Sherbrooke Lake Watershed

Water Quality Report

2010

Trudy Carey Photo

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LaHave River Watershed Committee

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Introduction

Sherbrooke Lake is the largest body of water in the LaHave River watershed. It was scoured out of the bedrock by glaciers some 15,000 years ago, and is now the home of numerous species of aquatic and terrestrial life, including humans, all depending on the lake for sustenance of one kind or another. The lake receives drainage from small rivers and brooks mainly to the north, east, and south. The main outlet (North Branch LaHave River) from the lake is located on the southwest side of the lake. The North Branch LaHave River is a main tributary of the LaHave River that eventually joins the main branch through Wentzell's Lake. This document is intended as the first of a series of annual reports on the quality of water in the vicinity of Sherbrooke Lake.

Water Quality Monitoring

In mid-2007, Bluenose Coastal Action Foundation (BCAF) (http://www.coastalaction.org/) of Lunenburg, Nova Scotia, began a program of water monitoring at 15 locations in the LaHave River watershed. Water sampling takes place every four weeks (13 times per year) and the water is analyzed at Maxxam Analytics (http://maxxam.ca/) at an annual cost of approximately $2700 per site per annum. One of those sampling locations, Site 14, also known as Franey Corner, samples one input at the northern end of Sherbrooke Lake, but no early water sampling location monitored the output from the lake. In 2010, the Sherbrooke Forest Homeowners' Association funded the cost of water sampling at Site 15, also known as Sherbrooke, so that it would be possible to begin to understand what happens to the quality of the water as it passes through the lake.

Locations of the two sampling sites relevant to Sherbrooke Lake.

Rationale for Sampling Sites 14 and 15

All LaHave River watershed sampling sites must be accessible throughout the year, including the Winter when secondary roads may be impassable; therefore, Sites 14 and 15 are at places where main roads intersect main water courses. Although Site 14 provides an excellent sample of the water entering Sherbrooke Lake, it is not the only input to the lake. Other inputs include the Forties River, numerous brooks, surface runoff, direct precipitation of rain and snow, and groundwater. As shown later in this report, Site 14 is among the most pristine water in the entire LaHave River watershed, thus it provides a good indication of water quality conditions from an area with minimal human activity, compared to further downstream locations which have more development and/or land-use activities (such as agriculture). Site 15 provides a good indication of the water quality leaving Sherbrooke Lake, because it includes all the additional inputs listed above plus the natural and human influences from Sherbrooke Lake, North Branch LaHave, and Texas Lake. Any differences between upstream Site 14 and downstream Site 15 output must reflect the combined total of these effects.

Sampling and Analytical Protocol

Maxxam Analytics, located in the Atlantic Acres Industrial Park on Kearney Lake Road, provides sterilized bottles for each sampling run. Samples are collected according to procedures described in the BCAF Baseline Report, are kept in coolers during the sampling run, and are delivered with chain-of-custody forms to Maxxam the same day. Analyses are done by accepted procedures, duplicates are run of some samples, and known standards are run at the same time to check for analytical accuracy. The laboratory is accredited by the Canadian Association for Laboratory Accreditation (www.cala.ca).

Water Quality Standards

Water quality standards for Nova Scotia are adopted from the Canadian Council of Ministers of the Environment (CCME) and depend on the uses for which that water is intended. Of principal interest to us on Sherbrooke Lake are the CCME standards for: drinking water (updated to 2011), recreational water (not updated since 1992), and protection of aquatic life (updated to 2010), and they all appear at http://ceqe.ccme.ca/ Where relevant to our analytical package, these standards are included in the data at the back of this report.

Goals

Of interest to the residents of Sherbrooke Lake are the following questions:

1. what are the absolute values of the various physical and chemical measurements at Sites 14 and 15?
2. where are those values in relation to the CCME water quality standards?
3. how does the quality of the water change from Site 14 to Site 15?
4. how does the quality of water change over the years (trends over time)?

Details of the Analyses

Measurements are of two kinds: field measurements using an electronic device known as a sonde, and Maxxam's laboratory measurements by various accredited analytical techniques. The complete analytical data set is in the Appendix at the end of this report. The data are organized to show the measurements for Sherbrooke Site 15 first, then Franey Corner Site 14 below, and finally the residuals obtained by subtracting Franey results from Sherbrooke results. A positive residual means that a measured parameter has increased as water passes through the lake (the lake adds that component and , therefore, may be a SOURCE); a negative residual means that parameter has decreased in the lake (the lake subtracts that component and, therefore, may be a SINK, and is shaded in blue on the data sheets). This section provides some explanation of each of the parameters measured.

Left – the portable YSI 600QS electronic sonde used for measuring temperature, atmospheric pressure, pH, conductivity, and dissolved oxygen in naturally occurring surface water.
Right – Andy Breen, triumphantly recovering the sonde that had become stuck in the river at Site 15, on January 7, 2011. Water temperature, as measured by the sonde, was a chilly 0.68^{o}C.

GENERAL PROPERTIES – essential general measurements

Temperature – in degrees Celsius, as measured in the field by the sonde

Barometric Pressure (BP) – in mm of mercury (Hg), as measured in the field by the sonde

pH – in obscure units ($\log_{10}$ x (1/aH$^+$)) that give values which range from 0 to 14, as measured in the field by the sonde (values lower than 7 are considered acidic) – the scale is logarithmic, so a pH of 4 is ten times more acidic than a pH of 5

SOLIDS – occur in the water in two forms, dissolved and suspended

Specific Conductance – in milliSiemens/centimetre (mS/cm), as measured by the sonde, is a measure of the ability of the water to conduct an electrical current, and that conductance is related to the amount of dissolved material in the water

Total Dissolved Solids (TDS Field) – in milligrams per litre (mg/L = parts per million (ppm)), as calculated by the sonde using the specific conductance measurements above (water is a universal solvent, meaning it can dissolve just about anything, and rivers carry away about 30 tonnes of dissolved material per square kilometer drained per year!)

