Kiggavik Project
Final Environmental Impact Statement

Tier 3 Technical Appendix 5C Attachment 5C-1

Summary of the 2013 Aquatic Data Collected for the Kiggavik Project

September 2014

History of Revisions

Revision Number	Date	Details of Revisions
01	December 2011	Initial release Draft Environmental Impact Statement (DEIS)
02	September 2014	FINAL Environmental Impact Statement

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1 2013 Aquatic Baseline Survey

This attachment presents the results of the 2013 aquatic environment baseline investigations. These surveys were carried out as an additional component of the Kiggavik Project (Project) aquatic baseline program.

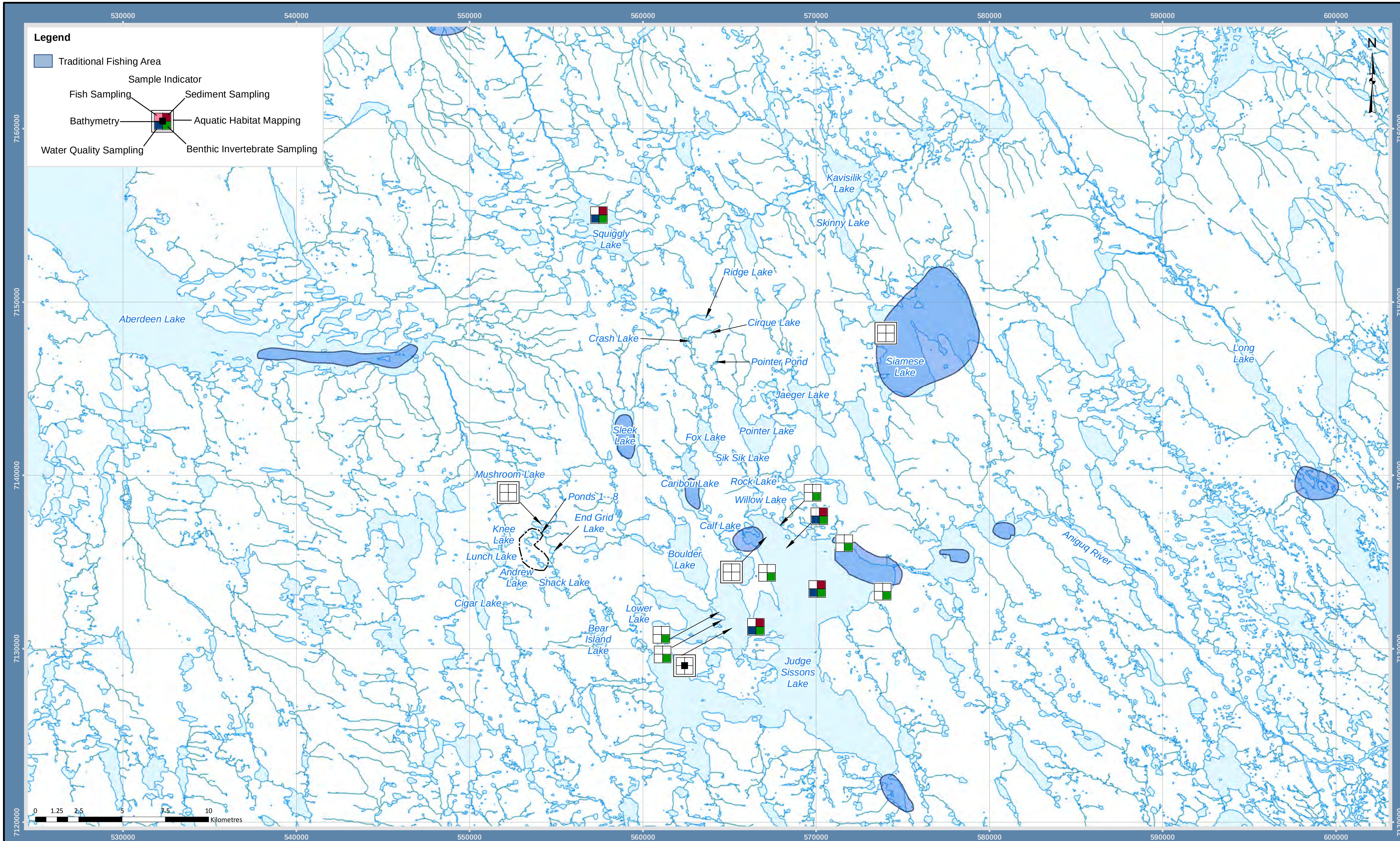
The field work included the following four investigations:

- collection of pre-development aquatic benthic invertebrate community and coincident sediment chemistry baseline data;
- collection of water samples for low detection limit cadmium analysis;
- collection of benthic invertebrates for chemical analysis; and
- collection of detailed aquatic habitat information at four proposed pipeline locations (two water intake locations and two effluent diffuser locations).

Field work was completed between August 30, 2013 and September 9, 2013, by two crews of three people, which included one local assistant per crew.

1.1 Study Areas

The 2013 field work included collecting additional habitat data at the proposed locations of the two water intakes in Siamese and Mushroom lakes, and at the two effluent diffusers in Judge Sissons Lake. It also included collecting additional water and sediment chemistry, and benthic invertebrate community data at the proposed location of the two effluent diffusers (two bays of Judge Sissons Lake), a potential far-field location downstream of the effluent diffusers (Judge Sissons Lake, centre of the north bay), and a potential reference location (Squiggly Lake). Benthic invertebrate chemistry data were collected at the three locations in Judge Sissons Lake. Sampling locations are shown on Figure 1; the coordinates of the sampling locations are presented in Table 1 and 2.



Projection: NAD 1983 UTM Zone 14N
Creator: LMR
Date: 21/02/2014 Scale: 1:200,000
File: KI08C384
Data Sources: *NTS Mapsheet 66A 02; AREVA Resources Canada Inc. Hattie Mannik and the Baker Lake Elder's Focus Group Baker Lake HTO, Baker Lake Hunter Focus Group*

FIGURE 1
AQUATIC BASELINE LAKE SAMPLING
2013

KIGGAVIK PROJECT - EIS

Golder Associates
AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5

Table 1 Locations of Water Quality, Sediment Quality, and Benthic Invertebrate Communities Sampling Stations for Lakes in the Kiggavik Project Area, Fall 2013

Sub-Basin and Waterbody	Station[(a)]	Northing	Easting	Water Quality	Low-Level Cadmium	Sediment Quality (tech ops core)	Benthic Invertebrates (Ekman)
Judge Sissons Lake	JSL2-001-F13	7135779	568278	composite from surface, 3.5 m, 6.0 m	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	JSL2-002-F13	7135763	568262	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	5 sub-samples
	JSL2-003-F13	7135754	568240	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	JSL2-004-F13	7135761	568148	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	JSL2-005-F13	7135857	568161	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	JSL4-001-F13	7133467	570061	composite from surface, 3.5 m, 7.5 m	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	JSL4-002-F13	7133497	569991	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	JSL4-003-F13	7133437	570005	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	JSL4-004-F13	7133449	570049	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	JSL4-005-F13	7133396	570005	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	JSL8-001-F13	7131278	566518	composite from surface, 1.5 m, 3.0 m	surface grab	-	composite of 5 sub-samples
	JSL8-002-F13	7131375	566499	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	JSL8-003-F13	7131366	566607	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	JSL8-004-F13	7131367	566662	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	JSL8-005-F13	7131292	566766	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
Squiggly Lake	SQL-001-F13	7155037	557457	composite from surface, 3.5 m, 6.5 m	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	5 sub-samples
	SQL-002-F13	7155117	557469	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	SQL-003-F13	7155022	557332	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	SQL-004-F13	7155074	557436	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples
	SQL-005-F13	7155173	557388	-	surface grab	composite of 5 sub-samples (0 to 2 cm layer)	composite of 5 sub-samples

Note: North American Datum 83, Zone 14W.

(a) = Station identification code consists of three letter waterbody code with a number for the area, replicate number, and season-year.

JSL = ; SQL = ; m = metres; cm = centimetres; - = not applicable.

Table 2 Locations and Summary of the Field Information Related to the Benthic Chemistry Collection in Judge Sissons Lake, Fall 2013

Sampling Area	Sample Collection Date	Sample Identification	Sample Location Description	Location Coordinates[(a)] (Zone.Easting.Northing)		Sample Collection Method	Sample Composition[(b)]		Sample Wet Weights (g)		Sample Handling
				Start	End		Soft-Bodied Invertebrates[(c)]	Hard-Bodied Invertebrates	Soft-Bodied Invertebrates	Hard-Bodied Invertebrates	
JSL2 (West Shore)	1-Sep-13	JSL2-TIS001a-F13 (snails) and JSL2-TIS001b-F13 (soft bodied)	Substrate consisted mostly of cobble and boulders.	14W 567165E 7134387N	14W 566838E 7135265N	**D-Netting** - Prevalence of cobble and boulders through most of the sample location meant that D-netting was not successful.	<1% of Sample	Snails	7.21	1.85	Collected from rock or D-Net with forceps, rinsed in ambient water, and placed in a Ziploc bag. Transported back to camp. Kim wipes used to remove some of the water from the surface of invertebrates. Caddisfly larva removed from tubes. Soft-bodied invertebrates and hard-bodied invertebrates sorted into seperate bags. Bags placed into site specific jar and frozen.
						Manual Rock Picking with Forceps - Turning over rocks and removing invertebrates either on the rock face or on the underlying substrate with forceps.	stonefly nymph, caddisfly larva, crane fly larva.				
JSL2 (East Shore)	1-Sep-13	JSL2-TIS001a-F13 (snails) and JSL2-TIS001b-F13 (soft bodied)	Substrate consisted of cobbles overlying sand /gravel and fines as well as peat and fine organic material.	14W 567897E 7137084N	14W 567454E 7137507N	**D-Netting** - overturning large cobbles to expose underlying substrate (mixture of sand/gravel and fines) and lightly "kicking" the substrate into the net.	aquatic worms (3%) , crane fly larva (40%)				
						Manual Rock Picking with Forceps - Turning over rocks and removing invertebrates either on the rock face or on the underlying substrate with forceps.	diving beetle (10%), stonefly nymph and mayfly nymph (2%), caddisfly larva (10%), crane fly larva (35%).				
JSL4 (North Shore)	2-Sep-13	JSL4-TIS001a-F13 (soft bodied) and JSL4-TIS001b-F3 (snails)	Substrate consisted of cobbles overlying sand /gravel and fines as well as peat and fine organic material.	14W 571615E 7136096N	14W 573276E 7134867N	**D-Netting** - overturning large cobbles to expose underlying substrate (mixture of sand/gravel and fines) and lightly fanning the substrate into the D-net using hands and wave action.	aquatic worms (1%), crane fly larva (44%).	Snails	10.9	1.5	Collected from rock or D-Net with forceps, rinsed in ambient water, and placed in a Ziploc bag. Transported back to camp. Kim wipes used to remove some of the water from the surface of invertebrates. Caddisfly larva removed from tubes. Soft-bodied invertebrates and hard-bodied invertebrates sorted into seperate bags. Bags placed into site specific jar and frozen.
						Manual Rock Picking with Forceps - Turning over rocks and removing invertebrates either on the rock face or on the underlying substrate with forceps.	stonefly nymph and mayfly nymph (1%), caddisfly larva (5%), crane fly larva (44%).				
JSL4 (South Shore)	2-Sep-13	JSL4-TIS001a-F13 (soft bodied) and JSL4-TIS001b-F3 (snails)	Substrate consisted mostly of cobble and boulders.	14W 573843E 7133303N	14W 573843E 7133303N	**D-Netting** - Prevalence of cobble and boulders through most of the sample location meant that D-netting was not successful.	< 1% of sample				
						Manual Rock Picking with Forceps - Turning over rocks and removing invertebrates either on the rock face or on the underlying substrate with forceps.	stonefly nymph and mayfly nymph (<1%), caddisfly larva (2%), crane fly larva (2%).				
JSL8	31-Aug-13	JSL8-TIS001a-F13 (snails) and JSL8-TIS001b-F13 (soft bodied)	Substrate varied from fines to cobbles. Most invertebrates were found under flat cobbles overlying sand and gravel.	14W 564568E 7131623N	14W 564696E 7131818N	**D-Netting** - Prevalence of cobble through most of the sample location meant that D-netting was not successful.	< 1 % of sample	Snails	2.2	7	Collected from rock or D-Net with forceps, rinsed in ambient water, and placed in a Ziploc bag. Transported back to camp. Kim wipes used to remove some of the water from the surface of invertebrates. Caddisfly larva removed from tubes. Soft-bodied invertebrates and hard-bodied invertebrates sorted into seperate bags. Bags placed into site specific jar and frozen.
				14W 564466E 7131980N	14W 564051E 7132385N	**Manual Rock Picking with Forceps** - Turning over rocks and removing invertebrates either on the rock face or on the underlying substrate with forceps.	stonefly nymph and mayfly nymph (25%) , caddisfly larva (50 %), crane fly larva (25%).				

Note: The format for the date is day-month-year.

[(a)]Coordinates in Universal Transverse Mercator, North American Datum 83.

[(b)]Sample composition percentages are qualitative and assumed to be a percentage of the total sample by weight.

[(c)]"Grubs" noted in the field book are expected to be crane fly larva but could also be horse fly larva.

g = grams; JSL = ; Sep = September; Aug = August; < = less than; % = percentage.

2 Collection of Pre-Development Aquatic Baseline Data

The collection of pre-development aquatic baseline data in 2013 included water chemistry sampling, sediment quality sampling, limnology measurements, and benthic invertebrate sampling. Water sampling for low detection limit cadmium analysis is included within the water chemistry sampling section.

2.1 Water Quality

Water quality was collected in fall 2013 to expand and complement the existing baseline information on water chemistry for Judge Sissons and Squiggly lakes. Three water quality stations were established on Judge Sissons Lake and one station on Squiggly Lake (Table 1; Figure 1). In addition to water quality sampling, five replicate samples were collected at each sampling station for low level cadmium analysis.

2.1.1 Methods

Water chemistry samples were collected and processed according to the same methods and quality assurance/quality control (QA/QC) procedures as are outlined in Appendix 5C Aquatics Baseline; refer to Section 4.1.2.2. Surface water grab samples were collected for low level cadmium analysis, which was done by Trent University Water Quality Centre, while composite samples were collected for general chemistry analysis at Saskatchewan Research Council (SRC) Analytical Laboratories. Low-level cadmium in surface grab samples was analyzed using a NuAttom inductively coupled plasma mass spectrometer (ICP-MS) to obtain a detection limit of 0.053 nanogram per litre (ng/L). For the composite samples, the parameters analysed included conventional parameters, nutrients, major ions, total metals, metalloids and radionuclides. Major ions, metals, metalloids and radionuclides were measured using ICP-MS.

2.1.2 Results

Water chemistry results are presented in Table 3. For previously-collected baseline water chemistry results refer to Tables X.II-1 to X.II-8 of Appendix 5C Aquatics Baseline.

Table 3 Water Chemistry for Lakes in the Kiggavik Project Area, Fall 2013

Parameters	Units	Guidelines		Detection Limit	Judge Sissons Lake Sub-Basin			Squiggly Lake Sub-Basin		QA/QC	
					Judge Sissons Lake			Squiggly Lake		Field Blank	Trip Blank
					JSL2-001-F13	JSL4-001-F13	JSL8-001-F13	SQL-001-F13	SQL-001-F13 (SQL- DUP-F13)	FB-F13	TB-F-13
		SSWQO[a]	CWQG[b]		3-Sep-13	7-Sep-13	4-Sep-13	6-Sep-13	6-Sep-13	-	-
Conventional Parameters (Field-Measured)											
Dissolved Oxygen	mg/L	6.5/9.5[c]	6.5/9.5[c]	-	10.7	10.5	11.6	11.3		-	-
Water Temperature	°C	-	-	-	10.1	8.6	7.4	7.9		-	-
pH	pH unit	-	6.5-9.0	-	6.7[d]	6.4	6.7	6.4		-	-
Specific Conductivity	µS/cm	-	-	-	22	22	21	14		-	-
Conventional Parameters (Laboratory-Measured)											
Alkalinity Phenolphthalein	mg/L	-	-	1	<1	<1	<1	<1	<1	<1	<1
pH	pH unit		6.5-9.0	0.07	7.16	6.96	7.14	6.72	6.70	5.63	5.48
Specific Conductivity	µS/cm	-	-	1	21	22	20	14	14	<1	<1
Total Alkalinity	mg/L of $CaCO_3$/L	-	-	1	8	13	8	5	5	2	2
Total Hardness	mg/L of $CaCO_3$/L	-	-	1	10	10	10	6	6	<1	<1
Total Dissolved Solids	mg/L	-	-	1	11	17	12	10	8	<1	<1
Total Suspended Solids	mg/L	-	-	1	<1	<1	<1	<1	<1	<1	<1
Turbidity	NTU	-	-	0.1	0.4	0.3	0.4	0.4	0.4	<0.1	<0.1
Nutrients											
Ammonia as Nitrogen	mg N/L	10.3[e]	8.47[e]	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate[f]	mg N/L	-	13	0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Nitrate and Nitrite as Nitrogen	mg N/L	-	-	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite	mg N/L	-	0.197	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	-
Total Kjeldahl Nitrogen	mg N/L	-	-	0.05	0.27	0.25	0.31	0.18	0.17	<0.05	0.06
Total Nitrogen	mg/L	-	-	0.05	0.27	0.25	0.31	0.21	0.17	<0.05	0.06
Total Phosphorus	mg/L	-	-	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Phosphorus	mg/L	-	-	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Total Carbon	mg/L	-	-	1	5	6	5	3	3	<1	<1
Inorganic Carbon	mg/L	-	-	1	2	3	2	1	1	<1	<1
Total Organic Carbon	mg/L	-	-	0.2	2.8	2.8	2.9	2.1	2.2	<0.2	0.4
Dissolved Organic Carbon	mg/L	-	-	0.2	2.7	2.8	2.9	2.2	2.2	0.2	-
Major Ions											
Bicarbonate	mg/L	-	-	1	10	16	10	6	6	2	2
Calcium	mg/L	-	-	0.1	2.6	2.6	2.5	1.5	1.5	<0.1	<0.1
Carbonate	mg/L	-	-	1	<1	<1	<1	<1	<1	<1	<1
Chloride	mg/L	-	120	0.1	0.4	0.4	0.4	0.3	0.3	<0.1	<0.1
Fluoride	mg/L	-	0.12	0.01	0.05	0.07	0.07	0.04	0.04	0.01	<0.01
Hydroxide	mg/L	-	-	1	<1	<1	<1	<1	<1	<1	<1
Magnesium	mg/L	-	-	0.1	0.8	0.8	0.8	0.5	0.5	<0.1	<0.1
Potassium	mg/L	-	-	0.1	0.3	0.4	0.3	0.2	0.2	<0.1	<0.1
Sodium	mg/L	-	-	0.1	0.3	0.3	0.3	0.3	0.3	<0.1	<0.1
Sulphate	mg/L	-	-	0.2	0.7	0.7	0.6	0.5	0.5	<0.2	<0.2
Sum of ions	mg/L	-	-	1	15	21	15	9	9	2	2
Total Metals and Metalloids											
Aluminum	mg/L	0.005/0.1[g]	0.005/0.1[g]	0.0005	0.0013	0.0014	0.0039	**0.0080**	**0.0066**	<0.0005	<0.0005
Antimony	mg/L	-	-	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Arsenic	µg/L	5	5	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	<0.1
Barium	mg/L	-	-	0.0005	0.030	0.029	0.024	0.021	0.021	<0.0005	<0.0005

