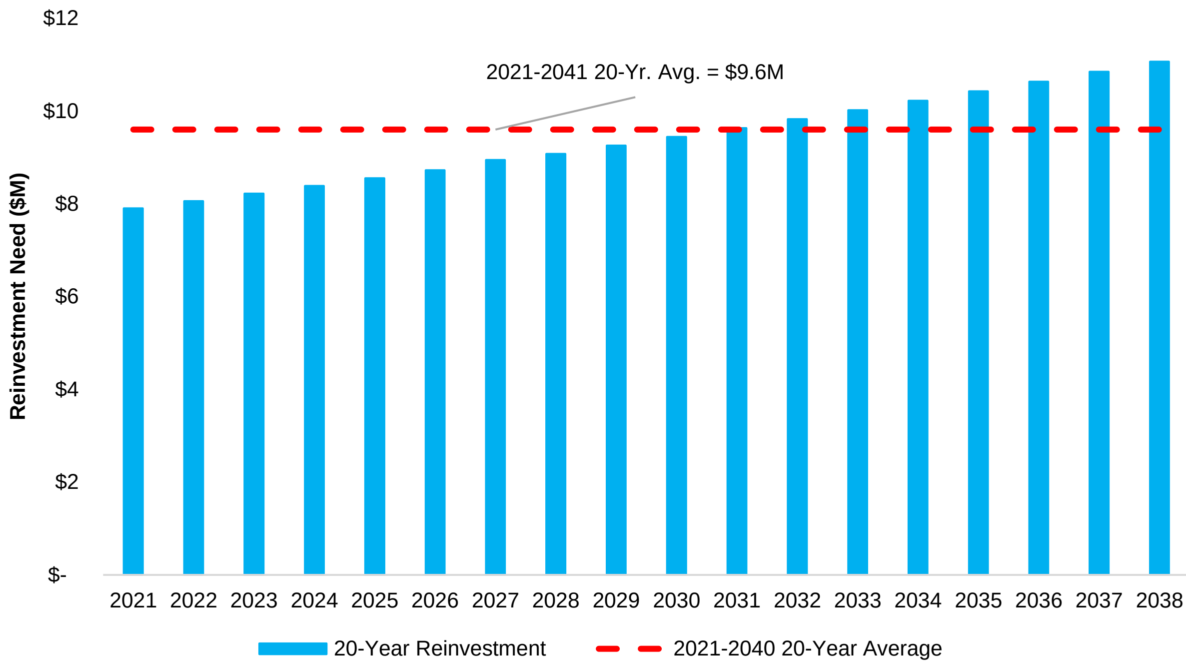


**Figure 5-8: Stormwater 20-Year Total Reinvestment Need**

It is important to note, as shown in **Figure 5-9**, there is a notable amount of reinvestment required for capital project costs for main and appurtenance renewal. The need for CCTV program is also noticeable, as the recommended annual percentage of length inspected by CCTV is targeted at 10% of the system. Looking ahead to the decade between 2031 and 2040 and beyond, the City should prepare for more reinvestment funding as pipes continue to age

$12

2021-2040 20-Yr Avg. = $9.6M

**Figure 5-9: Stormwater 20-Year Reinvestment Need Details**

The detailed reinvestment needs for pipes and appurtenances, stormwater culverts, in-out structures, devices, and the pump station are presented in **Table 5-4**.

**Table 5-4: 20-Year Total and Annual Average Reinvestment Need**

| | CCTV Program | Capital Renewal for Pipe and Appurtenance | Stormwater Culverts | In-out Structure | Devices | Pump Station | Total |
|---|---|---|---|---|---|---|---|
| Annual Average Need | $736,200 | $8,632,000 | $43,700 | $76,700 | $110,000 | $2,500 | $9,602,000 |
| 20-Year Total | $14,724,000 | $172,640,000 | $874,000 | $1,534,000 | $2,200,000 | $48,800 | $192,040,000 |

The total annual reinvestment rate from **Figure 5-8** has been overlaid with an idealised / target O&M annual budget (based on National Benchmarking utility median values, inflated dollar value) and the Average Stormwater Development Cost (DC), as presented in **Figure 5-10**.
(see Error! Reference source not found.).
**Figure 5-10** shows a full picture of the City's Stormwater Service funding need forecast over the next 20 years, which provides the City the full funding requirements in order to perform effective financial planning activities.

Stormwater assets requires approximately $110M over the next 20 years, equivalent to approximately $5.5M per year in inflated dollar value. The Stormwater DC requires approximately $152M over the next 20 years, equivalent to roughly $7.6M annually. As such, with the addition of O&M and Stormwater DC, the total average annual reinvestment rate for the City's stormwater assets increases to approximately $22.6M annually, for a total of $454M over the next 20-year period.

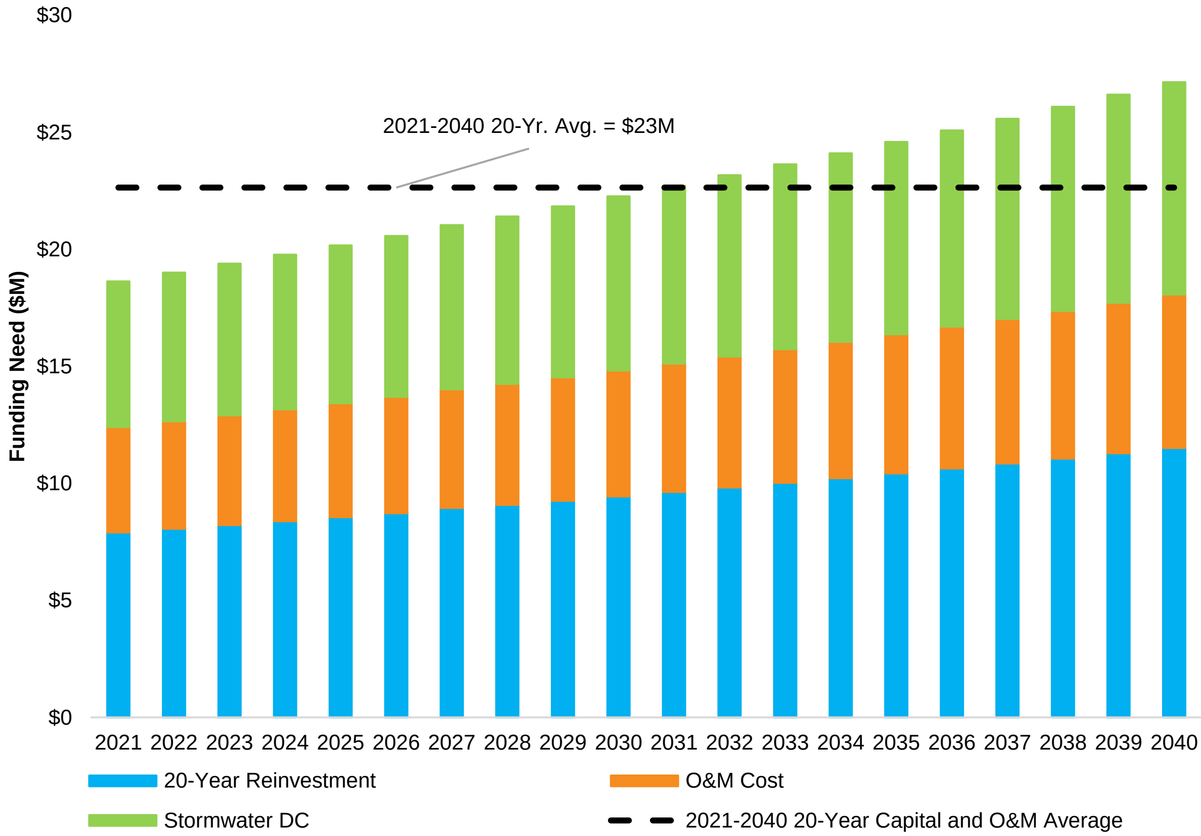


**Figure 5-10: Stormwater 20-Year Capital Investment and O&M Cost Forecast**

## 5.7 Recommendations for Stormwater AMP Continuous Improvement

Continuous improvement is an important component of any AM program and is achieved through the implementation of recommended improvement initiatives which support sustainable service delivery. While the City's stormwater assets are in a very good condition, there are current and future challenges that must be contended with. It is important to address these challenges thoroughly and promptly to leave a positive legacy for future generations.

AECOM has identified a set of activities that represents the next stage of AM planning and implementation within the City.

- **Continue to refine the asset inventory and close existing data gaps, so as to have a more accurate representation of the current state of the stormwater infrastructure; and, ultimately, to make more informed and defensible decisions.**
  - Continue to collect data and fill gaps in the GIS inventory. The City should also prioritize collecting condition data across all stormwater assets.
  - Assign a unique ID for each stormwater asset and link the ID across data sources so that assets can be tracked throughout their whole lifecycle. Old legacy asset ID's from the GIS inventory should be removed.
  - Develop a Data Governance Framework to define clear roles on data ownership and accountability, improve confidence in decision-making, improve asset data integrity and streamline information workflows.

