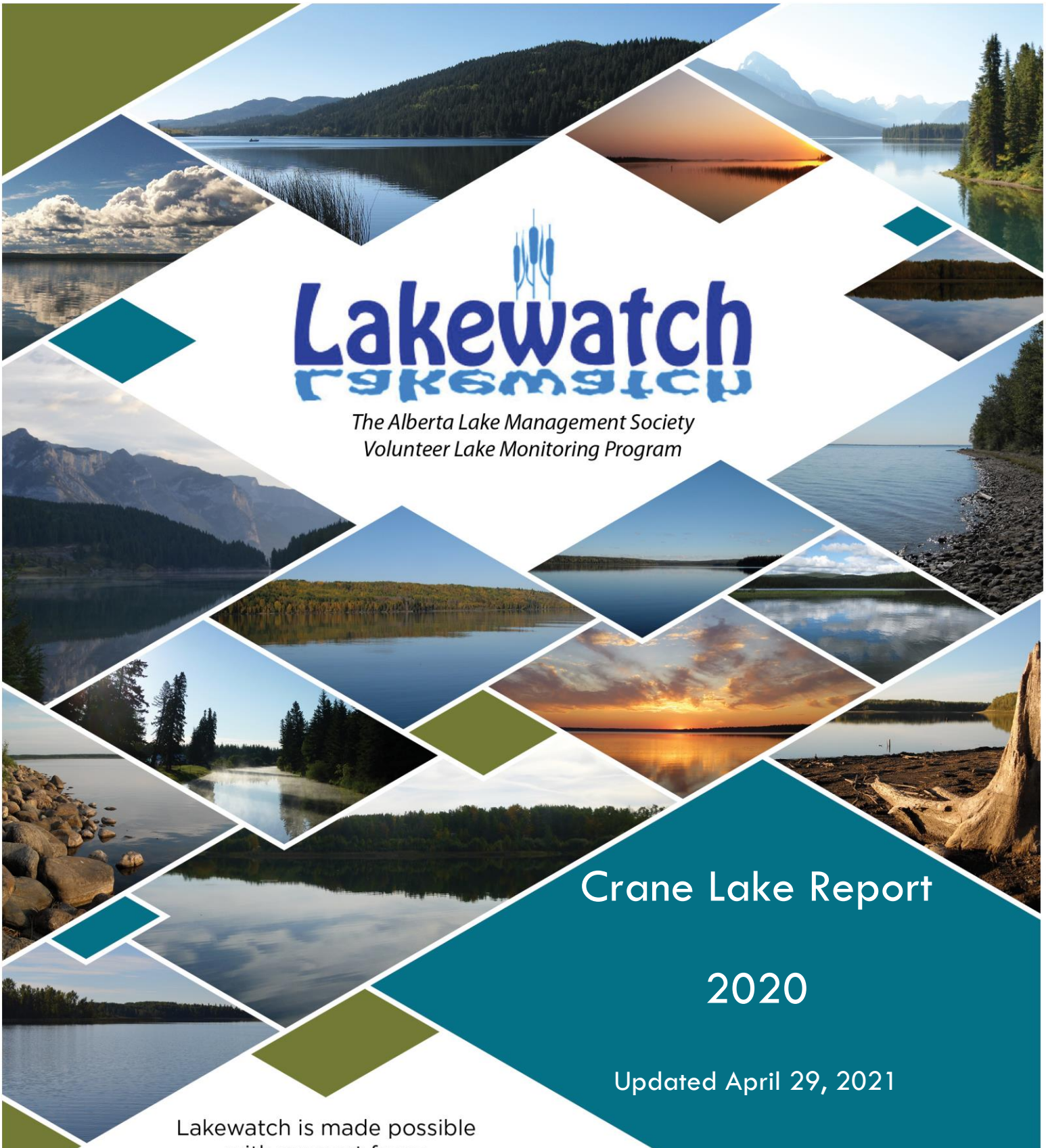


Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Crane 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.

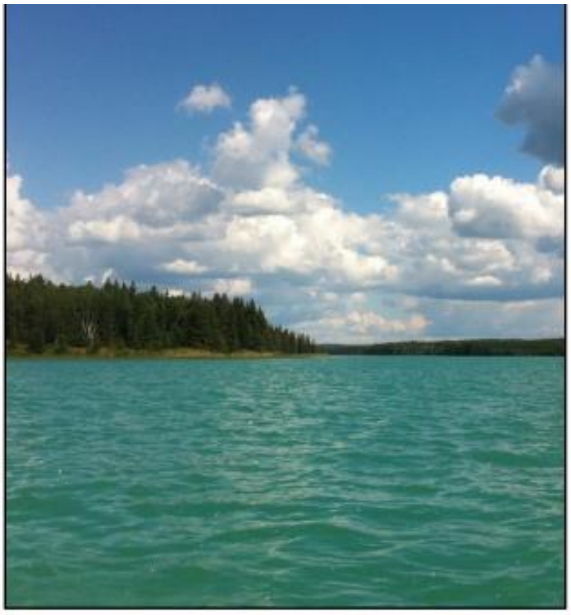
ALMS would like to thank all who express interest in Alberta's aquatic environments, and particularly those who have participated in the LakeWatch program. These leaders in stewardship give us hope that our water resources will not be the limiting factor in the health of our environment.

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 Ron Young for his commitment to collecting data at Crane 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.

CRANE LAKE



Crane Lake- Photo by Ageleky Bouzetos 2015

Crane Lake was originally named Moore Lake, after Dr. Bromley Moore, a former president of the College of Physicians and Surgeons and a friend of the surveyor Marshall Hopkins[1]. Moore Lake is locally referred to as Crane Lake. Crane Lake is a medium sized (surface area = 9.28 km^2) and deep (max depth = 26 m, mean depth = 8.3 m) water body located in the Beaver River Watershed.

The lake is situated about 280 km northeast of Edmonton in the municipal district of Bonnyville. The town of Bonnyville, south of the lake, and Cold Lake, east of the lake, are the principal urban centers of the area. Most of Crane Lake's shoreline is crown land. Two former Provincial Areas, Crane Lake East and West, have been disestablished and divested to the Municipal District of Bonnyville. There are two commercial resorts on the south shore. Crane Lake is a headwater lake with a small drainage basin that is only four times the size of the lake. The only inlets are two minor streams: one on the northeast shore and one on the west shore. The outlet flows from the east shore into nearby Hilda and Ethel Lakes and eventually into the Beaver River.

