WATER MASTER PLAN

FINAL REPORT

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WATER MASTER PLAN

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URBAN SYSTEMS

EXECUTIVE SUMMARY

A Water Master Plan is a planning tool to guide water utility improvements and infrastructure renewal decisions to ensure investments are completed in an organized and cost-effective manner. The last water master plan was completed in 2003 and in the ensuing years, the city has seen significant growth and operational changes to the water distribution system. This Water Master Plan provides a review of the hydraulic performance of the City of Courtenay's water distribution system and identifies deficiencies and recommended upgrades over the next 20 years.

Overall, the *Water Master Plan* addresses the following study objectives:

- **To develop an updated hydraulic water model that includes the growth and operational changes to the system since the last water model and will be updated in 5- to 10-years;**
- **To assess hydraulic performance of the system to ensure regulatory compliance is met while incorporating corrective measures brought forward that stem from public works services, engineering and planning and development departments;**
- **To develop a short- and long-range capital plan for the next 20 years, to address current and future demands and;**
- **To update the hydraulic model for use in the performance assessment and for all other future assessments for system capacity e.g., development reviews, preliminary design projects and,**
- **To identify projects for inclusion in the Development Cost Charges Bylaw.**

The Water Master Plan include an implementation plan which includes the following recommendations:

- Include Master Plan capital projects in the annual City financial plans beginning in the next budget cycle.

It is recommended that the City spend $1.9M per year for the next 5 Years on upgrades to address hydraulic deficiencies identified in this report. In addition, a minimum forecast of $2.2M to $2.8M in spending is also recommended in current in-service asset replacement per year for assets at or near the end of their useful life depending on the level of risk the City is willing to accept.

- Update the Development Cost Charge (DCC) bylaw with eligible projects from the Master Plan. DCC-eligible projects provide a cost-sharing approach with developers based on the ratio of new population to existing population serviced.

Within the scope of the Master Plan, 8 out of the 10 projects are DCC eligible growth-driven projects.

- Initiate discussions with Comox Valley Regional District (CVRD) regarding transmission and distribution system separation.
- Coordinate with CVRD on an ongoing basis, information sharing to inform capital project decisions that affect the City's water distribution system.
- Integrate the recommended projects from this plan into the Water System Asset Management Plan.
- Ensure that fire flow calculations are completed for all new non-single-family residential developments to ensure the system capacity is adequate to service the proposed growth.
- Implement a zone metering program to identify and isolate areas of high-water leakage and better account for water.
- Advance the business case for universal metering and continue to make all new construction meter-ready by installing meter pits.
- Investigate the deficiencies outlined in the Water Distribution System Model Development, Calibration and Capacity Analysis Report.
- Investigate the elimination of water flowing through private systems and the effect on the private and public systems.
- To continue to consult with K'omoks First Nation to support the servicing agreements in place among participating governments.

Based on the investigations undertaken and presented in this report, a total of ten (10) individual project were identified and have been recommended for inclusion in upcoming capital plans. These projects have been selected for various combination of reasons; growth, Advancing of Level of Service, Water Quality and Operational Efficiency.

These projects are summarized in **Table 1** below.

Table 1 – Capital Project Recommendations

Project Name	Timing	Budget
Regional Collaboration Projects to Support Growth		
South Courtenay Secondary Transmission (WAT 001)	*5 Year (Initiated 2021)*	**$3,400,000**
South Courtenay PRV and Booster Station Upgrades (WAT 010)	*5 Year*	**$500,000**
New PRV Connection to 87 Zone (WAT 010)	*5 Year*	**$300,000**
Lerwick Road Transmission Main (WAT 002)	*5-20 Year*	**$3,300,000**
Projects Related to Past System Performance Issues		
Braidwood Road (WAT 005)	*5 Year*	**$600,000**
North Island Hwy, Cotton Rd and Topland Rd (WAT 006)	*5-20 Year*	**$1,400,000**
South Hwy 19A (WAT 009)	*5 Year*	**$1,600,000**
Projects Related to Existing System Performance Issues		
District Metering (WAT 011)	*5 Year*	**$1,200,000**
Projects Related to Future System Performance Issues		
Arden Road – Lake Trail to Copperfield (WAT 003)	5 Year	**$1,600,000**
Arden Road – Cumberland to Brookfield (WAT 004)	5 Year	**$550,000**

1.0 BACKGROUND

1.1 INTRODUCTION

The City of Courtenay is expected to undergo significant growth over the next 20 years with current signs of rapid growth already occurring. Generally, the existing water distribution infrastructure can accommodate a range of water demands, yet there are areas of the City that are not yet able to provide the desired level of service for fire protection; in the future, more and more areas will not meet levels of service and incremental upgrades are needed. These are common conditions to plan for with respect to water utilities in growing communities. The Courtenay *Water Master Plan* provides a schedule of prioritized capital projects over the short- and medium-term including considerations and impacts to the DCC bylaw for eligible projects. Overall, the desired outcomes from the water master plan are:

- To create an accurate water model that integrates with City of Courtenay's GIS system for the 2019 scenario, which also allows for flow projections into the future scenarios of 2024 and 2039,
- To identify and confirm existing and future capacity and water quality deficiencies,
- To develop a prioritized list of capacity-based and condition-based projects for short-term capital planning and servicing,
- To identify projects eligible for inclusion in the Development Cost Charges Bylaw.
- To develop a strategy to adequately separate the regional and local infrastructure to optimize operational, financial, and quality conditions, and
- To provide a foundation for preliminary water system design including technical findings with respect to project locations, upgrade bundling for project efficiencies.

1.2 STUDY AREA

The study area is comprised of distribution zones throughout the City of Courtenay. Generally, the study area comprises the City boundary including lands serviced by the water utility, however due to the Courtenay water system's integration into the greater Comox Valley water system, the CVRD water utilities and the Town of Comox water system are influenced this study.

1.3 SUPPORTING DOCUMENTATION

GeoAdvice has prepared a technical report that documents the analysis completed to update and calibrate the City water model and the capacity analysis undertaken. This report is located in **Appendix A**.

The City has prepared project sheets for each of the major projects and also developed cost estimates for each project. These are contained in **Appendix B**.

1.4 INFRASTRUCTURE HIERARCHY AND GOVERNANCE

Levels of service, utility policy, asset management, master planning, capital planning, and annual programs are all related; however, they should be evaluated as their own focus areas then integrated to provide clarity and overall effectiveness. The conventional infrastructure hierarchy is summarized below.

- Includes all assets
- High level direction built on layers of detail
- Directed by Strategic Plans and Community Sustainability Plans
- Considers sustainable finance and achievable levels of service

- Planning to achieve a reliable level of service for current & future scenarios
- Focus on one asset, often in a defined area
- Analyze growth and demand trends
- Develop priorities and site specific projects

- Setting annual and 5-year budgets
- Selecting capital projects from Master Plans
- Confirm schedule (date) for capital project completion
- Annual operation and maintenance plans

While applying this hierarchy for infrastructure planning, it becomes clear that establishing service levels is a priority for any Water Master Plan. The process of evaluating system-performance against targeted service levels is described in the following section, prefaced by a brief description of assets in the utility as well as a performance summary from hydraulic analyses.

2.0 SYSTEM PERFORMANCE

System performance is the cornerstone of a water master plan, including current and future conditions. This section summarizes the infrastructure, presents summary results of hydraulic analyses, and defines the risk methodology for the analysis. Selecting levels of service to determine capital priorities and funding requirements is a key outcome of the *Water Master Plan*.

2.1 WATER INFRASTRUCTURE OVERVIEW

The City of Courtenay water distribution system as of 2020 was comprised of approximately 173 km of water mains, numerous pressure reducing valve stations, and 1 pump station owned and operated by the City situated throughout the 7 pressure zones. The two lower pressure zones (87m and 110m) are fed from the CVRD West Courtenay and Marsden Reservoirs while pressure zone 120m is fed from the East Courtenay Reservoir and the Dingwall and Ryan Road pump stations. Pressure zone 135m (Buckstone) is fed internally from the 87m zone and pressure zone 138m is fed from the CVRD Courtenay Booster Station. Pressure zone 150m is fed from the Marsden pump station out of the Marsden reservoir. Finally, pressure zone 97m is fed through PRVs from the CVRD water system and from pressure zone 138m.

Pipe Material: Installations of new or enhanced water distribution main have been ongoing for many decades which naturally results in a mix of materials, diameters, and construction standards. Asbestos cement (AC) and polyvinyl chloride (PVC) pipe comprise the majority of all water mains; the latter material is almost exclusively installed in new developments and upgrade projects and has an estimated useful life of 100 to 120 years.

Pipe Diameter: Approximately 70 percent of the pipes in the system are 200 millimeters (mm) in diameter or less. The remaining 20 percent of pipes are 250 mm diameter or greater, and generally comprise the distribution system including trunks.

Pressure Reducing Valve Stations: The City currently owns and operates seven (7) PRV stations in order to provide flows into the various pressure zones. In addition, there are multiple PRV stations owned and operated by the CVRD which control flow into the City system.

Pump Stations: While there are many pump stations that feed the City customers only one pump station (Beachwood) is currently owned and operated by the City.

Reservoirs: All peak hour balancing and fire flows are stored within reservoirs owned and operated by the CVRD. Future discussions with the CVRD are necessary in order to review the current reservoir size and capacity in the context of this most recent hydraulic modelling.

2.2 HYDRAULIC MODELING SUMMARY

This section provides an overview of the hydraulic modeling methodology, including the type of model used for the assessment as well as how flows were characterized and under what scenarios. Results of the performance assessment are provided as part of the capital plan development.

2.2.1 HYDRAULIC MODEL DEMAND METHODOLOGY

Prepare for Impacts of Climate Change and Water Use Variability

It is widely accepted that capital planning must now consider the impacts of climate change and its derivatives on infrastructure including changes in precipitation, temperature, water demand characteristics and sea level rise. Further, there is also the need to consider other factors that influence water use variability which include water efficient fixture design, public attitudes and behaviours and system losses and leakage.

Being cognizant of these changes and adapting the capital planning process accordingly, including engineering standards and design parameters, will help ensure that infrastructure is resilient, and our communities vibrant, over the long term. There are also major economic consequences of ignoring these impacts, as unanticipated infrastructure failure places significant stress on public finances, restricting the capacity of the government to respond and adapt. This also ties into current best practices for asset management and overall capital planning. For this master plan we have incorporated future resilience in the following ways:

- Identified future water use needs to be conservative but also incorporate best practices so as to avoid oversizing infrastructure;
- Evaluated proper separation and metering of all supply points form the CVRD so that actual water use by the City can be better understood; and,
- Recommended future consideration for individual water meters so that water use can be better understood and the impacts of various water conservation programs and initiatives can be best focused. Further universal metering also allows the City the ability to best understand water loss and strategies for reducing this and other sources of non-revenue water

Model Scenario Development

The water distribution model was developed with four demand scenarios:

a. Average Day Demand (ADD)
b. Maximum Day Demand (MDD)
c. Peak Hour Demand (PHD)
d. Maximum Day Demand + Fire Flow (MDD+FF)

The scenarios were modeled under the 2019-, 2024-, and 2039-time horizon.

Fire flow demands have been assigned to the model to reflect the existing land use of the parcels that are in proximity to the hydrant. The fire flow values are in accordance with the *MMCD Design Guidelines* © 2014 and the 2018 *City of Courtenay Supplementary Design Guidelines*. It is important to note that these values are intended to align with the *Water Supply for Public Fire Protection – A Guide to Recommended Practice* as published by the Fire Underwriters Survey. The FUS has completed a parcel by parcel geospatial review of required fire flows for existing development in Courtenay and the results are listed in the table below. As illustrated the range of required fire flows is large for existing development. The City has decided to maintain the minimum MMCD fire flow values as the level of service for the assessment of the existing system since this aligns with how the system has been designed to date.

These values are minimums and for any developments other than single family homes it is recommended that fire flow calculations be submitted with the development so that it can be ensured that the recommended fire flows do not exceed that capacity of the system.

Table 2.1 Fire Flow Requirements

Land Use	FUS Existing Calculated Fire Flows (L/s)	MMCD Minimum Required Fire Flow (L/s)
Single Family	76-235	60
Multi Family	76-364	90
Commercial	15-265	150
Institutional	91-227	150
Industrial	91-167	225
Agricultural	91-167	60

Prior to assigning growth, the model was calibrated based on twelve (12) field hydrant tests. The model demonstrated good agreement on both static and residual pressures with average results in the field and model agreeing within +/-3% on average for static pressures and a range of 0-12% and +/-2% for residual pressures with a range of 0-12%.

Population growth forecasts were developed by staff based on land use considerations as well as market forces and ongoing development projects. Growth was separated into 5-and 20-year increments to support the modelling scenarios described herein. The summary results of population include approximately 7,000 new persons by 2024 and a total increase of 9,600 by 2039. The location of growth is illustrated on a zone-by-zone basis in Figure 4.1 found in **Appendix A**.

Utility master plans often include conservative population estimates to remain prudent with respect to the timing and risk (of under sizing) related to upgrades. The likelihood of an additional 7,000 water customers (people, not new accounts) by 2024 is likely low but suitable for modelling at this time.

Hydraulic Performance and Design Criteria

Through discussions with the City, the following hydraulic performance and design criteria were established consistent with the *City of Courtenay Subdivision and Development Bylaw*.

Table 2.2 Hydraulic Performance and Design Criteria

Criteria	Parameter Value
Demands:	
Average Day (ADD)	635 L/person/day
Maximum Day (MDD)	2,100 L/person/day
Peak Hour (PHD)	3,000 L/person/day
Fire Flows (FF)	As per Table 2.1
Pressures:	
Maximum Static Pressure (ADD)	1034 kPa (150 psi)
Minimum Static Pressure (PHD)	300 kPa (44 psi)
Minimum Residual Pressure (MDD+FF)	150 kPa (22 psi)

The existing demands were developed from the existing model. The existing demands are summarized in **Table 2.3** below:

Table 2.3 Existing and Future Demand Summary

Scenario	Existing Demand (L/s)	2024 Demand (L/s)	2039 Demand (L/s)
Average Day Demand	175	226	246
Maximum Day Demand	578	748	812
Peak Hour Demand	825	1,068	1,159

2.2.2 CVRD/CITY SYSTEM SEPARATION AND DISTRICT METERING ZONES

One of the City's primary objectives for future system operation is the clear separation between the transmission system which is operated by the CVRD and the distribution system which is owned and operated by the City. This separation allows for accountability of water use and water quality, reduces liability confusion, allows for improved operating conditions, and improves the definition of asset-ownership and renewal responsibilities. Through the Sandwick water system transition, the City has already been working to introduce clearer separation and a long-term plan has been developed in collaboration with the City to provide complete system separation. This system separation can also be further defined by District Metering Zones (DMZ's) of all current connections allowing for detailed water accounting which is something that is not currently possible with the current interconnections.

2.2.3 ELIMINATION OF CROSS CONNECTIONS (PRIVATE LOOPS)

There are a number of locations throughout the City where two (or more) points of a distribution main connect through private property allowing water to potentially re-enter the public water system, also referred to as a private loop. Historically, the rationale for this arrangement involved the need to meet fire flow needs for either the private or public system. However, best practices of further hydraulic modeling will attempt to resolve the need for the connection through private property by closing valves or installing cross-connection controls. In this water model the multiple connections to these properties have been closed.

2.2.4 PRESSURE ZONE BOUNDARY REVIEW

The following table summarizes the current City pressure zones, the maximum and minimum serviced elevations and the corresponding system pressures.

Table. 2.4 Pressure Zone Summary

Zone Name	Minimum Elevation (m)	Maximum Elevation (m)	Minimum Pressure (kPa/Psi)	Maximum Pressure (kPa/Psi)
87	4.5	49.4	369/53	809/117
97	27.6	60.0	363/53	680/99
110	35.5	64.3	448/65	730/106
120	19.4	77.3	243/35	987/143
135	20.7	65.1	685/99	1121/162
138	58.6	94.3	428/62	779/113
150	66.1	89.5	594/86	823/119

*The red highlighted cells illustrate areas which fall outside of the maximum and minimum static pressure objectives of the City.

Pressure zones 87 and 110 are fed from the West Courtenay and Marsden reservoirs, respectively. From pressure zone 87, water is pumped through the Beachwood Road booster pump station to pressure zone 135 at the southeast corner of the City. Pressure zone 150 is fed from the Marsden pump station out of the Marsden reservoir. Pressure zone 120, which is serviced by the East Courtenay Reservoir, is fed from the Dingwall and Ryan Road pump stations. Pressure zone 138 is fed from the CVRD through the Courtenay booster pump station. Finally, pressure zone 97 is fed through PRVs from the CVRD and from pressure zone 138.

2.2.5 SYSTEM PERFORMANCE SUMMARY

The following sections outline the performance of the water distribution system under the various scenarios.

CVRD Supply Reservoirs and Pump Stations

Through discussions with the CVRD and City it was determined that CVRD reservoirs have been assumed to be operating at 80% full for the steady state analysis. For maximum day

plus fire flow analysis all pumps within the CVRD Ryan Road booster station and all except one of the largest pumps in Dingwall and Courtenay were assumed to be on.

The model indicates that the Courtenay Booster Station becomes deficient within the future 5-year growth scenario.

Beachwood Pump Station

The Beachwood Pump Station is the only City owned and operated booster pump station. It was installed as a temporary pump station when the initial phases of the Buckstone development were constructed. Through recent analysis we have confirmed that this station is suitably sized for some additional single-family development but that multi-family fire flows may cause the station to become deficient depending on the location of the development. The long-term plan when this station was built was based on the construction of a CVRD transmission main which has design currently underway. Based on this the pump station was only modelled under existing demand conditions.

Pressure Reducing Valves

The existing and future pressure reducing valves were evaluated within the water distribution model. Further details on the PRV analysis are contained in **Appendix A**. All PRVs remain within acceptable ranges for all existing and future scenarios.

Pipes

The hydraulic analysis of the City water distribution system illustrates the following results:

Table 2.5 Summary of Hydraulic Modeling Results

Criteria	Scenario	Existing	2024	2039
Number of Low Pressure Deficiencies: Demand Nodes < 44 psi	PHD	11	120	264
Number of Fire Flow Deficiencies Residual Pressure < 20 psi	MDD+FF	85	90	105

The modeling results indicate a limited number of pressure deficiencies under the existing scenario, but a significant increase in pressure deficiencies in future scenarios. These pressure deficiencies are caused primarily by high elevations and high headlosses through the 120m CVRD supply system. Low pressures in the 138m zone in future scenarios indicate the Courtenay Booster station will not be able to support increasing growth. The results are further illustrated in **Appendix A.**

Fire flow deficiencies are found at nodes throughout the City which is not uncommon for a system that has been built gradually over time. In the future fire flow deficiencies

dramatically increased unless upgrades are completed. The fire flow results are illustrated in **Appendix A**.

Hydrant Coverage

The City's existing hydrant coverage was assessed geospatially in accordance with Fire Underwriters Survey recommendations. These hydrant coverages, of course, are best practice averages. Where deficiencies exist, it is recommended that they be reviewed using best practices and spatial analysis to confirm if a deficiency actually exists and if so where additional hydrants are recommended to be placed.

