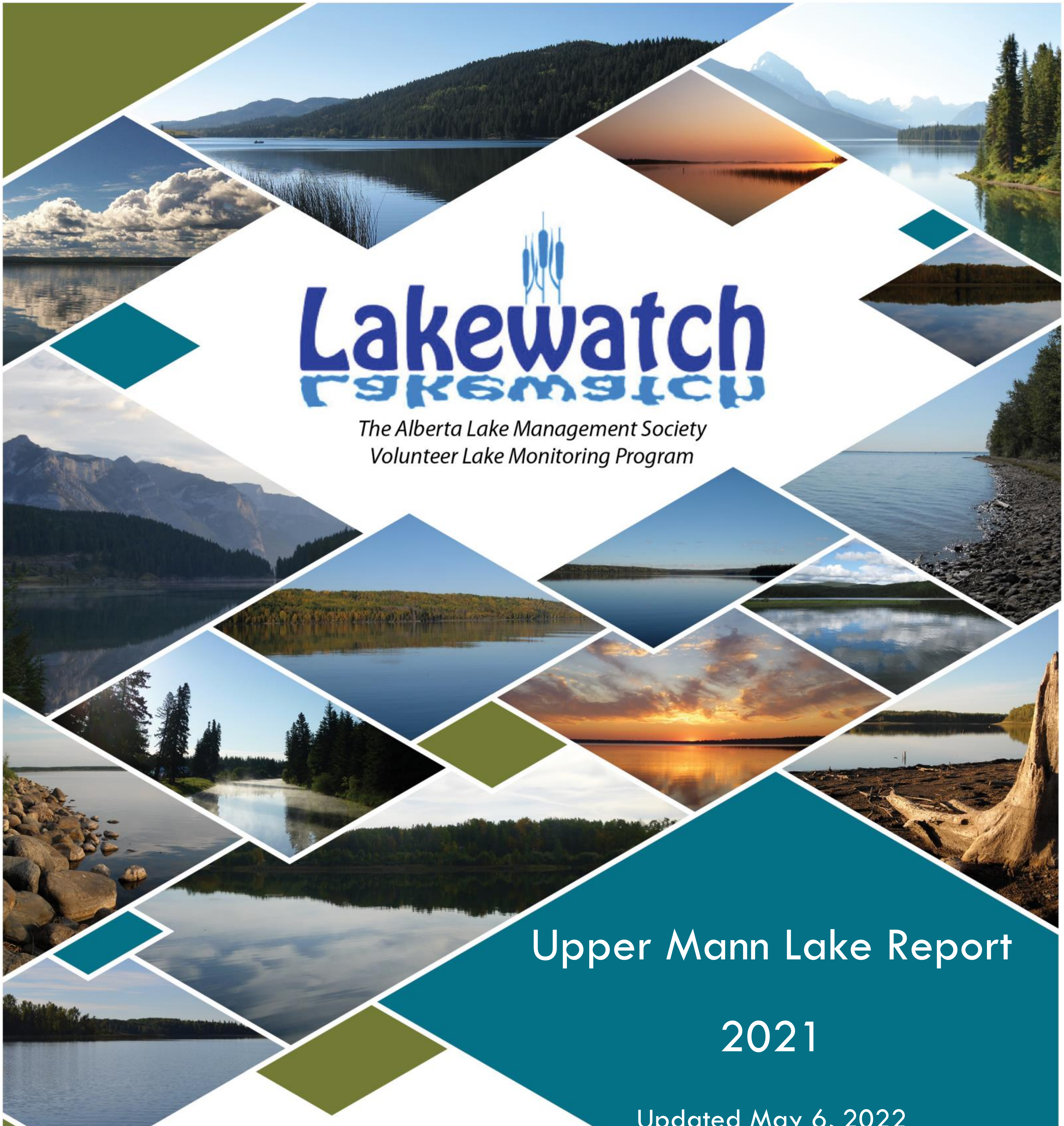

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Upper Mann Lake Report

2021

Updated May 6, 2022

Lakewatch is made possible
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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 Charity Sagert for her commitment to collecting data at Upper Mann 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.

Before reading this report, check out [A Brief Introduction to Limnology] at alms.ca/reports

UPPER MANN LAKE

Upper Mann Lake is a small lake in the southwest region of the Beaver River Watershed, and is located 22km northwest of St. Paul and lies within St. Paul County. Prior to the 1900s, Upper Mann and Lower Mann Lake formed one large lake which was called Island Lake.[1] Due to water level decline over the past century, the lakes are now only connected on the surface, through an intermittent stream that runs from Upper Mann Lake to Lower Mann Lake. Both lakes are named after Sir Donald Mann, who was the vice-president of the Canadian Northern Railway which built a line near the lakes in the early 1900s.

