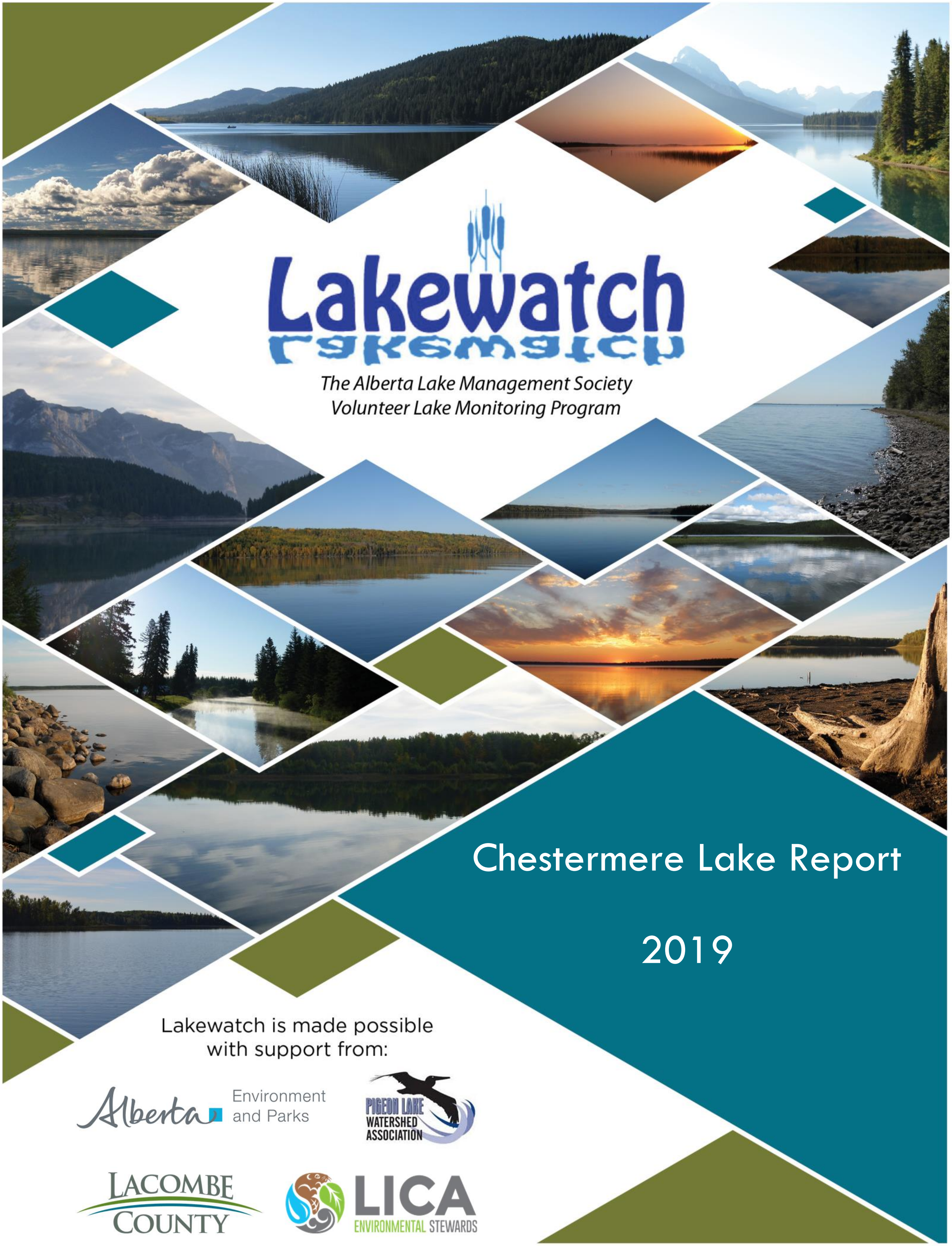

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Chestermere Lake Report

2019

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. We would like to extend a special thanks to Jay & Kathy Speck for the time and energy put into sampling Chestermere Lake in 2019. 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.

CHESTERMERE LAKE

Situated in the Town of Chestermere just minutes East of Calgary, Chestermere Lake is a popular recreational lake and a highly developed, urban, man-made reservoir. Chestermere Lake was originally built by the Canadian Pacific Railroad (CPR) in the 1880's as a waterbalancing reservoir, supplying water at 50 cents per acre to CPR land. In the 1940's, the CPR offered to forgive mortgages held on their land in return for settlers giving up their water rights. The irrigation system was turned over to the Western Irrigation District (WID), which currently owns and operates the structures feeding water to and from Chestermere Lake (Mitchell and Prepas, 1990). The drainage basin for the lake is only 7.65 km^2 including the 2.65 km^2 'reservoir' at its maximum capacity. Chestermere Lake is surrounded by urban development.


Chestermere Lake at sunset in 2019.

Chestermere Lake is shallow over most of its depth (<2.0 m over 50% of its area). During the original survey conducted by the Alberta Government, Chestermere Lake was more than seven meters deep. The deepest areas of the lake have accumulated little sediment as maximum depth still remains between five to seven meters depending on water levels. Sediment accumulation has been heaviest at the WID canal inflow (south) where as much as two meters of sediment has accumulated. Likely due to its shallow depth, aquatic weeds are prevalent in Chestermere Lake. Chestermere is an important site for recreational use and mechanical removal of weeds using harvesters is maintained on a continuous basis. Chestermere Lake receives a large volume of water during summer months, enough to replace the entire lake volume in eight days. Flushing of this magnitude may actually help to maintain the waters clarity and thus the success of weeds in comparison to other Alberta lakes of similar depth.

In 2016, two species of bryozoans were identified in Chestermere Lake: *Plumatella* sp. and *Cristatella mucedo*.

