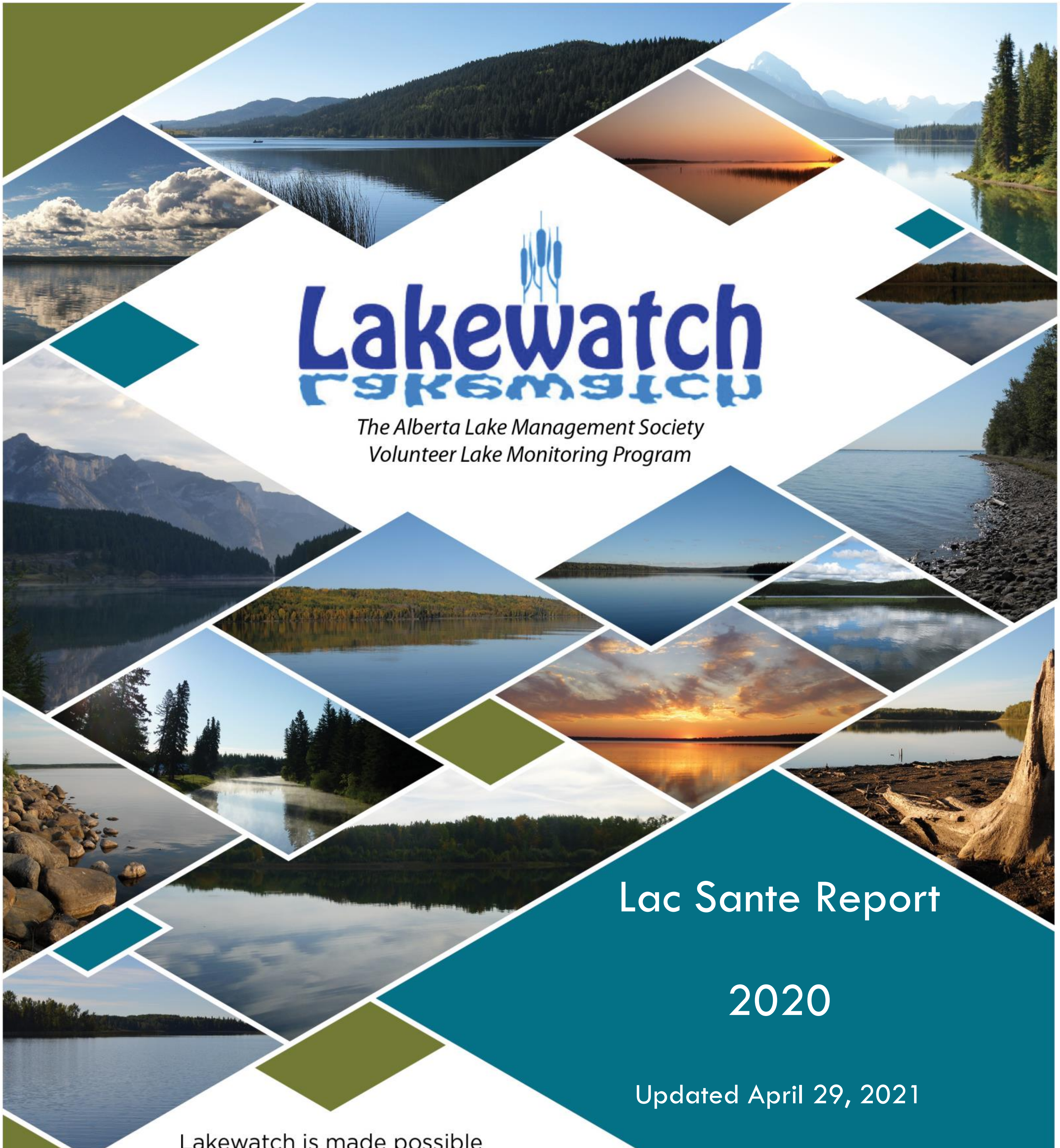

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Lac Sante Report

2020

Updated April 29, 2021

Lakewatch is made possible
with support from:

Alberta Environment and Parks

Pigeon Lake Watershed Association

Moose Lake Watershed Society

Lacombe County

LICA Environmental Stewards

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 Terry Noble for his commitment to collecting data at Lac Sante. We would also like to thank Kyra Ford and Ryan Turner, who were summer technicians in 2020. 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.

