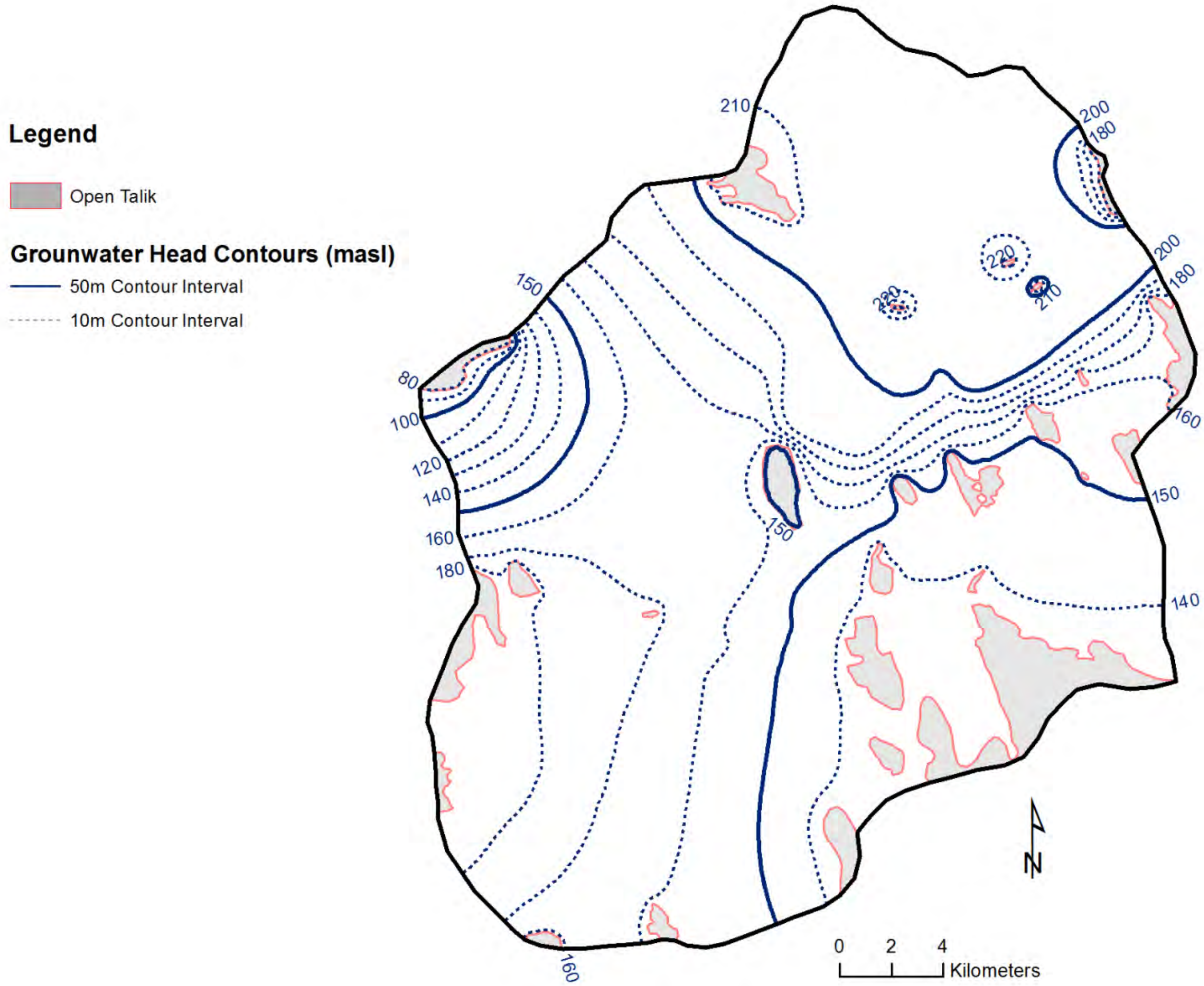

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Aquatic Environment
September 2014

Figure 5.2-6
Calibrated Steady-State Head Distribution

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Based on these results, the groundwater samples are considered to be representative of the formation water because of the high purge volume of the well by natural formation water prior to sampling, the consistency of water quality during development and sampling, and the concentration of sodium in groundwater which is associated with bedrock salinity but present in only trace amounts in the calcium chloride drilling water additive.

The isotopic composition of groundwater is similar to that of arctic precipitation (Clark and Fritz 1997). The isotopic composition of the groundwater may be suggestive of dilution with surface water, for example, through a hydrogeologically conductive fracture system as documented elsewhere (Clark et al. 2000; Frape and Fritz 1987). This could have an attenuating effect on groundwater salinity (the deep groundwater away from the effect of water-conductive fractures may be more saline than measured).

A comparison of the groundwater sample results with Canadian water quality guidelines suggests that iron concentrations in the vicinity of the Bong and Main Zone deposits exceed the Canadian Council of Ministers of the Environment (CCME) water quality guideline of 0.3 mg/L for the protection of aquatic life; radium-226 concentrations exceed the Health Canada guideline of 0.5 Becquerel's per litre (Bq/L) for drinking water quality.

5.2.6 Groundwater Use

Groundwater sources from both the active layer and from the deep groundwater below the permafrost are generally not presently used for drinking water in continuous permafrost regions. This is mainly due to the presence of deep permafrost, the seasonal nature of the active layer, and the availability of good quality drinking water from surface water sources. In addition, it is considered unlikely that groundwater in the Kiggavik Project area will be used as a drinking water source in the near future due to the low hydraulic conductivity of the deep aquifer, groundwater salinity, and the potential for elevated background iron and radium concentrations.

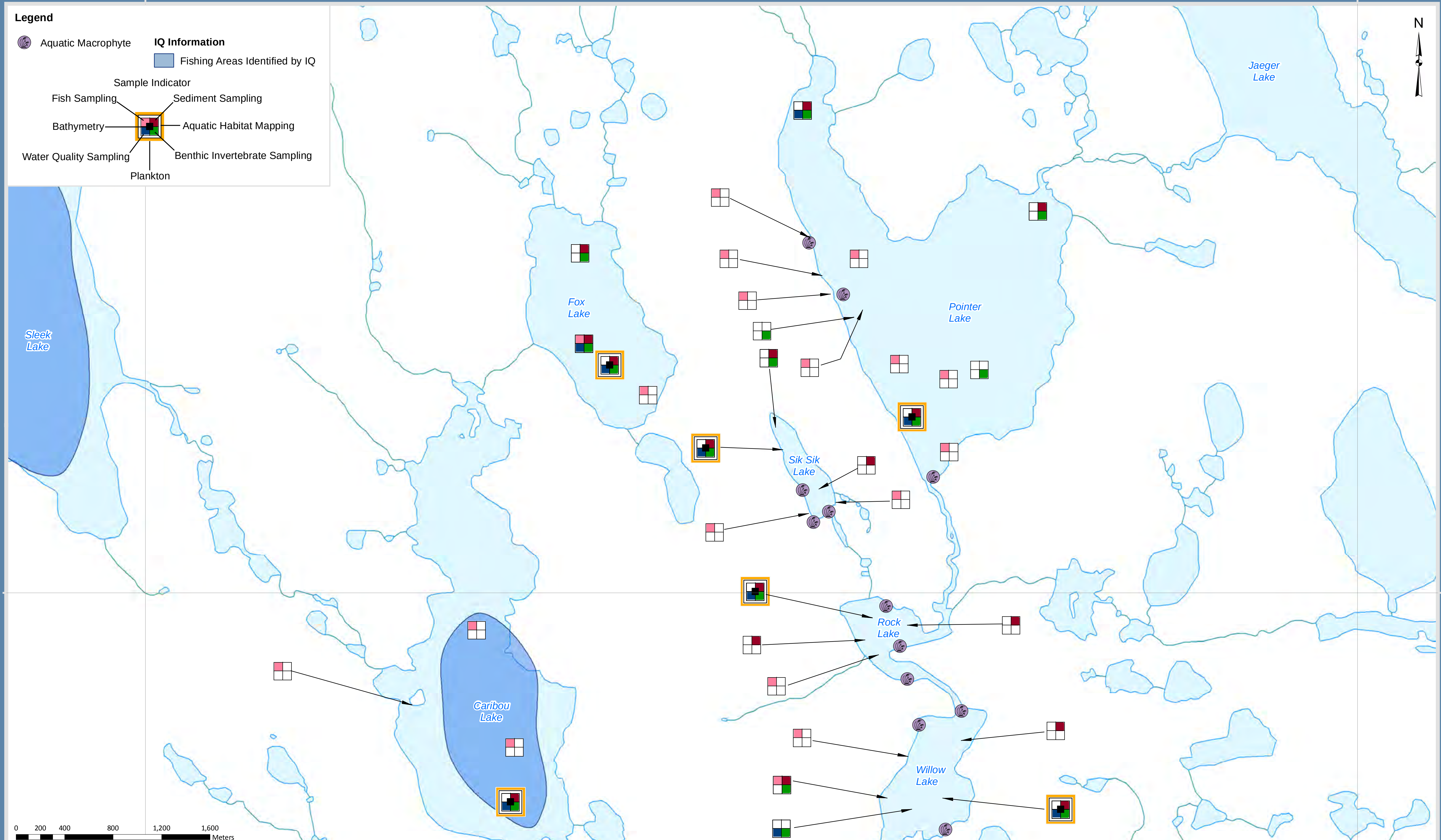
5.3 Surface Water Quality

Surface water quality is influenced by natural environmental conditions (e.g., groundwater quality and quantity, hydrology, and sediment and soil chemistry), as well as by activities related to human development (e.g., road and mine construction and operations, installation of water intakes, stream diversions, effluent discharges, etc.). Changes to surface water quality can affect aquatic and terrestrial organisms, human health, and traditional and non-traditional land use activities (e.g., fishing, trapping, and hunting).

This section presents the historical and current information available on surface water quality within the mine site local study area (LSA) (Table 5.3-1). Baseline surface water quality information is used in conjunction with information on hydrogeology, hydrology, and air quality to determine whether aquatic resources will be directly or indirectly influenced by the Project. Detailed methods and results can be found in Tier 3, Technical Appendix 5C (Section 4.0).

Baseline water quality data were collected from 23 lakes (including Baker Lake) and 21 streams (including the Aniguq River) between fall 2007 and fall 2013 (Figures 5.3-1 parts A to E, 5.3-2 parts A to C, and 5.3-3). A number of lakes and streams were sampled multiple times. The following water quality parameters were measured:

- limnology (i.e., pH, dissolved oxygen [DO], water temperature, and specific conductivity);
- conventional parameters (i.e., pH, specific conductivity, total alkalinity, total hardness, total dissolved solids, total suspended solids, and turbidity);
- nutrients (i.e., total ammonia, ammonia as nitrogen, nitrate, nitrite, total Kjeldahl nitrogen, total nitrogen, total and dissolved phosphorus, total carbon, total inorganic carbon, total organic carbon, and dissolved organic carbon);
- major ions by inductively coupled plasma atomic emission spectroscopy (ICP-AES) scan (i.e., bicarbonate, calcium, carbonate, chloride, fluoride, hydroxide, magnesium, potassium, sodium, sulphate, and sum of ions);
- organics (i.e., chlorophyll a);
- total and dissolved metals and metalloids by ICP-mass spectroscopy (ICP-MS) scan (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, tin, titanium, uranium, vanadium, and zinc);
- low-level cadmium, which was quantified by Dr. Bastian Georg of Trent University based on sample enrichment using anion-exchange chromatography and then analysis on ICP-MS to obtain a lower detection limit; and
- radionuclides including lead-210, polonium-210, radium-226, thorium-228, thorium-230, and thorium-232.



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File: KI08C365
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 5.3-1A
AQUATIC BASELINE LAKE SAMPLING
2007 TO 2013

KIGGAVIK PROJECT - EIS

NOTE: AQUATIC SAMPLING LOCATIONS HAVE BEEN ADJUSTED FOR CARTOGRAPHIC PURPOSES

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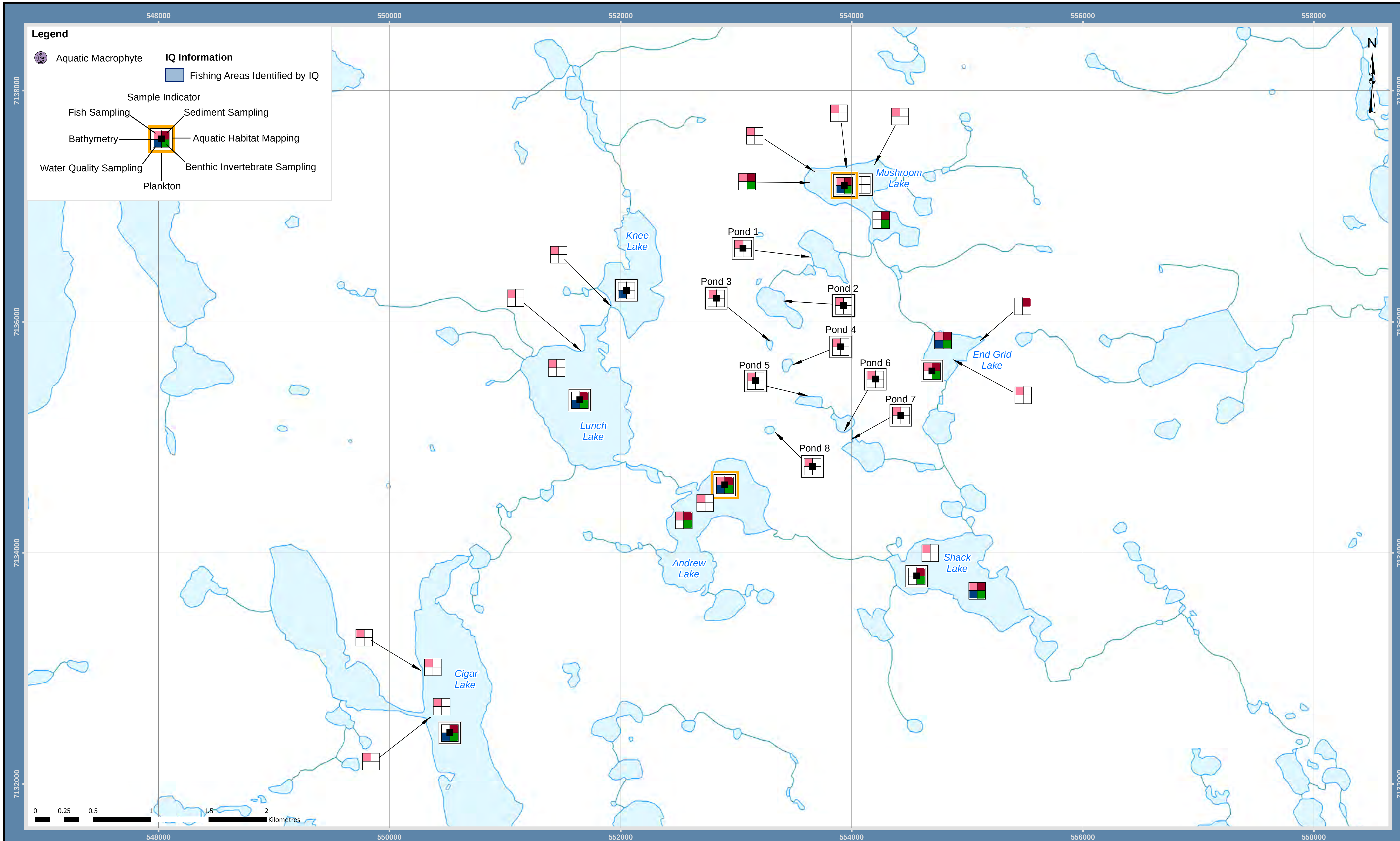

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Date: 29/05/2014 Scale: 1:30,000
File: KI08C366
Data Sources: *NTS Mapsheet 66A 02; AREVA Resources Canada Inc. Hattie Mannik and the Baker Lake Elder's Focus Group Baker Lake HTO, Baker Lake Hunter Focus Group*

FIGURE 5.3-1B
AQUATIC BASELINE LAKE SAMPLING
2007 TO 2013

KIGGAVIK PROJECT - EIS

NOTE: AQUATIC SAMPLING LOCATIONS HAVE BEEN ADJUSTED FOR CARTOGRAPHIC PURPOSES

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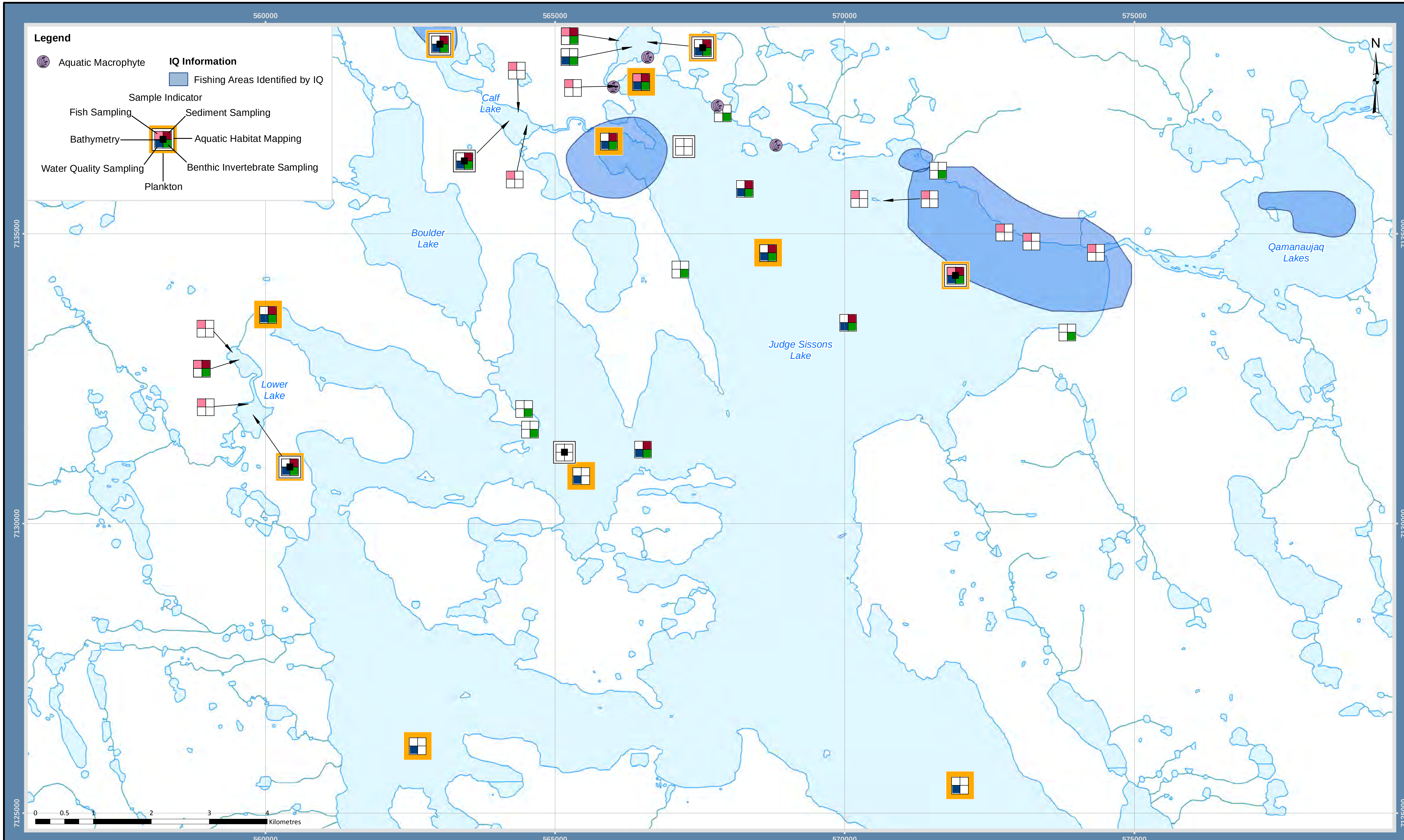

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Date: 29/05/2014 Scale: 1:60,000
File: KI08C367
Data Sources: *NTS Mapsheet 66A 02; AREVA Resources Canada Inc. Hattie Mannik and the Baker Lake Elder's Focus Group Baker Lake HTO, Baker Lake Hunter Focus Group*

FIGURE 5.3-1C
AQUATIC BASELINE LAKE SAMPLING
2007 TO 2013

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NOTE: AQUATIC SAMPLING LOCATIONS HAVE BEEN ADJUSTED FOR CARTOGRAPHIC PURPOSES

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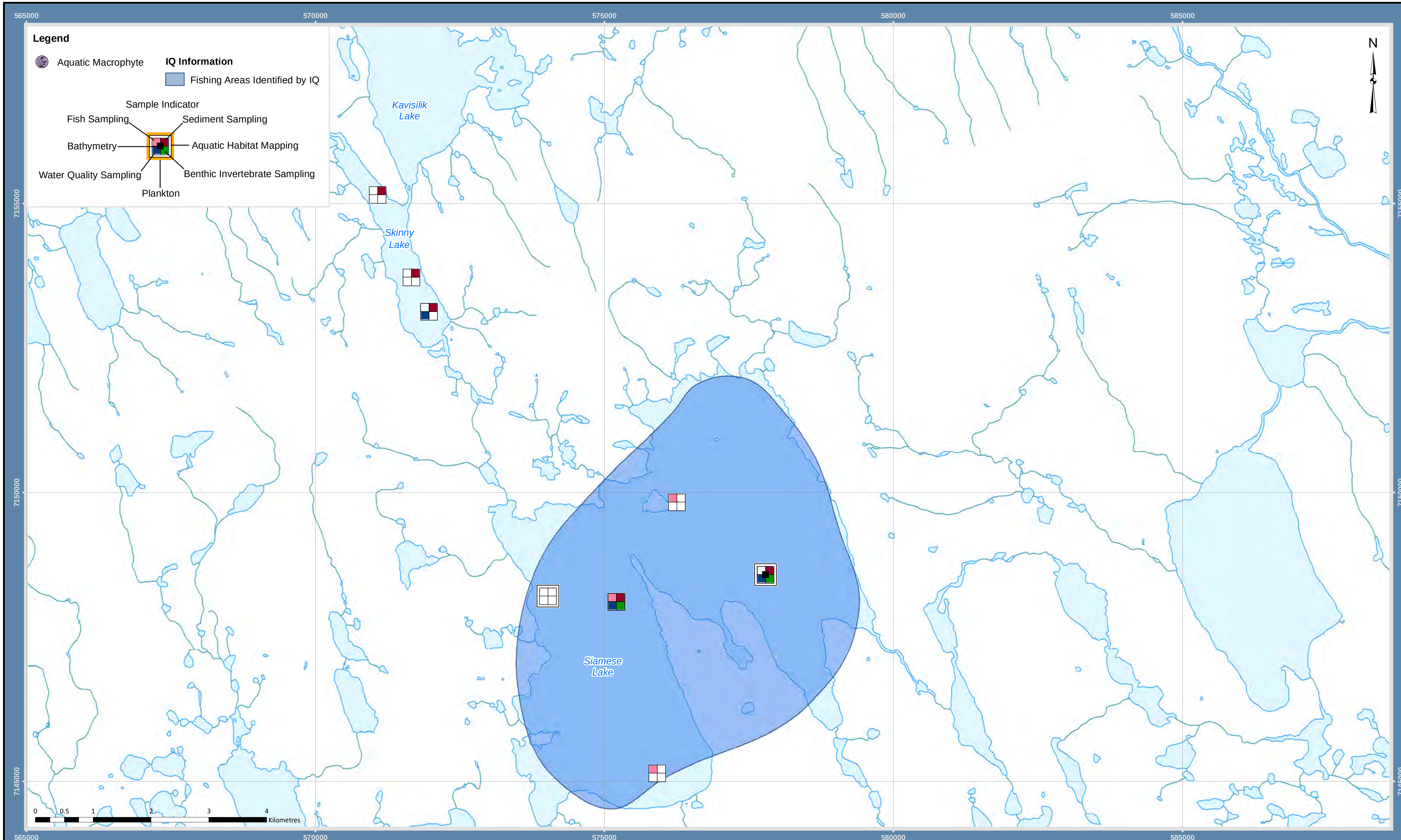

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Creator: MGD/LMR
Date: 29/05/2014 Scale: 1:60,000
File: KI08C368
Data Sources: *NTS Mapsheet 66A 02; AREVA Resources Canada Inc. Hattie Mannik and the Baker Lake Elder's Focus Group Baker Lake HTO, Baker Lake Hunter Focus Group*

FIGURE 5.3-1D
AQUATIC BASELINE LAKE SAMPLING
2007 TO 2013

KIGGAVIK PROJECT - EIS

NOTE: AQUATIC SAMPLING LOCATIONS HAVE BEEN ADJUSTED FOR CARTOGRAPHIC PURPOSES

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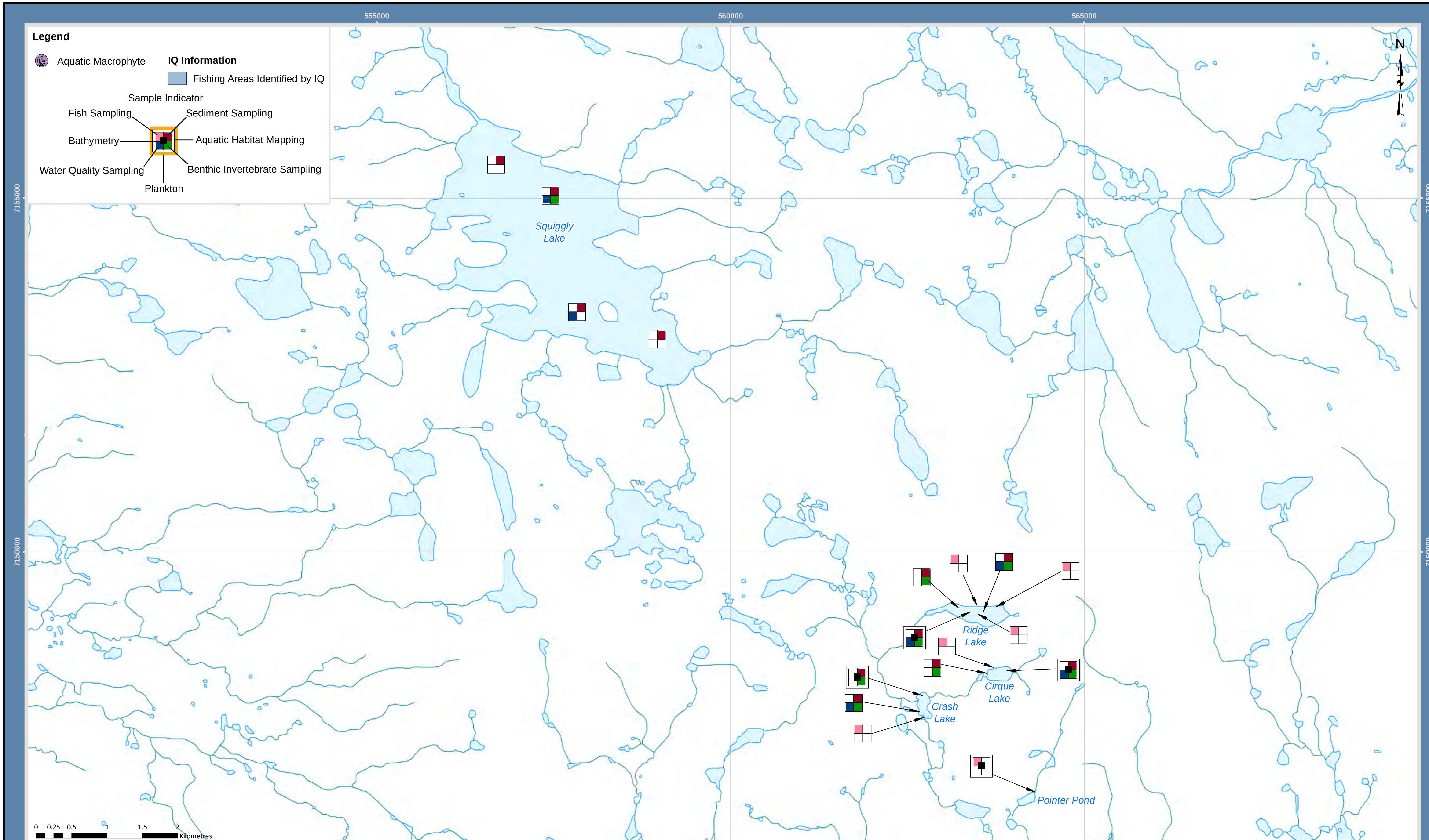

Projection: NAD 1983 UTM Zone 14N
Creator: MGD/LMR
Date: 29/05/2014 Scale: 1:50,000
File: KI08C369
Data Sources: *NTS Mapsheet 66A 02; AREVA Resources Canada Inc. Hattie Mannik and the Baker Lake Elder's Focus Group Baker Lake HTO, Baker Lake Hunter Focus Group*

FIGURE 5.3-1E
AQUATIC BASELINE LAKE SAMPLING
2007 TO 2013

KIGGAVIK PROJECT - EIS

NOTE: AQUATIC SAMPLING LOCATIONS HAVE BEEN ADJUSTED FOR CARTOGRAPHIC PURPOSES

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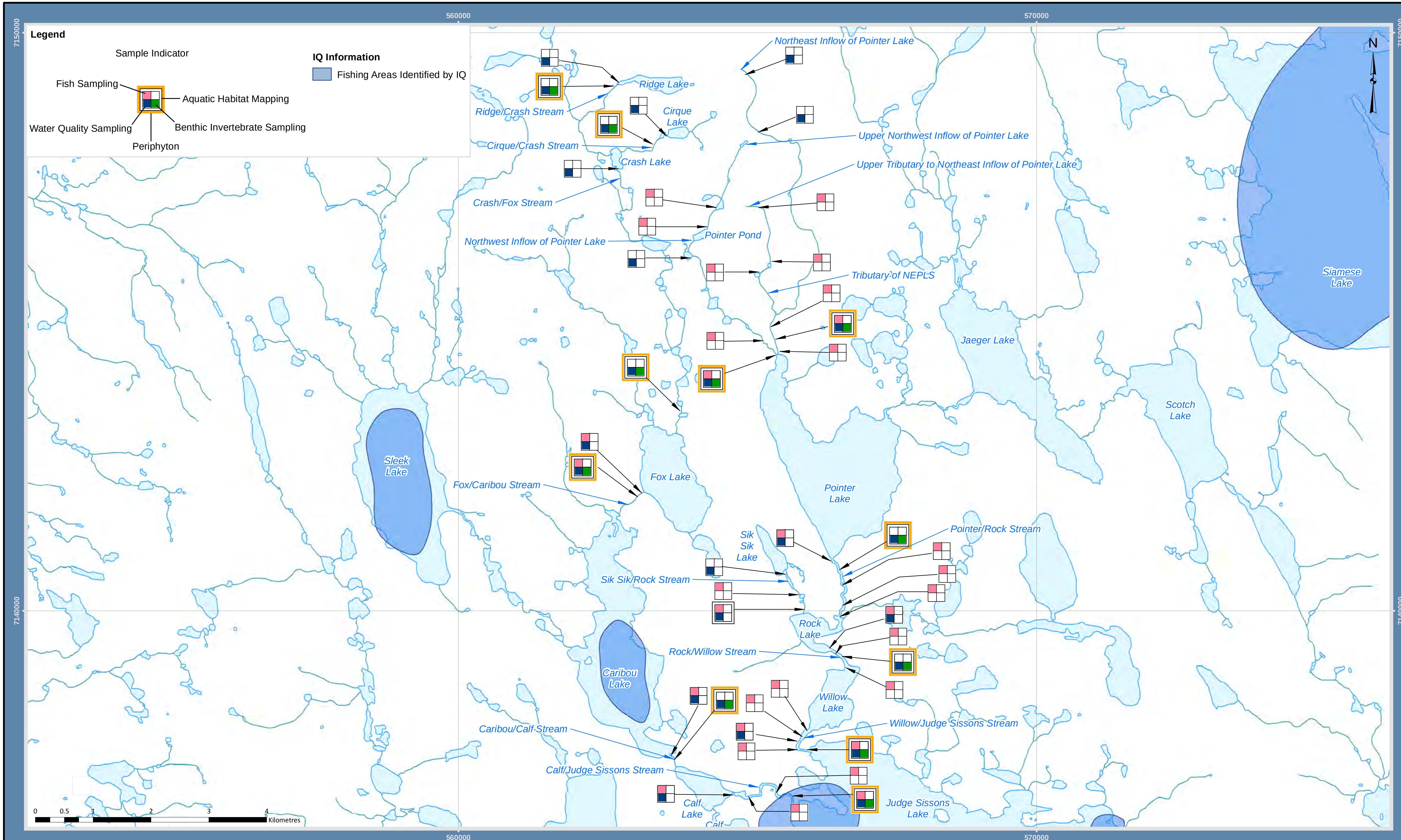

