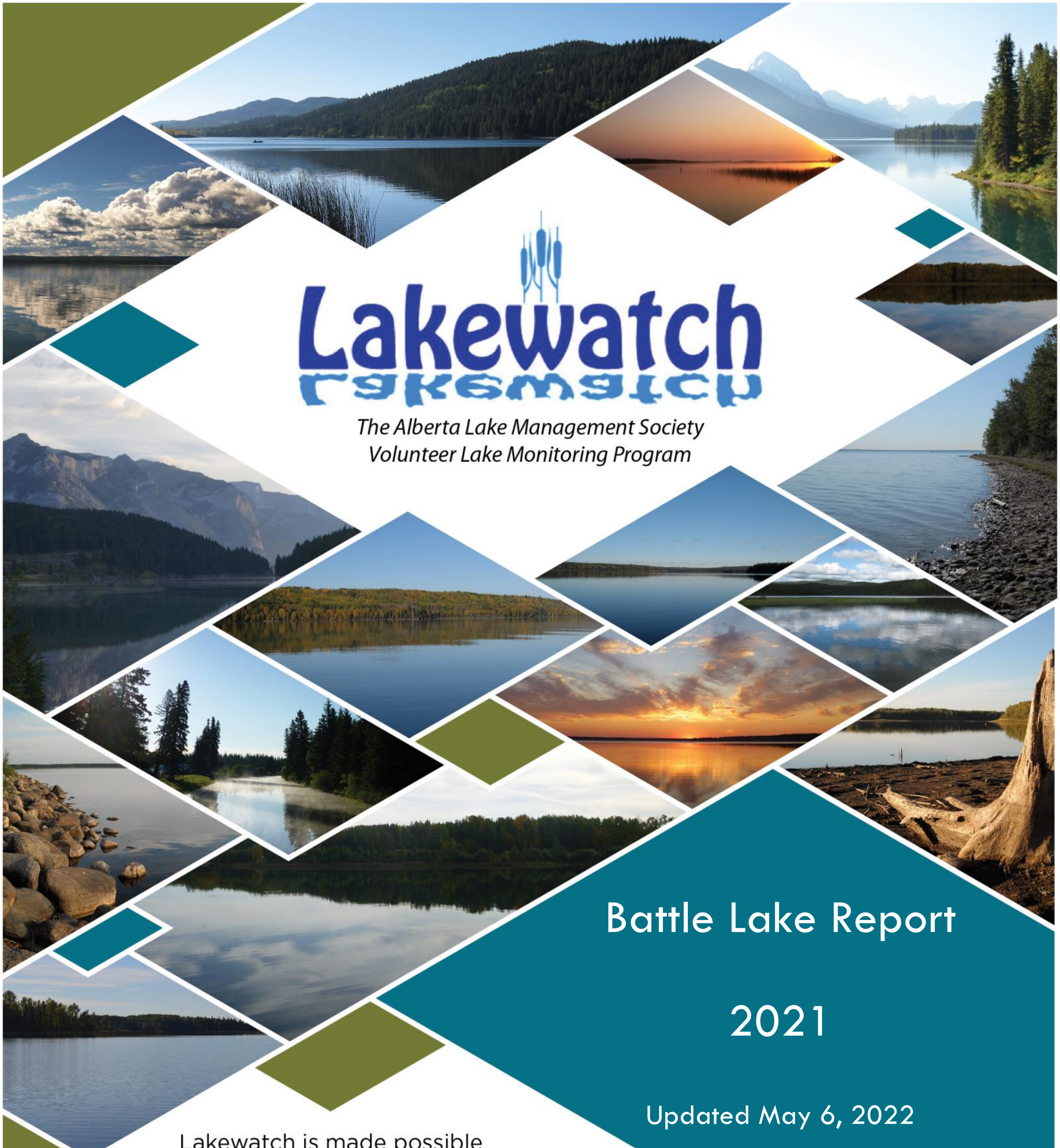

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Battle Lake Report

2021

Updated May 6, 2022

Lakewatch is made possible with support from:

Alberta
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ALBERTA LAKE MANAGEMENT SOCIETY'S LAKEWATCH PROGRAM

LakeWatch has several important objectives, one of which is to collect and interpret water quality data from Alberta's Lakes. Equally important is educating lake users about aquatic environments, 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 the widest 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 leaders in stewardship give us hope that our water resources will not be the limiting factor in the health of our environment.

If you require data from this report, please contact ALMS for the raw data files.

ACKNOWLEDGEMENTS

The LakeWatch program is made possible through the dedication of its volunteers. A special thanks to Sherry and Neil Christiansen for their commitment to collecting data at Battle Lake. We would also like to thank Keri Malanchuk and Brittany Onysyk, who were summer technicians in 2021. Executive Director Bradley Peter and Program Manager Caleb Sinn were instrumental in planning and organizing the field program. This report was prepared by Caleb Sinn and Bradley Peter.

