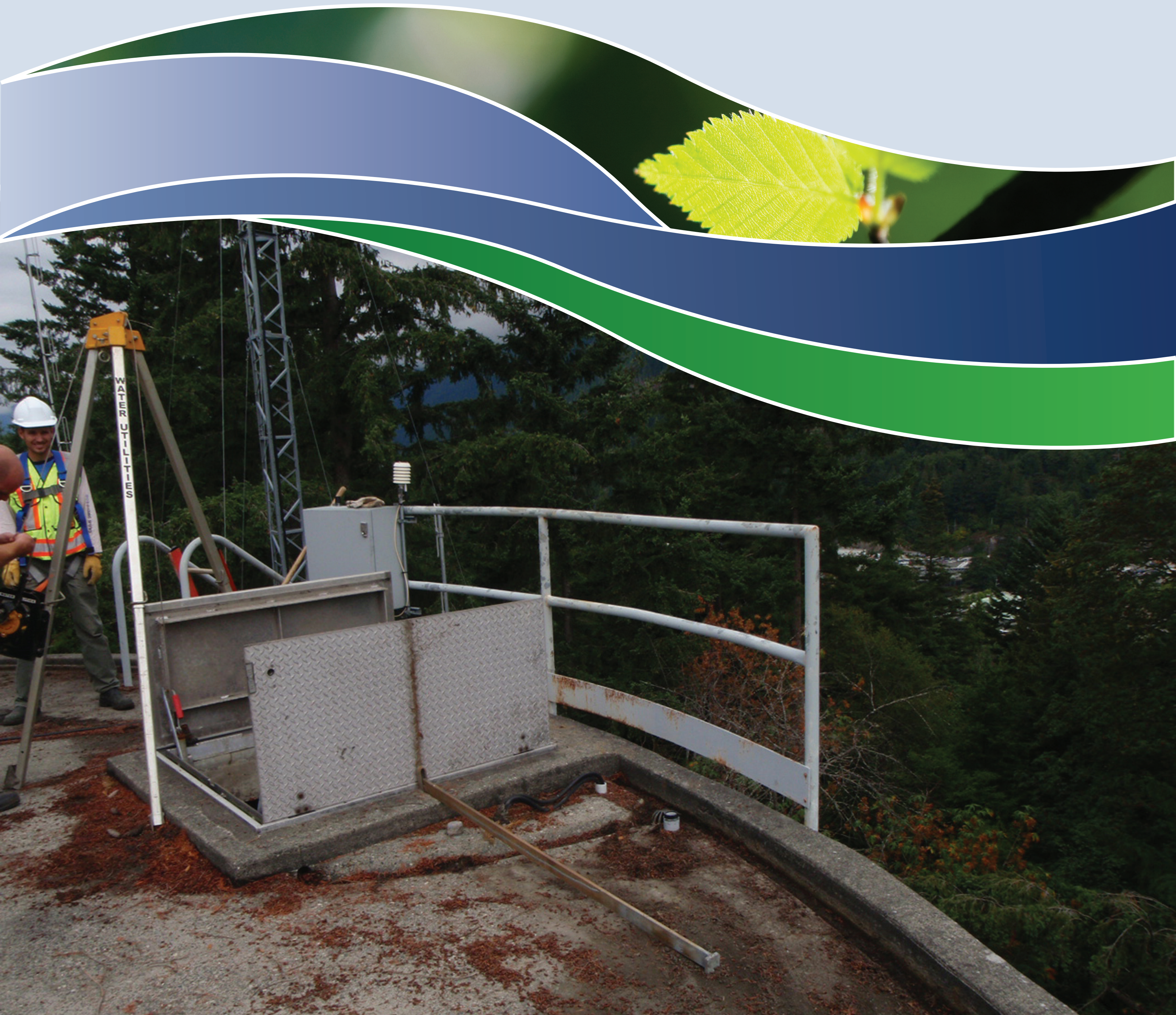
west vancouver

AECOM

Water Asset Management Plan

District of West Vancouver

February 24, 2010



AECOM

District of West Vancouver

Water Infrastructure Long Range Capital Renewal Forecast

FINAL REPORT

Prepared by:

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Project Number:

111064 (60118727)

Date:

February 24, 2010

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February 24, 2010 Project Number: 111064

Phil Bates, P. Eng.
Manager, Engineering Services
District of West Vancouver
750 17th Street
West Vancouver, V7V 3T3

Dear Phil,

Re: Report for West Vancouver's Water Infrastructure Long Range Capital Renewal Forecast

Please find attached our final report for West Vancouver's Water Infrastructure Asset Management Plan. We thank you for the opportunity to work with you on this interesting project.

Sincerely,
AECOM Canada Ltd.

Nancy Hill

Nancy Hill, P.Eng.
Project Manager
Nancy.hill@aecom.com

Encl:

NH

Version Log

Version #	By	Date	Description
1	AL/NH	October 22, 2009	1st complete draft
1	NH	October 29, 2009	Added figure 8.3 and submitted the document in MS-Word
2	NH	January 19, 2010	Revised based on comments received from West Vancouver, Dec 22, 2009
3	NH	February 10, 2010	Revised based on comments received from West Vancouver, Feb 3,2010
4	NH	February 18, 2010	Revised based on comments received from West Vancouver, Feb 17,2010
5	NH	February 24, 2010	Revised based on comments received from West Vancouver, Feb 24,2010

Signature Page

Report Prepared By:	Report Reviewed By:
Nancy Hill, P.Eng.	David Main

Executive Summary

Within its water system the District of West Vancouver owns and operates 320 km of watermain, 14,075 service connections, 4,323 valves, 1,250 hydrants, 2 dams, 2 water sources (Eagle Lake and Montizambert Creek), 1 (soon to be 2) water treatment plants, 2 creek diversion structures, 22 reservoirs, 10 pump stations, 3 chlorination stations, 30 water sampling stations, 1 power generation turbine and 29 pressure reducing valves. The replacement value for the system is estimated at $272 million. This study provides the District of West Vancouver with a long range forecast (100 years) of the financial resources required to support the renewal of all of West Vancouver's potable water assets.

Figure ES.1 below shows the potable water system's renewal requirements over the next 100 years in 2009 dollars. The figure demonstrates that the potable water system will have an average replacement requirement of $3.7 million per year over the next 100 years (backlog included). West Vancouver has approximately $15 million of 'backlog', which is shown in year 2009. This backlog represents water assets that are due for renewal, based on their age and/or condition, but have not yet been addressed.

Figure ES.1 Water System Annual Replacement Requirements 100 Year Forecast

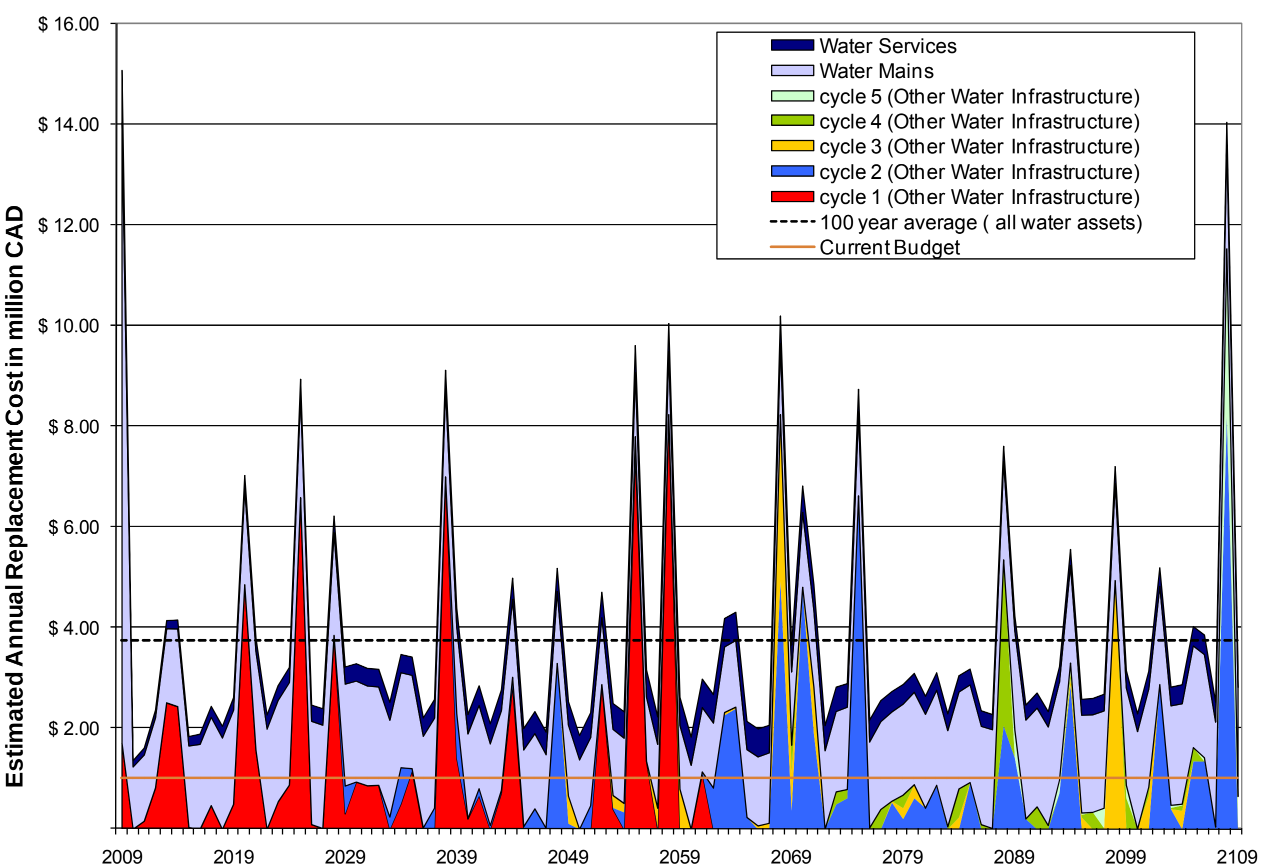
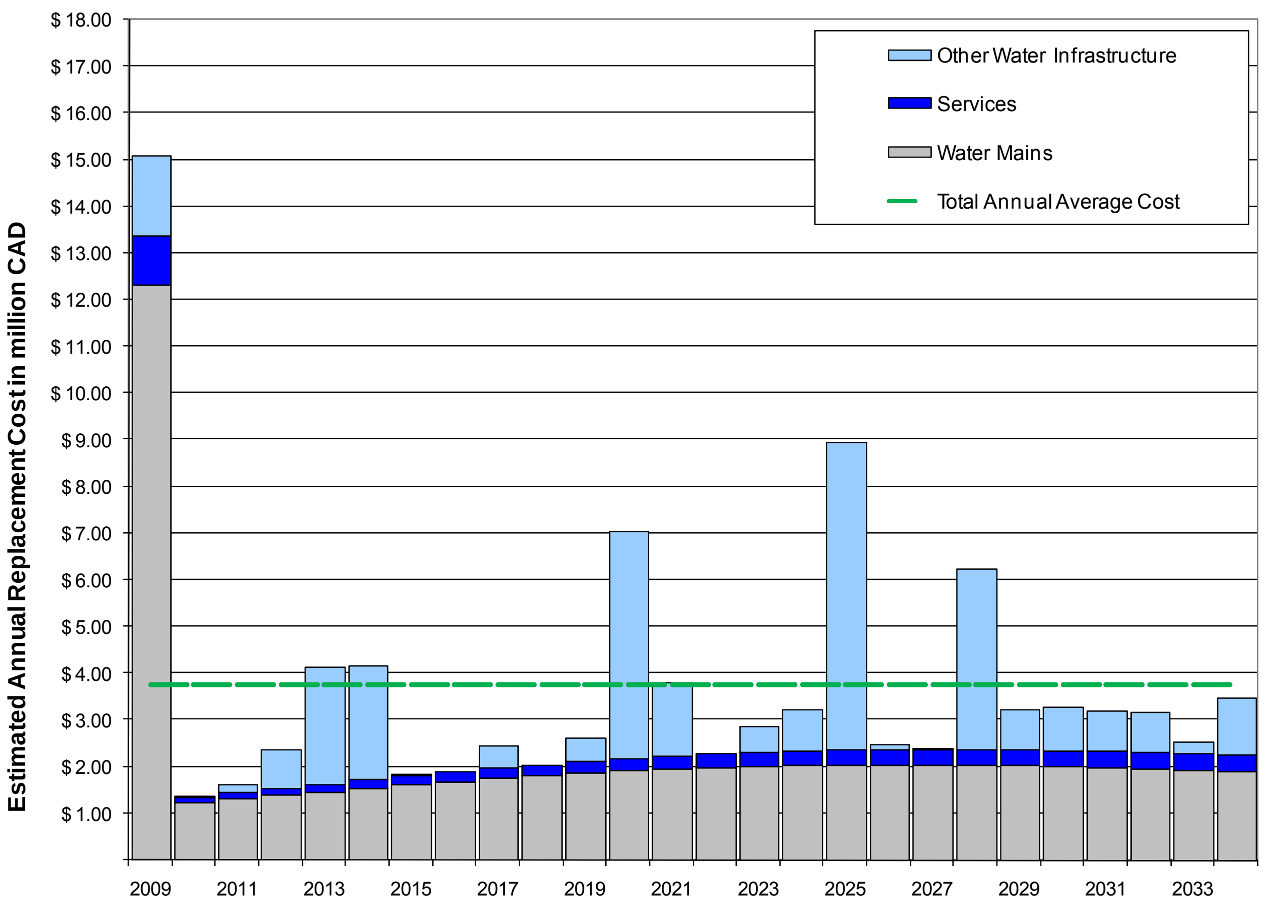


Figure ES.2 shows that the average annual estimated capital replacement for the next 25 years is also $3.7 million (backlog included). Currently, West Vancouver allocates $1,000,000 per year for water infrastructure renewal projects (not including the work conducted under the Eagle Lake Development Plan or for the Montizambert Water Treatment Plant).

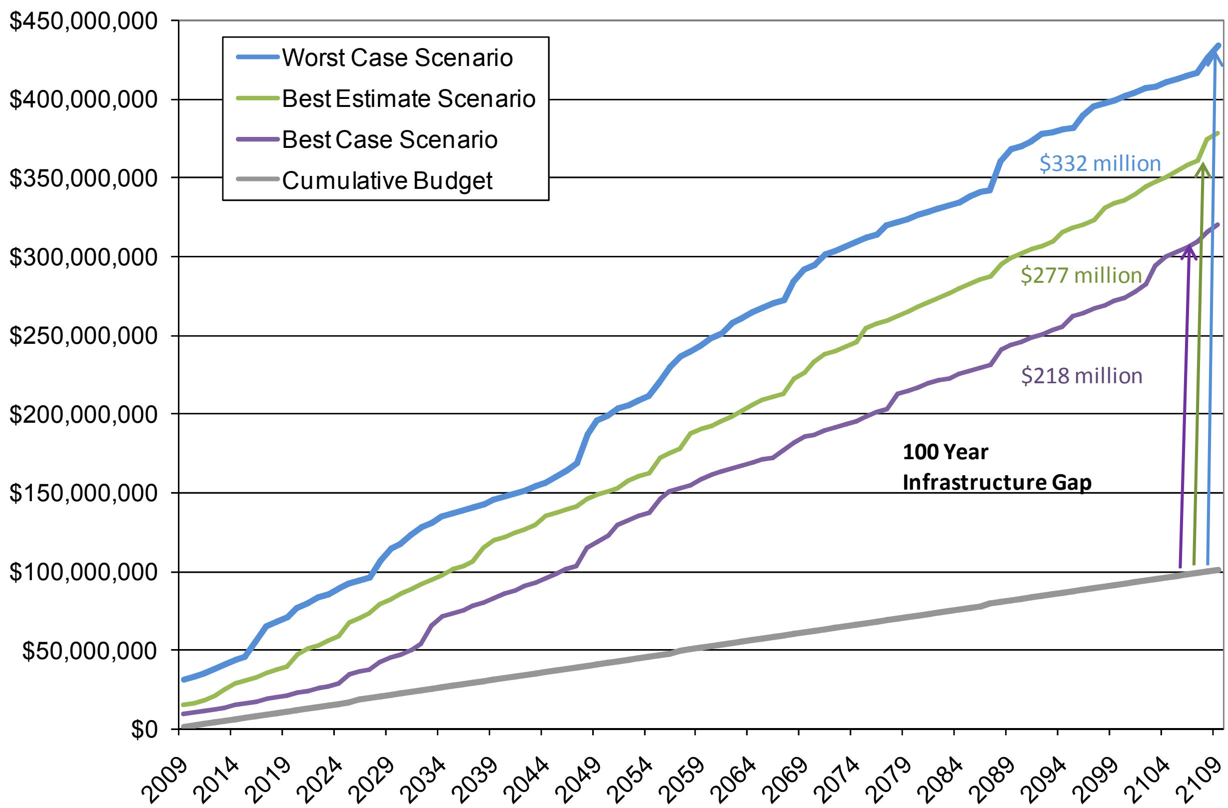
Figure ES.2 Annual Replacement Requirements - 25 Year Forecast



The financial projections in Figures ES.1 and ES.2 are based on typical lifespan estimates. Changing these estimates will impact the capital renewal forecast as demonstrated in Figure ES.3.

Figure ES.3 shows how the anticipated renewal requirements (cumulative) compare with the existing budget level under three scenarios. The first scenario represents our best estimate of the lifespan of West Vancouver's water assets (as depicted in ES.1 and ES.2). The best case scenario shows the water system renewal requirements if the assets last longer than expected and the worst case scenario shows the water system renewal requirements if the assets don't last as long as expected. The difference between the renewal requirements and the existing budget is known as the "infrastructure gap". Under all three scenarios there is an anticipated infrastructure gap; $218 - $332 million over the next 100 years.

Figure ES.3 Projected Infrastructure Gap – Three Scenarios

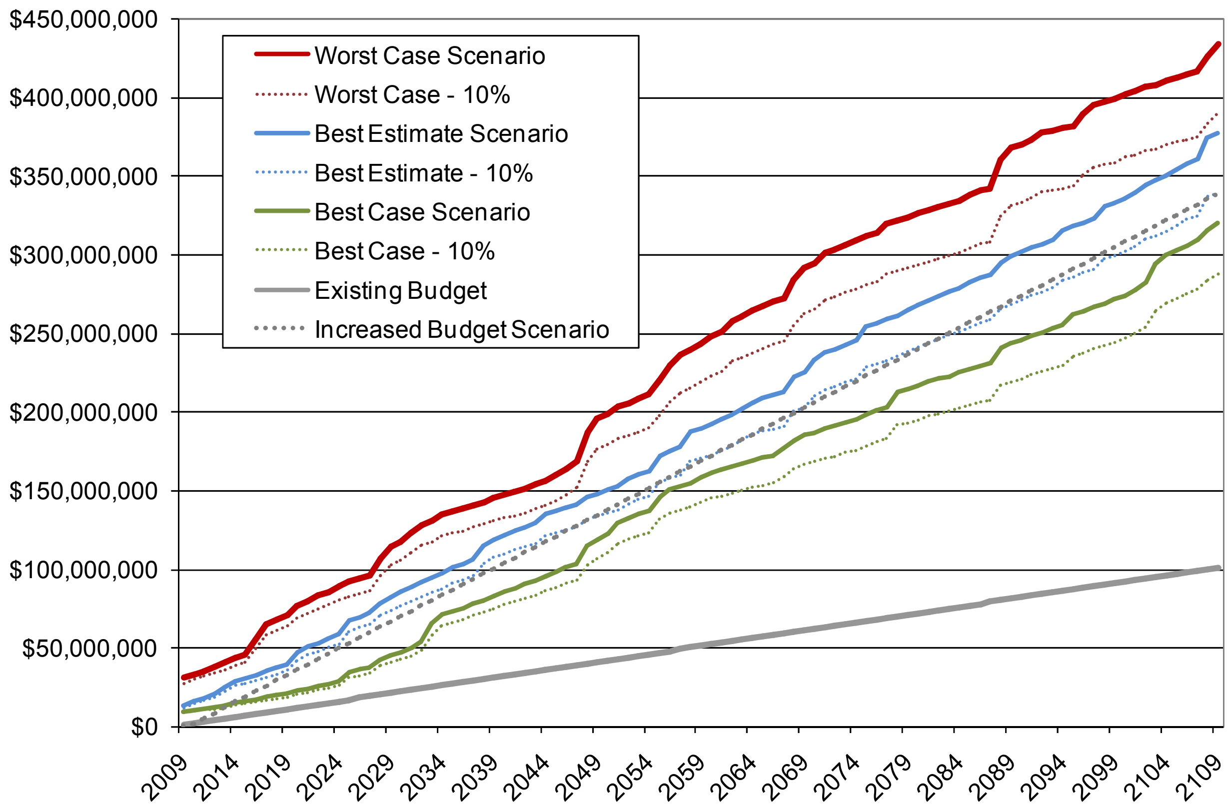


In general the anticipated infrastructure gap can be addressed by increasing the water renewal budget and by optimizing the life cycle costs of assets. West Vancouver can reduce the lifecycle costs of its assets through an effective preventative maintenance program, by identifying the most cost effective renewal strategy for each asset, and by coordinating capital works wherever possible. West Vancouver should also ensure that the cost of development driven infrastructure renewal projects are partially or wholly funded by the development itself so that capital renewal programs are funded in an equitable manner.

This study has adhered to present day best practices for performing strategic level asset management. A "needs-based" approach has been taken to estimate annual resource requirements that give consideration to our current knowledge of asset life spans, and current replacement costs.

The relationships shown in Figure ES.4 illustrate the benefit of reducing lifecycle costs by 10% for each scenario, and provide a potential funding strategy that satisfies theoretical asset replacement requirements. This solution reflects one possible way that resources could be implemented throughout their lifecycle, not necessarily how those resources would be provided. Consideration has not been given to factors that might either accelerate renewal efforts (e.g. elevation of risk or criticality, resource levelling, opportunistic cost sharing), or decelerate renewal efforts (e.g. short term affordability). Additional factors, including future reserve policies, remain a subject for continued public debate. Ultimately, a "budget-based" approach to asset management will govern the extent to which West Vancouver will manage assets in a sustainable fashion over the short and long term.

Figure ES.4 **Addressing the Infrastructure Gap**



The results of this study illustrate the need for West Vancouver to continue its preventative maintenance program and to increase its water capital renewal budget. Effective communication is critical to educate and engage stakeholders to assist in meeting the upcoming challenges associated with the management of the District's infrastructure.

