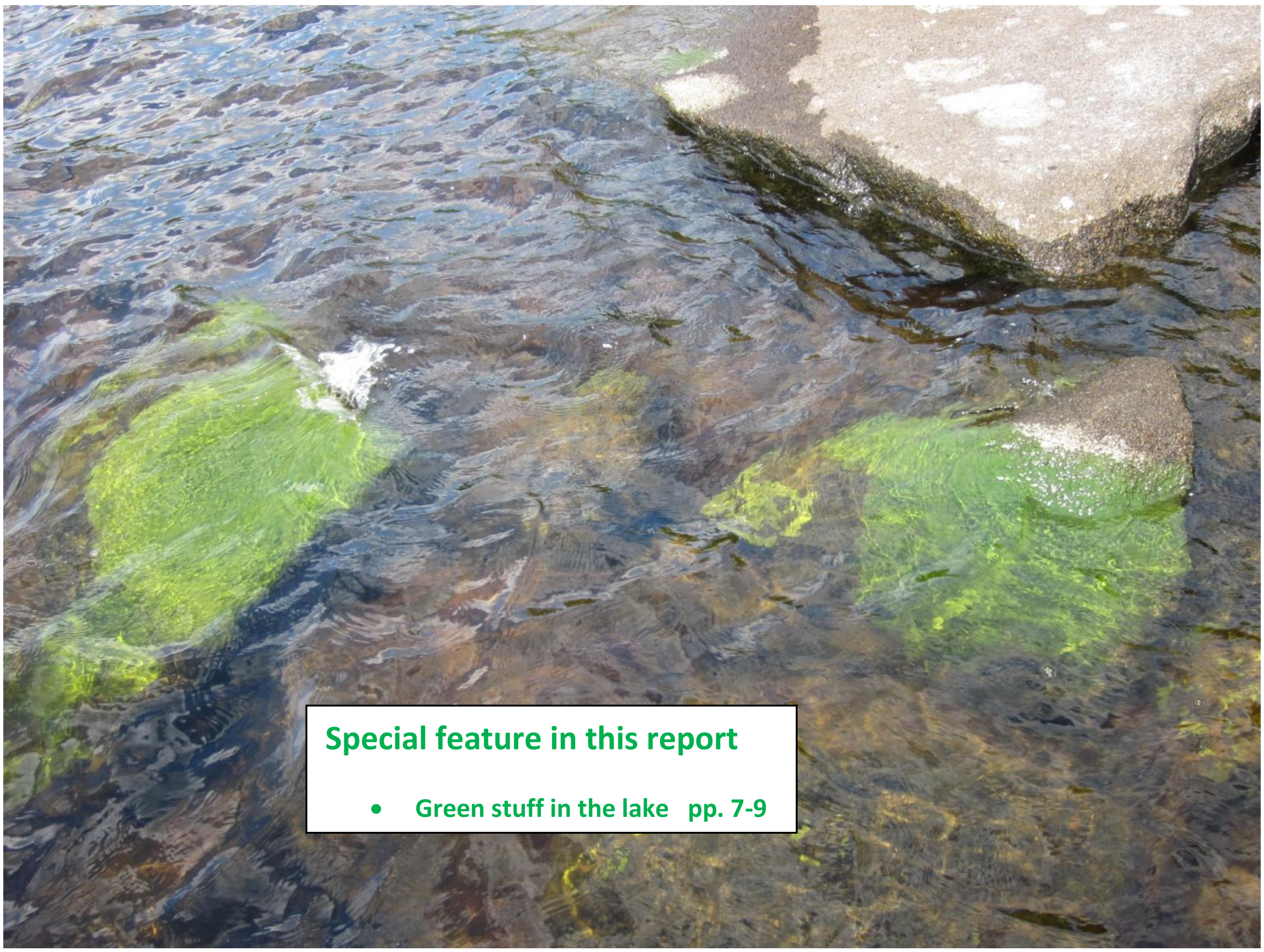
Sherbrooke Lake

Water Quality Report

2012



Barrie Clarke 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 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. We know from work last year that the volume of Sherbrooke Lake is approximately 141 million cubic metres, and that the *mean* residence time of water in the lake is approximately 5 months, meaning that *on average*, it flushes itself about twice a year.

This document is the third of a series of annual reports on the quality of water in the vicinity of Sherbrooke Lake. Previous years' reports are available at:
http://www.coastalaction.org/index_home.php?project=lrwp&page=fieldreports
however, the format of this report is different from the first two. For all of the details of sampling and analyzing, please refer to the reports for 2010 and 2011. Suffice to say here that Site 14 (Franey Corner) tests a principal source of water entering Sherbrooke Lake, Site 17 (Forties River) tests a lesser input to the lake, and Site 15 (Sherbrooke) tests the only outlet from the lake, as shown below.

Locations of the three sampling sites relevant to Sherbrooke Lake.

Goals

Of continuing 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, 15, and 17? To this end, all water analyses appear in Appendices 1 and 2 at the end of this report.

