Water

District of Central Saanich

Water Distribution Master Plan

Prepared by:

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Project Number: 60240374 Task ID #1

Date:
15 March, 2013

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15 March, 2013 **Project No: 60240374 Task ID #1**

Yvan Sylvestre
Senior Engineering Technologist
District of Central Saanich
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Saanichton, BC V8M 2A9

Dear Yvan

Re: Water Distribution Master Plan – Final Report

We have attached for District of Central Saanich review, our FINAL report on the work performed by AECOM Canada Ltd. (AECOM) on the Central Saanich Water Distribution Master Plan.

The FINAL report summarizes the effort and results of the hydraulic modelling, including recommendations related to proposed water system upgrading to meet both current and future conditions/requirements. Portions of the district that are currently Non-Serviced Areas are also addressed in this hydraulic analysis and review.

The report also includes the results of a Condition Assessment and prioritized replacement based upon a Risk and Criticality model, and using parameters and weightings specific to Central Saanich. While this approach does not indicate a significant amount of additional replacement and upgrades beyond the hydraulic needs currently required, it can be used to guide future requirements as existing pipes continue to age.

A prioritized replacement/upgrading program has been recommended, consisting of the hydraulic improvements plus some relatively minor upgrades from the Risk and Criticality model. The Risk and Criticality model has then been used to provide an indication of budgeting needs beyond the initial prioritized program.

We trust this report and its model deliverables provide Central Saanich with sufficient information to better understand its water system, its performance and upgrading requirements for the short term and future.

Please feel free to contact me if you have any questions.

Sincerely,
AECOM Canada Ltd.

Mike Brady, P.Eng.
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MB/bl
Encl.

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Revision Log

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0	M. Brady	Jan 2013	Draft
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AECOM Signatures

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Executive Summary

This report, “Water Distribution Master Plan” summarizes the work performed and the results of both Hydraulic and Risk/Criticality modelling for the water distribution system of Central Saanich.

Hydraulic Analysis

In doing so, the Hydraulic analysis examined the following:

- existing network of water mains
- assessment of total system water demands and allocation of water system demands based upon meter information (for large users) and eight separate land use types and parcel size (where appropriate)
- current required capacities during average-day, maximum-day, and peak-hour water demand scenarios, as well as providing flows for firefighting under the maximum-day demand condition
- required capacities, including firefighting flows, for future development scenarios in the years 2025 and 2050.

To accurately represent the hydraulic performance of the overall water distribution system, the hydraulic model was first calibrated to match measured results from known conditions. Those conditions were created through a series of fireflow tests conducted throughout the district, chosen to provide diversity of pipe sizes, pipe materials and geographic locations, representing various land use and hydraulic pressure zones.

Once the model calibration was confirmed as adequately representing the water system performance with acceptable accuracy, it was then used to determine system improvements and upgrades required to correct those areas of the system that are hydraulically inadequate so that they meet common performance criteria under the current and future demand scenarios including firefighting flows.

These hydraulic analyses result in a series of recommended improvements in a number of locations throughout the District. The hydraulic-related improvements ***(Ref. Table 5.6, Figure 5.18)*** needed to provide adequate flows and firefighting protection generally consist of replacement and new water mains, but also include three fire pump stations, and total approximately $7,353,000 in capital costs. Analysis of future demand conditions confirms that the improvements recommended to correct current capacities and performance will also provide adequate service in the future.

Non-Serviced Areas

Due to the unique character of Central Saanich, there are still significant areas within the community which are not served by the municipally-run water distribution system, including areas which are currently undeveloped. A specific objective of this project and study was to evaluate how servicing could be provided to these lands and the additional infrastructure needed to accomplish this. Further, within these non-serviced areas, the northwest quadrant (NWQ) was to be examined as a separate entity since it has been the subject of a specific review by another consultant and the District desired having the conclusions confirmed, or amended, using the hydraulic model developed for the entire water system.

AECOM’s analysis determined a number of improvements or system additions required to supply water to the non-serviced areas, excluding the NWQ ***(Ref. Figure 7.6)***. For the NWQ, our analysis generally confirmed the conclusions of the previous specific review, with a few amendments and refinements to optimize servicing here ***(Ref. Figure 7.8)***. These results are presented for a planning perspective only, and there is no urgency to proceed with any of the proposed/recommended upgrades for the non-serviced areas prior to development, at which time the planning level conclusions can be reconfirmed.

Condition Assessment/Risk and Criticality Model

In addition to the hydraulic analyses and recommended upgrades, an assessment of future pipe replacement needs was developed using a Risk and Criticality model. The model is spreadsheet-based and incorporates a number of evaluation parameters and weightings ***(Ref. Figure 8.1)*** to determine values for Probability of Failure (PoF), Consequence of Failure (CoF) and overall Risk (PoF x CoF) for each of the pipes, to arrive at a prioritization of future pipe replacements, for example, as they near or exceed their expected service life (ESL). The parameters used and the weightings of different factors were developed jointly with District staff and they, the PoF, CoF and overall Risk, reflect conditions and priorities specific to Central Saanich and its water distribution system. The results are presented on a scatter plot ***(Ref. Figure 8.3)*** which shows that the Central Saanich system is generally in good condition, requiring very few pipe replacements resulting from the PoF, CoF and Risk analyses. Three pipes have been identified through this process, of which one pipe appears to have anomalous data, a second is a short link that should be deferred until adjoining pipes are determined to be in need of replacement, and the third is recommended for replacement because it is adjacent to other pipes that are to be replaced to improve fire flows, based upon the previous hydraulic analysis. The Risk and Criticality model has been provided to the District and can be used in future years to re-assess the system as the pipes continue to age and approach their ESLs.

Shorter-Term Priority Program

The proposed upgrades/replacements recommended by both the Hydraulic and Risk and Criticality models and analyses have been assembled as a complete priority upgrading program ***(Ref. Table 9.1, Figure 9.1)***, with a total value of approximately $8,354,000.

AECOM recommends that this program be addressed as a priority and that this Shorter Term Priority program be completed over a period of 10 years, provided that funding is available (approximately $835,400 per year).

AECOM further recommends that both the Hydraulic and Risk and Criticality models be updated regularly (say, annually) to reflect new or replaced pipes and that the models be re-run, with resulting revised conclusions and priorities, on a minimum frequency of once every five years.

Longer-Term Priority Program

Beyond the Shorter Term Priority program, the Risk and Criticality model has been used to predict water main replacements that can be expected as existing pipes continue to age and approach, or exceed, their respective ESL values. The model shows that for the period between 10 and 25 years hence, the predicted annual costs for replacement can vary between $500,000 and $1,000,000 per year. While these values and budgets should be re-examined as part of updating the models, AECOM recommends that Central Saanich consider establishing a tentative annual budget of $750,000 per year for water main replacements during this period.

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1. Introduction

The District of Central Saanich is located on the Saanich Peninsula with a population of approximately 16,000 people residing in both rural and urban types of environment. As stated in the latest District's Official Community Plan (OCP), it is the District's fundamental philosophy to retain, protect and enhance the current rural village character of Central Saanich, its agricultural land base and environmentally sensitive areas, while allowing for modest, low-impact growth within the established Urban Settlement Area.

Consequently, the District is interested in undertaking a comprehensive study of the District's water distribution system, in order to gain a better understanding of the existing system as well as to plan for future needs to support the District's short and long-term vision.

1.1 Existing System Overview

The District's water system is part of the Saanich Peninsula Water System (SPWS) which, in general, receives its water supply from the Capital Regional District Integrated Water System (CRD-IWS) through Bear Hill Reservoir (HGL: 152 m) and Alderly PRV (HGL: 115 m). There are essentially two CRD transmission mains crossing the District with 11 supply points to the District's distribution network, either through direct connection or through a pressure regulating or reducing valve (PRV).

The District's water system network consists of about 125 km of watermains ranging in diameter from 50 mm to 300 mm. Within the District's distribution network, there are ten (10) pressure zones, two (2) active pump stations, one (1) reservoir, and nine (9) PRV stations. Because the District's water system is closely intertwined with the SPWS, some of these facilities are owned and operated by the CRD. ***Figure 1.1*** shows the existing water distribution system map of the District.

The supply points for each of the pressure zones in the system are summarized in ***Table 1.1***.

1.2 Key Objectives

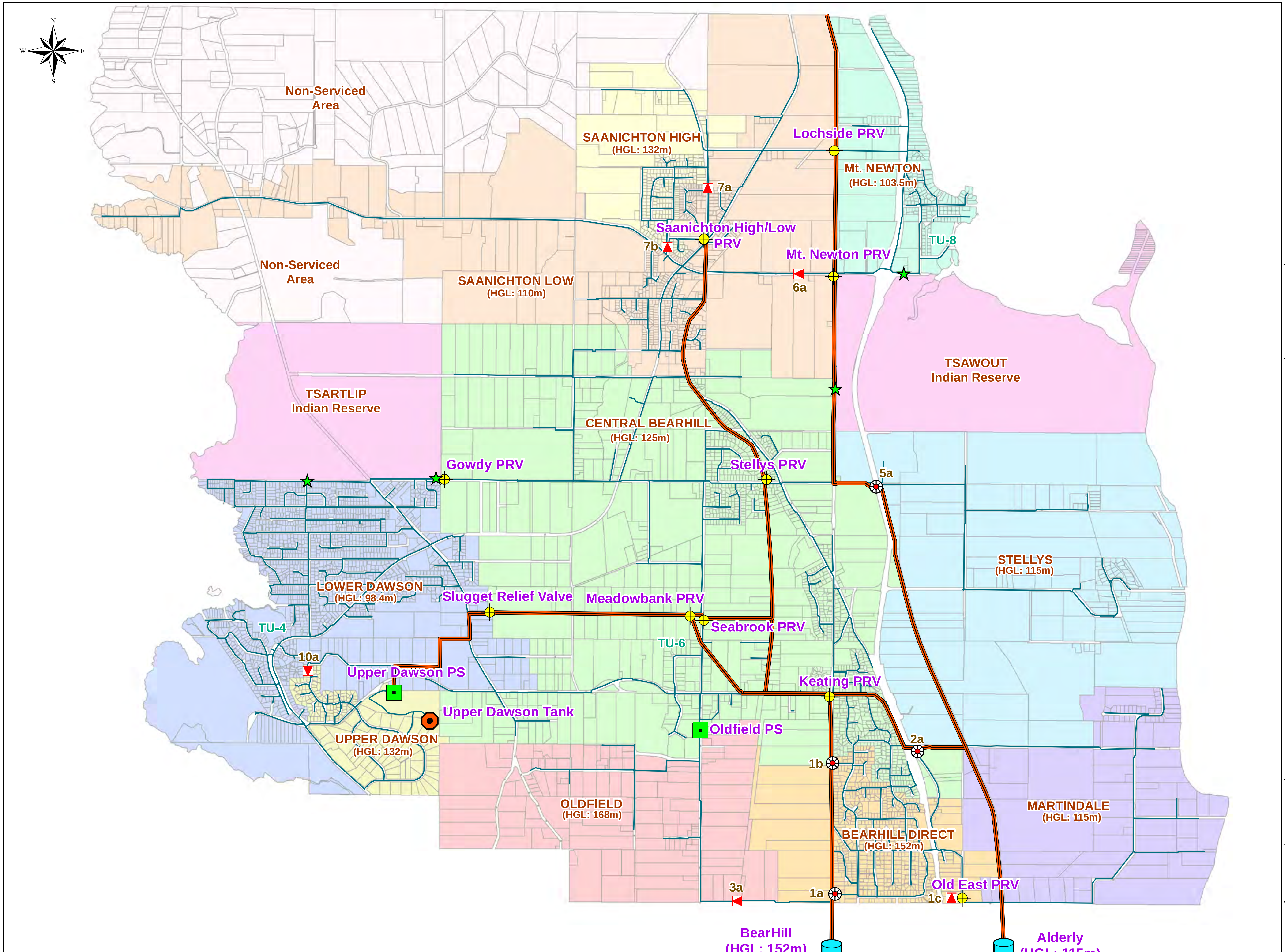
The main objectives of this study and report are as follows:

- Indentify existing and future system deficiencies under different demand conditions (including fire flow and agricultural irrigation needs),
- Estimate order of magnitude cost associated with proposed improvement works,
- Develop an up-to-date water hydraulic model (with GIS capability),
- Identify cost and phasing options to service areas that are not currently serviced with piped water, and
- Recommend a condition rating system for assessing the District's water distribution infrastructure assets.

Table 1.1 – Supply Points Summary

Pressure Zone	HGL (m)	No. (Shown in Fig 1.1)	Supply Points	Setting (m)
Bear Hill Direct	152		Direct connection from Bear Hill Transmission Main at:	N/A
		1a	Central Saanich Rd/Meadowland Dr	
		1b	Central Saanich Rd/Styan Rd	
		1c	Check valve at Old East PRV from Martindale Zone (during low pressure)	
Martindale	115		Direct connection from Alderly Transmission Main at:	N/A
		2a	Gliddon Rd/Martindale Rd	
			Old East PRV	48.7
Oldfield	168		Oldfield PS	N/A
		3a	Check valve on Bear Hill Rd from Bear Hill Direct Zone (during low pressure)	
Central Bear Hill	125		Keating PRV	63
			Seabrook PRV	59
			Stelly's PRV	67.8
Stelly's	115		Direct connection from Alderly Transmission Main at:	N/A
		5a	Stelly's X Rd/Lochside Dr	
Saanichton Low	110		Saanichton PRV (low)	55.4
		6a	Check valve at Saanich Hospital from Mt. Newton Zone (during low pressure)	N/A
Saanichton High	132		Saanichton PRV (high)	75.7
		7a	check valve at Jeffrey Rd/E. Saanich Rd from Saanichton Low Zone (during low pressure)	N/A
		7b	check valve at Mt. Newton X Rd/Simpson Rd from Saanichton Low Zone (during low pressure)	
Mt. Newton	103.5		Mt. Newton PRV	75
			Lochside PRV	56.5
Lower Dawson	98.4		Gowdy PRV	37.9
			Meadowbank PRV	33.5
Upper Dawson	132		Upper Dawson PS & Tank	N/A
		10a	Check valve at Greig Ave/Amwell Dr from Lower Dawson Zone (during low pressure)	

Note:
N/A – Not Applicable



District of Central Saanich

Water Distribution Master Plan

Water Distribution Existing System

Legend

- Existing Watermain
- CRD Transmission Main
- CRD Supply Point
- Control Valve
- Pump Station
- Tank
- Check Valve
- Direct Connection from CRD mains
- First Nations Supply Point

Figure No:	
Figure 1.1	
Project No: 60240374	Date: December 2012

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2. Software Selection

There are many software programs exist that are suitable for analyzing the District's water system, ranging from simple and free-of-charge to extensive, complex and very expensive. Thus a selection criteria needs to be developed to capture the essential and key factors that are suitable for the District's network conditions. The District's current hydraulic model is built in WaterCAD version 3.1, which is an AutoCAD based model and is not fully functional and compatible with GIS. One of the options would be to migrate the model to WaterGEMS (by the same software company) which is basically has the same file structure as WaterCAD but runs in ArcGIS.

Following discussion with the District's staff, it was decided to compare WaterGEMS (by Bentley) against InfoWater (by Innovyze) and assess their essential and relevant features to suit the District's needs, including: ease of use, graphical interface, GIS integration, hydraulic capabilities and stabilities, cost and support availability. The comparison summary is presented in ***Table 2.1***.

As can be observed from the table, for the most part, both of these software programs are comparable, and they both use EPANET as their basic hydraulic engine which is very reliable. The most significant differences between them are:

- Price for purchasing and annual support cost.
- Support availability.
- WaterGEMS (by Bentley) does not have local representative, therefore it may contribute to their response time. InfoWater (by Innovyze) has local representative in BC, thus their response time is relatively short.
- Graphics
- InfoWater has better graphics and color coding availability and options when compared to WaterGEMS.
- ArcGIS Integration
- InfoWater requires a separate ArcGIS licence while WaterGEMS has proprietary open GIS structure, and does not rely on ArcGIS package. However, the District already has an ArcGIS license, so either would be suitable and integratable.

It may also be important to consider that most (if not all) of the other municipalities within the regional CRD IWS, including CRD itself, are using InfoWater. This may speak to its reliability, ease of use, price, support availability among other features, and could offer an additional benefit that adjoining systems will be modeled/simulated with the same software and similar input/output data.

Based upon the foregoing and the comparisons made between the two software programs summarized in ***Table 2.1***, AECOM recommended that the District purchase InfoWater.

Table 2.1 - Software Selection Matrix

	Software Features	Description	InfoWater	WaterGEMS 8
1	**Cost**			
1.1	Purchase Cost	Cost to purchase model(CAD)	For 3000 pipes: $6,000 (single user) + $2,000 for floating license	For 2,000 pipes: $16,895 (assumed buying new, no credit for current WaterCAD) $10,400 (assumed CS currently owns a 1000-pipe, stand alone WaterCAD license) $6,500 (assumed CS currently owns a 1000-pipes, AutoCAD based WaterCAD license)
1.2	Support Cost (annual)	Annual software support from vendor (CAD)	$1,000	$4,060 (has to be purchased in order to receive credit for current WaterCAD license)
2	**User Friendly**			
2.1	Ease of Use	Ease of model use, learning, simulations and making changes	Moderate ease of use	Moderate ease of use
2.2	Graphical Interface	Color coding and tabular input	Good graphics, color coding, time-series plot; tables & graphs are easy to update	Standard graphics and color coding; multiple time series plots on one graph.
2.3	Help File Documentation and Website	Software Help File as well as on-line help information	Vendor is Innovyze. Good software help files; Unlimited phone and email support. Technical support is in US and local BC. Quick response.	Vendor is Bentley System. Good help files; Technical support is from US only, level of support varies per annual payment, therefore service can be slow to respond at times.
3	**Compatibility**			
3.1	GIS Integration	Integrated with ArcView and able to retrieve files and maintain data links to GIS	Works with ArcMap, so requires ESRI license. Allows complete GIS capability.	Has proprietary open GIS architecture, does not rely on ESRI. Can file share various GIS systems/
3.2	Output Results	Flexibility of output files for use in other applications; Quality and usefulness of output	Good output tables, can be copied to Excel or ODBC database. Reports/graphs from different scenarios can be compared at the same time.	Establishes persistent links between the model and GIS, spreadsheet and databases. Multiple scenario results presentation.
3.3	SCADA	Ability to import file related to SCADA	SCADA data can be integrated and overlaid on results. No direct integration of data to be input into model.	SCADA data can be integrated and overlaid on results. No direct integration of data to be input into model.
4	**Model Features**			
4.1	Extended Period Simulation	Ability to run EPS	Interactive EPS to allow modification of controls at any time step.	Basic EPS features, limited space to input demand patterns
4.2	Hydraulic Components	Ability to import hydraulic components (PRV, pump, valve, control, non-uniform reservoir)	Good hydraulic engine and excellent demand allocation features. Able to model all hydraulic components and control settings.	Good hydraulic engine and excellent demand allocation features. Able to model all hydraulic components and control settings.
4.3	Automated Fire Flow Analysis	Ability to simulate automated fire flow analysis and multiple nodes in the system	Yes, able to compute flow at any junction, given a specified min. pressure.	Yes, able to compute flow at any junction, given a specified min. pressure.
4.4	Multiple Demands	Ability to enter multiple demands at one node	Yes, multiple demands can be allocated to a commond node, including a number of demand patterns	Yes, multiple demands can be allocated to a commond node, including a number of demand patterns (less than that available in InfoWater)
4.6	Scenario Manager	Ability to model various demand and operational scenarios using a single model file	Able to model numerous scenarios including varying: demand, pipe network, controls, etc.	Able to model numerous scenarios including varying: demand, pipe network, controls, etc.
4.7	Uni-Directional Flushing	Develops optimum flushing patterns and plans	Source tracing add-on can assist with UDF analysis. A separate Add-On software is available for UDF analysis, although it's ability is limited as it's not fully automated	Similar to InfoWater, it can calculate the shortest transport path. Implementation plans are developed manually

3. Model Development and Demand Allocation

3.1 Model Development

The current version of the District's water system model was first created in the 1990s in WaterCAD version 3.1. The model has been amended several times but has not been updated within the past ten years. Through the years, various fireflow tests have been checked using the model but it has not been subjected to a rigorous calibration process. It has been used, at times, to check impacts from proposed developments on existing infrastructure and overall system performance. A study in the late 1990s used the model for analysis but its purpose was only to look at availability of flows for agricultural purposes. In addition, the identification numbers for the model pipes and nodes do not correspond or correlate with the District's GIS system. Set points for pressure regulating valves (PRVs) and pumps may have been changed within this timeframe for operational purposes, which emphasizes the need to be updated to reflect current conditions.

As part of the assignment, AECOM reviewed the existing system model, checked it for accuracy and physical representation. When developing the hydraulic model the following data sources were also reviewed, in addition to the current hydraulic model in WaterCAD:

1. Latest District's Water Distribution System Network in AutoCAD;
2. Pipe Database as per the District's 2008 Public Sector Accounting Board (PSAB) Asset Inventory and Valuation Study;
3. District of Central Saanich Water Distribution System Map Book;
4. CRD SPWS Integrated Water Map Index.

After reviewing all these data sources, it was decided to build the model directly from the network represented in AutoCAD (Source No.1 listed above) because it represents the most up-to-date pipe network and its connectivity throughout the system. Nevertheless some model clean-up process was still required particularly in the following areas:

- Unique ID

  Pipe ID available in AutoCAD was retained and used as the ID in the hydraulic model. The pipes without ID could not be imported automatically into the model and had to be drawn manually. For these pipes, new IDs were created.

- Watermain connectivity and hydraulic information

  - Pipe segmentation

    Within the hydraulic model each pipe has to be spatially connected to its connecting pipes and segmented properly with nodes at both ends. The tools available in the modelling software were used to ensure all pipes were snapped properly and subsequently nodes were created for each pipe segment.

  - Connectivity around PRV and Pump

    In the AutoCAD drawing most of the connectivity around the PRV and pump facilities was not drawn on the actual location rather it was drawn as a subset. Thus representative pipes' connectivity around these facilities had to be drawn manually within the hydraulic software.

  - Closed and check valves

    The locations of these valves were not immediately available to be imported into the model, thus manual check and verification had to be performed. The watermains interconnection throughout the system was reviewed, with emphasis on the pressure zone boundaries within the network to ensure there was no open connectivity across the different pressure zones existed in the system that would allow water to flow to the lower pressure zone during normal operating conditions.

- Interconnection between CRD Transmission Mains and District's watermains

  Some of these connections were not clearly represented in AutoCAD drawing, therefore the CRD and District's Map books were referenced to confirm these connection points, as well as discussion with District's staff.

- Pipes diameter and material information

  Both of this information was obtained from AutoCAD which was imported into the modelling software automatically (when possible) or manually.

- PRV Settings

  The setting for the ten (10) PRVs within the system was provided by the District through the District's weekly PRV reading and the other available SCADA data.

- Pump Information

  There was no pump curve information for the two (2) active pumps within the District; at Oldfield and Upper Dawson. The pump's design head and flow information available in the current WaterCAD model for Oldfield pump was retained (Design Head: 42 m; Design Flow: 6 L/s). For the Upper Dawson pump, the pump curve information obtained from the Saanich Peninsula Water Supply System Study conducted by AECOM in 2011 was retained.

- Tank Information

  The hydraulic information for the Upper Dawson tank was obtained from the CRD SPWS Integrated Water Map Index. The tank has two (2) cells with a volume of 360 m^3 each and a Top Water Level (TWL) of 132 m.

3.2 Existing System Demand Calculation

3.2.1 Data Sources

The following data sources were obtained and reviewed during the demand calculation process.

CRD-IWS

1. Daily water consumption for the entire Region (Japan Gulch) from July 1, 2007 – March 19, 2012
2. Daily flow from July 1, 2007 – October 1, 2007 for these connection points:
   - Hamsterly PS
   - Lochside 2-inch
   - Lochside 6-inch
   - Martindale (reading from just 1 connection point of total 2 connection points)
   - Mt. Newton
   - Tswaout 2 (all flow was zero)
   - Tswaout 10 (all flow was zero)
3. Hourly flow from July 17, 2009 – July 31, 2009 for:
   - Hamsterly
   - Dooley

4. Hourly tank level for Bear Hill tank from July 1, 2009 – July 31, 2009
5. Daily flow from July 1, 2009 – July 31, 2009 for:

   - Hamsterly
   - Dooley

6. District of Central Saanich water consumption calculation for 3 periods:

   - July 2007
   - September 2007
   - July 2009

District of Central Saanich

7. Water Billing Data for 2009 and 2010 periods

Additional water consumption information was also considered from *Saanich Peninsula Water Supply System Study* conducted by AECOM in 2011.

3.2.2 Data Analysis

3.2.2.1 CRD Data

The daily water consumption for the entire CRD had the longest span of flow data that could be used to assess how water demand varied throughout the years within the Region, as presented in ***Table 3.1*** below.

Table 3.1 – Water Consumption within CRD

	2007	2008	2009	2010	2011
Ave Consumption (ML)	145	143	144	134	130
Max Consumption (ML)	294	262	286	263	238
Max Day	July 11	July 16	July 29	July 8	July 6

The above table shows a general trend that the water consumption within the Region was decreasing starting from 2009 onward.

The daily and hourly flow data from different connection points between CRD and the District was also assessed for the two periods focused: July 2007 and July 2009. These two periods represented the highest water consumption within CRD for the last 5 years as presented in ***Table 3.1***. For the average day estimation, the flow during September 2007 was selected to be analyzed.

As can be observed from the Data Sources listed in *Section 3.2.1* above, the flow data received for July 2007 was not complete; however it could be complemented by the District of Central Saanich water consumption calculation provided by the CRD. There was no flow data for the CRD/District connection points for July 2009, nevertheless, it could also be complemented by the District of Central Saanich water consumption calculation, again provided by the CRD. The summary of all the flow data received from CRD is presented in ***Table 3.2***.

Table 3.2 – District of Central Saanich Water Demand Estimation

Monitoring Point	Maximum Day Demand (MDD)		Average Day Demand (ADD)
	July 2007 (L/s)	July 2009 (L/s)	Sept 2007 (L/s)
Bear Hill	151.17	174.92	94.17
Lochside	4.95	9.55	2.37
Martindale	9.34	13.86	4.85
Mt. Newton	10.16	9.78	7.29
Tswaout	13.62	14.37	9.90
Total Supply	**189.25**	**222.49**	**118.58**
Total Out - Dean Park (V2, V3)	**0.61**	**0.77**	**0.60**
Total Central Saanich	**188.64**	**221.72**	**117.98**

3.2.2.2 District of Central Saanich Data

The water billing data provided by the District contained quarterly flow data as well as zoning (land-use) for each property within the District. Therefore this billing data could only be used to assess ADD condition but not MDD. The summary of the billing data for both 2009 and 2010 is presented in ***Table 3.3*** below.

Table 3.3 – Water Billing Data Summary

Land-use	Zone ID	Consumption (L/s)	
		2010	2009
Agricultural	A, A1, A1-RE5	16.80	20.09
Commercial	C, CD, CR	5.91	6.07
Industrial	I	4.57	4.86
Institutional	P1, P3,A6	1.77	1.42
Res - SF	R1	32.74	27.08
Res - MF	R2, RCH,RM, RP1	8.83	12.84
Res - Rural	RE	3.84	4.48
Parks	P2,A4	0.14	0.15
Unidentified		0.19	4.18
First Nation		10.45	10.67
Outside C.S.(1)		1.71	1.71
TOTAL		**86.95**	**93.55**

Note:
(1) Outside C.S. are users from outside of the District of Central Saanich Municipality Boundary, mainly residing within the District of Saanich but serviced by Central Saanich.

It can be observed from ***Table 3.2*** that ADD for September 2007 based on CRD's water demand calculation is considerably higher than that summarized based on 2010 and 2009 billing data (***Table 3.3***) by about 26% and 20%, respectively. It should be noted that the billing data summarized in ***Table 3.3*** did not include the Unaccounted For Water (UFW), e.g., leakage, fire fighting, hydrant flushing, etc., while these items were accounted for when calculating the 2007 ADD based on CRD data which was mainly calculating water supply *Into* the District minus *Outflow* from the District.

If the difference between these two data sets was assumed to be all attributed to UFW then it would imply that the District experienced approximately 26% and 20% of UFW in 2010 and 2009, respectively.

3.2.2.3 AECOM Previous Study

Based on the analysis presented in the previous section, it was suspected that the UFW was higher than that really experienced by the District. Therefore a third data source was assessed: *Saanich Peninsula Water Supply System Study* done by AECOM in 2011.

In this study AECOM considered water consumption for the whole Saanich Peninsula but also broke it down to each municipality, i.e., Central Saanich, North Saanich and Sydney. The water demand calculation done in this study was based on the 2006 water consumption data. ***Table 3.4*** shows the summary of the demand for Central Saanich used in this study.

Table 3.4 – Central Saanich Water Demand Condition (Based on *Saanich Peninsula Water Supply Study*, 2011)

Land-use	Average Day Demand (ADD) (L/s)	Maximum Day Demand (MDD) (L/s)		Peak Hour Demand (PHD) (L/s)	
		Peaking Factor	Flow (L/s)	Peaking Factor	Flow (L/s)
Residential	70	2.8	196	4.7	329
ICI	12	1.2	14.4	1.8	21.6
Parks & Ag.	20	1.2	24	2	40
Undefined	4	1.1	4.4	1.8	7.2
UFW	10	1.0	10	1	10
TOTAL	**116**		**248.8**		**407.8**

3.2.3 Final Water Demand Calculation

The ADD reported in the Saanich Peninsula study had included the UFW water which was approximately 9.4% of the total water consumption, and it was similar to that calculated based on the CRD September 2007 data presented in ***Table 3.2***. This ADD water consumption was considered to be more conservative than using the billing data alone. Therefore, it was decided to use 116 L/s as the ADD for the District's water system.

However to maintain a more representative water demand allocation throughout the District, the 2010 meter billing data with its consumption and zoning information was nevertheless utilized as the base data when distributing the demand within the system. The discussion on the actual demand allocation process in the model is presented in *Section 3.3*.

Following the demand allocation process, the demand in the system was prorated to match the 116 L/s of total ADD discussed above, following the ratio established in ***Table 3.5*** below.

Table 3.5 – Demand Adjustment Factor

Land-use	2010 Billing Data (L/s)	2006 Demand (L/s)	Adjustment Factor
Residential	45.4	60.9	1.341
ICI	12.3	12	1.000
Parks & Ag.	16.9	20	1.181

It should be noted that the *First Nation*, *Outside C.S.*, and *Unidentified* water consumption identified in the 2010 billing records was kept as is and no adjustment was made to their water consumption. In addition, the UFW was kept to be the same percentage as that identified in the Saanich Peninsula study which was at 9.4% of total water consumption.

In order to establish the MDD to be used in the analysis, the MDD reported in the Saanich Peninsula Study (249 L/s) was compared to the two MDD datasets obtained from CRD for July 2007 (189 L/s) and July 2009 (222L/s). Based on this comparison, it could be concluded that the MDD of 249 L/s from the Saanich Peninsula Study was reasonably close to the ones reported based on the CRD datasets and it represented the most conservative number. Therefore it was decided to use 249 L/s as the MDD within the District's water system. Thus when establishing the MDD consumption, the Peaking Factors established in the Saanich Peninsula study were utilized and applied to the established ADD in the system.

In order to establish the PHD to be used in the analysis, the hourly data obtained from CRD was assessed. This included flow data from Dooley, Hamsterly and volumetric change at Bear Hill tank. However, this data was not sufficient in establishing the PHD peaking factor for Central Saanich specifically as these points also supply water to the entire Saanich Peninsula, and not to Central Saanich alone. In addition, not all of the connection points between CRD and the District were continuously monitored and read, therefore they did not capture the peak hour information. The PHD peaking factors established in the *Saanich Peninsula Water Supply System Study* were the only representative and available information for the District's system, thus these factors were used in the current study. The final demand allocated within the system is summarized in ***Table 3.6***.

Table 3.6 – Demand Allocation in Current Study

Land-use	ADD (L/s)	MDD (L/s)	PHD (L/s)
Residential	60.9	170.5	286.2
ICI	12	14.4	21.6
Parks & Ag.	20	24.0	40.0
Undefined	0.2	0.2	0.2
First Nation	10.5	29.3	49.1
Out of Town	1.7	4.8	8.0
UFW	9.9	9.9	9.9
TOTAL	**115.2**	**253.1**	**415.1**

3.3 Existing Demand Allocation Process

Once the total demand in the system had been estimated, the next step was to allocate this demand within the distribution system appropriately. The following data sets were utilized during this process:

- 2010 Billing Data with water consumption and land-use information for each parcel within the District

  Since there is no unique ID available on the billing data for each parcel nor was it available on the Parcel polygon dataset available from AutoCAD, both of these datasets could not be linked automatically. Thus in order to use the billing data, the water consumption was grouped for each land-use type as that summarized in ***Table 3.3***.

- Parcel polygon in AutoCAD

  As mentioned above, there is no unique ID available in this dataset, and this was used as the spatial reference only.

- Non Serviced parcel polygon in AutoCAD

  This dataset shows the parcels that are not currently serviced by the District's water distribution system.

- Zoning (Land-use) polygon in AutoCAD

  This dataset shows the different land-use types throughout the District.

- Nodes from the hydraulic model

  In the hydraulic model, the demand needs to be assigned to the nodes in the system. Thus the newly created nodes were selected from the model to be included in this demand allocation process. It should be noted that the nodes connected to CRD Transmission Mains, PRV and/or Pump Station, Tank were not included in this process to ensure that the demand was only assigned to the District's distribution system where actual service pipes would be connected.

Before the automated demand allocation process could be performed, there were four (4) different user types that needed to be treated separately and assigned manually within the distribution network:

1. Unidentified Users. The water consumption associated with these users was distributed evenly throughout the network.
2. First Nation. The water consumption associated with these users was assigned manually following the automated demand allocation process to ensure their true/representative locations in the system.
3. Out of Town Users. As with the First Nation, water consumption associated with these users was assigned manually following the automated demand allocation process to ensure their true/representative locations in the system.
4. Top Ten (10) Users. Based on the 2010 Billing Records, the top 10 users were selected as summarized in ***Table 3.7*** and shown in ***Figure 3.1***. To confirm their true locations in the system, manual demand allocation was also performed for these users.

Table 3.7 – Top Ten Users (Based on 2010 Billing Record Data)

Top Users	2010 Billing (L/s)
Butchart Garden Complex	1.83
Saanich Peninsula Hospital	1.20
Industrial at Butler Crescent	0.84
Townhouse complex	0.80
Agricultural	0.76
Food Processing	0.74
Hotel/Commercial	0.62
Townhouse complex	0.57
Agricultural	0.54
Townhouse complex	0.50

The automated allocation process was conducted following these steps:

1. Selected the “Serviced” polygon by comparing the overall district wide parcel polygon and the “Non-Serviced” polygon.
2. Assigned land-use type to the “Serviced” polygon based on the information available from the Zoning polygon.
3. Calculated the demand for each “Serviced” polygon based on comparing its parcel area and land-use to the Total Water Consumption based on 2010 billing data summarized above (refer to Table 3.3), excluding the Unidentified, First Nations and Out of Town and Top Ten (10) users consumptions as discussed above.
4. Allocated the “Serviced” polygon to the closest pipe in the network then proportionally divided the demand to the connected nodes based on distance (refer to Figure 3.1 for visual reference) using tools available in InfoWater.
5. Demand assigned in the model was kept separated based on the parcel’s landuse type.

Figure 3.2 shows the demand allocation process graphically.

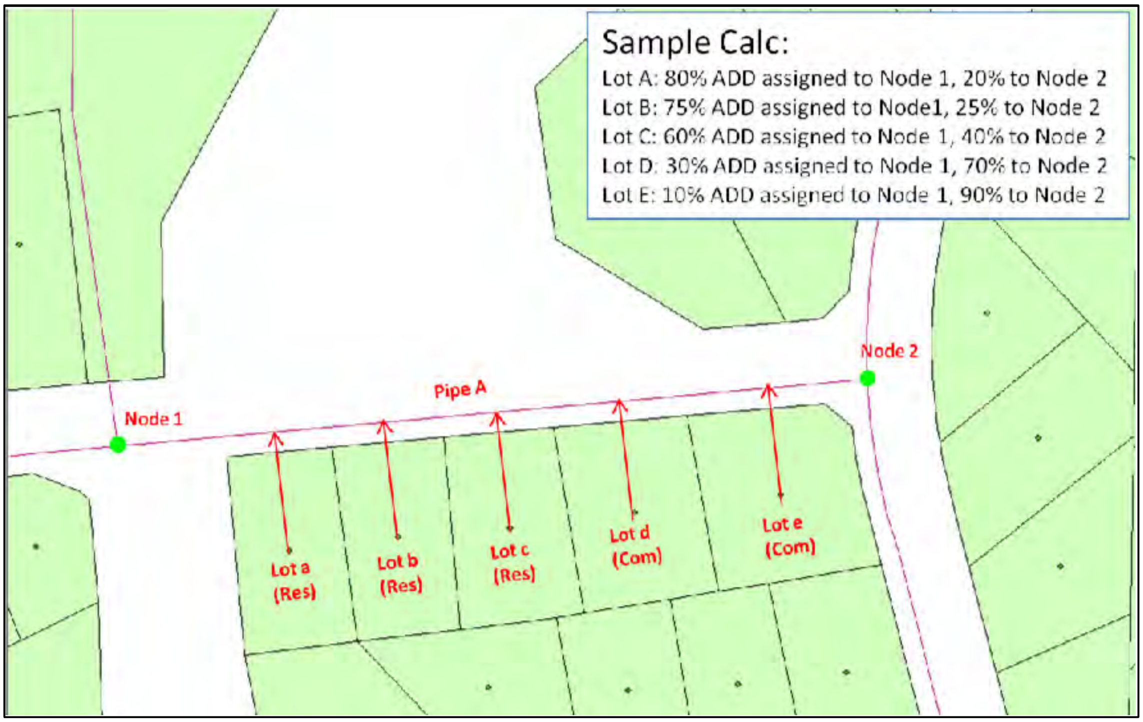


Figure 3.2 – Demand Allocation Process

As discussed in *Section 3.2* the 2010 Billing data allocated in the model was then adjusted to match the anticipated higher demand in the system based on the Saanich Peninsula Study with a ratio established in ***Table 3.5***. The final demand allocated in the model after this adjustment is summarized in Table 3.8

Table 3.8 – Existing Demand Allocation in the Model

Land-use	Demand In Model	ADD (L/s)	MDD (L/s)	PHD (L/s)
Res – Single Family	Demand 1	43.7	123.0	206.6
Res – Multi Family	Demand 2	11.8	33.3	56.0
Res – Rural	Demand 3	5.1	14.4	24.3
Industrial	Demand 4	4.6	5.5	8.3
Commercial	Demand 5	6.0	7.2	10.7
Institutional	Demand 6	1.8	2.1	3.2
Parks and Agricultural	Demand 7	20.1	24.1	40.2
Non-Revenue	Demand 8	9.3	9.3	9.3
First Nation	Demand 1	10.5	29.3	49.1
Out of Town	Demand 1	1.7	4.8	8.0
Total		**114.4**	**252.9**	**415.6**

3.4 Future System Demand Calculation

There were two (2) future scenarios developed for this study: 2025 and 2050. For the purpose of calculating the future population, the District's Official Community Plan (OCP) Bylaw No. 1600 was reviewed. This document provided population growth information within the District starting from year 1996 until 2006 as summarized in ***Table 3.9***.

Table 3.9 – Population Growth

	1986	1991	1996	2001	2006
Population	11,475	13,684	14,611	15,348	15,745
Calculated Annual Increase (%)		3.9%	1.4%	1.0%	0.5%

The above table shows that the population growth rate within the District for the last 20 years has been gradually decreasing, and it has stayed at a rate of around 1% for the last 10 years. In addition the OCP also stated that the expected residential housing increase within the District is at a rate of 1% annually which matches recent historical values. Thus based on this information, for the purposes of this study, it was assumed that the annual residential increase within the Serviced area of the District will be at a rate of 1%. Based on this assumption, the 2025 and 2050 population would be at 18,737 and 23,421, respectively.

In order to create the future scenarios, increased demand associated with this additional population needed to be calculated and for this purpose a representative water unit rate (L/cap/d) was required. Based on the total residential usage of 61 L/s (as listed in ***Table 3.8***) and the 2006 population of 15,745 the calculated water unit rate was 335 L/cap/d. This water unit rate was then used to calculate the additional residential demand for 2025 and 2050 scenarios.

With regards to the Industrial, Commercial and Institutional (ICI) water usage increase, it was assumed that there was no water usage increase from the existing serviced ICI parcels except for the two (2) areas identified in the OCP where changes would occur. The first is the gravel extraction operation in Keating Business Park, which following its closure, will be dedicated to light industrial business. The second one is the modest-scale redevelopment of the West Saanich Road and Keating Cross Road. There is no timeline offered in the OCP but it was assumed for the purpose of this study that the changes in landuse would occur by 2025. The area associated with these two development sites equals to 22.5 ha of industrial land and 2 ha of commercial land. In order to calculate the additional ICI water use associated with these two areas, a population density of 90 people/ha (as per MMCD guideline) and the calculated residential unit rate of 335 L/cap/d was used.

The total estimated system demand for the two future scenarios is presented in ***Table 3.10***.