Total Dissolved Solids (TDS Lab) – in mg/L (ppm), as measured by Maxxam Analytics

Total Suspended Solids (TSS) – in mg/L (ppm), as measured by Maxxam Analytics

SALINITY – salinity, is similar to TDS and is a measurement more commonly used for seawater

Salinity – in parts per thousand (ppt), as measured in the field by the sonde (for reference, seawater is about 35 ppt)

Choride – in mg/L (= ppm), as measured by Maxxam Analytics

OXYGEN – DO, DO%, and BOD are good measures of the health of the water

Dissolved Oxygen Concentration – in mg/L (= ppm) as measured in the field by the sonde

Dissolved Oxygen Percent – as calculated from DO Conc, Temperature, and Pressure by the sonde

Biological Oxygen Demand (BOD) – in mg/L (=ppm), measured by Maxxam Analytics, is a measure of the amount of dissolved oxygen that will be consumed by the oxidation of organic material in the water

CRITICAL NUTRIENTS – as measured by Maxxam Analytics – all life needs nitrogen and phosphorus, but levels above CCME guidelines are undesirable and could lead to algal blooms in the lake – Sherbrooke Lake water is generally, and desirably, nutrient-poor

Nitrate and Nitrite – in mg/L (= ppm), expressed as nitrogen, are two forms of oxidized nitrogen; becomes toxic at > 2.9 mg/L

Ammonia – in mg/L (= ppm), expressed as nitrogen, is a reduced form of nitrogen

Nitrogen – in mg/L (= ppm), is the total of all forms of nitrogen, including organic nitrogen forms

Phosphorus – in mg/L (= ppm) is normally the rate-limiting nutrient for algal growth in freshwater

BACTERIA – many species of bacteria inhabit natural waters, but fecal coliforms (including *E. coli*) are an indicator of the presence of wastes from warm-blooded animals (including humans)

Fecal Coliforms - in MPN/mL (Most Probable Number per mL), but note the units are per *millilitre*, so a value of 2/mL, which seems low, is really the same as 2000/L, which seems high!

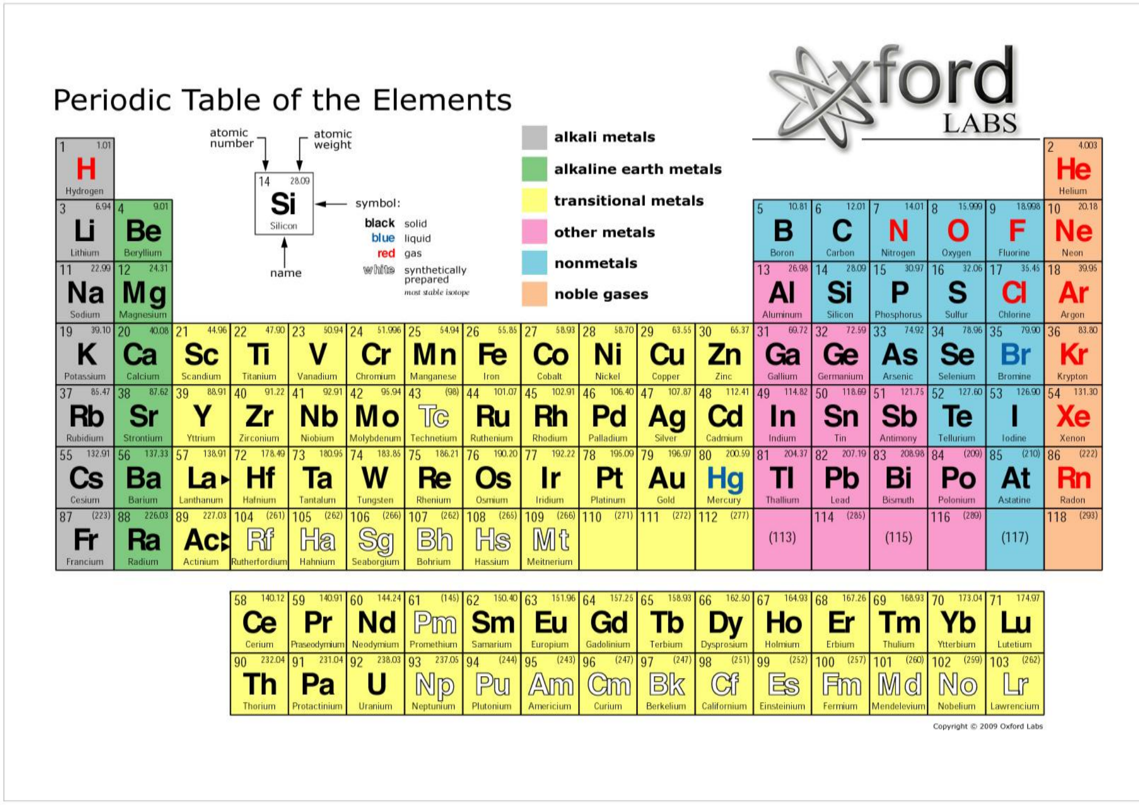
METALLIC CHEMICAL COMPONENTS – here begins a long list of chemical components, collected only twice a year and reported in μg/L (micrograms per litre = parts per billion (ppb)) by Maxxam Analytics – all analyses where the concentrations in the water are below the lower limit of detection of the analytical method are shaded in green – the values reported are the sum of dissolved and suspended material – note that, for every component above the lower limit of analytical detection, Sherbrooke Lake appears to be a sink, meaning that these metals are accumulating in the lake mainly as normal sedimentary deposits as a result of decreased flow velocities, and chemical precipitates probably related to increasing pH – for reference, a periodic table of the chemical elements appears on the next page.