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Creator: MGD/LMR
Date: 29/05/2014 Scale: 1:60,000
File: KI08C371
Data Sources: *NTS Mapsheet 66A 02; AREVA Resources Canada Inc. Hattie Mannik and the Baker Lake Elder's Focus Group Baker Lake HTO, Baker Lake Hunter Focus Group*

FIGURE 5.3-2A
AQUATIC BASELINE STREAM SAMPLING
2007 TO 2010

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Projection: NAD 1983 UTM Zone 14N
Creator: MGD/LMR
Date: 29/05/2014 Scale: 1:30,000
File: KI08C372
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 5.3-2B
AQUATIC BASELINE STREAM SAMPLING
2007 TO 2010

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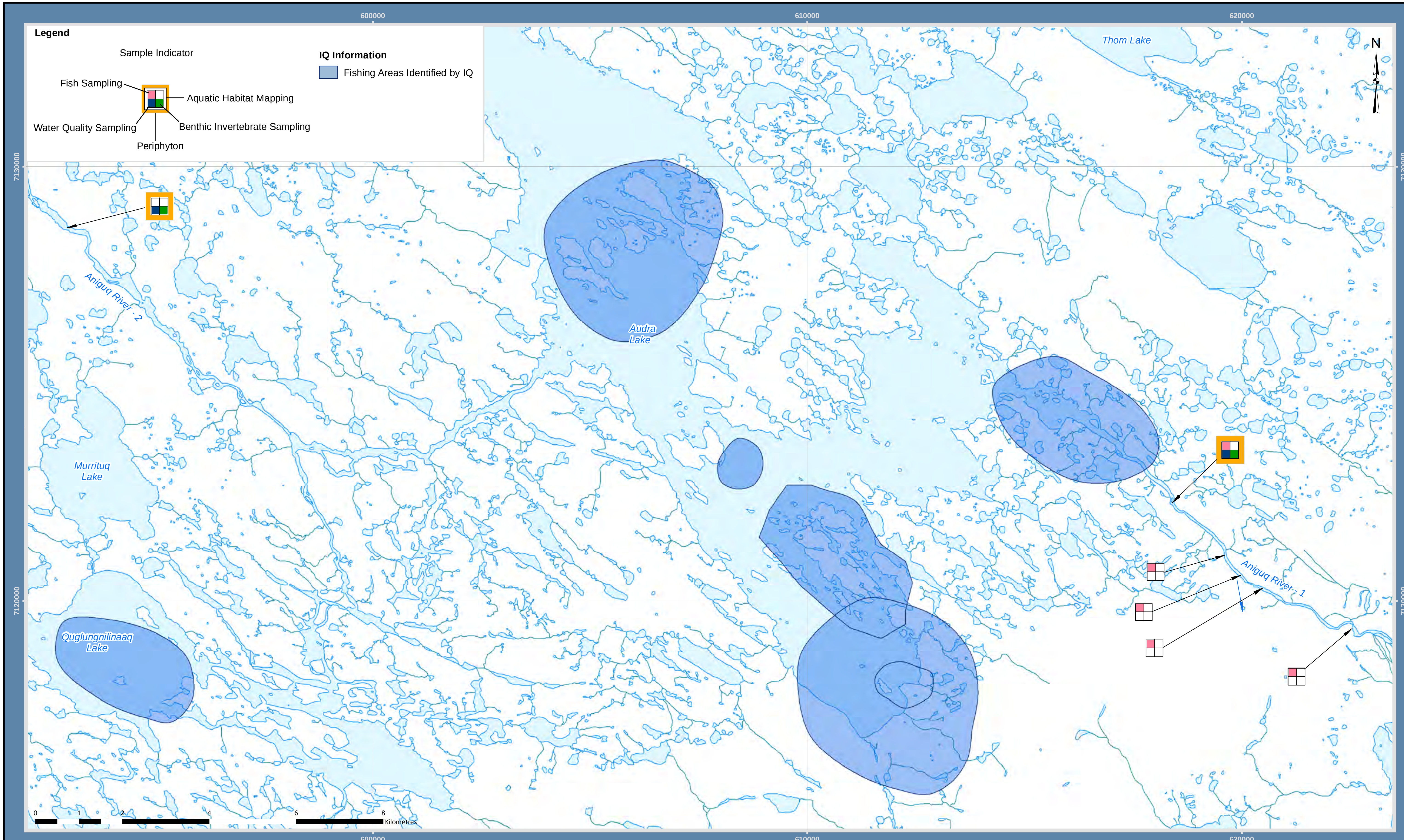

Projection: NAD 1983 UTM Zone 14N
Creator: MGD/LMR
Date: 29/05/2014 Scale: 1:80,000
File: KI08C373
Data Sources: *NTS Mapsheet 66A 02; AREVA Resources Canada Inc. Hattie Mannik and the Baker Lake Elder's Focus Group Baker Lake HTO, Baker Lake Hunter Focus Group*

FIGURE 5.3-2C
AQUATIC BASELINE STREAM SAMPLING
2007 TO 2010

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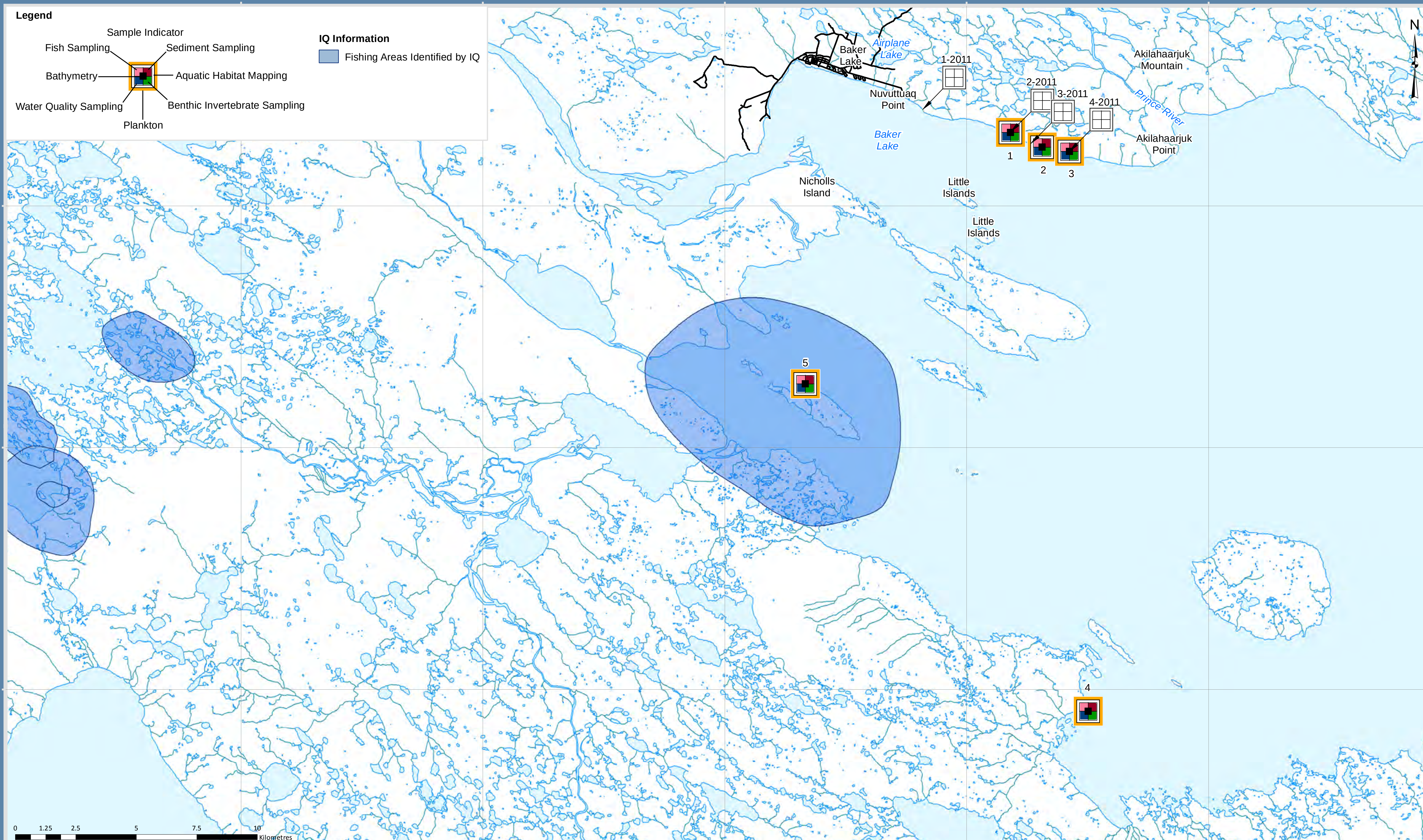

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Date: 29/05/2014 Scale: 1:150,000
File: KI08C361
Data Sources: *NTS Mapsheet 66A 02; AREVA Resources Canada Inc.*
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FIGURE 5.3-3
SAMPLING SITE LOCATIONS - BAKER LAKE, 2008 TO 2011

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Historical water quality data were collected in 22 lakes and five streams between 1974 and 1991. Eight of these lakes (i.e., Meadow, Felsenmeer, Escarpment, Drum, Lin, Scotch, Jaeger, and Kavisilik lakes) were not re-sampled during the 2007 to 2013 field programs because of their location upstream of the proposed mine site. Dissolved metals were not analyzed as part of the historical water quality sampling program; however, results for most other water quality parameters were available.

Water quality data were assessed for spatial and seasonal trends, and were compared to established objectives and guidelines for the protection of aquatic life. Specific objectives and guidelines included:

- the Saskatchewan Surface Water Quality Objectives (SSWQO), which are supported by the Saskatchewan Water Security Agency (WSA 2006); and
- the Canadian Water Quality Guidelines (CWQG) for the protection of freshwater aquatic life (CCME 1999c, with updates to 2014).

The SSWQO have been used by AREVA Resources Canada Inc. (AREVA) in assessments for its uranium mine and mill operations in northern Saskatchewan, and are included in this assessment for comparability and continuity. The Saskatchewan objectives were mostly based on the CCME CWQGs, and are therefore similar.

5.3.1 Water Uses

To date, water used as a source of drinking water in the LSA has been limited to a small pond near the AREVA working camp. Because the LSA is only accessible by helicopter during the open water season, use of other area lakes and streams as drinking water sources is considered negligible. However, some *[p]eople drink water and get ice from the rivers. Many people won't drink tap water because it's treated* (IQ-RB01 2009[108]). Some Elders in Baker Lake indicated during IQ interviews that they have not observed any changes to water quality near the Project site (IQ-BL12 2008[109]).

Water used for recreational purposes within the area of influence of the Project includes some limited use of Judge Sissons Lake in the mine site LSA. Access to Judge Sissons Lake during the open water period is very limited. Historically, camping (summer and winter) near Judge Sissons Lake allowed for fishing (summer and winter), hunting (e.g., caribou), and trapping (e.g., fox) in the area. These activities were completed by families that traveled back and forth between areas or by families who regularly used the area (IQ-BL16 2008[110]). A cabin located on the north shore of Judge Sissons

[108] IQ-RB01 2009: *People drink water and get ice from the rivers. Many people won't drink tap water because it's treated.*
[109] IQ-BL12 2008: *Some Elders in the Baker Lake indicated that they had not observed any changes in water quality.*
[110] IQ-BL16 2008: *The west shore of Baker Lake and Judge Sissons Lake were identified as fishing areas, as well as numerous fishing lakes in the Baker Lake region including areas close the Project lease area, such as Siamese Lake and the east shore of Aberdeen Lake.*

Lake belongs to the Baker Lake Hunting and Trapping Organization (BLHTO). Camping and domestic fishing around Judge Sissons Lake by residents of Baker Lake occurs occasionally.

Baker Lake and the Thelon River in the mine access LSA receive higher levels of recreational use, due to their being located nearer the community of Baker Lake, and, in the case of the Thelon River, being part of the Canadian Heritage Rivers System (Economic Development and Tourism of Northwest Territories 1990). Refer to Tier 3, Technical Appendix 9A, Attachment D for a discussion of the Thelon River as a Canadian Heritage River. The Thelon River provides opportunities for camping; fishing (e.g., Arctic grayling [*Thymallus arcticus*] and trophy sized lake trout [*Salvelinus namaycush*] and Arctic char [*Salvelinus alpinus*]); hiking and viewing (e.g. barren lands); wildlife viewing (e.g., muskoxen [*Ovibos moschatus*], barren-ground caribou [*Rangifer tarandus groenlandicus*], barren-ground grizzly bear [*Ursus arctos horribilis*], wolf [*Canis lupus*], tundra swans [*Cygnus columbianus*], moose [*Alces alces*], and other animals); human heritage viewing (e.g., Hornby's cabin, cabins at Wardens Grove, and tents rings) (Economic Development and Tourism of Northwest Territories 1990); hunting; and harvesting goose eggs). Domestic fishing, canoeing, boating, and snowmobiling are the most common recreational uses for Baker Lake.

5.3.2 Physical Characteristics of Surface Water

Lakes in the Judge Sissons Lake watershed are generally small and shallow (Table 5.3-1). The majority have mean depths of less than 2 m. Andrew Lake is one of the shallowest lakes in the mine site LSA with a maximum depth of 1 m and a surface area of 54 hectares (ha). Judge Sissons Lake is the largest (9,550 ha and deepest (20 m) of the lakes sampled in the mine site LSA. Baker Lake is the largest (189,000 ha) lake in the site access LSA.

Lakes are frozen for most of the year; smaller lakes generally start to become ice free in early June, with larger lakes becoming ice free in late June or early July. Ice thickness is known to reach about 2 m in depth; hence most lakes in the mine site LSA likely freeze to the bottom each winter. The smaller lakes start to freeze over in early to mid September with larger lakes freezing in late September or early October.

Table 5.3-1 Summary of Lake Characteristics in the Kiggavik Project Area

Watershed	Sub-Basin	Waterbody	Source	Drainage Area (km^2)[(a)]	Surface Area (ha)[(b)]	Maximum Depth (m)[(c)]	Mean Depth (m)[(d)]	Total Volume (m^3)[(e)]	Ice Thickness (May 09) (m)	Main Shoreline Perimeter (m)[(a)]	Shoreline Development[(e)]	Fish Observed/Captured (BEAK; McLeod et al. 1976; 2007 to 2010)
Aniguq River	Willow Lake	Meadow Lake	BEAK 1990	1.2	14.0	2.0	0.8	1.12E+05	-	1,507	1.1	none
		Felsenmeer Lake	BEAK 1990	1.3	20.8	6.0	2.0	4.16E+05	-	2,030	1.3	Arctic grayling; lake trout; round whitefish
		Escarpment Lake	BEAK 1990	2.7	12.7	8.0	2.2	2.79E+05	-	1,798	1.4	Arctic grayling; lake trout; round whitefish
		Drum Lake	BEAK 1990	5.6	25.0	2.0	1.3	3.25E+05	-	2,481	1.4	Arctic grayling
		Lin Lake	BEAK 1990	7.2	48.0	2.0	1.3	6.24E+05	-	3,016	1.2	Arctic grayling
		Scotch Lake	BEAK 1990	11.7	195	6.0	3.6	7.02E+06	-	7,645	1.5	lake trout; ninespine stickleback; round whitefish; slimy sculpin
		Jaegar Lake	BEAK 1987	50.4	281	4.0	1.6	4.50E+06	-	13,339	2.2	Arctic grayling
		Pointer Pond	2010	-	3.09	4.5	1.5	44,831	-	815	1.3	no fish observed or captured in pond; slimy sculpin captured in the stream immediately upstream
		Pointer Lake	2007	79.0	393	3.0	1.4	5.46E+06	-	11,756	1.7	Arctic grayling; cisco; lake trout; ninespine stickleback
		Sik Sik Lake	2009	1.8	17.5	1.7	0.9	1.63E+05	2.0[(g)]	2,155	1.5	ninespine stickleback
		Rock Lake	2008	99.2	32.4	1.5	0.7	2.29E+05	1.5[(g)]	3,648	1.8	Arctic grayling; lake trout
		Willow Lake	BEAK 1990	101.9	54.9	2.0	1.4	7.69E+05	2.0[(g)]	4,321	1.6	Arctic grayling; lake trout; ninespine stickleback
	Lower Lake	Mushroom Lake	2009	4.4	32.0	8.9	1.9	6.05E+05	2.0	3,416	1.7	Arctic grayling; cisco; lake trout; round whitefish
		Pond 1	2010	-	9.94	1.5	0.7	70,589	-	1,897	1.7	no fish observed or captured
		Pond 2	2010	-	6.56	1.2	0.6	38,683	-	1,348	1.5	no fish observed or captured
		Pond 3	2010	-	0.26	0.5	0.3	762	-	245	1.3	no fish observed or captured
		Pond 4	2010	-	0.67	0.7	0.3	1,866	-	354	1.2	no fish observed or captured
		Pond 5	2010	-	1.62	1.0	0.4	6,948	-	615	1.4	no fish observed or captured
		Pond 6	2010	-	1.76	1.2	0.7	11,422	-	636	1.4	no fish observed or captured
		Pond 7	2010	-	6.53	1.2	0.6	41,770	-	1,102	1.2	no fish observed or captured
		Pond 8	2010	-	0.44	0.7	0.4	1,748	-	259	1.1	no fish observed or captured

Table 5.3-1 Summary of Lake Characteristics in the Kiggavik Project Area

Watershed	Sub-Basin	Waterbody	Source	Drainage Area (km^2)[a]	Surface Area (ha)[b]	Maximum Depth (m)[c]	Mean Depth (m)[d]	Total Volume (m^3)[e]	Ice Thickness (May 09) (m)	Main Shoreline Perimeter (m)[a]	Shoreline Development[e]	Fish Observed/Captured (BEAK 1987, 1990, 1992a; McLeod et al. 1976; 2007 to 2010)
Aniguq River	Lower Lake	End Grid Lake	2008	7.1	13.2	1.4	0.8	1.03E+05	-	1,551	1.2	Arctic grayling
		Smoke Lake	BEAK 1992a	5.6	63.5	1.0	1.3	8.26E+05	-	4,460	1.6	Arctic grayling; cisco
		Cigar Lake	BEAK 1992a	11.8	113	3.6	1.5	1.70E+06	-	7,590	2.0	Arctic grayling; burbot; cisco; lake trout; round whitefish
		Knee Lake	BEAK 1992a	11.6	34.9	0.8	0.2	6.98E+04	-	3,331	1.6	Arctic grayling
		Lunch Lake	BEAK 1992a	29.6	77.8	1.6	0.6	4.67E+05	-	4,492	1.4	Arctic grayling; lake trout; round whitefish
		Andrew Lake	2009	33.6	54.3	1.0	0.2	9.78E+04	1.0[g]	5,029	1.9	Arctic grayling; burbot; cisco; round whitefish
		Shack Lake	BEAK 1992a	47.2	60.0	1.6	0.6	3.60E+05	-	4,983	1.8	Arctic grayling
		Bear Island Lake	BEAK 1992a	9.2	36.5	1.0	0.5	1.83E+05	-	6,365	3.0	Arctic grayling
		Lower Lake	BEAK 1992a	69.0	49.0	1.4	0.4	1.96E+05	-	4,828	1.9	Arctic grayling; burbot; cisco; ninespine stickleback; round whitefish
	Caribou Lake	Ridge Lake	BEAK 1990	2.1	16.7	7.1	2.3	3.84E+05	-	2,643	1.8	lake trout
		Cirque Lake	BEAK 1990	0.7	5.6	5.2	2.6	1.46E+05	-	946	1.1	Arctic grayling; ninespine stickleback
		Crash Lake	BEAK 1990	10.6	8.1	2.0	1.1	8.91E+04	-	1,078	1.1	Arctic grayling
		Rhyolite Lake	NTS	0.6	7	no bathymetry	no bathymetry	-	-	1,263	1.3	not sampled
		Fox Lake	BEAK 1990	28.9	128	2.7	1.7	2.18E+06	-	5,194	1.3	Arctic grayling; cisco; lake trout; ninespine stickleback
		Sleek Lake	NTS	31.8	376	no bathymetry	no bathymetry	-	-	9,429	1.4	not sampled
		Caribou Lake	BEAK 1990	80.9	341	2.7	1.4	4.77E+06	-	14,485	2.2	Arctic grayling; burbot; cisco; lake trout; ninespine stickleback; round whitefish
		Calf Lake	2008	88.2	35.8	1.2	0.6	2.14E+05	-	2,662	1.3	burbot; cisco; ninespine stickleback
	Boulder Lake	Boulder Lake	NTS	68.6	478	no bathymetry	no bathymetry	-	-	12,949	1.7	not sampled
	Judge Sissons Lake	Judge Sissons Lake	BEAK 1990, 2009, 2013	704.6	9,550	20.6	4.6	4.39E+08	1.8	119,370	3.4	Arctic grayling; burbot; cisco; lake trout; ninespine stickleback; round whitefish; slimy sculpin
	Siamese Lake	Siamese Lake	2008	85.2	2,792	12.0	4.1	1.14E+08	2.1	45,877	2.4	lake trout

Table 5.3-1 Summary of Lake Characteristics in the Kiggavik Project Area

Watershed	Sub-Basin	Waterbody	Source	Drainage Area (km^2)(a)	Surface Area (ha)(b)	Maximum Depth (m)(c)	Mean Depth (m)(d)	Total Volume (m^3)(e)	Ice Thickness (May 09) (m)	Main Shoreline Perimeter (m)(a)	Shoreline Development(e)	Fish Observed/Captured (BEAK; McLeod et al. 1976; 2007 to 2010)
	Skinny Lake	Skinny Lake	BEAK 1990	111.7	197	12.8	3.1	6.11E+06	-	12,474	2.5	Arctic grayling; cisco; lake trout; round whitefish
	Kavisilik Lake	Kavisilik Lake	BEAK 1990	148.4	564	12.0	4.2	2.37E+07	-	22,034	2.6	Arctic grayling; cisco; lake trout; round whitefish
Thelon River	Squiggly Lake	Squiggly Lake	BEAK 1990	41.8	638	17.6	6.0	3.83E+07	-	27,568	3.1	Arctic char; Arctic grayling; burbot; lake trout; round whitefish
Baker Lake	Baker Lake	Baker Lake	NTS, McLeod et al. 1976	-	189,000	no bathymetry	15.0	2.84E+10	-	-	-	Arctic char; Arctic grayling; burbot; fourhorn sculpin; cisco; lake trout; lake whitefish; longnose sucker; ninespine stickleback; round whitefish; slimy sculpin
Winter Access Road		L2	NTS	66.9	792.4	8.0(f)	no bathymetry	-	1.8	13,257	1.3	not sampled
		Long Lake	NTS	355.7	614.4	2.5(f)	no bathymetry	-	1.8	23,804	2.7	not sampled
		Audra Lake	NTS	2,740	9,520	6.8(f)	4.0	3.81E+08	2.0	-	-	not sampled
		Qinguq Bay	NTS	465.9	998	4.5(f)	no bathymetry	-	1.8	17,147	1.5	not sampled

Source: Modified from Tier 3, Technical Appendix 5C, Table X.VIII-1.

NOTES:

(a) Estimated from digital NTS coverage.

(b) Based on bathymetric data as presented in BEAK (1987; 1990; 1992a) or McLeod et al. (1976) unless recent bathymetric information was available. If no bathymetry was available at all, value was estimated from digital NTS coverage.

(c) Maximum depth is the maximum depth either collected at sampling stations, noted on recent bathymetry if information was available, or shown on bathymetry maps from BEAK (1987; 1990; 1992a).

(d) Based on bathymetric data as presented in BEAK (1987; 1990; 1992a) or McLeod et al. (1976) unless recent bathymetric information was available.

(e) Calculated from available data.

(f) Maximum depth is the maximum depth collected at sampling stations during winter sampling session of May 2009. Value was not corrected for ice thickness.

(g) Lake frozen to the bottom.

km2 = square kilometres; ha = hectares; m = metres; Arctic grayling = Thymallus arcticus; lake trout = Salvelinus namaycush; round whitefish = Prosopium cylindraceum; ninespine stickleback = Pungitius pungitius; slimy sculpin = Cottus cognatus; cisco = Coregonus artedi; burbot = Lota lota; Arctic char = Salvelinus alpinus; fourhorn sculpin = Myoxocephalus quadricornis; lake whitefish = Coregonus clupeaformis; longnose sucker = Catostomus catostomus; NTS = National Topographic System; - = not applicable.

5.3.3 Chemical Characteristics of Surface Water

Lakes in the mine site LSA had similar water chemistry (Table 5.3-2). Lakes were characterized by low ionic strength and neutral to alkaline pH. The range of total alkalinity values during open water conditions indicated that the lake waters had low to high sensitivity to acid (Table 5.3-3; Saffran and Trew 1996). Total hardness concentrations indicated that the waters had very soft to soft water hardness (Table 5.3-3; McNeely et al. 1979). Measured nutrient concentrations (particularly nitrogen and phosphorus) were typical of oligotrophic (nutrient poor) waterbodies in subarctic regions. Baseline water quality parameters were less than SSWQO and CWQG with the exception of some parameters (i.e., field and laboratory measured pH, ammonia, chloride, fluoride, aluminum, cadmium, chromium, copper, iron, lead, mercury, selenium, silver, zinc, and radium-226) in some lakes. Radionuclides were generally not detected or were detected near the analytical detection limits.

Baseline water quality parameters for lakes of special interest (i.e., Mushroom, Andrew, Judge Sissons, Siamese, and Baker lakes) were less than SSWQO and CWQG with the exception of a few parameters (i.e., field and laboratory measured pH, chloride, fluoride, aluminum, cadmium, chromium, copper, lead, silver, and zinc) (Table 5.3-2).

Streams of the study area were characterized by low ionic strength and neutral to alkaline pH (Table 5.3-2). The range of total alkalinity values measured during open water conditions indicated that the stream waters had low to high sensitivity to acid (Table 5.3-3; Saffran and Trew 1996). Total hardness concentrations indicated that stream waters had very soft water hardness (Table 5.3-3; McNeely et al. 1979). Measured nutrient concentrations were typical of oligotrophic waterbodies in subarctic regions. Baseline water quality parameters were less than SSWQO and CWQG with the exception of a few parameters (i.e., field and laboratory measured pH, fluoride, aluminum, cadmium, chromium, copper, iron, lead, zinc, and radium-226) in some streams. Radionuclides were generally not detected or were detected near the analytical detection limits.