Table 3.10 – Future Demand Allocation in Model

Land-use	2025			2050		
	ADD (L/s)	MDD (L/s)	PHD (L/s)	ADD (L/s)	MDD (L/s)	PHD (L/s)
Existing Demand	114.4	252.9	415.6	114.4	252.9	415.6
Additional Residential	12.7	35.6	59.7	33.5	93.9	157.6
Additional ICI	8.4	10.1	15.1	8.4	10.1	15.1
Total	**135.5**	**298.5**	**490.4**	**156.3**	**356.8**	**588.3**

3.5 Fire Flow Requirement Estimation

The water distribution system has to be able to supply its consumers' water consumption not only during typical average, maximum day or peak hour conditions but also during emergency conditions including fire. For the purpose of developing a representative fire flow requirement for the District, the hydrant flow test results done by Fire Underwriters Survey (FUS) in 2002 for the purpose of insurance grading were utilized. This information was provided by the District and was subsequently summarized to determine the required fire flow for different land-use types of development. The fire flow requirements estimated based on this approach was then compared to that listed in MMCD Design Guidelines as summarized in ***Table 3.11***.

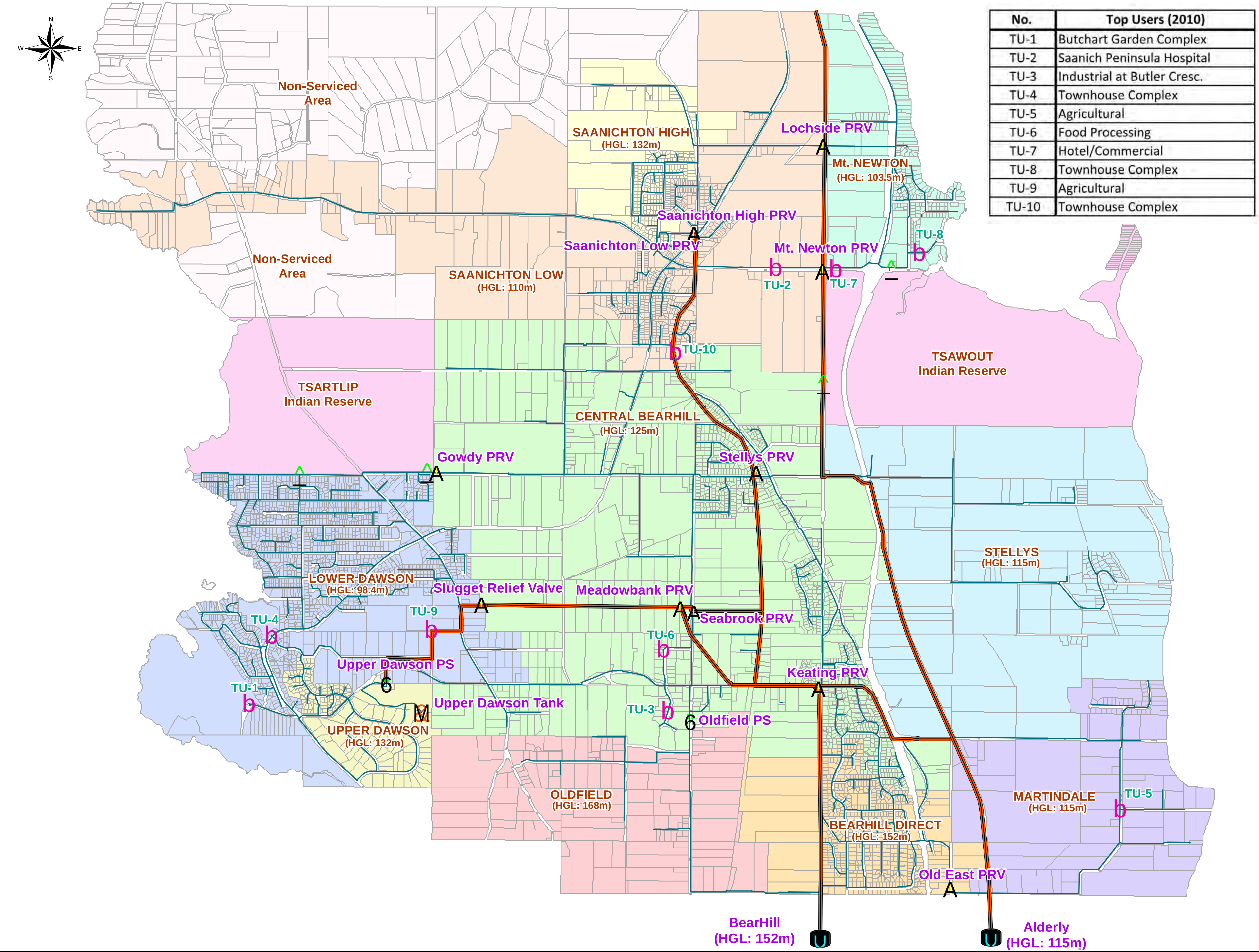
Table 3.11 – Fire Flow Requirement (based on FUS Test Results – 2002)

Land-Use	Fire Flow Requirement (L/s)	
	FUS Test Results	MMCD Guidelines
Res - SF	80	60
Res - MF	140	90
Res - Rural	80	-
Industrial	260	225
Commercial	210	150
Institutional	210	150
Parks	80	-
Agricultural	80	-

As can be seen in the above table, the Fire Flow requirement based on the FUS test results is considerably higher than that listed in the MMCD Design Guidelines. However, the fire flow requirement based on FUS tests has been:

- determined and developed specifically related to the Central Saanich land uses and water system,
- previously used by Central Saanich to assess potential developments for a number of years.

The fire flow requirements based on FUS will be used in this study.



No.	Top Users (2010)
TU-1	Butchart Garden Complex
TU-2	Saanich Peninsula Hospital
TU-3	Industrial at Butler Cresc.
TU-4	Townhouse Complex
TU-5	Agricultural
TU-6	Food Processing
TU-7	Hotel/Commercial
TU-8	Townhouse Complex
TU-9	Agricultural
TU-10	Townhouse Complex

LAND OF PLENTY

District of Central Saanich

Water Distribution Master Plan

Ten Top Water Users

Legend

- Existing Watermain
- CRD Transmission Main
- CRD Supply Point
- Control Valve
- Pump Station
- Tank
- Top Water User
- First Nations Supply Point

Figure No: Figure 3.1

Project No: 60240374

Date: March 2013

AECOM

4. Hydrant Test and Model Calibration

A computer model of a water distribution system is a mathematical representation of a physical system. To ensure the hydraulic model bears close resemblance to reality the results from the hydraulic model simulations must be compared to actual measured parameters within a certain level of accuracy. The comparison and calibration process is completed using hydrant flow tests.

In 1999 the American Water Works Association (AWWA) Engineering Computer Applications committee posted the following general calibration guidelines:

- Long Range Planning ± 10%
- Infrastructure Design ± 5%
- Operational Improvements ± 5%

Based on this guideline, the overall goal of calibration is to be within the ± 10% error of observed field conditions.

The scope of this project is to develop and calibrate a Steady State model, not an Extended Period Simulation (EPS). Typically, extensive operational data from the SCADA would be used to calibrate an EPS model, but, unfortunately this information is not available. Given the limited SCADA data and the need to calibrate a steady state model it was determined that hydrant flow testing would provide sufficient information. The goal of the hydrant flow testing is to confirm the static pressure at discreet locations in the distribution network and the pressure loss experienced during different flow conditions.

Field data collection programs through Hydrant Flow testing are required mainly for the following reasons:

- To estimate friction factor (C factor) based upon pipe material and age
- To perform system hydraulic test

To help determine system's Hazen-William C-factor, it is important to have the field testing done strategically and proportionally based on diameter, material type, age, and location. Hydrant testing was conducted at fifteen (15) representative locations. The hydrant flow test locations are listed in ***Table 4.1*** and shown in ***Figure 4.1***:

Table 4.1 – Flow Testing Locations

Test No.	General Location	Flow Hydrant ID	Pipe Information	
			Diam (mm)	Material
1	Simpson Rd	198	150	AC
2	Tanner Rd	132	150	AC
3	Cultra Ave	179	150	AC
4	Verdier Ave	76	150	PVC
5	Windview Dr	322	150	PVC
6	Garden Gate	389	150	PVC
7	James Island Rd	223	100	AC
8	Hovey/Tomlinson	373	100	AC
11	Mt. Newton X/Simpson	434	200	AC
12	Puckle Rd	400	200	PVC
13	Haidey Terrace	114	100	AC
14	Puckle Rd	359	200	PVC
15	Wallace Dr	275	200	AC

The average C-factor was calculated for each pipe material following the Hazen Williams formula based on these parameters:

- Estimated hydrant flow based on pressure reading at the flow hydrant (pitot gauge),
- Pressure Drop: static pressure minus pressure during the test at nearby monitoring hydrants,
- Pipe diameter, and
- Distance between the measured/gauged hydrants

Additionally, these calculated C-factors were also compared against the C-factors used in other studies as summarized in ***Table 4.2*** below.

Table 4.2 – C-Factor Comparison

Diam (mm)	Material	Ave C-Factor from Flow Test	Notes	District of West Kelowna	WaterCAD Model - Senanus Study	Saanich Peninsula Water Study	Recommended C-Factor
150	AC	125	Exclude Loc 2	125	133	135	125
150	PVC	150	Exclude Loc 4	135	141	145	140
100	AC	125	Exclude Loc 13	125	138.5	135	125
200	AC	120		125	130	135	125
200	PVC	150	assumed same as 150m PVC	135	140	145	140
	DI	N/A		137.5	110-116	135	110
	Steel	N/A		100	100	120	100

The Recommended C-Factor for each different pipe material is summarized in the final column of ***Table 4.2*** which was then applied to the pipes in the model.

During model calibration process, the model was run and the pressure reading results at hydrant testing points were compared to that observed in the field, and adjustment were made to the C-factor for the pipes in the vicinity of the testing points. Other necessary adjustments were also made in the model to bring the model results closer to the observed pressure value, including confirming any existing closed valves or check valves within the vicinity of testing areas.

Pressure reading comparison between the model and observed flow test data is summarized in ***Table 4.3*** below, and the complete copy of the flow testing records are compiled in **Appendix A**.

Table 4.3 – Model Calibration Results

Test No.	General Location	Flow Hydrant ID	Flow at Hyd (L/s)	Observed Pressure (psi)			Model Result Pressure (psi)			Differential	
				Static	During Test	Pressure Drop	Static	During Test	Pressure Drop	Pressure (psi)	%
1	Simpson Rd	198	1543.1	92	38	54	88.1	39.6	48.5	-5.5	-10.1%
				90	38	52	88.1	38.5	49.6	-2.4	-4.5%
				80	26	54	80.1	29.9	50.2	-3.8	-7.1%
2	Tanner Rd	132	1754.6	82	60	22	88.2	65.9	22.3	0.3	1.2%
				74	50	24	76.4	54.3	22.1	-1.9	-7.9%
				98	74	24	101.9	79.3	22.7	-1.3	-5.6%
3	Cultra Ave	179	1139.6	86	50	36	84.0	44.2	39.8	3.8	10.5%
				84	42	42	88.1	51.8	36.3	-5.7	-13.6%
4	Verdier Ave	76	131.3	80	62	18	81.2	59.6	21.6	3.6	20.1%
				68	50	18	71.2	49.5	21.7	3.7	20.5%
				82	66	16	84.1	64.6	19.5	3.5	21.8%
5	Windview Dr	322	1771.6	100	66	34	92.9	58.9	34.0	0.0	0.1%
				100	58	42	95.6	61.7	33.9	-8.1	-19.2%
				96	60	36	98.3	67.7	30.6	-5.4	-15.0%
6	Garden Gate	389	1628.2	96	70	26	97.0	74.2	22.7	-3.3	-12.6%
				56	45	11	58.4	38.5	19.9	8.9	80.5%
				56	45.5	10.5	54.1	44.4	9.7	-0.8	-7.6%
7	James Island Rd	223	1231.0	124	106	18	134.5	119.9	14.6	-3.4	-18.9%
				124	104	20	134.2	113.0	21.2	1.2	6.1%
				116	102	14	128.7	120.0	8.7	-5.3	-37.6%
8	Hovey/Tomlinson	373	1433.5	90	25	65	92.2	38.7	53.5	-11.5	-17.7%
				86	38	48	83.9	46.5	37.4	-10.6	-22.1%
				100	28	72	96.4	37.5	58.9	-13.1	-18.2%
11	Mt. Newton X/Simpson	434	1693.5	85	46	39	76.1	42.6	33.5	-5.5	-14.2%
				78	64	14	78.0	67.2	10.8	-3.2	-22.6%
				88	80	8	90.1	85.6	4.6	-3.5	-43.1%
12	Puckle Rd	400	1559.6	94	36	58	122.5	-34.2	156.7	98.7	170.2%
				104	56	48	135.4	12.7	122.8	74.8	155.7%
				98	55	43	135.4	17.6	117.8	74.8	174.0%
13	Haidey Terrace	114	827.1	70	34	36	73.4	36.3	37.1	1.1	3.1%
				62	43	19	65.2	50.2	15.0	-4.0	-21.2%
14	Puckle Rd	359	107.6	102	84	18	138.6	109.6	29.0	11.0	61.1%
				97	46	51	131.01	44.51	86.5	35.5	69.6%
				102	42	60	135.13	30.58	104.6	44.6	74.3%
15	Wallace Dr	275	82.5	70	48	22	72.26	43.06	29.2	7.2	32.7%
				78	56	22	74.83	48.09	26.7	4.7	21.5%
				64	49	15	64.3	45.06	19.2	4.2	28.3%

As can be observed in the table above, for most locations, the model's pressure reading is generally within 10% of that observed in the field. Some hydrant locations have marginally higher error percentage. It should be noted that even though the percentage seems high at some locations, the actual pressure drop difference between the flow test and the model results may not be significant, i.e., differences of as much as 5 psi, which may be attributable to reading error, pressure gauge accuracy, etc.

The area where the difference is the most dramatic is that on Puckle Road (Loc 12 and 14), where at both locations the model results showed far more pressure drop than that observed in the field. Our methodology emphasizes determination and comparison of pressure drops rather than pressure readings at each site - this tends to minimize the influence of such factors as elevation and individual gauge reading accuracy, however, the differences at Puckle remain unexplained.

Also, it is important to note that model calibration accuracy is dependent on the accuracy of numerous factors including: the initial modelling data, as well as instrumentation of flow testing done by the District. The following factors must be considered in model calibration:

- Accuracy of the pressure gauge used during flow testing – it was assumed to be calibrated;
- Model input data accuracy – as discussed above some of the information was obtained from the former (old) hydraulic model without any available/additional information to confirm its accuracy;
- PRV setting accuracy – these were obtained from the District's information checklist;
- Pump curve accuracy – there were no additional information to verify the data obtained from the former (old) hydraulic model;
- Storage facility geometry/volume accuracy – the dimensions obtained from the former models were reviewed by AECOM to ensure they corresponded with the record drawings;
- Accuracy of headloss assumptions, reflected in C-factor estimations;
- Accuracy of nodal demand allocation, developed using actual billing meter records. This distribution of nodal demands was not adjusted during calibration;
- Accuracy of initial state/boundary condition, including pump operation (On/Off) and initial tank level – no information was available, adjusted as necessary during calibration to better match flow testing results.

In general, the model accurately predicts the system performance for the conditions and locations tested and simulated under steady state condition. Therefore, for purposes of this study, the model calibration accuracy of the District of Central Saanich water system is considered to be sufficient.

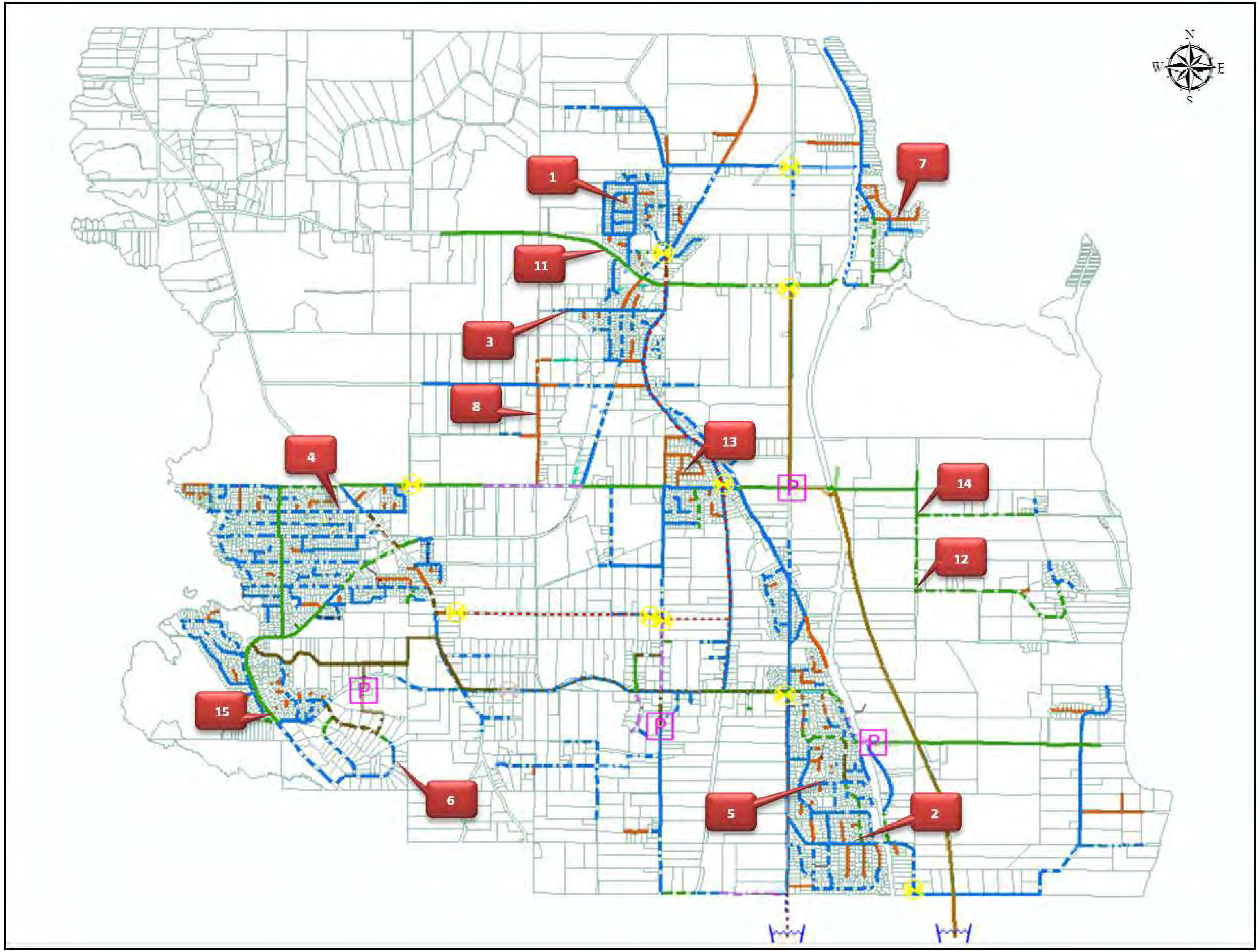


Figure 4.1 – Hydrant Flow Testing Locations

5. Existing System Deficiencies Identification and Improvement Works Recommendation

5.1 Hydraulic Performance Criteria

The above sections of this report described the approach taken in developing the water model, the calibration process and results as well as the creation of future scenarios that were developed to assist the District with planning for capital works required to service increased development. There were three (3) scenarios under which the system was assessed to identify deficiencies within the system:

- Existing demand conditions;
- Future 2025 population/demand conditions;
- Future 2050 population/demand conditions.

For each of these scenarios, four (4) different demand states were imposed to assess system capacity:

- Average Day Demand (ADD);
- Maximum Day Demand (MDD);
- Maximum Day Demand + Fire;
- Peak Hour Demand (PHD);

The fire flow requirement used in assessing the system capacity was dependent on zoning (land use) as had been listed in ***Section 3***, ***Table 3.11***. In general, the water system must provide service to meet the greatest demand of the four conditions listed above. In typical water system networks, the determining condition would be either the Maximum Day Demand + Fire or the Peak Hour demand condition. Therefore both of these demand conditions were utilized when assessing the system capacity and identifying its deficiencies.

The following criteria were used to evaluate system capacity, as per MMCD guidelines (which are the same as the conventional criteria when assessing water distribution capacity):

- Maximum static pressure: 1035 kPa (150 psi);
- Minimum static pressure during Peak Hour: 300 kPa (40psi);
- Minimum static pressure during Max Day + Fire: 150 kPa (20 psi).

5.2 Watermains Capacity Assessment

In order to assess the existing system capacity, the calibrated water model was simulated under the four population/demand conditions mentioned above: Average Day, Maximum Day, Peak Hour and Maximum Day + Fire. Figure 5.1 through 5.4 show the following:

- ***Figure 5.1*** – Minimum pressures under Average Day Demand
- ***Figure 5.2*** – Minimum pressures under Maximum Day Demand
- ***Figure 5.3*** – Minimum pressures under Peak Hour Demand
- ***Figure 5.4*** – Ratio of available fire flow to required fire flow with residual pressure of 15kPa (20psi) under Maximum Day Demand + Fire

As can be seen in these figures, the MDD+Fire, rather than the PHD was in fact the determining demand condition for the District's water system. It can be observed as well that there are numerous residual pressure issues throughout the system except for Bear Hill Direct and Upper Dawson pressure zones. This is mainly attributed to the availability of reliable reservoir (tank) supply, good system looping and good pipe sizing within these two pressure zones.

In general, it is expected and acceptable under fireflow conditions to have residual pressures less than 20 psi at short dead-end and cul-de-sac locations because typically these pipes would have diameters of 100 mm or less to minimize water quality issues during normal operating conditions. During fire conditions, the hydrant located at the entrance of the dead-end/cul-de-sac could also be utilized for firefighting purposes. Therefore the residual pressure issue on short dead-end and cul-de-sac locations, with pipe length of less than 100 m, was not treated as a capacity issue in this study.

However there are multiple dead-end locations within the District's water system that are long dead-ends formed due to limited ability to create system looping. This is evident in the following pressure zones:

- Oldfield
- Martindale
- Stelly's
- North section of Mt. Newton
- North section of Saanichton Low
- North section of Saanichton High.

These long dead-ends with low residual pressure were identified as capacity issues in the system and subsequently solutions to improve residual pressures were assessed.

Additionally there are some pocket areas within Lower Dawson, Central Bear Hill and Saanichton Low pressure zones where residual pressure issues were determined to be insufficient, therefore options for improving residual pressures were also analyzed for these areas.

5.3 Cost Estimate Unit Prices

When performing the analyses to improve the pressure and flow conditions throughout the system, ballpark cost estimates associated with each proposed improvement works also formed part of the decision making criteria. ***Table 5.1*** shows the summary of the unit price used for this purpose.

Table 5.1 – Unit Price

Asset	Unit	Cost ($)
Watermains		
100mm	per m	$300
150mm	per m	$325
200m	per m	$350
250mm	per m	$400
300mm	per m	$450
350mm	per m	$500
400mm	per m	$650
PRV Station	L.S	$75,000
Tank	per m3	$1,000
Fire pump	per HP	$5,000

The total unit cost listed in the above table has already included allowance for contingency (20%) and engineering (15%). However, it should be noted that this total unit cost number and subsequently the total estimated construction cost associated with each improvement work presented in the sections to follow only represents a ballpark cost estimate and a more comprehensive cost estimate should be prepared during detailed design stage of the selected improvement works.

5.4 Proposed Improvement Work Options

Following discussion with the District, it was concluded that the District's fire department is generally able to deliver a minimum of 80 L/s of fire flow in any given hydrant location throughout the system using a relay water truck and pumping arrangement. Moreover, the District also confirmed that the District had obtained a certificate from Fire Underwriter Survey (FUS) that verifies this ability having completed the pump relay exercise required by FUS for this certification.

Based on this condition, it is also important to assess the system based on the Available Flow at Hydrant (Node) in addition to the residual pressure, and compare that value to the required fire flow for that hydrant/node based on adjacent zoning (landuse) type. From this exercise the magnitude of fire flow deficiency for each node could be evaluated.

There are sixteen (16) areas where significant residual pressures and fire flow deficiencies were observed under existing demand and system conditions, as shown in ***Figure 5.5***. For these areas, upgrade options were analyzed to improve the residual pressure and fire flow availability.

It is important to emphasize that these upgrade options assessed were meant to improve the conditions during fire and may not solve all the poor pressure and/or fire flow availability throughout the District. Also, as explained in the previous section, the residual pressure issue on short dead-end and cul-de-sac locations, with pipe lengths of less than 100 m, was not treated as a capacity issue in this study, therefore these locations were excluded from the overall assessment.

The proposed improvement work options analyses were conducted on the zone by zone basis as discussed further in the following sections.

5.4.1 Lower Dawson Pressure Zone

There had been two studies performed previously by Bullock Baur that addressed watermains capacity issues in this area (*Brentwood Bay Water Study*, Bullock Baur, 2008 and *Brentwood Bay water System Upgrades – Pre-Design*, Bullock Baur, 2011). Both of these reports suggested that the existing Lower Dawson pressure zone (HGL: 98 m) should be divided into 2 pressure zones, namely Upper Brentwood (HGL: 112 m) and Lower Brentwood (HGL: 84 m). For these two studies, a simplified water model was utilized that only included essentially Lower Dawson area, and some parts of Central Bear Hill and Upper Dawson zones. The supply points included were Meadowbank PRV and Gowdy PRV for Lower Dawson and Stelly's PRV for Central Bear Hill. All of the PRVs were modeled as 'Fixed Head Reservoir' with constant head availability. The Upper Dawson pump was also included with a fixed output for the pump.

This simplified network may represent the average operational conditions reasonably well. However during MDD+Fire condition where high flow, especially that needed for Commercial or Institutional land uses, is expected to be drawn from nodes within Lower Dawson, our model of the entire District system shows that the PRVs in the system supplying Lower Dawson (i.e., Meadowbank and Gowdy) are not able to deliver the pressure as per their settings due to high headloss along the pipes upstream of the PRVs. Therefore, a 'Fixed Head Reservoir' approach with constant head availability does not fully represent the actual MDD+Fire residual pressure and flow conditions in the system.

Nevertheless, in our analysis to improve the pressure and flow conditions during MDD+Fire in Lower Dawson, we still evaluated this pressure zone split strategy using the all-pipe model that had been built along with one more scenario. The scenarios evaluated for Lower Dawson pressure zone are:

- Scenario 1 – pressure zone split + pipe upgrades

  Under this scenario, the Lower Dawson zone was split into two zones following the recommended new zone boundary along Hagan Rd as per Bullock Baur reports. However, the HGL settings for the new zones were different as follows:

  - Upper Brentwood - HGL: 125 m, this is the same as its neighbouring zone, Central Bear Hill. This will provide more significant head increase to this new zone without over pressurizing the system during normal operating conditions.
  - Lower Brentwood – HGL: 98 m, which is the same as the current Lower Dawson zone as this area did not have substantial high pressure issues to begin with, so there is no reason to reduce the HGL setting.

- Scenario 2 – no pressure zone split + pipe upgrades

  No zone split was implemented under this scenario and the HGL setting for Lower Dawson was kept to 98 m.

There are primarily three (3) areas where significant residual pressure and available fire flow issue was observed in this zone as shown in ***Figure 5.5***. Therefore these two scenarios had been set up to focus the improvement on these areas.

However in order to improve the pressure and flow condition at Butchart Garden while minimizing the amount of pipe upgrades in the system, the most efficient strategy is to have a Pressure Reducing Valve (PRV) on Wallace Dr north of Benvenuto Ave that allows feeding Lower Dawson zone from Upper Dawson zone, triggered by any low pressure events in Lower Dawson zone.

Figure 5.6 and ***Figure 5.7*** show the resulting residual pressures as well as the available fire flow as a proportion of the required fire flow at each node under MDD+Fire condition after implementing these two upgrade scenarios.

As can be observed from the above figure, there was no significant benefit of splitting the zone (Scenario 1) as opposed to just implementing pipe upgrades within the focused areas (Scenario 2). The increased HGL to Upper Brentwood area was counteracted by the high flow, velocity and headloss conditions along Stelly's X Rd during MDD+Fire. The simulation results showed that increasing the pipe sizes directly on the vicinity of the focused areas provided more or less the same outcome in terms of residual pressure and flow availability during MDD+Fire conditions in these areas.

Additionally, ***Table 5.2*** shows a ballpark cost estimate associated with each scenario following the unit rates shown in ***Table 5.1***.

Table 5.2 – Cost Estimate Comparison – Lower Dawson Proposed Upgrades

Scenario	Description	Watermains	PRV	Tank	Fire Pump	Total
1	Pressure zone split + pipe upgrades	$1,662,000	$450,000	$0	$0	$2,112,000
2	No pressure zone split + pipe upgrades	$1,030,000	$75,000	$0	$0	$1,105,000

Based on the analysis results and cost estimate comparison, Scenario 2 represents the recommended improvements to be considered by the District to increase the residual pressure and fire flow availability in Lower Dawson areas.

5.4.2 Oldfield Pressure Zone

There had been two studies done previously to address the insufficient fire flow residual pressure issue in this pressure zone: *Oldfield Road Pumping Area Hydraulic Assessment*, John Braybrooks Engineering, 2000 and *1746 Verling – Water Supply*, West Brook Consulting, 2007. There were a several options evaluated in these two studies including providing a storage tank and different combinations of pipe upgrade scenarios within the system.

In the current study, we narrowed down the options assessed to two scenarios:

- Scenario 1 – with tank + pipe upgrades
  - The tank volume was calculated based on the highest fire flow requirement in the zone of 260 L/s for industrial users for the duration of 3.4 hours as per 1999 Fire Underwriters Survey (FUS) guidelines . Additionally, the balancing and emergency volume requirement was calculated based on the MDD requirement of this zone. The total tank volume required based on this calculation was 4,100 m^3. A minimum Top Water Level (TWL) of 130 m was required to maintain residual pressure of 20 psi during MDD+Fire in most of the nodes in this zone. The most viable location for the tank was at the end of Hilltop Rd, which has a ground elevation of approximately 120 m, which translates to a 10 m height tank.
  - It should be noted that this zone is normally operating at an HGL of 168 m with the Oldfield booster pump on and there is backup supply from a check valve on Bear Hill Rd feeding this zone from Bear Hill Direct zone with an HGL of 152 m. Therefore during normal operating conditions this tank will not be in use and will be full most of the time, unless means are provided to move water out of the tank. If no efforts are made to circulate water from the tank into the zone, it may lead to potential water quality, maintenance and inefficiency issues.
  - Additionally pipe upgrades were still required at some locations within the network including introducing new pipes to create a loop system between Bryn Rd and Nicholas Rd.
- Scenario 2 – with pipe upgrades only
  - This scenario evaluated the impact of upgrading pipe size for nearly all of the watermains within this zone as well as introducing new pipes to create a loop system between Bryn Rd and Nicholas Rd.

Figure 5.8 and ***Figure 5.9*** show the resulting residual pressure as well as the available fire flow as a proportion of the required fire flow at each node under MDD+Fire condition after implementing these two upgrade scenarios.

As can be observed from these figures, the residual pressure and fire flow availability in the system were slightly better when implementing improvement works recommended under Scenario 2. This result confirmed that upgrading the pipe size is more efficient in improving the pressure and flow conditions during MDD+Fire.

Additionally, ***Table 5.3*** shows a ballpark cost estimate associated with each scenario following the unit rates shown in ***Table 5.1***. It should be noted that this estimated ballpark cost has not included the cost associated with acquiring the land for easements to accommodate portions of this upgrade, assuming none exists currently.

Table 5.3 – Cost Estimate Comparison – Oldfield Proposed Upgrades

Scenario	Description	Watermains	PRV	Tank	Fire Pump	Total
1	Tank + pipe upgrades	$910,000	$0	$4,000,000	$0	$4,910,000
2	Pipe upgrades only	$1,693,000	$0	$0	$0	$1,693,000

Based on the analysis results and cost estimate comparison, Scenario 2 represents the recommended improvements to be considered by the District to increase the residual pressure and fire flow availability in Oldfield areas.

5.4.3 Martindale Pressure Zone

The areas with poor residual pressure in this zone were mainly located at the end of a long dead-end on Livesay St, Companion Rd, Mallard Ave and north corner of Welch Rd. In order to improve this condition, there were two scenarios assessed in this study:

- Scenario 1 – fire pump and pipe upgrades
    - Under this scenario a fire booster pump with a design head of 40 m and design flow of 80 L/s (60 hp) was proposed at the corner of Welch Rd and Martindale Rd to help improve pressure and flow conditions at the north section of this zone. New pipe was proposed to create a loop system between Livesay St and Champion Rd, in addition to some pipe size upgrade on Champion St.
- Scenario 2 – pipe upgrades only
    - Under this scenario pipe sizes were upgraded along Martindale Rd, Welch Rd and Dooley Rd to minimize headloss along these pipes during MDD+Fire and subsequently improve the residual pressure and fire flow availability in the system. The same new pipes to create a loop system between Livesay St and Champion Rd under Scenario 1 were also implemented in this scenario.

Figure 5.10 and ***Figure 5.11*** show the resulted residual pressure as well as the available fire flow as a proportion of the required fire flow at each node under MDD+Fire condition after implementing these two upgrade scenarios.

As can be observed from these figures, the residual pressure and fire flow availability in the system were comparable for both of these scenarios, where one scenario's results are slightly better for the north section of this zone and the other's results are slightly better for the Livesay/Champion area.

Table 5.4 shows a ballpark cost estimate associated with each scenario following the unit rates shown in ***Table 5.1***. It should be noted that this estimated ballpark cost has not included the cost associated with acquiring the land for easements to accommodate portions of this upgrade, assuming none exists currently.

Table 5.4 – Cost Estimate Comparison – Martindale Proposed Upgrades

Scenario	Description	Watermains	PRV	Tank	Fire Pump	Total
1	Fire pump + pipe upgrades	$287,000	$0	$0	$300,000	$587,000
2	Pipe upgrades only	$2,104,000	$0	$0	$0	$2,104,000

Based on the analysis results and cost estimate comparison, Scenario 1 represents the recommended improvements to be considered by the District to increase the residual pressure and fire flow availability in Martindale areas.

5.4.4 Central Bear Hill Pressure Zone

Based on the analyses conducted, the areas with insufficient residual pressure and fire flow were located around Tanlee/Chatwell, Tomlinson Rd, the industrial area at Butler Crescent and along Keating Rd west of Butler Crescent. In order to improve this condition, pipe size upgrades were assessed for the first two areas. Additionally a new pipe was proposed to create a loop system between the north section of Tomlinson Rd and Hovey Rd.

For the industrial area at Butler Cres, as can be observed from ***Figure 5.4***, the available fire flow in this location was reasonably close to the required fire flow of 260 L/s. Therefore no improvement works were assessed for this location. However it should be made clear to the business owners in this neighbourhood that they are required to provide alternative methods, such as fire sprinklers and fire booster pumps to assist with fire protection to their property in the event of fire.

For the watermains along Keating Rd west of Butler Cres, the District acknowledged that there would be future development on this general area that may involve revising the current zoning (landuse). Therefore improvement works analysis on this general area was not conducted until more definite information became available.

Figure 5.12 shows the resulting residual pressure and available fire flow as a proportion of the required fire flow at each node under MDD+Fire condition after implementing the proposed pipe upgrades.

The estimated total cost associated with these upgrades is approximately $983,000. This estimated ballpark cost has not included the cost associated with acquiring the land for easements to accommodate portions of this upgrade, assuming none exists currently.

5.4.5 Stelly's Pressure Zone

The areas with poor residual pressure issues are mainly located close to the end of Island View Rd. In order to improve this condition, a new pipe to create a loop system between Island View Place and Lamont Rd was proposed. The resulting residual pressure and available fire flow conditions are presented in ***Figure 5.13***.

The estimated total cost associated with this proposed upgrade was $126,000. This estimated ballpark cost has not included the cost associated with acquiring the land for easements to accommodate this upgrade, assuming none exists currently.

As an aside, the District of Central Saanich notes that the Stelly's pressure zone is its only zone that is fed by a single watermain connection. Installing an additional link to the CRD transmission Main No. 4 along Island View Road would improve fire flow availability, and provide redundancy and increased system reliability for this zone. The cost to install approximately 470 m of 200 mm diameter pipe (to match the other zone feed) along Island View Road between Lochside Drive and Puckle Road is estimated to be approximately $164,000 plus any costs for an additional connection to CRD Main No. 4 – this latter amount could be significant since Main No. 4 is a concrete-cylinder pipe which requires specialized techniques and equipment to create a connection. Even though this cost is greater than the upgrade noted above, it may be assigned a higher priority by Central Saanich due to the redundancy and reliability it provides.

5.4.6 Saanichton Low Pressure Zone

There were mainly two areas with observed insufficient residual pressures and fire flows; around Cultra Ave/Wallace Dr and on the north section of Wallace Dr (north of Newman Rd) as depicted in ***Figure 5.5***. In order to improve this condition pipe size upgrades were proposed along Wallace Dr. Additionally, a new watermain was also proposed along Central Saanich Rd between Mt. Newton X Rd and Newman Rd to create a loop system.

The only source of water supply to this zone is the Saanichton Low PRV at Wallace Dr and East Saanich Rd. In order to supplement water supply to this zone, a PRV is proposed to feed this zone from the 600 mm CRD main at or near Lochside PRV at Central Saanich Rd./Newman Rd (Lochside PRV does not have direct connection to the CRD mains, and only allows water to flow from Saanichton Low zone to Mt. Newton zone). The pressure on this CRD main is governed by Alderly PRV with an HGL of 115 m.

Another approach would be to treat this proposed connection as a direct connection instead of introducing a PRV. However, with this approach it would mean that the entire Saanichton Low zone would be supplied at a slightly higher HGL of 115 m instead of 110 m as it is currently, and this new direct connection would be the main supply to the zone unless the PRV setting at Saanichton Low PRV is adjusted to be higher.

The resulting residual pressure and available fire flow conditions are presented in ***Figure 5.14***. The estimated total cost associated with this proposed upgrade was $1,039,000 (excluding the proposed PRV to connect to CRD main). This estimated ballpark cost has not included the cost associated with acquiring the land for easements to accommodate portions of this upgrade, assuming none exists currently.

5.4.7 Saanichton High Pressure Zone

The general residential areas within this zone around Jeffrey Rd/Simpson Rd had sufficient residual pressure and fire flow availability during MDD+Fire conditions. The north section of the zone, north of Newman Rd, was the area where poor pressure and flow was observed as seen in ***Figure 5.5***. In order to improve this condition, there were two scenarios assessed:

- Scenario 1 – with fire pump
  - Under this scenario a fire booster pump with a design head of 97 m and design flow of 210L/s (300 hp) was proposed at the corner of Newman Rd and East Saanich Rd to help improve pressure and flow conditions at the north section of this zone. This fire flow requirement of 210 L/s was attributed to service the parcel with Institutional zoning at this particular corner.
  - Additionally a new check valve was also proposed on Newman Rd at the currently/normally closed zone boundary valve to increase water supply to this area during low pressure conditions.
- Scenario 2 – with tank
  - The tank volume was calculated based on the worst fire flow requirement in the zone of 210 L/s for institutional users for the duration of 2.7 hours as per 1999 *Fire Underwriters Survey* (FUS) guidelines. Additionally, the balancing and emergency volume requirement was calculated based on the MDD requirement of this zone. The total tank volume required based on this calculation was 2,850 m^3. A minimum Top Water Level (TWL) of 110 was required to maintain residual pressure of 20 psi during MDD+Fire in most of the nodes in this zone. The most viable location for the tank was at highest ground elevation on Haldon Rd which has a ground elevation of approximately 83 m, which translates to a 27 m height tank.
  - It should be noted that this zone is normally operating at an HGL of 132 m with supply from Saanichton High PRV. Therefore during normal operation conditions this tank will not be in use and will remain full most of the time, unless means are provided to circulate the water into the zone. If no circulation means are included, it may lead to potential water quality, maintenance and inefficiency issues.
  - Additionally a new check valve was also proposed on Newman Rd at the currently/normally closed zone boundary valve to increase water supply to this area during low pressure conditions.

Figure 5.15 and ***Figure 5.16*** show the resulting residual pressure as well as the available fire flow as a proportion of the required fire flow at each node under MDD+Fire condition after implementing these two upgrade scenarios.

As can be observed from these figures, the residual pressure and fire flow availability in the system were comparable for both of these scenarios, where one scenario's results are slightly better for a particular section of this zone and the other's results are slightly better for the other area.

Table 5.5 shows a ballpark cost estimate associated with each scenario following the unit rates shown in ***Table 5.1***.

Table 5.5 – Cost Estimate Comparison – Saanichton High Proposed Upgrades

Scenario	Description	Watermains	CV	Tank	Fire Pump	Total
1	Fire pump	$0	$10,000	$0	$1,500,000	$1,510,000
2	Tank	$0	$10,000	$2,850,000	$0	$2,860,000

Based on the analysis results and cost estimate comparison, Scenario 1 represents the recommended improvements to be considered by the District to increase the residual pressure and fire flow availability in Saanichton High areas.

5.4.8 Mt. Newton Pressure Zone

The poor residual pressure and fire flow conditions were mainly observed at the end of James Island Rd and on the end of Lochside Dr and Mt. St. Michael Rd. This condition was expected as all of these areas were located on a long stretch of dead-end watermains. In order to improve this condition, a fire booster pump was proposed at the corner of Mt. Newton X Rd and Lochside Dr with a design head of 40 m and design flow of 80 L/s (60 hp). No pipe size upgrade was proposed so as not to impact water quality in these generally low demand areas.

