St. John's Regional Drinking Water Study

Final Report

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ST. JOHN'S

Prepared by:

CBCL 60 1955-2015

CBCL LIMITED

Consulting Engineers

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CBCL LIMITED
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February 1, 2016

Mr. Brendan O'Connell, P.Eng.
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City of St. John's
PO Box 908
St. John's, NL A1C 5M2

Dear Mr. O'Connell:

RE: St. John's Regional Drinking Water Study
Final Report

We are pleased to provide you with our Final Report for the above-noted project. We have enjoyed working on this project with all of the project stakeholders, and look forward to working with the City of St. John's and the other stakeholders on the implementation of the report recommendations.

Yours very truly,

CBCL Limited

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Executive Summary

Bay Bulls Big Pond supplies water to the municipalities of St. John's, Mount Pearl, Conception Bay South (CBS), Paradise and Portugal Cove - St. Philip's. Windsor Lake and Petty Harbour Long Pond supply water to the City of St. John's only. For the purposes of this study, the water treatment plants, along with the transmission and distribution infrastructure located in the municipalities serviced by Bay Bulls Big Pond, Windsor Lake and Petty Harbour Long Pond, are collectively referred to as the Existing Water Supply System (EWSS).

The water treatment plants located at Bay Bulls Big Pond, Windsor Lake and Petty Harbour Long Pond are owned and operated by the City of St. John's; however, representatives from the municipalities serviced by Bay Bulls Big Pond meet regularly with the City of St. John's representatives who operate the Bay Bulls Big Pond system to discuss operational issues. The Bay Bulls Big Pond system is called the Regional Water System.

The last review of the EWSS was carried out in 1994, with an update completed in 2007. In consideration of the pace at which the St. John's urban area is growing, and requests from the municipalities of Torbay and Holyrood to be supplied by the EWSS, the Regional Water System and the Provincial Department of Municipal and Intergovernmental Affairs commissioned a comprehensive review of the EWSS. This report contains the results of this review, including recommendations for infrastructure improvements and the infrastructure requirements for future expansion.

The study objectives are summarized as follows:

- To examine future anticipated water demands considering:
  - Regional population growth.
  - Development of areas above the 190-m contour.
  - Development of the East Kilbride area.
  - Increased densification of the City of St. John's urban area.
  - Supplying water to the Towns of Torbay and Holyrood.
- To examine the supply and distribution capabilities of the Regional Water System, while considering specific technical challenges such as potentially abandoning the Shea Heights water reservoir and replacing it with a reservoir for the entire East Kilbride area.
- To recommend system improvements for the 10, 25 and 35-year time horizons.

- To develop capital, operational and maintenance cost estimates for system improvements and new source developments.
- To recommend target dates for the implementation of system improvements and new source developments.

An integrated demographic analysis was used to forecast housing demands and associated populations in the St. John's urban region, including Torbay and Holyrood, for 10, 25 and 35-year periods. The analysis takes into account the current age structure in the region and includes allowances for migration. Water demand estimates were developed using the population projections and standard allowances for water consumption. Using a computer model, demands were allocated to areas where growth is expected to take place throughout the region. The computer model was then used to analyze the performance of the existing systems and to establish the infrastructure requirements for future servicing, including the provision of water to Torbay and Holyrood.

The key study conclusions are:

- Two potential sources for future development have been identified: Thomas Pond and Big Triangle Pond.
- Based on the median population projections, and without considering the implementation of additional water conservation measures, approximately 40-50,000 m^3/D of additional treated water is required to service the existing municipalities and the municipalities of Torbay and Holyrood over the 10-35 year study planning horizon.
- Due to the anticipated water deficit noted above, it is not possible to add municipalities to the EWSS until a new source becomes operational.
- Infrastructure requirements associated with addressing the anticipated water shortage have been established.
- Infrastructure deficits associated with the current water systems have been identified for both short-term and long-term planning horizons.
- Water conservation efforts currently implemented throughout the region are resulting in water savings; however, there are additional opportunities for water conservation.

The key recommendations are:

- The Regional Water System committee should develop a document that formalizes the Regional-Municipal responsibilities. This document should contain the responsibilities of the Regional Water System and the serviced municipalities with respect to the ownership and operation of water transmission components.
- In order to plan for a new water treatment plant, the following additional study work should be carried out as soon as possible:
  - Reliable yield study at Big Triangle Pond.
  - Treatability studies at Thomas Pond and Big Triangle Pond.
- Recommendations to offset the treated water deficit of 40-50,000 m^3/D include distribution system upgrades, and a new water treatment plant and associated transmission main.

- Recommendations to address the existing infrastructure deficits include additional distribution storage throughout the water systems, and a new pumping station, transmission main, and storage at Kilbride East.
- All serviced municipalities should consider implementing universal metering to increase water conservation.

Cost opinions for the infrastructure improvements noted above are presented below. An implementation schedule is included in the report.

Description	Cost
Additional Distribution Storage: Ruby Line Pump Station	$3,800,000
Additional Distribution Storage: CBS South	$7,800,000
Additional Distribution Storage: Mundy Pond	$8,200,000
Additional Distribution Storage: Airport Heights	$5,800,000
Additional Distribution Storage: Sugarloaf Road	$6,900,000
Additional Distribution Storage: Signal Hill	$7,600,000
Distribution System Upgrades	$1,600,000
Pump Station/Transmission Main/Storage: Kilbride East	$19,000,000
Windsor Lake Water Treatment Plant Process Improvements (Corrosion Control)	$5,000,000*
New Source – Option 1: Thomas Pond (Water Treatment Plant)	$50,000,000
New Source – Option 1: Thomas Pond (Transmission)	$31,800,000
New Source – Option 2: Big Triangle Pond (Water Treatment Plant)	$50,000,000
New Source – Option 2: Big Triangle Pond (Transmission)	$86,600,000
Torbay (transmission and storage; new water supply must be developed before Torbay can be added to the EWSS)	$17,400,000
Holyrood (required if Thomas Pond is developed as opposed to Big Triangle Pond; new water supply must be developed before Holyrood can be added to the EWSS)	$22,200,000

*Supplied by the City of St. John's.

CHAPTER 1 PROJECT OVERVIEW

1.1 Background

Bay Bulls Big Pond supplies water to the municipalities of St. John's, Mount Pearl, Conception Bay South (CBS), Paradise and Portugal Cove - St. Philip's. Windsor Lake and Petty Harbour Long Pond supply water to the City of St. John's only. The water treatment plants located at these sources are owned and operated by the City of St. John's. For the purposes of this study, the water treatment plants, along with the transmission and distribution infrastructure located in the municipalities serviced by Bay Bulls Big Pond, Windsor Lake and Petty Harbour Long Pond, are collectively referred to as the Existing Water Supply System (EWSS).

The last review of the EWSS was carried out in 1994, with an update completed in 2007. In consideration of the pace at which the St. John's urban area is growing, and requests from the municipalities of Torbay and Holyrood to be supplied by the EWSS, the Regional Water System and the Provincial Department of Municipal and Intergovernmental Affairs (MIGA) commissioned a comprehensive review of the EWSS.

In May 2014, the CBCL Limited (CBCL) was retained to carry out this review.

1.2 Objectives

The study objectives are summarized as follows:

- To examine future anticipated water demands considering:
  - Regional population growth.
  - Development of areas above the 190-m contour.
  - Development of the East Kilbride area.
  - Increased densification of the City of St. John's urban area.
  - Supplying water to the Towns of Torbay and Holyrood.
- To examine the supply and distribution capabilities of the Regional Water System, while considering specific technical challenges such as potentially abandoning the Shea Heights water reservoir and replacing it with a reservoir for the entire East Kilbride area.
- To recommend system improvements for the 10, 25 and 35-year time horizons.
- To develop capital cost estimates for system improvements and new source developments.
- To recommend target dates for the implementation of system improvements and new source developments.

1.3 Research

At the early stages of this project, CBCL met with all interested stakeholders, including St. John's, Mount Pearl, CBS, Paradise, Portugal Cove - St. Philip's, Torbay, Holyrood, MIGA and the Department of Environment and Conservation (ENVC). The municipalities provided information on their existing systems, including existing computer models and as-built drawings. In addition, areas of growth within each municipality were identified and comments on issues with water supply were provided to the study team.

Further, CBCL obtained copies of and reviewed the following reports:

- St. John's Regional Water System Study (Fenco Newfoundland, 1974).
- Windsor Lake Water Supply Improvement Study (NDAL, October 1990).
- St. John's Regional Water Supply Review Study Report (NDAL, 1994).
- St. John's Regional Water Supply – Update to 1994 Report (NDAL, 2007).
- Atlantic Canada Guidelines for the Supply, Treatment, Storage, Distribution and Operation of Drinking Water Supplies (ACWWA, 2004).
- NL Department of Environment and Conservation's Guidelines for Design, Construction and Operations of Water and Sewerage Systems.
- NL Department of Municipal and Intergovernmental Affairs' Municipal Water Sewer and Road Specifications.
- City of St. John's Specifications Book.
- NL Department of Environment and Conservation's Water Resources Portal.
- Latest municipal plans for the study area municipalities.

CHAPTER 2 WATER SYSTEMS

The EWSS consists of two separate systems: the St. John's Water System and the Regional Water System.

2.1 St. John's Water System

The St. John's Water System is owned and operated by, and exclusively services, the City of St. John's. Key system components include:

- Windsor Lake (WL) and Petty Harbour Long Pond (PHLP) water treatment plants (WTPs).
- The WL, Airport Heights, Shea Heights and PHLP reservoirs.
- The Airport Heights, Autumn Drive, Shea Heights, Densmore Lane, Fahey Street and Valleyview Road pump stations.
- The WL supply is supported by additional supply from the Broad Cove River Watershed via the Little Powers Pond pump station.
- Division gates (watermain isolation valves) that separate the WL, Bay Bulls Big Pond and PHLP service areas.

2.2 Regional Water System

The Regional Water System (RWS) is owned and operated by the City of St. John's. The RWS services the municipalities of St. John's, Mount Pearl, CBS, Paradise and Portugal Cove - St. Philip's. Key system components include:

- Bay Bulls Big Pond (BBBP) WTP.
- The Ruby Line, Kenmount and Paradise pump stations. (The Paradise pump station is owned by the Town of Paradise).
- The Mundy Pond, Kenmount Hill, Southlands, Fowler's Road, Camrose Drive and Skinner's Road reservoirs. (The reservoirs are operated by the City of St. John's; however, they are owned by the municipalities in which they are located).
- Some of the transmission mains that connect the above-listed components.
- Meter and valve chambers that are used to measure municipal flow rates, isolate sections of the transmission mains, and control system pressures.

A committee of representatives from the RWS and representatives from each municipality serviced by the RWS meets regularly to discuss operational issues.

2.2.1 Regional-Municipal Responsibilities

The development of land located in the vicinity of some sections of transmission mains within St. John's and the other serviced municipalities has resulted in the connection of distribution mains directly to transmission mains. As the RWS is responsible for the production and transmission of water only, the question of which entity should own and operate the transmission mains that are now also functioning as primary distribution mains has arisen. It is not possible to clearly assign responsibilities to the RWS and the serviced municipalities based on the strict definitions of a "transmission main" and a "distribution main" as there will always be exceptions. Instead, it is recommended that the RWS should own and operate the transmission mains listed below, which are the more significant transmission mains in the RWS. All water mains not listed below should be owned and operated by the municipality in which they are located.

- The 1050mm transmission main from the BBBP WTP to the Ruby Line pump station.
- The 750mm transmission main from the Ruby Line pump station to the Topsail Road/Dunn's Road intersection.
- The 750mm transmission main from the Ruby Line pump station to the Southlands reservoirs.
- The twinned 600mm and 450mm transmission mains from the Southlands reservoirs to the Paradise/CBS metering chamber.
- The 450mm and 400mm transmission main from the Paradise/CBS metering chamber to the CBS boundary.

It is further recommended that the committee of representatives develop a document that formalizes the Regional-Municipal responsibilities. This document should contain the responsibilities of the RWS and the serviced municipalities with respect to the ownership and operation of water transmission components. Detailed maps should be included in this document.

2.3 Water Treatment Plants

Water treatment is provided at WL, BBBP and PHLP. WTP capacities are provided in Table 2.1. Note that both summer and winter capacities are provided for the WL WTP. When the raw water temperature is greater than 15°C, the summer capacity is used; otherwise, the winter capacity is used.

Table 2.1: Water Treatment Plant Capacities

Facility	Capacity m^3/D
BBBP WTP	85,000
WL WTP *(Summer)*	70,000
WL WTP *(Winter)*	53,500
PHLP WTP	14,500
Total Capacity *(Summer)*	**169,500**
Total Capacity *(Winter)*	**153,000**

2.4 Water Distribution

Plans No. 1 and No. 2 (see Appendix A) present the locations of the existing WTPs, pump stations, storage reservoirs, water transmission mains and pressure reducing valve (PRV) stations. The plans also include the delineation of existing pressure zones.

Most reservoirs are fed by pumps with water level on/off control. Existing pump stations are listed in Table 2.2 and reservoir storage volumes and configurations are summarized in Table 2.3. For analysis purposes, the top water level (TWL) of each reservoir and the downstream setting of each PRV will be used as the Hydraulic Grade Line (HGL) for each pressure zone.

Transmission mains range in size from 400mm to 1200mm and are summarized in Appendix B.

Table 2.2: Pump Stations

System	Pump Station	Number of Pumps	Rated Capacity per Pump	Notes
BBBP	BBBP WTP	5	23,984 Lpm at 27.4 m (head)	
	Ruby Line – Mundy Pond	3	18,927 Lpm at 24.4 m (head)	
		1	7,570 Lpm at 9.1 m (head)	
	Ruby Line – Southlands	5	9,463 Lpm at 73.2 m (head)	
	Kenmount	4	13,627 Lpm at 82.3 m (head)	
	Paradise	3	5,205 Lpm at 122.0 m (head)	
	Pennywell Road*	1	284 Lpm at 27.4 m (head)	
		1	2,082 Lpm at 49.7 m (head)	Fire pump
	Mount Pearl*	2	1,060 Lpm at 140.0 m (head)	
	Donna Road*	3	1,893 Lpm at 62.8 m (head)	
		1	3,785 Lpm at 38.7 m (head)	Fire pump
WL	Airport Heights	1	4,997 Lpm at 82.9 m (head)	
		2	9,993 Lpm at 116.4 m (head)	
PHLP	Shea Heights	2	984 Lpm at 115.8 m (head)	
		1	1,007 Lpm	
	Densmore Lane	3	3,028 Lpm at 91.4 m (head)	
	Fahey Street	2	1,136 Lpm at 53.0 m (head)	
	Valleyview Road	2	852 Lpm at 21.3 m (head)	

*Not part of the RWS.

Table 2.3: Storage Reservoirs

System	Water Storage Reservoir		Volume	Top Water Level	Reservoir Parameters (m)			Comments	Year
	Primary Name	Secondary Name	m^3	m	Diameter	Floor Level (geodetic)	Water Height		
BBBP	BBBP WTP East Clearwell		4,365	133.8	N/A	128.02	5.79		1978
	BBBP WTP West Clearwell		6,000	133.8	N/A	128.02	5.79		1978
	Ruby Line Pump Station Clearwell		900	158.2	N/A	150.57	7.62		1976
	Mundy Pond	Intermediate Pressure Zone / Jensen Camp	11,760	157.0	45.11	149.20	7.77	In-ground Concrete	1974
	Kenmount Hill	St. John's Southwest Expansion Zone	17,300	227.0	38.37 38.37	219.46 219.46	7.54 7.54	Twin Tanks - Each at 8,650m^3	2001
	Mount Pearl*	Kenmount Business Park	1,575	264.0	9.4	242.00	22.00		
	West Southlands	New Mount Pearl	10,500	218.0	36.32	207.86	10.14		2005
	East Southlands	Old Mount Pearl	9,100	218.0	35.50	207.77	10.23		1974
	Fowler's Road	Conception Bay South	5,680	180.0	13.72 13.72	159.88 159.88	20.12 20.12	Twin Tanks - Each at 2,840m^3	2003
	Camrose Drive	Paradise	10,540	218.1	37.34	208.50	9.63		2004
	Skinner's Road	Portugal Cove – St. Philip's	2,840	209.5	18.90	200.50	9.00		2003
		Total Storage Volume	**80,560**						
WL	WL WTP		20,000	156.0	N/A	150.15	5.85	In-ground Concrete	2005
	Airport Heights	Penetanguishene	8,000	219.4	33.00	210.35	9.00		2002
		Total Storage Volume	**28,000**						
PHLP	PHLP WTP		10,000	158.2	N/A	151.5	6.7	In-ground Concrete	2011
	Shea Heights		2,200	172.5	15.24	160.3	12.2		1970
		Total Storage Volume	**12,200**						

*Not part of the RWS.

CHAPTER 3 WATER DEMANDS

3.1 Historical Flows

Measured water flows for the areas serviced by the BBBP WTP and the WL WTP for 2010-2014 were obtained from the City of St. John's. Note that historical data for the PHLP WTP does not exist because this facility was added to the St. John's Water System in mid-2015.

Total daily flows for BBBP and WL were reviewed in consultation with operations staff and the average and maximum day flows for each community were summarized.

- *Average Day Demand*: Total system water use for one year, divided by 365 days.
- *Maximum Day Demand:* Water use over the 24-hour period (midnight to midnight) with the highest demand during the year.

The average day and maximum day demands along with the average day per capita water consumption rates are presented in Table 3.1. These consumption rates are similar to jurisdictions that do not have universal metering. Table 3.2 shows consumption rates for other local municipalities. The BBBP and WL flow trends for 2010-2014 are presented in Figures 3.1 and 3.2.

Table 3.1: Measured Water Flows

System	Municipality	2011 Population (From Population Projections, Sec. 3.2)	Serviced Population		Measured Flow - m^3/D Average Day Demand	Measured Flow - m^3/D Max. Day Demand	Max. Day Factor	Average Day Water Consumption Rate L/C/D
BBBP	St. John's West (Fed by BBBP)	41,552*	41,552	100%	34,525	44,311	1.3	830.9
	Mount Pearl	24,105	24,105	100%	23,555	27,492	1.2	977.2
	Paradise	17,550	13,163	75%	9,689	12,243	1.3	736.1
	Portugal Cove - St. Philip’s	7,340	2,569	35%	2,115	3,586	1.7	823.3
	Conception Bay South	24,485	19,588	80%	13,661	18,337	1.3	697.4
	Totals	**115,032**	**100,977**		**83,545**	**105,969**	**1.3**	**827.4**
WL	St. John's East	**62,328**	**62,328**	100%	**53,800**	**65,400**	**1.2**	**863.2**

*BBBP services approximately 40% of St. John’s and WL services approximately 60% of St. John’s (prior to PHLP being added to the St. John’s Water System).

Table 3.2: Comparison of Average Daily Consumption Rates

Region	Average Daily Consumption Rates* (L/Person/Day)
Corner Brook	1,282
Gander	759
Grand Falls - Windsor	639
Happy Valley - Goose Bay	687
Newfoundland and Labrador	804**
Canada	510**

*Consumption rates are for total water usage (includes residential, commercial, industrial and institutional usage).

**2011 Environment Canada Municipal Water Use Report.

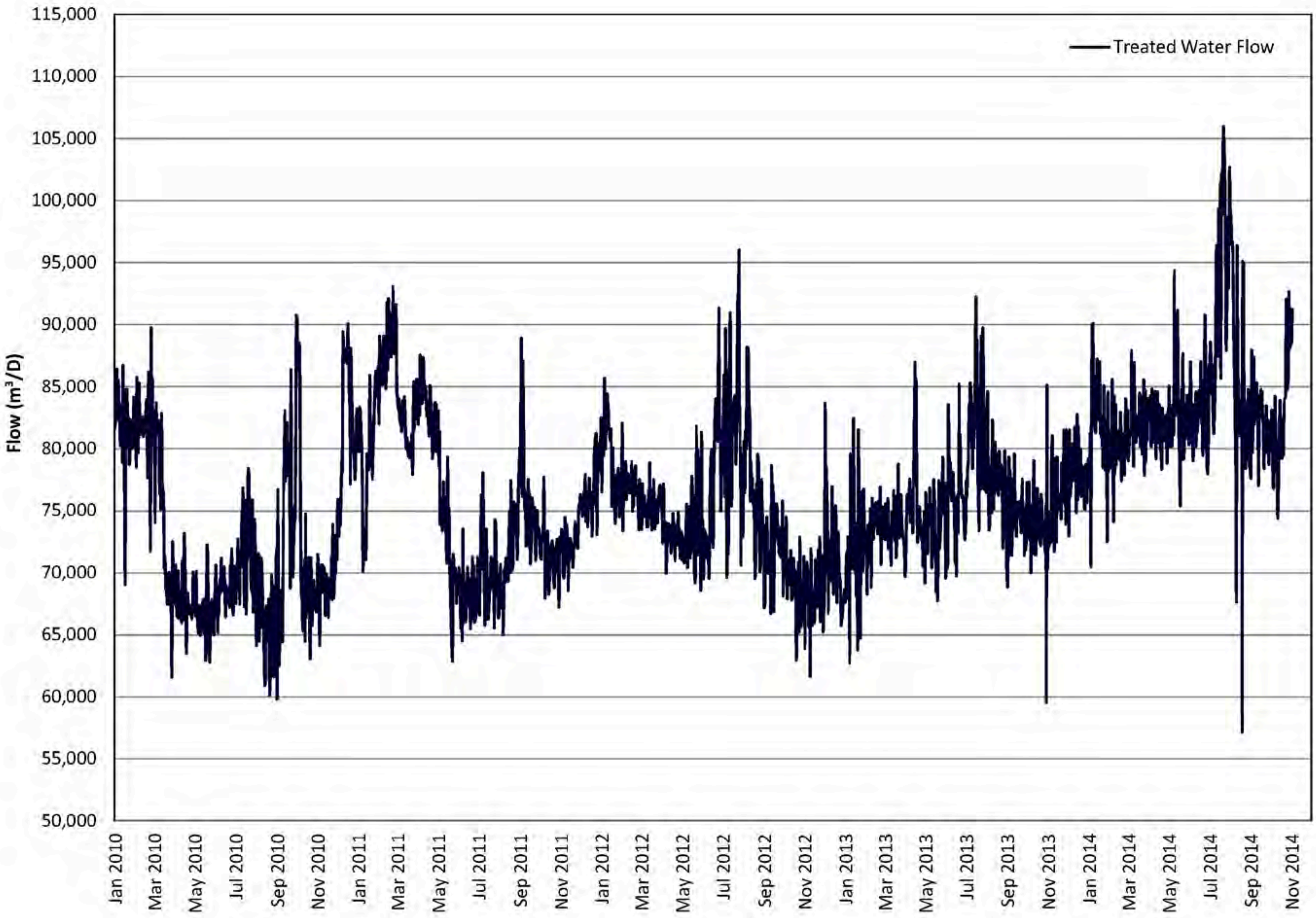

Figure 3.1: BBBP 2010-2014 Daily Flows

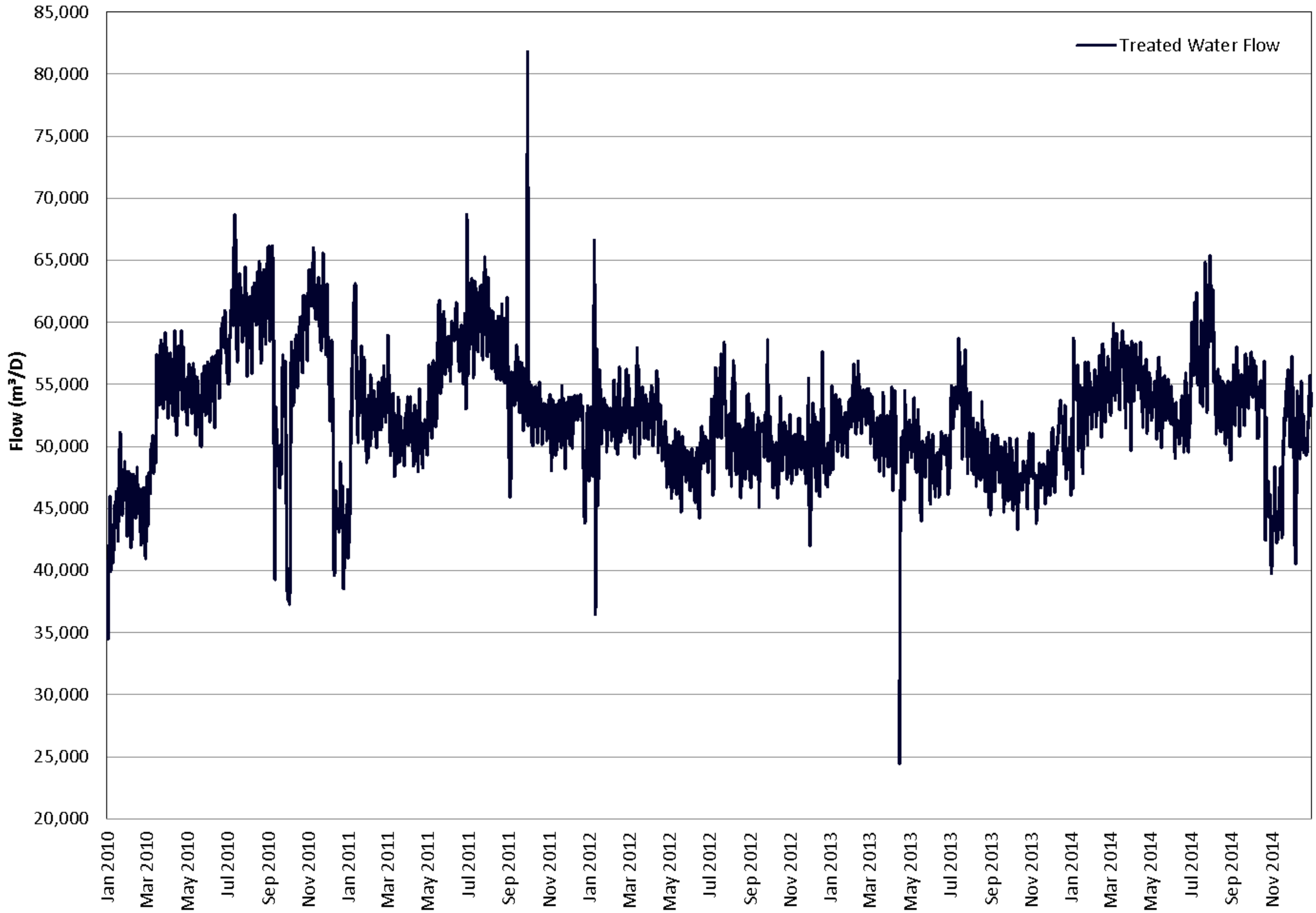

Figure 3.2: WL 2010-2014 Daily Flows

3.2 Population Projections

An integrated demographic analysis was used to forecast housing demands and associated populations in the St. John's urban region, including Torbay and Holyrood, for 10, 25 and 35-year periods. The analysis takes into account the current age structure in the region and includes allowances for migration. Low, median and high growth models were used, as follows:

- *Low Growth*: population with decreasing birth rates and increasing longevity, requiring positive net-migration to sustain and grow its existing population numbers.
- *Median Growth*: population with higher birth rates and increasing longevity and sustains existing population numbers.
- *High Growth*: population with high birth rates and low death rates.

In order to classify the growth potential of a population, estimates were carried out for population age cohort groups. (Cohort: a group of persons sharing demographic characteristics). For example, the younger cohort groups for the ages 0-4 to 25-34 represent the future population potential of a region. The estimated population is an integration of a starting point (2011), births (fertility by age), deaths by age, and in and out migration trends. After the population is forecasted for a time period, housing demand estimates are made based on the forecasted population by age cohort and historical occupancy statistics from Statistics Canada.

Results of the population forecasts are presented in *"Regional Water Supply Study: Report on Outcomes of Estimating Housing Type and Demands Using a Cohort Specific Demographic Forecast Model"* (Appendix C). Table 3.3 presents a summary of the population projections for the median growth scenario for each of the municipalities within the study area.

Table 3.3: Projected Population - Median Growth Scenario

Community	Census Population	Observed Population	Projected Population - Median Growth		
Year	**2011**	**2011**	**2021**	**2036**	**2046**
St. John's	106,172	103,880	125,093	133,393	136,408
Mount Pearl	24,248	24,105	26,810	28,711	28,964
Paradise	17,695	17,550	20,261	22,662	23,671
Portugal Cove - St. Philip's	7,366	7,340	8,088	8,767	8,966
Conception Bay South	24,848	24,485	27,294	29,511	30,167
Sub-total	**180,329**	**177,360**	**207,546**	**223,044**	**228,176**
Torbay	7,397	7,330	8,263	9,194	9,551
Holyrood	1,995	1,915	2,106	2,118	2,112
Sub-total	**9,392**	**9,245**	**10,369**	**11,312**	**11,663**
TOTAL - St. John's Urban Region	**189,721**	**186,605**	**217,915**	**234,356**	**239,839**

In Table 3.3, the census population figures for 2011 include long-term care facility residents, whereas the observed population figures for 2011 do not include these persons. The observed population figures are used as the basis for the population projections. Exclusion of the long-term care facility residents does not significantly impact the projections because the number of long-term care facility residents remains fairly consistent (i.e. the number of long-term care facility residents will only increase if additional facilities are built).

3.3 Water Demand Projections

Results of the population forecasts, summarized in the previous section, were used to estimate the future maximum day water demands for 2026, 2036, and 2046 for each of the communities in the study area. The 2026 population projections were calculated using linear interpolation in order to establish water demands for the 10-year time horizon (as opposed to using the 2021 population projections).

Table 3.4 presents a summary of the projected maximum day water demands. For the purposes of this study, the following assumptions were made in calculating the estimated demands:

- Average daily water consumption rate of 500 litres per person per day (includes residential, commercial, industrial and institutional usage).
- Residential population density of 40 persons per hectare.
- Average household size of 3.0 persons per household.

Based on the Census populations for 2011 and the population projections for 2016 presented in the population forecasting report (Appendix C), the current 2014 populations were estimated by linear interpolation.

In addition to the projected population increases, allowances for servicing existing unserviced populations in the communities of Paradise, Portugal Cove - St. Philip's, and CBS were included. Based on input provided by the Town of Paradise, it was assumed that approximately 200 currently unserviced houses will be connected, all by 2036. For the community of Portugal Cove - St. Philip's, it was assumed that 15% of the current unserviced population will be serviced by 2036. In CBS, it was assumed that 98% of currently unserviced population will be serviced by 2036.

The population of St. John's is split between the WL and BBBP service areas, with 60% assigned to WL and 40% to BBBP for 2014. Equal growth rates were assumed through to 2036 and 2046 for both areas. Due to the addition of the new PHLP WTP, a population of 13,500 was reallocated from the BBBP service area and the Shea Heights area (WL) to the PHLP service area for 2015.

The water demand projections were assigned to each community based on the information provided by the stakeholder communities. For CBS and Portugal Cove - St. Philip's, future demands were assigned to future growth areas that were identified by the individual municipalities. For the communities of Paradise and Mount Pearl, the future demands were allocated evenly across the communities.

Within the St. John's BBBP service area, demands were also allocated for known developments in the Glencrest, Galway and Kenmount Terrace areas. It was assumed that 85% of the population increase would be allocated for these new developments, while the remaining 15% would be applied evenly throughout the rest of the service area. Of the 85% for new developments, two-thirds was allocated to the Glencrest and Galway developments, and one-third to Kenmount Terrace. For the rest of St. John's, within the WL service area, demands were also spread evenly over the entire service area.

Table 3.4: Projected Water Demands

Water Service Areas		2014 Total Max. Day Demand	Projection Year								
			2026			2036			2046		
			2014 to 2026 Max. Day Demand Increase	Percent Increase	2026 Total Max. Day Demand	2014 to 2036 Max. Day Demand Increase	Percent Increase	2036 Total Max. Day Demand	2014 to 2046 Max. Day Demand Increase	Percent Increase	2046 Total Max. Day Demand
		m^3/D	m^3/D	2014 to 2026	m^3/D	m^3/D	2014 to 2036	m^3/D	m^3/D	2014 to 2046	m^3/D
BBBP Service Area	St. John's – BBBP	30,105	1,045	3%	31,150	1,917	6%	32,022	2,605	9%	32,710
	Mount Pearl	27,492	1,491	5%	28,983	2,733	10%	30,225	2,922	11%	30,414
	Paradise	12,243	1,922	16%	14,165	3,524	29%	15,767	4,281	35%	16,524
	Portugal Cove - St. Philip's	3,586	778	22%	4,364	1,427	40%	5,013	1,577	44%	5,163
	Conception Bay South	18,337	2,600	14%	20,937	4,766	26%	23,103	5,259	29%	23,596
	Total – BBBP	***91,763***	***7,836***	***9%***	***99,599***	***14,367***	***16%***	***106,130***	***16,644***	***18%***	***108,407***
WL Service Area	St. John's - WL	64,606	4,493	7%	69,099	8,237	13%	72,843	9,544	15%	74,150
PHLP Service Area	St. John's - PHLP	15,000*	2,232	15%	17,232	4,092	27%	19,092	4,360	29%	19,360

*The maximum day demand estimate for PHLP is based on measured flow data for October and November 2015. The PHLP was not in operation during 2014.

CHAPTER 4 SOURCE ANALYSIS

4.1 Reliable Yield

Reliable yields were updated for BBBP, WL, and Thomas Pond. These estimates were last updated in 2007 in the *St. John's Regional Water Supply Update to 1994 Report* completed by Newfoundland Design Associates Limited.

The reliable yield (i.e. the flow which can be used for distribution at any time, including dry periods) for each source was estimated by assembling a system model, which included adding historical gauged flows through the reservoir, and extracting potential water demands. Reservoir routing included inflow, storage and outflow. Inflows were created by prorating data from a nearby representative hydrometric gauge by a ratio of drainage areas. Outflows include flows required for fish, flows over the spillway, and flows that can be extracted for distribution. For this analysis, water extracted for hydroelectric purposes was omitted. Storage curves were used to relate flow and water level.

Since there are no flow measurement instruments on these reservoirs, daily flow series were generated using a nearby flow gauge and drainage area proration. Several gauges on the Avalon Peninsula were investigated for this analysis. The gauge selection was based on the following characteristics:

- Similar climatic conditions (close proximity to the regional sources).
- Long period of record.
- Up-to-date data.
- Natural flow (i.e. non-regulated).
- Similar land uses within the compared drainage basin.

Environment Canada's Northeast Pond River at Northeast Pond hydrometric gauge (02ZM006) was selected for the reliable yield analysis. This gauge is located in Portugal Cove - St. Philip's, near Anglican Cemetery Road. Figure 4.1 shows the selected gauge location in relation to the regional water sources. The Northeast Pond River gauge has 60 years of daily data (1953 to 2012) and is unregulated. Similar to the drainage basins for the regional sources, there is little to no developed land in the catchment for Northeast Pond River.

Flows from Northeast Pond River were prorated by drainage area to produce daily inflow series for BBBP, WL and Thomas Pond.

The flow released for fish at BBBP has been measured as 0.25 m^3/s (21,600 m^3/D). There is no flow released for fish at WL because the spillway at the outlet does not permit the passage of fish. Similarly, there is no flow released for fish at Thomas Pond because the control structure at the pond outlet does not permit the passage of fish. However, Section 4.3 suggests that the potential required fish flow for Thomas Pond is 0.318 m^3/s (27,475 m^3/D); taking this into account would reduce Thomas Pond's reliable yield to approximately 22,025 m^3/D. Spillway rating curves were created for each structure using the weir equation. Storage and flow were related by water level through storage curves and rating curves.

Table 4.1 presents the reliable yields for the watersheds in the EWSS. Table 4.2 contains the reliable yields for the watersheds which are available for future development. The reliable yield estimates presented in Tables 4.1 and 4.2 are net of fish flow requirements. Figure 4.2 shows the watershed locations.

Due to their potential reliable yields and geographical locations, both Thomas Pond and Big Triangle Pond should be considered as future water sources. The reliable yield calculation for Big Triangle Pond is presented in Section 4.1.1 of this report.

The proposed upgrading at Little Powers Pond includes the construction of an 8-m high dam. Due to the environmental challenges associated with dam construction in a developed area, the City of St. John's has decided not to pursue the upgrading of Little Powers Pond as a means to augment the WL reliable yield. However, for information, the potential yield is included in Table 4.2 and water quality data is presented later in this section.

Table 4.1: Existing Watershed Capacities

Watershed	Reliable Yield (m^3/D)		
	Previous Estimates		CBCL 2015
BBBP	108,800	NDAL 2011	112,300
Minimum Fish flow	-21,600	City 2011	-21,600
Total – BBBP	87,200		90,700
WL	41,700	NDAL 2007	50,000
Supplement from Little Powers Pond	4,500	NDAL 2007	4,500
Total – WL	46,200		54,500
Total – PHLP	15,900		
Total – North Pond	1,900		

Table 4.2: Potential Watershed Capacities

Watershed	Reliable Yield (m^3/D)	Drainage Area (km^2)
Thomas Pond	22,025	40.4
Big Triangle Pond	17,000	49.7
Upgrade Little Powers Pond	27,500	11.1

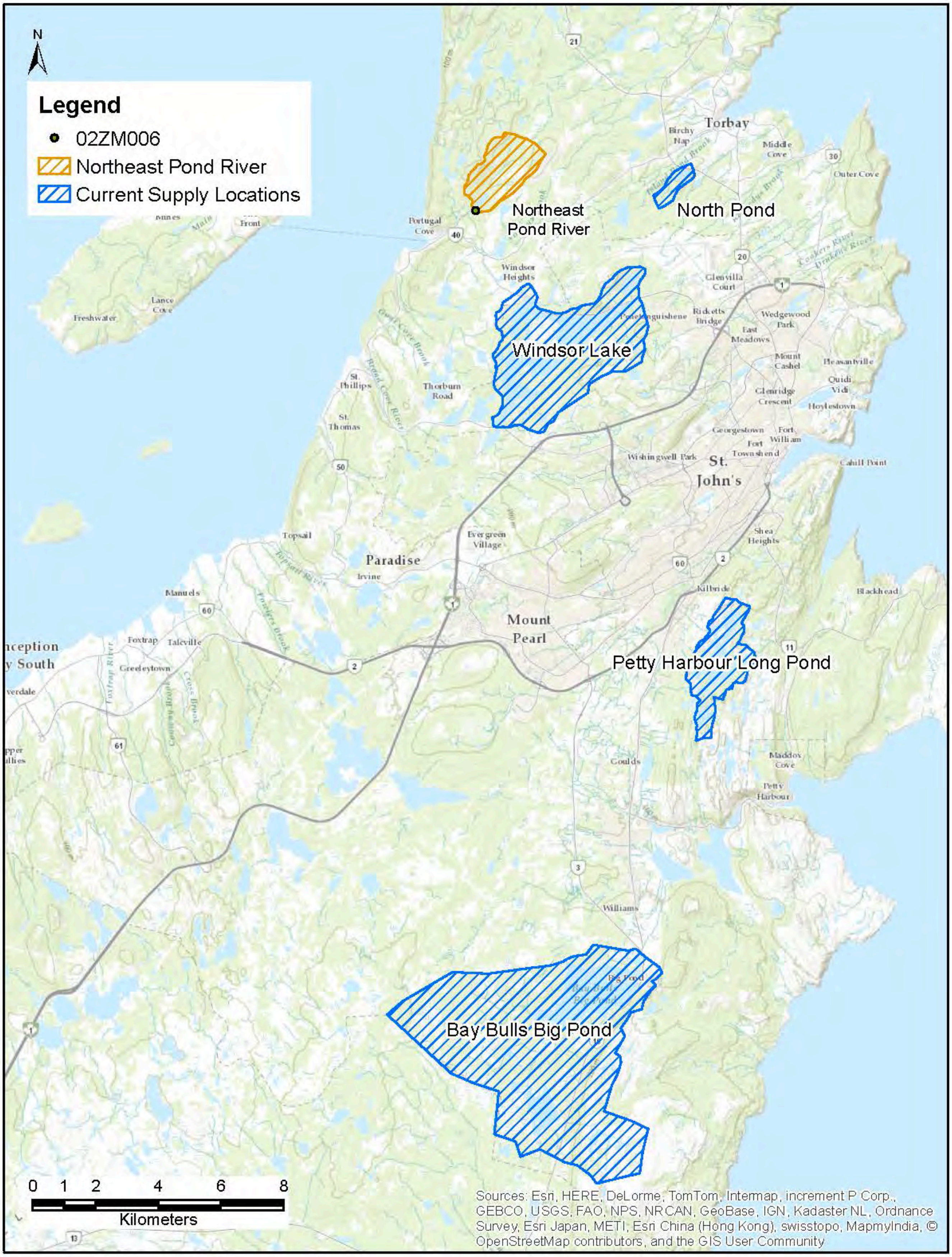

Figure 4.1: Hydrometric Gauge Location

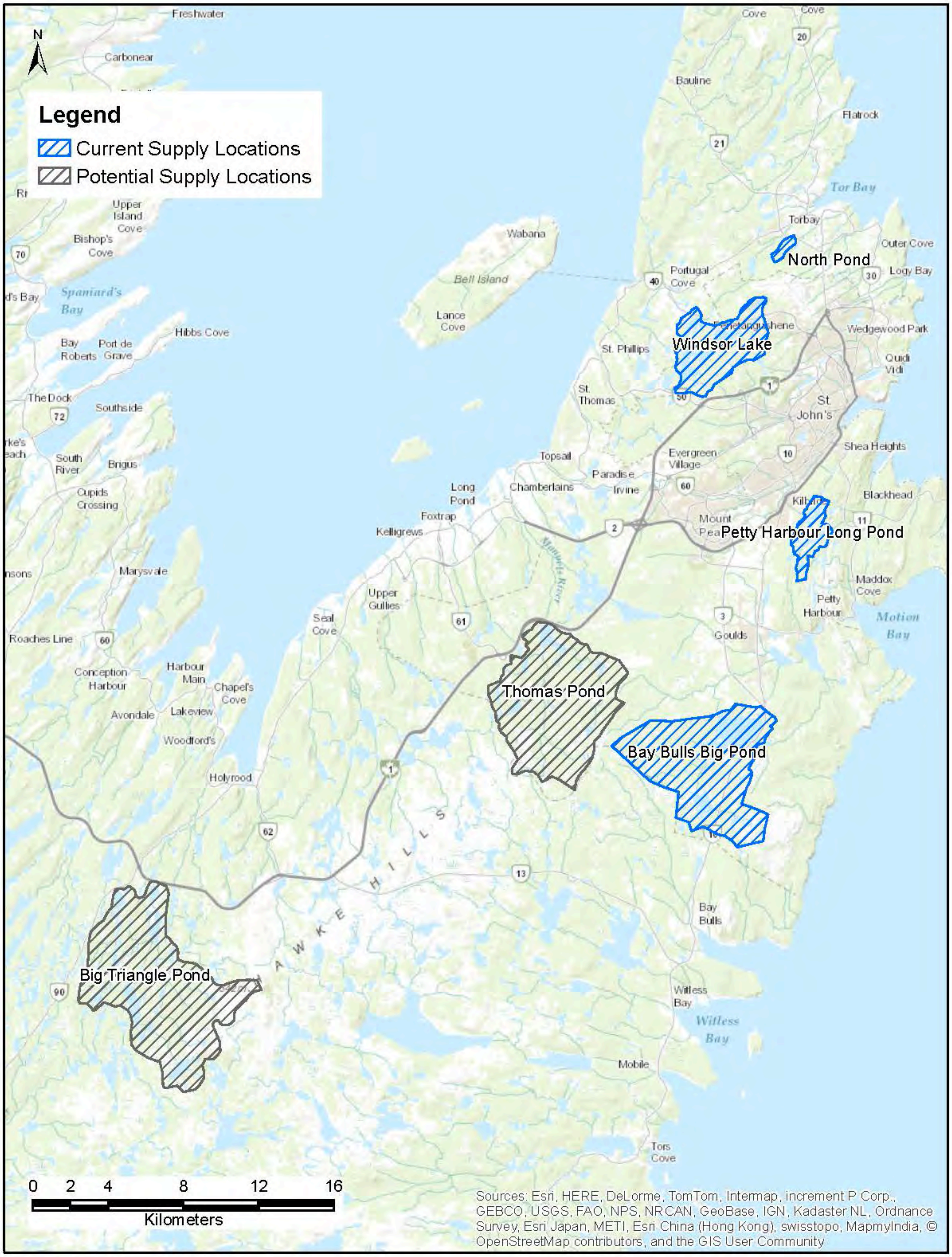

Figure 4.2: Existing and Potential Water Sources

4.1.1 Reliable Yield – Big Triangle Pond

Reliable yield was estimated for Big Triangle Pond using estimated stage-storage information and historical flows from a nearby flow gauge. This area has very limited topographic and survey information and the lake has no known bathymetric survey information. Surveying, more detailed topographic information, and long term monitoring of Big Triangle Pond is necessary to provide a more accurate reliable yield estimate. The calculation assumptions and their implications on the available yield at Big Triangle Pond are discussed in the following sections.

4.1.1.1 Hydrological Data

Big Triangle Pond is located adjacent to the Trans-Canada Highway near Holyrood. No surveying of Big Triangle Pond has been completed. Four corrugated metal culverts cross the Trans-Canada Highway that connects Big Triangle Pond to Little Triangle Pond. Directly upstream of Big Triangle Pond is Southern Peak Pond which drains into Big Triangle Pond through a series of streams and ponds. The configuration of the ponds is shown in Figure 4.3. 10-m topographic data was used to determine the levels of the lakes, which are summarized in Table 4.3. Survey and long-term monitoring should be completed to determine actual water levels. A watershed of approximately 49.7 km^2 drains to Big Triangle Pond. The watershed is primarily undeveloped, is unregulated and has a relatively high density of lakes. The majority of the watershed is within the potential water supply watershed of North Arm Brook, as shown on Figure 4.4.

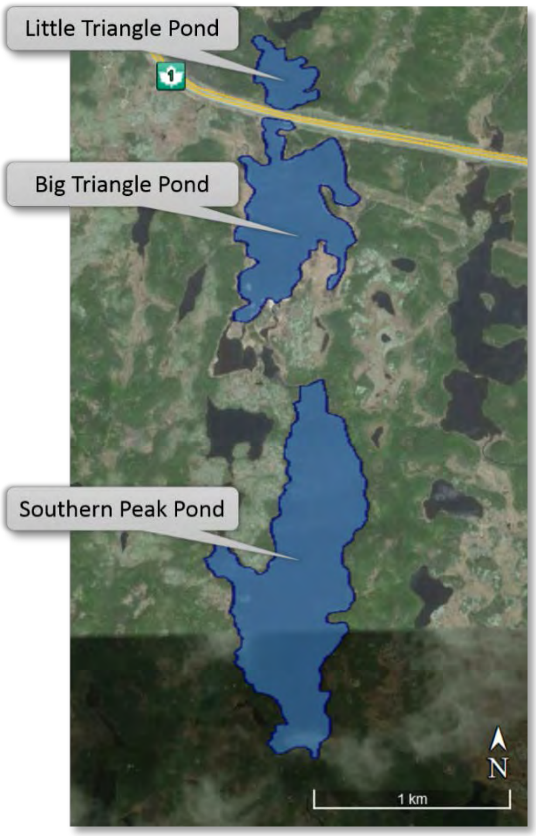

Figure 4.3: Configuration of Big Triangle Pond, Southern Peak Pond and Little Triangle Pond

The dynamics of this system are unknown and should be surveyed and monitored on a long-term basis. Monitoring should include long-term monitoring of lake levels (preferably Big Triangle Pond, Little Triangle Pond and Southern Peak Pond) as well as flow gauging to monitor natural variation of inflows and outflows. This information will help to determine current conditions in order to accurately assess long term conditions and therefore reliable yield.

Table 4.3: Areas and Water Elevation of Southern Peak Pond, Big Triangle Pond and Little Triangle Pond

Pond	Area	Water Elevation
Southern Peak Pond	75 ha	101 m
Big Triangle Pond	37.9 ha	98 m
Little Triangle Pond	8.1 ha	93 m

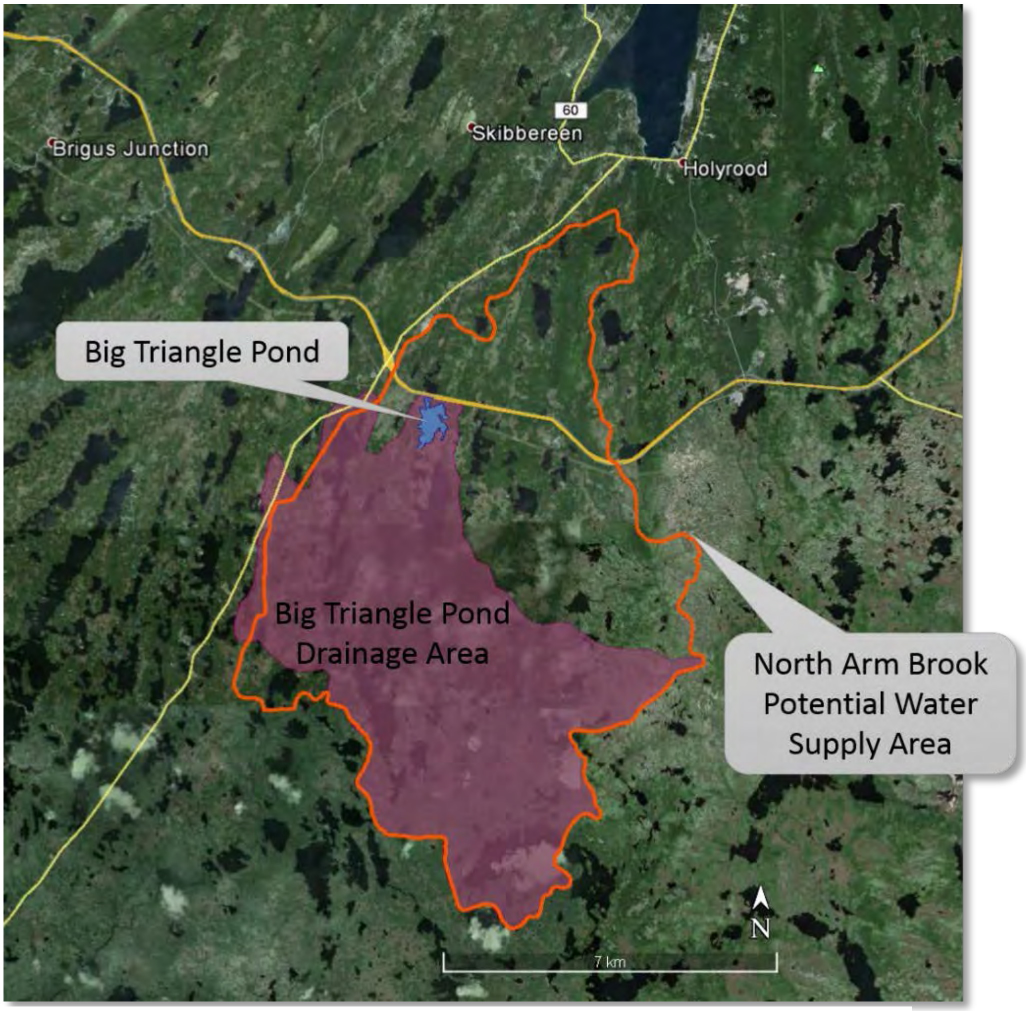

Figure 4.4: Big Triangle Pond Drainage Area

There are no hydrometric stations within the Big Triangle Pond watershed nor downstream of the pond. Therefore, several gauges on the Avalon Peninsula were explored for this analysis. The gauge selection was based on the following characteristics:

- Similar climatic conditions (based on the distribution of Mean Annual Precipitation and the Regional Flood Frequency Analysis for Newfoundland and Labrador 2014 Update).
- Long period of record.
- Up-to-date data.
- Natural flow (i.e. non-regulated).
- Similar land uses within the compared drainage basin.

Several gauges were identified based on the above requirements, including station 02ZM016, which is very close to Big Triangle Pond on South River near Holyrood. However, watershed parameters can also greatly influence runoff characteristics, particularly the influence of land cover and lakes and wetlands. Therefore, in order to determine which gauging station is the most appropriate to use for Big Triangle Pond's reliable yield assessment, the fractions of forested area, barren area, lakes, and wetlands were calculated and are shown in Table 4.4. The results of this analysis show that although Station 02ZM016 is the closest to Big Triangle Pond, Station 02ZK002 has similar hydrological properties to Big Triangle Pond, and therefore, better represents actual flow conditions.

Station 02ZK002 has daily average flow data available from January 1979 to December 2013. The flow data was prorated by drainage area to produce a daily inflow series for Big Triangle Pond. The annual 7-day minimum flows (daily flows averaged over 7 days) were then calculated for the prorated data and compared to a number of statistical distributions to find a representative distribution, as shown in Figure 4.5. The most appropriate distribution is the Gumbel distribution, which is confirmed using the Chi square test, student's T-test, and the R-squared test.