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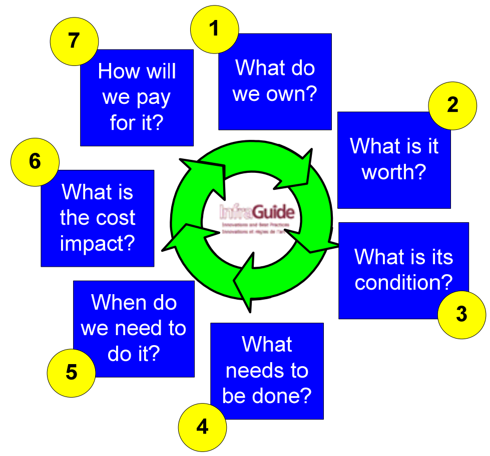
Appendices

1. Introduction

Figure 1.1 Seven Questions of Asset Management



The District of West Vancouver commissioned this study to develop a long range forecast (100 years) of water infrastructure renewal requirements to ensure the financial sustainability of its infrastructure in perpetuity.

To help West Vancouver meet its objectives, AECOM developed this Asset Management Plan using the "Seven Questions of Asset Management" approach that is recommended by InfraGuide's "Best Practice for Managing Infrastructure Assets". The results of each of the seven steps shown in ***Figure 1.1*** are outlined in this report.

This project leveraged work recently completed to satisfy PSAB reporting requirements and is being complemented by similar plans for West Vancouver's sanitary and stormwater systems. The results of this plan can be used to assist in developing infrastructure renewal budgets, identifying replacement priorities, determining water rates and communicating infrastructure needs to stakeholders.

This plan covers all components within West Vancouver's water system; namely 320 km of water mains, 14,075 service connections, 4323 valves, 1,250 hydrants, 22 reservoirs, 10 pump stations (PS), a power generation turbine, the Eagle Lake water treatment plant (WTP), 29 pressure reducing valves (PRV), 30 water sampling stations, 3 chlorination stations, and the Upper Nelson and Black Creek Diversions.

The renewal forecast for this study was completed using an MS-Excel based Capital Asset Planning (CAP) model. An electronic version of this model, with instructions for updating it, will be provided to West Vancouver. A print out of the water system inventory from the model is provided in Appendix A. It is important to note that this model and the findings in this report provide a current "snapshot" of West Vancouver's water infrastructure. If the system changes, such as the upgrade of an existing pump station or the replacement of a section of water main, then the model needs to be updated accordingly.

All costs estimates have been prepared using current (2009) dollars in order to facilitate year to year comparisons and to avoid the uncertainty of projecting inflation and discount rates far into the future.

2. Asset Inventory "What do we own?"

2.1 Data Sources

The GIS information on water main length and installation dates for water mains and trunks was initially obtained from the GISOFFLINE_WATER_TRUNKS_line and GISOFFLINE_WATER_MAINS_line shapefiles provided by West Vancouver in February 2009. An analysis of the data showed that a significant proportion of the water mains were installed in 1977 or had unknown installation dates.

The GIS group of West Vancouver reviewed the installation dates for the water mains in their system, providing revised data in a WATERMAINS3 shapefile, in May 2009.

Water mains identified as being owned by Metro Vancouver or the Park Royal shopping centre were removed from the asset inventory. Assets not belonging to the District of West Vancouver should be clearly labelled as such within GIS.

We assumed that the small length of 1500 mm pipe was actually 150 mm as this pipe was located in a residential neighbourhood and was not surrounded by other trunk mains.

Within the GIS database there were a variety of abbreviations given for the same material type. Table 2.1 below outlines the various abbreviations within the GIS database and what material type was assumed for this study. We recommend that the District adopt standard nomenclature for data such as pipe material to facilitate the collection and analysis of asset information.

Table 2.1 – Assumptions for the Nomenclature of Material Type

Pipe material	Listed as
Asbestos Cement	AC, tr
Aluminum	ALUM
Cast Iron	CI, C1
Copper	CU, SU
Ductile Iron	DI, DINA
Galvanized Steel	Ga, GAL
High Density Polyethylene	HDPE, SC, PE
Polyvinyl chloride	PVC
Steel	ST, STL
Vitrified Clay	VC, CP

West Vancouver has 14,075 service connections. Information on water service connections was obtained from the TEMPEST spreadsheet GISOFFLINE_GIS_SERVICE_WATER_VIEW provided by West Vancouver. There was one connection with an installation date of 1886. It was assumed that the actual installation date was 1986.

Information on the reservoirs, pump stations, power generation turbine, Eagle Lake water treatment plant, pressure reducing valves, SCADA systems and the Upper Nelson and Black Creek Diversions was provided to AECOM through the West Vancouver spreadsheet titled " DWV-#333844-v1-ASSET_PROJECT-WATER_SYSTEM". Additional information on PRVs was obtained from the West Vancouver document titled "DWV #229508-v2- VALUATION_ OF_INFRASTRUCTURE_ ASSET_SYSTEMS".

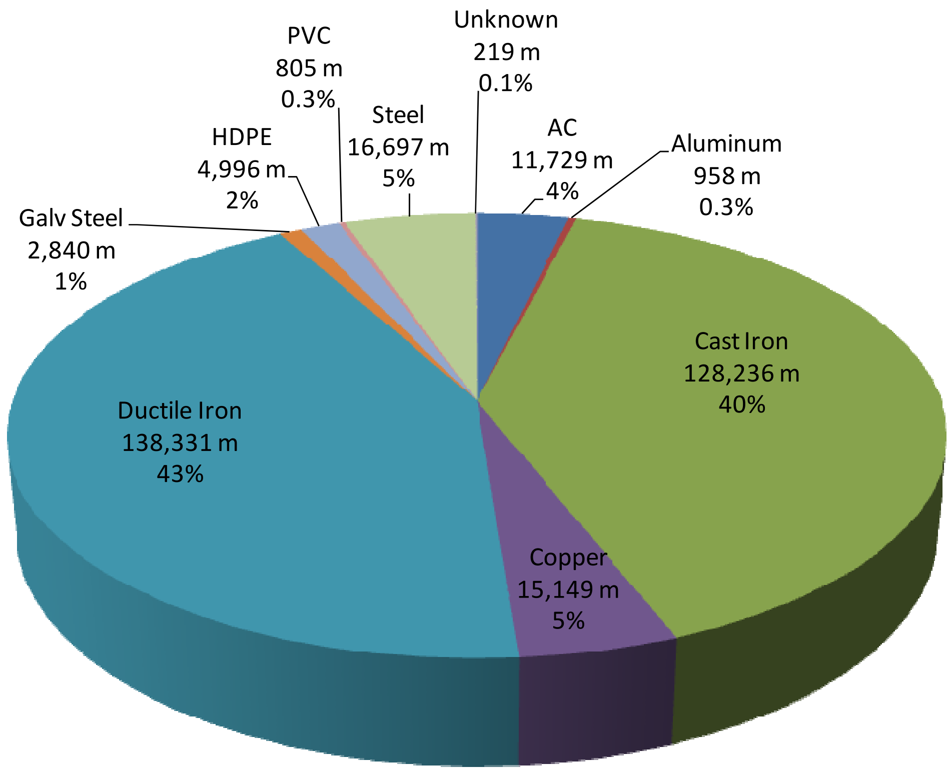
2.2 Asset Inventory Summary

West Vancouver owns and operates 320 km of water mains, 14,075 service connections, 4323 valves, 1,250 hydrants, 10 pump stations, the Eagle Lake intake and water treatment plant, Montizambert Creek source and treatment system, a power generation turbine, 22 reservoirs, 30 sampling stations, 29 pressure-reducing valves, 3 chlorination stations, and the Upper Nelson and Black Creek Diversions.

West Vancouver obtains water both from its own sources including: Eagle Lake, and Montizambert Creek, and from the GVWD which is typically provided from the Capilano or Seymour reservoirs. Water from the GVWD is purchased in bulk and currently supplies approximately 50-60% of West Vancouver's water. Eagle Lake supplies the western part of West Vancouver, while Montizambert Creek supplies the area north of Horseshoe Bay.

A summary of the attributes of existing water distribution mains is provided in Figures 2.1-2.3. Figure 2.1 shows that the majority of the water mains(83%) are comprised of cast iron (CI) or ductile iron (DI) pipe.

Figure 2.1 Length of Water Mains (in metres) by Material Type



It should be noted that the asset inventory used for this asset management plan only includes active assets and does not include any assets that have already been replaced.

As shown in Table 2.2 the current water distribution system has been constructed relatively evenly over the last 60 years, without the pronounced construction humps experienced in the sanitary and storm systems. Most of the sanitary sewers were constructed in the 1960's and 1970's when the Lion's Gate Wastewater Treatment Plant was built. However, since 1980 only 56 km of sanitary sewers have been built compared to 126 km of water main. In addition to servicing development in new areas, these new water mains were constructed to increase system capacity and to replace broken or leaky water mains.

Appendix E shows the location of water and sanitary mains that have been constructed before and after 1980.

Table 2.2 Installation of Water, Sanitary Sewer and Stormwater Mains by Decade

	Length of Installation (m)		
Decade of Installation	**Water**	**Sewer**	**Stormwater**
pre 1950	47,583	0	1,082
1950 - 1959	44,656	0	1,541
1960 -1969	60,788	175,641	33,615
1970 - 1979	40,606	103,778	83,568
1980 - 1989	48,745	27,419	62,029
1990 - 1999	43,146	16,253	36,399
2000 - 2009	34,323	12,055	16,848
TOTAL	**319,847**	**335,146**	**235,083**

Figure 2.2 shows that Cast Iron (CI) pipes were primarily installed during the early construction of the water system from 1947 through 1974. Ductile Iron (DI) water mains were primarily installed after 1974.

Figure 2.2 – Construction of the Current Water Distribution System by Material Type

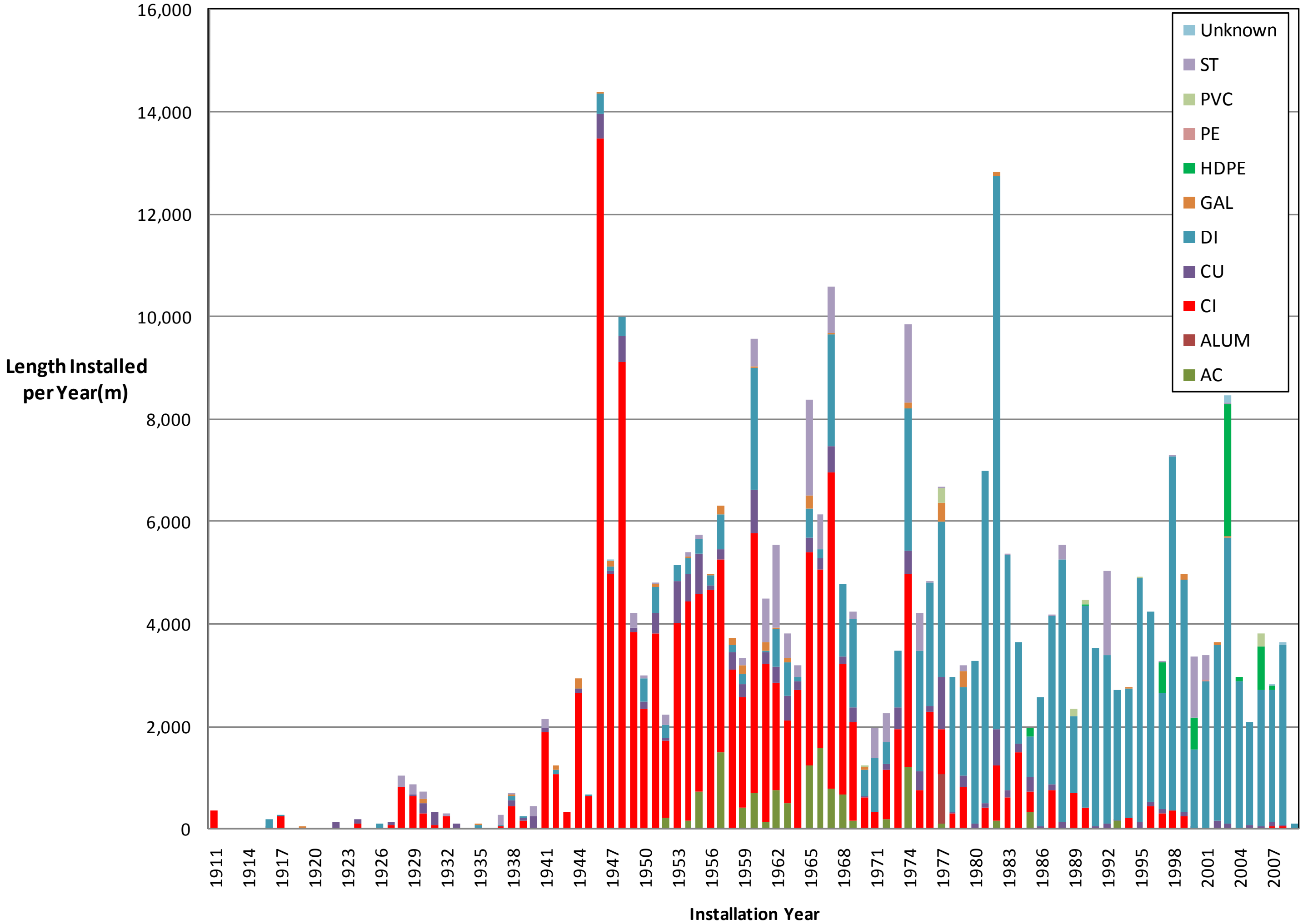
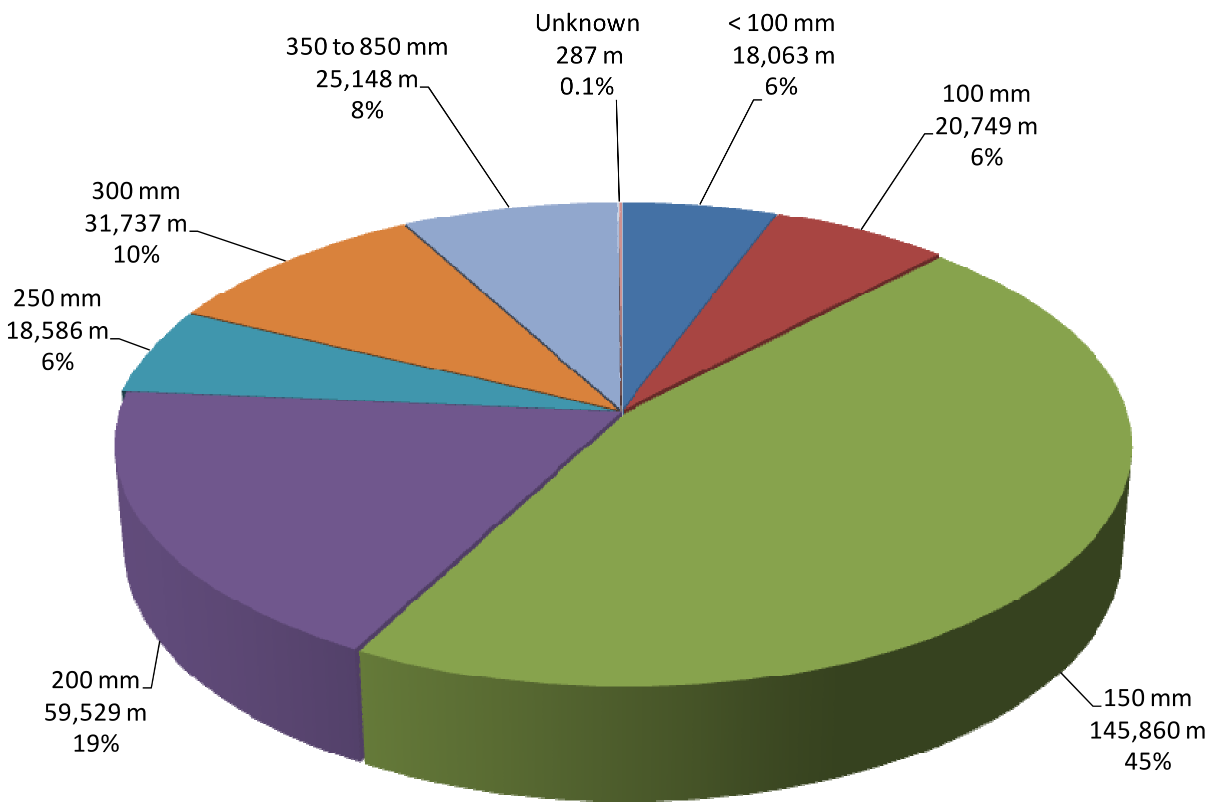


Figure 2.3 shows that 45% of West Vancouver's water distribution system consists of 150 mm diameter water main, and 19 % of the water distribution system consists of 200 mm diameter water main. The largest water main owned by West Vancouver has a diameter of 850 mm.

Figure 2.3 – Length of Water Main (in metres) by Diameter



3. Replacement Costs: "What is it worth?"

Table 3.1 shows the unit replacement costs (in 2009 dollars) used in this analysis for water mains. The estimated unit replacement costs were developed based on records of recent construction costs in the District of West Vancouver and other municipalities in the Lower Mainland. The unit costs include all appurtenances such as fire hydrants and valves but do not include water services.

Table 3.1 Unit Replacement Costs for Water Mains

Pipe Diameter (mm)	Unit Cost ($/m)
<250	$500
250	$600
300	$670
350	$700
400	$700
450	$700
500	$700
550	$800
600	$850
650	$850
660	$850
750	$1,200
850	$1,400
Unknown Pipe Diameter	$550

These costs are higher than figures typically used elsewhere in the Lower Mainland. The higher construction costs may be due to the need for frequent rock-blasting, the inability to use native soil as backfill, and the fact that West Vancouver does not always have utility right-of-ways.

Table 3.2 presents the replacement costs for service connections used in this analysis.

Table 3.2 Unit Replacement Costs for Service Connections

Service Connection (mm)	Unit Cost ($/connection)
<50 mm	$2000
≥50 mm	$3000

The replacement values for the pump station, reservoirs, chlorination stations, and the Upper Nelson and Black Creek Diversion were obtained from West Vancouver's PSAB asset information located within document "DWV-#333844-v1-ASSET_PROJECT-WATER_SYSTEM". The replacement values were converted to 2009 dollars using the Engineering News Record (ENR) index of construction price inflation. Additional information on PRVs was obtained from the PSAB information within the District's document "DWV #229508-v2- VALUATION_OF_ INFRASTRUCTURE_ ASSET_SYSTEMS".

The replacement value of the Eagle Water Treatment Plan was established at $16 million through personal communication with West Vancouver. Additionally, the replacement value of the Eagle Lake Dam (West) and the Eagle Lake Dam (East) were established as $5,000,000 each through personal communication with the District of West Vancouver. One of the Eagle Lake Dams is constructed of earth. For the long term financial forecast, it was assumed that the earth dam would need to be rehabilitated (at an estimated cost of $1,000,000) rather than replaced.

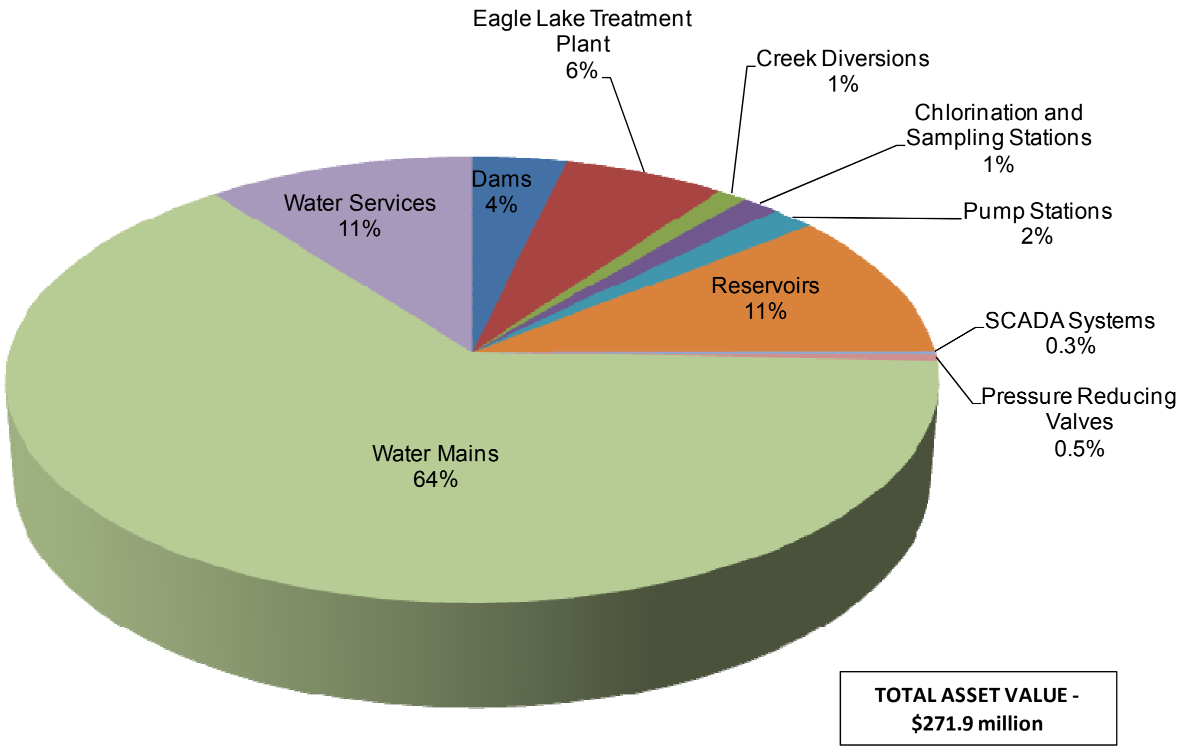
The renewal requirements of the planned Montizambert water treatment plant, which will be installed in 2011, were also included in the analysis. The replacement value for this asset was set at $2.5 million based on personal communication with the District of West Vancouver. It was assumed that the existing Montizambert chlorination station would not be replaced once the new water treatment plant was installed.

Table 3.3 and Figure 3.1 present the breakdown of the replacement value (in 2009 dollars) of West Vancouver's water system by asset type.

Table 3.3 – Current Asset Inventory of West Vancouver's water system

Infrastructure Type	Replacement Value
Dam Infrastructure	$10 million
Eagle Lake Treatment Plant & Intake	$17.2 million
Creek Diversions	$3.2 million
Chlorination Stations	$4 million
Pump Stations	$4.7 million
Reservoirs	$28.7 million
SCADA Systems	$0.8 million
Pressure Reducing Valves	$1.3 million
Water Mains	$173.5 million
Water Services	$28.5 million
TOTAL	**$271.9 million**

Figure 3.1 – West Vancouver's Asset Inventory by Replacement Value



4. What is its Condition?

West Vancouver regularly inspects its reservoirs, pump stations, chlorination stations, pressure-reducing valves (PRVs) and hydrants to ensure that they are in good operating condition. West Vancouver does not conduct regular inspections of its water mains. The best information available to approximate the condition of West Vancouver's water mains is the age of the mains and their break history. For the purpose of this long range plan, age was used as a proxy for water main condition.

The water main break history was reviewed to help determine the average service lives for water mains in West Vancouver (see Section 6). West Vancouver can also use their water main break data to prioritize specific water mains for replacement as part of a bottom-up asset management plan (see Section 6.4).