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. 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.

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[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 of Chestermere Lake in 2019 was 12 µg/L (Table 2). This puts Chestermere Lake in the mesotrophic classification, and is historically low. TP concentrations decreased through August 9, and then spiked on September 6 (Figure 1).

The average chlorophyll-*a* concentration was 4.9 µg/L, which was in line with historic values (Table 2). Chlorophyll-*a* increased throughout the season, being highest in September at 6.0 µg/L, and lowest on June 27 at 4.1 µg/L.

Average TKN concentration was 0.3 mg/L, which was also on the lower end of historical data (Table 2). TKN peaked on September 6, the same sampling date that TP peaked.

Average pH measured as 8.27 in 2019, buffered by moderate alkalinity (123 mg/L $CaCO_3$) and bicarbonate (148 mg/L HCO_3). Calcium and sulphate were the dominant ions contributing to a low conductivity measure of 375 µS/cm (Table 2).

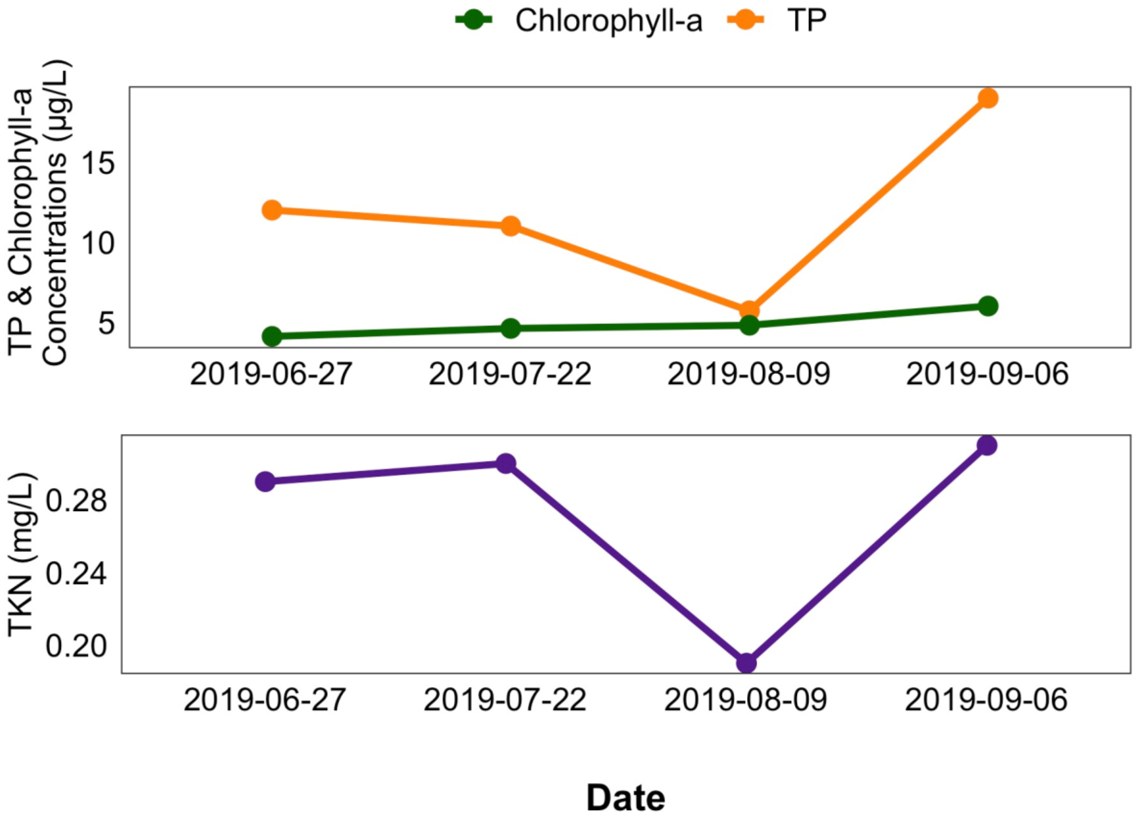


Figure 1. Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Chestermere Lake.

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 Chestermere Lake in 2019, but Table 3 displays historical metal concentrations.

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.

In Chestermere Lake was quite clear in June and July, decreasing slightly in August and September (Figure 2). Given that Chestermere Lake is relatively shallow, the euphotic zone reached lake bottom across most of the lake. The average Secchi depth was 2.4 m, and was relatively consistent throughout the season, fluctuating only by 0.6 m (Table 2).

