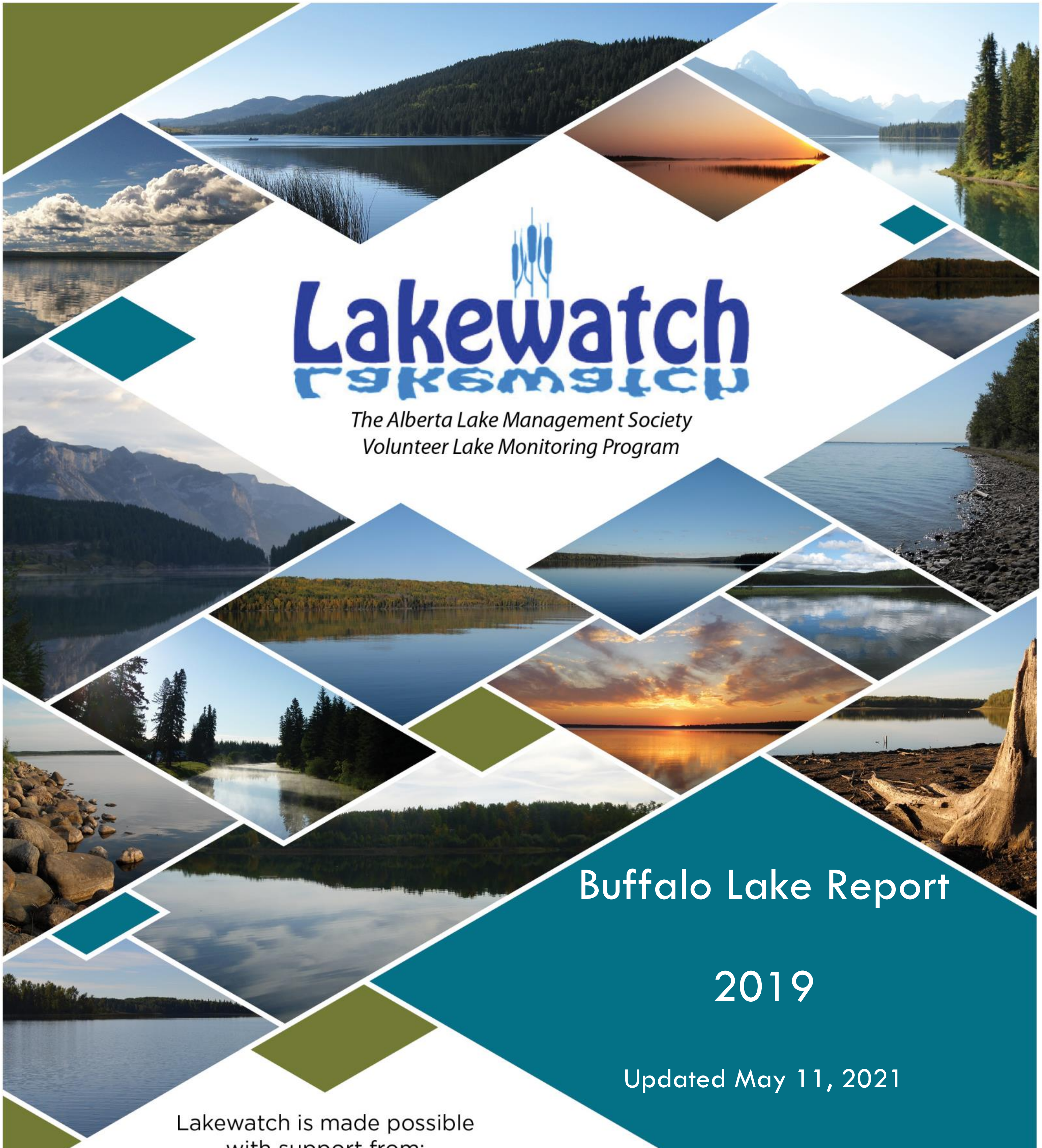


Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Buffalo Lake Report

2019

Updated May 11, 2021

Lakewatch is made possible
with support from:

Alberta Environment and Parks

Pigeon Lake Watershed Association

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.

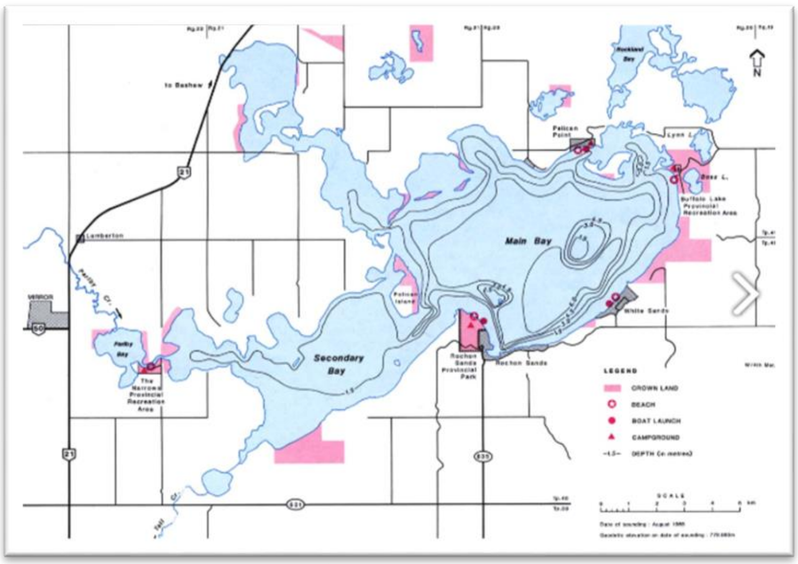
If you require data from this report, please contact ALMS for the raw data files.

ACKNOWLEDGEMENTS

The LakeWatch program is made possible through the dedication of its volunteers. A special thanks to Roger Nichols for his commitment to collecting data at Buffalo Lake. We would also like to thank Sarah Davis Cornet, Caleb Sinn, and Pat Heney, who were summer technicians in 2019. Executive Director Bradley Peter and Program Coordinator Caitlin Mader were instrumental in planning and organizing the field program. This report was prepared by Pat Heney, Bradley Peter, and Caleb Sinn.