Late September at Upper Mann Lake in 2019.

The lake is irregularly shaped, having numerous bays and islands. Comparing older maps of the lake with the current lake shoreline, a number of bays have receded partially or completely, and many islands have become peninsulas. The lake lies within the Boreal Mixedwood Ecoregion, and the surrounding forest includes Trembling Aspen, White Spruce, White Birch and Balsam Poplar trees. The lake is moderately developed, with cabins primarily situated in the southwest and north regions of the lake. In addition, Highway 28 runs along the north shore of the lake, making the lake quite accessible. A primitive boat launch also exists on the west shore of the lake. However, this development is mediated by the presence of the Upper Mann Lake Natural Area, which protects riparian habitat in the south, as well as the northeast and northwest areas of the lake.[2] Currently, hunting is the only advertised activity for the Upper Mann Lake Natural Area.

Aphanizomenon sp. bloom in June, 2019.

The lake supports an abundance of waterfowl, including pelicans and cormorants. Historically, the lake has had a variable fishery for northern pike and yellow perch, but also suffers frequent winterkill events.[1]

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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] Government of Alberta (2017). https://www.albertaparks.ca/parks/northeast/upper-mann-lake-na/

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 Upper Mann Lake was 265 µg/L (Table 2), falling into the hypereutrophic, or very highly productive trophic classification. This value falls above the range of historical averages, nearly double the next highest average from 2019. TP was lowest on the June 24th sampling event at 220 µg/L, and was highest on July 25th at 300 µg/L (Figure 1). Decreases in water levels will have contributed to higher nutrient concentrations in recent years compared to historical values.

Average chlorophyll-*a* concentration in 2021 was 32 µg/L (Table 2), falling into the hypereutrophic, or very highly productive trophic classification. Chlorophyll-*a* was lowest on July 25th at 6.5 µg/L, and peaked at 57.3 µg/L on August 14th (Figure 1).

