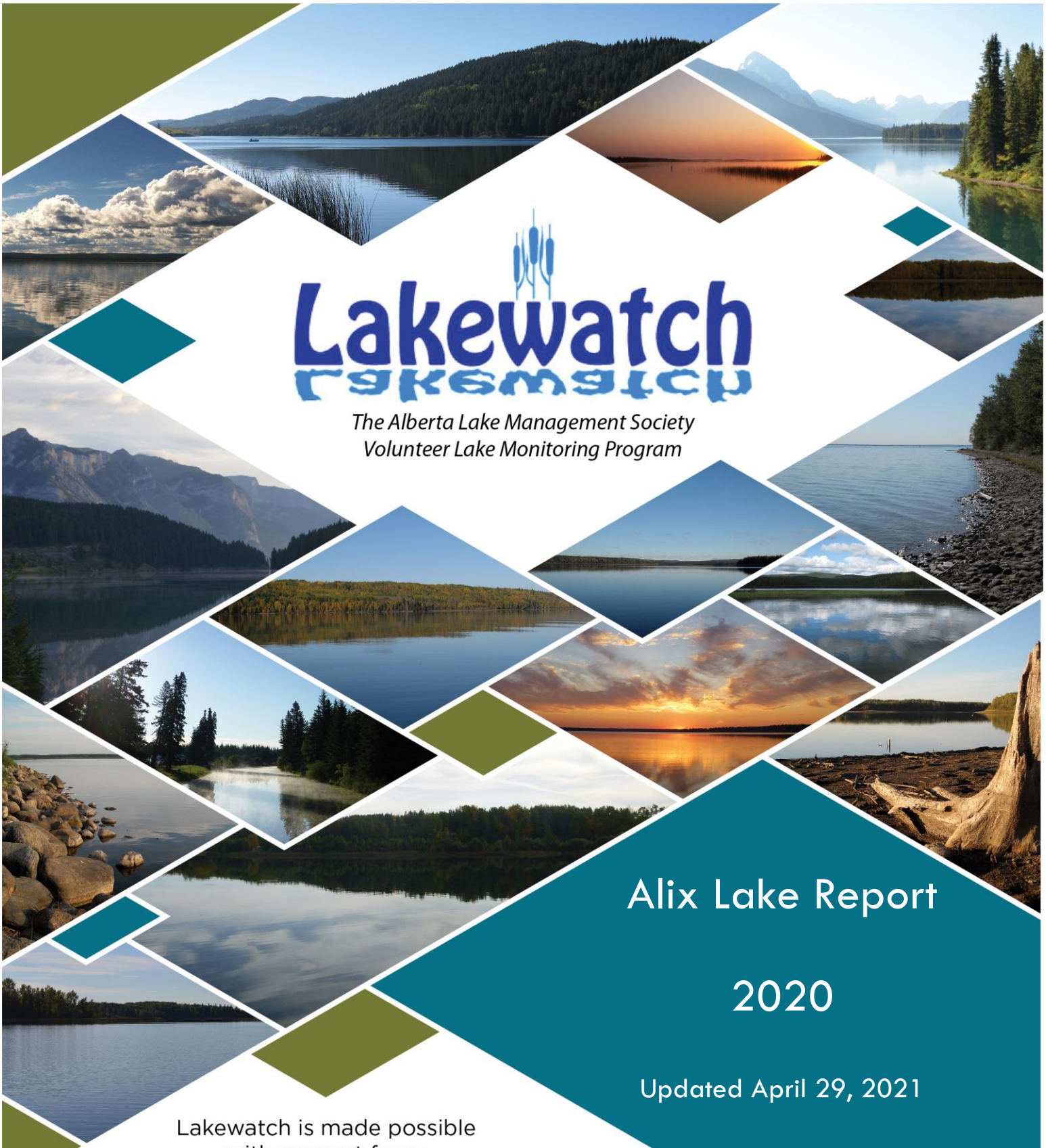


Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Alix Lake 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 Mike Carr and Terry Allan for their commitment to collecting data at Alix Lake. 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.

ALIX LAKE

Alix Lake is within the Red Deer River watershed approximately 40 km east of Lacombe. The lake is shallow, with a maximum depth of less than 3 m. The village of Alix lies on the northeast end of the lake. It was originally named Toddsville after Joseph Todd who came from Michigan, USA to homestead on the shores of the lake in 1900. Currently, the village has a population of 734. There is a campground and boat launch near the village for public access to the lake, and it is a popular recreation area for waterskiers, wakeboarders, and kayakers.

Alix Lake is part of the Parlby Creek-Buffalo Lake Water Management System which began diversions in 1996. This system involves a water conveyance system to divert water from the Red Deer River through a conduit system into Alix Lake, and from there through the Parlby-Creek channel to Buffalo Lake. Initial assessments suggested that the water quality of Alix Lake has been improved by diversions from the Red Deer River.[1] The diversion of river water into the lake was last operational in 2010 (AEP personal communication, April 28, 2021).

The southern-most arm of Alix Lake is an important nesting area for various species of waterfowl, making it a wonderful place for waterfowl and wildlife viewing. Alix Lake is located within the Central Parkland natural region (Government of Alberta, 2007). It is a productive lake, and may receive blue-green algae (cyanobacteria) advisories in the summer months.

Alix Lake - Photo by Lacombe Tourism

[1] Mitchell, P. 1999. Parlby Creek – Buffalo Lake Water Management Project Water Quality Update 1997-1998. Accessed 04/08/2020 from: https://open.alberta.ca/publications/1781200

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 Alix Lake was 29 µg/L (Table 2), falling into the mesotrophic, or moderately productive trophic classification. This value is on the lower end of the historical range of TP for Alix Lake (Table 2). TP was lowest when sampled on September 22nd at 19 µg/L, and peaked at 37 µg/L on July 28th (Figure 1).

