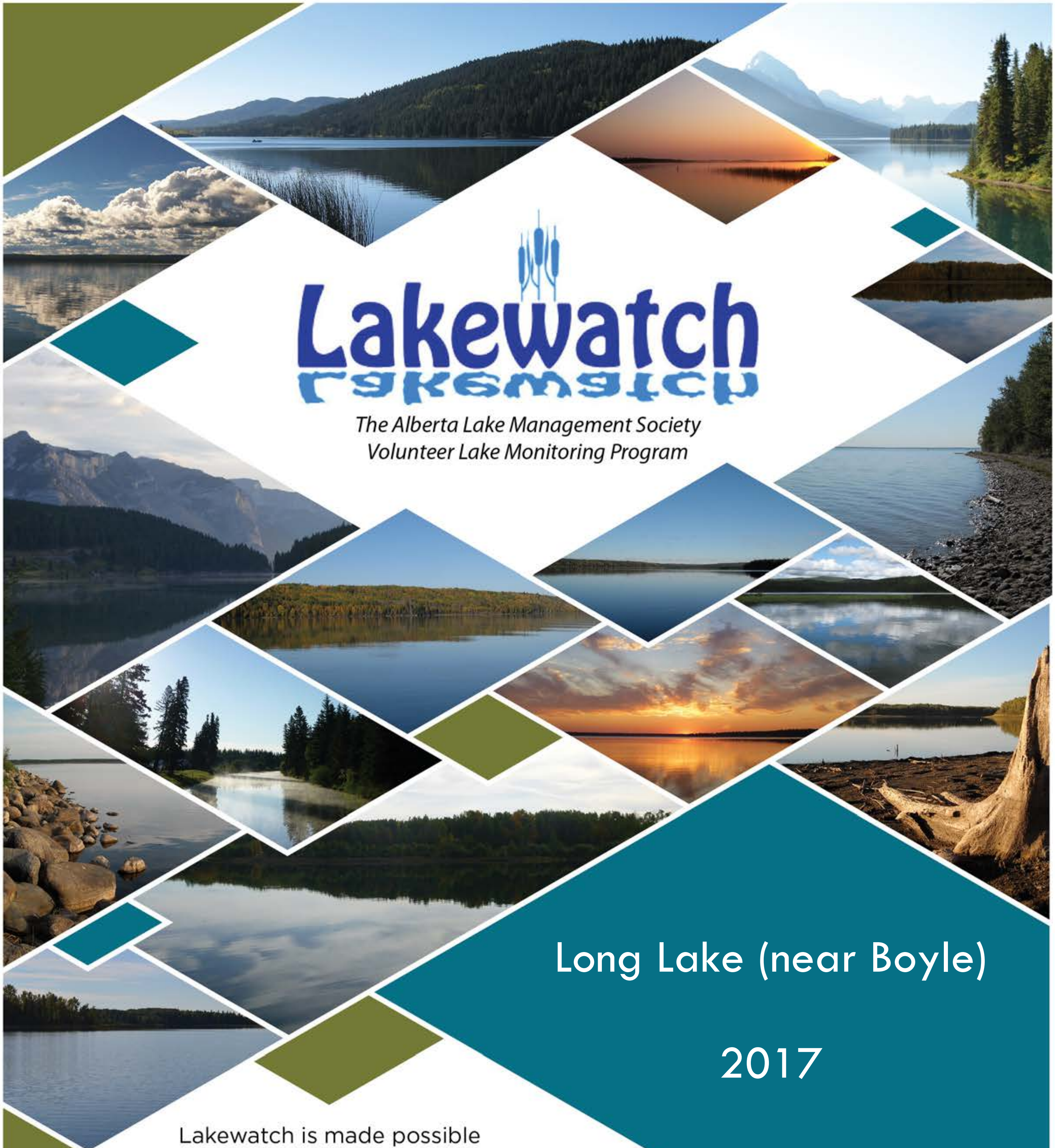

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Long Lake (near Boyle)

2017

Lakewatch is made possible with support from:

Cargill — Helping the world thrive
Jackfish Lake
Pigeon Lake Watershed Association
LICA — Lakeland Industry & Community Association
Red Deer River Watershed Alliance
Beaver River Watershed Alliance
Alberta Environment and Parks

ALBERTA LAKE MANAGEMENT SOCIETY'S LAKEWATCH PROGRAM

LakeWatch has several important objectives, one of which is to collect and interpret water quality data on Alberta Lakes. Equally important is educating lake users about their aquatic environment, encouraging public involvement in lake management, and facilitating cooperation and partnerships between government, industry, the scientific community and lake users. LakeWatch Reports are designed to summarize basic lake data in understandable terms for a lay audience and are not meant to be a complete synopsis of information about specific lakes. Additional information is available for many lakes that have been included in LakeWatch and readers requiring more information are encouraged to seek those sources.

