

Pigeon Lake Water Quality Report 2007



Prepared for:

The Pigeon Lake Watershed Association

Prepared by:

Aquality Environmental Consulting Ltd.
705, 10240 - 124 Street
Edmonton, Alberta
T5N 3W6

Writers:

Melissa Logan, B.Sc., P.Biol.
Jay S. White, M.Sc., P. Biol.

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Executive Summary

Pigeon Lake is a heavily used recreational lake just south of the City of Edmonton. Aquality Environmental Consulting Ltd. was retained to complete water quality sampling on the lake for comparison purposes with Alberta Environment data from previous years. Total phosphorus and nitrogen levels have increased since 1983, and the combination of excess nutrients and warm summers have produced optimal growth conditions for algal growth. Recommendations for addressing the nutrient additions and algal blooms include completing shoreline health assessments and educating area residents about responsible handling of domestic sewage and fertilizer use to help control phosphorus inputs into the lake.

Introduction

Pigeon Lake is a heavily used lake in central Alberta, just south of the City of Edmonton. Residents in the area have expressed concern over the recent poor water quality of the lake and the prolific algal blooms that have been occurring during the summer months. The algal blooms are of particular concern as the species present produce toxins and the blooms are unsightly, which greatly limits the recreational potential of the lake.

Alberta Environment has performed annual water quality testing on Pigeon Lake from 1983 to 2006. Unfortunately, the sampling program was not continued by Alberta Environment in 2007. Members of the Pigeon Lake Watershed Association were interested in continuing data collection and retained Aquality to sample the lake in August, 2007 in hopes of discovering an underlying problem causing the algal blooms.

Materials and Methods

Aquality sampled Pigeon Lake on August 30, 2007 with the assistance of two PLWA members. Discrete water column samples were collected at three locations on the lake (Figure 1) using a Kemmerer sampler. Two of the spots selected were in the deepest areas of the lake, while the third sample was collected near an inflow creek that has rumored to be used for sewage dumping. Samples were taken at two meter intervals starting at one meter, and then every meter for the last three meters before the bottom. Field measurements of temperature, conductivity, total dissolved solids and dissolved oxygen were taken using a YSI Multiprobe and Secchi depths were recorded at each site (Appendix 1). Unpreserved samples were collected in new, inert white plastic 500 mL and 1 L bottles and packed in coolers with ice packs. Samples were delivered to ALS Laboratories in Edmonton on the same day, and were analyzed for total phosphorus, total dissolved phosphorus, total nitrogen, pH and chlorophyll a.

Historical data was collected from Alberta Environment's Surface Water Quality website (2007), and unverified data from 2005 and 2006 was made available for use. It should be noted that this data is still going through the complete verification process and the final data will published on the Alberta Environment website in October 2007.