Table 5.3-2 Summary of Water Chemistry Data for Lakes and Streams in the Kiggavik Project Area, 1974-2013

Parameter	Units	Guidelines		Willow Lake Sub-Basin			Lower Lake Sub-Basin		
				All Lakes	Northeast Inflow of Pointer Lake	All Other Streams	Mushroom Lake	Andrew Lake	All Other Lakes
				1979, 1980, 1986, 1988, 1989, 1991, 2007, 2008, 2009	2008, 2009	1988, 2007, 2008, 2009	1991, 2008	2007, 2008, 2009	1991, 2007, 2008
		SSWQO[a]	CWQG[b]	n = 43[c]	n = 4[c]	n = 20[c]	n = 14[c]	n = 3[c]	n = 22[c]
Conventional Parameters (Field-Measured)									
Dissolved Oxygen	mg/L	6.5 / 9.5[d]	6.5 / 9.5[d]	10.32 - 12.06	10.66 - 11.31	10.03 - 12.58	-	11.19 - 11.63	11.84 - 11.97
Water Temperature	°C	-	-	6.30 - 14.80	4.92 - 14.4	1.91 - 13.11	8.21 - 17.14	7.42 - 9.80	6.01 - 13.10
pH	pH units	-	6.5-9.0	6.65 - 9.90	6.64 - 7.87	6.34 - 8.03	6.96 - 7.13	7.33 - 7.59	6.36 - 7.96
Specific Conductivity	µS/cm	-	-	12 - 58	16 - 39	12 - 45	-	30 - 31	25 - 34
Conventional Parameters (Laboratory-Measured)									
pH	pH units	-	6.5-9.0	5.6 - 7.55	6.56 - 6.90	6.60 - 7.39	6.70 - 7.08	6.94 - 7.24	6.35 - 7.54
Specific Conductivity	µS/cm	-	-	10.2 - 141[e]	16 - 40	14 - 116	20.3 - 50	31 - 36	13 - 53
Total Alkalinity	mg $CaCO_3$/L	-	-	1 - 53[e]	4 - 7	3 - 26	4 - 15	10 - 14	2 - 23
Alkalinity (pH 3.8)	mg $CaCO_3$/L	-	-	12 - 27[e]	-	23	-	-	-
Gran alkalinity	mg $CaCO_3$/L	-	-	2.6 - 56[e]	-	-	3.8 - 16	-	2.4 - 13.0
Total Hardness	mg $CaCO_3$/L	-	-	3.5 - 57[e]	7 - 17	6 - 44	9.0 - 15.9	14 - 16	4 - 22
Total Dissolved Solids	mg/L	-	-	2 - 58 (2 < DL)	18 - 45	11 - 80	22 - 25	34 - 35	13 - 45
Total Suspended Solids	mg/L	-	-	<1 - 10 (4 < DL)	<1 - 5 (2 < DL)	<1 - 8 (4 < DL)	<1 - <2 (4 < DL)	2 - 4	<1 - 10 (4 < DL)
Turbidity	NTU	-	-	0.57 - 4.6	0.7 - 6.2	0.6 - 3.0	0.5 - 1.1	1.8 - 2.2	0.7 - 6
True Colour (Co-Pt)	-	-	-	8 - 41	-	73	9 - 14	-	9 - 14
Chlorophyll a	µg/L	-	-	0.64 - 1.58	-	-	-	-	-
Chlorophyll *a*	mg/m^3	-	-	2.1 - 5.0	-	2.1 - 3.3		3.0 - 3.1	
Absorbance at 254 nm	-	-	-	0.066 - 0.124	-	0.404	-	-	-
Nutrients									
Ammonia as nitrogen	mg N/L	0.24[f]	0.24[f]	<0.01 - 0.23 (4 < DL)	<0.01 - 0.1 (1 < DL)	<0.01 - 0.11 (3 < DL)	0.008 - 0.029 (2 < DL)	0.03 - 0.1	<0.01 - 0.35 (2 < DL)
Nitrate and Nitrite as nitrogen	mg N/L	-	-	<0.01 - 0.04 (6 < DL)	<0.01 - 0.02 (1 < DL)	<0.01 - 0.01 (6 < DL)	<0.01 (2 < DL)	<0.01 - 0.01 (1 < DL)	<0.01 (10 < DL)
Nitrate[g]	mg N/L	-	13[h]	<0.003 - 0.24 (17 < DL)	<0.04 - 0.09 (1 < DL)	<0.02 - 0.04 (6 < DL)	<0.01 - <0.04 (5 < DL)	<0.04 (1 < DL)	<0.01 - <0.04[i] (9 < DL)
Nitrite	mg N/L	-	0.197[j]	<0.001 - <0.1[i] (10 < DL)	-	0.002	<0.01 (3 < DL)	-	<0.01 - 0.01 (2 < DL)
Total Kjeldahl Nitrogen	mg N/L	-	-	0.10 - 1.34[e]	0.41 - 0.52	0.34 - 0.69	0.20 - 0.46	0.43 - 0.64	0.25 - 1.3
Total Nitrogen	mg/L	-	-	0.10 - 0.89	0.41 - 0.44	0.35 - 0.68	0.20 - 0.36	0.64	0.27 - 0.66
Total Phosphorous	mg/L	-	-	<0.001 - 0.08 (17 < DL)	<0.01 - 0.02 (2 < DL)	0.005 - 0.02 (13 < DL)	0.006 - <0.01 (2 < DL)	<0.01 (3 < DL)	0.008 - 0.09 (5 < DL)
Dissolved Phosphorus	mg/L	-	-	<0.01 - 0.04 (9 < DL)	<0.01 - 0.02 (2 < DL)	<0.01 - 0.04 (11 < DL)	<0.01 (2 < DL)	<0.01 (2 < DL)	<0.01 - 0.07 (5 < DL)
Soluble Reactive Phosphorous	mg/L	-	-	<0.001 - 0.001 (12 < DL)	-	<0.001 (1 < DL)	<0.001 (3 < DL)	-	<0.001 - 0.003 (2 < DL)
Orthophosphate-P	mg/L	-	-	<0.1 (7 < DL)	-	-	-	-	-
Total Carbon	mg/L	-	-	4 - 19	4 - 10	4 - 23	6 - 7	9 - 10	4 - 13
Total Inorganic Carbon	mg/L	-	-	<1 - 7 (1 < DL)	1 - 2	<1 - 6 (1 < DL)	2 - 3	3	1 - 6
Total Organic Carbon	mg/L	-	-	2.3 - 12	2.7 - 8.7	3.1 - 18	3.6 - 4.6	5.6 - 7.3	3.3 - 9
Dissolved Inorganic Carbon	mg/L	-	-	0.7 - 13.4[e]	-	4.0	1.6 - 3.5	-	<0.5 - 3.9 (1 < DL)
Dissolved Organic Carbon	mg/L	-	-	2.5 - 26[e]	2.9 - 10	3.1 - 18	3.6 - 6.7	6.0 - 8.4	3.4 - 10
Major Ions									
Bicarbonate	mg/L	-	-	1 - 39	5 - 9	4 - 32	12 - 13	12 - 17	5 - 28
Calcium	mg/L	-	-	0.85 - 16.8[e]	1.5 - 4.3	1.4 - 13.3	2.3 - 4.8	3.5 - 4.3	0.1 - 6.2
Carbonate	mg/L	-	-	<1 (16 < DL)	<1 (4 < DL)	<1 (17 < DL)	<1 (2 < DL)	<1 (3 < DL)	<1 (10 < DL)
Chloride	mg/L	-	120	0.17 - 3.2[e] (1 < DL)	0.3 - 2.6	0.3 - 22	0.35 - 0.74	1.8 - 2.3	0.32 - 3.4
Fluoride	mg/L	-	0.12	<0.01 - 0.16 (1 < DL)	0.04 - 0.11	0.03 - 0.35	0.06 - 0.15	0.22 - 0.27	0.07 - 0.45
Hydroxide	mg/L	-	-	<1 (16 < DL)	<1 (4 < DL)	<1 (17 < DL)	<1 (2 < DL)	<1 (3 < DL)	<1 (10 < DL)
Magnesium	mg/L	-	-	0.30 - 5.2[e]	0.7 - 1.6	0.5 - 2.6	0.8 - 1.5	1.2 - 1.4	0.05 - 1.7
Potassium	mg/L	-	-	0.10 - 2.1[e]	0.3 - 0.5	<0.1 - 1.25 (1 < DL)	0.2 - 0.75	0.3 - 0.5	0.1 - 0.5
Silica (as $Si0_2$)	mg/L	-	-	0.08 - 0.58	-	2.5	0.28	-	0.48
Silicates	mg/L	-	-	0.43 - 0.97	-	-	-	-	-
Sodium	mg/L	-	-	0.2 - 2.5[e] (15 < DL)	0.4 - 0.7	0.2 - 1.5	0.3 - 0.5 (2 < DL)	0.5 - 0.7	0.3 - 0.8 (2 < DL)
Sulphate	mg/L	-	-	0.038 - 3.2[e]	0.6 - 6.9	0.3 - 2.9	0.4 - 0.99	0.5 - 0.8	0.2 - 1.5
Sum of Ions	mg/L	-	-	5 - 52	9 - 22	8 - 43	17 - 19	22 - 25	8 - 39
Sum of ions	%	-	-	-	-	-	-	-	-

Table 5.3-2 Summary of Water Chemistry Data for Lakes and Streams in the Kiggavik Project Area, 1974-2013

Parameter	Units	Guidelines		Willow Lake Sub-Basin			Lower Lake Sub-Basin		
				All Lakes	Northeast Inflow of Pointer Lake	All Other Streams	Mushroom Lake	Andrew Lake	All Other Lakes
				1979, 1980, 1986, 1988, 1989, 1991, 2007, 2008, 2009	2008, 2009	1988, 2007, 2008, 2009	1991, 2008	2007, 2008, 2009	1991, 2007, 2008
		SSWQO[a]	CWQG[b]	n = 43[c]	n = 4[c]	n = 20[c]	n = 14[c]	n = 3[c]	n = 22[c]
Total Metals									
Aluminum[k]	mg/L	0.005-0.1 [l]	0.005-0.1 [l]	0.013 - **0.1** (2 < DL)	0.079 - 0.094	0.016 - **0.138**	0.015 - 0.04 (1 < DL)	0.023 - 0.031	**0.018** - 0.057
Antimony	mg/L	-	-	<0.0002 - 0.0002 (15 < DL)	<0.0002 (4 < DL)	<0.0002 (17 < DL)	<0.0002 (2 < DL)	<0.0002 (3 < DL)	<0.0002 (10 < DL)
Arsenic	µg/L	5	5	0.1 - <5 (22 < DL)	0.2	0.1 - <1 (1 < DL)	0.1 - <5 (3 < DL)	<0.1 - 0.1 (1 < DL)	<0.1 - 2 (3 < DL)
Barium	mg/L	-	-	0.02 - 0.37[e]	0.057 - 0.095	0.027 - 0.14	0.02 - 0.04	0.05 - 0.055	0.01 - 0.098
Beryllium	mg/L	-	-	<0.0001 - <0.005 (23 < DL)	<0.0001 (4 < DL)	<0.0001 (17 < DL)	<0.0001 (2 < DL)	<0.0001 (3 < DL)	<0.0001 (10 < DL)
Boron	mg/L	-	1.5	<0.01 - 0.01 (15 < DL)	<0.01 - 0.01 (3 < DL)	<0.01 (17 < DL)	<0.01 (2 < DL)	<0.01 (3 < DL)	<0.01 - 0.01 (9 < DL)
Bromide	mg/L	-	-	-	-	-	-	-	-
Cadmium[k]	mg/L	0.000017-0.000032 [m]	0.00004-0.00011 [n]	<0.00001 - **0.017** (25 < DL)	<0.00001 - *<0.0001* (4 < DL)	<0.00001 - **0.0004** (15 < DL)	*<0.0001 - <0.002* (4 < DL)	<0.00001 - *<0.0001* (3 < DL)	*<0.0001* - **0.002** (12 < DL)
Cadmium (low levels) [o]	ng/L	17-32 [m]	40-110 [n]	-	-	-	-	-	-
Chromium[k]	mg/L	0.001 [p]	0.0010/0.0089 [q]	<0.0005 - *<0.5*[l] (35 < DL)	<0.0005 (4 < DL)	<0.0005 - **0.001** (16 < DL)	<0.0005 - *<0.01* (4 < DL)	<0.0005 - **0.0021** (2 < DL)	<0.0005 - *< 0.01* (13 < DL)
Cobalt	mg/L	-	-	<0.0001 - <0.01[l] (27 < DL)	<0.0001 - 0.0001 (2 < DL)	<0.0001 - 0.001 (12 < DL)	<0.0001 - <0.01 (4 < DL)	<0.0001 (3 < DL)	<0.0001 - <0.01[l] (8 < DL)
Copper[k]	mg/L	0.002 [r]	0.002 [r]	<0.0005 - **0.0143**[s] (6 < DL)	0.0014 - **0.0035**	0.0004 - **0.0045**	0.0007 - **0.005** (1 < DL)	0.0009 - 0.0012	0.0005 - *<0.005* (2 < DL)
Iron	mg/L	0.3	0.3	0.03 - **0.98**	0.048 - 0.230	0.055 - **2.5**	0.04 - 0.14	0.10 - 0.11	<0.02 - **0.32** (1 < DL)
Lead[k]	mg/L	0.001 - 0.002 [t]	0.00100 - 0.00180 [t]	<0.0001 - **0.59** (23 < DL)	<0.0001 (3 < DL)	<0.0001 - **0.001** (9 < DL)	<0.0001 - **0.02** (2 < DL)	0.0001	<0.0001 - *<0.02*[l] (3 < DL)
Manganese	mg/L	-	-	0.001 - 0.088 (7 < DL)	0.0007 - 0.0060	0.0018 - 0.113	0.0055 - <0.01 (2 < DL)	0.0015 - 0.0031	0.0005 - <0.01 (2 < DL)
Mercury[k, u]	µg/L	0.026 [v]	0.026 [w]	<0.005 - *<10*[l] (36 < DL)	<0.005 - *<0.05* (4 < DL)	<0.005 - *<0.05* (18 < DL)	*<0.05* (4 < DL)	<0.02 - *<0.05* (3 < DL)	*<0.05* - **0.3** (11 < DL)
Molybdenum	mg/L	-	0.073	<0.0001 - <0.01[l] (13 < DL)	<0.0001 - 0.0003 (1 < DL)	<0.0001 - 0.0002 (14 < DL)	<0.0001 - 0.0001 (1 < DL)	<0.0001 - 0.0001 (2 < DL)	<0.0001 - 0.0001 (6 < DL)
Nickel	mg/L	0.025 - 0.065 [x]	0.025 - 0.06889 [x]	0.0003 - <0.01 (17 < DL)	0.0013 - 0.0016	0.0003 - 0.002	0.0004 - <0.01 (2 < DL)	0.0004 - 0.0005	0.0002 - <0.01 (2 < DL)
Selenium	mg/L	0.001[y]	0.001[y]	<0.0001 - 0.0002 (12 < DL)	<0.0001 - 0.0001 (3 < DL)	<0.0001 - 0.0002 (13 < DL)	0.0001	<0.0001 - 0.0001 (2 < DL)	<0.0001 - 0.0001 (8 < DL)
Selenium [k]	µg/L	1 [y]	1.0 [y]	<0.1 - < 0.5[l] (17 < DL)	-	<0.1 (1 < DL)	<2 (2 < DL)	-	<2 - **2** (2 < DL)
Silicon	mg/L	-	-	-	-	-	-	-	-
Silver[k]	mg/L	0.0001	0.0001	<0.00001 - **0.0001** (26 < DL)	*<0.0001* (4 < DL)	*<0.0001* (18 < DL)	*<0.0001* - **0.00054** (2 < DL)	*<0.0001* (3 < DL)	*<0.0001* - **0.00048** (11 < DL)
Strontium	mg/L	-	-	<0.01 - 0.13[e] (1 < DL)	0.013 - 0.031	0.010 - 0.038	0.01 - 0.03	0.048 - 0.059	0.0084 - 0.095 (1 < DL)
Tellurium	µg/L	-	-	<2 (4 < DL)	-	-	-	-	-
Thallium	mg/L	-	0.0008	<0.0002 (16 < DL)	<0.0002 (4 < DL)	<0.0002 (17 < DL)	<0.0002 (2 < DL)	<0.0002 (3 < DL)	<0.0002 (10 < DL)
Tin	mg/L	-	-	<0.0001 - 0.0016 (13 < DL)	<0.0001 - 0.0001 (3 < DL)	<0.0001 - 0.0001 (16 < DL)	<0.0001 - 0.0001 (1 < DL)	<0.0001 (3 < DL)	<0.0001 - 0.0001 (8 < DL)
Titanium	mg/L	-	-	0.0002 - 0.0016	0.0005 - 0.0008	0.0002 - 0.0008	<0.0002 - 0.0005 (1 < DL)	0.0003 - 0.0004	<0.0002 - 0.0018 (1 < DL)
Uranium	µg/L	15	15	<0.1 - 8.6 (23 < DL)	<0.1 - 0.2 (2 < DL)	<0.1 - 11 (17 < DL)	<0.1 - <0.5[l] (2 < DL)	<0.1 - 0.2 (2 < DL)	<0.1 - <0.5[l] (8 < DL)
Uranium - preconcentrated	µg/L	-	-	0.15	-	-	0.5	-	0.5
Uranium - whole water	µg/L	-	-	0.005 - 0.5	-	-	-	-	-
Vanadium	mg/L	-	-	<0.0001 - <0.01[l] (8 < DL)	0.0001	<0.0001 - 0.0002 (1 < DL)	<0.0001 (2 < DL)	0.0001	<0.0001 - 0.0002 (2 < DL)
Zinc	mg/L	0.03	0.03	0.00001 - **8.19** (14 < DL)	0.0021 - 0.0087	<0.0005 - 0.0078 (2 < DL)	0.0015 - <0.01 (1 < DL)	0.0026 - 0.0087	<0.0005 - 0.02 (2 < DL)
Dissolved Metals									
Aluminum	mg/L	-	-	0.0036 - 0.024	0.055 - 0.085	0.0073 - 0.0660	0.0100 - 0.0094	0.0063 - 0.018	0.0037 - 0.0170
Antimony	mg/L	-	-	<0.0002 - 0.0002 (15 < DL)	<0.0002 (4 < DL)	<0.0002 (17 < DL)	<0.0002 (2 < DL)	<0.0002 (3 < DL)	<0.0002 - 0.0005 (9 < DL)
Arsenic	µg/L	-	-	0.1 - 0.5	0.1 - 0.2	0.1 - 0.3	<0.1 - 0.1 (1 < DL)	0.1	<0.1 - 0.2 (3 < DL)
Barium	mg/L	-	-	0.03 - 0.09	0.054 - 0.096	0.024 - 0.088	0.023	0.048 - 0.056	0.013 - 0.095
Beryllium	mg/L	-	-	<0.0001 (16 < DL)	<0.0001 (4 < DL)	<0.0001 (17 < DL)	<0.0001 (2 < DL)	<0.0001 (3 < DL)	<0.0001 (10 < DL)
Boron	mg/L	-	-	<0.01 - 0.04 (15 < DL)	<0.01 (4 < DL)	<0.01 (17 < DL)	<0.01 (2 < DL)	<0.01 (3 < DL)	<0.01 (10 < DL)
Cadmium	mg/L	-	-	<0.00001 - <0.0001 (16 < DL)	<0.00001 - 0.0001 (3 < DL)	<0.00001 - 0.0001 (11 < DL)	<0.0001 (2 < DL)	<0.00001 - <0.0001 (3 < DL)	<0.0001 (10 < DL)
Chromium	mg/L	-	-	<0.0005 (16 < DL)	<0.0005 - 0.0007 (3 < DL)	<0.0005 - 0.0005 (15 < DL)	<0.0005 (2 < DL)	<0.0005 (3 < DL)	<0.0005 - 0.0044 (9 < DL)
Cobalt	mg/L	-	-	<0.0001 - 0.0001 (14 < DL)	<0.0001 - 0.0005 (3 < DL)	<0.0001 - 0.0001 (13 < DL)	<0.0001 (2 < DL)	<0.0001 - 0.0001 (2 < DL)	<0.0001 - 0.0001 (8 < DL)
Copper	mg/L	-	-	0.0006 - 0.0038	0.0011 - 0.0035	0.0005 - 0.0016	0.0007 - 0.0008	0.0009 - 0.0012	0.0006 - 0.0013
Iron	mg/L	-	-	0.0092 - 0.15	0.034 - 0.094	0.013 - 0.350	0.023 - 0.035	0.02 - 0.045	0.0057 - 0.17
Lead	mg/L	-	-	<0.0001 - 0.0008 (11 < DL)	<0.0001 - 0.0001 (2 < DL)	<0.0001 - 0.0002 (8 < DL)	<0.0001 - 0.0001 (1 < DL)	<0.0001 - 0.0001 (1 < DL)	<0.0001 - 0.0001 (7 < DL)
Manganese	mg/L	-	-	<0.0005 - 0.0150 (2 < DL)	0.0006 - 0.0023	0.0012 - 0.0130	0.0006 - 0.0029	0.0006 - 0.0018	<0.0005 - 0.0036 (1 < DL)
Molybdenum	mg/L	-	-	<0.0001 - 0.0004 (9 < DL)	<0.0001 - 0.0003 (2 < DL)	<0.0001 - 0.0002 (3 < DL)	<0.0001 - 0.0001 (1 < DL)	<0.0001 - 0.0001 (2 < DL)	<0.0001 - 0.0002 (6 < DL)
Nickel	mg/L	-	-	0.0003 - 0.0007	0.0009 - 0.0016	0.0003 - 0.0011	0.0004 - 0.0005	0.0004 - 0.0005	0.0002 - 0.0009
Selenium	mg/L	-	-	<0.0001 - 0.0002 (10 < DL)	0.0001	<0.0001 - 0.0003 (5 < DL)	<0.0001 - 0.0002 (1 < DL)	<0.0001 - 0.0002 (1 < DL)	<0.0001 - 0.0002 (7 < DL)
Silver	mg/L	-	-	<0.0001 (16 < DL)	<0.0001 (4 < DL)	<0.0001 (17 < DL)	<0.0001 (2 < DL)	<0.0001 (3 < DL)	<0.0001 (10 < DL)
Strontium	mg/L	-	-	0.012 - 0.052	0.013 - 0.031	0.010 - 0.038	0.018 - 0.020	0.049 - 0.059	0.0083 - 0.0940
Thallium	mg/L	-	-	<0.0002 (16 < DL)	<0.0002 (4 < DL)	<0.0002 (17 < DL)	<0.0002 (2 < DL)	<0.0002 (3 < DL)	<0.0002 (10 < DL)
Tin	mg/L	-	-	<0.0001 - 0.0061 (3 < DL)	0.0001 - 0.0016	<0.0001 - 0.0011 (4 < DL)	0.0002 - 0.0005	<0.0001 - 0.0002 (1 < DL)	<0.0001 - 0.0062 (2 < DL)
Titanium	mg/L	-	-	<0.0002 - 0.0005 (9 < DL)	0.0003 - 0.0004	<0.0002 - 0.0005 (11 < DL)	<0.0002 (2 < DL)	<0.0002 - 0.0002 (2 < DL)	<0.0002 - 0.0004 (7 < DL)
Uranium	µg/L	-	-	<0.1 - 0.1 (14 < DL)	<0.1 - 0.2 (2 < DL)	<0.1 (17 < DL)	<0.1 (2 < DL)	<0.1 - 0.1 (2 < DL)	<0.1 - 0.1 (7 < DL)
Vanadium	mg/L	-	-	<0.0001 - 0.0001 (6 < DL)	0.0001	<0.0001 - 0.0001 (8 < DL)	<0.0001 (2 < DL)	<0.0001 (3 < DL)	<0.0001 - 0.0001 (7 < DL)
Zinc	mg/L	-	-	0.0009 - 0.0088	0.0016 - 0.0089	0.0011 - 0.0080	0.0043 - 0.0045	0.0023 - 0.0065	0.0012 - 0.0099

Table 5.3-2 Summary of Water Chemistry Data for Lakes and Streams in the Kiggavik Project Area, 1974-2013

Parameter	Units	Guidelines		Willow Lake Sub-Basin			Lower Lake Sub-Basin		
				All Lakes	Northeast Inflow of Pointer Lake	All Other Streams	Mushroom Lake	Andrew Lake	All Other Lakes
				1979, 1980, 1986, 1988, 1989, 1991, 2007, 2008, 2009	2008, 2009	1988, 2007, 2008, 2009	1991, 2008	2007, 2008, 2009	1991, 2007, 2008
		SSWQO[(a)]	CWQG[(b)]	n = 43[(c)]	n = 4[(c)]	n = 20[(c)]	n = 14[(c)]	n = 3[(c)]	n = 22[(c)]
Radionuclides									
Lead-210	Bq/L	-	-	<0.02 - <0.2[(i)] (25 < DL)	<0.02 - 0.03 (3 < DL)	<0.02 - 0.48 (16 < DL)	<0.02 (2 < DL)	<0.02 (3 < DL)	<0.02 (10 < DL)
Lead-210	pCi/L	-	-	<0.5 - 2 (6 < DL)	-	-	-	-	-
Polonium-210	Bq/L	-	-	<0.005 - 0.037 (15 < DL)	<0.005 - 0.008 (3 < DL)	<0.005 - 0.47 (11 < DL)	<0.005 (2 < DL)	0.007 - 0.010	<0.005 - 0.010 (3 < DL)
Polonium-210 - preconcentrated	Bq/L	-	-	0.0029		-	-	-	-
Polonium-210 - whole water	Bq/L	-	-	-		-	-	-	-
Radium-226	Bq/L	0.11 [(aa)]	-	0.00096 - **0.13** (23 < DL)	<0.005 (4 < DL)	<0.005 - **0.88** (14 < DL)	<0.002 - 0.005 (2 < DL)	<0.005 - 0.007 (2 < DL)	0.002 - 0.008 (7 < DL)
Radium-226	pCi/L	-	-	<0.1 - 1.0 (2 < DL)		-	-	-	-
Radium-226 - preconcentrated	Bq/L	-	-	0.0022		-	<0.002 (2 < DL)	-	<0.002 - 0.002 (1 < DL)
Radium-226 - whole water	Bq/L	-	-	-		-	-	-	-
Thorium	µg/L	-	-	1 - 8		-	-	-	-
Thorium-228	Bq/L	-	-	0.00059 - <0.02 (15 < DL)	<0.01 - 0.01 (3 < DL)	0.0084 - 0.02 (14 < DL)	<0.01 (2 < DL)	<0.01 (2 < DL)	<0.01 (7 < DL)
Thorium-228	pCi/L	-	-	<0.3 (3 < DL)		-	-	-	-
Thorium-228 - preconcentrated	Bq/L	-	-	0.0004		-	-	-	-
Thorium-228 - whole water	Bq/L	-	-	-		-	-	-	-
Thorium-230	Bq/L	-	-	0.000087 - <0.01 (23 < DL)	<0.01 - 0.03 (2 < DL)	<0.01 - 0.45 (16 < DL)	<0.01 - 0.01 (1 < DL)	<0.01 (3 < DL)	<0.01 - 0.01 (9 < DL)
Thorium-230	pCi/L	-	-	<0.3 (3 < DL)		-	-	-	-
Thorium-230 - preconcentrated	Bq/L	-	-	0.002		-	-	-	-
Thorium-230 - whole water	Bq/L	-	-	-		-	-	-	-
Thorium-232	Bq/L	-	-	0.000059 - 0.03 (20 < DL)	<0.01 (4 < DL)	<0.01 - 0.0038 (16 < DL)	<0.01 (2 < DL)	<0.01 (2 < DL)	<0.01 - 0.02 (6 < DL)
Thorium-232	pCi/L	-	-	<0.3 (2 < DL)		-	-	-	-
Thorium-232 - preconcentrated	Bq/L	-	-	<0.00005		-	-	-	-
Thorium-232 - whole water	Bq/L	-	-	-		-	-	-	-

Table 5.3-2 Summary of Water Chemistry Data for Lakes and Streams in the Kiggavik Project Area, 1974-2013

Parameter	Units	Guidelines		Lower Lake Sub-Basin		Caribou Lake Sub-Basin		Judge Sissons Lake Sub-Basin	
				Mushroom/End Grid Stream	All Other Streams	All Lakes	All Streams	Judge Sissons Lake	Inlet of Judge Sissons Lake
				2008	1990, 1991, 2007, 2008	1979, 1980, 1986, 1988, 1989, 1991, 2007, 2008	2007, 2008	1979, 1986, 1988, 1989, 1991, 2008, 2009, 2013	1979, 1980
		SSWQO[a]	CWQG[b]	n = 2[c]	n = 22[c]	n = 41[c]	n = 14[c]	n = 65[c]	n = 3[c]
Conventional Parameters (Field-Measured)									
Dissolved Oxygen	mg/L	6.5 / 9.5[d]	6.5 / 9.5[d]	-	11.98	11.64 - 12.08	12.02 - 12.11	9.88 - 12.86	-
Water Temperature	°C	-	-	5.97 - 7.16	4.12 - 10.55	4.71 - 15.80	4.95 - 12.16	5.60 - 15.16	-
pH	pH units	-	6.5-9.0	6.92 - 7.20	6.93 - 7.54	6.89 - 7.55	6.60 - 7.59	6.4 - 8.35	-
Specific Conductivity	µS/cm	-	-	-	33	11 - 25	7 - 25	21 - 24	-
Conventional Parameters (Laboratory-Measured)									
pH	pH units	-	6.5-9.0	6.88 - 7.13	6.45 - 7.51	5.9 - 7.24	6.43 - 7.26	5.45 - 7.25	-
Specific Conductivity	µS/cm	-	-	20 - 28	12.9 - 46	8.0 - 48	14 - 29	3 - 39	-
Total Alkalinity	mg $CaCO_3$/L	-	-	7 - 10	4 - 22	2 - 14	3 - 16	<1 - 13 (1 < DL)	-
Alkalinity (pH 3.8)	mg $CaCO_3$/L	-	-	-	-	16	-	21	-
Gran alkalinity	mg $CaCO_3$/L	-	-	-	4.3 - 7.5	2.5 - 13.8	-	0.1 - 10.1	-
Total Hardness	mg $CaCO_3$/L	-	-	9 - 13	6 - 22	3.3 - 14	6 - 13	<1 - 13 (1 < DL)	-
Total Dissolved Solids	mg/L	-	-	20 - 34	10 - 42	2 - 35 (1 < DL)	14 - 29	<10 - 33 (1 < DL)	-
Total Suspended Solids	mg/L	-	-	<1 - 1 (1 < DL)	<1 - 8 (4 < DL)	<1 - 4 (6 < DL)	<1 - 3 (3 < DL)	<1 - 2 (20 < DL)	-
Turbidity	NTU	-	-	0.6 - 0.9	0.4 - 6.6	0.7 - 3.1	0.5 - 6.2	0.3 - 2	-
True Colour (Co-Pt)	-	-	-	-	7 - 20	10 - 12	-	<1 - 6 (1 < DL)	-
Chlorophyll a	µg/L	-	-	-	-	-	-	1.48	-
Chlorophyll *a*	mg/m^3	-	-	-	-		-	1 - 2.9	-
Absorbance at 254 nm	-	-	-	-	-	0.079 - 0.109	-	0.060 - 0.063	-
Nutrients									
Ammonia as nitrogen	mg N/L	0.24[f]	0.24[f]	0.04	<0.01 - 0.08 (3 < DL)	<0.01 - 0.08 (4 < DL)	<0.01 - 0.14 (1 < DL)	<0.005 - 0.09 (12 < DL)	-
Nitrate and Nitrite as nitrogen	mg N/L	-	-	<0.01 - 0.01 (1 < DL)	<0.01 - 0.02 (8 < DL)	<0.01 - 0.02 (8 < DL)	<0.01 - 0.02 (6 < DL)	<0.01 - 0.04 (13 < DL)	-
Nitrate[g]	mg N/L	-	13[h]	<0.04 - 0.04 (1 < DL)	<0.01 - 0.01 (6 < DL)	<0.003 - 0.09 (14 < DL)	<0.04 - 0.09 (6 < DL)	0.003 - <0.04 (21 < DL)	-
Nitrite	mg N/L	-	0.197[i]	-	<0.01 - 0.09 (9 < DL)	0.001 - <0.1 (6 < DL)	-	0.001 - <0.1 (10 < DL)	-
Total Kjeldahl Nitrogen	mg N/L	-	-	0.38 - 0.4	0.32 - 0.57	0.16 - 0.62	0.23 - 0.39	0.04 - 1.50	-
Total Nitrogen	mg/L	-	-	0.38 - 0.41	0.34 - 0.57	0.23 - 0.45	0.23 - 0.40	0.18 - 1.50	-
Total Phosphorous	mg/L	-	-	<0.01 - 0.01 (1 < DL)	0.001 - 0.06 (9 < DL)	<0.001 - 0.05 (3 < DL)	<0.01 - 0.04 (9 < DL)	<0.001 - 0.04 (13 < DL)	-
Dissolved Phosphorus	mg/L	-	-	0.01 - 0.02	<0.01 - 0.03 (8 < DL)	<0.01 - 0.05 (3 < DL)	<0.01 - 0.06 (6 < DL)	<0.01 - 0.05 (13 < DL)	-
Soluble Reactive Phosphorous	mg/L	-	-	-	<0.001 (2 < DL)	<0.001 - 0.005 (1 < DL)	-	<0.001 - 0.003 (3 < DL)	-
Orthophosphate-P	mg/L	-	-	-	-	<0.1 (4 < DL)	-	<0.1 (1 < DL)	-
Total Carbon	mg/L	-	-	7 - 11	6 - 15	5 - 10	5 - 11	5 - 10	-
Total Inorganic Carbon	mg/L	-	-	2	1 - 6	2 - 4	1 - 4	2 - 4	-
Total Organic Carbon	mg/L	-	-	5.2 - 8.4	5.1 - 12	3.5 - 6.7	3.8 - 7	2.5 - 7.8	-
Dissolved Inorganic Carbon	mg/L	-	-	-	<0.5 - 3.9 (1 < DL)	0.7 - 3.0	-	<0.5 - 2.5 (1 < DL)	-
Dissolved Organic Carbon	mg/L	-	-	5.2 - 9	4.5 - 13	1.8 - 6.0	2.7 - 6.2	<0.5 - 8.2 (1 < DL)	-
Major Ions									
Bicarbonate	mg/L	-	-	9 - 12	5 - 27	2 - 17	4 - 20	7 - 16	-
Calcium	mg/L	-	-	2.3 - 3.3	1.4 - 5.9	0.85 - 4.3	1.4 - 3.1	0.05 - 3.3	-
Carbonate	mg/L	-	-	<1 (2 < DL)	<1 (15 < DL)	<1 (12 < DL)	<1 (14 < DL)	<1 (19 < DL)	-
Chloride	mg/L	-	120	0.4 - 0.7	0.27 - 3.0	0.17 - 0.65	0.2 - 0.4	0.22 - <1 (1 < DL)	-
Fluoride	mg/L	-	0.12	0.03 - 0.07	0.07 - 0.43	0.01 - 0.07	<0.01 - 0.03 (4 < DL)	<0.01 - 0.11 (2 < DL)	-
Hydroxide	mg/L	-	-	<1 (2 < DL)	<1 (15 < DL)	<1 (12 < DL)	<1 (14 < DL)	<1 (19 < DL)	-
Magnesium	mg/L	-	-	0.8 - 1.2	0.5 - 1.7	0.30 - 1.55	0.6 - 1.2	<0.05 - 1.1 (1 < DL)	-
Potassium	mg/L	-	-	0.4 - 0.9	0.10 - 1.2	0.10 - 0.85	0.1 - 0.6	<0.05 - 0.60 (1 < DL)	-
Silica (as $Si0_2$)	mg/L	-	-	-	0.18	0.26 - 0.74	-	0.05 - 0.16	-
Silicates	mg/L	-	-	-	-	-	-	-	-
Sodium	mg/L	-	-	0.5 - 2.4	0.2 - 3.8 (1 < DL)	0.2 - 5 (7 < DL)	<0.1 - 1.1 (4 < DL)	0.3 - 1.0 (6 < DL)	-
Sulphate	mg/L	-	-	0.7 - 1.3	0.20 - 1.6	<0.2 - 1.1 (1 < DL)	0.3 - 1.1	<0.1 - 1.1 (1 < DL)	-
Sum of Ions	mg/L	-	-	17 - 19	9 - 37	7 - 24	8 - 26	12 - 21	-
Sum of ions	%	-	-	-	-	-	-	-	-