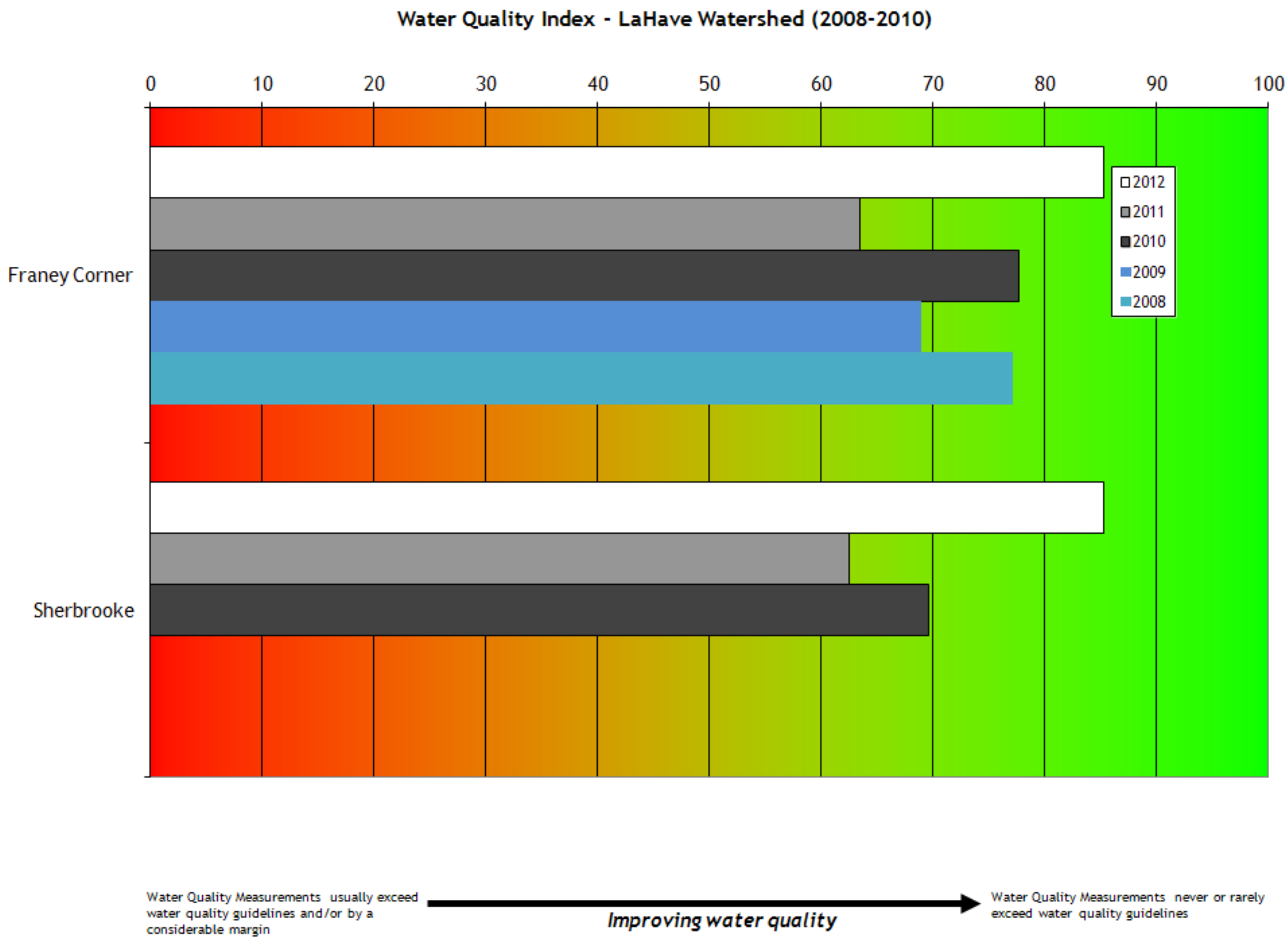
2. How does the water in Sherbrooke Lake compare with the Canadian Council of Ministers of the Environment (CCME) water quality standards? Where standards are set by CCME, these values also appear with the water analyses in Appendix 1. What is important are the so-called "exceedances", namely those measured parameters in the lake that exceed CCME guidelines. The CCME guidelines that interest us most are those for drinking and recreational water, but for the overall health of the lake, we also have to be concerned about the guidelines for aquatic life (e.g., fish, shellfish, loons, amphibians, mammals, etc.). The Summary of Findings for 2012 below draws attention to such exceedances.

3. How does the quality of the water change from Site 14 to Site 15? The data in Appendix 1 are arranged in such a way to facilitate a comparison of Site 14 Inlet and Site 15 Outlet. The lower tier of numbers represents the simple function, Outlet minus Inlet. For example, if the Outlet measurement is 10 and the Inlet measurement is 20, then Out minus In = -10 and the lake is a SINK, meaning that some of that component is left behind in the lake. On the other hand, if the Outlet is 20 and the Inlet is 10, then Out minus In = +10 and the lake is a SOURCE, meaning that some of that component has been added to the water as it passes through the lake.

OUTLET	**10**	**20**
INLET	**20**	**10**
OUT-IN	**-10**	**10**
	SINK	**SOURCE**

The Summary of Findings for 2012 below comments on the significance of the SINK-SOURCE relationships.

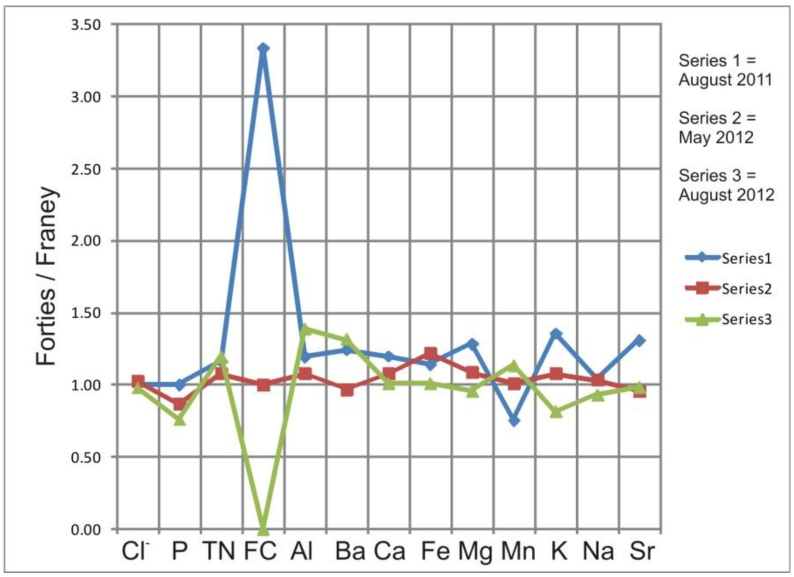
4. How does the quality of water change over the years (trends over time)? CCME has developed a tool that combines several measured parameters (temperature, pH, dissolved oxygen, total nitrate, phosphorus, iron, and total suspended sediment) into a single score called the Water Quality Index (WQI) in which the higher the score, the better the water quality. Details are documented at CCME.ca. We are now in a position to be able to calculate the WQI for the third year. The results look very good; however, with only three years' worth of data, it is not possible yet to define any long-term trends.