- **Develop a regular storm sewer condition assessment program**. Condition assessment is one of the primary steps utilized prior to performing maintenance, rehabilitation, or replacement activities. In sewers, the most commonly used inspection technique is CCTV. The results from this inspection are used to evaluate the internal condition of the pipeline to determine the structural and operational condition. Establishing a program that would annually inspect mains and manholes basins will aid in accomplishing three main objectives. The first relates to structural condition deficiencies and forms the basis for updating overall system upgrading requirements (short- and long-term). The second identifies re-inspection frequencies associated with sewer infrastructure that has no short-term upgrading requirements. The third is to identify portions of the infrastructure that have specialized cleaning requirements such as intruding lateral removal, root growth that cannot be removed by non-mechanical sewer cleaning equipment, etc. Overall, a CCTV program will allow the City to:
  - Better forecast infrastructure renewal and rehabilitation needs.
  - Avoid infrastructure failures and the resulting economic, social, and environmental costs.
  - Leverage cost-effective methods to extend the life of assets before the asset becomes too deteriorated and must be replaced.
- **Update new standards when new types of stormwater assets are constructed within the City.**
  - Design requirements would help the City and developers determine the appropriate sizing for any new type of assets as well ensure proper access for maintenance. For example, the City do not have design requirements for oil-grit separators (OGS) in place.
  - Maintaining and continuing updating standard as the City introduce new asset will ensure stormwater assets are up to standard for stormwater operations.
- **Continue to develop environmental and flooding protection initiatives to have a comprehensive understanding as to the impacts of climate change and stormwater infrastructure required to address environmental upgrades.**
  - Climate change is widely recognized as the most urgent problem facing humanity and has the potential to disrupt many municipal services, stormwater management being one of the most vulnerable. Early planning is critical to mitigate the impacts, particularly the added risk of flooding and erosion. It is recommended that The City further assess the impacts of climate change on the stormwater system, how it could affect levels of service, and potential mitigation strategies.
  - As the City projects future stormwater asset renewal needs, it is important to consider rainfall projections. The City should plan to replace existing assets with larger assets for greater capacity, and not like-for-like. Total asset renewal cost projections can be increased to account for the need to increase capacity for climate change.
- **Refine the Levels of Service Framework to quantify the gaps between existing and target service levels.**
  - Collect current asset performance data for key performance indicators (KPIs) that are not currently being tracked, including associated costs.
  - Analyze asset performance data to determine trends and to establish annual performance benchmarks.
  - Engage in a discussion with key stakeholders (see the **AM Strategy**) to establish service level targets and identify associated costs to meet those targets.
  - Once LoS targets have been decided upon, the City should develop strategies on how to meet service level targets considering its existing operating environment (i.e., staff availability, current funding, resources, etc.).
  - Develop a Customer Consultation Plan to engage the public and other stakeholders on the LoS framework and to better understand customers' willingness to pay for enhanced service levels.
- **Enhance the Stormwater risk assessment for future iterations of the AM plan, and use the risk assessment results to drive future stormwater condition assessments and financial needs forecasting.**
  - Update Risk model's Probability of Failure component to assess the ability of the asset to meet current and future operational requirements including capacity, regulatory, resilience and other LoS needs.

- Continuing from previous bullet, incorporate hydraulic modeling data to combine pipe capacity limitations together with pipe condition / remaining service life information to better predict when pipes need to be replaced.
- Assess criticality and risk comprehensively for new assets in the inventory;
- Frequently revisit and revise probability of failure and criticality model as needed;
- Review risk attribute values periodically to ensure alignment with business objective and appetite;
- Overlay the risk models with the current state of the assets (i.e., condition), and the 20-year financial forecast. Using this approach, the City could focus its monitoring, maintenance, and renewal and replacement budget and activities on high risk stormwater infrastructure. Medium risk infrastructure could be addressed through the mitigation of failure through regular monitoring, and the low risk infrastructure could be accepted with caution.

- **Establish a sustainable Stormwater funding model that fits the needs of the community.**
  - In light of the annual capital investment reinvestments outlined in **Figure 5-10**, the City should budget for stormwater expenditures on asset renewal, replacement, O&M, and new development to an estimated average of $23M per year over the next 20 years.
  - Review financial modeling assumptions on ESL and replacement values and update the financial model with new information as it becomes available (e.g., when the results from the CCTV inspection program become available). The financial model is based on a number of key assumptions for asset ESL and replacement values that could have a significant impact on the outcomes of the model.
  - The City should review its current stormwater funding model, and in consultation with staff, consider the following steps to improve its existing model:
    - Confirm criteria for selecting a stormwater funding model.
    - Select the preferred funding model that meets the chosen criteria.
    - Identify issues specific to the City that should be considered.
    - Conduct a financial analysis of the preferred funding model.
- **Continue to find ways to improve AM initiatives across the City by maintaining a high level of AM awareness through training, communication, and knowledge sharing.**
  - Conduct an AM Software Assessment to identify future system requirements that may include enhancing existing software, adding-on, or replacing.
  - Develop a Knowledge Retention Strategy & Internal Communications Plan to document staff AM knowledge and experience for reporting and succession planning purposes. Communicate AM improvement initiatives and enhance AM awareness internally through internal communication.
  - Aligning the Financial and Non-Financial Functions of AM. Refer to **Section 2.4.3** for the framewotk to address the need to achieve this alignment.

# 6. Transportation

The core transportation infrastructure the City operates and maintains including roads, bridges and culverts enables safe and effective travel. The City is dedicated to achieving the highest quality standards in the maintenance of the roads, bridges, and culverts infrastructure.

The City provides residents with a high level of snow-removal services. Whether it's reducing ice on roads, removing snow from roads or clearing it from paths, sidewalks and windrows, the City's crews strive to ensure residents and visitors can travel safely despite the weather.

## 6.1 Asset Inventory and Replacement Value

Table 6-1 and Table 6-2 summarize the asset inventory and replacement values for the roads, bridges, and culverts.

The current replacement value of the City's extensive roadways network is over $1.5 Billion. The total length of road assets is 2,335 Lane-kilometers. Roads are categorized by urban road, arterial road, rural road, and laneway.

The City has totally 193 bridges and culverts, currently valued at approximately $214 Million. Bridge and culvert assets are divided into Bridges, Pedestrian Bridges, Culverts and Pedestrian Culverts. Pedestrian Bridges and Culverts are structures that support pedestrian movement.

The City's core services including Water, Wastewater, Stormwater, and Transportation are coordinated with each other to ensure cost efficiencies to maintain the desired level of service while minimizing the risks. The core service areas are considered as a whole when considering the infrastructure lifecycle needs.

**Table 6-1: Asset Inventory & Valuation (Road Services)**

| Asset Category | Asset Type | No. | Unit of Measure | Unit Replacement Cost | Replacement Value |
|---|---|---|---|---|---|
| **Roads** | Urban Road | 2,162 | Lane-kilometer | $160/m$^2$ | $1,438,928,000 |
| | Arterial Road | 48 | Lane-kilometer | $160/m$^2$ | $26,866,000 |
| | Rural Road | 110 | Lane-kilometer | $160/m$^2$ | $57,045,000 |
| | Laneway | 15 | Lane-kilometer | $160/m$^2$ | $9,633,000 |
| **Total** | | **2,335** | Lane-kilometer | | **$1,532,472,000** |

**Table 6-2: Asset Inventory & Valuation (Bridges and Culverts)**

| Asset Category | Asset Type | No. | Unit of Measure | Unit Replacement Cost | Replacement Value |
|---|---|---|---|---|---|
| **Bridges** | Bridges | 33 | Ea. | $ 36,000 - $11,935,000 | $101,815,000 |
| | Pedestrian Bridges | 41 | Ea. | $ 92,000 - $ 3,374,000 | $17,652,000 |
| | **Sub-Total** | **74** | | | **$125,680,000** |
| **Culverts** | Culverts | 115 | Ea. | $ 137,000 - $ 3,791,000 | $86,659,000 |
| | Pedestrian Culverts | 4 | Ea. | $334,000 - $ 459,000 | $1,654,000 |
| | **Sub-Total** | **119** | | | **$88,313,000** |
| **Total** | | **193** | Ea. | | **$213,993,000** |

## 6.2 Age Summary

**Figure 6-1** shows the average road asset age as a proportion of the average useful life by asset type. The average useful life for a road is assumed to be 60 years and represents the construction of all necessary granular and surface treatments (asphalt or concrete) that comprise a road structure. The average age for road assets was calculated using the construction date in GIS record and weighted by replacement cost. The design life for most asphalt pavements is 15-20 years, and should be rehabilitated or replaced two to three times in order for the roadway to last to its expected service life (ESL) of 60 years. By applying pavement preservation treatments (e.g., crack sealing) and pavement rehabilitation approaches (e.g., mill and overlay) at the appropriate intervals, the City can achieve and extend the expected service life of a road pavement. As shown in **Figure 6-1**, the average age of the City's urban roads is 26 years, which means that there might be many urban roads that is due for rehabilitation within the next few years.

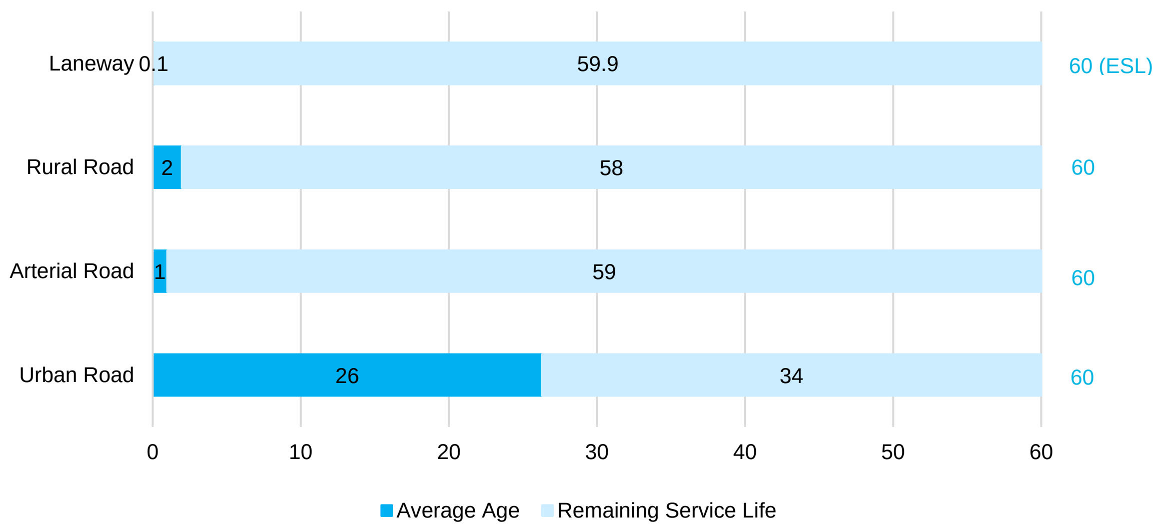


**Figure 6-1: Average Asset Age as a Proportion of Average Expected Service Life (Road Service)**

**Figure 6-2** shows the average asset age as a proportion of the average expected service life for bridges and culverts. The average expected service life for a culvert is assumed to be 50 years, and a bridge is assumed to be 70 years. Similar to roads, bridges and culverts require ongoing maintenance and rehabilitation in order to achieve their expected service life. Major rehabilitations are expected to occur two to three times over the life of a bridge for the bridge to last for its expected service life.