The watershed area for Crane Lake is 43.90 km^2 and the lake area is 10.29 km^2. The lake to watershed ratio of Crane Lake is 1:4. A map of the Crane Lake watershed area can be found at: http://alms.ca/wp-content/uploads/2016/12/Crane.pdf

[1] Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press. Retrieved from http://sunsite.ualberta.ca/projects/alberta-lakes/

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 Crane Lake was 13 µg/L (Table 2), falling into the mesotrophic, or moderately productive trophic classification. This value is lower than most historical averages for Crane Lake. Detected TP was lowest when sampled on August 17 at 10 µg/L, and peaked at 17 µg/L on July 16 (Figure 1).

Average chlorophyll-*a* concentration in 2020 was 6.8 µg/L (Table 2), falling into the mesotrophic, or moderately productive trophic classification. Chlorophyll-*a* was highest at the start of the season, with a maximum of 8.9 µg/L on June 10, then dropping in July and August to 5.6 µg/L and 5.4 µg/L, respectively, before going up again in September to 7.4 µg/L.

Finally, the average TKN concentration was 1.0 mg/L (Table 2) with concentrations being consistently between 0.9 and 1.0 mg/L on each individual sampling event throughout the 2020 sampling season.

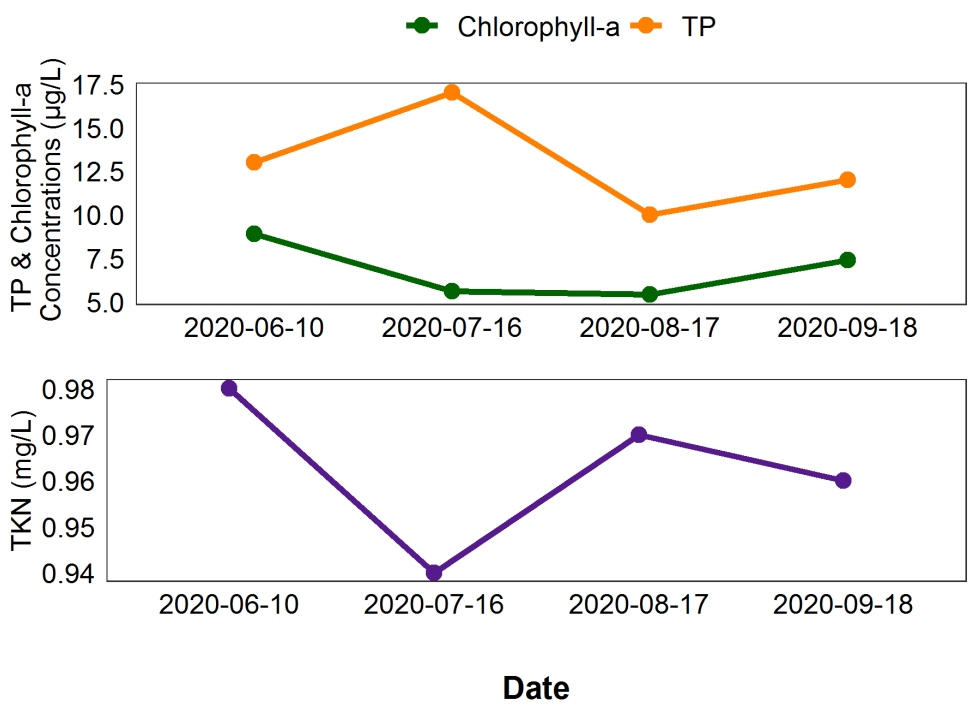


Figure 1. Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured four times over the course of the summer at Crane Lake.

Average pH was measured as 8.84 in 2020, buffered by moderate alkalinity (438 mg/L $CaCO_3$) and bicarbonate (410 mg/L HCO_3). Aside from bicarbonate, the dominant ion was sodium, contributing to a moderate conductivity of 905 µS/cm (Figure 2, top; Table 2). Crane Lake was on the upper end of ion levels compared to other LakeWatch lakes sampled in 2020, with the exception of having lower than average levels of calcium (Figure 2, bottom).