ALMS would like to thank all who express interest in Alberta's aquatic environments and particularly those who have participated in the LakeWatch program. These people prove that ecological apathy can be overcome and give us hope that our water resources will not be the limiting factor in the health of our environment.

ALMS is happy to discuss the results of this report with our stakeholders. If you would like information or a public presentation, contact us at info@alms.ca.

ACKNOWLEDGEMENTS

The LakeWatch program is made possible through the dedication of its volunteers. We would like to extend a special thanks to Colin Bussiere and Kathleen Bruce for the time and energy put into sampling Long Lake in 2017. We would also like to thank Elashia Young and Melissa Risto who were summer technicians in 2017. Executive Director Bradley Peter and LakeWatch Coordinator Laura Redmond was instrumental in planning and organizing the field program. This report was prepared by Laura Redmond and Bradley Peter. The Beaver River Watershed, the Lakeland Industry and Community Association, Environment Canada, and Alberta Environment and Parks are major sponsors of the LakeWatch program.

LONG LAKE

Long Lake is a long, narrow lake located approximately 130 km north of Edmonton and 15 km south of the Town of Boyle. The lake runs along a glacier melt-water channel called the Long Lake Valley and is surrounded by moderately steep, forested terrain. Historically the area around the lake was heavily used by the fur-traders. After the fur trade, the region supported the logging industry. Over time seven saw mills operated along the western shore of the lake.

Changing colours on Long Lake in September 2017 (Photo by Elashia Young).

Long Lake Provincial Park was established in 1957 and is located on the western and eastern shores of the lake. Popular swimming, boating, canoeing, water skiing, and fishing. Primary sport fish include yellow perch (Perca flavescens), walleye (Stizostedion vitreum), and northern pike (Esox lucius). There is a cottage subdivision located north of the provincial park on the western shore of the lake. The name of the lake is descriptive of its shape. Long Lake is about 13 km long and less than 1 km wide. The lake has two basins; the northern basin is smaller and shallower than the southern basin. The central part of the southern basin has the steepest gradient and is also the deepest part of the lake. Overall, the lake is moderately shallow, with an average depth of 4.3 m and a maximum depth of 9.0 m.

The area of Long Lake's watershed is 14 times larger than that of the lake itself. The terrain surrounding Long Lake is undulating and slopes steeply toward the lake. Ninety-eight percent of the drainage basin is forested; the dominant species are trembling aspen (Populus tremuloides) and balsam poplar (Populus balsamifera) but white spruce (Picea glauca) is present in areas that have not been harvested or burned. Jack pine (Pinus banksian) and black spruce (Picea mariana) are also common. The main soils in the drainage basin are Orthic Gray Luvisols.

METHODS

Profiles: Profile data is measured at the deepest spot in the main basin of the lake. At the profile site, temperature, dissolved oxygen, pH, conductivity and redox potential are measured at 0.5- 1.0 m intervals. Additionally, Secchi depth is measured at the profile site and used to calculate the euphotic zone. On one visit per season, metals are collected at the profile site by hand grab from the surface and at some lakes, 1 m off bottom using a Kemmerer.

Composite samples: At 10-sites across the lake, water is collected from the euphotic zone and combined across sites into one composite sample. This water is collected for analysis of water chemistry, chlorophyll-a, nutrients and microcystin. Quality control (QC) data for total phosphorus was taken as a duplicate true split on one sampling date. ALMS uses the following accredited labs for analysis: Routine water chemistry and nutrients are analyzed by Maxxam Analytics, chlorophyll-*a* and metals are analyzed by Alberta Innovates Technology Futures (AITF), and microcystin is analyzed by the Alberta Centre for Toxicology (ACTF). In lakes where mercury samples are taken, they are analyzed by the Biogeochemical Analytical Service Laboratory (BASL).