BUFFALO LAKE

Buffalo Lake is located in central Alberta, 40 km northeast of Red Deer. It resides in the counties of Camrose, Stettler and Lacombe. Buffalo Lake is host to four public recreation areas, with camping, picnic areas, swimming and boat launches.



Bathymetric map of Buffalo Lake (Source: Prepas & Mitchell 1990)

The Lake has four natural basins- Main Bay is the largest and deepest, Secondary Bay is smaller and very shallow, The Narrows is the channel west of Secondary Bay and is a popular fishing area, and Parlby Bay is shallow and home to dense aquatic plants and waterfowl. The lake was labelled as Buffalo Lake in 1814 on a map by David Thompson, named for its resemblance to a Buffalo with the legs to the north and the head to the east [1]. Buffalo were likely attracted to the lake with the surrounding trembling aspen and fescue grassland habitat. The lake was a favourite camping area for Cree and Blackfoot, and in 1858, Father Lacombe, a young missionary, travelled for two days to help the group of Blackfoot people dying from scarlet fever on the east shore of Buffalo Lake [2]. The settlement on the southwest side of Buffalo Lake was established in 1883 and was one of the first in central Alberta [2].

Buffalo Lake supports fisheries for northern pike, burbot, white sucker and brook stickleback, which are all tolerant of high salinity and alkalinity.

The watershed area for Buffalo Lake is 1476 km^2 and the lake area is 96 km^2. The lake to watershed ratio of Buffalo Lake is 1:15. A map of the Buffalo Lake watershed area can be found at http://alms.ca/lake-watershed-maps/.

---

[1] Alta. Cult. Multicult. n.d.

[2] Lamerton Hist. Soc. 1974.

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 Maxxam Analytics, 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. 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.

---

[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.

Buffalo Lake was sampled only twice in 2019 – this should be considered when comparing results to previous year sampling events.

The average total phosphorus (TP) concentration for Buffalo Lake was 41 µg/L (Table 2), falling into the category of eutrophic, or highly productive trophic classification. This value falls within the range of historical averages. Detected TP was lowest when first sampled on September 3 at 40 µg/L, and peaked at 41 µg/L on August 15 (Figure 1).

Average chlorophyll-*a* concentrations in 2019 was 15.7 µg/L (Table 2), falling into the eutrophic, or productive trophic classification. Like TP, Chlorophyll-*a* fluctuated slightly throughout the season, from a minimum of 12.9 µg/L in August to a maximum of 18.0 µg/L in September.

Finally, the average TKN concentration was 2.5 mg/L (Table 2) with concentrations peaking at 2.6 mg/L on September 3.

Average pH was measured as 9.22 in 2019, buffered by high alkalinity (1100 mg/L $CaCO_3$) and bicarbonate (875 mg/L HCO_3). Sodium and sulphate were the dominant ions contributing to a high conductivity of 2650 µS/cm (Table 2). The high conductivity may help to suppress the growth of cyanobacteria (blue-green algae).

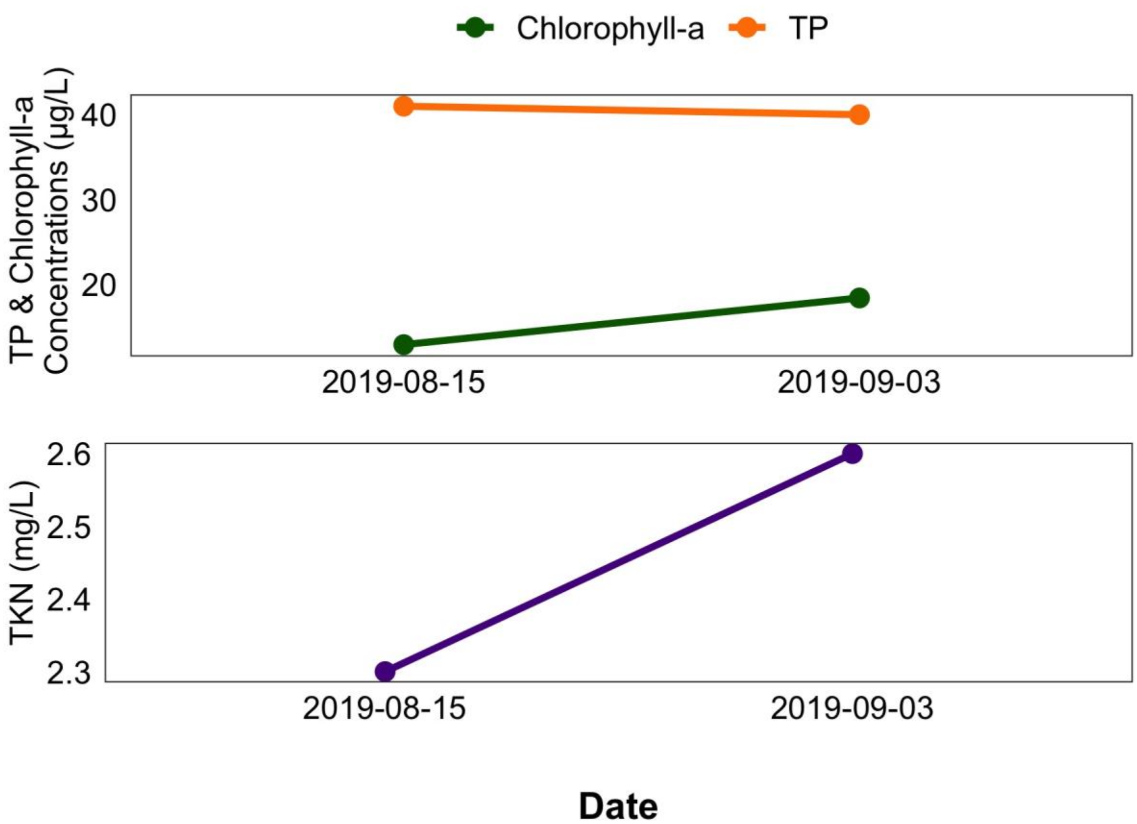


Figure 1. Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured twice over the course of the summer at Buffalo Lake.

