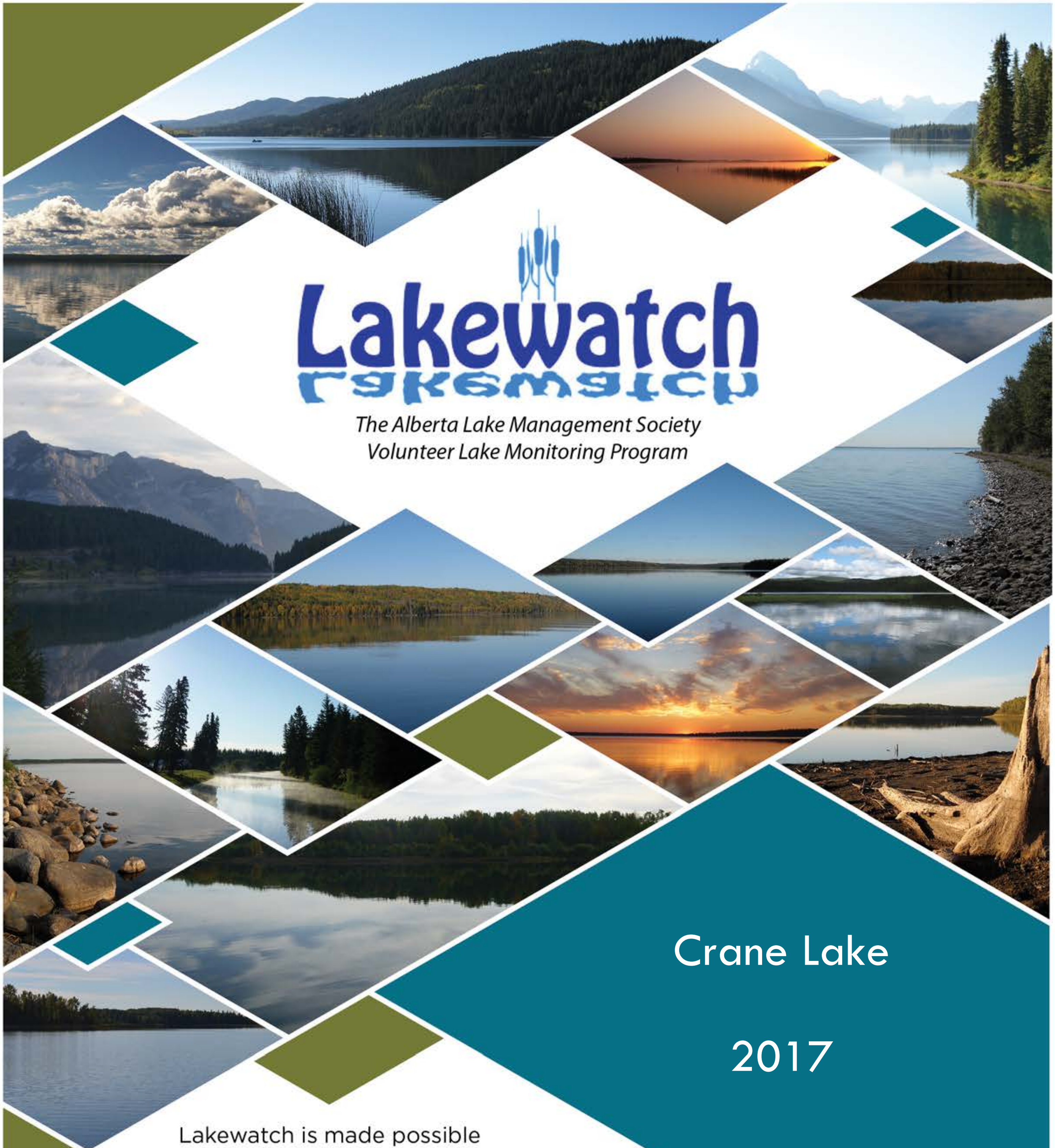


Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Crane Lake

2017

Lakewatch is made possible with support from:

Cargill – Helping the world thrive; Jackfish Lake; Pigeon Lake Watershed Association; LICA Lakeland Industry & Community Association; Red Deer River Watershed Alliance; Beaver River Watershed Alliance; Alberta Environment and Parks

ALBERTA LAKE MANAGEMENT SOCIETY'S LAKEWATCH PROGRAM

LakeWatch has several important objectives, one of which is to collect and interpret water quality data on Alberta Lakes. Equally important is educating lake users about their aquatic environment, 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 a lay 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 people prove that ecological apathy can be overcome and give us hope that our water resources will not be the limiting factor in the health of our environment.

