OPUS DAYTONKNIGHT

Village of Anmore

Water Utility Master Plan

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Water Utility Master Plan

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Executive Summary

The Village of Anmore (Anmore) is a growing community within the Lower Mainland, with an estimated existing 2014 population of 2,272 residents (based on 2011 Census). Anmore's water system currently consists of 9 pressure zones, 2 pump stations, 8 pressure reducing stations, and includes over 20 km of watermains. Anmore receives potable water from the Metro Vancouver Coquitlam source via a 300 mm diameter supply connection from the City of Port Moody's (City) 290 m HGL pressure zone. The water supply and distribution infrastructure is a key focus of Anmore's strategic infrastructure priorities, and thus this study provides Anmore with a comprehensive Water Utility Master Plan.

This study provides Anmore with an understanding of the capacity of its current system under existing and future demand requirements and identifies servicing opportunities and constraints to plan upgrades to the water utility in an economic and efficient manner. A Capital Upgrades Plan is provided with a proposed schedule and estimated costs to complete the works. Integral to the Water Utility Master Plan was the development of a hydraulic model for Anmore, which has allowed the review of the level of services provided to existing and future populations by the water utility. Future populations are forecasted to a 2032 planning horizon in the most recent Official Community Plan (OCP). Furthermore, an annual operations, maintenance, and inspections program and budget was developed in consultation with Anmore staff which will allow for sufficient monitoring and maintenance of the water utility assets. The cumulative costs of the recommendations were combined with historical costs and a long-term financial plan was developed. The result of which indicates that Anmore must increase revenues if the water utility is to work towards full-cost recovery.

Source Supply

Anmore's water system is supplied by the City via a 300 mm diameter watermain connection near the intersection of East Road and Blackberry Drive in Anmore. The water is supplied from the City's 290 m HGL Pressure Zone. Under existing and future (2032) population demands, Anmore's average daily withdrawal rate was found to be less than the available supply from the City stipulated in the 1998 Water Agreement between Anmore and the City. However, the maximum rate of flow in any one hour-interval stipulated in the Agreement was found to be exceeded under the existing and future fire flow scenarios using the maximum design criteria fire flow demand and duration. An update to the maximum rate of flow is required until such time that a reservoir can be constructed for Anmore. At that time, the majority of the fire flows will be delivered via the reservoir.

While there are no concerns with the supply capacity of the potable water supplied to Anmore to meet Average Day Demand, it is understood that Anmore staff would like to consider a secondary connection to the City of Port Moody via the Hickory Drive Reservoir, which would provide some measure of source supply redundancy. Opus DaytonKnight Consultants Ltd. (Opus DK) advises that a joint stakeholder meeting between Anmore and City staff to discuss this possible connection would be prudent.

Storage Reservoirs

Water storage reservoirs store water for balancing peak water demands, for fire protection, and for emergency conditions in the water utility. As Anmore does not currently own or operate any reservoirs, it currently relies heavily on storage volumes from the City of Port Moody's Hickory Drive Reservoir. However, it is envisioned in the near future that a reservoir will be built at the Pinnacle Ridge Development to provide storage volumes to Anmore's water system. As such, Opus DK has assessed the required reservoir sizing to meet storage volume requirements under future (2032) conditions. The proposed sizing of the Pinnacle Ridge Reservoir was calculated based on Anmore's storage requirements but reduced based on the estimated future excess storage of the City of Port Moody's Hickory Drive Reservoir. The Hickory Drive Reservoir may augment Anmore's water system with an excess storage volume of 0.71 ML in 2032. This would enable Anmore to reduce the sizing of the Pinnacle Ridge Reservoir to 1.06 ML rather than the 1.77 ML that is required. However, the continued reliance on the excess storage from the Hickory Drive Reservoir must be clearly understood by Anmore and communicated to the City well into the future. The continued access to storage volumes from the City's Hickory Drive Reservoir for Anmore's and the City's demands helps to promote turnover of the reservoir and benefits both municipalities. The volume of 0.71 ML was calculated as the future excess storage from the City's Water Master Plan.

Along with other system upgrades identified in the hydraulic analysis, the Pinnacle Ridge Reservoir was found to also provide additional benefit to the existing system by resolving some future fire flow deficiencies.

Pump Stations

The capacity of Anmore's two pump stations was assessed. In particular, the Uplands Pump Station was analysed under the existing and future demand conditions, while the Pinnacle Ridge Pump Station was only analysed under future demand conditions, as it is not currently operational.

The Uplands Pump Station was found to have adequate capacity under existing and future OCP demands.

The Pinnacle Ridge Pump Station was designed to provide flows to the proposed Pinnacle Ridge Storage Reservoir. The Pinnacle Ridge Pump Station was adequately sized for future conditions. Long-term phasing of the Pinnacle Ridge development was incorporated into the hydraulic model.

Distribution System

Under the existing population scenario, it was found through the hydraulic model that a minimal amount of low and high pressures were experienced within the system. However, the model revealed a large amount of fire flow deficiencies in the system, especially north of the intersection at Sunnyside Road and East Road, along undersized watermains in the system. Proposed upgrades were made to upgrade watermains, provide looping through new watermain construction, and adjust/upgrade existing pressure reducing station infrastructure. These identified upgrades are expected to resolve existing service pressure and fire flow deficiencies. As well, Anmore's concern over water quality will be addressed to a certain extent through the proposed looping upgrades which will address issues of water stagnation at dead ends.

Opus DK also carried out an assessment of Anmore's existing water system with its population estimated to future (2032) conditions. The water system was able to manage the increased water demand, however, with a few added deficiencies on top of those found in the existing system analysis. Two additional capital upgrades projects would be required to address the additional future fire flow deficiencies and include watermain looping between Chestnut Crescent and Eaglecrest Road, as well as the construction of the Pinnacle Ridge Storage Reservoir.

Hydrant Coverage

Anmore's Works and Services Bylaw No. 242-1998 should be revised to reflect the FUS 1999 'Water Supply for Public Fire Protection' guide, which recommends a maximum hydrant spacing of 180 metres in single-family residential areas and 90 metres in multi-family and institutional, commercial and industrial (ICI) areas.

A mapping of Anmore's existing fire hydrants was carried out to determine the area of influence and coverage of existing hydrants. In accordance with the FUS guidelines, there are an additional 4 fire hydrants recommended for Anmore's water distribution system.

Capital Plan

From the upgrades identified, a Capital Upgrades Plan was developed which prioritized capital projects according to resolving existing system deficiencies and critical system conveyance issues. The upgrades identified seek to improve system reliability by resolving existing fire flow deficiencies, increasing fire hydrant coverage, providing storage, resolving existing service pressure deficiencies, and addressing future deficiencies expected in the system based on estimated future (2032) demands.

The total estimated cost of the Capital Upgrades Plan in 2014 dollars is $2,738,710. The cost of the Plan is to be shared by Anmore and by developers through Development Cost Charges.

Long-Term Financial Plan

A long-term financial plan was developed to estimate the revenue required to sufficiently fund the total estimated costs of the water utility which include the purchase of potable water from the City; operations, maintenance, and inspection programs; administration; the Capital Upgrades Plan; the rehabilitation and replacement of existing infrastructure, and build reserves. Revenues need to increase to support the recommended OMI programs, the Capital Upgrades Plan, and contributions to reserves.

The cost of water supply is a significant component of Anmore's overall water costs, and Opus DK suggests that the 1998 Water Supply Agreement be reviewed to ensure the fairness embodied in its intent, is being implemented.

1 Introduction

The Village of Anmore (Anmore) retained Opus DaytonKnight Consultants Ltd. (Opus DK) to develop a Water Utility Master Plan. While Anmore strives to maintain its semi-rural character through slow growth, Anmore has grown in size since its incorporation on December 7th, 1987. Anmore is not expected to significantly change in the future, though the population is expected to increase by nearly 50% over the next 17 years (to the 2032 Official Community Plan (OCP) medium growth scenario build-out). A detailed assessment of the existing water utility is essential to providing the residents of Anmore with the proper level of service, while planning for future growth.

A technical assessment of the hydraulic infrastructure was undertaken by Opus DK to determine the condition of the existing supply network and to recommend improvements to address current deficiencies and meet future growth projections. A major component of the technical assessment included the development, calibration, and subsequent analysis of Anmore's hydraulic water model. The hydraulic model has enabled the project team to:

- Assess the existing hydraulic performance and current operational settings. This allowed the project team to determine the necessary short and/or medium term improvements;
- Assess the existing system's capability in coping with Anmore's future projected water demands generated through development and population growth. This allowed the project team to determine the long term improvement works necessary to serve the projected growth.

A Capital Upgrades Plan has been prepared at the end of this report which provides Anmore with recommendations for water infrastructure improvements to service both the existing population and to meet growth and redevelopment in accordance with Anmore's OCP. This report provides a complete analysis of Anmore's water supply source, pump stations, and transmission and distribution network.

1.1 Scope of Work

The terms of reference prepared by Anmore identified the key study issues to be addressed. The following summarizes the scope of work undertaken for the Water Utility Master Plan:

- Gather and review all existing information related to the water supply, such as studies, reports, drawings, water quality data, operational data, etc. from Anmore;
- Meet with Anmore operations staff to obtain and compile all relevant operational data;
- Obtain historical data on average day, maximum day and peak hour demands;
- Review field data and results from the hydrant flow testing program completed for Anmore;
- Model Development and Calibration;
- Assess the influence of the existing population and future growth on the water model;
- Assess the distribution system to design criteria requirements;
- Analyze existing and future water system deficiencies and propose recommendations for system improvements to address each deficiency;
- Prepare a Capital Upgrades Plan and cost estimates for proposed improvement projects; and
- Prepare a long-term financial plan and review Anmore's current funding model.

1.2 Data Collection and Information Review

Historical data, water system information and previous studies that have been reviewed during development of this report include:

- 2014 Village of Anmore Official Community Plan;
- 2014 Flow meter data at Anmore's Re-Chlorination Booster Station;
- 2009-2013 Peak flow records at the City of Port Moody connection;
- 2012 Village of Anmore residential water meter records;
- 2007 Report to Village of Anmore for Water Supply Study, McElhanney Consulting Services;
- Current operational information on Anmore's pump stations and PRVs;
- As-built drawings for Anmore watermains;
- Parcel, LiDAR and contour information for Anmore;
- Historical financial information;
- Anmore's Water Rates and Regulations Bylaw #161; and
- Anmore's Water Rates and Regulations Amendment Bylaw #530.

1.3 Acknowledgements

Opus DK acknowledges the support and cooperation of Anmore and extends its appreciation to Kevin Dicken, Manager of Public Works, for his assistance to the project team at Opus DK in preparing the report.

The Opus DK team, under the supervision and direction of Lisa Mirfatahi, P.Eng., consisted of: Clive Leung, P.Eng. and Michael Levin, E.I.T., who were responsible for the model development, analysis and reporting; Catherine Dallaire, P.Eng., who was responsible for the Service Levels and Operational Lifecycle Practices assessment and reporting; and Peter Hutchins, E.I.T., who was responsible for the financial model and reporting.

1.4 Abbreviations

ADD	Average Day Demand	MDD	Maximum Day Demand
BC	British Columbia	ML	Million Litres
FUS	Fire Underwriters Survey	ML/d	Million Litres per day
GIS	Geographic Information System	MV	Metro Vancouver
HGL	Hydraulic Grade Line	OCP	Official Community Plan
ICI	Industrial/Commercial/Institutional	PHD	Peak Hour Demand
L/c/d	Litres per capita per day	PRV	Pressure Reducing Valve
L/s	Litres per second	psi	pounds per square inch
GPM	Gallons per Minute	kPa	kilopascal
DCC	Development Cost Charges	VFD	Variable Frequency Drive
ENR	Engineering News Record	OMI	Operations, Maintenance, and Inspections

2 Existing Water System

2.1 System Overview

Anmore's water system consists of 9 pressure zones, 2 pump stations, 8 pressure reducing stations, and includes over 20 km of watermains. Anmore receives its potable water from the City of Port Moody (City) via a 300 mm diameter connection near the intersection of East Road and Blackberry Drive, which is directly fed off of the City's 290 m pressure zone. The City is in turn supplied through four connections to Metro Vancouver's trunk mains crossing the City. The aforementioned components of Anmore's distribution system are summarized in Table 2-1 and illustrated in Figures 2-1 and 2-2.

Table 2-1: Water System Summary

Component	Quantity
Pressure Zones	9
Port Moody Supply Connection	1
Pump Stations	2
Pressure Reducing Stations	8
Length of watermains (km)	20

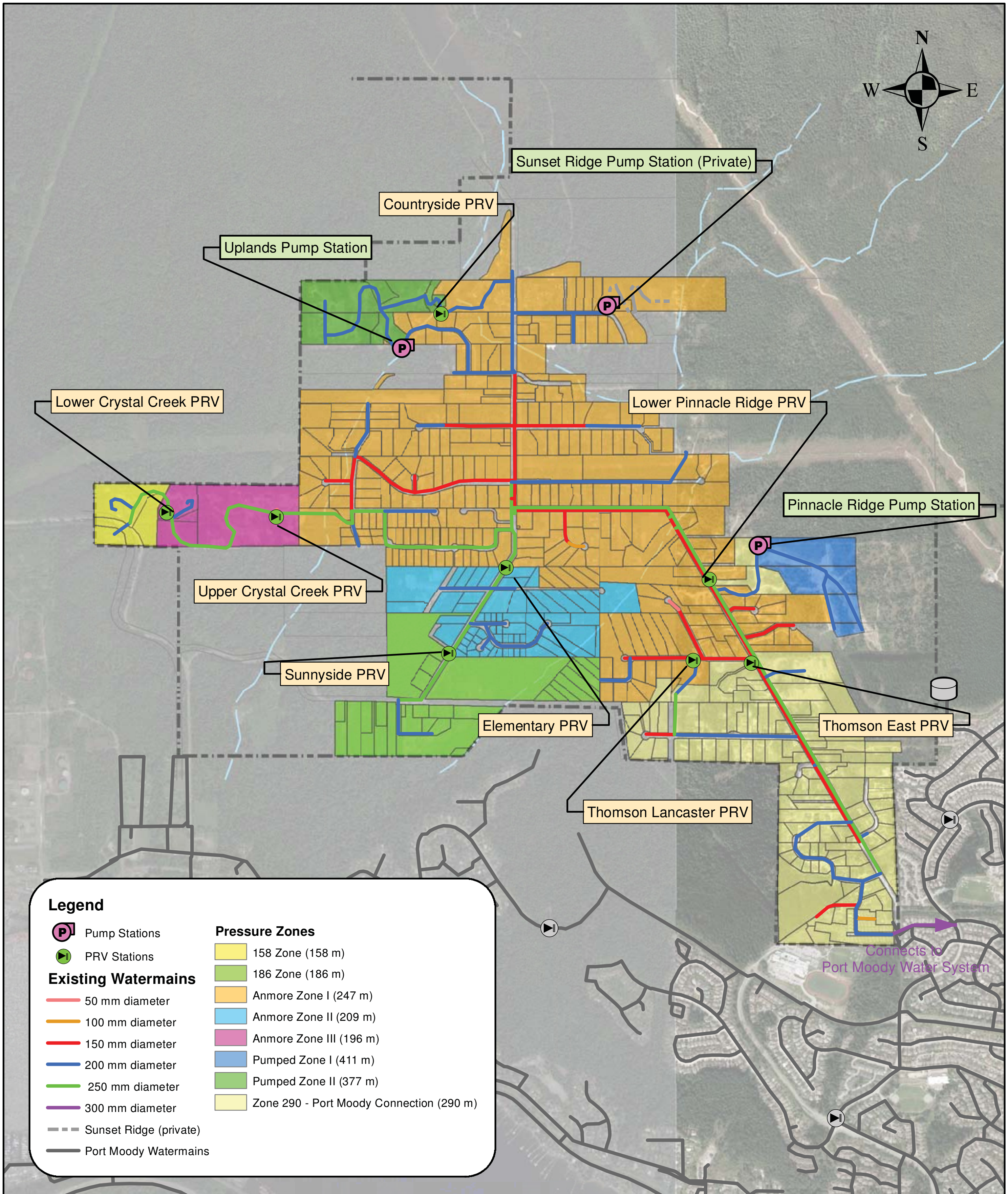
2.2 Water Supply and Treatment

The water supply to Anmore via the City is provided by Metro Vancouver's Coquitlam water source. Water treatment at the Coquitlam source consists of ozone treatment, ultra-violet radiation, and chlorination. While providing high quality drinking water to the City, there had been concerns in the past regarding the chlorine residual of the water reaching Anmore. Due to the nature of the City's water system, the chlorine residual is largely consumed by the time the water reaches Anmore. As such, there have been instances in the past in Anmore where chlorine residuals did not comply with the objectives of the local health authority, which requires a chlorine residual of at least 0.2 mg/L. This was addressed through the recent construction of the Anmore re-chlorination building at the intersection of Hummingbird Drive and Robin Way.

In addition to re-chlorination providing increased chlorine residuals in the water supplied to Anmore residents, a recently installed magnetic flow meter in the facility allows Anmore staff to verify recorded flows from its current connection to the City. Anmore currently holds a 1998 servicing agreement with the City for the water it is supplied. Anmore is currently billed through tracked total water usage at a City owned flow meter at the connection, therefore Anmore's newly installed flow meter provides valuable flow verification.

As the 1998 servicing agreement does not warranty the quality or quantity of water conveyed to Anmore by the City, Anmore's ability to internally monitor and measure the quality and quantity of water supplied to its residents is a key benefit of the new re-chlorination facility.

In terms of supply redundancy, Anmore does not currently hold any redundancy to its sole connection to the City's water system. As a follow-up to this Water Utility Master Plan, Opus DK will provide assistance in reviewing a secondary source supply via a possible connection to the City's water system through the Hickory Drive Reservoir. The modular design of the water treatment pallets in Anmore's re-chlorination facility could allow upon detailed review for an expedited set-up of a treatment system for another re-chlorination facility at any future secondary connection to the City's water system.



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Client: Village of ANMORE

Existing Water System

Project No:	D-85702.00
Designed:	ML
Drawn:	ML
Approved:	CL
Note:	Figure 2-1
Scale:	0 125 250 Meters — 1:40,000 @ Tabloid
Map No	1
Date	MAY 2015
Revision	
Revision Date	

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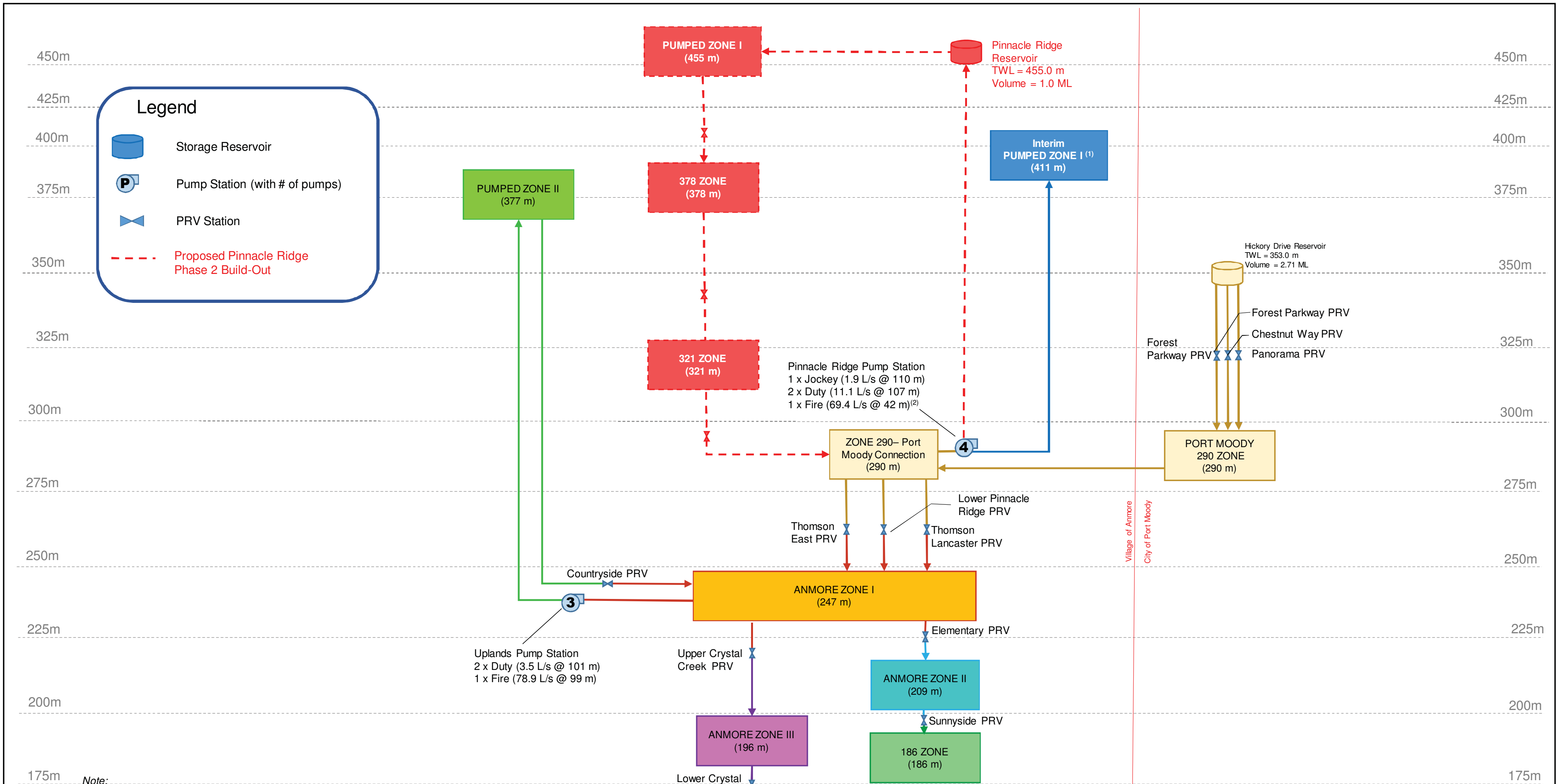

Note:

(1) Pumped Zone I (411 m) is an interim pressure zone preceding the completion of Phase 2 of the Pinnacle Ridge development, whereupon the Pinnacle Ridge Pump Station will pump potable water directly to the Pinnacle Ridge Storage Reservoir.

(2) Pump curve in hydraulic model for the Pinnacle Ridge fire pump based on September 2013 Fire Pump Flow Test. ***Annmore staff to confirm exact make and model.***

(3) Known proposed system configuration as of March 11, 2015. Other development details are not known at this time.

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Water System Schematic

Project: D-85702.00		Scale: Not to Scale	
Drawn: ML	Approved: CL		
Figure 2-2		Map No:	Date: MAR 2015
		Revision:	Date:

2.3 Pumping Stations

There are two pump stations owned and operated by Anmore, including the Uplands Pump Station and the Pinnacle Ridge Pump Station, the latter of which is currently not in service. The operating curves for Anmore's pumps were entered into the water model using manufacturer's pump curves and fire pump flow tests. A summary of the pump configurations at each station is provided in Appendix B.

In addition to the two pump stations, there is the privately owned Sunset Ridge Pump Station which is accessible by Anmore Staff. The Sunset Ridge Pump Station provides pumped water solely to a local development and does not affect the hydraulic analysis of Anmore's water system. Therefore, the Sunset Ridge Pump Station was not assessed in the hydraulic model, though some relevant details have been included in this report for completion. Note that pump operating curves are not included for the Sunset Ridge Pump Station, only general information which was made available to Opus DK.

Details of the pump stations and the number of pumps at each station are summarized in Table 2-2.

Table 2-2: Existing Pump Stations

ID	Pump Station	Number of Pumps	Elev (m)	Zone Supplied
3863, 3864, 3706	Uplands	3	181.0	Pumped Zone II
3701	Pinnacle Ridge	4	240.0	Pumped Zone I
-	Sunset Ridge (Private)	2	192.0	Private

2.4 Pressure Reducing Stations

There are 8 Pressure Reducing Valve (PRV) stations in Anmore's distribution system. Elevations of the PRVs and their lead and lag valve pressure settings are summarized in Table 2-3.

Table 2-3: PRV Parameters

ID	PRV Station	Elevation (m)	Valve Diameter (mm)	Pressure Setting (PSI)	Status	Zone Supplied
4144, 3701	Lower Pinnacle	205.0	50 and 150	61 and 53	Open	Zone I (247 m)
4136, 3697	Thomson East	199.0	50 and 200	68 and 60	Open	Zone I (247 m)
4150, 3700	Thomson Lancaster	188.6	50 and 150	84 and 70	Open	Zone I (247 m)
4112, 3699	Lower Crystal Creek	118.0	50 and 150	56 and 46	Open	158 m HGL Zone
4119, 3698	Upper Crystal Creek	164.6	50 and 150	45 and 38	Open	Zone III (196 m)

ID	PRV Station	Elevation (m)	Valve Diameter (mm)	Pressure Setting (PSI)	Status	Zone Supplied
4123, 3703	Countryside	171.9	50 and 150	108 and 95	Closed	Zone I (247 m)
4131, 3702	Sunnyside*	145.0	50 and 150	33 and 25	Open	168 HGL Zone
3696	Elementary*	171.0	150	54	Open	Zone II (209 m)

*PRV settings were reduced by 6 psi during calibration to match field results.

The table includes pressure setpoints that Anmore has recently reconfigured for its PRV stations based on discussions with Opus DK during the initial stages of the model development process.

2.5 Distribution System

Anmore's distribution system consists of over 20 kilometres of watermains supplying approximately 2,081 residential users. The distribution watermains range in diameter from 50 mm to 300 mm and were installed between 1990 and 2013. A summary of the existing pipe diameters and approximate total lengths are listed in Table 2-4.

Table 2-4: Existing Watermain Diameters

Diameter (mm)	Total Length (m)
50	41
100	132
150	5,370
200	9,200
250	5,615
300	64
TOTAL	**20,422**

3 Water Demand

This section primarily focuses on the methodology of deriving the existing water demand and anticipated future water demand associated with population growth in Anmore. A forecast of water demands is made based on historical water consumption records, estimated future populations, and anticipated future water usage trends.

3.1 Population

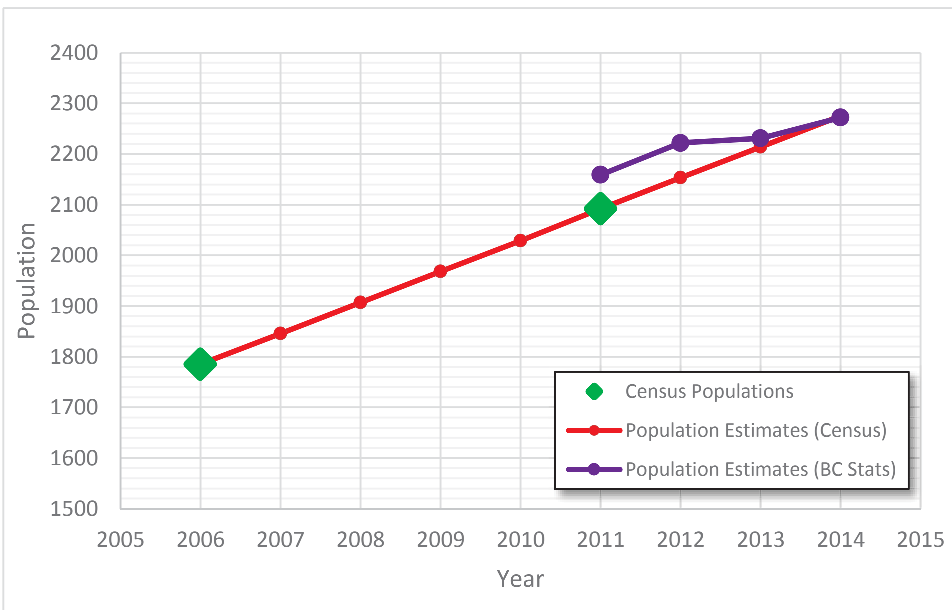
3.1.1 Serviced Population

Population data was available from various sources, which included:

- 2011 to 2014 BC Stats population estimates; and,
- 2006 and 2011 population estimates from Census Canada.

BC Stats estimated a 2014 population of 2,272 people in Anmore. The figure below illustrates the BC Stats population estimates from 2011 to 2014. Census data from 2006 and 2011 was used to cross-reference the BC Stats population estimates. A 2014 population estimate was extrapolated from the recent Census data using a growth rate of 3.22%, compounded annually. The 2014 population estimate based on Census data (illustrated in the figure below) was 2,275 people which closely matched the BC Stats estimate. Opus DK relied on the BC Stats estimate of 2,272 people for the existing population of Anmore in further analyses.

Population Estimates (based on Census data and BC Stats)



The total serviced population in Anmore was estimated by determining a unit population density per acre, which allowed for excluding properties serviced by private wells. The unit population density per acre calculation was performed using a map provided by Anmore staff and area estimates based on spatial analysis in GIS.

Of the current population, the **total serviced population is estimated at 2,078**. The remaining 194 residents are serviced by private wells.

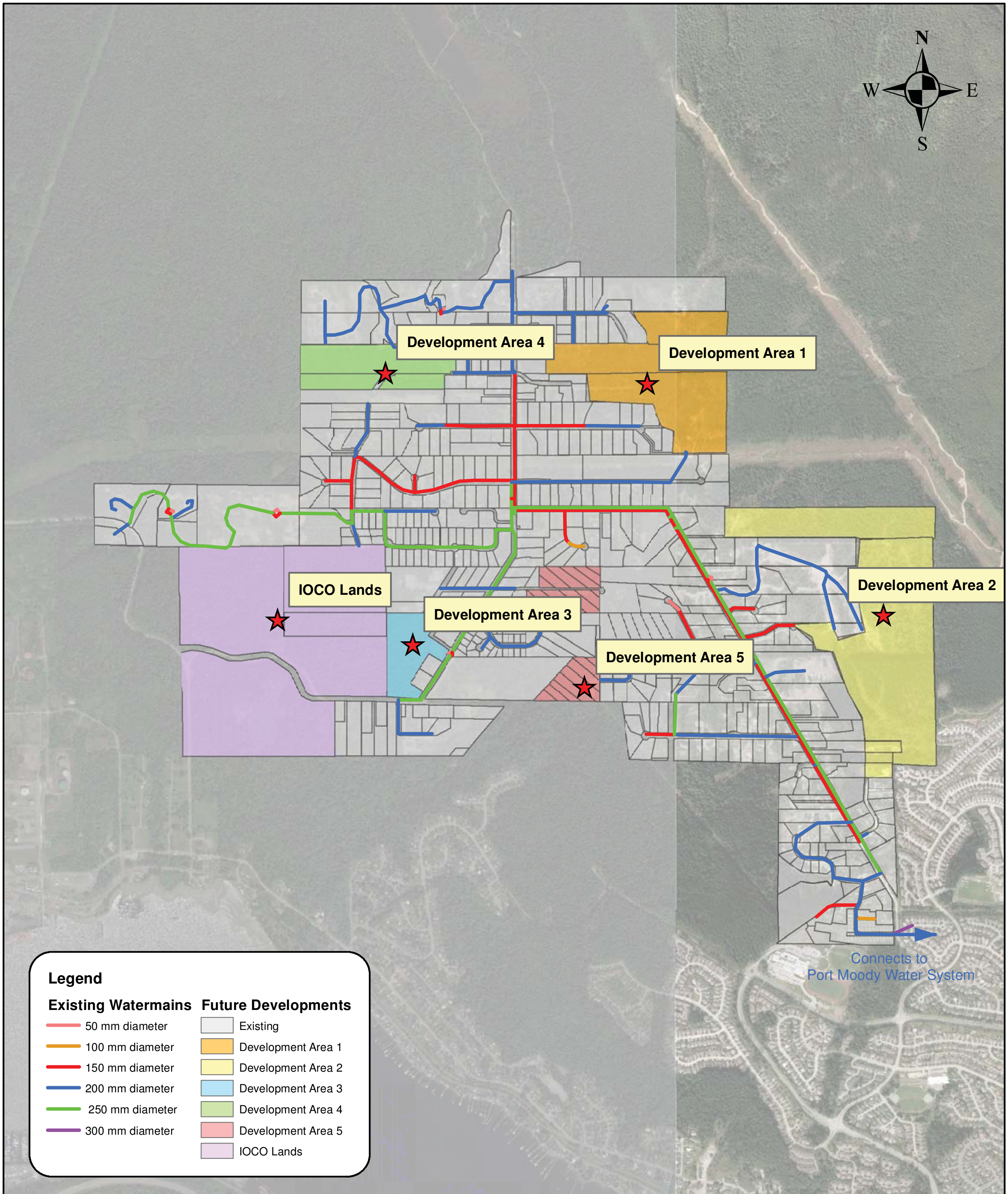
3.1.2 Projected Population

A forecast of the future serviced population was made for the end of the 2032 study period based on input from the planning department, figures from the OCP, and Opus DK's understanding of the growth priority areas as discussed with Anmore staff. During discussions with Anmore staff the medium growth scenario from the OCP was determined to be most appropriate for determining population growth. The annual average growth rate for the medium growth scenario to 2032 is 2.2% based on the total existing population of Anmore. Based on the medium growth scenario the estimated connected single family residential future population is 3,361.

Population estimates were then allocated to new development areas identified in consultation with Anmore staff, as summarized in Table 3-1 and illustrated in Figure 3-1.

Table 3-1: Future Population Estimates

Development Area	Total Approx. Area (Hectares)	Population
Area No. 1	58.3	182
Area No. 2	96.1	227
Area No. 3	13.6	76
Area No. 4	25.0	37
Area No. 5	19.0	61
IOCO Lands	147.5	506
Total Increase	**-**	**1,089**
Existing Population (2014)	-	2,272
OCP (2032) Population	**-**	**3,361**



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Client: Village of ANMORE

Future Development Projections

Project No: D-85702.00		Scale: 0 125 250 Meters	
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Note:		Map No 1	Date MAY 2015
Figure 3-1		Revision	Revision Date

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3.2 Existing Demands

Flow meter data from the re-chlorination facility was used to estimate maximum day and peak hour demand throughout the system. Water meter record data from 2009 to 2013 was used to determine Average Day Demand (ADD).

Demands were allocated to individual parcels using available meter data. After all demands had been assigned, land parcels and their demands were imported into the model and then proportionally distributed to the nearest model nodes.

3.2.1 Average Day Demand

The ADD is the average demand in a year regardless of season. The value is useful in analyzing historic demands and patterns, as well as for estimating future demands. The future ADD is important in determining the average supply requirements for the water system.

The existing ADD was estimated by analyzing Anmore's water utility billing records. The total metered water consumption in 2014 was 240,048 m^3 which equates to about 316 l/c/d. However, in 2014 the City charged Anmore for the use of approximately 278,109 m^3 (estimated from a total charge of $279,055 at a rate of $1.0034 per m^3) or equivalently 366 l/c/d.

For the purposes of hydraulic modelling, an average per capita demand of 366 L/c/d was chosen with an assumed leakage rate of about 13.5% (difference between amount of water supplied by the City and the total metered water consumption), with a portion of the volume of water unaccounted for due to hydrant flushing. With an estimated existing service population of 2,078 people, the ADD is estimated to be 8.8 L/s.

Anmore's Per Capita ADD for 2014 was estimated to be 366 L/c/d.

3.2.2 Maximum Day Demand

The Maximum Day Demand (MDD) gives an estimation of the maximum water usage per capita for one day (presumably in the summer) in a year. It is typically used for sizing a system's storage capacity in reservoirs and the capacity required at the source supply of a system.

The MDD was estimated by analysing flow meter data from Anmore's Re-Chlorination Booster Station. Flows were assessed over 24-hour periods, starting in May 2014 with the start of high seasonal flows, through to November 2014 to the end of the recorded data set. An MDD of 15.7 L/s was captured on July 15, 2014.

Anmore's Per Capita MDD for 2014 was estimated to be 653 L/c/d.

3.2.3 Peak Hour Demand

The Peak Hour Demand (PHD) is an estimation of the maximum water usage of the system in one hour during a day in a certain year. The peak hour demand usually occurs on or around the day when MDD occurs. The PHD is typically estimated through water usage from the source, as well as balancing storage in the system reservoirs. In the absence of reservoirs, such as in Anmore, the supply source from the City will supply this demand.

The PHD was measured using the flow meter data from the Anmore Re-Chlorination Booster Station. 2014 flow data between May and November was assessed over 1-hour intervals to determine the PHD. A PHD of 27.9 L/s was captured on August 6, 2014 at approximately 6:17 am.

Anmore's Per Capita PHD for 2014 is estimated to be 1160 L/c/d.

3.2.4 Demand Allocation

The spatial allocation of water demands in the model is based on water meter data for the fall of 2012, which was provided by Anmore. The top 20 users from the given data set were identified and their recorded meter demand was allocated to the nearest node in the model. Table 3-2 below summarizes the demands for the top 20 users:

Table 3-2: Demand Allocation

Rank	Parcel FID	Meter ID	Address	Land-Use	Meter Demand (L/s)
1	127	73615840	3230 Sunnyside Road	Commercial	0.285
2	216	1010013431	200 Alpine Drive	Residential	0.215
3	210	44063185	150 Hemlock Drive	Residential	0.199
4	276	49004291	Westridge Lane	Residential	0.175
5	308	79907326	2285 East Road	Residential	0.163
6	230	73615845	3151 Sunnyside Road	Residential	0.150
7	314	62894783	2185 Summerwood	Residential	0.144
8	268	44063190	133 Oak Court	Residential	0.143
9	15	60534897	1451 East Road	Residential	0.141
10	249	60484606	3053 Anmore Creek Way	Residential	0.131
11	458	70493120	700 Canterwood	Residential	0.128
12	119	69859272	1074 Magnolia Way	Residential	0.127
13	10	62894784	157 Dogwood Drive	Residential	0.111
14	484	65864969	1755 Lancaster Crescent	Residential	0.104
15	387	41467455	188 Wyndham Crescent	Residential	0.098
16	461	46292223	2415 East Road	Residential	0.093
17	307	49005620	Deerview Lane	Residential	0.093
18	33	80370943	110 Strong Road	Residential	0.093
19	29	81568701	105 Strong Road	Residential	0.092

Rank	Parcel FID	Meter ID	Address	Land-Use	Meter Demand (L/s)
20	478	73615846	1130 Mountain Ayre Lane	Residential	0.092
				Total Demand (top 20 users)	**2.8**
				Total Demand (All users)	**12.8**
				Remaining Demand (for allocation)	**10.0**

The combined demand of the top 20 users (2.8 L/s) was subtracted from the total demand for all metered lots (12.8 L/s). The remaining demand (10.0 L/s) was evenly distributed amongst the remaining residential, institutional and commercial properties. Parcel demands were then allocated to the nearest model nodes.

To attain a given demand scenario in the hydraulic model, every individual demand that was allocated to a node in the model was multiplied by a ratio of the demand scenario (ie. 8.8 L/s for existing ADD) over the total metered demand (12.8 L/s). Using this method, the ADD, MDD, and PHD for existing and future OCP scenarios were allocated in the hydraulic model.

3.3 Future OCP Demands

Future population estimates were based on the medium growth scenario (2.2%) identified in Anmore's OCP. In addition, Opus DK worked with Anmore staff to review schedules from the OCP, various development plans, and leveraged our understanding of the growth priority areas to determine the future residential development areas and corresponding populations in Anmore.

Table 3-3 provides a summary of the development populations and residential demands developed in conjunction with Anmore staff. Populations for Development Areas 1 to 4 were provided by Anmore. The IOCO Lands were assigned the remaining future populations. A per capita demand of 336 L/c/d was applied to the populations to determine the ADD. The resulting ADD formed the basis for demand loading under the medium growth scenario in Anmore's hydraulic water model.

Table 3-3: Future OCP Average Day Demands

Development	Population	ADD (L/s)
Area No. 1	182	0.8
Area No. 2	227	1.1
Area No. 3	76	0.3
Area No. 4	37	0.2
Area No. 5	61	0.3
IOCO Lands	506	2.1
Total Increase	**1089**	**4.6**

Development	Population	ADD (L/s)
Existing Population	2,272	9.6
OCP Population	**3,361**	**14.2**

3.4 Peaking Factors and Demands

Since most future population growth will be concentrated as single family residential demand, the residential peaking factors were important in estimating peak OCP demands.

Table 3-4 provides a comparison between the 2014 and 2032 OCP demand distributions, with peaking factors for the Anmore water system. Note that 2032 OCP demands assume no water conservation.

Table 3-4: Demand Distribution & Peaking Factors

Demand Horizon	ADD (L/s)	MDD (L/s)	PHD (L/s)	MDD/ ADD	PHD/ ADD
Existing (2014)	8.8	15.7	27.9	1.8	3.2
Future (2032 OCP)	14.2	25.4	45.1	1.8	3.2

3.5 Demand Summary

Demands developed through this section were used to assess the ability of Anmore's water system to adequately meet level of service requirements for existing residents and projected growth. These demands form an integral part of the model development process and are the basis on which recommendations for existing and future infrastructure improvements for the water utility are made.

4 Model Calibration

Model calibration was carried out to ensure that the hydraulic water model would correlate well to conditions found during field testing of the water system. To improve the accuracy of the model, the calibration process would improve any assumptions and/or estimates made in the development of the model through an iterative review process encompassing the details of each component of the water system including pipe lengths, pipe diameters, pipe materials, pipe roughness factors, node demands, node elevations, and pump configurations.

The results of the model calibration provided a good correlation between the field and computer predicted results. The methodology applied in calibrating the hydraulic model is summarized below.

4.1 Hydrant Flow Testing

A testing program was established by Opus DK to carry out hydrant flow tests in Anmore. Three sets of hydrant flow tests were conducted as follows:

- Set 1 – 290 m HGL Pressure Zone

- Set 2 – 247 m HGL Pressure Zone
- Set 3 – 209 m and 168 HGL m Pressure Zone

Details on the testing program can be found in Technical Memorandum #2: Hydrant Flow Testing Program (Appendix A), submitted on August 6th, 2014. The hydrant flow testing program was conducted with the assistance of Anmore operations staff on August 27th, 2014.

4.2 Calibration Results and Discussion

The results of the model calibration provided a good correlation between the field and computer predicted results. 76 out of 90 of the static and residual pressures were calibrated within a 10% difference in pressures. An acceptable calibration for much of Anmore's water distribution system was achieved. The results of the hydrant testing and the calibrated values of the water model can be found in Technical Memorandum #3: Village of Anmore Water Model Development, Calibration, and Existing System Analysis (Appendix A), submitted on February 5th, 2015.

Opus DK recommended field checks to be made by Anmore staff based on watermain diameter adjustments made to the model as detailed in Technical Memorandum #3. While additional spot checks can be made at future dates, Opus DK concluded that the calibration program provided sufficient calibration for the model for the purpose of system analysis.

5 Design Criteria

The design criteria used to review the system's service pressures, pump station capacity requirements, fire protection and storage, supply storage, water quality and fire hydrant coverage are described in this section.

5.1 Service Pressures

Minimum service pressures are required to ensure an adequate flow and pressure of water at all serviced properties in Anmore. There are, in most cases, two conditions in which systems should be designed for minimum service pressures. They are 1) the MDD plus fire flow condition, and 2) the PHD condition. Furthermore, maximum service pressures in the system also need to be regulated to prevent overpressurizing of the system.

Service pressures under various demand conditions were determined by consulting the Anmore Works and Services Bylaw No. 242-1998 and the 2014 MMCD Design Guideline Manual. Table 5-1 summarizes the range of service pressures used in the analysis.

Table 5-1: Service Pressure Requirements

During Average Day	Maximum	150 psi (1030 kPa)
During Maximum Day Plus Fire Flow	Minimum	20 psi (140 kPa)
During Peak Hour	Minimum	40 psi (300 kPa)

5.2 Pump Station Capacity

As outlined in the MMCD Design Guideline Manual, pump stations are generally designed to meet the MDD of the downstream service area with the largest pump out of service, provided that storage is available within the service area. If storage is not available, the pumping capacity should meet the PHD with the largest pump out of service. In the case of Anmore where there are no reservoirs present, pump station capacity was assessed against PHD with one duty pump operational.

5.3 Fire Protection and Storage

Water distribution systems must be able to deliver large volumes of water for fire protection in addition to normal water demands. Fire protection considerations are:

1. Only one fire will be fought at any one time;
2. To ensure pumper trucks obtain adequate water supplies from hydrants, a minimum residual pressure (20 psi) on the street main is required during fires; and,
3. Fire flow is coincident with MDD.

Table 5-2 shows the recommended minimum fire flow requirements for various land use areas and the required fire flow durations for Anmore's water pressure zones. These values are based on Anmore's Works and Services Bylaw No. 242-1998 and the 1999 Fire Underwriter's Survey guideline document entitled 'Water Supply for Public Fire Protection.'

Table 5-2: Proposed Fire Flow Requirements

Land Use (Zoning)		Min. Required Fire Flow (L/s)	Required Duration of Fire Flow (Hours)
Urban	Single Family (RS-1)	60	1.5
	Cluster Housing (RS-2, RS-3)	120	2.0
Suburban	Extensive Rural & Recreational (A-1)	60	1.5
	Campgrounds	60	1.5
School	(Any Zone)	120	2.0
Institutions	(P-1)	90	2.0
Commercial & Industrial	Isolated Commercial	90	2.0
	Small Group Commercial	120	2.0

Anmore's current land use zoning was used to assign fire flow requirements to each model node. Required fire flows at each node were chosen based on the land use surrounding the nodes. For nodes that neighboured two different land uses, the higher fire flow requirement was assigned to the node.

5.4 Supply Storage

Water storage reservoirs are located at specific elevations to establish pressure zones within the distribution system. Typical design pressures within a zone vary from a minimum of 40 psi to a maximum of 120 to 150 psi. During a fire event, minimum pressures are allowed to drop to 20 psi.

Water storage is used to balance and optimize supply and delivery of water. If properly sized, reservoirs will store water during low demand periods and supplement the source supply during PHD. Typically, reservoirs are designed to refill every day and to have adequate storage capacity to provide for balancing storage, which is estimated as 25% of MDD, and fire storage based on the FUS recommended flow and duration listed in Table 5-2. Emergency storage is also required. Storage volumes requirements are estimated based on the following formula:

$$Volume = A + B + C$$

Where:

- A = Fire Storage (required extent and duration of fire flow as noted in the guidelines above)
- B = Equalization Storage (25% of MDD of the area serviced by the reservoir)
- C = Emergency Storage (25% of A + B)

5.5 Water Quality

A chlorine residual of 0.2 mg/L is recommended for most drinking water distribution systems in North America. Challenges arise when municipalities are tasked with maintaining this residual chlorine concentration which is affected by numerous factors such as the fluctuations in usage within the system, the sizes and lengths of watermains, and the infrastructure available.

While the water model created under this Water Utility Master Plan was not a water quality model, recommendations arising as proposed system improvements under this Plan include looping upgrades which will, to a certain extent, help to improve water quality in Anmore's distribution system. Aside from this Water Utility Master Plan, Anmore had commissioned Opus DK to provide engineering services for the construction of the Anmore re-chlorination building to address any chlorine residual issues in 2013. The new facility allows Anmore to monitor the quality of water delivered to its residents. Further, other opportunities for preventing water stagnation are currently being pursued by Anmore, including the possible development of a Uni-directional Flushing Program for the utility.

5.6 Fire Hydrant Coverage

Anmore's Works and Services Bylaw No. 242-1998 sets out guidelines which stipulate a required fire hydrant spacing of 100 metres within its service system. It is noted that Anmore desires to update the required fire hydrant spacing distance to reflect the guidelines set out in the FUS 1999 'Water Supply for Public Fire Protection' guide, which recommends a maximum hydrant spacing of 180 metres in single-family residential areas and 90 metres in multi-family and institutional, commercial and industrial (ICI) areas.

6 System Capacity Analysis

This section of the report covers the hydraulic analysis of the existing and future Anmore water system, based on current and OCP demand conditions. The objective of the analysis is to assess the system's performance with respect to compliance with the level of service outlined in Section 5. The purpose of the analysis is to highlight deficiencies in the system and identify appropriate upgrading options for the short, medium and long term.

Analysis covered in this section includes a review of the capacity of the source supply, an assessment of the available storage capacity, a review of the operation of the existing pump stations, and the available system pressures and fire flows in the distribution system.

6.1 Source Supply Capacity

Water is supplied by the City, via a 300 mm diameter watermain connection near the intersection of East Road and Blackberry Drive in Anmore. The water is supplied from the City's 290 m HGL Pressure Zone. Table 6-1 provides a summary of Section 3.2 of the 1998 Water Supply Agreement between Anmore and the City, which identifies restrictions on the maximum daily water demand.