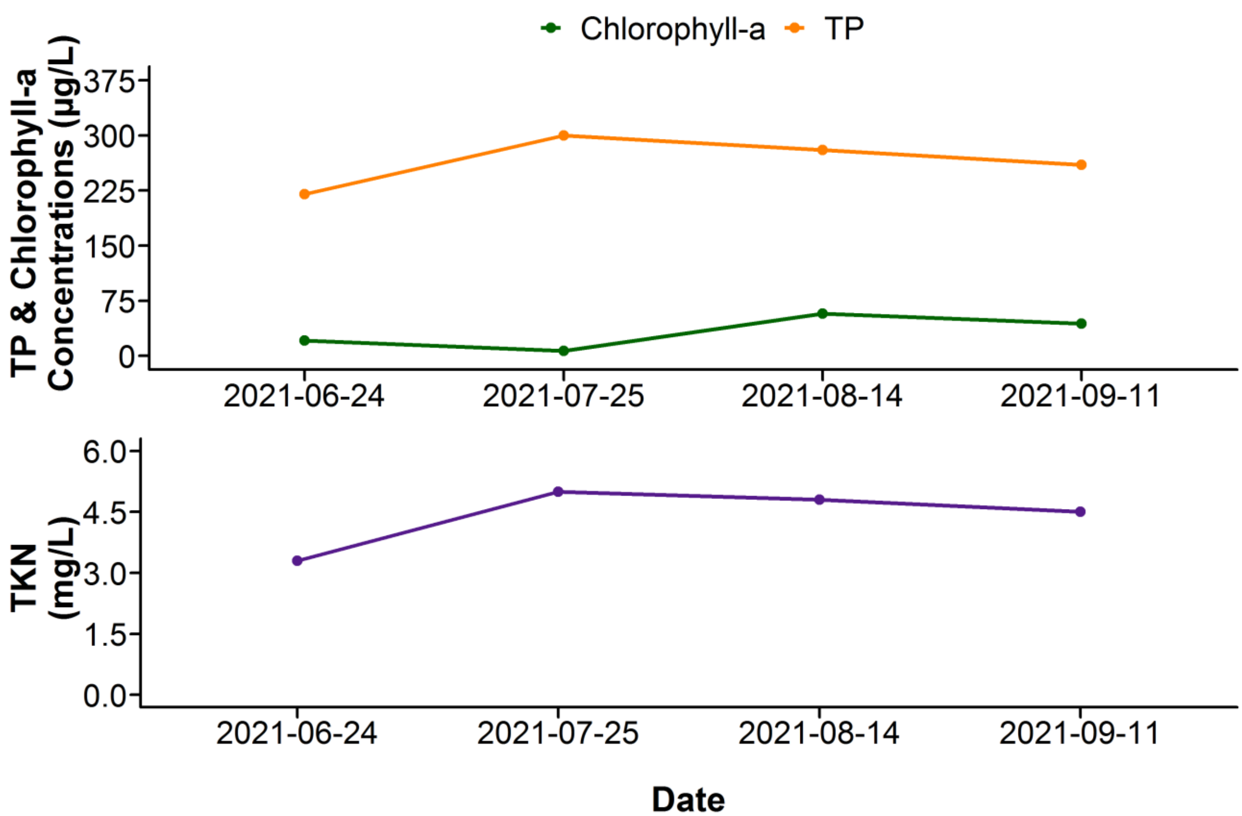

Figure 1. Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Upper Mann Lake.

The average TKN concentration was 4.4 mg/L (Table 2) and varied through the season from 3.3 – 5.0 mg/L (Figure 2). TKN concentrations were significantly positively correlated with TP (r = 0.97, p = 0.03). Additionally, the lake displayed high levels of ammonia (NH_3) through the season, which exceeded the CCME guideline for the protection of aquatic life[3] on each sampling event (Figure 2). NH_3 concentrations were also significantly positively correlated with TP (r = 0.97, p = 0.03).

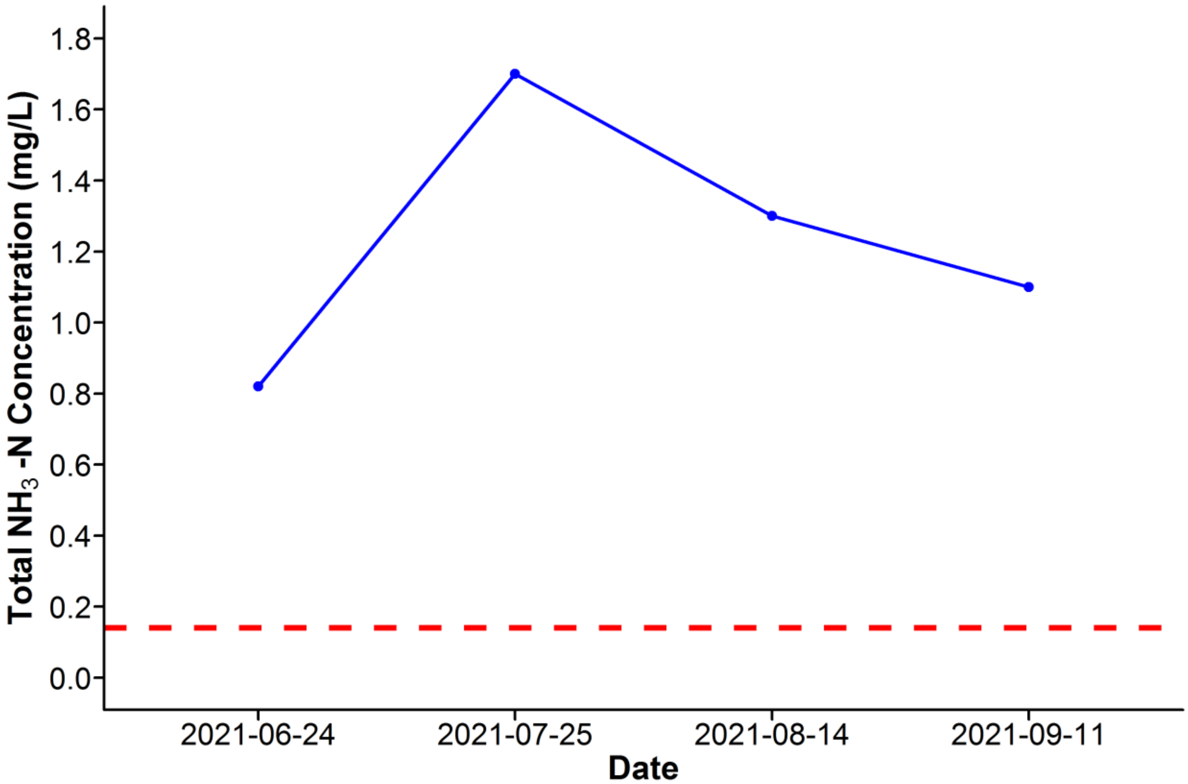

Figure 2. Total ammonia (NH_3-N) concentrations measured four times over the course of the summer at Upper Mann Lake, along with the CCME guideline for the protection of aquatic life, chronic exposure to Ammonia at pH=8.5, and water temperature at 20°C (0.141 mg/L). Note that the pH and water temperatures used are based on the average pH and water temperature at Upper Mann Lake in 2021. Also note that the guideline is based on NH_3 as N speciation, not NH_3 as NH_3 speciation.

