TECHNICAL MEMORANDUM

DATE	August 9, 2012	**PROJECT No.**	09-1427-0006-4000-4100
TO	Rudy Schmidtke AECOM Consultants Ltd.	**AECOM DOC. No.**	318-WTP-10-MEM-0002-Rev1-20120809
CC	Lisa Dyer, PWGSC	**GAL DOC. No.**	186
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BASELINE DATA COLLECTION FOR SNOW DEPTH, ICE THICKNESS AND WATER QUALITY FOR HYDRODYNAMIC MODELLING OF YELLOWKNIFE BAY, GREAT SLAVE LAKE, NWT

1.0 INTRODUCTION

The Giant Mine Remediation Project is proposing to modify the management of mine water discharge as part of the final reclamation plan. Currently, the mine water system collects mine water in the Northwest Pond year round and discharges treated effluent into Baker Pond during the open water season, typically between July and September. The proposed new water treatment system will be designed to treat and discharge mine water year round, with a new diffuser located in Yellowknife Bay, Great Slave Lake.

Modelling of hydrodynamic conditions in Yellowknife Bay is required to support the detailed design of the infrastructure associated with the diffuser. Calibration of this hydrodynamic model requires snow depth, ice thickness and water quality information. Golder Associates Ltd. (Golder) completed field surveys to collect snow depth, ice thickness and water quality on February 14, 2012 and March 26, 2012. This technical memorandum summarizes the results from these two field surveys.

2.0 METHODS

2.1 Sampling Station Locations

Sampling was completed at nine stations within Yellowknife Bay (Table 1 and Figure 1). All stations were accessible by snowmobile and were located using a handheld GPS.

2.2 Snow Depth, Ice Cover and Maximum Water Depth

In February and March, a Stihl ice auger was used to drill through the snow and ice at each station. An ice thickness gauge was used to measure the snow depth and ice thickness. Maximum water depth was measured using a YSI 600-QS multi-meter.

Table 1: Sampling Station Locations in Yellowknife Bay, 2012

Station	Location	Latitude	Longitude	UTM	
				Easting	Northing
S1	Back Bay	62°28'17.43" N	114°21'16.50" W	636386	6929501
S2	Pipeline alignment near marina	62°29'9.62" N	114°21'0.83" W	636544	6931125
S3	Proposed diffuser location	62°29'9.88" N	114°19'46.85" W	637602	6931176
S4	Downstream of proposed diffuser location	62°28'58.18" N	114°19'38.98" W	637730	6930819
S5	Upstream of proposed diffuser location	62°29'30.44" N	114°19'36.95" W	637717	6931818
S6	Yellowknife Bay near Latham Island	62°28'31.48" N	114°19'32.12" W	637862	6929997
S7	Near city Pump House 1 intake	62°27'0.78" N	114°20'50.59" W	636854	6927146
S8	Yellowknife Bay, near WSC station 07SB001	62°26'37.82" N	114°20'8.68" W	637484	6926461
S9	Yellowknife River, upstream of City Pump House 2 intake	62°31'22.84" N	114°18'58.80" W	638119	6935317

Notes: UTM = Universal Transverse Mercator; ° = degrees; ' = minutes' " = seconds; N = north; W = west. All coordinates are in NAD 83, Zone 11.

2.3 Water Quality

Limnology Profiles

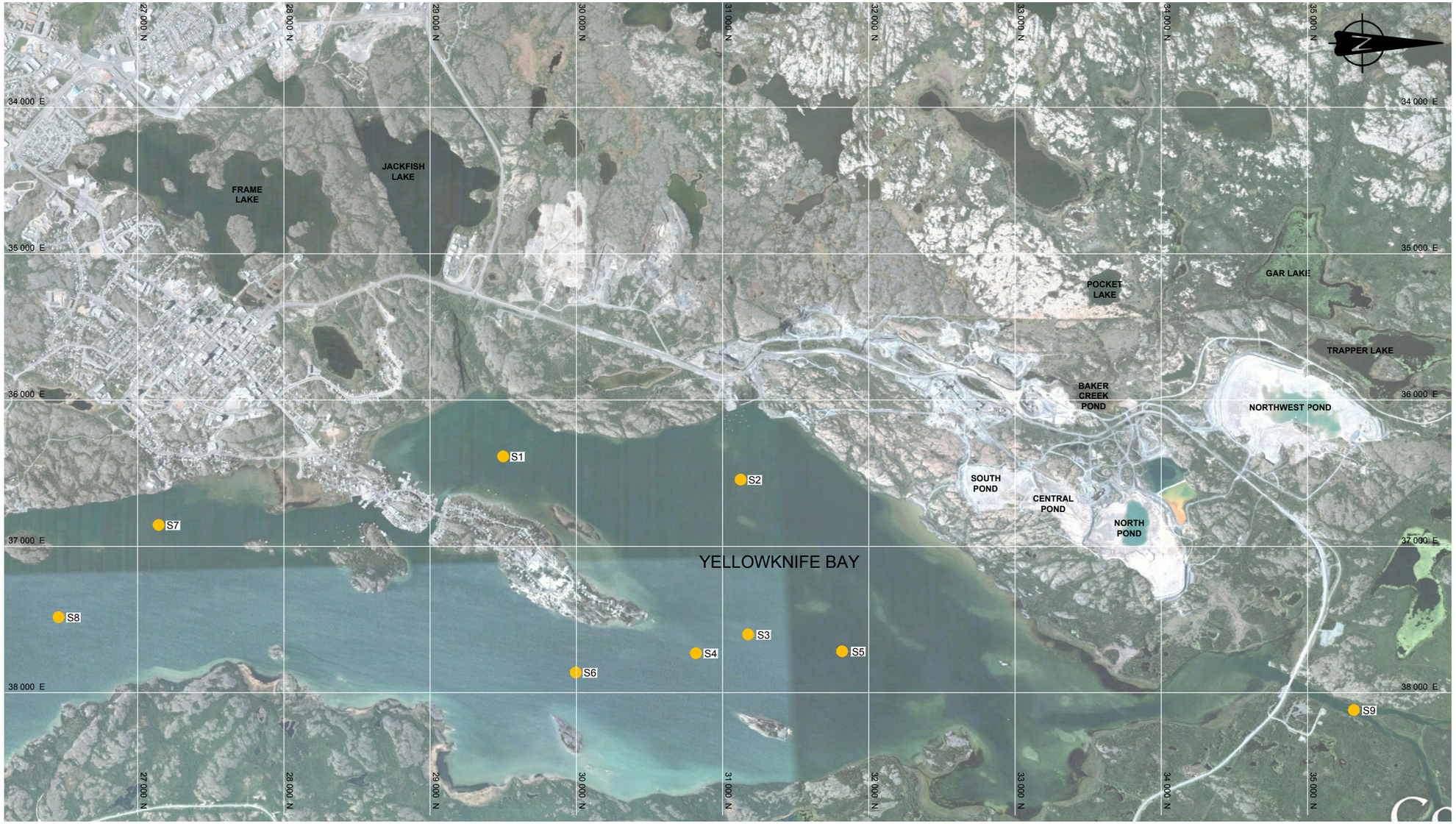
In February and March, depth profiles of pH, dissolved oxygen, conductivity, and water temperature were measured at each sampling station. These measurements were collected at 1.0 m intervals, beginning from the bottom of ice cover, with a YSI 600-QS multi-meter.