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 Buffalo Lake in 2019, but historical data is available in Table 3.

WATER CLARITY AND SECCHI 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 Secchi depth of Buffalo Lake in 2019 was 1.45 m (Table 2). Secchi depth was shallow throughout the season, varying by only 0.3 m between its highest and lowest points (Figure 2).

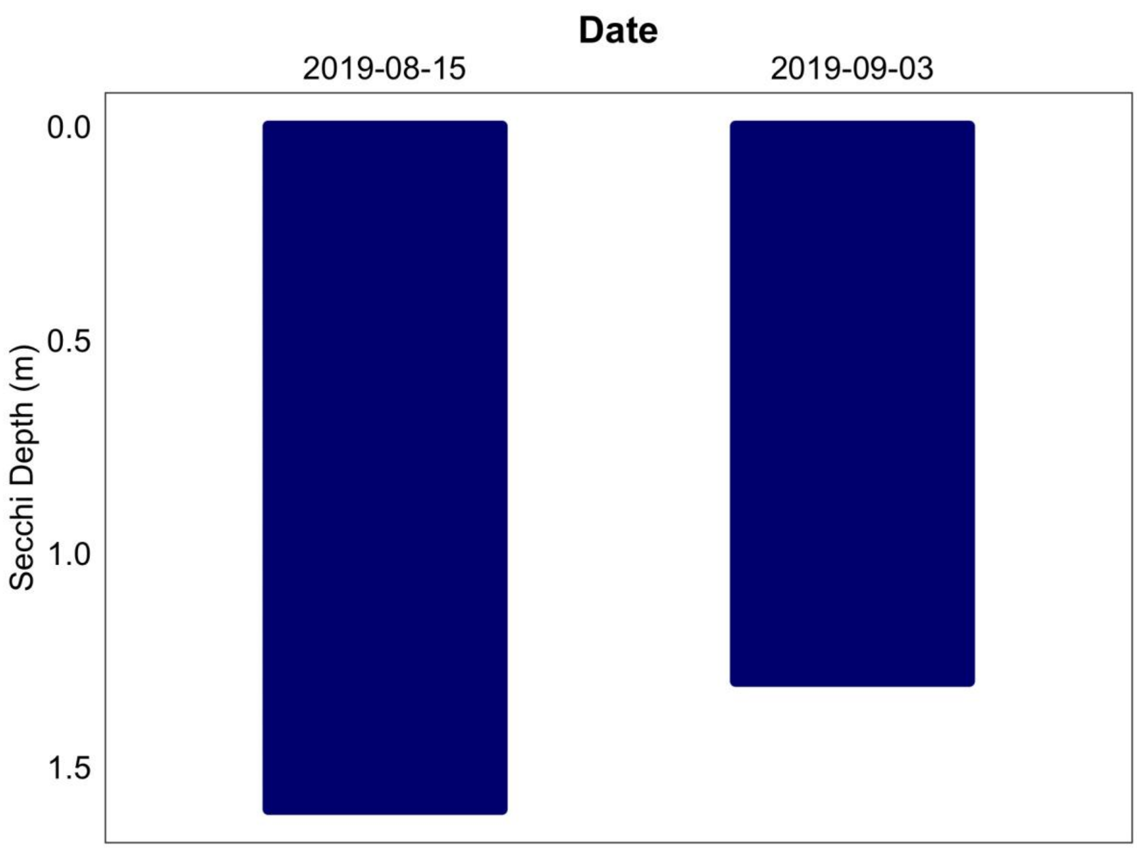


Figure 2. Secchi depth values measured two times over the course of the summer at Buffalo Lake in 2019.

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 Buffalo Lake varied throughout the summer, with a minimum temperature of 15.85 °C at the bottom on September 3, and a maximum temperature of 18.43°C measured at the lake bottom on August 3 (Figure 3a). The lake was not stratified during any of the sampling trips, with temperatures fairly constant from top to bottom, which indicates complete mixing throughout the season.

Buffalo Lake remained well oxygenated through most of the water column throughout the summer, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen (Figure 3b). The oxygen level did not fall below this guideline at any point during our visits this summer.