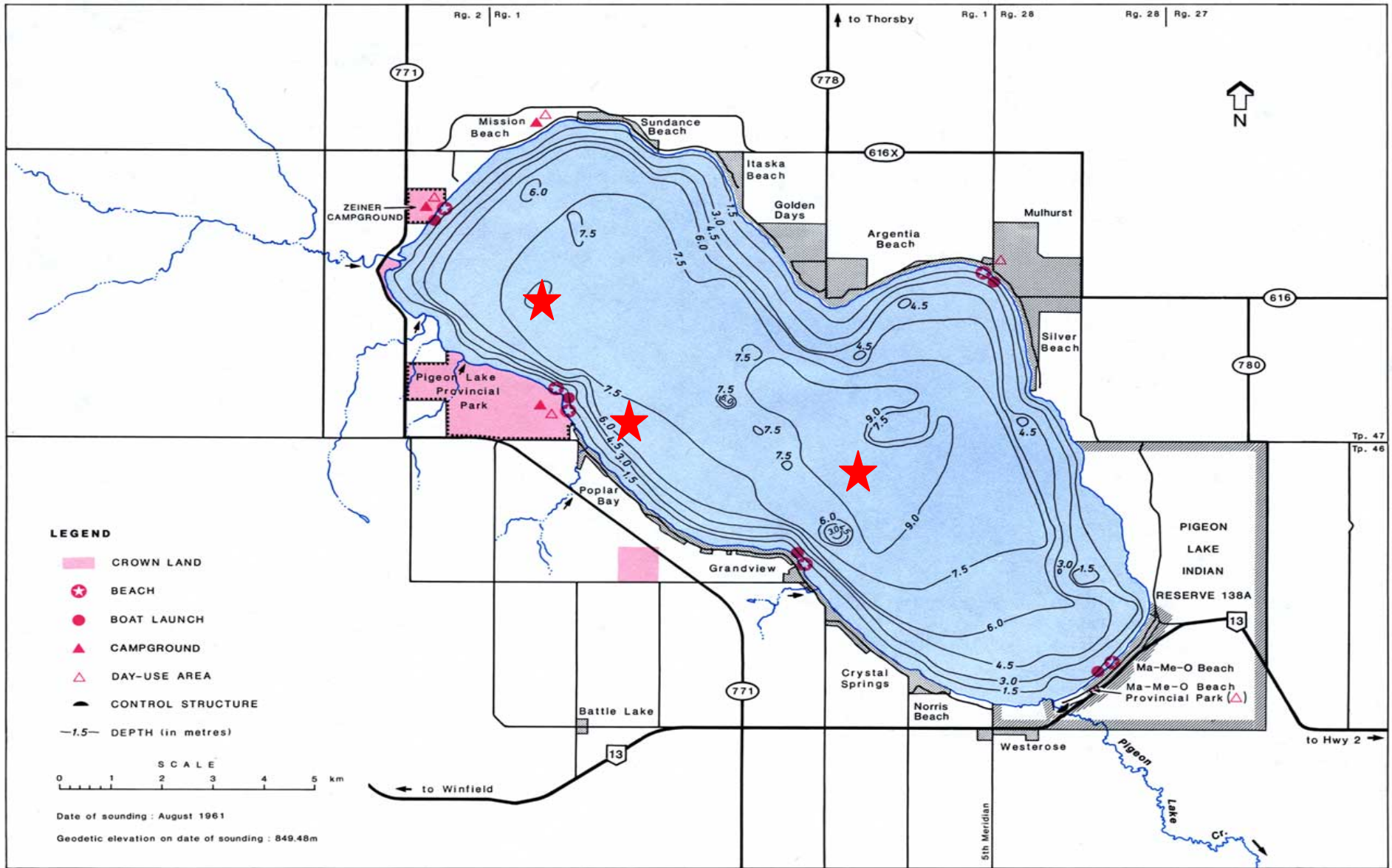


Figure 2. Bathymetry and shoreline features of Pigeon Lake.
BATHYMETRY SOURCE: Alta. Envir. n.d.[d].

Figure 1. Location of 2007 sampling sites on Pigeon Lake. Sites indicated by red stars. Adapted from Atlas of Alberta Lakes, 1991.

Results

Using the 2007 data and all available Alberta Environment data, it is apparent that there has been an increase in average total phosphorus and nitrogen levels within Pigeon Lake since 1983. Other water quality parameters, such as pH, conductivity, total dissolved solids have remained relatively steady over the time period addressed in this report.

Table 1. Average total phosphorus and nitrogen values for Pigeon Lake for 1983-2007, along with the percent increase in these parameters over the entire time period. Data from Alberta Environment (2007).

Time Period	TP Amount (µg/L)	TN Amount (µg/L)
1983-1989 (n = 42)	33.7	760.3
1990-1999 (n = 33)	32.6	860
2000-2007 (n = 19)	50.1	999.6
Percent Increase	49%	32%

