westvancouver

District of West Vancouver

Water System Asset Management Plan

4265733v1 2021

Document Control

Version: 2020 Water System Asset Management Plan

Document Prepared by: WSP Canada Inc.

Document Reference No. WSP: 19P-00252-00

Document Owner: District of West Vancouver

Date: July 2021

Document History and Status

Revision	Date	Revision Details	Author	Reviewer	Approver
0	Nov 2019	Draft WSAMP Outline	D. Manarin	M. Levin	C. Leung
1	Oct 2020	Draft WSAMP for Discussion	M. Levin	B. O'Connor	C. Leung
2	June 2021	Draft WSAMP for Review	A. Kovacevic	M. Levin	C. Leung
3	July 2021	Final WSAMP	A. Kovacevic	M. Levin	C. Leung

Contents

Executive Summary 1
Background 1
System Description (Inventory, Value, Condition) 2
Levels of Service and Demand Management 4
Managing Risk 4
Financial Forecast 6
Mitigative Measures / Next Steps 8
1 Introduction 11
1.1 Purpose 11
1.2 Scope 11
1.3 Plan Updates and Endorsement 12
1.4 Plan Icons 13
2 Asset Management System 14
2.1 What is the Asset Management System? 14
2.2 "Line of Sight" for Asset Management 14
2.3 Asset Management Policy 15
2.4 Asset Management Strategy 15
2.5 Asset Management System Improvement Actions 17
3 State of Infrastructure 18
3.1 Overview 18
3.2 Water Network 18
3.3 Condition Ratings 23
3.4 State of Infrastructure Improvement Actions 32
4 Levels of Service 33
4.1 Overview 33
4.2 Customers & Key Stakeholders 33
4.3 Legislative Requirements 34
4.4 Defining Levels of Service 34
4.5 Current Levels of Service 35
4.6 Levels of Service Improvement Actions 37
5 Lifecycle Management 38
5.1 Overview 38

5.2 Demand Management ... 39
5.3 Operations and Maintenance ... 39
5.4 Asset Renewals ... 40
5.5 Asset Upgrades and Expansion ... 41
5.6 Disposal of Assets ... 41
5.7 Lifecycle Management Improvement Items ... 41

6 Risk Strategy ... 42
6.1 Service Risks ... 42
6.2 Asset Level Risks ... 43
6.3 Risk Improvement Items ... 46

7 Financial Forecast ... 47
7.1 Operating and Maintenance Costs ... 47
7.2 Capital Renewal Costs ... 49
7.3 Capital New and Upgrade Costs ... 50
7.4 Future Forecast ... 52
7.5 Sensitivity Analysis ... 57
7.6 Revenues, Reserve Funds, and Alternative Measures for Funding Strategy ... 58
7.7 Forecast Reliability and Confidence ... 58
7.8 Financial Forecast Improvement Items ... 60

8 Continuous Improvement Plan ... 61
8.1 Overview ... 61
8.2 Improvement Plan ... 61
8.3 Review of this plan ... 63

Appendix A – Summary of Water System Assets ... 64

Executive Summary

Background

In 2010 the District developed its first Water System Asset Management Plan (WSAMP). The plan is referred to as 2010 WSAMP. The 2010 plan represented the first attempt to model the long-term renewal funding requirements for the entire water system and used the asset data that was available at the time, and best practices of the day. At the conclusion of the 2010 WSAMP, District staff spent time discussing the results with Council and the Public in multiple workshops and open houses. Concurrently, there was significant media attention being drawn to the Canadian National Infrastructure Gap which supported the findings of underfunding within the local system. At the conclusion of the consultation process, Council approved a new financial model for the Water System which included a higher level of capital renewal investment.

While the 2010 WSAMP was an important advancement in strategic system planning, it was deficient in several key areas. The 2010 plan used data and limited system models that were available at the time. Data limitations were especially noteworthy around non-linear assets such as the Eagle Lake Filtration Plant, Eagle Lake East and West Dams, water reservoirs, and pump stations. In terms of modelling, a fully calibrated hydraulic model was not available at that time either. Without a hydraulic model, the District's ability to analyze the system for capacity, working pressures, fire flow availability, and source and system redundancy was limited, and therefore asset upgrades or new assets required to meet the standard level of service criteria which would be required for residents as captured under a Master Water Servicing Study were not included in the 2010 WSAMP. The approach taken in 2010 was to replace assets 'like for like' with no upgrades or new assets envisioned.

In the summer of 2015, the Lower Mainland experienced what was termed a major drought. Metro Vancouver introduced unprecedented levels of water conservation measures. A new trend of warmer and wetter winters followed by longer drier summers consistent with climate change predictions seemed to have emerged. The West Vancouver water system benefits from having two sources: Metro Vancouver and Eagle Lake. However, in 2015 the Eagle Lake supply was drawn down to minimum allowable levels with only approximately one week of water available remaining. It was found in 2015 that relying entirely on Metro Vancouver water supply is not possible due to insufficient District pumping and transmission capabilities to supply the volume of Metro Vancouver water needed for the western regions of the District. In the face of changing climate, further considerations were required to review the previous management approach to water source and system redundancy in the District's water system.

In 2016, a Master Water Servicing Study (2016 MWSS) was completed for the District. The study examined the capacity of the system to deliver sufficient volumes of water at acceptable pressures and fire flows at all locations. Using a calibrated hydraulic model at that time, the study considered the effects of climate change on water supply provision, and future demands on the system due to increased population as projected by the OCP. While increases in population and the associated demands do influence the long-term water supply strategy, it is the level of service provided by the water system in the present day and the effects of climate change that was determined to be the most impactful.

The MWSS ushered in a new management approach to the water system. The new approach takes into consideration climate change; the anticipated drier summers and decreasing yearly snowpack will further stress and reduce the availability of supply redundancy within the system. Redundancy of supply and improving the ability to supply Metro Vancouver water to the western areas of the District is a significant challenge and requires increased pipe capacities, increased pumping, and storage. Without these alterations to the system, the District increases the risk to its ability to deliver adequate levels of service to its residents during summer high water usage and peak periods.

This latest iteration of the Water System Asset Management Plan, dubbed the 2020 WSAMP, is built upon the 2010 WSAMP and the findings and recommendations of the 2016 MWSS.

Comparing the renewal funding requirements of the 2010 and 2020 WSAMP's reveals the new management change in financial terms. The long term 100 year forecast from the 2020 plan is approximately $6.7 Million annually, inclusive of backlog, compared to the 2010 annual average expenditure of $4.8 Million, inclusive of backlog. Allowing for inflation, the numbers are fairly consistent in today's dollars. However, the backlog from 2020 ($34 Million) is significantly different than that described in 2010 ($15 Million). The largest difference is due to the construction cost inflation (>200% in unit cost rates over the last 10 years), as well as immediate needs to address the system deficiencies in capacity to provide system demands, fire flows and source and system redundancies which was not part of the original 2010 WSAMP. The main driver is the upfront costs for building new facilities, or the upgrade and update of non-linear infrastructures which have reached their end of useful life. For example, unlike replacement of a watermain which can be divided up into smaller sections and replaced through multiple years, it is not possible to build half a pump station or a quarter of a storage reservoir. The project must be completed all at once and capital investment cannot not be spread over time. For the WSAMP to be successful, a comprehensive funding strategy must be developed to complement the asset management strategies.

System Description (Inventory, Value, Condition)

As of 2020, the system is comprised of dams, water treatment plants, storage reservoirs, pump and PRV stations, transmission and distribution mains, service connections, fire hydrants and water meters, as summarized in the table below. Watermains are the largest asset group and represent 77% of the asset base. Pressure Reducing Valve (PRV) Stations are the smallest asset group by replacement cost. While the growth of West Vancouver is comparatively small, the length of water mains has increased by 9 km since 2010. Additionally, over the last decade, construction costs for main renewals have effectively doubled. Since watermains make up the majority of the system, the replacement value of the water system has also doubled since the 2010 WSAMP.

Water System Assets

Asset Group	Quantity	Total Estimated Replacement Value
Dams	2	$10,058,000
Water Treatment Plant	2	$26,428,000
Reservoirs	23 (1)	$41,889,000
Pump Stations	10	$42,222,000
Pressure Reducing Valves (PRV)	35	$4,655,000
Watermains (2)	329 km	$451,330,000
Water Services (2)	12,410	-
Fire Hydrants (2) (3)	1,427	-
Water Meters (4)	12,372	$10,200,000
Total		$586,782,000

(1) This total includes 3 reservoirs that are out of service: Cypress 1 (C1), Westmount, and Montizambert South Reservoirs.
(2) Hydrants, services and appurtenances costs have been included in the estimated Watermains cost of $451,330,000.
(3) Owned by the District, excludes any and all private hydrants.
(4) Meter information based on the data from the Meter Replacement Program supplied by the District.

Understanding asset condition is a critical step towards predicting what the future needs of an asset will be. Condition also reflects how well the asset can provide the services it supports. An asset in poor condition is likely to be less reliable and may not achieve service-level targets. Condition can also help to quantify and understand service risk.

In the context of the 2020 WSAMP, asset condition can be considered in three ways:

- Physical condition – i.e. is the asset fit for use and in a state of good repair, or is it near the end of its estimated service life?
- Functional condition – i.e. can the asset meet current requirements for levels of service, such as fire-fighting capacity and minimum service pressures?
- Demand condition – i.e. is the asset fully utilized, or not used at all?

To illustrate the difference between the three types of asset condition, consider a storage reservoir. It provides potable water to local residents and carries some emergency volume of water in the event of a fire. Physically, it might be in great shape if it has had regular upkeep and inspections. Functionally, it might now be considered poor if it can't meet more stringent firefighting requirements for some recently constructed high rises in the area. From a demand perspective, the day-to-day water usage might be low or there might be a pump station also supplying the area that does a sufficient job of meeting residential water consumption needs; in this case the reservoir has a poor demand condition rating. This example illustrates that while an asset might be in good physical shape and have a long remaining service life, it might not meet the changing needs of the area it services and therefore requires upgrades or operational changes to be useful.

In terms of functional condition, the 2016 MWSS recommended capital upgrade projects which have been carried forward and updated for this 2020 WSAMP. As noted, there is an approximate $34 Million backlog which represents high priority projects which are yet to be addressed. The backlog includes storage and pumping improvements to the District's major transmission system which pumps Metro Vancouver water to the western portions of the District. These projects are essential for improving water system resiliency to meet existing and future needs, providing water system redundancy to the western portions of the District. In addition, the backlog includes numerous watermain capacity upgrades required to improve available fire flows throughout the distribution network. There are also several priority renewals of high risk watermains (aged watermains in poor condition in high impact areas) included in the backlog. A full breakdown of the $34 Million backlog is presented in the Financial Forecast Section of the Executive Summary.

While the backlog indicates substantial improvement efforts are required, it is worth noting that the District has made significant strides to improve the water system network. Since the 2016 MWSS, the District has upgraded critical portions of the transmission mains supplying pumped water to the west. As well, the effective upsizing of key distribution mains along with recommended operational changes has drastically increased the available fire flows in some of the most heavily populated and vulnerable areas in the southeast portions of the District.

An independent 2018 Fire Underwriters Survey concluded that the District's Public Fire Protection Classification (PFPC) grading is 3/10, a 1 being the highest possible rating. The PFPC grading system is a measure of a community's overall fire defenses against fire hazards and safety risks present within the community. The overall grading considers a community's fire departments, fire safety controls, fire service communications, and the state of the water supply system. The District received grades of 1's and 2's in most of the categories except for the water supply system which received a grade of 4 which brought the overall grade to a 3. The water supply evaluation indicated shortfalls in fire flow delivery and pumping capacity; however, the District ranked exceptionally well in most other areas including source reliability, maintenance, distribution of hydrants, system management and other key factors.

In terms of physical and demand condition ratings, the District's water system assets are in good shape. In general, the District's water system assets (excluding watermains) are in Very Good to Fair physical condition. However, there are a few facilities such as the 11th Street Pump Station which are in Poor or Very Poor condition that require repairs and/or upgrades. Additionally, there are facilities in otherwise fair condition that have subcomponents which require major upgrades or repairs such as the membranes at the Eagle Lake Water Treatment Plant and the piping and valving at the Cross-Creek Pump Station. For watermains, determining physical condition is difficult given that they are buried infrastructure. Proxy measures of condition (i.e. age, break history, material type, method of installation, maximum service pressures) were used to estimate the physical condition of watermains, expressed as a probability of failure. The majority of watermains were found to have Very Low or Low probability of failure. Only 1% of the watermain network is rated at Very High failure probability requiring immediate repairs/upgrades, which is represented in the backlog.

Levels of Service and Demand Management

A key objective of asset management is to match the levels of service that the District plans on delivering, given its available resources, with the levels of service expected by its customers. This involves understanding customer expectations and the trade-offs they are willing to make between costs and services. The services provided by District assets must also meet the legislative requirements at the municipal, provincial and federal levels. Therefore, levels of service must be written in terms that the end user can understand, and the District can effectively communicate.

The current levels of service measured in this Plan are:

- Quality – Does the service meet users' needs?
- Reliability – Is the service maintained in a state of good repair and functionality?
- Capacity – Does the service have adequate capacity?

The 2010 WSAMP recommended a bottom up assessment of the water system to determine infrastructure renewal priorities. The District followed up the 2010 WSAMP with the 2016 MWSS which through hydraulic modelling, condition assessments, and risk-based renewal planning provided the District with a Capital Projects List identifying and prioritizing renewals and upgrades to the water system to meet existing and future levels of service.

The demand on District infrastructure can impact how the infrastructure is managed and maintained. The demand drivers that may impact the District's service delivery include changes in population, land use, per capita usage, and climate change. Demands for increased services due to population growth or densification will be addressed through a combination of upgrading existing assets and providing new assets. System resiliency and redundancy will remain a key strategic focus moving forward, especially due to uncertainties in future service delivery due to potential impacts from climate change.

Managing Risk

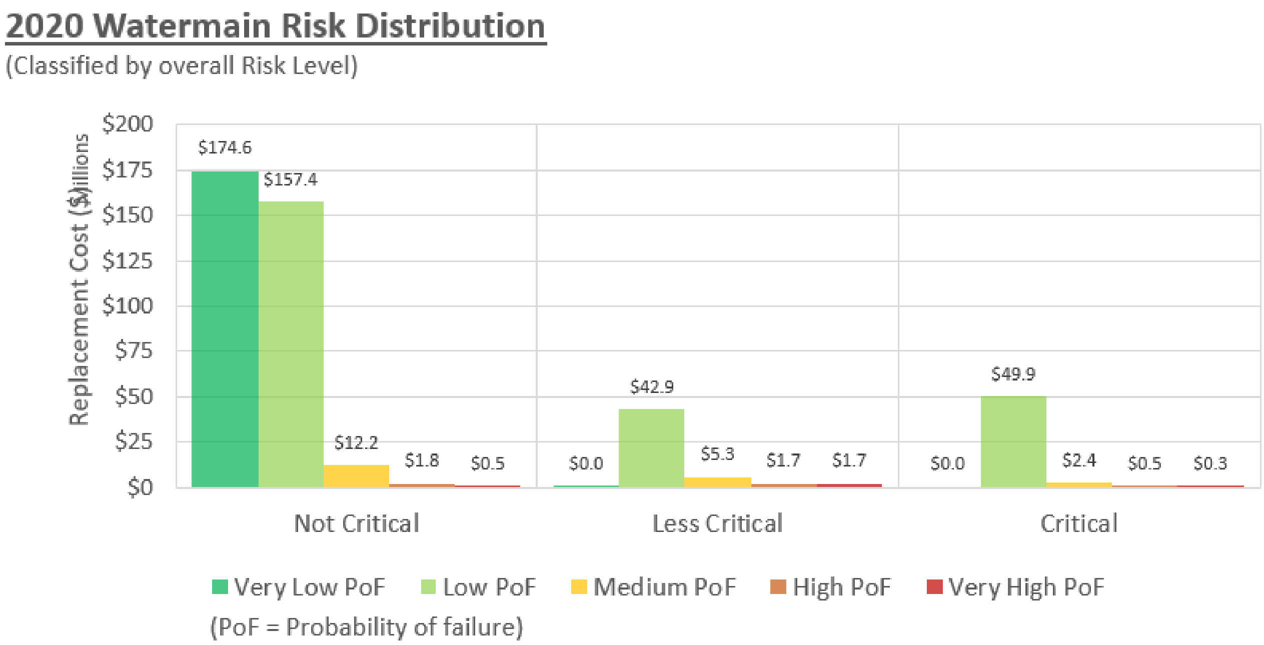
The importance of risk assessment at both the service level and the asset level is to provide early warning of potential issues that could adversely affect delivering levels of service. When risks are known and have a rating, District staff can focus on the high risks and adapt the management of those assets to reduce the risk level (i.e. design and implement appropriate mitigation measures). The results of asset level risk assessments are considered when reviewing lifecycle strategies to determine the most appropriate treatments, planned maintenance, and inspection frequencies for a particular asset or group of assets. Both asset level risk and service risks were considered in prioritizing capital works projects and other funding decisions.

A high-level assessment of risks associated with service delivery was developed at the water asset level, and included consideration towards planning, management, and hazards/environmental risks. The next step would be to refine the process and assign ratings for the likelihood and potential impact, to identify the high priority service risks for further action and mitigation.

The District has collected and continues to collect condition and risk data on the non-linear assets in the water network through maintenance activities, regular studies and risk assessments. Non-linear assets by their nature do not tolerate failures and outages in their service areas for prolonged period of times, therefore reinvestment in non-linear assets is typically prioritized by their likelihood of failure which is tied to estimated service lives. That is not to say that a risk-based approach is untenable; a ranking of the criticality of non-linear assets based on their service areas and levels of redundancy would help the District prioritize reinvestment needs for non-linear assets of similar vintages, and for some assets this has already been considered through priority upgrades over the next 20 years identified in the 2016 MWSS Capital Projects List. For this Plan, the financial reinvestment outlook for the next 100 years considers regular renewals of major non-linear asset subcomponents, with prioritized replacements and upgrades based on previous studies and assessments.

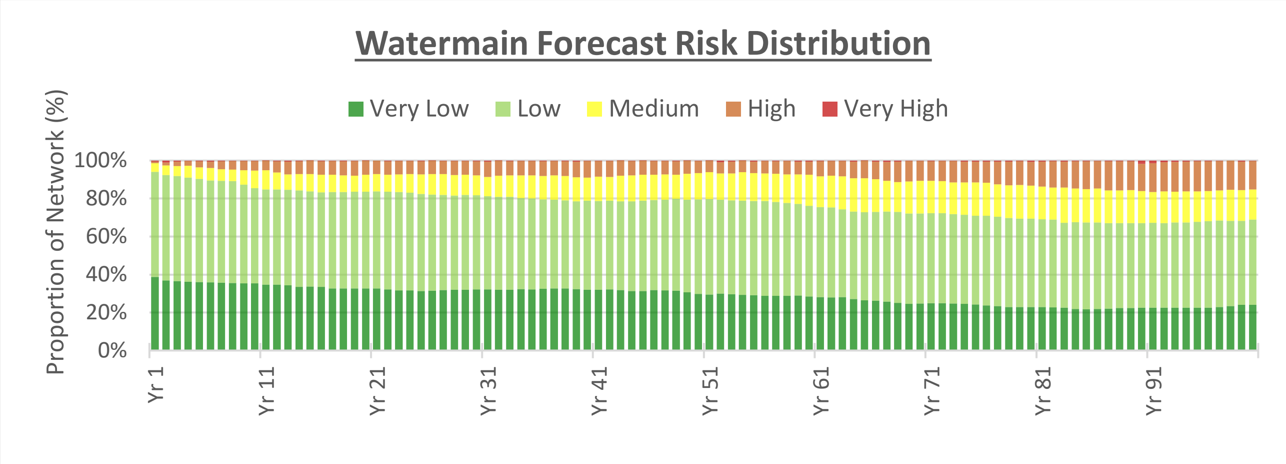
Watermains are the largest asset group in the District's water utility and represent 77% of the total water utility asset base. By virtue of being largely buried, direct measurement of their physical condition is difficult and cost-prohibitive, therefore watermains as an asset group across all municipal utilities present a challenge to managers responsible for assigning capital expenditures to their replacement or rehabilitation. The watermain risk model developed as part of the 2016 MWSS and updated for this Plan was designed to support informed management decisions about replacement programming. The tool helps to focus resources and efforts on critical watermains by standardizing assessments and decision criteria for watermains. The model uses a risk framework built around evaluating the consequence of failure relative to three primary types of impact (Social, Economic, and Environmental).

The following figure below shows the current condition of the District's watermain network, expressed as risk of failure probability (very high to very low) for pipes in critical, less critical and not critical categories. The majority of watermains have Very Low or Low probability of failure, and the replacement costs for higher risk critical pipes is a small fraction of the total asset base.



The current risk profile of the watermain network indicates that the majority of the mains are in Very Good to Fair physical condition. Therefore, there appears to be some capacity for the network to absorb some deterioration to within acceptable risk levels over the next twenty to sixty years. This would provide some opportunity to finance other projects such as the capital upgrades from the 2016 MWSS targeting improved firefighting capacity and system redundancy, which make up the bulk of the necessary projects in the next twenty years including most of the costs associated with the $34 Million backlog.

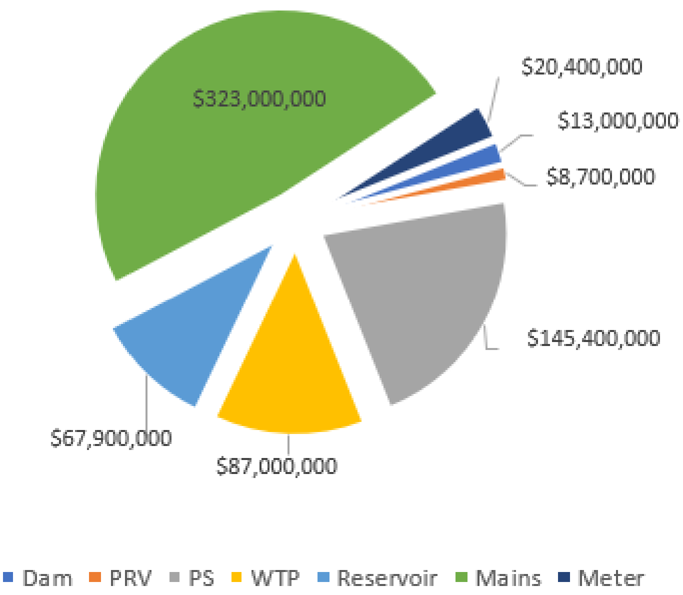
As illustrated in the following figure, a fixed annual budget of $3 Million for watermain renewals was found to be required to maintain most of the network in Very Good to Fair physical condition for the next 60 years with steady and gradual deterioration (increase in risk). The $34 Million backlog and the financial forecast presented in the following sections would be inclusive of this baseline $3 Million watermain renewal level. Beyond the 60-year horizon, annual watermain renewal budgets will need to increase to continue to manage risk at this level without further deterioration. In the next iteration of the WSAMP, as the District works toward completing all anticipated capital and upgrade projects in the next twenty years, consideration should be given towards a future shift in funding towards increased watermain renewals to mitigate undesired watermain network degradation in the long-term.



Watermain Forecast Risk Distribution for 100 Year Investment Timeline

Financial Forecast

The long-range financial forecast for the 2020 WSAMP indicates a 39% increase to the overall 2010 WSAMP forecast adjusted for today's dollars. This result may seem surprising considering the degree to which watermain construction in the District has increased in the last decade. However, significant increases in construction costs which have been a major factor in driving this gap wider have been partially offset by the refined approach to asset replacement as a function of a better understanding of asset conditions and total useful life estimates as captured in this 2020 WSAMP. By looking at the existing condition of the District's assets, estimated service lives have increased across the board which has reduced the number of renewals required over the 100-year period.



Forecasted Capital Expenditures by Asset Type – 100 Year Horizon

Where there are significant cost differences between the 2010 WSAMP and the current Plan are in the first twenty years. In particular, a funding gap has been identified to address front-loaded high priority upgrade projects aimed at improving current levels of service which require significant upfront financial investment. The following table breaks down the total expenditures estimated over the entire planning horizon, and it is clear an average annual expenditure of 14.2 Million for the next 5 years or 11.1 Million for the next 10 years is needed to maintain current levels of service.

Period	Total Expenditures	Average Annual Expenditures (1)
Backlog (2021)	$34 M	-
5 Years (2021-2025)	$71 M	$14.2 M
10 Years (2021-2030)	$111 M	$11.1 M
20 Years (2021-2040)	$208 M	$10.4 M
100 Years (2021-2120)	$665 M	$6.7 M

(1) Average annual expenditures over each period assume pay-as-you-go funding, with no provisions towards borrowing, DCCs, grant-funding, or other funding mechanisms.

While an average annual expenditure of $6.7 Million over the entire 100 year planning horizon might be reasonably achieved, bridging the gap between the current annual capital budget of approximately $4.8 Million and expenditures over the next 20 years to 2041 will require significant planning, effort, and discussion on how much and how fast to increase water utility rates and/or pursue other funding sources. The 2010 WSAMP identified a significant funding gap at the time which the District was able to drastically improve by increasing capital spending five-fold, going from a capital budget of approximately $1 Million in 2010 to almost $5 Million in the present day.

The current estimated backlog is approximately $34 Million compared to a backlog of $15 million in the 2010 WSAMP. The 2010 WSAMP provided a high-level top-down overview of funding requirements and used limited data and system models that were available at the time. Construction cost inflation (>200% in unit cost rates over the last 10 years) also affects the increase in overall projects costs. The approach taken in 2010 was to replace assets 'like for like' with no upgrades or new assets envisioned. The increase in the current backlog reflects the need for increased system resiliency, capacity upgrades, and risk-based priority renewals based on the comprehensive modelling analysis from the 2016 Master Water Servicing Study.

The following table breaks down the $34 Million backlog of high priority projects.