Invasive Species: Monitoring for invasive quagga and zebra mussels involved two components: monitoring for juvenile mussel veligers using a 63 μm plankton net at three sample sites and monitoring for attached adult mussels using substrates installed at each lake.

Data Storage and Analysis: Data is stored in the Water Data System (WDS), a module of the Environmental Management System (EMS) run by Alberta Environment and Parks (AEP). Data goes through a complete validation process by ALMS and AEP. Users should use caution when comparing historical data, as sampling and laboratory techniques have changed over time (e.g. detection limits). For more information on data storage, see AEP Surface Water Quality Data Reports at aep.alberta.ca/water.

Data analysis is done using the program R.[1] Data is reconfigured using packages tidyr [2] and dplyr [3] and figures are produced using the package ggplot2 [4]. Trophic status for each lake is classified based on lake water characteristics using values from Nurnberg (1996)[5]. The Canadian Council for Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life are used to compare heavy metals and dissolved oxygen measurements. Pearson's Correlation tests are used to examine relationships between TP, chlorophyll-*a,* TKN and Secchi depth, providing a correlation coefficient (r) to show the strength (0-1) and a p-value to assess significance of the relationship.

---

[1] R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

[2] Wickman, H. and Henry, L. (2017). tidyr: Easily Tidy Data with 'spread ( )' and 'gather ( )' Functions. R package version 0.7.2. https://CRAN.R-project.org/package=tidyr.

[3] Wickman, H., Francois, R., Henry, L. and Muller, K. (2017). dplyr: A Grammar of Data Manipulation. R package version 0.7.4. http://CRAN.R-project.org/package=dplyr.

[4] Wickham, H. (2009). ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York.

[5] Nurnberg, G.K. (1996). Trophic state of clear and colored, soft- and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. Lake and Reservoir Management 12: 432-447.

BEFORE READING THIS REPORT, CHECK OUT A BRIEF INTRODUCTION TO LIMNOLOGY AT ALMS.CA/REPORTS

WATER CHEMISTRY

ALMS measures a suite of water chemistry parameters. Phosphorus, nitrogen, and chlorophyll-a are important because they are indicators of eutrophication, or excess nutrients, which can lead to harmful algal/cyanobacteria blooms. One direct measure of harmful cyanobacteria blooms are Microcystins, a common group of toxins produced by cyanobacteria. See Table 1 for a complete list of parameters.

The average total phosphorus (TP) concentration for Long Lake was 56.25 µg/L (Table 2), falling into the eutrophic, or productive trophic classification. TP increased over the course of the sampling season, peaking in August (Figure 1).

Average chlorophyll-*a* concentration in 2017 was 40.18 µg/L (Table 2), putting Long Lake into the hypereutrophic classification. Chlorophyll-*a* concentrations also increased over the course of the sampling season, peaking at 62.5 µg/L on September 24.

Finally, average TKN concentration was 1.17 mg/L (Table 2), and concentrations increased in July and remained high for the remainder of the summer (Figure 1).

Average pH was measured as 8.75 in 2017, buffered by moderate alkalinity (225 mg/L $CaCO_3$) and bicarbonate (242.5 mg/L HCO_3). Calcium and sodium were the dominant ions contributing to a low conductivity of 452.5 µS/cm (Table 2).

METALS

Samples were analyzed for metals once throughout the summer (Table 3). In total, 27 metals were sampled for. It should be noted that many metals are naturally present in aquatic environments due to the weathering of rocks and may only become toxic at higher levels.

Metals and total and dissolved mercury were measured once on August 21 at Long Lake at the surface as well as 1 m above bottom depth. In 2017, all measured values fell within their respective guidelines (Table 3).