Average chlorophyll-*a* concentration in 2020 was 18.7 µg/L, falling into the eutrophic, or highly productive trophic classification, and is on the higher end of the historical range (Table 2). Chlorophyll-*a* was relatively consistent throughout the season, being highest at the end of the season, with a maximum of 23.4 µg/L on September 22nd, and lowest on July 28th at 14.4 µg/L (Figure 1).

Average TKN concentration was 2.2 mg/L (Table 2) with concentrations being consistently between 2.1 and 2.2 mg/L on each individual sampling event throughout the 2020 sampling season.

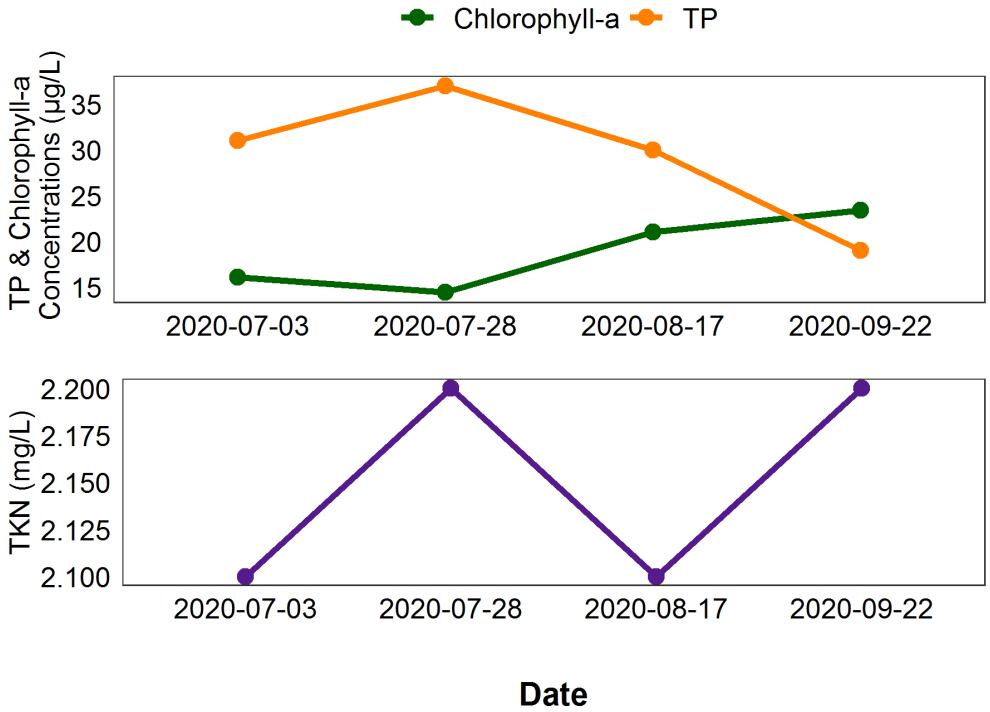


Figure 1. Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Alix Lake.

Average pH was measured as 8.54 in 2020, buffered by moderate alkalinity (370 mg/L $CaCO_3$) and bicarbonate (428 mg/L HCO_3). Aside from bicarbonate, the dominant ions were sulphate and sodium, contributing to a moderate to high conductivity of 1000 µS/cm (Figure 2, top; Table 2). Alix Lake was on the upper end of ion levels compared to other LakeWatch lakes sampled in 2020 (Figure 2, bottom).