LIGHT ELEMENTS – aluminum is probably present mainly in suspended clays, whereas beryllium and boron may be mainly dissolved, but very minor, constituents

FIRST TRANSITION SERIES – represents a chemically related group of metals, the only ones of which with concentrations well above the lower limit of detection are iron and manganese – there are some old manganese mines northeast of New Ross, but they drain into the Gold River, not the LaHave watershed; the movie "Erin Brokovich" was all about the occurrence of hexavalent chromium in water, but no such highly oxidized species of chromium occurs in natural waters

SECOND TRANSITION SERIES – another chemically related group of metals, of more concern than the First Transition Series, especially cadmium – if new mining ever took place in our watershed, at least some of these elements would risk being released into the hydrosphere

ASSORTED OTHER ELEMENTS – except perhaps for barium and strontium, a toxic group of elements, an rather undesirable group of elements, particularly arsenic, lead, and uranium, requiring close monitoring



Water Quality Index (WQI)

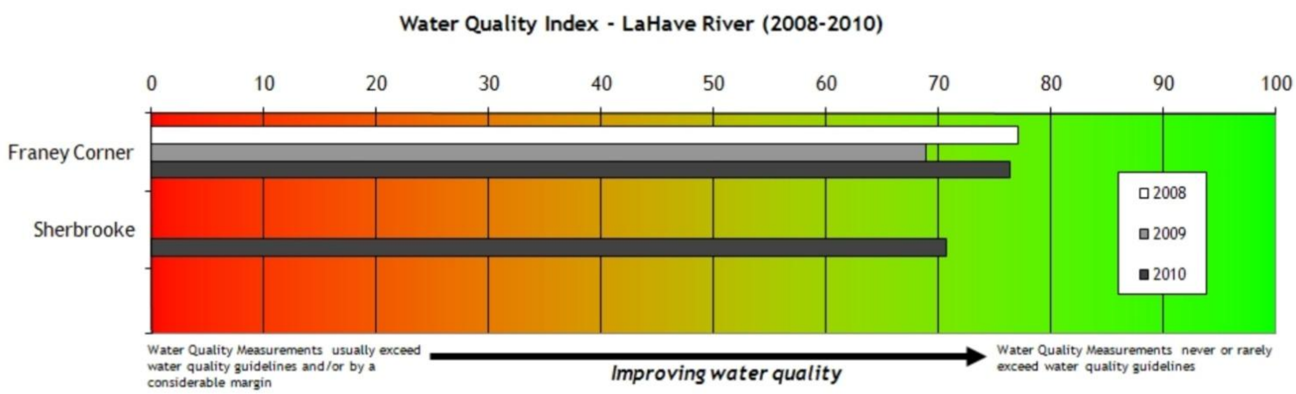
The Canadian Council of Ministers of the Environment (CCME) has developed a water quality index (WQI) as a communication tool to summarize complex water quality data into a single measure. WQIs for the years 2008-2010 have been calculated for all the sampling sites in the LaHave River watershed, using the following parameters and the corresponding aquatic life or recreational (fecal coliforms only) guidelines:

	Water Quality Parameter	Non-compliance if:	Value1	Value 2	Unit
1	Dissolved_Oxygen	<	5.5		mg/L
2	Temp	>	20		Degrees
3	pH	<	5.3		mg/L
4	Ammonia	compute	0.019		mg/L
5	Phosphorous	>	0.03		mg/L
6	TSS	>	5		mg/L
7	Fecal_Coliform	>	2		MPN/mL
8	Iron	>	300		ug/L

The CCME scale of WQIs ranges from 0 (worst) to 100 (best). The results for all sites in the entire LaHave River watershed over three years (2008-2010) ranged from a high of 77.1 (at Franey Corner) to a low of 46.1 (elsewhere in the watershed). A summary of the WQIs at all sites over the last three years are in the table below:

WQI	Number
45-50	1
50-55	6
55-60	5
60-65	12
65-70	6
70-75	4
75-80	4

Of particular interest to us, Site 14 (Franey Corner) had WQI scores of 77.1 in 2008, 68.9 in 2009, and 76.3 in 2010, meaning that this particular input to Sherbrooke Lake has amongst the highest quality water in the entire LaHave River watershed. On the other hand, Site 15 (Sherbrooke) had a WQI score of 70.7 in 2010, lower than the WQI score of 76.3 at Site 14 in 2010. The bar graph below illustrates these data.



A bar graph showing WQIs for Franey Corner (Site 14) for three years (2008-2010), and Sherbrooke (Site 15) for the current year only (2010). Note the extent of annual variation at Franey Corner, and the difference in WQI between the Franey Corner and Sherbrooke sites in 2010.

Summary of Principal Findings in 2010

1. Water leaving the lake is generally warmer than water entering the lake, except in the Spring when lake water takes time to become warmer than incoming river water.
2. Water leaving the lake is generally less acid than water entering the lake. The reason for this change is unknown.
3. Water at Sites 14 and 15 exceeds some of the CCME guidelines for drinking water and is, therefore, not potable without filtration, particularly for reasons of acidity and fecal coliform bacteria. As a matter of fact, the Nova Scotia Department of the Environment recommends that *all surface water be treated prior to drinking* (http://www.gov.ns.ca/nse/surface.water/).
4. Water in the lake is generally within CCME recreational guidelines, although technically the water is too acidic for swimming. This situation is not, however, unique to Sherbrooke Lake and represents a case where the national guidelines need regional adjustment.
5. Concentrations of most chemical parameters are lower at the Sherbrooke monitoring station compared to the Franey Corner monitoring station. These decreases indicate that processes within the lake, and influence from other sources, are reducing the concentrations by some combination of dilution by rain and snow, mechanical deposition in the lake as sediments, chemical precipitation as a consequence of increasing pH, or biological consumption within the lake.
6. Although the WQIs at Sites 14 and 15 are amongst the highest in the LaHave River watershed, at least the first year of sampling at Site 15 suggests that the WQI decreases as water passes through Sherbrooke Lake.
7. This report establishes a baseline against any future upstream agricultural, forestry, mining, or other development that could potentially have a negative impact on the water quality in Sherbrooke Lake.