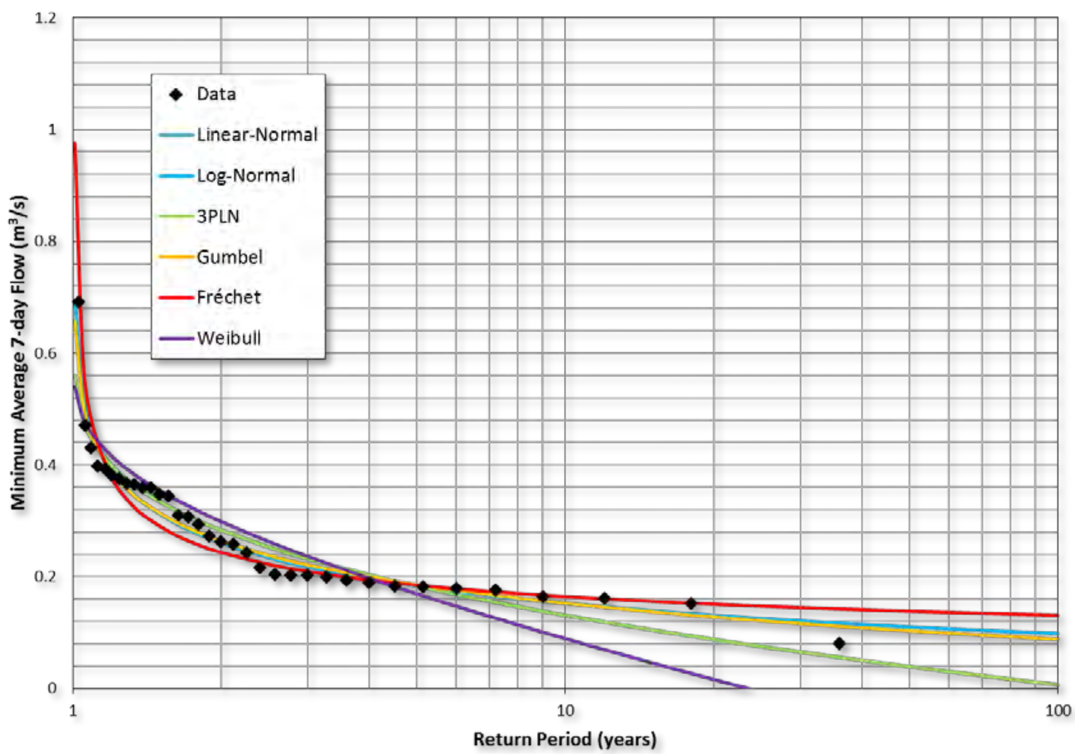

Figure 4.5: Statistics on Big Triangle Pond Annual Minimum 7 Day Flow

Table 4.4: Comparison of Big Triangle Pond Watershed Characteristics to Hydrometric Stations

Station ID	Station Name	Start Year	End Year	Monitoring Years	Drainage Area (km^2)	FRACTION TREES (%)	FRACTION SWAMP (%)	FRACTION LAKE (%)	FRACTION LAKE&SWAMP (%)	FRACTION BARREN (%)
	Big Triangle Pond*				49.7	60%	8%	16%	24%	16%
02ZK002	Northeast River Near Placentia**	1979	2013	33	89.6	48%	16%	15%	31%	24%
02ZM016	South River Near Holyrood**	1983	2013	29	17.3	22%	5%	6%	11%	68%
02ZK003	Little Barachois River Near Placentia**	1983	2013	29	37.2	86%	11%	2%	13%	1%
02ZK004	Little Salmonier River Near North Harbour**	1983	2013	29	104	23%	38%	8%	46%	31%
02ZK001	Rocky River Near Colinet**	1948	2013	64	301	51%	2%	10%	12%	37%
02ZL004	Shearstown Brook At Shearstown**	1983	2013	29	28.9	70%	0%	4%	4%	27%
02ZL005	Big Brook At Lead Cove**	1985	2013	27	11.2	39%	3%	7%	10%	51%
02ZM006	Northeast Pond River At Northeast Pond**	1954	2013	58	3.63	75%	17%	4%	21%	4%
02ZM009	Seal Cove Brook Near Cappahayden**	1980	2013	32	53.6	38%	1%	12%	14%	51%
02ZN001	Northwest Brook At Northwest Pond**	1966	1996	30	53.3	9%	0%	13%	13%	79%
02ZN002	St. Shotts River Near Trepassey**	1985	2013	27	15.5	88%	0%	12%	12%	0%
02ZL004	Shearstown Brook At Shearstown**	1983	2013	29	16.5	70%	0%	4%	4%	27%

* Calculated

** Source: Regional Flood Frequency Analysis (2014 Update) Newfoundland and Labrador Water Resources Division

A return period of 1 in 50 years was chosen for the annual 7-day minimum flow, which is approximately 0.1 m^3/s. The historical data set recorded a minimum 7-day flow around 0.08 m^3/s, which is less than the 1 in 50 year 7-day minimum flow and more conservative. The historical flow was therefore used for the preliminary assessment of yield for Big Triangle Pond..

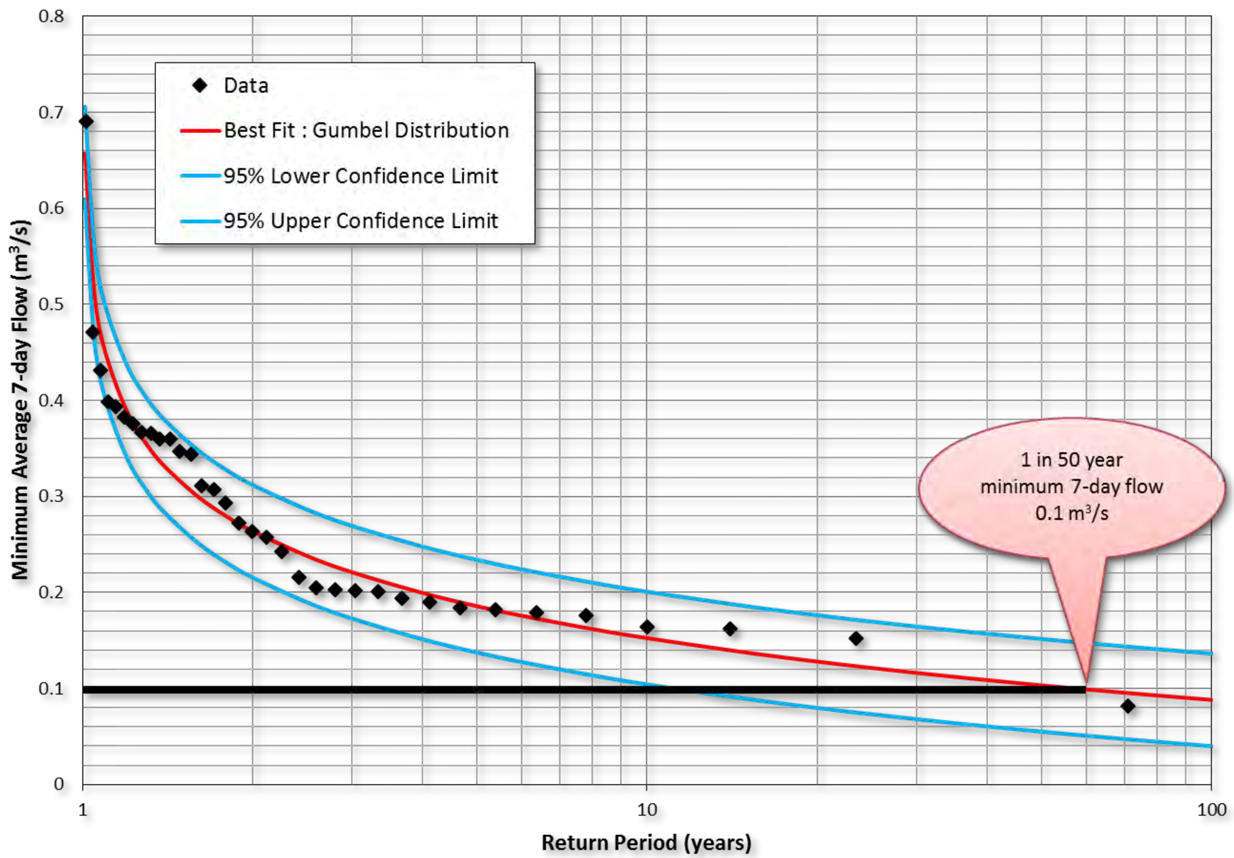

Figure 4.6: Big Triangle Pond Annual Minimum 7-Day Flow for 1 in 50 Year Return Period

4.1.1.2 Stage-Storage

No stage-storage information was available for Big Triangle Pond, which is critical for accurately assessing the reliable yield. Storage is one of the most important aspects of a reliable yield assessment. It is recommended that bathymetric survey be completed in order to evaluate the reliable yield of Big Triangle Pond more accurately.

In order to estimate an approximate stage-storage curve, the stage-storage curve from Thomas Pond was modified based on the difference in mean depths and the surface area of the ponds. Very little reliable data exists with regards to the depth of Big Triangle Pond; however, one Federal Department of Fisheries and Oceans (DFO) Report from 1984 reports the mean depth of Big Triangle Pond as 9.1 ft. (2.8 m) and the mean depth of Thomas Pond as 13.3 ft. (4.14 m). It is unknown how these values were measured or how reliable the data is. The ratio between the mean depths was used to modify the depths of the Thomas Pond stage-storage curve. The ratio of the surface areas of Big Triangle Pond and Thomas Pond was used to directly modify the storage at each depth.

4.1.1.3 Availability of Additional Storage at Big Triangle Pond

Since storage may be a restricting factor for the reliable yield of Big Triangle Pond, options of increasing the storage at this location were explored. Constructing a dam to increase the level of the pond can have some benefits, but it is recommended that a water quality assessment be first carried out, since the pond is surrounded by bogs and this would have the potential of decreasing the water quality of the pond.

An alternative option would be to increase the storage of Big Triangle Pond by constructing a control structure at the outlet of Little Triangle Pond, and slightly raising the available volume in both ponds. Southern Peak Pond could also be used as an additional source. Southern Peak Pond is directly upstream of Big Triangle Pond and connects to Big Triangle Pond through a series of streams and ponds. Similar to Big Triangle Pond, there is no bathymetric information on Southern Peak Pond. DFO reported in 1977, that the mean depth of Southern Peak Pond is 13.6 ft. (4.23 m), which is approximately 1.4 m more than the mean depth of Big Triangle Pond. The topographic relief surrounding the pond also suggests that it may be deeper than Big Triangle Pond. The surface area of Southern Peak Pond is 75 ha which is much larger than the surface area of Big Triangle Pond at 39.7 ha. These findings suggest that Southern Peak Pond has more storage capacity than Big Triangle Pond.

4.1.1.4 Fish Flow Requirements

Allowing enough flow for fish is an essential part of the yield assessment for Big Triangle Pond. The water from Big Triangle Pond eventually drains into the North Arm River and finally into Conception Bay. The North Arm River Project, which is an initiative by Salmon and Trout Restoration Association of Conception Bay Central (STRACC), other non-profits and a group of volunteers, aims to restore the wild salmon population in the North Arm River. This river has experienced a large decline in wild Atlantic Salmon due to a variety of reasons including over fishing, inland poaching, and a significant decrease in spawning and rearing habitat when the Trans-Canada Highway was constructed in 1961. At this location culverts were installed that prevented migrating Salmon from entering Big Triangle Pond and therefore, the other ponds south of the Trans-Canada Highway. In 1991, the culverts were replaced to allow salmon migration. Further efforts are being made to help restore the population of adult salmon in this river.

For this analysis, the fish flow requirement was calculated to be 41,507 m^3/D by using the methodology described in Section 4.2. At this stage in the analysis, the equation chosen corresponds to 25% of the Mean Annual Flow (MAF) and is shown in Table 4.5. Using a standard method for assessing the flow required for fish can be useful for preliminary assessment of yield; however, a full wetted perimeter study is recommended to confirm the amount of flow required for fish.

Table 4.5: Method Chosen for Estimating Fish Flow from Big Triangle Pond

Threshold Method	Equation	Flow (m^3/D)
25% MAF	$Q_{\text{Threshold}} = 0.0093DA + 0.0182$	41,507

4.1.1.5 Results

It is important to note that this assessment is based on very little information, and therefore, has a very high level of uncertainty. The yield for Big Triangle Pond was determined by using the pro-rated historical time series from Station 02ZK002 as inflow into the reservoir and includes a coarse assumption for fish flows, whereby they were set at a constant rate and not dependent on water levels in the ponds. Groundwater seepage into and from the pond, as well as infiltration and evaporation from the pond were not included. The storage curve, estimated by adjusting the storage curve of Thomas Pond based on surface area and mean depth, was used to relate flow and water level. Water extraction was then increased until the water level reached a maximum of 2 m below the normal water level (assumed to be 98 m from 10-m topographic data). Based on this analysis, the reliable yield is approximately 17,000 m^3/D. It is important to note the affect that the amount of storage available has on the reliable yield. When the storage is increased by 50%, the reliable yield increases by approximately 85%, to 31,000 m^3/D. When it is decreased by 50%, the pond cannot provide any sustainable reliable yield. Storage is one of the limiting factors in this assessment. If storage is not available at Big Triangle Pond, increasing the storage by including Southern Peak Pond should be evaluated.

This above analysis is summarized in Table 4.6. Note that the reliable yields presented in Table 4.6 include the allowances for fish flow (i.e. the fish flow allowances have been subtracted from the figures presented in Table 4.6).

Table 4.6: Results of Reliable Yield Assessment and Sensitivity to Available Storage

Pond	Reliable Yield	Notes
Big Triangle Pond	17,000 m^3/D	Storage Curve Modified Directly from Thomas Pond
Big Triangle Pond	31,000 m^3/D	Storage Increased by 50%
Big Triangle Pond	No sustainable yield	Storage Decreased by 50%

4.1.1.6 Future Works

Many assumptions were made in order to provide a preliminary estimate of reliable yield for the Big Triangle Pond. More reliable data is required in order to refine and better assess the reliable yield at this location. The following information will be required in order to provide a more accurate evaluation of the yield:

- Survey, including:
  - Bathymetric survey of both Big Triangle Pond and Southern Peak Pond for stage-storage information.
  - Topographic survey of Big Triangle Pond, Southern Peak Pond and Little Triangle Pond including culverts at Trans-Canada Highway.
- Pond level monitoring for Big Triangle Pond, Little Triangle Pond and Southern Peak Pond.
- Flow gauging at outlet of Little Triangle Pond and at the various inflows to Southern Peak Pond or Big Triangle Pond. This will also help to assess the contribution of groundwater to the yield.
- Complete hydrologic and hydraulic model calibrated to long term monitoring and surveyed data in order to determine the natural variation of the water level in the ponds and the hydrodynamics of the pond system.
- Wetted perimeter study for required fish flow.

- It is noted that if Southern Peak Pond is also investigated as a potential source, similar information will be needed at this location to produce a dependable estimate of reliable yield.

4.2 Wetted Perimeter

Environmental instream flows are defined as flows in a river that are deemed as minimum flow required for maintaining the aquatic ecosystem. Flows below these thresholds are considered hazardous to river ecosystem and do not provide adequate wetted perimeter. Three major categories in which these flow thresholds are evaluated are the Habitat method; the Hydraulic Rating method; and the Hydrological method. The Hydrological method has been recognized as the most popular method to estimate the environmental instream flow requirement to allow for river ecosystem conservation, and therefore, is used in this study.

The Hydrological method is based on the history of flows. It relies solely on the recorded, or estimated, streamflow. There are several ways in this method to describe the environmental instream flow requirement as thresholds. Some methods assume that a percentage of the mean flow is needed to maintain a healthy stream environment. Other hydrological methods recommend flows based on the flow duration curve or an exceedance probability. In this study, four different hydrologically-based methods were examined to estimate the required instream flow, including:

- 85 percentile flow duration curve.
- 95 percentile flow duration curve.
- Tennant's method.
- 25% of the mean annual flow.

The required flows have been estimated for a group of selected hydrometric gauges on the island of Newfoundland. Comparison of the methods and analysis of water availability from each method were carried out. Then, regional models were developed using regression analysis that estimates the required stream flows at any site within the region. These regional models were applied to the current and potential water supply sources to determine minimum flow required at the outlets to allow for aquatic habitat conservation.

4.2.1 Study Area and Data

The study area is the Island of Newfoundland. Streamflow data are available through the HYDAT database (Environment Canada) for rivers in the province. The criterion for selecting gauges included:

- Minimum of 20 years of complete streamflow record.
- Unregulated rivers.
- Drainage areas up to 100 km^2.

This lead to the selection of 27 gauged stations, as presented in Appendix D. It should be noted that only complete years of data were used in this study with no attempt to extend the recorded data. An illustration of the gauge locations is also presented in Appendix D.

4.2.2 Environmental Instream Requirement as Threshold

Details on how to estimate instream flow requirement using different hydrological methods are provided in this section.

4.2.2.1 Percentiles of FDC

As discussed earlier, a certain percentile of flow duration curve (FDC) can be used as instream flow thresholds, for example, Q85 or Q95. It should be noted that the percentiles derived based on period of record FDC are more sensitive to extreme low flow events than other methods, even though a period of record more than the minimum recommended ten years may have been taken. Period of record FDCs were constructed for the 27 selected hydrometric gauges. The 85th and 95th percentiles of them were adopted as instream flow requirements. These percentiles can be used as a constant threshold flow of minimum environmental instream flow requirement throughout a year.

4.2.2.2 Percent of Mean Annual Flow

The mean annual flow (MAF) is based on complete years of record data available from each hydrometric gauge under study. It is calculated by first finding the mean flow of each year of data, and then taking the mean of these means. This type of instream requirement is less sensitive to extreme low flows than the FDC method. Two different percentages of MAF were selected in this study as threshold values: Tennant's method and 25% MAF.

Tennant's Method

Tennant's method takes into account seasonal variability of flow, and it reduces the weight given to extreme stream flows as compared to period of record FDCs. Because of these advantages, Tennant's method is now widely used.

It was concluded in Tennant's 1976 study, that aquatic habitat conditions were similar on streams carrying similar MAFs. Width, depth and velocity of stream flows were considered and studied as the important physical instream flow parameters which are vital to the well-being of aquatic organisms and their habitat. The changes in these parameters were studied and categorized to reveal the aquatic condition. Tennant concluded that the width, depth, and velocity all changed more rapidly from no flow to a flow of 10% of the average than in any range thereafter. It was found that 10% of the average flow covered 60% of the substrates, depth average 0.3 m, and velocities averaged 0.2 m/s. Tennant's study showed that these are critical points, or the lower limits, for the well-being of many aquatic organisms, particularly fish. This substantiates the conclusion that this is the area of most severe degradation, or that 10% is a minimum short term survival flow at best. Flows from 30% to 100% of average result in a gain of 40% for wetted substrate, average depth increases from 0.5 m to 0.6 m, and average velocities rise from 0.2 m/s to 0.5 m/s. These are within good to optimum ranges for aquatic organisms.

Tennant then defined recommended flows during summer and winter months, according to different river conditions for aquatic life, that are necessary to be maintained or enhanced. Table 4.7 summarizes Tennant's Method.

Table 4.7: Tennant's Method

River Condition	Recommended Minimum Flow (%MAF)	
	October to March	April to September
Flushing or Maximum	200%	200%
Optimum Range	60 to 100%	60 to 100%
Outstanding	40%	60%
Excellent	30%	50%
Good	20%	40%
Fair or Degraded	10%	30%
Poor or Minimum	10%	10%
Severe Degradation	< 10%	< 10%

The good river condition is used as the environmental instream flow requirement in the current study. Therefore, 20% MAF and 40% MAF (on average 30% MAF) are defined as the recommended minimum flow to maintain good condition in winter and summer respectively.

25% MAF

This method is also called the modified Tennant's method. Similar to the percentile of the period of record FDC, the threshold value is held constant throughout the year for this method. This threshold is widely used throughout Atlantic Canada since a fixed percentage of MAF is best suited to water abstraction systems whose intake structures corresponds to a specific stream water elevation.

4.2.2.3 Threshold Stream Flows

For each selected hydrometric gauge, the above mentioned stream flow thresholds were computed. The results are tabulated in Appendix D.

4.2.3 Comparison of Estimated Flows at Different Thresholds

In terms of comparing the estimated flows at different thresholds, the Tennant's method is easily compared to the 25% MAF as they both use a fixed percentage of MAF (Tennant's method is on average equal to 30% MAF). The Tennant's method is 20% below the 25% MAF for the period of October-March, and it exceeds the 25% MAF by 60% for the periods April-September. Comparison of the estimated flows obtained from other methods is not as straightforward. Therefore, a percentage difference between estimated flow from FDC Q85 and Q95 with 25% MAF method is calculated for the selected hydrometric gauges. Figure 4.7 illustrates these comparisons in the form of a boxplot. The y-axis represents a percentage difference between estimated flow for the compared method and the 25% MAF. 0% represents the complete agreement between the estimated flows of the two methods. One can observe from this graph that the estimated flows for FDC Q95 method show a significant underestimation in contrast to the 25% MAF and have the lowest threshold values.

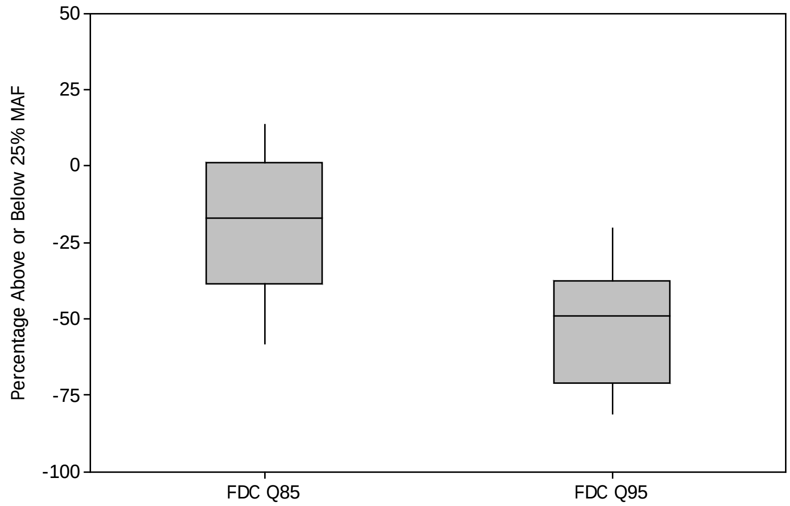

Figure 4.7: Comparison of Estimated Flows for Different Threshold Methods with 25% MAF

4.2.4 Water Availability

Following the instream flow technique comparative study, an analysis of water availability was carried out by calculating the probability of occurrence of the instream flows. It determines the percentage of the time that the stream flow is greater than the calculated threshold flow for all the available period of data.

Using FDC Q85 and Q95, minimum instream flow requirement would be available 85% and 95% of the time respectively by definition. The results of this analysis for the other hydrologically-based methods for Newfoundland hydrometric gauges are provided in Appendix D.

It can be observed from the provided data that the Tennant's method (taken as 30% MAF on average) provides the lowest probability of exceedance followed by 25% MAF method as expected. The method with the highest probability of exceedance, and therefore, lowest instream flow threshold, is FDC Q95. This means that using this particular technique as water abstraction regulation could in fact allow removing available stream flow 95% of time which leaves the required instream flow for other usages only 5% of time.

Based on the provided results, instream flows calculated using the Tennant's method on average are available 73.23% of the time for the gauges under study. The 25% MAF provides on average available instream flows 78.94% of the time.

It can be concluded that the Tennant's method provides the best degree of protection of aquatic sources followed by 25% MAF method. The FDC Q95 method clearly results in the lowest instream flows, and therefore, is not recommended as instream flow technique in Newfoundland.

4.2.5 Regionalization of Instream Flow Requirements

Hydrologically-based instream flow assessments can be applied on a regional basis using regression analysis. Regional regression equations can be obtained by linking instream flow thresholds to physiographic characteristics of watersheds such as drainage area.

Linear relationships between stream flow threshold values (m^3/s) of different methodologies and the respective drainage areas (km^2) for all gauges under study were obtained. Figure 4.8 present these linear relationships. Table 4.8 provides the final prediction equations along with their R-squared values which show a strong relationship between thresholds and drainage areas.

Table 4.8: Relationship between Thresholds and Drainage Areas in Newfoundland

Threshold Method	Equation	R^2
25% MAF	$Q_{Threshold} = 0.0093DA + 0.0182$	0.8206
20% MAF	$Q_{Threshold} = 0.0075DA + 0.0145$	0.8206
40% MAF	$Q_{Threshold} = 0.0149DA + 0.0290$	0.8206
FDC Q85	$Q_{Threshold} = 0.0074DA + 0.0365$	0.5437
FDC Q95	$Q_{Threshold} = 0.0036DA + 0.0447$	0.4104

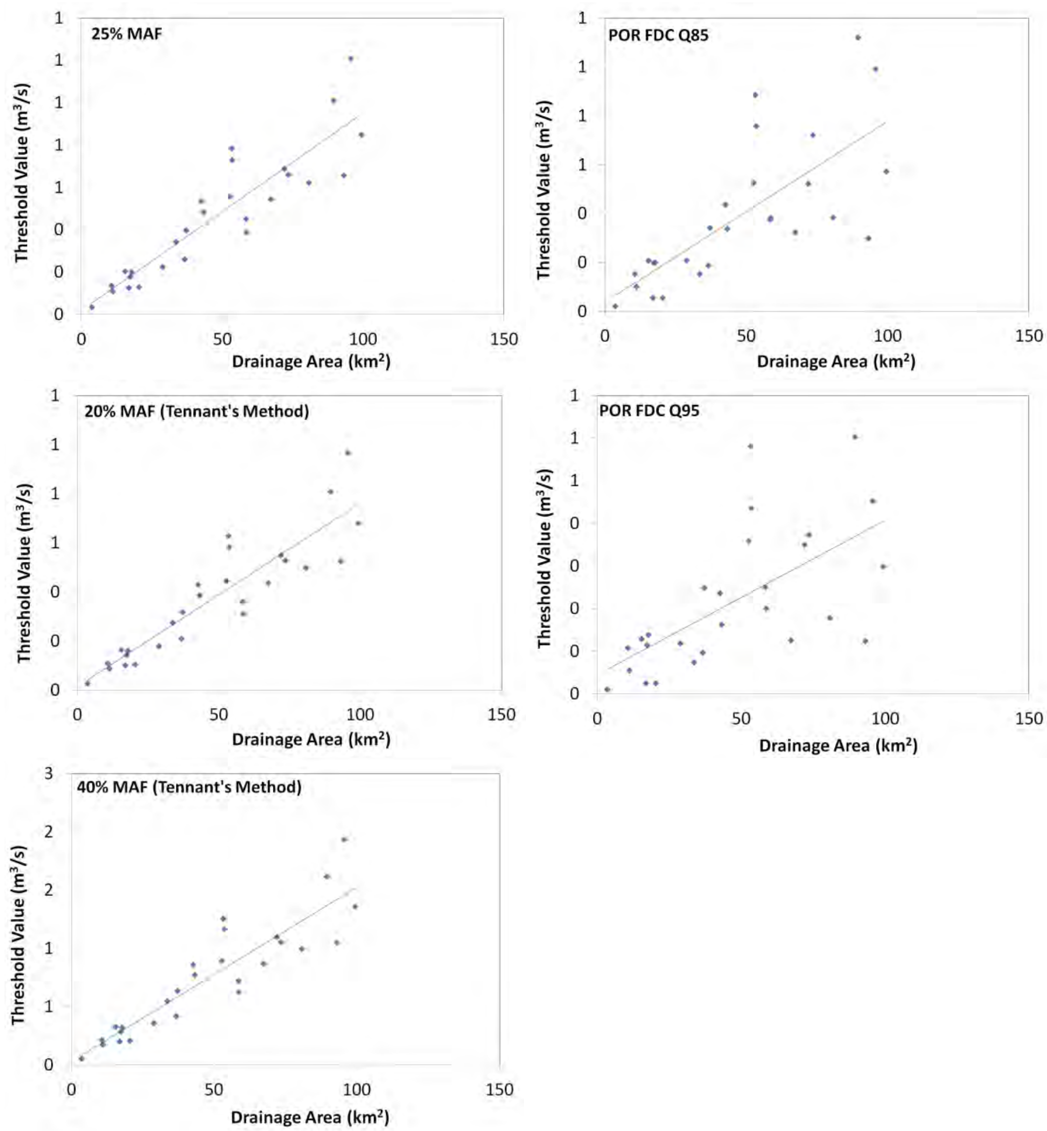

Figure 4.8: Threshold Values as a Function of Drainage Areas of Newfoundland Gauges

Using these regression sets, estimates of the instream required flows for any desired location within the study region can be obtained. Drainage areas were delineated for the water supply sources and are provided in Table 4.9. The table also provides the summary of the minimum required flows at the outlet of water supply reservoirs for aquatic habitat conservation using the regional regression equations.

Based on the previous discussions, it is concluded that the Tennant's method provides the best degree of protection of aquatic ecosystems in comparison to other methods. Tennant's method takes into account seasonal variability of flow, and it reduces the weight given to extreme stream flows. In order to maintain good river condition, 20% MAF and 40% MAF are defined as the recommended minimum flow in winter and summer respectively. The relevant minimum flows based on this methodology and for the reservoirs under study can be obtained from Table 4.9.

Table 4.9: Required Flows (m^3/D) at the Outlet of Water Supply Reservoirs

Source	DA (km^2)	25% MAF	20% MAF*	40% MAF**	FDC Q85	FDC Q95
WL	15.8	14,256	11,491	22,810	13,219	8,813
BBBP	36.4	30,845	24,883	49,334	26,438	15,206
PHLP	5.0	5,616	4,493	8,986	6,394	5,443
North Pond	0.8	2,246	1,814	3,542	3,629	4,147
Thomas Pond	40.4	34,042	27,475	54,518	28,944	16,416
Big Triangle Pond	49.7	41,472	33,437	66,528	34,906	19,354

* Required flow for October-March period

** Required flow for April-September period

As noted in Section 4.1, fish flows are not provided at WL or PHLP. The 20% MAF figure for BBBP is close to the fish flow that is currently being released.

4.3 Watershed Conflicts

Some examples of potential conflicts include:

- Agriculture.
- Forestry.
- Quarrying.
- Tourism/recreation.
- Power generation.
- Fisheries.
- Mining.
- Peat harvesting.
- Existing developments.
- Aquatic habitat.
- Seaplane bases.

Conflicts with Current Sources

- BBBP: Although BBBP is a designated protected water supply under the "Water Resources Act", it also provides water to the Petty Harbour hydroelectric plant.

Conflicts with Potential Sources

- Thomas Pond: Currently part of the Topsail Generating Station supply, water from Thomas Pond supplements Paddy's Pond. There is also a rock quarry located within the Thomas Pond drainage area. Thomas Pond has also been a frequented location for recreation, such as camping and water sport. In April, 2015 the City of St. John's cleaned up the camp sites and dug ditches to deter such illegal camping and dumping.
- Big Triangle Pond: A subbasin of North Arm Brook, Big Triangle Pond basin also contains part of the Avalon Wilderness Reserve and is subject to mineral exploration. In addition, this potential source drains to North Arm Brook, which is a scheduled Salmon River.

4.4 Watershed Protection

In the St. John's area, there are two options for protecting a water supply:

- Designation of a watershed as protected public water supply area (PPWSA) under Section 39 of the "Water Resources Act" (ex. BBBP).
- Protection of a watershed under the "City of St. John's Act" (ex. WL). It is noteworthy that the minimum requirements set out in the "Water Resources Act" apply to a watershed that is protected under the "City of St. John's Act".

ENVC has developed a wealth of information on watershed protection measures, which can be found on the department's website at the following link:
http://www.env.gov.nl.ca/env/waterres/quality/drinkingwater/protectedareas.html

Policy Directive W.R. 95-01, "Policy for Land and Water Related Developments in Protected Public Water Supply Areas", lists activities that are prohibited and regulated within a PPWSA, and can be found at the following link: www.env.gov.nl.ca/env/waterres/regulations/policies/water_related.html. Some examples of prohibited activities include the following:

- Placing, depositing, discharging or allowing to remain in the area, material that might negatively affect the quality of the source.
- Use of intake ponds, lakes, or buffer zones for activities that might negatively affect the quality of the source.
- Storing or discarding pesticides, use of manure or chemicals within a buffer zone, or clearing of large areas of land.
- Aggregate extraction and mineral exploration, and the operations and facilities required to carry out such activities.

Regulated activities in a PPWSA require prior written approval from the Minister. Some examples of regulated activities include:

- Construction of buildings and related land development activities, such as land clearing, drainage, and installation of access roads and services.

- Development of farm lands.
- Recreational activities.
- Installation of pipeline for sanitary, storm or water transmission.

W.R. 95-01 also describes the process for obtaining approval from the Minister, buffer zones, responsibilities of the municipal authority, and corrective measures in the event the quality of the source has been compromised.

If there are conflicting uses within the PPSWA, a watershed management plan is recommended. Once a watershed has been designated as PPWSA, the provincial government and the municipality can control development inside the watershed through permitting. ENVC encourages the establishment of a watershed management committee, which is responsible for developing, implementing and monitoring the watershed management plan. The objectives outlined in the watershed management plan can be achieved through the implementation of existing regulations, best management practices and education. Acts, regulations and policies have shown to be the most effective means of enforcing a management plan; for example, the "Water Resources Act" regulates development within a PPWSA, and Policy Directive W.R. 95-01 clearly defines buffer zones (areas where development is prohibited) around waterbodies. Similarly, many best management practices, or guidelines, have been developed by various government agencies, for example the Wildlife Division has developed guidelines to deal with the removal of beavers in the case of giardiasis, also known as beaver fever, outbreaks. Educating and involving the community is also an effective way to administer the watershed management plan. Members of the community should be encouraged to monitor and report any irregular or inappropriate activities within the watershed. The report titled *A Municipal Guide to the Development of a Watershed Management Plan* developed by ENVC in 2007 includes an extensive list of regulatory, non-regulatory, and educational items to help achieve goals set out in a watershed management plan.

4.5 Groundwater Development Potential

A desktop investigation was carried out and provided an indication of the aquifers and geographic areas where the potential for groundwater supply development appeared to be greatest. This assessment was completed by reviewing and analyzing the following sources of data:

- Engineering and servicing studies, groundwater supply assessments for subdivision developments, and government-commissioned hydrogeological investigations.
- Mapping of topography, hydrology, quaternary and bedrock geology, watersheds and wetlands.
- Drilled well records to summarize the range of well depths, depth to bedrock, static water level, yield, fracture occurrence and bedrock descriptions.
- Aquifer testing data to determine the bedrock transmissivity for given bedrock units.
- Consultation with local government officials and drilling contractors to determine any additional information.

4.5.1 Hydrogeologic Setting

- The Northeastern Avalon Peninsula is underlain by a broad range of rock types:
  - Broad groupings include plutonic, volcanic and sedimentary to metasedimentary, collectively characterized by fracture flow through crystalline rock.

- The predominant overburden type is mapped as granular till and exposed-to-poorly concealed bedrock:
  - Figure 4.9 shows 14 isolated deposits of glaciofluvial material throughout the study area, which would typically be predominantly sand and gravel material, with the potential to provide desirable well yields.
  - One study identified outwash channels along the coastal areas of CBS (between Topsail Cove and Seal Cove), including several channels mapped to the southeast of Seal Cove, with thicknesses of up to 15 metres (FracFlow, 1984).
  - The province's drilled well database indicates that these units have not been widely developed.
- Contacts between adjacent bedrock formations are oriented predominantly from north to south, with local deviations associated with folding, syncline-anticline structures and coastal zones:
  - In the crystalline rocks of the Northeastern Avalon, the orientation of structural features (contacts, bedding planes, local faults and fractures) is expected to influence groundwater flow patterns and well yields.
  - Regional flow paths are expected to originate near the centre of the NE Avalon Peninsula and discharge to near and more distant coastal areas.
  - Local flow paths are expected to originate in upland areas and discharge to nearby rivers and bays.
  - Numerous inland lakes and wetlands throughout the study area are potential groundwater recharge features.
  - Highly productive wells are those that have intercepted major fractures or fracture networks.
  - The productivity of these wells may be controlled by as few as one or two individual, local structural features.
- Aquifer vulnerability mapping is shown on Figure 4.9 (areas with the greatest apparent vulnerability are shown in red) (CBCL Limited, 2013).
  - Exposed bedrock, granular soil, and high transmissivity rock can all contribute to a higher vulnerability index.
  - A higher vulnerability index suggests that the aquifer is more susceptible to contaminants released at the ground surface.

4.5.2 Aquifer Data

Outlined below is a summary of geographic areas and formations where favourable yields are most common. Owing to the crystalline nature of rocks in the study area, the highest well yields are location specific, and can only be confirmed on a case-by-case basis through field investigation:

- Figure 4.9 shows the transmissivity measured through pumping tests of selected wells:
  - The transmissivity provides an indication of the expected long-term yield of the well.
  - Municipal supply wells are typically in an aquifer with a transmissivity of 25 to 100 m^2/day or greater.
  - Transmissivity data provides a reliable indication of the aquifer yield, whereas airlift yield data are variable and provide a very general approximation of the aquifer performance.
  - The transmissivity measured at the Holyrood well field indicates that it is one of the most productive known aquifers in the study area.
- Bedrock units on the Avalon Peninsula were grouped according to an airlift yield index using a geostatistical approach:

- The Bona Vista and Elliot's Cove Formations in the CBS-Paradise area exhibited some of the highest airlift yields.
- Other formations with favourable yields are rocks of the Holyrood plutonic suite and volcanic rocks of the Harbour Main Group.

- Figure 4.9 shows wells with a favourable yield index (in purple):
  - Many of these wells are located in the CBS-Paradise area.
  - Several of these wells are concentrated to the south of Topsail Cove.
  - Several high capacity wells are reported for the zone between St. John's and Mt. Pearl. Higher well yields in this area could be related to regional geologic contacts.
  - Well yields and aquifer productivity in Torbay are moderate to low, yet the density of unserviced development relying on groundwater is relatively high.
  - The airlift yield index was calculated as: Ln [(Yield) / (Well Depth)]. This provides a depth-normalized indication of the rock yield on a log-normal scale (well yields in fractured rock are not distributed on a linear scale).

4.5.3 Well Yields and Demand

- The hydrogeologic setting indicates that considerable exploration and test well drilling would be required in order to develop a well field of 6 or more bedrock wells.
- For larger communities, groundwater resources may be adequate to supply only a fraction of total demand.
- Glaciofluvial deposits may represent a potential groundwater resource that has not been widely explored, and could provide yields in excess of those observed for bedrock units in the study area.

4.5.4 Results

Due to the limited potential that exists to develop a regional groundwater source, only surface water sources will be considered further in this study.

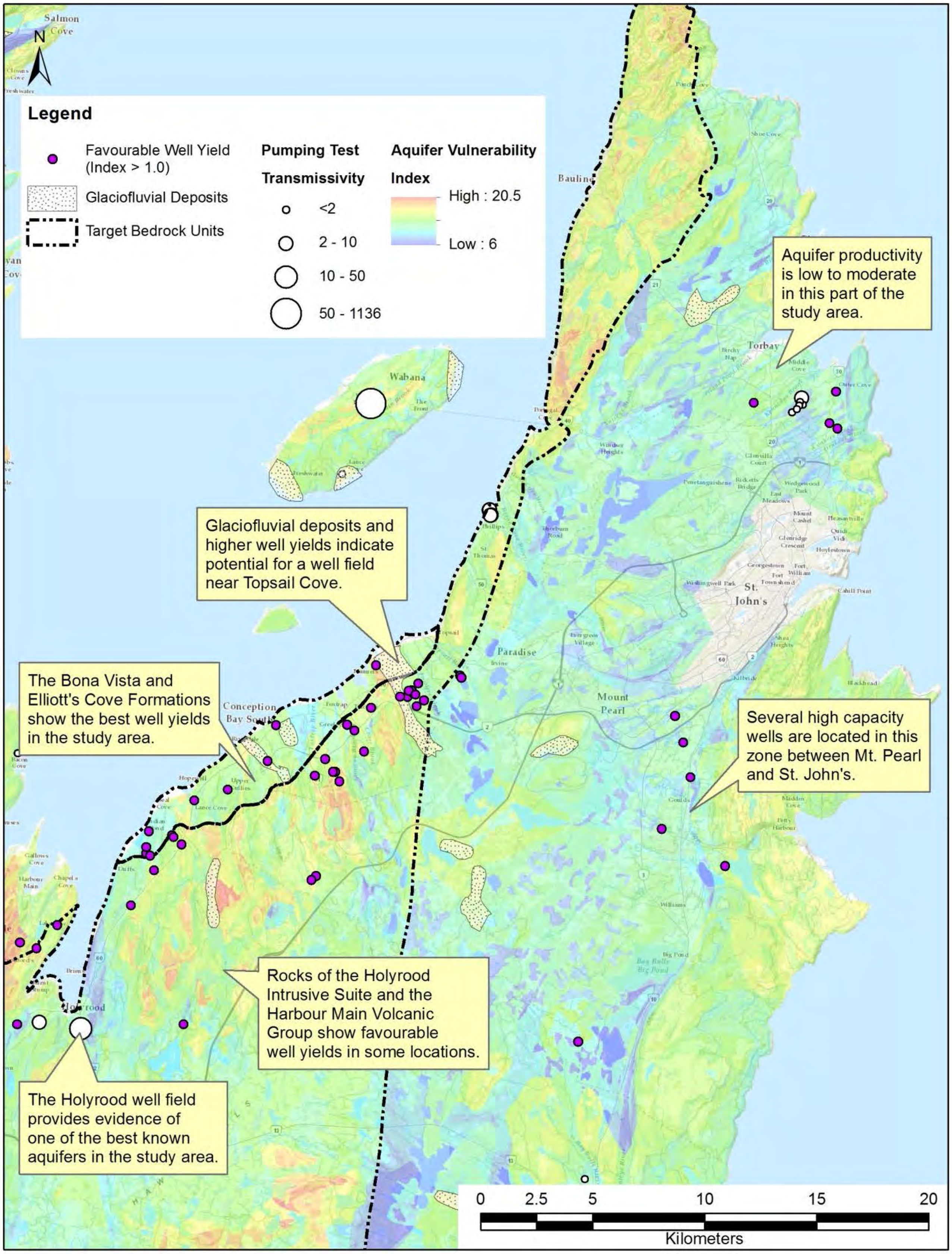

Figure 4.9: Groudwater Development Potential

4.6 Source Water Quality

Water samples were collected for the three current sources as well as North Pond, Thomas Pond, Little Powers Pond and Big Triangle Pond. Table 4.10 provides the dates the samples were taken.

Table 4.10: Water Sample Dates

Source	Date of Sample				
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
WL	22/08/2014 9:05	30/09/2014 9:20	13/11/2014 9:25		
BBBP	22/08/2014 11:05	30/09/2014 11:05	13/11/2014 11:10		
PHLP	22/08/2014 10:25	30/09/2014 10:30	13/11/2014 10:20		
North Pond	22/08/2014 13:10	30/09/2014 12:30	13/11/2014 12:21	04/02/2015 10:50	31/03/2015 15:00
Thomas Pond	22/08/2014 11:50	30/09/2014 11:45	13/11/2014 11:47	04/02/2015 10:05	31/03/2015 14:20
Little Powers Pond	22/08/2014 9:30	30/09/2014 9:45	13/11/2014 9:50		
Big Triangle Pond	04/02/2015 9:30	31/03/2015 13:45			

Appendix E contains the complete results of the water sampling program to date. Of particular interest is raw water quality parameters which vary significantly between sources and/or have a significant impact on the cost and complexity of treatment processes needed to meet potable water quality criteria. These selected parameters are summarized below in Table 4.11, with exceedances of limits set out in the Health Canada document "Guidelines for Canadian Drinking Water Quality" (GCDWQ) bolded.

Table 4.11: Summarized Water Quality Test Results for Existing and Potential Supplies

Parameters	WL	BBBP	PHLP	Little Powers Pond	North Pond	Thomas Pond	Big Triangle Pond
	n = 29	n = 44	n = 10	n = 3	n = 5	n = 5	n = 2
Total Alkalinity (mg/L as $CaCO_3$)	2.2	3.0	1.0	6.1	ND	5.2	7.8
Colour (TCU)	6.2	**20.7**	10.9	**74**	11	**72**	**40**
Total Organic Carbon (mg/L)	2.5	3.5	2.4	10.2	2.6	6.9	4.5
pH	**6.2**	**6.2**	**6.0**	**6.43**	**6.25**	**6.00**	6.70
Turbidity (NTU)	0.5	0.8	0.6	1.26	0.51	1.26	0.42
Iron (μg/L)	31.3	96.7	59.5	**993**	102	**682**	125
Manganese (μg/L)	14.2	28.2	30.7	**104**	**54**	**53**	16

The existing water supplies (WL, BBBP, and PHLP) have a significant degree of variation according to both historical raw water quality data retrieved from ENVC's Water Resources Portal and recent sampling conducted as part of this study. Results from both these sets of data have been included above in Table 4.11.

The most common exceedances of the GCDWQ criteria in the water sources are considered aesthetic objectives—iron, manganese and colour.

For treatability, the water quality can be described in general characteristics by the concentration of organics (represented by colour and TOC), metals (primarily iron and manganese) and particulate matter (represented by turbidity). The "particulate matter" category includes pathogenic (disease-spreading) microorganisms present in the water, or other debris which may act to shield these pathogens from disinfection processes. The primary goal of water treatment facilities is to prevent viable pathogens from entering the distribution system. Colour is loosely correlated with the concentration of dissolved organics in the water. While colour is only an aesthetic objective, the concentration of organics is a special concern for treatment. If not removed from the raw water prior to chlorination, free chlorine and complex organic molecules react to form disinfection by-products (DBPs), including trihalomethanes (THMs) and haloacetic acids (HAAs) which have maximum limits recommended by Health Canada. Metals with aesthetic objectives, such as iron and manganese, are a concern as specialized treatment processes may be required to achieve effective removal.

The water quality characteristics of the existing and potential water sources are summarized below in Table 4.12, with the relative presence or absence of the characteristics of concern for treatability compared. The ranges of different parameters that were used to define the "low", "medium" and "high" designations in Table 4.12 are relative only to the sources being considered under this study. For example, on a broad scale all the noted sources would be considered to have low particles (i.e. turbidity), but relative to one another there are differences and preferences with respect to treatment. The ranges used to define the categories are noted in Table 4.13.

Table 4.12: General Water Quality Comparison of Existing and Potential Sources

Source	Organics	Metals	Particles
WL	Low	Low	Low
BBBP	Medium	Low	Medium
PHLP	Low	Low	Low
North Pond	Low	Medium	Low
Thomas Pond	Medium	High	High
Little Powers Pond	High	High	High
Big Triangle Pond	Medium	Low	Low

Table 4.13: Water Quality Ranges Used in Defining Comparison for Existing and Potential Sources

Source	Organics	Metals	Particles
Low	Colour < 15 TCU TOC < 3 mg/L	Fe < 300 μg/L Mn < 50 μg/L	Turbidity < 0.7 NTU
Medium	15 < Colour < 50 3 < TOC < 10	300 < Fe < 500 50 < Mn < 100	0.7 < Turbidity < 1.0
High	Colour > 50 TCU TOC > 10 mg/L	Fe > 500 μg/L Mn > 100 μg/L	Turbidity > 1 NTU

WL and PHLP have low levels of each of the general characteristics, organics, metals and particles. BBBP has a low level of metals but has organics and particle concentrations higher than the other existing facilities. The treatment processes at the WL and BBBP facilities include engineered filtration along with modified disinfection processes to mitigate the formation of DBPs. In the WL and PHLP facilities, primary disinfection is achieved using UV disinfection, which does not produce DBPs. In the BBBP facility, chloramination is used instead of free chlorine for secondary disinfection, greatly reducing the potential for formation of DBPs in the distribution system.

Given the small number of samples taken from the potential sources, the degree of confidence in the treatability of each source is limited. However, if the samples are found to be representative and the treatability is similar to other water sources in the region with similar characteristics, the treatment complexity required in facilities drawing from each of the potential sources may be as follows:

- Little Powers Pond and Thomas Pond – Similar water quality, more challenging for treatment than the three existing or two other potential sources. Suitable treatment processes may include:
  - Coagulation/flocculation, dissolved air flotation.
  - Relatively high doses of coagulation and pH control chemicals at Little Powers Pond.
  - Aeration for iron precipitation.
  - Oxidant addition for metals precipitation.
  - Conventional gravity filtration.
  - Membrane filtration.
  - Catalytic oxidation for continuous metals removal.
  - Conventional disinfection.
  - UV disinfection.
  - Chlorination or chloramination.

- North Pond – Similar quality to WL, suitable treatment processes may include:

- Coagulation/flocculation, dissolved air flotation.
- Oxidant addition for metals precipitation.
- Conventional gravity filtration.
- Membrane filtration.
- Catalytic oxidation for continuous metals removal.
- Chlorine disinfection.
- UV disinfection.
- Chlorination or chloramination.

- Big Triangle Pond – Similar quality to BBBP, suitable treatment processes may include:
  - Coagulation/flocculation, dissolved air flotation.
  - Conventional gravity filtration.
  - Membrane filtration.
  - Chlorine disinfection.
  - UV disinfection.
  - Chlorination or chloramination.

CHAPTER 5 TREATMENT PLANT CAPACITY ANALYSIS

5.1 Existing Treatment Plant Capacities

Table 5.1 presents the maximum day demand for 2014 and the maximum day demand estimates for 2026, 2036 and 2046 along with the watershed reliable yields and treatment plant capacities. The existing treatment plants are designed to provide fully-treated potable water in excess of the capacities presented in Table 5.1 *for short durations*. Factors which determine the maximum *short-term* capacity for each plant differ among the plants; however, parameters such as water quality and hydraulic capacity must be considered. The *short-term* capacities for each water treatment plant are listed below:

- BBBP: 126,000 m^3/D.
- WL: 83,000 m^3/D (summer-time).
- WL: 63,000 m^3/D (winter-time).
- PHLP: 26,000 m^3/D.

Separate from the treatment plant capacities, each of the three watersheds that supply raw water to the treatment plants have finite sustainable water yields. These reliable yields are noted in Table 5.1 and are considered to be the maximum quantity of water that can be consistently and reliably supplied from each water source. It is evident from Table 5.1 that each facility has a capacity which is nearly equal to the watershed yield. Water sources can have short-term yields that are considerably higher than the long-term yields, which can allow treatment plants to operate at higher capacities during periods of increased demand.

To illustrate how the WTPs typically operate, Table 5.2 presents the average day demand for 2014 and average day demand estimates for 2026, 2036 and 2046. However, for long-term planning purposes, the figures presented in Table 5.1 should be used. Figure 5.1 illustrates the information presented in Tables 5.1 and 5.2 graphically.

Table 5.1: Maximum Day Demands and Treatment Plant Capacities

Water System		2014 Total Max. Day Demand	2026 Total Max. Day Demand	2036 Total Max. Day Demand	2046 Total Max. Day Demand	Watershed Reliable Yield	WTP Capacity
		m^3/D	m^3/D	m^3/D	m^3/D	m^3/D	m^3/D
BBBP Service Area	St. John's - BBBP	30,105	31,150	32,022	32,710		
	Mount Pearl	27,492	28,983	30,225	30,414		
	Paradise	12,243	14,165	15,767	16,524		
	Portugal Cove - St. Philip’s	3,586	4,364	5,013	5,163		
	Conception Bay South	18,337	20,937	23,103	23,596		
	Total - BBBP	**91,763**	**99,599**	**106,130**	**108,407**	90,700	85,000
WL Service Area	Total - WL	64,606*	69,099	72,843	74,150	54,500	70,000**
PHLP Service Area	Total - PHLP	15,000***	17,232	19,092	19,360	15,900	14,500
	Total	***171,369***	***185,930***	***198,065***	***201,917***	**161,100**	**169,500**

*The maximum day demand for WL occurred during August 2014.

**Summer-time normal capacity. The WL WTP winter-time capacity is 53,500 m^3/D.

***The maximum day demand estimate for PHLP is based on measured flow data for October and November 2015.

Table 5.2: Average Day Demands and Treatment Plant Capacities

Water System		2014 Total Avg. Day Demand	2026 Total Avg. Day Demand	2036 Total Avg. Day Demand	2046 Total Avg. Day Demand	Watershed Reliable Yield	WTP Capacity
		m^3/D	m^3/D	m^3/D	m^3/D	m^3/D	m^3/D
BBBP Service Area	St. John's - BBBP	24,201	25,041	25,742	26,295		
	Mount Pearl	23,555	24,832	25,897	26,058		
	Paradise	9,689	11,210	12,478	13,077		
	Portugal Cove - St. Philip’s	2,115	2,574	2,957	3,045		
	Conception Bay South	13,661	15,598	17,212	17,579		
	Total - BBBP	***73,221***	***79,256***	***84,285***	***86,054***	90,700	85,000
WL Service Area	Total - WL	52,023	55,641	58,656	59,708	54,500	70,000*
PHLP Service Area	Total - PHLP	12,101	13,902	15,403	15,619	15,900	14,500
	Total	***137,345***	***148,798***	***158,343***	***161,381***	**161,100**	**169,500**

*Summer-time normal capacity.

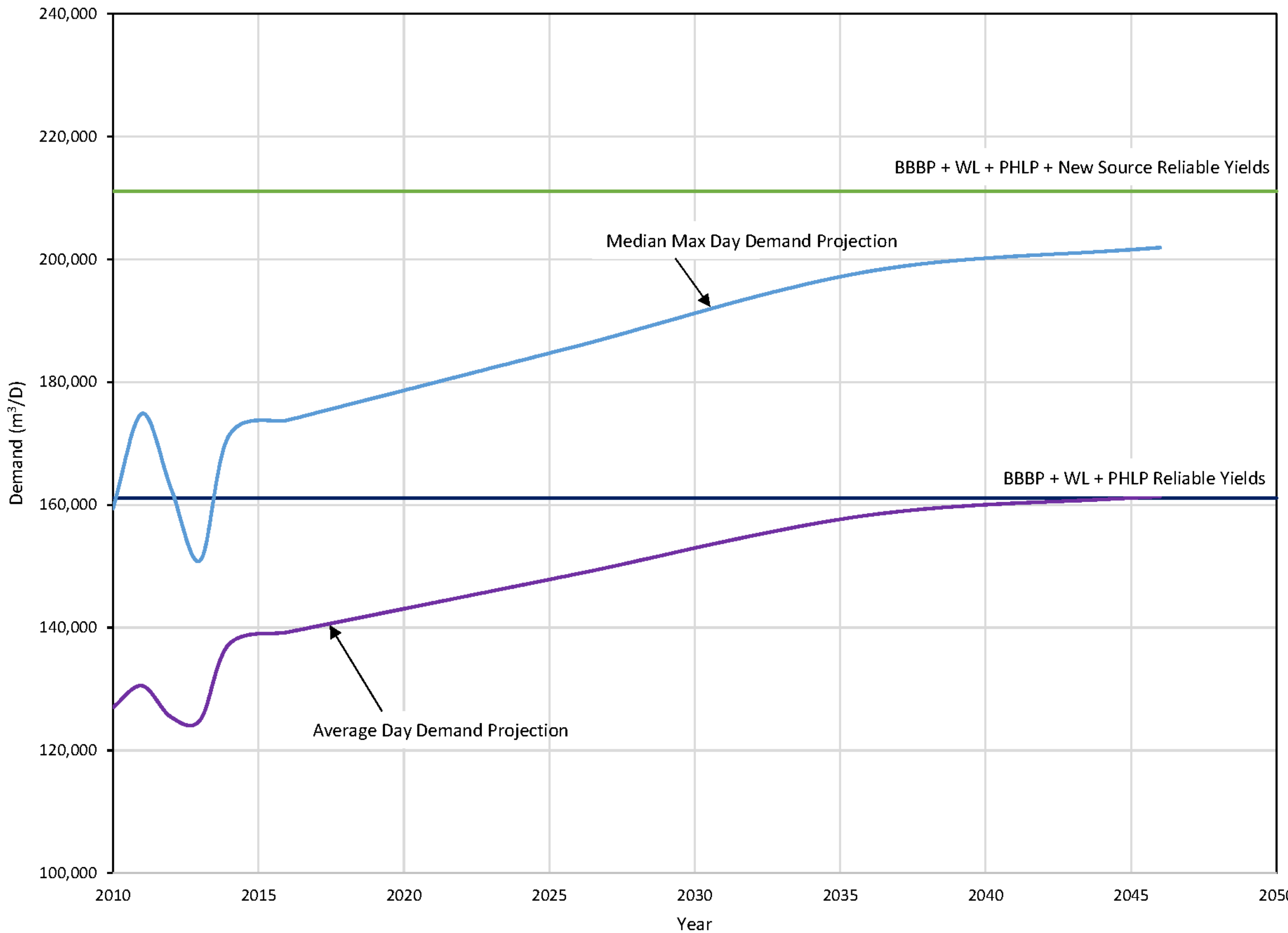

Figure 5.1: Comparison of Water Demands and Reliable Yields Beyond 2016

Considering the reliable yields of BBBP, WL and PHLP, as well as the various planning horizons, the net excess or deficit of water supply capacity in relation to water demand can be examined. Table 5.3 presents a summary of total water deficit based on the projection year being considered. These figures do not account for any additional future system demand that may be present by servicing Torbay or Holyrood.