BATTLE LAKE

Fall at Battle Lake. Photo by Brad Peter, 2012.

Battle Lake, located 102 km southwest of Edmonton, is a long lake nestled within a glacial meltwater channel which was formed during the Pleistocene. Battle Lake, the headwater for the Battle River, is fed by Battle Creek and several tributaries with an overall drainage basin of ~103 km^2.

Battle Lake derives its name from the frequent territorial battles which took place there between Blackfoot and Cree tribes. In 1900, settlers began arriving in the area, and logging activity began in 1904.[1] The industry warranted a small sawmill operation that was established in the 1920's. By 1944, logging had ended and today the area is maintained as a natural area for secondary recreational use (hiking, canoeing, relaxation, and sight seeing). It is zoned by the County of Wetaskiwin as a watershed protection district. Battle Lake's steep sided valley is connected to a steep ravine, carved by a creek that formed a delta along the west side of the lake. The terrain limits extensive agricultural use and few cottages are developed along the shoreline, except near the outlet (the lowest elevation). There is also a 4-H facility located on the southwestern shore and a public campground with boat launch on the southeastern shore. Oil and gas operators in the area restrict their activities through a unique watershed development plan that outlines restrictions in the lakes' riparian areas.[2] The Battle Lake Watershed Synergy Group (BLWSG), whose goal is to ensure effective and sensitive planning of oil and gas development, was key to the development and implementation of the plan. More information, published reports, and maps of current oil and gas activity in the watershed can be found at the BLSWG website.[3]

Battle Lake is 13.1 m in the deepest area (Fig. 1) of the basin. The substrate is sand and a few gravel shoals. Battle Lake is classified as eutrophic, or high nutrient levels, with clear water early in the summer and algal blooms occurring by late summer due to the mixing of phosphorus released from the sediments. Fishing for sport fish such as lake whitefish, pike, perch, and walleye is a popular activity.

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[1] Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press. Retrieved from http://sunsite.ualberta.ca/projects/alberta-lakes/

[2] http://www.synergyalberta.ca/docs/resources/battle_lake_watershed_pilot.pdf

[3] http://synergyalberta.ca/group/battle-lake-watershed-synergy-group

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 Battle Lake was 55 µg/L (Table 2), falling into the eutrophic, or highly productive trophic classification. This value falls within the range of historical averages. TP ranged from a minimum of 16 µg/L on the July 9th sampling event, and increased through the season to a maximum of 110 µg/L on September 14th (Figure 1).

Average chlorophyll-*a* concentration in 2021 was 19.6 µg/L (Table 2), falling into the eutrophic, or highly productive trophic classification. Chlorophyll-*a* was lowest earliest in the season, at 10.5 µg/L on July 9th and peaked at 30.9 µg/L on September 1st (Figure 1). Chlorophyll-*a* concentrations had a significantly positive correlation with TP ($r = 0.99$, $p = 0.009$).

The average TKN concentration was 0.8 mg/L (Table 2) and increased very slightly through the season, from 0.72 mg/L to 0.93 mg/L (Figure 2).