The LaHave Watershed in a Global Context

Entirely coincidentally with our program of monitoring water quality in Sherbrooke Lake, the scientific journal Nature (Volume 467, pages 555-561, 2010) published an article entitled "Global threats to human water security and river biodiversity". This study divides the land mass of the Earth into 0.5^{o} Latitude by 0.5^{o} Longitude cells, and for each of these 46,517 cells it makes an assessment of the impact of 23 different stressors on the quality of water in rivers. Some of those stressors include: farming, nitrogen loading, phosphorus loading, mercury loading , pesticides, organic loading, acidification, thermal loading, human water stress, fishing pressure, and aquaculture pressure. Each cell is assessed a numerical score depending on the combined effects of those stressors – the higher the score, the more the river is at risk. The worst cells in the world are in China and India, whereas the best cells are in Arctic Canada and Siberia. The correlation of water stressors with human population density is obvious. All 46,517 cells are ranked into percentiles for human water security and biodiversity: the higher the percentile, the greater the threat to security and biodiversity. If a cell is in the 0th percentile, it means that ~0% of the cells are better off; if a cell is in the 100th percentile, it means that ~100% of the cells are better off. The cells containing the LaHave watershed are in approximately the 70th percentile, meaning that ~70% of the cells on Earth are better off than the LaHave is, bearing in mind, however, that many of those better-off cells are in sparsely populated areas of the Earth. Because all the rankings are relative, even if nothing changes in absolute terms in the LaHave watershed, our ranking could improve as some other watershed systems become more stressed, but our ranking could also decline as yet other watershed systems are cleaned up. Nevertheless, the 70th percentile is not particularly good, and we should be taking steps to move down the percentile ranking (for example, as BCAF is actively doing with its riparian assessment and restoration program – A. Breen, Riparian Restoration Work with LaHave River Farmers, BCAF 2010).

The Importance of Ongoing Monitoring

This report represents a snapshot of water quality in the Sherbrooke Lake watershed for one year (2010), but it does not tell us how the water quality is changing as a function of time. Any such change is an important question for all of us who, at some point in the future, plan either to sell our properties or to will them to our families. However and whenever that transfer of property takes place, all parties will want those properties to be of the highest value possible. That value will depend to some significant extent on the health of the lake. Only a program of ongoing monitoring will allow us to detect trends, and allow us to take remedial action before any crisis develops, as has already happened to some recreational lakes in Ontario. If everyone around the lake were to contribute to a program of annual water quality monitoring , the cost would be less than $1 per month per property. Where else is an insurance policy obtainable for about $10 a year? Of necessity, water sampling for 2011 is already underway, and it needs broad-based and committed financial support to continue. Our current work in the LaHave watershed puts us ahead of the curve, but very recently the Province has opened a new portal for water-related matters in Nova Scotia: http://waterforlife.gov.ns.ca/

Future Questions

What we have learned from this first report is enlightening, but there is certainly much more to learn about the water of Sherbrooke Lake itself (e.g., vertical profiles of temperature, pH, DO, water clarity) at stations within the lake. Also, it would be useful to know about the effect of the Forties River on the change in water quality in Sherbrooke Lake, especially because it passes through an agricultural area, but that would mean an additional sampling site with attendant costs. It would also be helpful to find out the residence time of water in the lake, i.e., on average, how long does water stay in the lake? A short residence time means the WQIs in the lake would fluctuate almost as much as the inputs (see bar graph for Franey Corner) , whereas a long residence time means water stays in the lake a long time and the WQI would be more resistant to change (for better or for worse). To be able to calculate the residence time, we need a good estimate of the volume of water in Sherbrooke Lake (which we can do from the bathymetric map at http://www.gov.ns.ca/fish/sportfishing/lakesurvey/3-L-sherbrooke.pdf), and we would also need a reliable measurement of the flow rate in the North Branch LaHave.

Acknowledgements

This report constitutes a small part of the work being done in the whole watershed by the LaHave River Watershed Committee, under the auspices of the Bluenose Coastal Action Foundation. Thanks are due to Bluenose Coastal Action for funding the sampling at Site 14, and to Sherbrooke Forest Homeowners' Association for funding the sampling at Site 15. Many thanks to Andrew Breen and all others who worked faithfully to sample the river thirty-nine times over the last three years. Thanks also to Andrew Breen, Brooke Nodding, Carroll Randall, and particularly Denis Parent, fellow members of the LaHave River Watershed Committee, all of whom offered helpful comments on a first draft of this report.

Appendix – The Analytical Data for 2010

Explanatory Notes

1. The upper part of the tables gives the values for downstream Site 15, the middle part gives the measurements for upstream Site 14, and the lower part gives the residuals from subtracting the upstream value from the downstream value. Let's say the upstream value is 25 mg/L and the downstream value is 5 mg/L. The residual value is 5 - 25 = -20 mg/L. The *negative* number signifies that the value is *decreasing* in the lake, and suggest that the lake is a SINK. *Positive* residuals signify that the values are *increasing* in the lake and suggest that the lake is a SOURCE.
2. However, because there are so many other variables at play, all these residual values may be only an **apparent** Sherbrooke Lake effect. For example, if some component increased from upstream Site 14 to downstream Site 15, the SOURCE might indeed be Sherbrooke Lake, but it could alternatively be in the Forties River, or take place between Sherbrooke Lake and the Site 15 sampling site. Such are the limitations of the current sampling regime. Better resolution would require more sites and more expense.

