Assessment of the Mackenzie Drinking Water Supply: Source Water Characteristics

James Jacklin, March 2004[1]

Introduction

In British Columbia, drinking water quality is becoming a significant public issue. We all want to have confidence in the quality of the water we consume. Its protection is also important to local purveyors, who act as our water suppliers, and to provincial government ministries responsible for water management. Within the Omineca-Peace region of B.C., our most common potable source is ground water, although many communities do make use of rivers, streams or lakes. Our basic drinking water quality is determined by a number of factors including local geology, climate and hydrology. In addition to these, human land use activities such as urbanization, agriculture and forestry, and the pollution they may cause, are becoming increasingly important influences. Environmental managers have a responsibility to control land use development so as to minimise the effects of these activities on source water quality.

The province's Drinking Water Protection Act, enacted in October, 2002, places the responsibility for drinking water quality protection with the B.C. Ministry of Health and local water purveyors. However, through the B.C. Environmental Management Act, the British Columbia Ministry of Environment (MOE) is responsible for managing and regulating activities in watersheds that have a potential to affect water quality. Accordingly, the Ministry plans to take an active role in protecting drinking water quality at its source.

Plate 1. A view of the Mackenzie pump house where the raw water samples were collected. Morfee Lake is in the background.

MOE implemented a raw water quality and stream sediment monitoring program at selected communities in the Omineca-Peace region in 2002. Community sites were selected using a risk assessment process that considered:

- whether the source supply was surface water or ground water,
- the level of water treatment,
- the population size served,
- the potential for upstream diffuse and point-source pollution,
- the availability of current, high-quality and representative data on each raw water source,
- whether past outbreaks of waterborne illness had been reported,
- the ability/willingness of local purveyors to assist with sampling.

Through this process and with available funding, a total of 18 community water supplies in the Omineca-Peace region were selected for monitoring during 2002/03.

This brief report will summarise water quality data collected from the Village of Mackenzie raw potable water source (ground water) (Plate 1). The data are compared to current provincial drinking water quality guidelines meant to protect finished water if no treatment other than disinfection is present. This comparison should identify parameters with concentrations that represent a risk to human health. It is intended that this program will lead to the identification of human activities responsible for unacceptable source water quality, and that it will assist water managers to develop measures to improve raw water quality where needed.

[1]A template report was prepared for the author by Todd D. French of TDF Watershed Solutions, Research & Management and Bruce Carmichael, Ministry of Environment.

