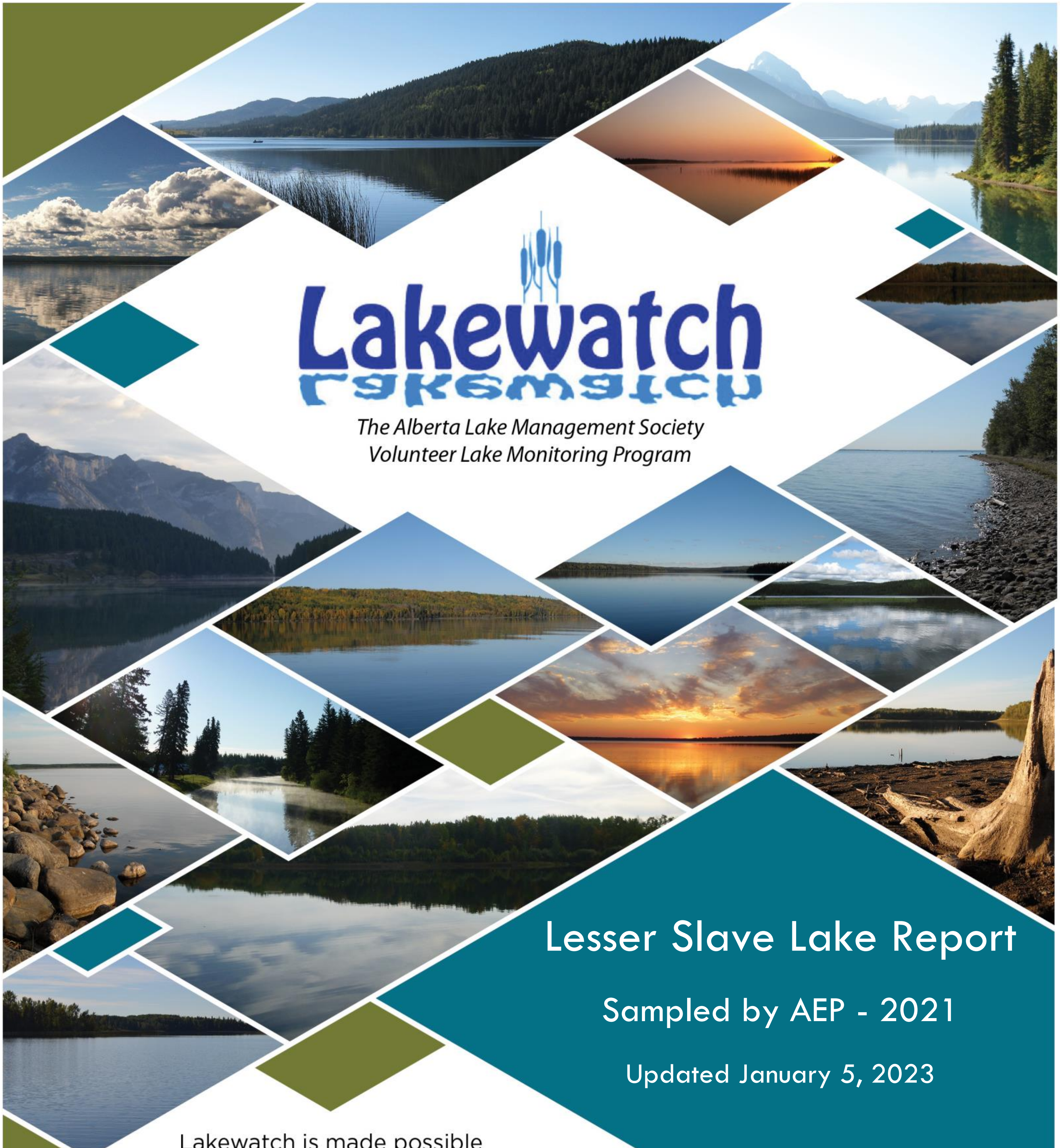

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Lesser Slave Lake Report

Sampled by AEP - 2021

Updated January 5, 2023

Lakewatch is made possible with support from:

Alberta
LICA Environmental Stewards
Pigeon Lake Watershed Association
MD 61 Wainwright
Alberta Ecotrust
Discover Hardisty - More than you imagine
Municipal District Bonnyville No. 87

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

Lesser Slave Lake was sampled by Alberta Environment and Parks (AEP) in 2021. A report summarizing the data collected in 2021 was requested by the Lesser Slave Watershed Council (LSWC). This report was prepared by Caleb Sinn and Bradley Peter (ALMS), and Meghan Payne (LSWC).

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

LESSER SLAVE LAKE

Lesser Slave Lake is located in the Municipal District of Lesser Slave River, and Big Lakes County, approximately 250 km northwest of the city of Edmonton in the Lesser Slave Lake watershed. Lesser Slave Lake is the third largest lake in the province and is the central feature of the watershed. [1] The watershed supports strong agricultural, forestry, and oil and gas industries, and is a tourist destination for people who are drawn to the lake for the abundant recreation and sport-fishing opportunities.

Lesser Slave Lake, photo by S. Riemersma, from the Lesser Slave Integrated Watershed Management Plan report, April 2018.

The lake's name refers to the original inhabitants of the land near the lake, the Slavey people. In more recent times, the lakeshore was inhabited by the Cree, and then later on, also by fur traders who set up fur trading posts throughout the lake's watershed.[1]

The main sport fish are northern pike (Esox lucius), yellow perch (Perca flavescens), walleye (Sander vitreus), burbot (Lota lota), and lake whitefish (Coregonus clupeaformis). Lake trout used to be abundant in the lake, but were extirpated from the lake in the early 1990s.[1]

Lesser Slave Lake has a large drainage basin covering an area of 12,400 km^2, mostly to the south, west, and northwest of the lake. The main outlet, the Lesser Slave River, flows from the southeast end of the lake to the Athabasca River, approximately 50 km downstream. Lesser Slave Lake has a surface area of 1,160 km^2, making it one of Alberta's largest lakes, with a moderate maximum depth of 20.5 m in the centre of the east basin, and an average depth of 11.4 m.[1]

[1] Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press.

METHODS

Profiles: Profile data was measured at the deepest spot in the main basin of the lake using a multi-meter probe. At the profile site, temperature, dissolved oxygen, pH, conductivity and redox potential were measured at 0.5 – 1.0 m intervals. Additionally, Secchi depth was measured at the profile site and used to calculate the euphotic zone. If the calculated depth of the euphotic zone is greater than the depth of the lake, then the euphotic zone was recorded as the depth of the lake. Metals were collected at the profile site, by hand grab, from the surface on one visit over the season. Metals were also sampled from near the bottom of the lake using a Kemmerer.

Composite samples: At 15-sites across the lake, water was collected from the euphotic zone using weighted tygon tubing with a one-way foot valve and combined across sites into one composite sample. This water was 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.

Sample Analysis: AEP used the following accredited labs for analysis: Routine water chemistry and nutrients were analyzed by Bureau Veritas, chlorophyll-*a* and metals were analyzed by Innotech Alberta, and microcystin was analyzed by the Alberta Centre for Toxicology (ACFT).

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.

