City of Iqaluit Supplementary Water Supply Study

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City of Iqaluit Supplementary Water Supply Study

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Project No.: FRE-00209588-A0	Date: August 2014
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1 Introduction

The City of Iqaluit's municipal water supply requirement is currently met by impoundment of runoff from the Lake Geraldine Watershed. The *City of Iqaluit General Plan* (City of Iqaluit, 2010) notes that storage volume available within the existing Lake Geraldine reservoir impoundment is likely sufficient to supply a population of 12,300 subject to the limitation of the existing treatment plant capacity to service 11,300 population However, due to available water **quantity** limitations of the Lake Geraldine watershed, the population that the Lake Geraldine system can support is estimated to be limited to approximately 8,300; beyond that number the City will need to supplement its current system.

The City's *General Plan* identifies the Niaqunguk (Apex) River as a potential supplementary source. To assist in feasibility assessment, the City retained **exp** Services Inc. (**exp**) to complete a study for use of the Apex River (Niaqunguk River) to supplement water quantity available to the Lake Geraldine system. The following report presents results of the study findings.

It is **exp**'s understanding that there would typically be three agencies with jurisdiction regarding review and approval of the supplemental water supply plan and preliminary design approval process: the Nunavut Water Board (NWB); the Nunavut Impact Review Board (NIRB); and the Nunavut Planning Commission (NPC). As part of the approval process, it is expected that select stakeholders will also require input into the supplementary water supply plan and preliminary design including the City of Iqaluit, the Department of Fisheries and Ocean (DFO), Environment Canada, the navigable waters division of Transport Canada and the residents of Iqaluit.

It is **exp**'s understanding that the application for the supplemental water supply plan and preliminary design would include the following completed documentation:

- Application for amendment to the current water license;
- Appropriate supporting documentation; and
- The Supplemental Information Guideline (SIG).

In addition to the above mentioned documents select permits, licences, or other forms of approval from other territorial or federal departments or agencies with regulatory authorities in relation to the project may be required. However, it is anticipated that the information and process required to address the NW B, NIRB and NPC processes would be sufficient to meet other possible permitting requirements.

2 Background

The Lake Geraldine watershed and related reservoir/ impoundment are the City of Iqaluit's current water supply source. Previous work (e.g. Trow 2004), and population projections cited in the City's *General Plan* (2010), suggest that the Lake Geraldine system is approaching its servicing capacity due to the limited available water quantity from the Lake Geraldine watershed. Given these conditions and current City of Iqaluit population growth planning projections, the City has identified the requirement for further consideration of the **quantity** of water currently available, and possible supplementation of its existing system.

In late 2012 the City issued a proposal to complete a water balance study of the existing Lake Geraldine system, and a separate proposal for a study to assess possible use of the adjacent Apex River watershed to serve as a supplementary supply. The purpose of the Lake Geraldine Water Balance study was to assess the City's long term water recharge needs. In addition, based on earlier work (Trow, 2004) completed by **exp** (formerly Trow Associates), it was understood that the Lake Geraldine system is nearing capacity and a more complete understanding of the overall water balance was warranted to assist in immediate and longer term operation and planning.

The Lake Geraldine water balance study was awarded to Golder Associates Ltd. (Golder) who subsequently submitted a final report on the work (Golder, 2013). The Golder report provided a summary of recommended supplemental water volume requirements corresponding to various climatic/ population planning scenarios and municipal potable water demand on the Lake Geraldine system.

The Apex River supplementary water supply work was awarded to **exp**, and the report herein provides results of the study. The report focused on two possible locations (A1 and A2) identified in earlier work (Trow, 2004) for consideration of locating a water intake along the Apex River. The locations of these respective points and related information (e.g. watershed boundaries, general catchment area boundaries) are indicated on Figure 2-1.

Figure 2-Ia: Location of Apex River Withdrawal Point Options Al and A2, and Watershed Boundaries.

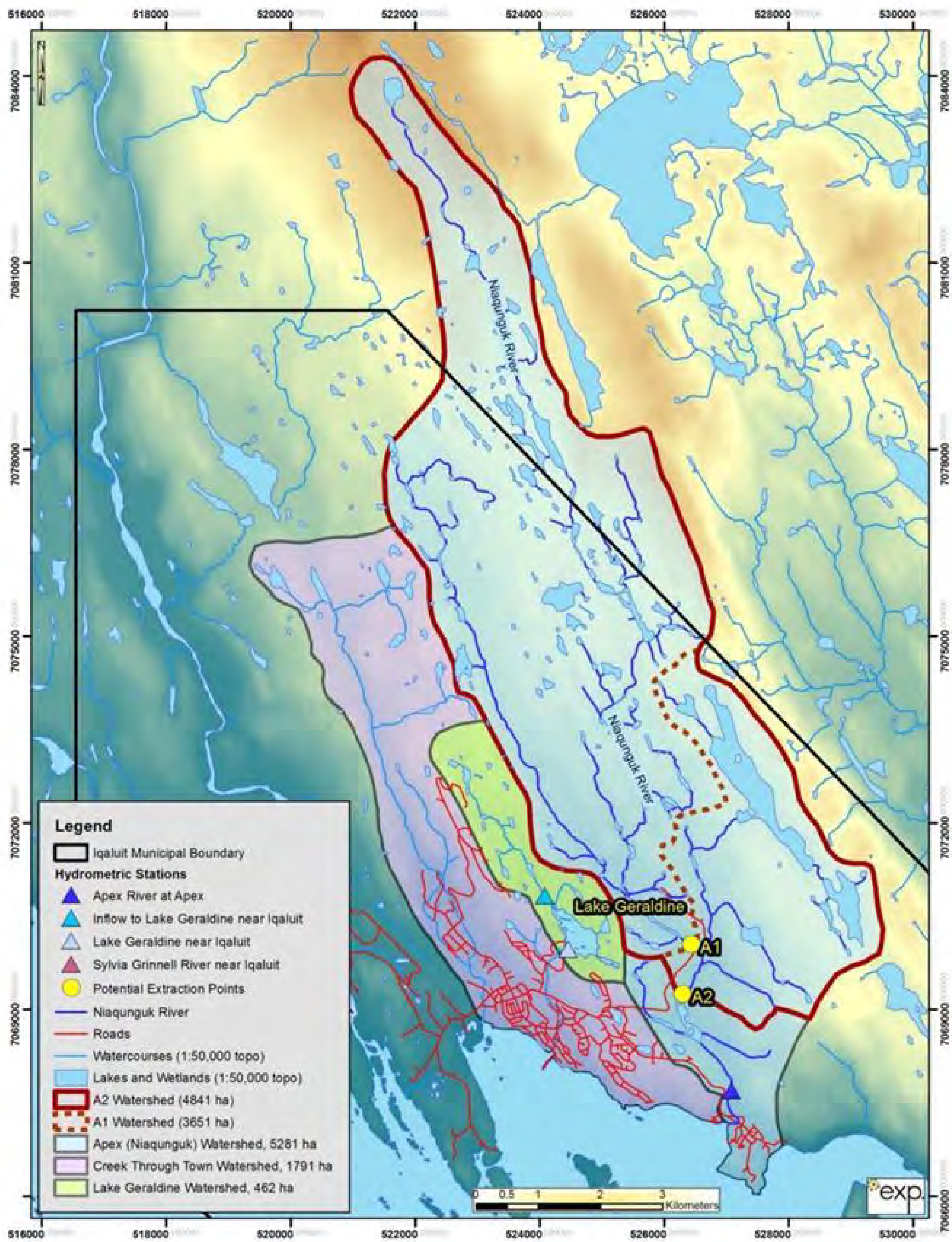


Figure 2-lb: Perspective view, Location of Apex River Hydrometric Station, Withdrawal Point
Options AI and A2, and related points of interest

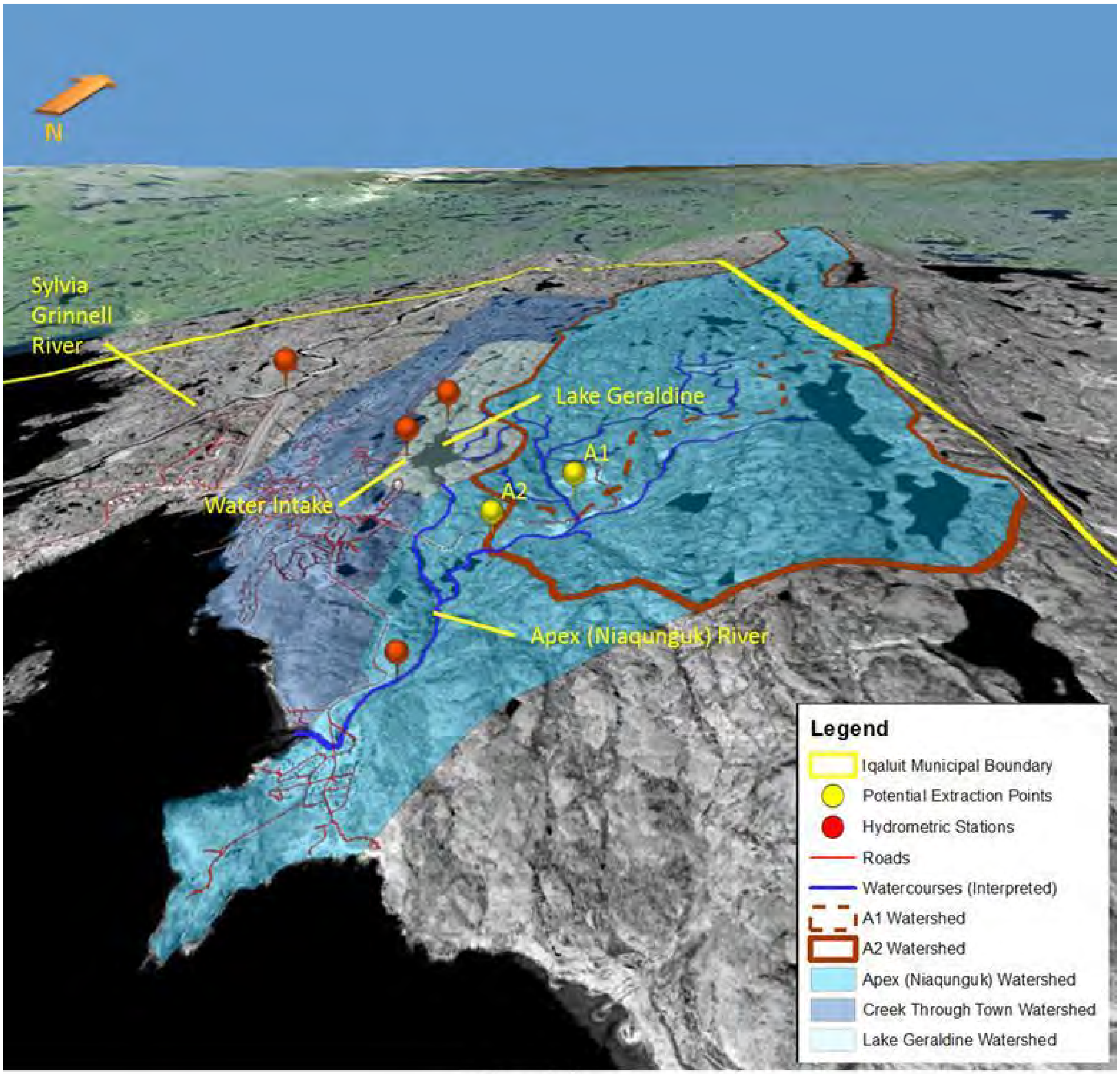


Figure 2-1b

3 Methodology

Study methodology was in accordance to the two main components identified in the exp Scope of Work. The first component being the "soft engineering" aspects including assessment of water source feasibility regarding quality and quantity, and screening of expected agency review process and requirements. The second component of the study was the "hard engineering" aspects which covered the supplementary water supply plan and preliminary design. An overview of the study methodology and aspects is provided in Table 3-1.

Table 3-1 Overview of Supplementary Water Supply Study Methodology

Study Component	Aspect/ Comments
A) Water Source Feasibility and Agency Screening	
Agency Approvals	- Contact with various stakeholders to identify anticipated regulatory application process and information requirements
Water Source Feasibility Study	- Develop water quality/ watershed sampling plan. - Water quality screening including review of existing data, and collection (by City) and analyses of water samples from the Apex River watershed. - Development of digital mapping database. - Hydrologic assessment and Climate Change Screening of the Apex River watershed. - Completion of water quantity feasibility assessment based on consideration of supplemental water supply requirement determined from parallel 2012 study of Lake Geraldine system completed by Golder (see Section 2.0 Background, above). - Watershed development/ land use screening. - Screening and comment on possible Source Water Management and Protection (SW MP) strategies.
B) Supplementary Water Supply Plan and Preliminary Design	
Supplementary Wafter Supply Plan	- Source point identification. - Source point attributes. - Refill protocol. - Risk assessment to identify mitigation measures in the event of potential contamination of the watershed.
Preliminary Design	- Preliminary design and cost estimate.

To assist in addressing study objectives, in addition to obtaining Environment Canada hydrometric data which formed the basis for assessing water quantity in the Apex River system, mapping was obtained and developed within the scope of the study as summarized below.

Available Mapping – Various data layers were used to compile mapping for the purpose of assessing water source feasibility, water intake location, and transmission line route. The data was acquired from a number of sources including the City of Iqaluit, the Geological Survey of Canada, and NRCAN. A general list of these data layers is provided below. The data layers were converted to a consistent geographic coordinate system (UTM Zone 19 NAD 83) and stored in an ESRI File Geodatabase. Geospatial data processing and modeling were performed using ESRI ArcGIS software. A list of information and data sets, and source follows.

#	Data Set	Scale	Comments
1	Bedrock Geology	1:100,000	downloaded from GSC
2	Surficial Geology	1:100,000	downloaded from GSC
5	High resolution satellite/orthophotograpy	.5m	downloaded from GSC
6	Medium Resolution Elevation data	1:50,000	NRCAN - support hydrology, geologic interpretation, drainage
7	Watercourses - lakes	1:50,000	NRCAN
8	Watercourses - rivers/streams	1:50,000	NRCAN - exp supplemented and corrected with medium and high resolution satellite
9	Wetlands	1:50,000	NRCAN
10	Watersheds	1:50,000	Trow (2004), Lake Geraldine and Apex River from GSC
11	Transportation Networks	< 1:2,500	from City of Iqaluit
12	Climate	1:250,000	Environment Canada
13	Water sample data	< 1:2,500	City of Iqaluit
14	High Resolution Elevation data	< 1:2,500	from City of Iqaluit
16	Municipal Plans - Land Use Zoning	< 1:5,000	from City of Iqaluit
17	Municipal Plans - Future Land Use	< 1:5,000	from City of Iqaluit
18	Property boundaries	< 1:2,500	from City of Iqaluit
19	Sacred lands and special places	< 1:2,500	from City of Iqaluit
21	Medium resolution SPOT or Landsat (if required)	10m or	from GEOBASE
23	Anthropological features (dumps, pits, etc)	< 1:2,500	from City of Iqaluit

4 Water Source Feasibility

4.1 Water Quality

4.1.1 Water Quality Information

Available water quality information from Trow (2004) and the City of Iqaluit's Lake Geraldine potable water quality sampling work was obtained and reviewed.

To supplement existing data, a sampling plan was developed and implemented (2013 sampling plan) to collect additional water quality information to support the objectives of the supplementary water supply study. A copy of the plan is provided in Appendix A. During implementation, some aspects of the planned work were deleted (e.g. sampling of sediment was not completed primarily due to the interpreted coarse nature of the stream bottom), or only partially completed (e.g. field readings due to logistics such as equipment/ meter procurement).

4.1.2 Water Quality Analyses

The results of the general chemistry analyses on the existing Lake Geraldine source water and current water samples collected to date as part of the sampling plan are summarized in Table B.1 of Appendix B. The following are noted.

4.1.2.1 General Chemistry

- In general, relatively negative Langelier Index values are observed. There is no drinking water criteria specified for the Langelier Index, and it is not a direct indicator as to whether a particular water source is suitable for consumption or not. The Langelier Index is an approximate indicator of the degree of saturation of calcium carbonate in water using the pH, alkalinity, calcium concentration, total dissolved solids, and water temperature of a water sample. If the Langelier Index is negative, then the water is under saturated with calcium carbonate and will tend to be corrosive in the distribution system. With a positive Langelier Index, then the water is over saturated with calcium carbonate and will tend to deposit calcium carbonate forming scale in the distribution system. If the Langelier Index is close to zero, then the water is just saturated with calcium carbonate and will neither be strongly corrosive or scale forming. The Langelier Index is one of several tools used for stabilizing water to control both internal corrosion and the deposition of scale. It can be used to optimize the water supply system and identify leakage potentials. Leakage is a common problem in surface water systems due to the acidic nature of some natural waters. Experience has shown that a Langelier Index in the range of -1 to +1 has a relatively low corrosion impact on metallic components of the distribution system. The existing water distribution has a reported Langelier value of <-2.0. As a general observation, it is noted that late summer values at Apex River station A2 were lower than for the existing Lake Geraldine W TP samples which may suggest potential for some degree of buffering in the event the waters were mixed.
- Concentrations/ parameters in excess of the Canadian Drinking Water Quality Guidelines (CDW QG) included pH at station A1 (Oct 26/12) and stations A1 and A2 (Jun 14/13) and turbidity at A2 (Jun
- 14/13 and Jun 19/13) and in W TP (Sept 11/13). All other general chemistry parameters are well within their respective CDWQG.
- Concerning pH, when less than 6.5 (which is the case for the samples noted), it is not a health risk in itself, but corrosive water can dissolve metals, such as lead, cadmium, zinc and copper present in pipes. This could lead to increased concentrations of these metals in drinking water, which could cause health concerns. However, it is noted that the pH observed for the Apex River stations and in particular at A2 is similar to the pH observed in samples from the WTP which are from the existing Lake Geraldine system,

i.e. it is anticipated that use of the Apex River water would have minimal, if any, change on pH within the existing system.

- Regarding turbidity, there are several means that can be used to reduce the level of turbidity in water (i.e. filtering systems). Again, similar to pH, the turbidity levels observed are generally within the range reported for the Lake Geraldine W TP location, i.e. it is anticipated that turbidity objectives could be met with no necessary upgrade to the existing Lake Geraldine system. It is possible that pumping of water could elevate turbidity in water from the Apex River which may require additional consideration in managing the influent to Lake Geraldine. At this time, it is assumed this potential can be minimized through design measures such as locating the discharge pipe in such a manner so settlement and mixing would address potential elevated turbidity.

4.1.2.2 Dissolved and Trace Metals

Dissolved Metals - The results of the dissolved metals analyses on the current water samples collected to date as part of the sampling plan are summarized in Table B.2a of Appendix B. All dissolved metals parameters were within their respective CDW QG.

As a general comment it is noted that calcium, magnesium, silicon and sulphur concentrations tend to have increased over time since the start of the sampling program (June 2013) in A1, A2 and the hydrometric station; this trend may be due to seasonal conditions (e.g. as the water warms during the spring through late summer period).

Total Metals – The results of the total metals analyses on the existing Lake Geraldine source water and the current water samples collected to date as part of the sampling plan are summarized in Table B.2b of Appendix B. All total metals parameters are within their respective CDW QG with the exception of aluminum in A2 (Jun 14/13). A1, A2 and Lake Geraldine Reservoir (Oct 26/12) had an elevated report detection limit (RDL) for lead which was above the CDWQG; however all subsequent samples were reported to be well below guidelines and on this basis lead is expected to meet CDW QG. Aluminum is noted to be a naturally occurring abundant metal in the environment.

As noted above for the dissolved metals, calcium, magnesium, silicon and sulphur concentrations suggested an increase over time since the start of the sampling program (June 2013) in A1, A2 and the hydrometric station.

4.1.2.3 Bacteria

The results of the bacteria analyses on the existing Lake Geraldine source water and the current water samples collected to date as part of the sampling plan are summarized in Table B.3 of Appendix B. Analytical results indicated that total coliforms were present in most of the existing and current data collected to date. Faecal coliforms were present in A1 (Sept 11/13) and in A2 (Jun 26/13, Aug 28/134 and Sept 11/13). E-coli was present in A1 (Sept 11/13) and A2 (Aug 14/13). The presence of bacteria is typically addressed through general public health disinfection procedures (e.g. chlorination) included in municipal water system procedures and operations. Generally, presence of detectable bacteriological parameters such as coliform can be common in raw surface water sources and will typically require a higher level of treatment (e.g. particulate filtration) in comparison to groundwater.

4.1.2.4 Organic Compound

Petroleum Hydrocarbons - The results of the petroleum hydrocarbon analyses on the existing Lake Geraldine source water and the current water samples collected to date as part of the sampling plan are summarized in Table B.4 of Appendix B. Non-detectable concentrations of petroleum hydrocarbon were noted for all samples collected from the Lake Geraldine data and the current water samples collected as part of the sampling plan.

Polycyclic Aromatic Hydrocarbon (PAH) – The results of the PAH analyses on the current water samples collected to date as part of the sampling plan are summarized in Table B.5 of Appendix B. All PAH parameters were non-detectable for all samples collected during the sampling plan.

4.1.2.5 Summary of Water Quality Analytical Results

A summary table of the 2013 water quality sampling plan analytical results for the Lake Geraldine and Apex River samples is provided in Table 4-1. The table lists the minimum, maximum and average concentrations of representative general chemistry, trace metals and bacteriological parameters typically monitored as indicators of acceptable drinking water quality (e.g. City of Iqaluit NWB Licence potable water quality monitoring parameters).

The summary table for the two watersheds (i.e. Lake Geraldine WTP, and Apex River sampling sites A1, A2, and Apex HS) is interpreted to indicate that the water from Lake Geraldine and the Apex River are very similar for the parameters listed. Some differences noted include generally lower bacteriological results; marginally higher manganese and copper; and marginally lower aluminum for Lake Geraldine. These differences are attributed to the fact that Apex samples are grab samples from a running stream reach whereas water from Lake Geraldine is from an impoundment.

In summary, results are interpreted to indicate the following.

- In general, the water quality of the Apex River is similar to that of the Lake Geraldine. In this context, use of the Apex River as a supplemental source is expected to impose no additional treatment requirements over and above what is currently in place for the existing Water Treatment Plant which includes UV disinfection, Gravity Sand Filtration, and Chlorination and Fluoride Addition. - The existing Lake Geraldine water supply has negative Langelier Index values. The Apex River also has generally similar negative values. Marginally less negative values observed in the 2013 Apex River samples suggests supplementation could possibly have some buffering effect on the existing system. Negative Langelier Index values can indicate potentially corrosive water which can effect longevity and maintenance aspects of water infrastructure.
- Based on review of the sampling results to date, it is expected that the waters could be mixed with no need for additional treatment over and above the requirements for the existing Lake Geraldine source. However, it must be appreciated that mixing of waters from different sources can potentially have unexpected effects (e.g. changes in color, taste, odour, turbidity) that cannot be conclusively ruled out based solely on comparison of a limited analytical database.

4.1.3 Field Readings

As part of the sampling plan (Appendix A) developed to support the current study, field readings including stage level information, and general water quality parameters (e.g. field pH, conductivity, ORP) were collected, where practical.

