Wolf River Water Supply Impact Assessment Report

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Prepared for:

Hamlet of Arviat

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File No: N-O15746

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1.0 Introduction

Arviat is located at (61°06'N, 94°03'W) on the western coastline of Hudson Bay, 225 km south of Rankin Inlet and 265 km north of Churchill, Manitoba (Figure 1). The community is situated on the northern shore of a peninsula that extends easterly into Hudson Bay.

The Hamlet of Arviat operates their municipal water supply facility under the Nunavut Water Board (NWB) License 3AM-ARV1015. The licence was issued on August 23, 2010 and expires on August 31, 2015. The Hamlet of Arviat currently receives water from the Wolf River water supply located 8.0 km southwest of the Hamlet (Figure 2). Water is pumped from the river during late summer and held in reservoirs located just outside of the community. Water is delivered to residents by water truck. A truck fill station is located beside the reservoirs.

1.1 Study Background

A study was completed in 2005 by IEG Environmental to evaluate the community's water supply options. Based on the geomorphological study and river flow estimates, it found that the Wolf River supply was the best option for the Hamlet and that it is sustainable and should have sufficient capacity to meet the Hamlet's needs for the next 20 years.

There are some concerns in the community with regards to the long term capacity of the Wolf River Water Supply. These concerns were expressed in the public hearings conducted in 2010 as part of the approval process for the Hamlet of Arviat's Class A licence. This study was listed as a condition of the licence in Part C, Item 8.

2.0 Site Location

2.1 Climate

The closest climate station to Arviat is the Rankin Inlet Airport Weather Station located 225 km north of Arviat. The Rankin Inlet area receives an average of 18.1 cm of rainfall and 119.7 cm of snowfall per annum. Mean annual precipitation totals 29.7 cm per annum. In July mean high and low temperatures are 14.9^{o}C and 5.9^{o}C, respectively. January mean high and low temperatures are -28.3^{o}C and -35.5^{o}C, respectively. Winds are generally north-west, and average 23 km/h (Rankin Inlet Weather Station, Climate Normals 1991-2000, Environment Canada, 2010). Climate data is included in Appendix A.

2.2 Topography and Geomorphology

The topography surrounding the Hamlet of Arviat is relatively flat with a slight rise when moving inland away from Hudson Bay. Topographic highs in the area are found along eskers made of glacially deposited sands and gravels. Approximately 20 to 30 percent of the land is shallow ponds with depths of 1 m or less. Land between the ponds is marshy tundra vegetated by grasses and sedges. Figure 3 illustrates the topography and land cover of the area. The area is located in a zone of continuous permafrost, extending from 30 m to over 100 m.

2.3 Drainage

Drainage around the Hamlet of Arviat and surrounding areas all eventually go into Hudson Bay. Since the area is so flat the main drainage divides located along eskers and bedrock outcrops. The Wolf River is located southwest of the community. The Wolf River drainage area is an estimated 650 km^2 (IEG Environmental, 2005). The interpreted drainage basin of Wolf River is shown in Figure 4.

2.4 Geology

Arviat is located in the physiographic region of the Hudson Bay lowlands, characterized by low topographic relief, occasional bedrock outcrops and glacial and glacio-fluvial overburden sediments. Boulder fields and eskers are common. The Wolf River is located in a flat area that was once a glacial lake basin. The surficial geology includes alluvium deposits with some marine silt and sand as shown in Figure 5. Lakes that feed the Wolf River are formed in off lap sediments that have been affected by periglacial process and gullying.

Local bedrock is Archean in age and generally overlain by glacial fluvial sediments. Bedrock on the peninsula where the Hamlet is located consists of tonalites, diorites and gabbros. Bedrock at the Wolf River intake consists of granitic rocks, granites and granodiorites. The bedrock geology of the area is displayed in Figure 6.

3.0 Wolf River Water Supply Intake

The Hamlet of Arviat water supply intake is located on Wolf River approximately 8 km southwest of the community. The Hamlet pumps water from the intake during the late summer months August and September and stores the water in its water reservoirs to be used throughout the year. The water is typically pumped for approximately 27-30 days until the reservoirs are full. In 2010 due to technical issues the pumping period extended from August 17th to approximately October 25, 2010. The reservoir consists of two cells. Cell one has a storage capacity of 87,000 m^3 and Cell two is 56,000 m^3 with a total storage of 145,000 m^3.

The intake consists of a pumphouse which houses a pump and generator and a fuel storage tank (Figure 2). The intake pumps from a large ponded area of the river approximately 30 metres from the river bank.

The intake screen is metal with 3/16 inch round holes throughout. A 150 ø reinforced suction hose is connected to the pump to provide suction. The screen on the intake is described in 1991 tender specs as a “Dolphin” floating suction strainer with 18/8 stainless steel strainer and tube with adaptors to 150 ø reinforced suction hose. The top of the intake floats at surface and the bottom of the intake is 3 to 4 feet off of the bottom.

The intake pipe consists of (ten) 4 meter lengths of tan, 150 ø reinforced suction hose. (Tender Specs,1991). The inside diameter of the pipe is 6 inches. Water is transported from the pumphouse to the water reservoirs (8 km away) by way of a black 8” HDPE pipe. Pictures of the intake are provided in Appendix B.

The pump used at the intake is a 4” Gorman Rupp self priming centrifugal pump. Based on the flow rate curve provided by the pump manufacturer and the intake design, the maximum pumping capacity is 34 L/s. The Hamlet does not currently measure the flow rate of water at the intake pump house however it is likely less than the maximum capacity. To be conservative, we have assumed that the pump is running at maximum capacity for the calculations in this report.

There were no “as-built” drawings of the intake created after construction of the facility in the early nineties. Nuna Burnside has produced an as-built drawing (Appendix C-1) based on field observations and information provided by the Hamlet and GN.

4.0 Field Work

In July and September 2010, Nuna Burnside visited the site to collect information on the intake and river for use in this assessment. A topographic survey was completed around the intake area. Stream bottom profiles were collected upstream and downstream of the intake and flow rates were estimated. River flow calculations are provided in Appendix D.

Water quality samples were taken up stream and downstream of the intake. Sampling locations are shown in Figure 7. There were no adverse water quality results identified. A summary of the results and laboratory Certificates of Analysis are provided in Appendix E.

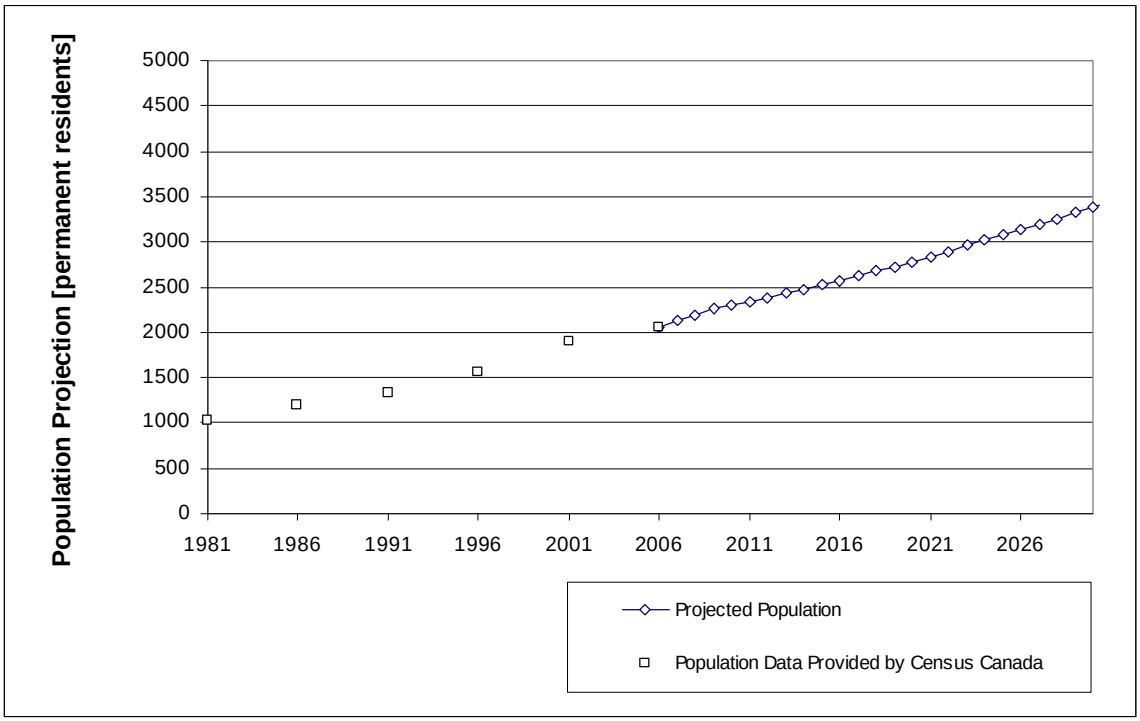
5.0 Future Water Supply Demands

The Nunavut Bureau of Statistics has projected population growth for communities in the Kivalliq region such as Arviat to have a 3.2% growth rate. Population projections from 2009 to 2036 were obtained from data provided on their website. Table 1 and Graph A show the projected population of the Hamlet for the next 10 years. Detailed calculations are shown in Appendix D.