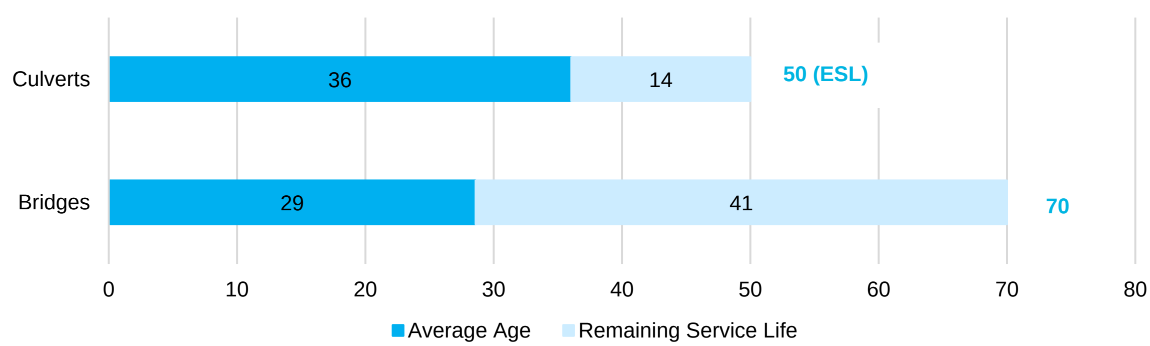


**Figure 6-2: Average Asset Age as a Proportion of Average Expected Service Life (Bridge and Culverts)**

As shown in **Figure 6-2**, the average age of the City's bridges is 29 years, which means that there might be many bridges that are due for major rehabilitation in the next few years. Major rehabilitations bring the existing structure up to the current design code requirements, and with good planning, can extend the expected service life of a structure beyond the average expected service life. Culverts are more than halfway through their expected service life. Major rehabilitation efforts are required especially for the structures that were not rehabilitated at the first major rehabilitation year mark.

## 6.3 Asset Condition

### 6.3.1 Roads

The Pavement Composite Index or PCI (0 - worst to 100 - best) was used as one of the indicators for optimizing pavement life cycle cost. The PCI is a function of the health of the network, the ability / service (capacity) of the network, and the physical environment of the network[3]. The City divides pavement conditions into four classes by PCI ranges: Very Good (80-100), Good (60-80), Fair (35-60), and Poor (0-35) (also refer to **Figure 6-8**). **Figure 6-3** presents the summary of current road network condition. The road service has 93.8% of assets in Very Good condition, which indicates the City's road network is very young and meets the current need. Attention may be required as they are aging in the future years.

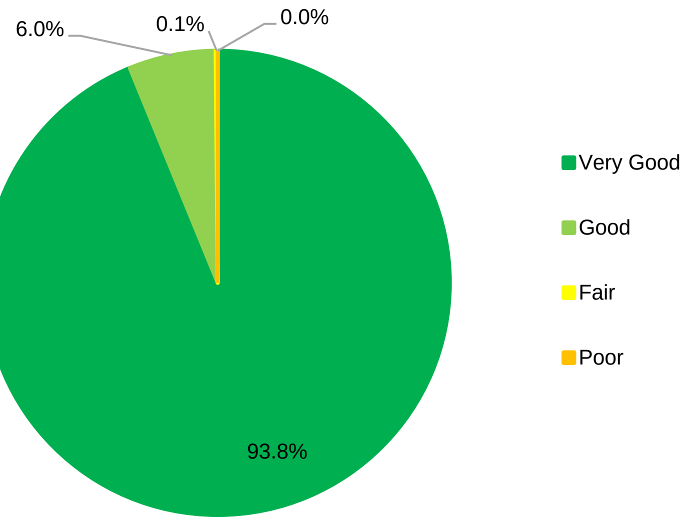


**Figure 6-3: Asset Condition Summary (Road Services)**

[3] Deighton Associates Limited (2007): City of Vaughan Pavement Management System dTIMS CT Technical Memorandum

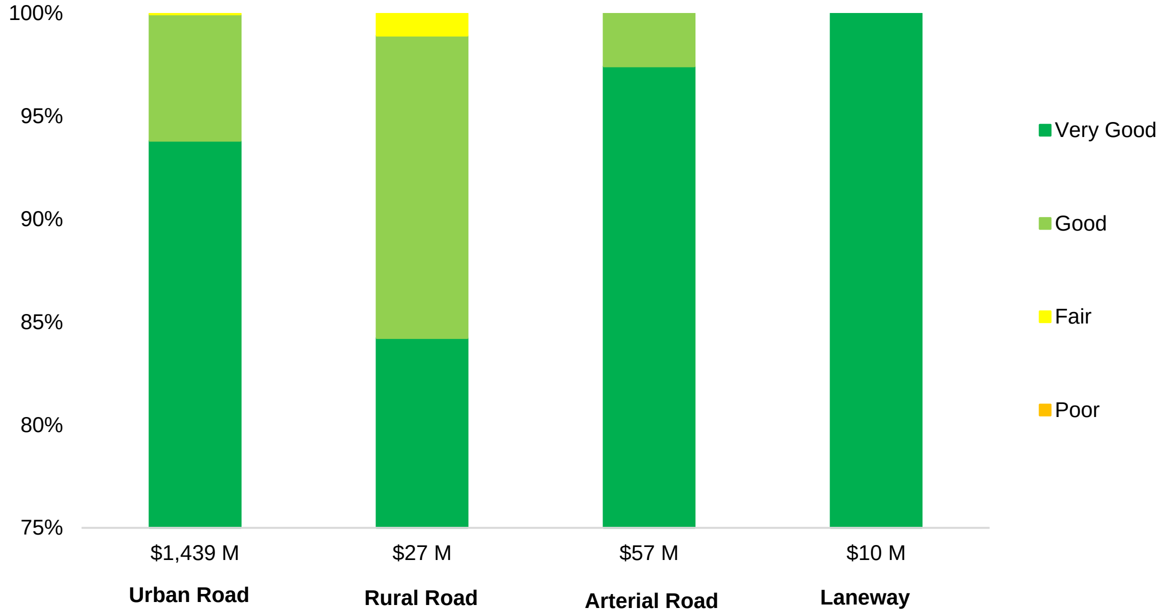


Figure 6-4: Asset Condition Detail (Road Services)

### 6.3.2 Bridges and Culverts

The City owned Bridges and Culverts are managed in accordance with Provincial Bridge Legislation and Guidelines. Assets are managed based on biennial field inspections by qualified experts to identify structural issues and concerns following Ontario Structure Inspection Manual (OSIM). Inspection results are documented, and prioritized capital needs are identified in consultant reports. To have a consistence condition rating system across the City's service areas, the bridge conditions are divided into four classes by BCI ranges: Very Good (80-100), Good (60-80), Fair (35-60), and Poor (0-35) (also refer to **Figure 6-9** and **Figure 6-9**).

Approximately 90% of the City's bridges and culverts are in Very Good and Good condition. There are 3.6% of the City's bridges and culverts in Poor condition, indicating that these structures will require rehabilitation in the short to medium-term.

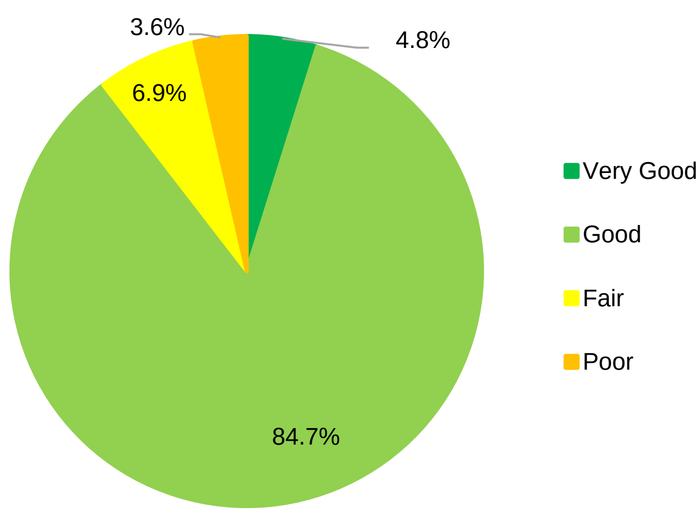


Figure 6-5: Asset Condition Summary (Bridges and Culverts)

Detailed condition profile of bridges and culverts are shown in Figure 6-6. Both bridges and culverts are nearly all in a Good or Very Good condition. It is observed that 0.3% culverts by replacement value has exceeded their expected service life, which indicates a short term need of investment.. The detailed condition information for bridges and culverts are available from Keystone bridge inspection report[4].

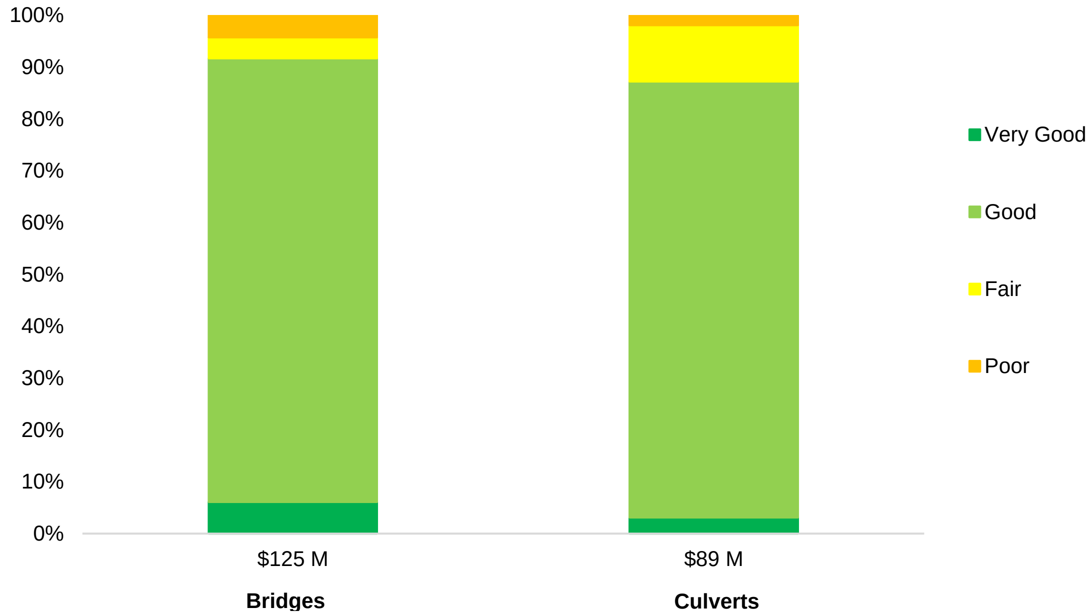


Figure 6-6: Asset Condition Detail (Bridges and Culverts)

## 6.4 Levels of Service

Ontario Regulation (O. Reg.) 588/17 requires legislated community levels of service for core assets. Community levels of service use qualitative descriptions to describe the scope or quality of service delivered by an asset category. O. Reg. 588/17 also requires legislated technical levels of service for core assets. Technical levels of service use metrics to measure the scope or quality of service being delivered by the service area. Table 6-3 and Table 6-4 lists the performance measures that are included in the O. Reg 588/17 requirements for roads, bridges and culverts assets. References are provided to indicate where O. Reg 588/17 requirements have been attained.