LAC SANTE

Shoreline of Lac Sante – Photo by Pauline Pozsonyi

Lac Sante is a moderately sized lake located northeast of the Town of Two Hills. It is a multi-basin lake, and the maximum depth of the deepest basin is ~25 m. Lac Sante's catchment is largely devoted to agricultural practices and its shoreline is well developed. The southern-most basin is the largest and deepest of four basins. The three other basins (to the northeast) are smaller and all of similar depth (15-19 m; Figure 2). Lac Santé is a dimictic lake, undergoing thermal stratification during the open water season.

The lake is located approximately 140 km northeast of Edmonton. To get to this lake, take Hwy 16 east for 86 km, turn left onto Hwy 63 for 29 km, followed by a left on Hwy 46 (past the town of Two Hills), crossing the North Saskatchewan River. Turn east on the first paved road north of the river and continue for 13 km to the lake. The boat launch is situated amongst a cluster of private lots. All campgrounds along the shores of this lake are privately owned; however, boats may be launched at the county boat launch.

The watershed area for Lac Sante is 144.99 km^2 and the lake area is 11.30 km^2. The lake to watershed ratio of Lac Sante is 1:13. A map of the Lac Sante watershed area can be found at: https://alms.ca/wp-content/uploads/2016/12/Lac-Sante.pdf

A significant bloom of green algae was observed in June 2020. This bloom created offensive odours and had the potential to impede recreation. Local stewards attempted to remove the algae as the bloom was washed onto the shore. A significant wind event may have lifted this bloom from the lake bottom, as green algae species that cause these blooms are generally lake bottom dwelling (benthic).

Lac Sante benthic green algae bloom 2020 – Photo by Terry Noble

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. For select lakes, metals are collected at the profile site by hand grab from the surface on one visit over the season.

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 Bureau Veritas, chlorophyll-*a* and metals are analyzed by Innotech Alberta, and microcystin is analyzed by the Alberta Centre for Toxicology (ACTF).

Invasive Species: : Invasive mussel monitoring involved sampling with a 63 µm plankton net at three sample sites twice through the summer season to determine the presence of juvenile dreissenid mussel veligers, and spiny water flea. Technicians also harvested potential Eurasian watermilfoil (*Myriophyllum spicatum)* samples and submitted them for further analysis at the Alberta Plant Health Lab to genetically differentiate whether the sample was the invasive Eurasian watermilfoil or a native watermilfoil. In addition, select lakes were subject to a bioblitz, where a concerted effort to sample the lake's aquatic plant diversity took place.

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 www.alberta.ca/surface-water-quality-data.aspx.

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 total phosphorus (TP), chlorophyll-*a,* total kjeldahl nitrogen (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. For lakes with >10 years of long term data, trend analysis is done with non-parametric methods. The seasonal Kendall test estimates the presence of monotonic (unidirectional) trends across individual seasons (months) and is summed to give an overall trend over time. For lakes that had multiple samplings in a single month, the value closest to the middle of the month was used in analysis

[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 Sante was 50 µg/L (Table 2), falling into the eutrophic, or highly productive trophic classification. This value is within the range of historical averages for Lac Sante. TP was lowest when sampled on September 11th at 39 µg/L, and was highest at 60 µg/L on June 22nd (Figure 1).

Average chlorophyll-*a* concentration in 2020 was 18 µg/L (Table 2), falling into the eutrophic, or highly productive trophic classification. Chlorophyll-*a* was lowest at the start of the season, with a minimum of 2.0 µg/L on June 22, then increased in July to a maximum of 24.3 µg/L, and remained above 20 µg/L in the August and September sampling events (Figure 1).

Finally, the average TKN concentration was 2.5 mg/L (Table 2) with concentrations being consistently between 2.3 and 2.7 mg/L on each individual sampling event throughout the 2020 sampling season.

