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Memorandum

Date: **October 10, 2012**

To: **Kelly Krist, Director of Community Services, Seguin Township**

From: **Tammy Karst-Riddoch**

Re: **J100033 – 2012 Water Quality Monitoring Summary**

In 2012, Seguin Township completed the fifth year of sampling for its Water Quality Monitoring Program. This program collects total phosphorus (TP) concentration data and other pertinent lake information (e.g., Secchi depth, dissolved oxygen concentration, lake depth, dissolved organic carbon, etc.) in support of the water quality model developed by AECOM (2009) to predict phosphorus concentrations in Township lakes. Continued monitoring will also allow the Township to identify potential problems in lake water quality as they emerge.

The 2012 monitoring was conducted by summer students employed by Seguin Township. HESL staff provided sampling instructions, a half day training session and ongoing technical guidance, and assisted coordination with the laboratory at Dorset Environmental Science Centre (DESC). In May, water samples were collected from 50 lakes for analysis of spring overturn TP concentration and in August, 49 of those lakes were revisited to measure dissolved oxygen and temperature profiles, Secchi depth and lake depth.

The major findings from the 2012 monitoring period are summarized below and recommendations are provided for future sampling.

1. Spring Total Phosphorus Sampling

Duplicate water samples from 50 lakes were analyzed for spring TP concentrations. We evaluated the analytical precision of the data (i.e., how well sample duplicates agreed). Contamination of samples can occur during sample collection or as a result of zooplankton biomass, which can produce elevated TP concentrations and 'bad splits' between field duplicates. Even with careful sampling, bad splits are common and occur for approximately 10% of sample submissions to DESC (pers. comm., Bev Clark). For the 2012 data, we flagged all sample pairs that differed by more than a) 40% from the minimum of the two values, and b) 4 μg/L, and removed the higher of the two values, assuming contamination, which is the approach currently used by the District Municipality of Muskoka. There were 4 bad splits identified in the 2012 samples, representing 8% of the samples (Table 1). This percentage of bad splits represents good sampling practices as it is below the average for samples submitted to DESC. We recommend continued vigilance in following sampling protocol when collecting water samples to minimize the potential for sample contamination. We note that samples flagged as outliers due to contamination should be reassessed by comparison with data from additional years of sampling as the monitoring program progresses.

Table 1. Bad Splits Between Duplicate Samples Collected by the Seguin Township Monitoring Program (ST) and the Lake Partner Program (LPP)

Year	# of Bad Splits (>40% and >4 μg/L difference between sample pairs)	Total # of Samples	% Bad Splits
2008 (ST)	3	25	12
2009 (ST)	7	37	19
2010 (ST)	6	36	17
2011 (ST)	11	47	23
2012 (ST)	4	50	8
LPP (02-10)	16	233	7

Note: The total number of samples exceeds the number of lakes sampled in 2011 because 4 lakes were sampled twice during spring 2011.

Outliers between years of data were identified using the Dixon's Q and Grubbs' outlier tests at a significance level of α = 0.05. In total, 6 values were identified as outliers based on both tests and were removed from the dataset (Table 2). We note that these values should be reassessed as outliers each year as additional data are collected.

Table 2. TP values (2002-2011) in Seguin Township lakes identified as outliers in 2012.

Lake	Year	Outlier TP (μg/L)	Mean 2002-2011 TP (μg/L) (outlier excluded)
Cosh Lake	2008	21.0	7.22
Joselin (Burnt) Lake	2002	10.6	5.12
Little Whitefish Lake	2006	10.1	4.53
McNutt Lake	2008	16.5	8.69
Salmon Lake	2002	13.2	6.02
Sucker Lake	2008	8.36	5.21

Table 3 summarizes the 2012 total phosphorus concentration results and mean concentrations of data collected in previous years by both the Seguin Township monitoring program (2008-2012) and the Lake Partner Program (2002-2011). Combined, these two monitoring programs provide spring overturn total phosphorus data for 74 of the 128 lakes in Seguin Township that have a surface area of at least 10 ha. The LPP data for 2012 have not yet been posted, but these data should be reviewed and included in future revisions to the phosphorus model if applicable.