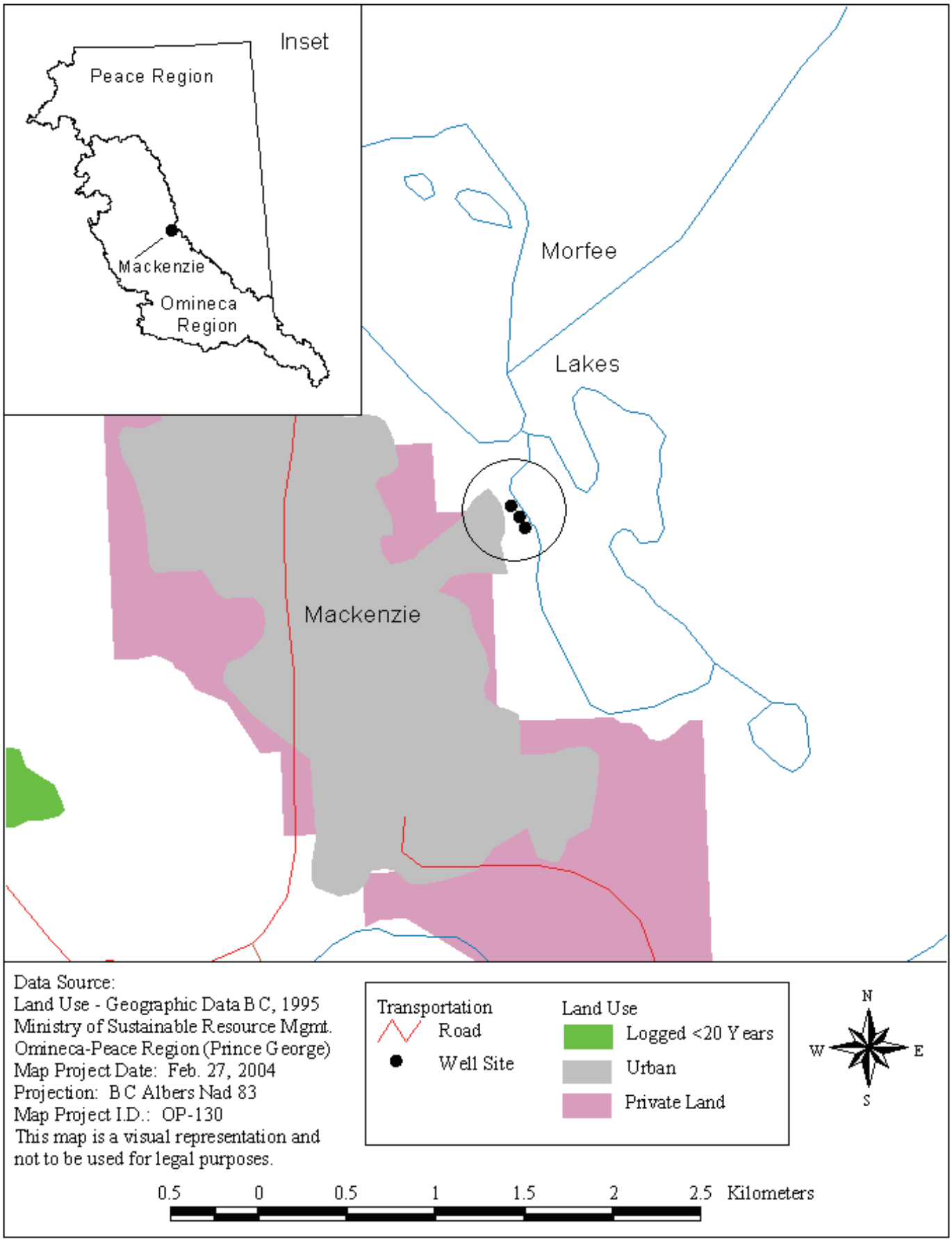

Figure 1. Mackenzie water wells and nearby land use practices. A 300 m radius surrounds the wells indicating the zone where contamination is most probable to occur.

Site Description

Watershed Overview

The Village of Mackenzie drinking water supply consists of three wells, located beside the Morfee Lakes. This area lies within the Sub-Boreal Spruce and Engleman Spruce/Subalpine Fir biogeoclimatic zones. The Sub-Boreal Spruce zone is characterized by gently rolling terrain, dense coniferous forests and extremes in the annual temperature range of ˉ40°C to 30°C. The Engleman Spruce/Subalpine Fir zone has more hilly, mountainous terrain, cold and snowy conditions (a snowpack of 2-3 m) for 5-7 months of the year, and short cool summers (B.C. Ministry of Forests, 1998).

The predominant land-use activities in the vicinity of the Mackenzie wells are urban use and forestry activities. These activities may pose a risk to well water quality, especially due to their close proximity.

According to Grant Parker, the water purveyor for the village, the current withdrawal rate for the wells is approximately 1100 gallons/minute (5000 L/min). The wells draw water from a bed composed dominantly of sands and gravels (Table 1). The sands and gravels throughout the lithology profile suggest an unconfined aquifer. This implies that the well is particularly sensitive to land-use activities where chemicals or contaminants could easily leach into the ground, compared to a well with an overlying clay or bedrock layer. The well depths, according to the logs at the time of construction, range from 38-70 feet (12-21 m).