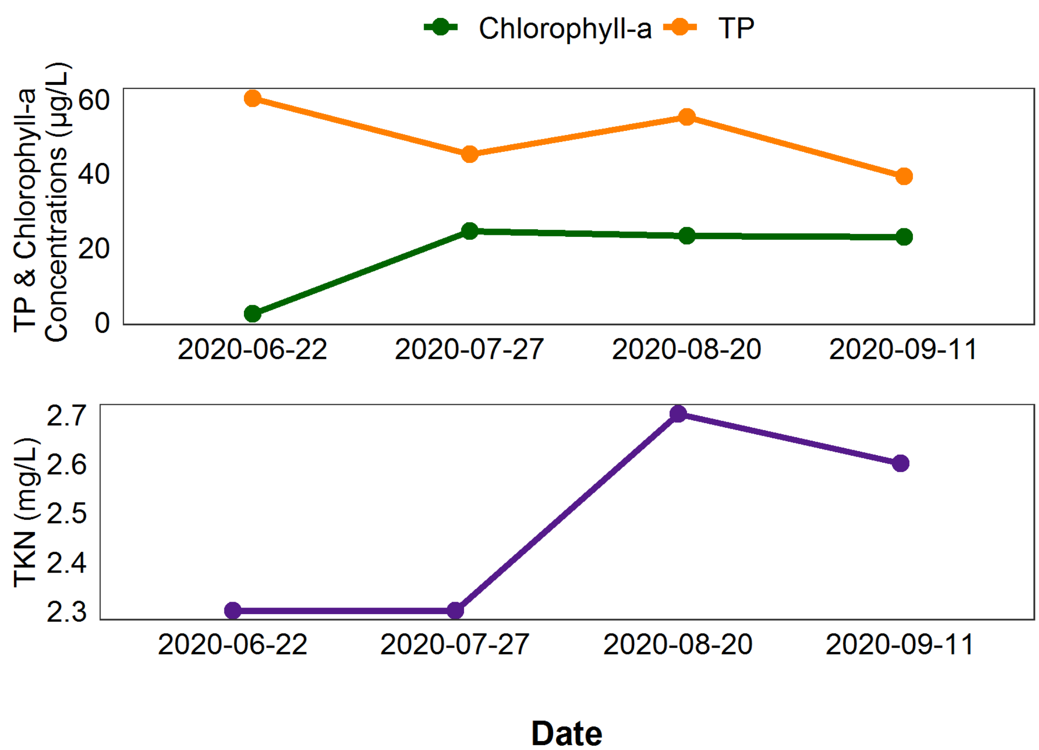

Figure 1. Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Lac Sante.

Average pH was measured as 9.04 in 2020, buffered by high alkalinity (815 mg/L $CaCO_3$) and bicarbonate (688 mg/L HCO_3). Aside from bicarbonate, the dominant ions were sulphate, carbonate, sodium and magnesium, contributing to a high conductivity of 1900 µS/cm (Figure 2, top; Table 2). Lac Sante is on the high end of ion levels compared to other LakeWatch lakes sampled in 2020 (Figure 2, bottom). Lac Sante had the highest levels of magnesium, potassium, sulphate, and bicarbonate, but also was on the low end of calcium levels.