Table 5.3: Projected Water Supply Deficit Based on Future Maximum Day Demands

Service Area	Projected 2026 Deficit (m^3/D)	Projected 2036 Deficit (m^3/D)	Projected 2046 Deficit (m^3/D)
	vs. Reliable Yield	vs. Reliable Yield	vs. Reliable Yield
BBBP	(8,899)	(15,430)	(17,707)
WL	(14,599)	(18,343)	(19,650)
PHLP	(1,332)	(3,192)	(3,460)
Total	**(24,830)**	**(36,965)**	**(40,817)**

For illustrative purposes, Table 5.4 shows the deficits based on the average day demand projections.

Table 5.4: Projected Water Supply Deficit Based on Future Average Day Demands

Service Area	Projected 2026 Deficit (m^3/D)	Projected 2036 Deficit (m^3/D)	Projected 2046 Deficit (m^3/D)
	vs. Reliable Yield	vs. Reliable Yield	vs. Reliable Yield
BBBP	11,444	6,415	4,646
WL	(1,141)	(4,156)	(5,208)
PHLP	1,998	497	281
Total	**12,301**	**2,756**	**(281)**

5.2 Future Treatment Plant Requirements

Section 4.6 presents the generalized source water quality of potential future sources. Furthermore, Section 4.1 indicates that, among the available additional water sources, Thomas Pond and Big Triangle Pond have potential yields that could offset the water production deficit identified in Table 5.3. The actual available yield of either source is only an approximation at this time, pending further delineation of the watersheds and storage.

Selection of the preferred future source for water supply is a balance between available yield, source water quality, geographical location, and hydraulics. In terms of water quality, the Big Triangle Pond source is preferred, as the sample data suggests the treatment burden to be significantly lower than

Thomas Pond. However, pending a detailed yield assessment, Thomas Pond may be the only supply capable of meeting the future demands based on the assumptions carried for water consumption.

In considering the geographical location and the hydraulic and service boundary aspects of Thomas Pond and Big Triangle Pond, it appears that a reasonable approach to servicing for either supply would be to include Paradise, Portugal Cove - St. Philip's and CBS, plus Holyrood and Torbay in the service area for the new WTP. In one scenario, Thomas Pond would supply water to the Fowler's Road reservoirs and then to the existing serviced municipalities and to the new municipalities at the extreme ends of the new service area. In another scenario, Big Triangle Pond would supply water into Holyrood and onward to the existing municipalities and Torbay at the extreme end of the new service area.

The future total demand of Paradise, Portugal Cove - St. Philip's and CBS is in the range of 40-45,000 m^3/D depending on the projection year considered. Supplying these communities with water from a new source removes the same volume from the BBBP supply, but is less than the 25-40,000 m^3/D total deficit in reliable yield over the study planning horizon (see table 5.3). In order to achieve an overall system balance between the total reliable yield and total demand, including servicing for Holyrood and Torbay, the measures noted below, and summarized in Table 5.5, present a suggested feasible approach to be taken over a long-term planning period. These measures do not include for any demand reduction (conservation).

- Service Paradise, Portugal Cove - St. Philip's and CBS areas from new WTP, achieving a 40-45,000 m^3/D reduction at BBBP.
- Add Holyrood to service area of new WTP, increasing required capacity by about 1-1,500 m^3/D.
- Add Torbay to service area of new WTP, increasing required capacity by about 3,000 m^3/D.
- Transfer portion of WL service area to BBBP service area to achieve a net demand that coincides with the system capacity.

As can be seen in Table 5.5, these measures result in an overall system that balances water supply against reliable yield, while also balancing the supply and demand scenarios for each of the four separate sources and service areas. The net result of this assessment, however, is a projected future water shortage of approximately 50,000 m^3/D. From the preliminary analysis of source and yield potential conducted to date, it appears unlikely that a single source of sufficient capacity can be obtained. In the event that a source capable of supplying 50,000 m^3/D is not feasible, the remaining options for achieving future system balance include developing more than one additional water source and treatment plant, and/or implementing water conservation measures to reduce the overall system demand.

5.3 Proposed Improvements

As noted in Section 4.1, Thomas Pond and Big Triangle Pond have been identified as potential water sources. It appears from the current analysis that the reliable yield for Thomas Pond can support the 2026 maximum day demand for the current service area (i.e. St. John's, Mount Pearl, Paradise, Portugal Cove - St. Philip's and CBS) and for Torbay and Holyrood. However, it is recommended that both water sources be included in the water system master plan as there is a possibility that both sources may be needed in the future. The recommended additional study work for Big Triangle Pond regarding reliable yield is described in Section 4.1 and is summarised again in Chapter 9. It is also recommended that water treatability studies be carried out for both sources.

Table 5.5: Future System Configuration, Service Area Maximum Day Demands and Existing Treatment Plant Capacities

Water System		2014 Total Max. Day Demand	2026 Total Max. Day Demand	2036 Total Max. Day Demand	2046 Total Max. Day Demand	Watershed Reliable Yield	WTP Capacity
		m^3/D	m^3/D	m^3/D	m^3/D	m^3/D	m^3/D
BBBP Service Area	St. John's - BBBP	30,105	31,150	32,022	32,710		
	Mount Pearl	27,492	28,983	30,225	30,414		
	Paradise	12,243					
	Portugal Cove - St. Philip's	3,586					
	Conception Bay South	18,337					
	BBBP (diverted from WL service area)		15,000	15,000	15,000		
	Total - BBBP	**91,763**	**75,133**	**77,247**	**78,124**	**90,700**	**85,000**
WL Service Area	St. John's - WL	64,606	69,099	72,843	74,150		
	(Demand diverted to BBBP service area)		-15,000	-15,000	-15,000		
	Total - WL	**64,606**	**54,099**	**57,843**	**59,150**	**54,500**	**70,000***
PHLP Service Area	***Total - PHLP***	**15,000**	**17,232**	**19,092**	**19,360**	**15,900**	**14,500**
New Service Area	Paradise		14,165	15,767	16,524		
	Portugal Cove - St. Philip's		4,364	5,013	5,163		
	Conception Bay South		20,937	23,103	23,596		
	Torbay		±3,000	±3,000	±3,000		
	Holyrood		±1,500	±1,500	±1,500		
	Total - New WTP		43,966	48,383	49,783	50,000**	
Total – All Serviced Areas		***171,369***	***185,931***	***202,565***	***206,417***	***211,100***	

*Summer-time normal capacity.

**Required.

PHLP1 – Distribution System Upgrades: Mundy Pond Service Area

The current service areas for WL, BBBP and PHLP will change with the introduction of a new water supply and the diversion of water from the WL service area to BBBP (as noted in Table 5.5). It is proposed that BBBP again service portions of the west end of St. John's which are currently serviced by PHLP and that PHLP service the west end of the downtown which is currently serviced by WL. Also, it is proposed that the Mundy Pond service area be expanded to include part of the existing WL service area. Figures 5.2, 5.3 and 5.4 show the existing and proposed 2026 service areas, and the distribution system upgrades which would be required to support the proposed changes.

New WTP

Thomas Pond would supply water to the Fowler's Road reservoirs and onto the existing Paradise/CBS metering chamber through an upgraded transmission main. Figure 5.5 shows Thomas Pond and a preliminary alignment for the transmission main. Figure 5.6 shows a preliminary hydraulic grade line. For Big Triangle Pond, a transmission main through Holyrood which would connect to an existing transmission main in CBS is proposed. Figure 5.7 shows Big Triangle Pond and a preliminary alignment for the transmission main. Figure 5.8 shows a preliminary hydraulic grade line. For both options, a new pump station would be required at the Fowler's Road reservoirs.

New Customer1 – Torbay

An additional water supply is required before new customers can be added to the RWS. As noted in Table 5.5, it is proposed that Torbay ultimately be serviced by a new water source. Transmission system upgrades would be required to bring water to Torbay from the regional water system. Figure 5.9 shows a preliminary alignment and tank location. Figure 5.10 shows a preliminary hydraulic grade line.

New Customer2 – Holyrood

The way in which Holyrood could be serviced in the future depends on whether Thomas Pond or Big Triangle Pond is developed. If Thomas Pond is developed, a transmission main will have to be extended from the west end of the existing CBS system. If Big Triangle Pond is developed, Holyrood could be serviced from the transmission main that would run from the new WTP to CBS.

WL WTP – Process Improvements (Corrosion Control)

The existing lime system at the WL WTP is unable to supply lime at a rate that is sufficient to meet finished water pH and alkalinity targets. Current dosing rates need to be increased significantly in order to meet the targets that are achievable at the BBBP and PHLP WTPs. At WL, the targets can be achieved by relocating the hydrated lime and CO_2 injection points to downstream of the membrane system. This will allow all treated water within the EWSS to have the same stability with regards to corrosion potential. For short-term planning purposes, the City of St. John's has requested that this proposed improvement be noted in this study report. The City of St. John's also provided the cost estimate.

The cost estimates for the distribution system upgrades required for the changes in the service areas and the proposed WTP and supporting infrastructure are presented in Chapter 7.

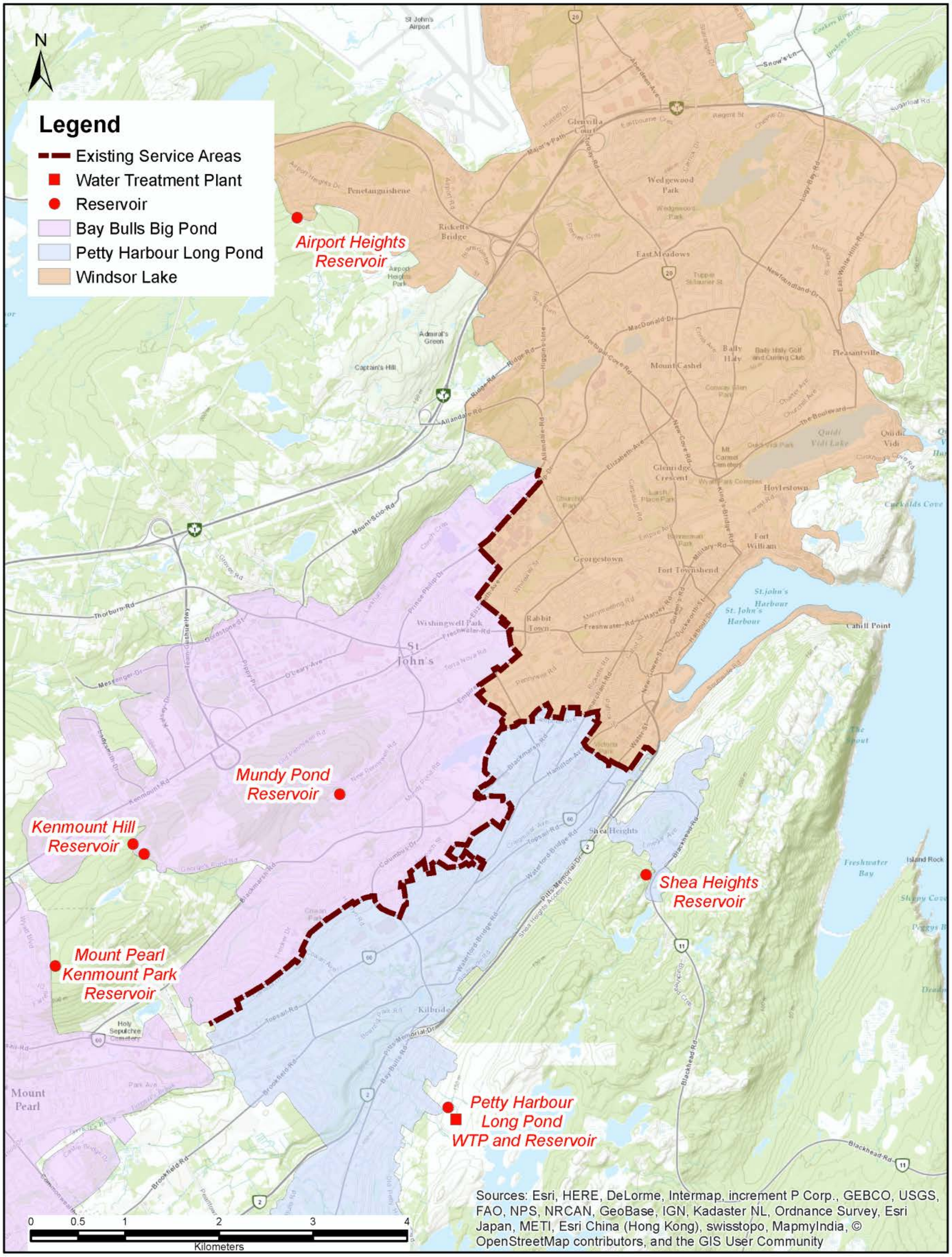

Figure 5.2: Existing Service Areas

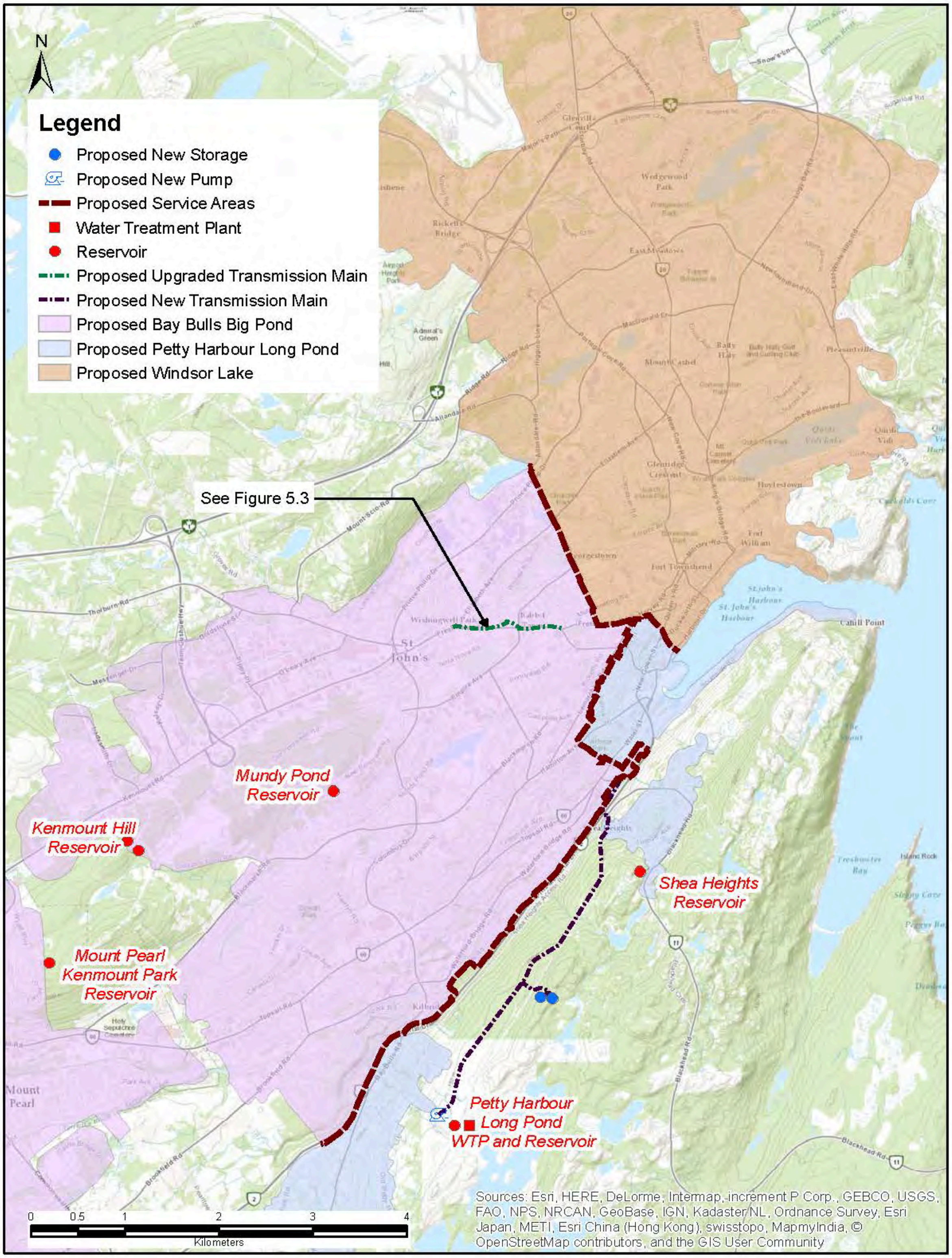

Figure 5.3: Proposed Changes to Service Areas

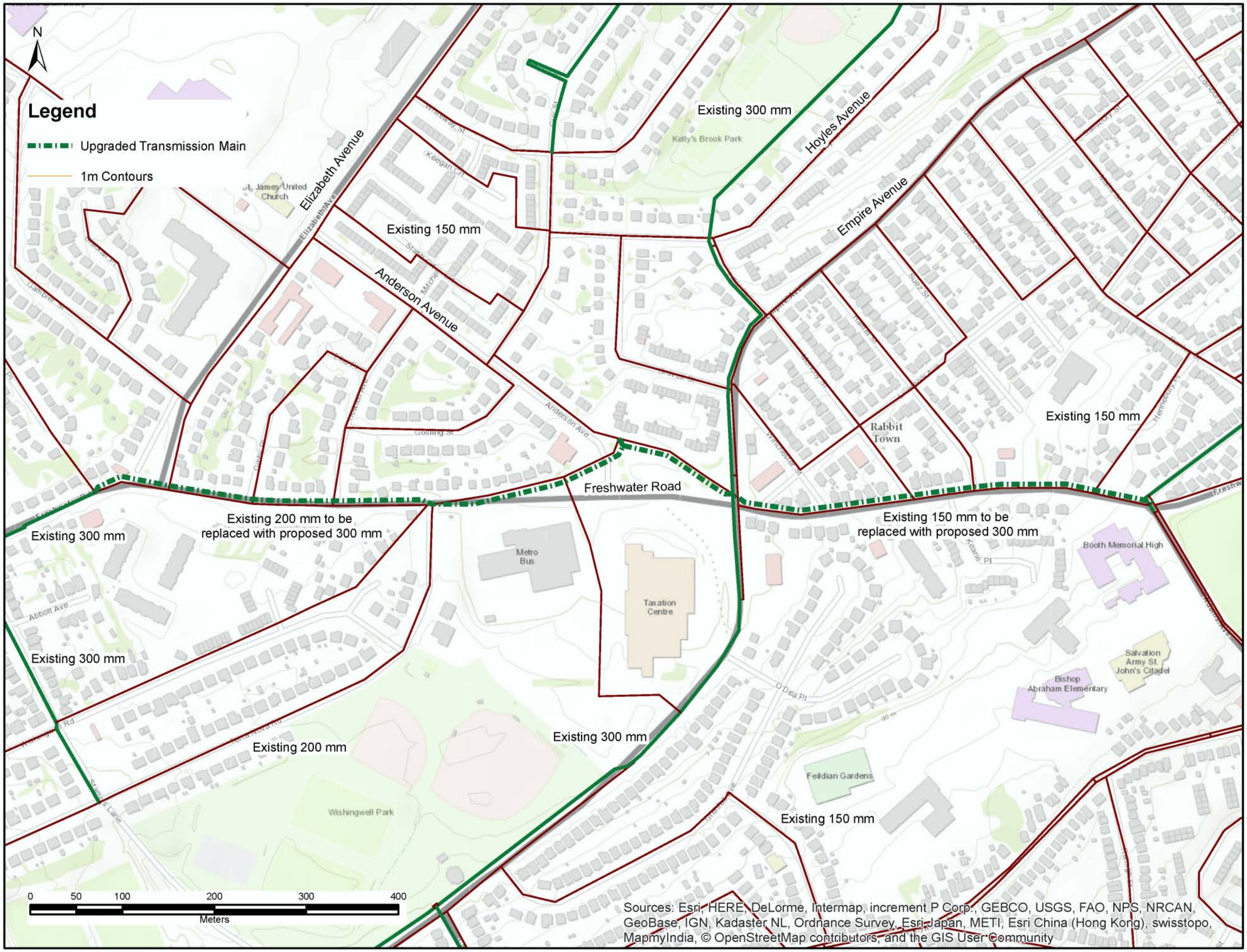

Figure 5.4: Blow-up of Upgraded Transmission Main

Figure 5.5: Thomas Pond

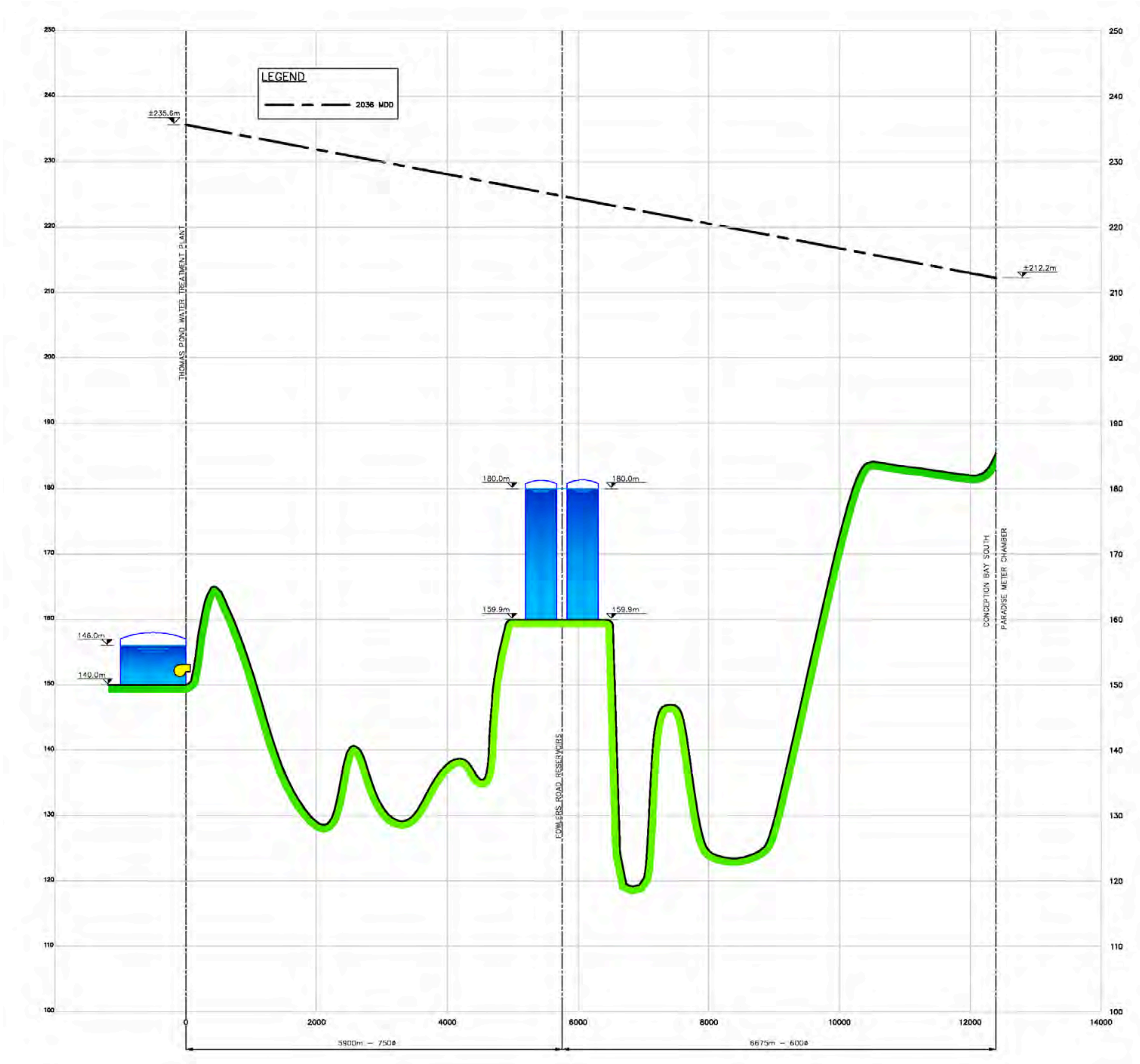

Figure 5.6: Thomas Pond Preliminary HGL

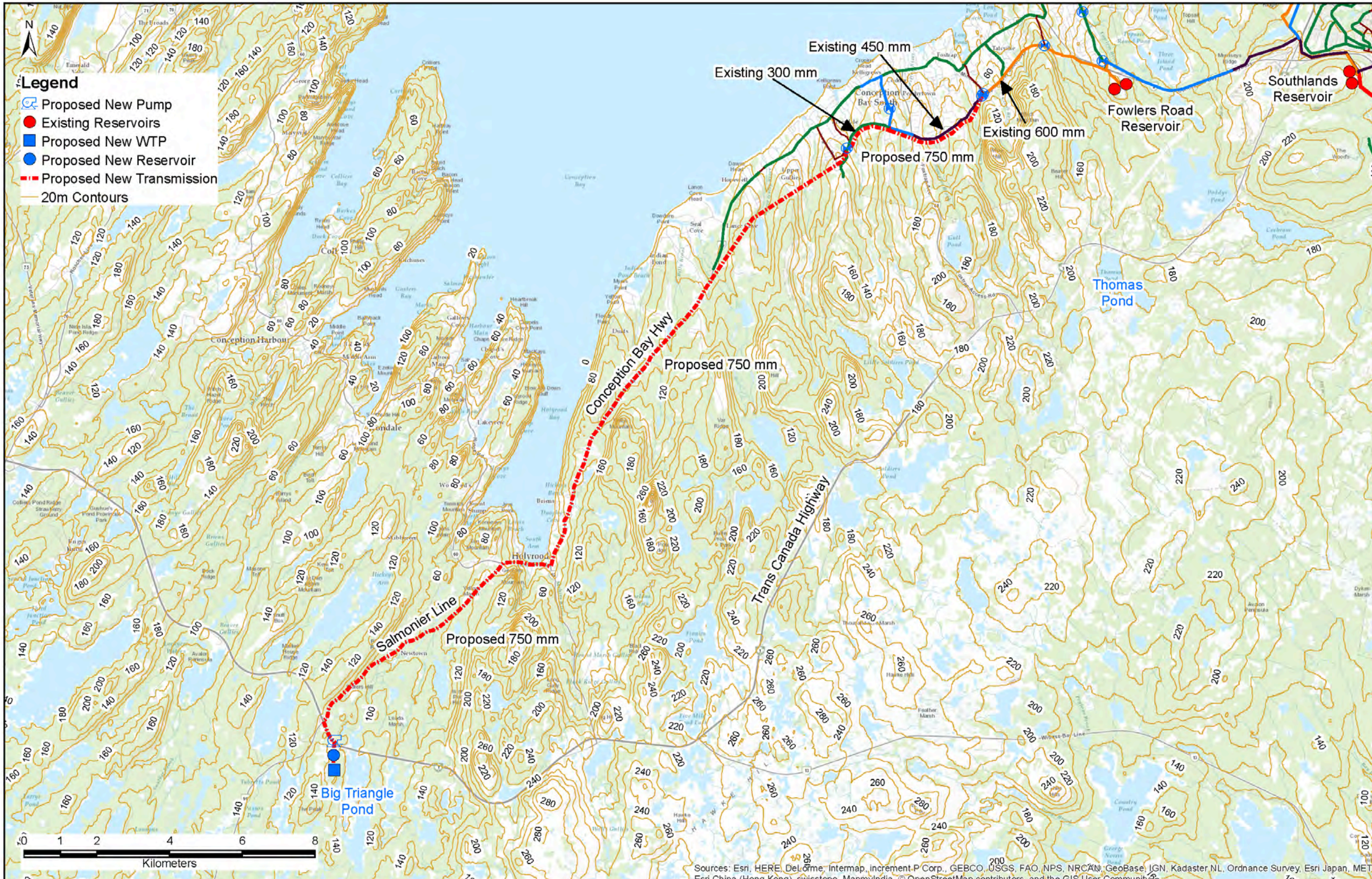

Figure 5.7: Big Triangle Pond

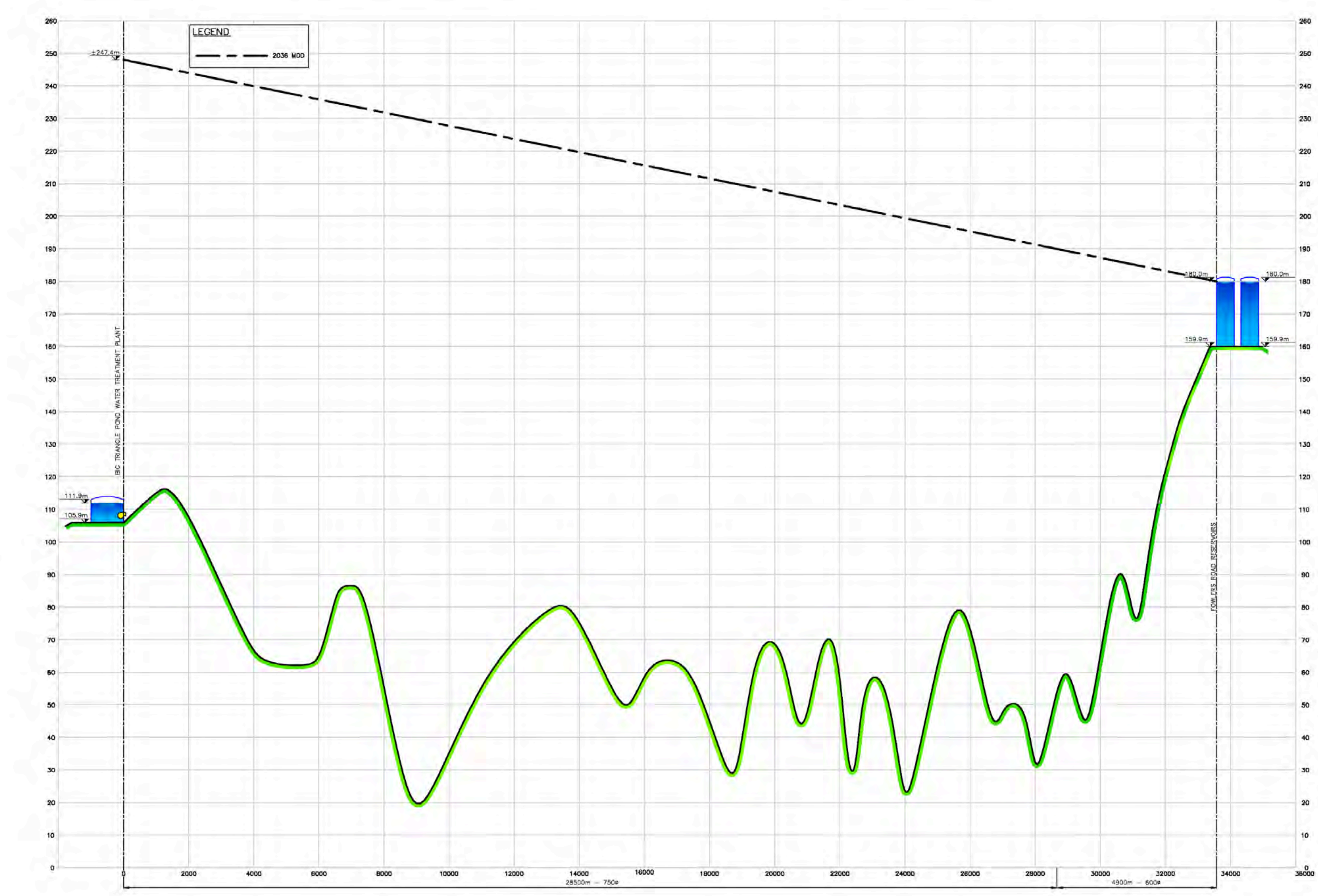

Figure 5.8: Big Triangle Pond Preliminary HGL

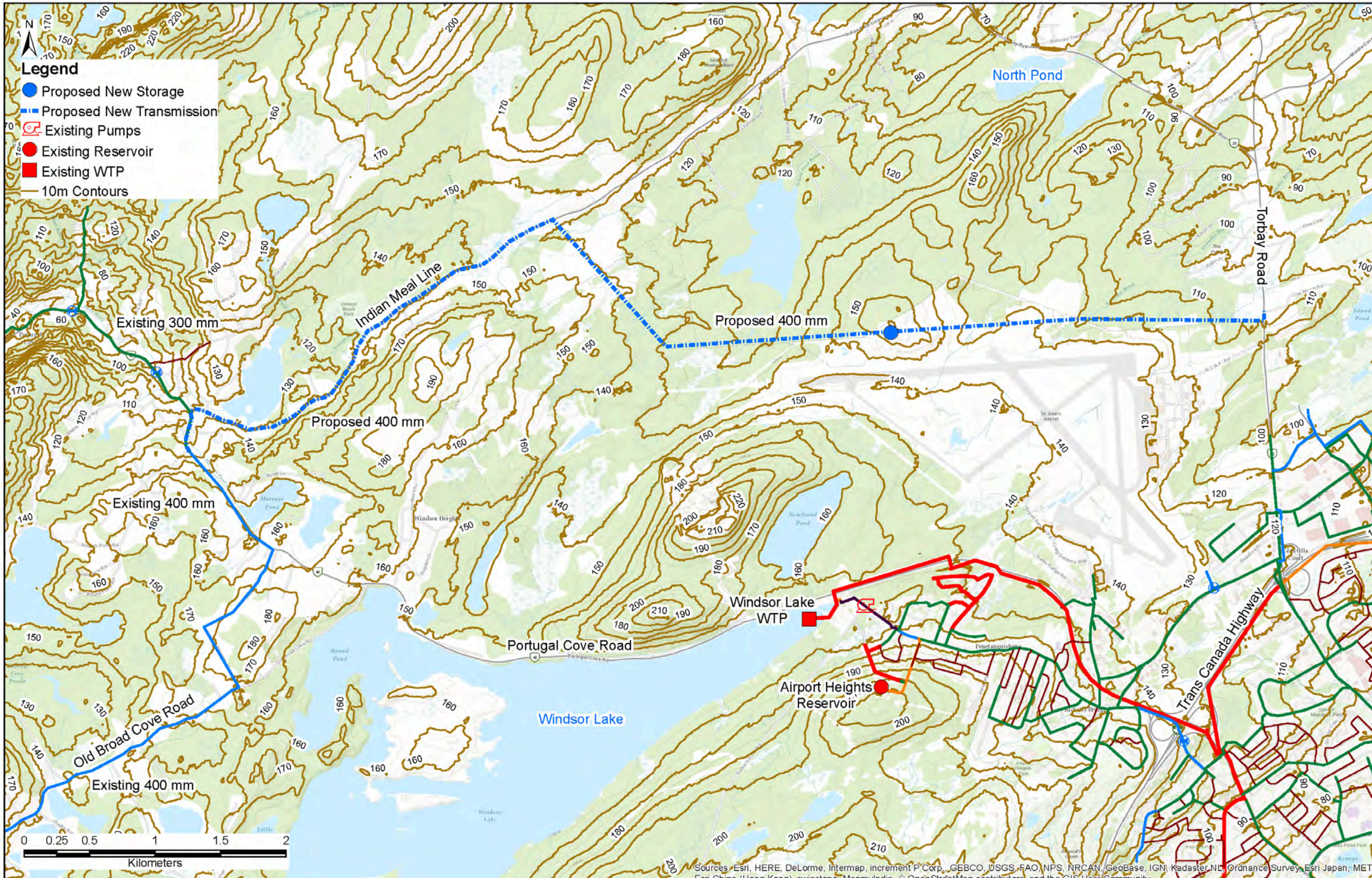

Figure 5.9: Torbay Servicing Scheme

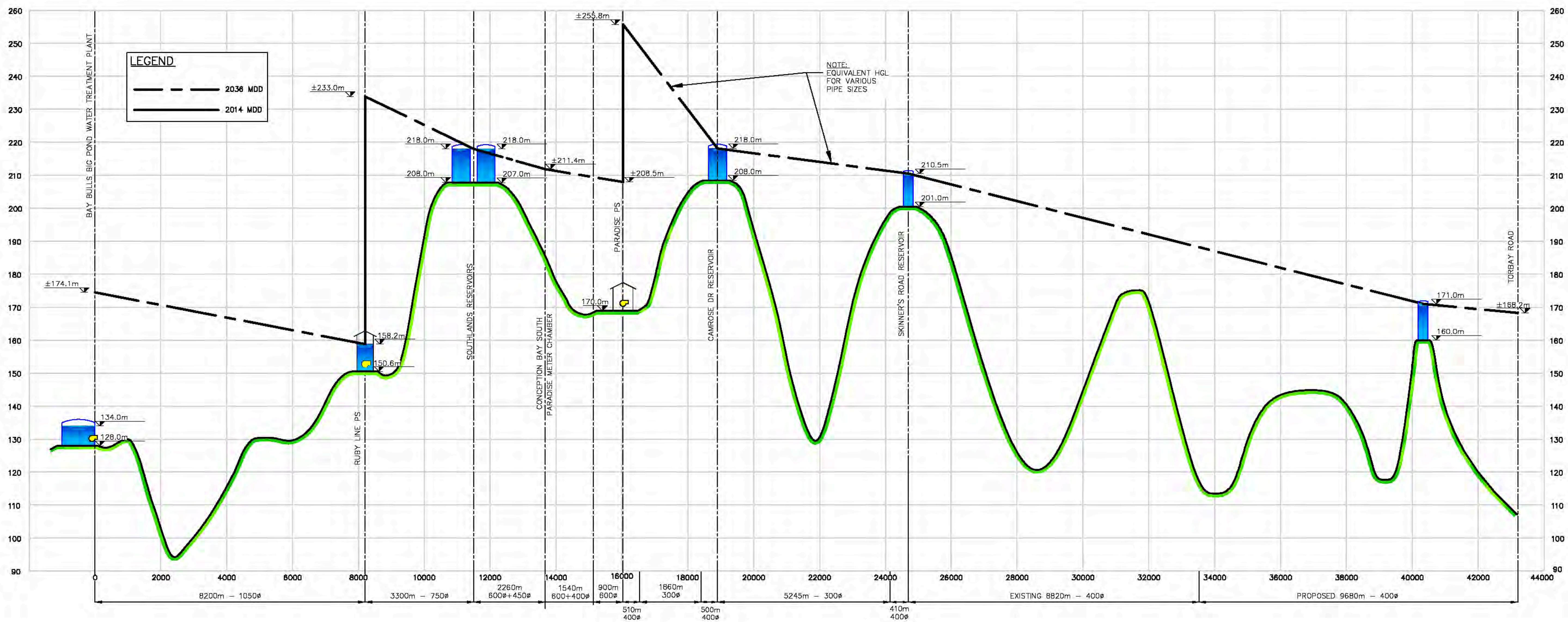

Figure 5.10: Torbay Preliminary HGL

CHAPTER 6 DISTRIBUTION SYSTEM ANALYSIS

6.1 Approach

The distribution system analysis included assessing the existing pump stations, transmission mains and storage tanks under the existing and future demand conditions presented in Section 3.3. Fire flow and storage requirements were also assessed. Proposed system upgrades were developed for present and anticipated future deficiencies in the current distribution system. Also, infrastructure requirements for the expansion of the existing regional service area have been proposed.

To facilitate the analysis, the water distribution system was modeled using Innovyze's InfoWater software. InfoWater is a water distribution system modeling and management software which uses a geographic information system (GIS) interface. A water system model is developed by inputting distribution system components (pipes, reservoirs/tanks, pumps, PRVs, etc.) and demands into the software. Additional steps, including calibration and sensitivity analyses, are often carried out to establish confidence in the model. Several simulation scenarios are usually required to assess the performance of a water system.

For this project, computer model development included the following steps:

- The City of St. John's water model provided to CBCL for this study contained over 9,000 pipes. CBCL contracted Innovyze to skeletonize the City's model and it now contains approximately 3,000 pipes. All areas within the water distribution are well-represented in the skeletonized model. Our analysis focused on transmission and primary distribution mains, which, for the most part, are greater than 300mm. However, there are several 200mm lines that are of significance. The skeletonized water distribution systems for Mount Pearl, Paradise, CBS and Portugal Cove - St. Philip's have been added to the computer model.
- Measured water flows for each community were obtained from the City of St. John's (refer to Section 3.1). Using the total flow to each community, water demands were apportioned to each pipe node based on a review of topographic and aerial maps of the areas and assessing the housing density and the amount of commercial/industrial land that would be tributary to the node.
- The flows were checked against the maximum day flows presented in Section 3.1. For the BBBP water system, the maximum day flow supplied during 2010-2014 is 105,969 m^3/D. The maximum day flow in the water model for the BBBP system is 100,910 m^3/D, which suggests that the model has a good correlation with the actual daily flows. When comparing measured flows at meters serving the four communities with the model flows, some are off by 10% to 15%, typically due to variable operating

conditions such as reservoir top water level and whether pumps are on or off. For the WL water system, the maximum day flow supplied during 2010-2014 is 65,400 m^3/D. The maximum day flow in the water model for the WL water system is 65,592 m^3/D.

- Future demands were developed and applied to the model. Then, various model scenarios were run to evaluate system performance and to identify deficiencies and assess system expansion opportunities.

6.2 Hydraulic Design Criteria

The hydraulic design criteria are as follows:

- Maximum Day Factor for new development:
  - As per guidelines for population size in *Guidelines for the Design, Construction and Operation of Water and Sewerage Systems* published by ENVC.
- Minimum Design Pressure: 276 kPa (40 psi).
- Maximum Design Pressure: 621 kPa (90 psi) (in accordance with the ENVC Guidelines).
- Maximum Acceptable Pressure (for St. John's): 550 kPa (80 psi). Section 2.6.3.3 of the 2010 National Plumbing Code requires that pressure reducing valves be installed where the static pressure exceeds 550 kPa (80 psi). The City of St. John's has required that pressure reducing valves be installed at the service entrances of all properties (regardless of the static pressure) since the late 1990s.
- Maximum pipeline velocity: 1.5 m/s.
- Proposed watermain "C" factor: 120.
- Minimum suction line pressure for pump stations: 207 kPa (30 psi).
- Fire Flow Residual Pressure: 152 kPa (22 psi).

Distribution storage was assessed using the following equation:

$$S = A + B + C$$

Where, S = Storage (m^3)

A = Fire storage (fire flow over specified duration – dependent on type of construction).

B = Peak balancing storage (25% of maximum day demand).

C = Emergency and maintenance storage (25% of A + B).

The key considerations for assessing distribution storage opportunities include:

- Size and locate new storage reservoirs that can provide service to multiple pressure zones.
- Locate a sufficient number of new reservoirs so that the combination of new and existing tanks adequately services, by gravity, the largest area feasible.
- Ensure tanks have sufficient water turnover capability to address potential water quality problems.
- Expand service areas to include adjacent areas (where hydraulically feasible) if the existing tank water volumes have excess capacity for the present areas serviced.

6.2.1 Existing Distribution System Conditions

6.2.1.1 Transmission

A hydraulic analysis was carried out to assess the existing transmission mains for the 2014 water demands. The transmission mains were assessed for velocity during maximum day demand conditions. Transmission mains that exceed the maximum allowable velocity of 1.5 m/s during these conditions are shown below in Table 6.1.

Table 6.1: Transmission Main Analysis - 2014 Maximum Day Demands

Water Service Area	Pipe Description	Pipe Diameter	Approx. Pipe Length	Velocity	Responsibility (RWS or Municipal)
		mm	m	m/s	
BBBP	Ruby Line Pump Station to Southlands Reservoirs	750	3400	1.6	RWS
	Southlands Reservoirs to Mount Pearl	450	700	1.6	Municipal (Mount Pearl)
		350	400	1.6	
	Transmission Main along CBS Bypass Highway	400	3800	1.7	RWS (from metering chamber to CBS boundary) Municipal (from CBS boundary to tank)

6.2.1.2 Storage

Tables 6.3, 6.4, 6.5 and 6.6 (see Appendix F) contain the storage analysis results for the 2014 conditions. The capacities of the existing storage facilities have been analyzed. In addition, new storage facilities are proposed.

Fire flow assumptions are based on the recommendations contained in *Water Supply for Public Fire Protection (1999 edition)* published by the Fire Underwriters Survey.

6.2.2 Future Distribution System Requirements

6.2.2.1 Transmission

A detailed hydraulic analysis was carried out to assess the existing transmission mains for the 2036 water demands. The transmission mains were assessed for velocity during maximum day demand conditions. Transmission mains that exceed the maximum allowable velocity of 1.5 m/s during these conditions are identified below in Table 6.2. A complete list of the transmission mains that are 400 mm in diameter or greater is contained in Appendix B.

Table 6.2: Transmission Mains Analysis - 2036 Maximum Day Demands

<table>
<tr><th rowspan="2">Water Service Area</th><th rowspan="2">Pipe Description</th><th>Pipe Diameter</th><th>Approx. Pipe Length</th><th>Velocity</th><th rowspan="2">Responsibility (RWS or Municipal)</th></tr>
<tr><th>mm</th><th>m</th><th>m/s</th></tr>
<tr><td rowspan="5">BBBP</td><td>Ruby Line Pump Station to Southlands Reservoirs</td><td>750</td><td>3400</td><td>2.0</td><td>RWS</td></tr>
<tr><td rowspan="2">Southlands Reservoirs to Mount Pearl</td><td>450</td><td>700</td><td>1.8</td><td rowspan="2">Municipal (Mount Pearl)</td></tr>
<tr><td>350</td><td>400</td><td>1.8</td></tr>
<tr><td rowspan="2">Transmission Main along CBS Bypass Highway</td><td>400</td><td>3800</td><td>2.1</td><td rowspan="2">RWS (from metering chamber to CBS boundary)
Municipal (from CBS boundary to tank)</td></tr>
<tr><td>450</td><td>2100</td><td>1.7</td></tr>
</table>

Figures 6.1 through 6.12 show the Hydraulic Grade Line (HGL) profiles for existing transmission mains using the maximum day flows for 2014 and 2036.

6.2.2.2 Storage

Tables 6.7, 6.8, 6.9 and 6.10 (see Appendix F) contain the storage analysis results for the 2036 conditions. The capacities of the existing storage facilities have been analyzed. In addition, new storage facilities are proposed.

Fire flow assumptions are based on the recommendations contained in *Water Supply for Public Fire Protection (1999 edition)* published by the Fire Underwriters Survey.

6.3 Proposed Improvements

The proposed distribution system improvements presented above are discussed below in further detail. The labels used for each proposed improvement are carried forward to Chapter 7 where they are costed and presented in the implementation schedule.

6.3.1 Bay Bulls Big Pond Service Area

<u>BBBP1 – Additional Distribution Storage: Ruby Line Pump Station</u>

Before the PHLP system was brought on-line, the Ruby Line Pump Station wet well did not have adequate storage to accommodate demands during peak periods. This issue has been rectified; however, the BB-B pressure zone (refer to Plan No.1) should be transferred back to the BBBP service area when a new source is added to the EWSS. Additional storage at the Ruby Line Pump Station should be provided at that time.

<u>BBBP2 – Transmission Main Upgrades: Ruby Line Pump Station to Southlands Reservoirs, Southlands Reservoirs to Mount Pearl and along CBS Bypass Highway</u>

The velocities in the 750mm transmission main from the Ruby Line Pump Station to the Southlands Reservoirs, the 350mm and 450mm transmission main from the Southlands Reservoirs to Mount Pearl, and the 400mm and 450mm transmission main along the CBS Bypass Highway marginally exceed the maximum design value of 1.5 m/s under maximum day conditions for 2036. The velocities in these transmission mains exceed the design value as summarized below:

- 750mm from Ruby Line Pump Station to the Southlands Reservoirs: 2.0 m/s or 133% of the design value.
- 450mm and 350mm from Southlands Reservoirs to Mount Pearl: 1.8 m/s or 120% of the design value.
- 400mm along CBS Bypass Highway: 2.1 m/s or 140% of the design value.
- 450mm along CBS Bypass Highway: 1.7 m/s or 113% of the design value.

It is recommended that, as the Southlands area grows, the velocities in the pipes be periodically re-assessed to determine if the energy usage by the pumps would justify upsizing the transmission mains. Further, the CBS transmission mains will be upgraded when the new source is developed. Therefore, upgrading these transmission mains based on the above results will not be required.

<u>BBBP3 – Additional Distribution Storage: CBS South</u>

Based on the analysis presented in Table 6.6, it is recommended that additional storage be provided for CBS South. Figure 6.13 shows the proposed tank location. The existing pressure zones would have to be changed to accommodate the new tank.

<u>BBBP4 – Additional Distribution Storage: Fowler’s Road and Skinner’s Hill</u>

The tanks at Fowler’s Road and Skinner’s Hill appear to be undersized according to the 2036 requirements. Portugal Cove - St. Philip’s is planning to construct an additional storage tank which would address the capacity issue at Skinner’s Hill. According to the 2036 calculations, the Fowler’s Road tanks are about 25% undersized. As CBS develops, the maximum day demand should be checked periodically to determine when a third tank would be required.

BBBP5 – Additional Distribution Storage: Mundy Pond

The twinning of the Mundy Pond tank is not currently required; however, the need for an additional reservoir should be periodically re-evaluated as the BBBP service area expands to take in some of the WL service area (see Figures 5.2, 5.3 and 5.4). A cost estimate for this additional tank is included for long-term planning purposes.

6.3.2 Windsor Lake Service Area

WL1 – Additional Distribution Storage: Airport Heights

Based on the analysis presented in Table 6.10, it is recommended that the volume of the existing Airport Heights storage reservoir be increased to accommodate future development. The existing site was designed to allow for the construction of an identical 8,000 m^3 tank.

WL2 – Additional Distribution Storage: Sugarloaf Road

Based on the analysis presented in Table 6.10, it is recommended that additional storage be provided for pressure zones WL-E and WL-G (see Plan No. 1). Figure 6.14 shows the proposed tank location.

WL3 – Additional Distribution Storage: Signal Hill

Based on the analysis presented in Table 6.10, it is recommended that additional storage be provided for pressure zones WL-J and WL-K. Figure 6.15 shows the proposed tank location. It is proposed that pressure zone WL-K be adjusted to accommodate the tank. Further, this tank would require a control building complete with an altitude valve because the HGL of the line feeding the tank would be higher than the required tank HGL.

6.3.3 Petty Harbour Long Pond Service Area

PHLP2 – Pump Station/Transmission Main/Storage: Kilbride East

In accordance with the study terms of reference, we have investigated the feasibility of decommissioning the existing Shea Heights pump station and storage reservoir and replacing them with new infrastructure. The scheme outlined in Section 5.3 for diverting water from the WL service area also addresses the need to replace the aging Shea Heights infrastructure. Figure 6.16 shows the proposed pump station, transmission main and storage reservoir. The cost opinion for this work also includes the decommissioning of the existing Shea Heights pump station and tank.

6.3.4 Development above the 190-m Contour

As noted in Section 3.3, a significant portion of the future water demands for St. John's were allocated for known developments in the Glencrest, Galway and Kenmount Terrace areas. The water supply system for the Glencrest and Galway developments in currently under construction by a private developer and includes a pump station, storage tank and distribution mains. It is expected that the water supply system for the Kenmount Terrace area will also be undertaken by a private developer.