Asset Group	Description	2020 Estimated Cost
Pump Stations	11th St	$ 5.3 M
	Westmount	$ 6.6 M
Reservoirs	Westmount	$ 6.8 M
Watermains	Capital Upgrades (1)	$ 7.8 M
	Priority Renewals (2)	$ 6.9 M
Other	Various renewals (3)	$ 0.6 M
Total		$ 34.0 M

(1) Watermain capital upgrades capture new or upsized watermains proposed in the 2016 MWSS which are required for increasing available firefighting capacities and improving system redundancies. They are prioritized and sized to the 2041 OCP horizon to meet future population needs as well as current levels of service.

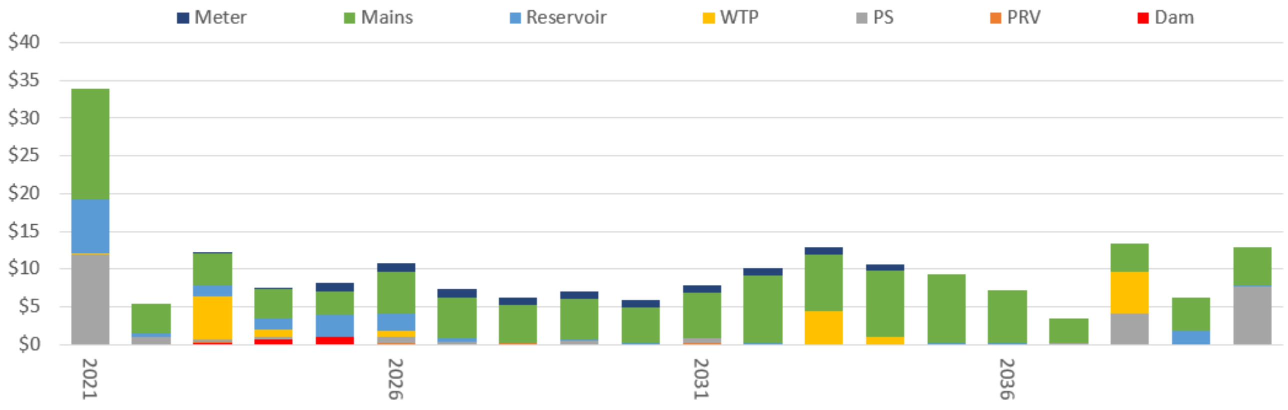
(2) Watermain priority renewals are size-on-size replacements determined by the watermain risk model using a $3 Million annual reinvestment budget. Renewal timelines were compared and aligned with the watermain capital upgrades to determine the most appropriate intervention periods and sizing requirements. Beyond the 2041 horizon, all watermain works are size-on-size renewals prioritized based on risk ratings.

(3) Include various facility renewals, chiefly mechanical upgrades at reservoirs.

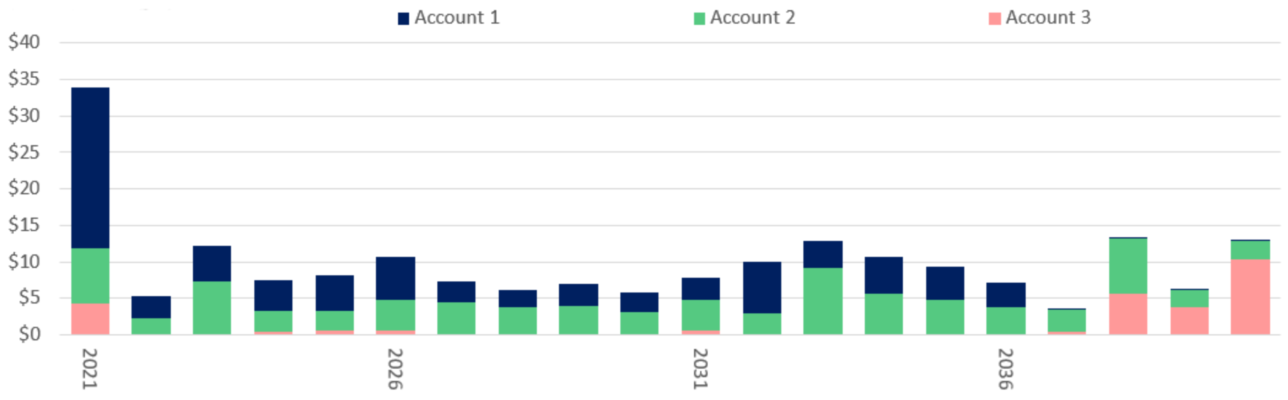
Per the table above, the 11th Street Pump Station, Westmount Pump Station, and Westmount Reservoir projects account for 50% of the backlog. All three assets are currently undersized to meet existing and future water conveyance, water supply redundancy, and fire fighting needs, based on the latest hydraulic modelling studies available. They form the critical backbone of the supply system that pumps Metro Vancouver water to the western portions of the District. Without the upsizing of these critical assets, there is significant risk towards the future uninterrupted supply of potable water to the western portions of the District during hot summer periods when there is a limited water supply at the District's Eagle Lake source. As there is a component of future growth associated with these projects, the District will have the opportunity to recover the costs associated with the growth components through future development.

The $7.8 Million in watermains capacity upgrades are to improve the availability of fire flows throughout the network. These upgrade projects were identified and prioritized during the 2016 MWSS using the latest hydraulic water model, which was not a tool available during the development of the 2010 WSAMP. The remaining $6.9 Million in watermain projects address priority renewals for high-risk watermains. These are borne out of a watermain risk model developed for the 2016 Master Water Servicing Study and updated for the 2020 WSAMP.

The financial forecast depicted in the following figure illustrates the current level of tolerance for risk and service levels over the next 20 years.



20-year Forecast Expenditure by Asset Group



20-year Forecast Expenditure by Account Type

Note:

— Account 1 describes upgrades to the network to improve firefighting capabilities and system redundancy

— Account 2 describes size-on-size renewals and replacements, based on estimated theoretical service lives of assets and their components

— Account 3 describes infrastructure upgrades that are associated with OCP growth, which the developer would be partially or wholly funding

Many large projects identified in the 20-year financial forecast are critical infrastructure with limited redundancies that cannot tolerate prolonged outages or reduced service levels due to failure or increased loading on the network, which makes deferring key projects difficult. Therefore, being explicit about the risk of pursuing or not pursuing critical projects will require a dialogue on balancing additional funding needs and resources in the immediate future with safe and reasonable adjustments to current risk tolerances and levels of service provided.

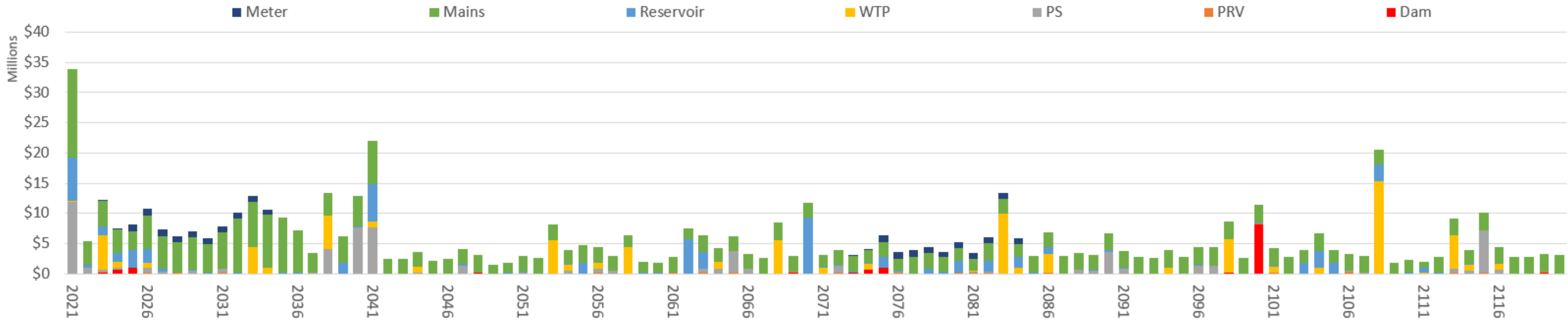
As construction costs, population growth, and climate trends towards longer, drier summers continue to rise, a “business-as-usual” approach to water utility reinvestment poses significant risks to the District’s ability to deliver adequate levels of service. This includes risks to supply redundancy and the ability to supply Metro Vancouver water to the western areas of the District, as well as risks to adequate firefighting supply to all users within the District, especially during summer high water usage and peak periods.

Mitigative Measures / Next Steps

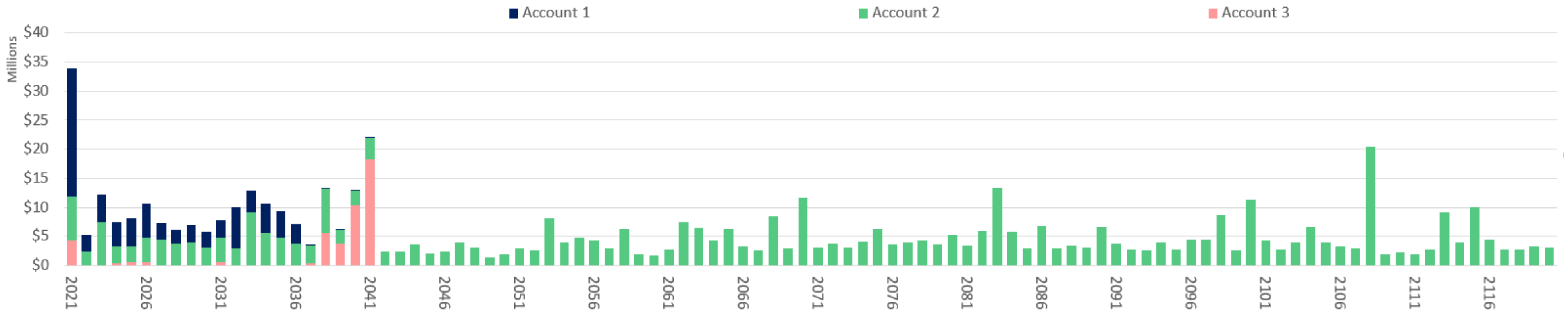
Mitigative measures such as tighter summer watering restrictions, and more punitive tiers in the water rate system may help to reduce risk and strain on the water utility which may allow deferral of some project costs; however, none of these measures will eliminate the need for a comprehensive funding strategy to pay for the proposed improvements required to maintain the system at the expected level of service.

A “pay-as-you-go” approach to utility funding will not adequately bridge the gap between current and required funding levels without steep utility rate increases. Considerations towards grant funding, debt servicing, DCC’s, and any other possible funding mechanisms should be considered for the District’s ultimate funding strategy moving forward.

This Plan has been prepared to contribute to informed decision-making, improved management of risks, and a reduction in costs over time. A key purpose of the Plan is to provide an updated long-term roadmap to manage the water system assets so that costs, risks and benefits are effectively balanced over the next 100 years and to deliver a sustainable service to the community. The following figures illustrate the financial forecast over the entire 100-year planning horizon.



100-year Forecast Expenditure by Asset Group



100-year Forecast Expenditure by Account Type

Note:

- Account 1 describes upgrades to the network to improve firefighting capabilities and system redundancy
- Account 2 describes size-on-size renewals and replacements, based on estimated theoretical service lives of assets and their components
- Account 3 describes infrastructure upgrades that are associated with OCP growth, which the developer would be partially or wholly funding

1 Introduction

1.1 Purpose

The District of West Vancouver provides potable water to a population of over 42,000 residents. This includes the supply, pumping, storage and distribution of an average of 25 Million Litres of water daily. Each aspect of the municipal water network requires responsible operation, maintenance and renewal of physical assets.

Asset management helps deliver services in a way that achieves the required level of service for the least overall cost and within acceptable risk boundaries. Value is delivered to the community by effectively managing existing and new physical assets. This will help build a resilient community over the long-term.

This Asset Management Plan (Plan) provides details on the District's water services. It outlines the current state of the District's water infrastructure assets, objectives, practices and the actions that will be taken when delivering services to the District's customers.

This Plan is an internal document that provides a long-term view over the next 100 years. It has been prepared to contribute to informed decision-making, improved management of risks, and a reduction in costs over time. A key purpose of the Plan is to provide an updated roadmap to manage the water system assets so that costs, risks and benefits are effectively balanced to deliver a sustainable service to the community.

1.2 Scope

Table 1-1 outlines the sections included in this Asset Management Plan, along with the key question each section will answer, and a brief content description.

Table 1-1 Asset Management Plan Sections

Plan section	Key question to be answered	Content description
Executive Summary	Key outcome points	Provides an introduction and overview of the plan and answers key questions about the asset portfolio for the reader and discusses next steps.
Introduction	Why is a plan needed?	Purpose and scope of the plan.
Asset Management System	What is an asset management system and its key components?	Outlines the key components of an asset management system. Provides a summary of the asset management policy and asset management strategy.
State of Infrastructure	How is the District doing?	Outlines the state of infrastructure including: • What does the District own and where it is • Core and high value assets • The condition of assets • The cost to replace assets
Levels of Service	Why does the District own assets?	Describes the outputs the District intends to deliver. Discusses customer expectations, and the trade-offs they are willing to make between costs and services.
Lifecycle Management	How does the District provide service?	Optimizing the management of its existing and future assets to provide the required services by: • Maintaining and operating existing assets • Renewing existing assets • Providing new assets • Understanding the confidence in forecast based on data reliability

Plan section	Key question to be answered	Content description
Risk Strategy	How does the District manage risk	Identifying and managing risk.
Financial Forecast	What will it cost and how to pay for it?	Estimates the costs to operate, maintain, renew or replace existing assets, and acquire new assets, and identifies funding sources to cover the costs.
Continuous Improvement Plan	How can the District do things better?	A prioritised list of the areas for future improvement within the Asset Management Plan.

1.3 Plan Updates and Endorsement

In 2010 the District developed its first Water System Asset Management Plan (WSAMP). The plan is referred to as 2010 WSAMP. The 2010 plan represented the first attempt to model the long-term renewal funding requirements for the entire water system and used the asset data that was available at the time, and best practices of the day. At the conclusion of the 2010 WSAMP, District staff spent time discussing the results with Council and the Public in multiple workshops and open houses. Concurrently, there was significant media attention being drawn to the Canadian National Infrastructure Gap which supported the findings of underfunding within the local system. At the conclusion of the consultation process, Council approved a new financial model for the Water System which included a higher level of capital renewal investment.

While the 2010 WSAMP was an important advancement in strategic system planning, it was deficient in several key areas. The 2010 plan used data and limited system models that were available at the time. Data limitations were especially noteworthy around non-linear assets such as the Eagle Lake Filtration Plant, water reservoirs, and pump stations. In terms of modelling, a fully calibrated hydraulic model was not available at that time either. Without a hydraulic model, the District's ability to analyze the system for capacity, working pressures, fire flow availability, and source and system redundancy was limited. Therefore, asset upgrades or new assets required to meet the standard level of service criteria which would be required for residents (as captured under a Master Water Servicing Study) were not included in the 2010 WSAMP. The approach taken in 2010 was to replace assets 'like for like' with no upgrades or new assets envisioned.

In the summer of 2015, the Lower Mainland experienced what was termed a major drought. Metro Vancouver introduced unprecedented levels of water conservation measures. A new trend of warmer and wetter winters followed by longer drier summers consistent with climate change predictions seemed to have emerged. The West Vancouver water system benefits from having two sources: Metro Vancouver and Eagle Lake. However, in 2015 the Eagle Lake supply was drawn down to minimum allowable levels with only approximately one week of water available remaining. It was found in 2015 that relying entirely on Metro Vancouver water supply is not possible due to insufficient District pumping and transmission capabilities to deliver the required Metro Vancouver water to the western regions of the District. In the face of changing climate, further considerations were required to review the previous management approach to water source and system redundancy in the District's water system.

In 2016, a Master Water Servicing Study (2016 MWSS) was completed for the District. The study examined the capacity of the system to deliver sufficient volumes of water at acceptable pressures and fire flows at all locations. Using a calibrated hydraulic model at that time, the study considered the effects of climate change on water supply provision, and future demands on the system due to increased population as projected by the OCP. While increases in population and the associated demands do influence the long-term water supply strategy, it is the level of service provided by the water system in the present day and the effects of climate change that was determined to be the most impactful.

The MWSS ushered in a new management approach to the water system. The new approach takes into consideration climate change; the anticipated drier summers and decreasing yearly snowpack will further stress and reduce the availability of supply redundancy within the system. Redundancy of supply and improving the ability to supply Metro

Vancouver water to the western areas of the District is a significant challenge and requires increased pipe capacities, increased pumping, and storage. Without these alterations to the system, the District increases the risk to its ability to deliver adequate levels of service to its residents during summer high water usage and peak periods.

This latest iteration of the Water System Asset Management Plan, dubbed 2020 WSAMP, is built upon the 2010 WSAMP and the findings and recommendations of the 2016 MWSS.

The District's asset management journey since 2010 reflects that all asset management strategies and plans are "living documents", and as such are regularly reviewed (every 3-5 years) and updated to reflect continuous improvement.

The Council and Chief Administration Officer will be given the opportunity to review this plan and acknowledge the need to support implementation and continuous improvement of asset management by the District.

1.4 Plan Icons

Table 1-2 shows some key icons that are used throughout this Plan to emphasize areas for improvement of the Plan.

Table 1-2 Plan Icons

Icon	Definition
	**WSAMP Update** - Indicates how new information has been incorporated in this Asset Management Plan revision and how this may revise assumptions found in the previous Asset Management Plan.
	**Opportunity for Improvement** - Indicates an opportunity to develop asset management practices or activities to improve the performance or outcomes of the system or activities.

2 Asset Management System

2.1 What is the Asset Management System?

An Asset Management System is more than just asset management software. An asset management system would encompass the District's policies, plans, business processes, and information systems, which together achieve the District's asset management objectives, and ultimately its long-term vision. It includes the people, processes, and technology needed to help the District achieve these.

While there is a strong knowledge base within the District regarding asset issues, documentation and monitoring of the issues is informal, which can lead to inconsistencies. For example, an Operations staff member held detailed knowledge of the install dates of SCADA equipment at some of the District's reservoirs, information that was not readily found in any formal documentation, instead relying on institutional knowledge for day-to-day functionality. A formalised asset management system structure will help the District to describe how asset management functions within the organization and establish this consistency. A framework is provided showing how separate asset management processes and resources relate to each other in the asset management system. The overview provided in this section sets the context for the remainder of the Asset Management Plan.

2.2 "Line of Sight" for Asset Management

The District needs to show how the management and operation of assets contributes to achieving goals and objectives. There needs to be a clear "line of sight" between those high-level objectives and the day-to-day activities carried out on the District's assets.

Figure 2-1 shows the concept of "line of sight" from the District's Vision, Mission and Values down through the District's strategic plans, Asset Management Policy, strategy and Asset Management Plans, through to implementation of physical works and performance of assets.

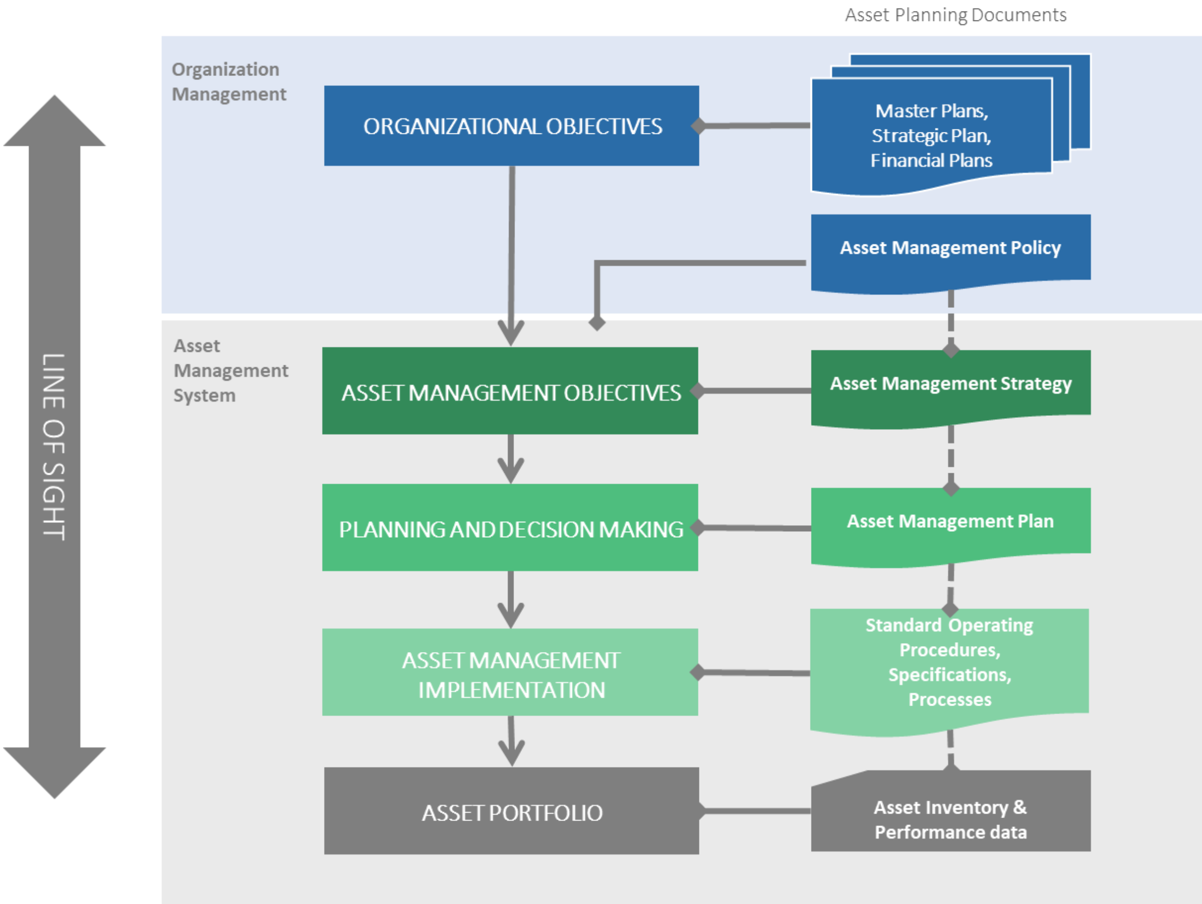


Figure 2-1 Line of Sight for asset management outcomes

2.3 Asset Management Policy

An asset management policy clearly sets out a council's commitment to asset management. It provides fundamental principles that set out the District's high-level approach to asset management and will directly influence staff decision-making throughout all levels of the organization.

The District's Capital Asset Management Policy (#0054) establishes guidelines for an effective system for the management of the District's investment in capital assets, to comply with legislation, and to ensure that best practices in asset accounting and financing are followed. The Capital Asset Management policy is based on asset management principles set out by Asset Management BC, and on principles for the accounting treatment of public sector capital assets which comply with General Accepted Accounting Principles (GAAP) and with the Public Sector Accounting Board (PSAB) Section 3150.

2.4 Asset Management Strategy

District assets are managed by several departments and personnel, though team integration and collaboration has been an ongoing focus. The objective of the Strategy is to establish a framework that guides more consistent planning and decision-making across the District, supporting the District's ability to provide services to the community more efficiently through its assets.

The District's Capital Asset Management Procedure (#0055) is associated with Capital Asset Management Policy #0054. The purpose of the procedure is to outline the process to be undertaken to achieve effective ongoing management and planning for the District's capital assets, recognizing that effective management of capital assets is crucial to the long-term fiscal sustainability of the District. The procedure articulates the District's focus on sound management and funding practices for the District's capital assets through a coordinated, cost effective and sustainable approach.

The Water System Asset Management Plan for the District has been developed with the District's Capital Asset Management Policy #0054 and Capital Asset Management Procedure (#0055) in mind, to align with key corporate objectives and procedures for the safe and effective management of the District's water utility.

Figure 2-2 presents a framework to demonstrate an asset management system showing the key practices, processes and tools, including the Asset Management Plan.

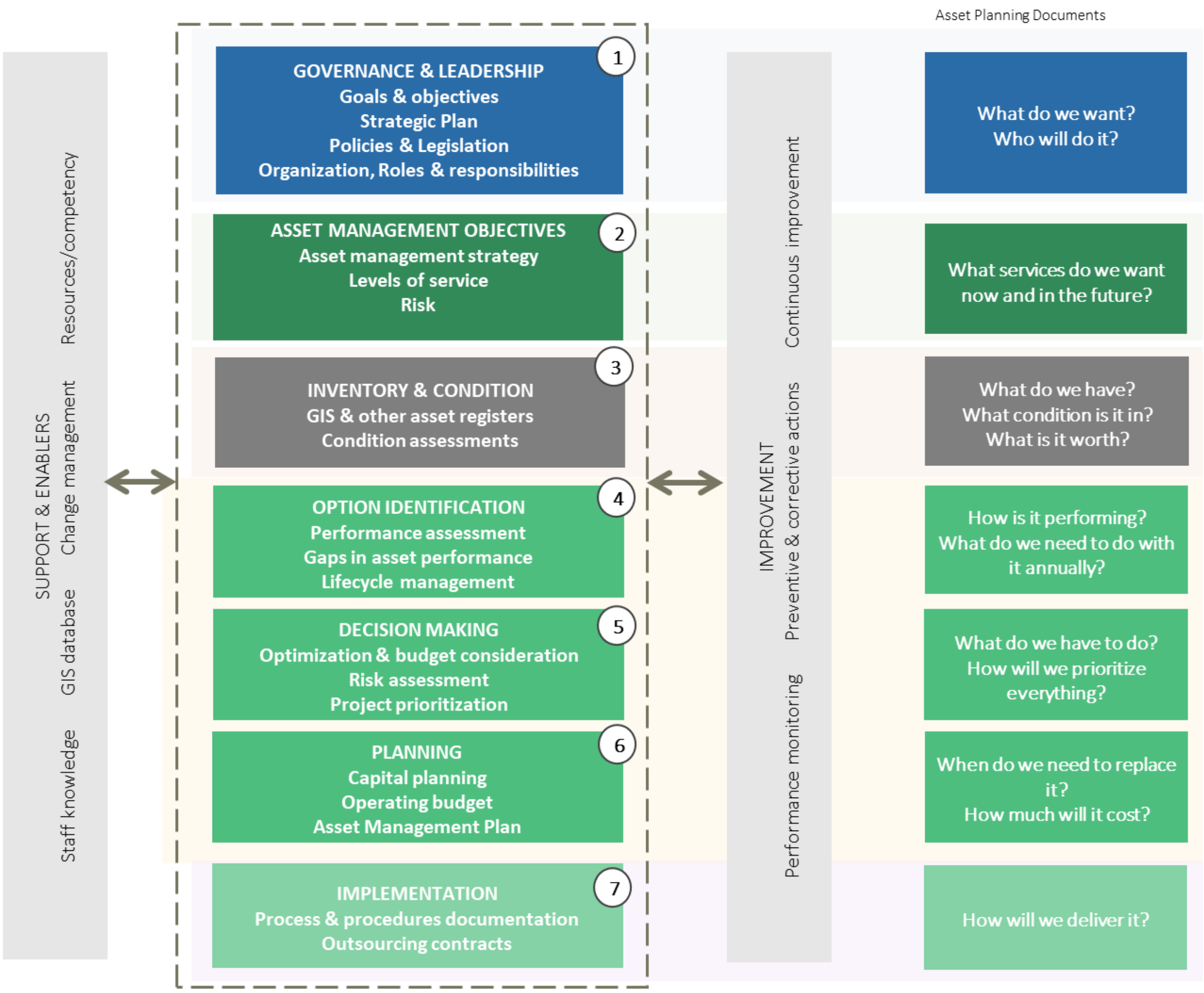


Figure 2-2 Asset Management Framework

Figure 2-3 identifies the asset management roles and high-level responsibilities within the District.