The MOE recommends a minimum of two years of spring overturn TP data to be 95% confident of being within 20% of the mean annual concentration of a lake. For Seguin Township lakes, 56 lakes now have at least two years of monitoring data, in comparison to 47 lakes in 2011, 39 lakes in 2010, and only 28 lakes in 2009. With continued monitoring by the program, approximately half of the Seguin Township lakes will have at least 3 years of data by 2014 when a review of the 2009 water quality model and development capacity estimates of the lakes were recommended by Aecom (2009). These data will provide more reliable estimates of long term, steady-state total phosphorus concentration of the lakes for calibration and validation of the model, thereby providing more robust and confident assessment of shoreline development capacity.

Table 3. Mean Spring Total Phosphorus (TP) Concentrations in Seguin Township Lakes (n=74)

Lake	# of Years Sampled (02-09)	Mean TP (02-09) (µg/L)	TP 2012 (µg/L)	# of Years Sampled (02-12)	Mean TP (02-12) (µg/L)
Armishaw Lake	1	6.50	4.84	2	5.67
Baby Lake	2	6.38	5.28	5	6.01
Back Lake	1	5.50	6.86	2	6.18
Black Water Lake	4	11.75		6	11.12
Blue Lake	3	4.93	3.15	5	4.48
Brennan Lake	0		11.07	1	11.07
Capton Lake	1	6.95		1	6.95
Clear Lake	6	3.12	3.11	9	3.24
Cosh Lake	0		7.17	3	7.22
Diamond Lake	1	13.84	6.73	4	10.17
Draper Lake	1	7.60	5.08	3	7.58
Dyson Lake	3	5.39		5	4.64
Fair Lake	1	8.25		1	8.25
Faris Lake	1	3.90	4.21	2	4.05
First Lake	1	7.10	7.17	2	7.13
Flaxman Lake	1	4.50	3.90	2	4.20
Forget Lake	1	7.06		3	5.79
Gilbank Lake	3	9.75		5	8.43
Haines Lake	1	4.90	6.46	2	5.68
Horseshoe Lake	8	7.23	5.16	11	7.42
Isabella Lake	8	9.38	10.45	11	9.71
Joselin (Burnt) Lake	7	5.08		8	5.12
Kight Lake	1	11.10	9.12	2	10.11
Kingshott Lake	0		7.48	2	9.39
Lane Lake	1	5.10	4.83	2	4.96
Lieback Lake	1	6.40	4.24	2	5.32
Linger Long (Napken)	1	11.07		3	9.46
Little Lake Joe	0		3.08	2	3.84
Little Seguin/Duck Lake	4	8.60	8.52	7	9.21
Little Whitefish Lake	3	4.63	3.69	6	4.53
Long Lake	2	9.67	3.82	4	7.34
Long Lake 1	1	4.82		1	4.82