Table 2.7: Fire Flows and Hydrant Spacing by Land Use Type

Land Use	Required Fire Flow (L/s)	Average Area per Hydrant (m^2)	Average Radius per Hydrant (m)
Single Family	60	15,200	70
Multi Family	90	14,300	68
Commercial	150	12,500	63
Institutional	150	12,500	63
Industrial	225	10,250	57

3.0 CAPITAL PLAN DEVELOPMENT

3.1 CAPITAL PLAN OVERVIEW

A Water Master Plan incorporates multiple inputs and utility factors so as to identify new policies, programs, or projects to maintain adequate levels of service into the future. Key elements of the implementation plan provided in Section 2 outline recommendations for programs and projects that address the following major categories:

Table 3.1: Implementation Plan – Key Elements

Category	Description
Minimum Levels of Service	To address gaps in providing minimum levels of service in areas such as providing a minimum main size.
Advancing Levels of Service	To expand levels of service beyond minimum levels in areas such as fire protection.
Growth	To provide capacity for servicing of new growth.
Water Quality	To improve the water quality within the current distribution system.
Operational Efficiencies	To improve areas of operational efficiency in the system

Section 3.2 provides details on the fundamental factors that drive the scoping, bundling, and sequencing of major capital projects. Other major capital projects are presented as well. The major projects have been selected based on the results of the modeling exercise and other investigations completed as part of this project, along with field considerations, discussions with operations staff and other information reviewed for previous studies.

The combination of major capital projects and the overall implementation plan (Section 3.4) comprises the overall Water Master Plan.

Overall, the number of infrastructure upgrades and the scale of financial resources is reasonable.

3.2 CAPITAL PLAN

The following **Table A** summarizes the capital plan elements and aligns the projects with the associated improvement category and provides Class D cost estimates for each project. Detailed project summaries are contained in **Appendix B**.

Table A: Summary of Capital Projects – Water Master Plan

Project Name	Timing	Justification/Benefit	Improvement Category *(Additional Benefits)*	Budget *(Class D)*
Regional Collaboration Projects to Support Growth				
South Courtenay Secondary Transmission (WAT 001)	*5 Year (Initiated 2021)*	As part of the CVRD transmission main to South Courtenay, Royston Water Service Area and proposed K'ómoks First Nation development, this project would provide a secondary water supply to the South Courtenay Area and ensure future development capacity	**Growth**	**$3,400,000**
South Courtenay PRV and Booster Station Upgrades (WAT 010)	*5 Year*	Contingent on the construction of the South Courtenay Transmission Main, connections to the existing Courtenay distribution system would meet fire supply demands and provide a second water source to remote areas.	**Growth, Advancing Level of Service** *(Fire Protection),* **Water Quality, Operational Efficiency,**	**$500,000**
New PRV Connection to 87 Zone (WAT 010)	*5 Year*	Contingent on the construction of the South Courtenay Transmission Main, a connection to the Courtenay 87m pressure zone would meet fire supply demands and provide a second water source to remote areas.	**Growth, Advancing Level of Service** *(Fire Protection),* **Water Quality, Operational Efficiency,**	**$300,000**
Lerwick Road (WAT 002)	*5-20 Year*	Extending the Courtenay supply main would reduce water distribution system deficiencies and remove the City distribution system from the regional transmission system.	**Advancing Level of Service** *(Fire Protection),* **Water Quality, Operational Efficiency,**	**$3,300,000 (Approx.)**

Project Name	Timing	Justification/Benefit	Improvement Category *(Additional Benefits)*	Budget *(Class D)*
City Projects Related to Past System Performance Issues				
Braidwood Road (WAT 005)	*5 Year*	Upgrading the undersized main on Braidwood Rd would improve fire flow and meet bylaw requirements.	**Growth, Advancing Level of Service** (*Fire Protection)*,	**$600,000**
North Island Hwy, Cotton Rd and Topland Rd (WAT 006)	*5-20 Year*	Upgrading the undersized mains in this area would improve fire flow and meet bylaw requirements.	**Advancing Level of Service** (*Fire Protection)*,	**$1,400,000**
South Hwy 19A (WAT 009)	*5 Year*	Upgrading the undersized main on S. Island Hwy. and connecting with other mains to create loops would improve fire flow and meet bylaw requirements. Project dependent on S. Courtenay Transmission Main.	**Growth, Advancing Level of Service** *(Fire Protection)*,	**$1,600,000**
City Projects Related to Existing System Performance Issues				
District Metering (WAT 011)	*5 Year*	As part of the advancement toward system separation as well as incorporating water smart initiatives, zone metering of all current transmission/distribution connections will allow for detailed water accounting which is something that is not currently possible with the current interconnections.	**Growth, Operational Efficiency**	**$1,200,000**

Project Name	Timing	Justification/Benefit	Improvement Category *(Additional Benefits)*	Budget (*Class D*)
City Projects Related to Future System Performance Issues				
Arden Road – Cumberland to Brookfield (WAT 004)	5 Year	Upgrading the undersized main on Arden Rd would improve fire flow and meet bylaw requirements.	**Growth, Advancing Level of Service** *(Fire Protection),* **Water Quality, Operational Efficiency,**	**$550,000**
Arden Road – Lake Trail to Copperfield (WAT 003)	5 Year	The undersized main on Arden Road would need to be upgraded to meet fire flow and bylaw requirements should development proceed.	**Growth Service, Advancing Level of** (Fire Protection), **Water Quality, Operational Efficiency, Infrastructure Renewal**	**$1,600,000**
			Capital Projected Total	**$14,450,000**
			5-Year Projected Capital Costs	**$9,750,000**

Notes:
1) Projects WAT 003 and WAT 004 Would Not be Required If South Courtenay Secondary Transmission Line (WAT 001) is Constructed.
2) South Courtenay Secondary Transmission Line cost assume current collaboration approach with the CVRD. Costs would increase if the City Were to Construct it Independently.

Distribution system growth and expansion related upgrades are not shown in the 5-year plan since they are to be planned in conjunction with the timing of development that benefit from the upgrades.

In addition to the above upgrades, the City of Courtenay's Water Distribution system has a replacement cost of $233M in 2020 dollars[1], using industry standard life cycle replacement data it is recommended that an annual $3.4M investment in the renewal of existing infrastructure be spent. Using alternate extended life scenarios where replacement is based on complete failure, not including risk costs it would range from $2.2M to 2.8M[2]. Based on the extensive asset inventory and using asset management principals it has been determined the Water system has a $3.2M infrastructure deficit and as a whole has approximately 55% remaining life.

Asset deterioration is not a linear process and tends to increase as assets age. As such while the next 5-year investment plan is less than the average noted above this will need to be evaluated and updated every year as budgets are set in order to align with ongoing condition assessment work. Prioritizing capacity-based upgrades to align with condition priorities further reduces the overall burden on the utility.

3.3 DEVELOPMENT COST SHARE REVIEW

A complete water master plan signals the opportunity to update financial tools such as the development cost charge bylaw (DCC). Growth-driven upgrades below comprise the eligible projects for consideration in future DCC program analysis. Of the eight (8) DCC eligible and growth-driven projects, one of the projects may be deemed completely driven by growth with very limited benefit to existing customers (the CVRD extension), and the remaining seven (8) projects are better aligned with a cost-sharing approach that would see the ratio of new population to existing population applied to project costs so as to identify the portion potentially attributable to the DCC program. The CVRD extension implies that a city-identified project should be completed for the regional system: therefore, there should be adequate project planning including financial confirmation of the resources (e.g., including which DCC program to apply) to construct the works. **Table B** summarizes the DCC-eligible projects and their proposed cost-sharing method. Normally a DCC program includes the full

[1] *2020 dollars are based on contracted projects over the last 5 years, the City may not have had obtained the best pricing available due budget cycles and Contract windows. (Reduced pricing may be possible through releasing RFP's beginning of the year or developing additional in-house resources) – Source: City of Courtenay*

[2] *Higher risk changes end of life of asbestos cement pipe from 60 to 80 years, & PVC pipe from 100 to 120 years – Source: City of Courtenay*

20-year plan and so as part of the update it is recommended that the full 20-year time period be considered, and additional projects be added as appropriate.

Table B: DCC-eligible projects and their proposed cost-sharing method

Project Name	Timing	Cost Sharing	Budget
South Courtenay Secondary Transmission (WAT 001)	*5 Year*	*Completely Growth-Driven*	**$3,400,000**
Arden Road – Lake Trail to Copperfield (WAT 003)	*5 Year*	*Population-Ratio*	**$1,600,000**
Arden Road – Cumberland to Brookfield (WAT 004)	*5 Year*	*Population-Ratio*	**$550,000**
Braidwood Road (WAT 005)	*5 Year*	*Population-Ratio*	**$600,000**
South Hwy 19A (WAT 009)	*5 Year*	*Population-Ratio*	**$1,600,000**
New PRV Connection to 87 Zone (WAT 010)	*5 Year*	*Population-Ratio*	**$300,000**
South Courtenay PRV and Booster Station Upgrades (WAT 010)	*5 Year*	*Population-Ratio*	**$500,000**
District Metering (WAT 011)	*5 Year*	*Population-Ratio*	**$1,200,000**
		Total DCC-Eligible Projects	**$9,750,000**

An update to the DCC Bylaw is scheduled in the near future and the results from this study can be incorporated following additional analysis (e.g. planning considerations such as growth projections and development equivalencies) alongside City staff.

3.4 IMPLEMENTATION PLAN AND RECOMMENDATIONS

- **To phase in projects outlined in the Capital Plan in the short-term and medium-term.** Take advantage of opportunities to partner in regional collaboration initiatives or work with development for growth-related projects.
- **To initiate discussions with CVRD** to both advance the separation of transmission and distribution mains, notable the CVRD main on Lerwick Road, and to ensure adequate supply capacity for future needs.
- **To update the DCC bylaw for the eligible projects.** The results of this master plan can inform the next update of the DCC program. Within the short- and medium-term period eight (8) projects are DCC eligible and growth-driven projects, one of the projects may be deemed completely driven by growth with very limited benefit to existing customers (the CVRD extension), and the remaining seven(7) projects are better aligned with a cost-sharing approach that would see the ratio of new population to existing population applied to project costs so as to identify the portion potentially attributable to the DCC program. Normally a DCC program includes the full 20-year plan and so as part of the update it is recommended that the full 20-year time period be considered and additional projects be added as appropriate.
- **To continue to advance condition investigation activities** to ensure prioritization of both condition and capacity-based projects.
- **To ensure that fire flow calculations are completed** for all new non-single-family residential developments to ensure the system capacity is adequate to service the proposed growth.
- **To advance the business case for universal metering** and continue to make all new construction meter-ready by installing meter pits.
- **To investigate the deficiencies outlined in the Water Distribution System Model Development, Calibration and Capacity Analysis Report.**
- **To investigate the elimination of water flowing through private systems** and the effect on the private and public systems.
- **To advance the creation of a water quality model** after system separation is complete. With the system separation complete the city can better track water quality within the system to help understand and inform system water movement and water age.
- **To conduct and to coordinate, on an ongoing basis with CVRD (Comox Valley Regional District),** select initiatives including regular meetings to improve data quality and information sharing at major facilities.
- **To continue to consult with K'omoks First Nation** to support the servicing agreements in place among participating governments.
- **To complete the Asset Management Plan** aligning renewal needs with Capital Upgrades outlined in this plan.
- **To Revisit the Water Master Plan every 5 year** or as the recommended projects are completed.

A

WATER DISTRIBUTION SYSTEM MODEL DEVELOPMENT, CALIBRATION, AND CAPACITY ANALYSIS

Water Distribution System Model Development, Calibration, and Capacity Analysis
City of Courtenay, BC

Report

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1 Introduction

The City of Courtenay, BC (City) retained GeoAdvice Engineering Inc. (GeoAdvice) to develop and calibrate a new hydraulic model of the City water distribution system and use the model to analyze the capacity of the system.

This report describes the methodology, assumptions and results of the hydraulic model development, calibration, capacity analysis, and system improvement recommendations.

The hydraulic modeling was conducted using InfoWater. InfoWater is a GIS based water system modeling and management software application produced by Innovyze.

In the preparation of this report, GeoAdvice would like to acknowledge the support of the following City Staff:

- Rodney Armstrong
- Chris Thompson
- Julie Machin

2 Model Development

The hydraulic model development was divided into multiple tasks as follows:

- Task 1: Data collection and review
- Task 2: Model development
- Task 3: Data gaps and connectivity analysis
- Task 4: Primary System Components
- Task 5: Node elevation extraction
- Task 6: Pressure zone boundaries
- Task 7: Existing demand
- Task 8: Existing demand scenario development
- Task 9: Fire flow demand

2.1 Data Collection and Review

Prior to developing the model, information on the City water distribution system was compiled, collected and reviewed. This included reviewing the following pertinent information:

- Previous InfoWater hydraulic model
- Updated GIS database
- PRV station operation
- Pump station operation
- Storage reservoir operation
- Land-use and zoning maps
- Record drawings
- Background reports
- Field data
- Planned future infrastructure

2.2 Model Development

The City's GIS data was the primary source of up-to-date information on the system to develop the pipe and node network topology model. Attributes of the water mains, such as nominal diameter, material and age were extracted from the GIS database. Nominal diameters were used to build the model. The coordinate system used in the model is UTM NAD 83 Zone 10.

No private water mains were modeled, including private mains that create loops in the water distribution system. In the future, the City is aiming to equip all loops created by private mains with check valves or close them off to prevent flow through and back into the distribution system.

2.3 Data Gaps and Connectivity Analysis

After the model was built, the next task involved reviewing the database information, identifying data gaps (e.g. missing diameter) and checking system connectivity (e.g. orphan node). All data gaps and connectivity issues were addressed and resolved as part of this task. GeoAdvice worked together with the City to create a one-to-one relationship between the model and GIS data to facilitate future model updates.

2.4 Primary System Components

One of the most important tasks associated with the model development was accurately representing system boundary conditions and all major water system components (e.g. supply points, pressure reducing valves (PRV), pump stations, and storage reservoirs).

The City system is supplied by the Comox Valley Water System (CVWS), which is operated by the Comox Valley Regional District (CVRD). The CVWS normally draws water from the BC Hydro penstock from Comox Lake via the Penstock Diversion Weir. If the penstock is unavailable, water is drawn directly from the Puntledge River. From the source, water is supplied through the CVWS transmission main system to a number of storage reservoirs and pump stations. From the storage reservoirs and pump stations, water is then carried through the City owned distribution network to meet domestic and fire flow demands.

It is important to note that in order to model and analyze the City distribution system, it was assumed that CVWS supply system is able to provide the required flows to the City system.

Appendix A presents a detailed summary of the model data and system components.

2.5 Node Elevation Extraction

The City's GIS data was the primary source of up-to-date information for the junction elevations. Junction elevations provided in the City's GIS were primarily obtained using GPS, with some supplemented using LIDAR data. For those elevations not provided by the City, a Digital Elevation Model (DEM) was used to determine missing node elevations. Ground elevations were assigned to the junction nodes in the model, where elevation data was missing. The DEM was also used to validate node elevations in the model.

2.6 Pressure Zone Boundaries

The City water distribution system is separated into seven (7) pressure zones as shown in **Table 2.1**.

Table 2.1: Pressure Zone Elevation Summary

Zone Name	Minimum Elevation	Maximum Elevation
87	1.4 m	49.4 m
97	27.6 m	60.0 m
110	35.5 m	64.3 m
120	19.4 m	77.3 m
135	20.7 m	65.1 m
138	58.6 m	94.3 m
150	66.1 m	89.5 m

Pressure zones 87 and 110 are fed from the West Courtenay and Marsden reservoirs, respectively. From pressure zone 87, water is pumped through the Beachwood Road booster pump station to pressure zone 135 at the southeast corner of the City. Pressure zone 150 is fed from the Marsden pump station out of the Marsden reservoir. Pressure zone 120, which is serviced by the East Courtenay Reservoir, is fed from the Dingwall and Ryan Road pump stations and the Puntledge Road PRV from the CVWS. Pressure zone 138 is fed from the CVWS through the Courtenay booster pump station. Finally, pressure zone 97 is fed through PRVs from the CVWS and from pressure zone 138.

All pump stations except for the Beachwood Road booster pump station are owned and operated by the CVRD. Also, all storage reservoirs are owned and operated by the CVRD.

There are also control valves that feed back into pressure zones 87, 110, and 120. These control valves are zone boundary valves that are configured to open during a 25 psi zone differential pressure drop.

Appendix B provides a more detailed summary of the pressure zones, including storage reservoirs, imports and exports.

2.7 Existing Demands

The next step was to import the water demands into the model. Existing average day demands (ADD) were determined on a per parcel basis using estimated parcel population, 2018 water meter records, and 2018 bulk water consumption data.

Non-revenue water (NRW) was assumed to be 11% of the total water consumption, consistent with the 2012 CVRD water audit.

Table 2.2 summarizes the existing water demands.

Table 2.2: Existing Average Day Demand (ADD) Summary

Land Use	Estimated Water Serviced Population	ADD Water Consumption
Single Family	23,894	109.3 L/s
Multi-Family	4,155	13.6 L/s
Institutional		7.5 L/s
Commercial		24.1 L/s
Industrial		0.7 L/s
Agricultural		0.0 L/s
Non-Revenue Water (11%)		19.5 L/s
Total	**28,049**	**174.7 L/s**

Based on the data available a residential metered demand rate of 257 L/cap/day and an unmetered rate of 411 L/cap/day were determined.

The maximum day demands (MDD) and peak hour demands (PHD) were developed using the peaking factors summarized in **Table 2.3**. The peaking factors were determined using the City's design demand rates.

Table 2.3: Water Demand Peaking Factors

Scenario	Peaking Factor
MDD/ADD	3.31
PHD/MDD	1.43

Table 2.4 summarizes the total water system demands for each existing scenario.

Table 2.4: Existing Water Demand Summary

Scenario	Total Water Demand
ADD	174.7 L/s
MDD	577.7 L/s
PHD	825.3 L/s

In addition to the City of Courtenay water demands, export demands through the regional supply system were also modeled. The City provided the populations to allocate at specific exports from the City model on October 31, 2019. The map showing the export populations can be found in **Appendix C** along with a table summarizing the populations and their allocation junctions.

The export demands were calculated using the unmetered per capita demand rate and peaked for MDD and PHD in the same manner as the City demands. The total export demands are summarized in **Table 2.5**.

Table 2.5: Existing CVRD Export Water Demand Summary

Scenario	Total Water Demand
ADD	95.6 L/s
MDD	316.1 L/s
PHD	451.6 L/s

The next step was the allocation of water demands in the model. This step consisted of initially spatially allocating demands using the "Closest Pipe – Closest Junction" method. The spatial allocation was then verified against the service lines provided in the City's GIS and updated to ensure that demands were generally being drawn from the correct flow path. **Figure 2.1** shows the existing serviced parcels and their modeled demand allocation.

2.8 Fire Flow Demand

Fire flow demands were assigned to selected nodes located near hydrants in the model. The required fire flow at each hydrant node was allocated based on the Fire Underwriters Survey (FUS) assessment and the Master Municipal Construction Documents (MMCD) design guidelines.

FUS required fire flows were provided by the City on September 10, 2019 in geospatial format for most of the City parcels.

Table 2.6 summarizes the fire flow requirements per land use type for the FUS assessment and the MMCD design guidelines.