SHERBROOKE SITE 15 (DOWNSTREAM)			GENERAL PROPERTIES			TOTAL DISSOLVED/SUSPENDED SOLIDS				SALINITY	
Site Number	Site Name	Date Time	Temp	BP	pH	SpCond	TDS Field	TDS Lab	TSS	Salinity	Chloride
Units			°C	mmHg	$[H^+]^{-14}$	mS/cm	mg/L	mg/L	mg/L	permil (‰)	mg/L
15	Sherbrooke	Jan-7-2010 08:46	0.19	734.4	5.51	0.016	19	23	<1	*	5
15	Sherbrooke	Feb-4-2010 08:25	-0.08	746.4	5.73	0.012	15	32	<1	*	5
15	Sherbrooke	Mar-4-2010 7:45	1.70	736.0	5.15	0.015	18	30	<1	0.01	4
15	Sherbrooke	Apr-1-2010 13:31	6.89	749.6	5.31	0.017	17	43	1	0.01	4
15	Sherbrooke	Apr-29-2010 14:24	10.23	732.1	5.75	0.019	26	100	<1	0.01	5
15	Sherbrooke	May-27-2010 13:46	16.30	745.0	5.77	0.022	18	26	<2	0.01	5
15	Sherbrooke	Jun-24-2010 13:30	20.32	744.5	5.84	0.024	17	33	2	0.01	4
15	Sherbrooke	July-22-2010 10:10	23.39	741.7	5.47	0.027	18	34	2	0.01	4
15	Sherbrooke	Aug-19-2010 10:37	22.27	751.2	5.38	0.027	18	45	<1	0.01	5
15	Sherbrooke	Sept-16-2010 09:02	16.72	749.0	5.49	0.023	18	28	<1	0.01	4
15	Sherbrooke	Oct-14-2010 09:23	11.38	753.0	5.70	0.020	18	41	<1	0.01	4
15	Sherbrooke	Nov-9-2010 14:18	11.25	744.0	4.58	0.020	18	26	2	0.01	5
15	Sherbrooke	Dec-9-2010 14:41	3.90	747.8	4.86	0.016	17	*	<1	0.01	5
CCME Drinking (2011)		http://ceqg-rcqe.ccme.ca/	<15.00		6.50-8.50			500			250
CCME Recreation (1992)		http://ceqg-rcqe.ccme.ca/	αt		5.00-9.00						
CCME Aquatic Life (2010)		http://ceqg-rcqe.ccme.ca/									

FRANEY CORNER SITE 14 (UPSTREAM)			GENERAL PROPERTIES			TOTAL DISSOLVED/SUSPENDED SOLIDS				SALINITY	
Site Number	Site Name	Date Time	Temp	BP	pH	SpCond	TDS Field	TDS Lab	TSS	Salinity	Chloride
Units			°C	mmHg	$[H^+]^{-14}$	mS/cm	mg/L	mg/L	mg/L	permil (‰)	mg/L
14	Franey Corner	Jan-7-2010 09:16	0.21	731.3	5.20	0.016	20	23	<1	*	5
14	Franey Corner	Feb-4-2010 09:07	*	743.5	4.92	*		32	<1	*	6
14	Franey Corner	Mar-4-2010 8:16	0.29	732.2	4.61	0.014	17	29	1	0.01	4
14	Franey Corner	Apr-1-2010 12:55	7.71	746.5	4.98	0.018	17	36	1	0.01	4
14	Franey Corner	Apr-29-2010 13:59	10.87	729.2	5.69	0.018	16	19	2	0.01	4
14	Franey Corner	May-27-2010 13:09	17.60	742.3	6.27	0.026	20	28	4	0.01	6
14	Franey Corner	Jun-24-201013:05	20.80	741.5	6.15	0.020	27	29	<1	0.01	4
14	Franey Corner	July-22-2010 9:48	22.53	738.9	5.17	0.028	18	62	3	0.01	4
14	Franey Corner	Aug-19-2010 10:04	20.18	747.5	5.21	0.029	19	77	<2	0.01	5
14	Franey Corner	Sept-16-2010 09:28	14.49	746.1	5.16	0.026	20	55	<1	0.01	5
14	Franey Corner	Oct-14-2010 09:59	8.64	750.0	5.10	0.023	21	67	1	0.01	6
14	Franey Corner	Nov-9-2010 13:16	11.35	741.0	4.21	0.020	17	24	<1	0.01	5
14	Franey Corner	Dec-9-2010 14:17	2.15	744.4	4.27	0.015	17	*	2	0.01	4
CCME Drinking (2011)			<15.00		6.50-8.50			500			250
CCME Recreation (1992)			αt		5.00-9.00						
CCME Aquatic Life (2010)											