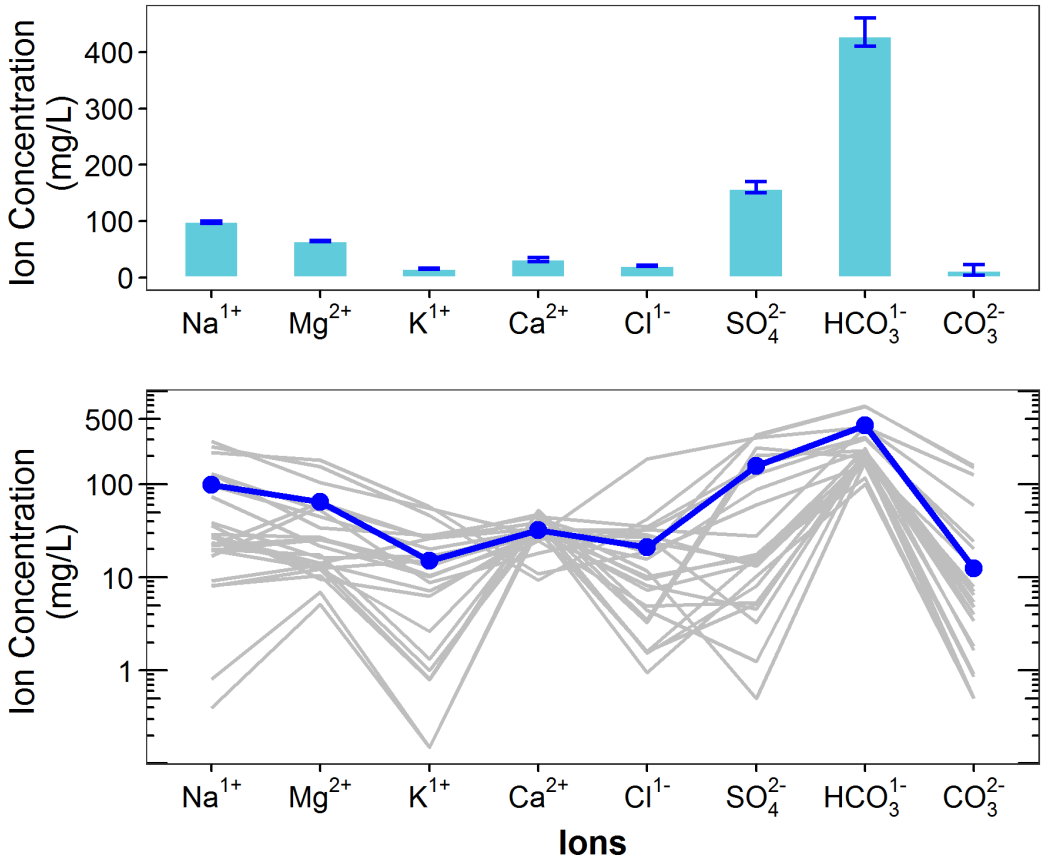


Figure 2. Average levels of cations (sodium = Na^{1+}, magnesium = Mg^{2+}, potassium = K^{1+}, calcium = Ca^{2+}) and anions (chloride = Cl^{1-}, sulphate = SO_4^{2-}, bicarbonate = HCO_3^{1-}, carbonate = CO_3^{2-}) from four measurements over the course of the summer at Alix Lake. Top) bars indicate range of values measured, and bottom) Schoeller diagram of average ion levels at Alix Lake (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 Alix Lake 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 Alix Lake in 2020 was 2.13 m corresponding to an average Secchi depth of 1.06 m, which is on the smaller end of the historical record (Table 2). Euphotic depth was greatest at the beginning of the summer, and was lowest during the September 22nd sampling at 1.6 m (Figure 3).

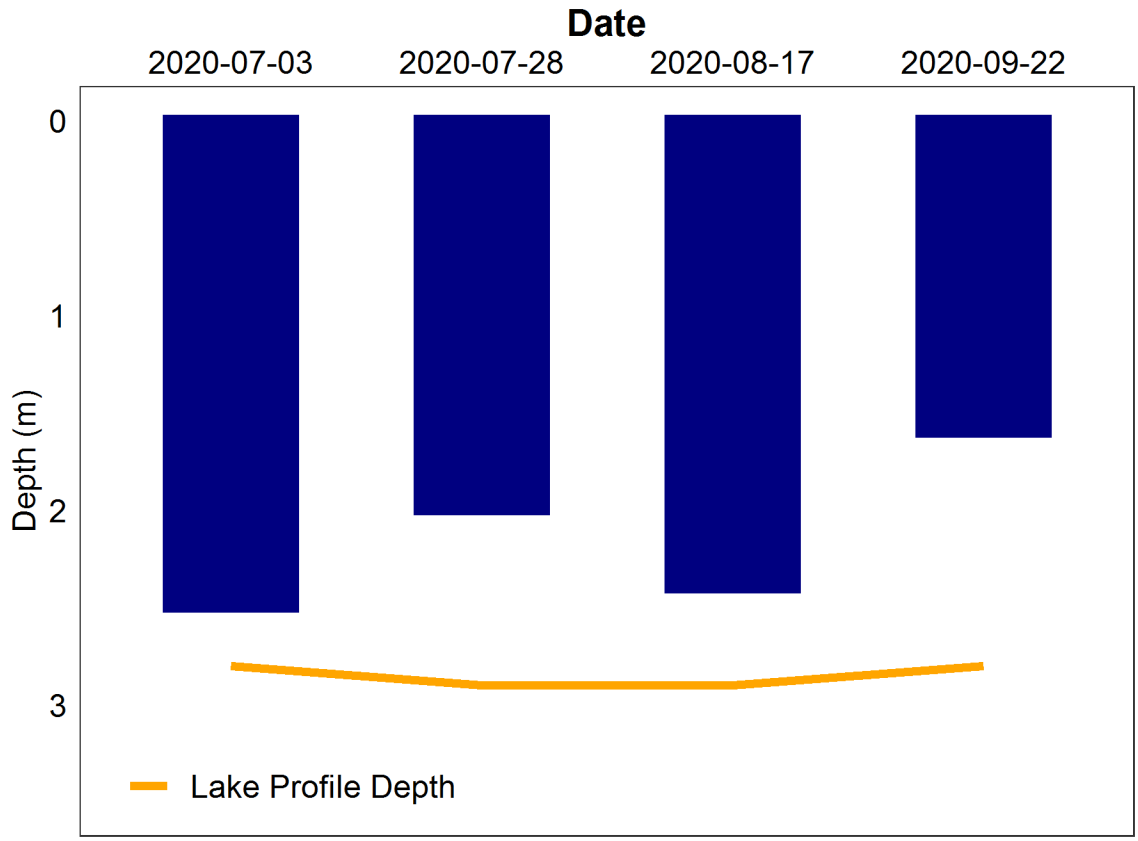


Figure 3. Euphotic depth values measured four times over the course of the summer at Alix Lake in 2020.

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 Alix Lake varied throughout the summer, with a minimum temperature of 14.3°C throughout the whole water column on September 22nd, and a maximum temperature of 22.2°C measured near the surface on July 28th (Figure 4a). The lake was not stratified during any of the sampling trips, as indicated by the consistency of profile temperature measurements. This indicates partial or complete mixing throughout the season.

Alix Lake remained well oxygenated throughout the summer, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen in all dates and depths except at 2.5 m on July 28th and August 17th (Figure 4b).