Table 2.6: FUS and MMCD Fire Flow Requirements

Land Use	FUS Required Fire Flow (@ 20 psi)			MMCD Required Fire Flow (@ 22 psi)
	Minimum	Average	Maximum	
Single Family Residential	76 L/s	114 L/s	235 L/s	60 L/s
Multi-family Residential	76 L/s	168 L/s	364 L/s	90 L/s
Institutional	91 L/s	133 L/s	227 L/s	150 L/s
Commercial	15 L/s	160 L/s	265 L/s	150 L/s
Industrial	91 L/s	148 L/s	167 L/s	225 L/s
Agricultural	91 L/s	114 L/s	167 L/s	60 L/s

For the existing scenarios, the required fire flow for each parcel was set at the MMCD required fire flow based on the existing land use of the parcel except where the FUS assessed required fire flow was lower. For the future scenarios, the same methodology was applied based on the OCP land use of the parcel except for expected development areas, where the MMCD required fire flow was used.

The required fire flows for each parcel were then allocated to each hydrant node in the model. Where the contributing area to a model hydrant node contained multiple required fire flows, the higher fire flow requirement was allocated.

Where the required fire flow was based on FUS, the minimum residual pressure was analyzed at 20 psi as per the FUS requirements. Conversely, where the required fire flow was based on MMCD, the minimum residual pressure was analyzed at 22 psi as per the MMCD requirements.

3 Model Calibration

3.1 Field Data Review

Results from twelve (12) field tests provided by the City were used to calibrate the model. A total of thirty (30) measurements were used to calibrate the model, with a breakdown shown in **Table 3.1**.

Table 3.1: Number of Hydrant Measurements

Type of Pressure Reading	Number of Readings
Static Pressure	12
Residual Pressure	18
Total	**30**

The complete field test results can be found in **Appendix D.**

3.2 Model Calibration Methodology and Assumptions

When calibrating the model, the goal was to compare the measured values from the tests against the predicted results from the model, to show that the new model results are in agreement with the observed field data.

Before presenting the calibration results, it is useful to examine why the model may not match the measured field data. Most of the sources of errors or mismatches are:

- Input data errors
- System demand errors
- Node elevation errors
- Operational control errors
- Poorly calibrated measuring equipment
- Outdated data

The cumulative effect of these areas of uncertainty or "approximation" is that, without verification and validation of the model's ability to recreate known conditions, there is a high probability that the modeling results would be inaccurate.

The main benefits of a well calibrated model are listed below:

- Confidence: Demonstrate the model's ability to reproduce existing conditions.
- Understanding: Confirm the understanding of the performance of the system.
- Troubleshooting: Uncover missing information and misinformation or anomalies about the system, such as incorrect pump settings or gross demand errors.

The model uses the Hazen-Williams headloss formula to estimate friction loss through water mains based on pipe roughness C-factors. As part of the calibration, the model was calibrated by adjusting roughness coefficients for pipes grouped based on similar characteristics (i.e. diameter, material, and age).

The pipe groups remained largely the same compared to the previous modeling study. Only the PVC pipe groups were adjusted, with the roughness reduced by 10. The pipe groups and corresponding calibrated roughness coefficients are detailed in **Appendix F**.

3.3 Model Calibration Results

Table 3.2 summarizes the differences between the field data and the model results. The complete results are provided in **Appendix E**.

Table 3.2: Summary of the Model Calibration Results

Test #	Location	Static Pressure Difference (%)	Residual Pressure Difference (%)
Test 1	Eagle View Crescent	1.1%	8.8%
Test 2	Swanson Street	0.4%	**11.7%**
Test 2a	Swanson Street	0.9%	1.8%
Test 2b	Swanson Street	0.9%	4.5%
Test 2c	Swanson Street	0.9%	7.0%
Test 2d	Swanson Street	0.9%	1.3%
Test 3	Park Lane	0.2%	5.9%
Test 4	Tunner Drive	2.4%	1.4%
Test 5	Majestic Drive	1.0%	4.3%
Test 6	Sussex Place	0.4%	2.0%
Test 7a	Marble Place	0.7%	7.5%
Test 7b	Marble Place	2.7%	0.1%
Test 8	Cascara Crescent	1.3%	6.4%
Test 9	Malcolm Place	2.8%	8.5%
Test 10a	Mallard Drive	1.0%	4.0%
Test 10b	Mallard Drive	0.6%	1.6%
Test 11	Gatehouse Place	**11.6%**	**12.2%**
Test 12	Suffield Road	**11.1%**	7.7%
	Average	**3.0%**	**2.3%**

Typically, static pressure agreements within 5% and residual pressure agreements within 10% are considered “good”.

Overall, a good correlation is achieved between the model and measured data for the static and residual pressure results.

The measured flow for Test 2 was suspiciously low for the measured pressure drop; therefore, a retest was conducted. The results of Tests 2a, 2b, 2c, and 2d were used in lieu of the original Test 2 to calibrate the model.

Furthermore, the measured static pressures in pressures in pressure zone 97 (Tests 11 and 12) were approximately 6 m higher than expected based on the settings provided at the PRVs feeding the zone. It is suspected that there is a discrepancy between the intended PRV settings and the settings in the field, or there may be a zone boundary valve partially open from one of the higher head zones.

Pressure zone 97 is a new pressure zone, and, currently, interim settings are being used at the PRVs until zone flushing is complete. It is recommended that once the ultimate settings are implemented, further field testing should be conducted. In addition, the intended pressure zone head should be validated, and all boundary valve closures should be checked.

For the purposes of the model capacity analysis, the ultimate PRV settings were assigned in the model.

4 Future Scenario Development

4.1 Future Population and Demand Growth

This study considered population for the 5-year and 20-year growth outlooks. In consultation with the City, anticipated development population was collated with the City's projected population growth over the next five years and over the next twenty years to develop the two future modeling scenarios. **Table 4.1** provides a summary of the scenarios to be modeled.

Table 4.1: Summary of Modeling Scenarios

Scenario	Serviced Population	Description
2019	Existing (28,049)	Identify existing system deficiencies.
2024	Existing (28,049) + 5-Year Growth (+ 7,004)	Identify timing of upgrades.
2039	Existing (28,049) + 20-Year Growth (+ 9,623)	Identify future system deficiencies. Size all upgrades for 20-year growth flows.

4.1.1 Development Applications

Recent development applications were reviewed to determine the population and demand growth associated with specific development applications. The total population growth projected for specific development applications is summarized in **Table 4.2**.

Table 4.2: Population Growth – Development Applications

Growth Type	Population Growth	
	5-Year	20-Year*
Development Applications	+ 2,580	+ 2,830

***The 20-Year population growth is inclusive of the 5-Year population growth.**

A complete list of the development applications is outlined in **Appendix G**, including the population growth for each development application and the allocation junction ID.

4.1.2 Other Specific Development Areas

In addition to the development applications, the City also provided other specific anticipated development areas, as summarized in **Table 4.3**.

Table 4.3: Population Growth – Other Specific Development Areas

Development Area	Junction ID	Population Growth	
		5-Year	20-Year*
Copperfield	BO-B35	+ 0	+ 387
Buckstone	JCT-P-01	+ 439	+ 439
South Courtenay	WFIT0601	+ 0	+ 313
North Sandwick	WFIT0939	+ 0	+ 54
Crown Isle Greenwood	JCT-P-13	+ 500	+ 1,200
Crown Isle South of Ryan	BO-E04	+ 0	+ 500
Lannan Property	BO-E201	+ 500	+ 500
North Island College	WFIT2400	+ 600	+ 600
3200 Majestic Dr	WFIT1622	+ 200	+ 200
1900 Ryan Rd	WV2306	+ 0	+ 200
2600 Mission Rd	WFIT1697	+ 100	+ 100
2700 Mission Rd	WFIT1118	+ 0	+ 100
3000 Mission Rd	WFIT1126	+ 0	+ 40
3300 Mission Rd	WV1547	+ 85	+ 85
3301 Mission Rd	WV1547	+ 0	+ 75
595 Silverdale Cres	WFIT1167	+ 300	+ 300
Total		**+ 2,724**	**+ 5,093**

***The 20-Year population growth is inclusive of the 5-Year population growth.**

4.1.3 Other Non-Specific Development Areas

Finally, the City also provided additional anticipated growth at specific points in the water distribution system that are not yet associated with a specific development. This population growth is summarized in **Table 4.4**.

Table 4.4: Population Growth – Other Non-Specific Development Areas

Junction ID	Population Growth	
	5-Year	20-Year*
WFIT0172	+ 300	+ 300
WFIT0271	+ 100	+ 100
WFIT0443	+ 150	+ 150
WFIT2580	+ 150	+ 150
WFIT2458	+ 200	+ 200
WFIT0938	+ 150	+ 150
WFIT1122	+ 150	+ 150
BO-E04	+ 500	+ 500
Total	**+ 1,700**	**+ 1,700**

***The 20-Year population growth is inclusive of the 5-Year population growth.**

Table 4.5 summarizes the total population growth projected over the next 5 and 20 years.

Table 4.5: Total Projected Population Growth

Scenario	Population Growth
5-Year Outlook	+ 7,004
20-Year Outlook*	+ 9,623

***The 20-Year population growth is inclusive of the 5-Year population growth.**

The unit demand rates summarized in **Table 4.6** were used to determine demands associated with future growth. The rates are based on the City of Courtenay Subdivision and Development Servicing Bylaw No. 2919.

Table 4.6: City of Courtenay Design Demand Rates

Scenario	Demand Rate
ADD	635 L/cap/day
MDD	2,100 L/cap/day
PHD	3,000 L/cap/day

Generally, existing demands and their spatial allocation were carried forward through all future demand scenarios; however, where specific redevelopment growth was projected, the existing demands were overwritten.

Table 4.7 shows the existing and future demand data.

Table 4.7: Future Demand Growth Summary

Scenario	Existing Demand	Growth Demand	
		5-Year	20-Year*
ADD	175 L/s	+ 51 L/s	+ 71 L/s
MDD	578 L/s	+ 170 L/s	+ 234 L/s
PHD	825 L/s	+ 243 L/s	+ 334 L/s

***20-year demands include 5-year demands.**

The growth population data and allocation are shown in **Figure 4.1**.

4.1.4 CVRD Population and Demand Growth

Growth was also allocated for the CVRD exports by assuming a 0.9% annual growth rate as indicated by the City. The growth populations assumed for the 5- and 20-year planning horizons are provided in **Appendix C**.

Table 4.8 shows the existing and future CVRD export demand data.

Table 4.8: CVRD Export Water Demand Growth Summary

Scenario	Existing Demand	Growth Demand	
		5-Year	20-Year*
ADD	96 L/s	+ 6 L/s	+ 29 L/s
MDD	316 L/s	+ 23 L/s	+ 96 L/s
PHD	452 L/s	+ 32 L/s	+ 137 L/s

***20-year demands include 5-year demands.**

4.2 Future System Operation

In the current system operation, there are a number of interconnections between the City and CVRD systems, which allow flow both into and out of the City system. These connections result in additional stress to the City system, since flows are being transmitted through the City distribution system and back into the CVRD system to neighbouring municipalities and communities.

A separation of the transmission and distribution systems could involve closing off interconnections between the two systems or installing meters with check valves so that the flow between the two systems can be properly controlled and quantified.

In addition to the above operational changes, the City provided a map and the geospatial data for the City's known planned future infrastructure projects on October 17, 2019. These projects are included in the base future analysis scenarios. Future operational changes, along with recommended system improvements, are shown in **Figure 7.1**.

The above future system operational considerations are all part of the base 5-year and 20-year growth scenarios, which were used to analyze the City water distribution system.

5 Hydraulic Performance and Design Criteria

Based on the City's design specifications and discussions with the City, the analysis and design criteria shown in **Table 5.1** were used to analyze the capacity of the City's water distribution system.

Table 5.1: Hydraulic Performance and Design Criteria

Criteria	Parameter Value
Maximum Static Pressure	150 psi
Minimum Static Pressure	44 psi
Minimum Residual Pressure (MDD+FF) FUS MMCD	 20 psi 22 psi
Maximum Velocity: New Pipe (PHD)	1.5 m/s
Material: New Pipe	PVC
Roughness Coefficient: New Pipe	140
Minimum Diameter: New Pipe (Residential)	150 mm
Minimum Diameter: New Pipe (ICI)	200 mm

6 System Capacity Analysis

The City's water distribution system was analyzed under existing (2019), 5-year growth (2024), and 20-year growth (2039) conditions. For all scenarios, only infrastructure owned by the City was analyzed.

Furthermore, for the PHD analysis scenarios, all pumps within the Dingwall and Ryan Road CVRD pump stations were assumed to be on. For the MDD+FF analysis scenarios, all pumps within the Dingwall and Ryan Road CVRD pump stations were assumed to be on, except one pump at the Dingwall pump station (reflecting the largest pump out of service according to the Fire Underwriters Survey standards).

Finally, all storage reservoirs were set at 80% capacity for all analysis scenarios.

6.1 Pump Station Capacity Analysis

Although there are many pump stations servicing the City distribution system, only the Beachwood Road pump station is owned and operated by the City. As such, only the Beachwood Road pump station capacity was analyzed.

There are five pumps in the Beachwood Road pump station, three domestic flow pumps and two fire pumps. The pump capacity assumes three domestic pumps and one fire pump in service, with one fire pump out of service. As such, one of the fire pumps will function as both a duty pump and a fire pump. In so doing, one of the fire pumps becomes the largest duty pump and, in accordance with the Fire Underwriters Survey, needs to be considered out of service when assessing the station capacity.

Under PHD conditions, the pump capacity was determined using the model by identifying the range of flows available throughout the downstream pressure zone while maintaining 44 psi. Under MDD+FF conditions, the pump capacity was determined using the model by identifying the range of flows available throughout the downstream pressure zone while maintaining 20 psi. The required capacity range under MDD+FF is based on the different fire flow requirements based on land use. The range of excess capacity was determined based on the excess flow that the pump station can provide to each fire node.

The Beachwood Road pump station was designed as a temporary feed to the Buckstone (The Ridge) development. The current concept for servicing the Buckstone development in the future is a PRV feed from the future CVWS supply main, as shown in **Figure 7.1**. This servicing concept is not finalized and is still in negotiation between the City and the CVRD. However, for the purposes of this study the Beachwood Road pump station was only analyzed under existing demand conditions.

The existing capacity results under PHD and MDD+FF conditions are summarized in **Table 6.1**.

Table 6.1: Beachwood Road Pump Station Capacity Results

Scenario	Modeled Capacity (L/s)	Capacity Required (L/s)	Excess (L/s)	Deficient?
PHD	25.8 – 135.5	12.9	12.9 – 122.6	No
MDD+FF	98.4 – 165.5	100.0 – 122.7	29.3 – 96.5	No

As shown in **Table 6.1**, the existing Beachwood Road pump station meets the required capacity under the existing PHD and MDD+FF scenarios.

6.2 PRV Capacity Analysis

PRVs were reviewed for peak velocities under PHD and MDD+FF conditions for the existing and future scenarios. The recommended peak velocity through a PRV should be less than or equal to 7.5 m/s, with intermittent flow between 6.0 m/s and 7.5 m/s.

Table 6.2 summarizes the PRV velocity results under PHD for the existing and future scenarios.

Table 6.2: PHD PRV Velocity Modeling Results

PRV ID	Diameter (mm)	PHD Velocity (m/s)		
		2019	2024	2039
PRV-CLIFFE-1	75	0.00	0.00	0.00
PRV-CLIFFE-2	150	0.00	0.00	0.00
PRV-CUMBERLANDROAD	150	0.00	0.59	1.02
PRV-MUIR_RD_8IN	150	0.26	0.28	0.29
PRV-POWERHOUSE_3IN	75	2.09	0.00	0.00
PRV-RYANROAD	250	2.30	1.71	1.81
PRV-STAFFORD_3INBYP	75	0.00	0.00	0.00
PRV-STAFFORD_3INMAIN	75	4.50	4.50	4.50
PRV-TURNBERRY_6IN	150	0.07	1.83	1.35
PRV-TURNBERRY_8IN	200	0.00	0.00	0.00
PRV-VANIER_3IN#1	75	4.19	4.18	4.17
PRV-VANIER_8IN	200	0.21	0.18	0.19
PRV-VMP_6IN	150	2.89	3.11	3.21
PRV-VMP_8IN	200	0.00	0.00	0.00

As shown in **Table 6.2**, the velocity through all PRVs remains within the acceptable range in all existing and future PHD scenarios.

Table 6.3 summarizes the PRV velocity results under MDD+FF for the existing and future scenarios.

Table 6.3: MDD+FF PRV Velocity Modeling Results

PRV ID	Diameter (mm)	MDD+FF Velocity (m/s)		
		2019	2024	2039
PRV-CLIFFE-1	75	2.32	3.02	3.03
PRV-CLIFFE-2	150	2.53	3.28	3.30
PRV-CUMBERLANDROAD	150	1.61	2.17	2.30
PRV-MUIR_RD_8IN	150	2.31	2.39	2.40
PRV-POWERHOUSE_3IN	75	6.81	5.96	5.96
PRV-RYANROAD	250	3.57	2.95	3.00
PRV-STAFFORD_3INBYP	75	1.91	6.90	6.93
PRV-STAFFORD_3INMAIN	75	6.73	6.88	6.92
PRV-TURNBERRY_6IN	150	3.28	3.74	3.48
PRV-TURNBERRY_8IN	200	0.09	0.00	0.00
PRV-VANIER_3IN#1	75	4.27	4.24	4.24
PRV-VANIER_8IN	200	3.71	3.69	3.68
PRV-VMP_6IN	150	3.17	4.34	4.39
PRV-VMP_8IN	200	3.18	3.21	3.21

As shown in **Table 6.3**, there are no velocity deficiencies through any of the PRVs under the MDD+FF scenarios; however, the velocity through the Powerhouse Road PRV is within the intermittent flow range (6 m/s < v < 7.5 m/s) in the existing scenario, and one or both of the Stafford PRVs are within the intermittent flow range (6 m/s < v < 7.5 m/s) in all MDD+FF scenarios.

6.3 Pipe Network Capacity Analysis

A summary of the modeling results is shown in the table below. The fire flow analysis was only conducted on fire flow nodes (nodes near fire hydrants).