Table 6-3: O. Reg. 588/17 Required Levels of Service Metrics (Roads)

| Community levels of service | Technical levels of service |
|---|---|
| • Description, which may include maps, of the road network in the municipality and its level of connectivity. (Figure 6-7) | • Number of lane-kilometers of each of arterial roads (48 lane-km), urban local roads and laneways (2,177 lane-km), and rural roads (110 lane-km) as a proportion of square kilometers of land area of the municipality (273.7 km$^2$). |
| • Description or images that illustrate the different levels of road class pavement condition. (Figure 6-8) | • For paved roads in the municipality, the average pavement condition index value. (89.3%, "Very Good").<br>• For unpaved roads in the municipality, the average surface condition (64.1%, "Good"). |

[4] Keystone Bridge Management Corp. (2020): Bridge Inspection Report

**Table 6-4: O. Reg. 588/17 Required Levels of Service Metrics (Bridges and Culverts)**

| Community levels of service | Technical levels of service |
|---|---|
| • Description of the traffic that is supported by municipal bridges (e.g., heavy transport vehicles, motor vehicles, emergency vehicles, pedestrians, cyclists). (The City's bridges have been designed in accordance with the standard and requirements of the Bridge Design Code. The bridges have been designed to carry heavy transport vehicles, motor vehicles, emergency vehicles, pedestrians, and cyclists.) | • Percentage of bridges in the municipality with loading or dimensional restrictions (1.6%). |
| • Description or images of the condition of bridges and how this would affect use of the bridges. (**Figure 6-9**)<br>• Description or images of the condition of culverts and how this would affect use of the culverts. (**Figure 6-10**) | • For bridges in the municipality, the average bridge condition index value (78.6%).<br>• For structural culverts in the municipality, the average bridge condition index value (71.8%). |


**Figure 6-7: Road Network Connectivity**

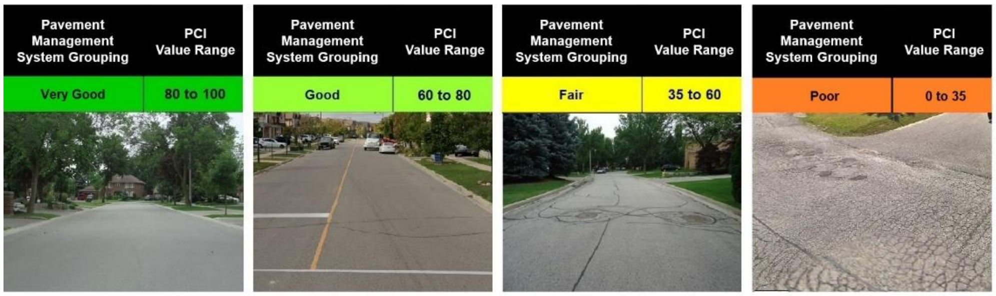


**Figure 6-8: Images of Pavement Inspections Compared to Asset Management Condition Rating**


**Figure 6-9: Images of Bridge Inspections Compared to Asset Management Condition Rating**


**Figure 6-10: Images of Culvert Inspections Compared to Asset Management Condition Rating**

## 6.5 Life Cycle Strategies

### 6.5.1 Asset Acquisition / Procurement / Construction Strategies

Added to City-purchased inventory, the City takes on new transportation core assets from developers and private, and also the City downloads roads from York Region. The most common avenue for new roads to be brought into the City's portfolio is through development. The minority of the cases would see the upload and download of roads from or to the Region. The assumption of private roads is less common.

The City accepts roads from developers (and takes immediate financial responsibility for) as new neighborhoods are constructed. For example, as developers build new neighborhoods, the new local infrastructure (including roads and bridges) is paid for by the developer and then transferred to the City for operations, maintenance and ultimately replacement. The City's transportation infrastructure inventory was therefore created over many decades through infrastructure paid for by the City or by developers.

For roads that are downloaded from the Region, the roads are normally in a state of good repair. There is a development cost (DC) budgeted for the roads downloaded but the City will need to assume the life cycle costs for the downloaded roads.

A situation could also occur where the City uploads roads to the Region, and the Region takes responsibility. The upload and download activity are determined by transportation planning. There are criteria established between the Region and the City e.g., what type of road should be classified as a regional road or local road? As traffic pattern changes, originally a road that is a regional road, could become a local road, and vise versa. Generally, there is a candidate list for road upload and download based on the discussion between the City and the Region, and DC can be shifted based on whether a road is uploaded or downloaded.

With regards to the transportation asset assumption process, Development Engineering is involved in the subdivision plans and approving plans from developers. Inspectors from Development Engineering perform inspections to make sure transportation assets are up to standard for transportation operations. The entire road GIS database at the City was transferred from the Region, and the City will make changes when there is a technical memorandum provided by Development Engineering specifying changes.

### 6.5.2 Asset Operations and Maintenance (O&M) Strategies

Road operations and maintenance cost consists of three major components: pure winter control activities, pure roads O&M activities (exclude winter control activities), and overhead. Table 6-5 presents the breakdown activities and five-year average cost for the City's road assets.

The City's road and bridges O&M cost are largely comprised of winter control costs and overhead costs. The five-year average winter control activities cost is $10,958,000. The five-year annual average O&M cost for other pure roads and bridges cost is totally $1,899,000. The overhead cost is approximately half of winter control O&M cost.

The City's winter control activities include winter equipment fueling, truck plowing, grader plowing, spot plowing, ice removal, snow removal, winter drainage, windrow snow clearing, snow fencing, salting and sanding, winter road patrol, stockpiling, sand purchase, salt purchase, and winter control standby activities. It is noticeable that there are significant costs for winter control standby ($5.8M), salt purchasing ($2.8M), and salting and sanding ($1.3M).

Other than winter control, the pure road and bridges O&M activities includes pavement marking, street sweeping, roadside vegetation maintenance, culvert installation maintenance, road platform maintenance, washout repairs, rural road maintenance, curb cut, boulevard interlock repair, bridge repairs, sign install/maintenance, graffiti removal, guiderail maintenance, and railway crossing maintenance.

**Table 6-5: Transportation O&M Activities and Five-year Average Costs**

| O&M Activities | Description | Five-year Average Cost |
|---|---|---|
| **Pure Winter Control Activities** | Winter road patrol, sand and salt purchase, salting and sanding, winter equipment fueling, plowing, ice and snow removal / cleaning, drainage, snow fencing, and winter control standby. | $10,958,000 |
| **Pure Roads and bridges O&M Activities (exclude winter control activities)** | road, bridge and culvert repairs and maintenance, pavement marking, street sweeping, curb cut, boulevard interlock repair, sign install/maintenance, graffiti removal, guiderail maintenance, railway crossing maintenance (excluded street sweeping amount recovered by wastewater service) | $1,899,000 |
| **Overhead** | All overhead cost (e.g., Vehicle Maintenance, Staff Training, Yard Operations, etc.) (one item Transportation Services, Parks and Forestry Operations (TSPFO) Admin. is $2.8M) | $5,456,000 |
| **Total** | | **$18,313,000** |

It should be noted that street sweeping is performed by the road service and partially recovered by environmental services (wastewater and stormwater services). Other costs recovered by environmental services include debris clean up, rural grass cutting, rural vegetation, and culverts and so on. Thus, in Table 6-5, costs recovered from other service areas are excluded and accounted for in other related service areas.

In the dTIMS analysis, crack seal, crack seal subsequent treatment, and drainage major treatment are categorized as pavement maintenance activities. These activities will be optimized along with the renewal and replacement activities in the dTIMS's life cycle cost analysis under defined budget scenarios.

### 6.5.3 Asset Renewal and Replacement Strategies

#### 6.5.3.1 Road Pavements

The City's road renewal and replacement activities include rehabilitation, remove and replace, reconstruction, and rural road upgrade. It should be noted that the City has taken the initiative to apply different treatment approaches for the rural environment to improve its pavement management approach. The detailed pavement renewal and replacement treatment approaches for the City is presented in Table 6-6.

**Table 6-6: The City's Pavement Renewal and Replacement Activities**

| Renewal and replacement activity | Treatment Method | Description |
|---|---|---|
| Reconstruction | Complete reconstruction | Reconstruction involves removing the existing pavement layers and rebuilding the pavement layers from the ground. |
| Remove and Replace | Remove and replace | Remove and replace involve removing the existing pavement layers and rebuilding the pavement layers to replace the equivalent pavement thickness. |
| Rehabilitation | Drainage ancillary treatment | Adequate drainage is very important to pavement performance. Drainage ancillary treatment can include ditching and installing subdrains, and cleaning of outlets, culverts and subdrains. |
| | Low class bituminous (LCB) surface treatment | LCB treatment refers to thin surface treatment of liquid asphalt covered with an aggregate on surface treated roads, which often applied to pavements with lower traffic volumes. |
| | LCB upgrade to high class bituminous (HCB) | HCB refer to paved road with high class bituminous; upgrade road with LCB to HCB can accommodate increasing traffic demand |
| | Micro surface | Micro surfacing is used to correct surface distresses such as raveling |
| | Mill and overlay | Mill and overlay are also used to address distresses and other deficiencies in the pavement |
| | Pulverize and overlay | Pulverize and overlay involves grinding up existing surface layers right in place, blending the layers with any sub-layers, essentially creating a new paving mix using all the old materials. |
| | Micro surface subsequent treatment | Subsequent micro surface treatment |
| | Mill and overlay subsequent treatment | Subsequent mill and overlay treatment |
| Rural Road Upgrade | Gravel to HCB | Upgrade rural gravel road to high class bituminous |
| | Gravel to LCB | Upgrade rural gravel road to low class bituminous |

The dTIMS pavement analysis was utilized for performing life cycle cost optimization considering various budget scenarios. A number of treatment strategies are generated for the analysis period, and present value costs and benefits for the budget scenarios are calculated. The optimization then selects the "best" economic strategy out of the list of probable treatment strategies, for a specified budget scenario. The output of a dTIMS analysis provides the recommended optimized maintenance and construction program. Maintenance programs are also output from the analysis as part of the life cycle cost optimization. Please refer to Pavement Management System dTIMS technical memorandum referenced earlier, for more details on pavement life cycle analysis.