TABLE 4-1: 2013 Water Quality Summary

Table 4-1a: Summary of General Chemistry Water Quality Parameters (2013 Sampling Plan)

Parameter	Units	Guideline	Sampling Location A1			A2			Apex HS			Lake Geraldine WTP		
			min	max	avg.	min	max	avg.	min	max	avg.	min	max	avg.
General Chemistry (as per Licence)														
Alkalinity	mg/L		3.8	30.0	20.5	5.5	29.0	20.9	5.4	30.0	18.9	12.0	25.0	18.0
Acidity	mg/L		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chloride	mg/L	250	<1	1	<1	<1	1	<1	<1	1	<1	<1	2	1.3
Carbonate	mg/L		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate	mg/L		3.8	30.0	20.5	5.5	29.0	20.9	5.4	29.0	18.6	12.0	25.0	18.0
Total Hardness Sulphate	mg/L		6.2	39.0	26.7	14.0	40.0	28.6	8.1	38.0	23.8	15.0	27.0	21.3
Total Suspended Solids (TSS)	mg/L	500	<1	12.0	6.4	1.0	12.0	7.3	1.0	11.0	6.0	2.0	5.0	3.5
Total Dissolved Solids (TDS)	mg/L		<1	<1	<1	<1	27.0	3.4	<1	14.0	3.9	<1	1.0	<1
Total Organic Carbon (TOC)	mg/L	500	<10	80.0	44.2	<10	84.0	43.8	44.0	68.0	53.3	24.0	46.0	37.3
Total Inorganic Carbon (TIC)	mg/L		0.9	3.3	1.3	0.9	3.2	1.3	1.0	3.6	1.8	1.6	2.5	2.0
pH (field)	mg/L		1.0	7.0	4.8	2.0	7.0	4.9	2.0	6.0	4.3	3.0	5.0	4.3
pH (lab) ORP (field)			8.3	8.7	8.5	7.5	8.1	7.8						
Conductivity (field)		6.5 - 8.5	6.4	7.7	7.3	6.5	7.7	7.2	6.6	7.6	7.2	6.8	7.3	7.1
Conductivity (lab)			213.5	232.9		137.0	308.4							
Temperature (field)	uS		80.6	81.3	81.0	81.4	82.9	82.2						
Turbidity			17.0	88.0	59.6	29.0	88.0	63.0	23.0	89.0	55.5	36.0	65.0	48.8
	deg C		2.6	5.9		2.7	5.4							
Other	NTU	2	<0.2	0.7	0.3	<.2	1.8	0.4	<0.2	0.8	0.5	0.5	3.2	1.2
Flouride Nitrate														
(as N) Langelier														
Index	mg/L	1.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1
	mg/L	10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
			-3.12	-1.04	-1.73	-2.94	-1.05	-1.74	-2.72	-1.15	-1.68	-2.32	-2.26	-2.30

Note - only two field readings for stations A1 and A2.

Table 4-1b: Summary of Bacteriological Results (Total) (2013 Sampling Plan)

Microbiological	Units	Guideline	Sampling Location A1			A2			Apex HS			Lake Geraldine WTP		
			min	max	avg.	min	max	avg.	min	max	avg.	min	max	avg.
Total Coliform	CTS/100ml	0	0	170	38	2	120	35	11	240	97	0	2	1
Faecal Coliform	CTS/100ml	0	0	1	0	0	2	0	0	0	0	0	0	0
E. Coli	CTS/100ml	0	0	1	0	0	1	0	0	0	0	0	0	0
Background	CTS/100ml		20	550	178	37	470	189	110	230	190	41	310	183

Table 4-1c: Summary of Trace Metals (Dissolved) (2013 Sampling Plan)

Trace Metals (Dissolved)	Units	Guideline	Sampling Location A1			A2			Apex HS			Lake Geraldine WTP		
			min	max	avg.	min	max	avg.	min	max	avg.	min	max	avg.
Aluminum (Al)		100	4.5	89	14.2	4.8	20	10.3	4.3	24	14.8	<3	16	5.3
Antimony (Sb)			<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Arsenic (As)		5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Barium (Ba)			<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Berylium (Be)			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Boron (B)			<20	57	<20	<20	27	<20	<20	<20	<20	<20	<20	<20
Cadmium (Cd)			<0.005	0.01	0.007	<0.005	0.015	0.006	<0.005	0.012	<0.005	<0.005	<0.005	<0.005
Chromium (Cr)		1	<1	1	<1	<1	<1	<1	<1	1.1	<1	<1	1.1	<1
Cobalt (Co)			<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Copper (Cu) Iron		1000	0.3	2.5	0.75	0.29	1.2	0.67	0.5	1.3	0.89	1.7	3.2	2.36
(Fe) Lead (Pb)		300	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
Lithium (Li)		10	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Manganese (Mn)			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Molybdenum (Mo)		50	<4	7.1	<4	<4	13	4.4	<4	13	4.2	<4	<4	<4
Nickel (Ni)			<0.2	0.27	<0.2	<0.2	0.23	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Selenium (Se) Tin			<0.5	0.84	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
(Sn)		10	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Silver (Ag)			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.3
Strontium (Sr)			<0.1	<0.1	0.14	<0.1	<0.1	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4
Thalium (Tl)			<20	<20	<20	<20	21	<20	<20	20	<20	<20	<20	<0.5
Titanium (Ti)			<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.6
Uranium (Ur)			<1	<1	<1	<1	8.7	<1	<1	<1	<1	<1	<1	<0.7
Vanadium (V)		20	<0.1	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.8
Zinc (Zn)			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.9
Mercury (Hg)		5000	<1	5.7	<1	<3	8.4	<3	<3	<3	<3	<3	4.3	<0.10
		1												

Table 4-1d: Summary of Trace Matals (Total) (2013 Sampling Plan)

Trace Metals (Total)	Units	Guideline	Sampling Location A1			A2			Apex HS			Lake Geraldine WTP		
			min	max	avg.	min	max	avg.	min	max	avg.	min	max	avg.
Aluminum (Al)	ug/L	100	<3	34	13.4	5.3	130	31.5	8.5	110	37.4	<3	16	8.7
Antimony (Sb)	ug/L		<0.6	0.83	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	1.2	<0.6
Arsenic (As)	ug/L	5	<0.2	1.5	0.21	<0.2	0.74	<0.2	<0.2	0.25	<0.2	<0.2	0.24	<0.2
Barium (Ba)	ug/L		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Berylium (Be)	ug/L		<1	<10	<1	<1	<10	<10	<1	<1	<1	<1	<1	<1
Boron (B)	ug/L		<20	45	<10	<20	23	<20	<20	<20	<20	<20	<20	<20
Cadmium (Cd)	ug/L		<0.005	0.02	0.006	<0.005	0.02	0.005	<0.005	0.06	0.02	<0.005	0.01	0.007
Chromium (Cr)	ug/L	1	<1	1	<1	<1	<1	<1	<1	1.1	<1	<1	1.1	<1
Cobalt (Co)	ug/L		<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Copper (Cu) Iron	ug/L	1000	0.31	6.6	1.12	0.27	2.4	0.78	0.52	1.7	1.06	2.6	8.1	4.93
(Fe) Lead (Pb)	ug/L	300	<60	<60	<60	<60	250	61.9	<60	190	70	<60	90	64
Lithium (Li)	ug/L	10	<0.2	0.4	<0.2	<0.2	0.22	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Manganese (Mn)	ug/L		<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20

Results of field water quality monitoring parameters are provided as Table C.1 (Appendix C). Although intended to be collected once per week, available readings as provided in Table C.1 are limited to three dates for A1, and two dates for A2. The data is generally too limited to provide definitive comment on seasonal observations and trends. One general observation is that field pH readings tended to be higher than laboratory readings (particularly for station A1); differences between lab and field readings can be expected given the potential for pH to adjust between the time the sample is collected and when it is received in the laboratory.

To assist in understanding the relative "stage level" of the Apex River as a function of time, river water levels were collected using arbitrary datum points at each of stations A1 and A2. A summary of readings is included in Table C.2, Appendix C, and for the period of readings (June 14 – Sept 11, 2013) suggest a decrease in stream stage level of approximately 0.7 m at A1, and 0.5 m at A2.

4.1.4 Photographs

As part of the sampling plan work, photographs at each sampling location were collected. This was to provide for a visual comparison of general conditions at each of the sampling stations including a qualitative comparison of relative flow and conditions regarding possible development of a water source intake. A record of photographs collected to date is provided in Appendix D. Summary comments relative to consideration of withdrawal point siting within the Apex River include the following:

- Abundant snow cover observed during the June 14, 2013 site visit (completed around the time breakup is understood to have essentially begun), is essentially gone or minimal by July 10, 2013.
- Observation of the progressive photographic record suggests that the use of A2 as a withdrawal point would be preferred over option A1; reasons include:
    - Flow is much more dispersed at the upstream location (A1) than at A2.
    - At location A2, looking upstream, the stream channel/ flow appears to change from a dispersed, cobble and boulder strewn channel flow to a more quiescent pool like feature which on exiting the pool (looking downstream) changes to a well-defined drainage course with minimal dispersion due to cobble/ boulders (relative to A1). The pool appears to provide for some sedimentation of finer material (e.g. A2 late August, upstream photos) prior to entering the more defined downstream channel. The transition area from the pool to the downstream channel section, or the defined downstream channel itself, could be favourable for placement of an intake.
- In late August/ early September, there appears an appreciable decrease in flow within the watercourse such that the flow at A1 looks like it could be extremely difficult to construct an intake to collect the dispersed flow; flow at A2 is also notably lower but still appears concentrated in a "defined" drainage reach such that placement of an intake is expected to be more feasible.

4.2 Water Quantity

The water quantity portion of the feasibility study included an evaluation of watershed flows (hydrologic assessment), and consideration of climate change effects. This information was used to determine if the required quantity of water determined in the companion study by others entitled *Lake Geraldine Water Balance Study* (Golder, 2013) could be reasonably expected to be met based on the results of the hydrologic and climate change aspects of the **exp** assessment. Results are summarized below.

4.2.1 Apex River - Flow Duration and Minimum Flow Curves

Available hydrometric data for the Environment Canada Hydrometric Station *Apex River at* Apex was obtained. The available data set is for the years 1973-1995 (22 year period) and 2007 – 2012 (5 year period). This information was used to develop flow duration curves (CDF curves) and minimum flow (Qmin) for the months of June, July, August and September; flows for other months are either nonexistent due to frozen conditions, or data is questionable due to sporadic and/ or anomalous conditions (e.g. related to spring breakup). Predicted flows were plotted to actual flows using the Weibull method which is a statistical probability distribution function suitable to development of probability plots for stream flow data. Data plots generated are provided in Figure 4.1. The following summarizes interpreted findings relevant to consideration of the Apex River to serve as a supplementary water supply source.

1. June is not a good month in which to rely on flow to be present; the flow discharge data seems to have two populations (i.e. non-linear behaviour, Figure 4.1 c) indicating the data is not homogenous. It is even difficult to fit a distribution function to June data (referring to the Weibull plot – Figure 4.1c - there is a definite non-linear trend in the Q-Q plot). Explanations for the difficulty in fitting data for June include the influence and variability of seasonal conditions during June (basically June is the month that snow melt starts which can lead to highly variable flow volumes), and the field related problems in obtaining a rigorous data set for the station as a whole (Environment Canada).

2. The months of July, August and September will have to be relied on to support Lake Geraldine. (This does not mean that if flow is available in June (e.g. early spring thaw), or in October prior to freeze up, that it could not be used if warranted).

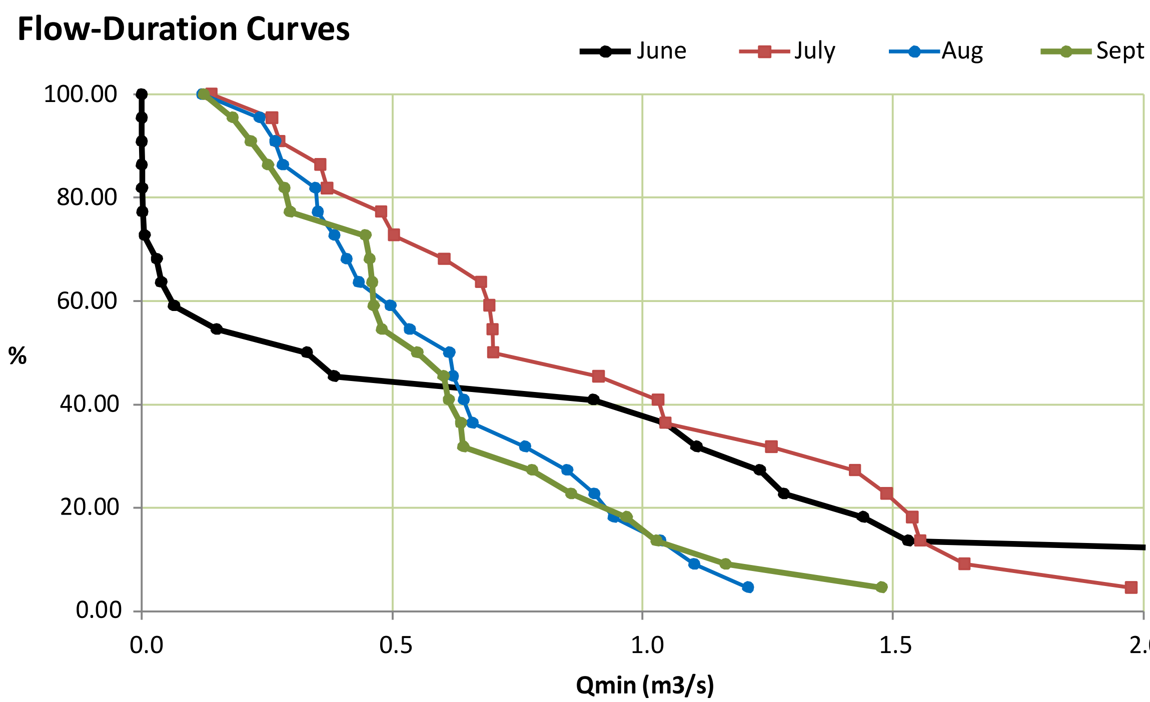
3. The Flow –Duration Curves show that a minimum flow or instream 7 day 10 year flow (7Q10) is valid approximately 90% of time or more. This suggests that for July, August and September, that under most conditions there would be enough water to supplement the needs and that a baseflow could likely be maintained most of the time. (This is discussed further in Section 4.2.3, below).

It is important to note that the flow discharge plots shown in Figure 4.1 are for the Apex River Hydrometric Station. As currently understood, the water intake for the proposed supplemental supply will be installed upstream of the Apex station (i.e. at A-1 or A-2). Therefore, it is necessary to adjust (pro-rate) the predicted flows of Figure 4.1 to the contributing drainage area corresponding to the respective proposed intake locations. For example, the approximate drainage area contributing to flow at A1 is 3,650 hectares, and for A2 4840 hectares. Relative to the EC Apex Station at 5,850 hectare drainage area, A1 is 62 %, and A2 83 % (Table 4-2). In comparison the Lake Geraldine watershed drainage area is 7 % relative to the Apex Hydrometric Station catchment area.

Table 4-2 Catchment Area Size Relative to Apex Hydrometric Station (Approximate)

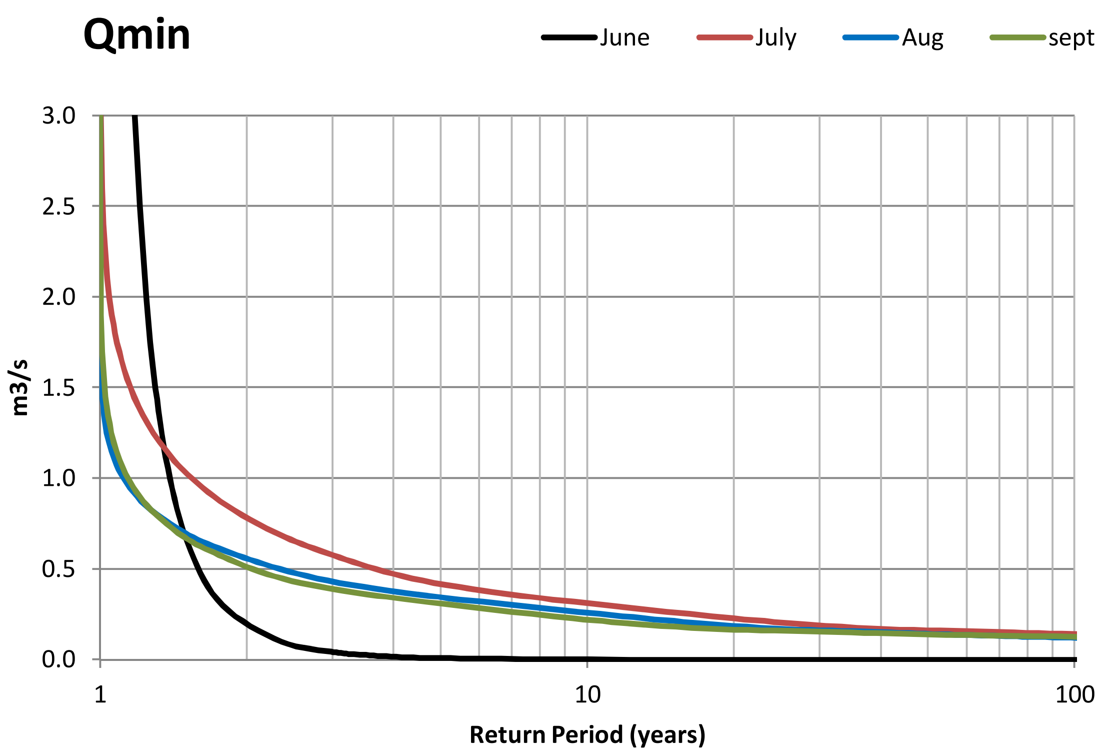
Location	Drainage Area (ha)	Drainage Area Size Relative to Apex Hydrometric Station	Comments
EC Apex Hydrometric Station	5850	1.00 (100%)	Area from Trow 2004
Intake Location – A2 (includes A1)	4841	0.83 (83%)	Area estimated from GIS
Intake Location – A1	3651	0.62 (62%)	Area estimated from GIS.
Lake Geraldine	385	0.07 (7%)	Area from Trow 2004

Figure 4.1a - Flow Duration Curve



a) Flow (Q)-duration curves for Apex Hydrometric station. The flow duration curve is a plot of percent of time that a particular discharge can be expected to be equal to or exceeded. For example, during June and July, it can be expected that a flow equal to or greater than 1.0 m^3/second will occur approximately 40 % of the time; for August and September, this flow would be expected to be met or exceeded only 15 % of the time.

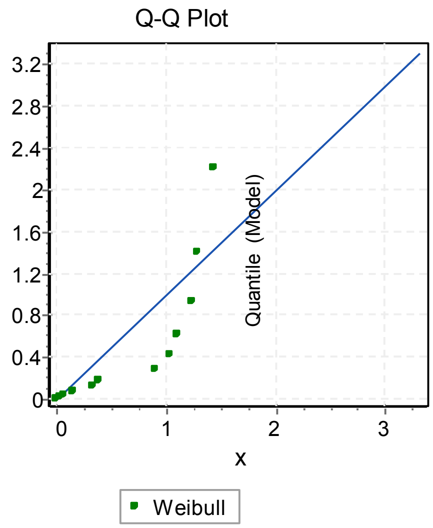
Note that during June, no flow is expected 30 % of the time likely due to June spring thaw data present in the period of record used to generate the curves; i.e. the curve for June says at least 70 % of the time flow will be zero or greater, and 30 % of the time flow will be zero (presumably due to frozen condition).



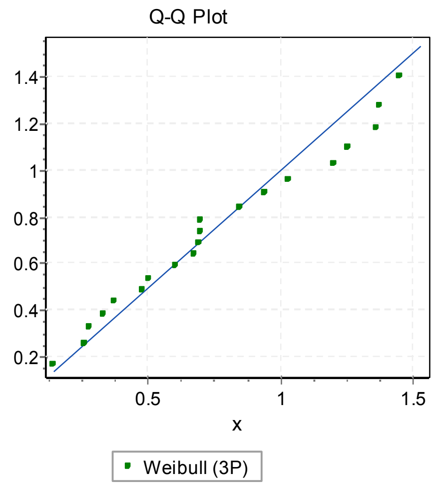
b) Minimum flow (Q_{min}) in cubic meters per second (m^3/sec) in Apex River for various return periods. The Q_{min} plot indicates the return period in years in which a particular minimum discharge can be expected to occur. For example, the minimum flow in any 10 year period for July, August and September can be expected to be in the range 0.2 to 0.3 m^3/sec. Note that for June, the plot indicates that a flow of zero would be expected within a 3 to 4 year return period.

Figure 4.1c – Data Fit Plots

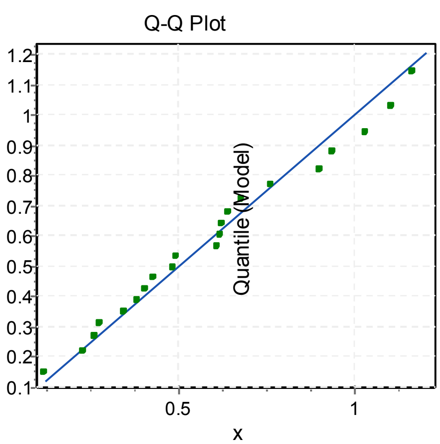
JUNE



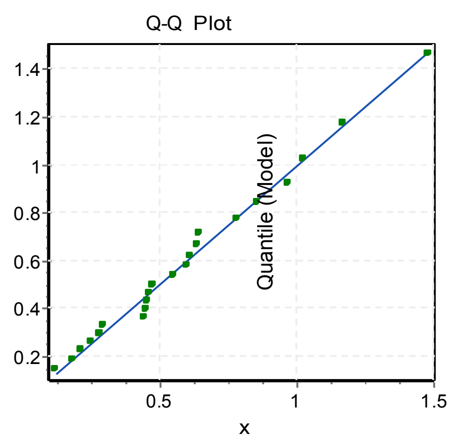
JULY



AUGUST



SEPTEMBER



c) Weibull plots for June, July, August and September. The Weibull plot is a statistical/ probability method used to test the goodness of fit of a particular data set; it is generally accepted to describe the minimum flow in a stream where the data is "homogenous"; note that data for June is not homogenous (non-linear behaviour attributed to melt conditions, i.e. one population of the data represents normal runoff, and the second frozen conditions).

4.2.2 Climate Change Screening

It can be reasonably expected that climate change will affect two hydrologic parameters:

1. Air temperature (maximum, average and minimum) and consequently water temperature and ice conditions of Lake Geraldine, and

2. Solid and liquid precipitation will be affected by climate change in the future.

These two parameters will affect evaporation, and runoff and consequently surface flow in the Apex River (and Lake Geraldine). To take into consideration this effect for the next 20 years (2012-2032), the Canadian Climate Model was used to make a scaling of the global information.

The climate model used in the present study is the third generation coupled global climate model (CGCM3.1). Further information concerning the details of the model can be found at https://www.ec.gc.ca/ccmac-cccma/default.asp?lang=En&n=1299529F-1.

The time-slice simulations follow IPCC "observed 20th century" 20C3M scenario B1 and A2 (see Figure 4.2 below) for years 2000-2030. Use of these scenarios are interpreted to provide upper and lower bounds regarding projected climate change effects.

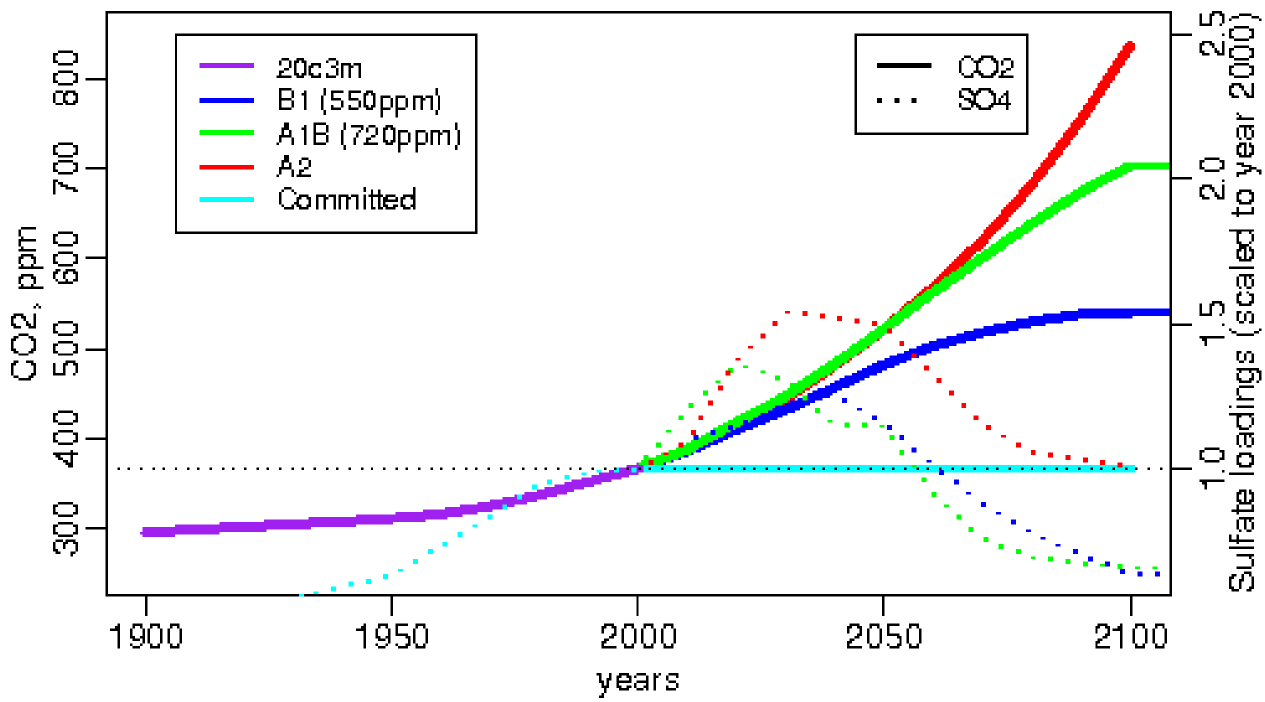


Figure 4.2 Climate Change Scenarios (IPCC, 2000).