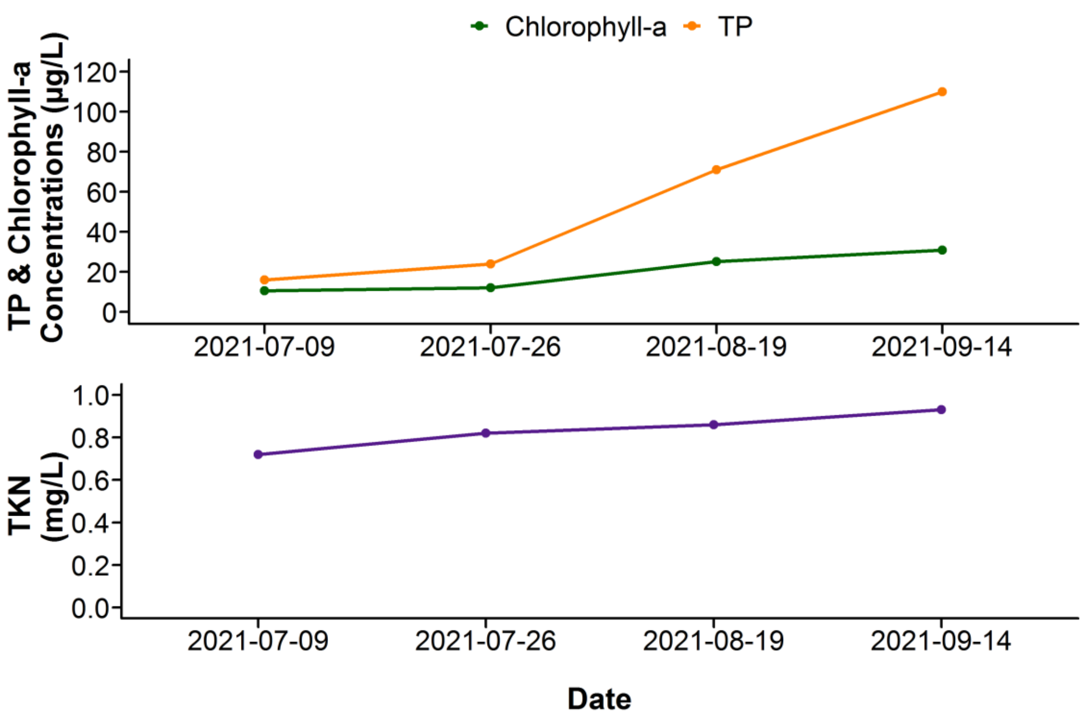

Figure 1. Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Battle Lake.

Average pH was measured as 8.46 in 2021, buffered by moderate alkalinity (198 mg/L $CaCO_3$) and bicarbonate (230 mg/L HCO_3). Aside from bicarbonate, sodium and calcium were higher than all other major ions, and together contributed to a low conductivity of 380 µS/cm (Figure 2, top; Table 2). Battle Lake is in the average to low end range of ion levels compared to other LakeWatch lakes sampled in 2021, with the exception of calcium, where it was slightly higher than most of the other lakes (Figure 2, bottom).

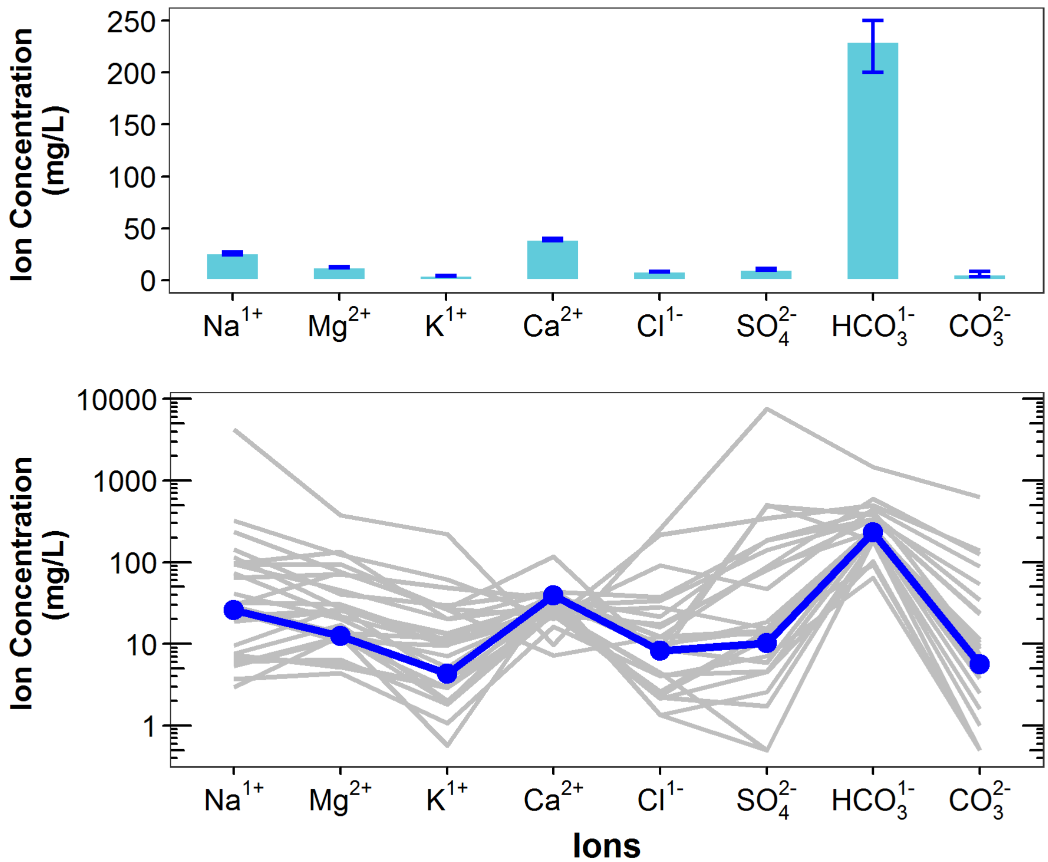

Figure 2. Average levels of cations (sodium = Na^{1+}, magnesium = Mg^{2+}, potassium = K^{1+}, calcium = Ca^{2+}) and anions (chloride = Cl^{1-}, sulphate = SO_4^{2-}, bicarbonate = HCO_3^{1-}, carbonate = CO_3^{2-}) from four measurements over the course of the summer at Battle Lake. Top) bars indicate range of values measured, and bottom) Schoeller diagram of average ion levels at Battle Lake (blue line) compared to 25 lake basins (gray lines) sampled through the LakeWatch program in 2021 (note $\log_{10}$ scale on y-axis of bottom figure).