Table 1 Hamlet of Arviat Population Projections

Year	Projected Population
2009	2254
2010	2296
2011	2339
2012	2383
2013	2428
2014	2474
2015	2521
2016	2571
2017	2622
2018	2674
2019	2728

Graph A Population Projections, Arviat Nunavut



The North West Territories Municipal and Community Affairs (MACA) planning guidelines suggest that the increase in the projected per capita water use in a community of less than 2000 people should be calculated using the following formulae. Although Arviat has a population greater than 2000, they are still on a truck distribution system and therefore this formula remains valid.

RWU x (1.0 + (0.00023 x Population)

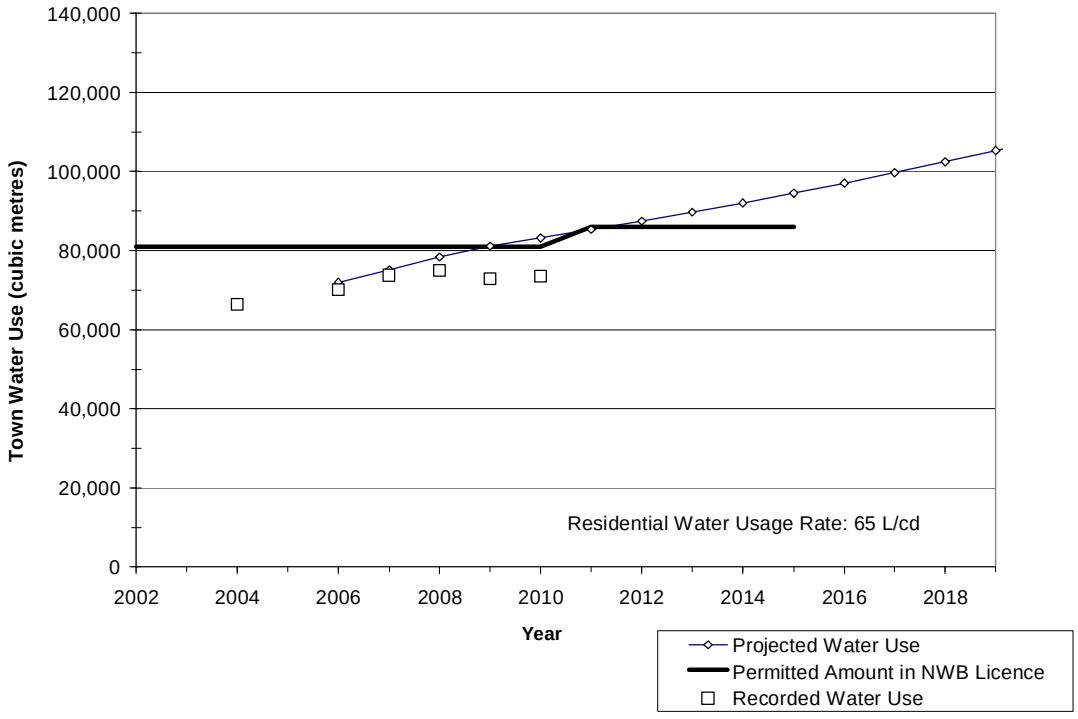
The RWU is the residential water use rate per capita. In the MACA guidelines it is assumed to be 90 L per capita for municipalities where water is not distributed by a piping system. A RWU of 65 L per capita (Lpcd) was used in the “Potable Water Supply Study” completed by IEG in 2005, to fit the recorded water usage rates for the Hamlet. This is a lower RWU than most communities however it has been confirmed that Arviat has a lower water use rate per capita than other communities. The factor 0.00023 x population represents commercial and industrial water use.

This equation was used to produce projected water use requirements for the next 10 years (Table 2 and Graph B). Calculations are included in Appendix D.

Table 2 Projected Water Use Requirements

Year	Projected Population	Projected Daily Consumption m^3	Projected Annual Consumption m^3
2009	2254	222	81,199
2010	2296	228	83,238
2011	2339	234	85,346
2012	2383	240	87,524
2013	2428	246	89,773
2014	2474	252	92,095
2015	2521	259	94,491
2016	2571	266	97,066
2017	2622	273	99,721
2018	2674	281	102,458
2019	2728	289	105,331

Graph B Water Use Projections, Arviat Nunavut



Water use data was obtained from the Hamlet for 2004 to 2010. Graph B plots the recorded water use data and the projected water use based on projected population increases for the next 10 years. Table 2 indicates that based on the MACA formulae, in 2009 the annual consumption should be 81,199 m^3. The actual measured water consumption used in 2009 was 72,807 m^3. The current license states that the allowable water use for the community is 86,000 m^3 per year.

Graph B indicates that water use has levelled off over the past few years and that the actual water use is less than the projected water use. This is likely because the projected water use is determined based on population increases however water use in Arviat is controlled by the Hamlet's capacity to deliver water to its residents. Discussions with the Hamlet and residents confirm that there have been issues with meeting the demands of water supply with their current infrastructure, equipment and funding.

6.0 Impact Assessment

6.1 Water Balance

The Wolf River drainage area is an estimated 650 km^2 (IEG Environmental, 2005). The interpreted drainage basin of Wolf River is shown in Figure 4. Using an annual precipitation rate of 297 mm and an annual evapotranspiration rate of 200 mm, the net recharge to the catchment area is approximately 63,180,000 m^3 per year (calculation details are included in Appendix D).

The annual withdrawal rate of the Hamlet will be approximately 105,331 m^3 by year 2019. This is less than 1 percent of the estimated river catchment recharge rate of approximately 63,180,000 m^3 a year. Average flows for the Wolf River estimated using flow modeling resulted in 0.01 m^3/s Dec-May and 11.6 m^3/s June-Nov (IEG, 2005). The average flow of the river upstream of the intake was measured by Nuna Burnside to be approximately 14.3 m^3/s in September 2010 which is a time when the river level is seasonally low. The maximum intake rate of the pump is 0.034 m^3/sec. This is 0.2% of the total estimated flow of the river at the intake.

Since the volume of water pumped from the Wolf River at the intake is only a fraction of the total water in the river, pumping should not affect the water levels of the river.

6.2 Fish Impact Assessment

As part of the conditions of the NWB water licence (Part C Item 4) the water intake has been evaluated to ensure compliance with the DFO guidelines for freshwater intakes. Compliance with the guidelines provided by the Department of Fisheries and Oceans will ensure that fish are not impacted by the intake.

6.2.1 Existing Intake Information

The existing intake location is at Wolf River. This intake operates during the summer months, pumping water from the river to fill the Hamlet reservoirs (Operations staff, pers. comm.). The intake floats approximately 1 to 1.2 metres off the river bed. Based on information gathered from a local fisherman, the main species of fish found in this location are grayling *(Thymallus arcticus)* and stickleback *(Gasterosteus)*. Stickleback fish have been found in the Hamlet's reservoirs (observations by operations staff). The intake is a "Dolphin Floating Suction Strainer" used primarily for oil spills and dewatering applications in the mining industry and is described as a cylindrical perforated stainless steel screen (24.2cm long x 40.0cm diameter) with a sealed top and bottom.

6.2.2 DFO Fish Screen Guidelines

The DFO guideline on end-of-pipe intakes requires protection of fish with a minimum fork length of 25mm and a maximum screen opening of 2.54mm to prevent entrainment or impingement of fish. The DFO guideline is based upon fish swimming ability and water velocities around the intake being less than critical swimming velocities. This calculation requires a maximum intake flow rate to be provided.

6.2.3 Compliance of Existing Screen with DFO Guidelines

The intake screen open and effective areas were determined based on a round screen diameter of 3/16" (4.76mm). This resulted in an Open Screen Area of 37%. The velocity through the existing screen was estimated to be 0.29 m/s which is greater than the recommended velocity for swimming ability of subcarangiform fish (salmonids, cyprinids, percids) of 0.11m/sec. The opening of the existing screen is 4.76mm which also exceeds the recommended maximum opening of 2.54mm.