#### 6.5.3.2 Bridges and Culverts

Bridge and culvert treatments include minor rehabilitation, major rehabilitation, and replacement activities. The detailed bridges treatment options include pre-emptive treatment for deck component on structure, pre-emptive treatment for substructure component on structure, pre-emptive treatment for superstructure component on structure, minor rehab treatment for deck component on structure, minor rehab treatment for substructure component on structure, minor rehab treatment for superstructure component on structure, major rehab treatment for deck component on structure, major rehab treatment for substructure component on structure, major rehab treatment for superstructure component on structure, replacement treatment for deck component on structure, replacement treatment for substructure component on structure, replacement treatment for superstructure component on structure, pre-emptive structure treatment, complete replacement structure treatment, partial replacement structure treatment, rehab structure treatment, and deck replacement structure treatment. Please refer to the Keystone bridge inspection report for more details on the OSIM renewal and replacement analysis.

### 6.5.4 Decommissioning and Disposal Activities

Asset decommissioning and disposal activities are performed to decommission and dispose of assets due to ageing or changes in performance and capacity requirements. This decision process includes the consideration of costs and benefits of rationalization using a whole life approach, the impact of asset rationalisation on other infrastructure and the processes for disposal of assets. More specifically, the following factors need to be evaluated when considering the decommission and disposal of assets:

- Assets not required for the delivery of services, either currently, or over the longer planning period.
- Assets that have become uneconomical to maintain or operate. (e.g., roads with excessively high maintenance costs.)
- Assets that are not suitable for service delivery.
- Assets that have a negative impact on service delivery, the environment, or community. (e.g., roads which have persistent erosion problems, often located in areas of extremely erodible soils.)
- Assets that no longer support the City's service objectives due to a change in type of service being delivered or the delivery method.
- Assets which can no longer be used for the purpose originally intended. (e.g., roads and bridges constructed for temporary access such as designated temporary roads).

Considerations for the City's asset decommissioning and disposal activities include, but are not limited to:

- Updates to the City's Statement of Tangible Capital Assets. Considerations related to the determination of residual value and the disposal of assets include:
  - Residual value and the useful life of an asset should be reviewed, at the very least, at each financial year-end and, if expectations differ from previous estimates, any change should be accounted for prospectively as a change in estimate.
  - Residual value or salvage value for pavement can be significant because it involves the remaining value of significant expenditures not fully consumed at the end of the analysis period. The residual value of a pavement material depends on several factors: location, volume, recycling / re-use policies, age, anticipated use the end of the design life, etc. The last preservation or rehabilitation treatment in the analysis is often used to estimate the end of life residual value.
  - The depreciation method used should reflect the pattern in which the asset's economic benefits are consumed.

- The depreciation method should be reviewed, at the very least, annually and, if the pattern of consumption of benefits has changed, the depreciation method should be changed prospectively as a change in estimate.

- Updates to asset databases such as the GIS and CMMS.
- Environmental impact of disposal and implications for land rehabilitation, where applicable.
- Continued service delivery while a new road asset is being constructed / commissioned.
- Cost of decommissioning and disposal.

### 6.5.5 Risk Assessment

As presented in **Section 2.3.4.1**, risk score can be calculated for each road segment, bridge and culvert by using its Probability of Failure (PoF) and Consequence of Failure (CoF) score. For the City's roads, PoF can be estimated using the City's four-point PCI rating system (Very Good, Good, Fair, and Poor) by assigning a score of 1 (Very Good) to 4 (Poor) for each road segment. The CoF or criticality rating considers evaluation of the relative importance of assets based on select criteria. With a comprehensive criticality rating, the following factors could be incorporated:

- Economic: Impact of the asset's failure on monetary resources e.g., replacement cost and the economic impact on commercial areas should the asset fail.
- Operational: Impact of the asset's failure on operational ability e.g., road functional classes, AADT, underlaying water, wastewater, and stormwater systems.
- Social: Impact of the asset's failure on society e.g., residential areas and commercial areas.
- Environmental: Impact of the asset's failure on the environment e.g., environmental sensitive areas.

It is recommended that the City perform a risk assessment to prioritize resources if there are budget constrains.

## 6.6 Funding Need Analysis

### 6.6.1 Transportation Asset Condition Forecasts and Budget Scenarios

#### 6.6.1.1 Roads

The following three budget scenarios were performed for the road pavement asset reinvestment analysis: Do-Nothing, Unlimited, and $9M budget. **Figure 6-11** shows the road network condition trends over the next 20 year for different budget scenarios. The condition trend of the $9M scenario fall approximately in the middle between the do-nothing and the unlimited budget over the analysis period.

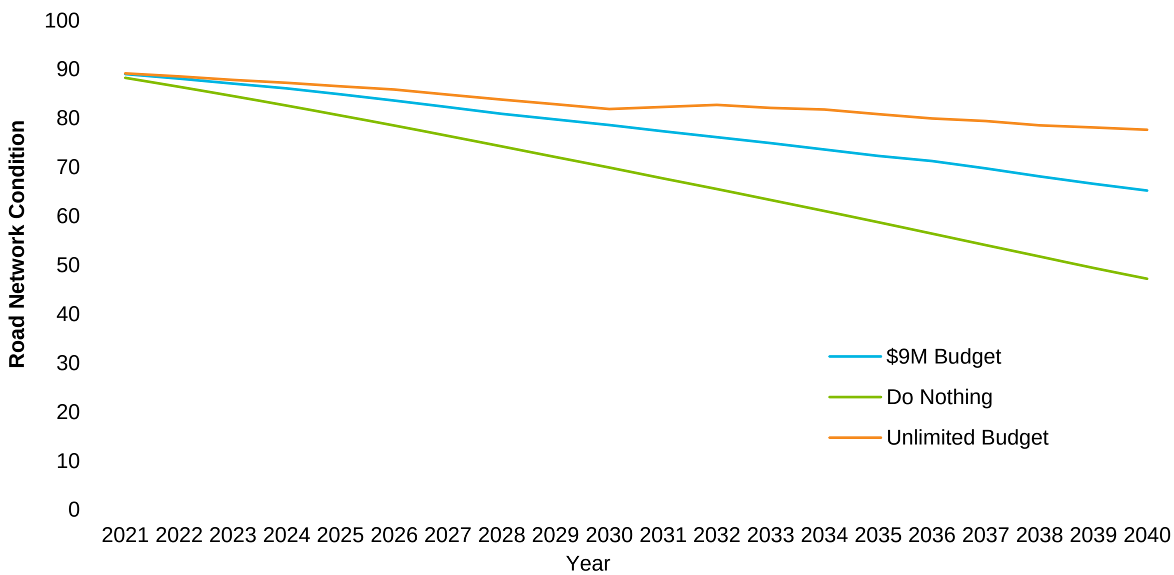

**Figure 6-11: Road Pavement Condition Forecasts and Budget Scenarios**

The $9M road asset budget scenario will be carried forth in the Road 20-Year Funding Need Analysis in Section **6.6.2.1**.

**Figure 6-12** presents the road assets condition profile projection for the next 20 years based on the $9M budget scenario. The analysis considers the current condition of road assets, the rate that the condition is expected to degrade, and appropriate condition triggers for life cycle activities to forecast the condition profile into the future. Some of the City's road assets currently in the Very Good to Good condition category is predicted to move to the Good to Fair condition category at the end of the 20-Year period under the $9M budget scenario. It is predicted that the City will have a small percentage of roads in Poor condition starting from 2026 to approximately 6% in 2040under the recommended budget scenario.

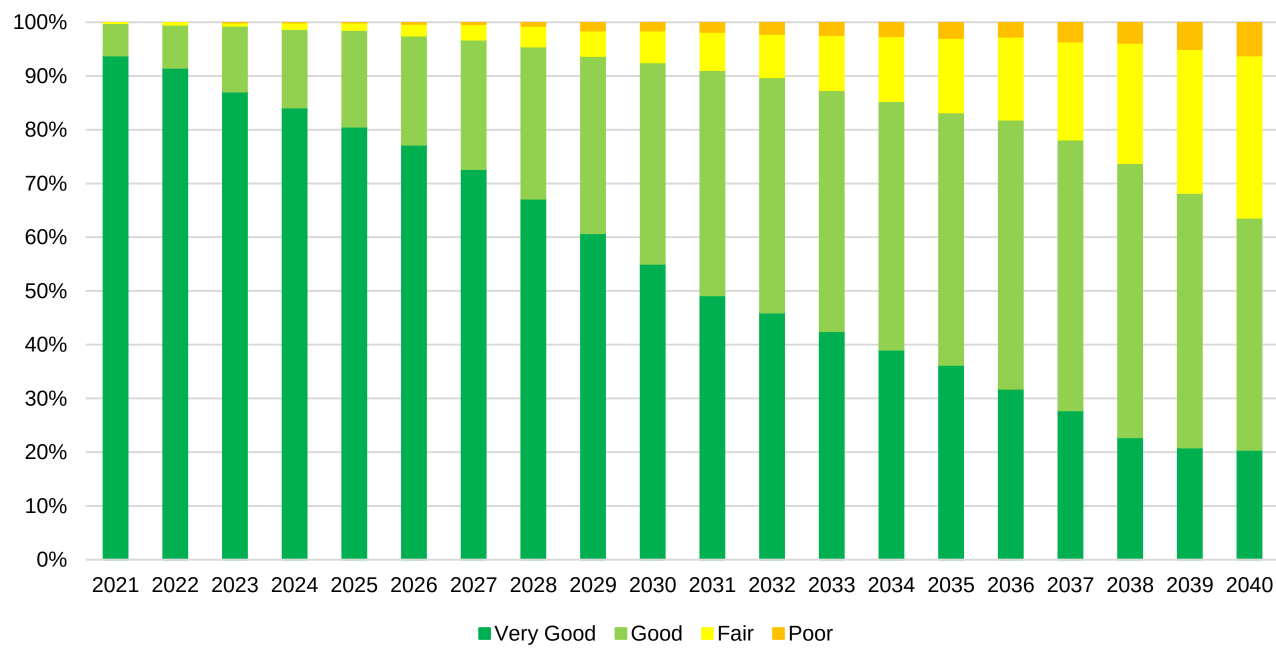


**Figure 6-12: Road 20-Year Network Condition Profile Forecast**

## 6.6.2 Transportation 20-Year Funding Need Analysis

### 6.6.2.1 Roads

The average annual reinvestment rate for the City's entire road network is equivalent to $10M over the next 20 years in inflated dollar values. This is equivalent to a total of approximately $199M over the next 20 year period, as presented in **Figure 6-13**.