The Capital Asset Planning (CAP) model was designed to allow the District of West Vancouver to refine the capital renewal forecast with condition assessment and risk ratings for their infrastructure, as information comes available. The District of West Vancouver can therefore enter a condition rating from 1 (good) to 5 (poor) for the different components of their infrastructure. These condition ratings, along with the average expected service life for each asset type, can be used to help determine when each asset needs to be replaced (see Section 6).

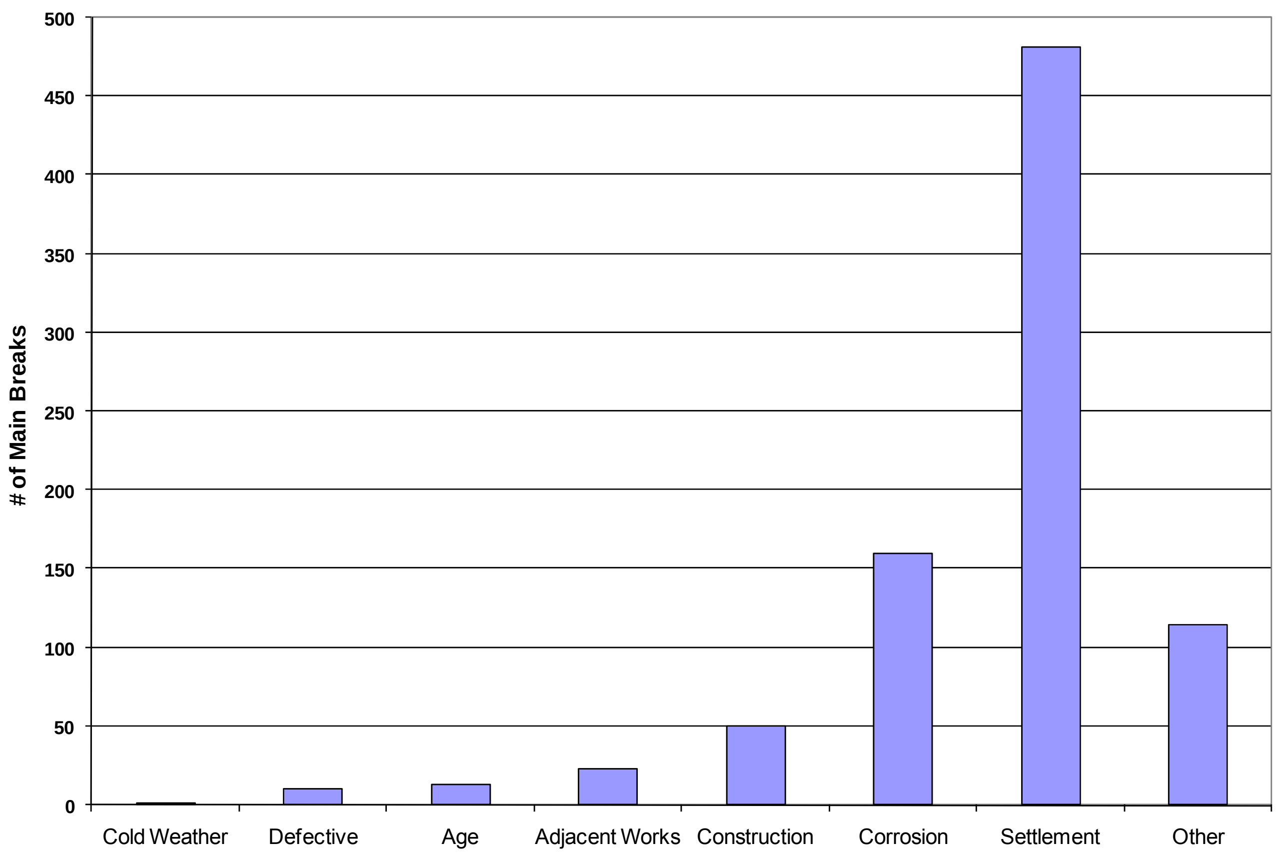
Condition ratings were determined for those few assets where condition assessment information was readily available (i.e. some reservoirs). Reservoir condition information was obtained from document DWV-#232684-v1-RESERVOIR_INFORMATION. When more condition assessment information is available, the capital renewal forecast could be further refined.

4.1 Water Mains

Water main break history has been tracked by West Vancouver staff since 1983. The water main break data was mapped and analysed to identify trends and to assist in renewal planning. The water main break maps are provided in Appendix C.

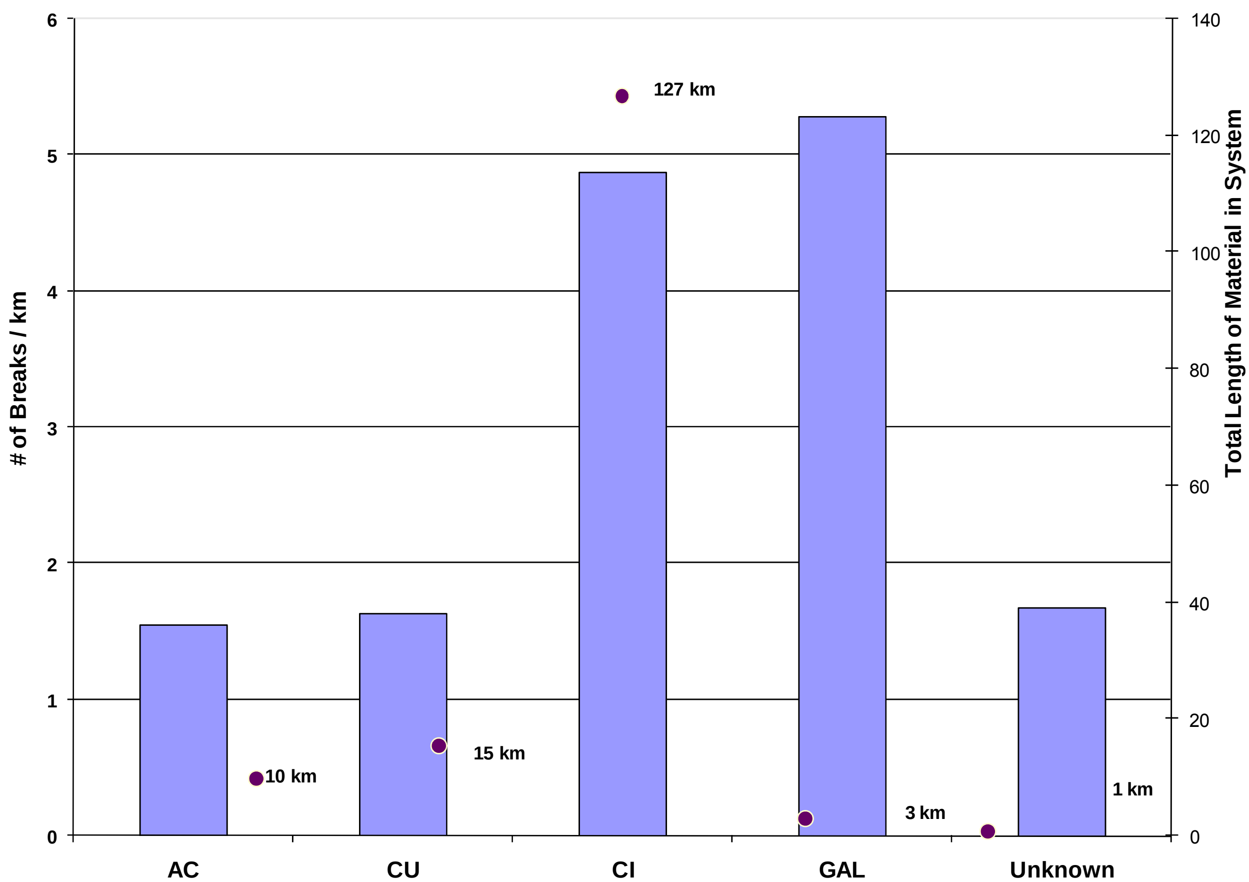
The water main break data collected by West Vancouver shows that the majority of water main breaks are due to settlement, as can be seen in Figure 4.1. This is not surprising due to the steep and rocky terrain found in West Vancouver.

Figure 4.1 # of Main Breaks (1983-2008) by Cause



The majority of the breaks have occurred in cast iron water mains, as can be seen in Figure 4.2. Cast iron pipe is a brittle material that would be susceptible to cracking during settlement.

Figure 4.2 Main Breaks (1983 - 2008) by Material / Material Length (km)



Based on the fact that the majority of the breaks occurred in cast iron pipe, a more in depth analysis of the cast iron water main breaks was conducted to further identify any trends. In other municipalities in the Lower Mainland, AECOM has found that cast iron from certain eras (i.e. thin walled cast iron installed in the 1960's) was more prone to failure and accordingly has a shorter service life.

In West Vancouver cast iron pipe installed since 1951 has experienced a significant number of breaks in the last 26 years (i.e. 1983 – 2008). Much of the pipe has experienced between 9 and 16 breaks per kilometre which is equivalent to one break every 1.5 to 2.5 years. In addition, pipes installed in certain years, such as 1955 and 1963, have experienced an extraordinarily high number of breaks per kilometre. These sections of pipe still appear to be in operation and are scattered throughout West Vancouver.

The results of the water main break analysis helped in determining estimated service lives for water mains of different material types, which are presented in Section 6.2. West Vancouver can also use the results of the water main break analysis to help identify priorities for water main testing and renewal; particularly as part of a bottom-up asset management plan (see Section 6.4).

Figure 4.3 shows the number of water main breaks for West Vancouver (DWV) in comparison with various cities across Canada and compares it with the average age of the water distribution system. In addition to impacting customers, water main breaks will affect operational staff availability. Figure 4.4 shows West Vancouver's unplanned maintenance hours for its water system, a significant proportion of which is a result of staff responding to water main and service breaks.

Figure 4.3 Number of Water Main Breaks in West Vancouver per Year in Comparison with Other Cities in the National Water and Wastewater Benchmarking Initiative

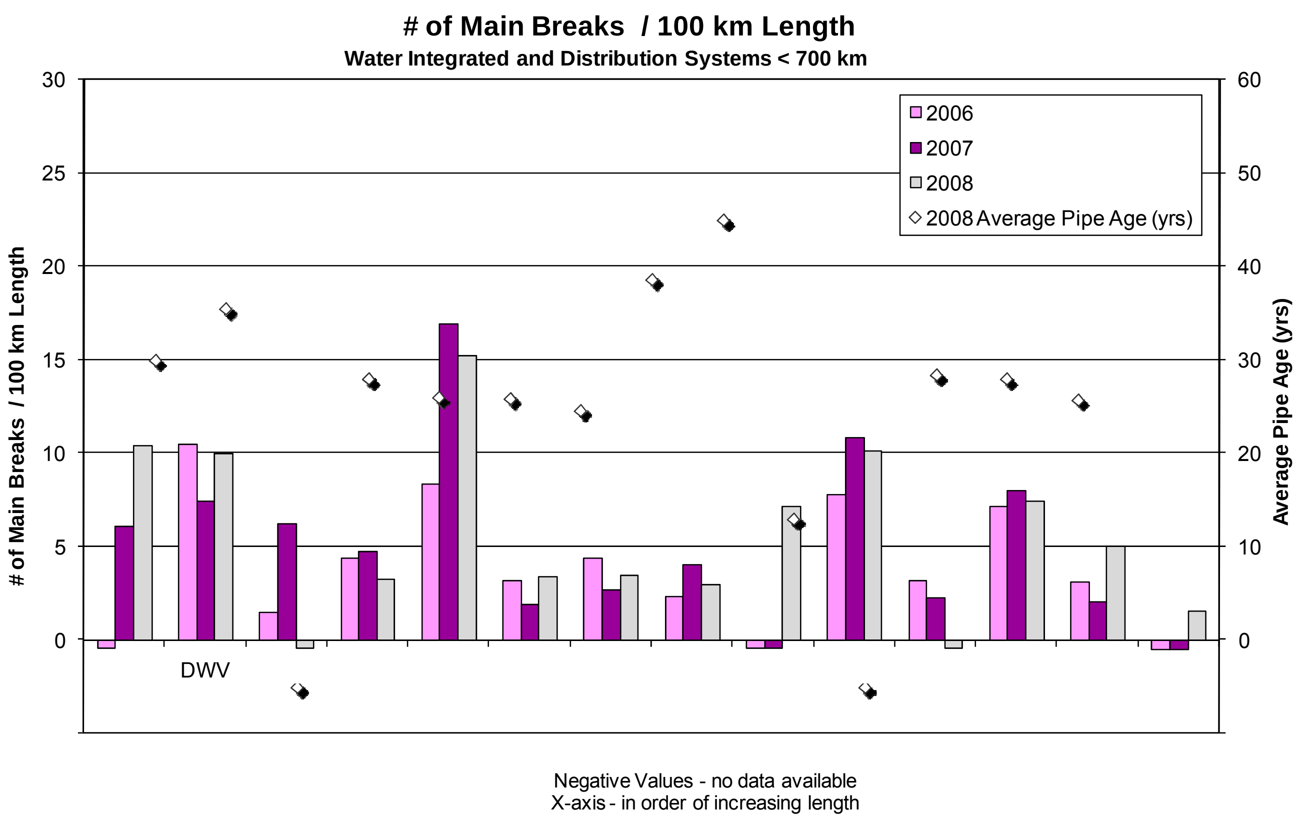
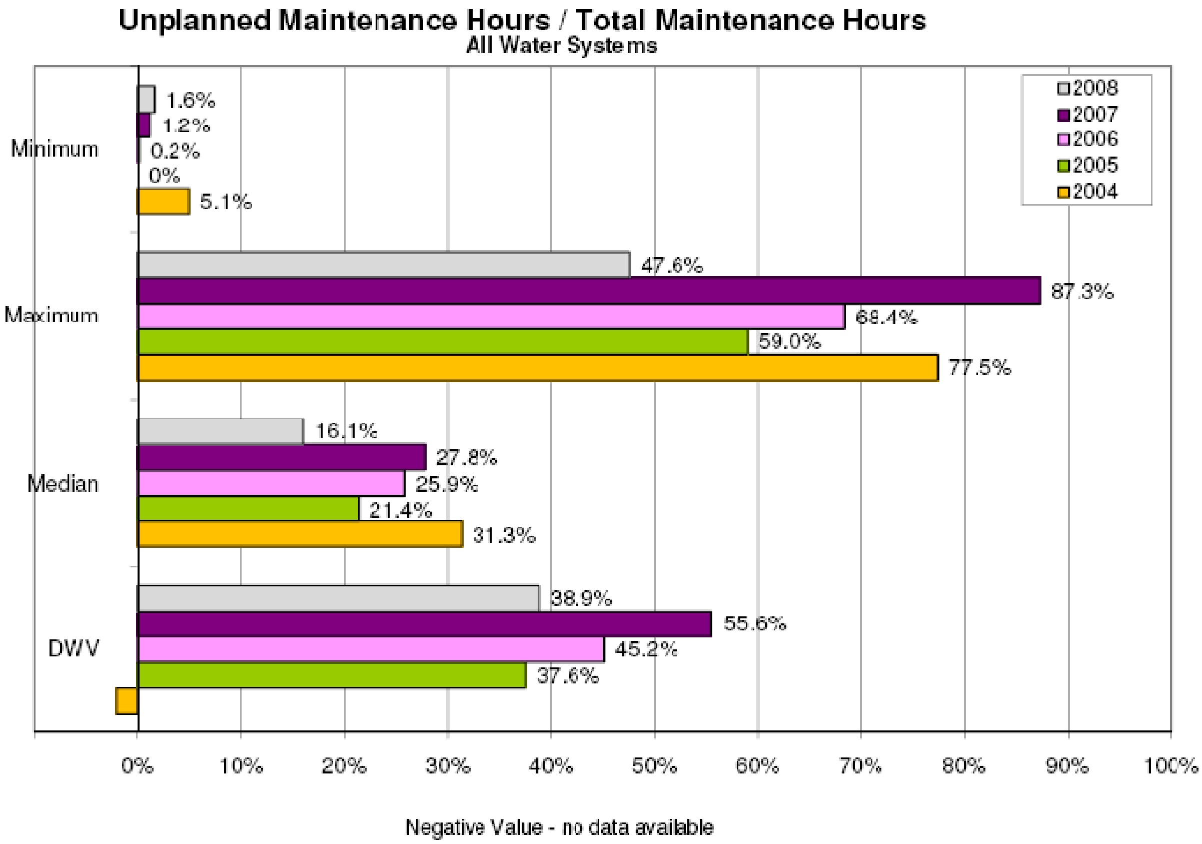


Figure 4.4 West Vancouver's Unplanned Maintenance Hours in Comparison with Other Cities in the National Water and Wastewater Benchmarking Initiative



If West Vancouver expands its water main renewal program, the number of water main breaks should decrease, thereby decreasing the number of unplanned maintenance hours. This will free West Vancouver operations staff to work on their preventative maintenance program (as discussed in Section 5).

4.2 Water Services

Water service break history has been tracked by West Vancouver staff since 2001. This information was used to approximate the condition of the water services. From 2001 to 2008 the District attended to 646 leaking services, an average of 80 services per year. A map showing the water service breaks is provided in Appendix D.

Although the water services may last on average 70 years, 40% of the breaks were on pipes that were less than 30 years old. Therefore, as presented in Section 6.2, an estimated service life for water services of 70 years was used with a Weibull distribution that predicts a portion of the connections failing before 30 years of age.

4.2.1 Identifying Water Services for Replacement

The District of West Vancouver would like to determine which water services it should replace within a roadway that is about to be paved. Currently West Vancouver aims to replace any water service that is 30 years or older, before paving a street, depending on available budgets. In general, the older a service the more likely it is to break but the data doesn't suggest that there is a sudden increase in the probability of a service breaking after 30 years of age.

To determine the likelihood of a water service requiring repair within 5 years of a street being paved, we have developed a variety of scenarios based on the assumption that there are 20 water services within a block. If all of the water services within a block were 20 years old then the probability of one of the water services breaking within 5 years of the street being paved is 36%. If all of the water services were 30 years old then the probability of one of the water services breaking within 5 years of the street being paved is 50%.

The probability of one water service within a block of breaking within 5 years is significant. The high number of breaks may be due to the steep rocky terrain found throughout West Vancouver. However, the District may want to review its water service design/installation standards to see if it can make changes that reduce the number of water service breaks. An initial investigation into water service design standards could be achieved within the National Water and Wastewater Benchmarking Initiative.

5. What Needs to be Done?

To sustain the functionality of West Vancouver's water system, numerous preventative and corrective maintenance activities must occur, and asset renewals must be made. In general, maintenance practices impact renewal requirements as effective preventative maintenance programs will help to extend the life of a given asset. In addition, some operational activities such as managing the quality and pressure of the water within the system can extend the life of water infrastructure and reduce or delay the need for rehabilitation and replacement.

West Vancouver currently has a preventative maintenance program for its water infrastructure but there remain some areas where this program could be further enhanced. For example, West Vancouver currently does not have a valve cycling program in place, which is typical of other municipalities. A program of this nature could increase the longevity of West Vancouver's water valves and reduce costly emergency repairs.

Once it is determined that an asset needs rehabilitation or replacement, West Vancouver must determine the best approach to renewing that asset. By selecting appropriate technologies, municipalities can then make capital improvement, operations, and maintenance decisions in the best interests of the community they serve. The National Guide to Sustainable Municipal Infrastructure produced a Best Practice Report titled "Selection of Technologies for the Rehabilitation or Replacement of a Water Distribution System". The InfraGuide Best Practice Reports can be found at http://www.sustainablecommunities.fcm.ca/Infraguide/Best_Practice_Reports.asp.

As this study provides a high level view of asset renewal requirements, the maintenance and rehabilitation of specific assets – such as the rebuilding of aging pumps – has not been identified. Instead, all assets are assumed to require replacement at the end of their predicted service life, which provides a more conservative approach to budgeting than if rehabilitation strategies were also considered. The estimated cost of renewing West Vancouver's water assets is presented in Section 7.0.

6. When Do We Need To Do It?

The CAP (Capital Asset Planning) model predicts the replacement year of an asset based on its age, the expected service life for the type of asset, its condition, and the consequences associated with its failure. In reality, replacement may also be based on externalities such as development or new regulations but as these externalities are largely unknown at this time they have not been considered in this analysis. The model assumes that the whole asset category (i.e. the entire mechanical system for a given pump station) is replaced at the same time.

The model is well suited for developing long term financial projections for a group of assets but it is not an appropriate tool for determining short term capital programs. Identifying specific assets for replacement in the short term should be done in consultation with inspection results, maintenance records, capacity requirements, replacement programs of other utilities and roadways, and an understanding of the risk associated with a given asset failing.

6.1 Risk

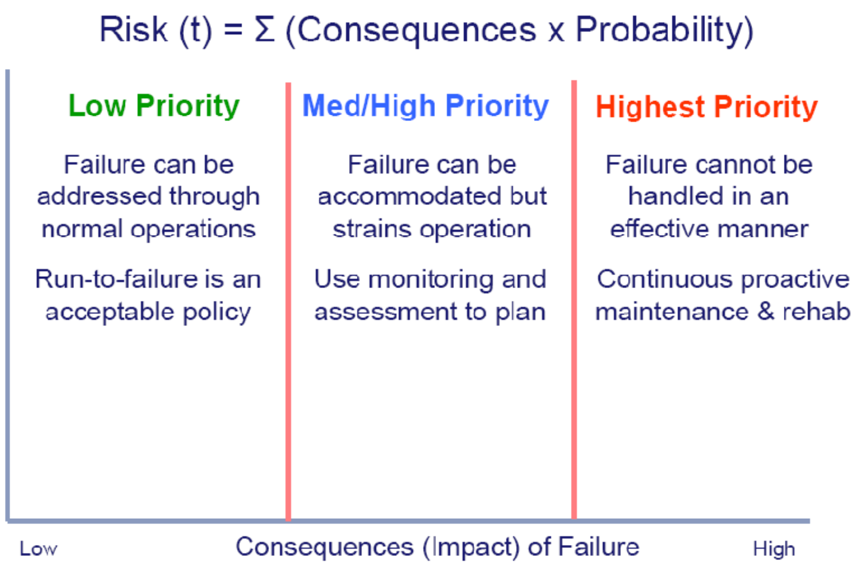
The risk associated with an asset failing can be determined by multiplying the probability of an asset failing by the consequences of it failing (defined as its criticality). The CAP model determines the probability of an asset failing based on its age, expected service life (for the given type of asset) and condition (where known).

Risk Exposure = Consequences of Failure x Probability of Failure

The CAP model allows users to input a criticality rating to capture the consequences of an asset failing. As asset criticality has not yet been formally determined for West Vancouver's water system, a criticality rating was not used for this analysis. This extra level of refinement could be done in a second more detailed renewal forecast.

Once West Vancouver determines the criticality of different assets within its water system it could also use a risk based approach to determine maintenance practices and short term capital renewal programs. A risk based approach, as outlined in Figure 6.1, will allow West Vancouver to determine the most cost-effective strategy for maintaining an asset based on the consequences of failure.