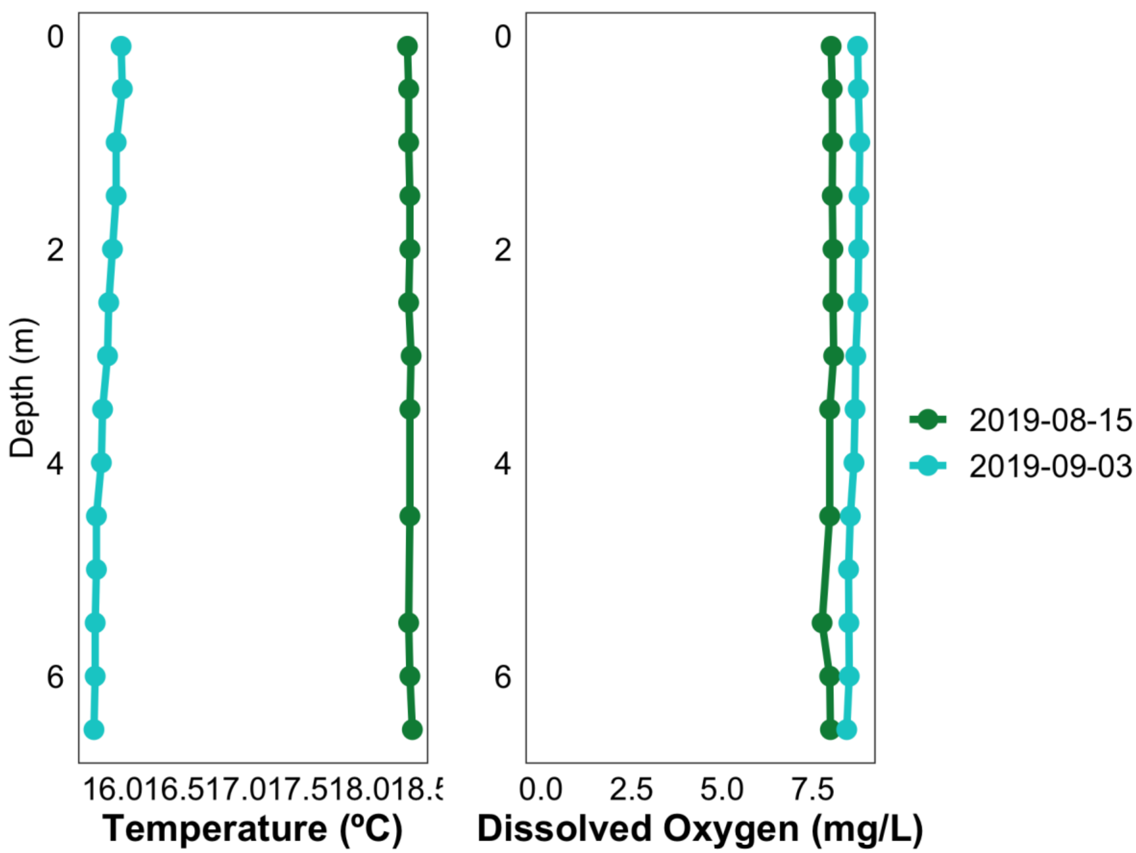


Figure 3. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Buffalo Lake measured twice over the course of the summer of 2019.

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 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 in Buffalo Lake fell below the recreational guideline of 20 μg/L for at the locations and times sampled in Buffalo Lake in 2019.

Table 1. Microcystin concentrations measured two times at Buffalo Lake in 2019.

Date	Microcystin Concentration (μg/L)
15-Aug-19	0.41
03-Sep-19	0.39
Average	**0.40**

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 have been linked to creating toxic cyanobacteria blooms, decreasing the amount of nutrients needed for fish and other native species, and causing millions of dollars in annual costs for repair and maintenance of water-operated infrastructure and facilities.

Monitoring involved using a 63 μm plankton net at three sample sites to look for juvenile mussel veligers in each lake sampled. No mussels were detected at Buffalo Lake in the summer of 2019.

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.

No milfoil, native or Eurasian, was observed at Buffalo Lake in 2019.

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 in Buffalo Lake have remained relatively stable since Environment Canada began monitoring the lake in 1965 (Figure 4). Since 1965, Buffalo Lake water levels have fluctuated between a maximum of 781.4 masl and a minimum of 779.7 masl.

In 1985, Alberta Environment commenced the Parlby Creek-Buffalo Lake Water Management project in order to stabilize water levels, secure water supplies, enhance wildlife and fish habitat and provide flooding control. A full supply level (FSL) target of 780.85 m was established, but natural fluctuation of lake water levels were maintained[3].

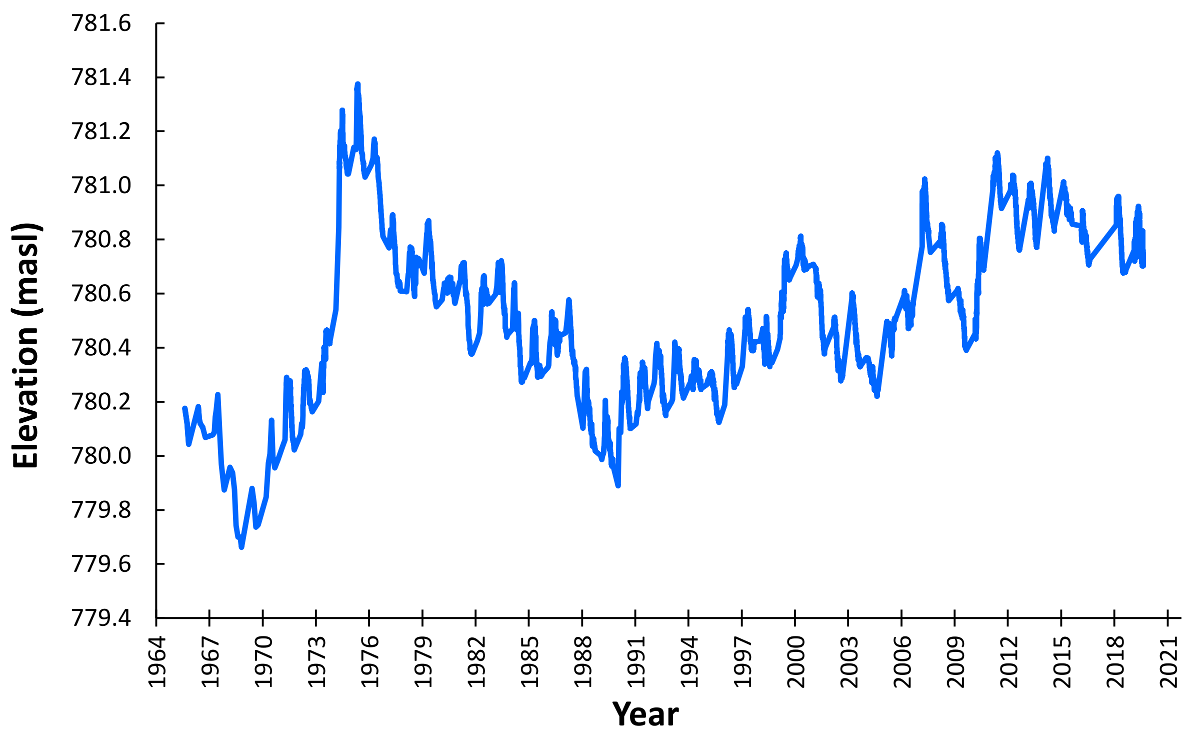


Figure 4. Water levels measured in meters above sea level (masl) from 1965-2019. Data retrieved from Environment Canada (1965 – 2018), and Alberta Environment and Parks (2019).