It is important to note, there is significant reinvestment required for rehabilitation program as shown in **Figure 6-14**. Looking ahead to the decade between 2031 and 2040, the City should prepare for more reinvestment as roads continue to age and deteriorate.

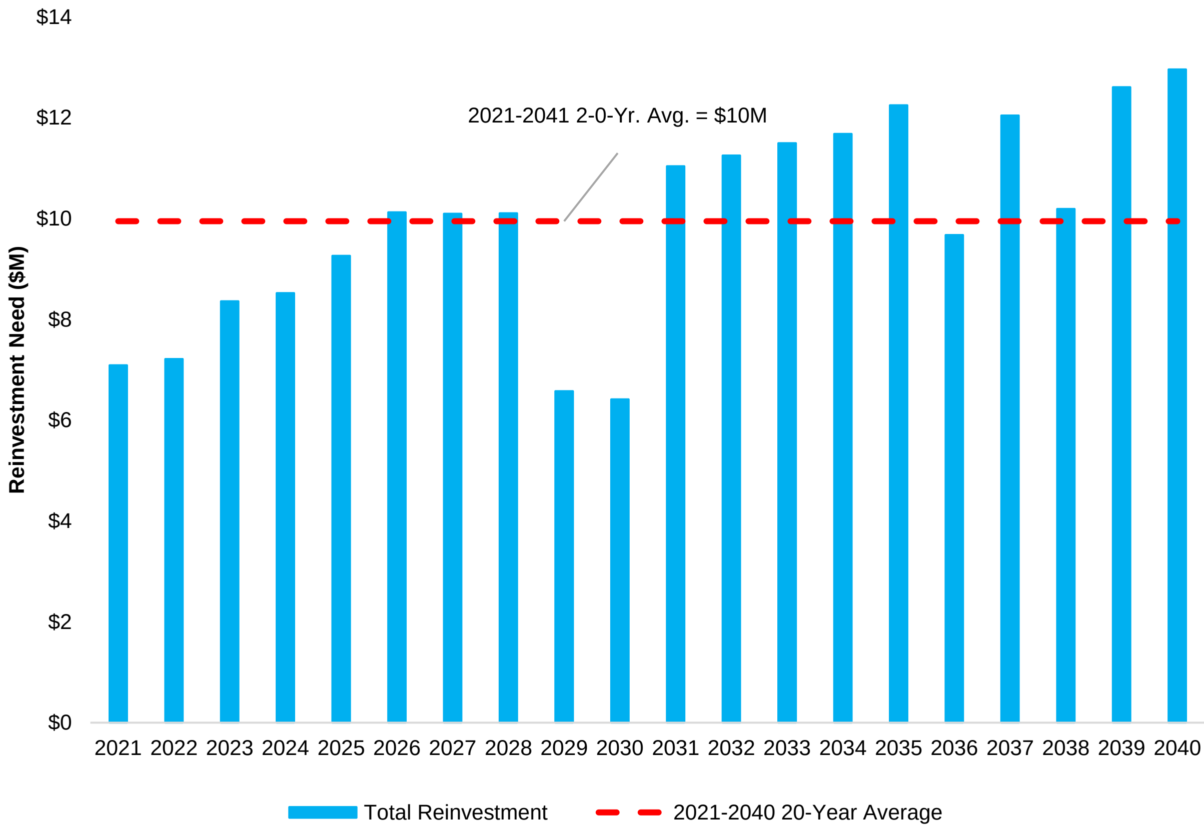


**Figure 6-13: Roads 20-Year Reinvestment Need**

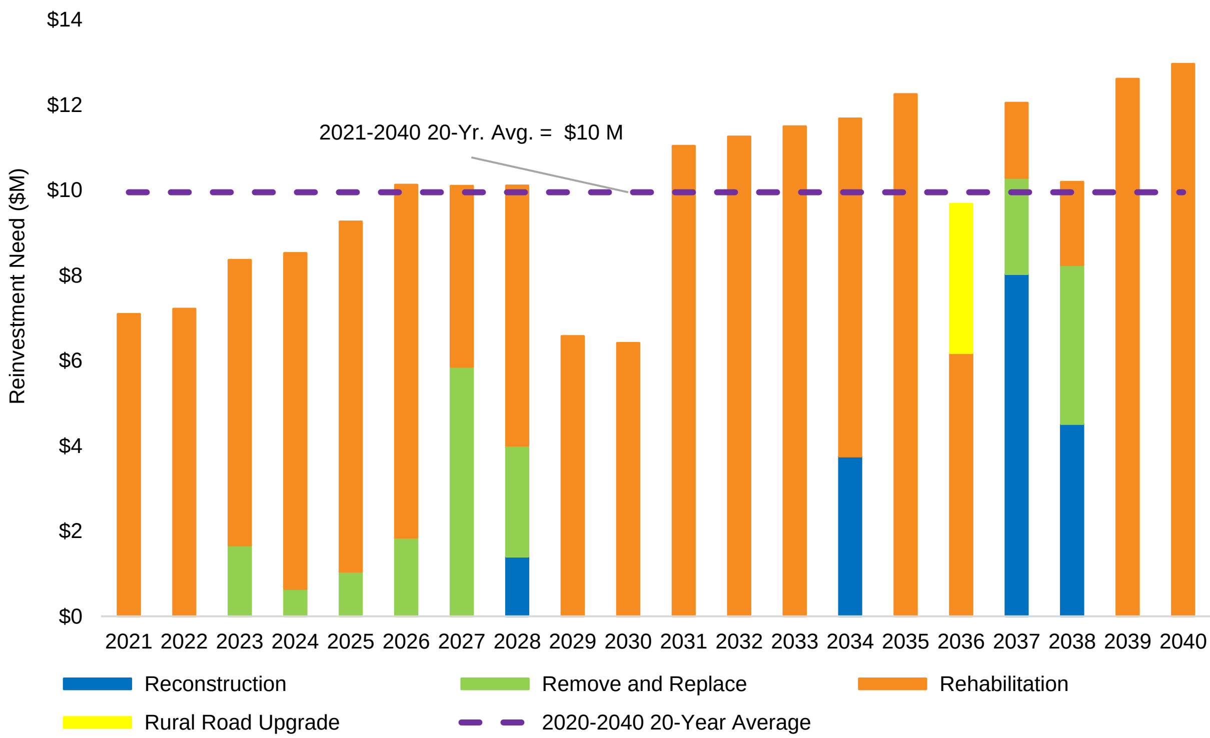


**Figure 6-14: Roads 20-Year Reinvestment Need Details**

The detailed reinvestment needs in inflated dollar values for Reconstruction, Remove and Replace, Rehabilitation, Rural Road Upgrade are presented in **Table 6-7.**

**Table 6-7: Road 20-Year Total and Annual Average Reinvestment Need**

| | Reconstruction | Remove and Replace | Rehabilitation | Rural Road Upgrade | Total |
|---|---|---|---|---|---|
| Annual Average Need | $885,000 | $983,000 | $7,907,000 | $175,000 | $9,950,000 |
| 20-Year Total | $17,700,000 | $19,660,000 | $158,140,000 | $3,500,000 | $199,000,000 |

The total annual reinvestment rate from **Figure 6-13** was overlaid with O&M cost (based on the dTIMS output, inflated dollar value) and the average Road Development Cost (DC), as presented in **Figure 6-15**.

Road assets requires approximately $14M O&M funding over the next 20 years, equivalent to $0.7M per year in inflated dollar value. The Road service development requires approximately $376M over the next 20 years, equivalent to roughly $18.8M annually. As such, with the addition of O&M and Road DC, the total average annual reinvestment rate for the City's road assets increases to approximately $33.5M annually, for a total of $670M over the next 20-year period.