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 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 was done using the program R.[2] Data was reconfigured using packages tidyr[3] and dplyr[4] and figures are produced using the package ggplot2.[5] Trophic status for each lake is classified based on lake water characteristics using values from Nurnberg (1996).[6] 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.

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[2] 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/.

[3] 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.

[4] 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.

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

[6] 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.

Weather data incorporated into this report to contextualize lake temperature, mixing and stratification was accessed through the 'Weather Station Data' tool from the Alberta Climate Information Service (ACIS; http://agriculture.alberta.ca/acis/weather-data-viewer.jsp). Data represented in the 'Weather & Lake Stratification' figures in the LakeWatch 2021 reports are daily data, from June 1st, 2021 to October 15th, 2021. Parameters incorporated are 'Observed Temperature,' 'Normal Temperature,' 'Observed Accumulated Precipitation,' 'Normal Accumulated Precipitation,' 'Total Solar Radiation at 2m,' 'Normal Total Solar Radiation Energy,' 'Wind Speed at 10m' or 'Wind Speed at 2m, and Normal Average Wind Speed at 10 meter height.' Note that normal data represents average data that has been interpolated, from 1961 – 2018.[7] For each basin, the weather station was selected to best represent the weather conditions that lake experienced, based on proximity to that lake's profile sampling location. Weather stations selected for temperature and precipitation data were all within 25km of the lake's profile location, with the exception of Lesser Slave Lake East (~27km). If wind and solar radiation data was not available for the weather station in closest proximity, then this data was accessed at the next closest weather station, within 40km from the profile location of the lake.

Water level data incorporated into the reports is accessed online from either Alberta Environment and Parks (https://rivers.alberta.ca/), and/or from Environment and Climate Change Canada (https://wateroffice.ec.gc.ca/search/historical_e.html). The data was visualized at the frequency reported from Alberta Environment and Parks, and as daily data from Environment and Climate Change Canada. The historical yearly average line on the figures is calculated by first calculating an average level for each year, and then calculating the average from those yearly averages. This was done to reduce the influence of water levels in years where level measurements were collected at high frequencies – this buffers the yearly average line against variability in measurement numbers over the historical record.

Historical Data Tables: The data used to report average yearly levels of lake water quality parameters is presented in the tables within the reports and is accessed online from Alberta Environment and Parks (http://environment.alberta.ca/apps/EdwReportViewer/LakeWaterQuality.aspx). For all data that is reported as below detection limit, a value of half of the reported detection limit is used to calculate the yearly averages, for each water quality parameter. Note that sampling effort can vary between lakes and between years, and not all parameters reported within the table will always have been analyzed historically (leading to '\' being used to indicate when data is unavailable). While microcystin and metals data is also reported in tables within the reports, this data is not available through the link above. Historical metals and microcystin data reported is gathered by request from AEP.

[7] Agriculture, Forestry and Rural Economic Development, Government of Alberta (2019). Alberta Climate Information Service (ACIS) Definitions. http://agriculture.alberta.ca/acis/docs/Station-viewer-y2019_m03_d27.pdf

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 Tables 2 and 3 for a complete list of parameters.

East Basin:

The average total phosphorus (TP) concentration for the East Basin was 9 µg/L (Table 2), falling into the oligotrophic, or low productivity trophic classification. This value falls below the range of historical averages. TP ranged from a minimum of 6 µg/L on the August 4th sampling event, and was highest during the July 7th sampling event at 13 µg/L (Figure 1, top). The average total Kjeldahl nitrogen (TKN) concentration was 0.6 mg/L (Table 2) and was relatively stable through the season, varying between 0.51 – 0.7 mg/L (Figure 1, top).

The average chlorophyll-*a* concentration in 2021 was 5.6 µg/L (Table 2), falling into the mesotrophic, or moderately productive trophic classification. Chlorophyll-*a* was lowest during the July 7th and August 4th sampling events at 5.2 µg/L, and was slightly higher during the June 2nd sampling event at 6.4 µg/L (Figure 1, top).

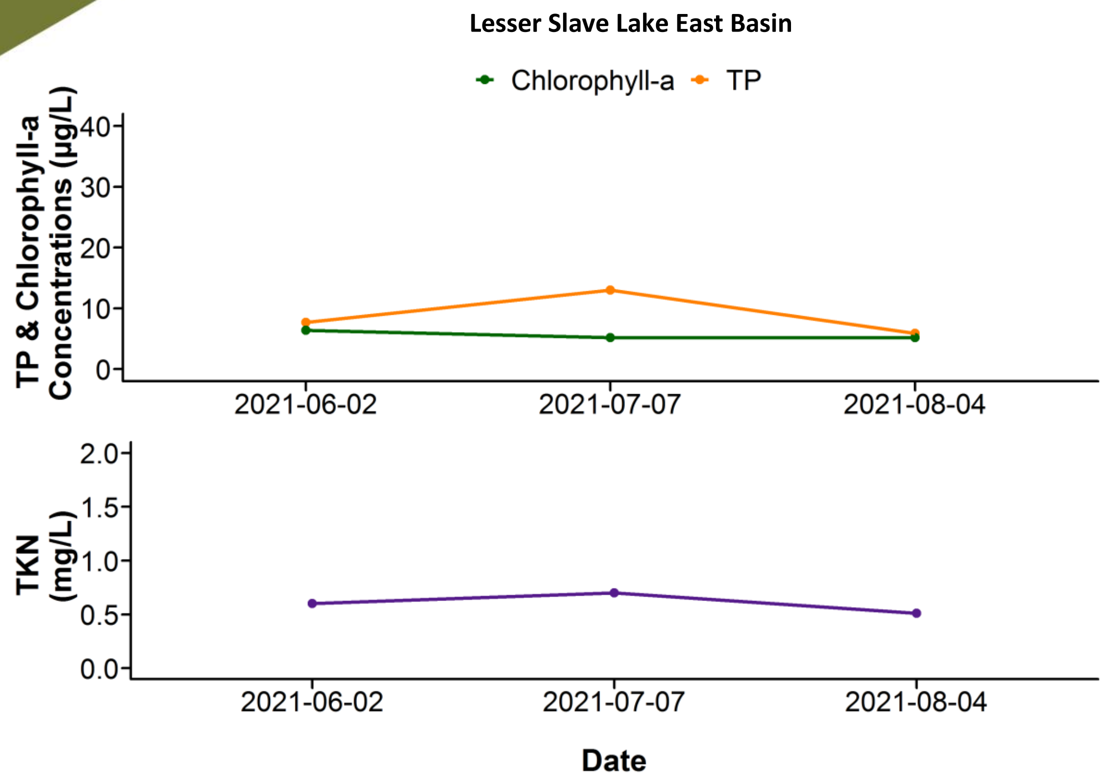
Average pH was measured as 7.58 in 2021, buffered by low alkalinity (79 mg/L $CaCO_3$) and bicarbonate (98 mg/L HCO_3). Aside from bicarbonate, only calcium and sulphate were appreciably higher than all other major ions, and together contributed to a low conductivity of 183 µS/cm (Figure 2, top; Table 2). Compared to the West Basin, the East Basin had higher variability of bicarbonate values through the season. The East Basin of Lesser Slave Lake displays lower ion levels compared to lakes sampled through the LakeWatch program in 2021 (Figure 2, top).