Table 5.3-2 Summary of Water Chemistry Data for Lakes and Streams in the Kiggavik Project Area, 1974-2013

Parameter	Units	Guidelines		Lower Lake Sub-Basin		Caribou Lake Sub-Basin		Judge Sissons Lake Sub-Basin	
				Mushroom/End Grid Stream	All Other Streams	All Lakes	All Streams	Judge Sissons Lake	Inlet of Judge Sissons Lake
				2008	1990, 1991, 2007, 2008	1979, 1980, 1986, 1988, 1989, 1991, 2007, 2008	2007, 2008	1979, 1986, 1988, 1989, 1991, 2008, 2009, 2013	1979, 1980
		SSWQO[a]	CWQG[b]	n = 2[c]	n = 22[c]	n = 41[c]	n = 14[c]	n = 65[c]	n = 3[c]
Total Metals									
Aluminum[k]	mg/L	0.005-0.1 [l]	0.005-0.1 [l]	0.032 - 0.056	0.01 - 0.067	0.013 - **0.12**	0.012 - **0.19**	0.0013 - 0.0420 (6 < DL)	-
Antimony	mg/L	-	-	<0.0002 (2 < DL)	<0.0002 (15 < DL)	<0.0002 (12 < DL)	<0.0002 (14 < DL)	<0.0002 (19 < DL)	-
Arsenic	µg/L	5	5	0.1 - 0.2	<0.1 - 2 (11 < DL)	<0.1 - <2 (9 < DL)	0.1 - 0.2	<0.1 - 2 (8 < DL)	<0.2 - <0.5 (2 < DL)
Barium	mg/L	-	-	0.022 - 0.027	0.019 - 0.096	0.025 - 0.1	0.028 - 0.072	<0.01 - 0.04 (1 < DL)	-
Beryllium	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 (15 < DL)	<0.0001- <0.005 (16 < DL)	<0.0001 (14 < DL)	<0.0001 - <0.005 (20 < DL)	-
Boron	mg/L	-	1.5	<0.01 (2 < DL)	<0.01 (15 < DL)	<0.01 (12 < DL)	<0.01 (14 < DL)	<0.01 - 0.03 (18 < DL)	-
Bromide	mg/L	-	-	-	<0.05 (5 < DL)	-	-	-	-
Cadmium[k]	mg/L	0.000017-0.000032 [m]	0.00004-0.00011 [n]	*<0.0001* (2 < DL)	*<0.0001 - <0.002*[l] (20 < DL)	*<0.0001* - **0.002** (16 < DL)	*<0.0001* (14 < DL)	<0.00001 - *< 0.01*[l] (24 < DL)	*<0.0005* - **0.002** (1 < DL)
Cadmium (low levels)[o]	ng/L	17-32[m]	40-110[n]	-	-	-	-	0.972 - 2.554 (n = 15)	-
Chromium[k]	mg/L	0.001 [p]	0.0010/0.0089 [q]	<0.0005 (2 < DL)	<0.0005 - *<0.01* (21 < DL)	<0.0005 - **0.005** (17 < DL)	<0.0005 - **0.0520** (12 < DL)	<0.0005 - <0.01[l] (24 < DL)	<0.0005 (2 < DL)
Cobalt	mg/L	-	-	<0.0001 - 0.0001 (1 < DL)	<0.0001- <0.01[l] (15 < DL)	<0.0001 - 0.01 (17 < DL)	<0.0001 - 0.0001 (10 < DL)	<0.0001 - <0.01[l] (23 < DL)	-
Copper[k]	mg/L	0.002 [r]	0.002 [r]	0.0007 - 0.0010	0.0005 - *<0.005* (7 < DL)	<0.0005 - **0.0148**[s] (6 < DL)	0.0005 - 0.0014	0.00012[s] - *<0.005* (6 < DL)	0.00011[s] - 0.0012
Iron	mg/L	0.3	0.3	0.066 - 0.160	0.058 - **0.400**	0.04 - 0.16	0.045 - 0.190	0.013 - 0.14 (5 < DL)	-
Lead[k]	mg/L	0.001 - 0.002 [t]	0.00100 - 0.00180 [t]	<0.0001 (2 < DL)	<0.0001 - *<0.02*[l] (15 < DL)	<0.0001 - **0.84** (8 < DL)	<0.0001 - 0.0001 (9 < DL)	<0.0001 - *<0.05*[l] (14 < DL)	**0.002** - **0.011**
Manganese	mg/L	-	-	0.0043 - 0.0083	0.0018 - 0.013 (7 < DL)	0.0006 - 0.0120 (4 < DL)	0.002 - 0.019	<0.002 - 0.02 (3 < DL)	-
Mercury[k, u]	µg/L	0.026 [v]	0.026 [w]	*<0.05* (2 < DL)	*<0.05* (22 < DL)	<0.02 - *<10*[l] (18 < DL)	*<0.05* (14 < DL)	<0.005 - *<10* (26 < DL)	0.01
Molybdenum	mg/L	-	0.073	<0.0001 (2 < DL)	<0.0001 - 0.0003 (10 < DL)	<0.0001 - <0.01[l] (10 < DL)	<0.0001 - 0.0002 (7 < DL)	<0.0001 - <0.01[l] (15 < DL)	-
Nickel	mg/L	0.025 - 0.065 [x]	0.025 - 0.06889 [x]	0.0005 - 0.0008	0.0003 - <0.01 (7 < DL)	0.0004 - <0.01 (6 < DL)	0.0004 - 0.0011	0.0002 - <0.01 (6 < DL)	-
Selenium	mg/L	0.001[y]	0.001[y]	<0.0001 (2 < DL)	<0.0001 - 0.0001 (13 < DL)	<0.0001 - 0.0001 (11 < DL)	<0.0001 - 0.0001 (11 < DL)	<0.0001 - 0.0001 (12 < DL)	-
Selenium [k]	µg/L	1 [y]	1.0 [y]	-	*<1* - <2 (7 < DL)	<0.1 - <2 (7 < DL)	-	<0.1 - <2 (7 < DL)	<0.5 (1 < DL)
Silicon	mg/L	-	-	-	0.18 - 0.52	-	-	-	-
Silver[k]	mg/L	0.0001	0.0001	*<0.0001* (2 < DL)	*<0.0001 - <0.005* (22 < DL)	<0.00001 - *<0.0001*[l] (17 < DL)	*<0.0001* (14 < DL)	<0.00005 - **0.0002** (22 < DL)	-
Strontium	mg/L	-	-	0.015 - 0.020	0.01 - 0.09	<0.00001 - 0.03 (2 < DL)	0.010 - 0.020	<0.01 - 0.022 (1 < DL)	-
Tellurium	µg/L	-	-	-	-	<2 (1 < DL)	-	<2 (1 < DL)	<2 (1 < DL)
Thallium	mg/L	-	0.0008	<0.0002 (2 < DL)	<0.0002 (15 < DL)	<0.0002 (12 < DL)	<0.0002 (14 < DL)	<0.0002 (19 < DL)	-
Tin	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 - 0.0002 (12 < DL)	<0.0001 - 0.0022 (10 < DL)	<0.0001 - 0.0001 (13 < DL)	<0.0001 - 0.0018 (10 < DL)	-
Titanium	mg/L	-	-	0.0004 - 0.0005	<0.0002 - 0.0029 (1 < DL)	0.0002 - 0.0017	0.0002 - 0.00028	<0.0002 - 0.0013 (9 < DL)	-
Uranium	µg/L	15	15	<0.1 (2 < DL)	<0.1 - <0.5[l] (16 < DL)	<0.1 - <0.5 (16 < DL)	<0.1 - 0.1 (13 < DL)	<0.1 - 1.1 (22 < DL)	<0.5 (3 < DL)
Uranium - preconcentrated	µg/L	-	-	-	-	-	-	0.08 - 0.5	-
Uranium - whole water	µg/L	-	-	-	-	0.005	-	0.5	-
Vanadium	mg/L	-	-	<0.0001 - 0.0001 (1 < DL)	<0.0001 - 0.0002 (5 < DL)	<0.0001 - <0.01[l] (7 < DL)	<0.0001 - 0.0002 (5 < DL)	<0.0001 - <0.005[l] (18 < DL)	-
Zinc	mg/L	0.03	0.03	0.0031 - 0.0037	0.0009 - 0.01 (6 < DL)	<0.00001 - **8.53** (8 < DL)	0.0007 - 0.0084	<0.00001 - **0.08** (6 < DL)	0.0016 - **0.07**
Dissolved Metals									
Aluminum	mg/L	-	-	0.026 - 0.037	0.0056 - 0.0550	0.0085 - 0.0700	0.0072 - 0.1100	<0.0005 - 0.0240 (1 < DL)	-
Antimony	mg/L	-	-	<0.0002 (2 < DL)	<0.0002 (15 < DL)	<0.0002 (12 < DL)	<0.0002 (14 < DL)	<0.0002 (16 < DL)	-
Arsenic	µg/L	-	-	0.1 - 0.2	<0.1 - 0.2 (7 < DL)	0.1 - 0.3	<0.1 - 0.2 (1 < DL)	<0.1 -0.2 (4 < DL)	-
Barium	mg/L	-	-	0.021 - 0.027	0.019 - 0.093	0.028 - 0.074	0.028 - 0.069	0.023 - 0.032	-
Beryllium	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 (15 < DL)	<0.0001 (12 < DL)	<0.0001 (14 < DL)	<0.0001 (16 < DL)	-
Boron	mg/L	-	-	<0.01 (2 < DL)	<0.01 (15 < DL)	<0.01 (12< DL)	<0.01 (14 < DL)	<0.01 (16 < DL)	-
Cadmium	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 - 0.0001 (14 < DL)	<0.0001 (2 < DL)	<0.0001 (14 < DL)	<0.00001 - <0.0001 (16 < DL)	-
Chromium	mg/L	-	-	<0.0005 (2 < DL)	<0.0005 - 0.0032 (12 < DL)	<0.0005 - 0.0016 (11 < DL)	<0.0005 (14 < DL)	<0.0005 - 0.0017 (14 < DL)	-
Cobalt	mg/L	-	-	<0.0001 - 0.0001 (1 < DL)	<0.0001 - 0.0001 (10 < DL)	<0.0001 - 0.0001 (10 < DL)	<0.0001 - 0.0002 (12 < DL)	<0.0001 - 0.0001 (15 < DL)	-
Copper	mg/L	-	-	0.0008 - 0.0011	0.0005 - 0.0016	0.0006 - 0.0017	0.0006 - 0.0014	0.0002 - 0.0010	-
Iron	mg/L	-	-	0.045 - 0.120	0.045 - 0.140	0.011 - 0.110	0.020 - 0.096	0.0033 - 0.0590	-
Lead	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 - 0.0001 (9 < DL)	<0.0001 - 0.0002 (5 < DL)	<0.0001 - 0.0001 (12 < DL)	<0.0001 - 0.0002 (7 < DL)	-
Manganese	mg/L	-	-	0.0034- 0.0055	0.0016 - 0.0100	<0.0005 - 0.0033 (3 < DL)	0.001 - 0.016	<0.0005 - 0.0120 (4 < DL)	-
Molybdenum	mg/L	-	-	<0.0001 - 0.0001 (1 < DL)	<0.0001 - 0.0002 (7 < DL)	<0.0001 - 0.0004 (6 < DL)	<0.0001 - 0.0002 (9 < DL)	<0.0001 - 0.0001 (11 < DL)	-
Nickel	mg/L	-	-	0.0005 - 0.0008	0.0003 - 0.0012	0.0004 - 0.0010	0.0004 - 0.001	0.0002 - 0.0008	-
Selenium	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 - 0.0002 (6 < DL)	<0.0001 - 0.0001 (10 < DL)	<0.0001 - 0.0003 (11 < DL)	<0.0001 - 0.0001 (13 < DL)	-
Silver	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 (15 < DL)	<0.0001 (12 < DL)	<0.0001 (14 < DL)	<0.0001 (16 < DL)	-
Strontium	mg/L	-	-	0.015 - 0.020	0.011 - 0.091	0.012 - 0.021	0.01 - 0.02	0.0100 - 0.0220	-
Thallium	mg/L	-	-	<0.0002 (2 < DL)	<0.0002 (15 < DL)	<0.0002 (12 < DL)	<0.0002 (14 < DL)	<0.0002 (16 < DL)	-
Tin	mg/L	-	-	0.0001	<0.0001 - 0.0012 (1 < DL)	<0.0001 - 0.0022 (8 < DL)	<0.0001 - 0.0260 (6 < DL)	<0.0001 - 0.0061 (3 < DL)	-
Titanium	mg/L	-	-	<0.0002 - 0.0004 (1 < DL)	<0.0002 - 0.0003 (7 < DL)	<0.0002 - 0.0009 (7 < DL)	<0.0002 - 0.0013 (7 < DL)	<0.0002 - 0.0002 (15 < DL)	-
Uranium	µg/L	-	-	<0.1 (2 < DL)	<0.1 - 0.2 (11 < DL)	<0.1 (12 < DL)	<0.1 (14 < DL)	<0.1 - 0.1 (15 < DL)	-
Vanadium	mg/L	-	-	<0.0001 - 0.0001 (1 < DL)	<0.0001 - 0.0001 (9 < DL)	<0.0001 - 0.0002 (7 < DL)	<0.0001 - 0.0001 (10 < DL)	<0.0001 - 0.0001 (15 < DL)	-
Zinc	mg/L	-	-	0.0023 - 0.0027	0.0024 - 0.0110	0.0024 - 0.0180	0.0017 - 0.0097	<0.0005 - 0.0110 (1 < DL)	-

Table 5.3-2 Summary of Water Chemistry Data for Lakes and Streams in the Kiggavik Project Area, 1974-2013

Parameter	Units	Guidelines		Lower Lake Sub-Basin		Caribou Lake Sub-Basin		Judge Sissons Lake Sub-Basin	
				Mushroom/End Grid Stream	All Other Streams	All Lakes	All Streams	Judge Sissons Lake	Inlet of Judge Sissons Lake
				2008	1990, 1991, 2007, 2008	1979, 1980, 1986, 1988, 1989, 1991, 2007, 2008	2007, 2008	1979, 1986, 1988, 1989, 1991, 2008, 2009, 2013	1979, 1980
		SSWQO[a]	CWQG[b]	n = 2[c]	n = 22[c]	n = 41[c]	n = 14[c]	n = 65[c]	n = 3[c]
Radionuclides									
Lead-210	Bq/L	-	-	<0.02 (2 < DL)	<0.02 - 0.08 (19 < DL)	<0.02 - <0.04 (14 < DL)	<0.02 (14 < DL)	<0.02 - <0.03 (20 < DL)	0.026 - 0.04 (1 < DL)
Lead-210	pCi/L	-	-	-	-	<0.5 - <1 (2 < DL)	-	<1 (1 < DL)	<0.5 - 1 (1 < DL)
Polonium-210	Bq/L	-	-	<0.005 - 0.009 (1 < DL)	<0.005 - 0.04 (8 < DL)	<0.005 - 0.007 (11 < DL)	<0.005 - 0.030 (8 < DL)	<0.005 - <0.05 (20 < DL)	-
Polonium-210 - preconcentrated	Bq/L	-	-	-	-	-	-	0.0026	-
Polonium-210 - whole water	Bq/L	-	-	-	-	-	-	-	-
Radium-226	Bq/L	0.11 [aa]	-	0.006 - 0.007	<0.002 - 0.010 (17 < DL)	0.0008 - 0.037 (11 < DL)	<0.005 - 0.008 (7 < DL)	<0.0015 - <0.02[f] (20 < DL)	<0.004 - 0.03 (1 < DL)
Radium-226	pCi/L	-	-	-	-	<0.2 - 1.0 (1 < DL)	-	0.3	<0.1 - 0.8 (1 < DL)
Radium-226 - preconcentrated	Bq/L	-	-	-	-	-	-	0.0004 - <0.002 (2 < DL)	-
Radium-226 - whole water	Bq/L	-	-	-	-	-	-	-	-
Thorium	µg/L	-	-	-	-	<1 (1 < DL)	-	<1 (1 < DL)	<1 (1 < DL)
Thorium-228	Bq/L	-	-	<0.01 - 0.01 (1 < DL)	<0.01 - 0.01 (10 < DL)	<0.01 - 0.01 (8 < DL)	<0.01 - 0.01 (10 < DL)	0.0012 - <0.01 (19 < DL)	<0.01 (1 < DL)
Thorium-228	pCi/L	-	-	-	-	<0.3 (1 < DL)	-	-	<0.3 (2 < DL)
Thorium-228 - preconcentrated	Bq/L	-	-	-	-	-	-	0.0002	-
Thorium-228 - whole water	Bq/L	-	-	-	-	-	-	-	-
Thorium-230	Bq/L	-	-	<0.01 (2 < DL)	<0.01 - <0.02[f] (19 < DL)	<0.01 - 0.01 (12 < DL)	<0.01 - 0.02 (11 < DL)	0.00025 - <0.01 (20 < DL)	<0.01 (1 < DL)
Thorium-230	pCi/L	-	-	-	-	<0.3 (1 < DL)	-	-	<0.3 (2 < DL)
Thorium-230 - preconcentrated	Bq/L	-	-	-	-	-	-	0.00026	-
Thorium-230 - whole water	Bq/L	-	-	-	-	-	-	-	-
Thorium-232	Bq/L	-	-	<0.01 (2 < DL)	<0.01 (14 < DL)	<0.01 - <0.04[f] (10 < DL)	<0.01 - 0.01 (11 < DL)	0.00012 - <0.01 (19 < DL)	<0.004 - <0.01 (3 < DL)
Thorium-232	pCi/L	-	-	-	-	<0.3 (1 < DL)	-	-	<0.3 (2 < DL)
Thorium-232 - preconcentrated	Bq/L	-	-	-	-	-	-	0.00002	-
Thorium-232 - whole water	Bq/L	-	-	-	-	-	-	-	-

Table 5.3-2 Summary of Water Chemistry Data for Lakes and Streams in the Kiggavik Project Area, 1974-2013

Parameter	Units	Guidelines		Aniguq River Sub-Basin	Siamese Lake Sub-Basin	Skinny Lake Sub-Basin	Kavisilik Lake Sub-Basin	Squiggly Lake Sub-Basin	Baker Lake Sub-Basin
				Aniguq River	Siamese Lake	Skinny Lake	Kavisilik Lake	Squiggly Lake	Baker Lake
				1980, 2009	2008	1986, 1988, 1989, 2007, 2008	1980	1980, 2008, 2013	1974-1982[z], 1989[z], 2008, 2009
		SSWQO[a]	CWQG[b]	n = 3[c]	n = 2[c]	n = 7[c]	n = 1[c]	n = 4[c]	n = 17[c]
Conventional Parameters (Field-Measured)									
Dissolved Oxygen	mg/L	6.5 / 9.5[d]	6.5 / 9.5[d]	11.54 - 12.29	-	11.65	-	11.3	-
Water Temperature	°C	-	-	10.02 - 10.31	10.61 - 10.76	8.01 - 8.36	-	7.9 - 8.68	-
pH	pH units	-	6.5-9.0	7.92 - 8.09	6.62 - 6.79	6.86 - 7.14	-	6.4 - 6.58	-
Specific Conductivity	µS/cm	-	-	28 - 30	-	16	-	14	-
Conventional Parameters (Laboratory-Measured)									
pH	pH units	-	6.5-9.0	7.18 - 7.2	6.88 - 7.03	6.1 - 7.06	-	6.61 - 6.72	5.6 - 7.2
Specific Conductivity	µS/cm	-	-	29 - 30	15	11.3 - 25	-	13 - 14	32 - 2180
Total Alkalinity	mg $CaCO_3$/L	-	-	13 - 22	6	<1 - 8 (1 < DL)	-	5	3.0 - 12.0
Alkalinity (pH 3.8)	mg $CaCO_3$/L	-	-	-	-	14 - 15	-	-	-
Gran alkalinity	mg $CaCO_3$/L	-	-	-	-	4.5 - 9	-	-	8.9 - 9.6
Total Hardness	mg $CaCO_3$/L	-	-	11 - 12	6 - 7	5 - 7	-	6	18.5 - 64
Total Dissolved Solids	mg/L	-	-	26 - 29	12	6 - 60 (1 < DL)	-	8 - 12	17 - 1040
Total Suspended Solids	mg/L	-	-	<1 - 2 (1 < DL)	<1 - 1 (1 < DL)	<1 - 10 (2 < DL)	-	<1 (3 < DL)	<2 - 6 (1 < DL)
Turbidity	NTU	-	-	38 - 40	0.4 - 0.5	0.49 - 0.9	-	0.4 - 0.5	-
True Colour (Co-Pt)	-	-	-	-	-	9 - 14	-	-	7 - 10
Chlorophyll a	µg/L	-	-	-	-	-	-	-	-
Chlorophyll a	mg/m^3	-	-	0.5 - 2.6					
Absorbance at 254 nm	-	-	-	-	-	0.086 - 0.118	-	-	0.073
Nutrients									
Ammonia as nitrogen	mg N/L	0.24[f]	0.24[f]	<0.01 - 0.04 (1 < DL)	0.02 - 0.07	<0.01 - 0.08 (1 < DL)	-	<0.01 (3 < DL)	<0.01 - 0.09 (1 < DL)
Nitrate and Nitrite as nitrogen	mg N/L	-	-	-	<0.01 (2 < DL)	<0.01 - 0.01 (1 < DL)		<0.01 (3 < DL)	<0.01 (9 < DL)
Nitrate[g]	mg N/L	-	13[h]	-	<0.04 (2 < DL)	<0.003 - 0.06 (4 < DL)	-	<0.04 (3 < DL)	0.02 - 0.09
Nitrite	mg N/L	-	0.197[i]	-	-	<0.001 - <0.1[i] (2 < DL)	-	<0.03 (2 < DL)	0.003
Total Kjeldahl Nitrogen	mg N/L	-	-	0.33 - 0.35	0.1 - 0.11	0.12 - 0.38	-	0.17 - 0.49	0.23 - 41 (1 < DL)
Total Nitrogen	mg/L	-	-	-	0.1 - 0.11	0.19		0.17 - 0.49	
Total Phosphorous	mg/L	-	-	<0.01 - 0.04 (1 < DL)	<0.01 - 0.02 (1 < DL)	0.002 - 0.01 (1 < DL)	-	<0.01 (3 < DL)	<0.003 to 0.033 (7 < DL)
Dissolved Phosphorus	mg/L	-	-	<0.01 - 0.03 (1 < DL)	<0.01 - 0.04 (1 < DL)	<0.01 (1 < DL)		<0.01 - 0.01 (2 < DL)	
Soluble Reactive Phosphorous	mg/L	-	-	-	-	<0.001 (4 < DL)	-	-	<0.001 (3 < DL)
Orthophosphate-P	mg/L	-	-	-	-	<0.1 (1 < DL)	-	-	<0.01 (9 < DL)
Total Carbon	mg/L	-	-	7 - 8	4	5		3	
Total Inorganic Carbon	mg/L	-	-	3 - 5	2	2		1	
Total Organic Carbon	mg/L	-	-	2.9 - 3.9	2 - 2.3	3.2 - 4.0	-	1.9 - 2.2	2.1 - 3.6
Dissolved Inorganic Carbon	mg/L	-	-	-	-	1.1 - 2.5	-	-	2.1 - 2.2
Dissolved Organic Carbon	mg/L	-	-	3.1 - 4	2.1 - 2.4	2.2 - 4.5	-	1.3 - 2.2	2.6 - 2.7
Major Ions									
Bicarbonate	mg/L	-	-	16 - 27	7	<1 - 10 (1 < DL)	-	6	10 - 15
Calcium	mg/L	-	-	3.1 - 3.3	1.7 - 1.8	1.40 - 2.65	-	1.4 - 1.5	1.8 - 24
Carbonate	mg/L	-	-	<1 (2 < DL)	<1 (2 < DL)	<1 (2 < DL)	-	<1 (3 < DL)	-
Chloride	mg/L	-	120	0.8 - 1.7	0.4	0.25 - 0.42	-	0.3	3.2 - 580
Fluoride	mg/L	-	0.12	0.04 - 0.05	<0.01 (2 < DL)	0.11 - 0.18	-	<0.01 - 0.04 (1 < DL)	0.05 - 0.08
Hydroxide	mg/L	-	-	<1 (2 < DL)	<1 (2 < DL)	<1 (2 < DL)	-	<1 (3 < DL)	-
Magnesium	mg/L	-	-	0.8 - 1	0.5	0.50 - 0.95	-	0.5	1.7 - 12
Potassium	mg/L	-	-	0.4	0.2 - 0.3	0.15 - 0.40	-	0.2 - 0.3	0.5 - 12
Silica (as Si0_2)	mg/L	-	-	-	-	0.24 - 0.6	-	-	0.44 - 0.52
Silicates	mg/L	-	-	-	-	0.47	-	-	-
Sodium	mg/L	-	-	0.6 - 1.1	0.3	0.4 - 0.50 (4 < DL)	-	0.3	5.8 - 94
Sulphate	mg/L	-	-	0.7 - 0.8	0.5 - 0.6	0.40 - 0.65	-	0.5	1.7 - 68
Sum of Ions	mg/L	-	-	23 - 35	11	4 - 14	-	9	-
Sum of ions	%	-	-	-	-	-	-	-	-

Table 5.3-2 Summary of Water Chemistry Data for Lakes and Streams in the Kiggavik Project Area, 1974-2013

