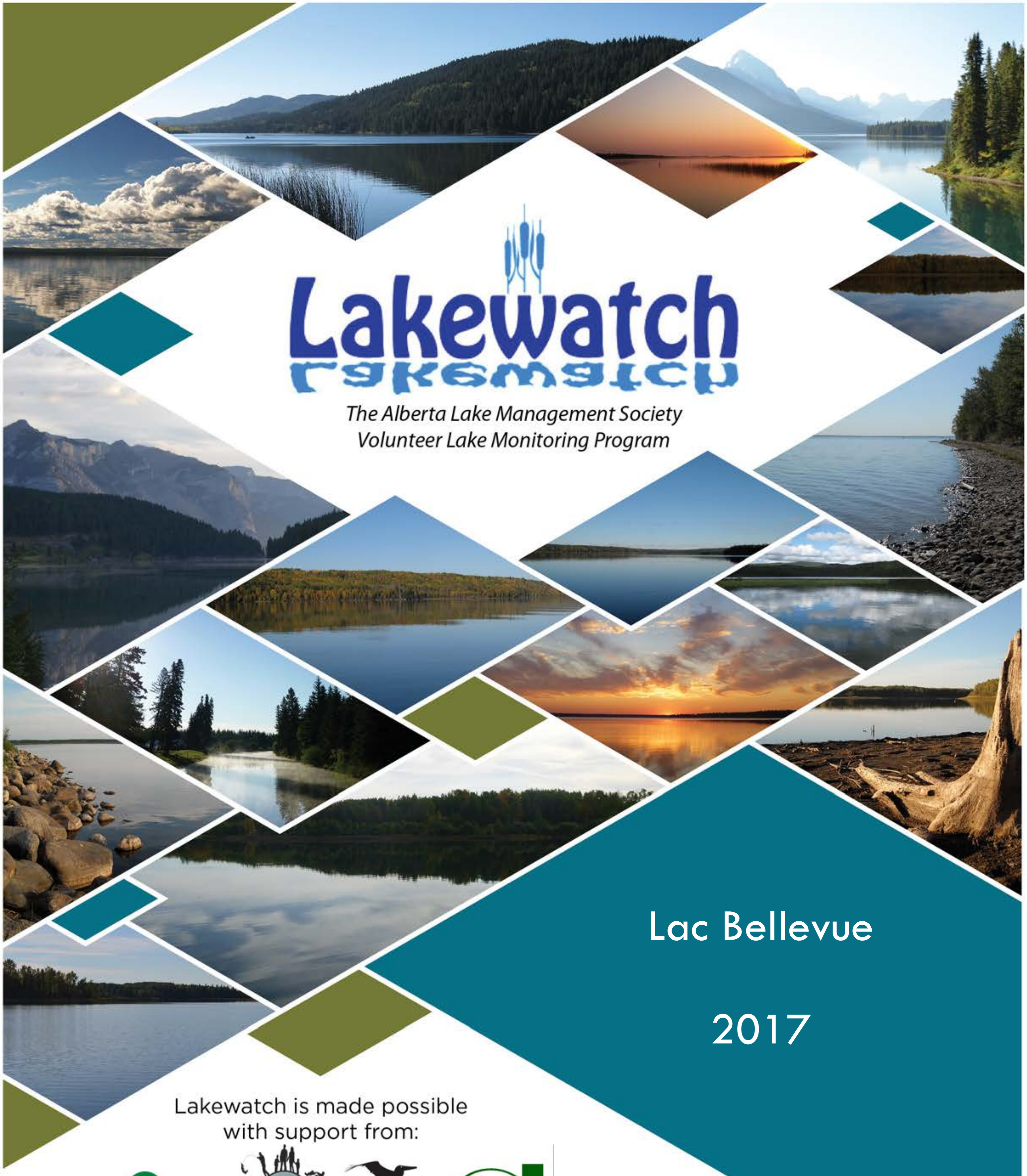

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Lac Bellevue

2017

Lakewatch is made possible with support from:

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 Robert Tymofichuk for the time and energy put into sampling Lac Bellevue 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.