Table 6-1: Maximum Daily Water Demand (Section 3.2, 1998 Water Service Agreement)

Maximum Daily Water Demand	5.455 ML/day
Maximum rate of flow in any one hour-interval from Zone 5 (Hickory Drive Reservoir)	0.385 ML/hr
Available supply from City's Zone 5 system	1.5 ML/day

Under the existing and future OCP population demands, Anmore's average daily withdrawal rate was found to be less than the available supply of 1.5 ML/day from the City as stipulated in the 1998 Water Service Agreement. The required and available average daily withdrawals are illustrated in Table 6-2.

Table 6-2: Average Daily Withdrawal Rates

Demand Scenario	Average Daily Withdrawal		Available Daily Supply (ML/day)	Excess (ML/day)	Deficient?
	ADD (L/s)	ADD (ML/day)			
2014 ADD	8.8	0.8	1.5	0.7	NO
2032 ADD	14.2	1.2	1.5	0.3	NO

Table 6-3 illustrates the maximum rate of flow in a one-hour interval under existing and future OCP demands for a fire flow scenario using a maximum design criteria flow of 120 L/s and a duration of 2 hours, as set out in Table 5-2 Proposed Fire Flow Requirements.

Table 6-3: Maximum Rate of Flow – Fire Flow Scenarios

Demand Scenario	Fire Flow Coincident to Maximum Day Demand			Allowable Maximum Rate of Flow (ML/hr)	Excess (ML/day)	Deficient?
	MDD (L/s)	Maximum Fire Flow Demand and Duration	MDD + FF (ML/hr)			
2014 MDD	15.7	120 L/s @ 2 hrs	0.489	0.385	-0.104	YES
2032 MDD	25.4	120 L/s @ 2 hrs	0.523	0.385	-0.138	YES

The maximum rate of flow in any one hour-interval stipulated in the 1998 Water Supply Agreement was found to be exceeded under existing and future OCP demands for a fire flow scenario using the maximum design criteria fire flow demand and duration. These results illustrate the need for adequate system storage to meet fire flow and emergency demands, which Anmore is actively pursuing through the proposed construction of the Pinnacle Ridge Storage Reservoir discussed in the following section.

Consideration towards increasing the maximum rate of flow allowed would be prudent. It is also understood that Anmore staff would like to consider a secondary connection to the City via the Hickory Drive Reservoir, which would provide some measure of source supply redundancy. The viability of this connection should be investigated further after completion of this Water Utility Master Plan. A joint stakeholder meeting between Anmore and City staff to discuss the secondary connection would be prudent.

6.2 Storage Reservoir Capacity

Anmore does not currently own or operate any existing reservoirs. The option to construct a new reservoir as part of Phase 2 of the Pinnacle Ridge development has been assessed in the hydraulic model by Opus DK. Table 6-4 illustrates the components that contribute to the storage volume capacity requirements under existing and future OCP demand conditions.

Table 6-4: Future Storage Analysis

Reservoir	A -Fire Storage (ML)	B - Equalization Storage (ML)	C - Emergency Storage (ML)	Required Storage A+B+C (ML)	Available Storage (ML)	Excess (ML)	Deficient?
Existing							
Pinnacle Ridge	0.86	0.34	0.30	1.50	0.00	-1.50	YES
2032 OCP							
Pinnacle Ridge	0.86	0.55	0.35	1.77	0.00	-1.77	YES

While the forecasted storage volume requirement for the proposed Pinnacle Ridge Reservoir is 1.77 ML, this requirement may be lowered if Anmore is allowed to take advantage of the excess storage at the City's Hickory Drive Reservoir. In the City's Water Distribution System Hydraulic Analysis Report (Opus DaytonKnight Consultants Ltd., 2014), under the City's 2041 OCP demand condition, the excess storage at the Hickory Drive Reservoir was determined to be 0.71 ML.

If the Pinnacle Ridge Reservoir is constructed and the projected excess storage volume at the City's Hickory Drive Reservoir is taken advantage of, **the required storage volume to meet balancing, fire, and emergency storage in Anmore can be supplied by a Pinnacle Ridge Reservoir sized at 1.06 ML.**

Based on a previous study entitled "Water Servicing Options for the Pinnacle Ridge Development Village of Anmore" (Dayton & Knight Ltd., November 2007), the recommended size of the Pinnacle Ridge Reservoir was 0.75 ML, based on demand estimates projected for the year 2021.

6.2.1 Storage Reservoir Recommendations

The proposed Pinnacle Ridge Reservoir was reviewed to provide Anmore with the necessary balancing, fire, and emergency storage volumes required under future demand conditions. It is recommended that the Pinnacle Ridge Reservoir be constructed with a storage volume capacity of 1.06 ML, provided that Anmore takes advantage of the excess storage at the City's Hickory Drive Reservoir. Anmore's continued reliance on the excess storage from the Hickory Drive Reservoir must be clearly understood by Anmore and communicated to the City well into the future. The continued access to storage volumes from the City's Hickory Drive Reservoir for Anmore's and the City's demands helps to promote turnover of the reservoir and benefits both municipalities.

6.3 Pump Station Capacity

This section provides an assessment on the capacities of Anmore's pump stations to determine if they are able to meet the design criteria set out in Section 5. The model build-out of the Uplands and Pinnacle Ridge Pump Stations, along with key assumptions and pump curves used, is detailed in Appendix B.

Table 6-5 compares the required capacity to the available pumping capacity under the PHD condition, for both the existing and 2032 OCP demand conditions. For the existing system, only the Uplands Pump Station was analyzed, as the Pinnacle Ridge Pump Station is not normally operational under current conditions.

Table 6-5: Uplands Pump Station Analysis

Pump Station	Service Area Zone (HGL)	Capacity Required (L/s)	Design Capacity (L/s)	Excess (L/s)	Deficient?
Existing					
Pinnacle Ridge	Pump Zone I (411 m)	-	-	-	-
Uplands	Pumped Zone II (377 m)	1.0	3.0	2.0	No
2032 OCP					
Pinnacle Ridge	Pump Zone I (411 m)	0.13	6.4	6.3	No
Uplands	Pumped Zone II (377 m)	1.27	3.0	1.73	No

Based on the analysis above, the Uplands Pump Station is adequate in meeting the existing PHD of Pumped Zone II. Furthermore, both the Uplands Pump Station and the Pinnacle Ridge Pump Station are adequately sized in terms of meeting the future PHD.

6.3.1 Pump Station Recommendations

6.3.1.1 Uplands Pump Station

The Uplands Pump Station was found to adequately meet existing and future service level requirements. No recommendations are required at this time.

6.3.1.2 Pinnacle Ridge Pump Station

The Pinnacle Ridge Pump Station was designed to provide flows to the proposed Pinnacle Ridge Storage Reservoir. Under the proposed development plan, the storage reservoir would provide balancing and fire storage for the entire Anmore water system. To meet future service pressure and fire flow requirements, Phase 2 of the Pinnacle Ridge development should be implemented, and the Pinnacle Ridge Pump Station should be configured as intended for the future build-out, as shown in Water System Schematic (Figure 2-2 in Section 2).

6.4 Transmission and Distribution

The hydraulic analysis of the watermains was performed using the hydraulic water model built in WaterCAD.

6.4.1 Service Pressure Analysis

Existing and future ADD, MDD, and PHD scenarios were simulated to review service pressures throughout the system. Figures 6-1 and 6-2 illustrates the peak hour pressures throughout the system under existing and 2032 OCP demand scenarios. Figures 6-3 and 6-4 illustrate available fire flows coincident to MDD throughout the system under existing and 2032 OCP demand scenarios.

6.4.1.1 Average Day Demand

The maximum pressure within each zone occurs at the property at the lowest elevation compared to the HGL of the zone set either by a reservoir, PRV or pump.

Under the existing demand scenario, no nodes were identified with pressures exceeding 150 psi. Under the 2032 OCP demand scenario, there are 2 nodes with pressures exceeding 150 psi immediately downstream of the Pinnacle Ridge Pump Station, which was designed to pump to an elevation of 455 m to reach the proposed reservoir in Phase 2 of the development construction. As such, it is expected that there would be service pressure exceedances if the existing system without the further development build-out was used to meet future ADD in the area.

Recommendations at the end of this section will address these high pressure concerns.

6.4.1.2 Peak Hour Demand

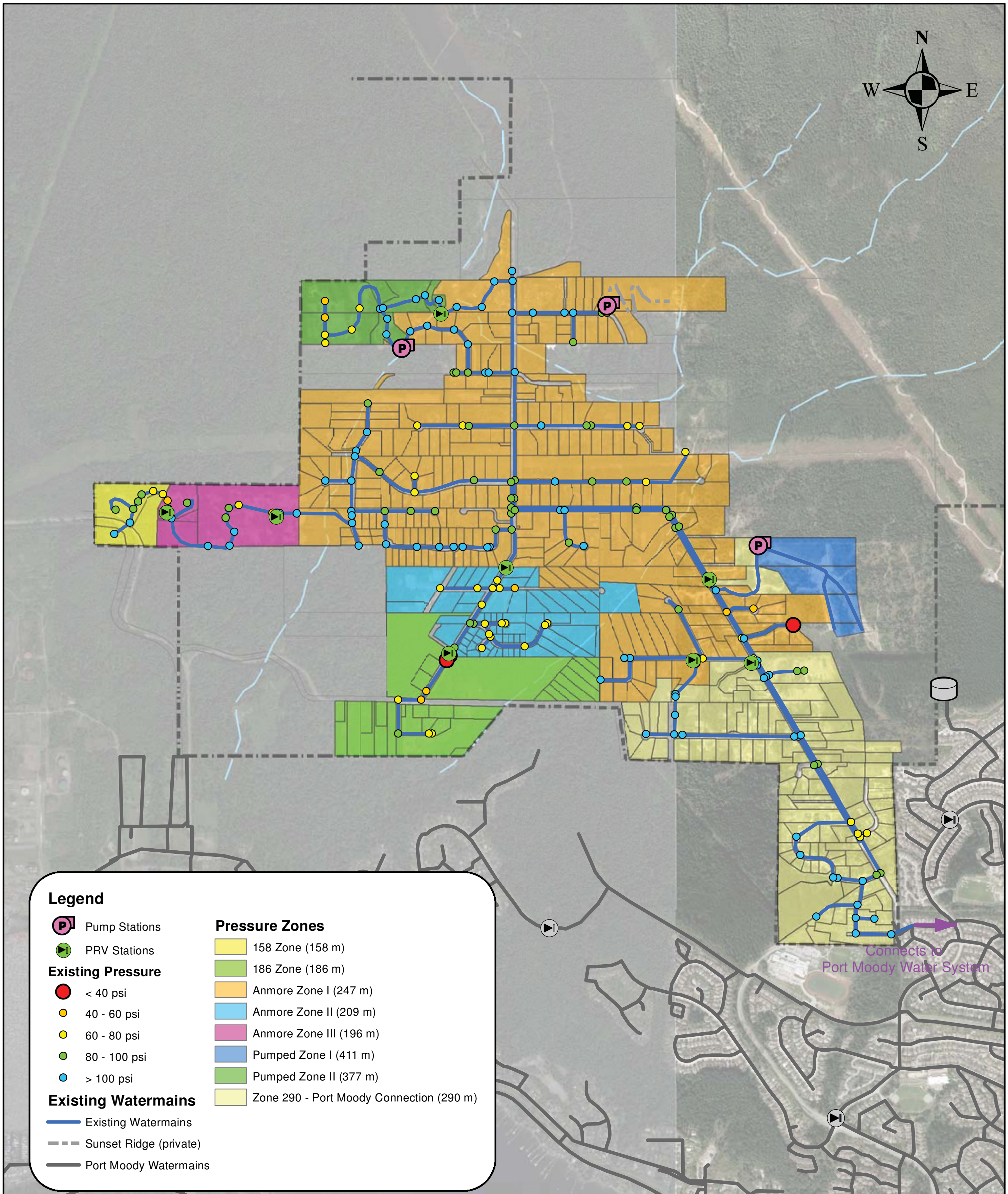
The minimum pressures within each zone occur at the property at the highest elevation compared to the HGL of the zone set either by a reservoir, PRV or pump. Three (3) nodes were identified as pressure deficient (pressure < 40 psi) under the existing and 2032 OCP demand scenarios. Table 6-6 below compares the existing and OCP deficiencies.

Table 6-6: Existing and OCP Service Pressure Deficiencies

Model Node ID	Location	Existing Peak Hour Service Pressure (PSI)	OCP Peak Hour Service Pressure (PSI)
3646	Downstream of the Thomson East PRV, at the end of Wyndham Crescent	39.1	37.4
3692, 4069	Immediately downstream of the Sunnyside PRV station	36.2, 34.4	36.0, 34.3

Though Anmore had requested Opus DK to provide PRV setpoints prior to the construction of the model for the purposes of establishing suitable pressures within its zones, the model calibration process has found a lower than expected setpoint set at the Sunnyside and Elementary PRV stations.

Recommendations at the end of this section will address these low pressure concerns.



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Client: Village of ANMORE

Existing Pressures
Peak Hour Demand

Project No: D-85702.00		Scale: 0 125 250 Meters	
Designed: ML		1:40,000 @ Tabloid	
Drawn: ML	Approved: CL		
Note:		Map No 1	Date MAY 2015
Figure 6-1		Revision	Revision Date

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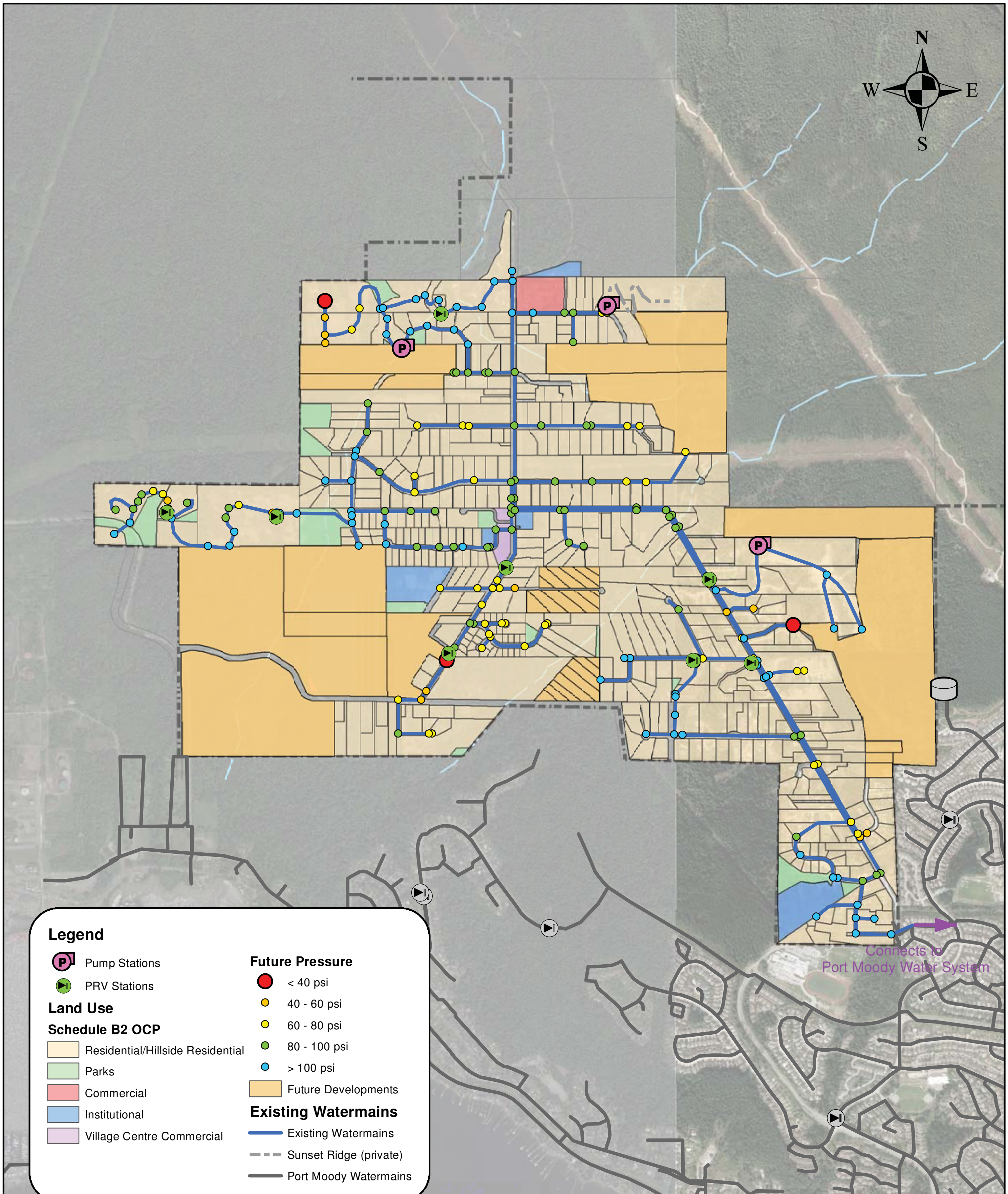

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Future Pressures Peak Hour Demand

Project No: D-85702.00		Scale: 0 125 250 Meters	
Designed: ML			
Drawn: ML	Approved: CL	1:40,000 @ Tabloid	
Note:		Map No 1	Date MAY 2015
Figure 6-2		Revision	Revision Date

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6.4.1.3 Maximum Day Demand Plus Fire Flow

The results from the fire flow analysis are summarized in Figures 6-3 and 6-4 which illustrate the various ranges of fire flow requirements and availabilities throughout the system, as well as identify where deficiencies are occurring. A model node is fire flow deficient if the node fails to maintain a residual pressure of at least 20 psi while supplying the required fire flow under the MDD.

Under the existing and 2032 OCP demand scenarios, the model predicted thirty-one (31) and forty-one (41) fire flow deficient nodes, respectively. Additional deficient nodes were manually checked and disregarded as deficient if one of the following applied:

- The deficient node is located along a private main; or,
- There is no hydrant in the vicinity of the deficient node.

Results from the fire flow analysis coincident to MDD are broken down by land use and demand scenario as listed in Table 6-7.

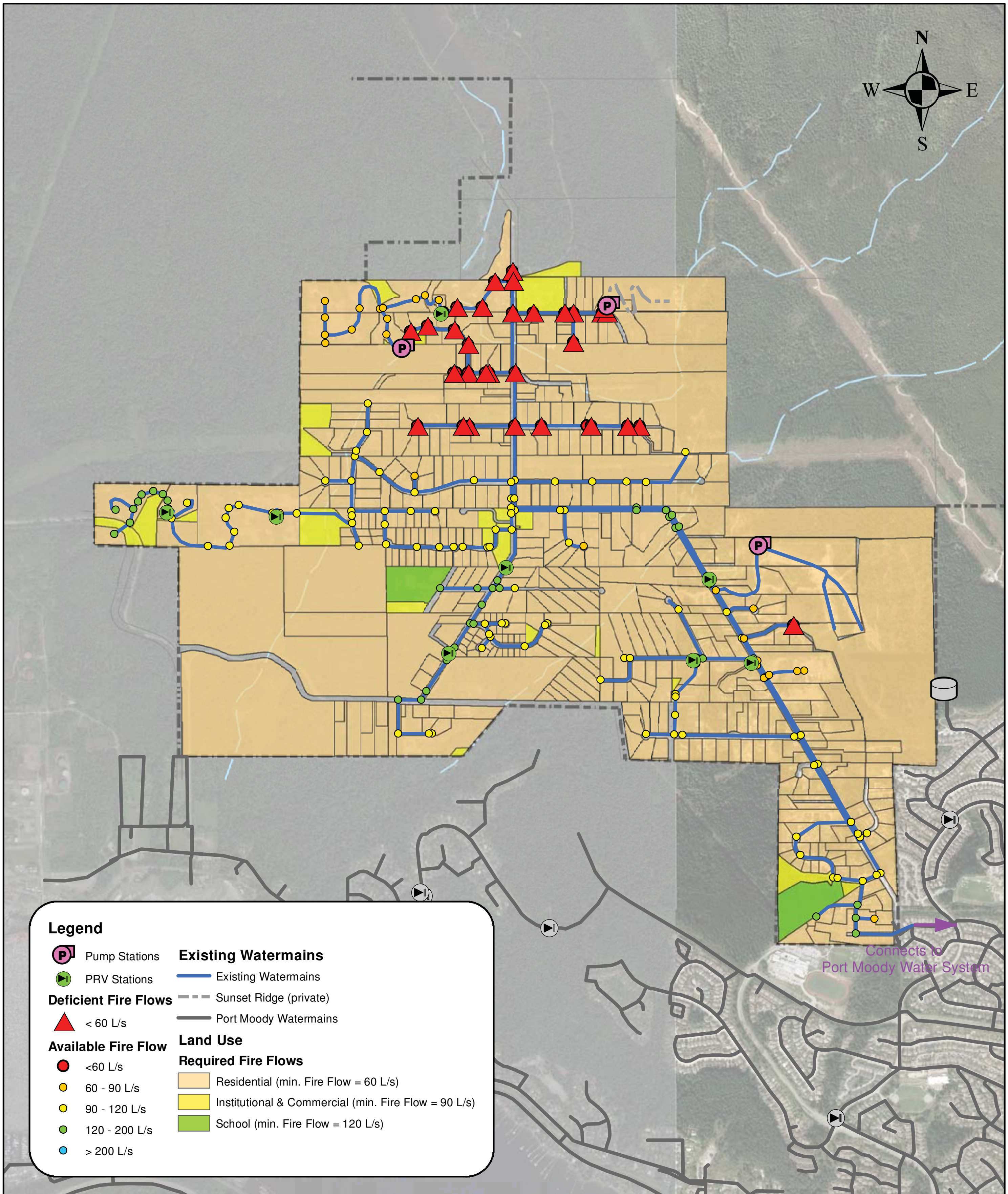
Table 6-7: Summary of Fire Flow Deficiencies

Land Use		Number of Fire Flow Deficient Nodes(1)	
		Existing	2032 OCP
Urban	Single Family (RS-1)	24	33
	Cluster Housing (RS-2, RS-3)	0	0
Suburban	Extensive Rural & Recreational (A-1)	2	2
	Campgrounds		
School	(Any Zone)	0	1
Institutions	(P-1)	0	0
Commercial & Industrial	Isolated Commercial	5	5
	Small Group Commercial	0	0
	TOTAL	**31**	**41**

(1) Based on current approximation of hydrant locations; subject to change.

The number of nodes unable to achieve the required residual pressure at the desired fire flows account for over 15% (31/205) and 20% (41/210) of the system nodes under the existing and 2032 OCP demand scenarios, respectively. Many areas where the desired fire flow levels cannot be achieved are either at dead ends in the system, or along undersized watermains within the water network.

Recommendations at the end of this section are able to resolve the existing fire flow deficiencies.



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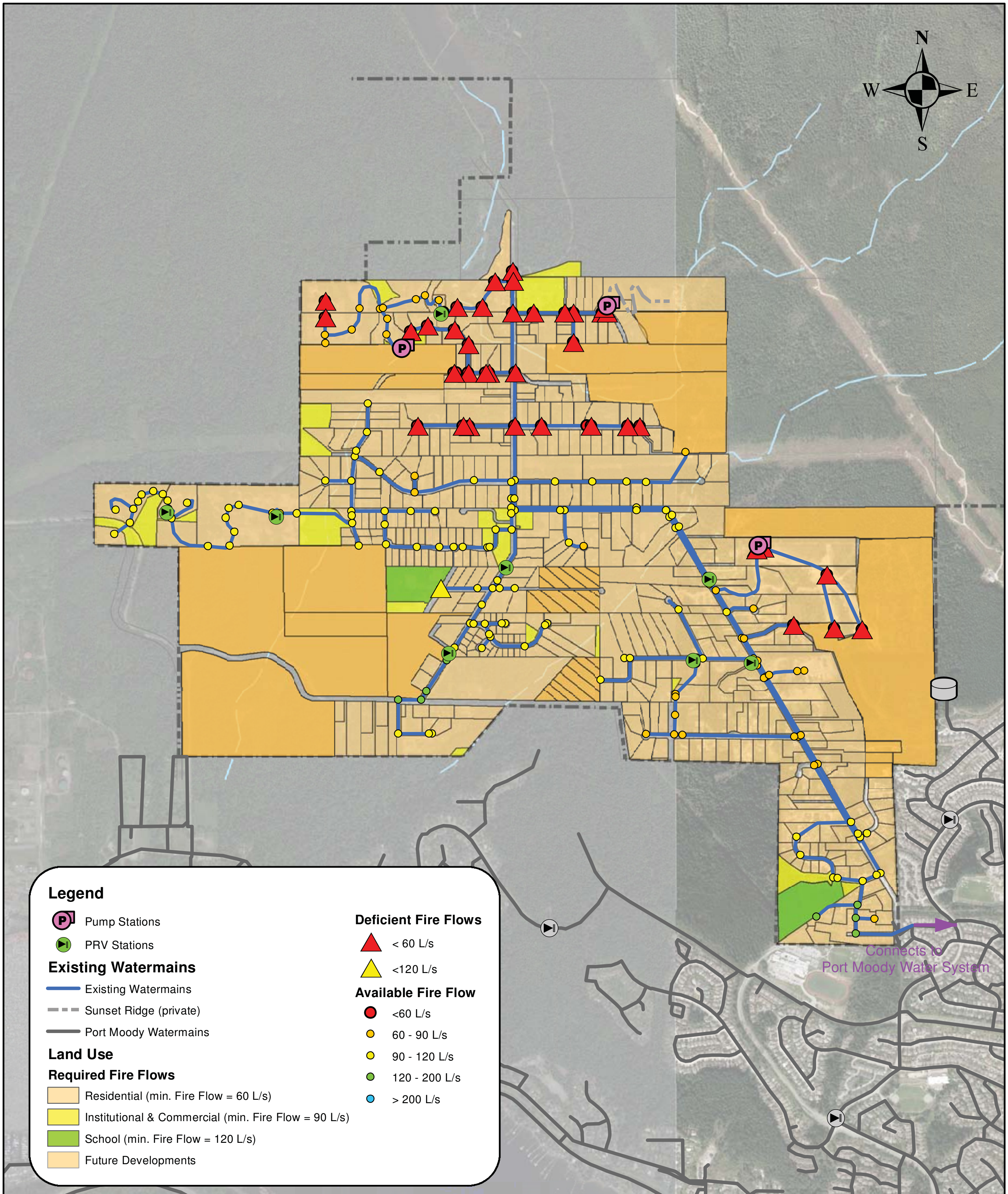
Existing Fire Flow
Maximum Day Demand

Project No:	D-85702.00
Designed:	ML
Drawn:	ML
Approved:	CL
Note:	
Scale:	0 125 250 Meters
	1:40,000 @ Tabloid
Map No	1
Date	MAY 2015
Revision	
Revision Date	

Figure 6-3



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Client: Village of ANMORE

Future Fire Flow Maximum Day Demand

Project No:	D-85702.00
Designed:	ML
Drawn:	ML
Approved:	CL
Note:	
Scale:	0 125 250 Meters; 1:40,000 @ Tabloid
Map No	1
Date	MAY 2015
Revision	
Revision Date	

Figure 6-4

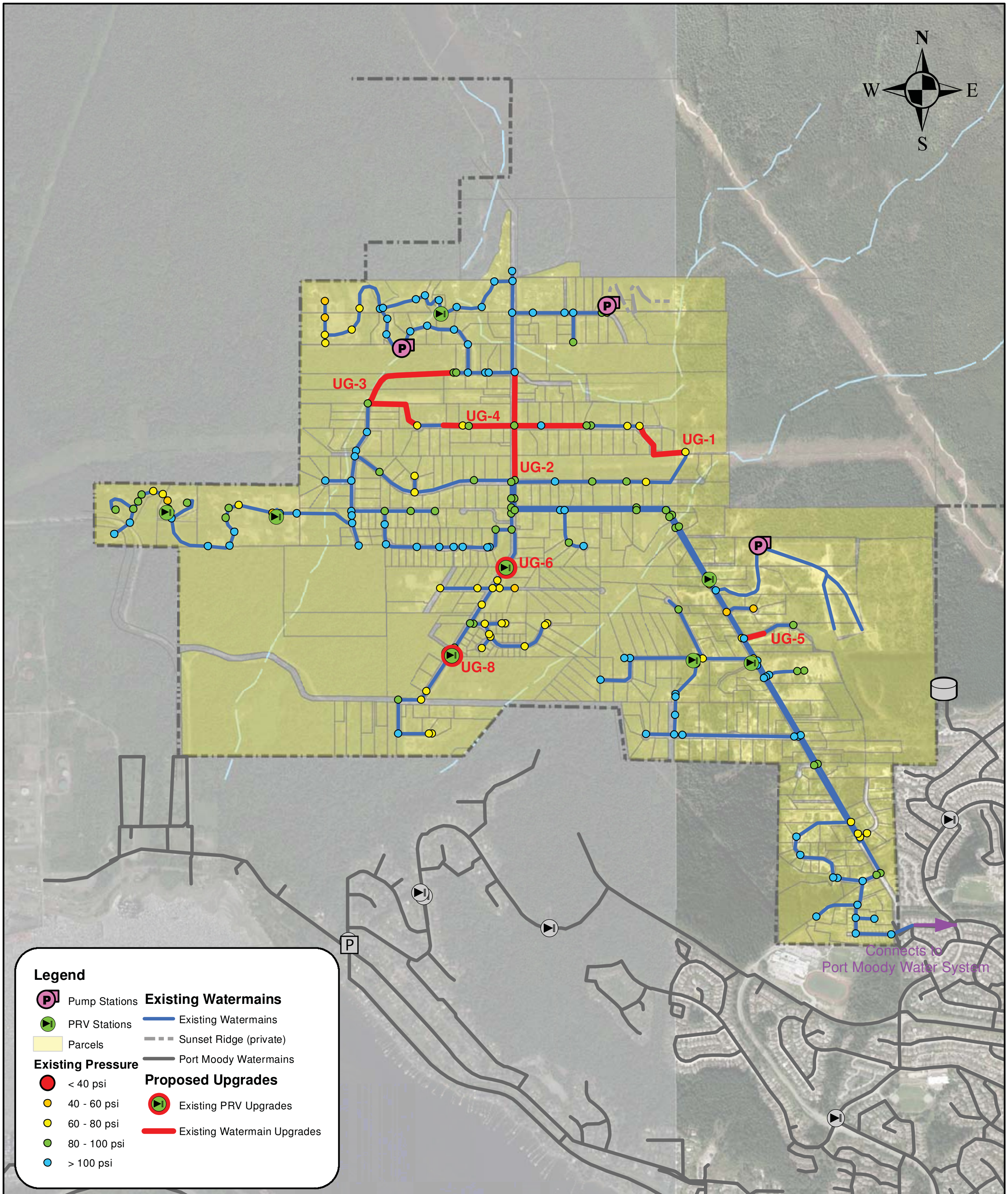
6.4.2 Distribution System Recommendations

The recommendations to overcome the deficiencies above are detailed below in Table 6-8 and are illustrated in Figures 6-5 through 6-8. One additional project (UG-6) was included to improve the reliability of the water system. UG-6 involves the replacement of the aging Elementary PRV station with a new PRV station which would have a lead and a lag valve for times of high and low flows, respectively. The new PRV station would be built adjacent to the existing Elementary PRV station, which would allow for continued service downstream until such time that the new PRV station is commissioned.

Table 6-8: Existing Distribution System Upgrade Recommendations

Item	Proposed Work	Deficiency Resolved
UG-1	The watermain along Spence Way should be looped to the watermain along Leggett Drive with a 200 mm diameter watermain, 688 m in length.	Fire Flows, Dead End System
UG-2	The 150 mm ø watermain along Sunnyside Road between Anmore Creek Way and Hemlock Drive should be replaced with a 250 mm diameter watermain.	Fire Flows
UG-3	The watermains along Anmore Creek Way and Sugar Mountain Way should be looped to the watermain terminating at the north end of Fern Drive using 200 mm diameter watermains, 662 m in total length.	Fire Flows, Dead End System
UG-4	The 150 mm ø watermain along Sugar Mountain Way/Spence Way crossing Sunnyside Road should be replaced with a 200 mm diameter watermain, 561 m in length.	Fire Flows
UG-5	The properties along Wyndham Crescent should be disconnected from the 247 m HGL pressure zone and reconnected to the 288 m HGL Pressure Zone via a tie-in to the 250 mm diameter watermain along East Road.	Fire Flows, Low Service Pressures
UG-6	The Elementary PRV Station is to be replaced with a new PRV station which would have a lead and a lag valve for times of high and low flow.	System Reliability
UG-7	The watermain along Chestnut Crescent should be looped to the watermain along Sunnyside Road via Eaglecrest Road with a 200 mm diameter watermain, 391 m in length.	Fire Flows, Dead End System
UG-8(1)	The lead and lag PRV setting at the Sunnyside PRV station should be increased by 14 psi, from 33 psi to 47 psi, and 25 to 39 psi, respectively.	Low Service Pressures

(2) Sunnyside PRV settings to be changed during annual maintenance, therefore this upgrade is not included in the Capital Upgrades Plan.



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Client: Village of ANMORE

Existing Pressures Peak Hour Demand With Upgrades

Project No:	D-85702.00
Designed:	ML
Drawn:	ML
Approved:	CL
Note:	
	Figure 6-5
Scale:	0 125 250 Meters; 1:40,000 @ Tabloid
Map No	1
Date	MAY 2015
Revision	
Revision Date	

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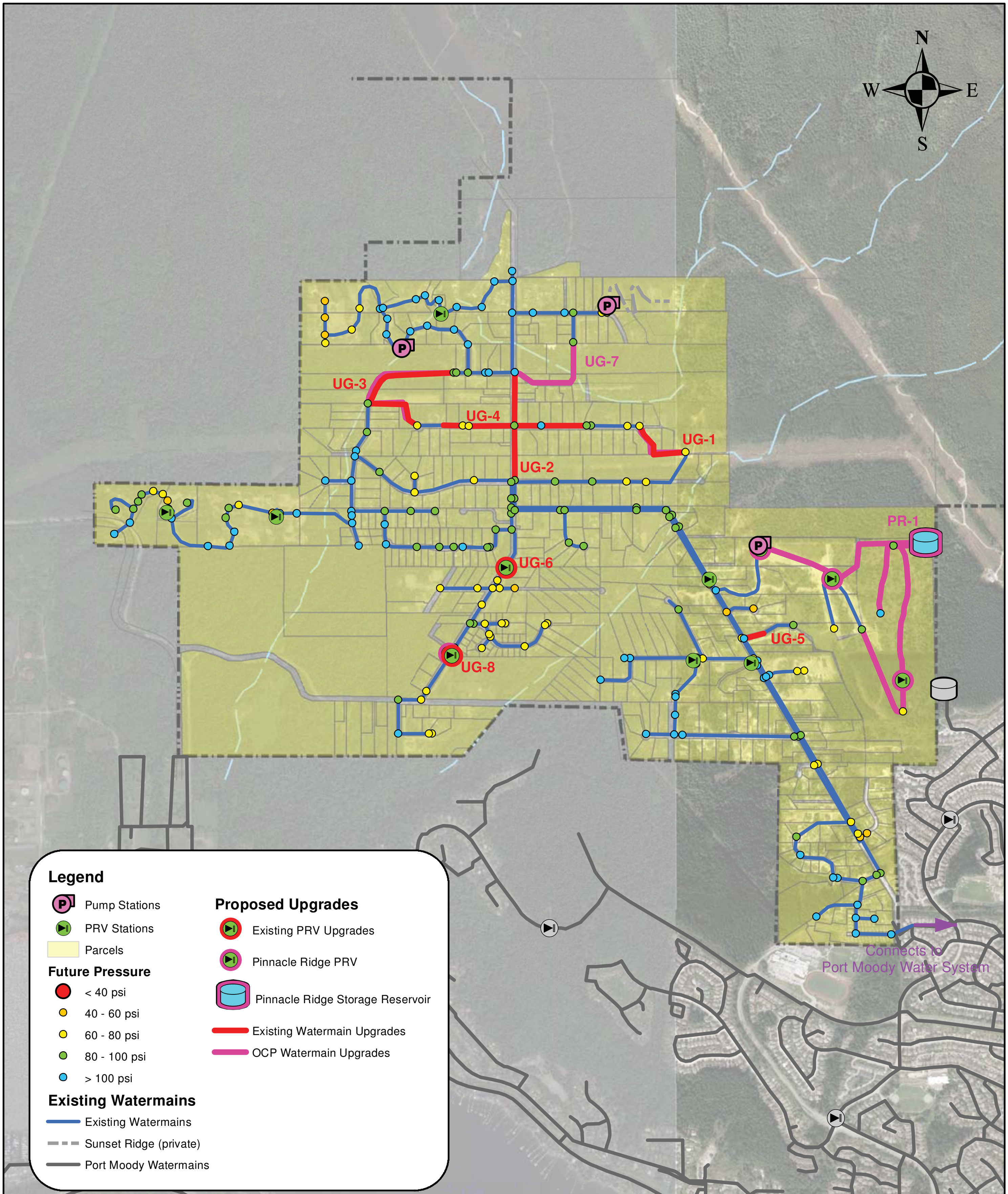

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Future Pressures Peak Hour Demand OCP Upgrades

Project No:	D-85702.00
Designed:	ML
Drawn: ML	Approved: CL
Note:	
Scale: 0 125 250 Meters	1:40,000 @ Tabloid
Map No 1	Date MAY 2015
Revision	Revision Date

Figure 6-6

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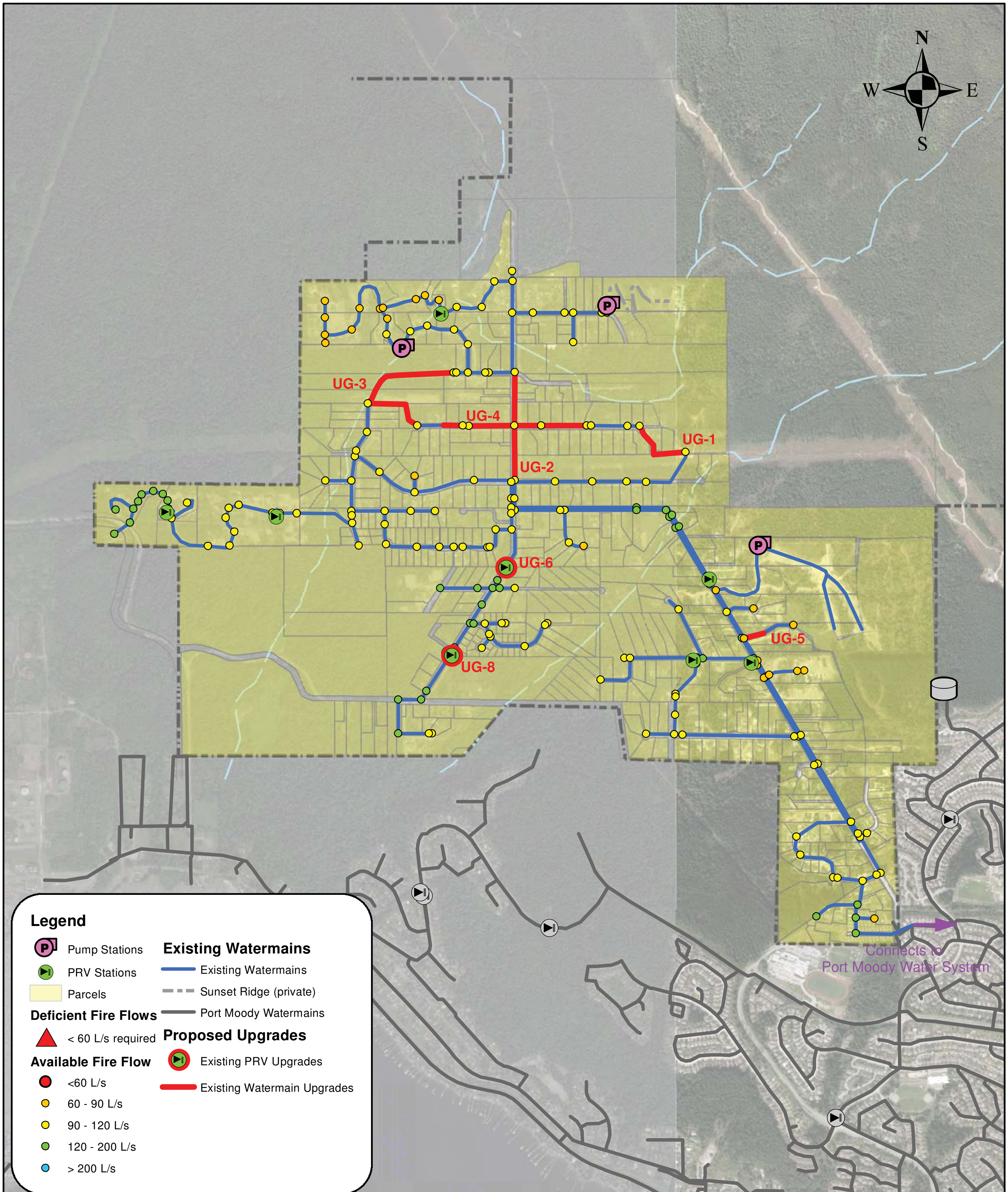

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Client: Village of ANMORE

Existing Fire Flow Maximum Day Demand With Upgrades

Project No:	D-85702.00
Designed:	ML
Drawn:	ML
Approved:	CL
Note:	
	Figure 6-7
Scale:	0 125 250 Meters
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Date	MAY 2015
Revision	
Revision Date	

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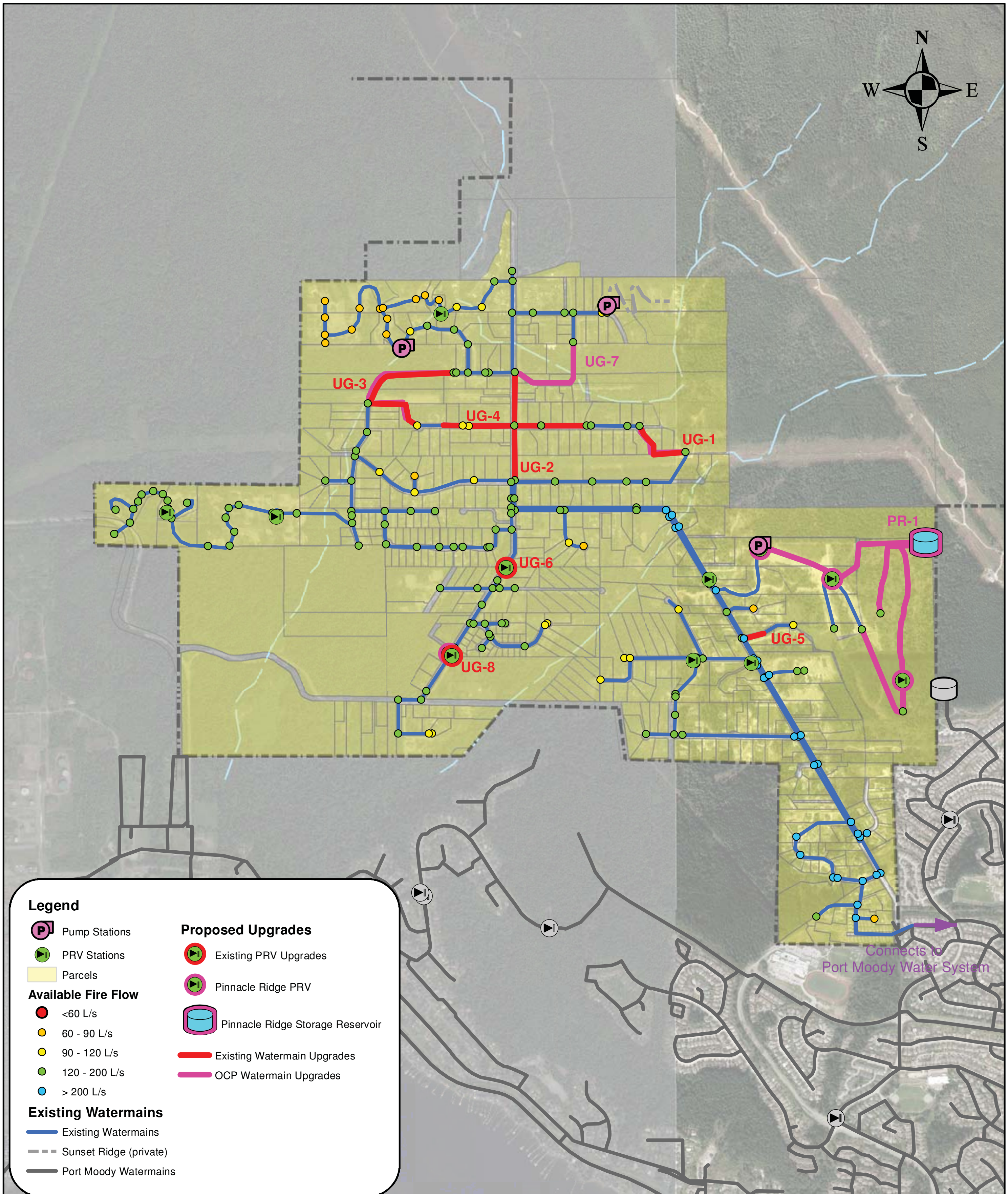

OPUS DAYTONKNIGHT

North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

Client: Village of ANMORE

Future Fire Flow Maximum Day Demand OCP Upgrades

Project No:	D-85702.00
Designed:	ML
Drawn: ML	Approved: CL
Note:	
Figure 6-8	
Scale: 0 125 250 Meters	1:40,000 @ Tabloid
Map No: 1	Date: MAY 2015
Revision	Revision Date

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6.5 Hydrant Coverage

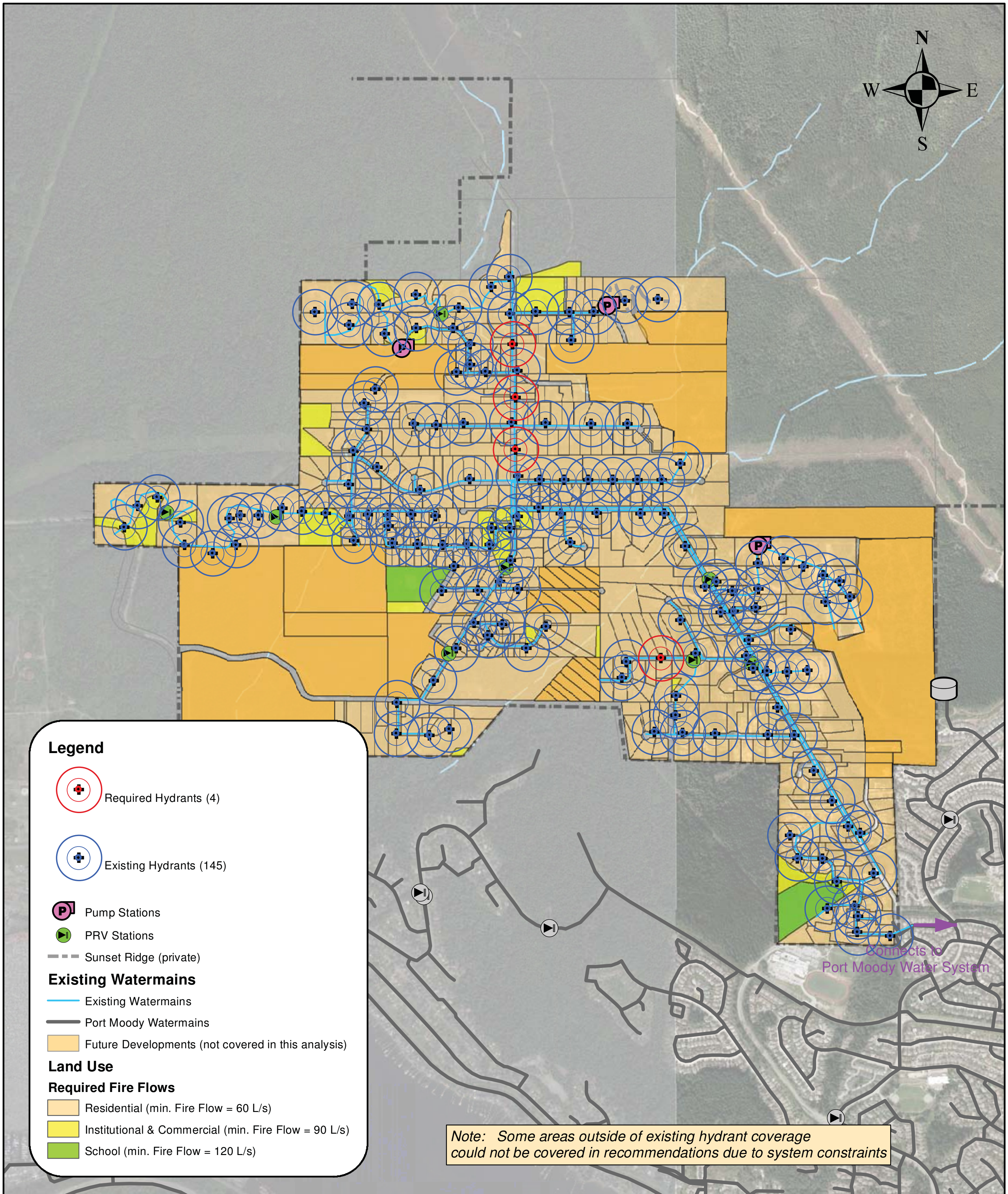
A mapping of Anmore's existing fire hydrants was carried out to determine the area of influence and coverage of existing hydrants. Based on available record data, Anmore currently operates 145 hydrants. Figure 6-9 illustrates the existing hydrant coverage mapping and identifies areas where coverage is deficient through recommended locations of new hydrants. Coverage for hydrants is illustrated in two circles as required for each hydrant, a smaller circle representing a 90 metres diameter coverage (which indicates the multi-family and ICI servicing distance), and a larger circle representing a 180 metres diameter coverage(which indicates the single-family residential servicing distance).