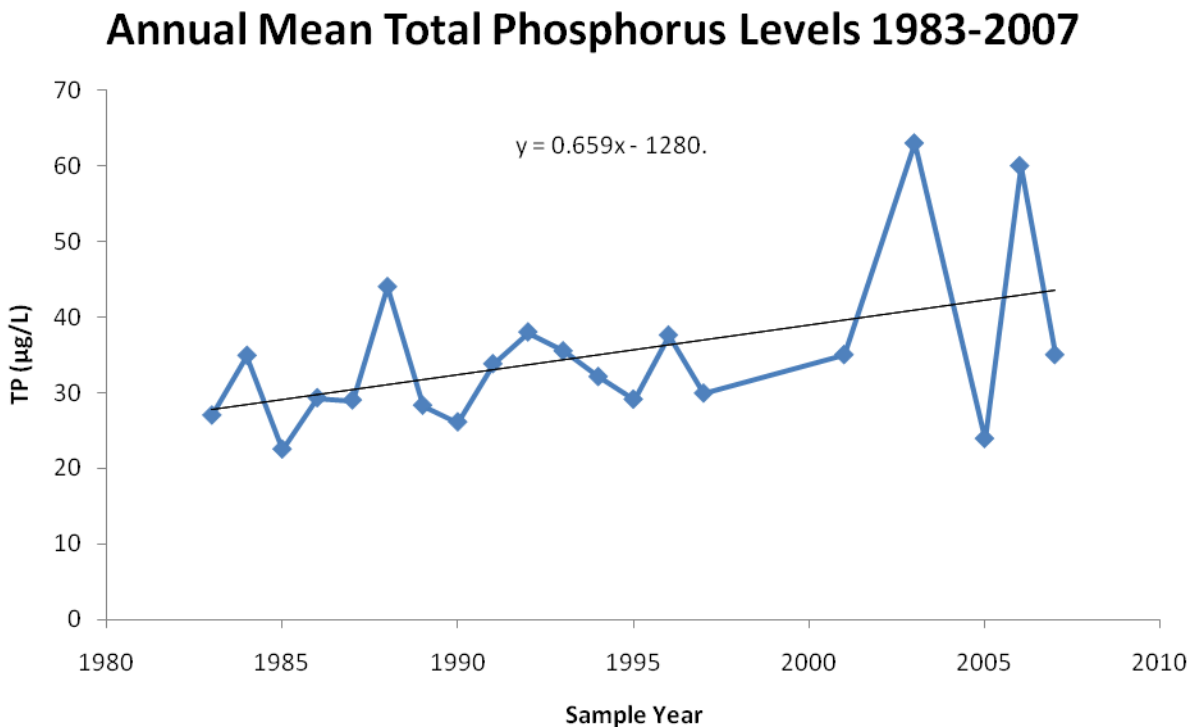


Figure 2. Annual mean total phosphorus concentrations for Pigeon Lake, 1983 - 2007.