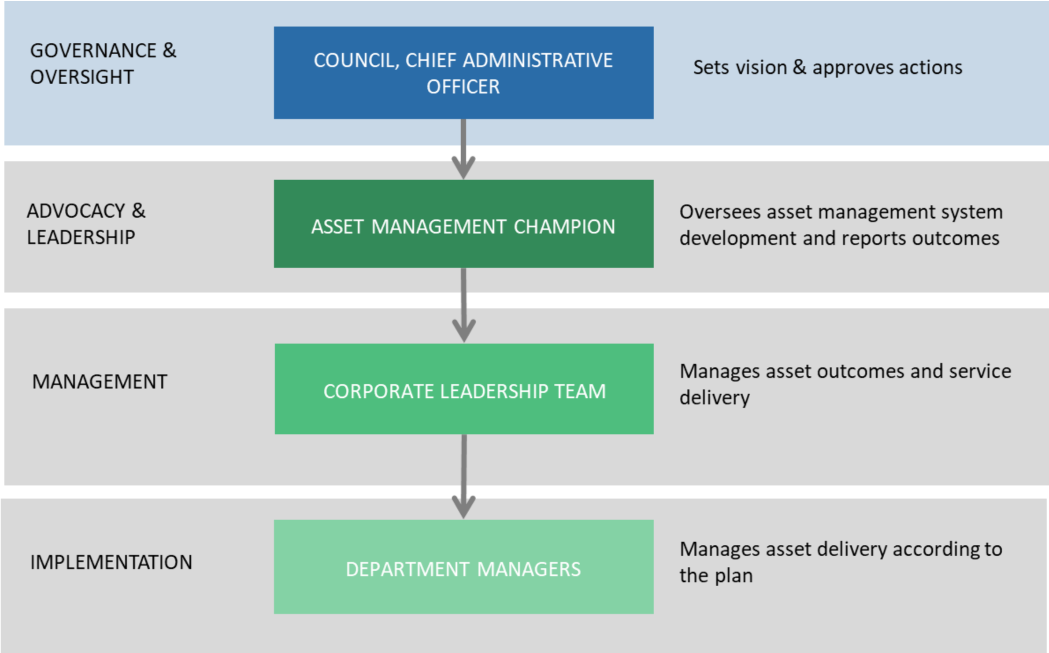


Figure 2-3 Governance Roles and Responsibilities

2.5 Asset Management System Improvement Actions

Table 2-1 lists the improvement actions that will improve the quality and usefulness of the key asset management system elements, including the asset management strategy.

Table 2-1 Asset Management System Improvement Actions

Task No.	Improvement Task Name	Improvement Task Description
2.1	Asset Management Policy & Procedure	Review and revise draft Capital Asset Management Policy (#0054) and Procedure (#0055).
2.2	Roles and Responsibilities	Review key asset management roles and responsibilities and identify who will fulfill these.
2.3	Resource Plan	Develop a Resource Plan to identify resource needs for completing asset management improvement tasks.
2.4	Asset Management Goals	Document departmental asset management goals.
2.5	Asset Management Training	Establish an asset management education and training program to support staff in learning key asset management principles and applying these to their everyday work.

Opportunity for Improvement – The new AMBC Competency Framework can be used to identify capabilities and skillsets that the District needs and design a training program to deliver those capabilities and skills and build capacity within the organization.

The Service Sustainability Assessment Tool is also a useful AMBC resource made to help local governments identify current sustainability performance and prepare for the future. Once populated with data, the SSAT dashboard tool generates reports for all levels of organization (i.e. staff, managements, Council).

3 State of Infrastructure

3.1 Overview

This section of the plan provides a State of the Infrastructure assessment of the District's current infrastructure assets. It describes the age, condition profile, and current replacement values of the District's infrastructure assets. By creating and tracking this information, the District can understand what it owns, where it is, what condition it is in, and how much it would cost to replace it. These four pieces of data are core asset management requirements. By understanding and tracking these requirements over time, the District can better understand the investments that are required to achieve the stated service levels.

3.2 Water Network

The District currently serves over 42,000 people on its water system and provides over 25 million litres of potable water for consumption daily. As of 2021, the system is comprised of dams, water treatment plants, storage reservoirs, pump and PRV stations, transmission and distribution mains, service connections, fire hydrants and water meters as summarized in Table 3-1.

Table 3-1 Water Supply System Asset Summary

Asset Group	Quantity	Total Estimated Replacement Value
Dams	2	$10,058,000
Water Treatment Plant	2	$26,428,000
Reservoirs	23 (1)	$41,889,000
Pump Stations	10	$42,222,000
Pressure Reducing Valves (PRV)	35	$4,655,000
Watermains (2)	329 km	$451,330,000
Water Services (2)	12,410	-
Fire Hydrants (2) (3)	1,427	-
Water Meters (4)	12,372	$10,200,000
Total		$586,782,000

(1) This total includes 3 reservoirs that are out of service: Cypress 1 (C1), Westmount, and Montizambert South Reservoirs.
(2) Hydrants, services and appurtenances costs have been included in the estimated Watermains cost of $451,330,000.
(3) Owned by the District, excludes any and all private hydrants.
(4) Meter information based on the data from the Meter Replacement Program supplied by the District.

Figure 3-1 is a visual representation of the District's water supply system asset base, with a breakdown of each asset group replacement cost as a percentage of the total. Watermains are the largest asset group and represent 77% of the asset base. PRV Stations are the smallest asset group by replacement cost.

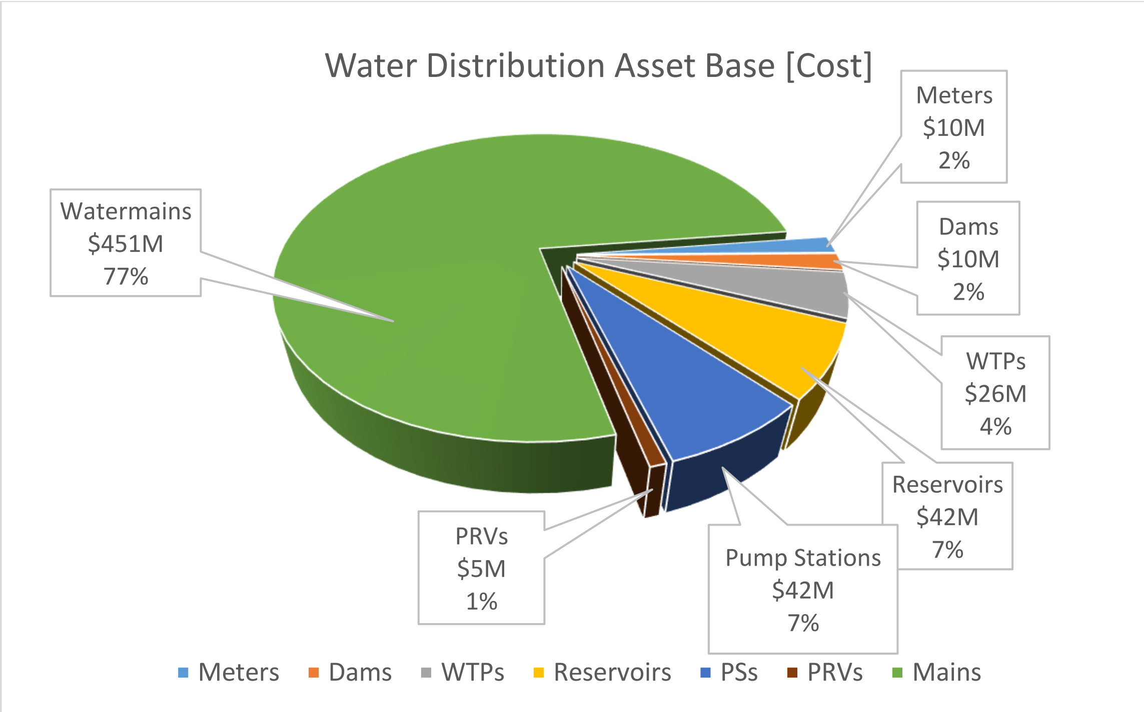
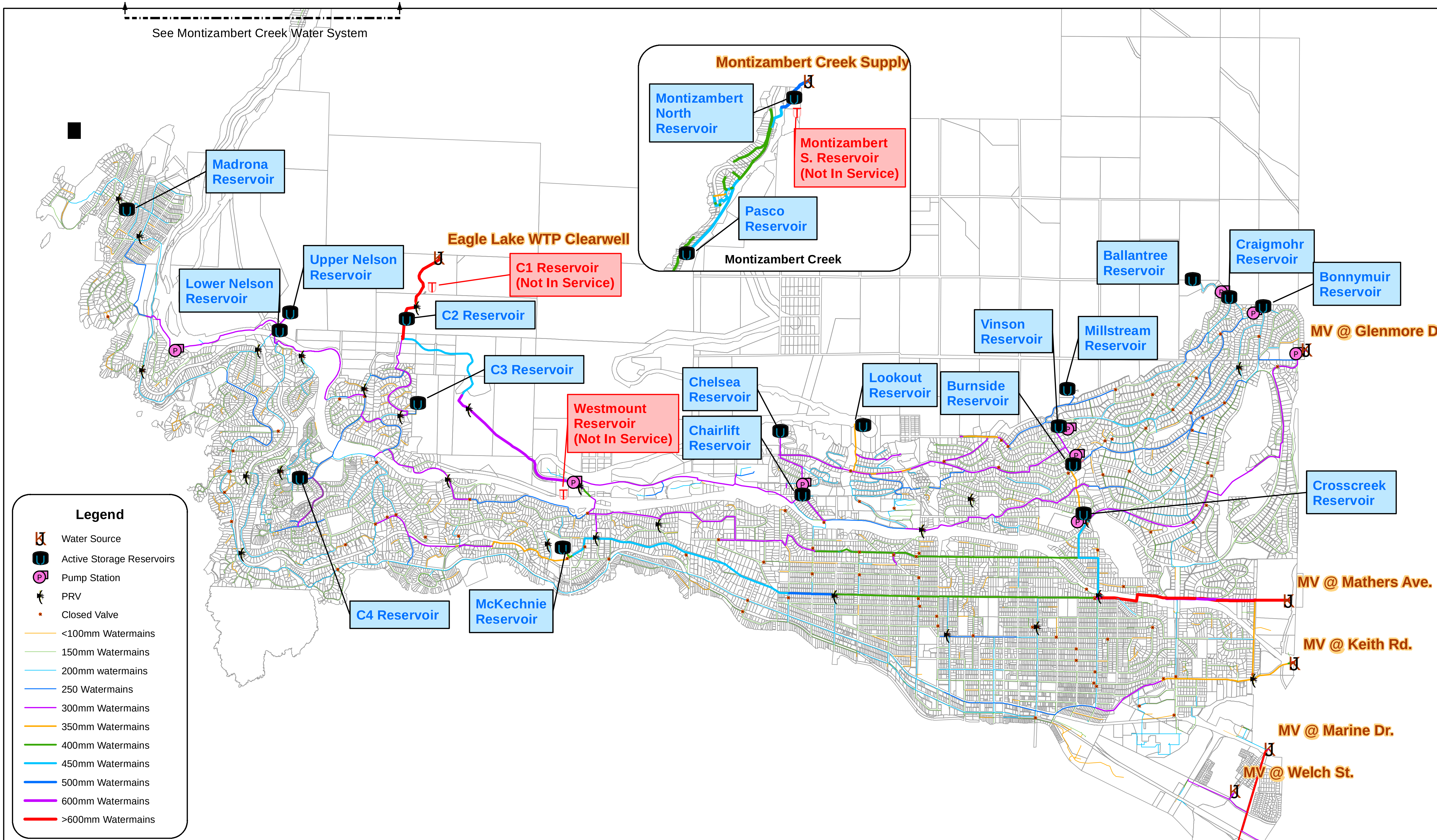


Figure 3-1 Water Supply System Asset Percentage of Total Asset Base

The District's water system draws from three sources of water. This includes two surface water sources operated and maintained by the District (Eagle Lake and Montizambert Creek). The third source is the Metro Vancouver (MV) supply source. The MV water distribution system supplies water from a total of five (5) connections to the District, with most of the flow (more than 95%) entering through the Glenmore, Mathers, and Keith Road supply connections. Montizambert Creek feeds a small water system in the northwest part of the District. Figure 3-2 is a schematic representation of the District's water system.



west vancouver

WATER SYSTEM LAYOUT

Scale
0 125 250 500 Meters
1:35,000 @ Tabloid

Figure 3-2

Date JUN 2021

Path: \\ca-nvr-win01\vc_gen_g\opus_dk\municipal\032 West Van\gis\D-032C9.00 Master Water Servicing Study\Report\Figure 2-1 Repaired Water System Layout.mxd

The District's Maintenance Connection is proprietary software used to coordinate maintenance and work orders. It is a database of the District's assets, and includes information on asset install date, make and size. All major asset groups are represented, as well as important sub-components. The software includes a GIS interface so that the location of each asset and components are also detailed.

The Maintenance Connection was established in recent years and inputting data for each asset category is an ongoing work in progress. Meanwhile, some of the District's assets date as far back as the 1950s, for which a substantial portion of records are now illegible or incomplete. Maintenance Connection does not explicitly contain information on physical condition, though for most assets various condition and inspection reports can be accessed through the portal which detail condition. The notable exception is PRV Stations and Water Treatment Plants, for which condition reports were limited. Much of the asset data for the District's two dams comes from the Eagle Lake Dam Safety Report (exp, 2017). Though the access road is detailed in Maintenance Connection, the Dams as earthern embankments with associated piping and valves, are not listed.

Table 3-2 and Figure 3-3 provide a summary of the build decade for each non-linear asset group, allowing for ready comparison of vintages for different infrastructure. For example, all of the District's pump stations and 40% of the District's reservoirs were built before 1980. This infrastructure is now at least over 40 years old. Further details on capacity, install dates, estimated remaining useful lives based on age, and breakdown of estimated replacement values for the District's non-linear assets are given in Appendix A.

Table 3-2 Non-Linear Asset Build Decade

Build Decade	Age	Dam	WTP	Reservoir	Pump Station	PRV Station
1950s	> 60 years	2 (100%)	-	-	-	1 (3%)
1960s	> 50 years	-	-	2 (10%)	4 (40%)	4 (11%)
1970s	> 40 years	-	-	6 (30%)	1 (10%)	6 (17%)
1980s	> 30 years	-	-	7 (35%)	5 (50%)	8 (23%)
1990s	> 20 years	-	-	-	-	2 (6%)
2000s	> 10 years	-	1 (50%)	5 (25%)	-	7 (20%)
2010s	< 10 years	-	1 (50%)	-	-	7 (20%)
Total		**2**	**2**	**20**	**10**	**35**

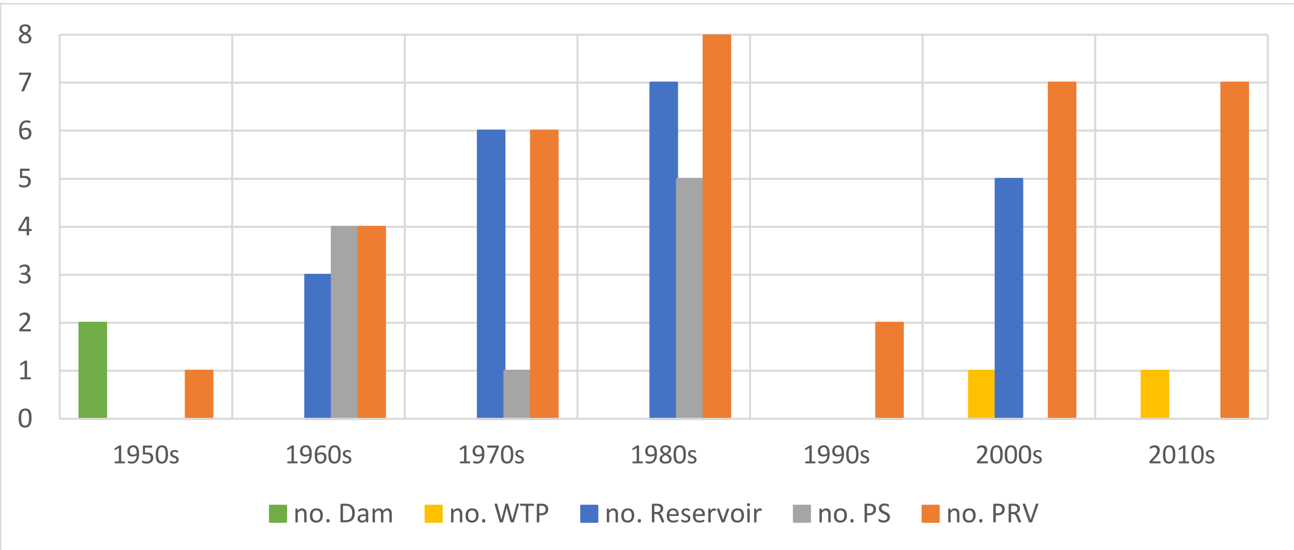


Figure 3-3 Non-Linear Asset Build Decade

The District's water distribution network consists of 329 kilometres of mains of various sizes, materials and ages. Table 3-3 provides a summary of the mains in terms of size, average age, average theoretical useful life and average remaining useful life and estimated replacement value. Figure 3-4 is a visual summary of watermain age by pipe material. It's expected that cast iron (CI) and asbestos cement (AC) watermains installed post WWII are nearing their end of service life. As illustrated in Figure 3-4, ductile iron (DI) watermains have become the standard pipe material used in construction since the 1970s onwards.

Table 3-3 Linear Infrastructure (Mains) Summary

Mains	Quantity (km)	Average Age	Average Theoretical Useful Life (years)	Average Remaining Useful Life (years)	Estimated Replacement Value [1]
Mains: > 250 mm	64.55	30.5	95.0	68.3	$104,740,000
Mains: 150 – 250 mm	230.12	42.8	95.1	55.1	$301,820,000
Mains: < 150 mm	34.44	50.4	83.3	35.5	$44,770,000
Total	**329.10**	-	-	-	**$451,330,000**

(1) Assumes all renewals are ductile iron pipe.

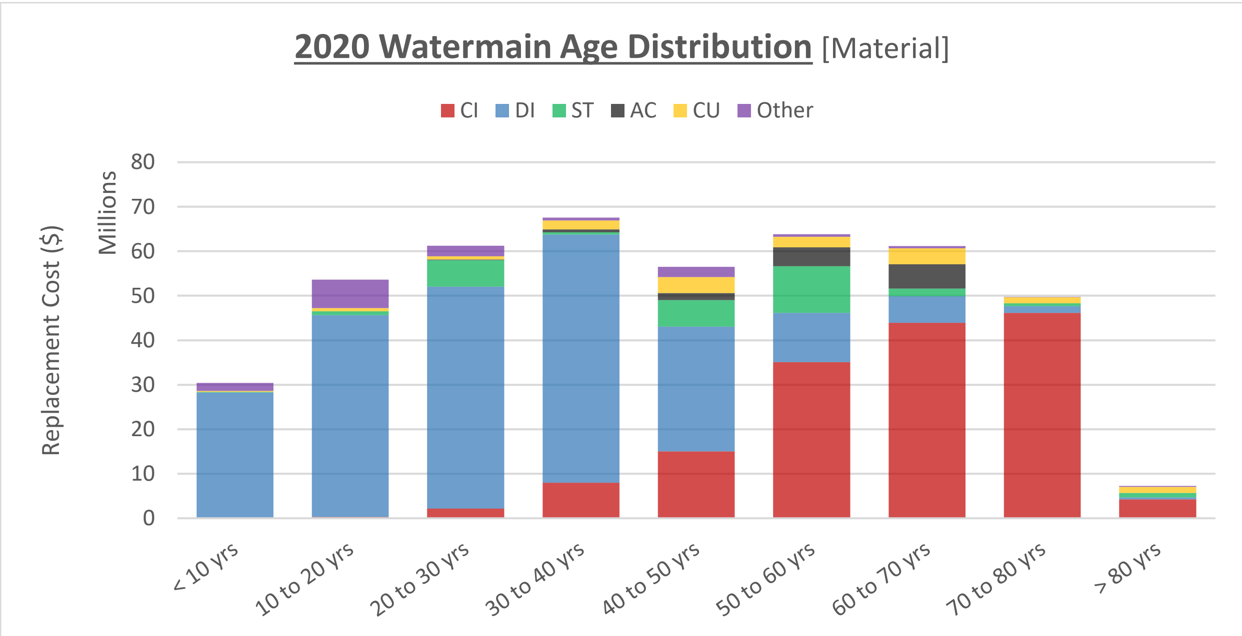


Figure 3-4 Watermain Age Distribution (by Material)

A robust asset data inventory is the foundation for enabling most asset management functions. All financial and technical data associated with an asset's life-cycle should be linked directly to the asset.

Table 3-4 outlines the data that has been captured for this plan and where it can be found.

Table 3-4 Types of Data

Type of Data	Where it can be located
Location	The District keeps As-built drawings and GIS shapefiles as records of location for their assets. This information is housed and accessible from the Maintenance Connection platform, software used to schedule and organise maintenance of infrastructure.
Quantity	Number of assets is also contained in Maintenance Connection inventory.
Performance/Condition Data	The District undertakes regular maintenance and inspection programs, including yearly PRV breakdowns and reservoir inspections on a 7 year cycle.

Type of Data	Where it can be located
	Multiple reports were reviewed, including: • Reservoir Inspection Reports (various) • Pump Station Condition Assessment (Opus DaytonKnight, 2014) • Eagle Lake Dam Safety Review (exp, 2017)
Theoretical Useful Life	Water Asset Management Plan (AECOM, 2010) Master Water Servicing Study (Opus DaytonKnight, 2016)
Remaining Useful Life	Determined by known condition data, or if this information was not available, an age-based assessment.
Replacement Value	Multiple data sources were used, and as required, translated into 2020 costs. The following reports and sources were reviewed: • Eagle Lake Dam Safety Review (exp, 2017) • Water Asset Management Plan (AECOM, 2010) • Master Water Servicing Study (Opus DaytonKnight, 2016) • Unit rates as supplied by the District based on recent watermain construction projects

3.3 Condition Ratings

Understanding asset condition is a critical step towards predicting what the future needs of an asset will be. Condition also reflects how well the asset can provide the services it supports. An asset in poor condition is likely to be less reliable and may not achieve service-level targets. Condition can also help to quantify and understand service risk.

In the context of the 2020 WSAMP, asset condition can be considered in three ways:

- Physical condition – i.e. is the asset fit for use and in a state of good repair, or is it near the end of its estimated service life?
- Functional condition – i.e. can the asset meet current requirements for levels of service, such as fire-fighting capacity and minimum service pressures?
- Demand condition – i.e. is the asset fully utilized, or not used at all?

To illustrate the difference between the three types of asset condition, consider a storage reservoir. It provides potable water to local residents and carries some emergency volume of water in the event of a fire. Physically, it might be in great shape if it has had regular upkeep and inspections. Functionally, it might now be considered poor if it can't meet more stringent firefighting requirements for some recently constructed high rises in the area. From a demand perspective, the day-to-day water usage might be low or there might be a pump station also supplying the area that does a sufficient job of meeting residential water consumption needs; in this case the reservoir has a poor demand condition rating. This example illustrates that while an asset might be in good physical shape and have a long remaining service life, it might not meet the changing needs of the area it services and therefore requires upgrades or operational changes to be useful.

Using a standardized physical condition rating assessment method helps to compare asset condition across the different asset categories and groups.

For this Plan a "performance - aged-based" physical condition assessment profile is assumed, that reflects the expected performance of assets over their service life, as shown in Table 3-5.

Table 3-5 Condition Rating Assessment Implemented

Condition Rating	Description	Condition rating criteria	Rating Description
1	Very Good	Age < 25% of expected design service life	"like new"
2	Good	Age 25% < 65% of expected design service life	"performing well"
3	Fair	Age 65% < 85% of expected design service life	"showing signs of age"
4	Poor	Age 85% < 95% of expected design service life	"starting to impact service"
5	Very Poor	Age > 95% of expected design service life	"nearing failure"

Table 3-6 gives the percentage of assets in each sub-category for which physical condition data is available from inspection reports.

Table 3-6 Percent of Assets with Adjusted RSLs Using Known Condition Data

Asset Group	Facility/Structural	Process/Mechanical	Electrical/Instrumentation
Dam	100%	-	-
WTP	50%	-	-
Reservoir	65%	-	-
Pump Station	54%	54%	-
PRV Station	100%	100%	100%

Physical condition data from inspections reports has been used to adjust age-based estimates of remaining service life. Inspection reports detailing condition of PRV stations are not available on Maintenance Connection, though some undated photos for some stations are available. Discussion with the District's Operations staff, together with Work Orders in Maintenance Connection confirm that the District has a comprehensive O&M program for PRV stations including annual teardowns and rebuilds. Therefore, it is reasonable to assume these assets are in good physical condition.