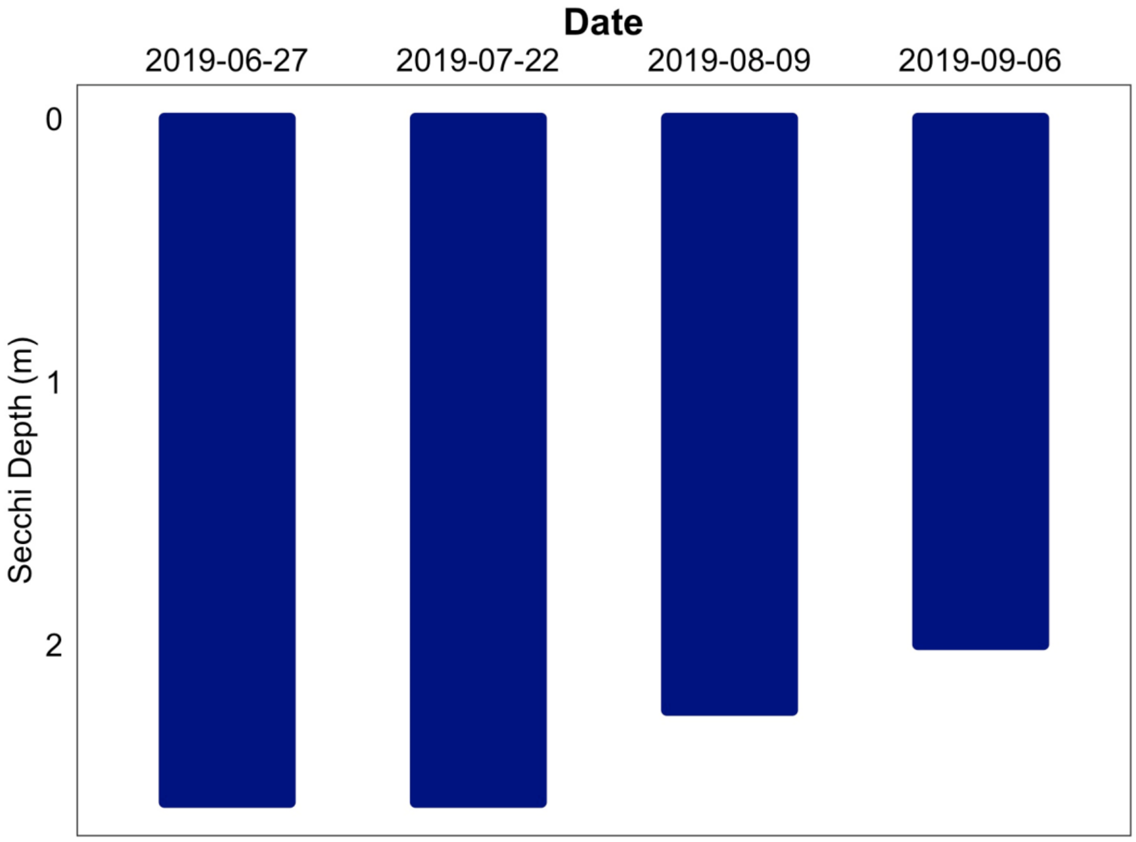


Figure 2. Secchi depth values measured four times over the course of the summer at Chestermere Lake in 2019.

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.

Given the shallow depth of Chestermere Lake, it can be classified as polymictic, because it does not stratify over the course of the ice-off season (Figure 3a). This means that temperatures are consistent through the water column on each individual sampling date. The maximum water temperature of 19.0 °C was measured from the surface to 5.5 meters on August 9. The lowest temperature observed was 14.6 °C on the lake bottom on June 27.

Chestermere Lake remained well oxygenated throughout the summer, measuring above the Canadian Council for Ministers of the Environment guidelines of 6.5 mg/L dissolved oxygen (Figure 3b). The water column remained oxygenated throughout, because the lake had multiple mixing and turnover events throughout the summer.

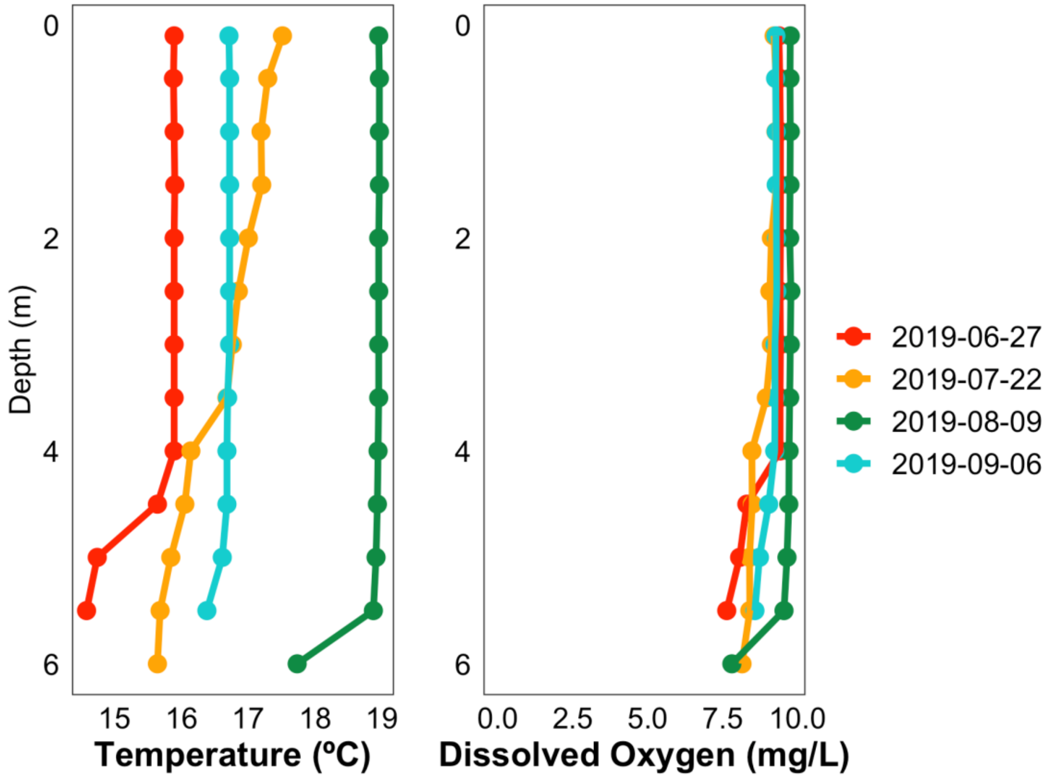


Figure 3. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Chestermere Lake measured four times over the course of the summer of 2019.

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 Chestermere Lake fell below the recreational guideline of 20 µg/L in 2019. In fact, microcystin levels fell below the limit of detection on all 4 sampling events.

Table 1. Microcystin concentrations measured four times at Chestermere Lake in 2019.