West Basin:

The average TP concentration for the West Basin was 11 µg/L (Table 3), falling into the mesotrophic, or moderate productivity trophic classification. This value falls below the range of historical averages. TP ranged from a minimum of 8 µg/L on the August 8th sampling event, and was highest during the June 2nd sampling event at 16 µg/L (Figure 1, bottom). The average TKN concentration was 0.9 mg/L (Table 3) and was relatively stable through the season, varying between 0.74 – 1.10 mg/L (Figure 1, bottom).

The average chlorophyll-*a* concentration in 2021 was 15.3 µg/L (Table 3), falling into the eutrophic, or highly productive trophic classification. Chlorophyll-*a* was lowest during the July 7th sampling event at 6.2 µg/L, and was much higher during the August 4th sampling event at 28.4 µg/L (Figure 1, bottom).

Average pH was measured as 7.57 in 2021, buffered by low alkalinity (76 mg/L $CaCO_3$) and bicarbonate (92 mg/L HCO_3). Aside from bicarbonate, only calcium and sulphate were appreciably higher than all other major ions, and together contributed to a low conductivity of 183 µS/cm (Figure 2, bottom; Table 3). The West Basin of Lesser Slave Lake displays lower ion levels compared to lakes sampled through the LakeWatch program in 2021 (Figure 2, bottom).



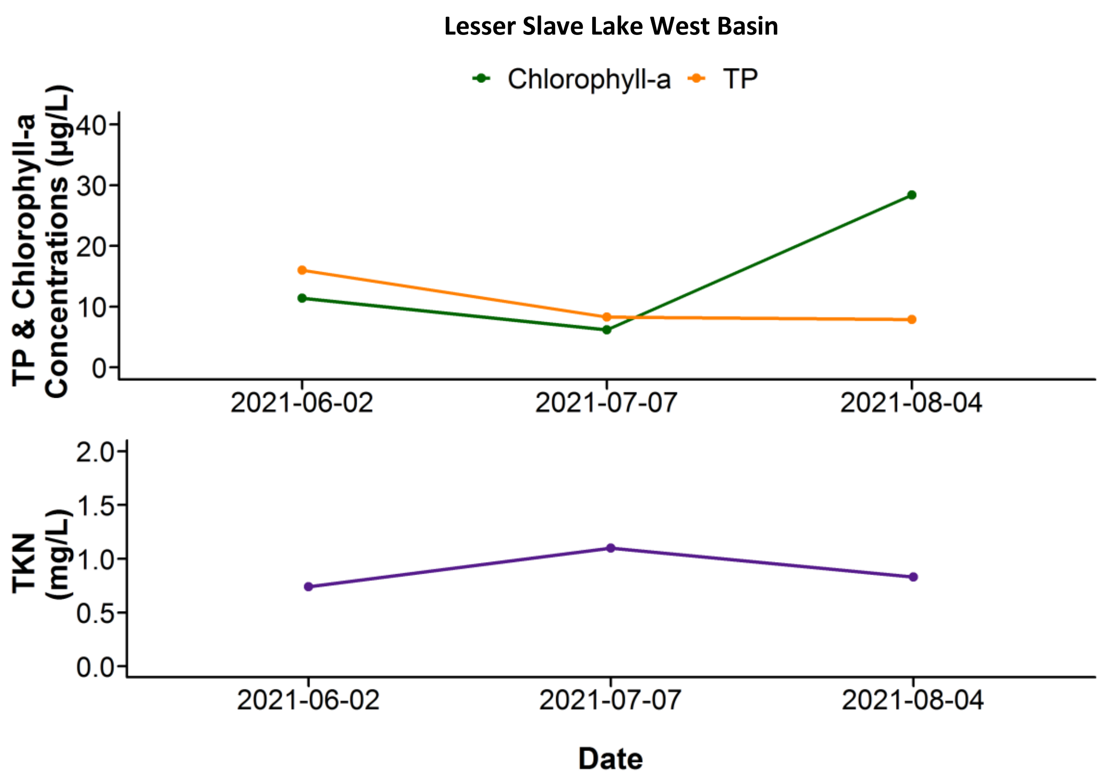
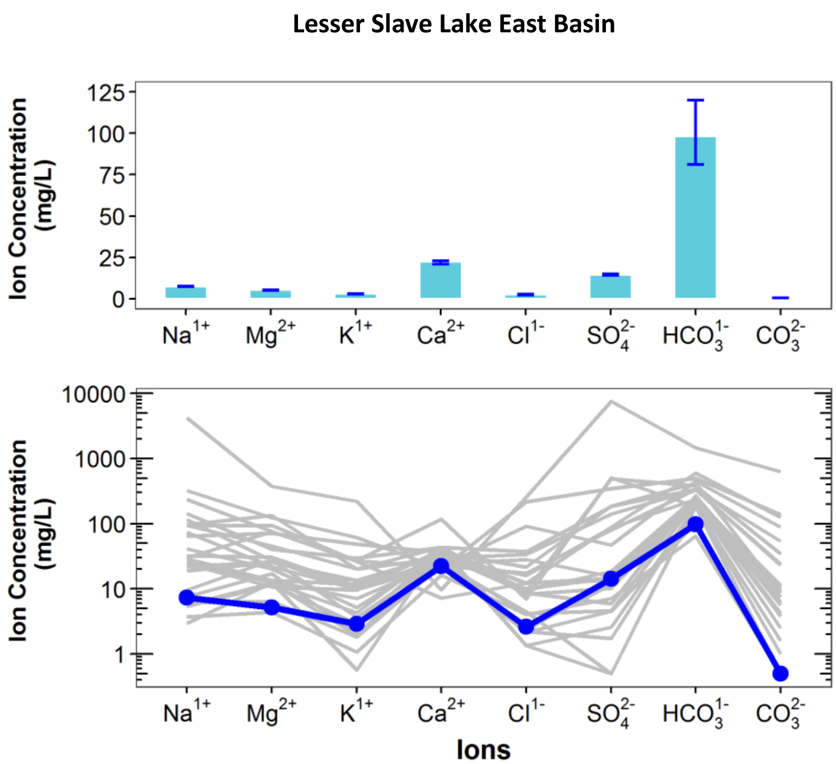


Figure 1. Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured three times over the course of the summer at Lesser Slave Lake East Basin (top) and Lesser Slave Lake West Basin (bottom) in the summer of 2021.