Figure 6.1 Risk-based Approach to Asset Renewal Planning



6.2 Expected Service Life for Different Asset Types

A water main's service life depends on many factors – material, quality of installation, soil conditions, and disturbances by adjacent construction. Of these factors, West Vancouver, like most municipalities, only has reliable information on the material of its water mains. Fortunately, various industry sources exist that estimate a water main's typical service life based on its material type.

Table 6.1 summarises information on the estimated service life of water mains that were collected from the experience of various municipalities in British Columbia and a survey from the National Water and Wastewater Benchmarking program. The table also outlines the service lives that were used in this study.

Table 6.1 Estimated Average Service Lives (years) for Water Mains by Material Type

Pipe material	Used for this analysis	Port Moody	City of Vancouver	West Van PSAB	Canadian-wide Benchmarking Survey	Prince George
Asbestos Cement	50	50		100	86	80
Aluminum	100			100		
Cast Iron	75		100 for pre 1957; 65 for 1963- 1969 and 80 for 1958 - 1962	100	84	80
Copper	65	65	63	100		
Ductile Iron	100		100	100	87	
Galvanized Steel	100	100		100		
High Density Polyethylene	85			100	85	80
Unknown	85			100		
Polyvinyl chloride	85			100	87	80
Steel	85		40 from 1930 to 1950 90 years for Transmission mains or riveted or welded steel	100	86	80

Although we have assumed that a given pipe, such as ductile iron (DI), will last on average 100 years, not all DI pipes will fail at exactly 100 years of life. To simulate this reality, we used the Weibull probability distribution to model a replacement envelope and predict pipe failure as the network ages. This means that a portion of the pipes will fail before their expected service life and a portion will last beyond their expected service life.

Any pipe of an unknown material has been given an estimated service life of 85 years based on the average weighted service life of the water main infrastructure with known pipe material.

As the majority of the pipes are cast iron and ductile iron, the estimated average service lives for these two materials will have the largest impact on the study findings. As described in Section 6.3, we have tested the sensitivity of the service lives used in the CAP model for cast and ductile iron water main.

As discussed in Section 4.2 we assumed that service connections would have an average service life of 70 years but we also used the Weibull probability distribution to model the replacement of water service connections in West Vancouver. The installation dates for service connections were obtained from West Vancouver's inventory in the TEMPEST system.

To complete the analysis, the pump stations, chlorination stations and the Eagle Lake water treatment plant were divided up into their civil (i.e. structural), mechanical, electrical and SCADA components. Table 6.2 presents the average expected service life for each group of infrastructure components.

Table 6.2 Estimated Average Service Lives for Pump Stations, Chlorination Stations and Treatment Plant by Asset Type

Asset Type	Estimated Service Life
Civil	50 years
Mechanical	30 years
Electrical	20 years
SCADA	20 years

Estimated average service lives for the Eagle Lake pumping system components and the Creek Diversions were obtained from the service lives listed in the PSAB inventories completed by West Vancouver.

The average expected service life of the PRV's was estimated to be 25 years based on discussions with the supplier Corix. A 25 year service life can be expected where a regular preventative maintenance program is in place, as is the case in West Vancouver.

Table 6.3 summarises the estimated average service lives for the remaining water assets.

Table 6.3 Estimated Average Service Lives for Other West Vancouver Water Assets

Asset Type	Estimated Service Life
Reservoirs	50 years
Dam	100 years
Black Creek Diversion	50 years
Upper Nelson Creek Diversion	35 years
PRV	25 years
Power Turbine	50 years
Sampling Stations	50 years

6.3 Sensitivity Analysis

Sensitivity analysis was used to test some of the recommended asset service lives, as shown in table 6.4. Through this, best and worst case financial scenarios for renewal funding were developed, the outcome of which is discussed in Section 8.

The sensitivity analysis was conducted only on the assets that represent the system's most significant cost components. Water mains represent 60% of the 25 year total costs and 46% of the 100 year total costs. The majority of the water mains (83%) are cast iron (CI) or ductile iron (DI). Eighty percent of the value of the pump stations and the water treatment plants consists of their civil and mechanical components. Together, these assets comprise 70% of the total value of the water system. The following table shows the range of estimated service lives used to complete the sensitivity analysis.

Table 6.4 Ranges of Estimated Average Service Lives Used

Asset Type	Estimated Average Service Life (years)		
	Worst Case	Best Estimate	Best Case
Cast Iron Water Mains	65	75	90
Ductile Iron Water Mains	80	100	120
Reservoirs	40	50	70
Black Creek Diversion	15	50	65
Civil (WTP and PS)	40	50	70
Mechanical (WTP and PS)	20	30	40

The impact of using a range of estimated average service lives on the long term financial forecast can be seen in Section 7.

6.4 Bottom-up Asset Renewal Planning

This asset management plan represents a "top-down" approach to renewal planning, which is appropriate for strategic long-term planning and estimating future renewal budgets. A "bottom-up" asset renewal plan identifies specific assets for replacement based on priority and is critical for optimising available renewal budgets.

The bottom-up approach, which is used for short-term capital planning of projects, outlines asset renewal priorities based on asset condition and criticality. It is therefore important that West Vancouver determine the condition and criticality of its assets in order to develop a bottom-up water asset renewal plan.

7. How Much Will It Cost?

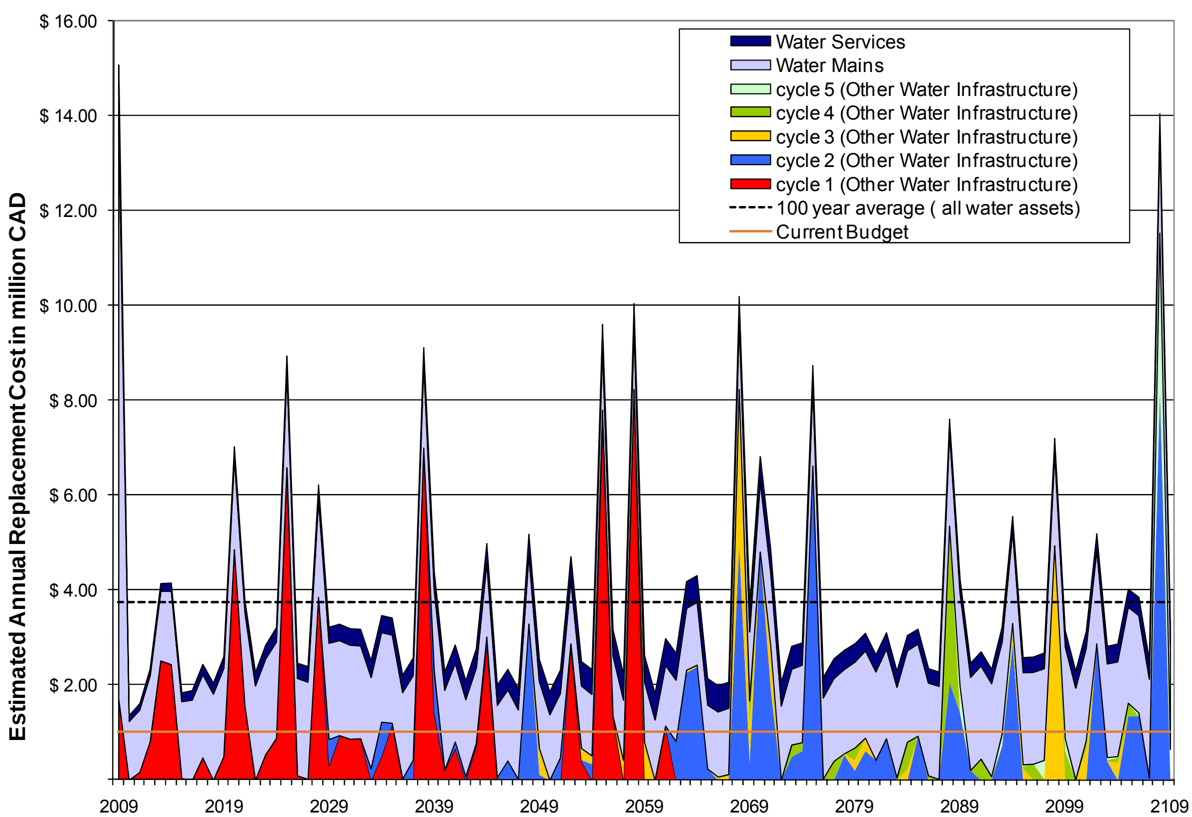
This study estimates required capital renewal budgets over the long term, which facilitates the setting of capital budgets and associated water rates. The District will still need to develop a prioritized short term capital renewal plan which identifies specific assets for renewal.

7.1 Long Range Forecast

The main objective of this study was to provide West Vancouver with a long range forecast of future water infrastructure renewal requirements. Costs presented in this report are all in 2009 dollars, in order to provide a consistent view for year to year comparisons. If inflation were included, then it would be difficult to see if future cost increases were due to aging infrastructure or simply due to the selected inflation rate.

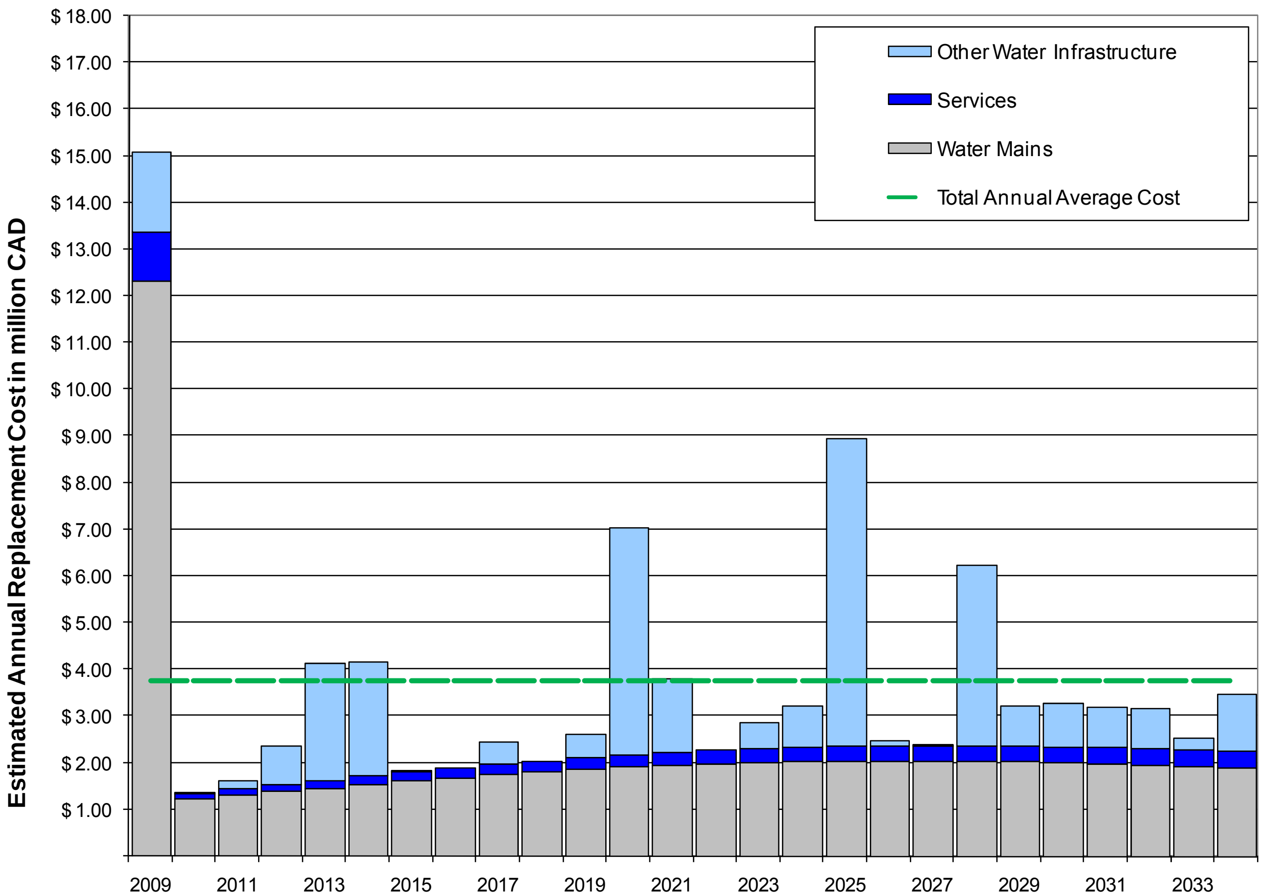
Figure 7.1 shows the total annual capital replacement costs predicted by the CAP model for the next 100 years. There is currently $15 million of "backlog" which is shown in the year 2009. This "backlog" represents water assets that are due for renewal, based on their age and/or condition, but have not yet been addressed. The average capital renewal cost over the next 100 years is $3.7 million per year (backlog included).

Figure 7.1 Water System Annual Replacement Requirements 100 Year Forecast



If we take a 25 year view, as shown in Figure 7.2, we can see that the average capital replacement cost estimated over the next 25 years is also $3.7 million per year (backlog included).

Figure 7.2 - 25 Year Annual Capital Renewal Costs



As described in Section 6.3 a range of estimated service lives for different asset types was used to determine the sensitivity of key assumptions. The total capital renewal forecast using the original estimate of service lives as well as the worst and best case scenarios are presented in Figure 7.3. Figure 7.4 shows the total capital renewal forecast for the three scenarios over the next 25 years.

Figure 7.3 Total Annual Replacement Requirements Using a Range of Estimated Service Lives (100 year view)

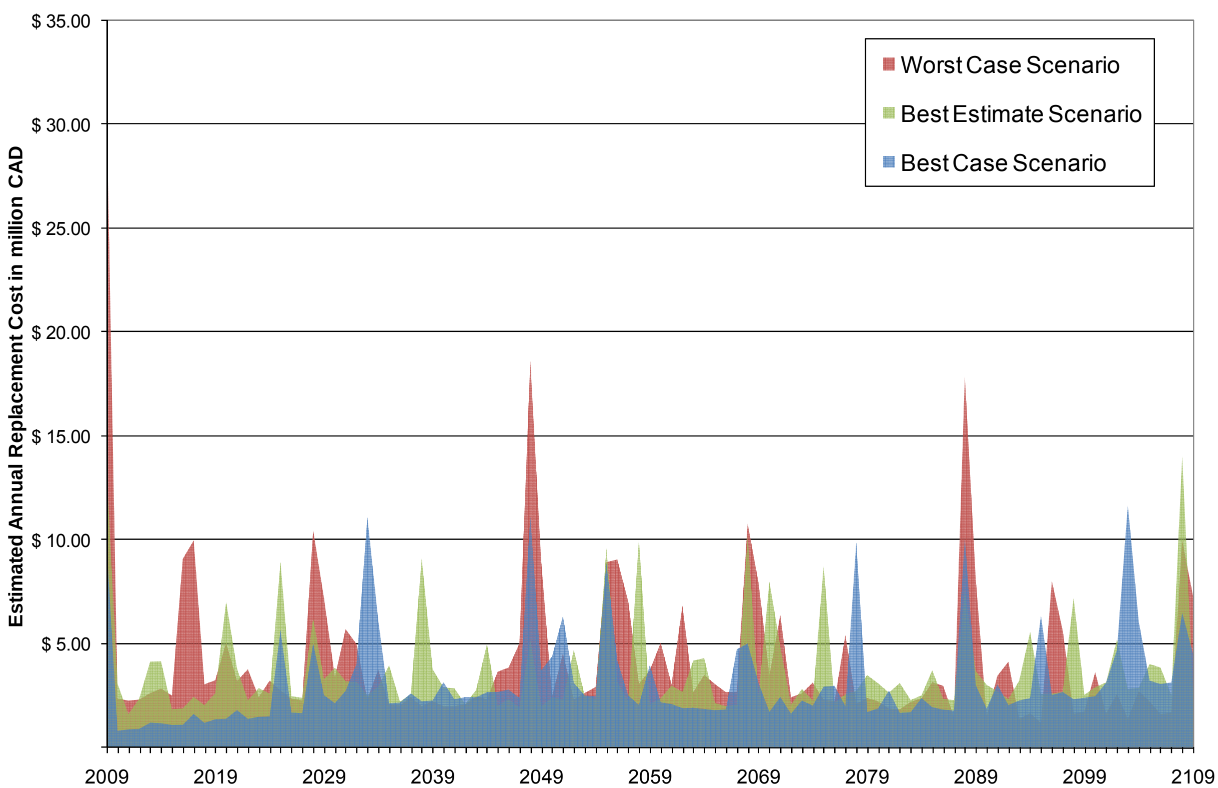
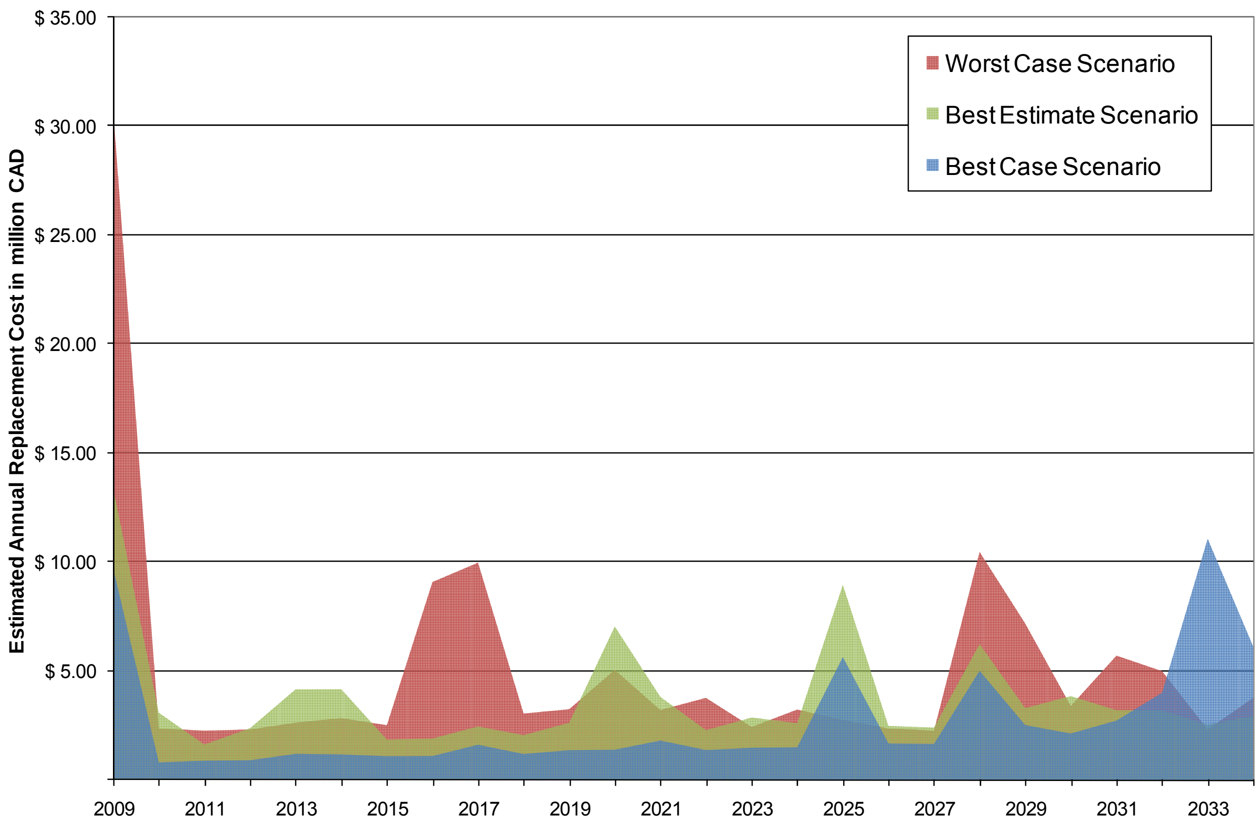


Figure 7.4 Total Annual Replacement Requirements Using a Range of Estimated Service Lives (25 year view)



The most significant difference between the three scenarios is the size of the back log ($31 million under the worst case scenario, $13 million under the best estimate scenario and $10 million under the best case scenario). Figure 8.2 in Section 8 shows the difference in the infrastructure gap between the three scenarios.

8. Funding Strategies: "How will we pay for it?"

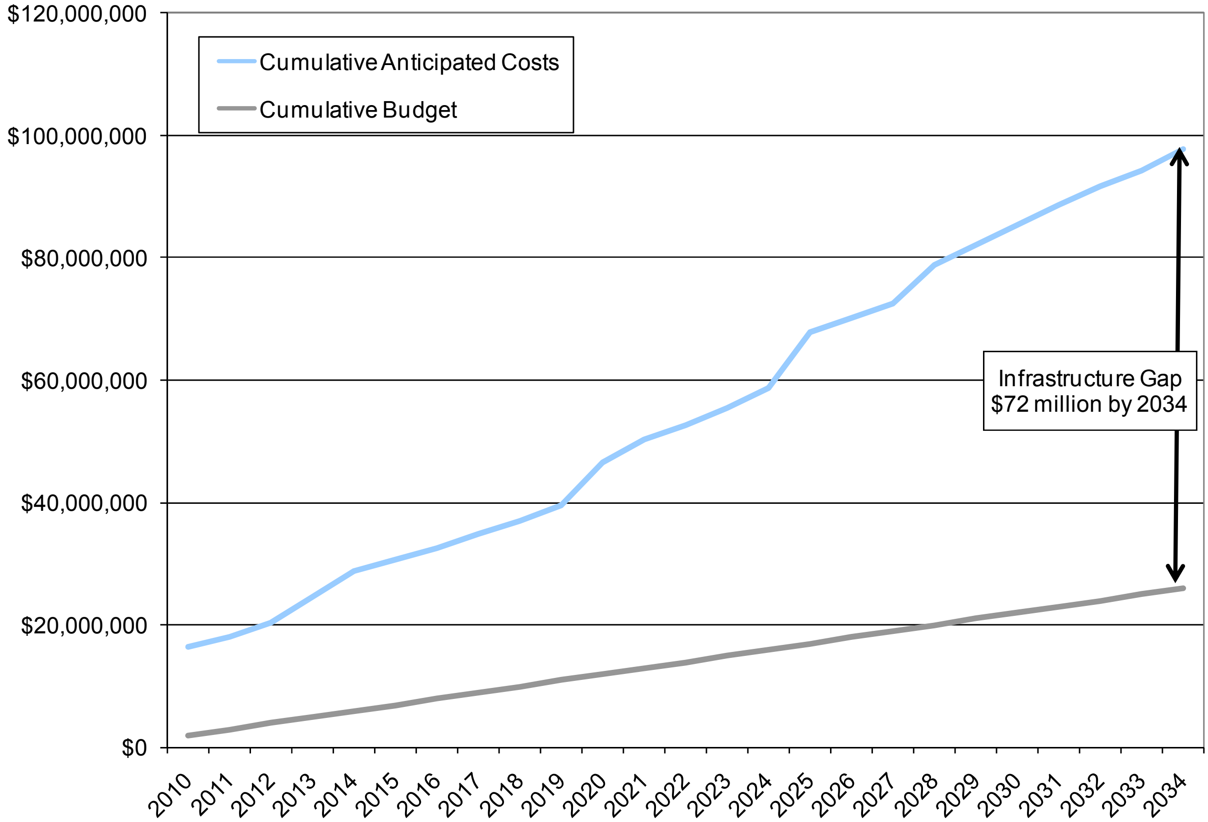
This study has estimated the total reinvestment requirements for West Vancouver's water system over the next 100 years. It shows when the District can expect waves of capital expenditures, thereby helping West Vancouver to better determine utility revenue needs and to optimise O&M practices to extend the life of existing assets.