The resulting residual pressure and available fire flow conditions are presented in ***Figure 5.17***. The estimated total cost associated with this proposed upgrade was $300,000. This estimated ballpark cost has not included the cost associated with acquiring the land for easements to accommodate portions of this upgrade, assuming none exists currently.

5.5 Proposed Improvement Work Recommendation

Following the comprehensive analyses of the entire water distribution network, there were options proposed to improve the residual pressure and fire flow availability conditions throughout the District. It should be emphasized that this exercise was not intended to solve all the pressure and flow issues but rather to improve the general conditions especially under MDD+Fire.

It is not fiscally reasonable to provide for all water system improvements required within the Central Saanich system to completely meet all the FUS firefighting flow requirements. In addition, a second part of this evaluation and study is to examine replacement watermains a part of a condition assessment. That work is expected to recommend further upgrades/improvements that would occur over a longer time period.

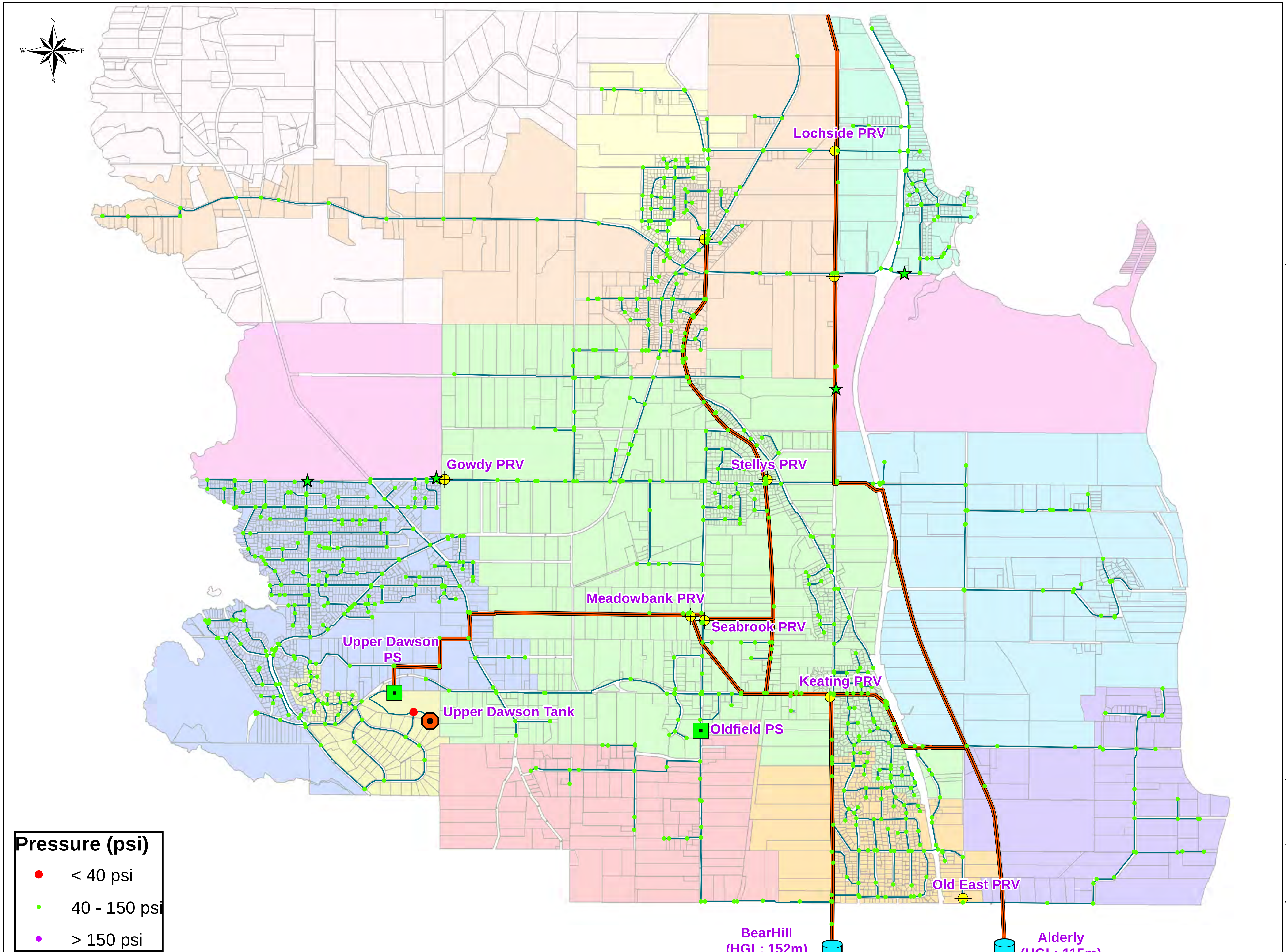
For most areas, pipe size upgrades appear to be the most efficient way to improve firefighting conditions, with the exception of three areas where a fire booster pump is recommended. The utilization of a storage tank to improve the conditions was also assessed in some areas, but in each case it proved to be not cost effective.

The summary of all the options considered for each pressure zone together with its associated ballpark cost estimate are presented in ***Table 5.6***, where the complete list of upgrade items for each zone and its associated cost is shown in ***Appendix B***.

Table 5.6 – Proposed Hydraulic-Related Upgrade Options Summary

Zone ID	Scenario Desc	Estimated Cost ($)	Recommended Upgrades	
			Recommended Upgrade	Estimated Cost ($)
Lower Dawson	Scenario 1 – PZ Split + pipe upgrade	$2,112,000		
	Scenario 2 – No PZ split + pipe upgrade	$1,105,000	√	$1,105,000
Upper Dawson	No required upgrade	$0		$0
Oldfield	Scenario 1 – Tank	$4,910,000		
	Scenario 2 – Pipe upgrades only	$1,693,000	√	$1,693,000
Bear Hill Direct	No required upgrades	$0		$0
Martindale	Scenario 1 –Fire Pump	$587,000	√	$587,000
	Scenario 2 – Pipe upgrades only	$2,104,000		
Central Bear Hill	Pipe upgrades only	$993,000	√	$993,000
Stelly's	Pipe upgrades only	$126,000	√	$126,000
Saanichton Low	Pipe upgrades only (without proposed PRV)	$1,039,000	√	$1,039,000
Saanichton High	Scenario 1 – Fire Pump	$1,510,000	√	$1,510,000
	Scenario 2 – Tank	$2,860,000		
Mt. Newton	With Fire Pump	$300,000	√	$300,000
			TOTAL ESTIMATED COST	**$7,353,000**

Figure 5.18 shows the residual pressure and fire flow availability throughout the system after implementing the recommended proposed upgrades.



District of Central Saanich

Water Distribution Master Plan

Existing System

Average Day Demand (ADD) Minimum Pressure Conditions

Legend

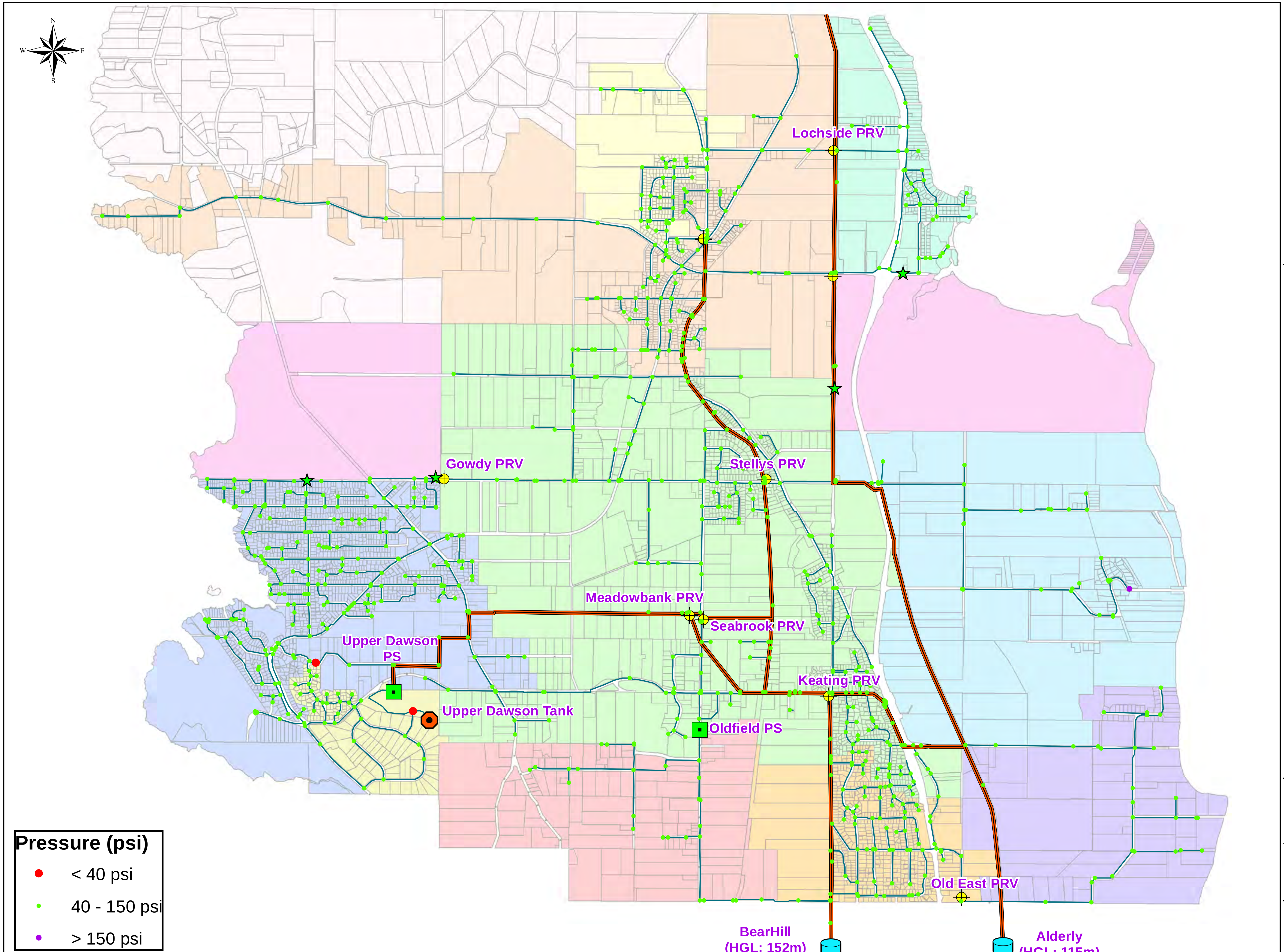
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- First Nations Supply Point

Figure No: Figure 5.1

Project No: 60240374

Date: December 2012

AECOM



LAND OF PLENTY

District of Central Saanich

Water Distribution Master Plan

Existing System

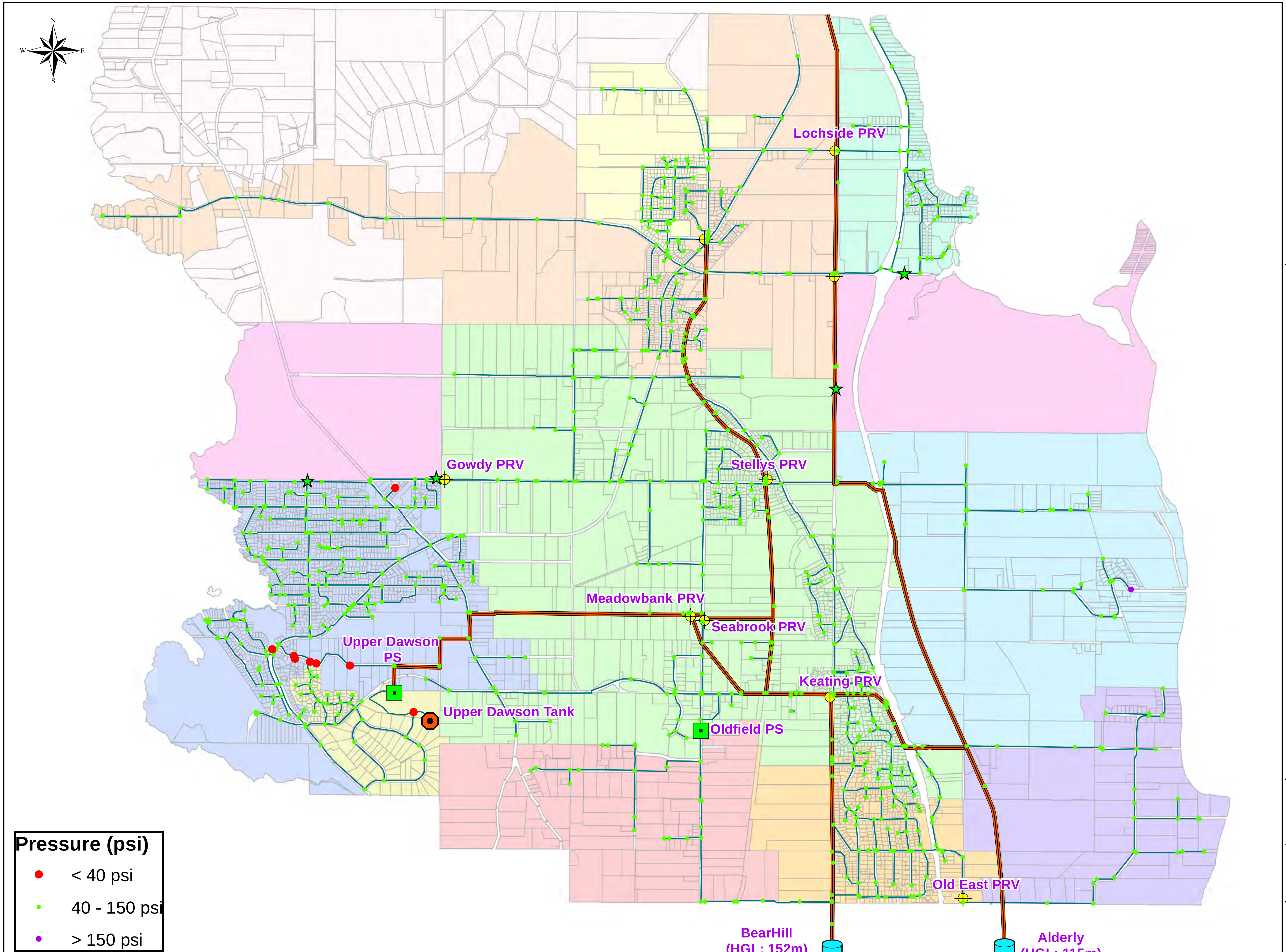
Max Day Demand (MDD) Minimum Pressure Conditions

Legend

- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- First Nations Supply Point

Figure No:	
Figure 5.2	
Project No:	Date:
60240374	December 2012

AECOM



District of Central Saanich

Water Distribution Master Plan

Existing System

Peak Hour Demand (PHD) Minimum Pressure Conditions

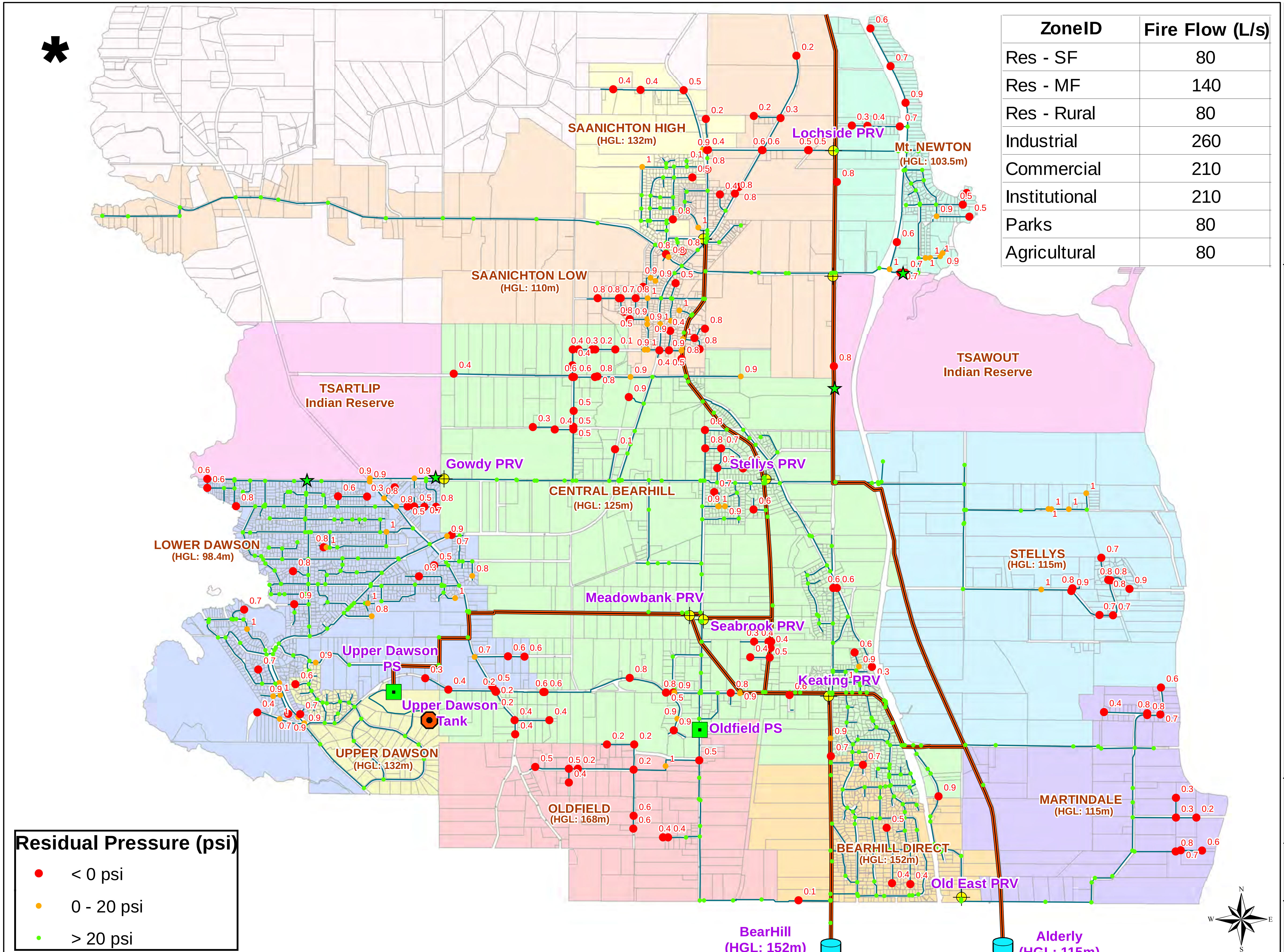
Legend

- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- First Nations Supply Point

Figure No: Figure 5.3

Project No:	Date:
60240374	December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Existing System
Max Day Demand+Fire (MDD+Fire)

Residual Pressure
(Based on FUS Survey-2002)

Legend

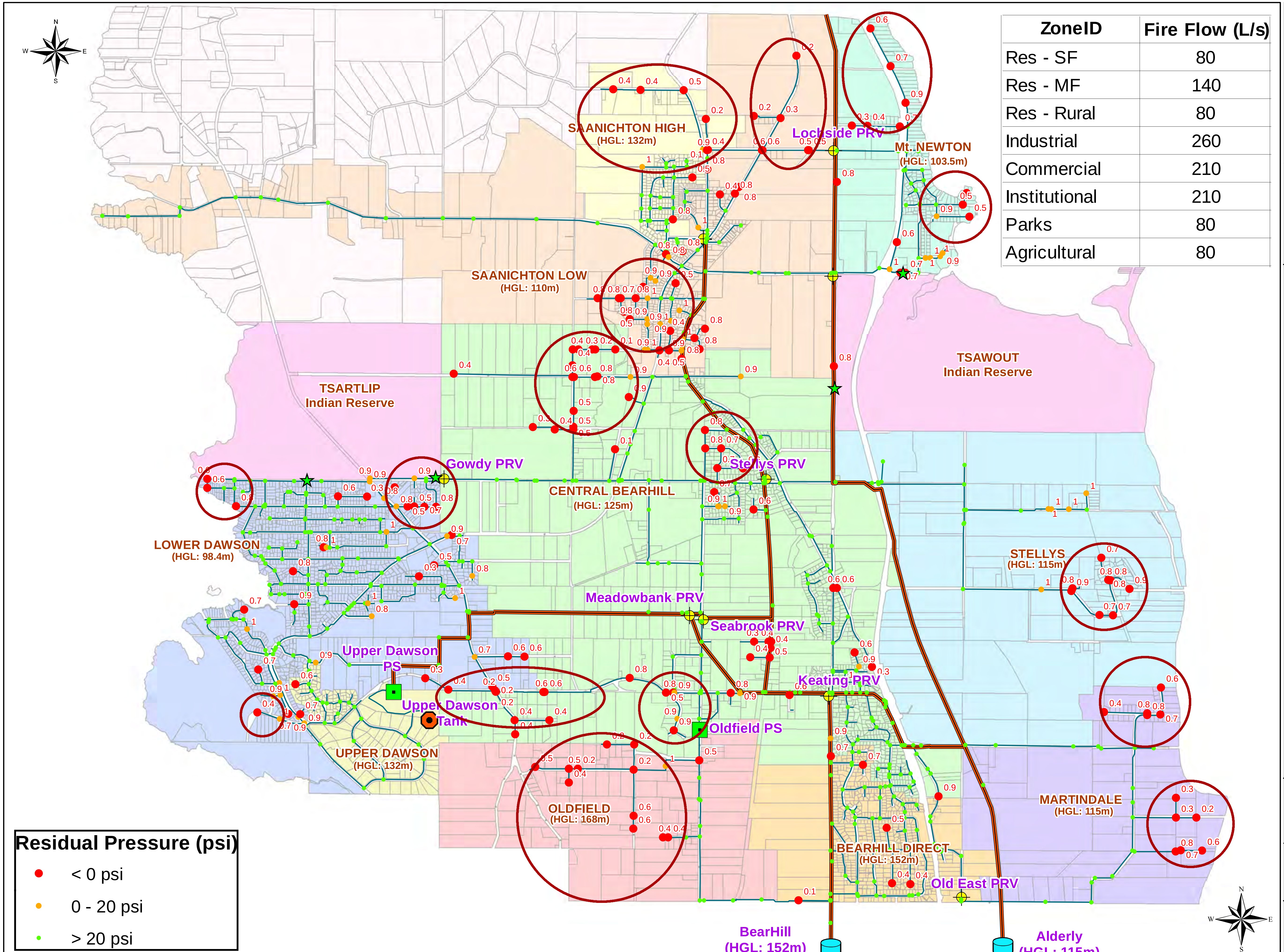
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- First Nations Supply Point
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No: Figure 5.4

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Existing System
Max Day Demand + Fire

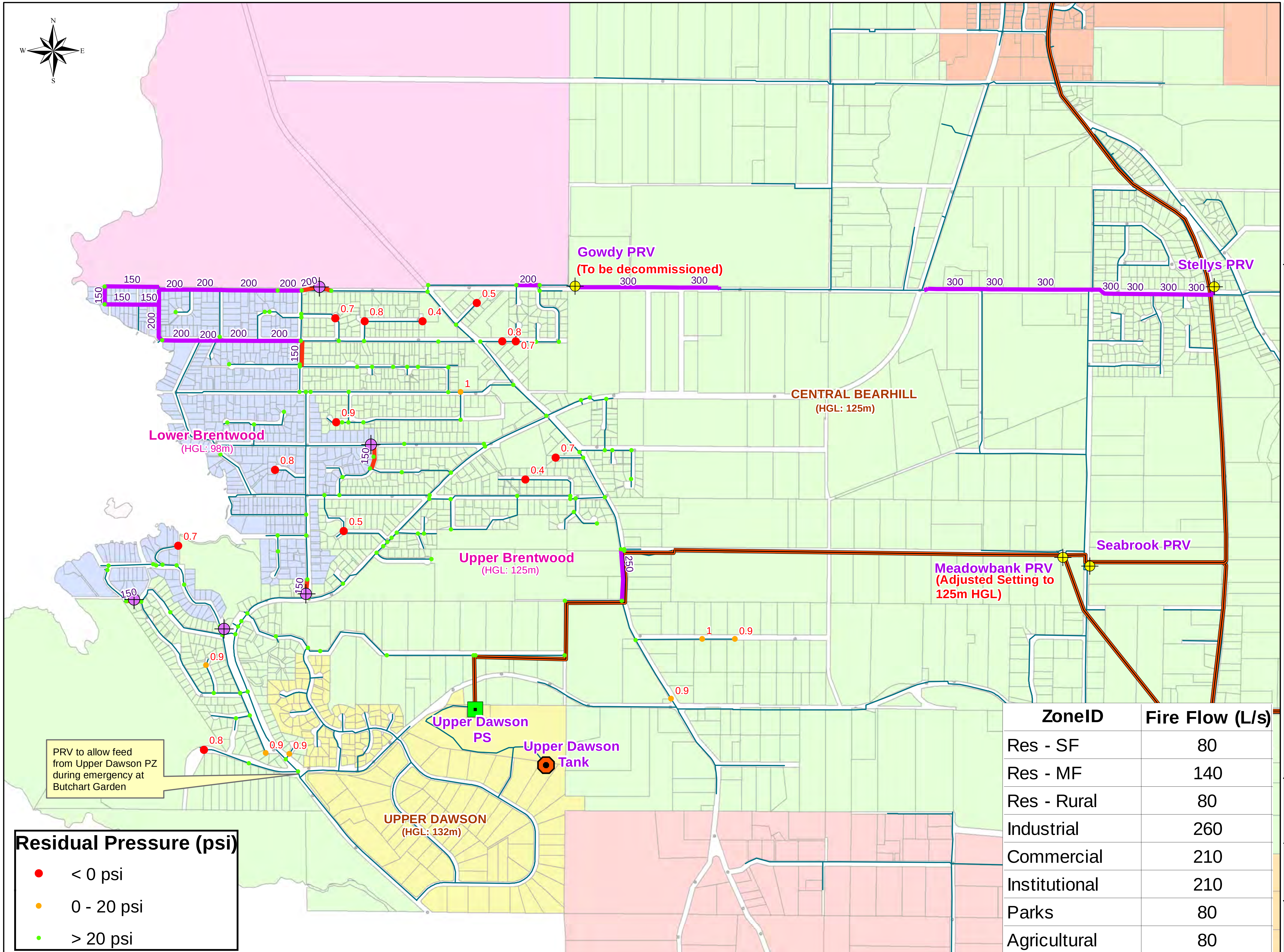
Focused Areas

Figure No:
Figure 5.5

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Lower Dawson With Upgrade Sce 1 - PZ Split + Pipe Upgrade

MDD + Fire Residual Pressure (Based on FUS Survey-2002)

Legend

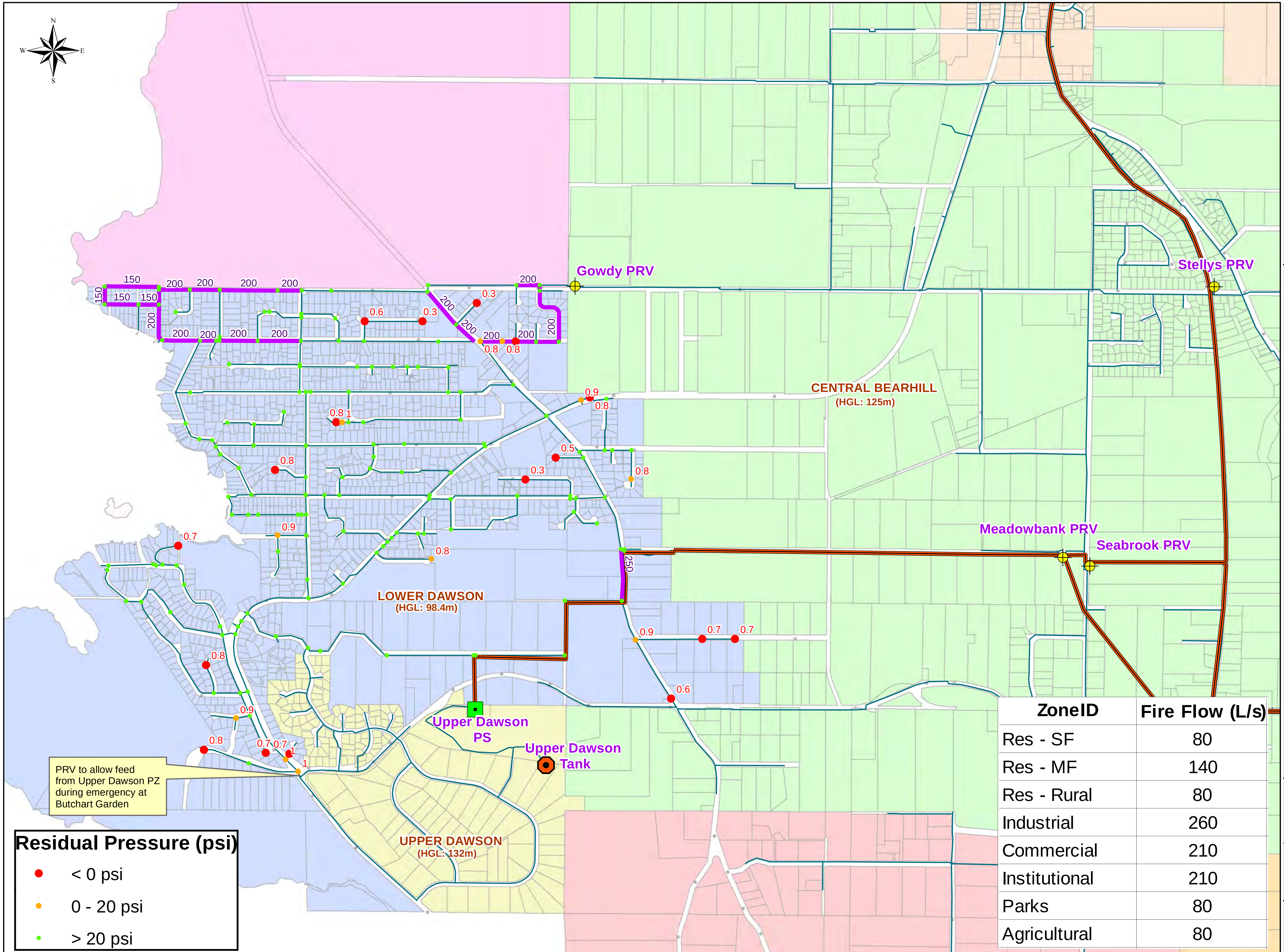
- Proposed New Control Valve
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed Pipe Upgrade
- Proposed New Pipe
- CRD Transmission Main
- Existing Watermain
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No: Figure 5.6

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Lower Dawson With Upgrades
Sce 2 - No PZ Split + Pipe Upgrade

MDD+Fire Residual Pressure
(Based on FUS Survey-2002)

Legend

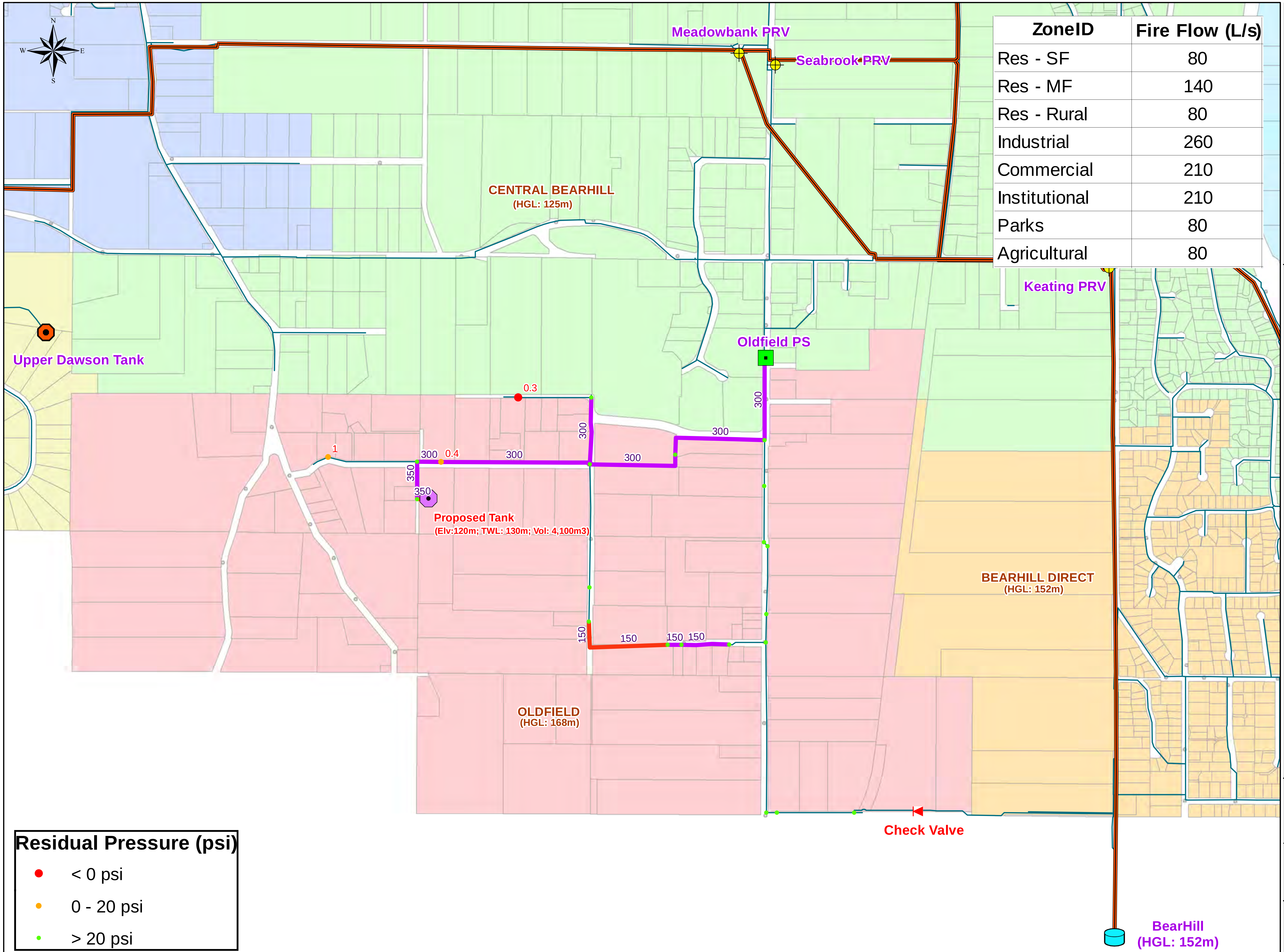
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed Upgrade Pipe
- CRD Transmission Main
- Existing Watermain
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No: Figure 5.7

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Oldfield with Upgrades
Sce 1 - Tank+Pipe Upgrade

MDD+ Fire Residual Pressure (Based on FUS Survey-2002)

Legend

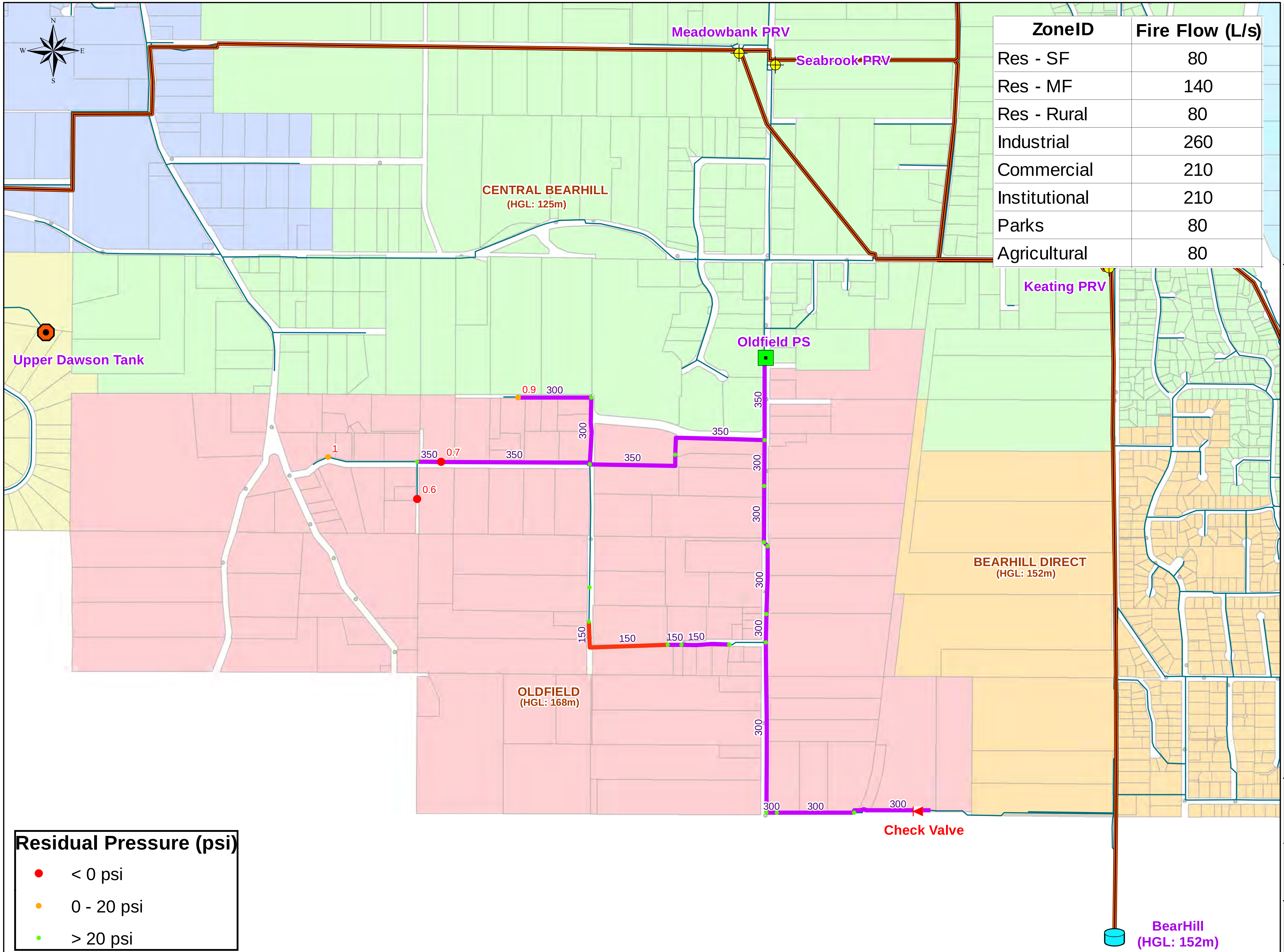
- Proposed New Tank
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed Pipe Upgrade
- Proposed New Pipe
- CRD Transmission Main
- Existing Watermain
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No: Figure 5.8

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Oldfield - With Upgrades
Sce 2 - Pipe Upgrades Only

MDD+ Fire Residual Pressure (Based on FUS Survey-2002)

Legend

- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed New Pipe
- Proposed Pipe Upgrade
- CRD Transmission Main
- Existing Watermain
- 0.7 Available Flow at Node/ Required Fire Flow

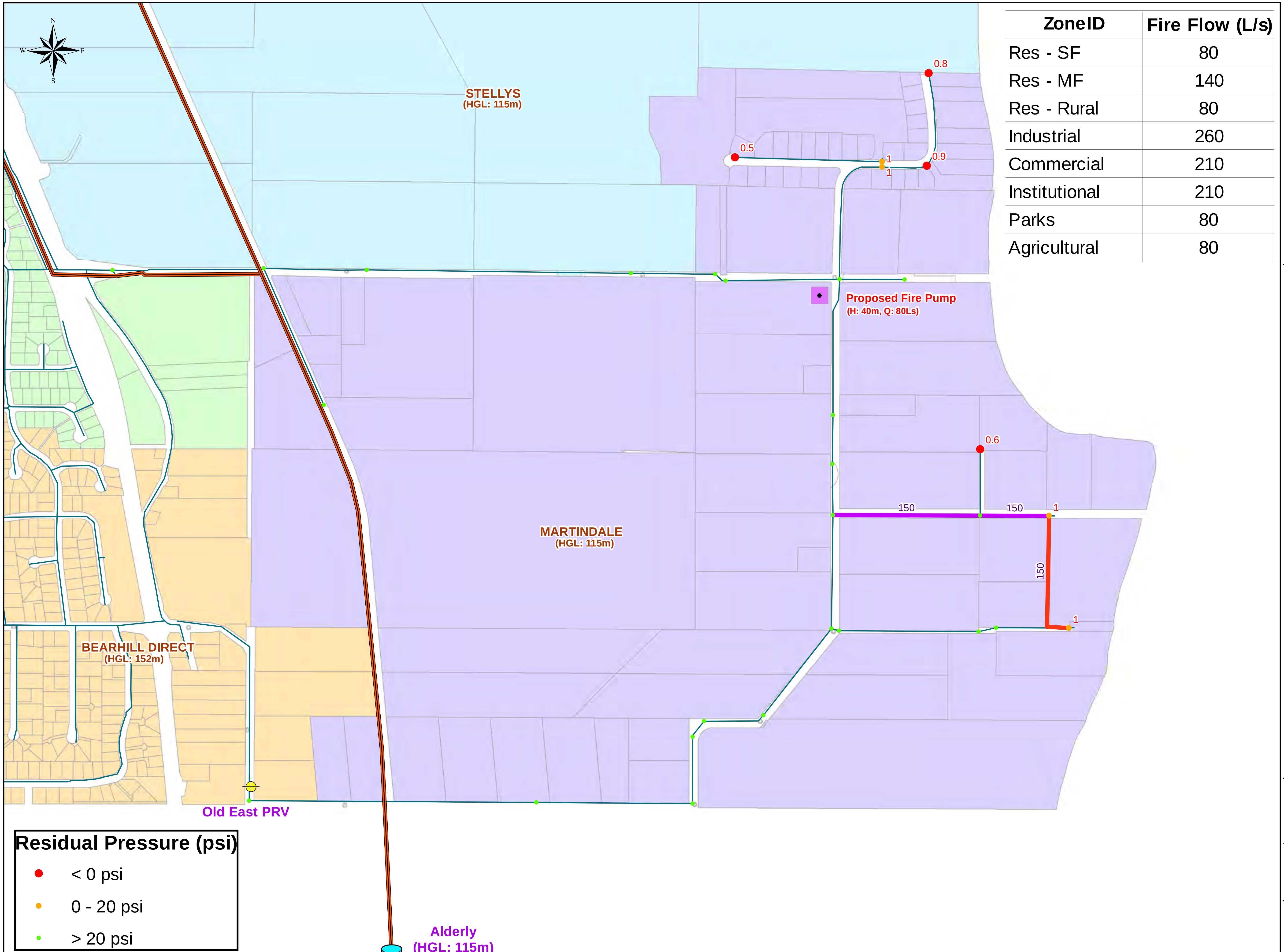
Figure No: Figure 5.9

Project No: 60240374

Date: December 2012

AECOM

ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80



District of Central Saanich

Water Distribution Master Plan

Martindale With Upgrades
Sce 1 - Fire Pump+Pipe Upgrade

MDD+Fire Residual Pressure
(Based on FUS Survey-2002)