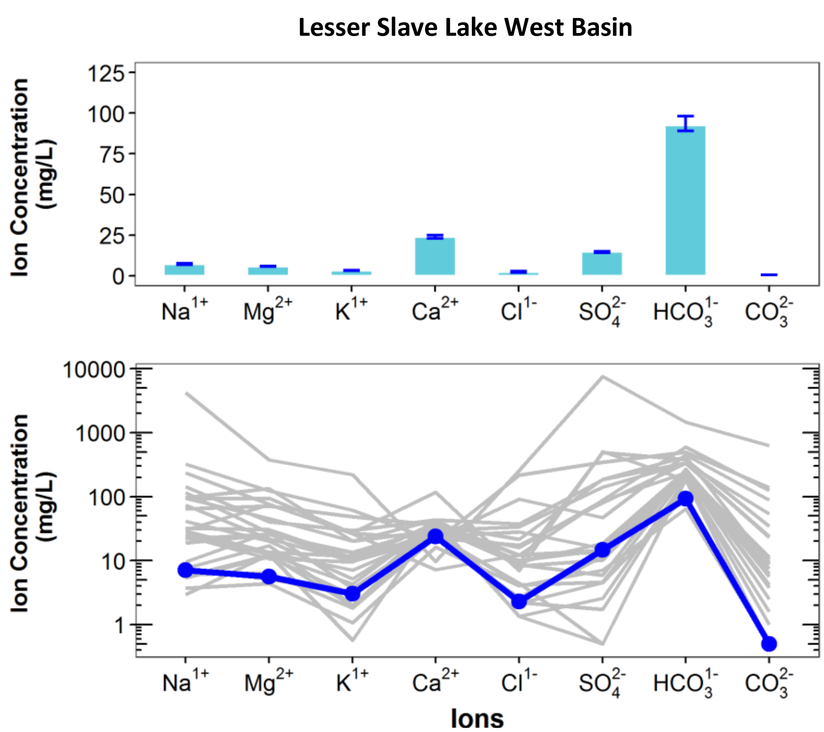


Figure 2. Average levels of cations (sodium = Na^{1+}, magnesium = Mg^{2+}, potassium = K^{1+}, calcium = Ca^{2+}) and anions (chloride = Cl^{1-}, sulphate = SO_4^{2-}, bicarbonate = HCO_3^{1-}, carbonate = CO_3^{2-}) from three measurements over the course of the summer at Lesser Slave Lake East Basin (top pair of figures), and Lesser Slave Lake West Basin (bottom pair of figures). Top) bars indicate range of values measured, and bottom) Schoeller diagram of average ion levels at Calling Lake (blue line) compared to 26 lake basins (gray lines) sampled through the LakeWatch program in 2021 (note $\log_{10}$ scale on y-axis of bottom figure).

METALS

Samples were analyzed for metals once throughout the summer (Table 3). In total, there were 27 metals sampled. 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 in both basins of Lesser Slave Lake in 2021, during the August 8th sampling events. Samples were collected from surface waters, as well as near the bottom of the lake. No metals exceeded the CCME guidelines for the protection of aquatic life in either basin, or from top or bottom samples (Tables 4 and 5). The only metal to come close to exceedance in both basins is copper. Due to the risk that copper poses to aquatic life, future monitoring efforts should include analysis of copper. Metal levels in both basins were otherwise fairly comparable, with bottom levels of some metals being slightly higher than surface levels.

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.

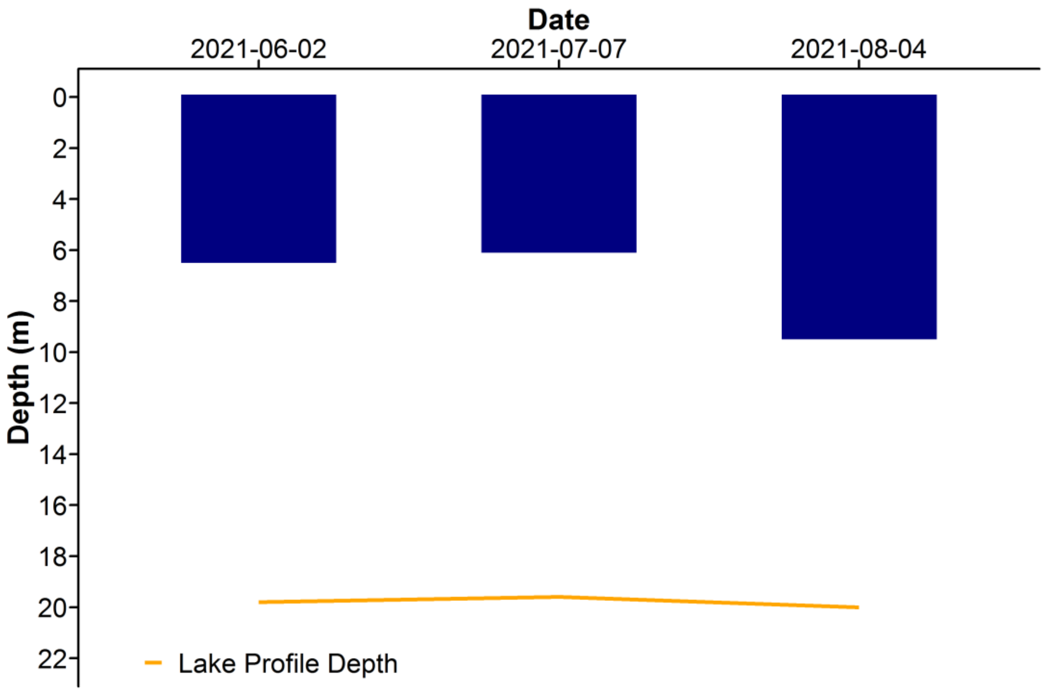
East Basin:

The average euphotic depth of the East Basin in 2021 was 7.26 m, corresponding to an average Secchi depth of 3.63 m (Table 2). Euphotic depth varied over the season, ranging from as deep as 9.40 m on August 4th to as shallow as 6.00 m on July 7th (Figure 3, top). Euphotic depths measured in the East Basin between June and August indicate relatively high water clarity.

West Basin:

The average euphotic depth of the West Basin in 2021 was 3.80 m, corresponding to an average Secchi depth of 1.90 m (Table 3). Euphotic depth varied over the season, ranging from as deep as 5.00 m on July 7th to as shallow as 2.80 m on September 3rd (Figure 3, bottom). The relatively lower water clarity measured during the August 8th sampling event is likely due to slightly increased algal growth, as indicated by the chlorophyll-*a* levels in Figure 1, bottom.