An analysis for future hydrant coverage requirements was not carried out for the purposes of this report. Future hydrant servicing requirements should be made on a case-by-case basis in the course of the construction approval processes for new developments as they occur in Anmore.

6.5.1 Recommendations

Anmore's Works and Services Bylaw No. 242-1998 should be revised to reflect the FUS 1999 'Water Supply for Public Fire Protection' guide, which recommends a maximum hydrant spacing of 180 metres in single-family residential areas and 90 metres in multi-family and institutional, commercial and industrial (ICI) areas.

In accordance with the FUS guidelines, there are an additional 4 fire hydrants recommended for Anmore's water distribution system, which are illustrated in Figure 6-9.



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Tel (604) 990 4800 Fax (604) 990 4805

Client: Village of ANMORE

Hydrant Coverage Analysis

Project No: D-85702.00		Scale: 0 125 250 Meters	
Designed: ML			
Drawn: ML	Approved: CL	1:40,000 @ Tabloid	
Note:		Map No 1	Date MAY 2015
Figure 6-9		Revision	Revision Date

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7 Capital Upgrades Plan and Costs

Section 6 has set out the recommended water system upgrades to address water system deficiencies under the existing and future OCP demand scenarios. The projects identified through our hydraulic analysis prioritize existing system deficiencies and critical system conveyance issues, with consideration for long term improvements which focus on addressing level of service deficiencies under future OCP conditions.

7.1 Cost Estimate Basis

Cost estimates provided in the Capital Upgrades Plan were prepared based on unit cost rates from recent construction projects within Anmore and Opus DK's cost database, adjusted to 2014 dollars. Table 7-1 summarizes the unit costs used to estimate the capital upgrades works. These unit costs do not include additional costs for desired right-of-ways for the watermain looping projects.

Table 7-1: Unit Rates for Budgeting

Asset	Size	Unit Cost ($)	Unit
Watermains	200 mm	500	Lin. m
	250 mm	600	Lin. m
PRV Stations	150 mm Lead PRV	53,000	L. Sum
Reservoir	All	700	Cubic m
Fire Hydrant	All	4,000	Each

In addition to the base costs derived from the unit rates above, allowances were made for 15% engineering fees and 15% for contingency.

For future adjustment, an Engineering News Record (ENR) Construction Cost Index of 9,806 (2014 average) is recommended to account for inflation and increased labour and construction costs over time.

The ENR indexes measure how much it costs to purchase a package of goods compared to what it was in the base year. For Anmore, Opus DK recommends using the ENR's Construction Cost Index (CCI) as this index is typically used to estimate costs for jobs where labour costs are a high proportion of total costs. Comparatively, ENR's Building Cost Index (BCI) provides estimates which are more applicable for structures (ie. commercial buildings and private dwellings). Anmore staff should note that the ENR costs merely offer a snapshot of general cost trends, though they do allow for a rough estimation of project costs as they occur in the future.

7.2 Capital Upgrades Plan

The improvement projects for Anmore's water system identified in Section 6 (including recommendations on storage, pump stations, distribution mains and fire hydrants) form the basis of the Capital Upgrades Plan summarized in Table 7-2.

Table 7-2 Capital Upgrades Plan

Village of Anmore - Water Utility Master Plan

Engineering and Contingency (%) 30%

ID	Description	System Requirement Addressed	Infrastructure Upgrade	Capital Investment	Developer Funded	Quantity	Unit	Unit Costs [2]	Cost ($)	Cost + E&C ($) (2014 dollars)	Cost Allocation (%)[1]		Cost Allocation ($) (2014 dollars)		Year	2016	2017	2018	2019	2020	Subtotal
											Village of Anmore	DCC/Developers	Village of Anmore	DCC/Developers							
UG-1	Install a 200 mm watermain to connect Spence Way to Legget Drive	Fire Flows, Dead End System		●		256	Lin. m	$ 500	$ 128,000	$ 166,400	67.33%	32.67%	$ 112,037	$ 54,363	2017-2016		$ 124,800	$ 41,600			**$ 166,400**
H-1	Install four new fire hydrants	Hydrant Coverage		●		4	each	$ 4,000	$ 16,000	$ 20,800	67.33%	32.67%	$ 14,005	$ 6,795	2016	$ 20,800					**$ 20,800**
UG-2	Upsize 150 mm watermain along Sunnyside Road between Anmore Creek Way and Hemlock Drive to 250 mm	Fire Flows	●			422	Lin. m	$ 600	$ 253,200	$ 329,160	67.33%	32.67%	$ 221,623	$ 107,537	2017		$ 329,160				**$ 329,160**
PR-1[3]	Construct the 1.06 ML Pinnacle Ridge Storage Reservoir	Storage			●	1060	Cubic m	$ 700	$ 742,000	$ 964,600	0.00%	100.00%	$ -	$ 964,600	2018-2019			$ 144,690	$ 819,910		**$ 964,600**
UG-3	Install a 200 mm watermain to connect watermains along Anmore Creek Way, Fern Drive, and Sugar Mountain Way	Fire Flows, Dead End System		●		662	Lin. m	$ 500	$ 331,000	$ 430,300	67.33%	32.67%	$ 289,721	$ 140,579	2019				$ 430,300		**$ 430,300**
UG-4	Upsize 150 mm watermain along Sugar Mountain Way/ Spence Way, crossing Sunnyside Road, to 200 mm	Fire Flows	●			561	Lin. m	$ 500	$ 280,500	$ 364,650	67.33%	32.67%	$ 245,519	$ 119,131	2017		$ 364,650				**$ 364,650**
UG-5	Reconnect properties along Wyndham Crescent to 288 m Pressure Zone via a tie-in to the 250 mm watermain along East Road	Fire Flows, Low Service Pressures	●			215	Lin. m	$ 500	$ 107,500	$ 139,750	67.33%	32.67%	$ 94,094	$ 45,656	2019				$ 139,750		**$ 139,750**
UG-6	Replace the Elementary PRV Station with a new PRV station with a lead and lag valve	System Reliability		●		1	each	$ 53,000	$ 53,000	$ 68,900	67.33%	32.67%	$ 46,390	$ 22,510	2020					$ 68,900	**$ 68,900**
UG-7[4]	Install a 200 mm watermain to connect Chestnut Crescent to Eaglecrest Road	Fire Flows, Dead End System			●	391	Lin. m	$ 500	$ 195,500	$ 254,150	0.00%	100.00%	$ -	$ 254,150	2017		$ 254,150				**$ 254,150**
															Village of Anmore Infrastructure Upgrades	$ -	$ 467,142	$ -	$ 94,094	$ -	**$ 561,236**
															Village of Anmore Capital Investments	$ 14,005	$ 84,028	$ 28,009	$ 289,721	$ 46,390	**$ 462,153**
															DCC funded Capital Upgrades & Investments	$ 6,795	$ 267,440	$ 13,591	$ 186,235	$ 22,510	**$ 496,571**
															Developer Funded	$ -	$ 254,150	$ 144,690	$ 819,910	$ -	**$ 1,218,750**
															Subtotal	**$ 20,800**	**$ 1,072,760**	**$ 186,290**	**$ 1,389,960**	**$ 68,900**	**$ 2,738,710**

Notes:

(1) According to best practices, Cost Allocation includes a minimum 1% Assist Factor for DCC funded projects which is the contribution to the DCC cost that the existing municipality is recommended provide.

(2)Watermain installations do not include desired right-of-ways

(3) Current Capital Upgrades Plan assumes that the Pinnacle Ridge Development will fully fund the construction of the reservoir.

(4) Current Capital Upgrades Plan assumes that the Development will fully fund the construction of the watermain

8 Long-Term Financial Plan

Anmore's water distribution system in comparison to other municipalities in British Columbia is relatively new with the majority of infrastructure installed over the past decade. Unlike municipalities with aging water distribution systems and associated infrastructure backlogs, Anmore has the opportunity to financially plan the long-term operation, maintenance, and renewal of its potable water infrastructure. In other words, Anmore is in a position from which to plan for the long-term financial sustainability of the water utility.

> ***Financial sustainability*** *means having adequate funds to pay for the current cost of operating and maintaining our water and wastewater systems, and proactively planning to ensure there will be funds to eventually replace systems as they age and come to the end of their useful life. Financial sustainability is a key principle for safeguarding water, sewer, and storm water system so that they continue to protect public health and the environment, and contribute to economic development.*
>
> *Are our Water Systems at Risk?*
> *Assessing the Financial Sustainability of BC's Municipal Water and Sewer Systems*
> *BC Water & Waste Association, February 2015*

8.1 Asset Management and Financial Plan Best Practices

Achieving financial sustainability of a water utility takes time and requires well established asset management practices that are integrated with long-term financial plans. The financial recommendations included in this report were made to help put Anmore on the path towards sustainable water rates and charges. They should allow for Anmore staff to appropriately budget for and fund the ongoing costs of operating, maintaining, renewing, and growing its water utility.

Some of the preliminary steps of asset management planning outlined in the InfraGuide document "Managing Infrastructure Assets" were taken by the project team on behalf of Anmore. These formed the basis of the recommended long-term financial plan. The preliminary steps taken and the recommended next steps that will assist Anmore in improving their asset management planning practices are outlined in Table 8-1: Managing Infrastructure Assets.

Table 8-1: Managing Infrastructure Assets

Asset Management Component Requirements[1]	Preliminary Steps	Next Steps
Asset Value	• An asset inventory of the water distribution system assets was developed. The facilities were broken down into mechanical, electrical, and structural components. • Asset installation dates, estimated replacement costs, and expected service lives were used to forecast when the renewal costs of the water distribution system components would occur. • Operational levels of service were reviewed and recommendations were put forth to improve the management of the water distribution system.	• Inventory the components of facilities to a greater level of detail and capture the attribute data through ongoing operational practices.
Life-Cycle Management		
Sustainability		
Integration of Technical and Financial Plans	• The financial plan was developed from the costs associated with the recommendations for operational levels of service review, the renewal schedule derived from the asset inventory, and the Capital Upgrades Plan.	• Revisions to replacement costs and operational levels of service should be completed once a year through the budgeting process.
Risk Assessment	• A risk assessment of the network was not completed as part of this Water Utility Master Plan. • Elements of risk management were captured in the operational levels of service review.	• Operational levels of service should be revised as the condition of the assets changes over time, the network expands, and customer expectations change.
Performance Measurement	• Hydraulic analyses of the existing system and forecasted future system demands were conducted to identify areas of the network that do not meet performance threshold. • Recommended capital projects were put forward to improve network performance according to fire flow and pressure indicators.	• Verification of the network performance through a subsequent Water Master Plan.
High-Level and Detailed Plans	• An asset management plan was not documented as part of this Water Utility Master Plan though a preliminary analysis was completed as part of the financial analysis. It is based on service life assumptions and assumptions on the cost breakdown of facility components.	• Future revisions to the financial analysis, should include a breakdown of the facility components and revisions to service lives according to the condition of assets.

1. https://www.fcm.ca/Documents/reports/Infraguide/Managing_Infrastructure_Assets_EN.pdf

The Government Finance Officers Association which represents public finance officials throughout Canada has developed best practices for the elements of a long-term financial plan. These best practices and how the recommended long-term financial plan meets them are outlined in Table 8-2: Long-Term Financial Plan Best Practices.

Table 8-2: Long-Term Financial Plan Best Practices

	Best Practice[1]	Financial Plan
Time Horizon	A plan should look at least five to ten years into the future.	The Capital Upgrade Plan accounts for growth projected in the OCP and addresses existing and future deficiencies in the water distribution system. Operational, maintenance, and inspection (OMI) programs were recommended to improve the monitoring and maintenance of the physical sate of the water utility infrastructure. The recommended programs were scheduled to commence in 2016 when funds were assumed to become available. The financial plan forecasts expenses through to the year 2112 to account for complete system renewal – a ductile iron water main installed in 2013 has an expected service life of 100 years.
Scope	A plan should consider all appropriated funds, but especially those funds that are used to account for the issues of top concern to elected officials and the community.	The plan forecasts revenues from the existing funding model as well as the use of capital and operating reserves.
Frequency	Governments should update long-term planning activities as needed in order to provide direction to the budget process, though not every element of the long-range plan must be repeated.	It is recommended that on an annual basis the financial plan be reviewed, expenditures forecasts be updated, and inflation estimates be revised. The funding model should then be reviewed in light of the revised financial plans.
Content	A plan should include an analysis of the financial environment, revenue and expenditure forecasts, debt position and affordability analysis, strategies for achieving and maintaining financial balance, and plan monitoring mechanisms, such as scorecard of key indicators of financial health.	The plan includes forecasts of all expenditures related to the water utility, reserve balances are tracked on an annual basis, reserve balance targets are achieved by the end of time horizon, and liability servicing costs are calculated on an annual basis. The 'Indicators of Financial Sustainability' recently released by the BC Water & Waste Association were used to assess the forecasted financial health of the Anmore Water Utility.
Visibility	The public and elected officials should be able to easily learn about the long-term financial prospects of the government and strategies for financial balance. Hence, governments should devise an effective means for communicating this information, through either separate plan documents or by integrating it with existing communication devices.	A financial model was developed for the purposes of communicating the financial plan to various stakeholders. The financial model combines the complexities of the financial and engineering disciplines and is able to illustrate the short and long term implications of various decisions.

1. http://www.gfoa.org/long-term-financial-planning-0

8.2 Financial Planning

A long-term financial plan should be considered a living document which should be revised in light of changing environmental, economic, and social conditions.

Forecasting costs and the development of a long-term financial plan for the water utility is an iterative process whereby the results of the analysis based on today's assumptions provide the feedback which influences the decisions on the timing of capital and rehabilitation projects, service levels, and the funding model. To develop the long-term financial plan, a financial model specific to Anmore's water utility was created. The financial model forecasts costs and revenues based on today's assumptions, translates the modelling results into a financial plan, and is able to communicate the financial planning process to various stakeholders through illustrative graphs.

The financial model calculates the revenues required to fund:

- Water supply costs from the City;
- Levels of Service – Operations, Maintenance, and Inspections (OMI) programs;
- Water utility administration
- Rehabilitation and replacement of existing infrastructure;
- Capital Upgrades Plan;
- Long-term borrowing costs; and
- Reserve contributions.

The forecasted revenues and expenses of the water utility are checked against the indicators of financial sustainability outlined Table 8-3. The 'Optional Long-Term Targets' were referenced from literature and it is recommended that Anmore develop their own long-term targets for each of the indicators.

Table 8-3: Indicators of Financial Sustainability

	Description of Indicator	Optional Long-Term Target
Operating Surplus Ratio	The **Operating Surplus Ratio** indicates whether revenues recover the full costs to operate and sustain the system, including renewal and replacement of existing infrastructure.[1] • A positive ratio indicates the percentage of total revenues available to fund proposed capital expenditures.[2] • A negative ratio indicates the percentage increase in total revenues that would have been required to achieve a break-even operating result.[2] **Note:** A positive Operating Surplus Ratio must correspond with revenues and expenses that achieve full-cost recovery.	0% to 15%[1,2]

	Description of Indicator	Optional Long-Term Target
Reserves to Operating Expense Ratio	The **Reserves to Operating Expense Ratio** indicates the short-term resilience to unexpected changes in revenues or costs.[1] • A reserve to operating expense ratio of 12.5% or greater means that the reserve savings are considered to be adequate to buffer against unexpected changes in revenues or operating costs from year to year.[1] • A reserve to operating expense ratio below 12.5% indicates that a community may be vulnerable to unexpected revenue shortfalls or unanticipated expenses, and as a result may have difficulty delivering the expected level of service or recovering from change when an unexpected event occurs.[1]	Greater than 12.5%[1]
Liability Servicing Cost	The Liability Servicing Cost indicates the ability of a municipality to pay for past transactions and events. The maximum value is 25% of a municipalities controllable and sustainable revenues from the previous year.[3] **Note:** For a self-funded water utility it can be argued that the same maximum should apply.	Maximum 25%[3]

1. Are our Water Systems at Risk? Assessing the Financial Sustainability of BC's Municipal Water and Sewer Systems, BC Water & Waste Association, February 2015. https://www.bcwwa.org/resourcelibrary/Are%20Our%20Water%20Systems%20at%20Risk%20-%20Full%20Report.pdf
2. LGA 'Financial Sustainability' Information Paper No.9: Financial Indicators, LGA of South Australia, 2012.
3. British Columbia *Community Charter* – Liability Servicing Limits.

8.2.1 General Assumptions

General assumptions regarding the serviced population, water demand, inflation, engineering design and contingency costs were made in the development of the long-term financial plan. Some of the financial risks associated with these assumptions were highlighted and scenarios of long-term revenue projections were provided to illustrate the potential risks to revenues.

8.2.1.1 Financial Modelling Period

The year 2014 was selected as the base year from which to forecast future costs.

Expenses and revenues were forecasted to the end of 2032 to be consistent with the planning period of the 2014 Official Community Plan (OCP). Expenses were also forecasted to the end of 2112 to illustrate the long-term rehabilitation and replacement costs for complete renewal of the water utility infrastructure as it relates to services lives that go well beyond 2032.

8.2.1.2 Serviced Population

Anmore's 2014 OCP provided low, medium, and high population growth rates. For the purposes of modelling the future hydraulic demands of the water distribution system a medium growth rate was considered conservative. This ensures that if the medium growth rate is achieved Anmore would have adequately planned for meeting future water demands. However, the projection of future revenues were considered to be conservative if based on a lower than expected serviced population growth rate. An under-estimation of growth was logical for the purposes of planning for financial sustainability in light of the investments required to provide expected levels of service, improve fire flows and service pressures, and contribute to planned capacity upgrades.

As estimated in Section 3.1.1, a population of 2,078 was serviced by Anmore's water distribution system in 2014 with an additional 194 residents serviced by private wells. Anmore's 2014 OCP forecasted that in the low growth scenario an average annual growth rate of 1.6% per year would result in an additional 924 people by 2032. For the purposes of the long-term financial plan, it was further assumed that all new residents, as well as half of the existing residents serviced by private wells, will be serviced by Anmore's water distribution system for a total serviced population of 3,100 people in 2032. The equivalent average annual serviced population growth rate was therefore assumed to be about 2.25% per year.

A financial implication to note here is that an average annual serviced population growth rate of 2.25% per year is aggressive as the average annual growth rates in the low and medium scenarios of the OCP were only 1.6% and 2.2% per year, respectively. To illustrate the financial risk associated with population projections, a scenario was analysed in which the average annual serviced population growth rate was limited to 1.6% per year while maintaining the same Capital Upgrades Plan and the recommended OMI programs - see Alternative 1 in Section 8.2.9.2.

8.2.1.3 Water Demand

According to Anmore's water utility billing records, the total metered water consumption in 2014 was 240,048 m^3 which equates to about 316 l/c/d. However, in 2014 the City charged Anmore for the use of approximately 278,109 m^3 (estimated from a total charge of $279,055 at a rate of $1.0034 per m^3) or equivalently 366 l/c/d. For the purposes of modelling the future water demands of Anmore, an average per capita demand of 366 litres per day with an assumed leakage rate of about 13.5% was chosen (ratio of the total metered water consumption and the amount of water supplied by the City), with a portion of the volume of water unaccounted for due to hydrant flushing.

The amount of water supplied by the City was based on a water supply meter that is thought to have a reduced accuracy and is scheduled to be replaced in 2015. Therefore, leakage rate and amount paid to the City in future years may change.

A financial implication to note here is that the total metered water consumption is the primary source from which Anmore recovers the revenues required to operate and maintain the utility. Therefore, a decrease in the total metered water consumption directly results in a decrease in revenues recovered. A decrease in water consumption could be due to, for example, changes in water use practices, weather, or as a consequence of higher volumetric water rates. To illustrate the financial risk, a scenario was analysed in which water consumption is reduced by 5% (~10 l/c/d) each year until the average per capita demand reaches 300 l/c/d (equivalent to net water demand of 260 l/c/d if the leakage rate remains at 13.5%) - see Alternative 2 in Section 8.2.9.2.

8.2.1.4 Inflation

Increased costs due to inflation are an important yet unpredictable variable in long-term financial plans. To provide an order-of-magnitude estimate of future costs due to inflation all costs were inflated from 2014 dollars based on the assumed inflation rates listed in Table 8-4.

Table 8-4: Inflation Rates

Cost	Inflation Rate (per year)	Rationale
Infrastructure	3%	Based on a review of the Engineering News Record Historical Construction Cost Index. The average annual increase over the past 5 years was close to 2.75% and the January 2014 to January 2015 increase was 3.19%. A forecast of 3% was therefore considered to be a reasonable estimate that is sufficiently conservative for financial planning.
Operations	1.5%	Based on a review of the historical Vancouver Consumer Price Index. The average annual increase over the past 5 years was 1.34% with a minimum of 0.2% in 2013 and a maximum of 2.3% in 2011. A forecast of 1.5% was therefore considered to be a reasonable estimate that is sufficiently conservative for financial planning.
Water Supply Costs	$0.05	See Section 8.2.2.

8.2.1.5 Engineering Design and Contingency

The rehabilitation and replacement cost estimates were increased by 30% to account for engineering design and contingencies.

8.2.2 Water Supply Costs from the City

As per the 1998 Anmore Water Supply Agreement, the City provides potable water to Anmore. The volumetric charge for water supplied by the City to Anmore is the total of:

- The unit rate for City water, as established by the City bylaw from year to year; and,
- The estimated direct power cost to the City for the relevant year of pumping water to Anmore under this Agreement which shall be the Power Usage multiplied by the B.C. Hydro rate.

Therefore, Anmore's volumetric charge is dependent on the volumetric rate charged by the City which is, in turn, dependent on rates set by Metro Vancouver and B.C. Hydro. The historical rate increases from the City were used to estimate future increases.

Table 8-5: City of Port Moody Volumetric Charge

City of Port Moody	2011	2012	2013	2014	2015
Water Rate ($/m³) *($/100ft³)*	$0.7734 *$2.19*	$0.7946 *$2.25*	$0.7946 *$2.25*	$0.8334 *$2.36*	$0.8652 *$2.45*
Direct Power Cost ($/m³)	$0.15*	$0.16*	$0.16	$0.17	$0.18*
Total Volumetric Charge	**$0.9234**	**$0.9546**	**$0.9546**	**$1.0034**	**$1.0452**
Annual Increase		**$0.0312**	**$0**	**$0.0488**	**$0.0418**

*Estimate of the Direct Power Cost for illustrative purposes.

Based on the historical increases in volumetric rates from the City, it was assumed that the Total Volumetric Charge would increase by $0.05 per year after 2015. While this assumption may be an over-estimate, it is prudent to be conservative because of the number of variables contributing to the

Total Volumetric Charge for water; namely, Metro Vancouver bulk water rates, B.C. Hydro rates, and the City's water utility costs.

Our high-level review of the unit rates charged by the City to Anmore indicate that they are based on the City's standard rates to residents and City ICI users, and that these rates could include costs not associated with delivering water directly from the GVWD system to Anmore. While it is not within the scope of our assignment to critically review the terms and application of this agreement, we comment as follows:

- The \$0.8334/m^3 unit rate being used by the City as the basis for charging Anmore is the rate established under City of Port Moody Fees Bylaw No. 2971 of 2013. This bylaw is applicable to residents and ICI users living within the City and will likely include costs for operating, administrating, supplying water, and ultimately the capital replacement of the entire City's water system. Operating costs would include for the cost of pumping water throughout the distribution system.

- Anmore is being charged for pumping power costs of \$0.17/m^3 which is in addition to the \$0.8334/m^3 unit rate.

- It could be argued, that Anmore, as a member of the GVWD should only be paying for the direct costs of supplying water from the GVWD trunk main to the Anmore boundary, and that this could likely include:
  - The GVWD cost of water supplied to Anmore (currently approximately \$0.57/m^3 - \$0.72/m^3, depending on the season);
  - Proportion of operating and maintaining the infrastructure used to convey water from GVWD to Anmore. The proportioning of cost should be related to the proportion of water conveyed in the infrastructure that is used by Anmore versus the City. Infrastructure associated with supplying Anmore's water would mostly include portions of: the 800 m long 300 mm diameter supply pipe; storage; and the pumping facility;
  - Proportion of capital replacement similar to that of proportioning the operating and maintenance costs; and,
  - An administration cost for the City related to supply water to Anmore.

The cost of water supply is a significant component of Anmore's overall water costs, and we suggest the 1998 agreement be reviewed to ensure the fairness embodied in its intent, is being implemented. Note that the agreement makes provision for its review every 5 years.

Note that these comments are being made at a relatively high level, and there may well be issues with which we are unaware, that have been accounted for in the application of the current unit rate.

8.2.3 Levels of Service –Operations, Maintenance, and Inspections

As part of the 2015 Water Utility Master Plan, Anmore requested a review of the existing service levels to determine an appropriate funding model to support current and long-term operating needs. One of the goals of asset management is to ensure delivery of the service level agreed to, and paid for, by customers at the lowest life cycle cost. A key element in achieving this goal is to ensure assets meet their expected service lives through asset care measures. Another key element is to monitor asset condition and asset performance to intervene at the optimum point in its service life to either upgrade, repair, or replace the asset or its components. Maintenance and monitoring must be completed with sufficient regularity that mitigates the risk of not delivering the level of service agreed to. The question is: what do we do, what do we measure, and how often do we do this?

Local governments most often build their operating budgets based on the previous year's expenditures. This approach reinforces the political and public expectation that budgets should remain static, yet, this is not a true reflection of the variance in the financial investments that governments like Anmore require to maintain infrastructure over time.

The legitimacy of Anmore's sought after long-term financial plan is reliant on well-defined Operations, Maintenance, and Inspection (OMI) programs and appropriate service levels for each. Opus DK provided recommendations in Technical Memorandum #4: OMI Program Plan & Condition Rating System regarding the scope of current operational practice/procedures and technical service levels. These recommendations were captured in an annual OMI program plan which was built to also reflect the changes to the asset inventory that will stem from the Capital Upgrades Plan. Table 8-6 provides a breakdown of the recommended annual OMI costs for each asset class identified in the detailed lifecycle review.

Table 8-6: OMI Program Financial Analysis

Asset Class	Approximate Annual OMI Cost (2014 Dollars)
Water Sampling Stations	$11,527
Rechlorination Station	$24,869
Pump Stations	$23,297
Distribution Mains	$67,120
Service Connections	$3,719
Meters	$10,058
Hydrants[1]	$14,126
PRV Stations[2]	$33,581
Valves (Mainline)	$1,332
Air Valve	$2,603
Reservoirs[3]	$5,789

Asset Class	Approximate Annual OMI Cost (2014 Dollars)
Repairs/Corrective Maintenance	$7,238
Other OMI Expenses	$68,910
TOTAL	**$274,169**

1. Average of Hydrant Level A and B Servicing which alternate every other year.
2. Assumed to increase to $64,030 in 2020 due to additional PRV's in the Pinnacle Ridge Development
3. Starts in the year 2020 when the new Pinnacle Ridge Reservoir is constructed

The scope of each program, the requirement, and the benefits of the existing program were reviewed and documented by Opus DK. Program shortcomings were also identified. Opus DK included the following during the OMI program development:

- Regulatory requirements are being met in the program base
- Operational practices promote the service life of assets
- OMI related standards, policies, and bylaws are reviewed
- Operational practices promote a safe potable water supply and maintain water quality
- The program base encompasses elements of industry standards appropriate for Anmore

Through discussions with Anmore staff, Opus DK brought forward high level recommendations for alternative approaches to existing programs or new programs. The scope of work involved in each program's typical work order is the basis for the operating funding needs analysis.

8.2.4 Water Utility Administration

A portion of revenues generated through water rates and charges should be allocated to the general administration of the water utility.

The National Water & Wastewater Benchmarking Initiative 2013 Public Report summarized data from 50 water utilities and included the median total operating costs based on the length of the water distribution system. The Indirect Charge-back (ie. the water utility administration charge) was calculated from the data reported in the report as summarized in Table 8-7.

Table 8-7: Water Utility Administration (Actual Indirect Charge-Back) Expenses ('000) / km length

Year	Total Operating Cost with Actual Indirect Charge-back[1]	O&M Cost[1]	Indirect Charge-back
2007	7.1	6.3	0.8
2008	7.8	7.0	0.8
2009	8.6	7.5	1.1
2010	8.1	7.5	0.6
2011	8.9	7.7	1.2
		AVERAGE	0.9

1. http://nationalbenchmarking.ca/public/docs/Public_Report_2013.pdf

The average actual indirect charge-back was estimated to $900 per km length of the water distribution system. Anmore's water distribution system is approximately 20 km long and therefore the indirect charge back was estimated at $18,000 per year.

The 2015-2019 Financial Plan includes $10,188 for Audit/Accounting and Administration Costs in 2015. When compared to the estimated average actual indirect charge-back of $18,000 it appears that Anmore could only be budgeting for a portion of the potential costs associated with administration of the water utility. It is recommended that Anmore staff review the actual costs of water utility administration such as the time required of the Manager of Public Works and other miscellaneous costs. These costs should be appropriately charged to the water utility such that the administrative costs of the water utility are funded through User Fees and not general taxation.

8.2.5 Rehabilitation and Replacement of Existing Infrastructure

The long-term forecast of rehabilitation and replacement of existing infrastructure is dependent on both the assumed service lives and the estimated rehabilitation and replacement costs.

8.2.5.1 Expected Service Life

An asset's expected service life depends on both its physical condition (which is influenced by local environmental conditions – pressure, water quality, soil characteristics, etc.) and its hydraulic capacity (which may no longer be sufficient to meet demands).

The hydraulic analysis of existing and future conditions (until 2032) allows for existing assets to be upgraded due to limited hydraulic capacity or service levels; these were included in the Capital Upgrades Plan.

The physical condition of Anmore's assets will not be known until a condition assessment framework and condition rating system is implemented. The condition rating system will ultimately be used by Anmore to refine their capital reinvestment planning and to maintain levels of service. In lieu of physical condition assessments, expected service lives were used to estimate the rehabilitation and replacement dates. While it is understood that the actual service life of an asset will differ from the expected service life, it provides a basis from which to estimate when rehabilitation and replacement costs will occur over the long term. Table 8-8 lists the expected service lives of the assets of Anmore's water distribution system.

Anmore's water distribution system is made up of various assets and some assets will need to be replaced more than once during another assets life. For example, the components of the Uplands Pump Station include the pumps, generator, electrical system, building structure, and monitoring equipment and it is reasonable to expect that the pumps and monitoring equipment will need to be replaced before the building is replaced. As such, the actual expected rehabilitation or replacement date of an asset should be based on hydraulic and physical condition assessments (deterministic or probabilistic) which are completed as part of established asset management practices.

Table 8-8: Expected Service Life of Components of Anmore's Water Distribution System

Asset	Subcomponent/ Material	Expected Service Life (years)
Watermains	Ductile Iron	100
	PVC	80
Service Connections[1]		-
PRVs		25
Blow-off Valves		40
System Valves		40
Hydrants[2]		40
Water Meters		15
Reservoir[3]		50
Pump Stations	Civil	50
	Mechanical	30
	Electrical	20
	Instrumentation/Controls	20
Re-Chlorination Station	Civil	50
	Mechanical	30
	Chlorine Dosing and Booster Pumps	20
	Electrical	20

1. Service connections were assumed to be replaced when the watermain was replaced
2. Hydrants were assumed to be replaced at 5 hydrants per year starting in 2030.
3. A reservoir is included in the Capital Upgrade Plan for the Pinnacle Ridge Development.

8.2.5.2 Rehabilitation and Replacement Costs

Anmore's Tangible Capital Asset (TCA) Inventory was referenced to estimate rehabilitation and replacement costs of the majority of the water distribution system assets. The asset original construction costs (initial values) were inflated to 2014 dollars using the ENR CCI.

Table 8-9: Estimated Replacement Costs of PRV Stations and Valves

Asset	Installation Year	Initial Cost	Estimated Replacement Cost (2014 Dollars)
PRV Station			
Countryside	2010	$ 47,700	$ 51,029
Elementary	2002	$ 39,687	$ 59,524[1]
Lower Crystal Creek	2009	$ 45,000	$ 51,490
Upper Crystal Creek	2009	$ 45,000	$ 51,490
Lower Pinnacle	2012	$ 40,000	$ 42,140
Sunnyside	2009	$ 45,000	$ 51,490
Thomson Lancaster	2010	$ 47,700	$ 53,141
Thomson East	1998	$ 36,704	$ 60,797
Blow-off Valves			
Fern Drive	2012	$ 600	$632
Kinsey Drive	2012	$ 1,500	$1,580
Leggett Drive	2013	$ 1,700	$1,746
North Charlotte Road	2012	$ 1,500	$1,580
Ridge Mountain Drive	2012	$ 3,000	$3,161
System Valves			
East Elementary 2	2013	$ 640	$ 657
East Road	2012	$ 4,250	$ 4,477
Kinsey Drive	2012	$ 8,600	$ 9,060
Leggett Drive 2	2013	$ 14,500	$ 14,893
North Charlotte Road	2012	$ 3,450	$ 3,635
Ridge Mountain Drive	2012	$ 15,900	$ 16,751

1. Replacement cost based on Capital Upgrade Plan

Table 8-10: Estimated Replacement Costs of Pumping and Chlorination Stations

Asset	Installation Year	Initial Cost	% of Total Cost[1]	Replacement Cost (2014 Dollars)
Pinnacle Ridge Pump Station				
Civil	2012	$761,000	40%	$320,686
Mechanical			30%	$240,515
Electrical			25%	$200,429
Instrumentation/Controls			5%	$40,086
Uplands Pumping Station				
Civil	2010	$350,000	40%	$155,969
Mechanical			30%	$116,977
Electrical			25%	$97,481
Instrumentation/Controls			5%	$19,496
Chlorine Booster Station[2]				
Civil	2014	$448,465	58%	$260,110
Mechanical			12%	$53,816
Electrical			7%	$31,393
Chlorine Dosing and Booster Pumps			23%	$103,147

1. Engineering estimate.
2. Percentage of Total Cost estimated from the final progress payment issued for the construction of the facility.

Table 8-11: Estimated Replacement Costs of Watermains and Service Connections

Material	Diameter	Replacement Unit Cost ($/m^3)[1] (2014 Dollars)
PVC	50	$520
PVC	100	$520
PVC	200	$650
PVC	300	$845
Ductile Iron	50	$520
Ductile Iron	100	$520
Ductile Iron	150	$585
Ductile Iron	200	$650
Ductile Iron	250	$780
Service Connection	-	$2,600

1. Includes 30% for engineering and contingency.

Anmore's 20+ kilometers of watermains were installed over the past 25 years. To estimate when these watermains will need to be replaced, a high-level conservative approach was taken. It was assumed that some of the watermains will start to fail at 80% of their expected service life and that all watermains will need to be replaced by the end of their expected service life. For example, a PVC watermain installed in 1990 may need to be replaced as early as 2061 (80% of an expected 80 year service life). Therefore, the total replacement cost of all PVC and ductile iron watermains were averaged between the earliest year of replacement and end of the expected service life of the newest watermain. Figure 8-1 below illustrates both the annual replacement cost at the end of the expected life and the average annual replacement cost.

The estimated annual replacement cost of watermains was approximately $330,000 (2014 dollars). This estimated annual replacement cost provides Anmore with an indication of the costs associated with watermain renewals. It is recommended that the estimated replacement dates and costs of watermains be reviewed and revised in subsequent Water Utility Master Plan updates as more data is compiled as the infrastructure ages and asset management practices are implemented.

The cost to replace the existing service connections to the 628 residential, 13 park, 5 institutional, 28 commercial, and 3 village commercial parcels was assumed be incurred at the same time as the connecting watermain was replaced. Therefore, the annual service connection replacement cost was assumed to be proportional to the annual watermain replacement cost. The estimated annual replacement cost of service connections is approximately $40,500 (2014 dollars).

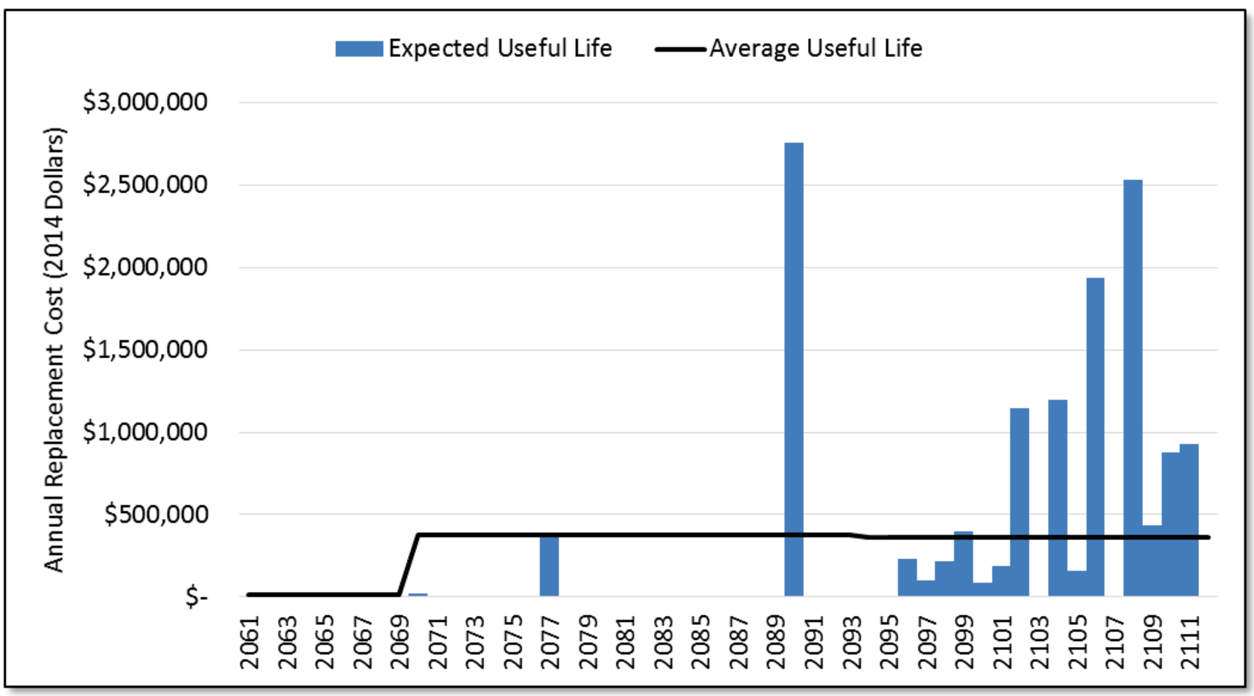

Figure 8-1: Estimated Annual Replacement Cost of Watermains

Anmore has an estimated 145 hydrants installed between 1990 and 2014 which equates to about 6 hydrants per year. Therefore, it was assumed that starting in 2030 the existing hydrants would start to be replaced at a rate of 6 hydrants per year for a cost of $31,200 per year (2014 dollars). This hydrant replacement cost does not include the additional hydrants recommended to be installed in the hydrant coverage analysis.

Anmore has an estimated 628 water meters. The cost to replace a 19 mm and 25 mm water meter is estimated at $450, excluding labour cost. It was assumed that the average service life of a water meter is 15 years and therefore approximately 6.7% of all water meters will need to be replaced each year resulting in an annual cost of about $24,000 per year (2014 dollars).

The water supply meter from the City is scheduled to be replaced in 2015 for a cost of $20,000. The recurring replacement of the water supply meter every 15 years was added to the long-term rehabilitation and replacement cost estimate.

Overall, assuming a 3% infrastructure inflation rate and 30% for engineering design and contingencies, an estimated total of $1.67 million will likely be required for rehabilitation and replacement between 2015 and 2032 in addition to the projects of the Capital Upgrades Plan. Included in this estimated total cost was:

- $52,000 for a new water supply meter in 2015 and again in 2030;
- $585,000 for residential and commercial water meter replacement;
- $155,000 for hydrant replacement;
- $103,500 for replacement of the Thomson East PRV in 2023;
- $244,000 for replacement of electrical, instrumentation, and controls of the Uplands Pump Station in 2030; and,
- $532,500 for replacement of electrical, instrumentation, and controls of the Pinnacle Ridge Pump Station in 2032.

It is important to reiterate that the above costs and replacement dates were estimates derived primarily from Anmore's TCA Inventory and average expected service lives. It is recommended that Anmore revises these estimates as additional information becomes available through asset management practices.

8.2.5.3 Additional Assets from Capital Upgrades Plan

(a) Fire Flows, Dead Ends, and Service Pressures

Approximately 1,000 linear metres of 150 mm diameter watermains will be upsized to 200 mm or 250 mm diameter watermains to improve fire flows and service pressures. This represents about 5% of the total length of the watermains in the water distribution system. These watermains were removed from the average long-term rehabilitation and replacement forecasts above in Figure 8-1 as their replacement was included in the Capital Upgrades Plan.

(b) Hydrant Coverage

Four new fire hydrants are to be installed in 2016 to provide for adequate hydrant coverage. These additional hydrants were added to the long-term rehabilitation and replacement forecast.

(c) System Reliability

The Elementary PRV Station is recommended to be decommissioned and rebuilt with a lead and lag valve in 2020. The new Elementary PRV Station was added to the long-term rehabilitation and replacement forecast.

(d) Storage

The 1.06 ML Pinnacle Ridge Reservoir is scheduled to be constructed in 2020. Assuming a 50 year service life, the reservoir would be scheduled for replacement in 2070 and therefore was added to the long-term rehabilitation and replacement forecast.

8.2.5.4 Complete System Renewal

A long-term forecast of expenditures until complete system renewal by the year 2112 was also completed. The long-term forecast focused on the future rehabilitation and replacement costs of existing infrastructure and infrastructure added through the Capital Upgrade Plan and did not account for any additional increases in operational expenses beyond 2032. It is clear from Figure 8-2 that Anmore must plan for significant rehabilitation costs estimated to begin around 2070. The long-term costs were based on assumptions documented in previous sections and were reported in 2014 dollars. The fact that these expenses were reported in 2014 dollars reinforces the argument that Anmore must start to plan for these future costs because a $100,000 (2014 dollars) watermain replacement may cost upwards of $525,000 by 2070 when costs are inflated at 3% annually.

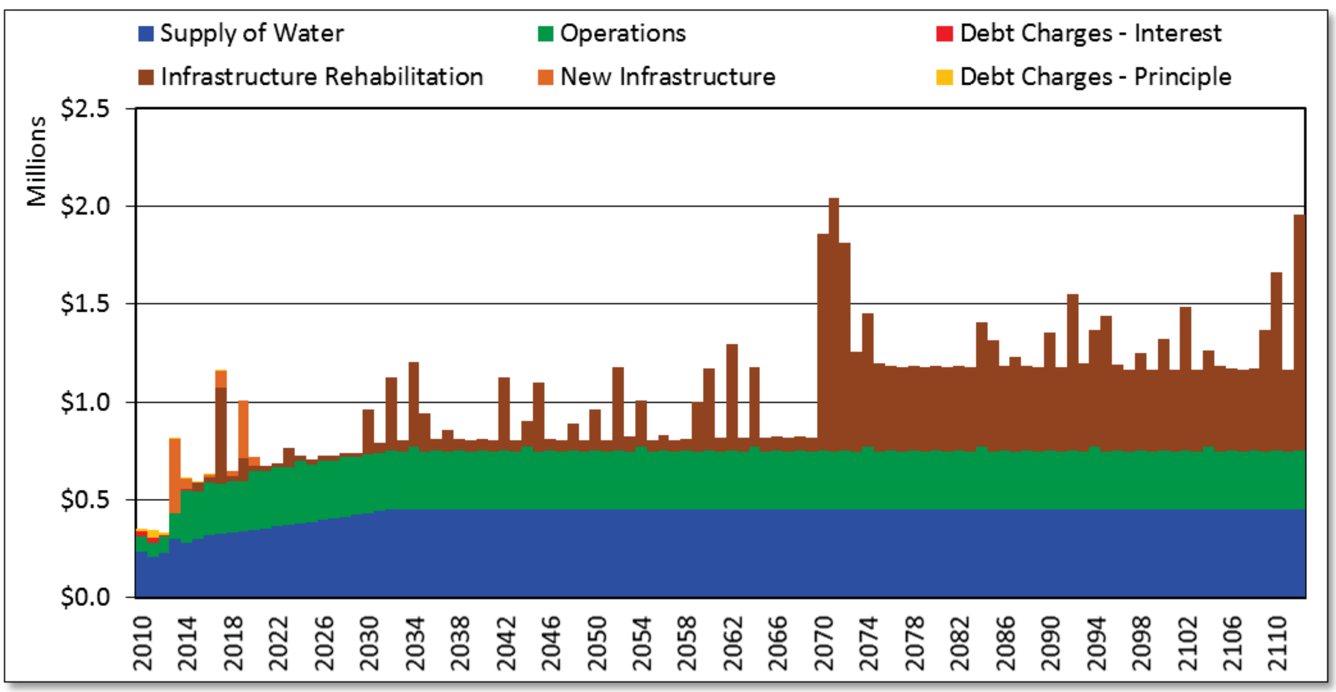

Figure 8-2: Estimated Annual Expenses 2015-2112 (excludes inflation)

8.2.6 Long Term Borrowing Costs

Anmore will complete the repayment of the existing loan for Water Specified Area 4 by the end of 2017. Principle payments of $2,588 are due in 2015, 2016, and 2017. Interest Payments of $3,894 are due in 2015 and 2016 and $1,947 is due in 2017.

At this time, it is expected that no future loans will be required for the water utility between 2015 and 2032.

8.2.7 Summary of Forecasted Water Utility Total Annual Expenses

The Water Utility Master Plan provides Anmore with a comprehensive long-term forecast of future expenditures from 2015 to 2032 as shown in Figure 8-3. These expenses were based on the infrastructure cost estimates and growth assumptions made earlier, including:

- Average annual serviced population growth rate: 2.25% per year
- Average day total water demand: 366 L/c/d
- Average day revenue water demand: 316 L/c/d
- Inflation cost of infrastructure: +3% per year;
- Inflation cost of operations: +1.5% per year; and,
- Increase in water supply costs: +$0.05 per year.

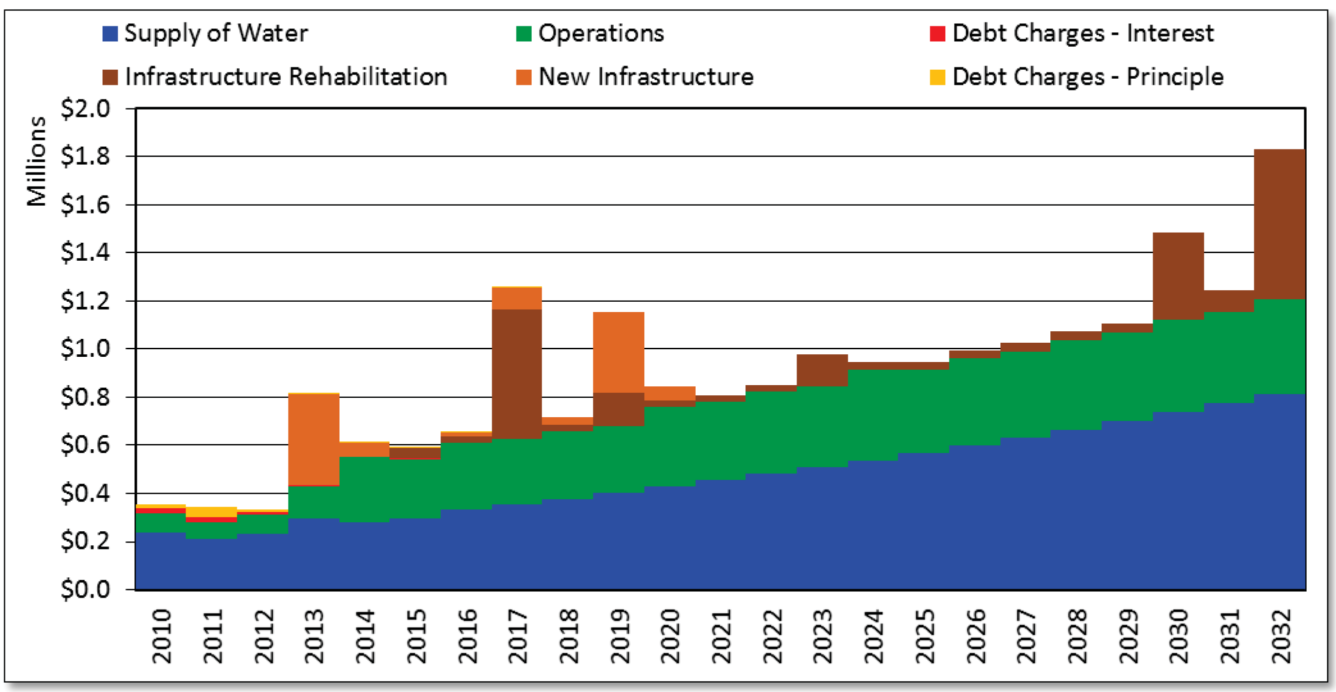

Figure 8-3: Estimated Annual Expenses 2015-2032

The most significant forecasted annual expense is the cost of purchasing water from the City. It is therefore important to reiterate that Anmore and the City should revisit the water supply agreement and the associated unit costs for water as recommended in Section 8.2.2.