Water Chemistry

In March, water chemistry samples were collected from the nine sampling stations in Yellowknife Bay. Surface grab samples were collected at all stations and bottom grab samples were collected from the maximum water depth at four of the stations (i.e., stations S3, S4, S5 and S6).

All water chemistry samples were submitted to ALS Environmental Laboratories (ALS) in Vancouver and analysed for the following parameters:

- routine parameters (e.g., major ions, alkalinity);
- total dissolved solids (TDS);
- total suspended solids (TSS);
- total and dissolved metals and metalloids;
- sulphate;
- total and dissolved organic carbon;
- total and dissolved phosphorus; and
- nitrogen compounds.



LEGEND

S2 SAMPLING STATION

REFERENCES

1. IMAGE FROM GOOGLE EARTH. DATE: 16/05/2012

0 300 600 900 1200 1500

SCALE IN METRES

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
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SERVICES IMMOBILIERS
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PRELIMINARY

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Revision/ Révision	Description/Description	Date/Date
1	ISSUED WITH MEM-0002-REV1	2012-08-09
0	ISSUED WITH MEM-0002-REV0	2012-05-18

Client/client

PUBLIC WORKS GOVERNMENT SERVICES CANADA

Project title/Titre du projet

GIANT MINE REMEDIATION PROJECT
GIANT MINE REMEDIATION PROJECT, NWT

WASTE WATER TREATMENT PLANT

Approved by/Approuvé par: JAH

Designed by/Concept par: KMH

Drawn by/Dessiné par: RH

PWGSC Project Manager/Administrateur de Projets TPSGC: PWGSC

PWGSC, Architectural and Engineering Resources Manager/ Ressources Architectural et de Directeur d'ingénierie, TPSGC:

Client/client: PWGSC

Drawing title/Titre du dessin

SAMPLING STATION LOCATIONS IN YELLOWKNIFE BAY, 2012

Project No./No. du projet	Sheet/Feuille	Revision no./ La Révision no.
R.014204	FIGURE 1 OF 1	1

Drawing File: N:\Burnaby\Projects\2000\1427-2000\Drafting\4000\Mxd\ 4000\GIS\1427000A_4000_4200_01.dwg Layout:SAMPLING STATION LOCATIONS IN YELLOWKNIFE BAY 2012 Thursday, May 17, 2012 3:58:17 PM By: RHewlett

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2.4 Data Analysis

A qualitative review of the snow depth, ice thickness and water quality data was completed, but no quantitative comparisons (i.e., statistical analyses) were conducted. The qualitative review included a comparison to historical data collected by Jackson et al. (1996) and Golder (2010). While these historic measurements are not directly comparable because they were not collected from the same locations, they provide some regional context for the 2012 data.

The City of Yellowknife measures ice thickness annually at various locations around the Yellowknife area on a weekly basis in October and November until ice thicknesses reach a minimum of 6 inches. No qualitative comparison was made to these data because the timing is not comparable. In addition, Environment Canada also has long term records of snow depth and ice thickness at one location in the Yellowknife area. However, no qualitative comparison was made to these data, as the sampling location is not within the Yellowknife Bay area.

2.5 Quality Assurance/Quality Control

Quality assurance/quality control (QA/QC) procedures and requirements are an important aspect of any field or laboratory testing program. The objective of having good QA/QC practices is to standardize methods so that field sampling, data entry, data analysis and report preparation produce technically sound and scientifically defensible results.

As part of routine QA/QC for field operations, water quality meters were calibrated according to manufacturer's specifications prior to sample collection. All surface water samples were collected by experienced personnel following standard protocols. Chain-of-custody (COC) forms were used to track all sample shipments from the field to ALS.

A duplicate water sample was collected to assess precision, consistency and variability introduced during sample collection, sample handling and during laboratory analysis. A field blank and a trip blank were also submitted as part of the quality control program. The field and trip blanks were prepared, preserved, stored, shipped and analyzed in the same manner as the field water samples. Blank samples are used to determine if sample contamination occurred during sample collection, handling, shipping or analysis.

Detailed field notes were recorded in pencil in a waterproof field notebook and on waterproof datasheets. Field data was checked at the end of the sampling event for completeness and accuracy. Upon returning to the Golder office in Yellowknife, the YSI profile data was downloaded and the field notes and datasheets were scanned into electronic format. All field data were transcribed into an electronic spreadsheet, which was checked for completeness and accuracy by a second person not involved in the initial data entry.

3.0 RESULTS

3.1 Maximum Water Depth, Snow Depth and Ice Thickness

2012 Results

Maximum water depths measured at each sampling station were consistent between the February and March field surveys. Mean water depth among stations was approximately 9 m. The deepest water depth of approximately 17.0 m was measured at Station S6. The shallowest water depth of approximately 4.5 m was measured at Station S9.

Snow depth increased at all stations between February and March, with the exception of Station S2, where snow depth remained consistent at 0.20 m during both field surveys (Table 2). In February, mean snow depth among stations was 0.12 m, with a maximum snow depth of 0.20 m at Station S2 and a minimum snow depth of 0.06 m at Station S9 (Table 2). In March, mean snow depth among stations increased to 0.22 m, with a maximum snow depth of 0.30 m at Stations S3 and S4 and a minimum snow depth of 0.15 m at Station S6 (Table 2).