Lake	# of Years Sampled (02-09)	Mean TP (02-09) (µg/L)	TP 2012 (µg/L)	# of Years Sampled (02-12)	Mean TP (02-12) (µg/L)
Lower Fry Lake	0		15.13	3	15.38
Manitouwaba Lake	8	6.26		9	6.19
Maple Lake	5	12.56	8.03	8	11.53
Martin Lake	4	7.20		5	7.22
McDonald Lake	1	10.80	7.15	2	8.97
McGowan Lake	7	4.46	5.91	9	5.14
McKechine Lake	1	3.40	3.58	3	3.96
McLean Lake	1	8.40	5.15	3	7.45
McNutt Lake	4	8.97	9.06	6	8.69
Mirror Lake	1	5.00	7.27	2	6.13
Murdock Lake	1	13.45		2	12.68
Mutton Lake	0		9.39	3	10.73
Neville Lake	1	9.80	8.88	2	9.34
Oastler Lake	5	6.36		7	6.43
Otter Lake	8	6.41	3.65	11	6.02
Pender Lake	0		4.48	1	4.48
Portage Lake	1	7.77	4.25	4	6.08
Rankin Lake	8	8.57	7.03	10	8.30
Roberts Lake	3	7.25		4	6.89
Salmon Lake	7	6.05		8	6.03
Scime Lake	0		9.06	1	9.06
Scott Lake	1	7.09		3	5.83
Second Lake	1	13.75	11.24	2	12.50
Star Lake	8	9.46	9.65	11	9.63
Storm Lake	1	5.65		2	6.08
Sucker Lake	0		5.22	3	5.21
Sugar Lake	7	7.39	4.93	10	7.01
Ten Mile Lake	0		9.05	2	11.08
Third Lake	1	12.10	10.60	2	11.35
Three-Legged Lake	6	5.88		7	5.56
Tiffin Lake/Silver	1	6.14	4.95	4	6.55
Trout Lake	1	5.40		3	4.17
Tub Lake	1	7.85	6.04	2	6.95
Tucker Lake	1	9.15		3	7.72
Turtle Lake	5	8.56	7.63	8	8.03
Upper Fry Lake	6	14.03	14.18	9	15.09
Virtue Lake	2	10.38	6.03	4	8.45
Whitefish Lake	1	3.40		3	4.97

Lake	# of Years Sampled (02-09)	Mean TP (02-09) (µg/L)	TP 2012 (µg/L)	# of Years Sampled (02-12)	Mean TP (02-12) (µg/L)
Windfall Lake	1	7.65		2	7.58
Yarrow Lake	0		7.17	1	7.17

Simple linear regression was used to determine whether TP concentrations were changing significantly over time (2002-2012) in any of the lakes. Only lakes with at least 5 years of data were analyzed. None of the lakes displayed a significant trend in TP over time ($p<0.05$).

2. August Field Sampling

Many of the lakes in Seguin Township are shallow, with the potential have internal phosphorus loading due to resuspension of phosphorus in the water column with wind mixing and/or have relatively high concentrations of dissolved organic carbon (tea-stained lakes), which were suspected as contributing to error in the 2009 model predictions. In addition, some lakes may be prone to anoxia (lack of oxygen) in the hypolimnion, which can also result in internal phosphorus loading and error in the model predictions. To identify these potential problems, dissolved oxygen and temperature profiles, lake depth, Secchi depth and water colour (qualitative) were monitored at 49 study lakes in August. These field data are summarized in Table 4.

Of the 49 lakes monitored in August 2012, 24 were shallow and mixed to the bottom (Table 4). These lakes should be evaluated for potential internal phosphorus loading due to wind mixing and resuspension of phosphorus into the water column in future revisions to the model.

Table 4. Summary of August 2012 Field Sampling Results

Lake Name	Depth (m)	Surface Water Temperature (°C)	Dissolved Oxygen (1-m off bottom) (mg/L)	Potentially Anoxic Hypolimnion? [1]	Shallow Mixed Water Column?	Secchi Depth (m)	Water Colour
Armishaw Lake	6	23.1	0.08		yes	5.7	green
Baby Lake	9	22.1	0.12		yes	5.6	yellow/brown
Back Lake	10	20.6	0.05	yes		4.9	green
Blue Lake	16	24.2	0.07			7.15	blue
Brennan Lake	3.5	24.9	7.46		yes	bottom	
Clear Lake	24	22	11.06			7.75	blue
Cosh Lake	7.3	23.1	0.06		yes	4.1	yellow/brown
Diamond Lake	3.9	21.7	8.1		yes	2.7	yellow/brown
Draper Lake	4.3	24.8	7.07		yes	bottom	green
Faris Lake	16	21.8	0.05			5.5	green
First Lake	3.5	22.2	8.08		yes	bottom	green
Flaxman Lake	16	21.3	4.89			4.4	green/clear