Date	Microcystin Concentration (µg/L)
27-Jun-19	0.05
22-Jul-19	0.05
09-Aug-19	0.05
06-Sep-19	0.05
Average	0.05

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 Chestermere 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 Chestermere 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 Chestermere Lake have remained relatively stable since Environment Canada began monitoring the lake in 1991 (Figure 4). Water levels of the reservoir fluctuated each year between 1023.5 masl and 1025.7 masl.

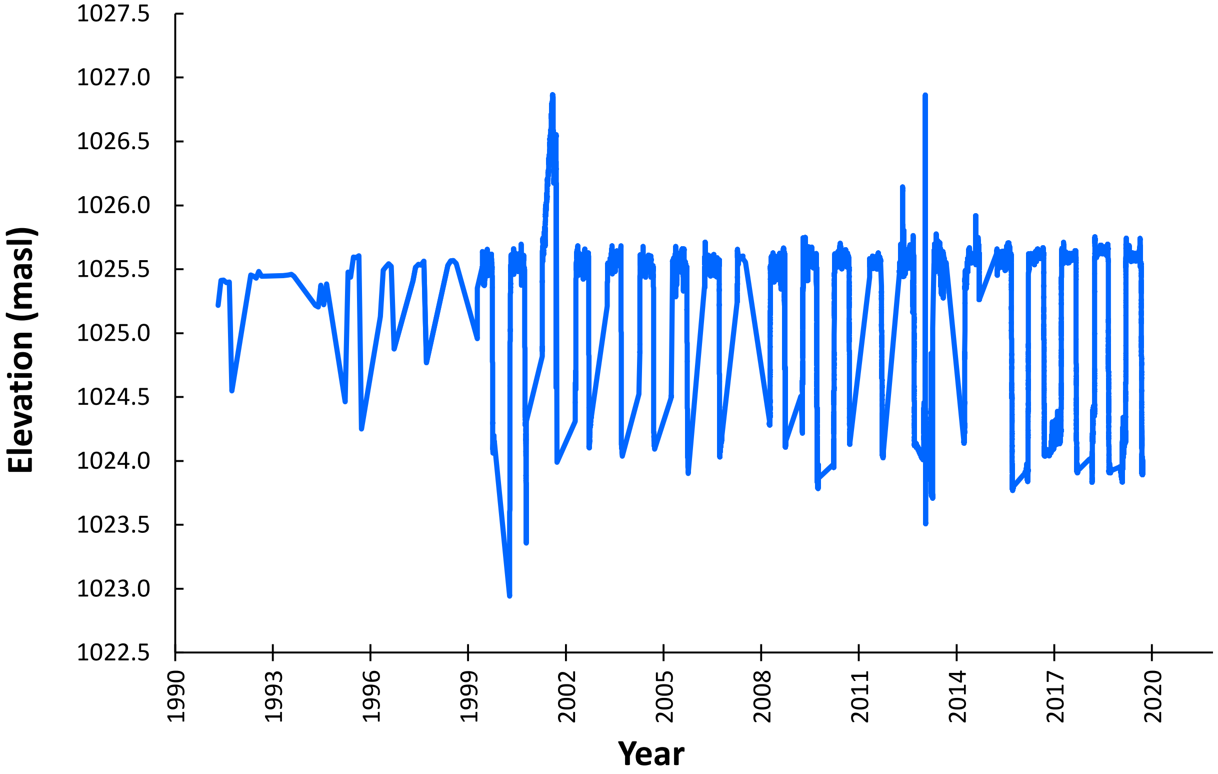


Figure 4. Water levels measured in meters above sea level (masl) from 1991-2019. Data retrieved from Environment Canada (1991 – 1998), and Alberta Environment and Parks (1999-2019).

Table 2. Average Secchi depth and water chemistry values for Chestermere Lake. Historical values are provided for reference.

Parameter	1983	1999	2000	2001	2007	2010	2011	2013	2015	2016	2019
TP (µg/L)	36	32	25	19	31	24	24	18	16	13	12
TDP (µg/L)	/	/	/	/	11	7	8	5	4	4	4
Chlorophyll-a (µg/L)	5.5	9.0	7.6	3.4	2.7	3.4	8.0	3.1	6.4	8.7	4.9
Secchi depth (m)	2.90	2.60	/	/	3.90	4.25	3.43	2.98	2.22	2.70	2.36
TKN (mg/L)	0.4	0.3	0.2	0.7	0.5	0.3	0.4	0.3	0.3	0.3	0.3
NO2 and NO3 (µg/L)	/	/	229	739	226	30	87	85	27	33	48
NH3 (µg/L)	/	/	/	/	/	18	18	14	25	25	17
DOC (mg/L)	/	/	/	/	4	2	3	3	2	2	3
Ca (mg/L)	35	37	37	37	42	32	43	43	39	42	41
Mg (mg/L)	12	15	13	14	15	17	18	16	16	18	16
Na (mg/L)	7	15	8	5	46	19	23	18	18	24	15
K (mg/L)	1	1	1	1	3	1	2	2	1	2	1
SO42- (mg/L)	38	/	43	38	100	58	66	49	60	74	51
Cl- (mg/L)	4	7	5	3	37	13	16	11	14	17	14
CO3 (mg/L)	/	/	/	/	2	1	2	2	1	1	1
HCO3 (mg/L)	/	/	/	/	158	146	162	175	142	150	148
pH	/	/	/	/	8.31	8.42	8.34	8.38	8.31	8.29	8.27
Conductivity (µS/cm)	/	/	/	/	563	149	432	421	392	430	375
Hardness (mg/L)	/	/	/	/	185	375	181	173	162	180	168
TDS (mg/L)	/	/	/	/	330	212	251	227	220	254	218
Microcystin (µg/L)	/	/	/	/	/	0.03	0.08	0.05	<0.1	0.05	0.05
Total Alkalinity (mg/L CaCO3)	111	/	116	110	132	120	135	147	116	122	123