METALS

Metals will naturally be present in aquatic environments due to in-lake processes or the erosion of rocks, or introduced to the environment from human activities such as urban, agricultural, or industrial developments. Many metals have a unique guideline as they may become toxic at higher concentrations. Where current metal data are not available, historical concentrations for 27 metals have been provided (Table 3).

Metals were not measured at Battle Lake in 2021, but Table 3 displays historical metal concentrations.

WATER CLARITY AND EUPHOTIC 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 euphotic depth of Battle Lake in 2021 was 6.34 m, corresponding to an average Secchi depth of 3.17 m (Table 2). Euphotic depth varied over the season, ranging from as deep as 8.2 m on July 9th to 5.0 m on August 19th (Figure 3). Interestingly, phytoplankton growth, as indicated by chlorophyll-a levels, did not change proportionally through the season to the changes seen in water clarity, as indicated by euphotic depth.

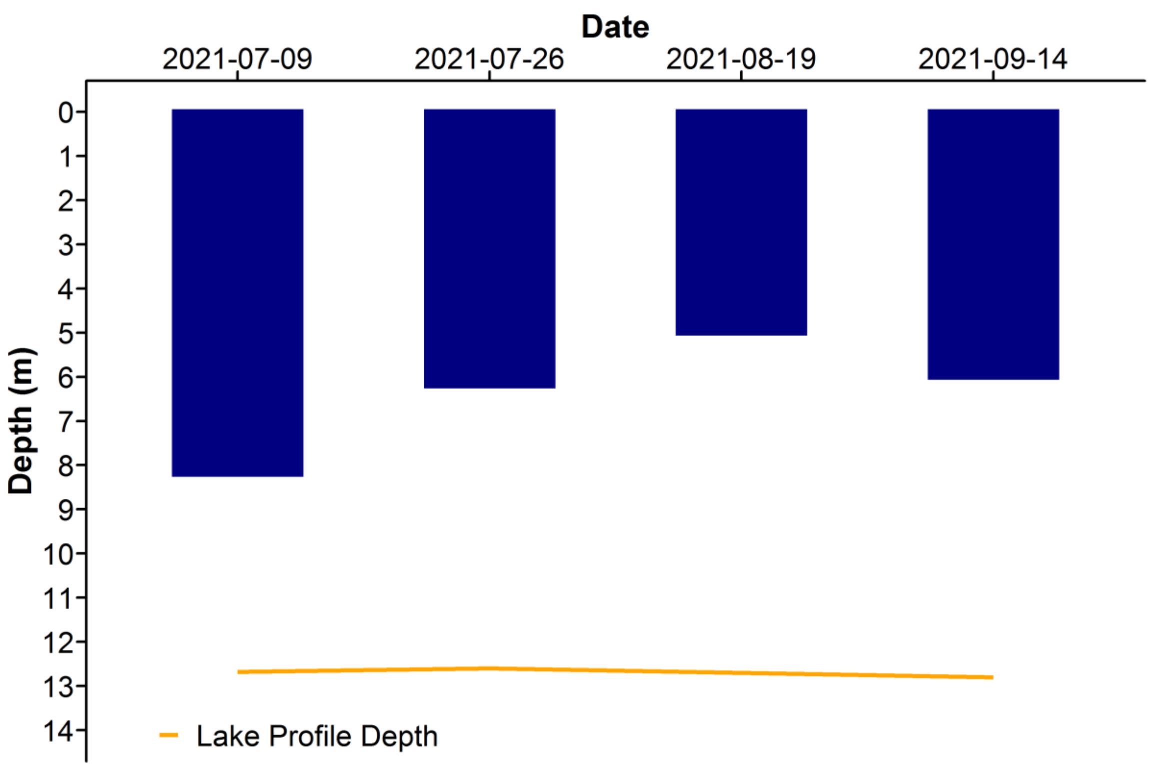

Figure 3. Euphotic depth values measured four times over the course of the summer at Battle Lake in 2021.

WATER TEMPERATURE AND DISSOLVED OXYGEN

Water temperature and dissolved oxygen (DO) 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.

