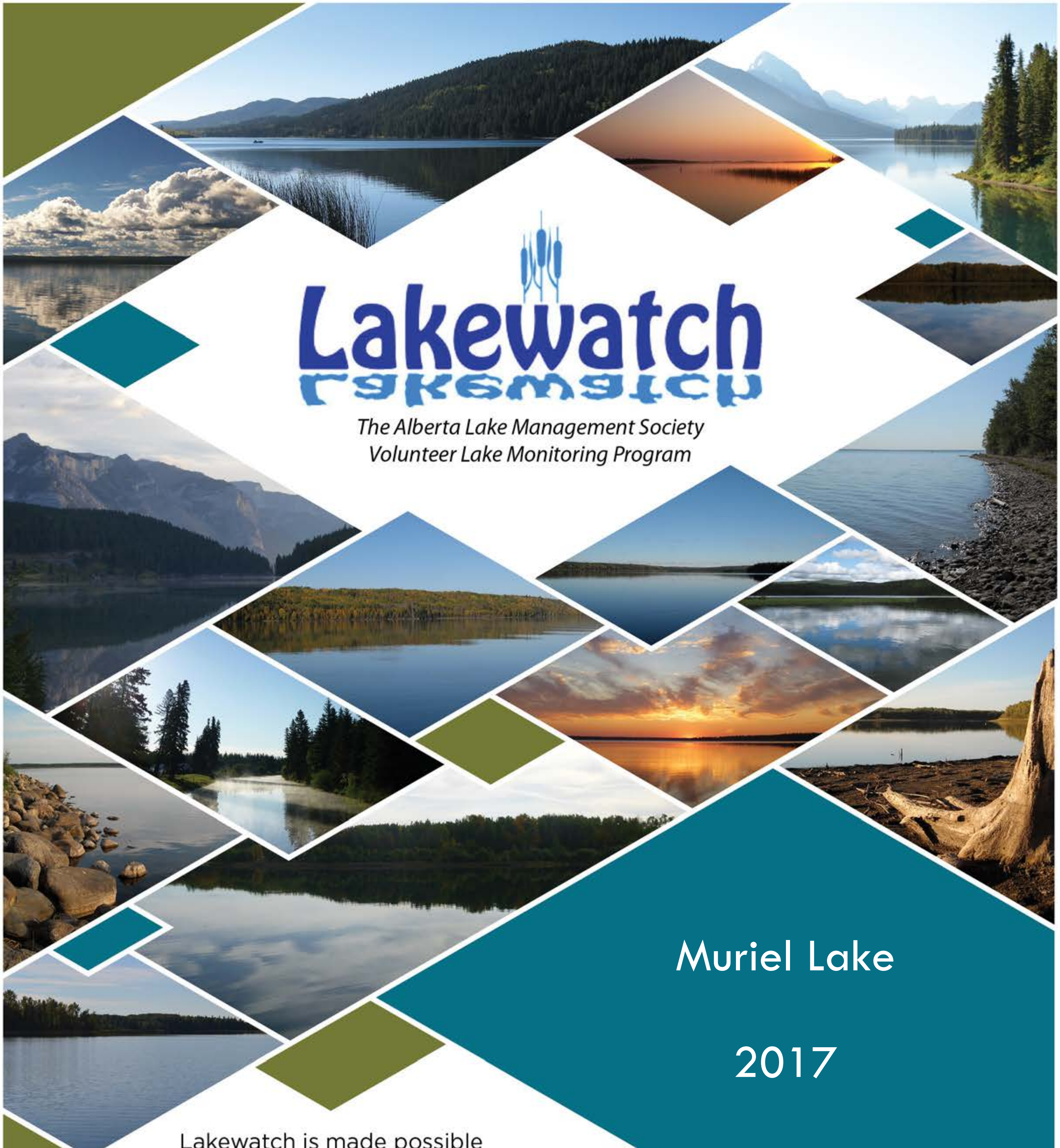

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Muriel Lake

2017

Lakewatch is made possible with support from:

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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 Jeff Hlewka for the time and energy put into sampling Muriel 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.

MURIEL LAKE

Muriel Lake—photo by Ageleky Bouzetos 2015

Muriel Lake is located 13 km south of the town of Bonnyville and 250 km northeast of Edmonton. The first establishment in the area by non-aboriginal peoples was a fur-trading post in 1781 by the North West Company near the present-day hamlet of Beaver Crossing, about 35 km northeast of Muriel Lake. The first settlers came to the Bonnyville area in 1907 and established an economy based on the timber industry. Two sawmills were located at Muriel Lake, one at the northeastern tip and the other on the large island/peninsula on the eastern shore.