Now that West Vancouver has identified its water capital reinvestment funding requirements, it can subtract any external contributions (i.e. from development or infrastructure grants) to determine required budget levels.

8.1 Current Funding Levels

Currently West Vancouver budgets $1,000,000 annually for the renewal of its water assets. Figure 8.1 shows how the anticipated renewal requirements compare with the existing budget. The infrastructure gap measures the difference between the required capital renewal budget and the available capital renewal budget. Assuming that the water capital renewal budget is only raised to keep up with inflation, we have estimated the infrastructure gap for the water system by 2034 (i.e. in 25 years) to be $72 million.

Figure 8.1 Renewal Requirements vs. Existing Budget Levels – 25 Year View

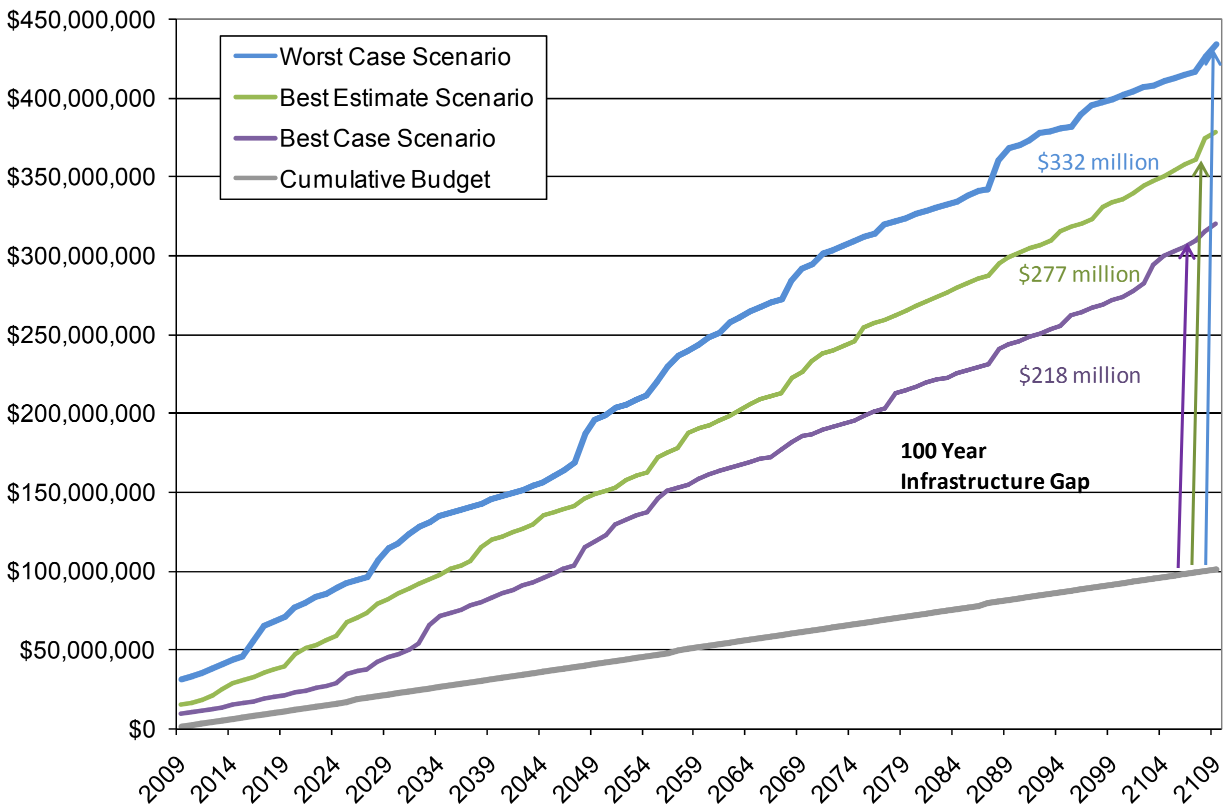


As described in Section 6.3 we used a range of estimated service lives for different asset types to determine the sensitivity of our assumptions. The infrastructure gap using our original estimate of service lives as well as the worst and best case scenarios are presented in Figure 8.2.

Figure 8.2 shows that the current renewal budget is not sufficient even for the best case scenario. In 100 years, the infrastructure gap will range from $218 million under the best case scenario to $332 million under the worst case scenario.

Therefore the question isn't whether there will be an infrastructure gap if existing renewal budgets are only increased to match inflation but how much will the infrastructure gap be. Therefore it is recommended that West Vancouver take steps now, as discussed in Section 8.2, to address the pending infrastructure gap.

Figure 8.2 - Best and Worst Case Estimate of 100 Year Infrastructure Gap



8.2 Future Strategies

The District needs to determine how it will address the forecasted infrastructure gap. The ultimate solution will likely come from a variety of sources:

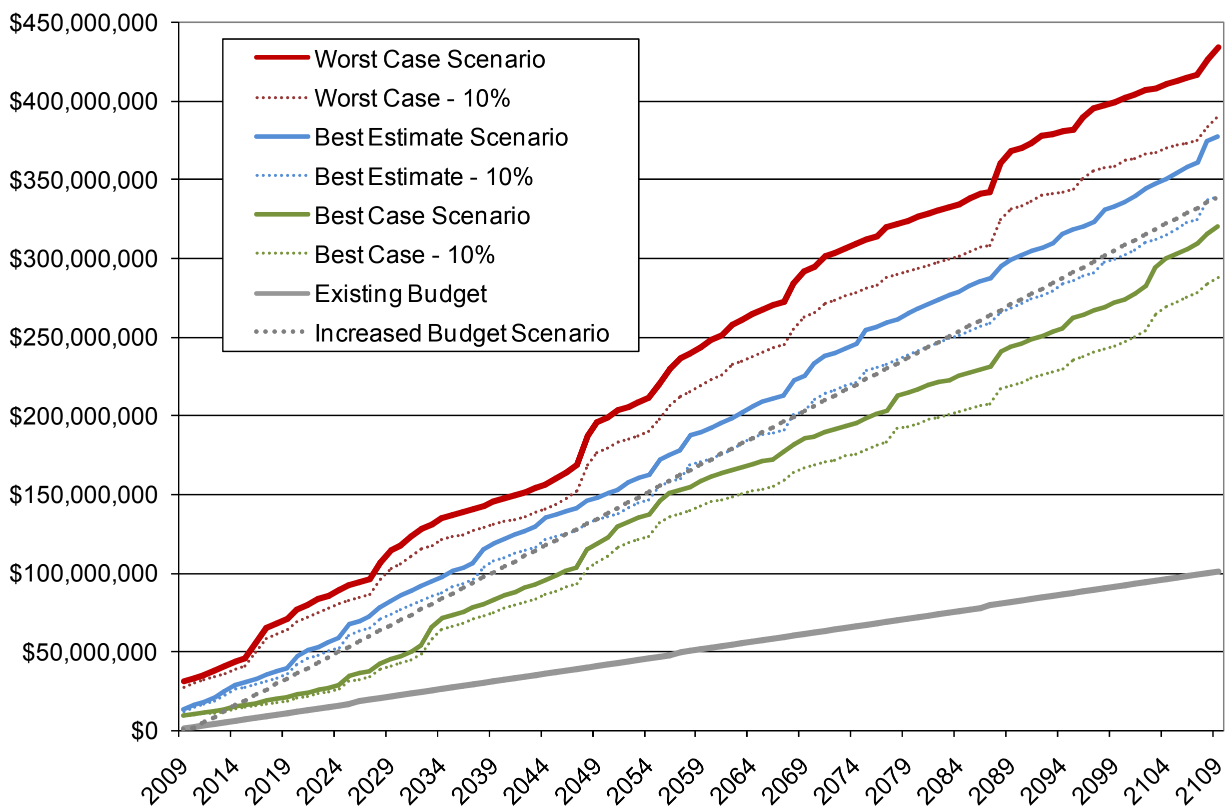
- Extend the life of assets through a proactive inspection and rehabilitation program;
- Reduce capital renewal costs through good asset management planning (see Section 9);
- Gradual but steady increase in capital renewal budgets; and
- Ensure that development driven improvements are partially or wholly funded by the development itself.

If West Vancouver were able to reduce the lifecycle cost of its assets by 10% then the average annual replacement cost under the best estimate scenario would be reduced from $3.7 million to $3.4 million. Figure 8.3 shows the impact on the infrastructure gap if West Vancouver were able to reduce the lifecycle cost of its assets by 10% and increase its annual renewal budget in 2011 to $3.4 million (i.e. 340% increase). West Vancouver could then maintain a $3.4 million annual budget (i.e. 0% increase) for the next 100 years. Under this scenario West Vancouver would have eliminated its backlog by 2019. All cost estimates are in

2009 dollars and would need to be reviewed at future dates based on new asset information and to consider inflation.

The potential spending scenario illustrated in Figure 8.3 is theoretical and assumes that all assets will be replaced on a "just in time" basis. This information provides order of magnitude costs for the theoretical replacement; however, many factors will impact the actual rate of infrastructure renewal. Examples of some of these factors include assessments of risk or criticality, resource leveling, opportunistic cost sharing, short term affordability, and future reserve policies. These factors will be as important in the development of future capital financial planning as the physical replacement requirements identified by this theoretical replacement curve.

Figure 8.3 Addressing the Infrastructure Gap



Effective communication is critical to educate and engage stakeholders to assist in meeting the upcoming challenges associated with the management of the District's infrastructure. Municipalities such as Edmonton and Hamilton have spent years quantifying their infrastructure renewal needs and communicating those needs to stakeholders. We recommend that West Vancouver use the information from this report and the National Water and Wastewater Benchmarking Initiative to inform senior management, City Council and the public on the following points:

- What assets does West Vancouver own?
- How much are the assets worth?
- What is their condition?
- How much needs to be spent on infrastructure renewal?
- What is the relationship between renewal costs and maintenance costs?
- What is the level of service that West Vancouver residents receive?
- What is the relationship between infrastructure costs and levels of service?

8.3 Infrastructure Funding Mechanisms

Effective infrastructure renewal funding:

- Allocates costs to those benefiting from the service thus increasing equity in provision of services;
- Supports accountability by clear allocation of funds;
- Incorporates life cycle costs of infrastructure (i.e. depreciation, O&M and renewal);
- Provides reliable, predictable, dedicated funding to support multi-year infrastructure investment strategies; and
- Supports demand management efforts.

The District's water system operates on a cost recovery basis, in which the total fees charged to customers cover the operating and capital infrastructure costs of the utility. The District of West Vancouver currently uses water utility charges (which are tied to indoor water consumption), DCC's (development cost charges), and provincial and federal funding to support the renewal of its infrastructure. Water utility charges represent the largest, most stable source of funding for a long term infrastructure renewal program. West Vancouver will need to determine whether they want to create a reserve to pay for infrastructure renewal projects or to adopt a "pay as you go" approach.

It is recommended that West Vancouver take a long term approach to its rate planning in order to create relatively consistent rates to meet its renewal needs, rather than having rates fluctuate according to the capital works within a given year. Using a specifically designated reserve fund to collect renewal funding (similar to a capital reserve fund) facilitates a long term approach to rate planning. The results of this study are ideally suited for estimating the requirements of future reserves. It is important to note, that since the estimates in this study are based on 2009 replacement costs, they need to be revised on a periodic basis to reflect the actual renewal costs in future years.

A program of uniform replacement, rather than only reacting to emergencies, allows for better coordination with the work of other District and development activities. This coordination helps the District to minimize the public impacts of work, and allows for a lower combined net cost for water, sewer and street construction activities.

Should West Vancouver want to investigate new funding mechanisms we recommend that they refer to the *National Guide to Sustainable Municipal Infrastructure's* best practice titled *"Alternative Funding Mechanisms"*. The *National Guide to Sustainable Municipal Infrastructure: Innovations and Best Practices* is a compendium of technical best practices for addressing infrastructure issues. The best practice on alternative funding mechanisms describes eight methods for developing innovation funding sources to meet infrastructure needs, or to align costs with benefits to users. The eight alternative funding mechanisms described are:

- Special Levies,
- Development Fees,
- Utility Models,
- Sponsorships,
- Innovative Transportation Revenues and Incentives,
- Government Service Partnerships,
- Funding Partnerships, and
- Strategic Funding Allocations.

8.4 Next Steps

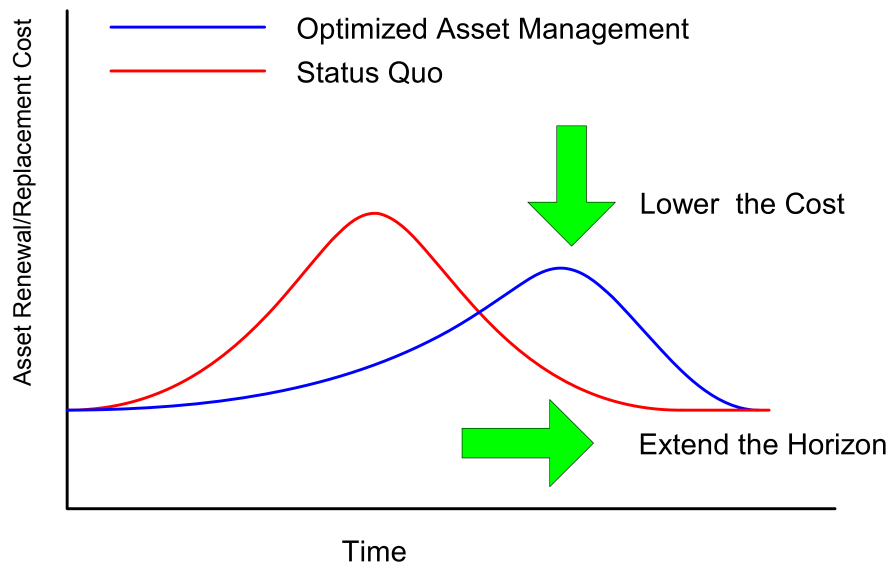
This study provides a long term view of infrastructure renewal needs. In order to determine infrastructure renewal priorities over the next 10 years, West Vancouver needs to conduct a bottom-up assessment of the water system that considers asset condition, maintenance history, criticality, and coordination with roads and other utilities. This will allow West Vancouver to better quantify short term infrastructure renewal requirements and determine the actual impact on water rates.

This study has adhered to present day best practices for performing strategic level asset management. A "needs-based" approach has been taken that gives consideration to our current knowledge of asset life spans, and current replacement costs. Consideration has not been given to factors that might either accelerate renewal efforts (e.g. elevation of risk or criticality, resource levelling), or decelerate renewal efforts (e.g. short term affordability). These additional factors will remain for continued public debate, and provide input into the annual rate setting process. Ultimately, a "budget-based" approach to asset management will govern the extent to which West Vancouver will manage assets in a sustainable fashion over the short and long term.

9. Adopting Asset Management Practices

Good asset management planning seeks to capitalize on two means of cost savings: preventative maintenance and effective asset renewal planning. This will result in the optimization of lifecycle costs for individual assets as depicted in Figure 9.1.

Figure 9.1 Means of Achieving Savings through Asset Management



By continuing with its preventative maintenance program West Vancouver can attain, and hopefully extend, the expected service life of its infrastructure, and will benefit accordingly. West Vancouver can also periodically review its preventative maintenance program to ensure that it is gaining maximum benefit from its inspections, leak detection and water main cleaning program.

In addition to reducing life-cycle costs, good asset management can also have social and environmental benefits. Unexpected infrastructure failures may disrupt water service to customers, result in road closures, impact nearby creeks and provide an avenue for contamination of the water system.

By identifying the most cost effective renewal and/or replacement strategy for each asset and by integrating capital works of different utilities (stormwater, sanitary, road etc.) whenever possible, the District will optimise its capital renewal budgets. Together this will have the benefit of lowering the actual cost of the renewal program.

The efficient integration of capital works of different utilities requires coordinating the capital renewal programs for the water, sanitary, storm and road systems. Accomplishing this requires developing procedures and communication channels, which can be facilitated but not replaced by information management systems. Effectively managing and communicating asset information as outlined in the District of West Vancouver's Asset Management Information Management Strategy will help West Vancouver optimize water asset maintenance and rehabilitation needs.

In addition, a proactive infrastructure maintenance program can reduce the long-term impact of main breaks on system operational costs. The National Water and Wastewater Benchmarking results show that, in 2007, main break repairs accounted for 10% of the District of West Vancouver's water operational costs.

10. Recommendations

This section outlines the nine (9) key recommendations that are a result of this study. The recommendations fall under three main categories:

- Sustainable funding;
- Reducing infrastructure costs; and
- Data management.

10.1 Sustainable Funding

Without sustainable funding an asset manager cannot maintain a given level of service from its assets. The effective communication of this study's results to Council and the general public is key to obtaining sustainable infrastructure funding.

Recommendation #1
The District of West Vancouver should plan and implement an appropriate water rate structure to ensure that sufficient resources will be available to address both current and future infrastructure maintenance and replacement requirements.

Recommendation #2
The District of West Vancouver should develop a specific "Renewal Reserve Fund" for capital reinvestment in order to smooth out water rates, provide equitable and transparent infrastructure funding and to ensure that funds are available as required.

Recommendation #3
The District of West Vancouver should continue to communicate future requirements of the infrastructure management plan in advance of revising the current water rate structure.

Recommendation #4
West Vancouver should maintain and update the CAP model (or similar tool) to periodically check that its renewal funding is sufficient to meet its capital renewal needs.

10.2 Reducing Infrastructure Costs

By identifying the most cost effective renewal and/or replacement strategy for each asset and by integrating capital works of different utilities (drainage, sanitary, road etc.) whenever possible, the District will optimise its capital renewal budgets. Together this will have the benefit of lowering the actual cost of the renewal program, but can only be accomplished with sufficient information about the assets. The following three recommendations outline actions that are critical for identifying the most cost effective asset renewal strategy and reducing O&M costs.

Recommendation #5
The District should coordinate its water capital renewal program with other utilities (sanitary, roads and drainage) to ensure that total costs are minimized.

Recommendation #6
The District of West Vancouver should continue to assess the condition of its water assets. This would allow West Vancouver to prioritize water maintenance and rehabilitation work, to extend the life of its water assets, and to refine the financial projections presented in this report.

Recommendation #7
The District should review its water service design/installation standards to see if it can make changes that reduce the number of water service breaks.

10.3 Data Management

Access to timely and accurate data is critical for the effective management of assets. The following two recommendations outline actions that would support West Vancouver's efforts to effectively manage its asset data.

Recommendation #8
Effectively managing and communicating asset information as outlined in the District of West Vancouver's Asset Management Information Management Strategy will help West Vancouver optimize water asset maintenance and rehabilitation needs.

Recommendation #9
Assets that belong to other entities such as Metro Vancouver or Park Royal should be clearly labelled as such within West Vancouver's GIS.