The graph above shows the time evolution of the CO2 concentrations and globally averaged sulphate aerosol loadings (measures of global warming/ climate change gas emissions) scaled to year 2000 for different scenarios including the 20C3M, SRES B1 and SRES A2, and the so-called "Committed" scenario in which the greenhouse gas concentrations and aerosol loadings were held fixed at the year2000 level (IPCC, 2000). These scenarios represent various alternative global socio-economic development pathways. For example, the B1 storyline and scenario family describes a convergent world with low population growth and rapid changes in economic structures towards a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. This is in essence an optimistic scenario where social and economic trends serve to minimize greenhouse gas build up and therefore the projected rate of climate warming. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

The A2 storyline and scenario family describes a very heterogeneous world where greenhouse gas emissions (and climate change) increase more rapidly. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in high population growth. Economic development is primarily regionally oriented and per capita economic growth and technological changes are more fragmented and slower than in other storylines (i.e., B1). Essentially, the A2 scenario represents a more rapid rate of greenhouse gas emission build up and i.e. climate change; this scenario was used to model stream flow projections for the Apex River.

Apex River Climate Change Screening Results - Results of the climate change screening for the Apex River watershed using the IPCC A2 scenario are summarized in Figure 4.3. Although the model predicted an increase in amount of precipitation over the modelled time period (top graph, Figure 4-3), this does not seem to translate to an increase in flow (middle graph), i.e. there is no notable increase in minimum and average yearly stream flow through to year 2100 relative to current flow volumes. A possible explanation is that sublimation, in general, is important in the high latitude conditions in which the Iqaluit is located.

Given the increase in precipitation over the modelled time period, generally no significant corresponding increase (or decrease) is compiled in projected stream flow. For the purpose of the water quantity (feasibility assessment of the Apex River), historical data can be assumed to provide for a conservative estimate of available flow for the existing and projected future conditions.

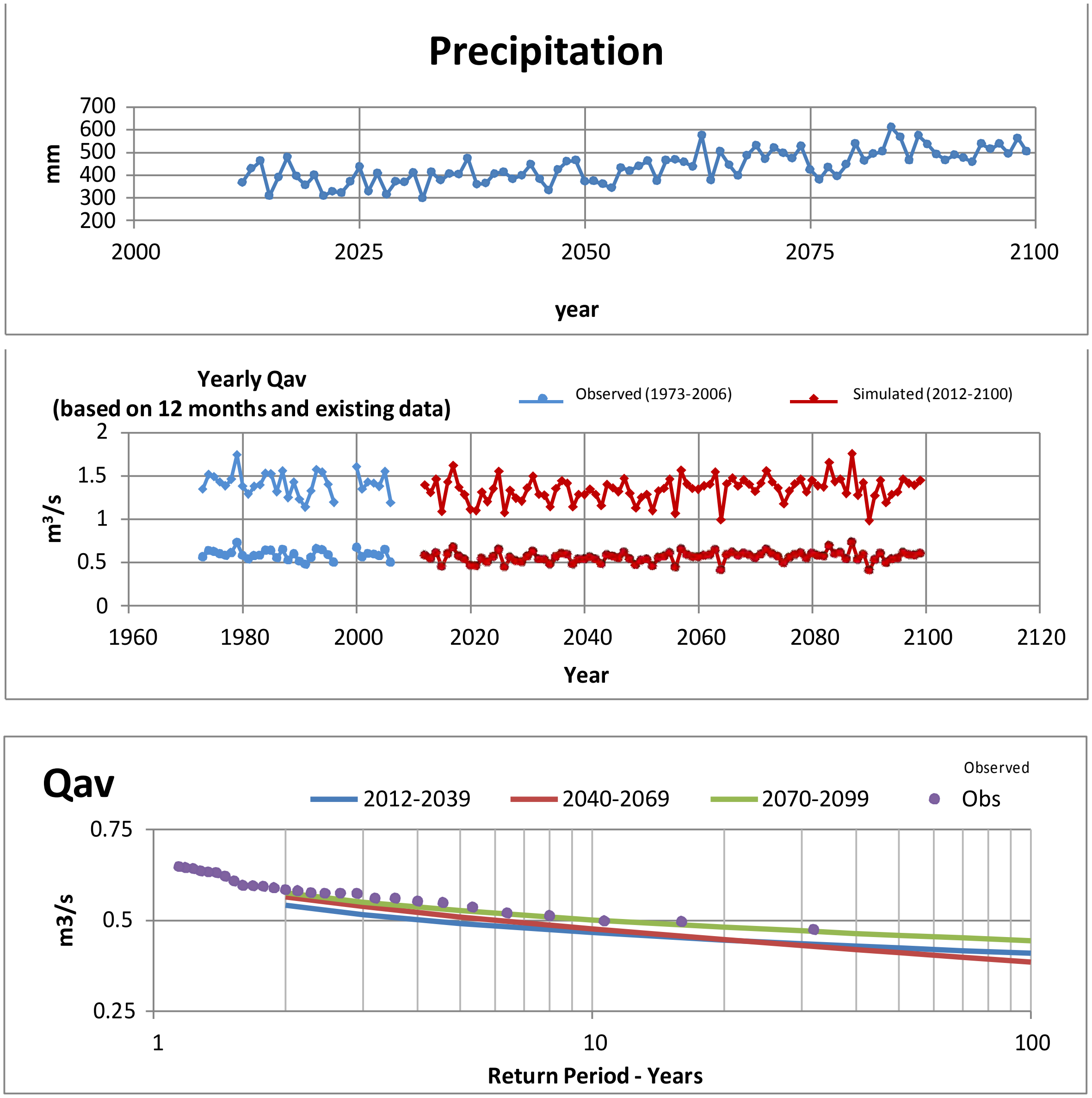


Figure 4.3 Climate Change Screening Interpretive Plots – Precipitation and Apex River Stream Flow for an A2 Climate Modelling Scenario (higher greenhouse gas loadings representing more rapid climate change). The upper graph shows modelled precipitation; the middle graph shows yearly minimum and average yearly flows in the Apex River. Although a marginal increasing trend in precipitation is observed, there is minimal increase in flow; indicating that flow projections based on historical data should provide a reasonable prediction of future water availability. The lower figure shows the predicted average river flow for various return periods; e.g. within a 10 year return period, an average yearly stream flow of approximately 0.5 m^3/s will occur. Note that the observed data and predicted curves generally coincide indicating that current/ historical conditions can be expected to be representative of future conditions to at least 2100.

4.2.3 Water Requirement and Feasibility

Water Requirement - Water deficit scenarios and corresponding supplementary volume requirements were determined as part of the water balance study completed and provided by Golder (2013). The various scenarios and respective volumetric water requirements are listed in Table 4-3, below.

Table 4-3 Supplementation Volumes

Winter Duration	Snow	Rain	Supplementation Requirement
100%ile	**50%ile**	**50%ile**	**845 ML (845,000 m^3)**
60%ile	**75%ile**	**75%ile**	**1,328 ML (1,328,000 m^3)**
50%ile	**100%ile**	**100%ile**	**1,853 ML (1,853,000 m^3)**

These estimates of supplemental requirement are understood to give volumes that could be required based on various climactic conditions, and range from 845,000 m^3 to 1,853,000 m^3. In comparison, the available volume of the Lake Geraldine reservoir is understood to be on the order of 1,800,000 m^3.

Available Water Quantity – Feasibility to meet the volumetric water requirements determined by Golder and summarized in Table 4-3 (above) was assessed using the historic record of stream flows obtained from the Environment Canada Apex River hydrometric station records which included the periods 1973 – 1995, and 2007 – 2012, representing 28 years of daily stream flow measurements.

Method and related assumptions by **exp** to assess water quantity available (i.e. supplementary supply feasibility) were as follows:

- The historical record was used as the basis for calculating available flow volume that could be reasonably expected on a month by month basis. A summary of the monthly flows (e.g. June, July, August, and September) was prepared (Table 4-4). The respective monthly flows were calculated by multiplying the individual Environment Canada daily stream flow reading (m^3/s) times 86,400 sec/day, and adding the daily flow volumes to provide a total for the respective month.
- The supplemental requirements would be addressed assuming only the months of July, August and September were available for withdrawal. This is based on the observation of possibly no flow during June (e.g. long winter duration with late breakup) as suggested by the non-linear behaviour of the June flow data (Figure 4.1) and occasionally observed in the historical stream flow record (see Table 4-4).
- There is no requirement to maintain a minimum stream flow, i.e. all water flowing is available for withdrawal if needed.

Table 4-4 summarizes available water quantity at the Apex River Hydrometric Station (assumed as 100
% of the drainage basin area), and for the two withdrawal point options A1 an A2. (As noted in Table 4-4, the flow at withdrawal point options A1 and A2 is prorated to flow at Apex HS, with the catchment area for A-1 at 62 %, and A-2 at 83 % relative to the Apex Hydrometric Station drainage area).

The summary of historical data for the 28 years of record (Table 4-4) indicate the following:

1. The minimum total 3 month (July, Aug and Sept.) stream flow calculated for withdrawal point A1 is on the order of 2,900,000 m^3, and 3,900,000 m^3 for A2. The average three month total stream flows are on the order of 6,400,000 m^3 for A1, and 8,500,000 m^3 for A2. In comparison, the supplemental flow volume required (Golder, 2013) is in the range 845,000 m^3 to 1,853,000 m^3.

Table 4-4: Apex River Monthly Stream Flows - Historical Record

APEX HS - Total Monthy Flows in cubic meters (m3) at EC Apex Hydrometric Station

Year	June	July	August	September	October	July, Aug, Sept 3 Month Total	Comment
1973	9,941,270	6,528,125	2,444,947	3,733,171		12,706,243	Missing 7 days for June;
1974	5,147,194	991,958	2,822,774	1,877,386		5,692,118	Missing 10 d - Sept
1975	3,959,712	3,959,712	2,761,776	2,088,893		8,810,381	Missing 18 d - June
1976	5,206,464	6,544,800	2,398,291	1,217,981		10,161,072	Missing 15 d - June
1977	0	4,328,208	1,639,094	1,133,827		7,101,130	No data for June (frozen?)
1978	0	13,215,744	4,368,038	212,544		17,796,326	No June data (frozen), very high initial July flows; ONLY Sept 1 -2 flow
1979	0	5,995,296	3,028,752	3,673,382		12,697,430	No June data (frozen?)
1980	2,012,256	2,401,056	910,570	1,476,490		4,788,115	No June data until June 24th
1981	2,433,888	2,413,757	870,998	2,666,736		5,951,491	No June data until June 23th; No flow past Sept 17th
1982	5,764,090	2,845,584	1,517,443	1,743,638		6,106,666	Very low flow until June 12th; freeze up looks like around Sept 25
1983	8,463,744	3,781,210	479,434	400,378		4,661,021	Low flow June 7 - 16, then large flow starts
1984	No data						
1985	8,054,208	3,905,798	2,612,563	3,643,834		10,162,195	Good flow even at June 1
1986	6,746,544	9,603,360	5,703,091	5,019,408		20,325,859	Run off starts June 6
1987	11,899,872	6,694,272	3,907,440	2,944,858		13,546,570	Runoff start looks like June 2
1988	6,202,656	7,594,560	3,515,098	2,302,819		13,412,477	Runoff starts June 10 - 16
1989	4,604,342	5,071,594	3,216,413	1,221,437		9,509,443	No runoff till June 16
1990	6,990,970	5,477,155	5,666,371	3,270,067		14,413,594	Low flow from June 1 - 15 then increase to spring runoff
1991	4,338,490	1,257,379	3,153,946	5,370,624		9,781,949	Main spring melt begins June 14
1992	1,184,803	9,559,296	1,609,027	1,165,190		12,333,514	Late spring melt (e.g. around June 26)
1993	132,192	2,311,286	5,169,139	2,519,424		9,999,850	Note - only one day of flow on June 30
1994	9,330,768	2,592,432	3,252,096	2,235,600		8,080,128	Early springmelt (i.e. on or before June 1)
1995	553,824	2,010,960	4,024,685	3,388,262		9,423,907	No flow until June 26
1996 - 2006	No data						
2006				4,111,171	4,279,910		Freeze up Nov 4
2007	8,883,648	5,836,320	5,863,363	1,360,022	124,416	13,059,706	Runoff starts May 28; Freeze up essentially by Oct 12
2008	8,056,800	2,701,555	1,746,230	2,836,858	403,056	7,284,643	Breakup on May 23 gives May flow of 1,535,328; Freeze up by essentially Oct 12
2009	10,040,198	4,316,458	2,737,411	3,895,344	205,891	10,949,213	Breakup June 8, Freeze up around Oct 10
2010	9,914,400	2,535,926	4,580,410	3,060,288	3,023,914	10,176,624	Breakup May 23 = 230,861 m3; Late Freeze up Nov 7 = 150,000 m3 in early Nov
2011	9,211,363	3,868,042	2,556,490	2,525,818	434,506	8,950,349	Break up starts May 31; Freeze up essentially Oct 8
2012	9,912,499	1,949,011	2,714,947	5,321,635	1,548,547	9,985,594	Break up on June 1; Freeze up essentially Oct 30
Max	11,899,872	13,215,744	5,863,363	5,370,624		20,325,859	Note - Monthly Max, Min values do not occur in same year.
Min	0	991,958	479,434	212,544		4,661,021	
Avg	5,678,078	4,653,245	3,045,387	2,582,354		10,280,986	
A1 - Prorated (62 % drainage area relative to Apex HS)							
Max	7,377,921	8,193,761	3,635,285	3,329,787		12,602,033	
Min	0	615,014	297,249	131,777		2,889,833	
Avg	3,520,409	2,885,012	1,888,140	1,601,060		6,374,211	
A2 - Prorated (83 % drainage area relative to Apex HS)							
Max	9,876,894	10,969,068	4,866,591	4,457,618		16,870,463	
Min	0	823,325	397,930	176,412		3,868,647	
Avg	4,712,805	3,862,193	2,527,671	2,143,354		8,533,218	

Therefore, for the 28 years of record, both the average and minimum cumulative three month flow volumes at A1 and A2 would be sufficient to meet the supplementation volume required.

2. The three month minimum flow volume at A2 is approximately 1,000,000 m^3 (30 %) greater than the minimum at A1; the average three month flow volume at A2 is over 2,000,000 m^3 higher than the average three month flow at A1. Therefore, relative to the upper value of supplementation requirement (1,853,000 m^3), the additional 1,000,000 m^3 minimum flow at A2 represents approximately 50 % buffer relative to A1. The additional 2,000,000 m^3 for the average total three month flow provides for greater than 100 % buffer relative to A1.

3. There is considerable variability from year to year, and for any individual month. Also, for any given year, there appears to be no one year where the minimum flow for two given months over the July, August, September period will occur in the same year. This latter observation suggests that even though there may be one month of extremely low flow, it is reasonable to expect that the deficit could be made up over one (or both) of the other two months of pumping. For example, in 1978 monthly flow during September was at its historical low (only 212,544 m^3). However, for the preceding two months roughly 13,000,000 m^3 was observed in July and 4,300,000 m^3 was observed in August; therefore the September low flow could be easily met by pumping more water in July and/or August.

In practice, on review of the flow records it is noted that there are some years where breakup occurs early and there can be significant flow volume during June (refer to Table 4-4 June data). Also, freeze-up can occur later than October 1, and in this case there is the possibility that some flow may be available for withdrawal during October (e.g. 2010). These observations, and the observation that there is no obvious pattern observed for the yearly/ monthly flow volumes listed in Table 4-4 highlight the fact that no two yearly runoff conditions will be identical, and that in reality significant differences in yearly (and monthly) volumetric flow can be observed from one year to the next. In this sense, the assumption of flow only being withdrawn during July, August and September flow is somewhat conservative. In practice, based on the historic record summarized in Table 4-4, it is likely that there would be some flow in June and possibly some flow in October prior to freeze up that could be used if warranted. As water is expected to be most needed when low flow conditions prevail, it is recommended that the reservoir be topped up as soon as practical in the event of dry conditions later on in the pumping season.

Minimum Flow Maintenance – As noted above, it has been assumed that all water flowing past the proposed intake point will be available for withdrawal if needed. Therefore, it is assumed that there will be no requirement to maintain a minimum flow (e.g. baseflow) in the river.

The assumption of no minimum flow maintenance requirement is considered reasonable based on information obtained over the course of the study, and the understanding of current regulatory management framework (e.g. the Apex River is not considered a commercial fishery). Further, it is understood that there is no active recreational fishery along the stream reach (in particular at or upgradient of the A1 and A2 withdrawal point options); with the only fishing activity near the watershed understood to occur beyond the point of discharge where the Apex enters into the estuary at its mouth.

Regarding minimum flow, it is of general interest to compare the occurrence of “extreme” low flows in the hydrographic record to a representative baseline. In this regard, as a general comparison, a summary of 7 day average minimum flow by month for the historical record from 1973 - 1995 is provided in Table 4-5. Also listed is the 7 day/ 10 year low flow for each respective month interpreted from Figure 4-1b. The data listed indicates that the average monthly 7 day minimum low flows are on the order of 2.5 to 3 times the respective month 7 day/ 10 year low flow. Further, for the 66 months listed in Table 4-5, there are only 7 months (highlighted in red) where the 7 day low flow is less than the 7 day/ 10 year flow. In conclusion, it is anticipated that under most flow conditions, there will be flow downstream of the withdrawal point while still meeting reservoir recharge requirements over the assumed three month pumping period.

Table 4-5: Apex River Minimum Flows (7 day average)

Qmin (average 7 day low flow by month, m^3/s)				
Year	**June**	**July**	**August**	**September**
1973	0.384	1.031	0.621	0.613
1974	1.108	*0.260*	*0.235*	0.637
1975	0.902	0.700	0.643	0.447
1976	1.440	1.554	0.497	0.296
1977	0.000	0.702	0.347	0.285
1978	0.000	1.539	0.942	1.167
1979	0.000	1.487	0.433	0.463
1980	3.327	0.504	0.266	0.455
1981	3.170	0.357	0.282	0.480
1982	0.039	0.677	0.385	*0.182*
1983	0.001	*0.139*	*0.121*	*0.124*
1984				
1985	1.234	1.046	0.765	0.968
1986	0.006	1.643	0.904	1.028
1987	0.330	1.257	1.211	0.602
1988	0.150	1.424	0.614	0.550
1989	0.001	0.694	1.036	0.218
1990	0.065	0.912	0.850	0.642
1991	0.030	*0.275*	0.352	1.477
1992	0.000	1.976	0.409	0.253
1993	1.530	0.370	1.103	0.858
1994	1.045	0.478	0.535	0.460
Max	*3.327*	*1.976*	*1.211*	*1.477*
Min	*0.000*	*0.139*	*0.121*	*0.124*
Mean	*0.729*	*0.892*	*0.600*	*0.590*
Qmin 7d/10yr	*m^3/sec*	***0.303***	***0.250***	***0.197***

5 Watershed Protection Framework

It is understood that the Government of Nunavut (as with most provinces) owns all fresh waters and therefore has jurisdiction concerning its management and protection. It is understood the current municipal plan and by-laws specify most of the Apex River watershed area as designated protected watershed area, although an upper section of the watershed may lie outside currently designated area (i.e. it is not within current City of Iqaluit municipal limits – see Figure 2.1a).

One other aspect of possible concern is to confirm the question of ownership of land versus ownership of mineral resource under the land surface. For example, in some jurisdictions, for metallic resources whoever owns the mineral claims owns the mineral resource under the land and can develop it. It should be clarified if there are such possible conditions in the Apex River (and Lake Geraldine) watershed to avoid any possibility such as a mineral exploration company identifying a potential resource within the watershed that they could develop regardless of it being inside a protected watershed.

6 Preliminary Design/ Cost Estimate

6.1 Preliminary Design and Opinion of Cost

Given the findings from the Water Feasibility screening (Section 4, above), it is recommended that should a supplemental supply be established, it would be located at A2 with a pipeline routed to Lake Geraldine. Preliminary drawings and figures are provided in Appendix E.

The pipeline will convey pumped water from the Apex watershed (from the A2 withdrawal point). A service road will be needed to access the pumping station at the A2 withdrawal point and at the pipe exit point at Lake Geraldine. This roadway would be installed adjacent to the pipeline routing. Delineator posts would be placed along the alignment to identify the pipe location. The purpose of the service road would be to allow maintenance activities to take place, check for leaks, operate valves, and verify/ maintain the pipeline integrity.

The pipeline would cross the Road to Nowhere via a culvert and continue along the terrain. There are two high points at which it is anticipated an air release valve system will have to be installed. At the low points of the line, a drain point will be required to evacuate water from the line before freeze-up. The drain point can be either extended to Lake Geraldine or located at the edge of watershed. The pipeline is to be placed on graded bedding, and either placed within a small berm or in an insulated metal jacket for protection against potential damage due to factors such as sun exposure, motor bikes (or other vehicles), rocks, vandals, etc.

The pumping will be using three variable frequency vertical turbine pumps at location A2 (capacity of 2000 USgpm each). Units are to be equipped with soft start/ soft stop to mitigate water hammer. These pumps will be set on a concrete foundation with a basic screen system located at the intake. Water from the Apex River will be pumped using one to 2 duty pumps with the third pump as an alternate (rotating duty) to a pipeline. The pipeline length from the withdrawal point to the discharge located near the drainage basin of Lake Geraldine is approximately 1,400m. The discharge is placed such that water conveyed from the pipe drains by gravity within the Lake Geraldine watershed. The location was selected such that it is one of the closest points from the withdrawal points to reduce the length of piping required, and is placed to be generally accessible

The withdrawal point (site A2) is located about 1,500m from Iqaluit's existing three phase electrical grid, and it is proposed that the electrical grid be extended along the Road to Nowhere to the pumping site withdrawal point. A benefit of this A2 site is that no diesel backup is planned at the site (given the proximity to existing electrical services) thus avoiding a potential risk to the watershed if fuel had to be stored on site.

At this time, recommended size of the pipeline is 500mm in diameter, and it is proposed that High-density polyethylene (HDPE) piping be used. This material is typical for such pumping systems. Pipe would be placed on a graded pipe bed within a shallow mound. Pipe would generally follow the existing terrain alignment to drain into the Lake Geraldine watershed. It is planned that pumping will be done for a general timeframe window (from June 18th to October 5th) for approximately 105 days* during the summer (understanding that this will vary pending on climate and reservoir level conditions). For the remaining time, the pipe would be drained.

Control system would require remote access, monitoring and operator alarm features.

** 105 days represents a historic percentage probability of occurrence of 85% as defined in Golder Associates report Table 10, section 5.1.2*

Opinion of Cost for the above scenario is provided in Table 6-1. A general plan and profile of the proposed setup, and representative system layout are provided in Appendix E.