In the 1920's, a large fire forced the economic base to switch to agriculture. There are several subdivisions (391 lots) around the lakeshore, mostly on the south and east sides of the lake. Much of the watershed is occupied by the Kehewin Cree Nation Reserve 123, located on 8200 ha of land southwest of the lake. The largest recreational facility on Muriel Lake is Muriel Lake Park, which is operated by the Municipal District of Bonnyville.

Northern pike, yellow perch, lake whitefish, and walleye were once prevalent in the lake, however these fish are no longer stocked, and a 2012 netting of the lake performed by Environment and Sustainable Resource Development revealed no sport fishes are present in Muriel Lake; only brook stickleback and longnose suckers were captured in 2012 netting[1]. Low winter dissolved oxygen levels (3.0 mg/L) leaves Muriel Lake at a high risk for fish kills.[1] Muriel Lake is a large (64.1 km^2) but shallow water body with a relatively small drainage basin, measuring only 4.8 times the size of the lake area. The shorelines consist primarily of steep rocky slopes, but there are also several attractive sandy beaches. Water levels have been monitored since the late 1960's and since then have dropped by as much as 4.5 m.

[1] Latty, D. (2012). Muriel Lake Fall Walleye Index Netting, 2012. Alberta Environment and Sustainable Resource Development. Retrieved on February 21st, 2012 from: http://srd.alberta.ca/FishWildlife/FisheriesManagement/FallWalleyeIndexNetting/Default.aspx

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 Muriel Lake was 48.3 µg/L (Table 2), falling into the eutrophic, or productive, trophic classification. This average lies within the range of historical values. TP remained relatively constant but increased slightly over the course of the sampling season (Figure 1).

Average chlorophyll-*a* concentration in 2017 was 20.9 µg/L (Table 2), also putting Muriel Lake into the eutrophic classification. This chlorophyll-*a* average is high when compared to historical records, although not as high as in 2015. Chlorophyll-*a* concentrations increased throughout the summer, reaching a maximum concentration of 43.3 µg/L on August 29.

Finally, average TKN concentration was 3.4 mg/L (Table 2), and the maximum concentration of 3.7 mg/L was measured on August 4.

Average pH was measured as 9.30 in 2017, buffered by high alkalinity (998 mg/L $CaCO_3$) and bicarbonate (782.5 mg/L HCO_3). Sulphate, and sodium were the dominant ions contributing to a high conductivity of 2200 µS/cm (Table 2). The high conductivity of Muriel Lake may be in part due to decreasing water levels.

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 were measured on August 29 at Muriel Lake at the surface. Arsenic, Boron and Selenium were measured as above the recommended guidelines. Historically, arsenic levels have been high at Muriel Lake. Selenium was measured as high in 2006, but Boron has never exceeded guideline before. In 2017, all other measured values fell within their respective guidelines (Table 3).