Surface temperatures of Battle Lake varied throughout the summer, with the July 9th sampling date having the warmest temperatures at 24.6°C (Figure 4a). The lake was stratified during all sampling trips except September, and also displayed progressive deepening and weakening of the thermocline between the June and August sampling events.

Battle Lake was well oxygenated in the surface waters on all sampling dates, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen (Figure 4b). Surface levels were appreciably higher during the July 9th sampling event indicating high algal productivity likely due to high temperature and solar radiation (Figure 5). All dates displayed sharp decreases in oxygen between 5 – 11 m depth, below which oxygen was 0 mg/L.

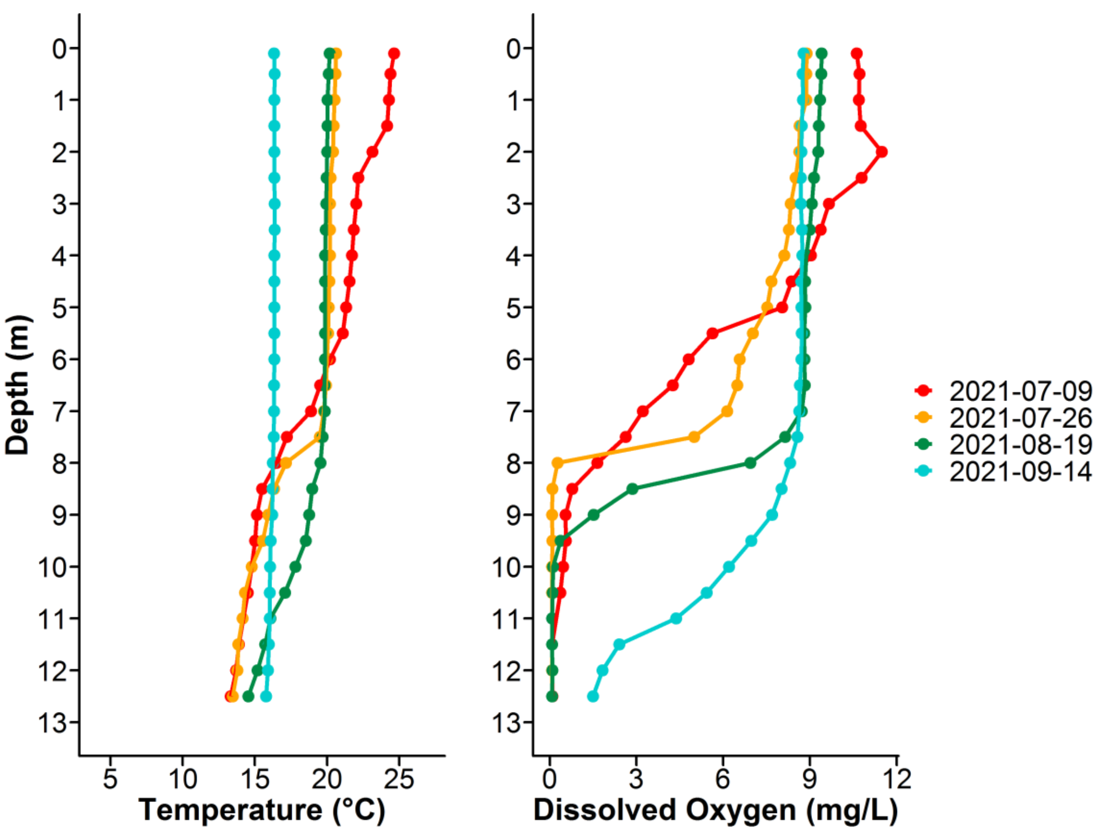

Figure 4. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Battle Lake measured four times over the course of the summer of 2021.

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 one of the most common cyanobacteria toxins. In Alberta, recreational guidelines for microcystin are set at 10 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 Battle Lake fell below the recreational guideline of 10 μg/L during every sampling event in 2021. Even though low levels of microcystin were detected, caution should always be observed when recreating around cyanobacteria.

Table 1. Microcystin concentrations measured four times at Battle Lake in 2021.

Date	**Microcystin Concentration (μg/L)**
9-Jul-21	0.11
26-Jul-21	0.37
19-Aug-21	0.25
14-Sep-21	0.90
Average	0.41

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 can change lake conditions which can then lead to toxic cyanobacteria blooms, decrease the amount of nutrients needed for fish and other native species, and cause millions of dollars in annual costs for repair and maintenance of water-operated infrastructure and facilities. Spiny water flea pose a concern for Alberta because they alter the abundance and diversity of native zooplankton, as they are aggressive zooplankton predators. Through over-predation, they will impact higher trophic levels such as fish. They also disrupt fishing equipment by attaching in large numbers to fishing lines.