Table 3 Water Chemistry for Lakes in the Kiggavik Project Area, Fall 2013

Parameters	Units	Guidelines		Detection Limit	Judge Sissons Lake Sub-Basin			Squiggly Lake Sub-Basin		QA/QC	
					Judge Sissons Lake			Squiggly Lake		Field Blank	Trip Blank
					JSL2-001-F13	JSL4-001-F13	JSL8-001-F13	SQL-001-F13	SQL-001-F13 (SQL- DUP-F13)	FB-F13	TB-F-13
		SSWQO[a]	CWQG[b]		3-Sep-13	7-Sep-13	4-Sep-13	6-Sep-13	6-Sep-13	-	-
Beryllium	mg/L	-	-	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Boron	mg/L	-	1.5	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	mg/L	0.000017[h]	0.00004[i]	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Cadmium (low levels)[j]	ng/L	17[h]	40[i]	0.053	0.990-2.464	0.972-2.554	1.325-1.488	1.212-1.886	-	0.064	-
Chromium	mg/L	0.001[k]	0.0010/0.0089[l]	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Cobalt	mg/L	-	-	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper	mg/L	0.002[m]	0.002[m]	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Iron	mg/L	0.3	0.3	0.0005	0.014	0.013	0.016	0.0097	0.0092	<0.0005	<0.0005
Lead	mg/L	0.001[n]	0.001[n]	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Manganese	mg/L	-	-	0.0005	0.0023	0.0022	0.0025	0.0012	0.0012	<0.0005	<0.0005
Mercury	µg/L	0.026[o]	0.026[p]	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Molybdenum	mg/L	-	0.073	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	0.025[q]	0.025[q]	0.0001	0.0003	0.0002	0.0002	0.0002	0.0002	<0.0001	<0.0001
Selenium	mg/L	0.001	0.001[r]	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Silver	mg/L	0.0001	0.0001	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Strontium	mg/L	-	-	0.0005	0.014	0.013	0.013	0.0073	0.0072	<0.0005	<0.0005
Thallium	mg/L	-	0.0008	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Tin	mg/L	-	-	0.0001	0.0011	0.0004	0.0003	0.0003	0.0003	<0.0001	<0.0001
Titanium	mg/L	-	-	0.0002	<0.0002	0.0004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Uranium	µg/L	15	15	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	mg/L	-	-	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Zinc	mg/L	0.03	0.03	0.0005	0.0009	0.0063	0.0014	0.0021	0.0034	<0.0005	<0.0005
Radionuclides											
Lead-210	Bq/L	-	-	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Polonium-210	Bq/L	-	-	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Radium-226	Bq/L	0.11[s]	-	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Thorium-228	Bq/L	-	-	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Thorium-230	Bq/L	-	-	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Thorium-232	Bq/L	-	-	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Notes: Values that are equal to or exceed the SSWQO are bolded. Values that are equal to or exceed the CWQG are underlined. Non-detect values that are higher than one or more guideline are italized.

[a] = Water Security Agency (2006) Saskatchewan Surface Water Quality Objectives (SSWQO).

[b] = Canadian Council of Ministers of the Environment's (CCME) Canadian Water Quality Guidelines (CWQG) for the protection of aquatic life - freshwater (CCME 1999a, with updates to 2014).

[c] = The objectives and guidelines for dissolved oxygen for cold-water biota are 9.5 mg/L for early life stages and 6.5 mg/L for other life stages.

[d] = This pH value represents the average of the pH values measured at the composite depths (surface, 3.5 [3 and 4 m], and 6 m) at the four replicate stations.

[e] = The objectives and guidelines for ammonia are dependent on temperature and pH; therefore, the guidelines for each station was calculated and the lowest overall value was used for screening.

[f] = Nitrate values were calculated using the equation Nitrate Concentration = Nitrate-Nitrite Concentration * 62/14; non-detect values were substituted with the detection limit in calculations.

[g] = The objectives and guidelines for aluminum are pH-dependent; the guideline is 0.005 mg/L at pH<6.5; 0.1 mg/L at pH ≥6.5. Field pH values were used in the screening.

[h] = The objectives for cadmium are hardness-dependent; at hardnesses ranging from 0 to 48.5 mg/L as $CaCO_3$, the objective is 0.000017 mg/L.

[i] = The guidelines for cadmium are hardness-dependent; at hardnesses lower than 17 mg/L as $CaCO_3$, the guideline is 0.00004 mg/L .

Table 3 Water Chemistry for Lakes in the Kiggavik Project Area, Fall 2013

Parameters	Units	Guidelines		Detection Limit	Judge Sissons Lake Sub-Basin			Squiggly Lake Sub-Basin		QA/QC	
					Judge Sissons Lake			Squiggly Lake		Field Blank	Trip Blank
					JSL2-001-F13	JSL4-001-F13	JSL8-001-F13	SQL-001-F13	SQL-001-F13 (SQL- DUP-F13)	FB-F13	TB-F-13
		SSWQO[(a)]	CWQG[(b)]		3-Sep-13	7-Sep-13	4-Sep-13	6-Sep-13	6-Sep-13	-	-

[(j)] = Low level cadmium was analyzed by the Trent University Water Quality Centre. Five replicate samples were collected within proximity. The range of values is presented.

[(k)] = This objective is for hexavalent chromium.

[(l)] = The guideline for chromium is speciation-dependent; the guideline is 0.0089 mg/L for trivalent chromium and 0.0010 mg/L for hexavalent chromium.

[(m)] = The objectives and guidelines for copper are hardness-dependent; at hardnesses ranging from 0 to 120 mg/L as $CaCO_3$, the objective is 0.002 mg/L; at hardnesses ranging from 6 to 10 mg/L, the guideline is also 0.002 mg/L.

[(n)] = The objectives and guidelines for lead are hardness-dependent; at hardnesses ranging from 0 to 60 mg/L as $CaCO_3$, the objective is 0.001 mg/L; at hardnesses ranging from 6 to 10 mg/L, the guideline is also 0.001 mg/L.

[(o)] = Mercury objective is for inorganic mercury only.

[(p)] = Mercury guidelines differ depending on mercury type: inorganic mercury = 0.026 µg/L; methylmercury = 0.004 µg/L.

[(q)] = The objectives and guidelines for nickel are hardness-dependent; at hardnesses ranging from 0 to 60 mg/L as $CaCO_3$, the objective is 0.025 mg/L; at hardnesses ranging from 6 to 10 mg/L, the guideline is also 0.025 mg/L.

[(r)] = Selenium guideline is based on waterborne exposure. However, selenium has a bioaccumulation pathway similar to mercury; therefore, the guideline may not be protective of effects through reproductive impairment due to maternal transfer, resulting in embryotoxicity and teratogenicity (Chapman et al. 2009).

[(s)] = The objective for radium-226 was missed in the 2006 SSWQO (SMOE) revisions; an objective of 0.11 mg/L was presented in 1997 SSWQO (SMOE) and is expected to be added to the next SSWQO revision (T. Moulding pers. comm.).

SSWQG = Saskatchewan Surface Water Quality Objectives; CWQG = Canadian Water Quality Guidelines; Sep = September; JSL = ; SQL = ; FB = ; QA/QC = quality assurance/quality control; mg/L = milligrams per litre;
°C = degrees Celsius; µS/cm = microSiemens per centimetre; mg of CaCO3/L = milligrams of calcium carbonate per litre; NTU = Nephelometric Turbidity Unit; mg N/L = milligrams of nitrogen per litre; µg/L = micrograms per litre; ng/L = nanograms per litre;

Bq/L = Becquerels per litre; < = less than; - = not applicable or not collected; ≥ = greater than or equal to.

2.1.2.1 Judge Sissons Lake

Water chemistry samples were collected at three areas in Judge Sissons Lake in fall 2013. For the low level cadmium analysis, 15 samples were collected; five replicate stations per area. The results of the chemical analyses indicate that water chemistry was quite uniform throughout the lake. Concentrations of water chemistry parameters were similar to historical concentrations reported for Judge Sissons Lake (1979 to 2009).

Field measured pH values ranged from pH 6.4 to 6.7; one station had a pH value lower than the range presented by the Canadian Water Quality Guidelines (CWQG) for the protection of aquatic life – freshwater (Canadian Council of Ministers of the Environment [CCME] 1999a; with updates to 2014). Specific conductivity values ranged from 21 to 22 microSiemens per centimetre (µS/cm). Total alkalinity concentrations ranged from 8 to 13 milligrams per litre (mg/L). Total hardness concentrations were 10 mg/L at all three stations.

Total ammonia, nitrate, and nitrite concentrations were below the reported detection limits in all lake samples. Concentrations of total Kjeldahl nitrogen (TKN) ranged from 0.25 to 0.31 milligrams of nitrogen per litre (mg N/L). Total phosphorus concentrations were below the reported detection limit. Concentrations of dissolved organic carbon (DOC) ranged from 2.7 to 2.9 mg/L.

Chloride concentrations were 0.4 mg/L for all stations and were below the applicable guideline (CWQG). Fluoride concentrations ranged from 0.05 to 0.07 mg/L and were below the applicable guideline (CWQG).

Detection limits for total metals were at or below the most conservative guideline (i.e., CWQG) or objective (Saskatchewan Surface Water Quality Objectives [SSWQO; Water Security Agency 2006]). All total metal concentrations were either below the detection limits or below applicable guidelines.

The detection limit for radium-226 was below the applicable guideline (SSWQO). Lead-210, polonium-210, radium-226, thorium-228, thorium-230, and thorium-232 were below the reported detection limits in all lake samples.

2.1.2.2 Squiggly Lake

Water chemistry samples were collected at one area (including a duplicate sample) in Squiggly Lake in fall 2013. Five samples were collected for low-level cadmium analysis. Concentrations of water chemistry parameters were similar to historical concentrations reported for Squiggly Lake (1980 to 2008).

The field measured pH value was pH 6.4, which is lower than the range presented by the CWQG for the protection of aquatic life – freshwater (i.e., pH 6.5 to 9.0; CCME 1999a, with updates to 2014). the specific conductivity value was 14 µS/cm. Total alkalinity and total hardness concentrations were 5 mg/L and 6 mg/L, respectively.

Total ammonia, nitrate, and nitrite concentrations were below the reported detection limits in all samples. Concentrations of TKN ranged from 0.17 to 0.18 mg N/L. Total phosphorus concentrations were not detected. The concentration of DOC was 2.2 mg/L.

Chloride and fluoride concentrations were 0.3 mg/L and 0.04 mg/L, respectively, and were below the applicable guidelines (CWQG).

Detection limits for total metals were at or below the most conservative guideline (SSWQO or CWQG). Total metal concentrations were either below the detection limits or below applicable guidelines with one exception. Aluminum concentrations ranged from 0.0066 to 0.0080 mg/L, which were higher than the most conservative objective and guideline of 0.005 mg/L for aluminum at a pH of 6.4 (CCME 1999a, with updates to 2014; Water Security Agency 2006).

The detection limit for radium-226 was below the applicable guideline (SSWQO). Lead-210, polonium-210, radium-226, thorium-228, thorium-230, and thorium-232 were below the detection limits in all samples.

2.2 Sediment Quality

Sediment sampling was conducted in fall 2013 to expand and complement the existing baseline information on sediment chemistry for Judge Sissons and Squiggly lakes. Sediment sampling locations were chosen as per the benthic invertebrate community requirements[1]. Three sampling areas were established on Judge Sissons Lake and one sampling area on Squiggly Lake (Table 1; Figure 1). Five replicate stations were sampled for each area, except for one area where only four replicate stations were located due to lake bottom conditions (abundance of sand). Replicate stations were selected based on similar water depth and sediment texture as much as possible. Two duplicate sediment samples were collected in Judge Sissons Lake.

2.2.1 Methods

Sediment chemistry samples were collected using different techniques than previous sampling described in the Kiggavik project baseline report, but were analyzed according to the same methods and QA/QC procedures outlined in Appendix 5C Aquatics Baseline; Sections 5.1.2.3 and 5.1.2.4. Sediment chemistry samples were collected according to procedures outlined in Golder's Technical Procedure 8.2-3: Sediment Sampling Methods (unpublished file information) and AREVA's Work Instruction SHEQ-801-07: Winter Sediment Coring (with modifications for open water sampling). Sediment core samples were obtained using a 10 centimetre (cm) diameter Tech Ops sediment corer. Prior to sampling, the tube and the plug sections of the Tech Ops sediment corer were rinsed twice with ambient water to remove any attached sediment or other material. The 0 to 2 cm horizon

[1] Benthic invertebrate community sampling stations were selected to be as similar as possible in water depth and sediment texture.

of sediment from multiple sub-samples (3 to 5 sub-samples) was collected at each replicate station and combined into a single composite sample. The composite sediment samples from each sampling location were placed into a polyethylene bag. The sample was double bagged and a waterproof paper label was inserted between the bags. The outer bag was labelled with the appropriate sample information using a waterproof marker. Samples were frozen, kept in the dark, and shipped in sealed coolers to Golder's Saskatoon office prior to submission to SRC for analysis.

2.2.2 Laboratory Analysis

Sediment chemistry samples were analyzed for the following parameters:

- physical properties (i.e., particle size [according to Environmental Effects Monitoring {EEM} size classes; analysed by volume percentage using laser diffraction], moisture);
- nutrients (i.e., total organic carbon [TOC]);
- metals and metalloids (i.e., aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, tin, titanium, uranium, vanadium, zinc); and
- radionuclides (lead-210, polonium-210, radium-226, thorium-228, thorium-230, thorium-232).

Note that particle size and TOC are supporting environmental parameters required for the benthic invertebrate study (refer to Section 2.4).

2.2.3 Results

Sediment chemistry results are presented in Table 4. For the historical sediment chemistry results refer to tables X.III-1 to X.III-6 of the Aquatics Baseline report.