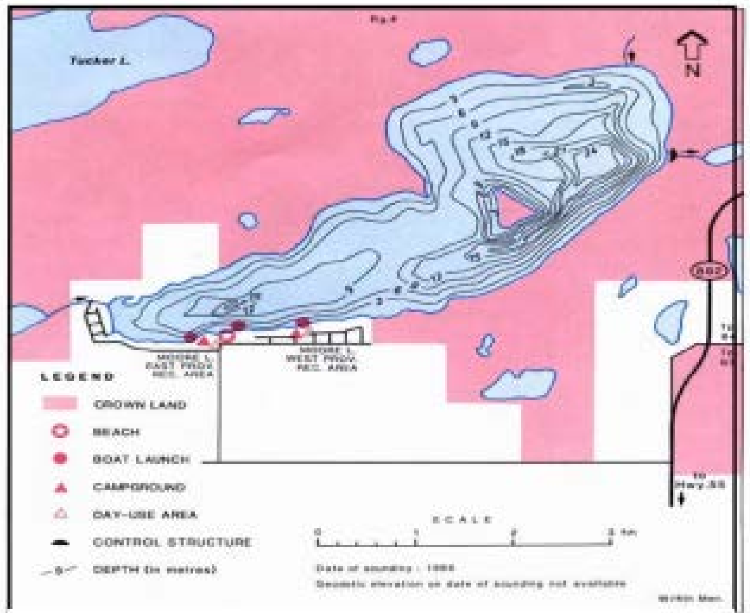
ALMS is happy to discuss the results of this report with our stakeholders. If you would like information or a public presentation, contact us at info@alms.ca.

ACKNOWLEDGEMENTS

The LakeWatch program is made possible through the dedication of its volunteers. We would like to extend a special thanks to Ron Young for the time and energy put into sampling Crane Lake in 2017. We would also like to thank Elashia Young and Melissa Risto who were summer technicians in 2017. Executive Director Bradley Peter and LakeWatch Coordinator Laura Redmond was instrumental in planning and organizing the field program. This report was prepared by Laura Redmond and Bradley Peter. The Beaver River Watershed, the Lakeland Industry and Community Association, Environment Canada, and Alberta Environment and Parks are major sponsors of the LakeWatch program.

CRANE LAKE

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 (Figure 1, 2). Located in Alberta's Lakeland Region, Crane Lake is valued for its clear water and natural shoreline.



Bathymetric map of Crane Lake (Mitchell & Prepas 1990)

Crane Lake- Photo by Ageleky Bouzetos 2015

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.

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

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. On one visit per season, metals are collected at the profile site by hand grab from the surface and at some lakes, 1 m off bottom using a Kemmerer.

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 Alberta Innovates Technology Futures (AITF), and microcystin is analyzed by the Alberta Centre for Toxicology (ACTF). In lakes where mercury samples are taken, they are analyzed by the Biogeochemical Analytical Service Laboratory (BASL).

Invasive Species: Monitoring for invasive quagga and zebra mussels involved two components: monitoring for juvenile mussel veligers using a 63 µm plankton net at three sample sites and monitoring for attached adult mussels using substrates installed at each lake.

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 aep.alberta.ca/water.

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 TP, chlorophyll-*a,* 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 nonparametric 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 for Crane Lake was 13.2 µg/L (Table 2), falling into the mesotrophic, or moderately productive, trophic classification. This value is historically low, but similar to averages in recent years. TP fluctuated over the sampling season but was highest on August 29th (Figure 1).

Average chlorophyll-*a* concentration in 2017 was 3.72 µg/L (Table 2), also putting Crane Lake into the mesotrophic classification. Chlorophyll-*a* concentrations remained relatively constant over the five sampling visits.