Monitoring involved sampling with a 63 μm plankton net at three sample sites to look for juvenile mussel veligers and spiny water flea in each lake sampled. In 2021, no mussels or spiny water flea were detected at Battle Lake.

Eurasian watermilfoil is a non-native aquatic plant that poses a threat to aquatic habitats in Alberta because it grows in dense mats preventing light penetration through the water column, reduces oxygen levels when the dense mats decompose, and outcompetes native aquatic plants. Eurasian watermilfoil can look similar to the native Northern watermilfoil, thus genetic analysis is ideal for suspect watermilfoil species identification.

No suspect watermilfoil was observed or collected from Battle Lake in 2021.

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 at Battle Lake in 2021 remain near the historical average, but dropped relative to 2019 and 2020 (Figure 5).

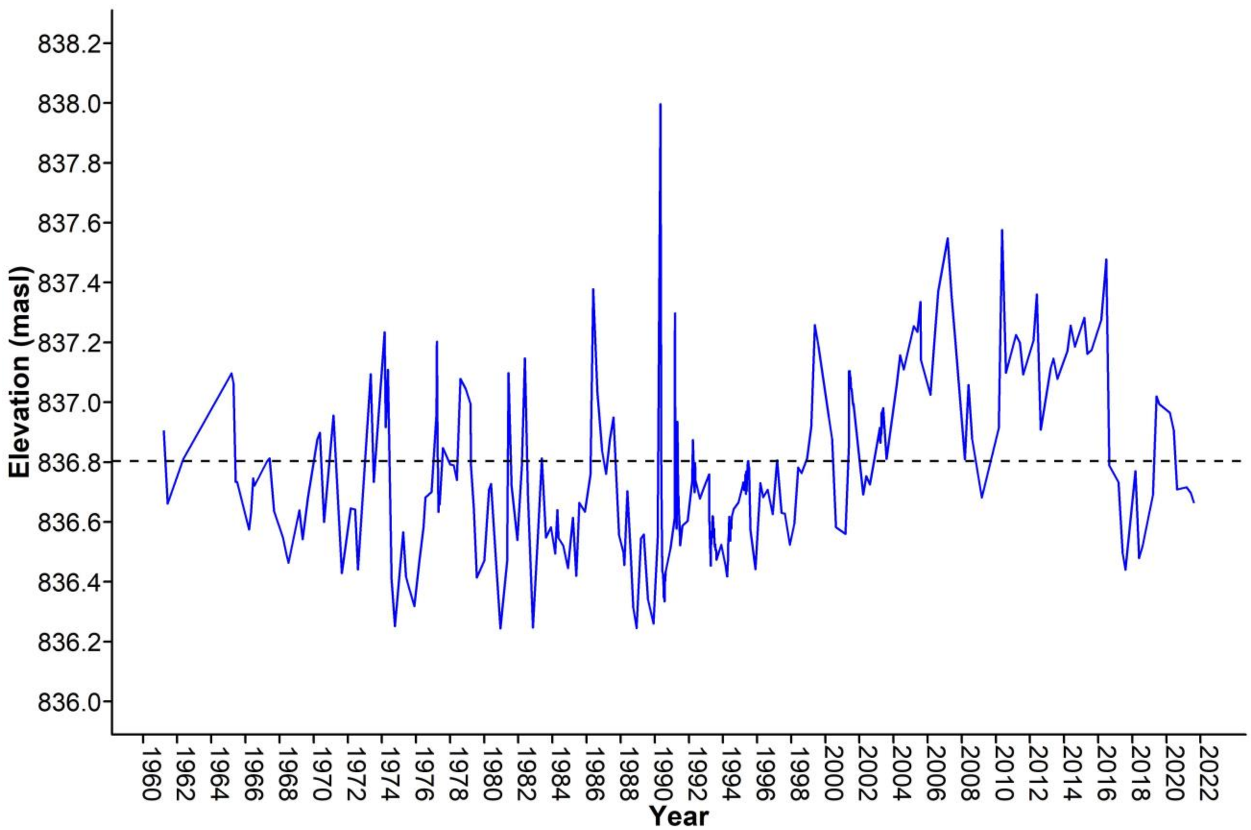

Figure 5. Water levels measured at Battle Lake in metres above sea level (masl) from 1961-2021. Data retrieved from Alberta Environment and Parks. Black dashed line represents historical yearly average water level.

WEATHER & LAKE STRATIFICATION

Air temperature will directly impact lake temperatures, and result in different temperature layers (stratification) throughout the lake, depending on its depth. Wind will also impact the degree to which a lake mixes, and how it will stratify. The amount of precipitation that falls within a lake's watershed will have important implications, depending on the context of the watershed and the amount of precipitation that has fallen. Solar radiation represents the amount of energy that reaches the earth's surface, and has implications for lake temperature & productivity.