Technical Memorandum #4: OMI Program Plan & Condition Rating System approximated that the total cost to operate and maintain the water utility is in the order of $275,000 per year (2014 dollars). This is a significant increase over the historical operations and maintenance budgets (the 2014 budget was $80,745 which excluded the cost of labour) and highlights the fact that the water utility has been underfunded. Therefore, to prevent issues such as the 2013 boil water advisory, it is recommended that Anmore increase the budget allocated to the operations and maintenance of the water utility.

The costs of the Capital Upgrades Plan and estimated rehabilitation of existing infrastructure are relatively dispersed throughout the planning horizon. These dispersed costs highlight the importance of building the Water Capital Asset Reserve such that these projects can be funded through reserves instead of through long-term loans. The recent decision by Council to dedicate $110,000 to the Water Capital Asset Reserve in 2014 and committing to increasing this amount by $20,000 each year was an important step towards funding the Capital Upgrades Plan.

8.2.8 Water Utility Reserves

Anmore maintains three reserves for the water utility:

a. Water Capital Asset Reserve – 2014 End of Year Balance: $512,212
Use of Funds: Repair, renewal and replacement

The Water Capital Asset Reserve provides funding for infrastructure projects when revenue contributions are insufficient and is currently funded through the Water Levy and transfers from User Fees.

It was estimated that Anmore should target a Water Capital Asset Reserve balance of $1,600,000 by the end of 2029. Between 2030 and 2035 it was estimated that $2,300,000 will be required to fund rehabilitation of existing infrastructure. Therefore by starting to build reserves now and targeting a reserve balance of $1,600,000 at the end of 2029 Anmore will be better positioned to plan for and fund infrastructure projects through reserves and revenues rather than relying on borrowing or delaying projects. It was estimated that by the end of 2035, the Water Capital Asset Reserve would have a balance close to $500,000.

After 2020, it was estimated that the annual User Fee Contribution could decrease to $200,000 to continue to build reserves to fund rehabilitation and replacement of existing infrastructure. The decrease in the contribution to the Water Capital Asset Reserve corresponds to the additional $85,000 per year contribution to the Water Storage Reserve starting in 2020 (see paragraph below).

As indicated by Figure 8-2: Estimated Annual Expenses 2015-2112, Anmore will eventually be facing significant costs associated with rehabilitation and replacement of existing infrastructure. It is recommended that the targeted reserve balance and annual contributions be revised in subsequent studies.

The Water Capital Asset Reserve also includes a Water Storage Account which had a 2014 end of year balance of $34,777. While the initial construction of the Pinnacle Ridge Reservoir will be funded by the developer(s), Anmore will have to pay for the eventual rehabilitation and replacement of the reservoir around 2070. It is advisable that Anmore start to contribute to the reserve fund once the reservoir is constructed. Based on the estimated construction cost and inflation rates, approximately $85,000 per year should be contributed to the Water Storage Account starting in 2021.

b. Water Stabilization Reserve– 2014 End of Year Balance: $25,609
Use of Funds: Contingencies & Emergencies. Residual for other projects

Stabilization reserves allow for the water utility to withstand cash flow fluctuations and buffer against unexpected costs. The American Water Works Association Manual of Water Supply Practices M54 references an industry standard for minimum operating reserve balances of between 12.5% and 25% of annual cash operating and maintenance expenses with additional funds required for contingencies.

Anmore currently collects user fees twice a year and the revenue collected is entirely dependent on the amount of water used. It is therefore advisable that Anmore contribute funds to the Water Stabilization Reserve until an end of year balance equal to at least 50% of the average annual operating costs, or approximately $400,000, is achieved.

c. Water DCC Reserves – 2014 End of Year Balance: $550,000
Use of Funds: Developer Cost Charges (DCC) Water Projects

The total estimated cost of DCC funded Capital Upgrades Projects was just over $550,000 after inflation was taken into account. It was therefore assumed that sufficient DCC funds will be available to support the DCC portion of the Capital Upgrades Projects.

8.2.9 Water Utility Revenues

Anmore's existing funding model recovers close to 99% of revenues through User Rates, Parcel Taxes, a Water Levy, and New Water Service Fees. For the purposes of forecasting the revenues required for full-cost recovery, the unpredictable revenues from investment income, miscellaneous income, and grant funding were ignored. The details of the reliable revenue sources are outlined in Table 8-12.

Table 8-12: Anmore's Water Utility Funding Model

Revenue Source	Description	Current Purpose
Parcel Taxes	A flat annual parcel tax applied to a Water Specified Area.	Dedicated to the repayment of loans.
Water Levy	A flat annual property tax based on the assessed value of property improvements. This levy was previously termed the 'Fire Flow and Protection Levy'.	Dedicated to the Water Capital Reserve.
New Water Service Fee	A fee based on the actual cost of installation of a water connection.	To recover the full cost of the installation of a water connection
User fees	A metered rate applied to the quantity of water supplied as measured by the water meter.	Administration, O&M, Utilities, Water Supply Costs to the City, etc.

The existing funding model defines a purpose for each revenue source. Therefore, additional revenue from each source were assumed to be limited to the expenses which the revenue source is defined to fund.

Parcel Taxes will continue to fund the repayment of long-term debt until 2017. After which no additional long-term debt is forecasted and as such no additional Parcel Taxes are required.

The **Water Levy** is currently dedicated to the Water Capital Asset Reserve. Only customers who are serviced by a fire hydrant are currently charged a Water Levy. The Capital Upgrades Plan recommendations to install an additional 4 hydrants will result in hydrant coverage for all residents. It is therefore recommended that Anmore consider removing the Water Levy and instead recover these revenues through User Fees. This transition will help to improve the equity of water utility charges by fully supporting the 'user pay' principle and to improve transparency by incorporating all water utility charges into User Fees.

The **New Water Service Fee** is based on actual cost of the water connection. Therefore, the expenses and revenues related to the installation of a water connection were excluded from the financial analysis.

User Fees fund the cost of administration, maintenance, operations, and water supply. The revenues from User Fees must also be contributed to the Water Capital Asset Reserve to fund rehabilitation and capital projects.

8.2.9.1 Historical Revenues

Anmore's historical revenues are provided in Table 8-13. It is noted that Parcel Taxes have decreased from 2010 to 2014 as Anmore has completed the repayment of long-term debt.

Table 8-13: Anmore's Historic Revenues

<table>
<tr><th>Revenue Source</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th></tr>
<tr><td>Parcel Taxes</td><td>($39,944)</td><td>($34,606)</td><td>($15,944)</td><td>($15,770)</td><td>($6,520)</td></tr>
<tr><td>Water Levy</td><td>($28,342)</td><td>($30,589)</td><td>($32,133)</td><td>($35,552)</td><td>($32,780)</td></tr>
<tr><td>User Fees – Anmore</td><td>($70,465)</td><td>($44,920)</td><td>($122,198)</td><td>($93,876)[1]</td><td>($148,177)</td></tr>
<tr><td>User Fees – City</td><td>($235,686)</td><td>($209,713)</td><td>($230,285)</td><td>($296,977)[1]</td><td>($279,410)</td></tr>
<tr><td>Sub-Total Revenue</td><td>($374,437)</td><td>($319,828)</td><td>($400,560)</td><td>($442,175)</td><td>($466,887)</td></tr>
<tr><td>New Water Service Fee</td><td>($17,512)</td><td>($5,668)</td><td>($12,681)</td><td>($10,090)</td><td>($12,813)</td></tr>
<tr><td>Investment Income</td><td>($274)</td><td rowspan="2">($51,886)</td><td>($759)</td><td>($4,189)</td><td>($881)</td></tr>
<tr><td>Miscellaneous</td><td>($13,293)</td><td>($9,112)</td><td>($7,105)</td><td>($5,520)</td></tr>
<tr><td>Total Revenue</td><td>($405,516)</td><td>($377,382)</td><td>($423,112)</td><td>($463,559)</td><td>($486,101)</td></tr>
</table>

1. Total revenues from User Fees in 2013 were estimated from the total consumption recorded on customer water meters and the water rate for the year. This was necessary as there were discrepancies in the reported user fees.

8.2.9.2 Required Revenues

Anmore's 2015 Water Rate was recently increased to $1.89 per cubic metre and the Water Levy was increased by 8.2% over 2014 by Council, these increases were accounted for in the projection of 2015 forecasted revenues in the financial model developed for Anmore. The model was then used to estimate how much more revenues need to increase for full-cost recovery of the water utility based on the assumptions and recommendations of this 2015 Water Utility Master Plan.

Table 8-14: Summary of Assumptions

<table>
<tr><th colspan="3">Assumptions</th><th>Section(s) of Report</th></tr>
<tr><td colspan="3">General assumptions:
• Average annual serviced population growth rate: 2.25% per year
• Average day total water demand: 366 L/c/d
• Average day revenue water demand: 316 L/c/d
• Inflation cost of infrastructure: +3% per year; and
• Inflation cost of operations: +1.5% per year.</td><td>8.2.1</td></tr>
<tr><td colspan="3">Water Supply Costs from the City
• Water supply costs assumed to increase at $0.05 per year.</td><td>8.2.2</td></tr>
<tr><td colspan="3">Levels of Service – OMI Programs
• Assumed to be fully implemented in 2016.</td><td>8.2.3
Tech. Memo. #4</td></tr>
<tr><td colspan="3">Water Utility Administration
• Assumed to be equal to the previously budgeted amounts for Audit/Accounting and Administration Costs.</td><td>8.2.4</td></tr>
<tr><td colspan="3">Rehabilitation and Replacement of Existing Infrastructure
• Future costs of rehabilitation and replacement were estimated to determine reserve contributions and reserve balance targets.</td><td>8.2.5</td></tr>
<tr><td colspan="3">Capital Upgrades Plan
• Anmore's contribution to new capital projects are funded through increases to revenues and the Water Capital Asset Reserve.</td><td>7.2
8.2.5.3</td></tr>
<tr><td colspan="3">Principle and Interest Payments
• Existing loans repaid in full by end of 2017.</td><td>8.2.6</td></tr>
<tr><td colspan="3">Reserve Contributions</td><td rowspan="2">8.2.8</td></tr>
<tr><td><u>Water Capital Asset Reserve:</u>
• 2015: $36,269 (Water Levy)
• 2016: $160,000
• 2017: $190,000
• 2018: $220,000
• 2019: $250,000
• 2020: $250,000
• 2021-2032: $200,000
Targeted Balance: $1.6M by 2029</td><td><u>Water Storage Account</u>
• $85,000 per year starting in 2020</td><td><u>Water Stabilization Fund</u>
• Targeted Balance of $0.4M by 2032</td></tr>
</table>

Alternatives to the assumptions documented in Table 8-14 were also developed to illustrate the impact of lower water demands or lower water supply costs from the City.

- Alternative No. 1 assumes that the serviced population growth is limited to 1.6% per year;
- Alternative No. 2 assumes that the average water demand decreases annually by 5% (~10 litres per person per day) until the average water demand is 300 litres per person per day;
- Alternative No. 3 assumes that the water supply cost increase from the City is $0.02 per cubic meter per year.

Alternative 1: A 1.6% serviced population growth rate results in total revenues which are less than those calculated with the 2.25% growth rate due to a reduced total water demand. While a lower population growth results in a lower total cost of water purchased from the City, User Fees are collected based on the amount of water used and therefore a lower population growth rate would result in fewer people using water and thus fewer revenues would be available to fund the water utility. The result of a lower growth rate is that each person would effectively need to pay more for the water utility.

Alternative 2: A decrease in water demand could be due to changes in water use practices, weather, or as a consequence of higher volumetric water rates. Reduced water demand results in lower total revenues as the total cost of purchasing water from the City is reduced. However, User Fees are collected based on the amount of water used and therefore if less water is used, similar to Alternative 1, the revenue required per person increases.

Alternative 3: The results of this alternative illustrate that the tax burden on Anmore's residents is highly dependent on the cost of water from the City as illustrated in Figure 8-5.

The results of the financial analysis of the assumptions of Table 8-14 and of the Alternatives are illustrated in Figures 8-4 and 8-5 on the following page.

The results of the analysis indicate that regardless of the 'General Assumptions' or the annual increase to the 'Water Supply Costs from the City' it is clear that revenues need to increase sharply in the short-term if the water utility is to be fully funded and able to support the recommendations of this 2015 Water Master Plan. Over the long-term, the accuracy of the assumptions plays a larger role and the long-term variation in revenues per person illustrated in Figure 8-5 highlights the importance of revising the financial plan on an annual basis to ensure that projections are as accurate as possible.

Table 8-15: Total Revenue per Person per Year[1]

Scenario	2014	2016		2017-2020
	Total Revenue per Person[1]	Total Revenue per Person[1]	% Increase over 2014	Additional % Increase per Year
Base Assumptions	$225	$358	59%	~5%
Alternative 1		$371	65%	~5%
Alternative 2		$362	61%	~5%
Alternative 3		$354	57%	~4%[1]

1. Slightly less due to the lower cost increase for water from the City.

The revenue increases represent the cost of implementing the ideal recommendations based on: direction from Anmore staff; achieving best practices as soon as possible; implementing a Capital Upgrades Plan that provides for improved fire flows, service pressures, system reliability, and water storage; and OMI projects that allow for sufficient monitoring and maintenance of the water utility's assets.

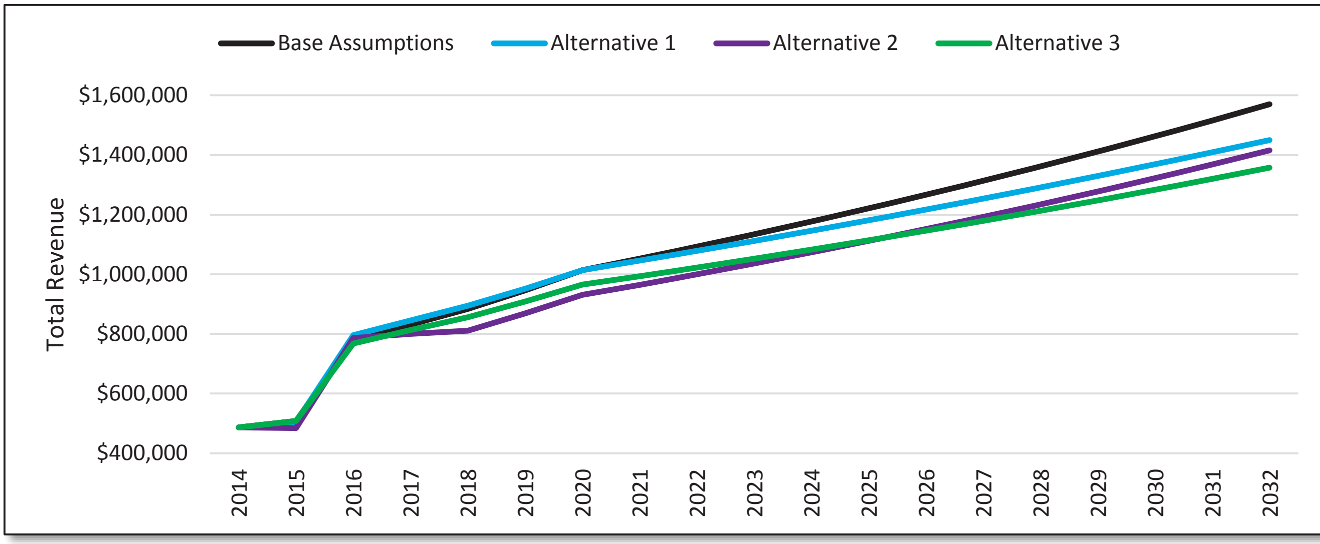

Figure 8-4: Total Required Revenues

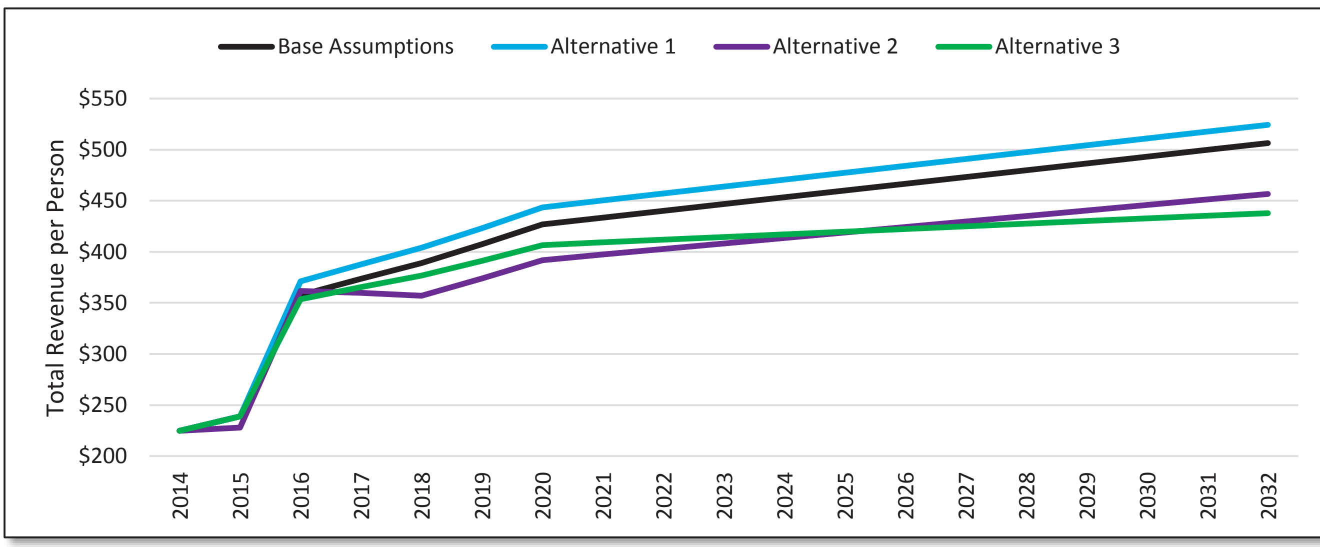

Figure 8-5: Total Revenue per Person per Year

If revenues do not increase, it was forecasted that Anmore could generate a cumulative infrastructure and operating deficit of $4.0 million by 2032 as illustrated in Figure 8-6 which would be further compounded by the lack of ability to build reserves.

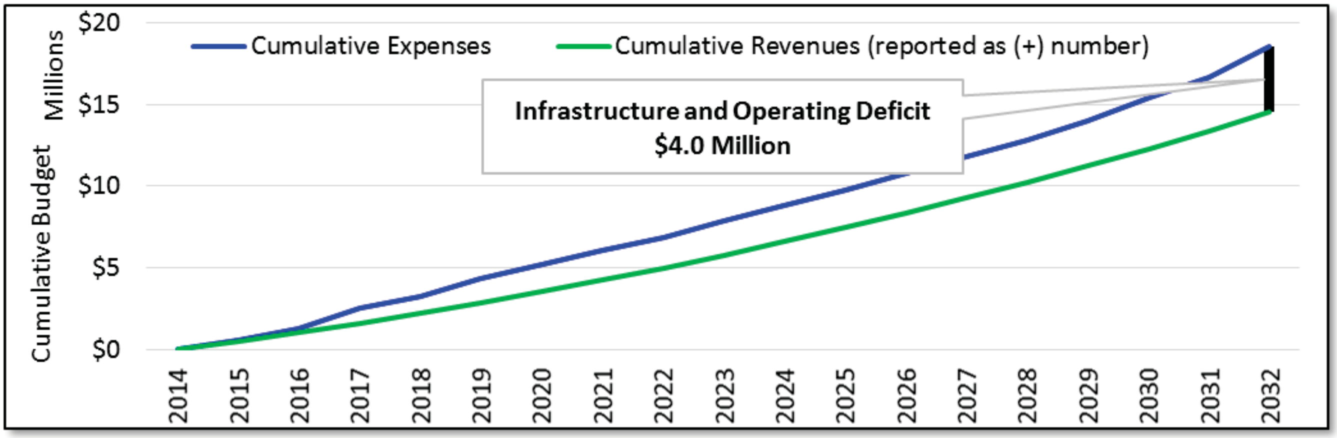

Figure 8-6: Forecasted Infrastructure and Operating Deficit without Additional Revenue

As a detailed illustration of why revenues need to increase, the historical and forecasted expenses are summarized in detail in Table 8-16. There are two critical findings to note:

1. Expenses exceeded revenues in 2014 and the water utility reserves were relied upon to fund the difference. Therefore, the forecasted revenues must not only increase to fund the additional OMI programs, the Capital Upgrades Plan, and the rehabilitation of existing infrastructure, but must also increase to fund the revenue shortfall experienced in 2014 which resulted in the need to draw from reserves. Based on our analysis, the revenue shortfall in 2014 was largely a result of (a) accounting for the cost of labour associated with OMI – which is in accordance with best practices and (b) water supply costs which appear to have been higher than anticipated.

2. The 2016 contribution to the Water Capital Asset Reserve of $160,000 is greater than the $150,000 currently planned for in the existing 2015-2019 Financial Plan. The increase in the reserve contribution is a result of the estimated revenues in 2015 being insufficient to fund the estimated expenses in 2015. In fact, it was estimated that there would be no additional contribution to the Water Capital Asset Reserve in 2015 beyond what is transferred from the Water Levy. This is because the water utility has started (in accordance with best practices) to work towards accounting for the cost of labour in the administration and OMI expenses and there has not yet been a corresponding increase in revenues. If $130,000 were to be transferred to the Water Capital Asset Reserve in 2015 it was estimated that there could be insufficient funds available for administration and OMI due to a combination of limited revenues and limited funds in the Water Stabilization Reserve.

Table 8-16: Comparison of Historical and Forecasted Expenses

Expense	2014 Estimate	2016 Estimate	Difference	
Water Supply Costs	$279,410[1]	$318,916[9]	$39,506	1. 2014 Transaction Inquiry for Account: 02-00-6711 dated February 13, 2015. 9. $1.0952 / m^3 * 291,194 m^3 = $318,916.
Water Administration	~$10,000[2]	$289,787[10]	$51,090	2. Estimated from 2014 budgeted expenses.
Water Maintenance and Operations	$215,135[3]			3. 2014 Transaction Inquiry for Account: 02-00-6701 dated May 4, 2015. Includes a one-time cost of ~$25,000 that is not expected in the future.
Water System and Utilities	$13,562[4]			4. Long-term Borrowing Amortization Schedule 10. Recommended OMI Programs inflated at 1.5% per year from the reported 2014 dollars plus ~$10,400 for audit/accounting/administration costs (taken from the existing 2015-2019 Water Utility Fund Budget).
Interest and Principle Payments	$6,482[5]	$6,482[5]	$0	5. Long-term Borrowing Amortization Schedule.
Oversizing Costs	$5,000[6]	$0	-$5,000	6. 1998 Water Supply Agreement - $5000 per year from 2005 to 2014.
Water System Modelling	$27,517[7]	$0	-$27,517	7. 2014 Transaction Inquiry for Account: 02-00-6802 dated February 16, 2015.
Sub-Total Expenses	**$557,106**	**$615,185**	**$58,079**	
Water Capital Asset Reserve Contributions	$110,000[8]	$160,000[11]	$50,000	8. Based on the 2015-2019 Water Utility Fund Financial Plan. 11. Increased to provide funding for the Capital Upgrades Plan. The Water Capital Asset Reserve was assumed to provide funding for the Capital Upgrades Plan projects and required asset rehabilitation projects; therefore, the expenses for these projects are not included in the table otherwise they would have been double counted.
Water Stabilization Fund Contributions	$0	$2,115[12]	$2.115	12. Estimated contribution required to start rebuilding the Water Stabilization Fund.
Total Expenses	**$667,106[13]**	**$777,300**	**$110,194**	13. Excludes the costs of the Rechlorination Station as this budget was carried over from the previous year.
Total Revenue	**($486,101)**	**($777,300)**		
Deficit / (Surplus)	**$181,005**	**$0**		

Note: The 2014 Estimate contains some unaudited numbers and as such the numbers may not be exact and are provided here for illustrative purposes of the order of magnitude difference between 2014 and 2016.

8.2.10 Financial Sustainability

The long-term financial sustainability of the revenue increases required for the assumptions documented in Table 8-14 were assessed using the financial indicators described in Table 8-3: Indicators of Financial Sustainability.

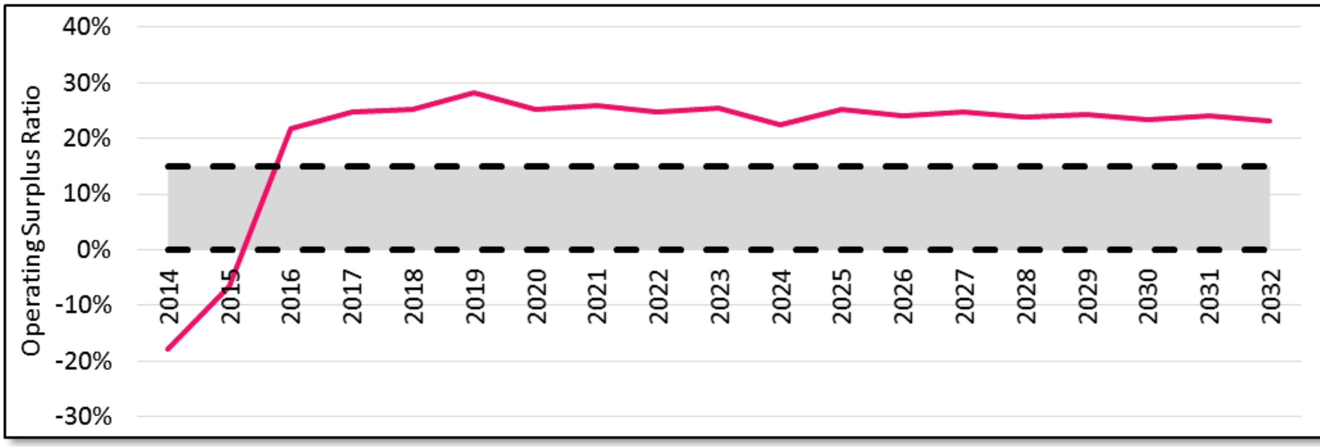

Figure 8-7: Operating Surplus Ratio

The suggested range for the Operating Surplus Ratio is between 0% and 15%. Figure 8-7 shows the Operating Surplus Ratio. In 2014, Anmore's Operating Surplus Ratio was estimated to be negative 15%. The negative ratio was likely a result of accounting for the cost of labour in 2014 without a corresponded increase to revenues from User Fees.

The recommended revenue increases should allow Anmore to achieve a positive Operating Surplus Ratio in 2016. By maintaining a positive Operating Surplus between 20% and 30%, Anmore should be able to build the reserves necessary to fund the future rehabilitation and replacement of existing infrastructure while also setting aside funds in the Water Stabilization Reserve.

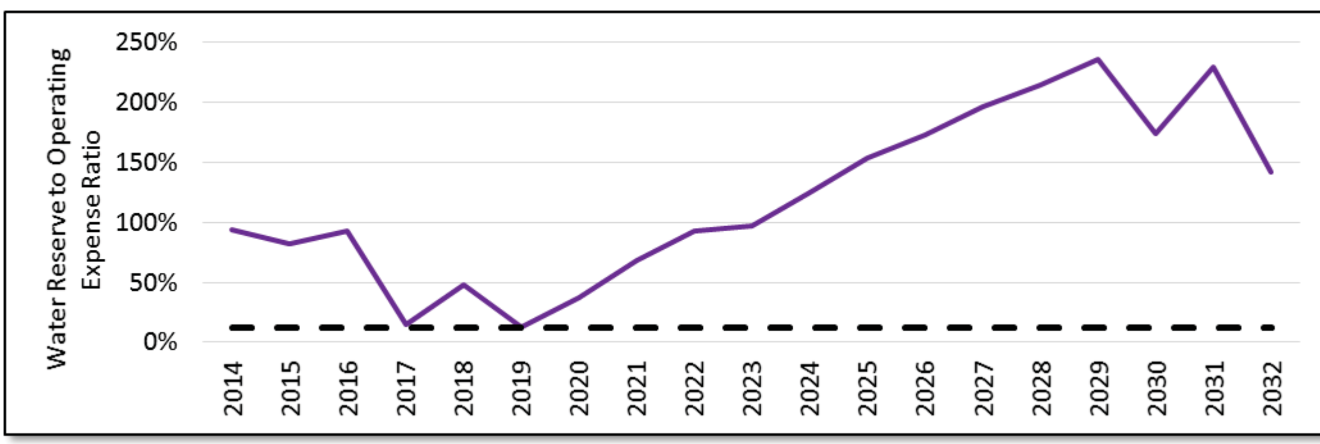

Figure 8-8: Reserves to Operating Expense Ratio

Figure 8-8 shows the Reserves to Operating Expense Ratio. Anmore funds infrastructure projects through the Water Capital Asset Reserve and provides for emergencies and contingencies through the Water Stabilization Reserve. It was recommended in the preceding sections that Anmore continues to contribute to these reserves until target balances are achieved.

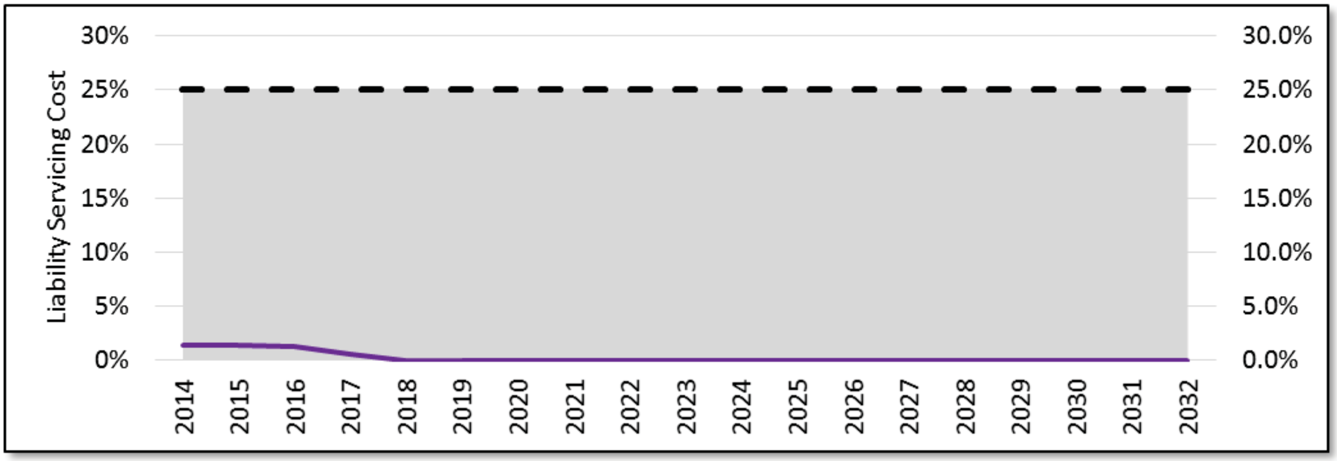

Figure 8-9: Liability Servicing Cost Ratio

Figure 8-9 shows the Liability Servicing Cost Ratio. The maximum Liability Servicing Cost Ratio (Limit) for a municipality is 25% of the previous year's reliable and sustainable revenues. For a self-funded water utility, it can be argued that the same maximum should apply. The existing long-term loans are expected to be fully repaid by the end of 2017 and therefore the Liability Servicing Cost will reach zero in 2017.

8.3 Long-term Financial Plan Recommendations

The following summarizes the recommendations documented in preceded sections. The recommendations, in no particular order, were developed to help put Anmore on the path towards sustainable water rates and charges which will enable Anmore staff to appropriately budget for and fund the ongoing costs of operating, maintaining, rehabilitating, and growing their water utility.

1. Anmore's staff and Council should develop long-term targets for each of the indicators of financial sustainability outlined in Table 8-3;

2. Review the assumptions and limitations in light of changing social, economic, and environmental conditions;

3. Review the 1998 water supply agreement with the City to ensure costs levied against Anmore are within the spirit of the agreement and are equitable. There is potential that Anmore could inadvertently be paying more than their share of City costs;

4. Implement the recommended OMI programs;

5. Work towards full-cost recovery by accounting for the cost of administration of the water utility;

6. Further develop and maintain an asset management plan that will allow a better understanding of the long-term rehabilitation and replacement costs facing the water utility;

7. Refine the costs of the Capital Upgrades Plan;

8. Improve equity and transparency of water utility charges by incorporating the Water Levy charges into the User Fees;

9. Increase revenues to provide sufficient funding to support the Capital Upgrades Program, the recommended OMI programs, and contributions to reserves.

8.4 2015-2032 Financial Plan

The 2015-2032 Financial Plan is provided in Table 8-17 below.

Table 8-17 - Long Term Financial Plan 2015-2032 (Base Assumptions)

Revenues	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Total Revenue	**$ (507,627)**	**$ (777,300)**	**$ (830,778)**	**$ (883,759)**	**$ (946,471)**	**$ (1,013,603)**	**$ (1,052,393)**	**$ (1,092,740)**	**$ (1,134,253)**	**$ (1,176,954)**	**$ (1,220,862)**	**$ (1,266,447)**	**$ (1,313,293)**	**$ (1,361,420)**	**$ (1,411,318)**	**$ (1,462,550)**	**$ (1,515,621)**	**$ (1,570,079)**
Transfer from Water Capital Asset Reserve	$ (104,901)	$ (40,581)	$ (628,774)	$ (58,815)	$ (473,055)	$ (84,345)	$ (29,821)	$ (30,715)	$ (134,761)	$ (32,586)	$ (33,564)	$ (34,571)	$ (35,608)	$ (36,676)	$ (37,776)	$ (364,163)	$ (91,646)	$ (626,693)
Transfer from Water Storage Reserve	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Transfer from Water Stabilization Fund	$ (16,171)	$ -	$ -	$ -	$ -	$ -	$ (12,393)	$ (13,726)	$ -	$ (20,273)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TOTAL REVENUES	**$ (628,699)**	**$ (817,881)**	**$ (1,459,552)**	**$ (942,574)**	**$ (1,419,526)**	**$ (1,097,948)**	**$ (1,094,607)**	**$ (1,137,182)**	**$ (1,269,015)**	**$ (1,229,814)**	**$ (1,254,426)**	**$ (1,301,018)**	**$ (1,348,901)**	**$ (1,398,096)**	**$ (1,449,094)**	**$ (1,826,713)**	**$ (1,607,266)**	**$ (2,196,772)**
Expenditures	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Administration, Operations, Maintenance	$ 243,341	$ 289,787	$ 283,033	$ 296,669	$ 292,297	$ 345,992	$ 342,105	$ 357,233	$ 353,259	$ 392,080	$ 364,800	$ 380,915	$ 376,756	$ 393,384	$ 389,135	$ 406,302	$ 401,961	$ 419,686
Water Supply Costs	$ 297,633	$ 318,916	$ 340,995	$ 363,891	$ 387,624	$ 412,214	$ 437,681	$ 464,233	$ 491,715	$ 520,147	$ 549,551	$ 580,160	$ 611,793	$ 644,470	$ 678,446	$ 713,521	$ 749,961	$ 787,552
Debt Charges - Interest + Principle	$ 6,482	$ 6,482	$ 4,535	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Infrastructure Rehabilitation	$ 44,974	$ 25,724	$ 26,495	$ 27,290	$ 28,109	$ 28,952	$ 29,821	$ 30,715	$ 134,761	$ 32,586	$ 33,564	$ 34,571	$ 35,608	$ 36,676	$ 37,776	$ 364,163	$ 91,646	$ 626,693
Projects from Capital Plan	$ -	$ 14,858	$ 602,278	$ 31,525	$ 444,946	$ 55,393	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Expenses	**$ 592,430**	**$ 655,766**	**$ 1,257,336**	**$ 719,375**	**$ 1,152,976**	**$ 842,551**	**$ 809,607**	**$ 852,182**	**$ 979,735**	**$ 944,814**	**$ 947,915**	**$ 995,645**	**$ 1,024,156**	**$ 1,074,530**	**$ 1,105,357**	**$ 1,483,986**	**$ 1,243,568**	**$ 1,833,931**
Transfer to Water Capital Asset Reserve	$ 36,269	$ 160,000	$ 190,000	$ 220,000	$ 250,000	$ 250,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000
Transfer to Water Storage Reserve	$ -	$ -	$ -	$ -	$ -	$ -	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000
Transfer to Water Stabilization Fund	$ -	$ 2,115	$ 12,216	$ 3,200	$ 16,550	$ 5,396	$ -	$ -	$ 4,280	$ -	$ 21,511	$ 20,373	$ 39,745	$ 38,565	$ 58,737	$ 57,727	$ 78,699	$ 77,841
TOTAL EXPENSES	**$ 628,699**	**$ 817,881**	**$ 1,459,552**	**$ 942,574**	**$ 1,419,526**	**$ 1,097,948**	**$ 1,094,607**	**$ 1,137,182**	**$ 1,269,015**	**$ 1,229,814**	**$ 1,254,426**	**$ 1,301,018**	**$ 1,348,901**	**$ 1,398,096**	**$ 1,449,094**	**$ 1,826,713**	**$ 1,607,266**	**$ 2,196,772**
(Surplus)/Deficit after Reserve Transfers	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Reserve Balances	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Water Capital Asset Reserve	$ (443,580)	$ (562,998)	$ (124,225)	$ (285,410)	$ (62,354)	$ (228,009)	$ (398,188)	$ (567,473)	$ (632,712)	$ (800,126)	$ (966,562)	$ (1,131,991)	$ (1,296,384)	$ (1,459,708)	$ (1,621,932)	$ (1,457,769)	$ (1,566,123)	$ (1,139,430)
Water Storage Reserve	$ (34,777)	$ (34,777)	$ (34,777)	$ (34,777)	$ (34,777)	$ (34,777)	$ (119,777)	$ (204,777)	$ (289,777)	$ (374,777)	$ (459,777)	$ (544,777)	$ (629,777)	$ (714,777)	$ (799,777)	$ (884,777)	$ (969,777)	$ (1,054,777)
Water Stabilization Fund	$ (9,438)	$ (11,553)	$ (23,769)	$ (26,968)	$ (43,518)	$ (48,915)	$ (36,521)	$ (22,795)	$ (27,075)	$ (6,801)	$ (28,312)	$ (48,685)	$ (88,430)	$ (126,996)	$ (185,733)	$ (243,460)	$ (322,159)	$ (400,000)

9 Recommendations

9.1 Source Supply Capacity

Under existing and future (2032) population demands, Anmore's average daily withdrawal rate was found to be less than the available supply from the City stipulated in the 1998 Water Agreement between Anmore and the City. However, the maximum rate of flow in any one hour-interval stipulated in the Agreement was found to be exceeded under the existing and future fire flow scenarios using the maximum design criteria fire flow demand and duration. An update to the maximum rate of flow is required until such time that a reservoir can be constructed for Anmore. At that time, the majority of the fire flows will be delivered via the reservoir.

While there are no concerns with the supply capacity of the potable water supplied to Anmore to meet Average Day Demand, it is understood that Anmore staff would like to consider a secondary connection to the City of Port Moody via the Hickory Drive Reservoir, which would provide some measure of source supply redundancy. Opus DaytonKnight Consultants Ltd. (Opus DK) advises that a joint stakeholder meeting between Anmore and City staff to discuss this possible connection would be prudent.

9.2 Storage Reservoir Capacity

Anmore currently relies heavily on storage volumes from the City of Port Moody's Hickory Drive Reservoir as it does not currently own or operate any reservoirs. However, it is envisioned in the near future that a reservoir will be built at the Pinnacle Ridge Development to provide storage volumes to Anmore's water system. As such, Opus DK has assessed the required reservoir sizing to meet storage volume requirements under future (2032) conditions. The proposed sizing of the Pinnacle Ridge Reservoir was calculated based on Anmore's storage requirements but reduced based on the estimated future excess storage of the City of Port Moody's Hickory Drive Reservoir. The Hickory Drive Reservoir may augment Anmore's water system with an excess storage volume of 0.71 ML in 2032. This would enable Anmore to reduce the sizing of the Pinnacle Ridge Reservoir to 1.06 ML rather than the 1.77 ML that is required. However, the continued reliance on the excess storage from the Hickory Drive Reservoir must be clearly understood by Anmore and communicated to the City well into the future. The continued access to storage volumes from the City's Hickory Drive Reservoir for Anmore's and the City's demands helps to promote turnover of the reservoir and benefits both municipalities. The volume of 0.71 ML was calculated as the future excess storage from the City's Water Master Plan.

9.3 Pinnacle Ridge Pump Station

The Pinnacle Ridge Pump Station was designed to provide flows to the proposed Pinnacle Ridge Storage Reservoir. Under the proposed development plan, the storage reservoir would provide balancing and fire storage for the entire Anmore water system. To meet future service pressure and fire flow requirements, Phase 2 of the Pinnacle Ridge development should be implemented, and the Pinnacle Ridge Pump Station should be configured as intended for the future build-out, as shown in Water System Schematic (Figure 2-2 in Section 2).

9.4 Distribution System Upgrade Recommendations

The recommendations to existing service pressure and fire flow deficiencies are detailed below in Table 9-1.

Table 9-1: Existing Distribution System Upgrade Recommendations

Item	Proposed Work	Deficiency Resolved
UG-1	The watermain along Spence Way should be looped to the watermain along Leggett Drive with a 200 mm diameter watermain, 688 m in length.	Fire Flows, Dead End System
UG-2	The 150 mm ø watermain along Sunnyside Road between Anmore Creek Way and Hemlock Drive should be replaced with a 250 mm diameter watermain.	Fire Flows
UG-3	The watermains along Anmore Creek Way and Sugar Mountain Way should be looped to the watermain terminating at the north end of Fern Drive using 200 mm diameter watermains, 662 m in total length.	Fire Flows, Dead End System
UG-4	The 150 mm ø watermain along Sugar Mountain Way/Spence Way crossing Sunnyside Road should be replaced with a 200 mm diameter watermain, 561 m in length.	Fire Flows
UG-5	The properties along Wyndham Crescent should be disconnected from the 247 m HGL pressure zone and reconnected to the 288 m HGL Pressure Zone via a tie-in to the 250 mm diameter watermain along East Road.	Fire Flows, Low Service Pressures
UG-6	The Elementary PRV Station is to be replaced with a new PRV station which would have a lead and a lag valve for times of high and low flow.	System Reliability
UG-7	The watermain along Chestnut Crescent should be looped to the watermain along Sunnyside Road via Eaglecrest Road with a 200 mm diameter watermain, 391 m in length.	Fire Flows, Dead End System
UG-8(1)	The lead and lag PRV setting at the Sunnyside PRV station should be increased by 14 psi, from 33 psi to 47 psi, and 25 to 39 psi, respectively.	Low Service Pressures

(1) Sunnyside PRV settings to be changed during annual maintenance, therefore this upgrade is not included in the Capital Upgrades Plan.

9.5 Hydrant Coverage

Anmore's Works and Services Bylaw No. 242-1998 should be revised to reflect the FUS 1999 'Water Supply for Public Fire Protection' guide, which recommends a maximum hydrant spacing of 180 metres in single-family residential areas and 90 metres in multi-family and institutional, commercial and industrial (ICI) areas.

In accordance with the FUS guidelines, there are an additional 4 fire hydrants recommended for Anmore's water distribution system.

9.6 Long-Term Financial Plan Recommendations

The following summarizes the recommendations of the long-term financial plan. The recommendations, in no particular order, were developed to help put Anmore on the path towards sustainable water rates and charges which will enable Anmore staff to appropriately budget for and fund the ongoing costs of operating, maintaining, rehabilitating, and growing their water utility.

1. Anmore's staff and Council should develop long-term targets for each of the indicators of financial sustainability outlined in Table 8-3;
2. Review the assumptions and limitations in light of changing social, economic, and environmental conditions;
3. Review the 1998 water supply agreement with the City to ensure costs levied against Anmore are within the spirit of the agreement and are equitable. There is potential that Anmore could inadvertently be paying more than their share of City costs;
4. Implement the recommended OMI programs;
5. Work towards full-cost recovery by accounting for the cost of administration of the water utility;
6. Further develop and maintain an asset management plan that will allow a better understanding of the long-term rehabilitation and replacement costs facing the water utility;
7. Refine the costs of the Capital Upgrades Plan;
8. Improve equity and transparency of water utility charges by incorporating the Water Levy charges into the User Fees;
9. Increase revenues to provide sufficient funding to support the Capital Upgrades Program, the recommended OMI programs, and contributions to reserves.

10 References

Technical Memorandum No.1 “Village of Anmore Water System Asset Inventory”, Opus DaytonKnight Consultants Ltd., July 2014.

Technical Memorandum No. 2 “Hydrant Flow Testing Program”, Opus DaytonKnight Consultants Ltd., August 2014.

Technical Memorandum No. 3 “Village of Anmore Water Model Development, Calibration, and Existing System Analysis”, Opus DaytonKnight Consultants Ltd., February 2015.

Technical Memorandum No. 4 “OMI Program Plan & Condition Rating System”, Opus DaytonKnight Consultants Ltd., March 2015.

Draft Report, “Water Servicing Options for the Pinnacle Ridge Development Village of Anmore”, Dayton & Knight Ltd., November 2007.

OPUS DAYTONKNIGHT

Village of Anmore Water Utility Master Plan

Appendix A

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To	Kevin Dicken
From	Gurjit Sangha, P.Eng.
Date	July 21, 2014
File	D-85702
Subject	Technical Memorandum #1: Village of Anmore Water System Asset Inventory

The Village of Anmore (Anmore) retained Opus DaytonKnight Consultants Ltd. (Opus DK) to develop a Water Master Plan which involves the development of a hydraulic model of Anmore's water distribution system. A prerequisite requires a detailed review of Anmore's existing water infrastructure data with the objective to identify key hydraulic parameters and to determine the latest system's configuration. This technical memorandum summarizes Anmore's asset inventory as well as the data sources from which the inventory was created. A GIS shapefile format of the watermain data is also provided.

1 Data Sources

The Village of Anmore provided Opus DK with engineering drawings for the majority of the watermains, pump stations, and pressure reducing valves (PRVs) in the system. Opus DK reviewed all the drawings for pertinent asset information such as location, year of installation, pipe diameter, material and network connectivity. In addition, all data gap and connectivity issues identified by Opus DK have been resolved with input from Anmore staff.

2 Asset Inventory Summary

The Anmore's water distribution system consists of roughly 20 km of watermains, two (2) Anmore owned pump stations, one (1) privately owned pump station, and eight (8) PRVs. Anmore obtains water off a direct connection to the City of Port Moody's water distribution system near the Blackberry Drive and Aspenwood Drive intersection located at the southeast boundary of the Village.

2.1 Distribution Mains

The majority of Anmore's watermains consists of Ductile Iron pipes, with less than 3% being PVC. This is expected considering that the system is relatively new with most of the watermains (53%) installed in the last decade. The majority of the pipes (43%) are 200 mm in size, the remaining are mostly 150 mm and 250 mm. The tables below illustrate the pipe material, diameter, and year of installation statistics.

Table 2-1: Pipe Material Statistics

Material	Length (m)	%
Ductile Iron	20,089	97.2%
PVC	569	2.8%
Total	**20,658**	**100.0%**

Table 2-2: Pipe Diameter Statistics

Diameter	Length (m)	%
100	133	0.6%
150	6,105	29.6%
200	8,772	42.5%
250	5,648	27.3%
Total	**20,658**	**100.0%**

Table 2-3: Pipe Installation Year Statistics

Year Range	Length (m)	%
1990-1994	5,823	28.2%
1995-1999	1,858	9.0%
2000-2004	4,321	20.9%
2005-2009	6,578	31.8%
2010-2014	2,079	10.1%
Total	**20,658**	**100.0%**

In summary, with the oldest pipes installed in the early 1990s, there is sufficient service life remaining for at least 75 years, assuming a 100 year useful life for Ductile Iron pipes (*Ministry of Community Services: Guide to the Amortization of Tangible Capital Assets*).