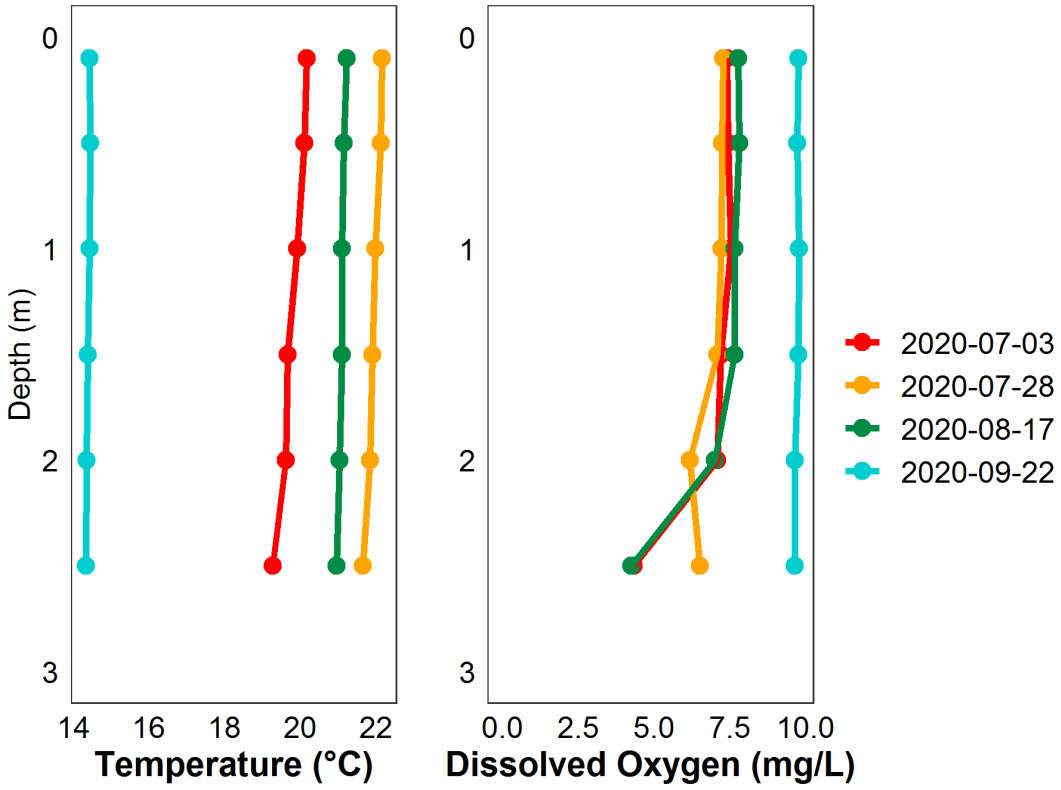


Figure 4. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Alix Lake measured four times over the course of the summer of 2020.

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 fell below the recreational guideline of 20 µg/L at the locations and times sampled in Alix Lake in 2020. Despite microcystin concentrations remaining low throughout the summer, caution should be observed when recreating in visible blooms, which are known to occur at Alix Lake.

Table 1. Microcystin concentrations measured four times at Alix Lake in 2020.

Date	Microcystin Concentration (µg/L)
3-Jul-20	1.92
28-Jul-20	1.07
17-Aug-20	1.01
22-Sep-20	0.63
Average	1.16

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 Alix Lake.

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 Alix Lake 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 or Environment and Climate Change Canada.

Water levels in Alix Lake have remained relatively stable since monitoring began in 1996, with some relatively short-lived low levels in 1998, 2001, 2012, and 2017 (Figure 5). Since 1996, Alix Lake water levels have fluctuated within about a 0.6m range.

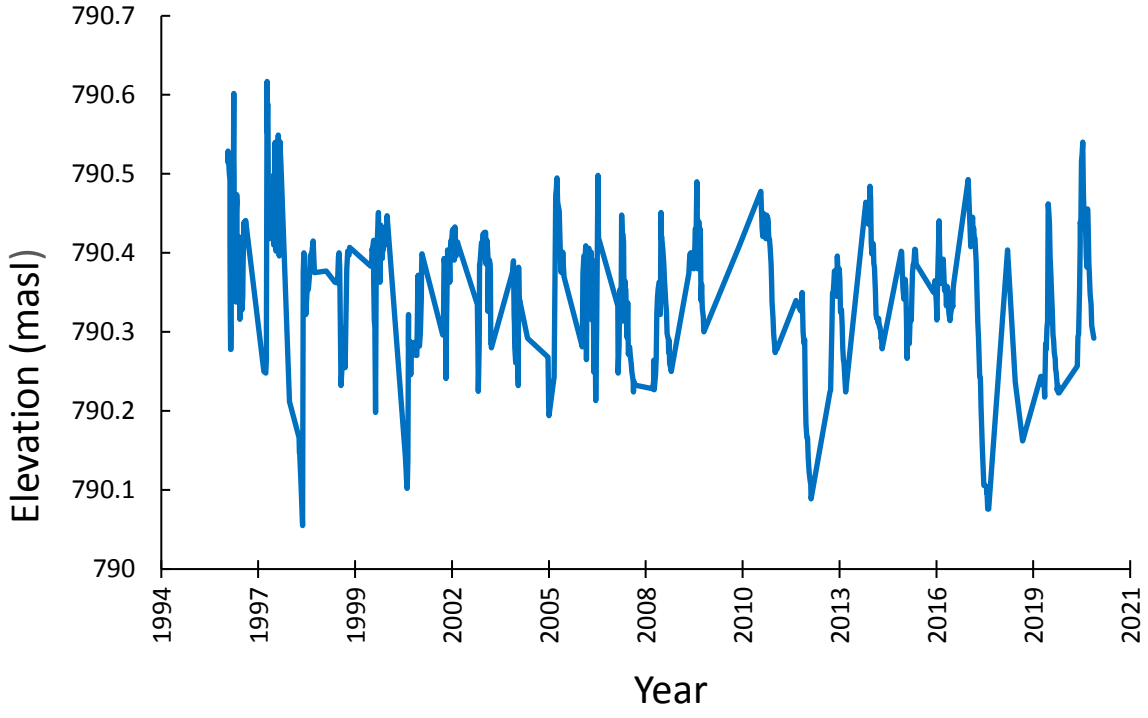


Figure 5. Water levels measured in meters above sea level (masl) from 1996- 2020. Data retrieved from Alberta Environment and Parks.