LAC BELLEVUE

Lac Bellevue is located south of St. Paul west of Highway 881. The lake is approximately 4.6 km north of the North Saskatchewan River. Lac Bellevue is located in the low-aspen parkland ecosystem and is in a mosaic of developed pastures and deciduous upland forests. The lake is also within the St. Paul Provincial Grazing Reserve. Lac Bellevue has four camping-recreational facilities. Fishing is a popular pastime, and sport fish include walleye, pike, perch, and whitefish.

Blue-green algae in Lac Bellevue—photo by Elashia Young 2017

Lac Bellevue has a maximum width of ~3 km and a perimeter of ~ 9.7 km. (Tele Atlas 2008). The lake has a maximum depth of around 11 m, though water level declines have impacted Lac Bellevue in the past.

Lac Bellevue- photo by Elashia Young 2017

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.

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[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 2 for a complete list of parameters.

The average total phosphorus (TP) concentration for Lac Bellevue was 33.5 µg/L (Table 2), falling into the eutrophic, or productive, trophic classification. TP increased over the course of the sampling season and was highest in September (Figure 1).

Average chlorophyll-*a* concentration in 2017 was 10.2 µg/L (Table 2), also putting Lac Bellevue into the eutrophic classification. Chlorophyll-*a* concentrations increased over the summer, reaching a maximum concentration of 27.7 µg/L on September 16 (Figure 2).

Finally, the average TKN concentration was 1.2 mg/L (Table 2), and the maximum concentration was measured on September 16.

Average pH was measured as 8.83 in 2017, buffered by moderate alkalinity (342.5 mg/L $CaCO_3$) and bicarbonate (355 mg/L HCO_3). Magnesium followed by calcium were the dominant ions contributing to a moderate conductivity of 620 µS/cm (Table 2).

METALS

Samples were analyzed for metals (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 as well as total and dissolved mercury were measured on September 16 at Lac Bellevue at the surface and from 1m off bottom. In 2017, all measured values fell within their respective guidelines (Table 3).