[3] Canadian Council of Ministers of the Environment (CCME). 2010. Canadian water quality guidelines for the protection of aquatic life: Ammonia. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Average pH was measured as 8.45 in 2021, buffered by high alkalinity (360 mg/L $CaCO_3$) and bicarbonate (420 mg/L HCO_3). Aside from bicarbonate, sulphate was the other dominant ion (Figure 3, top). Together, the ions contributed to a high conductivity of 1075 µS/cm (Table 2). Upper Mann Lake is in the high range of most ion levels compared to other LakeWatch lakes sampled in 2021 (Figure 3, bottom). Ion concentrations have increased compared to historical values, likely related to historical changes in water quantity (Figure 6).

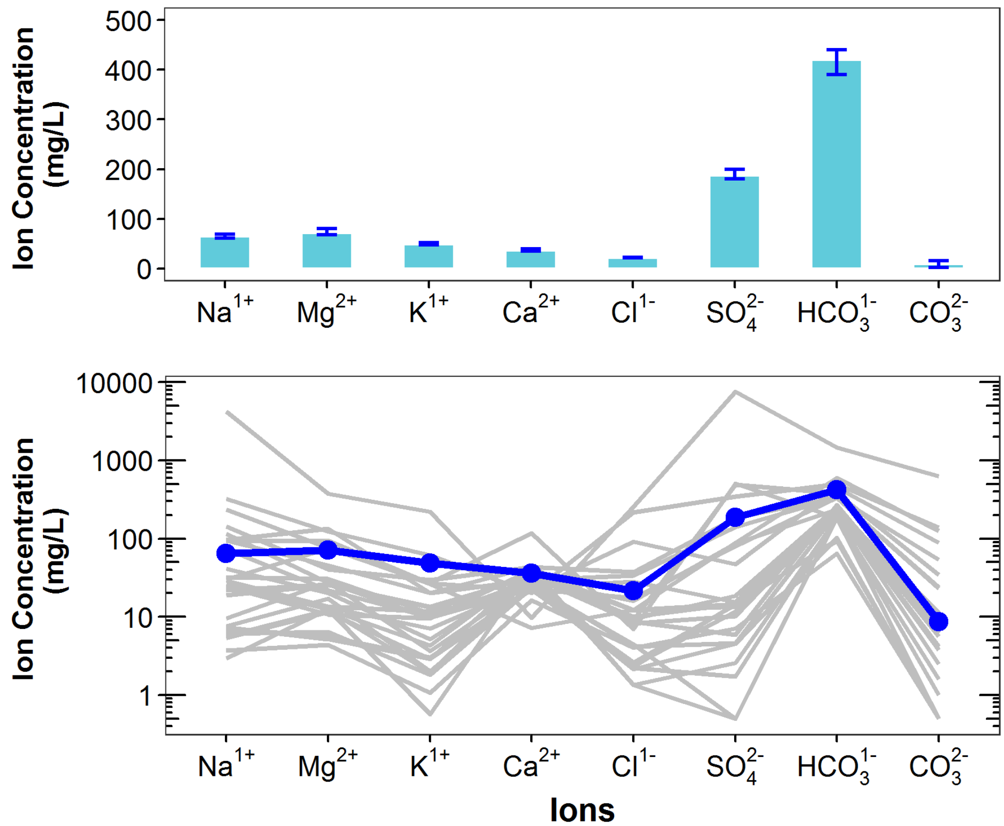

Figure 3. Average levels of cations (sodium = Na^{1+}, magnesium = Mg^{2+}, potassium = K^{1+}, calcium = Ca^{2+}) and anions (chloride = Cl^{1-}, sulphate = SO_4^{2-}, bicarbonate = HCO_3^{1-}, carbonate = CO_3^{2-}) from four measurements over the course of the summer at Upper Mann Lake. Top) bars indicate range of values measured, and bottom) Schoeller diagram of average ion levels at Upper Mann 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 measured at Upper Mann Lake in 2021, and no metal concentrations exceeded CCME guidelines (Table 3).