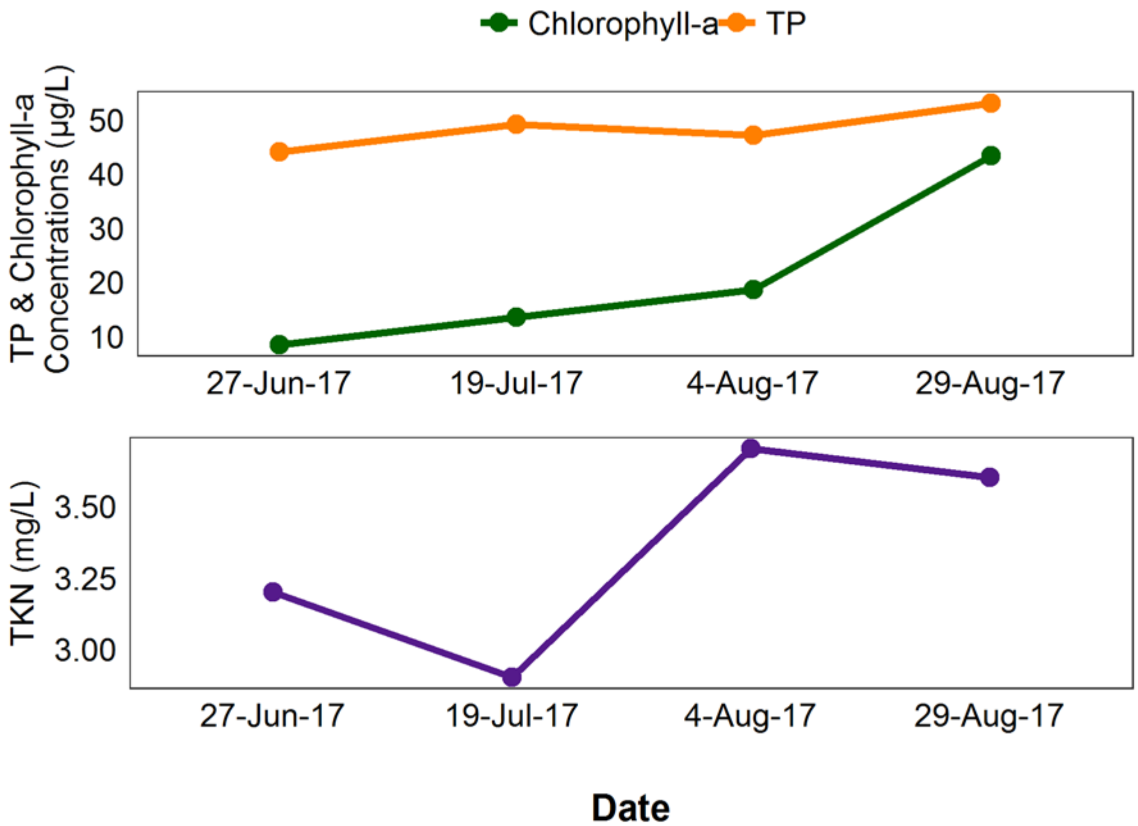

Figure 1- Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Muriel Lake.

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 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 Muriel Lake in 2017 was 1.03 m (Table 2). Water clarity measured as Secchi depth fluctuated around 1.00 m in 2017.