Parameter	Units	Guidelines		Aniguq River Sub-Basin	Siamese Lake Sub-Basin	Skinny Lake Sub-Basin	Kavisilik Lake Sub-Basin	Squiggly Lake Sub-Basin	Baker Lake Sub-Basin
				Aniguq River	Siamese Lake	Skinny Lake	Kavisilik Lake	Squiggly Lake	Baker Lake
				1980, 2009	2008	1986, 1988, 1989, 2007, 2008	1980	1980, 2008, 2013	1974-1982[z], 1989[z], 2008, 2009
		SSWQO[a]	CWQG[b]	n = 3[c]	n = 2[c]	n = 7[c]	n = 1[c]	n = 4[c]	n = 17[c]
Total Metals									
Aluminum[k]	mg/L	0.005-0.1 [l]	0.005-0.1 [l]	0.0074 - 0.0130	0.0036 - 0.0040	0.0099 - 0.055	-	**0.0066** - **0.0080**	0.0039 - **0.11** (1 < DL)
Antimony	mg/L	-	-	<0.0002 (2 < DL)	<0.0002 (2 < DL)	<0.0002 (2 < DL)	-	<0.0002 (3 < DL)	-
Arsenic	µg/L	5	5	0.1 - 0.2 (1 < DL)	<0.1 - 0.1 (1 < DL)	<0.1 - <2[l] (4 < DL)	<0.2	<0.1 - <0.2 (3 < DL)[l]	<0.1 - <1[l] (6 < DL)
Barium	mg/L	-	-	0.027 - 0.034	0.049 - 0.050	0.03 - 0.06	-	0.021	0.018 to 0.1 (1 < DL)
Beryllium	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 (2 < DL)	<0.0001 - <0.005 (3 < DL)	-	<0.0001 (3 < DL)	-
Boron	mg/L	-	1.5	<0.01 (2 < DL)	<0.01 (2 < DL)	<0.01 (2 < DL)	-	<0.01 (3 < DL)	-
Bromide	mg/L	-	-	-	-	-	-	-	-
Cadmium[k]	mg/L	0.000017-0.000032 [m]	0.00004-0.00011 [n]	<0.00001 (2 < DL)	*<0.0001* (2 < DL)	*<0.0001* - **0.0008** (3 < DL)	**0.002**	<0.00001 - *<0.0001* (3 < DL)	*<0.0001* - **0.001** (15 < DL)
Cadmium (low levels) [o]	ng/L	17-32 [m]	40-110 [n]					1.212 - 1.886 (n = 5)	-
Chromium[k]	mg/L	0.001 [p]	0.0010/0.0089 [q]	<0.0005 (3 < DL)	<0.0005 (2 < DL)	<0.0005 - *<0.01*[l] (5 < DL)	<0.0005	<0.0005 (4 < DL)	<0.0005 - **0.01** (16 < DL)
Cobalt	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 (2 < DL)	<0.0001 - <0.01 (6 < DL)	-	<0.0001 (3 < DL)	<0.001 - 0.001 (3 < DL)
Copper[k]	mg/L	0.002 [r]	0.002 [r]	0.0003 - 0.0008	0.0002 - 0.0003	<0.0005 - *<0.005*[l] (3 < DL)	0.0008	<0.0002 - 0.0008 (2 < DL)	<0.0002 - 0.001 (6 < DL)
Iron	mg/L	0.3	0.3	0.029 - 0.041	0.014 - 0.018	0.025 - 0.08	-	0.0092 - 0.014	0.0012 - 0.16 (1 < DL)
Lead[k]	mg/L	0.001 - 0.002 [t]	0.00100 - 0.00180 [t]	<0.0001 (2 < DL)	<0.0001 (2 < DL)	<0.0001 - *<0.05*[l] (5 < DL)	**0.002**	<0.0001 - **0.0020** (3 < DL)	<0.0001 - **0.005** (13 < DL)
Manganese	mg/L	-	-	0.0025 - 0.0039	0.0027 - 0.0032	0.0024 - 0.016 (1 < DL)	-	0.0012 - 0.0016	0.008 - 0.012 (1 < DL)
Mercury[k, u]	µg/L	0.026 [v]	0.026 [w]	<0.02 (2 < DL)	*<0.05* (2 < DL)	*<0.05* (5 < DL)	**0.05**	<0.01 - *<0.05* (4 < DL)	*<0.05* (3 < DL)
Molybdenum	mg/L	-	0.073	0.0001	<0.0001 (2 < DL)	<0.0001 - <0.01[l] (1 < DL)	-	<0.0001 (3 < DL)	<0.0001 - 0.0001 (3 < DL)
Nickel	mg/L	0.025 - 0.065 [x]	0.025 - 0.06889 [x]	0.0002 - 0.0003	0.0002	0.0003 - <0.01 (3 < DL)	-	0.0002	<0.0001 - 0.005 (7 < DL)
Selenium	mg/L	0.001[y]	0.001[y]	<0.0001 - 0.0001 (1 < DL)	<0.0001 (2 < DL)	<0.0001 - 0.0001 (1 < DL)	-	<0.0001 (3 < DL)	<0.0001 - 0.0002 (8 < DL)
Selenium [k]	µg/L	1 [y]	1.0 [y]	-	-	<0.1 (3 < DL)	-	-	<0.1 - 0.1 (1 < DL)
Silicon	mg/L	-	-	-	-	-	-	-	-
Silver[k]	mg/L	0.0001	0.0001	*<0.0001* (2 < DL)	*<0.0001* (2 < DL)	*<0.0001* (5 < DL)	-	<0.00005 - *<0.0001* (3 < DL)	*<0.0001* (16 < DL)
Strontium	mg/L	-	-	0.015 - 0.016	0.013 -0.014	<0.00001 - 0.013 (1 < DL)	-	0.0068 - 0.0073	0.00003 - 0.085
Tellurium	µg/L	-	-	-	-	-	-	-	-
Thallium	mg/L	-	0.0008	<0.0002 (2 < DL)	<0.0002 (2 < DL)	<0.0002 (2 < DL)	-	<0.0002 (3 < DL)	<0.0002 (13 < DL)
Tin	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 - 0.0001 (1 < DL)	<0.0001 - 0.0021 (1 < DL)	-	<0.0001 - 0.0003 (1 < DL)	-
Titanium	mg/L	-	-	<0.0002 (2 < DL)	<0.0002 (2 < DL)	<0.0002 - 0.0004 (1 < DL)	-	<0.0002 (3 < DL)	-
Uranium	µg/L	15	15	<0.1 - <0.5 (3 < DL)	<0.1 (2 < DL)	<0.1 - 0.5 (4 < DL)	<0.5	<0.1 - <0.5 (4 < DL)	<0.1 (13 < DL)
Uranium - preconcentrated	µg/L	-	-	-	-	-	-	-	0.37
Uranium - whole water	µg/L	-	-	-	-	-	-	-	0.5
Vanadium	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 (2 < DL)	<0.0001 - <0.005 (3 < DL)	-	<0.0001 (3 < DL)	<0.001 - 0.003 (1 < DL)
Zinc	mg/L	0.03	0.03	0.0015 - 0.0020	0.0058 - 0.0068	<0.00001 - 0.0050 (4 < DL)	0.0028	0.0021 - **4.6**	<0.0005 - 0.012 (6 < DL)
Dissolved Metals									
Aluminum	mg/L	-	-	0.0025 - 0.0059	0.0013 - 0.0016	0.0065 - 0.0098	-	0.0036	-
Antimony	mg/L	-	-	<0.0002 (2 < DL)	<0.0002 (2 < DL)	<0.0002 (2 < DL)	-	<0.0002 (1 < DL)	-
Arsenic	µg/L	-	-	0.1 - 0.2	<0.1 (2 < DL)	<0.1 - 0.1 (1 < DL)	-	<0.1 (1 < DL)	-
Barium	mg/L	-	-	0.027 - 0.034	0.047 - 0.049	0.042	-	0.021	-
Beryllium	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 (2 < DL)	<0.0001 (2 < DL)	-	<0.0001 (1 < DL)	-
Boron	mg/L	-	-	<0.01 (2 < DL)	<0.01 (2 < DL)	<0.01 (2 < DL)	-	<0.01 (1 < DL)	-
Cadmium	mg/L	-	-	<0.00001 (2 < DL)	<0.0001 (2 < DL)	<0.0001 (2 < DL)	-	<0.0001 (1 < DL)	-
Chromium	mg/L	-	-	<0.0005 (2 < DL)	<0.0005 - 0.0019 (1 < DL)	<0.0005 (2 < DL)	-	<0.0005 (1 < DL)	-
Cobalt	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 (2 < DL)	<0.0001 (2 < DL)	-	<0.0001 (1 < DL)	-
Copper	mg/L	-	-	0.0003 - 0.0004	0.0002 - 0.0003	0.0005 - 0.0006	-	0.0003	-
Iron	mg/L	-	-	0.0075 - 0.0260	0.0021 - 0.0022	0.017	-	0.0035	-
Lead	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 (2 < DL)	<0.0001 - 0.0002 (1 < DL)	-	<0.0001 (1 < DL)	-
Manganese	mg/L	-	-	0.0006 - 0.0020	<0.0005 (2 < DL)	<0.0005 - 0.0006 (1 < DL)	-	<0.0005 (1 < DL)	-
Molybdenum	mg/L	-	-	0.0001	<0.0001 - 0.0001 (1 < DL)	<0.0001 - 0.0001 (1 < DL)	-	<0.0001 (1 < DL)	-
Nickel	mg/L	-	-	0.0002 - 0.0003	0.0002	0.0003	-	0.0002	-
Selenium	mg/L	-	-	0.0001 - 0.0002	0.0001	<0.0001 - 0.0001 (1 < DL)	-	<0.0001 (1 < DL)	-
Silver	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 (2 < DL)	<0.0001 (2 < DL)	-	<0.0001 (1 < DL)	-
Strontium	mg/L	-	-	0.016	0.013 - 0.014	0.012 - 0.013	-	0.0067	-
Thallium	mg/L	-	-	<0.0002 (2 < DL)	<0.0002 (2 < DL)	<0.0002 (2 < DL)	-	<0.0002 (1 < DL)	-
Tin	mg/L	-	-	0.0001	0.0001 - 0.0002	0.0010 - 0.0022	-	0.0001	-
Titanium	mg/L	-	-	<0.0002 (2 < DL)	<0.0002 (2 < DL)	<0.0002 (2 < DL)	-	<0.0002 (1 < DL)	-
Uranium	µg/L	-	-	<0.1 (2 < DL)	<0.1 (2 < DL)	<0.1 (2 < DL)	-	<0.1 (1 < DL)	-
Vanadium	mg/L	-	-	<0.0001 (2 < DL)	<0.0001 (2 < DL)	<0.0001 - 0.0001 (1 < DL)	-	<0.0001 (1 < DL)	-
Zinc	mg/L	-	-	-	0.0032 - 0.0043	0.0022 - 0.0047	-	0.0039	-

Table 5.3-2 Summary of Water Chemistry Data for Lakes and Streams in the Kiggavik Project Area, 1974-2013

Parameter	Units	Guidelines		Aniguq River Sub-Basin	Siamese Lake Sub-Basin	Skinny Lake Sub-Basin	Kavisilik Lake Sub-Basin	Squiggly Lake Sub-Basin	Baker Lake Sub-Basin
				Aniguq River	Siamese Lake	Skinny Lake	Kavisilik Lake	Squiggly Lake	Baker Lake
				1980, 2009	2008	1986, 1988, 1989, 2007, 2008	1980	1980, 2008, 2013	1974-1982[(z)], 1989[(z)], 2008, 2009
		SSWQO[(a)]	CWQG[(b)]	n = 3[(c)]	n = 2[(c)]	n = 7[(c)]	n = 1[(c)]	n = 4[(c)]	n = 17[(c)]
Radionuclides									
Lead-210	Bq/L	-	-	<0.02 (3 < DL)	<0.02 (2 < DL)	<0.02 - <0.2 (4 < DL)	0.033	<0.02 (4 < DL)	<0.02 (12 < DL)
Lead-210	pCi/L	-	-	-	-	-	0.9	<0.5	-
Polonium-210	Bq/L	-	-	<0.005 - 0.007 (1 < DL)	<0.005 (2 < DL)	<0.005 - <0.03 (4 < DL)	-	<0.005 (3 < DL)	<0.005 (12 < DL)
Polonium-210 - preconcentrated	Bq/L	-	-	-	-	-	-	-	0.0028
Polonium-210 - whole water	Bq/L	-	-	-	-	-	-	-	-
Radium-226	Bq/L	0.11 [(aa)]	-	<0.005 - 0.03 (2 < DL)	0.006 - 0.009	<0.005 - <0.02 (4 < DL)	0.007	<0.005 - <0.007 (4 < DL)	<0.005 (12 < DL)
Radium-226	pCi/L	-	-	-	-	-	0.2	<0.2	-
Radium-226 - preconcentrated	Bq/L	-	-	-	-	-	-	-	0.0016
Radium-226 - whole water	Bq/L	-	-	-	-	-	-	-	-
Thorium	µg/L	-	-	-	-	-	-	-	-
Thorium-228	Bq/L	-	-	<0.01 (3 < DL)	<0.01 (2 < DL)	<0.01 (1 < DL)	<0.01	<0.01 (4 < DL)	-
Thorium-228	pCi/L	-	-	-	-	-	<0.3	<0.3	-
Thorium-228 - preconcentrated	Bq/L	-	-	-	-	-	-	-	0.0006
Thorium-228 - whole water	Bq/L	-	-	-	-	-	-	-	-
Thorium-230	Bq/L	-	-	<0.01 (3 < DL)	<0.01 (2 < DL)	<0.002 - 0.01 (3 < DL)	<0.01	<0.01 - 0.02 (3 < DL)	<0.01 (12 < DL)
Thorium-230	pCi/L	-	-	-	-	-	<0.3	0.5	-
Thorium-230 - preconcentrated	Bq/L	-	-	-	-	-	-	-	0.0008
Thorium-230 - whole water	Bq/L	-	-	-	-	-	-	-	-
Thorium-232	Bq/L	-	-	<0.01 (3 < DL)	<0.01 (2 < DL)	<0.005 - <0.01 (2 < DL)	<0.01	<0.01 - 0.01 (3 < DL)	-
Thorium-232	pCi/L	-	-	-	-	-	<0.3	<0.3	-
Thorium-232 - preconcentrated	Bq/L	-	-	-	-	-	-	-	0.0001
Thorium-232 - whole water	Bq/L	-	-	-	-	-	-	-	-

Source: Modified from Appendix 5C, Tables X.II-1 to X.II-8 and Attachment 5C-1, Table 3.

Notes: Multiple entries for single stations and parameters represent laboratory replicates; composite samples consisting of water from several lakes were analyzed but are not included in this analysis. The waterbodies included in the composite samples include: Drum-Scotch-Sik Sik Lakes; Meadow-Escarpment-Felsenmeer Lakes; Ridge-Cirque Lakes; Crash-Caribou Lakes.

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 1999, with updates to 2014).

(c) Not all parameters were analysed during each sampling period.

(d) The objectives and guidelines dissolved oxygen for cold-water biota are 9.5 mg/L for early life stages and 6.5 mg/L for other life stages.

(e) Highest value came from winter sampling.

(f) The guidelines for ammonia are dependent on temperature and pH; therefore, the guideline for each station was calculated and the lowest overall value was used for screening. However, the guideline could not be calculated for historical data due to lack of water temperature information.

(g) = For 2008 data, 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.

(h) The guideline for nitrate is 13 mg NO_3/L or 2.9 mg N/L. It was assumed that the reported values were expressed in mg NO_3/L.

(i) Highest detected value was between the range of non-detected values presented.

(j) The guideline for nitrite is 0.197 mg NO_2/L or 0.06 mg N/L.

(k) Values below detection limits were often equal to or exceeded the SSWQO and CWQG.

(l) The 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.

(m) 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; at hardnesses ranging from 48.5 to 97 mg/L $CaCO_3$, the objective is 0.032 mg/L.

(n) The guidelines for cadmium are hardness-dependent. Based on the CCME equation: at hardness 1 mg/L as $CaCO_3$, the guideline is 0.00004 mg/L and at hardness 64 mg/L as $CaCO_3$, the guideline is 0.00011 mg/L.

(o) Low level cadmium was analyzed by the Trent University Water Quality Centre. Five replicate samples were collected within proximity. The range of value is presented.

(p) The objective is for hexavalent chromium.

(q) 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.

(r) 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 1 to 64 mg/L, the guideline is also 0.002 mg/L.

(s) Original document states the measured unit is µg/mL, but based on results from other studies in the project area this is assumed to be an error with the actual unit being µg/L.

(t) 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 60 to 120 mg/L as $CaCO_3$, the objective is 0.002 mg/L. Based on the CCME equation: at hardness 1 mg/L, the guideline is 0.00100 mg/L and at hardness 64 mg/L, the guideline is 0.00180 mg/L.

(u) In 2007, mercury was determined on a nitric-acid preserved sample as a potassium dichromate/nitric-acid perserved sample was not supplied.

(v) Mercury objective is for inorganic mercury only.

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

(x) 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 60 to 120 mg/L, the objective is 0.065 mg/L. Based on the CCME equation: at hardness 1 mg/L, the guideline is 0.025 mg/L and at hardness 64 mg/L, the guideline is 0.06889 mg/L.

(y) 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).

(z) Conducted by the Water Survey of Canada (BEAK 1990).

(aa) 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.).

n = number of samples analyzed; °C = degrees Celsius; µS/cm = microSiemens per centimetre; µg/L = micrograms per litre; mg/L = milligrams per litre; mg $CaCO_3$/L = milligrams of calcium carbonate per litre; mg/m^3 = milligrams per cubic metre; mg N/L = milligrams nitrogen per litre; ng/L = nanograms per litre; Bq/L = Becquerels per litre; pCi/L = picoCuries per litre; NTU = Nephlometric Turbity Units; % = percent; < = less than; NO_3 = nitrate; N = nitrogen; NO_2 = nitrite; DL = detection limit; - = no data.

Table 5.3-3 Definitions of Waterbody Characteristics

Parameter	Definition and Notes with Applicable Reference
Total Alkalinity (mg/L as $CaCO_3$)[(a)]	High sensitivity to acid deposition (<10), Moderate sensitivity (11 to 20), Low sensitivity (21 to 40) Low or minimal sensitivity (>40) (Saffran and Trew 1996).
Total Hardness (mg/L as $CaCO_3$)	Very soft (0 to 30) Soft (31 to 60) Moderately soft (61 to 120) Hard (121 to 180) Very hard (>180) (McNeely et al. 1979).

Sources as indicated in the table.

NOTES:

(a) Alkalinity is the capacity of water for neutralizing an acid solution and as such can be used as a measure of a lake's sensitivity to acid inputs such as acid rain.

mg/L = milligram per litre; $CaCO_3$ = calcium carbonate; < = less than; > = greater than.

5.4 Sediment Quality

Lake sediments consist of organic and inorganic matter introduced through erosion of soils and other geologic materials in the watershed, as well as through the deposition of particulate mineral matter and organic material produced in the lake (BEAK 1990). Studies of sediment quality in the Kiggavik area were carried out between 1979 and 1991. These historical studies broadly covered the study area. The objectives were to collect baseline information on sediment particle size characteristics, sediment chemistry, and sedimentation rates. Recent studies were conducted between 2007 and 2013 to expand and complement the previously collected baseline information on sediment chemistry and sediment particle size characteristics.

This section presents the historical and current information available on surface sediment quality within the mine site LSA. Detailed methods and results can be found in Technical Appendix 5C (Tier 3, Section 5.0). The seasonal variation in physical and chemical sediment quality was not addressed due to the low but variable sedimentation rates identified in Section 5.4.4.

5.4.1 Sediment Sampling

Baseline sediment quality data were collected in 22 lakes (including Baker Lake) between fall 2007 and fall 2013 (Figures 5.3-1 parts A to E, 5.3-2 parts A to C, 5.3-3). Two lakes from the Willow Lake sub-basin (i.e., Sik Sik and Willow lakes), Andrew Lake from the Lower Lake sub-basin, and Judge Sissons Lake were sampled up to three times. The following parameters were measured for lakes sampled in the mine site LSA:

- physical properties (i.e., particle size, moisture content, and loss on ignition);
- nutrients (i.e., total nitrogen, ammonia as nitrogen, nitrite+nitrate as nitrogen, total phosphorus, and total organic carbon [TOC]);
- major ions (i.e., calcium, magnesium, potassium, sodium, and sulphate);
- 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, and zinc); and
- radionuclides (i.e., lead-210 [Pb-210], polonium-210 [Po-210], radium-226 [Ra-226], thorium-228 [Th-228], thorium-230 [Th-230], and thorium-232 [Th-232]).

Baker Lake sediment chemistry samples were analyzed for some or all of the following parameters in 2008 and 2009:

- nutrients (i.e., total phosphorus [2008 only]);
- major ions (i.e., calcium, magnesium, potassium, and sodium);
- metals and metalloids (i.e., aluminum, arsenic, barium, beryllium, boron, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, strontium, titanium, uranium, vanadium, and zinc);
- polycyclic aromatic hydrocarbons (PAHs) (acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, naphthalene, perylene, phenanthrene, and pyrene [2008 only]); and
- radionuclides (i.e., lead-210, polonium-210, radium-226, and thorium-230).

Sample collection methods are detailed in Tier 3, Technical Appendix 5C Section 5.1 and Attachment 5C-1.

Historical sediment quality data were collected in 17 lakes between 1979 and 1991. Six of these lakes were not recently re-sampled (i.e. Felsenmeer, Escarpment, Lin, Scotch, Jaeger, and Boulder lakes) because of their location upstream of the proposed mine site. Particle sizes, moisture, total nitrogen, ammonia as nitrogen, nitrite+nitrate nitrogen, sulphate, antimony, thallium, and tin were not available in the historical sediment quality data, and arsenic, selenium, and tellurium results from samples collected in 1979 were reported in wet weight instead of dry weight. However, most other parameters were available, as well as cation exchange capacity, chemical oxygen demand, total Kjeldahl nitrogen, tellurium, Po-220, and Ra-228.

Following the protocols commonly used in analyzing data from environmental effects monitoring studies at uranium mines, sediment chemistry results were compared among sediment sampling stations as well as to the CCME Freshwater Interim Sediment Quality Guidelines (ISQG) and probable effects levels (PEL) (CCME 1999a, with updates to 2001). Results for metals, metalloids and radionuclides were compared with lowest effect level (LEL) and severe effect level (SEL) reference values reported in Thompson et al. (2005).

5.4.2 Physical Characteristics of Sediment

Bottom substrates of lakes in the Kiggavik area vary from rock, boulder, and sand in shallow areas to organic-rich (soft light to dark brown) sediments in deeper depositional areas. The surficial light to dark brown sediments are typically 2 to 10 centimetres (cm) deep, and usually have an underlying layer of tan or grey deposits (BEAK 1987).

BEAK (1990) reported the results of a quantitative assessment of sediment particle size that was conducted in 1988. Silt was the dominant particle size category in all lakes sampled, except in Pointer Lake and Judge Sissons Lake. Surface sediment in the main body of Pointer Lake was dominated by dense clay, sand, and rock. Judge Sissons Lake sediment samples had nearly equal amounts of fine sand, very fine sand, silt and clay. BEAK (1990) presented quantitative particle size data for only two lakes: Pointer Lake and Jaeger Lake (Table 5.4-1).

The core sample collected in Judge Sissons Lake in 1991 consisted of sticky glacial clay and no soft organic sediments (BEAK 1990, 1992a). The 1991 result suggests that sediment deposition occurs sporadically in Judge Sissons Lake (BEAK 1992a). Differences in sediment texture between smaller lakes and Judge Sissons Lake can be attributed to the much greater depth of Judge Sissons Lake, and the varying depositional environment provided in deep lakes (BEAK 1990).

Table 5.4-1 Particle Size of Surficial Lake Sediments in Pointer and Jaeger Lakes

Category	Size Range (mm)	Pointer Lake 1 (%)	Pointer Lake 2A[(a)] (%)	Pointer Lake 2B (%)	Pointer Lake 2C (%)	Jaeger Lake (%)
Coarse sand	0.5 to 1.0	0	0	0	0	1.01
Medium sand	0.25 to 0.5	0.62	1.28	1.08	7.66	2.54
Fine sand	0.088 to 0.025	3.71	3.2	3.54	12.31	16.71
Very fine sand	0.0625 to 0.088	49.41	13.15	13.67	26.29	39.49
Silt	0.0039 to 0.0625	37.69	71.53	70.18	42.96	27.69
Clay	<0.0039	8.59	10.82	11.54	10.77	12.47

SOURCE: BEAK 1990

NOTES:

(a) Pointer Lake samples 2A, 2B, and 2C are field replicates.

mm = millimetres; % = percent; < = less than.

5.4.3 Chemical Characteristics of Sediment

The historical dataset did not contain any information about sediment moisture content, and very few values for TOC. More recent data (i.e., 2007 to 2013) indicates that these parameters were variable among lakes, with moisture content ranging from 18 to 93%, and TOC ranging from less than 0.01% to 9.1% (Table 5.4-4 in Attachment 5C-1).

Overall, total metal concentrations were similar among the lakes in the mine site LSA and the site access LSA. Arsenic concentrations usually exceeded the ISQG of 5.9 micrograms per gram of dry weight (µg/g dw), but not the PEL of 17.0 µg/g dw, with the exception of one sample collected in 1986 from Escarpment Lake (30 to 34 µg/g dw), three samples collected in Ridge Lake (60 µg/g dw in 1986, 31 µg/g dw in 2007, and 45 µg/g dw in 2008) and one sample collected in 2009 from Judge Sissons Lake (39 µg/g dw). Also, one sample collected in 2013 from Squiggly Lake (17 µg/g dw) was equal to the PEL. Cadmium concentrations in one sample collected in 2008 from Cirque Lake, and one sample from Squiggly Lake, were equal to 0.6 µg/g dw, or the ISQG. Chromium concentrations also exceeded the ISQG of 37.3 µg/g dw, but not the PEL of 90 µg/g dw, with the exception of one sample collected in 1979 from Jaeger Lake (100 µg/g dw). A few exceedances of copper, mercury, and zinc ISQGs, as well as the mercury and zinc PEL, were observed; however, no trends were evident (Table 5.4-4). Baseline sediment quality parameters were generally less than the LEL and SEL concentrations identified by Thompson et al. (2005). Exceedences of arsenic, chromium, copper, molybdenum, nickel, selenium, and vanadium LELs were observed on some samples, but no trends were evident.

Radionuclides were detected in almost all sediment samples, except those from Baker Lake, and were generally reported at concentrations below 0.3 Becquerels per gram of dry weight (Bq/g dw). One sample collected in Squiggly Lake in 2008 had a Po-210 concentration of 0.45 Bq/g dw and a Pb-210 concentration of 0.38 Bq/g dw. Almost all 2013 samples collected in Judge Sissons Lake and in Squiggly Lake had Pb-210 and Po-210 concentrations equal to or above 0.3 Bq/g dw. In Judge Sissons Lake, Pb-210 concentrations ranged from 0.26 to 0.85 Bq/g dw and Po-210 concentrations ranged from 0.27 to 0.70 Bq/g dw. In Squiggly Lake, Pb-210 concentrations ranged from 0.31 to 0.87 Bq/g dw and Po-210 concentrations ranged from 0.36 to 1.0 Bq/g dw. Three historical samples collected from Scotch, Pointer, and Judge Sissons lakes in 1979 were also reported to have concentrations above 0.3 Bq/g dw for Pb-210, Ra-226, Th-228, Th-230, and Th-232. Several samples were equal to or in exceedance of the Thompson et al. (2005) LEL value for Pb-210, Po-210, and Ra-226. Lead-210 concentrations were usually below the LEL value of 0.5 Bq/g dw, with the exception of 34 samples (i.e., two samples collected in Scotch Lake in 1979; ten samples collected in Pointer lake in 1979; 14 samples collected in Judge Sissons Lake in 1979; 5 samples collected in Judge Sissons Lake in 2013; and three samples collected in Squiggly Lake in 2013). Polonium-210 concentrations were usually below the LEL value of 0.6 Bq/g dw, with the exception of two samples in Judge Sissons Lake (0.61 and 0.70 Bq/g dw in 2013) and three samples in Squiggly Lake (0.6, 0.76, and 1.0 Bq/g dw in 2013). Radium-226 concentration were usually below the LEL concentration of 0.1 Bq/g dw, with the exception of 39 samples (i.e., two samples collected in Scotch Lake in 1979; ten samples collected in Pointer lake in 1979; one sample collected in Lunch Lake in 1990; two samples collected in Shack Lake in 1991; one sample collected in Skinny Lake in 2007; 18 samples collected in Judge Sissons Lake in 1979; 4 samples collected in Judge Sissons Lake in 2013; and five samples collected in Squiggly Lake in 2013) (Table 5.4-4).

Individual PAH compounds were sampled in Baker Lake in 2008. Concentrations were below analytical detection limits in most samples (Table 5.4-2), and all values were well below ISQG. Total PAH levels were less than 0.1 µg/g.

Table 5.4-2 Polycyclic Aromatic Hydrocarbon Concentrations in Sediment from Baker Lake, 2008

Parameter	Units	CCME Sediment Quality Guidelines		Baker Lake Sub-Basin
				Baker Lake
				2008
		ISQG[(a)]	PEL[(b)]	n = 5
Total PAH	µg/g	-	-	<0.1 (5 < DL)
Acenaphthene	µg/g	6.71	88.9	<0.01 (5 < DL)
Acenaphthylene	µg/g	5.87	128	<0.01 (5 < DL)
Anthracene	µg/g	46.9	245	<0.01 (5 < DL)
Benzo(a)anthracene	µg/g	31.7	385	<0.02 (5 < DL)
Benzo(a)pyrene	µg/g	31.9	782	<0.1 (5 < DL)
Chrysene	µg/g	57.1	862	<0.02 (5 < DL)
Dibenzo(a,h)anthracene	µg/g	6.22	135	<0.1 (5 < DL)
Fluoranthene	µg/g	111	2355	<0.01 (5 < DL)
Fluorene	µg/g	21.2	144	<0.01 (5 < DL)
Naphthalene	µg/g	34.6	391	<0.01 (5 < DL)
Phenanthrene	µg/g	41.9	515	<0.01 to 0.03 (3 < DL)
Pyrene	µg/g	53	875	<0.01 to 0.01 (3 < DL)

SOURCE: Modified from Tier 3, Technical Appendix 5C, Table X.III-6.

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 italicized.

(a) ISQG = Interim Freshwater Sediment Quality Guidelines (CCME 1999a, with updates to 2001).

(b) PEL = Probable Effect Levels (CCME 1999a, with updates to 2001).

CCME = Canadian Council of Ministers of the Environment; n = number of samples analyzed; µg/g = micrograms per gram; < = less than; DL = detection limit.

5.4.4 Sedimentation Rates

Sedimentation rates were measured in Pointer Lake and Judge Sissons Lake using the Pb-210 method (BEAK 1990). Sediment chronologies can be determined from the Pb-210 method when the supply of Pb 210 occurs at a constant (or proportional) rate to the sedimentation rate (McKee et al. 1987). This method has been used to estimate sedimentation rates in other Arctic lakes (BEAK 1990).

Duplicate sediment cores were collected in 1988, using a Kajak-Brinkhurst (KB) corer equipped with 4.7 cm (inside diameter) polycarbonate core tubes. Cores were collected from two depths (11 and 13 m) in Judge Sissons Lake, and one depth (approximately 1.8 m) in Pointer Lake. Attempts to collect cores from depths of 2 to 2.3 m in the main body of Pointer Lake and from depths greater than 10 m in the eastern basin of Judge Sissons Lake were unsuccessful due to the presence of rock, coarse sand, or dense clay on the sediment surface that prevented the corer from penetrating the lake sediments. Core samples were sliced into 0.5 to 2 cm sections in a plastic collar.

Sedimentation rates were measured in Judge Sissons Lake and Pointer Lake to assess the rate at which material in the water column settles out of suspension (BEAK 1990). The lakes were found to have low but variable sedimentation rates, reflecting the oligotrophic conditions of the aquatic ecosystem and possibly frequent wind-driven sediment re-suspension (BEAK 1990). Given the small volume of many of the lakes, it is also possible that there is a short water retention time in the lakes, which would also influence sedimentation rates.

Sedimentation rates in the mine site LSA cores were 1.6 mm/year in Pointer Lake and between 0.11 and 0.26 mm/year in Judge Sissons Lake (Table 5.4-3). The average annual depth of accumulation (mm/year) is based on mass accumulation rates and on the dry bulk densities for the four surface core slices collected from the top 2 to 2.5 cm (BEAK 1990).

Table 5.4-3 Sedimentation Rates in the Kiggavik Project Area Measured Before 1990

Unit	Pointer Lake	Judge Sissons Lake	
		11 m depth	13 m depth
Grams per square metre per year ($g/m^2/y$)	300	11	20
Millimetres per year (mm/year)	1.6	0.11	0.26

SOURCE: BEAK 1990.
NOTES:
m = metre; $g/m^2/y$ = grams per square metre per year; mm/year = millimetres per year.

Within the Judge Sissons Lake cores taken at a depth of 22 m, a sticky grey clay was encountered below 18.4 cm. This is likely a layer deposited during deglaciation, which occurred in the area about 6,000 to 8,000 years before present (BEAK 1990). The total mass accumulated above this layer was 5.3 grams per square centimetre (g/cm^2), which is equivalent to an overall average annual rate of 7.6 grams per square metre per year ($g/m^2/y$) over 7,000 years. This is about 70% of the 11 $g/m^2/y$ measured in recent sediments by Pb-210 method, probably reflecting an increase in sedimentation rate in recent history relative to the post-glacial period. These changes can be attributed to various factors, including glacial rebound, changes in erosion rates, climatic vegetation changes, and changes in the lake basin itself (BEAK 1990).

5.5 Freshwater Aquatic Environment

Various assessments of the aquatic environment have been undertaken over the history of the Project. The historical field studies were either carried out over a two year period (e.g., 1979 to 1980, 1988 to 1989, and 1990 to 1991), or in a single year (e.g., 1975 and 1986) (BEAK 1990, 1992a). A review of the available historical information is presented. Between 2007 and 2013, additional aquatic field studies were carried out to supplement and update the historical information.