The existing screen does not comply with the DFO Freshwater Intake End-of-Pipe Intake Guidelines (DFO, 1995) based on screen opening and velocity.

A fabricated screen using the recommended sized opening (2.54mm or less) could be retrofitted to the existing intake. Based on the calculations used from the DFO guideline, a screen that was 40cm in diameter and 50cm long with a maximum screen opening of 2.54mm would comply with the DFO Fish Screen Guidelines. The supporting calculations are provided in Appendix D.

7.0 Mitigation Measures

To ensure that the water level is not impacted by pumping the NWB license requires river water levels will be monitored at Wolf River monthly during thawed conditions. This data can then be used to establish typical water levels and provide a better understanding of fluctuations of flow in the river. A minimum water level should be established and used as a reference during pumping to ensure that pumping does not negatively affect the river water levels. The water level will be measured based on a benchmark location established on the pumphouse. The benchmark location is shown in Figure C-1 and as a photograph in Appendix B. In September 2010, the water level was measured as 2.36 m below the benchmark.

If impacts to river water levels are observed, mitigation measures could include reducing pumping rates and increasing the length of time of pumping.

8.0 Recommendations

The current intake screen does not comply with the DFO guidelines for Freshwater Intakes. A new screen that meets the requirements as described in Section 6.23 is required to meet the license conditions.

The installation of a flow meter at the pump house would provide a better indication of the flow rate at the intake screen. A flow meter was recommended by INAC in their 2009 inspection of the facility.

9.0 Implementation Schedule

A new screen should be installed before pumping begins in late summer 2011. Monitoring of water levels at the intake during thawed conditions should commence in the spring of 2011 as part of the annual monitoring program.

10.0 References

DFO, 1995. Freshwater Intake End of Pipe Fish Screen Guidelines, Department of Fisheries and Oceans, Government of Canada, 1995.

Environment Canada, 2010. Canadian Climate Normals 1971-2000, Rankin Inlet A Weather Station, Environment Canada. <http://climate.weatheroffice.ec.gc.ca/climate_normals/results_e.html?StnID=1721&autofwd=1>. Accessed Sept 21, 2010.

IEG, 2005. Potable Water Supply Study, Arviat, NU, IEG Environmental, December 2005.

Nunavut Bureau of Statistics, 2010. Kivalliq Community Population Projections, 2009 to 2036, Government of Nunavut. <http://www.gov.nu.ca/eia/stats/population.html>. Accessed Sept 21, 2010.

Respectively Submitted,

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Christopher Pfohl, A.Sc.T.

Jim Walls, P.Geo.

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J.R. WALLS
LICENSEE
NWT/NU

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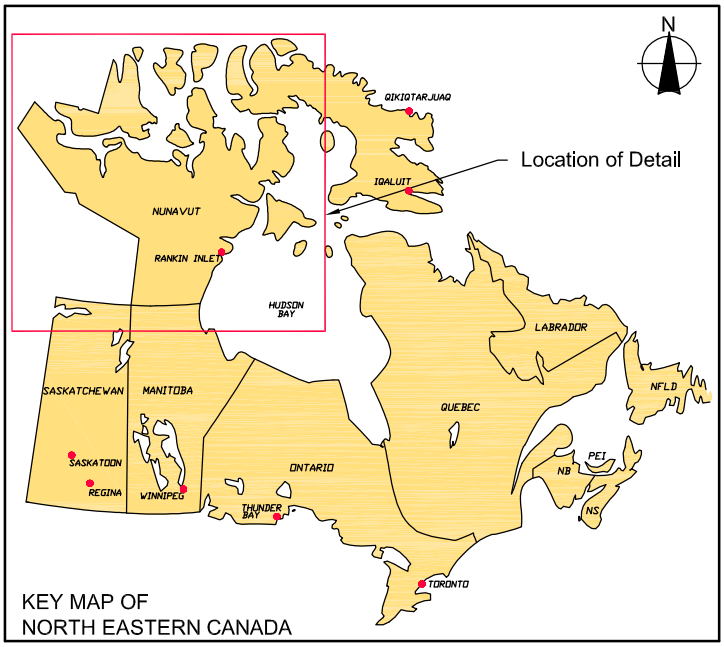
Figures

Map Reference:
Map Art Publishing



KEY MAP OF
NORTH EASTERN CANADA

FIGURE 1 - SITE LOCATION MAP

HAMLET OF ARVIAT
HAMLET OF ARVIAT, NUNAVUT

WOLF RIVER WATER SUPPLY IMPACT ASSESSMENT

December, 2010
Project Number: N-O15746

Prepared by: C. Dickie

Verified by: S. Charity

BURNSIDE

N-O15746 WOLF RIVER IMPACT ASSESS 2010 SL.dwg

Plot Time: Dec 22, 2010 - 2:35pm

FIGURE 2

HAMLET OF ARVIAT
HAMLET OF ARVIAT, NUNAVUT
WATER SUPPLY IMPACT ASSESSMENT

WOLF RIVER WATER SUPPLY INTAKE

LEGEND

WATER FLOW DIRECTION

Satellite Image Source:
Background colour satellite image obtained from Google Earth Pro. © Google Earth Pro: Image © 2010 DigitalGlobe, Photo Date: July, 2006

N

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Metres

1:1,500
December, 2010
Project Number: N-O15746

Projection: UTM Zone 15
Datum: NAD83

Prepared by: C. Dickie

Verified by: S. Charity

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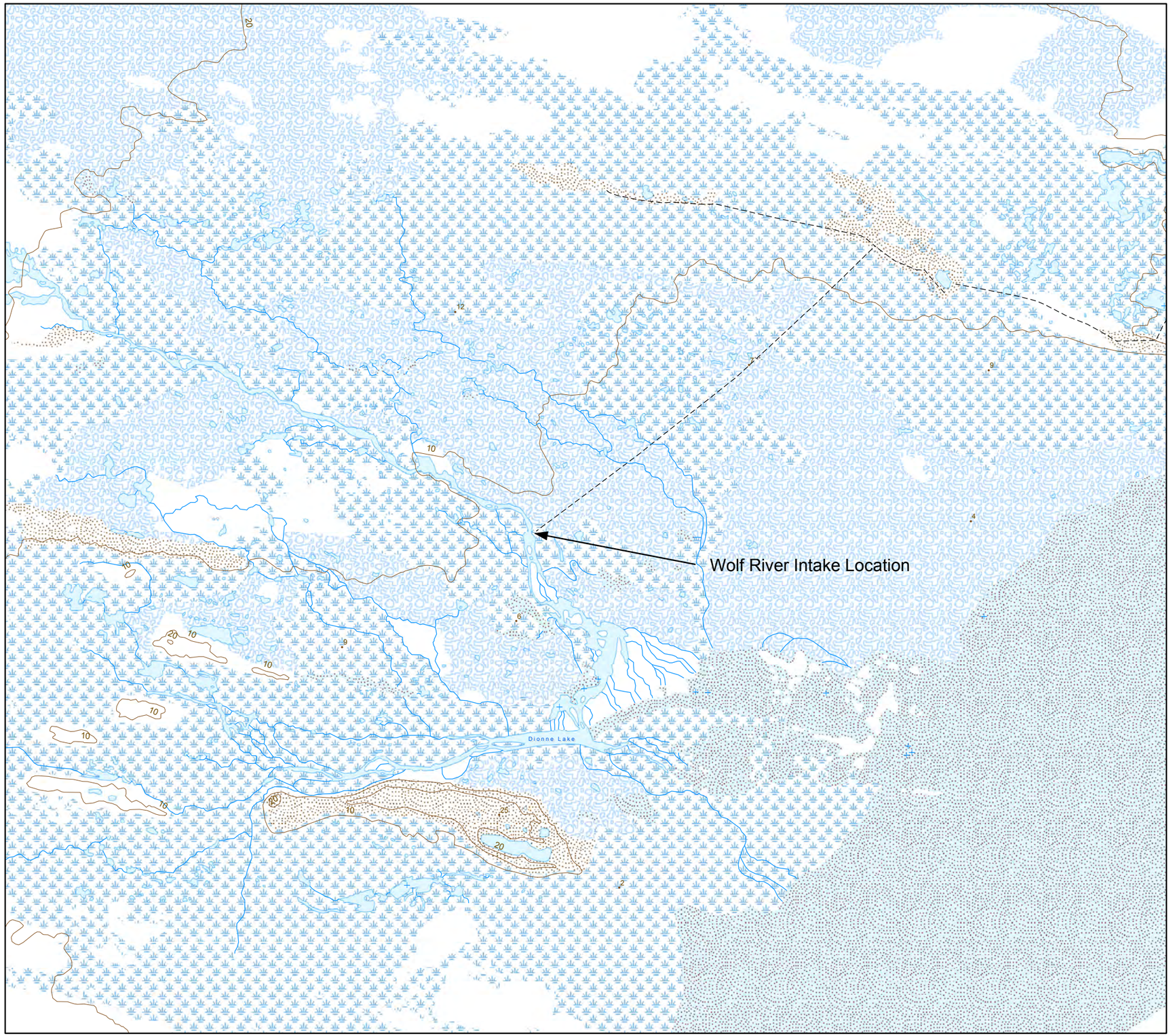