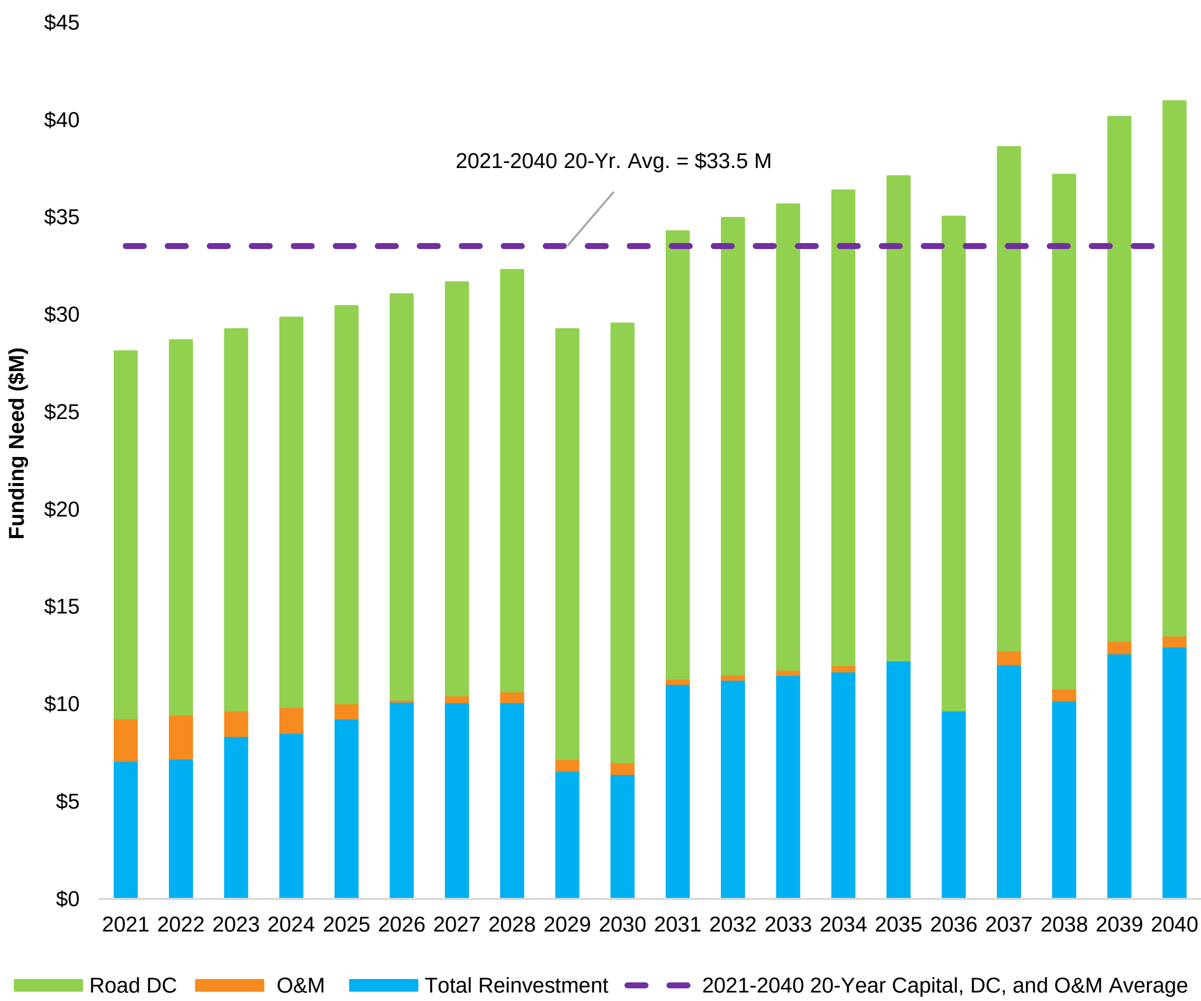


**Figure 6-15: Roads 20-Year Capital Investment and O&M Cost Forecast**

#### 6.6.2.2 Bridges and Culverts

Reinvestment need analysis for bridges & Culverts was based on the City's 2020 OSIM inspection capital recommendations from the Keystone Bridge Inspection Report. The report recommended capital works for 2021 to 2030 and AECOM applied a flat rate based on the first 10 years to the period of 2031 to 2040 to achieve a 20-year reinvestment analysis.

The average annual reinvestment rate for the City's bridges & culverts is approximately $1.8M over the next 20 years in inflated dollar values. This is equivalent to a total of approximately $36M over the next 20 year period, as presented in **Figure 6-16**.

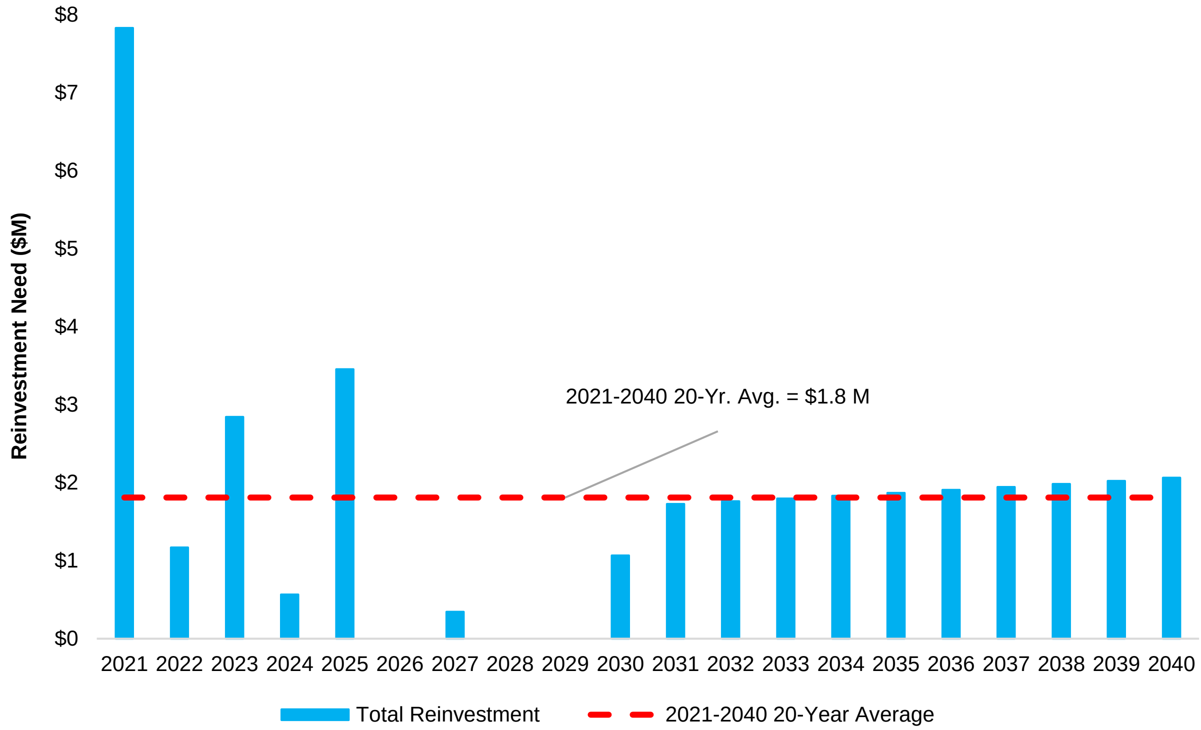


**Figure 6-16: Bridges & Culverts 20-Year Reinvestment Need**

The total annual reinvestment rate from **Figure 6-16** was overlaid with the average Bridges Development Cost (DC), as presented in **Figure 6-17**.

The bridges & culverts service development requires approximately $200M over the next 20 years, equivalent to roughly $10 M annually in inflated dollar value. As such, with the addition bridge DC, the total average annual capital rate for the City's bridges & culverts assets increases to approximately $11.8 M annually, for a total of $236M over the next 20-year period.