Table 4 Sediment Chemistry for Lakes in the Kiggavik Project Area, Fall 2013

Parameter	Units	CCME Sediment Quality Guidelines		Thompson et al. (2005) values[c]		DL	Judge Sissons Lake Sub-Basin											
							Judge Sissons Lake											
							Station Near the Proposed Kiggavik Diffuser						Station Near the Centre of the North Bay					
							JSL2-001-F13	JSL2-002-F13	JSL2-002-F13 (JSL2-DUP1-F13)	JSL2-003-F13	JSL2-004-F13	JSL2-005-F13	JSL4-001-F13	JSL4-001-F13 (JSL4-DUP3-F13)	JSL4-002-F13	JSL4-003-F13	JSL4-004-F13	JSL4-005-F13
		ISQG[a]	PEL[b]	LEL[d]	SEL[e]		3-Sep-13	4-Sep-13	4-Sep-13	4-Sep-13	4-Sep-13	4-Sep-13	7-Sep-13	7-Sep-13	7-Sep-13	7-Sep-13	7-Sep-13	7-Sep-13
Physical Properties																		
Gravel	vol %	-	-	-	-	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
Coarse Sand	vol %	-	-	-	-	0.01	0.30	0.94	0.06	0.08	0.10	0.15	0.04	0.07	1.50	0.26	0.42	0.33
Fine Sand	vol %	-	-	-	-	0.01	52.5	55.6	50.9	52.4	53.3	49.5	50.7	51.8	60.2	52.6	55.0	55.8
Silt	vol %	-	-	-	-	0.01	40.3	37.2	42.0	40.9	40.8	43.3	42.1	42.3	33.1	40.5	38.4	38.4
Clay	vol %	-	-	-	-	0.01	6.90	6.22	7.06	6.63	5.85	6.99	7.19	5.9	5.19	6.59	6.14	5.52
Moisture	%	-	-	-	-	0.01	84.38	88.38	89.69	82.69	83.58	85.62	91.93	85.00	93.14	87.59	93.25	92.18
Nutrients																		
Total Organic Carbon	%	-	-	-	-	0.01	7.64	8.22	8.10	7.53	7.75	6.99	7.37	5.91	8.28	6.57	7.22	7.14
Metals and Metalloids																		
Aluminum	µg/g dw	-	-	-	-	20	19900	20400	20400	20100	19500	19600	16400	15700	15600	17700	14600	16800
Antimony	µg/g dw	-	-	-	-	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	<0.2	0.2
Arsenic	µg/g dw	5.9	17	9.3, 9.8	56, 346.4	0.1	**12**	**13**	**14**	**13**	**14**	**8.8**	**12**	**11**	**11**	**9.0**	**13**	**10**
Barium	µg/g dw	-	-	-	-	0.5	290	300	310	250	250	270	240	210	240	220	250	220
Beryllium	µg/g dw	-	-	-	-	0.1	1.3	1.3	1.3	1.2	1.2	1.3	1.0	0.9	1.0	1.0	1.0	1.0
Boron	µg/g dw	-	-	-	-	1	47	47	50	44	44	47	38	37	42	38	39	40
Cadmium	µg/g dw	0.6	3.5	-	-	0.1	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4
Chromium	µg/g dw	37.3	90.0	36.7, 47.6	69.2, 115.4	0.5	**44**	**45**	**48**	**44**	**46**	**46**	**38**	36	**38**	**39**	36	**40**
Cobalt	µg/g dw	-	-	-	-	0.2	6.8	7.8	8.1	7.6	7.7	6.5	6.3	6.1	7.5	6.6	6.2	6.7
Copper	µg/g dw	35.7	197	12, 22.2	200, 268.8	0.5	**36**	**37**	**39**	**36**	**36**	**36**	30	26	31	29	28	31
Iron	µg/g dw	-	-	-	-	20	36500	40400	38600	38600	40400	29500	35700	29200	33500	27400	34000	30500
Lead	µg/g dw	35.0	91.3	27.7, 36.7	380, 412.4	0.1	18	19	17	16	16	17	15	15	18	16	15	14
Manganese	µg/g dw	-	-	-	-	0.5	620	540	460	450	450	410	560	400	370	330	410	320
Mercury	µg/g dw	0.17	0.486	-	-	0.05	0.07	0.07	0.08	0.07	0.05	0.08	0.09	0.05	0.09	0.09	0.12	0.08
Molybdenum	µg/g dw	-	-	8.3, 13.8	540, 1238.5	0.1	1.6	1.9	1.9	1.9	2.2	1.3	1.5	1.3	1.6	1.3	1.4	1.7
Nickel	µg/g dw	-	-	21, 23.4	170, 484	0.1	31	34	36	32	33	30	28	26	31	28	27	29
Selenium	µg/g dw	-	-	0.9, 1.9	4.7, 16.1	0.1	0.8	0.9	0.9	0.8	0.8	0.8	0.8	0.6	0.8	0.7	0.7	0.7
Silver	µg/g dw	-	-	-	-	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
Strontium	µg/g dw	-	-	-	-	0.5	160	170	180	140	140	150	160	130	140	130	140	150
Thallium	µg/g dw	-	-	-	-	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/g dw	-	-	-	-	0.1	0.7	0.8	0.7	0.7	0.7	0.7	0.6	1.0	0.7	0.9	0.5	0.6
Titanium	µg/g dw	-	-	-	-	0.5	590	600	630	540	580	620	520	520	560	540	560	530
Uranium	µg/g dw	-	-	32, 104.4	3410, 5874.1	0.1	3.7	3.9	4.1	3.8	3.9	3.9	3.2	2.8	3.2	3.0	2.9	3.2
Vanadium	µg/g dw	-	-	27.3, 35.2	77, 160	0.1	42	42	46	37	39	42	34	32	37	32	36	35
Zinc	µg/g dw	123	315	-	-	0.5	97	100	120	100	110	84	81	77	84	78	74	86
Radionuclides																		

Lead-210	Bq/g dw	-	-	0.5, 0.9	9.7, 20.8	0.04	0.36	0.57	0.34	0.35	0.26	0.26	0.59	0.42	0.85	0.41	0.68	0.45
Polonium-210	Bq/g dw	-	-	0.6, 0.8	8.7, 12.1	0.01	0.38	0.56	0.30	0.37	0.35	0.27	0.42	0.33	0.70	0.42	0.61	0.41
Radium-226	Bq/g dw	-	-	0.1, 0.6	13, 14.4	0.01	0.06	0.08	0.06	0.08	0.07	0.08	0.10	0.06	0.11	0.09	0.14	0.11
Thorium-228	Bq/g dw	-	-	-	-	0.02	0.06	0.06	0.11	0.08	0.06	0.08	0.07	0.06	0.10	0.06	0.05	0.05
Thorium-230	Bq/g dw	-	-	-	-	0.02	<0.02	0.07	0.03	0.04	0.04	0.02	0.02	0.02	0.03	0.04	0.03	0.03
Thorium-232	Bq/g dw	-	-	-	-	0.02	0.06	0.09	0.06	0.07	0.04	0.05	0.08	0.03	0.07	0.05	0.04	0.05

Table 4 Sediment Chemistry for Lakes in the Kiggavik Project Area, Fall 2013

Parameter	Units	CCME Sediment Quality Guidelines		Thompson et al. (2005) values(c)		DL	Judge Sissons Lake Sub-Basin				Squiggly Lake Sub-Basin					
							Judge Sissons Lake				Squiggly Lake					
							Station Near the Proposed Sissons Diffuser				Potential Reference Site					
							JSL8-002-F13	JSL8-003-F13	JSL8-004-F13	JSL8-005-F13	SQL-001-F13	SQL-001-F13 (SQL-DUP2-F13)	SQL-002-F13	SQL-003-F13	SQL-004-F13	SQL-005-F13
		ISQG(a)	PEL(b)	LEL(d)	SEL(e)		4-Sep-13	5-Sep-13	5-Sep-13	5-Sep-13	6-Sep-13	6-Sep-13	6-Sep-13	6-Sep-13	6-Sep-13	6-Sep-13
Physical Properties																
Gravel	vol %	-	-	-	-	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Coarse Sand	vol %	-	-	-	-	0.01	8.81	12.7	7.32	12.4	<0.01	0.01	0.03	0.05	0.02	0.23
Fine Sand	vol %	-	-	-	-	0.01	62.2	53.5	58.7	55.2	40.9	40.5	45.0	49.5	41.6	43.4
Silt	vol %	-	-	-	-	0.01	25.3	29.4	29.4	28.3	52.5	53.2	49.4	44.9	52.6	50.6
Clay	vol %	-	-	-	-	0.01	3.65	4.45	4.67	4.08	6.66	6.28	5.49	5.57	5.77	5.73
Moisture	%	-	-	-	-	0.01	89.11	83.96	85.24	74.76	86.58	88.85	90.27	92.19	83.17	92.26
Nutrients																
Total Organic Carbon	%	-	-	-	-	0.01	9.10	6.45	7.49	5.28	5.88	6.10	8.52	9.00	8.52	7.72
Metals and Metalloids																
Aluminum	µg/g dw	-	-	-	-	20	12800	11500	13200	9400	30100	32300	32500	30800	34500	30500
Antimony	µg/g dw	-	-	-	-	0.2	0.6	<0.2	<0.2	<0.2	0.2	<0.2	0.2	0.3	<0.2	0.2
Arsenic	µg/g dw	5.9	17	9.3, 9.8	56, 346.4	0.1	**5.9**	5.3	**6.2**	4.5	**9.8**	**9.1**	**13**	**<u>17</u>**	**11**	**14**
Barium	µg/g dw	-	-	-	-	0.5	190	140	160	140	270	280	290	250	320	300
Beryllium	µg/g dw	-	-	-	-	0.1	0.8	0.6	0.8	0.5	1.4	1.6	1.6	1.6	1.7	1.8
Boron	µg/g dw	-	-	-	-	1	35	28	35	27	130	140	140	120	160	160
Cadmium	µg/g dw	0.6	3.5	-	-	0.1	0.3	0.2	0.3	0.2	0.2	0.2	0.3	0.4	0.4	0.4
Chromium	µg/g dw	37.3	90.0	36.7, 47.6	69.2, 115.4	0.5	28	22	28	18	**44**	**41**	**40**	**41**	**42**	**42**
Cobalt	µg/g dw	-	-	-	-	0.2	5.7	3.9	5.2	3.3	7.3	6.5	6.8	6.9	7.0	6.6
Copper	µg/g dw	35.7	197	12, 22.2	200, 268.8	0.5	20	14	19	12	30	32	**36**	**40**	**37**	**42**
Iron	µg/g dw	-	-	-	-	20	17000	15000	19000	11700	31500	28000	38300	41700	32000	36500
Lead	µg/g dw	35.0	91.3	27.7, 36.7	380, 412.4	0.1	10	8.9	10	7.8	15	15	20	22	18	20
Manganese	µg/g dw	-	-	-	-	0.5	440	280	310	240	540	470	400	310	520	310
Mercury	µg/g dw	0.17	0.486	-	-	0.05	0.06	0.05	0.06	<0.05	0.06	0.06	0.10	0.09	0.07	0.07
Molybdenum	µg/g dw	-	-	8.3, 13.8	540, 1238.5	0.1	1.2	0.9	1.1	0.7	2.4	2.1	3.8	4.9	3.0	4.5
Nickel	µg/g dw	-	-	21, 23.4	170, 484	0.1	22	17	22	14	29	28	28	30	29	29
Selenium	µg/g dw	-	-	0.9, 1.9	4.7, 16.1	0.1	0.5	0.3	0.4	0.3	0.7	0.7	0.9	1.0	0.8	1.0
Silver	µg/g dw	-	-	-	-	0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.2	0.1	0.2	0.2	0.2
Strontium	µg/g dw	-	-	-	-	0.5	110	88	92	82	180	150	150	140	150	150
Thallium	µg/g dw	-	-	-	-	0.2	<0.2	<0.2	<0.2	<0.2	0.2	0.2	0.2	0.2	0.2	0.2
Tin	µg/g	-	-	-	-	0.1	0.6	0.5	0.4	0.5	0.8	0.9	0.8	0.9	0.8	0.7

Table 4 Sediment Chemistry for Lakes in the Kiggavik Project Area, Fall 2013

Parameter	Units	CCME Sediment Quality Guidelines		Thompson et al. (2005) values[c]		DL	Judge Sissons Lake Sub-Basin				Squiggly Lake Sub-Basin					
							Judge Sissons Lake				Squiggly Lake					
							Station Near the Proposed Sissons Diffuser				Potential Reference Site					
							JSL8-002-F13	JSL8-003-F13	JSL8-004-F13	JSL8-005-F13	SQL-001-F13	SQL-001-F13 (SQL-DUP2-F13)	SQL-002-F13	SQL-003-F13	SQL-004-F13	SQL-005-F13
		ISQG[a]	PEL[b]	LEL[d]	SEL[e]		4-Sep-13	5-Sep-13	5-Sep-13	5-Sep-13	6-Sep-13	6-Sep-13	6-Sep-13	6-Sep-13	6-Sep-13	6-Sep-13
	dw															
Titanium	µg/g dw	-	-	-	-	0.5	420	330	440	330	450	460	430	410	470	460
Uranium	µg/g dw	-	-	32, 104.4	3410, 5874.1	0.1	2.1	1.6	2.0	1.4	4.4	4.5	5.0	5.2	4.9	5.4
Vanadium	µg/g dw	-	-	27.3, 35.2	77, 160	0.1	26	21	27	21	37	35	37	34	38	39
Zinc	µg/g dw	123	315	-	-	0.5	52	44	61	36	65	63	78	94	76	91
Radionuclides																
Lead-210	Bq/g dw	-	-	0.5, 0.9	9.7, 20.8	0.04	0.53	0.47	0.34	0.40	0.42	0.31	0.80	0.87	0.45	0.50
Polonium-210	Bq/g dw	-	-	0.6, 0.8	8.7, 12.1	0.01	0.51	0.47	0.32	0.38	0.36	0.41	0.76	1.0	0.51	0.60
Radium-226	Bq/g dw	-	-	0.1, 0.6	13, 14.4	0.01	0.07	0.06	0.09	0.03	0.15	0.08	0.12	0.10	0.10	0.14
Thorium-228	Bq/g dw	-	-	-	-	0.02	0.06	0.03	0.06	0.05	0.04	0.10	0.06	0.07	0.09	0.08
Thorium-230	Bq/g dw	-	-	-	-	0.02	0.03	<0.02	<0.02	<0.02	0.03	0.04	0.03	0.04	0.06	<0.02
Thorium-232	Bq/g dw	-	-	-	-	0.02	0.04	0.04	0.03	<0.02	0.03	0.06	0.06	0.07	0.06	0.05

Notes: Sediment samples were collected with a tech ops core sampler. The results presented are for the top (0 to 2 cm) layer of the core sample.

Notes: Values greater than or equal to ISQGs are bolded. Values greater than or equal to PELs are bolded and underlined. Non-detect values that have detection limits that are greater than guidelines are italized. Values greater than or equal to LEL are shaded.

(a) = ISQG = Interim freshwater sediment quality guidelines from the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME 1999b).

(b) = PEL = Probable effect levels from the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME 2002).

(c) = Thompson et al. (2005) present two LEL values and two SEL values. The lowest values are derived using the closest observation method; the highest values are derived using the weighted method. Both values are presented, but the screening was completed with the lowest values.

(d) = LEL = Lowest effect level from Thompson et al. (2005).

(e) = SEL = Severe effect level from Thompson et al. (2005).

CCME = Canadian Council of Ministers of the Environment; DL = detection limit; Sep = September; vol % = volume percentage; % = percentage; µg/g dw = micrograms per gram in dry weight; Bq/g dw = Becquerels per gram in dry weight; - = not applicable; < = less than.

2.2.3.1 Judge Sissons Lake

Particle size distribution in Judge Sissons Lake was similar among the three sampling areas (i.e., JSL2, JSL4, and JSL8). Sediment primarily consisted of fine sand and silt. However, the JSL8 sampling area had more coarse sand than the two other sampling areas (i.e., JSL2 and JSL4). Moisture contents ranged from 75 to 93 percent (%). Total organic carbon ranged from 5.28 to 9.10%. Particle size distribution was relatively similar between samples in 2013 (fine sand and silt) compared to the highly variable results obtained in 2008, and the less variable results from 2009 (silt-clay or sand). Although a different particle size methods was used in 2013 compared to 2008 and 2009, the higher consistency between samples in 2013 was mainly due to enhanced efforts made in selecting sites with similar texture and depth. This was done to accommodate the benthic invertebrate community requirements and obtain a higher similarity in sampling conditions to ultimately inform future EEM program designs. In contrast, the purpose of the previous sampling was to broadly characterize sediment habitat in the lakes, and therefore the sites differed in texture and depth.

Total metal concentrations were generally higher in sediment samples from JSL2 or occasionally similar to samples from JSL4, while the results were generally lower for samples from JSL8. Sediment concentrations for all samples in Judge Sissons Lake were below the interim freshwater sediment quality guidelines (ISQG) for the protection of aquatic life (CCME 1999b, with updates to 2002) for cadmium, lead, mercury, and zinc. Arsenic concentrations met or exceeded the ISQG of 5.9 microgram per gram of dry weight (µg/g dw) in 14 of the 16 samples collected in 2013.

In 10 samples, the arsenic concentrations were also higher than the lowest effect level (LEL) from Thompson et al. (2005) of 9.3 µg/g dw. Chromium concentrations exceeded the ISQG of 37.3 µg/g dw and the LEL of 36.7 µg/g dw in 10 samples; concentrations in these samples ranged from 38 to 48 µg/g dw. Chromium concentrations in the other samples ranged from 18 to 36 µg/g dw. Copper concentrations in 6 samples collected in JSL2 ranged from 36 to 39 µg/g dw, which exceeded the ISQG of 35.7 µg/g dw. All 16 samples in Judge Sissons Lake had copper concentrations exceeding the LEL of 12 µg/g dw. Nickel concentrations exceeded the LEL of 21 µg/g dw in 14 samples; concentrations in these samples ranged from 22 to 36 µg/g dw. Selenium concentrations in two samples were equal to the LEL of 0.9 µg/g dw. Vanadium concentrations in all 12 samples collected at JSL2 and JSL4 ranged from 32 to 46 µg/g dw, which exceeded the LEL of 27.3 µg/g dw; samples collected at JSL8 had vanadium concentrations that ranged from 21 to 27 µg/g dw, which was below the LEL. No other exceedances were observed.

Radionuclides were detected in all samples, except in four samples for thorium-230 (three samples from JSL8 and one from JSL2) and in one sample for thorium-232 (from JSL8). Measured concentrations were equal to or above detection limits. Lead-210 concentrations exceeded the LEL of 0.5 Becquerel per gram of dry weight (Bq/g dw) in five samples; concentrations in these samples ranged from 0.53 to 0.85 Bq/g dw. Polonium-210 concentrations in two samples were 0.61 and 0.70 Bq/g dw, which exceeded the LEL of 0.6 Bq/g dw. Radium-226 concentrations in four samples collected at JSL4 ranged from 0.10 to 0.14 Bq/g dw, which was equal to or exceeded the LEL of 0.1 Bq/g dw.

2.2.3.2 Squiggly Lake

Particle size distribution in Squiggly Lake was similar among the sediment samples, and primarily consisted of silt and fine sand, followed by clay; one sediment sample consisted of fine sand and silt, also followed by clay. Moisture contents ranged from 83 to 92%. Total organic carbon ranged from 5.88 to 9.00%. Particle size distribution cannot be compared to results from 2008, as particle size was not analyzed in 2008.

Total metal concentrations were generally similar among samples. Sediment concentrations for all samples in Squiggly Lake were below the ISQG for the protection of aquatic life (CCME 1999b, with updates to 2002) for cadmium, lead, mercury, and zinc. Arsenic concentrations exceeded the ISQG of 5.9 µg/g dw in all six samples collected in 2013 and one sample was equal to the probable effect levels from the Canadian Sediment Quality Guidelines for the protection of aquatic life (CCME 1999b, with updates to 2002). In five samples, the arsenic concentrations were also higher than the LEL of 9.3 µg/g dw. Chromium concentrations exceeded the ISQG of 37.3 µg/g dw and the LEL of 36.7 µg/g dw in all six samples; concentrations in these samples ranged from 40 to 44 µg/g dw. Copper concentrations in four samples ranged from 36 to 42 µg/g dw, which exceeded the ISQG of 35.7 µg/g dw. All six samples in Squiggly Lake had copper concentrations exceeding the LEL of 12 µg/g dw. Nickel concentrations exceeded the LEL of 21 µg/g dw in all six samples; concentrations in these samples ranged from 28 to 30 µg/g dw. Selenium concentrations in three samples were equal to or exceeded the LEL of 0.9 µg/g dw. Vanadium concentrations in all six samples exceeded the LEL of 27.3 µg/g dw, ranging from 34 to 39 µg/g dw. No other exceedances were observed.