Appendix A – Water Asset Inventory

Site	Asset Group	Asset Type	Asset Name	Asset Component	Quantity or Length in km	Unit Cost	Cost Year	Replacement Cost ENR Ratio	2009 Replacement value (Unit Cost in CAD)	Date in Service	Expected Service Life (yrs)	Expected Replacement Year	% of Expected Service Life Used	Remaining service life (yrs)	Condition Rating (1=good, 5=poor)	Criticality	Condition adjustment factor	Condition Adjusted Remaining Service Life	Condition adjusted replacement year	Risk adjustment factor	Risk & Condition Adjusted Remaining Service Life	Condition and Risk Adjusted Replacement Year	2009 Replacement Value
EAGLE LAKE DAM																							
Eagle Lake West Dam (rock)	Supply and Treatment	Dam and Spillway	Dam - Core	Civil	1	$ 5,000,000	2008	1.03	$ 5,146,360	1955	100	2055	55%	45		3	1.00	45	2055	1.00	45	2055	$ 5,146,359.81
Eagle Lake East Dam (earth)	Supply and Treatment	Dam and Spillway	Dam - Core	Civil	1	$ 1,000,000	2008	1.03	$ 1,029,272	1955	100	2055	55%	45		3	1.00	45	2055	1.00	45	2055	$ 1,029,271.96
TREATMENT PLANTS																							
Eagle Lake WTP	Supply and Treatment	Treatment Plant	Membrane Filtation Plant	Mechanical	1	$ 4,800,000	2008	1.03	$ 4,940,505	2008	30	2038	7%	28		3	1.00	28	2038	1.00	28	2038	$ 4,940,505.42
Eagle Lake WTP	Supply and Treatment	Treatment Plant	Membrane Filtation Plant	SCADA	1	$ 800,000	2008	1.03	$ 823,418	2008	20	2028	10%	18		3	1.00	18	2028	1.00	18	2028	$ 823,417.57
Eagle Lake WTP	Supply and Treatment	Treatment Plant	Membrane Filtation Plant	Civil	1	$ 8,000,000	2008	1.03	$ 8,234,176	2008	50	2058	4%	48		3	1.00	48	2058	1.00	48	2058	$ 8,234,175.69
Eagle Lake WTP	Supply and Treatment	Treatment Plant	Membrane Filtation Plant	Electrical	1	$ 2,400,000	2008	1.03	$ 2,470,253	2008	20	2028	10%	18		3	1.00	18	2028	1.00	18	2028	$ 2,470,252.71
Future Water Treatment Plant	Supply and Treatment	Treatment Plant	Membrane Filtation Plant	Mechanical	1	$ 750,000	2011	0.89	$ 669,643	2011	30	2041	-3%	31		3	1.00	31	2041	1.00	31	2041	$ 669,642.86
Future Water Treatment Plant	Supply and Treatment	Treatment Plant	Membrane Filtation Plant	SCADA	1	$ 125,000	2011	0.89	$ 111,607	2011	20	2031	-5%	21		3	1.00	21	2031	1.00	21	2031	$ 111,607.14
Future Water Treatment Plant	Supply and Treatment	Treatment Plant	Membrane Filtation Plant	Civil	1	$ 1,250,000	2011	0.89	$ 1,116,071	2011	50	2061	-2%	51		3	1.00	51	2061	1.00	51	2061	$ 1,116,071.43
Future Water Treatment Plant	Supply and Treatment	Treatment Plant	Membrane Filtation Plant	Electrical	1	$ 375,000	2011	0.89	$ 334,821	2011	20	2031	-5%	21		3	1.00	21	2031	1.00	21	2031	$ 334,821.43
EAGLE LAKE PUMPING SYSTEM																							
Eagle Lake Pumping System	Supply and Treatment	Floating Pipeline, Pump and Components	Floating Pump #1/ Floating Platform/ Floating Pump#2/Floating Pipeline/ Surge Tank	Mechanical	1	$ 329,720	2008	1.03	$ 339,372	1996	25	2021	56%	11		3	1.00	11	2021	1.00	11	2021	$ 339,371.55
Eagle Lake Pumping System	Supply and Treatment	Intake	Intake (old)	Civil	2	$ 25,349	2008	1.03	$ 52,182	1955	75	2030	73%	20		3	1.00	20	2030	1.00	20	2030	$ 52,182.03
Eagle Lake Pumping System	Supply and Treatment	Intake	Boat	Mechanical	1	$ 18,808	2008	1.03	$ 19,359	2007	20	2027	15%	17		3	1.00	17	2027	1.00	17	2027	$ 19,358.55
Eagle Lake Pumping System	Supply and Treatment	Valve Chamber (Gate Valve)	Gate Valve	Mechanical	8	$ 1,643	2008	1.03	$ 13,529	1995	60	2055	25%	45		3	1.00	45	2055	1.00	45	2055	$ 13,528.75
Eagle Lake Pumping System	Supply and Treatment	Valve Chamber (Gate Valve)	Gate Valve	Mechanical	2	$ 1,178	2008	1.03	$ 2,425	1995	60	2055	25%	45		3	1.00	45	2055	1.00	45	2055	$ 2,424.96
Eagle Lake Pumping System	Supply and Treatment	Electrical	Power Line for Floating Pump Stations	Electrical	1	$ 181,997	1999	1.41	$ 256,918	1999	20	2019	55%	9		3	1.00	9	2019	1.00	9	2019	$ 256,917.95
CREEK DIVERSIONS																							
Upper Nelson Creek Creek Diversion	Supply and Treatment	Creek Diversion	Structure and Components	Civil	1	$ 360,723	2008	1.03	$ 371,282	1999	35	2034	31%	24		3	1.00	24	2034	1.00	24	2034	$ 371,282.07
Black Creek Diversion	Supply and Treatment	Creek Diversion	Structure and Components	Civil	1	$ 2,196,721	2002	1.31	$ 2,873,831	2002	50	2052	16%	42		3	1.00	42	2052	1.00	42	2052	$ 2,873,830.51
CHLORINATION STATIONS																							
Montizambert Creek Chlorination Station (replaced by WTP)	Supply and Treatment	Chlorination Station	Structure	Civil	1		2006	1.10	$ -	1970	50	2020	80%	10		3	1.00	10	2020	1.00	10	2020	$ -
Montizambert Creek Chlorination Station (replaced by WTP)	Supply and Treatment	Chlorination Station	Flow Meter	Mechanical	1		2006	1.10	$ -	1970	30	2000	133%	-10		3	1.00	0	2010	1.00	0	2010	$ -
Montizambert Creek Chlorination Station (replaced by WTP)	Supply and Treatment	Chlorination Station	Dosage Equipment	Electrical	1		2007	1.07	$ -	2007	15	2022	20%	12		3	1.00	12	2022	1.00	12	2022	$ -
Montizambert Creek Chlorination Station (replaced by WTP)	Supply and Treatment	Chlorination Station	Back up Power Generator	Mechanical	1		2007	1.07	$ -	2007	30	2037	10%	27		3	1.00	27	2037	1.00	27	2037	$ -
Lower Nelson Creek Chlorination Station	Supply and Treatment	Chlorination Station	Structure	Civil	1		2006	1.10	$ -	1970	50	2020	80%	10		3	1.00	10	2020	1.00	10	2020	$ -
Lower Nelson Creek Chlorination Station	Supply and Treatment	Chlorination Station	Flow Meter	Mechanical	1	$ 2,913	2006	1.10	$ 3,215	1985	50	2035	50%	25		3	1.00	25	2035	1.00	25	2035	$ 3,214.50
Lower Nelson Creek Chlorination Station	Supply and Treatment	Chlorination Station	Dosage Equipment	Electrical	1	$ 21,367	2006	1.10	$ 23,579	2007	30	2037	10%	27		3	1.00	27	2037	1.00	27	2037	$ 23,578.54
McKechnie Reservoir Valve Chamber	Supply and Treatment	Valve Chamber	Structure	Civil	1		2006	1.10	$ -	1970	50	2020	80%	10		3	1.00	10	2020	1.00	10	2020	$ -
McKechnie Reservoir Valve Chamber	Supply and Treatment	Valve Chamber	Butterfly Valve	Electrical	1	$ 1,643	2006	1.10	$ 1,813	1995	20	2015	75%	5		3	1.00	5	2015	1.00	5	2015	$ 1,813.06
McKechnie Reservoir Valve Chamber	Supply and Treatment	Valve Chamber	Gate Valve	Mechanical	2	$ 1,643	2006	1.10	$ 3,626	1980	30	2010	100%	0		3	1.00	0	2010	1.00	0	2010	$ 3,626.11
McKechnie Reservoir	Supply and Treatment	Chlorination Station	Doseage Equipment	Mechanical	1	$ 2,177	2006	1.10	$ 2,402	2004	15	2019	40%	9		3	1.00	9	2019	1.00	9	2019	$ 2,402.33
Various Sites	Supply and Treatment	Water Sampling Stations	Structure	Civil	30	$ 40,808	2006	1.10	$ 1,350,952	2006	50	2056	8%	46		3	1.00	46	2056	1.00	46	2056	$ 1,350,952.24
C2 Reservoir	Supply and Treatment	Power Generation (Turbine)	Turbine	Mechanical	1	$ 363,921	2006	1.10	$ 401,588	2003	50	2053	14%	43		3	1.00	43	2053	1.00	43	2053	$ 401,587.83
PUMP STATIONS																3							
Westmount Pump Station	Pumping	Pump Station	Structure and Components	Mechanical	1	$ 214,959	2006	1.10	$ 237,207	1994	30	2024	53%	14		3	1.00	14	2024	1.00	14	2024	$ 237,207.36
Westmount Pump Station	Pumping	Pump Station	Structure and Components	Civil	1	$ 358,355	2006	1.10	$ 395,446	1994	50	2044	32%	34		3	1.00	34	2044	1.00	34	2044	$ 395,445.78
Westmount Pump Station	Pumping	Pump Station	Structure and Components	Electrical	1	$ 107,513	2006	1.10	$ 118,641	1994	20	2014	80%	4		3	1.00	4	2014	1.00	4	2014	$ 118,641.25
Glenmore	Pumping	Pump Station	Structure and Components	Mechanical	1	$ 102,038	2006	1.10	$ 112,599	2004	30	2034	20%	24		3	1.00	24	2034	1.00	24	2034	$ 112,599.37
Glenmore	Pumping	Pump Station	Structure and Components	Civil	1	$ 170,053	2006	1.10	$ 187,654	1970	50	2020	80%	10		3	1.00	10	2020	1.00	10	2020	$ 187,653.73
Glenmore	Pumping	Pump Station	Structure and Components	Electrical	1	$ 51,019	2006	1.10	$ 56,300	1970	20	1990	200%	-20		3	1.00	0	2010	1.00	0	2010	$ 56,299.68
Bonnymuir	Pumping	Pump Station	Structure and Components	Mechanical	1	$ 124,309.93	2006	1.10	$ 137,176	1981	30	2011	97%	1		3	1.00	1	2011	1.00	1	2011	$ 137,176.36
Bonnymuir	Pumping	Pump Station	Structure and Components	Civil	1	$ 207,170.10	2006	1.10	$ 228,613	1981	50	2031	58%	21		3	1.00	21	2031	1.00	21	2031	$ 228,612.78
Bonnymuir	Pumping	Pump Station	Structure and Components	Electrical	1	$ 62,154.97	2006	1.10	$ 68,588	2006	20	2026	20%	16		3	1.00	16	2026	1.00	16	2026	$ 68,588.18
Craigmohr	Pumping	Pump Station	Structure and Components	Mechanical	1	$ 104,161.89	2006	1.10	$ 114,943	2005	30	2035	17%	25		3	1.00	25	2035	1.00	25	2035	$ 114,942.94
Craigmohr	Pumping	Pump Station	Structure and Components	Civil	1	$ 173,592.16	2006	1.10	$ 191,559	1981	50	2031	58%	21		3	1.00	21	2031	1.00	21	2031	$ 191,559.43
Craigmohr	Pumping	Pump Station	Structure and Components	Electrical	1	$ 52,080.95	2006	1.10	$ 57,471	1981	20	2001	145%	-9		3	1.00	0	2010	1.00	0	2010	$ 57,471.47
11th Street	Pumping	Pump Station	Structure and Components	Mechanical	1	$ 275,470.76	2006	1.10	$ 303,983	1962	30	1992	160%	-18		3	1.00	0	2010	1.00	0	2010	$ 303,982.75
11th Street	Pumping	Pump Station	Structure and Components	Civil	1	$ 459,088.86	2006	1.10	$ 506,606	1962	50	2012	96%	2		3	1.00	2	2012	1.00	2	2012	$ 506,605.83
11th Street	Pumping	Pump Station	Structure and Components	Electrical	1	$ 137,735.38	2006	1.10	$ 151,991	1962	20	1982	240%	-28		3	1.00	0	2010	1.00	0	2010	$ 151,991.37
Crosscreek	Pumping	Pump Station	Structure and Components	Mechanical	1	$ 170,639.37	2006	1.10	$ 188,301	1962	30	1992	160%	-18		3	1.00	0	2010	1.00	0	2010	$ 188,301.02
Crosscreek	Pumping	Pump Station	Structure and Components	Civil	1	$ 284,380.94	2006	1.10	$ 313,815	1962	50	2012	96%	2		3	1.00	2	2012	1.00	2	2012	$ 313,815.16
Crosscreek	Pumping	Pump Station	Structure and Components	Electrical	1	$ 85,319.69	2006	1.10	$ 94,151	1962	20	1982	240%	-28		3	1.00	0	2010	1.00	0	2010	$ 94,150.51
Burnside	Pumping	Pump Station	Structure and Components	Mechanical	1	$ 114,521.71	2006	1.10	$ 126,375	1963	30	1993	157%	-17		3	1.00	0	2010	1.00	0	2010	$ 126,375.03
Burnside	Pumping	Pump Station	Structure and Components	Civil	1	$ 190,857.43	2006	1.10	$ 210,612	1963	50	2013	94%	3		3	1.00	3	2013	1.00	3	2013	$ 210,611.71
Burnside	Pumping	Pump Station	Structure and Components	Electrical	1	$ 57,260.86	2006	1.10	$ 63,188	1963	20	1983	235%	-27		3	1.00	0	2010	1.00	0	2010	$ 63,187.51
Vinson Creek	Pumping	Pump Station	Structure and Components	Mechanical	1	$ 111,775.83	2006	1.10	$ 123,345	2005	30	2035	17%	25		3	1.00	25	2035	1.00	25	2035	$ 123,344.94
Vinson Creek	Pumping	Pump Station	Structure and Components	Civil	1	$ 186,281.25	2006	1.10	$ 205,562	1964	50	2014	92%	4		3	1.00	4	2014	1.00	4	2014	$ 205,561.88
Vinson Creek	Pumping	Pump Station	Structure and Components	Electrical	1	$ 55,887.92	2006	1.10	$ 61,672	1964	20	1984	230%	-26		3	1.00	0	2010	1.00	0	2010	$ 61,672.47
Chelsea	Pumping	Pump Station	Structure and Components	Mechanical	1	$ 101,311.80	2006	1.10	$ 111,798	1989	30	2019	70%	9		3	1.00	9	2019	1.00	9	2019	$ 111,797.85

Site	Asset Group	Asset Type	Asset Name	Asset Component	Quantity or Length in km	Unit Cost	Cost Year	Replacement Cost ENR Ratio	2009 Replacement value (Unit Cost in CAD)	Date in Service	Expected Service Life (yrs)	Expected Replacement Year	% of Expected Service Life Used	Remaining service life (yrs)	Condition Rating (1=good, 5=poor)	Criticality	Condition adjustment factor	Condition Adjusted Remaining Service Life	Condition adjusted replacement year	Risk adjustment factor	Risk & Condition Adjusted Remaining Service Life	Condition and Risk Adjusted Replacement Year	2009 Replacement Value
Chelsea	Pumping	Pump Station	Structure and Components	Civil	1	$ 168,842.30	2006	1.10	$ 186,318	1989	50	2039	42%	29		3	1.00	29	2039	1.00	29	2039	$ 186,317.95
Chelsea	Pumping	Pump Station	Structure and Components	Electrical	1	$ 50,655.90	2006	1.10	$ 55,899	1989	20	2009	105%	-1		3	1.00	0	2010	1.00	0	2010	$ 55,898.93
Eagle Ridge	Pumping	Pump Station	Structure and Components	Mechanical	1	$ 20,898.07	2006	1.10	$ 23,061	2004	30	2034	20%	24		3	1.00	24	2034	1.00	24	2034	$ 23,061.07
Eagle Ridge	Pumping	Pump Station	Structure and Components	Civil	1	$ 34,827.90	2006	1.10	$ 38,433	1970	50	2020	80%	10		3	1.00	10	2020	1.00	10	2020	$ 38,432.69
Eagle Ridge	Pumping	Pump Station	Structure and Components	Electrical	1	$ 10,449.03	2006	1.10	$ 11,531	1970	20	1990	200%	-20		3	1.00	0	2010	1.00	0	2010	$ 11,530.54
RESERVOIRS																							
Ballantree	Storage	Reservoir Tank	Structure	Civil	1	$ 680,000	2008	1.03	$ 699,905	1982	50	2032	56%	22		3	1.00	22	2032	1.00	22	2032	$ 699,904.93
Craigmohr	Storage	Reservoir Tank	Structure	Civil	1	$ 1,200,000	2008	1.03	$ 1,235,126	1981	50	2031	58%	21	1	3	1.25	34	2044	1.00	34	2044	$ 1,235,126.35
Bonnymuir	Storage	Reservoir Tank	Structure	Civil	1	$ 1,200,000	2008	1.03	$ 1,235,126	1981	50	2031	58%	21	1	3	1.25	34	2044	1.00	34	2044	$ 1,235,126.35
Cross Creek	Storage	Reservoir Tank	Structure	Civil	1	$ 4,000,000	2008	1.03	$ 4,117,088	1962	50	2012	96%	2	3	3	1.15	10	2020	1.00	10	2020	$ 4,117,087.85
Burnside	Storage	Reservoir Tank	Structure	Civil	1	$ 2,000,000	2008	1.03	$ 2,058,544	1963	50	2013	94%	3		3	1.00	3	2013	1.00	3	2013	$ 2,058,543.92
Vinson Creek	Storage	Reservoir Tank	Structure	Civil	1	$ 2,000,000	2008	1.03	$ 2,058,544	1964	50	2014	92%	4		3	1.00	4	2014	1.00	4	2014	$ 2,058,543.92
Millstream	Storage	Reservoir Tank	Structure	Civil	1	$ 600,000	2008	1.03	$ 617,563	1980	50	2030	60%	20		3	1.00	20	2030	1.00	20	2030	$ 617,563.18
McKechnie	Storage	Reservoir Tank	Structure	Civil	1	$ 6,400,000	2008	1.03	$ 6,587,341	1970	50	2020	80%	10	3	3	1.10	15	2025	1.00	15	2025	$ 6,587,340.55
Lower Nelson Creek (Upper Tank)	Storage	Reservoir Tank	Structure	Civil	1	$ 1,200,000	2008	1.03	$ 1,235,126	1976	50	2026	68%	16	3	3	0.90	11	2021	1.00	11	2021	$ 1,235,126.35
Lower Nelson Creek (Lower Tank)	Storage	Reservoir Tank	Structure	Civil	1	$ 700,000	2008	1.03	$ 720,490	1980	50	2030	60%	20	2	3	1.10	25	2035	1.00	25	2035	$ 720,490.37
Madrona	Storage	Reservoir Tank	Structure	Civil	1	$ 600,000	2008	1.03	$ 617,563	1984	50	2034	52%	24	3	3	0.90	19	2029	1.00	19	2029	$ 617,563.18
Pasco	Storage	Reservoir Tank	Structure	Civil	1	$ 146,000	2008	1.03	$ 150,274	1982	50	2032	56%	22		3	1.00	22	2032	1.00	22	2032	$ 150,273.71
Sunset (North)	Storage	Reservoir Tank	Structure	Civil	1	$ 200,000	2008	1.03	$ 205,854	1979	50	2029	62%	19		3	1.00	19	2029	1.00	19	2029	$ 205,854.39
Sunset	Storage	Reservoir Tank	Structure	Civil	1	$ 200,000	2008	1.03	$ 205,854	1990	50	2040	40%	30		3	1.00	30	2040	1.00	30	2040	$ 205,854.39
Chairlift	Storage	Reservoir Tank	Structure	Civil	1	$ 200,000	2008	1.03	$ 205,854	1985	50	2035	50%	25		3	1.00	25	2035	1.00	25	2035	$ 205,854.39
Chelsea	Storage	Reservoir Tank	Structure	Civil	1	$ 1,200,000	2008	1.03	$ 1,235,126	1989	50	2039	42%	29		3	1.00	29	2039	1.00	29	2039	$ 1,235,126.35
Cypress 1	Structure	Reservoir Tank	Structure	Civil	1	$ 484,000	2008	1.10	$ 532,400	1978	50	2028	64%	18		3	1.00	18	2028	1.00	18	2028	$ 532,400.00
Cypress 2	Storage	Reservoir Tank	Structure	Civil	1	$ 484,000	2008	1.03	$ 498,168	1978	50	2028	64%	18	3	3	0.90	13	2023	1.00	13	2023	$ 498,167.63
Cypress 3	Storage	Reservoir Tank	Structure	Civil	1	$ 400,000	2008	1.03	$ 411,709	1975	50	2025	70%	15	3	3	0.90	10	2020	1.00	10	2020	$ 411,708.78
Cypress 4	Storage	Reservoir Tank	Structure	Civil	1	$ 700,000	2008	1.03	$ 720,490	1980	50	2030	60%	20	1	3	1.25	33	2043	1.00	33	2043	$ 720,490.37
Westmount	Storage	Reservoir Tank	Structure	Civil	1	$ 2,000,000	2008	1.03	$ 2,058,544	1968	50	2018	84%	8	1	3	1.40	28	2038	1.00	28	2038	$ 2,058,543.92
Lookout	Storage	Reservoir Tank	Structure	Civil	1	$ 1,264,000	2008	1.03	$ 1,301,000	2005	50	2055	10%	45		3	1.00	45	2055	1.00	45	2055	$ 1,300,999.76
SCADA SYSTEMS																							
11th Street Pump Station	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$23,000	2008	1.03	$ 23,673	1993	20	2013	85%	3		3	1.00	3	2013	1.00	3	2013	$ 23,673.26
11th Street Pump Station	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$7,000	2008	1.03	$ 7,205	1993	20	2013	85%	3		3	1.00	3	2013	1.00	3	2013	$ 7,204.90
Ballantree Reservoir	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$21,750	2008	1.03	$ 22,387	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 22,386.67
Ballantree Reservoir	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$2,000	2008	1.03	$ 2,059	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 2,058.54
Bonnymuir Reservoir and Pump Station	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$24,750	2008	1.03	$ 25,474	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 25,474.48
Bonnymuir Reservoir and Pump Station	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$5,750	2008	1.03	$ 5,918	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 5,918.31
Burnside Reservoir and Pump Station	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$23,000	2008	1.03	$ 23,673	1993	20	2013	85%	3		3	1.00	3	2013	1.00	3	2013	$ 23,673.26
Burnside Reservoir and Pump Station	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$4,500	2008	1.03	$ 4,632	1993	20	2013	85%	3		3	1.00	3	2013	1.00	3	2013	$ 4,631.72
C2 Reservoir and Power Generator	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$23,000	2008	1.03	$ 23,673	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 23,673.26
C2 Reservoir and Power Generator	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$6,250	2008	1.03	$ 6,433	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 6,432.95
C4 Reservoir	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$21,750	2008	1.03	$ 22,387	2003	20	2023	35%	13		3	1.00	13	2023	1.00	13	2023	$ 22,386.67
C4 Reservoir	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$2,000	2008	1.03	$ 2,059	2003	20	2023	35%	13		3	1.00	13	2023	1.00	13	2023	$ 2,058.54
Chairlift Court Reservoir	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$19,750	2008	1.03	$ 20,328	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 20,328.12
Chairlift Court Reservoir	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$2,000	2008	1.03	$ 2,059	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 2,058.54
Chelsea Court Pump Station	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$23,500	2008	1.03	$ 24,188	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 24,187.89
Chelsea Court Pump Station	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$13,750	2008	1.03	$ 14,152	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 14,152.49
Chelsea Reservoir and Sewer Meter Station	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$19,750	2008	1.03	$ 20,328	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 20,328.12
Chelsea Reservoir and Sewer Meter Station	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$13,250	2008	1.03	$ 13,638	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 13,637.85
Craigmohr Reservoir and Pump Station	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$25,500	2008	1.03	$ 26,246	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 26,246.44
Craigmohr Reservoir and Pump Station	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$4,000	2008	1.03	$ 4,117	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 4,117.09
Cross Creek Reservoir and Pump Station	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$22,750	2008	1.03	$ 23,416	1993	20	2013	85%	3		3	1.00	3	2013	1.00	3	2013	$ 23,415.94
Cross Creek Reservoir and Pump Station	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$13,000	2008	1.03	$ 13,381	1993	20	2013	85%	3		3	1.00	3	2013	1.00	3	2013	$ 13,380.54
Eagle Lake CL2 and Reservoir	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$25,250	2008	1.03	$ 25,989	1993	20	2013	85%	3		3	1.00	3	2013	1.00	3	2013	$ 25,989.12
Eagle Lake CL2 and Reservoir	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$39,500	2008	1.03	$ 40,656	1993	20	2013	85%	3		3	1.00	3	2013	1.00	3	2013	$ 40,656.24
Eagleridge PRV and Pump Station	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$22,000	2008	1.03	$ 22,644	2003	20	2023	35%	13		3	1.00	13	2023	1.00	13	2023	$ 22,643.98
Eagleridge PRV and Pump Station	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$3,500	2008	1.03	$ 3,602	2003	20	2023	35%	13		3	1.00	13	2023	1.00	13	2023	$ 3,602.45
Glenmore Pump Station	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$24,750	2008	1.03	$ 25,474	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 25,474.48
Glenmore Pump Station	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$5,000	2008	1.03	$ 5,146	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 5,146.36
Lookout Reservoir	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$22,000	2008	1.03	$ 22,644	2004	20	2024	30%	14		3	1.00	14	2024	1.00	14	2024	$ 22,643.98
Lookout Reservoir	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$2,500	2008	1.03	$ 2,573	2004	20	2024	30%	14		3	1.00	14	2024	1.00	14	2024	$ 2,573.18
Madrona Reservoir	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$21,500	2008	1.03	$ 22,129	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 22,129.35
Madrona Reservoir	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$3,750	2008	1.03	$ 3,860	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 3,859.77
McKechnie Valve Chamber	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$20,500	2008	1.03	$ 21,100	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 21,100.08
McKechnie Valve Chamber	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$9,750	2008	1.03	$ 10,035	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 10,035.40
McKechnie Reservoir	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$21,000	2008	1.03	$ 21,615	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 21,614.71
McKechnie Reservoir	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$2,000	2008	1.03	$ 2,059	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 2,058.54