Table 1. Lithology profile from one of the Mackenzie water wells (well tag number 28591). Data from the aquifer database of B.C..

Depth (Ft)	Grain Size
0-2	Sandy till (gravelly)
2-30	Fine, coarse sand and gravel
30-60	Fine coarse sand (gravel) - thin layer of gravelly clay @ 58’
60-63	Fractured rock, sand and gravel, finer sand, dark grey colour
63-65	Fractured rock, sand and gravel, dark grey colour
65-70	Clay, gravel fractured rock

There are two waste disposal permits within Mackenzie, however neither of these permits are located in the same area as the water wells, so are not expected to affect water quality.

Drinking Water Supply & Treatment

The Village of Mackenzie draws its domestic water from a ground water supply, consisting of three wells. The wells are situated adjacent to the Morfee Lakes, near the pump house. As measured with a GPS unit, the geographic coordinates of the pump house are 55.3368N/123.07233W.

From the pump house, the water is distributed to approximately 5000 water users. There is currently no village treatment on the source water.

According to Grant Parker, the village has no concerns regarding the current water system.

Materials & Methods

Review of Previous Data

Historical data relevant to the Mackenzie source water supply assessment have been included in this report. The data were copied from Northern Health Authority (NHA) computer and paper files and include data from March 2002-August 2002.

Sample Collection & Analyses for the 2002/03 Water Monitoring Program

Water Quality

An experienced consultant and/or MOE staff member collected water samples in laboratory certified polyethylene bottles for a variety of chemical and bacterial analyses. Representative grab samples were collected from the raw water tap (Plate 2) inside the Mackenzie pump house (site E249349 - Water Source ID Tag 1337). The chemical results, analytical detection levels and drinking water quality guidelines are provided in Table 2, Appendix A.

Plate 2. A picture of the raw water tap inside the Mackenzie pump house.

Bottles used for general ion analyses were rinsed three times with source water prior to sample collection. Metal and bacterial bottles were not rinsed and metal samples were lab preserved. Prior to sampling the raw water tap, the source was flushed for 5 minutes in order to minimize contamination by system piping. Water samples were shipped by overnight courier in coolers with ice packs to

CanTest Ltd. (from September 2002-March 2003) and JR Laboratories Inc. (April 2003 to September 2003) for bacteria and PSC Environmental Services Ltd. for chemistry. Bacterial samples were analysed using membrane filtration. Metals analysis made use of ICPMS technology.

Quality Assessment (QA)

To ensure accuracy and precision of data, quality assurance and control (QA/QC) procedures were incorporated into the monitoring program. This included use of rigorous sampling protocols, proper training of field staff, setting of data quality objectives and the submission of QA samples to the lab. Field QA included duplicate and blind blank samples. Blank samples detect contamination introduced in the field and/or in the lab. A comparison of duplicate results measures the effect of combined field error, laboratory error and real between-sample variability. The blind blank and duplicate program accounted for roughly 20% of the overall chemistry and bacterial sample numbers.

Results

Review of Previous Data

Bacteriology

The NHA sampled the Mackenzie raw water supply from the pump house 24 times between March and August 2002. All 24 samples were tested for both total and fecal coliforms. Bacterial concentrations were less than detectable during all sample collection's. This suggests that bacterial concentrations are generally low in the Mackenzie water system. It should be noted that this data is from only a six month period.

Water Monitoring Program (2002/03)

Quality Assessment (QA)

The field blank and duplicate results indicate that minimal field or lab contamination of samples with bacteria occurred and that acceptable precision in bacterial sampling and analysis was observed.

The five water chemistry field blank samples that were prepared either the same day or within one day of the Mackenzie collections tested positive for some parameters. The concentration of most of these parameters was either very close to or less than 5-fold the minimum detectable concentration, an acceptable threshold as per the lab acceptance criteria. Three parameters exceeded these acceptance criteria and are listed in Table 3.

Table 3. Blind blank samples that tested strongly positive (≥ 5-fold MDL) for chemical contamination.