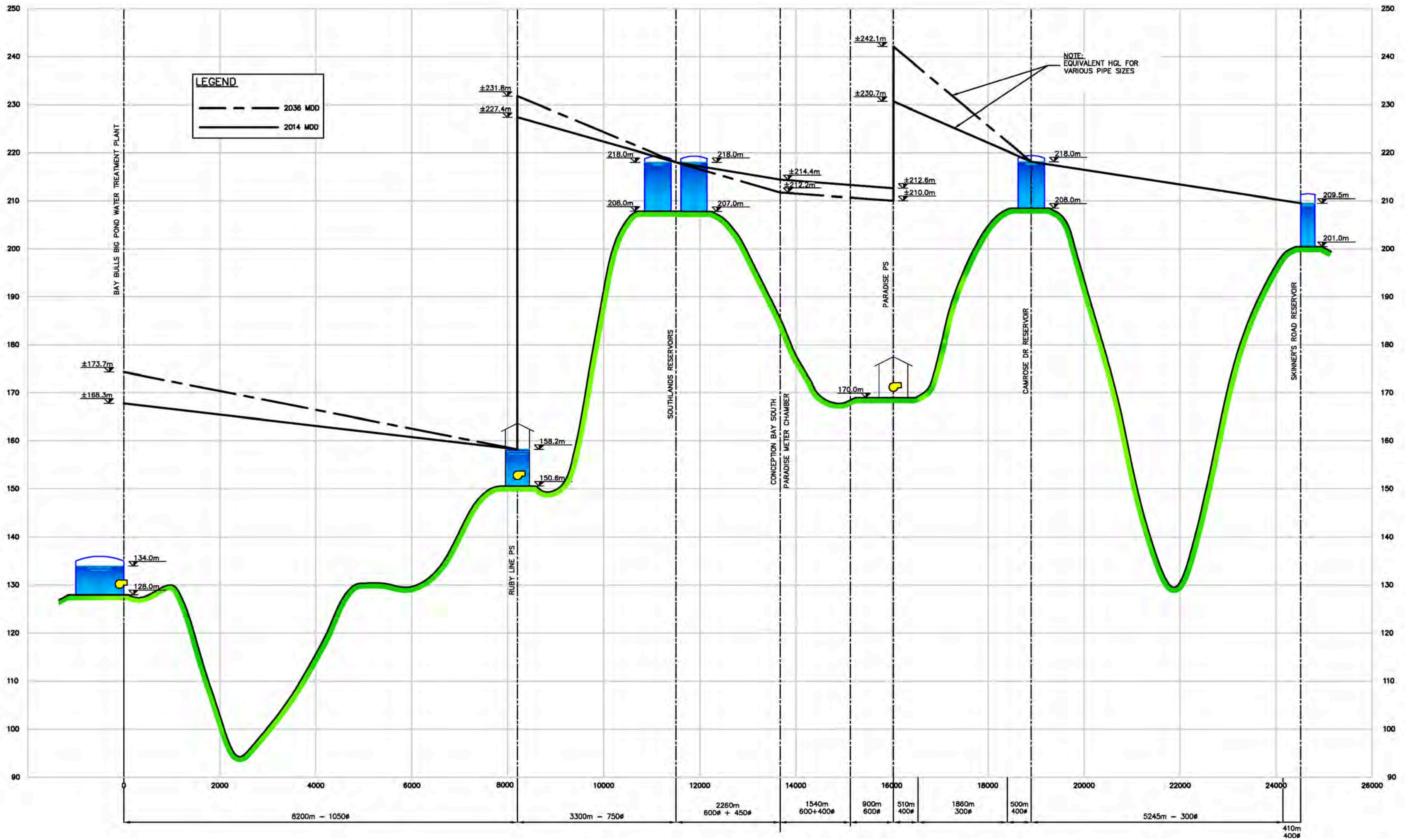

Figure 6.1: HGL Profile: BBBP to Skinner's Road Reservoir

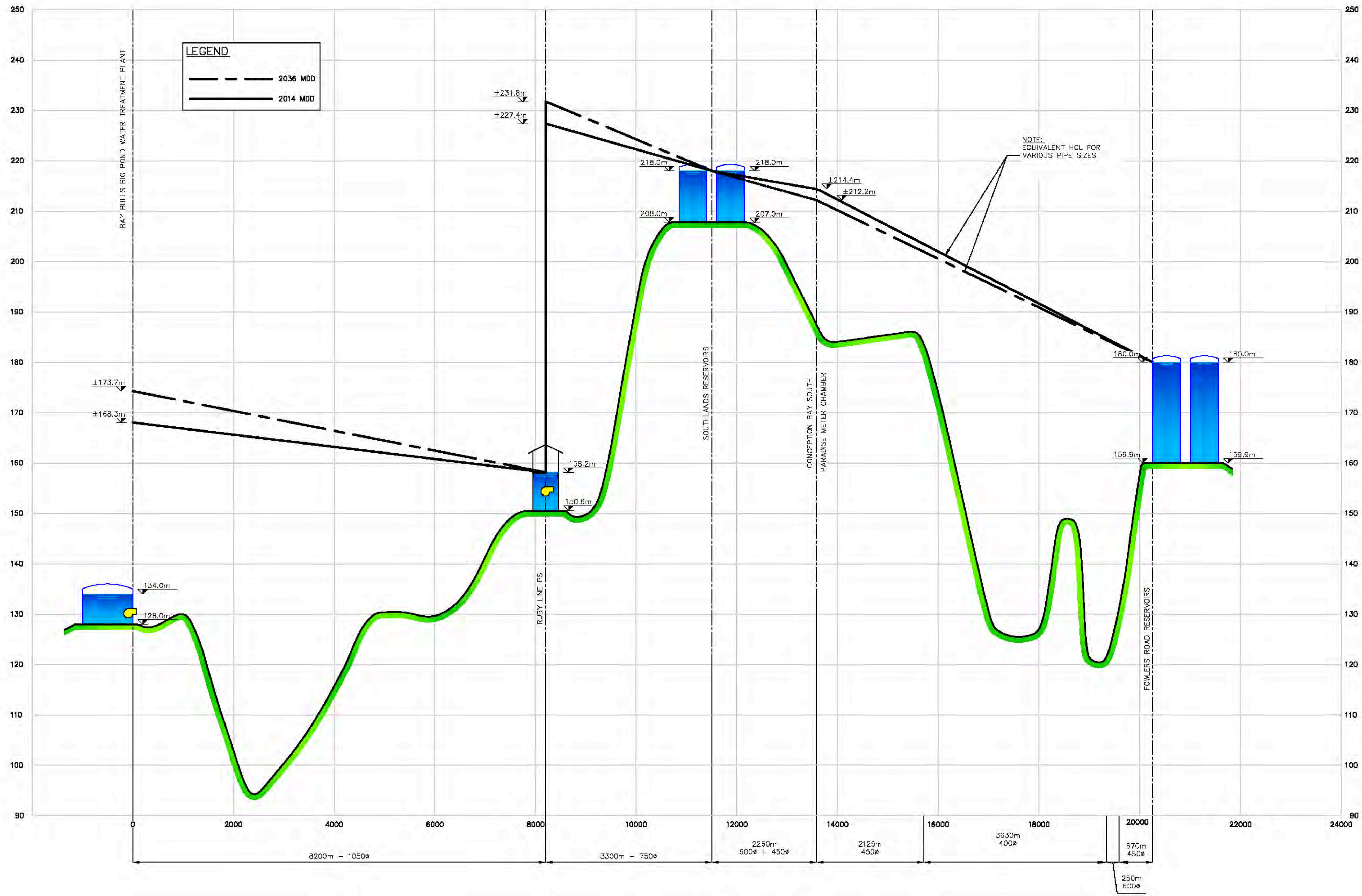

Figure 6.2: HGL Profile: BBBP to Fowler's Road Reservoir

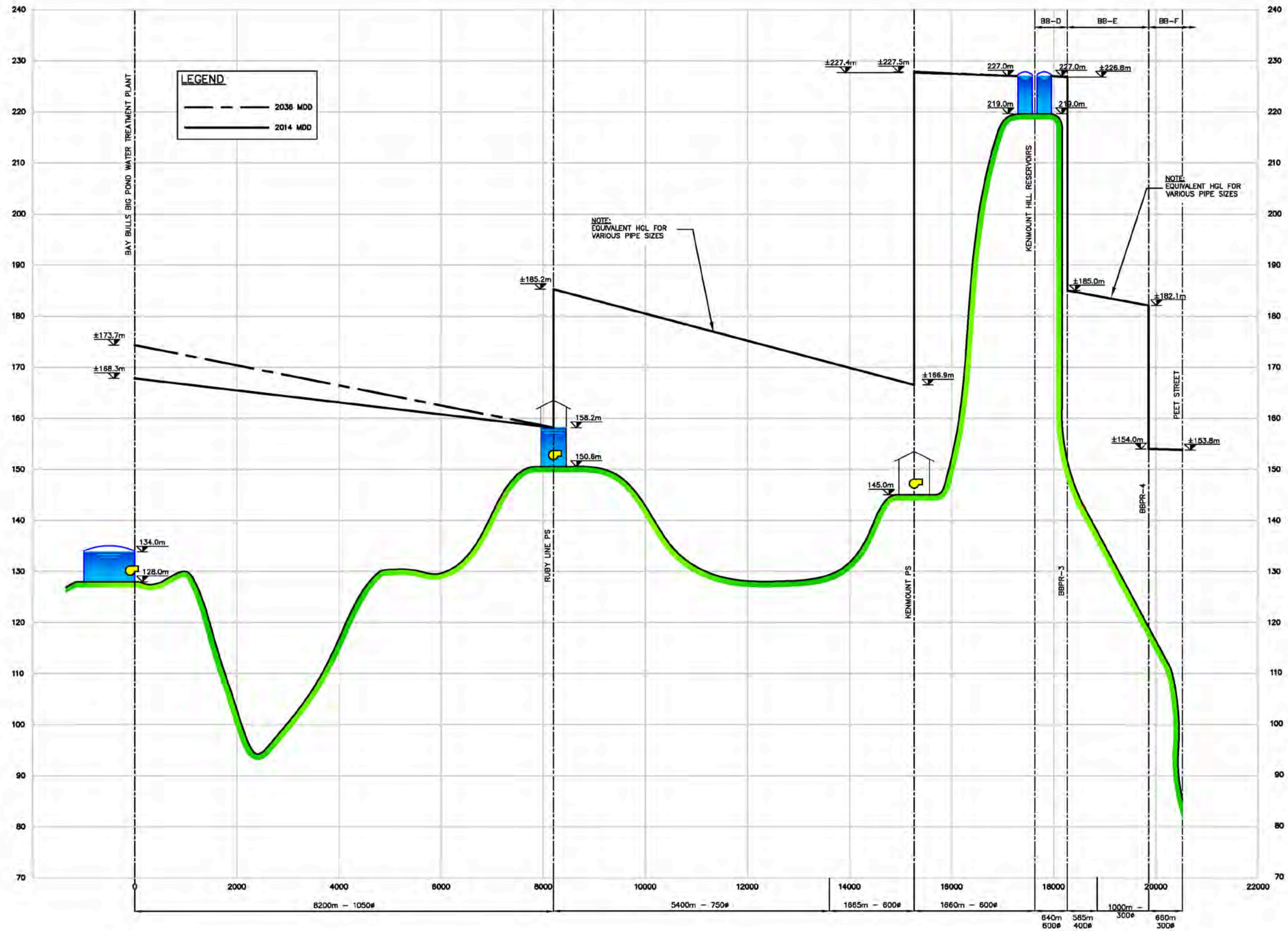

Figure 6.3: HGL Profile: BBBP to Pressure Zone BB-F

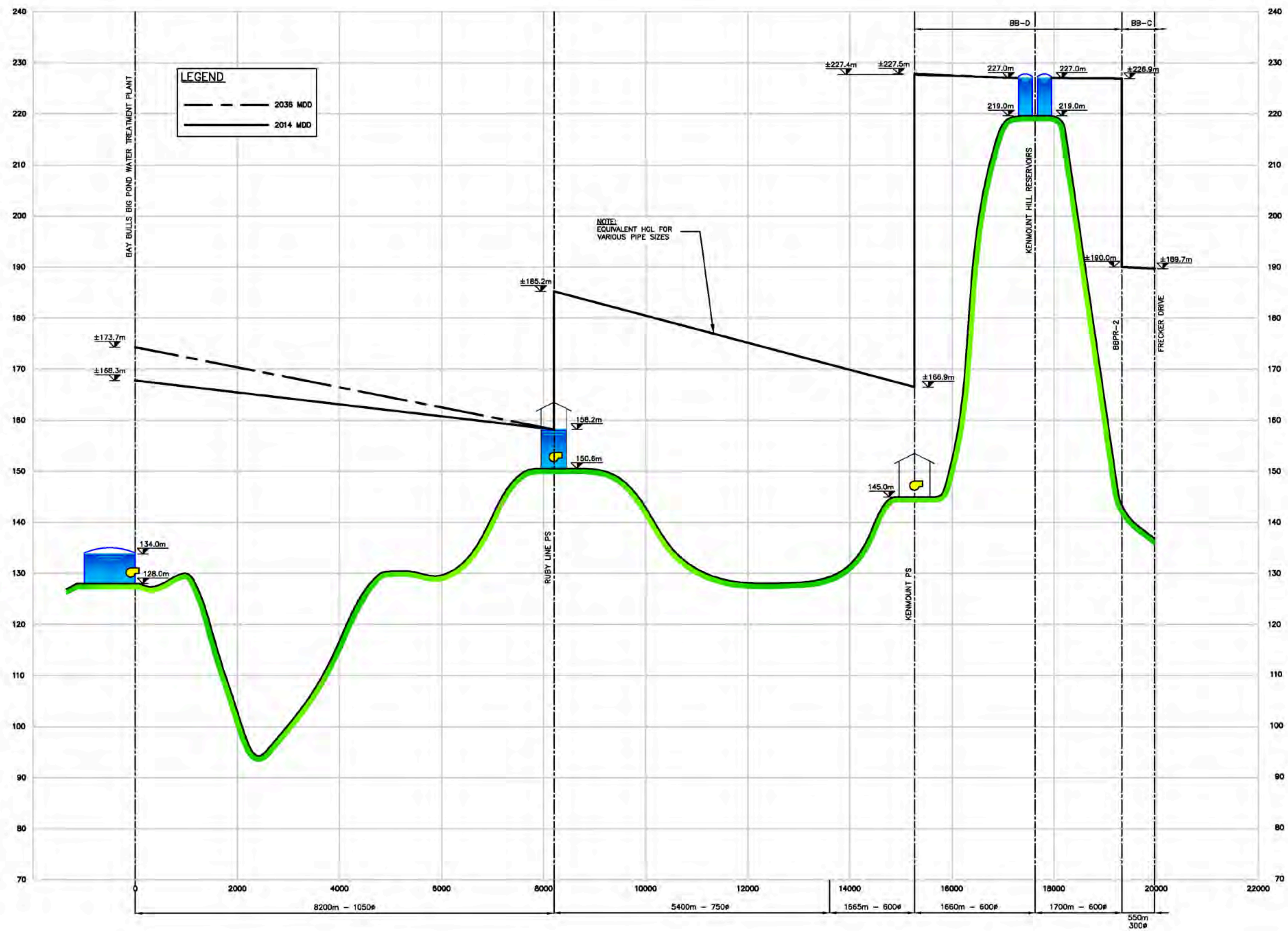

Figure 6.4: HGL Profile: BBBP to Pressure Zone BB-C

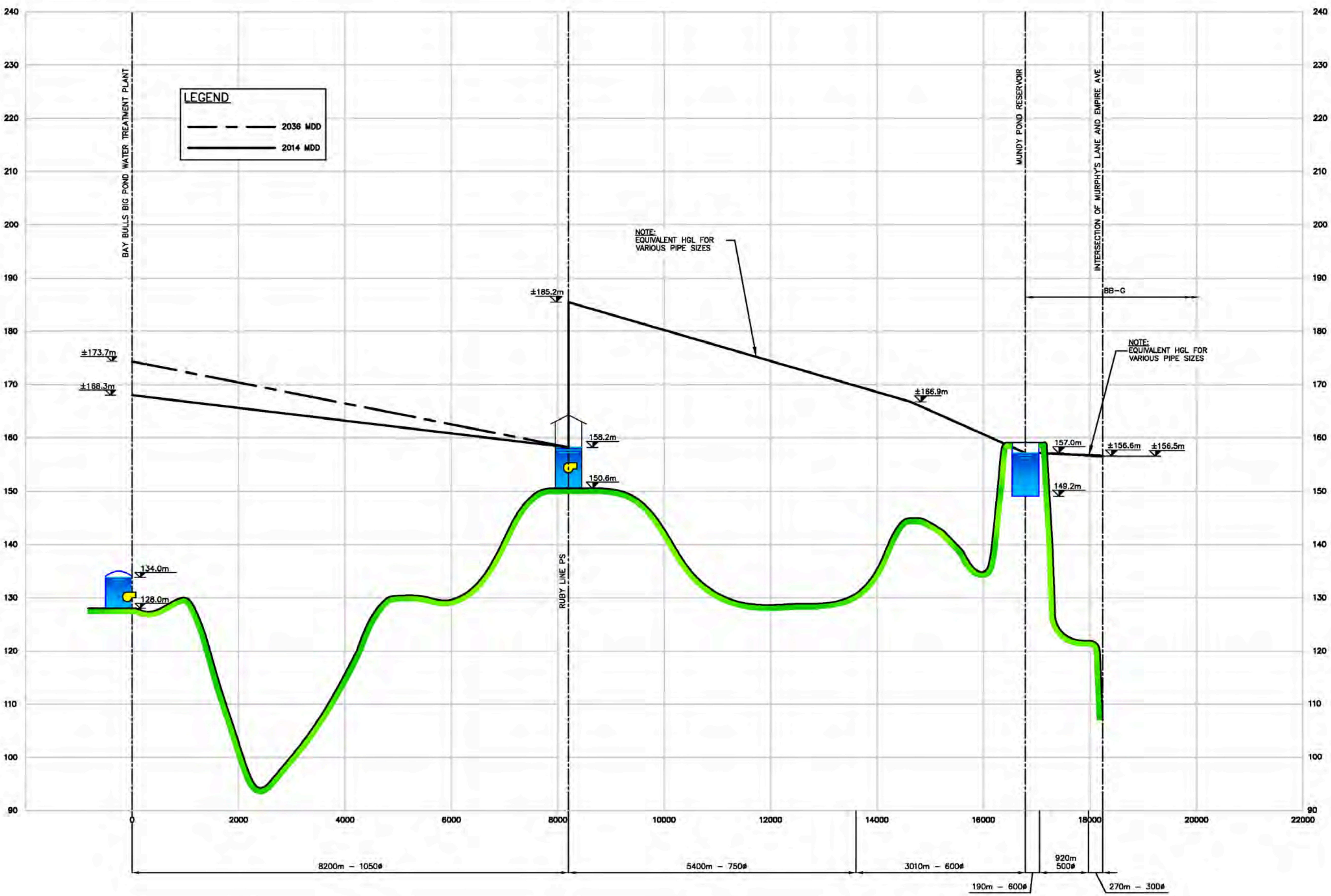

Figure 6.5: HGL Profile: BBBP to Pressure Zone BB-G

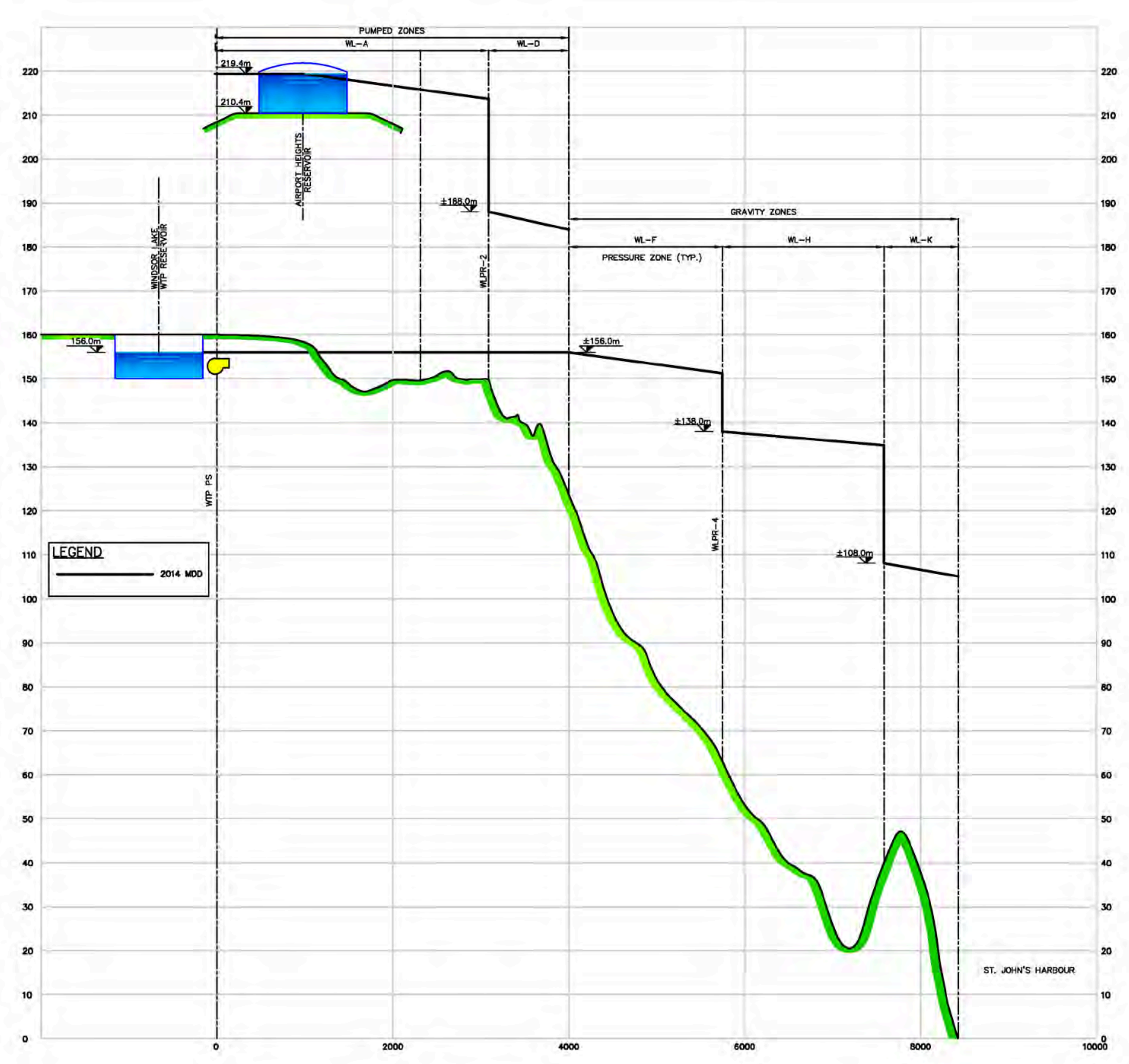

Figure 6.6: HGL Profile: WL to St. John's Harbour

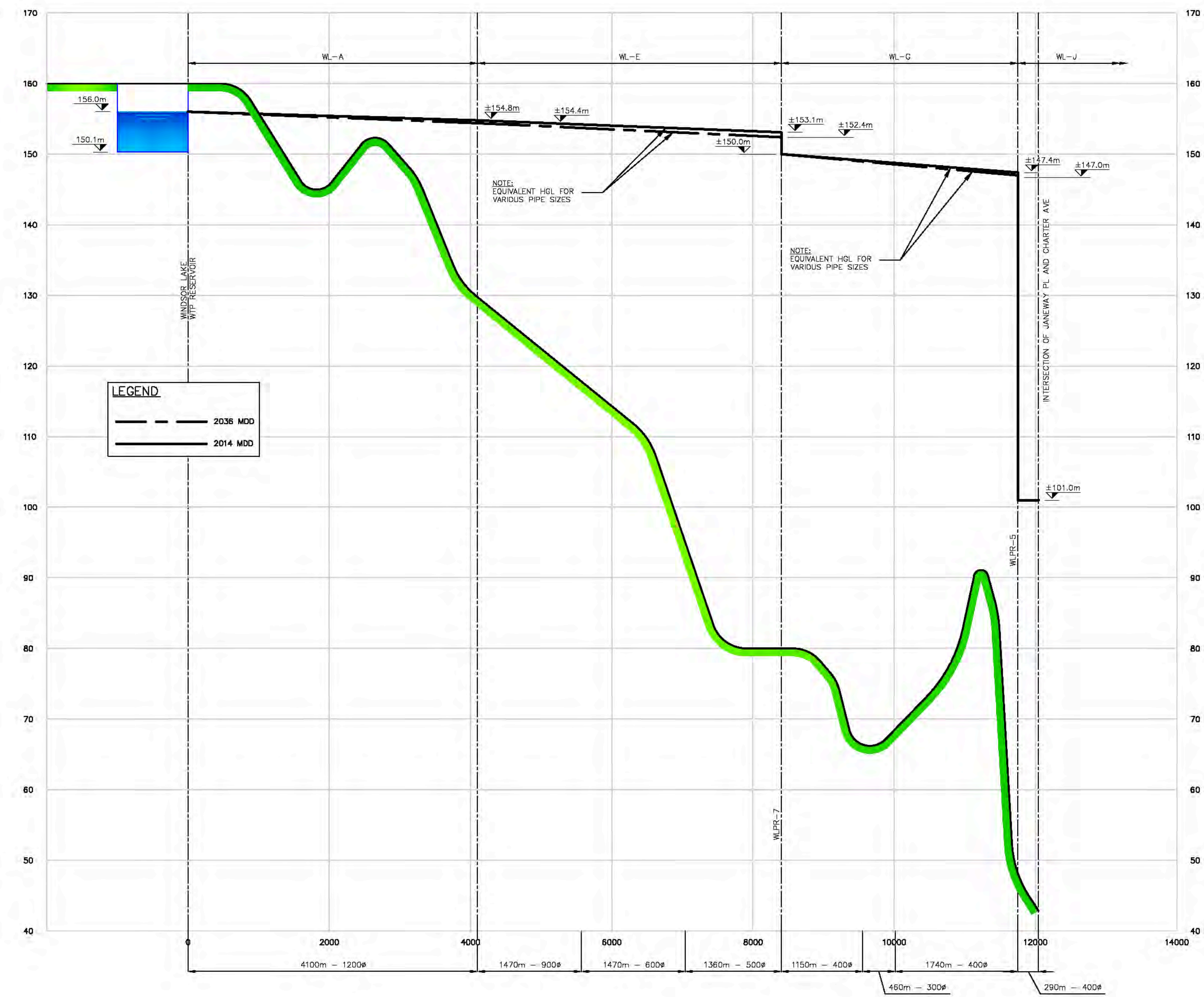

Figure 6.7: HGL Profile: WL to Pressure Zone WL-J

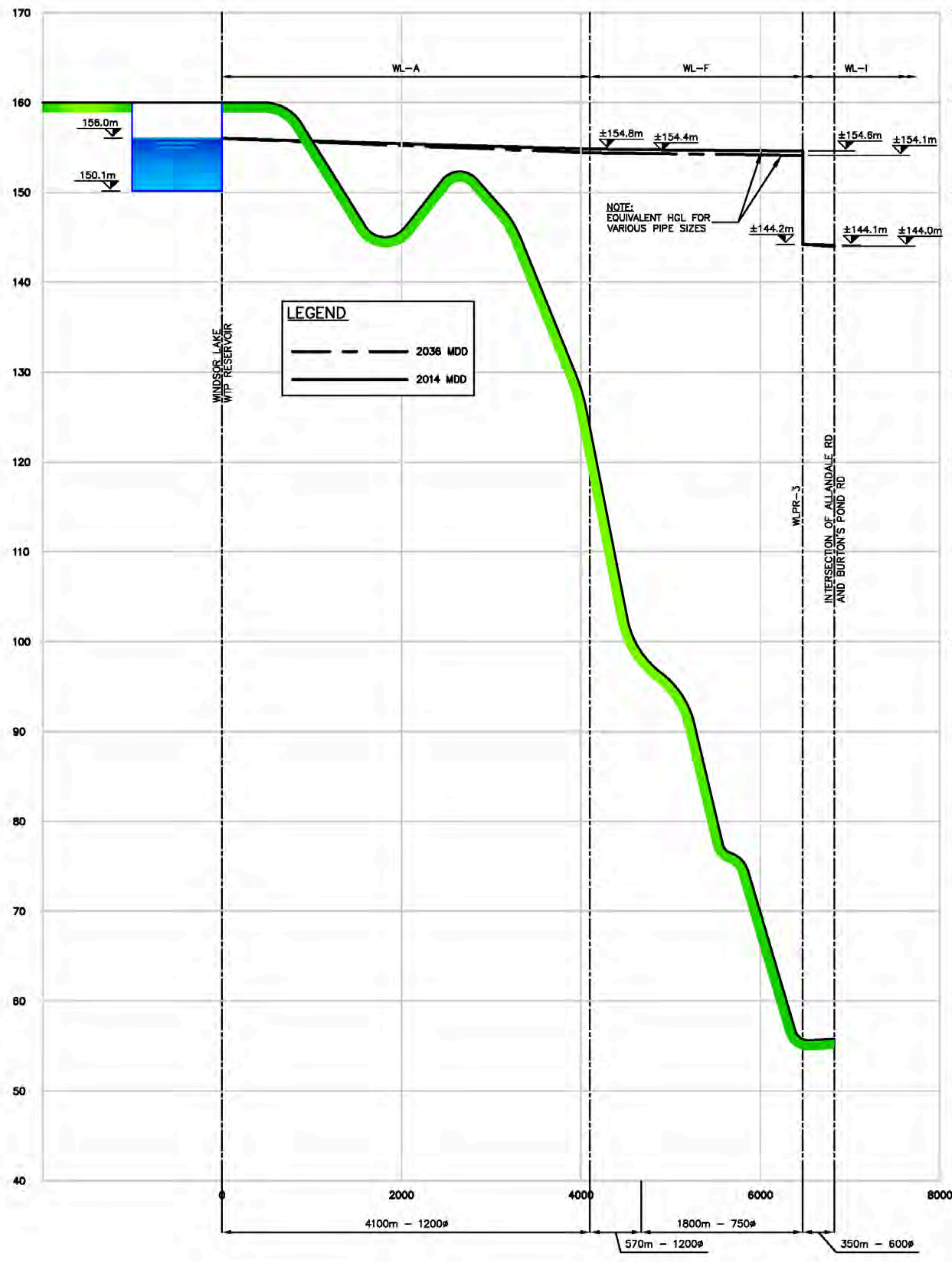

Figure 6.8: HGL Profile: WL to Pressure Zone WL-I

Figure 6.9: HGL Profile: WL to Pressure Zone WL-C

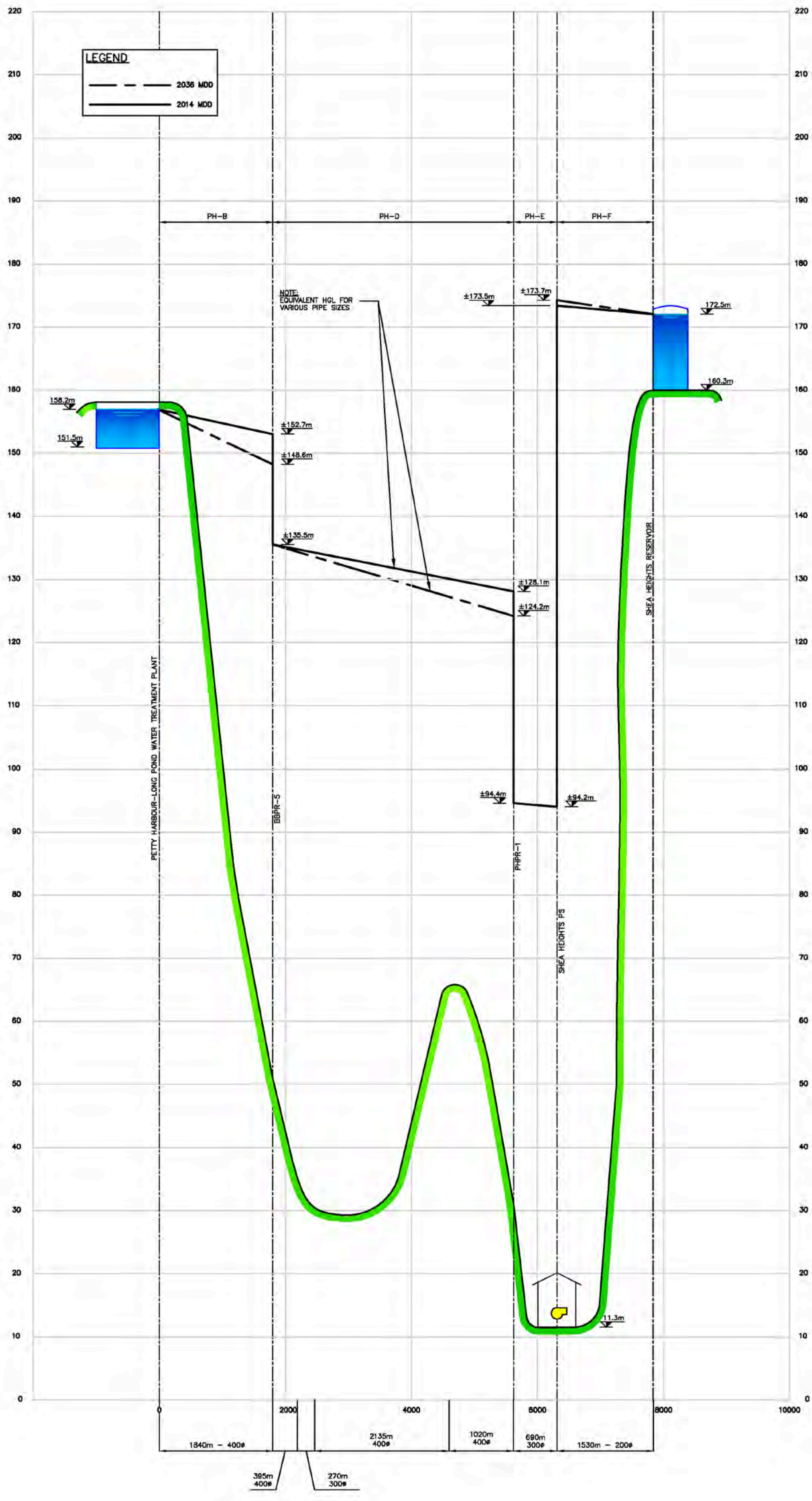

Figure 6.10: HGL Profile: PHLP to Shea Heights Reservoir

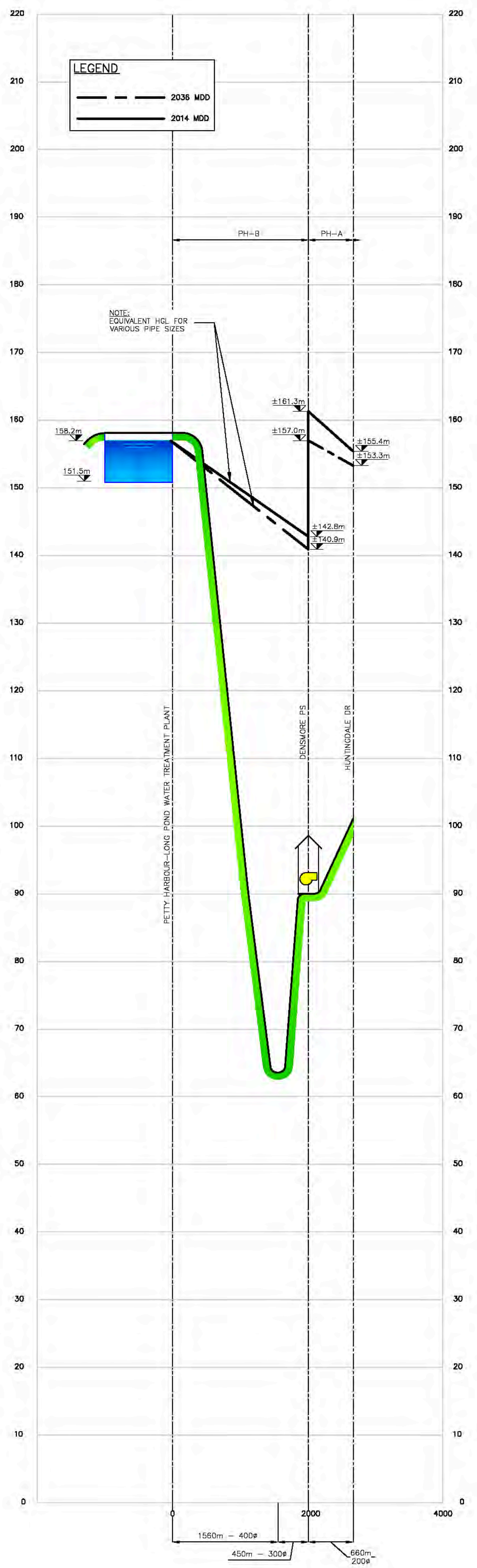

Figure 6.11: HGL Profile: PHLP to Pressure Zone PH-A

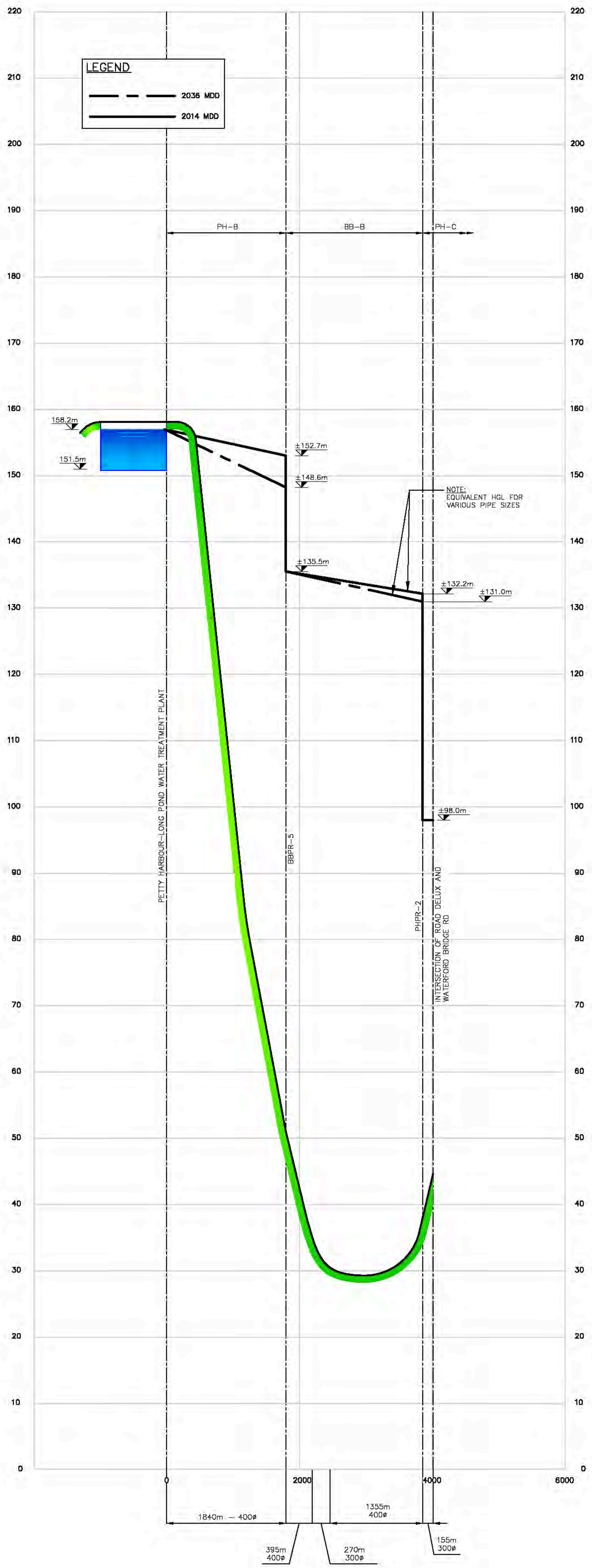

Figure 6.12: HGL Profile: WL to Pressure Zone PH-C

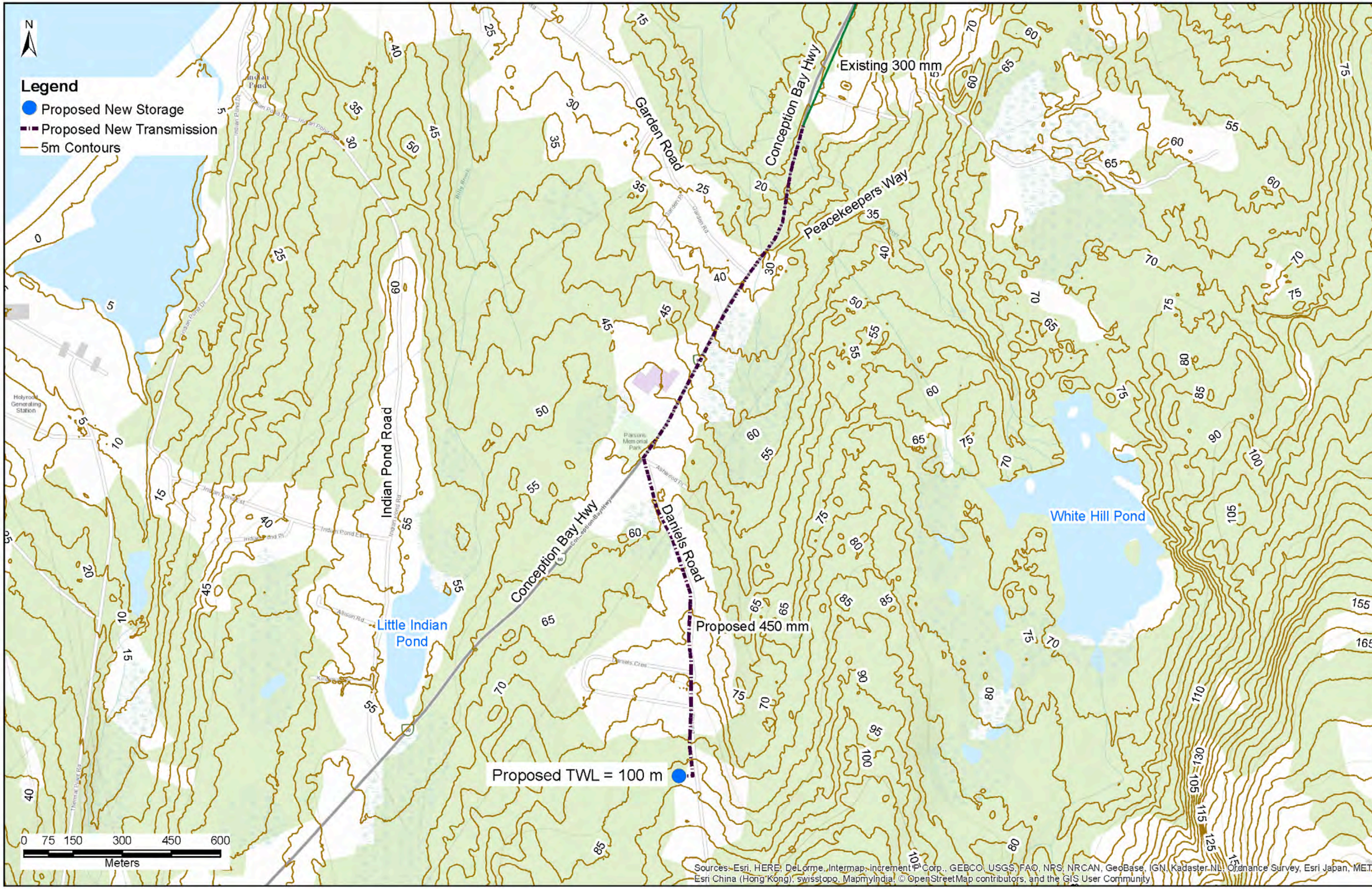

Figure 6.13: Proposed Additional Storage: CBS

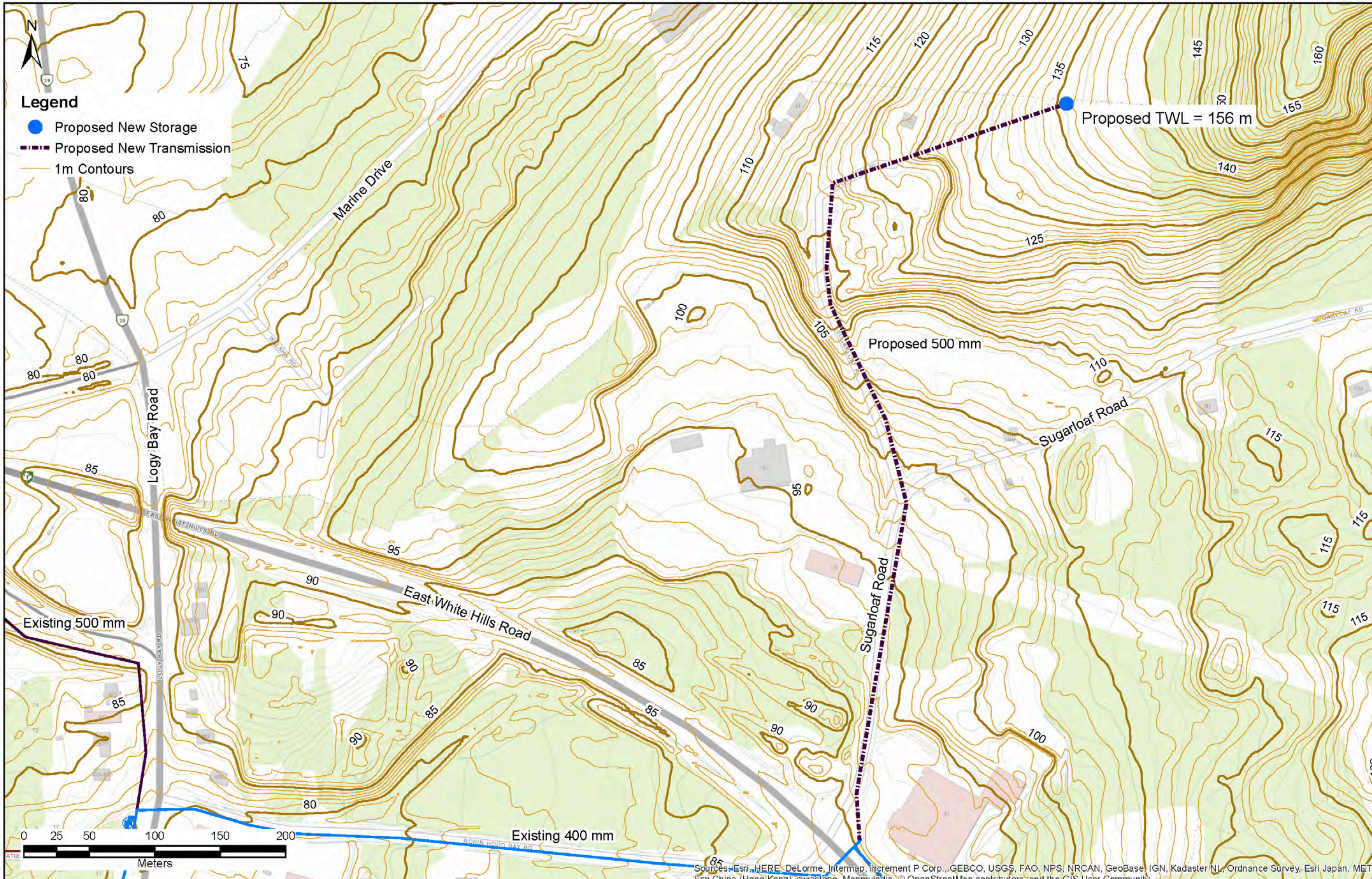

Figure 6.14: Proposed Additional Storage: Sugarloaf Road

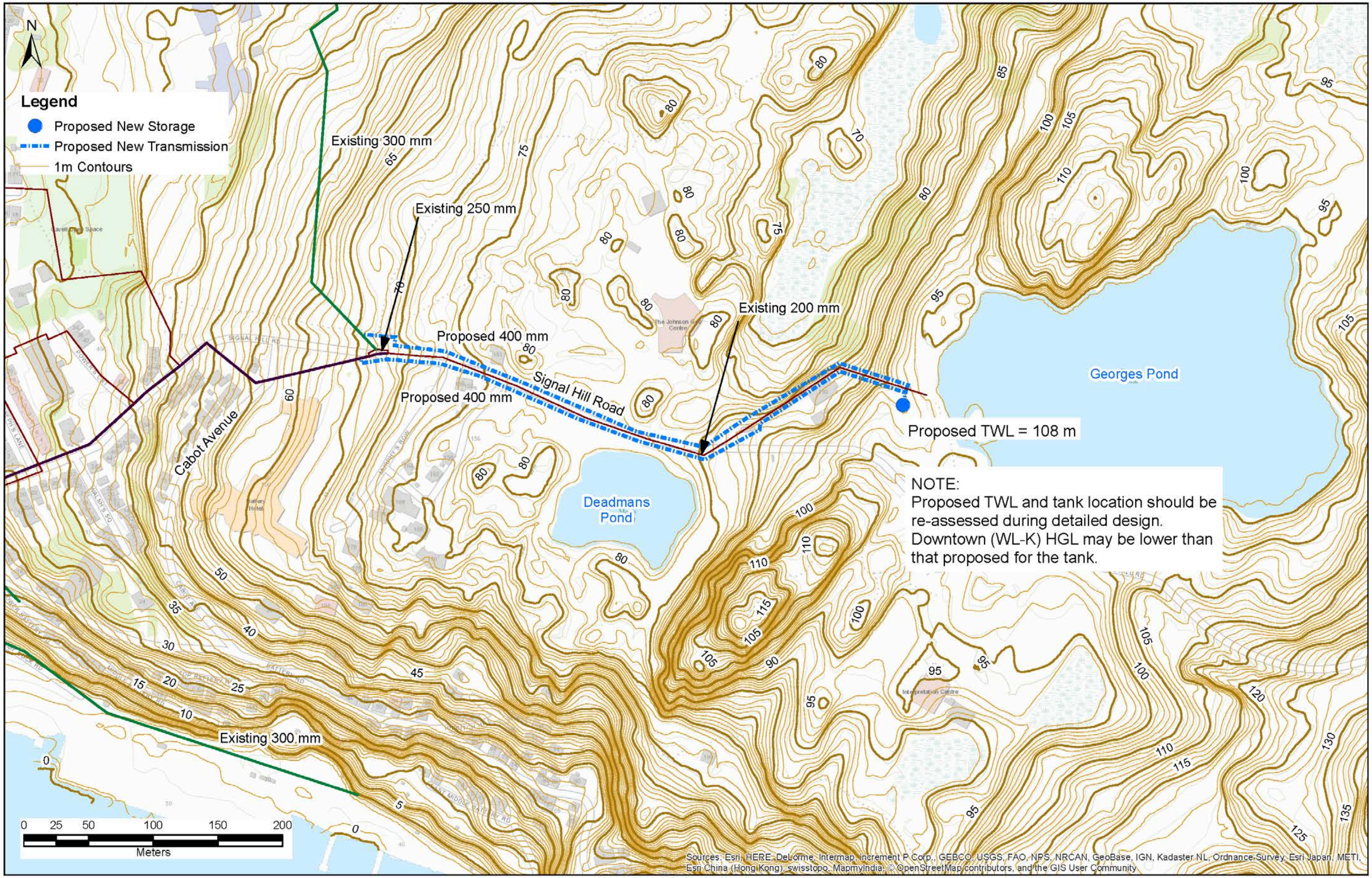

Figure 6.15: Proposed Additional Storage: Signal Hill

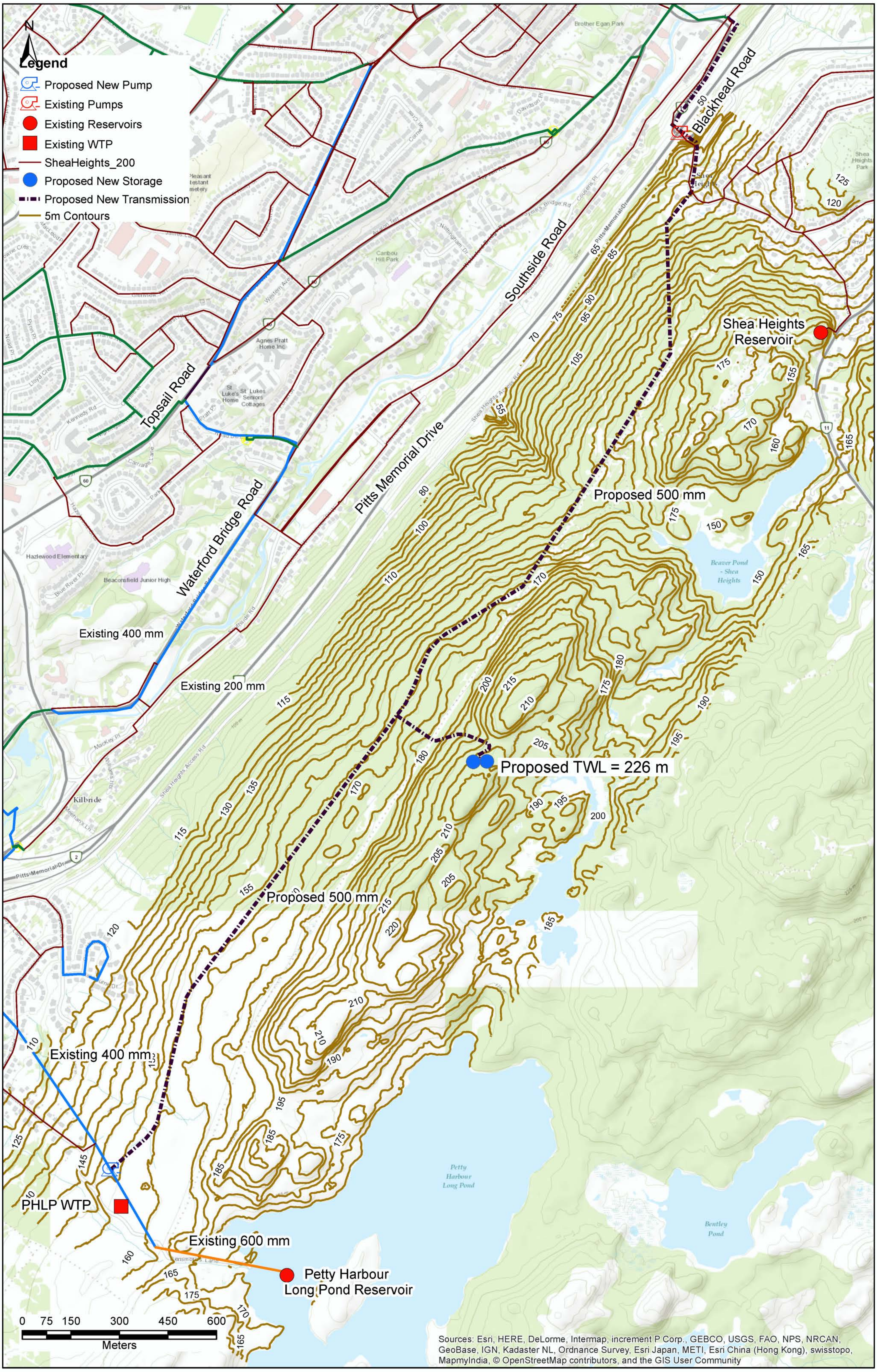

Figure 6.16: Proposed Additional Storage: East Kilbride Upgrades

CHAPTER 7 COST OPINIONS AND IMPLEMENTATION SCHEDULE

7.1 Cost Opinions

Cost opinions for the recommendations provided in Sections 5.3 and 6.3 are presented in Table 7.1. Detailed break-downs of these opinions are provided in Appendix G.

Table 7.1: Cost Opinions

Item No.	Description	Cost
BBBP1	Additional Distribution Storage: Ruby Line Pump Station	$3,800,000
BBBP3	Additional Distribution Storage: CBS South	$7,800,000
BBBP5	Additional Distribution Storage: Mundy Pond	$8,200,000
WL1	Additional Distribution Storage: Airport Heights	$5,800,000
WL2	Additional Distribution Storage: Sugarloaf Road	$6,900,000
WL3	Additional Distribution Storage: Signal Hill	$7,600,000
PHLP1	Distribution System Upgrades: Mundy Pond Service Area	$1,600,000
PHLP2	Pump Station/Transmission Main/Storage: Kilbride East	$19,000,000
WL WTP	Process Improvements (Corrosion Control)	$5,000,000*
New WTP (Option 1)	Thomas Pond: WTP	$50,000,000
	Thomas Pond: Transmission	$31,800,000
New WTP (Option 2)	Big Triangle Pond: WTP	$50,000,000
	Big Triangle Pond: Transmission	$86,600,000
New Customer1	Torbay (transmission and storage; new water supply must be developed before Torbay can be added to the EWSS)	$17,400,000
New Customer2	Holyrood (required if Thomas Pond is developed as opposed to Big Triangle Pond; new water supply must be developed before Holyrood can be added to the EWSS)	$22,200,000

*Supplied by the City of St. John's.

These cost opinions are Class 'D' estimates (±20%). Design development contingencies of 10% and construction contingencies of 20% have been included in the transmission and distribution storage infrastructure estimates. Allowances for land acquisition have not been included. Engineering and HST are included in the estimates.

The water treatment plant cost opinion is based on CBCL's recent experience as Owner's Engineer for the Corner Brook WTP design-build project and feedback received from City of St. John's staff on the final costs for the PHLP WTP. Without further developing the treatment requirements, it is challenging to provide a more detailed cost opinion. Accordingly, a design development contingency of 20% and a construction contingency of 20% have been included in the treatment plant estimate.

The above opinions of probable costs are presented on the basis of experience, qualifications and best judgement. They have been prepared in accordance with acceptable principles and practices. Sudden market trend changes, non-competitive bidding situations, unforeseen labour and material adjustments and the like are beyond the control of CBCL Limited. We cannot warrant or guarantee that actual costs will not vary significantly from the opinions provided.

7.2 Implementation Schedule

The implementation schedule for the recommendations provided in Sections 5.3 and 6.3 is presented in Table 7.2. The need for the short-term capital works projects is based on the median growth scenario used throughout this report without considering the implementation of additional water conservation schemes. The short-term improvements cover existing infrastructure deficits in the St. John's and Regional Water Systems.

The long-term infrastructure improvements are not required during the next ten-year period and should be re-assessed during the next water systems review.

Torbay and Holyrood cannot become customers of the RWS until the new source is operational.