We have enclosed a GIS shapefile of the watermains which includes all the information mentioned above. In addition, the majority of the pipes are referenced in the "DrawingRef" field to the drawings in the Compact Disc provided by Anmore staff (e.g. "[16]0024" refers to "MYSCAN_20140516_0024.pdf").

2.2 PRVs

The Village operates and maintains eight (8) PRVs and the key parameters are summarized in Table 2-4.

Table 2-4: PRV Parameters

PRV	Operational Status	Year of Installation	Size (mm)**		Elevation* (m)	Pressure Setting** (psi)
			Lead	Lag		
Countryside PRV	Usually Closed	2010	50	150	172	108
Elementary PRV	Active	2002	50	150	171	39
Lower Crystal Creek PRV	Active	2006	50	150	118	46
Upper Crystal Creek PRV	Active	2006	50	150	165	38
Lower Pinnacle PRV	Active	2008	50	150	205	61
Sunnyside PRV	Active	2008	50	150	145	39
Thomas Lancaster PRV	Active	2008	50	150	189	84
Thomson East PRV	Active	1998	50	200	199	69

*based on ground elevation estimated from City of Port Moody contours
**to be confirmed by Anmore staff

2.3 Pump Stations

There are three (3) pump stations in Anmore's water system, one of which is privately owned and for completeness, has been included in this memo. The operating curves for the Village owned pumps are available and will be used in the water model.

Table 2-5: Pump Information

Pump Station	Pump	Manufacturer & Model	Year of Installation	Elevation* (m)
Sunset Ridge	1 Duty Pump	GRUNFRDOE CR5-13U	2004	192
	1 Fire Pump	-		
Pinnacle	2 Duty Pumps	GOULDS 33SV62GN4E60	2008	240
	1 Jockey pump	GOULDS 5SV23FH4E60		
	1 Fire Pump	AC FIRE 8100 SPLIT CASE		
Uplands	2 Duty Pumps	GRUNDFOS CR 10-9	2004	178
	1 Fire Pump	AC FIRE 8100 HSC 6X4X11F		

*based on ground elevation estimated from City of Port Moody contours

3 Closure

We trust you will find the foregoing technical memorandum suitable. Please do not hesitate to contact the undersigned should you have any questions.

Yours truly,

Opus DaytonKnight Consultants Ltd

Gurjit Sangha P.Eng.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA G. S. SANGHA #27289

df/CL/GS

Encl: Anmore Watermain GIS Shapefile

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TO	Kevin Dicken
FROM	Clive Leung, E.I.T.
DATE	August 6, 2014
FILE	D-85702
SUBJECT	Technical Memorandum #2: Hydrant Flow Testing Program

This memorandum outlines the hydrant flow testing program developed for the Village of Anmore (Anmore) for the purposes of data collection and calibration of Anmore's water model. We provide the approach and methodology of the hydrant testing program and identify the hydrants to be tested. We request Anmore's operations staff review the selected flow hydrants with respect to general safety, drainage, environmental and adjacent property concerns.

It is normally recommended that hydrant testing be carried out during the summertime when system demands are high and the water system is stressed.

1 Introduction

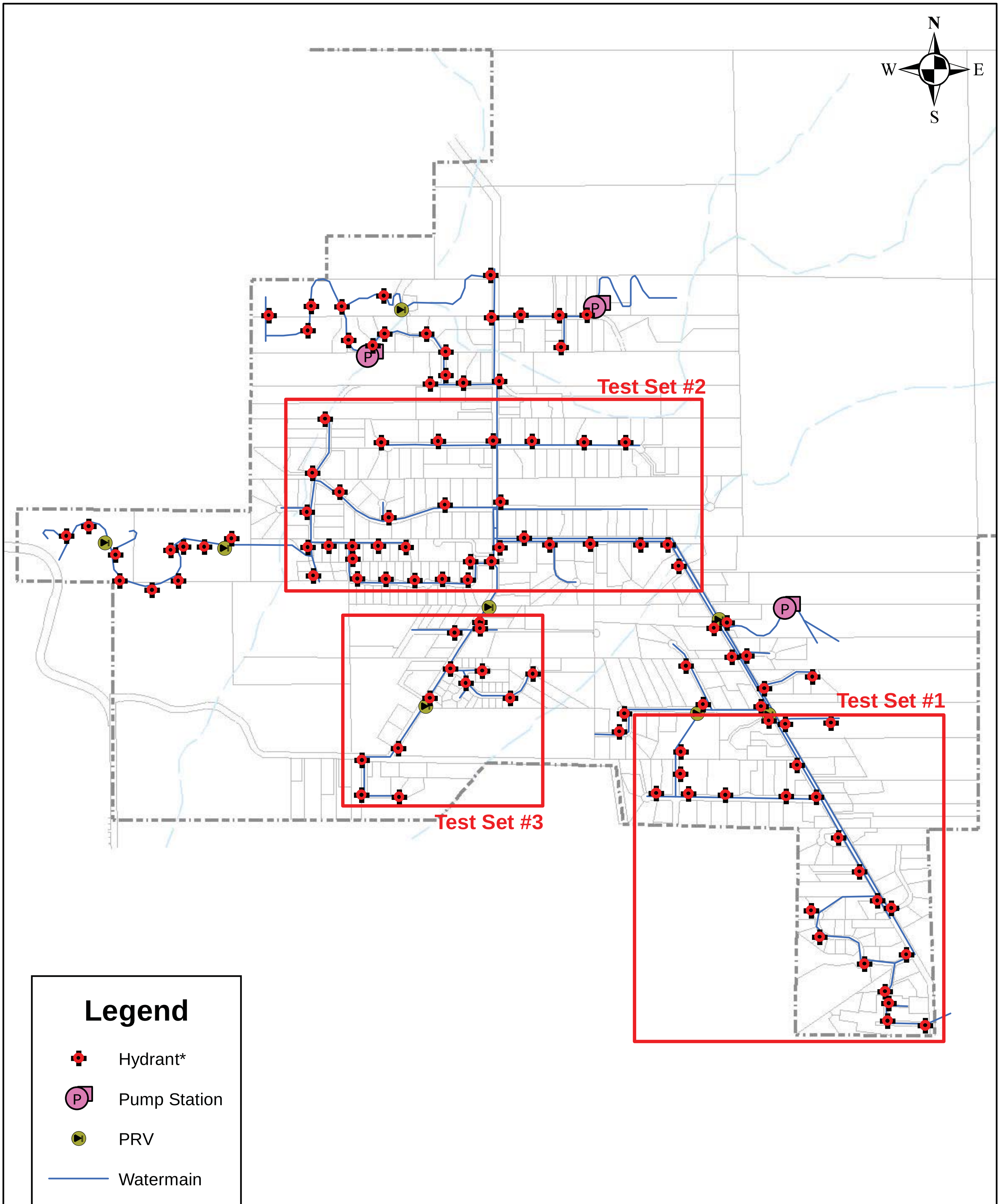
Anmore retained Opus DaytonKnight Consultants Ltd. (Opus DK) to develop a Water Master Plan which involves the development of a hydraulic model of Anmore's water distribution system. As part of the work plan, a hydrant testing program is required to obtain relevant field data (flows and pressures) for model calibration.

The hydrant testing program is anticipated to last one day. We will require two (2) of Anmore's operations staff to operate the hydrants during the hydrant testing program.

2 Approach

The hydrant flow testing process includes fully opening a pre-determined hydrant and measuring flow from it, while simultaneously recording residual pressures at four other hydrants in the surrounding area. Field measurements may then be simulated in the model to compare flows and pressures at multiple locations in order to calibrate the model.

Three (3) flow sets are scheduled, each consisting of four (4) static pressure reading sites, one (1) residual pressure reading site, and four (4) variable flow sites. This results in 40 pressure measurements per set (20 static and 20 residual) and a total of 120 pressure measurements (60 static and 60 residual) across Anmore. An overview of the location of the three hydrant flow test sets is illustrated in Figure 2-1.



*Hydrant locations are estimated

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Client: Village of ANMORE

WATER UTILITY MASTER PLAN
HYDRANT TEST PROGRAM

Project No: D-85702.00		Scale: 0 125 250 Meters	
Designed: CL		1:16,950 @ Tabloid	
Drawn: CL	Approved		
Note:		Map No: 1	Date: August 2014
Figure 2-1		Revision	Revision Date

Path: G:\opus_dk\municipal\857 Anmore\gis\D-85701.00 Water Utility Master Plan\TM2 - Hydrant Testing Program\Figure 2-1 Hydrant Test Program.mxd

The following are considered in the selection of the hydrant flow and pressure locations:

- All hydrants are in the same pressure zone;
- Low and high elevations to capture maximum and minimum pressures;
- General location and populated areas to obtain a representative coverage of the entire zone; and,
- Land use.

3 Methodology

The procedure used to collect data for model calibration is multi-pressure monitoring, and is outlined as follows:

1. Four high resolution pressure loggers (±0.2% of full scale) will be installed on predetermined pressure hydrants, and one additional logger installed on a hydrant adjacent to the flow hydrant. After bleeding the air, the flow hydrant is opened completely.
2. A turbine flow meter shall be installed on a pre-determined flow hydrant port to measure full hydrant flow; alternatively, a pitot gauge shall be installed on the flow hydrants and the velocity pressures shall be recorded. These pressures will be later converted into hydrant flow.
3. The type of hydrant orifice or nozzle on the flow hydrant must be recorded, as this information affects flow characteristics. The actual internal diameter of the outlet or nozzle must be measured to the nearest sixteenth of an inch.
4. Operations staff are needed to monitor flows, supervise drainage and provide dechlorination as required. Each hydrant flow period is anticipated to take around **five minutes** but will also be dependent on the time required to reduce turbidity within the system.
5. Pressure loggers will then be removed and downloaded into a computer program. The recorded data in the pressure loggers provides the static and residual pressures needed to calibrate the model.

The residual pressure at the flow hydrant (measured at the hydrant adjacent to the flow hydrant) should never be allowed to drop below 20 psi (138 kPa). If it does, slowly close the flow hydrant to bring the pressure back to 20 psi. At 20 psi on the residual pressure hydrant, record the readings on the flow hydrant.

Other data required from the Village of Anmore, and possibly City of Port Moody, to adequately calibrate the hydraulic water model includes information on the recorded background demand (e.g. flows from the chlorination booster station) and pump flow rates, as well as any special operational changes to the system (such as main closures, valve closures, etc.).

The acceptable tolerance between field and computer predicted results are ten percent, the accepted industry standard.

4 Field Test Locations

Figures 4-1 to 4-3 illustrate the proposed hydrant testing sites for flow and pressure measurements. Three sets of hydrant flow tests shall be conducted as follows:

- Set #1 – 290 m HGL zone
- Set #2 – 242 m HGL zone
- Set #3 – 190 m and 200 m HGL zones

Field predicted results will be correlated to computer predicted results by Opus DK upon completion of the field program.

5 Summary

In summary, Opus DaytonKnight will provide:

- one staff during the testing program to coordinate the works;
- one hydrant flow meter;
- five pressure loggers; and,
- the necessary pressure logger software.

We require the Village of Anmore staff to:

- approve, in consultation with Opus DaytonKnight, that each of the flow hydrants are appropriate (with respect to general safety, drainage, environmental, and property concerns), and make recommendations for testing alternative hydrants if warranted;
- fully open flow hydrants for 5 minutes each, at 3 x 4 = 12 hydrant flows over 1 day;
- supervise drainage and provide dechlorination during the flow tests; and,
- provide information (during the testing periods) relating to background demand, PRV settings, which pumps are operating, and any other operational changes that would affect the system (such as closed valves, etc).

6 Closure

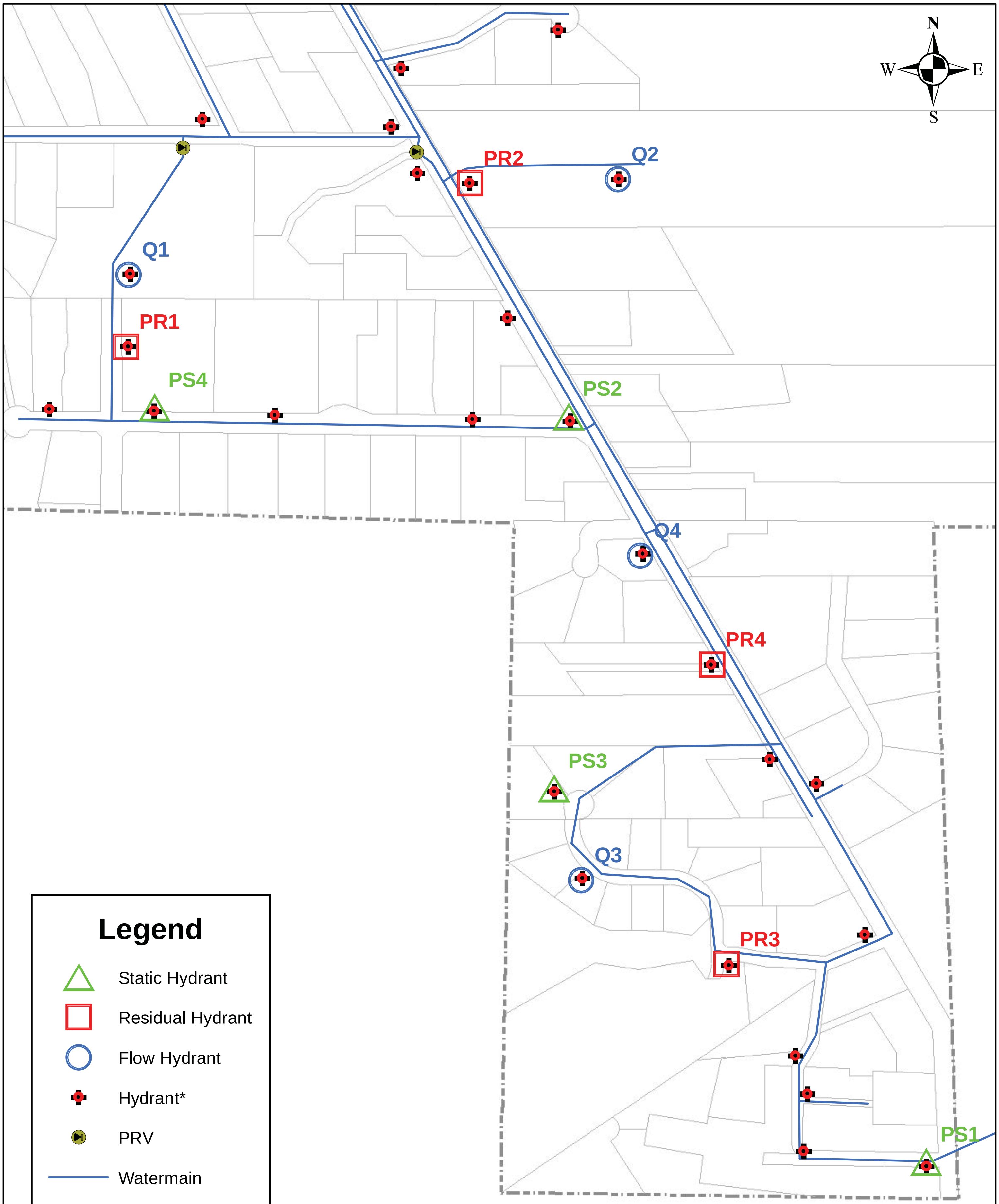
We trust you will find the foregoing technical memorandum suitable. Please inform Opus DK when Village operations staff will carry out the hydrant flow testing program. We anticipate carrying out the hydrant testing program by August 29, 2014.

Yours truly,

Opus DaytonKnight Consultants Ltd

Clive Leung, E.I.T.

df/CL/GS



*Hydrant locations are estimated

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Village of ANMORE

WATER UTILITY MASTER PLAN
HYDRANT TEST SET #1

Project No: D-85702.00		Scale 0 45 90 Meters 1:5,194 @ Tabloid	
Designed: CL			
Drawn CL	Approved		
Note: Figure 4-1		Map No 1	Date August 2014
		Revision	Revision Date

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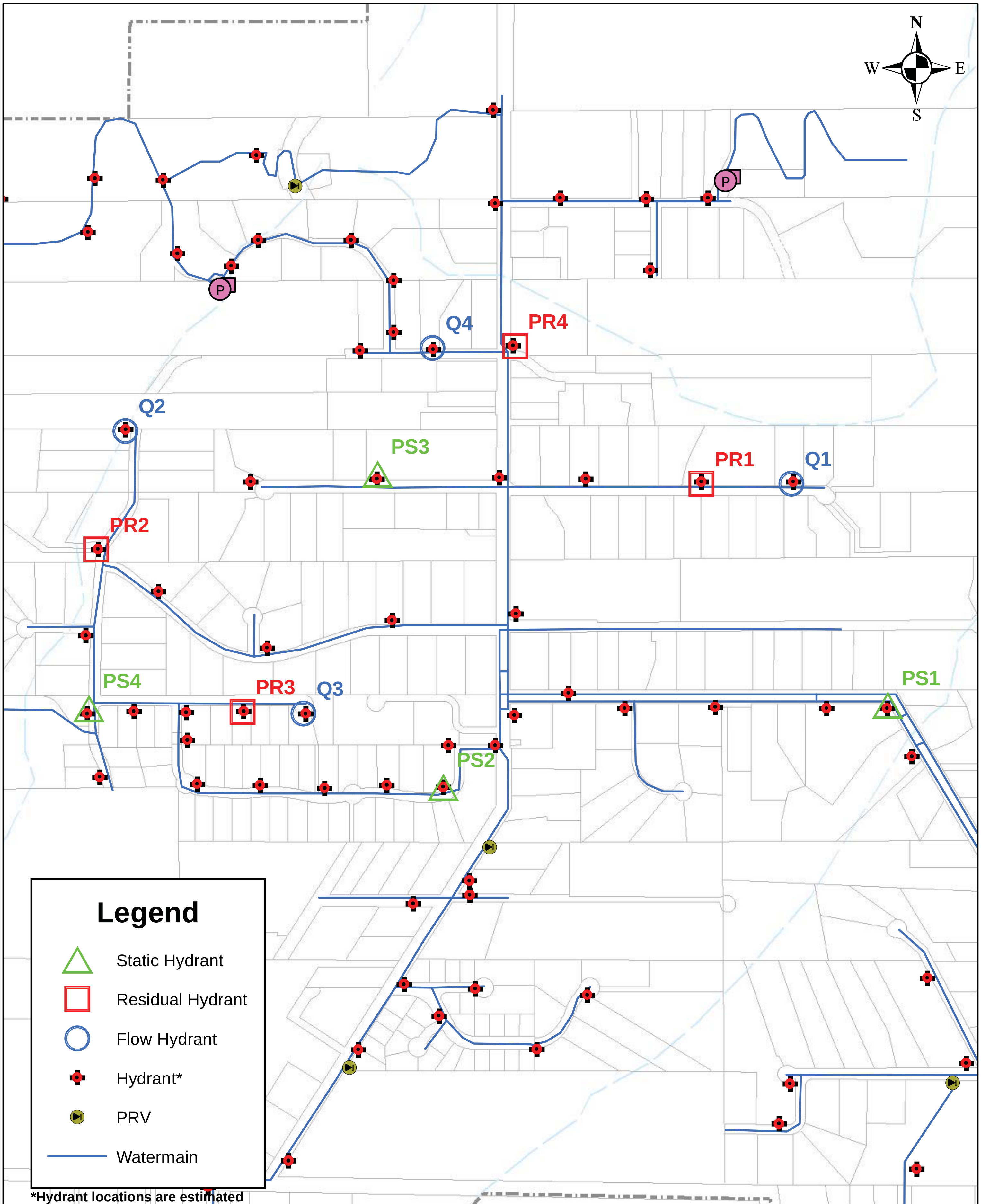

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Client: Village of ANMORE

WATER UTILITY MASTER PLAN
HYDRANT TEST SET #2

Project No: D-85702.00		Scale: 0 60 120 Meters	
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Drawn: CL	Approved		
Note:		Map No: 1	Date: August 2014
Figure 4-2		Revision	Revision Date

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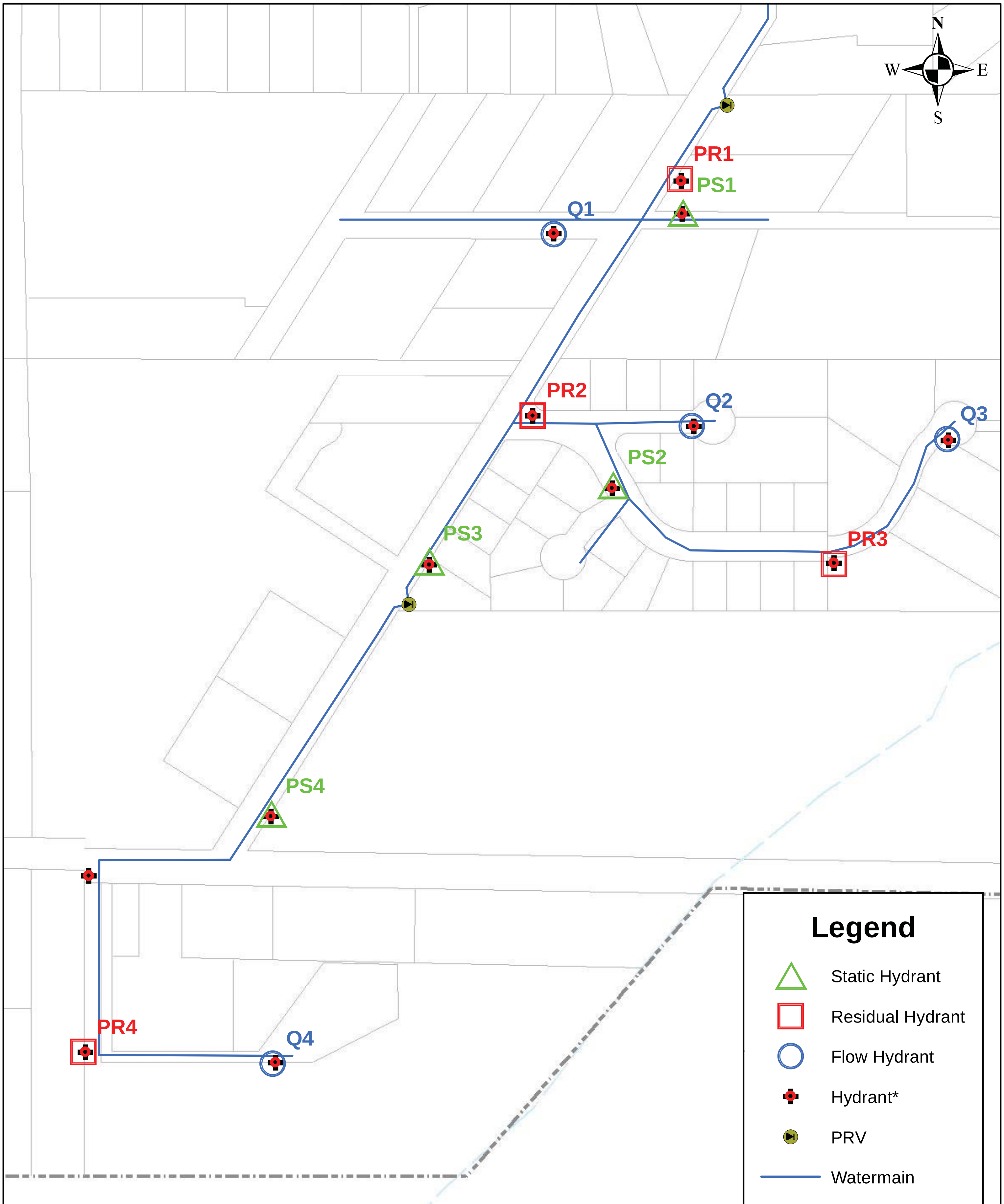

***Hydrant locations are estimated**

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WATER UTILITY MASTER PLAN
HYDRANT TEST SET #3

Project No: D-85702.00		Scale 0 25 50 Meters 1:3,379 @ Tabloid	
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Drawn CL	Approved		
Note: Figure 4-3		Map No 1	Date August 2014
		Revision	Revision Date

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To	Kevin Dicken
From	Clive Leung, P.Eng.
Date	February 5, 2015
File	D-85702.00
Subject	Technical Memorandum #3: Village of Anmore Water Model Development, Calibration, and Existing System Analysis

The Village of Anmore (Anmore) retained Opus DaytonKnight (Opus DK) to provide a Water Utility Master Plan to assess the current state of its water distribution system and plan for future growth. Details of the Master Plan will assist Anmore in determining the strategic infrastructure priorities within its water system, operations and maintenance requirements, and its needs for upgrades, expansion, and renewal to serve current and future needs. Opus DK submitted Technical Memorandum #1 on July 21, 2014, which provided Anmore with a detailed inventory of the existing infrastructure assets in the water utility. Technical Memorandum #2, submitted on August 6, 2014, summarized the hydrant flow testing program carried out by Opus DK staff.

This memorandum summarizes the steps taken in the development of Anmore's hydraulic model as well the calibration program used to ensure the model's accuracy. In addition, this memorandum provides an overview of Opus DK's analysis of Anmore's existing water system.

1 Background

1.1 Data Collection and Information Review

Historical data, water system information, and previous studies that have been reviewed during development of the hydraulic model includes:

- 2014 Village of Anmore Official Community Plan;
- 2012 Village of Anmore residential water meter records;
- 2009-2013 peak flow records at City of Port Moody connection;
- 2007 Report to Village of Anmore for Water Supply Study, McElhanney Consulting Services;
- Current operational information on Anmore's Pump stations and PRVs;
- As-built drawings for Anmore watermains; and,
- LiDAR and contour information for Anmore.

1.2 WaterCAD

Anmore's water model was developed in WaterCAD V8i from Bentley Systems Inc.

WaterCAD is a stand-alone program for the analysis of water supply distribution systems developed by Bentley Systems Inc. It allows the user to construct a graphical representation of the water distribution network from record drawings, CAD drawings, or GIS databases. Network simulations are performed using a hydraulic computational engine. Results can be displayed in the form of tables, graphs and colour-coded network maps. Results can also be exported as shapefiles for display in a GIS program.

2 Existing Water System & Model Development

2.1 System Overview

Anmore's water system consists of 9 pressure zones, 2 pump stations, 8 pressure reducing stations, and includes over 20 km of watermain. Anmore receives its potable water from the City of Port Moody, which in turn is supplied through four connections to Metro Vancouver Trunk Mains crossing the City. The aforementioned components of Anmore's distribution system are summarized in Table 2-1 and illustrated in Figure 2-1.

Table 2-1
Water System Summary

Water System Component	Quantity
Pressure Zones	9
Port Moody Supply Connection	1
Pump Stations	2
Pressure Reducing Stations	8
Length of watermains (km)	20

The 2014 population of Anmore is estimated to be approximately 2,275 people. The 2014 population was extrapolated from recent Census population data using a growth rate of 3.22%. This growth rate was compounded annually based on Census data from 2006 and 2011.

The total service population was estimated by determining a unit population density per acre, which allowed for excluding properties serviced by private wells, using a map provided by Anmore staff and area estimates based on spatial analysis in GIS.

Of the current population, the **total serviced population is approximately 2,061**. The remaining 214 residents are serviced by private wells.

2.2 Port Moody Connection

Anmore's water system is currently supplied by the City of Port Moody, via a 200 mm watermain connection at the intersection of Water Street and Blackberry Drive in Anmore. The water is supplied from the City of Port Moody's 290 m HGL Pressure Zone.

Anmore currently holds a 1998 servicing agreement with the City of Port Moody for the water it is supplied. Anmore is currently billed through tracked total water usage at a Port Moody owned flow meter at the connection. Anmore has recently installed its own magnetic flow meter at its newly constructed re-chlorination building at the intersection of Hummingbird Drive and Robin Way which will enable verification of the recorded flows from Port Moody.

2.3 Pump Stations

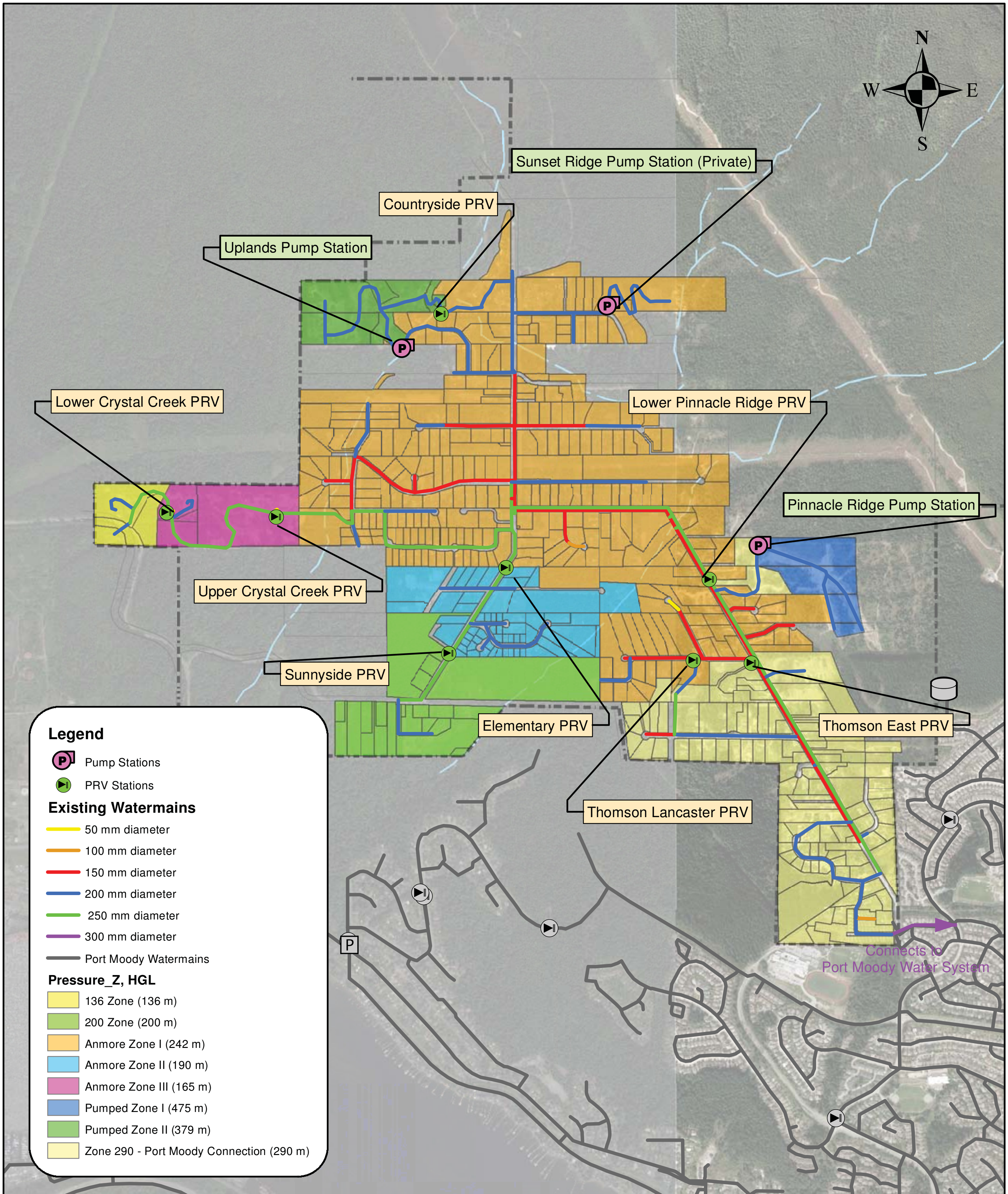
There are two pump stations in Anmore, including the Uplands pump station and the Pinnacle Ridge pump station, the latter of which is currently not in service. The operating curves for Anmore's pumps were available and entered into the water model.

In addition to the two Anmore pump stations, there is the privately owned Sunset Ridge pump station which is accessible by Anmore Staff. The assessment of the private Sunset Ridge pump station is outside the scope of this assignment but it has been included in this memorandum for completion. Note that pump operating curves are not included for the Sunset Ridge pump station, only general information which was made available to Opus DK.

Details of the pump stations and the number of pumps at each station are summarized in Table 2-2.

Table 2-2
Existing Pump Stations

ID	Pump Station	Number of Pumps	Elev (m)	Zone Supplied
3863, 3864, 3706	Uplands	3	178.0	Pumped Zone II
3704, 4521, 4522, 4523	Pinnacle Ridge	4	240.0	Pumped Zone I
3994, 3997	Sunset Ridge (Private)	2	192.0	Private



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Client: Village of ANMORE

Existing Water System

Project No: D-85702.00
Designed: ML
Drawn: ML
Approved: CL
Note:

Figure 2-1

Scale: 0 125 250 Meters
1:40,000 @ Tabloid
Map No: 1
Date: FEB 2015
Revision
Revision Date

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2.4 Pressure Reducing Stations

There are 8 pressure reducing (PRV) stations in Anmore's distribution system. Elevations of the PRVs and their lead and lag valve pressure settings are summarized in Table 2-3.

Table 2-3
PRV Parameters

ID	PRV Station	Elevation (m)	Valve Diameter (mm)	Pressure Setting (PSI)	Status	Zone Supplied
4144 and 3701	Lower Pinnacle	205.0	50 and 150	61 and 53	Open	Zone 1 (242 m)
4136 and 3697	Thomson East	199.0	50 and 200	68 and 60	Open	Zone 1 (242 m)
4150 and 3700	Thomson Lancaster	188.6	50 and 150	84 and 70	Open	Zone 1 (242 m)
4112 and 3699	Lower Crystal Creek	118.0	50 and 150	56 and 46	Open	136 m HGL Zone
4119 and 3698	Upper Crystal Creek	164.6	50 and 150	45 and 38	Open	Zone 3 (165 m)
4123 and 3703	Countryside	171.9	50 and 150	108 and 95	Closed	Zone 1 (242 m)
4131 and 3702	Sunnyside*	145.0	50 and 150	33 and 25	Open	200 HGL Zone
3696	Elementary*	171.0	150	54	Open	Zone 2 (190 m)

*PRV settings were reduced by 6 psi during calibration to match field results.

The table includes pressure setpoints that Anmore has recently reconfigured for its PRV stations based on discussions with Opus DK during the initial stages of the model development process.

2.5 Distribution System

Anmore's distribution system consists of over 20 kilometres of watermain supplying approximately 2,061 residential users. The distribution pipes range in diameter from 50 mm to 300 mm and were installed between 1990 and 2013. A summary of the existing pipe diameters and approximate total lengths are listed in Table 2-4.

Table 2-4
Existing Watermain Diameters

Diameter (mm)	Total Length (m)
50	41
100	132
150	5,205
200	9,490
250	5,620
300	64
TOTAL	**20,552**

Pipe diameters, age, and construction materials used for the watermain network were taken from as-built drawings as provided by Anmore and entered into a GIS shapefile database. This information was added to the hydraulic model. A key part of the model development assignment was adding pipe roughness coefficient 'C' factors to the watermains according to their age and construction material.

Opus DK has developed an extensive database of pipe roughness 'C' values through practical experience in the development and calibration of numerous water models throughout the Lower Mainland. Anmore's water distribution system is primarily composed of Ductile Iron watermains, with a small percentage of PVC watermains in close proximity to the City of Port Moody connection. A 'C' factor of 130 was chosen for all the watermains as the initial 'C' factor, based on the construction material and relative age of the watermains. Table 2-5 summarizes the distribution of watermains by material and age.

Table 2-5
Existing Watermain Materials

Material	1990 – 2000	2000 – 2014	Total Length (m)	Initial 'C'-Factor
Ductile Iron	6,883	13,084	19,967	130
PVC	585	-	585	130

3 Water Demand Allocation

Demand allocation is a detailed process in which the water model is populated with the overall demand of the water system. It is an important step in creating a hydraulic model which will accurately depict the current demands and stresses on the water system, and enables the municipality to assess the impact of water usage and the level of service provided to its residents across its system.

The process used to allocate demands in the water model for Anmore was to first characterize the Average Day, Maximum Day and Peak Hour Demands. After these demands had been finalized, water demands under each demand scenario were allocated to a parcel shapefile based on a combination of addresses on water meter records reviewed and peaking factors. After all demands had been assigned, land parcels were converted into nodes and their demands were imported into the model and then proportionally distributed to the nearest model nodes.

The following information was provided to characterize the water demand in Anmore:

- Individual meter data in pdf format;
- Total system demands available from the Port Moody connection; and,
- Additional metered data was available in three month intervals from 2009 to 2013.

3.1 Average Day Demand

The Average Day Demand (ADD) was found by comparing historical metered flow data using three-month intervals for the given 5-year period, as summarized in Table 3-1. The highest recorded demand, which was in 2013, was used as a conservative estimate, and adjusted for the projected increase in population from 2013 to 2014.

Pipe diameters, age, and construction materials used for the watermain network were taken from as-built drawings as provided by Anmore and entered into a GIS shapefile database. This information was added to the hydraulic model. A key part of the model development assignment was adding pipe roughness coefficient 'C' factors to the watermains according to their age and construction material.

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PVC	585	-	585	130

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Table 3-1
Average Day Demand

Year	ADD (L/s)
2009	8.2
2010	8.2
2011	7.7
2012	7.9
2013	10.0

3.2 Maximum Day Demand

The Maximum Day Demand (MDD) was estimated by analysing flow data from the Anmore Re-Chlorination Booster Station, which measures flow rates provided to Anmore at the Port Moody connection. Anmore provided Opus DK with flow meter data from February to November 2014. The flow meter logs flows in 10-second intervals.

Flows were averaged over 24-hour intervals, starting in May with the start of high seasonal flows, through to November to the end of the recorded data set.

3.3 Peak Hour Demand

Using the flow data from the Anmore Re-Chlorination Booster Station, which was used to determine the MDD, the Peak Hour Demand (PHD) was similarly calculated. 2014 flow data between May and November was averaged over 1-hour intervals to determine the PHD.

3.4 Demand Summary & Allocation

Table 3-2 summarizes the 2014 demand distribution for Anmore.

Table 3-2
Demand Distribution

Demand Condition	Demand (L/s)	Demand (L/capita/day)	Peaking Factors
ADD	10.3	431.8	1.0
MDD	15.7	658.2	1.52
PHD	27.9	1169.6	2.71

The spatial allocation of water demands in the model is based on peak period consumption data for the fall of 2012, which was provided by Anmore. The fall 2012 peak period consumption data was available by parcel address. This allowed Opus DK to rank users based on high to low water usage.

The top 20 users from the given data set were identified and assigned their recorded peak flow in the parcel shapefile. The remaining flows from the consumption data, excluding the top 20 users, were summed and then evenly distributed amongst the remaining parcels.

Using appropriate conversion factors, the parcel demands were adjusted until the total water demand for the system was equal to a given demand scenario (ie. ADD, MDD or PHD). Using this method, Average Day, Maximum Day and Peak Hour demands were appropriate allocated to the water model.

4 Model Calibration

Model calibration was carried out to ensure that the hydraulic water model would correlate to conditions found during field testing of the water system. To improve the accuracy of the model, the calibration process would improve any assumptions and/or estimates made in the development of the model through an iterative review process encompassing the details of each component of the water system including pipe lengths, pipe diameters, pipe materials, pipe roughness factors, node demands, node elevations, and pump configurations.

The result of the model calibration has provided a good correlation between the field and computer predicted results. Only 14 out of 90 of the static and residual pressures differ between the field and model results by more than 10%. The calibration results are found in Appendix A.

The methodology applied in calibrating the hydraulic model is summarized below.

4.1 Hydrant Flow Testing

A testing program was established by Opus DK to carry out hydrant flow tests in Anmore. Details on the testing program can be found in Technical Memorandum #2: Hydrant Flow Testing Program submitted August 6th, 2014. The hydrant flow testing program was conducted with the assistance of Anmore operations staff on August 27th, 2014.

4.2 Model Calibration

For the purposes of calibration, a number of adjustments were made to the model in matching computer results to field recorded results as detailed below. A general adjustment made that was found to aid in matching results was to lower the pressures downstream of two Port Moody PRVs in Port Moody's water distribution system upstream of the connection to Anmore. The altered settings are summarized in Table 4-1.

Table 4-1
Background Settings

Port Moody PRV	Initial Setting (PSI)	Calibration Setting (PSI)
Chestnut Parkway	91	86
Forest Park	45	40

Results of the calibration for the three hydrant flow test sets are detailed below.

4.2.1 Test Set #1 (290m HGL Zone)

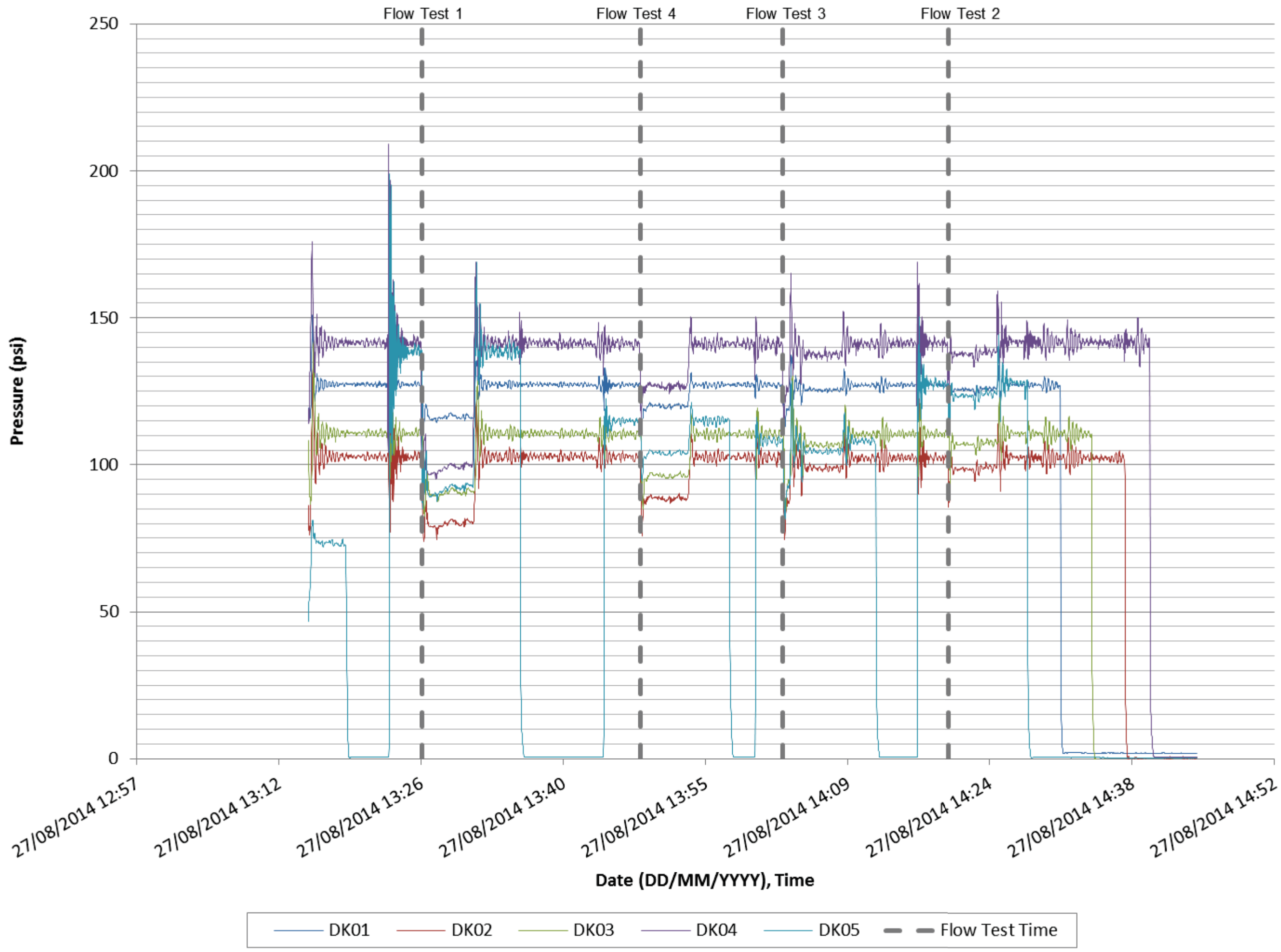


Figure 4-2 Flow Test Set # 1

Inflow into the 290 m HGL Zone comes directly from the Port Moody Connection. All lead valves at the Anmore PRVs were active for static pressure comparisons. For residual pressure comparison, lead valves were closed and all lag valves were opened for the PRVs.

Initially, the static pressures correlated well, while the residual pressures did not correlate well with the model results. Adjusting the diameter of the watermain along Strong Road between Lancaster Court and East Road, from 150 mm to 200 mm, allowed the resolution of two (2) uncalibrated measurements in Hydrant Test #1.

Field investigations by Anmore staff are recommended to confirm the size of the watermain identified above. The remaining uncalibrated results in Hydrant Tests #2 and #3 are likely due to poor field results.

For the 290 m HGL Zone, 32 out of the 40 field (static and residual) pressures correlated well with model predicted results.

4.2.2 Test Set #2 (242 m HGL Zone)

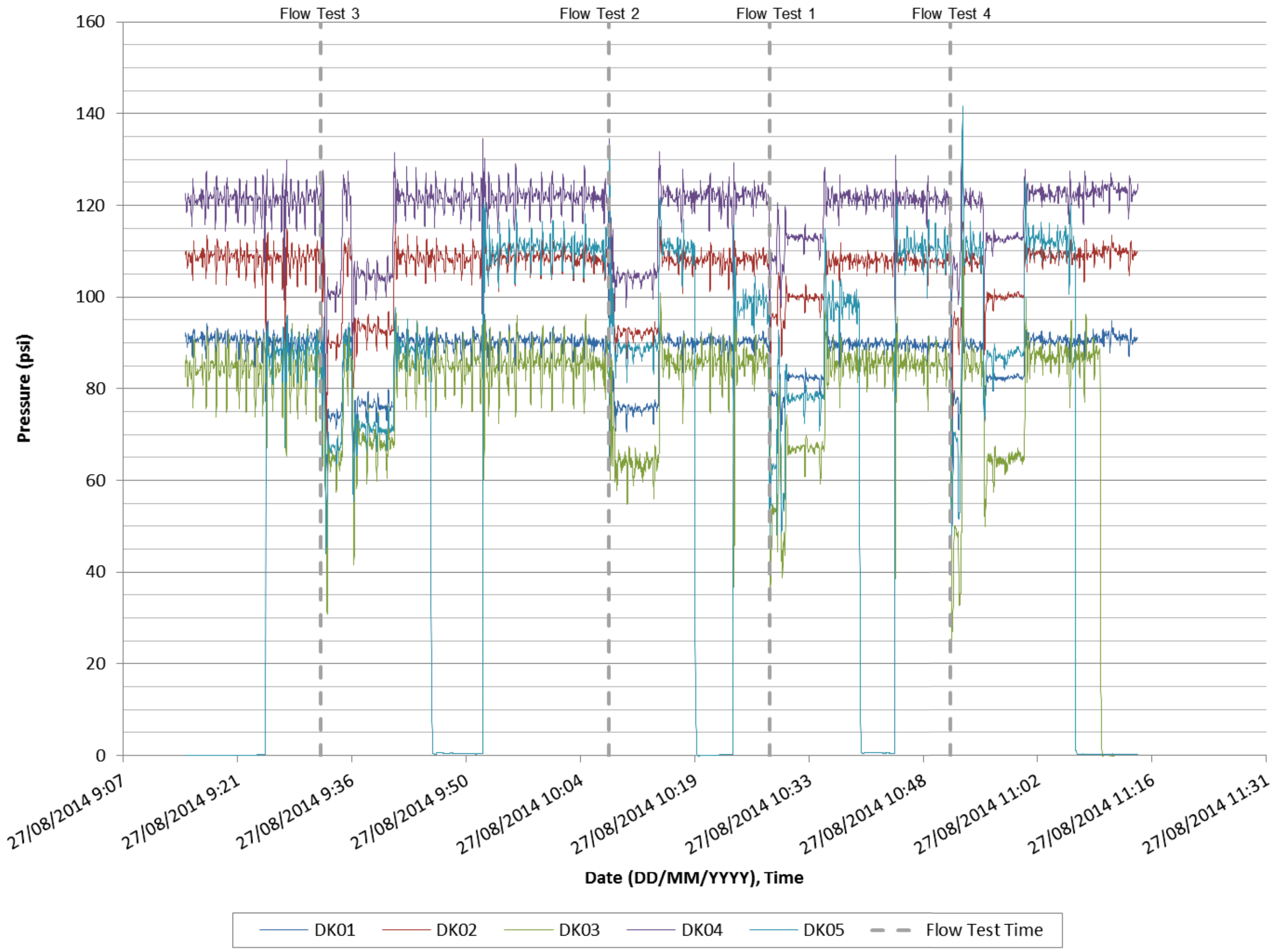


Figure 4-3 Flow Test Set #2

Inflow into the 242 m HGL Zone is downstream of the Lower Pinnacle, Thomson East, and Thomson Lancaster PRVs. All lead valves at the Anmore PRVs were active for static pressure comparisons. For residual pressure comparison, lead valves were closed and all lag valves were opened for the PRVs mentioned above. For the remaining PRVs, lead valves remained active.