Date	Parameter	Measured Concentration	MDL
March 20/03	Copper-Total	0.37 µg/L	0.05 µg/L
March 20/03	Lead-Total	0.06 µg/L	0.01 µg/L
March 20/03	Strontium-Total	0.1 µg/L	0.005 µg/L

Although the levels of some of these blank results are equal to or greater than the actual concentrations observed in Mackenzie on some dates, the values are usually well below provincial raw drinking water guidelines by greater than two orders of magnitude. The contamination that did occur may have resulted during the deionization process in the lab or during the transfer of the deionized water between bottles in the field. Regardless, these levels of blank contamination should not limit the comparison of data to water quality guidelines.

The four water chemistry duplicate samples that were prepared either the same day or within one day of the Mackenzie collections did have some values outside the lab acceptance criteria of 25% relative percent difference (Table 4, Appendix A). The differences that are present may be due to problems with collection and/or analytical precision. All of the parameters that did have differences greater than 25% between the duplicates occurred well below recommended drinking water guidelines.

Bacteriology

The 2002/03 bacterial data are summarised in Table 5. Drinking water quality guidelines for *E. coli, Enterococci* and fecal coliforms are all 0 CFU/100mL in drinking water supplies that undergo no treatment.

Table 5. Results of bacterial analyses for the Mackenzie raw water supply. Units are CFU/100mL.

Date	Total Coliform	*E. coli*	*Enterococci*	Fecal Coliform
Provincial Guideline	No Provincial Guideline	0 CFU/100 mL	0 CFU/100 mL	0 CFU/100 mL
Oct. 10/02	<1	<1	<1	<1
Jan. 13/03	<1	<1	<1	-
Mar. 20/03	<1	<1	<1	<1
May 6/03	6	**1**	**1**	**1**
May 29/03	<1	<1	<1	<1
Aug 14/03	<1	<1	<1	<1

Most samples collected from this water supply contained no detectable bacteria. The May 6th sample did have positive results for all of the bacterial types, however, a long holding time or warm bottle temperatures were probably a factor. The presence of total coliforms at 6 CFU/100mL suggests that other bacteria of a more harmful nature may be present, and that further bacterial sampling should occur.

Water Chemistry

In 2002/03, ground water samples were collected on six different dates. The water samples were analysed for 15 general parameters as well as for the ICPMS low level metals package that includes 27 metals in the total form.

Of the chemical parameters tested through the duration of this study, none exceeded the provincial guidelines for raw drinking water.

Water hardness, which can often be a problem in ground water supplies, had a mean concentration of 137 mg/L $CaCO_3$. Waters that exceed 120 mg/L $CaCO_3$ are considered hard. Hard water can reduce the toxicity of some metals, but can also leave scale deposits on piping. Some anthropogenic sources that contribute to water hardness are mining and industrial effluents. Hard water also occurs naturally in many ground water systems due to the dissolution of calcium and magnesium bearing rocks and minerals.

The data from 2002/03 indicates that chemical parameters in the Mackenzie water supply are generally low for drinking water use.

A complete list of the results as well as their corresponding guideline is attached in Table 2, Appendix A. The raw water quality data set is attached in Table 6, Appendix A.

Conclusions & Recommendations

Review of the Village of Mackenzie ground water data indicates an overall high raw drinking water quality. Most water soluble contaminants were present at concentrations well below drinking water guidelines. The only parameter of note is water hardness. This may cause problems with the scaling of pipes, as well as aesthetic concerns. There are treatment methods to deal with water hardness, however those will not be discussed here.

Based on the lack of information regarding the wells, a 300 m radius is arbitrarily assigned as the zone where contamination is most likely (Mike Wei, Senior Hydrogeologist, MOE, p.c.). Since the lithology profile of the well indicates dominantly sands and gravels, the aquifer is probably unconfined and therefore more susceptible to leaching materials compared to aquifers with an upper confining layer. Because of this, it is recommended that a site assessment be done on land use activities within this zone to indicate where there is potential for contamination.