FIGURE 3
HAMLET OF ARVIAT
HAMLET OF ARVIAT, NUNAVUT
WATER SUPPLY IMPACT ASSESSMENT

TOPOGRAPHY & GEOMORPHOLOGY

LEGEND

- Elevation Point
- Rock
- Water Course Permanecy: None
- Water Course Permanecy: Intermittent
- Water Course Permanecy: Permanent
- Water Course Permanecy: Unknown
- Portage
- Trail
- Trail: Undefined
- Contour
- Sand Area
- Sand & Gravel Pit
- Wetland
- Waterbody: Permanent
- Waterbody: Intermittent
- Tundra Pond

N

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Meters

Scale: 1:40,000
December, 2010
Project Number:N-O157460

Projection: UTM Zone 15
Datum: NAD 83

Prepared By: Z. Nevar, C. Dickie

Verified By: S. Charity

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FIGURE 4

HAMLET OF ARVIAT
HAMLET OF ARVIAT, NUNAVUT
WATER SUPPLY IMPACT ASSESSMENT

INTERPRETED WOLF RIVER DRAINAGE BASIN

LEGEND

10m	EXISTING CONTOUR, 10m INTERVAL Obtained from the National Topographic Digital Database
9m	INTERPOLATED CONTOUR, 1m INTERVAL Obtained by using AutoCAD to interpolate 1m contours from the National Topographic Digital 10m contours
	INTERPOLATED MAJOR DRAINAGE BOUNDARY
	INTERPOLATED WOLF RIVER DRAINAGE BASIN
	INTERPOLATED SURFACE WATER & SHALLOW GROUNDWATER FLOW DIRECTION

Map Source:
Background mapping obtained from the National Topographic Digital Database.

N

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Kilometres

1:50,000
December, 2010
Project Number: N-O15746

Projection: UTM Zone 15
Datum: NAD83

Prepared by: C. Dickie

Verified by: S. Charity

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N-O15746 WOLF RIVER IMPACT ASSESS 2010 DRAINAGE BASIN.dwg

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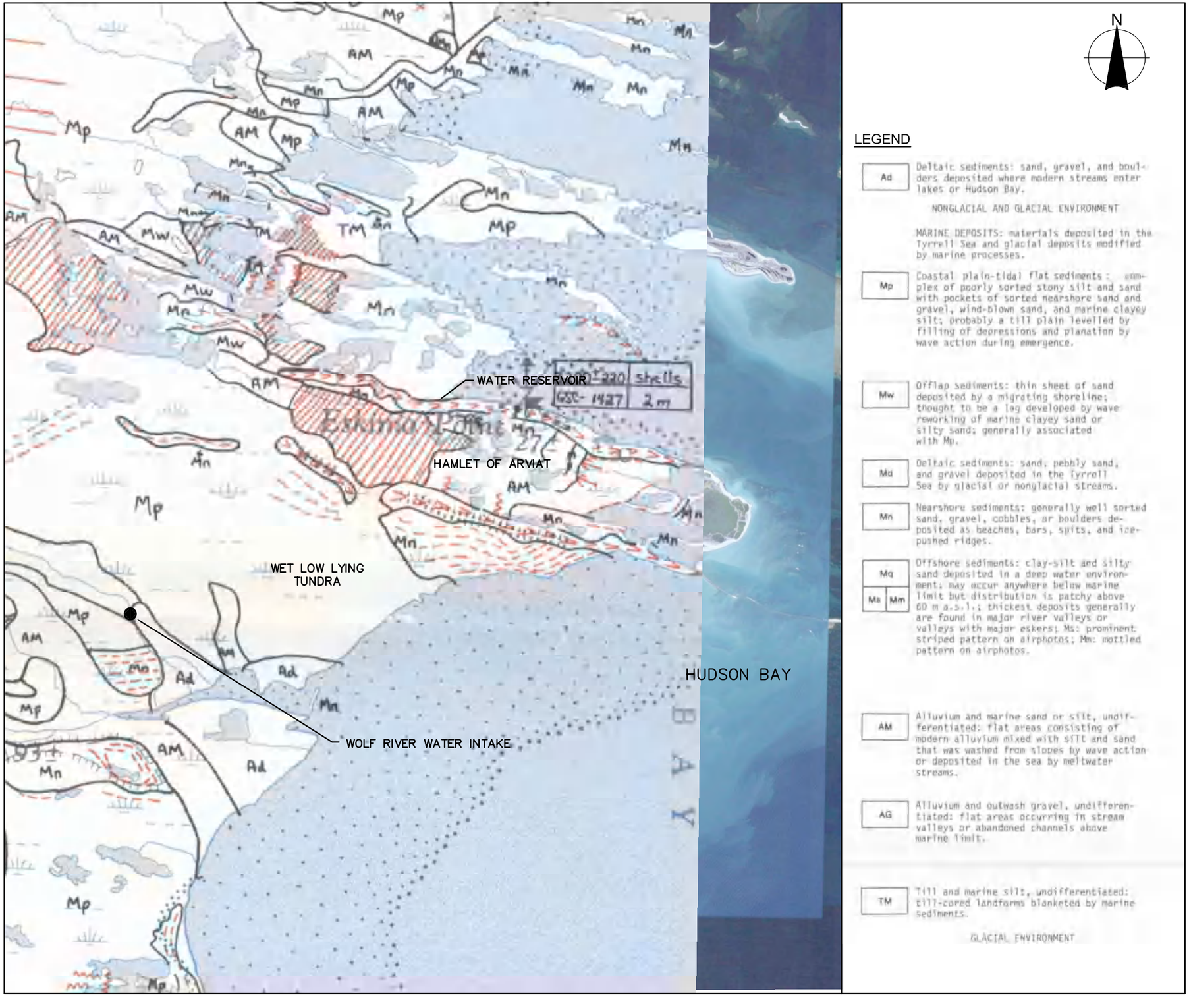

LEGEND

Ad	Deltaic sediments: sand, gravel, and boulders deposited where modern streams enter lakes or Hudson Bay.
	NONGLACIAL AND GLACIAL ENVIRONMENT
	MARINE DEPOSITS: materials deposited in the Tyrrell Sea and glacial deposits modified by marine processes.
Mp	Coastal plain-tidal flat sediments: complex of poorly sorted stony silt and sand with pockets of sorted nearshore sand and gravel, wind-blown sand, and marine clayey silt; probably a till plain levelled by filling of depressions and planation by wave action during emergence.
Mw	Offlap sediments: thin sheet of sand deposited by a migrating shoreline; thought to be a lag developed by wave reworking of marine clayey sand or silty sand; generally associated with Mp.
Md	Deltaic sediments: sand, pebbly sand, and gravel deposited in the Tyrrell Sea by glacial or nonglacial streams.
Mn	Nearshore sediments: generally well sorted sand, gravel, cobbles, or boulders deposited as beaches, bars, spits, and ice-pushed ridges.
Mq	Offshore sediments: clay-silt and silty sand deposited in a deep water environment; may occur anywhere below marine limit but distribution is patchy above 60 m a.s.l.; thickest deposits generally are found in major river valleys or valleys with major eskers; Ms: prominent striped pattern on airphotos; Mm: mottled pattern on airphotos.
Ms Mm	
AM	Alluvium and marine sand or silt, undifferentiated: flat areas consisting of modern alluvium mixed with silt and sand that was washed from slopes by wave action or deposited in the sea by meltwater streams.
AG	Alluvium and outwash gravel, undifferentiated: flat areas occurring in stream valleys or abandoned channels above marine limit.
TM	Till and marine silt, undifferentiated: till-cored landforms blanketed by marine sediments.
	GLACIAL ENVIRONMENT