Radionuclides were detected in all samples, except in one sample for thorium-230. Lead-210 and polonium-210 concentrations exceeded the LEL of 0.5 and 0.6 Bq/g dw, respectively, in three samples; concentrations in these samples ranged from 0.50 to 0.87 Bq/g dw for lead-210 and from 0.60 to 1.0 Bq/g dw for polonium-210. Radium-226 concentrations in five of six samples ranged from 0.10 to 0.15 Bq/g dw, which was equal to or exceeded the LEL of 0.1 Bq/g dw.

2.3 Limnology

Limnology measurements were taken as supporting environmental information for water and sediment quality and benthic invertebrate sampling (Table 1, Figure 1).

2.3.1 Methods

Limnology measurements were collected according to methods and QA/QC procedures outlined in Appendix 5C Aquatics Baseline (Sections 6.1.2.2 to 6.1.2.5).

2.3.2 Results

The limnology information collected during the 2013 field program is presented in Table 5. An updated bathymetry map for a sub-basin of Judge Sissons Lake is presented in Figure 2.

Table 5 Supporting Environmental Variables and Limnology Data for Lakes in the Kiggavik Project Area, Fall 2013

Sub-Basin and Waterbody	Station Code[a]	Date	Air Temperature (°C)	Cloud Cover (%)	Precip Rate	Precip Type	Wind Direction	Wind Rate	Secchi Depth (m)	Maximum Depth (m)	Profile Depth (m)	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (µS/cm)	pH
Judge Sissons Lake	JSL2-001-F13	3-Sep-13	5	50-75	-	none	north east	heavy	4.0	8.0	0.2	10.0	10.8	22	(b)
											1.0	10.1	10.7	22	(b)
											2.0	10.1	10.7	22	(b)
											3.0	10.1	10.7	22	(b)
											4.0	10.1	10.7	22	(b)
											5.0	10.1	10.6	22	(b)
											6.0	10.1	10.6	22	(b)
											7.0	10.1	10.6	22	(b)
											7.25	10.1	9.6	22	(b)
	JSL2-002-F13	4-Sep-13	2	75-100	-	none	north	light	6.1	7.5	0.2	9.4	10.8	22	6.8
											1.0	9.5	10.8	22	6.8
											2.0	9.5	10.7	22	6.7
											3.0	9.5	10.7	22	6.7
											4.0	9.5	10.7	22	6.7
											5.0	9.5	10.7	22	6.7
											6.0	9.5	10.6	22	6.7
											7.0	9.5	10.6	22	6.7
											7.25	9.5	10.6	22	6.7
	JSL2-003-F13	4-Sep-13	2	75-100	-	none	north	light	5.8	7.6	0.2	9.3	10.9	22	6.6
											1.0	9.4	10.9	22	6.6
											2.0	9.4	10.9	22	6.6
											3.0	9.4	10.8	22	6.6
											4.0	9.4	10.8	22	6.6
											5.0	9.5	10.8	22	6.6
											6.0	9.5	10.8	22	6.7
											7.0	9.5	10.8	22	6.6
											7.25	9.5	10.8	22	6.7
	JSL2-004-F13	4-Sep-13	4	50-75	-	none	north	light	6.1	7.6	0.2	9.5	10.9	22	6.7
											1.0	9.5	10.9	22	6.7
											2.0	9.5	10.9	22	6.7
											3.0	9.5	10.8	22	6.7
											4.0	9.5	10.8	22	6.7
											5.0	9.5	10.8	22	6.7
											6.0	9.4	10.8	22	6.6
											7.0	9.0	11.0	22	6.7
											7.25	8.9	11.0	22	6.7
	JSL2-005-F13	4-Sep-13	5	75-100	-	none	-	calm	6.8	7.3	0.2	9.4	11.1	22	6.7
											1.0	9.5	10.9	22	6.7
											2.0	9.5	10.9	22	6.7
											3.0	9.5	10.9	22	6.7
											4.0	9.5	10.9	22	6.7
											5.0	9.4	10.8	22	6.7
											6.0	8.8	11.0	22	6.7
											6.5	8.7	11.0	22	6.7
											7.0	8.6	11.0	22	6.7
											7.25	8.8	**9.3**	22	6.7
	JSL4-001-F13	7-Sep-13	2	75-100	-	none	west	light	6.7	8.6	0.2	8.6	10.5	22	**6.4**
											1.0	8.6	10.5	22	**6.4**
											2.0	8.6	10.5	22	**6.4**
											3.0	8.7	10.5	22	**6.4**
											4.0	8.6	10.5	22	**6.4**

Table 5 Supporting Environmental Variables and Limnology Data for Lakes in the Kiggavik Project Area, Fall 2013

Sub-Basin and Waterbody	Station Code[a]	Date	Air Temperature (°C)	Cloud Cover (%)	Precip Rate	Precip Type	Wind Direction	Wind Rate	Secchi Depth (m)	Maximum Depth (m)	Profile Depth (m)	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (µS/cm)	pH
Judge Sissons Lake	JSL4-001-F13	7-Sep-13	2	75-100	-	none	west	light	6.7	8.6	5.0	8.6	10.5	22	**6.4**
											6.0	8.6	10.5	22	**6.4**
											7.0	8.6	10.5	22	**6.4**
											8.0	8.6	10.5	22	**6.4**
											8.25	8.6	10.5	22	**6.4**
											8.35	8.6	10.4	22	**6.4**
											8.5	8.6	**1.1**	22	**6.4**
	JSL4-002-F13	7-Sep-13	2	75-100	light	rain	south west	light	-	8.9	0.2	8.4	10.6	22	**6.4**
											1.0	8.6	10.6	22	**6.4**
											2.0	8.6	10.5	22	**6.4**
											3.0	8.6	10.5	22	**6.4**
											4.0	8.6	10.5	22	**6.3**
											5.0	8.6	10.5	22	**6.4**
											6.0	8.6	10.5	22	**6.4**
											7.0	8.6	10.5	22	**6.4**
											7.5	8.6	10.5	22	**6.4**
											8.0	8.6	10.5	22	**6.4**
											8.25	8.6	10.5	22	**6.4**
											8.5	8.6	**9.0**	22	**6.4**
	JSL4-003-F13	7-Sep-13	4	75-100	light	rain	south east	moderate	5.1	8.8	0.2	8.5	10.6	22	**6.4**
											1.0	8.6	10.6	22	**6.4**
											2.0	8.6	10.6	22	**6.3**
											3.0	8.6	10.6	22	**6.4**
											4.0	8.6	10.6	22	**6.4**
											5.0	8.6	10.6	22	**6.4**
											6.0	8.6	10.5	22	**6.4**
											7.0	8.6	10.5	22	**6.4**
											7.5	8.6	10.5	22	**6.4**
											8.0	8.7	10.5	22	**6.4**
											8.25	8.7	10.5	22	**6.4**
											8.5	8.7	10.5	22	**6.4**
	JSL4-004-F13	7-Sep-13	5	75-100	-	none	south east	moderate	-	8.3	0.2	8.6	10.6	22	**6.5**
											1.0	8.7	10.6	22	**6.4**
											2.0	8.7	10.6	22	**6.4**
											3.0	8.7	10.6	22	**6.4**
											4.0	8.7	10.6	22	**6.4**
											5.0	8.7	10.5	22	**6.4**
											6.0	8.7	10.5	22	**6.4**
											7.0	8.7	10.5	22	**6.4**
											7.5	8.7	10.5	22	**6.4**
											7.75	8.7	10.5	22	**6.4**
											8.0	8.7	10.5	22	**6.4**
											8.25	8.7	10.5	22	**6.5**
	JSL4-005-F13	7-Sep-13	5	75-100	-	none	south east	moderate	4.9	8.9	0.2	8.6	10.6	22	**6.5**
											1.0	8.6	10.6	22	**6.5**
											2.0	8.6	10.6	22	**6.5**
											3.0	8.6	10.6	22	**6.5**
											4.0	8.7	10.6	22	**6.4**
											5.0	8.6	10.6	22	**6.5**
											6.0	8.7	10.6	22	**6.5**

Table 5 Supporting Environmental Variables and Limnology Data for Lakes in the Kiggavik Project Area, Fall 2013

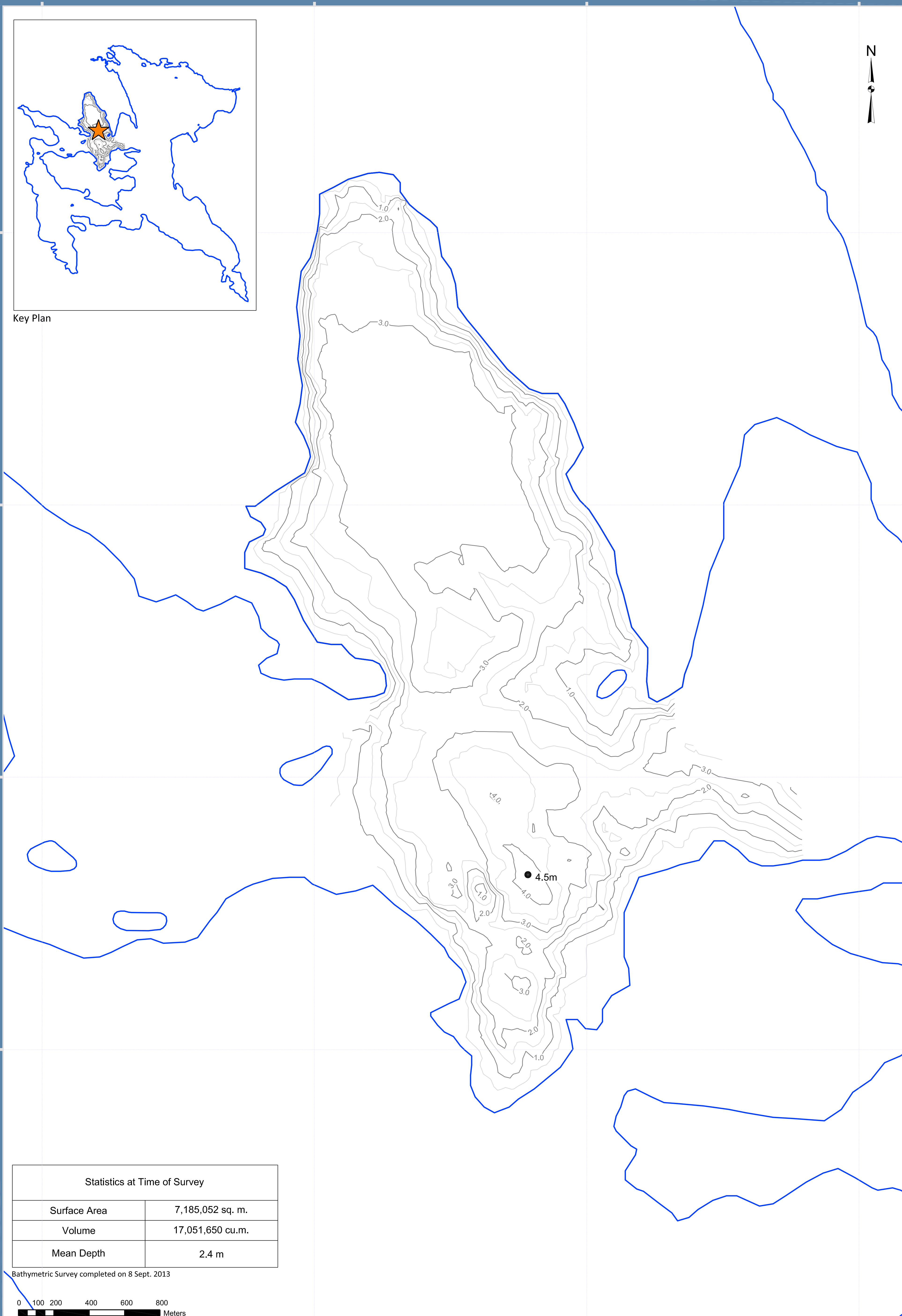
											7.0	8.7	10.5	22	**6.5**
											8.0	8.7	10.5	22	**6.5**
											8.25	8.7	10.5	22	**6.5**

Sub-Basin and Waterbody	Station Code[a]	Date	Air Temperature (°C)	Cloud Cover (%)	Precip Rate	Precip Type	Wind Direction	Wind Rate	Secchi Depth (m)	Maximum Depth (m)	Profile Depth (m)	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (µS/cm)	pH
Judge Sissons Lake	JSL4-005-F13	7-Sep-13	5	75-100	-	none	south east	moderate	4.9	8.9	8.5	8.7	10.5	22	**6.5**
											8.75	8.7	10.5	22	**6.5**
	JSL8-001-F13	4-Sep-13	4	75-100	-	none	south	light	4.0	4.0	0.2	7.4	11.6	21	6.7
											1.0	7.4	11.6	21	6.7
											2.0	7.4	11.6	21	6.7
											3.0	7.2	11.7	21	6.7
											3.5	6.9	11.6	21	6.7
											3.75	7.0	11.7	21	6.7
	JSL8-002-F13	4-Sep-13	5	75-100	-	none	south	moderate	4.1	4.1	0.2	7.5	11.7	21	6.7
											1.0	7.5	11.6	21	6.7
											2.0	7.6	11.6	21	6.6
											3.0	7.6	11.6	21	6.7
											3.5	7.6	11.6	21	6.7
											3.75	7.6	11.6	21	6.7
											4.0	7.6	11.3	21	6.8
	JSL8-003-F13	5-Sep-13	6	75-100	-	none	south east	moderate	4.3	4.3	0.2	7.2	11.7	21	6.9
											1.0	7.1	11.7	21	6.9
											2.0	7.1	11.7	21	6.9
											3.0	7.1	11.7	21	6.8
											4.0	7.1	11.7	21	6.8
											4.25	7.2	11.0	22	6.9
	JSL8-004-F13	5-Sep-13	7	75-100	-	none	south west	moderate	4.4	4.4	0.2	7.1	11.8	21	6.7
											1.0	7.1	11.8	21	6.7
											2.0	7.1	11.8	21	6.7
											3.0	7.1	11.8	21	6.7
											4.0	7.1	11.8	21	6.7
											4.25	7.1	11.7	21	6.7
	JSL8-005-F13	5-Sep-13	7	75-100	-	none	north	heavy	4.1	4.1	0.2	7.5	11.7	21	6.7
											1.0	7.5	11.7	21	6.7
											2.0	7.5	11.7	21	6.7
											3.0	7.5	11.7	21	6.7
											3.5	7.5	11.7	21	6.7
											3.75	7.5	11.5	21	6.7
Squiggly Lake	SQL-001-F13	6-Sep-13	4	75-100	light	rain	north	light	4.5	7.1	0.2	7.9	11.1	14	**6.4**
											1.0	7.9	11.4	14	**6.4**
											2.0	7.9	11.4	14	**6.4**
											3.0	7.9	11.3	14	**6.4**
											4.0	7.9	11.3	14	**6.4**
											5.0	7.9	11.3	14	**6.4**
											6.0	7.9	11.3	14	**6.3**
											6.5	7.9	11.3	14	**6.3**
											7.0	7.9	11.2	14	**6.3**
	SQL-002-F13	6-Sep-13	4	75-100	light	rain	north west	moderate	-	7.0	0.2	7.8	11.4	14	**6.3**
											1.0	7.8	11.4	14	**6.3**
											2.0	7.8	11.4	14	**6.3**
											3.0	7.8	11.4	14	**6.3**
											4.0	7.8	11.4	14	**6.3**
											5.0	7.8	11.4	14	**6.3**
											6.0	7.8	11.4	14	**6.3**

Table 5 Supporting Environmental Variables and Limnology Data for Lakes in the Kiggavik Project Area, Fall 2013

											6.5	7.8	11.4	14	**6.3**
											6.75	7.9	11.4	14	**6.3**
											7.0	7.9	11.4	14	**6.3**
Sub-Basin and Waterbody	**Station Code[a]**	**Date**	**Air Temperature (°C)**	**Cloud Cover (%)**	**Precip Rate**	**Precip Type**	**Wind Direction**	**Wind Rate**	**Secchi Depth (m)**	**Maximum Depth (m)**	**Profile Depth (m)**	**Water Temperature (°C)**	**Dissolved Oxygen (mg/L)**	**Specific Conductivity (µS/cm)**	**pH**
Squiggly Lake	SQL-003-F13	6-Sep-13	4	75-100	moderate	rain	north	moderate	4.1	8.0	0.2	7.8	11.5	14	**6.3**
											1.0	7.8	11.5	14	**6.3**
											2.0	7.8	11.5	14	**6.3**
											3.0	7.8	11.5	14	**6.3**
											4.0	7.8	11.5	14	**6.3**
	SQL-003-F13	6-Sep-13	4	75-100	moderate	rain	north	moderate	4.1	8.0	5.0	7.9	11.5	14	**6.3**
											6.0	7.9	11.4	14	**6.3**
											7.0	7.9	11.4	14	**6.3**
											7.25	7.9	11.4	14	**6.3**
											7.5	7.9	11.4	14	**6.3**
											7.75	7.9	11.4	14	**6.3**
	SQL-004-F13	6-Sep-13	5	75-100	-	none	north	heavy	4.1	7.1	0.2	7.8	11.5	14	**6.4**
											1.0	7.8	11.5	14	**6.3**
											2.0	7.8	11.5	14	**6.3**
											3.0	7.8	11.5	14	**6.3**
											4.0	7.9	11.5	14	**6.3**
											5.0	7.9	11.5	14	**6.3**
											6.0	7.9	11.5	14	**6.3**
											6.5	7.9	11.4	14	**6.3**
											6.75	7.9	11.4	14	**6.3**
	SQL-005-F13	6-Sep-13	4	75-100	-	none	north	heavy	4.2	7.8	0.2	7.8	11.5	14	**6.4**
											1.0	7.8	11.5	14	**6.3**
											2.0	7.8	11.5	14	**6.3**
											3.0	7.8	11.5	14	**6.3**
											4.0	7.8	11.5	14	**6.3**
											5.0	7.8	11.5	14	**6.3**
											6.0	7.8	11.5	14	**6.4**
											6.5	7.8	11.5	14	**6.4**
											7.0	7.8	11.5	14	**6.4**
											7.25	7.8	11.5	14	**6.3**
											7.5	7.8	11.4	14	**6.3**

Notes: Dissolved oxygen concentrations that were less than the Canadian Water Quality Guidelines (CWQG) of 9.5 mg/L are bolded. pH values that were outside the CWQG of pH 6.5 to 9 are bolded.
[a] = Station Code consisted of three letter waterbody code with a number for the area, replicate number, and season-year.
[b] = pH values measured at this station ranged from 8.35 at the surface to 6.17 at the bottom. These values are not believable comparded to the replicate stations, therefore they were deleted.
°C = degrees Celsius; % = percent; Precip = precipitation; m = metre; mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; JSL = ; SQL = ; Sep = September; - = not colleted or not applicable.