For the 242 m HGL Zone, 37 out of the 40 field (static and residual) pressures correlated well with model predicted results.

4.2.3 Test Set #3 (190 m and 200 m HGL Zone)

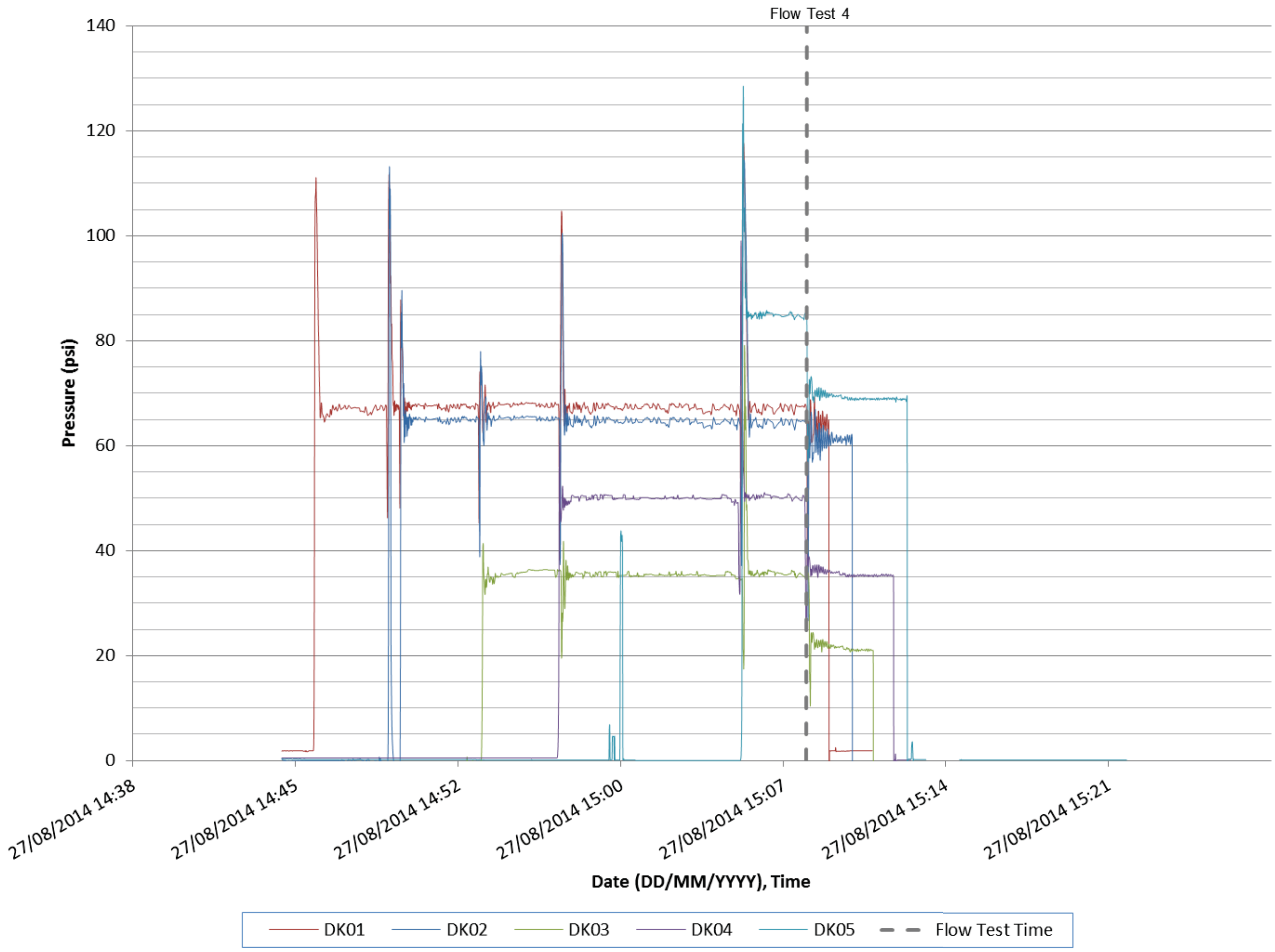


Figure 4-4 Flow Test Set #3

Inflow into the 190 and 200 m HGL Zone is downstream of the Lower Pinnacle, Thomson East, Thomson Lancaster, Elementary and Sunnyside PRVs. All lead valves at the Anmore PRVs were active for static pressure comparisons. For residual pressure comparison, lead valves were closed and all lag valves were opened for the PRVs mentioned above. For the remaining PRVs, lead valves remained active.

Field results were available only for Hydrant Test #4 due to equipment malfunction during field testing. Initially, the static pressures correlated well, while the residual pressures did not correlate well with the model results. Adjusting the 'C'-factor for all pipes downstream of the Sunnyside PRV, from 130 to 100, allowed for better results. Additionally, the downstream pressure settings at the Elementary and Sunnyside lead and lag PRVs were reduced by 6 psi, which allowed for the resolution of three (3) uncalibrated measurements in Hydrant Test #4.

For the 190 m and 200 m HGL Zone, 7 out of the 10 field (static and residual) pressures correlated well with model predicted results.

4.3 Calibration Summary

In summary, an acceptable calibration for much of Anmore's water distribution system has been achieved. Opus DK recommends some field checks to be made by Anmore staff based on adjusted watermain diameters made to the model as detailed above.

While additional spot checks can be made at future dates should Anmore require some verification for those pressure zones not covered through the model calibration process, Opus DK concludes that the calibration program has provided sufficient calibration for the model for the purposes of system analysis.

5 Design Criteria

This section summarizes the design and evaluation criteria used in the assessment of various components within Anmore's water distribution system which includes a review of the pump stations, PRV stations, and the distribution network.

5.1 Pump Stations

As outlined in the MMCD design guideline manual, pump stations are generally designed to meet the maximum day demand of the downstream service areas with the largest pump out of service, provided that storage is available within the service area. If storage is not available, the pumping capacity should meet the peak hour demand with the largest pump out of service. In the case of Anmore where there are no reservoirs present, pump station capacity was assessed against peak hour demands with one pump operational. Only the Uplands pump station was analyzed, as the Pinnacle Ridge pump station is not normally operational under current conditions.

5.2 Service Pressures

Anmore's Works and Services Bylaw No. 242-1998, combined with recommendations from the 2014 MMCD Design Guideline Manual, was used to determine the allowable minimum and maximum pressures in the water system under different demand conditions and is summarized in Table 5-1.

Table 5-1
Service Pressure Requirements

During Maximum Day Plus Fire Flow	Minimum	20 psi (150 kPa)
During Peak Hour	Minimum	40 psi (300 kPa)

5.3 Fire Protection

Water distribution systems must be able to deliver large volumes of water for fire protection in addition to normal water demands. Fire protection assumptions/considerations are:

a. Only one fire will be fought at any one time;
b. To ensure pumper trucks obtain adequate water supplies from hydrants, a minimum residual pressure (20 psi) on the street main is required during fires;
c. Fire flow is coincident with maximum day demand;

Table 5-2 shows the recommended minimum fire flow requirements for various land use areas in Anmore. These values are based on Anmore's Works and Services Bylaw No. 242-1998.

Table 5-2
Fire Flow Requirements

Land Use		Min. Required Fire Flow (L/s)
Urban	Single Family (RS-1)	60
	Cluster Housing (RS-2, RS-3)	120
Suburban	Extensive Rural & Recreational	60
	Campgrounds	60
School	(Any Zone)	120
Institutions	(P-1)	90
Commercial & Industrial	Isolated Commercial	90
	Small Group Commercial	120

6 Model Scenarios

Modeling scenarios were developed in the hydraulic model in order to assess the impact of various demand scenarios on Anmore's existing distribution system. The Average Day Demand calculated in Section 3 was factored by 2.75% to establish 2014 water demands, taking into account a yearly projected population increase of 61 persons. Maximum Day and Peak Hour Demands calculated in Section 3 were based on 2014 data.

The following model scenarios were developed for Anmore's water model:

- **2014 ADD** – 2014 Average Day Demand
- **2014 MDD** – 2014 Maximum Day Demand
- **2014 MDD+FF** – 2014 Maximum Day Demand plus Fire Flow
- **2014 PHD** – 2014 Peak Hour Demand

These scenarios are steady state scenarios and reflect demand consumptions under the existing conditions.

6.1 Fire Flow Scenario Development

In order to assess the current distribution system in its ability to provide sufficient fire flows throughout Anmore, the 2014 MDD+FF scenario was developed.

In the 2014 MDD+FF scenario, with reference to the current landuse zoning provided by Anmore, all of the model nodes were assigned a fire flow criteria based on the landuse type adjacent to the node as noted in Schedule B2 of the OCP. Table 5-2 outlines the fire flow requirements for each landuse type. For nodes neighbouring two different landuse types, the landuse with the higher fire flow requirement was assigned to the node.

7 Existing System Analysis

This section covers the hydraulic analysis of the Anmore water system under existing demand conditions. The objective of the analysis is to assess the system's performance with respect to compliance with the design criteria outlined in Section 5 and to highlight system deficiencies.

7.1 Pump Capacity Analysis

The design capacity of the Uplands pump station is the combined design flow of all the pumps minus that of the largest pump. Table 7-1 compares the required capacity to the available pumping capacity under the existing peak hour demand condition. Based on the analysis below, the Uplands pump station is adequate in meeting the existing peak hour demand.

Table 7-1
Pump Station Analysis

Pump Station	Service Area Zone (HGL)	Capacity Required (L/s)	Design Capacity (L/s)	Excess (L/s)	Deficient?
Uplands	Pumped Zone II (379 m)	1.0	4.2	3.2	No

7.2 Distribution System Analysis

A review of the capacity of Anmore's water distribution mains was carried out with respect to their ability to convey adequate service pressures and fire flows throughout the entire water distribution system. The level of service provided by Anmore's water system under existing demands is highlighted below.

7.2.1 System Pressure Analysis

The system pressure analysis identifies areas in the water distribution system that do not satisfy the minimum pressure criteria of 40 psi under the peak hour demand (PHD) condition. Figure 7-1 illustrates the model predicted PHD pressures throughout the system.

Three (3) nodes under the existing PHD scenario were identified as pressure deficient (pressure < 40 psi). One node, downstream of the Thomson East PRV, is within 5% of meeting minimum pressure criteria, and as such, it is determined that the existing water system network is capable of providing adequate system pressure to the area. The remaining two nodes are immediately downstream of the Sunnyside PRV, and are 10% and 14% below the minimum pressure criteria.

Though Anmore had requested Opus DK to provide PRV setpoints prior to the construction of the model for the purposes of establishing suitable pressures within its zones, the model calibration process has found a lower than expected setpoint set at the Sunnyside and Elementary PRV stations.

7.2.2 Fire Flow Analysis

The fire flow analysis identifies areas within the water distribution system that do not meet the fire flow requirements as outlined in Section 5. A model node is found deficient if the node fails to maintain a residual pressure of at least 20 psi while supplying the required fire flow under the maximum day demand (MDD) condition.

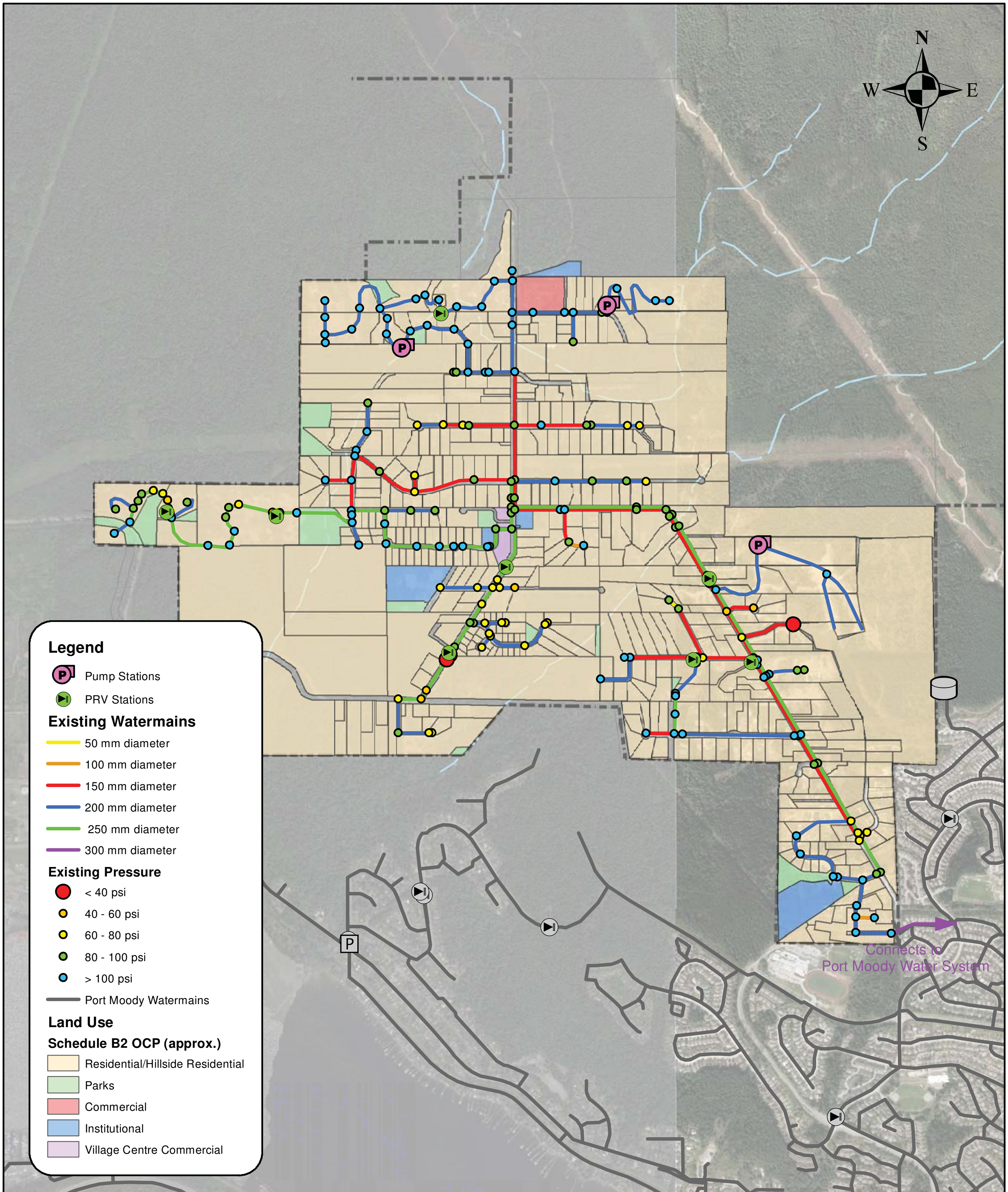
Under the 2014 MDD+FF scenario, the model predicted forty-three (43) fire flow deficient nodes. Additional deficient nodes which are excluded were manually checked and disregarded as deficient if one of the following applies:

- If deficient node is located along a private main
- If deficient node is a non-demand node
- If there is no hydrant in the vicinity of the deficient node

Deficient nodes are highlighted in Figure 7-2. Table 7-1 categorizes the fire flow deficient nodes according to their land use types.

Table 7-1
Summary of Fire Flow Deficiencies

Land Use		
Urban	Single Family (RS-1)	36
	Cluster Housing (RS-2, RS-3)	0
Suburban	Extensive Rural & Recreational	2
	Campgrounds	
School	(Any Zone)	0
Institutions	(P-1)	0
Commercial & Industrial	Isolated Commercial	5
	Small Group Commercial	0



OPUS DAYTONKNIGHT

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Client: Village of ANMORE

Existing Pressures Peak Hour Demand

Project No: D-85702.00		Scale: 0 125 250 Meters	
Designed: ML		1:40,000 @ Tabloid	
Drawn: ML	Approved: CL		
Note:		Map No 1	Date FEB 2015
Figure 7-1		Revision	Revision Date

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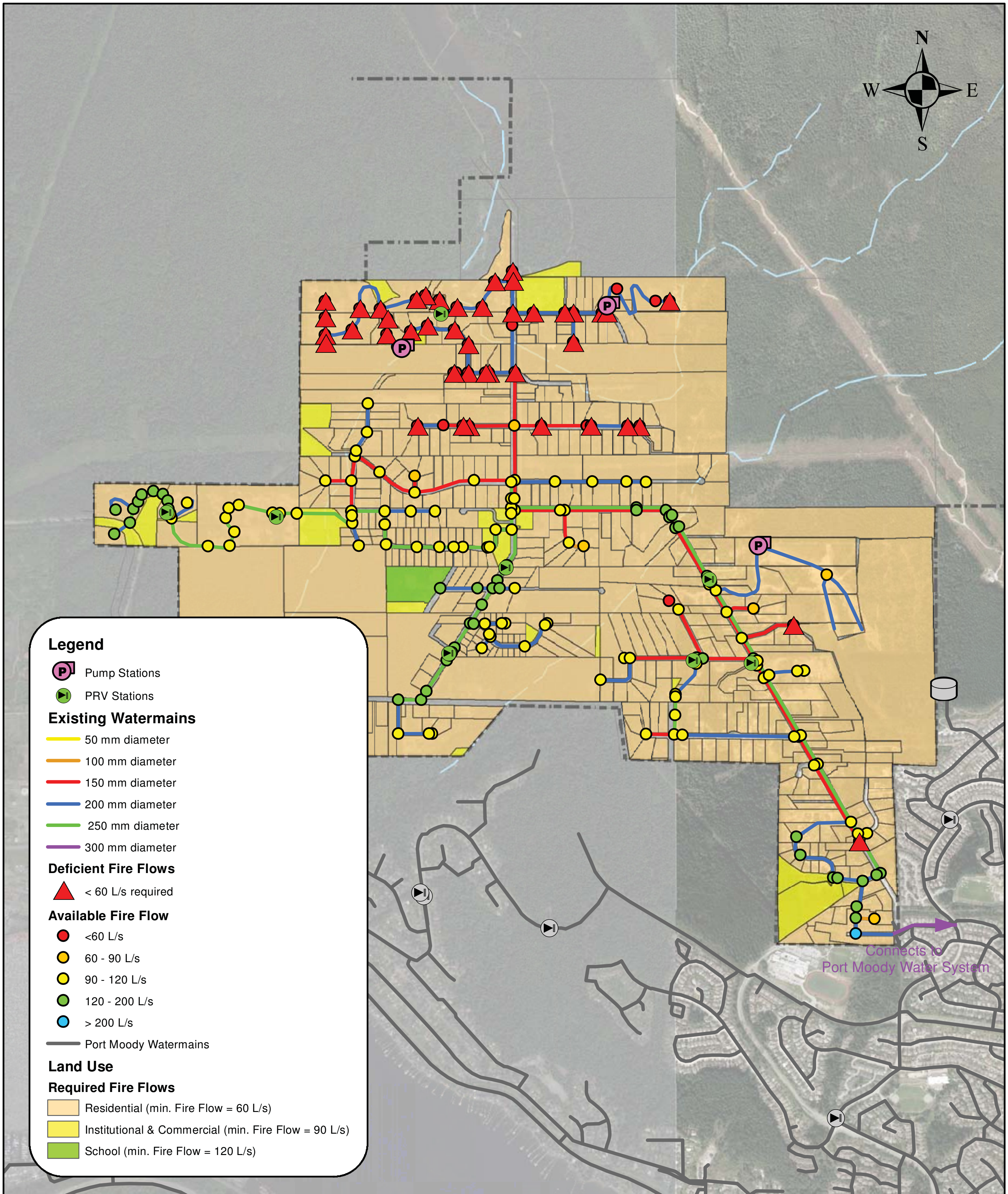

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Client: Village of ANMORE

Existing Fire Flow Maximum Day Demand

Project No:	D-85702.00
Designed:	ML
Drawn:	ML
Approved:	CL
Note:	
Scale:	0 125 250 Meters 1:40,000 @ Tabloid
Map No	1
Date	FEB 2015
Revision	
Revision Date	

Figure 7-2

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8 Closure

This technical memorandum presents Opus DK's progress to date on developing Anmore's Water Utility Master Plan. Works include the water model development, demand allocation, model calibration, design criteria development, model scenario development, and a capacity analysis of the existing system. The existing system analysis has identified current pressure and fire flow deficiencies in Anmore's water distribution system, and does not include any improvement options.

Improvement projects to address deficiencies (such as watermain upsizing to address fire flow deficiencies) will be sized towards resolving future system deficiencies in the Water Utility Master Plan. At that time, resolutions to deficient nodes under the existing condition would also be assessed for comparison to determine a suitable timeframe to undertake the improvement works.

We trust you will find the foregoing technical memorandum suitable. Please do not hesitate to contact the undersigned should you have any questions.

Yours truly,

Opus DaytonKnight Consultants Ltd

Clive Leung, P.Eng.
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Village of Anmore Model Development, Calibration, and Existing System Analysis

Appendix A

Date	Flow set no.	Location	Hydrant Test No. & Time	Flow (L/s)	Test ID	Nearest WaterCAD node	Hydrant No.	Elev. (m)	Field Result Static (psi)	Field Result Residual (psi)	Field Result Static HGL (m)	Field Result Residual HGL (m)	Computer Result Static (psi)	Computer Result Residual (psi)	Computer Result Static HGL (m)	Computer Result Residual HGL (m)	Static Pressure Diff (psi)	% diff Static Pressure	Residual Pressure Diff (psi)	% diff Residual Pressure	Demand Boundary Conditions
27-Aug-14	1	290 m HGL zone	Q1	65.1	S1-Q1	2091	97	191													MDD
			13:27		S1-PR1	2091	96	192	138.2	89.2	289.0	254.5	139.2	93.3	289.7	257.4	1.0	0.7%	4.1	4.6%	
					S1-PS1	376	91	202	127.3	115.4	291.1	282.7	127.4	121.0	291.2	286.7	0.1	0.1%	5.7	4.9%	
					S1-PS2	1006	79	214	102.5	78.9	286.4	269.9	107.2	78.9	289.8	269.9	4.7	4.6%	0.0	0.0%	
					S1-PS3	2069	87	209	110.6	89.9	287.0	272.4	115.2	93.1	290.2	274.7	4.6	4.1%	3.2	3.6%	
					S1-PS4	2088	94	189	141.5	96.7	288.6	257.1	143.1	99.5	289.7	259.1	1.6	1.1%	2.8	2.9%	
			Q2	66.9	S1-Q2	2105	77	218													
			14:20		S1-PR2	2107	75	201	127.1	122.6	289.9	286.8	126.6	94.6	289.6	267.1	-0.5	-0.4%	-28.0	-22.8%	
					S1-PS1	376	91	201.6	126.9	125.4	290.8	289.7	127.4	120.8	291.2	286.6	0.5	0.4%	-4.6	-3.6%	
					S1-PS2	1006	79	214.4	101.6	97.6	285.8	283.0	107.2	78.3	289.8	269.5	5.6	5.5%	-19.3	-19.7%	
					S1-PS3	2069	87	209.2	111.0	105.5	287.3	283.4	115.2	92.1	290.2	274.0	4.2	3.8%	-13.4	-12.7%	
					S1-PS4	2088	94	189.1	141.3	138.1	288.4	286.2	143.1	114.2	289.7	269.4	1.8	1.3%	-23.9	-17.3%	
			Q3	71.0	S1-Q3	2069	86	208.4													
			14:03		S1-PR3	2067	85	214.4	108.5	104.3	290.7	287.7	108.4	83.7	290.6	273.3	-0.1	-0.1%	-20.6	-19.8%	
					S1-PS1	376	91	201.6	127.2	125.6	291.0	289.9	127.4	120.3	291.2	286.2	0.2	0.2%	-5.3	-4.2%	
					S1-PS2	1006	79	214.4	103.0	98.7	286.8	283.8	107.2	82.7	289.8	272.6	4.2	4.1%	-16.0	-16.2%	
					S1-PS3	2069	87	209.2	110.6	106.8	287.0	284.3	115.2	88.8	290.2	271.6	4.6	4.1%	-18.0	-16.9%	
					S1-PS4	2088	94	189.1	141.3	137.0	288.5	285.4	143.1	118.5	289.7	272.4	1.8	1.2%	-18.5	-13.5%	
			Q4	58.0	S1-Q4	J-1500	83	241.8													
			13:48		S1-PR4	2076	H-1	208	115.7	102.5	289.4	280.1	117.8	103.9	290.8	281.1	2.1	1.8%	1.4	1.3%	
					S1-PS1	376	91	201.6	124.8	118.7	289.4	285.1	127.4	121.9	291.2	287.3	2.6	2.1%	3.2	2.7%	
					S1-PS2	1006	79	214.4	101.4	87.5	285.7	275.9	107.2	88.3	289.8	276.5	5.8	5.8%	0.8	0.9%	
					S1-PS3	2069	87	209.2	111.4	95.3	287.5	276.2	115.2	96.8	290.2	277.3	3.8	3.4%	1.5	1.6%	
					S1-PS4	2088	94	189.1	141.1	124.9	288.3	276.9	143.1	124.1	289.7	276.4	2.0	1.4%	-0.8	-0.6%	
27-Aug-14	2	242 m HGL zone	Q1	36.9	S2-Q1	1021	26	192.9													MDD
			10:28		S2-PR1	2054	25	180.9	97.4	77.5	249.4	235.4	94.8	59.0	247.6	222.4	-2.6	-2.7%	-18.5	-23.9%	
					S2-PS1	1008	66	186.7	89.3	82.7	249.5	244.8	86.9	77.4	247.8	241.1	-2.4	-2.7%	-5.3	-6.4%	
					S2-PS2	J-1562	45	173.6	108.4	100.1	249.8	244.0	105.3	93.6	247.7	239.4	-3.1	0.0	-6.5	-6.5%	
					S2-PS3	J-1525	22	191.7	87.4	66.2	253.2	238.3	79.5	55.6	247.6	230.8	-7.9	-0.1	-10.6	-16.0%	
					S2-PS4	1031	34	159.9	120.1	113.2	244.3	239.5	124.8	112.9	247.7	239.3	4.7	0.0	-0.3	-0.2%	
			Q2	52.2	S2-Q2	2195	32	185.1													
			10:08		S2-PR2	1034	31	168.2	111.5	90.1	246.6	231.5	112.9	89.7	247.6	231.3	1.4	1.2%	-0.4	-0.4%	
					S2-PS1	1008	66	186.7	88.6	76.8	249.0	240.7	86.9	76.7	247.8	240.6	-1.7	0.0	-0.1	-0.1%	
					S2-PS2	J-1562	45	173.6	107.4	93.8	249.1	239.5	105.3	90.7	247.7	237.4	-2.1	-2.0%	-3.1	-3.3%	
					S2-PS3	J-1525	22	191.7	87.6	65.4	253.3	237.7	79.5	64.4	247.6	237.0	-8.1	-9.2%	-1.0	-1.5%	
					S2-PS4	1031	34	159.9	121.4	105.1	245.3	233.8	124.8	108.3	247.7	236.1	3.4	2.8%	3.2	3.0%	
			Q3	50.1	S2-Q3	1033	39	186													
			9:36		S2-PR3	1030	38	187.5	88.9	66.9	250.0	234.6	85.6	66.9	247.7	234.5	-3.3	-3.7%	0.0	0.0%	
					S2-PS1	1008	66	186.7	91.4	74.1	251.0	238.8	86.9	76.8	247.8	240.7	-4.5	-4.9%	2.8	3.7%	
					S2-PS2	J-1562	45	173.6	109.0	89.7	250.3	236.6	105.3	90.7	247.7	237.4	-3.7	-3.4%	1.0	1.1%	
					S2-PS3	J-1525	22	191.7	84.7	66.2	251.3	238.3	79.5	65.6	247.6	237.8	-5.2	-6.2%	-0.6	-0.9%	
					S2-PS4	1031	34	159.9	122.5	99.9	246.0	230.1	124.8	108.0	247.7	235.8	2.3	1.9%	8.2	8.2%	
			Q4	33.6	S2-Q4	J-1553	12	175.9													
			10:50		S2-PR4	J-1537	13	170.9	110.9	87.3	248.9	232.3	109.1	81.5	247.6	228.2	-1.8	-1.7%	-5.8	-6.6%	
					S2-PS1	1008	66	186.7	89.8	82.5	249.8	244.7	86.9	77.6	247.8	241.3	-2.9	-3.2%	-4.9	-5.9%	
					S2-PS2	J-1562	45	173.6	108.2	100.3	249.7	244.1	105.3	94.1	247.7	239.8	-2.9	-2.7%	-6.2	-6.2%	
					S2-PS3	J-1525	22	191.7	84.9	64.7	251.4	237.2	79.5	57.7	247.6	232.3	-5.4	-6.4%	-7.0	-10.9%	
					S2-PS4	1031	34	159.9	121.7	113.3	245.5	239.5	124.8	113.4	247.7	239.6	3.1	2.5%	0.2	0.1%	
27-Aug-14	3	190 m and 200 m HGL zones	Q1	71.0	S3-Q1	2159	51	157.9													MDD
			15:45		S3-PR1	2159	49	164.2	-	-	-	-	-	-	-	-	-	-	-	-	
					S3-PS1	2159	50	163.1	-	-	-	-	-	-	-	-	-	-	-	-	
					S3-PS2	2176	54	158.3	-	-	-	-	-	-	-	-	-	-	-	-	
					S3-PS3	2244	57	143	-	-	-	-	-	-	-	-	-	-	-	-	
					S3-PS4	2182	58	132.8	-	-	-	-	-	-	-	-	-	-	-	-	
			Q2	0.0	S3-Q2	2174	53	161.7													
			0:00		S3-PR2	2170	52	152.1	-	-	-	-	-	-	-	-	-	-	-	-	
					S3-PS1	2159	50	163.1	-	-	-	-	-	-	-	-	-	-	-	-	
					S3-PS2	2176	54	158.3	-	-	-	-	-	-	-	-	-	-	-	-	
					S3-PS3	2244	57	143	-	-	-	-	-	-	-	-	-	-	-	-	
					S3-PS4	2182	58	132.8	-	-	-	-	-	-	-	-	-	-	-	-	
			Q3	58.0	S3-Q3	2178	56	162.9													
			15:25		S3-PR3	J-1516	55	160.8	-	-	-	-	-	-	-	-	-	-	-	-	
					S3-PS1	2159	50	163.1	-	-	-	-	-	-	-	-	-	-	-	-	
					S3-PS2	2176	54	158.3	-	-	-	-	-	-	-	-	-	-	-	-	
					S3-PS3	2244	57	143	-	-	-	-	-	-	-	-	-	-	-	-	
					S3-PS4	2182	58	132.8	-	-	-	-	-	-	-	-	-	-	-	-	
			Q4	60.4	S3-Q4	2186	61	122.9													
			15:08		S3-PR4	J-1571	60	106.3	84.9	69.9	166.0	155.4	87.9	69.9	168.1	155.5	3.0	3.5%	0.1	0.1%	
					S3-PS1	2159	50	163.1	67.7	61.3	210.7	206.2	65.3	64.2	209.0	208.2	-2.4	-3.5%	3.0	4.8%	
					S3-PS2	2176	54	158.3	64.8	57.9	203.8	199.0	72.1	69.5	209.0	207.2	7.3	11.3%	11.6	20.0%	
					S3-PS3	2244	57	143	35.7	23.7	168.1	159.6	35.9	27.4	168.2	162.3	0.2	0.6%	3.7	15.7%	
					S3-PS4	2182	58	132.8	50.2	36.5	168.1	158.5	50.3	39.8	168.2	160.8	0.1	0.2%	3.3	9.0%	

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TO	Kevin Dicken
COPY	Lisa Mirfatahi
FROM	Catherine S. Dallaire
DATE	May 15, 2015
FILE	D-85702.00
SUBJECT	Technical Memorandum #4: OMI Program Plan & Condition Rating System

1 Background

Local governments most often build their operating budgets based on the previous year's expenditures. This approach reinforces the political and public expectation that budgets should remain static, yet, this is not a true reflection of the variance in the financial investments that governments like the Village of Anmore (Anmore) require to maintain infrastructure over time. By discounting the variable nature of the state of the infrastructure and the fact that its scale expands as the community grows, this historical approach does not ensure the sustainability of acceptable levels of service.

As part of its Water Utility Master Plan (WUMP), Anmore requested a review of the existing utility billing structure and service levels to determine an appropriate funding model to support current and long-term capital and operating needs. The full cost recovery funding analysis undertaken by Opus DaytonKnight Consultants Ltd. (Opus DK) within this WUMP considers both the growth of the system, its condition, and Operations, Maintenance and Inspection (OMI) Plan in determining the annual budget. The OMI Program was determined as per the findings included in this Technical Memorandum.

2 Asset & Maintenance Management

Assets are the means by which an organization delivers services to its customers. An asset's functional failure can be considered to have occurred when an asset can no longer fulfill its prescribed function in service delivery. Asset failure can thus be a result of physical deterioration, or a result of a change in demand exceeding the assets capacity to deliver what is a newly prescribed service. In the case of water assets for example, capacity is generally hydraulic performance, but can also include quality measures such as established water quality parameters.

While the focus of this report is on developing the approach to monitoring the physical state of water utility assets, it is important to understand that this is merely one piece of the puzzle. The assets ability to meet changing service expectations (hydraulically, for example) is equally important and was verified through the WUMP.

One of the goals of Asset Management (AM) is to ensure delivery of the service level agreed to, and paid for, by customers at the lowest life cycle cost. A key element in achieving this goal is to ensure assets meet their expected service lives through asset care measures. Another key element is to monitor asset condition and asset performance to intervene at the optimum point in its service life to either upgrade, repair, or replace the asset or its components. Maintenance and monitoring must be completed with sufficient regularity that mitigates the risk of not delivering the level of service agreed to. The question is: what do we do, what do we measure, and how often do we do this?

The legitimacy of Anmore's sought after financial plan, completed within the WUMP project is reliant on well-defined Operations, Maintenance, and Inspection (OMI) programs and appropriate service levels for each. Opus DK provided recommendations regarding the scope of current operational practice/procedures and technical service levels within this WUMP project task. These were captured in an annual OMI program plan.

3 Methodology

Annual OMI program plans enable utility managers to improve their OMI management practice, prepare budgets, and defend utility rate reviews. We used a similar approach with Anmore by capturing the optimised scope, unit costs, benefit, operational levels of service, and governance aspects of each program in an annual OMI program plan. The OMI financial analysis that will stem from this project task will be incorporated in the water utility financial model. It will offer a baseline operating funding requirement that will be revised to determine the appropriate and affordable levels of service for Anmore during the Financial Modelling project task.

3.1 Activity Types

The OMI program plan that was developed with utility personnel is a high level outline of the full range of services and activities needed for the operation, maintenance, and inspection of the following asset classes at Anmore:

- Service Connections
- Hydrants
- Pressure Reducing Valves
- Meters
- Air Valves
- Watermains
- Mainline Valves
- Pump Stations
- Chlorination Equipment
- Reservoir (Proposed in WUMP)

For the purposes of the OMI program plan the programs were analysed as either: maintenance, operation, inspection, or capital work. Operational inspections and preventative maintenance are actions that ensure the proper care of assets and the monitoring of the system's operation. These activities, typically, are the first programs to suffer from budget strapped organisations as funds get diverted to repairs and capital projects that inherently require immediate attention. This straightforward categorisation of each program identified the varying degree of control Anmore has on operational service levels and consequently the annual operating program costs.

Activities that may not be linked to an individual asset that must be accounted for in the annual OMI program plan will also be captured. Responding to water quality complaints and water quality sampling are examples of such activities that draw on resources.

3.2 Scope of Activities

Knowledge and available records of existing programs served as the basis for the plan and the description of each activity. These were captured during a workshop with Anmore staff and during subsequent meetings over the phone and the internet.

The scope of each program, the requirement, and the benefits of the existing program were reviewed and documented by Opus DK. Program shortcomings were also identified. Opus DK included the following during the OMI program development:

- All regulatory requirements are being met in the program base
- Operational practices promote the service life of assets
- OMI related standards, policies, and bylaws are reviewed
- Operational practices promote a safe potable water supply and maintain water quality
- The program base encompasses elements of industry standards appropriate for Anmore

Through discussions with Anmore staff, Opus DK brought forward high level recommendations for alternative approaches to existing programs or new programs. The scope of work involved in each program's typical work order is the basis for the operating funding needs analysis.

3.3 Unit Costs

The outline of unit labour, vehicle cost, and contracted service for each OMI activity is the basis for the financial analysis. Typical work order and unit costs for each OMI program were therefore developed to include labour rates, hours, and burdened salaries, equipment, and contracted service costs. These typical unit costs were determined with the use of existing records where possible or estimated in consultation with key Anmore staff.

Knowing the availability and skill set of the human resources in the utility, the Manager of Water Operations played a pivotal role here. During OMI program review meetings with Opus DK he estimated, for each new program, the resources that would be required to complete one standard work order and the average time to complete each work order. He also determined when hired services should be contracted to complete maintenance activities.

Anmore provided the unit labour and vehicle rates as well as the complete list of transactions charged to the water utility accounts for 2013 and 2014. The time charges are coded using an alphanumerical code that is as follows UT##. In order to decipher the transactions, many labelled "AP Invoice Entry," Anmore shared with Opus DK the vendor # codes used by the accountants. This complete set of information was then used to calculate the unit cost of each OMI activity and overall utility expenditures on consumables.

During the workshop Opus DK will review with utility staff current operational service levels by identifying system trends, missed targets, and any overuse of existing programs. Opus DK will also seek to quantify with Anmore staff the current ratio of operation, to maintenance/repair, to reinvestment work being completed. This will serve to inform how the current frequency of repair activities may increase or remain steady over the long term planning horizon of the financial plan.

3.4 Service Level Assessment & Affordability

The desired operational service levels establishes an ideal annual frequency for the full range of OMI program activities that were incorporated into the OMI program plan. Anmore staff were given the opportunity to revise the desired technical service level of each program.

This desired frequency in conjunction with asset quantities and unit costs were used to develop a baseline operating funding requirement. The initial OMI financial analysis of desired operational service levels was revised to appropriate service levels. This revision was completed to ensure that the total operating funding requirement is affordable and any consequent rate increase is reasonable. As identified in the RFP, Anmore was right to expect that service levels would be reviewed to determine an appropriate funding model to support current and long term capital and operating needs.

The appropriate operational service levels of the OMI programs were determined in collaboration with key Anmore staff during the financial modelling WUMP project task. This was to ensure buy-in from Anmore staff for the final OMI program plan and practice a justification methodology to determine the annual operating budget for Anmore.

With this information Opus DK subsequently conducted an analysis of the current annual vs. desired frequency or predicted occurrences of OMI activities. The operational service levels of current and new OMI programs were scaled to:

- Meet water quality objectives
- Mitigate risk exposure
- Balance the impacts of an aging system with reinvestment
- Reflect industry standards
- Reflect growth related network expansion
- Reflect regulation
- Correct historical gaps by diverting efforts to programs that require an increase in resources

3.5 Budget

The proposed annual budget is the product of each program annual occurrence (service level) multiplied by its total unit cost. The calculation results of existing programs were compared to the actual historical expenditures when the information was available. The required revenues identified during this WUMP project phase were used to provide recommendations for O&M revenue requirements in the financial modelling project task of the WUMP.

4 Condition Rating System

4.1 Basis for a Condition Assessment Framework

Completing inspections, collating condition information, and keeping the datasets up-to-date can require significant effort. The cost of this effort and the method employed must be balanced against the realistic influence that this information has on:

- Financial planning with improved estimates of service lives;
- Mitigating medium or high risk;
- Determining most appropriate (optimal) treatment option or maintenance intervention;
- Demonstrating due diligence; and
- Maintaining compliance.

Therefore Anmore must determine what it intends to achieve with the condition information before initiating the changes to its condition assessment programs, especially record keeping of operational inspections. It is only when it formally plans to include the result of condition assessments in its AM practice that it can defend the need for a protocol for consistent condition assessments and recording that would have to be followed by the field crews.

Condition assessments primarily completed to maintain compliance or to demonstrate due diligence are an exception to this, they have limited influence on the optimisation of decisions. The findings of these assessments, such as fire hydrant tear downs and water quality tests, predominantly direct immediate corrective action (repairs) to critical assets or services. There is also little effect one can have on the scope and frequency of these assessments.

4.2 Decisions Based on Asset Condition

A decision maker's condition information needs should be economical to satisfy and just adequate at providing a reasonable level of confidence in the outcome of the AM analysis. It is important to bear in mind that only a sufficient and cost-effective level of data is necessary to make most AM related decisions effectively; extraneous but interesting condition information for these analyses add little value and draw on limited resources. Condition assessments completed to inform financial plans for example fall within this broader analytical process.

Other decisions are much more engaged and require a higher input of technical information. Similarly the failure of certain complex assets that must be avoided at all reasonable cost may also require the employ of a specialist. Any expense on such high cost condition data needs to be justified by high asset criticality, either because of its replacement cost or its functional role, or the nature of the asset which requires a specialist rehabilitation.

The following table, adapted from the "*Visual Assessment Manual For Utility Assets*[1]", depicts how decision makers can employ condition data for each of these purposes that generally build

[1] New Zealand Water and Wastes Association Inc., *Visual Assessment Manual For Utility Assets*, (Wellington, NZ: NZWWA, 2008).

on each other. Its contents guided the development of the optimised OMI program plan recommendations.

Table 4-1 Three Stages to Asset Condition Analysis

Purpose of Assessment	Recommended Analysis
To identify general condition of assets for long term planning.	• Determine general trends in condition of asset group with maintenance records and visual assessment (including operational inspection) results. • Assign or revise condition grading. • Identify assets that need urgent attention according to visual assessment and operational inspections. • Determine longer-term AM strategy
To identify the condition of critical assets to mitigate risk.	• Ensure criticality ratings are current and robust –conduct criticality review as needed. • Maintenance records review, asset assessment, and condition grading by experienced engineer or asset specialist to determine remaining life and failure modes of critical assets. • Condition assessment method may also include online-condition monitoring and analysis of reading by specialist. • Develop an end-of-life management strategy based on above.
To identify the type and/or timing of corrective maintenance needed to restore or maintain agreed levels of service.	• Consider specialist assessment – e.g. by materials specialist, structural or electrical or mechanical engineer etc. • Experienced engineer or asset specialist determines works required to restore or maintain agreed levels of service. • Determine intervention options and develop management program.

The description of the pipelines, structures, mechanical components, and electrical components condition rating scales are provided in the sections that follow with the list of asset groups they should be applied to.

4.3 Condition Ratings

Developing a consistent measure of asset condition is an important part of AM. It quickly enables a high level understanding of system state of good repair, and contributes to making re-investment decisions across different asset types. There is a variety of condition rating scales used in the industry for this purpose, but the predominantly accepted scale is the numeric one.

The numeric scale is structured with the lowest number indicating an "excellent" condition and the highest number indicating a failed state or an imminent failure. The IIMM suggests a 1 – 5 numeric scale as a simple condition rating measure.

Condition rating scales are not necessary for assets whose conditions do not impact decision making regarding their maintenance or replacement. The maintenance strategy for certain assets involves an immediate repair or replacement, covered by the operating budget, as soon as they are found to be faulty during an operational inspection (fire hydrant). This strategy is usually applied to assets which reach technological obsolescence prior to failing (SCADA) or with random and sudden failure pattern (automatic transfer switch, light bulb). A 1-5 condition rating would not equal the value that accurate work history records provide for these types of assets.

In our view, the 1 – 5 scale provides a sufficiently detailed and appropriate indication of condition for Anmore as it works towards improving various aspects of its AM practice. The sections that follow provide a broad description of the 1 – 5 scale that can be applied to all relevant assets.

4.3.1 Pipelines and Structures

Table 4-2 outlines the proposed 1-5 condition ratings and descriptions to be referenced when undertaking a condition assessment on assets such as pipelines and structures.

Table 4-2 Proposed Condition Ratings for Pipelines and Structures

Grade	Condition Rating	Pipelines and Structures Description
1	Very Good	Sound physical condition. Component able to perform adequately without major work.
2	Good	Acceptable physical condition; some signs of early deterioration, but minimal short-term failure risk. Only minor work required (if any).
3	Fair	Showing signs of component deterioration; failure unlikely within next 2 years but further deterioration likely and major replacement likely within next 10 years. Minor components or isolated sections of the asset need replacement or repair now but asset still functions safely at adequate level of service. Work required but asset is still serviceable.
4	Poor	Failure likely in short-term. Likely need to replace most or all of asset within 2 years. No immediate risk to health or safety but work required within 2 years to ensure asset remains safe. Substantial work required in short-term; asset barely serviceable.
5	Critical	Failed or failure imminent. Immediate need to replace most or all of asset. Health and safety hazards exist which present a possible risk to public safety or asset cannot be serviced/operated without risk to personnel. Major work or replacement required urgently.

This rating should be used to log condition of the following assets:

- Watermains
- Chambers (PRV and Air Valve)
- Reservoir
- Buildings (Pump & Rechlorination Stations)

4.3.2 Mechanical Components

Table 4-3 outlines the proposed 1-5 condition ratings and descriptions to be referenced when undertaking a condition assessment on mechanical components.

Table 4-3 Proposed Condition Ratings for Mechanical Components

Grade	Condition Rating	Mechanical Description
1	Very Good	Equipment is physically sound & performing as intended. Maintenance costs (Mechanical) are within normal range.
2	Good	Acceptable physical condition; Minor signs of equipment deterioration such as increased vibration, looseness, misalignment, slight leaks. Maintenance costs (Mechanical) increasing but still within normal range.
3	Fair	Showing signs of equipment deterioration greater than 2 above. Increasing corrosion, vibration etc. Maintenance (Mechanical) beginning to exceed standards.
4	Poor	The condition of the equipment is impacting on performance, serviceability and affecting the process. Significant leaks, vibration, looseness, misalignment or out of balance. Maintenance costs (Mechanical) greatly exceed standards.
5	Critical	No longer performs required function. Maintenance costs (Mechanical) unacceptably high.

This rating should be used to log condition of the following assets:

- Pumps
- Motor
- Piping and valves (in Pump Stations, Rechlorination Station, and PRV Stations)
- Generator
- PRV

4.3.3 Electrical Components

Table 4-4 outlines the proposed 1-5 condition ratings and descriptions to be referenced when undertaking a condition assessment on electrical components.

Table 4-4 Proposed Condition Ratings for Electrical Components

Grade	Condition Rating	Electrical Description
1	Very Good	No abnormalities and resembles as new. Maintenance costs (Electrical) are within normal range.
2	Good	Acceptable physical condition. Minor signs of equipment deterioration but requires little, if any repairs and is not generally affecting safety and its ability to perform its function. Maintenance costs (Electrical) increasing but still within normal range.
3	Fair	Showing signs of equipment deterioration. Maintenance (Electrical) beginning to exceed standards.
4	Poor	Equipment condition is impacting performance, serviceability and affecting the process. Maintenance costs (Electrical) greatly exceed standards.
5	Critical	No longer performs required function. Maintenance costs (Electrical) unacceptably high.

The majority of electrical assets fail suddenly; they do not have a gradual deterioration pattern. This rating should therefore be used to log condition of the electrical components which fail gradually. These components are namely motor control centres, wiring, and connectors.

4.4 Asset Condition and Record Keeping

Once the Anmore leadership has established how the asset condition information will be used they are in a position to communicate this to those members of the organisation and the hired service providers that will be responsible for gathering it. This plays a great deal in developing buy-in for the internal program changes which can lead to consistency and quality of the asset condition information base for future capital planning and OMI projects.

5 Detailed OMI Program Review

5.1 Preventative Maintenance and Inspections

5.1.1 Rechlorination Station

The rechlorination station is a critical asset that enables Anmore to monitor water quality and quantity in its utility network. It is one of the most complex assets on the network. It is comprised of structural and mechanical components, such as the booster pumps, hypochlorite pumps, and piping valves, as well as electrical and instrumentation components. Each asset sub-group has different deterioration patterns that should be monitored.

The station requires regular operational inspections; it is not equipped with a backup generator nor is it remotely monitored with SCADA. Though the station is equipped with a direct dialer to contact on-call personnel in case of an alarm (low chlorine, low tank level, spill, intrusion, etc...)

this does not prevent the need for operators to routinely verify the sound operation of the facility. Operators tend to the station Monday, Wednesday, and Friday. The operational inspection program already in effect was included in the list of OMI programs for the station.

The building's wood siding requires annual preventative care measures to ensure the aesthetic function of this building element is maintained. Though not listed here condition assessment of architectural elements of the building enclosure and grounds is included in the cost of the same activity for the pump station to ensure consistency in the assessment methods.