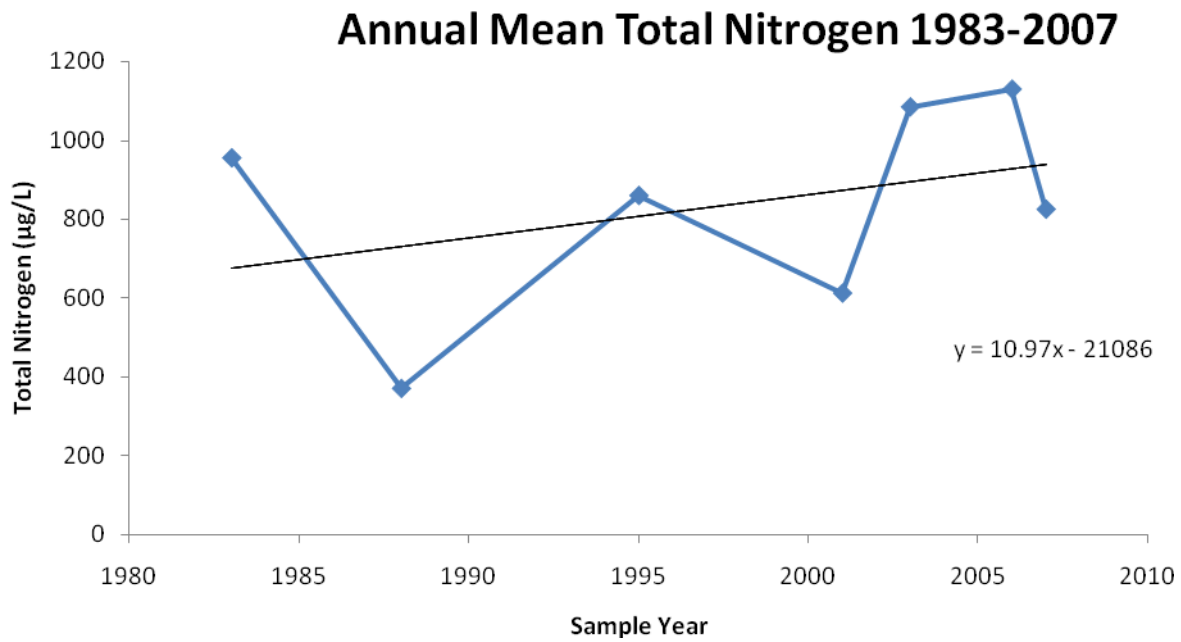


Figure 3. Annual mean total nitrogen concentrations for Pigeon Lake, 1983-2007.

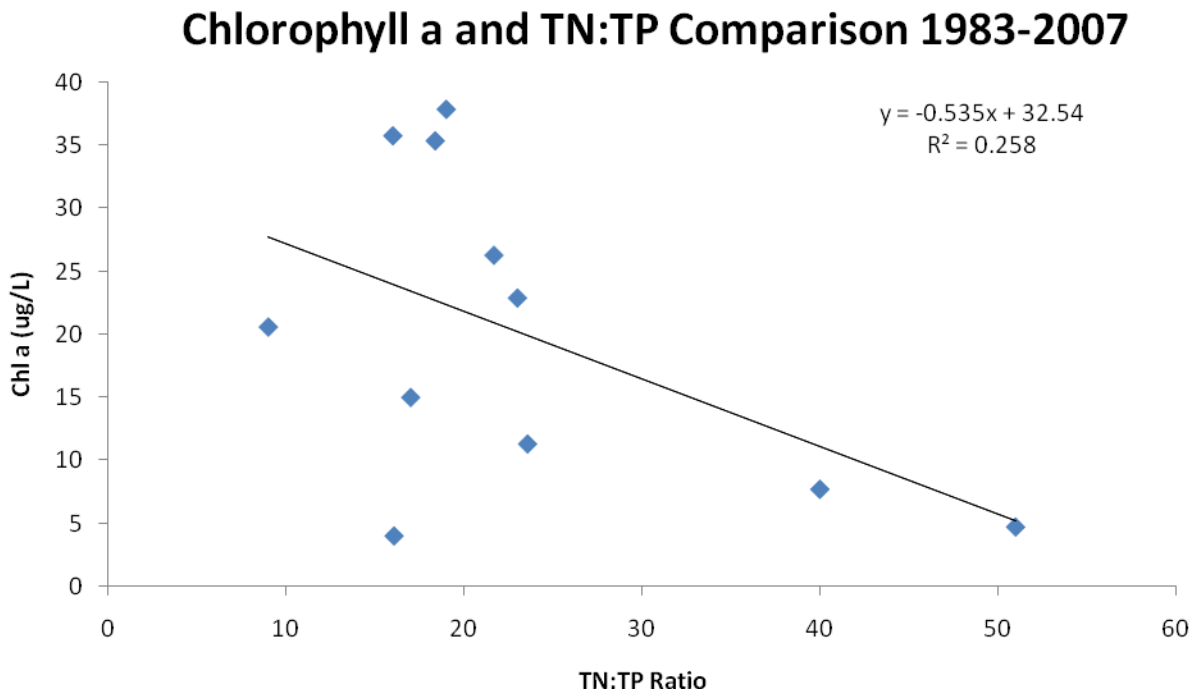


Figure 4. Comparison between chlorophyll a levels and TN:TP in Pigeon Lake from 1983 to 2007.

Table 2. Average total phosphorus and nitrogen values for Pigeon Lake for 2006 and 2007, along with the percent change in these parameters over the entire time period. Data from Alberta Environment (2007).