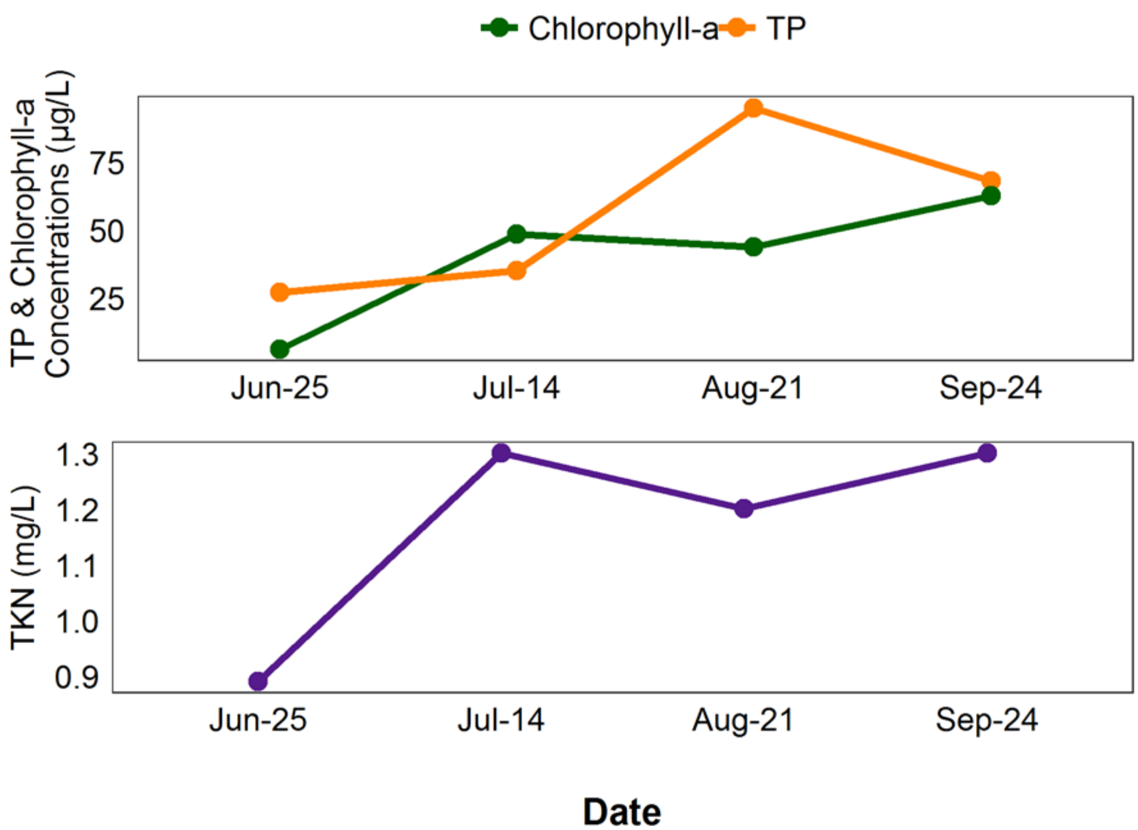

Figure 2- Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Long Lake.

WATER CLARITY AND SECCHI DEPTH

Water clarity is influenced by suspended materials, both living and dead, as well as dissolved colored compounds in the water column. During the melting of snow and ice in spring, lake water can become turbid (cloudy) from silt transported into the lake. Lake water usually clears in late spring but then becomes more turbid with increased algal growth as the summer progresses. The easiest and most widely used measure of lake water clarity is the Secchi disk depth. Two times the Secchi disk depth equals the euphotic depth – the depth to which there is enough light for photosynthesis.

The average Secchi depth of Long Lake in 2017 was 1.78 m (Table 2). Secchi depth was deepest early in the season, and then decreased to around 1 m later in the season (Figure 2). The decreasing water clarity may be associated with increasing algae biomass in the warmer months of the summer.