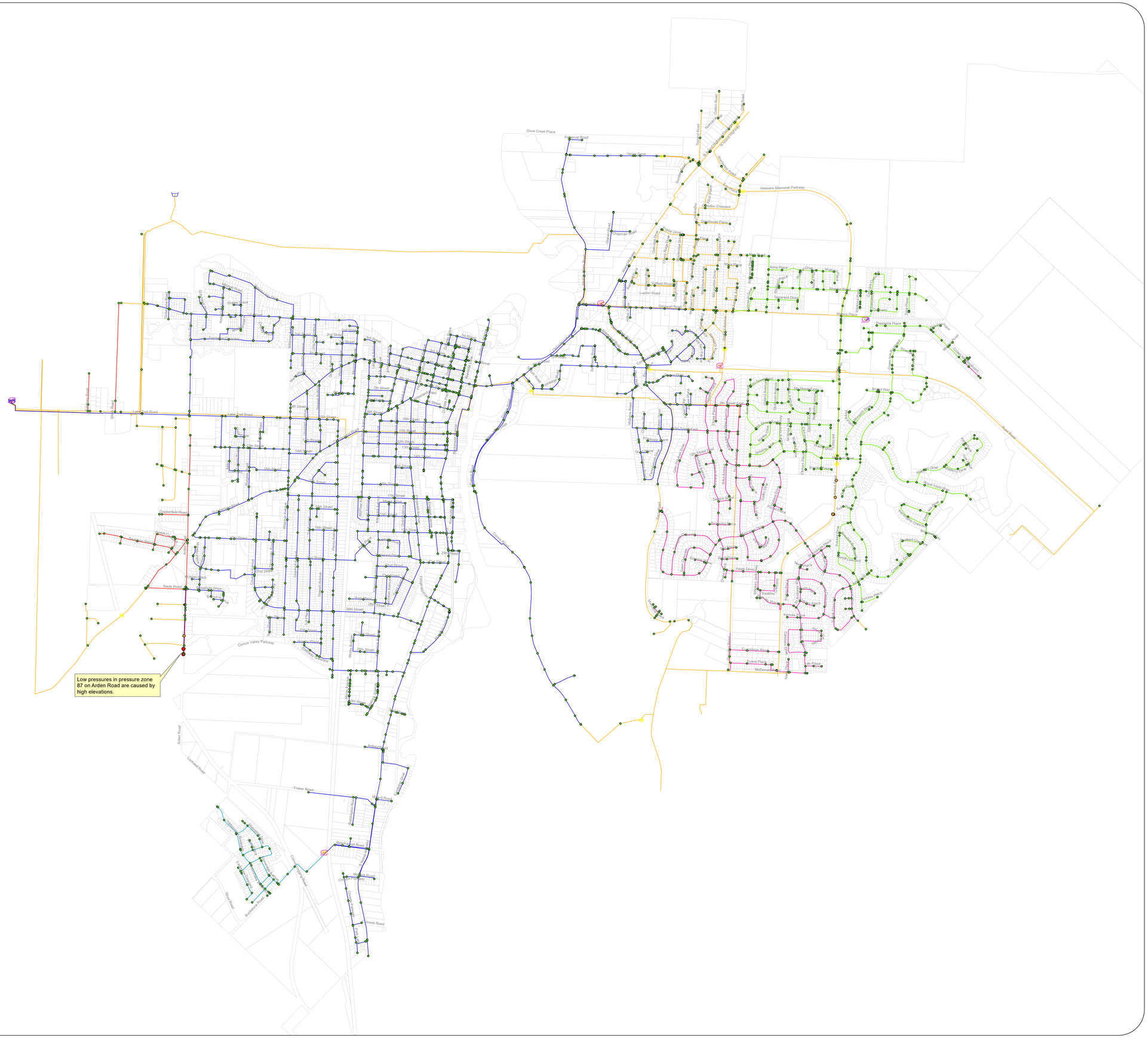
Table 6.4: Summary of Hydraulic Modeling Results

Criteria	Scenario	2019	2024	2039
# of Low Pressure Deficiencies Demand Nodes < 44 psi	PHD	11	120	264
Average Pressure (psi)	PHD	75 psi	73 psi	71 psi
# of Fire Flow Deficiencies Residual Pressure < 20 psi	MDD + FF	85	90	105
Average Available Fire Flows (L/s)	MDD + FF	194 L/s	209 L/s	204 L/s

Hydraulic results indicate that 11 demand nodes experience low pressures in the 2019 PHD scenario and 264 in the 2039 scenario. The pressure deficiencies are caused primarily by high elevations and by high headlosses through the 120 m CVWS supply system. The 2019, 2024, and 2039 PHD pressure modeling results are illustrated in **Figure 6.1**, **Figure 6.2**, and **Figure 6.3**, respectively.

Based on the current model demand allocation and land use assignments, the fire flow results indicate that 85 fire nodes are unable to satisfy the required fire flow in the 2019 scenario. In the 2039 scenario, 105 fire nodes are unable to satisfy the required fire flow. The 2019, 2024, and 2039 residual pressure and available fire flow modeling results are illustrated in **Figure 6.4**, **Figure 6.5**, and **Figure 6.6**, respectively.

Refer to **Appendix H** for a complete list of pressure and fire flow deficiencies under the existing and future scenarios.



GeoAdvice Engineering Inc.

Legend

Pressure

- < 40 psi
- 40 psi - 44 psi
- > 44 psi
- Comox Dam/Puntledge River
- Pump Station
- CVRD Storage Reservoir
- PRV
- CVRD Supply System

City Distribution System Pressure Zone

- 87 m
- 101 m
- 110 m
- 120 m
- 135 m
- 138 m

2019 PHD Pressure Modeling Results

Project: **Water Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
Date: **February 2020**
Created by: **AKd'A**
Reviewed by: **WdS**

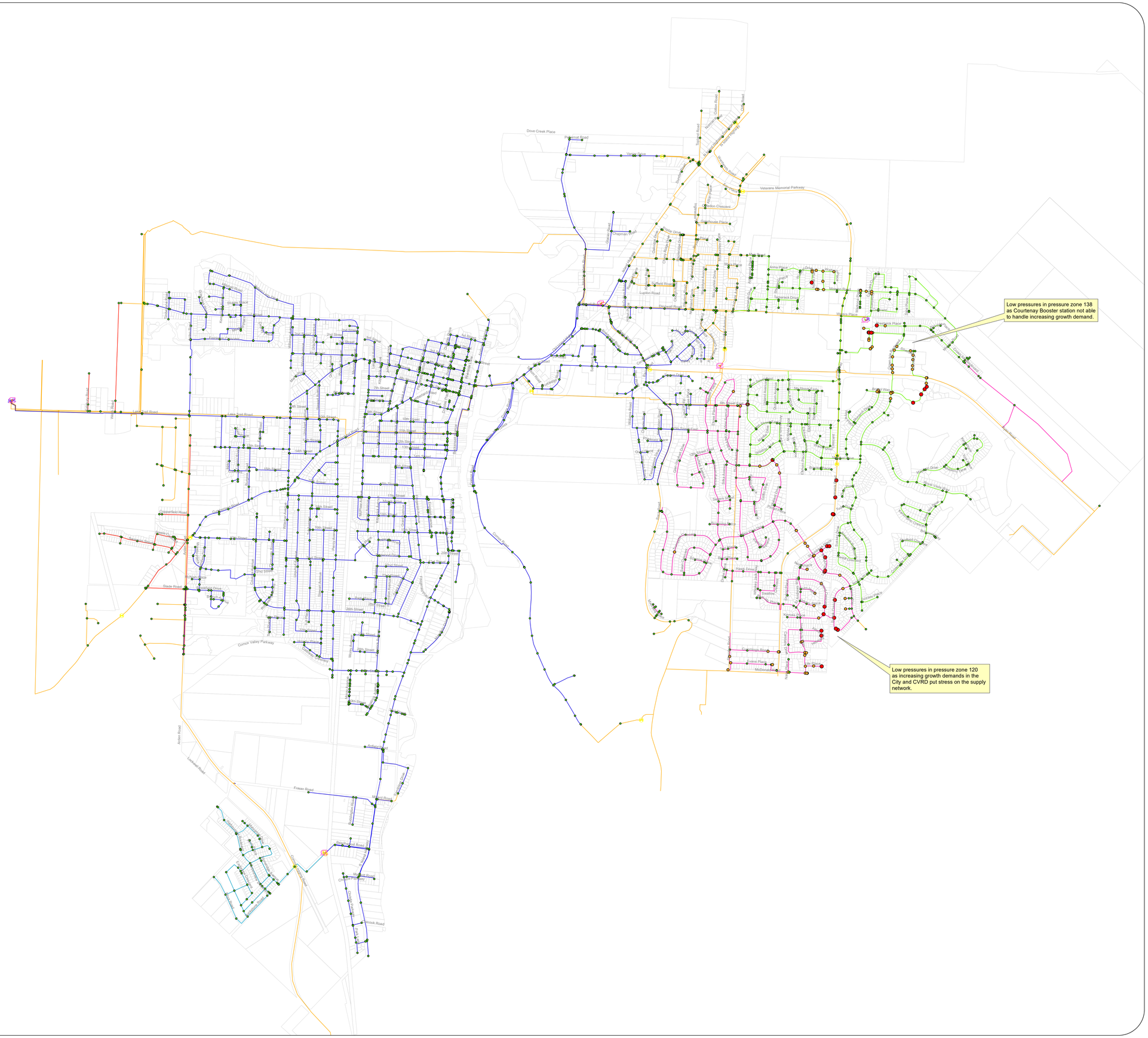
DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 0.5 1 2
Kilometers

N W E S

Figure 6.1

Document Path: W:\2019-050-COU\02\Mapping\2019-050-COU_F61_2019PHDResults_r1_2019-11-20.mxd



GeoAdvice Engineering Inc.

Legend

Pressure

- < 40 psi
- 40 psi - 44 psi
- > 44 psi
- Pump Station
- CVRD Storage Reservoir
- PRV
- CVRD Supply System

City Distribution System Pressure Zone

- 87 m
- 101 m
- 110 m
- 120 m
- 135 m
- 138 m

2024 PHD Pressure Modeling Results

Project: **Water Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
Date: **February 2020**
Created by: **AKd'A**
Reviewed by: **WdS**

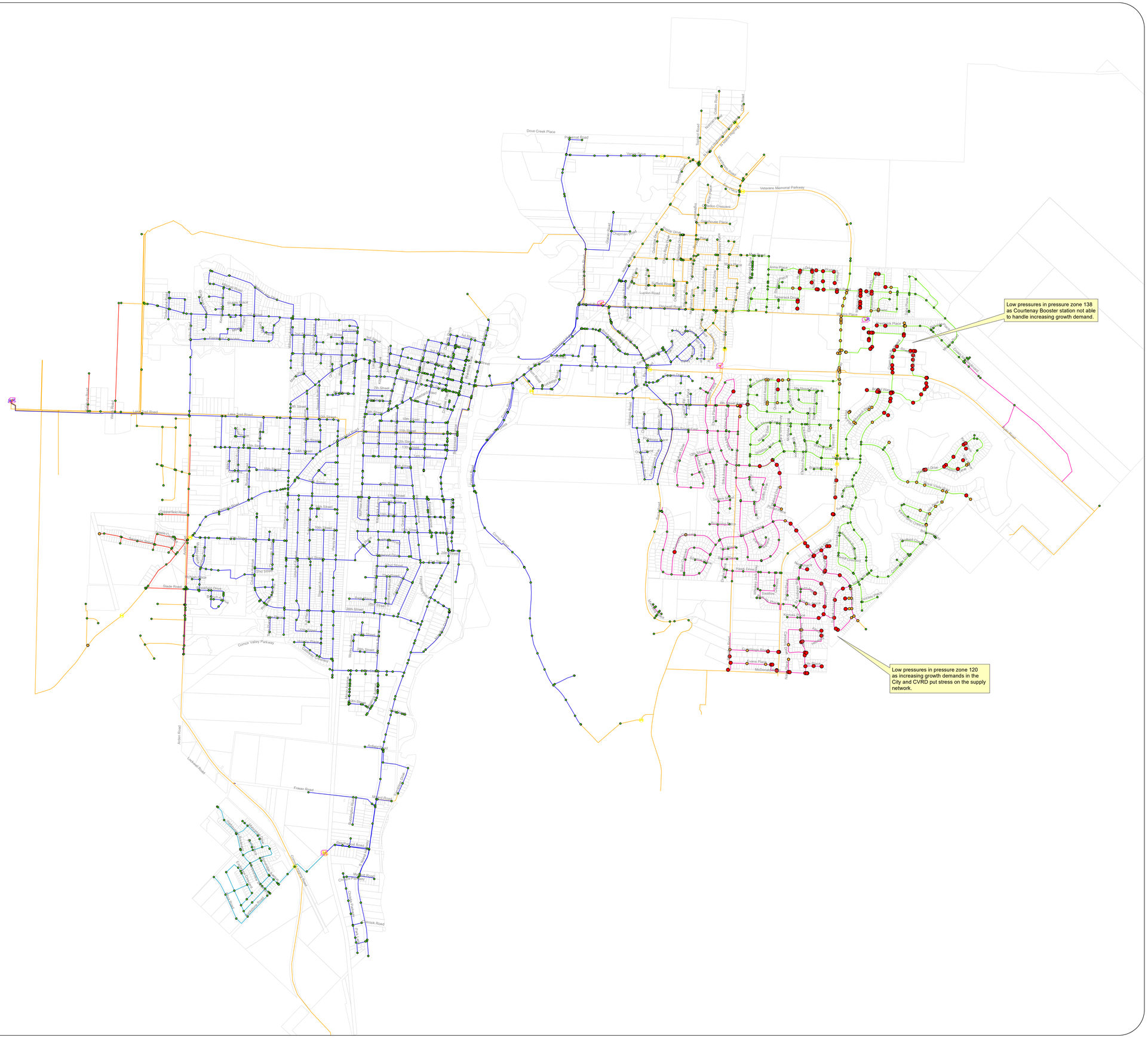
DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 0.5 1 2
Kilometers

N W E S

Figure 6.2

Document Path: W:\2019-050-COU\02\Mapping\2019-050-COU_F62_2024PHDResults_r1_2019-11-20.mxd



GeoAdvice Engineering Inc.

Legend

Pressure

- < 40 psi
- 40 psi - 44 psi
- > 44 psi
- Pump Station
- CVRD Storage Reservoir
- PRV
- CVRD Supply System

City Distribution System Pressure Zone

- 87 m
- 101 m
- 110 m
- 120 m
- 135 m
- 138 m

2039 PHD Pressure Modeling Results

Project: **Water Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
Date: **February 2020**
Created by: **AKd'A**
Reviewed by: **WdS**

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0 0.5 1 2
Kilometers

N W E S

Figure 6.3

Document Path: W:\2019-050-COU\02\Mapping\2019-050-COU_F63_2039PHDResults_r1_2019-11-20.mxd

GeoAdvice Engineering Inc.

Legend

Percentage of Required Fire Flow Available (Available Fire Flow Labeled)

- < 90%
- 90% - 100%
- > 100%
- Comox Dam/Puntledge River
- Pump Station
- CVRD Storage Reservoir
- PRV
- CVRD Supply System

City Distribution System Pressure Zone

- 87 m
- 101 m
- 110 m
- 120 m
- 135 m
- 138 m

2019 MDD+FF Fire Flow Modeling Results

Project: **Water Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
Date: **February 2020**
Created by: **AKd'A**
Reviewed by: **WdS**

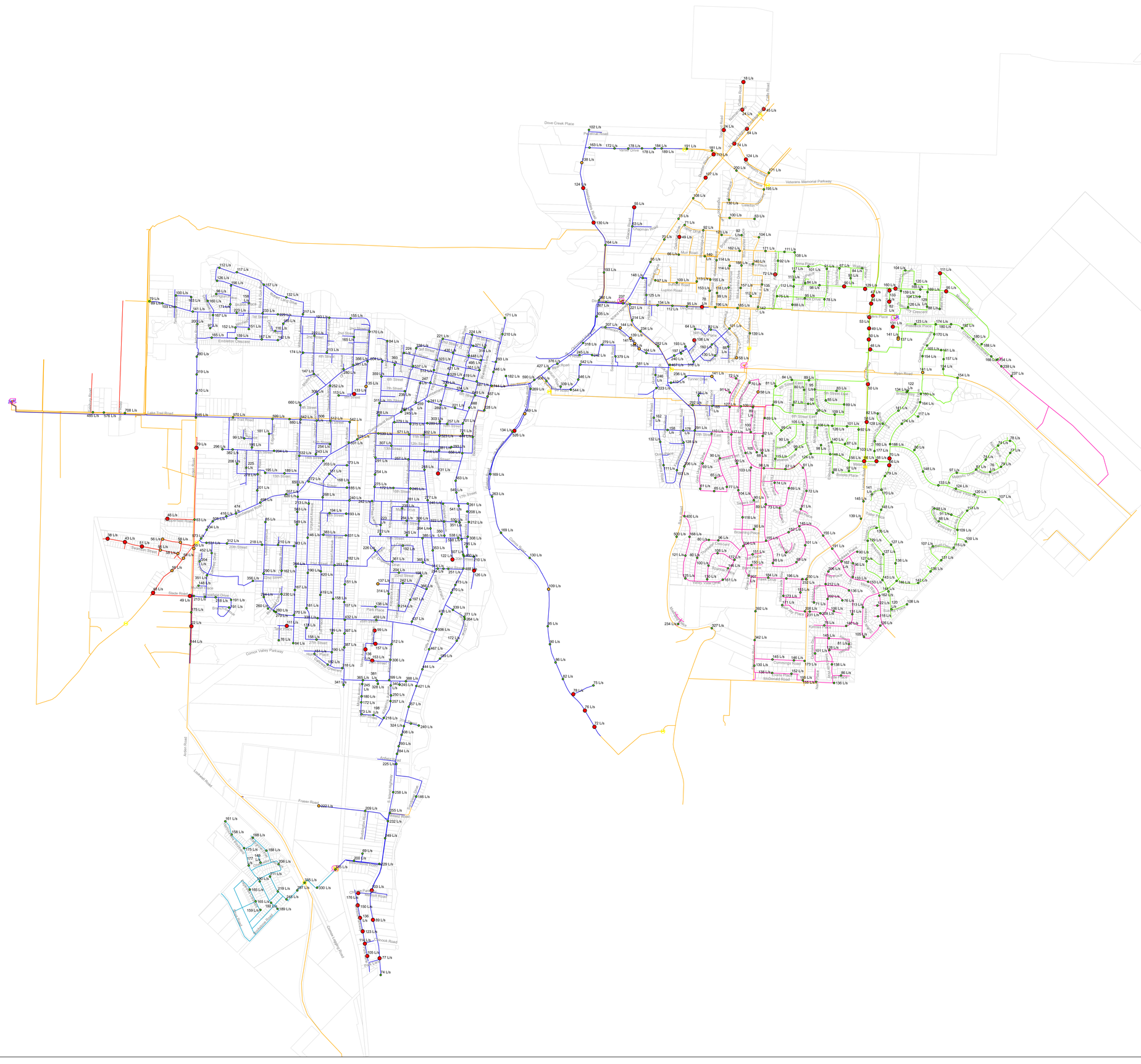
DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 0.5 1 2
Kilometers

N W E S

Figure 6.4

Document Path: W:\2019-050-COU\02\Mapping\2019-050-COU_F64_2019MDD+FFResults_r1_2019-11-20.mxd



GeoAdvice Engineering Inc.