Lesser Slave Lake East Basin



Lesser Slave Lake West Basin

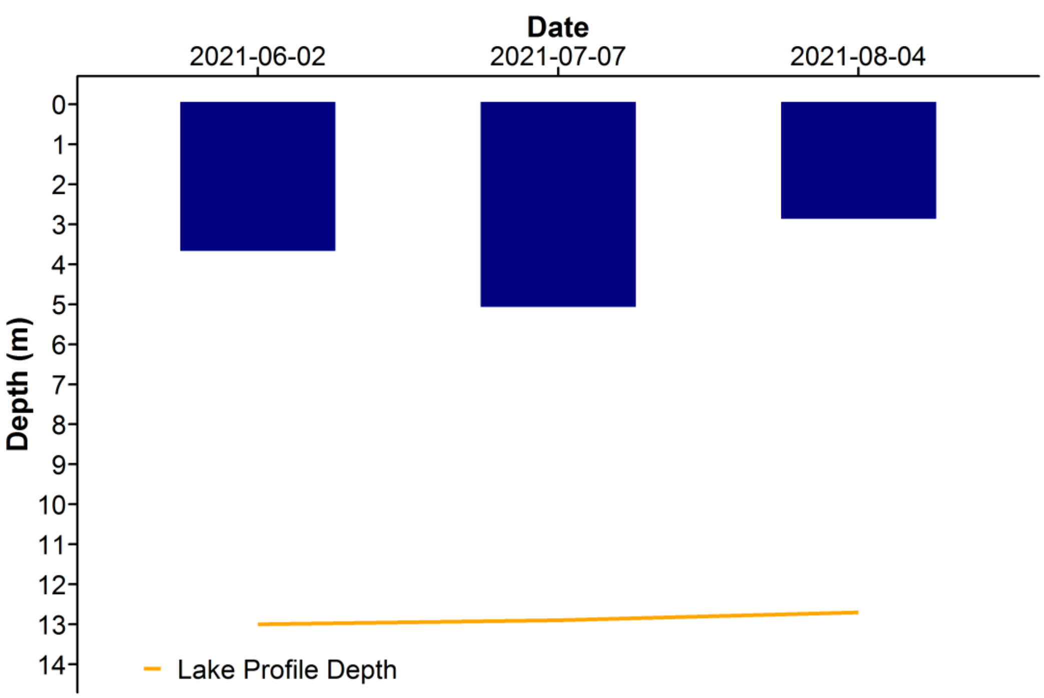


Figure 3. Euphotic depth values measured three times over the course of the summer at Lesser Slave Lake East Basin (top) and Lesser Slave Lake West Basin (bottom) in the summer of 2021.

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.

East Basin:

Water temperatures in the East Basin varied throughout the summer, with a maximum temperature of 20.3°C measured at the surface on August 8th, and a minimum temperature of 7.5°C measured near the bottom at 19.5 m, on June 2nd. (Figure 4a, top). The temperature profiles indicate that the lake does mix completely, and that the lake gradually warmed from June to August. However, slight stratification is evident during each sampling event, and particularly during the July 7th sampling event. The extent to which the lake will stratify can be interpreted by evaluating weather conditions leading up to the sampling date. Prior to the July 7th sampling event, average air temperatures were relatively high, and wind levels relatively calm – such conditions could result in the slightly increased stratification observed. Similar weather conditions existed leading up to the August 8th sampling event.

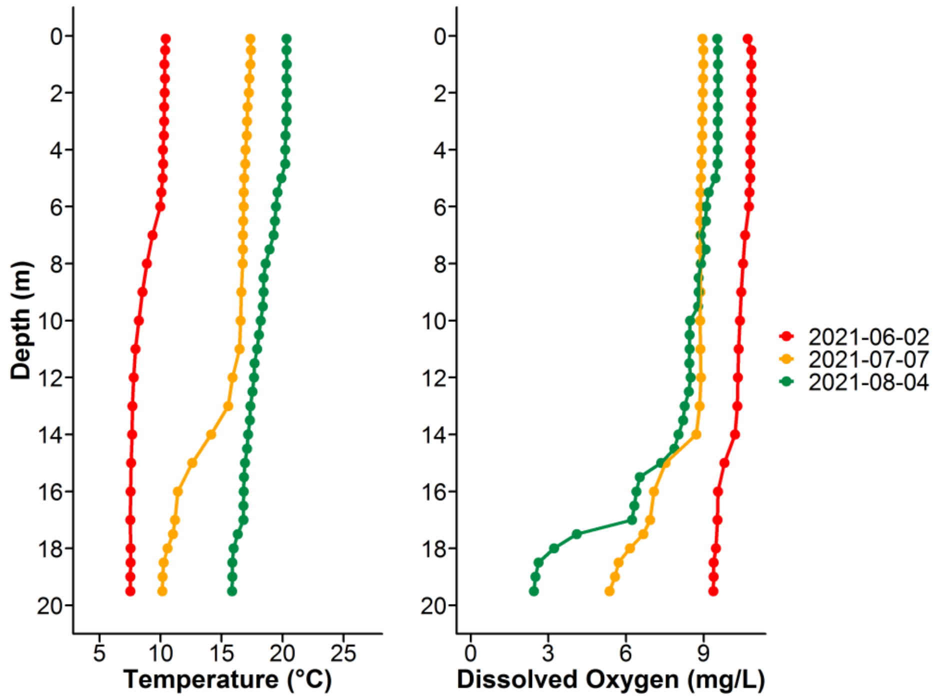
The East Basin remained well oxygenated at the surface and in most of the water column throughout the summer, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen (Figure 4b, top). During the June 2nd sampling event, the entire water column was above 6.5 mg/L. Oxygen levels fell below 6.5 mg/L during the July 7th and August 8th sampling events at 18 m and 16 m, respectively. Near-bottom oxygen levels displayed increasing depletion between the June and August sampling events.

West Basin:

Water temperatures in the West Basin varied throughout the summer, with a maximum temperature of 20.6°C measured at the surface on August 8th, and a minimum temperature of 9.3°C measured near the bottom at 13.0 m on June 2nd (Figure 4a, bottom). The temperature profiles indicate that the lake does mix completely, and that the lake was appreciably warmer in July and August compared to June. Slight stratification is evident during each sampling event. The strongest stratification was evident during the August 8th sampling event, likely due to a sustained period of relatively warmer and calmer conditions leading up to the sampling event (Figure 6b). The West Basin was warmer through the season than the East Basin.

The West Basin remained well oxygenated at the surface and throughout most of the water column through the summer, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen (Figure 4b, bottom). During the June 2nd sampling event, the entire water column was above 6.5 mg/L. Oxygen levels fell below 6.5 mg/L during the July 7th and August 8th sampling events at 11 m and 9 m, respectively. Near-bottom oxygen levels displaying increasing depletion between the June and August sampling events. In addition, the relatively stronger stratification evident during the August 4th sampling event corresponded with the greatest difference in oxygen levels above and below the depth of greatest temperature change, about 7m.

Lesser Slave Lake East Basin



Lesser Slave Lake West Basin

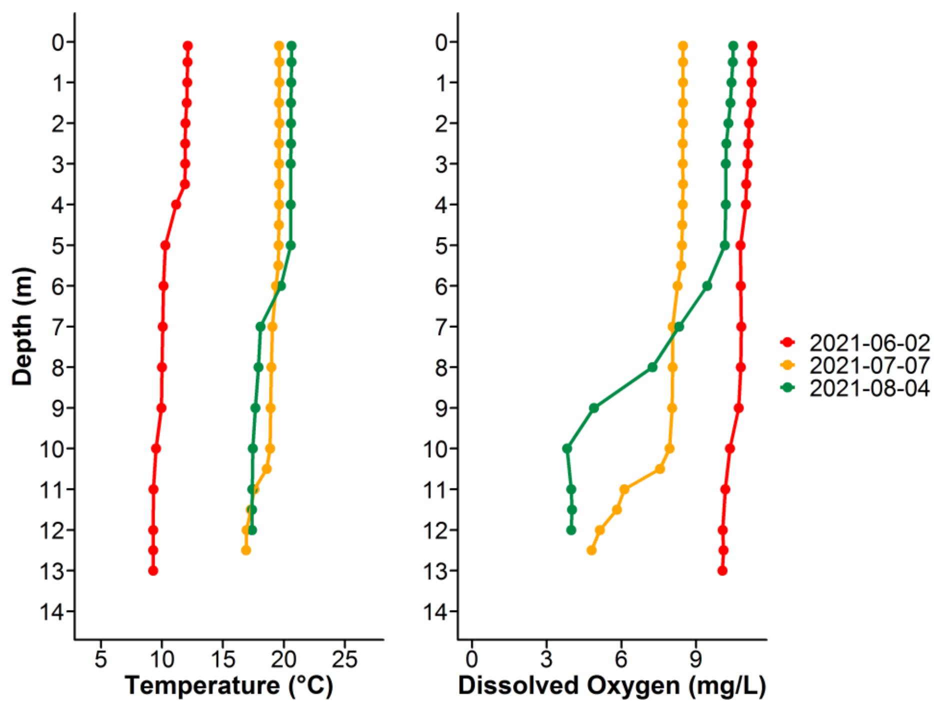


Figure 4. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Lesser Slave Lake measured three times over the course of the summer at Lesser Slave Lake East Basin (top) and Lesser Slave Lake West Basin (bottom) in the summer of 2021