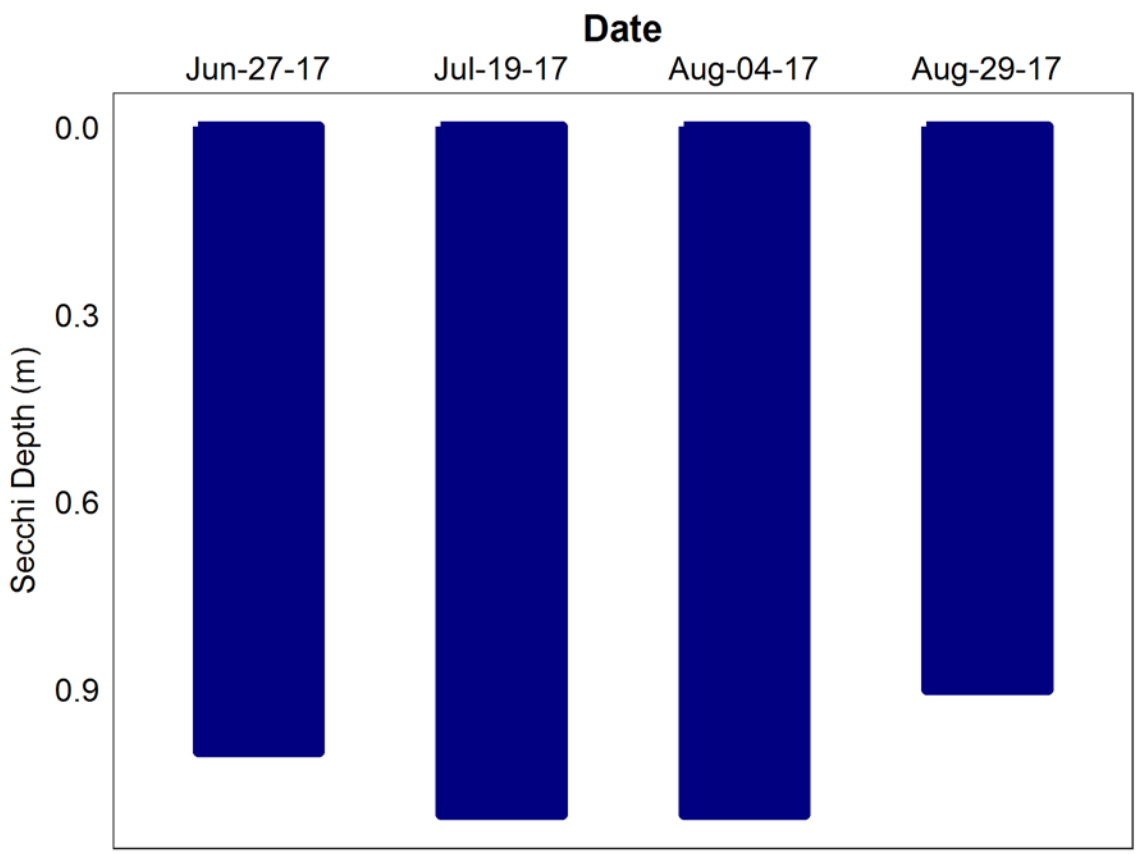

Figure 2 – Secchi depth values measured four times over the course of the summer at Muriel Lake in 2017.

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 Muriel Lake varied throughout the summer, with a maximum temperature of 21.4 °C measured at the surface on August 4 (Figure 3a). The lake was well mixed throughout the summer as no significant stratification events were observed.

Muriel Lake remained well oxygenated throughout the summer, measuring above the CCME guidelines of 6.5 mg/L for the Protection of Aquatic Life (Figure 3b). The entire water column was well oxygenated, although dissolved oxygen levels decreased near the bottom.

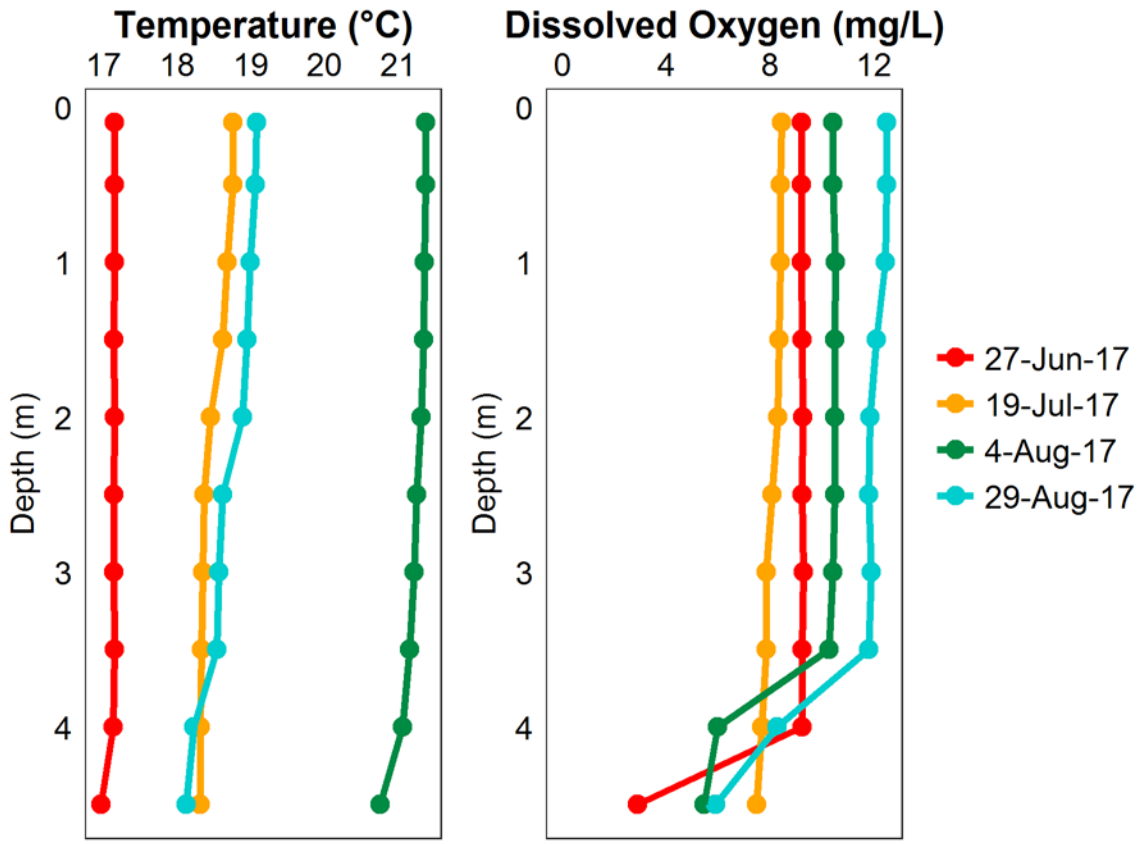

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Muriel Lake measured four times over the course of the summer of 2017.

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 Muriel Lake was measured below the recreational guideline for the entire sampling period of 2017 (Table 1).