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

Parameter	1992	1993	1996	1997	1998	1999	2000	2001
TP (µg/L)	58	59	30	22	28	27	21	30
TDP (µg/L)	21	17	10	8	8	9	8	9
Chlorophyll-*a* (µg/L)	16.1	11.7	7.8	3.9	5.8	6.2	4.5	8.0
Secchi depth (m)	1.30	1.33	2.05	2.67	*2.62	2.62	2.66	*2.23
TKN (mg/L)	2.4	2.0	0.7	0.5	0.7	0.6	0.5	0.5
NO_2-N and NO_3-N (µg/L)	4	5	3	3	2	2	2	8
NH_3-N (µg/L)	133	55	55	16	14	13	14	6
DOC (mg/L)	27	/	/	/	/	/	10	/
Ca (mg/L)	21	20	33	37	26	32	30	29
Mg (mg/L)	69	67	24	19	16	18	17	18
Na (mg/L)	146	138	22	15	13	16	18	15
K (mg/L)	20	20	4	3	2	3	3	2
SO_4^{2-} (mg/L)	187	124	42	34	28	36	36	38
Cl^- (mg/L)	12	12	3	4	3	5	5	4
CO_3 (mg/L)	21	35	3	2	4	1	1	1
HCO_3 (mg/L)	519	530	207	181	143	180	171	161
pH	8.64	8.75	8.37	8.24	8.31	8.19	8.03	8.24
Conductivity (µS/cm)	1178	1132	408	354	/	356	338	313
Hardness (mg/L)	329	/	180	169	134	154	146	148
TDS (mg/L)	/	/	234	203	167	202	195	187
Microcystin (µg/L)	/	/	/	/	/	/	/	/
Total Alkalinity (mg/L $CaCO_3$)	461	493	175	151	125	149	141	133

*Contains sampling events where Secchi depth reading was equal to lake depth where reading took place.

Table 2b. Average historical Secchi depth and water chemistry values for Alix Lake.

Parameter	2002	2007	2014	2016	2017	2020
TP (µg/L)	22	55	56	38	38	29
TDP (µg/L)	8	7	13	15	10	7
Chlorophyll-*a* (µg/L)	4.2	21.3	13.8	21.7	18.7	18.7
Secchi depth (m)	2.95	1.40	1.30	0.70	0.72	1.06
TKN (mg/L)	0.5	1.3	1.9	1.3	2.1	2.2
NO_2-N and NO_3-N (µg/L)	3	2	6	3	2	2
NH_3-N (µg/L)	17	104	111	47	27	79
DOC (mg/L)	/	12	/	22	27	22
Ca (mg/L)	28	41	/	27	32	32
Mg (mg/L)	16	25	/	61	70	65
Na (mg/L)	15	30	81	100	112	99
K (mg/L)	2	5	/	12	15	15
SO_4^{2-} (mg/L)	39	53	147	173	164	158
Cl^- (mg/L)	5	6	12	18	20	21
CO_3 (mg/L)	5	5	16	33	32	12
HCO_3 (mg/L)	147	247	364	348	424	428
pH	8.50	8.38	8.61	8.90	8.80	8.54
Conductivity (µS/cm)	311	487	882	953	1040	1000
Hardness (mg/L)	137	205	297	318	372	348
TDS (mg/L)	182	287	533	603	668	623
Microcystin (µg/L)	/	/	/	/	0.31	1.16
Total Alkalinity (mg/L $CaCO_3$)	128	210	325	340	402	370

Table 3. Concentrations of metals measured in Alix Lake since 2017. 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)	2017	Guidelines
Aluminum µg/L	4.3	100[a]
Antimony µg/L	0.173	/
Arsenic µg/L	2.37	5
Barium µg/L	94.4	/
Beryllium µg/L	0.0055	100[c,d]
Bismuth µg/L	0.0055	/
Boron µg/L	92.2	1500
Cadmium µg/L	0.025	0.26[b]
Chromium µg/L	0.25	/
Cobalt µg/L	0.114	1000[d]
Copper µg/L	1.64	4[b]
Iron µg/L	19.1	300
Lead µg/L	0.029	7[b]
Lithium µg/L	70.7	2500[e]
Manganese µg/L	50	200[e]
Molybdenum µg/L	0.432	73[c]
Nickel µg/L	0.43	150[b]
Selenium µg/L	0.5	1
Silver µg/L	0.0025	0.25
Strontium µg/L	429	/
Thallium µg/L	0.005	0.8
Thorium µg/L	0.014	/
Tin µg/L	0.15	/
Titanium µg/L	1.54	/
Uranium µg/L	1.38	15
Vanadium µg/L	0.761	100[d,e]
Zinc µg/L	2.5	30

Values represent means of total recoverable metal concentrations.
[a] Based on pH ≥ 6.5
[b] Based on water hardness > 180mg/L (as $CaCO_3$)
[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.

LONG TERM TRENDS

Trend analysis was conducted on the parameters total phosphorus (TP), chlorophyll-*a*, total dissolved solids (TDS) and Secchi depth to look for changes over time in Alix Lake. In sum, a significant increases was observed in TDS, and no significant trends were detected for TP, chlorophyll-*a*, and Secchi depth. Secchi depth can be subjective and is sensitive to variation in weather - trend analysis must be interpreted with caution. Data is presented below as both line graph and box-and-whisker plots. Detailed methods are available in the *ALMS Guide to Trend Analysis on Alberta Lakes.*

Table 4. Summary table of trend analysis on Crane Lake data from 2005 to 2019.

Parameter	Date Range	Direction of Significant Trend
Total Phosphorus	1992-2020	No Trend Detected
Chlorophyll-*a*	1992-2020	No Trend Detected
Total Dissolved Solids	1996-2020	Increasing
Secchi Depth	1992-2020	No Trend Detected

Definitions:

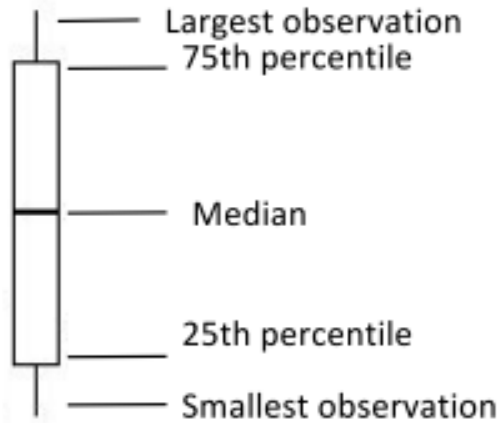
Median: the value in a range of ordered numbers that falls in the middle.

Trend: a general direction in which something is changing.

Monotonic trend: a gradual change in a single direction.

Statistically significant: The likelihood that a relationship between variables is caused by something other than random chance. This is indicated by a p-value of <0.05. Variability: the extent by which data is inconsistent or scattered.