Tables 3-7 and 3-8 summarize the Expected Useful Life (EUL) for non-linear and linear asset groups respectively.

Based on available condition data and operating history, the appropriate design of the assets, the durable nature of the materials used in construction, and the careful and extensive maintenance carried out to date, structural service lives of non-linear concrete assets was assumed to be 100 years. This is an increase to structural service life that was estimated in the District's previous Water Asset Management Plan (AECOM, 2010) where in general 50 years was assumed, following industry standard guidelines in the absence of asset specific condition data.

Similarly, thorough and regular maintenance of the District's PRV chambers suggests that a full overhaul of mechanical components within these chambers can be extended to 50 years (previously 25 years; AECOM, 2010). A similar argument has been applied to the mechanical components of reservoirs, where it is assumed these components are mainly valves that are likewise well maintained. The high complexity, wear and repetitive cycling of mechanical components in pump stations suggests that the initial estimate of 25 years be retained for this asset group. Mechanical components in WTPs see similar wear and repetitive cycling, and often in more corrosive and chemical environments. With feedback from the District about the current rate of valve and mechanical component replacement in WTPs the estimated service life for these components is 15 years.

Table 3-7 Estimated Useful Life for Non-Linear Infrastructure

Asset Group	Facility/Structural	Process/Mechanical	Electrical/Instrumentation
Dam	200 years	50 years	25 years
WTP	100 years	15 years (1)	25 years
Reservoir	100 years	50 years	25 years
Pump Station	75 years	25 years	25 years
PRV Station	100 years (2)	50 years	25 years

(1) Refers to estimated useful life for mechanical components such as pumps and valves. Filter membrane replacement at Eagle Lake Water Treatment Plant occurs every 7 years (estimated after one replacement cycle) and depending on the outcome of existing studies (and potentially a change in operating standards), estimated useful life could be extended to 10 years. Filter replacement occurs every 10 years at Montizambert Water Treatment Plant. In both treatment plants, filter replacements are significant renewal costs.

(2) 100 year estimated useful life applies to concrete reservoirs. Bolted steel reservoirs have an estimated useful life of 75 years, which has been applied to Bonnymuir, Chairlift, Craigmohr, and Pasco Reservoirs.

Table 3-8 Estimated Useful Life for Linear Infrastructure (Mains)

Pipe Material (1)	EUL (Years)	Assumptions / Comments
Asbestos Cement	55	Adopted from the MWSS, similar to the previous WSAMP (AECOM, 2010) EUL of 50 years.
Cast Iron (2)	90	Adopted from the MWSS, similar to the EUL assumed in the previous WSAMP (AECOM, 2010) (75 years).
Ductile Iron	100	Adopted from the MWSS, identical to the EUL assumed in the previous WSAMP (AECOM, 2010)
Polyvinyl Chloride	95	Adopted from the MWSS, similar to the EUL assumed in the previous WSAMP (AECOM, 2010) (85 years).
High Density Polyethylene	100	Adopted from the MWSS, similar to the EUL assumed in the previous WSAMP (AECOM, 2010) (85 years).
Steel	85	Adopted from the MWSS, identical to the EUL assumed in the previous WSAMP (AECOM, 2010)
Aluminium	50	Adopted from the MWSS. Conservative compared to the EUL assumed in the previous WSAMP (AECOM, 2010) (100 years).
Galvanized Steel	75	Adopted from the MWSS. Conservative compared to the EUL assumed in the previous WSAMP (AECOM, 2010) (100 years).

(1) The network contains approximately 100 m of copper pipe, excluded from this summary.

(2) Due to water quality issues associated with tuberculation, Cast Iron mains may be replaced prior to the end of their EUL.

WSAMP update – The District's previous Water Asset Management Plan (AECOM, 2010) assumed watermain EULs following industry practises at the time. With more available break history data and updated industry guidelines, watermain EULs have been adapted and extended for some material types.

3.3.1 Overall System Condition

In terms of functional condition, the 2016 MWSS recommended capital upgrade projects which have been carried forward and updated for this 2020 WSAMP. These projects and their financial implications are detailed under the Levels of Service discussion in Section 4 and included in the Financial Forecast under Section 7.

In terms of physical and demand condition ratings, the District's water system assets are in good shape. In general, the District's water system assets (excluding watermains) are in Very Good to Fair physical condition. However, there are a few facilities such as the 11th Street Pump Station which are in Poor or Very Poor condition that require repairs and/or upgrades. Additionally, there are facilities in otherwise fair condition that have subcomponents which require major upgrades or repairs such as the membranes at the Eagle Lake Water Treatment Plant and the piping and valving at the Cross-Creek Pump Station. The major upgrades and repairs are discussed in detail under the Financial Forecast in Section 7.

Figure 3-5 summarizes estimated physical condition at the asset facility/structural, mechanical/ process and electrical/instrumentation sub-category level for non-linear infrastructure. Where there was a lack of condition data for mechanical/process or electrical/instrumentation components, condition is an age-based calculation. Generally speaking, the District's non-linear assets are in Very Good to Fair condition, though approximately 15% of structures are in Poor or Very Poor condition, requiring replacement or major refurbishment. Financial implications of structures nearing the end of the remaining service life are discussed in detail in Section 7.

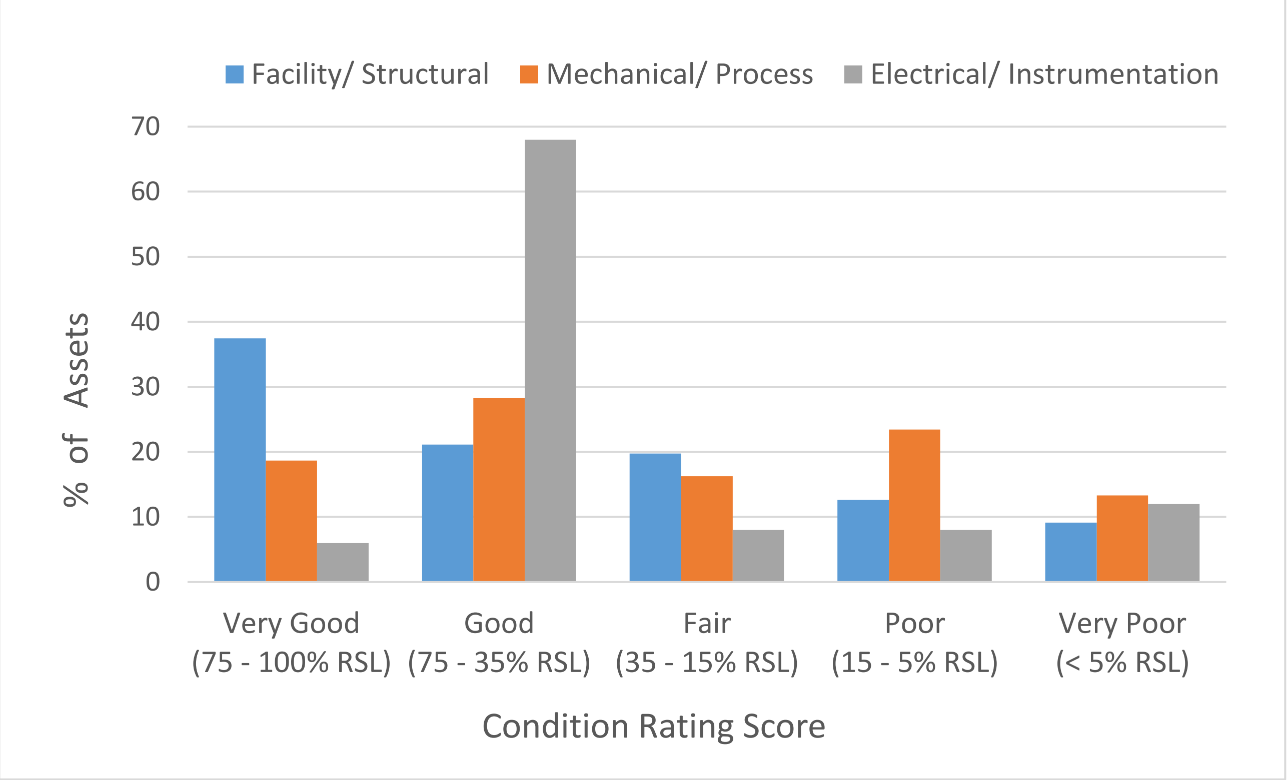


Figure 3-5 Physical Condition by Sub-Category for Non-Linear Assets

The District maintains an extensive 329 km of watermains. Unlike above ground non-linear infrastructure, physical condition data for buried continuous linear infrastructure is hard to obtain and keep up to date. Given the lack of condition data for the District's water distribution network, proxy measures of physical condition (break history, material type, year and method of installation, together with known local operating conditions such as pressure) were used to develop a risk-based approach to estimating watermain condition and probability of failure. Section 6 of this WSAMP describes in greater detail how estimated watermain condition is used in a risk-based decision-making tool which prioritises main renewal based on likelihood of failure, consequence of failure and asset criticality, with the understanding that limited funds need to be invested optimally to extract maximum value (life) from the assets at the best balance between lifecycle cost and risks to service.

3.3.2 Dam Condition

The Eagle Lake West and East Dams date from the 1950s. Dam embankments made of static and compacted construction materials are extremely long-lived assets if well maintained. The Eagle Lake Dam Safety Review (exp, 2017) highlighted some non-compliances to be addressed by the District which are directed at the long-term safety of the dams, and include:

- Installation upstream headgate or valve system on the East and West outlets as the current downstream valve is only accessible under favourable conditions.
- Installation of improved monitoring and surveillance of both East and West Dam embankments for rate and turbidity of seepage, including SCADA and redundancy systems for continuous autonomous monitoring.
- Increasing the height of the East Dam embankment such that it is equal or slightly higher than the West Dam elevation.

These recommendations are important to the ongoing safe operation of the Dams and have been interpreted using the descriptors of the asset condition rating system described in Section 3.3.1 and are reflected in the following asset sub-category condition scores. Once these recommended safety actions have been undertaken, the condition score for the dam embankments and conduits, condition scores will be improved. Figure 3-6 shows the estimated RSL on the x-axis and the number of dam components expressed as a percentage of the total number of dams on the y-axis.

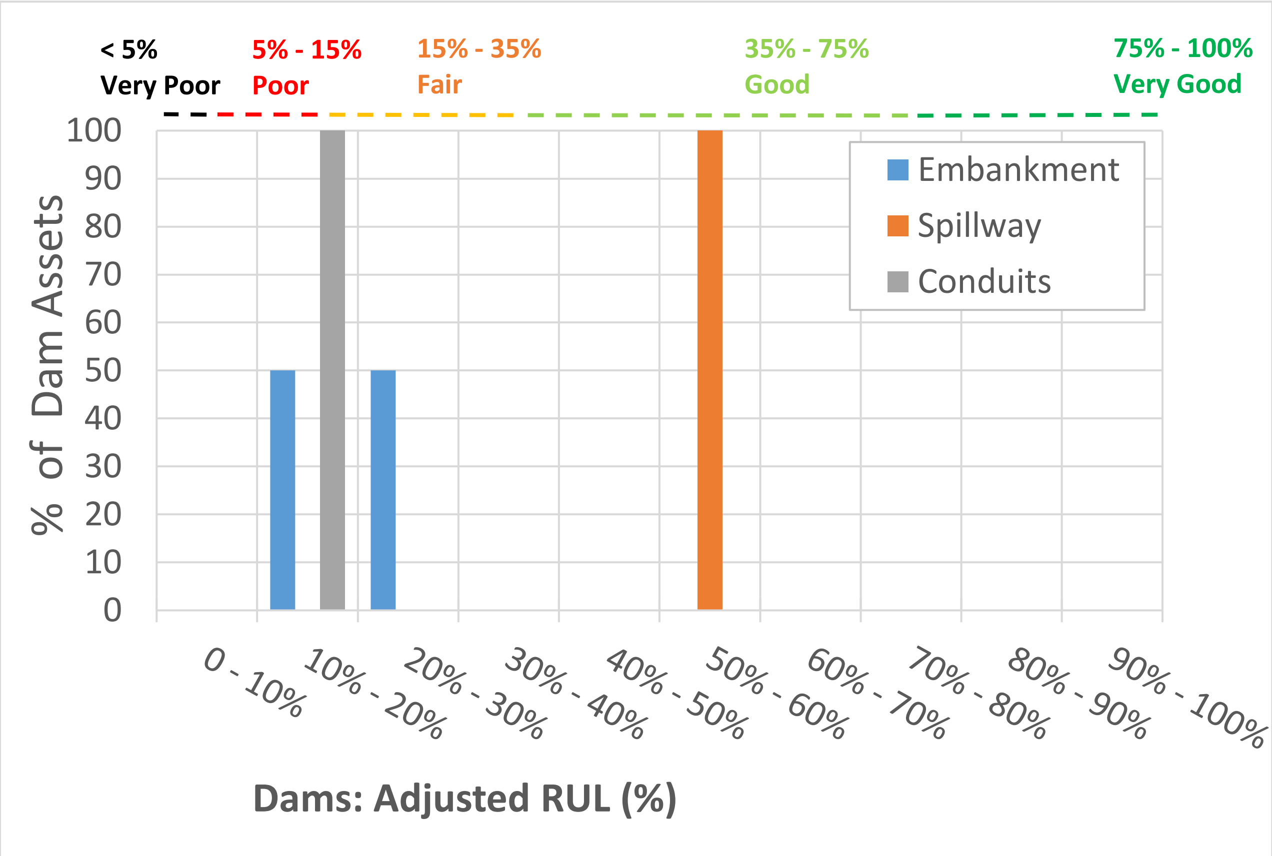


Figure 3-6 Adjusted Estimated Remaining Useful Life for Dam Assets by Asset Sub-Category

3.3.3 Water Treatment Plant Condition

The Eagle Lake Water Treatment Plant (built in 2007) and Montizambert Water Treatment Plant (built in 2011) have been recently constructed and are assumed to be in an almost new condition. A recent site visit to the Eagle Lake Treatment Plant in 2019 confirmed this assumption visually.

However, the filter membranes at each plant are approaching the end of their remaining useful life; the filter membranes at Montizambert WTP are slated for replacement in 2021. Since being built in 2008, the filter membranes at Eagle Lake WTP have been replaced once, in 2014, suggesting a replacement period of 7 years. Depending on the outcome of existing studies, and potentially a change in operating standards, the District estimates that the useful life of the membranes could be extended to 10 years. For the purpose of financial forecasting, a useful life of 10 years has been estimated for the membranes at the Eagle Lake WTP.

Replacement of the floating pumps at the end of their useful life for fish friendly pumps at the Eagle Lake intake was recommended in the DWV Eagle Lake Pump Station Upgrades Technical Memo (ISL, 2019). Extensive condition data for Montizambert WTP was not available at the time of writing. Figure 3-7 shows the adjusted RSL on the x-axis and the number of WTPs components expressed as a percentage of the total number of WTPs on the y-axis.

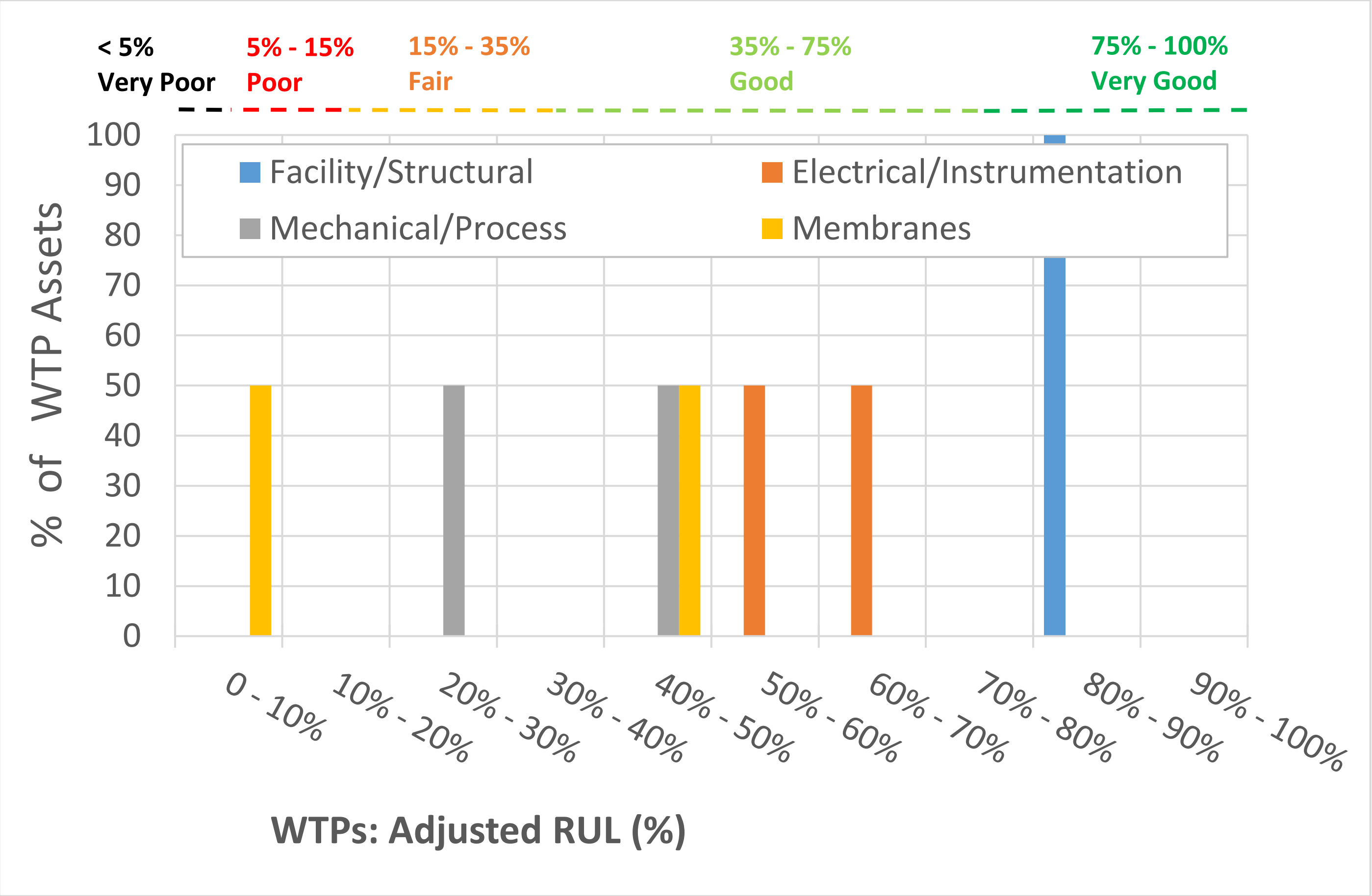


Figure 3-7 Adjusted Estimated Remaining Useful Life for WTP Assets by Asset Sub-Category

3.3.4 Reservoir Condition

The District's reservoirs are in generally good condition, as evidenced from the structural inspections that the District undertakes whereby each reservoir that can be taken offline and emptied is inspected approximately every seven years.

Minor maintenance, such as replacing ladders or railings, has been recommended in the inspection reports for Lower Nelson, Ballantree, Burnside, Millstream, Chairlift, McKechnie and Upper Nelson Reservoirs. More intensive maintenance work, such as sealing of cracks and boltholes has been recommended in the inspection reports for Madrona, Craigmohr, Chelsea and McKechnie Reservoirs.

A seismic screening assessment (MMM Group, 2013) suggested Madrona and Chairlift Reservoirs were at very high risk of destabilisation during earthquake, while Pascoe, McKechnie and Cross Creek Reservoirs are in the high-risk category. Retrofit options have been recommended to reduce the risk of overtopping during earthquake for each of these reservoirs (hxg consulting, 2018). Because of the historic leakage issues with Madrona, and identified high risk during earthquake, this reservoir has been given a "Poor" condition description. This is seen in Figure 3-8, which shows the estimated RSL on the x-axis and the number of reservoir components expressed as a percentage of the total number of reservoirs on the y-axis. Mechanical/Process and Electrical/Instrumentation components (where they exist) have been given age-based condition scores as inspected condition data for reservoirs is confined to structural components.

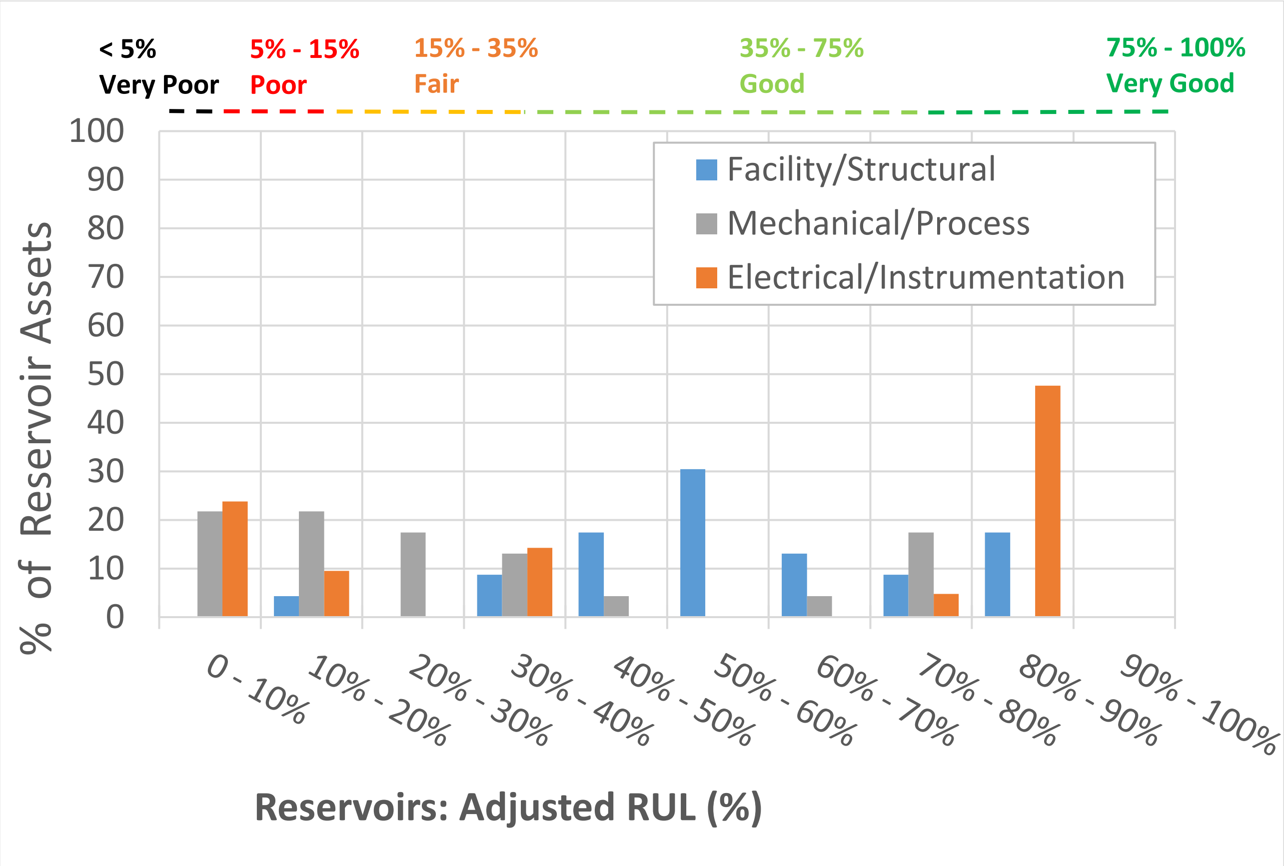


Figure 3-8 Adjusted Estimated Remaining Useful Life for Reservoir Assets by Asset Sub-Category

3.3.5 Pump Station Condition

The District's pump stations are in mostly good to fair condition, with some assets of declining condition, as evidenced from the Pump Station Condition Assessment Report (Opus Dayton Knight, 2014). The District revised the condition of some components in 2020 as part of this study and identified that 11th Street Pump Station condition was "Very Poor" across all asset subcategories. This is seen in Figure 3-9, which shows the estimated RSL on the x-axis and the number of pump station components expressed as a percentage of the total number of pump stations on the y-axis.

Following a June 2019 inspection, the District has scheduled full replacement of electrical substations (which transform BC Hydro supply power to station voltage) at Vinson Creek, 11th St (Mathers St), Cross Creek and Burnside pump stations. These are among the oldest pump stations in the District; all were built in the 1960s.