Finally, the average total Kjeldahl nitrogen (TKN) concentration was 0.9 mg/L (Table 2), and the maximum concentration of 0.92 mg/L was measured on August 29th.

Average pH was measured as 8.93 in 2017, buffered by moderate alkalinity (446 mg/L $CaCO_3$) and bicarbonate (458 mg/L HCO_3). Sodium and magnesium were the dominant ions contributing to a moderate-high conductivity of 906 µS/cm (Table 2).

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 once on August 29 on Crane Lake at the surface. In 2017, Arsenic, Boron and Selenium were measured to be above their respective guidelines (Table 3). These metals have not been observed to exceed their guidelines since metal monitoring began in 2005.

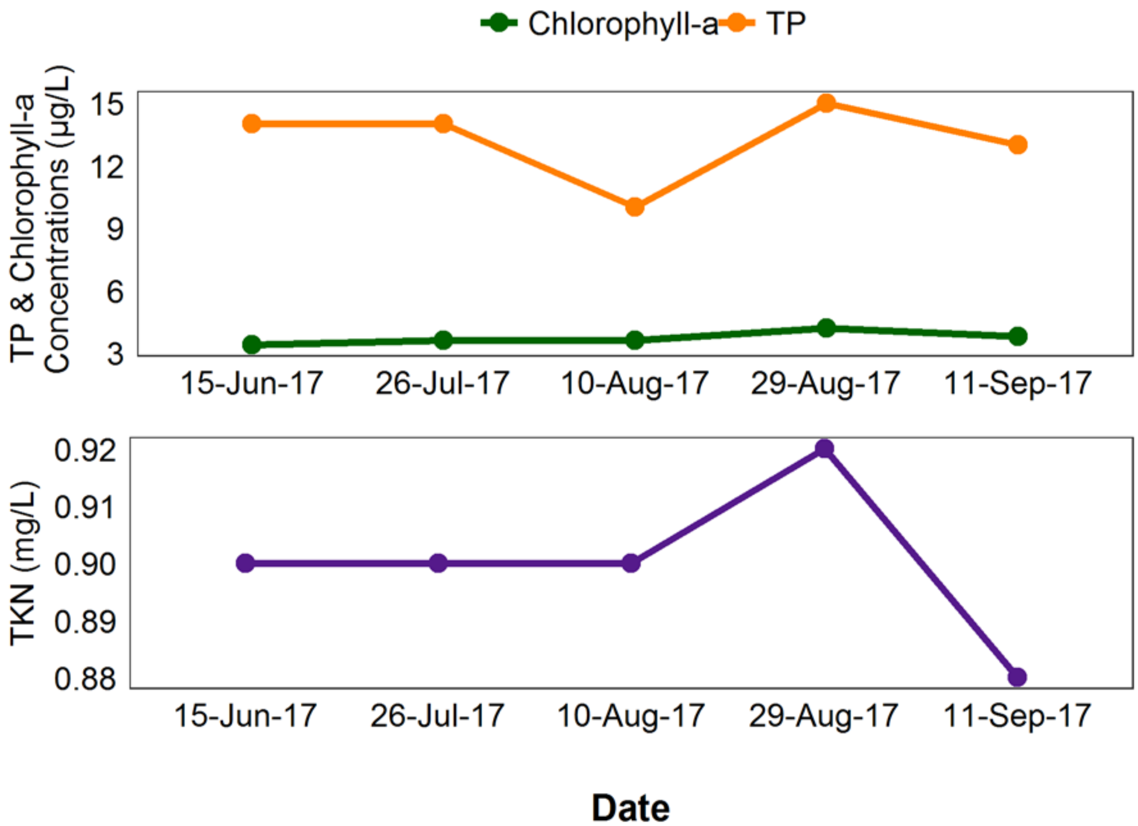


Figure 1- Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentrations measured five times over the course of the summer at Crane Lake.

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 Crane Lake in 2017 was 3.86 m (Table 2). Secchi depth was deepest on August 10^{th} at a depth of 5 m (Figure 2).