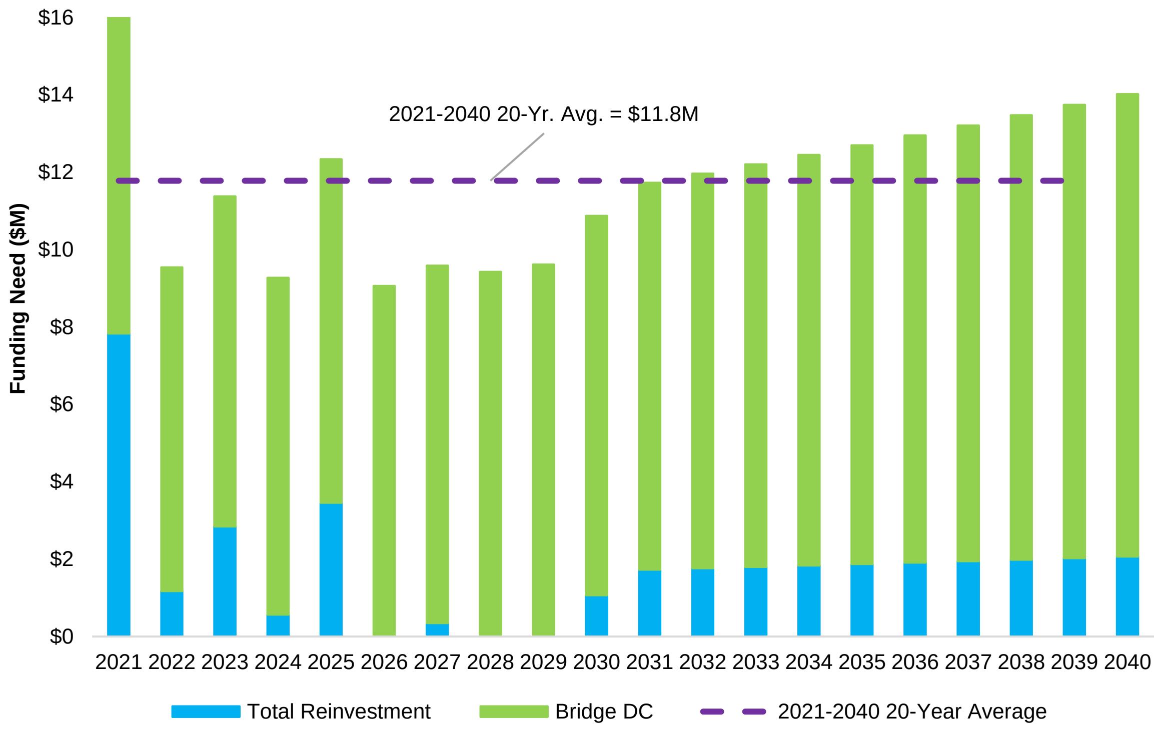


**Figure 6-17: Bridges & Culverts 20-Year Capital Investment Forecast**

### 6.6.3 Full Funding Need Profile

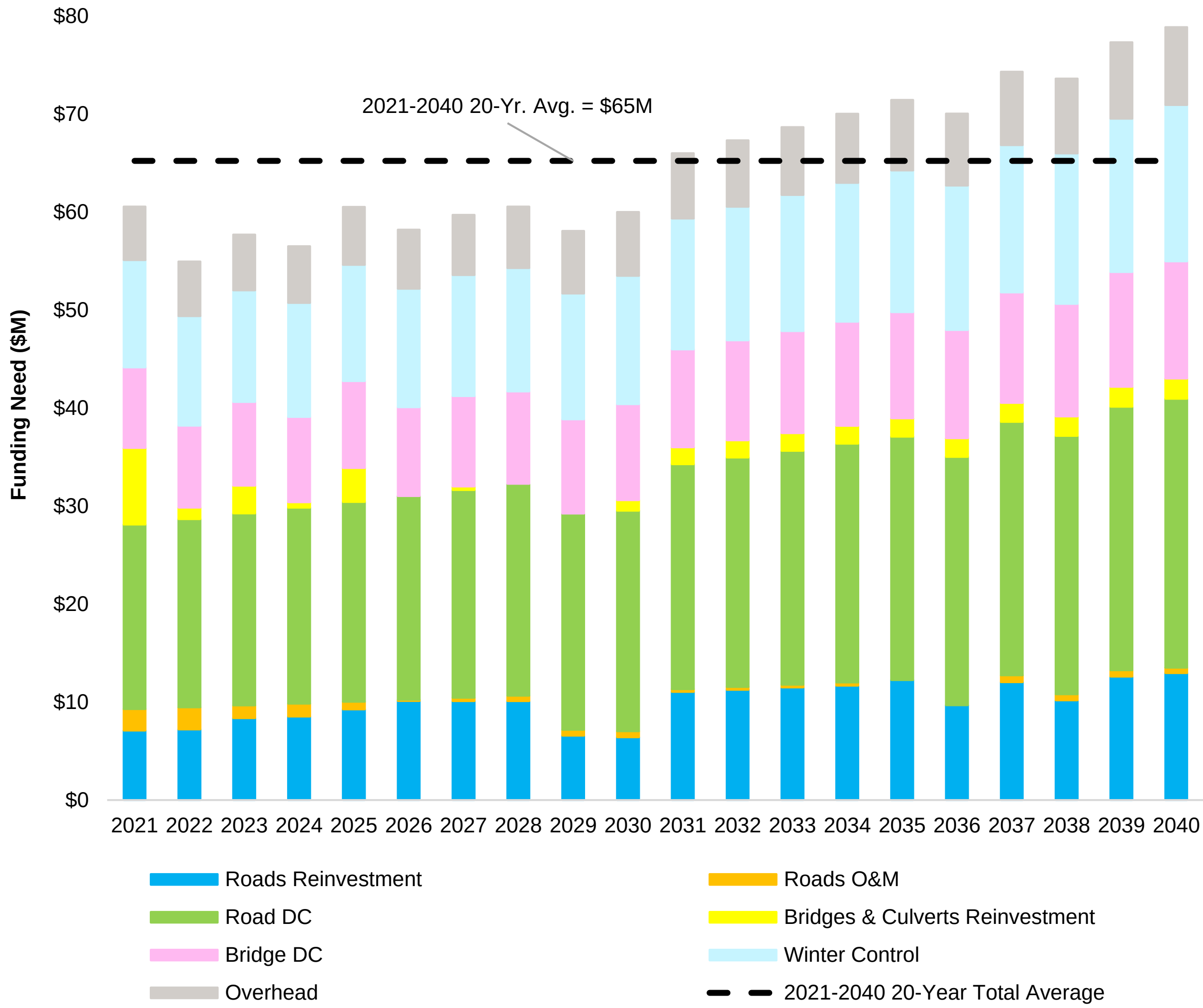


Figure 6-18 shows a full picture of the City's Transportation Core Assets funding need forecast over the next 20 years, which provides the City the full funding requirements for performing effective financial planning activities. The total annual reinvestment rate from **Figure 6-13** and **Figure 6-16** was overlaid with the City's Roads O&M cost, five-year annual average winter control activities costs, transportation overhead costs, annual average Road DC, and Bridges & Culverts DC.

The City's transportation core service funding requirement increases to approximately $1.3B over the next 20 years with additional funding requirement of winter control, O&M and DC, equivalent to $65M per year in inflated dollar value. It is noticeable that the funding requirement for winter control is significant compared to capital requirement and O&M requirement, as presented in **Figure 6-18**.

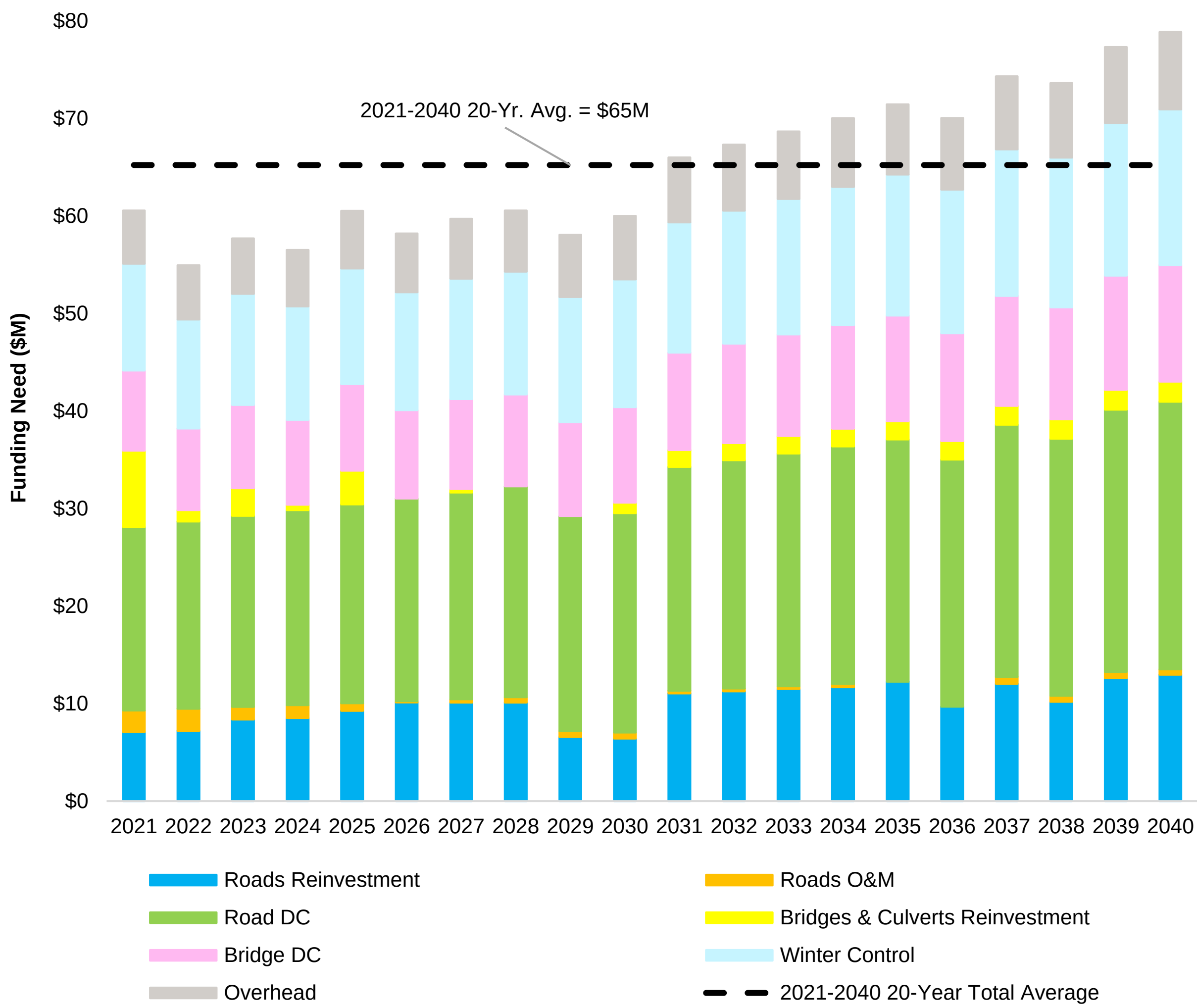


**Figure 6-18: Transportation Core Assets Full Funding Need Profile**

## 6.7 Recommendations for Transportation AMP Continuous Improvement

Continuous improvement is an important component of any AM program and is achieved through the implementation of recommended improvement initiatives which support sustainable service delivery. While the City's Transportation core assets are in a very good condition, there are current and future challenges that must be contended with. It is important to address these challenges thoroughly and promptly to leave a positive legacy for future generations.

AECOM has identified a set of activities that represents the next stage of AM planning and implementation within the City.

- **Continue to update and maintain road asset inventory and bridges and culvert asset inventory,** so as to have a more accurate representation of the current state of the transportation infrastructure; and, ultimately, to make more informed and defensible decisions.
- **Refine the Levels of Service Framework to quantify the gaps between existing and target service levels.**
  - Collect current asset performance data for key performance indicators (KPIs) that are not currently being tracked, including associated costs.
  - Analyze asset performance data to determine trends and to establish annual performance benchmarks.

  - Engage in a discussion with key stakeholders (see the **AM Strategy**) to establish service level targets and identify associated costs to meet those targets.
  - Once LoS targets have been decided upon, the City should develop strategies on how to meet service level targets considering its existing operating environment (i.e., staff availability, current funding, resources, etc.).
  - Develop a Customer Consultation Plan to engage the public and other stakeholders on the LoS framework and to better understand customers' willingness to pay for enhanced service levels.

- **Perform a risk assessment of transportation assets for future iterations of the AM plan, and use the risk assessment results to drive future condition assessments and financial needs forecasting.**
  - Calculate a risk score for each road segment, bridge and culvert by using its Probability of Failure (PoF) and Consequence of Failure (CoF) score, to assess the ability of the assets to meet current and future operational requirements including capacity, regulatory, resilience and other LoS needs.
  - Frequently revisit and revise PoF and criticality model as needed.
  - Review risk attribute values periodically to ensure alignment with business objective and appetite
  - Overlay the risk models with the current state of the assets (i.e., condition), and the 20-year financial forecast. Using this approach, the City could focus its monitoring, maintenance, and renewal and replacement budget and activities on high risk infrastructure. Medium risk infrastructure could be addressed through the mitigation of failure through regular monitoring, and the low risk infrastructure could be accepted with caution.

- **Establish a sustainable transportation asset funding model that fits the needs of the community.**
  - In light of the roads annual capital investment outlined in **Figure 6-15**, the City should budget for road expenditures on renewal, replacement, O&M, and new development to an average of $33.5M estimated per year over the next 20 years. For bridges, the City should budget for capital expenditures to an average of $11.8M estimated per year over the next 20 years as outlined in **Figure 6-17.**
  - Review financial modeling assumptions on ESL and replacement values and update the financial model with new information as it becomes available. The financial model is based on a number of key assumptions for asset ESL and replacement values that could have a significant impact on the outcomes of the model.
  - The City should review its current transportation funding model, and in consultation with staff, consider the following steps to improve its existing model:
    - Confirm criteria for selecting a transportation funding model.
    - Select the preferred funding model that meets the chosen criteria.
    - Identify issues specific to the City that should be considered.
    - Conduct a financial analysis of the preferred funding model.

- **Continue to find ways to improve AM initiatives across the City by maintaining a high level of AM awareness through training, communication, and knowledge sharing.**
  - Conduct an AM Software Assessment to identify future system requirements that may include enhancing existing software, adding-on, or replacing.
  - Develop a Knowledge Retention Strategy & Internal Communications Plan to document staff AM knowledge and experience for reporting and succession planning purposes. Communicate AM improvement initiatives and enhance AM awareness internally through internal communication.
  - Aligning the Financial and Non-Financial Functions of AM. Refer to **Section 2.4.3** for the framewotk to address the need to achieve this alignment.

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