Table 6-1: Class "C" Opinion of Probable Cost Estimate

Item	Description	Quantity	Unit	Cost/Unit	Opinion of Costs
1	Pump Units, Installed (2072 USgpm at 87 psi - electric motor)	3	ea	$ 119,000	$ 357,000
2	Pump Unit (spare)	1	ea	$ 56,000	$ 56,000
3	Concrete Foundation & Wetwell	1	ls	$ 350,000	$ 350,000
4	Building Structure	45	m²	$ 4,820	$ 217,000
5	Wetwell Access (Stairs or Ladder/Platform)	1	ls	$ 28,000	$ 28,000
6	Electrical	1	ls	$ 240,000	$ 240,000
7	Utility Power Line	285	m	$ 245	$ 70,000
8	Maintenance Laneway Construction	285	m	$ 1,720	$ 490,000
9	Controls, Programming and Commissioning	1	ls	$ 40,000	$ 40,000
10	Inlet Screen	1	ea	$ 28,000	$ 28,000
11	Well Service Air Valve	1	ea	$ 1,000	$ 1,000
12	Check Valve	3	ea	$ 3,500	$ 10,500
13	Grub and Clear for Pipeline	1150	m	$ 70	$ 80,500
14	Pipeline (500mm Ø Pre-Insulated HDPE DR11)	1200	m	$ 775	$ 930,000
15	Insulated HDPE joint kit (500mm)	79	ea	$ 760	$ 60,000
16	Covering Pipeline and Bedding	1200	m	$ 350	$ 420,000
17	Labour for Pipeline Installation (1 crew of 6 people)	15	crew/ day	$ 7,265	$ 109,000
18	Roadway Crossing	1	ls	$ 70,000	$ 70,000
19	Combination Air Valves	4	ea	$ 4,220	$ 16,880
20	Air Vacuum Valves	2	ea	$ 750	$ 1,500
21	Discharge and Chambers	1	ea	$ 168,000	$ 168,000
	Subtotal				$ 3,743,380
	Engineering (15%)				$ 561,507
	Contingency (20%)				$ 748,676
	Contractor Mobilization (15%)				$ 561,507
	Contract Administration (10%)				$ 374,338
	Subtotal				$ 5,989,408
	GST (5%)				$ 299,470
	Opinion of probable costs Total*				**$ 6,300,000**

*Note: Estimates and final costs can vary significantly pending on timing of tender call, schedule, time of year and deadlines, and number of contractors available to do the work. Costs are 2014 dollars.

6.2 Refill Trigger(s) and Protocol

The objective is for Lake Geraldine Reservoir to be full at the end of the summer season (prior to winter freeze-up period) for consumption throughout the winter. In order to achieve this objective, Golder (2013) has developed a 'Tool' for the City of Iqaluit (refer to Golder, 2013 report, *Chapter 6.0 Overview of Water Supply Forecasting Tool*). In summary, this tool uses the following factors to enable the City to plan its water pumping strategy:

- Snow Accumulation (reservoir implication of water shed contribution based on Meteorological/Climate data)
- Water Supply Forecasts (based on the water levels in Lake Geraldine, timing of first spring melt and first freeze-up and projected consumption rate)

To assist in planning, it is suggested that a record of data to be collected and maintained by the City. Specifically, record of population growth and trends;

- water level of Lake Geraldine (secondary measurement point, and addition of a real-time measurement system);
- flow demands/ rate of consumption (required use of flow meters) for residences, institutions and businesses;
- leak monitoring and leak mitigation in the distribution system;
- leak monitoring in the reservoir (infiltration, etc);

With this data, action plans can be developed by the City in anticipation of conditions requiring Lake Geraldine supplementation. For example, if the reservoir level is trending to low levels in the spring, water conservation measures could be taken as soon as possible, and plans to continue conservation measures through the summer demand period should be made. This may reduce the amount of pumping required.

It is also suggested that when water conservation measures are implemented, that the demands are monitored to determine the 'elasticity' of the water demand, e.g. what is the effectiveness of the City's conservation measures and communication, and associated minimum consumption rate which conservation measures can attain? Presently, water consumption demand planning numbers use an average consumption rate of 400l/c/d (liters per capita per day).

In June, water temperatures should be monitored and pumping initiated. Pumping should continue until it is forecasted that there is sufficient water in the reservoir to meet winter demands. As the temperature drops, pumping will not be possible and it is anticipated that pumping would stop no later than late September or early October (or sooner should conditions warrant) and the line drained of water and capped off for the winter.

6.3 Contingency Plans

1. Contingency Plans (Lake Geraldine)

a. **Flow demands are trending too high**: Clear water conservation measures need to be outlined to Iqaluit residences and industrial users. One of the best control measures is monitoring flows at the demand points. This is basically flow metering implementation, which aids not only the municipality in managing water, but also communicates to the water users the amount of water consumed, and then a basis can be made to compare year to year. Other water conservation measures are well known and can be implemented using guides as published by American Water Works Association (AWWA) (http://awwa.org/resources-tools/water-knowledge/water-conservation.aspx).

b. **Flow demands are too high**: This may indicate system leaks. Flow meters and the demand points and distribution nodes such as booster stations should be reviewed and used as a tool to determine the location of leaks or reason for increased demand.

c. **Reservoir water level is dropping faster that flow demands**: This may indicate infiltration within the bathymetry of the reservoir or the dam structure system. This would require immediate attention and an action plan developed and repair implemented.

d. Long winter and low water level: In addition to the above, this should trigger a higher pumping rate at the pump house than for a long winter and normal water level at the Lake.

2. Contingency Plans (Supplemental Pumping)

a. Piping: If there is a pipe break, there should be enough spare parts and fusing equipment available to make repairs to the piping. HDPE pipe can easily be cut to remove the bad section, and a new section replaced and butt-fused (or mechanical repair made with a service clamp). Monitoring setup in the controls should trend water pumped and associated pressures to also signal an alarm if there is a change in operating conditions.

b. Pumping: Although there are three pumps, two are duty and one is spare to cycle the usage, it is recommended that a fourth pump and spare parts be purchased and placed in storage. (To replace a pump is typically a 10 to 16 week delivery, which would mean that if a pump failure occurred during the spring, most of the pumping requirement time would have been missed.) Pumps should be maintained as soon as the pumping period has been completed so that they are ready for spring pumping efforts.

c. Intake and discharge: Verify status of intake and discharge prior to pumping, during pumping and post pumping activities.

7 Summary and Conclusions

Historical and recent work concerning demand on, and water balance of, the City of Iqaluit's existing Lake Geraldine water source suggest that the municipal reservoir watershed is at or near capacity. Current population projections used for planning purposes certainly suggest that demand on the existing system will exceed supply in the near future or if extreme climatic conditions were to occur.

A preliminary study (documented herein) concerning feasibility to supplement the existing Lake Geraldine system with additional supply from the adjacent Apex River watershed was completed. Two possible locations were assessed in terms of water quality and quantity.

Regarding water quality, sampling completed as part of the current study and comparison to historical Lake Geraldine data suggest no significant concern; i.e. it is expected that the supplementation water withdrawn from Apex River could be mixed with minimal, if any, requirement for additional treatment other than perhaps increased capacity concerning current general public health protection procedures (e.g. chlorination).

Regarding water quantity, results of the preliminary work documented herein suggest that of the two locations considered, based on a 28 year historical stream record, location A2 (or further downstream) would be preferred given a significant additional buffer (e.g. 30 %) for the minimum flow for the three month period in which it is assumed supplementation requirement will be met, and an even higher buffer for the average flow condition relative to the higher supplementary volume requirement identified by others (Golder, 2013).

Under operational conditions, it is recommended that the City implement monitoring measures as described by Golder (2013) to document reservoir levels, demand trends and climate conditions. Pumping should begin as early as possible in the spring to ensure that the reservoir is topped up; this will minimize the possibility that low flow conditions in late summer months might be insufficient to maintain adequate volume in the reservoir at the beginning of the over winter period.

The Opinion of Probable Cost for the Apex River supplemental supply assuming a system was put in place at location A2, is **$6,300,000.00.**

8 References

City of Iqaluit Raw Water Supply and Storage Review, Trow Associates Inc., OTC00016888A, April 2004.

City of Iqaluit Lake Geraldine Water Balance Assessment – Final, Golder Report no. 12-1151-0264 to City of Iqaluit, August 20, 2013.

IPCC Emissions Scenarios Special Report – Summary for Policymakers, Intergovernmental Panel on Climate Change, A Special Report of Working Group III of the Intergovernmental Panel on Climate Change, 2000.

9 Closure

This report was prepared by **exp** Services Inc. for the account of the **City of Iqaluit**. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. **Exp** Services Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Appendix A – Water Sampling Plan

City of Iqaluit

Apex River Supplemental Water Source Sampling Plan

Type of Document:
Draft

Project Number:
FRE-00209588-A0

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May 2013

Legal Notification

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Project No.: FRE-00209588-A0	Date: May 9, 2013
Type of Document: Draft	Revision No.: 0
Prepared By: John Sims, M.Sc.	
Reviewed By: Fred Baechler, M.Sc.	

1 Introduction

Exp Services Inc. (**exp**) was retained by the City of Iqaluit to develop a sampling plan as part of the Supplementary Water Supply Study currently in progress to assess feasibility of the Apex River to supplement the City's existing Lake Geraldine Reservoir. The purpose of the sampling plan is to collect preliminary information on the natural water quality and stream sediment geochemistry of the Apex River.

This report outlines the proposed "Ambient Trend" monitoring program intended to answer the question: *what is the natural water and sediment chemistry quality of the Apex River at the proposed extraction site(s)*. It should be noted that the sampling sites identified herein include the Apex River extraction options suggested in earlier work (Trow 2004). Feasibility and final location of the actual extraction site will be dependent on related work tasks (e.g. hydrologic assessment, ground truthing) of the supplementary study currently in progress. Should it be determined that the project is feasible, results of the preliminary program presented herein will form the basis for refinement of longer term operational sampling requirements (if any).

It is understood that the City will complete the sampling work outlined herein (the City completed the initial sample round in the fall of 2012), with support from **exp** as practical (e.g. if and when **exp** staff are on site). **Exp** will coordinate shipping of sampling containers from the analytical laboratory (Maxxam, Ottawa), and complete data compilation and interpretation.

It is important that the overall rationale and scope of the sampling plan outlined herein be appreciated in the context of the study objectives and availability of available staffing and resources; notably:

- the proposed sampling work outlined in this plan is focussed on screening drinking water quality consistent with the general nature of the overall Apex River feasibility study, i.e. the primary purpose of the work is to identify stream water quality trends to confirm that the water is suitable as a supplemental drinking water source.
- the extent to which the sampling aspects identified in this plan can be completed will depend on field conditions and availability of personnel, equipment and related resources. For example, the proposed sampling locations have been selected for the most part based on desk top review of earlier work, with no onsite field visits completed by exp. It is recognized that equipment and expertise to complete certain aspects beyond basic sample collection and shipping to the laboratory for water quality analyses may not be possible. In this context, certain aspects of the plan (e.g. stream stage measurement) may not be practical at the locations identified.
- it is possible that as part of the regulatory review and approvals process other aspects may be identified for water quality consideration (e.g aquatic habitat quality). However, since at this time no agencies (e.g. DFO) have provided any guidance in this regard the program design focuses solely on potable water criteria.

2 General

2.1 Background

The City of Iqaluit relies on the Lake Geraldine watershed to provide all its municipal water supply requirements. Previous work has suggested that development of a supplemental supply will be required to address the City's projected long term (e.g. 20 year) increase in population and related potable water demand.

To address the projected increase in demand, the City initiated a feasibility assessment to develop a supplementary water supply source (extraction point) within the Apex River watershed located to the east of the Lake Geraldine watershed. Part of the feasibility study is to collect water samples from the Apex River to confirm suitability for development of the supplementary supply.

2.2 Existing Sampling Program

The City's potable water sampling requirements for its existing Lake Geraldine system are outlined in its license to operate issued by the Nunavut Water Licensing Board. It is the intent that the sampling plan outlined herein will include all parameters in the existing plan, as well as additional parameters to document baseline water chemistry for the proposed Apex River supplemental supply.

Existing sampling list for Lake Geraldine include field measured parameters. It is the suggested that the City may wish to consider purchase of a field meter (e.g. YSI brand or equivalent) capable of measuring field parameters (e.g. conductivity, pH, temperature), and that this meter be used as part of the sampling plan outlined herein.

3 Apex River Sampling Plan

3.1 Sampling Locations

Sampling locations identified at this time include the tentative extraction point options A1 and A2 proposed by Trow 2004. It is suggested that, if practical, samples also be collected from the Apex River hydrologic monitoring station established by Environment Canada (Apex River at Apex), and from the existing raw water monitoring station on Lake Geraldine (raw water before treatment plant).

The approximate locations of sampling points are indicated on Figure 3-1, and are summarized below.

1) **Location A1** - utm zone 19 nad83 coordinate 526480E 7070000N (to be confirmed by field GPS) at bridge; actual site to be finalized by field inspection

2) **Location A2** - utm zone 19 nad83 coordinate 526300E 7069250N (to be confirmed by field GPS); actual site to be confirmed by field inspection

3) **Lake Geraldine** - at a valve as the main enters the Water Treatment Plant (if sampling personnel other than regular operations staff, verify with Operator before taking sample)

4) **Apex River EC Hydrometric Station**

These locations were selected based on practical considerations including:

- sampling locations required identification early in the study and without the aid of field observation.
- they were understood to have been near a previously sampled location and would provide a basis for comparison to previous results with "one less" variable (i.e. similar locations).
- they are considered representative of the watershed area along which extraction point options could reasonably be expected to be established at the preliminary stage of the study.
- sampling of Lake Geraldine concurrent with sampling along the Apex will provide for comparison of the existing water source to the proposed supplementary supply.

3.2 Sampling Matrices and Analytical Suites

3.2.1 Water Samples

General Chemistry and Trace Metals - Water quality analytical parameters are summarized in Table 1. Proposed sampling suite will include RCAp (rapid chemical analytical package), metal scan (including uranium and mercury), total nitrogen, total phosphorous, acidity, and total suspended sediment.

It is suggested that for water samples, two samples be collected for metals analysis - one field filtered and acidified and one untreated. Currently it is understood that the City is not equipped to collect field filtered samples. As the sampling work progresses, **exp** will work to provide ongoing support to assist the City with the logistics related to collection of filtered samples (e.g. package of disposable syringes with field filters will be forwarded with instructions).

Microbiological - Total and faecal (e-coli) bacteria with counts (**note** - not limited to presence absence). It is noted that these may not be practical given the short turn around times required by laboratory analytical holding time protocols. However, where sampling time permits, it is recommended that microbiological parameters be sampled.

Organic Contaminants - Analytical screening for organic contaminants is recommended to include total petroleum hydrocarbons, BTEX, and PAH compounds. Because these analytical packages are typically more costly than general chemistry, sampling frequency will be lower, and continued sampling and frequency for these organic contaminant screening packages will be based on preliminary results.

The low frequency for organic contaminant sampling is based mainly on the understanding that the Apex River is a relatively “pristine” watershed (e.g. low level of current and historical commercial/ institutional development). Pending discussion with the City, it is possible that additional organic parameters may be added on a “one time” basis to more completely reflect the full range of drinking water quality parameters listed by Health Canada – for example, if it is suspected that herbicides or pesticides have been or are known to be used in the water shed, samples may be suggested to screen for these or other parameters.

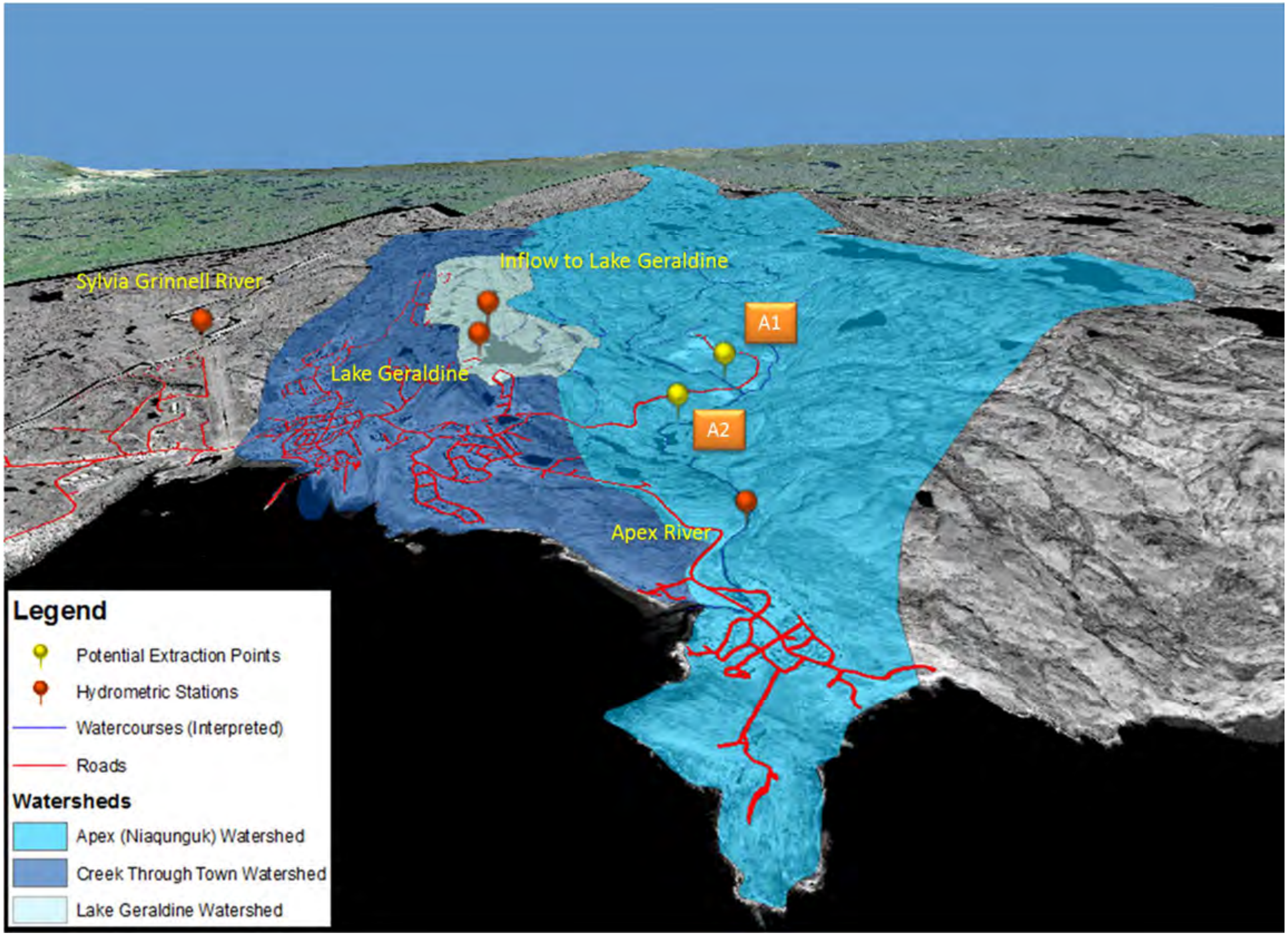


Figure 3-1a) Sampling locations and related points of interest.

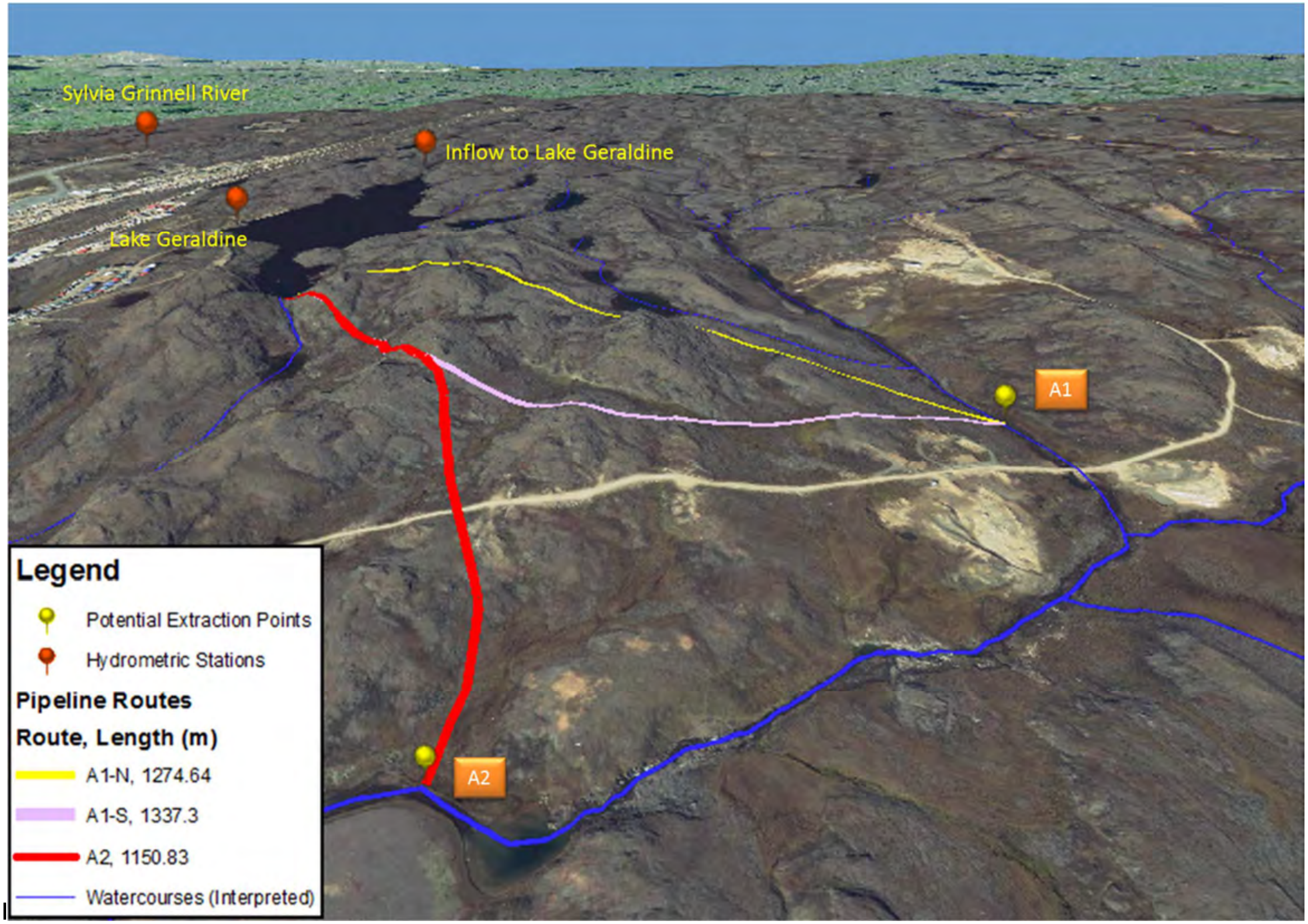


Figure 3-1b) Oblique perspective of sampling reaches and possible transmission line routes from Apex to Lake Geraldine.

Table 1 – Apex River Monitoring Schedule and Analytical Suites

Sample Type	Sample Location	Month												Analyses
		J	F	M	A	M	J	J	A	S	O	N	D	
Surface Water Quality Monitoring	***Weekly***													
	A1					✓	✓	✓	✓	✓	✓			✓ RCAp General Chemistry, Trace Metals, total nitrogen, total phosphorous, acidity, suspended sediment, microbiology and Field readings to be taken during each monitoring round – e.g. water stage level; if meter is available readings for pH, temperature, and conductivity (also DO and turbidity if equipment is capable) . ***NOTE – exp will work with the City to identify and develop capacity to complete field readings.***
	A2					✓	✓	✓	✓	✓	✓			
	Monthly													
	Apex Hydrometric Station					✓	✓	✓	✓	✓				✓ RCAp General Chemistry, Trace Metals, total nitrogen, total phosphorous, acidity, suspended sediment and microbiology. □ organic contaminant screening suite (petroleum hydrocarbons, PAHs).
	Lake Geraldine					✓	✓	✓	✓	✓				
	A1					□	□	□	□	□				
	A2					□	□	□	□	□				
Sediment Sampling	***One Sample Event Only (in July or August)***													
	A1						■	■	■	■				■ metal scan including uranium and mercury on: total, -80 and –230 mesh fractions using CCME protocols (CGSB-164-GP-IMP)
	A2						■	■	■	■				

Note –

1) for water samples two samples should be collected for metals analysis - one field filtered and acidified and one untreated (*note – exp will work to provide instruction and materials to assist in field filtering samples*).
2) samples should be collected as grab samples within a good mixing zone at the sampling station, not depth or width integrated – at this time it is assumed since samples will be collected along running stream reaches, locations will be well mixed – note standing or stagnant water to be avoided; disturbance of stream bed also to be avoided.
3) Monthly sample round can correspond to the weekly round; i.e. supplement one week per month with the organic screening suite listed above.