This Freshwater Aquatic Environment section includes information on the limnology of LSA lakes and streams (i.e., a description of the physical aquatic habitat conditions), as well as information about freshwater organisms from the following trophic levels:

- primary producers (i.e., plants [macrophytes] and algae [phytoplankton and periphyton] which make their own food);
- primary consumers (i.e., herbivores [zooplankton] that eat macrophytes, phytoplankton, and periphyton, as well as benthic detritivors [benthic invertebrates] that feed on detritus (decaying material) at the bottom of lakes and streams);
- secondary consumers (i.e., fish and other aquatic organisms that eat zooplankton or benthic invertebrates); and
- tertiary consumers (i.e., fish that eat other fish).

Limnology and water chemistry are important components of aquatic ecosystem health. To sustain aquatic life, specific physical characteristics of water must be present at appropriate levels; these characteristics include temperature, DO, and pH (acidity/alkalinity). The chemical makeup of water is also important to the maintenance of conditions suitable for aquatic life. For example, bicarbonates, carbonates, sulphates, and chlorides are four major anions that influence the total ionic salinity of the water. Calcium is a nutrient important for the growth of underwater plants and other aquatic organisms including fish. Nitrogen and phosphorus are nutrients critical to the growth of aquatic primary producers (phytoplankton, periphyton, and aquatic macrophytes). The energy uptake and growth of primary producers is subsequently used by primary, secondary, and tertiary consumers (e.g., zooplankton, benthic and other aquatic invertebrates, and fish) (Wetzel 2001).

Aquatic macrophytes are an important component of aquatic systems, providing habitat for fish and invertebrates, offering protection against currents and predators, and forming a substrate for the deposition of eggs. As primary producers, macrophytes represent an important food resource for aquatic and non-aquatic organisms; they also play a significant role in the oxygen balance and nutrient cycle of many watercourses.

The term "plankton" is a general term referring to small, usually microscopic, organisms that live suspended in open water. For the purpose of the Project, the term "phytoplankton" refers to the open-water, algal component (i.e., non-vascular, photosynthetic plants) of plankton and includes the following seven major taxonomic groups:

- Cyanobacteria (blue-green algae);
- Chlorophyta (green algae);
- Chrysophyta (golden-brown algae);
- Cryptophyta (cryptomonads);
- Bacillariophyta (diatoms);
- Pyrrophyta (dinoflagellates); and
- other taxa (which includes Xanthophyta and Haptophyta).

Chlorophyll a is the primary photosynthetic pigment contained in phytoplankton, although there are a number of secondary pigments (e.g., chlorophyll b, chlorophyll c, and carotenoids) (Wetzel 2001). Chlorophyll a concentration has been used to provide a practical and economical alternative to full taxonomic analysis of the phytoplankton community, and has been widely used as a measure of the trophic status (i.e., nutrient status and productivity) of lakes. Chlorophyll a concentrations can range from less than 8 micrograms per litre (μg/L) in unproductive waters to greater than 75 μg/L in highly productive waters (Mitchell and Prepas 1990). Chlorophyll a concentrations are known to vary seasonally and taxonomically (Wetzel 2001), which results in uncertainty in the use of chlorophyll a as a measure of phytoplankton biomass.

Periphyton consists of a biofilm of algae, bacteria, fungi, protozoa and associated non-cellular material that surround solid surfaces in aquatic systems (Lock et al. 1984). For the purpose of the Project, the term "periphyton" refers only to the algal component as opposed to the entire biofilm. Periphyton is the term used to describe the algal community that grows attached to the substrate (generally rocks) in streams and lakes. They are a primary producer, similar to phytoplankton; however, periphyton is attached to the substrate, where as phytoplankton are suspended in the water column.

The term "zooplankton" refers to microscopic animals that float, drift or swim weakly, and includes crustaceans (i.e., Cladocera [cladocerans], Calanoida, and Cyclopoida) and rotifers. Cyclopoid and calanoid copepods are considered separately because of taxonomic differences, but also because Calanoida are almost exclusively planktonic, while Cyclopoida are dominated by littoral species

(Wetzel 2001). However, the few planktonic species of Cyclopoida can account for a major component of the plankton community (Wetzel 2001).

Benthic invertebrates are also referred to as “benthic macroinvertebrates” because of their relatively large size, with some species reaching a few centimetres in length. Benthic invertebrates are present in nearly all waterbodies, are typically abundant, and remain in a small area throughout the aquatic phase of their life cycle so exposure to any contaminants or nutrient enrichment is maximized (Rosenberg and Resh 1993).

Fish can be referred to as “planktivorous,” “benthivorous,” “piscivorous,” “omnivorous,” or “apex predators” depending on what they feed on and if they have predators (Table 5.5-1). A planktivorous fish (i.e., cisco [*Coregonus artedi*]) is an adult fish feeding mainly on zooplankton, phytoplankton, and periphyton. Often, young-of-the-year (YOY) and juvenile fish will originally be planktivorous, but will change food sources as they grow larger. A benthivorous fish (i.e., longnose sucker [*Catostomus catostomus*], ninespine stickleback [*Pungitius pungitius*], round whitefish [*Prosopium cylindraceum*], and slimy sculpin [*Cottus cognatus*]) is an adult fish feeding mainly on benthic invertebrates. Fish like Arctic char and lake whitefish (*Coregonus clupeaformis*) are both planktivorous and benthivorous. A piscivorous fish (i.e., lake trout) is an adult fish feeding mainly on other fish species. An omnivorous fish (i.e., burbot [*Lota lota*]) is an adult fish that feeds on plankton, benthic invertebrates, as well as other fish species, depending on what food source is available. An apex predator (i.e., burbot and lake trout) is a fish that has no higher predator controlling its population, other than humans. Arctic grayling has a diet completely different from the other fish in the area, as it mainly feeds on aquatic and terrestrial insects.

Table 5.5-1 Summary of Trophic Levels Consumed by Fish Species That Occur in the Mine Site and Site Access Local Study Areas

Fish Species	Food Type by Fish Life Stage							Major Fish Type	Predator	Trophic Level Consumer
	Plants	Phytoplankton and Periphyton	Zooplankton	Benthic Invertebrates	Terrestrial Insects	Fish or Fish Eggs	Small Mammals			
Arctic char (*Salvelinus alpinus*)	-	-	juvenile, adult	juvenile, adult	-	adults eat small fish	-	planktivorous and benthivorous	seal	middle to high
Arctic grayling (*Thymallus arcticus*)	-	-	-	juvenile, adult	adult	adults eat grayling fry, and lake trout and lake whitefish eggs	adult (lemming)	insectivorous	lake trout	middle
burbot (*Lota lota*)	-	-	juvenile	juvenile, adult	-	adults eat ninespine stickleback	-	omnivorous	-	apex predator
cisco (*Coregonus artedi*)	-	juvenile, adult	juvenile, adult	adult	juvenile, adult	-	-	planktivorous	lake trout, burbot	middle
fourhorn *sculpin* (*Myoxocephalus quadricornis*)	-	-	-	juvenile, adult	-	adults eat small fish and fish eggs (including of its own species)	-	benthivorous	lake trout, burbot	middle
lake trout (*Salvelinus namaycush*)	-	young-of-the-year	young-of-the-year	juvenile	-	adults eat cisco and longnose sucker	-	piscivorous	-	apex predator
lake whitefish (*Coregonus clupeaformis*)		juvenile, adult	juvenile, adult	juvenile, adult	juvenile, adult	adults eat fish eggs and small fish	-	planktivorous and benthivorous	lake trout, ospreys, eagle, river otter	middle
longnose sucker (*Catostomus catostomus*)	juvenile, adult	-	-	juvenile, adult	-	-	-	benthivorous	lake trout	low to middle
ninespine stickleback (*Pungitius pungitius*)	-	juvenile, adult	juvenile, adult	juvenile, adult	-	-	-	benthivorous	lake trout, burbot	middle
round whitefish (*Prosopium cylindraceum*)	-	juvenile, adult	juvenile, adult	juvenile, adult	-	adults eat fish eggs and small fish	-	benthivorous	lake trout	middle
slimy sculpin (*Cottus cognatus*)	-	-	juvenile, adult	juvenile, adult	-	adults eat fish eggs and small fish	-	benthivorous	lake trout, burbot	middle

SOURCE: Morrow 1980; Scott and Crossman 1973; Scott and Scott 1988; Steward and Watkinson 2004.

5.5.1 Limnology

This section presents the historical and current information available on limnology within the LSA. Detailed methods and results can be found in Technical Appendix 5C (Tier 3, Section 6.0 and Attachment 5C-1).

Limnological measurements were collected as a component of other aquatic sampling efforts such as benthic invertebrate community sampling, aquatic macrophyte collection, and fish community sampling to provide supporting environmental information (Figures 5.3-1 parts A to E, 5.3-2 parts A to C, and 5.3-3). The following parameters were recorded:

- depth (m);
- DO (mg/L);
- pH;
- temperature (degrees Celsius [^{o}C]);
- specific conductivity (microSiemens per centimetre [µS/cm]);
- maximum water depth (m);
- Secchi depth (m); and
- ice thickness (m) (where applicable).

Vertical profiles (DO, water temperature, pH, and specific conductivity) were recorded for lakes greater than 3 m deep between 2007 and 2013. Table 5.5-2 summarizes the season and year that limnology information was collected from various lakes in the LSA. Streams in the LSA were also included in surface water limnological data collection. Table 5.5-3 summarizes the season and year that limnology information was collected from various stream segments or rivers ("streams") in the mine site LSA.

In general, lakes in the mine site LSA were shallow (many with maximum depths less than 3 m), of very low specific conductivity (range of 6 to 35 µS/cm in the historical data and 11 to 61 µS/cm in the 2007 to 2013 data), and did not experience thermal stratification in summer. Secchi depth was usually greater than 2 m and was often equal to total depth. Because ice thickness ranged from 1.8 m to 2.1 m by the end of the winter, it is expected that many of the shallow lakes would freeze to the bottom during winter.

Table 5.5-2 Summary of Limnology Data Collected from Lakes in the Kiggavik Project Area, 1979 to 2013

Watershed	Sub-Basin	Waterbody	1979	1980	1988	1991	2007	2008	2009	2010	2013
Aniguq River	Willow Lake	Escarpment Lake	-	-	X	-	-	-	-	-	-
		Scotch Lake	X	X	-	-	-	-	-	-	-
		Jaeger Lake	X	-	X	-	-	-	-	-	-
		Pointer Pond	-	-	-	-	-	-	-	P	-
		Pointer Lake	X	X	X	X	F	U, F	F	-	-
		Sik Sik Lake	-	-	-	-	F	F	W[(a)], U, F	-	-
		Rock Lake	-	-	-	-	-	U, F	W[(a)], U, F	-	-
		Willow Lake	-	-	-	-	F	F	W[(a)], U, F	-	-
	Lower Lake	Mushroom Lake	-	-	-	X	-	U, F	W	-	-
		Pond 1 to Pond 8	-	-	-	-	-	-	-	P	-
		End Grid Lake	-	-	-	-	F	U, F	-	-	-
		Cigar Lake	-	-	-	X	-	U, F	-	-	-
		Knee Lake	-	-	-	-	-	U, F	-	-	-
		Lunch Lake	-	-	-	-	-	U, F	-	-	-
		Andrew Lake	-	-	-	-	F	U, F	W[(a)], F	-	-
		Shack Lake	-	-	-	-	F	U, F	-	-	-
		Lower Lake	-	-	-	-	F	U, F	-	-	-
	Caribou Lake	Ridge Lake	-	-	-	X	F	U, F	-	-	-
		Cirque Lake	-	-	-	-	F	F	-	-	-
		Crash Lake	-	-	-	-	F	F	-	-	-
		Fox Lake	-	-	-	-	F	U, F	-	-	-
		Caribou Lake	-	-	-	-	-	U, F	-	-	-
		Calf Lake	-	-	-	-	-	U, F	-	-	-

Table 5.5-2 Summary of Limnology Data Collected from Lakes in the Kiggavik Project Area, 1979 to 2013

Watershed	Sub-Basin	Waterbody	1979	1980	1988	1991	2007	2008	2009	2010	2013
	Judge Sissons Lake	Judge Sissons Lake	X	X	-	X	-	U, F	W, U, F	-	F
	Siamese Lake	Siamese Lake	-	-	-	-	-	U, F	W	-	-
		L2	-	-	-	-	-	-	W	-	-
	Skinny Lake	Skinny Lake	-	-	X	-	F	F	-	-	-
	Kavisilik Lake	Kavisilik Lake	-	X	-	-	-	-	-	-	-
	Long Lake	Long Lake	-	-	-	-	-	-	W	-	-
	Audra Lake	Audra Lake	-	-	-	-	-	-	W	-	-
Thelon River	Squiggly Lake	Squiggly Lake	-	X	-	-	-	F	-	-	F
Baker Lake	Baker Lake	Qinguq Bay	-	-	-	-	-	-	W	-	-
		Baker Lake	-	-	-	-	-	F	W, U, F	-	-

SOURCE: Modified from Tier 3, Technical Appendix 5C, Table 6.0-1 and Attachment 5C-1.

NOTES:

(a) Waterbody was frozen to the bottom.

X = no season of sampling specified; F = fall, U = summer, W = winter, P = spring, - = no data.

Table 5.5-3 Summary of Limnology Data Collected from Streams in the Kiggavik Project Area, 2007 to 2010

Watershed	Sub-Basin	Watercourse	2007	2008	2009	2010
Aniguq River	Willow Lake	Northeast Inflow of Pointer Lake	-	P, F	P, F	P
		Upper Tributary to the Northeast Inflow of Pointer Lake	-	-	-	P
		Upper Northwest Inflow of Pointer Lake	-	-	-	P
		Northwest Inflow of Pointer Lake	-	P, F	P	-
		Pointer/Rock Stream	F	P, F	P	-
		Sik Sik/Rock Stream	-	P, F	P, F	-
		Rock/Willow Stream	-	P, F	P, F	-
		Willow/Judge Sissons Stream	-	P, F	P, F	-
	Lower Lake	Mushroom/End Grid Stream	-	P, F	-	-
		End Grid/Shack Stream	-	P, F	-	-
		Cigar/Lunch Stream	-	P, F	-	-
		Knee/Lunch Stream	-	P, F	-	-
		Lunch/Andrew Stream	-	P, F	P	-
		Andrew/Shack Stream	-	P, F	P	-
		Shack/Lower Stream	F	P, F	-	-
		Lower/Judge Sissons Stream	-	P, F	-	-
	Caribou Lake	Ridge/Crash Stream	-	P, F	-	-
		Cirque/Crash Stream	-	P, F	-	-
		Crash/Fox Stream	F	P, F	-	-
		Fox/Caribou Stream	F	P, F	-	-
		Caribou/Calf Stream	-	P, F	-	-
		Calf/Judge Sissons Stream	-	P, F	-	-
	Aniguq River	Aniguq River	-	-	F	-
Access Local Study Area		several stream crossings	-	F	U, F	-

SOURCE: Modified from Tier 3, Technical Appendix 5C, Table 6.0-2.

NOTES:

F = fall, U = summer, P = spring, - = no data.

Lakes in the mine site LSA for which the maximum depth recorded was greater than or equal to 3 m include:

- Felsenmeer (6. 0 m), Escarpment (8.0 m), Scotch (6.0 m), Jaegar (4.0 m), Pointer (3.0 m) lakes, and Pointer Pond (4.5 m) in the Willow Lake sub-basin;
- Mushroom (8.9 m) and Cigar (3.6 m) lakes in the Lower Lake sub-basin;
- Ridge (7.1 m) and Cirque (5.2 m) lakes in the Caribou Lake sub-basin;
- Judge Sissons Lake (20.6 m) in the Judge Sissons Lake sub-basin;
- Siamese Lake (12.0 m) in the Siamese Lake sub-basin;
- Skinny Lake (12.8 m) in the Skinny Lake sub-basin; and
- Kavisilik Lake (12.0 m) in the Kavisilik Lake sub-basin.

Judge Sissons Lake is the largest (9,550 ha) and deepest (20.6 m) lake in the mine site LSA. In winter 2008, the DO concentration measured at the bottom of Judge Sissons Lake was 0.3 mg/L, considerably less than the CWQG of 9.5 mg/L for the protection of early life stages of cold water biota. However, DO levels at depths of 2.0 to 7.0 m were higher than the CWQG; this is the depth where most fall spawning species (e.g., lake trout and lake whitefish) would deposit their eggs. Generally, DO was above the CWQG for the protection of early life stages of cold water biota (9.5 mg/L) in most lakes. On occasion, DO measurements in some lakes were below the early life stages guideline, but still above the guideline for other life stages (6.5 mg/L).

Although lake pH values in the mine site LSA varied among lakes and within an individual lake over time, values generally fell within the CWQG range of 6.5 to 9.0. Exceptions were Cigar Lake and Siamese Lake where pH levels were below 6.5 on occasion, and Judge Sissons Lake and Squiggly Lake where pH levels were below 6.5 for all replicate stations in specific area of the lakes in fall 2013. Pointer Lake pH was especially variable, ranging from 9.9 in 2007 to 6.7 in 2009 (Tier 3, Technical Appendix 5C, Section 6.2 and Attachment 5C-1).

Streams in the mine site LSA had similar limnology characteristics as the lakes and were generally shallow (less than 1.5 m deep).

5.5.2 Benthic Invertebrates

5.5.2.1 Benthic Invertebrate Communities

This section presents the historical and current information available on benthic invertebrate communities within the LSA. Detailed methods and results can be found in Tier 3, Technical Appendix 5C (Section 7.0 and Attachment 5C-1).

Benthic invertebrate community surveys were conducted between 1979 and 2013 in lakes and between 1989 and 2009 in streams of the mine site LSA. Table 5.5-4 summarizes the locations of benthic invertebrate community sampling in lakes by year. Table 5.5-5 summarizes the locations of benthic invertebrate community sampling in streams by year. Figures 5.3-1 parts A to E, 5.3-2 parts A to C, and 5.3-3 show where the recent samples were collected.

Overall, benthic invertebrate communities in lakes in the LSA were characterized by low to moderate density and diversity. Taxa richness varied from four to 26 taxa per lake in the LSA (including Baker Lake). Chironomids were the dominant taxa, followed by fingernail clams, in all lakes except Lunch Lake, Fox Lake, Crash Lake, Calf Lake, and samples collected from Judge Sissons Lake in fall 2013. Some of the samples collected from Judge Sissons Lake in 2013 had a larger proportion of snails than fingernail clams, but chironomids were consistently the dominant taxa present. Lakes with very high proportions of sandy or coarse substrate tended towards high proportions of chironomids and decreased taxa richness. A previously unidentified species of orthoclads was documented in Willow Lake in 2007 (Tier 3, Technical Appendix 5C, Section 7.2). None of the taxa present are federally listed as being endangered or at risk species.

Table 5.5-4 Summary of Benthic Invertebrate Community Sampling Collected from Lakes in the Kiggavik Project Area, 1979 to 2013

Watershed	Sub-Basin	Waterbody	1979	1980	1990	1991	2007	2008	2009	2013
Aniguq River	Willow Lake	Scotch Lake	X	X	-	-	-	-	-	-
		Pointer Lake	X	X	-	-	X	X	-	-
		Sik Sik Lake	-	-	-	-	X	X	X	-
		Rock Lake	-	-	-	-	-	X	X	-
		Willow Lake	-	-	-	-	X	X	X	-
	Lower Lake	Mushroom Lake	-	-	-	X	-	X	-	-
		End Grid Lake	-	-	-	-	X	X	-	-
		Cigar Lake	-	-	-	X	-	X	-	-
		Knee Lake	-	-	X	-	-	-	-	-
		Lunch Lake	-	-	X	-	-	X	-	-
		Andrew Lake	-	-	-	-	X	X	X	-
		Shack Lake	-	-	X	-	X	X	-	-
		Lower Lake	-	-	-	-	X	X	-	-

Table 5.5-4 Summary of Benthic Invertebrate Community Sampling Collected from Lakes in the Kiggavik Project Area, 1979 to 2013

Watershed	Sub-Basin	Waterbody	1979	1980	1990	1991	2007	2008	2009	2013
	Caribou Lake	Ridge Lake	-	-	-	-	X	X	-	-
		Cirque Lake	-	-	-	-	X	X	-	-
		Crash Lake	-	-	-	-	X	X	-	-
		Fox Lake	-	-	-	-	X	X	-	-
		Caribou Lake	-	-	-	-	-	X	-	-
		Calf Lake	-	-	-	-	-	X	-	-
	Judge Sissons Lake	Judge Sissons Lake	X	X	-	-	-	X	X	X
	Siamese Lake	Siamese Lake	-	-	-	-	-	X	-	-
	Kavisilik Lake	Kavisilik Lake	-	X	-	-	-	-	-	-
Thelon River	Squiggly Lake	Squiggly Lake	-	X	-	-	-	-	-	X
Baker Lake	Baker Lake	Baker Lake	-	-	-	-	-	X	-	-

SOURCE: Modified from Tier 3, Techncial Appendix 5C, Table 7.0-1 and Attchment 5C-1.
NOTES:
X = data collected, - = data not collected.

Judge Sissons Lake had variable taxa richness and density; this is likely a reflection of its large size relative to other lakes in the LSA. However, similar to most other lakes in the LSA, chironomids, and then fingernail clams or snails, were the dominant taxa (Tier 3, Technical Appendix 5C, Section 7.2 and Attachment 5C-1, Section 2.4.2.1).

Stream benthic invertebrate communities generally had higher taxa richness than the lakes of the LSA. As in the lakes, chironomids were generally the dominant taxa. When the proportion of chironomids decreased, the proportion of seed shrimp and Hydridae generally increased. A few streams were dominated by oligochaete worms or Hydridae.

Table 5.5-5 Summary of Benthic Invertebrate Community Sampling Collected from Streams on the Kiggavik Project Area, 1989 to 2009

Watershed	Sub-Basin	Watercourse	1989	1990	1991	2008	2009
Aniguq River	Willow Lake	Northeast Inflow of Pointer Lake	-	-	-	X	X
		Northwest Inflow of Pointer Lake	-	-	-	X	-
		Jaeger Lake outlet	X	-	-	-	-
		Pointer/Rock Stream	X	-	X	X	-
		Rock/Willow Stream	-	-	-	X	X
		Willow/Judge Sissons Stream	-	-	-	X	X
	Lower Lake	Mushroom/End Grid Stream	-	-	-	X	-
		End Grid/Shack Stream	-	-	-	X	-
		Shack Lake Inlet Stream	-	X	-	-	-
		Cigar/Lunch Stream	-	-	-	X	-
		Lunch Lake Inlet Stream	-	X	-	-	-
		Knee Lake Inlet Stream	-	X	-	-	-
		Knee/Lunch Stream	-	-	-	X	-
		Lunch/Andrew Stream	-	-	-	X	-
		Andrew/Shack Stream	-	-	-	X	-
		Andrew Lake Study Area outflow	-	-	X	-	-
		Shack/Lower Stream	-	X	-	X	-
		Lower/Judge Sissons Stream	-	-	-	X	-
	Caribou Lake	Ridge/Crash Stream	X	-	-	X	-
		Cirque/Crash Stream	-	-	-	X	-
		Crash/Fox Stream	-	-	-	X	-
		Fox/Caribou Stream	-	-	-	X	-
		Caribou/Calf Stream	-	-	-	X	-
		Calf/Judge Sissons Stream	-	-	-	X	-
	Skinny Lake	Skinny Lake outlet	X	-	-	-	-
	Aniguq River	Judge Sissons Lake outlet	-	-	X	-	-
		Aniguq River	-	-	-	-	X

SOURCE: Modified from Tier 3, Technical Appendix 5C, Table 7.0-2.
NOTES:
X =data collected, - = data not collected.

5.5.2.2 Benthic Invertebrate Tissue Chemistry

Benthic invertebrate tissue chemistry is used to determine baseline chemistry concentrations in potential dietary items of higher trophic level organisms, and ultimately to inform future Environmental Effects Monitoring (EEM) programs. Recent studies were conducted in 2013 in Judge Sissons Lake to collect this baseline information.

This section presents the information collected in 2013 on benthic invertebrate tissue chemistry within the LSA. Detailed methods and results can be found in the technical memo for 2013 data (Tier 3, Appendix 5C, Attachment 5C-1, Section 3.0).

Baseline benthic invertebrate tissue quality data were collected at three locations in Judge Sissons Lake in fall 2013 (Figure 5.3-1 part C). The following parameters were analysed for Judge Sissons Lake samples:

- 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).

The detection limits for the analyses varied depending on the quantity of dry weight (dw) sample available. Assuming 90% moisture content, 5 grams (g) wet weight (ww) was required to obtain the minimal laboratory requirement of 0.5 g dw for metal analysis. The detection limits for radionuclides was dependent on the available sample volume for analysis (i.e., the more sample volume available, the lower the detection limits). All soft-bodied invertebrate samples were analyzed for metals and radionuclides. All hard-bodied invertebrates (snails) were analysed for metals, but the samples were combined for the radionuclides analysis.

Results from the chemical analyses for moisture, aluminum, iron, manganese, strontium, titanium, and zinc 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). This is likely related to the variation in species composition among the stations. Similarly, results from the chemical analyses of aluminum, barium copper, iron, manganese, strontium, titanium, and zinc varied considerably among stations for the hard-bodied invertebrates (snails). Thus, a general comparison between the soft-bodied and hard-bodied invertebrates cannot be provided. Non-detect values were obtained only for antimony in some samples (n=4; 3 snails, 1 soft-bodied invertebrate) (Table 5.5-6).

Polonium-210 was detected in all samples. Non-detect values or values close to the detection limit were observed for all other radionuclide parameters (i.e., lead-210, radium-226, thorium-230) (Table 5.5-6).

Table 5.5-6 Summary of Benthic Invertebrate Chemistry for Soft Bodied Invertebrates and Snails Collected in Judge Sissons Lake, 2013

Parameter	Units	Soft-Bodied 2013 n = 3[(a)]	Hard-Bodied (snails) 2013 n = 3[(a)]
Physical Properties			
Moisture	%	75.10 to 85.10	63.11 to 69.89
Total Metals and Metalloids			
Aluminum	µg/g	1,100 to 2,900	280 to 580
Antimony	µg/g	<0.02 to 0.02 (1 < DL)	<0.02 (3 < DL)
Arsenic	µg/g	1.4 to 1.9	3.2 to 3.7
Barium	µg/g	73.8 to 82.6	216 to 292
Beryllium	µg/g	0.068 to 0.12	0.024 to 0.036
Boron	µg/g	3 to 4.5	1.5 to 1.8
Cadmium	µg/g	0.16 to 0.26	0.50 to 1.0
Chromium	µg/g	2.1 to 7.2	0.7 to 1.2
Cobalt	µg/g	1.3 to 2.4	0.91 to 1.8
Copper	µg/g	11.6 to 18.7	50.0 to 79.6
Iron	µg/g	2,200 to 5,400	1,000 to 1,800
Lead	µg/g	0.92 to 1.8	0.23 to 0.98
Manganese	µg/g	320 to 410	190 to 290
Molybdenum	µg/g	0.82 to 1.1	0.44 to 0.62
Nickel	µg/g	4.1 to 6.7	2.9 to 4.3
Selenium	µg/g	0.41 to 0.71	0.64 to 0.91
Silver	µg/g	0.045 to 0.10	0.30 to 0.56
Strontium	µg/g	9.8 to 20	240 to 270
Thallium	µg/g	0.03 to 0.04	0.04 to 0.08
Tin	µg/g	0.04 to 0.10	0.01 to 0.03

Table 5.5-6 Summary of Benthic Invertebrate Chemistry for Soft Bodied Invertebrates and Snails Collected in Judge Sissons Lake, 2013

Parameter	Units	Soft-Bodied 2013 n = 3[(a)]	Hard-Bodied (snails) 2013 n = 3[(a)]
Titanium	µg/g	32 to 86	9.7 to 28
Uranium	µg/g	0.25 to 0.45	0.28 to 0.48
Vanadium	µg/g	1.7 to 7.3	0.51 to 1.2
Zinc	µg/g	50 to 85	47 to 93
Radionuclides			
Lead-210	Bq/g	<0.06 to 0.1 (2 < DL)	<0.04[(b)] (1 < DL)
Polonium-210	Bq/g	0.10 to 0.21	0.27[(b)]
Radium-226	Bq/g	<0.02 (2 < DL)	0.01[(b)]
Thorium-230	Bq/g	<0.03 to <0.04 (2 < DL)	<0.02[(b)]

SOURCE: Modified From Table 7 in Attachment 5c-1.

NOTE:
All results are reported on a freeze dried basis.
(a) Not all parameters were analyzed during each sampling period.
(b) Composite of all snail stations from 2013.
n = number of samples analyzed; % = percentage; µg/g = micrograms per gram; Bq/g = Becquerels per gram; < = less than;
DL = detection limit.

5.5.3 Aquatic Macrophytes

Aquatic macrophytes are an important component of aquatic systems, providing habitat for both fish and invertebrates. They also offer fish and invertebrates protection against currents and predators, as well as a substrate for the deposition of eggs. Aquatic macrophytes can also be used as an indicator of the health of the aquatic ecosystem.

Macrophytes can be used to monitor metals in the aquatic environment (Prasad 2009). Prasad (2009) identified *Carex juncell* and *C. rostrata* for use in the biomonitoring of trace elements of chromium, cobalt, copper, lead, molybdenum, nickel, uranium, and zinc. *Carex* species have also been used for monitoring metals such as cadmium, iron, lead, and manganese (Prasad 2009). This section presents the current information available on macrophyte chemistry within the mine site LSA. Detailed methods and results can be found in Tier 3, Technical Appendix 5C (Section 8.0).

Baseline macrophyte data (i.e., roots and shoots of *Carex* species) were collected in five lakes during fall 2009, including Pointer, Sik Sik, Rock, and Willow lakes in the Willow Lake sub-basin, and Judge Sissons Lake (Figures 5.3-1 parts A to C, 5.3-2, and 5.3-3). The following parameters were measured:

- physical properties (i.e., percent moisture);
- total metals by ICP-MS scan (i.e., aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, strontium, thallium, tin, titanium, uranium, vanadium, and zinc); and
- radionuclides, including lead-210, polonium-210, radium-226, thorium-228, thorium-230, and thorium-232.

All results were reported on a dry weight basis. Macrophyte chemistry data for roots and shoots were compared between paired samples of roots and shoots from the same lake, among sampling stations in the same lake, and among lakes.

Because *Carex* species have been used successfully in the past to monitor various metals in macrophyte tissues, these plants were used to assess metal and radionuclide background concentrations in the LSA. Macrophytes were only sampled in 2009. In general, concentrations in roots and shoots differed, with percent moisture and concentrations of most metals and radionuclides higher in roots than shoots. Concentrations in shoots were near or below detection limits for most metals and radionuclides (Table 5.5-7).

Baseline macrophyte chemistry parameters for Judge Sissons Lake were within the range observed in lakes from the Willow Lake sub-basin (i.e., Pointer, Sik Sik, Rock, and Willow lakes) for roots and for shoots with the exception of a few parameters (i.e., barium, boron, uranium, and Ra-226 for the roots, and moisture, cadmium, cobalt, copper, and manganese for the shoots). The range of manganese concentration in the shoots from Judge Sissons Lake (i.e., 390 to 650 µg/g dw) was higher than for lakes from the Willow Lake sub-basin (i.e., 90 to 350 µg/g dw) (Table 5.5-7).