Year	Mean TP Amount (µg/L)	TN Amount (µg/L)
2007 (n = 12)	35	825
2006	60	1130
Percent Change	-42%	-27%

Discussion

As shown in Table 1, total phosphorus levels have increased by 49% from the 1980's to present. Algal blooms are most often the result of excess nutrient levels within a water body, particularly phosphorus. Most lakes in Alberta are phosphorus limited, which means that any addition of phosphorus to the water will result in a rapid growth of plant and algal matter. Alberta lakes are generally quite nutrient rich to begin with due to the presence of phosphorus rich glacial till that underlies most lakes. Additions of phosphorus and nitrogen can also come through deposition and internal and external loading. Common sources of internal loadings are plant and algal decay; common external sources include agricultural and stormwater runoff as well as sewage and manure inputs. In Table 2 we can see that total phosphorus levels decreased by 42% from 2006 to 2007; the TP levels seen in 2007 are not out of the ordinary for Pigeon Lake.

Total nitrogen in Pigeon Lake has increased by 32% over the same time period (Table 1). Cyanobacteria require certain conditions for growth. Optimal conditions for cyanobacteria include low N:P ratios, warm water temperatures, sufficient available phosphorus and calm conditions. Optimal growing temperatures are 15-25 °C , with 25°C offering the optimum temperature for peak reproduction (R. Zurawell, 2007, pers. comm.). Algae tend to take up to six weeks to bloom within the water column before they come to the surface (R. Zurawell, 2007, pers. comm.) where they become readily visible to lake users. Prolific and persistent late summer blooms can continue to float to the surface until October in Alberta lakes. Nitrogen is typically not a limiting factor for the growth of these algae. In Table 2 we can see that total nitrogen decreased by 27% from 2006 to 2007.

Nutrient loading in Pigeon Lake is likely originating from a number of sources with a major source being improper sewage and manure management. Inflows into the lake are limited in number and size, so inputs from these sources are likely small. Shoreline alteration and cottage development has risen sharply in the last 10 years which is exacerbating the nutrient loading problem. A theoretical phosphorus loading budget was completed for the lake in 1989 (Atlas of Alberta Lakes, 1991) and should be updated to reflect the current available data. This budget indicated that approximately 30% of the nutrient load to Pigeon Lake occurred through agricultural inputs, and the major source (38%) being precipitation and dustfall (Table 3). It is important to consider that this budget is theoretical only. Extensive recreational use of the lake is likely aiding in nutrient resuspension through disturbance of the lake sediments, and the large algal blooms that have occurred over the last couple of years eventually fall to the lake bottom; their decay results in the return of nutrients to the water column.

Table 3. Theoretical phosphorus loadings for Pigeon Lake. Adapted from Atlas of Alberta Lakes, 1991.

Table 5. Theoretical total external phosphorus loading to Pigeon Lake.

Source		Phosphorus (kg/yr)	Percentage of Total
watershed	forested/bush	900	16
	agricultural/cleared	1 702	30
	residential/cottage	770	14
sewage ^a		133	2
precipitation/dustfall		2 127	38
TOTAL		5 632	100
annual areal loading (g/m ² of lake surface)		0.06	

NOTE: ^aunmeasured: assumes 4% of all sewage effluent from residences and camps enters the lake, as in Mitchell 1982
SOURCE: Alta. Envir. 1989

Summer water temperatures in Pigeon Lake fall in the range for supporting prolific algal growth and have even been recorded to be as high as 25°C. Mean temperatures during the 2007 sampling run fell into the lower end of the optimal growth range. Based on the results of the 2007 sampling, the molecular ratio of nitrogen:phosphorus indicated the lake was phosphorus limited; so that any input of phosphorus into this system will result in immediate plant and algal uptake and growth. The in-lake variation in phosphorus levels could indicate “hot spots”; locations where phosphorus levels are higher for a reason such as external loading from a creek, high decomposition or sewage release. The causes and locations of all these hot spots are not apparent at this time and would need further investigation to determine their cause. Hot spots may cause areas of heavy localized algal growth due to higher concentrations of available nutrients. Overall, however, Pigeon Lake was well mixed with no thermocline (a zone of rapid change in temperature between the surface and the bottom), indicating that phosphorus inputs will eventually be mixed throughout the water column, which explains why algae can be seen growing throughout the entire lake. The residence time of the lake water is quite long, (> 100 years), which means there is very little flushing of “old” nutrient rich lake water with “new” dilute water from inflows. The combination of warm temperatures, calm conditions and the right amount of available phosphorus worked together to generate the algal blooms seen today.