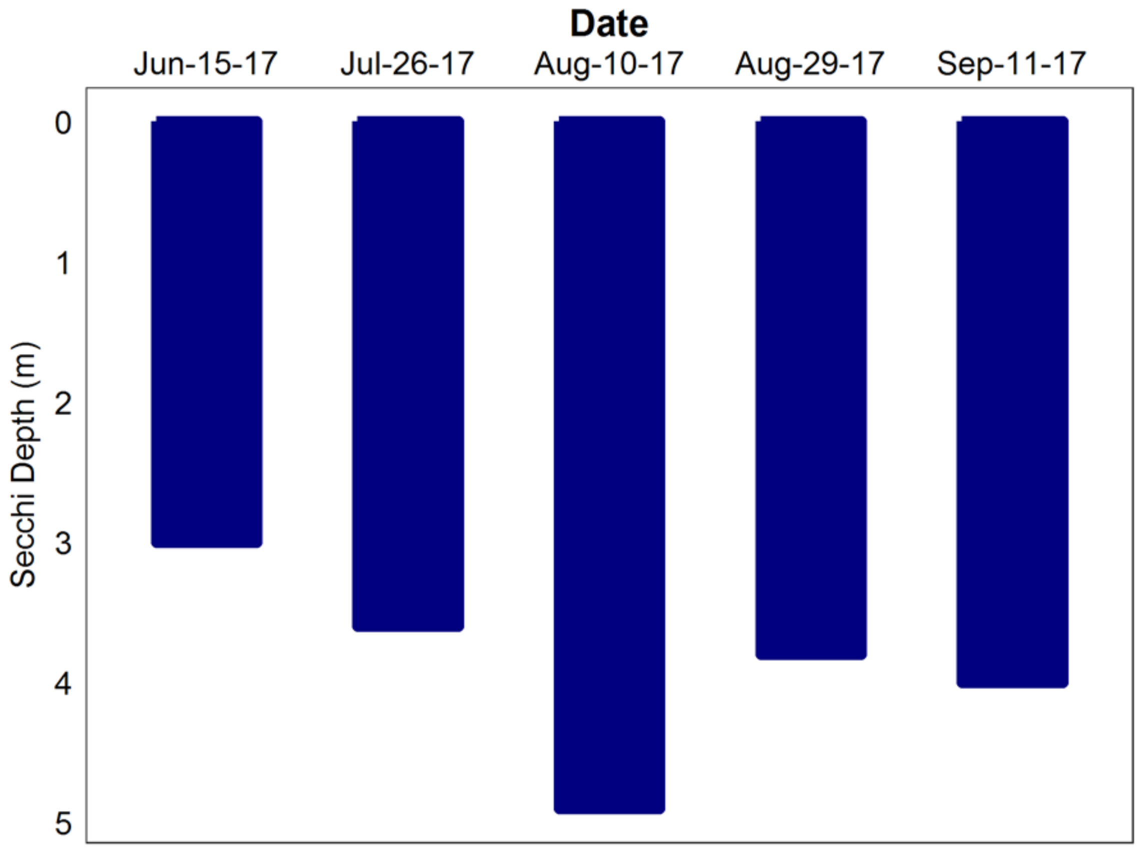


Figure 2 – Secchi depth values measured five times over the course of the summer at Crane Lake in 2017.

WATER TEMPERATURE AND DISSOLVED OXYGEN

Water temperature and dissolved oxygen 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 over the course of the summer, with a maximum temperature of 21.3°C measured at the surface on August 10 (Figure 3a). The lake was thermally stratified on all five sampling visits, and the thermocline deepened over the course of the summer.

Crane Lake remained well oxygenated at the surface throughout the summer, measuring above the CCME guidelines of 6.5 mg/L for the Protection of Aquatic Life (Figure 3b). Thermal stratification prevented atmospheric oxygen from reaching bottom waters, resulting in anoxia at the bottom on all sampling visits except June, when thermal stratification was weaker.