Legend

- Proposed Fire Pump
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed Pipe Upgrade
- Proposed New Pipe
- CRD Transmission Main
- Existing Watermain
- 0.7 Available Flow at Node/ Required Fire Flow

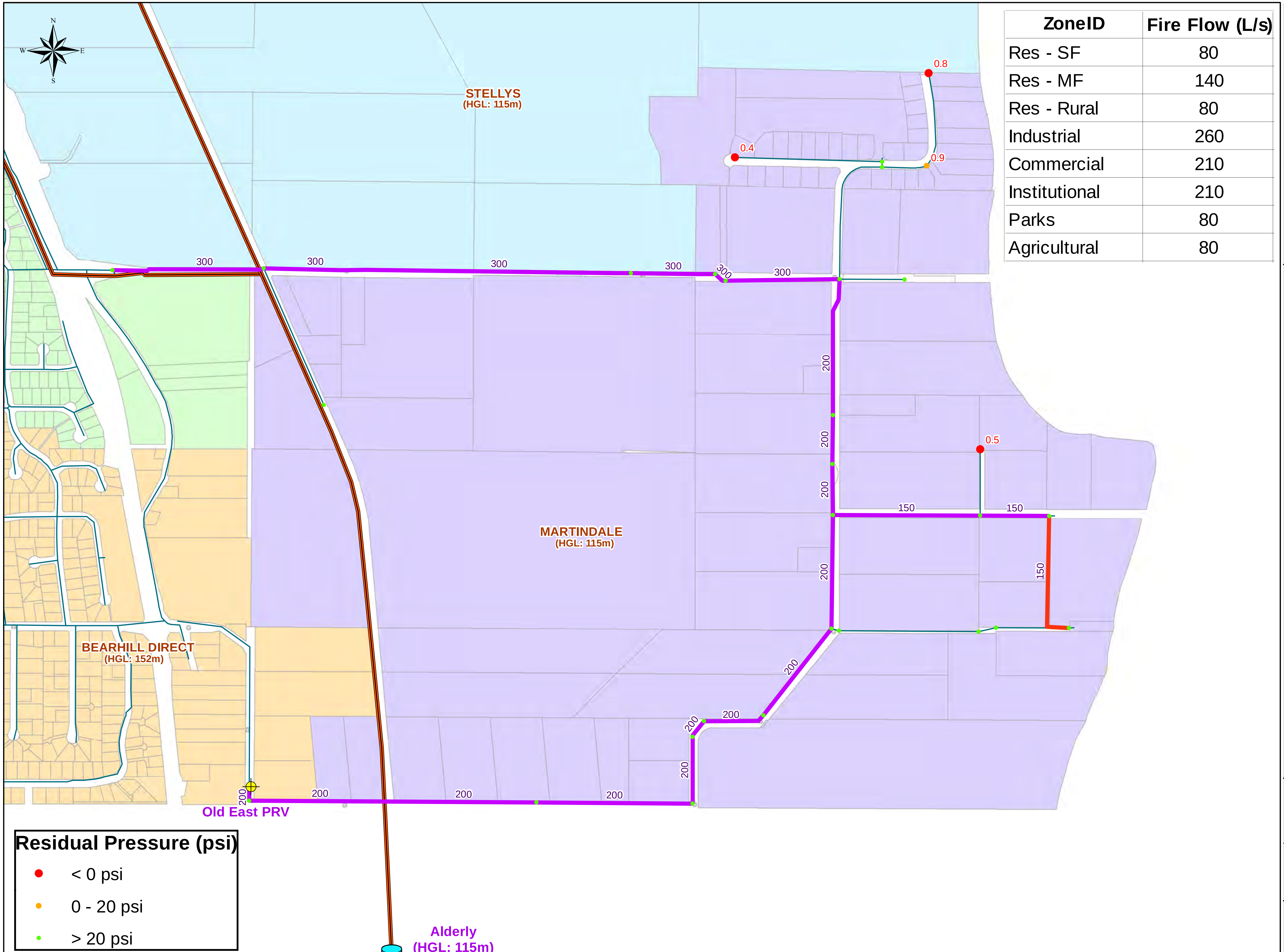
Figure No:

Figure 5.10

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Martindale with Upgrades
Sce 2 - Pipe Upgrades Only

MDD+Fire Residual Pressure
(Based on FUS Survey-2002)

Legend

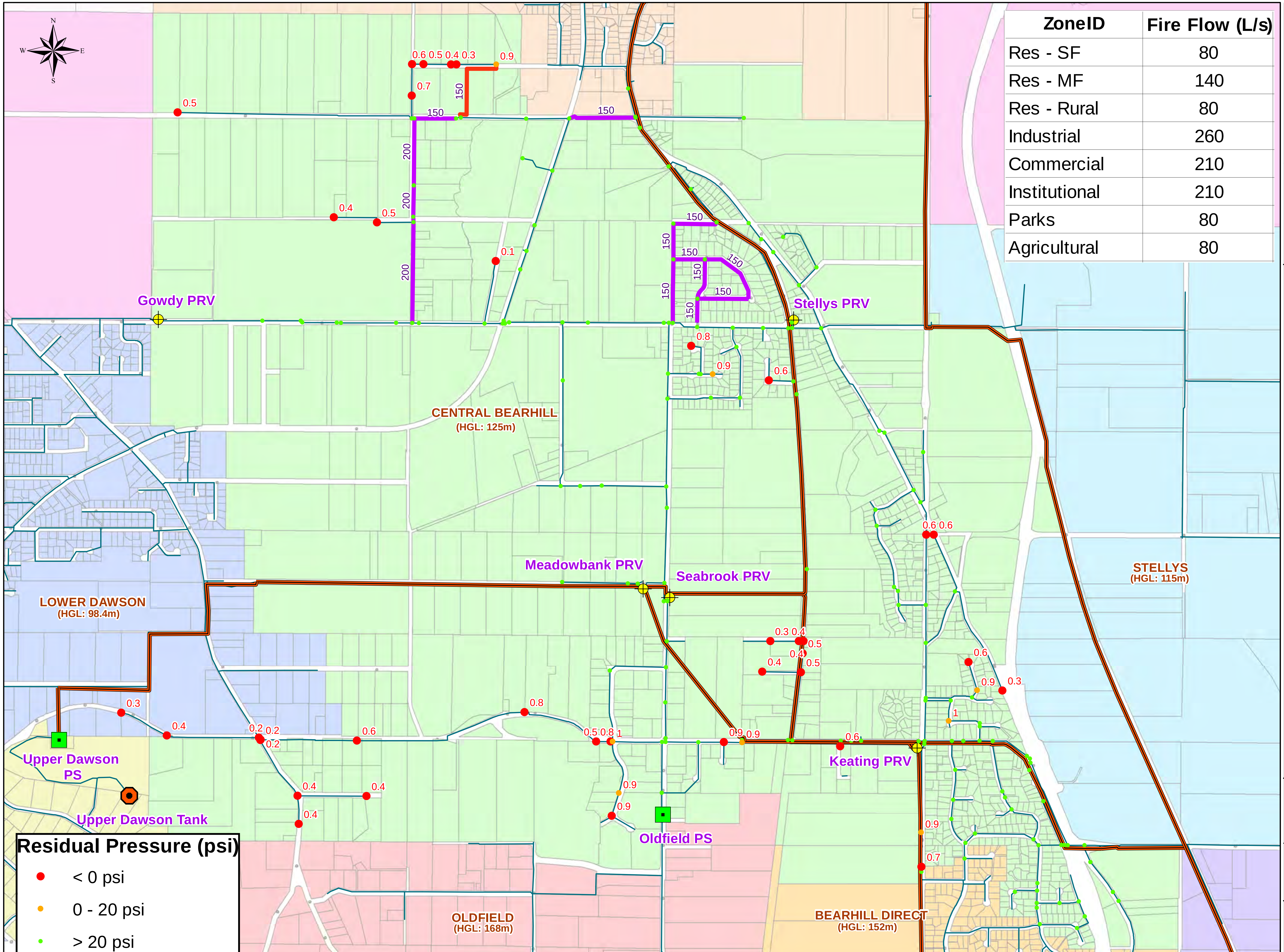
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed Pipe Upgrade
- Proposed New Pipe
- CRD Transmission Main
- Existing Watermain
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No:

Figure 5.11

Project No:	Date:
60240374	December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Central Bear Hill with Upgrades

MDD+Fire Residual Pressure (Based on FUS Survey-2002)

Legend

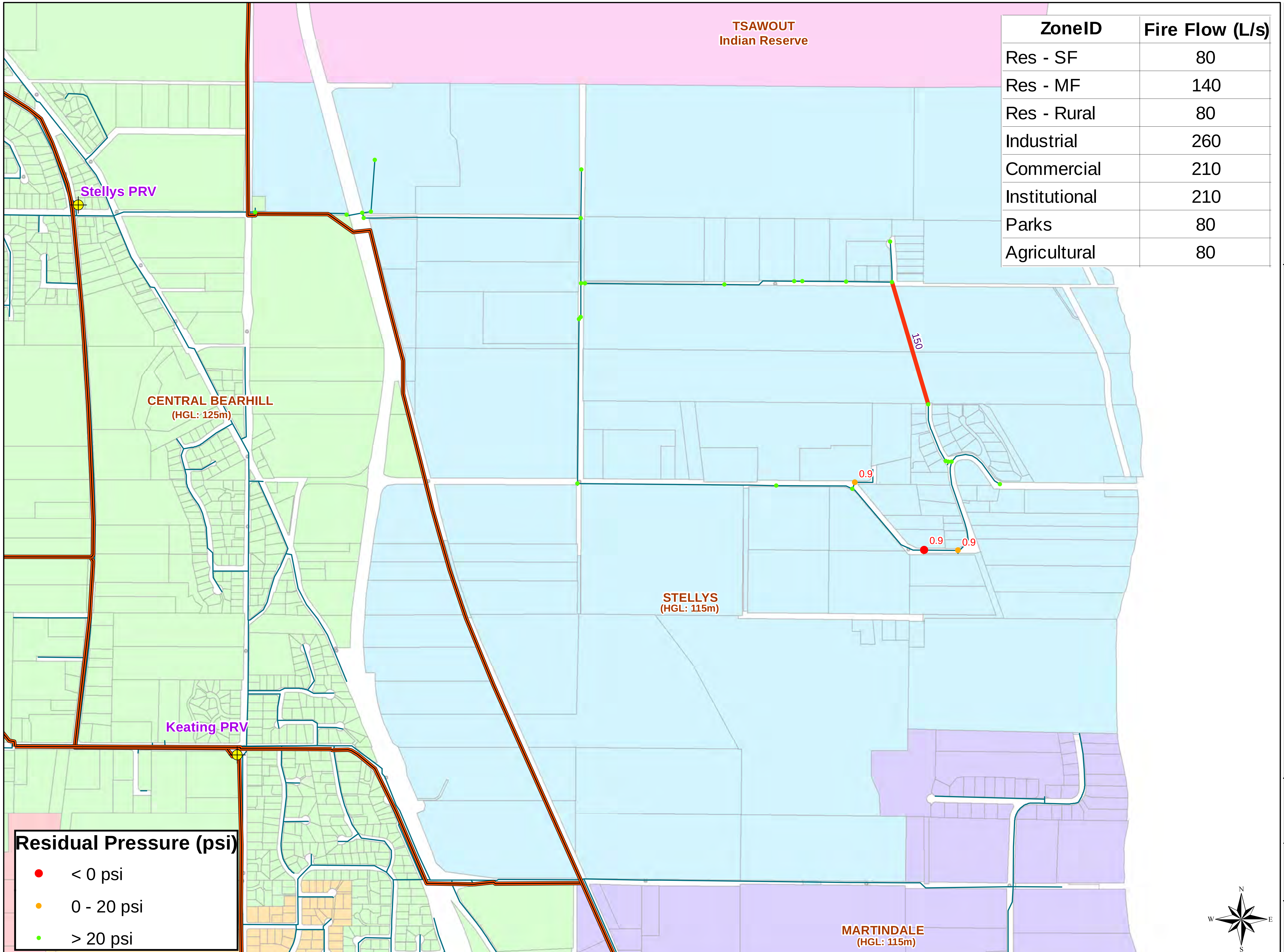
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed New Pipe
- Proposed Pipe Upgrade
- CRD Transmission Main
- Existing Watermain
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No:

Figure 5.12

Project No:	Date:
60240374	December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Stellys with Upgrades

MDD+Fire Residual Pressure (Based on FUS Survey-2002)

Legend

- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed New Pipe
- CRD Transmission Main
- Existing Watermain
- 0.7 Available Flow at Node/ Required Fire Flow

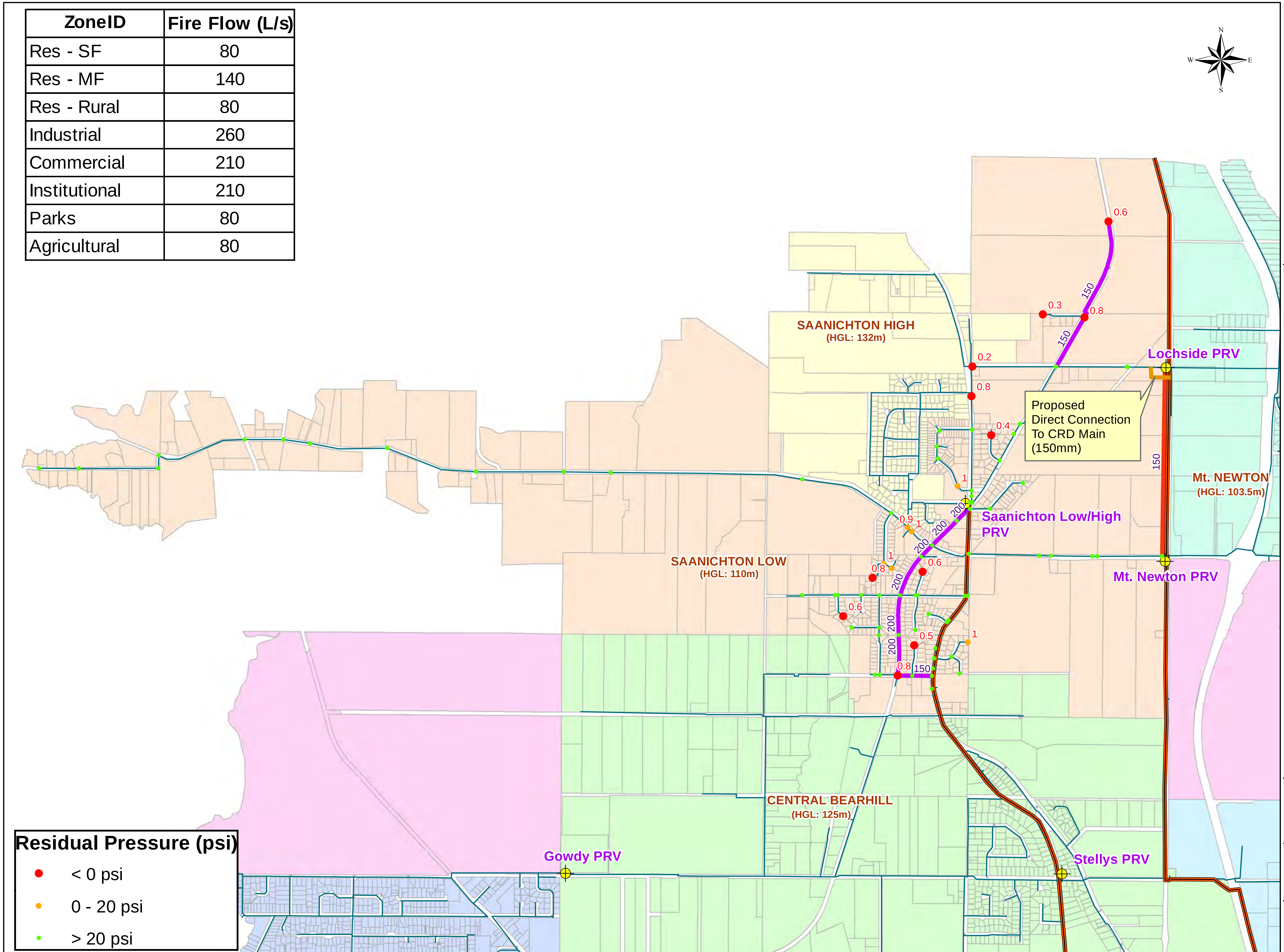
Figure No: Figure 5.13

Project No: 60240374

Date: December 2012

AECOM

ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80



District of Central Saanich

Water Distribution Master Plan

Saanichton Low with Upgrades

MDD+Fire Residual Pressure (Based on FUS Survey-2002)

Legend

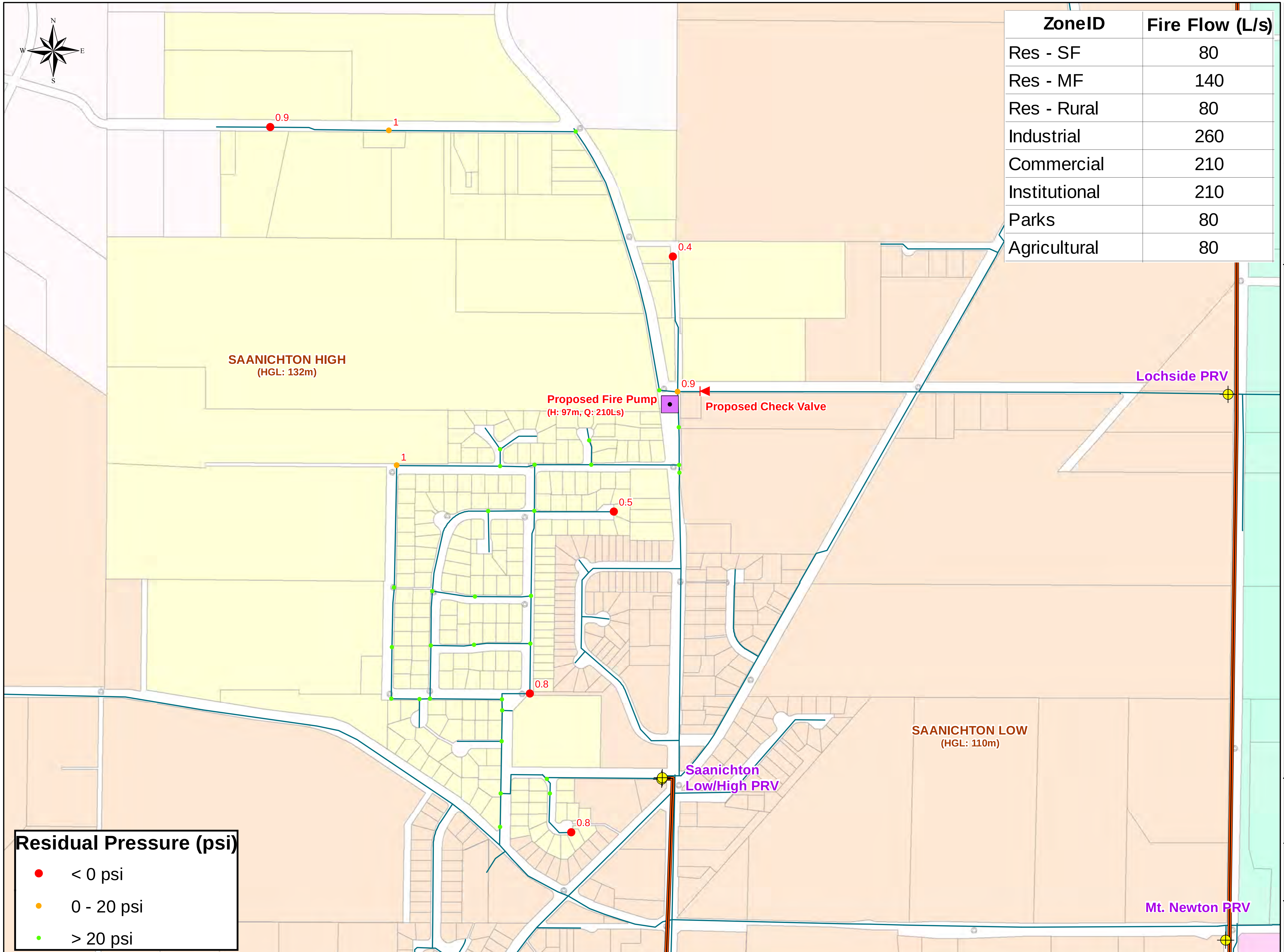
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed New Pipe
- Proposed Upgrade Pipe
- CRD Transmission Main
- Existing Watermain
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No: Figure 5.14

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Saanichton High with Upgrades
Sce 1 - Fire Pump

MDD+Fire Residual Pressure (Based on FUS Survey-2002)

Legend

- Proposed Fire Pump
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- 0.7 Available Flow at Node/ Required Fire Flow

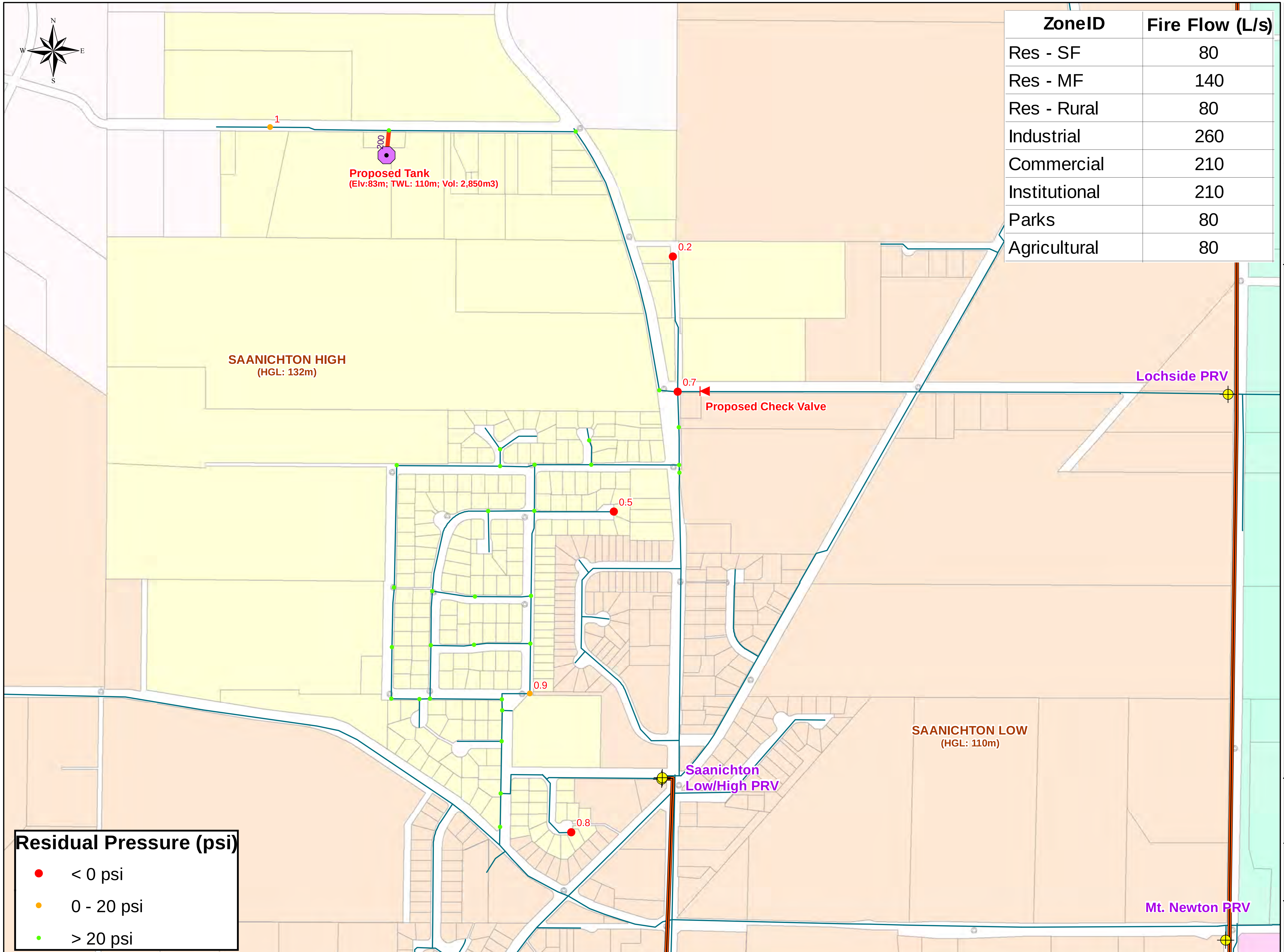
Figure No:

Figure 5.15

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Saanichton High with Upgrades Sce 2 - Tank

MDD+Fire Residual Pressure (Based on FUS Survey-2002)

Legend

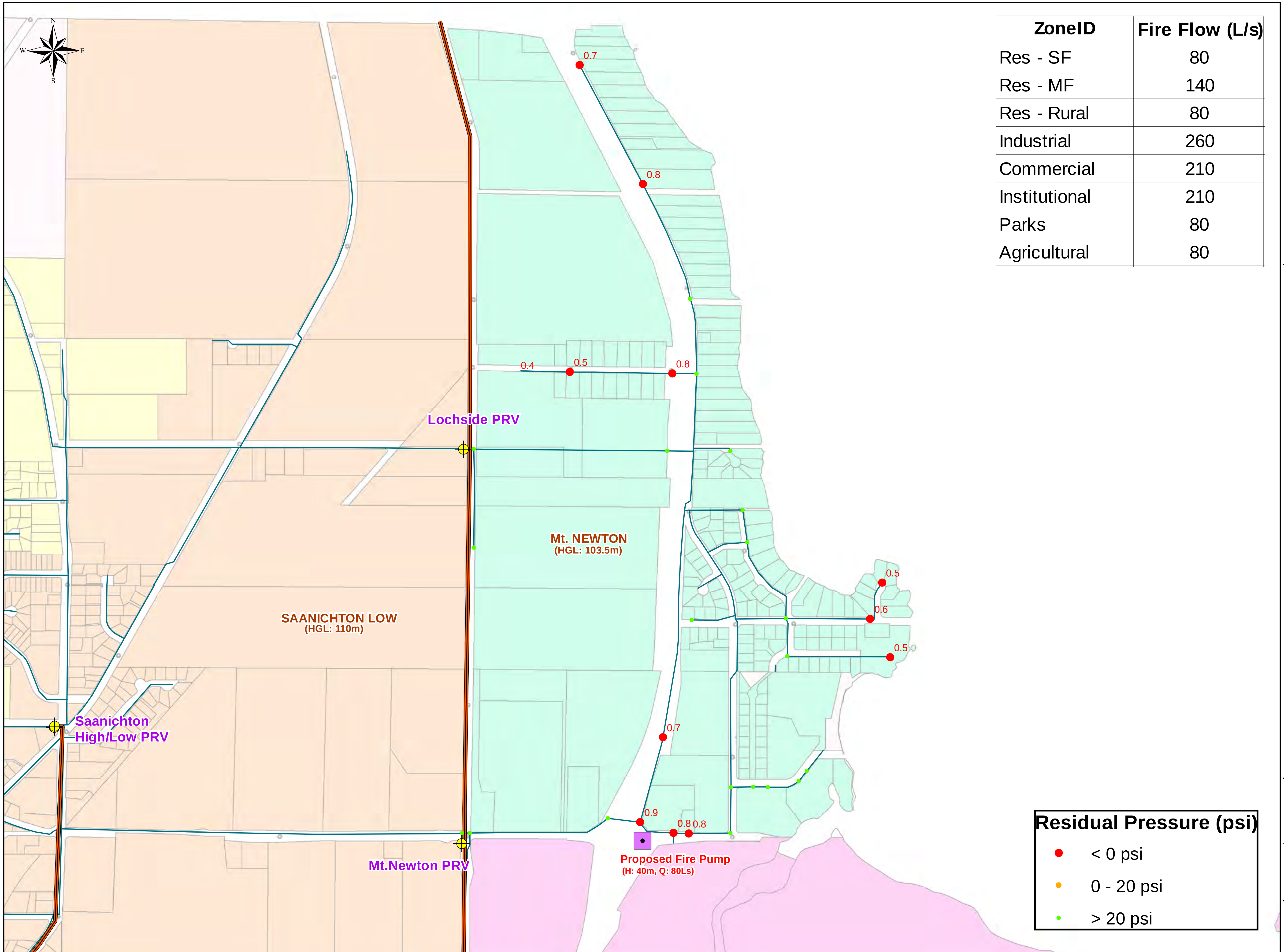
- Proposed Tank
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed New Pipe
- CRD Transmission Main
- Existing Watermain
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No: Figure 5.16

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

Residual Pressure (psi)

- < 0 psi
- 0 - 20 psi
- > 20 psi

District of Central Saanich

Water Distribution Master Plan

Mt. Newton with Upgrades

MDD+Fire Residual Pressure (Based on FUS Survey-2002)

Legend

- Proposed Fire Pump
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- 0.7 Available Flow at Node/ Required Fire Flow

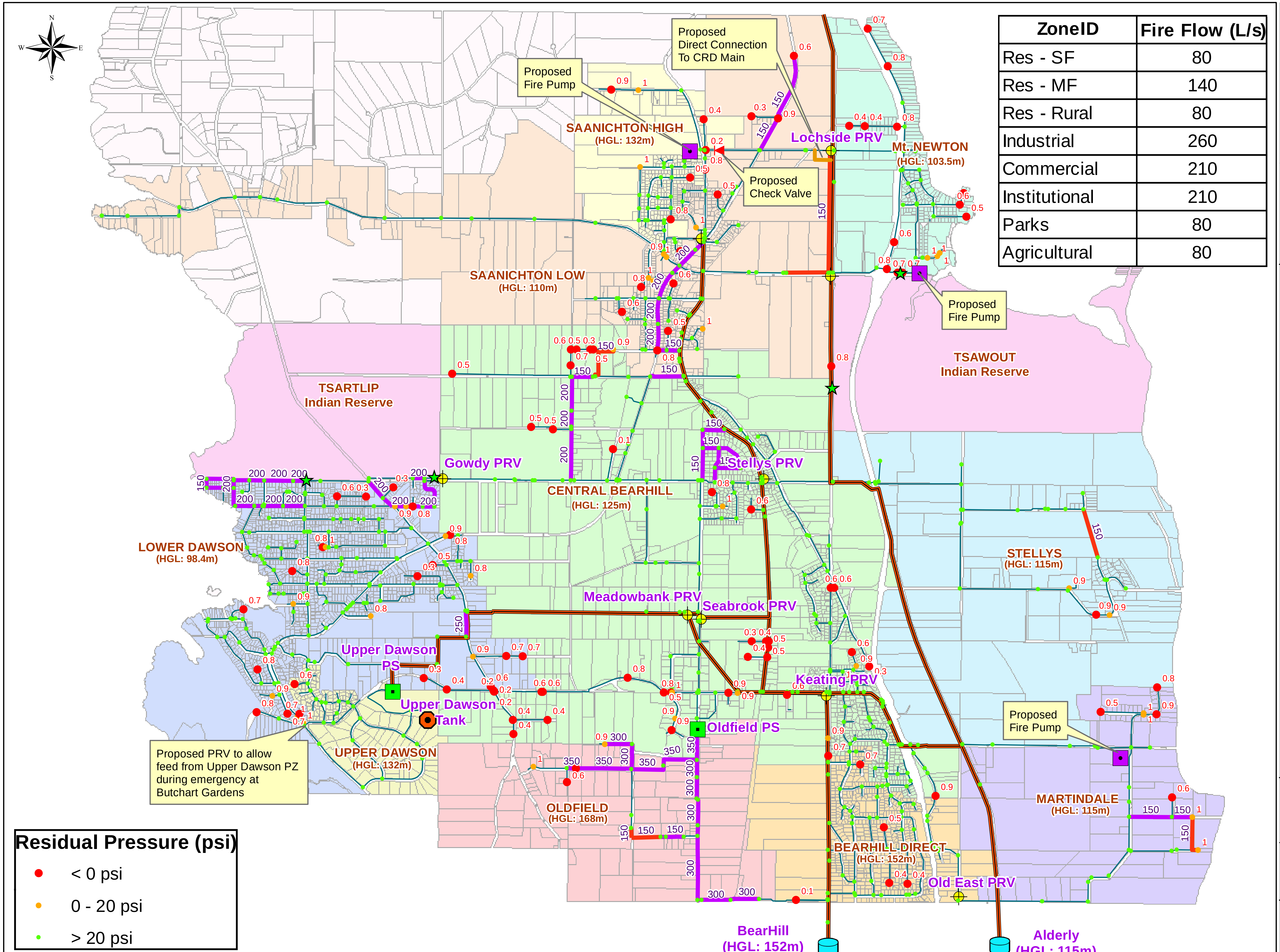
Figure No:

Figure 5.17

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Existing System With Recommended Upgrades

MDD+Fire Residual Pressure (Based on FUS Survey-2002)

Legend

- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed New Pipes
- Proposed Upgraded Pipes
- CRD Transmission Main
- Existing Watermain
- First Nations Supply Point
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No: Figure 5.18

Project No: 60240374

Date: December 2012

AECOM

6. Future System Assessment

As explained on Section 3, there were two future scenarios assessed in this study: 2025 and 2050. The increased population and demand associated with the expected future growth within the system has been discussed on Section 3 as well, as re-shown here in ***Table 6.1***.

Table 6.1 – Future Demand Allocation in Model

Land-use	2025			2050		
	ADD (L/s)	MDD (L/s)	PHD (L/s)	ADD (L/s)	MDD (L/s)	PHD (L/s)
Existing Demand	114.4	252.9	415.6	114.4	252.9	415.6
Additional Residential	12.7	35.6	59.7	33.5	93.9	157.6
Additional ICI	8.4	10.1	15.1	8.4	10.1	15.1
Total	**135.5**	**298.5**	**490.4**	**156.3**	**356.8**	**588.3**

As can be observed from the above table, the water demand increase was estimated at 21 L/s (18%) and 42 L/s (36%) for 2025 and 2050 scenario respectively when compared to the existing demand in the system. This increase was relatively minor, especially considering that the majority of the increase was attributed to residential users where the demand was distributed across the system. The additional ICI demand was mainly on Keating X Rd west of Butler Cres.

This section of the report discusses the ability of the existing water distribution system as well as the recommended proposed upgrades (discussed in Section 5) to meet the increased water demand for both of these future scenarios.

6.1 Future (2025) Conditions

In order to assess the existing water distribution system capacity under future (2025) demand conditions, the water model was simulated under the four population/demand conditions: Average Day, Maximum Day, Peak Hour and Maximum Day + Fire. Figures 6.1 through 6.4 show the following:

- ***Figure 6.1*** – Minimum pressures under 2025 Average Day Demand
- ***Figure 6.2*** – Minimum pressures under 2025 Maximum Day Demand
- ***Figure 6.3*** – Minimum pressures under 2025 Peak Hour Demand
- ***Figure 6.4*** – Ratio of available fire flow to required fire flow with residual pressure of 15 kPa (20 psi) under 2025 Maximum Day Demand + Fire

As can be observed from these figures, under the ADD, MDD and PHD conditions, the existing system has the capacity to accommodate the increased water demand. Under MDD+Fire, the same residual pressure and fire flow availability issues were observed for 2025 demands as for current demands. This condition was expected since the increased water demand associated with the increase residential and/or ICI population was not significant and the fire flow requirement was still the governing element when assessing the overall system capacity.

Figure 6.5 shows the residual pressure and fire flow availability conditions after implementing the recommended upgrades throughout the system as discussed in ***Section 5***. As can be seen in this figure, virtually the same level of improvement was achieved in 2025 scenario as that achieved for the existing demand conditions.

6.2 Future (2050) Conditions

In order to assess the existing water distribution system capacity under future (2050) demand conditions, the water model was simulated under the four population/demand conditions: Average Day, Maximum Day, Peak Hour and Maximum Day + Fire. Figures 6.6 through 6.9 show the following:

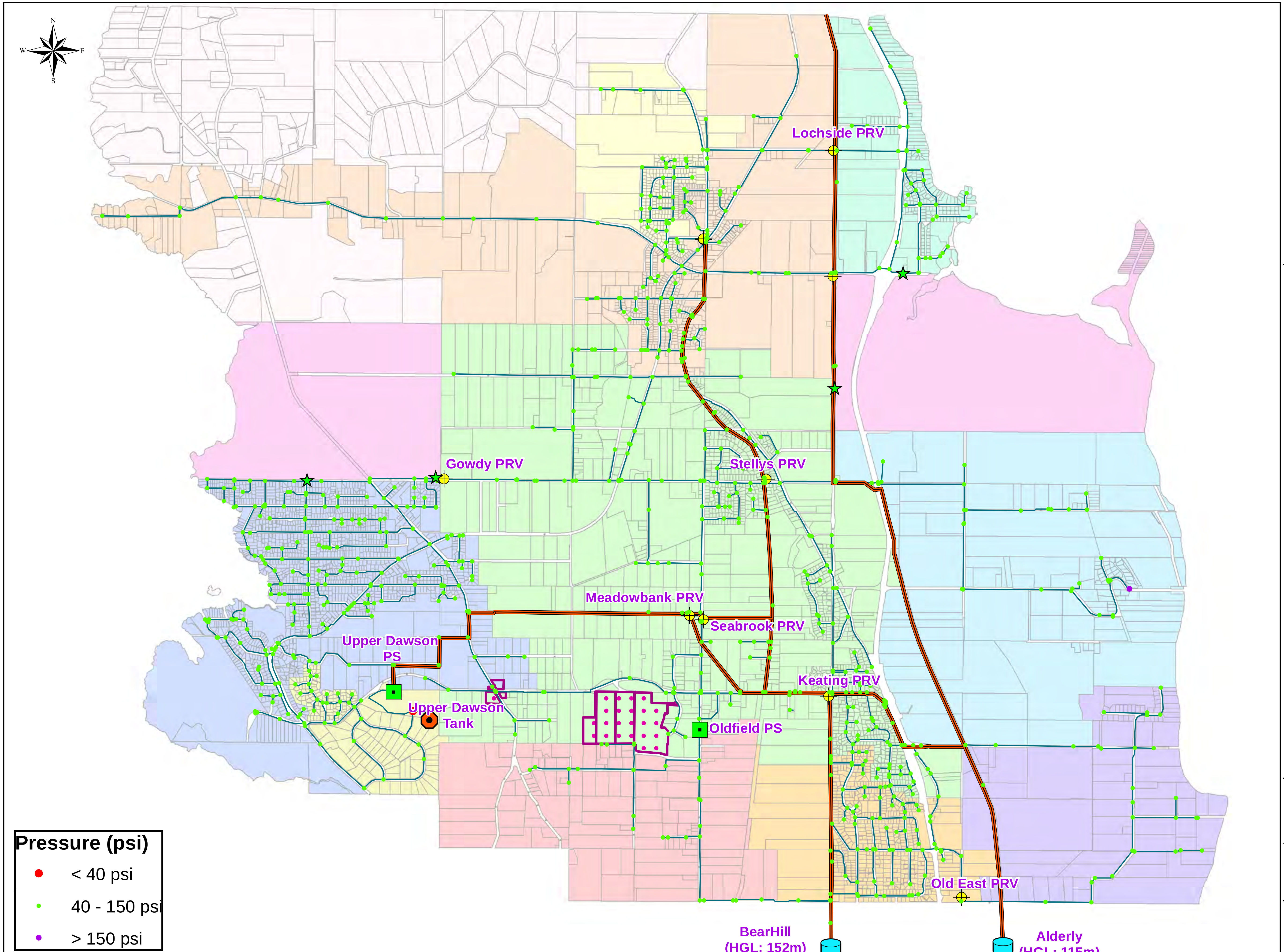
- ***Figure 6.6*** – Minimum pressures under 2050 Average Day Demand
- ***Figure 6.7*** – Minimum pressures under 2050 Maximum Day Demand
- ***Figure 6.8*** – Minimum pressures under 2050 Peak Hour Demand
- ***Figure 6.9*** – Ratio of available fire flow to required fire flow with residual pressure of 15kPa (20psi) under 2050 Maximum Day Demand + Fire

As can be observed from these figures, under the ADD, MDD and PHD conditions, the existing system has the capacity to accommodate the increased water demand to 2050. Under MDD+Fire, the same residual pressure and fire flow availability issues were observed for 2050 demands as for current demands. This condition was expected since the increased water demand associated with the increase residential and/or ICI population was not significant and the fire flow requirement was still the governing element when assessing the overall system capacity.