A bar graph showing WQIs for Franey Corner (Site 14) for five calendar years (2008-2012), and Sherbrooke (Site 15) for three years (2010-2012). The WQIs depend on which measured parameters exceed the CCME guidelines, how frequently they exceed the guidelines, and by how much they exceed the guidelines. The improved WQIs at both stations are attributable to fewer exceedances of the guidelines in 2012 than in previous years.

Investigation of the Forties River

Although most lakes, including Sherbrooke Lake, have only one output, they have many inputs (rivers, streams, direct precipitation in the form of rain or snow, and groundwater). Sampling Site 14 (Franey Corner) is only one of these inputs, albeit a very important one because of its volume and relative freedom from human influences. In 2011, we decided to do a spot check at Site 17 (Forties River) where there is upstream human activity, and in 2012 we have sampled the Forties River twice, on the same days as the rest of the sampling in the LaHave watershed was also being done. The precise location of Site 17 is just upstream from the bridge on North Fork Road (44^{o} 41.436' North Latitude, 64^{o} 35.760' West Longitude). The analytical data are in Appendix 2, and the summary figure below enables an easy comparison of the Franey Corner and Forties River inputs with each other.



Comparison of the Forties and Franey sampling sites. If the two sites are the same, all values on the vertical axis will be 1.00.

The way to read the figure is as follows: if concentrations in the Forties River are the same as in the relatively pristine Franey sampling site, all the quotients (i.e., Forties divided by Franey) will be 1.0. If Forties is better than Franey, quotients will be less than 1.0, and if Forties is worse than Franey, quotients will be great than 1.0. For most parameters, the quotients are close to 1.0. Only the fecal coliforms (FC) vary widely. In August 2011, Forties had nearly 3.5 times higher levels than Franey, in May 2012, Forties and Franey were the same (1.0), and in August 2012 when the Forties River was nearly dry, Forties had 0.0 times the level at Franey! The bottom line from this short investigation is: (i) the nutrient (N-P-K) levels in the Forties River do not seem to be much different from Franey; (ii) the fecal coliforms vary erratically; and (iii) given the high cost of sampling the Forties River, and absence of any further authorization, this work has been discontinued for 2013.

Green Stuff in the Lake

In 2012, several residents commented on seeing a lot of "green stuff" in the lake, in fact more than at any time in the last 20-25 years. Many comments come to mind:

1. Such reports of increased growth of green stuff in the lake, as valuable as they are, are unfortunately anecdotal and impossible to quantify and verify (unlike the analytical data we are collecting in these reports). At least so far, the only indicators we have are irregular observations by residents.

2. Just like green plants on the land, green plants (algae) in the water are a normal part of a healthy ecosystem. There are thousands of species of freshwater algae. The particular one that prompted this section in this report was collected by Hugh Harper. It appears to primarily be a form of Fontinalis, with some secondary filamentous algae attached to it (photos below). Other species certainly also occur in the lake (more photos below).

The freshwater "seaweed" is probably Fontinalis sp., on which is attached some filamentous algae.

Does anyone not remember the unpleasant stench from rotting algae along the shoreline in August?

Algae and more algae in the lake.

3. Algae become a problem only if there are too many of them. Excess growth of algae is like the proverbial canary in the coal mine – a warning sign of problems in the aqueous system. When sudden growth of algae occurs in response to newly favourable conditions, it is called an algal bloom, and the most important conditions are increased nutrients (nitrogen, phosphorus, potassium – N-P-K) and temperature. Sources of phosphorus include lawn, garden, and agricultural fertilizers as well as some household cleaning compounds, whereas nitrogen also comes from most fertilizers as well as urine.

4. In terms of nutrients, at least, it is difficult to reconcile the apparent increased growth of algae with the rather good, CCME-acceptable, concentrations of N-P-K in water samples from Sites 14 and 15. If algae are on the increase, and if higher nutrient levels are the cause, then water along the shore, proximal to human sources, may not yet be well mixed chemically. (The water is certainly not well mixed thermally, as we all know when we go swimming and encounter warm and cold patches, so perhaps it is not well mixed chemically either close to the source of nutrients – our cottages.)

5. The algae you see stuck on the rocks are, as noted above, plants, and they photosynthesize, producing oxygen during the day, and consuming it again at night when they respire. Most of these algae don't live very long, and when they die, they become decomposing organic matter in the water.

6. The "algae" you don't so easily see are the so-called blue-green algae, which are not really algae at all, but rather cyanobacteria. They normally occur as single cells suspended in the water. Concentrations of cyanobacteria may range from thousands to millions of cells per millilitre. These bright green cyanobacteria feed on dead organic material and, in so doing, consume dissolved oxygen in the water, thus making the water less habitable for fish, ultimately leading to fish kills. To make matters worse, some species of these bacteria produce biotoxins and neurotoxins, further endangering other wildlife and even humans. These kinds of problems already exist in some lakes in SW Nova Scotia, especially those downstream from mink farms (see reading list below).

7. HydroQual Laboratories in Calgary does a test for Microcystin-LR associated with cyanobacteria, and at some point we may want to check Sherbrooke Lake for such toxin concentrations, but the cost *per sample* is about $105!

8. Because of the horrendous “blue-green algae”/cyanobacteria problem in Lake Winnipeg, the Global Nature Fund, based in Germany, has awarded it the dubious distinction of being the most threatened lake in the world for the year 2013. Agriculture and sewage are the sources of excess nutrients. http://www.cbc.ca/news/canada/manitoba/story/2013/02/02/mb-lake-winnipeg-most-threatened-in-world.html

9. To learn more about these subjects, Google terms such as: algae, algal blooms, blue-green algae, cyanobacteria, biotoxin, neurotoxin, microcystin.

10. Also, check out these articles and opinion pieces from other Nova Scotians

http://thechronicleherald.ca/thenovascotian/193922-mending-nova-scotia-s-broken-rivers

http://thechronicleherald.ca/opinion/467370-mink-farm-regs-the-scoop-on-poop

http://thechronicleherald.ca/opinion/127705-water-worries-worsening

11. Or, if you want something more scientific, here are two useful articles about cyanobacteria in Canadian lakes:

Orihel, D. M. et al. (2012) High microcystin concentrations occur only at low nitrogen-to-phosphorus ratios in nutrient-rich Canadian lakes. Canadian Journal of Fisheries and Aquatic Sciences 69, 1457-1462. http://www.nrcresearchpress.com/doi/pdf/10.1139/f2012-088

Kotak, B. G. and Zurawell, R. W. (2007). Cyanobacterial toxins in Canadian freshwaters: A review. Lake and Reservoir Management 23, 109-122. http://dx.doi.org/10.1080/07438140709353915

12. Finally, “Last Call at the Oasis” is an interesting full-length documentary about the bad things people do to water. It is available until February 27, 2013 at:
http://www.cbc.ca/passionateeye/episode/last-call-at-the-oasis.html
but presumably can be found elsewhere in cyberspace after that date.