Table 5-1 Rechlorination Station Programs

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
Operational Inspection (UT05)	Operators verify that the equipment operates as intended. Logs required for regulatory purposes are maintained. Data stored on the data logger is transferred to a USB drive and then saved on a computer at the utility office. If a repair is required or a deficiency is identified these are reported and corrective actions are discussed. Equipment condition and set points are also verified at this point. Signs of corrosion and other deterioration mechanisms should be noted.	$22,311	240
Condition Inspection - Mechanical & Electrical	Detailed condition rating of mechanical and electrical equipment and controls.	$1,872	4
Treatment of Building Wood Siding	Treatment of the wood sidings of the chlorination station building.	$686	2
	Total	**$24,869**	**246**

5.1.2 Water Sampling Stations

Water sampling stations are an asset class that do not have established preventative care methods to mitigate their deterioration. The OMI activity identified for the water sampling station is water quality related and pertains to the collection of water samples to be tested. Their condition is visually observed and monitored as part of this activity.

Service-level adjustments and optimisations could not be determined for this asset class since the collection of water samples is a regulated activity. Its frequency is predetermined by the health authority.

Table 5-2 Water Sampling Station Program

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
Operational Inspection & Water Quality Tests (UT02)	Every other week a water operator verifies that the equipment operates and records the station inspection in the station's log. This task also covers the collection of chlorine residual samples at the stations and elsewhere in the network as well as the transport of the water samples to an accredited laboratory to be tested. If a repair is required or a deficiency is identified these are reported and corrective actions are discussed. Equipment condition and set points are also verified at this point. Signs of corrosion and other deterioration mechanisms should be noted.	$11,527	124
	Total	**$11,527**	**124**

5.1.3 Water Pump Stations

Pump stations are one of the most complex assets in a water utility network as they are made of very different components with different deterioration patterns. They are comprised of structural and mechanical components such as the pumps and piping valves, as well as electrical components such as the generators. Each asset sub-group has different deterioration patterns that should be monitored.

Pinnacle Ridge pump station must be inspected on a weekly basis, and when triggered by an alarm, by an operator to verify that it is operating smoothly. This activity is in keeping with industry practice which is akin to a maintenance superintendent walking the factory floor. It is currently completed by Anmore staff. Vegetation control and ground keeping activities also occur on a regular basis. The frequency of this activity depends on the season we estimated an average of 52 occurrences over the course of the year. This activity was separated into a different line item on the pump station programs list because it is completed by different staff and has different scope.

Generator inspections by a hired specialist are currently completed on a regular basis in Anmore. The scope of work completed and report submitted by the specialist must be in keeping with the CSA C282 Generator Maintenance Requirement Standard. The report submitted by the specialist should include the assignment of a condition rating in keeping with the condition rating framework adopted by Anmore. Though generator inspections lead to corrective measures this asset group will deteriorate over time at which point it will be more economical to replace the high cost asset.

A specialist is hired annually to inspect the fire pump's operation. This is a preventative care measure on a critical asset that needn't be revised. This program is sufficient to monitor the condition of the pumps, it is not economical to tear down the pumps to complete a detailed inspection of its components. Depending on the water quality these assets are not exposed to harsh environmental factors. This is unlike sewer pumps which are impacted by grit, fats, oils, and grease.

In keeping with best practices, annual inspections of building enclosures and grounds were added so that the needs for repairs are identified and are not left unattended. Condition inspections for the building enclosure and grounds are important since these asset are the most exposed to the environment and weather elements.

Table 5-3 Pump Station Programs

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
Pump Station Weekly Inspection (UT05)	Weekly inspection of facility and equipment for cleanliness, leaks, corrosion and damage. Pumps are checked for noise and vibrations. The lights, ventilation fans, heater, sump pump and drains are also checked for operation. The pump meters are read and, where applicable, fire pumps are tested. The pump control valves are inspected. Standby generators are also visually inspected and periodically operated. Strainer is cleaned and inspected. Pump oil levels on pumps are checked.	$7,809	84
Vegetation Control	Clearing of vegetation around pump station and other facilities.	$4,834	52
Generator Inspection (UT##)	This annual inspection must follow the maintenance tasks dictated by the CSA C282 Generator Maintenance Requirement Standard. The condition of the fuel storage tank needs to be monitored as this component poses a unique environmental risk; this is also a part of CSA C282. A condition rating should be recorded for the generator and fuel tank assets following the inspection findings.	$5,372	4
Condition Inspection - Mechanical & Electrical (UT##)	Detailed condition rating of mechanical and electrical equipment and controls.	$2,850	4

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
Condition Inspection – Building Enclosure & Grounds (UT##)	Detailed inspection of architectural elements of the building enclosure and grounds (fence, paving, sidewalks, etc.). This cost also covers an inspection of the rechlorination station building to ensure consistency in assessment methods for each asset. A condition rating should be recorded for building assets following the inspection findings.	$1,372	4
	Total	**$23,297**	**148**

5.1.4 Distribution Mains

Distributions mains are an asset class that do not have established preventative care methods to mitigate their deterioration. Though there are proactive condition assessment measures that Anmore can take to monitor their aging process these are currently cost prohibitive. The OMI activities identified for the distribution mains are water quality related.

The two watermain flushing programs identified have the purpose of maintaining water quality in the network either by targeting chlorine residuals or sediment build up. Service-level adjustments and optimisations could not be determined for this asset class at this time due to insufficient residual chlorine information. Adjustments were only made in the long-term financial plan to account for the impact of looping projects planned within the WUMP.

The costs listed in Table 5-4 only include labour and equipment hours, it does not include the cost of water flushed. Anmore has the UT 06 timecode to monitor flushing activities. The hours recorded to this code in 2014 do not reflect the level of activity actually completed according to the operational practices discussed with senior staff. Usage patterns of the time code and the time code structure for flushing should be revised. Dead end main flushing should be tracked separately from unidirectional flushing. Each activity has different scope and serves a different function. Optimization of each practice would benefit from better time and cost data.

Table 5-4 Distribution Main Programs

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
Dead End Mains Flushing (UT06)	This is the weekly high pressure flushing of the dead-end watermains in the network by the Anmore water operators. This activity targets water quality issues, in areas with low levels of chlorine residuals due to their low flows.	$41,090	442
Unidirectional Mains Flushing (UT06)	This is the seasonal high pressure flushing of watermains to remove sediment accumulation in the pipes. This activity involves closing	$26,030	280

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
	mainline valves to increase velocities in the pipe such that sediment may be removed. It is completed to prevent the occurrence of water quality issues.		
	Total	**$67,120**	**722**

5.1.5 Service Connections

Water service connections are an asset class that does not require preventative care and does not warrant proactive condition assessment measures. The OMI activities identified for service connections are all customer service related and reactive as they are all completed on an as requested basis either by customers or a contractor. For this reason service-level adjustments and optimisations were not identified for this asset group.

Situations that dictate water service turn on and off are dictated by the Anmore Water Rates and Regulations Bylaw. From discussions with utility staff we accounted for the average annual number of: water service turn on and off, service inquiries, and the number of new water connections requests. These activities are all completed by Anmore staff and are each tracked with a time code with sufficient granularity.

According to Anmore staff there have not been many new water connection requests in the past few years. In the short term, the total number of new water connections inspected per year, possibly 3 to 5, will increase as areas of the community get developed. An allocation was made for this in the optimised OMI Program.

Table 5-5 Service Connection Programs

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
Water Service Turn On/Off (UT08)	Water Service Turn Ons/Shut Offs under Anmore responsibility. These are completed as per the conditions written in the bylaw.	$465	5
Service Inquiry Handling (UT08)	Service Inquiries, also called Call Outs, are general customer service responses. They may be required for a check for leaks or a low water pressure call. Crews may also be asked to locate difficult to find service boxes and charge to this code.	$1,395	15
New Water Connection (UT50)	Anmore does not complete new service connection installations. An Anmore water operator is required to do an inspection of every new connection before it is tied into the network and activated as per the bylaw.	$1,859	20
	Total	**$3,719**	**40**

5.1.6 Meters

Anmore owns and operates customer meters at each billed service connection and a network meter. The one network meter owned and operated by Anmore, located in the rechlorination station, is a magnetic meter. Though the bulk water meter located at the Anmore boundary is owned by Anmore, it is operated and maintenance by the City of Port Moody.

The majority of OMI activities identified for this asset group are customer service related. No suitable preventative care practice was identified for the meters in Anmore. Though the magnetic meter at the rechlorination station is critical to chemical dosing, it has a high degree of reliability and this type of meter can only be recalibrated at the factory. The customer meters do not have the same degree of accuracy, theirs can deteriorate at an approximate rate of 0.1% per year. However, the cost of calibrating customer meters relative to the cost of each inaccuracy does not warrant this preventative care measure. Meters in Anmore should thus simply be replaced at the end of their expected service life.

The customer service related activities that pertain to the meter asset class have to do with meter installation and meter reading. They are each tracked with a time code with sufficient granularity. The frequency of meter readings follow the biennial billing cycle. The meter installations and re-reads occur on an as needed basis at the request of customers. For this reason service-level adjustments and optimisations were not identified for this asset group.

Table 5-6 Meter Programs

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
Meter Installation (UT51)	Meter installations on Anmore property and under Anmore jurisdiction.	$2,231	24
Meter Reading (UT52)	Biennial customer meter reading to inform water utility bills charged to customers. The cost of this program includes the service fee charged by Sensus to assist Anmore with meter troubleshooting.	$4,341	18
Meter Re-Reads (UT52)	Meter re-reads at the request of a utility customer to confirm the volume of water to be billed.	$3,486	37.5
	Total	**$10,058**	**79.5**

5.1.7 Hydrants

Fire hydrants are an asset class with regulated preventative care methods (hydrant servicing) that must be maintained for safety and due diligence purposes. Historically budget constraints and time pressures have limited utility personnel's ability to consistently complete the hydrant inspection programs which should go unmissed from year to year.

The A and B Services must be completed on a regular basis; hydrants must be serviced at least once a year. The two types of services have been scheduled on an alternating schedule from year to year to comply with the directives outlined in the BC Fire Code and industry practice. The findings of these servicing activities direct immediate corrective action when a need for repair, painting, or clearance is identified by the contractor.

Each of the servicing programs are completed by a hired company. Painting and clearance activities are completed by Anmore staff. Technical service-level adjustments and optimisations could not be determined for this asset class since hydrant servicing is a regulated activity. Adjustments were only made in the long-term financial plan to account for the impact of hydrants added to the inventory as planned within the WUMP. The other two programs are completed on an as needed basis.

Anmore has the UT23 timecode to monitor hydrant servicing. Level A checks should be tracked separately from Level B checks. Each activity has different scope and has very different costs. Analysis and reporting of these programs would be facilitated by a separation of the data. Anmore should continue to track hydrant painting and approach clearing programs separately. Keeping records on all hydrant related activities will serve to prove due diligence if and when necessary.

Table 5-7 Hydrant Programs

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
Operational Inspection - Level A Servicing (UT23)	Regulated activity during which the need for repairs to hydrants is verified in detail to ensure proper continued operation in the event of a fire event. It includes disassembly of the hydrant to check threads, seals, alignment, check for leaks, check the isolation valve, etc. Worn parts are replaced, components are lubricated, and the hydrant is reassembled.	$17,363	4
Operational Inspection - Level B Servicing (UT##)	Regulated inspection activity during which the operation of the hydrant is verified. It includes an operational check for check for leaks and check of the isolation valve.	$8,842	4
Painting (UT24)	Painting of the hydrant on an as needed basis to protect its surface from weather related wear.	$372	4
Approaches (UT25)	Clearing of the area surrounding the hydrant on an as needed basis to maintain or correct hydrant visibility and access to it.	$651	7
	Total	**$14,126**	**15**

*The average cost and labour hours of the two hydrant servicing programs is embedded in the approximate Total annual cost and labour hours.

5.1.8 PRV Stations

Pressure Regulating Valves (PRV) are an asset class with standard preventative care methods followed across the water utility sector to mitigate their deterioration and monitor the network's operation. These methods are followed to keep the asset in good working order but also for due diligence purposes. Historically budget constraints have limited Anmore's utility personnel's ability to consistently complete the PRV inspection and tear down programs which should go unmissed from year to year. The inspections have recently been completed on an as needed basis when problems in the network were identified or the condition of assets had significantly deteriorated.

Each of the PRV programs are completed by a hired company. The routine inspection of a PRV costs approximately $300/PRV and there are eight PRV's in Anmore's inventory. This equates to a program unit cost of $2,400. Many utilities, including the City of Abbotsford and the City of Port Moody, inspect the PRV stations once a week. Other utilities equipped with online monitoring of the PRVs inspect them every two months. The weekly frequency is not currently affordable for Anmore nor does the risk of failure warrant this frequency for this utility.

Technical service-level adjustments were made to this routine inspection program to manage the cost burden associated with it. The frequency of the inspections was thus established to a two month basis, with the exception of the period during which the annual tear-down, described below, occurs. Under the routine inspection program the PRVs will be inspected 5 times a year. This program will require a new time code to be generated.

The tear-down of a PRV costs approximately $2,500/PRV; the program unit cost is $20,000 according to the numbers of PRVs currently across the Anmore network. This activity should be completed at the very least annually to prevent premature deterioration of the asset and monitor its condition. The frequency of the program was established at once per year as a starting point for Anmore. Expanding the program to a biennial schedule to complete a spring overhaul and fall check should would increase the annual OMI program cost for this asset class to over $50,000. Routine inspections on a two month basis were prioritised over completing annual tear-downs on a biennial basis. This program will require a new time code to be generated.

Table 5-8 PRV Station Programs

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
***Routine Facility Inspection (UT##)**	Inspection of facility and equipment for cleanliness, leaks, corrosion and damage every two weeks. The lights, ventilation fans, heater, sump pump and drains are also checked for operation. Y-strainers and basket strainers are cleaned and inspected. Control pilot and surge pilot valves are checked. The valve, chamber, and piping condition needs to be visually observed and monitored as part of this activity.	$12,930	25.5

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
Tear-down & Inspection – Valves and Strainers (UT##)	The Y-strainers and basket strainers are cleaned and inspected at this time as per the operational inspection but this activity also includes an annual tear-down and detailed inspection of the pressure regulating valves (PRV). As the PRV is disassembled the PRV diaphragm is replaced. The valve, chamber, and piping condition needs to be visually observed and monitored as part of this activity.	$20,651	7
	Total	**$33,581**	**32.5**

5.1.9 Valves (Mainline)

The OMI activity identified for the mainline valves in Anmore is periodic valve exercising. Service-level adjustments were determined for this asset class since the current maintenance approach applied to the valves is "Run to Fail". Like many other small utilities, Anmore is not currently equipped to complete a mainline valve exercising program since this program has not been funded.

Valves need to be exercised regularly to avoid seizes or breaks. This should be done more so in high consequence areas (nearby schools, etc) to start as per the AWWA M44 which advises that: "It is important to identify the critical valves necessary to maintain the effective provision of service in an emergency or during a crisis. Once selected, it should be the intent of the agency to schedule maintenance and operation on these valves in a manner that can be achieved within a reasonable time frame." Recording of mainline valve condition after exercising them is not necessary since these assets are typically replaced at the same time as the network or when they have seized.

The median percentage of valves cycled in the National Water and Wastewater Benchmarking Initiative participating utilities between 2007 and 2011 is 29%. For that time period the median % of inoperable or leaking valves is 0.4%. Cycling the valves by a hired service provider on a four year rotation should thus be a starting point for Anmore. This program will require a new time code to be generated.

Table 5-9 Valve Program

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
Valve Exercising (UT##)	Periodic maintenance to exercise the valve, clean out valve box, paint valve lid, and record data about the valve. It offers a record of the operability of the valves across the network and can lead to point repairs and/or adjustments to larger rehabilitation/replacement plans. It allows field crews to be informed of the operability of the valves across the system and adapt their work plans.	$1,332	4
	Total	**$1,332**	**4**

5.1.10 Air Valve

Air valves are an asset class with established preventative care methods to mitigate their deterioration. These methods, which entail disassembling the air valve, are most cost effective for large diameter or very expensive valves, which Anmore doesn't have in its inventory. The only OMI activity identified for the air valves in Anmore are the operational inspections. The valve, chamber, and piping condition needs to be visually observed and monitored as part of this activity.

Service-level adjustments were determined for this asset class since operational inspections were typically completed on an as needed basis when problems in the network were identified. This activity should be completed biennially by Anmore staff to prevent issues from occurring and monitor the condition of the assets. This program will require a new time code to be generated.

Table 5-10 Air Valve Program

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
Operational Inspection (UT##)	Biennial inspection to verify the working order of the valves. It offers a record of the operability of the valves and can lead to point repairs and/or adjustments to larger rehabilitation/replacement plans. The valve, chamber, and piping condition needs to be visually observed and monitored as part of this activity.	$2,603	28
	Total	**$2,603**	**28**

5.1.11 Reservoirs

As Anmore does not currently own or operate any reservoirs it relies on storage from the City of Port Moody's Hickory Drive Reservoir. However, it is envisioned in the near future that a reservoir will be built at the Pinnacle Ridge Development to provide additional storage to

Anmore. As such, preventative maintenance and inspections programs for this asset have been prepared and are detailed below.

They are developed to monitor the structural integrity of the asset and monitor its operation. The operational inspections are scheduled on a bi-monthly basis. The reservoir draining, cleaning and inspection are scheduled every year for the first five years of the reservoir's operation. After these five years the reservoirs may be inspected at the time of an asset management plan project to verify its condition. These program will require a new time code to be generated.

Table 5-11 Reservoir Programs

Program Name	Description	Approximate Annual Cost	Approximate Labour Hours
Reservoir Draining, Cleaning, and Inspection (UT##)	Draining, cleaning, inspection, leak test, and disinfection of reservoir. Ensures water quality and monitors integrity of structure.	$3,372	4
Operational Inspections (UT##)	Routine inspection of general condition of reservoir, including vent screens, overflows, dry well, control chamber, piping, and valves. Security is checked (hatch alarm, locks, fence) and cleaning is done as required.	$2,417	26
	Total	**$5,789**	**30**

5.2 Repairs / Corrective Maintenance

To financially plan for unforeseen repairs an approximate cost for corrective maintenance of each asset was estimated based on available repair cost information. An estimated frequency of failure occurrences (e.g. once every 5 years) for each asset group was also developed based on local knowledge of the assets. These values served to calculate an annual average cost for repairs. The annual cost of repairs that was thus estimated equates to $7,238.

In 2014 a large amount of resources was dedicated to meter repairs. The level of effort experienced that year is expected to diminish significantly as a consequence of the replacement of meters across the utility. In the development of the annual average cost of repairs the historical trends for the meter asset group were adjusted to reflect the new inventory.

5.3 Other OMI Expenses

Other costs related to OMI, such as miscellaneous consumables, identified in the Transaction Inquiry that could not be attributable to a particular OMI activity were also accounted for in this study. These costs also include labour hours related to the supervision of staff, training of staff to maintain operator certification, and miscellaneous activities that cannot be efficiently tracked as they cause too much granularity. One periodic $20k asset management study was also included in this cost category on a ten year basis. All these costs were compiled in a separate table in order to inform the financial analysis completed as part of the WUMP.

Table 5-12 Other OMI Expenses

Description	Approximate Annual Cost
Staff	
Supervision	$16,413
Training	$8,104
Miscellaneous Labour	$18,880
Chemicals	
Sodium Hypochlorite	$4,213
Energy	
Hydro (Pinnacle Pump Stn.) b0078	$2,226
Hydro (Uplands Pump Stn.) b0061	$3,764
Hydro (Chlorination Station) b0076	$1,361
Water Meter Manhole (b0047)	$430
Fuel	$561
TeleComms	
Radio License	$2,500
Utility Alarm Monitoring (T0035)	$690
Pinnacle Ridge Alarm Monitoring	$285
Anmore Pump STN Alarm Monitoring	$288
Chlorination Station Telus Comms (T0069)	$241
Telus Uplands (T0049)	$753
Misc.	
Anmore Pump STN	$424
Uplands pump STN	$260
Uplands Pump STN	$80
Chlorination Station	$227
Health Permit	$2,369
Keys/GPS	$534
AP Invoice Entry	$1,254
Misc Parts TD Visa	$3,053
Total	**$68,910**

6 Conclusion Operations & Maintenance Costs

The total annual cost of general operations and maintenance efforts for the water utility is $274,169 and 1,852 labour hours. Of this total amount $66,794 is attributable to contracted services, the majority of which is related to PRV inspections and hydrant servicing. Table 6-1 below provides a breakdown of the annual OMI Program costs and labour hours for each asset class identified in the OMI Program review.

Table 6-1 OMI Program Financial Analysis

Asset Class	Asset Inventory	Approximate Annual O&M Cost	Approximate Labour Hours
Water Sampling Stations	3	$11,527	124
Rechlorination Station	1	$24,869	246
Pump Stations	2	$23,297	148
Distribution Mains	20,422 m	$67,120	722
Service Connections	628	$3,719	40
Meters	629	$10,058	79.5
Hydrants	146	$14,126	15
PRV Stations	8	$33,581	32.5
Valves (Mainline)	6	$1,332	4
Air Valve	5	$2,603	28
Reservoirs	To be constructed as per WUMP	$5,789	30
Repairs/Corrective Maintenance	N/A	$7,238	38
Other OMI Expenses	N/A	$68,910	345
	Total	**$274,169**	**1,852**

*The average cost of the two hydrant servicing programs is embedded in the approximate annual cost.

The labour hours calculated as part of this analysis equates to 1,852. This is approximately one full time equivalent staff person on a 35 hour per work week schedule. There is a difference of 400 hours with the total hours recorded on the water maintenance management charges of 2014 and the calculated amount in this study. The differences in part due to new programs that were added (108.5 hours) in the program plan and a gap in the existing time keeping practice. Revisions to time keeping codes are recommended to improve monitoring of existing programs. Existing programs that require a new time code include: Unidirectional Mains Flushing and the Air Valve Operational Inspection. In implementing these new codes staff should be trained on the importance and use of time keeping data for financial and maintenance and asset management analysis.

Table 6-2 provides a breakdown of the annual operations and maintenance costs and labour hours for all new or additional operations and maintenance programs identified in the detailed OMI review. The costs and labour hours in Table 6-2 are included in the total approximate values reported in Table 6-1.

Table 6-2 New O&M Programs

Asset Class & Activity	Approximate Annual O&M Cost	Approximate Labour Hours
Treatment of Building Wood Siding	$686	2
Pump Station Condition Inspection – Building Enclosure & Grounds	$1,372	4
PRV Station Routine Facility Inspection	$12,930	25.5
PRV Station Tear-down & Inspection – Valves and Strainers	$20,651	7
Valve Exercising	$1,332	4
Air Valve Operational Inspection	$2,603	28
Reservoir Draining, Cleaning, and Inspection	$3,372	4
Reservoir Operational Inspections	$2,417	26
Hydrant Operational Inspection - Level A Servicing (UT23)	$17,363	4
Hydrant Operational Inspection - Level B Servicing	$8,842	4
Total	$71,568	108.5

*It is important to note that the two hydrant servicing programs will occur in alternate years and the entire mainline valve inventory is exercised on a 4 year rotation.

7 Closure

We trust you will find the foregoing technical memorandum suitable. Please do not hesitate to contact the undersigned should you have any questions.

Yours truly,

Opus DaytonKnight Consultants Ltd.

Catherine Dallaire, P.Eng.
Asset Management Engineer

ML/LM/CD/lp

OPUS DAYTONKNIGHT

Village of Anmore Water Utility Master Plan

Appendix B

Pump Configuration

Pump configurations at Anmore's two pump stations were determined from received as-built drawings, fire pump flow tests, and rated pump curves from manufacturers. The methodology applied in determining each pump configuration is detailed below. Relevant sources are included at the end of the appendix.

1.1 Uplands Pump Station

The Uplands Pump Station is located along Uplands Drive at an elevation of 181 m. It services the existing 377 m HGL zone, designated as Pumped Zone II on Figure 2-1. The pump station houses two (2) duty pumps and one (1) fire pump, as detailed below.

1.1.1 Fire Pump

The pump curve for the Upland Fire Pump (AC Fire 8100 HSC 6x4x11F) was taken from the manufacturer's pump curve and confirmed with Anmore's Fire Pump Flow Test Report dated November 2013. Both these sources were provided by Anmore staff.

1.1.2 Duty Pumps

The configuration, make and model of the Uplands Duty Pumps (Grundfos CR10-9 Pumps c/w 7.5 HP) was determined from as-built drawings from September 2008, provided by Anmore staff. Pump curves for the given make and model were found from the manufacturer's website. The rated pump curve was chosen by matching the shutoff head to the fire pump. The design capacity of the Uplands duty pumps was determined based on the assumption that the rated head was the same as for the Uplands Fire Pump (155 psi); this yielded a design capacity of 3.0 L/s.

The Uplands Pump Station Description of Operation document set out the typical operating regime of the Variable Frequency Drive (VFD) pumps. For the purposes of modelling the existing and future Peak Hour Demand (PHD) scenarios, a less efficient pump operating regime at a lower pump curve was used to match field results.

1.2 Pinnacle Ridge Pump Station

1.2.1 Fire Pump

The pump curve for the Pinnacle Ridge Fire Pump (AC Fire 8100 Split Case) was taken from the manufacturer's pump curve and confirmed with Anmore's Fire Pump Flow Test Report dated September 2013. Both these sources were provided by Anmore staff.

1.2.2 Duty & Jockey Pumps

The configuration, make and model of the Pinnacle Ridge Duty Pumps (Goulds 33SV63GN4E60 Inline multistage pumps, 30 HP) and Jockey Pump (Goulds 5SV23FH5E60 Inline Multistage pumps, 7.5HP) were determined from as-built drawings dated September 2009, provided by Anmore staff. The design point for the duty pumps was specified within Anmore's as-built drawings, which allowed us to determine the appropriate pump curve from the manufacturer's website. The Jockey Pump was assumed to have the same shutoff head as the duty pumps.

Uplands Pump Station

Description of Operation

The equipment installed in the pump station includes the following:

1- ITT Fire pump (125 hp)
1- Fire pump controller including pressure sensor
1- Fire pump suction control valve (Hydraulic)
1- Main relief valve (Hydraulic)
2- Grundfos booster pumps (7.5 hp)
1- Booster pump controller with variable speed drives.
1- Suction pressure transmitter (0 to 300 PSI range)
1- Discharge pressure transmitter. (0 to 300 PSI range)
1- Diesel gen-set with automatic transfer switch

The system is used to boost the municipal water pressure to a subdivision with variable speed constant pressure booster pumps. The Fire pump has its own pressure sensor and will be set-up to start at the pressure set by the fire pump controller.

The Booster Pumps operate as follows.

- With the selector switches in the "**OFF**" position the pumps will remain off

- With the selector switches in the "**MANUAL**" position the pumps will run continuously at full speed

- With the selector switches in the "**AUTOMATIC**" position the pumps operate as follows:

Running:

When the discharge pressure falls below the set-point pressure minus 5 PSI (The set point pressure is adjustable through the operator interface.) the lead pump will start and vary in speed to maintain a constant discharge pressure. If the lead pump is unable to maintain the set-point pressure the "Follower" pump will start when the set point pressure drops below 5 PSI the set-point pressure and will also vary in speed to maintain the set-point pressure.

Stopping:

If the lead pump is running at the minimum speed and able to hold the set-point for one minute the pump will stop.

If the follower pump is running at minimum speed and is able to hold the set-point for one minute the pump will stop.

If the fire pump starts the booster pumps will stop.

Starting:

When the discharge pressure reaches the **set point minus 5 PSI** the lead pump will start and vary in speed to hold the set point. The system will operate as described above in the "Running" paragraph.

Alternating:

The lead and follower pumps will alternate on pump starts.

Low Suction Shutdown / Alarm:

The booster pumps will stop, after an adjustable time delay, on low Suction pressure sensed by the suction pressure transducer. This pressure setting and the time delay are adjustable through the operator interface. Manual re-set is required to re-start the pumps.

High discharge pressure shut-down / Alarm:

The booster pumps will stop, after a time delay, when there is a high discharge pressure sensed by the discharge pressure transmitter. The high pressure setting and the associated time delay are adjustable through the operator interface. Manual re-set is required to re-start the pumps.

Low discharge pressure:

The booster pumps will stop, after a time delay, when there is a low discharge pressure sensed by the discharge pressure transducer. The low discharge pressure setting and the associated time delay are adjustable through the operator interface. Manual re-set is required to re-start the pumps.

Power failure:

Should there be a power failure the Gen-Set will automatically start and the auto transfer switch will power up the booster pump control panel and the pumps shall function normally. However should the fire pump start the booster pumps will stop.

Current settings are:

Set Value	=	170 PSI	Adjustable
Follower start	=	5% below Set Value when lead pump is running	
High Discharge Pressure	=	190 PSI	Adjustable
High discharge Time Delay	=	5 Seconds	Adjustable
Low Discharge Pressure	=	100 PSI	Adjustable
Low Discharge Time Delay	=	5 Seconds	Adjustable
Low Suction Pressure	=	10 PSI	Adjustable
Low discharge Time Delay	=	5 Seconds	Adjustable
Stop frequency	=	40% of full speed	
Start Set Point	=	5% below set-point	
Main Relief Valve	=	180 PSI	
Suction Control Valve	=	10 PSI	

Note:

The set value of 170 PSI results in 60 PSI at the highest house.

Main Control Panel Programmable Logic Controller I/O Addresses
(See NWTC Drawing # 11906-1)
Inputs

Input #	Wire #	Description
I0		Spare
I1	11	Booster Pump 1 switch in auto
I2	12	Booster Pump 2 switch in auto
I3	13	VFD-1 fail
I4	14	VFD-2 fail
I5	15	VFD-1 run
I6	16	VFD-2 run
I7	17	Fire Pump run
I8	18	Fire Pump Fault
I9	19	Power Fail
I10	110	General Intrusion
I11		Spare
I12		Spare
I13		Spare
I14		Spare
I15	115	Alarm reset

Outputs

Output #	Wire #	Description
Q0	Q0	Booster Pump 1 start relay (CR1)
Q1	Q1	Booster Pump 2 start relay (CR2)
Q2	Q2	Common alarm relay (CR7)
Q3	Q3	General Intrusion (CR5)
Q$	Q4	Spare (terminal 22)
Q5	Q5	Spare (Terminal 23)
Q6	Q6	Spare (Terminal 24)
Q7		Not Used
Q8		Not Used
VDC Com2	-	24VDC minus
Q9		Not Used
Q10 & Q11		Not Used

Alarm Resetting

VFD fault Resetting

Each VFD has a panel door mounted display panel labeled VFD 1 and VFD 2. The top line of these displays will read "Fault" if a fault occurs. There will also be a "VFD fault displayed on the Panel mate display. To re-set a VFD fault press the Red button on the VFD display panel and the Black "Alarm Reset" on the mail panel door. The VFD Fault display on the Panel Mate is only a visual alarm which gets recorded in the alarm history. By touching the reset on the panel mate the screen will return then show a common alarm. When this common alarm is re-set the screen will return to it's normal display. Should the VFD Fault return immediately after resetting call for servicing.

Fire Pump Fault Resetting:

Should there be a motor fault or the main disconnect switch on the fire pump control panel a Fire Pump Fault will be displayed on the PanelMate screen. This will also trigger the Common Alarm. The Booster pumps are not affected by this alarm. To reset the alarm the power to the fire pump control must be turned on and the motor fault must be corrected. Once these items are corrected press the Black Alarm switch on the main control panel. The PanelMate display alarm readings can be re-set. As mentioned above these PanelMate alarms are recorded in the alarm history and by clearing the display will return to the normal display screen.

Common Alarm Resetting:

All common alarms are reset by pressing the Black "Alarm Reset" button on the main control panel. The common alarm display on the PanelMate can also be reset. As above the alarms are recorded into the alarm history

The Fire Pump operates as follows

The Fire pump has its own controller and is independent from the booster pump controls. The Fire pump has its pressure sensor mounted on the discharge header.

Starting:

The controller is currently set-up to start the fire pump, after a time delay, when the discharge pressure drops and stays at 145 PSI or lower. The time delay is currently set for 30 seconds

The controller is fitted with a manual start switch which can be used if the automatic circuit fails. Refer to the Tornatech manual for the manual override

Stopping:

The fire pump is set-up to automatically stop when the discharge pressure is maintained at 175 PSI for a minimum time of 10 minutes. After the 10 minute time delay the pump will stop.

The controller is fitted with a manual stop switch which can be used if the automatic circuit fails.

Notes:

1- The purpose of the time delay start is used to allow the pressure relief valve time to close and the booster pumps time to re-pressurize the system after the fire pump stops preventing the fire pump from false starts.
2- The fire pump controller sends a signal to the booster pump control panel which sends an alarm to the security system alarming that the fire pump is running.
3- The fire pump piping is fitted with a suction control valve which will throttle the fire pump flow to maintain a minimum suction pressure. The minimum suction pressure is currently set to 10 PSI.

Nameplate Information

Pump #1

Make	Model	Serial Number
Grundfos	CR10-9-A-GJ-E-HQQE	A96126738-P10851164

Motor #1

Make	Model	Serial Number
WEG W21 CC029A	04NOV-1003379729	85782255
HP	RPM	Voltage
7.5	3560	575
Enclosure	Amperage	Frame
TEFC	6.93	213TC

Pump #2

Make	Model	Serial Number
Grundfos	CR10-9-A-GJ-E-HQQE	A96126738-P10851164

Motor #2

Make	Model	Serial Number
WEG W21 CC029A		85782255
HP	RPM	Voltage
7.5	3560	575
Enclosure	Amperage	Frame
TEFC	6.93	213TC

Fire Pump

Make	Model	Serial Number
ITT A-C	8100 -6 x 4 x 11F	08-052333

Fire Pump Motor

Make	Model	Serial Number
WEG	28FEV08 100670261	VP125502PBB
HP	RPM	Voltage
125	3555	600
Enclosure	Amperage	Frame
ODP	110	404/5TS

Fire Pump Controller

Make	Model	Serial Number
Tornatech	GPS-600-125	Z31419

Booster Pump Control Panel

Make	Model	Serial Number
North West Tech-Con	B-DCP-600	130906

Transfer Switch

Make	Model	Serial Number
Thompson Technology	TS873A0250AAY3AKKAA	MW-000268-002

Suction Control Valve

Make	Model	Serial Number
Clayton	50B-5KG-1	91648G

Main Pressure Relief Valve

Make	Model	Serial Number
Clayton	50B-4KG-1	9945302K

Discharge Pressure Sensors (Suction &)

Make	Model	Serial Number	Pressure Range
Endress Hauser	PMC131-C22F1Q4S	A706401052-discharge	0 to 300 PSI MWP 400psi

Suction Pressure Sensors

Make	Model	Serial Number	Pressure Range
Endress Hauser	PMC131-C22F1Q4S	C7122801052	0 to 300 PSI MWP 400psi

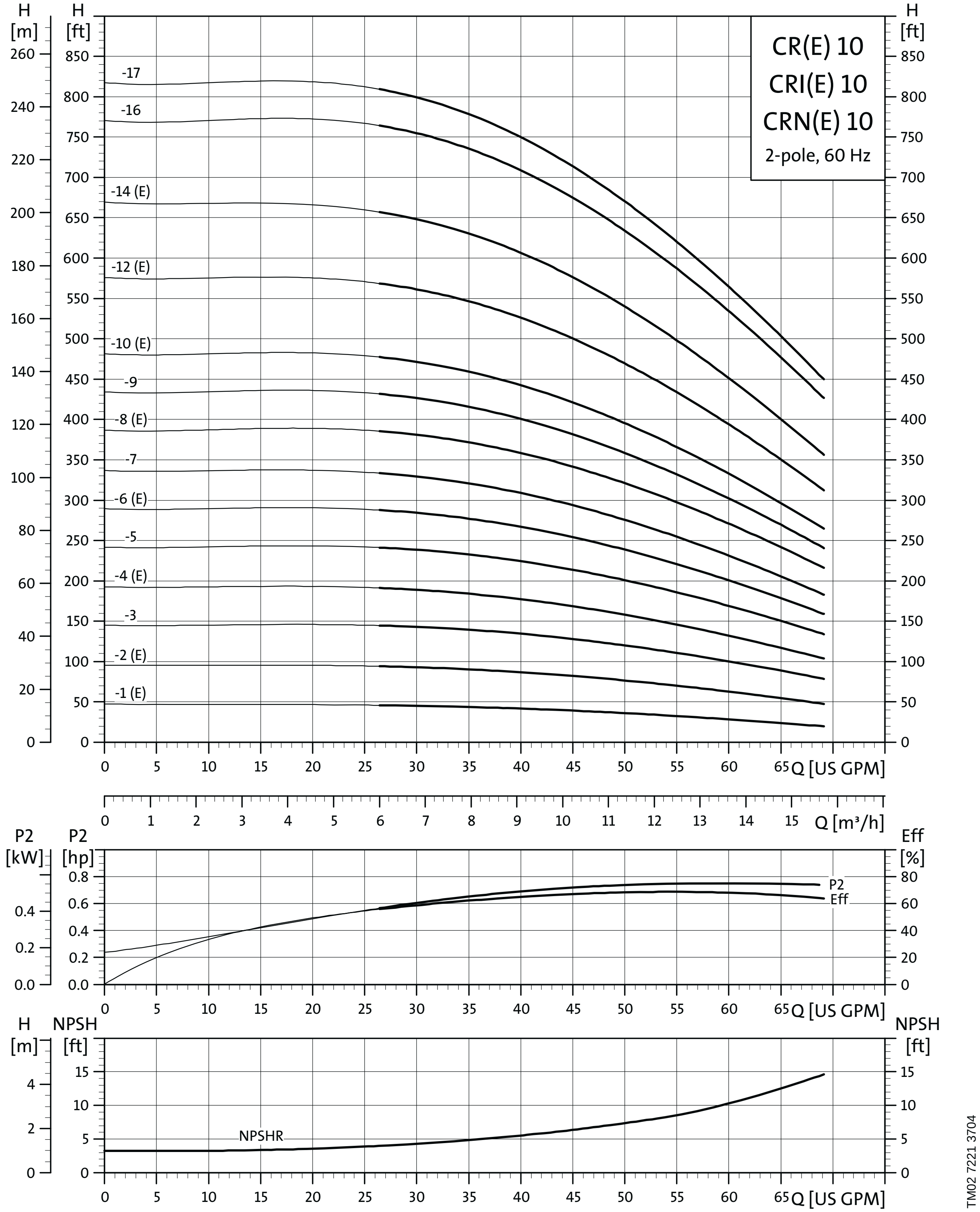
Load Bank

Make	Model	Serial Number
Northwest Tech-Con	ATL-600-Remote	14543-4

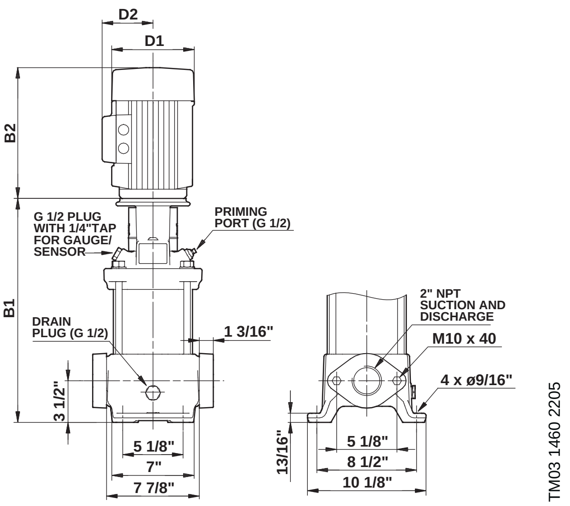
GENERATOR

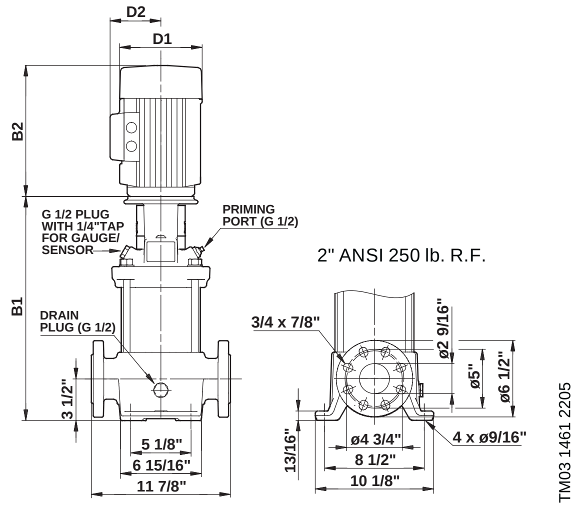
Make	Model	Serial Number
Kohler	150REOZBJ	2212106
Make	Model	Serial Number
John Deere	6068	PE6068H731635

CR(E), CRI(E), CRN(E) 10



Technical data



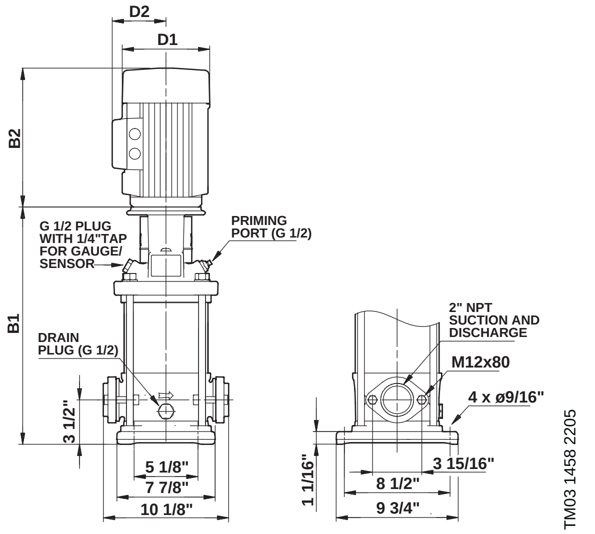


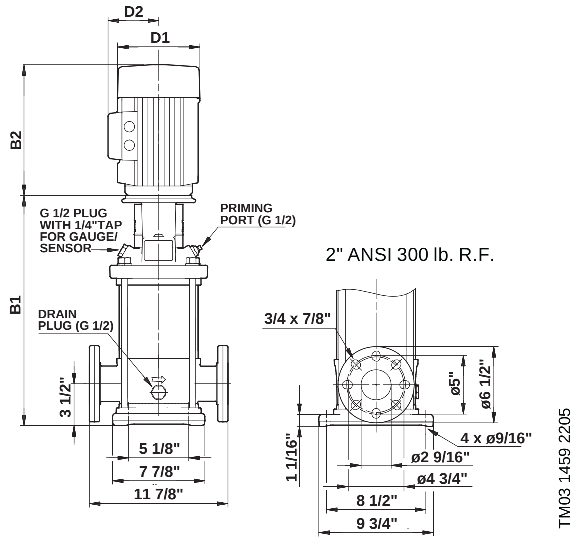
Pump type	P2 [hp]	Ph.	Oval*	ANSI dimensions [inch]							Ship Wt. [lbs.]	ANSI dimensions [inch]			Ship Wt. [lbs.]
				B1	TEFC			ODP				MLE			
					D1	D2	B1+B2	D1	D2	B1+B2		D1	D2	B1+B2	
CR(E) 10-1	3/4	1	•	15.28	7.19	5.73	26.47	-	-	-	115	5.55	5.51	24.26	108
		3	•	15.28	5.55	4.57	22.72	-	-	-	106	7.01	6.57	28.08	128
CR(E) 10-2	1 1/2	1	•	15.28	7.19	5.73	26.96	-	-	-	128	-	-	-	-
		3	•	15.28	5.55	4.57	23.90	-	-	-	106	7.01	6.57	28.08	128
CR 10-3	3	1	•	17.20	8.60	6.87	31.85	-	-	-	183	-	-	-	-
		3	•	17.20	7.01	4.33	30.43	-	-	-	153	-	-	-	-
CR(E) 10-4	3	1	•	18.39	8.60	6.87	33.04	-	-	-	183	-	-	-	-
		3	•	18.39	7.01	4.33	31.62	-	-	-	156	7.01	6.57	31.70	163
CR 10-5	5	1	•	19.57	10.62	7.46	35.09	-	-	-	209	-	-	-	-
		3	•	19.57	8.66	5.28	35.08	-	-	-	206	-	-	-	-
CR(E) 10-6	5	1	•	20.75	10.62	7.46	36.27	-	-	-	212	-	-	-	-
		3	•	20.75	8.66	5.28	36.26	-	-	-	208	8.66	7.40	36.26	201
CR 10-7	7 1/2	1	-	22.25	10.22	7.62	37.78	-	-	-	232	-	-	-	-
		3	-	22.25	8.66	5.28	37.76	-	-	-	221	-	-	-	-
CR(E) 10-8	7 1/2	1	-	23.43	10.22	7.62	38.96	-	-	-	234	-	-	-	-
		3	-	23.43	8.66	5.28	38.94	-	-	-	223	8.66	7.40	38.94	236
CR 10-9	7 1/2	1	-	24.61	10.22	7.62	40.14	-	-	-	236	-	-	-	-
		3	-	24.61	8.66	5.28	40.12	-	-	-	225	-	-	-	-
CR(E) 10-10	7 1/2	1	-	25.79	10.22	7.62	41.32	-	-	-	238	-	-	-	-
		3	-	25.79	8.66	5.28	41.30	-	-	-	227	8.66	7.40	41.30	240
CR(E) 10-12	10	1	-	28.15	10.23	10 30	44.22	-	-	-	355	-	-	-	-
		3	-	28.15	8.66	5.28	43.66	-	-	-	232	10.24	8.39	43.07	251
CR(E) 10-14	15	3	-	33.06	10.22	8.67	49.64	10 62	7 33	49.37	443	-	-	-	-
CR 10-16	15	3	-	35.43	10.22	8.67	52.01	10 62	7 33	51.74	451	-	-	-	-
CR 10-17	15	3	-	37.80	10.22	8.67	54.38	10 62	7 33	54.11	455	-	-	-	-

All dimensions in inches unless otherwise noted.

*Oval flanged pump B1 and B1+B2 dimension is equal to ANSI flanged pumps and weight is approximately 3 lbs. less.

• Available.