3.2.2 Stream Bed Sediment Sampling

Pending field conditions (i.e. presence of sediment in the stream bed), sampling of fine grained (very fine sand to clay) stream bed sediment should be acquired once during July/August. Samples should be collected if sediment is available at four different locations within approximately 0.5 km up and downstream of the sampling stations.

Analytical parameters will include a metal scan including uranium and mercury on: total, -80 mesh and – 230 mesh fractions using CCME protocols (CGSB-164-GP-IMP). (**Note** – the inclusion of sediment sampling in the preliminary monitoring program will be dependent on current request for information from the Geological Survey of Canada regarding any stream/lake sediment sampling program on the Apex River that has been completed or is in progress).

NOTE – AT TIME OF WRITING NOTHING BACK FROM GSC PERSONNEL AS YET. NOTE URANIUM AND MERCURY ARE NOT THE ONLY METALS BEING MONITORED JUST EXTRA ABOVE AND BEYOND THE NORMAL METAL SCAN

3.2.3 Field Parameters

If practical, recommended field parameters include temperature, conductivity, dissolved oxygen (DO), turbidity and pH. However, at this time it is recognized that the City has minimal field equipment to complete field readings. **Exp** can assist the City in identifying appropriate field gear (e.g. YSI multi-function field meter) to complete field reading, if desired.

Digital photographs should be acquired during each sampling event looking upstream and downstream from the sampling station, as well as across the channel and down into the water at the station. An object should be included in the photograph (e.g. field book) to provide sense of scale.

A visual description should be made of colour, turbidity, floating material on surface and any discolouration on bed material (precipitate, floc etc).

During the beginning and end of the field season it will be important to ensure photographs and visual descriptions key in on ice development and release. This should at a minimum noted % and type of surface ice cover, presence of frazil ice and anchor ice, floating ice pans, as well as ice jams and any backwater effects.

The presence of any obvious groundwater springs along the channel banks, valley floor or upwelling in the bed should be identified, located with a GPS, field parameters monitored and photographs taken. At that time a decision will have to be made as to whether to sample these as well for chemistry. Weather related information e.g. precipitation (rain/snow), depth of snow on ground and mean daily air temperature will be obtained from the local Env. Can climate station. Since depth of snow cover will change considerably over the terrain a note should also be made by the sampler as to snow cover near sampling station - accompanied with photographs.

3.3 Steam Discharge

Development and implementation of a protocol to document stream discharge and stage level for the sampling rounds at each station is suggested. However, at this time it is recognized that the City has minimal field equipment to complete stream flow readings.

Assuming sampling is completed at the Environment Canada Apex River stream gauging station, the EC data for this station can be used. For the other Apex River locations (A1 and A2), in recognition that there is minimal equipment and capacity to measure flow, suggested options for consideration at this time include:

- At Station A-1 where a bridge is present, measure distance from bridge deck to water level near sampling station, if there is a bridge nearby.

- Drive a stake or metal rod into stream bed, mark, label and record water level/ date on the measuring stake/rod and in field notes. If a survey crew is available the top of the measuring point should be surveyed into geodetic for horizontal and vertical (0.01m) control. If possible at low summer flows and if safe to do so the survey crew should survey in a detailed channel cross section where stage level is being monitored.

3.4 Quality Control/ Quality Assurance (QA/QC)

Laboratory Certification - Sample analyses should be completed by a CALA accredited (or equivalent) laboratory to fresh drinking water standards. If fisheries becomes an important aspect of watershed consideration, then lower detection limits to meet fresh water aquatic standards may have to be considered as part of possible future work (beyond the scope of this plan).

QA/ QC – QA/QC will be limited to the standard analytical laboratory provided QA/ QC program. Based on ongoing review by **exp**, additional quality control and quality assurance considerations may be suggested and include the following.

A. any sample with greater than 10% ion balance error should be re-run by lab, and

B. a blind, same lab duplicate, should be collected for analysis on every 5th sample

3.5 Sampling Frequency

Sampling frequency is summarized in Table 1. For the first year sample at once/week frequency for general chemistry suite, attempting to acquire samples at a variety of discharges. This should be maintained for 1 calendar year – it is assumed that samples will only be collected during open water conditions ice free period. Less frequency should be adequate for the other analytical suites. The results should be analyzed at that time and then decisions made for design of the longer term program.

Note that Table 1 lists sampling for May and October; feasibility of collecting samples during these months will be dependent on suitable conditions.

3.6 Data Management

Field data should be recorded in a field book and photographs appended. A copy of the Chain of Custody accompanying each sample shipment to the laboratory should be included with the field report.

On receipt of laboratory data, it is understood a copy will be provided to **exp**.

3.7 Health & Safety

Health and Safety considerations should be a key component in implementation of field work. Aspects include the remote nature of sampling locations and potential harsh environment conditions.

4 Reporting

A report should be prepared after the first year of monitoring which analyzes the results and determines how the program should be modified for the following years (if warranted) in terms of answering the question posed by the monitoring program design.

5 Closing and Limitations

This report was prepared by **exp** for the account of the City of Iqaluit. The material in this report reflects **exp**'s best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance or decisions to be made based upon it, are the responsibility of such third parties. **Exp** accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

If site conditions or applicable standards change or if additional information becomes available at a future date, modifications to the findings, conclusions and recommendations in this report may be necessary.

This report was written by John Sims, M.Sc. and reviewed by Fred Baechler. M.Sc..

Appendix B – Water Quality Results

Table B.1: Analytical Results for General Chemistry

FRE-00209588-A0

					Previous Results (2000 and 2003)					City Supplied Data			2012 Analytical Results								
Laboratory ID:										100342-001	974525	994161	PK1717	PK1717	PK1718	PK1719	PK1719	RX6456	RY8359	RY8361	SB1597
Client ID:					Iqaluit 2000	Creek 1	Creek 3	Sylvia Grinnell	Lake Geraldine	Iqaluit Raw Potable	Iqaluit Raw Potable	Iqaluit Raw Potable	AS1	AS1 Lab Dup	AS2	Lake Geraldine Reservoir	Lake Geraldine Reservoir Lab	A1	A1	A3 Field Dup A1	A1
Date: (YYYY/MM/DD)					July 26/00	Sept 4/03	Sept 4/03	Sept 4/03	Sept 4/03	Jul 1/10	Jul 25/12	Oct 25/12	Oct 26/12	Oct 26/12	Oct 26/12	Oct 26/12	Oct 26/12	Jun 14/13	Jun 19/13	Jun 19/13	June 26/13
	Units	**MDL**	**Guideline[1]**	**Guideline[2]**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Alkalinity	mg/L	1			-	-	-	-	-	9.4	15		44	44	38	20		3.8	8.5	8.3	9
Ammonia	mg/L	0.05			0.22	<0.01	<0.01	<0.01	<0.01	<0.01			0.12		0.11	0.11		0.03	0.01	0.05	0.03
Chloride	mg/L	1.0	250	120	-	-	-	-	-	<0.7	1		1		1	<1	<1	1	<1	<1	<1
Conductivity	μS/cm	120			96	72	99	45	50	24	38		120	120	110	49		17	29	28	25
Fluoride	mg/L	0.100	1.5	120	-	<0.1	<0.1	<0.1	<0.1				-		-	-			<0.10	<0.10	<0.10
Nitrite	mg/L	0.01	1			<0.1	<0.1	<0.1	<0.1	0.12			<0.010		<0.010	<0.010		<0.01	<0.010	<0.010	<0.010
Nitrate	mg/L	0.10	10	13	0.77	0.10	0.10	0.10	0.10				<0.10		<0.10	<0.10		<0.1	<0.1	<0.1	<0.10
Nitrate + Nitrite																		<0.1	<0.1	<0.1	<0.10
o-Phosphate	mg/L	0.01			-	<0.01	<0.01	<0.01	<0.01				<0.010		<0.010	<0.010		<0.010	<0.010	<0.010	<0.010
pH		-	6.5 - 8.5	6.5-9	7.93	7.81	7.98	7.81	7.81	6.93	6.76		**6.35**	**6.4**	6.67	6.57		**6.39**	6.76	6.68	7.45
Sulfate	mg/L	1	500		4	7	4	3	2	1	3		15		14	3	3	<1	2	2	2
Dissolved Organic Carbon	mg/L	1.0			-	2.0	3.0	2.0	2.0				1.0		1	1.7	<0.010	2.6	1.8	1.9	1.4
Total Inorganic Carbon	mg/L	1.0			-	-	-	-	-		3.7		8.0		8	4	4	1	2	2	2
Total Organic Carbon	mg/L	0.2			-	-	-	-	-		2.4		1.0		0.99	1.9		3.3	2.1	1.7	1.5
Turbidity	NTU	0.2	2	1	0.9	0.4	0.3	0.8	0.8	0.43			0.3		0.3	0.6		0.5	0.7	0.4	<0.2
Calculated Parameters													-		-	-					
Bicarbonate	mg/L	1			-	-	-	-	-		15		44.000		38.000	20.000		3.8	8.5	8.3	9
Carbonate	mg/L	1			-	-	-	-	-		NA		<1.0		<1	<1		<1	<1	<1	<1
Cation sum	meq/L	-			-	-	-	-	-				1.130		1.050	0.473		0.152	0.255	0.263	0.23
Anion sum	meq/L	-			-	-	-	-	-				1.230		1.080	0.459		0.108	0.221	0.217	0.214
Calculated TDS					-	-	-	-	-		25		69.000		61.000	25.000		7	13	14	12
Hardness	mg/L	1			-	-	-	-	-	11.4	12		53.000		49.000	21.000		6.2	12	12	10
Ion Balance (% difference)	%	-			-	-	-	-	-				NC		NC	NC		NC	NC	NC	NC
Saturation pH 20C	-	-			-	-	-	-	-				8.44		8.53	9.18		NC	9.79	9.81	9.79
Saturation pH 4 C	-	-			-	-	-	-	-				8.69		8.78	9.44		NC	10	10.1	10
Langelier Index 20 C	-	-			-	-	-	-	-				-2.08		-1.86	-2.62		NC	-3.03	-3.12	-2.34
Langelier Index 4 C	-	-			-	-	-	-	-				-2.34		-2.12	-2.87		NC	-3.28	-3.37	-2.59
Kjeldahl Nitrogen	mg/L	0.25				-	-	-	-									0.19	0.95	0.13	0.15
Phosphorus	mg/L										<0.01							0.005	0.005	0.005	<0.002
Acidity	mg/L	10				-	-	-	-		<5		12		12	<10	<10	<10	<10	<10	<10
Total Dissolved Solids	mg/L	10	500			-	-	-	-				52		50	28		<10	42	48	16
Total Suspended Solids	mg/L	10			5	<3	<3	<3	<3	<3	<2		19		<10	<10		<1	<1	<1	<1

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012
Guideline [2] - CCME Freshwater Aquatic Life, CCME 2010
(-) Not Analyzed

Underlined concentrations - Above CCME Fresh Water Aquatic Life Guidelines
Bolded concentrations - Above Health Canada Canadian Drinking Water Guidelines

Table B.1: Analytical Results for General Chemistry

FRE-00209588-A0

					2013 Analytical Results																		
Laboratory ID:					SC8961	SC8961	SF0390	SH7911	SK0026	SM4855	SO3905	SQ8881	ST4354	SV9028	SX8285	TA4618	TF4268	TF4270	TI0675	RX6457	RY8360	SB1598	SC8962
Client ID:					A1	A1 Lab-Dup	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A1	A3 Field Dup A1	A1	A2	A2	A2	A2
Date: (YYYY/MM/DD)					July 3/13	July 3/13	July 10/13	July 17/13	July 24/13	July 31/13	Aug 7/13	Aug 14/13	Aug 21/13	Aug 28/13	Sept 4/13	Sept 11/13	Sept 25/13	Sept 25/13	Oct 2/13	Jun 14/13	Jun 19/13	June 26/13	July 3/13
	Units	**MDL**	**Guideline[1]**	**Guideline[2]**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Alkalinity	mg/L	1			12		14	17	21	24	26	29	29	30	29	30	28	27	24	5.5	9.6	10	12
Ammonia	mg/L	0.05			0.02		0.02	0.03	0.04	0.01	0.07	0.05	0.05	0.06	0.02	0.03	0.1	0.08	0.08	0.06	<0.01	0.04	0.02
Chloride	mg/L	1.0	250	120	<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	1	<1	<1
Conductivity	µS/cm	120			34		43	49	53	63	73	80	84	81	83	85	84	88	74	23	35	33	38
Fluoride	mg/L	0.100	1.5	120			<0.10	<0.10	<0.10	<0.10		<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10		<0.10	<0.10	
Nitrite	mg/L	0.01	1		<0.010		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01	<0.010	<0.010	<0.01	<0.01	<0.010	<0.010	<0.01
Nitrate	mg/L	0.10	10	13	<0.10		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate + Nitrite					<0.10		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
o-Phosphate	mg/L	0.01			<0.010		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
pH		-	6.5 - 8.5	6.5-9	7.09		7.05	7.22	7.48	7.43	7.66	7.72	7.64	7.71	7.58	7.59	7.5	7.54	7.19	**6.49**	6.74	6.65	6.69
Sulfate	mg/L	1	500		3		4	5	5	7	8	8	9	9	10	10	10	12	9	1	4	3	4
Dissolved Organic Carbon	mg/L	1.0			1.2		1.1	1.1	1.1	1	0.93	1.2	1	0.94	1.1	1.1	1.1	1.1	1.2	2.7	1.8	1.3	1.3
Total Inorganic Carbon	mg/L	1.0			3		4	4	5	6	7	6	6	7	6	6	7	7	5	2	3	3	3
Total Organic Carbon	mg/L	0.2			1.2		1.1	1.3	1.1	1.3	0.98	1.1	0.97	0.98	1.1	0.93	0.99	0.97	1.1	3.2	1.8	1.5	1.3
Turbidity	NTU	0.2	2	1	0.3	0.3	<0.2	0.2	0.2	<0.2	<0.2	0.3	0.4	<0.2	0.2	0.2	0.2	0.2	<0.2	1.8	1	0.4	0.5
Calculated Parameters																							
Bicarbonate	mg/L	1			12		14	17	20	24	26	29	29	30	29	30	28	27	24	5.5	9.5	10	12
Carbonate	mg/L	1			<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cation sum	meq/L	-			0.362		0.4	0.5	0.539	0.575	0.687	0.744	0.843	0.823	0.798	0.801	0.815	0.81	0.73	0.209	0.304	0.311	0.372
Anion sum	meq/L	-			0.288		0.359	0.45	0.525	0.609	0.683	0.758	0.779	0.776	0.79	0.807	0.767	0.785	0.668	0.174	0.301	0.272	0.319
Calculated TDS					18		22	27	30	34	38	43	46	45	46	46	46	46	41	11	18	16	20
Hardness	mg/L	1			16		19	23	25	27	32	35	39	39	38	38	38	38	34	8.6	14	14	17
Ion Balance (% difference)	%	-			NC		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Saturation pH 20C	-	-			9.51		9.38	9.17	9.06	8.99	8.89	8.78	8.73	8.75	8.78	8.75	8.79	8.8	8.91	NC	9.68	9.58	9.48
Saturation pH 4 C	-	-			9.77		9.63	9.42	9.31	9.24	9.14	9.04	8.98	9	9.03	9	9.04	9.05	9.16	NC	9.93	9.83	9.73
Langelier Index 20 C	-	-			-2.42		-2.33	-1.94	-1.58	-1.56	-1.23	-1.07	-1.08	-1.04	-1.2	-1.16	-1.29	-1.26	-1.72	NC	-2.94	-2.93	-2.79
Langelier Index 4 C	-	-			-2.67		-2.58	-2.2	-1.83	-1.81	-1.48	-1.32	-1.33	-1.29	-1.45	-1.41	-1.54	-1.51	-1.97	NC	-3.19	-3.18	-3.04
Kjeldahl Nitrogen	mg/L	0.25			<0.1	<0.1	<0.10	0.15	<0.10	0.3	0.68	<0.10	0.14	0.28	0.18	<0.10	0.26	0.38	0.23	0.29	0.19	0.15	<0.1
Phosphorus	mg/L				<0.002		<0.002	<0.002	0.003	<0.002	0.003	<0.002	<0.002	0.004	0.002	<0.002	<0.002	<0.002	<0.002	0.046	0.015	0.01	<0.002
Acidity	mg/L	10			<10		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total Dissolved Solids	mg/L	10	500		32	34	42	24	20	42	78	42	40	52	66	44	68	64	80	<10	72	12	46
Total Suspended Solids	mg/L	10			<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	27	11	6	<1

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012
Guideline [2] - CCME Freshwater Aquatic Life, CCME 2010
(-) Not Analyzed

Underlined concentrations - Above CCME Fresh Water Aquatic Life Guidelines
Bolded concentrations - Above Health Canada Canadian Drinking Water Guidelines

Table B.1: Analytical Results for General Chemistry

FRE-00209588-A0

Laboratory ID:					SF0391	SH7912	SK0027	SM4856	SO3934	SQ8882	ST4355	SV9029	SX8286	TA4619	TF4269	TI0676	RX5069	SC9452	SO3221	TA4349	RX5070	SC9451	SO3220
Client ID:					A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	WTP	WTP	WTP	WTP	Hydrometric Station	Hydrometric Station	Hydrometric Station
Date: (YYYY/MM/DD)					July 10/13	July 17/13	July 24/13	July 31/13	Aug 7/13	Aug 14/13	Aug 21/13	Aug 28/13	Sept 4/13	Sept 11/13	Sept 25/13	Oct 2/13	Jun 14/13	July 3/13	Aug 7/13	Sept 11/13	Jun 14/13	July 3/13	Aug 7/13
	Units	**MDL**	**Guideline[1]**	**Guideline[2]**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Alkalinity	mg/L	1			15	16	21	24	25	27	29	28	29	29	29	25	25	22	12	13	5.4	13	27
Ammonia	mg/L	0.05			0.02	0.04	0.02	<0.01	0.03	0.04	0.04	0.02	0.07	0.03	0.07	0.06	0.05	<0.01	0.05	0.04	0.03	0.03	0.08
Chloride	mg/L	1.0	250	120	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2	2	<1	1	1	<1	<1
Conductivity	µS/cm	120			47	53	58	67	73	77	82	81	85	87	88	81	65	57	36	37	23	38	72
Fluoride	mg/L	0.100	1.5	120	<0.10	<0.10	<0.10	<0.10		<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10				<0.10			
Nitrite	mg/L	0.01	1		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate	mg/L	0.10	10	13	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate + Nitrite					<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
o-Phosphate	mg/L	0.01			<0.010	<0.010	<0.010	<0.010	ND	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
pH		-	6.5 - 8.5	6.5-9	6.67	6.95	7.5	7.49	7.62	7.67	7.68	7.63	7.6	7.55	7.55	7.27	7.29	6.75	7.29	7.19	6.57	6.71	7.73
Sulfate	mg/L	1	500		5	6	7	8	8	8	9	9	11	11	11	12	5	4	2	3	1	4	8
Dissolved Organic Carbon	mg/L	1.0			1.2	1.1	1.1	0.98	0.95	1.1	0.98	1.1	0.99	1.1	1	1.3	2	2.2	1.5	1.6	2.7	1.3	0.97
Total Inorganic Carbon	mg/L	1.0			4	4	5	6	7	6	6	6	6	6	7	5	5	5	4	3	2	3	6
Total Organic Carbon	mg/L	0.2			1.2	1.2	1.1	1.2	1.1	0.94	0.98	0.91	1	0.95	1	1.3	2.5	2.3	1.6	1.9	3.6	1.5	1
Turbidity	NTU	0.2	2	1	0.4	<0.2	<0.2	0.3	<0.2	0.2	0.3	<0.2	0.2	0.3	0.2	<0.2	0.5	0.6	0.5	**3.2**	0.8	0.4	<0.2
Calculated Parameters																							
Bicarbonate	mg/L	1			15	16	21	24	25	27	29	28	29	29	29	25	25	22	12	13	5.4	13	27
Carbonate	mg/L	1			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cation sum	meq/L	-			0.449	0.567	0.583	0.614	0.669	0.735	0.85	0.85	0.846	0.826	0.813	0.786	0.59	0.588	0.339	0.362	0.2	0.387	0.658
Anion sum	meq/L	-			0.401	0.449	0.548	0.633	0.664	0.72	0.762	0.747	0.794	0.795	0.821	0.752	0.649	0.569	0.296	0.341	0.175	0.331	0.699
Calculated TDS					24	28	32	35	38	41	45	45	47	47	48	45	34	32	17	19	11	20	38
Hardness	mg/L	1			21	26	27	29	32	35	40	40	40	39	38	37	27	27	15	16	8.1	18	31
Ion Balance (% difference)	%	-			NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Saturation pH 20C	-	-			9.25	9.13	9.02	8.95	8.91	8.82	8.74	8.77	8.76	8.75	8.77	8.85	NC	9.06	9.55	9.5	NC	9.44	8.89
Saturation pH 4 C	-	-			9.5	9.38	9.27	9.2	9.16	9.07	8.99	9.02	9.01	9	9.02	9.11	NC	9.32	9.8	9.75	NC	9.69	9.14
Langelier Index 20 C	-	-			-2.58	-2.18	-1.51	-1.46	-1.28	-1.15	-1.05	-1.13	-1.16	-1.2	-1.21	-1.59	NC	-2.32	-2.26	-2.31	NC	-2.72	-1.17
Langelier Index 4 C	-	-			-2.84	-2.43	-1.77	-1.71	-1.53	-1.41	-1.3	-1.39	-1.41	-1.45	-1.46	-1.84	NC	-2.57	-2.51	-2.57	NC	-2.98	-1.42
Kjeldahl Nitrogen	mg/L	0.25			<0.10	0.23	0.17	0.46	0.31	0.11	0.21	0.22	0.45	0.17	0.17	0.2	0.16	0.26	0.29	0.99	0.2	0.27	0.2
Phosphorus	mg/L				<0.002	<0.002	<0.002	0.014	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	0.004	0.006	0.019	0.007	<0.002
Acidity	mg/L	10			<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total Dissolved Solids	mg/L	10	500		10	22	22	44	66	48	46	62	60	40	62	84	<10	46	42	24	<10	44	68
Total Suspended Solids	mg/L	10			<1	<1	2	<1	<1	<1	<1	2	<1	<1	<1	1	1	<1	1	<1	14	<1	<1

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012
Guideline [2] - CCME Freshwater Aquatic Life, CCME 2010
(-) Not Analyzed

Underlined concentrations - Above CCME Fresh Water Aquatic Life Guidelines
Bolded concentrations - Above Health Canada Canadian Drinking Water Guidelines