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 Lesser Slave Lake fell below the recreational guideline of 10 μg/L during every sampling event in 2021. In addition, microcystin levels from all sampling events in the East Basin and during the June and August events in the West Basin were below the laboratory detection limit of 0.10 μg/L. A value of 0.05 μg/L is assigned to each date that is below detection in order to calculate an average. Even though low levels of microcystin were detected, caution should always be observed when recreating around cyanobacteria.

Table 1a. Microcystin concentrations measured three times at Lesser Slave Lake East Basin in 2021.

Date	**Microcystin Concentration (μg/L)**
2-Jun-21	<0.10
7-Jul-21	<0.10
8-Aug-21	<0.10
Average	0.05

Table 1b. Microcystin concentrations measured three times at Lesser Slave Lake West Basin in 2021.

Date	Microcystin Concentration (μg/L)
2-Jun-21	<0.10
7-Jul-21	0.11
8-Aug-21	<0.10
Average	0.07

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 either basin of Lesser Slave Lake.

Lesser Slave Lake West Basin, photo by Meghan Payne, taken on August 24th, 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 Lesser Slave Lake in 2021 remain near the historical average, but dropped relative to 2020 (Figure 5). The lake appears to have been in a slightly increasing trajectory of water levels since approximately 2000. However, there has still been considerable variation in water levels within the previous 20 years, with the range in variation spanning over 2 m.

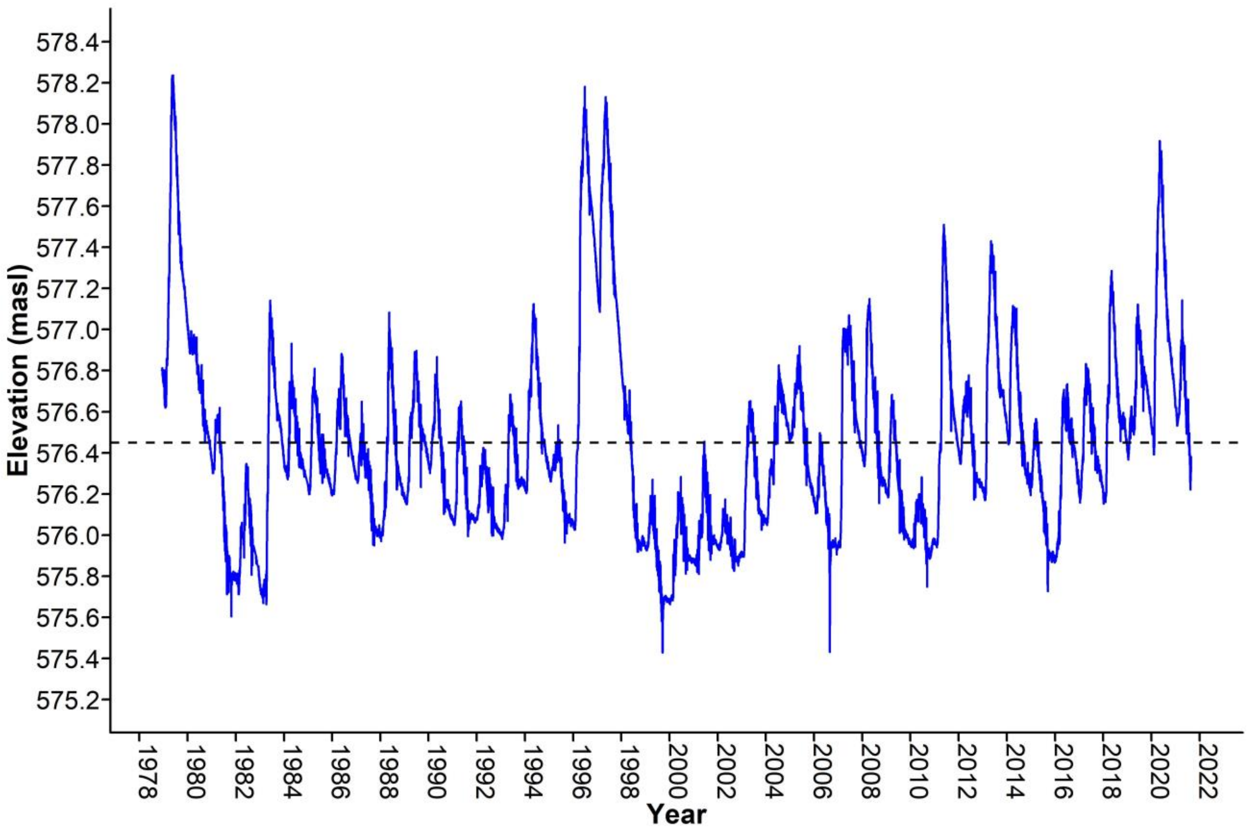


Figure 5. Water levels measured at Lesser Slave Lake in metres above sea level (masl) from 1978-2021. Data retrieved from Environment Canada. Black dashed line represents historical yearly average water level.

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.

Lesser Slave Lake East Basin experienced a warmer, drier, and windier summer compared to normal (Figure 6a). Despite higher wind levels and the size of the lake, the lake displayed slight stratification during the sampling events, due to relatively warm and calm conditions leading up to each sampling event. In addition, despite the heat wave event in late June, the lake remained relatively cool compared to the impact of the heat wave on other lakes in Alberta, likely due to the size and depth of the lake.