Statistics at Time of Survey	
Surface Area	7,185,052 sq. m.
Volume	17,051,650 cu.m.
Mean Depth	2.4 m

Bathymetric Survey completed on 8 Sept. 2013

Projection: NAD 1983 UTM Zone 14N
Creator: AJL
Date: 16/01/14 Scale: 1:20000
File: KI08C325
Data Sources: BEAK 1990, AREVA 2006, GOLDER 2009, 2013

FIGURE 2
UPDATED BATHYMETRY FOR SELECTED SUB-BASIN OF JUDGE SISSONS LAKE

KIGGAVIK PROJECT - EIS

Golder Associates
AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5

2.3.2.1 Judge Sissons Lake

Surface limnology measurements were collected at 15 stations in three areas in Judge Sissons Lake in fall 2013. Specific conductivity ranged from 21 to 22 µS/cm. Values of pH ranged from 6.4 to 6.9; all measurements collected at JSL4 were equal to or below the CWQG of pH 6.5 to 9. Surface dissolved oxygen (DO) concentrations ranged from 10.5 to 11.8 mg/L, which were above the CWQG of 9.5 mg/L. Surface water temperatures ranged from 7.1 to 10.0 degrees Celsius (°C).

Limnology profiles were taken at all sampling stations. Station depths in Judge Sissons Lake ranged from 7.3 to 8.0 metres (m) for JSL2, from 8.3 to 8.9 m for JSL4, and from 4.0 to 4.4 m for JSL8. Maximum Secchi depth was 6.8 m for JSL2, 6.7 m for JSL4, and 4.4 m for JSL8. Specific conductivity, pH, and water temperature were similar among depths. Specific conductivity ranged from 21 to 22 µS/cm; pH ranged from 6.3 to 6.9. Temperature ranged from 6.9 to 10.1 °C depending on the individual stations; thermal stratification was not observed. Concentrations of DO were above the CWQG of 9.5 mg/L at all depths with the exception of the bottom measurement from three stations which ranged from 1.1 to 9.3 mg/L. The depths at these stations ranged from 7.25 to 8.5 m.

2.3.2.2 Squiggly Lake

Surface limnology measurements were collected at five stations in Squiggly Lake. Specific conductivity was 14 µS/cm. Values of pH ranged from 6.3 to 6.4, which were below the CWQG of pH 6.5 to 9. Surface DO concentrations ranged from 11.1 to 11.5 mg/L, which were above the CWQG of 9.5 mg/L. Surface water temperatures ranged from 7.8 to 7.9 °C.

Limnology profiles were taken at all stations. Station depths in Squiggly Lake ranged from 7.0 to 8.0 m. Maximum Secchi depth was 4.5 m in Squiggly Lake. Specific conductivity, pH, DO, and water temperature were similar among depths. Specific conductivity was 14 µS/cm; pH ranged from 6.3 to 6.4. Dissolved oxygen (DO) ranged from 11.1 to 11.5 mg/L, and temperature ranged from 7.8 to 7.9 °C. Thermal stratification was not observed.

2.4 Benthic Invertebrate Communities

Additional benthic invertebrate sampling was conducted in fall 2013 to expand and complement the existing baseline information in Judge Sissons and Squiggly lakes and to inform future EEM program design. Three sampling areas were established in Judge Sissons Lake and one in Squiggly Lake (Table 1; Figure 1).

2.4.1 Methods

Benthic invertebrate community samples were collected and processed, with minor exceptions, according to methods and QA/QC procedures outlined in Appendix 5C Aquatic Baseline (Sections 7.1.2.1 to 7.1.2.5). The exceptions were as follows: instead of using a 6 inch (") Ekman grab sampler, benthic samples were collected using a 9" Ekman grab sampler (22.86 cm) with an area of 0.0523 square metres (m^2); five replicate stations were sampled for each area. The change in equipment and process was made in order to match benthic sampling methods at other AREVA facilities. As before, replicate stations were selected based on similar water depth and sediment texture to the extent possible. Sampling at each replicate station involved collection of a composite of five field sub-samples as previously done. At one station on each lake, the five sub-samples were analysed separately.

Benthic invertebrate density refers to the total number of organisms/m^2. The relative density quantifies the relative proportion of each family composing the benthic invertebrate community. Lowest level taxonomic richness for each of the sampling sites is based on the number of distinct taxa estimated at the family level. Richness is an indicator of benthic invertebrate diversity, with higher richness values generally being indicative of healthy and balanced invertebrate communities.

Simpson's diversity index (SDI) values are calculated values between 0 and 1 that represent the proportional distributions of organisms in the community. The SDI accounts for the patterns of abundance and taxonomic richness within the community. Communities having more taxa, among which abundance is more equally distributed, will have larger associated SDI values.

Simpson's evenness index (SEI) is a measure of the relative abundance of different benthic invertebrate taxa within a given area. A community that is dominated by one or two species is considered less diverse than a community that contains several different species with similar abundances, and will have a lower SEI. Stressed communities generally have lower SEI values than healthy benthic invertebrate communities.

2.4.2 Results

The benthic invertebrate community information collected during the 2013 field program is presented in Table 6). The habitat characterization was analyzed from the sediment core samples collected under the sediment chemistry section. These results are presented in Table 4.

Table 6 **Summary of Benthic Invertebrate Community Data for Judge Sissons Lake and Squiggly Lake, Fall 2013**

Watershed	Sub-Basin	Waterbody	Station	Total Invertebrate Density (#/m^2)	Lowest Level Taxonomic Richness (# of Taxa)[a]	Simpson's Diversity Index	Simpson's Evenness Index
Aniguq River	Judge Sissons Lake	Judge Sissons Lake	JSL-2	185 to 685	5 to 9	0.47 to 0.59	0.27 to 0.38
			JSL-4	606 to 1,346	6 to 7	0.54 to 0.60	0.31 to 0.41
			JSL-8	1,595 to 19,029	6 to 8	0.20 to 0.34	0.16 to 0.24
Thelon River	Squiggly Lake	Squiggly Lake	SQL	251 to 2,239	4 to 8	0.27 to 0.49	0.21 to 0.38

Note: Values reported represent the range of values
= number, #/m^2 = number of organisms per square metre

[a] Family-level richness

2.4.2.1 Judge Sissons Lake

Total invertebrate densities in Judge Sissons Lake ranged from 185 organisms/m2 at sampling site JSL2 to 19,029 organisms/m2 at JSL8 (Table 6). Chironomids were the dominant taxa (49.3 to 88.9%) in all samples collected from Judge Sissons Lake. The greatest chironomid densities were observed at station JSL8 (80.6 to 88.9% of taxa). Remaining invertebrate taxa identified in the samples from Judge Sissons Lake were represented primarily by Valvatidae (snails) (3.2 to 40.3%) and/or Sphaeridae (clams) (1.9 to 5.8%). Densities of sphaerid clams were similar among samples collected from JSL2 and JSL4, but much higher than the densities measured in samples collected from JSL8.

Taxonomic richness (i.e., the number of taxa) was most variable at station JSL2 (5 to 9 taxa) and least variable at JSL4 (6 to 7 taxa). Taxonomic richness values for fall 2013 were generally lower than those reported for Judge Sissons Lake and other lakes in the Kiggavik Project area, based on the 2007 to 2009 baseline data (Table 7.2-3 in Appendix 5C, Section 7.1.2).

The SDI values for samples collected from stations JSL2 and JSL4 (Table 6) were similar and were likely attributed to the more equal distribution of invertebrate abundance among chironomids, snails, and clams. The lower SDI value associated with station JSL8 was likely representative of the overwhelming abundance (80.6 to 88.9% of taxa) of chironomids in the sample.

2.4.2.2 Squiggly Lake

Total invertebrate densities at the sampling site in Squiggly Lake were between 251 and 2,239 organisms/m2, and are similar to historical data for Squiggly Lake (Table 7.2-1 in Appendix 5C, Section 7.2.1). In fall 2013, chironomids were the dominant taxa (62.3 to 84.3%), followed by sphaerid clams (15.4 to 35.5%). Total invertebrate densities in Squiggly Lake were within the range of densities reported for the three stations in Judge Sissons Lake (Table 6).

Taxonomic richness varied between four to eight taxa. The family level taxa richness value of seven that was reported for Squiggly Lake based on the 1979 to 1991 historical data (Table 7.2-1 in Appendix 5C, Section 7.2.1) falls within this range. Simpson's Diversity Index (SDI) and SEI values for the 2013 sampling in Squiggly Lake were within the range of values reported in Section 2.4.2.1 for Judge Sissons Lake.

3 Collection of Benthic Invertebrate Tissue for Chemical Analysis

3.1 Methods

Initially, benthic invertebrate tissue chemistry samples were collected according to Golder's and AREVA's standard work instructions for sampling techniques and study designs, as well as according to Environment Canada's Metal Mining Technical Guidance for Environmental Effects Monitoring (Environment Canada 2012). Benthic invertebrates were sampled using D-nets and sweeping techniques in the shallower depths along the littoral zones of Judge Sissons Lake. However, this method was modified to adjust to the field conditions encountered, and a second method, manual rock picking with forceps, was added.

The D-netting method was not successful in areas with a prevalence of cobble and boulders (JSL2-west shore and JSL4-south shore) or prevalence of cobble (JSL8). However, the sampling success increased by overturning large cobbles to expose underlying substrate (mixture of sand/gravel and fines) and either lightly "kicking" the substrate into the D-net (JSL2-east shore) or lightly "fanning" the substrate into the D-net using hands and wave action (JSL4-north shore). The second method involved turning over rocks and removing invertebrates either on the rock face or on the underlying substrate with forceps.

The invertebrates collected were rinsed in ambient water and stored in a Ziploc bag. Once at camp, Kim Wipes™ were used to remove some of the water from the surface of the invertebrates. Caddisfly larvae were removed from their tubes. Soft-bodied invertebrates and hard-bodied invertebrates were sorted, weighed, and placed into separate bags. A general list of species or family groups that were collected is provided in Table 2. Note that taxonomic identification or enumeration was not conducted. The sample was double bagged and a waterproof paper label was inserted between the bags. The outer bag was labelled with a waterproof marker with the appropriate information. While on site, samples were placed into site specific jars, frozen, kept in the dark, and shipped in sealed coolers to Golder's Saskatoon office prior to submission to SRC for analysis.

3.2 Laboratory Analysis

Benthic invertebrate tissue chemistry samples were analyzed for the following parameters:

- moisture content;
- metals and metalloids (i.e., aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, strontium, thallium, tin, titanium, uranium, vanadium, zinc); and
- radionuclides (i.e., lead-210, polonium-210, radium-226, thorium-230).

Detection limits were dependent on the quantity of dry weight sample available for analysis. For metals, SRC requested at least 0.5 gram (g) dry weight; so assuming 90% moisture content, 5 g wet weight was requested. The remaining sample was used for analysis of radionuclides; thus, the more sample weight available, the lower the detection limits. All soft-bodied invertebrate samples were analyzed for metals and radionuclides. As there was limited sample available for JSL8 (Table 2), radium-226 and thorium-230 were not measured in that soft-bodied invertebrate sample (Table 7). All hard-bodied invertebrate samples (i.e., snails) were analyzed for metals. To achieve the lowest possible detection limits, all hard-bodied invertebrate samples were combined into one composite sample for the analysis of radionuclides (Table 7).

Table 7 Benthic Invertebrate Tissue Chemistry for Judge Sissons Lake in the Kiggavik Project Area, Fall 2013

Soft-Bodied			Hard-Bodied (Snails)		
JSL2-TIS001B-F13	**JSL4-TIS001A-F13**	**JSL8-TIS001B-F13**	**JSL2-TIS001A-F13**	**JSL4-TIS001B-F13**	**JSL8-TIS001A-F13**
1-Sep-13	**2-Sep-13**	**31-Aug-13**	**1-Sep-13**	**2-Sep-13**	**31-Aug-13**
75.10	85.10	82.49	63.11	68.33	69.89
2900	1100	1200	580	390	280
0.02	<0.02	0.02	<0.02	<0.02	<0.02
1.9	1.4	1.5	3.2	3.7	3.6
82.6	79.0	73.8	274	292	216
0.12	0.078	0.068	0.036	0.031	0.024
4.5	3.0	4.0	1.7	1.5	1.8
0.16	0.26	0.25	0.50	1.0	1.0
7.2	2.1	2.4	1.2	1.0	0.7
2.4	1.3	1.7	1.1	0.91	1.8
11.6	18.7	15.2	50.0	74.2	79.6
5400	2200	2600	1800	1000	1000
1.8	1.8	0.92	0.54	0.98	0.23
320	410	390	190	240	290
0.82	1.1	0.87	0.44	0.54	0.62
6.7	6.0	4.1	2.9	3.1	4.3
0.41	0.52	0.71	0.64	0.91	0.80
0.045	0.065	0.10	0.30	0.56	0.50
20	16	9.8	240	270	240
0.03	0.04	0.03	0.04	0.06	0.08
0.10	0.04	0.05	0.03	0.03	0.01
86	32	36	28	16	9.7
0.34	0.45	0.25	0.28	0.38	0.48
7.3	1.7	2.0	1.2	0.51	0.52
50	59	85	47	93	49
<0.06	0.1	<0.08	<0.04[(a)]		
0.10	0.21	0.20	0.27[(a)]		
<0.02	<0.02	-	0.01[(a)]		
<0.03	<0.04	-	<0.02[(a)]		

3.3 Results

Results from the benthic invertebrate tissue chemistry analysis conducted on the benthic invertebrates collected in Judge Sissons Lake during the 2013 field program is presented in Table 7.

Results from the chemical analysis varied considerably among the stations for the soft-bodied invertebrates (i.e., aquatic worms, caddisfly larva, crane fly larva, diving beetle, mayfly nymph, stonefly nymph) for moisture, aluminum, iron, manganese, strontium, titanium, and zinc. There was high variability in metals concentrations in both soft- and hard-bodied invertebrate samples (Table 7). Non-detect values were obtained only for antimony in some samples (n=4; 3 snails, 1 soft-bodied invertebrate).

Polonium-210 was detected in all samples; otherwise, non-detect values or values close to the detection limit were observed for lead-210, radium-226 and thorium-230).

4 Collection of Detailed Aquatic Habitat Information

Additional field studies were conducted in fall 2013 to quantify the amount and types of fish habitat that may be altered, disrupted, or destroyed as a result of the construction and operation of the proposed water pipeline with associated water intakes (Mushroom and Siamese lakes), and with treated effluent pipeline and diffusers (two locations in Judge Sissons Lake).

4.1 Methods

Fish habitat information was collected using a modification of the habitat mapping protocols outlined in the Golder's Aquatic Technical Procedure 8.19-0: Lake Habitat Mapping (unpublished file information). The habitat mapping was based on grid sampling that extended from the shoreline to past the proposed intake/diffuser location; the in-water assessed area was wider near the shoreline, particularly where the most substrate disturbance is expected due to pipeline excavation and installation, and narrower near the proposed intake and diffuser structures.

Characteristics, such as location, water depth, sediment texture, and presence of submerged vegetation were identified at each selected grid point using a global positioning system, a weighted line, an Ekman dredge sampler, and an underwater camera, respectively. An underwater viewing tube was also used in shallow areas to assess sediment texture (mainly in areas with coarse substrate like cobble and boulder), and to assess the presence of submerged vegetation. Underwater photos were taken within the assessed areas; habitat information was recorded in the field book.

Upon return to the office, the geo-referenced field information was used to develop detailed habitat maps of the areas of interest. The depth contours were established based on the field information collected, and substrate groupings were identified. This information was then transferred to a computer-aided design system to generate a habitat map.

Additional bathymetry mapping of a section of Judge Sissons Lake (Figure 2) was completed in accordance with methods and QA/QC procedures outlined in Appendix 5C Aquatics Baseline (Sections 10.1.2 to 10.1.5).

4.2 Results

Detailed bathymetry and aquatic habitat information collected in 2013 is presented in Table 8.
Habitat maps are presented in Figures 3, 4, 5, and 6.