Because the Village of Mackenzie currently uses no form of water treatment and some bacteria were detected, it is also recommended that periodic bacterial samples are collected to ensure that levels do not exceed recommended drinking water guidelines of 0 CFU/100 mL.

Acknowledgements

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Contact Information

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References

Greenberg, A.E., L.S. Clesceri, and A.D. Eaton (EDS.). 1992. Standard methods for the examination of water and wastewater (18th Edition). Published Jointly by American Public Health Association, American Water Works Association, and Water Environment Federation.

Provincial Health Officer. 2001. Drinking water quality in British Columbia: the public health perspective. A report of the health of British Columbians. Provincial Health Officer's Annual Report 2000, B.C. Ministry of Health Planning, Victoria, B.C.. 147 pp.

PSC. 2002. 2002-2006 analysis & pricing information. Prepared by PSC Environmental Services, 8577 Commerce Court, Burnaby, B.C., V5A 4N5, for B.C. Ministry of Water, Land and Air Protection. 47pp.

Resource Inventory Committee. 1998. Guidelines for interpreting water quality data. Province of British Columbia.

The Ecology of the Sub-Boreal Spruce Zone. 1998. Ministry of Forests Research Branch, Victoria, B.C.

The Ecology of the Engleman Spruce-Sub Alpine Fir Zone. 1998. Ministry of Forests Research Branch, Victoria, B.C.

MOE. 2004. Aquifers and Water Wells of British Columbia.

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Appendix A

Table 2. 2002/03 sample parameters, summaries of current results and associated B.C. drinking water guidelines.