“Green Stuff” bottom line: If there really is increased growth of algae in the lake, then this condition can lead to increased levels of cyanobacteria feeding off the dead algae, depleting oxygen in the water, and potentially releasing toxins. We need a trained biologist to volunteer to monitor and research all aspects of “green stuff” in the lake and to agree to contribute annually to these water quality reports.

Summary of Principal Findings for 2012

The main findings for 2012 are:

1. WATER QUALITY INDEX. Not only are the WQIs at Franey Corner and Sherbrooke *higher* than in the previous years, but also this year the WQI of water leaving the lake (WQI=85.3) was virtually identical to the water entering the lake (WQI=85.2). These values show how good the water quality can be, and presumably we'd like to keep it that way.
2. EXCEEDANCES. The WQI is sensitive to which parameters exceed the CCME guidelines, how frequently they exceed the guidelines, and by how much they exceed the guidelines. Generally speaking, this year, exceedances were fewer than in years past, and in most cases the amounts of the exceedances were not very large; hence, the WQIs were better this year than any other year so far. Specifically, the best news is that, for the first time since water quality monitoring started, there was not a single exceedance of coliform bacteria or F. Enterococcus in 2012 at Sites 14, 15, or 17. However, we did have other exceedances of the CCME guidelines, including, at times: temperature (too warm), pH (too acidic), and iron (too high).
3. SINK-SOURCE RELATIONSHIPS. Any component that the analytical data indicate is a SINK is left behind as water passes through the lake. Those components are: oxygen, nitrogen, phosphorus, F. Enterococcus, aluminum, magnesium, sodium, calcium, and iron. Any component that the analytical data indicate is a SOURCE is somehow added to the water as it passes through the lake. Those components are: temperature, potassium, manganese, and barium. It is not clear what subtracts or adds these components in the lake, but the more data we have, the more reliable these SINK-SOURCE relationships will become.
4. FORTIES RIVER. Except for containing widely varying levels of fecal coliforms, the water in the Forties River is rather similar to the water at Franey Corner, even including the N-P-K nutrients. To be more confident of this statement, the Forties River would have to be monitored as frequently as Franey Corner for a long period of time.
5. ALGAE. Normal levels (whatever that is!) of algal growth is OK. Excess growth of algae, followed by rapid die-off, and consumption by cynobacteria is not OK, because of depleted oxygen levels in the water and release of toxins. We should somehow monitor the algae in the lake.
6. LONG-TERM IMPLICATIONS. These three water quality reports for 2010-2012 represent the beginning of establishing an important 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. Sampling for 2013 is already under way.

Cost and Importance of Ongoing Monitoring

The total cost for this sampling year (2012) at the Sherbrooke and Forties sites was $2942, covered as follows:
Headwaters Park $500 (approximately $20 per property)
Sherbrooke Forest $1792 (approximately $60 per property)
Wil-Dor Park $650 (approximately $10 per property)
(Generous individual contributions of $50 each from two residents in Russells Cove, originally intended for 2012, will instead be put toward the cost of monitoring in 2013.)
As in the past, we make these reports available to everyone on the lake, and encourage every association to contribute to the costs for 2013 and beyond. If everyone were to contribute to this program of annual water quality monitoring, the cost would be about $10 per year per property. It's a very small investment to ensure that our lake remains as good as it is. Let's not ever attract the attention of the Global Nature Fund as it searches for future threatened lakes.

Future Work

The *first challenge* is to keep the water quality monitoring program going. We now have three years of data, but Environment Canada recommends that we have at least five years of data before looking for any significant long-term trends. The longer the period of sampling, the more confidently we can detect any such trends, but we can't reach this goal unless we have long-term financial commitment.

The *second challenge* is to focus more on the "green stuff" in the lake. If anyone reading this report is a trained biologist and would like to design and run a monitoring program and contribute on this subject in future reports, please make yourself known.

The *third question* concerns learning more about water in the lake itself (as opposed to water that enters the lake at Site 14 and leaves the lake at Site 15, as we do now). How different are the deep waters from the surface waters? We have a generous offer from a water quality professional to help us do some profiling of temperature, pH, dissolved oxygen, and conductivity every metre down into the two deepest parts of the lake this summer, at no additional financial cost, to learn how the properties change with depth in the lake. What we need is a stable platform (my kayak definitely won't do!) that has the ability to stay on station for about an hour at each site. It would require one calm morning in mid-July, mid-August, and mid-September to do the measurements.

A *fourth question* concerns the levels of other undesirable components in the water, such as PCBs, PAHs, dioxins, and microcystins, to name a few. Such work cannot even begin without a broader and firmer financial base, and to this end, the development of a pan-Sherbrooke Lake committee to oversee such work is proceeding very slowly. Barrie Clarke and Murray Coolican have been nominated by the Sherbrooke Forest Homeowners' Association to serve. We eagerly await nominees from other contributing associations.

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. Many thanks to Andrew Breen, Jennifer Campbell, and all others who worked faithfully to sample the river scores of times over the last five years. Jennifer McKinnon was instrumental in identifying the algae collected by Hugh Harper. Many thanks also to Denis Parent for his calculation of the Water Quality Index. Jennifer McKinnon, Brooke Nodding, and Denis Parent carefully reviewed a draft of this report. Any remaining errors of omission or commission are attributable to the author.