Table 8 Locations of Stations Sampled for Bathymetry and Habitat Mapping for Lakes in the Kiggavik Project Area, Fall 2013

Treated Effluent Pipeline and Diffuser	Waypoint	Position (NAD 83, Zone 14)		Bathymetric Depth (m)	Aquatic Vegetation	Substrate[a]	Comments	Aqua-Vu Camera		Other Cameras (Photo ID Number)
		Easting	Northing					Video ID Number	Photo ID Number	
Mushroom Lake proposed water intake	193	553951	7137027	-	-	-	tundra on land	-	-	-
	194	553950	7137041	-	-	-	tundra on land	-	-	-
	195	553952	7137041	0	no	pattern: Sa/Co/Bo - Co/Gr/Bo - Sa/Co/Bo	water edge	-	-	-
	196	553956	7137051	-	no	pattern: Bo/Co - Gr/Co/Sa - Bo	algae	-	-	-
	197	553958	7137064	-	no	pattern: Bo/Co - Gr/Co/Sa - Bo	algae	-	-	-
	198	553933	7137042	-	-	-	tundra on land	-	-	-
	199	553935	7137043	0	no	Sa/Co	water edge	-	-	J421-J422
	200	553935	7137055	-	no	pattern: Bo - Gr/Co/Sa - Bo	-	-	-	-
	201	553934	7137073	-	no	pattern: Bo - Gr/Co/Sa - Sa/Bo - Bo	-	-	-	-
	202	553913	7137044	0	no	Co/Gr	water edge	-	-	J398-J399, J424
	203	553857	7137072	0.55	no	pattern: Bo - Sa/Bo - Bo	-	-	-	J390-J391
	204	553876	7137061	0.30	no	pattern: Gr/Co/Sa - Bo - Sa/Gr/Co - Bo	-	-	-	-
	205	553896	7137054	0.15	no	pattern: Bo - Co/Gr/Sa - Bo/Sa	-	-	-	J395-J397
	206	553917	7137042	-	-	-	tundra on land; substrate out of water: Gr/Sa/Co	-	-	-
	207	553974	7137065	0.25	no	pattern: Bo - Gr/Co/Sa/Or - Bo/Co	-	-	-	J400-J402
	208	553992	7137053	0.29	no	pattern: Bo - Gr/Sa/Co - Bo	-	-	-	-
	209	554015	7137048	0.60	no	pattern: Bo - Gr/Co/Sa	-	-	-	J403-J405
	210	554031	7137037	0.28	no	pattern: Bo - Co/Gr - Bo	-	-	-	-
	211	554047	7137026	0.29	no	pattern: Bo - Gr/Sa/Co - Bo/Sa	-	-	-	J406-J407
	212	554035	7137001	0	no	Si/Sa	water edge	-	-	J408-J409
	213	554023	7137008	0	no	Sa/Gr/Si	water edge	-	-	J410
	214	554008	7137023	0	SM	-	water edge	-	-	J411-J412
	215	553988	7137034	0	no	Sa/Gr/Si	water edge	-	-	J413
	216	553969	7137041	0	no	Co/Gr/Sa	water edge	-	-	J414
	217	553955	7137048	0	no	Co/Gr/Sa/Bo	water edge	-	-	J415-J417
	218	553959	7137073	0.47	no	Sa/Gr	-	-	-	J418-J420
	219	553892	7137040	0	no	Gr/Co/Sa	water edge	-	-	J425
	220	553874	7137040	0	no	Co/Bo/Gr/Sa	water edge	-	-	J426
	221	553852	7137032	0.20	no	Or	-	-	-	J428
	222	553852	7137027	0	-	-	water edge	-	-	-
	223	553867	7137135	1.2	no	Si/Bo/Co	-	-	-	-
	224	553897	7137112	0.9	no	pattern: Bo - Si/Co	-	-	-	-
	225	553910	7137091	1.0	no	pattern: Bo - Co/Bo	-	-	-	-
	226	553919	7137098	1.1	sparse SM	pattern: Sa - Co/Sa/Gr	-	-	-	-
	227	553946	7137086	0.25	sparse SM	Gr/Sa/Co	-	-	-	-
	228	553881	7137173	3.1	sparse SM	Si/Sa	-	-	-	-
	229	553913	7137164	2.2	no	Si/Sa/Gr	-	-	-	-
	230	553936	7137146	1.8	no	Sa/Co/Bo	-	-	-	-
	231	553955	7137140	1.3	no	Bo/Co	-	-	-	J430
	232	553975	7137122	1.1	sparse SM	pattern: Gr/Sa - Co/Bo	-	V3	P1-P2	J431-J432
	233	553992	7137118	1.1	no	Bo/Co	-	-	-	J433
	234	554010	7137109	1.0	sparse-moderate SM	Sa/Si/Co	-	-	-	J435
	235	554025	7137097	1.0	sparse-moderate SM	Sa/Si/Co	-	-	-	J440
	236	554045	7137085	1.0	no	Bo/Co/Si	-	-	-	J441
	237	554055	7137074	1.0	no	Bo/Co/Si	-	-	-	J442
	238	553982	7137174	4.3	sparse SM	Or/Si/Sa	-	V5	P4	J443-J444
	239	553961	7137169	2.8	no	Sa/Si	-	-	-	J445
	240	553941	7137190	4.3	no	Or/Sa/Si	-	-	-	J446

	241	553945	7137203	5.4	no	Or/Si/Sa	-	-	-	J447
	242	553957	7137192	4.6	no	Or/Si/Sa	-	-	-	J448
	243	553982	7137184	4.7	no	Or/Si/Sa	-	V7	P6	J449-J450
	244	554003	7137173	4.3	no	Or/Si/Sa	-	-	-	-
	245	554014	7137157	3.5	no	Or/Si/Sa	-	-	-	-
	246	554025	7137169	4.2	no	Or/Si/Sa	-	-	-	J451
	247	553995	7137156	3.8	no	Or/Si/Sa	-	-	-	J452
	248	554005	7137182	4.9	no	Or/Si/Sa	-	-	-	-
	249	553988	7137203	5.6	no	Or/Si/Sa	-	V10	P8-P9	J453
	250	553968	7137204	5.5	no	Or/Si/Sa	-	-	-	J454
	251	553948	7137212	5.8	no	Or/Si/Sa	-	-	-	J455
	252	553961	7137223	7.0	no	-	depth test	-	-	-
Treated Effluent Pipeline and Diffuser	**Waypoint**	**Position (NAD 83, Zone 14)**		**Bathymetric Depth (m)**	**Aquatic Vegetation**	**Substrate[(a)]**	**Comments**	**Aqua-Vu Camera**		**Other Cameras (Photo ID Number)**
		Easting	**Northing**					**Video ID Number**	**Photo ID Number**	
Siamese Lake proposed water intake	254	574041	7148206	4.7	no	Or/Si/Sa	-	V13	P12	J456
	255	574037	7148188	4.9	sparse SM	Or/Si/Sa/Cl	-	-	-	J457
	256	574039	7148169	5.0	sparse SM	Or/Si/Sa	-	-	-	J458
	257	574062	7148175	5.0	no	Or/Si/Sa	-	-	-	-
	258	574055	7148193	4.9	sparse SM	Or/Si/Sa/Gr	-	-	-	J460
	259	574051	7148212	4.9	no	Or/Si/Sa	-	V15	P14	J461
	260	574055	7148236	5.0	no	Or/Si/Sa/Cl	-	-	-	J462
	261	574055	7148260	4.9	no	Or/Si/Sa	-	-	-	-
	262	574021	7148252	4.7	no	Or/Sa/Cl	-	-	-	J463
	263	574035	7148227	4.8	no	Or/Sa/Cl	-	-	-	J464
	264	574073	7148239	4.9	no	Sa/Cl	-	-	-	-
	265	574129	7148219	5.0	no	Sa/Cl	-	-	-	-
	266	574012	7148164	4.8	no	Or/Si/Sa/Cl	-	-	-	J465
	267	574004	7148187	4.8	no	Or/Si/Sa	-	-	-	-
	268	574012	7148205	4.8	no	Or/Si/Sa	-	V17	P16	-
	269	574005	7148223	4.8	no	Or/Si/Sa	-	-	-	J466
	270	574009	7148234	4.8	no	Sa/Si	-	-	-	-
	271	573963	7148193	4.4	no	Si/Sa	-	V20	P18-P19	J467
	272	573975	7148142	4.4	no	Or/Si/Sa	-	-	-	J468
	273	573960	7148171	4.4	no	Or/Si/Sa/Cl	-	-	-	J469
	274	573959	7148203	4.4	no	Or/Si/Sa	-	V22	P21	J470
	275	573961	7148218	4.5	no	Or/Si/Sa	-	-	-	-
	276	573954	7148236	4.5	no	Or/Si/Sa	-	-	-	-
	277	573867	7148132	3.5	no	Or/Sa/Si/Gr	-	-	-	J471
	278	573859	7148155	3.2	no	Or/Sa/Si	-	-	-	-
	279	573861	7148174	2.8	no	Co/Sa/Gr/Bo	-	V25	P23-P24	-
	280	573857	7148195	2.4	no	Co/Gr/Sa/Bo	-	-	-	J472
	281	573860	7148218	2.6	no	Sa/Gr/Bo	-	-	-	J473
	282	573912	7148183	4.0	no	Or/Si/Sa	-	V27	P26	-
	283	573817	7148171	2.8	no	Co/Bo/Gr/Sa	-	V30	P28-P29	-
	284	573805	7148125	2.5	no	pattern: Sa - Co/Gr	-	-	-	-
	285	573807	7148144	2.4	no	Co/Gr/Sa	-	-	-	J474
	286	573803	7148183	2.6	no	Sa/Gr/Si	-	-	-	-
	287	573801	7148203	2.5	no	Sa/Gr/Co/Bo	-	-	-	J475
	288	573763	7148147	2.2	no	Bo/Co/Sa	-	-	-	J476
	289	573763	7148107	2.2	no	Co/Bo/Gr/Sa	-	-	-	J477
	290	573759	7148130	2.2	no	Sa/Bo/Co/Gr	-	-	-	J478

	291	573756	7148172	2.2	no	Si/Sa/Gr/Co	-	-	-	J479
	292	573758	7148182	2.4	no	Sa/Si	-	-	-	-
	293	573701	7148261	0.20	no	Bo/Co	-	-	-	J480
	294	573703	7148242	0.54	no	Co/Si	-	-	-	J485
	295	573701	7148222	0.35	no	pattern: Bo - Co	-	-	-	J486-J487
	296	573698	7148207	0.40	no	Bo	-	-	-	J488
	297	573707	7148184	0.45	no	Bo	-	-	-	J489
	298	573704	7148143	0.78	no	pattern: Bo - Co/Gr/Bo	-	-	-	J490
	299	573704	7148123	0.74	no	Co/Bo	-	-	-	J491
	300	573708	7148098	1.1	no	Bo	-	-	-	J492
	301	573715	7148084	0.95	sparse SM	Co/Gr/Bo	-	-	-	J493
	302	573715	7148059	0.84	no	Bo	-	-	-	J494
	303	573718	7148047	0.60	no	pattern: Bo - Co/Gr/Sa - Bo	-	-	-	J495
	304	573666	7148034	0	no	Bo/Co	water edge	-	-	J499
	305	573664	7148059	0.12	no	pattern: Bo - Gr/Sa	-	-	-	J500
	306	573666	7148072	0.55	no	Bo	-	-	-	J501
	307	573660	7148096	0.30	no	Bo	-	-	-	J502
	308	573662	7148112	0.40	no	Bo/Co	-	-	-	J503
	309	573661	7148132	0.30	no	Co/Bo	-	-	-	J504
	310	573660	7148153	0.10	no	Bo	-	-	-	J505
	311	573660	7148173	-	-	-	tundra on land; Bo at the edge	-	-	J506
	312	573658	7148194	-	-	-	tundra on land	-	-	J507

Treated Effluent Pipeline and Diffuser	**Waypoint**	**Position (NAD 83, Zone 14)**		**Bathymetric Depth (m)**	**Aquatic Vegetation**	**Substrate[(a)]**	**Comments**	**Aqua-Vu Camera**		**Other Cameras (Photo ID Number)**
		Easting	**Northing**					**Video ID Number**	**Photo ID Number**	
Judge Sissons Lake; Site for proposed Kiggavik treated effluent diffuser	JH045	566727	7136597	0.05	no	Co		-	-	shore edge: J529-J532; water: J511-J514
	JH046	566723	7136578	0	no	Co		-	-	J515-J517
	JH047	566719	7136557	0	no	Co		-	-	J518-J520
	JH048	566728	7136617	0.15	no	Co/Gr		-	-	J533-J536
	JH049	566731	7136637	0.20	no	Co/Bo		-	-	J537-J540
	JH050	566735	7136657	0.30	no	Co/Bo		-	-	J541
	JH051	566738	7136677	0.60	no	Bo/Co		-	-	J542
	JH052	566740	7136697	2.4	no	Co/Gr		-	-	-
	JH003	567242	7136516	5.5	no	Sa/Gr	-	V3	P4-P6	-
	JH053	567227	7136541	5.4	no	Sa		-	-	J543
	JH004	567221	7136503	5.2	no	Sa/Si	-	-	-	J544
	JH005	567245	7136469	5.5	no	Sa	-	-	-	J545
	JH006	567214	7136484	5.0	no	Sa	-	-	-	J546
	JH007	567215	7136473	5.0	no	Sa	-	-	-	J547
	JH008	567227	7136523	4.5	no	Sa	-	-	-	J548
	JH009	567199	7136494	5.5	no	Sa	-	-	-	J549
	JH010	567158	7136526	5.6	no	Sa/Si	-	V7	P8-P12	-
	JH011	566784	7136686	2.6	no	Sa/Gr	-	-	-	-
	JH012	566782	7136631	2.4	no	Bo/Co/Gr/Sa	-	-	-	J551-J552
	JH013	566779	7136606	2.6	no	Sa/Gr/Co	-	-	-	J553
	JH014	566776	7136563	1.2	no	Co	-	-	-	J554
	JH015	566770	7136552	1.1	no	Co/Gr	-	-	-	J555
	JH016	566768	7136527	1.8	no	Gr/Co/Bo	-	-	-	J556
	JH017	566762	7136515	1.7	no	Co/Gr	-	-	-	J557-J558
	JH018	566766	7136486	2.1	no	Co/Gr/Sa	-	-	-	J559
	JH019	566786	7136591	3.0	no	Sa/Gr	-	V15-V16	P13-P14, P17	-
	JH020	566839	7136571	3.3	no	Gr/Sa	-	-	P18	-
	JH021	566882	7136575	4.2	no	Sa/Gr	-	V20	P19, P21-P22	-
	JH022	566933	7136564	4.9	no	Sa/Gr/Si	-	V25	P23-P24	-

	JH023	566983	7136545	5.2	no	Sa/Gr/Si	-	V26	P27-P28	-
	JH024	567032	7136549	5.4	no	Sa/Si	-	V29-V30	P31	-
	JH025	567072	7136535	5.6	sparse SM	Sa/Si	-	V34	P32-P33	-
	JH026	567128	7136531	5.9	no	Sa/Si	-	V37	P38-P39	-
	JH027	567123	7136543	5.5	no	Sa	-	-	-	J561
	JH028	567129	7136561	5.2	no	Sa/Gr	-	-	-	J562
	JH029	567117	7136499	5.7	no	Sa/Si/Or	-	-	-	J563
	JH030	567115	7136471	5.2	no	Sa/Si/Or	-	-	-	J564
	JH031	567026	7136502	5.0	no	Sa/Si/Or	-	-	-	J567
	JH032	567018	7136519	5.1	no	Sa/Si/Or	-	-	-	J568
	JH033	567024	7136560	5.4	no	Sa/Si/Or	-	-	-	J569
	JH034	567031	7136583	5.1	no	Sa/Si/Or	-	-	-	J570-J571
	JH035	566912	7136513	4.8	no	Sa/Si/Or	-	-	-	J572
	JH036	566928	7136540	4.9	no	Sa/Si/Or	-	-	-	J573
	JH037	566927	7136572	4.8	no	Sa/Gr/Or	-	-	-	J574
	JH054	566927	7136598	4.3	no	Sa/Gr	-	-	-	J575
	JH038	566828	7136530	3.1	no	Sa/Gr/Co	-	-	-	-
	JH039	566822	7136556	3.0	no	Sa/Gr	-	-	-	-
	JH040	566833	7136601	3.5	no	Sa/Gr	-	-	-	-
	JH041	566828	7136617	3.6	no	Sa/Gr/Co	-	-	-	-
	JH042	566717	7136508	1.2	no	Gr/Co/Bo	-	-	-	J579
	JH043	566713	7136526	1.1	no	Gr/Sa/Co/Bo	-	-	-	J580
	JH044	566720	7136543	1.0	no	Gr/Sa/Co/Bo	-	-	-	J581
Judge Sissons Lake; Site for proposed Sissons treated effluent diffuser	3	564589	7131634	-	-	Bo/Co	tundra on land, bare in water	-	-	F2-F4
	4	564601	7131653	-	-	-	tundra on land	-	-	F5-F8
	5	564641	7131632	0	no	Bo/Co/Or/Si	water edge, bare, algae	-	-	F9-F12
	6	564602	7131676	-	-	-	tundra on land	-	-	F13-F15
	7	564606	7131689	-	-	-	tundra on land	-	-	F16-F17
	8	564610	7131713	-	-	-	tundra on land	-	-	F18-F19
	9	564615	7131731	-	-	-	tundra on land	-	-	F20-F23