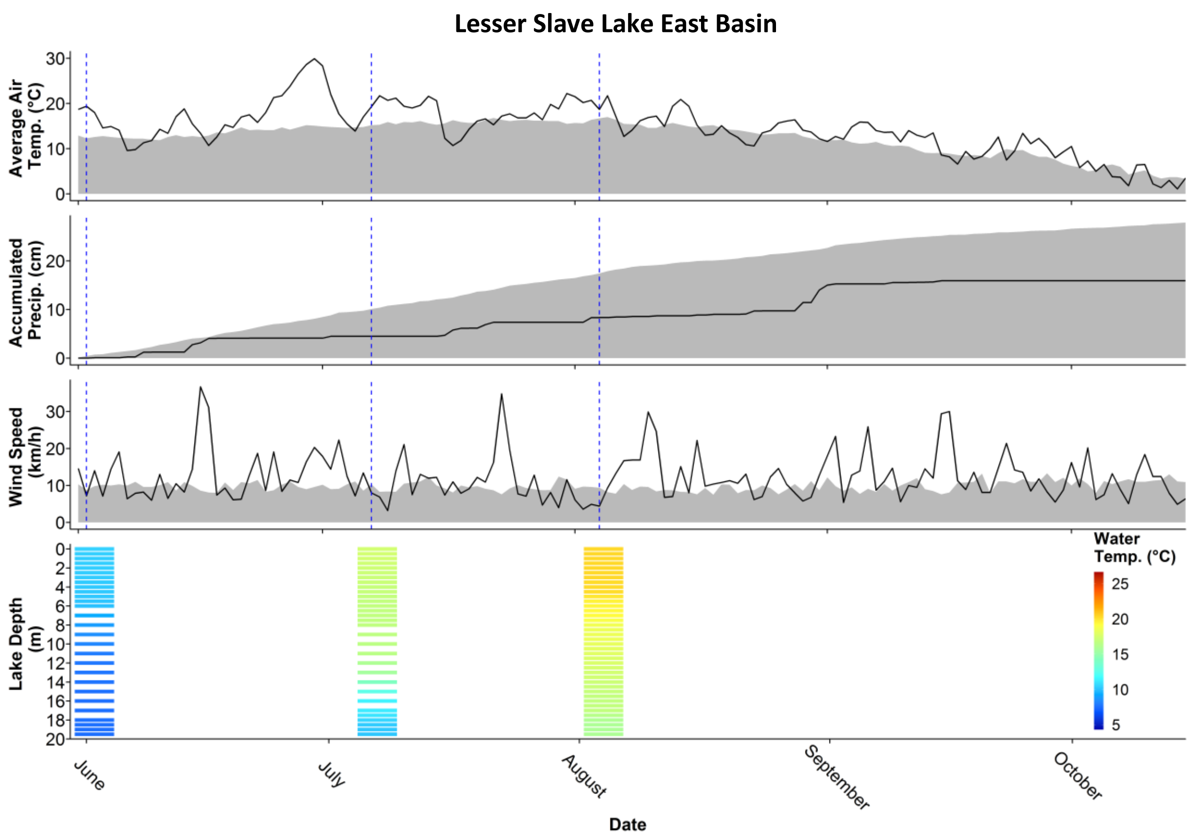


Figure 6a. Average air temperature (°C), accumulated precipitation (cm) and wind speed (km/h) measured from Slave Lake RCS, with Lesser Slave Lake East Basin temperature profiles (°C) at the bottom. Black lines indicate 2021 levels, gray indicates long-term normals, and blue lines indicate sampling dates for Lesser Slave Lake East Basin 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). *Note: Solar Radiation not available at Slave Lake RCS.

Lesser Slave Lake West Basin experienced a warmer, drier, slightly windier summer with slightly less solar radiation compared to normal (Figure 6b). Despite higher wind levels and the size of the lake, the lake displayed slight stratification during the sampling events, due to relatively warm and calm conditions leading up to each sampling event.

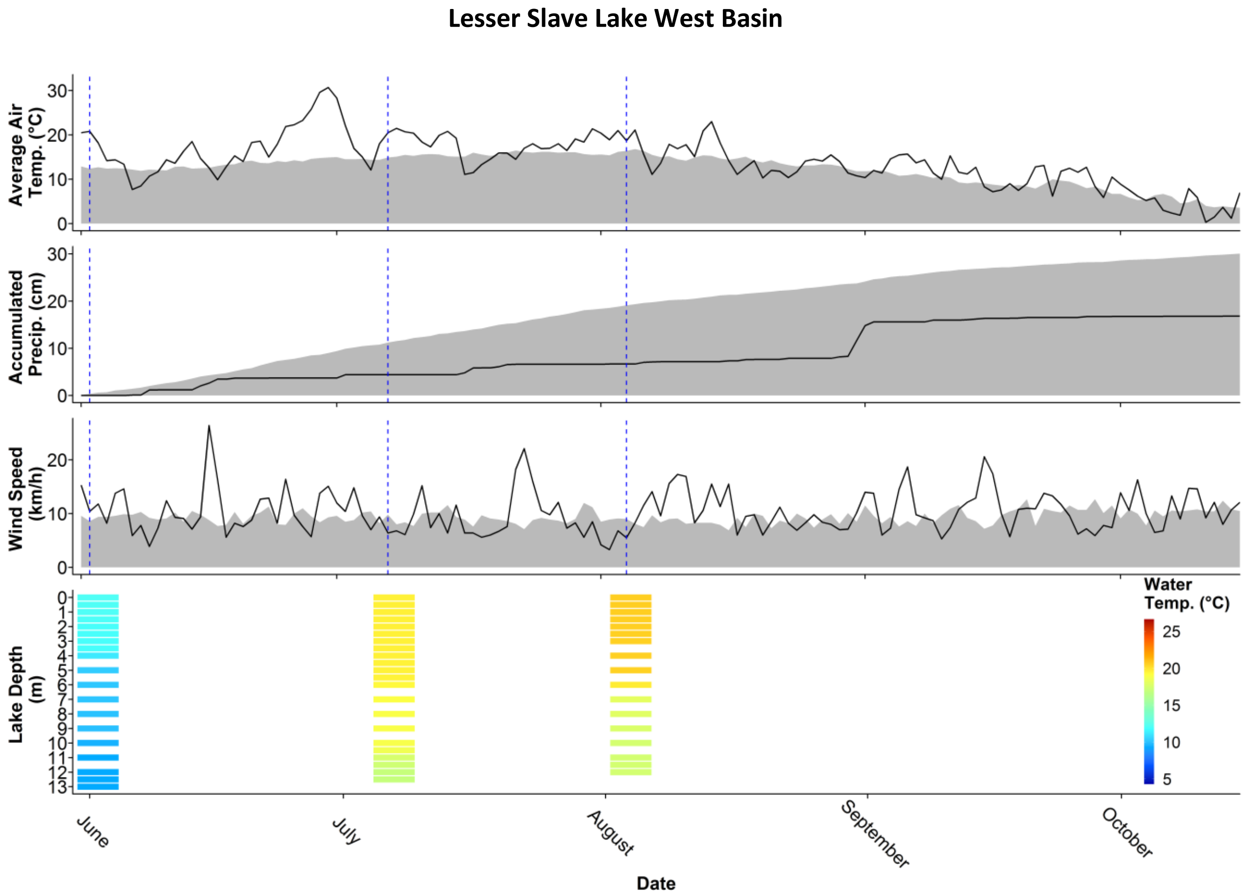


Figure 6b. Average air temperature (°C), accumulated precipitation (cm) and wind speed (km/h) measured from Kinuso Auto, with Lesser Slave Lake West Basin temperature profiles (°C) at the bottom. Black lines indicate 2021 levels, gray indicates long-term normals, and blue lines indicate sampling dates for Lesser Slave Lake West Basin 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). *Note: Solar Radiation not available at Kinuso Auto.

Table 2. Average Secchi depth and water chemistry values for Lesser Slave Lake East Basin. Historical values are given for reference. Number of sample trips are inconsistent between years.