FIGURE 5

HAMLET OF ARVIAT
HAMLET OF ARVIAT, NUNAVUT
WATER SUPPLY IMPACT ASSESSMENT

SURFICIAL GEOLOGY

LEGEND

Symbols

- Small bedrock outcrop
- Drumlin or fluting (direction of ice flow known, unknown)
- Crag and tail (direction of ice flow known)
- Linear feature related to ice flow but obscured by solifluction processes, water-laid deposits, wave reworking, or kelp
- Glacial striae (direction of ice movement known, unknown; location of measurement at centre of staff; older striae drawn with broken staff)
- Trend of ribbed or minor moraine ridges
- Hummocky moraine
- DeGeer moraines; straight, approximately 2 m high end moraine ridges built parallel to an ice front; possibly deposited annually by floating ice submerged in a sea or lake
- Area of ridges formed by pack-ice shove
- Trend of nearshore marine ridges originating as beaches, bars, spurlines, and ice-shoved ridges
- Esker (direction of flow known, unknown), may be confused with or obscured by nearshore features; projected beneath water surfaces where known or inferred
- Meltwater channel; steep-sided channel commonly cut in bedrock or till
- Permanently stratified postglacial lake basin; may include deposits of silty sediment with up to 10 per cent organic carbon
- Turbid lake; contains continual load of suspended sediment during ice-free periods; rarely occurs above marine limit, and indicates instability or alteration of the active layer due to wave washing or solifluction processes
- Limit of marine submergence
- Escarpment; generally in unconsolidated sediments
- Palsa-like feature
- Slump deposits; commonly formed where ice shove or bank failures have disrupted the vegetation mat over alluvial sand
- Geological boundary
- Delineation data

Satellite Image Source:
Background colour satellite image obtained from Google Earth Pro.

Surficial Geology Map Source:
Surficial Geology Map 8-1980 obtained from the Natural Resources Canada, MIRAGE website.

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Project Number: N-O157460

Projection: UTM Zone 15
Datum: NAD83

Prepared by: C. Dickie
Verified by: S. Charity

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N-O15746 WOLF RIVER IMPACT ASSESS 2010 SG.dwg

Plot Time: Dec 22, 2010-2:19pm

FIGURE 6

HAMLET OF ARVIAT
HAMLET OF ARVIAT, NUNAVUT
WATER SUPPLY IMPACT ASSESSMENT

BEDROCK GEOLOGY

LEGEND

ARCHEAN

Atd	*Tonalites, diorites, and gabbros*
Agd	*Granitic rocks, granites, and granodiorites*

Bedrockl Geology Map Source:
Bedrock Geology Map Open File 4236 obtained from the Natural Resources Canada, MIRAGE website.

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December, 2010
Project Number: N-O15746

Projection: UTM Zone 15
Datum: NAD83

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N-O15746 WOLF RIVER IMPACT ASSESS 2010 BG.dwg

Plot Time: Dec 22, 2010 - 2:14pm

FIGURE 7

HAMLET OF ARVIAT
HAMLET OF ARVIAT, NUNAVUT
WATER SUPPLY IMPACT ASSESSMENT

SAMPLING LOCATIONS

LEGEND

- WATER SAMPLE LOCATION
- WATER ELEVATION BENCHMARK
- WATER FLOW DIRECTION

Satellite Image Source:
Background colour satellite image obtained from Google Earth Pro. © Google Earth Pro: Image © 2010 DigitalGlobe, Photo Date: July, 2006

N

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1:1,500
December, 2010
Project Number: N-O15746

Projection: UTM Zone 15
Datum: NAD83

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N-O15746 WOLF RIVER IMPACT ASSESS 2010 SAMPLE LOCATIONS.dwg

Plot Time: Dec 22, 2010–2:16pm

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Appendix A
Climate Data

Climate Data

Rankin Inlet Climate Normals Data Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Total Precipitation (mm)	6.6	8.9	12.6	14.3	18.4	29.8	39.5	57.6	43.8	34.6	19.8	11.3	297.2
Rain (mm)	0.0	0.1	0.0	1.0	7.4	25.0	39.5	57.3	39.2	11.9	0.1	0.0	181.5
Snow (cm)	6.7	9.3	12.9	13.6	11.5	4.9	0.0	0.3	4.6	23.1	20.9	11.9	107.8
Wind Speeds (km/hour)	23.9	23.9	23.4	22.4	22.1	19.8	19.2	21.1	24.2	26.5	25.3	24.0	
Average Temperatures (°C)	-31.9	-30.1	-25.2	-16.3	-5.9	4.2	10.4	9.5	3.4	-5.3	-17.8	-26.7	

*Canadian Climate Normals 1971-2000, Environment Canada, Rankin Inlet Airport Weather Station

Specific climate data for Arviat was not available. The closest weather station is located in Rankin Inlet, 225 km north of Arviat.