Treated Effluent Pipeline and Diffuser	Waypoint	Position (NAD 83, Zone 14)		Bathymetric Depth (m)	Aquatic Vegetation	Substrate[a]	Comments	Aqua-Vu Camera		Other Cameras (Photo ID Number)
		Easting	Northing					Video ID Number	Photo ID Number	
Judge Sissons Lake; Site for proposed Sissons treated effluent diffuser	10	564652	7131700	-	-	-	tundra on land	-	-	F24-F25
	11	564687	7131668	-	-	-	tundra on land	-	-	F26-F27
	12	564697	7131640	-	-	Bo/Co/Gr/Or/Si	algae	-	-	F28-F29
	14	564584	7131612	0.3	no	Bo/Co	algae	-	-	F32
	15	564579	7131598	0.6	sparse SM	Bo/Si	-	-	-	J331-J332
	16	564576	7131573	0.8	sparse SM	Bo/Co/Si	-	-	-	J335-J336
	17	564632	7131606	0.5	no	Co/Bo/Si	algae, bare	-	-	J337
	18	564626	7131589	0.8	no	Co/Bo/Si	algae, bare	-	-	J338
	19	564623	7131561	1.3	sparse SM	Co/Bo/Si	algae	-	-	J339-J340
	20	564619	7131539	1.2	sparse SM	Co/Gr/Bo	algae	-	-	J341-J343
	21	564675	7131494	2.0	no	Si/Bo	algae, bare	-	-	J344
	22	564687	7131519	2.0	sparse SM	Sa/Cl	-	-	P6	J345
	23	564702	7131541	1.9	sparse SM	Sa/Cl	-	-	-	J346
	24	564730	7131572	2.2	sparse SM	Sa/Cl	-	V8	P7	J347
	25	564679	7131593	1.6	no	Co/Bo	algae	V10	P9	J348
	26	564686	7131569	1.7	sparse SM	Bo/Co	algae	-	-	J349
	27	564654	7131561	1.6	sparse SM	Co/Bo/Si	algae	-	-	J350
	28	564662	7131532	2.0	sparse SM	Sa/Cl	-	-	-	J351
	29	564660	7131513	1.8	sparse-moderate SM	Co/Bo/Sa	-	-	-	J352
	30	564735	7131462	2.3	no	Sa/Gr/Co	algae	-	-	-
	31	564782	7131492	2.6	sparse SM	Si/Sa/Or	-	-	-	J353

	32	564711	7131492	2.2	no	Sa/Gr/Cl/Co	-	-	-	-
	33	564735	7131529	2.2	sparse SM	Sa/Cl/Gr	-	-	-	-
	34	564765	7131535	2.5	sparse SM	Si/Sa	-	-	P11-P13	-
	35	564774	7131554	2.6	no	Si/Sa/Cl	-	-	-	J354
	36	564783	7131572	2.7	no	Si/Sa/Cl/Or	-	-	-	-
	37	564794	7131590	2.8	no	Si/Sa/Cl/Or	-	-	-	-
	38	564806	7131606	2.8	no	Si/Sa/Cl/Gr	-	-	-	-
	39	564769	7131626	2.5	no	Sa/Si	-	-	-	-
	40	564760	7131601	2.5	no	Sa/Si/Cl/Gr/Or	-	-	-	-
	41	564740	7131595	2.3	no	Sa/Si/Cl/Gr	-	-	-	-
	42	564739	7131570	2.3	sparse SM	Sa/Gr	-	-	-	-
	43	564692	7131612	1.5	no	Sa/Gr/Si/Bo	algae	-	-	J355
	44	564804	7131502	2.7	sparse SM	Sa/Si/Cl/Or	-	V15	P14	-
	45	564819	7131527	2.7	no	Sa/Si/Cl/Or/Gr	-	-	-	-
	46	564822	7131544	2.8	sparse SM	Sa/Si/Cl/Or/Gr	-	-	-	-
	47	564876	7131513	2.8	no	Sa/Si/Cl/Gr	-	-	-	-
	48	564861	7131491	2.7	no	Sa/Gr/Si	-	-	-	-
	49	564835	7131473	2.6	no	Sa/Gr/Si	-	V17	P16	-
	50	564822	7131467	2.5	no	Sa/Gr/Si	-	-	-	J356
	51	564810	7131448	2.2	no	Sa/Gr/Co	-	-	-	-
	52	564867	7131420	2.4	no	Sa/Gr/Bo	-	-	-	-
	53	564867	7131443	2.4	no	Sa/Gr/Co/Bo	-	-	-	-
	54	564891	7131469	2.4	no	Sa/Gr/Co	-	-	-	-
	55	564892	7131444	2.5	no	Sa/Gr/Co/Bo	-	V19	P18	-
	56	564911	7131482	2.5	no	Sa/Gr	-	-	-	-
	57	564978	7131452	2.6	no	Sa/Gr/Co	-	-	-	-
	58	564959	7131436	2.6	no	Sa/Gr/Co/Bo	-	-	-	-
	59	564939	7131425	2.6	no	Sa/Gr/Co	-	-	-	-
	60	564919	7131423	2.5	no	Sa/Gr/Co	-	V21	P20	-
	61	564899	7131398	2.5	no	Sa/Gr/Co	-	-	-	-
	62	564886	7131380	2.5	no	Sa/Gr/Co	-	-	-	-
	63	564963	7131314	3.0	no	Sa/Or	-	-	-	-
	64	564987	7131347	3.0	no	Sa/Gr	-	-	-	-
	65	565006	7131371	0.9	no	Sa/Gr	-	V23	P22	-
	66	565026	7131400	3.0	no	Sa/Or/Gr	-	-	-	-
	67	565020	7131369	3.0	no	Sa/Gr	-	-	-	-
	68	565106	7131305	3.6	sparse SM	Sa/Si	-	V24	-	-
	69	565093	7131295	3.6	sparse SM	Sa/Cl/Or	-	V26	P25	-
	70	565087	7131313	3.6	sparse-moderate SM	Sa/Si/Cl	-	-	-	-
Judge Sissons Lake; Site for proposed Sissons treated effluent diffuser	71	565082	7131295	3.6	moderate SM	Sa/Si/Cl	-	V28	P27	-
	72	565057	7131283	3.5	moderate SM	Sa/Si/Cl	-	-	-	J357
	73	565046	7131272	3.4	moderate SM	Sa/Si/Cl	-	-	-	-
	74	565177	7131242	3.8	sparse SM	Si/Cl	-	-	-	-
	75	565174	7131229	3.8	sparse SM	Cl/Si/Sa	-	V30	P29	-
	76	565167	7131206	3.7	sparse SM	Si/Sa/Cl/Or	-	-	-	-
	82	565304	7131319	4.0	-	-	deepest location observed	-	-	-

[(a)] = Substrate with a pattern has different groups of substrate composition separated by a dash (e.g., Bo - Sa/Bo - Bo).

NAD = North American Datum; m = metre; SM = submergent vegetation; Si = silt; Sa = sand; Gr = gravel; Co = cobble; Bo = boulder; Or = organic material; - = not applicable.

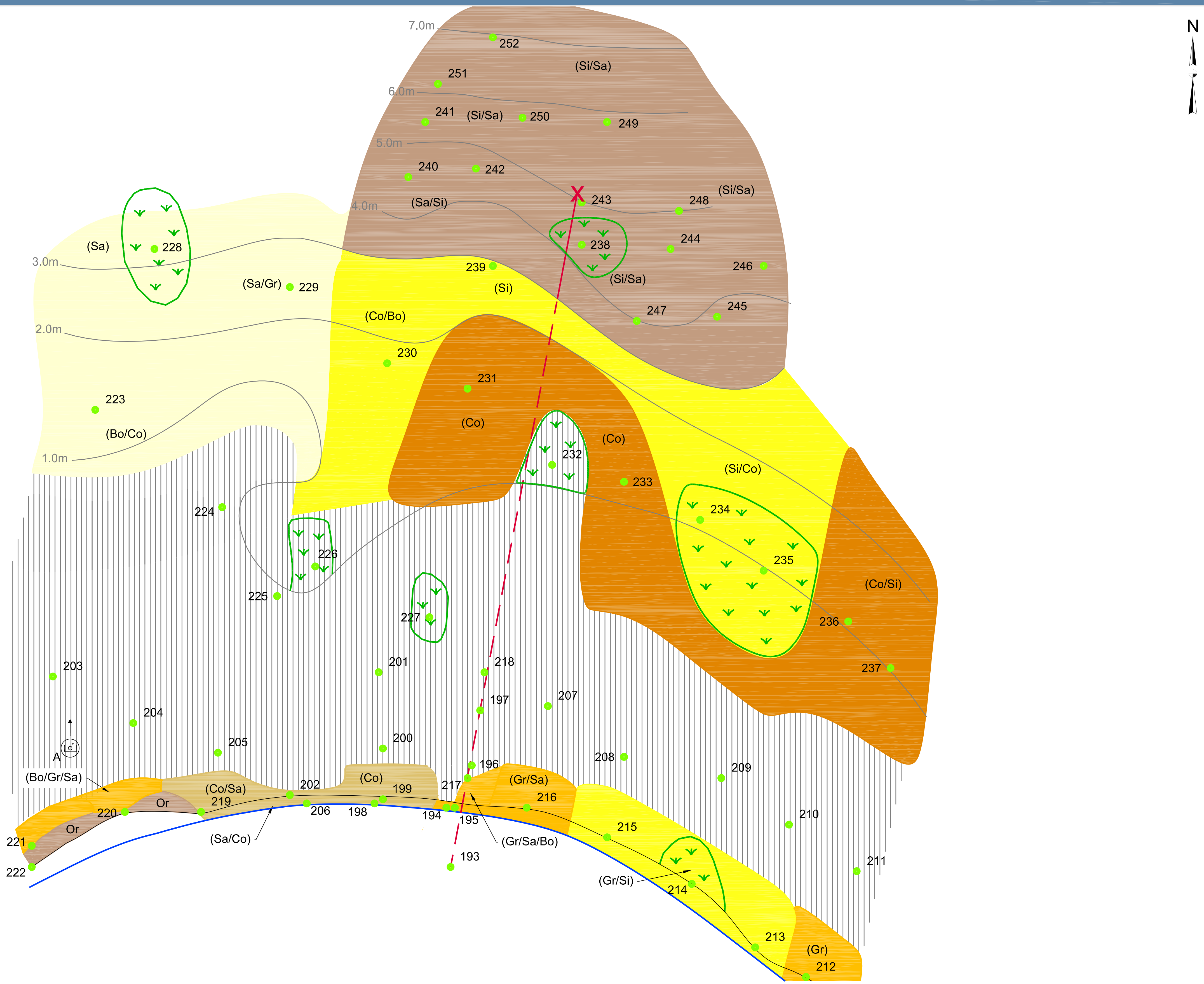


Photo A: Looking North at patterned substrate observed near shore

Patterned substrate: The area from 0.25 m to 1 m water depth had a majority of deeper sections (troughs) with boulders occasionally mixed with cobbles, interspersed with several shallower and narrower sections (crests) with variable substrate patches, either dominated by sand, gravel, or cobble (i.e., sand-gravel, sand-gravel-cobble, sand-cobble-boulder, sand-boulder, gravel-sand, gravel-sand-cobble, gravel-cobble-sand, cobble-sand-gravel, cobble-gravel, and cobble-gravel-sand). These crests started near the shore and extended into water about 0.5 m deep, but occasionally to depths of 1.1 m. The crests exhibited a regular pattern, with crests being two to five metres apart

Projection: NAD 1983 UTM Zone 15N
Creator: BDS/AL
Date: 12/02/14 Scale: 1:1,000
File: KI08C378
Data Sources: 0.5m Ortho Imagery

FIGURE 3

BATHYMETRY AND AQUATIC HABITAT AT PROPOSED MUSHROOM LAKE WATER INTAKE

KIGGAVIK PROJECT - EIS

Golder Associates AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5

Legend

- Bathymetry Contour Line (1 metre Interval)
- Submergent Vegetation
- Waypoint and Number
- Patterned Substrate
- Or - Organic Material
- Cl - Clay
- Si - Silt
- Sa - Sand
- Gr - Gravel
- Co - Cobble
- Bo - Boulder
- ( ) Subdominant Substrates are in Brackets
- Photo Location
- Proposed Water Intake Location
- Proposed Buried Pipeline (0-3m)
- Proposed Above Substrate Pipeline (3m+)

N

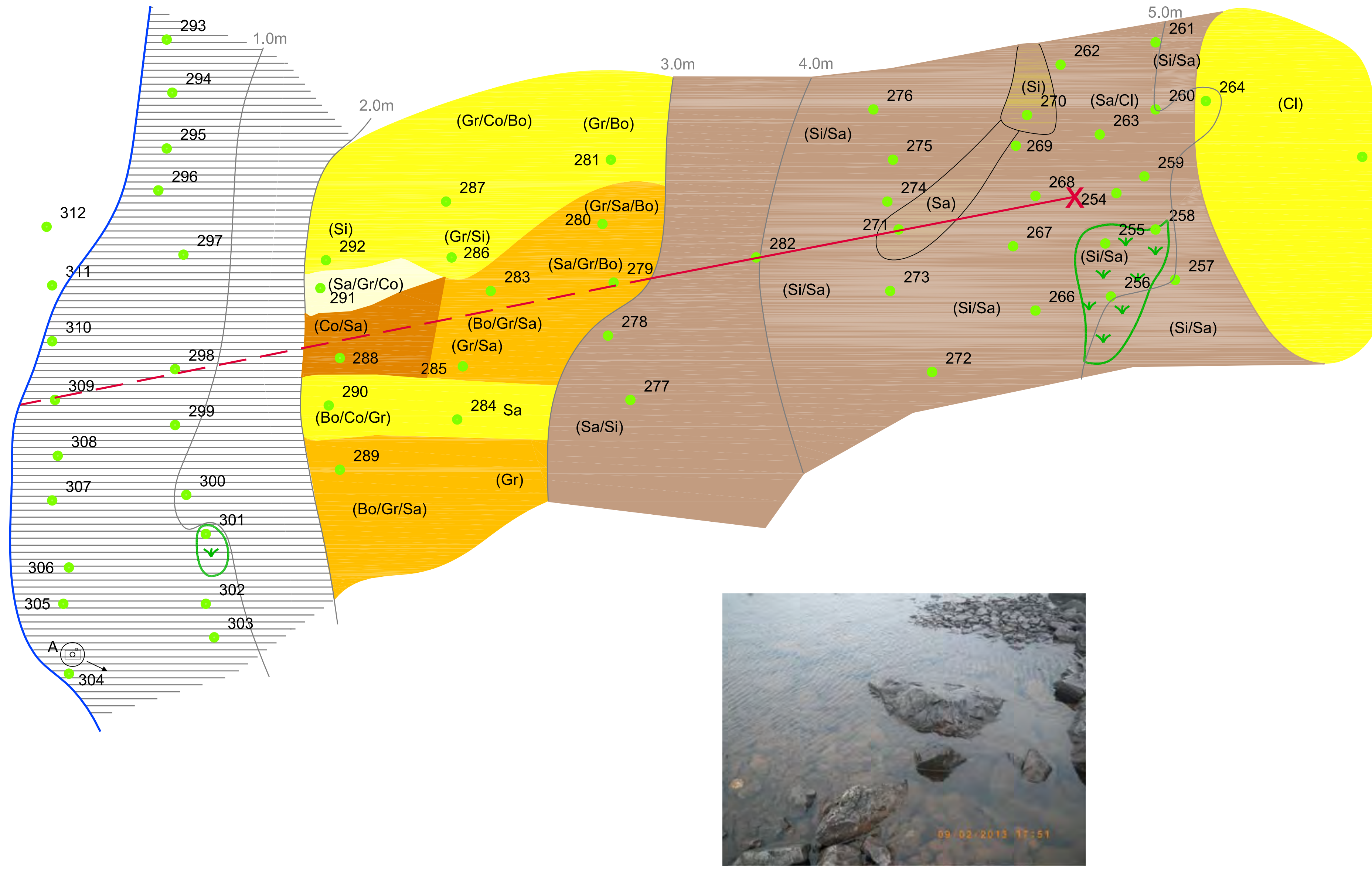


Photo A: looking south at patterned substrate observed near shore

Patterned substrate: The area from the shore to 2 m water depth had a majority of deeper sections (troughs) with boulders occasionally mixed with cobbles, interspersed with some shallower and narrower sections (crests) with variable substrate patches, either dominated by gravel or cobble (i.e., gravel-sand, cobble-silt, cobble-gravel-sand, cobble-gravel-boulder, cobble-boulder). These crests started near the shore and extended into water about 2.0 m deep. The crests exhibited a regular pattern, with crests being three to five metres apart

0 7.5 15 30 45 60 Meters

Projection: NAD 1983 UTM Zone 15N
Creator: BDS/AL
Date: 12/02/14 Scale: 1:2,000
File: KI08C379
Data Sources: *0.5m Ortho Imagery*

FIGURE 4

BATHYMETRY AND AQUATIC HABITAT AT PROPOSED SIAMESE LAKE WATER INTAKE

KIGGAVIK PROJECT - EIS

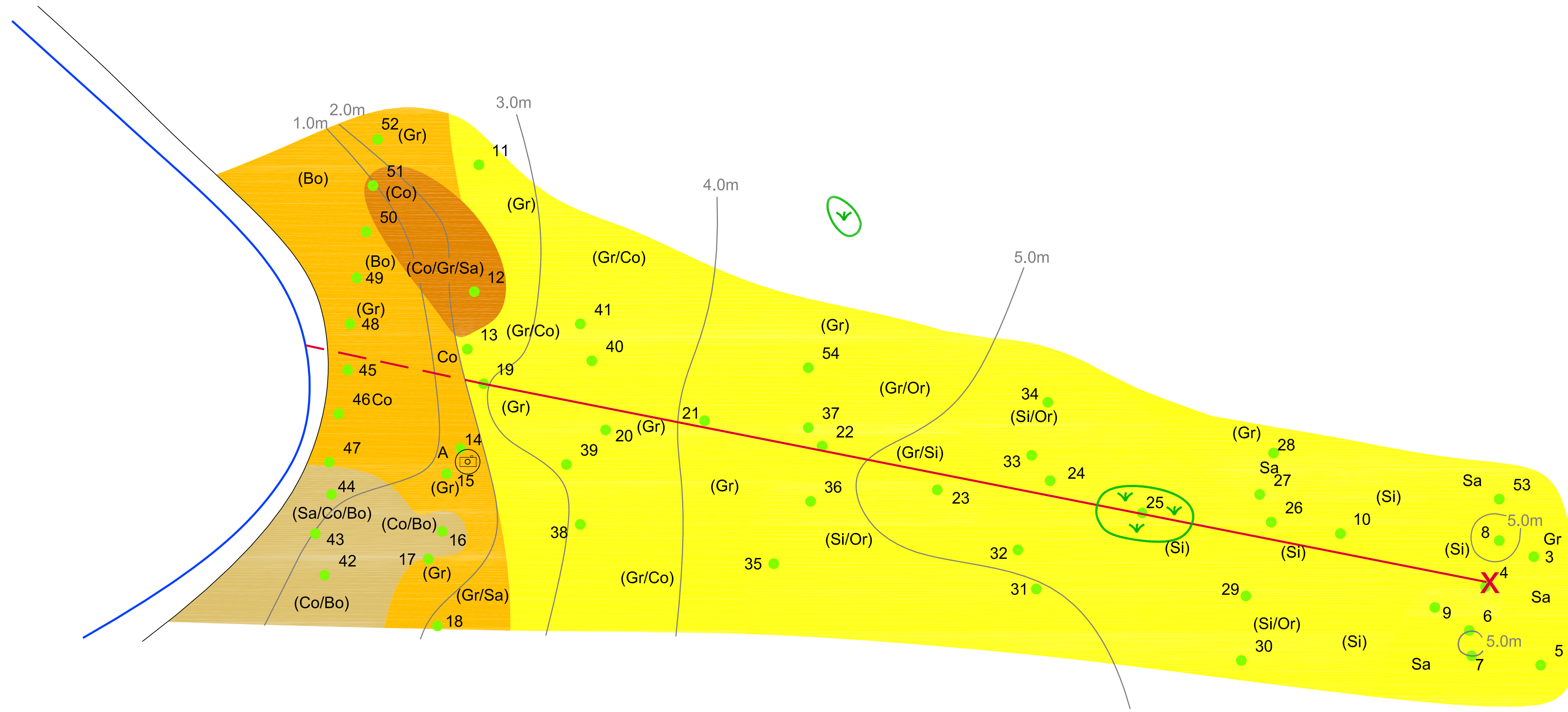
Golder Associates AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5