Legend

Percentage of Required Fire Flow Available (Available Fire Flow Labeled)

- < 90 %
- 90% - 100%
- > 100%
- Pump Station
- CVRD Storage Reservoir
- PRV
- CVRD Supply System

City Distribution System Pressure Zone

- 87 m
- 101 m
- 110 m
- 120 m
- 135 m
- 138 m

2024 MDD+FF Fire Flow Modeling Results

Project: **Water Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
Date: **February 2020**
Created by: **AKd'A**
Reviewed by: **WdS**

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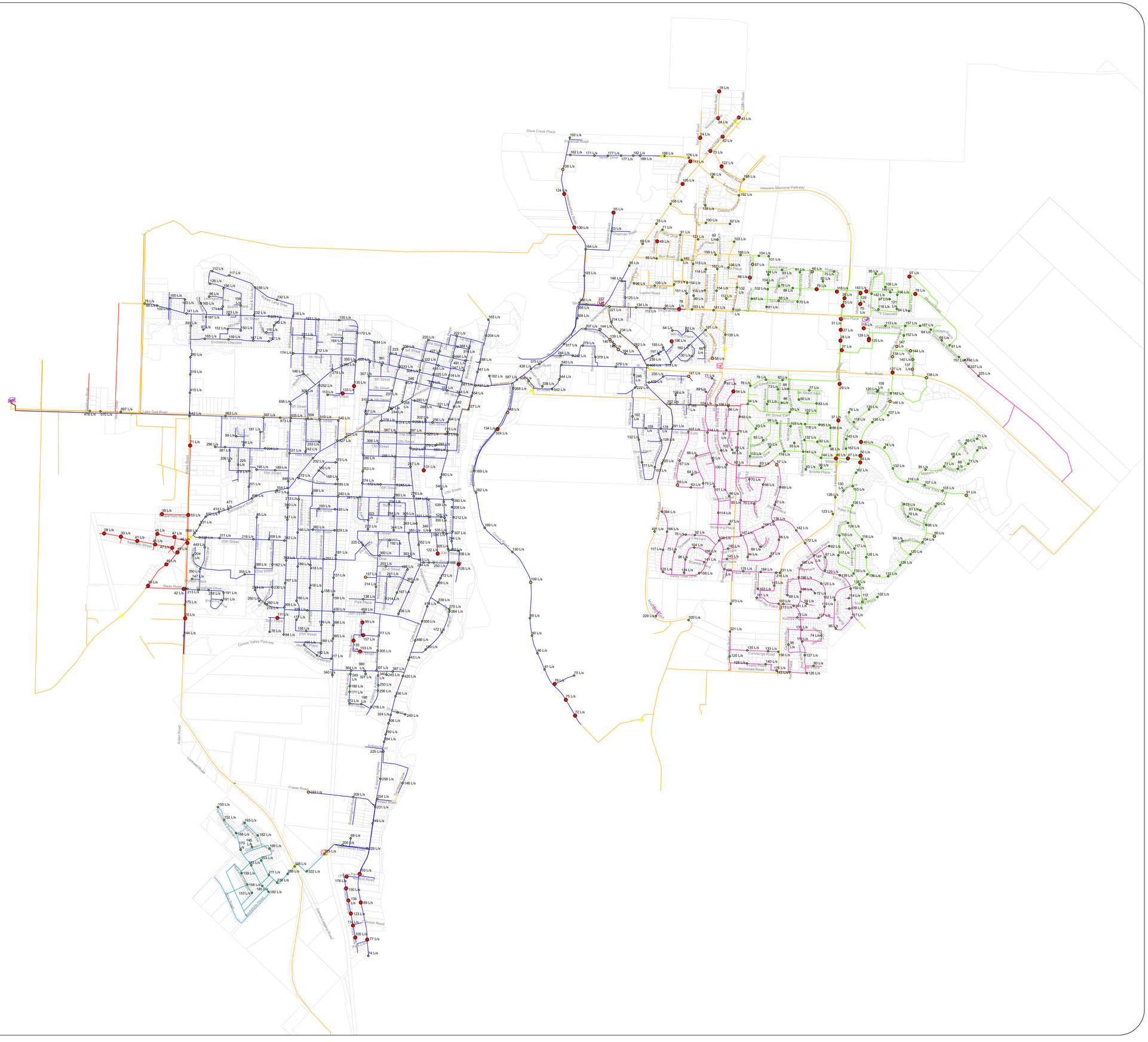
0 0.5 1 2
Kilometers

N W E S

Figure 6.5

Document Path: W:\2019-050-COU\02\Mapping\2019-050-COU_F65_2024MDD+FFResults_r1_2019-11-20.mxd



GeoAdvice Engineering Inc.

Legend

Percentage of Required Fire Flow Available (Available Fire Flow Labeled)

- < 90%
- 90% - 100%
- > 100%
- Pump Station
- CVRD Storage Reservoir
- PRV
- CVRD Supply System

City Distribution System Pressure Zone

- 87 m
- 101 m
- 110 m
- 120 m
- 135 m
- 138 m

2039 MDD+FF Fire Flow Modeling Results

Project: **Water Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
Date: **February 2020**
Created by: **AKd'A**
Reviewed by: **WdS**

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0 0.5 1 2
Kilometers

W N S E

Figure 6.6

Document Path: W:\2019-050-COU\02\Mapping\2019-050-COU_F66_2039MDD+FFResults_r1_2019-11-20.mxd

7 Proposed System Improvements

Water system improvements were recommended based on the assessment of the City water distribution system under future growth conditions. Water system improvement projects were developed to satisfy the 2039 pressure and flow requirements of the City.

To size upgrades in the City water distribution system, it was assumed that the Courtenay booster pump station (CVRD) will be adequately sized in the future, providing the required flow capacity at the pressure zone head of 138 m.

System improvements were grouped into three (3) categories:

- Growth through Development
- Proposed City Projects

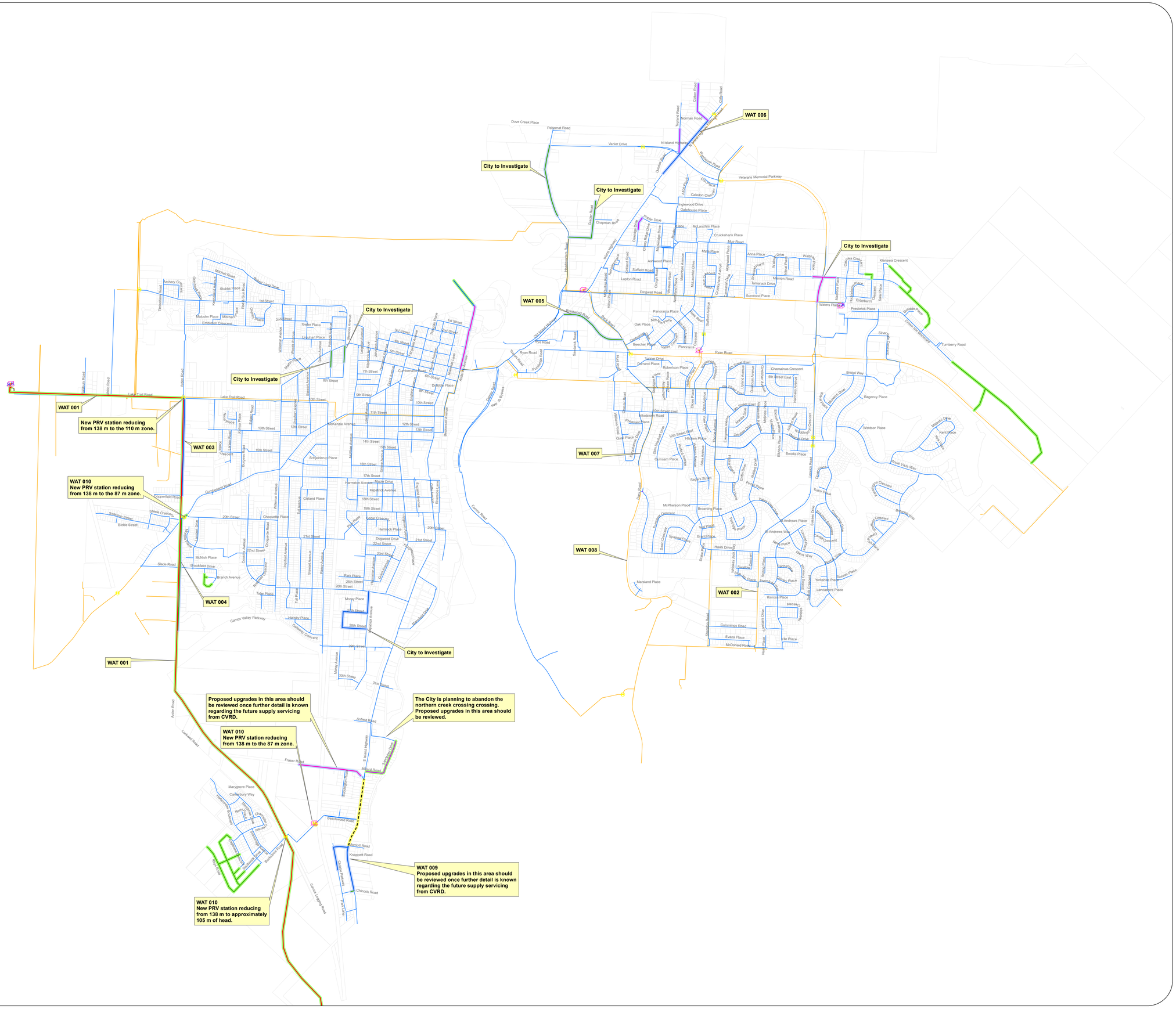
The system improvements are summarized in **Table 7.1** and shown in **Figure 7.1**. Details on the proposed improvements can be found in **Appendix I**.

Table 7.1: Summary of Proposed Improvements Projects

Improvement Category	Improvement Type	Quantity
Growth through Development	New Water Mains	4.6 km
	Water Main Replacements	224 m
	New PRV Stations	4
Proposed City Projects	New Water Mains	227 m
	Water Main Upgrades	7.8 km
	Water Mains to Abandon	584 m

***There are no planned improvements in the model under the 20-year horizon.**

With the proposed system improvements, there are several remaining pressure and fire flow deficiencies. The remaining fire flow deficiencies and explanations for why they were not addressed are described in **Appendix J**. The remaining pressure deficiencies are all located in the 120 m pressure zone and are caused by undersized CVWS supply infrastructure (pumps and water supply mains). These pressure deficiencies are expected to occur at higher elevations within the pressure zone as well as in the areas where water is exported to the City of Comox water system.



GeoAdvice Engineering Inc.

Legend

- Pump Station
- CVRD Storage Reservoir
- PRV
- Existing City Distribution System
- CVRD Supply System
- Growth Through Development
- Proposed City Project

Water Main Improvement

- 150 mm
- 200 mm
- 250 mm
- 300 mm
- 400 mm
- 600 mm
- Pipe to Abandon

System Improvement Recommendations

Project: **Water Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
Date: **February 2020**
Created by: **AKd'A**
Reviewed by: **WdS**

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0 0.5 1 2
Kilometers

W N S E

Figure 7.1

8 Conclusions

The City of Courtenay, BC retained GeoAdvice Engineering Inc. to develop and calibrate a new hydraulic model of the City water distribution system and use the model to analyze the capacity of the system.

Model Inputs

- The City InfoWater model was developed based on the City's most up-to-date GIS data.
- The existing demands were calculated and allocated on a per parcel basis using estimated parcel population, 2018 water meter records, and 2018 bulk water consumption data. The City average day demand (ADD) in the model is 175 L/s.
- Fire flow demands were allocated in the model based on a combination of geospatial FUS required fire flow data and MMCD required fire flows per land use.
- The model was calibrated against twelve (12) field test results provided by the City.
- On average, calibration agreements for static pressure are within 3.0% and within 2.3% for residual pressure agreements.
- Future water demands were estimated based on projected population growth. For the 5-year growth outlook, 7,004 people were added to the existing population, and for the 20-year growth outlook, 9,623 people were added to the existing population.
- The base future scenarios included planned infrastructure and system operational changes, including infrastructure upgrade projects, and separation from the CVRD supply system.

System Performance

- Storage reservoir capacity was not analyzed, as all storage reservoirs servicing the City system are owned and operated by the CVRD.
- The pumping capacity analysis indicates that the Beachwood Road pump station meets the minimum pumping requirements in the existing PHD and MDD+FF scenarios.
- The PRV capacity analysis indicates that there are no velocity deficiencies through any PRVs; however, the Powerhouse Road PRV and the Stafford PRV station are predicted to have velocities within the intermittent flow range ($6 \text{ m/s} < v < 7.5 \text{ m/s}$) under the existing and future MDD+FF scenarios.
- The hydraulic modeling results (with no system improvements) indicate that 11 demand nodes in the existing scenario and 264 demand nodes in the future scenario experience PHD pressures less than 44 psi.
- Based on the current model demand allocation and land use assignments, the fire flow modeling results (with no system improvements) indicate that 85 fire nodes in the existing scenario and 105 fire nodes in the future scenario cannot provide the required fire flows at their respective minimum residual pressures.

System Improvement Recommendations

- System improvements were recommended to address the deficiencies identified in the capacity analysis. The system improvements were grouped into three (3) categories:
  - Growth through Development
    - 4.6 km of new water mains
    - 224 m of water main replacements
    - 4 new PRV stations
  - Proposed City Projects
    - 227 m of new water mains
    - 7.8 km of water main upgrades
    - 584 m of water mains to abandon

Recommendations

Upgrade Timing and Ranking Analyses

Timing and ranking analyses should be performed for the system improvement recommendations identified in this report.

Additional Hydrant Testing and Static Model Calibration in Pressure Zone 97

When the ultimate settings are implemented for the PRVs feeding pressure zone 97, additional hydrant testing should be completed to ensure the model reflects the actual system operation.

Cross Connection Control with CVWS

The City should implement a cross connection control program with the CVWS to ensure flows are not transmitted through the City distribution system and back into the CVWS to neighbouring municipalities and communities. The current connections create additional stress to the City water distribution system capacity.

EPS Model Calibration

Utilizing the calibrated steady state model and the information collected in the field from a multi-day flow and pressure monitoring program, a detailed extended period simulation (EPS) model calibration should be completed.

Water Quality Modeling

Consideration of water quality within the distribution system should be incorporated into the modeling and analyzed.

Unidirectional Flushing Program

The City is currently developing a unidirectional flushing (UDF) program in house. The City's designed flushing sequences should be validated utilizing the City model to ensure key flushing criteria are met (e.g. minimum flushing velocities achieved, system pressures maintained, unidirectional flow achieved, etc.).

Criticality Analysis on the Existing System (Asset Management)

A network criticality or vulnerability analysis should be completed using the model to assess the system's ability to satisfy water demands and minimum pressures with possible pipe failures (breaks).

Development of Modeling Standards, Conventions and Guidelines

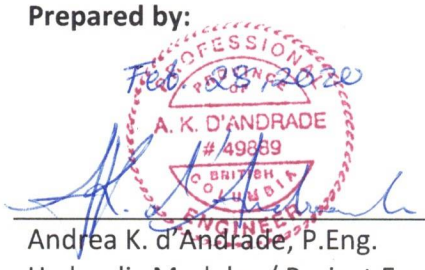
Modeling rules should be established for the City to observe when updating and running the model.

Maintenance of Water System Model

Ongoing development, zoning and infrastructure changes dictate that the model should be updated every year.

Submission

Prepared by:



Feb 28 2022

Andrea K. d'Andrade, P.Eng.
Hydraulic Modeler / Project Engineer

Reviewed and Approved by:

Werner de Schaetzen, Ph.D., P.Eng.
Project Manager

Appendix A Primary Water System Components

Sources

InfoWater Source ID	HGL (m)
RES-PUNTLEDGERIVER	126

Storage Tanks

InfoWater Storage ID	Zone	Base Elevation (m)	Diameter (m)	Maximum Level (m)	Volume (ML)
TNK-EASTCOURTENAY	120	93.8	24.4	25.7	12.0
TNK-MARSDEN	110	80.5	10.5	29.5	2.6
TNK-WESTCOURTENAY	87	80.5	42.4	6.5	9.2

Control Valves

InfoWater Valve ID	Type	From Zone	To Zone	Elevation (m)	Diameter (mm)	Setting (psi)	Minorloss Coefficient (/)
PRV-CLIFFE-1	Fire	120	97	43.2	75	60.0	10
PRV-CLIFFE-2	Fire	120	97	43.2	150	55.0	10
PRV-CUMBERLANDROAD	Fire	150	110	53.0	150	68.0	10
PRV-MUIR_RD_8IN	Fire	138	97	62.5	200	44.0	10
PRV-POWERHOUSE_3IN	Fire	110	87	44.6	75	45.0	10
PRV-RYANROAD	Fire	110	87	14.6	250	86.0	10
PRV-STAFFORD_3INBYP	Domestic	120	97	58.7	75	51.3	10
PRV-STAFFORD_3INMAIN	Domestic	120	97	58.7	75	52.3	10
PRV-TURNBERRY_6IN	Domestic	138	120	63.4	150	80.2	10
PRV-TURNBERRY_8IN	Fire	138	120	63.4	200	70.2	10
PRV-VANIER_3IN#1	Domestic	97	87	35.4	75	77.0	10
PRV-VANIER_8IN	Fire	97	87	35.4	200	69.0	10
PRV-VMP_6IN	Domestic	120	97	52.5	150	59.1	10
PRV-VMP_8IN	Fire	120	97	52.5	200	54.1	10

Pumps

InfoWater Pump ID	From Zone	To Zone	Elevation (m)	Design Head (m)	Design Flow (L/s)
PMP-BEACHWOOD-1	87	135	27.2	63	5.68
PMP-BEACHWOOD-2	87	135	27.2	63	5.68
PMP-BEACHWOOD-3	87	135	27.2	63	5.68
PMP-BEACHWOOD-4	87	135	27.2	70	37.85
PMP-BEACHWOOD-5	87	135	27.2	70	37.85
PMP-CB-1	120	138	92.0	25	32.22
PMP-CB-2	120	138	92.0	25	32.22
PMP-CB-3	120	138	92.0	25	32.22
PMP-CB-4	120	138	92.0	25	32.22
PMP-CB-5	120	138	92.0	27	28.39
PMP-CB-6	120	138	92.0	27	28.39
PMP-DINGWALL-1	110	120	15.7	22	132.49
PMP-DINGWALL-2	110	120	15.7	22	132.49
PMP-DINGWALL-3	110	120	15.7	22	132.49
PMP-DINGWALL-4	110	120	15.7	22	132.49
PMP-MARSDEN-1	110	150	78.3	46	7.57
PMP-MARSDEN-2	110	150	78.3	46	7.57
PMP-MARSDEN-3	110	150	78.3	46	7.57
PMP-MARSDEN-4	110	150	78.3	32	150.00
PMP-RYANROAD-1	110	120	58.0	23	105.99
PMP-RYANROAD-2	110	120	58.0	23	105.99
PMP-RYANROAD-3	110	120	58.0	23	105.99
PMP-RYANROAD-4	110	120	58.0	23	105.99

*No pump station data available. Pump assumed off.