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Appendix B
Photographs

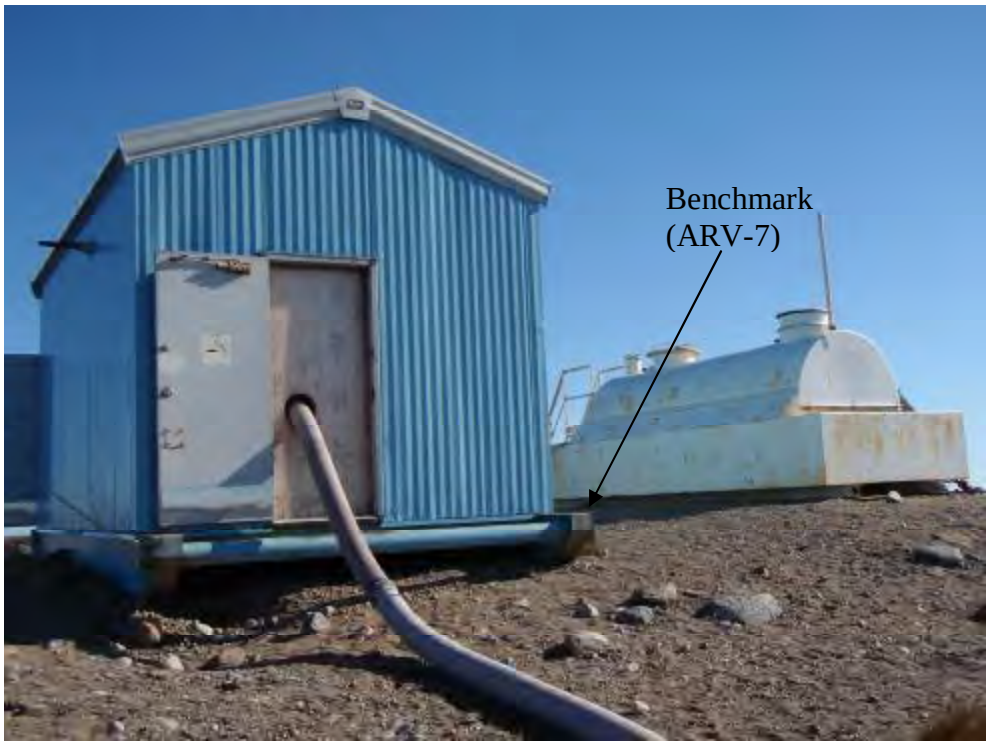

Photo 1: Wolf River Water Intake Pumphouse


Photo 2: Wolf River Water Intake

Photo 3: Water intake pipe

Photo 4: Water intake floating in water

Photo 6: Water Intake Screen

Photo 5: Looking downstream of Intake

Photo 8: Upstream of Wolf River Intake

Photo 7: Water pipeline going back towards Arviat

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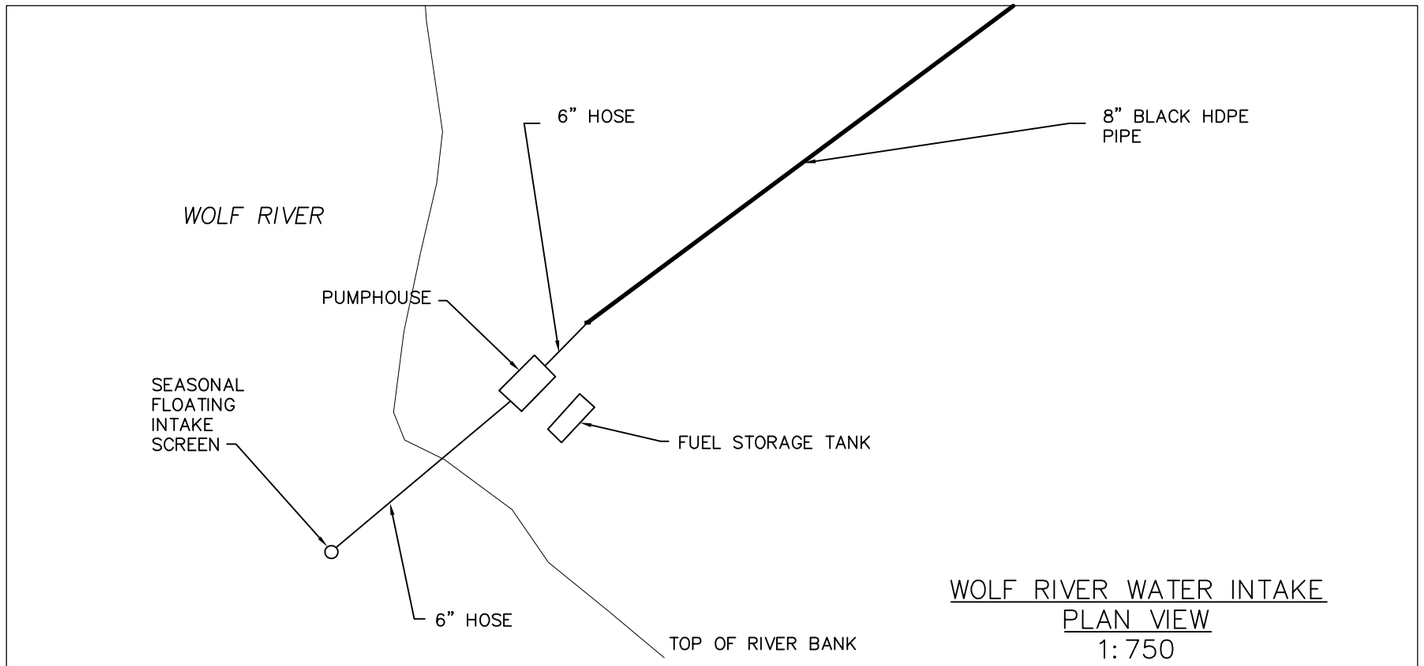
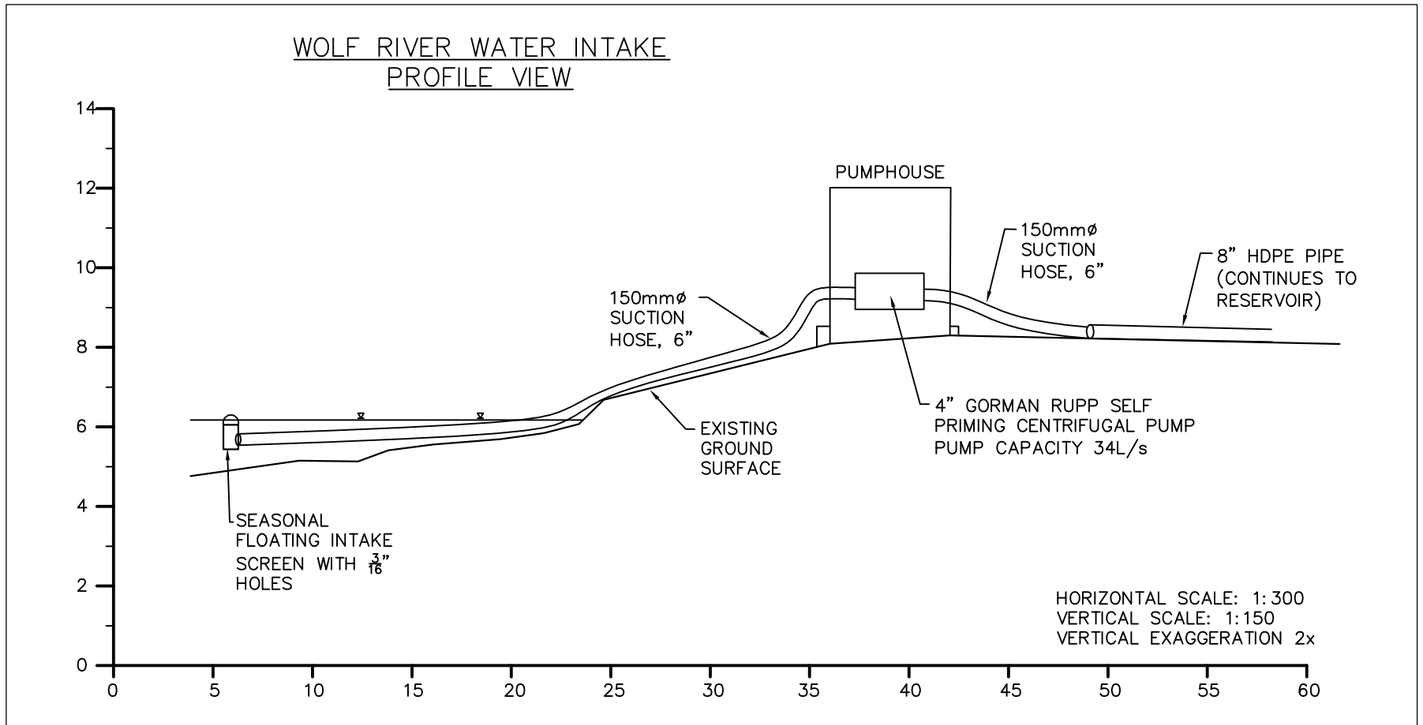
Appendix C
As-Built Drawing



WOLF RIVER WATER INTAKE
PLAN VIEW
1:750



1. This drawing is th exclusive property of Nuna Burnside Engineering and Environmental Ltd. and the reproduction of any part without prior written consent of this office is strictly prohibited.
2. Drawing has been completed based on field observations by Nuna Burnside.
3. This drawing is to be read and understood in conjunction with all other plans and documents applicable to this project.
4. Do not scale the drawings.

No.	Issue / Revision	Date
1	Client Review and Approval	Dec, 2010

NUNA BURNSIDE

Project Title
HAMLET OF ARVIAT
ARVIAT, NUNAVUT
WOLF RIVER WATER SUPPLY
IMPACT ASSESSMENT

Drawing Title
WOLF RIVER WATER INTAKE
PLAN AND PROFILE DETAILS

Rev 0

Drawn	Checked	Designed	Checked	Drawing No.
CD	SC	SC	GP	C-1
Scale: AS NOTED		Project No.: N-0157460		

N-015746 WOLF RIVER IMPACT ASSESS PLAN DETAILS.dwg
Date Plotted: Dec 22, 2010 - 2:00pm

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Appendix D
Calculation Worksheets

Wolf River Flow Calculations

FLOW MEASUREMENTS

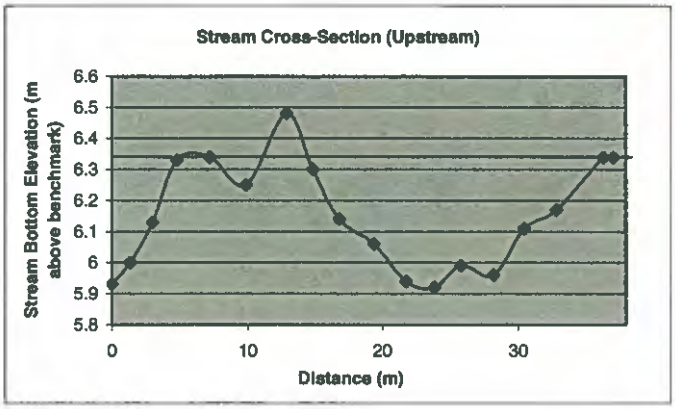
Trial	Distance (m)	Time (sec)	Flow (m/s)	
1	60	72	0.83	
2	60	92	0.65	
3	10	21	0.48	
4	10	19	0.53	
		Average	0.62	m/s

Depth Measurements - River Cross-sections

Section A - Upstream of Intake

Avg Flow Velocity 0.62 m/s
Water Elevation 6.34 m above benchmark

	Distance (m)	Bottom of Stream Elevation (m abm)	Water Depth (m)	Average Velocity (m/s)	Area (m^2)	Flow (m^3/s)
West Bank	0	5.93	0.41	0	0.00	0.00
	1.35	6	0.34	0.62	0.51	0.31
	3	6.13	0.21	0.62	0.45	0.28
	4.8	6.33	0.01	0.62	0.20	0.12
	7.2	6.34	0	0	0.01	0.00
	9.9	6.25	0.09	0.62	0.12	0.08
	12.9	6.48	0	0	0.14	0.00
	14.85	6.3	0.04	0.62	0.04	0.02
	16.8	6.14	0.2	0.62	0.23	0.15
	19.35	6.06	0.28	0.62	0.61	0.38
	21.75	5.94	0.4	0.62	0.82	0.51
	23.85	5.92	0.42	0.62	0.86	0.53
	25.8	5.99	0.35	0.62	0.75	0.47
	28.2	5.96	0.38	0.62	0.88	0.54
	30.45	6.11	0.23	0.62	0.69	0.43
	32.85	6.17	0.17	0.62	0.48	0.30
	36.3	6.34	0	0	0.29	0.00
East Bank	37.05	6.34	0	0	0.00	0.00
					Total Flow	4.11