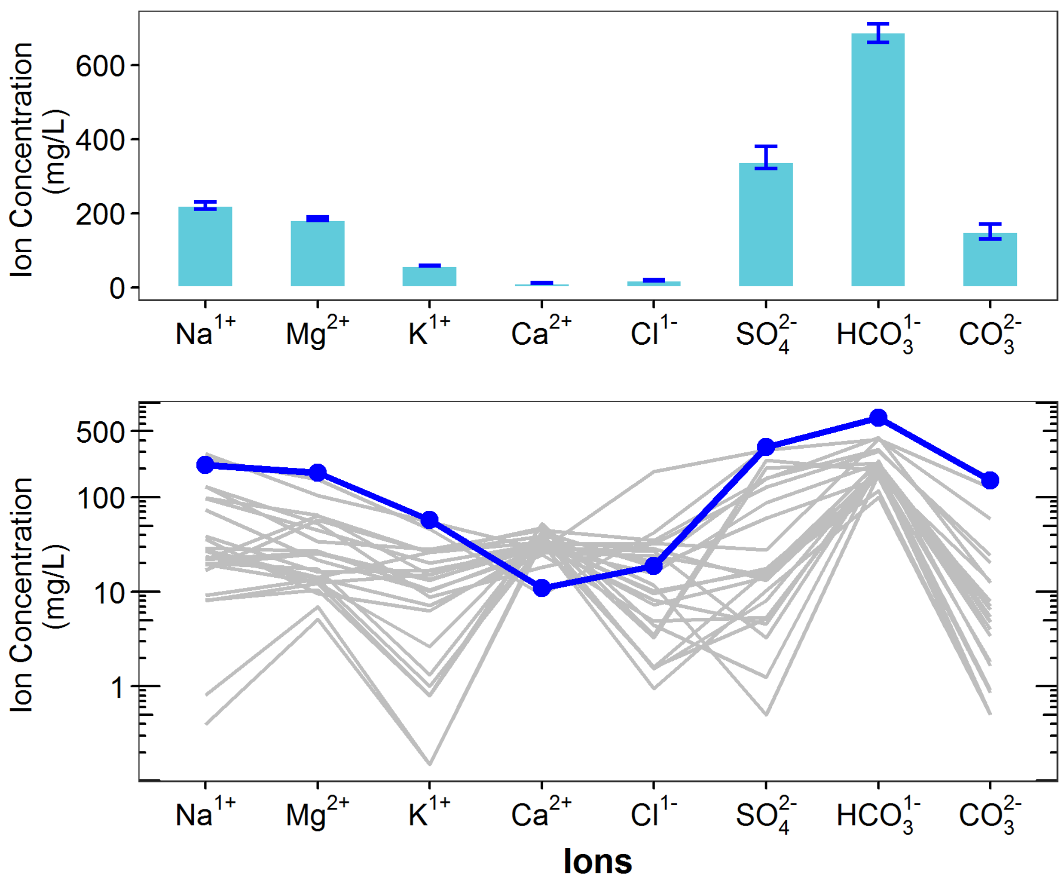

Figure 2. Average levels of cations (sodium = Na^{1+}, magnesium = Mg^{2+}, potassium = K^{1+}, calcium = Ca^{2+}) and anions (chloride = Cl^{1-}, sulphate = SO_4^{2-}, bicarbonate = HCO_3^{1-}, carbonate = CO_3^{2-}) from four measurements over the course of the summer at Lac Sante. Top) bars indicate range of values measured, and bottom) Schoeller diagram of average ion levels at Lac Sante (blue line) compared to 25 lake basins (gray lines) sampled through the LakeWatch program in 2020 (note $\log_{10}$ scale on y-axis of bottom figure).

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 were not measured at Lac Sante in 2020. 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 Lac Sante in 2020 was 7.21 m corresponding to an average Secchi depth of 3.61 m, which is on the low end of the historical range of average Secchi values (Table 2). Euphotic depth was high during the June 22nd sampling event, and then decreased sharply in July, and remained lower through August and September (Figure 3). Secchi depth was significantly negatively correlated with chlorophyll-*a* ($r = -0.97$, $p = 0.025$).