Appendix B Pressure Zones

Zone Name	Minimum Elevation	Maximum Elevation	Zone Imports	Zone Exports	Zone Storage
87	1.4 m	49.4 m	From Zone 110 (CVWS) • Ryan Road PRV Station • Powerhouse Road PRV Station From Zone 97 • Vanier PRV Station	To Zone 135 • Beachwood Road Booster Pump Station	West Courtenay Reservoir (CVRD)
97	27.6 m	60.0 m	From Zone 120 (CVWS) • Veterans Memorial Parkway PRV Station • Stafford Road PRV Station From Zone 138 • Muir Road PRV Station	To Zone 87 • Vanier PRV Station To Zone 120 (CVWS) • Cliffe Road PRV Station	None
110	35.5 m	64.3 m	From CVWS Source • Comox Dam – BC Hydro Penstock From Zone 150 (CVWS) • Cumberland Road PRV Station	To Zone 120 (CVWS) • Dingwall Pump Station • Puntledge Road PRV Station • Ryan Road Pump Station To Zone 150 • Marsden Pump Station To Zone 87 • Ryan Road PRV Station • Powerhouse Road PRV Station	Marsden Reservoir (CVRD)

Zone Name	Minimum Elevation	Maximum Elevation	Zone Imports	Zone Exports	Zone Storage
120	19.4 m	77.3 m	From Zone 120 (CVWS) • Dingwall Pump Station • Puntledge Road PRV Station • Ryan Road Pump Station From Zone 138 • Turnberry Road PRV Station From Zone 97 • Cliffe Road PRV Station	To Zone 97 • Veterans Memorial Parkway PRV Station • Stafford Road PRV Station To Zone 138 • Courtenay Booster Pump Station	East Courtenay Reservoir (CVRD)
135	20.7 m	65.1 m	From Zone 87 • Beachwood Road Booster Pump Station	None	None
138	58.6 m	94.3 m	From Zone 120 • Courtenay Booster Pump Station	To Zone 97 • Muir Road PRV Station To Zone 120 • Turnberry Road PRV Station	None
150	66.1 m	89.5 m	From Zone 110 • Marsden Pump Station	To Zone 110 • Cumberland Road PRV Station	None

Appendix C CVRD Export Populations

Junction ID	Existing Population	Population Growth	
		5-Year	20-Year*
WFIT2005	60	+ 3	+ 12
WFIT0793	300	+ 14	+ 59
WFIT1992	200	+ 9	+ 39
WFIT2169	30	+ 1	+ 6
WFIT2177	30	+ 1	+ 6
WFIT2178	30	+ 1	+ 6
WFIT2179	30	+ 1	+ 6
WFIT2180	30	+ 1	+ 6
WFIT1042	400	+ 18	+ 79
WFIT0940	400	+ 18	+ 79
WFIT1699	3,800	+ 174	+ 746
WFIT1686	400	+ 18	+ 79
WFIT1693	2,800	+ 128	+ 550
WV0838	2,800	+ 128	+ 550
JCT-COMOX	8,700	+ 399	+ 1,707
WFIT0807	100	+ 5	+ 20
Total	**20,110**	**+ 921**	**+ 3,947**

***The 20-Year population growth is inclusive of the 5-Year population growth.**

Appendix D Field Test Results

Test #	Location	Pressure Zone	Flow Hydrant ID	Pressure Hydrant ID	Date	Time	Flow (L/s)	Static Pressure (psi)	Residual Pressure (psi)
Test 1	Eagle View Crescent	135	C3150	C3149	2019-10-09	9:40 AM	23.8	97	87
Test 2*	Swanson Street	110	B2099	B2098	2019-10-09	10:49 AM	6.6	67	57
Test 2a	Swanson Street	110	B2099	B2098	2019-10-22	1:00 PM	17.6	67	58
Test 2b	Swanson Street	110	B2099	B2098	2019-10-22	1:00 PM	23.8	67	54
Test 2c	Swanson Street	110	B2099	B2098	2019-10-22	1:00 PM	27.5	67	51
Test 2d	Swanson Street	110	B2099	B2098	2019-10-22	1:00 PM	33.9	67	50
Test 3	Park Lane	87	C3165	C3164	2019-10-09	N/A**	40.5	96	86
Test 4	Tunner Drive	87	E5017	E5016	2019-10-09	1:53 PM	32.5	100	90
Test 5	Majestic Drive	138	E5175	E5139	2019-10-10	10:46 AM	25.7	75	58
Test 6	Sussex Place	138	E5236	E5235	2019-10-10	11:19 AM	22.0	95	84
Test 7a	Marble Place	138	E5065	E5064	2019-10-10	2:16 PM	23.8	86	84
Test 7b	Marble Place	138	E5065	E5066	2019-10-10	2:32 PM	23.8	91	79
Test 8	Cascara Crescent	138	F6021	F6017	2019-10-10	9:16 AM	19.8	62	52
Test 9	Malcolm Place	87	B2052	B2023	2019-10-11	10:02 AM	31.1	77	72
Test 10	Mallard Drive	120	E5059	E5058	2019-10-11	10:39 AM	40.5	78	74
Test 10b	Mallard Drive	120	E5059	E5060	2019-10-11	10:48 AM	38.1	78	72
Test 11	Gatehouse Place	97	D4062	D4063	2019-10-11	11:38 AM	24.7	70	59
Test 12	Suffield Road	97	D4107	D4108	2019-10-11	12:19 PM	26.6	81	71

***Test results disregarded due to suspiciously low measured flow. Retest completed.**

****Data not provided.**

Appendix E Model Calibration Results

Test #	Flow Hydrant ID	Flow (L/s)	Pressure Hydrant ID	Pressure Hydrant Elevation (m)	Static Pressure (m)		Difference (%)	Residual Pressure (m)		Difference (%)
					Measured	Modeled		Measured	Modeled	
Test 1	C3150	23.8	C3149	62.7	68.4	67.7	+ 1.1%	61.3	66.6	- 8.8%
Test 2*	B2099	6.6	B2098	57.9	47.3	47.5	- 0.4%	40.2	44.9	- 11.7%
Test 2a	B2099	17.6	B2098	57.9	47.1	47.5	- 0.9%	40.8	41.5	- 1.8%
Test 2b	B2099	23.8	B2098	57.9	47.1	47.5	- 0.9%	38.0	39.7	- 4.5%
Test 2c	B2099	27.5	B2098	57.9	47.1	47.5	- 0.9%	35.9	38.4	- 7.0%
Test 2d	B2099	33.9	B2098	57.9	47.1	47.5	- 0.9%	35.2	35.6	- 1.3%
Test 3	C3165	40.5	C3164	15.3	67.7	67.9	- 0.2%	60.8	57.2	+ 5.9%
Test 4	E5017	32.5	E5016	14.4	70.2	68.5	+ 2.4%	63.3	64.2	- 1.4%
Test 5	E5175	25.7	E5139	82.2	52.4	51.9	+ 1.0%	40.7	42.5	- 4.3%
Test 6	E5236	22.0	E5235	67.8	66.5	66.3	+ 0.4%	59.3	60.5	- 2.0%
Test 7a	E5065	23.8	E5064	72.9	60.7	61.1	- 0.7%	59.1	54.7	+ 7.5%
Test 7b	E5065	23.8	E5066	71.9	63.9	62.1	+ 2.7%	55.3	55.4	- 0.1%
Test 8	F6021	19.8	F6017	90.9	43.9	43.3	+ 1.3%	36.4	38.7	- 6.4%
Test 9	B2052	31.1	B2023	28.0	54.2	55.6	- 2.8%	50.6	54.9	- 8.5%
Test 10	E5059	40.5	E5058	62.3	54.9	54.3	+ 1.0%	51.8	49.8	+ 4.0%
Test 10b	E5059	38.1	E5060	62.3	54.6	54.3	+ 0.6%	50.8	50.0	+ 1.6%
Test 11	D4062	24.7	D4063	52.9	49.2	43.5	+ 11.6%	41.8	36.7	+ 12.2%
Test 12	D4107	26.6	D4108	45.6	57.2	50.9	+ 11.1%	49.6	45.8	+ 7.7%

***Test results disregarded due to suspiciously low measured flow. Retest completed.**

Appendix F Calibrated Pipe Roughness Coefficients

Pipe Group	Material	Diameter (mm)	Installation Year	Calibrated Roughness (/)
1	Asbestos Cement	≤ 200	≤ 1965	110
2	Asbestos Cement	≤ 200	1965 - 1985	115
3	Asbestos Cement	≤ 200	Unknown	120
4	Asbestos Cement	200 - 400	≤ 1965	115
5	Asbestos Cement	200 - 400	1965 - 1985	120
6	Asbestos Cement	200 - 400	> 2005	125
7	Asbestos Cement	200 - 400	Unknown	120
8	Asbestos Cement	> 400	ALL	125
9	Cast Iron	≤ 200	≤ 1965	100
10	Cast Iron	≤ 200	> 1965	105
11	Cast Iron	> 200	ALL	105
12	Copper	ALL	ALL	100
13	Ductile Iron	≤ 400	≤ 1985	115
14	Ductile Iron	≤ 400	> 1985	120
15	Ductile Iron	≤ 400	Unknown	115
16	Ductile Iron	> 400	≤ 1965	115
17	Ductile Iron	> 400	1965 - 1985	120
18	Ductile Iron	> 400	1985 - 2005	125
19	Ductile Iron	> 400	> 2005	130
20	Ductile Iron	> 400	Unknown	125
21	PVC	≤ 200	1965 - 1985	125*
22	PVC	≤ 200	1985 - 2005	130*
23	PVC	≤ 200	> 2005	135*
24	PVC	≤ 200	Unknown	130*
25	PVC	200 - 400	≤ 1985	130*
26	PVC	200 - 400	1985 - 2005	135*
27	PVC	200 - 400	> 2005	140*
28	PVC	200 - 400	Unknown	135*
29	PVC	> 400	1985 - 2005	145*
30	PCCP	ALL	ALL	145
31	SP	ALL	≤ 1985	130
32	SP	ALL	> 1985	135

***Reduced roughness of all PVC pipe groups by 10 based on model calibration results.**

Appendix G Development Applications

Development Location	Junction ID	Population Growth	
		5-Year	20-Year*
3610 Christie Parkway	WFIT2092	+ 65	+ 65
2784 Wentworth Road	WFIT2500	+ 14	+ 14
770 Harmston Avenue	WFIT1777	+ 383	+ 383
4100 Fraser Road	BO-C56	+ 63	+ 63
750 30th Street	WFIT0638	+ 14	+ 14
2525 Mission Road	WFIT1108	+ 183	+ 183
344 & 356 12th Street	WFIT1803	+ 18	+ 18
4098 Buckstone Road	WFIT0598	+ 92	+ 92
The Ridge	JCT-P-01	+ 153	+ 153
	JCT-P-02		
	JCT-P-03		
	JCT-P-04		
	JCT-P-05		
	JCT-P-06		
	JCT-P-07		
	JCT-P-26		
632-680 5th Street	WFIT0326	+ 48	+ 48
2485 Idiens Way	WFIT1487	+ 53	+ 53
Puntledge IR#2	JCT-P-15	+ 250	+ 500
605 Crown Isle Boulevard	WFIT1162	+ 195	+ 195
1790 Cliffe Avenue	WFIT0525	+ 14	+ 14
1850 Cliffe Avenue and 1878/1880 Riverside Lane	WFIT1914	+ 215	+ 215
14th Street and England Avenue	WFIT1808	+ 174	+ 174
The Streams (Brooksfield Drive and Lambert Drive)	BO-C04	+ 166	+ 166
	BO-C46		
	JCT-P-08		
13th Street, west of Krebs Crescent	WFIT2017	+ 26	+ 26
925 Braidwood Road	WFIT2503	+ 208	+ 208
2800 Arden Road	WFIT0937	+ 22	+ 22
2900 Cliffe Avenue	WFIT0549	+ 26	+ 26
1025 Ryan Road	WFIT1719	+ 193	+ 193
800 Chaster Road	BO-E51	+ 5	+ 5

***The 20-Year population growth is inclusive of the 5-Year population growth.**

Appendix H Water System Deficiencies

PHD Pressure Deficiencies

Junction ID	PHD Pressure (psi)		
	2019	2024	2039
BO-B33	52.8	49.9	43.8
BO-D02	61.2	45.7	38.6
BO-D06	55.4	39.9	32.7
BO-D08	62.0	46.5	39.1
BO-E02	69.5	48.5	40.0
BO-E03	68.9	47.9	39.4
BO-E04	71.8	50.1	40.5
BO-E06	70.2	51.0	43.6
BO-E08	64.0	45.6	38.9
BO-E101	52.1	42.9	38.5
BO-E102	52.9	43.6	39.2
BO-E105	54.2	44.9	40.5
BO-E27	53.2	43.9	39.6
BO-E30	52.2	43.0	38.6
BO-E71	51.8	42.5	38.2
BO-E99	48.5	39.2	34.8
BO-F03	59.5	44.1	37.8
BO-F09	65.4	49.5	43.1
BO-F11	57.6	39.4	33.1
BO-F12	66.6	48.4	42.1
WFIT0219	67.4	50.0	43.5
WFIT0220	67.3	49.9	43.4
WFIT0226	73.4	51.8	42.9
WFIT0739	42.6	33.8	29.7
WFIT0743	62.5	46.4	40.3
WFIT0791	100.3	75.5	40.0
WFIT0813	54.3	45.0	40.6
WFIT0827	50.8	41.5	37.1
WFIT0831	45.5	36.3	31.9
WFIT0832	52.1	42.9	38.5
WFIT0857	67.9	49.7	43.0
WFIT0858	67.7	49.4	42.7
WFIT0859	67.7	49.4	42.7
WFIT0860	64.2	47.7	41.4
WFIT0867	63.2	48.7	42.8

Junction ID	PHD Pressure (psi)		
	2019	2024	2039
WFIT0868	63.2	48.5	42.6
WFIT0869	62.9	48.2	42.2
WFIT0870	62.1	47.1	41.1
WFIT0871	62.9	47.4	41.3
WFIT0872	64.4	48.4	42.3
WFIT0873	64.7	48.7	42.5
WFIT0874	64.0	47.7	41.4
WFIT0875	64.3	48.0	41.7
WFIT0884	62.4	46.3	40.1
WFIT0885	62.6	46.4	40.3
WFIT0887	59.6	42.6	36.4
WFIT0889	61.7	43.4	37.0
WFIT0890	61.7	43.4	37.0
WFIT0892	61.8	43.4	37.0
WFIT0894	56.3	40.8	33.7
WFIT0895	56.2	40.7	33.6
WFIT0896	57.3	41.8	34.7
WFIT0898	64.2	49.1	42.8
WFIT0899	61.4	45.8	38.6
WFIT0998	53.4	44.1	39.7
WFIT0999	51.0	41.7	37.4
WFIT1004	53.0	43.7	39.3
WFIT1007	53.3	44.0	39.6
WFIT1009	56.3	47.1	42.7
WFIT1092	62.5	46.9	39.6
WFIT1093	62.1	46.6	39.2
WFIT1098	65.7	50.2	42.9
WFIT1099	60.8	45.2	38.0
WFIT1102	61.6	46.1	38.9
WFIT1103	56.2	40.6	33.5
WFIT1104	57.3	41.8	34.7
WFIT1105	56.2	40.6	33.5
WFIT1106	57.9	42.4	35.3
WFIT1107	59.0	43.5	36.4
WFIT1108	61.7	46.1	39.5
WFIT1109	61.8	46.2	39.6
WFIT1110	61.7	46.1	39.5

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Junction ID	PHD Pressure (psi)		
	2019	2024	2039
WFIT1116	64.1	48.9	42.6
WFIT1117	59.9	44.5	38.2
WFIT1118	59.2	43.8	37.5
WFIT1119	59.8	44.4	38.1
WFIT1120	59.2	43.8	37.4
WFIT1121	57.6	42.1	35.8
WFIT1122	57.7	42.2	35.8
WFIT1123	57.8	42.3	36.0
WFIT1124	60.3	44.5	38.2
WFIT1125	61.4	45.5	39.2
WFIT1130	60.5	46.8	41.0
WFIT1131	60.5	46.7	40.9
WFIT1132	59.3	46.1	40.4
WFIT1138	64.0	45.8	39.6
WFIT1139	65.2	47.0	40.7
WFIT1140	66.1	47.9	41.6
WFIT1151	64.2	49.2	43.0
WFIT1152	63.4	48.7	42.7
WFIT1153	63.3	49.0	43.1
WFIT1154	58.8	41.4	35.1
WFIT1155	58.8	41.4	35.1
WFIT1156	53.7	36.3	30.0
WFIT1157	54.7	37.3	31.1
WFIT1158	59.1	41.7	35.5
WFIT1159	58.8	41.4	35.1
WFIT1161	59.3	42.2	36.0
WFIT1162	63.6	45.4	39.1
WFIT1163	63.3	45.1	38.8
WFIT1164	61.9	43.6	37.3
WFIT1165	61.6	43.4	37.0
WFIT1166	60.9	42.7	36.2
WFIT1167	62.4	44.1	37.7
WFIT1168	62.1	43.8	37.4
WFIT1169	62.5	44.1	37.8
WFIT1171	61.3	43.0	36.6
WFIT1172	61.1	42.8	36.4
WFIT1173	60.7	42.4	36.0

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Junction ID	PHD Pressure (psi)		
	2019	2024	2039
WFIT1174	60.4	42.1	35.7
WFIT1175	64.3	48.0	41.8
WFIT1277	52.4	43.1	38.9
WFIT1304	40.6	31.3	27.1
WFIT1306	51.0	41.7	37.5
WFIT1308	55.9	46.6	42.4
WFIT1310	65.5	48.1	41.6
WFIT1311	65.9	48.5	41.9
WFIT1312	67.3	49.9	43.3
WFIT1317	62.6	45.2	38.7
WFIT1318	63.2	45.8	39.2
WFIT1319	65.5	48.1	41.6
WFIT1341	67.6	50.1	43.5
WFIT1357	47.0	37.8	33.6
WFIT1359	52.7	43.4	39.2
WFIT1367	49.4	40.2	35.9
WFIT1368	52.0	42.8	38.5
WFIT1369	54.5	45.2	41.0
WFIT1440	54.5	45.1	41.1
WFIT1441	53.0	43.6	39.6
WFIT1469	53.4	44.2	39.9
WFIT1483	51.5	42.2	37.9
WFIT1484	51.5	42.2	37.9
WFIT1486	51.4	42.2	37.9
WFIT1487	51.9	42.7	38.4
WFIT1489	51.2	42.0	37.6
WFIT1490	51.1	41.9	37.5
WFIT1491	47.1	37.9	33.5
WFIT1492	45.4	36.2	31.8
WFIT1493	44.7	35.5	31.2
WFIT1494	47.3	38.1	33.7
WFIT1495	47.5	38.3	34.0
WFIT1523	56.4	47.1	42.7
WFIT1524	56.2	46.9	42.5
WFIT1525	55.3	46.0	41.6
WFIT1526	53.1	43.8	39.4
WFIT1527	53.3	44.1	39.7

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Junction ID	PHD Pressure (psi)		
	2019	2024	2039
WFIT1528	52.9	43.7	39.3
WFIT1529	53.1	43.8	39.4
WFIT1530	52.6	43.3	38.9
WFIT1531	50.1	40.8	36.4
WFIT1532	52.2	42.9	38.5
WFIT1533	52.1	42.8	38.4
WFIT1534	52.5	43.2	38.8
WFIT1535	52.0	42.8	38.4
WFIT1536	45.7	36.5	32.1
WFIT1537	49.3	40.1	35.7
WFIT1538	54.9	45.7	41.3
WFIT1539	48.7	39.4	35.1
WFIT1540	48.2	38.9	34.5
WFIT1541	50.5	41.2	36.9
WFIT1542	55.0	45.7	41.3
WFIT1543	55.1	45.9	41.5
WFIT1544	46.5	37.3	32.9
WFIT1545	46.1	36.9	32.5
WFIT1546	54.8	45.6	41.2
WFIT1547	55.0	45.8	41.3
WFIT1548	55.7	46.5	42.1
WFIT1549	55.5	46.2	41.8
WFIT1550	56.3	47.0	42.6
WFIT1551	56.1	46.9	42.5
WFIT1572	42.1	33.1	28.9
WFIT1594	66.7	48.2	41.5
WFIT1595	68.9	50.6	43.9
WFIT1596	68.4	50.2	43.5
WFIT1597	65.9	49.2	42.9
WFIT1600	57.6	39.3	32.9
WFIT1601	56.7	38.3	31.8
WFIT1602	61.3	42.9	36.3
WFIT1603	61.5	43.1	36.4
WFIT1604	61.2	42.9	36.2
WFIT1605	60.4	42.1	35.7
WFIT1606	60.2	41.9	35.4
WFIT1607	60.2	41.9	35.4