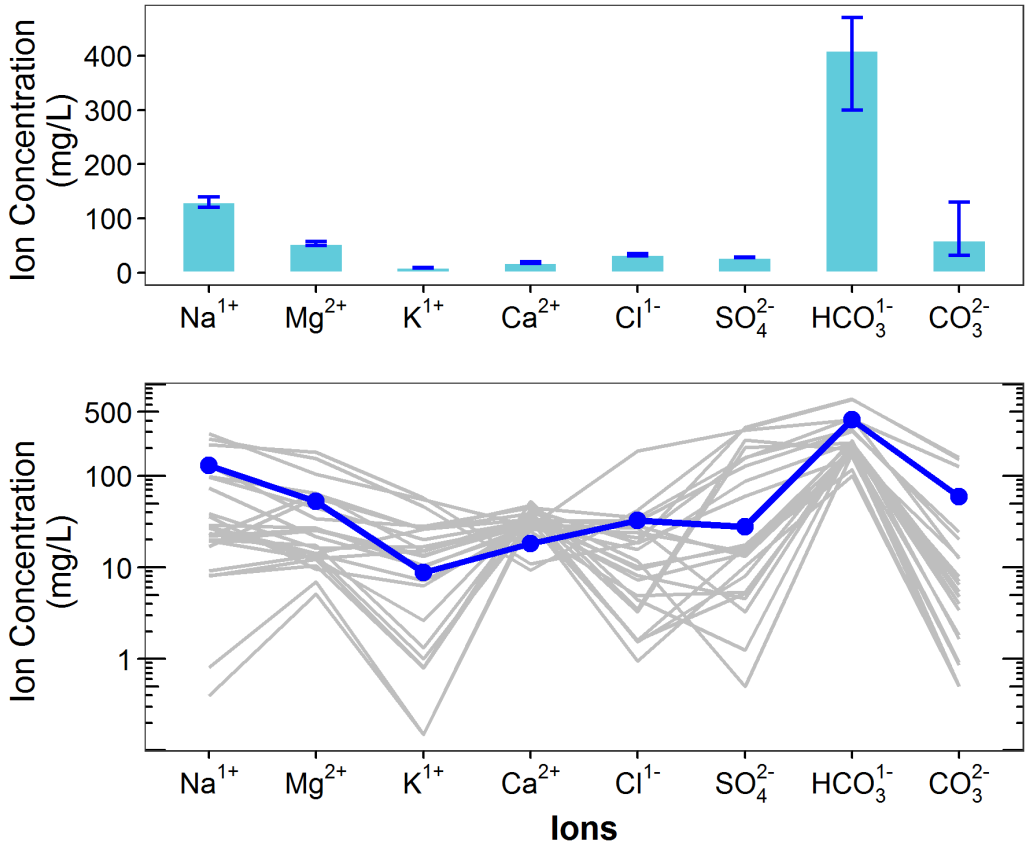


Figure 2. Average levels of cations (sodium = Na^{1+}, magnesium = Mg^{2+}, potassium = K^{1+}, calcium = Ca^{2+}) and anions (chloride = Cl^{1-}, sulphate = SO_4^{2-}, bicarbonate = HCO_3^{1-}, carbonate = CO_3^{2-}) from four measurements over the course of the summer at Crane Lake. Top) bars indicate range of values measured, and bottom) Schoeller diagram of average ion levels at Crane 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 measured on August 17, 2020 at Crane Lake at the surface and all measured values fell within their respective 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 Crane Lake in 2020 was 6.01 m corresponding to an average Secchi depth of 3.00 m, which is low compared to the historical record (Table 2). Euphotic depth was greatest at the beginning of the summer, and steadily decreased through to September (Figure 3).

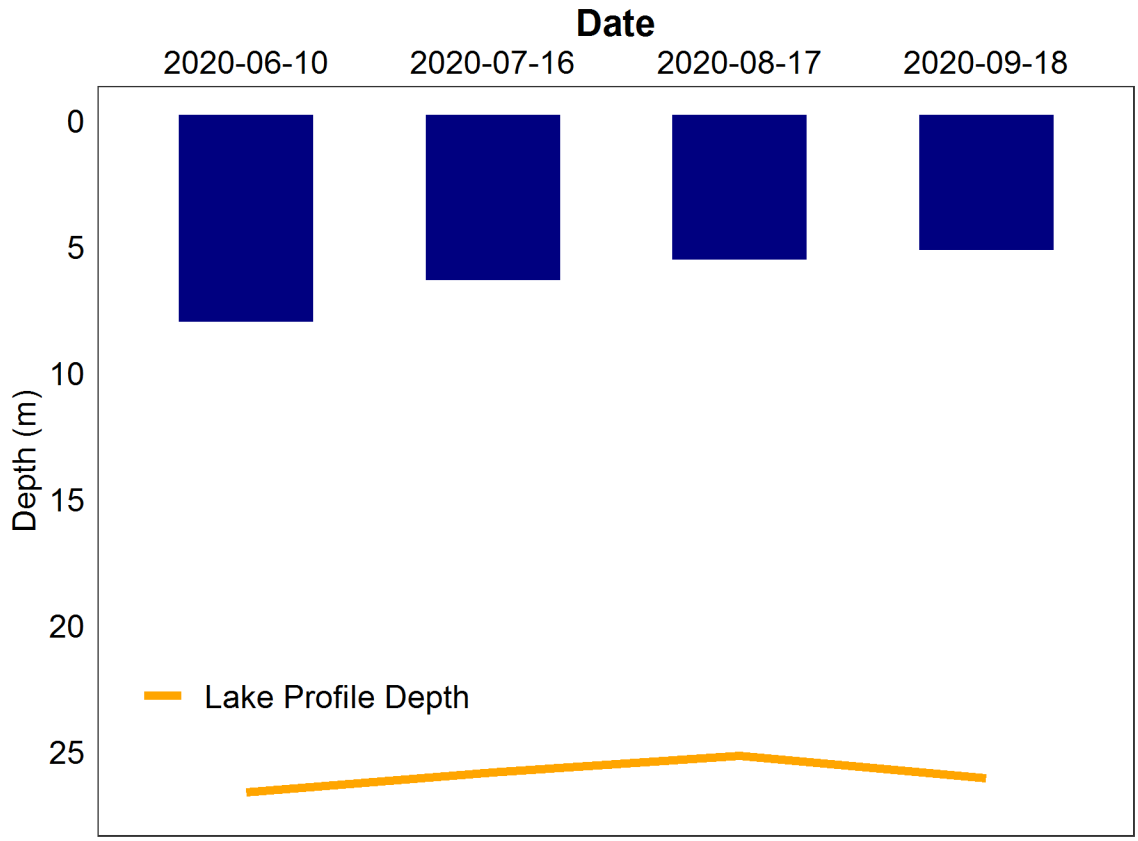


Figure 3. Euphotic depth values measured four times over the course of the summer at Crane Lake in 2020.

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 Crane Lake varied throughout the summer, with a minimum temperature of 5.74°C at 26.0 m on June 10th, and a maximum temperature of 21.1°C measured at 0.1 m on August 17th (Figure 4a). The lake was strongly stratified during all of the sampling trips, with a steep drop in temperature and dissolved oxygen between 10 and 14 meters below the surface. This indicates that the top and bottom of the water column mix little throughout the open water season. The strongest and most shallow thermoclines were measured during the warmer July and August sampling trips.

Crane Lake remained well oxygenated through the upper layer of the water column throughout the summer, measuring above the CCME guidelines of 6.5 mg/L dissolved oxygen (Figure 4b). The oxygen level fell below this level in the bottom 10 to 15 meters throughout the sampling season, due to a lack of mixing with the warmer water on the surface. This is typical for a stratified lake such as Crane Lake.