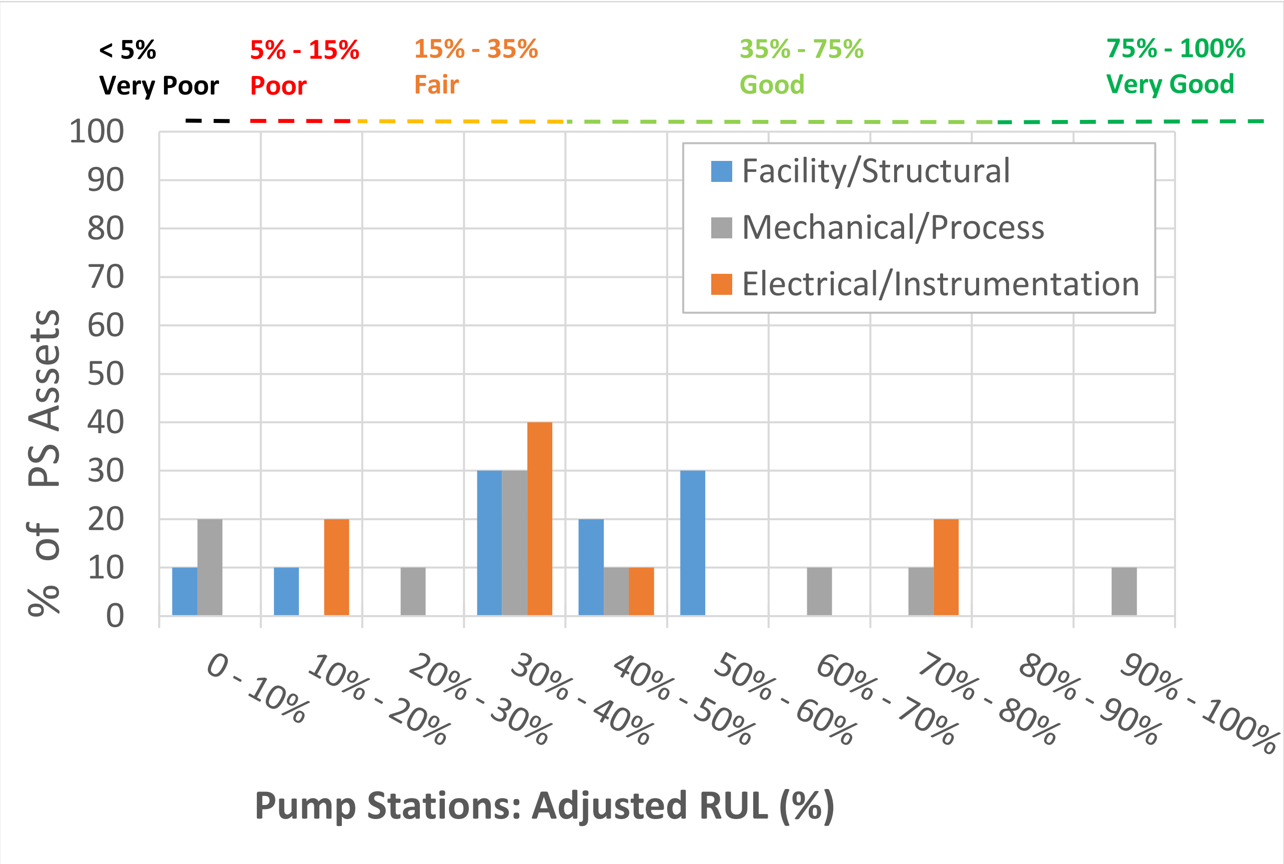


Figure 3-9 Adjusted Estimated Remaining Useful Life for Pump Station Assets by Asset Sub-Category

3.3.6 PRV Station Condition

There were no inspection reports detailing PRV station condition available on Maintenance Connection, and undated photos were limited to a few stations. Discussion with the District's Operations staff for a previous project, together with Work Orders in Maintenance Connection confirm that the District has an annual tear down schedule for PRV Stations. This is an extremely thorough maintenance program. As such, structural and mechanical components with an age based physical condition score of 4 (20 – 40% remaining life) or 5 (<20 % remaining life) were adjusted to 3 (40 – 60% remaining life) and 4 (20 – 40% remaining life) respectively. Figure 3-10 shows the estimated RSL on the x-axis and the number of PRV components expressed as a percentage of the total number of PRVs on the y-axis.

Terrace PRV, the District's oldest, is reaching estimated service life and replacement is upcoming. As well, Cranley, Eagle Lake Rd, McKechnie and Cross Creek PRV mechanical components are nearing their end of estimated life and are due for replacement soon.

Only three PRVs are listed as having electrical components in Maintenance Connection. One of these, Chippendale PRV, was built in 2015 and electrical components are assumed to be in good condition. The remaining two (11th St Mathers and Westmount) are related to adjacent pump stations which were built before the 1980s, though the District notes that electrical overhaul of these stations was completed in 2010 as part of an Opus DaytonKnight Optimization Study.

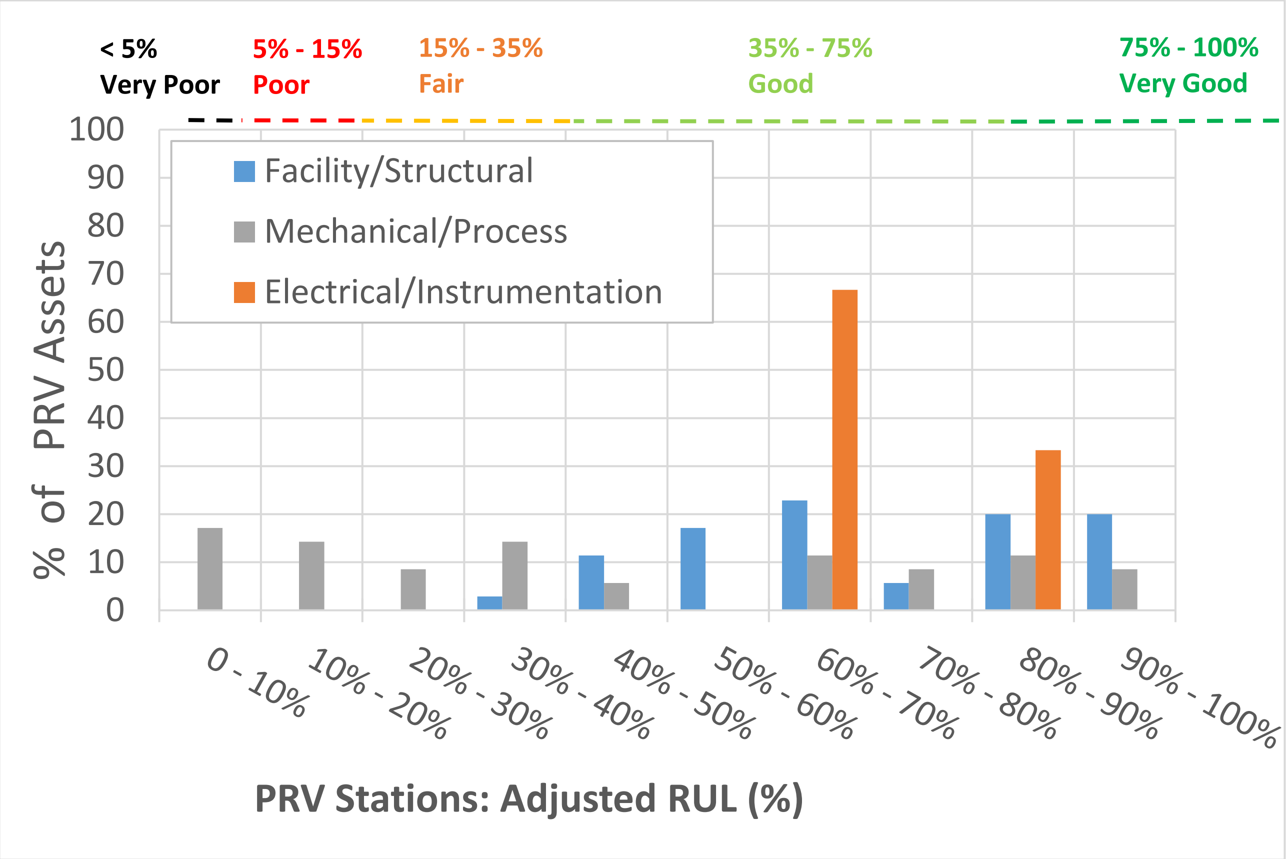


Figure 3-10 Adjusted Estimated Remaining Useful Life for PRV Station Assets by Asset Sub-Category

3.4 State of Infrastructure Improvement Actions

Table 3-9 lists the improvement actions that will improve the quality and usage of state of infrastructure information.

Table 3-9 State of Infrastructure Improvement Plan

Task No.	Improvement Task Name	Improvement Task Description
3.1	Asset Hierarchy	Review the asset hierarchy to provide a consistent naming convention for data collection and reporting.
3.2	Condition Capture Plan	Review existing condition data gaps and determine a plan for collecting the data. Consider the level of effort to collect the data, as well as the anticipated impact the data will have on informing current asset management practices.
3.3	Data Updating	Design, document and implement procedure for returning field information to asset register and GIS when work is undertaken on any asset.

Opportunity for Improvement – The District does not currently collect much data when watermains are excavated or replaced for planned or emergency repairs/renewals. Detailed testing and opportunistic sampling would need to be evaluated for reliability and cost-effectiveness in managing the distribution network, however taking photos for future reference, especially on old cast iron mains to note tuberculation, is a low-cost effort which could be useful in future iterations of the AMP.

4 Levels of Service

4.1 Overview

Levels of service are statements describing the outputs the District intends to deliver (e.g. clean, safe drinking water is always available). A key objective of asset management is to match levels of service the District plans on delivering, given its available resources, with the levels of service expected by its customers. This involves understanding customer expectations, and the trade-offs they are willing to make between costs and services. Therefore, levels of service must be written in terms that the end user can understand, and the District can effectively communicate.

This section of the plan describes:

- The services the District currently delivers
- Key stakeholders or customers using the District's services
- Legislation setting service requirements
- How levels of service are defined, and
- Current levels of service provided by the District where these are documented.

4.2 Customers & Key Stakeholders

One of the first steps in understanding what customers expect is to identify who uses the services, and other stakeholders that affect how the services are provided.

Customers are those people who use services provided by the District. This includes people living in the community, local industry, visitors, and emergency services.

Key stakeholders are those groups or individuals who can help the District to focus asset management planning on the right things. They have information and knowledge to help the District make better decisions. They may also contribute funding to meet the cost of providing water assets for use by customers.

Generally, service users (customers) and other stakeholders can be categorized as shown in Table 4-1. These stakeholder categories can be used as a starting point toward identifying a full list of stakeholders and developing an understanding of their needs and expectations for the services the District provides.

Table 4-1 Key Stakeholders

Stakeholder categories	Description
Service providers	District staff and other entities using the water service to provide their services – this includes Engineering, Parks, Culture and Community Services, Finance and Facilities departments, among others
Regulators	Provincial or Federal Government expressing their influence through legislation, regulations and higher-level plans
Service users (current & future)	Virtually everyone who lives and/or works in the community, whether they just use the municipal infrastructure, or make use of the associated assets, and also include developers and users in future developments.
Wider community	Others influential stakeholders in the community
Neighbouring Communities	Share inter-collaboration agreements, services and responsibilities with West Vancouver.

4.3 Legislative Requirements

The services provided by District assets must meet the legislative requirements at the municipal, provincial and federal levels. Key legislative requirements applicable to municipal organizations are included in Table 4-2.

Table 4-2 Organizational Legislation

Legislation	Requirement
Community Charter **Local Government Act**	Sets out role, purpose, responsibilities and powers of local governments
Municipal by-laws	Regulations approved by Council to safeguard and protect persons and properties
Building Act	Rules and regulations for buildings and building codes
Public Health Act	Rules and regulations for public health and safety
Environmental Management Act	Sets out rules and requirements for environmental regulations and requirements, including: Municipal Wastewater Regulation, Liquid Waste Management Plan, Waste Discharge Regulation, Solid Waste Management Plan
Wildlife Act	Rules around wildlife protection and management
Water Sustainability Act	Rules and regulations around surface and groundwater use and projection, including: Water Sustainability Regulation, Groundwater Projection Regulation, Dam Safety Regulation, Water Sustainability Fees, Rentals and Charges Tariff Regulation
Water Protection Act	Defines ownership of surface and groundwater resources
Riparian Areas Protection Act	Requirements for protection of riparian areas in developed areas
Workers Compensation Act (WorkSafeBC)	Rules governing health and safety in workplaces, including Occupational Health and Safety Regulation
Fisheries and Oceans Canada (DFO)	Provides guidelines and laws to protect fisheries habitat in proximity to roadways and bridges
Migratory Birds Convention Act	Protects migratory birds
Canada Water Act	Contains provisions for formal consultation and agreements with the provinces
Drinking Water Protection Act	Rules and regulations for drinking water, including Drinking Water Protection Regulation

4.4 Defining Levels of Service

Levels of service are typically expressed in relation to service attributes such as quality, reliability, responsiveness, sustainability, timeliness, accessibility and cost.

Clear levels of service goals are the cornerstone of service delivery in government. Service levels set the targets that municipal officials strive to meet. They have a significant impact on the cost to provide services to communities and define requirements for equipment, personnel, and capital budgets. The higher the service level, the higher the cost.

Figure 4-1 shows the process that the District will use for future levels of service development.

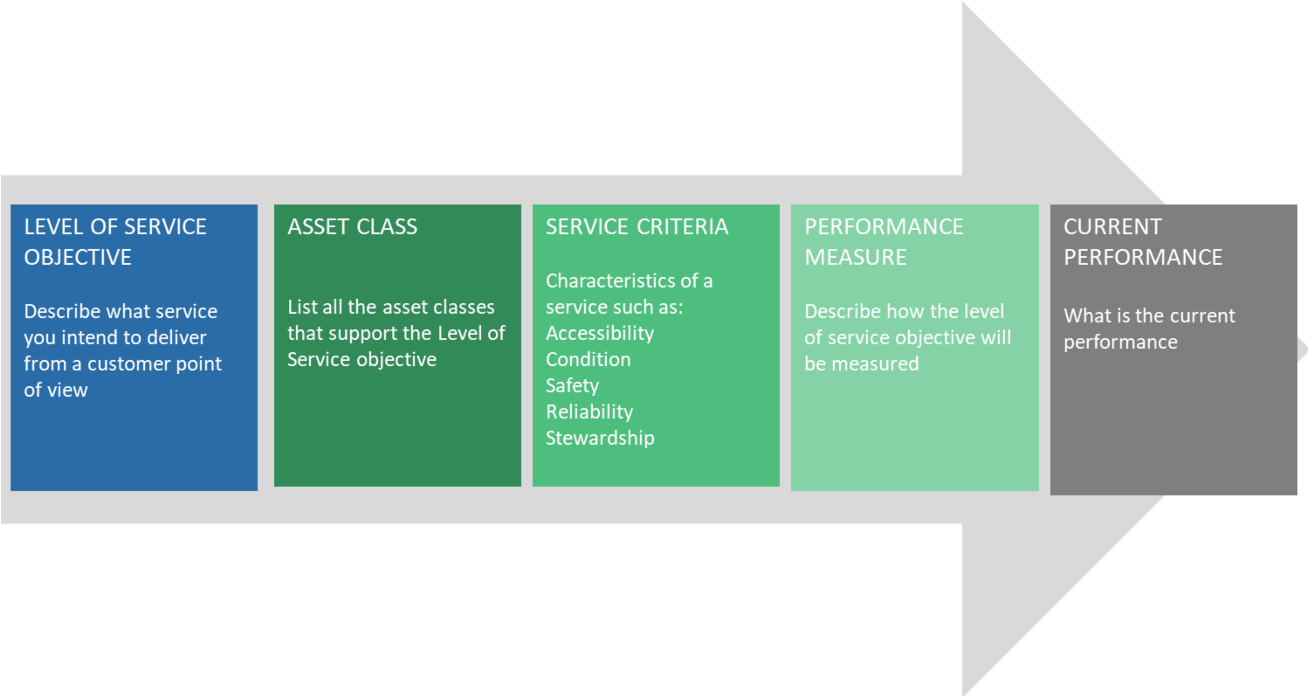


Figure 4-1 Levels of Service Development Process

4.5 Current Levels of Service

The current levels of service measured in this Plan are:

- Quality – Does the service meet users' needs?
- Reliability – Is the service maintained in a state of good repair and functionality?
- Capacity – Does the service have adequate capacity?

The District's current service levels are detailed in Table 4-3.

Table 4-3 Levels of Service

Service Attribute	Service Objective	Technical Performance Measure	Measurement Procedure	Current Performance	Performance Target
Quality	Water is clean/ safe to drink	Within allowable legislative margins for purity, turbidity	Regular Sampling	Compliant	Meeting regulations and standards
Reliability	Clean, safe drinking water is always available	Asset Condition / Redundancy	Historic repairs & outages / watermain risk profiles	Acceptable	<5 days annually of boil water advisories / <40 watermain break incidents annually
Capacity (Service Pressures)	Drinking water supplied at suitable pressures	# of service requests / % of network with pressures within acceptable range	Service Requests / Hydraulic modelling	90% of the network within allowable operating pressures. 47 service complaints in 2019.	Less than 50 complaints

Service Attribute	Service Objective	Technical Performance Measure	Measurement Procedure	Current Performance	Performance Target
Capacity (Fire-Fighting)	Water is available for fire fighting	% of network providing adequate fire flow	Hydraulic modelling / hydrant coverage / FF pressure tests	Two-thirds of all users have sufficient fire flow or are within 10% of their minimum fire flow requirement / 94% of the network has sufficient hydrant coverage.	100% of all users meeting required fire flows / 100% hydrant coverage

As noted in Table 4-3, while the District's existing levels of service with regards to quality, reliability, and service pressures are within acceptable levels, there are some gaps in terms of fire-fighting capacity. The 2016 MWSS recommended capital upgrade projects which have been carried forward and updated for this 2020 WSAMP. This includes numerous watermain capacity upgrades required to improve available fire flows throughout the distribution network. There are also several priority renewals of high risk watermains (aged watermains in poor condition in high impact areas). In addition, these projects include storage and pumping improvements to the District's major transmission system which pumps Metro Vancouver water to the western portions of the District. These projects are essential for improving water system resiliency to meet existing and future needs, providing water system redundancy to the western portions of the District. A full breakdown of these critical projects is presented in the Financial Forecast under Section 7.

While substantial improvement efforts are required to improve functional condition and levels of service, it is worth noting that the District has made significant strides to improve the water system network. Since the 2016 MWSS, the District has upgraded critical portions of the transmission mains supplying pumped water to the west. As well, the effective upsizing of key distribution mains along with recommended operational changes has drastically increased the available fire flows in some of the most heavily populated and vulnerable areas in the southeast portions of the District.

An independent 2018 Fire Underwriters Survey concluded that the District's Public Fire Protection Classification (PFPC) grading is 3/10, with 1 being the highest possible rating. The PFPC grading system is a measure of a community's overall fire defenses against fire hazards and safety risks present within the community. The overall grading considers a community's fire departments, fire safety controls, fire service communications, and the state of the water supply system. The District received grades of 1's and 2's in most of the categories except for the water supply system which received a grade of 4 which brought the overall grade to a 3. The water supply evaluation indicated shortfalls in fire flow delivery and pumping capacity (which the District is actively improving through annual capital projects); however, the District ranked exceptionally well in most other areas including source reliability, maintenance, distribution of hydrants, system management and other key factors.

Figure 4-2 taken from the 2018 Fire Underwriters Survey illustrates that most of the District's water supply system is graded quite favourably with near full marks across the board, with the exception of one category being fire flow delivery. The 2016 MWSS capital projects brought forward into the current iteration of the District's WSAMP provide a prioritized approach to addressing the fire flow delivery issues, which the District has been steadily working on in the last five years.

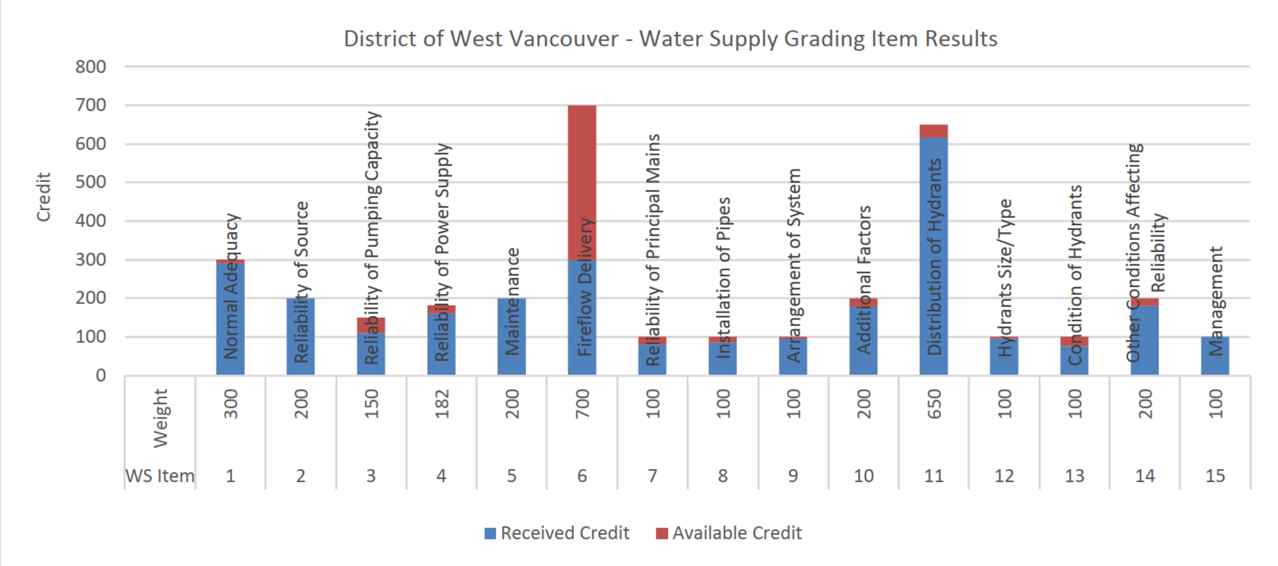


Figure 4-2 Water Supply Grading Items Overall Summary (Figure 15 from the District of West Vancouver 2018 FUS report)

WSAMP Update – The 2010 WSAMP recommended a bottom up assessment of the water system to determine infrastructure renewal priorities. The District followed up the 2010 WSAMP with the 2016 MWSS, which through hydraulic modelling, condition assessments, and risk-based renewal planning, provided the District with a Capital Projects List identifying and prioritizing renewals and upgrades to the water system.

4.6 Levels of Service Improvement Actions

Table 4-4 lists the improvement actions that will improve levels of service definition and use.

Table 4-4 Levels of Service Improvement Plan

Task No.	Improvement Task Name	Improvement Task Description
4.1	Levels of Service Identification	Hold workshops to identify and document existing levels of service for each asset category.
4.2	Levels of Service Performance Measures	Develop performance measures and data requirements for all levels of service. Identify which measures are Key Performance Indicators for the District.
4.3	Levels of Service Cost Identification	Identify, refine, and document existing costs for services provided.
4.4	Levels of Service Sustainability	Review the relationship between cost of service, level of service and risk, to establish if current levels of service are sustainable into the future.

5 Lifecycle Management

5.1 Overview

Lifecycle management refers to the different phases through which an asset passes as it ages. An awareness of these phases is important because different management interventions are appropriate (or required) for different phases of the asset lifecycle and will affect both the achievable lifespan of the asset and future financial planning. Figure 5-1 demonstrates eight stages of an asset's lifecycle. As condition deteriorates over time, various opportunities for intervention are available to extend the service life of the asset. Preventive maintenance treatments are less costly than rehabilitation. Likewise, rehabilitation treatments are less costly than reconstruction. Both rehabilitation and preventative maintenance need to be assessed on cost and level of effort required against the asset life extension. The purpose of lifecycle strategies is to maintain the assets in an appropriate way that will deliver the required level of service for least overall cost, while keeping risk within agreed boundaries.

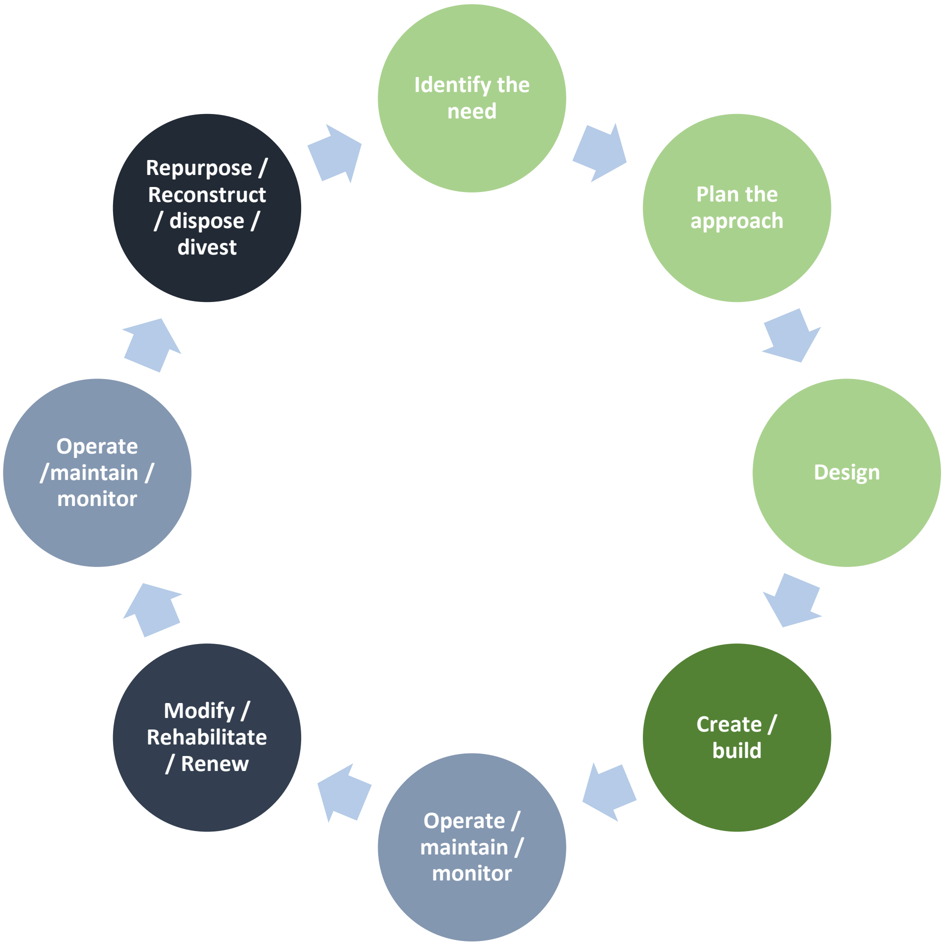


Figure 5-1 Phases of an Assets Lifecycle

This section of the Plan includes the District's plans for:

- Addressing demand drivers that might impact future service delivery
- Operating and maintaining assets
- Renewing or replacing assets
- Adding new assets or improving existing assets
- Disposing of assets that are no longer needed or have met the end of service life
- Any decision processes to manage the assets to the current levels of service (defined in Section 4) for the lowest whole-of-life cost.

Associated costs and the timing of the above efforts over the Plan's 100 year horizon are detailed in Sections 6 and 7.

5.2 Demand Management

The demand on District infrastructure can impact how the infrastructure is managed and maintained. The demand drivers that may impact the District's service delivery include changes in population, land use, per capita usage, and climate change. The present position and projections for key demand drivers that may have possible impacts on the District's service delivery are summarized in Table 5-1.