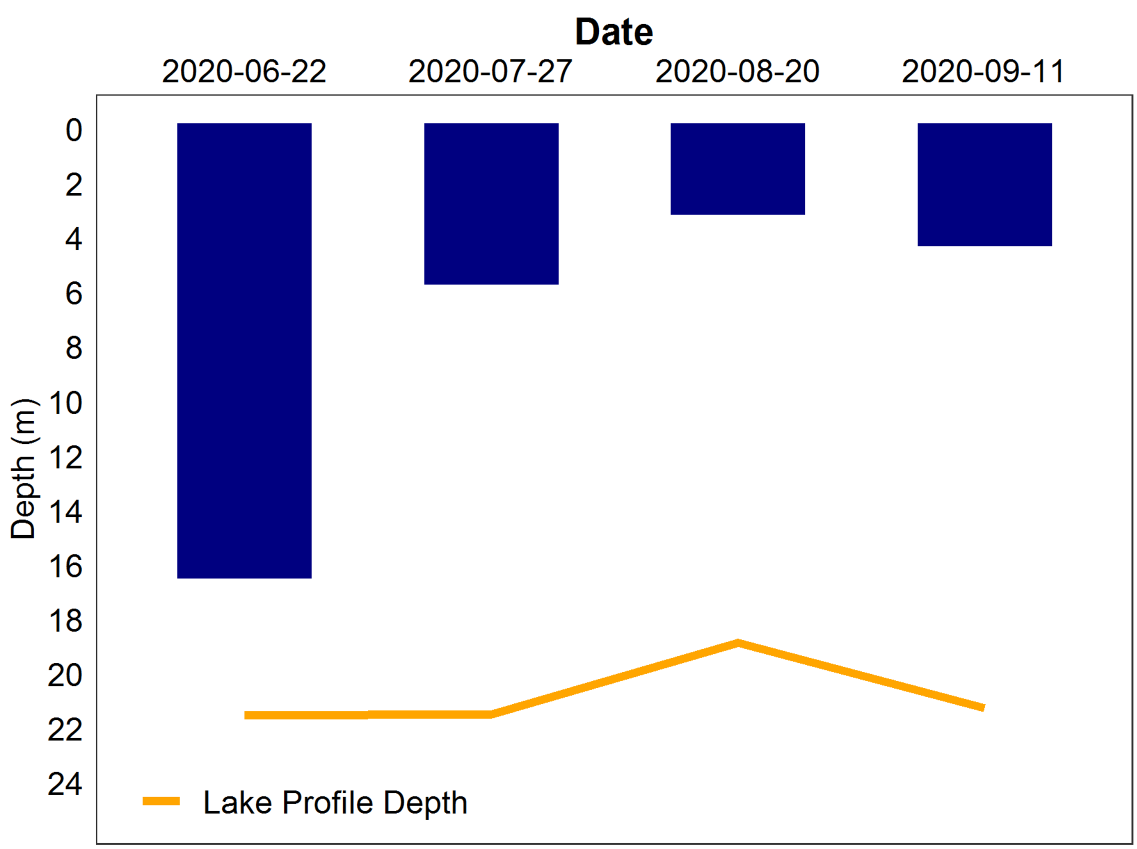

Figure 3. Secchi depth values measured four times over the course of the summer at Lac Sante in 2020.

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.

Temperatures of Lac Sante varied throughout the summer, with a minimum temperature of 6.3°C at 21.5 m on June 22nd, and a maximum temperature of 20.5°C measured at the surface on August 20th (Figure 4a). The lake was stratified during all of the sampling trips, with a steep drop in temperature and dissolved oxygen between 7.5 and 13 m below the surface. This indicates that the top and bottom of the water column mix little throughout the open water season.

Lac Sante remained well oxygenated through the upper layer of the water column during the summer, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen (Figure 4b). The oxygen level fell below this guideline below 8 to 13 m depending on the sampling date, due to a lack of mixing with the warmer water on the surface. This is typical for a stratified lake such as Lac Sante.

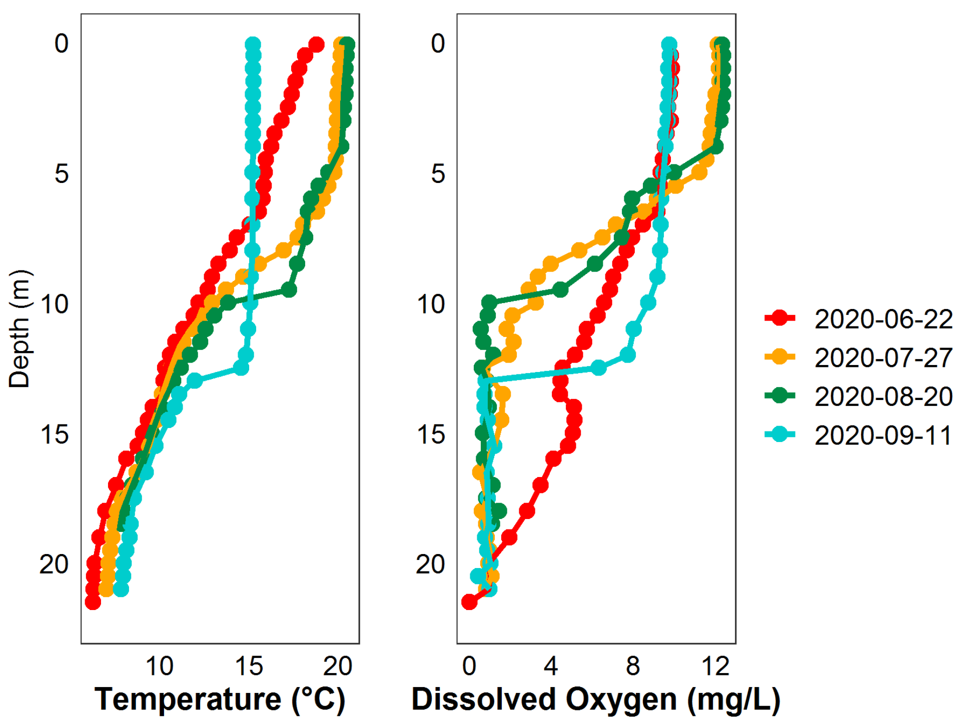

Figure 4. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Lac Sante measured four times over the course of the summer of 2020.