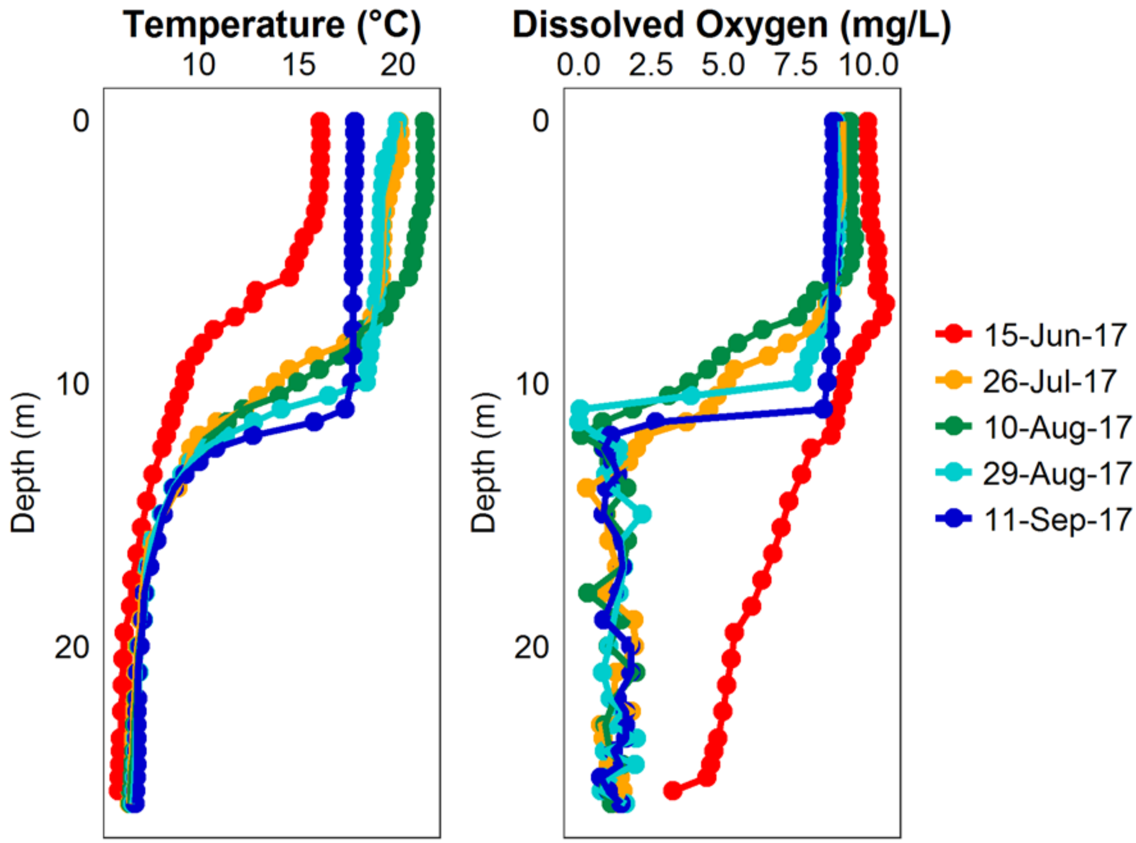


Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Crane Lake measured five times over the course of the summer of 2017.

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 Crane Lake fell below the recreational guideline for the entire sampling period of 2017 (Table 1).

Table 1 – Microcystin concentrations measured five times at Crane Lake in 2017.

Date	Microcystin Concentration (μg/L)
Jun-15-17	0.12
Jul-26-17	0.13
Aug-10-17	0.14
Aug-29-17	0.13
Sep-11-17	0.11
Average	0.13

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 algae 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 two components: monitoring for juvenile mussel veligers using a plankton net and monitoring for attached adult mussels using substrates installed in each lake. No mussels have been detected in Crane Lake since monitoring for invasive species began in 2013.

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 Alberta Environment began monitoring the lake in 1980 (Figure 4). Since 1980, Crane Lake water levels have fluctuated between 548.8 m asl and 549.6 m asl. Data from Environment Canada was only available until 2014.

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.