Table 5-1 Example Demand Drivers

Demand Driver	Anticipated Trend	Present Position	Projection	Possible Impact on Services	Mitigation Strategy
Population	Increase	42,474 ppl (2016)	60,000 by 2041 (based on regional projections from 2016 MWSS)	Demand Increase	Monitor trends / Identify intervention triggers
Land Use Changes	Infill & New Buildout	Single Family – 89% Multi-Family – 11% (% residential consumption)	Single Family – 82% Multi-Family – 18% (% residential consumption)	Demand Decrease	-
Per Capita Use	Reduction	High Single-Family usage in summer	Increased water conservation	Demand Decrease	-
Climate Change	Increasing demand in summer / reduced lake supply	Peak summer dependence on MV supply	Eagle Lake less reliable during peak summer	Cost increases / strain on service deliver	Water Conservation Strategy & Education

Demands for increased services due to population growth or densification will be addressed through a combination of upgrading existing assets and providing new assets. System resiliency and redundancy will remain a key strategic focus moving forward, especially due to potential impacts from climate change. The 25-year capital projects list in the 2016 MWSS was developed to the 2041 buildout horizon to account for the demand drivers listed above. The capital projects from the 2016 MWSS have been carried forward into this iteration of the WSAMP.

Opportunity for Improvement – As the District continues to pursue high-priority upgrades to the water utility, the next iteration of the WSAMP can include an up-to-date capital projects list with recommended improvements and upgrades based on consideration towards demand drivers beyond the 2041 buildout horizon from the 2016 MWSS.

5.3 Operations and Maintenance

Operating assets means completing the regular (both cyclic and periodic) activities needed to make sure they are providing the required services. Maintenance may be classified into reactive, planned or specific maintenance work activities as outlined below:

- **Reactive maintenance** is unplanned repair work carried out in response to service requests and management / supervisory directions.
- **Planned maintenance** is repair work that is identified and managed through a maintenance management system. Such activities include inspection, assessment of the condition against failure/breakdown experience,

prioritization, scheduling, actioning of the work and reporting what was done. These actions help develop a maintenance history and improve maintenance and service delivery performance.

- **Preventative maintenance** is the set of servicing activities necessary to ensure assets achieve their expected lifespans (e.g. repainting, replacing O-rings, exercising valves, etc.). This work typically falls below the capital/maintenance threshold but may require a specific budget allocation.

Generally, operating and maintenance works are completed by the District's operations staff. Where specialized maintenance requires external contractors, they are engaged to complete the work. Decision approaches to planned and preventative maintenance use available asset information such as condition, wherever possible. This is supplemented with knowledge from experienced District operations staff and from external experts and reports (i.e. recent Eagle Lake dam safety review, reservoir seismic screening assessments, pump station condition assessment, etc.). Planned maintenance works are prioritized by engineering and operations staff, with Maintenance Connection used to track and develop work orders throughout the District.

Table 5-2 provides a summary of the typical operations and maintenance cycles for the District's key water utility assets groups.

Table 5-2 Lifecycle Strategy Assessment

Asset Category	Reactive Maintenance	Planned Maintenance	Maintenance History Documentation	Regular Inspections(4)	Life Extension	Run to Failure
Dams	Yes	Yes	Yes	Yes	Yes	No
WTP	Yes	Yes	Yes	Yes	Yes	No
Reservoirs	Yes	Yes	Yes	Yes	Yes	No
Pump Stations	Yes	Yes	Yes	Yes	Yes	No
PRV Stations(1)	Yes	Yes	No	Yes	Yes	No
Watermains(2)	Yes	No	No	No	No	Yes/No
Services(3)	Yes	No	No	No	No	Yes
Fire Hydrants	Yes	Yes	Yes	Yes	Yes	No

(1) PRV Stations undergo annual teardowns and rebuilds, however this has not been historically documented internally.

(2) Watermains are inherently difficult to inspect, therefore a risk-based approach is used to estimate watermain condition and prioritize renewals, as detailed further in Section 6. High priority watermains are prioritized for interventions before estimated breaks occur, while low-risk watermains are potential candidates to "Run to failure."

(3) Service connections are inherently difficult to inspect. Renewals are typically tied to either reactive maintenance works in the case of a break or renewed when adjacent watermains are prioritized for replacement or upgrade.

(4) Regular inspections include planned or scheduled condition assessments and related studies by external consultants and contractors.

5.4 Asset Renewals

Renewal and replacement of assets is major work which does not increase the asset's design capacity but restores the asset to its original service potential. Any work over and above this is considered an improvement or new asset.

The age and condition of major components in non-linear assets such as pump stations and reservoirs were used to estimate replacement years for key structural, mechanical, and electrical components. The 2016 MWSS prioritized renewals for non-linear assets to the 2041 horizon. This Plan considers a 100-year outlook, therefore renewals were assumed at regular intervals based on the estimated service lives from the 2016 MWSS. For example, if the estimated service life of an electrical kiosk at a PRV station was assumed at 20 years old and was prioritized for renewal in 2032, then the 2016 MWSS would have only captured one renewal cycle in the capital plan. For the 100-year outlook, the financial forecast captures additional renewal cycles at 20 year intervals including 2052, 2072, 2092, and 2112.

For watermains, an age-based risk approach was used to prioritize renewals, described in more detail in Section 6 of this Plan. The 2016 MWSS used the risk-based model to prioritize renewals to the 2041 horizon. For this Plan, the model was expanded to prioritize renewals to the 100 year horizon.

5.5 Asset Upgrades and Expansion

It is important to plan works for creation of new assets that did not previously exist or works which will upgrade or improve an existing asset beyond its existing capacity, where these are required within the planning period. These new assets may result from growth, social or environmental needs. Where there is a component of future growth, the District will have the opportunity to recover the costs associated with the growth components through future development.

The 2016 MWSS identified priority renewals and upgrades for linear and non-linear water utility assets to the 2041 horizon. In some cases, capacity or redundancy related upgrades overlapped with prioritized renewal works, in which case the earliest intervention timeframe was used and the ultimate sizing approach taken (i.e. an existing 150 mm watermain slated for upsizing in 2035 to meet growth needs but due for renewal in 2025 would be prioritized for upsizing in 2025 with an eye towards having sufficient capacity to meet 2035 needs).

WSAMP Update – the first WSAMP in 2010 did not include forecasts or assessment for future system upgrades and network expansion. This 2020 version of the WSAMP now includes a forecast of future infrastructure investments and the long-term needs associated with these additions and network upgrades.

5.6 Disposal of Assets

Disposal includes any activity associated with the disposal of a decommissioned asset including sale, demolition or relocation. For this Plan, it is assumed that all disposed assets have no residual value.

5.7 Lifecycle Management Improvement Items

Table 5-3 lists the improvement actions that will improve lifecycle management asset management practices.

Table 5-3 Lifecycle Management Improvement Items

Task No.	Improvement Task Name	Improvement Task Description
5.1	Document existing lifecycle strategies	Investigate and capture any existing lifecycle strategies that staff are currently implementing. Formalize and document these strategies in this plan.
5.2	Maintenance strategies	Document information regarding roles and responsibilities; maintenance goals; typical maintenance options, methods, and protocols; decision criteria and rules for evaluating maintenance options; what maintenance performance indicators are to be tracked and reported; when to flag an asset for renewal.
5.3	Asset Valuations	Continue to review and update unit rate tables and asset lifespans, update replacement cost estimates for all assets.
5.4	Update 20 year capital works plan	Based on the asset valuation, inventory data established, and capital planning and risk-based planning exercises conducted, update and prioritize a list of high impact projects.

6 Risk Strategy

Risk is uncertainty and can be quantified by combining the likelihood that an event will occur and the impact if it does. However, risk is not an exact science and is unique to every community. Steps and actions can be taken to minimize risk. A structured risk assessment will allow the District to think through all the possibilities of "what can go wrong" and look at them with the lens of likelihood and impact, and then determine whether the risk can be avoided, reduced, or removed.

The importance of risk assessment at both the service level and the asset level is to provide early warning of potential issues that could adversely affect delivering service. When risks are known and have a rating, District staff can focus on the assets with high risk ratings and adapt the management of those assets to reduce the risk level (i.e. design and implement appropriate mitigation measures).

The results of asset level risk assessments are considered when reviewing lifecycle strategies (refer to Section 5) to determine the most appropriate treatments, planned maintenance, and inspection frequencies for a particular asset or group of assets. Both asset level risk and service risks were considered in prioritizing capital works projects and other funding decisions.

6.1 Service Risks

A high-level assessment of risks associated with service delivery has been developed at the water utility level, as highlighted in Table 6-1. The next step would be to refine the risk identification and screening assessment and assign ratings for the likelihood and potential impact in order to identify high priority service risks for further action and mitigation.

Table 6-1 Service Delivery Risks

Risk Category	Service Risk	Potential Mitigative Measures
Planning	Regulatory changes such as for water filtration	Monitor legislative changes and work with provincial and regional authorities.
	Changing demand and/or population and demographic changes	Monitor trends and identify intervention triggers.
	Decreased revenues	Review of forecast expenditure vs funding/revenue streams to establish future funding constraints.
	Large portions of regional infrastructure constructed during boom cycles due for renewal in similar timeframes at repeating intervals	Regular update of asset management plan and capital works program. Continued efforts in risk-based prioritization models, condition assessments, asset life extensions through planned maintenance to "smooth out" the spikes in regular renewals over a manageable timeframe with sufficient funding, planning, and resources.
	Supply security from Metro Vancouver	Monitor and develop, continue to work with Metro Vancouver.
	Water network model / estimated useful life accuracy impacting renewal and upgrade timing	Regular updates to the water network hydraulic model including calibration through field testing. Continue to develop and improve detailed condition assessment procedures and documentation to improve confidence in estimated useful life estimates.

Risk Category	Service Risk	Potential Mitigative Measures
Management	Organizational change / staff turnover, loss of institutional knowledge and processes	Documents information regarding roles and responsibilities, methods and protocols, decision criteria and internal databases.
	Lack of resources to implement or advance asset management	Review of forecast expenditure vs funding/revenue streams to establish future funding constraints.
	Lack of records / documentation on existing assets	Review existing condition and asset data gaps and determine a plan for collecting the data.
Hazards / Environmental Risks	Accidental or deliberate sabotage and vandalism of municipal assets and/or danger to people	Provisions for secure enclosures and limited access to public, monitor trends.
	Extreme weather events such as heat waves and droughts	Water conservation strategy and education, built system resiliency and redundancy.
	Climate change impacts on water quality and quantity.	Water conservation strategy and education, built system resiliency and redundancy.

6.2 Asset Level Risks

6.2.1 Non-Linear Asset Level Risks

The District has collected and continues to collect condition and risk data on the non-linear assets in the water network through maintenance activities, regular studies and risk assessments. Non-linear assets by their nature do not tolerate failures and outages in their service areas for prolonged period of times, therefore reinvestment in non-linear assets is typically prioritized by their likelihood of failure which is tied to estimated service lives. That is not to say that a risk-based approach is untenable; a ranking of the criticality of non-linear assets based on their service areas and levels of redundancy would help the District prioritize reinvestment needs for non-linear assets of similar vintages, and for some assets this has already been considered (i.e. major reservoir and pump station upgrades identified in the 2016 MWSS Capital Projects List). For this Plan, the financial reinvestment outlook for the next 100 years considers regular renewals of major non-linear asset subcomponents, with prioritized replacements and upgrades based on previous studies and assessments, as follows:

- Remedial actions and associated costs to address main safety risks to the integrity of the Eagle Lake West and East Dams have been included in the financial forecast of this Plan, based on recent review;
- Given the recent age of the Eagle Lake and Montizambert Water Treatment Plants, there were no pressing issues or risks of componentized failures identified, with the exception of the membranes at the ELWTP which have a short 7-year useful life and have been accounted for in the financial forecast for this Plan;
- The two reservoirs identified with very high seismic risk, Madrona and Chairlift, have recommended remediation and retrofits incorporated into the financial plan. McKechnie, Cross Creek and Pascoe reservoirs were identified as high seismic risk and likewise have remediation and retrofits works recommended. Additional maintenance works for the District’s reservoirs have also been included in the financial forecast, based on condition data collected since 2013, as well as reservoir expansions from the 2016 MWSS Capital Projects List;
- The District’s pump stations were most recently inspected in 2014, with prioritized replacement and upgrades included in the 2016 MWSS capital works plan to address high risk assets. These have been reflected in the financial forecast for this Plan; and,
- While PRV stations have been classified as low-risk due to the District’s thorough annual tear down maintenance schedule, there is a lack of documentation and photos on their condition.

Section 7 summarizes the financial implications of reinvestment needs for non-linear assets in the District’s water network.

6.2.2 Linear Asset Level Risks

As noted in Section 3, watermains are the largest asset group in the District's water utility and represent 77% of the total water utility asset base. By virtue of being largely buried, direct measurement of their physical condition is difficult and cost-prohibitive. Therefore, watermains as an asset group across all municipal utilities present a challenge to managers responsible for assigning capital expenditures to their replacement or rehabilitation. While the water infrastructure includes "echoes" from the original patterns of development, the current and future reinvestment demand is modified by additional factors including the varying quality and type of pipe materials used, construction quality, and local operating environments.

Aging water mains are subject to more frequent breaks and other failures that can threaten public health and safety (such as compromising water quality and fire-fighting flows). Buried infrastructure failures also may impose significant damages and risks (for example, through flooding and landslides jeopardizing public safety), are costly to repair, disrupt businesses and residential communities, and waste precious water resources. These failures weaken the economy and undermine reliance and quality of life.

The reinvestment challenge is significant, and it is critical that funds are invested optimally to extract maximum value (life) from the assets at the best balance between lifecycle cost and risks to the service. Getting it wrong will add to the scale of the financial challenge faced in the years to come and increase the likelihood of reduced service standards.

The watermain risk model developed as part of the 2016 MWSS was designed to support the District's replacement programming decisions and help focus resources and efforts on critical watermains. This was achieved by standardizing assessments, and decision criteria for watermains using a risk framework built around evaluating the consequence of failure relative to three primary types of impact (Social, Economic, and Environmental). The evaluation assesses the potential adverse impact on the asset, the service, the organization, and the community. Subsequently, the evaluation weighs the potential harm against the likelihood of it happening, to produce a value for that risk.

Initially built for a 20-year planning window, the 2016 watermain risk model was updated for the current Plan. The District's latest GIS database was first reviewed to update the watermain risk model for recent upgrades and renewals conducted since the 2016 MWSS. The model horizon was then extended to the Plan's 100-year outlook, and unit rates were updated to reflect current construction cost estimates.

Figure 6-1 shows the current condition of the District's watermain network, expressed as risk of failure probability (very high to very low) for pipes in critical, less critical and not critical categories. The majority of watermains have Very Low or Low probability of failure, and the replacement costs for higher risk critical pipes is a small fraction of the total asset base.

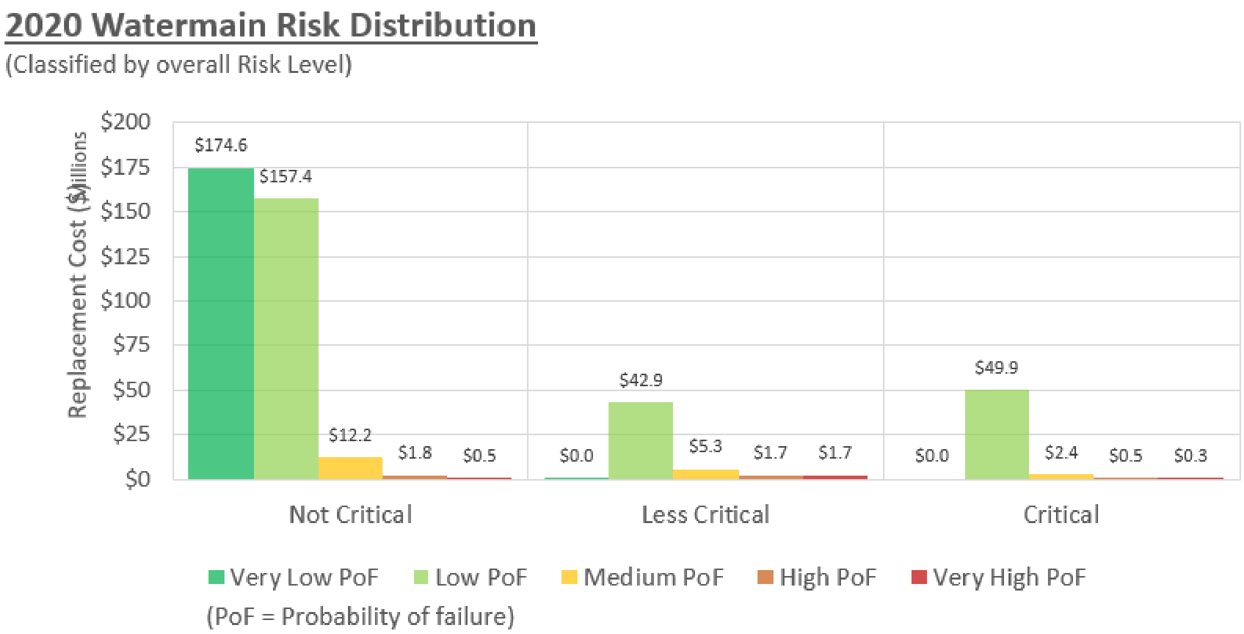


Figure 6-1 Water Distribution Network – Risk by Replacement Cost

The current risk profile of the watermain network indicates that the majority of the mains are in Very Good to Fair physical condition. Therefore, there appears to be some capacity for the network to absorb some deterioration to within acceptable risk levels over the next twenty to sixty years. This would provide some opportunity to finance other projects such as the capital upgrades from the 2016 MWSS targeting improved firefighting capacity and system redundancy, which make up the bulk of the necessary projects in the next twenty years. Renewal timelines were compared and aligned with the 2016 MWSS capital projects list to determine the most appropriate intervention periods and sizing requirements to meet future population needs as well as current levels of service.

As illustrated in Figure 6-2, a fixed annual budget of $3 Million for watermain renewals was found to be required to maintain most of the network in Very Good to Fair physical condition for the next 60 years with steady and gradual deterioration (increase in risk). Beyond the 60-year horizon, annual watermain renewal budgets will need to increase to continue to manage risk at this level without further deterioration. The financial forecast presented in the following Section 7 would be inclusive of this baseline $3 Million watermain renewal level.

In the next iteration of the WSAMP, as the District works toward completing all anticipated capital and upgrade projects in the next twenty years, consideration should be given towards a future shift in funding towards increased watermain renewals to mitigate undesired watermain network degradation in the long-term.

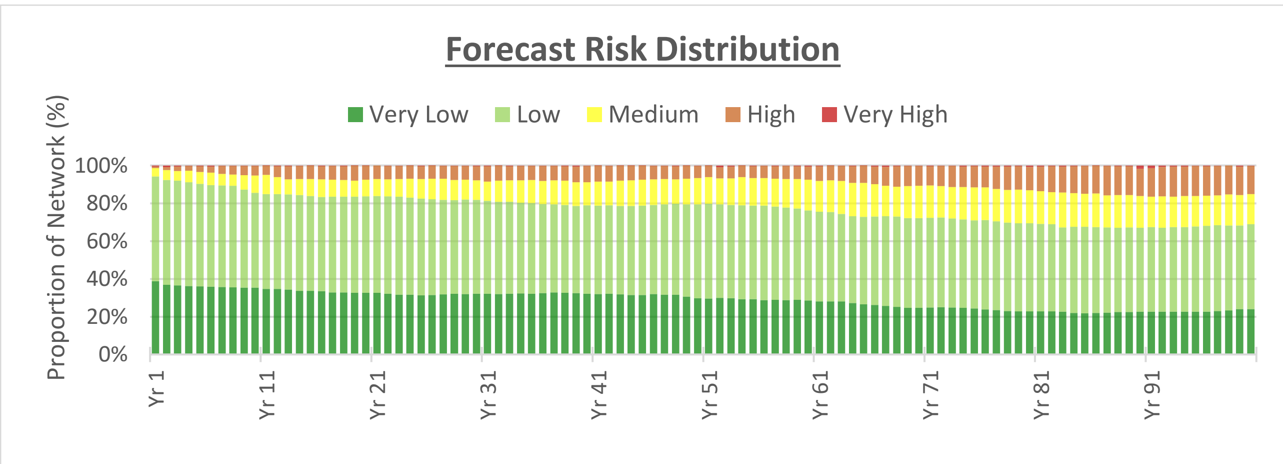


Figure 6-2 Forecast Risk Distribution for 100 Year Investment Timeline

6.3 Risk Improvement Items

Table 6-2 lists the improvement actions that will improve lifecycle management asset management practices.

Table 6-2 Risk Improvement Items

Task No.	Improvement Task Name	Improvement Task Description
6.1	Identify Critical Non-Assets	Identify and document critical non-linear assets by evaluating respective service areas and levels of redundancy in providing levels of service.
6.2	Calculate Risk Scores for Non-Linear Assets	Develop standardized risk evaluation frameworks for each group of non-linear assets, using criticality ratings and condition-based probability of failure ratings to determine risk scores for each asset.
6.3	Maintain and refine the Watermain risk model	Maintain and refine the watermain risk model inputs, as more condition information becomes available and consequence ratings are refined.
6.4	Service Level Screening and Prioritization	Refine the risk identification and screening assessment for service delivery risks in order to identify and prioritize high priority risks for further corporate action and mitigation.

7 Financial Forecast

A financial strategy is a funding plan for implementing the asset management strategies adopted by the District to provide its target levels of service. The current strategy for the next 100 years is to replace existing assets that reach the end of their expected useful lives or reach a very poor condition state, with additional upfront costs in the immediate 20-year horizon to address capacity and redundancy-related upgrades to improve current levels of service.

The following sections present the District's current revenues and expenditures, forecasted costs to renew and upgrade existing infrastructure as required over the planning horizon, and plans for bridging gaps between current budget levels and the estimated annual investment requirements over the 100-year planning horizon.

> **WSAMP Update** – the first WSAMP in 2010 did not include information on operations and maintenance activities and related costs. This 2020 version of the WSAMP now includes information on the District's operating and maintenance costs and expectations for future needs in this area.

7.1 Operating and Maintenance Costs

Table 7-1 provides the District's 2019 Water Distribution System Operation and Maintenance Budget. Included in this budget are line items relating to Water Debt and Water Purchase which pertains to funds allocated to buy water from Metro Vancouver. It is important to note that this budget is separate and distinct from the District's Capital Budget (for the strategic replacement of aging infrastructure to address issues with service and for new infrastructure associated with a growing service base).

Table 7-1 O&M 2019 Budget

	Annual Budget	% Total Annual Budget
General	$1,029,109	9%
Water - General Ops Exp	$551,879	5%
Water - Ops Cent & Admin	$477,230	4%
Water Debt	$1,995,700	18%
Water Purchase	$4,235,335	38%
Dams	$53,700	0%
Eagle Lake and Montizambert WTPs	$844,121	8%
Reservoirs	$78,100	1%
Reservoir Cleaning	$22,300	0%
Reservoir Inspection	-	-
Reservoir Maintenance	$55,800	1%
Pump Stations	$380,100	3%
Building Maintenance	$33,000	0%
Pump repair	$20,500	0%
Pump maintenance	$29,200	0%
Water Pumping Hydro	$297,400	3%
PRVs	$73,400	1%
PRV Maintenance	$63,100	1%

	Annual Budget	% Total Annual Budget
PRV Replacement	$10,300	0%
Mains	$1,659,384	15%
General - Mains	-	-
General - Water Supply	-	-
Water Transfer	$11,200	0%
Customer Service	$212,800	2%
Power Generation Maintenance	$11,000	0%
Proactive Leak Detection	$15,600	0%
Conservation Initiatives	$13,300	0%
Service Locations	$18,600	0%
Service Repairs	$252,600	2%
Service Renewal	$510,000	5%
Locate Water Shutoffs	-	-
Water Service Turn Ons/Offs	-	-
Valve Repair	$82,600	1%
Valve Exercise Program	$61,900	1%
Main Repairs	$257,600	2%
Main Flushing	$74,600	1%
Site Inspections	$54,000	0%
Water Sampling	$31,400	0%
Water Sampling Analysis	$8,100	0%
Notices and Advertising	-	-
Roads and Easements	$15,600	0%
Chlorination Supplies	$10,500	0%
Chlor. Maint. - Nelson Cr	$17,984	0%
Hydrants	$136,092	1%
Hydrant Painting	$8,600	0%
Hydrant Maintenance	$87,800	1%
Hydrant Repair	$39,692	0%
Meters	$554,429	5%
Total	$11,039,470	100%

The District’s current Operating and Maintenance budget is providing sufficient upkeep of system integrity, as is evidenced by various inspection and condition reports which largely indicate that the majority of the District’s assets are being maintained in good physical condition. However, the Operating and Maintenance Budget should increase with time as the asset base grows, the service population increases and the asset base ages to account for growth. It is also recommended that the District consider implementing a 120-day reserve as well.

7.2 Capital Renewal Costs

The Capital Renewal Costs are allocated for the strategic replacement of aging infrastructure to address issues with service or poor performance. Unit rates and assumptions used to estimate the renewal costs in the future are provided in Table 7-2. Replacement or renewal costs for Pump Stations have been considered separately and are provided in Table 7-3. Mechanical and electrical component replacement costs for other assets are given in Table 7-4.