Box and Whisker Plot: a box-and-whisker plot, or boxplot, is a way of displaying all of our annual data. The median splits the data in half. The 75th percentile is the upper quartile of the data, and the 25th percentile is the lower quartile of the data. The top and bottom points are the largest and smallest observations.



Total Phosphorus (TP)

Total phosphorus (TP) has not changed significantly over the course of data collection at Alix Lake (Tau = -0.12, *p* = 0.23).

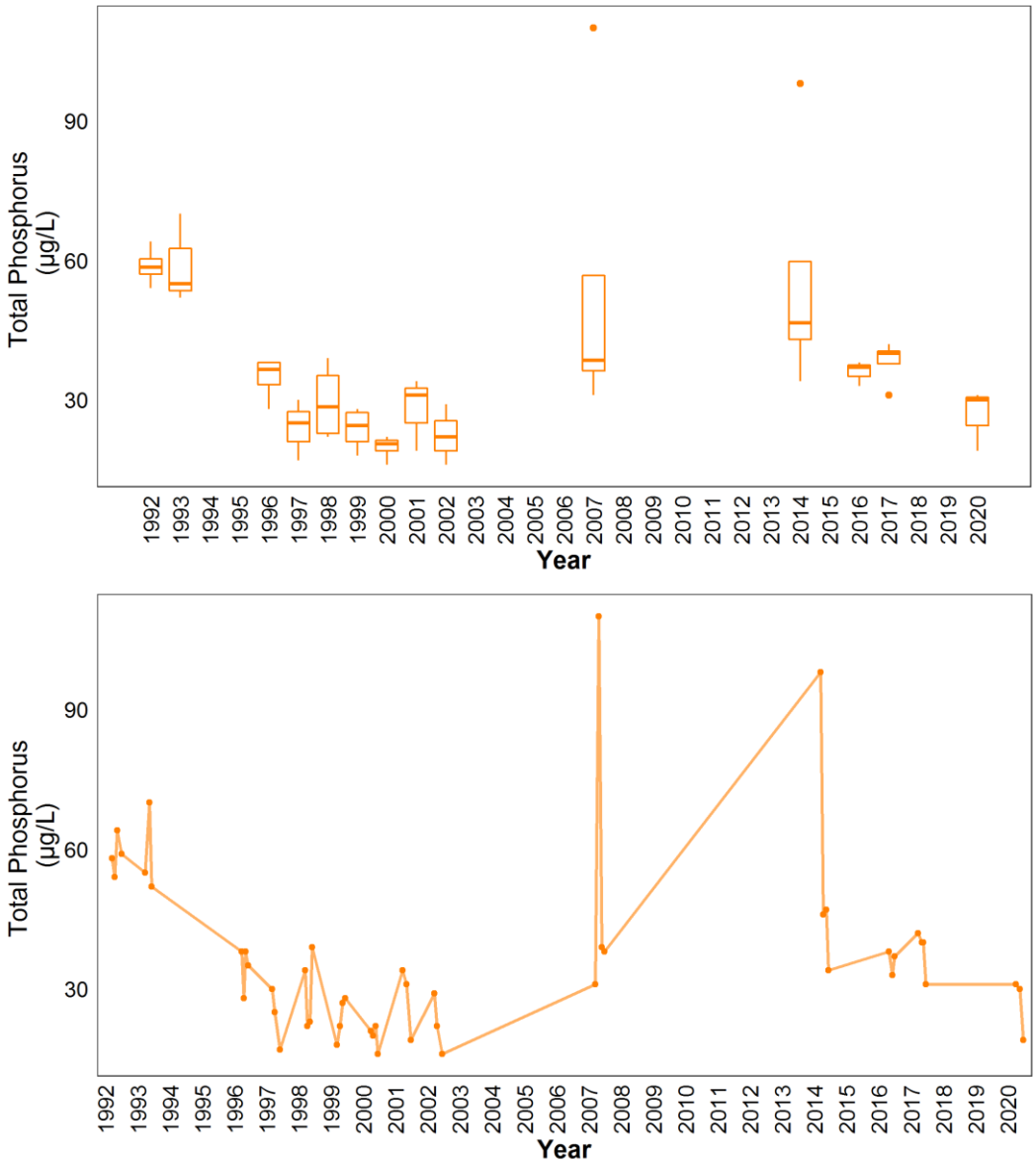


Figure 6. Monthly total phosphorus (TP) concentrations measured between June and September over the long term sampling dates between 1992 and 2020 (n = 50). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Chlorophyll-*a*

Chlorophyll-*a* has not changed significantly since sampling began at Alix Lake (Tau = 0.12, p = 0.28). When historical data is examined, TP and Chlorophyll *a* do significantly correlate (r = 0.48, p = 0.0004).