Table B.1: Analytical Results for General Chemistry

FRE-00209588-A0

Laboratory ID:					TA4347
Client ID:					Hydrometric Station
Date: (YYYY/MM/DD)					Sept 11/13
	Units	**MDL**	**Guideline[1]**	**Guideline[2]**	**Results**
Alkalinity	mg/L	1			30
Ammonia	mg/L	0.05			0.03
Chloride	mg/L	1.0	250	120	1
Conductivity	µS/cm	120			89
Fluoride	mg/L	0.100	1.5	120	
Nitrite	mg/L	0.01	1		<0.01
Nitrate	mg/L	0.10	10	13	<0.1
Nitrate + Nitrite					<0.1
o-Phosphate	mg/L	0.01			<0.010
pH		-	6.5 - 8.5	6.5-9	7.6
Sulfate	mg/L	1	500		11
Dissolved Organic Carbon	mg/L	1.0			1.2
Total Inorganic Carbon	mg/L	1.0			6
Total Organic Carbon	mg/L	0.2			0.99
Turbidity	NTU	0.2	2	1	0.5
Calculated Parameters					
Bicarbonate	mg/L	1			29
Carbonate	mg/L	1			<1
Cation sum	meq/L	-			0.832
Anion sum	meq/L	-			0.851
Calculated TDS					48
Hardness	mg/L	1			38
Ion Balance (% difference)	%	-			NC
Saturation pH 20C	-	-			8.75
Saturation pH 4 C	-	-			9.01
Langelier Index 20 C	-	-			-1.15
Langelier Index 4 C	-	-			-1.41
Kjeldahl Nitrogen	mg/L	0.25			0.28
Phosphorus	mg/L				<0.002
Acidity	mg/L	10			<10
Total Dissolved Solids	mg/L	10	500		48
Total Suspended Solids	mg/L	10			<1

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012
Guideline [2] - CCME Freshwater Aquatic Life, CCME 2010
(-) Not Analyzed

Underlined concentrations - Above CCME Fresh Water Aquatic Life Guidelines
Bolded concentrations - Above Health Canada Canadian Drinking Water Guidelines

Table B.2a: Analytical Results for Dissolved Trace Metals

FRE-00209588-A0

Laboratory ID:				GR5115	RY8359	RY8361	SB1597	SC8961	SF0390	GZ1922	HA4657	HB9247	HB9247	HD8862	HF5413	HH5005	HJ5456	HK8415	HM9696	HQ8465
Client ID:				A1	A1	A3 Field Dup A1	A1	A1	A1	A1	A1	A1	A1 Lab Dup	A1	A1	A1	A1	A1	A1	A1
Date: (YYYY/MM/DD)				Jun 14/13	Jun 19/13	Jun 19/13	June 26/13	July 3/13	July 10/13	July 17/13	July 24/13	July 31/13	July 31/13	Aug 7/13	Aug 14/13	Aug 21/13	Aug 28/13	Sept 4/13	Sept 11/13	Sept 25/13
	Units	**Guideline[1]**	**Guideline[2]**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Aluminum	µg/L	100	5 (pH<6.5) 100 (pH>=6.5)	18	16	14	89	7.7	8.6	5.4	11	6.7	na	12	7.9	5.7	4.5	7.4	12	6.9
Antimony	µg/L	6		<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	na	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Arsenic	µg/L	10	5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	na	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Barium	µg/L	1000		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Beryllium	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	<1	na	<1	<1	<1	<1	<1	<1	<1
Boron	µg/L	5000	1500	<20	57	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium	µg/L	5		0.01	<0.025	<0.025	0.0084	0.021	0.011	0.0074	<0.0050	0.0073	na	<0.0050	<0.0050	0.0088	<0.005	<0.005	<0.0050	<0.0050
Calcium	µg/L			1900	3300	3300	3300	4400	5800	7200	6800	9800	9800	11000	12000	11000	12000	11000	13000	13000
Chromium	µg/L	50	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	na	<1	2.2	<1	<1	<1	<1	<1
Cobalt	µg/L			<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	na	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Copper	µg/L	1000		0.66	0.57	0.98	0.8	2.5	0.97	1	0.71	0.57	na	0.58	0.55	0.76	0.3	0.69	0.44	0.57
Iron	µg/L	300	300	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
Lead	µg/L	10		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	na	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Lithium	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Magnesium	µg/L			320	510	510	470	600	820	940	950	1300	1300	1400	1600	1600	1700	1600	1900	1900
Manganese	µg/L	50		7.1	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Molybdenum	µg/L		73.0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.21	<0.2	<0.2	na	0.23	0.27	0.23	0.21	0.27	<0.2	0.24
Nickel	µg/L			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	na	<0.5	0.84	<0.5	<0.50	<0.5	<0.5	<0.5
Phosphorus				<100	<100	<100	<100	<100	<100	<100	<100	120	<100	<100	<100	<100	<100	<100	<100	<100
Potassium	µg/L			<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
Selenium	µg/L	10	1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	na	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Silicon				300	500	520	510	660	750	810	870	1100	1100	1100	1200	1200	1400	1300	1600	1700
Silver	µg/L		0.1	<0.1	<0.1	<0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	na	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium	µg/L	200000		800	<500	<500	<500	710	620	630	660	770	770	810	840	840	870	920	970	860
Strontium	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<0.020	<20	<20	<20	<20	<20	<20	20	20
Sulphur	µg/L			540	810	950	680	870	1300	1600	1600	2100	2100	2500	2800	2700	3000	3000	3300	3700
Thallium	µg/L		0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	na	<0.2	<0.20	<0.2	<0.2	<0.2	<0.2	<0.2
Tin	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	<1	na	<1	<1	<1	<1	<1	<1	<1
Titanium	µg/L			<1	<1	<5	<1	<1	<1	<1	<1	<1	na	<1	<1	<1	<1	<1	<1	<1
Uranium	µg/L	20	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	na	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.12
Vanadium	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	<1	na	<1	<1	<1	<1	<1	<1	<1
Zinc	µg/L	5000	30	<3	<3	<3	<3	3.5	<3	<3	<3	<3	na	<3	<3	<3	<3	<3	5.7	4.3

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012
Guideline [2] - CCME Freshwater Aquatic Life, CCME 2010
(-) Not Analyzed

Underlined concentrations - Above CCME Fresh Water Aquatic Life Guidelines
Bolded concentrations - Above Health Canada Canadian Drinking Water Guidelines

Table B.2a: Analytical Results for Dissolved Trace Metal

FRE-00209588-A0

				2013 Analytical Results																
Laboratory ID:				HQ8467	HT7727	GR5116	RY8360	SB1598	SC8962	SF0391	GZ1923	HA4658	HB9248	HD8863	HF5414	HH5006	HJ5456	HK8416	HM9697	HQ8466
Client ID:				A3 Field Dup A1	A1	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2
Date: (YYYY/MM/DD)				Sept 25/13	Oct 2/13	Jun 14/13	Jun 19/13	June 26/13	July 3/13	July 10/13	July 17/13	July 24/13	July 31/13	Aug 7/13	Aug 14/13	Aug 21/13	Aug 28/13	Sept 4/13	Sept 11/13	Sept 25/13
	Units	**Guideline[1]**	**Guideline[2]**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Aluminum	µg/L	100	5 (pH<6.5) 100 (pH>=6.5)	11	12	20	16	9.9	9.8	11	8.1	11	9.7	9.1	9.8	7.6	7.5	4.8	4.8	7.5
Antimony	µg/L	6		<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
Arsenic	µg/L	10	5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Barium	µg/L	1000		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Beryllium	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Boron	µg/L	5000	1500	<20	<20	<20	27	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium	µg/L	5		<0.0050	0.0067	0.014	<0.025	<0.0050	0.015	<0.005	<0.0050	<0.005	0.0087	<0.0050	<0.0050	0.011	<0.005	<0.0050	<0.0050	<0.005
Calcium	µg/L			13000	11000	2700	4300	4500	5200	6600	7900	7600	10000	11000	12000	11000	12000	12000	13000	13000
Chromium	µg/L	50	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cobalt	µg/L			<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Copper	µg/L	1000		0.44	1.3	1.2	0.89	0.56	0.75	0.36	0.71	0.39	0.67	0.57	0.75	0.93	0.29	0.85	0.4	0.42
Iron	µg/L	300	300	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
Lead	µg/L	10		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Lithium	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Magnesium	µg/L			1900	1600	400	600	570	640	890	980	1000	1300	1400	1500	1500	1700	1700	1900	1900
Manganese	µg/L	50		4.3	<4	13	7	4.5	<4	<4	4.5	6.6	<4	<4	<4	<4	<4	<4	<4	7.7
Molybdenum	µg/L		73.0	0.21	0.21	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	0.22	0.23	<0.2	0.21
Nickel	µg/L			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.50
Phosphorus				<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Potassium	µg/L			<300	<300	340	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
Selenium	µg/L	10	1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Silicon				1600	1600	350	550	480	640	780	810	850	1000	1000	1100	1100	1300	1300	1500	1600
Silver	µg/L		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium	µg/L	200000		860	860	960	<500	500	540	610	620	650	790	830	840	850	870	940	960	870
Strontium	µg/L			20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	20
Sulphur	µg/L			3900	3100	700	1300	1100	1200	1700	1900	2000	2500	2500	2700	2700	3200	3300	3700	3900
Thallium	µg/L		0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.20	<0.20	<0.20	<0.2	<0.20	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Tin	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Titanium	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Uranium	µg/L	20	15	<0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Zinc	µg/L	5000	30	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	8.4	<3	<3	<3	4.1

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012
Guideline [2] - CCME Freshwater Aquatic Life, CCME 2010
(-) Not Analyzed

Underlined concentrations - Above CCME Fresh Water Aquatic Life Guidelines
Bolded concentrations - Above Health Canada Canadian Drinking Water Guidelines

Table B.2a: Analytical Results for Dissolved Trace Metal

FRE-00209588-A0

Laboratory ID:				HT7728	GR5138	GV1593	HD8949	HD8949	HM9719	GV1592	GV1592	GV1592	HD8948	HM9718
Client ID:				A2	WTP	WTP	WTP	WTP	WTP	Hydrometric Station	Hydrometric Station	Hydrometric Station Lab-Dup	Hydrometric Station	Hydrometric Station
Date: (YYYY/MM/DD)				Oct 2/13	Jun 14/13	July 3/13	Aug 7/13	Aug 7/13	Sept 11/13	Jun 14/13	July 3/13	July 3/13	Aug 7/13	Sept 11/13
	Units	**Guideline[1]**	**Guideline[2]**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Aluminum	µg/L	100	5 (pH<6.5) 100 (pH>=6.5)	18	<3	16	<3	6	<3	21	24	na	10	4.3
Antimony	µg/L	6		<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	na	<0.60	<0.60
Arsenic	µg/L	10	5	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	na	<0.20	<0.20
Barium	µg/L	1000		<10	<10	<10	<10	na	<10	<10	<10	<10	<10	<10
Beryllium	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	na	<1	<1
Boron	µg/L	5000	1500	<20	<20	<20	<20	na	<20	<20	<20	<20	<20	<20
Cadmium	µg/L	5		<0.0050	<0.005	<0.005	<0.005	na	<0.0050	0.012	<0.0050	na	<0.0050	<0.0050
Calcium	µg/L			12000	8300	7300	4700	na	4900	2800	5200	5200	11000	13000
Chromium	µg/L	50	1	<1	<1	<1	<1	<1	<1	<1	<1	na	<1	<1
Cobalt	µg/L			<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	na	<0.3	<0.3
Copper	µg/L	1000		0.98	3.2	2.6	1.7	2	2.3	1.3	0.55	na	1.2	0.5
Iron	µg/L	300	300	<60	<60	<60	<60	na	<60	<60	<60	<60	<60	<60
Lead	µg/L	10		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	na	<0.2	<0.2
Lithium	µg/L			<20	<20	<20	<20	na	<20	<20	<20	<20	<20	<20
Magnesium	µg/L			1800	1600	1400	900	na	950	410	650	640	1400	1900
Manganese	µg/L	50		8.5	<4	<4	<4	na	<4	13	<4	<4	<4	<4
Molybdenum	µg/L		73.0	0.21	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	na	<0.2	<0.2
Nickel	µg/L			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	na	<0.5	<0.5
Phosphorus				<100	<100	<100	<100	na	<100	<100	<100	<100	<100	<100
Potassium	µg/L			<300	<300	<300	<300	na	<300	330	<300	<300	<300	<300
Selenium	µg/L	10	1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	na	<0.2	<0.2
Silicon				1700	860	730	440	na	360	360	640	640	1000	1500
Silver	µg/L		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	na	<0.1	<0.1
Sodium	µg/L	200000		850	1400	1100	670	na	770	1100	560	560	810	960
Strontium	µg/L			<20	<20	<20	<20	na	<20	<20	<20	<20	<20	<20
Sulphur	µg/L			3800	1500	1300	770	na	770	710	1200	1200	2600	3700
Thallium	µg/L		0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	na	<0.2	<0.2
Tin	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	na	<1	<1
Titanium	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	na	<1	<1
Uranium	µg/L	20	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	na	<0.1	<0.1
Vanadium	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	na	<1	<1
Zinc	µg/L	5000	30	<3	4.3	<3	<3	<3	<3	<3	<3	na	<3	<3

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012

Guideline [2] - CCME Freshwater Aquatic Life, CCME 2010

(-) Not Analyzed

Underlined concentrations - Above CCME Fresh Water Aquatic Life Guidelines

Bolded concentrations - Above Health Canada Canadian Drinking Water Guidelines

Table B.2b: Analytical Results for Trace Metals

FRE-00209588-A0

				Previous Results (2000 and 2003)					City of Iqaluit Raw Supply Water Data 2010 and 2012			2012 Analytical Results											
Laboratory ID:									100342-001	974525	994161	PK1717	PK1717	PK1718	PK1719	GR5115	RY8359	RY8361	SB1597	SC8961	GW6869	GZ1922	HA4657
Client ID:				Iqaluit 2000	Creek 1	Creek 3	Sylvia Grinnell	Lake Geraldine	Iqaluit Raw Potable	Iqaluit Raw Potable	Iqaluit Raw Potable	AS1	AS1 Lab Dup	AS2	Lake Geraldine Reservoir	A1	A1	A3 Field Dup A1	A1	A1	A1	A1	A1
Date: (YYYY/MM/DD)				July 26/00	Sept 4/03	Sept 4/03	Sept 4/03	Sept 4/03	Jul 1/10	Jul 25/12	Oct 25/12	Oct 26/12	Oct 26/12	Oct 26/12	Oct 26/12	Jun 14/13	Jun 19/13	Jun 19/13	June 26/13	July 3/13	July 10/13	July 17/13	July 24/13
	Units	**Guideline[1]**	**Guideline[2]**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Aluminum	µg/L	100	5 (pH<6.5) 100	-	-	-	-	-	13.2	<10	<10	14	8.6	99	8.8	20	34	18	11	9.7	8	<3	15
Antimony	µg/L	6		-	-	-	-	-	<0.1	<0.5	<0.5	<0.50	<0.50	<0.50	<0.50	<0.6	0.83	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Arsenic	µg/L	10	5	1	<1	<1	<1	<1	<0.2	<1	<1	<1	<1	<1	<1	0.28	1.5	0.4	<0.2	<0.2	<0.2	<0.2	<0.2
Barium	µg/L	1000		-	-	-	-	-	1.4	<10	<10	4.3	4.9	4.2	<2.0	<10	<10	<10	<10	<10	<10	<10	<10
Beryllium	µg/L			-	-	-	-	-	<0.1	<0.5	<0.5	<0.50	<0.50	<0.50	<0.50	<1	<10	<10	<1	<1	<1	<1	<1
Boron	µg/L									<10	<10					<20	45	<20	<20	<20	<20	<20	<20
Cadmium	µg/L	5		-	-	-	-	-	<0.05	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	0.0098	<0.025	<0.025	<0.005	0.007	<0.0050	<0.0050	<0.005
Calcium	µg/L			-	-	-	-	-		5000	6000					1800	3200	3300	3300	4400	5700	6900	6800
Chromium	µg/L	50	1	-	-	-	-	-	<0.1	<1	<1	<5	<5	<5	<5	<1	<10	<10	<1	<1	<1	<1	<1
Cobalt	µg/L			-	-	-	-	-	<0.1	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Copper	µg/L	1000		2	<2	<2	<2	<2	0.9	3	2	<1	<1	2.5	2.2	0.98	2.1	0.88	0.4	0.5	0.31	0.5	0.61
Iron	µg/L	300	300	90	25	38	30	53	52	50	40	<100	<100	<100	<100	<60	<60	<60	<60	<60	<60	<60	<60
Lead	µg/L	10		1	<0.5	<0.5	<0.5	<0.5	<0.1	<1	<1	**<50**	**<50**	**<50**	**<50**	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Lithium	µg/L			-	-	-	-	-	<0.2			<5	<5	<5	<5	<20	<20	<20	<20	<20	<20	<20	<20
Magnesium	µg/L															310	510	500	470	630	790	940	950
Manganese	µg/L	50		-	-	-	-	-	19.1	20	10	4.9	4.6	7.2	9.8	7.4	<4	<4	<4	<4	<4	<4	<4
Mercury	mg/L	1.0	0.026	0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.01	<0.0001	<0.1	<0.00010		<0.00010	<0.00010		<0.01		<0.01	-	<0.01	<0.01	<0.01
Molybdenum	µg/L		73.0	-	-	-	-	-	<0.1	<5	<5	<0.50	<0.50	1.8	<0.50	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nickel	µg/L			<1	<10	<10	<10	<10	0.1	<5	<5	<1	<1	<1	<1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Phosphorus	µg/L															<100	<100	<100	<100	<100	<100	<100	<100
Potassium	µg/L															<300	<300	<300	<300	<300	<300	<300	<300
Selenium	µg/L	10	1	-	-	-	-	-	<0.3	<1	<1	<2	<2	<2	<2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Silicon	µg/L															300	500	520	510	640	760	820	860
Silver	µg/L		0.1	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium	µg/L	200000		-	-	-	-	-								780	<500	<500	630	<500	<500	<500	600
Strontium	µg/L			-	-	-	-	-	7.8	11	15	31	30	30	15	<20	<20	<20	<20	<20	<20	<20	<20
Sulphur	µg/L															500	930	970	640	830	1300	1600	1700
Thallium	µg/L		0.8	-	-	-	-	-	<0.1	<0.1	<0.1	<0.05	<0.05	0.092	<0.05	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Tin	µg/L			-	-	-	-	-				<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Titanium	µg/L			-	-	-	-	-	0.1	<10	<10	<5	<5	<5	<5	1.4	<1	<1	<1	<1	<1	<1	<1
Uranium	µg/L	20	15	-	-	-	-	-	<0.1			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	µg/L			-	-	-	-	-	<0.1	<1	<1	<0.50	<0.50	<0.50	<0.50	1.5	<1	<1	<1	<1	<1	<1	<1
Zinc	µg/L	5000	30	-	-	-	-	-	2.2	<10	<10	<5	<5	11	<5	<3	<3	<3	<3	<3	<3	<3	5.3

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012
Guideline [2] - CCME Freshwater Aquatic Life, CCME 2010
(-) Not Analyzed

Underlined concentrations - Above CCME Fresh Water Aquatic Life Guidelines
Bolded concentrations - Above Health Canada Canadian Drinking Water Guidelines

Table B.2b: Analytical Results for Trace Metals

FRE-00209588-A0

2013 Analytical Results

Laboratory ID:				HB9247	HD8863	HF5413	HH5005	HJ5455	HK8415	HM9696	HQ8465	HQ8467	HT7727	GR5116	RY8360	SB1598	SC8962	GW6870	GZ1923	HA4658	HB9248	HD8863	HF5414
Client ID:				A1	A1	A1	A1	A1	A1	A1	A1	A3 Field Dup A1	A1	A2	A2	A2	A2	A2	A2	A2	A2	A2	A2
Date: (YYYY/MM/DD)				July 31/13	Aug 7/13	Aug 14/13	Aug 21/13	Aug 28/13	Sept 4/13	Sept 11/13	Sept 25/13	Sept 25/13	Oct 2/13	Jun 14/13	Jun 19/13	June 26/13	July 3/13	July 10/13	July 17/13	July 24/13	July 31/13	Aug 7/13	Aug 14/13
	Units	**Guideline[1]**	**Guideline[2]**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Aluminum	µg/L	100	5 (pH<6.5) 100	7.6	11	9.2	8.5	5.7	6.4	11	14	27	23	130	85	82	19	15	7.7	16	12	11	13
Antimony	µg/L	6		<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Arsenic	µg/L	10	5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.26	<0.2	<0.2	<0.2	0.31	0.74	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Barium	µg/L	1000		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Beryllium	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1
Boron	µg/L			<20	<20	<20	<20	<20	<20	22	<20	<20	<20	<20	23	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium	µg/L	5		0.0051	<0.0050	<0.0050	<0.0050	<0.005	0.0096	<0.0050	<0.0050	0.019	0.0053	0.015	<0.025	<0.005	0.0065	<0.0050	<0.0050	<0.005	<0.0050	<0.0050	<0.0050
Calcium	µg/L			9800	11000	12000	11000	10000	12000	12000	12	13	9800	2900	4400	4500	5300	6500	7600	7800	10000	11000	11000
Chromium	µg/L	50	1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1
Cobalt	µg/L			<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Copper	µg/L	1000		0.67	0.47	6.6	0.71	0.87	0.9	0.75	0.59	1.1	1.3	1.8	0.95	0.55	0.55	0.27	0.46	0.68	0.54	0.27	0.69
Iron	µg/L	300	300	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	250	160	150	<60	<60	<60	71	<60	<60	<60
Lead	µg/L	10		<0.20	<0.20	0.4	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Lithium	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Magnesium	µg/L			1300	1400	1700	1600	1600	1700	1800	1800	1900	1400	470	650	560	680	830	990	1000	1300	1400	1500
Manganese	µg/L	50		<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	18	10	8.5	<4	<4	<4	8.5	4	4.9	<4
Mercury	mg/L	1.0	0.026	<0.01	-	-	<0.01	<0.01	<0.01	-	<0.01		<0.01	-	<0.01	0.01	-	<0.01	-	<0.01	<0.01	-	<0.01
Molybdenum	µg/L		73.0	<0.2	0.21	0.2	0.25	0.33	0.28	0.34	0.25	0.24	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.21	<0.2	<0.2	<0.2
Nickel	µg/L			<0.5	<0.5	4.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Phosphorus	µg/L			<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Potassium	µg/L			<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
Selenium	µg/L	10	1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Silicon	µg/L			1100	1100	1300	1300	1300	1400	1500	1600	1600	1500	600	690	570	640	760	820	870	1100	990	1100
Silver	µg/L		0.1	0.14	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	<0.1
Sodium	µg/L	200000		810	770	960	850	850	810	1100	860	920	830	790	<500	630	<500	<500	<500	640	810	800	930
Strontium	µg/L			<20	<20	21	<20	<20	21	21	<20	21	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Sulphur	µg/L			2100	2500	2700	2800	2900	3100	3300	3400	3800	2800	690	1300	1000	1300	1600	1900	2000	2500	2500	2600
Thallium	µg/L		0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Tin	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Titanium	µg/L			<1	1.2	<1	<1	<1	<1	<1	<1	<1	<1	8.7	4.1	4.1	<1	<1	<1	<1	<1	<1	<1
Uranium	µg/L	20	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.5	<1	<1	<1	<1	<1	<1	<1	1.2	<1
Zinc	µg/L	5000	30	<3	<3	6.3	<3	<3	<3	16	<3	14	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012