Parameter	# of Values	Min.	Max.	Mean	Std. Dev.	MDL	D.W. Guideline	Guideline Type
General								
pH	6	8	8.2	8.1	0.06	0.1	6.5-8.5	aesthetic objective
Colour (TCU)	6	5	5	5.0	0.00	5	≤ 15	aesthetic objective
Specific Conductance (µS/cm)	6	247	272	258	9.2	1	≤ 700	maximum acceptable concentration
Turbidity (NTU)	5	0.1	0.23	0.16	0.049	0.1	≤ 5	maximum acceptable concentration
Hardness Total (mg/L)	6	131	142	137	4.3			
Hardness Total -Diss. (mg/L)	1	137	137	137			≤ 500 $CaCO_3$	aesthetic objective
Alkalinity (mg/L)	6	124	135	129	4.0	0.5		
Residue Non-Filterable (mg/L)	6	4	9	4.8	2.04	4		
Total Organic Carbon (mg/L)								
TOC	5	0.5	1	0.7	0.21	0.5	≤ 4	maximum, to control THM production
Anions (mg/L)								
Chloride Dissolved	6	1.5	4.6	2.47	1.115	0.5	≤ 250	aesthetic objective
Fluoride Dissolved	6	0.03	0.05	0.04	0.008	0.01	≤ 1.5	maximum acceptable concentration
Bromide Dissolved	6	0.1	0.1	0.1	0.00	0.1		
Nutrients (mg/L)								
Nitrate+Nitrite	6	0.069	0.104	0.085	0.013	0.002	≤ 45 (Nitrate)	maximum acceptable concentration
Phosphorus Total	2	0.002	0.002	0.002	0.000	0.002		
Phosphorus Total-Diss.	1	0.002	0.002	0.002	0.000	0.002		
Sulphate (mg/L)								
Sulphate	6	7.1	8.8	7.7	0.641	0.5	≤ 500	aesthetic objective
Metals Total (ug/L)								
Aluminum-T	6	0.3	0.9	0.6	0.22	0.3		
Aluminum-D	1	0.7	0.7	0.7	0.00	0.3	≤ 200	maximum acceptable concentration
Antimony-T	6	0.012	0.047	0.031	0.014	0.005	≤ 6	interim maximum acceptable concentration
Antimony-D	1	0.043	0.043	0.043	0.000	0.005		
Arsenic-T	6	0.2	0.3	0.23	0.052	0.1	≤ 25	interim maximum acceptable concentration
Arsenic-D	1	0.2	0.2	0.2	0.00	0.1		
Barium-T	6	35.7	39.4	36.58	1.391	0.02	≤ 1000	maximum acceptable concentration
Barium-D	1	36.1	36.1	36.1	0.00	0.02		
Beryllium-T	6	0.02	0.02	0.02	0.000	0.02		
Beryllium-D	1	0.02	0.02	0.02	0.000	0.02		
Bismuth-T	6	0.02	0.05	0.025	0.012	0.02		
Bismuth-D	1	0.02	0.02	0.02	0.000	0.02		
Cadmium-T	6	0.01	0.01	0.01	0.000	0.01	≤ 5	maximum acceptable concentration
Cadmium-D	1	0.01	0.01	0.01	0.000	0.01		
Calcium-T (mg/L)	6	43.8	47	45.4	1.30	0.05		
Calcium-D (mg/L)	1	45.4	45.4	45.4	0.00	0.05		
Chromium-T	6	0.2	1.3	0.38	0.449	0.2	≤ 50	maximum acceptable concentration
Chromium-D	1	0.2	0.2	0.2	0.00	0.2		
Cobalt-T	6	0.005	0.035	0.011	0.012	0.005		
Cobalt-D	1	0.005	0.005	0.005	0.000	0.005		
Copper-T	6	0.56	2.15	1.17	0.561	0.05	≤ 1000	aesthetic objective
Copper-D	1	2.06	2.06	2.06	0.000	0.05		
Iron-T (mg/L)	5	0.005	0.005	0.005	0.000	0.005	≤ 0.3	aesthetic objective
Iron-D (mg/L)	1	0.005	0.005	0.005	0.000	0.005		
Lead-T	6	0.05	0.26	0.132	0.074	0.01	≤ 10	maximum acceptable concentration
Lead-D	1	0.05	0.05	0.05	0.000	0.01		
Lithium-T	6	0.05	3.09	2.263	1.109	0.05		
Lithium-D	1	2.74	2.74	2.74	0.000	0.05		

Table 2 continued.

Parameter	# of Values	Min.	Max.	Mean	Std. Dev.	MDL	D.W. Guideline	Guideline Type
Magnesium-T (mg/L)	6	5.28	5.98	5.67	0.271	0.05		
Magnesium-D (mg/L)	1	5.66	5.66	5.66	0.000	0.05	≤ 100	aesthetic objective
Manganese-T	6	0.008	0.067	0.030	0.024	0.008	≤ 50	aesthetic objective
Manganese-D	1	0.028	0.028	0.028	0.000	0.008		
Molybdenum-T	6	0.37	0.61	0.435	0.090	0.05	≤ 250	maximum acceptable concentration
Molybdenum-D	1	0.41	0.41	0.41	0.000	0.05		
Nickel-T	6	0.05	0.05	0.05	0.000	0.05		
Nickel-D	1	0.05	0.05	0.05	0.000	0.05		
Selenium-T	6	0.2	0.4	0.23	0.082	0.2	≤ 10	maximum acceptable concentration
Selenium-D	1	0.2	0.2	0.2	0.000	0.2		
Silver-T	6	0.02	0.02	0.02	0.000	0.02		
Silver-D	1	0.02	0.02	0.02	0.000	0.02		
Sodium-T (mg/L)	5	1.9	2.7	2.21	0.381	0.05	≤ 200	aesthetic objective
Strontium-T	6	145	171	157	9.6	0.005		
Thallium-T	6	0.002	0.002	0.002	0.000	0.002	≤ 2	maximum acceptable concentration
Thallium-D	1	0.002	0.002	0.002	0.000	0.002		
Tin-T	6	0.01	0.02	0.012	0.004	0.01		
Tin-D	1	0.01	0.01	0.01	0.000	0.01		
Uranium-T	6	1.04	1.27	1.172	0.089	0.002	≤ 100	maximum acceptable concentration
Uranium-D	1	1.21	1.21	1.21	0.000	0.002		
Vanadium-T	6	0.11	1.34	0.575	0.428	0.06	≤ 100	maximum acceptable concentration
Vanadium-D	1	0.15	0.15	0.15	0.000	0.06		
Zinc-T	6	1	2.4	1.62	0.492	0.1	≤ 5000	aesthetic objective
Zinc-D	1	2.3	2.3	2.3	0.00	0.1		