Table 7.2: Implementation Schedule

<table>
<tr><th>Term</th><th>Item No.</th><th>Description</th><th>Notes</th></tr>
<tr><td rowspan="9">Short-term (before 2026)</td><td>BBBP1</td><td>Additional Storage at the Ruby Line Pump Station</td><td></td></tr>
<tr><td>BBBP3</td><td>Additional Distribution Storage: CBS South</td><td></td></tr>
<tr><td>WL1</td><td>Additional Distribution Storage: Airport Heights</td><td></td></tr>
<tr><td>WL2</td><td>Additional Distribution Storage: Sugarloaf Road</td><td></td></tr>
<tr><td>WL3</td><td>Additional Distribution Storage: Signal Hill</td><td></td></tr>
<tr><td>PHLP1</td><td>Distribution System Upgrades: Mundy Pond Service Area</td><td></td></tr>
<tr><td>PHLP2</td><td>Pump Station/Transmission Main/Storage: Kilbride East</td><td></td></tr>
<tr><td>WL WTP</td><td>Process Improvements (Corrosion Control)</td><td></td></tr>
<tr><td>New WTP</td><td>Thomas Pond or Big Triangle Pond</td><td></td></tr>
<tr><td rowspan="3">Long-term (after 2026)</td><td>BBBP2</td><td>Transmission Main Upgrades</td><td>Monitor</td></tr>
<tr><td>BBBP4</td><td>Additional Distribution Storage: Fowler's Road</td><td>Monitor</td></tr>
<tr><td>BBBP5</td><td>Additional Distribution Storage: Mundy Pond</td><td>Monitor</td></tr>
<tr><td rowspan="2">To be determined</td><td>New Customer1</td><td>Torbay (transmission and storage; new water supply must be developed before Torbay can be added to the EWSS)</td><td></td></tr>
<tr><td>New Customer2</td><td>Holyrood (required if Thomas Pond is developed as opposed to Big Triangle Pond; new water supply must be developed before Holyrood can be added to the EWSS)</td><td></td></tr>
</table>

*Supplied by the City of St. John's.

CHAPTER 8 WATER CONSERVATION

Many factors contribute to water loss, such as leakage, meter error, firefighting, pipe flushing, and theft. Leakage is a significant component of water loss, and may occur along transmission mains, distribution pipes, service connections, joints, valves and hydrants. Causes of leaks include corrosion, material defects, faulty installation, excessive water pressure, water hammer, ground movement due to freeze/thaw, and excessive loads from road traffic.

A water audit, as outlined in AWWA M36, can be used to determine how much water is being lost throughout the distribution system. The critical output of a water audit is the resulting estimate of Non-Revenue Water (NRW), which is the difference between the water supplied and the amount billed to customers. The reduction of NRW generally results in cost savings to the agency responsible for water supply and delivery.

Water conservation measures, which assist in the reduction of NRW, may target either leakage or customer attitudes and include:

- Leak detection.
- District metering.
- Universal metering (metering all water customers at the point-of-use).
- By-laws or regulations that restrict water use.
- Education programs.

St. John's and Mount Pearl have extensive leak detection programs. Also, St. John's has successfully implemented district metering. Many communities in the service area have by-laws and public education programs in place.

Water conservation measures may delay capital works projects associated with water supply, treatment and transmission upgrades. Many jurisdictions across North America have noticed a drop in overall water usage with the implementation of universal water metering. The decision to implement a universal water metering program should only be made after careful analysis and further study, including detailed cost-benefit analysis, which is beyond the scope of this study.

CHAPTER 9 CONCLUSIONS AND RECOMMENDATIONS

The key study conclusions are:

- Two potential sources for future development have been identified: Thomas Pond and Big Triangle Pond.
- Based on the median population projections, and without considering the implementation of additional water conservation measures, approximately 40-50,000 m^3/D of additional treated water is required to service the existing municipalities and the municipalities of Torbay and Holyrood over the 10-35 year study planning horizon.
- Due to the anticipated water deficit noted above, it is not possible to add municipalities to the EWSS until a new source becomes operational.
- Infrastructure requirements associated with addressing the anticipated water shortage have been established.
- Infrastructure deficits associated with the current water systems have been identified for both short-term and long-term planning horizons.
- Water conservation efforts currently implemented throughout the region are resulting in water savings; however, there are additional opportunities for water conservation.

The key recommendations are:

- The RWS committee should develop a document that formalizes the Regional-Municipal responsibilities. This document should contain the responsibilities of the RWS and the serviced municipalities with respect to the ownership and operation of water transmission components.
- In order to plan for a new water treatment plant, the following additional study work should be carried out as soon as possible:
  - Reliable yield study at Big Triangle Pond.
  - Treatability studies at Thomas Pond and Big Triangle Pond.
- Recommendations to offset the treated water deficit of 40-50,000 m^3/D are discussed in detail in Section 5.3, and include distribution system upgrades (PHLP1), a new water treatment plant and associated transmission main (New WTP), and new transmission main and storage (New Customer1 and New Customer2).

- Recommendations to address the existing infrastructure deficits are discussed in detail in Section 6.3, and include additional distribution storage at Ruby Line Pump Station (BBBP1), CBS South (BBBP3), Airport Heights (WL1), Sugarloaf Road (WL2), and Signal Hill (WL3), and new pumping station, transmission main, and storage at Kilbride East (PHLP2).
- All serviced municipalities should consider implementing universal metering to increase water conservation.

Prepared by: Greg Sheppard, P.Eng. Project Manager	Reviewed by: Andrew Gates, P.Eng. VP Infrastructure

APPENDIX A

Plans No. 1 and No. 2

ST. JOHN'S REGIONAL DRINKING WATER STUDY

Plan No. 1

Existing Water Distribution System

St John's, Mount Pearl, Paradise, Portugal Cove - St Philip's

LEGEND

- Water Resevoir
- PRV
- Water Treatment Plant
- Booster Pump

Watermains

- < 300 mm
- 300 - 350 mm
- 400 mm
- 450 - 500 mm
- 600 mm
- 750 - 1400 mm
- Municipal Boundaries
- Major Roads
- Roads - Community Mapping
- Watercourses
- Existing Serviced Limits

Watershed Protection

- Potential
- Protected
- Unprotected

Date: 29/01/2016

Project Number: 143051.00

Drawn By: IB

Approved By: GES

Scale at 36" x 48" 1:37,500

CBCL LIMITED
Consulting Engineers

ST. JOHN'S
NEWFOUNDLAND AND LABRADOR, CANADA

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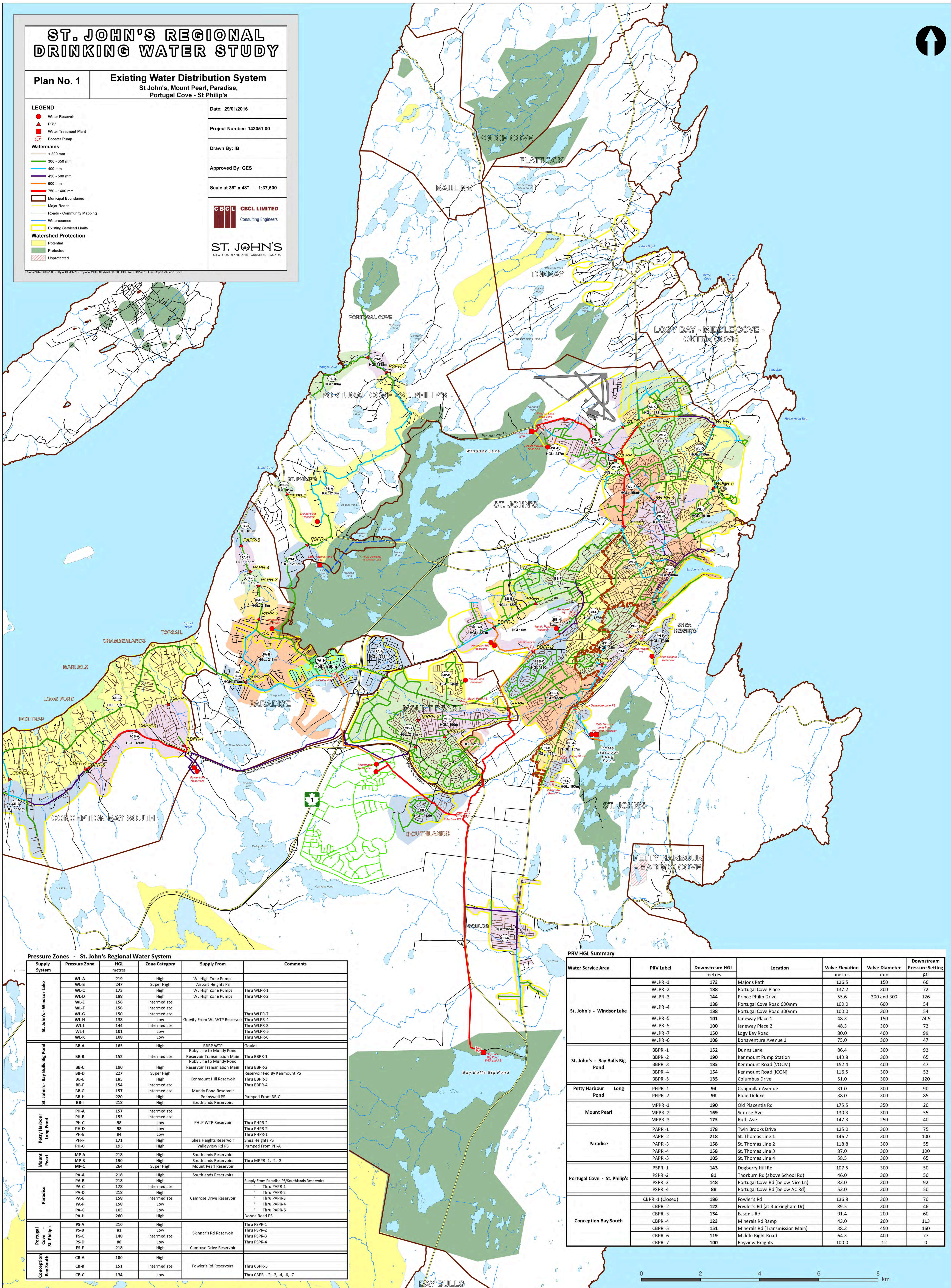

Pressure Zones - St. John's Regional Water System

Supply System	Pressure Zone	HGL (metres)	Zone Category	Supply From	Comments
St. John's - Windsor Lake	WL-A	219	High	WL High Zone Pumps	
	WL-B	247	Super High	Airport Heights PS	
	WL-C	173	High	WL High Zone Pumps	Thru WLPR-1
	WL-D	188	High	WL High Zone Pumps	Thru WLPR-2
	WL-E	156	Intermediate	Gravity From WL WTP Reservoir	
	WL-F	156	Intermediate		
	WL-G	150	Intermediate		Thru WLPR-7
	WL-H	138	Low		Thru WLPR-4
	WL-I	144	Intermediate		Thru WLPR-3
	WL-J	101	Low		Thru WLPR-5
	WL-K	108	Low		Thru WLPR-6
St. John's - Bay Bulls Big Pond	BB-A	165	High	BBBP WTP	Goulds
	BB-B	152	Intermediate	Ruby Line to Mundy Pond Reservoir Transmission Main	Thru BBPR-1
	BB-C	190	High	Ruby Line to Mundy Pond Reservoir Transmission Main	Thru BBPR-2
	BB-D	227	Super High	Kenmount Hill Reservoir	Reservoir Fed By Kenmount PS
	BB-E	185	High		Thru BBPR-3
	BB-F	154	Intermediate		Thru BBPR-4
	BB-G	157	Intermediate	Mundy Pond Reservoir	
	BB-H	220	High	Pennywell PS	Pumped From BB-C
	BB-I	218	High	Southlands Reservoirs	
Petty Harbour Long Pond	PH-A	157	Intermediate	PHLP WTP Reservoir	
	PH-B	155	Intermediate		
	PH-C	98	Low		Thru PHPR-2
	PH-D	98	Low		Thru PHPR-2
	PH-E	94	Low		Thru PHPR-1
	PH-F	171	High	Shea Heights Reservoir	Shea Heights PS
	PH-G	193	High	Valleyview Rd PS	Pumped From PH-A
Mount Pearl	MP-A	218	High	Southlands Reservoirs	
	MP-B	190	High	Southlands Reservoirs	Thru MPPR -1, -2, -3
	MP-C	264	Super High	Mount Pearl Reservoir	
Paradise	PA-A	218	High	Southlands Reservoirs	
	PA-B	218	High	Camrose Drive Reservoir	Supply From Paradise PS/Southlands Reservoirs
	PA-C	178	Intermediate		" Thru PAPR-1
	PA-D	218	High		" Thru PAPR-2
	PA-E	158	Intermediate		" Thru PAPR-3
	PA-F	158	Low		" Thru PAPR-4
	PA-G	105	Low		" Thru PAPR-5
	PA-H	260	High		Donna Road PS
Portugal Cove - St. Philip's	PS-A	210	High	Skinner's Rd Reservoir	Thru PSPR-1
	PS-B	81	Low		Thru PSPR-2
	PS-C	148	Intermediate		Thru PSPR-3
	PS-D	88	Low		Thru PSPR-4
	PS-E	218	High	Camrose Drive Reservoir	
Conception Bay South	CB-A	180	High	Fowler's Rd Reservoirs	
	CB-B	151	Intermediate		Thru CBPR-5
	CB-C	134	Low		Thru CBPR - 2, -3, -4, -6, -7

PRV HGL Summary

Water Service Area	PRV Label	Downstream HGL (metres)	Location	Valve Elevation (metres)	Valve Diameter (mm)	Downstream Pressure Setting (psi)
St. John's - Windsor Lake	WLPR -1	**173**	Major's Path	126.5	150	66
	WLPR -2	**188**	Portugal Cove Place	137.2	300	72
	WLPR -3	**144**	Prince Philip Drive	55.6	300 and 300	126
	WLPR -4	**138**	Portugal Cove Road 600mm	100.0	600	54
		138	Portugal Cove Road 300mm	100.0	300	54
	WLPR -5	**101**	Janeway Place 1	48.3	150	74.5
	WLPR -5	**100**	Janeway Place 2	48.3	300	73
	WLPR -7	**150**	Logy Bay Road	80.0	400	99
	WLPR -6	**108**	Bonaventure Avenue 1	75.0	300	47
St. John's - Bay Bulls Big Pond	BBPR -1	**152**	Dunns Lane	86.4	300	93
	BBPR -2	**190**	Kenmount Pump Station	143.8	300	65
	BBPR -3	**185**	Kenmount Road (VOCM)	152.4	400	47
	BBPR -4	**154**	Kenmount Road (ICON)	116.5	300	53
	BBPR -5	**135**	Columbus Drive	51.0	300	120
Petty Harbour Long Pond	PHPR -1	**94**	Craigmillar Avenue	31.0	300	90
	PHPR -2	**98**	Road Deluxe	38.0	300	85
Mount Pearl	MPPR -1	**190**	Old Placentia Rd	175.5	350	20
	MPPR -2	**169**	Sunrise Ave	130.3	300	55
	MPPR -3	**175**	Ruth Ave	147.3	250	40
Paradise	PAPR -1	**178**	Twin Brooks Drive	125.0	300	75
	PAPR -2	**218**	St. Thomas Line 1	146.7	300	100
	PAPR -3	**158**	St. Thomas Line 2	118.8	300	55
	PAPR -4	**158**	St. Thomas Line 3	87.0	300	100
	PAPR -5	**105**	St. Thomas Line 4	58.5	300	65
Portugal Cove - St. Philip's	PSPR -1	**143**	Dogberry Hill Rd	107.5	300	50
	PSPR -2	**81**	Thorburn Rd (above School Rd)	46.0	300	50
	PSPR -3	**148**	Portugal Cove Rd (below Nice Ln)	83.0	300	92
	PSPR -4	**88**	Portugal Cove Rd (below AC Rd)	53.0	300	50
Conception Bay South	CBPR -1 (Closed)	**186**	Fowler's Rd	136.8	300	70
	CBPR -2	**122**	Fowler's Rd (at Buckingham Dr)	89.5	300	46
	CBPR -3	**134**	Eason's Rd	91.4	200	60
	CBPR -4	**123**	Minerals Rd Ramp	43.0	200	113
	CBPR -5	**151**	Minerals Rd (Transmission Main)	38.3	450	160
	CBPR -6	**119**	Middle Bight Road	64.3	400	77
	CBPR -7	**100**	Bayview Heights	100.0	12	0

ST. JOHN'S REGIONAL DRINKING WATER STUDY

Plan No. 2

Existing Water Distribution System

Conception Bay South / Holyrood

LEGEND

- Water Resevoir
- PRV
- Water Treatment Plant
- Booster Pump

Watermains

- < 300 mm
- 300 - 350 mm
- 400 mm
- 450 - 500 mm
- 600 mm
- 750 - 1400 mm
- Municipal Boundaries
- Major Roads
- Roads - Community Mapping
- Watercourses
- Existing Serviced Limits

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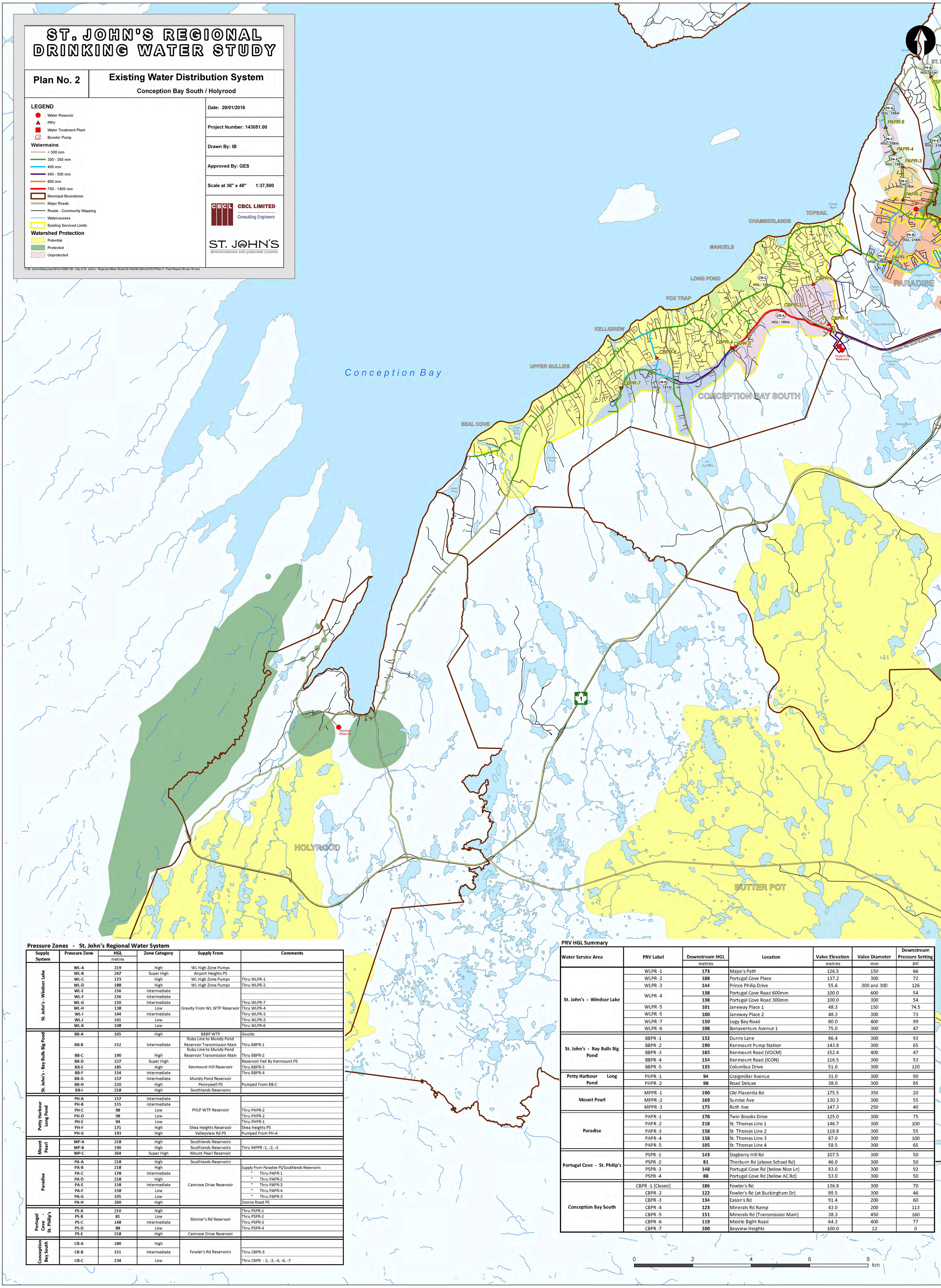

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	WL-F	156	Intermediate		
	WL-G	150	Intermediate		Thru WLPR-7
	WL-H	138	Low		Thru WLPR-4
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St. John's - Bay Bulls Big Pond	BB-A	165	High	BBBP WTP	Goulds
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	BB-G	157	Intermediate	Mundy Pond Reservoir	
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	PH-C	98	Low		Thru PHPR-2
	PH-D	98	Low		Thru PHPR-2
	PH-E	94	Low		Thru PHPR-1
	PH-F	171	High	Shea Heights Reservoir	Shea Heights PS
	PH-G	193	High	Valleyview Rd PS	Pumped From PH-A
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	PA-E	158	Intermediate		" Thru PAPR-3
	PA-F	158	Low		" Thru PAPR-4
	PA-G	105	Low		" Thru PAPR-5
	PA-H	260	High		Donna Road PS
Portugal Cove - St. Philip's	PS-A	210	High	Skinner's Rd Reservoir	Thru PSPR-1
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	PS-C	148	Intermediate		Thru PSPR-3
	PS-D	88	Low		Thru PSPR-4
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	CB-C	134	Low		Thru CBPR - 2, -3, -4, -6, -7

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	WLPR -3	144	Prince Philip Drive	55.6	300 and 300	126
	WLPR -4	138	Portugal Cove Road 600mm	100.0	600	54
		138	Portugal Cove Road 300mm	100.0	300	54
	WLPR -5	101	Janeway Place 1	48.3	150	74.5
	WLPR -5	100	Janeway Place 2	48.3	300	73
	WLPR -7	150	Logy Bay Road	80.0	400	99
	WLPR -6	108	Bonaventure Avenue 1	75.0	300	47
St. John's - Bay Bulls Big Pond	BBPR -1	152	Dunns Lane	86.4	300	93
	BBPR -2	190	Kenmount Pump Station	143.8	300	65
	BBPR -3	185	Kenmount Road (VOCM)	152.4	400	47
	BBPR -4	154	Kenmount Road (ICON)	116.5	300	53
	BBPR -5	135	Columbus Drive	51.0	300	120
Petty Harbour Long Pond	PHPR -1	94	Craigmillar Avenue	31.0	300	90
	PHPR -2	98	Road Deluxe	38.0	300	85
Mount Pearl	MPPR -1	190	Old Placentia Rd	175.5	350	20
	MPPR -2	169	Sunrise Ave	130.3	300	55
	MPPR -3	175	Ruth Ave	147.3	250	40
Paradise	PAPR -1	178	Twin Brooks Drive	125.0	300	75
	PAPR -2	218	St. Thomas Line 1	146.7	300	100
	PAPR -3	158	St. Thomas Line 2	118.8	300	55
	PAPR -4	158	St. Thomas Line 3	87.0	300	100
	PAPR -5	105	St. Thomas Line 4	58.5	300	65
Portugal Cove - St. Philip's	PSPR -1	143	Dogberry Hill Rd	107.5	300	50
	PSPR -2	81	Thorburn Rd (above School Rd)	46.0	300	50
	PSPR -3	148	Portugal Cove Rd (below Nice Ln)	83.0	300	92
	PSPR -4	88	Portugal Cove Rd (below AC Rd)	53.0	300	50
Conception Bay South	CBPR -1 (Closed)	186	Fowler's Rd	136.8	300	70
	CBPR -2	122	Fowler's Rd (at Buckingham Dr)	89.5	300	46
	CBPR -3	134	Eason's Rd	91.4	200	60
	CBPR -4	123	Minerals Rd Ramp	43.0	200	113
	CBPR -5	151	Minerals Rd (Transmission Main)	38.3	450	160
	CBPR -6	119	Middle Bight Road	64.3	400	77
	CBPR -7	100	Bayview Heights	100.0	12	0

APPENDIX B

Transmission Mains Inventory

Water Service Area	Pipe Description	Pressure Zone	Pipe Diameter	Approx. Pipe Length	2014 Max Day Demands Velocity	2036 Max Day Demands Velocity
			mm	m	m/s	m/s
Windsor Lake	From Windsor Lake WTP along Portugal Cove Rd., to Higgins Line.	WL-A, WL-D	1200	4604	0.7 to 0.4	0.8 to 0.4
	From Portugal Cove Rd. along the Trans Canada Hwy to Logy Bay Rd.	WL-D, WL-E	900	1472	0.3	0.3
		WL-E	600	1468	0.4	0.5
		WL-E	500	1356	0.6	0.6
	Along Higgins Line, and Alandale Rd. from Portugal Cove Road to PRV WLPR-3	WL-F	750	1820	0.4 to 0.3	0.4 to 0.3
	Along Bonaventure Ave., and Mayor Ave., from PRV WLPR-3 to Empire Ave.	WL-I	600	1149	0.5 to 0.3	0.5 to 0.4
	Along Mayor Ave., from Empire Ave., to Merrymeeting Rd.	WL-I	500	528	0.3	0.4
	Along Mayor Ave., from Merrymeeting Rd. to Freshwater Rd.	WL-I	400	180	0.3 to 0.2	0.4 to 0.3
	Along Freshwater Rd. from Mayor Ave., to Pennywell Rd.	WL-I	400	330	0.2	0.2 to 0.1
	Along Portugal Cove Rd. from Higgins Line to First Ave.	WL-F, WL-H	600	2345	0.8	0.9
	Along Portugal Cove Rd. and Rennies Mill Rd. from First Ave., to Kings Rd.	WL-H	500	1020	1.1 to 0.8	1.2 to 0.9
	Along Kings Rd., from Rennies Mill Rd., to Duckworth St.	WL-K	500	439	0.8	0.9
	Along New Gower St. and Duckworth St. from Queen St., to Signal Hill Rd.	WL-K	500	1559	0.5 to 0.1	0.5 to 0.1
	Along Signal Hill Rd., from Duckworth St.	WL-K, WL-J	500	1086	0.1	0.1
	Windsor Lake Pump Station to Hercules Place	WL-A	400	520	0.6 to 0.4	0.7 to 0.4
	Along Portugal Cove Rd., from Rhodora St. to PRV WLPR-2	WL-A	400	473	0.1	0.1
	Along Portugal Cove Pl., from PRV WLPR-2 to Hunts Ln.	WL-D	400	280	0.1	0.1
	Along Robin Hood Bay Rd., and East White Hills Rd., from PRV WLPR-7 to the Regional Waste Management Facility	WL-E	400	1104	0.0	0.0
	Along Logy Bay Rd., from PRV WLPR-7 to Harding Rd.	WL-G	400	1268	0.9 to 0.6	0.9 to 0.6
	Along East White Hills Rd., to PRV WLPR-5	WL-G	400	391	0.0	0.0
	Along Portugal Cove Rd., and Rennies Mill Rd., from Winter Ave., to King's Rd.	WL-H	400	991	0.1	0.1
	From Military Rd., to PRV WLPR-6	WL-H, WL-I	400	791	0.0	0.0
	From PRV WLPR-6 to Mayor Ave.	WL-I	400	726	0.0	0.0
	Along Mayor Ave., from Merrymeeting Rd. to Freshwater Rd.	WL-I	400	180	0.3	0.4
	Along Freshwater Rd. from Mayor Ave., to Harvey Rd.	WL-I	400	357	0.2 to 0.1	0.3 to 0.2
	Along New Gower St. from Queen St. to Water St.	WL-K	400	880	0.3	0.3 to 0.2
	Along Prescott St., and Harbour Dr. to Water St.	WL-K	400	1363	0.2 to 0.1	0.2 to 0.1
Petty Harbour Long Pond	PHLP WTP to PRV BBPR-5	PH-A, PH-B	600	400	0.5	0.6
			400	1475	1.2 to 0.7	1.4 to 0.9
	Along Waterford Bridge Rd. from Columbus Dr. to Road De Luxe	PH-C	400	1268	0.7	0.8
	Along Road De Luxe from Waterford Bridge Rd. to Topsail Rd.	PH-D	400	436	0.5	0.6
	Along Topsail Rd., and Cornwall Ave. to Hamilton Ave.	PH-D	400	1200	0.4 to 0.2	0.5 to 0.3
Bay Bulls Big Pond	BBBP WTP to Ruby Line Pump Station	-	1050	8280	1.2	1.5
	Robert E. Howlett Memorial Dr. to Howletts Line (Goulds)	BB-A	500	4115	0.2	0.2
			400	468	0.0	0.0
	Ruby Line Pump Station to Kenmount Rd. Pump Station	-	750	5400	0.8 to 0.5	0.8
			600	1700	0.7	0.8
	Kenmount Rd. Pump Station to Mundy Pond Reservoir	BB-C	600	1344	0.2	0.2
	Jensen Camp Rd. to Thorburn Rd.	BB-G	500	2344	0.3	0.3
	Kenmount Rd. Pump Station to Kenmount Hills Reservoirs	BB-D	600	1635	0.4	0.4
	Kenmount Hills Reservoirs to Nautilus St.	BB-D	600	1310	0.4	0.4
			400	82	0.0	0.0
	West along Kenmount Rd. from Ladysmith Dr.	BB-D	400	1382	0.0	0.0
	Along Kenmount Rd. East from PRV BBPR-3	BB-E	400	584	0.5	0.5
	Ruby Line Pump Station to Southlands Reservoir	-	750	3400	*1.6*	*2.0*
	Southlands Reservoir to Mount Pearl PRV MPPR-1	-	450	690	*1.6*	*1.8*
			350	305	*1.6*	*1.8*
	Southlands Reservoir to Paradise and Conception Bay South branch connections at the Trans Canada Hwy.	-	450	2293	0.8	1.0
			600	2285	0.9	1.2
	Along Conception Bay South Bypass to PRV CBPR-1	-	400	3832	*1.7*	*2.1*
			450	2124	1.4	*1.7*
	Fowlers Rd. Reservoirs to PRV CBPR-3	CB-A	600	2409	0.6	0.7
	PRV CBPR-3 to PRV CBPR-5	CB-A	450	54	0.5	0.7
			600	2786	0.4	0.5
	PRV CBPR-5 to PRV CBPR-6	CB-B	400	1179	0.5 to 0.3	0.7 to 0.5
			450	2449	0.5 to 0.4	0.7
	Along Middle Bight Rd. and Conception Bay Hwy. from PRV CBPR-6 to Marsh Rd.	CB-C	400	1607	0.3	0.5 to 0.4
	Transmission Main to Paradise from Trans Canada Hwy. to Kenmount Rd.	PA-A	400	1433	0.4	0.5
			600	1645	0.5	0.6
	Along Karwood Dr. and Topsail Rd. from Kenmount Rd. to Paradise Pump Station	PA-A	600	900	0.6	0.8
	Along Topsail Rd. from Paradise Pump Station to Paradise Rd.	PA-B	400	480	*4.4 to 1.2*	*4.4 to 1.6*
	Along Topsail Rd. from Paradise Rd. to Topsail Rd.	PA-B	400	2735	0.6	0.9 to 0.7
	Along St. Thomas Line from Topsail Rd. to Paradise Rd.	PA-B	400	2231	0.3	0.5
	Skinners Rd. Reseroir to Nearys Pond Rd.	PS-A	400	8109	0.2 to 0.1	0.3 to 0.2

APPENDIX C

Population Forecasting Study

Regional Water Supply Study:
Report on Outcomes of Estimating Housing Type and Demands Using a Cohort Specific Demographic Forecast Model

November 30th, 2014

A Report by:
Alvin Simms PhD
Jamie Ward MSc
Department of Geography
Harris Centre Regional Analytics Lab

1.0 Introduction

This report presents the outcomes of an integrated demographic analytics model used to forecast population counts and housing demands in the St. John's Urban Region (see Figure 1.0) for 10, 25 and 35 year periods. The forecast data produced by the model are used as inputs for predicting future water demands in the study area.

The report is in three parts: [1] a discussion on the importance of age structure in the population for forecasting and a brief discussion on the distribution of age cohorts by NL Statistics neighbourhood geography, [2] the assumptions of the forecast model, and [3] a presentation of outcomes in tabular format.

2.0 Age Structure by Neighbourhood

The age structure of a population is indicative of the future growth potential of a region in terms of natural replacement of the population. This growth is not entirely exclusive of migration factors given that the number of in-out migrants of different age cohorts may change the age structure of an area and thus a population's sustainability potential. For example, continued out migration of young people with zero in-migration will ultimately lead to the absolute decline of a community. Generally the current age structure of a region is compared against some conceptual model for population sustainability and in this study three scenarios are used and they are low, median and high population growth models. Low growth represents a population with decreasing birth rates and increasing longevity and is a characteristic of many industrialized countries. Places with this characteristic will eventually require positive net-migration to sustain and grow its existing population numbers. The median growth structure represents a situation of higher birth rates (i.e. fertility of 2.1 or slightly higher) and increasing longevity as well as the ability to sustain existing population numbers. Finally the high growth model represents a population characteristic whereby a place has high birth and death rates that are common in many developing countries. It is more likely that in developed regions of the world the future age structure of its populations will follow the "low growth" model. Ideally it should be somewhere between the low and median growth scenarios for sustaining current population numbers. However, for regions where the age structure characteristics is at or below the distribution for "low growth" a population's growth and sustainability can only be maintained through migration.

Table 1.0 contains a summary of the low, median and high growth thresholds by age cohorts that are required to classify the growth potential of a population. These percentages have to be met for all age cohorts in the population especially for the 0-4 to 25-34 cohorts which represent the future population potential of a place. These values are used to classify and map the distribution of age cohorts for the study area neighbourhoods. For example, if the 0-4 cohort percentage of population for a neighbourhood is between 6.7% and 11.87% it would represent a good concentration of that cohort in that particular neighbourhood.

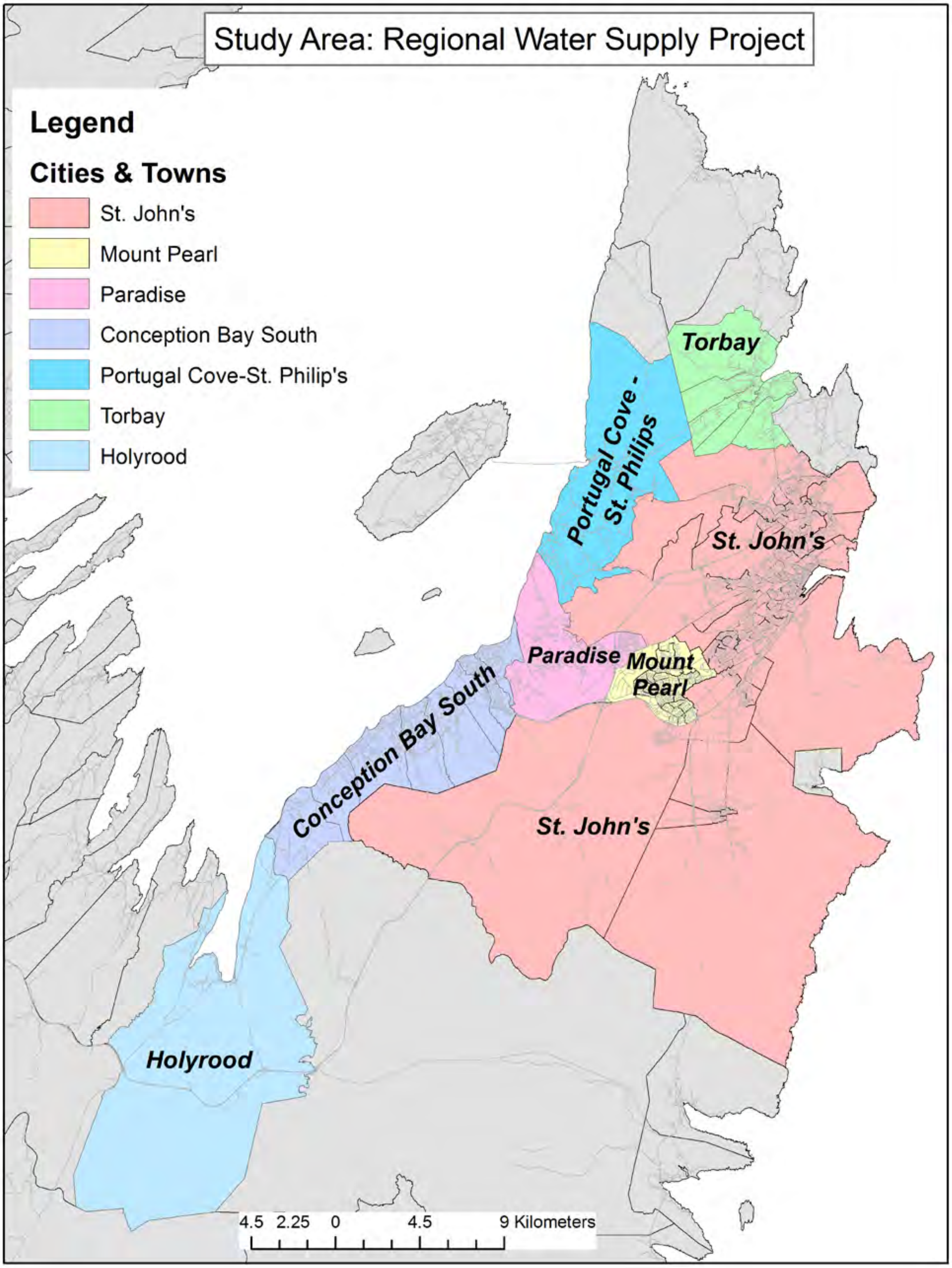

Figure 1.0 St. John's Regional Water Supply Study Area

But for the neighbourhood to exhibit a low to median growth age structure all the other age cohorts would have to be represented in the range of values presented in the table.

A query of the outcomes indicated that although some neighbourhoods had concentrations of individual cohorts that are within the ranges for low to median growth characteristics they could not be explicitly classed as low or median growth potential because the overall age structure did not conform to required distributions. However, it does not mean that the potential growth is low and in a majority of cases it is in those neighbourhoods with the highest concentration of 0-4 to 25-34 cohort range that are displaying the highest growth from 2006 to 2011.

Table 1.0 Percent of Population for Low, Median and High Growth Age Cohort Thresholds

Age Cohort	Low Growth	Median Growth	High Growth
0-4 Years	6.70%	11.85%	17.00%
5-14 Years	14.60%	17.80%	21.00%
15-19 Years	8.30%	9.15%	10.00%
20-24 Years	7.60%	8.30%	9.00%
25-34 Years	15.60%	14.30%	13.00%
35-44 Years	13.50%	11.25%	9.00%
45-54 Years	12.40%	9.20%	6.00%
55-64 Years	12.80%	8.90%	5.00%
65 Plus Years	18.03%	12.52%	7.00%

To examine the spatial coincidence between the difference age cohort map layers Pearson's r was adapted to measure the strength of the spatial association by neighbourhood. Pearson's r ranges from -1 to +1 where -1 indicates a very strong negative correlation and that two age cohorts do not coincide spatially. Furthermore, when the relationship is negative one can state that on average when the concentration of one cohort increases the other decreases. However, an observed Pearson's r value of -0.582 between the 34-44 and 65 Plus cohorts would suggest that you are more likely not to find 65 Plus cohorts in neighbourhoods where the 34-44 is the dominant age group but there are some neighbourhoods where you would find both age groups but as the concentration of 34-44 cohort increases the 65 Plus group decreases and vice versa. Similarity, if Pearson's r was +1 it would indicate the opposite where the concentration of one cohort is strongly spatially associated with the increasing concentration of another cohort. For example, the calculated r score for the 5-15 and 35-44 cohorts is 0.635 indicates a good spatial coincidence between the two cohorts and generally the present of one is associated with an increase in the other.

An assessment of the correlations between the various age cohorts by neighbourhood (Figure 2.0) indicates that the 0-4 cohort is positively correlated with the 5-14 and 35-44 cohorts and with a Pearson's r values of 0.62 and 0.73 respectively, would suggest that these associations are representative of "family type neighbourhoods". The 20-24 cohort is negatively associated with all three cohorts but exhibit a weak positive association (0.20) with the 15-19 cohort. On average the 20-24 cohort represent neighbourhoods where University and College students live. Generally, cohorts with a positive Pearson's r indicates on average that they are living in the same neighbourhood while a negative value would suggest age cohorts live in different neighbourhoods. Note this not exclude the fact that a neighbourhood may contain a mixture of age cohorts. The correlations for all age cohorts are presented in Table 2.0. Note that the 65 Plus cohort has a negative correlation with all cohorts except for a weak positive correlation (0.05) with the 55-64 age group (Table 2.0) indicating on average this cohort is living in ageing neighbourhoods.

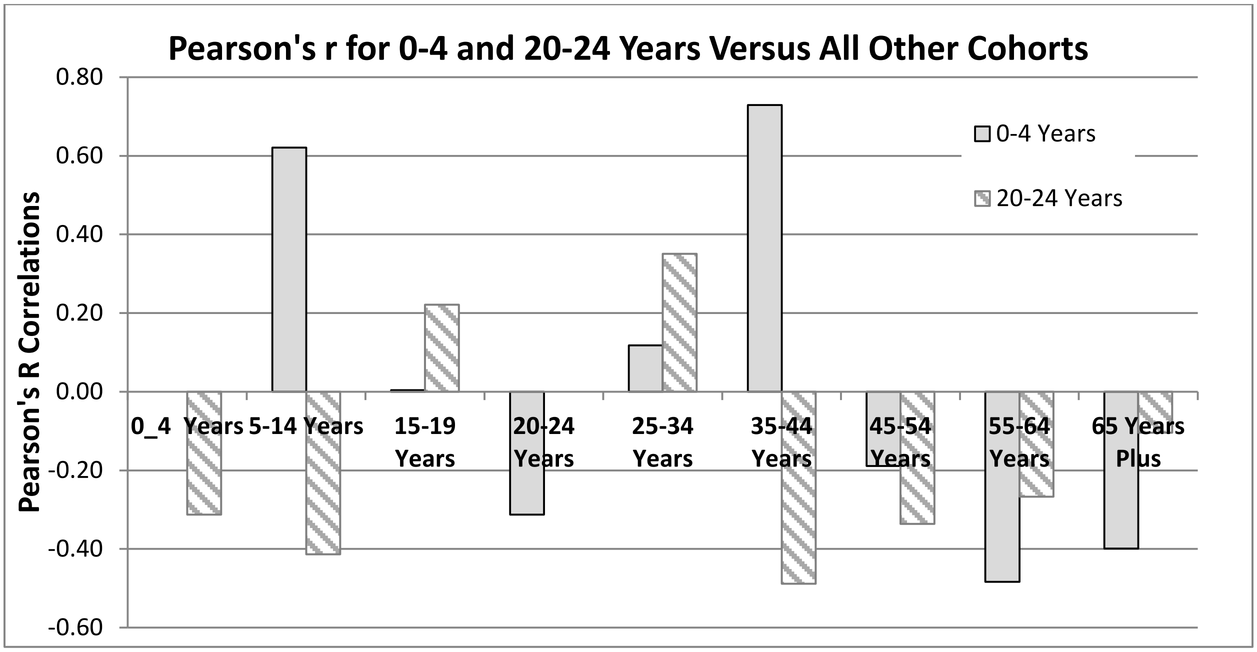

Figure 2.0 Pearson's r Correlations by Neighbourhood Age Cohort

Table 2.0 Neighbourhood Pearson's r Correlations by Age Cohort

Age Cohort	0 to 4 Yrs.	5 to 14 Yrs.	15 to 19 Yrs.	20 to 24 Yrs.	25 to 34 Yrs.	35 to 44 Yrs.	45 to 54 Yrs.	55 to 64 Yrs.	65 Plus Yrs.
0 to 4 Yrs.	1.000	0.621	0.004	-0.313	0.118	0.729	-0.189	-0.483	-0.399
5 to 14 Yrs.	0.621	1.000	0.454	-0.414	-0.359	0.635	0.248	-0.110	-0.517
15 to 19 Yrs.	0.004	0.454	1.000	0.221	-0.334	-0.010	0.379	0.042	-0.480
20 to 24 Yrs.	-0.313	-0.414	0.221	1.000	0.350	-0.488	-0.336	-0.267	-0.104
25 to 34 Yrs.	0.118	-0.359	-0.334	0.350	1.000	0.119	-0.398	-0.440	-0.298
35 to 44 Yrs.	0.729	0.635	-0.010	-0.488	0.119	1.000	0.159	-0.273	-0.582
45 to 54 Yrs.	-0.189	0.248	0.379	-0.336	-0.398	0.159	1.000	0.448	-0.369
55 to 64 Yrs.	-0.483	-0.110	0.042	-0.267	-0.440	-0.273	0.448	1.000	0.047
65 Plus Yrs.	-0.399	-0.517	-0.480	-0.104	-0.298	-0.582	-0.369	0.047	1.000

Mapping age cohorts by neighbourhood will provide information on the distributions of various age cohorts and identify those areas that are growing versus ageing. The population change map for the study area (Figure 3.0) shows the variability in growth by neighbourhoods ranges from a decline of -13.77% to increases of over 50%. The decline is mostly in older established neighbourhoods while the largest growth is occurring in the newer developments. When mapping the age cohorts it is important to examine the low, median and high growth values identified in the Figure title. Figure 4.0 displays the distribution of the 0-4 cohort and the map class of 6.70% indicates a neighbourhood concentration that is characteristic of a low growth model.

It is important to interpret the maps (Figures 4.0 to 12.0) in terms of growth curve percentages and within the context of potential future populations. For cohorts ranging from 0-4 to 25-34 and if their observed percentages are above the different growth curve values it represents sustainable growth because there is potential for future replacement of the older cohorts. However, in situations where the older cohorts exceed the growth curve percentages it could be an indication of future population decline. Again the interpretations must be within the context of the age structure of the population. For example, if a neighbourhood has a sufficient concentration of young cohorts along with a higher than expected percentage of older cohorts it also represents a high potential for sustainability. Whereas if younger cohorts are below the requisite low curve values and the older cohorts are above the values it is a scenario of population decline rather than growth.

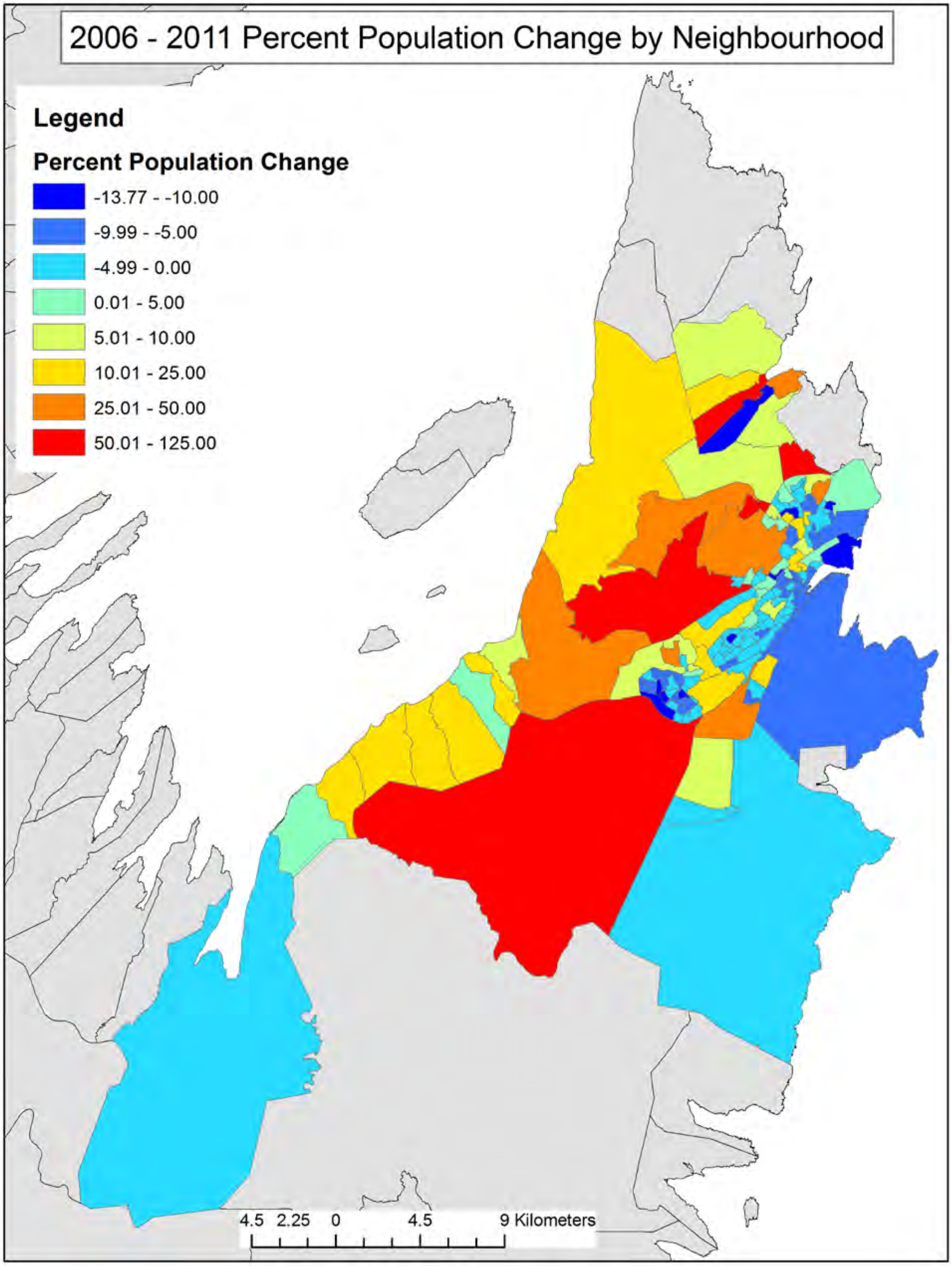

Figure 3.0 Percent Population Change 2006 to 2011 by Neighbourhood

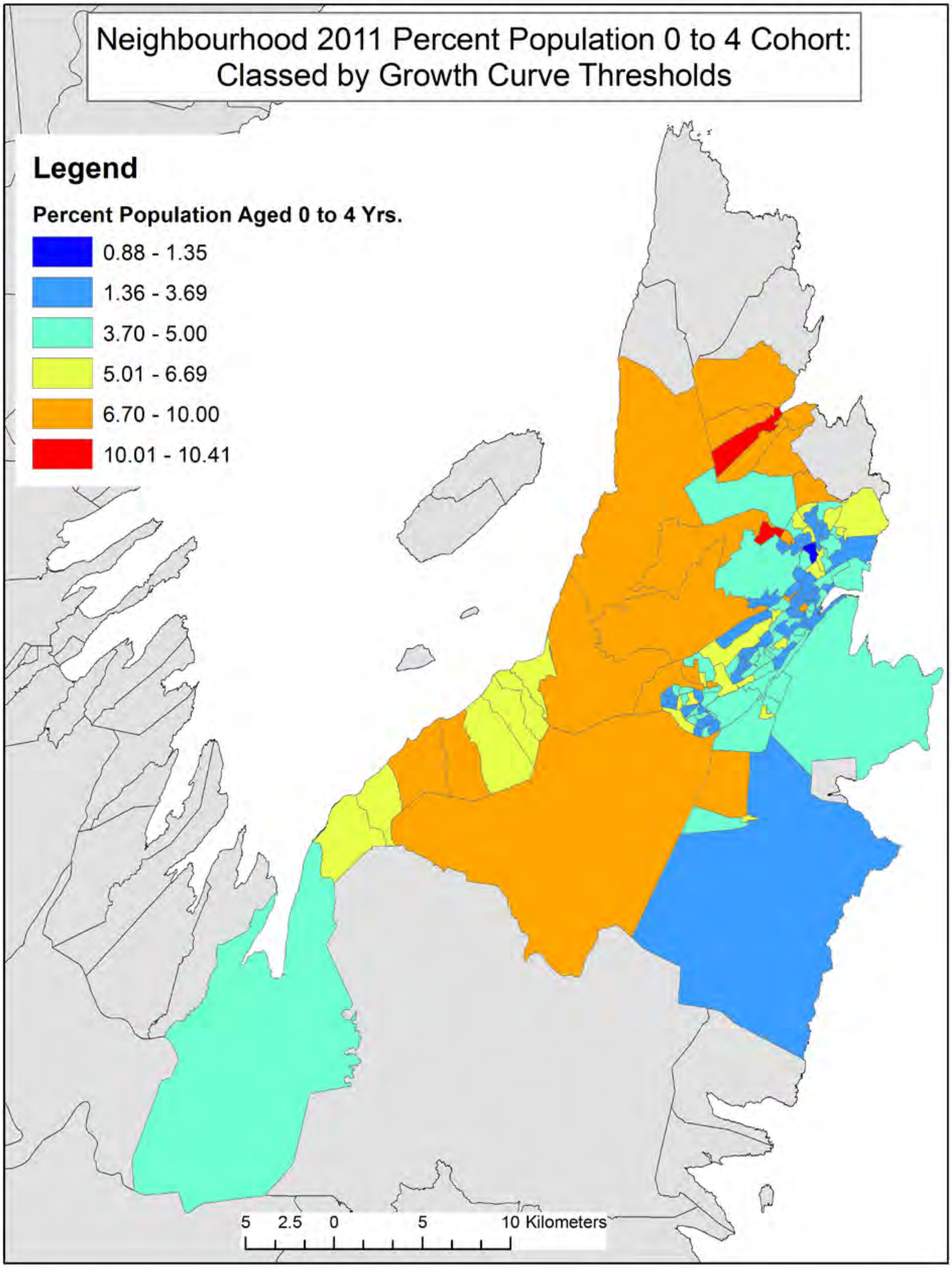

Figure 4.0 2011 Percent Population Aged 0-4 by Neighbourhood - Low to Median Growth Thresholds Range From 6.70% to 11.85%