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

Date	Microcystin Concentration (μg/L)
Jun-27-17	0.33
Jul-19-17	0.33
Aug-04-17	0.25
Aug-29-17	0.30
Average	0.30

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 Muriel Lake.

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.

Water levels in Muriel Lake have decreased since Environment Canada began monitoring the lake in 1981 (Figure 4). Muriel Lake decreased from 559.7 m in 1981 to 555.6 m in 2014. At the beginning of the ALMS sampling season, Muriel Lake water levels were at 555.8 m and by the end of September were 555.7 m.

Real-time water quantity data for Muriel Lake is available at:

https://wateroffice.ec.gc.ca/report/real_time_e.html?stn=06AC007

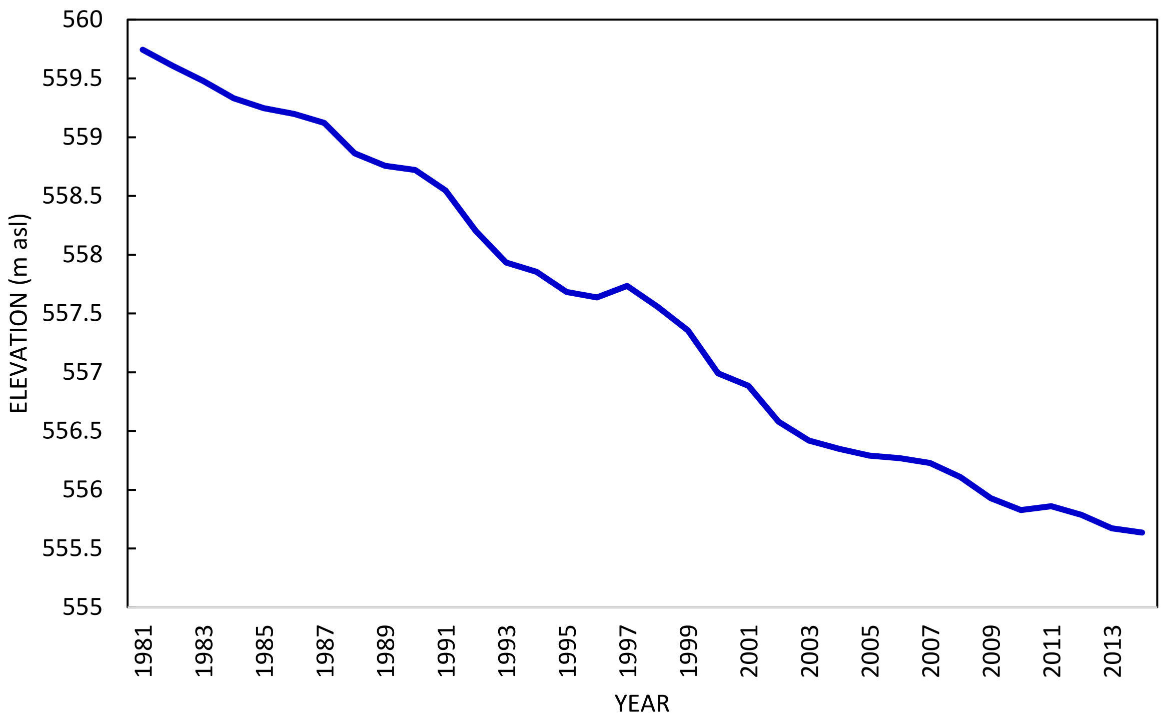

Figure 4- Water levels measured in metres above sea level (m asl) from 1981 to 2014. Data retrieved from Environment and Climate Change Canada.