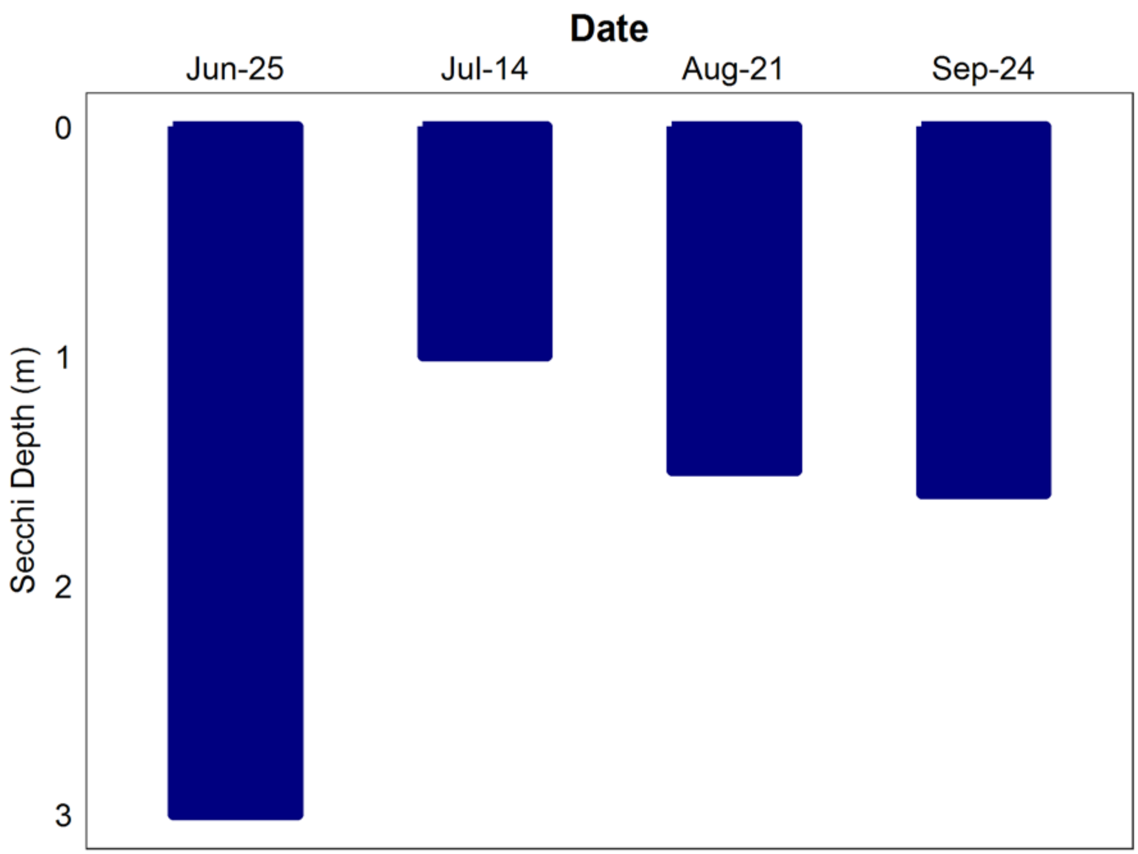

Figure 3 – Secchi depth values measured four times over the course of the summer at Long Lake in 2017.

WATER TEMPERATURE AND DISSOLVED OXYGEN

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. The depth of the thermocline is important in determining the depth to which dissolved oxygen from the surface can be mixed. Please refer to the end of this report for descriptions of technical terms.

Temperatures of Long Lake varied throughout the summer, with a maximum temperature of 23.3 °C measured at the surface on July 14 (Figure 3a). The lake was well mixed for most of the summer, with weak stratification occurring during the warmest visit (July 14).

Long Lake remained well oxygenated at the surface throughout the summer, measuring above the CCME guidelines of 6.5 mg/L for the Protection of Aquatic Life (Figure 3b). During thermal stratification, oxygen levels decreased near the bottom due to separation from atmospheric oxygen that is circulated at the water surface. On July 14, Long Lake reached anoxia around 6 m.