[3]Government of Alberta. 2010. Buffalo Lake Integrated Shoreland Management Plan.

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

Parameter	1984	1985	1986	1989	1990	1992	1993	1994
TP (µg/L)	65	44	58	80	69	66	/	79
TDP (µg/L)	/	/	/	/	/	/	/	/
Chlorophyll-*a* (µg/L)	9.5	8.3	6.2	14.0	12.2	10.8	19.1	4.1
Secchi depth (m)	3.36	2.22	2.88	1.59	2.00	2.10	1.37	2.05
TKN (mg/L)	/	2.5	/	/	/	/		/
NO_2 and NO_3 (µg/L)	30	30	30	10	10	10	/	10
NH_3 (µg/L)	/	/	/	/	/	/	/	/
DOC (mg/L)	/	/	/	/	/	/	/	/
Ca (mg/L)	8	7	7	6	6	12	/	5
Mg (mg/L)	73	81	77	85	87	77	/	85
Na (mg/L)	508	535	520	612	590	485	/	600
K (mg/L)	37	40	38	43	42	35	/	42
SO_4^{2-} (mg/L)	412	390	401	478	478	402	/	495
Cl^- (mg/L)	12	13	12	15	14	14	/	16
CO_3 (mg/L)	/	172	161	212	210	158	/	199
HCO_3 (mg/L)	976	997	952	1032	1004	1060	/	1235
pH	9.20		9.26	9.32	9.34	9.27	/	9.48
Conductivity (µS/cm)	2450	2640	2536	2878	2795	2410	/	2850
Hardness (mg/L)	320	349	334	362	374	346	/	362
TDS (mg/L)	1677	1720	1686	1957	1921	1625	/	1951
Microcystin (µg/L)	/	/	/	/	/	/	/	/
Total Alkalinity (mg/L $CaCO_3$)	1044	1091	1051	1200	1174	1001	/	1179

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

Parameter	1997	1998	1999	2000	2001	2002	2007	2014	201
TP (µg/L)	80	68	68	61	62	57	32	41	46
TDP (µg/L)	39	36	34	34	34	33	13	26	15
Chlorophyll-*a* (µg/L)	12.9	12.7	13.9	7.4	14.6	6.9	7.0	5.7	12.1
Secchi depth (m)	1.74	1.88	1.80	2.38	2.50	2.13	2.20	1.93	1.61
TKN (mg/L)	2.7	2.2	2.2	1.7	2.2	2.3	2.4	2.2	2.6
NO_2 and NO_3 (µg/L)	20	30	30	20	10	10	0	10	6
NH_3 (µg/L)	50	50	50	70	30	80	120	40	25
DOC (mg/L)	/	/	/	38	/	/	34	/	36
Ca (mg/L)	7	7	6	7	7	6	7	/	9
Mg (mg/L)	80	77	70	75	76	74	67	/	82
Na (mg/L)	572	529	504	574	555	613	519	526	558
K (mg/L)	44	42	39	43	44	42	39	/	46
SO_4^{2-} (mg/L)	463	469	395	443	454	467	413	405	408
Cl^- (mg/L)	18	17	17	17	17	19	20	22	26
CO_3 (mg/L)	190	192	197	174	187	209	177	176	185
HCO_3 (mg/L)	1048	1001	976	954	924	1032	943	950	945
pH	9.23	9.16	9.05	8.99	9.09	9.24	9.17	9.19	9.22
Conductivity (µS/cm)	2818	/	2722	2543	2508	2735	2563	2600	265
Hardness (mg/L)	348	336	300	327	330	318	295	334	365
TDS (mg/L)	1899	1826	1710	1805	1796	1940	1705	1723	177
Microcystin (µg/L)	/	/	/	/	/	/	/	/	0.37
Total Alkalinity (mg/L $CaCO_3$)	1177	1142	1128	1072	1070	1193	1070	1073	110

Table 3. Concentrations of metals were last measured in Buffalo Lake in 2016. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference. Values over these levels are presented in red.

Metals (Total Recoverable)	1993	2014	2016	Guidelines
Aluminum µg/L	/	104.75	64.5	100[a]
Antimony µg/L	/	0.438	0.441	6[d]
Arsenic µg/L	7.8	7.21	7.8	5
Barium µg/L	/	39.5	39.1	1000[d]
Beryllium µg/L	/	0.0075	0.004	100[c,e]
Bismuth µg/L	/	0.0005	0.003	/
Boron µg/L	/	347	382	1500
Cadmium µg/L	/	0.006	0.003	0.23[b]
Chromium µg/L	/	0.53	0.16	/
Cobalt µg/L	/	0.134	0.157	1000[e]
Copper µg/L	/	1.05	1.77	4[b]
Iron µg/L	/	97.7	110	300
Lead µg/L	/	0.069	0.075	7[b]
Lithium µg/L	/	134	155	2500[f]
Manganese µg/L	/	2.06	2.83	200[f]
Molybdenum µg/L	/	2.09	2.01	73[c]
Nickel µg/L	/	0.621	0.75	150[b]
Selenium µg/L	/	0.25	1.18	1
Silver µg/L	/	0.003	0.003	0.25
Strontium µg/L	/	231	218	/
Thallium µg/L	/	0.0013	0.0015	0.8
Thorium µg/L	/	0.0201	0.018	/
Tin µg/L	/	0.045	0.019	/
Titanium µg/L	/	2.66	2.53	/
Uranium µg/L	/	/	2.77	15
Vanadium µg/L	/	1.69	1.71	100[e,f]
Zinc µg/L	/	1.6	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 CaCO3)
[c] CCME interim value.
[d] Based on Canadian Drinking Water Quality guideline values.
[e] Based on CCME Guidelines for Agricultural use (Livestock Watering).
[f] Based on CCME Guidelines for Agricultural Use (Irrigation).
A forward slash (/) indicates an absence of data or guidelines

LONG TERM DATA

Buffalo Lake presents a fairly unique dataset. Data is available for the parameters of interest dating back to 1984, and the lake was consistently monitored until 2002. However, a gap in the data from 2003 to 2013 when only one year of data was collected (in 2007) means the trend results must be interpreted with caution. Trend analysis can still be performed to get a broad picture of how the lake has changed over time. However, only 4 years of data in the past ten years, it is hard to know if these years are bucking the trend, or give the impression of continuing the trend due to random year-to-year variation.