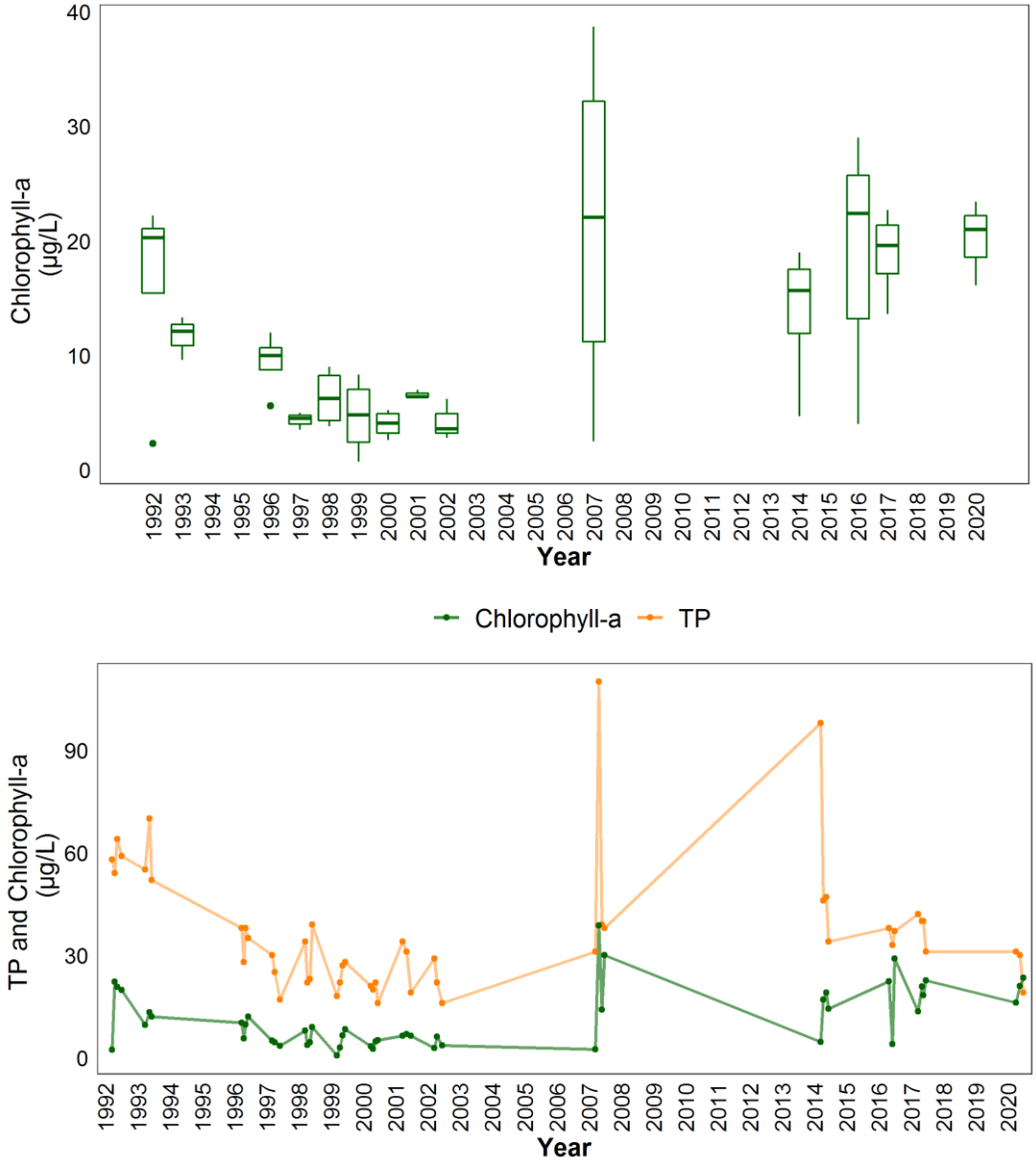


Figure 7. Monthly chlorophyll-*a* concentrations measured between June and September over the long term sampling dates between 1992 and 2020 (n = 50). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples. Line graph is overlain by TP concentrations.

Total Dissolved Solids (TDS)

Total dissolved solids have increased significantly since sampling began in 1996 (Tau= 0.52, $p < 0.001$). This is likely not due to evaporative losses, as Alix Lake's water levels have not declined in recent years.