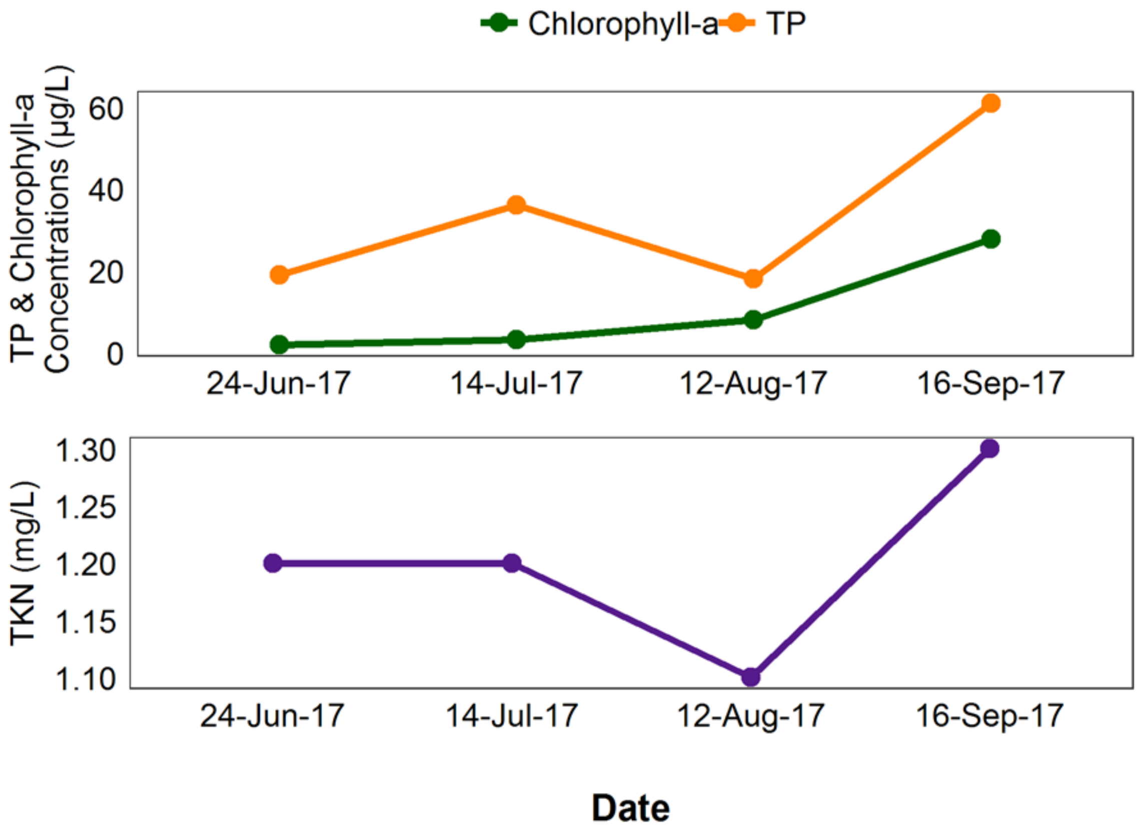

Figure 1- Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Lac Bellevue.

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 depth. Two times the Secchi depth equals the euphotic depth – the depth to which there is enough light for photosynthesis.

The average Secchi depth of Lac Bellevue in 2017 was 4.85 m (Table 2). Water clarity measured as Secchi depth decreased over the course of the summer. The decreasing water clarity could be associated with increasing algae biomass in the warmer months of the summer.