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 Upper Mann Lake in 2021 was 4.18 m, corresponding to an average Secchi depth of 2.10 m (Table 2). The date with the highest euphotic depth was July 25th, when it was equal to lake bottom, and the lowest euphotic depth was present on June 24th, at 3.40 m.

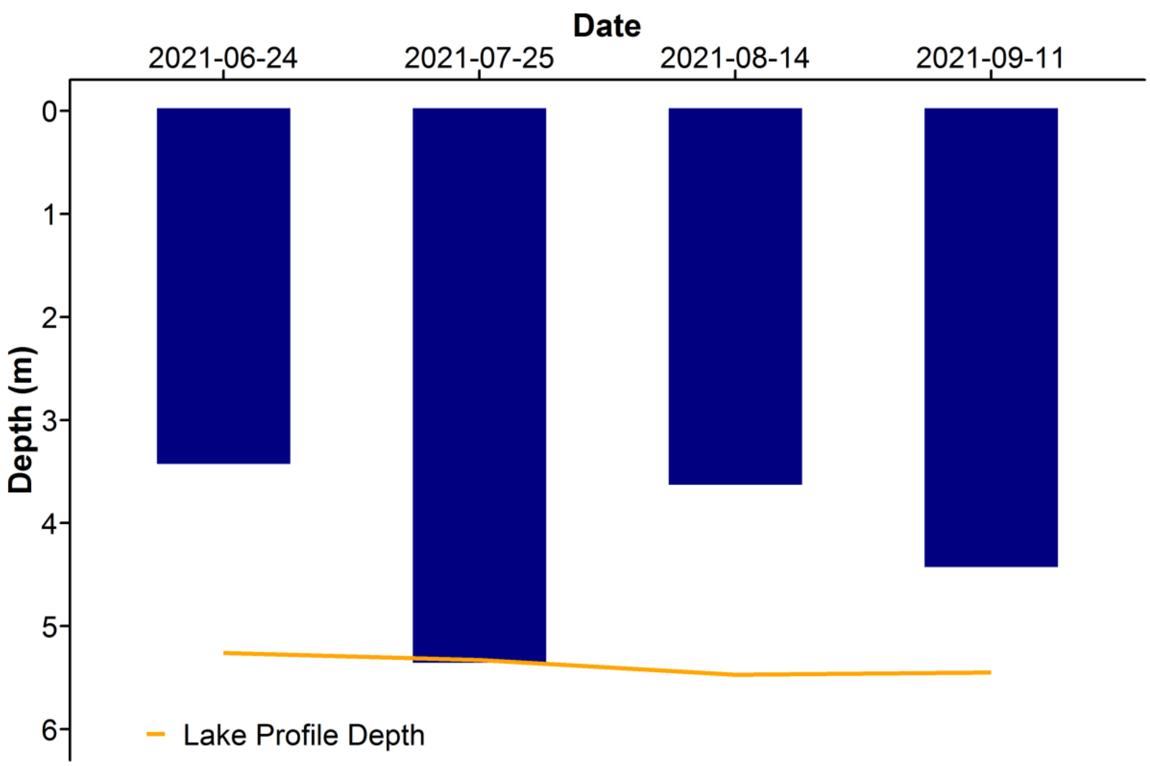

Figure 4. Euphotic depth values measured four times over the course of the summer at Upper Mann Lake in 2021.

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 Upper Mann Lake varied throughout the summer, with the June 24th sampling date having the warmest temperatures at 20.3°C (Figure 5a). The lake displayed the same temperatures throughout the whole lake on each sampling event, meaning the lake was mixed on each date.

Upper Mann Lake was well oxygenated in the surface waters only during the August and September sampling dates, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen (Figure 5b). The oxygen levels through the lake during the June and July sampling events were below 6.5 mg/L. This could be due to a combination of factors including; high water temperatures present throughout the lake following a heat wave event in late June (Figure 7), high decomposition rates, or low algal productivity early in the season.