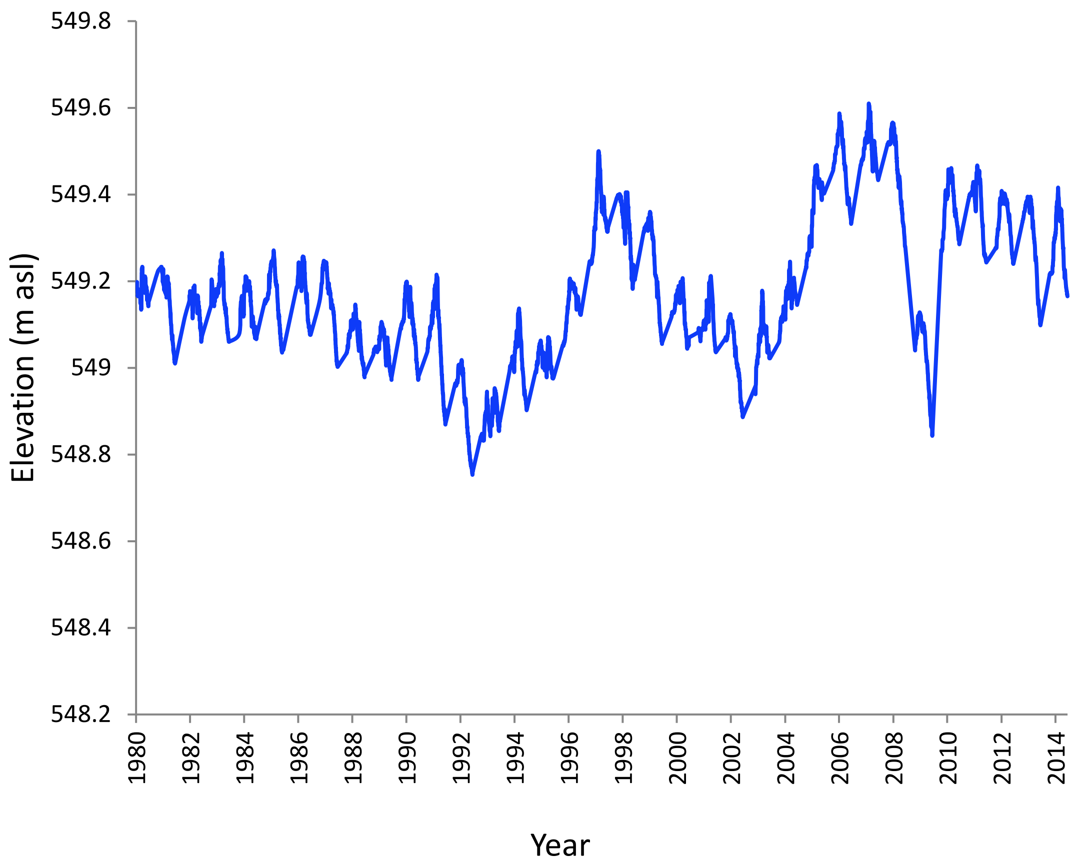


Figure 4- Water levels measured in meters above sea level (m asl) from 1980- 2016. Data retrieved from Environment Canada.

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

Parameter	1980	1981	1997	2005	2006	2007	2008
TP (µg/L)	/	26.8	23	24	23.25	22	22.5
TDP (µg/L)	/	11	10	10.6	10.75	10	12.25
Chlorophyll-*a* (µg/L)	7.9	8.2	7	7.06	4.77	3.59	2.45
Secchi depth (m)	2.7	3.3	3.5	3.22	2.88	3.15	4
TKN (mg/L)	1.240	0.940	0.970	0.982	0.980	0.856	0.933
NO_2-N and NO_3-N (µg/L)	5	3	8	5.5	5.88	3.33	2.5
NH_3-N (µg/L)	29	22	7	9.6	14	13.4	9.75
DOC (mg/L)	14.5	13.8	/	13.7	13.65	13.87	13.4
Ca (mg/L)	16.6	16.7	15.7	13.67	15.15	15.4	15.37
Mg (mg/L)	41	39.8	48	41.83	47.65	49.27	50.37
Na (mg/L)	89	81	116	125.3	112.2	123.67	124.3
K (mg/L)	6.6	7.7	7.8	8.13	8.2	8.43	8.13
SO_4^{2-} (mg/L)	18	20.5	27.9	24	28	25.7	29.67
Cl^- (mg/L)	20.7	21	26.2	29.3	29.65	30.43	30.3
CO_3 (mg/L)	0.22	/	39	41	40.5	43.3	42.67
HCO_3 (mg/L)	/	/	415	457.3	459	460.67	468.67
pH	/	/	8.9	8.92	8.94	8.88	8.89
Conductivity (µS/cm)	8.7	8.5	822	842.3	873	862	869.67
Hardness (mg/L)	724	704	233	206.67	234	241.3	245.67
TDS (mg/L)	/	/	482	508.67	507	523	531.67
Microcystin (µg/L)	/	/	/	0.162	0.39	0.13625	0.098
Total Alkalinity (mg/L $CaCO_3$)	354	356	400	443.3	444	450.3	455.7

Table 2: Continued- Average Secchi depth and water chemistry values for Crane Lake.