Table 3. Concentrations of metals measured once in Chestermere Lake. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2013**	**2015**	**2016**	**Guidelines**
Aluminum µg/L	95.6	227	28.5	100[a]
Antimony µg/L	0.1165	0.148	0.145	6[d]
Arsenic µg/L	0.5775	0.6335	0.802	5
Barium µg/L	54.45	51.25	46.7	1000[d]
Beryllium µg/L	0.0015	0.0065	0.004	100[c,e]
Bismuth µg/L	0.0077	0.00225	0.012	/
Boron µg/L	14.2	18.65	18.7	1500
Cadmium µg/L	0.0226	0.033	0.019	0.26[b]
Chromium µg/L	0.317	0.57	0.21	/
Cobalt µg/L	0.06575	0.1055	0.047	1000[e]
Copper µg/L	1.303	4.295	1.32	4[b]
Iron µg/L	90.15	298.5	73.7	300
Lead µg/L	0.136	0.338	0.107	7[b]
Lithium µg/L	4.89	5.125	6.21	2500[f]
Manganese µg/L	7.185	19.9	9.71	200[f]
Molybdenum µg/L	0.9945	1.08	1.08	73[c]
Nickel µg/L	0.438	0.3875	0.302	150[b]
Selenium µg/L	0.9035	0.58	0.92	1
Silver µg/L	0.0255	0.0055	0.008	0.25
Strontium µg/L	237	225.5	239	/
Thallium µg/L	0.0057	0.0094	0.0528	0.8
Thorium µg/L	0.0208	0.025025	0.0348	/
Tin µg/L	0.02805	0.057	0.026	/
Titanium µg/L	1.35	4.875	0.91	/
Uranium µg/L	1.065	1.16	1.25	15
Vanadium µg/L	0.5045	0.655	0.36	100[e,f]
Zinc µg/L	1.58	3.35	1.5	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 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 Chestermere Lake. In sum, significant increases were observed in TDS. Significant decreasing trends were observed in chlorophyll-*a*. It should be noted that although significant, the slope for both of these trends is very low, so in reality, little change has occurred. Data is presented below as both a line graph (all data points) and a box-and-whisker plot. Detailed methods are available in the *ALMS Guide to Trend Analysis on Alberta Lakes.*

Table 4. Summary table of trend analysis on Chestermere Lake data from 1983 to 2019.

Parameter	Date Range	Trend	Probability
Total Phosphorus	1983-2019	Decreasing	Significant
Chlorophyll-*a*	1983-2019	Increasing	Not significant
Total Dissolved Solids	1983-2019	Increasing	Significant
Secchi Depth	1983-2019	No change	Not significant

Definitions:

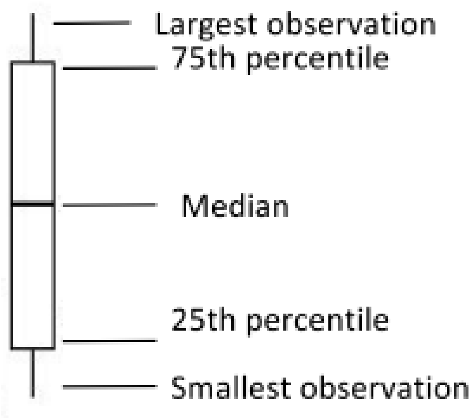
Median: the value in a range of ordered numbers that falls in the middle.

Trend: a general direction in which something is changing.

Monotonic trend: a gradual change in a single direction.

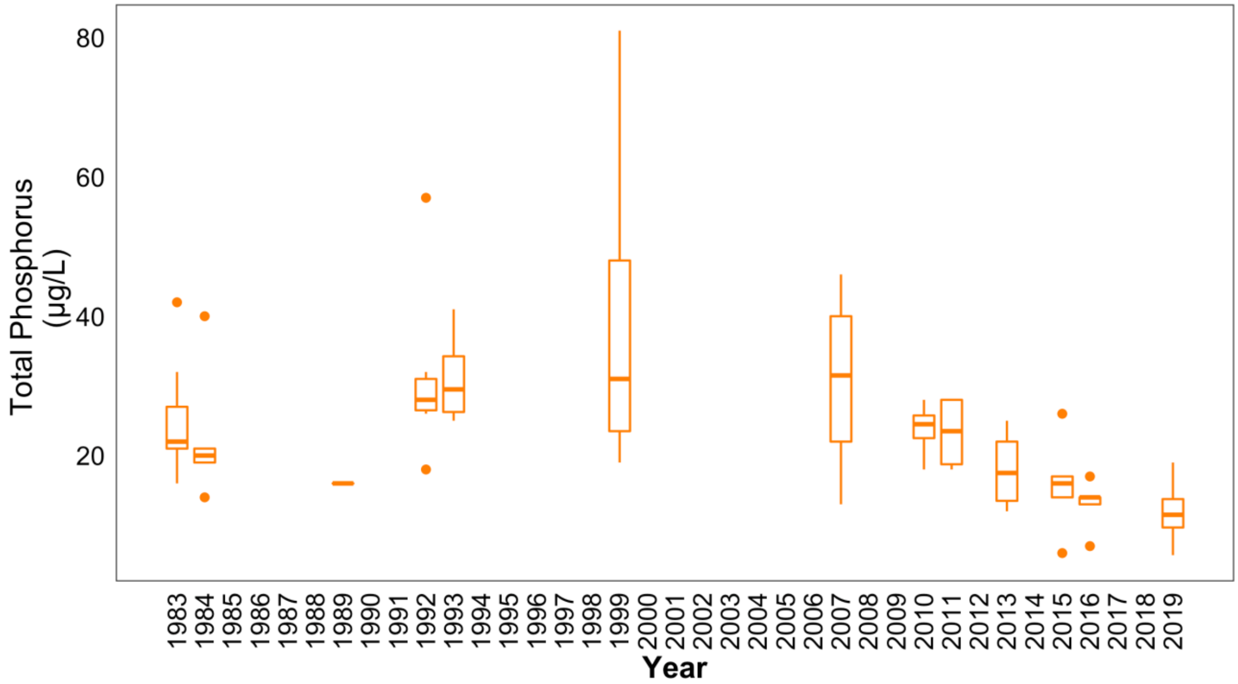
Statistically significant: The likelihood that a relationship between variables is caused by something other than random chance. This is indicated by a p-value of <0.05. Variability: the extent by which data is inconsistent or scattered.