Guideline [2] - CCME Freshwater Aquatic Life, CCME 2010

(-) Not Analyzed

Underlined concentrations - Above CCME Fresh Water Aquatic Life Guidelines

Bolded concentrations - Above Health Canada Canadian Drinking Water Guid

Table B.2b: Analytical Results for Trace Metals

FRE-00209588-A0

Laboratory ID:				HH5006	HJ5456	HK8416	HM9697	HQ8466	HT7728	GR5138	SC9452	HD8949	HM9719	GR5139	SC9451	HD8948	HM9718
Client ID:				A2	A2	A2	A2	A2	A2	WTP	WTP	WTP	WTP	Hydrometric Station	Hydrometric Station	Hydrometric Station	Hydrometric Station
Date: (YYYY/MM/DD)				Aug 21/13	Aug 28/13	Sept 4/13	Sept 11/13	Sept 25/13	Oct 2/13	Jun 14/13	July 3/13	Aug 7/13	Sept 11/13	Jun 14/13	July 3/13	Aug 7/13	Sept 11/13
	Units	**Guideline[1]**	**Guideline[2]**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Aluminum	µg/L	100	5 (pH<6.5) 100	8.3	5.3	10	10	15	64	<3	7.5	11	16	110	19	12	8.5
Antimony	µg/L	6		<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	1.2	<0.6	<0.6	<0.6	<0.6
Arsenic	µg/L	10	5	<0.2	<0.2	<0.2	0.22	<0.2	<0.2	0.24	<0.2	<0.2	0.23	0.23	<0.2	<0.2	0.25
Barium	µg/L	1000		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Beryllium	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Boron	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium	µg/L	5		<0.0050	0.0057	<0.0050	0.0069	<0.0050	<0.0050	0.0051	0.01	<0.0050	0.0087	0.0074	0.063	<0.0050	<0.0050
Calcium	µg/L			11000	10000	12000	13000	14000	11000	8200	7400	4800	5000	2700	5300	11000	13000
Chromium	µg/L	50	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.1	<1	<1	<1	1.1
Cobalt	µg/L			<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Copper	µg/L	1000		0.72	0.62	2.4	0.35	0.6	1.1	4.8	4.2	2.6	8.1	1.3	1.7	0.7	0.52
Iron	µg/L	300	300	<60	<60	<60	<60	<60	<60	63	<60	73	90	190	<60	<60	<60
Lead	µg/L	10		<0.20	<0.20	0.22	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Lithium	µg/L			<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Magnesium	µg/L			1500	1600	1800	1900	1900	1600	1500	1400	910	940	450	670	1400	1900
Manganese	µg/L	50		<4	<4	<4	<4	<4	9.3	23	28	46	38	17	<4	<4	<4
Mercury	mg/L	1.0	0.026	<0.01	<0.01	<0.01	-	<0.01	<0.01	-	-	-	-	-	-	-	-
Molybdenum	µg/L		73.0	<0.2	0.25	0.21	0.31	0.24	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.25
Nickel	µg/L			<0.5	<0.5	<0.5	<0.5	<0.5	0.62	<0.5	<0.5	<0.5	1.5	<0.5	<0.5	<0.5	3.8
Phosphorus	µg/L			<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Potassium	µg/L			<300	<300	<300	<300	<300	<300	<300	<300	<300	310	<300	<300	<300	<300
Selenium	µg/L	10	1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Silicon	µg/L			1200	1200	1.4	1500	1700	1600	850	710	500	390	500	630	1100	1500
Silver	µg/L		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium	µg/L	200000		900	830	830	970	970	830	1400	1000	640	910	720	570	760	980
Strontium	µg/L			<20	<20	21	20	21	<20	<20	<20	<20	<20	<20	<20	<20	20
Sulphur	µg/L			2700	3100	3400	3600	4000	3600	1400	1300	860	890	690	1200	2600	3800
Thallium	µg/L		0.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Tin	µg/L			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Titanium	µg/L			<1	<1	<1	<1	<1	1	1.4	<1	<1	<1	6.1	<1	<1	<1
Uranium	µg/L	20	15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	µg/L			<1	<1	<1	<1	<1	<1	1.1	<1	<1	<1	1.4	<1	<1	<1
Zinc	µg/L	5000	30	<3	<3	<3	<3	9.9	3	<3	<3	<3	7.8	<3	3.2	<3	<3

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012
Guideline [2] - CCME Freshwater Aquatic Life, CCME 2010
(-) Not Analyzed

Underlined concentrations - Above CCME Fresh Water Aquatic Life Guidelines
Bolded concentrations - Above Health Canada Canadian Drinking Water Guid

Table B.3: Microbiological Examination of Water

MON-00209588-A0

			Previous Results (2000 and 2003)														
Laboratory ID:								001	993859	RY8359	RY8361	SB1597	SF0390	SH7911	SK0026	SO3905	SQ8881
Client Sample ID:			Iqaluit 2000	Creek 1	Creek 3	Sylvia Grinnell	Lake Geraldine	Iqaluit Raw Water	Iqaluit Raw Water	A1	A3 Field Dup A1	A1	A1	A1	A1	A1	A1
Date Sampled:			July 26/00	Sept 4/03	Sept 4/03	Sept 4/03	Sept 4/03	Jul 01/10	Oct 25/12	Jun 19/13	Jun 19/13	June 26/13	July 3/13	July 17/13	July 24/13	Aug 7/13	Aug 14/13
		Guideline[1]	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Analyses	**Units**																
Total Coliforms	cts/100 ml	0	-	**4**	**2**	**8**	<1	Holding Time Exceeded		**170**	**150**	**74**	**10**	**5**	**22**	**26**	**35**
Fecal Coliforms	cts/100 ml	0	-	-	-	-	-		0	0	0	0	0	0	0	0	0
E. coli	cts/100 ml	0	-	<1	<1	<1	<1			0	0	0	0	0	0	0	0
Background	cts/100 ml		-	-	-	-	-	-	-	**210**	**150**	**210**	**20**	**200**	**260**	**36**	**280**

(-) Not Analyzed

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012

Bolded concentrations - Above Health Canada Canadian Drinking Water Guidelines

Table B.3: Microbiological Examination of Water

MON-00209588-A0

			2013 Analytical Results														
Laboratory ID:			ST4354	SV9028	SX8285	TA4618	TF4268	TF4270	TI0675	RY8360	SB1598	SF0391	SH7912	SK0027	SO3934	SQ8882	ST4355
Client Sample ID:			A1	A1	A1	A1	A1	A3 Field Dup A1	A1	A2	A2	A2	A2	A2	A2	A2	A2
Date Sampled:			Aug 21/13	Aug 28/13	Sept 4/13	Sept 11/13	Sept 25/13	Sept 25/13	Oct 2/13	Jun 19/13	June 26/13	July 3/13	July 17/13	July 24/13	Aug 7/13	Aug 14/13	Aug 21/13
		Guideline[1]	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Analyses	**Units**																
Total Coliforms	cts/100 ml	0	**48**	0	**10**	**9**	**6**	**7**	**2**	**120**	**62**	**20**	**25**	**52**	**35**	**25**	**64**
Fecal Coliforms	cts/100 ml	0	0	0	0	**1**	0	0	0	0	**1**	0	0	0	0	0	0
E. coli	cts/100 ml	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	**1**	0
Background	cts/100 ml		**110**	**110**	**200**	**210**	**42**	**80**	**550**	**160**	**170**	**40**	**240**	**470**	**130**	**290**	**180**

(-) Not Analyzed

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012

Bolded concentrations - Above Health Canada Canadian Drinking Water Gui

Table B.3: Microbiological Examination of Water

MON-00209588-A0

Laboratory ID:			SV9029	SX8286	TA4619	TF4269	TI0676	RY8362	SO3220	TA4347	RY8363	SC9452	SO3221	TA4349
Client Sample ID:			A2	A2	A2	A2	A2	Hydrometric Station	Hydrometric Station	Hydrometric Station	WTP	WTP	WTP	WTP
Date Sampled:			Aug 28/13	Sept 4/13	Sept 11/13	Sept 25/13	Oct 2/13	Jun 19/13	Aug 7/13	Sept 11/13	Jun 19/13	July 3/13	Aug 7/13	Sept 11/13
		Guideline[1]	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Analyses	**Units**													
Total Coliforms	cts/100 ml	0	**2**	**8**	**16**	**20**	**2**	**240**	**40**	**11**	**1**	**2**	0	0
Fecal Coliforms	cts/100 ml	0	**2**	0	**1**	0	0	0	0	0	0	0	0	0
E. coli	cts/100 ml	0	0	0	0	0	0	0	0	0	0	0	0	0
Background	cts/100 ml		**240**	**180**	**210**	**37**	**110**	**230**	**110**	**230**	**300**	**310**	**41**	**82**

(-) Not Analyzed

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012

Bolded concentrations - Above Health Canada Canadian Drinking Water Gui

Table B.4: Hydrocarbon Analytical Result of Water

FRE-00209588-A0

				City of Iqaluit Data		2013 Analytical Results								
Laboratory ID:				100342-001	100341-004	RX6456	SC8961	SO3905	TA4618	RX6457	SC8962	SO3934	TA4619	RX5069
Client Sample ID:				Iqaluit Potable	Iqaluit Potable	A1	A1	A1	A1	A2	A2	A2	A2	WTP
Date Sampled:				Jul 1/10	Jul 13/10	Jun 14/13	July 3/13	Aug 7/13	Sept 11/13	Jun 14/13	July 3/13	Aug 7/13	Sept 11/13	Jun 14/13
		Guideline[1]	**Guideline[2]**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Analyses	**Units**													
Benzene	mg/L	0.005	4.6	<0.005		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Ethylbenzene	mg/L	0.0024	3.2	<0.005		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Hexane Extractable Material	mg/L			<2.0	<2.0									
m/p-Xylene	mg/L	0.3	2.8	<0.005		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Oil and Grease, visible				non-visual										
o-Xylene	mg/L	0.3	2.8	<0.005		<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Toluene	mg/L	0.024	4.2	<0.005		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
C6-C10 Hydrocarbons	mg/L					<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
C10-C16 Hydrocarbons	mg/L					<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
C16-C34 Hydrocarbons	mg/L					<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
C34-C50 Hydrocarbons	mg/L					<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Total Hydrocarbons	mg/L	4.4 Gas 3.2 Diesel 7.8 Lube	13 Gas 0.84 Diesel 0.48 Lube			<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100

Guideline[1] - Atlantic RBCA Version 3.0, Table 4a For Coarse-grained soils on Residential receptor sites with potable water use (2012 update)

Guideline [2] - Atlantic RBCA Version 3.0, Table 3a For Groundwater Ecological Screening Levels for the Protection of Freshwater Aquatic Life(2012 update)

(-) Not Analyzed

<u>Underlined concentrations - Above the Atlantic RBCA Version 3.0, Table 3a For Groundwater Ecological Screening Levels for the Protection of Freshwater Aquatic Life</u>

Bolded concentrations - Above the Atlantic RBCA Version 3.0, Table 4a For Coarse-grained soils on Residential receptor sites with potable water use (2012 update)

Table B.5: Hydrocarbon Analytical Result of Water

FRE-00209588-A0

					2013 Analytical Results									
Laboratory ID:					RX6456	SC8961	SO3905	TA4618	RX6457	SC8962	SC8962	SO3934	TA4619	RX5069
Client Sample ID:					A1	A1	A1	A1	A2	A2	A2 Lab-Dup	A2	A2	WTP
Date Sampled:					Jun 14/13	July 3/13	Aug 7/13	Sept 11/13	Jun 14/13	July 3/13	July 3/13	Aug 7/13	Sept 11/13	Jun 14/13
			Guideline[1]	**Guideline[2]**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
Analyses	**Units**	**MDL**												
Acenaphthene	ug/L	0.01		5.8	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	ug/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	ug/L	0.01		0.012	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	ug/L	0.01		0.018	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	ug/L	0.01	0.001	0.015	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b/j)fluoranthene	ug/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	ug/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	ug/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	ug/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenz(a,h)anthracene	ug/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	ug/L	0.01		0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	ug/L	0.01		3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	ug/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1-Methylnaphthalene	ug/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Methylnaphthalene	ug/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	ug/L	0.01		1.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	ug/L	0.01		0.4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	ug/L	0.01		0.025	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Guideline[1] - Canadian Drinking Water Quality, Health Canada 2012
Guideline [2] - CCME Freshwater Aquatic Life, CCME 2010
(-) Not Analyzed

Underlined concentrations - Above CCME Fresh Water Aquatic Life Guidelines
Bolded concentrations - Above Health Canada Canadian Drinking Water Guidelines

Appendix C – Field Readings

Table C.1: Field Measurements (Water Quality Parameters)

FRE-00209588-A0

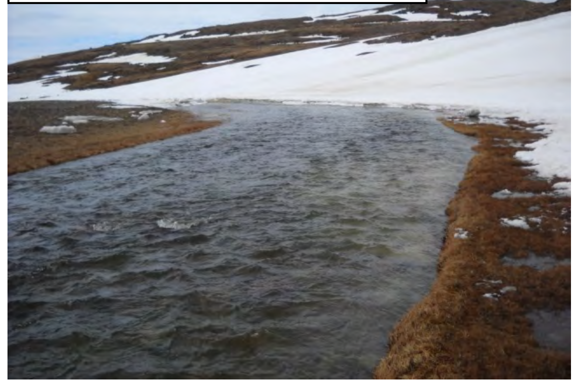
Client Sample ID:		A1	A1	A1	A2	A2
Date Sampled:		Aug 28/13	Sept 4/13	Sept 25/13	Aug 28/13	Sept 4/13
Parameters	**Units**	**Result**	**Result**	**Result**	**Result**	**Result**
Temperature	Degree Celcius	2.6	5.9	1.4	2.7	5.4
Barometric Pressure	mmHg	753.8	735.5	756.4	755.2	737
Dissolved Oxygen	%	115.7	106.2	120.1	106.3	107.7
Dissolved Oxygen	mg/L	15.63	12.83	16.78	14.35	13.17
Specific Conductivity	us/cm	80.6	81.3	83.7	81.4	82.9
Conductivity	uS/cm	46.1	51.6	46	46.7	62.6
pH	na	8.68	8.25	8.95	8.07	7.53
pH mV value	mV	-91.7	-69	-106.1	-58.1	-30
ORP	mV	213.5	232.9	178.6	308.4	-137

Table C.2: Sample Locations, Dates and Stream Stage Measurements

UTM Coordiates for Sampling				Height of River	
Dates	A1	A2	Hydrometric Station	Bridge	A2
Monthly Sample 1 June 14	0526290 7070101 + or - 5 meters	0526349 7069257 + or - 7 meters	0527047 7067734 + or - 2 meters	NA	NA
Weekly Sample 1 June 19	0526288 7070099 + or - 2 meters	0526354 7069261 + or - 4 meters	NA	105 Inches from top of railing to water	Submerged stick 21.5 inches (marked location)
Weekly Sample 2 June 26	0526283 7070102 + or - 5 meters	0526354 7069263 + or - 6 meters	NA	108 Inches from top of railing to water	Submerged stick 15 inches (marked location)
Monthly Sample 2 July 3	0526287 7070099 + or - 6 meters	0526352 7069263 + or - 6 meters	Taken at Hydrometric Station	115 inches from top of railing to water	Submerged stick 4.5 inches (marked location)
Weekly Sample 3 July 10	0526284 7070111 + or - 6 meters	0526354 7069263 + or - 5 meters	NA	119 inchies from the top of railing to water	Submerged stick 2.25 inches (marked loaction)
Weekly Sample 4 July 17	0526284 7070113 0 m	0526356 7069268 NE 7m	NA	125 inchies from the top of railing to water	Submerged stick 0.25 inches (marked loaction)
Weekly Sample 5 July 24	0526283 7070113 + or - 5 meters	0526354 7069263 + or - 5 meters	NA	125 inchies from the top of railing to water	1.25 inches below marked rock loaction.
Weekly Sample 6 July 31	0526283 7070113 + or - 4 meters	0526354 7069261 + or - 5 meters	NA	125.5 inchies from the top of railing to water	3 inches below marked rock loaction.
Monthly Sample 3 August 7	0526284 7070114 + or - 2 meters	0526355 7069263 + or - 2 meters	Taken at Hydrometric Station	126.5 inches from the top of railing to water	4 inches below marked rock loaction.
Weekly Sample 7 August 14	0526321 7070095 + or - 25 meters	0526352 7069264 + or - 3 meters	NA	131 inches from the top of railing to water	7 inches below marked rock loaction.
Weekly Sample 8 August 21	0526329 7070093 + or - 5 meters	0526352 7069264 + or - 2 meters	NA	133 inches from the top of railing to water	Water to low to take reading
Weekly Sample 9 August 28	05026326 7070090 + or - 4 meters	0526353 7069262 + or - 4 meters	NA	133 inches from the top of railing to water	Water to low to take reading
Weekly Sample 10 September 4	0526334 7070083 + or - 4 meters	0526352 7069262 + or - 4 meters	NA	130 inches from the top of railing to water	Water to low to take reading
Monthly Sample 4 September 11	0526331 7070091 + or - 4 meters	0526352 7069264 + or - 4 meters	Taken at Hydrometric Station	133 inches from the top of railing to water	Water to low to take reading

Appendix D – Photographs


A1- Downstream – June 14, 2013


A2- Downstream – June 14, 2013


HS- Downstream – June 14, 2013


A1- Cross Section – June 14, 2013

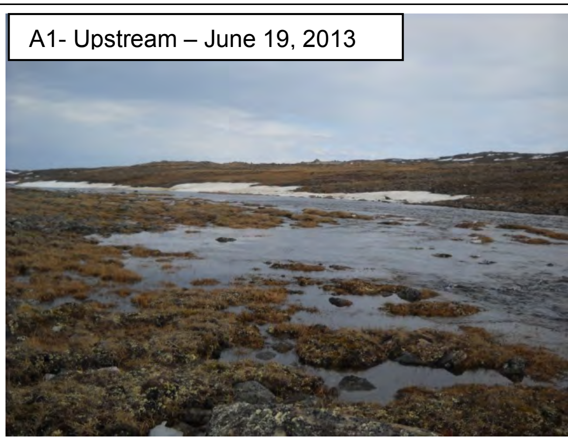

A2- Cross Section – June 14, 2013


HS- Cross Section – June 14, 2013


A1- Upstream – June 14, 2013


A2- Upstream – June 14, 2013


HS- Upstream – June 14, 2013

 A1- Downstream – June 19, 2013		
 A1- Cross Section – June 19, 2013		
 A1- Upstream – June 19, 2013		


A1- Downstream – June 26, 2013

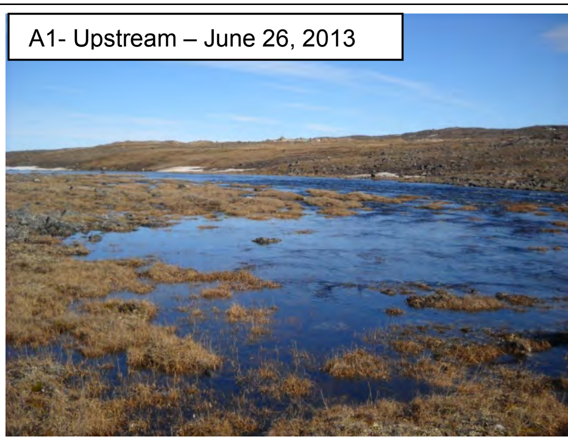

A2- Downstream – June 26, 2013

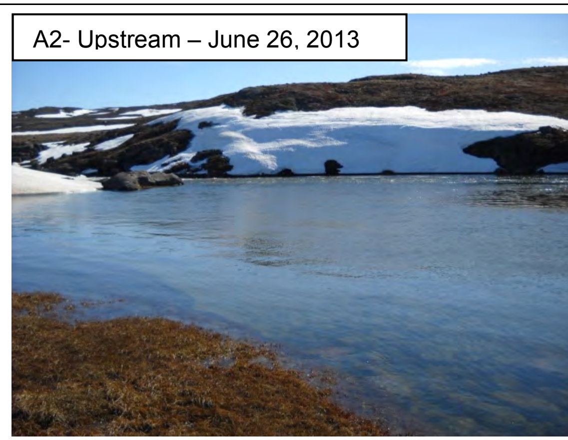

A1- Into the Water– June 26, 2013

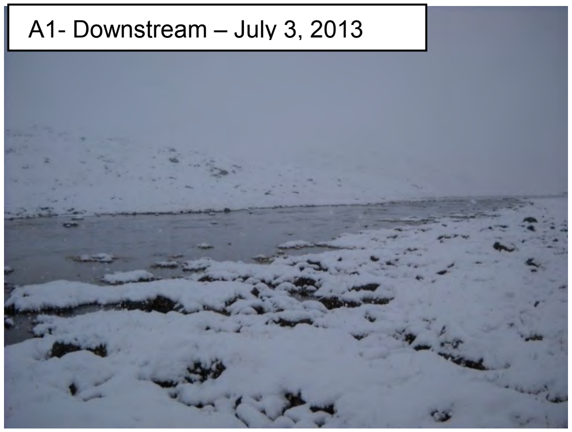

A1- Cross Section – June 26, 2013


A2- Cross Section – June 26, 2013


A2- Into the Water– June 26, 2013

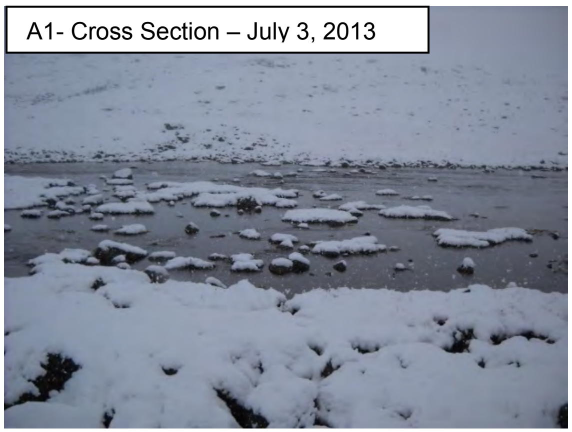

A1- Upstream – June 26, 2013


A2- Upstream – June 26, 2013


A1- Downstream – July 3, 2013


A2- Downstream – July 3, 2013


HS- Downstream – July 3, 2013


A1- Cross Section – July 3, 2013


A2- Cross Section – July 3, 2013


HS- Cross Section – July 3, 2013

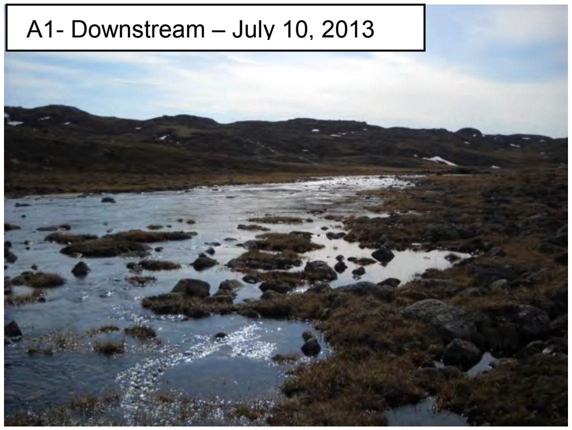

A1- Upstream – July 3, 2013


A2- Upstream – July 3, 2013

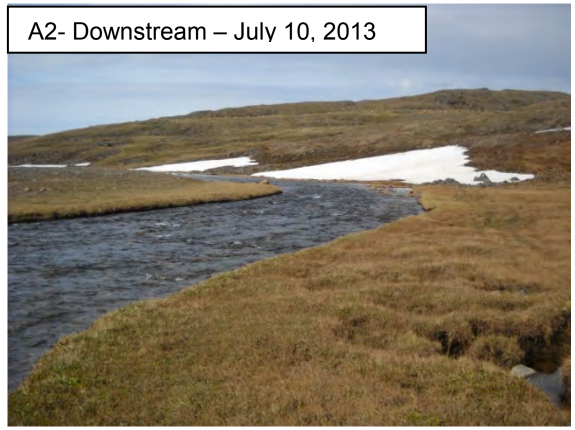

HS- Upstream – July 3, 2013

A1- Into the Water– July 3, 2013 	A2- Into the Water– July 3, 2013 	

A1- Downstream – July 10, 2013



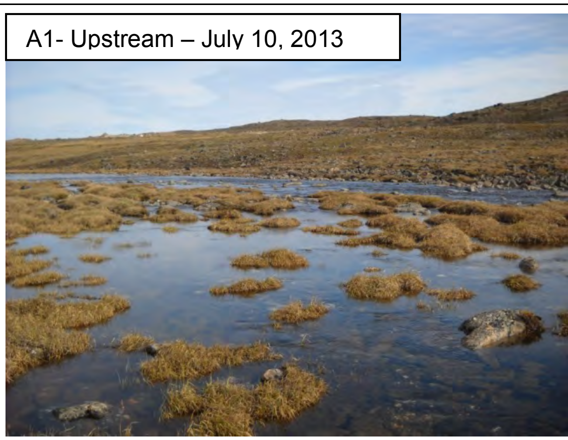
A2- Downstream – July 10, 2013



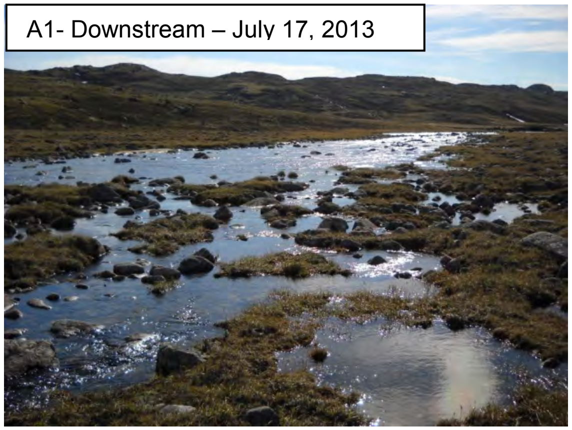
A1- Cross Section – July 10, 2013

A2- Cross Section – July 10, 2013

A1- Upstream – July 10, 2013



A2- Upstream – July 10, 2013


A1- Downstream – July 17, 2013


A2- Downstream – July 17, 2013


A1- Cross Section – July 17, 2013


A2- Cross Section – July 17, 2013

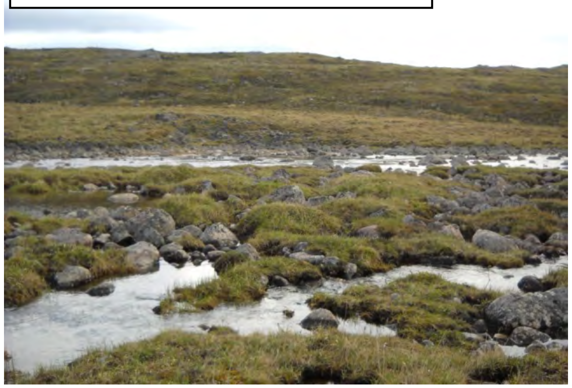

A1- Upstream – July 17, 2013


A2- Upstream – July 17, 2013

A1- Downstream – July 24, 2013

A2- Downstream – July 24, 2013

A1- Cross Section –July 24, 2013

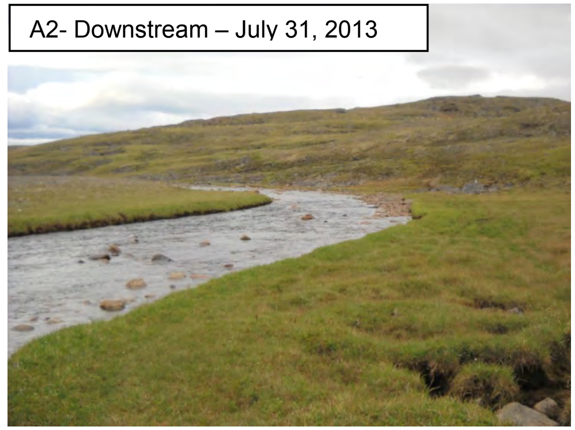


A2- Cross Section – July 24, 2013

A1- Upstream – July 24, 2013

A2- Upstream – July 24, 2013


A1- Downstream – July 31, 2013


A2- Downstream – July 31, 2013


A1- Cross Section –July 31, 2013


A2- Cross Section – July 31, 2013


A1- Upstream – July 31, 2013


A2- Upstream – July 31, 2013


A1- Downstream – August 7, 2013


A2- Downstream – August 7, 2013


HS- Downstream – August 7, 2013


A1- Cross Section – August 7, 2013


A2- Cross Section – August 7, 2013


HS- Cross Section – August 7, 2013


A1- Upstream – August 7, 2013


A2- Upstream – August 7, 2013


HS- Upstream – August 7, 2013

 A1- Downstream – August 21, 2013	 A2- Downstream – August 21, 2013	
 A1- Cross Section – August 21, 2013	 A2- Cross Section – August 21, 2013	
 A1- Upstream – August 21, 2013	 A2- Upstream – August 21, 2013	