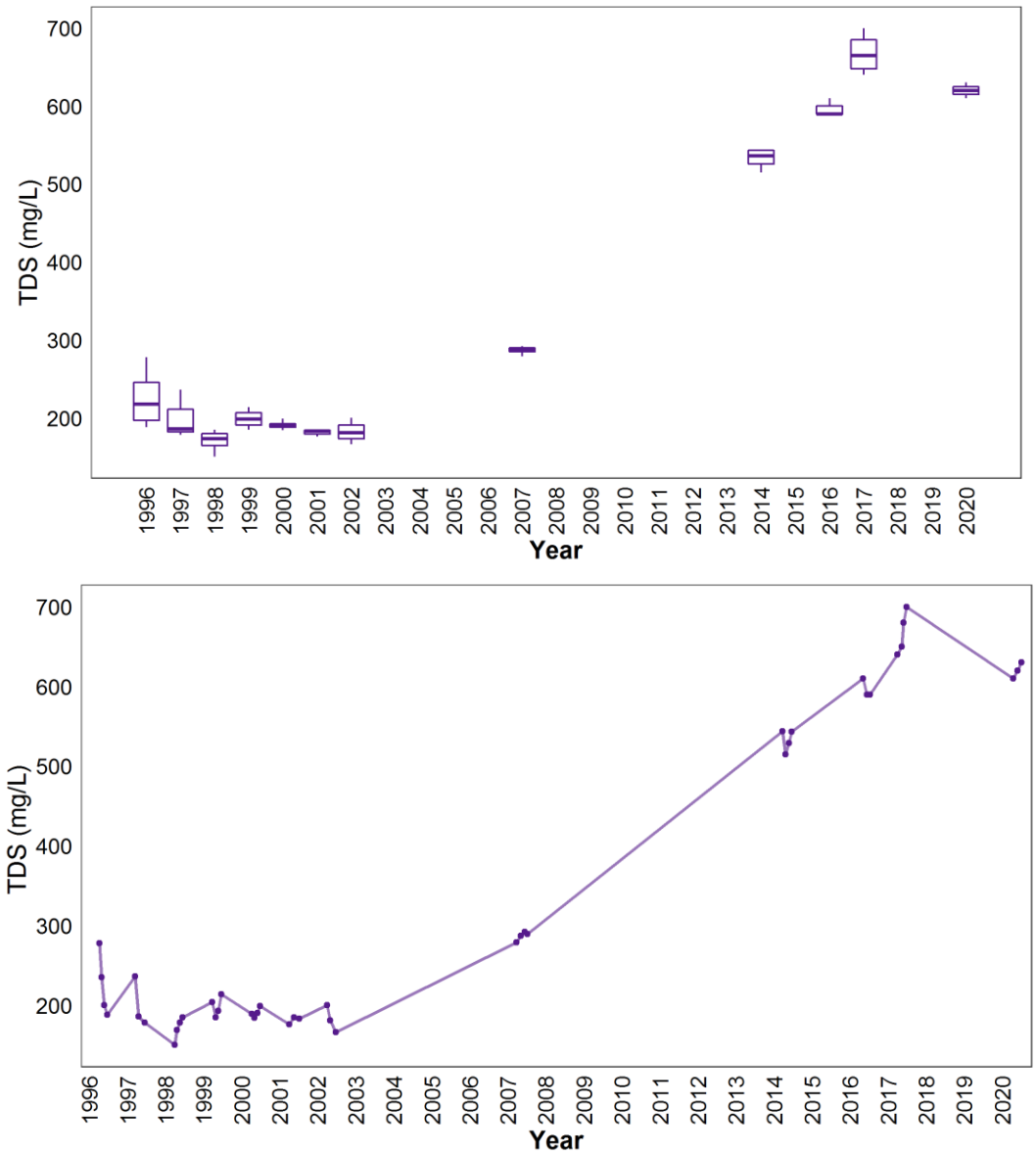


Figure 8. Monthly TDS values measured between June and September over the long term sampling dates between 1996 and 2020 (n = 43). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Secchi Depth

Trend analysis found that water quality measured as Secchi depth has not significantly changed over the sampling period (Tau = - 0.14, *p* = 0.18).

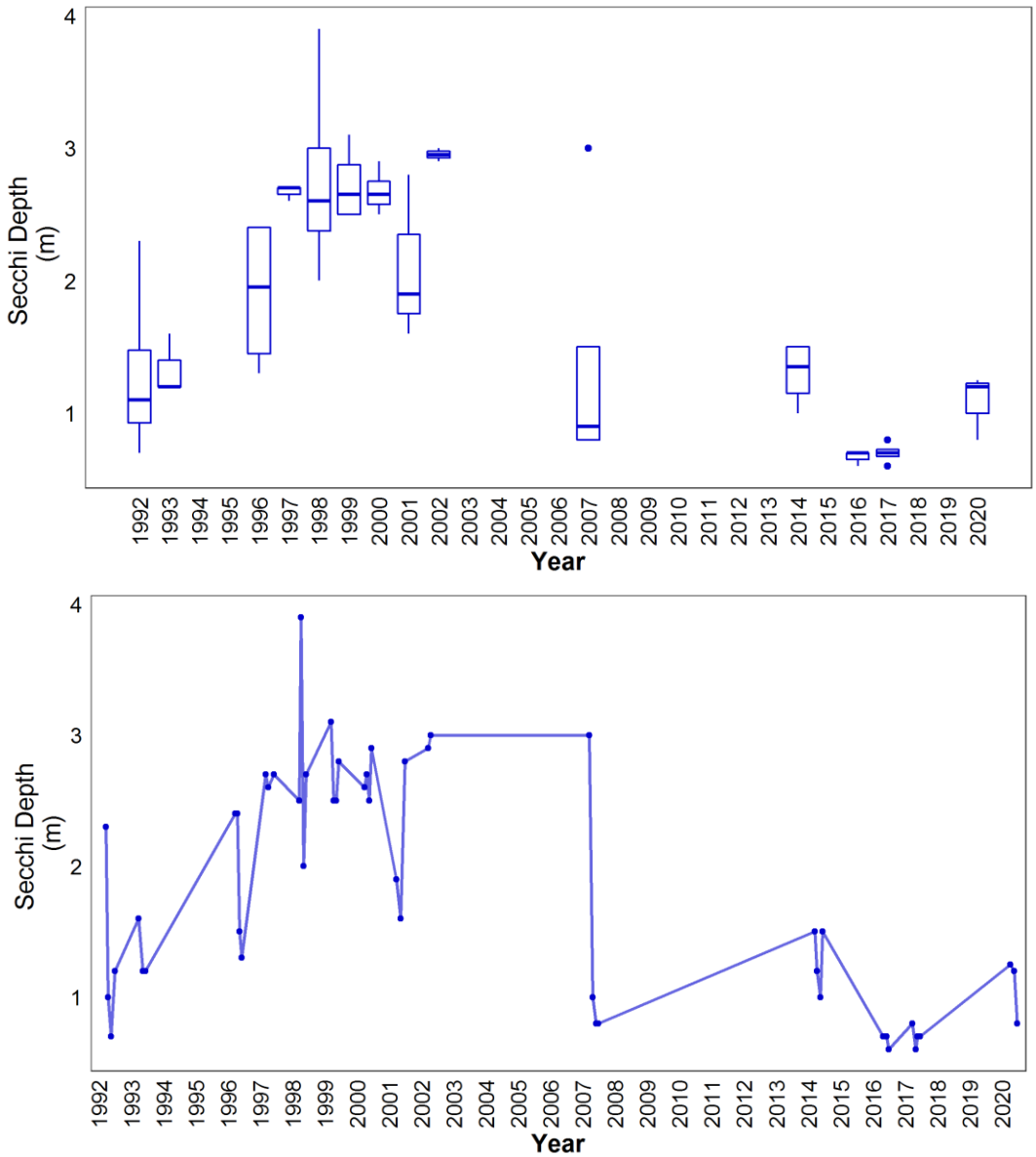


Figure 9. Monthly Secchi depth values measured between June and September over the long term sampling dates between 1992 and 2020 (n = 49). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Table 6. Results of Seasonal Kendall Trend test using monthly total phosphorus (TP), chlorophyll-*a* and Secchi depth data from June to September on Alix Lake data.

Definition	Unit	Total Phosphorus (TP)	Chlorophyll-a	Total Dissolved Solids (TDS)	Secchi Depth
Statistical Method	-	Seasonal Kendall	Seasonal Kendall	Seasonal Kendall	Seasonal Kendall
The strength and direction (+ or -) of the trend between -1 and 1	Tau	-0.12	0.12	0.52	-0.14
The extent (slope) of the trend	Slope	-0.43	0.17	19.35	-0.02
The statistic used to find significance of the trend	Z	-1.19	1.09	4.39	-1.34
Number of samples included	n	50	50	43	49
The significance of the trend	*p*	0.23	0.28	1.11×10^{-5}*	0.18

*$p < 0.05$ is significant within 95%