Table 2: Maximum Water Depth, Snow Depth and Ice Thickness, Yellowknife Bay, 2012

Station	Maximum Water Depth (m)		Snow Depth (m)		Ice Thickness (m)	
	February	March	February	March	February	March
S1	6.6	7.0	0.12	0.25	0.79	1.03
S2	9.5	9.7	0.20	0.20	0.74	0.96
S3	11.1	11.0	0.10	0.30	0.90	1.06
S4	12.0	11.8	0.10	0.30	0.93	1.10
S5	6.1	6.6	0.14	0.20	0.79	1.03
S6	17.0	16.8	0.11	0.15	0.88	1.12
S7	7.5	8.0	0.13	0.20	0.80	1.04
S8	7.3	7.4	0.12	0.20	0.80	0.92
S9	4.4	4.5	0.06	0.20	0.25	0.20
Mean	**9.1**	**9.2**	**0.12**	**0.22**	**0.76**	**0.94**
Minimum	**4.4**	**4.5**	**0.06**	**0.15**	**0.25**	**0.20**
Maximum	**17.0**	**16.8**	**0.20**	**0.30**	**0.93**	**1.12**

Note: m = metres.

Ice thickness increased at all stations between February and March, with the exception of Station S9, where ice thickness remained essentially the same (Table 2). Mean ice thickness among stations was 0.76 m in February and 0.94 m in March. Maximum ice thickness was measured at Station S4 (0.93 m) in February and at Station S6 (1.12 m) in March. Minimum ice thickness was measured at Station S9 in both February (0.25 m) and March (0.20 m).

Historical Comparison

In February 1993, snow depth measurements within the Yellowknife Bay area ranged from 0.08 to 0.9 m, with a mean snow depth among stations of 0.21 m (Jackson et al. 1996). Ice thickness from this time ranged from 0.58 to 1.20 m, with a mean ice thickness of 0.90 m (Jackson et al. 1996). Snow depth and ice thickness measurements from March 2012 are comparable to these historic measurements. In March 2010, ice thickness measurements ranged from 0.72 to 0.90 m, with a mean ice thickness among stations of 0.79 m (Golder 2010). Ice thickness measurements from February 2012 are comparable to the March 2010 (Golder 2010). There is insufficient data to determine if this variation is a reflection of normal variation or long term trend.

3.2 Water Quality

Limnology Profiles

Detailed limnology profile data for water temperature, conductivity, dissolved oxygen and pH are provided in Table 3. These data were deemed valid with the exception of dissolved oxygen concentrations measured at Station S6 in March 2012. At this station, the dissolved oxygen probe recorded uncharacteristically high concentrations. Upon inspection at Station S7, the field crew noticed a tear in the dissolved oxygen membrane. The crew exchanged the sonde, but did not return to resample Station S6; therefore, the March dissolved oxygen data for Station S6 have been excluded.

In general, water temperatures were consistent between stations and exhibited a typical seasonal pattern, with higher temperatures occurring at depth, with the exception of Station S5 where water temperatures decreased with depth. In February and March, the mean water temperature among stations was 0.3°C. Mean surface temperature among stations was 0.1°C in February and 0.2°C in March. Mean bottom temperature among stations was 0.5°C in February and 0.6°C in March.

Conductivity values exhibited a slight increased with depth at all stations, with the greatest conductivity gradients being observed at Stations S6 and S8 (Table 3). In February, the mean conductivity among stations was 71 µS/cm, with a mean surface conductivity of 56 µS/cm and a mean bottom conductivity of 91 µS/cm. Conductivities observed in March were similar to those in February, that is, mean conductivity among stations was 71 µS/cm; mean surface conductivity was 57 µS/cm; and mean bottom conductivity was 92 µS/cm. Minimum conductivity values were observed at station S4 (51 µS/cm at 1.2 m in February and 52 µS/cm between 1.5 and 4.0 m in March) and maximum conductivity was observed at Station S8 (191 µS/cm at 6.0 m in February and 208 µS/cm at 7.0 m in March).

Overall, dissolved oxygen concentrations decreased with depth. The water column remained well oxygenated at all stations in both February and March, with the exception of Station S1 (5.4 mg/L at 7.0 m) (Table 3). Mean dissolved oxygen concentration among stations was 13.1 mg/L in February and 15.2 mg/L in March. Minimum dissolved oxygen concentration was measured at Station S3 in both February (9.3 mg/L at 11.0 m) and March (10.7 mg/L at 11.0 m).

In general, pH values were within the neutral range, with a mean pH value among stations of 6.9 in February and 7.2 in March. At all stations, pH values exhibited a slight decreasing gradient with depth. In February, the mean surface and bottom pH values among stations were consistent at 6.9. In March, the mean surface pH was 7.2 and the mean bottom pH was 7.0. The minimum pH was measured at Station S4 (6.7 at 11.0 m in February and 6.5 at 11.0 m in March). The maximum pH was measured in February at Station S7 (7.3 at 1.1 m) and in March at Station S3 (8.1 at 2.0 m).