Haines Lake	12	22.5	0.03			5.4	green
Horseshoe Lake	19	21.8	0.04			4.2	green
Isabella Lake	15	22.3	0.08			2.7	brown
Kight Lake	3.7	21	6.47		yes	2.7	green
Kingshott Lake	4.3	22.8	8.28		yes	2.7	orange/brown
Lieback Lake	16	24.3	0.09			4.8	
Little Lake Joseph	39	22.2	9.3			6.1	green
Little Seguin (Duck) Lake	17	23.1	0.06			3.85	brown/green
Little Whitefish Lake	13	22.1	0.23			4.7	blue/brown
Long Lake 1	8	21.3	8.6		yes	4.8	green/clear
Lower Fry Lake	10	21.9	0.02	yes		1.9	brown/red
Maple Lake	12	21.8	4.07			3.4	yellow/brown
McDonald Lake	2	23.4	7.78		yes	bottom	brown
McGowan Lake	11	22.6	0.09		yes	6.2	green
McKechnie Lake	5.4	23.2	7.17		yes	3.9	green
McLeans Lake	13	22	0.03			3	orange/brown
McNutt Lake	11	21.7	0.06	yes		4.2	yellow/brown
Mirror Lake	4	24.8	7.02		yes	2.2	green/brown
Mutton Lake	4.3	21.8	8.47		yes	2.5	yellow/brown
Neville Lake	5.8	21.7	0.17		yes	3.3	yellow
Otter Lake	44	22.1	10.08			4.7	green/brown
Pender Lake	12	24.6	0.1			4.9	brown
Portage Lake	17	22.1	6.51			5.1	green
Rankin Lake	20	21.8	0.08			5.4	green
Scime Lake	8.1	21.7	0.04		yes	3.15	orange/red
Second Lake	3	22.7	8.16		yes	bottom	green
Tiffin Lake/Silver	18	22.3	2.43			4.6	green
Star Lake	22	23.9	3.12			2.2	brown
Sucker Lake	16	24.1	2.16			4.55	green/brown
Sugar Lake	12	21.4	1.59			3.9	green
Ten Mile Lake	8.2	22.2	0.05		yes	3.7	brown
Third Lake	8.5	22.8	0.1		yes	4.4	green
Tub Lake	3.2	21.8	7.96		yes	1.8	green
Turtle Lake	14	21.5	0.03	yes		4	green
Upper Fry Lake	4.5	20.9	6.54		yes	1.7	brown/red
Virtue Lake	3.1	21.6	8.14		yes	bottom	blue/green
Yarrow Lake	3	24.6	5.01		yes	2.4	

[1]mean hypolimnetic dissolved oxygen concentration <0.1 mg/L.

The water of 22 lakes was noted as being tea-stained or ‘brown’ with relatively shallow Secchi depths indicating that they likely have high DOC concentrations (Table 4). These lakes should be identified in revisions to the model to explain possible error in the model predictions.

Several of the lakes displayed low oxygen concentrations (<0.1 mg/L) within 1 m of the lake bottom, but only four of the lakes (Back, Lower Fry, McNutt, and Turtle lakes) were considered to potentially develop anoxic (no oxygen) hypolimnia as mean dissolved oxygen concentrations in the bottom waters of these lakes was <0.1 mg/L. Dissolved oxygen concentration in the hypolimnion of lakes can continue to decline until fall overturn and so anoxia and internal phosphorus loading potentially occurs in these lakes. Potential internal phosphorus loading in these lakes should considered in future revisions of the model.