Figure 6.10 shows the residual pressure and fire flow availability conditions after implementing the recommended upgrades throughout the system as discussed in ***Section 5***. As can be seen in this figure, more or less the same level of improvement was achieved in 2050 scenario as that achieved for the existing demand conditions.

Normally, planning water system needs for years as far into the future are more related to overall water supply or water source needs, rather than infrastructure improvements. This is because there are many variables, such as population growth, per capita demand, firefighting flow requirements, that can change over this long period. As a result, the analyses of the 2050 scenario are useful in terms of understanding that the governing criteria in the future are similar to today.

However, we do not recommend that any specific replacement program be developed or implemented based upon the 2050 analyses. Rather, it would be more appropriate to revisit the analyses in a 5-year cycle, to confirm the shorter term replacements/upgrades remain valid or to adapt to any significant short-term changes to land use, population, demand, or firefighting that might change that program or direction.



District of Central Saanich

Water Distribution Master Plan

Existing System

2025 Average Day Demand Minimum Pressure Conditions

Legend

- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- Additional ICI Parcel
- First Nations Supply Point

Figure No: Figure 6.1

Project No: 60240374

Date: December 2012

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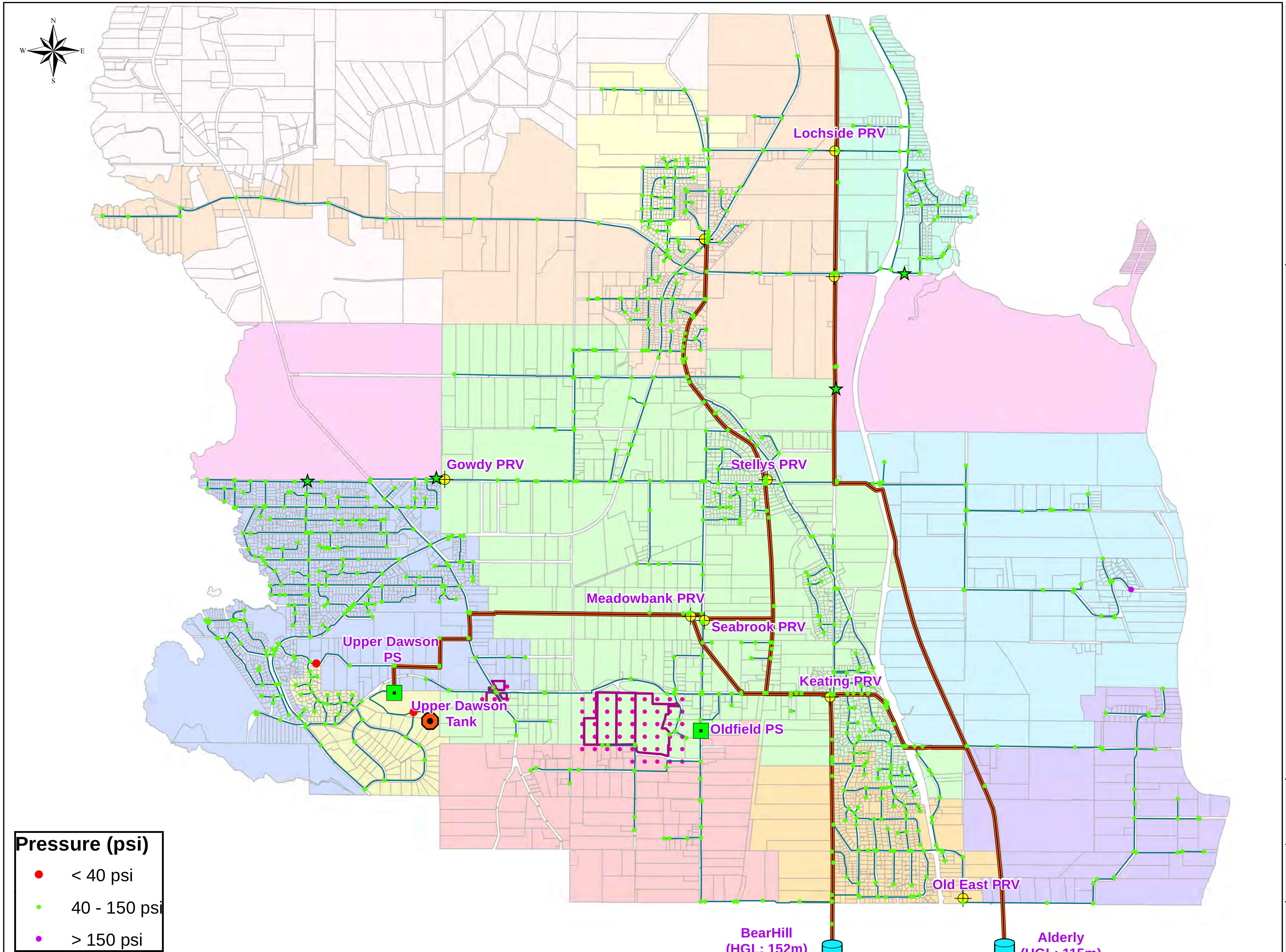


District of Central Saanich

Water Distribution Master Plan

Existing System

2025 Max Day Demand Minimum Pressure Conditions

Legend

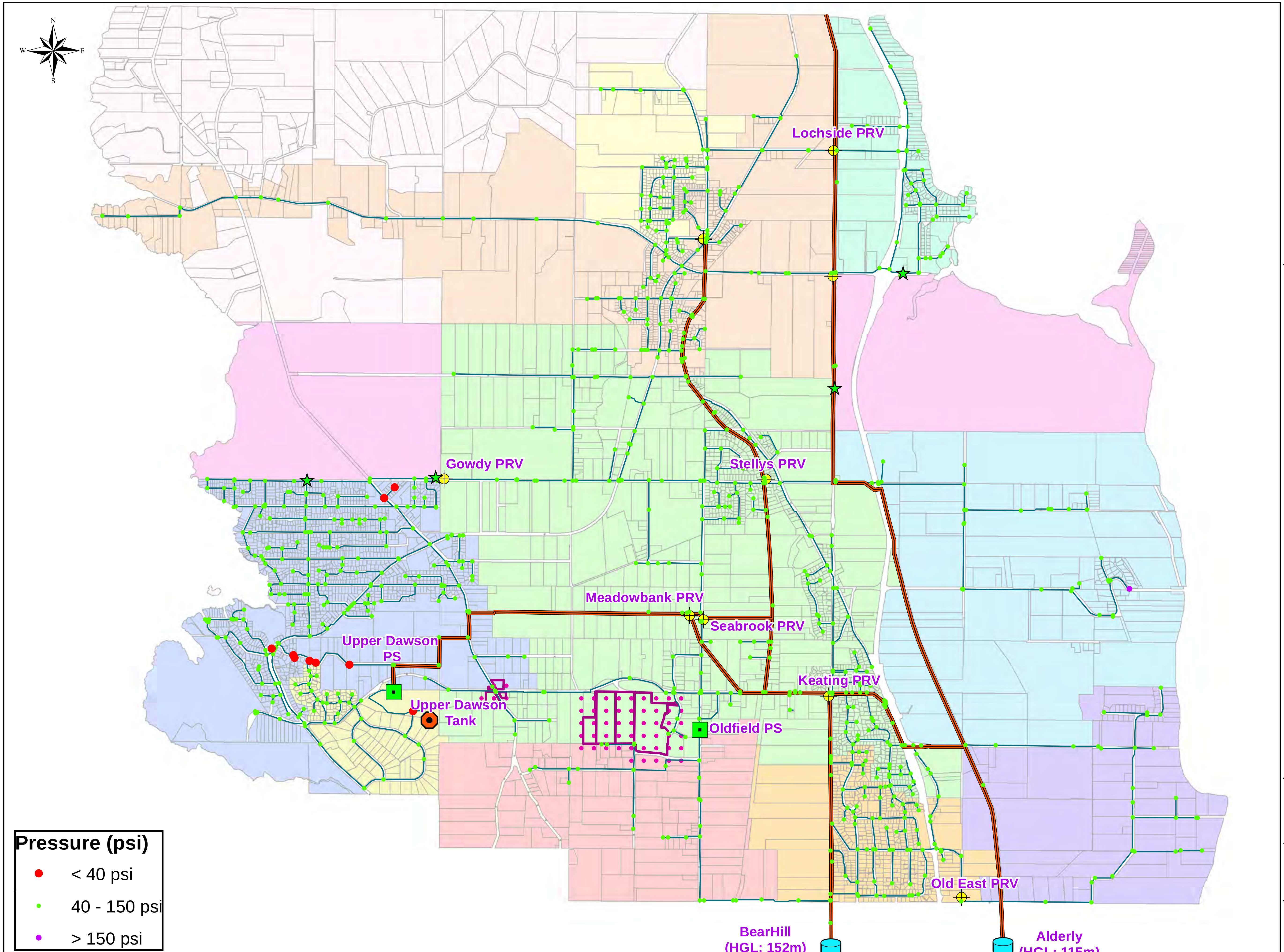
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- Additional ICI Parcel
- First Nations Supply Point

Figure No: Figure 6.2

Project No: 60240374

Date: December 2012

AECOM



LAND OF PLENTY

District of Central Saanich

Water Distribution Master Plan

Existing System

2025 Peak Hour Demand Minimum Pressure Conditions

Legend

- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- Additional ICI Parcel
- First Nations Supply Point

Figure No:

Figure 6.3

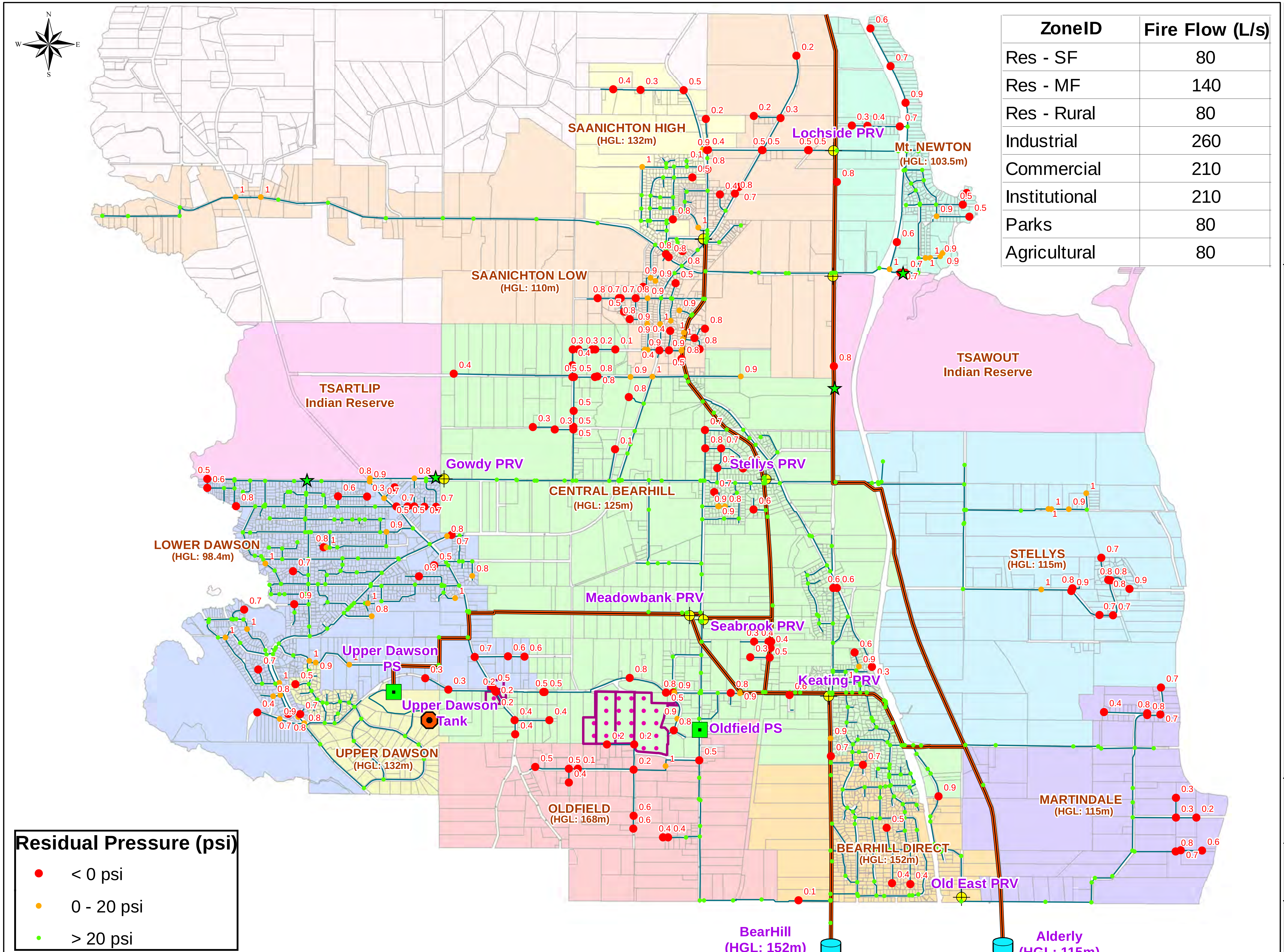
Project No:

60240374

Date:

December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

Residual Pressure (psi)

- < 0 psi
- 0 - 20 psi
- > 20 psi

District of Central Saanich

Water Distribution Master Plan

Existing System
2025 Max Day Demand + Fire

Residual Pressure
(Based on FUS Survey-2002)

Legend

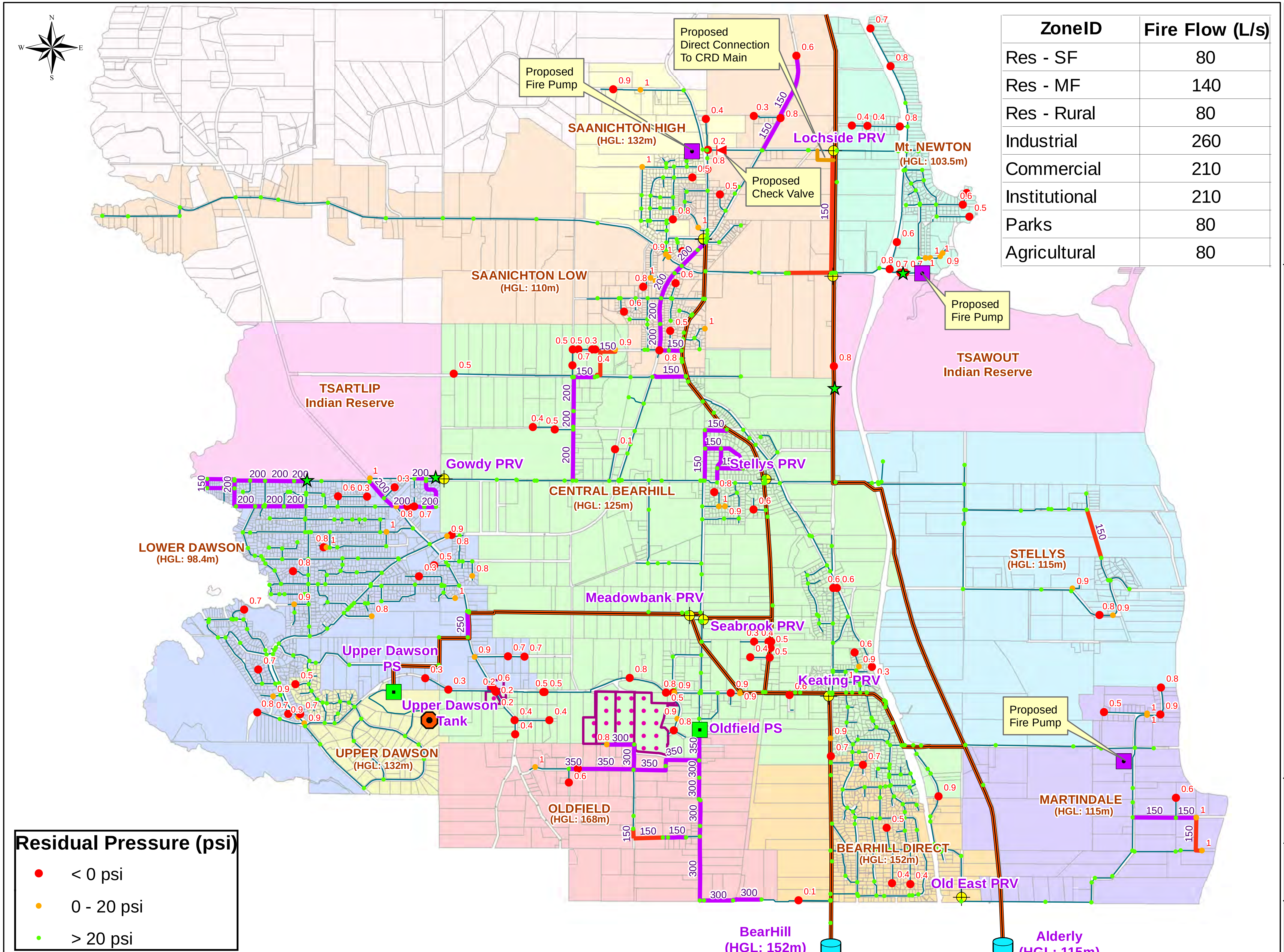
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- Additional ICI Parcel
- First Nations Supply Point
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No: Figure 6.4

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Existing System With Recommended Upgrades 2025 MDD+Fire Residual Pressure (Based on FUS Survey-2002)

Legend

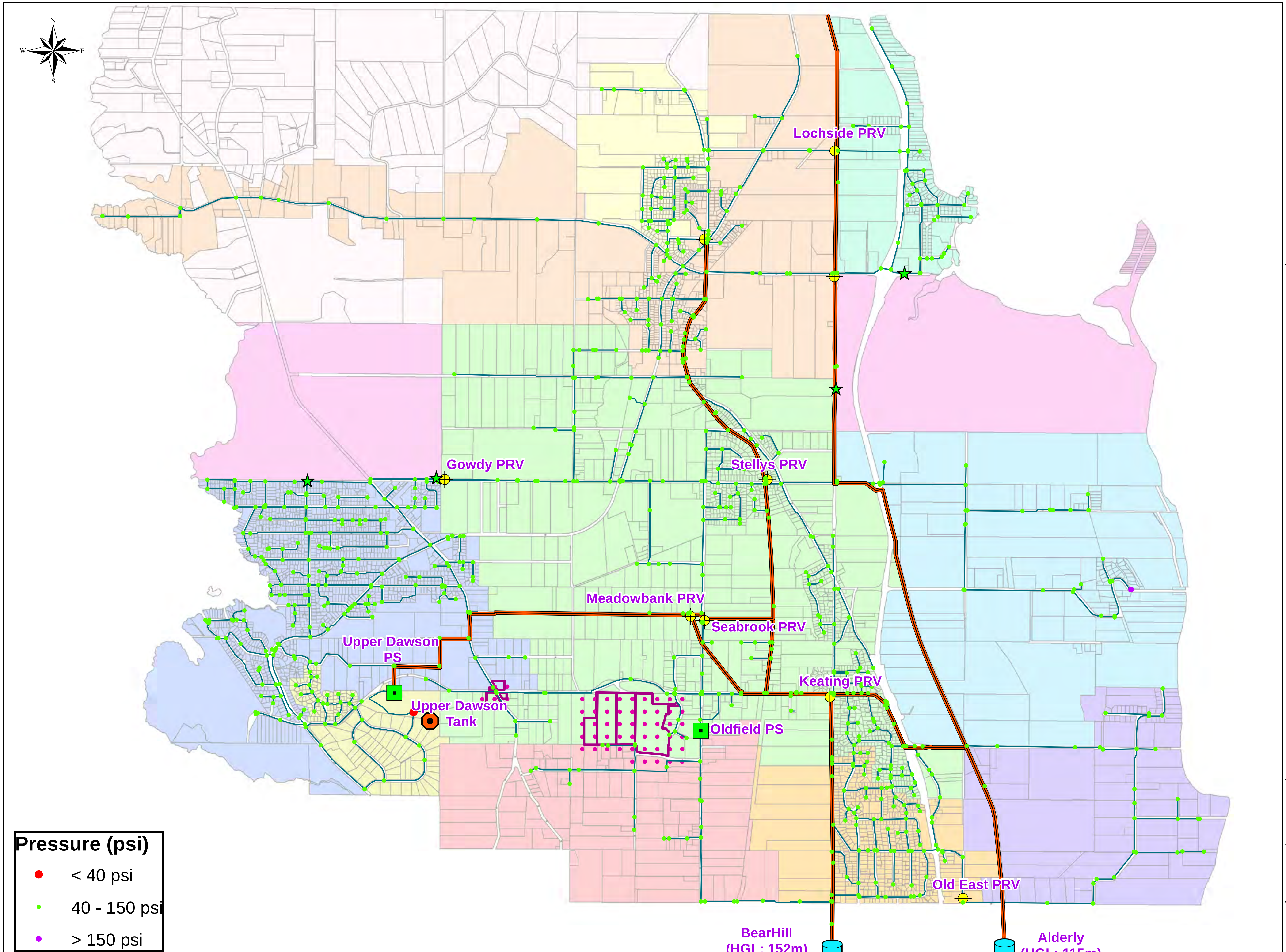
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed New Pipes
- Proposed Upgraded Pipes
- CRD Transmission Main
- Existing Watermain
- Additinal ICI Parcel
- First Nations Supply Point
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No: Figure 6.5

Project No: 60240374

Date: December 2012

AECOM



LAND OF PLENTY

District of Central Saanich

Water Distribution Master Plan

Existing System

2050 Average Day Demand Minimum Pressure Conditions

Legend

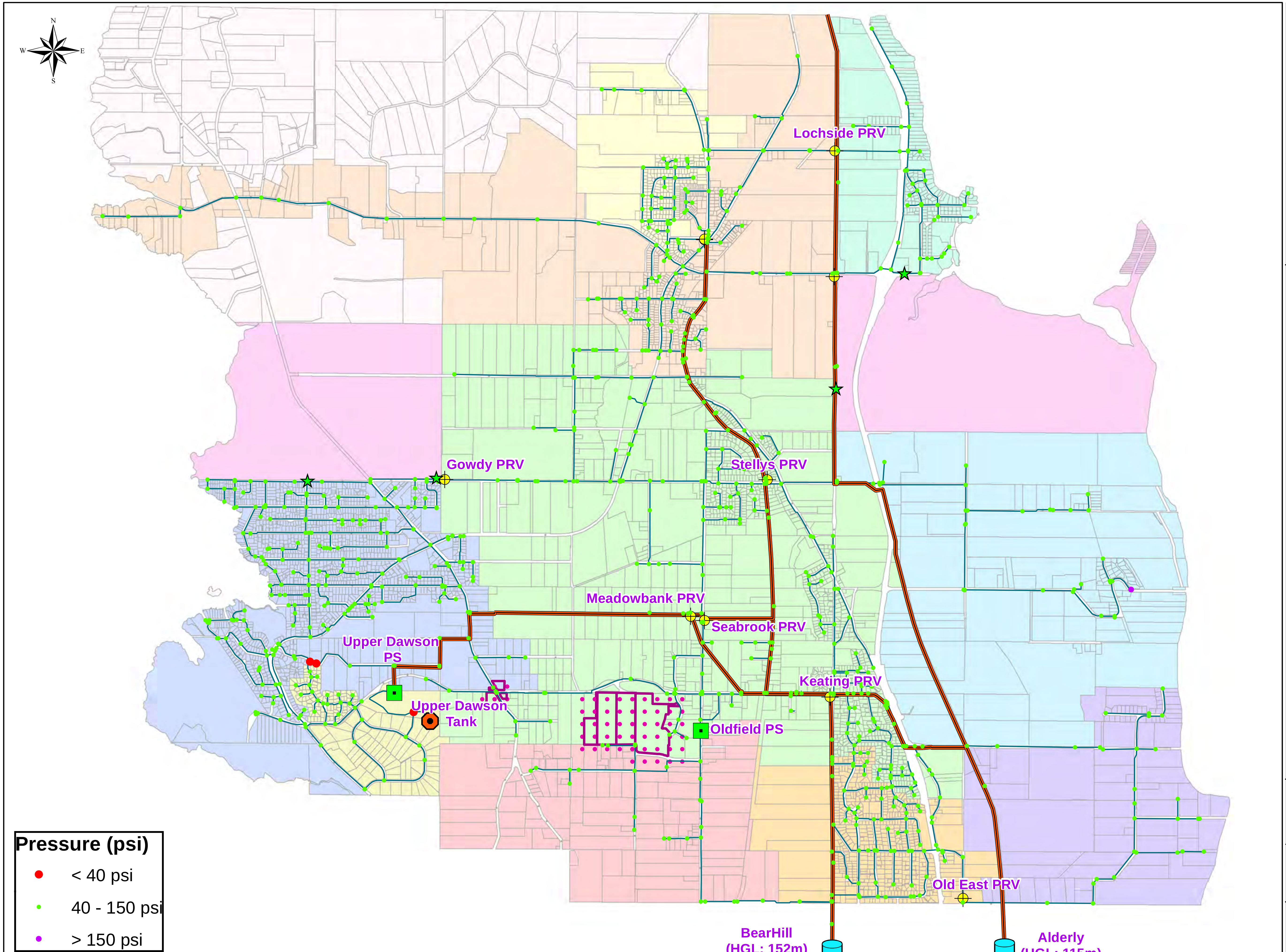
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- Additional ICI Parcel
- First Nations Supply Point

Figure No: Figure 6.6

Project No: 60240374

Date: December 2012

AECOM



District of Central Saanich

Water Distribution Master Plan

Existing System

2050 Maximum Day Demand Minimum Pressure Conditions

Legend

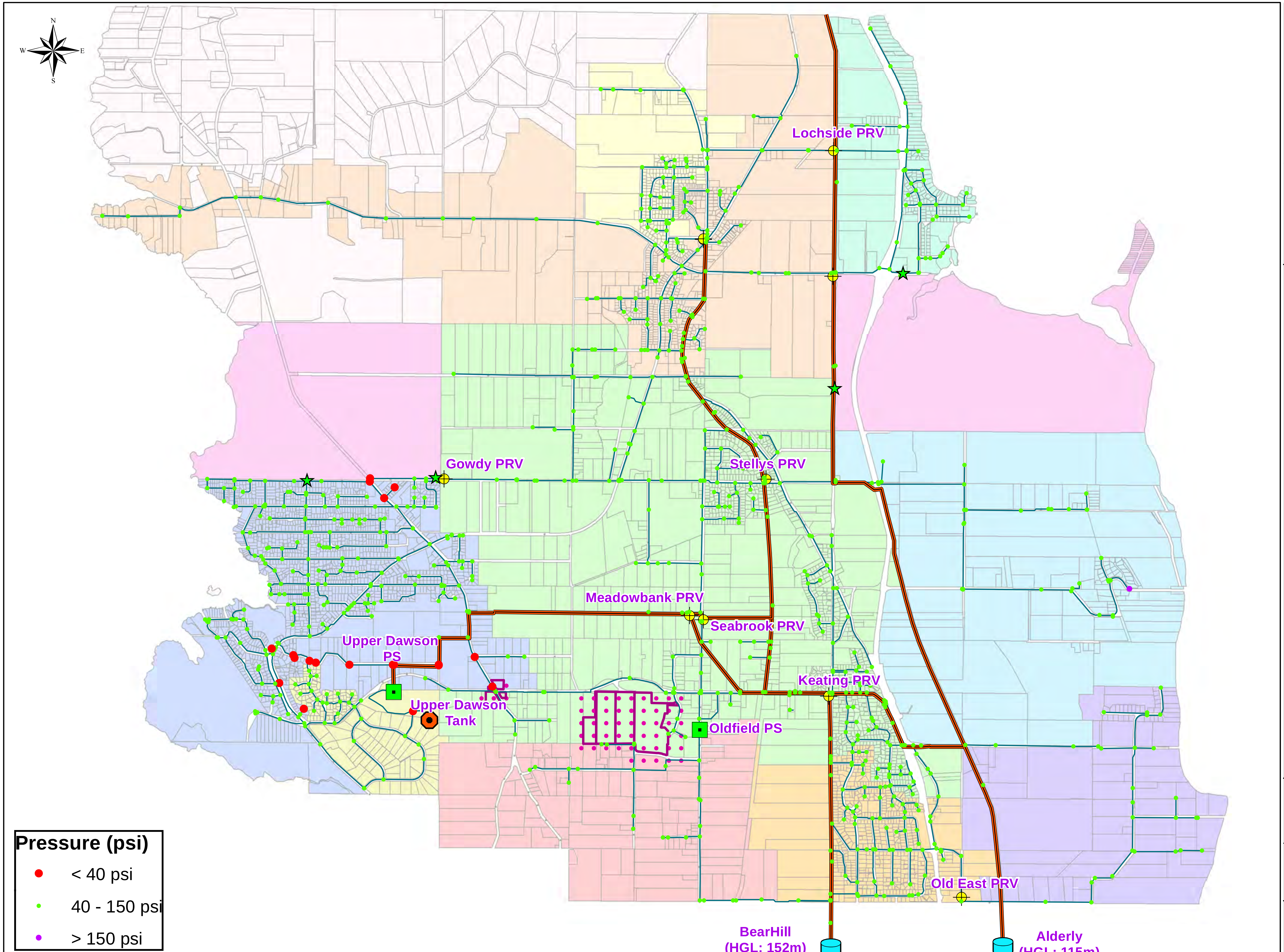
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- Additional ICI Parcel
- First Nations Supply Point

Figure No: Figure 6.7

Project No: 60240374

Date: December 2012

AECOM



District of Central Saanich

Water Distribution Master Plan

Existing System

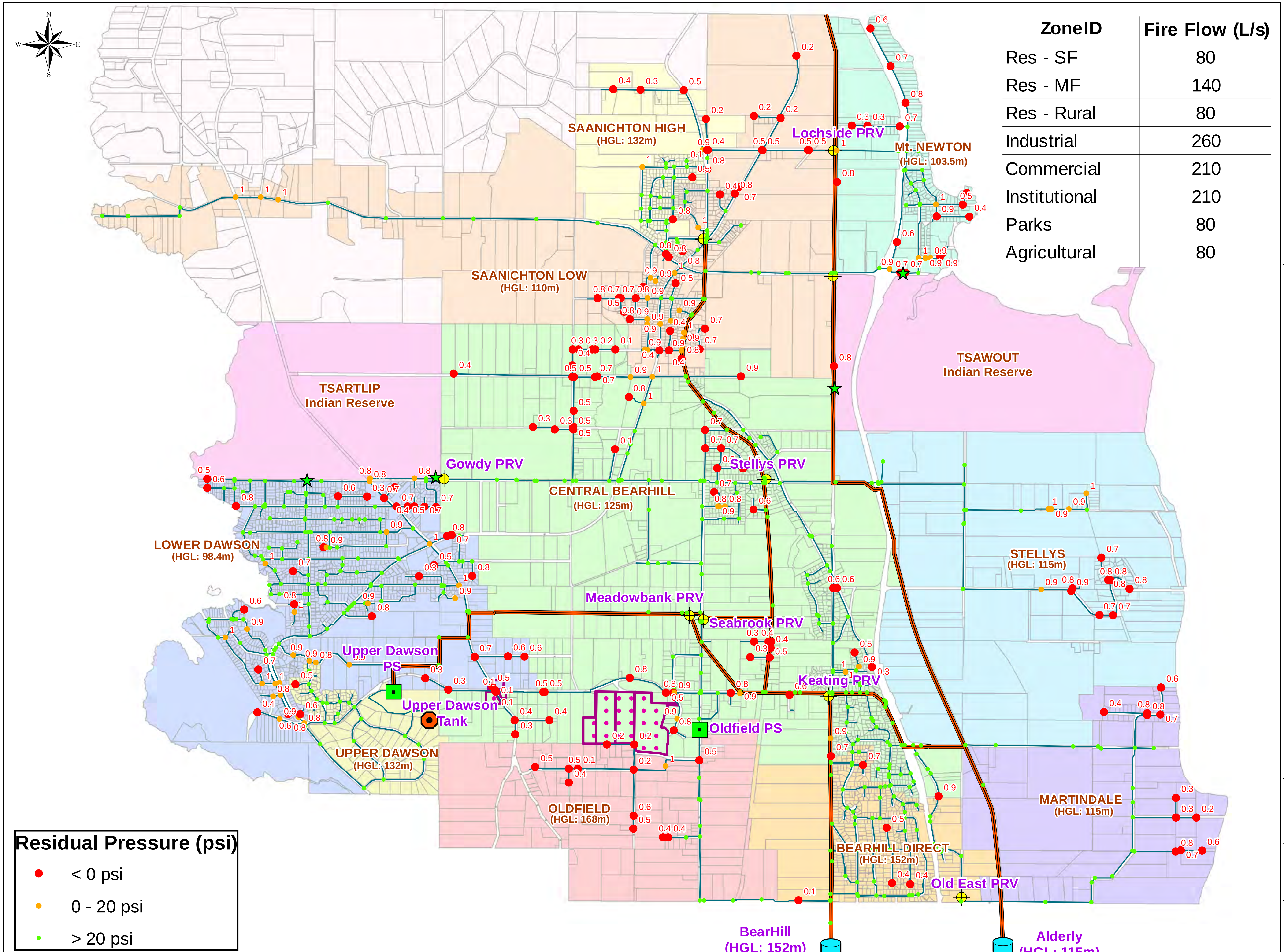
2050 Peak Hour Demand Minimum Pressure Conditions

Legend

- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- Additional ICI Parcel
- First Nations Supply Point

Figure No: Figure 6.8

Project No:	Date:
60240374	December 2012



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Existing System
2050 Max Day Demand + Fire

Residual Pressure
(Based on FUS Survey-2002)

Legend

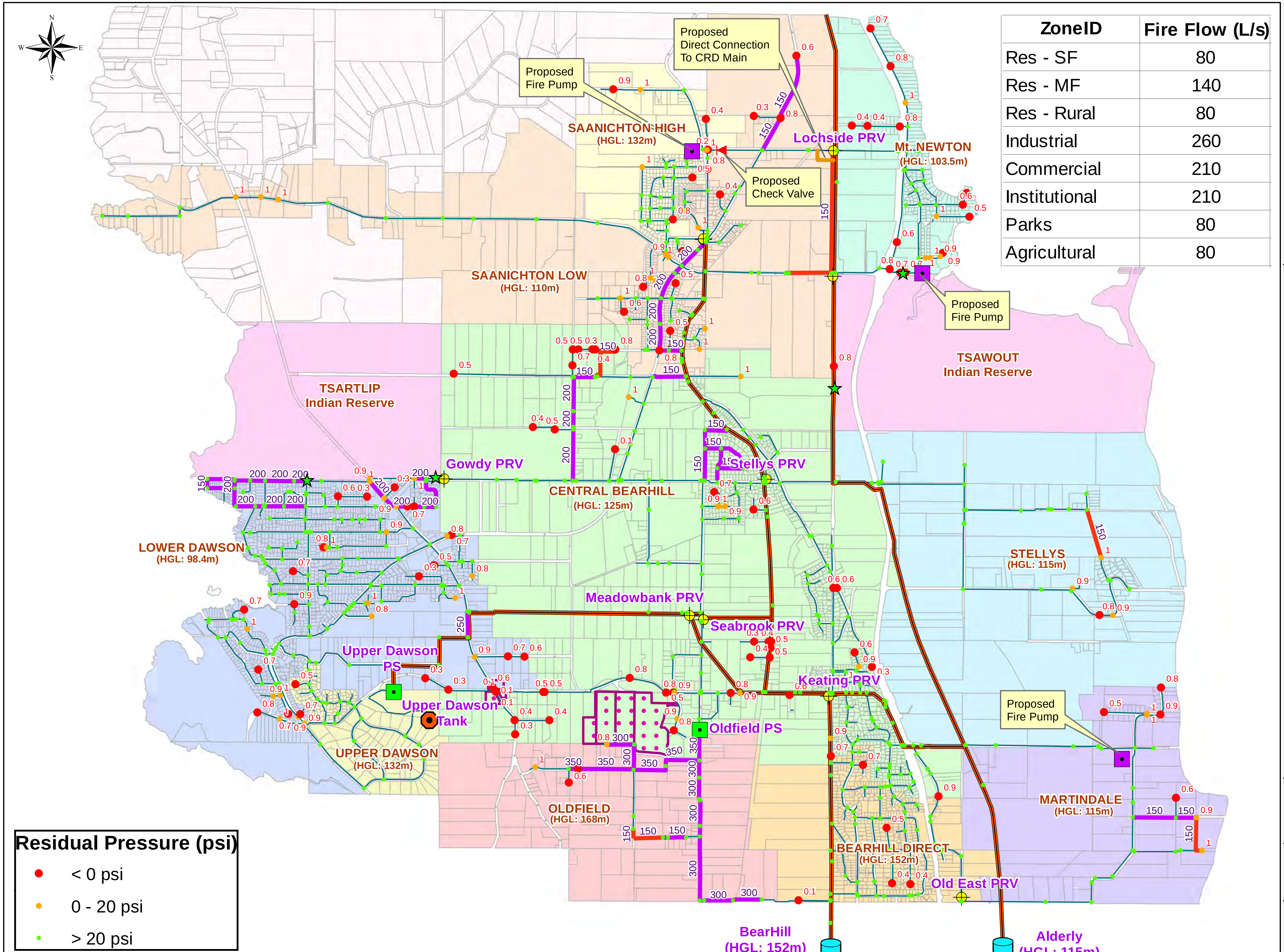
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- Additional ICI Parcel
- First Nations Supply Point
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No: Figure 6.9

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Existing System With Recommended Upgrades 2050 MDD+Fire Residual Pressure (Based on FUS Survey-2002)

Figure No: Figure 6.10

Project No: 60240374

Date: December 2012

AECOM

7. Non Serviced Areas

As part of this study, AECOM reviewed areas within the District that were identified as not yet serviced with piped water. The District provided the associated parcel fabrics as shown in ***Figure 7.1***. Previously a study was completed by Kerr Wood Leidal (KWL) that addressed servicing portions of these Non Serviced Areas (NSA) labelled as "North West Quadrant" (NWQ) (*North West Quadrant Water Servicing Conceptual Design Report*, Kerr Wood Leidal, 2010). The discussion on servicing this portion of the NSA will be treated separately from that of the rest of the NSA.

7.1 Population and Water Demand Calculation (Excluding NWQ)

For this serviceability study, some of the key parameters that were assessed are as follows:

- The availability and ability of the existing and planned future infrastructure (watermains, pump station, tank, etc.) to service these areas;
- Optimal feeder main route to service these areas, considering:
  - Extent of lands to be serviced
  - Possibility to introduce loop system and redundancy in the system
  - Road classification
  - Construction accessibility

When developing the estimated demand associated with these non serviced areas, the land use for each of these parcels was first determined by using the zoning (land-use) polygon available. There were three different land-use types identified for these non serviced areas: rural residential, agricultural and park.

In order to calculate the water demand associated with these non serviced parcels, the established unit consumption rates based on existing system demands were applied. The summary of the calculated rates is presented in ***Table 7.1*** below.

Table 7.1 – Unit Rates for Non Serviced Areas

Land use	Existing Demand (L/s)	Total Pop	Total Area (Ha)	Recommended Unit Rate	Unit
Residential	60.9	15,745	NA	335	L/cap/d
Agricultural/Park	20.0	NA	2,745.8	629	L/Ha/d

The estimated population density for each of the non serviced residential parcel is at 3 people/parcel therefore bringing the total water consumption unit rate to 1,005 L/parcel/d. This number correlates well with the unit rate used in the previous study performed by KWL in 2010 mentioned above (700-1000 L/Day/property).

For the Agricultural and Park usage, the same report suggested a unit rate of 1,000 L/parcel/d which they noted only reflected the domestic use (and not the irrigation of crops). The recommended Agricultural/Park unit rate of 629 L/ha/d shown in the above table equates to 3,675 L/parcel/d after taking into account a total serviced Agricultural/Park parcels of 470 parcels. This number was developed based on the existing water meter data and thus would have included the water use for crop irrigation in addition to the domestic use for this type of land use. Therefore the recommended unit rate of 629 L/ha/d was chosen and applied to the identified non serviced Agricultural and Park parcels and results in a higher total demand value.

The maximum day and peak hour demand conditions were also calculated for these areas based on the same peaking factor used for the existing and future scenarios as listed in ***Section 3, Table 3.4.*** The summary of the additional demand associated with these non serviced areas but excluding the North West quadrant is shown in ***Table 7.2***.