Table 7-2 Unit Rates for Renewals

Asset	Unit	Rate (2020 Dollars)
East Dam	each	$7,587,000[(1)]
West Dam	each	$2,471,000[(1)]
Eagle Lake WTP	each	$21,893,000[(1)]
Montizambert WTP	each	$2,969,000[(1)]
Reservoir	m^3	$1,300
Pump Station	kW	$23,700
PRV Station[(1)]	each	$83,000
Mains - 200 mm	lin. m	$1,300
Mains - 250 mm	lin. m	$1,300
Mains - 300 mm	lin. m	$1,400
Mains - 350 mm	lin. m	$1,600
Mains - 400 mm	lin. m	$1,690
Mains - 450 mm	lin. m	$1,690
Mains - 500 mm	lin. m	$1,690
Mains - 550 mm	lin. m	$1,690
Mains - 600 mm	lin. m	$1,840
Mains - 650 mm	lin. m	$1,950
Mains - 660 mm	lin. m	$1,950
Mains - 750 mm	lin. m	$1,950
Mains - 850 mm	lin. m	$2,470
Mains - 900 mm	lin. m	$2,730

(1) Replacement cost as given by the District of West Vancouver Water Asset Management Plan (AECOM, 2010)
(2) An extra allowance of 35,000 dollars is provided for PRV Stations with electrical components

Replacement costs for Pump Stations come from 2014 Pump Station Condition Assessment Report, inflated to 2020 dollars using the ENR Cost Index, as per Table 7-3 below. The replacement costs for 11th Street, Burnside and Vinson Creek Pump Stations have been revised according to recent cost estimates from the KWL Technical Memo “Rodgers Creek Water Upgrades” (September 2018).

Table 7-3 Replacement Costs for Existing Pump Stations

Pump Station	Structural/ Facility Replacement Cost (2020 Dollars)	Mechanical/ Process Replacement Cost (2020 Dollars)	Electrical/ Instrumentation Replacement Cost (2020 Dollars)	Total Cost (2020 Dollars)
11th Street	$5,947,900	$3,776,400	$1,468,600	$11,192,900
Westmount	$5,686,900	$5,416,100	$1,063,200	$12,166,200
Burnside	$2,354,600	$1,152,400	$386,200	$3,893,200
Cross Creek	$3,383,000	$3,221,900	$1,181,400	$7,786,300
Vinson Creek	$1,327,200	$1,082,700	$509,900	$2,919,800
Bonnymuir	$1,477,800	$625,500	$232,600	$2,335,900
Eagleridge	$122,600	$25,300	$46,700	$194,600
Craigmohr	$733,300	$675,400	$148,600	$1,557,300
Glenmore	$1,703,300	$968,800	$247,800	$2,919,900
Chelsea	$716,400	$678,700	$162,100	$1,557,200

The assumed replacement costs for mechanical and electrical components for the remaining assets under consideration are given in Table 7-4.

Table 7-4 Mechanical and Electrical Replacement Costs for Non-Linear Assets

Asset	Mechanical/ Process Replacement Cost (2020 Dollars)	Electrical/ Instrumentation Replacement Cost (2020 Dollars)
Pump Station	See Table 7-3	**See Table 7-3**
PRV	$43,000	$35,000
Reservoirs(1)	$57,000	$35,000
WTP(2)	$600,000	$450,000
East Dam(3)	$950,000	$150,000
West Dam(3)	$640,000	$110,000

(1) Reservoirs are assumed to have mechanical and electrical components (if any) similar in complexity and scale to PRVs, and hence have the same estimated replacement costs.

(2) Replacement cost as estimated by the District and in terms of mechanical and process replacement costs include $400K for at Eagle Lake WTP and $200K at Montizambert WTP. In terms of electrical and instrumentation replacement costs, $3000 K is estimated at Eagle Lake WTP, with the remaining $150K estimated for Montizambert WTP.

(3) Costs are taken from the Dam Safety Review report for automated continuous monitoring (electrical component) and headgate control (mechanical component) at each Dam respectively.

7.3 Capital New and Upgrade Costs

Capital New and Upgrade Costs have been estimated for infrastructure that is required to service new developments, and upgrades to existing infrastructure to meet changes in water usage patterns, design criteria, and densification. The 2016 MWSS prioritised capital upgrade projects for the District and this forms the basis of the assumed costs in this Plan.

The watermain risk model developed as part of the 2016 MWSS has been used to forecast which watermains are to be renewed and when. As found in the 2016 MWSS, a fixed budget approach strikes a balance between reinvestment and ongoing risk management. A fixed budget of $3,000,000 per year has been chosen, as with the new watermain renewal rates, this amount is sufficient to manage the network in a condition with minimal Very High or Extreme risk sections of watermain. However, if the District wants to avoid the gradual and longer-term deterioration of the network, more than $3,000,000 per year would have to be invested. It should be noted that the $3,000,000 watermain renewal budget is a baseline only. Additional funding and consideration is required for priority capital upgrades from the 2016 MWSS.

Renewal timelines have been compared to and aligned with the capital projects for watermains given in the MWSS. This means that watermains highlighted for renewal may be renewed at a larger pipe size to account for future capacity needs. Where the MWSS suggests upgrade of a watermain before the renewal timeline, the upgrade is prioritised and assumed to occur within the timeline suggested by the MWSS.

Table 7-5 provides the unit rates for new construction assumed in the financial forecasting. These costs have been reviewed and revised with the District. Unit rates for watermain renewals were revised by the District and, on average, have been increased by 30% from the initial rate as suggested by the 2016 MWSS based on recent construction projects.

Table 7-5 Unit Rates for New Construction

Asset	Unit	Rate (2020 Dollars)
Reservoir	m^3	$1,250(1)
Pump Station	kW	$23,700
PRV Station(2)	each	$83,000
Mains - 200 mm	lin. m	$1,300
Mains - 250 mm	lin. m	$1,300
Mains - 300 mm	lin. m	$1,430
Mains - 350 mm	lin. m	$1,620
Mains - 400 mm	lin. m	$1,690
Mains - 450 mm	lin. m	$1,690
Mains - 500 mm	lin. m	$1,690
Mains - 550 mm	lin. m	$1,690
Mains - 600 mm	lin. m	$1,840
Mains - 650 mm	lin. m	$1,950
Mains - 660 mm	lin. m	$1,950
Mains - 750 mm	lin. m	$1,950
Mains - 850 mm	lin. m	$2,470
Mains - 900 mm	lin. m	$2,730

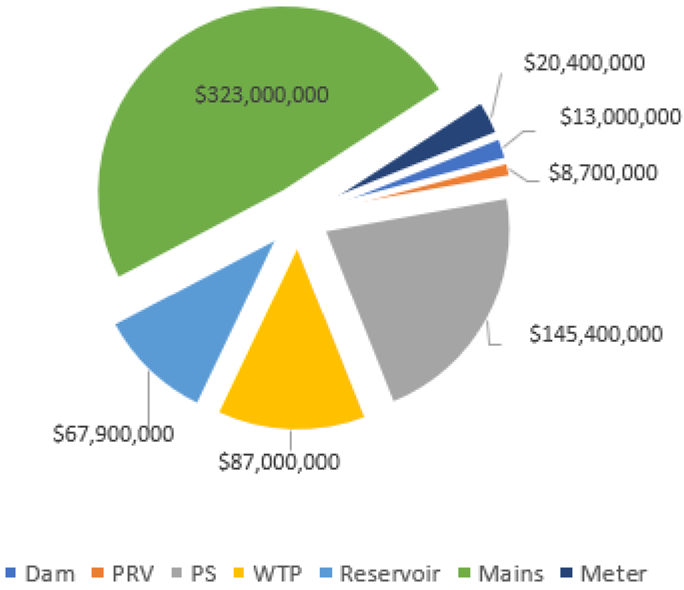
(1) The unit rate for reservoirs as advised by the District is $1,800 per m^3, based on a Class C estimate to replace Lookout Reservoir provided in the KWL Technical Memo "Rodgers Creek Water Upgrades" (September 2018). It should be noted that this is significantly different to the reservoir unit rate of $660 per m^3 in the 2016 MWSS, which was developed with costs from the District for recently constructed reservoirs at that time. The discrepancy arises from different building materials (concrete or bolted steel) and construction methods (above or underground). An average unit rate has been applied to all reservoirs in order to capture this variation in materials and construction type. The one exception is Lookout Reservoir, where more information regarding the proposed reservoir is known, and so the unit rate of 1,800 per m^3 has been retained.

7.4 Future Forecast

Unit rates and replacement costs, together with the reported condition of assets as detailed in the preceding sections, form the basis of the financial forecast. A 0% inflation rate has been assumed for future costs to present the long-range 100-year horizon in today's dollars. The 2016 MWSS details capital projects required to address current and future deficiencies up to 2041. These capital projects have also been included in the forecast. As in the 2016 MWSS Capital Projects list, three accounts have been specified to differentiate the different drivers behind the capital projects:

- Account 1 describes upgrades to the network to improve firefighting capabilities and system redundancy
- Account 2 describes size-on-size renewals and replacements, based on estimated theoretical service lives of assets and their components
- Account 3 describes infrastructure upgrades that are associated with OCP growth, which the developer would be partially or wholly funding

The long-range financial forecast for the 2020 WSAMP indicates a 39% increase to the overall 2010 WSAMP forecast adjusted for today's dollars. This result may seem surprising considering the degree to which watermain construction in the District has increased in the last decade. However, significant increases in construction costs which have been a major factor in driving this gap wider have been partially offset by the refined approach to asset replacement as a function of a better understanding of asset conditions and total useful life estimates as captured in this 2020 WSAMP. By looking at the existing condition of the District's assets, estimated service lives have increased across the board which has reduced the number of renewals required over the 100-year period.



Forecasted Capital Expenditures by Asset Type – 100 Year Horizon

Where there are significant cost differences between the 2010 WSAMP and the current Plan are in the first twenty years. In particular, a funding gap has been identified to address front-loaded high priority upgrade projects aimed at improving current levels of service which require significant upfront financial investment. Table 7-6 breaks down the total expenditures estimated over the entire planning horizon, and it is clear an average annual expenditure of 14.2 Million for the next 5 years or 11.1 Million for the next 10 years is needed to maintain current levels of service.

Table 7-6 Total Estimated Expenditures over 100-year Planning Horizon

Period	Total Expenditures	Average Annual Expenditures (1)
Backlog (2021)	$34 M	-
5 Years (2021-2025)	$71 M	$14.2 M
10 Years (2021-2030)	$111 M	$11.1 M
20 Years (2021-2040)	$208 M	$10.4 M
100 Years (2021-2120)	$665 M	$6.7 M

(1) Average annual expenditures over each period assume pay-as-you-go funding, with no provisions towards borrowing, DCCs, grant-funding, or other funding mechanisms.

While an average annual expenditure of $6.7 Million over the entire 100 year planning horizon might be reasonably achieved, bridging the gap between the current annual capital budget of approximately $4.8 Million and expenditures over the next 20 years to 2041 will require significant planning, effort, and discussion on how much and how fast to increase water utility rates and/or pursue other funding sources. The 2010 WSAMP identified a significant funding gap at the time which the District was able to drastically improve by increasing capital spending five-fold, going from a capital budget of approximately $1 Million in 2010 to almost $5 Million in the present day.

The current estimated backlog is approximately $34 Million compared to a backlog of $15 million in the 2010 WSAMP. The 2010 WSAMP provided a high-level top-down overview of funding requirements and used limited data and system models that were available at the time. Construction cost inflation (>200% in unit cost rates over the last 10 years) also affects the increase in overall projects costs. The approach taken in 2010 was to replace assets 'like for like' with no upgrades or new assets envisioned. The increase in the current backlog reflects the need for increased system resiliency, capacity upgrades, and risk-based priority renewals based on the comprehensive modelling analysis from the 2016 Master Water Servicing Study.

Table 7-7 breaks down the $34 Million backlog of high priority projects.

Table 7-7 Summary of High Priority Projects in Backlog

Asset Group	Description	2020 Estimated Cost
Pump Stations	11th St	$5.3 M
	Westmount	$6.6 M
Reservoirs	Westmount	$6.8 M
Watermains	Capital Upgrades (1)	$7.8 M
	Priority Renewals (2)	$6.9 M
Other		$0.6 M
Total	Various renewals (3)	$34.0 M

(1) Watermain capital upgrades capture new or upsized watermains proposed in the 2016 MWSS which are required for increasing available firefighting capacities and improving system redundancies. They are prioritized and sized to the 2041 OCP horizon to meet future population needs as well as current levels of service.

(2) Watermain priority renewals are size-on-size replacements determined by the watermain risk model using a $3 Million annual reinvestment budget. Renewal timelines were compared and aligned with the watermain capital upgrades to determine the most appropriate intervention periods and sizing requirements. Beyond the 2041 horizon, all watermain works are size-on-size renewals prioritized based on risk ratings.

(3) Include various facility renewals, chiefly mechanical upgrades at reservoirs.

As indicated in Table 7-7, the 11th Street Pump Station, Westmount Pump Station, and Westmount Reservoir projects account for 50% of the backlog. All three assets are currently undersized to meet existing and future water conveyance, water supply redundancy, and fire fighting needs, based on the latest hydraulic modelling studies available. They form the critical backbone of the supply system that pumps Metro Vancouver water to the western portions of the District. Without the upsizing of these critical assets, there is significant risk towards the future uninterrupted supply of potable water to the western portions of the District during hot summer periods when there is a limited water supply at the District's Eagle Lake source. As these projects benefit future growth, there is opportunity for cost-sharing with developers.

The $7.8 Million in watermains capacity upgrades are to improve the availability of fire flows throughout the network. These upgrade projects were identified and prioritized during the 2016 MWSS using the latest hydraulic water model, which was not a tool available during the development of the 2010 WSAMP. The remaining $6.9 Million in watermain projects address priority renewals for high-risk watermains. These are borne out of a watermain risk model developed for the 2016 Master Water Servicing Study and updated for the 2020 WSAMP.

Looking beyond the immediate Backlog, some of the additional major costs in the next five years include:

- By 2026, six additional reservoirs/expansions to address existing and future capacity deficiencies at Upper Nelson, Cypress 2, Bonnymuir, Cypress 4, Lookout, and Sunset (Montizambert South) reservoirs, as initially recommended in the 2016 MWSS, totalling approximately $7.8 million dollars. Of these new reservoirs, five have an allowance of $1M for land acquisition in the 2016 MWSS. There is potential to delay works to increase storage capacity such that these coincide with the end of service life of the existing reservoirs. Replacement reservoirs could then be sized to include future storage requirements. Other than the Sunset Reservoir (which is currently not in service), and Cypress 2 reservoir (which the District notes has some operational issues) these reservoirs are in Good or Very Good condition, and replacement or upgrade costs could be delayed beyond 2050. A cost-benefit analysis to assess the risks of deferring reservoir upgrades is required.
- A total of 4 projects to address recommendations from the Dam Safety Review including new weirs and improved automated seepage monitoring at the toe of the West Dam ($110,000) and East Dam ($150,000), incurred in 2022 and 2023 respectively. Also, upstream head gate control projects for conduits in the West Dam ($660,000) and East Dam ($950,000) were assumed to occur in 2024 and 2025 respectively.
- Replacement of the existing floating pumps at Eagle Lake WTP for fish friendly pumps has been suggested, at an estimated cost of $611,000. This cost is assumed to be incurred in 2021.
- Membrane replacement at the Eagle Lake WTP, which cost an estimated $1,000,000 and require renewal every 10 years.

The financial forecast depicted in Figure 7-1 illustrates the current level of tolerance for risk and service levels over the next 20 years.

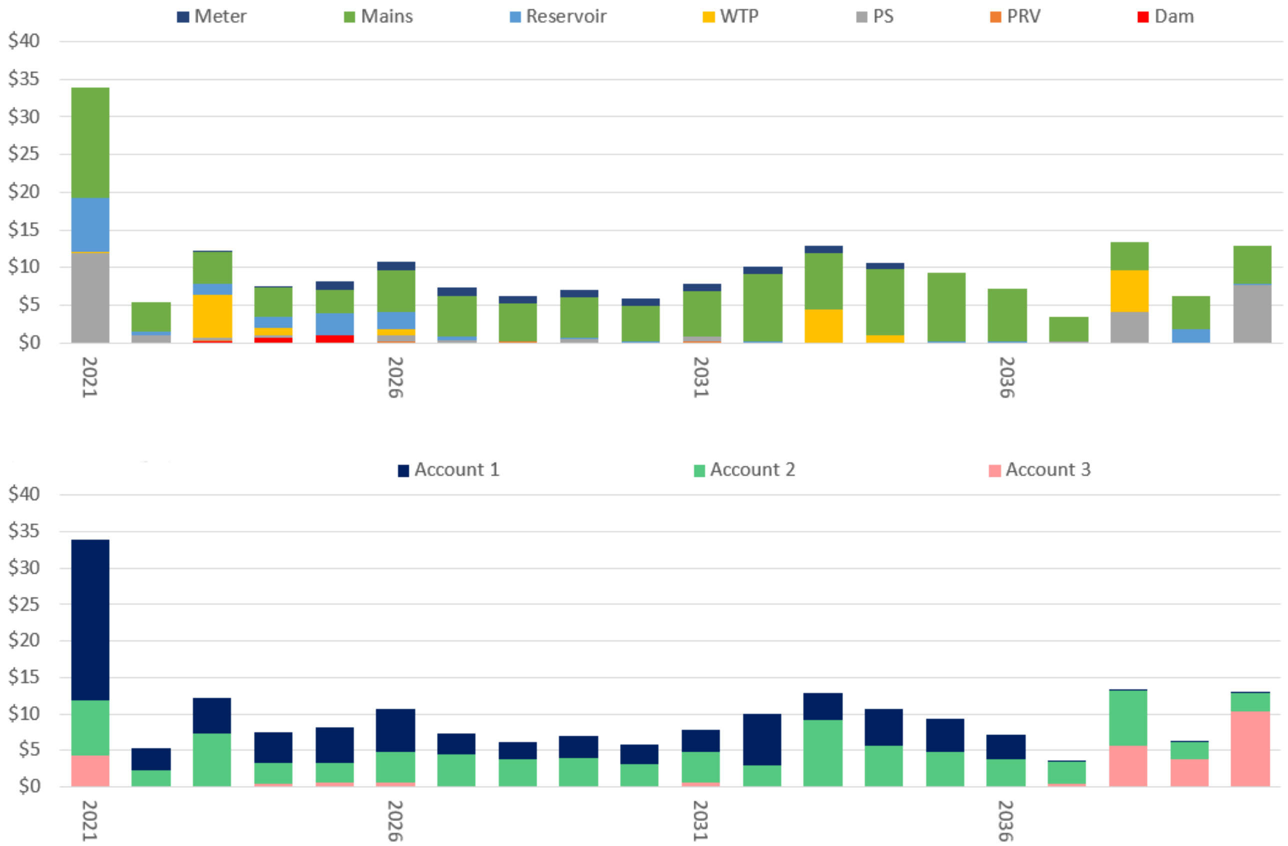


Figure 7-1 20 year Financial Forecast for All Assets

Note:

— Account 1 describes upgrades to the network to improve firefighting capabilities and system redundancy

— Account 2 describes size-on-size renewals and replacements, based on estimated theoretical service lives of assets and their components

— Account 3 describes infrastructure upgrades that are associated with OCP growth, which the developer would be partially or wholly funding

Many large projects identified in the 20-year financial forecast are critical infrastructure with limited redundancies that cannot tolerate prolonged outages or reduced service levels due to failure or increased loading on the network, which makes deferring key projects difficult. Therefore, being explicit about the risk of pursuing or not pursuing critical projects will require a dialogue on balancing additional funding needs and resources in the immediate future with safe and reasonable adjustments to current risk tolerances and levels of service provided.

As construction costs, population growth, and climate trends towards longer, drier summers continue to rise, a "business-as-usual" approach to water utility reinvestment poses significant risks to the District's ability to deliver adequate levels of service. This includes risks to supply redundancy and the ability to supply Metro Vancouver water to the western areas of the District, as well as risks to adequate firefighting supply to all users within the District, especially during summer high water usage and peak periods.

Figure 7-1 depicts the long term 100-year forecast of spending to maintain, operate and expand the water system, and includes capital project costs as well as renewal costs for linear and non-linear asset combined. Projected costs have been allocated to their respective accounts (1, 2 or 3).

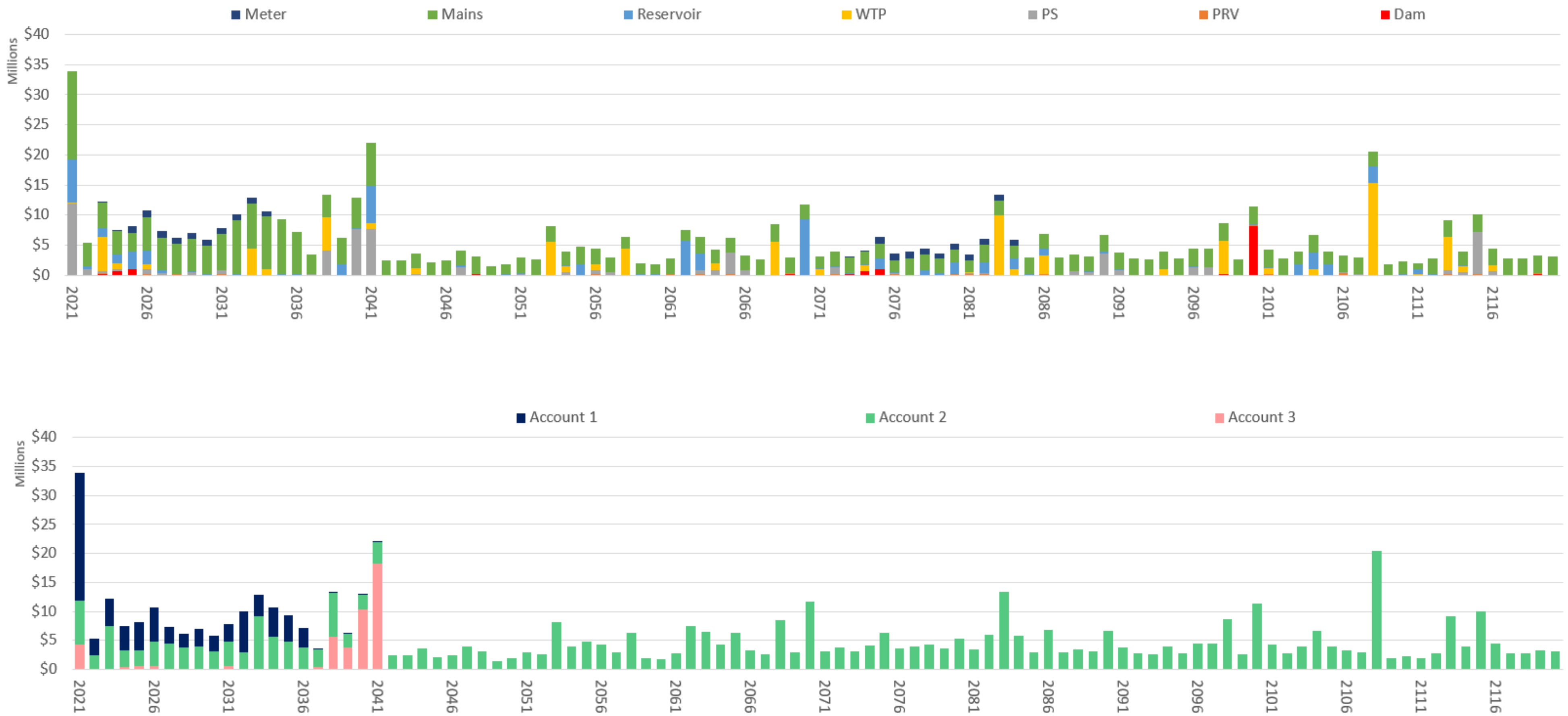


Figure 7-2 Long Term 100-year Financial Forecast for All Assets

Note:

— Account 1 describes upgrades to the network to improve firefighting capabilities and system redundancy

— Account 2 describes size-on-size renewals and replacements, based on estimated theoretical service lives of assets and their components

— Account 3 describes infrastructure upgrades that are associated with OCP growth, which the developer would be partially or wholly funding

7.5 Sensitivity Analysis

To ascertain how sensitive future forecast spending is to estimated service life estimates, a sensitivity analysis was conducted, where the estimated service life as provided in Table 3-8 and 3-9 were reduced and increased by 15%.

Figure 7-3 shows the results of the sensitivity analysis.

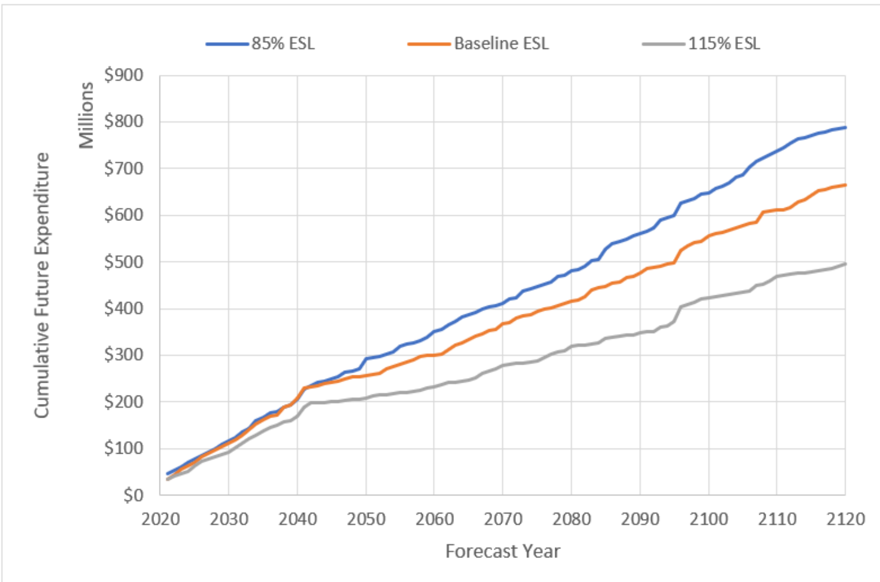


Figure 7-3 ESL Sensitivity Analysis – Cumulative Future Spend

For the first 20 years of the financial forecast there is little difference between the baseline ESL scenario and altered ESL scenarios, as during this period expenditure is driven by the capital projects outlined in the 2016 MWSS and are largely not renewal based (or ESL influenced) costs. Beyond 2041 (the last year for capital projects in the 2016 MWSS) the forecasts for ±15% ESL scenarios begin to diverge, as expenditure shifts to being renewal based.

For non-linear assets, an increased ESL means that renewals are less frequent which results in less expenditure cumulatively over time, and vice-versa for the decreased ESL scenario.