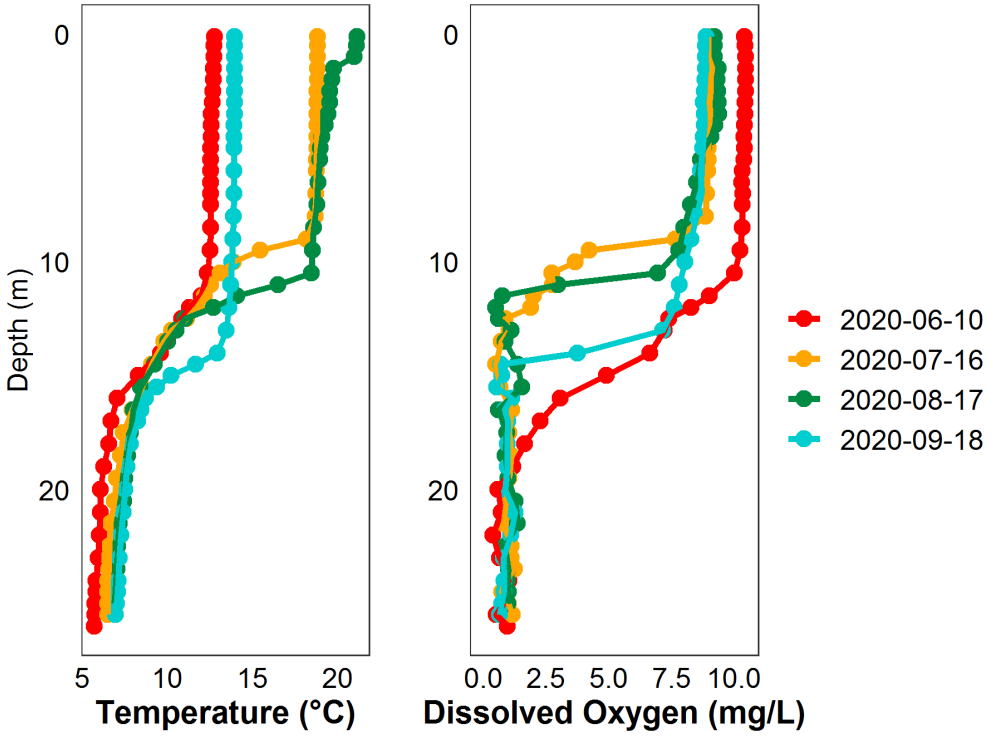


Figure 4. a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Crane Lake measured four times over the course of the summer of 2020.

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 Crane Lake in 2020. Microcystin concentrations were below the detection limit of 0.1 µg/L on all dates sampled except August 17th, where it was detected right at 0.1 µg/L. A value of 0.05 µg/L is used for the purpose of calculating average concentration in instances of no detection.

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

Date	Microcystin Concentration (µg/L)
10-Jun-20	<0.10
16-Jul-20	<0.10
17-Aug-20	0.10
18-Sep-20	<0.10
Average	0.06

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 Crane 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 Crane 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 Monitoring and Science division.

Water levels in Crane Lake have remained relatively stable since monitoring began in 1980 (Figure 5). Since 1980, Crane Lake water levels have fluctuated within about a 0.5m range.

Note: Environment Canada provided a revision for Crane Lake water level data from May, 1980 to October, 2009. A correction of -0.344m was applied to the stage record from 1980 to 2009.

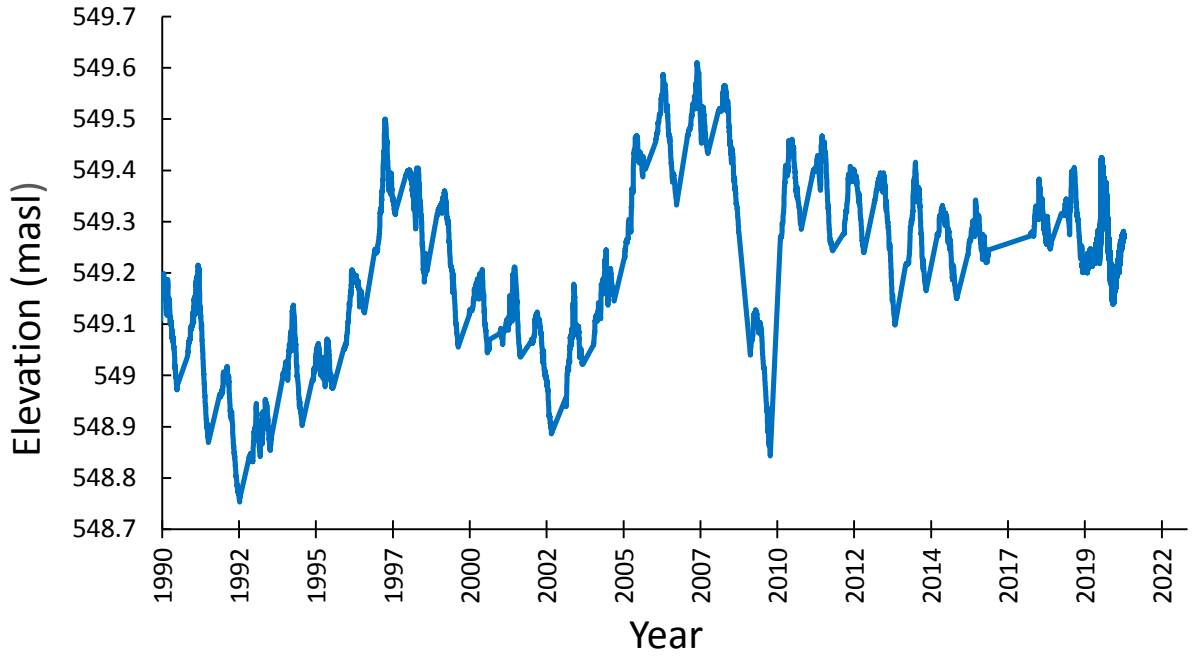


Figure 5. Water levels at Crane Lake measured in meters above sea level (masl) from 1980- 2019. Data retrieved from Environment Canada (1980 – 2019), and Alberta Environment and Parks (2020, early 2021).

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

Parameter	1980	1981	1997	2005	2006	2007	2008	2009
TP (µg/L)	/	27	23	24	23	22	23	19
TDP (µg/L)	/	11	10	11	11	10	12	12
Chlorophyll-*a* (µg/L)	7.9	8.2	7.0	7.1	4.8	3.6	2.5	2.3
Secchi depth (m)	2.70	3.30	3.50	3.22	2.88	3.15	4.00	3.81
TKN (mg/L)	1.2	0.9	1.0	1.0	1.0	0.9	0.9	0.8
NO_2-N and NO_3-N (µg/L)	5	3	8	6	6	3	3	5
NH_3-N (µg/L)	29	22	7	10	14	13	10	15
DOC (mg/L)	15	14	/	14	14	14	13	14
Ca (mg/L)	17	17	16	14	15	15	15	15
Mg (mg/L)	41	40	48	42	48	49	50	47
Na (mg/L)	89	81	116	125	112	124	124	125
K (mg/L)	7	8	8	8	8	8	8	8
SO_4^{2-} (mg/L)	18	21	28	24	28	26	30	35
Cl^- (mg/L)	21	21	26	29	30	30	30	31
CO_3 (mg/L)	0.2	/	39	41	41	43	43	42
HCO_3 (mg/L)	/	/	415	457	459	461	469	467
pH	/	/	8.90	8.92	8.94	8.88	8.89	8.94
Conductivity (µS/cm)	9	9	822	842	873	862	870	867
Hardness (mg/L)	724	704	233	207	234	241	246	231
TDS (mg/L)	/	/	482	509	507	523	532	533
Microcystin (µg/L)	/	/	/	0.16	0.39	0.14	0.10	0.13
Total Alkalinity (mg/L $CaCO_3$)	354	356	400	443	444	450	456	454

Table 2b. Average historical Secchi depth and water chemistry values for Crane Lake. Historical values are given for reference.