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)

TP has significantly decreased over the course of data collection at Chestermere Lake (Tau = -0.42, $p < 0.001$).



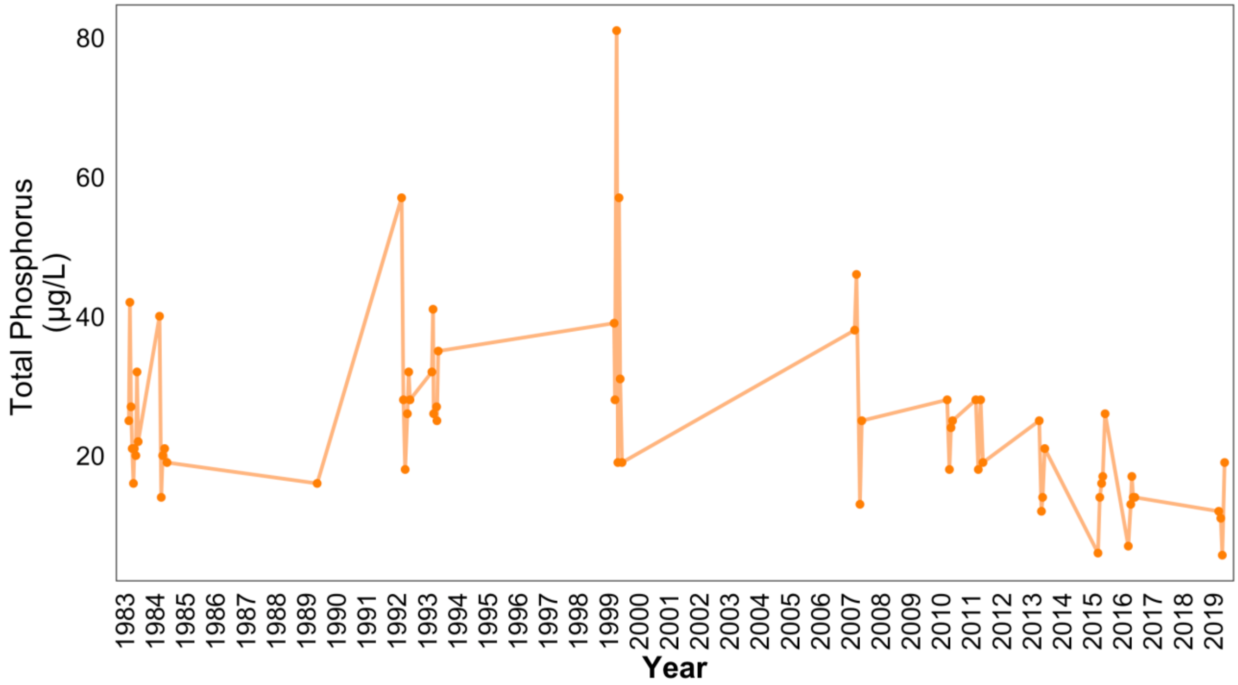


Figure 5. Total phosphorus (TP) concentrations measured between June and September over the long term sampling dates between 1983 and 2019 (n = 47).

Chlorophyll-*a*

Chlorophyll-*a* has not significantly increased over the course of data collection at Chestermere Lake (Tau = 0.14, p = 0.17). Chlorophyll-*a* trends are not correlated with TP trends over time (r = 0.14, $p < 0.28$).