Table 5.5-7 Summary of Macrophyte Chemistry for Roots and Shoots of *Carex* Species Collected in the Kiggavik Project Area, 2009

Parameter	Unit	Willow Lake Sub-Basin		Judge Sissons Lake Sub-Basin	
		All Lakes		Judge Sissons Lake	
		Roots (n = 12)	Shoots (n = 12)	Roots (n = 3)	Shoots (n = 3)
Physical Properties					
Moisture	%	76.75 to 84.98	66.80 to 75.87	78.97 to 82.04	65.79 to 77.24
Metals					
Aluminum	µg/g dw	87 to 2,900	3.8 to 160	310 to 2,000	5.0 to 31
Antimony	µg/g dw	<0.1 (12 < DL)	<0.1 (12 < DL)	<0.1 to 0.1 (2 < DL)	<0.1 (3 < DL)
Arsenic	µg/g dw	0.64 to 31	<0.05 to 0.24 (1 < DL)	5.0 to 9.4	<0.05 to 0.11 (1 < DL)
Barium	µg/g dw	63 to 180	45 to 110	50 to 230	63 to 80
Beryllium	µg/g dw	0.02 to 0.25	<0.01 to 0.01 (11 < DL)	0.06 to 0.22	<0.01 to 0.01 (2 < DL)
Boron	µg/g dw	2 to 4	3 to 5	3 to 8	4 to 5
Cadmium	µg/g dw	0.06 to 0.71	<0.01 to 0.03 (2 < DL)	0.10 to 0.29	0.02 to 0.05
Chromium	µg/g dw	<0.5 to 5.3 (6 < DL)	<0.5 to 0.6 (11 < DL)	0.8 to 5.3	<0.5 (3 < DL)
Cobalt	µg/g dw	0.38 to 5.0	<0.01 to 0.17 (1 < DL)	0.84 to 2.2	0.10 to 0.23
Copper	µg/g dw	2.2 to 27	2.2 to 4.9	5.1 to 20	3.3 to 5.9
Iron	µg/g dw	3,200 to 17,300	70 to 900	5,100 to 11,400	150 to 250
Lead	µg/g dw	0.44 to 7.2	0.03 to 0.25	0.99 to 2.3	0.01 to 0.04
Manganese	µg/g dw	70 to 340	90 to 350	80 to 160	390 to 650
Molybdenum	µg/g dw	0.1 to 1.5	0.2 to 1.7	0.2 to 0.6	0.7 to 2.3
Nickel	µg/g dw	0.93 to 5.7	0.2 to 1.8	0.95 to 5.2	1.0 to 2.1
Selenium	µg/g dw	<0.05 to 0.18 (7 < DL)	<0.05 (12 < DL)	0.07 to 0.19	<0.05 (3 < DL)
Silver	µg/g dw	<0.01 to 0.03 (8 < DL)	<0.01 (12 < DL)	<0.01 to 0.02 (1 < DL)	<0.01 (3 < DL)
Strontium	µg/g dw	5.9 to 22	13 to 27	6.6 to 15	15 to 19
Thallium	µg/g dw	<0.05 to 0.19 (2 < DL)	<0.05 (12 < DL)	<0.05 (3 < DL)	<0.05 (3 < DL)

Table 5.5-7 Summary of Macrophyte Chemistry for Roots and Shoots of *Carex* Species Collected in the Kiggavik Project Area, 2009

Parameter	Unit	Willow Lake Sub-Basin		Judge Sissons Lake Sub-Basin	
		All Lakes		Judge Sissons Lake	
		Roots (n = 12)	Shoots (n = 12)	Roots (n = 3)	Shoots (n = 3)
Tin	µg/g dw	<0.05 to 0.10 (10 < DL)	<0.05 to 0.08 (9 < DL)	<0.05 (3 < DL)	<0.05 (3 < DL)
Titanium	µg/g dw	2.2 to 97	0.08 to 4.9	6.2 to 45	0.16 to 0.57
Uranium	µg/g dw	0.02 to 0.61	<0.01 to 0.05 (8 < DL)	0.24 to 0.86	<0.01 (3 < DL)
Vanadium	µg/g dw	0.5 to 8.8	<0.1 to 0.4 (10 < DL)	3.0 to 7.0	<0.1 (3 < DL)
Zinc	µg/g dw	13 to 44	11 to 35	19 to 27	37 to 50
Radionuclides					
Lead-210	Bq/g dw	0.038 to 0.30	0.018 to 0.059	0.068 to 0.17	0.013 to 0.034
Polonium-210	Bq/g dw	0.028 to 0.16	0.012 to 0.035	0.052 to 0.097	0.012 to 0.027
Radium-226	Bq/g dw	0.004 to 0.017	0.001 to 0.004	0.006 to 0.047	0.002 to 0.004
Thorium-228	Bq/g dw	0.005 to 0.041	0.001 to 0.005	0.02 to 0.024	<0.001 to 0.002 (2 < DL)
Thorium-230	Bq/g dw	<0.001 to 0.008 (1 < DL)	<0.0009 to 0.001 (10 < DL)	0.003 to 0.006	<0.001 to 0.002 (1 < DL)
Thorium-232	Bq/g dw	0.001 to 0.01	<0.0009 to 0.001 (11 < DL)	0.002 to <0.006 (1 < DL)	<0.001 (3 < DL)

SOURCE: Modified from Tier 3, Technical Appendix 5C, Tables X.VI-1 and X.VI-2.

NOTES:

Moisture = moisture content by percent weight; µg/g dw = microgram per gram dry weight; Bq/g dw = Becquerels per gram dry weight; % = percent; n = number of samples.

5.5.4 Plankton and Periphyton Communities

The term “plankton” is a general term referring to small, usually microscopic, organisms that live suspended in open water. For the purpose of the Project, the term “phytoplankton” refers to the open-water, algal component (i.e., non-vascular, photosynthetic plants). Chlorophyll a is the primary photosynthetic pigment contained in phytoplankton (Wetzel 2001). The term “zooplankton” refers to microscopic animals that float, drift or swim weakly, and includes crustaceans (i.e., Cladocera [cladocerans], Calanoida and Cyclopoida [copepods]) and rotifers. For the purpose of the Project, the term “periphyton” refers only to the algal component as opposed to the entire biofilm. Periphyton is the term used to describe the algal community that grows attached to the substrate (generally rocks) in streams and lakes. They are a primary producer, similar to phytoplankton; however, periphyton is attached to the substrate where as phytoplankton is suspended in the water column.

This section presents the historical and current information available for plankton (i.e., phytoplankton and zooplankton) and periphyton within the LSA. Detailed methods and results can be found in Tier 3, Technical Appendix 5C (Section 9.0).

Plankton community surveys were carried out between 1979 and 2009 in lakes and streams of the mine site LSA. Table 5.5-8 provides a summary of the plankton sampling locations by year. Periphyton community surveys were completed between 2008 and 2009. Table 5.5-9 provides a summary of the periphyton sampling locations in streams by year. Figures 5.3-1 parts A to E, 5.3-2 parts A to C, and 5.3-3 show where the recent samples were collected.

Table 5.5-8 Summary of Phytoplankton and Zooplankton Sampling in Lakes and Streams in the Kiggavik Project Area, 1979 to 2009

Watershed	Sub-Basin	Waterbody	1979	1989	1990	1991	2008	2009
Aniguq River	Willow Lake	Scotch Lake	ZP	-	-	-	-	-
		Jaeger Lake	ZP	PP, ZP	-	-	-	-
		Pointer Lake	ZP	PP, ZP	-	ZP	PP, ZP	-
		Pointer Lake Outfall	-	-	-	PP	-	-
		Sik Sik Lake	-	-	-	-	-	PP, ZP
		Rock Lake	-	-	-	-	-	PP, ZP
		Willow Lake	-	-	-	-	-	PP, ZP
	Lower Lake	Mushroom Lake	-	-	PP, ZP	PP, ZP	PP, ZP	-
		Cigar Lake	-	-	PP, ZP	PP, ZP	-	-
		Andrew Lake	-	-	-		-	PP, ZP
		Andrew Lake Outfall	-	-	PP	PP	-	-
		Shack Lake	-	-	ZP	-	-	-
		Bear Island Lake	-	-	ZP	-	-	-
		Bear Island Lake Outfall	-	-	PP	-	-	-
		Lower Lake	-	-	ZP	-	PP, ZP	-
		Lower Lake Outfall	-	-	PP	-	-	-
	Caribou Lake	Ridge Lake	-	PP, ZP	-	PP	-	-
		Cirque Lake	-	PP, ZP	-	-	-	-
		Fox Lake	-	-	-	-	PP, ZP	-
		Caribou Lake	-	-	-	-	PP, ZP	-
	Judge Sissons Lake	Judge Sissons Lake	ZP	PP, ZP	-	PP, ZP	PP, ZP	PP, ZP
		Judge Sissons Outfall	-	-	-	PP	-	-
Baker Lake	Baker Lake	Baker Lake	-	-	-	-	ZP	-

SOURCE: Modified from Tier 3, Technical Appendix 5C, Table 9.0-1.

NOTES:

- = not collected; PP = phytoplankton; ZP = zooplankton.

Table 5.5-9 Summary of Periphyton Sampling in Streams in the Kiggavik Project Area, 2008 to 2009

Watershed	Sub-Basin	Watercourse	2008	2009
Aniguq River	Willow Lake	Northeast Inflow of Pointer Lake	X	X
		Northwest Inflow of Pointer Lake	X	-
		Pointer/Rock Stream	X	-
		Sik Sik/Rock Stream	[a]	[a]
		Rock/Willow Stream	X	X
		Willow/Judge Sissons Stream	X	X
	Lower Lake	Mushroom/End Grid Stream	X	-
		End Grid/Shack Stream	X	-
		Cigar/Lunch Stream	X	-
		Knee/Lunch Stream	X	-
		Lunch/Andrew Stream	X	-
		Andrew/Shack Stream	X	-
		Shack/Lower Stream	X	-
		Lower/Judge Sissons Stream	X	-
	Caribou Lake	Ridge/Crash Stream	X	-
		Cirque/Crash Stream	X	-
		Crash/Fox Stream	X	-
		Fox/Caribou Stream	X	-
		Caribou/Calf Stream	X	-
		Calf/Judge Sissons Stream	X	-
	Aniguq River	Aniguq River	-	X

SOURCE: Modified from Technical Appendix 5C, Table 9.0-2.

NOTES:

(a) Sampling was not completed at this station due to inappropriate substrate type.

X = data collected; - = data not collected.

5.5.4.1 Phytoplankton

Historical phytoplankton data from 1989 to 1991 are limited. The historical phytoplankton community data indicated some inter-lake variability in phytoplankton biomass, particularly in August 1990. Chrysophytes tended to be the dominant taxonomic group; however, cyanobacteria and diatoms were also identified as dominant taxonomic groups, but this may be related to variation in the timing of sample collection (i.e., under ice versus summer open water conditions). Overall, the historical phytoplankton community data indicated lakes within the Project area exhibited characteristics typical of unproductive Canadian Shield lakes.

In general, chrysophytes were the most abundant taxonomic group in the phytoplankton communities of lakes sampled within the Project area in both 2008 and 2009. In 2008, phytoplankton community biomass was more variable both across lakes and between the two sampling seasons. With the exception of Fox Lake (2008), Andrew Lake (2009), and Sik Sik Lake (2009), cyanobacteria biomass was consistently low in lakes sampled within the Project area. Diatoms and “Other Taxa” were consistently low in abundance and biomass in all lakes. Species richness varied across lakes, with chlorophytes and chrysophytes exhibiting the greatest diversity. Several unique phytoplankton taxa were identified within various waterbodies in both 2008 and 2009; however, none of these are federally or territorially listed as endangered or ‘at risk’ taxa.

In 2008 and 2009, chlorophyll a concentrations were within the range specified for oligotrophic lakes. In general, higher chlorophyll a concentrations in 2008 were observed in the summer and decreased in the fall, which is inconsistent with the pattern observed for phytoplankton biomass. This suggests that seasonal and taxonomical variation may be affecting overall chlorophyll a concentrations.

5.5.4.2 Zooplankton

Historical zooplankton data from 1979 to 1991 are limited. Biomass data are absent for this period, and although rotifers were identified in 1989, 1990 and 1991 samples, they were not enumerated. This group is ecologically important, but is often overlooked because of their small size. In general, the zooplankton communities were either dominated by cladocerans or calanoid copepods. However, variation in crustacean species richness is likely a reflection of differences in sampling methods (i.e., vertical tows versus stationary sampling) and locations (i.e., deep basin versus outflow areas).

In both 2008 and 2009, rotifers consistently exhibited the highest relative density in all lakes sampled within the Project area. Rotifers also accounted for the majority of the zooplankton biomass, with the exception of Fox Lake (2008) and Sik Sik Lake (2009). In both summer and fall 2008, the zooplankton community within Fox Lake was dominated by cladocerans, specifically by the large sized *Daphnia middendorffiana*. The presence of this species suggests fish predation in this lake is limited. In 2009, the zooplankton community biomass in Sik Sik Lake was co-dominated by calanoids and cladocerans. *Leptodiaptomus sicilis* (calanoid) and *D. middendorffiana* were the predominant species, suggesting that fish predation in this lake is also limited. Several unique zooplankton taxa were identified within various waterbodies in both 2008 and 2009; however, none of these are federally or territorially listed as endangered or 'at risk' species.

5.5.4.3 Periphyton

In both 2008 and 2009, chlorophytes had the highest density in the majority of stream periphyton communities within the Project area, although a number of streams within the Lower Lake sub-basin had high densities of diatoms. Cyanobacteria were present in variable numbers within all streams within the Project area. Chlorophytes and cyanobacteria dominated the periphyton community biomass in many of the streams; however, diatom biomass was greater in several streams within the Lower Lake sub-basin. Overall, lowest level taxonomic richness in periphytic communities was similar between sub-basins, with diatoms being the most taxonomically rich group within streams in the Project area, followed by chlorophytes and cyanobacteria. Chrysophytes and cryptophytes, as well as dinoflagellates, were represented by a small number of taxa and were absent from several of the Project area streams. These three taxonomic groups represented a small proportion of the density and biomass of the periphyton community in all streams sampled within the Project area. Several unique periphyton taxa were identified within various waterbodies in both 2008 and 2009; however, none of these are federally or territorially listed as endangered or 'at risk' species.

5.5.5 Freshwater Habitats

This section presents the historical and current information available on freshwater habitats (i.e., lakes and streams) within the LSA. Detailed methods and results can be found in Tier 3, Technical Appendix 5C (Section 10.0 and Attachment 5C-1).

Bathymetric maps were produced between 1979 and 2013. Habitat maps were produced between 1979 and 2013 for lakes of the mine site LSA, and between 2008 and 2010 for all streams in the mine site and site access LSAs. Table 5.5-10 provides a summary of the lakes and ponds assessed for bathymetry and aquatic habitat. Table 5.5-11 provides a summary of the streams assessed for aquatic habitat. Table 5.5-12 provides a summary of stream crossings assessed along the proposed Kiggavik access road alignments between 2008 and 2010. Figures 5.3-1 parts A to E, 5.3-2 parts A to C, and 5.3-3 show where the recent bathymetric and habitat mapping data were collected.

Table 5.5-10 Summary of the Lakes and Ponds Assessed for Bathymetry and Aquatic Habitat, Kiggavik Project Area, 1979 to 2013

Watershed	Sub-Basin	Waterbody	Bathymetry Map	Aquatic Habitat Map
Aniguq River	Willow Lake	Meadow Lake	1979 to 1986	-
		Felsenmeer Lake	1979 to 1986	-
		Escarpment Lake	1979 to 1986	-
		Drum Lake	1979 to 1986	-
		Lin Lake	1979 to 1986	-
		Scotch Lake	1979 to 1986	-
		Jaeger Lake	1979 to 1986	-
		Pointer Pond	2010	2010
		Pointer Lake	1979 to 1986, 2007	2007
		Sik Sik Lake	1979 to 1986, 2009	2007, 2009
		Rock Lake	1979 to 1986, 2008	2008
		Willow Lake	1979 to 1986	2007
	Lower Lake	Mushroom Lake	1990, 2009	2008, 2013
		Pond 1 to Pond 8	2010	2010
		End Grid Lake	2008	2007
		Smoke Lake	1990	-
		Cigar Lake	1990	2008
		Knee Lake	1990	2008
		Lunch Lake	1990	2008
		Andrew Lake	1990, 2009	2007, 2009
		Shack Lake	1990	2007
		Bear Island Lake	1990	-
		Lower Lake	1990 to 1991	2007

Table 5.5-10 Summary of the Lakes and Ponds Assessed for Bathymetry and Aquatic Habitat, Kiggavik Project Area, 1979 to 2013

Watershed	Sub-Basin	Waterbody	Bathymetry Map	Aquatic Habitat Map
	Caribou Lake	Ridge Lake	1979 to 1986	2007
		Cirque Lake	1979 to 1986	2007
		Crash Lake	1979 to 1986	2007
		Fox Lake	1979 to 1986	2007
		Caribou Lake	1979 to 1986	2008
		Calf Lake	2008	2008
	Judge Sissons Lake	Judge Sissons Lake	1979 to 1986, 2009 (north), 2013 (west)	2008 (north) 2013 (west)
	Siamese Lake	Siamese Lake	2008	2008, 2013
	Skinny Lake	Skinny Lake	1979 to 1986	1979 to 1986
	Kavisilik Lake	Kavisilik Lake	1979 to 1986	-
Thelon River	Squiggly Lake	Squiggly Lake	1979 to 1986	-
Baker Lake	Baker Lake	Baker Lake	2008, 2009	2008, 2009

SOURCE: Tier 3, Technical Appendix 5C, Table 10.0-1 and Attachment 5C-1

NOTES:

- = no data

Table 5.5-11 Summary of the Streams Assessed for Aquatic Habitat, Kiggavik Project Area, 2008 to 2010

Watershed	Sub-Basin	Watercourse	Aquatic Habitat
Aniguq River	Willow Lake	Northeast Inflow of Pointer Lake	2008
		Upper Tributary to the Northeast Inflow of Pointer Lake	2010
		Upper Northwest Inflow of Pointer Lake	2010
		Northwest Inflow of Pointer Lake	2008
		Pointer/Rock Stream	2008
		Sik Sik/Rock Stream	2008
		Rock/Willow Stream	2008
		Willow/Judge Sissons Stream	2008

Table 5.5-11 Summary of the Streams Assessed for Aquatic Habitat, Kiggavik Project Area, 2008 to 2010

Watershed	Sub-Basin	Watercourse	Aquatic Habitat
	Lower Lake	Mushroom/End Grid Lake	2008
		End Grid/Shack Stream	2008
		Cigar/Lunch Stream	2008
		Knee/Lunch Stream	2008
		Lunch/Andrew Stream	2008
		Andrew/Shack Stream	2008
		Shack/Lower Stream	2008
		Lower/Judge Sissons Stream	2008
	Caribou Lake	Ridge/Crash Stream	Flight overview only
		Cirque/Crash Stream	Flight overview only
		Crash/Fox Stream	Flight overview only
		Fox/Caribou Stream	2008
		Caribou/Calf Stream	2008
		Calf/Judge Sissons Stream	2008
	Aniguq River	Aniguq River	Flight overview only[(a)]

SOURCE: Modified from Tier 3, Technical Appendix 5C, Table 10.0-2.

NOTES:

(a) In 2009, habitat mapping was conducted on the Aniguq River at the alternate S5 crossing.

Table 5.5-12 Summary of Stream Crossings Assessed Along the Proposed Kiggavik All-Season and Winter Access Road Alignments Between 2008 and 2010

Crossing Identification	Habitat Mapping	Fish Community
Km 2.0	2008, 2009	2008, 2009
Km 2.9	2009 (no map)	-
Km 6.7	2009	2009
Km 11.3	2009	2009
Km 14.1	2009 (no map)	-
Km 15.6	2009	2009

Table 5.5-12 Summary of Stream Crossings Assessed Along the Proposed Kiggavik All-Season and Winter Access Road Alignments Between 2008 and 2010

Crossing Identification	Habitat Mapping	Fish Community
Km 17.2	2009	2009
Km 19.6	2009 (no map)	-
Km 100.2	2009	2009
Km 109.8	2009	2009
Km 112.9	2009 (no map)	-
Km 127.5	2009	2009
Km 129.2	2009	2008[(a)], 2009
Km 130.1	2009	-
Km 131.3	2009	-
Km 145.3	2009	2009
Km 147.1	2009	2009
Km 147.6	2009	2009
Km 154.8	2009 (no map)	-
Km 157.3	2009	2008[(b)], 2009
Km 157.7	2009	2009
Km 159.5	2009 (no map)	-
Km 161.5	2009 (no map)	-
Km 163.2	2009 (no map)	-
Km 168.0	2009 (no map)	-
Km 171.2	2009 (no map)	-
Km 172.2	2009	2009
Km 174.3	2009	-
Km 174.8	2008, 2009, 2010	2008, 2009
Alternate EC30	-	2009
Km 193.3	-	2009
Km 195.1	-	2009
Km 197.5	-	2009
Km 203.0	2009	2009

Table 5.5-12 Summary of Stream Crossings Assessed Along the Proposed Kiggavik All-Season and Winter Access Road Alignments Between 2008 and 2010

Crossing Identification	Habitat Mapping	Fish Community
Km 209.4	2009	2009
Km 212.2	2009	2009
Km 213.1	2009	2009
Alternate W1	2009	2009
Alternate W2	2009	2009
Alternate W3	2009	2009
Alternate W4	2009	-
Alternate W5	2009	2009
Alternate W6	2009	2009
S14	2009	2009

SOURCE: Modified from March 18, 2011 Golder Technical Memo to Nicola Banton, AREVA titled "Summary of Aquatics Studies for the Kiggavik Uranium Project".

NOTES:
(a) In 2008, fish community was assessed 4 km downstream of Km 129.2.
(b) In 2008, fish community was assessed 0.5 km upstream of Km 157.3.
- = no data; km = kilometres; no map = no habitat mapping produced because section of stream had no visible channel or stream was dry at the time of survey.

5.5.5.1 Mine Site Local Study Area

A brief summary of lake and stream habitat characteristics is provided in the following sections.

Willow Lake Sub-Basin (Surrounding the Proposed Kiggavik Mine Site)

Habitat assessment of lakes (i.e., Pointer Pond, Pointer Lake, Sik Sik Lake, Rock Lake, and Willow Lake) in the Willow Lake sub-basin was completed between 2007 and 2010 (Table 5.5-10; Figure 5.3-1 parts A and E). Surface area ranged from 3 ha for Pointer Pond to 393 ha for Pointer Lake. Maximum depth ranged from 1.5 m in Rock Lake to 4.5 m in Pointer Pond. The shoreline development index ranged from 1.3 for Pointer Pond to 1.8 for Rock Lake, which has a more complex shoreline that includes several bays (Table 5.5-13).

Shoreline substrate in all lakes consisted primarily of boulder and cobble (n = 3) or cobble and boulder (n = 2) substrates. The shoreline slope was predominantly flat (n = 4) or varied from flat to moderately steep (n = 1). Shoreline vegetation was primarily grasses and low shrubs. In-lake habitat consisted of inundated vegetation, and/or interstitial spaces in the coarse cobble and boulder substrate. Some lakes contained areas of emergent and/or submergent aquatic vegetation (Table 5.5-13).

Habitat assessments of streams (i.e., Northeast Inflow of Pointer Lake Stream, Upper Tributary to the Northeast Inflow of Pointer Lake Stream, Upper Northwest Inflow of Pointer Lake Stream, Northwest Inflow of Pointer Lake Stream, Pointer/Rock Stream, Sik Sik/Rock Stream, Rock/Willow Stream, and Willow/Judge Sissons Stream) in the Willow Lake sub-basin were completed between 2008 and 2010 (Table 5.5-11; Figure 5.3-2 part A). The stream lengths assessed ranged from 420 m for Rock/Willow Stream to 5,575 m for the Northeast Inflow of Pointer Lake Stream. Maximum depth recorded ranged from 0.8 m in Upper Northwest Inflow of Pointer Lake Stream to deeper than 2 m in Willow/Judge Sissons Stream. Wetted width ranged from 0.1 m in the Upper Northwest Inflow of Pointer Lake Stream to 1,000 m in an area of unconfined flow during high water conditions in the Northeast Inflow of Pointer Lake Stream. Bankfull width ranged from 0.1 m in the Upper Northwest Inflow of Pointer Lake Stream to wider than 100 m in a pond area on the lower section of the same stream (Table 5.5-14).

Dominant habitat types recorded were run (n = 8, for a total of 8,212 m) and riffle (n = 7, for a total of 2,318 m) habitats, with flats (n = 6, for a total of 2,260.5 m) also being common (Table 5.5-13). Pool (n = 4, for a total of 412.5 m), pond (n = 2, for a total of 396 m), rapid (n = 1, for a total of 350.5 m), and cascade (n = 1, for a total of 108 m) habitat types were observed less frequently. Some sections of boulder garden (n = 3, for a total of 608 m), no defined/visible channel (n = 2, for a total of 429 m), and falls (n = 1, for a total of 172 m) were also observed.

Organic material was observed as the dominant substrate in three streams. Cobble, gravel, and boulders were observed as the dominant substrate types in two, two, and one stream, respectively (Table 5.5-14). The shoreline slope was predominantly flat (n = 6) or varied from flat to moderate or steep (n = 2). Shoreline vegetation was primarily grasses and low shrubs. Overhead cover was limited and consisted of undercut banks. In-stream cover generally consisted of inundated vegetation and/or interstitial spaces between the coarse substrate. In addition, some streams contained in-stream cover in the form of areas of emergent and/or submergent vegetation, deeper sections or areas of water turbulence, and woody debris (Tier 3, Technical Appendix 5C, Table 10A-1).

Table 5.5-13 Summary of Lake Habitat Characteristics in the Kiggavik Project Area, Historical Data and from 2007 to 2010

Sub-Basin	Waterbody	Survey Year or Reference	Surface Area (ha)[(a)]	Maximum Depth (m)[(b)]	Mean Depth (m)[(c)]	Shoreline Development[(d)]	Fish Observed/Captured (BEAK 1990, 1992a; 2007 to 2010)	Substrate	Habitat Assessment
Willow Lake	Pointer Pond	2010	3.09	4.5	1.5	1.3	no fish observed or captured in pond; slimy sculpin captured in the stream immediately upstream of pond	boulder/cobble	shoreline vegetation was predominantly grasses and low shrubs with areas bare or with moss, backed by tundra; shoreline slope varied from flat to moderately steep; cover consisted primarily of interstitial spaces in coarse substrate and inundated vegetation, with emergent and submergent vegetation also present .
	Pointer Lake	2007	393	3.0	1.4	1.7	Arctic grayling; cisco; lake trout; ninespine stickleback	cobble/boulder	shoreline vegetation was predominantly grasses and low shrubs, backed by tundra; predominantly a flat slope; exposed boulders present; shoreline cover consisted primarily of interstitial spaces in the coarse substrate and some areas with emergent vegetation.
	Sik Sik Lake	2009	17.5	1.7	0.9	1.5	ninespine stickleback	boulder/cobble	shoreline vegetation was predominantly grasses and low shrubs, backed by tundra; predominantly a flat slope; exposed boulders present; shoreline cover consisted primarily of interstitial spaces between coarse substrate with some inundated vegetation.
	Rock Lake	2008	32.4	1.5	0.7	1.8	Arctic grayling; lake trout	cobble/boulder	shoreline slope was predominantly flat; shoreline cover consisted primarily of interstitial spaces between coarse substrate and submergent vegetation; shoreline vegetation was dominated by grass, backed with tundra; secondary shoreline vegetation consisted of low shrubs; areas with boulder fields.
	Willow Lake	BEAK 1990	54.9	2.0	1.4	1.6	Arctic grayling; lake trout; ninespine stickleback	boulder/cobble	shoreline vegetation was predominantly grasses and low shrubs, backed by tundra; predominantly a flat slope; exposed boulders present; shoreline cover consisted primarily of interstitial spaces in the coarse substrate and inundated vegetation.
Lower Lake	Mushroom Lake	2009	32.0	8.9	1.9	1.7	Arctic grayling; cisco; lake trout; round whitefish	cobble/boulder	shoreline slope was predominantly flat with an area of moderate to moderately steep slope; shoreline cover consisted primarily of interstitial space between coarse substrate; shoreline vegetation was dominated by grass, backed with tundra; areas of exposed boulders and sand beach present.
	Pond 1	2010	9.94	1.5	0.7	1.7	no fish observed or captured	sand/boulder	shoreline vegetation was predominantly grasses and low shrubs, backed by tundra; flat shoreline slope; cover consisted of interstitial spaces between coarse substrate and emergent vegetation.
	Pond 2	2010	6.56	1.2	0.6	1.5	no fish observed or captured	sand/boulder	shoreline vegetation was predominantly grasses and low shrubs, backed by tundra; flat shoreline slope; exposed boulders present; cover consisted of inundated vegetation, emergent vegetation, and interstitial spaces between coarse substrate.
	Pond 3	2010	0.26	0.5	0.3	1.3	no fish observed or captured	silt/sand (permafrost at 0.5 m)	shoreline vegetation was predominantly grasses and low shrubs, backed by tundra; flat shoreline slope; cover consisted of emergent vegetation and interstitial spaces between coarse substrate.
	Pond 4	2010	0.67	0.7	0.3	1.2	no fish observed or captured	silt/cobble	shoreline vegetation was predominantly grasses and low shrubs, backed by tundra; flat shoreline slope; cover consisted primarily of interstitial spaces between coarse substrate, and emergent vegetation.
	Pond 5	2010	1.62	1.0	0.4	1.4	no fish observed or captured	silt/sand	shoreline vegetation was predominantly grasses and low shrubs, backed by tundra; flat shoreline slope; cover consisted of inundated vegetation, emergent vegetation, and interstitial spaces between coarse substrate.