Junction ID	PHD Pressure (psi)		
	2019	2024	2039
WFIT1608	59.6	41.2	34.7
WFIT1609	61.3	43.0	36.3
WFIT1610	61.3	43.0	36.3
WFIT1611	61.7	43.4	36.7
WFIT1612	62.6	44.2	37.5
WFIT1613	64.7	46.3	39.6
WFIT1614	64.9	46.5	39.8
WFIT1615	66.8	48.5	41.8
WFIT1619	72.4	51.7	43.5
WFIT1620	70.8	49.8	41.4
WFIT1621	68.7	47.7	39.2
WFIT1622	68.6	47.5	39.0
WFIT1623	66.8	45.7	37.2
WFIT1624	66.5	45.4	36.9
WFIT1625	65.4	44.3	35.9
WFIT1626	67.6	46.6	38.1
WFIT1627	72.8	51.7	43.3
WFIT1628	71.7	50.6	42.2
WFIT1632	68.5	47.4	38.9
WFIT1634	71.2	50.1	41.5
WFIT1635	71.2	49.7	40.7
WFIT1636	72.1	50.6	41.7
WFIT1638	73.3	51.7	42.8
WFIT1639	72.9	51.3	42.4
WFIT1640	72.7	51.1	42.3
WFIT1644	73.8	52.1	43.3
WFIT1645	73.6	52.0	43.1
WFIT1675	65.4	48.0	41.4
WFIT1676	64.0	46.6	40.1
WFIT1682	53.0	43.8	39.4
WFIT1684	46.6	37.3	32.9
WFIT1685	45.6	36.3	31.9
WFIT1687	50.6	41.3	36.9
WFIT1688	50.5	41.2	36.8
WFIT1689	54.2	45.0	40.6
WFIT1690	53.8	44.5	40.2
WFIT1691	53.3	44.0	39.6

Junction ID	PHD Pressure (psi)		
	2019	2024	2039
WFIT1692	53.2	43.9	39.5
WFIT1712	64.0	48.1	41.8
WFIT1721	56.4	47.1	42.9
WFIT1724	70.6	48.9	39.5
WFIT1725	40.4	31.5	27.4
WFIT1726	52.6	43.3	38.9
WFIT1731	61.5	43.2	36.5
WFIT1732	69.5	48.4	40.0
WFIT2393	42.1	33.1	28.9
WFIT2394	42.1	33.1	28.9
WFIT2399	65.7	49.7	43.5
WFIT2400	65.7	49.7	43.5
WFIT2434	61.6	43.2	36.5
WFIT2435	62.0	43.6	36.9
WFIT2450	53.4	44.1	39.7
WFIT2462	52.2	43.0	38.6
WFIT2463	46.9	37.7	33.3
WFIT2467	55.9	40.4	33.2
WFIT2475	66.2	47.9	41.2
WFIT2496	59.5	41.2	34.8
WFIT2497	56.9	38.6	32.1
WFIT2498	54.9	36.5	30.1
WFIT2502	59.6	42.6	36.4
WFIT2575	60.6	45.2	38.8
WFIT2576	60.6	45.2	38.8
WFIT2577	60.2	44.8	38.5
WFIT2578	59.6	44.2	37.8
WFIT2579	59.6	44.2	37.8
WFIT2614	56.5	39.0	32.8
WFIT2615	54.5	45.3	41.0
WV0620	67.3	49.9	43.4
WV0838	54.1	44.4	40.2
WV0841	51.0	41.7	37.3
WV0958	56.8	47.5	43.3
WV1144	61.4	45.8	38.6
WV1432	56.6	47.4	42.9
WV1469	63.6	47.3	41.0

Junction ID	PHD Pressure (psi)		
	2019	2024	2039
WV1515	60.5	44.7	38.4
WV2339	59.4	42.4	36.2
WV2403	40.6	31.3	27.1
WV2405	40.6	31.3	27.1
WV2731	55.8	46.5	42.3
WV2911	66.0	47.8	41.6
WV2966	60.1	41.9	35.6

MDD+FF Fire Flow Deficiencies

Junction ID	Existing Required Fire Flow (L/s)	Future Required Fire Flow (L/s)	MDD+FF Available Fire Flow (L/s)		
			2019	2024	2039
JCT-P-15	N/A	225	N/A	156	156
WFIT0171	150	150	117	113	111
WFIT0570	225	225	77	222	222
WFIT0576	150	225	64	77	77
WFIT0578	152	225	83	105	105
WFIT0579	152	225	89	114	114
WFIT0581	114	225	94	123	123
WFIT0582	167	225	101	136	136
WFIT0583	167	225	107	150	150
WFIT0585	167	225	74	89	89
WFIT0589	225	225	81	103	103
WFIT0687	150	150	77	78	78
WFIT0693	114	114	107	109	109
WFIT0702	150	150	131	134	134
WFIT0703	150	150	145	149	148
WFIT0715	91	91	55	55	55
WFIT0735	150	150	147	146	146
WFIT0743	152	152	112	48	27
WFIT0758	60	60	62	58	47
WFIT0760	60	60	60	56	45
WFIT0845	150	150	246	66	46
WFIT0867	152	152	120	53	31
WFIT0870	152	152	115	49	27
WFIT0871	152	152	116	50	28
WFIT0890	150	150	190	154	138
WFIT0895	150	150	130	90	79

Junction ID	Existing Required Fire Flow (L/s)	Future Required Fire Flow (L/s)	MDD+FF Available Fire Flow (L/s)		
			2019	2024	2039
WFIT0911	114	60	19	18	18
WFIT0941	60	60	46	45	43
WFIT0948	60	60	28	24	24
WFIT0949	150	150	74	74	73
WFIT0963	150	150	138	138	138
WFIT0964	150	150	124	124	124
WFIT0965	150	150	130	130	130
WFIT0970	150	150	109	107	105
WFIT1021	150	150	78	78	78
WFIT1032	60	60	49	49	49
WFIT1037	150	150	127	124	122
WFIT1074	90	90	85	72	68
WFIT1105	60	60	94	67	60
WFIT1110	150	225	176	129	116
WFIT1117	152	152	113	82	75
WFIT1119	150	225	174	133	120
WFIT1121	150	225	198	160	143
WFIT1136	60	150	170	95	78
WFIT1151	150	225	250	47	26
WFIT1152	152	225	116	46	25
WFIT1154	152	152	169	131	119
WFIT1155	152	152	179	141	129
WFIT1159	152	152	175	137	125
WFIT1164	150	150	202	165	147
WFIT1166	150	150	191	154	138
WFIT1168	150	150	198	161	144
WFIT1172	150	150	194	157	140
WFIT1174	150	150	191	154	137
WFIT1191	150	150	105	106	106
WFIT1207	150	150	141	141	140
WFIT1208	150	150	140	139	139
WFIT1243	150	150	74	76	75
WFIT1244	150	150	71	72	72
WFIT1270	150	150	140	141	141
WFIT1277	60	60	66	58	54
WFIT1342	150	150	253	58	37
WFIT1367	60	60	72	61	57

Junction ID	Existing Required Fire Flow (L/s)	Future Required Fire Flow (L/s)	MDD+FF Available Fire Flow (L/s)		
			2019	2024	2039
WFIT1416	60	60	67	61	59
WFIT1585	150	150	240	66	46
WFIT1587	114	114	249	70	50
WFIT1589	150	150	250	68	47
WFIT1591	60	60	236	188	40
WFIT1597	150	150	254	50	29
WFIT1608	150	150	182	141	127
WFIT1612	150	150	210	164	146
WFIT1647	60	90	143	100	90
WFIT1662	114	150	56	54	52
WFIT1667	150	150	166	111	97
WFIT1670	60	60	58	58	58
WFIT1703	60	60	24	24	24
WFIT1710	90	90	108	92	87
WFIT1724	90	90	154	107	91
WFIT1857	150	150	128	135	135
WFIT1860	150	150	126	133	133
WFIT1896	150	150	126	131	131
WFIT1963	152	152	115	122	122
WFIT2003	90	90	85	79	71
WFIT2056	150	150	125	137	137
WFIT2073	167	167	92	99	99
WFIT2078	225	225	141	157	157
WFIT2079	225	225	122	136	135
WFIT2080	225	225	138	153	153
WFIT2092	167	225	117	176	176
WFIT2137	60	60	59	55	46
WFIT2139	60	60	62	58	47
WFIT2141	60	60	56	51	41
WFIT2143	60	60	49	43	33
WFIT2144	60	60	44	38	28
WFIT2145	60	60	64	59	49
WFIT2146	60	60	60	56	46
WFIT2147	60	60	53	48	39
WFIT2163	60	60	23	22	20
WFIT2171	60	90	53	49	42
WFIT2183	60	60	60	56	45

Junction ID	Existing Required Fire Flow (L/s)	Future Required Fire Flow (L/s)	MDD+FF Available Fire Flow (L/s)		
			2019	2024	2039
WFIT2184	60	60	68	63	53
WFIT2186	60	60	50	46	39
WFIT2223	167	167	99	111	111
WFIT2248	167	167	119	126	126
WFIT2488	150	150	144	144	144

Appendix I Proposed System Improvements

Water Main Improvements

Pipe ID	Location	Type	Length (m)	Existing Diameter (mm)	Upgrade Diameter (mm)
WMAIN-0408	27th Street	Proposed City Project – Pipe Upgrade	128.1	150	250
WMAIN-0409	27th Street	Proposed City Project – Pipe Upgrade	55.4	150	250
WMAIN-2565	27th Street	Proposed City Project – Pipe Upgrade	16.4	150	250
WMAIN-0412	28th Street	Proposed City Project – Pipe Upgrade	106.8	150	250
WMAIN-2563	28th Street	Proposed City Project – Pipe Upgrade	37.8	150	250
WMAIN-0113	Anderton Avenue	Proposed City Project – Pipe Upgrade	145.9	200	300
WMAIN-0116	Anderton Avenue	Proposed City Project – Pipe Upgrade	4.9	200	300
WMAIN-0117	Anderton Avenue	Proposed City Project – Pipe Upgrade	53.1	200	300
WMAIN-0118	Anderton Avenue	Proposed City Project – Pipe Upgrade	32.0	200	300
WMAIN-2157	Anderton Avenue	Proposed City Project – Pipe Upgrade	3.2	200	300
WMAIN-2636	Anderton Avenue	Proposed City Project – Pipe Upgrade	72.1	200	300
WMAIN-2961	Anderton Avenue	Proposed City Project – Pipe Upgrade	7.4	200	300
WMAIN-2963	Anderton Avenue	Proposed City Project – Pipe Upgrade	0.4	200	300
WMAIN-2964	Anderton Avenue	Proposed City Project – Pipe Upgrade	1.3	200	300
WMAIN-2965	Anderton Avenue	Proposed City Project – Pipe Upgrade	70.8	200	300
WMAIN-2968	Anderton Avenue	Proposed City Project – Pipe Upgrade	44.8	200	300
WMAIN-2969	Anderton Avenue	Proposed City Project – Pipe Upgrade	26.9	200	300
WMAIN-3300	Anderton Avenue	Proposed City Project – Pipe Upgrade	17.6	200	300
WMAIN-3302	Anderton Avenue	Proposed City Project – Pipe Upgrade	40.9	200	300
WMAIN-3303	Anderton Avenue	Proposed City Project – Pipe Upgrade	25.3	200	300
WMAIN-3304	Anderton Avenue	Proposed City Project – Pipe Upgrade	11.8	200	300

Pipe ID	Location	Type	Length (m)	Existing Diameter (mm)	Upgrade Diameter (mm)
PPE-P-29	Anderton Avenue	Growth through Development	271.0	-	250
PPE-P-38	Arden Road	Proposed City Project – New Pipe	178.1	-	250
WMAIN-0546	Arden Road	Proposed City Project – Pipe Upgrade	25.4	100	200
WMAIN-0547	Arden Road	Proposed City Project – Pipe Upgrade	362.8	100	200
WMAIN-0548	Arden Road	Proposed City Project – Pipe Upgrade	127.4	100	200
WMAIN-1924	Arden Road	Proposed City Project – Pipe Upgrade	68.0	100	200
WMAIN-0550	Arden Road	Proposed City Project – Pipe Upgrade	210.0	100	200
WMAIN-0555	Arden Road	Proposed City Project – Pipe Upgrade	212.2	150	250
WMAIN-0556	Arden Road	Proposed City Project – Pipe Upgrade	232.0	150	250
WMAIN-1717	Arden Road	Proposed City Project – Pipe Upgrade	1.9	150	250
WMAIN-1723	Arden Road	Proposed City Project – Pipe Upgrade	1.0	150	250
WMAIN-0549	Arden Road	Proposed City Project – Pipe Upgrade	23.8	100	200
WMAIN-1925	Arden Road	Proposed City Project – Pipe Upgrade	19.4	150	200
WMAIN-2871	Arden Road	Proposed City Project – Pipe Upgrade	0.9	100	200
WMAIN-1950	Arden Road	Proposed City Project – Pipe Upgrade	14.9	100	200
WMAIN-2239	Arden Road	Proposed City Project – Pipe Upgrade	69.8	100	200
WMAIN-2241	Arden Road	Proposed City Project – Pipe Upgrade	0.9	150	250
WMAIN-2667	Arden Road	Proposed City Project – Pipe Upgrade	83.8	150	250
WMAIN-3105	Arden Road	Proposed City Project – Pipe Upgrade	123.6	150	250
WMAIN-3250	Arden Road	Proposed City Project – Pipe Upgrade	12.5	100	200
PPE-P-34	Beachwood Road	Proposed City Project – New Pipe	6.3	-	300
WMAIN-3429	Braidwood Road	Proposed City Project – Pipe Upgrade	12.0	150	200
WMAIN-3439	Braidwood Road	Proposed City Project – Pipe Upgrade	1.0	150	200
WMAIN-3440	Braidwood Road	Proposed City Project – Pipe Upgrade	16.9	150	200
WMAIN-3443	Braidwood Road	Proposed City Project – Pipe Upgrade	24.7	150	200

Pipe ID	Location	Type	Length (m)	Existing Diameter (mm)	Upgrade Diameter (mm)
WMAIN-3452	Braidwood Road	Proposed City Project – Pipe Upgrade	20.0	150	200
WMAIN-3666	Braidwood Road	Proposed City Project – Pipe Upgrade	19.9	150	200
WMAIN-3687	Braidwood Road	Proposed City Project – Pipe Upgrade	13.3	150	200
WMAIN-2505	Braidwood Road	Proposed City Project – Pipe Upgrade	16.0	150	200
WMAIN-2506	Braidwood Road	Proposed City Project – Pipe Upgrade	24.8	150	200
WMAIN-2850	Braidwood Road	Proposed City Project – Pipe Upgrade	83.9	150	200
WMAIN-2851	Braidwood Road	Proposed City Project – Pipe Upgrade	24.9	150	200
WMAIN-2852	Braidwood Road	Proposed City Project – Pipe Upgrade	53.0	150	200
WMAIN-2853	Braidwood Road	Proposed City Project – Pipe Upgrade	48.6	150	200
WMAIN-3351	Braidwood Road	Proposed City Project – Pipe Upgrade	6.6	150	200
WMAIN-3386	Braidwood Road	Proposed City Project – Pipe Upgrade	0.4	150	200
WMAIN-0653	Braidwood Road	Proposed City Project – Pipe Upgrade	110.1	150	200
WMAIN-2002	Braidwood Road	Proposed City Project – Pipe Upgrade	46.4	150	200
WMAIN-3693	Braidwood Road	Proposed City Project – Pipe Upgrade	9.1	150	200
WMAIN-3698	Braidwood Road	Proposed City Project – Pipe Upgrade	27.3	150	200
WMAIN-3699	Braidwood Road	Proposed City Project – Pipe Upgrade	9.1	150	200
PPE-P-10	Branch Avenue	Growth through Development	21.5	-	200
PPE-P-09	Brookfield Drive	Growth through Development	138.6	-	200
PPE-P-26	Brookfield Drive	Growth through Development	22.7	-	200
PPE-P-11	Buckstone Road	Growth through Development	234.6	-	200
PPE-P-08	Buckstone Road	Growth through Development	132.6	-	200
PPE-P-04	Cascara Crescent	Growth through Development	86.8	-	200
PPE-P-36	Christie Parkway	Proposed City Project – New Pipe	27.8	-	200
WMAIN-1263	Christie Parkway	Proposed City Project – Pipe Upgrade	94.7	200	250
WMAIN-1264	Christie Parkway	Proposed City Project – Pipe Upgrade	94.0	200	250

Pipe ID	Location	Type	Length (m)	Existing Diameter (mm)	Upgrade Diameter (mm)
WMAIN-2414	Christie Parkway	Proposed City Project – Pipe Upgrade	22.7	200	250
WMAIN-2420	Christie Parkway	Proposed City Project – Pipe Upgrade	101.6	200	250
PPE-P-32	Comox Logging Road	Growth through Development	1973.6	-	600
WMAIN-1112	Cotton Road	Proposed City Project – Pipe Upgrade	220.0	100	150
WMAIN-3164	Cotton Road	Proposed City Project – Pipe Upgrade	131.6	100	150
PPE-P-23	Crown Isle Boulevard	Growth through Development	356.1	-	200
PPE-P-24	Crown Isle Boulevard	Growth through Development	210.4	-	200
PPE-P-27	Crown Isle Boulevard	Growth through Development	856.6	-	200
WMAIN-1258	Fraser Road	Proposed City Project – Pipe Upgrade	369.8	200	300
WMAIN-2411	Fraser Road	Proposed City Project – Pipe Upgrade	148.5	200	300
WMAIN-2412	Fraser Road	Proposed City Project – Pipe Upgrade	22.1	200	300
WMAIN-0645	Glacier Road	Proposed City Project – Pipe Upgrade	349.4	150	200
WMAIN-0647	Glacier Road	Proposed City Project – Pipe Upgrade	152.5	150	200
WMAIN-2994	Glacier Road	Proposed City Project – Pipe Upgrade	4.0	150	200
WMAIN-0649	Headquarters Road	Proposed City Project – Pipe Upgrade	268.7	150	200
WMAIN-2258	Headquarters Road	Proposed City Project – Pipe Upgrade	177.8	150	200
WMAIN-2259	Headquarters Road	Proposed City Project – Pipe Upgrade	123.7	150	200
WMAIN-3372	Headquarters Road	Proposed City Project – Pipe Upgrade	26.4	150	200
WMAIN-3375	Headquarters Road	Proposed City Project – Pipe Upgrade	18.3	150	200
WMAIN-0407	Kilpatrick Avenue	Proposed City Project – Pipe Upgrade	146.5	200	250
WMAIN-3240	Kilpatrick Avenue	Proposed City Project – Pipe Upgrade	4.4	200	250
WMAIN-3486	Kilpatrick Avenue	Proposed City Project – Pipe Upgrade	32.5	200	250
PPE-P-19	Klanawa Crescent	Growth through Development	317.7	-	200
WMAIN-0749	Lerwick Road	Proposed City Project – Pipe Upgrade	19.3	250	300
WMAIN-1175	Lerwick Road	Proposed City Project – Pipe Upgrade	84.8	250	300