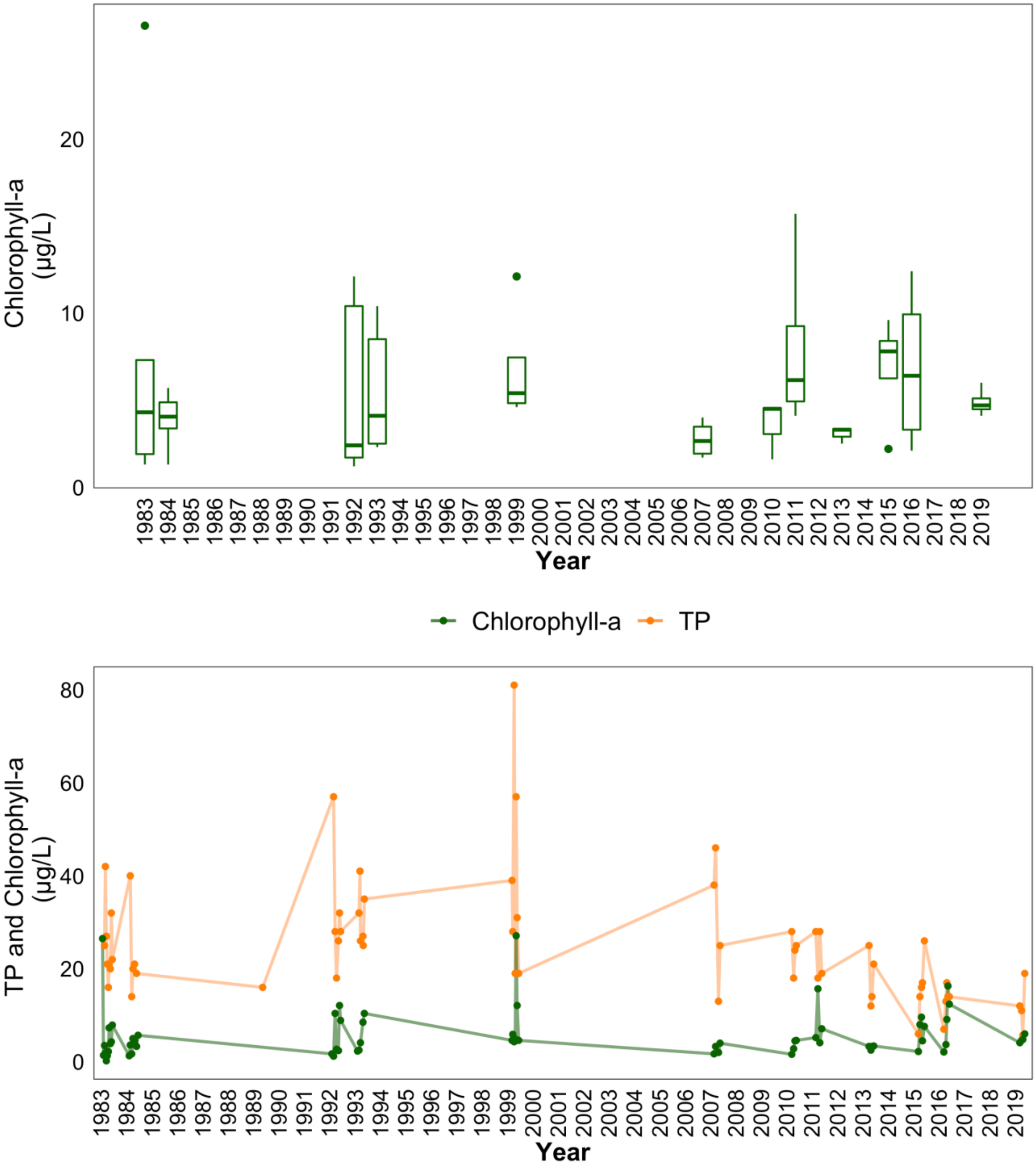


Figure 6. Chlorophyll-*a* concentrations measured between June and September over the long term sampling dates between 1983 and 2019 (n = 51).

Total Dissolved Solids (TDS)

Trend analysis on TDS shows a significant increase in TDS over the course of sampling (Tau = 0.48, *p* < 0.001).