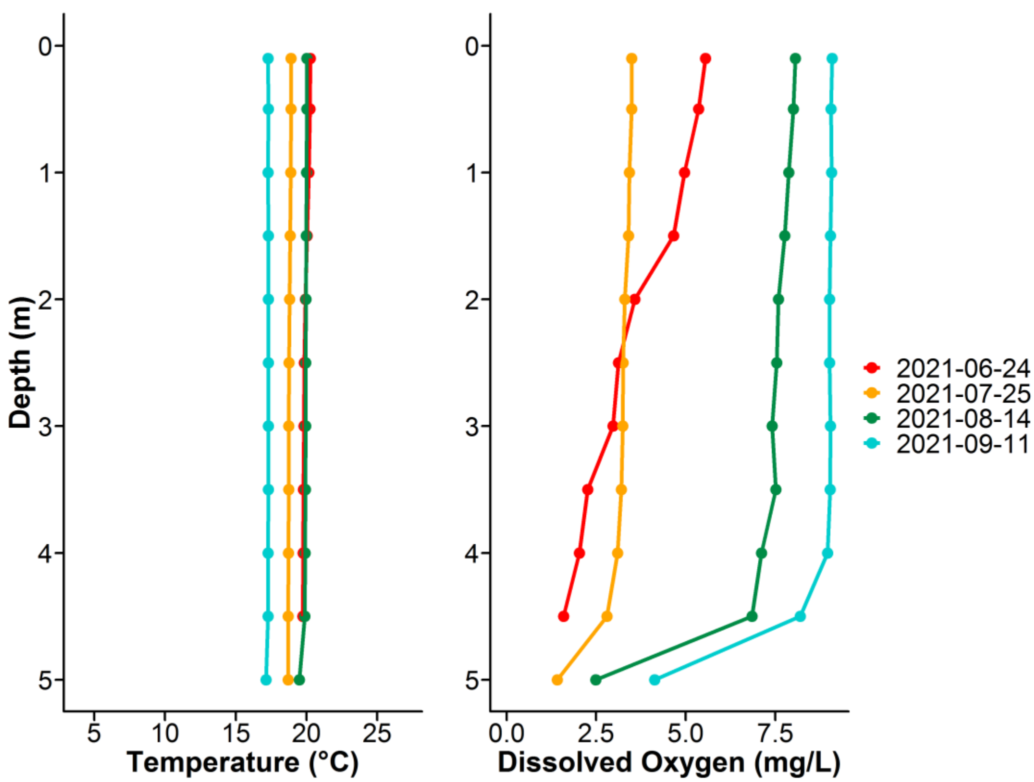

Figure 5. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Upper Mann Lake measured four times over the course of the summer of 2021.

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 Upper Mann 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 Upper Mann Lake in 2021.

Date	Microcystin Concentration (µg/L)
24-Jun-21	0.15
25-Jul-21	0.76
14-Aug-21	2.28
11-Sep-21	0.88
Average	1.02

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 Upper Mann 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.

A watermilfoil specimen was collected from Upper Mann Lake during the July 25th sampling event, and was confirmed to be the native Northern Watermilfoil.

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 level data from Upper Mann Lake indicate that 2021 levels are well below the historical average, but the level of the lake has been increasing since the historical low of 2016 (Figure 6).