Table 4. Duplicate samples that exceeded precision acceptability criteria (≤25% difference when >5-fold MDL). All concentrations in µg/L unless otherwise indicated.

Parameter	MDL (µg/L)	January/03			March/03			May/03			May/June/03		
		Conc. 1	Conc. 2	RPD %	Conc. 1	Conc. 2	RPD %	Conc. 1	Conc. 2	RPD %	Conc. 1	Conc. 2	RPD %
Copper-T	0.05	0.55	0.78	**35**	1.69	2.32	**31**						
Iron-T (mg/L)	0.005										13.8	10.7	**25**
Turbidity (NTU)	0.1	3.9	2.86	**31**									
Vanadium-T	0.06							0.28	0.57	**68**			
Zinc-T	0.1	4.4	6.4	**37**									

RPD %=Relative Percent Difference

**Data are presented for the purpose of batch specific QA assessment. Most QA samples were not collected at Mackenzie.*

Date	Total Coliform (CFU/100mL)	Fecal Coliform (CFU/100mL)	Enterococci (CFU/100mL)	E. Coli (CFU/100mL)	pH (pH Units)
10-Oct-02	<1	<1	<1	<1	8.2
13-Jan-03	<1	<1	<1		8.1
20-Mar-03	<1	<1	<1	<1	8
06-May-03	6	1	1	1	8.1
29-May-03	<1	<1	<1	<1	8.1
14-Aug-03	<1	<1	<1	<1	8.1

True Colour (Col. Unit)	Specific Conductance (µS/cm)	Residues - NonFilt. (mg/L)	Turbidity (NTU)	Hardness - Total (mg/L)	Hardness - Dissolved (mg/L)
<5	266	<4		131	
<5	247	<4	0.17	141	
5	255	9	0.13	142	
<5	272	<4	0.15	136	
<5	255	<4	<0.1	133	137
<5	253	<4	0.23	137	

Alkalinity - T as $CaCO_3$ (mg/L)	Bromide - Diss. (mg/L)	Chloride - Diss. (mg/L)	Fluoride - Diss. (mg/L)	Carbon - Tot. Org. (mg/L)	$NO_2 + NO_3$ (mg/L)
128	<0.1	1.5	0.04	<0.5	0.069
132	<0.1	1.9	0.05		0.073
130	<0.1	2	0.05	0.6	0.081
124	<0.1	4.6	0.04	1	0.095
135	<0.1	2.7	0.03	0.7	0.09
126	<0.1	2.1	0.04	<0.5	0.104

Phosphorus - Tot. Diss. (mg/L)	Phosphorus - Tot. (mg/L)	Sulfate (mg/L)	Aluminum - Tot. (µg/L)	Aluminum - Diss. (µg/L)	Antimony - Tot. (µg/L)
		7.8	<0.3		0.021
		8.2	0.7		0.024
		7.3	0.5		0.042
		7.1	0.8		0.012
<0.002	<0.002	7.4	0.6	0.7	0.039
	<0.002	8.8	0.9		0.047

Table 6. 2002/03 raw water data collected from the Mackenzie drinking water supply.