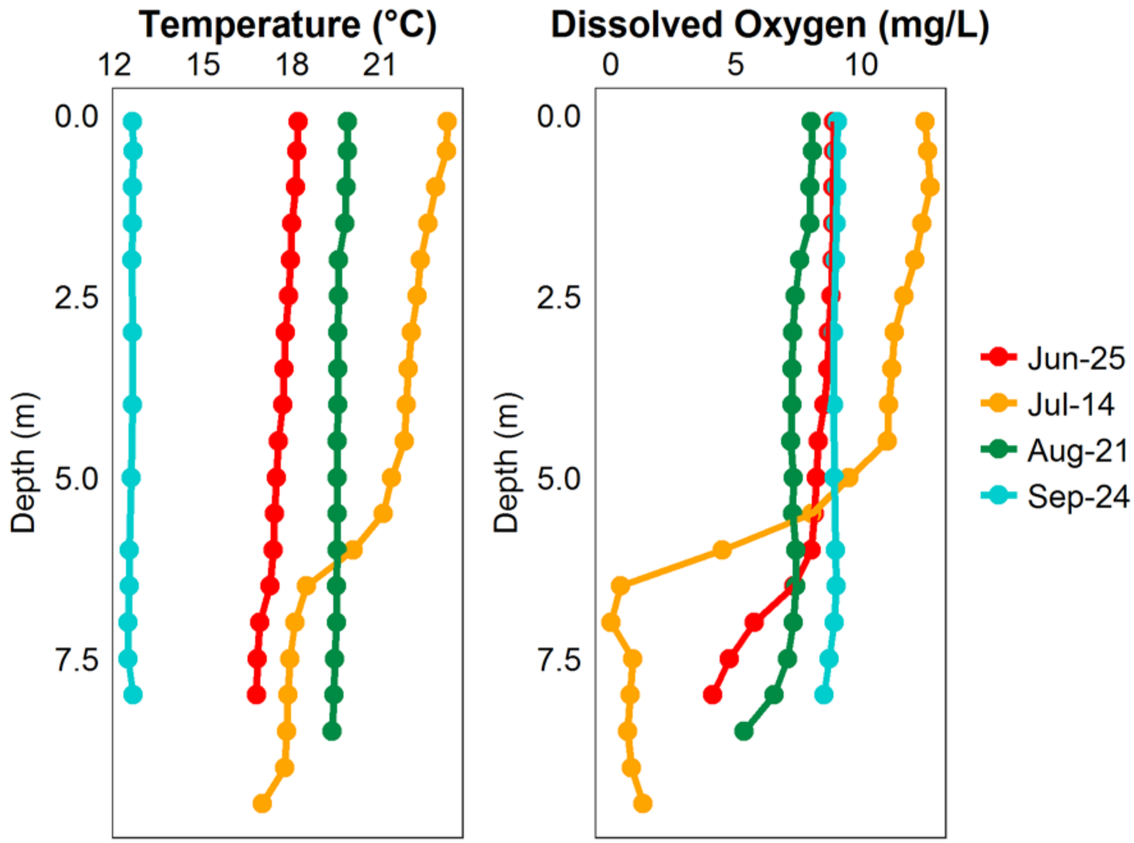

Figure 4 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Long Lake measured four times over the course of the summer of 2017.

MICROCYSTIN

Microcystins are toxins produced by cyanobacteria (blue-green algae) which, when ingested, can cause severe liver damage. Microcystins are produced by many species of cyanobacteria which are common to Alberta's Lakes, and are thought to be the one of the most common cyanobacteria toxins. In Alberta, recreational guidelines for microcystin are set at 20 μg/L. Blue-green algae advisories are managed by Alberta Health Services. Recreating in algal blooms, even if microcystin concentrations are not above guidelines, is not recommended.

Microcystin levels in Long Lake were measured below the recreational guideline for the entire sampling period of 2017 (Table 1).

Table 1 – Microcystin concentrations measured four times at Long Lake in 2017.

Date	Microcystin Concentration (μg/L)
Jun-25-17	0.19
Jul-14-17	0.26
Aug-21-17	2.32
Sep-24-17	4.98
Average	1.94

INVASIVE SPECIES MONITORING

Dreissenid mussels pose a significant concern for Alberta because they impair the function of water conveyance infrastructure and adversely impact the aquatic environment. These invasive mussels have been linked to creating toxic algae blooms, decreasing the amount of nutrients needed for fish and other native species, and causing millions of dollars in annual costs for repair and maintenance of water-operated infrastructure and facilities.

Monitoring involved two components: monitoring for juvenile mussel veligers using a plankton net and monitoring for attached adult mussels using substrates installed in each lake. No mussels have been detected in Long Lake.

WATER LEVELS

There are many factors influencing water quantity. Some of these factors include the size of the lakes drainage basin, precipitation, evaporation, water consumption, ground water influences, and the efficiency of the outlet channel structure at removing water from the lake. Requests for water quantity monitoring should go through Alberta Environment and Parks Monitoring and Science division.

Water quantity data is currently unavailable for Long Lake.

Table 2A: Average Secchi depth and water chemistry values for Long Lake. Historical values are given as reference.