Water Use Projections for the Hamlet of Arviat, Nunavut

Key Assumptions

Starting Year:	2006	Starting Population:	2060
Population Growth Rate:	3.2%	Residential Water Usage Rate [L/cd]::	65.0

Planning Year	Calendar Year	Projected Population[1]	Projected Water Consumption[2]	Projected Total Consumption Volume			
			[Lpcd]	[Litres/day]	[Litres/year]	[m3/day]	[m3/year]
	2006	2060	95.8	197342	72,029,764	197	72,030
	2007	2126	96.8	205762	75,103,183	206	75,103
	2008	2195	97.8	214704	78,367,133	215	78,367
0	2009	2254	98.7	222464	81,199,256	222	81,199
	2010	2296	99.3	228051	83,238,491	228	83,238
	2011	2339	100.0	233825	85,346,223	234	85,346
	2012	2383	100.6	239791	87,523,861	240	87,524
	2013	2428	101.3	245953	89,772,845	246	89,773
5	2014	2474	102.0	252314	92,094,649	252	92,095
	2015	2521	102.7	258879	94,490,778	259	94,491
	2016	2571	103.4	265935	97,066,316	266	97,066
	2017	2622	104.2	273210	99,721,473	273	99,721
	2018	2674	105.0	280707	102,457,919	281	102,458
10	2019	2728	105.8	288578	105,330,846	289	105,331
	2020	2784	106.6	296832	108,343,792	297	108,344
	2021	2841	107.5	305331	111,445,688	305	111,446
	2022	2898	108.3	313926	114,583,041	314	114,583
	2023	2957	109.2	322926	117,867,823	323	117,868
	2024	3017	110.1	332184	121,247,241	332	121,247
	2025	3076	111.0	341394	124,608,646	341	124,609
	2026	3136	111.9	350866	128,065,986	351	128,066
	2027	3196	112.8	360446	131,562,615	360	131,563
	2028	3257	113.7	370295	135,157,796	370	135,158
20	2029	3319	114.6	380421	138,853,529	380	138,854
	2030	3379	115.5	390329	142,469,988	390	142,470
	2031	3439	116.4	400344	146,125,735	400	146,126
	2032	3499	117.3	410468	149,820,771	410	149,821
	2033	3561	118.2	421042	153,680,249	421	153,680
	2034	3623	119.2	431731	157,581,679	432	157,582
	2035	3685	120.1	442534	161,525,061	443	161,525
	2036	3747	121.0	453453	165,510,394	453	165,510
	2037	3867	122.8	474913	173,343,117	475	173,343
	2038	3991	124.7	497540	181,602,031	498	181,602
30	2039	4119	126.6	521379	190,303,374	521	190,303

Note:

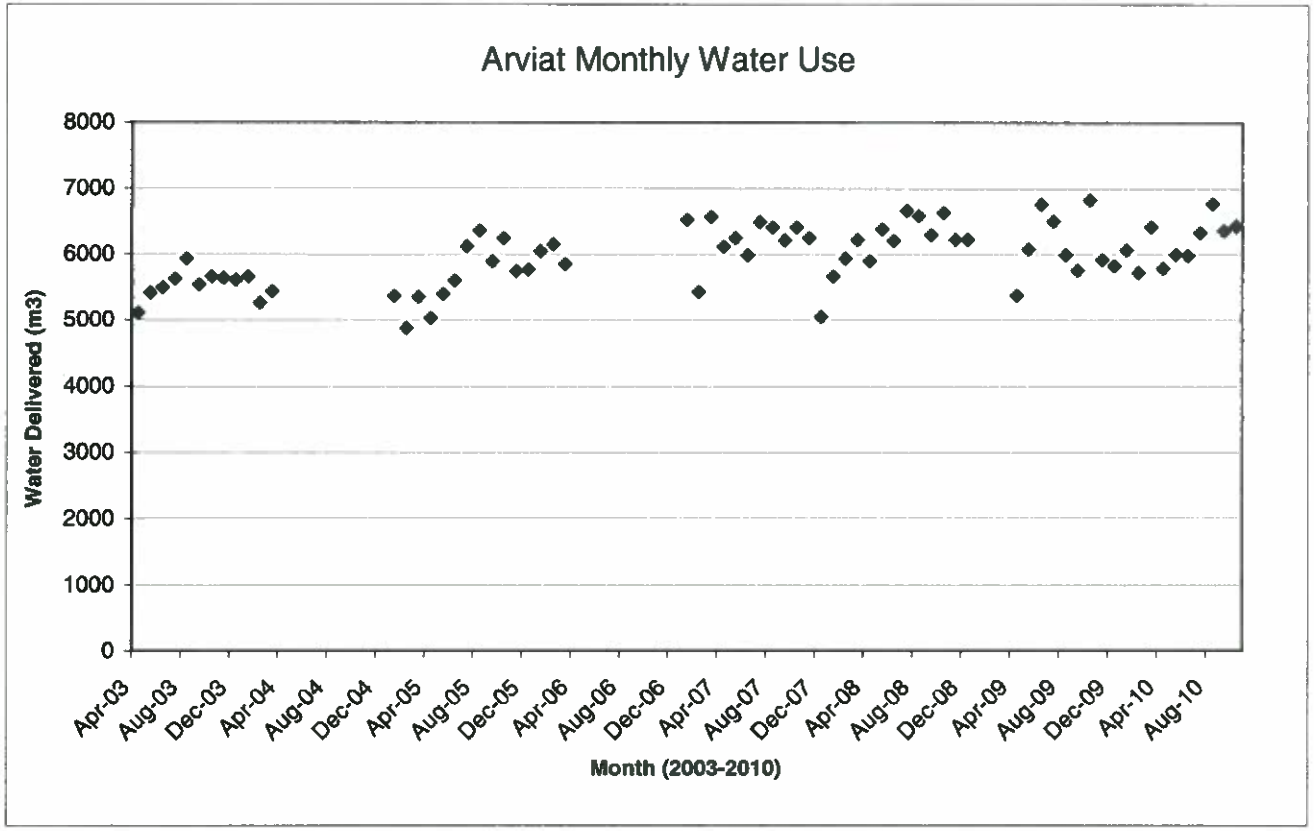
1) Population in 2006 taken from Statistics Canada 2006 Census of Population. A population growth of 3.2% was applied to the subsequent years.

2) The projected water consumption is based on the Nunavut water usage formula [RWU L/c/d x (1 + (0.00023 x [population]).

3) The Residential Water Usesage Rate is estimated to be 90 L/c/d for municipalities where water is not distributed by a piping system. To fit the recorded water use data the RWU rate was lowerd to 65 L/c/d.

Recorded Water Use - Hamlet of Arviat

Year	Recorded Water Use (m^3)
2003	66,399
2005	67,745
2007	73,686
2008	74,900
2009	72,807
2010	73,523



Hydrology Calculations, Hamlet of Arviat

Annual Rainfall (m/year)	0.2972	*Canadian Climate Normals 1971-2000, Environment Canada, Rankin Inlet Airport Weather Station
Evapotranspiration (m/year)	0.200	* Specific values for Arviat were not available, estimated using several references, see below.

Wolf River Drainage Basin

River Catchment Area (m^2)*	650,000,000
Rain and Runoff (m^3/year)	193,180,000
Evapotranspiration (m^3/year)	130,000,000
Net Recharge of Catchment Area (m^3/year)	63,180,000

* IEG Environmental, 2005

Evapotranspiration Rates

Location	Value (mm)	Reference
Arviat, Nunavut	203	FSC Architects & Engineers, 2003
Mackenzie Basin, Yukon	241	Serrereze et al, 2003
Lena Basin, Russai	182	Serrereze et al, 2003
Knob Lake, Quebec	280	Church, 1974
Boot Creek, Inuvik, NWT	75	Church, 1974
Mackenzie River Basin, Yukon	216	Yi Yip, 2008
Average	**200**	

References:

FSC Architects & Engineers, 2003. Design Concept for Arviat Sewage Lagoon prepared for Department of Community Government and Transportation, Government of Nunavut.