MICROCYSTIN

Microcystins are toxins produced by cyanobacteria (blue-green algae) which, can cause severe liver damage when ingested and skin irritation with prolonged contact. 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 of composited samples from Lac Sante fell below the recreational guideline of 20 μg/. Despite microcystin concentrations remaining low throughout the summer, caution should be observed when recreating in visible cyanobacteria blooms, which were identified at Lac Sante in the summer of 2020.

Table 1. Microcystin concentrations measured four times at Lac Sante in 2020.

Date	Microcystin Concentration (μg/L)
22-Jun-20	0.15
27-Jul-20	1.46
20-Aug-20	1.53
11-Sep-20	0.80
Average	0.99

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 2020, no mussels or spiny water flea were detected at Lac Sante.

Eurasian watermilfoil is 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 Lac Sante in 2020.

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.

Although water levels in Lac Sante were steady for the first decade of monitoring beginning in the 1968, levels decreased steadily over the next 4 decades until a low in 2015 (Figure 5). In this time, levels dropped more than 4 m. Since 2015, levels have increased about 1 m.

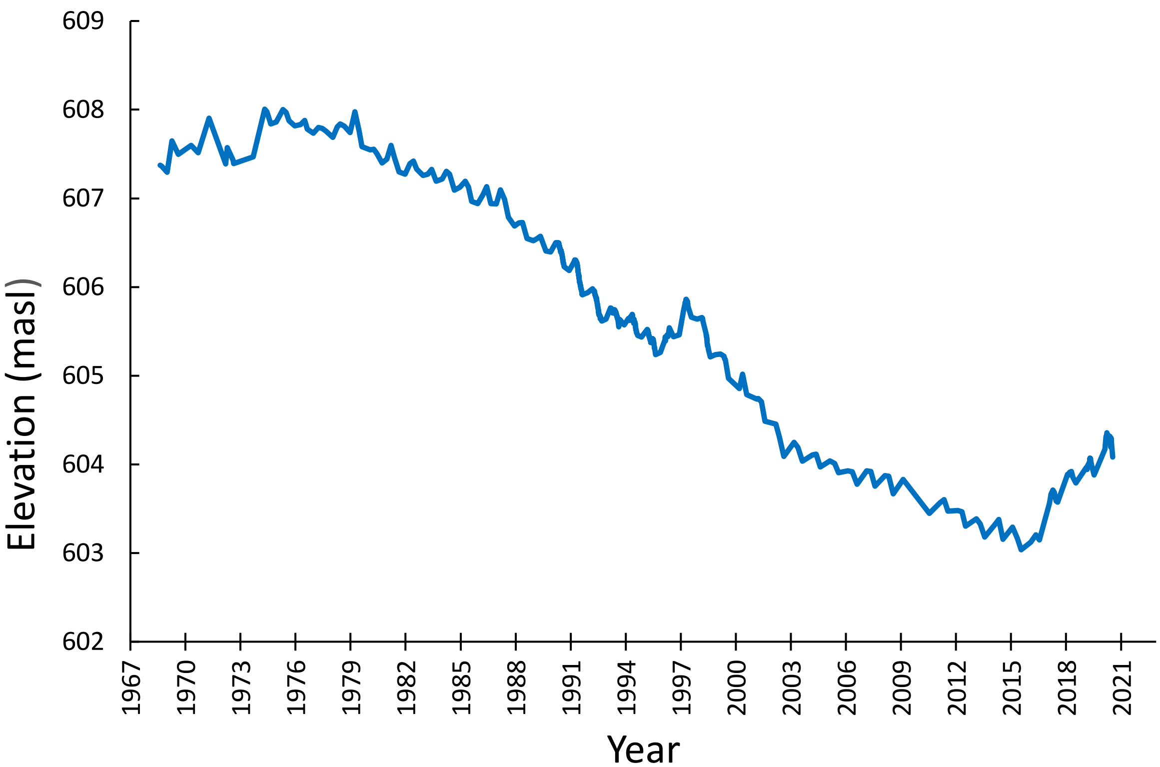

Figure 5. Water levels at Lac Sante measured in meters above sea level (masl) from 1968- 2020. Data retrieved from Alberta Environment and Parks.