Table 7.2 – Increase Demand Associated with Non Serviced Areas (Excluding NWQ)

Land Use	Average Day (ADD) (L/s)	Maximum Day (MDD) (L/s)	Peak Hour (PHD) (L/s)
Residential	0.30	0.85	1.42
Agricultural/Park	2.66	3.19	5.32
Total	**2.96**	**4.04**	**6.74**

The same allocation process as that used to allocate the existing and future water demands was then applied for these areas.

7.2 Servicing Strategy for Non Serviced Areas (Excluding NWQ)

When analyzing the serviceability of these parcels, the existing system network and water demand conditions were used as the base. Nevertheless, in order to service these parcels, new watermains were proposed and system looping was introduced wherever feasible to improve the District's system performance in general. The newly proposed/introduced network loops are located in:

- Oldfield pressure zone, on Old West Saanich Rd/Bryn Rd/Verling Ave
- Martindale and Stelly's pressure zones are combined into one pressure zone (HGL: 115 m). New system loop was also proposed on Island View Rd/McIntyre Rd/McHugh Rd
- Central Bear Hill, on Wallace Dr/Willow Way/Keating X Rd
- Mt. Newton X Rd, on Mt. Newton X Rd/Hwy 17/Newman Rd

The same approach was used to assess the system capacity; that is, simulating the system under Average Day (ADD), Maximum Day (MDD), Peak Hour (PHD) and Maximum Day+Fire (MDD+Fire). The simulation results were shown in ***Figure 7.2*** – ***Figure 7.5*** which show the following:

- ***Figure 7.2*** – Minimum pressures under Average Day Demand
- ***Figure 7.3*** – Minimum pressures under Maximum Day Demand
- ***Figure 7.4*** – Minimum pressures under Peak Hour Demand
- ***Figure 7.5*** – Ratio of available fire flow to required fire flow with residual pressure of 15kPa (20psi) under Maximum Day Demand + Fire

As can be observed from these figures, under the current ADD, MDD and PHD conditions, the existing system has the capacity to accommodate the increased water demands associated with servicing currently non-serviced areas. Under MDD+Fire, the same residual pressure and fire flow availability issues were observed. This condition was expected since the increased water demand associated with the increase residential and/or ICI population was not significant and the fire flow requirement was still the governing element when assessing the overall system capacity.

Figure 7.6 shows the residual pressure and fire flow availability conditions after implementing the recommended upgrades throughout the system as discussed in ***Section 5***. As can be seen in this figure, more or less the same level of improvement was achieved in this scenario as that achieved for the existing demand conditions.

7.3 Servicing Strategy for Non Serviced Area within NWQ

As mentioned earlier in this section, Kerr Wood Leidal (KWL) had performed a study in 2010 to assess servicing options to North West Quadrant (NWQ) section of the Non Serviced Areas. AECOM has reviewed this study and in general was in agreement with the recommendations made in this study. The items reviewed and any relevant comments associated with them are summarized in the following subsections.

7.3.1 Pressure Zone Breakdown and Its Boundary

AECOM reviewed the elevation information available and agreed that the NWQ should be divided into three (3) pressure zones: PZ-110 m, PZ-180 m and PZ-190 m. There is a slight difference in terms of the proposed PZ boundary between PZ-110 m and PZ-180 m from that proposed by KWL. Based on the elevation information available and the ideal static pressure range of 40 psi – 150 psi, there are some areas that AECOM feels should be serviced by PZ-110m instead of PZ-180m, as identified in ***Figure 7.7***. This modification would also mean less twinned watermains along West Saanich Rd to serve both PZ-110 m and PZ-180 m.

For PZ-190 m, to keep the static pressure between 40 psi – 150 psi, the elevation range should be between 85 m – 160 m. Based on the elevation data available the ground elevation within this proposed PZ ranges from 75 m to 220 m on the southern and northern corners of the parcels. The elevation on the streets in this proposed PZ do lie within this ideal range, so it was expected that any potential low/high pressure issues would be on the private sides of the system. Therefore, future property owners at this neighbourhood would need to install their own booster pump or PRV accordingly to mitigate the possible low/high pressure issues on their properties.

It is also important to point out that the elevation information available was in the form of DEM points and it may not be the most accurate information available. It is recommended that more precise elevation information be made available during a future design stage when properties within the Northwest Quadrant proceed to development stage.

7.3.2 Servicing Options

Table 7.3 summarizes the servicing options evaluated by KWL in their 2010 report.

Table 7.3 – NWQ Servicing Options as per KWL Report 2010

PZ-110 and PZ-180 Servicing Options

Option	Description
1	Service from Saanichton Low (110m) via Mt. Newton X Rd
1B	Service from Saanichton Low (110m) via Mt. Newton X Rd;
	Install fire pump at Tomlinson Rd
2	Service from Saanichton Low (110m) via Mt. Newton X Rd;
	Construct PZ-110 tank
3	Service from Saanichton Low (110m) via Mt. Newton X Rd AND
	from Upper Brentwood (112m), currently Lower Dawson (98m)

PZ-190 Servicing Options

Option	Description
A	Booster pump from Saanichton Low (110m) at Mt. Newton X Rd
	and Thomson Rd
B	Booster pump from Saanichton High (132m) at Thomson Place
	and Tomlinson Rd ROW
C	Gravity feed from Middle John Dean Reservoir (186m)

The overall recommendations made by KWL were as follows:

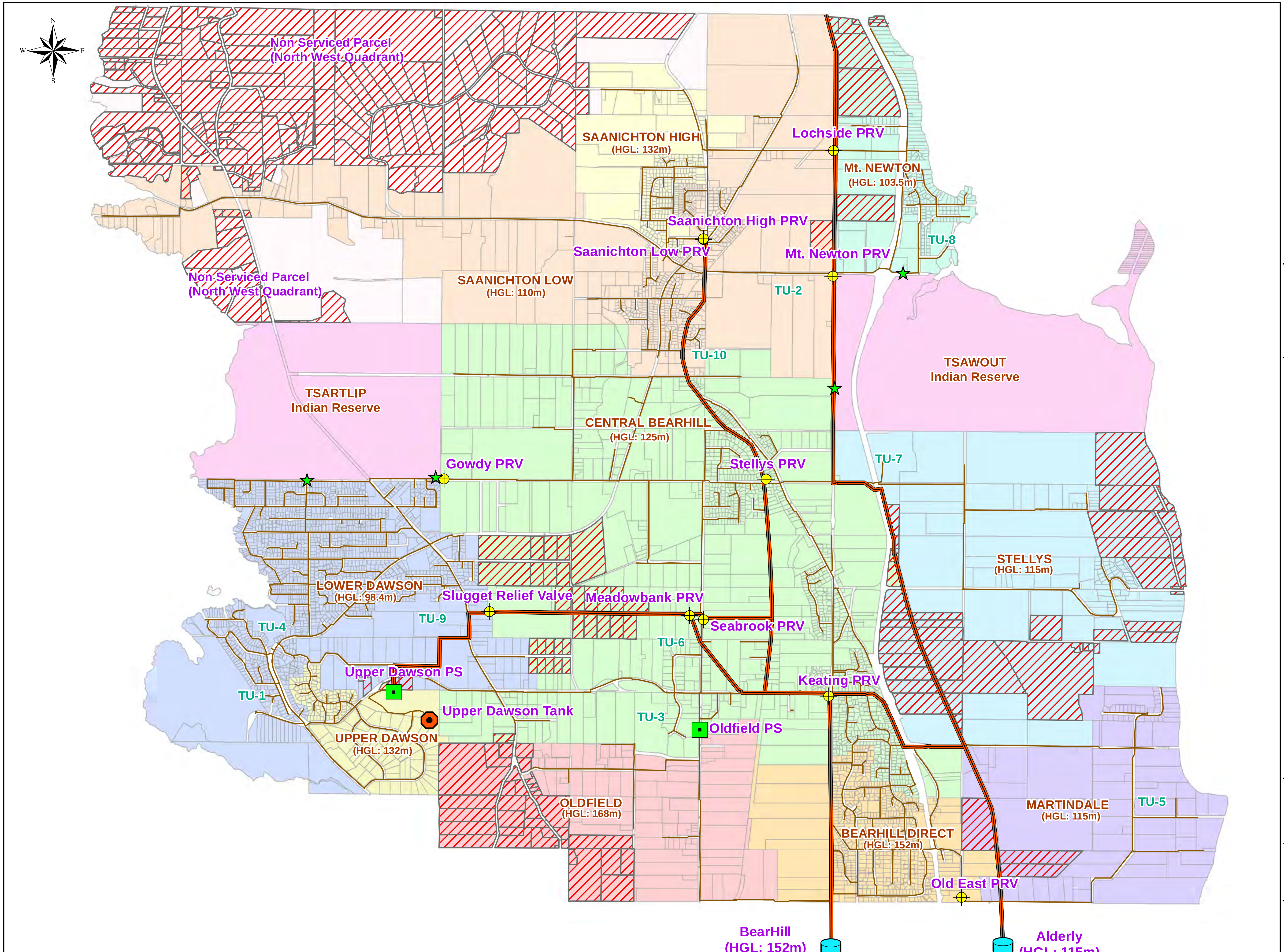
1. Options A and C, including investigating land acquisition and siting, should be considered when performing preliminary design to service PZ-190m;
2. Any decisions related to Senanus Drive Watermain Extension project should consider the scenarios presented in this report (i.e., KWL 2010 report) as they would impact any potential overall servicing for the NWQ;
3. Option 3 is the preferred option for servicing NWQ in its entirety. Option 1B and 2 are also feasible and may be preferred when considering the selected scenario for the Senanus Drive Watermain Extension project and the schedule for upgrades to the Brentwood system.

Following assessments of the existing system based on the latest information provided in this study, AECOM concurred that Option A and C were the recommended servicing strategies to serve PZ-190 m. For servicing PZ-110 m and PZ-180 m, there were two important factors considered:

- The Senanus Drive Watermain Extension project. For this project, it was decided to build a fire pump on Tomlinson Rd, therefore it is currently an existing entity in the District.

- Creation of Upper Brentwood zone. As has been discussed in ***Section 5.4.1***, the AECOM results using the full system model indicate there was no significant benefit of creating a separate Upper Brentwood zone with an HGL of 112 m or even with an HGL of 125 m (treated as the same zone as Central Bear Hill).

Based on these reasons, Option 1B would be the recommended servicing option to serve PZ-110 m and PZ-180 m. The final recommendations to serve NWQ are presented in ***Figure 7.8***.



District of Central Saanich

Water Distribution Master Plan

Non Serviced Areas

Legend

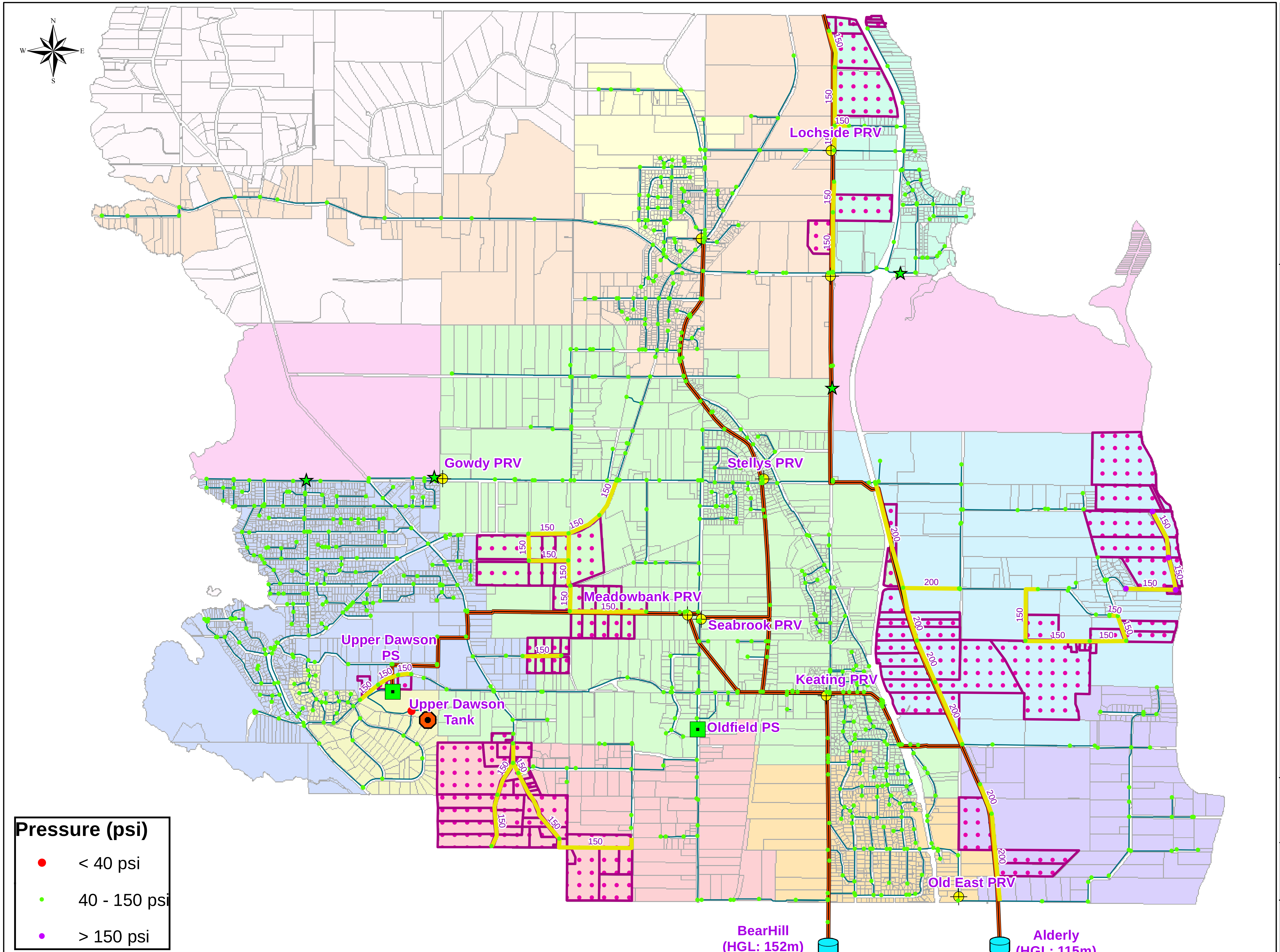
- CRD Supply Point
- Control Valve
- Pump Station
- Tank
- Existing Watermain
- CRD Transmission Main
- Non Serviced Parcel
- First Nations Supply Point

Figure No: Figure 7.1

Project No: 60240374

Date: December 2012

AECOM



District of Central Saanich

Water Distribution Master Plan

Existing System Including Non Serviced Areas (No North West Quadrant)

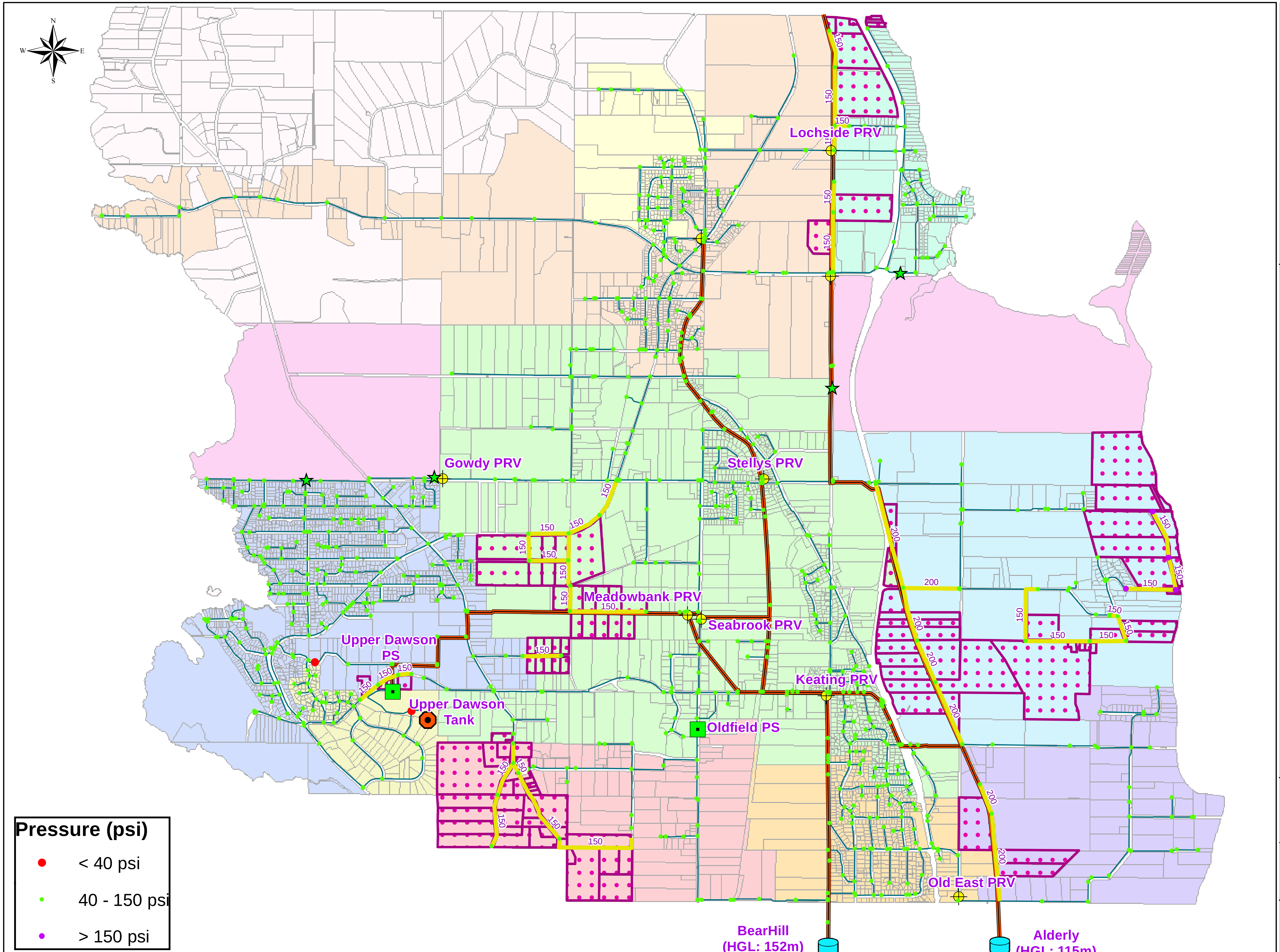
Average Day Demand Minimum Pressure Conditions

Legend

- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- Proposed Pipes (Non Serviced Areas)
- Non Serviced Areas (No North West Quadrant)
- First Nations Supply Point

Figure No: Figure 7.2	
Project No: 60240374	Date: December 2012

AECOM



District of Central Saanich

Water Distribution Master Plan

Existing System Including Non Serviced Areas (No North West Quadrant)

Maximum Day Demand Minimum Pressure Conditions

Legend

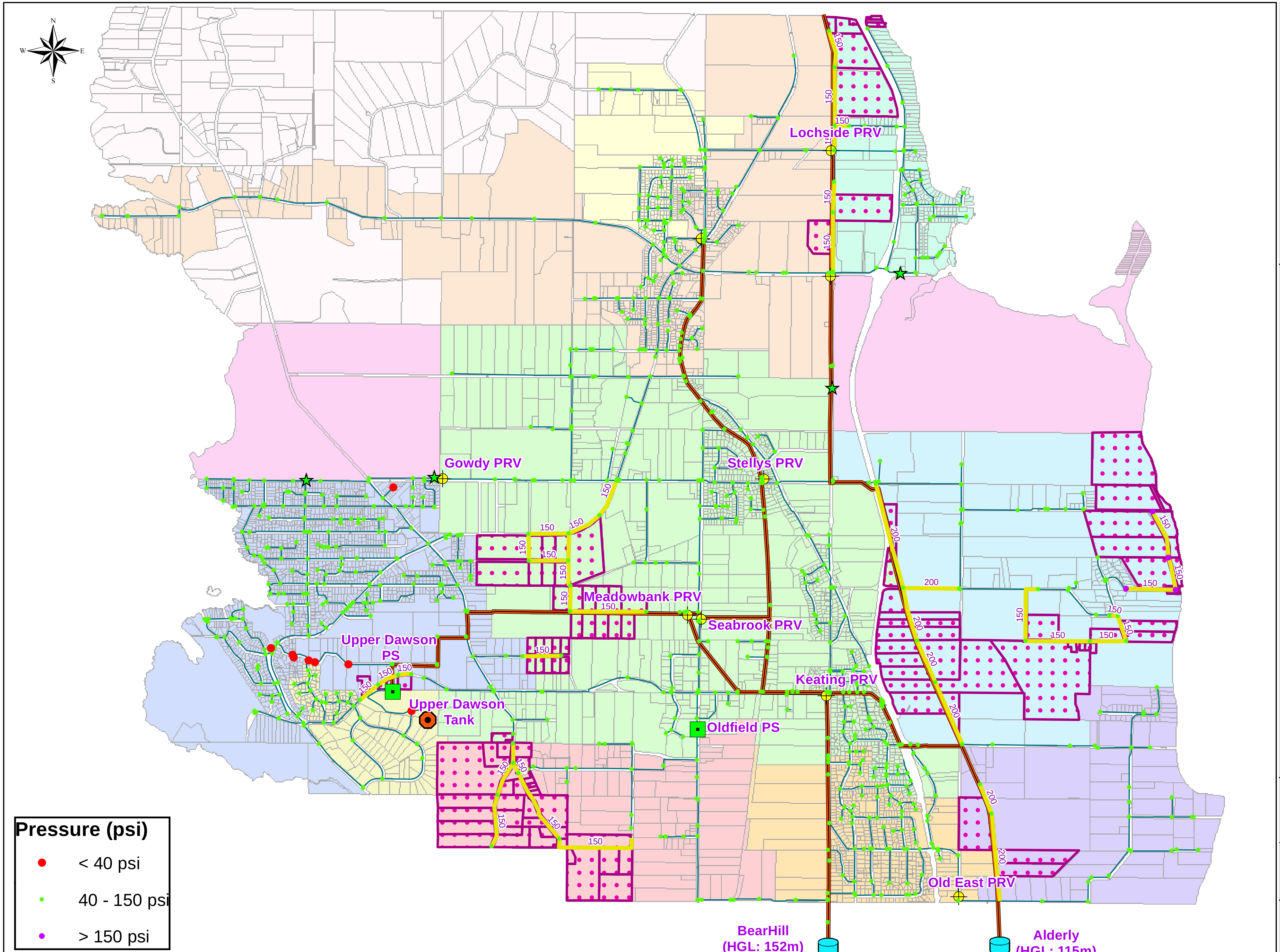
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- Proposed Pipes (Non Serviced Areas)
- Non Serviced Areas (No North West Quadrant)
- First Nations Supply Point

Figure No: Figure 7.3

Project No: 60240374

Date: December 2012

AECOM



District of Central Saanich

Water Distribution Master Plan

Existing System Including Non Serviced Areas (No North West Quadrant)

Peak Hour Demand Minimum Pressure Conditions

Legend

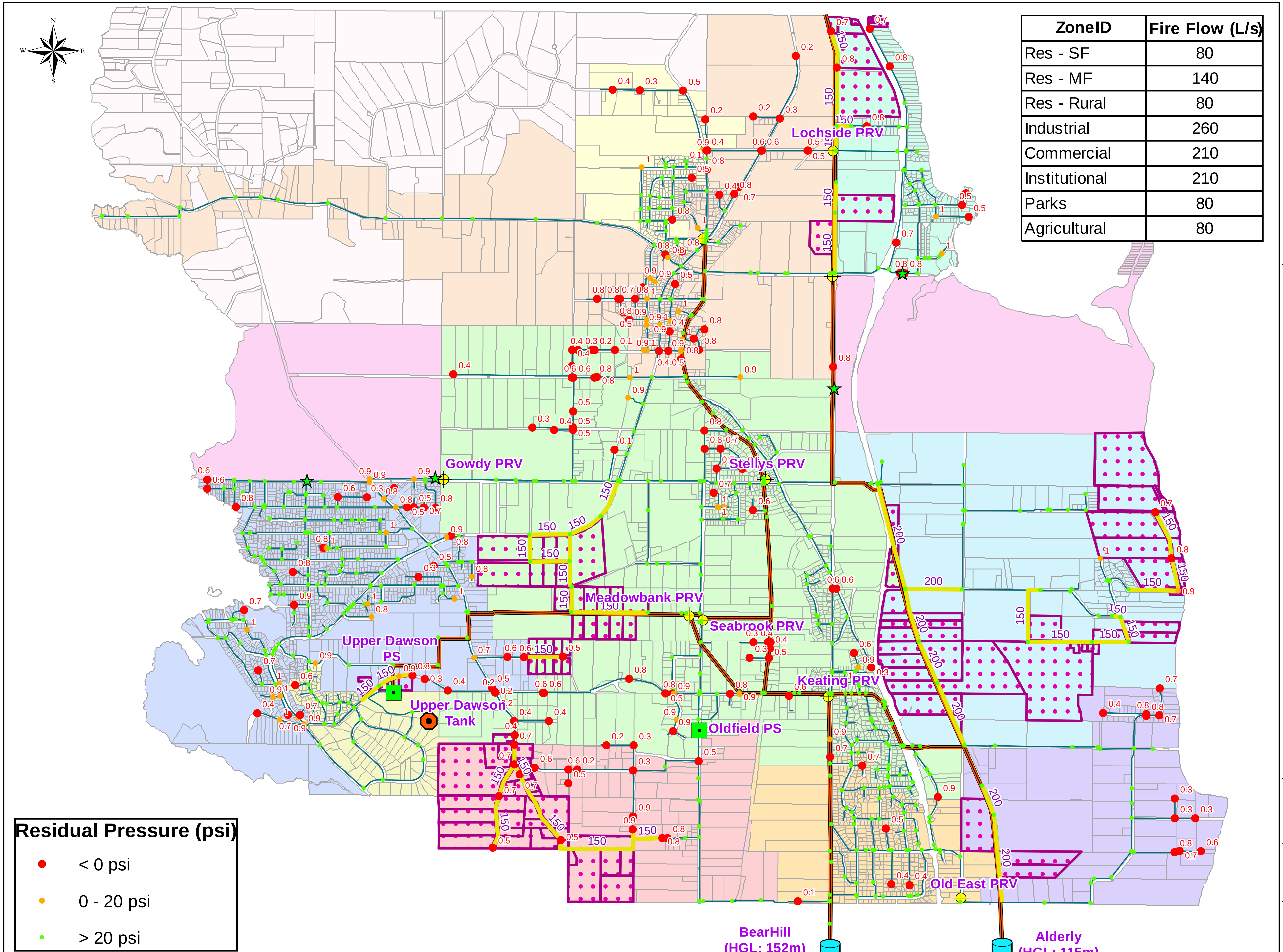
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- Proposed Pipes (Non Serviced Areas)
- Non Serviced Areas (No North West Quadrant)
- First Nations Supply Point

Figure No: Figure 7.4

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

LAND OF PLENTY

District of Central Saanich

Water Distribution Master Plan

Existing System Including Non Serviced Areas (No North West Quadrant)

MDD+Fire Residual Pressure

Legend

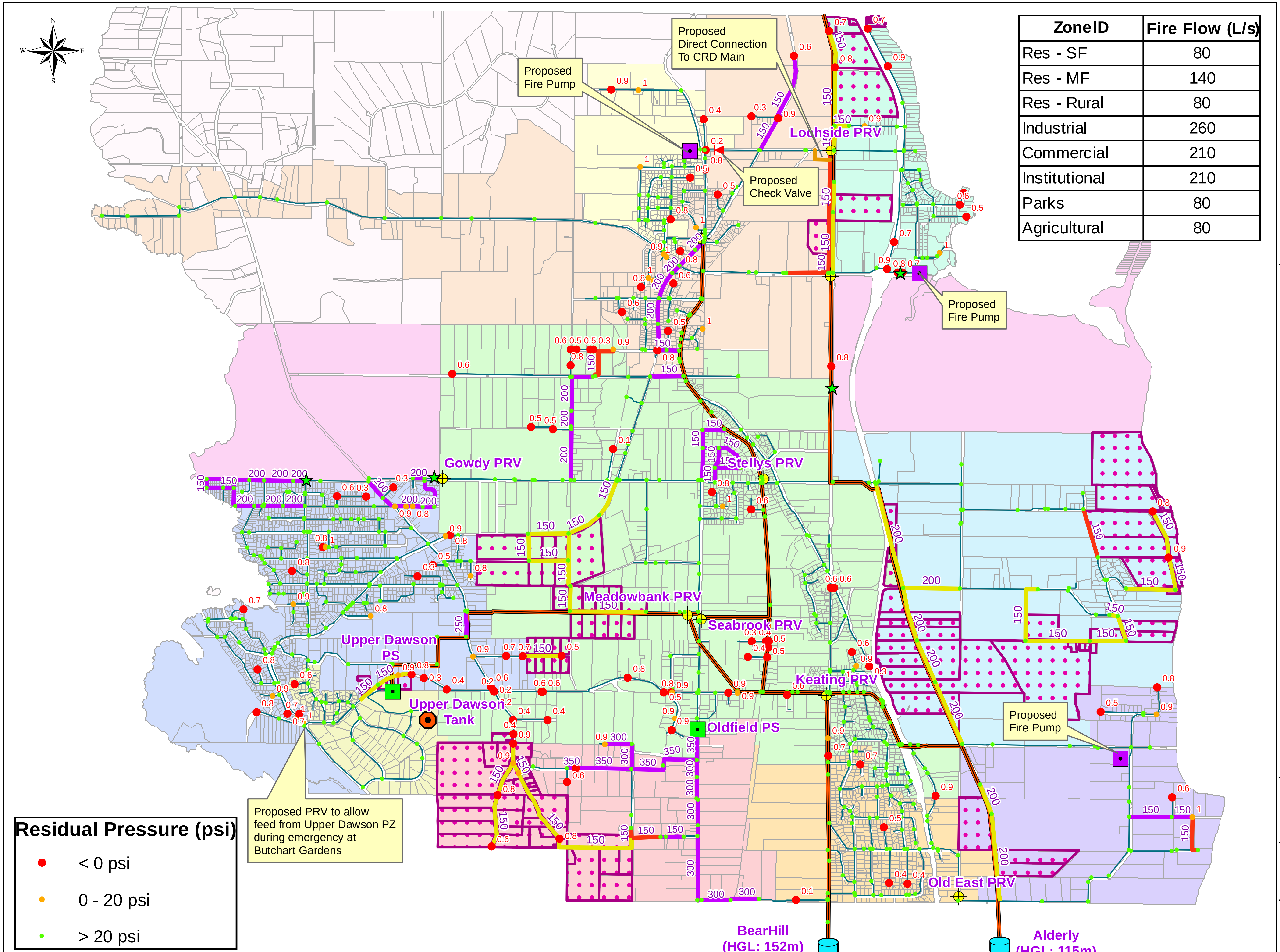
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Existing Watermain
- Proposed Pipes (Non Serviced Areas)
- Non Serviced Areas (No North West Quadrant)
- First Nations Supply Point
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No: Figure 7.5

Project No: 60240374

Date: December 2012

AECOM



ZoneID	Fire Flow (L/s)
Res - SF	80
Res - MF	140
Res - Rural	80
Industrial	260
Commercial	210
Institutional	210
Parks	80
Agricultural	80

District of Central Saanich

Water Distribution Master Plan

Existing System With Upgrades Including Non Serviced Areas (No North West Quadrant)

MDD+Fire Residual Pressure

Legend

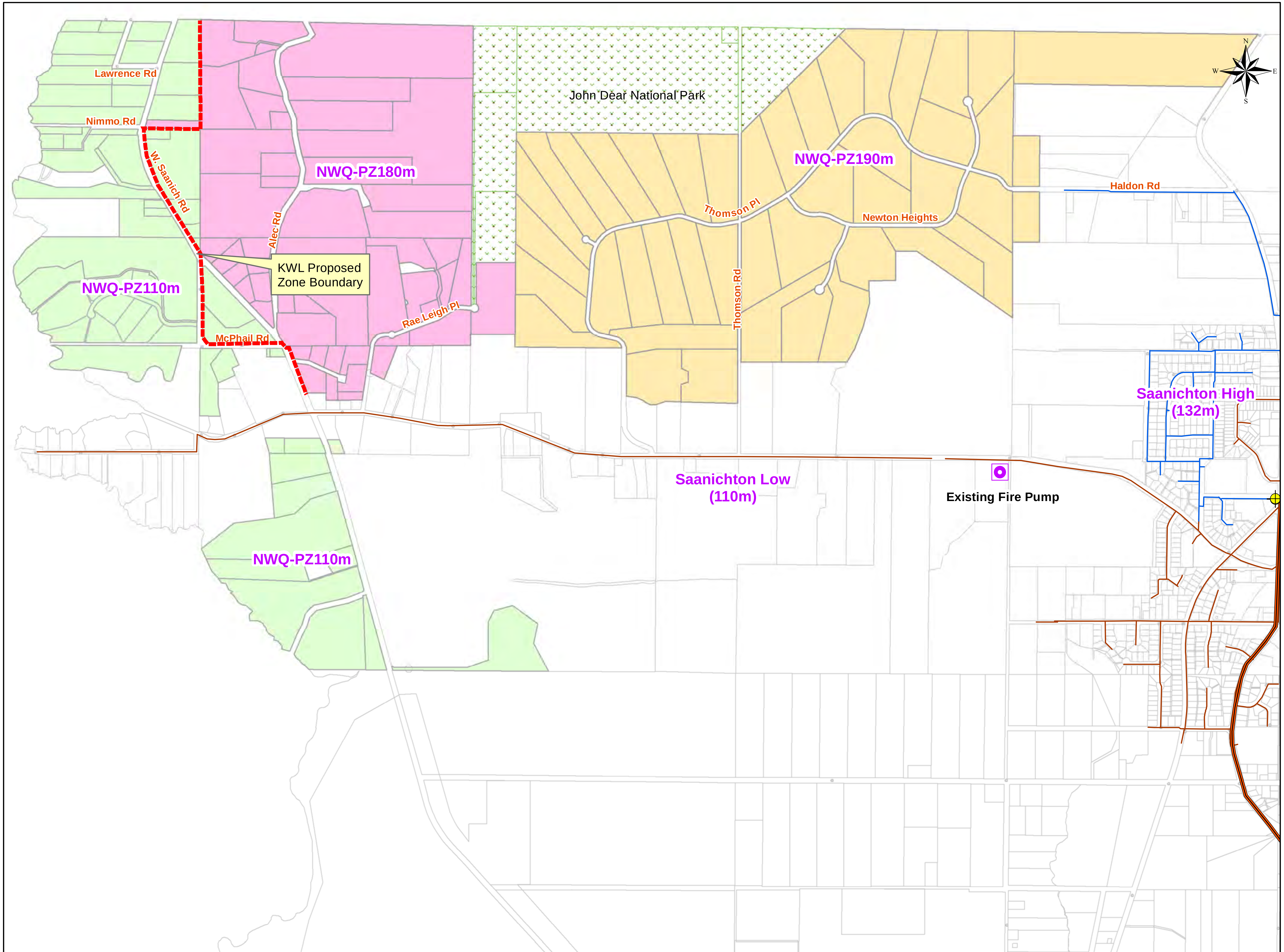
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- Proposed Pipe Upgrade
- Proposed New Pipe
- CRD Transmission Main
- Existing Watermain
- Proposed Pipes (Non Serviced Areas)
- Non Serviced Areas (No North West Quadrant)
- First Nations Supply Point
- 0.7 Available Flow at Node/ Required Fire Flow

Figure No: Figure 7.6

Project No: 60240374

Date: December 2012

AECOM



LAND OF PLENTY

District of Central Saanich

Water Distribution Master Plan

Non Serviced Area (North West Quadrant)

Proposed Pressure Zone Boundary

Legend

Existing Watermain

- SaanichtonHigh
- SaanichtonLow
- Non Serviced Area (110m)
- Non Serviced Area (180m)
- Non Serviced Area (190m)

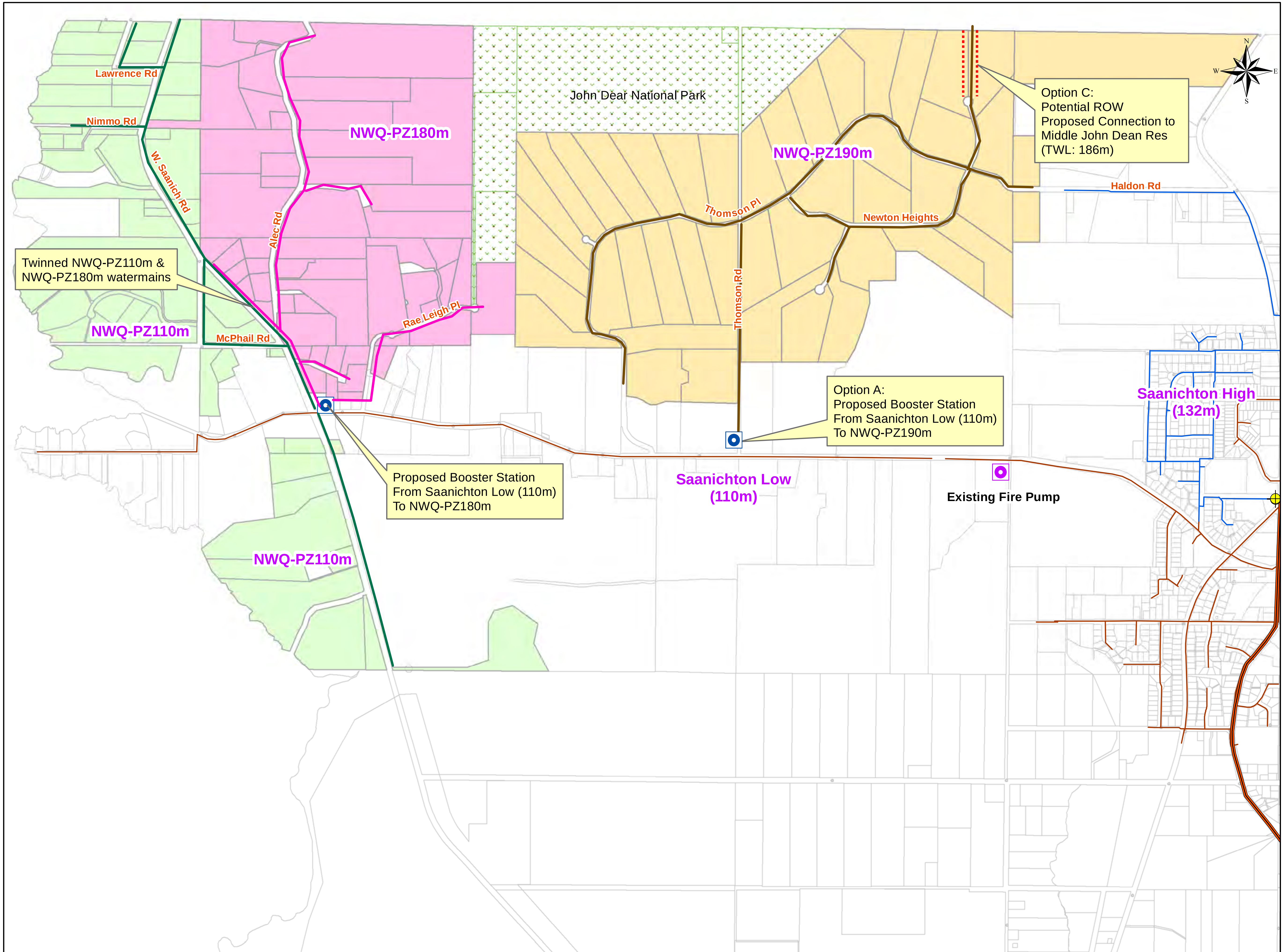
Figure No:

Figure 7.7

Project No: 60240374

Date: December 2012

AECOM



District of Central Saanich

Water Distribution Master Plan

Non Serviced Area (North West Quadrant)

Recommended Servicing Options

Legend

Existing Watermain

- SaanichtonHigh
- SaanichtonLow
- Non Serviced Area (110m)
- Non Serviced Area (180m)
- Non Serviced Area (190m)

Figure No: Figure 7.8

Project No: 60240374

Date: December 2012

AECOM

8. Condition Assessment

There is growing need by cities and municipalities to find better ways to prioritize their infrastructure asset maintenance, rehabilitation and replacement projects, especially in an environment where there is competition for limited financial and other resources. As this infrastructure ages, it becomes increasingly more challenging to assign limited capital expenditures to the repair, renewal or replacement of the assets. This section describes how AECOM developed the excel-based condition assessment tool which performed criticality assessment for each asset. This tool can be used in day-to-day decision making and capital improvement program prioritization for the watermains in the system. The intent of this tool is to answer questions such as "Which asset will have the greatest impact if a failure were to occur?" in order to focus resources and effort on these assets before they fail.

The criticality model developed in this study exists as an excel-based tool. Over the long term, this tool should be integrated with the District's GIS, work prioritization/management process and/or other related software tools as much as possible.

8.1 Risk and Criticality Model (RCM) Development

Effective asset management uses risk exposure and the concept of infrastructure "criticality" in evaluating the effectiveness of competing alternatives. According to the "risk equation", the estimated Total Risk posed by a given asset is based on the Consequences (CoF) and Probability (PoF) of its failure:

$$\text{Total Risk} = \text{PoF} * \text{CoF}$$

Probability of Failure (PoF) reflects the relative "likelihood" of a given asset to fail to provide the required level of service. It should be cautioned that PoF score does not represent the true probability that the asset will fail, but a general indication of its likelihood given the conditions under which it operates.