Pipe ID	Location	Type	Length (m)	Existing Diameter (mm)	Upgrade Diameter (mm)
WMAIN-2397	Lerwick Road	Proposed City Project – Pipe Upgrade	47.3	250	300
WMAIN-2398	Lerwick Road	Proposed City Project – Pipe Upgrade	64.8	250	300
WMAIN-0180	Menzies Avenue	Proposed City Project – Pipe Upgrade	131.5	150	200
WMAIN-3003	Menzies Avenue	Proposed City Project – Pipe Upgrade	4.5	150	200
PPE-P-02	Millard Road	Growth through Development	210.3	-	150
WMAIN-0731	Mission Road	Proposed City Project – Pipe Upgrade	82.7	200	300
WMAIN-0750	Mission Road	Proposed City Project – Pipe Upgrade	110.7	200	300
PPE-P-20	Mission Road	Growth through Development	85.9	-	200
PPE-P-21	Mission Road	Growth through Development	127.7	-	200
PPE-P-22	Mission Road	Growth through Development	245.0	-	200
WMAIN-0410	Moray Avenue	Proposed City Project – Pipe Upgrade	145.0	150	250
WMAIN-3660	Moray Avenue	Proposed City Project – Pipe Upgrade	0.8	150	250
WMAIN-3487	Moray Avenue and 28th Street	Proposed City Project – Pipe Upgrade	54.9	150	250
WMAIN-1966	North Island Hwy	Proposed City Project – Pipe Upgrade	2.8	200	250
WMAIN-1892	North Island Hwy	Proposed City Project – Pipe Upgrade	2.5	200	250
WMAIN-1105	North Island Hwy	Proposed City Project – Pipe Upgrade	154.4	150	250
WMAIN-1637	North Island Hwy	Proposed City Project – Pipe Upgrade	127.6	150	250
WMAIN-3598	North Island Hwy	Proposed City Project – Pipe Upgrade	80.6	150	250
WMAIN-2376	North Island Hwy	Proposed City Project – Pipe Upgrade	201.5	150	250
WMAIN-2466	North Island Hwy	Proposed City Project – Pipe Upgrade	9.6	150	250
WMAIN-2918	North Island Hwy	Proposed City Project – Pipe Upgrade	4.9	150	250
WMAIN-2919	North Island Hwy	Proposed City Project – Pipe Upgrade	4.3	150	250
WMAIN-2388	Oakridge Drive	Proposed City Project – Pipe Upgrade	107.7	100	150
WMAIN-0182	Pidcock Avenue	Proposed City Project – Pipe Upgrade	123.5	150	200

Pipe ID	Location	Type	Length (m)	Existing Diameter (mm)	Upgrade Diameter (mm)
WMAIN-3269	Pidcock Avenue	Proposed City Project – Pipe Upgrade	13.1	150	200
PPE-P-07	Rhys Road	Growth through Development	175.2	-	200
PPE-P-30	Rhys Road	Growth through Development	214.1	-	200
WMAIN-2549	Sandpiper Drive	Replacement - 5 Year Time Horizon	92.5	150	150
WMAIN-0425_2	Sandpiper Drive	Replacement - 5 Year Time Horizon	131.6	200	150
PPE-P-35	South Island Hwy	Proposed City Project – New Pipe	15.2	-	250
WMAIN-1222_1	South Island Hwy	Proposed City Project – Pipe Upgrade	163.4	200	250
WMAIN-2403	South Island Hwy	Proposed City Project – Pipe Upgrade	221.9	200	250
WMAIN-1261	South Island Hwy	Proposed City Project – To Abandon	351.9	200	200
WMAIN-2401	South Island Hwy	Proposed City Project – To Abandon	216.7	200	200
WMAIN-2402	South Island Hwy	Proposed City Project – To Abandon	14.7	200	200
WMAIN-3014	South Island Hwy	Proposed City Project – To Abandon	0.7	200	200
PPE-P-12	The Ridge Development	Growth through Development	115.1	-	200
PPE-P-13	The Ridge Development	Growth through Development	132.0	-	200
PPE-P-14	The Ridge Development	Growth through Development	131.1	-	200
PPE-P-15	The Ridge Development	Growth through Development	68.4	-	200
PPE-P-16	The Ridge Development	Growth through Development	99.7	-	200
PPE-P-17	The Ridge Development	Growth through Development	53.6	-	200
PPE-P-18	The Ridge Development	Growth through Development	55.6	-	200
PPE-P-05	The Ridge Development	Growth through Development	165.0	-	200
PPE-P-25	The Ridge Development	Growth through Development	79.0	-	200
WMAIN-1113	Topland Road	Proposed City Project – Pipe Upgrade	20.3	150	250
WMAIN-2382	Topland Road	Proposed City Project – Pipe Upgrade	196.6	100	150

PRV Improvements (Growth through Development)

InfoWater Valve ID	Location	Type	From Zone	To Zone	Elevation (m)	Diameter (mm)	Setting (psi)	Minorloss Coefficient (/)
PRV-20THSTREET-1	20th Street & Cumberland Road	Domestic	138	87	37.2	150	71.0	10
PRV-20THSTREET-2		Fire	138	87	37.2	200	66.0	10
PRV-BEACHWOOD-1	Buckstone Road & Comox Logging Road	Domestic	138	105	38.8	150	95.0	10
PRV-BEACHWOOD-2		Fire	138	105	38.8	200	90.0	10
PRV-BEACHWOOD-3	Beachwood Road	Domestic	105	87	20.5	150	94.7	10
PRV-BEACHWOOD-4		Fire	105	87	20.5	200	90.7	10
PRV-ARDENROAD-1	Arden Road & Lake Trail Road	Domestic	138	110	36.3	150	104.8	10
PRV-ARDENROAD-2		Fire	138	110	36.3	200	99.8	10

Appendix J Remaining Water System Deficiencies with Proposed Pipe Improvements

Junction ID	Explanation
WFIT0171	Dead end with required fire flow available upstream
WFIT0576	Dead end with required fire flow available upstream
WFIT0578	Dead end with required fire flow available upstream
WFIT0687	Komoks First Nation
WFIT0693	Available fire flow is within 10% of the required fire flow
WFIT0702	Available fire flow is within 10% of the required fire flow
WFIT0703	Available fire flow is within 10% of the required fire flow
WFIT0895	Available fire flow is within 10% of the required fire flow
WFIT1021	Dead end with required fire flow available upstream
WFIT1037	Dead end with required fire flow available upstream
WFIT1074	Dead end with required fire flow available upstream
WFIT1117	Dead end with required fire flow available upstream
WFIT1191	Dead end with required fire flow available upstream
WFIT1243	Komoks First Nation
WFIT1244	Komoks First Nation
WFIT1270	Available fire flow is within 10% of the required fire flow
WFIT1277	Available fire flow is within 10% of the required fire flow
WFIT1367	Available fire flow is within 10% of the required fire flow
WFIT1416	Available fire flow is within 10% of the required fire flow
WFIT1670	Available fire flow is within 10% of the required fire flow
WFIT1896	Dead end with required fire flow available upstream
WFIT1963	Dead end with required fire flow available upstream
WFIT2056	Available fire flow is within 10% of the required fire flow
WFIT2073	Dead end with required fire flow available upstream
WFIT2223	Dead end with required fire flow available upstream
WFIT2248	Dead end with required fire flow available upstream

B

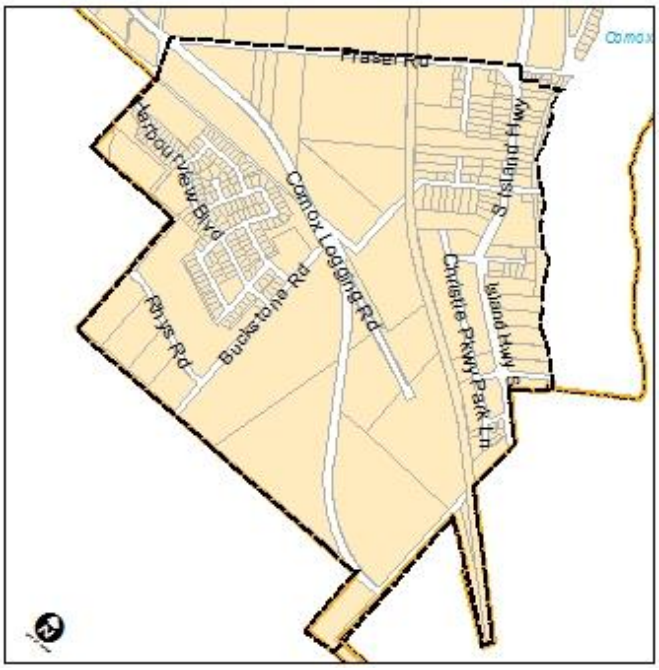
CAPTIAL PROJECT LIST

Project ID: WAT 001

SOUTH COURTENAY SECONDARY TRANSMISSION

Project Description:

- **TO PROVIDE SECONDARY WATERSUPPLY TO SOUTH COURTENAY AREA**
- **ENSURE FUTURE DEVELOPMENT CAPACITY**



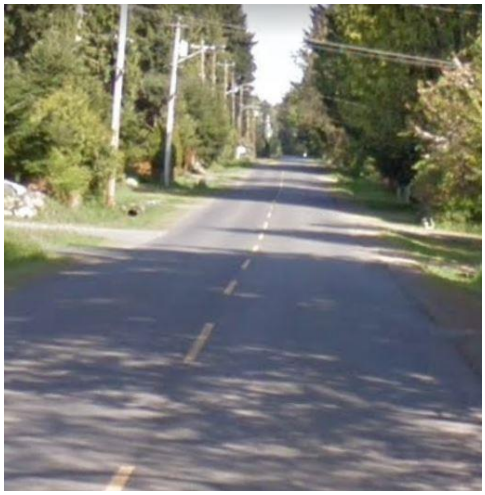
Estimated Project Budget : $3,400,000

Project ID: WAT 003

ARDEN RD – LAKE TRAIL TO COPPERFIELD

Project Description:

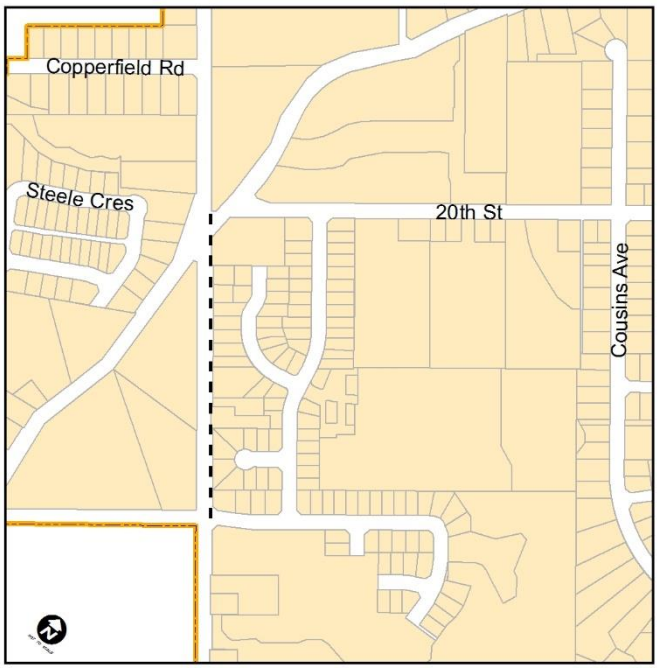
- DEVELOPMENT DEPENDENT
- **LOCAL DOMESTIC WATER DISTRIBUTION**
- **REPLACE EXISTING UNDERSIZED END OF LIFE WATER MAIN**
- **TO MEET FIREFLOW AND BYLAW REQUIREMENTS**



Estimated Project Budget : $1,600,000

Project ID: WAT 004

ARDEN RD – CUMBERLAND TO BROOKFIELD



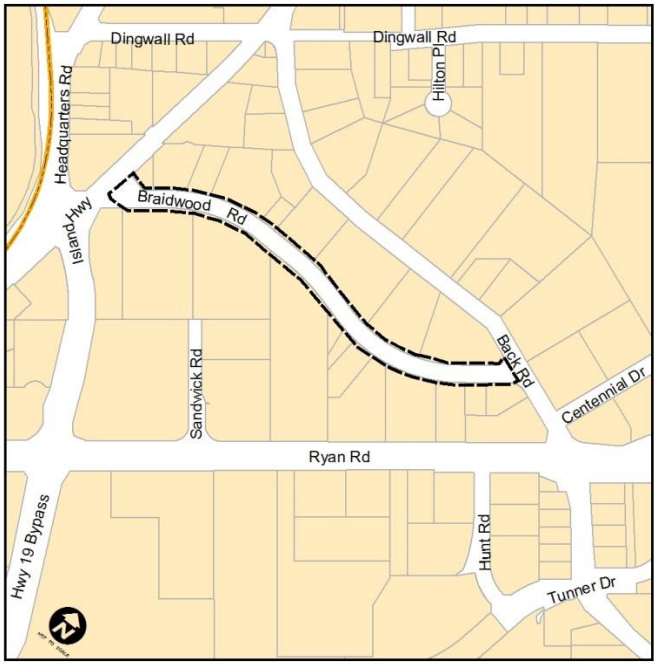
Project Description:

- **REPLACE EXISTING UNDERSIZED END OF LIFE WATER MAIN**
- **TO MEET FIREFLOW AND BYLAW REQUIREMENTS**

Estimated Project Budget : $550,000

Project ID: WAT 005

BRAIDWOOD RD – ROAD & UTILITY – WATER



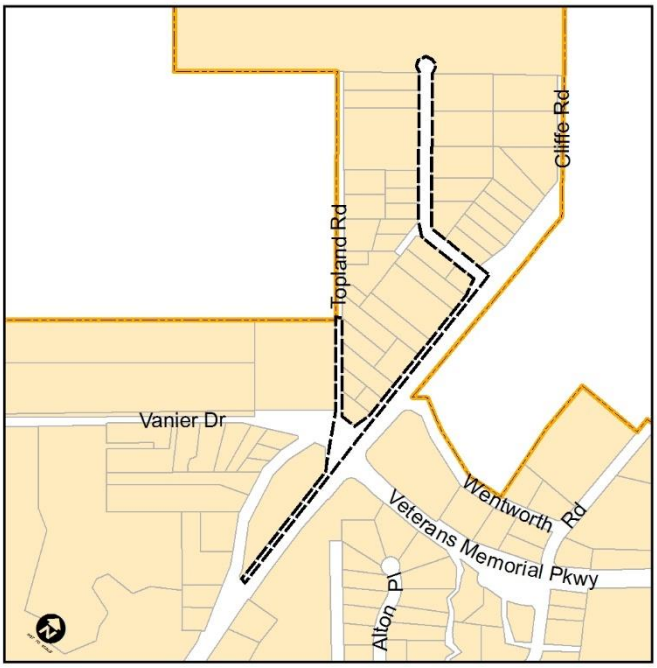
Project Description:

- **REPLACE EXISTING UNDERSIZED END OF LIFE WATER MAIN**
- **TO MEET FIREFLOW AND BYLAW REQUIREMENTS**

Estimated Project Budget : $600,000

Project ID: WAT 006

NORTH ISLAND HWY, TOPLAND RD & COTTON RD



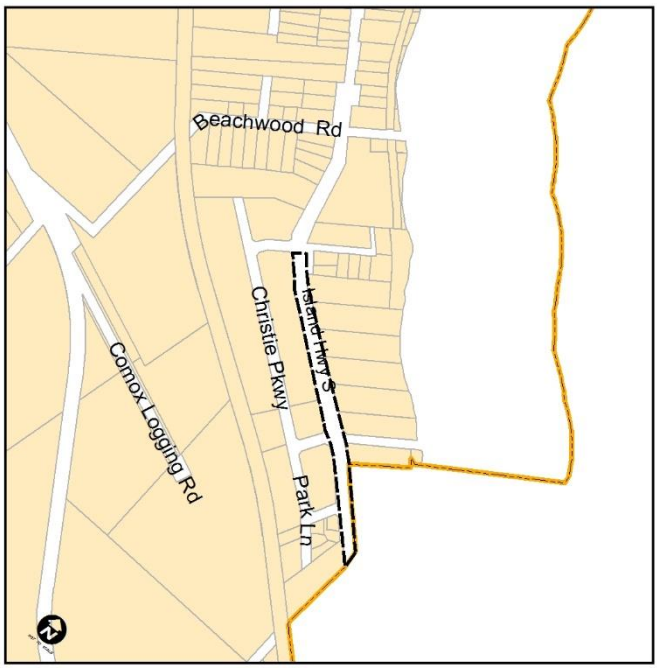
Project Description:

- **REPLACE EXISTING UNDERSIZED END OF LIFE WATER MAIN**
- **TO MEET FIREFLOW AND BYLAW REQUIREMENTS**

Estimated Project Budget : $1,400,000

Project ID: WAT 009

SOUTH ISLAND HWY



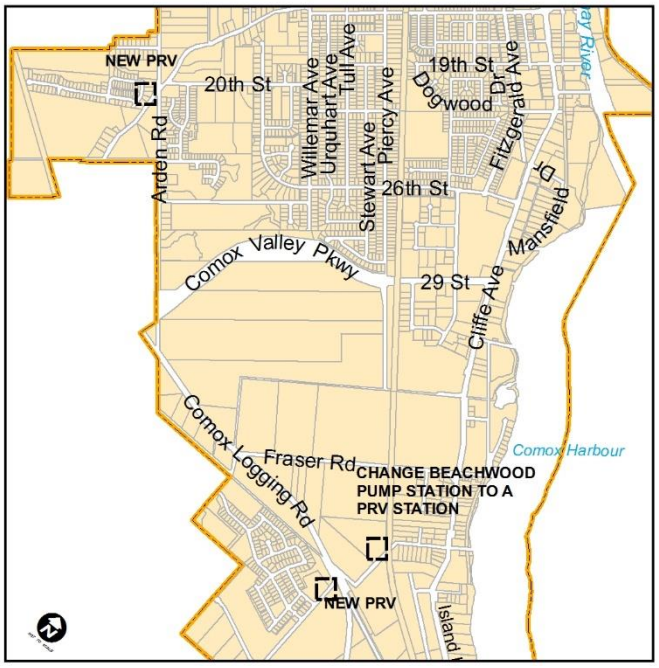
Project Description:

- **SCOPE DEPENDENT ON SOUTH COURTENAY TRANSMISSION MAIN**
- **REPLACE EXISTING UNDERSIZED END OF LIFE WATER MAIN**
- **TO MEET FIREFLOW AND BYLAW REQUIREMENTS**

Estimated Project Budget : $1,600,000

Project ID: WAT 010

FUTURE SOUTH & WEST COURTENAY SUPPLY CONNECTIONS



Project Description:

- **CONTINGENT ON THE SOUTH COURTENAY TRANSMISSION MAIN**
- **CONNECTIONS FROM SOUTH COURTENAY WATER SUPPLY**
- **THREE NEW PRESSURE REDUCING VALVE (PRV) STATIONS TO SUPPLY WEST & SOUTH COURTENAY AREAS**
  - **PRV STATION CUMBERLAND RD & ARDEN RD**
  - **PRV STATION BUCKSTONE RD & COMOX LOGGING RD**
  - **CONVERT BEACHWOOD PUMP STATION TO A PRV STATION**
- **TO MEET FIRE SUPPLY DEMANDS AND BYLAW REQUIREMENTS**
- **PROVIDE SECOND SOURCE TO REMOTE AREAS**

Estimated Project Budget : $800,000