Parameter	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020
TP (µg/L)	29	25	26	20	12	14	13	13	17	13
TDP (µg/L)	11	14	13	9	7	6	5	4	6	5
Chlorophyll-*a* (µg/L)	2.3	6.3	3.2	2.5	3.1	4.2	3.7	4.7	5.3	6.8
Secchi depth (m)	3.75	3.69	3.55	3.65	3.65	3.65	3.86	4.02	4.01	3.0
TKN (mg/L)	1.0	1.0	1.3	0.9	1.0	0.9	0.9	0.9	0.9	1.0
NO_2-N and NO_3-N (µg/L)	4	5	4	22	3	3	2	4	2	2
NH_3-N (µg/L)	15	11	13	23	25	25	15	15	12	25
DOC (mg/L)	13	13	21	14	13	12	13	13	15	12
Ca (mg/L)	13	14	14	16	12	12	14	15	16	18
Mg (mg/L)	51	50	54	40	55	57	53	54	52	53
Na (mg/L)	133	121	129	135	125	136	128	128	123	130
K (mg/L)	8	6	8	8	8	9	9	9	8	9
SO_4^{2-} (mg/L)	27	21	22	26	30	29	30	29	27	28
Cl^- (mg/L)	31	30	30	31	34	34	33	33	36	33
CO_3 (mg/L)	37	41	41	45	42	48	43	42	53	60
HCO_3 (mg/L)	480	471	413	549	480	466	458	468	445	410
pH	8.89	8.95	9.08	8.80	8.91	8.96	8.93	8.87	8.92	8.84
Conductivity (µS/cm)	893	890	819	914	916	924	906	900	908	905
Hardness (mg/L)	243	243	256	205	254	264	254	260	255	265
TDS (mg/L)	536	515	543	556	540	550	536	544	535	533
Microcystin (µg/L)	0.09	0.09	0.07	0.08	0.06	0.14	0.13	0.12	0.12	0.06
Total Alkalinity (mg/L $CaCO_3$)	456	454	407	450	460	464	446	454	453	438

Table 3a. Concentrations of metals measured in Crane Lake on in each sampling year since 2005. 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)	2005	2006	2007	2008	2009	2010	Guidelines
Aluminum µg/L	2.10	9.07	5.36	8.86	7.95	4.37	100[a]
Antimony µg/L	0.03	0.03	0.03	0.04	0.03	0.03	/
Arsenic µg/L	4.27	3.02	3.66	4.48	3.67	3.06	5
Barium µg/L	13.4	14.4	14.4	13.8	14.0	13.3	/
Beryllium µg/L	0.003	0.003	<0.003	<0.003	<0.003	0.005	100[c,d]
Bismuth µg/L	0.0005	0.001	0.002	0.004	0.0019	0.0005	/
Boron µg/L	255	327	276	289	311	301	1500
Cadmium µg/L	0.010	0.005	0.010	0.013	0.012	0.013	0.26[b]
Chromium µg/L	0.24	0.36	0.22	0.41	0.47	0.18	/
Cobalt µg/L	0.010	0.025	0.013	0.015	0.020	0.009	1000[d]
Copper µg/L	0.25	0.38	0.24	1.31	0.29	0.24	4[b]
Iron µg/L	6.5	6.0	6.8	8.8	19.9	5.2	300
Lead µg/L	0.050	0.066	0.100	0.035	0.013	0.014	7[b]
Lithium µg/L	65.7	72.5	61.8	62.1	73.1	66.1	2500[e]
Manganese µg/L	1.8	1.7	2.5	1.9	1.3	1.4	200[e]
Molybdenum µg/L	3.19	3.59	3.15	3.23	3.00	2.90	73[c]
Nickel µg/L	0.01	0.09	0.06	<0.005	0.13	0.06	150[b]
Selenium µg/L	0.2	0.5	0.4	0.7	0.4	0.4	1
Silver µg/L	0.001	0.001	<0.0005	0.0014	0.0038	0.000875	0.25
Strontium µg/L	68	75.2	73.8	69	69.9	69.2	/
Thallium µg/L	0	0.01	0.002	0.0018	0.0031	0.0013	0.8
Thorium µg/L	0.004	0.006	0.018	0.020	0.001	0.005	/
Tin µg/L	0.02	0.03	<0.03	<0.03	<0.03	0.015	/
Titanium µg/L	0.61	0.79	0.07	0.74	0.57	0.59	/
Uranium µg/L	0.19	0.21	0.21	0.21	0.18	0.18	15
Vanadium µg/L	0.15	0.25	0.21	0.235	0.268	0.181	100[d,e]
Zinc µg/L	2.08	2.5	0.751	0.362	0.329	0.66	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.

Table 3b. Concentrations of metals measured in Crane Lake on in each sampling year since 2005. 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)	2018	2019	2020	Guidelines
Aluminum µg/L	1.70	3.7	3.4	100[a]
Antimony µg/L	0.03	0.024	0.03	/
Arsenic µg/L	4.08	4.61	4.61	5
Barium µg/L	13.8	15.4	16.6	/
Beryllium µg/L	0	0.0015	0.0015	100[c,d]
Bismuth µg/L	0	0.0015	0.0015	/
Boron µg/L	289	288	270	1500
Cadmium µg/L	0.010	0.005	0.005	0.26[b]
Chromium µg/L	0.10	0.05	0.05	/
Cobalt µg/L	0.020	0.021	0.016	1000[d]
Copper µg/L	0.08	0.14	0.004	4[b]
Iron µg/L	7.0	8	8.9	300
Lead µg/L	0.000	0.004	0.008	7[b]
Lithium µg/L	67.9	63.9	61.3	2500[e]
Manganese µg/L	1.4	2.42	3.11	200[e]
Molybdenum µg/L	2.29	2.16	1.99	73[c]
Nickel µg/L	0.05	0.07	0.07	150[b]
Selenium µg/L	0.8	0.4	0.6	1
Silver µg/L	<0.0005	<0.1	0.0005	0.25
Strontium µg/L	70.9	80.4	83.9	/
Thallium µg/L	<0.001	0.001	0.001	0.8
Thorium µg/L	<0.001	0.002	0.001	/
Tin µg/L	0.06	0.03	0.03	/
Titanium µg/L	0.36	0.35	0.32	/
Uranium µg/L	0.17	0.151	0.15	15
Vanadium µg/L	0.11	0.097	0.637	100[d,e]
Zinc µg/L	0.5	0.4	0.7	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 Crane Lake. In sum, significant increasing trends were observed in chlorophyll-*a* and TDS, a significant decreasing trend was observed in TP, and no trend was detected in Secchi depth. Secchi depth can be subjective and is sensitive to variation in weather - trend analysis must be interpreted with caution. In addition, chlorophyll-*a* trends should be interpreted with caution as sampling of Crane Lake takes place early in the morning before most phytoplankton activity in the water column occurs. Data is presented below 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 Crane Lake data from 2005 to 2020.