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

There is currently no standard method for the creation of a Risk and Criticality Model (RCM). It remains a subjective process in which District staff are intimately involved with the selection and ranking of criticality parameters that they felt affected asset management, rehabilitation and replacement within the District. The proposed criticality model evaluates the relative importance of assets based on four (4) Criticality Indices:

- ***Economic:*** Influence of the asset's failure on monetary resources.
- ***Operational:*** Influence of the asset's failure on operational ability.
- ***Social:*** Influence of the asset's failure on society.
- ***Environmental:*** Influence of the asset's failure on the environment.

Additionally, the Probability of Failure (PoF) is mainly evaluated based on the condition of the asset.

Each index (economic, operational, social, environmental and condition) is comprised of several factors that are in turn evaluating the data available. The following sections discuss each of the factors proposed under each index along with its relative score and weighting factors. The overall proposed model hierarchy is shown in ***Figure 8.1.***

8.1.1 Economic Index (CoF)

8.1.1.1 Pipe Size

The District's watermains have diameters ranging from 50 mm-300 mm. The scores developed in the "Pipe Size" table reflect the increasing impacts of watermain breaks based on their sizes. Larger mains would tend to have more significant impact when they break. From the economic point of view larger mains will cost more to replace, both in terms of material and construction costs, as they also tend to be located in larger roads. The score distribution was roughly established by examining the distribution of pipe sizes within the District (excluding CRD's mains).

8.1.1.2 Pipe Material

The scores developed in the "Pipe Material" table reflect the severity of watermain break mechanisms based on its material type. Permastand (Perma) and PVC were given the highest score because when these types of materials break, they tend to break catastrophically. CCP is more resilient to damage from outside forces (such as construction) but a small defect can also lead to loss of complete length of pipe. AC is more prone to damage (or large damage) than DI which tends to fail through small leaks than can often be readily repaired.

8.1.1.3 Adjacent LandUse

The typical land uses (zoning) available within the District are listed in the "Adjacent Landuse" table. The scores in this table reflect the level of disturbance given by a watermain break to any type of landuse. Higher scores are given to the type of landuse where more people and/or activities would be impacted economically with the loss or limited supply of water and the subsequent repair works that need to be done.

8.1.2 Operational Index (CoF)

8.1.2.1 Percent Available Fire Flow

The values listed in the table "% Available Fire Flow" represent the percent of Available Fire Flow at either end of the pipes as it compared to the Required Fire Flow at that location based on the adjacent landuse (zoning) type. This value is obtained from the model simulation results under Maximum Day Demand plus Fire (MDD+Fire) conditions. The pipes with higher percentage of Available Fire Flow are given lower score as they have more flow availability for firefighting purposes. The pipes with lower percentage of Available Fire Flow are given increasingly higher scores to represent the increasing firefighting operational difficulties in the event of them breaking.

8.1.3 Social Index (CoF)

8.1.3.1 Flow Rate

The flow rate listed in the table "Flow Rate" is a measure of the quantity of water conveyed by a watermain during Average Day Demand (ADD) conditions in L/s, i.e., flow rates during normal operating conditions. This information is obtained from the hydraulic model results. Pipes with lower flow rates are given lower score as it is assumed that these pipes are serving a lesser number of properties, therefore in the event of watermain break the impact would be minimal and/or localized. Pipes with larger flow rates are given increasingly higher scores to represent the increasing impact of their breaks to the surrounding areas.

8.1.4 Environmental Index (CoF)

In event of a watermain break, it is expected that there would be some consequences to the surrounding natural environment. Typically the two main factors contributing to this Environment Index are: Stream Classification and Flow Rate.

8.1.4.1 *Stream Classification*

This classification would identify pipe proximity to different classes of fish-bearing watercourses. The scoring system suggested in the table "Stream Class." has been established under the basis that pipes with less distance to a fish-bearing watercourse will have a greater chance of detrimentally impacting the watercourse than pipes farther away. To date there is not sufficient information contained within the databases to incorporate this factor in the analysis but it should be integrated as more information is available.

8.1.4.2 *Flow Rate*

The flow rate listed in the table "Flow Rate" is a measure of the quantity of water conveyed by a watermain during Average Day Demand (ADD) conditions in L/s, i.e., flow rates during normal operating conditions. This information is obtained from the hydraulic model results. Pipes with lower flow rates are given lower score as it is assumed that the breaks of these pipes would contribute less volume to the environment and, therefore, cause less environmental damage when compared to the pipes conveying larger flow rate under normal operating conditions.

8.1.5 Conditions Index (PoF)

8.1.5.1 *Age vs. ESL*

The values listed in the table "Age vs. ESL" provides indication of the lifecycle stage of an asset. Older assets can generally be assumed to be in 'worse' conditions than newer assets of the same type. Scores listed in this table are established by assigning greater scores to older assets according to a scale roughly analogous to the expected deterioration curve of the assets. To quantify variation in deterioration rates in pipelines, the Weibull Probability Density Function (PDF) has previously proven useful[1,2]. A Weibull variable is one which has a cumulative distribution function $F(s_R)$ written as

$$F(s_R) = 1 - exp\{-(s_R/\alpha)^\eta\}$$

$F(s_R)$ is the cumulative probability that the pipeline has failed at a particular year value s_R. An empirical estimate of $F(s_R)$ can be obtained from the degradation rate data. α is the scale parameter of the Weibull probability distribution function (PDF) and η is the shape parameter.

The scale parameter is related to the expected life of the pipeline, and the shape parameter is related to the rate of deterioration. If we substitute years with percent expected service life, altering the scale parameter will not alter the form of the curve. Based on published data for Weibull PDFs of pipeline deterioration the shape factor tends to fall between 7 and 8, the cumulative distribution function can then be plotted as in ***Figure 8.2***.

It can be seen that at 100% expected service life, only 60% of the population is expected to fail. This makes sense in that although the term normally used in "Expected Service Life (ESL)" it is also true that many pipes last well past their ESL. In order to score the influence of likelihood of failure arising from asset age, the percent expected service life (%ESL) can be used to provide a weighted score as per ***Table 8.1***.

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[1] P. Davis, et al. Long-Term Performance Prediction for PE Pipes, AwwaRF, 2007
[2] S. Burn, et al. Long-Term Performance Prediction for PVC Pipes, AwwaRF, 2005

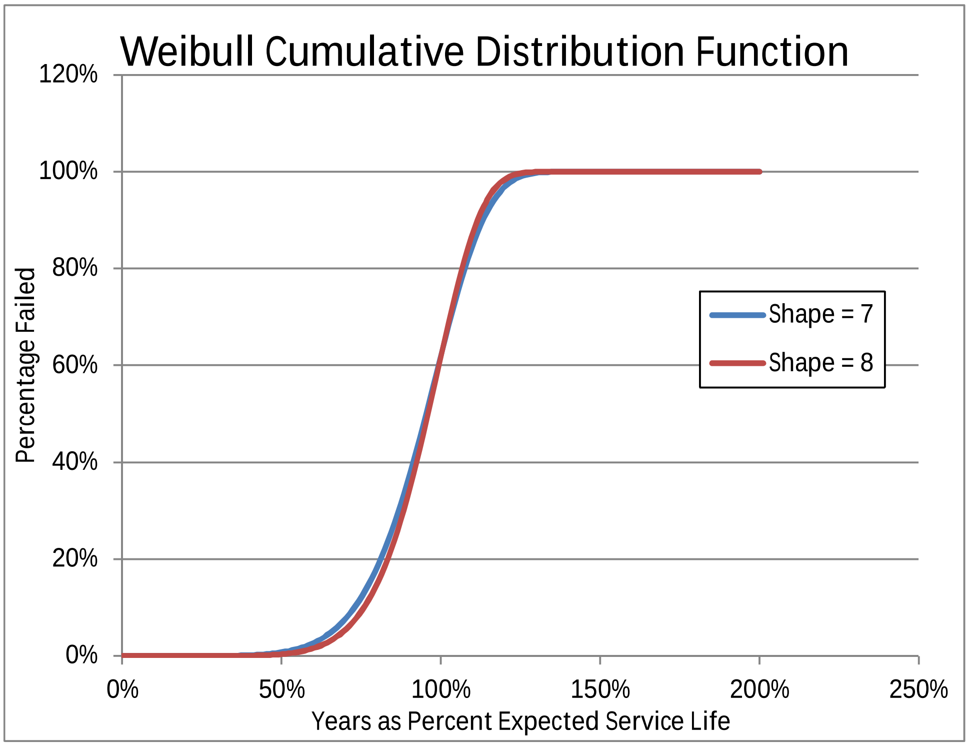


Figure 8.2 – Weibull Cumulative Distribution Function

Table 8.1 – Weighted Score for Age vs. ESL - Determination Likelihood of Failure

% Age vs. ESL	Score
<50%	0
50 – 60%	2
60 – 70%	6
70 – 80%	15
80 – 90%	35
90 – 100%	60
100 – 110%	85
110 – 120%	98
120 – 125%	100

The ESL by pipe material is summarized in ***Table 8.2***.

Table 8.2 – Expected Service Life by Pipe Material

Pipe Material	Expected Service Life (ESL)
Asbestos Cement	60
Ductile Iron	75
Permastrand	75
PVC	100
CCP	50

8.1.5.2 Pressure

The pressure listed in the table “Pressure” is a measure of the maximum pressure conditions at either end of the pipes during Average Day Demand (ADD) conditions in psi, i.e., pressure on the nodes during normal operating conditions. This information is obtained from the hydraulic model results. The pipes with lower pressure during normal operating condition are given lower scores as they would be expected to maintain their general conditions longer due to less stress being imposed on a daily basis. The pipes with higher pressure are given increasingly higher scores to represent higher stress being imposed on them which would lead to higher rate of condition deterioration or possible failure.

8.1.5.3 Break History

This table identifies the number of breaks experienced on a pipe segment, as a measure of the overall condition of the pipe. The theoretical basis of the scoring would be to assign a higher score to pipes with greater numbers of breaks. To date there is no sufficient information contained within the databases to incorporate this factor in the analysis but it should be integrated as more information is available.

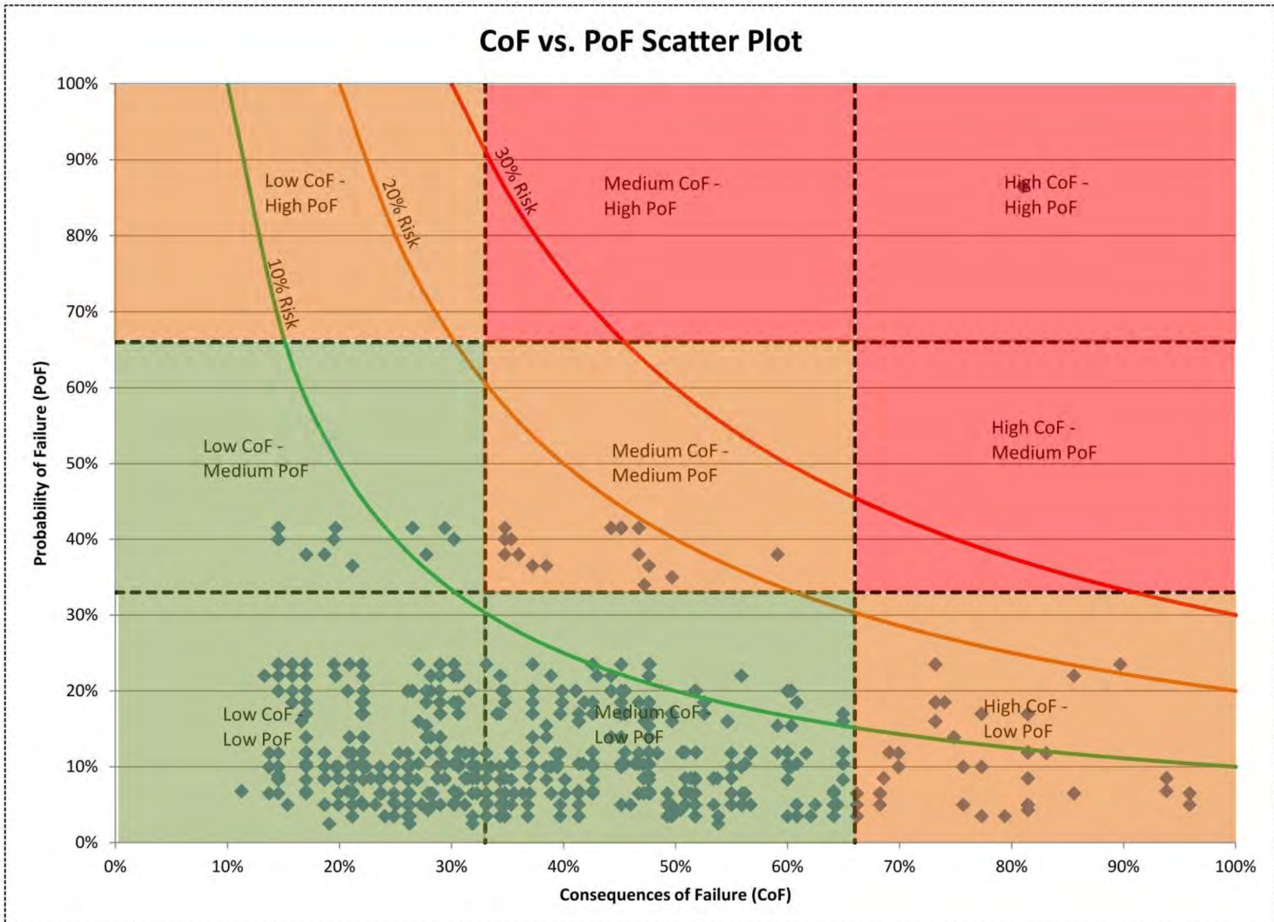
8.2 Summary of Results

Based on the approach and weighted factors established, the Consequences of Failure (CoF), Probability of Failure (PoF) and Risk Scores were calculated for each pipe within the system represented in the model, except for:

- pipes in the model representing CRD mains,
- pipes in the model representing connectivity within pump and/or PRV stations (i.e., the modeled pipes within pump and/or PRV stations are only the simplified version of the actual pipes connectivity within these facilities).

To show the results distribution in terms of CoF and PoF a scatter plot was developed as shown in ***Figure 8.3***.

Figure 8.3 – Consequences vs. Probability Scatter Plot



Within the scatter plot, colour combinations have been applied to visually separate the pipes into the following combinations of CoF and PoF:

- Highest combination of CoF and PoF includes pipes with:
  - High CoF and High PoF
  - High CoF and Medium PoF
  - Medium CoF and High PoF
- Medium combination of CoF and PoF includes pipes with:
  - High CoF and Low PoF
  - Medium CoF and Medium PoF
  - Low CoF and High PoF
- Lowest Combination of CoF and PoF includes pipes with:
  - Medium CoF and Low PoF
  - Low CoF and medium PoF
  - Low CoF and Low PoF

Figure 8.4 shows the locations of all pipes colour-coded into the Highest, Medium, and Lowest Combinations of CoF and PoF. It also includes lines denoting calculated Risk, showing 10%, 20% and 30% Risk scores. For simplicity and because there are few pipes with high Risk scores, lines showing Risk values greater than 30% have been omitted.

As can be seen, the vast majority of the pipes within the District have low to medium Consequences of Failure (CoF) with low to medium Probability of Failure (PoF). In addition, all but three pipe segments fall below the 20% Risk curve.

This is a positive outcome, since even pipes with Risk scores in the order of 20 -30% would not normally be considered to be priorities for replacement.

Figure 8.5 shows the locations of all pipes colour-coded into five levels of Total Risk scores, further breaking down the ranges of 0 -10%, and 10-20%. As noted earlier Total Risk for each pipe in the system is calculated as the product of Probability of Failure (PoF) multiplied by Consequences of Failure (CoF).

From these figures, it can be observed that there is a relatively low number of watermains with higher combinations of CoF, PoF and Total Risk scores. The three most critical locations with Risk scores greater than 20% are as follows:

1. Central Saanich Road crossing, South of Ridgedown Place.
2. Oldfield Road South of the Oldfield Pump Station.
3. Keating Cross Road/Veyaness Road

Of the above noted locations, it should be noted that Location 1 and Location 3 are both short, isolated pipe segments and could possibly be data anomalies.

Location 1 consists of a 5.09 m segment of 300 mm diameter CCP pipe with a risk score of 70%. This is the only record of CPP pipe in the criticality model and the high risk is attributed to high pressure and the fact that the 53 year old pipe has passed the 50 year ESL of CPP pipe. Because CPP pipe is not normally made in small diameters it is possible that this pipe has erroneous material information – correcting that information would change the pipe's PoF and total Risk scores. It is recommended that the District of Central Saanich look into additional record information before proceeding with any remedial works in this location.

Location 2 consists of a 231.92 m segment of 150 mm AC pipe with a risk score of 21%. This risk is still relatively low, however, the pipe is geographically located adjacent to an area recommended for upgrading for hydraulic reasons to improve available fireflow in the Oldfield Pressure Zone area. As such, it is being recommended for replacement in conjunction with the other system improvements.

Location 3 consists of a 6.22 m segment of 150 mm diameter AC pipe that connects the 200 mm AC distribution watermain on Keating Cross Road to the 250 mm PVC CRD transmission main. The risk score for this pipe segment is 22% which, although one of the higher Risk scores, would not normally be targeted for improvement on Risk score alone. We would recommend that replacement of this pipe be deferred until there is a need to replace the adjacent pipe(s), unless it has historically been known as problematic to operations staff.

The criticality model suggests that there are a relatively low number of pipes in the District with a high *immediate* risk; however these results essentially represent a snapshot of current conditions. It is important to use this tool as a working model to monitor the system as time progresses. Since many of the pipes in the model are made of AC and were installed several decades ago, they will begin to approach the end of their ESLs, thus raising their PoF and calculated total Risk scores. We have determined that by forecasting just 5 and10 years into the future, it is evident that probability of failure (PoF) and total Risk significantly increases for many pipes in the system.

Updating the Risk and Criticality Model spreadsheet each year to reflect changes or upgrades implemented and re-running the Risk and Criticality model at a regular frequency (at a minimum, once per five years) will allow the District to maintain a moving snapshot of “current” replacement priorities.

The following section discusses the recommended total watermain rehabilitation program intended to combine those recommended improvements as a result of both:

- The hydraulic analyses related to the fireflow capacities
- The Risk and Criticality model analyses.

DISTRICT OF CENTRAL SAANICH
RISK AND CRITICALITY MODEL - WATER

Acronyms and Abbreviations:

AC:	Asbestos Cement
ESL:	Estimated Service Life
Res-SF:	Residential Single Family
Res-MF:	Residential Multi Family
Ministry:	Ministry of Transportation
Perma:	Permastrand
PVC:	Polyvinyl Chloride

Pipe Size (25%)

Value	Score
0 - 100	10
100 - 200	25
200 - 250	50
250 - 300	75
300+	100

Material (25%)

Value	Score
AC	50
Ductile Iron	10
Perma	100
PVC	100
CCP	75

Adjacent Land Use (50%)

Value	Score
Agricultural	10
Res-SF	25
Res-Rural	25
Res-MF	50
Institutional	75
Commercial	100
Industrial	100

Economic 33%

Flow Rate (ADD) (25%)

Value	Score
0 - 10	10
10 - 25	25
25 - 50	50
50+	100

Pressure (ADD) (25%)

Value	Score
0 - 20	10
20 - 40	25
40 - 75	50
75 - 100	75
100 - 150	100
> 150	100

% Available Fire Flow (50%)

Value	Score
100+	10
80 - 100	25
50 - 80	50
25 - 50	75
10 - 25	75
0 - 10	100

Operational 34%

Adjacent Land Use (50%)

Value	Score
Agricultural	10
Res-SF	25
Res-Rural	25
Res-MF	50
Institutional	75
Commercial	100
Industrial	100

Flow Rate (ADD) (50%)

Value	Score
0 - 10	10
10 - 25	25
25 - 50	50
50+	100

Social 33%

Stream Classification:

Class A: Red, Orange, Magenta
Class B.: Yellow
Class C: Green

Stream Class. (Insufficient Data – TBD)

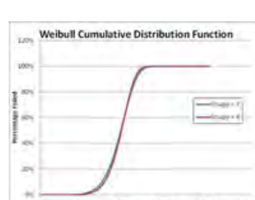
Dist., Class	Score
>15m	0
<15m, C	0
<15m, B	75
<15m, A	100

Flow Rate (ADD) (TBD)

Value	Score
0 - 10	10
10 - 25	25
25 - 50	50
50+	100

Environmental 0%

Consequence of Failure (CoF)



Age vs. ESL (50%)

Value	Score
< 50%	0
50% - 60%	2
60% - 70%	6
70% - 80%	15
80% - 90%	35
90% - 100%	60
100% - 110%	85
110% - 120%	98
120% - 125%	100

Pressure (ADD) (50%)

Value	Score
0 - 20	10
20 - 40	25
40 - 75	50
75 - 100	75
100 - 150	100
> 150	100

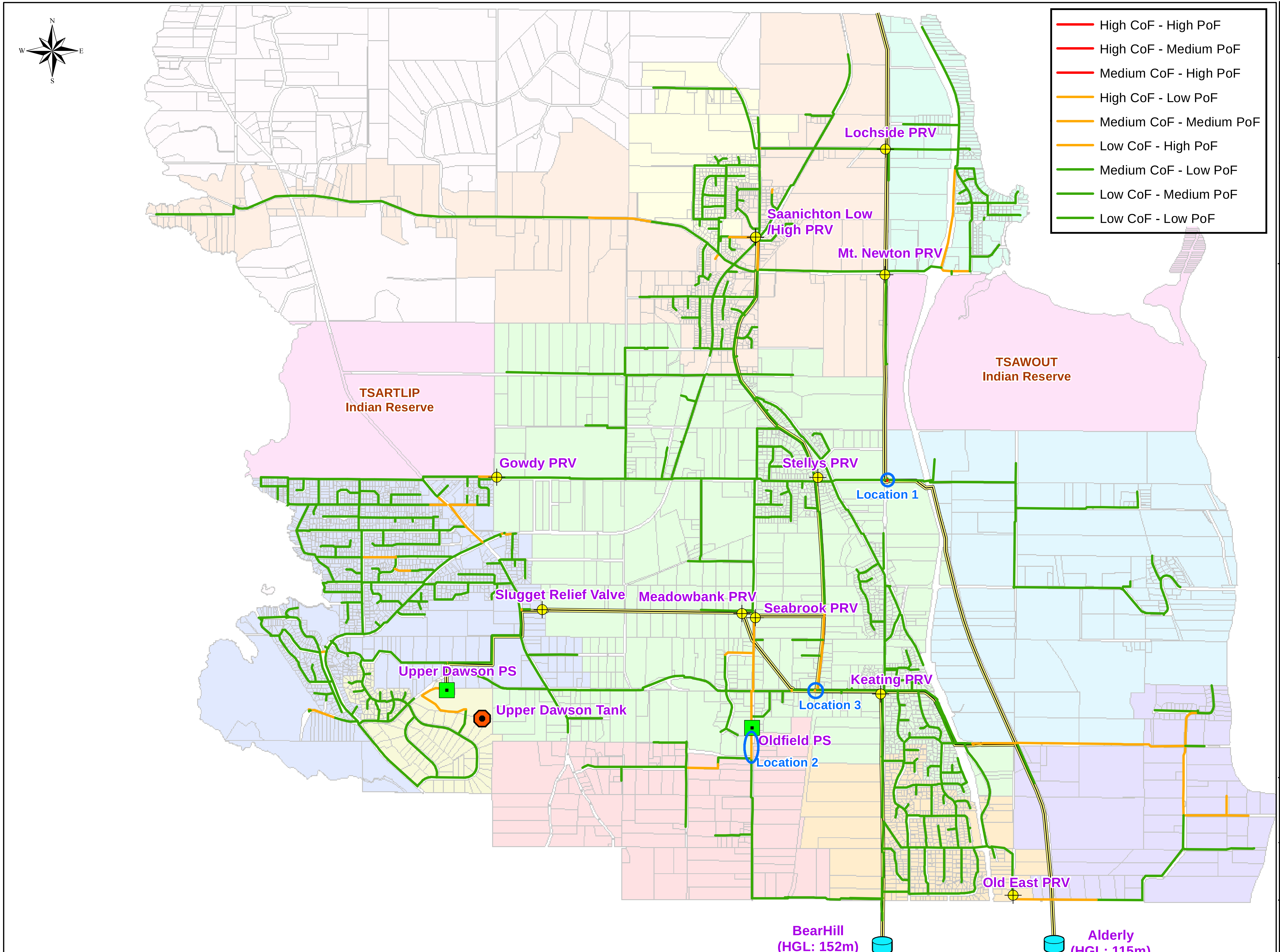
Break History (Insufficient Data - 0%)

Value	Score
Yes	100
No	0

Condition 100%

Probability of Failure (PoF)

RISK



District of Central Saanich

Water Distribution Master Plan

Existing Watermains Consequences of Failure (CoF) Vs. Probability of Failure (PoF)

Legend

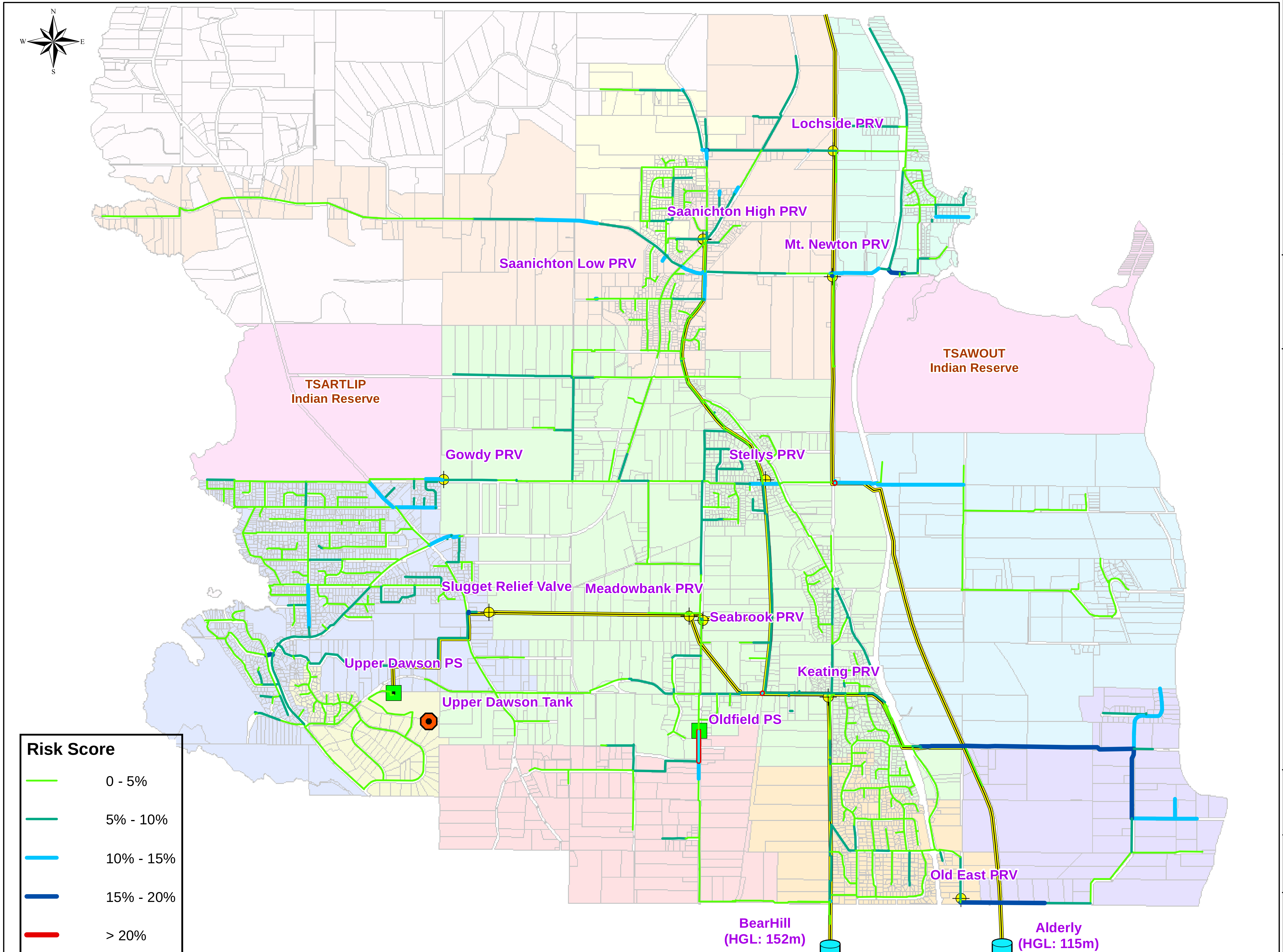
- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- High CoF/PoF/Risk Score

Figure No: Figure 8.4

Project No: 60240374

Date: March 2013

AECOM



District of Central Saanich

Water Distribution Master Plan

Existing Watermains Risk Scores

Legend

- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main

Figure No:

Figure 8.5

Project No:	Date:
60240374	March 2013

AECOM

9. Replacement Program Recommendations

This study has investigated the need for water main replacements or upgrades based upon two separate series of criteria.

Hydraulic assessments were performed using the newly completed and calibrated hydraulic model to assess the capacity availability of the existing distribution system in meeting the demand of the system with adequate pressures during normal operation as well as during fire flow conditions. Based on the hydraulic analyses conducted, there is a list of upgrades recommended to improve the system's ability to deliver water to the customers principally driven by the maximum day demand + fire conditions. The results of these analyses are summarized in ***Section 5.5*** of this report.

AECOM also conducted condition assessments of the existing watermains in the system using a Risk and Criticality Model spreadsheet approach. Under this task, AECOM, together with the District's staff, developed the key factors and their associated weighting scores that would influence the Consequences of Failure (CoF) as well as Probability of Failure (PoF) of any given pipe in the system. The factors included in these analyses were:

- pipe material,
- pipe diameter,
- pipe age,
- normal operating flow rate,
- available fire flow,
- normal operating pressure, and
- adjacent land use.

The results of these analyses are summarized in ***Section 8.2*** of this report where the pipes in the system with relatively higher combinations of CoF, PoF or total Risk scores are highlighted. As noted, the analysis indicates that the Central Saanich water system is in generally good condition relative to possible failures and overall risk.

9.1 Current, Shorter Term Priority Program

In order to develop watermain replacement program prioritization for the District's distribution system, both the hydraulic assessment and the condition assessment need to be considered. While there are only a few pipes recommended for replacement due to the Risk and Criticality model evaluation, we have developed the following criteria, and ordering of criteria, to arrive at a prioritized series of replacement "projects" that combines both sets of analyses and links replacements geographically to one another. In later reviews or updates to these analyses, this same approach can be used to re-prioritize replacement projects.

1. Pipe with high Total Risk score;
   The calculated Total Risk score for each pipe allowed all of the pipes within the system to be ranked, where pipes with higher Total Risk scores got lower rank (i.e., will be at the top of the replacement list). Under this 2012 – 13 study, the calculated total Risk scores are relatively low within the system, so that the large majority of priority upgrades are actually based on the hydraulic analysis. Replacing older pipes as part of the hydraulic improvements will reduce the PoF and Risk scores associated with that (new) pipe, which will also reduce the overall Risk scores for the total water system.

2. Proposed upgrades summarized under hydraulic assessments results;
   The hydraulic analysis resulted in a significant number of water main upgrades being recommended to improve the overall system performance. The majority of suggested replacements are based upon the hydraulic analysis. Any hydraulically triggered proposed upgrades located in the vicinity of the high Total Risk pipes will be considered for replacement as a priority, and at the same time. Within the various projects recommended for hydraulic improvements, the projects have been placed in order of greatest relative fireflow deficiency – that is, projects with the lowest percentage available fireflow were ranked first.

3. Adjacent or in between pipes with the same material type and age.
   Any pipes connected to or located in between the pipes to be replaced, with the same material type and age, will be considered for replacement at the same time as other pipes indicated and recommended for replacement due to hydraulic requirements or Risk and Criticality determinations.

Table 9.1 and ***Figure 9.1*** show the watermain replacement program that AECOM recommends based upon the above prioritization approach, and totals approximately $8,354,000 in capital costs.

We would further recommend that the projects indicated be implemented as a Priority over the next 10 years or so, subject to available funding (approximately $835,400 per year).

Following that period, numerous pipes will have their PoF and total Risk scores increase due to increasing age, bringing them closer to, or beyond their assigned ESL. These pipes with higher Risk scores, or combined PoF and CoF rankings, would then form the next Priority Replacement program.

We recommend that both the Hydraulic model and the Risk and Criticality model be updated regularly to reflect:

- Changes in population, demands and targeted level of service
- Pipe replacements
- New developments
- Revised opinions on the assignment of parameters, and relative weightings, for the Risk and Criticality model
- Additional information, such as watermain breaks, to be added as another guide to priority replacement decision making.

In this way, both models can remain current and can provide updated recommendations for Priority Replacement programs that reflect the conditions within Central Saanich at the time.

To keep information current and to guide evolving decision making, the data within the models should be updated yearly, if possible, and the models should be re-evaluated or re-run on a minimum frequency of once every five years.

9.2 Longer Term Priority Program(s)

As noted, as existing pipes to continue to age they will begin to approach or exceed their ESLs. With all other parameters remaining unchanged, increasing age will result in higher Probability of Failure (PoF) and calculated Total Risk values being determined for each pipe. An analysis has been performed, using the Risk and Criticality model, to essentially age the pipes within the system, taking into account the pipe replacements that would be expected to be performed as part of the shorter term Priority Replacement program.

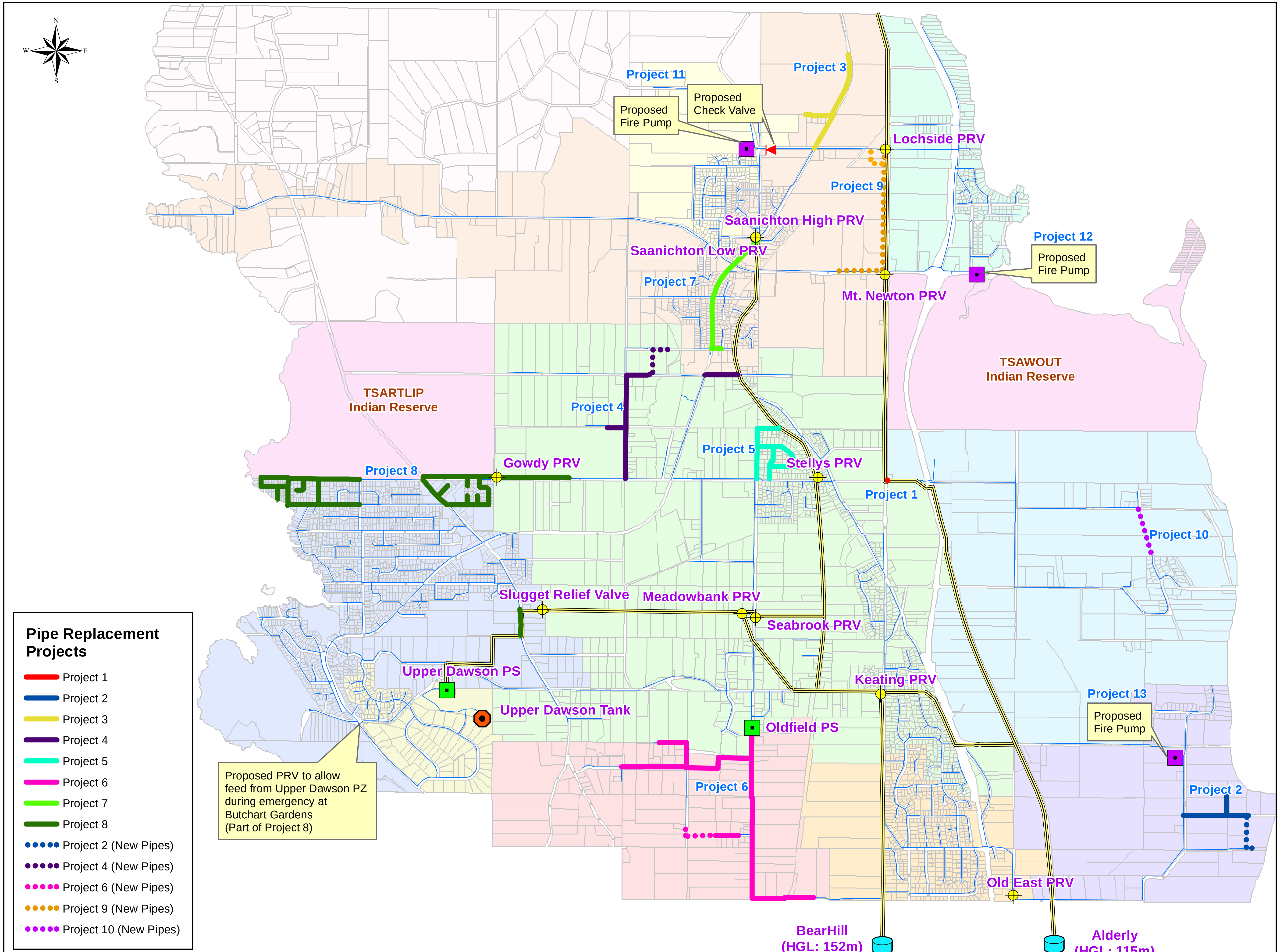
The analysis shows that additional pipe replacements can be expected to be required beyond the next 10 years due to higher PoFs and risk. The model shows that during the period between 10 and 25 years, when the majority of AC pipe will have reached its ESL, the predicted cost for water main replacement will vary between approximately $500,000 and $1,000,000 per year.

While these conclusions, and budgets, should be revisited and refined as more information is acquired and updated, we recommend that Central Saanich tentatively establish an annual replacement budget of $750,000 for this period following the initial short-term Prioritized Replacement program.

Table 9.1 – Recommended Shorter Term Priority Program

Project #	Description	Diameter (mm)	Length (m)	Estimated Cost ($)
Project 1	Central Saanich Road crossing, South of Ridgedown Place.	300	5.09	$2,000
	Subtotal		*5.1*	$2,000
Project 2	Pipe upgrade on Campion Road	150	594.3	$193,000
	Pipe replacement on Spooner Way	100	138.1	$41,000
	New pipe connecting Campion Road and Livesay Street	150	299.8	$97,000
	Subtotal		*1,032.2*	$331,000
Project 3	Pipe upgrade on Wallace Drive	150	797.1	$259,000
	Pipe replacement on Straits View Road	100	211.8	$64,000
	Subtotal		*1,008.9*	$323,000
Project 4	Pipe upgrade on Tomlinson Road	200	798.3	$279,000
	Pipe segment replacement on White Road	150	144.3	$47,000
	Pipe segment upgrades on Hovey Road	150	426.0	$138,000
	New pipe connecting end of Hovey Road to dead end of Tomlinson Road	150	348.4	$113,000
	Subtotal		*1,717.0*	*577,000.0*
Project 5	Pipe upgrade on Seabrook Road	150	386.8	$126,000
	Pipe upgrade on White Road	150	172.4	$56,000
	Pipe upgrade on Tanlee Crescent	150	383.4	$125,000
	Pipe upgrade on Haidey Terrace	150	197.1	$64,000
	Pipe upgrade on Chatwell Drive	150	273.6	$89,000
	Subtotal		*1,413.3*	*460,000.0*
Project 6	Pipe upgrade on Oldfield Road to Sean Road.	350	231.9	$116,000
	Pipe upgrade along Sean Road and Verling Ave	350	1,091.6	$546,000
	Pipe upgrade on Oldfield Rd to Bear Hill Rd	300	1,082.7	$487,000
	Pipe upgrade on Bryn Rd and Sean Heights, North of Verling Ave.	300	383.7	$173,000
	New pipes connecting Bryn Road and Nicholas Road	150	299.1	$97,000
	Pipe replacement on Nicholas Road	150	177.4	$58,000
	Pipe upgrade on Bear Hill Road	300	481.2	$217,000
	Subtotal		*3,747.6*	*$1,694,000*
Project 7	Wallace Dr between E.Saanich Road & Prosser Road	200	963.8	$337,000
	Segment on Prosser Road	150	73.8	$24,000
	Subtotal		*1,037.6*	*$361,000*
Project 8	Stellys Cross Road within Lower Dawson pressure zone	100	622.9	$187,000
	Stellys Cross Road within Lower Dawson pressure zone	150	636.3	$207,000
	Stellys Cross Road within Lower Dawson pressure zone	200	4,005.6	$1,402,000
	Segment along West Saanich Road	250	199.7	$80,000
	PRV installation at Wallace Dr and Benvenuto Ave			$75,000
	Subtotal		*5,464.4*	$1,951,000
Project 9	New pipe direct to CRD Transmission Main at Central Saanich Rd	150	1,289.0	$419,000
	Subtotal		*1,289.0*	*$419,000.00*
Project 10	New pipe connecting Island View Place to Lamont Road	150	*386.8*	*$126,000.00*
	Subtotal		*386.8*	*126,000.0*
Project 11	Check Valve on Newman Rd			$10,000
	New fire booster pump in Saanichton High PZ (H: 97m; Q: 210Ls) - 300hp			$1,500,000
	Subtotal			*1,510,000.0*
Project 12	New fire booster pump in Mt. Newton PZ (H: 40m; Q: 80Ls) - 60hp			300,000.0
	Subtotal			*300,000.0*
Project 13	New fire booster pump in Martindale PZ (H: 40m; Q: 80Ls) - 60hp			300,000.0
	Subtotal			*300,000.0*
TOTAL				**$8,354,000**

* All costs are displayed in 2013 dollars.