For watermains, renewals are based on risk-level approach, therefore in order to maintain an acceptable network degradation and risk profile similar to the baseline condition, a higher annual renewal rate of $4 Million is required for the -15% ESL scenario, while the annual reinvestment budget for the +15% ESL scenario is $2 Million, as longer watermain life means less reinvestment is required year to year to maintain a similar risk profile.

In the 2010 AMP, the sensitivity analysis was limited to just watermains which was considered representative of long-range renewals since watermains made up and still make up the largest asset group within the District's water utility. The greatest impact from the sensitivity analysis in the 2010 WSAMP was on the backlog, as watermains came up for renewal either sooner or later than expected based on the decrease or increase in the baseline ESL's at the time, respectively. That effect of uncertainty on short term financial needs is mitigated through the capital-projects driven 20-year expenditures included in the latest financial forecast of this Plan, due to better understanding and available data on specific water system improvement needs.

7.6 Revenues, Reserve Funds, and Alternative Measures for Funding Strategy

Mitigative measures such as tighter summer watering restrictions, and more punitive tiers in the water rate system may help to reduce risk and strain on the water utility which may allow deferral of some project costs; however, none of these measures will eliminate the need for a comprehensive funding strategy to pay for the proposed improvements required to maintain the system at the expected level of service. Therefore, mitigative measures should be considered along with the development of a comprehensive funding strategy. The District has several revenue streams to support the future investment in service delivery to the community:

- Property taxes and utility fees paid by residents of the community;
- Regular grants and other revenue streams from other levels of government (e.g. Federal Gas Tax Funding);
- Development cost sharing arrangements;
- Operating fund surplus reserves;
- Capital fund surplus reserves; and,
- Capital replacement reserves;

A "pay-as-you-go" approach to utility funding will not adequately bridge the gap between current and required funding levels without steep utility rate increases. Considerations towards grant funding, debt servicing, DCC's, and any other possible funding mechanisms should be considered for the District's ultimate funding strategy moving forward.

7.7 Forecast Reliability and Confidence

The condition, valuation, and forecast renewals in this Plan are based on the best available data at the time of analysis. This data review section provides a grade of reliability for the data used for the state of infrastructure analysis for the asset portfolio. Up-to-date and accurate asset data is critical to effective asset management, accurate financial forecasts, and informed decision-making. More important than this, however, is knowing how reliable the information is. Even data that is not highly accurate can be of benefit to decision-makers provided the accuracy is declared. For this reason, the data used for the state of infrastructure analysis has been graded for reliability.

Table 7-6 provides a description for the data confidence grades used to classify the reliability of the available asset data used in the analysis for this Plan.

Table 7-8 Data Confidence Grading

Confidence Grade	Description
A – Highly Reliable	Data based on sound records, procedures, investigations and analysis, documented properly and agreed as the best method of assessment. Dataset is complete and estimated to be highly accurate.
B - Reliable	Data based on sound records, procedures, investigations and analysis, documented properly but has some minor shortcomings, for example some of the data is old, some documentation is missing and/or reliance is placed on unconfirmed reports or some extrapolation. Dataset is complete and estimated to be reasonably accurate.
C – Uncertain	Data based on sound records, procedures, investigations and analysis which are incomplete or unsupported, or extrapolated from a limited sample for which Grade A or B are available. Dataset is substantially complete but up to 50% is extrapolated data and accuracy
D – Very Uncertain	Data is based on unconfirmed verbal reports and/or cursory inspections and analysis. Dataset may not be fully complete, and most data is estimated or extrapolated.
E – Unknown	None or very little data held.

Table 7-7 provides a summary of the data confidence and the reliability of this database for application within the context of this Plan.

Table 7-9 Water System Data Confidence

Asset Type	Inventory	Condition	Remaining Useful Life	Upgrade Needs	Cost Estimates	Comments
Dam	B	B	B	B	C	Short term repairs and costs well documented, long term costs extrapolated from 2010 AMP.
Water Treatment Plants	D	D	B	B	C	Both plants recently constructed, therefore assumed no pressing issues. Some condition data available for ELWTP but not for Montizambert. Short term costs for membrane replacement known, long term costs extrapolated from 2010 AMP.
Reservoirs	B	B	B	B	B	Good condition data available. Upgrade needs based on 2016 MWSS service area demand estimates and hydraulic modelling results (hydraulic model last calibrated in 2011).
Pump Stations	B	B	B	B	B	Good condition data available. Upgrade needs based on 2016 MWSS service area demand estimates and hydraulic modelling results (hydraulic model last calibrated in 2011).
PRV Stations	B	C	B	B	B	No inspection reports, however thorough annual tear down program provides confidence in assuming assets are in good condition.
Watermains	B	C	C	B	B	Assumed condition from watermain risk model. Upgrade needs based on 2016 modelling results (hydraulic model last calibrated in 2011).

7.8 Financial Forecast Improvement Items

Table 7-8 lists the improvement actions that will improve lifecycle management asset management practices.

Table 7-10 Financial Forecast Improvement Items

Task No.	Improvement Task Name	Improvement Task Description
7.1	Operations and Maintenance Forecast	Based on lifecycle management requirements and cost tracking outcomes, develop a forecast for O&M costs that also aligns with renewals and new capital forecasts.
7.2	Funding Works required	Review of forecast expenditure vs funding/revenue streams to establish future funding constraints.
7.3	Funding Works required	The capital renewal escalation factor (CREF) used within the 5 year financial utility rate model should be reviewed periodically to ensure actual construction cost inflation is captured more accurately.

8 Continuous Improvement Plan

8.1 Overview

This Asset Management Plan builds upon the previous 2010 WSAMP and related studies completed since that time to consolidate the District's asset management policy, asset management strategy and lifecycle management planning for its water utility assets. Comparing the renewal funding requirements of the 2010 and 2020 WSAMP's reveals the new management change in financial terms.

The long term 100 year forecast from the 2020 plan is approximately $6.7 Million annually, inclusive of backlog, compared to the 2010 annual average expenditure of $4.8 Million, inclusive of backlog. Allowing for inflation, the numbers are fairly consistent in today's dollars. However, the backlog from 2020 ($34 Million) is significantly different than that described in 2010 ($15 Million).

The largest difference is due to the construction cost inflation (>200% in unit cost rates over the last 10 years), as well as immediate needs to address the system deficiencies in capacity to provide system demands, fire flows and source and system redundancies which was not part of the original 2010 WSAMP.

The main driver is the upfront costs for building new facilities, or the upgrade and update of non-linear infrastructures which have reached their end of useful life. For example, unlike replacement of a watermain which can be divided up into smaller sections and replaced through multiple years, it is not possible to build half a pump station or a quarter of a storage reservoir. The project must be completed all at once and capital investment cannot not be spread over time.

For the WSAMP to be successful, a comprehensive funding strategy must be developed to complement the asset management strategies. This Plan has been prepared to contribute to informed decision-making, improved management of risks, and a reduction in costs over time. A key purpose of the Plan is to provide an updated long-term roadmap to manage the water system assets so that costs, risks and benefits are effectively balanced over the next 100 years and to deliver a sustainable service to the community.

8.2 Improvement Plan

Improvement plan tasks have been identified at the end of each section throughout this Plan. These improvement tasks form the basis of the Asset Management Improvement Plan as shown in Table 8-1.

Table 8-1 Asset Management Improvement Plan

Task No.	Improvement Task Name	Improvement Task Description
2.1	Asset Management Policy & Procedure	Review and revise draft Capital Asset Management Policy (#0054) and Procedure (#0055).
2.2	Roles and Responsibilities	Review key asset management roles and responsibilities and identify who will fulfill these.
2.3	Resource Plan	Develop a Resource Plan to identify resource needs for completing asset management improvement tasks.
2.1	Asset Management Policy & Procedure	Review and revise draft Capital Asset Management Policy (#0054) and Procedure (#0055).
2.2	Roles and Responsibilities	Review key asset management roles and responsibilities and identify who will fulfill these.
2.3	Resource Plan	Develop a Resource Plan to identify resource needs for completing asset management improvement tasks.

Task No.	Improvement Task Name	Improvement Task Description
2.4	Asset Management Goals	Document departmental asset management goals.
2.5	Asset Management Training	Establish an asset management education and training program to support staff in learning key asset management principles and applying these to their everyday work.
3.1	Asset Hierarchy	Review the asset hierarchy to provide a consistent naming convention for data collection and reporting.
3.2	Condition Capture Plan	Review existing condition data gaps and determine a plan for collecting the data. Consider the level of effort to collect the data, as well as the anticipated impact the data will have on informing current asset management practices.
3.3	Data Updating	Design, document and implement procedure for returning field information to asset register and GIS when work is undertaken on any asset.
4.1	Levels of Service Identification	Hold workshops to identify and document existing levels of service for each asset category.
4.2	Levels of Service Performance Measures	Develop performance measures and data requirements for all levels of service. Identify which measures are Key Performance Indicators for the District.
4.3	Levels of Service Cost Identification	Identify, refine, and document existing costs for services provided.
4.4	Levels of Service Sustainability	Review the relationship between cost of service, level of service and risk, to establish if current levels of service are sustainable into the future.
5.1	Document existing lifecycle strategies	Investigate and capture any existing lifecycle strategies that staff are currently implementing. Formalize and document these strategies in this plan.
5.2	Maintenance strategies	Document information regarding roles and responsibilities; maintenance goals; typical maintenance options, methods, and protocols; decision criteria and rules for evaluating maintenance options; what maintenance performance indicators are to be tracked and reported; when to flag an asset for renewal.
5.3	Asset Valuations	Continue to review and update unit rate tables and asset lifespans, update replacement cost estimates for all assets.
5.4	Update twenty-year capital works plan	Based on the asset valuation, inventory data established, and capital planning and risk-based planning exercises conducted, update and prioritize a list of high impact projects.
6.1	Identify Critical Non-Assets	Identify and document critical non-linear assets by evaluating respective service areas and levels of redundancy in providing levels of service.
6.2	Calculate Risk Scores for Non-Linear Assets	Develop standardized risk evaluation frameworks for each group of non-linear assets, using criticality ratings and condition-based probability of failure ratings to determine risk scores for each asset.
6.3	Maintain and refine the Watermain risk model	Maintain and refine the watermain risk model inputs, as more condition information becomes available and consequence ratings are refined.
6.4	Service Level Screening and Prioritization	Refine the risk identification and screening assessment for service delivery risks to identify and prioritize high priority risks for further corporate action and mitigation.
7.1	Operations and Maintenance Forecast	Based on lifecycle management requirements and cost tracking outcomes, develop a forecast for O&M costs that also aligns with renewals and new capital forecasts.
7.2	Funding Works required	Review of forecast expenditure vs funding/revenue streams to establish future funding constraints.
7.3	Funding Works required	The capital renewal escalation factor (CREF) used within the 5 year financial utility rate model should be reviewed periodically to ensure actual construction cost inflation is captured more accurately.

8.3 Review of this plan

This Asset Management Plan is intended to be a “living” document, and as such should be reviewed regularly and amended to recognize any material changes in or understanding of service levels and/or resources available to provide those services as a result of budget decisions.

Appendix A – Summary of Water System Assets

Details of capacity, install date, estimated remaining useful life based on age, and estimated replacement value for both dams maintained by the District is provided in Table A-1.

Table A-1 Dam Summary

Dam	Asset Sub-Category	Capacity (HP)	Install or Last Renewal Date	Theoretical Useful Life (years)	Remaining Useful Life (years)	Estimated Replacement Value
Eagle Lake West	Embankment		1979	150	53	$ 6,840,000[(1)]
	Conduits		1950	100	30	$ 747,000[(2)]
	Spillway (operational)		1950	150	53	
Eagle Lake East	Embankment		1979	150	53	$ 1,369,000[(1)]
	Conduits		1950	100	30	$ 1,102,000[(2)]
	Spillway (operational)		1950	150	53	

(1) Replacement cost as given by the District of West Vancouver Water Asset Management Plan (AECOM, 2010)

(2) Replacement and/or required upgrades with cost estimates as provided in the Dam Safety Review Report (exp, 2017)

Details of capacity, install date, estimated remaining useful life based on age, and estimated replacement value for each of the District's water treatment plants is provided in Table A-2.

Table A-2 Water Treatment Plant Summary

WTP	Asset Sub-Category	Capacity (ML)	Install or Last Renewal Date	Theoretical Useful Life (years)	Remaining Useful Life (years)	Estimated Replacement Value
Eagle Lake	Facility/Structural		2008	100	88	$ 10,946,000[(1)]
	Process		2008	7	1	$ 1,000,000
	Mechanical		2008	25	13	$ 5,568,000[(1)]
	Electrical/Instrumentation		2008	25	13	$ 4,79,000[(1)]
Montizambert	Facility/Structural		2011	100	91	$ 1,488,000[(1)]
	Process		2011	10	1	$ 72,000
	Mechanical		2011	25	16	$ 819,000[(1)]
	Electrical/Instrumentation		2011	25	16	$ 594,000[(1)]

(1) Replacement cost as given by the District of West Vancouver Water Asset Management Plan (AECOM, 2010)

Details of capacity, install date, estimated remaining useful life based on age, and estimated replacement value for each of the District's reservoirs is provided in Table A-3, including 3 reservoirs currently out of service.

Table A-3 Reservoir Summary

Reservoir	Asset Sub-Category	Capacity (m³)	Install or Last Renewal Date	Theoretical Useful Life (years)	Remaining Useful Life (years)	Estimated Replacement Value
Madrona	Facility/Structural	727	1984	100	64	$ 1,441,924
	Mechanical/Process		1984	50	14	$ 57,000
	Electrical/Instrumentation		1984	25	-11	$ 35,000
Lower Nelson	Facility/Structural	766	1980	100	60	$ 1,519,276
	Mechanical/Process		1980	50	10	$ 57,000
Bonnymuir	Facility/Structural	1363	2009	100	89	$ 2,703,360
	Mechanical/Process		2009	50	39	$ 57,000
Craigmohr	Facility/Structural	1363	2009	100	89	$ 2,703,360
	Mechanical/Process		2009	50	39	$ 57,000
Ballantree	Facility/Structural	773	1986	100	66	$ 1,533,160
	Mechanical/Process		1986	50	16	$ 57,000
	Electrical/Instrumentation		1986	25	-9	$ 35,000
Cross Creek	Facility/Structural	4545	1962	100	42	$ 9,014,504
	Mechanical/Process		1962	50	-8	$ 57,000
Burnside	Facility/Structural	2273	1963	100	43	$ 4,508,244
	Mechanical/Process		1963	50	-7	$ 57,000
Millstream	Facility/Structural	796	1980	100	60	$ 1,578,778
	Mechanical/Process		1980	50	10	$ 57,000
	Electrical/Instrumentation		1980	25	-15	$ 35,000
Vinson Creek	Facility/Structural	2273	2004	100	84	$ 4,508,244
	Mechanical/Process		2004	50	34	$ 57,000
	Facility/Structural	227	1985	100	65	$ 450,229
Chairlift	Mechanical/Process		1985	50	15	$ 57,000
	Electrical/Instrumentation		1985	25	-10	$ 35,000
	Facility/Structural	1364	1989	100	69	$ 2,705,343
Chelsea	Mechanical/Process		1989	50	19	$ 57,000
	Electrical/Instrumentation		1989	25	-6	$ 35,000
Westmount (out of service)	Facility/Structural	1364	1965	100	45	$ 2,705,343
	Mechanical/Process		1965	50	-5	$ 57,000
McKechnie	Facility/Structural	7545	1970	100	50	$ 14,964,672
	Mechanical/Process		1970	50	0	$ 57,000
	Electrical/Instrumentation		1970	25	-25	$ 35,000
Cypress 1 (C1) (out of service)	Facility/Structural	-	1962	100	42	
	Mechanical/Process		1962	50	-8	$ 57,000
Cypress 2 (C2)	Facility/Structural	550	1978	100	58	$ 1,090,864

Reservoir	Asset Sub-Category	Capacity (m^3)	Install or Last Renewal Date	Theoretical Useful Life (years)	Remaining Useful Life (years)	Estimated Replacement Value
	Mechanical/Process		1978	50	8	$ 57,000
	Electrical/Instrumentation		1978	25	-17	$ 35,000
Cypress 3 (C3)	Facility/Structural	455	1975	100	55	$ 902,442
	Mechanical/Process		1975	50	5	$ 57,000
	Electrical/Instrumentation		1975	25	-20	$ 35,000
Cypress 4 (C4)	Facility/Structural	796	1975	100	55	$ 1,578,778
	Mechanical/Process		1975	50	5	$ 57,000
	Electrical/Instrumentation		1975	25	-20	$ 35,000
Upper Nelson	Facility/Structural	1364	1976	100	56	$ 2,705,343
	Mechanical/Process		1976	50	6	$ 57,000
Pasco	Facility/Structural	166	1982	100	62	$ 329,243
	Mechanical/Process		1982	50	12	$ 57,000
Lookout	Facility/Structural	897	2005	100	85	$ 1,779,100
	Mechanical/Process		2005	50	35	$ 57,000
	Electrical/Instrumentation		2005	25	10	$ 35,000
Eagle lake Clearwell	Facility/Structural	2273	2008	100	88	$ 4,508,244
	Mechanical/Process		2008	50	38	$ 57,000
Montizambert (North)	Facility/Structural	228	1979	100	59	$ 452,213
	Mechanical/Process		1979	50	9	$ 57,000
Montizambert (South) (out of service)	Facility/Structural	228	1990	100	70	$ 452,213
	Mechanical/Process		1990	50	20	$ 57,000

There are a total of 10 booster pump stations in the District water system. Details of pump station capacity, install date, estimated remaining useful life based on age, and estimated replacement value are provided in Table A-4.

Table A-4 Pump Station Summary

Pump Station	Asset Sub-Category	Capacity (HP)	Install or Last Renewal Date (1)	Theoretical Useful Life (years)	Remaining Useful Life (years)	Estimated Replacement Value
11th Street Pump Station	Facility/Structural		1963	100	43	$ 773,660
	Mechanical/Process	500	2007	25	12	$ 434,520
	Electrical/Instrumentation		2007	25	12	$ 227,840
Bonnymuir Pump Station	Facility/Structural		1982	100	62	$ 416,510
	Mechanical/Process	120	2012	25	17	$ 176,300
	Electrical/Instrumentation		2012	25	17	$ 65,560
Burnside Pump Station	Facility/Structural		1964	100	44	$ 476,940
	Mechanical/Process	200	2012	25	17	$ 237,390

Pump Station	Asset Sub-Category	Capacity (HP)	Install or Last Renewal Date (1)	Theoretical Useful Life (years)	Remaining Useful Life (years)	Estimated Replacement Value
	Electrical/Instrumentation		2012	25	17	$ 81,890
Chelsea Pump Station	Facility/Structural		1989	100	69	$ 209,360
	Mechanical/Process	80	2003, 2019	25	8	$ 198,340
	Electrical/Instrumentation		2003	25	8	$ 47,380
Craigmohr Pump Station	Facility/Structural		1989	100	69	$ 209,360
	Mechanical/Process	80	2019	25	24	$ 192,830
	Electrical/Instrumentation		2012	25	17	$ 42,420
Cross Creek Pump Station	Facility/Structural		1964	100	44	$ 514,920
	Mechanical/Process	400	2000, 2012	25	5	$ 396,680
	Electrical/Instrumentation		2000	25	5	$ 145,450
Glenmore Pump Station	Facility/Structural		1981	100	61	$ 416,510
	Mechanical/Process	150	2013, 2018	25	18	$ 236,900
	Electrical/Instrumentation		2013	25	18	$ 60,600
Vinson Creek Pump Station	Facility/Structural		1965	100	45	$ 476,940
	Mechanical/Process	150	2002, 2012	25	7	$ 232,920
	Electrical/Instrumentation		2002	25	7	$ 81,890
Westmount Pump Station	Facility/Structural		1975	100	55	$ 624,770
	Mechanical/Process	300	1994	25	-1	$ 595,020
	Electrical/Instrumentation		1994	25	-1	$ 116,800
Eagleridge Pump Station	Facility/Structural		1983	100	63	$ 104,130
	Mechanical/Process	10	2006, 2010	25	11	$ 21,490
	Electrical/Instrumentation		2006	25	11	$ 39,670

(1) Mechanical components with multiple renewal dates denote different replacement dates for 2 duty pumps. Renewal dates for electrical components are not as well documented and so are assumed to coincide with mechanical renewals as when pumps are replaced, starters and motors also often require replacing.

The District maintains and operates 35 PRV stations. Table A-5 provides information on size, install date, estimated remaining useful life based on age, and estimated replacement value for each PRV station. Unlike pump stations and some reservoirs, the majority of PRV stations do not have any significant electrical or instrumentation components. The notable exceptions are 11th Street and Westmount PRVs, where Maintenance Connection lists electrical components.

Table A-5

PRV Stations	Asset Sub-Category	PRV Size (mm, lead/lag)	Install or Last Renewal Date (1)	Theoretica l Useful Life (years)	Remaining Useful Life (years)	Estimated Replacement Value
Westport Road	Facility/Structural		1988	100	68	$ 41,500
	Mechanical/Process	75/150	1988	50	18	$ 41,500

PRV Stations	Asset Sub-Category	PRV Size (mm, lead/lag)	Install or Last Renewal Date [1]	Theoretical Useful Life (years)	Remaining Useful Life (years)	Estimated Replacement Value
Cranley	Facility/Structural		1972	100	52	$ 41,500
	Mechanical/Process	200	1972	50	2	$ 41,500
5168 Meadfield Rd	Facility/Structural		1986	100	66	$ 41,500
	Mechanical/Process	50/150	1986	50	16	$ 41,500
Terrace	Facility/Structural		1956	100	36	$ 41,500
	Mechanical/Process	150	1956	50	-14	$ 41,500
Almondel	Facility/Structural		2003	100	83	$ 41,500
	Mechanical/Process	100/200	2003	50	33	$ 41,500
Eagle Lake Rd	Facility/Structural		1965	100	45	$ 41,500
	Mechanical/Process	150	1965	50	-5	$ 41,500
3323 Bayridge Ave	Facility/Structural		2006	100	86	$ 41,500
	Mechanical/Process	150	2006	50	36	$ 41,500
4626 Woodgreen Dr	Facility/Structural		2010	100	90	$ 41,500
	Mechanical/Process	200	2010	50	40	$ 41,500
Nelson	Facility/Structural		1977	100	57	$ 41,500
	Mechanical/Process	50/150	1977	50	7	$ 41,500
6775 Marine Dr	Facility/Structural		1979	100	59	$ 41,500
	Mechanical/Process	50/150	1979	50	9	$ 41,500
McKechnie	Facility/Structural		1963	100	43	$ 41,500
	Mechanical/Process	150	1963	50	-7	$ 41,500
5983 Marine Dr	Facility/Structural		1974	100	54	$ 41,500
	Mechanical/Process	200	1974	50	4	$ 41,500
Northwood	Facility/Structural		1986	100	66	$ 41,500
	Mechanical/Process	100/150	1986	50	16	$ 41,500
Seascapes	Facility/Structural		2006	100	86	$ 41,500
	Mechanical/Process	150/200	2006	50	36	$ 41,500
School Board	Facility/Structural		1992	100	72	$ 41,500
	Mechanical/Process	50/150	1992	50	22	$ 41,500
Crossway	Facility/Structural		2002	100	82	$ 41,500
	Mechanical/Process	150	2002	50	32	$ 41,500
11th St	Facility/Structural		1961	100	41	$ 41,500
	Mechanical/Process	100/150	1961	50	-9	$ 41,500
	Electrical/Instrumentation		1961	25	-34	$ 35,000
Meadfield Wynd	Facility/Structural		2006	100	86	$ 41,500
	Mechanical/Process	50/150	2006	50	36	$ 41,500

PRV Stations	Asset Sub-Category	PRV Size (mm, lead/lag)	Install or Last Renewal Date [1]	Theoretical Useful Life (years)	Remaining Useful Life (years)	Estimated Replacement Value
Chairlift	Facility/Structural		1985	100	65	$ 41,500
	Mechanical/Process	50/100	1985	50	15	$ 41,500
Cross Creek	Facility/Structural		1966	100	46	$ 41,500
	Mechanical/Process	100/200	1966	50	-4	$ 41,500
Folkestone Way	Facility/Structural		1973	100	53	$ 41,500
	Mechanical/Process	75/100	1973	50	3	$ 41,500
Mathers	Facility/Structural		1982	100	62	$ 41,500
	Mechanical/Process	150/250	1982	50	12	$ 41,500
Upper Nelson	Facility/Structural		1976	100	56	$ 41,500
	Mechanical/Process	100/150	1976	50	6	$ 41,500
Westmount	Facility/Structural		1980	100	60	$ 41,500
	Mechanical/Process	75/150/200	1980	50	10	$ 41,500
	Electrical/Instrumentation		1980	25	-15	$ 35,000
Eagle Lake C2	Facility/Structural		2000	100	80	$ 41,500
	Mechanical/Process	150	2000	50	30	$ 41,500
Welch St	Facility/Structural		2001	100	81	$ 41,500
	Mechanical/Process	75/200	2001	50	31	$ 41,500
20th St & Inglewood Ave	Facility/Structural		1989	100	69	$ 41,500
	Mechanical/Process	150/300	1989	50	19	$ 41,500
25th St & Mathers Ave	Facility/Structural		2014	100	94	$ 41,500
	Mechanical/Process	200	2014	50	44	$ 41,500
2376 Westhill Dr	Facility/Structural		2013	100	93	$ 41,500
	Mechanical/Process	200	2013	50	43	$ 41,500
Benbow	Facility/Structural		1991	100	71	$ 41,500
	Mechanical/Process	100/150	1991	50	21	$ 41,500
Chippendale	Facility/Structural		1982	100	62	$ 41,500
	Mechanical/Process	100	1982	50	12	$ 41,500
	Electrical/Instrumentation		2012	100	92	$ 41,500
Barnham	Facility/Structural	150	2012	50	42	$ 41,500
	Mechanical/Process		2015	100	95	$ 41,500
Gleneagles	Facility/Structural	100/250	2015	50	45	$ 41,500
	Mechanical/Process		2015	25	20	$ 35,000

(1) The District has a thorough maintenance regime of annual teardowns where repairs and component replacements are addressed as necessary. The years represented here denote install date or major replacements.