Trend analysis was conducted on the parameters total phosphorus (TP), chlorophyll-*a*, total dissolved solids (TDS) and Secchi depth to look for changes from 1984 to 2019 in Buffalo Lake. In sum significant decreases were detected for TP, TDS, and Secchi depth, and no significant trend was detected for chlorophyll-*a.* Secchi depth can be subjective and is sensitive to variation in weather - trend analysis must be interpreted with caution. Data is presented below for the different parameters in each lake as both line 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 Buffalo Lake data from 1984 to 2019.

Parameter	Date Range	Direction of Significant Trend
Total Phosphorus	1984-2019	Decreasing
Chlorophyll-*a*	1984-2019	No Change
Total Dissolved Solids	1984-2019	Decreasing
Secchi Depth	1984-2019	Decreasing

Definitions:

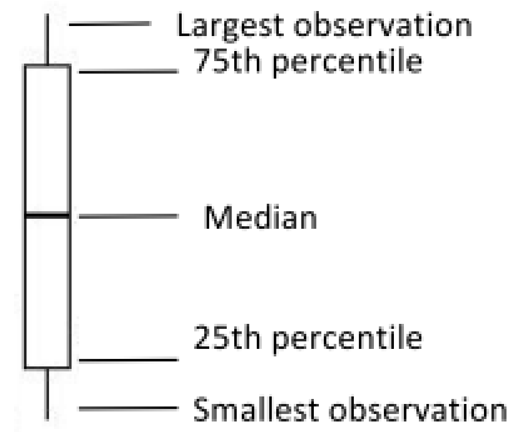
Median: the value in a range of ordered numbers that falls in the middle.

Trend: a general direction in which something is changing.

Monotonic trend: a gradual change in a single direction.

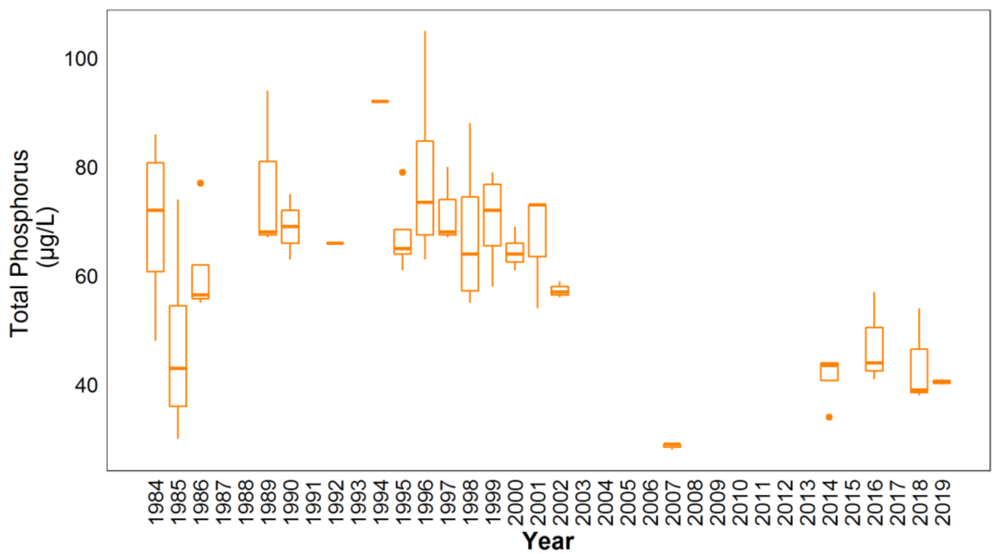
Statistically significant: The likelihood that a relationship between variables is caused by something other than random chance. This is indicated by a p-value of <0.05. Variability: the extent by which data is inconsistent or scattered.

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) did significantly decrease between 1984 and 2019 at Buffalo Lake (Tau = -0.35, p = 0.0003).



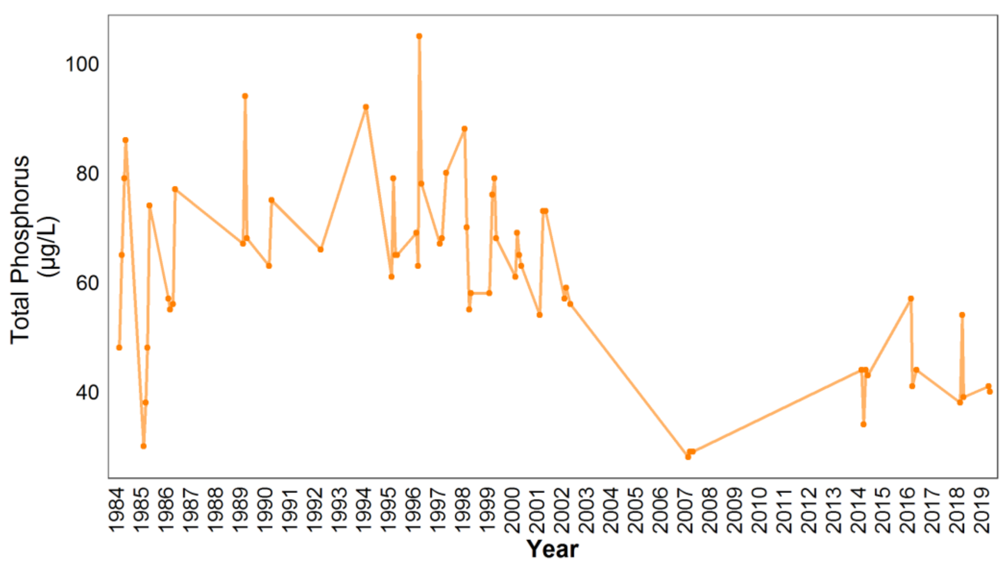


Figure 5. Monthly total phosphorus (TP) concentrations measured between June and September over the long term sampling dates between 1984 and 2019 (n = 63). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Chlorophyll-*a*

Chlorophyll-*a* did not change significantly between 1984 and 2019 (Tau = 0.04, p = 0.69).