Legend

- Bathymetry Contour Line (1 metre Interval)
- Submergent Vegetation
- Waypoint and Number
- Patterned Substrate
- Or - Organic Material
- Cl - Clay
- Si - Silt
- Sa - Sand
- Gr - Gravel
- Co - Cobble
- Bo - Boulder
- ( ) Subdominant Substrates are in Brackets
- Photo Location
- Proposed Diffuser Location
- Proposed Buried Pipeline (0-3m)
- Proposed Above Substrate Pipeline (3m+)

N



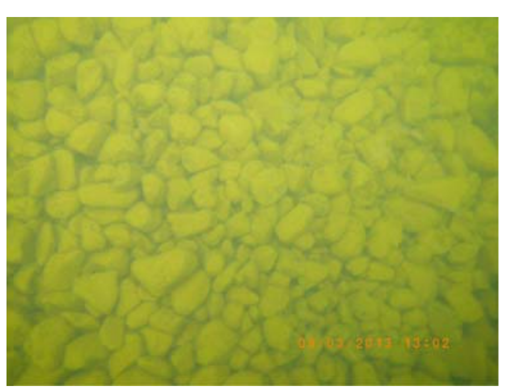


Photo A: cobble substrate in 1.2 m of water

0 7.5 15 30 45 60 Meters

Projection: NAD 1983 UTM Zone 15N
Creator: BDS/AL
Date: 12/02/14 Scale: 1:2,500
File: KI08C380
Data Sources: 0.5m Ortho Imagery

FIGURE 5
BATHYMETRY AND AQUATIC HABITAT AT PROPOSED KIGGAVIK TREATED EFFLUENT DIFFUSER - JUDGE SISSONS LAKE

KIGGAVIK PROJECT - EIS

Golder Associates AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5

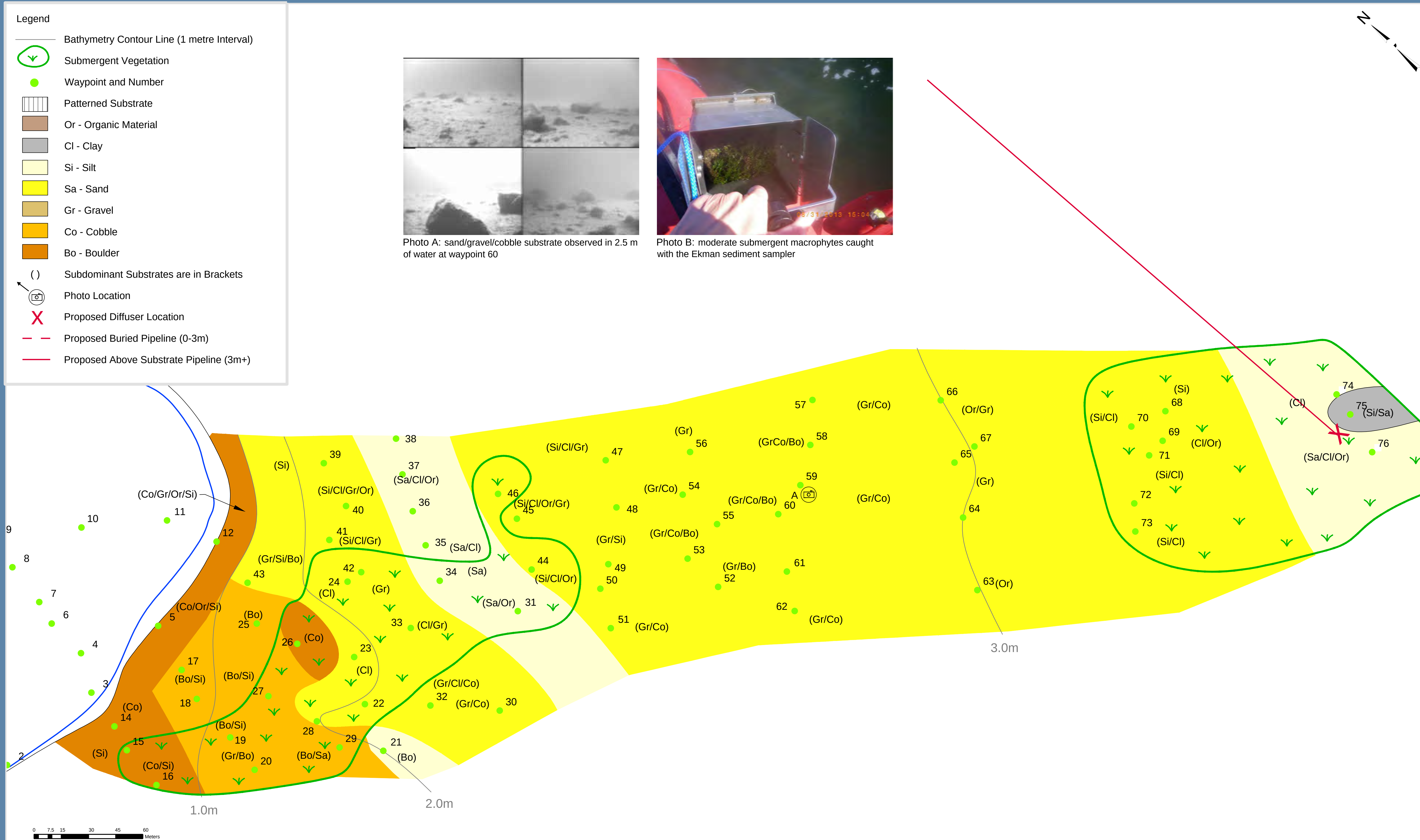


Photo A: sand/gravel/cobble substrate observed in 2.5 m of water at waypoint 60

Photo B: moderate submergent macrophytes caught with the Ekman sediment sampler

Projection: NAD 1983 UTM Zone 15N
Creator: BDS/AL
Date: 12/02/14 Scale: 1:2,000
File: KI08C391
Data Sources: *0.5m Ortho Imagery*

FIGURE 6

BATHYMETRY AND AQUATIC HABITAT AT PROPOSED SISSONS TREATED EFFLUENT DIFFUSER - JUDGE SISSONS LAKE

KIGGAVIK PROJECT - EIS

Golder Associates

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5

4.2.1 Water Intakes

Two water intake structures are proposed for the Project; one located on the south shore of Mushroom Lake will provide water to the Sissons mine site, while the other on the west shore of Siamese Lake will provide water to the Kiggavik mine and mill site.

4.2.1.1 Mushroom Lake

A detailed aquatic habitat and substrate assessment was completed for an area of about 4 hectares (ha) located on the south shore of Mushroom Lake where the proposed water intake is to be installed. The assessed area measured about 200 m by 200 m located immediately adjacent to the shoreline. The maximum depth measured was 7 m, about 200 m off shore. The minimum required water depth for the water intake (5 m) was measured a distance of 160 m from shore (Figure 3).

In general, fine substrate (i.e., organic material, silt, and sand) dominates areas greater than 2 m in depth and the patterns are relatively constant. The littoral area between 1 m and 2 m deep exhibits more variability with some sections dominated by fine substrate and other sections with coarse substrate. However, a substrate gradient appears to be present with coarser substrates generally being found at shallower depths. Coarse substrate (i.e., boulder, cobbles, and gravel) dominates the littoral area shallower than 1 m. A high degree of substrate heterogeneity was observed.

More specifically, the littoral zone from the shore to 0.25 m water depth exhibited variable substrate, including sections with mainly organic material, silt-sand, sand-gravel-silt, sand-cobble-boulder, cobble-gravel-sand, and cobble-boulder-gravel-sand substrates. The area from 0.25 m to 1 m water depth had a majority of deeper sections (troughs) with boulders occasionally mixed with cobbles, interspersed with several shallower and narrower sections (crests) with variable substrate patches, either dominated by sand, gravel, or cobble (i.e., sand-gravel, sand-gravel-cobble, sand-cobble-boulder, sand-boulder, gravel-sand, gravel-sand-cobble, gravel-cobble-sand, cobble-sand-gravel, cobble-gravel, and cobble-gravel-sand). These crests started near the shore and extended roughly perpendicular to shore into water about 0.5 m deep, but occasionally to depths of 1.1 m. The crests exhibited a regular pattern, with crests being 2 to 5 m apart (Photo 4-1).

Macrophytes in the surveyed area were sparse to moderate, but were observed at seven locations in Mushroom Lake:

- near the shoreline on an area of sand-gravel-silt substrate;
- at a depth of 0.25 m in an area of gravel-sand-cobble substrate located within the patterned area;
- at a depth of 1.0 m in an area of sand-silt-cobble substrate;
- at a depth of 1.1 m in an area of sandy substrate and in an area of gravel-sand substrate, both located within the patterned area;

- at a depth of 3.1 m in an area of silt-sand substrate; and
- at a depth of 4.3 m in an area of organic material-silt-sand.

Photo 4-1: Photo of a crest substrate in the trough-crest-trough patterned substrate observed near shore in Mushroom Lake

4.2.1.2 Siamese Lake

A detailed aquatic habitat and substrate assessment was completed for an area of about 9.5 ha located on the west shore of Siamese Lake where the proposed water intake is to be installed. The assessed area measured about 200 m by 475 m adjacent to the shoreline. The maximum depth measured was 5.1 m, about 380 m off shore. The minimum required water depth for the water intake (5 m) was measured a distance of 475 m from shore; another suitable location (equal to or greater than 5 m) was documented 400 m from shore about 20 m south of the current proposed location transect (Figure 4).

In general, fine substrates (i.e., organic material, silt, and sand) dominate areas greater than 3 m in depth. The littoral area between 2 m and 3 m deep exhibits more variability with some sections dominated by fine substrate and other sections with coarse substrate. Coarse substrate (i.e., boulder and cobbles) dominates the littoral area shallower than 2 m. A high degree of substrate heterogeneity was observed.

Similar to Mushroom Lake, the littoral zone from the shore to 2 m water depth had a majority of deeper sections (troughs) with boulders occasionally mixed with cobbles, interspersed with some shallower and narrower sections (crests) with variable substrate patches, either dominated by gravel or cobble (i.e., gravel-sand,

cobble-silt, cobble-gravel-sand, cobble-gravel-boulder, cobble-boulder). These crests started near shore and extended into water about 2.0 m deep. The crests exhibited a regular pattern, with crests being 3 to 5 m apart (Figure 4).

Macrophytes in the surveyed area were sparse, but were observed at two locations:

- at a depth of less than 1 m in an area of cobble-gravel-boulder located within the trough and crest patterned area; and
- at a depth deeper or equal to 5 m in an organic material-silt-sand substrate area.

4.2.2 Treated Effluent Diffusers in Judge Sissons Lake

Two treated effluent pipelines and diffuser structures are proposed for the Project; a treated effluent diffuser located in the main basin of Judge Sissons Lake will originate from the Kiggavik mine and mill site, while the second diffuser located in a smaller, north-central bay of Judge Sissons Lake will handle treated effluent originating from the Sissons mine site.

4.2.2.1 Kiggavik Site

A detailed aquatic habitat and substrate assessment was completed for an area of about 10.5 ha located on the northwest shore of Judge Sissons Lake where the proposed Kiggavik treated effluent diffuser is to be installed. The assessed area measured about 200 m by 525 m adjacent to the shoreline. The maximum depth measured was 5.9 m, about 400 m off shore. The minimum required water depth for the treated effluent diffuser (5 m) was measured a distance of 260 m (5.2 m deep) from shore (Figure 5).

In general, fine substrates (i.e., sand) dominate areas greater than 2.5 m in depth. Coarse substrate (i.e., boulder, cobbles, and gravel) dominates the littoral area shallower than 2.5 m. The littoral zone from the shore to 2.5 m water depth had a majority of cobble in the north portion of the surveyed area occasionally mixed with boulder, gravel, or gravel-sand; a majority of gravel in the south portion of the surveyed area was occasionally mixed with sand-cobble-boulder or cobble-boulder; most boulder substrate were mixed with cobble, and occasionally with gravel-sand.

Macrophytes in the surveyed area were sparse and were observed at one location only, at a depth of 5.6 m in an area of sand-silt.

4.2.2.2 Sissons Site

A detailed aquatic habitat and substrate assessment was completed for an area of about 14.2 ha located on the midwest shore of Judge Sissons Lake where the proposed Sissons treated effluent diffuser is to be installed. The assessed area measured about 200 m by 710 m adjacent to the shoreline. The maximum depth measured was 4.0 m, about 775 m off shore; the maximum depth measured near the proposed transect was 3.8 m, about 710 m off shore. The minimum desired water depth for the treated effluent diffuser (5 m) was not found in line with the proposed transect (Figure 6).

In general, fine substrates (i.e., clay, silt, and sand) dominate areas greater than 2 m in depth. The littoral area between 1 m and 2 m deep exhibits more variability with some sections dominated by fine substrates and other sections with coarse substrates. Coarse substrate (i.e., boulder and cobbles) dominates the littoral area shallower than 1 m. The littoral zone from the shore to 1 m water depth consisted mostly of cobble in the north portion of the surveyed area, occasionally mixed with boulder or boulder-silt; most substrate in the south portion of the surveyed area consisted of boulder mixed with silt, cobble, or cobble-silt. The littoral zone from 1 to 2 m water depth had a majority of sand to the north mixed with clay or gravel-silt; a majority of cobble in the south portion was mixed with gravel-boulder or boulder-silt; and a small patch dominated by boulder with some cobble.

Macrophytes in the surveyed area were sparse to moderate; but were observed at several locations:

- at depths between 0.6 m and 0.8 m in areas of boulder-silt and boulder-cobble-silt substrates;
- at depths between 1.2 and 1.8 m in areas of cobble-gravel-boulder, cobble-boulder-silt,
- cobble-boulder-sand (sparse to moderate), and boulder-cobble;
- at depths between 1.9 m and 2.8 m in areas of silt-sand, silt-sand-organic material, sand-clay, sand-clay-gravel, sand-silt-clay-organic material, sand-silt-clay-organic material-gravel, and sand-gravel; and
- at depths between 3.5 m and 3.8 m in clay-silt-sand, silt-clay, silt-sand-clay-organic material, sand-clay-organic material, sand-silt, sand-silt-clay (sparse to moderate) substrate areas.

Based on the bathymetry data generated in fall 2013, the Sissons treated effluent pipeline may be extended, above the lake substrate, in order to locate the diffuser at 5 m depth. Aquatic habitat and substrate information for this additional in-lake area will be collected before licensing, which is required before any work on the Project, including the installation of pipeline and diffusers, could begin.

5 References

Chapman P.M., W.J. Adams, M.L. Brooks, C.G. Delos, S.N. Luoma, W.A. Maher, H.M. Ohlendorft, T.S. Presser, D.P. Shaw. 2009. Ecological Assessment of Selenium in the Aquatic Environment: Summary of a SETAC Pellston Workshop. Society of Environmental Toxicology and Chemistry (SETAC), Pensacola, FL.

CCME (Canadian Council of Ministers of the Environment). 1999a (with updates to 2014). Canadian Water Quality Guidelines (CWQG) for the Protection of Aquatic Life. In: Canadian Environmental Quality Guidelines, 1999. Canadian Council of Ministers of the Environment, Winnipeg, MB.

CCME. 1999b (with updates to 2014). Canadian Sediment Quality Guidelines (CSQG) for the Protection of Aquatic Life. In: Canadian Environmental Quality Guidelines, 1999. Canadian Council of Ministers of the Environment, Winnipeg, MB.

Environment Canada. 2012. Metal Mining Technical Guidance for Environmental Effects Monitoring. Environment Canada, Ottawa, ON.

Moulding, T., 2011. Email communication outlining the absence of the objective for radium-226 in the 2006 Saskatchewan Surface Water Quality Objectives (SSWQO) revisions, September 1, 2011.

Thompson, P.A., J. Kurias, and S. Mihok. 2005. Derivation and Use of Sediment Quality Guidelines for Ecological Risk Assessment of Metals and Radionuclides Released to the Environment form Uranium Mining and Milling Activities in Canada. In: Environmental Monitoring and Assessment (2005) 110: 71-85.

Water Security Agency. 2006. Surface Water Quality Objectives. Interim Editions, EPB 356. 9 p.