RESIDUALS (DOWNSTREAM SITE 15 - UPSTREAM SITE 14)			GENERAL PROPERTIES			TOTAL DISSOLVED/SUSPENDED SOLIDS				SALINITY	
Site Number	Site Name	Date Time	Temp	BP	pH	SpCond	TDS Field	TDS Lab	TSS	Salinity	Chloride
Units			°C	mmHg	$[H^+]^{-14}$	mS/cm	mg/L	mg/L	mg/L	permil (‰)	mg/L
15-14	S-F	Jan-7-2010 09:16	-0.02		0.31	0.000	-1	0		*	0
15-14	S-F	Feb-4-2010 09:07	*		0.81	*	15	0		*	-1
15-14	S-F	Mar-4-2010 8:16	1.41		0.54	0.001	1	1		0.000	0
15-14	S-F	Apr-1-2010 12:55	-0.82		0.33	-0.001	0	7	0.000	0.000	0
15-14	S-F	Apr-29-2010 13:59	-0.64		0.06	0.001	10	81		0.000	1
15-14	S-F	May-27-2010 13:09	-1.30		-0.50	-0.004	-2	-2		0.000	-1
15-14	S-F	Jun-24-201013:05	-0.48		-0.31	0.004	-10	4		0.000	0
15-14	S-F	July-22-2010 9:48	0.86		0.30	-0.001	0	-28	-1.000	0.000	0
15-14	S-F	Aug-19-2010 10:04	2.09		0.17	-0.002	-1	-32		0.000	0
15-14	S-F	Sept-16-2010 09:28	2.23		0.33	-0.003	-2	-27		0.000	-1
15-14	S-F	Oct-14-2010 09:59	2.74		0.60	-0.003	-3	-26		0.000	-2
15-14	S-F	Nov-9-2010 13:16	-0.10		0.37	0.000	1	2		0.000	0
15-14	S-F	Dec-9-2010 14:17	1.75		0.59	0.001	0	*		0.000	1
Mean 15-14			**0.643**		**0.28**	**-0.001**	**0.62**	**-2**		**0.000**	**-0.23**
SL SOURCE OR SINK			"SOURCE"		"SOURCE"	SINK	SOURCE	SINK			SINK

Additional Notes:

1. The atmospheric pressure (BP), as measured in the field by the sonde, is not a property of the water, but is used by the sonde to determine dissolved oxygen percentage (DO%).
2. The "αt" symbol for temperature recreational guidelines means that the temperature is a function of time (t) – the colder the water, the shorter the time you can swim safely.

SHERBROOKE SITE 15 (DOWNSTREAM)			OXYGEN			CRITICAL NUTRIENTS				BACTERIA
Site Number	Site Name	Date Time	DO Conc	DO%	BOD	Nitrate+Nitrite	Ammonia	Nitrogen	Phosphorus	Fecal Coliform
Units			mg/L	%sat	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/mL
15	Sherbrooke	Jan-7-2010 08:46	16.93	116.5	<5	0.05	<0.05	0.27	0.004	<1
15	Sherbrooke	Feb-4-2010 08:25	13.10	90.5	<5	0.06	<0.05	0.32	<0.002	<1
15	Sherbrooke	Mar-4-2010 7:45	13.69	96.5	<5	0.05	<0.05	0.28	0.005	<1
15	Sherbrooke	Apr-1-2010 13:31	12.54	103.0	<5	<0.05	<0.05	0.21	0.005	*
15	Sherbrooke	Apr-29-2010 14:24	11.54	102.8	<5	0.05	<.05	0.21	0.006	<1
15	Sherbrooke	May-27-2010 13:46	9.30	94.9	<5	<0.05	<0.05	0.22	0.002	<1
15	Sherbrooke	Jun-24-2010 13:30	8.71	95.8	<5	0.06	<0.05	0.21	0.060	3
15	Sherbrooke	July-22-2010 10:10	8.27	97.1	<5	<0.05	<0.05	0.20	0.007	1
15	Sherbrooke	Aug-19-2010 10:37	9.03	104.0	<5	0.05	0.06	0.25	<0.002	2
15	Sherbrooke	Sept-16-2010 09:02	9.16	94.2	<5	<0.05	<0.05	0.22	0.009	1
15	Sherbrooke	Oct-14-2010 09:23	10.37	95.5	<5	<0.05	<0.05	0.22	0.005	<1
15	Sherbrooke	Nov-9-2010 14:18	10.02	91.4	<5	<0.05	0.06	0.26	0.010	<1
15	Sherbrooke	Dec-9-2010 14:41	12.29	93.8	*	<0.05	<0.05	0.27	0.017	<1
CCME Drinking (2011)		http://ceqg-rcqe.ccme.ca/				45				0
CCME Recreation (1992)		http://ceqg-rcqe.ccme.ca/								2
CCME Aquatic Life (2010)		http://ceqg-rcqe.ccme.ca/						13		
FRANEY CORNER SITE 14 (UPSTREAM)			OXYGEN			CRITICAL NUTRIENTS				BACTERIA
Site Number	Site Name	Date Time	DO Conc	DO%	BOD	Nitrate+Nitrite	Ammonia	Nitrogen	Phosphorus	Fecal Coliform
Units			mg/L	%sat	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/mL
14	Franey Corner	Jan-7-2010 09:16	17.64	121.6	<5	0.06	<0.05	0.24	0.008	<1
14	Franey Corner	Feb-4-2010 09:07	14.35	98.4	<5	0.06	<0.05	0.25	0.003	<1
14	Franey Corner	Mar-4-2010 8:16	14.12	97.3	<5	<0.05	<0.05	0.22	0.010	<1
14	Franey Corner	Apr-1-2010 12:55	11.94	100.2	<5	<0.05	<0.05	0.21	0.006	*
14	Franey Corner	Apr-29-2010 13:59	10.87	98.3	<5	<0.05	<0.05	0.29	0.010	<1
14	Franey Corner	May-27-2010 13:09	9.70	102.3	<5	<0.05	<0.05	0.32	0.013	<1
14	Franey Corner	Jun-24-201013:05	9.07	101.1	<5	<0.05	<0.05	0.36	0.019	2
14	Franey Corner	July-22-2010 9:48	8.42	97.3	<5	<0.05	0.06	0.47	0.020	<1
14	Franey Corner	Aug-19-2010 10:04	9.43	104.1	<5	0.05	0.15	0.46	0.019	<1
14	Franey Corner	Sept-16-2010 09:28	10.06	98.2	<5	<0.05	<0.05	0.41	0.026	1
14	Franey Corner	Oct-14-2010 09:59	11.48	98.4	<5	<0.05	<0.05	0.39	0.011	<1
14	Franey Corner	Nov-9-2010 13:16	10.31	94.1	<5	<0.05	<0.05	0.30	0.015	1
14	Franey Corner	Dec-9-2010 14:17	13.09	94.9	*	<0.05	<0.05	0.28	0.014	<1
CCME Drinking (2011)						45				0
CCME Recreation (1992)										2
CCME Aquatic Life (2010)								13		
RESIDUALS (DOWNSTREAM SITE 15 - UPSTREAM SITE 14)			OXYGEN			CRITICAL NUTRIENTS				BACTERIA
Site Number	Site Name	Date Time	DO Conc	DO%	BOD	Nitrate+Nitrite	Ammonia	Nitrogen	Phosphorus	Fecal Coliform
Units			mg/L	%sat	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/mL
15-14	S-F	Jan-7-2010 09:16	-0.71	-5.10		0		0.030	-0.004	
15-14	S-F	Feb-4-2010 09:07	-1.25	-7.90		0		0.070	*	
15-14	S-F	Mar-4-2010 8:16	-0.43	-0.80				0.060	-0.005	
15-14	S-F	Apr-1-2010 12:55	0.60	2.80				0.000	-0.001	
15-14	S-F	Apr-29-2010 13:59	0.67	4.50				-0.080	-0.004	
15-14	S-F	May-27-2010 13:09	-0.40	-7.40				-0.100	-0.011	
15-14	S-F	Jun-24-201013:05	-0.36	-5.30				-0.150	0.041	
15-14	S-F	July-22-2010 9:48	-0.15	-0.20				-0.270	-0.013	
15-14	S-F	Aug-19-2010 10:04	-0.40	-0.10		0	-0.090	-0.210	*	
15-14	S-F	Sept-16-2010 09:28	-0.90	-4.00				-0.190	-0.017	
15-14	S-F	Oct-14-2010 09:59	-1.11	-2.90				-0.170	-0.006	
15-14	S-F	Nov-9-2010 13:16	-0.29	-2.70				-0.040	-0.005	
15-14	S-F	Dec-9-2010 14:17	-0.80	-1.10				-0.010	0.003	
Mean 15-14			**-0.43**	**-2.32**	**<5**	**<0.05**	**<0.05**	**-0.082**	**-0.002**	
SL SOURCE OR SINK			SINK	SINK				SINK	SINK	