District of Central Saanich

Water Distribution Master Plan

Recommended Rehabilitation Programs

Legend

- Control Valve
- Pump Station
- CRD Supply Point
- Tank
- CRD Transmission Main
- Proposed Fire Pump

Figure No: Figure 9.1

Project No: 60240374

Date: March 2013

AECOM

Appendix A: Flow Testing Records

Location 1 - Simpson Rd & Jeffree Rd (FRICTION TEST)
Date: 2-May-12

Flow Hydrant ID (F1): 198 (Simpson Rd & Jeffree Rd)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 203 (Simpson Rd &Venross Pl)
G2 ID: 202 (Simpson Rd & Seaboard Cresc)
G3 ID: 193 (Simpson Rd & Dovey Rd)
G4 ID: (at Haldon Rd, just as a check high point in the system)

Closed Valve:
V1: at Simpson Rd
V2: at Galbrath Cresc
V3: at Farell Cres
V4: at Seaboard Cres

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		2:05			2:10			
F1	Press-Side Port (psi)	86					86		
	Press-Pitot (psi)		7			7			79
	Flow - Pitot/Side Port (US GPM)		870.4			870.4		870.4	
G1	Press-Side Port (psi)	90	24	92	92	25	92		66.5
G2	Press-Side Port (psi)	90	44	90	90	44	90		46
G3	Press-Side Port (psi)	94	65	94	94	65	94		29
G4	Press-Side Port (psi)		46			46			

Location 1 - Simpson Rd & Jeffree Rd (SYSTEM TEST)
Date: 2-May-12

Flow Hydrant ID (F1): 198 (Simpson Rd & Jeffree Rd)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 203 (Simpson Rd &Venross Pl)
G2 ID: 204 (Jeffree Rd & Jewett Pl)
G3 ID: 196 (Corner of Jeffree Rd)
G4 ID: (at Haldon Rd, just as a check high point in the system)

Closed Valve:
V1: N/A
V2: N/A
V3: N/A
V4: N/A

Readings:

No.	Parameter	Test 1			Test 2			Test 3 (w/ Hose Monster)		
		Before	During	After	Before	During	After	Before	During	After
Time			1:27			1:33			1:44	
F1	Press-Side Port (psi)	85	21			22			30	85
	Press-Pitot (psi)		22			22				
	Press-HoseMonster(psi)								11	
	Flow - Pitot/Side Port (US GPM)		1543.1			1543.1			1801.9	
	Flow-HoseMonster (USGPM)		N/A						959.2	
G1	Press-Side Port (psi)	92	38	92	92	38	92	92	45	92
G2	Press-Side Port (psi)	90	38	90	90	38	90	90	45	90
G3	Press-Side Port (psi)	80	26	80	80	26	80	80	32	80
G4	Press-Side Port (psi)		32			32				

Location 2 - Tanner Rd (FRICTION TEST)

Hydrant discharge coef: 0.8

Date: 23-Oct-12

Flow Hydrant ID (F1): 132 (Tanner & Rudolph)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 141 (at Tanner & Elaine Way)
G2 ID: 371 (at Tanner & Bella Vista)
G3 ID:
G4 ID:

Closed Valve:
V1: at Sunny Slope
V2: at Robin Way
V3: at Bella Vista
V4: at Tanner

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time	10:40	10:50						
F1	Press-Side Port (psi)	74	0						
	Press-Pitot (psi)		8						66
	Flow - Pitot/Side Port (US GPM)		827.1					827.1	
G1	Press-Side Port (psi)	104	46	104					58
G2	Press-Side Port (psi)	98	34	98					64
G3	Press-Side Port (psi)								
G4	Press-Side Port (psi)								

test was only conducted once to minimize dirty water complain

Location 2 - Tanner Rd (SYSTEM TEST)

Date: 23-Oct-12

Flow Hydrant ID (F1): 132 (Tanner & Rudolph)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 130 (Rudolph & Wilcox)
G2 ID: 311 (Rudolph, south of Tanner)
G3 ID: 371 (at Tanner & Bella Vista)
G4 ID:

Closed Valve:
V1:
V2:
V3:
V4:

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
Time		10:15	10:25						
F1	Press-Side Port (psi)	75	28						
	Press-Pitot (psi)		32						47
	Flow - Pitot/Side Port (US GPM)		1654.2					1654.2	
G1	Press-Side Port (psi)	82	60	72					22
G2	Press-Side Port (psi)	74	50	74					24
G3	Press-Side Port (psi)	98	74	98					24
G4	Press-Side Port (psi)								

test was only conducted once to minimize dirty water complain

Location 3 - Cultra Ave (FRICTION TEST)

Date: 3-May-12

Flow Hydrant ID (F1): 179 (Cultra Ave - west of Colin Dr)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 454 (Cultra Ave & Wallace Dr)
G2 ID: 177 (Cultra Ave - east of Wallace Dr)
G3 ID: 176 (Cultra Ave - east of H177)

Closed Valve:
V1: at Colin Pl
V2: at Wallace Dr (North & South)
V3: N/A

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		9:40			9:45			
F1	Press-Side Port (psi)	78	7			7	78		
	Press-Pitot (psi)		8			8			70
	Flow - Pitot/Side Port (US GPM)		930.5			930.5		930.5	
G1	Press-Side Port (psi)	84	34	84	84	34	84		50
G2	Press-Side Port (psi)	90	48	90	90	48	90		42
G3	Press-Side Port (psi)	92	58	92	92	58	92		34

Location 3 - Cultra Ave (SYSTEM TEST)

Date: 3-May-12

Flow Hydrant ID (F1): 179 (Cultra Ave - west of Colin Dr)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 454 (Cultra Ave & Wallace Dr)
G2 ID: 177 (Cultra Ave - east of Wallace Dr)
G3 ID: N/A

Closed Valve:
V1: N/A
V2: N/A
V3: N/A

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		9:10			9:30			
F1	Press-Side Port (psi)	80	14			14	80		
	Press-Pitot (psi)		12			12			68
	Flow - Pitot/Side Port (US GPM)		1139.6			1139.6		1139.6	
G1	Press-Side Port (psi)	86	50	84	84	50	84		35
G2	Press-Side Port (psi)	84	42	82	82	42	82		41
G3	Press-Side Port (psi)								0

Location 4 - Verdier Ave (FRICTION TEST)

Date: 22-Oct-12

Flow Hydrant ID (F1): 76 (Verdier and Hagan)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 74 Verdier, east of Holly Park Rd
G2 ID: 75 Verdier and Waverly Terr
G3 ID: 303 Verdier, east of Hyd ID 74

Closed Valve:
V1: Hagan at Verdier
V2: Waverly Terr at Verdier
V3:

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		12:00						
F1	Press-Side Port (psi)	74	4	74					
	Press-Pitot (psi)		17						57
	Flow - Pitot/Side Port (US GPM)		1356.4					1356.4	
G1	Press-Side Port (psi)	62	24	64					38
G2	Press-Side Port (psi)	70	18	68					52
G3	Press-Side Port (psi)	54	30	54					24

test was conducted once because it was hard to contain the water

Location 4 - Verdier Ave (SYSTEM TEST)

Date: 3-May-12

Flow Hydrant ID (F1): 179 (Cultra Ave - west of Colin Dr)
Size Nozzle (in): 3.5

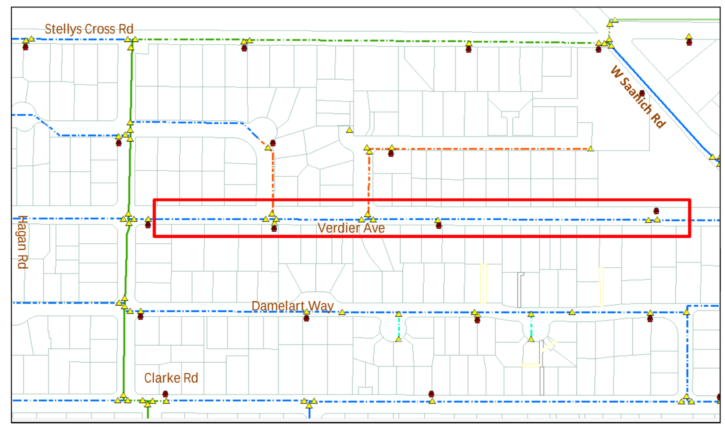
Gauge Hydrant:
G1 ID: 325 Waverly Terr North & Hagan
G2 ID: 75 Verdier and Waverly Terr
G3 ID: 67 Damlert Way & Hagan

Closed Valve:
V1: N/A
V2: N/A
V3: N/A

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		10:50						
F1	Press-Side Port (psi)	75	34						
	Press-Pitot (psi)		40						35
	Flow - Pitot/Side Port (US GPM)		2080.7					2080.7	
G1	Press-Side Port (psi)	80	62	80					18
G2	Press-Side Port (psi)	68	50	70					18
G3	Press-Side Port (psi)	82	66	82					16

test was conducted once because it was hard to contain the water



Location 5 - Twinview Dr (FRICTION TEST)

Date: 23-Oct-12

Flow Hydrant ID (F1): 322 (Twinview Dr, west of Janaud Close)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 323 (Twinview Dr, east of Janaud Close)
G2 ID: 318 (loganberry Pl)
G3 ID: 319 (Bella Vista & Wilcox Terr)
G4 ID:

Closed Valve:
V1: at Rudolph
V2: at Wilcox
V3: at Twinview
V4:

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time	11:18	11:20						
F1	Press-Side Port (psi)	85	0						
	Press-Pitot (psi)		13						72
	Flow - Pitot/Side Port (US GPM)		1186.2					1186.2	
G1	Press-Side Port (psi)	94	28	94					66
G2	Press-Side Port (psi)	92	38	92					54
G3	Press-Side Port (psi)	108	76	108					32
G4	Press-Side Port (psi)								

test was conducted once to minimize dirty water complain

Location 5 - Twinview Dr (SYSTEM TEST)

Date: 31-May-12

Flow Hydrant ID (F1): 322 (Twinview Dr, west of Janaud Close)
Size Nozzle (in): 3.5

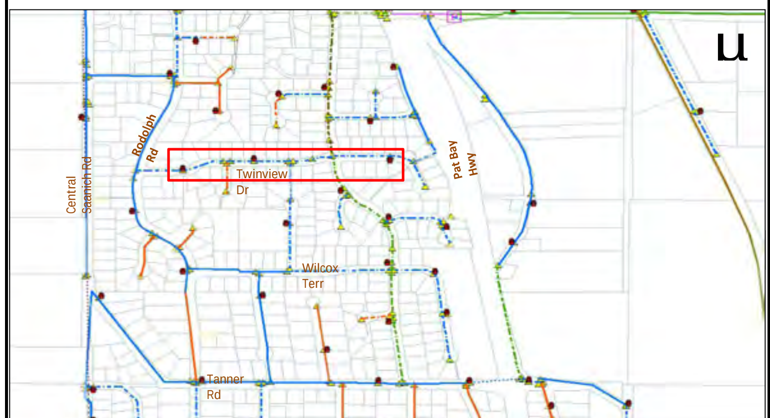
Gauge Hydrant:
G1 ID: 131 (at Rudolph)
G2 ID: 323 (Twinview Dr, east of Janaud Close)
G3 ID: 318 (loganberry Pl)
G4 ID:

Closed Valve:
V1: at Wilcox
V2:
V3:
V4:

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
Time			14:44						
F1	Press-Side Port (psi)	93	29	93					
	Press-Pitot (psi)		40						64
	Flow - Pitot/Side Port (US GPM)		2080.7					2080.7	
G1	Press-Side Port (psi)	100	66	100					34
G2	Press-Side Port (psi)	100	58	100					42
G3	Press-Side Port (psi)	96	60	96					36
G4	Press-Side Port (psi)								

test was conducted once due to water damage



Location 6 - Garden Gate Dr (FRICTION TEST) Hydrant discharge coef: 0.8

Date: 31-May-12

Flow Hydrant ID (F1): 389 (Garden Gate, north of Torin Dr

Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 390 (Garden Gate & Torin)
G2 ID: 383 (west of 390)
G3 ID: 382 (west of 383)
G4 ID:

Closed Valve:
V1: at Garden Gate & Torin
V2: at hydrant 388
V3:
V4:

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time	13:40	13:46		13:50	13:55			
F1	Press-Side Port (psi)	80	3	80	80	3	80		
	Press-Pitot (psi)		13			13			67
	Flow - Pitot/Side Port (US GPM)		506.5			506.5		506.5	
G1	Press-Side Port (psi)	96	32	96	96	32	96		64
G2	Press-Side Port (psi)	110	60	110	110	60	110		50
G3	Press-Side Port (psi)	114	80	114	114	80	114		34
G4	Press-Side Port (psi)								

Location 6 - Garden Gate Dr (SYSTEM TEST)

Date: 31-May-12

Flow Hydrant ID (F1): 389 (Garden Gate, north of Torin Dr

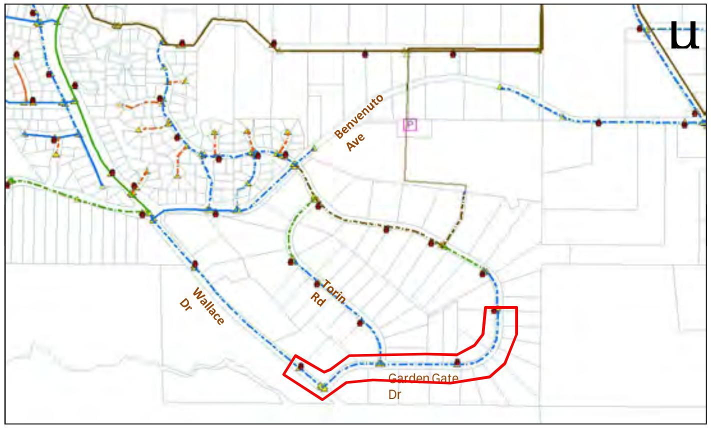
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 390 (Garden Gate & Torin)
G2 ID: 388 (east of 389)
G3 ID: 386 (2nd hydrant east of 388)
G4 ID:

Closed Valve:
V1:
V2:
V3:
V4:

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
Time		13:10	13:20	13:25		13:25			
F1	Press-Side Port (psi)	80	31	80	80	31	80		
	Press-Pitot (psi)		40			36			42
	Flow - Pitot/Side Port (US GPM)		1628.2			1628.2		1628.2	
G1	Press-Side Port (psi)	96	70	96	96	70			26
G2	Press-Side Port (psi)	56	46	56	56	44			11
G3	Press-Side Port (psi)	56	46	56	56	45			10.5
G4	Press-Side Port (psi)								



Location 7 - James Island Rd (FRICTION TEST)
Date: 3-May-12

Flow Hydrant ID (F1): 223 (end of road of James Island Rd)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 224 (Arthur Dr - north of James Island Rd)
G2 ID: 225 (Lochside Dr & Wakeman Rd)
G3 ID:

Closed Valve:
V1: James Island Rd,west of Arthur)
V2: N/A
V3: N/A

Readings:

No.	Parameter	Test 1 (w/Hose Monster & Hose)			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		12:20						
F1	Press-Side Port (psi)	120	12	120					108
	Press-Pitot (psi)								
	Press-HoseMonster(psi)		2						
	Flow - Pitot/Side Port (US GPM)		1139.6					1139.6	
	Flow-HoseMonster (USGPM)		413.6						
G1	Press-Side Port (psi)	124	94	124					30
G2	Press-Side Port (psi)	118	104	116					14
G3	Press-Side Port (psi)								

Test was only conducted once due to limited flow & press drop in gauge hyd
Hose approx. length is 75m

Location 7 - James Island Rd (SYSTEM TEST)
Date: 3-May-12

Flow Hydrant ID (F1): 223 (end of road of James Island Rd)
Size Nozzle (in): 3.5

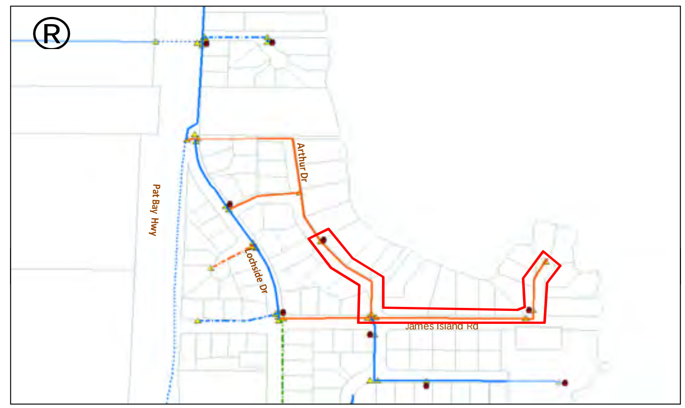
Gauge Hydrant:
G1 ID: 224 (Arthur Dr - north of James Island Rd)
G2 ID: 220 (Arthur Dr - south of James Island Rd)
G3 ID: 219 (James Island & Lochside Dr)

Closed Valve:
V1: N/A
V2: N/A
V3: N/A

Readings:

No.	Parameter	Test 1 (w/Hose Monster & Hose)			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		12:10						
F1	Press-Side Port (psi)	120	14						106
	Press-Pitot (psi)								
	Press-HoseMonster(psi)		3						
	Flow - Pitot/Side Port (US GPM)		1231.0					1231.0	
	Flow-HoseMonster (USGPM)		501.6						
G1	Press-Side Port (psi)	124	106	126					18
G2	Press-Side Port (psi)	124	104	124					20
G3	Press-Side Port (psi)	116	102	118					

Test was only conducted once due to limited flow & press drop in gauge hyd
Hose approx. length is 75m



Location 8 - Tomlinson Rd (FRICTION TEST)

Date: 3-May-12

Flow Hydrant ID (F1): 373 (Hovey Rd - 2nd Hyd west of Wallace Dr)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 374 (Hovey Rd - 3rd Hyd west of Wallace Dr)
G2 ID: 106 (Hovey Rd & Tomlinson Rd)
G3 ID: 104 (Tomlinson Rd - north of Stellys X Rd)

Closed Valve:
V1: (just east of F1)
V2:
V3:

Readings:

No.	Parameter	Test 1			Test 2		
		Before	During	After	Before	During	After
	Time		10:45				
F1	Press-Side Port (psi)	98					
	Press-Pitot (psi)						
	Flow - Pitot/Side Port (US GPM)		N/A				
G1	Press-Side Port (psi)	100	0				
G2	Press-Side Port (psi)	90	8				
G3	Press-Side Port (psi)	90					

test was not continued due to poor residual pressure

Location 8 - Tomlinson Rd (SYSTEM TEST)

Date: 3-May-12

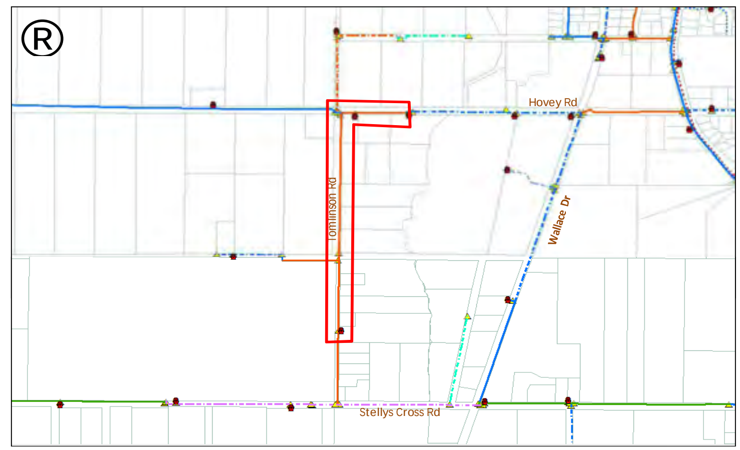
Flow Hydrant ID (F1): 373 (Hovey Rd - 2nd Hyd west of Wallace Dr)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 106 (Hovey Rd & Tomlinson Rd)
G2 ID: 423 (on White Rd)
G3 ID: 374 (Hovey Rd - 3rd Hyd west of Wallace Dr)

Closed Valve:
V1: N/A
V2: N/A
V3: N/A

Readings:

No.	Parameter	Test 1 (with Hose Monster)			Test 2 (with Hose Monster)			Average	
		Before	During	After	Before	During	After		dH
	Time		10:25			10:30			
F1	Press-Side Port (psi)	90	20			20	98		
	Press-Pitot (psi)		18						80.5
	Press-HoseMonster(psi)		13			14		13.5	
	Flow - Pitot/Side Port (US GPM)		1395.8			1471.3			
	Flow-HoseMonster (USGPM)		1042.8			1086.8			
G1	Press-Side Port (psi)	90	26	90	90	25	90		64.5
G2	Press-Side Port (psi)	86	38	86	86	38	86		48
G3	Press-Side Port (psi)	N/A	N/A	N/A	100	28	100		72



Location 11 - Mt. Newton X Rd (FRICTION TEST)
Date: 2-May-12

Flow Hydrant ID (F1): 434 (Mt. Newton X Rd - 2nd Hyd west of Schon Dr)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 187 (Mt Newton X Rd - west of Schon Dr)
G2 ID: 184 (Mt Newton X Rd & Simpson Rd)
G3 ID: 183 (Mt Newton X Rd - west of Wallace Dr)

Closed Valve:
V1: at Simpson Rd
V2:
V3:

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		2:35			2:45			
F1	Press-Side Port (psi)	110	27			27	110		
	Press-Pitot (psi)		28			28			82
	Flow - Pitot/Side Port (US GPM)		1740.8			1740.8		1740.8	
G1	Press-Side Port (psi)	85	46	85	85	45	85		39.5
G2	Press-Side Port (psi)	75	52	74	74	52	74		22.5
G3	Press-Side Port (psi)	78	64	78	78	64	78		14

Location 11 - Mt. Newton X Rd (SYSTEM TEST)
Date: 2-May-12

Flow Hydrant ID (F1): 434 (Mt. Newton X Rd - 2nd Hyd west of Schon Dr)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 187 (Mt Newton X Rd - west of Schon Dr)
G2 ID: 183 (Mt Newton X Rd - west of Wallace Dr)
G3 ID: 182 (Mt Newton X Rd & E.Saanich Rd)

Closed Valve:
V1: N/A
V2: N/A
V3: N/A

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		3:00			3:10			
F1	Press-Side Port (psi)	110	30			30	110		
	Press-Pitot (psi)		26			27			83.5
	Flow - Pitot/Side Port (US GPM)		1677.5			1709.5		1693.5	
G1	Press-Side Port (psi)	85	46	75	85	46	85		39
G2	Press-Side Port (psi)	78	64	78	78	64	78		14
G3	Press-Side Port (psi)	88	80	88	88	80	88		8

Location 12 - Puckle Rd (FRICTION & SYSTEM TEST)

Date: 3-May-12

Flow Hydrant ID (F1): 400 (Island View Rd, 3rd Hyd from Puckle Rd)

Size Nozzle (in): 3.5

Gauge Hydrant:

G1 ID: 399 (Island View Rd, 2nd Hyd from Puckle Rd)

G2 ID: 398 (Island View Rd & Puckle Rd)

G3 ID: 397 (Puckle Rd - north of Island View Rd)

Closed Valve:

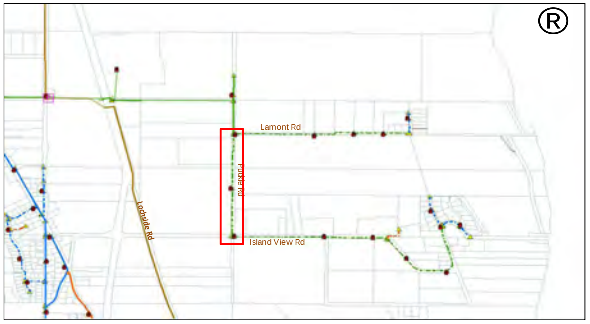
V1: N/A

V2: N/A

V3: N/A

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		12:55			1:07			
F1	Press-Side Port (psi)	90	24			23	92		
	Press-Pitot (psi)		24			21			68.5
	Flow - Pitot/Side Port (US GPM)		1611.7			1507.6		1559.6	
G1	Press-Side Port (psi)	94	36	94	94	34	94		59
G2	Press-Side Port (psi)	104	56	104	104	54	54		49
G3	Press-Side Port (psi)	98	55	98	98	55	55		43



Location 13 - Haidey Terrace (FRICTION TEST) Hydrant discharge coef: 0.8
Date: 31-May-12

Flow Hydrant ID (F1): 114 (Haidey Terrace)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 113 (Chatwell & Tanlee)
G2 ID: 273 (on Seabrooke)
G3 ID:
G4 ID:

Closed Valve:
V1: at White & Veyaness
V2: at Stellys & Chatwell
V3:
V4:

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		9:40						
F1	Press-Side Port (psi)	78	6	78					
	Press-Pitot (psi)		0						72
	Flow - Pitot/Side Port (US GPM)		716.3					716.3	
G1	Press-Side Port (psi)	72	8	72					64
G2	Press-Side Port (psi)	62	40	62					22
G3	Press-Side Port (psi)								
G4	Press-Side Port (psi)								

test was conducted once due to out of water conditions at Chatwell & Haidey

Location 13 - Haidey Terrace (SYSTEM TEST)
Date: 31-May-12

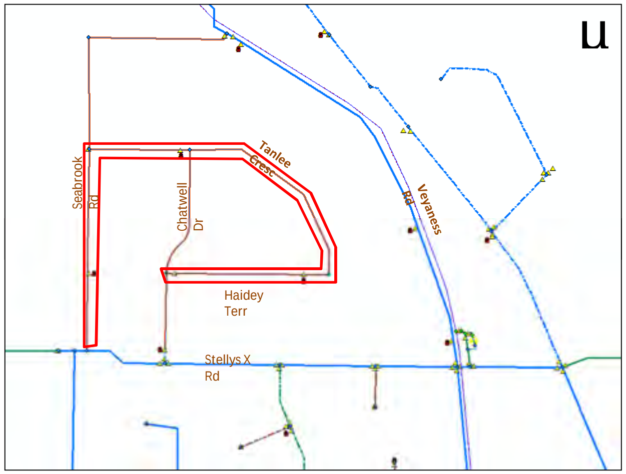
Flow Hydrant ID (F1): 114 (Haidey Terrace)
Size Nozzle (in): 3.5

Gauge Hydrant:
G1 ID: 113 (Chatwell & Tanlee)
G2 ID: 273 (on Seabrooke)
G3 ID:
G4 ID:

Closed Valve:
V1:
V2:
V3:
V4:

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
Time			9:15						
F1	Press-Side Port (psi)	80	8	80	80	8	80		
	Press-Pitot (psi)		12			11			68.5
	Flow - Pitot/Side Port (US GPM)		827.1			827.1		827.1	
G1	Press-Side Port (psi)	70	34	70	70	34	70		36
G2	Press-Side Port (psi)	62	44	62	62	42	60		19
G3	Press-Side Port (psi)								
G4	Press-Side Port (psi)								



Location 14 - Puckle Rd (FRICTION & SYSTEM TESTS)

Date: 23-Oct-12

Flow Hydrant ID (F1): 359 Puckle Rd & Lamont Rd

Size Nozzle (in): 3.5

Gauge Hydrant:

G1 ID: 337 north west end of Puckle Rd

G2 ID: 164 7280 Puckle Rd

G3 ID: 368 end of Highcrest Terr

Closed Valve:

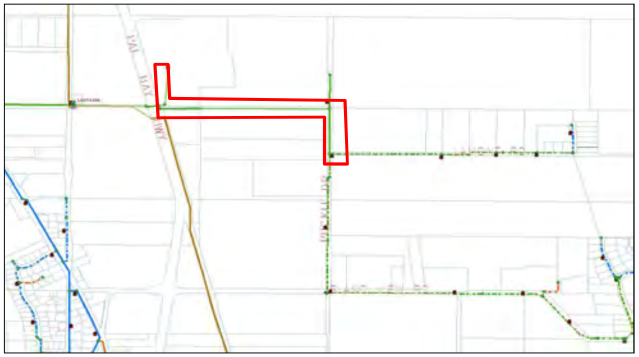
V1: N/A

V2:

V3:

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time	9:05	9:20						
F1	Press-Side Port (psi)	101	34			34	101		
	Press-Pitot (psi)		38			38			63
	Flow - Pitot/Side Port (US GPM)		2028.0			2028.0		2028.0	
G1	Press-Side Port (psi)	102	84	102	102	84	104		18
G2	Press-Side Port (psi)	97	46	97	97	46	97		51
G3	Press-Side Port (psi)	102	42	102	102	42	102		60



Location 15 - Wallace Dr (FRICTION TEST)

Hydrant discharge coef: 0.8

Date: 22-Oct-12

Flow Hydrant ID (F1): 275 (Wallace Dr north of Jedora Dr)
Size Nozzle (in): 3.5

Gauge Hydrant:		Closed Valve:	
G1 ID:	48 Wallace and Hagan	V1:	at Wallace
G2 ID:	446 Wallace, west of Hagan	V2:	at Greig
G3 ID:	31 Wallace and Greig	V3:	at Hagan

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		10:40						
F1	Press-Side Port (psi)	58	4			4	58		
	Press-Pitot (psi)		16			15			42.5
	Flow - Pitot/Side Port (US GPM)		1169.7			1132.6		1151.2	
G1	Press-Side Port (psi)	70	53	68	68	52	68		16.5
G2	Press-Side Port (psi)	68	46	68	68	48	68		21
G3	Press-Side Port (psi)	64	34	64	64	36	64		29

Location 15 - Wallace Dr (SYSTEM TEST)

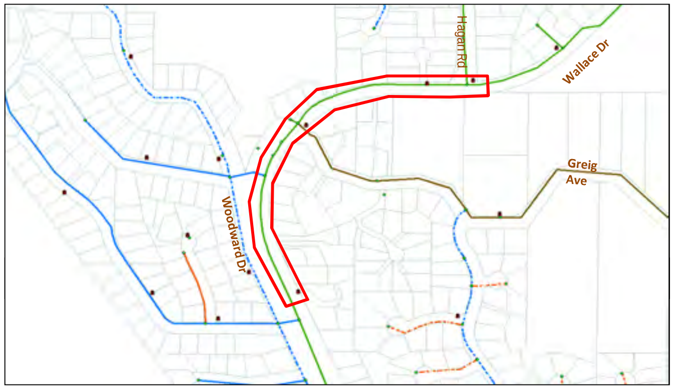
Date: 22-Oct-12

Flow Hydrant ID (F1): 275 (Wallace Dr north of Jedora Dr)
Size Nozzle (in): 3.5

Gauge Hydrant:		Closed Valve:	
G1 ID:	22 Jedora and Wendonna	V1:	N/A
G2 ID:	30 Wallace and Brentwood Heights	V2:	N/A
G3 ID:	31 Wallace and Greig	V3:	N/A

Readings:

No.	Parameter	Test 1			Test 2			Average	
		Before	During	After	Before	During	After		dH
	Time		10:00						
F1	Press-Side Port (psi)	60	12			12	60		
	Press-Pitot (psi)		20			20			40
	Flow - Pitot/Side Port (US GPM)		1307.8			1307.8		1307.8	
G1	Press-Side Port (psi)	70	48	70	70	48	70		22
G2	Press-Side Port (psi)	78	56	78	78	56	78		22
G3	Press-Side Port (psi)	64	49	64	64	49	64		15



Appendix B: Proposed Improvement Work Options

District of Central Saanich - Water Distribution Master Plan
Proposed Upgrades Options for Existing System

LOWER DAWSON PZ

Scenario 1 - Split PZ with pipe upgrades

Desc	Watermain				PRV Station			Storage			Fire Pump			
	Diam (mm)	Length (m)	Unit Cost ($)	Cost ($)	Unit	Unit Cost ($)	Cost ($)	Vol (m3)	Unit Cost ($)	Cost ($)	HP	Unit Cost ($)	Cost ($)	
Split PZ at curent Lower Dawson PZ	150	883.9	$325	$287,264	6	$75,000	$450,000	0	$1,000	$0	0	$5,000	$0	
Pipe Upgrades on Stellys X Rd/Brentview Dr/Verdier Ave	200	1,502.4	$350	$525,826										
Pipe Upgrades on Stellys X Rd/West Saanich Rd	250	199.7	$400	$79,888										
Pipe Upgrades on Stellys X Rd/Wallace Dr	300	1,709.0	$450	$769,041										
Pipe Upgrades on West Saanich/Meadowbank														
Decommision Gowdy PRV														
Adjust Setting at Meadowbank PRV to HGL of 125m														
Adjust PRV Setting at Stellys PRV to HGL of 124m														
PRV on Benvenuto/Wallace to allow feeding Lower Dawson from														
Upper Dawson during Fire (pressure at Butchart is below 20 psi)														
TOTAL		**4,295.0**		**$1,662,019**			**$450,000**			**$0**			**$0**	**$2,112,000**

Scenario 2 - Pipe upgrades only

Desc	Watermain				PRV Station			Storage			Fire Pump			
	Diam (mm)	Length (m)	Unit Cost ($)	Cost ($)	Unit	Unit Cost ($)	Cost ($)	Vol (m3)	Unit Cost ($)	Cost ($)	HP	Unit Cost ($)	Cost ($)	
No Split PZ at curent Lower Dawson PZ	150	502.1	$325	$163,183	1	$75,000	$75,000	0	$1,000	$0	0	$5,000	$0	
Pipe Upgrades on Stellys X Rd/Brentview Dr/Verdier Ave	200	2,248.2	$350	$786,856										
Pipe Upgrades on Stellys X Rd/West Saanich/Verdier Ave	250	199.7	$400	$79,888										
Pipe Upgrades on West Saanich/Meadowbank														
Adjust PRV Setting at Stellys PRV to HGL of 124m														
PRV on Benvenuto/Wallace to allow feeding Lower Dawson from														
Upper Dawson during Fire (pressure at Butchart is below 20 psi)														
TOTAL		**2,950.0**		**$1,029,927**			**$75,000**			**$0**			**$0**	**$1,105,000**

Oldfield PZ

Scenario 1 - With emergency tank and pipe upgrades

Desc	Watermain				PRV Station			Storage			Fire Pump			
	Diam (mm)	Length (m)	Unit Cost ($)	Cost ($)	Unit	Unit Cost ($)	Cost ($)	Vol (m3)	Unit Cost ($)	Cost ($)	HP	Unit Cost ($)	Cost ($)	
Proposed Tank (Vol: 4,000m3; TWL: 130m)	150	476.5	$325	$154,853	0	$75,000	$0	4,000	$1,000	$4,000,000	0	$5,000	$0	
Pipe upgrade on Oldfield Rd to Sean Rd	300	1,522.0	$450	$684,918										
Pipe upgrade on Sean and Verling Ave	350	140.4	$500	$70,205										
New pipe to connect Nicholas Rd and Bryn Rd														
TOTAL		**2,138.9**		**$909,976**			**$0**			**$4,000,000**			**$0**	**$4,910,000**

Scenario 2 - Pipe upgrades only

Desc	Watermain				PRV Station			Storage			Fire Pump			
	Diam (mm)	Length (m)	Unit Cost ($)	Cost ($)	Unit	Unit Cost ($)	Cost ($)	Vol (m3)	Unit Cost ($)	Cost ($)	HP	Unit Cost ($)	Cost ($)	
Pipe upgrade on Oldfield Rd to Bear Hill Rd	150	476.5	$325	$154,853	0	$75,000	$0	0	$1,000	$0	0	$5,000	$0	
Pipe pgrade on Bear Hill Rd	300	1,947.6	$450	$876,407										
Pipe upgrade on Sean and Verling Ave	350	1,323.6	$500	$661,775										
New pipe to connect Nicholas Rd and Bryn Rd														
TOTAL		**3,747.6**		**$1,693,034**			**$0**			**$0**			**$0**	**$1,693,000**

District of Central Saanich - Water Distribution Master Plan
Proposed Upgrades for Existing System

Central Bear Hill PZ

Desc	Watermain				PRV Station			Storage			Fire Pump			
	Diam (mm)	Length (m)	Unit Cost ($)	Cost ($)	Unit	Unit Cost ($)	Cost ($)	Vol (m3)	Unit Cost ($)	Cost ($)	HP	Unit Cost ($)	Cost ($)	
Pipe upgrade on Tomlinson/Hovey	150	2196.5	$325	$713,863	0	$75,000	$0	0	$1,000	$0	0	$5,000	$0	
Pipe upgrade around Tanlee Cres.	200	798.3	$350	$279,409										
New pipe to connect Tomlinson Rd & Hovey Rd (East of Tomlinson)														
TOTAL		**2994.8**		**$993,271**			**$0**			**$0**			**$0**	**$993,000**

Mt. Newton PZ

Desc	Watermain				PRV Station			Storage			Fire Pump			
	Diam (mm)	Length (m)	Unit Cost ($)	Cost ($)	Unit	Unit Cost ($)	Cost ($)	Vol (m3)	Unit Cost ($)	Cost ($)	HP	Unit Cost ($)	Cost ($)	
New fire booster pump (H: 40m; Q: 80Ls) - 60hp			$0	$0	0	$75,000	$0	0	$1,000	$0	60	$5,000	$300,000	
TOTAL				**$0**			**$0**			**$0**			**$300,000**	**$300,000**

Saanichton Low PZ

Desc	Watermain				PRV Station			Storage			Fire Pump			
	Diam (mm)	Length (m)	Unit Cost ($)	Cost ($)	Unit	Unit Cost ($)	Cost ($)	Vol (m3)	Unit Cost ($)	Cost ($)	HP	Unit Cost ($)	Cost ($)	
Pipe upgrade on Wallace Dr between Hovey & Mt. Newton X Rd	150	2159.0	$325	$701,675	0	$75,000	$0	0	$1,000	$0	0	$5,000	$0	
Pipe upgrade on Wallace Dr north of Newman Rd	200	963.8	$350	$337,334										
New pipe between Newman Rd & Mt. Newton X Rd														
Direct Connection to CRD Main on Newman Rd														
TOTAL		**3,122.8**		**$1,039,009**			**$0**			**$0**			**$0**	**$1,039,000**

Stellys PZ

Desc	Watermain				PRV Station			Storage			Fire Pump			
	Diam (mm)	Length (m)	Unit Cost ($)	Cost ($)	Unit	Unit Cost ($)	Cost ($)	Vol (m3)	Unit Cost ($)	Cost ($)	HP	Unit Cost ($)	Cost ($)	
New pipe between Island View Pl & Lamont Rd	150	386.8	$325	$125,710	0	$75,000	$0	0	$1,000	$0	0	$5,000	$0	
TOTAL		**386.8**		**$125,710**			**$0**			**$0**			**$0**	**$126,000**

District of Central Saanich - Water Distribution Master Plan
Proposed Upgrades for Existing System

Saanichton High PZ

Scenario 1 - With fire booster pump

Desc	Watermain				Check Valve			Storage			Fire Pump			
	Diam (mm)	Length (m)	Unit Cost ($)	Cost ($)	Unit	Unit Cost ($)	Cost ($)	Vol (m3)	Unit Cost ($)	Cost ($)	HP	Unit Cost ($)	Cost ($)	
New fire booster pump (H: 97m; Q: 210Ls) - 300hp			$0	$0	1	$10,000	$10,000	0	$1,000	$0	300	$5,000	$1,500,000	
Check Valve on Newman Rd														
TOTAL				**$0**			**$10,000**			**$0**			**$1,500,000**	**$1,510,000**

Scenario 2 - With emergency tank

Desc	Watermain				Check Valve			Storage			Fire Pump			
	Diam (mm)	Length (m)	Unit Cost ($)	Cost ($)	Unit	Unit Cost ($)	Cost ($)	Vol (m3)	Unit Cost ($)	Cost ($)	HP	Unit Cost ($)	Cost ($)	
Proposed Tank (Vol: 2,850m3; TWL: 110m)				$0	1	$10,000	$10,000	2,850	$1,000	$2,850,000	0	$5,000	$0	
Check Valve on Newman Rd														
TOTAL		**0.0**		**$0**			**$10,000**			**$2,850,000**			**$0**	**$2,860,000**

Martindale PZ

Scenario 1 - With fire booster pump

Desc	Watermain				PRV Station			Storage			Fire Pump			
	Diam (mm)	Length (m)	Unit Cost ($)	Cost ($)	Unit	Unit Cost ($)	Cost ($)	Vol (m3)	Unit Cost ($)	Cost ($)	HP	Unit Cost ($)	Cost ($)	
New pipe to connect north/south Noble Rd	150	883.7	$325	$287,199	0	$75,000	$0	0	$1,000	$0	60	$5,000	$300,000	
New fire booster pump (H: 40m; Q: 80Ls) - 60hp														
TOTAL		**883.7**		**$287,199**			**$0**			**$0**			**$300,000**	**$587,000**

Scenario 2 - Pipe Upgrades Only

Desc	Watermain				PRV Station			Storage			Fire Pump			
	Diam (mm)	Length (m)	Unit Cost ($)	Cost ($)	Unit	Unit Cost ($)	Cost ($)	Vol (m3)	Unit Cost ($)	Cost ($)	HP	Unit Cost ($)	Cost ($)	
New pipe to connect north/south Noble Rd	150	883.7	$325	$287,199	0	$75,000	$0	0	$1,000	$0	0	$5,000	$0	
Pipe upgrade on Martindale Rd	200	3072.7	$350	$1,075,449										
Pipe upgrade on Welch Rd	300	1647.2	$450	$741,236										
Pipe upgrade on Dooley Rd														
TOTAL		**5,603.6**		**$2,103,883**			**$0**			**$0**			**$0**	**$2,104,000**