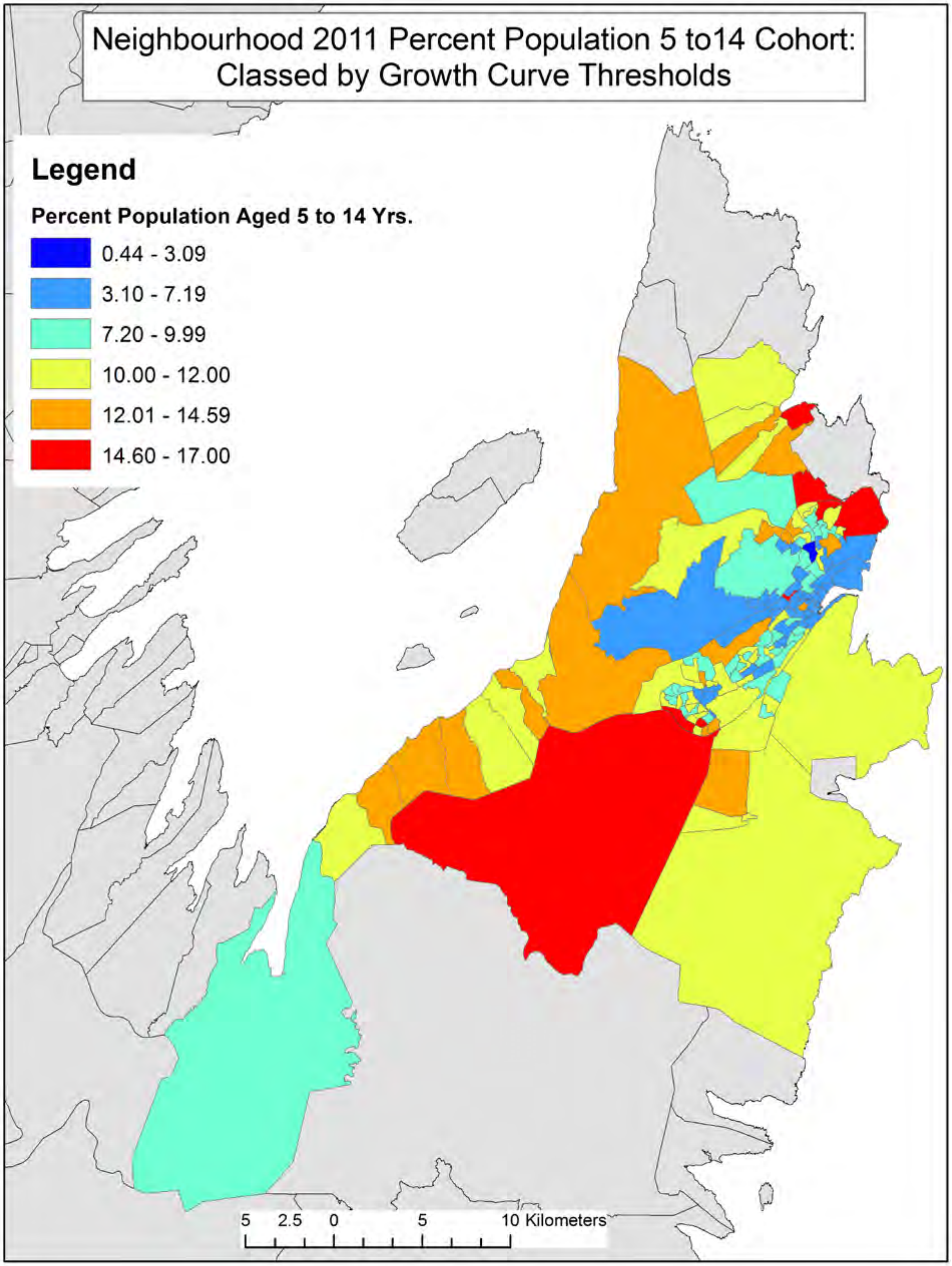

Figure 5.0 2011 Percent Population Aged 5-14 by Neighbourhood - Low to Median Growth Thresholds Range From 14.6% to 17.80%

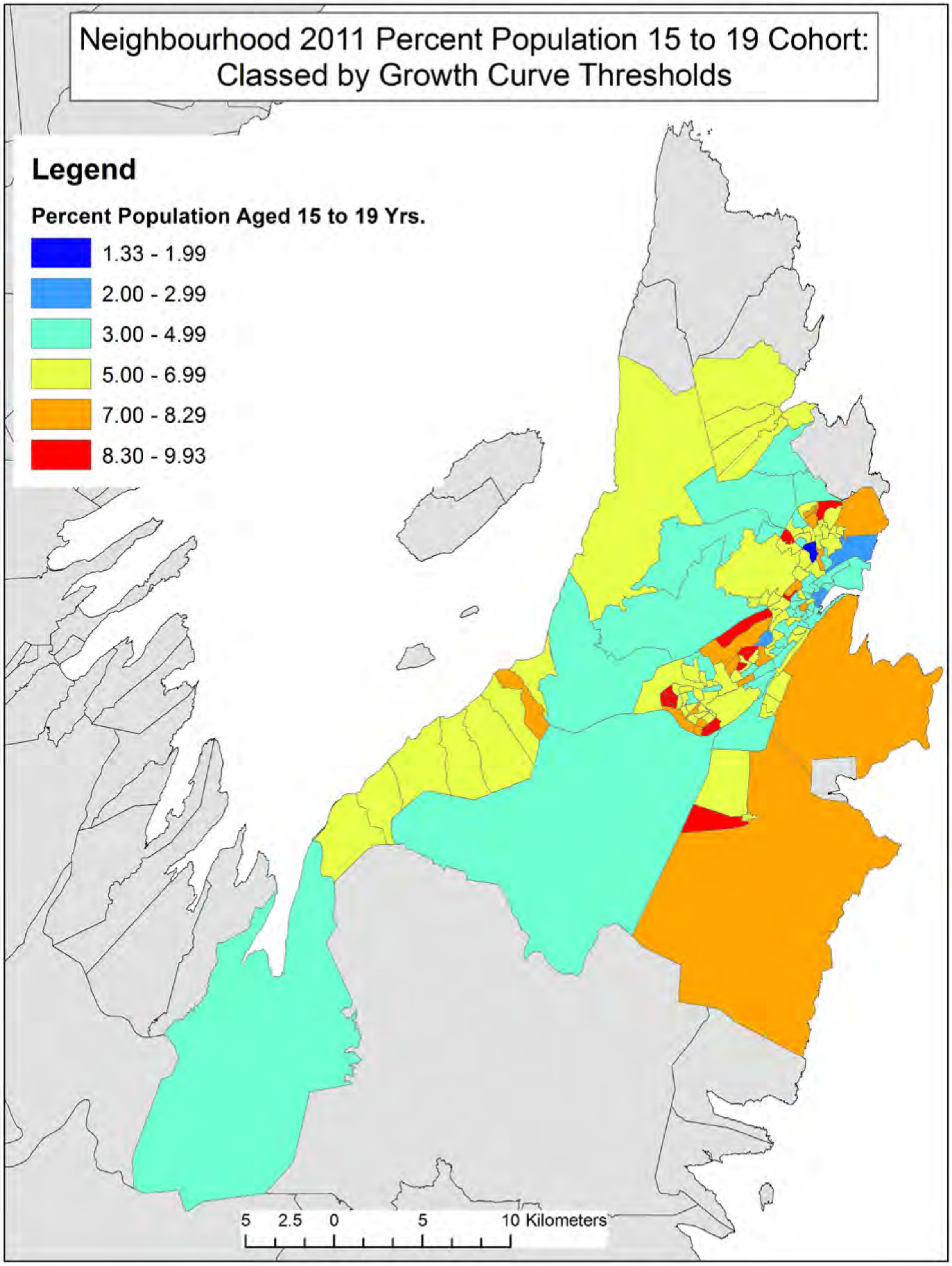

Figure 6.0 2011 Percent Population Aged 15-19 by Neighbourhood - Low to Median Growth Thresholds Range From 8.30% to 9.15%

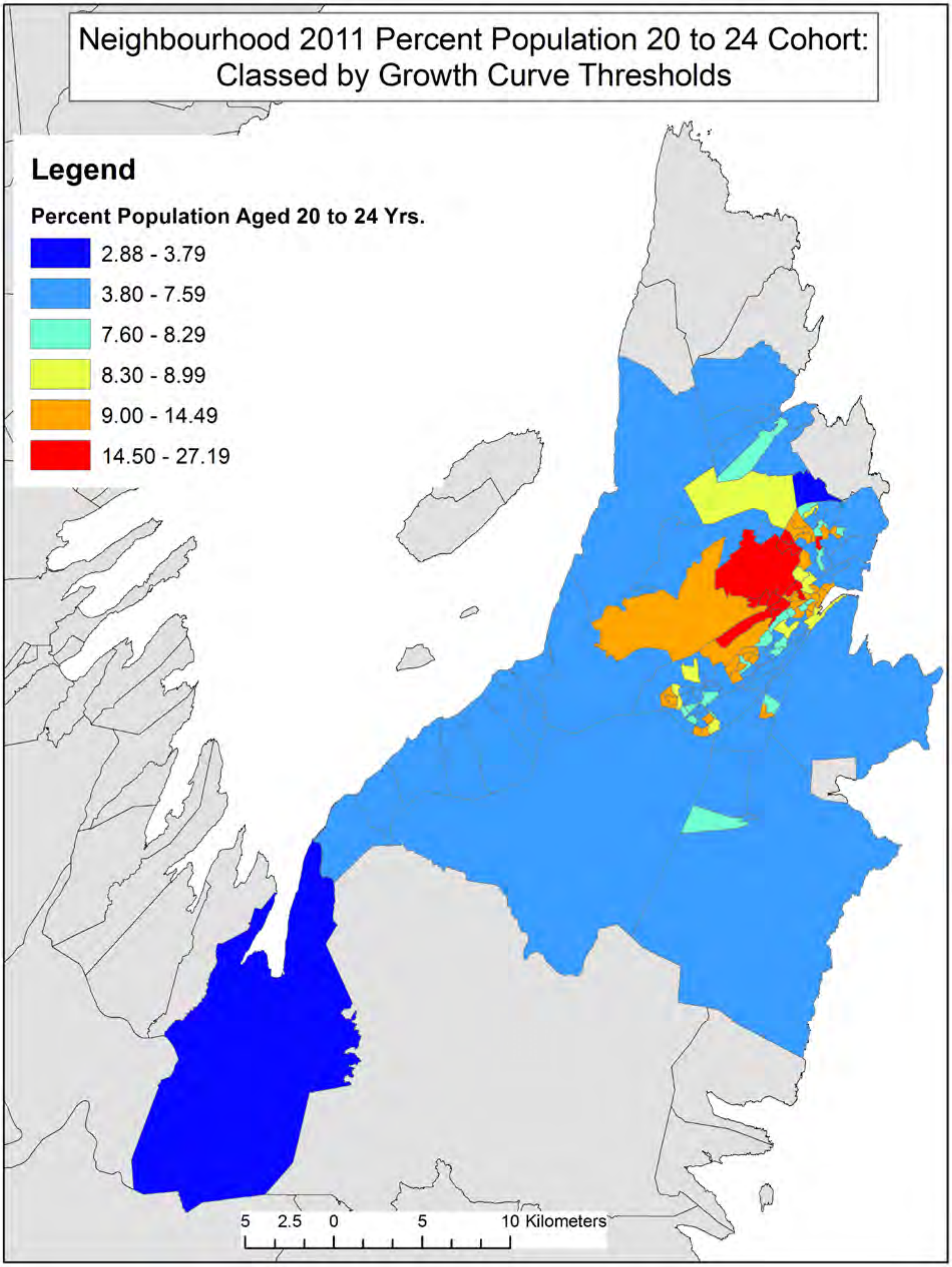

Figure 7.0 2011 Percent Population Aged 20-24 by Neighbourhood - Low to High Growth Thresholds Range From 7.6% to 9.00%

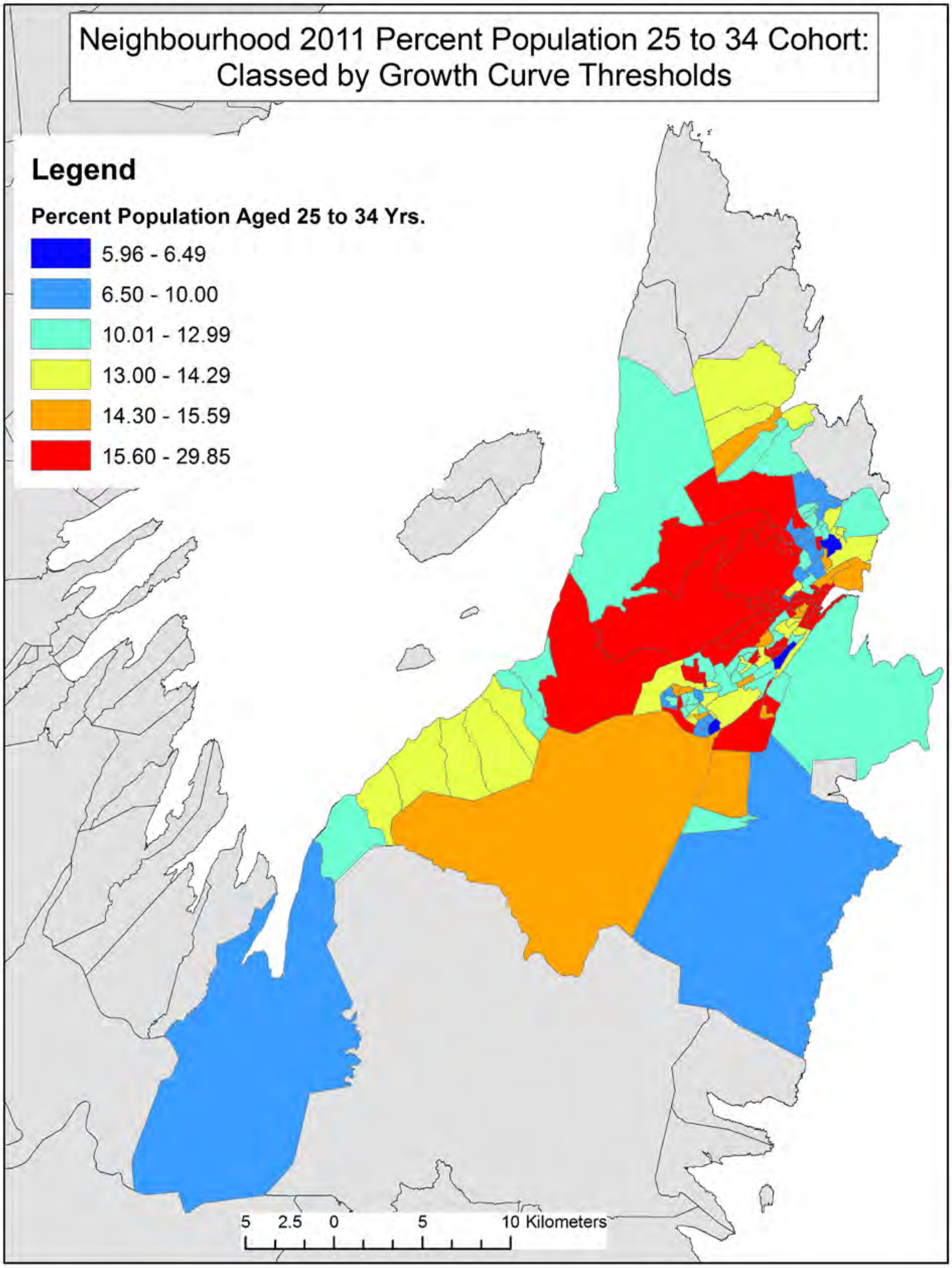

Figure 8.0 2011 Percent Population Aged 25-34 by Neighbourhood - Low to Median Growth Thresholds Range From 15.6% to 14.30%

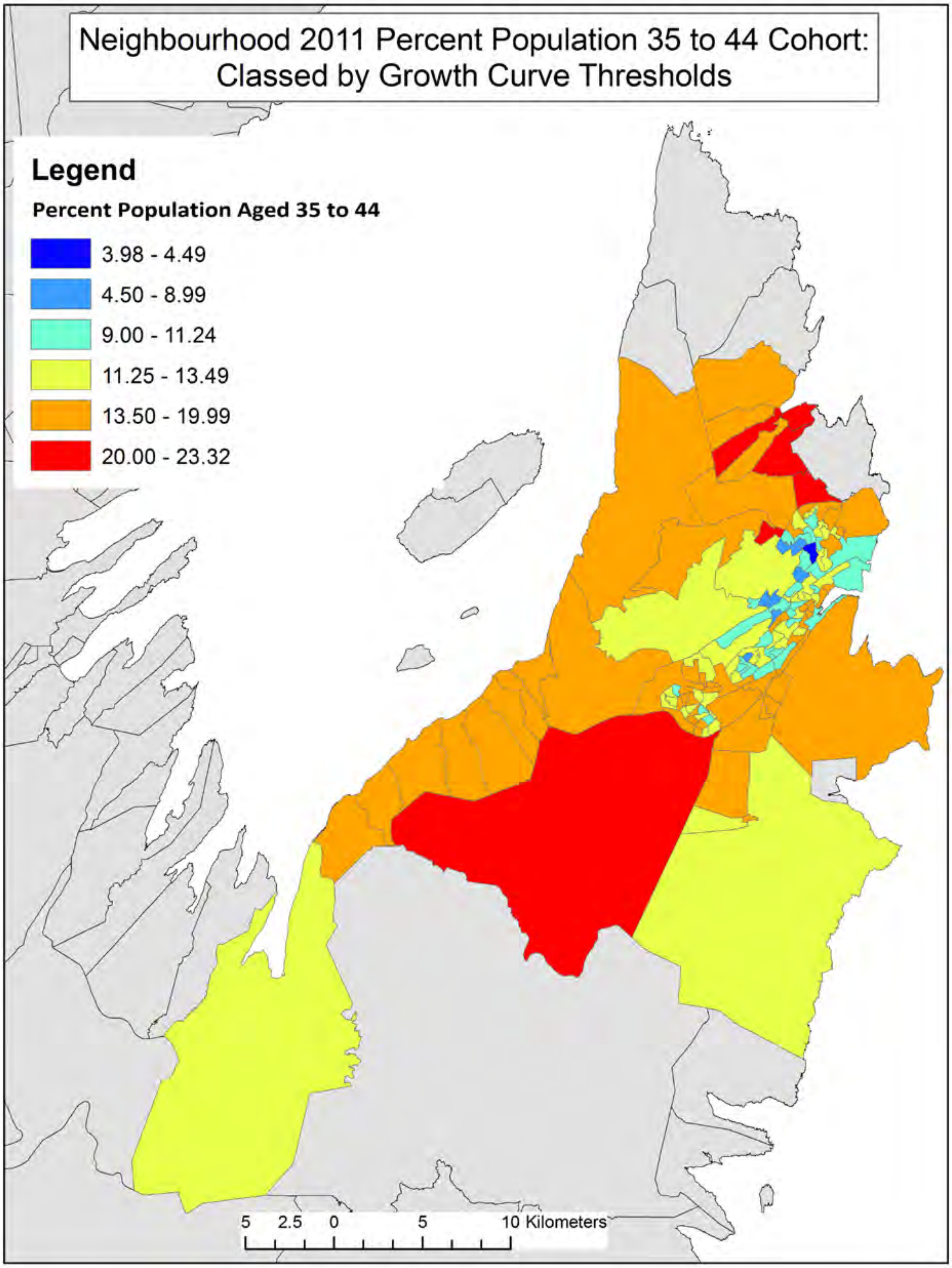

Figure 9.0 2011 Percent Population Aged 35-44 by Neighbourhood - Low to Median Growth Thresholds Range From 13.50% to 11.25%

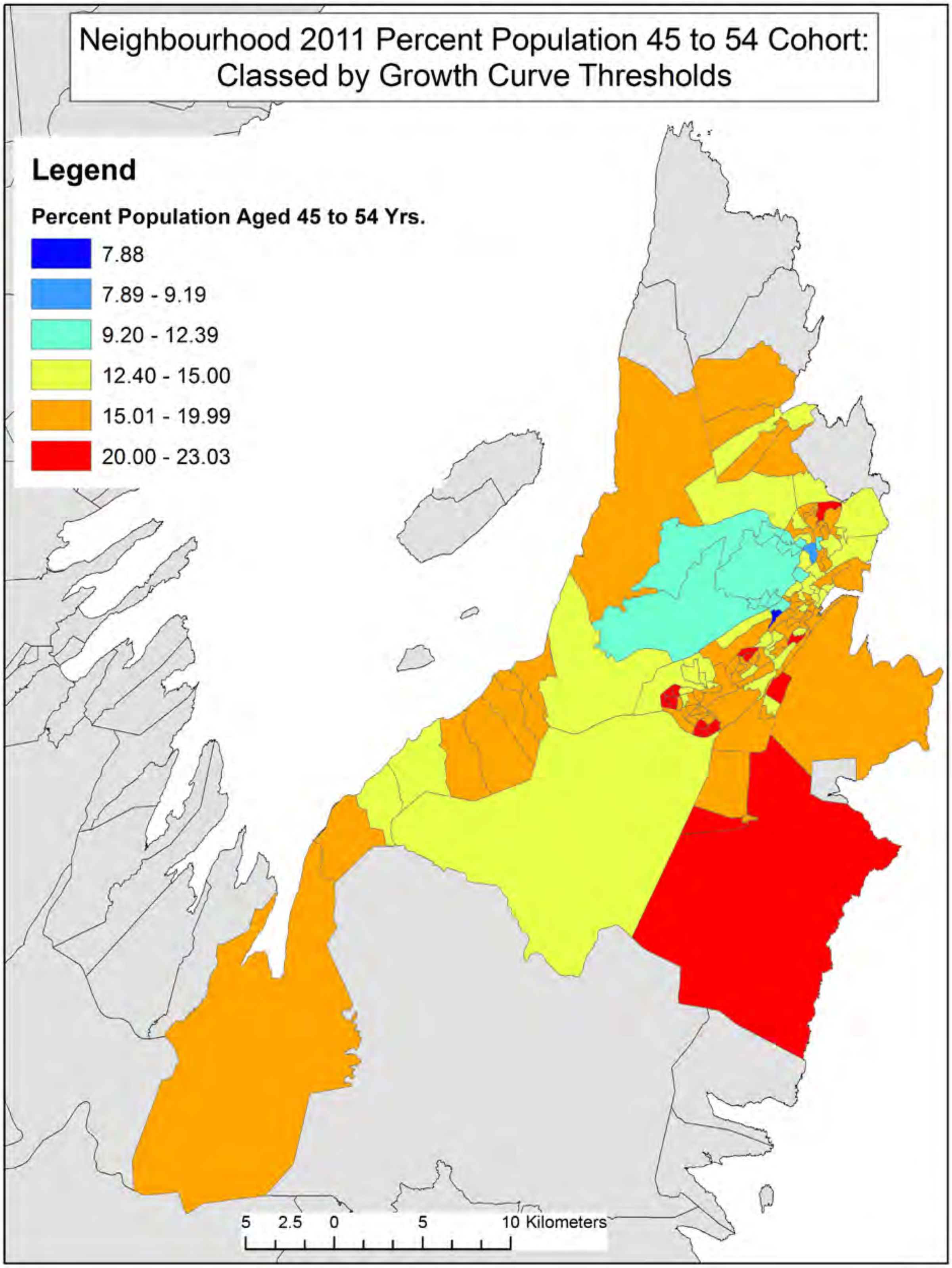

Figure 10.0 2011 Percent Population Aged 45-54 by Neighbourhood - Low to Median Growth Thresholds Range From 12.40% to 9.20%

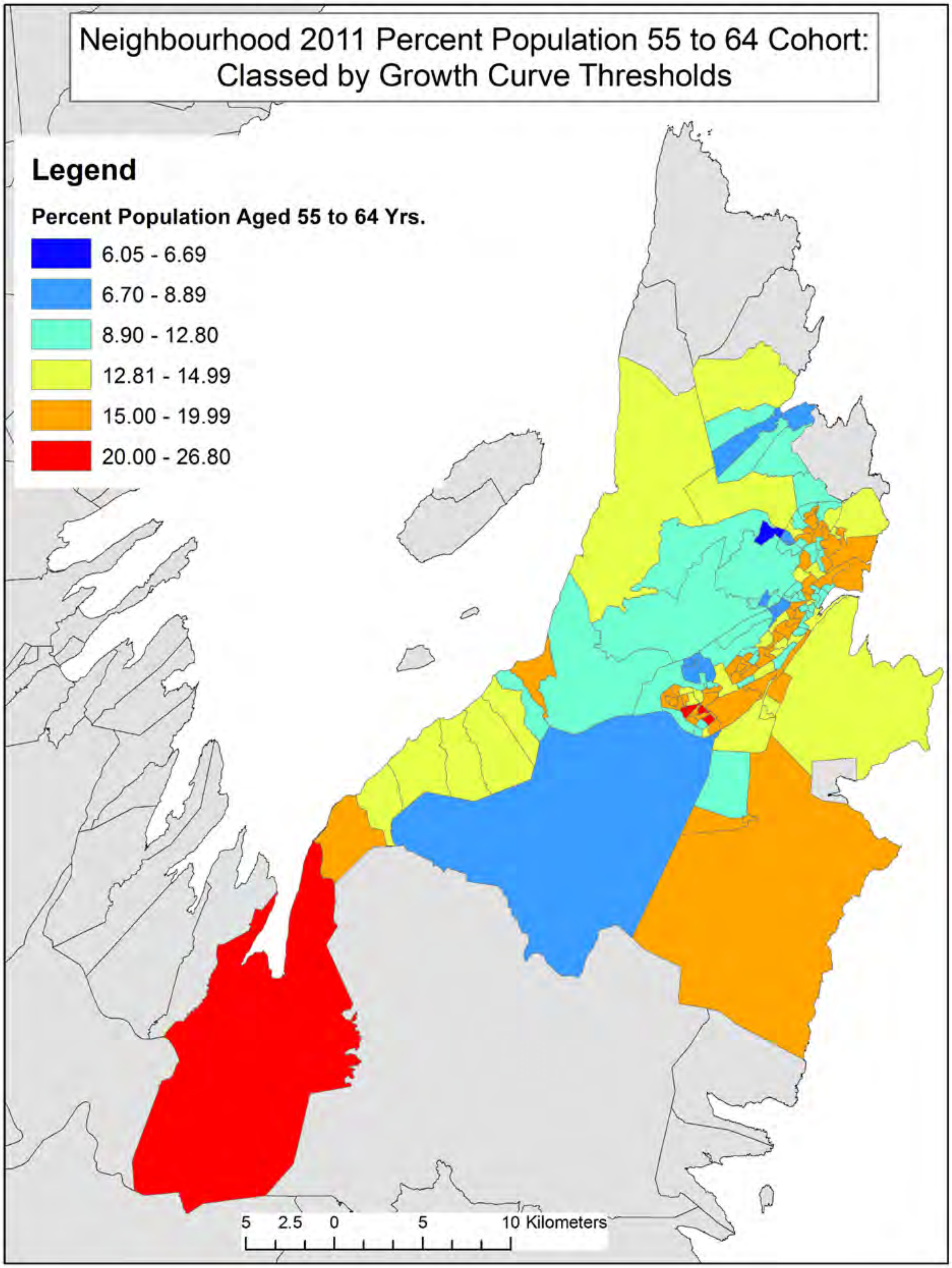

Figure 11.0 2011 Percent Population Aged 55-64 by Neighbourhood - Low to Median Growth Thresholds Range From 12.80% to 8.90%

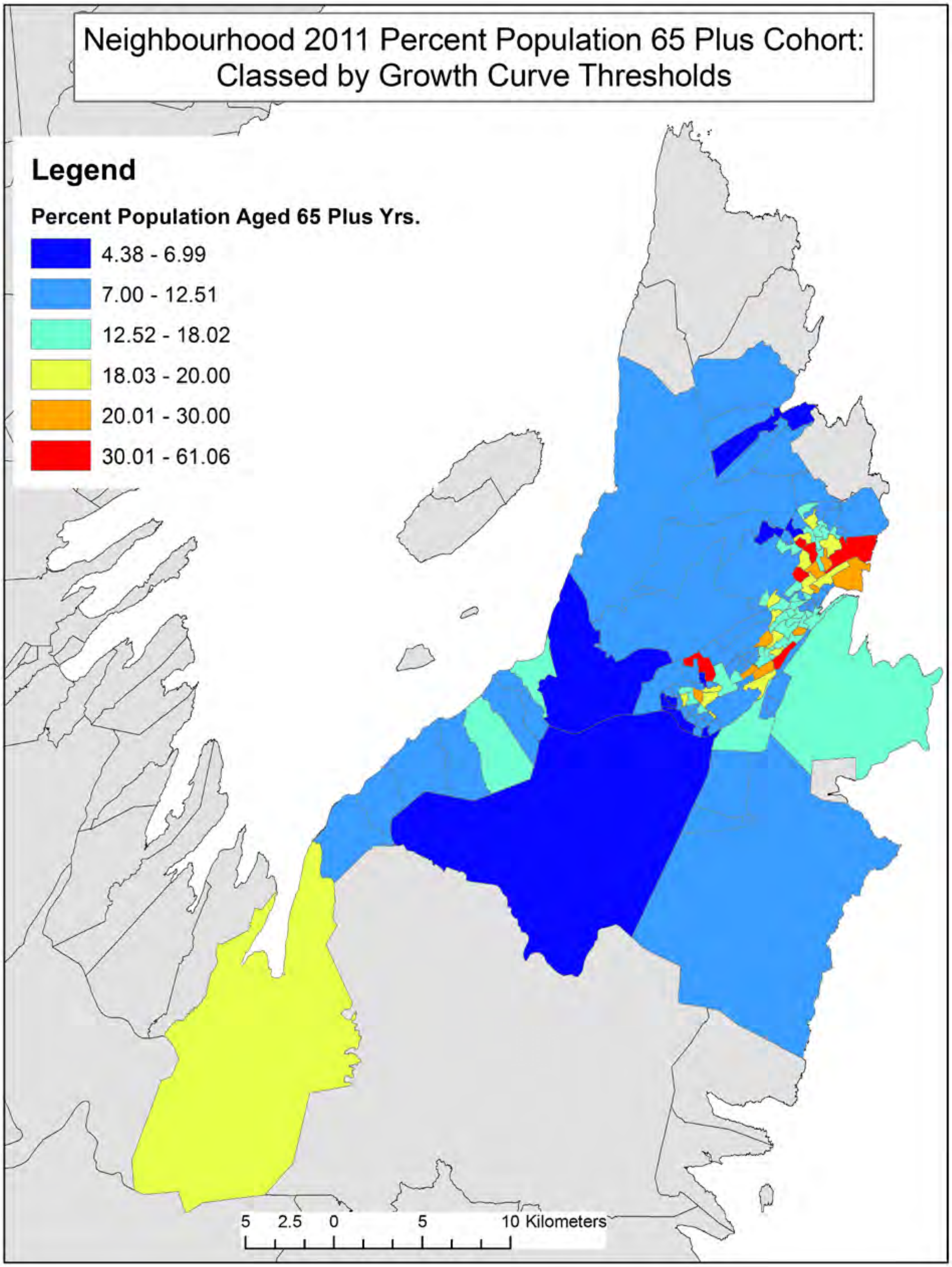

Figure 12.0 2011 Percent Population Aged 65 Plus by Neighbourhood - Low to Median Growth Thresholds Range From 18.03% to 12.52%

Using the data from the age cohort map layers Pearson's r is used to determine the association between the neighbourhood percentage population change from 2006 to 2011 and the 2011 age cohort percentages. The outcomes indicate that the highest positive correlations and growing neighbourhoods are associated with 0-4 (0.565) and 35-44 (0.446) cohorts while the 45-54 to 65 Plus cohorts all have negative correlations and on average represent neighbourhoods of population decline (see Figure 13.0). However, neighbourhoods with the highest concentrations of the younger cohorts (ranging from 0-4 to 25-34) have the highest potential for future growth. In the case of the 20-24 cohort it is a matter of retention given that a majority of this group generally attend University or College and once finished are very mobile and tend to migrate for job opportunities after graduation.

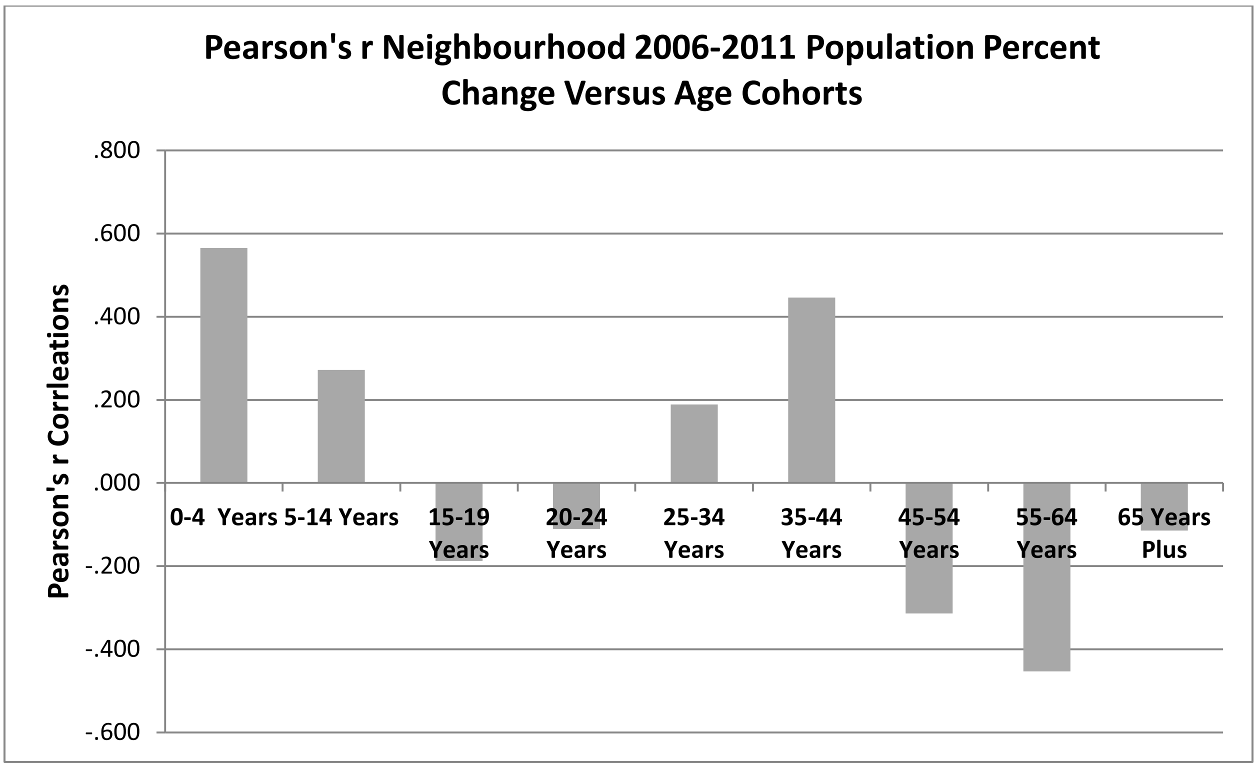

Figure 13.0 Pearson's r Percentage Neighbourhood Population Change 2006-2011 Versus Percentage of 2011 Age Cohort Concentration by Neighbourhood

2.0 Assumptions of the Model

The demography model is constructed by using age cohort specific values for births, deaths and migrations as well as demands for various types of housing. The premise for this approach is that as a population ages so does its propensity for births, deaths and in and out migration trends. Figures 14.0 to 17 .0 illustrates the type of trends integrated in top the forecast model. **These figures are for illustration only and in the model data are standardized for the study area regional analysis**. Data sources for the analysis are the Newfoundland and Labrador Statistics Agency and Statistics Canada online census databases.

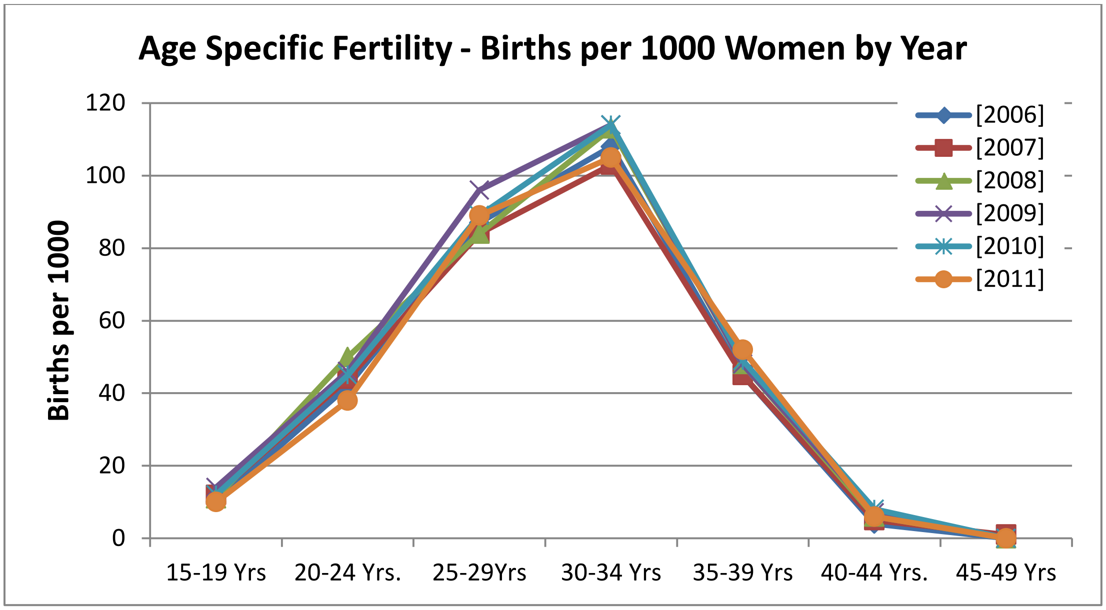

Figure 14.0 North East Avalon Age Specific Fertility Trends 2006 to 2011

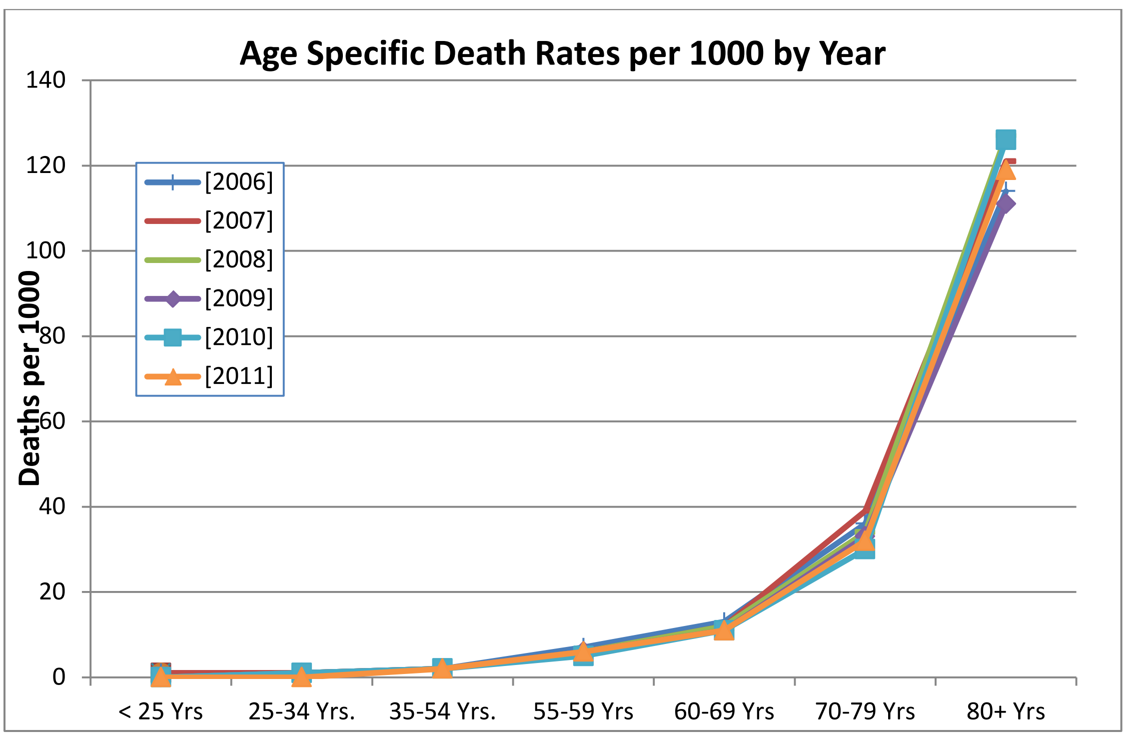

Figure 15.0 North East Avalon Age Specific Death Rate Trends 2006 to 2011

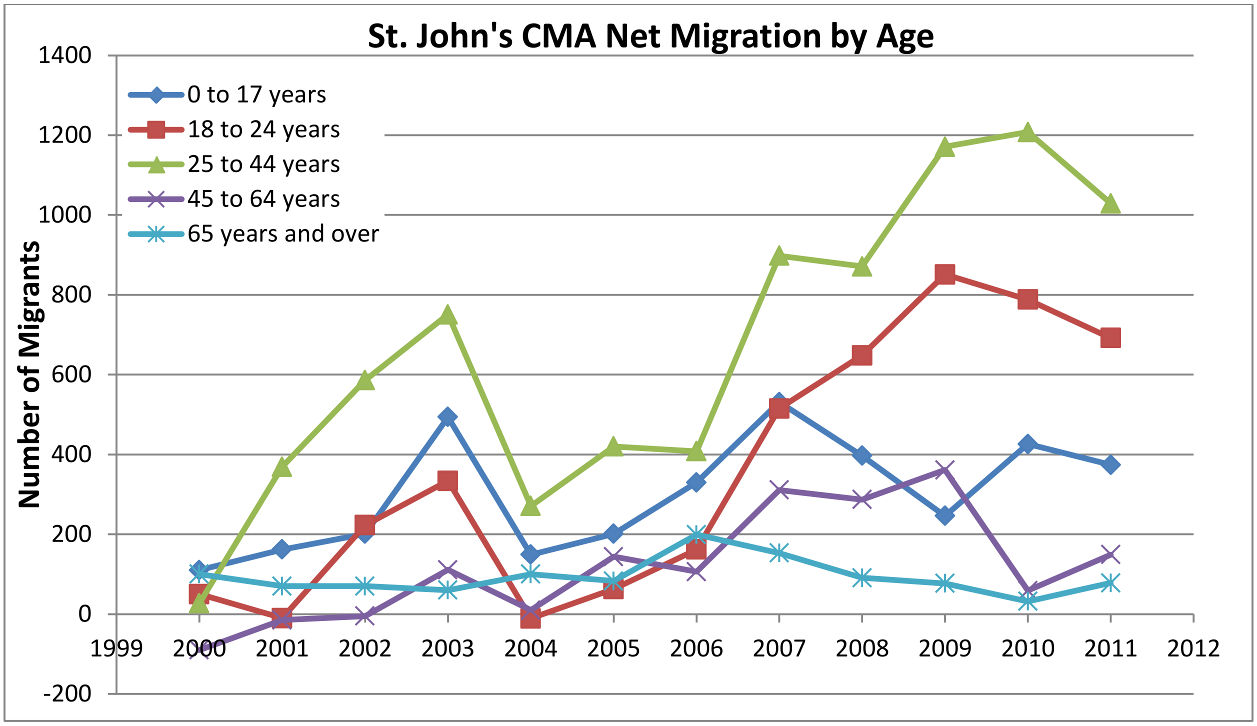

Figure 16.0 St. John's CMA Net Migration by Age Cohort 2000 to 2011

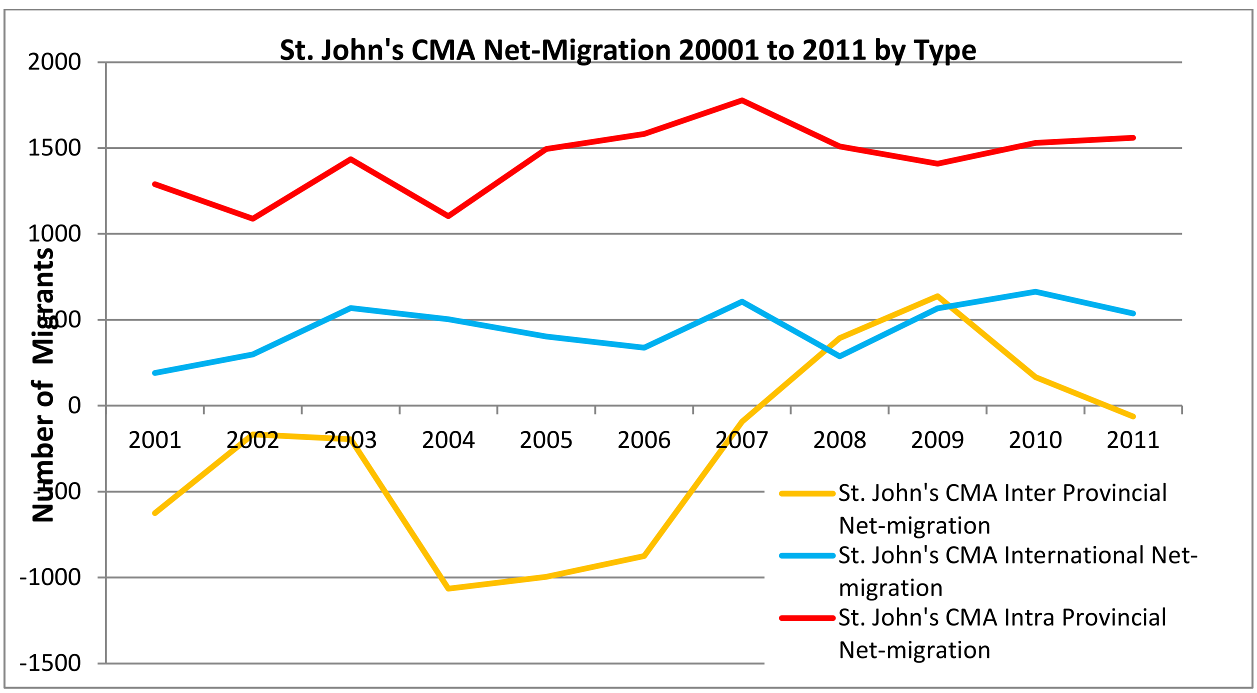

Figure 17.0 St. John's CMA Net-Migration Trends 2001 to 2011

The forecast population is an integration of a starting population (2011) , births (fertility by age), deaths by age, as well as in and out migration trends. Within the model migration is sub-divided into inter provincial, intra provincial and international. After the population is forecasted for a time period housing demand estimates are based on the forecast population by age cohort and historical occupancy statistics from Statistics Canada. Table 3.0 contains information on dwelling type by occupant age, 28.25 % of apartment building (units) with 5 or more storeys are occupied by people less than 55 years while 71.85% are occupied by 55 plus years. These occupancy relationships are used to estimate overall housing demands by type whereby the information is integrated with forecasted population counts and age structure.

Table 3.0 Dwelling Type By Occupant Age – Interpret Across Rows

Structural type	Under 15 Yrs	15 to 19 Yrs	20 to 24 Yrs	25 to 29 Yrs	30 to 34 Yrs	35 to 39 Yrs	40 to 44 Yrs	45 to 49 Yrs
Total - Structural type of dwelling	15.98%	5.79%	7.83%	7.58%	7.08%	7.22%	7.48%	8.08%
Single-detached house	**17.07%**	**5.94%**	**6.19%**	**5.83%**	**6.51%**	**7.41%**	**8.10%**	**8.70%**
Apartment, building that has five or more storeys	**1.48%**	**0.74%**	**1.48%**	**4.44%**	**2.22%**	**2.96%**	**3.70%**	**5.19%**
Movable dwelling	19.30%	5.26%	3.51%	8.77%	5.26%	8.77%	8.77%	7.02%
Other dwelling	14.35%	5.60%	10.54%	10.42%	8.06%	6.94%	6.51%	7.11%
Semi-detached house	15.66%	6.26%	9.02%	9.29%	8.10%	7.56%	7.29%	7.56%
Row house	18.01%	7.02%	7.06%	8.70%	7.83%	7.09%	6.81%	7.41%
Apartment, duplex	**14.75%**	**5.61%**	**11.97%**	**11.01%**	**8.31%**	**7.18%**	**6.58%**	**7.28%**
Apartment, building that has fewer than five storeys	**6.44%**	**3.02%**	**11.63%**	**11.83%**	**7.30%**	**5.18%**	**4.83%**	**5.74%**
Other single-attached house	**11.63%**	**4.65%**	**11.63%**	**10.47%**	**8.14%**	**6.98%**	**5.81%**	**8.14%**

Structural type	50 to 54 Yrs	55 to 59 Yrs	60 to 64 Yrs	65 to 69 Yrs	70 to 74 Yrs	75 to 79 Yrs	80 to 84 Yrs	85 Yrs +
Total - Structural type of dwelling	7.74%	7.18%	6.10%	4.45%	2.98%	2.06%	1.42%	1.04%
Single-detached house	**8.26%**	**7.76%**	**6.53%**	**4.72%**	**2.94%**	**1.92%**	**1.21%**	**0.90%**
Apartment, building that has five or more storeys	**5.93%**	**5.93%**	**8.89%**	**14.81%**	**11.11%**	**11.85%**	**10.37%**	**8.89%**
Movable dwelling	7.02%	7.02%	7.02%	3.51%	1.75%	3.51%	1.75%	1.75%
Other dwelling	6.90%	6.25%	5.37%	3.91%	2.98%	2.18%	1.68%	1.18%
Semi-detached house	7.45%	6.70%	5.24%	3.51%	2.48%	1.89%	1.19%	0.81%
Row house	6.95%	6.11%	5.09%	3.93%	2.95%	2.25%	1.68%	1.12%
Apartment, duplex	**6.77%**	**5.94%**	**4.86%**	**3.43%**	**2.53%**	**1.67%**	**1.20%**	**0.90%**
Apartment, building that has fewer than five storeys	**6.59%**	**7.30%**	**7.80%**	**6.14%**	**5.18%**	**4.33%**	**3.93%**	**2.77%**
Other single-attached house	**8.14%**	**5.81%**	**8.14%**	**5.81%**	**1.16%**	**2.33%**	**1.16%**	**0.00%**

Additional assumptions of the mode are:

- All students attending advanced learning institutes reside in St. John's (assigned as temporary residents in the model e.g. LowTemp2016 etc.)
- Temporary workers are spread equally across the 20-24 25-29, 30-34 and 35-39 age cohorts (this group is also assigned to the temporary resident category in the outcomes)
- Number of temporary workers are assigned to CSDs according to the existing population distribution for each CSD

- Student totals are based on Memorial University institutions enrollments for 2013 and assumes enrollment is stable across all time periods
- Temporary worker numbers are based in part on observed counts associated with the Hebron Project
- Temporary workers and external students housing type demands are based on the resident age cohort housing type distribution
- The retention of external students are accounted for in the migration statistics
- In-out migration for inter provincial and international as well as intra provincial are trended for low, median and high values using a 10 year St. John’s CMA cycle (2001 to 2011).
- Fertility and mortality (age specific) trends are based on the study arearegional data
- Inter- provincial migration is the most volatile and quasi moving average over the ten year cycle is used to capture the highs and lows

In addition, the total population for dwelling types will not equal the overall total population (e.g. 2011 dwelling population for St. John’s is 103,875 while the total population is **106,170**). Projections beyond 2016 are based on current low, median and high trends and interpretation of outcomes from 2021 onwards should be made within the context of current trends continuing. It is recommended that the models be re-run after each census period.

Results are presented in the following tables by housing population counts and number of households per dwelling type.

Table 4.0 St. John's Estimated Housing Population by Dwelling Type

Dwelling Type	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	53035	56197	57009	57866	3232	3290	3407
Apartment, building that has five or more storeys	650	774	781	788	9	9	10
Movable dwelling	260	292	296	301	9	9	10
Semi-detached house	6545	6884	6994	7110	580	591	612
Row house	11865	12597	12795	13004	755	772	805
Apartment, duplex	22370	23235	23622	24031	2732	2772	2851
Apartment, building that has fewer than five storeys	8865	9550	9684	9826	917	931	958
Other single-attached house	290	294	299	304	34	35	36
Total Population	**103880**	**109823**	**111480**	**113231**	**8268**	**8408**	**8688**

Dwelling Type	Obs.2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	53035	58614	60310	62102	3232	3290	3407
Apartment, building that has five or more storeys	650	837	851	865	9	9	10
Movable dwelling	260	304	313	323	9	9	10
Semi-detached house	6545	7050	7275	7514	580	591	612
Row house	11865	13042	13453	13888	755	772	805
Apartment, duplex	22370	23417	24194	25016	2732	2772	2851
Apartment, building that has fewer than five storeys	8865	9714	9984	10269	917	931	958
Other single-attached house	290	295	304	314	34	35	36
Total Population	**103880**	**113273**	**116685**	**120290**	**8268**	**8408**	**8688**

Table 4.0 continued……

Dwelling Type	Obs.2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	53035	60484	65156	70092	3232	3290	3407
Apartment, building that has five or more storeys	650	986	1029	1074	9	9	10
Movable dwelling	260	301	326	352	9	9	10
Semi-detached house	6545	7046	7626	8239	580	591	612
Row house	11865	13022	14097	15233	755	772	805
Apartment, duplex	22370	23542	25482	27533	2732	2772	2851
Apartment, building that has fewer than five storeys	8865	10249	10946	11682	917	931	958
Other single-attached house	290	300	324	350	34	35	36
Total Population	**103880**	**115930**	**124985**	**134554**	**8268**	**8408**	**8688**

Dwelling Type	Obs.2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	53035	59615	66266	73296	3232	3290	3407
Apartment, building that has five or more storeys	650	1015	1087	1163	9	9	10
Movable dwelling	260	304	338	374	9	9	10
Semi-detached house	6545	7028	7837	8692	580	591	612
Row house	11865	12838	14329	15905	755	772	805
Apartment, duplex	22370	23507	26213	29076	2732	2772	2851
Apartment, building that has fewer than five storeys	8865	10566	11593	12679	917	931	958
Other single-attached house	290	303	337	373	34	35	36
Total Population	**103880**	**115176**	**128000**	**141559**	**8268**	**8408**	**8688**

Table 5.0 St. John's Estimated Household Counts by Dwelling Type

Dwelling Type	Obs.2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	20120	20713	21012	21328	1191	1213	1256
Apartment, building that has five or more storeys	510	625	631	636	7	7	8
Movable dwelling	100	111	113	115	3	3	4
Semi-detached house	2915	2946	2994	3044	248	253	262
Row house	5175	5523	5610	5702	331	338	353
Apartment, duplex	10270	10426	10599	10783	1226	1244	1279
Apartment, building that has fewer than five storeys	5810	6167	6254	6346	592	601	619
Other single-attached house	125	129	131	133	15	15	16
Total Housing	**45025**	**46641**	**47344**	**48087**	**3614**	**3675**	**3796**

Dwelling Type	Obs.2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	20120	21604	22229	22889	1191	1213	1256
Apartment, building that has five or more storeys	510	676	687	699	7	7	8
Movable dwelling	100	116	120	123	3	3	4
Semi-detached house	2915	3018	3114	3216	248	253	262
Row house	5175	5719	5899	6089	331	338	353
Apartment, duplex	10270	10507	10856	11224	1226	1244	1279
Apartment, building that has fewer than five storeys	5810	6273	6448	6632	592	601	619
Other single-attached house	125	129	134	138	15	15	16
Total Housing	**45025**	**48042**	**49486**	**51011**	**3614**	**3675**	**3796**

Note: Calculating annual requirements by dwelling type: For example, " single – detached house" for projected Median 2016"

Prelimiary Estimate = (Median 2016 - Observed 2011)/5 where (22312 – 20120)/5 = 2192/5 = 438 units

New Estimate = ((Median 2016 + MedTemp 2016) – Observed 2011)/5 where = ((21012 + 1213) – 20120)/5 = 2105/5 = 421 units

Table 5.0 continued…..