Table 3: Limnology Profile Data, Yellowknife Bay, 2012

Station	Depth (m)	Temperature (°C)		Conductivity (µS/cm)		Dissolved Oxygen (mg/L)		pH	
		February	March	February	March	February	March	February	March
S1	1.0	0.2	-	57	-	13.6	-	6.9	-
	1.5	-	0.2	-	61	-	15.9	-	6.9
	2.0	0.1	0.1	57	60	13.6	15.9	6.9	6.9
	3.0	0.1	0.1	56	61	13.5	16.0	6.9	6.9
	4.0	0.1	0.1	56	61	13.5	16.0	6.9	7.0
	5.0	0.1	0.1	57	61	13.4	16.0	6.8	6.9
	6.0	0.1	0.1	56	61	13.3	16.0	6.8	6.9
	7.0	-	0.5	-	64	-	5.4	-	6.8
S2	1.0	0.4	-	56	-	13.7	-	6.8	-
	1.5	-	0.4	-	60	-	15.9	-	6.9
	2.0	0.2	0.1	56	61	13.8	16.0	6.8	6.9
	3.0	0.1	0.1	56	60	13.8	16.1	6.8	6.9
	4.0	0.1	0.1	56	60	13.7	16.1	6.8	6.9
	5.0	0.1	0.1	56	60	13.7	16.1	6.8	6.9
	6.0	0.1	0.1	56	62	13.6	16.0	6.8	6.9
	7.0	0.1	0.2	59	89	13.5	15.5	6.8	6.8
	8.0	0.3	0.4	79	88	13.2	14.8	6.7	6.8
	9.0	0.9	0.7	78	92	12.3	14.0	6.8	6.9
S3	1.2	<0.1	-	56	-	13.8	-	6.9	-
	1.5	-	0.1	-	58	-	15.8	-	8.1
	2.0	<0.1	0.04	56	55	13.7	15.5	6.8	8.1
	3.0	<0.1	0.03	56	54	13.7	15.2	6.8	8.1
	4.0	<0.1	0.01	56	54	13.7	15.0	6.8	8.1
	5.0	0.1	0.1	56	53	13.6	14.7	6.8	8.0
	6.0	0.1	0.1	58	54	13.5	14.4	6.8	8.0
	7.0	0.4	0.3	64	62	13.0	14.0	6.8	8.0
	8.0	0.6	0.5	75	74	12.5	13.1	6.8	8.0
	9.0	0.7	0.6	83	85	12.1	12.5	6.8	7.9
	10.0	1.0	0.7	86	87	11.5	11.8	6.8	7.9
	11.0	1.4	1.2	87	84	9.3	10.7	6.7	7.8
S4	1.2	<0.1	-	51	-	13.5	-	6.9	-
	1.5	-	0.01	-	52	-	15.8	-	7.8
	2.0	<0.1	0.01	54	52	13.6	15.8	6.9	7.8
	3.0	<0.1	0.01	56	52	13.6	15.8	6.9	7.8
	4.0	<0.1	0.01	56	52	13.6	15.6	6.9	7.7
	5.0	<0.1	0.1	56	53	13.6	15.4	6.9	7.7
	6.0	<0.1	0.2	56	58	13.6	15.3	6.8	7.6
	7.0	0.1	0.4	58	69	13.4	14.3	6.9	7.6
	8.0	0.1	0.5	68	78	13.1	14.0	6.8	7.4
	9.0	0.3	0.6	81	85	12.3	13.8	6.8	7.4
	10.0	0.4	0.6	85	92	12.1	13.7	6.8	7.3
	11.0	0.6	0.7	91	92	11.7	13.4	6.7	7.3
	12.0	1.3	-	95	-	10.9	-	6.8	-
S5	1.0	0.2	-	56	-	13.6	-	6.9	-
	1.5	-	1.1[(a)]	-	61	-	15.4	-	6.9
	2.0	0.1	0.5	56	61	13.6	15.8	6.9	6.9
	3.0	0.1	0.3	56	61	13.6	15.9	6.9	6.9
	4.0	0.1	0.3	56	61	13.6	15.9	6.9	6.9
	5.0	<0.1	0.2	56	60	13.6	16.0	6.8	6.9
	6.0	0.1	0.2	56	63	13.6	13.4	6.9	6.8
S6	1.2	0.1	-	56	-	13.7	[(b)]	7.0	-
	1.5	-	0.01	-	52	-		-	7.5
	2.0	0.1	0.01	56	52	13.7		7.0	7.4
	3.0	<0.1	0.01	56	52	13.7		7.0	7.3
	4.0	0.1	0.02	56	53	13.6		7.0	7.3
	5.0	0.1	0.1	57	56	13.6		7.0	7.2
	6.0	0.2	0.2	60	61	13.4		6.9	7.2
	7.0	0.3	0.4	64	78	13.1		6.9	7.1
	8.0	0.5	0.4	74	84	12.7		6.9	7.1
	9.0	0.6	0.5	81	88	12.4		6.9	7.1
	10.0	0.6	0.5	88	98	12.2		6.9	7.0
	11.0	0.8	0.6	91	98	12.0		6.9	7.1
	12.0	0.9	0.8	93	94	11.8		6.9	7.1
	13.0	1.0	1.0	98	92	11.6		6.9	7.0

Station	Depth (m)	Temperature (°C)		Conductivity (µS/cm)		Dissolved Oxygen (mg/L)		pH	
		February	March	February	March	February	March	February	March
	14.0	1.2	1.1	105	93	11.1		6.9	7.0
	15.0	1.4	1.3	109	96	10.8		6.9	7.0
	16.0	1.6	1.6	116	99	10.4		6.9	7.0
S7	1.1	0.1	-	59	-	13.5	-	7.3	-
	1.5	-	0.1	-	55	-	14.3	-	7.3
	2.0	0.1	0.04	59	54	13.4	14.3	7.2	7.1
	3.0	0.1	0.1	59	56	13.3	14.3	7.2	7.0
	4.0	0.1	0.1	59	56	13.3	14.2	7.1	7.0
	5.0	0.2	0.2	60	60	13.2	14.1	7.1	6.8
	6.0	0.2	0.2	60	67	13.2	13.9	7.1	6.9
	7.0	0.2	0.2	64	71	13.1	13.8	7.1	6.9
	8.0	-	0.3	-	83	-	13.8	-	6.8
S8	1.1	0.1	-	57	-	13.7	-	7.1	-
	1.5	-	0.02	-	53	-	14.4	-	7.2
	2.0	0.1	0.1	64	57	13.5	14.6	7.1	7.1
	3.0	0.2	0.2	69	64	13.3	14.6	7.0	7.0
	4.0	0.3	0.2	105	94	13.2	14.3	7.0	6.9
	5.0	0.3	0.3	184	165	13.1	14.2	7.0	6.8
	6.0	0.3	0.3	196	191	13.1	14.2	7.1	6..8
	7.0	0.3	0.3	208	190	13.1	14.3	7.2	6.8
S9	0.5	0.1	0.1	56	60	13.7	16.1	6.8	6.5
	1.0	0.1	0.1	56	60	13.7	16.1	6.8	6.6
	1.5	-	0.03	-	60	-	16.8	-	6.7
	2.0	<0.1	0.1	56	60	13.7	16.1	6.8	6.6
	2.5	-	0.03	-	60	-	16.4	-	6.7
	3.0	<0.1	0.1	56	60	13.7	16.2	6.8	6.7
	3.5	-	0.04	-	60	-	16.2	-	6.7
	4.0	<0.1	0.1	56	60	13.7	16.2	6.8	6.7
	4.5	-	0.1	-	60	-	16.2	-	6.7

Note: m = metres; °C = degrees Celsius; µS/cm = microSiemens per centimetre; mg/L = milligrams per litre; - = parameter not measured at specified water depth.