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

Parameter	1988	1993	1997	2003	2006	2009	2012	2015	2017
TP (µg/L)	35.7	32.0	41.1	47.5	54.0	64.3	54.2	100	48.3
TDP (µg/L)	12.3	17.0	16.0	18.0	21.5	28.7	32.0	21	16.25
Chlorophyll-*a* (µg/L)	6.70	/	6.74	9.15	8.49	9.59	4.59	31.7	20.9
Secchi depth (m)	2.16	/	1.86	1.13	1.5	1.08	2.86	0.75	1.03
TKN (mg/L)	1.5	1.8	2.0	2.5	2.7	3.4	3.1	3.9	3.4
NO_2-N and NO_3-N (µg/L)	1.2	1.0	3.0	2.5	2.5	23.2	3.8	2.5	2.275
NH_3-N (µg/L)	21.3	111	22.8	20.5	45	26	64.4	56	43.5
DOC (mg/L)	26.2	32.5	28.0	/	44.7	47.1	48.1	62	53
Ca (mg/L)	10.58	7	7.52	5.03	6.02	4.85	5.16	4.2	7.2
Mg (mg/L)	97.7	115	126	173	163.5	152.7	154.7	210	207.5
Na (mg/L)	117.8	140	160.2	237.5	245	288.7	283.3	313	302.5
K (mg/L)	21.3	26.8	30.28	38.65	40.6	53.8	57.97	56	58.75
SO_4^{2-} (mg/L)	116.3	143	154.4	239	256.5	332.7	334	398	360
Cl^- (mg/L)	16.7	/	23.18	34.2	35.7	40.96	41.3	51	44.5
CO_3 (mg/L)	70.5	108.0	114.6	209.5	181.0	213.3	154.9	265	212.5
HCO_3 (mg/L)	535.04	703	620	746	800	858	962.6	873	782.5
pH	9.03	9.15	9.18	9.28	9.24	9.25	9.19	9.27	9.30
Conductivity (µS/cm)	1142.8	1350	1354	/	1925	2156.7	2212	2475	2200
Hardness (mg/L)	427.33	491	537.6	725.5	688	640.33	649.7	875	877.5
TDS (mg/L)	713.9	853	919.4	1305	1325	1510	1506.7	1725	1600
Microcystin (µg/L)	/	/	/	/	0.18	0.22	0.36	16.25	0.30
Total Alkalinity (mg/L $CaCO_3$)	556	667	696	961	957	1060	1050	1175	998

Table 3: Concentrations of metals measured on August 29 in Muriel Lake. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2003**	**2006**	**2009**	**2012**	**2015**	**2017**	**Guidelines**
Aluminum µg/L	34	31.8	20.15	16.485	19.8	85.7	100[a]
Antimony µg/L	0.22	0.183	0.1825	0.2265	0.2435	1.31	/
Arsenic µg/L	7.6	8.54	9.21	8.72	10.7	54.8	5
Barium µg/L	3.9	5.13	3.105	2.88	2.63	15.2	/
Beryllium µg/L	0.07	0.0015	0.0015	0.00625	0.004	0.0055	100[c,d]
Bismuth µg/L	0.013	0.0032	0.0046	0.00245	0.008	0.0055	/
Boron µg/L	319	290	325.5	377.5	441	1760	1500
Cadmium µg/L	0.01	0.0088	0.00365	0.0077	0.006	0.025	0.26[b]
Chromium µg/L	0.63	0.696	0.72	0.6335	0.265	0.25	/
Cobalt µg/L	0.036	0.23	0.0576	0.0489	0.055	0.364	1000[d]
Copper µg/L	1	1.87	1.435	0.995	1.57	3.54	4[b]
Iron µg/L	15	26.3	14.585	23.3	20.3	63.8	300
Lead µg/L	0.115	0.0944	0.04865	0.0444	0.1005	0.174	7[b]
Lithium µg/L	114	132	154	195.5	227.5	819	2500[e]
Manganese µg/L	2.4	4.26	1.665	2.35	2.77	9.57	200[e]
Molybdenum µg/L	1.25	1.49	1.58	1.885	1.995	8.45	73[c]
Nickel µg/L	0.08	0.206	0.1315	0.12535	0.1735	1.33	150[b]
Selenium µg/L	0.7	1.41	0.759	0.466	0.055	12.8	1
Silver µg/L	0.0025	0.0024	0.00575	0.0018	0.0015	0.018	0.25
Strontium µg/L	9.9	11	9.405	9.38	5.535	47.8	/
Thallium µg/L	0.077	0.0098	0.00155	0.000525	0.00045	0.018	0.8
Thorium µg/L	0.015	0.0134	0.00725	0.007825	0.00045	0.043	/
Tin µg/L	0.05	0.015	0.015	0.05495	0.076	0.15	/
Titanium µg/L	2.7	2.58	2.12	1.211	2.13	6.38	/
Uranium µg/L	1.55	1.44	1.595	1.56	1.9	7.23	15
Vanadium µg/L	0.9	0.597	0.703	0.578	0.51	4.55	100[d,e]
Zinc µg/L	2.8	2.46	1.525	1.42	1.7	14.8	30

Values represent means of total recoverable metal concentrations.

[a] Based on pH ≥ 6.5

[b] Based on water hardness > 180mg/L (as CaCO3)

[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.