Church, M. t974. Hydrology and Permafrost with Reference to Northern North America. In Proceedings: Workshop Seminar on Permafrost Hydrology, 7-20. Ottawa: Canadian National Committee, International Hydrological Decade (IHD).

Yi Yip, Q.M. 2008. Climate Impacts on Hydrometric Variables in Mackenzie River Basin. University of Waterloo, Waterloo, 2008.

Serreze, M.C., D.H. Bromwich, M.P. Clark, A.J. Etringer, T. Zhang and R. Lammers, 2003. Large-scale hydro-climatology of the terrestrial Arctic drainage system. Journal Geophysical Research, 108(D2). Doi:10. t029/2002JD000919

Date: November 23, 2010
Municipality: Hamlet of Arviat
Project No.: N-O157460
Prepared by: C. Phohl
Checked by: M. Hartley

End-of-Pipe Fish Screen Size Calculations

ASSUMPTIONS: **Screen has a maximum opening of 2.54 mm**
Target fish minimum fork length is 25 mm
Maximum endurance swimming time is 10 min
Approximate approach velocity (subcarangiform) is 0.11 m/s
Approximate approach velocity (anguilliform) is 0.038 m/s

Given flow…	Q (m^3/s)	0.034	34			
			Note 1	*Note 2*	*Note 1*	*Note 2*
Table 2 lookup for Open Screen Area Required:	OSA (m^2)		0.31	0.89	0.31	0.89
% Open Area for given material (Table 3)	%		51	51	69	69
Calculate - Effective Screen Area	ESA (m^2)		0.61	1.75	0.45	1.29
Given Screen Diamater	D (m)		0.40	0.40	0.40	0.40
Calculate Screen Length	L (m)		0.48	1.39	0.36	1.03

Note 1: Subcarangiform swimming mode
Note 2: Anguilliiform swimming mode

Ref: "Freshwater intake end-of-pipe fish screen guideline" DFO 1995

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Appendix E
Sampling Results

Table E-1: Water Quality Sampling Results - Wolf River

Parameter	Unit	Detection Limits	Canadian Drinking Water Quality Standards	Wolf River Water Intake	
				9/8/2010 WI-Up	9/8/2010 WI-Down
Colour	TCU	5	15*	8	9
Electrical Conductivity	µS/cm	2	-	76	76
pH	N/A	-	6.5-8.5	6.84	6.86
Turbidity	NTU	0.5	1	0.7	0.6
Alkalinity (as CaCO3)	mg/L	5	-	7	7
Bicarbonate (as CaCO3)	mg/L	5	-	7	7
Total Hardness (as CaCO3)	mg/L	10	200*	16	15
Ammonia as N	mg/L	0.02	-	<0.02	0.11
Nitrate as N	mg/L	0.05	45	<0.05	<0.05
Nitrite as N	mg/L	0.05	3.2	<0.05	<0.05
Calcium	mg/L	0.05	-	3.5	3.38
Chloride	mg/L	0.1	250*	16.6	16.7
Fluoride	mg/L	0.05	1.5	<0.05	<0.05
Magnesium	mg/L	0.05	-	1.67	1.66
Orthophosphate as P	mg/L	0.1	-	<0.1	<0.1
Potassium	mg/L	0.05	-	0.76	0.74
Reactive Silica	mg/L	0.05	-	<0.05	<0.05
Sodium	mg/L	0.05	200*	7.57	7.54
Sulphate	mg/L	0.1	500*	3.1	3.16
Total Dissolved Solids	mg/L	20	500*	46	46
Total Organic Carbon	mg/L	0.5	-	5	5
Total Phosphorus	mg/L	0.05	-	<0.05	<0.05
Aluminum	mg/L	0.004	0.1	0.008	0.007
Arsenic	mg/L	0.003	0.025	<0.003	<0.003
Barium	mg/L	0.002	1	0.005	0.006
Boron	mg/L	0.01	5	<0.010	<0.010
Cadmium	mg/L	0.002	0.005	<0.002	<0.002
Chromium Total	mg/L	0.003	0.05	<0.003	<0.003
Copper	mg/L	0.003	1.0*	<0.003	<0.003
Iron	mg/L	0.01	0.3*	0.043	0.038
Lead	mg/L	0.002	0.01	<0.002	<0.002
Manganese	mg/L	0.002	0.05*	0.008	0.008
Mercury	mg/L	0.0001	0.001	-	-
Molybdenum	mg/L	0.002	-	<0.002	<0.002
Nickel	mg/L	0.003	-	<0.003	<0.003
Selenium	mg/L	0.004	0.01	<0.004	<0.004
Silver	mg/L	0.002	-	<0.002	<0.002
Strontium	mg/L	0.005	-	0.027	0.026
Thallium	mg/L	0.006	-	<0.006	<0.006
Titanium	mg/L	0.002	-	<0.002	<0.002
Uranium	mg/L	0.002	0.02	<0.002	<0.002
Vanadium	mg/L	0.002	-	<0.002	<0.002
Zinc	mg/L	0.005	5.0*	<0.005	<0.005

Guidelines: Canadian Drinking Water Quality Standards, Health Canada

* Aesthetic Objective

"-" indicates that there is no guideline for drinking water

AGAT Laboratories

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Certificate of Analysis

AGAT WORK ORDER: 10T434776
PROJECT NO: N-015746

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES LTD

ATTENTION TO: Stephanie Charity

BURNSIDE - Water Quality Assessment

DATE SAMPLED: Sep 08, 2010 | DATE RECEIVED: Sep 13, 2010 | DATE REPORTED: Sep 21, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	WI-Up 1987361	WI-Down 1987362
Aluminum	mg/L		0.004	0.008	0.007
Arsenic	mg/L		0.003	<0.003	<0.003
Barium	mg/L		0.002	0.005	0.006
Boron	mg/L		0.010	<0.010	<0.010
Cadmium	mg/L		0.002	<0.002	<0.002
Calcium	mg/L		0.05	3.50	3.38
Chromium	mg/L		0.003	<0.003	<0.003
Copper	mg/L		0.003	<0.003	<0.003
Iron	mg/L		0.010	0.043	0.038
Potassium	mg/L		0.05	0.76	0.74
Magnesium	mg/L		0.05	1.67	1.66
Manganese	mg/L		0.002	0.008	0.008
Molybdenum	mg/L		0.002	<0.002	<0.002
Sodium	mg/L		0.05	7.57	7.54
Nickel	mg/L		0.003	<0.003	<0.003
Total Phosphorus	mg/L		0.05	<0.05	<0.05
Lead	mg/L		0.002	<0.002	<0.002
Selenium	mg/L		0.004	<0.004	<0.004
Silver	mg/L		0.002	<0.002	<0.002
Strontium	mg/L		0.005	0.027	0.026
Thallium	mg/L		0.006	<0.006	<0.006
Titanium	mg/L		0.002	<0.002	<0.002
Uranium	mg/L		0.002	<0.002	<0.002
Vanadium	mg/L		0.002	<0.002	<0.002
Zinc	mg/L		0.005	<0.005	<0.005
Fluoride	mg/L		0.05	<0.05	<0.05
Chloride	mg/L		0.10	16.6	16.7
Nitrite as N	mg/L		0.05	<0.05	<0.05
Ortho phosphate as P	mg/L		0.10	<0.10	<0.10
Bromide	mg/L		0.05	<0.05	<0.05
Nitrate as N	mg/L		0.05	<0.05	<0.05
Sulphate	mg/L		0.10	3.10	3.16
pH	pH Units		NA	6.84	6.86

Certified By:

AGAT Laboratories

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AGAT WORK ORDER: 10T434776
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DATE SAMPLED: Sep 08, 2010 | DATE RECEIVED: Sep 13, 2010 | DATE REPORTED: Sep 21, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	WI-Up 1987361	WI-Down 1987362
Ammonia as N	mg/L		0.02	<0.02	0.11
Total Organic Carbon	mg/L		0.5	5.0	5.0
Electrical Conductivity	uS/cm		2	76	76
Total Dissolved Solids	mg/L		20	46	46
Saturation pH				9.66	9.67
% Difference/ Ion Balance			0.1	0.9	1.3
Total Hardness (as CaCO3)	mg/L		10	16	15
Langlier Index				-2.82	-2.81
Carbonate (as CaCO3)	mg/L		5	<5	<5
Bicarbonate (as CaCO3)	mg/L		5	7	7
Turbidity	NTU		0.5	0.7	0.6
Alkalinity (as CaCO3)	mg/L		5	7	7
Hydroxide (as CaCO3)	mg/L		5	<5	<5
Reactive Silica	mg/L		0.05	<0.05	<0.05
Colour	TCU		5	8	9

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By: