

# Chemical Analyses of Water from Lakes and Streams in Quttinirpaaq National Park, Nunavut, 2001-2008

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**CHEMICAL ANALYSES OF WATER FROM LAKES AND STREAMS  
IN QUTTINIRPAAQ NATIONAL PARK, NUNAVUT, 2001-2008**

by

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**ABSTRACT**

Babaluk, J.A., Gantner, N., Michaud, W., Muir, D.C.G., Power, M., Reist, J.D., Sinnatamby, R., and Wang, X. 2009. Chemical analyses of water from lakes and streams in Quttinirpaaq National Park, Nunavut, 2001-2008. Can. Data Rep. Fish. Aquat. Sci. 1217: v + 24 p.

Selected chemical data collected between 2001 and 2008 from lakes and streams in Quttinirpaaq National Park, Nunavut are tabulated.

Key words: chemical elements; lake surveys; nutrients (mineral); stream surveys; trace elements; water analysis; water chemistry.

**RÉSUMÉ**

Babaluk, J.A., Gantner, N., Michaud, W., Muir, D.C.G., Power, M., Reist, J.D., Sinnatamby, R., and Wang, X. 2009. Chemical analyses of water from lakes and streams in Quttinirpaaq National Park, Nunavut, 2001-2008. Can. Data Rep. Fish. Aquat. Sci. 1217: v + 24 p.

Certaines données chimiques recueillies entre 2001 et 2008, sur les lacs et ruisseaux du parc national Quttinirpaaq (Nunavut), sont présentées sous forme de tableau.

Mots-clés: éléments chimiques; relevés des lacs; nutriments (élément minéral); relevés de cours d'eau; oligoéléments; analyse de l'eau; composition chimique de l'eau.

## INTRODUCTION

Fisheries and Oceans Canada (DFO), with the cooperation of Parks Canada, has been conducting field research in Quttinirpaaq National Park (formerly Ellesmere Island National Park Reserve), Nunavut since 1990. Initial research involved studies of contaminants in sediments (Muir et al. 1995) and in muscle tissue of Arctic char (*Salvelinus alpinus*) (Muir and Lockhart 1992; Muir and Lockhart 1993; Gantner et al. 2009) in one of the Park's lakes (Lake Hazen). Intermittently between 1992 and 2008, DFO and Environment Canada personnel, along with students and staff from the universities of Guelph and Waterloo, also conducted assessments of the char populations within the Park, in particular Lake Hazen char (e.g., population structure, genetic and morphological variation, life history types). Some results of these studies have been reported by Brown Gladden et al. (1995), Reist et al. (1995), Babaluk et al. (1997, 2001, 2002), and Guiguer et al. (2002). Babaluk et al. (2007a, b) and Gantner et al. (2009) have also summarized most of the available biological data for char populations within the Park.

Water samples for chemical analysis were collected opportunistically in Quttinirpaaq National Park during the course of the char studies. Babaluk et al. (1999) summarized the chemical data from water samples between 1990-1998, adding to the existing information base on the area's water chemistry (Oliver and Corbett 1966; Gregor and Dahl 1990; Clark 1997; Keatley et al. 2007). This report presents the chemical data from additional water samples collected in the Park between 2001 and 2008.

## MATERIALS AND METHODS

### DESCRIPTION OF THE STUDY AREA

Quttinirpaaq National Park is located at the northern end of Ellesmere Island, Nunavut (Fig. 1, inset). The Park, with an area of 37 775 km<sup>2</sup>, is the second largest national park in Canada and is described in detail in Parks Canada (1994). There are relatively few lakes in the Park and most are located on the Hazen Plateau and along the coastal areas of the Grant Land Mountains (Fig. 1). This study was confined to lakes from these two areas that either contain Arctic char populations or were assumed to, including Lake Hazen (81° 50' N, 70° 25' W, Fig. 1). Lake Hazen is the largest lake in the Canadian Arctic Archipelago, with a surface area of 537.5 km<sup>2</sup> (Inland Waters Directorate 1973) and a recorded maximum depth of 267 m (G. Köck, Austrian Academy of



Science, Vienna, pers. comm. 2008).

## **WATER SAMPLING AND ANALYSIS**

Water samples were collected from the following lakes in Quttinirpaaq National Park in 2001 (unnamed lakes were assigned unofficial names based on nearby officially named topographic features; map coordinates are given as were recorded in the field): an unnamed lake, hereafter Clements Markham Lake (82° 38' N, 68° 50' W); Heintzelman Lake (81° 42' N, 66° 56' W); Lake Hazen (~81° 49' N, 71° 20' W); an unnamed lake, hereafter Lower Beaufort Lake (81° 54' N, 63° 17' W); Turnabout Lake (81° 54' N, 68° 16' W); and an unnamed lake, hereafter Upper Beaufort Lake (81° 54' N, 63° 16' W).

Water samples were collected from Lake Hazen and several adjacent streams in Quttinirpaaq National Park in 2005 (map coordinates are given as were recorded in the field). Inflowing streams included: Blister Creek (81° 48' 29" N, 71° 31' 30" W); Mesa Creek (81° 54' 25" N, 69° 46' 26" W); Skeleton Creek (81° 49' N, 71° 15' W); and Snow Goose River (81° 50' N, 71° 05' W). Water was also collected from the Ruggles River (Lake Hazen's outlet) (81° 42' N, 70° 25' W).

In 2006, a single water sample was collected from Lake Hazen.

Water samples were collected from the following lakes in Quttinirpaaq National Park in 2007 (unnamed lakes were assigned unofficial "letter" names as there were no nearby officially named topographic features; map coordinates are given as were recorded in the field): Heintzelman Lake; an unnamed lake, hereafter Lake D (82° 06' N, 67° 32' W); an unnamed lake, hereafter Lake E (81° 49' N, 69° 26' W); an unnamed lake, hereafter Lake F (81° 49' N, 69° 24' W); an unnamed lake, hereafter Lake G (81° 50' N, 69° 14' W); an unnamed lake, hereafter Lake H (81° 57' N, 69° 56' W); and Lake Hazen.

Water samples were collected from the following lakes in Quttinirpaaq National Park in 2008 (unnamed lakes were assigned unofficial "letter" names as there were no nearby officially named topographic features; map coordinates are given as were recorded in the field): Clements Markham Lake (82° 37' 27" N, 68° 59' 07" W) (previously named, see above); Craig Lake (81° 51' 40" N, 68° 53' 47" W); an unnamed lake, hereafter Lake C (82° 05' 12" N, 68° 24' 23" W); and Lake Hazen.

Water samples were collected from the following streams flowing into either Lake Hazen or Craig Lake in 2008 (map coordinates are given as were recorded in the field): Blister Creek; an unnamed stream flowing into Craig Lake, hereafter Craig Creek; Cuesta Creek (81° 52' 49" N, 70° 12' 56" W); an unnamed stream flowing into Lake Hazen in the vicinity of the Henrietta Nesmith Glacier, hereafter, Henrietta Nesmith Creek (81° 45' 45" N, 72° 22' 14" W); Mesa Creek; an unnamed stream flowing into Lake Hazen near Hazen Camp, hereafter Muskox Creek (81° 50' 12" N, 71° 15' 37" W); Ptarmigan Creek (81° 47' 03" N, 71° 56' 00" W); Salor Creek (81° 54' 09" N, 68° 54' 28" W); and Traverse River (81° 40' 45" N, 72° 02' 25" W).

Lake and stream sampling locations including dates sampled are shown in Figs. 1 and 2, respectively and Tables 1-13.

Water samples from the lakes were collected in acid-washed polyethylene bottles during the open-water season by hand-dipping the samples from a boat, except for Lake Hazen in 2005 when the samples were collected through a hole in the ice. Water samples from the streams were collected in acid-washed polyethylene bottles during the open-water season by hand-dipping the samples from shore. Samples for dissolved element and nutrient analyses were refrigerated after collection and samples for trace element analyses were preserved in the field by addition of nitric acid (50% by vol.). Water samples collected for  $\sigma^{18}\text{O}$  analysis were obtained in situ by immersing a 125 mL bottle after rinsing in local waters twice. Bottles were filled and sealed subsurface to eliminate all atmospheric oxygen in the bottle. Bottles were stored in refrigerated, dark conditions until analysed. The samples were transported to laboratories in Winnipeg, MB, Waterloo, ON, or Burlington, ON for subsequent analyses.

The majority of water samples for dissolved element and nutrient analyses were analyzed at Fisheries and Oceans Canada's Freshwater Institute Analytical Water Chemistry Laboratory in Winnipeg (Tables 1, 4, 5, 6, 7, 8, and 9) following the procedures of Stainton et al. (1977). Estimates of precision for these procedures are given in Appendix 1 and Stainton et al. (1977). Others were analyzed at Environment Canada's Canada Centre for Inland Waters Analytical Water Chemistry Laboratory in Burlington, ON (Tables 2 and 3). Trace elements were analyzed at the Bodycote Testing Group Laboratory (formerly Norwest Labs) in Winnipeg by inductively coupled plasma mass spectrometry (ICP-MS) using commercial ICP standards and NRC standard reference materials (Tables 10, 11, and 12). Detection limits are given in Appendix 2. Analysis of  $\sigma^{18}\text{O}$  (Table 13) was conducted at the University of Waterloo Environmental Isotope Lab (UW-EIL), with  $\sigma^{18}\text{O}$  values obtained following the  $\text{CO}_2$  water equilibration method outlined in Epstein and

Mayeda (1953) and Fritz et al. (1987). CO<sub>2</sub> was equilibrated with water in a 25°C temperature controlled bath with continuous shaking for 3 hours. CO<sub>2</sub> was then extracted using a VG903 Dual Inlet Isotope Mass Spectrometer to determine  $\sigma^{18}\text{O}$  values. All obtained results were corrected based on EIL-12 (sealed container of laboratory water) calibrated to the international reference materials for VSMOW (Vienna Standard Mean Ocean Water) and SLAP (Standard Light Antarctic Precipitation) from the International Atomic Energy Agency.

## DATA PRESENTATION

Chemical data for Quttinirpaaq National Park waters collected in 2001 are presented in Tables 1 and 10; chemical data for Quttinirpaaq National Park waters collected in 2005 are presented in Tables 2 and 3; chemical data for Quttinirpaaq National Park waters collected in 2006 are presented in Tables 2 and 3; chemical data for Quttinirpaaq National Park waters collected in 2007 are presented in Tables 2, 3, 4, 5, 11, and 13; and chemical data for Quttinirpaaq National Park waters collected in 2008 are presented in Tables 6, 7, 8, 9, 12, and 13.

In all tables, standard symbols are used to represent elements (Weast 1990). Other symbols and abbreviations used in the tables are as follows: Alk. = alkalinity, Chl. A = chlorophyll A, Cond. = conductivity, DIC = dissolved inorganic carbon, DOC = dissolved organic carbon, NH<sub>3</sub> = ammonia, NO<sub>3</sub> = nitrate, NO<sub>2</sub> = nitrite, Org. acids = organic acids, POC = particulate organic carbon, PON = particulate organic nitrogen, SC = suspended carbon, SiO<sub>2</sub> = silica, SN = suspended nitrogen, SO<sub>4</sub> = sulphate, SRP = soluble reactive phosphorus, SRSi = soluble reactive silicon, TDN = total dissolved nitrogen, TDP = total dissolved phosphorus, and TSS = total suspended solids.

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Table 1. Chemical analyses of surface water samples collected in 2001 from selected lakes in Quttinirpaaq National Park, Nunavut.

Location	Date collected	TDN	TDP	SRSI	Na	K	Mg	Ca	Cl	SO <sub>4</sub>	TSS	DIC	DOC	Cond.	pH	Alk.
Clements Markham Lake	Aug. 10	40	1	0.297	36.30	1.65	8.65	32.30	64.88	34.32	1	1370	50	437	8.30	1345
Heintzelman Lake	Aug. 6	210	1	0.892	6.10	1.21	8.45	33.20	9.48	19.77	6	1980	170	271	8.41	2060
Lake Hazen	Aug. 5	40	<1	0.392	0.47	0.36	2.25	18.10	0.31	8.79	<1	1030	70	120	8.20	1010
Lower Beaufort Lake	Aug. 8	105	1	0.251	1.58	0.26	2.80	21.10	3.15	1.22	<1	1310	60	139	8.36	1331
Turnabout Lake	Aug. 6	80	13	0.523	0.89	1.09	1.12	9.05	0.14	3.55	384	570	100	66	7.90	566
Upper Beaufort Lake	Aug. 9	120	1	0.268	1.50	0.25	3.00	22.70	3.04	1.30	1	1430	60	147	8.34	1430

Table 2. Chemical analyses of surface water samples collected between 2005 and 2007 from selected streams and lakes in Quttinirpaaq National Park, Nunavut. C = corrected (degradation product, pheophytin, subtracted), UF = unfiltered, F = filtered.

Location	Date collected	$\mu\text{g}\cdot\text{L}^{-1}$										$\text{mg}\cdot\text{L}^{-1}$				
		Chl. A (C)	Chl. A (UF)	$\text{NO}_3\text{NO}_2$ (UF)	$\text{NO}_3\text{NO}_2$ (F)	$\text{NO}_2$ (UF)	$\text{NO}_2$ (F)	$\text{NH}_3$ (UF)	$\text{NH}_3$ (F)	Cl	$\text{SO}_4$	DOC	DIC			
Blister Creek	June 8, 2005	<0.1	<0.1	0.131	0.069	0.002	0.004	0.005	<0.005	0.76	33.10	4.3	10.3			
Lake Hazen	June 5, 2005	<0.1	na	0.035	0.049	0.002	0.002	<0.005	0.022	0.30	10.70	0.6	13.8			
Lake Hazen	June 6, 2005	<0.1	<0.1	0.042	0.039	0.003	0.002	0.006	<0.005	0.31	11.00	0.9	14.4			
Lake Hazen	June 9, 2005	<0.1	<0.1	0.034	0.037	0.004	0.002	0.005	<0.005	0.30	10.70	0.6	14.1			
Mesa Creek	June 6, 2005	4.9	<0.1	0.230	0.177	0.003	0.010	0.008	0.007	1.13	157.00	8.0	10.0			
Ruggles River	June 11, 2005	<0.1	<0.1	0.035	0.049	0.002	0.004	<0.005	<0.005	0.34	10.70	0.7	14.0			
Skeleton Creek	June 8, 2005	1.4	1.7	0.193	0.066	0.004	0.007	0.011	0.016	1.24	69.10	12.1	15.7			
Snow Goose River	June 7, 2005	1.7	<0.1	0.208	0.083	0.002	0.005	0.010	0.008	1.28	83.60	8.2	14.0			
Lake Hazen	August 3, 2006	0.8	na	0.023	0.032	0.003	0.004	0.005	0.005	0.18	9.23	0.5	11.5			
Lake D	July 28, 2007	1.2	0.8	0.005	0.020	0.004	0.009	0.022	<0.005	0.48	1.22	2.8	9.5			
Lake G	July 27, 2007	1.0	0.8	<0.005	0.008	0.003	0.003	<0.005	<0.005	2.09	20.50	1.6	31.6			
Heintzelman Lake	July 26, 2007	2.0	1.4	0.020	0.031	0.004	0.004	0.012	<0.005	11.20	28.40	2.2	25.2			
Lake Hazen	July 31, 2007	1.0	<0.1	0.028	0.035	0.004	0.003	<0.005	<0.005	0.16	8.64	0.6	11.5			



Table 3. Chemical analyses of surface water samples collected between 2005 and 2007 from selected streams and lakes in Quttinirpaaq National Park, Nunavut. UF = unfiltered, F = filtered.

Location	Date collected	Ca (UF)	Mg (UF)	K (UF)	Na (UF)	POC	PON	SiO <sub>2</sub> (UF)	SRP (UF)	SRP (F)	TDN (UF)	TDN (F)	TDP (UF)	TDP (F)
mg·L <sup>-1</sup>														
Blister Creek	June 8, 2005	24.5	2.41	1.14	0.75	0.754	0.080	1.94	0.0064	0.0009	0.386	0.265	0.0371	0.0057
Lake Hazen	June 5, 2005	22.6	2.55	0.42	0.56	0.053	<0.002	0.96	0.0003	0.0010	0.070	0.174	<0.0005	0.0082
Lake Hazen	June 6, 2005	23.3	2.61	0.43	0.59	0.050	0.003	1.00	0.0004	0.0005	0.073	0.085	<0.0005	0.0017
Lake Hazen	June 9, 2005	22.7	2.53	0.42	0.57	0.045	0.003	0.95	0.0003	0.0004	0.079	0.078	<0.0005	0.0007
Mesa Creek	June 6, 2005	48.6	14.60	3.86	7.31	13.500	0.705	2.25	0.0048	0.0012	0.824	0.508	0.2360	na
Ruggles River	June 11, 2005	22.5	2.56	0.42	0.58	0.048	<0.002	0.97	0.0003	0.0005	0.081	0.077	0.0006	0.0015
Skeleton Creek	June 8, 2005	37.2	8.59	3.35	3.80	2.630	0.248	2.90	0.0101	0.0012	0.807	0.572	0.0720	0.0148
Snow Goose River	June 7, 2005	43.7	7.42	2.58	3.33	5.720	0.505	2.32	0.0079	0.0012	0.783	0.411	0.3390	0.0112
Lake Hazen	Aug. 3, 2006	18.2	2.06	0.32	0.45	0.138	0.0100	0.75	0.0005	0.0008	0.054	0.058	0.0021	0.0021
Lake D	July 28, 2007	12.4	1.66	0.61	0.45	0.254	0.031	0.65	0.0016	0.0003	0.217	0.202	0.0132	0.0043
Lake G	July 27, 2007	38.3	12.50	2.84	2.70	0.306	0.015	2.66	0.0010	0.0004	0.096	0.103	0.0040	0.0031
Heintzelman Lake	July 26, 2007	37.7	9.21	1.27	6.83	0.188	0.024	2.08	0.0011	0.0010	0.153	0.156	0.0078	0.0035
Lake Hazen	July 31, 2007	18.3	2.03	0.32	0.50	0.095	0.010	0.74	<0.0002	0.0002	0.056	0.063	0.0012	0.0018

Table 4. Chemical analyses of surface water samples collected in 2007 from selected lakes in Quttinirpaaq National Park, Nunavut.

Location	Date collected	Na	K	Ca	Mg	TSS	Cl	SO <sub>4</sub>	Cond.	pH	Alk.
		mg·L <sup>-1</sup>						μS·cm <sup>-1</sup>		μeq·L <sup>-1</sup>	
Heintzelman Lake	July 26	6.72	1.25	37.20	9.10	1	10.23	27.98	293	7.67	2075
Lake D	July 28	0.47	0.64	12.60	1.71	<1	0.63	1.26	83	7.35	832
Lake E	July 28	3.02	2.99	36.60	13.50	14	2.69	18.52	305	8.10	2945
Lake F*	July 28	3.41	3.34	33.90	14.40	1	3.14	16.32	296	8.16	2806
Lake F*	July 29	3.44	3.36	33.90	14.70	<1	2.44	17.88	297	8.12	2967
Lake G	July 27	2.62	2.75	37.20	11.80	<1	2.14	20.66	291	8.10	2646
Lake H	July 29	2.57	3.28	25.30	8.15	1	1.78	3.44	205	7.73	2007
Lake Hazen, off Blister Creek	Aug. 5	0.51	0.36	19.40	2.25	2	0.24	9.08	124	7.40	985

\* replicate sample.

Table 5. Chemical analyses of surface water samples collected in 2007 from selected lakes in Quttinirpaaq National Park, Nunavut.

Location	Date collected	NO <sub>3</sub>	NO <sub>2</sub>	TDN	TDP	SN	SC	DIC	DOC
Heintzelman Lake	July 26	12	1	144	1	24	250	2459	212
Lake D	July 28	<1	4	180	2	78	220	905	268
Lake E	July 28	1	<1	138	1	46	570	3142	244
Lake F*	July 28	1	<1	100	1	24	250	3102	201
Lake F*	July 29	<1	<1	111	1	10	210	3125	217
Lake G	July 27	1	<1	91	<1	16	200	2965	190
Lake H	July 29	<1	<1	561	2	30	320	2344	738
Lake Hazen, off Blister Creek	Aug. 5	28	<1	39	<1	12	270	1185	92

\* replicate sample.

Table 6. Chemical analyses of surface water samples collected in 2008 from selected lakes in Quttinirpaaq National Park, Nunavut.

Location	Date collected	SRSi	Na	K	Ca	Mg	TSS	Fe	Cl	SO <sub>4</sub>	Cond.	pH	Alk.
Clements Markham Lake	Aug. 8	0.318	44.50	2.14	37.20	9.80	1	<0.01	74.09	44.19	504	7.95	1463
Craig Lake	Aug. 6	1.140	4.44	2.44	44.20	16.30	12	0.02	2.47	56.65	343	8.18	2622
Lake C	Aug. 4	0.623	1.17	0.96	28.60	3.60	<1	<0.01	0.78	2.08	158	7.95	1745
Lake Hazen, off Hazen Camp	Aug. 13	0.400	0.57	0.42	21.20	2.40	3	0.02	0.25	10.40	113	7.73	1067
Lake Hazen, off Ptarmigan Creek	Aug. 13	0.402	0.57	0.42	22.00	2.30	2	0.02	0.27	11.10	117	7.77	1061

Table 7. Chemical analyses of surface water samples collected in 2008 from selected lakes in Quttinirpaaq National Park, Nunavut.

Location	Date collected	NO <sub>3</sub>	NO <sub>2</sub>	TDN	TDP	SN	SC	DIC	DOC
		$\mu\text{g}\cdot\text{L}^{-1}$						$\mu\text{m}\cdot\text{L}^{-1}$	
Clements Markham Lake	Aug. 8	<1	63	75	1	44	210	1628	91
Craig Lake	Aug. 6	32	<1	136	2	44	470	2810	277
Lake C	Aug. 4	<1	<1	154	2	27	260	1902	243
Lake Hazen, off Hazen Camp	Aug. 13	27	<1	67	1	6	140	1164	62
Lake Hazen, off Ptarmigan Creek	Aug. 13	28	<1	52	<1	20	150	1164	52

Table 8. Chemical analyses of surface water samples collected in 2008 from selected streams flowing into Lake Hazen or Craig Lake, Quttinirpaaq National Park, Nunavut.

Location	Date collected	SRSi	Na	K	Ca	Mg	TSS	Fe	Cl	SO <sub>4</sub>	µS·cm <sup>-1</sup>			Alk.
											Cond.	pH	µeq·L <sup>-1</sup>	
Blister Creek	Aug. 12	0.687	1.60	0.78	69.60	5.00	3	0.02	0.68	157.59	400	7.62	815	
Craig Creek	Aug. 6	1.590	2.65	2.82	65.60	18.90	50	0.05	3.13	54.14	419	8.15	3635	
Cuesta Creek	Aug. 10	0.877	1.19	0.52	28.60	3.60	2	<0.01	0.70	95.46	289	7.78	1052	
Henrietta Nesmith Creek	Aug. 5	0.689	0.98	0.78	63.60	3.50	3	0.02	0.50	104.90	332	7.87	1343	
Mesa Creek	Aug. 7	0.348	0.49	0.24	20.20	1.63	11	<0.01	0.19	34.02	118	7.31	479	
Muskox Creek	Aug. 1	1.930	2.05	1.19	69.30	11.60	20	0.09	0.58	134.00	429	8.00	1818	
Ptarmigan Creek	Aug. 11	0.738	2.69	0.93	99.20	7.20	7	<0.01	1.00	238.32	550	7.70	995	
Salor Creek	Aug. 3	1.150	4.58	2.40	43.80	16.60	1	0.02	2.59	56.29	347	8.16	2674	
Traverse River	Aug. 4	1.130	1.87	0.91	54.90	12.90	3	<0.01	2.98	54.09	357	8.13	2753	

Table 9. Chemical analyses of surface water samples collected in 2008 from selected streams flowing into Lake Hazen or Craig Lake, Quttinirpaaq National Park, Nunavut.

Location	Date collected	NO <sub>3</sub>	NO <sub>2</sub>	TDN	TDP	SN	SC	DIC	DOC
Blister Creek	Aug. 12	<1	<1	323	<1	16	100	884	103
Craig Creek	Aug. 6	<1	<1	228	1	138	1470	3801	351
Cuesta Creek	Aug. 10	<1	2	107	1	22	280	1161	160
Henrietta Nesmith Creek	Aug. 5	1	<1	145	1	26	180	1455	109
Mesa Creek	Aug. 7	80	2	108	1	23	410	538	63
Muskox Creek	Aug. 1	500	10	212	2	71	800	1976	391
Ptarmigan Creek	Aug. 11	26	<1	574	2	48	250	1112	93
Salor Creek	Aug. 3	2	<1	130	1	<1	170	2849	211
Traverse River	Aug. 4	520	<1	744	1	12	220	2987	143

Table 10. Concentrations of trace elements in surface water samples collected in 2001 from selected lakes in Quttinirpaaq National Park, Nunavut. Collection dates are in parentheses. All values in mg·L<sup>-1</sup>.

Element	Location					
	Clements Markham Lake (Aug. 10)	Heintzelman Lake (Aug. 6)	Lake Hazen (Aug. 5)	Lower Beaufort Lake (Aug. 8)	Turnabout Lake (Aug. 6)	Upper Beaufort Lake (Aug. 9)
Aluminum (Al)	0.078	0.406	0.063	0.071	11.2	0.134
Antimony (Sb)	<0.006	<0.006	0.008	<0.006	<0.010	<0.006
Arsenic (As)	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01
Barium (Ba)	0.0170	0.0233	0.0111	0.0038	0.112	0.0040
Beryllium (Be)	<0.0006	<0.0006	<0.0006	<0.0006	<0.001	<0.0006
Bismuth (Bi)	<0.008	<0.008	<0.008	<0.008	<0.01	<0.008
Boron (B)	0.008	0.004	<0.002	<0.002	0.025	<0.002
Cadmium (Cd)	<0.0006	<0.0006	<0.0006	<0.0006	<0.001	<0.0006
Calcium (Ca)	33.2	33.7	19.1	22.2	11.6	23.8
Chromium (Cr)	<0.0009	<0.0009	<0.0009	<0.0009	0.012	<0.0009
Cobalt (Co)	<0.0008	<0.0008	<0.0008	<0.0008	0.0050	<0.0008
Copper (Cu)	<0.001	0.002	<0.001	<0.001	0.014	<0.001
Iron (Fe)	0.034	0.333	0.025	0.044	11.5	0.088
Lead (Pb)	<0.002	<0.002	<0.002	<0.002	0.009	<0.002
Lithium (Li)	0.003	0.003	0.002	<0.001	0.016	0.001
Magnesium (Mg)	8.61	8.54	2.14	2.77	3.02	2.98
Manganese (Mn)	0.0010	0.0054	0.0002	0.0016	0.124	0.0026
Molybdenum (Mo)	<0.001	<0.001	<0.001	<0.001	<0.002	<0.001
Nickel (Ni)	<0.001	0.002	<0.001	<0.001	0.009	<0.001
Phosphorus (P)	<0.03	<0.03	<0.03	<0.03	0.24	<0.03
Potassium (K)	1.5	1.3	<0.4	<0.4	4.9	<0.4
Selenium (Se)	0.009	0.029	0.018	0.018	0.018	0.022
Silicon (Si)	0.416	1.78	0.501	0.357	21.5	0.489
Silver (Ag)	<0.001	<0.001	<0.001	<0.001	<0.002	<0.001
Sodium (Na)	36.2	5.7	0.5	1.7	1.1	1.5
Strontium (Sr)	0.192	0.131	0.0950	0.0367	0.0684	0.0392
Sulfur (S)	12.9	7.01	2.86	0.502	1.41	0.507
Thallium (Tl)	0.005	<0.004	<0.004	<0.004	<0.008	<0.004
Tin (Sn)	<0.003	<0.003	<0.003	0.003	0.011	<0.003
Titanium (Ti)	<0.0004	0.0136	<0.0004	0.0019	0.319	0.0009
Vanadium (V)	<0.001	0.001	0.002	0.002	0.020	0.002
Zinc (Zn)	0.0048	0.0036	0.0049	0.0064	0.0366	0.0068





Table 12. Concentrations of trace elements in surface water samples collected in 2008 from selected lakes in Quttinirpaaq National Park, Nunavut. Collection dates are in parentheses. All values are in mg·L<sup>-1</sup>.

Element	Location			
	Clements Markham Lake* (Aug. 8)	Clements Markham Lake* (Aug. 11)	Lake C (Aug. 4)	Lake Hazen, off Hazen Camp (Aug. 13)
Aluminum (Al)	0.031	0.020	0.008	0.067
Antimony (Sb)	<0.0002	<0.0002	<0.0002	<0.0002
Arsenic (As)	<0.0002	<0.0002	0.0002	<0.0002
Barium (Ba)	0.020	0.020	0.009	0.013
Beryllium (Be)	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth (Bi)	<0.0005	<0.0005	<0.0005	<0.0005
Boron (B)	0.017	0.017	0.005	0.003
Cadmium (Cd)	0.00002	<0.00001	<0.00001	<0.00001
Calcium (Ca)	37.9	38.5	29.8	21.4
Chromium (Cr)	0.0006	<0.0005	<0.0005	<0.0005
Cobalt (Co)	<0.0001	<0.0001	<0.0001	<0.0001
Copper (Cu)	<0.001	<0.001	<0.001	<0.001
Iron (Fe)	<0.05	<0.005	<0.05	0.07
Lead (Pb)	0.0003	<0.0001	<0.0001	0.0001
Lithium (Li)	0.003	0.003	0.002	0.002
Magnesium (Mg)	9.8	9.9	3.5	2.3
Manganese (Mn)	<0.005	<0.005	<0.005	<0.005
Molybdenum (Mo)	<0.001	<0.001	<0.001	<0.001
Nickel (Ni)	<0.0005	<0.0005	<0.0005	0.0005
Potassium (K)	1.7	1.7	0.8	<0.4
Selenium (Se)	<0.0002	<0.0002	<0.0002	<0.0002
Silicon (Si)	0.32	0.32	0.58	0.48
Silver (Ag)	<0.00001	<0.00001	<0.00001	<0.00001
Sodium (Na)	44.8	45.3	1.1	0.5
Strontium (Sr)	0.240	0.248	0.098	0.112
Sulfur (S)	13.5	13.7	0.8	3.2
Thallium (Tl)	<0.00005	<0.00005	<0.00005	<0.00005
Tin (Sn)	<0.001	<0.001	<0.001	<0.001
Titanium (Ti)	0.0027	0.0022	<0.0005	0.0016
Uranium (U)	0.0006	0.0006	<0.0005	<0.0005
Vanadium (V)	<0.0001	<0.0001	0.0001	0.0002
Zinc (Zn)	0.002	<0.001	<0.001	<0.001
Zirconium (Zr)	<0.001	<0.001	<0.001	<0.001

\*replicate sample.

Table 13.  $\sigma^{18}\text{O}$  signatures of surface water samples collected from selected lakes and streams in Quttinirpaaq National Park, Nunavut.  $\sigma^{18}\text{O}$  are in parts per mil (‰) relative to the international reference standard Vienna Standard Mean Ocean Water (VSMOW).

Location	Date collected	$\sigma^{18}\text{O}$
		VSMOW
Lake D	July 23, 2007	-23.84
Lake E	July 29, 2007	-20.21
Lake F	July 29, 2007	-19.01
Lake F*	July 29, 2007	-20.81
Lake G	July 23, 2007	-21.54
Lake Hazen	Aug. 5, 2007	-28.04
Clements Markham Lake	Aug. 8, 2008	-28.59
Clements Markham Lake*	Aug. 8, 2008	-28.50
Craig Lake	Aug. 6, 2008	-22.17
Lake C	Aug. 4, 2008	-23.36
Lake Hazen, off Hazen Camp	Aug. 13, 2008	-28.38
Lake Hazen, off Ptarmigan Creek	Aug. 13, 2008	-28.23
Blister Creek	Aug. 12, 2008	-26.25
Craig Creek	Aug. 6, 2008	-19.79
Cuesta Creek	Aug. 10, 2008	-26.03
Henrietta Nesmith Creek	Aug. 5, 2008	-26.31
Mesa Creek	Aug. 7, 2008	-26.22
Mesa Creek*	Aug. 7, 2008	-26.19
Muskox Creek	Aug. 1, 2008	-25.70
Ptarmigan Creek	Aug. 11, 2008	-26.20
Ptarmigan Creek*	Aug. 11, 2008	-26.13
Salor Creek	Aug. 3, 2008	-21.77
Traverse River	Aug. 4, 2008	-25.97

\* replicate sample.

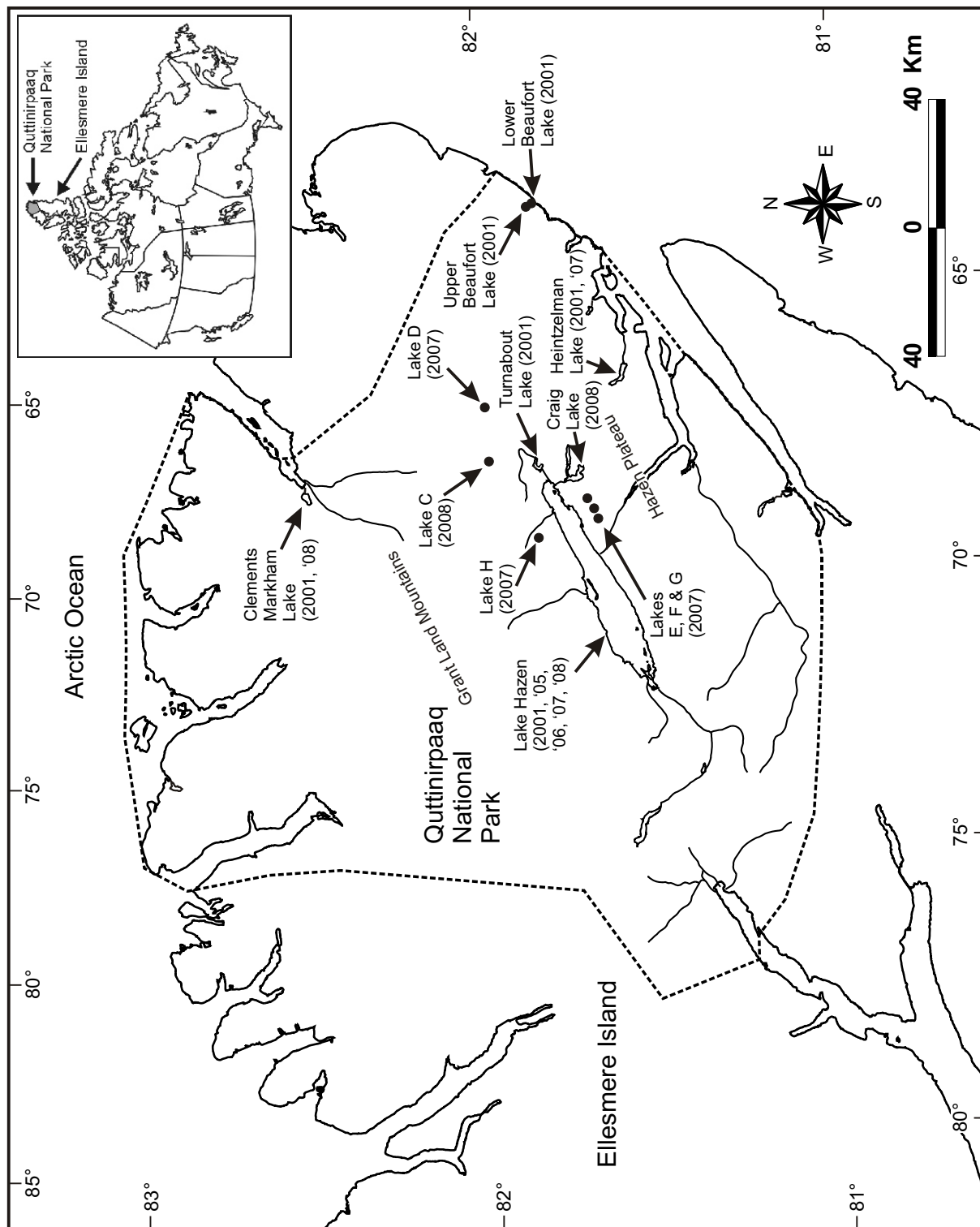


Figure 1. Map of Quttinirpaaq National Park (within dashed line), Nunavut showing approximate locations of water sample collection sites (arrows/dots) and years samples were collected.