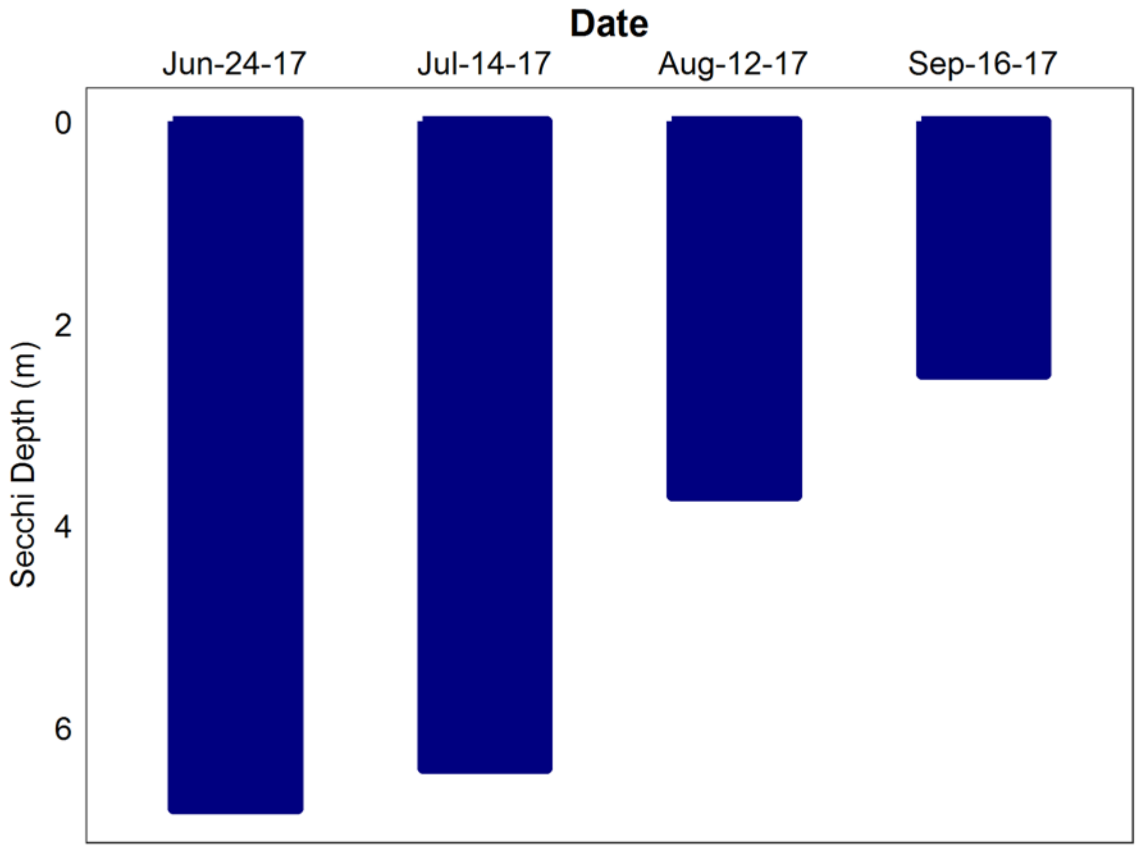

Figure 2 – Secchi depth values measured four times over the course of the summer at Lac Bellevue in 2017.

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 Lac Bellevue varied throughout the summer, with a maximum temperature of 21.0 °C measured at the surface on August 12 (Figure 3a). The lake was weakly thermally stratified in June, and stronger stratification was stabilized in July and August. By September, the entire water column was mixed at about 16 °C.

Lac Bellevue 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 lake's surface. By September when thermal stratification had broken down, the entire water column was well oxygenated.

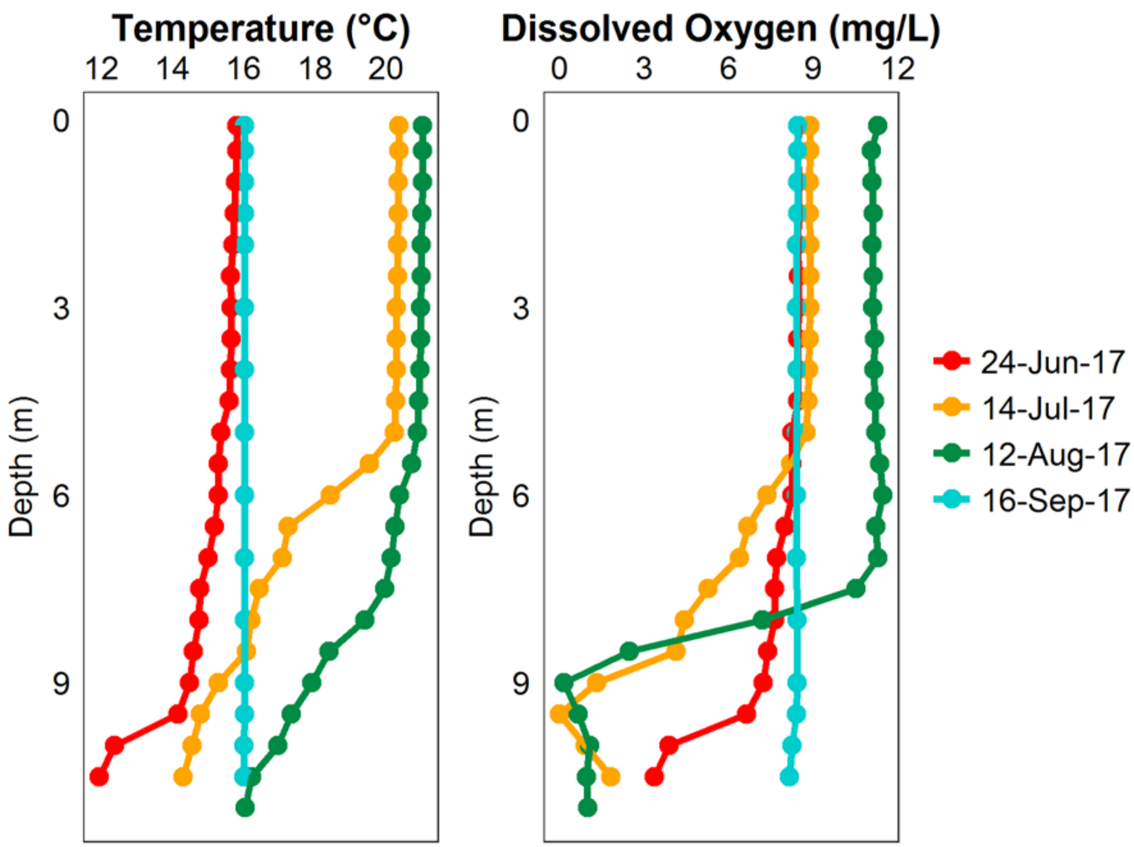

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Lac Bellevue measured four times over the course of the summer of 2017.