Appendix 1 – Analytical Data for Franey and Sherbrooke in 2012

Explanatory Notes

1. The upper part of the tables gives the values for downstream Site 15 (Sherbrooke), the middle part gives the measurements for upstream Site 14 (Franey Corner), 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 then: 5 - 25 = -20 mg/L. The *negative* number signifies that the concentration of the element has *decreased* as the water passed through the lake, suggesting that the lake is SINK for that element. Conversely, *positive* residual values signify that the concentrations are *increasing* in the lake, suggesting somehow that the lake is a SOURCE for that element. Note that residuals close to zero probably mean that there is no analytically detectable difference between inflow and outflow.
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	TSS	Salinity	Chloride
			°C	mmHg	$[H^+]^{-14}$	mS/cm	mg/L	mg/L	permil (‰)	mg/L
15	Sherbrooke	Jan-16-2012 08:52	0.61	759.0	5.22	0.024	0.016	<1	0.01	3.4
15	Sherbrooke	Feb-9-2012 13:26	0.95	*	5.67	0.0226	*	1.4	*	4.3
15	Sherbrooke	Mar-8-2012 12:34	2.81	*	5.57	0.027	*	2	*	4.6
15	Sherbrooke	Apr-04-2012 13:02	5.05	734.1	5.71	0.024	0.016	1.4	0.01	4.2
15	Sherbrooke	May-3-2012 14:12	12.55	754.0	5.70	0.024	0.016	1	*	3.8
15	Sherbrooke	May-31-2012 12:15	15.97	746.8	5.91	0.026	0.017	<2	0.01	4.2
15	Sherbrooke	Jun-28-2012 08:31	18.45	743.1	5.66	0.026	0.017	<2	0.01	4.0
15	Sherbrooke	July-26-2012 08:35	21.92	743.9	5.84	0.026	0.017	<1	0.01	3.9
15	Sherbrooke	Aug-23-2012 08:32	23.73	755.3	6.27	0.026	0.017	<1.0	0.01	4.1
15	Sherbrooke	Sep-19-2012 8:30	18.16	752.2	6.67	0.027	0.017	1.2	0.01	15.0
15	Sherbrooke	Oct-18-2012 1:35	12.82	754.7	5.53	0.027	0.018	<1.0	0.01	4.1
15	Sherbrooke	Nov-14-2012 11:35	9.10	760.2	5.39	0.028	0.018	<1.0	0.01	*
15	Sherbrooke	Dec-13-2012 11:51	2.87	759.0	5.19	0.028	0.018	<1.0	0.01	4.5
CCME Drinking (2011)		http://ceqg-rcqe.ccme.ca/	<15.00				500			250
CCME Recreation (1992)		http://ceqg-rcqe.ccme.ca/	αt							
CCME Aquatic Life (2010)		http://ceqg-rcqe.ccme.ca/								120
FRANEY CORNER SITE 14 (UPSTREAM)			GENERAL PROPERTIES			TOTAL DISSOLVED/SUSPENDED SOLIDS			SALINITY	
Site Number	Site Name	Date Time	Temp	BP	pH	SpCond	TDS	TSS	Salinity	Chloride
Units			°C	mmHg	$[H^+]^{-14}$	mS/cm	mg/L	mg/L	permil (‰)	mg/L
14	Franey Corner	Jan-16-2012 09:18	0.45	755.9	5.26	0.014	0.009	<1	0.01	3.5
14	Franey Corner	Feb-9-2012 13:05	0.01	*	5.81	0.023	*	<2	*	4.5
14	Franey Corner	Mar-8-2012 12:00	1.40	*	5.54	0.024	*	<1	*	4.6
14	Franey Corner	Apr-04-2012 12.43	6.34	731.0	5.91	0.023	0.015	1.4	0.01	3.7
14	Franey Corner	May-3-2012 12:50	10.78	750.9	5.71	0.024	0.015	1.4	*	4.0
14	Franey Corner	May-31-2012 11:48	16.23	743.4	6.18	0.016	0.011	2.7	0.01	4.7
14	Franey Corner	Jun-28-2012 08:53	17.87	740.1	5.61	0.029	0.019	1.6	0.01	5.0
14	Franey Corner	July-26-2012 08:53	18.98	741.1	6.05	0.030	0.020	2.2	0.01	4.3
14	Franey Corner	Aug-23-2012 9:00	19.78	752.1	6.26	0.032	0.021	<1.0	0.01	4.9
14	Franey Corner	Sep-19-2012 9:00	16.96	748.8	5.55	0.031	0.020	<1.0	0.01	4.6
14	Franey Corner	Oct-18-2012 1:05	10.86	751.4	5.05	0.029	0.019	<1.0	0.01	4.9
14	Franey Corner	Nov-14-2012 11:00	7.94	757.2	5.06	0.028	0.018	<1.0	0.01	*
14	Franey Corner	Dec-13-2012 11:30	2.13	755.6	4.73	0.029	0.019	<1.0	0.01	5.0
CCME Drinking (2011)			<15.00				500			250
CCME Recreation (1992)			αt							
CCME Aquatic Life (2010)										120
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 Lab	TSS	Salinity	Chloride
Units			°C	mmHg	$[H^+]^{-14}$	mS/cm	mg/L	mg/L	permil (‰)	mg/L
15-14	S-F	Jan-16-2012	0.16	*	-0.04	0.010	0.007	*	0.000	-0.1
15-14	S-F	Feb-9-2012	0.94	*	-0.14	-0.001	*	*	*	-0.2
15-14	S-F	Mar-8-2012	1.41	*	0.03	0.003	*	*	*	0.0
15-14	S-F	Apr-04-2012	-1.29	*	-0.20	0.001	0.001	0.000	0.000	0.5
15-14	S-F	May-3-2012	1.77	*	-0.01	0.000	0.001	-0.400	*	-0.2
15-14	S-F	May-31-2012	-0.26	*	-0.27	0.010	0.006	*	0.000	-0.5
15-14	S-F	Jun-28-2012	0.58	*	0.05	-0.003	-0.002	*	0.000	-1.0
15-14	S-F	July-26-2012	2.94	*	-0.21	-0.004	-0.003	*	0.000	-0.4
15-14	S-F	Aug-23-2012	3.95	*	0.01	-0.006	-0.004	*	0.000	-0.8
15-14	S-F	Sep-19-2012	1.20	*	1.12	-0.004	-0.003	*	0.000	10.4
15-14	S-F	Oct-18-2012	1.96	*	0.48	-0.002	-0.001	*	0.000	-0.8
15-14	S-F	Nov-14-2012	1.16	*	0.33	0.000	0.000	*	0.000	*
15-14	S-F	Dec-13-2012	0.74	*	0.46	-0.001	-0.001	*	0.000	-0.5
Mean 15-14			**1.17**	*	**0.12**	**0.000**	**0.000**	*	**0.000**	**-0.1**
SHERBROOKE LAKE SOURCE OR SINK			SOURCE	*	SOURCE**	NEITHER	NEITHER	*	NEITHER	~NEITHER
					**water becomes less acidic in the lake					