[a] Temperature reading on YSI was high for the surface. No problem was detected with the temperature probe.

[b] The dissolved oxygen measurements appeared high at Station S6; upon inspection the dissolved oxygen membrane was observed to be torn. The sonde was replaced at Station S7 and the new sonde was used for Stations S7 and S8. The dissolved oxygen data at Station S6 was deemed suspect and has been excluded.

Water Chemistry

Detailed water chemistry results are provided in Table 4. A detailed QA/QC review was completed on the results, which is provided in Appendix A. Minor QA/QC issues were identified and are discussed in Appendix A; however the affected analytes accounted for less than 10% of the total analytes. The water chemistry data were therefore deemed valid.

In general, concentrations of water chemistry parameters were consistent among sampling stations. Higher concentrations of parameters were typically detected in samples collected from depth. Within Yellowknife Bay, many of the total and dissolved metal concentrations were below applicable MDLs.

Total arsenic concentrations ranged from 0.00035 to 0.00060 mg/L in the surface water samples and 0.00036 to 0.00332 mg/L in the bottom water samples. At all sampling stations, dissolved arsenic accounted for the majority of the total arsenic concentrations.

Copper concentrations exhibited some variability among sampling stations, ranging from 0.0007 to 0.0012 mg/L in the surface water samples and 0.0007 to 0.0019 mg/L in the bottom water samples. Dissolved copper concentrations exhibited less variability among stations, with surface concentrations ranging from 0.0006 to 0.0009 mg/L and bottom concentrations ranging from 0.0006 to 0.0010 mg/L.

Total iron concentrations in surface water samples were 0.02 mg at most sampling stations. Concentrations of total iron were higher in the bottom water samples, ranging from 0.3 to 0.06 mg/L. In general, dissolved iron concentrations were below the MDL, with the exception of surface water samples from Station S1 (0.02 mg/L) and both surface and bottom water samples from Station S5 (0.02 mg/L).

4.0 SUMMARY OF KEY FINDINGS

The following list summarises key findings:

- baseline data for snow depth, ice thickness and under ice water quality in Yellowknife Bay were collected in 2012 and can be used to support validation of the hydrodynamic model required for the detailed design of the water treatment system;
- snow depth and ice thickness increased slightly at all stations between February and March with the exception of S2 (snow depth) and S9 (ice thickness);
- snow depth and ice thickness measurements were comparable to historical data (Jackson et al. 1996; Golder 2010); and
- water chemistry results were generally consistent between stations, with parameters typically exhibiting higher concentrations with depth.