Parameter	Date Range	Direction of Significant Trend
Total Phosphorus	2005-2020	Decreasing
Chlorophyll-*a*	2005-2020	Increasing
Total Dissolved Solids	2005-2020	Increasing
Secchi Depth	2005-2020	No Trend Detected

Definitions:

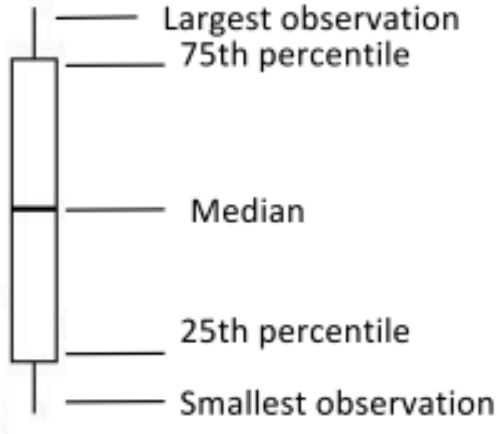
Median: the value in a range of ordered numbers that falls in the middle.

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 decreased significantly over the course of data collection at Crane Lake (Tau = -0.49, $p < 0.001$).

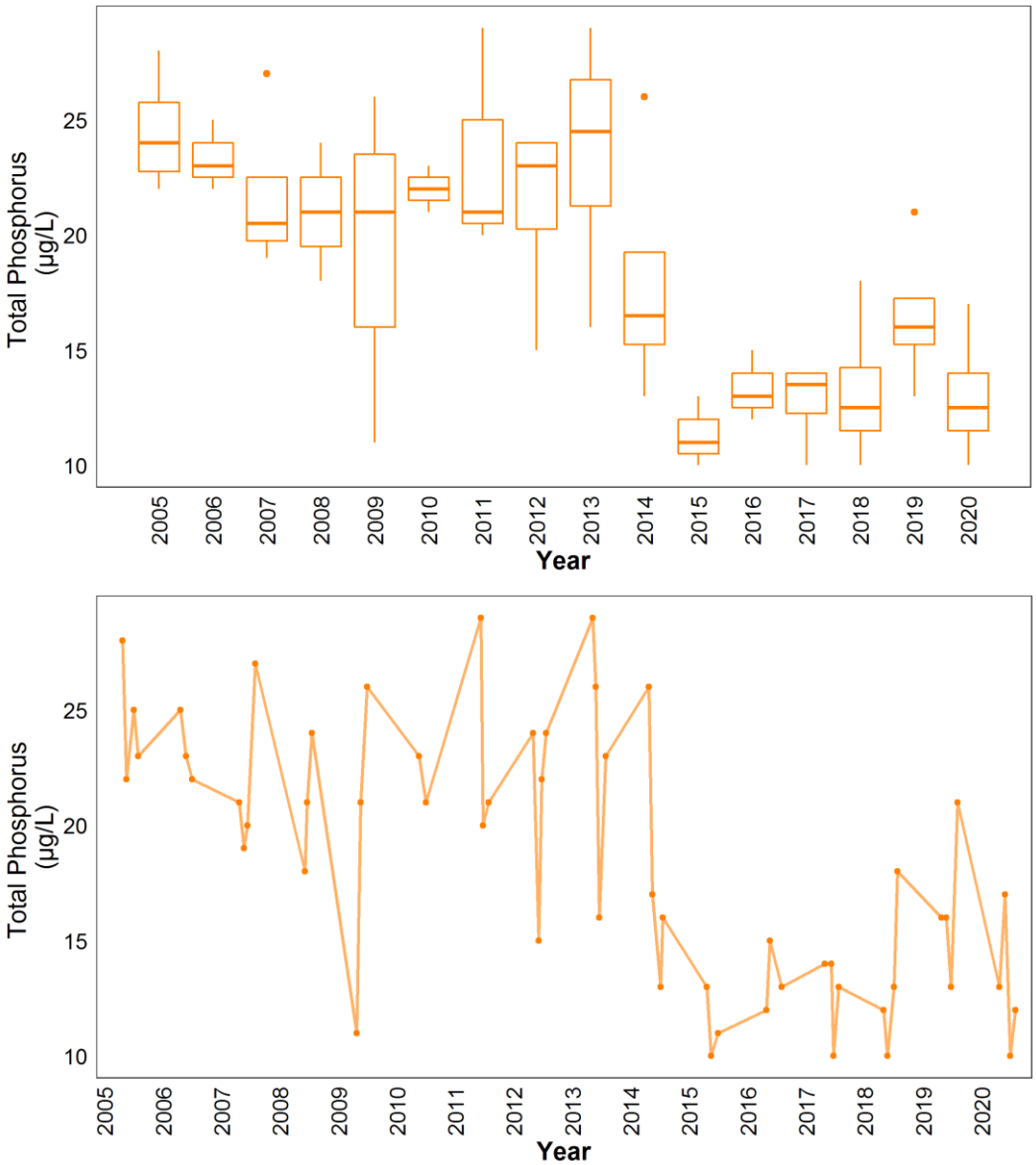


Figure 6. Monthly total phosphorus (TP) concentrations measured between June and September over the long term sampling dates between 2005 and 2020 (n = 56). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Chlorophyll-*a*

Chlorophyll-*a* has significantly increased since sampling began at Crane Lake (Tau = 0.21, p = 0.029, Table 2). When the past 16 years are examined, TP and Chlorophyll *a* did not significantly correlate (r = 0.07, p = 0.62).