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%	Nitrate+Nitrite	Nitrogen	Phosphorus	Fecal Coliform	F. Enterococcus
Units			mg/L	%sat	mg/L	mg/L	mg/L	MPN/mL	CFU/100ml
15	Sherbrooke	Jan-16-2012 08:52	*	*	<0.05	0.26	0.011	<1	
15	Sherbrooke	Feb-9-2012 13:26	13.52	95.20	<0.05	0.26	0.014	<1	
15	Sherbrooke	Mar-8-2012 12:34	13.53	100.20	<0.05	0.28	0.014	<1	
15	Sherbrooke	Apr-04-2012 13:02	12.39	97.00	<0.05	0.25	0.009	<1	
15	Sherbrooke	May-3-2012 14:12	10.71	100.50	0.063	0.23	0.012	<1	
15	Sherbrooke	May-31-2012 12:15	9.17	92.80	<0.05	0.22	0.005	<1	
15	Sherbrooke	Jun-28-2012 08:31	7.88	84.00	<0.05	0.33	0.013		87
15	Sherbrooke	July-26-2012 08:35	8.51	97.30	<0.05	0.21	0.006		15
15	Sherbrooke	Aug-23-2012 08:32	7.36	85.40	<0.05	0.22	0.010		20
15	Sherbrooke	Sep-19-2012 8:30	8.56	97.30	<0.05	0.23	0.007		10
15	Sherbrooke	Oct-18-2012 1:35	9.51	89.90	0.051	0.26	<0.002		<1
15	Sherbrooke	Nov-14-2012 11:35	8.83	76.70	0.053	0.29	0.011		1
15	Sherbrooke	Dec-13-2012 11:51	14.38	106.60	0.061	0.26	0.012		10
CCME Drinking (2011)		http://ceqg-rcqe.ccme.ca/			45			0	0
CCME Recreation (1992)		http://ceqg-rcqe.ccme.ca/					(0.03)	2	200
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%	Nitrate+Nitrite	Nitrogen	Phosphorus	Fecal Coliform	F. Enterococcus
Units			mg/L	%sat	mg/L	mg/L	mg/L	MPN/mL	CFU/100ml
14	Franey Corner	Jan-16-2012 09:18	*	*	<0.05	0.23	0.013	<1	
14	Franey Corner	Feb-9-2012 13:05	14.31	97.50	<0.05	0.22	0.014	<1	
14	Franey Corner	Mar-8-2012 12:00	14.37	102.30	<0.05	0.20	0.008	<1	
14	Franey Corner	Apr-04-2012 12.43	12.16	98.40	<0.05	0.24	0.01	<1	
14	Franey Corner	May-3-2012 12:50	11.38	102.60	<0.05	0.26	0.015	<1	
14	Franey Corner	May-31-2012 11:48	9.74	99.20	<0.05	0.32	0.017	<1	
14	Franey Corner	Jun-28-2012 08:53	8.62	90.70	<0.05	0.45	0.028		110
14	Franey Corner	July-26-2012 08:53	8.47	91.50	0.058	0.46	0.027		88
14	Franey Corner	Aug-23-2012 9:00	7.89	86.30	<0.05	0.41	0.029		40
14	Franey Corner	Sep-19-2012 9:00	9.13	94.40	<0.05	0.52	0.022		20
14	Franey Corner	Oct-18-2012 1:05	10.20	92.20	<0.05	0.38	<0.002		3
14	Franey Corner	Nov-14-2012 11:00	9.27	78.20	<0.05	0.32	0.011		2
14	Franey Corner	Dec-13-2012 11:30	14.68	108.10	0.18	0.29	0.011		<10
CCME Drinking (2011)					45			0	0
CCME Recreation (1992)							(0.03)	2	200
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%	Nitrate+Nitrite	Nitrogen	Phosphorus	Fecal Coliform	F. Enterococcus
Units			mg/L	%sat	mg/L	mg/L	mg/L	MPN/mL	CFU/100ml
15-14	S-F	Jan-16-2012	*	*	*	0.03	-0.002	*	
15-14	S-F	Feb-9-2012	-0.79	-2.30	*	0.04	0.000	*	
15-14	S-F	Mar-8-2012	-0.84	-2.10	*	0.08	0.006	*	
15-14	S-F	Apr-04-2012	0.23	-1.40	*	0.01	-0.001	*	
15-14	S-F	May-3-2012	-0.67	-2.10	*	-0.03	-0.003	*	
15-14	S-F	May-31-2012	-0.57	-6.40	*	-0.10	-0.012	*	
15-14	S-F	Jun-28-2012	-0.74	-6.70	*	-0.12	-0.015		-23
15-14	S-F	July-26-2012	0.04	5.80	*	-0.25	-0.021		-73
15-14	S-F	Aug-23-2012	-0.53	-0.90	*	-0.19	-0.019		-20
15-14	S-F	Sep-19-2012	-0.57	2.90	*	-0.29	-0.015		-10
15-14	S-F	Oct-18-2012	-0.69	-2.30	*	-0.12	*		*
15-14	S-F	Nov-14-2012	-0.44	-1.50	*	-0.03	0.000		-1
15-14	S-F	Dec-13-2012	-0.30	-1.50	-0.12	-0.03	0.001		*
Mean 15-14			**-0.49**	**-1.54**	*	**-0.077**	**-0.007**	*	**-25**
SHERBROOKE LAKE SOURCE OR SINK			SINK	SINK	*	SINK	SINK	*	SINK

Note change in species and units for bacterial measurement half way through the year.