Table 5.5-13 Summary of Lake Habitat Characteristics in the Kiggavik Project Area, Historical Data and from 2007 to 2010

Sub-Basin	Waterbody	Survey Year or Reference	Surface Area (ha)[(a)]	Maximum Depth (m)[(b)]	Mean Depth (m)[(c)]	Shoreline Development[(d)]	Fish Observed/Captured (BEAK 1990; 1992a; 2007 to 2010)	Substrate	Habitat Assessment
Lower Lake	Pond 6	2010	1.76	1.2	0.7	1.4	no fish observed or captured	silt/sand	shoreline vegetation was predominantly grasses and low shrubs, backed with tundra; flat shoreline slope; cover consisted of inundated vegetation, emergent vegetation, and interstitial spaces between coarse substrate.
	Pond 7	2010	6.53	1.2	0.6	1.2	no fish observed or captured	sand/boulder	shoreline vegetation was predominantly grasses and low shrubs, backed with tundra; flat shoreline slope; cover consisted primarily of inundated vegetation, emergent vegetation, and interstitial spaces between coarse substrate.
	Pond 8	2010	0.44	0.7	0.4	1.1	no fish observed or captured	sand/silt	shoreline vegetation was predominantly grasses and low shrubs, backed with tundra; flat shoreline slope; cover consisted primarily of emergent vegetation and inundated vegetation.
	End Grid Lake	2008	13.2	1.4	0.8	1.2	Arctic grayling	sand/organic material/ cobble	shoreline vegetation was predominantly grasses, backed by tundra; predominantly a flat slope; exposed boulders present; inundated vegetation present
	Cigar Lake	BEAK 1992a	113	3.6	1.5	2.0	Arctic grayling; burbot; cisco; lake trout; round whitefish	cobble/boulder	shoreline slope was predominantly flat with an area of moderate to moderately steep slope; shoreline cover consisted primarily of interstitial spaces between coarse substrate; shoreline vegetation was dominated by grass, backed with tundra; areas of exposed boulders and boulder fields present.
	Knee Lake	BEAK 1992a	34.9	0.8	0.2	1.6	Arctic grayling	sand/gravel	shoreline slope was predominantly flat with an area of moderate slope; shoreline cover consisted primarily of interstitial spaces between coarse substrate and inundated vegetation; shoreline vegetation was dominated by grass, backed with tundra; areas of boulder fields and boulder gardens present.
	Lunch Lake	BEAK 1992a	77.8	1.6	0.6	1.4	Arctic grayling; lake trout; round whitefish	boulder/silt	shoreline slope was predominantly flat; shoreline cover consisted primarily of interstitial spaces between coarse substrate; shoreline vegetation was dominated by grass, backed with tundra; areas of boulder gardens present.
	Andrew Lake	2009	54.3	1.0	0.2	1.9	Arctic grayling; burbot; cisco; round whitefish	sand/cobble	shoreline vegetation was predominantly grasses and low shrubs, backed by tundra; predominantly a flat slope; exposed boulders present; shoreline cover consisted primarily of interstitial spaces between coarse substrate, with some areas of inundated vegetation.
	Shack Lake	BEAK 1992a	60.0	1.6	0.6	1.8	Arctic grayling	sand/boulder/ cobble	shoreline vegetation was predominantly grasses and low shrubs, backed by tundra; predominantly a flat slope; exposed boulders present; shoreline cover consisted primarily of interstitial spaces between coarse substrate, with inundated vegetation.
	Lower Lake	BEAK 1992a	49.0	1.4	0.4	1.9	Arctic grayling; burbot; cisco; ninespine stickleback; round whitefish	cobble/boulder	shoreline vegetation was predominantly grasses, backed by tundra; predominantly a flat slope; exposed boulders present; shoreline cover consisted primarily of interstitial spaces between coarse substrate, and areas with inundated vegetation.; channel connecting north and south ends of lake had run and riffle habitat.
Caribou Lake	Ridge Lake	BEAK 1990	16.7	7.1	2.3	1.8	lake trout	cobble/boulder	shoreline vegetation was minimal, predominantly cobble/boulder, backed by tundra; predominantly had a flat slope; exposed boulders present; shoreline cover consisted primarily of interstitial spaces between coarse substrate.
	Cirque Lake	BEAK 1990	5.6	5.2	2.6	1.1	Arctic grayling; ninespine stickleback	cobble/boulder	shoreline vegetation was predominantly grasses backed by tundra; predominantly a flat slope; exposed boulders present, shoreline cover consisted primarily of interstitial spaces between coarse substrate with some inundated vegetation.

Table 5.5-13 Summary of Lake Habitat Characteristics in the Kiggavik Project Area, Historical Data and from 2007 to 2010

Sub-Basin	Waterbody	Survey Year or Reference	Surface Area (ha)[a]	Maximum Depth (m)[b]	Mean Depth (m)[c]	Shoreline Development[d]	Fish Observed/Captured (BEAK 1990, 1992a; 2007 to 2010)	Substrate	Habitat Assessment
Caribou Lake	Crash Lake	BEAK 1990	8.1	2.0	1.1	1.1	Arctic grayling	silt/sand/boulder	shoreline vegetation was predominantly grasses and low shrubs, backed by tundra; predominantly a flat slope; exposed boulders present; shoreline cover consisted primarily of interstitial spaces between the coarse substrates.
	Fox Lake	BEAK 1990	128	2.7	1.7	1.3	Arctic grayling; cisco; lake trout; ninespine stickleback	cobble/boulder	shoreline vegetation was predominantly grasses, backed by tundra; predominantly a flat slope; exposed boulders present; shoreline cover consisted of interstitial spaces between the coarse substrate.
	Caribou Lake	BEAK 1990	341	2.7	1.4	2.2	Arctic grayling; burbot; cisco; lake trout; ninespine stickleback; round whitefish	cobble/boulder	Shoreline slope was predominantly flat; shoreline cover consisted primarily of interstitial spaces between coarse substrate; shoreline vegetation was dominated by grass, backed with tundra; areas of exposed boulders and boulder fields present.
	Calf Lake	2008	35.8	1.2	0.6	1.3	burbot; cisco; ninespine stickleback	cobble/boulder	Shoreline slope was predominantly flat with an area of moderately steep slope; shoreline cover consisted primarily of interstitial spaces between coarse substrate; shoreline vegetation was dominated by grass and low shrubs, backed with tundra; areas of submergent vegetation and some inundated vegetation also present.
Judge Sissons Lake	Judge Sissons Lake	BEAK 1990, 2009	9,550	20.6	4.6	3.4	Arctic grayling; burbot; cisco; lake trout; ninespine stickleback; round whitefish; slimy sculpin	sand/gravel	Shoreline slope was predominantly flat; shoreline cover consisted primarily of interstitial spaces between coarse substrate, emergent and submergent vegetation, and inundated vegetation; shoreline vegetation was dominated by grass, backed with tundra; areas of exposed boulders and boulder fields present.
Siamese Lake	Siamese Lake	2008	2,792	12.0	4.1	2.4	lake trout	boulder/cobble	Shoreline slope was predominantly flat with an area of moderate to moderately steep slope; shoreline cover consisted primarily of interstitial spaces between coarse substrate, and inundated vegetation; shoreline vegetation was dominated by grass and low shrubs, backed with tundra.

SOURCE:

Modified from Tier 3, Technical Appendix 5C, Table X.VIII-1.

[a] Based on bathymetric data as presented in BEAK (1990; 1992a) unless recent bathymetric information was available. If no bathymetry was available at all, value was estimated from digital NTS coverage.

[b] Maximum depth is the maximum depth either collected at sampling stations, noted on recent bathymetry, or shown on bathymetric maps from BEAK (1990; 1992a).

[c] Based on bathymetric data as presented in BEAK (1990; 1992a) unless recent bathymetric information was available.

[d] Calculated from available data.

NOTES:

km^2 = square kilometres; ha = hectares; m = metres; slimy sculpin = *Cottus cognatus*; Arctic grayling = *Thymallus arcticus*; cisco = *Coregonus artedi*; lake trout = *Salvelinus namaycush*; ninespine stickleback = *Pungitius pungitius*; round whitefish = *Prosopium cylindraceum*; burbot = *Lota lota*; NTS = National Topographic System; - = not applicable.

Table 5.5-14 Summary of Stream Habitat Characteristics in the Kiggavik Project Area, 2008 to 2010

Sub-Basin	Watercourse	Total Stream Length (m)	Habitat Classification and Total Habitat Unit Length (m)											Maximum Depth (m)	Wetted Width (m)	Bankfull Width (m)	Substrate (dominant/ subdominant)	Fish Observed/Captured
			Falls	Cascade	Rapids	Riffle	Run	Flat	Pool	Pond	Backwater/Snye	Boulder Garden	No Defined/ Visible Channel					
Willow Lake	Northeast Inflow of Pointer Lake Stream	5,575	172[a]	108	-	410	4,789	211	57	-	-	280[b]	-	>1.0	0.2 to 1,000	0.2 to 43.9	cobble/organic material	ninespine stickleback
	Upper Tributary to the Northeast Inflow of Pointer Lake Stream	1,660	-	-	-	173	419	336	164	174	-	-	395	0.9	channel: 0.4 to15; pond: 20 to 100; NDC: 20 to120	channel: 0.4 to15; pond: 20 to 100	organic material/ boulder	no fish observed or captured
	Upper Northwest Inflow of Pointer Lake Stream	1,815	-	-	-	283	192	962	122	222	-	included in other	34	0.8	channel: 0.1 to 10; pond: 30 to 100	channel: 0.1 to 6; pond: 30 to 100	organic material/ boulder	slimy sculpin
	Northwest Inflow of Pointer Lake Stream	2,426	-	-	-	530[c]	1,542[c]	284	70	-	-	-	-	>1.0	1.0 to 75	0.6 to >100	gravel/cobble	Arctic grayling; lake trout
	Pointer/Rock Stream	1,071	-	-	350.5[d]	374.5[d]	346	-	-	-	-	156[b]	-	>1.5	-	-	boulder/cobble	Arctic grayling; burbot; ninespine stickleback; round whitefish
	Sik Sik/Rock Stream	925	-	-	-	-	547	378	-	-	-	-	-	0.9	2.5 to 100	-	organic material/ boulder	ninespine stickleback
	Rock/Willow Stream	420	-	-	-	329	91	-	-	-	-	172[b]	-	2	24.7 to 47.6	17.8 to 50.7	gravel/cobble	Arctic grayling; cisco; lake trout; ninespine stickleback; round whitefish
	Willow/Judge Sissons Stream	595	-	-	-	218.5	286[e]	90[e]	-	-	-	-	-	>2.0	60 to 110	-	cobble/organic material	Arctic grayling; lake trout; ninespine stickleback; slimy sculpin
Lower Lake	Mushroom/End Grid Stream	1,313	-	-	-	-	1,313	-	-	-	-	-	-	0.3	5.2 to 18.6	1.0 to 6.2	cobble/gravel	Arctic grayling; lake trout
	End Grid/Shack Stream	1,431	-	-	-	-	110	736	585	-	-	-	-	>1.0	30 to 500	1.9 to 25	organic material/ silt	Arctic grayling
	Cigar/Lunch Stream	1,190	-	-	-	120	840	230	-	-	-	-	-	0.8	12 to 200	2.5 to 6.5	cobble/boulder	no fish observed or captured
	Knee/Lunch Stream	258	-	-	-	106	152	-	-	-	-	-	-	0.8	4.5 to 19.1	0.8 to 3.8	sand/cobble	lake trout
	Lunch/Andrew Stream	763	-	-	-	-	288	475	-	-	-	-	-	1.2	10 to 34.5	8.6 to 27.5	silt/cobble	Arctic grayling
	Andrew/Shack Stream	1,014	-	-	-	320	694	-	-	-	-	-	-	1.1	12.0 - 60	7.5 to 15.4	cobble/boulder	Arctic grayling

Table 5.5-14 Summary of Stream Habitat Characteristics in the Kiggavik Project Area, 2008 to 2010

Sub-Basin	Watercourse	Total Stream Length (m)	Habitat Classification and Total Habitat Unit Length (m)											Maximum Depth (m)	Wetted Width (m)	Bankfull Width (m)	Substrate (dominant/ subdominant)	Fish Observed/Captured
			Falls	Cascade	Rapids	Riffle	Run	Flat	Pool	Pond	Backwater/Snye	Boulder Garden	No Defined/ Visible Channel					
Lower Lake	Shack/Lower Stream	6,002	-	-	1,227.7	232	2,325	1,244	974	-	-	-	-	>1.3	7.0 to 100	2.0 to 25	boulder/cobble	lake trout
	Lower/Judge Sissons Stream	976	-	-	-	92.5	743	140	-	-	-	-	-	0.89	23.5 to 75	4.0 to 5.0	cobble/organic material	lake trout; ninespine stickleback
Caribou Lake	Fox/Caribou Stream	650	-	-	-	540	110	-	-	-	-	-	-	0.5	14.5 to 40	7.5 to 20	cobble/boulder	no fish observed or captured
	Caribou/Calf Stream	251	-	-	-	180	71	-	-	-	-	-	-	0.5	18.4 to 18.5	20.4 to 21.6	boulder/cobble	no fish observed or captured
	Calf/Judge Sissons Stream	1,765	-	-	-	-	1,325	440	-	-	-	-	-	0.8	60 to 150	7.0 to 49.4	gravel/cobble	Arctic grayling; lake trout
Aniguq River	S5 (Aniguq River)	290	-	-	-	-	203	-	-	-	87	-	-	>2	13 to 98	15 to 100	silt/cobble	Arctic grayling, burbot, lake trout, ninespine stickleback[f]

SOURCE: Modified from Tier 3, Technical Appendix 5C, Table 10A-1.

NOTE:

Wetted and bankfull widths collected from transect data are the minimum and maximum widths recorded.

Habitat mapping and fish community survey were not completed for Ridge/Crash, Cirque/Crash, and Crash/Fox streams in the Caribou Lake sub-basin, but an overview flight was conducted. No obstacles were observed and fish habitat observed was similar to other streams in the area.

(a) falls present on a small section of a primary habitat classification, total habitat classification length is representative of two habitat classifications.

(b) boulder gardens accompanied a primary habitat classification, total habitat classification length is representative of two habitat classifications.

(c) 126 m of stream section was riffle/run; length of stream was separated half for riffle (63 m) and the other half for run (63 m).

(d) 325 m of stream section was riffle/rapids; length of stream was separated half for riffle (162.5 m) and the other half for rapids (162.5 m).

(e) 180 m of stream section was flat/run; length of stream was separated half for flat (90 m) and the other half for run (90 m).

(f) Burbot and ninespine stickleback were captured in fall 2009 near the proposed road location; Arctic grayling and lake trout were captured further upstream during 2009 fall fish community survey.

m = metre; > = greater than; NDC = no defined channel; - = not available or not applicable; ninespine stickleback = *Pungitius pungitius*; slimy sculpin = *Cottus cognatus*; Arctic grayling = *Thymallus arcticus*; lake trout = *Salvelinus namaycush*; burbot = *Lota lota*; round whitefish = *Prosopium cylindraceum*; cisco = *Coregonus artedi*.

Lower Lake Sub-Basin (Surrounding the Proposed Sissons Mine Site)

Habitat assessments of lakes (i.e., Mushroom Lake, Pond 1 to Pond 8, End Grid Lake, Cigar Lake, Knee Lake, Lunch Lake, Andrew Lake, Shack Lake, and Lower Lake) in the Lower Lake sub-basin were completed between 2007 and 2010 (Table 5.5-10; Figure 5.3-1 parts B and C). Surface area ranged from 0.26 ha for Pond 3 to 113 ha for Cigar Lake. Maximum depth ranged from 0.5 m in Pond 3 (with permafrost at 0.5 m) to 8.9 m in Mushroom Lake. The shoreline development index ranged from 1.1 for Pond 8 to 2.0 for Cigar Lake, which had an elongated shape (Table 5.5-13).

Shoreline substrate in all lakes consisted primarily of sand (n = 8), silt (n = 4), cobble (n = 3), and boulder (n = 1). The shoreline slope was predominantly flat (n = 13) or varied from flat to moderately steep (n = 3). Shoreline vegetation was primarily grasses and low shrubs. In-lake habitat consisted of inundated vegetation, and/or interstitial spaces between the coarse cobble and boulder substrate. Some lakes contained areas of emergent vegetation as well (Table 5.5-13).

Habitat assessments of streams (i.e., Mushroom/End Grid, End Grid/Shack, Cigar/Lunch, Knee/Lunch, Lunch/Andrew, Andrew/Shack, Shack/Lower, and Lower/Judge Sissons streams) in the Lower Lake sub-basin were completed in 2008 (Table 5.5-11; Figure 5.3-2 part B). The stream lengths assessed ranged from 258 m for Knee/Lunch Stream to 6,002 m for Shack/Lower Stream. Maximum depth recorded ranged from 0.3 m in Mushroom/End Grid Stream to deeper than 1.3 m in Shack/Lower Stream. Wetted width ranged from 4.5 m in Knee/Lunch Stream to 500 m in an area of unconfined flow during high water conditions in End Grid/Shack Stream. Bankfull width ranged from 0.8 m in Knee/Lunch Stream to 27.5 m in Lunch/Andrew Stream (Table 5.5-14).

Dominant habitat types recorded were run (n = 8, for a total of 6,464.5 m) and flat (n = 5, for a total of 2,825 m) habitats, with riffles (n = 5, for a total of 870.5 m) also being common (Table 5.5-14). Pool (n = 2, for a total of 1,559 m) and rapid (n = 1, for a total of 1,227.7 m) habitat types were observed less frequently.

Cobble was observed as the dominant substrate in four streams. Organic material, sand, silt, and boulder were observed as the dominant substrate types in one stream each (Table 5.5-14). The shoreline slope was predominantly flat (n = 4) or varied from flat to moderate or steep slopes (n = 4). Shoreline vegetation was primarily grasses and low shrubs. Overhead cover habitat was limited and consisted of undercut banks. In-stream cover consisted of inundated vegetation and interstitial spaces between the coarse substrate. Some streams contained in-stream cover in the form of areas of emergent and/or submergent vegetation, deeper sections or areas of water turbulence, and/or turbidity (Tier 3, Technical Appendix 5C, Table 10A-1).

An additional detailed aquatic habitat and substrate assessment was completed in 2013 for an area of approximately 4 ha located on the south shore of Mushroom Lake where the proposed water intake is to be installed (Figure 5.3-1 part B). The assessed area measured about 200 m by 200 m and was located immediately adjacent to the shoreline. The maximum depth measured was 7 m, about 200 m off shore. The proposed installation depth for the water intake (5 m) was measured a distance of 160 m from shore (Tier 3, Technical Appendix 5C, Attachment 5C-1).

In general, fine substrate (i.e., organic material, silt, and sand) dominates areas greater than 2 m in depth; this pattern is relatively constant. The littoral area between 1 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 patchiness was observed.

More specifically, the littoral zone from the shore to 0.25 m water depth exhibited variable substrate composition, 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 to 1 m water depth had a number of deeper sections (troughs) with boulders (occasionally mixed with cobbles) interspersed with several shallower and narrower sections (crests) having variable substrate patches. These were dominated by sand, gravel, and/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, reaching 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 5.5-1).

Photo 5.5-1 A crest of substrate in the trough-crest-trough patterned substrate observed near shore in Mushroom Lake.

Macrophytes in the surveyed area were sparse, but were observed at four locations in Mushroom Lake.

Caribou Lake Sub-Basin (Traversed by the Proposed Haul Road)

Habitat assessments of lakes (i.e., Ridge, Cirque, Crash, Fox, Caribou, and Calf lakes) in the Caribou Lake sub-basin were completed between 2007 and 2008 (Table 5.5-10; Figure 5.3-1 parts A, C, and E). Surface area ranged from 5.6 ha for Cirque Lake to 341 ha for Caribou Lake. Maximum depth ranged from 1.2 m in Calf Lake to 7.1 m in Ridge Lake. The shoreline development index ranged from 1.1 for Cirque and Crash lakes to 2.2 for Caribou Lake, which had an elongated shape (Table 5.5-13).

Shoreline substrate in all lakes consisted primarily of cobble and boulder (n = 5) or silt, sand, and boulder (n = 1). The shoreline slope was predominantly flat (n = 5) or varied from flat to moderately steep (n = 1). Shoreline vegetation was primarily grasses and low shrubs. In-lake habitat consisted of interstitial spaces between the coarse cobble and boulder substrate and/or inundated vegetation, or submergent vegetation (Table 5.5-13).

Habitat assessments of streams (i.e., Fox/Caribou, Caribou/Calf, and Calf/Judge Sissons streams) in the Caribou Lake sub-basin were completed in 2008 (Table 5.5-11; Figure 5.3-2 part A). The stream lengths assessed ranged from 251 m for Caribou/Calf Stream to 1,765 m for Calf/Judge Sissons Stream. Maximum depth recorded ranged from 0.5 m in Fox/Caribou and Caribou/Calf streams to 0.8 m in Calf/Judge Sissons Stream. Wetted width ranged from 14.5 m in Fox/Caribou Stream to 150 m in an area of unconfined flow during high water conditions in the Calf/Judge Sissons Stream. Bankfull width ranged from 7.0 to 49.4 m in Calf/Judge Sissons Stream (Table 5.5-14).

Dominant habitat types recorded were run (n = 3, for a total of 1,506 m) and riffle (n = 2, for a total of 720 m) habitats (Table 5.5-14). Flats (n = 1, for a total of 440 m) were observed less frequently.

Cobble, gravel, and boulder were observed as the dominant substrate types in one stream each (Table 5.5-14). The shoreline slopes of streams werepredominantly flat (n = 3). Shoreline vegetation types were primarily grasses and low shrubs. In-stream cover consisted of inundated vegetation, and/or interstitial spaces between the coarse substrate. Some streams contained areas of deeper flow and concealing turbulence (Tier 3, Technical Appendix 5C, Table 10A-1).

Judge Sissons Lake (Proposed Treated Effluent Discharge)

A habitat assessment for the northern section of Judge Sissons Lake was completed in 2008 (Table 5.5-10; Figure 5.3-1 part C). The surface area was 9,550 ha, maximum depth was 20.6 m, and the shoreline development index was 3.4 due to the more complex shoreline that includes several large bays (Table 5.5-13). Given that no potential Project-related effects to aquatic habitat are anticipated in the southern portion of the lake, the habitat assessment was limited to the northern portions where the proposed treated effluent will be discharged.

The shoreline substrate on the west shoreline consisted primarily of sand mixed with coarse substrate. Gravel mixed with coarse substrates was the dominate substrate along the northwest and east shorelines, with several areas of cobble and boulder substrate. The shoreline slope was predominantly flat in the northwest section of Judge Sissons Lake, and ranged from low to high slopes in the northeast section of the lake. Shoreline vegetation included grass with some patches of low shrubs; several areas of exposed cobble, boulder, gravel, or sand were present. Shoreline cover consisted primarily of interstitial spaces between coarse substrates, with small areas of emergent and submergent vegetation and inundated terrestrial vegetation (Table 5.5-13).

Two additional detailed aquatic habitat and substrate assessments were completed in 2013 where the proposed Kiggavik and Sissons treated effluent diffusers are to be installed (Figure 5.3-1 part C).

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, at a location 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 (Tier 3, Technical Appendix 5C, Attachment 5C-1).

In general, fine substrates (i.e., sand) dominated areas greater than 2.5 m in depth. Coarse substrate (i.e., boulder, cobbles, and gravel) dominated the littoral area shallower than 2.5 m. The littoral zone from the shore to 2.5 m water depth had a large proportion of cobble in the north portion of the surveyed area, although this was occasionally mixed with boulder, gravel, or gravel-sand. A large proportion of gravel was observed in the south portion of the surveyed area, and was occasionally mixed with sand-cobble-boulder or cobble-boulder. Most boulder substrates were mixed with cobble, and occasionally with gravel-sand.

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

For the 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, near the site 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 (Tier 3, Technical Appendix 5C, Attachment 5C-1).

In general, fine substrates (i.e., clay, silt, and sand) dominated areas greater than 2 m in depth. The littoral area between 1 and 2 m deep exhibited more variability, with some sections dominated by fine substrates and other sections with coarse substrates. Coarse substrate (i.e., boulder and cobbles) dominated the littoral area shallowere 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 m to 2 m water depth was dominated by sand to the north, albeit mixed with clay or gravel-silt. Alarge proportion of cobble in the south portion was mixed with gravel-boulder or boulder-silt; a small patch was dominated by boulder with some cobble.

Macrophytes in the surveyed area were sparse, but were observed at several locations.

Based on maps of the bathymetric and aquatic habitat data collected in fall 2013, the Sissons treated effluent diffuser may require re-design for a shallower discharge, or may need to be extended or relocated in order to obtain a minimum 5 m water depth. It is anticipated that the littoral habitat in Judge Sissons Lake near the road crossing on Boulder/Judge Sissons Stream is similar to the habitat area mapped. The under water pipeline will be extended to reach the diffuser point located in the habitat-mapped area.

Siamese Lake (Proposed Water Supply Lake, Traversed by Proposed Winter Access Road, and Near Proposed Alternate Option All-Season Access Road)

A habitat assessment of Siamese Lake was completed in 2008 (Table 5.5-10). The surface area was 2,792 ha; maximum depth was 12.0 m; and the shoreline development index was 2.4 due to the complexity of the shoreline, which includes two distinct basins as well as several bays (Table 5.5-13).

The shoreline substrate consisted primarily of boulder and cobble, but also contained some large areas of exposed sand or gravel mixed with the larger substrate. The shoreline slope was predominantly flat, ranging from flat to moderately steep slopes in the southwest and northeast sections of the lake. Shoreline vegetation was dominated by grass with some patches of low shrubs. Shoreline cover consisted primarily of interstitial space between coarse substrates and small areas of inundated terrestrial vegetation (Table 5.5-13).

An additional detailed aquatic habitat and substrate assessment was completed in 2013 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 (Figure 5.3-1 part D). 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 proposed installation 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 and about 20 m south of the current proposed location transect (Tier 3, Technical Appendix 5C, Attachment 5C-1, Figure 5).

In general, fine substrates (i.e., organic material, silt, and sand) dominated areas greater than 3 m in depth. The littoral area between 2 and 3 m deep exhibited 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 higher degree of substrate patchiness was observed.

Similar to Mushroom Lake, the littoral zone from the shore to 2 m water depth had a number of deeper sections (troughs) with boulders that were occasionally mixed with cobbles or gravel-sand, interspersed with some shallower and narrower sections (crests) with variable substrate patches, or dominated by gravel or cobble (i.e., gravel-sand, cobble-silt, cobble-gravel-sand, cobble-gravel-boulder, cobble-boulder). Crests started near shore and extended into water to about 1.5 m deep. The crests exhibited a regular pattern, with crests being 3 to 5 m apart (Tier 3, Technical Appendix 5C, Attachment 5C-1, Figure 5).

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

Skinny Lake

Habitat assessment of Skinny Lake was completed before 1992. The surface area was 197 ha; the maximum depth was 12.8 m; and the shoreline development index was 2.5 due to the lake's elongated shape (Tier 3, Technical Appendix 5C, Figure X.III-30a).

The shoreline substrate consisted primarily of cobble and boulder, but also contained some areas of sand. Sand is also present in the deep section of the lake. Shoreline cover consisted primarily of interstitial spaces between coarse substrates (Tier 3, Technical Appendix 5C, Figure X.III-30a).

Proposed Kiggavik Sissons Haul Road (Kiggavik Site – Sissons Site)

The proposed Kiggavik-Sissons Haul Road crosses eight streams; three have no defined or visible channels, four are small to intermediate in size (i.e., channel widths less than 5 m) and one is classified as a large stream (i.e., channel width greater than 5 m).

Habitat assessments of eight stream crossings (i.e., kilometre (Km) 2.0, 2.9, 6.7, 11.3, 14.1, 15.6, 17.2, and 19.6) located on the proposed haul road were completed between 2008 and 2009 (Table 5.5-12). The stream lengths assessed ranged from 77 m at Km 2.9 to 1,313 m at Km 2.0 (Mushroom/End Grid Stream). Maximum depth recorded ranged from 0.3 m at Km 2.0 (Mushroom/End Grid Stream) and Km 11.3 (Sleek/Caribou Stream) to 1.1 m at Km 6.7 (West Inflow of Boulder Lake). Wetted width ranged from 0.3 m at Km 15.6 (Rhyolite/Fox Stream) to 45 m in a backwater area at Km 2.9. Bankfull width ranged from 0.3 m at Km 15.6 (Rhyolite/Fox Stream) to 95 m in a backwater area at Km 2.9 (Table 5.5-15; Figure 5.5-1 part A).

Dominant habitat types recorded were run (n = 4, for a total of 1,632 m), riffle (= 4, for a total of 867 m), and flat (n = 3, for a total of 807 m) habitats (Table 5.5-15). Ponds (n = 2, for a total of 115 m) and backwater (n = 1, for a total of 75 m) habitat types were observed less frequently. Some sections of boulder garden (n = 2, for a total of 167 m), and no visible channel/dry channel (n = 3) were also observed.

Gravel was observed as the dominant substrate in three streams. Silt and boulder were observed as the dominant substrate types in two and one stream, respectively (Table 5.5-15). Overhead cover was limited and consisted of undercut banks, overhanging vegetation and ledges. In-stream cover consisted of inundated vegetation and interstitial spaces between coarse substrates. Some streams containing areas of emergent and/or submergent vegetation, as well as cover associated with areas of depth, turbulence, and/or turbidity (Tier 3, Technical Appendix 5C, Table 10A-2).

Summary Table 5.5-16 includes the stream type, maximum depth, habitat condition, habitat suitability, and fish-bearing potential for the entire reach assessed within each stream. The bankfull width and substrate as close as possible to the proposed crossing locations, are also included, along with the upstream and downstream connections for the assessed streams (Figure 5.5-2 part A). Additional information provided includes hydrological information (i.e., drainage area, flood frequency prediction, and crossing design).

Proposed Water Intake - Kiggavik Road (Kiggavik Site – Siamese Lake)

The proposed road for the water intake pipeline at the Kiggavik site crosses four streams; one has no defined or visible channel, two are small to intermediate in size (i.e., channel widths less than 5 m), and one is classified as a large stream (i.e., channel width greater than 5 m).

Habitat assessments of four stream crossings (i.e., Km 100.2, alternate W1, alternate W2, and alternate W3) located on the proposed road for the water intake pipeline at the Kiggavik site were completed in 2009 (Table 5.5-12). The stream lengths assessed ranged from 320 m for alternate W1 (Meadow/Jaegar Stream) to 630 m for alternate W3 (North Inflow of Drum Lake). Maximum depths recorded ranged from 0.3 m in Km 100.2 (Northeast Inflow of Pointer Lake) to 0.5 m in alternate W2 (Escarpment/Jaegar Stream). Wetted and bankfull widths ranged from 0.4 m in alternate W2 (Escarpment/Jaegar Stream) to 75 m in alternate W3 (North Inflow of Drum Lake). The bankfull width of alternate W3 was 1 to 3 m for most of its length; however, there were also several ponds that were 40 to 75 m wide (Table 5.5-15; Figure 5.5-1 part A).

Dominant habitat types recorded were flat (n = 3, for a total of 600 m) and run (n = 2, for a total of 550 m) habitats (Table 5.5-15). Ponds (n = 2, for a total of 280 m), pools (n = 1, for a total of 139 m), and riffles (n = 2, for a total of 45 m) were observed less frequently. Some sections of no visible channel/dry channel (n = 2) were also observed.

Cobble and organic material were observed as the dominant substrate in two streams each (Table 5.5-15). In-stream cover consisted of inundated vegetation, with some streams containing areas of emergent vegetation, as well as deeper sections and areas of concealing water turbulence (Tier 3, Technical Appendix 5C, Table 10A-2).

Summary Table 5.5-16 includes the stream type, maximum depth, habitat condition, habitat suitability, and fish-bearing potential for the entire reach assessed within each stream; the bankfull width and substrate as close as possible to the proposed crossing locations are included, along with upstream and downstream connections for the assessed streams (Figure 5.5-2 part A). Additional information provided includes hydrological information (i.e., drainage area, flood frequency prediction, and crossing design). Hydrological information is not available for the three alternate sites (i.e., W1, W2, and W3) since these sites were originally related to the winter road, which did not require a hydrological assessment.