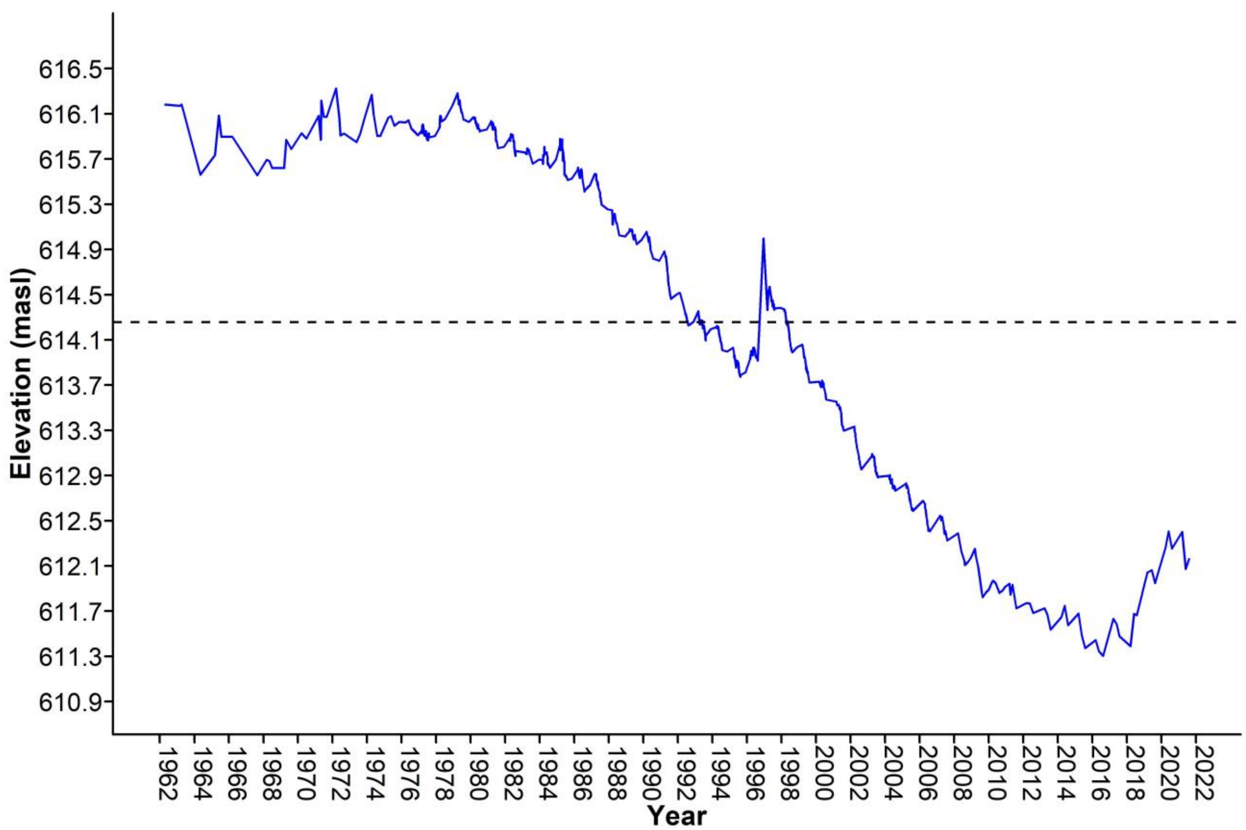

Figure 6. Water levels measured at Upper Mann Lake in metres above sea level (masl) from 1962-2021. Data retrieved from Alberta Environment and Parks.

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.

Upper Mann Lake experienced a warmer, drier, summer with more solar radiation compared to normal, and near normal levels of wind (Figure 7). As the lake is constantly mixing, it will track with the average air temperatures through the season, and is more vulnerable to heat wave events due to its small size and low average depth.