Parameter	2009	2010	2011	2013	2014	2015	2016	2017
TP (µg/L)	19.25	28.7	25	25.6	19.8	12	14	13.2
TDP (µg/L)	11.5	11.3	13.8	12.8	8.8	7.4	6	5.14
Chlorophyll-*a* (µg/L)	2.28	2.31	6.33	3.18	2.52	3.12	4.2	3.7
Secchi depth (m)	3.81	3.75	3.69	3.55	3.65	3.65	3.65	3.86
TKN (mg/L)	0.75	0.96	0.97	1.282	0.90	0.96	0.91	0.9
NO_2-N and NO_3-N (µg/L)	5.1	3.67	5.38	4.1	22	2.5	2.5	2.26
NH_3-N (µg/L)	15	15.3	11.3	12.8	23.2	25	25	14.5
DOC (mg/L)	13.77	13.17	12.8	20.73	13.7	13	12.12	13.4
Ca (mg/L)	14.73	12.73	14.4	14.17	16.37	12	12.4	13.6
Mg (mg/L)	47.2	51.37	50.4	53.53	40.13	55	56.6	53.4
Na (mg/L)	125.3	133.3	121	129	134.67	125	136	128
K (mg/L)	8.27	7.83	5.67	8.47	8.34	8.4	9.22	8.76
SO_4^{2-} (mg/L)	34.67	26.67	20.7	22.3	26.33	30	29.2	29.6
Cl^- (mg/L)	30.6	30.83	30	30.3	30.7	34	33.6	33.4
CO_3 (mg/L)	42.3	37	40.75	41.2	45.44	42	47.8	43.2
HCO_3 (mg/L)	467.3	480	470.5	412.6	549.4	480	466	458
pH	8.94	8.89	8.95	9.08	8.80	8.91	8.96	8.93
Conductivity (µS/cm)	867.33	893.33	890	819	914	916	924	906
Hardness (mg/L)	231.3	243	243	256	205	254	264	254
TDS (mg/L)	533	536.3	515	543.3	556	540	550	536
Microcystin (µg/L)	0.1275	0.087	0.09	0.07	0.08	0.06	0.136	0.13
Total Alkalinity (mg/L $CaCO_3$)	454	456	454	407.4	450.4	460	464	446