3. Summary and Recommendations

- A total of 72 of 128 lakes (56%) in Seguin Township have measured spring total phosphorus concentration data and at the conclusion of the 2013 spring monitoring program, at least 65 lakes will each have a minimum of 3 years of data.
- A list of suggested lakes for spring total phosphorus monitoring in 2013 (35 lakes) is provided in Appendix A. If there is time or funding available to sample additional lakes, we have provided a prioritized list of additional lakes.
- Due to the complex lake shape and bathymetry of Horseshoe Lake, we recommend that spring total phosphorus sampling should be conducted at 3 locations in the lake in 2013 to support multi-basin modeling of the lake when the model is revised in 2014.
- August monitoring of dissolved oxygen, temperature, lake depth and Secchi depth has been completed for 68 lakes. These data have been useful to flag shallow lakes, high DOC lakes and lakes that potentially undergo anoxia for refinement of the model in 2014. We recommend that monitoring in 2013 focus on lakes that have not yet been monitored, lakes that have been flagged as potentially developing anoxia in the hypolimnion and lakes that are designated as Lake Trout Lakes by the Ministry of Natural Resources (Appendix A). If additional resources are available, we recommend monitoring lakes with no existing data and we will work with the Township to identify suitable lakes.
- A large percentage of the Seguin Township monitoring lakes potentially have high dissolved organic carbon concentrations that could result in error in model predictions. If additional time or funding is available, we recommend that a subset of lakes be sampled for dissolved organic carbon. HESL will work with Seguin Township to select the most appropriate lakes for additional sampling if this is possible.

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Appendix A. Suggested Monitoring Lakes for 2013

Lake Name	2013 Spring TP		2013 August Sampling	
	1st Priority	2nd Priority	1st Priority	Rationale
Armishaw Lake		✓		no data
Back Lake		✓	✓	possible anoxia
Black Water Lake	✓			
Brennan Lake	✓			
Capton Lake	✓		✓	no data
Dyson Lake	✓			
Fair Lake	✓		✓	no data
Faris Lake		✓		
First Lake		✓		
Flaxman Lake		✓	✓	Lake Trout lake
Forget Lake	✓		✓	Lake Trout lake
Gilbank Lake	✓			
Haines Lake		✓		
Horseshoe Lake	✓ (3 basins)		✓ (3 basins)	multi basin sampling, possible anoxia in shallow bays
Isabella Lake	✓			
Joselin (Burnt) Lake	✓			
Kight Lake		✓		
Kingshott Lake		✓		
Lane Lake		✓	✓	no data
Lieback Lake		✓		
Linger Long (Napken) Lake	✓			
Little Lake Joe		✓		
Little Seguin/Duck Lake	✓		✓	Lake Trout lake
Long Lake 1		✓	✓	no data
Lower Fry Lake			✓	possible anoxia
Manitouwaba Lake	✓			
Maple Lake	✓			
Martin Lake	✓			
McDonald Lake		✓		

Lake Name	2013 Spring TP		2013 August Sampling	
	1st Priority	2nd Priority	1st Priority	Rationale
McNutt Lake			✓	possible anoxia
Mirror Lake		✓		
Murdock Lake	✓			
Neville Lake		✓		
Oastler Lake	✓			
Otter Lake	✓		✓	Lake Trout lake
Pender Lake	✓			
Portage Lake			✓	Lake Trout lake
Rankin Lake	✓			
Roberts Lake	✓			
Salmon Lake	✓			
Scime Lake	✓			
Scott Lake	✓			
Second Lake		✓		
Star Lake	✓		✓	Lake Trout lake
Storm Lake	✓			
Sucker Lake			✓	Lake Trout lake
Sugar Lake	✓			
Ten Mile Lake		✓		
Third Lake		✓		
Three-Legged Lake	✓		✓	Lake Trout lake
Tiffin Lake/Silver			✓	Lake Trout lake
Trout Lake	✓			
Tub Lake		✓		
Tucker Lake	✓			
Turtle Lake			✓	possible anoxia
Upper Fry Lake	✓			
Whitefish Lake	✓		✓	Lake Trout lake
Windfall Lake	✓			
Yarrow Lake	✓			
Total	**34**	**19**	**19**	