Table 4: Water Chemistry at Sampling Stations in Yellowknife Bay, 2012

Parameter	Units	MDL	Field Samples													Quality Control Samples		
			Station S1	Station S2	Station 3		Station 4		Station 5		Station 6		Station 7	Station 8	Station 9	Station 8-Duplicate	Field Blank	Travel Blank
			Surface	Surface	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Surface	Surface	Surface		
Physical/Chemical Parameters																		
Acidity (as $CaCO_3$)	mg/L	1.0	1.9	1.8	2.0	1.9	1.8	1.7	1.8	1.8	1.8	1.8	1.8	1.9	1.8	1.9	1.4	1.5
Bicarbonate alkalinity (as $CaCO_3$)	mg/L	1.0	24.0	23.8	24.7	31.0	24.0	38.5	23.7	23.6	23.8	40.9	25.2	23.9	23.9	24.5	1.8	2.9
Carbonate alkalinity (as $CaCO_3$)	mg/L	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
Hydroxide alkalinity (as $CaCO_3$)	mg/L	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
Total alkalinity (as $CaCO_3$)	mg/L	1.0	24.0	23.8	24.7	31.0	24.0	38.5	23.7	23.6	23.8	40.9	25.2	23.9	23.9	24.5	1.8	2.9
Conductivity	µS/cm	2	57	56	58	76	57	97	56	57	57	104	59	57	56	58	<2	<2
Hardness (as $CaCO_3$)	mg/L	0.5	23.2	22.7	21.3	32.6	21.8	38.7	22.8	23.0	22.1	42.9	23.8	23.1	23.0	23.6	<0.50	<0.50
pH	n/a	0.1	7.3	7.2	7.5	7.3	7.2	7.4	7.3	7.3	7.2	7.4	7.3	7.2	7.3	7.3	5.6	5.8
Total suspended solids	mg/L	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	<3.0
Total dissolved solids	mg/L	10	34	34	37	44	33	57	32	34	32	56	39	34	34	38	<10	<10
Turbidity	NTU	0.1	0.6	0.7	0.5	1.0	0.6	1.4	0.7	0.6	0.8	1.4	0.9	0.8	0.6	0.7	<0.1	<0.1
Major Ions																		
Bromide	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Calcium (Total)	mg/L	0.02	5.84	5.76	4.92	7.70	5.32	11.1	5.83	5.75	5.74	12.0	6.07	5.82	5.87	6.04	<0.02	<0.02
Calcium (Dissolved)	mg/L	0.02	5.70	5.56	5.21	8.70	5.39	10.5	5.63	5.65	5.45	12.0	5.96	5.72	5.66	5.91	-	<0.02
Chloride	mg/L	0.5	2.1	2.0	2.0	2.6	2.0	3.3	2.1	2.0	2.2	3.5	2.1	2.1	2.0	2.1	<0.5	<0.5
Fluoride	mg/L	0.02	0.07	0.07	0.07	0.08	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	<0.02	<0.02
Magnesium (Total)	mg/L	0.005	2.16	2.19	1.95	2.52	2.05	3.29	2.19	2.18	2.13	3.25	2.19	2.18	2.17	2.24	<0.005	<0.005
Magnesium (Dissolved)	mg/L	0.005	2.17	2.14	2.01	2.64	2.02	3.01	2.12	2.15	2.07	3.18	2.17	2.14	2.14	2.15	-	<0.005
Potassium (Total)	mg/L	0.05	1.1	1.1	1.0	1.1	1.1	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	<0.05	<0.05
Potassium (Dissolved)	mg/L	0.05	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	<0.05	<0.05
Sodium (Total)	mg/L	0.01	2.1	2.1	2.0	2.6	2.1	3.5	2.2	2.1	2.1	3.5	2.2	2.2	2.1	2.2	<0.01	<0.01
Sodium (Dissolved)	mg/L	0.01	2.13	2.08	2.02	2.73	2.02	3.22	2.08	2.09	2.11	3.38	2.17	2.11	2.06	2.16	-	<0.01
Sulfate	mg/L	0.5	3.7	3.7	3.7	5.5	3.7	8.1	3.7	3.7	3.7	8.9	3.9	3.8	3.7	3.8	<0.5	<0.5
Nutrients																		
Ammonia (as nitrogen)	mg/L	0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	0.006	0.005	<0.005	<0.005	0.010	<0.000	<0.005	<0.005	<0.005	<0.005
Nitrate (as nitrogen)	mg/L	0.005	0.062	0.062	0.061	0.088	0.062	0.093	0.063	0.061	0.072	0.114	0.069	0.062	0.060	0.063	<0.005	<0.005
Nitrite (as nitrogen)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Total Nitrogen	mg/L	0.05	0.23	0.25	0.25	0.28	0.24	0.28	0.24	0.25	0.26	0.27	0.28	0.26	0.25	0.27	<0.05	<0.05
Total Phosphorus	mg/L	0.002	0.006	0.007	0.005	0.007	0.005	0.008	0.006	0.005	0.005	0.010	0.005	0.005	0.005	0.005	<0.002	<0.002
Dissolved Phosphorus	mg/L	0.002	0.003	0.003	0.003	0.005	0.003	0.006	0.003	0.003	0.003	0.009	0.004	0.003	0.003	0.003	<0.002	<0.002
Orthophosphate (as phosphorus)	mg/L	0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.003	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Total organic carbon	mg/L	0.50	5.84	5.67	5.56	5.68	5.58	5.58	5.63	5.72	5.66	5.32	5.81	5.62	5.81	5.70	0.67	<0.50
Dissolved organic carbon	mg/L	0.50	5.20	5.09	5.30	5.24	5.16	5.09	5.07	5.02	5.16	5.22	5.36	5.19	5.04	5.21	<0.50	0.87
Total Metals and Metalloids																		
Aluminum[(a)]	mg/L	0.003	<0.021	<0.027	<0.024	0.037	<0.030	0.059	<0.024	<0.024	<0.024	0.053	<0.027	<0.024	<0.021	<0.030	<0.003	<0.003
Antimony	mg/L	0.00005	<0.00005	<0.00005	<0.00005	0.00018	<0.00005	0.00013	<0.00005	<0.00005	0.00006	0.00021	0.00008	0.00006	<0.00005	0.00019	<0.00005	<0.00005
Arsenic	mg/L	0.00003	0.00040	0.00038	0.00036	0.00211	0.00041	0.00185	0.00040	0.00036	0.00037	0.00332	0.00060	0.00040	0.00035	0.00045	<0.00003	<0.00003
Barium	mg/L	0.00005	0.00463	0.00465	0.00464	0.00902	0.00600	0.0161	0.00462	0.00444	0.00479	0.0168	0.00517	0.00487	0.00442	0.00518	<0.000050	<0.000050
Beryllium	mg/L	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Bismuth	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron	mg/L	0.005	0.010	0.010	0.008	0.010	0.009	0.012	0.010	0.010	0.010	0.013	0.010	0.010	0.010	0.010	<0.005	<0.005
Cadmium	mg/L	0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	0.000064	<0.000017	<0.000017
Chromium	mg/L	0.0001	0.0001	0.0001	0.0006	0.0002	0.0001	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	<0.0001	<0.0001
Cobalt	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper	mg/L	0.0005	0.0007	0.0008	0.0008	0.0017	0.0008	0.0019	0.0007	0.0007	0.0012	0.0013	0.0008	0.0008	0.0008	0.0012	<0.0005	<0.0005
Iron	mg/L	0.01	0.02	0.02	0.02	0.03	0.04	0.06	0.02	0.04	0.04	0.02	0.04	0.02	0.02	0.02	<0.01	<0.01
Lead	mg/L	0.00005	<0.00005	<0.00005	<0.00005	0.00011	<0.00005	0.00075	<0.00005	<0.00005	0.00012	0.00008	<0.00005	0.00006	<0.00005	0.00014	<0.00005	<0.00005