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 Lac Bellevue fell below the recreational guideline for the entire sampling period of 2017 (Table 1).

Table 1 – Microcystin concentrations measured four times at Lac Bellevue in 2017.

Date	Microcystin Concentration (μg/L)
Jun-24-17	0.15
Jul-14-17	0.25
Aug-12-17	0.43
Sep-16-17	0.28
Average	0.28

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 Lac Bellevue.

WATER LEVELS

There are many factors influencing water quantity. Some of these factors include the size of the lake's 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.

Historical Alberta Environment data collected from 1969-2002 showed water level declines from ~647 meters above sea level in 1969 to ~644 meters above sea level in 2002, a drop of nearly 3 m. Recent water level data is not available for Lac Bellevue.

Table 2: Average Secchi depth and water chemistry values for Lac Bellevue.

Parameter	**2007**	**2017**
TP (µg/L)	28.3	33.5
TDP (µg/L)	13.3	7.8
Chlorophyll-*a* (µg/L)	6.6	10.2
Secchi depth (m)	4.4	4.85
TKN (mg/L)	1.1	1.2
NO_2-N and NO_3-N (µg/L)	<0.09	2.275
NH_3-N (µg/L)	/	34.625
DOC (mg/L)	13.4	13.75
Ca (mg/L)	23.5	26.75
Mg (mg/L)	58.7	65
Na (mg/L)	18.8	18.5
K (mg/L)	20.3	25.5
SO_4^{2-} (mg/L)	7	19.5
Cl^- (mg/L)	2.2	2.7
CO_3 (mg/L)	24	29.75
HCO_3 (mg/L)	363	355
pH	8.7	8.83
Conductivity (µS/cm)	592	620
Hardness (mg/L)	/	335
TDS (mg/L)	/	367.5
Microcystin (µg/L)	/	0.28
Total Alkalinity (mg/L $CaCO_3$)	337	342.5

Table 3: Concentrations of metals measured in Lac Bellevue on September 16. Concentrations were measured at the surface and 1 m off bottom. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	Top	Bottom	Guidelines
Aluminum µg/L	3.6	4.2	100[a]
Antimony µg/L	0.099	0.103	/
Arsenic µg/L	2.53	2.53	5
Barium µg/L	81.9	82.2	/
Beryllium µg/L	0.0015	0.0015	100[c,d]
Bismuth µg/L	0.0015	0.0015	/
Boron µg/L	87.3	87.4	1500
Cadmium µg/L	0.005	0.005	0.26[b]
Chromium µg/L	0.05	0.05	/
Cobalt µg/L	0.105	0.106	1000[d]
Copper µg/L	0.49	0.59	4[b]
Iron µg/L	6	7.2	300
Lead µg/L	0.012	0.014	7[b]
Lithium µg/L	75.9	75.8	2500[e]
Manganese µg/L	6.96	9.15	200[e]
Mercury (dissolved) ng/L	0.21	0.21	/
Mercury (total) ng/L	0.43	0.42	26
Molybdenum µg/L	1.27	1.28	73[c]
Nickel µg/L	0.46	0.47	150[b]
Selenium µg/L	0.1	0.2	1
Silver µg/L	5.00E-04	0.002	0.25
Strontium µg/L	223	222	/
Thallium µg/L	0.001	0.002	0.8
Thorium µg/L	0.005	0.003	/
Tin µg/L	0.03	0.03	/
Titanium µg/L	0.89	0.84	/
Uranium µg/L	2.18	2.16	15
Vanadium µg/L	0.913	0.859	100[d,e]
Zinc µg/L	1	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.