Table 2. Average Secchi depth and water chemistry values for Lac Sante. Historical values are given for reference.

Parameter	1999	2006	2007	2008	2009	2011	2012	2015	2020
TP (µg/L)	49	61	49	52	61	61	47	43	50
TDP (µg/L)	33	46	32	29	39	32	36	20	33
Chlorophyll-*a* (µg/L)	5.3	7.3	7.1	3.5	7.7	7.2	2.9	5.1	18
Secchi depth (m)	/	4.76	3.25	4.83	5.75	3.90	6.83	5.08	3.61
TKN (mg/L)	2.1	2.3	2.0	2.2	2.3	2.3	2.2	2.2	2.5
NO_2-N and NO_3-N (µg/L)	5	4	202	7	11	5	4	3	15
NH_3-N (µg/L)	46	151	32	34	40	40	33	51	89
DOC (mg/L)	26	31	31	27	30	29	29	30	25
Ca (mg/L)	9	/	/	/	/	/	/	8	11
Mg (mg/L)	156	/	/	/	/	/	/	190	183
Na (mg/L)	174	210	215	207	218	218	217	213	220
K (mg/L)	45	49	51	50	55	52	57	55	58
SO_4^{2-} (mg/L)	264	295	273	283	320	294	318	332	338
Cl^- (mg/L)	15	16	16	16	17	17	17	19	19
CO_3 (mg/L)	125	148	147	140	144	143	150	172	150
HCO_3 (mg/L)	719	791	790	808	821	826	830	812	688
pH	9.10	9.15	9.12	9.00	9.10	9.10	9.13	9.12	9.04
Conductivity (µS/cm)	1700	1873	1880	1887	1918	1940	1985	2000	1900
Hardness (mg/L)	664	756	740	648	677	702	652	804	775
TDS (mg/L)	1138	1293	1275	1253	1325	1307	1330	1400	1325
Microcystin (µg/L)	/	0.66	0.68	0.17	0.13	/	0.19	0.21	0.99
Total Alkalinity (mg/L $CaCO_3$)	795	895	892	897	913	916	931	952	815

Table 3. Concentrations of metals measured in Lac Sante on in each sampling year since 2011. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference. Values exceeding these guidelines are presented in red.

Metals (Total Recoverable)	2011	2012	2015	Guidelines
Aluminum µg/L	20.1	22	14.05	100[a]
Antimony µg/L	0.1525	0.159	0.1395	/
Arsenic µg/L	5.43	5.62	4.06	5
Barium µg/L	4.36	4.69	22.595	/
Beryllium µg/L	0.00435	0.016	0.011	100[c,d]
Bismuth µg/L	0.0018	0.0005	0.01225	/
Boron µg/L	434	378	259	1500
Cadmium µg/L	0.00425	0.0189	0.0035	0.26[b]
Chromium µg/L	0.3045	0.362	0.245	/
Cobalt µg/L	0.09975	0.119	0.0795	1000[d]
Copper µg/L	1.2235	1.03	0.99	4[b]
Iron µg/L	14.425	18.1	18.15	300
Lead µg/L	0.02425	0.0202	0.077	7[b]
Lithium µg/L	261.5	205	140.75	2500[e]
Manganese µg/L	5.625	3.68	14.935	200[e]
Molybdenum µg/L	1.14	1.26	0.816	73[c]
Nickel µg/L	0.2125	0.506	0.3475	150[b]
Selenium µg/L	0.349	0.239	0.065	1
Silver µg/L	0.015725	0.0167	0.002	0.25
Strontium µg/L	22.3	23.1	88.85	/
Thallium µg/L	0.000425	0.0004	0.0139	0.8
Thorium µg/L	0.02115	0.00015	0.005925	/
Tin µg/L	0.015	0.0375	0.034	/
Titanium µg/L	1.42	1.35	1.675	/
Uranium µg/L	4.575	4.55	3.1855	15
Vanadium µg/L	1.365	1.62	0.935	100[d,e]
Zinc µg/L	1.345	1.39	1	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.