SHERBROOKE SITE 15 (DOWNSTREAM)				LIGHT ELEMENTS					ALKALI/ALKALI EARTH ELEMENTS		
Site Number	Site Name	Date Time		Aluminum	Beryllium	Boron	Magnesium		Sodium	Potassium	Calcium
Units				µg/L	µg/L	µg/L	µg/L		µg/L	µg/L	µg/L
15	Sherbrooke	Jan-16-2012 08:52									
15	Sherbrooke	Feb-9-2012 13:26									
15	Sherbrooke	Mar-8-2012 12:34									
15	Sherbrooke	Apr-04-2012 13:02									
15	Sherbrooke	May-3-2012 14:12		224	<1	<50	459		3210	355	1210
15	Sherbrooke	May-31-2012 12:15									
15	Sherbrooke	Jun-28-2012 08:31									
15	Sherbrooke	July-26-2012 08:35									
15	Sherbrooke	Aug-23-2012 08:32		129	<1	<50	491		3450	371	1300
15	Sherbrooke	Sep-19-2012 8:30									
15	Sherbrooke	Oct-18-2012 1:35									
15	Sherbrooke	Nov-14-2012 11:35									
15	Sherbrooke	Dec-13-2012 11:51									
CCME Drinking (2011)		http://ceqg-rcqe.ccme.ca/		100	*	5000			<200000	*	*
CCME Recreation (1992)		http://ceqg-rcqe.ccme.ca/							*	*	*
CCME Aquatic Life (2010)		http://ceqg-rcqe.ccme.ca/				1.5			*	*	*
FRANEY CORNER SITE 14 (UPSTREAM)				LIGHT ELEMENTS					ALKALI/ALKALI EARTH ELEMENTS		
Site Number	Site Name	Date Time		Aluminum	Beryllium	Boron	Magnesium		Sodium	Potassium	Calcium
Units				µg/L	µg/L	µg/L	µg/L		µg/L	µg/L	µg/L
14	Franey Corner	Jan-16-2012 09:18									
14	Franey Corner	Feb-9-2012 13:05									
14	Franey Corner	Mar-8-2012 12:00									
14	Franey Corner	Apr-04-2012 12.43									
14	Franey Corner	May-3-2012 12:50		238	<1	<50	370		2830	331	1040
14	Franey Corner	May-31-2012 11:48									
14	Franey Corner	Jun-28-2012 08:53									
14	Franey Corner	July-26-2012 08:53									
14	Franey Corner	Aug-23-2012 9:00		138	<1	<50	596		4100	375	1520
14	Franey Corner	Sep-19-2012 9:00									
14	Franey Corner	Oct-18-2012 1:05									
14	Franey Corner	Nov-14-2012 11:00									
14	Franey Corner	Dec-13-2012 11:30									
CCME Drinking (2011)				100	*	5000			<200000	*	*
CCME Recreation (1992)									*	*	*
CCME Aquatic Life (2010)						1.5			*	*	*
RESIDUALS (DOWNSTREAM SITE 15 - UPSTREAM SITE 14)				LIGHT ELEMENTS					ALKALI/ALKALI EARTH ELEMENTS		
Site Number	Site Name	Date Time		Aluminum	Beryllium	Boron	Magnesium		Sodium	Potassium	Calcium
Units				µg/L	µg/L	µg/L	µg/L		µg/L	µg/L	µg/L
15-14	S-F	Jan-16-2012									
15-14	S-F	Feb-9-2012									
15-14	S-F	Mar-8-2012									
15-14	S-F	Apr-04-2012									
15-14	S-F	May-3-2012		-14	*	*	89		380	24	170
15-14	S-F	May-31-2012									
15-14	S-F	Jun-28-2012									
15-14	S-F	July-26-2012									
15-14	S-F	Aug-23-2012		-9	*	*	-105		-650	-4	-220
15-14	S-F	Sep-19-2012									
15-14	S-F	Oct-18-2012									
15-14	S-F	Nov-14-2012									
15-14	S-F	Dec-13-2012									
Mean 15-14				**-11.5**	*	*	**-8**		**-135**	**10**	**-25**
SHERBROOKE LAKE SOURCE OR SINK				SINK	*	*	SINK		SINK	SOURCE	SINK

SHERBROOKE SITE 15 (DOWNSTREAM)				FIRST TRANSITION SERIES ELEMENTS								
Site Number	Site Name	Date Time		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
15	Sherbrooke	Jan-16-2012 08:52										
15	Sherbrooke	Feb-9-2012 13:26										
15	Sherbrooke	Mar-8-2012 12:34										
15	Sherbrooke	Apr-04-2012 13:02										
15	Sherbrooke	May-3-2012 14:12		<2	<2	<1	20.4	165	<0.4	<2	<2	5.6
15	Sherbrooke	May-31-2012 12:15										
15	Sherbrooke	Jun-28-2012 08:31										
15	Sherbrooke	July-26-2012 08:35										
15	Sherbrooke	Aug-23-2012 08:32		<2	<2	<1	27.6	134	<0.40	<2	<2	<5
15	Sherbrooke	Sep-19-2012 8:30										
15	Sherbrooke	Oct-18-2012 1:35										
15	Sherbrooke	Nov-14-2012 11:35										
15	Sherbrooke	Dec-13-2012 11:51										
CCME Drinking (2011)		http://ceqg-rcqe.ccme.ca/		*	*	50	50	300	*	*	1000	5000
CCME Recreation (1992)		http://ceqg-rcqe.ccme.ca/										
CCME Aquatic Life (2010)		http://ceqg-rcqe.ccme.ca/						300				30

FRANEY CORNER SITE 14 (UPSTREAM)				FIRST TRANSITION SERIES ELEMENTS								
Site Number	Site Name	Date Time		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
14	Franey Corner	Jan-16-2012 09:18										
14	Franey Corner	Feb-9-2012 13:05										
14	Franey Corner	Mar-8-2012 12:00										
14	Franey Corner	Apr-04-2012 12.43										
14	Franey Corner	May-3-2012 12:50		<2	<2	<1	21.9	192	<0.4	<2	<2	7
14	Franey Corner	May-31-2012 11:48										
14	Franey Corner	Jun-28-2012 08:53										
14	Franey Corner	July-26-2012 08:53										
14	Franey Corner	Aug-23-2012 9:00		<2	<2	<1	13.5	306	<0.4	<2	<2	9.4
14	Franey Corner	Sep-19-2012 9:00										
14	Franey Corner	Oct-18-2012 1:05										
14	Franey Corner	Nov-14-2012 11:00										
14	Franey Corner	Dec-13-2012 11:30										
CCME Drinking (2011)				*	*	50	50	300	*	*	1000	5000
CCME Recreation (1992)												
CCME Aquatic Life (2010)								300				30