Battle Lake experienced a warmer, less windy summer with slightly less solar radiation and average precipitation compared to normal (Figure 6). A warm spell prior to the July 9th sampling event resulted in relatively high surface temperatures. Calm spells through July and August maintained stratification, which disappeared by the September 14th sampling event with cooler temperatures and more wind.

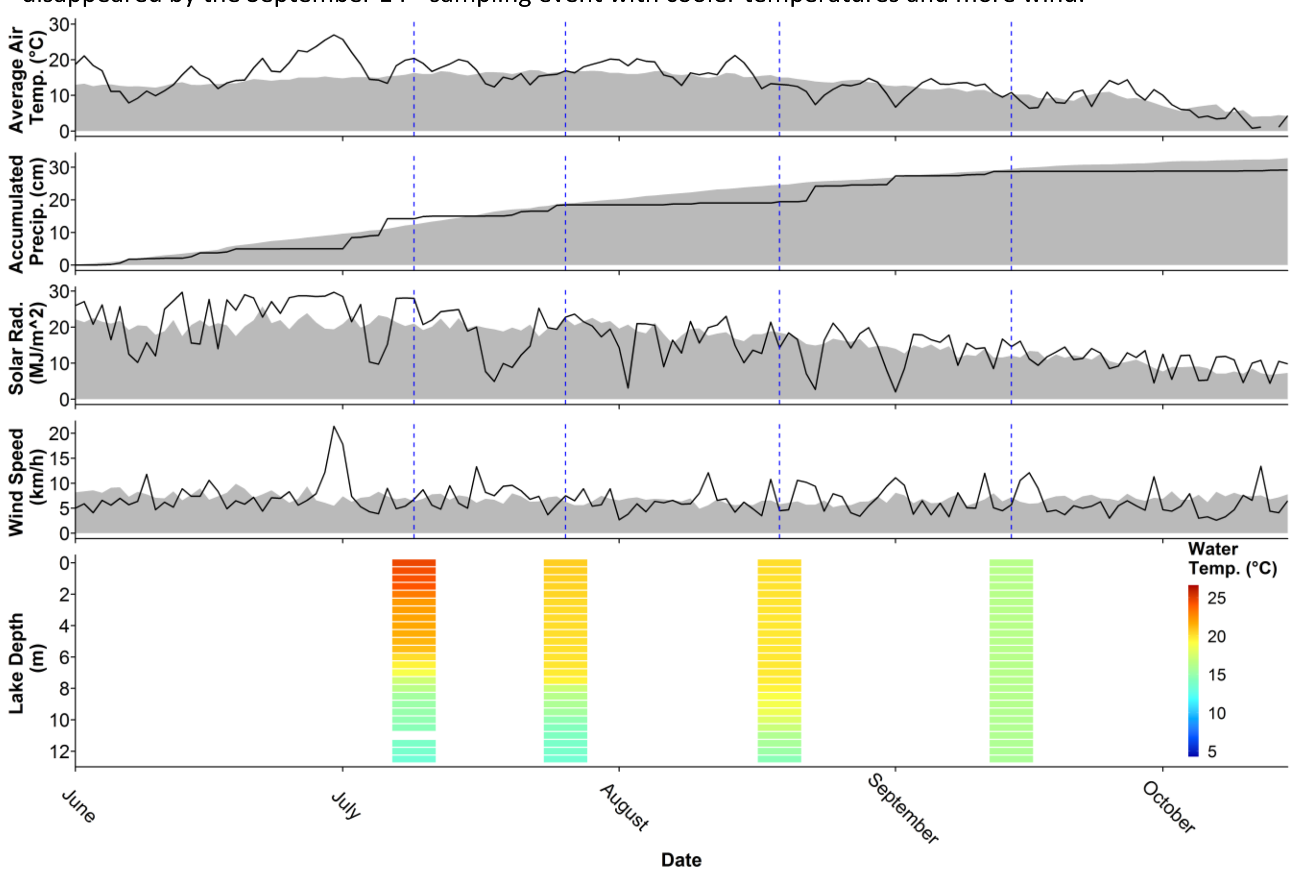

Figure 6. Average air temperature (°C) and accumulated precipitation (cm) measured from Battle River Headwaters, as well as solar radiation (MJ/m^2) and wind speed (km/h) measured from Breton Plots, with Battle Lake temperature profiles (°C) at the bottom. Black lines indicate 2021 levels, gray indicates long-term normals, and blue lines indicate sampling dates for Battle Lake over the summer. Further information about the weather data provided is available in the LakeWatch 2021 Methods report. Weather data provided by Agriculture, Forestry and Rural Economic Development, Alberta Climate Information Service (ACIS) https://acis.alberta.ca (retrieved April 2022).