A1- Downstream – August 28, 2013


A2- Downstream – August 28, 2013


A1- Cross Section – August 28, 2013


A2- Cross Section – August 28, 2013


A1- Upstream – August 28, 2013


A2- Upstream – August 28, 2013


A1- Downstream – Sept. 4, 2013


A2- Downstream – Sept. 4, 2013


A1- Cross Section – Sept. 4, 2013


A2- Cross Section – Sept. 4, 2013


A1- Upstream – Sept. 4, 2013


A2- Upstream – Sept. 4, 2013

Appendix E – Waterline Profile & Representative System Layout

No.	Issue	Date
1	FINAL REVIEW DRAFT	2014.JAN.16
2	REPORT SUBMISSION	2014.JAN.29

No.	Revision	Ckd. By	Date

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Project No: CHA-00213458-A0

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PRELIMINARY

Const. North

Drawn By: PD

Dwg. Standards Ckd. By:

Designed By: MAF

Date Printed

Dwg. Design Ckd. By:

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Project Title

IQALUIT SUPPLEMENTARY WATER SUPPLY PUMP HOUSE

Dwg. Title

SITE PLAN

Project No. FRE-00209588-A0

Dwg. No. C1

Rev. No. 0

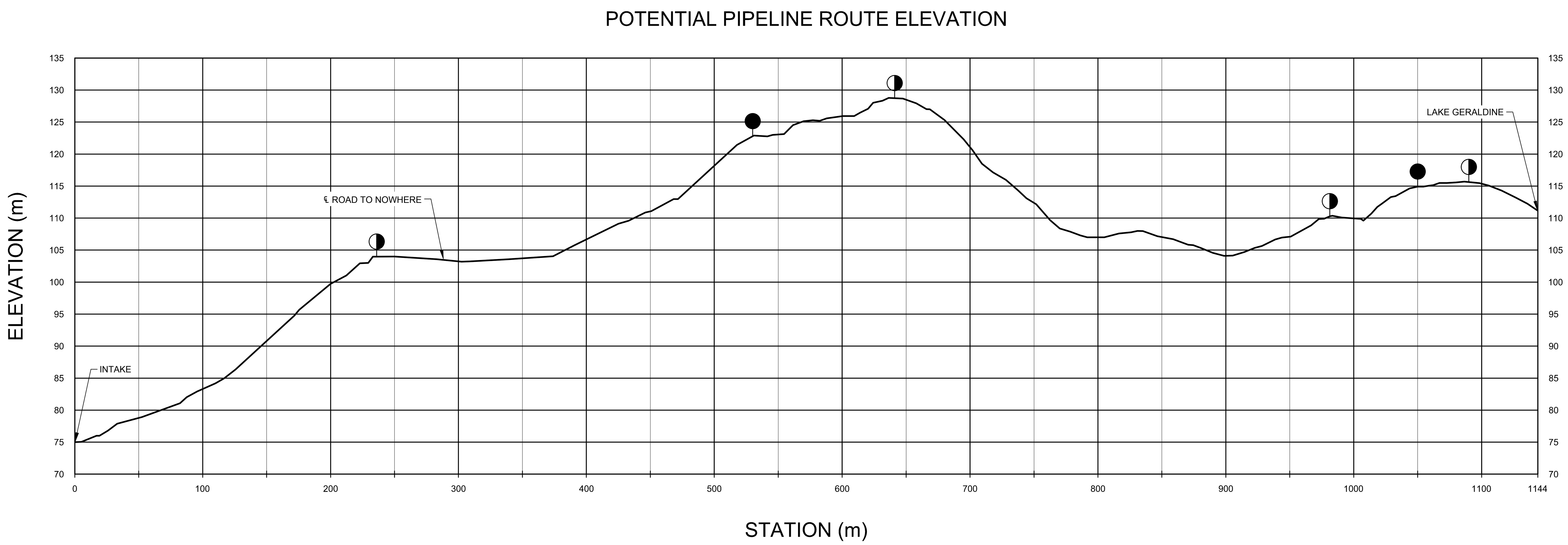
Scale 1:2500

This drawing is not to be scaled

No.	Issue	Date
1	FINAL REVIEW DRAFT	2014.JAN.16
2	REPORT SUMBISSION	2014.JAN.29

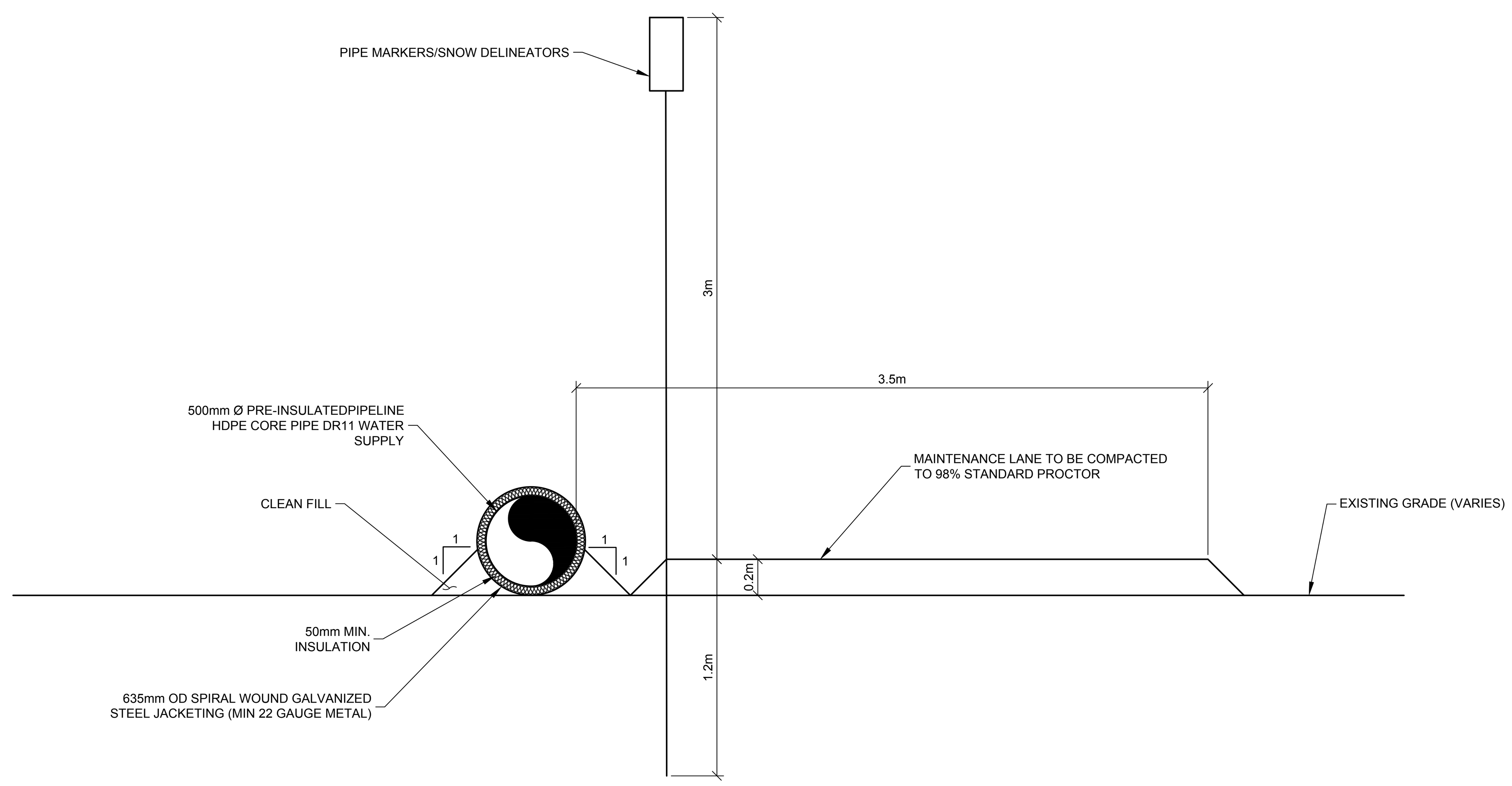
LEGEND

- ● AIR/VACUUM VALVE
- ◐ COMBINATION AIR VALVE



PIPELINE PROFILE

NOT TO SCALE



A / C1 SECTION
MAINTENANCE LANE

1:25

No.	Revision	Ckd. By	Date

PRELIMINARY

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Project Title

IQALUIT SUPPLEMENTARY WATER SUPPLY PUMP HOUSE

Dwg. Title

PIPELINE PROFILE RIVER TO LAKE GERALDINE

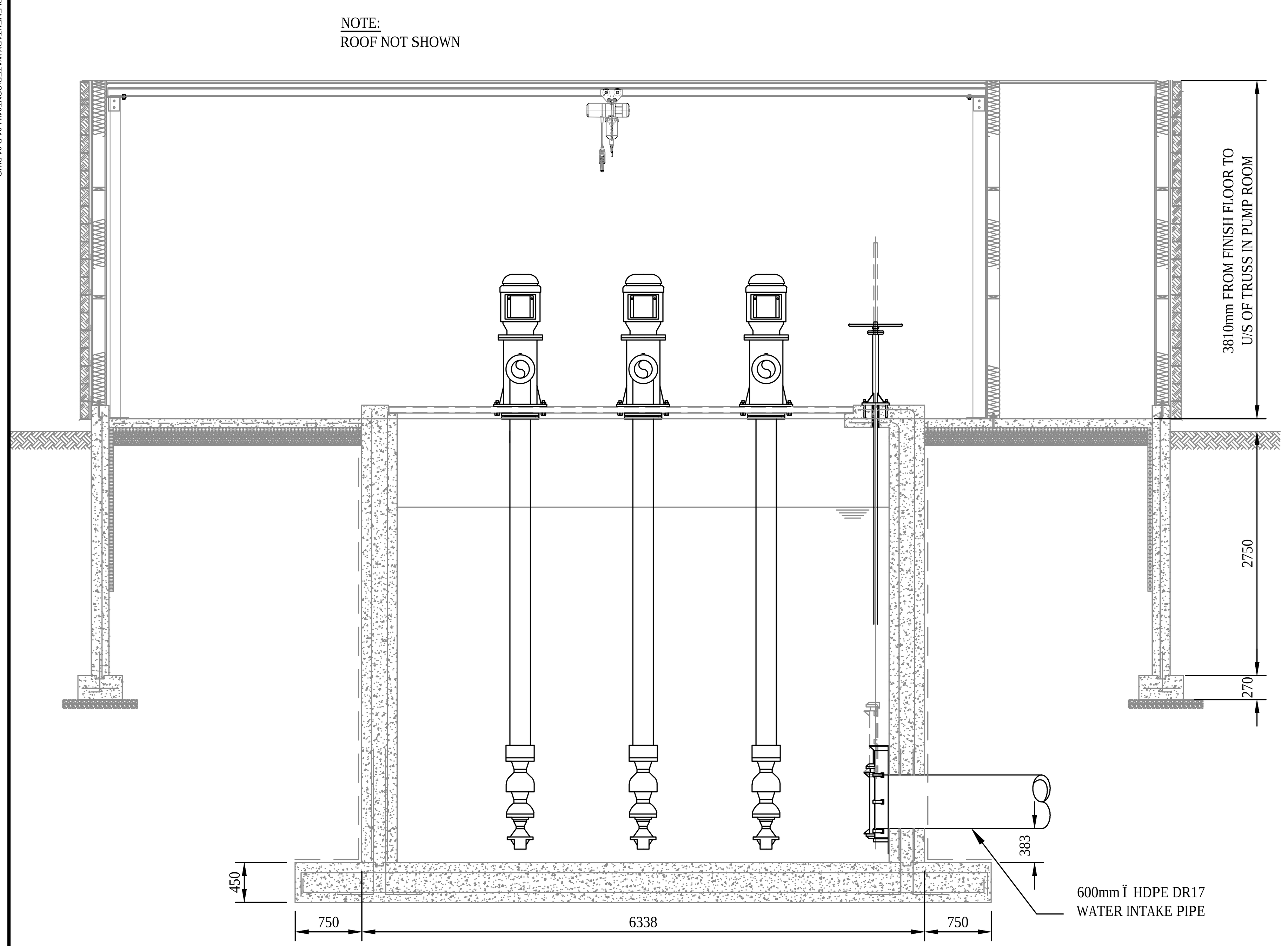
Project No. FRE-00209588-A0

Dwg. No. **P1**

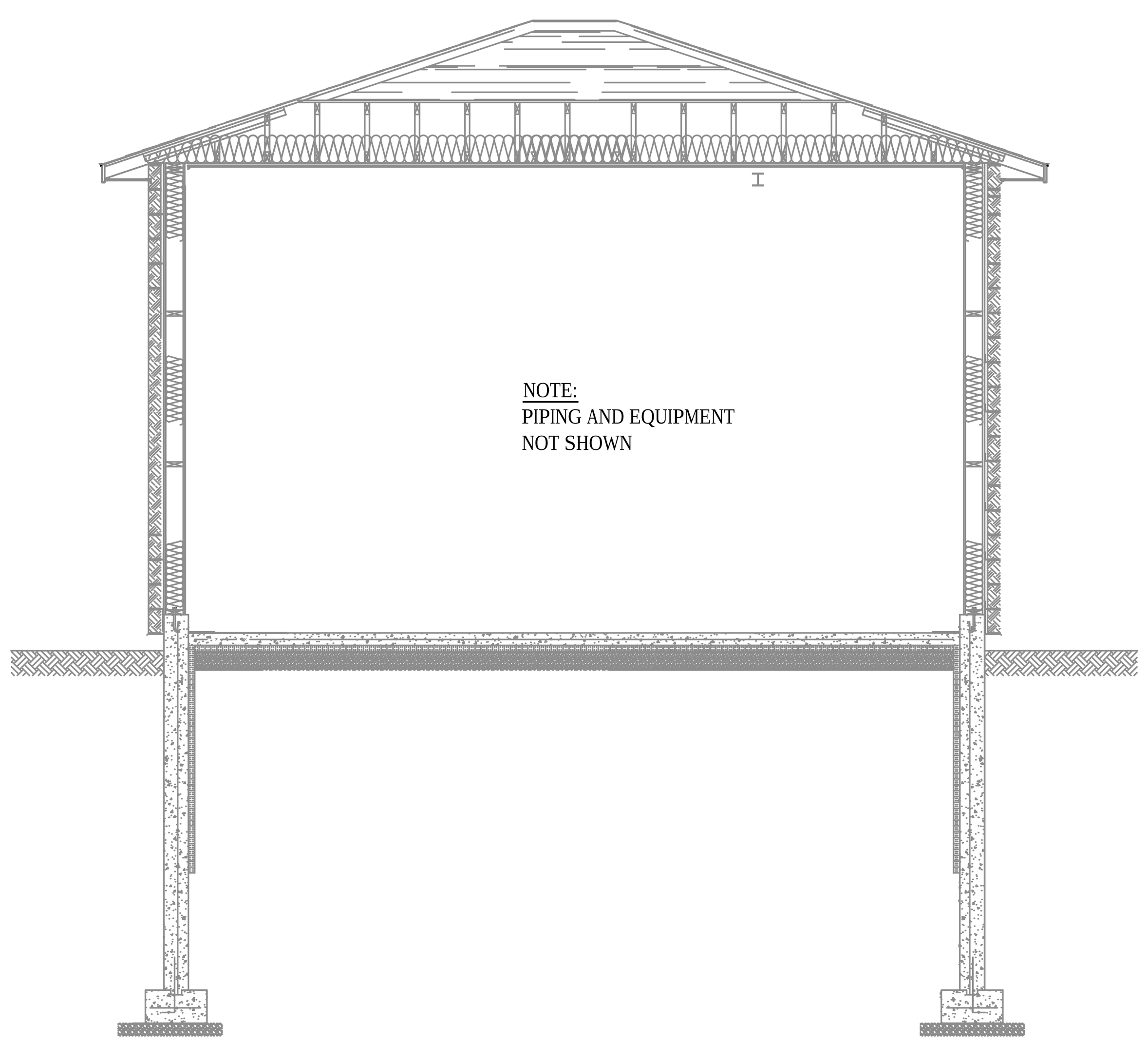
Rev. No. 0

Scale NOT TO SCALE

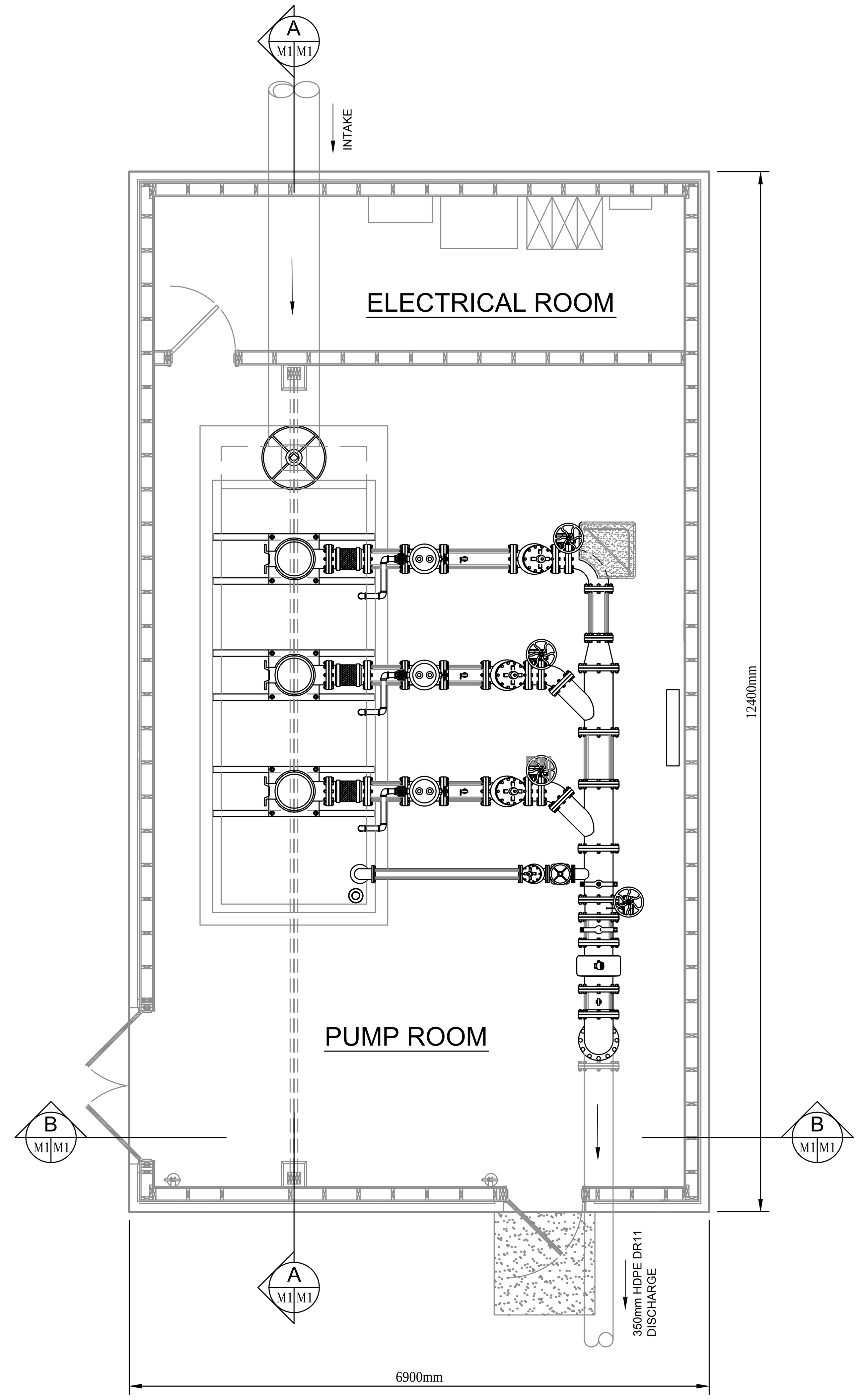
This drawing is not to be scaled



SECTION A M1 M1
SCALE 1 : 50



SECTION B M1 M1
SCALE 1 : 50



MECHANICIAL FLOOR PLAN
SCALE 1 : 50

No.	Issue	Date
1	PRELIMINARY REVIEW	2013.SEPT.30
2	CLIENT REVIEW	2013.OCT.22
3	FINAL REVIEW DRAFT	2014.JAN.16
4	REPORT SUBMISSION	2014.JAN.29

No.	Revision	Ckd. By	Date

PRELIMINARY

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Project Title

IQALUIT
SUPPLEMENTARY WATER
SUPPLY PUMP HOUSE

Dwg. Title

MECHANICAL PLAN AND SECTIONS

Project No. FRE-00209588-A0

Dwg. No. **M1**

Rev. No. 0

Scale

AS SHOWN

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