Note that fecal coliforms exceeded recreational guidelines at the Sherbrooke Site 15 in June.

SHERBROOKE SITE 15 (DOWNSTREAM)				LIGHT ELEMENTS				FIRST TRANSITION SERIES ELEMENTS								
Site Number	Site Name	Date Time		Aluminum	Beryllium	Boron		Titanium	Vanadium	Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc
Units				µg/L	µg/L	µg/L		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
15	Sherbrooke	Jan-7-2010 08:46														
15	Sherbrooke	Feb-4-2010 08:25														
15	Sherbrooke	Mar-4-2010 7:45														
15	Sherbrooke	Apr-1-2010 13:31														
15	Sherbrooke	Apr-29-2010 14:24														
15	Sherbrooke	May-27-2010 13:46														
15	Sherbrooke	Jun-24-2010 13:30														
15	Sherbrooke	July-22-2010 10:10														
15	Sherbrooke	Aug-19-2010 10:37		173	<1	<5		<2	<2	<1	24.4	117	<0.4	<2	<2	5.1
15	Sherbrooke	Sept-16-2010 09:02														
15	Sherbrooke	Oct-14-2010 09:23		176	<1	<5		<2	<2	<1	13.8	132	<0.4	<2	<2	<5
15	Sherbrooke	Nov-9-2010 14:18														
15	Sherbrooke	Dec-9-2010 14:41														
CCME Drinking (2011)		http://ceqg-rcqe.ccme.ca/		100	*	5000		*	*	50	50	300	*	*	1000	5000
CCME Recreation (1992)		http://ceqg-rcqe.ccme.ca/														
CCME Aquatic Life (2010)		http://ceqg-rcqe.ccme.ca/				1.5						300				30

FRANEY CORNER SITE 14 (UPSTREAM)				LIGHT ELEMENTS				FIRST TRANSITION SERIES ELEMENTS								
Site Number	Site Name	Date Time		Aluminum	Beryllium	Boron		Titanium	Vanadium	Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc
Units				µg/L	µg/L	µg/L		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
14	Franey Corner	Jan-7-2010 09:16														
14	Franey Corner	Feb-4-2010 09:07														
14	Franey Corner	Mar-4-2010 8:16														
14	Franey Corner	Apr-1-2010 12:55														
14	Franey Corner	Apr-29-2010 13:59														
14	Franey Corner	May-27-2010 13:09														
14	Franey Corner	Jun-24-201013:05														
14	Franey Corner	July-22-2010 9:48														
14	Franey Corner	Aug-19-2010 10:04		371	<1	<5		2.6	<2	<1	20.0	510	<0.4	<2	<2	5.8
14	Franey Corner	Sept-16-2010 09:28														
14	Franey Corner	Oct-14-2010 09:59		417	<1	<5		2.8	<2	<1	33.5	467	<0.4	<2	<2	8.1
14	Franey Corner	Nov-9-2010 13:16														
14	Franey Corner	Dec-9-2010 14:17														
CCME Drinking (2011)				100	*	5000		*	*	50	50	300	*	*	1000	5000
CCME Recreation (1992)																
CCME Aquatic Life (2010)						1.5						300				30