Dwelling Type	Obs.2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	20120	22293	24015	25835	1191	1213	1256
Apartment, building that has five or more storeys	510	797	831	868	7	7	8
Movable dwelling	100	115	124	134	3	3	4
Semi-detached house	2915	3016	3264	3527	248	253	262
Row house	5175	5710	6181	6679	331	338	353
Apartment, duplex	10270	10563	11433	12354	1226	1244	1279
Apartment, building that has fewer than five storeys	5810	6619	7069	7544	592	601	619
Other single-attached house	125	132	142	153	15	15	16
Total Housing	**45025**	**49244**	**53060**	**57093**	**3614**	**3675**	**3796**

Dwelling Type	Obs.2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	20120	21973	24424	27016	1191	1213	1256
Apartment, building that has five or more storeys	510	820	878	940	7	7	8
Movable dwelling	100	116	129	143	3	3	4
Semi-detached house	2915	3008	3354	3720	248	253	262
Row house	5175	5629	6283	6974	331	338	353
Apartment, duplex	10270	10547	11762	13046	1226	1244	1279
Apartment, building that has fewer than five storeys	5810	6823	7487	8188	592	601	619
Other single-attached house	125	133	148	164	15	15	16
Total Housing	**45025**	**49050**	**54465**	**60190**	**3614**	**3675**	**3796**

Table 6.0 Mount Pearl Estimated Housing Population by Dwelling Type

Dwelling Type	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	12090	12625	12806	12996	14	27	55
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	1805	1833	1862	1893	2	5	10
Row house	2015	2161	2193	2227	3	6	11
Apartment, duplex	7670	7971	8100	8236	12	25	49
Apartment, building that has fewer than five storeys	495	552	559	567	1	1	3
Other single-attached house	30	31	31	32	0	0	0
Total Population	**24105**	**25171**	**25550**	**25950**	**32**	**64**	**128**

Dwelling Type	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	12090	12981	13354	13748	14	27	55
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	1805	1868	1929	1994	2	5	10
Row house	2015	2285	2352	2423	3	6	11
Apartment, duplex	7670	8199	8462	8739	12	25	49
Apartment, building that has fewer than five storeys	495	601	616	631	1	1	3
Other single-attached house	30	32	34	35	0	0	0
Total Population	**24105**	**25966**	**26746**	**27570**	**32**	**64**	**128**

Table 6.0 continued….

Dwelling Type	Obs. 2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	12090	13133	14153	15231	14	27	55
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	1805	1898	2058	2228	2	5	10
Row house	2015	2504	2679	2864	3	6	11
Apartment, duplex	7670	8325	8997	9707	12	25	49
Apartment, building that has fewer than five storeys	495	686	726	769	1	1	3
Other single-attached house	30	31	34	37	0	0	0
Total Population	**24105**	**26577**	**28647**	**30835**	**32**	**64**	**128**

Dwelling Type	Obs. 2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	12090	12826	14287	15831	14	27	55
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	1805	1834	2055	2288	2	5	10
Row house	2015	2452	2700	2962	3	6	11
Apartment, duplex	7670	8159	9097	10089	12	25	49
Apartment, building that has fewer than five storeys	495	669	729	793	1	1	3
Other single-attached house	30	29	33	37	0	0	0
Total Population	**24105**	**25968**	**28900**	**32000**	**32**	**64**	**128**

Table 7.0 Mount Pearl Estimated Household Counts by Dwelling Type

Dwelling Type	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	4315	4653	4720	4790	5	10	20
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	715	784	797	810	1	2	4
Row house	895	947	962	977	1	2	5
Apartment, duplex	3415	3576	3634	3695	6	11	22
Apartment, building that has fewer than five storeys	285	356	361	366	0	1	2
Other single-attached house	15	14	14	14	0	0	0
Total Dwelling	**9640**	**10331**	**10487**	**10652**	**13**	**27**	**53**

Dwelling Type	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	4315	4785	4922	5067	5	10	20
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	715	799	826	853	1	2	4
Row house	895	1002	1031	1062	1	2	5
Apartment, duplex	3415	3679	3797	3921	6	11	22
Apartment, building that has fewer than five storeys	285	388	397	408	0	1	2
Other single-attached house	15	14	15	15	0	0	0
Total Dwelling	**9640**	**10667**	**10988**	**11327**	**13**	**27**	**53**

Table 7.0 continued….

Dwelling Type	Obs. 2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	4315	4841	5217	5614	5	10	20
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	715	812	881	954	1	2	4
Row house	895	1098	1175	1256	1	2	5
Apartment, duplex	3415	3736	4037	4355	6	11	22
Apartment, building that has fewer than five storeys	285	443	469	497	0	1	2
Other single-attached house	15	14	15	16	0	0	0
Total Dwelling	**9640**	**10943**	**11793**	**12691**	**13**	**27**	**53**

Dwelling Type	Obs. 2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	4315	4727	5266	5835	5	10	20
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	715	785	879	979	1	2	4
Row house	895	1075	1184	1299	1	2	5
Apartment, duplex	3415	3661	4082	4527	6	11	22
Apartment, building that has fewer than five storeys	285	432	471	512	0	1	2
Other single-attached house	15	13	15	16	0	0	0
Total Dwelling	**9640**	**10693**	**11896**	**13168**	**13**	**27**	**53**

Table 8.0 Paradise Estimated Housing Population by Dwelling Type

Dwelling Type	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	14075	15111	15329	15559	18	35	71
Apartment, building that has five or more storeys	10	8	8	8	0	0	0
Movable dwelling	5	0	0	0	0	0	0
Semi-detached house	490	535	543	551	1	1	2
Row house	215	254	257	260	0	0	1
Apartment, duplex	2600	2707	2752	2799	5	9	18
Apartment, building that has fewer than five storeys	130	161	164	166	0	0	1
Other single-attached house	25	38	39	39	0	0	0
Total Population	**17550**	**18814**	**19091**	**19382**	**23**	**47**	**93**

Dwelling Type	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	14075	15767	16218	16694	18	35	71
Apartment, building that has five or more storeys	10	6	7	7	0	0	0
Movable dwelling	5	0	0	0	0	0	0
Semi-detached house	490	555	571	588	1	1	2
Row house	215	288	294	301	0	0	1
Apartment, duplex	2600	2818	2907	3001	5	9	18
Apartment, building that has fewer than five storeys	130	172	177	182	0	0	1
Other single-attached house	25	40	41	42	0	0	0
Total Population	**17550**	**19645**	**20214**	**20815**	**23**	**47**	**93**

Table 8.0 continued…

Dwelling Type	Obs. 2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	14075	16707	17915	19193	18	35	71
Apartment, building that has five or more storeys	10	10	11	12	0	0	0
Movable dwelling	5	0	0	0	0	0	0
Semi-detached house	490	607	649	693	1	1	2
Row house	215	351	371	392	0	0	1
Apartment, duplex	2600	3164	3386	3621	5	9	18
Apartment, building that has fewer than five storeys	130	213	226	240	0	0	1
Other single-attached house	25	54	57	60	0	0	0
Total Population	**17550**	**21105**	**22615**	**24210**	**23**	**47**	**93**

Dwelling Type	Obs. 2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	14075	16993	18702	20508	18	35	71
Apartment, building that has five or more storeys	10	8	9	10	0	0	0
Movable dwelling	5	0	0	0	0	0	0
Semi-detached house	490	658	717	780	1	1	2
Row house	215	382	413	445	0	0	1
Apartment, duplex	2600	3181	3495	3827	5	9	18
Apartment, building that has fewer than five storeys	130	215	234	255	0	0	1
Other single-attached house	25	50	54	59	0	0	0
Total Population	**17550**	**21486**	**23624**	**25884**	**23**	**47**	**93**

Table 9.0 Conception Bay South Housing Estimated Population by Dwelling Type

Dwelling Type	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	19945	21005	21318	21648	26	52	104
Apartment, building that has five or more storeys	5	12	13	13	0	0	0
Movable dwelling	5	5	5	5	0	0	0
Semi-detached house	365	387	393	398	0	1	1
Row house	90	96	97	98	0	0	0
Apartment, duplex	3710	3878	3940	4006	6	12	23
Apartment, building that has fewer than five storeys	305	322	327	333	0	1	2
Other single-attached house	60	62	63	64	0	0	1
Total Population	**24485**	**25768**	**26156**	**26566**	**33**	**65**	**131**

Dwelling Type	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	19945	21534	22180	22862	26	52	104
Apartment, building that has five or more storeys	5	15	15	15	0	0	0
Movable dwelling	5	4	5	5	0	0	0
Semi-detached house	365	401	412	424	0	1	1
Row house	90	104	106	109	0	0	0
Apartment, duplex	3710	3973	4100	4234	6	12	23
Apartment, building that has fewer than five storeys	305	335	345	355	0	1	2
Other single-attached house	60	65	67	70	0	0	1
Total Population	**24485**	**26431**	**27229**	**28073**	**33**	**65**	**131**

Table 9.0 continued…

Dwelling Type	Obs. 2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	19945	22200	23923	25744	26	52	104
Apartment, building that has five or more storeys	5	23	24	25	0	0	0
Movable dwelling	5	5	5	6	0	0	0
Semi-detached house	365	418	449	480	0	1	1
Row house	90	108	115	122	0	0	0
Apartment, duplex	3710	4148	4473	4816	6	12	23
Apartment, building that has fewer than five storeys	305	359	385	412	0	1	2
Other single-attached house	60	68	73	79	0	0	1
Total Population	**24485**	**27328**	**29446**	**31684**	**33**	**65**	**131**

Dwelling Type	Obs. 2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	19945	22010	24454	27038	26	52	104
Apartment, building that has five or more storeys	5	27	28	30	0	0	0
Movable dwelling	5	5	5	6	0	0	0
Semi-detached house	365	420	463	510	0	1	1
Row house	90	105	115	126	0	0	0
Apartment, duplex	3710	4109	4564	5045	6	12	23
Apartment, building that has fewer than five storeys	305	359	397	436	0	1	2
Other single-attached house	60	68	76	84	0	0	1
Total Population	**24485**	**27103**	**30102**	**33274**	**33**	**65**	**131**

Table 10.0 Conception Bay South Estimated Household Counts by Dwelling Type

Dwelling Type	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	7240	7742	7857	7979	10	19	38
Apartment, building that has five or more storeys	5	10	10	10	0	0	0
Movable dwelling	0	2	2	2	0	0	0
Semi-detached house	140	166	168	171	0	0	1
Row house	45	42	43	43	0	0	0
Apartment, duplex	1515	1740	1768	1798	3	5	10
Apartment, building that has fewer than five storeys	165	208	211	215	0	1	1
Other single-attached house	20	27	28	28	0	0	0
Total Dwelling	**9130**	**9937**	**10087**	**10245**	**13**	**25**	**51**

Dwelling Type	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	7240	7937	8175	8426	10	19	38
Apartment, building that has five or more storeys	5	12	12	12	0	0	0
Movable dwelling	0	2	2	2	0	0	0
Semi-detached house	140	172	176	181	0	0	1
Row house	45	45	47	48	0	0	0
Apartment, duplex	1515	1783	1840	1900	3	5	10
Apartment, building that has fewer than five storeys	165	216	223	229	0	1	1
Other single-attached house	20	29	30	31	0	0	0
Total Dwelling	**9130**	**10195**	**10503**	**10829**	**13**	**25**	**51**

Table 10.0 continued…

Dwelling Type	Obs. 2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	7240	8182	8818	9489	10	19	38
Apartment, building that has five or more storeys	5	18	19	20	0	0	0
Movable dwelling	0	2	2	2	0	0	0
Semi-detached house	140	179	192	206	0	0	1
Row house	45	47	50	53	0	0	0
Apartment, duplex	1515	1861	2007	2161	3	5	10
Apartment, building that has fewer than five storeys	165	232	249	266	0	1	1
Other single-attached house	20	30	32	35	0	0	0
Total Dwelling	**9130**	**10552**	**11368**	**12232**	**13**	**25**	**51**

Dwelling Type	Obs. 2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	7240	8113	9013	9965	10	19	38
Apartment, building that has five or more storeys	5	22	23	24	0	0	0
Movable dwelling	0	2	2	2	0	0	0
Semi-detached house	140	180	198	218	0	0	1
Row house	45	46	50	55	0	0	0
Apartment, duplex	1515	1844	2048	2264	3	5	10
Apartment, building that has fewer than five storeys	165	232	256	282	0	1	1
Other single-attached house	20	30	33	37	0	0	0
Total Dwelling	**9130**	**10467**	**11624**	**12847**	**13**	**25**	**51**

Table 11.0 Portugal Cove-St. Philip's Housing Estimated Population by Dwelling Type

Dwelling Type	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	6925	7190	7298	7412	9	18	36
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	5	12	12	12	0	0	0
Semi-detached house	55	47	48	49	0	0	0
Row house	10	11	11	12	0	0	0
Apartment, duplex	290	302	307	312	0	1	2
Apartment, building that has fewer than five storeys	50	62	63	65	0	0	1
Other single-attached house	5	5	5	5	0	0	0
Total Population	**7340**	**7630**	**7745**	**7866**	**10**	**19**	**39**

Dwelling Type	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	6925	7377	7599	7834	9	18	36
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	5	16	16	16	0	0	0
Semi-detached house	55	49	51	52	0	0	0
Row house	10	13	13	13	0	0	0
Apartment, duplex	290	310	320	330	0	1	2
Apartment, building that has fewer than five storeys	50	64	66	69	0	0	1
Other single-attached house	5	4	4	4	0	0	0
Total Population	**7340**	**7833**	**8069**	**8318**	**10**	**19**	**39**

Table 11.0 continued

Dwelling Type	Obs. 2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	6925	7636	8227	8851	9	18	36
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	5	21	21	22	0	0	0
Semi-detached house	55	51	55	59	0	0	0
Row house	10	14	15	15	0	0	0
Apartment, duplex	290	338	362	388	0	1	2
Apartment, building that has fewer than five storeys	50	58	64	70	0	0	1
Other single-attached house	5	4	4	5	0	0	0
Total Population	**7340**	**8122**	**8748**	**9410**	**10**	**19**	**39**

Dwelling Type	Obs. 2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	6925	7586	8422	9306	9	18	36
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	5	23	25	26	0	0	0
Semi-detached house	55	44	50	56	0	0	0
Row house	10	11	12	14	0	0	0
Apartment, duplex	290	334	369	406	0	1	2
Apartment, building that has fewer than five storeys	50	57	65	73	0	0	1
Other single-attached house	5	5	5	6	0	0	0
Total Population	**7340**	**8060**	**8947**	**9885**	**10**	**19**	**39**

Table 12.0 Portugal Cove-St. Philip's Estimated Household Counts by Dwelling Type

Dwelling Type	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	2515	2650	2690	2732	3	7	13
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	5	5	5	5	0	0	0
Semi-detached house	20	20	21	21	0	0	0
Row house	5	5	5	5	0	0	0
Apartment, duplex	110	136	138	140	0	0	1
Apartment, building that has fewer than five storeys	25	40	41	42	0	0	0
Other single-attached house	5	2	2	2	0	0	0
Total Dwelling	**2685**	**2858**	**2901**	**2946**	**4**	**7**	**15**

Dwelling Type	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	2515	2719	2801	2888	3	7	13
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	5	6	6	6	0	0	0
Semi-detached house	20	21	22	22	0	0	0
Row house	5	6	6	6	0	0	0
Apartment, duplex	110	139	143	148	0	0	1
Apartment, building that has fewer than five storeys	25	41	43	44	0	0	0
Other single-attached house	5	2	2	2	0	0	0
Total Dwelling	**2685**	**2934**	**3022**	**3116**	**4**	**7**	**15**

Table 12.0 continued…

Dwelling Type	Obs. 2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	2515	2815	3032	3262	3	7	13
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	5	8	8	8	0	0	0
Semi-detached house	20	22	23	25	0	0	0
Row house	5	6	6	7	0	0	0
Apartment, duplex	110	151	162	174	0	0	1
Apartment, building that has fewer than five storeys	25	38	41	45	0	0	0
Other single-attached house	5	2	2	2	0	0	0
Total Dwelling	**2685**	**3041**	**3276**	**3524**	**4**	**7**	**15**

Dwelling Type	Obs. 2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	2515	2796	3104	3430	3	7	13
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	5	9	9	10	0	0	0
Semi-detached house	20	19	21	24	0	0	0
Row house	5	5	5	6	0	0	0
Apartment, duplex	110	150	165	182	0	0	1
Apartment, building that has fewer than five storeys	25	37	42	47	0	0	0
Other single-attached house	5	2	2	3	0	0	0
Total Dwelling	**2685**	**3017**	**3350**	**3701**	**4**	**7**	**15**

Table 13.0 Torbay Estimated Housing Population by Dwelling Type

Dwelling Type	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	6850	7238	7345	7459	9	18	36
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	25	19	19	19	0	0	0
Row house	10	5	5	5	0	0	0
Apartment, duplex	410	441	448	455	1	1	2
Apartment, building that has fewer than five storeys	30	41	41	42	0	0	0
Other single-attached house	5	0	0	0	0	0	0
Total Population	**7330**	**7743**	**7859**	**7981**	**10**	**20**	**39**

Dwelling Type	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	6850	7477	7699	7933	9	18	36
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	25	18	18	19	0	0	0
Row house	10	4	5	5	0	0	0
Apartment, duplex	410	461	475	490	1	1	2
Apartment, building that has fewer than five storeys	30	45	47	48	0	0	0
Other single-attached house	5	0	0	0	0	0	0
Total Population	**7330**	**8005**	**8243**	**8495**	**10**	**20**	**39**

Table 13.0 continued …

Dwelling Type	Obs. 2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	6850	7971	8562	9186	9	18	36
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	25	20	21	23	0	0	0
Row house	10	4	4	5	0	0	0
Apartment, duplex	410	501	537	575	1	1	2
Apartment, building that has fewer than five storeys	30	46	49	53	0	0	0
Other single-attached house	5	0	0	0	0	0	0
Total Population	**7330**	**8542**	**9174**	**9841**	**10**	**20**	**39**

Dwelling Type	Obs. 2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	6850	8069	8905	9789	9	18	36
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	25	19	21	23	0	0	0
Row house	10	4	5	5	0	0	0
Apartment, duplex	410	502	553	607	1	1	2
Apartment, building that has fewer than five storeys	30	43	47	53	0	0	0
Other single-attached house	5	0	0	0	0	0	0
Total Population	**7330**	**8637**	**9531**	**10477**	**10**	**20**	**39**

Table 14.0 Torbay Estimated Household Counts by Dwelling Type

Dwelling Type	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	2390	2668	2707	2749	3	7	13
Apartment, building that has five or more storeys	5	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	10	8	8	8	0	0	0
Row house	0	2	2	2	0	0	0
Apartment, duplex	165	198	201	204	0	1	1
Apartment, building that has fewer than five storeys	20	26	27	27	0	0	0
Other single-attached house	0	0	0	0	0	0	0
Total Dwelling	**2590**	**2902**	**2945**	**2991**	**4**	**7**	**15**

Dwelling Type	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	2390	2756	2838	2924	3	7	13
Apartment, building that has five or more storeys	5	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	10	8	8	8	0	0	0
Row house	0	2	2	2	0	0	0
Apartment, duplex	165	207	213	220	0	1	1
Apartment, building that has fewer than five storeys	20	29	30	31	0	0	0
Other single-attached house	0	0	0	0	0	0	0
Total Dwelling	**2590**	**3001**	**3091**	**3185**	**4**	**7**	**15**

Table 14.0 continued…

Dwelling Type	Obs. 2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	2390	2938	3156	3386	3	7	13
Apartment, building that has five or more storeys	5	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	10	8	9	10	0	0	0
Row house	0	2	2	2	0	0	0
Apartment, duplex	165	225	241	258	0	1	1
Apartment, building that has fewer than five storeys	20	30	32	34	0	0	0
Other single-attached house	0	0	0	0	0	0	0
Total Dwelling	**2590**	**3203**	**3440**	**3690**	**4**	**7**	**15**

Dwelling Type	Obs. 2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	2390	2974	3282	3608	3	7	13
Apartment, building that has five or more storeys	5	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	10	8	9	10	0	0	0
Row house	0	2	2	2	0	0	0
Apartment, duplex	165	225	248	272	0	1	1
Apartment, building that has fewer than five storeys	20	28	31	34	0	0	0
Other single-attached house	0	0	0	0	0	0	0
Total Dwelling	**2590**	**3237**	**3572**	**3926**	**4**	**7**	**15**

Table 15.0 Holyrood Estimated Housing Population by Dwelling Type

Dwelling Type	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	1745	1842	1871	1901	2	5	10
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	15	12	12	12	0	0	0
Row house	20	34	34	35	0	0	0
Apartment, duplex	95	97	98	100	0	0	1
Apartment, building that has fewer than five storeys	25	36	36	37	0	0	0
Other single-attached house	15	14	14	14	0	0	0
Total Population	**1915**	**2035**	**2067**	**2100**	**3**	**5**	**11**

Dwelling Type	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	1745	1828	1887	1949	2	5	10
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	15	11	12	12	0	0	0
Row house	20	45	46	46	0	0	0
Apartment, duplex	95	100	103	107	0	0	1
Apartment, building that has fewer than five storeys	25	38	38	39	0	0	0
Other single-attached house	15	15	15	16	0	0	0
Total Population	**1915**	**2037**	**2101**	**2169**	**3**	**5**	**11**

Table 15.0 continued…

Dwelling Type	Obs. 2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	1745	1745	1902	2068	2	5	10
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	15	8	9	9	0	0	0
Row house	20	52	53	55	0	0	0
Apartment, duplex	95	96	105	114	0	0	1
Apartment, building that has fewer than five storeys	25	29	31	34	0	0	0
Other single-attached house	15	12	14	15	0	0	0
Total Population	**1915**	**1942**	**2113**	**2294**	**3**	**5**	**11**

Dwelling Type	Obs. 2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	1745	1686	1907	2141	2	5	10
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	15	7	8	8	0	0	0
Row house	20	41	43	46	0	0	0
Apartment, duplex	95	90	102	115	0	0	1
Apartment, building that has fewer than five storeys	25	29	33	37	0	0	0
Other single-attached house	15	13	15	17	0	0	0
Total Population	**1915**	**1865**	**2107**	**2364**	**3**	**5**	**11**

Table 16.0 Holyrood Estimated Household Counts by Dwelling Type

Dwelling Type	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	700	679	690	701	1	2	4
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	5	5	5	5	0	0	0
Row house	15	15	15	15	0	0	0
Apartment, duplex	40	43	44	45	0	0	0
Apartment, building that has fewer than five storeys	15	23	23	24	0	0	0
Other single-attached house	5	6	6	6	0	0	0
Total Dwelling	**780**	**772**	**784**	**796**	**1**	**2**	**4**

Dwelling Type	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	700	674	695	718	1	2	4
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	5	5	5	5	0	0	0
Row house	15	20	20	20	0	0	0
Apartment, duplex	40	45	46	48	0	0	0
Apartment, building that has fewer than five storeys	15	24	25	25	0	0	0
Other single-attached house	5	6	7	7	0	0	0
Total Dwelling	**780**	**774**	**798**	**824**	**1**	**2**	**4**

Table 16.0 continued…

Dwelling Type	Obs. 2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	700	643	701	762	1	2	4
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	5	3	4	4	0	0	0
Row house	15	23	23	24	0	0	0
Apartment, duplex	40	43	47	51	0	0	0
Apartment, building that has fewer than five storeys	15	18	20	22	0	0	0
Other single-attached house	5	5	6	7	0	0	0
Total Dwelling	**780**	**736**	**801**	**870**	**1**	**2**	**4**

Dwelling Type	Obs. 2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	700	621	703	789	1	2	4
Apartment, building that has five or more storeys	0	0	0	0	0	0	0
Movable dwelling	0	0	0	0	0	0	0
Semi-detached house	5	3	3	4	0	0	0
Row house	15	18	19	20	0	0	0
Apartment, duplex	40	40	46	52	0	0	0
Apartment, building that has fewer than five storeys	15	18	21	24	0	0	0
Other single-attached house	5	6	7	7	0	0	0
Total Dwelling	**780**	**707**	**799**	**896**	**1**	**2**	**4**

Table 17.0 Regional Water Supply Study Area Estimated Housing Population by Dwelling Type

Dwelling Type Totals	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	114665	121209	122976	124841	3310	3446	3718
Apartment, building that has five or more storeys	665	795	801	809	9	9	10
Movable dwelling	275	309	313	318	9	9	10
Semi-detached house	9300	9717	9871	10034	584	598	626
Row house	14225	15158	15393	15641	758	778	817
Apartment, duplex	37145	38631	39267	39939	2756	2819	2946
Apartment, building that has fewer than five storeys	9900	10724	10875	11035	918	934	964
Other single-attached house	430	444	451	458	34	35	37
Total Population	**186605**	**196985**	**199947**	**203076**	**8378**	**8628**	**9128**

Dwelling Type Totals	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	114665	125578	129247	133122	3310	3446	3718
Apartment, building that has five or more storeys	665	858	873	888	9	9	10
Movable dwelling	275	324	334	344	9	9	10
Semi-detached house	9300	9952	10268	10602	584	598	626
Row house	14225	15782	16269	16785	758	778	817
Apartment, duplex	37145	39277	40560	41917	2756	2819	2946
Apartment, building that has fewer than five storeys	9900	10968	11272	11593	918	934	964
Other single-attached house	430	451	465	480	34	35	37
Total Population	**186605**	**203190**	**209288**	**215731**	**8378**	**8628**	**9128**

Table 17.0 continued…

Dwelling Type Totals	Obs. 2011	LowPop_2036	MedPop_2036	HighPop_2036	LowTemp_2036	MedTemp_2036	HighTemp_2036
Single-detached house	114665	129876	139838	150365	3310	3446	3718
Apartment, building that has five or more storeys	665	1019	1064	1111	9	9	10
Movable dwelling	275	326	352	380	9	9	10
Semi-detached house	9300	10048	10866	11732	584	598	626
Row house	14225	16055	17333	18684	758	778	817
Apartment, duplex	37145	40113	43341	46754	2756	2819	2946
Apartment, building that has fewer than five storeys	9900	11641	12428	13260	918	934	964
Other single-attached house	430	468	505	545	34	35	37
Total Population	**186605**	**209547**	**225728**	**242830**	**8378**	**8628**	**9128**

Dwelling Type Totals	Obs. 2011	LowPop_2046	MedPop_2046	HighPop_2046	LowTemp_2046	MedTemp_2046	HighTemp_2046
Single-detached house	114665	128785	142942	157909	3310	3446	3718
Apartment, building that has five or more storeys	665	1050	1125	1203	9	9	10
Movable dwelling	275	332	368	406	9	9	10
Semi-detached house	9300	10009	11150	12357	584	598	626
Row house	14225	15833	17616	19503	758	778	817
Apartment, duplex	37145	39881	44393	49165	2756	2819	2946
Apartment, building that has fewer than five storeys	9900	11937	13098	14325	918	934	964
Other single-attached house	430	467	520	576	34	35	37
Total Population	**186605**	**208294**	**231212**	**255444**	**8378**	**8628**	**9128**

Table 18.0 Regional Water Supply Study Area Estimated Household Counts by Dwelling Type

Dwelling Type Totals	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	42265	44675	45326	46014	1220	1270	1371
Apartment, building that has five or more storeys	525	642	647	653	7	7	8
Movable dwelling	105	118	120	121	3	3	4
Semi-detached house	3985	4159	4225	4295	250	256	268
Row house	6235	6646	6749	6858	332	341	358
Apartment, duplex	16660	17333	17619	17921	1237	1265	1322
Apartment, building that has fewer than five storeys	6390	6925	7023	7126	593	603	623
Other single-attached house	180	195	198	201	15	15	16
Total Dwelling	**76345**	**80694**	**81907**	**83190**	**3657**	**3761**	**3969**

Dwelling Type Totals	Obs. 2011	LowPop_2021	MedPop_2021	HighPop_2021	LowTemp_2021	MedTemp_2021	HighTemp_2021
Single-detached house	42265	46285	47638	49066	1220	1270	1371
Apartment, building that has five or more storeys	525	693	705	717	7	7	8
Movable dwelling	105	124	127	131	3	3	4
Semi-detached house	3985	4260	4395	4538	250	256	268
Row house	6235	6920	7134	7360	332	341	358
Apartment, duplex	16660	17623	18199	18808	1237	1265	1322
Apartment, building that has fewer than five storeys	6390	7083	7279	7487	593	603	623
Other single-attached house	180	198	204	211	15	15	16
Total Dwelling	**76345**	**83186**	**85681**	**88317**	**3657**	**3761**	**3969**

Table 18.0 continued….

Dwelling Type Totals	Obs. 2011	LowPop_2016	MedPop_2016	HighPop_2016	LowTemp_2016	MedTemp_2016	HighTemp_2016
Single-detached house	42265	44675	45326	46014	1220	1270	1371
Apartment, building that has five or more storeys	525	642	647	653	7	7	8
Movable dwelling	105	118	120	121	3	3	4
Semi-detached house	3985	4159	4225	4295	250	256	268
Row house	6235	6646	6749	6858	332	341	358
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Apartment, building that has five or more storeys	525	693	705	717	7	7	8
Movable dwelling	105	124	127	131	3	3	4
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Row house	6235	6920	7134	7360	332	341	358
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APPENDIX D

Wetted Perimeter Analysis Information

Selected Hydrometric Stations in Newfoundland (HYDAT Database)

ID	Station Number	Station Name	Start Year	End Year	Drainage Area (km^2)
1	02YA002	BARTLETTS RIVER NEAR ST. ANTHONY	1986	2013	33.6
2	02YE001	GREAVETT BROOK ABOVE PORTLAND CREEK	1984	2013	95.7
3	02YK008	BOOT BROOK AT TRANS-CANADA HIGHWAY	1986	2012	20.4
4	02YL004	SOUTH BROOK AT PASADENA	1983	2012	58.5
5	02YL005	RATTLER BROOK NEAR MCIVERS	1985	2013	17
6	02YM003	SOUTH WEST BROOK NEAR BAIE VERTE	1980	2013	93.2
7	02YO012	SOUTHWEST BROOK AT LEWISPORTE	1989	2012	58.7
8	02YQ005	SALMON RIVER NEAR GLENWOOD	1987	2013	80.8
9	02YS003	SOUTHWEST BROOK AT TERRA NOVA PARK	1968	2012	36.7
10	02ZA002	HIGHLANDS RIVER AT TRANS-CANADA	1982	2013	72
11	02ZE004	CONNE RIVER AT OUTLET OF CONNE POND	1990	2013	99.5
12	02ZG004	RATTLE BROOK NEAR BOAT HARBOUR	1981	2012	42.7
13	02ZH002	COME BY CHANCE RIVER NEAR GOOBIES	1961	2012	43.3
14	02ZJ001	SOUTHERN BAY RIVER NEAR SOUTHERN BAY	1977	2012	67.4
15	02ZJ002	SALMON COVE RIVER NEAR CHAMPNEYS	1983	2012	73.6
16	02ZK002	NORTHEAST RIVER NEAR PLACENTIA	1979	2012	89.6
17	02ZK003	LITTLE BARACHOIS RIVER NEAR PLACENTIA	1983	2012	37.2
18	02ZL004	SHEARSTOWN BROOK AT SHEARSTOWN	1983	2012	28.9
19	02ZL005	BIG BROOK AT LEAD COVE	1985	2012	11.2
20	02ZM006	NORTHEAST POND RIVER AT NORTHEAST POND	1954	2012	3.63
21	02ZM008	WATERFORD RIVER AT KILBRIDE	1974	2012	52.7
22	02ZM009	SEAL COVE BROOK NEAR CAPPAHAYDEN	1980	2012	53.6
23	02ZM016	SOUTH RIVER NEAR HOLYROOD	1983	2012	17.3
24	02ZM018	VIRGINIA RIVER AT PLEASANTVILLE	1984	2012	10.7
25	02ZM020	LEARY BROOK AT PRINCE PHILIP DRIVE	1986	2012	17.8
26	02ZN001	NORTHWEST BROOK AT NORTHWEST POND	1966	1996	53.3
27	02ZN002	ST. SHOTTS RIVER NEAR TREPASSEY	1985	2012	15.5

Location of 27 selected hydrometric stations in Newfoundland

Threshold streamflows (m^3/s) obtained for rivers in Newfoundland

ID	Station Num.	25% MAF	20% MAF*	40% MAF**	FDC Q85	FDC Q95
1	02YA002	0.342	0.273	0.546	0.153	0.074
2	02YE001	1.207	0.966	1.931	0.99	0.452
3	02YK008	0.129	0.103	0.206	0.054	0.025
4	02YL004	0.451	0.36	0.721	0.374	0.25
5	02YL005	0.125	0.1	0.2	0.054	0.025
6	02YM003	0.656	0.525	1.049	0.298	0.124
7	02YO012	0.389	0.311	0.622	0.382	0.2
8	02YQ005	0.621	0.497	0.994	0.383	0.178
9	02YS003	0.261	0.209	0.417	0.188	0.096
10	02ZA002	0.686	0.549	1.098	0.522	0.35
11	02ZE004	0.848	0.679	1.357	0.572	0.298
12	02ZG004	0.536	0.428	0.857	0.436	0.236
13	02ZH002	0.482	0.386	0.771	0.337	0.162
14	02ZJ001	0.543	0.434	0.869	0.323	0.125
15	02ZJ002	0.659	0.527	1.054	0.72	0.373
16	02ZK002	1.009	0.807	1.614	1.12	0.602
17	02ZK003	0.396	0.317	0.634	0.342	0.248
18	02ZL004	0.223	0.179	0.357	0.208	0.118
19	02ZL005	0.108	0.087	0.173	0.101	0.054
20	02ZM006	0.034	0.027	0.055	0.02	0.01
21	02ZM008	0.555	0.444	0.888	0.526	0.357
22	02ZM009	0.728	0.583	1.165	0.757	0.435
23	02ZM016	0.178	0.142	0.285	0.198	0.114
24	02ZM018	0.134	0.107	0.215	0.153	0.107
25	02ZM020	0.2	0.16	0.321	0.199	0.138
26	02ZN001	0.784	0.627	1.254	0.885	0.581
27	02ZN002	0.204	0.163	0.326	0.207	0.129

* Tennant's method: Threshold for October-March period

** Tennant's method: Threshold for April-September period

Probability of Exceedance by Flow Duration Analysis for Newfoundland

Station ID	Station Num.	25% MAF	Tennant
1	02YA002	66.5	63.7
2	02YE001	80.7	77.9
3	02YK008	65.6	62.2
4	02YL004	78.1	73
5	02YL005	64.2	61.8
6	02YM003	64.8	63.6
7	02YO012	84.7	80.4
8	02YQ005	72.7	69.4
9	02YS003	75.8	71
10	02ZA002	75.3	71.7
11	02ZE004	73.9	70.9
12	02ZG004	80.3	74.2
13	02ZH002	77.3	72.2
14	02ZJ001	75.5	71.4
15	02ZJ002	86.9	81.4
16	02ZK002	87.2	79.5
17	02ZK003	79.1	70.7
18	02ZL004	83.2	75.5
19	02ZL005	83.6	75.8
20	02ZM006	70.5	67.3
21	02ZM008	83.4	74.4
22	02ZM009	86.1	78.4
23	02ZM016	87.9	78.7
24	02ZM018	89.3	79
25	02ZM020	84.7	75.6
26	02ZN001	88.8	80.2
27	02ZN002	85.3	77.6

APPENDIX E

Water Quality Data

Calculated Parameters	Units	Windsor Lake		
		Sample 1	Sample 2	Sample 3
		22/08/2014 9:05	30/09/2014 9:20	13/11/2014 9:25
Anion Sum	me/L	0.63	0.62	0.840
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	11
Calculated TDS	mg/L	38	37	47
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	ND
Cation Sum	me/L	0.65	0.65	0.770
Hardness (CaCO3)	mg/L	7	6.5	12
Ion Balance (% Difference)	%	1.56	2.36	4.35
Langelier Index (@ 20C)	N/A	NC	NC	-2.83
Langelier Index (@ 4C)	N/A	NC	NC	-3.08
Nitrate (N)	mg/L	0.052	ND	0.067
Saturation pH (@ 20C)	N/A	NC	NC	9.74
Saturation pH (@ 4C)	N/A	NC	NC	9.99
Inorganics				
Total Alkalinity (Total as CaCO3)	mg/L	ND	ND	11
Dissolved Chloride (Cl)	mg/L	20	20	20
Colour	TCU	6.6	ND	7.7
Nitrate + Nitrite	mg/L	0.052	ND	0.067
Nitrite (N)	mg/L	ND	ND	ND
Nitrogen (Ammonia Nitrogen)	mg/L	ND	ND	0.11
Total Organic Carbon (C)	mg/L	2.1	2.4	2.4
Orthophosphate (P)	mg/L	ND	ND	ND
pH	pH	6.77	6.55	6.91
Reactive Silica (SiO2)	mg/L	0.68	0.51	1.2
Dissolved Sulphate (SO4)	mg/L	2.8	2.2	2.5
Turbidity	NTU	0.31	0.52	0.45
Conductivity	uS/cm	77	78	81
Metals				
Total Aluminum (Al)	ug/L	19	15	43
Total Antimony (Sb)	ug/L	ND	ND	ND
Total Arsenic (As)	ug/L	ND	ND	ND
Total Barium (Ba)	ug/L	2.2	1.5	2.6
Total Beryllium (Be)	ug/L	ND	ND	ND
Total Bismuth (Bi)	ug/L	ND	ND	ND
Total Boron (B)	ug/L	ND	ND	ND
Total Cadmium (Cd)	ug/L	ND	ND	ND
Total Calcium (Ca)	ug/L	1700	1500	3400
Total Chromium (Cr)	ug/L	ND	ND	ND
Total Cobalt (Co)	ug/L	ND	ND	ND
Total Copper (Cu)	ug/L	ND	ND	ND
Total Iron (Fe)	ug/L	ND	ND	ND
Total Lead (Pb)	ug/L	ND	ND	ND
Total Magnesium (Mg)	ug/L	700	680	780
Total Manganese (Mn)	ug/L	17	16	22
Total Molybdenum (Mo)	ug/L	ND	ND	ND
Total Nickel (Ni)	ug/L	ND	ND	ND
Total Phosphorus (P)	ug/L	ND	110	100
Total Potassium (K)	ug/L	340	330	360
Total Selenium (Se)	ug/L	ND	ND	ND
Total Silver (Ag)	ug/L	ND	ND	ND
Total Sodium (Na)	ug/L	11000	12000	12000
Total Strontium (Sr)	ug/L	7.6	6.9	9.6
Total Thallium (Tl)	ug/L	ND	ND	ND
Total Tin (Sn)	ug/L	ND	ND	ND
Total Titanium (Ti)	ug/L	ND	ND	ND
Total Uranium (U)	ug/L	ND	ND	ND
Total Vanadium (V)	ug/L	ND	ND	ND
Total Zinc (Zn)	ug/L	ND	ND	ND

Calculated Parameters	Units	Bay Bulls Big Pond		
		Sample 1	Sample 2	Sample 3
		22/08/2014 11:05	30/09/2014 11:05	13/11/2014 11:10
Anion Sum	me/L	0.45	0.38	0.680
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5.7	ND	13
Calculated TDS	mg/L	27	25	39
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	ND
Cation Sum	me/L	0.45	0.45	0.670
Hardness (CaCO3)	mg/L	6.9	5.9	16
Ion Balance (% Difference)	%	0	8.43	0.740
Langelier Index (@ 20C)	N/A	-3.62	NC	-2.41
Langelier Index (@ 4C)	N/A	-3.87	NC	-2.66
Nitrate (N)	mg/L	ND	0.055	0.067
Saturation pH (@ 20C)	N/A	10.3	NC	9.46
Saturation pH (@ 4C)	N/A	10.6	NC	9.71
Inorganics				
Total Alkalinity (Total as CaCO3)	mg/L	5.7	ND	13
Dissolved Chloride (Cl)	mg/L	12	13	15
Colour	TCU	12	9.5	ND
Nitrate + Nitrite	mg/L	ND	0.055	0.067
Nitrite (N)	mg/L	ND	ND	ND
Nitrogen (Ammonia Nitrogen)	mg/L	ND	ND	0.053
Total Organic Carbon (C)	mg/L	3.1	4.1	11
Orthophosphate (P)	mg/L	ND	ND	ND
pH	pH	6.69	6.63	7.05
Reactive Silica (SiO2)	mg/L	2.4	1.4	1.8
Dissolved Sulphate (SO4)	mg/L	ND	ND	ND
Turbidity	NTU	1.1	1	6.6
Conductivity	uS/cm	50	53	66
Metals				
Total Aluminum (Al)	ug/L	120	1100	8600
Total Antimony (Sb)	ug/L	ND	ND	ND
Total Arsenic (As)	ug/L	ND	ND	1.1
Total Barium (Ba)	ug/L	ND	ND	1.3
Total Beryllium (Be)	ug/L	ND	ND	ND
Total Bismuth (Bi)	ug/L	ND	ND	ND
Total Boron (B)	ug/L	ND	ND	ND
Total Cadmium (Cd)	ug/L	ND	0.013	0.014
Total Calcium (Ca)	ug/L	1700	1400	5200
Total Chromium (Cr)	ug/L	ND	ND	ND
Total Cobalt (Co)	ug/L	ND	ND	ND
Total Copper (Cu)	ug/L	ND	ND	ND
Total Iron (Fe)	ug/L	ND	140	570
Total Lead (Pb)	ug/L	ND	ND	ND
Total Magnesium (Mg)	ug/L	640	560	720
Total Manganese (Mn)	ug/L	10	81	170
Total Molybdenum (Mo)	ug/L	ND	ND	ND
Total Nickel (Ni)	ug/L	ND	ND	ND
Total Phosphorus (P)	ug/L	ND	ND	120
Total Potassium (K)	ug/L	240	260	290
Total Selenium (Se)	ug/L	ND	ND	ND
Total Silver (Ag)	ug/L	ND	ND	ND
Total Sodium (Na)	ug/L	7000	7300	7300
Total Strontium (Sr)	ug/L	7.3	6.5	11
Total Thallium (Tl)	ug/L	ND	ND	ND
Total Tin (Sn)	ug/L	ND	ND	ND
Total Titanium (Ti)	ug/L	ND	ND	4.8
Total Uranium (U)	ug/L	ND	ND	ND
Total Vanadium (V)	ug/L	ND	ND	ND
Total Zinc (Zn)	ug/L	ND	ND	ND

Calculated Parameters	Units	Petty Harbour Long Pond		
		Sample 1	Sample 2	Sample 3
		22/08/2014 10:25	30/09/2014 10:30	13/11/2014 10:20
Anion Sum	me/L	0.26	0.27	0.260
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	ND
Calculated TDS	mg/L	17	17	17
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	ND
Cation Sum	me/L	0.31	0.32	0.310
Hardness (CaCO3)	mg/L	3.9	4.1	3.9
Ion Balance (% Difference)	%	8.77	8.47	8.77
Langelier Index (@ 20C)	N/A	NC	NC	NC
Langelier Index (@ 4C)	N/A	NC	NC	NC
Nitrate (N)	mg/L	ND	0.052	ND
Saturation pH (@ 20C)	N/A	NC	NC	NC
Saturation pH (@ 4C)	N/A	NC	NC	NC
Inorganics				
Total Alkalinity (Total as CaCO3)	mg/L	ND	ND	ND
Dissolved Chloride (Cl)	mg/L	9.3	9.4	9.2
Colour	TCU	10	8.2	12
Nitrate + Nitrite	mg/L	ND	0.052	ND
Nitrite (N)	mg/L	ND	ND	ND
Nitrogen (Ammonia Nitrogen)	mg/L	ND	ND	ND
Total Organic Carbon (C)	mg/L	2.5	2.7	3.0
Orthophosphate (P)	mg/L	ND	ND	ND
pH	pH	6.11	6.27	6.12
Reactive Silica (SiO2)	mg/L	0.93	0.95	1.1
Dissolved Sulphate (SO4)	mg/L	ND	ND	ND
Turbidity	NTU	0.6	0.64	0.32
Conductivity	uS/cm	36	37	34
Metals				
Total Aluminum (Al)	ug/L	43	34	55
Total Antimony (Sb)	ug/L	ND	ND	ND
Total Arsenic (As)	ug/L	ND	ND	ND
Total Barium (Ba)	ug/L	1.8	1.8	1.6
Total Beryllium (Be)	ug/L	ND	ND	ND
Total Bismuth (Bi)	ug/L	ND	ND	ND
Total Boron (B)	ug/L	ND	ND	ND
Total Cadmium (Cd)	ug/L	ND	ND	0.044
Total Calcium (Ca)	ug/L	610	690	640
Total Chromium (Cr)	ug/L	ND	ND	ND
Total Cobalt (Co)	ug/L	ND	ND	ND
Total Copper (Cu)	ug/L	ND	ND	ND
Total Iron (Fe)	ug/L	57	63	50
Total Lead (Pb)	ug/L	ND	ND	ND
Total Magnesium (Mg)	ug/L	590	580	570
Total Manganese (Mn)	ug/L	83	33	12
Total Molybdenum (Mo)	ug/L	ND	ND	ND
Total Nickel (Ni)	ug/L	ND	ND	ND
Total Phosphorus (P)	ug/L	ND	ND	100
Total Potassium (K)	ug/L	300	330	310
Total Selenium (Se)	ug/L	ND	ND	ND
Total Silver (Ag)	ug/L	ND	ND	ND
Total Sodium (Na)	ug/L	5000	5100	5100
Total Strontium (Sr)	ug/L	5.5	5.8	5.5
Total Thallium (Tl)	ug/L	ND	ND	ND
Total Tin (Sn)	ug/L	ND	ND	ND
Total Titanium (Ti)	ug/L	ND	ND	ND
Total Uranium (U)	ug/L	ND	ND	ND
Total Vanadium (V)	ug/L	ND	ND	ND
Total Zinc (Zn)	ug/L	ND	ND	ND

Calculated Parameters	Units	Little Powers Pond		
		Sample 1	Sample 2	Sample 3
		22/08/2014 9:30	30/09/2014 9:45	13/11/2014 9:50
Anion Sum	me/L	1.03	1.06	0.730
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	6.1	6.9	5.2
Calculated TDS	mg/L	64	67	47
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	ND
Cation Sum	me/L	1.06	1.16	0.770
Hardness (CaCO3)	mg/L	9.8	10	7.3
Ion Balance (% Difference)	%	1.44	4.5	2.67
Langelier Index (@ 20C)	N/A	-3.62	-3.23	-4.34
Langelier Index (@ 4C)	N/A	-3.88	-3.49	-4.59
Nitrate (N)	mg/L	ND	ND	ND
Saturation pH (@ 20C)	N/A	10.1	10	10.3
Saturation pH (@ 4C)	N/A	10.4	10.3	10.6
Inorganics				
Total Alkalinity (Total as CaCO3)	mg/L	6.1	6.9	5.2
Dissolved Chloride (Cl)	mg/L	31	33	22
Colour	TCU	85	46	92
Nitrate + Nitrite	mg/L	ND	ND	ND
Nitrite (N)	mg/L	ND	ND	ND
Nitrogen (Ammonia Nitrogen)	mg/L	ND	0.064	ND
Total Organic Carbon (C)	mg/L	11	8.6	11
Orthophosphate (P)	mg/L	ND	ND	ND
pH	pH	6.49	6.81	5.99
Reactive Silica (SiO2)	mg/L	3.5	4.1	4.3
Dissolved Sulphate (SO4)	mg/L	2.2	ND	ND
Turbidity	NTU	0.77	1.6	1.4
Conductivity	uS/cm	110	130	80
Metals				
Total Aluminum (Al)	ug/L	180	130	250
Total Antimony (Sb)	ug/L	ND	ND	ND
Total Arsenic (As)	ug/L	ND	ND	ND
Total Barium (Ba)	ug/L	2.8	3.3	4.1
Total Beryllium (Be)	ug/L	ND	ND	ND
Total Bismuth (Bi)	ug/L	ND	ND	ND
Total Boron (B)	ug/L	ND	ND	ND
Total Cadmium (Cd)	ug/L	ND	0.016	ND
Total Calcium (Ca)	ug/L	2700	2800	1800
Total Chromium (Cr)	ug/L	ND	1	ND
Total Cobalt (Co)	ug/L	ND	0.48	ND
Total Copper (Cu)	ug/L	ND	ND	ND
Total Iron (Fe)	ug/L	860	1200	920
Total Lead (Pb)	ug/L	ND	0.79	ND
Total Magnesium (Mg)	ug/L	760	840	650
Total Manganese (Mn)	ug/L	120	130	63
Total Molybdenum (Mo)	ug/L	ND	ND	ND
Total Nickel (Ni)	ug/L	ND	ND	ND
Total Phosphorus (P)	ug/L	ND	110	110
Total Potassium (K)	ug/L	400	510	540
Total Selenium (Se)	ug/L	ND	ND	ND
Total Silver (Ag)	ug/L	ND	ND	ND
Total Sodium (Na)	ug/L	19000	21000	13000
Total Strontium (Sr)	ug/L	11	10	7.2
Total Thallium (Tl)	ug/L	ND	ND	ND
Total Tin (Sn)	ug/L	ND	ND	ND
Total Titanium (Ti)	ug/L	3.7	3.4	5.3
Total Uranium (U)	ug/L	ND	ND	ND
Total Vanadium (V)	ug/L	ND	ND	ND
Total Zinc (Zn)	ug/L	ND	ND	ND

Calculated Parameters	Units	North Pond				
		Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
		22/08/2014 13:10	30/09/2014 12:30	13/11/2014 12:21	04/02/2015 10:50	31/03/2015 15:00
Anion Sum	me/L	0.43	0.45	0.380	0.39	0.430
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	ND	ND	ND
Calculated TDS	mg/L	28	30	26	27	29
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	ND	ND	ND
Cation Sum	me/L	0.46	0.5	0.470	0.46	0.490
Hardness (CaCO3)	mg/L	6.9	7	6.7	5.7	6.9
Ion Balance (% Difference)	%	3.37	5.26	10.6	8.24	6.52
Langelier Index (@ 20C)	N/A	NC	NC	NC	NC	NC
Langelier Index (@ 4C)	N/A	NC	NC	NC	NC	NC
Nitrate (N)	mg/L	ND	0.051	ND	0.054	0.058
Saturation pH (@ 20C)	N/A	NC	NC	NC	NC	NC
Saturation pH (@ 4C)	N/A	NC	NC	NC	NC	NC
Inorganics						
Total Alkalinity (Total as CaCO3)	mg/L	ND	ND	ND	ND	ND
Dissolved Chloride (Cl)	mg/L	13	14	14	12	13
Colour	TCU	8.5	9.4	15	7.7	13
Nitrate + Nitrite	mg/L	ND	0.051	ND	0.054	0.058
Nitrite (N)	mg/L	ND	ND	ND	ND	ND
Nitrogen (Ammonia Nitrogen)	mg/L	ND	0.056	ND	ND	ND
Total Organic Carbon (C)	mg/L	2.6	2.5	3.2	2	2.6
Orthophosphate (P)	mg/L	ND	ND	ND	ND	ND
pH	pH	6.49	6.59	6.27	5.92	5.99
Reactive Silica (SiO2)	mg/L	2.2	2.4	2.6	2.4	2.6
Dissolved Sulphate (SO4)	mg/L	2.7	2.1	ND	2.3	2.3
Turbidity	NTU	0.38	0.51	0.38	ND	0.76
Conductivity	uS/cm	55	57	51	52	56
Metals						
Total Aluminum (Al)	ug/L	20	24	46	49	100
Total Antimony (Sb)	ug/L	ND	ND	ND	ND	ND
Total Arsenic (As)	ug/L	ND	ND	ND	ND	ND
Total Barium (Ba)	ug/L	1.3	1.3	1.7	1.9	2.9
Total Beryllium (Be)	ug/L	ND	ND	ND	ND	ND
Total Bismuth (Bi)	ug/L	ND	ND	ND	ND	ND
Total Boron (B)	ug/L	ND	ND	ND	ND	ND
Total Cadmium (Cd)	ug/L	ND	0.01	ND	0.014	0.037
Total Calcium (Ca)	ug/L	1400	1400	1400	1000	1300
Total Chromium (Cr)	ug/L	ND	ND	ND	ND	ND
Total Cobalt (Co)	ug/L	ND	ND	ND	ND	ND
Total Copper (Cu)	ug/L	ND	ND	ND	ND	ND
Total Iron (Fe)	ug/L	ND	85	88	85	150
Total Lead (Pb)	ug/L	ND	ND	ND	ND	ND
Total Magnesium (Mg)	ug/L	800	820	790	780	890
Total Manganese (Mn)	ug/L	50	110	38	32	39
Total Molybdenum (Mo)	ug/L	ND	ND	ND	ND	ND
Total Nickel (Ni)	ug/L	ND	ND	ND	ND	ND
Total Phosphorus (P)	ug/L	ND	ND	ND	ND	ND
Total Potassium (K)	ug/L	360	540	490	340	390
Total Selenium (Se)	ug/L	ND	ND	ND	ND	ND
Total Silver (Ag)	ug/L	ND	ND	ND	ND	ND
Total Sodium (Na)	ug/L	7200	7900	7300	7700	7700
Total Strontium (Sr)	ug/L	7.1	7.4	6.6	5.8	7.2
Total Thallium (Tl)	ug/L	ND	ND	ND	ND	ND
Total Tin (Sn)	ug/L	ND	ND	ND	ND	ND
Total Titanium (Ti)	ug/L	ND	ND	2.6	2.4	5.4
Total Uranium (U)	ug/L	ND	ND	ND	ND	ND
Total Vanadium (V)	ug/L	ND	ND	ND	ND	ND
Total Zinc (Zn)	ug/L	ND	ND	ND	ND	5.3

Calculated Parameters	Units	Thomas Pond				
		Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
		22/08/2014 11:50	30/09/2014 11:45	13/11/2014 11:47	04/02/2015 10:05	31/03/2015 14:20
Anion Sum	me/L	0.21	0.35	0.330	0.17	0.350
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	ND	5.2	5.1	ND	ND
Calculated TDS	mg/L	17	21	21	13	25
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	ND	ND	ND
Cation Sum	me/L	0.37	0.38	0.350	0.29	0.440
Hardness (CaCO3)	mg/L	5.9	5.8	5.8	3.6	7.2
Ion Balance (% Difference)	%	27.6	4.11	2.94	26.1	11.4
Langelier Index (@ 20C)	N/A	NC	-3.97	-4.70	NC	NC
Langelier Index (@ 4C)	N/A	NC	-4.22	-4.95	NC	NC
Nitrate (N)	mg/L	ND	0.054	ND	ND	ND
Saturation pH (@ 20C)	N/A	NC	10.4	10.4	NC	NC
Saturation pH (@ 4C)	N/A	NC	10.7	10.7	NC	NC
Inorganics						
Total Alkalinity (Total as CaCO3)	mg/L	ND	5.2	5.1	ND	ND
Dissolved Chloride (Cl)	mg/L	7.5	8.7	8.1	6	12
Colour	TCU	100	82	120	16	44
Nitrate + Nitrite	mg/L	ND	0.054	ND	ND	ND
Nitrite (N)	mg/L	ND	ND	ND	ND	ND
Nitrogen (Ammonia Nitrogen)	mg/L	ND	0.062	ND	ND	ND
Total Organic Carbon (C)	mg/L	8.5	9.1	11	1.8	4.2
Orthophosphate (P)	mg/L	ND	ND	ND	ND	ND
pH	pH	6.25	6.45	5.75	5.66	5.88
Reactive Silica (SiO2)	mg/L	1.5	1.1	2.0	0.61	3.0
Dissolved Sulphate (SO4)	mg/L	ND	ND	ND	ND	ND
Turbidity	NTU	1.2	1.1	3.4	0.24	0.38
Conductivity	uS/cm	35	38	34	28	49
Metals						
Total Aluminum (Al)	ug/L	180	180	210	44	110
Total Antimony (Sb)	ug/L	ND	ND	ND	ND	ND
Total Arsenic (As)	ug/L	ND	ND	ND	ND	ND
Total Barium (Ba)	ug/L	3.2	2.9	3.8	1.6	3.9
Total Beryllium (Be)	ug/L	ND	ND	ND	ND	ND
Total Bismuth (Bi)	ug/L	ND	ND	ND	ND	ND
Total Boron (B)	ug/L	ND	ND	ND	ND	ND
Total Cadmium (Cd)	ug/L	ND	ND	0.016	ND	0.064
Total Calcium (Ca)	ug/L	1400	1400	1300	710	1500
Total Chromium (Cr)	ug/L	ND	ND	ND	ND	ND
Total Cobalt (Co)	ug/L	0.41	ND	ND	ND	ND
Total Copper (Cu)	ug/L	ND	ND	ND	ND	ND
Total Iron (Fe)	ug/L	1200	1100	720	88	300
Total Lead (Pb)	ug/L	ND	ND	ND	ND	ND
Total Magnesium (Mg)	ug/L	570	570	590	450	870
Total Manganese (Mn)	ug/L	110	36	40	15	65
Total Molybdenum (Mo)	ug/L	ND	ND	ND	ND	ND
Total Nickel (Ni)	ug/L	ND	ND	ND	ND	ND
Total Phosphorus (P)	ug/L	ND	120	110	ND	ND
Total Potassium (K)	ug/L	280	230	390	400	270
Total Selenium (Se)	ug/L	ND	ND	ND	ND	ND
Total Silver (Ag)	ug/L	ND	ND	ND	ND	ND
Total Sodium (Na)	ug/L	4700	4900	4600	4600	6400
Total Strontium (Sr)	ug/L	5.8	5.9	5.3	2.7	6.1
Total Thallium (Tl)	ug/L	ND	ND	ND	ND	ND
Total Tin (Sn)	ug/L	ND	ND	ND	ND	ND
Total Titanium (Ti)	ug/L	6.1	6.1	6.1	2.2	2.5
Total Uranium (U)	ug/L	ND	ND	ND	ND	ND
Total Vanadium (V)	ug/L	ND	ND	ND	ND	ND
Total Zinc (Zn)	ug/L	ND	ND	ND	5.3	6.9