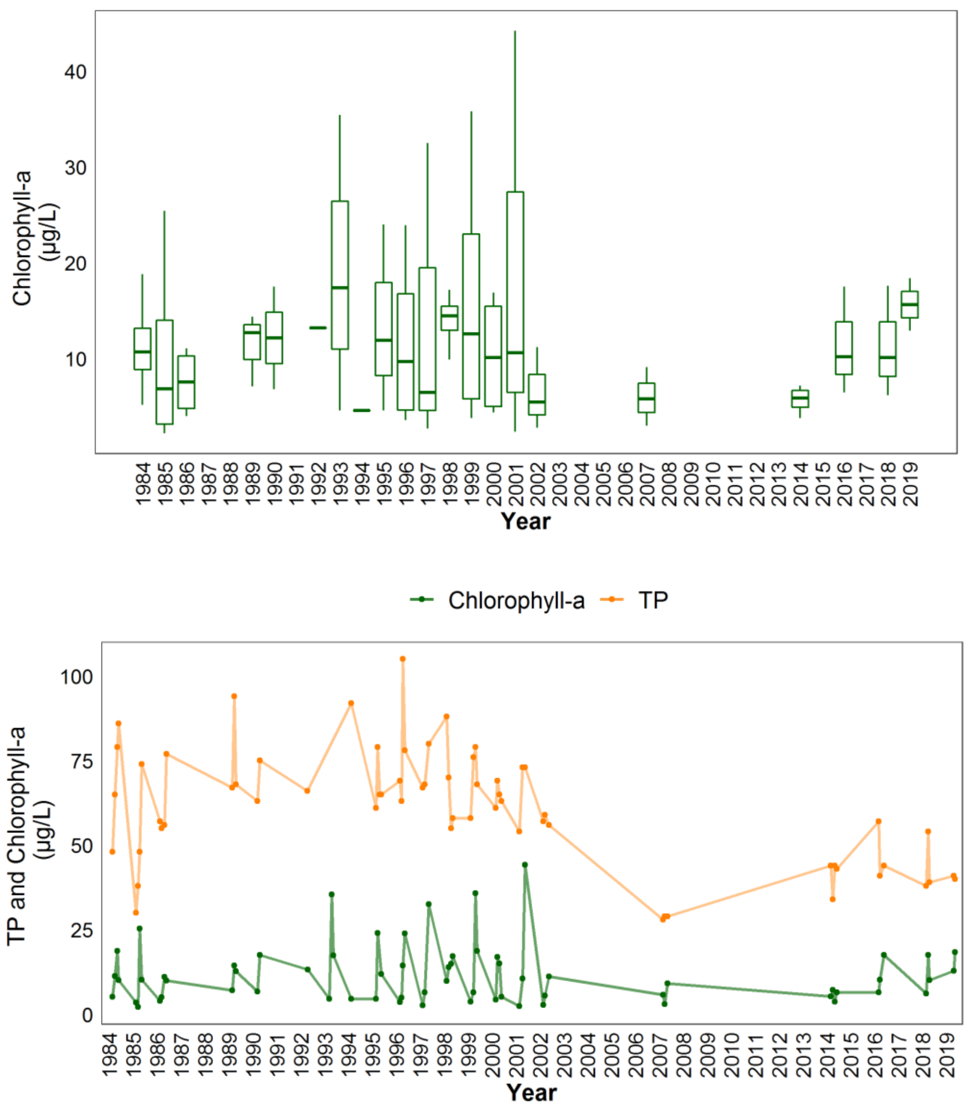
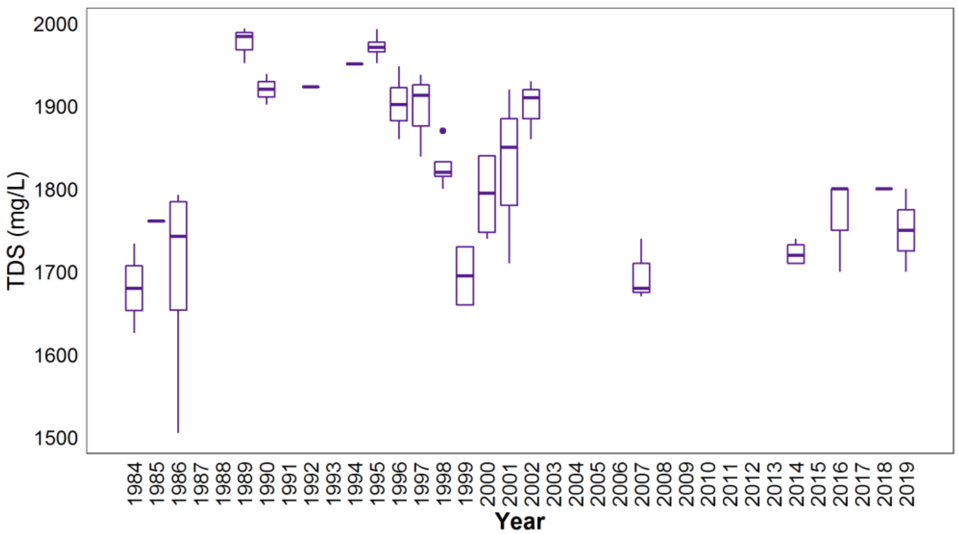


Figure 6. Monthly chlorophyll-*a* concentrations measured between June and September over the long term sampling dates between 1984 and 2019 (n = 65). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples. Line graph is overlain by TP concentrations.

Total Dissolved Solids (TDS)

Total dissolved solids did significantly decrease between 1984 and 2019 (Tau = -0.24, *p* = 0.014).