Site	Asset Group	Asset Type	Asset Name	Asset Component	Quantity or Length in km	Unit Cost	Cost Year	Replacement Cost ENR Ratio	2009 Replacement value (Unit Cost in CAD)	Date in Service	Expected Service Life (yrs)	Expected Replacement Year	% of Expected Service Life Used	Remaining service life (yrs)	Condition Rating (1=good, 5=poor)	Criticality	Condition adjustment factor	Condition Adjusted Remaining Service Life	Condition adjusted replacement year	Risk adjustment factor	Risk & Condition Adjusted Remaining Service Life	Condition and Risk Adjusted Replacement Year	2009 Replacement Value
Mill Stream Reservoir	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$23,750	2008	1.03	$ 24,445	1995	20	2015	75%	5		3	1.00	5	2015	1.00	5	2015	$ 24,445.21
Mill Stream Reservoir	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$9,500	2008	1.03	$ 9,778	1995	20	2015	75%	5		3	1.00	5	2015	1.00	5	2015	$ 9,778.08
Nelson Creek CL2 and Reservoir	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$29,750	2008	1.03	$ 30,621	1993	20	2013	85%	3		3	1.00	3	2013	1.00	3	2013	$ 30,620.84
Nelson Creek CL2 and Reservoir	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$27,500	2008	1.03	$ 28,305	1993	20	2013	85%	3		3	1.00	3	2013	1.00	3	2013	$ 28,304.98
Sunset CL2 and Reservoir	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$21,250	2008	1.03	$ 21,872	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 21,872.03
Sunset CL2 and Reservoir	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$49,500	2008	1.03	$ 50,949	1997	20	2017	65%	7		3	1.00	7	2017	1.00	7	2017	$ 50,948.96
Vinson Creek Reservoir and Pump Station	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$21,000	2008	1.03	$ 21,615	1993	20	2013	85%	3		3	1.00	3	2013	1.00	3	2013	$ 21,614.71
Vinson Creek Reservoir and Pump Station	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$2,000	2008	1.03	$ 2,059	1993	20	2013	85%	3		3	1.00	3	2013	1.00	3	2013	$ 2,058.54
Westmount PRV and Pump Station	Hardware	SCADA	Components (Radio, enclosure, programming)	SCADA	1	$27,000	2008	1.03	$ 27,790	1994	20	2014	80%	4		3	1.00	4	2014	1.00	4	2014	$ 27,790.34
Westmount PRV and Pump Station	Hardware	SCADA	Instruments (switches, chart recorders)	SCADA	1	$26,500	2008	1.03	$ 27,276	1994	20	2014	80%	4		3	1.00	4	2014	1.00	4	2014	$ 27,275.71
PRESSURE REDUCING VALVES																							
Welch St. PRV 1,2,3	Distribution	PRV Station	Complete Station	Mechanical	3	$25,000	2008	1.03	$ 77,195	1980	25	2005	120%	-5		3	1.00	0	2010	1.00	0	2010	$ 77,195.40
3rd and Keith Avenue PRV 1&2	Distribution	PRV Station	Complete Station	Mechanical	1	$75,000	2008	1.03	$ 77,195	1994	25	2019	64%	9		3	1.00	9	2019	1.00	9	2019	$ 77,195.40
Millstream	Distribution	PRV Station	Complete Station	Mechanical	1	$36,794	2008	1.03	$ 37,871	2005	25	2030	20%	20		3	1.00	20	2030	1.00	20	2030	$ 37,871.03
Jefferson and 14th Street	Distribution	PRV Station	Complete Station	Mechanical	1	$25,000	2008	1.03	$ 25,732	1972	25	1997	152%	-13		3	1.00	0	2010	1.00	0	2010	$ 25,731.80
20th and Inglewood Avenue	Distribution	PRV Station	Complete Station	Mechanical	1	$25,000	2008	1.03	$ 25,732	1972	25	1997	152%	-13		3	1.00	0	2010	1.00	0	2010	$ 25,731.80
25th and Mathers	Distribution	PRV Station	Complete Station	Mechanical	1	$50,000	2008	1.03	$ 51,464	1995	25	2020	60%	10		3	1.00	10	2020	1.00	10	2020	$ 51,463.60
2376 Westhill Drive	Distribution	PRV Station	Complete Station	Mechanical	1	$25,000	2008	1.03	$ 25,732	1986	25	2011	96%	1		3	1.00	1	2011	1.00	1	2011	$ 25,731.80
Folkestone Way	Distribution	PRV Station	Complete Station	Mechanical	1	$50,000	2008	1.03	$ 51,464	1995	25	2020	60%	10		3	1.00	10	2020	1.00	10	2020	$ 51,463.60
Westmount	Distribution	PRV Station	Complete Station	Mechanical	1	$25,000	2008	1.03	$ 25,732	1964	25	1989	184%	-21		3	1.00	0	2010	1.00	0	2010	$ 25,731.80
3135 Mathers Ave	Distribution	PRV Station	Complete Station	Mechanical	1	$50,000	2008	1.03	$ 51,464	1994	25	2019	64%	9		3	1.00	9	2019	1.00	9	2019	$ 51,463.60
Schoolboard (Eagle Lake Road)	Distribution	PRV Station	Complete Station	Mechanical	1	$25,000	2008	1.03	$ 25,732	2003	25	2028	28%	18		3	1.00	18	2028	1.00	18	2028	$ 25,731.80
McKechnie	Distribution	PRV Station	Complete Station	Mechanical	1		2008	1.03	$ -	1970	25	1995	160%	-15		3	1.00	0	2010	1.00	0	2010	$ -
3323 Bayridge Ave	Distribution	PRV Station	Complete Station	Mechanical	1	$25,000	2008	1.03	$ 25,732	2007	25	2032	12%	22		3	1.00	22	2032	1.00	22	2032	$ 25,731.80
Almondel Road	Distribution	PRV Station	Complete Station	Mechanical	1	$50,000	2008	1.03	$ 51,464	2004	25	2029	24%	19		3	1.00	19	2029	1.00	19	2029	$ 51,463.60
C2	Distribution	PRV Station	Complete Station	Mechanical	1	$25,000	2008	1.03	$ 25,732	2001	25	2026	36%	16		3	1.00	16	2026	1.00	16	2026	$ 25,731.80
C2 (lower chamber)	Distribution	PRV Station	Complete Station	Mechanical	1	$25,000	2008	1.03	$ 25,732	1978	25	2003	128%	-7		3	1.00	0	2010	1.00	0	2010	$ 25,731.80
Northwood	Distribution	PRV Station	Complete Station	Mechanical	1	$75,000	2008	1.03	$ 77,195	1992	25	2017	72%	7		3	1.00	7	2017	1.00	7	2017	$ 77,195.40
Westport Road	Distribution	PRV Station	Complete Station	Mechanical	1	$50,000	2008	1.03	$ 51,464	1978	25	2003	128%	-7		3	1.00	0	2010	1.00	0	2010	$ 51,463.60
Lower Nelson Creek	Distribution	PRV Station	Complete Station	Mechanical	1	$50,000	2008	1.03	$ 51,464	*1976*	25	2001	136%	-9		3	1.00	0	2010	1.00	0	2010	$ 51,463.60
Woodgreen Dr	Distribution	PRV Station	Complete Station	Mechanical	1	$50,000	2008	1.03	$ 51,464	*1975*	25	2000	140%	-10		3	1.00	0	2010	1.00	0	2010	$ 51,463.60
5168 Meadfield Road	Distribution	PRV Station	Complete Station	Mechanical	1	$50,000	2008	1.03	$ 51,464	1980	25	2005	120%	-5		3	1.00	0	2010	1.00	0	2010	$ 51,463.60
Lookout	Distribution	PRV Station	Complete Station	Mechanical	1	$175,000	2008	1.03	$ 180,123	2005	25	2030	20%	20		3	1.00	20	2030	1.00	20	2030	$ 180,122.59
Terrace	Distribution	PRV Station	Complete Station	Mechanical	1	$25,000	2008	1.03	$ 25,732	2004	25	2029	24%	19		3	1.00	19	2029	1.00	19	2029	$ 25,731.80
Cranley Drive	Distribution	PRV Station	Complete Station	Mechanical	1	$25,000	2008	1.03	$ 25,732	2005	25	2030	20%	20		3	1.00	20	2030	1.00	20	2030	$ 25,731.80
Madrona	Distribution	PRV Station	Complete Station	Mechanical	1	$50,000	2008	1.03	$ 51,464	1984	25	2009	104%	-1		3	1.00	0	2010	1.00	0	2010	$ 51,463.60
5983 Marine Drive	Distribution	PRV Station	Complete Station	Mechanical	1	$25,000	2008	1.03	$ 25,732	2005	25	2030	20%	20		3	1.00	20	2030	1.00	20	2030	$ 25,731.80
6407 Nelson	Distribution	PRV Station	Complete Station	Mechanical	1	$50,000	2008	1.03	$ 51,464	1983	25	2008	108%	-2		3	1.00	0	2010	1.00	0	2010	$ 51,463.60
6775 Marine Drive	Distribution	PRV Station	Complete Station	Mechanical	1	$50,000	2008	1.03	$ 51,464	1982	25	2007	112%	-3		3	1.00	0	2010	1.00	0	2010	$ 51,463.60
Seascapes Sub-division	Distribution	PRV Station	Complete Station	Mechanical	1	$25,000	2008	1.03	$ 25,732	2004	25	2029	24%	19		3	1.00	19	2029	1.00	19	2029	$ 25,731.80
								TOTAL	**$ 66,112,848.79**													**TOTAL**	**$ 66,112,848.79**

Appendix B – Weibull Distribution

To simulate the reality that not all pipes with an expected service life of 90 years will fail at exactly 90 years, we used the Weibull Distribution to model a replacement envelope and predict pipe failure as the network ages. The Weibull Distribution, which has a broad range of applications, is used in this case to distribute the probability of assets failing over time and associates this probability with a cost. This statistical tool does not predict when each individual asset will fail but it accurately describes how a large inventory of similar assets (e.g. pipes) actually behaves in real life.

Another advantage of Weibull Distribution is that it provides a simple and informative graphical plot. X axis is a measure of time in calendar years and Y axis is either the annual length to be replaced or the annual cost of replacement anticipated for each year.

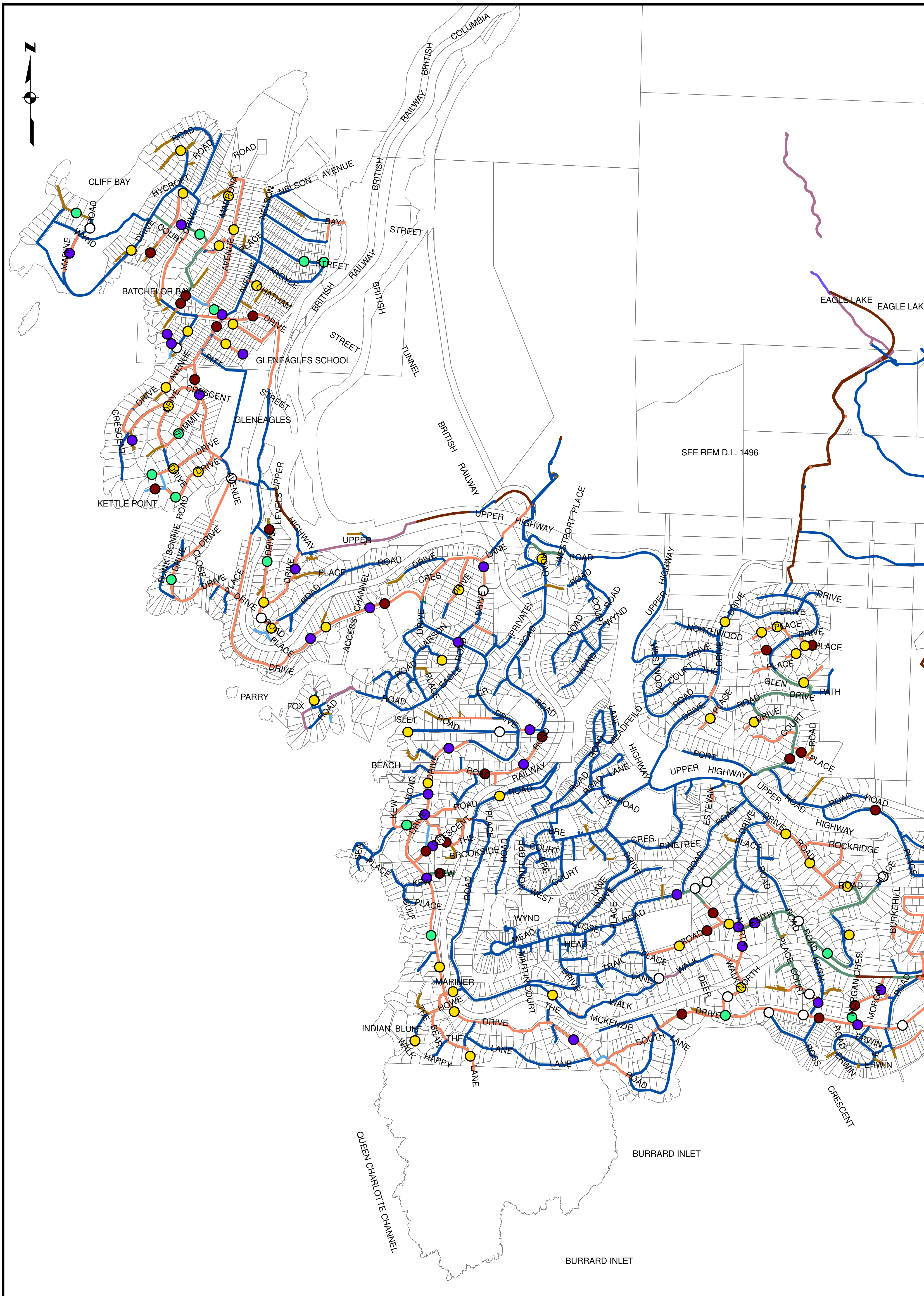
It is important to note that Weibull Distribution's reliability depends entirely on the accuracy of parameters used in the calculation. In our analysis, these parameters are:

- installation year;
- expected service life; and
- a shape parameter.

While the installation year is defined (or estimated), both the expected service life and the shape parameter are estimated. Pipe materials' expected service lives are described in Section 6. The shape parameter, or β, which is unitless and dimensionless, is also known as the slope. This is because the value of β is equal to the slope of the regressed line in a probability plot. In other words, it indicates whether the failure rate is increasing, constant or decreasing. A β <1.0 indicates that the asset has a decreasing failure rate. A β =1.0 indicates a constant failure rate and a β >1.0 indicates an increasing failure rate which is typical of assets that are wearing out like pipes. Based on research papers and actual field observations, it is generally agreed that for a pipe inventory, an accurate value for β is between 7.0 and 8.0.

Please note that all Weibull calculation sheets and charts produced with MS Excel for the purpose of this study are dynamic. This allows users to change most variables, including the shape parameter and expected service lives, and see in real-time the effects of these changes on the charts. With time, as more failure data becomes available, the shape parameter can be refined to fit the District's own failure rate. Eventually this will lead to more accurate results.

Appendix C – Water Main Break Map



District of
West Vancouver

Water Infrastructure
Long Range Capital Renewal Forecast

Project No:
111064

Date:
January 2010

Legend

Water Distribution Network
Material Type
- Asbestos Cement
- Aluminum
- Cast Iron
- Copper
- Ductile Iron
- Galvanized Steel
- High Density Polyethylene
- Polyvinyl Chloride
- Steel
- Unknown

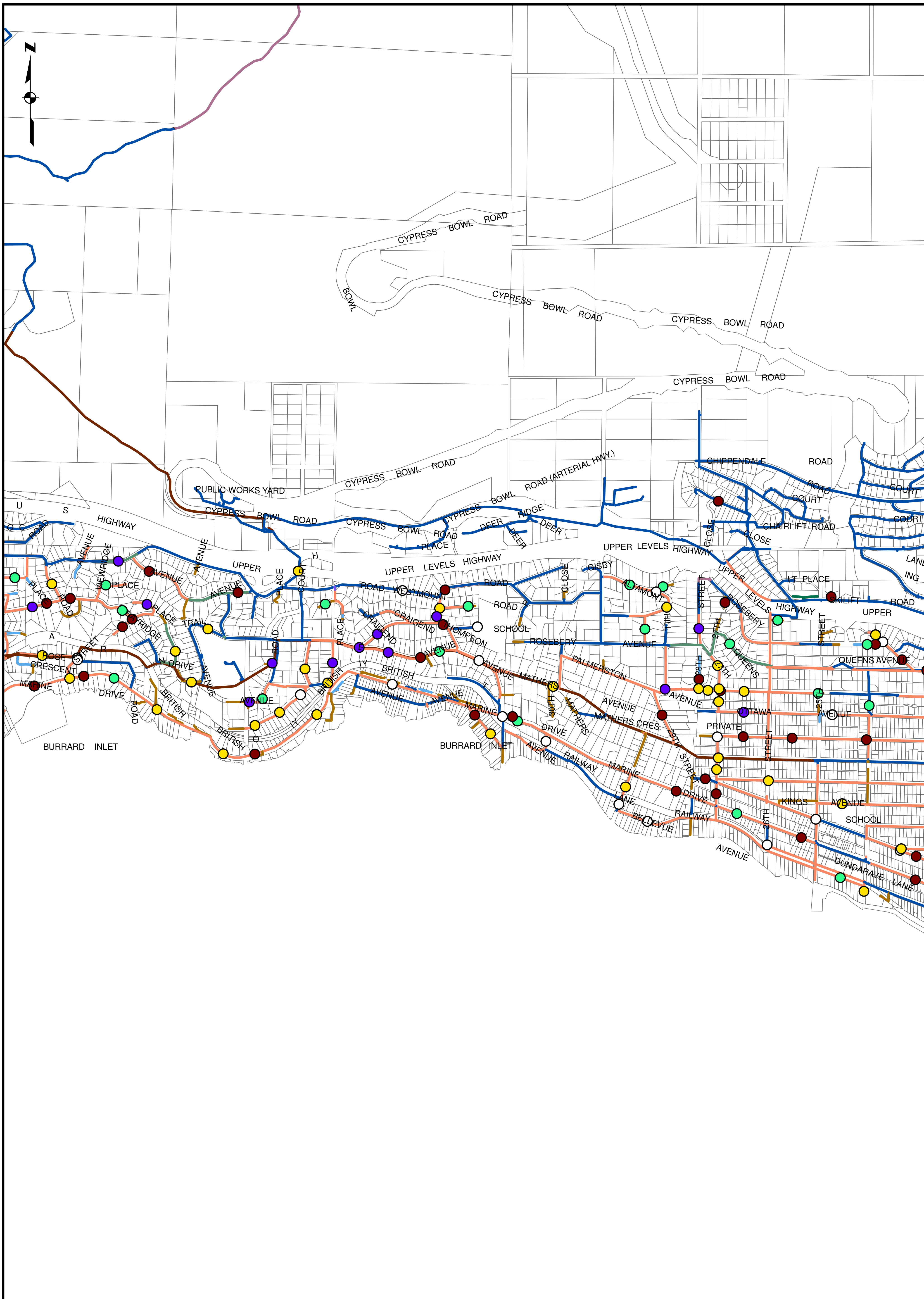
Main Breaks by Year
- 1983 - 1988
- 1989 - 1993
- 1994 - 1998
- 1999 - 2003
- 2004 - 2009

West Vancouver Lots

AECOM

Meters
0 100 200 300 400 500 600 700 800

West Vancouver
Water Main Breaks
By Year



District of
West Vancouver

Water Infrastructure
Long Range Capital Renewal Forecast

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111064

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Legend

Water Distribution Network
Material Type
- Asbestos Cement
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- Steel
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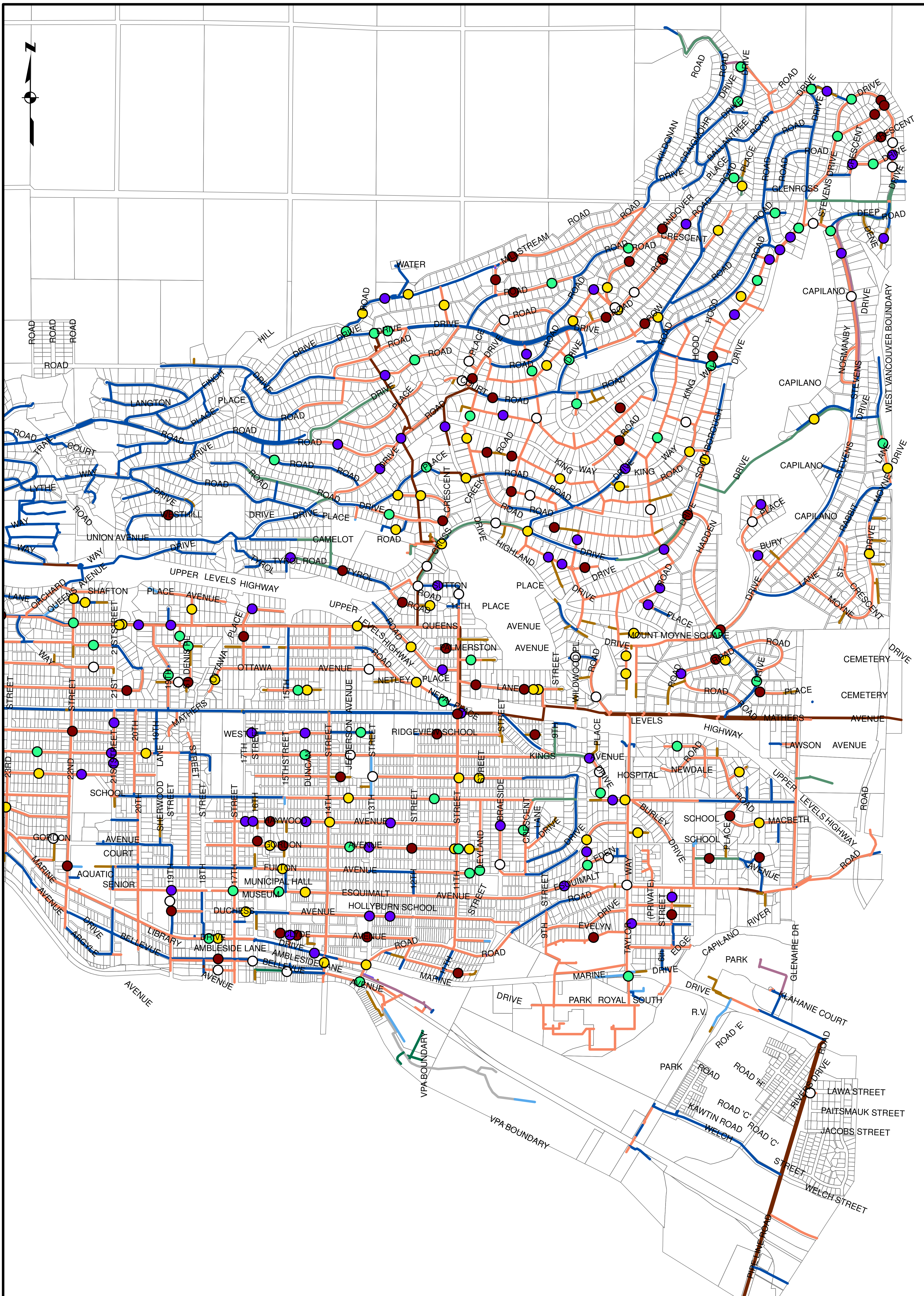
Main Breaks by Year
- 1983 - 1988
- 1989 - 1993
- 1994 - 1998
- 1999 - 2003
- 2004 - 2009
- West Vancouver Lots