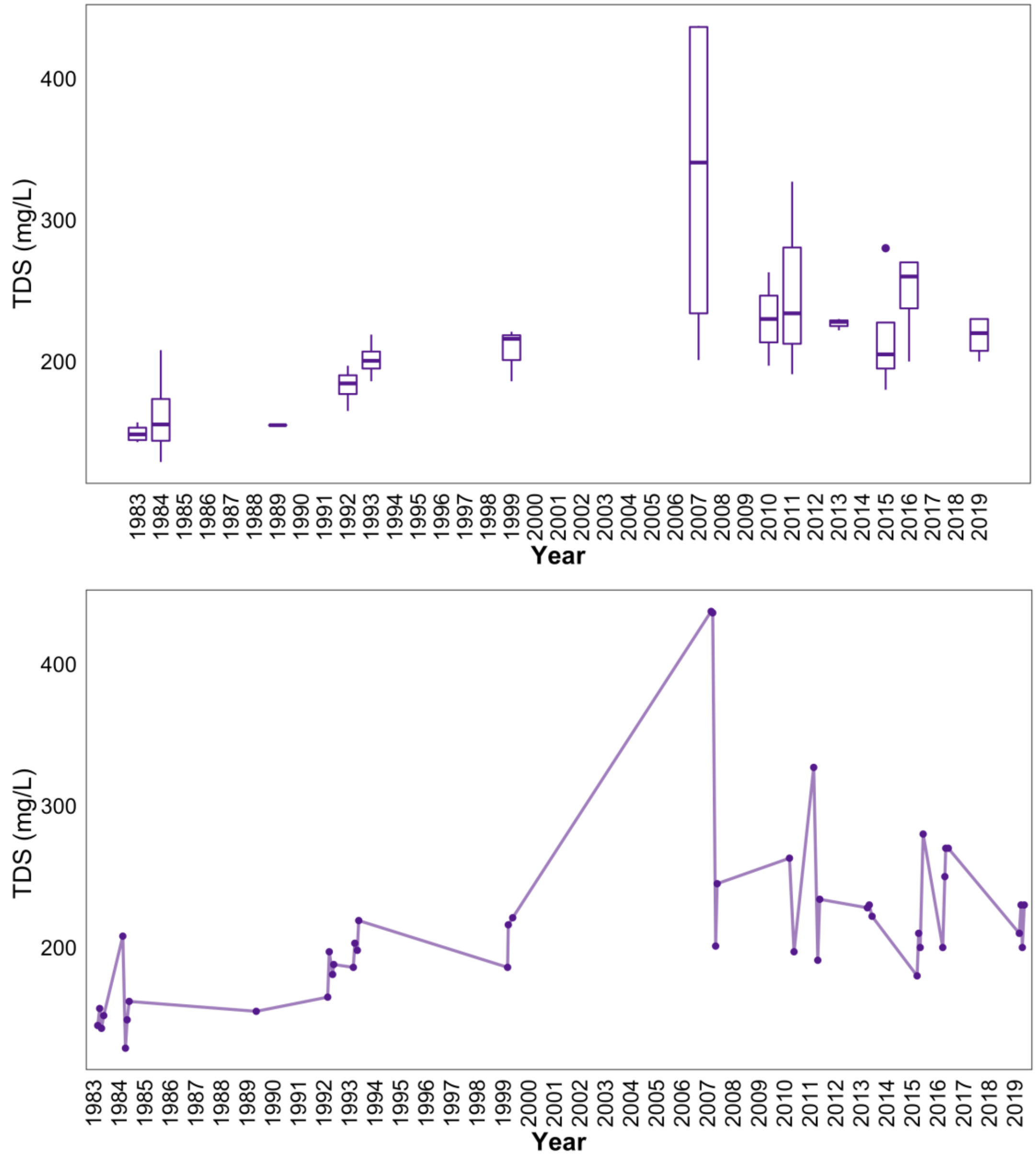


Figure 7. TDS measured between June and September over the long term sampling dates between 1983 and 2019 (n = 44).

Secchi Depth

Trend analysis found that water clarity measured as Secchi depth has not changed over the sampling period (Tau = -0.01, *p* = 0.93).

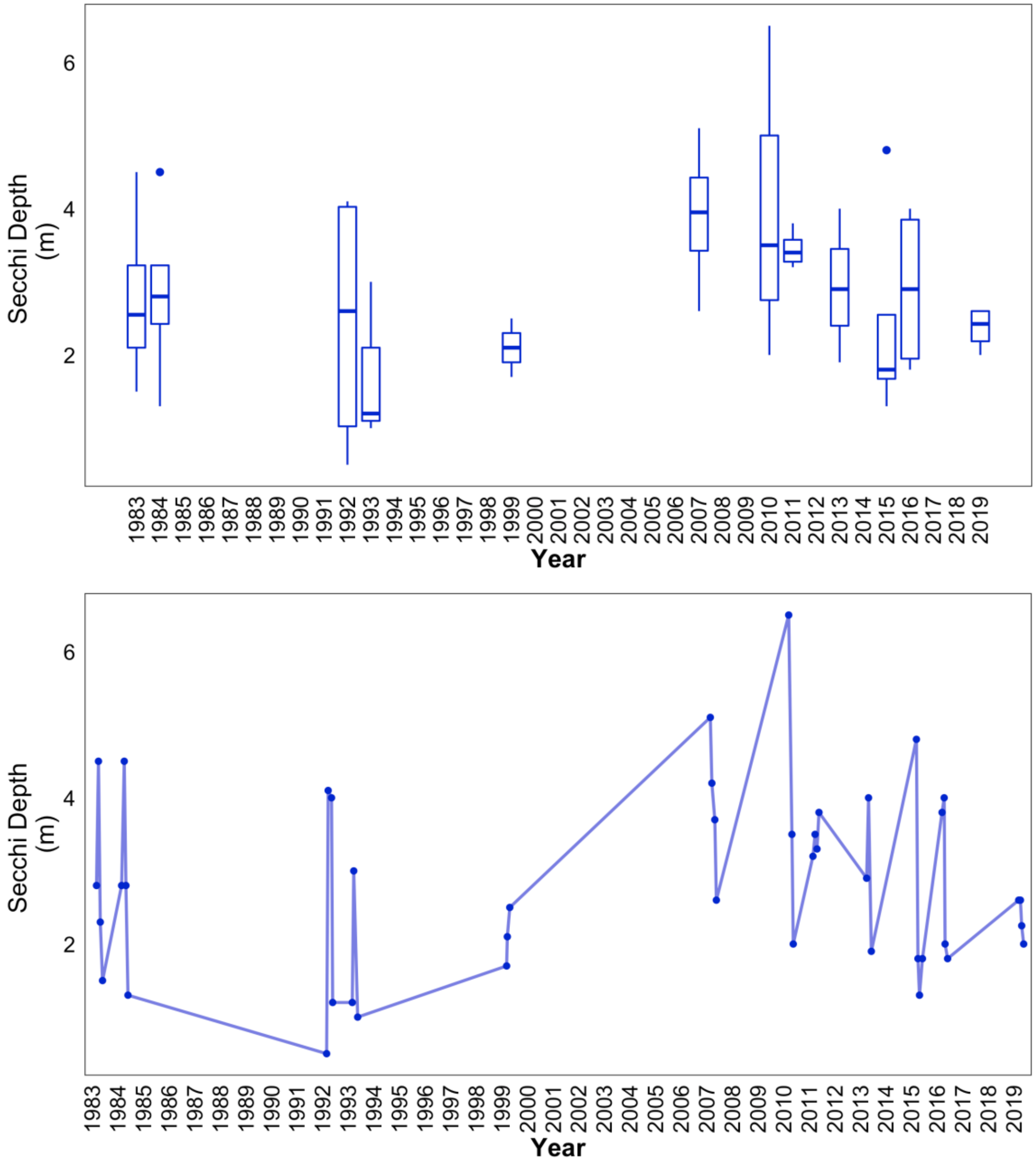


Figure 8. Secchi depth values measured between June and September over the long term sampling dates between 1983 and 2019 (n = 44).

Table 5. Results of Mann-Kendall Trend tests using total phosphorus (TP), chlorophyll-*a*, total dissolved solids (TDS) and Secchi depth data from June to September on Chestermere 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	-0.42	0.14	0.48	-0.01
The extent of the trend	Slope	-0.0014	0.0001	5.97×10^{-3}	0.00
The statistic used to find significance of the trend	Z	-4.17	1.39	4.61	-0.09
Number of samples included	n	47	51	44	44
The significance of the trend	p	3.01×10^{-5}	0.17	4.13×10^{-6}	0.93

*$p < 0.05$ is significant within 95%