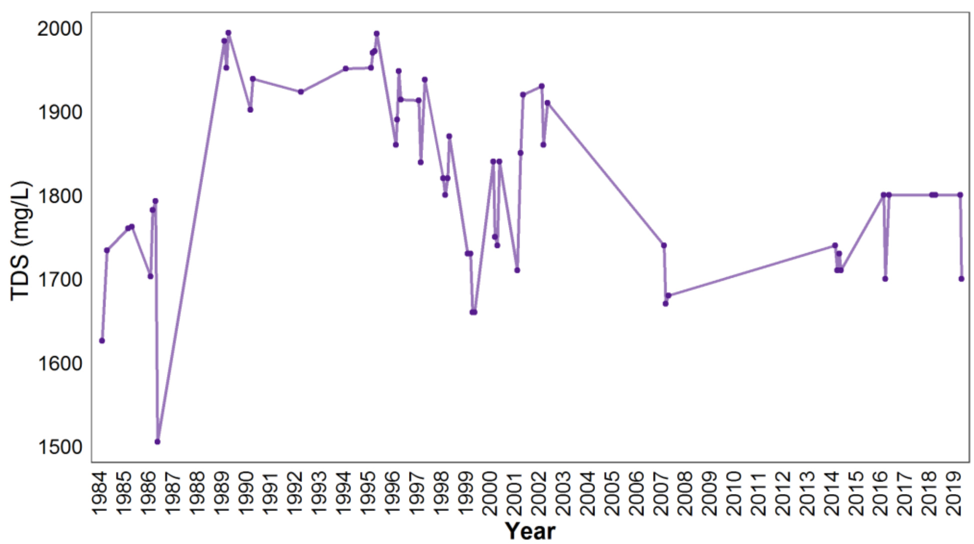


Figure 7. Monthly TDS values measured between June and September over the long term sampling dates between 1984 and 2019 (n = 59). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Secchi Depth

Secchi depth significantly decreased 1984 and 2019 (Tau = -0.23, p = 0.013).

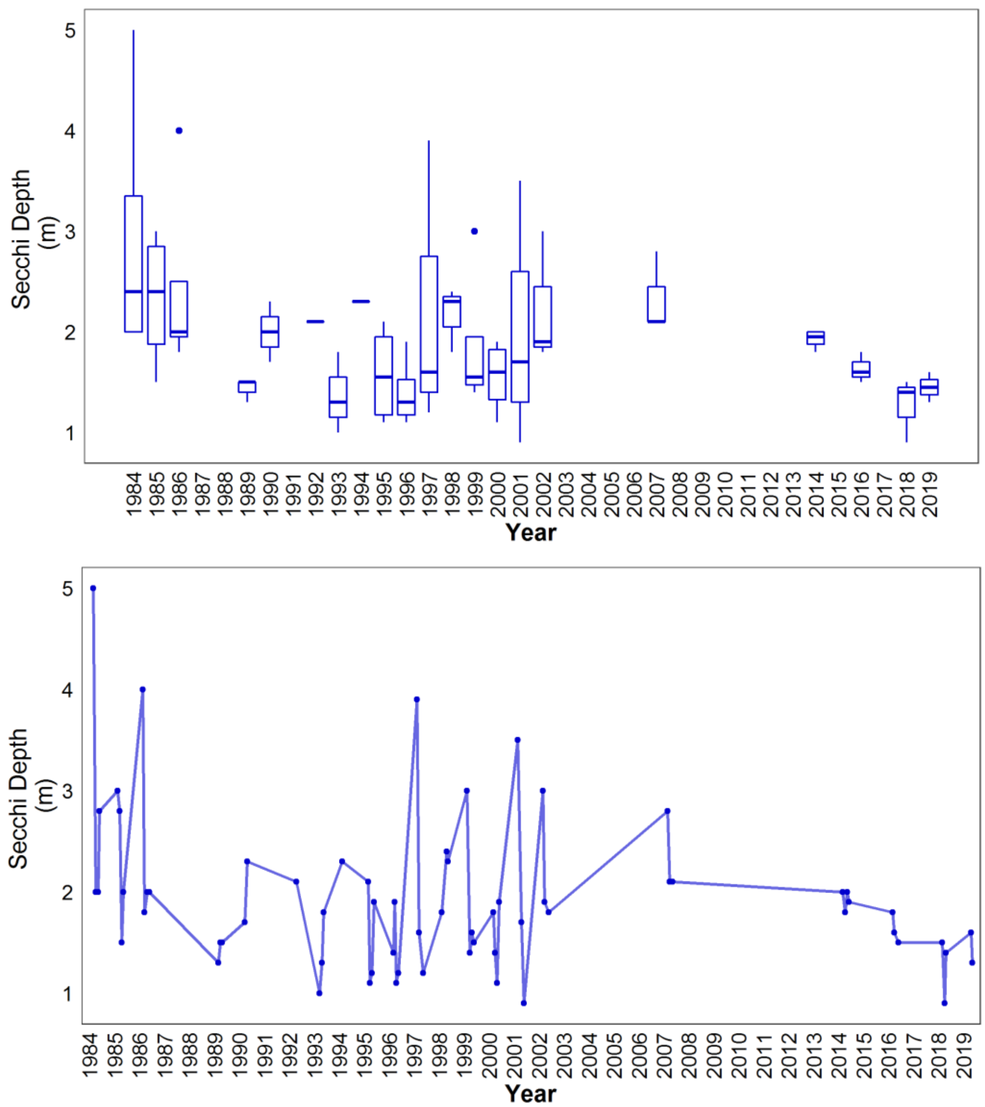


Figure 8. Monthly Secchi depth values measured between June and September over the long term sampling dates between 1984 and 2019 (n = 65). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Table 5. Results of Seasonal Kendall Trend test using monthly total phosphorus (TP), chlorophyll-*a* and Secchi depth data from June to September on Buffalo 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	-0.35	0.04	-0.24	-0.23
The extent (slope) of the trend	Slope	-0.90	0.03	-4.76	-0.02
Number of samples included	n	63	65	59	65
The significance of the trend	p	0.0003*	0.59	0.014*	0.013*

*$p < 0.05$ is significant within 95%