Parameter	Units	MDL	Field Samples													Quality Control Samples		
			Station S1	Station S2	Station 3		Station 4		Station 5		Station 6		Station 7	Station 8	Station 9	Station 8-Duplicate	Field Blank	Travel Blank
			Surface	Surface	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Surface	Surface	Surface		
Lithium	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Manganese	mg/L	0.00005	0.00098	0.00119	0.00110	0.00216	0.00149	0.00260	0.00157	0.00176	0.00117	0.00326	0.00109	0.00101	0.00217	0.00150	<0.000050	<0.000050
Mercury	mg/L	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	mg/L	0.00005	0.00011	0.00011	0.00011	0.00019	0.00011	0.00029	0.00012	0.00013	0.00011	0.00032	0.00012	0.00012	0.00010	0.00012	<0.00005	<0.00005
Nickel	mg/L	0.0001	0.0005	0.0005	0.0004	0.0008	0.0007	0.0009	0.0005	0.0005	0.0006	0.0008	0.0005	0.0005	0.0005	0.0005	<0.0001	<0.0001
Selenium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Silicon	mg/L	0.05	0.43	0.43	0.43	0.70	0.44	0.94	0.43	0.43	0.45	1.11	0.47	0.44	0.44	0.46	<0.05	<0.05
Silver	mg/L	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Strontium	mg/L	0.0001	0.0255	0.0249	0.0250	0.0383	0.0250	0.0552	0.0255	0.0251	0.0265	0.0583	0.0272	0.0258	0.0251	0.0269	<0.0001	<0.0001
Thallium	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Tin	mg/L	0.0001	0.0007	0.0020	0.0009	0.0043	0.0003	0.0034	0.0012	0.0013	0.0009	0.0056	0.0024	0.0007	0.0011	0.0007	<0.0001	<0.0001
Titanium	mg/L	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
Uranium	mg/L	0.00001	0.00028	0.00027	0.00029	0.00028	0.00029	0.00032	0.00027	0.00027	0.00030	0.00028	0.00027	0.00027	0.00027	0.00028	<0.00001	<0.00001
Vanadium	mg/L	0.00005	0.00006	0.00008	0.00008	0.00012	0.00009	0.00019	0.00007	0.00008	0.00008	0.00016	0.00008	0.00007	0.00008	0.00007	<0.00005	<0.00005
Zinc	mg/L	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	<0.003	0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Dissolved Metals and Metalloids																		
Aluminum	mg/L	0.003	0.016	0.005	0.006	0.007	0.009	0.008	0.019	0.017	0.008	0.007	0.006	0.005	0.005	0.005	<0.003	<0.003
Antimony	mg/L	0.00005	<0.00005	<0.00005	<0.00005	0.00014	<0.00005	0.00013	<0.00005	<0.00005	<0.00005	0.00017	0.00007	<0.00005	<0.00005	0.00008	<0.00005	<0.00005
Arsenic	mg/L	0.00003	0.00040	0.00033	0.00034	0.00169	0.00033	0.00157	0.00039	0.00032	0.00035	0.00307	0.00056	0.00038	0.00033	0.00040	-	<0.00003
Barium	mg/L	0.00005	0.00455	0.00419	0.00449	0.01050	0.00435	0.01410	0.00445	0.00447	0.00457	0.01570	0.00489	0.00452	0.00415	0.00490	-	<0.00005
Beryllium	mg/L	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Bismuth	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron	mg/L	0.005	0.006	0.009	0.008	0.009	0.008	0.010	0.006	0.005	0.008	0.012	0.009	0.008	0.008	0.009	<0.005	<0.005
Cadmium	mg/L	0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	<0.000017	0.000049	<0.000017	<0.000017
Chromium	mg/L	0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0004	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper	mg/L	0.0005	0.0006	0.0007	0.0009	0.0009	0.0007	0.0010	0.0006	0.0006	0.0007	0.0009	0.0009	0.0006	0.0009	0.0007	<0.0005	<0.0005
Iron	mg/L	0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Lithium	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Manganese	mg/L	0.00005	0.00091	0.00026	0.00039	0.00073	0.00049	0.00080	0.00147	0.00105	0.00041	0.00118	0.00075	0.00026	0.00030	0.00024	-	<0.00005
Mercury	mg/L	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	mg/L	0.00005	0.00010	0.00010	0.00011	0.00023	0.00012	0.00028	0.00010	0.00010	0.00010	0.00029	0.00021	0.00011	0.00010	0.00012	<0.00005	<0.00005
Nickel	mg/L	0.0001	0.0004	0.0005	0.0006	0.0007	0.0006	0.0007	0.0005	0.0004	0.0006	0.0007	0.0007	0.0004	0.0004	0.0005	<0.0001	<0.0001
Selenium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Silicon	mg/L	0.05	0.44	0.38	0.39	0.67	0.38	0.78	0.44	0.431	0.39	0.97	0.43	0.39	0.38	0.41	<0.05	<0.05
Silver	mg/L	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Strontium	mg/L	0.0001	0.0248	0.0243	0.0251	0.0423	0.0254	0.0517	0.0242	0.0243	0.0252	0.0556	0.0262	0.0250	0.0242	0.0261	<0.0001	<0.0001
Thallium	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Tin	mg/L	0.0001	0.0006	0.0017	0.0016	0.0008	0.0003	0.0011	0.0010	0.0010	0.0006	0.0004	0.0018	0.0007	0.0009	0.0008	<0.0001	<0.0001
Titanium	mg/L	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
Uranium	mg/L	0.00001	0.00025	0.00023	0.00025	0.00026	0.00025	0.00027	0.00025	0.00026	0.00025	0.00025	0.00023	0.00024	0.00021	0.00024	<0.00001	<0.00001
Vanadium	mg/L	0.00005	0.00006	<0.00005	0.00006	0.00007	0.00006	0.00008	0.00007	0.00006	0.00006	0.00007	0.00007	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Zinc	mg/L	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003

Note: MDL = method detection limit; $CaCO_3$ = calcium carbonate; N = nitrogen; P = phosphorous; mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; NTU = nephelometric turbidity units; < = less than; - = not analyzed; n/a = not applicable. Laboratory Number: L1128567.
(a) Total aluminum: Detection limit was raised due to detection of analyte at comparable level in Method Blank.

5.0 CLOSURE

We trust this report meets your current requirements for the collection of baseline snow depth, ice thickness and water quality in Yellowknife Bay in 2012. If you have any questions or require further information please contact the undersigned.

GOLDER ASSOCIATES LTD.

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Attachments: Appendix A – Quality Assurance/Quality Control Review of Yellowknife Bay 2012 Water Chemistry Data

MS/KMH/JAH/aw

6.0 REFERENCES

Golder (Golder Associates Ltd.). 2010. Technical Memorandum: Ice Thickness Survey – Diffuser Sites Giant Mine, Yellowknife, NWT. Prepared for Det'on Cho/Nuna Joint Venture by Golder Associates Ltd., Yellowknife, NWT.

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APPENDIX A
Quality Assurance/Quality Control Review of Yellowknife Bay 2012 Water Chemistry Data

QUALITY ASSURANCE/QUALITY CONTROL

The quality assurance/quality control (QA/QC) review was completed on the analytical data (L1128567) provided by ALS. Key findings of this QA/QC review are summarized below. The QA/QC review of the water chemistry data collected for the March 26, 2012 sampling program in Yellowknife Bay concluded that the data were of acceptable quality and adequate to address the objectives of the program.

Parameter List

The following parameters were required for the 2012 under ice water quality program in Yellowknife Bay:

- field parameters: water depth, temperature, pH, conductivity and dissolved oxygen;
- routine parameters: alkalinity, acidity, hardness, conductivity, total dissolved solids (TDS), total suspended solids (TSS);
- major ions: calcium, chloride, sulphate, magnesium, potassium, sodium;
- nutrients: total and dissolved organic carbon, total and dissolved phosphorous, and nitrogen; and
- total and dissolved metals: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, cobalt, copper, chromium, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, titanium, thallium, uranium, vanadium, zinc.