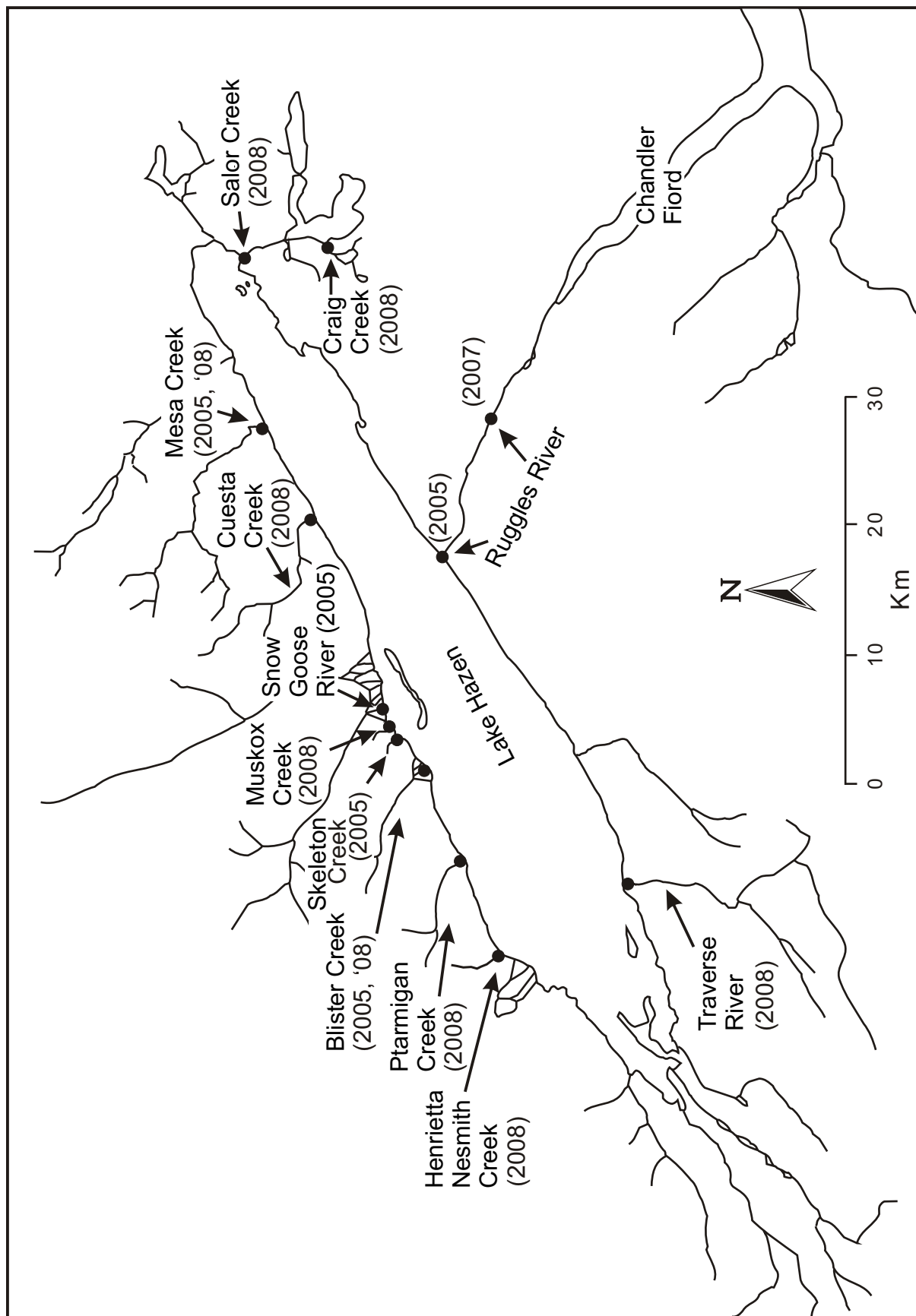


Figure 2. Map of the Lake Hazen area, Quttinirpaq National Park, Nunavut showing approximate locations of stream water sample collection sites (dots) and years samples were collected.

Appendix 1. Detection limits, where available, for individual water chemistry parameter analysis as provided by Fisheries and Oceans Canada, Arctic and Freshwater Institute Analytical Water Chemistry Laboratory, Winnipeg, MB (C. Anema, pers. comm. 2008).

Parameter	Detection limit	Units
NO <sub>3</sub>	0.8	µg·L <sup>-1</sup>
NO <sub>2</sub>	0.6	µg·L <sup>-1</sup>
SN	0.15	µg·L <sup>-1</sup>
TDN	9	µg·L <sup>-1</sup>
TDP	1	µg·L <sup>-1</sup>
DIC	29	µm·L <sup>-1</sup>
DOC	9.5	µm·L <sup>-1</sup>
SC	1	µg·L <sup>-1</sup>
SP	na	na
Alk.	na	µeq·L <sup>-1</sup>
SRSi	na	mg·L <sup>-1</sup>
Cl	0.05	mg·L <sup>-1</sup>
SO <sub>4</sub>	0.03	mg·L <sup>-1</sup>
TSS	0.1	mg·L <sup>-1</sup>
Cond.	1.2	µS·cm <sup>-1</sup>
Na	0.01	mg·L <sup>-1</sup>
K	0.01	mg·L <sup>-1</sup>
Mg	0.001	mg·L <sup>-1</sup>
Mn	na	na
Ca	0.045	mg·L <sup>-1</sup>
Fe	na	mg·L <sup>-1</sup>
pH	na	na

Appendix 2. Detection limits for individual trace element analysis (inductively-coupled plasma mass spectrometry method) as provided by Bodycote Testing Group (formerly Norwest Labs), Winnipeg, MB. All values in  $\text{mg}\cdot\text{L}^{-1}$ .

Element	Analysis Year		
	2001	2007	2008
Aluminum (Al)	0.009	0.005	0.005
Antimony (Sb)	0.006	0.0002	0.0002
Arsenic (As)	0.01	0.0002	0.0002
Barium (Ba)	0.0002	0.001	0.001
Beryllium (Be)	0.0006	0.0001	0.0001
Bismuth (Bi)	0.008	0.0005	0.0005
Boron (B)	0.002	0.002	0.002
Cadmium (Cd)	0.0006	0.00001	0.00001
Calcium (Ca)	0.2	0.2	0.2
Chromium (Cr)	0.0009	0.0005	0.0005
Cobalt (Co)	0.0008	0.0001	0.0001
Copper (Cu)	0.001	0.001	0.001
Iron (Fe)	0.003	0.1	0.05
Lead (Pb)	0.002	0.0001	0.0001
Lithium (Li)	0.001	0.001	0.001
Magnesium (Mg)	0.06	0.1	0.1
Manganese (Mn)	0.0002	0.1	0.005
Molybdenum (Mo)	0.001	0.001	0.001
Nickel (Ni)	0.001	0.0005	0.0005
Phosphorus (P)	0.03	na	na
Potassium (K)	0.4	0.4	0.4
Selenium (Se)	0.004	0.0002	0.0002
Silicon (Si)	0.004	0.05	0.05
Silver (Ag)	0.001	0.0001	0.00001
Sodium (Na)	0.4	0.4	0.4
Strontium (Sr)	0.0001	0.001	0.001
Sulfur (S)	0.009	0.3	0.3
Thallium (Tl)	0.004	0.00005	0.00005
Tin (Sn)	0.003	0.001	0.001
Titanium (Ti)	0.0004	0.0005	0.0005
Uranium (U)	na	0.0005	0.0005
Vanadium (V)	0.001	0.0001	0.0001
Zinc (Zn)	0.0007	0.001	0.001
Zirconium (Zr)	na	0.001	0.001