Parameter	1991	1992	1993	2000	2011	2021
TP (µg/L)	18	37	26	46	31	9
TDP (µg/L)	8	8	8	7	12	4
Chlorophyll-*a* (µg/L)	5.5	39.4	27.6	50.2	13.9	5.6
Secchi depth (m)	2.97	2.36	2.58	2.43	2.25	3.63
TKN (mg/L)	0.3	0.8	0.6	1	0.7	0.6
NO_2-N and NO_3-N (µg/L)	5	10	6	3	7	10
NH_3-N (µg/L)	10	14	15	12	13	13
DOC (mg/L)	10	9	10	10	10	12
Ca^{2+} (mg/L)	22	24	24	/	/	22
Mg^{2+} (mg/L)	6	5	5	/	5	5
Na^{+} (mg/L)	6	8	8	8	8	7
K^{+} (mg/L)	2	2	2	2	3	3
SO_4^{2-} (mg/L)	14	7	8	10	14	14
Cl^{-} (mg/L)	1	1	1	2	1	3
CO_3^{2-} (mg/L)	/	/	1	/	0.5	0.5
HCO_3^{-} (mg/L)	105	108	108	111	108	98
pH	8.11	7.96	8.27	8.09	8.04	7.58
Conductivity (µS/cm)	190	195	192	/	195	183
Hardness (mg/L)	81	81	82	83	82	78
TDS (mg/L)	103	101	102	107	108	107
Microcystin (µg/L)	/	/	/	/	/	0.05
Total Alkalinity (mg/L $CaCO_3$)	86	89	88	91	88	79

Table 3. Average Secchi depth and water chemistry values for Lesser Slave Lake West Basin. Historical values are given for reference. Number of sample trips are inconsistent between years.

Parameter	1991	1992	1993	2000	2005	2011	2021
TP (µg/L)	29	60	51	62	28	42	11
TDP (µg/L)	10	13	13	11	10	10	4
Chlorophyll-*a* (µg/L)	6.7	73	67.9	52.5	/	24.4	15.3
Secchi depth (m)	2.1	2.17	1.76	1.93	/	1.35	1.9
TKN (mg/L)	0.5	1.2	1.2	1	0.8	0.9	0.9
NO_2-N and NO_3-N (µg/L)	12	7	4	8	28	2	3
NH_3-N (µg/L)	18	22	29	24	22	11	12
DOC (mg/L)	10	12	12	10	11	12	12
Ca^{2+} (mg/L)	23	25	25	/	/	/	24
Mg^{2+} (mg/L)	6	6	6	/	/	5	6
Na^{+} (mg/L)	7	8	8	9	8	8	7
K^{+} (mg/L)	2	3	2	3	3	3	3
SO_4^{2-} (mg/L)	11	10	8	11	9	16	15
Cl^{-} (mg/L)	1	1	1	2	1	2	2
CO_3^{2-} (mg/L)	/	/	2	/	/	0.5	0.5
HCO_3^{-} (mg/L)	106	116	114	117	114	106	92
pH	8.13	7.88	8.19	8.01	8.26	7.81	7.57
Conductivity (µS/cm)	196	204	202	/	207	199	183
Hardness (mg/L)	83	86	86	89	80	81	82
TDS (mg/L)	103	109	106	114	107	110	107
Microcystin (µg/L)		/	/	/	/	/	0.07
Total Alkalinity (mg/L $CaCO_3$)	87	95	94	96	93	86	76

Table 4. Concentrations of metals measured in Lesser Slave Lake East Basin. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	2021 Top	2021 Bottom	Guidelines
Aluminum μg/L	21.5	22.6	100[a]
Antimony μg/L	0.114	0.132	/
Arsenic μg/L	0.67	0.64	5
Barium μg/L	62.2	66.4	/
Beryllium μg/L	0.0015	0.0015	100[c,d]
Bismuth μg/L	0.0015	0.0015	/
Boron μg/L	19.7	19.6	1500
Cadmium μg/L	0.005	0.005	0.13[b]
Chromium μg/L	0.05	0.05	/
Cobalt μg/L	0.053	0.044	50,1000[c,d]
Copper μg/L	1.08	1.16	2[b]
Iron μg/L	16.4	45.1	300
Lead μg/L	0.007	0.021	2.31[b]
Lithium μg/L	11.1	10.7	2500[d]
Manganese μg/L	4.96	53.2	440[e]
Molybdenum μg/L	0.79	0.844	73
Nickel μg/L	1.96	1.95	78.9[b]
Selenium μg/L	0.1	0.1	1
Silver μg/L	0.0005	0.0005	0.25
Strontium μg/L	104	101	/
Thallium μg/L	0.004	0.006	0.8
Thorium μg/L	0.001	0.003	/
Tin μg/L	0.03	0.03	/
Titanium μg/L	0.71	0.97	/
Uranium μg/L	0.219	0.186	15
Vanadium μg/L	0.138	0.173	100[c,d]
Zinc μg/L	0.3	1.2	34.7[f]

Values represent means of total recoverable metal concentrations.
[a] Based on pH ≥ 6.5
[b] Based on 2021 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 2021 avg. water hardness (as CaCO3) and avg. pH
[f] Based on 2021 avg. water hardness (as CaCO3), avg. pH, and avg. DOC with CCME equation
A forward slash (/) indicates an absence of data or guidelines

Table 5. Concentrations of metals measured in Lesser Slave Lake West Basin. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	2021 Top	2021 Bottom	Guidelines
Aluminum µg/L	22.2	16.1	100[a]
Antimony µg/L	0.103	0.129	/
Arsenic µg/L	1.19	1.16	5
Barium µg/L	54.3	61.2	/
Beryllium µg/L	0.004	0.0015	100[c,d]
Bismuth µg/L	0.0015	0.0015	/
Boron µg/L	20.6	20.1	1500
Cadmium µg/L	0.005	0.005	0.13[b]
Chromium µg/L	0.05	0.05	/
Cobalt µg/L	0.048	0.062	50,1000[c,d]
Copper µg/L	1.07	0.97	2[b]
Iron µg/L	35.6	57.4	300
Lead µg/L	0.018	0.023	2.48[b]
Lithium µg/L	11.2	11.2	2500[d]
Manganese µg/L	13.1	129	440[e]
Molybdenum µg/L	0.861	0.92	73
Nickel µg/L	1.81	1.84	82.4[b]
Selenium µg/L	0.2	0.1	1
Silver µg/L	0.0005	0.0005	0.25
Strontium µg/L	98.3	102	/
Thallium µg/L	0.006	0.006	0.8
Thorium µg/L	0.003	0.003	/
Tin µg/L	0.03	0.03	/
Titanium µg/L	0.66	0.94	/
Uranium µg/L	0.244	0.221	15
Vanadium µg/L	0.123	0.134	100[c,d]
Zinc µg/L	0.4	0.7	37.5[f]

Values represent means of total recoverable metal concentrations.

[a] Based on pH ≥ 6.5

[b] Based on 2021 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 2021 avg. water hardness (as CaCO3) and avg. pH

[f] Based on 2021 avg. water hardness (as CaCO3), avg. pH, and avg. DOC with CCME equation

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