AECOM

Meters
0 100 200 300 400 500 600 700 800

West Vancouver
Water Main Breaks
By Year



District of West Vancouver

Water Infrastructure
Long Range Capital Renewal Forecast

Project No: 111064

Date: January 2010

Legend

Water Distribution Network

Material Type
- Asbestos Cement
- Aluminum
- Cast Iron
- Copper
- Ductile Iron
- Galvanized Steel
- High Density Polyethylene
- Polyvinyl Chloride
- Steel
- Unknown

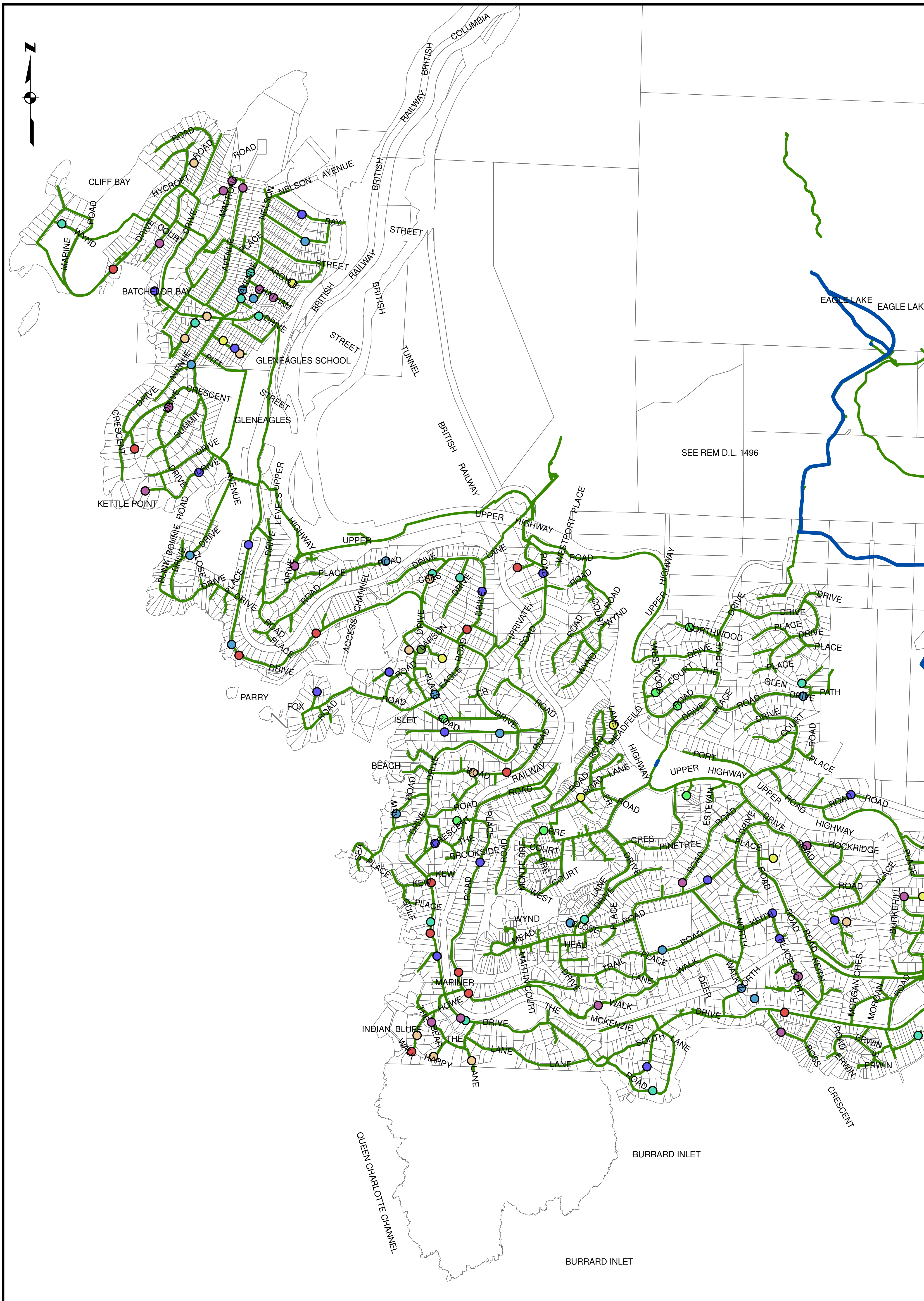
Main Breaks by Year
- 1983 - 1988
- 1989 - 1993
- 1994 - 1998
- 1999 - 2003
- 2004 - 2009
- West Vancouver Lots

AECOM

Meters
0 100 200 300 400 500 600 700 800

West Vancouver Water Main Breaks By Year

Appendix D – Water Service Break Map



District of
West Vancouver
Water Infrastructure
Long Range Capital Renewal Forecast

Project No:
111064

Date:
January 2010

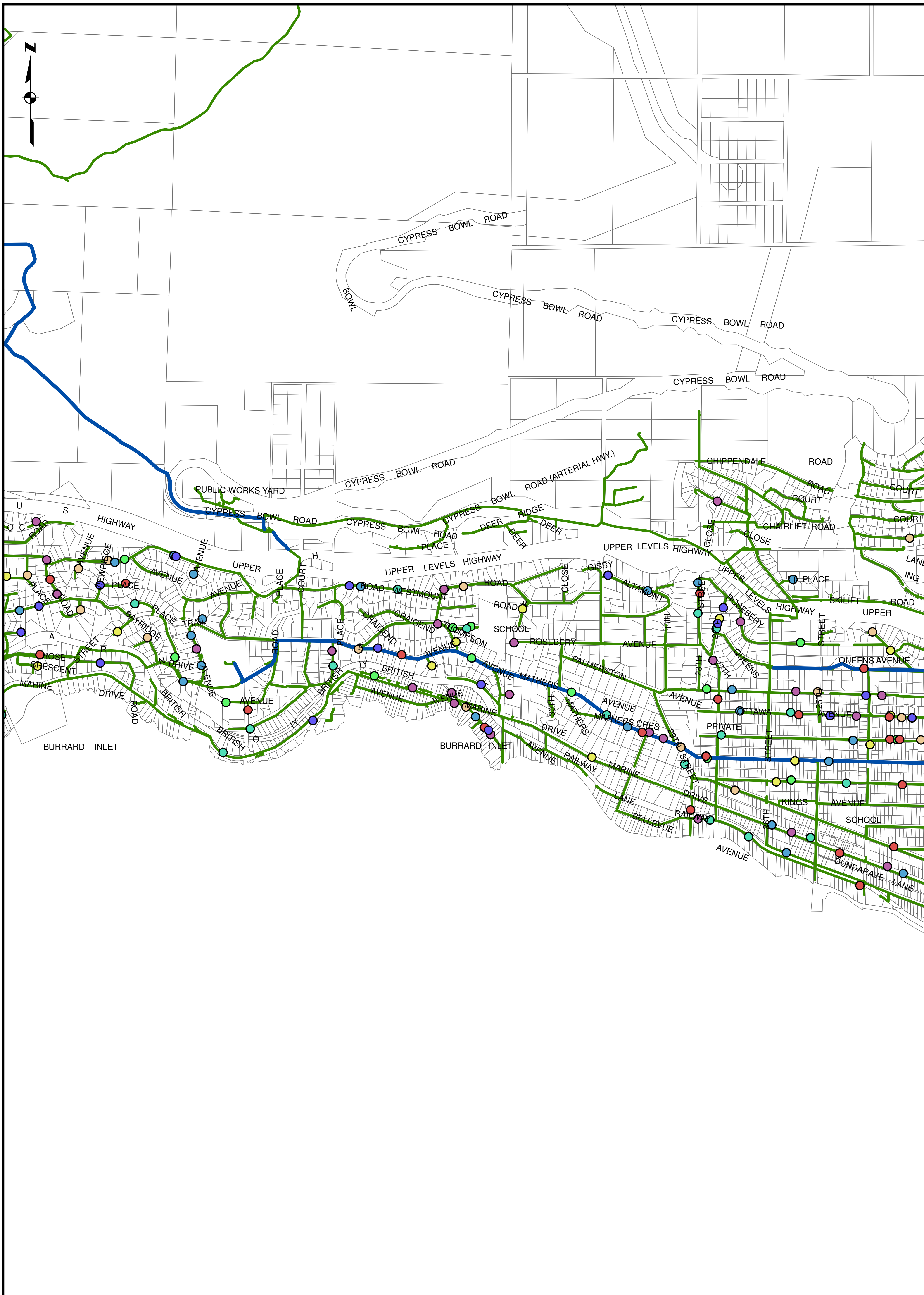
Legend

Water Mains
Water Trunks
West Vancouver Lots
Service Breaks by Year
2001
2002
2003
2004
2005
2006
2007
2008
Unknown Year

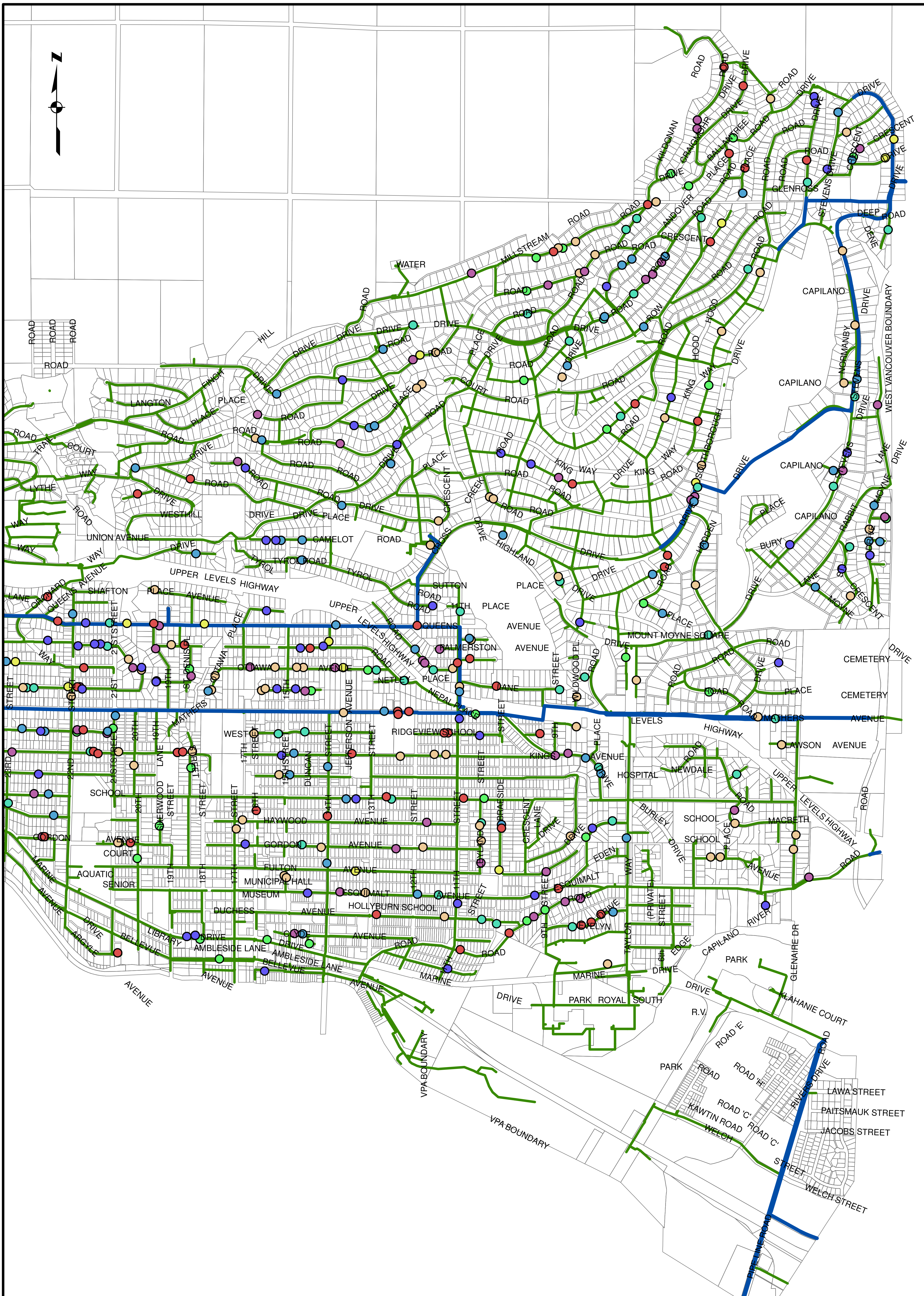
AECOM

0 100 200 300 400 500 600 700 800 Meters

West Vancouver
Water Service
Breaks By Year



District of West Vancouver	Legend	AECOM	West Vancouver Water Service Breaks By Year
Water Infrastructure Long Range Capital Renewal Forecast	Water Mains Water Trunks West Vancouver Lots **Service Breaks by Year** 2001 2002 2003 2004 2005 2006 2007 2008 Unknown Year	0 100 200 300 400 500 600 700 800 Meters	
Project No: 111064 / Date: January 2010			



District of
West Vancouver

Water Infrastructure
Long Range Capital Renewal Forecast

Project No: 111064

Date: January 2010

Legend

- Water Mains
- Water Trunks
- West Vancouver Lots

Service Breaks by Year

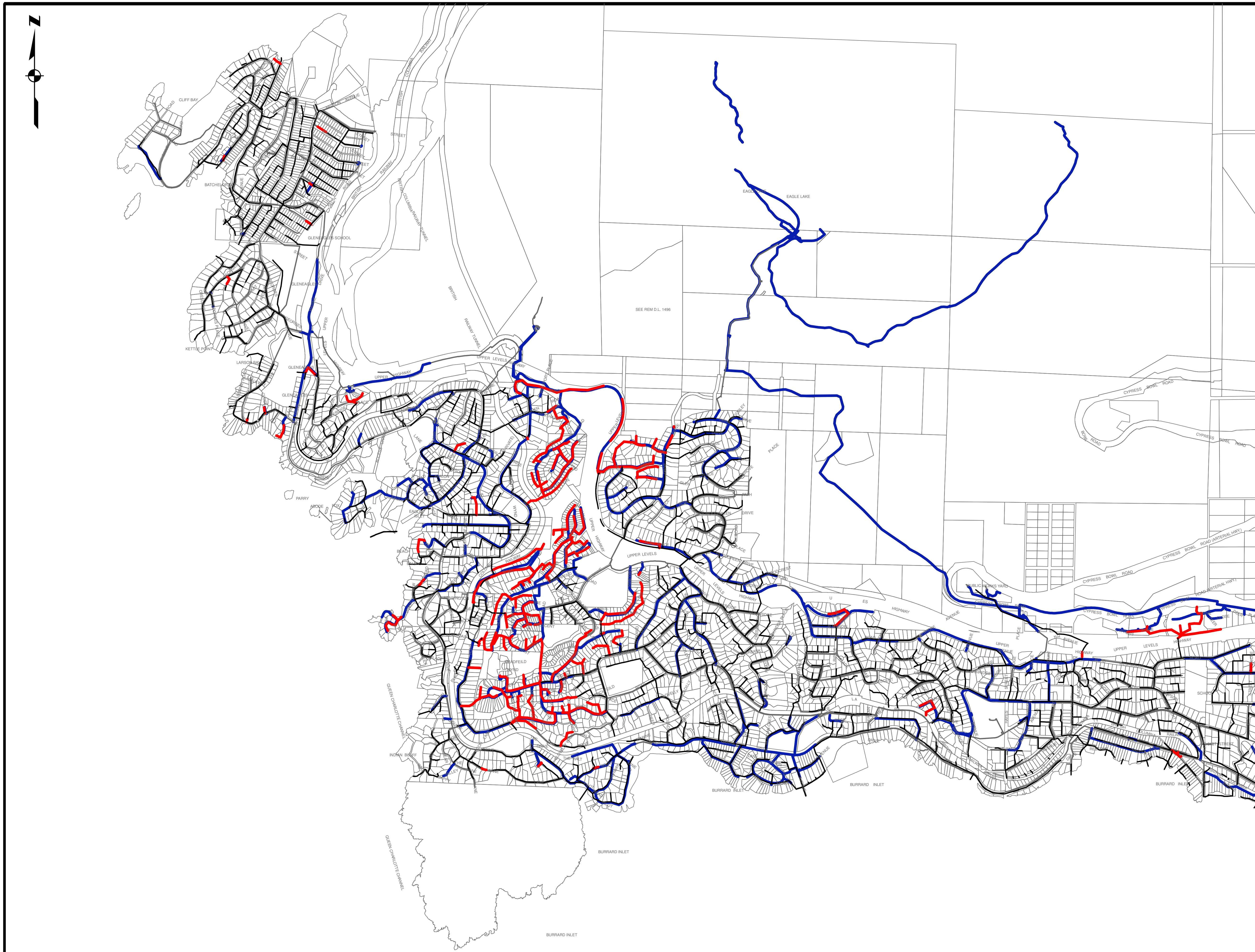
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- Unknown Year

AECOM

0 100 200 300 400 500 600 700 800 Meters

West Vancouver
Water Service
Breaks By Year

Appendix E – Water and Sewer Mains Constructed Since 1980



District of West Vancouver

Asset Management Evaluation

- Western Half of West Vancouver

Legend

Sanitary Mains

Year of Installation

Before 1980

After1980

Water Mains

Year of Installation

Before 1980

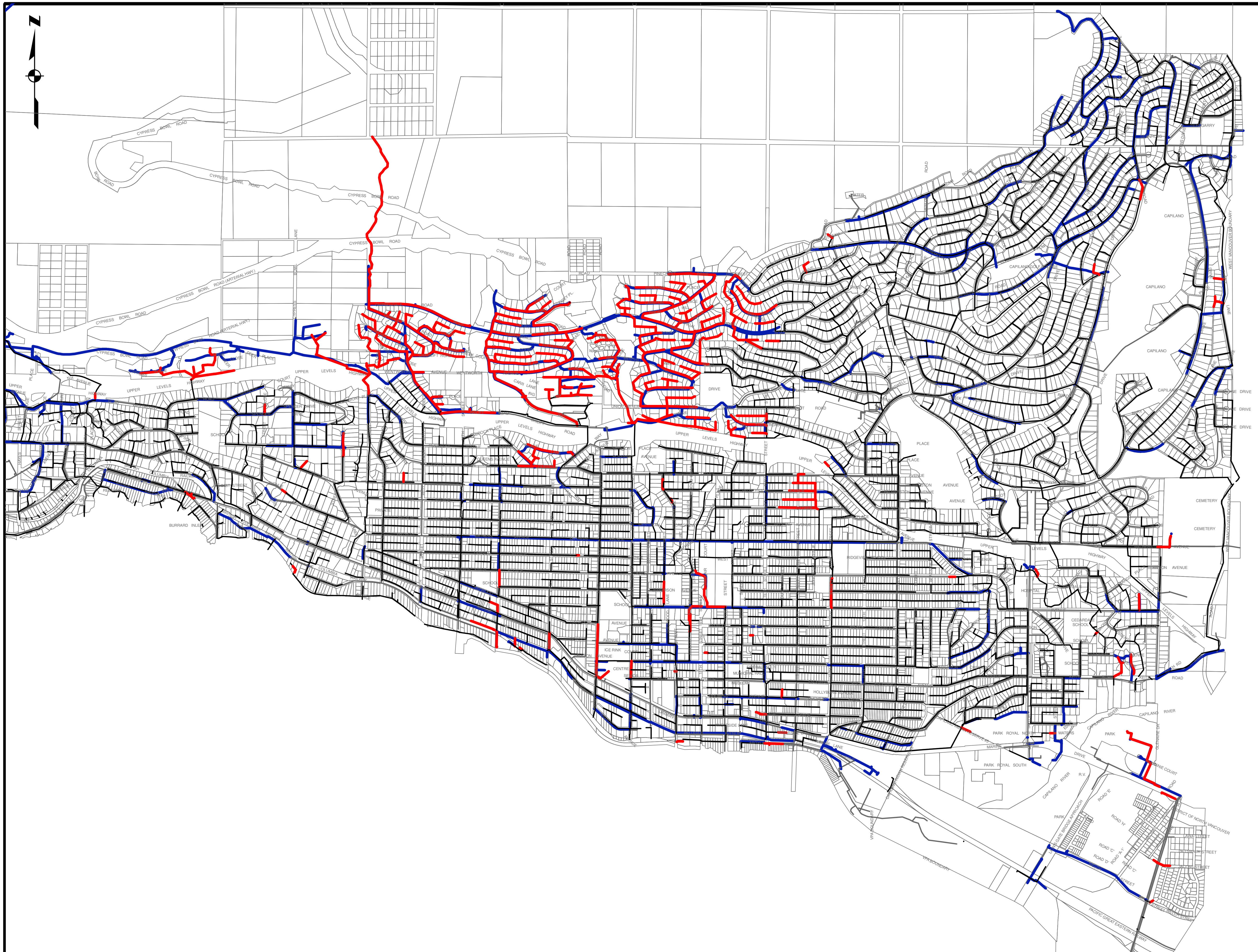
After 1980

AECOM

0 200 400 600 800 1,000 m

Project No.	Date
111064	February 2010

West Vancouver
Water and Sanitary System
Installed after 1980



District of West Vancouver

Asset Management Evaluation

- Eastern Half of West Vancouver

Legend

Sanitary Mains

Year of Installation

Before 1980

After1980

Water Mains

Year of Installation

Before 1980

After 1980

AECOM

0 200 400 600 800 1,000 m

Project No.	Date
111064	February 2010

West Vancouver
Water and Sanitary System
Installed after 1980

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