All parameters required for the baseline data collection in Yellowknife Bay were analyzed as required.

Duplicate Samples

A duplicate surface water sample was collected at Station S8. This duplicate water chemistry samples was collected to assess variability during sample collection, handling, and analysis. Variability in the duplicate sample was assessed based on the following criteria:

- a relative percent difference (RPD) less than or equal to 20% between samples; and
- a concentration less than or equal to five times the method detection limit (MDL) used by ALS Environmental Laboratories (ALS).

This threshold takes into account the potential for analytical uncertainty when concentrations approach MDLs (Weiner 2000). These criteria are consistent with those used by ALS for their internal quality control (QC) procedures. Variability between duplicate samples was rated as follows:

- low if less than 10% of the analytes included in the duplicate analysis were notably different from one another;
- moderate if 10 to 30% of the analytes included in the duplicate analysis were notably different from one another; and
- high if more than 30% of the analytes included in the duplicate analysis were notably different from one another.

These standards are based on the Practical Quantitation Limit defined by the U.S. EPA (1985), which takes into account the potential for analytical uncertainty when concentrations approach MDLs.

An RPD greater than 20% and a concentration less than five times the MDL was observed between the Station S8 field and duplicate samples for total and dissolved antimony, total and dissolved cadmium, total and dissolved chromium, and total copper. The RPD between the field and duplicate samples was greater than 20% for total manganese and the concentration was greater than five times the MDL. However, the overall variability encountered between the Station S8 field and duplicate samples was low, with less than 10% of the analytes being notably different from one another.

Field and Travel Blanks

A field blank sample was collected at site S9 and a travel blank was provided by ALS. Notable results observed in these blank samples were evaluated relative to concentrations observed in the surface water samples to determine if wide-spread contamination might have occurred, or if contamination was limited to the specific blank(s). Based on this comparison, if it appeared that contamination had occurred, then the affected data would be flagged and interpreted with this limitation in mind.

Results for all analytes in the field and travel blanks were at or below the MDLs, with the exception of total alkalinity and bicarbonate alkalinity in the field blank, and both total and dissolved organic carbon in the travel blank. Total and bicarbonate alkalinity were 2.9 mg/L in the field blank, while the MDL for both parameters was 1.0 mg/L. In the travel blank, the total organic carbon concentration was 0.67 mg/L and the dissolved organic carbon concentration was 0.87 mg/L; the MDLs for both of these parameters were 0.5 mg/L.

These QC items represent less than 10% of the total analytes; therefore, the results from the field and travel blanks were considered valid and sample contamination was not a concern.

Total versus Dissolved Metal and Major Ion Concentrations

The dissolved concentration of any given metal or major ion should, by definition, be less than or equal to the total concentration. If the reported dissolved concentration was greater than the reported total concentration, but was within 20% of the total concentration, the data were still considered valid. If the reported dissolved concentration exceeded the reported total concentration by 20% or more, and for more than 10% of the analytes, this may indicate uncertainty in the lab analysis.

The following analytes had reported dissolved concentrations more than 20% greater than total concentrations:

- chromium in sample S7-S had a total concentration of 0.00018 mg/L and a dissolved concentration of 0.00036 mg/L (RPD = 66.7%);
- molybdenum in sample S7-S had a total concentration of 0.000121 mg/L and a dissolved concentration of 0.000214 mg/L (RPD = 55.5%);
- nickel in sample S7-S had a total concentration of 0.00052 mg/L and a dissolved concentration of 0.00070 mg/L (RPD = 29.5%);
- nickel in sample S3-S had a total concentration of 0.00040 mg/L and a dissolved concentration of 0.00057 mg/L (RPD = 35.1%); and
- tin in sample S3-S had a total concentration of 0.00089 mg/L and a dissolved concentration of 0.00160 mg/L (RPD = 57%).

Analytes that had dissolved concentrations greater than total concentrations by more than 20% account for less than 10% of the total analytes. Therefore, the dissolved and total metal concentrations were considered valid.

Method Detection Limits

The MDLs achieved by ALS when analyzing water samples are required to be below CCME guidelines to allow potential comparisons of analytical results to these guidelines. MDLs for the Yellowknife Bay data were consistent for all analytes between sampling events, with the exception of total aluminum for all of the samples. The lab provided the following qualifier for the total aluminum MDLs:

- the detection limit was raised due to detection of analyte at comparable level in Method Blank.

The MDLs were increased for some samples due to method blank contamination on the total metal samples (Bethune pers comm. 2012). The method blanks associated with the total metal samples are different from the method blanks associated with the dissolved metal samples. Therefore, the MDLs were raised for the total aluminum but not the dissolved aluminum samples.

Holding Times

Holding times between sample collection and analysis for each parameter are specified by ALS and are based on CCME recommendations (CCME 2011). In order to obtain reliable data, holding times should not be exceeded. For this program, holding times were exceeded for the following analytes:

- turbidity for samples S1-S, S2-S, S5-S, S5-B, S9-S and Field Blank:
- pH for all samples;
- alkalinity for Field Blank'
- orthophosphate for samples S1-S, S2-S, S5-S, S5-B, S9-S and Field Blank;
- nitrate for samples S1-S, S2-S, S5-S, S5-B, S9-S and Field Blank;
- nitrite for samples S1-S, S2-S, S5-S, S5-B, S9-S and Field Blank;
- dissolved phosphorous for samples S1-S, S2-S, S5-S, S5-B, S9-S and Field Blank; and
- total phosphorous for samples S1-S, S2-S, S5-S, S5-B, S9-S and Field Blank.

Hold times were exceeded between one and four days depending on the parameter. These hold time issues are a result of the samples being collected in Yellowknife being shipped to Vancouver for analysis.

Data Qualifiers

The following data qualifiers reported by ALS were reviewed to determine if there were any laboratory issues that may have impacted data quality:

- total aluminum: detection limit was raised due to detection of analyte at comparable level in method blank; and
- dissolved organic carbon for the travel blank: reported result verified by repeat analysis.

All of the above data qualifiers address internal QC procedures at ALS. No impact on data quality was identified as a result of these data qualifiers.

Units

All reported units were correct and no issues were identified during the review of the reports provided by ALS.

REFERENCES

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