Parameter	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
TP (µg/L)	33.20	61.33	26.20	71.50	33.00	40.20	46.25	90.33	75.50	56.00	57.60	68.50	49.00	41.50
TDP (µg/L)	/	/	/	/	/	/	/	/	/	/	/	/	17.00	/
Chlorophyll-*a* (µg/L)	14.92	22.84	12.20	18.45	14.25	20.26	25.35	16.35	27.75	22.40	33.28	23.34	22.70	16.70
Secchi depth (m)	2.24	2.78	2.46	2.63	3.05	2.78	3.00	2.05	3.03	1.93	2.10	2.44	2.40	2.95
TKN (mg/L)	/	/	/	/	/	/	/	/	/	/	/	/	1.30	/
NO_2-N and NO_3-N (µg/L)	25.00	25.00	21.25	25.00	10.00	171.67	7.50	16.67	2.50	4.25	10.17	37.33	3.38	
NH_3-N (µg/L)	/	/	/	/	/	/	/	/	/	/	/	/	37.00	/
DOC (mg/L)	/	/	/	/	/	/	/	/	/	/	/	/	12.40	/
Ca (mg/L)	27.00	28.00	27.00	30.50	31.00	31.00	28.50	23.00	24.50	23.00	21.00	23.67	27.00	28.63
Mg (mg/L)	15.00	15.00	15.33	16.00	15.15	17.00	16.50	18.33	19.50	18.00	17.67	18.00	18.50	17.90
Na (mg/L)	24.33	25.00	26.67	25.50	23.50	30.33	29.50	31.67	31.50	36.00	36.33	36.00	36.25	35.90
K (mg/L)	3.77	3.75	3.97	3.75	3.65	3.80	3.65	3.90	3.95	4.30	4.10	4.27	4.28	4.33
SO_4^{2-} (mg/L)	17.33	13.00	12.00	12.50	18.00	16.67	16.50	11.00	10.00	10.50	9.33	6.33	9.50	13.37
Cl^- (mg/L)	1.00	0.50	2.00	0.50	1.00	1.33	1.90	1.77	2.00	2.15	2.17	2.40	2.43	5.30
CO_3 (mg/L)	2.50	13.20	2.50	9.60	2.00	4.25	8.00	8.00	2.00	7.50	9.33	5.50	6.75	1.07
HCO_3 (mg/L)	214.67	213.50	215.00	216.50	206.50	227.33	221.00	216.67	236.00	236.50	226.67	242.67	240.25	240.33
pH	8.37	8.40	8.37	9.00	8.25	8.38	8.58	8.34	7.70	8.58	8.66	8.41	8.50	8.12
Conductivity (µS/cm)	362.3	366.5	359.3	373.0	371.0	387.7	383.5	367.3	378.0	389.5	378.3	383.0	394.5	398.0
Hardness (mg/L)	129	132	131	142	139	147	139	133	142	132	124	133	143	145
TDS (mg/L)	196	198	194	201	196	217	213	202	209	214	208	212	223	227
Microcystin (µg/L)	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Total Alkalinity (mg/L $CaCO_3$)	179	186	178	186	172	193	194	187	196	201	198	202	209	199

Table 2B: Continued- Average Secchi depth and water chemistry values for Long Lake. Historical values are given as reference.