Table 2. Average Secchi depth and water chemistry values for Battle Lake.

Parameter	1983	1984	1988	2003	2005	2012	2013	2021
TP (µg/L)	31	33	90	38	46	72	66	55
TDP (µg/L)	14	14	\	15	10	27	28	38
Chlorophyll-*a* (µg/L)	13.8	9.4	37.8	22.8	18.8	36.9	32.7	19.6
Secchi depth (m)	3.63	3.82	1.5	2.18	3.13	1.5	1.85	3.17
TKN (mg/L)	1	0.6	\	0.7	0.8	1.2	0.9	0.8
NO_2-N and NO_3-N (µg/L)	6	2	10	8	4	10	13	4
NH_3-N (µg/L)	33	14	\	22	25	62	39	31
DOC (mg/L)	9	9	\	\	8	11	\	10
Ca^{2+} (mg/L)	40	37	32	\	31	\	\	39
Mg^{2+} (mg/L)	10	10	10	\	11	\	\	12
Na^{+} (mg/L)	20	20	20	23	24	23	24	26
K^{+} (mg/L)	3	3	4	4	4	4	\	4
SO_4^{2-} (mg/L)	10	9	4	10	8	10	7	10
Cl^{-} (mg/L)	1	1	1	3	4	5	5	8
CO_3^{2-} (mg/L)	3	4	2	7	4	5	4	6
HCO_3^{-} (mg/L)	207	215	181	187	202	196	198	230
pH	8.4	8.4	8.25	8.57	8.38	8.44	8.44	8.46
Conductivity (µS/cm)	347	352	301	\	338	341	334	380
Hardness (mg/L)	138	134	123	132	123	122	126	150
TDS (mg/L)	189	190	163	187	187	184	185	225
Microcystin (µg/L)	\	\	\	\	\	4.21	\	0.41
Total Alkalinity (mg/L $CaCO_3$)	175	181	151	166	172	169	169	198

Table 3. Concentrations of metals measured in Battle Lake. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference. Note that metal sample collection method changed in 2016 from composite to single surface grab at the profile location.

Metals (Total Recoverable)	2003	2005	2012	Guidelines
Aluminum µg/L	17.86	28.2	12.26	100[a]
Antimony µg/L	0.09	0.083	0.08055	/
Arsenic µg/L	1.64	1.41	3.125	5
Barium µg/L	70.9	69	60.25	/
Beryllium µg/L	0.089	0.0015	0.015	100[c,d]
Bismuth µg/L	0.0052	0.0005	0.0005	/
Boron µg/L	27.4	27.6	38.7	1500
Cadmium µg/L	0.0187	0.0106	0.01005	0.19[b]
Chromium µg/L	0.22	0.132	0.1203	/
Cobalt µg/L	0.0307	0.047	0.0303	50,1000[c,d]
Copper µg/L	0.96	0.56	0.4365	2.80[b]
Iron µg/L	21	25	10.15	300
Lead µg/L	0.084	0.079	0.05725	4.10[b]
Lithium µg/L	5.47	7.7	6.505	2500[d]
Manganese µg/L	28.3	17	85.2	250[e]
Molybdenum µg/L	1.31	1.26	1.054	73
Nickel µg/L	0.297	0.45	0.05575	111.2[b]
Selenium µg/L	0.37	0.05	0.0785	1
Silver µg/L	0.0037	0.00025	0.0011	0.25
Strontium µg/L	307.7	341	280	/
Thallium µg/L	0.0126	0.029	0.00095	0.8
Thorium µg/L	0.0015	0.0006	0.00015	/
Tin µg/L	0.05	0.015	0.04815	/
Titanium µg/L	0.83	0.88	0.841	/
Uranium µg/L	0.5793	0.584	0.4335	15
Vanadium µg/L	0.35	0.295	0.26	100[c,d]
Zinc µg/L	1.76	2.8	0.4415	30[f]

Values represent means of total recoverable metal concentrations.

[a] Based on pH ≥ 6.5

[b] Based on 2012 avg. water hardness (as CaCO3) with CCME equation

[c] Based on CCME Guidelines for Agricultural use (Livestock).

[d] Based on CCME Guidelines for Agricultural Use (Irrigation).

[e] Based on CCME Manganese variable calculation (https://ccme.ca/en/chemical/129#_aql_fresh_concentration), using 2012 avg. water hardness (as CaCO3) and avg. pH

[f] Based on 2012 avg. water hardness (as CaCO3), avg. pH, and avg. DOC with CCME equation

A forward slash (/) indicates an absence of data or guidelines