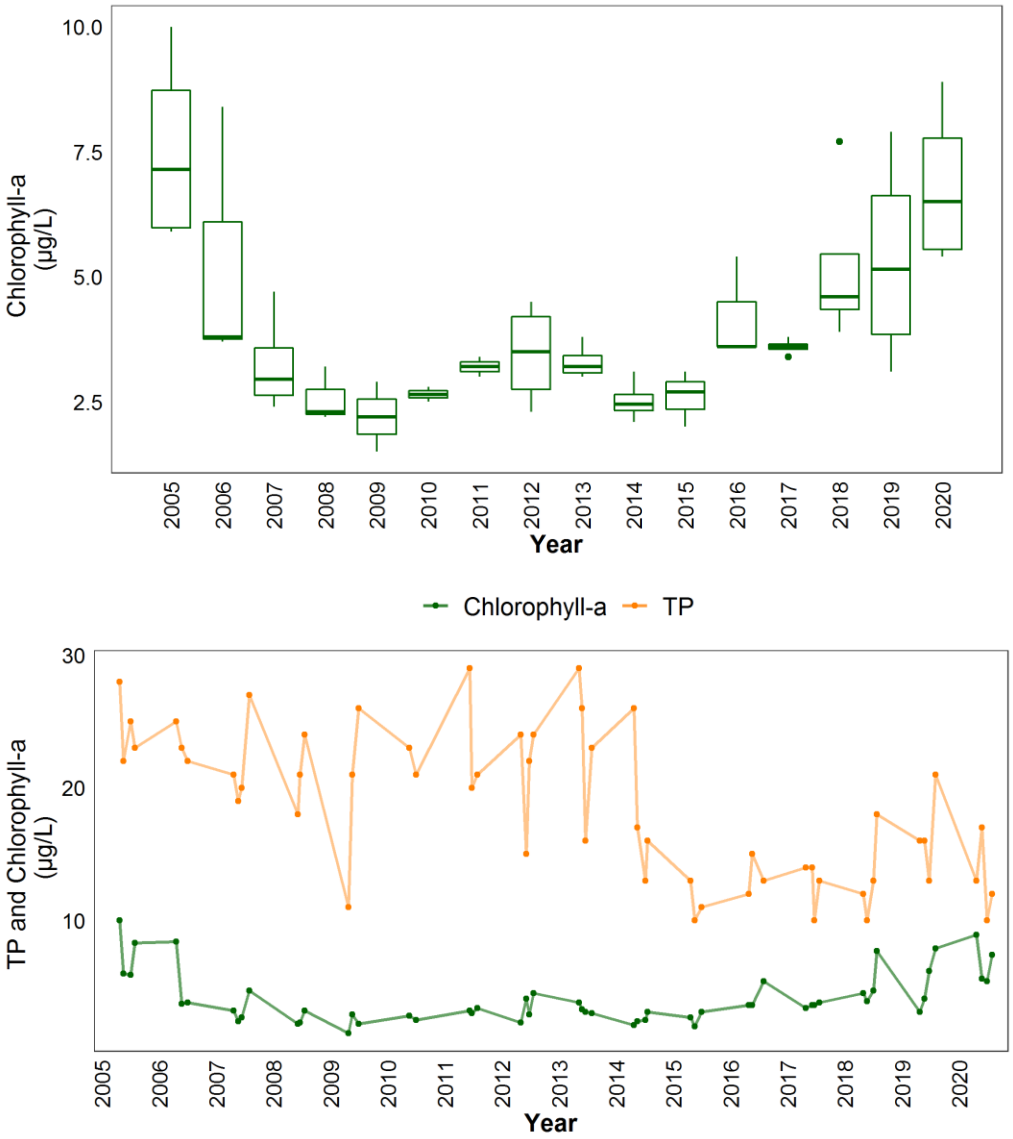


Figure 7. Monthly chlorophyll-*a* concentrations measured between June and September over the long term sampling dates between 2005 and 2020 (n = 56). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples. Line graph is overlain by TP concentrations.

Total Dissolved Solids (TDS)

Total dissolved solids have increased significantly since sampling began in 2005 (Tau= 0.35, p = 0.0014). This is likely not due to evaporative losses as Crane Lake's water levels have not declined in recent years.