Calculated Parameters	Units	Big Triangle Pond	
		Sample 1	Sample 2
		04/02/2015 9:30	31/03/2015 13:45
Anion Sum	me/L	0.51	0.500
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	8	7.6
Calculated TDS	mg/L	32	31
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND
Cation Sum	me/L	0.57	0.550
Hardness (CaCO3)	mg/L	11	12
Ion Balance (% Difference)	%	5.56	4.76
Langelier Index (@ 20C)	N/A	-3.16	-3.16
Langelier Index (@ 4C)	N/A	-3.42	-3.41
Nitrate (N)	mg/L	ND	ND
Saturation pH (@ 20C)	N/A	9.85	9.86
Saturation pH (@ 4C)	N/A	10.1	10.1
Inorganics			
Total Alkalinity (Total as CaCO3)	mg/L	8	7.6
Dissolved Chloride (Cl)	mg/L	12	12
Colour	TCU	50	29
Nitrate + Nitrite	mg/L	ND	ND
Nitrite (N)	mg/L	ND	ND
Nitrogen (Ammonia Nitrogen)	mg/L	ND	0.053
Total Organic Carbon (C)	mg/L	5.5	3.4
Orthophosphate (P)	mg/L	ND	ND
pH	pH	6.69	6.70
Reactive Silica (SiO2)	mg/L	3.1	2.8
Dissolved Sulphate (SO4)	mg/L	ND	ND
Turbidity	NTU	0.21	0.62
Conductivity	uS/cm	59	57
Metals			
Total Aluminum (Al)	ug/L	120	96
Total Antimony (Sb)	ug/L	ND	ND
Total Arsenic (As)	ug/L	ND	ND
Total Barium (Ba)	ug/L	9.8	10
Total Beryllium (Be)	ug/L	ND	ND
Total Bismuth (Bi)	ug/L	ND	ND
Total Boron (B)	ug/L	ND	ND
Total Cadmium (Cd)	ug/L	0.012	0.28
Total Calcium (Ca)	ug/L	3500	3500
Total Chromium (Cr)	ug/L	ND	ND
Total Cobalt (Co)	ug/L	ND	ND
Total Copper (Cu)	ug/L	ND	ND
Total Iron (Fe)	ug/L	130	120
Total Lead (Pb)	ug/L	ND	ND
Total Magnesium (Mg)	ug/L	650	830
Total Manganese (Mn)	ug/L	13	19
Total Molybdenum (Mo)	ug/L	ND	ND
Total Nickel (Ni)	ug/L	ND	ND
Total Phosphorus (P)	ug/L	ND	ND
Total Potassium (K)	ug/L	250	250
Total Selenium (Se)	ug/L	ND	ND
Total Silver (Ag)	ug/L	ND	ND
Total Sodium (Na)	ug/L	7600	6600
Total Strontium (Sr)	ug/L	13	13
Total Thallium (Tl)	ug/L	ND	ND
Total Tin (Sn)	ug/L	ND	ND
Total Titanium (Ti)	ug/L	2.8	ND
Total Uranium (U)	ug/L	ND	ND
Total Vanadium (V)	ug/L	ND	ND
Total Zinc (Zn)	ug/L	ND	18

APPENDIX F

Storage Tank Calculations

Table 6.3 - 2014 Max Day Demands (Existing Tanks)

Zones & Max Day Demand			Existing Tank Max. Day (m^3/d)											
			Windsor Lake		Bay Bulls Big Pond									PHLP
Pressure Zone	Max. Day Demand		WL WTP	Airport Heights	Bay Bulls Big Pond WTP	Ruby Line Clearwell	Kenmount Hill	Mundy Pond	Southlands	Kenmount Park	Fowler's Road	Camrose Drive	Skinner's Hill	PHLP WTP
	L/min	m^3/D	WL-E, F, G, H, I, J, K	WL-A, B, C, D	BB-A		BB-C, D, E, F, H	BB-G	BB-I, MP-A, B	MP-C	CB-A, B, C	PA-A/G, PS-E	PS-A/D	PH-A, B, C, D, E, F, G & BB-B
WL-A	3104	4469		4469										
WL-B	16	22		22										
WL-C	1213	1747		1747										
WL-D	810	1167		1167										
WL-E	5670	8164	8164											
WL-F	3155	4543	4543											
WL-G	6845	9857	9857											
WL-H	4507	6490	6490											
WL-I	7650	11016	11016											
WL-J	3434	4945	4945											
WL-K	9148	13173	13173											
BB-A	2834	4081			4081									
BB-B	3556	5121												5121
BB-C	2427	3495					3495							
BB-D	779	1122					1122							
BB-E	1112	1602					1602							
BB-F	4218	6073					6073							
BB-G	3793	5462						5462						
BB-H	101	146					146							
BB-I	852	1226							1226					
PH-A	586	843												843
PH-B	1709	2461												2461
PH-C	949	1367												1367
PH-D	3719	5355												5355
PH-E	440	633												633
PH-F	551	794												794
PH-G	49	70												70
MP-A	13080	18835							18835					
MP-B	2400	3456							3456					
MP-C	3600	5184								5184				
CB-A	1450	2088									2088			
CB-B	2183	3144									3144			
CB-C	9115	13126									13126			
PA-A	1872	2695										2695		
PA-B	4736	6820										6820		
PA-C	284	408										408		
PA-D	425	613										613		
PA-E	284	408										408		
PA-F	284	408										408		
PA-G	170	245										245		
PS-A	1260	1814											1814	
PS-B	360	518											518	
PS-C	360	518											518	
PS-D	300	432											432	
PS-E	240	346										346		
Max Day Total	115626	166502	58187	7405	4081	0	12437	5462	23518	5184	18357	11944	3283	16644

Table 6.4 - 2014 Tank Sizing (Existing Tanks)

Volume	Tank	Criteria	Service Zones	Existing Tanks											
				Windsor Lake		Bay Bulls Big Pond									PHLP
				WL WTP	Airport Heights	Bay Bulls Big Pond WTP	Ruby Line Clearwell	Kenmount Hill	Mundy Pond	Southlands	Kenmount Park	Fowler's Road	Camrose Drive	Skinner's Hill	PHLP WTP
				WL-E, F, G, H, I, J, K	WL-A, B, C, D	BB-A		BB-C, D, E, F, H	BB-G	BB-I, MP-A, B	MP-C	CB-A, B, C	PA-A/G, PS-E	PS-A/D	PH-A, B, C, D, E, F, G & BB-B
			Max Day Total (m^3/D)	**58187**	**7405**	**4081**	**0**	**12437**	**5462**	**23518**	**5184**	**18357**	**11944**	**3283**	**16644**
Peak Balancing Volume	***Name***			**Peak Balancing Volume (m^3)**											
	WL WTP	25% Max. Day		14547											
	Airport Heights				1851										
	Bay Bulls Big Pond WTP					1020									
	Ruby Line Clearwell						0								
	Kenmount Hill							3109							
	Mundy Pond								1366						
	Southlands									5879					
	Kenmount Park										1296				
	Fowler's Road											4589			
	Camrose Drive												2986		
	Skinner's Hill													821	
	PHLP WTP														4161
Fire Flow Volume	***Name***	**Flow (L/min)**	**Duration (Hours)**	**Fire Flow Volume (m^3)**											
	WL WTP	16000	3.5	3360											
	Airport Heights	16000	3.5		3360										
	Bay Bulls Big Pond WTP	16000	3.5			3360									
	Ruby Line Clearwell	12000	2.5												
	Kenmount Hill	16000	3.5					3360							
	Mundy Pond	12000	2.5						1800						
	Southlands	16000	3.5							3360					
	Kenmount Park	12000	2.5								1800				
	Fowler's Road	12000	2.5									1800			
	Camrose Drive	12000	2.5										1800		
	Skinner's Hill	12000	2.5											1800	
	PHLP WTP	12000	2.5												1800
Emergency Volume	***Name***			**Emergency Storage Volume (m^3)**											
	WL WTP	25% x (Peak Bal. + Fire)		4477											
	Airport Heights				1303										
	Bay Bulls Big Pond WTP					1095									
	Ruby Line Clearwell														
	Kenmount Hill							1617							
	Mundy Pond								791						
	Southlands									2310					
	Kenmount Park										774				
	Fowler's Road											1597			
	Camrose Drive												1196		
	Skinner's Hill													655	
	PHLP WTP														1490
		Required Tank Volumes (m^3)		**22383**	**6514**	**5475**	**900**	**8087**	**3957**	**11549**	**3870**	**7987**	**5982**	**3276**	**7451**
		Actual Tank Volumes (m^3)		**20000**	**8000**	**10365**	**900**	**17300**	**11760**	**19600**	**3550**	**5680**	**10540**	**2840**	**10000**

Table 6.5 - 2014 Max Day Demands (Existing and Proposed Tanks)

Zones & Max Day Demand			Proposed Tank Max. Day (m^3/d)					Existing Tank Max. Day (m^3/d)												
Pressure Zone	Max. Day Demand		Windsor Lake		Bay Bulls Big Pond		PHLP	Windsor Lake		Bay Bulls Big Pond										PHLP
			Sugarloaf	Signal Hill	RL Pump Station	CBS South	Kilbride East	WL WTP	Airport Heights	Bay Bulls Big Pond WTP	Ruby Line Clearwell	Kenmount Hill	Mundy Pond	Southlands	Kenmount Park	Fowler's Road	Camrose Drive	Skinner's Hill	PHLP WTP
	L/min	m^3/D	WL-E, G	WL-J, 33%K		50%CB-C	PH-A, B, F, G	WL-F, H, I, 67%K	WL-A, B, C, D	BB-A		BB-C, D, E, F, H	BB-G	BB-I, MP-A, B	MP-C	CB-A, B, 50%C	PA-A/G, PS-E	PS-A/D	PH-C, D, E, & BB-B
WL-A	3104	4469							4469										
WL-B	16	22							22										
WL-C	1213	1747							1747										
WL-D	810	1167							1167										
WL-E	5670	8164	8164																
WL-F	3155	4543						4543											
WL-G	6845	9857	9857																
WL-H	4507	6490						6490											
WL-I	7650	11016						11016											
WL-J	3434	4945		4945															
WL-K	9148	13173		4347				8826											
BB-A	2834	4081								4081									
BB-B	3556	5121																	5121
BB-C	2427	3495										3495							
BB-D	779	1122										1122							
BB-E	1112	1602										1602							
BB-F	4218	6073										6073							
BB-G	3793	5462											5462						
BB-H	101	146										146							
BB-I	852	1226												1226					
PH-A	586	843					843												
PH-B	1709	2461					2461												
PH-C	949	1367																	1367
PH-D	3719	5355																	5355
PH-E	440	633																	633
PH-F	551	794					794												
PH-G	49	70					70												
MP-A	13080	18835												18835					
MP-B	2400	3456												3456					
MP-C	3600	5184													5184				
CB-A	1450	2088														2088			
CB-B	2183	3144														3144			
CB-C	9115	13126				6563										6563			
PA-A	1872	2695															2695		
PA-B	4736	6820															6820		
PA-C	284	408															408		
PA-D	425	613															613		
PA-E	284	408															408		
PA-F	284	408															408		
PA-G	170	245															245		
PS-A	1260	1814																1814	
PS-B	360	518																518	
PS-C	360	518																518	
PS-D	300	432																432	
PS-E	240	346															346		
Max Day Total	115626	166502	18021	9292	0	6563	4168	30874	7405	4081	0	12437	5462	23518	5184	11794	11944	3283	12476

Table 6.6 - 2014 Tank Sizing (Existing and Proposed Tanks)

Volume	Tank	Criteria	Service Zones	Proposed Tanks					Existing Tanks											
				Windsor Lake		Bay Bulls Big Pond		PHLP	Windsor Lake		Bay Bulls Big Pond									PHLP
				Sugarloaf	Signal Hill	RL Pump Station	CBS South	Kilbride East	WL WTP	Airport Heights	Bay Bulls Big Pond WTP	Ruby Line Clearwell	Kenmount Hill	Mundy Pond	Southlands	Kenmount Park	Fowler's Road	Camrose Drive	Skinner's Hill	PHLP WTP
				WL-E, G	WL-J, 33%K		50%CB-C	PH-A, B, F, G	WL-F, H, I, 67%K	WL-A, B, C, D	BB-A		BB-C, D, E, F, H	BB-G	BB-I, MP-A, B	MP-C	CB-A, B, 50%C	PA-A/G, PS-E	PS-A/D	PH-C, D, E, & BB-B
			Max Day Total (m^3/D)	18021	9292	0	6563	4168	30874	7405	4081	0	12437	5462	23518	5184	11794	11944	3283	12476
Peak Balancing Volume	***Name***			Peak Balancing Volume (m^3)					Peak Balancing Volume (m^3)											
	Sugarloaf			4505																
	Signal Hill				2323															
	RL Pump Station																			
	CBS South						1641													
	Kilbride East							1042												
	WL WTP								7718											
	Airport Heights									1851										
	Bay Bulls Big Pond WTP										1020									
	Ruby Line Clearwell	25% Max. Day										0								
	Kenmount Hill												3109							
	Mundy Pond													1366						
	Southlands														5879					
	Kenmount Park															1296				
	Fowler's Road																2949			
	Camrose Drive																	2986		
	Skinner's Hill																		821	
	PHLP WTP																			3119
Fire Flow Volume	***Name***	**Flow (L/min)**	**Duration (Hours)**	Fire Flow Volume (m^3)					Fire Flow Volume (m^3)											
	Sugarloaf	12000	2.5	1800																
	Signal Hill	16000	3.5		3360															
	RL Pump Station	12000	2.5																	
	CBS South	12000	2.5				1800													
	Kilbride East	12000	2.5					1800												
	WL WTP	16000	3.5						3360											
	Airport Heights	16000	3.5							3360										
	Bay Bulls Big Pond WTP	16000	3.5								3360									
	Ruby Line Clearwell	0	0.0									0								
	Kenmount Hill	16000	3.5										3360							
	Mundy Pond	12000	2.5											1800						
	Southlands	16000	3.5												3360					
	Kenmount Park	12000	2.5													1800				
	Fowler's Road	12000	2.5														1800			
	Camrose Drive	12000	2.5															1800		
	Skinner's Hill	12000	2.5																1800	
	PHLP WTP	12000	2.5																	1800
Emergency Volume	***Name***			Emergency Storage Volume (m^3)					Emergency Storage Volume (m^3)											
	Sugarloaf			1576																
	Signal Hill				1421															
	RL Pump Station																			
	CBS South						860													
	Kilbride East							710												
	WL WTP								2770											
	Airport Heights									1303										
	Bay Bulls Big Pond WTP										1095									
	Ruby Line Clearwell	25% x (Peak Bal. + Fire)										0								
	Kenmount Hill												1617							
	Mundy Pond													791						
	Southlands														2310					
	Kenmount Park															774				
	Fowler's Road																1187			
	Camrose Drive																	1196		
	Skinner's Hill																		655	
	PHLP WTP																			1230
			Required Tank Volumes (m^3)	**7882**	**7104**	**0**	**4301**	**3552**	**13848**	**6514**	**5475**	**900**	**8087**	**3957**	**11549**	**3870**	**5936**	**5982**	**3276**	**6149**
								Actual Tank Volumes (m^3)	**20000**	**8000**	**10365**	**900**	**17300**	**11760**	**19600**	**3550**	**5680**	**10540**	**2840**	**10000**

Table 6.7 - 2036 Max Day Demands (Existing Tanks)

Zones & Max Day Demand			Existing Tank Max. Day (m^3/d)											
Pressure Zone	Max. Day Demand		Windsor Lake		Bay Bulls Big Pond									PHLP
			WL WTP	Airport Heights	Bay Bulls Big Pond WTP	Ruby Line Clearwell	Kenmount Hill	Mundy Pond	Southlands	Kenmount Park	Fowler's Road	Camrose Drive	Skinner's Hill	PHLP WTP
	L/min	m^3/D	WL-E, F, G, H, I, J, K	WL-A, B, C, D	BB-A	B-BB	BB-C, D, E, F, H	BB-G	BB-I, MP-A, B	MP-C	CB-A, B, C	PA-A/G, PS-E	PS-A/D	PH-A, B, C, D, E, F, G
WL-A	3442	8956		8956										
WL-B	21	30		30										
WL-C	1300	1872		1872										
WL-D	947	1364		1364										
WL-E	6177	8352	8352											
WL-F	3547	4796	4796											
WL-G	7325	9905	9905											
WL-H	5167	6986	6986											
WL-I	9112	12321	12321											
WL-J	3750	5070	5070											
WL-K	10498	14196	14196											
BB-A	2852	4107			4107									
BB-B	3589	5168				5168								
BB-C	2465	3550					3550							
BB-D	1162	1673					1673							
BB-E	1116	1607					1607							
BB-F	4248	6117					6117							
BB-G	3854	5550						5550						
BB-H	102	147					147							
BB-I	864	1245							1245					
PH-A	2329	3354												3354
PH-B	1912	2753												2753
PH-C	1017	1464												1464
PH-D	4375	6300												6300
PH-E	576	830												830
PH-F	631	908												908
PH-G	54	77												77
MP-A	14030	20203							20203					
MP-B	2970	4277							4277					
MP-C	3981	5732								5732				
CB-A	3114	4484									4484			
CB-B	2911	4192									4192			
CB-C	10033	14448									14448			
PA-A	1872	2695										2695		
PA-B	6206	8937										8937		
PA-C	529	761										761		
PA-D	670	965										965		
PA-E	529	761										761		
PA-F	529	761										761		
PA-G	170	245										245		
PS-A	1903	2740											2740	
PS-B	559	805											805	
PS-C	509	733											733	
PS-D	300	432											432	
PS-E	240	346										346		
Max Day Total	133485	192218	61627	12222	4107	5168	13094	5550	25725	5732	23124	15472	4710	15687

Table 6.8 - 2036 Tank Sizing (Existing Tanks)

Volume	Tank	Criteria	Service Zones	Existing Tanks											
				Windsor Lake		Bay Bulls Big Pond									PHLP
				WL WTP	Airport Heights	Bay Bulls Big Pond WTP	Ruby Line Clearwell	Kenmount Hill	Mundy Pond	Southlands	Kenmount Park	Fowler's Road	Camrose Drive	Skinner's Hill	PHLP WTP
				WL-E, F, G, H, I, J, K	WL-A, B, C, D	BB-A	B-BB	BB-C, D, E, F, H	BB-G	BB-I, MP-A, B	MP-C	CB-A, B, C	PA-A/G, PS-E	PS-A/D	PH-A, B, C, D, E, F, G
			Max Day Total (m^3/D)	**61627**	**12222**	**4107**	**5168**	**13094**	**5550**	**25725**	**5732**	**23124**	**15472**	**4710**	**15687**
Peak Balancing Volume	***Name***			**Peak Balancing Volume (m^3)**											
	WL WTP	25% Max. Day		15407											
	Airport Heights				3056										
	Bay Bulls Big Pond WTP					1027									
	Ruby Line Clearwell						1292								
	Kenmount Hill							3274							
	Mundy Pond								1388						
	Southlands									6431					
	Kenmount Park										1433				
	Fowler's Road											5781			
	Camrose Drive												3868		
	Skinner's Hill													1178	
	PHLP WTP														3922
Fire Flow Volume	***Name***	**Flow (L/min)**	**Duration (Hours)**	**Fire Flow Volume (m^3)**											
	WL WTP	16000	3.5	3360											
	Airport Heights	16000	3.5		3360										
	Bay Bulls Big Pond WTP	16000	3.5			3360									
	Ruby Line Clearwell	12000	2.5				1800								
	Kenmount Hill	16000	3.5					3360							
	Mundy Pond	12000	2.5						1800						
	Southlands	16000	3.5							3360					
	Kenmount Park	12000	2.5								1800				
	Fowler's Road	12000	2.5									1800			
	Camrose Drive	12000	2.5										1800		
	Skinner's Hill	12000	2.5											1800	
	PHLP WTP	12000	2.5												1800
Emergency Volume	***Name***			**Emergency Storage Volume (m^3)**											
	WL WTP	25% x (Peak Bal. + Fire)		4692											
	Airport Heights				1604										
	Bay Bulls Big Pond WTP					1097									
	Ruby Line Clearwell						773								
	Kenmount Hill							1658							
	Mundy Pond								797						
	Southlands									2448					
	Kenmount Park										808				
	Fowler's Road											1895			
	Camrose Drive												1417		
	Skinner's Hill													744	
	PHLP WTP														1430
		Required Tank Volumes (m^3)		**23459**	**8019**	**5483**	**3865**	**8292**	**3984**	**12239**	**4041**	**9476**	**7085**	**3722**	**7152**
		Actual Tank Volumes (m^3)		**20000**	**8000**	**10365**	**900**	**17300**	**11760**	**19600**	**3550**	**5680**	**10540**	**2840**	**10000**

Table 6.9 - 2036 Max Day Demands (Existing and Proposed Tanks)

Zones & Max Day Demand			Proposed Tank Max. Day (m^3/d)					Existing Tank Max. Day (m^3/d)											
	Max. Day Demand		Windsor Lake		Bay Bulls Big Pond		PHLP	Windsor Lake		Bay Bulls Big Pond									PHLP
Pressure Zone			Sugarloaf	Signal Hill	RL Pump Station	CBS South	Kilbride East	WL WTP	Airport Heights	Bay Bulls Big Pond WTP	Ruby Line Clearwell	Kenmount Hill	Mundy Pond	Southlands	Kenmount Park	Fowler's Road	Camrose Drive	Skinner's Hill	PHLP WTP
	L/min	m^3/D	WL-E, G	WL-J, 33%K	BB-B	50%CB-C	PH-A, B, F, G	WL-F, H, I, 67%K	WL-A, B, C, D	BB-A		BB-C, D, E, F, H	BB-G	BB-I, MP-A, B	MP-C	CB-A, B, 50%C	PA-A/G, PS-E	PS-A/D	PH-C, D, E
WL-A	3442	12956							12956										
WL-B	21	30							30										
WL-C	1300	1872							1872										
WL-D	947	1364							1364										
WL-E	6177	7810	7810																
WL-F	3547	4485						4485											
WL-G	7325	9262	9262																
WL-H	5167	6533						6533											
WL-I	9112	11521						11521											
WL-J	3750	4741		4741															
WL-K	10498	13275		4381				8894											
BB-A	2852	4107								4107									
BB-B	3589	5168																	
BB-C	2465	3550			3550							3550							
BB-D	1162	1673										1673							
BB-E	1116	1607										1607							
BB-F	4248	6117										6117							
BB-G	3854	5550											5550						
BB-H	102	147										147							
BB-I	864	1245												1245					
PH-A	2329	3354					3354												
PH-B	1912	2753					2753												
PH-C	1017	1464																	1464
PH-D	4375	6300																	6300
PH-E	576	830																	830
PH-F	631	908					908												
PH-G	54	77					77												
MP-A	14030	20203												20203					
MP-B	2970	4277												4277					
MP-C	3981	5732													5732				
CB-A	3114	4484														4484			
CB-B	2911	4192														4192			
CB-C	10033	14448				7224										7224			
PA-A	1872	2695															2695		
PA-B	6206	8937															8937		
PA-C	529	761															761		
PA-D	670	965															965		
PA-E	529	761															761		
PA-F	529	761															761		
PA-G	170	245															245		
PS-A	1903	2740																2740	
PS-B	559	805																805	
PS-C	509	733																733	
PS-D	300	432																432	
PS-E	240	346															346		
Max Day Total	133485	192218	17072	9122	3550	7224	7093	31433	16222	4107	0	13094	5550	25725	5732	15900	15472	4710	8594

Table 6.10 - 2036 Tank Sizing (Existing and Proposed Tanks)

Volume	Tank	Criteria	Service Zones	Proposed Tanks					Existing Tanks											
				Windsor Lake		Bay Bulls Big Pond		PHLP	Windsor Lake		Bay Bulls Big Pond									PHLP
				Sugarloaf	Signal Hill	RL Pump Station	CBS South	Kilbride East	WL WTP	Airport Heights	Bay Bulls Big Pond WTP	Ruby Line Clearwell	Kenmount Hill	Mundy Pond	Southlands	Kenmount Park	Fowler's Road	Camrose Drive	Skinner's Hill	PHLP WTP
				WL-E, G	WL-J, 33%K	BB-B	50%CB-C	PH-A, B, F, G	WL-F, H, I, 67%K	WL-A, B, C, D	BB-A		BB-C, D, E, F, H	BB-G	BB-I, MP-A, B	MP-C	CB-A, B, 50%C	PA-A/G, PS-E	PS-A/D	PH-C, D, E
			Max Day Total (m^3/D)	17072	9122	3550	7224	7093	31433	16222	4107	0	13094	5550	25725	5732	15900	15472	4710	8594
Peak Balancing Volume	**Name**			Peak Balancing Volume (m^3)					Peak Balancing Volume (m^3)											
	Sugarloaf	25% Max. Day		4268																
	Signal Hill				2281															
	RL Pump Station					888														
	CBS South						1806													
	Kilbride East							1773												
	WL WTP								7858											
	Airport Heights									4056										
	Bay Bulls Big Pond WTP										1027									
	Ruby Line Clearwell											0								
	Kenmount Hill												3274							
	Mundy Pond													1388						
	Southlands														6431					
	Kenmount Park															1433				
	Fowler's Road																3975			
	Camrose Drive																	3868		
	Skinner's Hill																		1178	
	PHLP WTP																			2149
Fire Flow Volume	**Name**	**Flow (L/min)**	**Duration (Hours)**	Fire Flow Volume (m^3)					Fire Flow Volume (m^3)											
	Sugarloaf	12000	2.5	1800																
	Signal Hill	16000	3.5		3360															
	RL Pump Station	12000	2.5			1800														
	CBS South	12000	2.5				1800													
	Kilbride East	12000	2.5					1800												
	WL WTP	16000	3.5						3360											
	Airport Heights	16000	3.5							3360										
	Bay Bulls Big Pond WTP	16000	3.5								3360									
	Ruby Line Clearwell	0	0.0									0								
	Kenmount Hill	16000	3.5										3360							
	Mundy Pond	12000	2.5											1800						
	Southlands	16000	3.5												3360					
	Kenmount Park	12000	2.5													1800				
	Fowler's Road	12000	2.5														1800			
	Camrose Drive	12000	2.5															1800		
	Skinner's Hill	12000	2.5																1800	
	PHLP WTP	12000	2.5																	1800
Emergency Volume	**Name**			Emergency Storage Volume (m^3)					Emergency Storage Volume (m^3)											
	Sugarloaf	25% x (Peak Bal. + Fire)		1517																
	Signal Hill				1410															
	RL Pump Station					672														
	CBS South						901													
	Kilbride East							893												
	WL WTP								2805											
	Airport Heights									1854										
	Bay Bulls Big Pond WTP										1097									
	Ruby Line Clearwell											0								
	Kenmount Hill												1658							
	Mundy Pond													797						
	Southlands														2448					
	Kenmount Park															808				
	Fowler's Road																1444			
	Camrose Drive																	1417		
	Skinner's Hill																		744	
	PHLP WTP																			987
		Required Tank Volumes (m^3)		7585	7051	3359	4507	4467	14023	9269	5483	0	8292	3984	12239	4041	7219	7085	3722	4936
								Actual Tank Volumes (m^3)	20000	8000	10365	900	17300	11760	19600	1575	5680	10540	2840	10000

APPENDIX G

Cost Opinions

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
BBBP1 - Proposed Additional Storage: Ruby Line Pump Station

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
153	MOBILIZATION/DEMOBILIZATION	LS	1	$150,000.00	$150,000
223	MANHOLES, CATCH BASINS, DITCH INLETS, HEADWALLS & CHAMBERS				
	Isolation Valve Chamber Complete	EA	1	$25,000.00	$25,000
230	WATERMAINS				
	Connection to Existing Main	LS	1	$2,500.00	$2,500
311	CLEARING AND GRUBBING	HA	1	$20,000.00	$20,000
321	STREET EXCAVATION				
	SR	CM	750	$35.00	$26,250
	OM	CM	3000	$15.00	$45,000
	USM	CM	1250	$15.00	$18,750
322	BORROW				
	Gravel Borrow	CM	3000	$12.00	$36,000
323	GRAVEL FOR STREETS				
	Granular "A" - Site	TONNE	2300	$22.00	$50,600
OTHER	NEW STORAGE TANKS				
	4 ML Bolted Steel Tank Complete	LS	1	$2,000,000.00	$2,000,000

Subtotal =	$2,374,100
Contingency (20%) =	$474,820
Engineering (15%) =	$427,338
Subtotal =	$3,276,258
HST (13%) =	$425,914
TOTAL =	**$3,702,172**
BUDGET =	**$3,800,000**

This opinion of probable costs is presented on the basis of experience, qualifications and best judgement. It has been prepared in accordance with acceptable principles and practices. Sudden market trend changes, non-competitive bidding situations, unforeseen labour and material adjustments and the like are beyond the control of CBCL Limited. We cannot warrant or guarantee that actual costs will not vary significantly from the opinion provided.

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
BBBP3 - Proposed Additional Storage: CBS South

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
153	MOBILIZATION/DEMOBILIZATION	LS	1	$350,000.00	$350,000
211	TRENCH EXCAVATION				
	SR	CM	900	$65.00	$58,500
	OM	CM	2160	$30.00	$64,800
	USM	CM	540	$15.00	$8,100
	Bedding	CM	1710	$45.00	$76,950
	Imported Fill	CM	800	$15.00	$12,000
	Marker Tape	LM	2180	$3.00	$6,540
223	MANHOLES, CATCH BASINS, DITCH INLETS, HEADWALLS & CHAMBERS				
	Isolation Valve Chamber Complete	EA	1	$25,000.00	$25,000
230	WATERMAINS				
	Connection to Existing Main	LS	1	$2,500.00	$2,500
	Pipe and Fittings, 450mm PVC, DR18	LM	2180	$770.00	$1,678,600
	Butterfly Valves - 450mm	EA	3	$5,000.00	$15,000
311	CLEARING AND GRUBBING	HA	2	$20,000.00	$30,000
321	STREET EXCAVATION				
	SR	CM	1350	$35.00	$47,250
	OM	CM	4440	$15.00	$66,600
	USM	CM	1250	$15.00	$18,750
	Asphalt Removal	SM	925	$5.00	$4,625
322	BORROW				
	Gravel Borrow	CM	3000	$12.00	$36,000
323	GRAVEL FOR STREETS				
	Granular "A" - Site/Access Road	TONNE	2500	$22.00	$55,000
	Granular "A" - Street	TONNE	215	$22.00	$4,730
	Granular "B" - Street	TONNE	430	$20.00	$8,600

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
BBBP3 - Proposed Additional Storage: CBS South

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
OTHER	NEW STORAGE TANKS				
	5 ML Bolted Steel Tank Complete	LS	1	$2,400,000.00	$2,400,000

Subtotal =	$4,969,545
Contingency (20%) =	$993,909
Engineering (15%) =	$894,518
Subtotal =	$6,857,972
HST (13%) =	$891,536
TOTAL =	**$7,749,508**
BUDGET =	**$7,800,000**

This opinion of probable costs is presented on the basis of experience, qualifications and best judgement. It has been prepared in accordance with acceptable principles and practices. Sudden market trend changes, non-competitive bidding situations, unforeseen labour and material adjustments and the like are beyond the control of CBCL Limited. We cannot warrant or guarantee that actual costs will not vary significantly from the opinion provided.

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
BBBP5 - Proposed Additional Storage: Mundy Pond

ST. JOHN'S
NEWFOUNDLAND AND LABRADOR, CANADA

CBCL
CBCL LIMITED
Consulting Engineers

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
153	MOBILIZATION/DEMOBILIZATION	LS	1	$350,000.00	$350,000
223	MANHOLES, CATCH BASINS, DITCH INLETS, HEADWALLS & CHAMBERS				
	Isolation Valve Chamber Complete	EA	1	$25,000.00	$25,000
230	WATERMAINS				
	Connection to Existing Main	LS	1	$2,500.00	$2,500
311	CLEARING AND GRUBBING	HA	0.50	$20,000.00	$10,000
321	STREET EXCAVATION				
	SR	CM	425	$35.00	$14,875
	OM	CM	1700	$15.00	$25,500
	USM	CM	700	$15.00	$10,500
322	BORROW				
	Gravel Borrow	CM	700	$12.00	$8,400
323	GRAVEL FOR STREETS				
	Granular "A" - Site	TONNE	1300	$22.00	$28,600
OTHER	NEW STORAGE TANKS				
	10 ML Bolted Steel Tank Complete	LS	1	$4,750,000.00	$4,750,000

Subtotal =	$5,225,375
Contingency (20%) =	$1,045,075
Engineering (15%) =	$940,568
Subtotal =	$7,211,018
HST (13%) =	$937,432
TOTAL =	**$8,148,450**
BUDGET =	**$8,200,000**

This opinion of probable costs is presented on the basis of experience, qualifications and best judgement. It has been prepared in accordance with acceptable principles and practices. Sudden market trend changes, non-competitive bidding situations, unforeseen labour and material adjustments and the like are beyond the control of CBCL Limited. We cannot warrant or guarantee that actual costs will not vary significantly from the opinion provided.

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
WL1 - Proposed Additional Storage: Airport Heights

ST. JOHN'S
NEWFOUNDLAND AND LABRADOR, CANADA

CBCL LIMITED
Consulting Engineers

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
153	MOBILIZATION/DEMOBILIZATION	LS	1	$250,000.00	$250,000
223	MANHOLES, CATCH BASINS, DITCH INLETS, HEADWALLS & CHAMBERS				
	Isolation Valve Chamber Complete	EA	1	$25,000.00	$25,000
230	WATERMAINS				
	Connection to Existing Main	LS	1	$2,500.00	$2,500
311	CLEARING AND GRUBBING	HA	1	$20,000.00	$20,000
321	STREET EXCAVATION				
	SR	CM	750	$35.00	$26,250
	OM	CM	3000	$15.00	$45,000
	USM	CM	1250	$15.00	$18,750
322	BORROW				
	Gravel Borrow	CM	3000	$12.00	$36,000
323	GRAVEL FOR STREETS				
	Granular "A" - Site	TONNE	2300	$22.00	$50,600
OTHER	NEW STORAGE TANKS				
	8 ML Bolted Steel Tank Complete	LS	1	$3,200,000.00	$3,200,000

Subtotal =	$3,674,100
Contingency (20%) =	$734,820
Engineering (15%) =	$661,338
Subtotal =	$5,070,258
HST (13%) =	$659,134
TOTAL =	**$5,729,392**
BUDGET =	**$5,800,000**

This opinion of probable costs is presented on the basis of experience, qualifications and best judgement. It has been prepared in accordance with acceptable principles and practices. Sudden market trend changes, non-competitive bidding situations, unforeseen labour and material adjustments and the like are beyond the control of CBCL Limited. We cannot warrant or guarantee that actual costs will not vary significantly from the opinion provided.

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
WL2 - Proposed Additional storage: Sugarloaf Road

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
153	MOBILIZATION/DEMOBILIZATION	LS	1	$300,000.00	$300,000
211	TRENCH EXCAVATION				
	SR	CM	170	$65.00	$11,050
	OM	CM	510	$30.00	$15,300
	Bedding	CM	615	$45.00	$27,675
	Marker Tape	LM	720	$3.00	$2,160
223	MANHOLES, CATCH BASINS, DITCH INLETS, HEADWALLS & CHAMBERS				
	Isolation Valve Chamber Complete	EA	1	$25,000.00	$25,000
230	WATERMAINS				
	Connection to Existing Main	LS	1	$2,500.00	$2,500
	Pipe and Fittings, 500mm PVC, DR18	LM	720	$950.00	$684,000
	Butterfly Valves - 500mm	EA	3	$7,500.00	$22,500
311	CLEARING AND GRUBBING	HA	1	$20,000.00	$10,000
321	STREET EXCAVATION				
	SR	CM	385	$35.00	$13,475
	OM	CM	925	$15.00	$13,875
	USM	CM	230	$15.00	$3,450
	Asphalt Removal	SM	550	$5.00	$2,750
322	BORROW				
	Gravel Borrow	CM	230	$12.00	$2,760
323	GRAVEL FOR STREETS				
	Granular "A"	TONNE	130	$22.00	$2,860
	Granular "B"	TONNE	260	$20.00	$5,200
351	HOT MIX ASPHALTIC CONCRETE				
	Surface Courses	SM	60	$160.00	$9,600
	Base Courses	SM	60	$160.00	$9,600

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
WL2 - Proposed Additional storage: Sugarloaf Road

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
OTHER	**NEW STORAGE TANKS**				
	8 ML Bolted Steel Tank Complete	**LS**	**1**	**$3,200,000.00**	**$3,200,000**

Subtotal =	$4,363,755
Contingency (20%) =	$872,751
Engineering (15%) =	$785,476
Subtotal =	$6,021,982
HST (13%) =	$782,858
TOTAL =	**$6,804,840**
BUDGET =	**$6,900,000**

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Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
WL3 - Proposed Additional Storage: Signal Hill

ST. JOHN'S
NEWFOUNDLAND AND LABRADOR, CANADA

CBCL LIMITED
Consulting Engineers

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
153	MOBILIZATION/DEMOBILIZATION	LS	1	$350,000.00	$350,000
211	TRENCH EXCAVATION				
	SR	CM	220	$65.00	$14,300
	OM	CM	520	$30.00	$15,600
	USM	CM	130	$15.00	$1,950
	Bedding	CM	615	$45.00	$27,675
	Marker Tape	LM	950	$3.00	$2,850
223	MANHOLES, CATCH BASINS, DITCH INLETS, HEADWALLS & CHAMBERS				
	Isolation Valve Chamber Complete	EA	1	$25,000.00	$25,000
230	WATERMAINS				
	Connection to Existing Main	LS	2	$2,500.00	$5,000
	Pipe and Fittings, 400mm PVC, DR18	LM	950	$625.00	$593,750
	Butterfly Valves	EA	3	$5,000.00	$15,000
311	CLEARING AND GRUBBING	HA	0.1	$20,000.00	$2,000
321	STREET EXCAVATION				
	OM	CM	1215	$15.00	$18,225
	Asphalt Removal	SM	475	$5.00	$2,375
322	BORROW				
	Gravel Borrow	CM	130	$12.00	$1,560
323	GRAVEL FOR STREETS				
	Granular "A"	TONNE	110	$22.00	$2,420
	Granular "B"	TONNE	220	$20.00	$4,400
351	HOT MIX ASPHALTIC CONCRETE				
	Surface Courses	SM	50	$160.00	$8,000
	Base Courses	SM	50	$160.00	$8,000
401	REMOVAL OF EXISTING STRUCTURE				
	Removal of Existing 200mm Water Main	LS	1	$12,000.00	$12,000

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
WL3 - Proposed Additional Storage: Signal Hill

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
OTHER	NEW STORAGE TANKS				
	7.5 ML Bolted Steel Tank Complete	LS	1	$3,000,000.00	$3,000,000
OTHER	NEW STORAGE TANKS CONTROL BUILDING				
	Site, Building Complete	LS	1	$750,000.00	$750,000

Subtotal =	$4,860,105
Contingency (20%) =	$972,021
Engineering (15%) =	$874,819
Subtotal =	$6,706,945
HST (13%) =	$871,903
TOTAL =	**$7,578,848**
BUDGET =	**$7,600,000**

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Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
PHLP1 - Distribution System Upgrades

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
153	MOBILIZATION/DEMOBILIZATION	LS	1	$50,000.00	$50,000
211	TRENCH EXCAVATION				
	SR	CM	740	$65.00	$48,100
	OM	CM	1780	$30.00	$53,400
	USM	CM	445	$15.00	$6,675
	Bedding	CM	735	$45.00	$33,075
	Marker Tape	LM	1210	$3.00	$3,630
223	MANHOLES, CATCH BASINS, DITCH INLETS, HEADWALLS & CHAMBERS				
	Air Release/Vacuum Valve Chamber Complete	EA	1	$15,000.00	$15,000
230	WATERMAINS				
	Connection to Existing Main	LS	2	$2,500.00	$5,000
	Pipe and Fittings, 300mm PVC, DR18	LM	1210	$425.00	$514,250
	Butterfly Valves - 300mm	EA	2	$5,000.00	$10,000
321	STREET EXCAVATION				
	Asphalt Removal	SM	1210	$5.00	$6,050
322	BORROW				
	Gravel Borrow	CM	445	$12.00	$5,340
323	GRAVEL FOR STREETS				
	Granular "A"	TONNE	280	$22.00	$6,160
	Granular "B"	TONNE	560	$20.00	$11,200

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
PHLP1 - Distribution System Upgrades

ST. JOHN'S
NEWFOUNDLAND AND LABRADOR, CANADA

CBCL LIMITED
Consulting Engineers

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
351	**HOT MIX ASPHALTIC CONCRETE**				
	Surface Courses	**SM**	**125**	**$160.00**	**$20,000**
	Base Courses	**SM**	**125**	**$160.00**	**$20,000**

Subtotal =	$807,880
Contingency (50%) =	$403,940
Engineering (15%) =	$181,773
Subtotal =	$1,393,593
HST (13%) =	$181,167
TOTAL =	**$1,574,760**
BUDGET =	**$1,600,000**

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Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
PHLP2 - Pump Station/Transmission Main/Storage: Kilbride East

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
153	MOBILIZATION/DEMOBILIZATION	LS	1	$850,000.00	$850,000
211	TRENCH EXCAVATION				
	SR	CM	2740	$65.00	$178,100
	OM	CM	8220	$30.00	$246,600
	USM	CM	2740	$15.00	$41,100
	Bedding	CM	3990	$45.00	$179,550
	Marker Tape	LM	4700	$3.00	$14,100
223	MANHOLES, CATCH BASINS, DITCH INLETS, HEADWALLS & CHAMBERS				
	Isolation Valve Chamber Complete	EA	2	$25,000.00	$50,000
	Air Release/Vacuum Valve Chamber Complete	EA	4	$15,000.00	$60,000
230	WATERMAINS				
	Connection to Existing Main	LS	2	$2,500.00	$5,000
	Pipe and Fittings, 500mm PVC, DR18	LM	4700	$950.00	$4,465,000
	Butterfly Valves - 500mm	EA	8	$7,500.00	$60,000
311	CLEARING AND GRUBBING	HA	10.0	$20,000.00	$200,000
321	STREET EXCAVATION				
	Asphalt Removal	SM	100	$5.00	$500
322	BORROW				
	Gravel Borrow	CM	2740	$12.00	$32,880
323	GRAVEL FOR STREETS				
	Granular "A"	TONNE	25	$22.00	$550
	Granular "B"	TONNE	50	$20.00	$1,000
351	HOT MIX ASPHALTIC CONCRETE				
	Surface Courses	SM	10	$160.00	$1,600
	Base Courses	SM	10	$160.00	$1,600
511	TOPSOILING, SODDING AND/OR HYDROSEEDING				
	Topsoil	SM	5170	$5.00	$25,850
	Hydroseeding	SM	5170	$5.00	$25,850

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study

Date: January 22, 2016

Prepared by: CBCL Limited

PHLP2 - Pump Station/Transmission Main/Storage: Kilbride East

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
OTHER	NEW PUMP HOUSE				
	Site, Building, Mech & Elec Complete	LS	1	$2,200,000.00	$2,200,000
OTHER	NEW STORAGE TANKS				
	3.5 ML Bolted Steel Tank Complete	LS	1	$1,750,000.00	$1,750,000
	3.5 ML Bolted Steel Tank Complete	LS	1	$1,750,000.00	$1,750,000

Subtotal =	$12,139,280
Contingency (20%) =	$2,427,856
Engineering (15%) =	$2,185,070
Subtotal =	$16,752,206
HST (13%) =	$2,177,787
TOTAL =	**$18,929,993**
BUDGET =	**$19,000,000**

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Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
WTP - Thomas Pond: Transmission

ST. JOHN'S
NEWFOUNDLAND AND LABRADOR, CANADA

CBCL LIMITED
Consulting Engineers

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
153	MOBILIZATION/DEMOBILIZATION	LS	1	$1,400,000.00	$1,400,000
211	TRENCH EXCAVATION				
	SR	CM	8850	$65.00	$575,250
	OM	CM	26500	$30.00	$795,000
	USM	CM	8850	$15.00	$132,750
	Bedding	CM	13300	$45.00	$598,500
	Marker Tape	LM	12400	$3.00	$37,200
223	MANHOLES, CATCH BASINS, DITCH INLETS, HEADWALLS & CHAMBERS				
	Air Release/Vacuum Valve Chamber Complete	EA	4	$15,000.00	$60,000
230	WATERMAINS				
	Connection to Existing Main	LS	3	$2,500.00	$7,500
	Pipe and Fittings, 600mm PVC, DR18	LM	6500	$1,300.00	$8,450,000
	Butterfly Valves - 600mm	EA	6	$5,000.00	$30,000
	Pipe and Fittings, 750mm PVC, DR18	LM	5900	$1,650.00	$9,735,000
	Butterfly Valves - 750mm	EA	5	$15,000.00	$75,000
311	CLEARING AND GRUBBING	HA	1.0	$20,000.00	$20,000
321	STREET EXCAVATION				
	OM	CM	400	$15.00	$6,000
	Asphalt Removal	SM	135	$5.00	$675
322	BORROW				
	Gravel Borrow	CM	8850	$12.00	$106,200
323	GRAVEL FOR STREETS				
	Granular "A"	TONNE	30	$22.00	$660
	Granular "B"	TONNE	60	$20.00	$1,200
351	HOT MIX ASPHALTIC CONCRETE				
	Surface Courses	TONNE	15	$160.00	$2,400
	Base Courses	TONNE	15	$160.00	$2,400

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
WTP - Thomas Pond: Transmission

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
401	**REMOVAL OF EXISTING STRUCTURE**				
	Removal of Existing 200mm Water Main	LS	1	$160,000.00	$160,000
511	**TOPSOILING, SODDING AND/OR HYDROSEEDING**				
	Topsoil	SM	1000	$5.00	$5,000
	Hydroseeding	SM	1000	$5.00	$5,000

Subtotal =	$22,205,735
Contingency (10%) =	$2,220,574
Engineering (15%) =	$3,663,946
Subtotal =	$28,090,255
HST (13%) =	$3,651,733
TOTAL =	**$31,741,988**
BUDGET =	**$31,800,000**

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Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
WTP - Big Triangle Pond: Transmission

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
153	MOBILIZATION/DEMOBILIZATION	LS	1	$3,000,000.00	$3,000,000
211	TRENCH EXCAVATION				
	SR	CM	28000	$65.00	$1,820,000
	OM	CM	84000	$30.00	$2,520,000
	USM	CM	28000	$15.00	$420,000
	Bedding	CM	99000	$45.00	$4,455,000
	Marker Tape	LM	28500	$3.00	$85,500
223	MANHOLES, CATCH BASINS, DITCH INLETS, HEADWALLS & CHAMBERS				
	Air Release/Vacuum Valve Chamber Complete	EA	10	$15,000.00	$150,000
230	WATERMAINS				
	Connection to Existing Main	LS	1	$2,500.00	$2,500
	Pipe and Fittings, 750mm PVC, DR18	LM	28500	$1,650.00	$47,025,000
	Butterfly Valves - 750mm	EA	30	$15,000.00	$450,000
311	CLEARING AND GRUBBING	HA	10.0	$20,000.00	$200,000
321	STREET EXCAVATION				
	OM	CM	600	$15.00	$9,000
	Asphalt Removal	SM	450	$5.00	$2,250
322	BORROW				
	Gravel Borrow	CM	28000	$12.00	$336,000
323	GRAVEL FOR STREETS				
	Granular "A"	TONNE	150	$22.00	$3,300
	Granular "B"	TONNE	300	$20.00	$6,000
351	HOT MIX ASPHALTIC CONCRETE				
	Surface Courses	TONNE	45	$160.00	$7,200
	Base Courses	TONNE	45	$160.00	$7,200

Class 'D' Cost Estimate
Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
WTP - Big Triangle Pond: Transmission

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
511	TOPSOILING, SODDING AND/OR HYDROSEEDING				
	Topsoil	SM	5000	$5.00	$25,000
	Hydroseeding	SM	5000	$5.00	$25,000
OTHER	NEW PUMP STATION				
	Complete Building	LS	1	$750,000.00	$750,000

Subtotal =	$60,548,950
Contingency (10%) =	$6,054,895
Engineering (15%) =	$9,990,577
Subtotal =	$76,594,422
HST (13%) =	$9,957,275
TOTAL =	**$86,551,697**
BUDGET =	**$86,600,000**

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Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
New Customer1 - Torbay

ST. JOHN'S
NEWFOUNDLAND AND LABRADOR, CANADA

CBCL LIMITED
Consulting Engineers

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
153	MOBILIZATION/DEMOBILIZATION	LS	1	$800,000.00	$800,000
211	TRENCH EXCAVATION				
	SR	CM	6375	$65.00	$414,375
	OM	CM	15300	$30.00	$459,000
	USM	CM	3825	$15.00	$57,375
	Bedding	CM	7250	$45.00	$326,250
	Marker Tape	LM	10000	$3.00	$30,000
223	MANHOLES, CATCH BASINS, DITCH INLETS, HEADWALLS & CHAMBERS				
	Isolation Valve Chamber Complete	EA	2	$25,000.00	$50,000
	Air Release/Vacuum Valve Chamber Complete	EA	8	$15,000.00	$120,000
230	WATERMAINS				
	Connection to Existing Main	LS	2	$2,500.00	$5,000
	Pipe and Fittings, 400mm PVC, DR18	LM	10000	$625.00	$6,250,000
	Butterfly Valves - 400mm	EA	15	$5,000.00	$75,000
311	CLEARING AND GRUBBING	HA	12.0	$20,000.00	$240,000
321	STREET EXCAVATION				
	Asphalt Removal	SM	4000	$5.00	$20,000
322	BORROW				
	Gravel Borrow	CM	3825	$12.00	$45,900
323	GRAVEL FOR STREETS				
	Granular "A"	TONNE	920	$22.00	$20,240
	Granular "B"	TONNE	1840	$20.00	$36,800
351	HOT MIX ASPHALTIC CONCRETE				
	Surface Courses	SM	415	$160.00	$66,400
	Base Courses	SM	415	$160.00	$66,400
511	TOPSOILING, SODDING AND/OR HYDROSEEDING				
	Topsoil	SM	6000	$5.00	$30,000
	Hydroseeding	SM	6000	$5.00	$30,000

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
New Customer1 - Torbay

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
OTHER	NEW STORAGE TANKS				
	4 ML Bolted Steel Tank Complete	LS	1	$2,000,000.00	$2,000,000

Subtotal =	$11,142,740
Contingency (20%) =	$2,228,548
Engineering (15%) =	$2,005,693
Subtotal =	$15,376,981
HST (13%) =	$1,999,008
TOTAL =	**$17,375,989**
BUDGET =	**$17,400,000**

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Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
New Customer2 - Holyrood

ST. JOHN'S
NEWFOUNDLAND AND LABRADOR, CANADA

CBCL LIMITED
Consulting Engineers

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
153	MOBILIZATION/DEMOBILIZATION	LS	1	$1,000,000.00	$1,000,000
211	TRENCH EXCAVATION				
	SR	CM	10200	$65.00	$663,000
	OM	CM	24480	$30.00	$734,400
	USM	CM	6120	$15.00	$91,800
	Bedding	CM	11600	$45.00	$522,000
	Marker Tape	LM	16000	$3.00	$48,000
223	MANHOLES, CATCH BASINS, DITCH INLETS, HEADWALLS & CHAMBERS				
	Isolation Valve Chamber Complete	EA		$25,000.00	$0
	Air Release/Vacuum Valve Chamber Complete	EA	8	$15,000.00	$120,000
230	WATERMAINS				
	Connection to Existing Main	LS	1	$2,500.00	$2,500
	Pipe and Fittings, 400mm PVC, DR18	LM	16000	$625.00	$10,000,000
	Butterfly Valves - 400mm	EA	20	$5,000.00	$100,000
311	CLEARING AND GRUBBING	HA	32.0	$20,000.00	$640,000
321	STREET EXCAVATION				
	Asphalt Removal	SM	1500	$5.00	$7,500
322	BORROW				
	Gravel Borrow	CM	6120	$12.00	$73,440
323	GRAVEL FOR STREETS				
	Granular "A"	TONNE	350	$22.00	$7,700
	Granular "B"	TONNE	700	$20.00	$14,000
351	HOT MIX ASPHALTIC CONCRETE				
	Surface Courses	SM	160	$160.00	$25,600
	Base Courses	SM	160	$160.00	$25,600

Class 'D' Cost Estimate

Project: St. John's Regional Drinking Water Study
Date: January 22, 2016
Prepared by: CBCL Limited
New Customer2 - Holyrood

The section numbers correspond to the City of St. John's Construction Specifications Book.

SECTION	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
511	TOPSOILING, SODDING AND/OR HYDROSEEDING				
	Topsoil	SM	16000	$5.00	$80,000
	Hydroseeding	SM	16000	$5.00	$80,000

Subtotal =	$14,235,540
Contingency (20%) =	$2,847,108
Engineering (15%) =	$2,562,397
Subtotal =	$19,645,045
HST (13%) =	$2,553,856
TOTAL =	**$22,198,901**
BUDGET =	**$22,200,000**

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