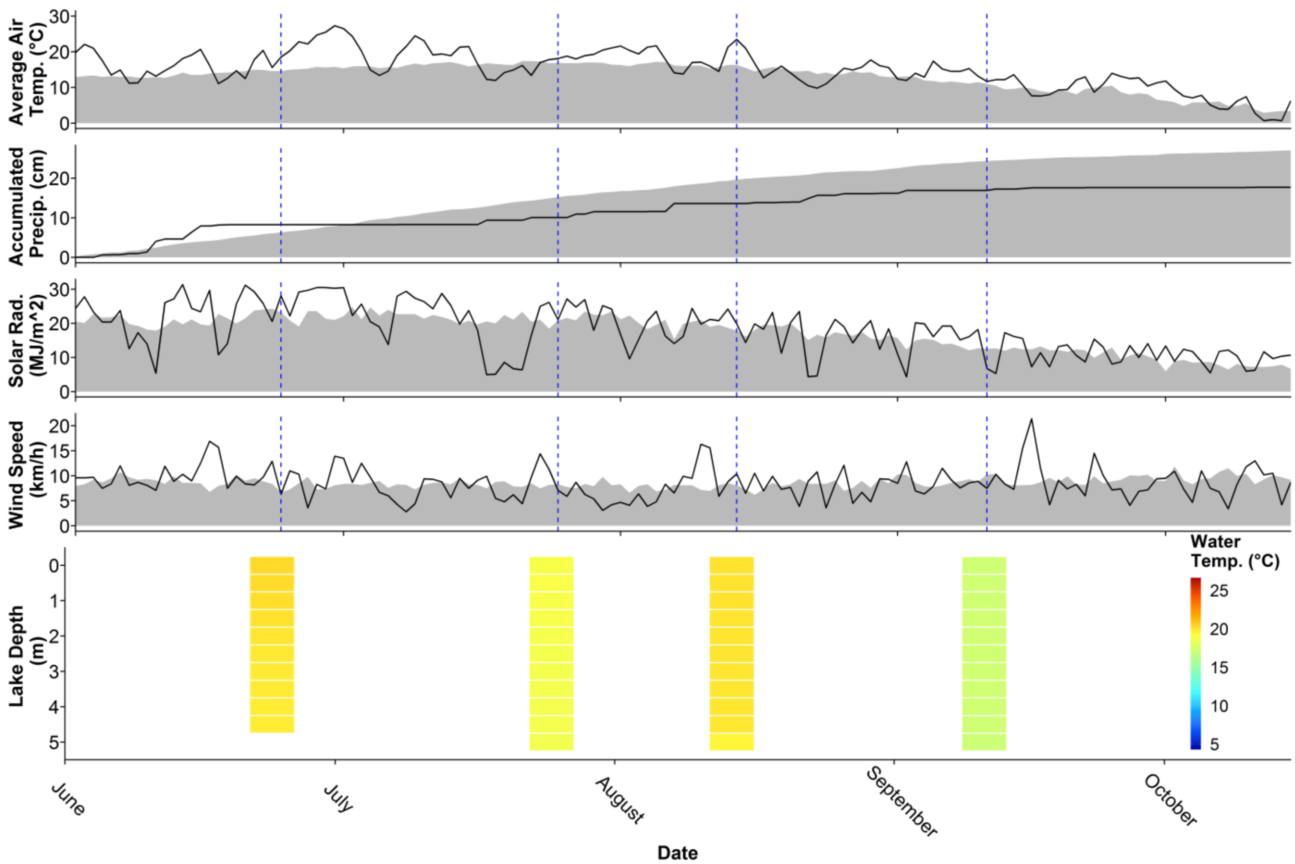

Figure 7. Average air temperature (°C), accumulated precipitation (cm), and wind speed (km/h) measured from St. Lina AGCM, and solar radiation (MJ/m^2) measured from St. Paul AGCM, with Upper Mann Lake temperature profiles (°C) at the bottom. Black lines indicate 2021 levels, gray indicates long-term normals, and blue lines indicate sampling dates for Upper Mann 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 Upper Mann Lake. Historical values are given for reference. Number of sample trips are inconsistent between years.

Parameter	**1983**	**1992**	**1993**	**2019**	**2021**
TP (µg/L)	53	49	46	187	265
TDP (µg/L)	24	21	15	122	238
Chlorophyll-*a* (µg/L)	68.4	20.7	/	26.8	32
Secchi depth (m)	1.00	2.77	/	2.30	2.1
TKN (mg/L)	2.1	1.9	2.0	3.3	4.4
NO_2-N and NO_3-N (µg/L)	<50	44	2	18	41
NH_3-N (µg/L)	29	40	34	129	1230
DOC (mg/L)	/	20	21	36	37
Ca (mg/L)	19	19	22	31	36
Mg (mg/L)	24	35	35	75	71
Na (mg/L)	20	28	29	68	64
K (mg/L)	19	21	23	51	49
SO_4^{2-} (mg/L)	20	26	24	193	188
Cl^- (mg/L)	3	5	5	20	22
CO_3 (mg/L)	23	30	35	41	9
HCO_3 (mg/L)	202	268	268	347	420
pH	9.00	9.11	9.32	8.88	8.45
Conductivity (µS/cm)	411	494	502	1000	1075
Hardness (mg/L)	146	191	199	390	385
TDS (mg/L)	227	280	288	656	662
Microcystin (µg/L)	/	/	/	5.15	1.02
Total Alkalinity (mg/L $CaCO_3$)	203	245	249	353	360

Table 3. Concentrations of metals measured in Upper Mann 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)	2021	Guidelines
Aluminum µg/L	0.5	100[a]
Antimony µg/L	18.8	/
Arsenic µg/L	0.117	5
Barium µg/L	3.42	/
Beryllium µg/L	80.3	100[c,d]
Bismuth µg/L	0.0015	/
Boron µg/L	0.005	1500
Cadmium µg/L	117	0.37[b]
Chromium µg/L	0.005	/
Cobalt µg/L	0.05	50,1000[c,d]
Copper µg/L	0.104	4[b]
Iron µg/L	0.27	300
Lead µg/L	77.6	7[b]
Lithium µg/L	0.074	2500[d]
Manganese µg/L	86.1	260[e]
Molybdenum µg/L	155	73
Nickel µg/L	0.271	150[b]
Selenium µg/L	0.66	1
Silver µg/L	0.4	0.25
Strontium µg/L	0.0005	/
Thallium µg/L	273	0.8
Thorium µg/L	0.001	/
Tin µg/L	0.008	/
Titanium µg/L	0.03	/
Uranium µg/L	2.79	15
Vanadium µg/L	0.6	100[c,d]
Zinc µg/L	0.573	30[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