RESIDUALS (DOWNSTREAM SITE 15 - UPSTREAM SITE 14)				FIRST TRANSITION SERIES ELEMENTS								
Site Number	Site Name	Date Time		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
15-14	S-F	Jan-16-2012										
15-14	S-F	Feb-9-2012										
15-14	S-F	Mar-8-2012										
15-14	S-F	Apr-04-2012										
15-14	S-F	May-3-2012		*	*	*	-1.5	-27	*	*	*	*
15-14	S-F	May-31-2012										
15-14	S-F	Jun-28-2012										
15-14	S-F	July-26-2012										
15-14	S-F	Aug-23-2012		*	*	*	14.1	-172	*	*	*	*
15-14	S-F	Sep-19-2012										
15-14	S-F	Oct-18-2012										
15-14	S-F	Nov-14-2012										
15-14	S-F	Dec-13-2012										
Mean 15-14				*	*	*	**6.3**	**-99.5**	*	*	*	*
SHERBROOKE LAKE SOURCE OR SINK				*	*	*	SOURCE	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-16-2012 08:52															
15	Sherbrooke	Feb-9-2012 13:26															
15	Sherbrooke	Mar-8-2012 12:34															
15	Sherbrooke	Apr-04-2012 13:02															
15	Sherbrooke	May-3-2012 14:12		<2	<0.1	<0.017	<2	<1		<1	3.3	<2	<0.5	<1	4.9	<0.1	0.11
15	Sherbrooke	May-31-2012 12:15															
15	Sherbrooke	Jun-28-2012 08:31															
15	Sherbrooke	July-26-2012 08:35															
15	Sherbrooke	Aug-23-2012 08:32		<2	<0.1	<0.017	<2	<1		<1	2.8	<2	<0.5	<1	6.2	<0.1	<0.1
15	Sherbrooke	Sep-19-2012 8:30															
15	Sherbrooke	Oct-18-2012 1:35															
15	Sherbrooke	Nov-14-2012 11:35															
15	Sherbrooke	Dec-13-2012 11:51															
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-16-2012 09:18															
14	Franey Corner	Feb-9-2012 13:05															
14	Franey Corner	Mar-8-2012 12:00															
14	Franey Corner	Apr-04-2012 12.43															
14	Franey Corner	May-3-2012 12:50		<2	<0.1	<0.017	<2	<1		<1	3.1	<2	<0.5	<1	4.5	<0.1	<0.1
14	Franey Corner	May-31-2012 11:48															
14	Franey Corner	Jun-28-2012 08:53															
14	Franey Corner	July-26-2012 08:53															
14	Franey Corner	Aug-23-2012 9:00		<2	<0.1	0.051	<2	<1		1.1	1.9	<2	<0.5	<1	6.3	<0.1	0.14
14	Franey Corner	Sep-19-2012 9:00															
14	Franey Corner	Oct-18-2012 1:05															
14	Franey Corner	Nov-14-2012 11:00															
14	Franey Corner	Dec-13-2012 11:30															
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-16-2012															
15-14	S-F	Feb-9-2012															
15-14	S-F	Mar-8-2012															
15-14	S-F	Apr-04-2012															
15-14	S-F	May-3-2012		*	*	*	*	*		*	0.2	*	*	*	0.4	*	*
15-14	S-F	May-31-2012															
15-14	S-F	Jun-28-2012															
15-14	S-F	July-26-2012															
15-14	S-F	Aug-23-2012		*	*	*	*	*		*	0.9	*	*	*	-0.1	*	*
15-14	S-F	Sep-19-2012															
15-14	S-F	Oct-18-2012															
15-14	S-F	Nov-14-2012															
15-14	S-F	Dec-13-2012															
Mean 15-14				*	*	*	*	*		*	**0.55**	*	*	*	**0.15**	*	*
SL SOURCE OR SINK				*	*	*	*	*		*	SOURCE	*	*	*	SOURCE	*	*

Appendix 2 – Analytical Data for the Forties River in 2012

		Forties	
	Units	May 3, 2012	August 23, 2012
Field Measurements			
Temperature	°C	9.75	20.61
pH	$[H^+]^{-14}$	5.38	5.83
TDS	mg/L	0.016	0.019
Dissolved Oxygen (DO)	mg/L	11.68	6.53
DO%		102.7	72.7
Sp Cond	mS/cm	0.023	0.030
Lab Measurements			
Chloride	mg/L	4.1	4.8
Nitrate+Nitrite	mg/L	<0.05	<0.05
Phosphorus	mg/L	0.013	0.022
Suspended Solids	mg/L	<2	1
Total Nitrogen	mg/L	0.28	0.49
Fecal Coliforms	**MPN/mL**	<1	
F. Enterococcus	**CFU/100 ml**		<1
Metals			
Al	µg/L	256	192
Sb	µg/L	<1	<1
As	µg/L	<1	<1
Ba	µg/L	3	2.5
Be	µg/L	<1	<1
Bi	µg/L	<2	<2
B	µg/L	<50	<50
Cd	µg/L	0.017	0.026
Ca	µg/L	1120	1540
Cr	µg/L	<1	<1
Co	µg/L	<0.4	<0.4
Cu	µg/L	<2	<2
Fe	µg/L	234	310
Pb	µg/L	<0.5	<0.5
Mg	µg/L	402	571
Mn	µg/L	22.10	15.31
Mo	µg/L	<2	<2
Ni	µg/L	<2	<2
K	µg/L	357	305
Se	µg/L	<1	<1
Ag	µg/L	<0.1	<0.1
Na	µg/L	2920	3820
Sr	µg/L	4.3	6.2
Tl	µg/L	<0.1	<0.1
Sn	µg/L	<2	<2
Ti	µg/L	2.5	2.8
U	µg/L	0.14	0.14
V	µg/L	<2	<2
Zn	µg/L	8.2	7.7