Parameter	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2013	2017
TP (µg/L)	52.50	39.33	38.75	44.50	43.25	55.50	53.80	65.00	50.55	86.00	57.0	32.40	75.40	56.25
TDP (µg/L)	/	/	9.00	/	/	/	/	/	16.67	/	/	11.80	38.60	11.2
Chlorophyll-*a* (µg/L)	26.87	24.58	10.90	22.38	20.73	18.33	11.88	34.17	16.83	37.46	22.04	10.50	26.30	40.18
Secchi depth (m)	2.15	2.28	2.76	1.95	2.78	2.58	2.64	2.32	2.79	2.34	2.54	3.28	1.90	1.78
TKN (mg/L)	/	/	/	/	/	/	/	1.37	1.11	1.33	/	0.88	1.40	1.17
NO_2-N and NO_3-N (µg/L)	/	/	13.88	75.00	8.67	8.50	2.50	8.30	13.83	26.80	/	5.90	4.80	2.28
NH_3-N (µg/L)	/	/	/	/	/	/	/	/	28.50	/	/	19.40	79.00	28.5
DOC (mg/L)	/	/	/	/	/	/	/	15.10	13.40	13.45	/	10.77	13.83	12.25
Ca (mg/L)	30.83	33.65	31.88	27.05	24.47	25.45	/	/	/	/	/	/	/	26.2
Mg (mg/L)	16.43	17.05	16.98	17.85	19.03	18.40	/	/	/	/	/	/	/	22
Na (mg/L)	29.83	30.30	34.63	35.50	38.00	40.50	40.50	42.90	43.50	50.65	/	46.50	47.27	52.25
K (mg/L)	4.17	4.05	4.65	4.25	4.63	5.15	4.60	4.80	4.87	5.30	/	5.03	4.80	5.43
SO_4^{2-} (mg/L)	12.33	16.00	21.45	21.80	24.17	23.45	19.00	16.00	17.00	19.00	/	19.67	16.67	18.25
Cl^- (mg/L)	2.70	2.25	2.85	3.00	2.67	2.50	2.90	3.10	3.47	4.15	/	4.27	5.13	7.23
CO_3 (mg/L)	1.40	4.43	1.90	9.25	2.50	2.50	7.00	14.00	9.00	9.00	/	8.50	11.30	13.55
HCO_3 (mg/L)	229.0	225.0	247.5	221.5	231.0	239.0	240.0	229.4	248.3	251.00	/	266.2	242.6	242.5
pH	8.24	8.30	8.24	8.50	8.23	8.35	8.46	8.76	8.55	8.56	/	8.33	8.67	8.75
Conductivity (µS/cm)	375.3	391.0	400.0	403.5	405.0	413.5	428.0	408.6	433.0	416.2	/	452.8	449.8	452.5
Hardness (mg/L)	145	155	150	141	140	140	148	/	149	/	/	145	139	155
TDS (mg/L)	212	226	236	227	227	234	238		247			257	248	270
Microcystin (µg/L)	/	/	/	/	/	/	/	/	0.16	0.42	1.328	0.12	0.64	1.94
Total Alkalinity (mg/L $CaCO_3$)	190	192	206	195	191	197	209	211	219	221		224	218	225

Table 3: Concentrations of metals measured in Long Lake on August 21. Measurements were taken at the surface and 1m from bottom. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2017 Top**	**2017 Bottom**	**Guidelines**
Aluminum µg/L	10	9.7	100[a]
Antimony µg/L	0.041	0.044	/
Arsenic µg/L	1.87	2.01	5
Barium µg/L	66.7	67.7	/
Beryllium µg/L	0.0015	0.0015	100[c,d]
Bismuth µg/L	0.0015	0.004	/
Boron µg/L	122	122	1500
Cadmium µg/L	0.005	0.005	0.26[b]
Chromium µg/L	0.05	0.05	/
Cobalt µg/L	0.071	0.045	1000[d]
Copper µg/L	0.34	0.33	4[b]
Iron µg/L	12.8	11.3	300
Lead µg/L	0.002	0.008	7[b]
Lithium µg/L	27.9	26.2	2500[e]
Manganese µg/L	77.7	63.8	200[e]
Mercury (dissolved) ng/L	0.23	0.24	/
Mercury (total) ng/L	0.5	0.55	26
Molybdenum µg/L	0.484	0.488	73[c]
Nickel µg/L	1.23	1.15	150[b]
Selenium µg/L	0.3	0.3	1
Silver µg/L	5.00E-04	5.00E-04	0.25
Strontium µg/L	198	199	/
Thallium µg/L	0.001	0.002	0.8
Thorium µg/L	0.015	0.017	/
Tin µg/L	0.03	0.03	/
Titanium µg/L	1.44	1.45	/
Uranium µg/L	0.369	0.364	15
Vanadium µg/L	0.273	0.287	100[d,e]
Zinc µg/L	0.4	0.7	30

Values represent means of total recoverable metal concentrations.
[a] Based on pH ≥ 6.5
[b] Based on water hardness > 180mg/L (as $CaCO_3$)
[c] CCME interim value.
[d] Based on CCME Guidelines for Agricultural use (Livestock Watering).
[e] Based on CCME Guidelines for Agricultural Use (Irrigation).
A forward slash (/) indicates an absence of data or guidelines.