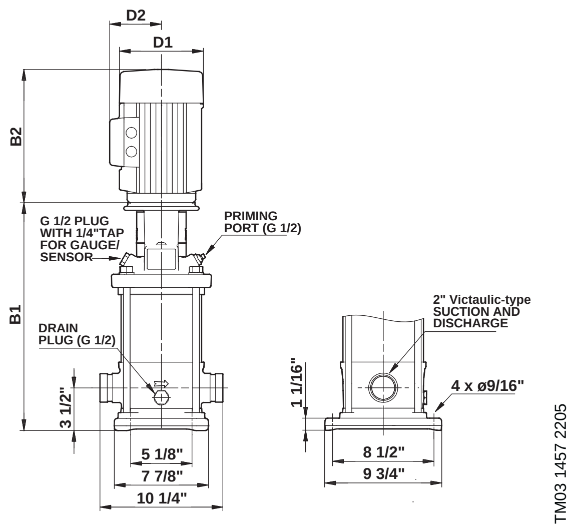
Pump type	P2 [hp]	Ph.	Oval*	ANSI dimensions [inch]							Ship Wt. [lbs.]	ANSI dimensions [inch]			Ship Wt. [lbs.]
				B1	TEFC			ODP				MLE			
					D1	D2	B1+B2	D1	D2	B1+B2		D1	D2	B1+B2	
CRI(E) 10-1	1	1	•	15 20	7.19	5.73	26 39	-	-	-	106	5.55	5.51	24.18	97
		3	•	15 20	5 55	4 57	22 64	-	-	-	97	7.01	6.57	28.00	119
CRI(E) 10-2	1 1/2	1	•	15 20	7.19	5.73	26 88	-	-	-	121	-	-	-	-
		3	•	15 20	5 55	4 57	23 82	-	-	-	99	7.01	6.57	28.00	119
CRI 10-3	3	1	•	17.13	8 60	6 87	31.78	-	-	-	174	-	-	-	-
		3	•	17.13	7 01	4 33	30 36	-	-	-	147	-	-	-	-
CRI(E) 10-4	3	1	•	18 31	8 60	6 87	32 96	-	-	-	176	-	-	-	-
		3	•	18 31	7 01	4 33	31 54	-	-	-	147	7.01	6.57	31.62	157
CRI 10-5	5	1	•	19.49	10.62	7.46	35 01	-	-	-	203	-	-	-	-
		3	•	19.49	8 66	5 28	35 00	-	-	-	199	-	-	-	-
CRI(E) 10-6	5	1	•	20 67	10.62	7.46	36.19	-	-	-	205	-	-	-	-
		3	•	20 67	8 66	5 28	36.18	-	-	-	201	8.66	7.40	36.18	194
CRI 10-7	7 1/2	1	•	22.17	10.22	7 62	37.70	-	-	-	225	-	-	-	-
		3	•	22.17	8 66	5 28	37 68	-	-	-	212	-	-	-	-
CRI(E) 10-8	7 1/2	1	•	23 35	10.22	7 62	38 88	-	-	-	227	-	-	-	-
		3	•	23 35	8 66	5 28	38 86	-	-	-	214	8.66	7.40	38.86	229
CRI 10-9	7 1/2	1	•	24 53	10.22	7 62	40 06	-	-	-	229	-	-	-	-
		3	•	24 53	8 66	5 28	40 04	-	-	-	216	-	-	-	-
CRI(E) 10-10	7 1/2	1	•	25.71	10.22	7 62	41 24	-	-	-	232	-	-	-	-
		3	•	25.71	8 66	5 28	41 22	-	-	-	218	8.66	7.40	41.22	234
CRI(E) 10-12	10	1	-	28 07	10.23	10.30	44.14	-	-	-	346	-	-	-	-
		3	-	28 07	8 66	5 28	43 58	-	-	-	225	10.24	8.39	42.99	243
CRI(E) 10-14	15	3	-	32 95	10.22	8 67	49 53	10 62	7.33	49.26	432	-	-	-	-
CRI 10-16	15	3	-	35.31	10.22	8 67	51 89	10 62	7.33	51.62	442	-	-	-	-
CRI 10-17	15	3	-	37.68	10.22	8 67	54 26	10 62	7.33	53.99	447	-	-	-	-

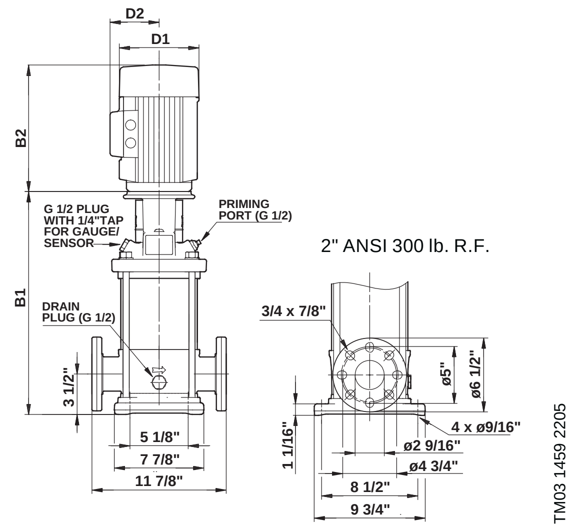
All dimensions in inches unless otherwise noted.

*Oval flanged pump B1 and B1+B2 dimension is equal to ANSI flanged pumps and weight is approximately 7 lbs. less.

• Available.

Technical data





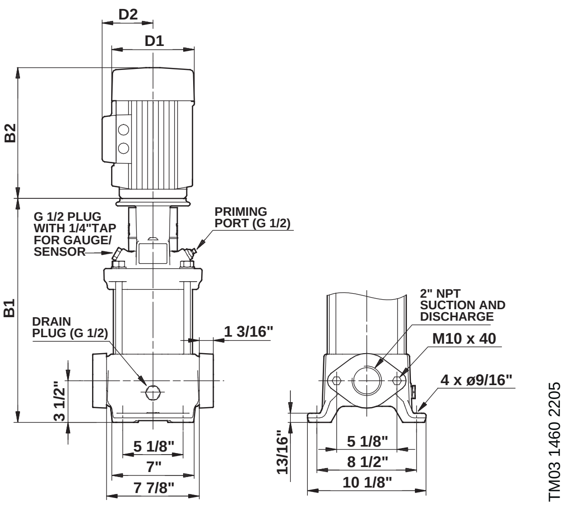
Pump type	P2 [hp]	Ph.	PJE*	ANSI dimensions [inch]							Ship Wt. [lbs.]	ANSI dimensions [inch]			Ship Wt. [lbs.]
				B1	TEFC			ODP				MLE			
					D1	D2	B1+B2	D1	D2	B1+B2		D1	D2	B1+B2	
CRN(E) 10-1	1	1	•	15 20	7.19	5.73	26.39	-	-	-	106	5.55	5.51	24.18	97
		3	•	15 20	5 55	4.57	22.64	-	-	-	97	7.01	6.57	28.00	119
CRN(E) 10-2	1 1/2	1	•	15 20	7.19	5.73	26.88	-	-	-	121	-	-	-	-
		3	•	15 20	5 55	4.57	23.82	-	-	-	99	7.01	6.57	28.00	119
CRN 10-3	3	1	•	17.13	8 60	6.87	31.78	-	-	-	176	-	-	-	-
		3	•	17.13	7 01	4.33	30.36	-	-	-	147	-	-	-	-
CRN(E) 10-4	3	1	•	18 31	8 60	6.87	32.96	-	-	-	176	-	-	-	-
		3	•	18 31	7 01	4.33	31.54	-	-	-	149	7.01	6.57	31.62	157
CRN 10-5	5	1	•	19.49	10.62	7.46	35.01	-	-	-	203	-	-	-	-
		3	•	19.49	8 66	5.28	35.00	-	-	-	199	-	-	-	-
CRN(E) 10-6	5	1	•	20 67	10.62	7.46	36.19	-	-	-	205	-	-	-	-
		3	•	20 67	8 66	5.28	36.18	-	-	-	201	8.66	7.40	36.18	194
CRN 10-7	7 1/2	1	•	22.17	10.22	7.62	37.70	-	-	-	227	-	-	-	-
		3	•	22.17	8 66	5.28	37.68	-	-	-	214	-	-	-	-
CRN(E) 10-8	7 1/2	1	•	23 35	10.22	7.62	38.88	-	-	-	229	-	-	-	-
		3	•	23 35	8 66	5.28	38.86	-	-	-	216	8.66	7.40	38.86	229
CRN 10-9	7 1/2	1	•	24 53	10.22	7.62	40.06	-	-	-	232	-	-	-	-
		3	•	24 53	8 66	5.28	40.04	-	-	-	218	-	-	-	-
CRN(E) 10-10	7 1/2	1	•	25.71	10.22	7.62	41.24	-	-	-	234	-	-	-	-
		3	•	25.71	8 66	5.28	41.22	-	-	-	221	8.66	7.40	41.22	234
CRN(E) 10-12	10	1	•	28 07	10.23	10 30	44.14	-	-	-	346	-	-	-	-
		3	•	28 07	8 66	5.28	43.58	-	-	-	225	10.24	8.39	42.99	243
CRN(E) 10-14	15	3	•	32 95	10.22	8.67	49.53	10.62	7 33	49.25	432	-	-	-	-
CRN 10-16	15	3	•	35 31	10.22	8.67	51.89	10.62	7 33	51.63	442	-	-	-	-
CRN 10-17	15	3	•	37 68	10.22	8.67	54.26	10.62	7 33	54.00	447	-	-	-	-

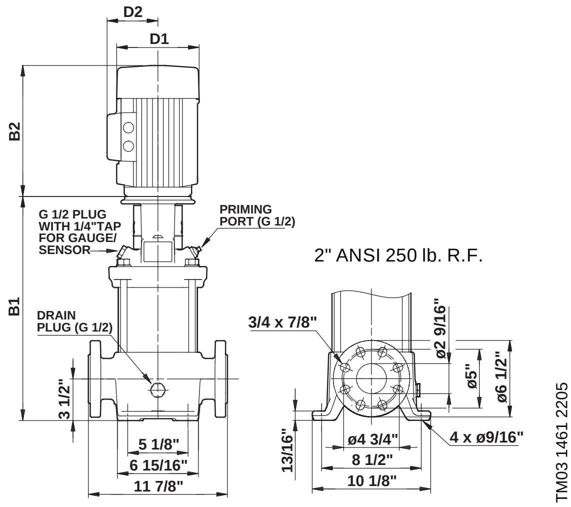
All dimensions in inches unless otherwise noted.

*PJE flanged pump B1 and B1+B2 dimension is equal to ANSI flanged pumps and weight is approximately 9 lbs. less.

• Available

Technical data





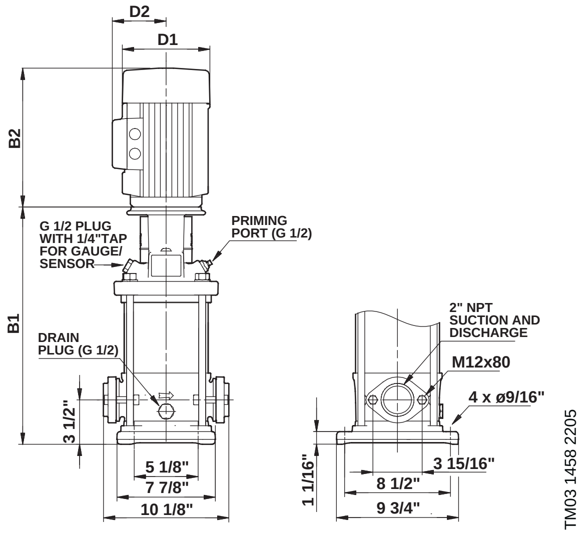
Pump type	P2 [hp]	Ph.	Oval*	ANSI dimensions [inch] B1	TEFC D1	TEFC D2	TEFC B1+B2	ODP D1	ODP D2	ODP B1+B2	Ship Wt. [lbs.]	ANSI dimensions [inch] MLE D1	MLE D2	MLE B1+B2	Ship Wt. [lbs.]
CR(E) 10-1	3/4	1	•	15.28	7.19	5.73	26.47	-	-	-	115	5.55	5.51	24.26	108
		3	•	15.28	5.55	4.57	22.72	-	-	-	106	7.01	6.57	28.08	128
CR(E) 10-2	1 1/2	1	•	15.28	7.19	5.73	26.96	-	-	-	128	-	-	-	-
		3	•	15.28	5.55	4.57	23.90	-	-	-	106	7.01	6.57	28.08	128
CR 10-3	3	1	•	17.20	8.60	6.87	31.85	-	-	-	183	-	-	-	-
		3	•	17.20	7.01	4.33	30.43	-	-	-	153	-	-	-	-
CR(E) 10-4	3	1	•	18.39	8.60	6.87	33.04	-	-	-	183	-	-	-	-
		3	•	18.39	7.01	4.33	31.62	-	-	-	156	7.01	6.57	31.70	163
CR 10-5	5	1	•	19.57	10.62	7.46	35.09	-	-	-	209	-	-	-	-
		3	•	19.57	8.66	5.28	35.08	-	-	-	206	-	-	-	-
CR(E) 10-6	5	1	•	20.75	10.62	7.46	36.27	-	-	-	212	-	-	-	-
		3	•	20.75	8.66	5.28	36.26	-	-	-	208	8.66	7.40	36.26	201
CR 10-7	7 1/2	1	-	22.25	10.22	7.62	37.78	-	-	-	232	-	-	-	-
		3	-	22.25	8.66	5.28	37.76	-	-	-	221	-	-	-	-
CR(E) 10-8	7 1/2	1	-	23.43	10.22	7.62	38.96	-	-	-	234	-	-	-	-
		3	-	23.43	8.66	5.28	38.94	-	-	-	223	8.66	7.40	38.94	236
CR 10-9	7 1/2	1	-	24.61	10.22	7.62	40.14	-	-	-	236	-	-	-	-
		3	-	24.61	8.66	5.28	40.12	-	-	-	225	-	-	-	-
CR(E) 10-10	7 1/2	1	-	25.79	10.22	7.62	41.32	-	-	-	238	-	-	-	-
		3	-	25.79	8.66	5.28	41.30	-	-	-	227	8.66	7.40	41.30	240
CR(E) 10-12	10	1	-	28.15	10.23	10 30	44.22	-	-	-	355	-	-	-	-
		3	-	28.15	8.66	5.28	43.66	-	-	-	232	10.24	8.39	43.07	251
CR(E) 10-14	15	3	-	33.06	10.22	8.67	49.64	10 62	7 33	49.37	443	-	-	-	-
CR 10-16	15	3	-	35.43	10.22	8.67	52.01	10 62	7 33	51.74	451	-	-	-	-
CR 10-17	15	3	-	37.80	10.22	8.67	54.38	10 62	7 33	54.11	455	-	-	-	-

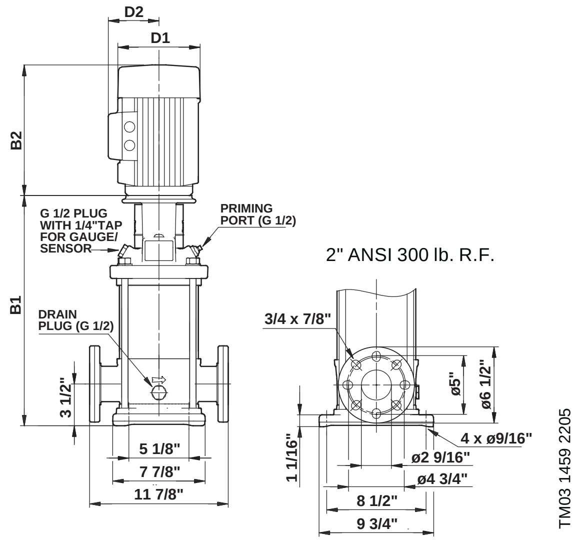
All dimensions in inches unless otherwise noted.

*Oval flanged pump B1 and B1+B2 dimension is equal to ANSI flanged pumps and weight is approximately 3 lbs. less.

• Available.

Technical data



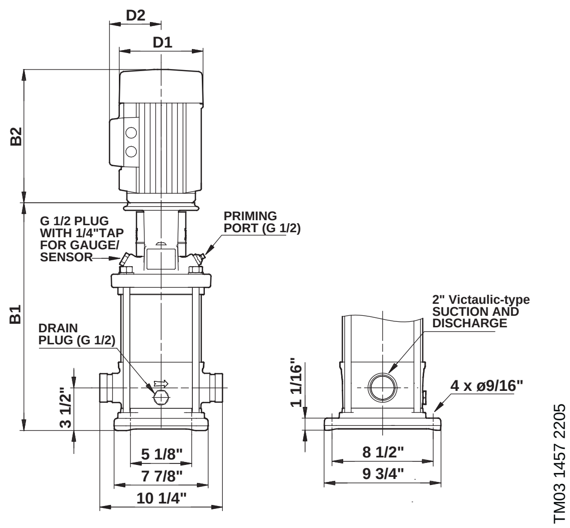


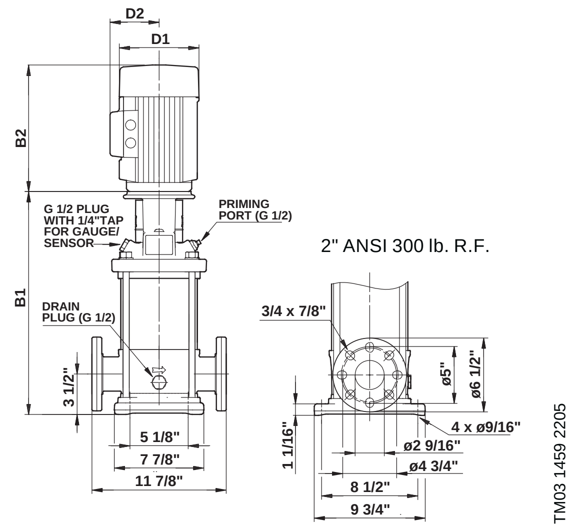
Pump type	P2 [hp]	Ph.	Oval*	ANSI dimensions [inch]							Ship Wt. [lbs.]	ANSI dimensions [inch]			Ship Wt. [lbs.]
				B1	TEFC			ODP				MLE			
					D1	D2	B1+B2	D1	D2	B1+B2		D1	D2	B1+B2	
CRI(E) 10-1	1	1	•	15 20	7.19	5.73	26 39	-	-	-	106	5.55	5.51	24.18	97
		3	•	15 20	5 55	4 57	22 64	-	-	-	97	7.01	6.57	28.00	119
CRI(E) 10-2	1 1/2	1	•	15 20	7.19	5.73	26 88	-	-	-	121	-	-	-	-
		3	•	15 20	5 55	4 57	23 82	-	-	-	99	7.01	6.57	28.00	119
CRI 10-3	3	1	•	17.13	8 60	6 87	31.78	-	-	-	174	-	-	-	-
		3	•	17.13	7 01	4 33	30 36	-	-	-	147	-	-	-	-
CRI(E) 10-4	3	1	•	18 31	8 60	6 87	32 96	-	-	-	176	-	-	-	-
		3	•	18 31	7 01	4 33	31 54	-	-	-	147	7.01	6.57	31.62	157
CRI 10-5	5	1	•	19.49	10.62	7.46	35 01	-	-	-	203	-	-	-	-
		3	•	19.49	8 66	5 28	35 00	-	-	-	199	-	-	-	-
CRI(E) 10-6	5	1	•	20 67	10.62	7.46	36.19	-	-	-	205	-	-	-	-
		3	•	20 67	8 66	5 28	36.18	-	-	-	201	8.66	7.40	36.18	194
CRI 10-7	7 1/2	1	•	22.17	10.22	7 62	37.70	-	-	-	225	-	-	-	-
		3	•	22.17	8 66	5 28	37 68	-	-	-	212	-	-	-	-
CRI(E) 10-8	7 1/2	1	•	23 35	10.22	7 62	38 88	-	-	-	227	-	-	-	-
		3	•	23 35	8 66	5 28	38 86	-	-	-	214	8.66	7.40	38.86	229
CRI 10-9	7 1/2	1	•	24 53	10.22	7 62	40 06	-	-	-	229	-	-	-	-
		3	•	24 53	8 66	5 28	40 04	-	-	-	216	-	-	-	-
CRI(E) 10-10	7 1/2	1	•	25.71	10.22	7 62	41 24	-	-	-	232	-	-	-	-
		3	•	25.71	8 66	5 28	41 22	-	-	-	218	8.66	7.40	41.22	234
CRI(E) 10-12	10	1	-	28 07	10.23	10.30	44.14	-	-	-	346	-	-	-	-
		3	-	28 07	8 66	5 28	43 58	-	-	-	225	10.24	8.39	42.99	243
CRI(E) 10-14	15	3	-	32 95	10.22	8 67	49 53	10 62	7.33	49.26	432	-	-	-	-
CRI 10-16	15	3	-	35.31	10.22	8 67	51 89	10 62	7.33	51.62	442	-	-	-	-
CRI 10-17	15	3	-	37.68	10.22	8 67	54 26	10 62	7.33	53.99	447	-	-	-	-

All dimensions in inches unless otherwise noted.

*Oval flanged pump B1 and B1+B2 dimension is equal to ANSI flanged pumps and weight is approximately 7 lbs. less.

• Available.





Pump type	P2 [hp]	Ph.	PJE*	ANSI dimensions [inch]							Ship Wt. [lbs.]	ANSI dimensions [inch]			Ship Wt. [lbs.]
				B1	TEFC			ODP				MLE			
					D1	D2	B1+B2	D1	D2	B1+B2		D1	D2	B1+B2	
CRN(E) 10-1	1	1	•	15 20	7.19	5.73	26.39	-	-	-	106	5.55	5.51	24.18	97
		3	•	15 20	5 55	4.57	22.64	-	-	-	97	7.01	6.57	28.00	119
CRN(E) 10-2	1 1/2	1	•	15 20	7.19	5.73	26.88	-	-	-	121	-	-	-	-
		3	•	15 20	5 55	4.57	23.82	-	-	-	99	7.01	6.57	28.00	119
CRN 10-3	3	1	•	17.13	8 60	6.87	31.78	-	-	-	176	-	-	-	-
		3	•	17.13	7 01	4.33	30.36	-	-	-	147	-	-	-	-
CRN(E) 10-4	3	1	•	18 31	8 60	6.87	32.96	-	-	-	176	-	-	-	-
		3	•	18 31	7 01	4.33	31.54	-	-	-	149	7.01	6.57	31.62	157
CRN 10-5	5	1	•	19.49	10.62	7.46	35.01	-	-	-	203	-	-	-	-
		3	•	19.49	8 66	5.28	35.00	-	-	-	199	-	-	-	-
CRN(E) 10-6	5	1	•	20 67	10.62	7.46	36.19	-	-	-	205	-	-	-	-
		3	•	20 67	8 66	5.28	36.18	-	-	-	201	8.66	7.40	36.18	194
CRN 10-7	7 1/2	1	•	22.17	10.22	7.62	37.70	-	-	-	227	-	-	-	-
		3	•	22.17	8 66	5.28	37.68	-	-	-	214	-	-	-	-
CRN(E) 10-8	7 1/2	1	•	23 35	10.22	7.62	38.88	-	-	-	229	-	-	-	-
		3	•	23 35	8 66	5.28	38.86	-	-	-	216	8.66	7.40	38.86	229
CRN 10-9	7 1/2	1	•	24 53	10.22	7.62	40.06	-	-	-	232	-	-	-	-
		3	•	24 53	8 66	5.28	40.04	-	-	-	218	-	-	-	-
CRN(E) 10-10	7 1/2	1	•	25.71	10.22	7.62	41.24	-	-	-	234	-	-	-	-
		3	•	25.71	8 66	5.28	41.22	-	-	-	221	8.66	7.40	41.22	234
CRN(E) 10-12	10	1	•	28 07	10.23	10 30	44.14	-	-	-	346	-	-	-	-
		3	•	28 07	8 66	5.28	43.58	-	-	-	225	10.24	8.39	42.99	243
CRN(E) 10-14	15	3	•	32 95	10.22	8.67	49.53	10.62	7 33	49.25	432	-	-	-	-
CRN 10-16	15	3	•	35 31	10.22	8.67	51.89	10.62	7 33	51.63	442	-	-	-	-
CRN 10-17	15	3	•	37 68	10.22	8.67	54.26	10.62	7 33	54.00	447	-	-	-	-

All dimensions in inches unless otherwise noted.

*PJE flanged pump B1 and B1+B2 dimension is equal to ANSI flanged pumps and weight is approximately 9 lbs. less.

• Available

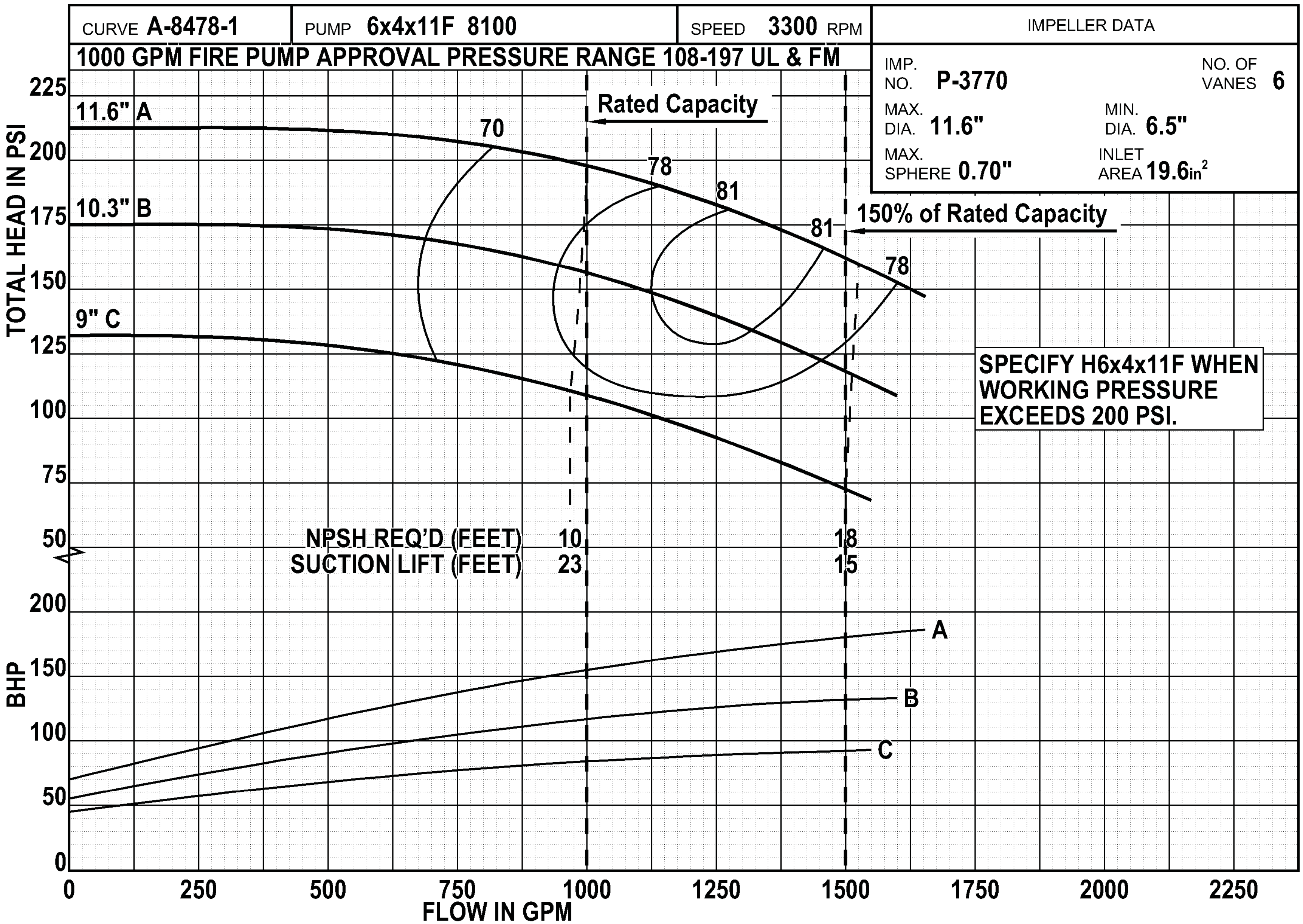
FP 2.0

PERFORMANCE CURVES

1000 GPM

OCTOBER 2012

SUPERSEDES ALL PREVIOUS ISSUES



Curves show performance with clear water at 85°F. If specific gravity is other than 1.0, BHP must be corrected.

RICH-TEK INDUSTRIES

101 - 31265 Wheel Avenue
Abbotsford, BC V2T 6H2

Phone: 1-855-557-0008
Fax: 1-866-229-5393
Email: info@richtek.ca

Fire Pump Flow Test Report

LOCATION: Uplands Booster Station **CUSTOMER:** Village of Anmore **DATE:** Nov 14 & Dec 16, 2013

ADDRESS: 1065 Uplands Drive, Anmore, BC **TECHNICIAN:** JS/JL **JOB #:** 15811

NAMEPLATE DATA

Pump

Make: AC Fire — Apprv'd: [✓] YES [ ] NO
Model: 8100 HSC 6x4x11F — Serial: 08-052333-01
Rated cap. (USGPM) @ **100%:** 1000 **150%:** 1500
Rated head (PSI) @ **100%:** 155 **150%:** 122
Shutoff head (PSI): 171 — Supply: City
Vert Type: Gauge to water: N/A — Pumping head: N/A
Static head: N/A

Driver

[✓] Electric [ ] Diesel [ ] Other
Make: WEG — Frame: 404/5TS
Model: N/A — Encl: ODP
Cyl: N/A — Volts: 575
HP: 125 — FLA: 110
RPM: 3560 — SF: 1.15
Serial: N/A

Controller

Manufacturer: Tornatech
Approved: [ ] YES [✓] NO
Model: GPS-600 — Serial: Z31419
[ ] Semi-Auto [✓] Full Auto
[ ] Limited Service [✓] Full Service
[ ] Across the line [✓] Soft Start
Transfer Switch: [ ] YES [✓] NO

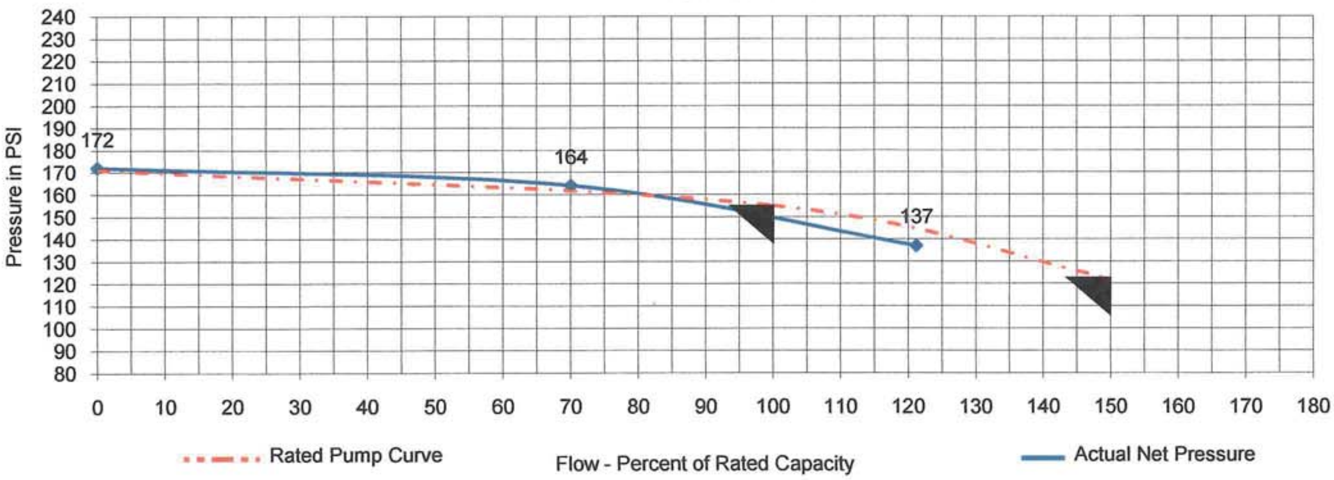
FLOW TEST DATA

Test #	Suction PSI	Dischrg PSI	Diff. PSI	Pitot 1	Pitot 2	Pitot 3	Pitot 4	Pitot 5	Pitot 6	% of R.C.	Flow USGPM	Volts AB	Volts AC	Volts BC	Amps L1	Amps L2	Amps L3	RPM
1	105	277	172	0	0	0	0	0	0	0	0	585	584	586	65	61	63	3578
2	26	190	164	15	0	0	0	0	0	70	700	574	572	575	94	98	94	3567
3	1	138	137	15	8	0	0	0	0	121	1212	589	587	589	110	109	111	3563
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	Pitot 1	Pitot 2	Pitot 3	Pitot 4	Pitot 5	Pitot 6
Nozzle Size:	2.5	2.5				
Nozzle Factor:	0.97	0.97				

Flow Meter: Make: N/A Range:

Flow Test Curve



We certify that this pump was tested in accordance with the NFPA 20/25 standards: **Pass:** [✓] **Fail:** [ ] **See Comments:** [✓]

Comments:

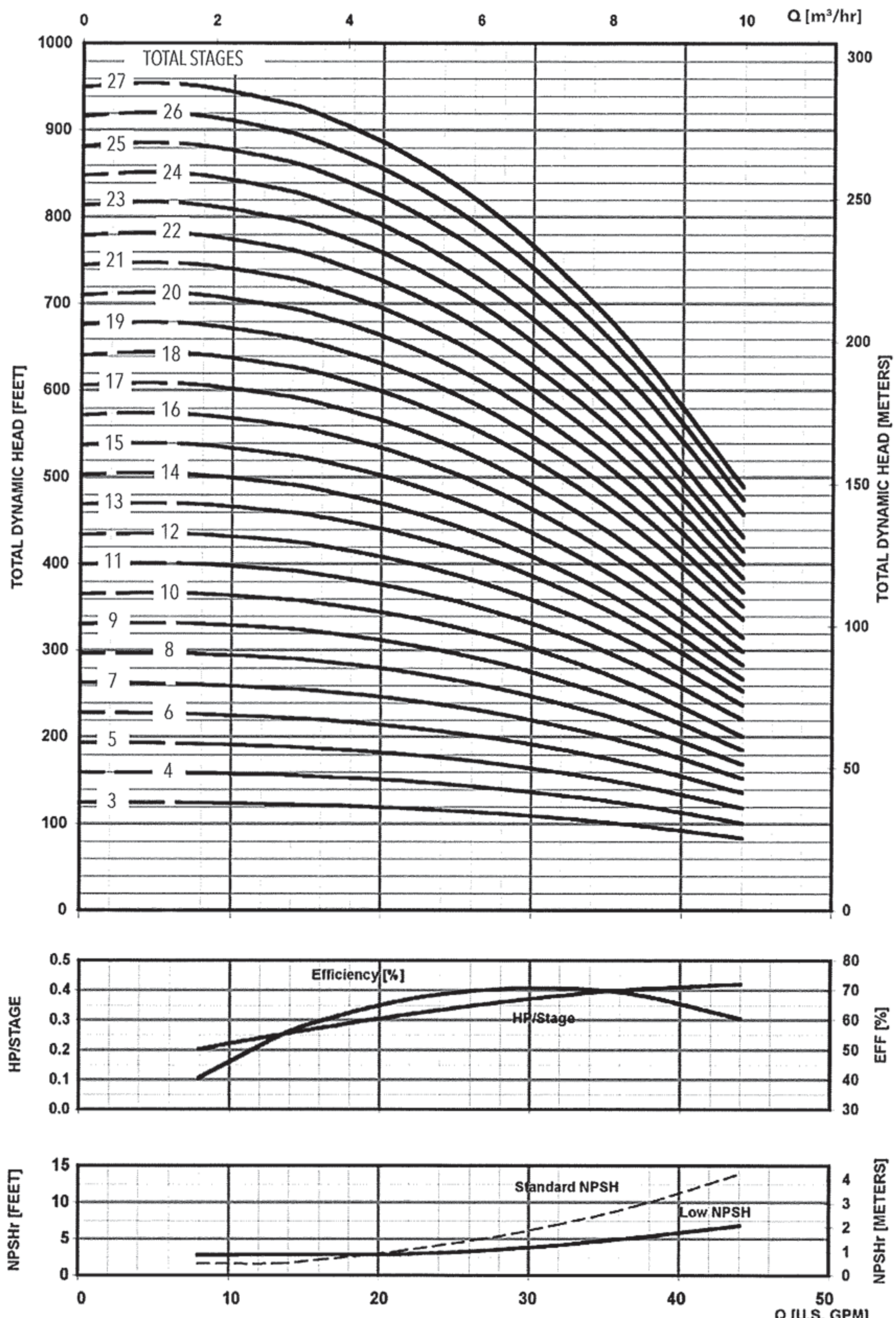
See Annual Report

The fire pump controller does not have a UL, ULC, FM or CSA listing on its nameplate.

Could not flow past 121% of rated pump capacity due to insufficient suction supply.

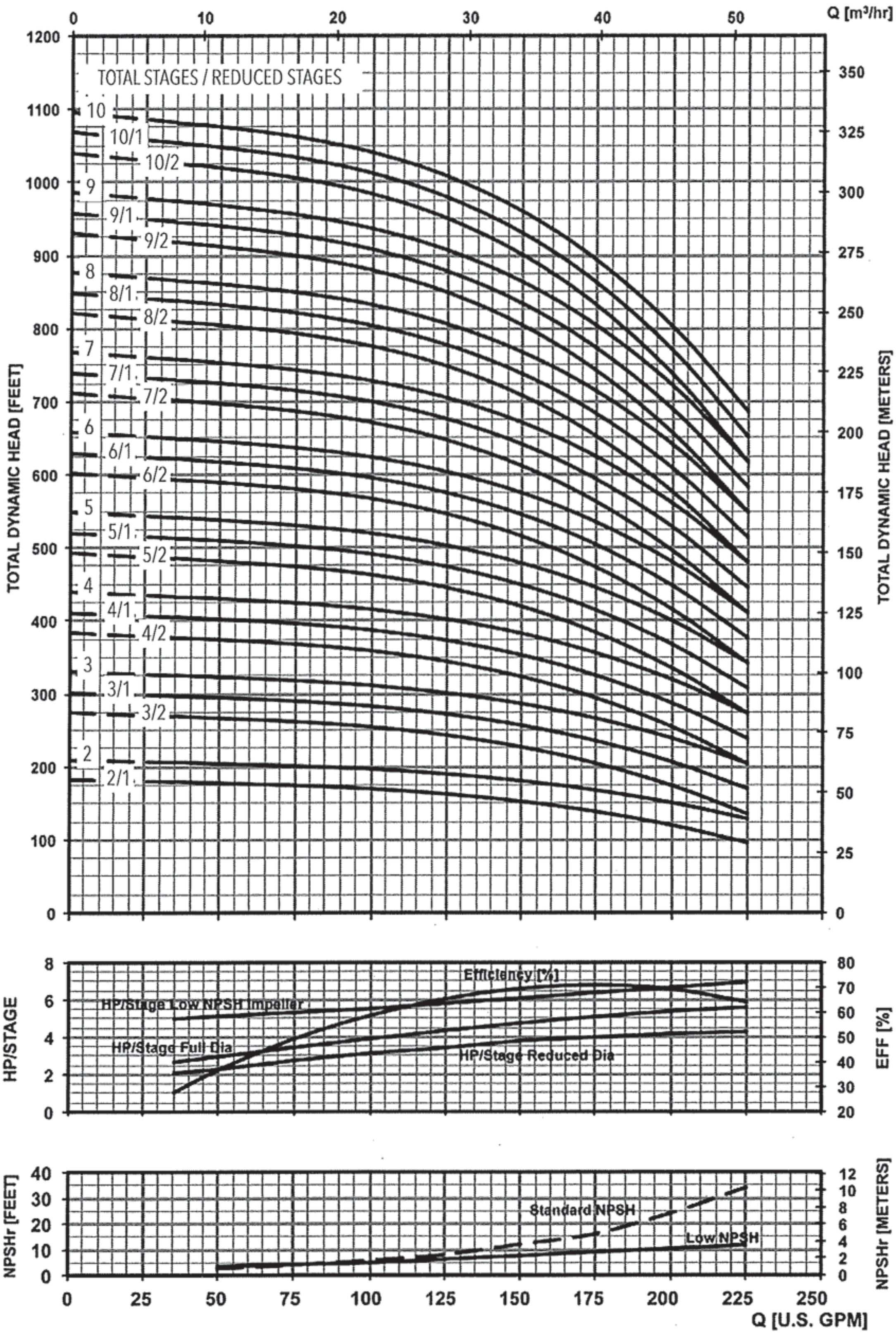
FIRE PROTECTION REGISTERED ASTTBC TECHNICIAN JEFFREY SUTTIS FP1203 FP

Performance Curve **5SV 60 Hz 3500 RPM** **LOW NPSH CURVE**



MINIMUM FLOW RATE: 7 GPM [1.6 m³/hr]

Performance Curve **33SV 60 Hz 3500 RPM** **LOW NPSH CURVE**



MINIMUM FLOW RATE: 35 GPM [8 m³/hr]

DUTY & JOCKEY PUMPS

SUPPLIER: **ADI SALES**
Austin & Denholm Industrial Sales
201 – 7188 Progress Way,
Delta, BC V4G 1M6

Phone: (604) 940-2722
Fax: (604) 940-2710
Web: www.adisales.com

MANUFACTURER: **GOULDS PUMPS, ITT CORPORATION**
55 Royal Road
Guelph, On N1H 1T1

Phone: (519) 826-0869
Fax:
Web: www.goulds.com

MODEL / SIZES: Duty Pumps:
Goulds 33SV62GN4E60 Inline multistage pumps, 30HP
575/3/60, 3450RPM, TEFC premium efficiency
Jockey Pump:
Goulds 5SV23FH4E60 Inline multistage pumps, 7.5HP
575/3/60, 3450RPM, TEFC premium efficiency

TAG: PMP-02, PMP-03, PMP-04 (On Mechanical Drawings)

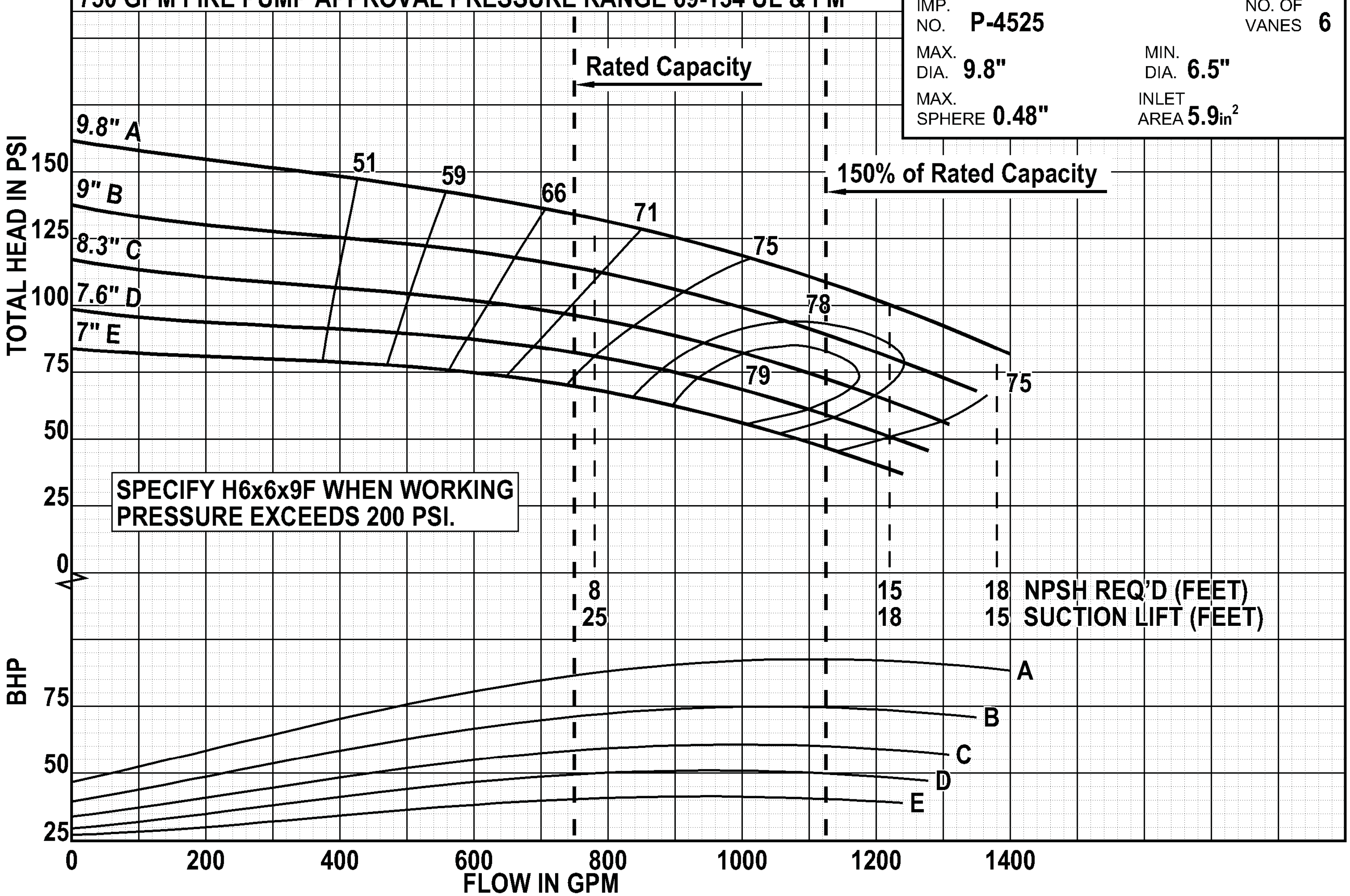
PERFORMANCE CURVES

750 GPM

OCTOBER 2012

SUPERSEDES ALL PREVIOUS ISSUES

CURVE A-8780	PUMP 6x6x9F 8100 Series	SPEED 3550 RPM	IMPELLER DATA
750 GPM FIRE PUMP APPROVAL PRESSURE RANGE 69-134 UL & FM			IMP. NO. P-4525; NO. OF VANES 6; MAX. DIA. 9.8"; MIN. DIA. 6.5"; MAX. SPHERE 0.48"; INLET AREA $5.9 in^2$



Curves show performance with clear water at 85°F. If specific gravity is other than 1.0, BHP must be corrected.

RICH-TEK INDUSTRIES

101 - 31265 Wheel Avenue
Abbotsford, BC V2T 6H2

Phone: 1-855-557-0008
Fax: 1-866-229-5393
Email: info@richtek.ca

Fire Pump Flow Test Report

LOCATION:	Pinnacle Ridge	**CUSTOMER:**	Village of Anmore	**DATE:**	September 20, 2013
ADDRESS:	60 Kinley Road, Anmore, BC	**TECHNICIAN:**	KJ/RG	**JOB #:**	15419

NAMEPLATE DATA

Pump

Make: AC Fire	Apprv'd ☑ YES ☐ NO		
Model: 8100 Split Case	Serial:	11-060576-01	
Rated cap: USGPM @ **100%**	750	**150%**	1125
Rated head in PSI @ **100%**	80	**150%**	57
Shutoff head in PSI: 99	Supply:	City	
Vert Type:	Gauge to water: N/A	Pumping head: N/A	
	Static head: N/A		

Driver

☑ Electric ☐ Diesel ☐ Other	
Make: WEG	Frame: 324TS
Model: N/A	Encl: DP
Cyl: N/A	Volts: 575
HP: 50	FLA: 47.3
RPM: 3555	SF: 1.15
Serial:	

Controller

Manufacturer: Tornatech	
Approved: ☑ YES	☐ NO
Model: GPS	Serial: Z86009
☐ Semi-Auto	☑ Full Auto
☐ Limited Service	☑ Full Service
☐ Across the line	☑ Autotransformer
Transfer Switch: ☐ YES	☑ NO

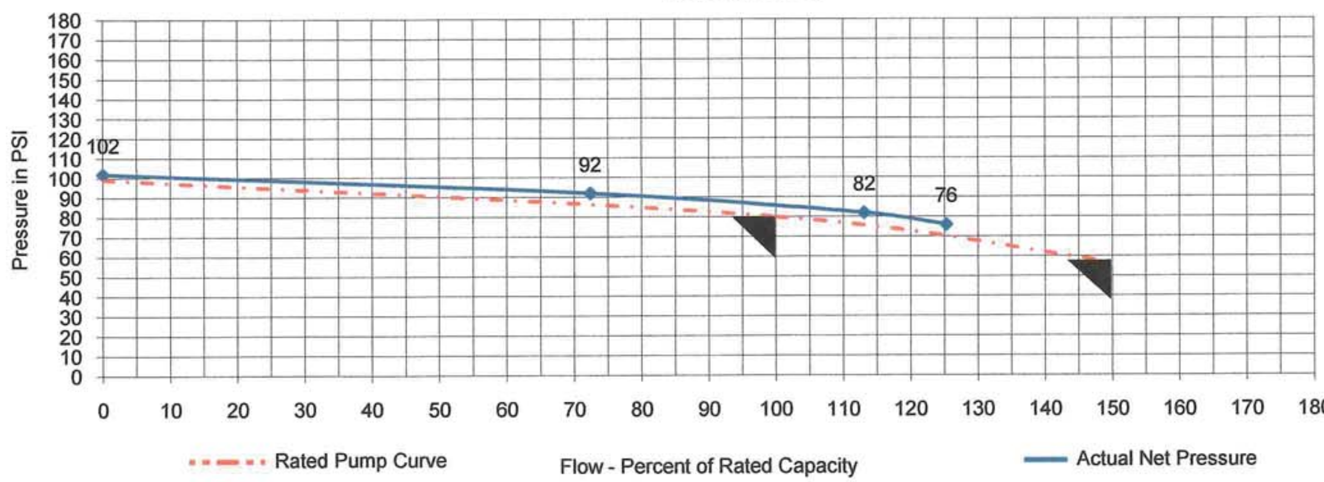
FLOW TEST DATA

Test #	Suction PSI	Dischrg PSI	Diff. PSI	Pitot 1	Pitot 2	Pitot 3	Pitot 4	Pitot 5	Pitot 6	% of R.C.	Flow USGPM	Volts AB	Volts AC	Volts BC	Amps L1	Amps L2	Amps L3	RPM
1	60	162	102	0	0	0	0	0	0	0	0	610	605	607	29	27	32	3582
2	44	136	92	9	0	0	0	0	0	72	543	609	604	606	45	39	38	3568
3	28	110	82	22	0	0	0	0	0	113	848	609	603	605	49	43	43	3565
4	20	96	76	27	0	0	0	0	0	125	940	609	603	606	49	44	43	3561
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Nozzle Size:	2.5					
Nozzle Factor:	0.97					

Flow Meter: Make: N/A
Range:

Flow Test Curve



We certify that this pump was tested in accordance with the NFPA 20/25 standards: **Pass:** ☑ **Fail:** ☐ **See Comments:** ☐

Comments:

See Annual Report

FIRE PROTECTION
REGISTERED ASTTBC TECHNICIAN
KEVIN JOHNSTON
FP1134
FP

Opus DaytonKnight Consultants Ltd
210-889 Harbourside Drive
North Vancouver BC V7P 3S1
Canada

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w: www.opusdaytonknight.com