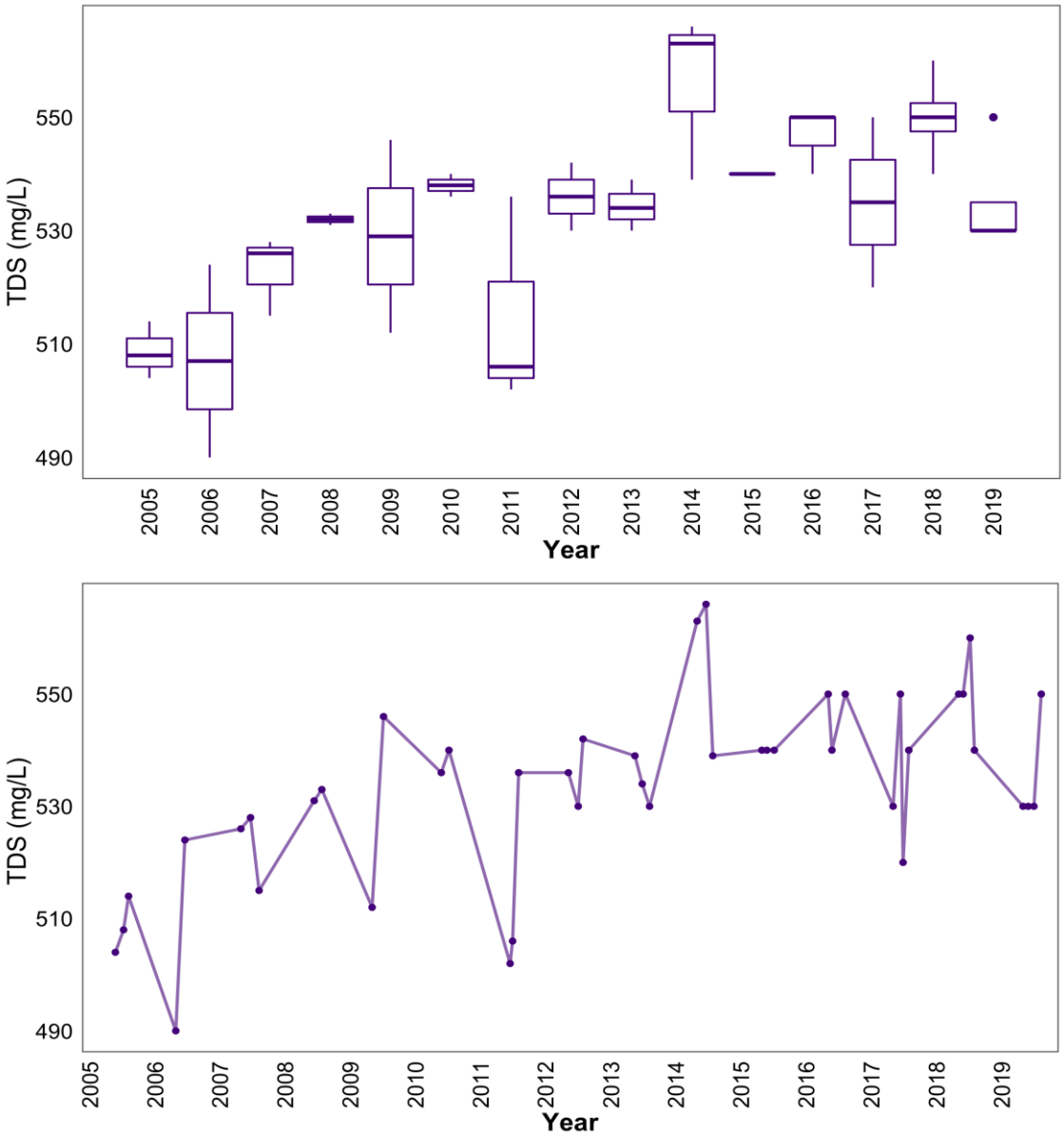


Figure 8. Monthly TDS values measured between June and September over the long term sampling dates between 2005 and 2020 (n = 48). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Secchi Depth

Trend analysis found that water quality measured as Secchi depth has not changed over the sampling period (Tau = 0.13, *p* = 0.15).

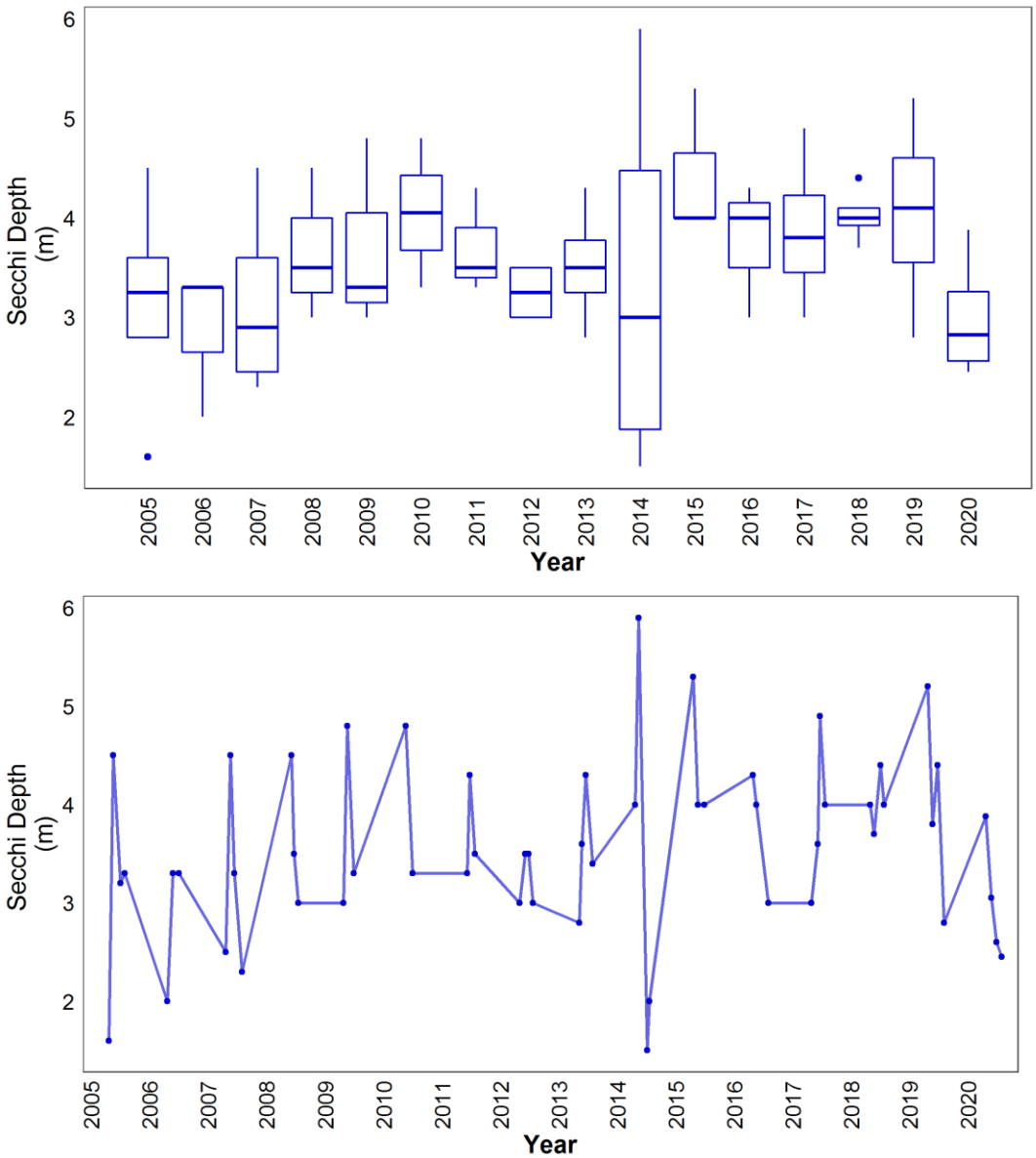


Figure 9. Monthly Secchi depth values measured between June and September over the long term sampling dates between 2005 and 2020 (n = 56). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Table 6. Results of trend tests using total phosphorus (TP), chlorophyll-*a*, total dissolved solids (TDS), and Secchi depth data from June to September on Crane Lake data.

Definition	Unit	Total Phosphorus (TP)	Chlorophyll-a	Total Dissolved Solids (TDS)	Secchi Depth
Statistical Method	-	Seasonal Kendall	Seasonal Kendall	Seasonal Kendall	Mann Kendall
The strength and direction (+ or -) of the trend between -1 and 1	Tau	-0.49	0.21	0.35	0.13
The extent (slope) of the trend	Slope	-0.83	0.11	2.0	0.0001
The statistic used to find significance of the trend	Z	-4.93	2.18	3.19	1.44
Number of samples included	n	56	56	48	56
The significance of the trend	*p*	8.41×10^{-7}*	0.029*	1.41×10^{-3}*	0.15

*$p < 0.05$ is significant within 95%