Antimony - Diss. (µg/L)	Arsenic - Tot. (µg/L)	Arsenic - Diss. (µg/L)	Barium - Tot. (µg/L)	Barium - Diss. (µg/L)	Beryllium - Tot. (µg/L)
	0.3		36.1		<0.02
	0.3		35.7		<0.02
	0.2		36		<0.02
	0.2		36.2		<0.02
0.043	0.2	0.2	36.1	36.1	<0.02
	0.2		39.4		<0.02

Beryllium - Diss. (µg/L)	Bismuth - Tot. (µg/L)	Bismuth - Diss. (µg/L)	Cadmium - Tot. (µg/L)	Cadmium - Diss. (µg/L)	Calcium - Tot. (mg/L)
	<0.02		<0.01		43.8
	<0.02		<0.01		46.5
	<0.02		<0.01		47
	0.05		<0.01		44.9
<0.02	<0.02	<0.02	<0.01	<0.01	44.1
	<0.02		<0.01		45.9

Calcium - Diss. (mg/L)	Chromium - Tot. (µg/L)	Chromium - Diss. (µg/L)	Cobalt - Tot. (µg/L)	Cobalt - Diss. (µg/L)	Copper - Tot. (µg/L)
	<0.2		<0.005		1.45
	<0.2		<0.005		0.82
	<0.2		<0.005		1.01
	<0.2		0.035		0.56
45.4	<0.2	<0.2	<0.005	<0.005	2.15
	1.3		0.011		1.05

Copper - Diss. (µg/L)	Iron - Tot. (mg/L)	Iron - Diss. (mg/L)	Lead - Tot. (µg/L)	Lead - Diss. (µg/L)	Lithium - Tot. (µg/L)
			0.26		<0.05
	<0.005		0.05		2.67
	<0.005		0.15		2.38
	<0.005		0.14		2.6
2.06	<0.005	<0.005	0.07	0.05	2.79
	<0.005		0.12		3.09

Lithium - Diss. (µg/L)	Magnesium - Tot. (mg/L)	Magnesium - Diss. (mg/L)	Manganese - Tot. (µg/L)	Manganese - Diss. (µg/L)	Molybdenum - Tot. (µg/L)
	5.28		<0.008		0.37
	5.98		<0.008		0.38
	5.95		0.051		0.61
	5.74		0.067		0.39
2.74	5.54	5.66	0.026	0.028	0.41
	5.53		0.019		0.45

Molybdenum - Diss. (µg/L)	Nickel - Tot. (µg/L)	Nickel - Diss. (µg/L)	Selenium - Tot. (µg/L)	Selenium - Diss. (µg/L)	Silver - Tot. (µg/L)
	<0.05		<0.2		<0.02
	<0.05		0.4		<0.02
	<0.05		<0.2		<0.02
	<0.05		<0.2		<0.02
0.41	<0.05	<0.05	<0.2	<0.2	<0.02
	<0.05		<0.2		<0.02

Silver - Diss. (µg/L)	Sodium - Tot. (mg/L)	Strontium - Tot. (µg/L)	Strontium - Diss. (µg/L)	Thallium - Tot. (µg/L)	Thallium - Diss. (µg/L)	Tin - Tot. (µg/L)
		149		<0.002		<0.01
	1.91	145		<0.002		0.02
	1.9	171		0.002		<0.01
	2.7	160		0.002		0.01
<0.02	2.54	153	155	0.002	<0.002	0.01
	2	163		<0.002		<0.01

Tin - Diss. (µg/L)	Uranium - Tot. (µg/L)	Uranium - Diss. (µg/L)	Vanadium - Tot. (µg/L)	Vanadium - Diss. (µg/L)	Zinc - Tot. (µg/L)	Zinc - Diss. (µg/L)
	1.1		0.39		1.7	
	1.24		1.34		1.2	
	1.27		0.76		1.6	
	1.16		0.39		1	
<0.01	1.22	1.21	0.11	0.15	2.4	2.3
	1.04		0.46		1.8	