Once the algae go through its growth period and eventually come to the water surface, the wind will concentrate it in areas of the lake and shoreline that receive the majority of the wind and wave action. This can give the impression that algal growth is heavy in those particular areas, where in fact it could be simply a collection or focusing point.

Conclusions and Recommendations

Based on the increase in nutrient levels seen in the lake and the prolific algal blooms seen over the last couple of years, it is our recommendation that the following steps be taken to help identify some potential sources of nutrient loading to the lake:

- Use aerial videography data from 2002 shoreline assessment to identify primary areas of riparian habitat loss; possibly update aerial survey
- Determine the subdivisions that still use septic tanks and research the frequency of tank cleaning and method of disposal
- Complete groundwater analysis to determine nutrient levels in shallow groundwater around the lake
- Continue annual water quality monitoring program with Alberta Environment or the Alberta Lake Management Society and ensure lake is sampled in winter, spring and summer
- Complete bacterial testing on the lake to determine fecal coliform levels; could partner with local Health Authority and focus on areas that utilize septic tanks
- Public education regarding fertilizer and pesticide use
- Examination of surrounding agricultural land use and gathering of livestock statistics for the area
- Development of best management practices for land use
- Update the nutrient budget for lake

It is our impression at this time that external nutrient inputs are of concern to Pigeon Lake. Land use practices, sewage and manure management around the lake should be investigated to determine if there are any point sources of nutrient loading. Another area of concern is the lack of healthy and functional riparian area around the lake; when present, riparian areas act as a very effective filter for removal of excess nutrients due to surface runoff. If external loads could be controlled, this would certainly help control in-lake nutrient levels and subsequently control the formation of algal blooms.

References

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Water Quality Data 2007

**Pigeon Lake
Sampling**

Site	Max dept h (m)	Site description	GPS Location	Sample Date	Sample Time	Secchi depth (m)	Sample Depth (m)	Temp (°C)	Specific Conductivity (µS/cm)	TDS (g/L)	DO (mg/L)	TP (mg/L)	TDP (mg/L)	TKN (mg/L)	Chl a (mg/m ³)	pH
1	9.5m	Straight out from Mulhurst Bay	53° 01.722' N 114°01.927' W	30-Aug-07	9:45	2.55	surface	16.26	302	0.196	10.48					
							1m	16.25	302	0.196	10.69	0.05	<0.02	1.1	17	8.8
							3m	16.19	302	0.196	10.29	0.04	<0.02	0.8	5	8.8
							5m	15.83	302	0.197	10.04	<0.02	<0.02	0.8	7	8.8
							7m	15.24	303	0.197	9.38	<0.02	<0.02	0.6	3	8.7
							8m	15.16	303	0.197	9.41	<0.02	<0.02	0.7	<1	8.8
							9m	15.13	304	0.197	9.28	<0.02	<0.02	0.8	2	8.7
2	7.8m	Zeiner / Fisher's Home	53° 03.082' N 114°08.817' W	30-Aug-07	10:45	2.4	surface	17.25	299	0.194	12.86					
							1m	17.15	300	0.195	11.62	0.04	<0.02	1.3	59	9
							3m	15.51	302	0.196	9.37	<0.02	<0.02	0.7	3	8.8
							5m	15.49	303	0.197	8.75	0.03	0.02	0.7	<1	8.7
							7m	15.34	305	0.198	7.82	0.02	<0.02	0.7	<1	8.7
3	5.5m	Between Provincial Park and Poplar Bay (Out front of Poplar Bay Creek)	53° 01.083' N 114°06.889' W	30-Aug-07	11:20	3.0	surface	16.26	301	0.196	13.2					
							1m	16	301	0.196	10.94	0.03	0.02	0.9	4	8.8
							5m	15.54	302	0.196	10.31	<0.02	<0.02	0.8	2	8.8