RESIDUALS (DOWNSTREAM SITE 15 - UPSTREAM SITE 14)				LIGHT ELEMENTS				FIRST TRANSITION SERIES ELEMENTS								
Site Number	Site Name	Date Time		Aluminum	Beryllium	Boron		Titanium	Vanadium	Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc
Units				µg/L	µg/L	µg/L		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
15-14	S-F	Jan-7-2010 09:16														
15-14	S-F	Feb-4-2010 09:07														
15-14	S-F	Mar-4-2010 8:16														
15-14	S-F	Apr-1-2010 12:55														
15-14	S-F	Apr-29-2010 13:59														
15-14	S-F	May-27-2010 13:09														
15-14	S-F	Jun-24-201013:05														
15-14	S-F	July-22-2010 9:48														
15-14	S-F	Aug-19-2010 10:04		-198	*	*		*	*	*	4.4	-393	*	*	*	-0.7
15-14	S-F	Sept-16-2010 09:28														
15-14	S-F	Oct-14-2010 09:59		-241	*	*		*	*	*	-19.7	-335	*	*	*	*
15-14	S-F	Nov-9-2010 13:16														
15-14	S-F	Dec-9-2010 14:17														
Mean 15-14				**-219.5**							**-7.65**	**-364**				
SL SOURCE OR SINK				SINK							SINK	SINK				

SHERBROOKE SITE 15 (DOWNSTREAM)				SECOND TRANSITION SERIES ELEMENTS						ASSORTED OTHER ELEMENTS							
Site Number	Site Name	Date Time		Molybdenum	Silver	Cadmium	Tin	Antimony		Arsenic	Barium	Bismuth	Lead	Selenium	Strontium	Thallium	Uranium
Units				µg/L	µg/L	µg/L	µg/L	µg/L		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
15	Sherbrooke	Jan-7-2010 08:46															
15	Sherbrooke	Feb-4-2010 08:25															
15	Sherbrooke	Mar-4-2010 7:45															
15	Sherbrooke	Apr-1-2010 13:31															
15	Sherbrooke	Apr-29-2010 14:24															
15	Sherbrooke	May-27-2010 13:46															
15	Sherbrooke	Jun-24-2010 13:30															
15	Sherbrooke	July-22-2010 10:10															
15	Sherbrooke	Aug-19-2010 10:37		<2	<0.1	<0.017	<2	<1		<1	3.5	<2	<0.5	<1	5.3	<0.1	0.11
15	Sherbrooke	Sept-16-2010 09:02															
15	Sherbrooke	Oct-14-2010 09:23		<2	<0.1	<0.017	<2	<1		<1	6	<2	<0.5	<1	5.7	<0.1	0.10
15	Sherbrooke	Nov-9-2010 14:18															
15	Sherbrooke	Dec-9-2010 14:41															
CCME Drinking (2011)		http://ceqg-rcqe.ccme.ca/		*	*	5	*	6		10	1000	*	10	10	*	*	20
CCME Recreation (1992)		http://ceqg-rcqe.ccme.ca/															
CCME Aquatic Life (2010)		http://ceqg-rcqe.ccme.ca/		73	0.1					5				1		0.8	15

FRANEY CORNER SITE 14 (UPSTREAM)				SECOND TRANSITION SERIES ELEMENTS						ASSORTED OTHER ELEMENTS							
Site Number	Site Name	Date Time		Molybdenum	Silver	Cadmium	Tin	Antimony		Arsenic	Barium	Bismuth	Lead	Selenium	Strontium	Thallium	Uranium
Units				µg/L	µg/L	µg/L	µg/L	µg/L		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
14	Franey Corner	Jan-7-2010 09:16															
14	Franey Corner	Feb-4-2010 09:07															
14	Franey Corner	Mar-4-2010 8:16															
14	Franey Corner	Apr-1-2010 12:55															
14	Franey Corner	Apr-29-2010 13:59															
14	Franey Corner	May-27-2010 13:09															
14	Franey Corner	Jun-24-201013:05															
14	Franey Corner	July-22-2010 9:48															
14	Franey Corner	Aug-19-2010 10:04		<2	<0.1	<0.017	<2	<1		1	4.3	<2	0.52	<1	6.8	<0.1	0.19
14	Franey Corner	Sept-16-2010 09:28															
14	Franey Corner	Oct-14-2010 09:59		<2	<0.1	0.018	<2	<1		<1	5.5	<2	<0.50	<1	8.3	<0.1	0.15
14	Franey Corner	Nov-9-2010 13:16															
14	Franey Corner	Dec-9-2010 14:17															
CCME Drinking (2011)				*	*	5	*	6		10	1000	*	10	10	*	*	20
CCME Recreation (1992)																	
CCME Aquatic Life (2010)				73	0.1					5				1		0.8	15

RESIDUALS (DOWNSTREAM SITE 15 - UPSTREAM SITE 14)				SECOND TRANSITION SERIES ELEMENTS						ASSORTED OTHER ELEMENTS							
Site Number	Site Name	Date Time		Molybdenum	Silver	Cadmium	Tin	Antimony		Arsenic	Barium	Bismuth	Lead	Selenium	Strontium	Thallium	Uranium
Units				µg/L	µg/L	µg/L	µg/L	µg/L		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
15-14	S-F	Jan-7-2010 09:16															
15-14	S-F	Feb-4-2010 09:07															
15-14	S-F	Mar-4-2010 8:16															
15-14	S-F	Apr-1-2010 12:55															
15-14	S-F	Apr-29-2010 13:59															
15-14	S-F	May-27-2010 13:09															
15-14	S-F	Jun-24-201013:05															
15-14	S-F	July-22-2010 9:48															
15-14	S-F	Aug-19-2010 10:04		*	*	*	*	*		*	-0.8	*	*	*	-1.5	*	-0.08
15-14	S-F	Sept-16-2010 09:28															
15-14	S-F	Oct-14-2010 09:59		*	*	*	*	*		*	0.5	*	*	*	-2.6	*	-0.05
15-14	S-F	Nov-9-2010 13:16															
15-14	S-F	Dec-9-2010 14:17															
Mean 15-14											**-0.15**				**-2.05**		**-0.065**
SL SOURCE OR SINK											SINK				SINK		SINK