Table 3: Concentrations of metals measured once in Crane Lake on August 29th. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Guidelines**
Aluminum µg/L	2.1	9.07	5.36	8.86	7.95	4.365	100[a]
Antimony µg/L	0.03	0.03	0.029	0.0423	0.0308	0.0308	/
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	13.25	/
Beryllium µg/L	0.003	0.003	<0.003	<0.003	<0.003	0.00475	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	310.5	300.5	1500
Cadmium µg/L	0.01	0.005	0.01	0.0131	0.0117	0.0129	0.26[b]
Chromium µg/L	0.24	0.359	0.217	0.405	0.472	0.1824	/
Cobalt µg/L	0.01	0.025	0.013	0.015	0.0203	0.0089	1000[d]
Copper µg/L	0.25	0.38	0.238	1.31	0.294	0.24	4[b]
Iron µg/L	6.5	6	6.81	8.8	19.9	5.175	300
Lead µg/L	0.05	0.066	0.1	0.0345	0.0132	0.01405	7[b]
Lithium µg/L	65.7	72.5	61.8	62.1	73.1	66.05	2500[e]
Manganese µg/L	1.8	1.7	2.45	1.87	1.32	1.36	200[e]
Molybdenum µg/L	3.19	3.59	3.15	3.23	3	2.9	73[c]
Nickel µg/L	0.01	0.092	0.064	<0.005	0.132	0.06375	150[b]
Selenium µg/L	0.19	0.52	0.416	0.721	0.433	0.364	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	0.00125	0.8
Thorium µg/L	0.004	0.006	0.018	0.0197	0.0008	0.005075	/
Tin µg/L	0.02	0.03	<0.03	<0.03	<0.03	0.015	/
Titanium µg/L	0.61	0.79	0.07	0.744	0.574	0.5875	/
Uranium µg/L	0.19	0.21	0.206	0.208	0.179	0.1815	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 CaCO3)
[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 3: Continued- Concentrations of metals measured once in Crane Lake. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Guidelines**
Aluminum µg/L	9.065	4.75	14.91	5.45	5.05	23	34.2	100[a]
Antimony µg/L	0.0267	0.0333	0.0279	0.03	0.0315	0.035	0.113	/
Arsenic µg/L	3.075	3.73	2.905	4.155	4.56	4.01	21.9	5
Barium µg/L	13.35	13.35	13.2	11.21	9.37	11.4	62.4	/
Beryllium µg/L	0.0015	0.01195	0.0065	0.004	0.004	0.004	0.0055	100[c,d]
Bismuth µg/L	0.0005	0.0005	0.0005	0.01925	0.0005	0.0005	0.0055	/
Boron µg/L	306.5	324.5	293	307	317	321	1500	1500
Cadmium µg/L	0.0059	0.0088	0.0061	0.006	0.005	0.141	0.025	0.26[b]
Chromium µg/L	0.197	0.32	0.2815	0.765	0.095	1.19	0.25	/
Cobalt µg/L	0.0015	0.00765	0.0118	0.0075	0.021	0.014	0.073	1000[d]
Copper µg/L	0.451	0.4475	0.287	0.195	0.355	1.35	0.76	4[b]
Iron µg/L	2.6	2.92	14.005	13.8	7.6	93.3	40.5	300
Lead µg/L	0.0208	0.00835	0.0764	0.0065	0.0375	0.157	0.122	7[b]
Lithium µg/L	68.35	70.4	66.95	67.7	71.6	76.7	303	2500[e]
Manganese µg/L	1.385	1.48	1.265	1.341	1.895	3.63	10.9	200[e]
Molybdenum µg/L	2.715	2.79	2.655	2.455	2.525	2.39	11	73[c]
Nickel µg/L	0.0025	0.0025	0.05035	0.009	0.012	0.301	1.19	150[b]
Selenium µg/L	0.5245	0.2945	0.219	0.455	0.03	0.55	4.2	1
Silver µg/L	0.0003	0.000375	0.007275	0.1275	0.002	0.028	0.008	0.25
Strontium µg/L	67.4	68.45	66.75	56.55	44.45	52	281	/
Thallium µg/L	0.0001	0.0004	0.000475	0.00285	0.00195	0.0011	0.01	0.8
Thorium µg/L	0.0034	0.00015	0.0032	0.047375	0.00045	0.004	0.04	/
Tin µg/L	0.015	0.03125	0.015	0.0225	0.022	7.23	0.15	/
Titanium µg/L	0.5195	0.5035	0.973	0.545	0.595	0.71	2.73	/
Uranium µg/L	0.176	0.1785	0.172	0.1675	0.164	0.179	0.784	15
Vanadium µg/L	0.1865	0.1845	0.216	0.355	0.16	0.24	0.726	100[d,e]
Zinc µg/L	0.4815	0.468	0.6575	0.5	0.9	69.1	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 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, non-significant decreases were observed in chlorophyll-*a,* significant increasing trends were observed in Secchi depth and TDS, and significant decreasing trends were observed in TP. 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 a line graph (all data points) or a box-and-whisker plot. Detailed methods are available in the *ALMS Guide to Trend Analysis on Alberta Lakes.*

Table 1: Summary table of trend analysis on Crane Lake data from 2005 to 2017.

Parameter	Date Range	Trend	Probability
Total Phosphorus	2005-2017	Decreasing	Significant
Chlorophyll-*a*	2005-2017	Decreasing	Non-significant
Total Dissolved Solids	2005-2017	Increasing	Significant
Secchi Depth	2005-2017	Increasing	Significant

Definitions:

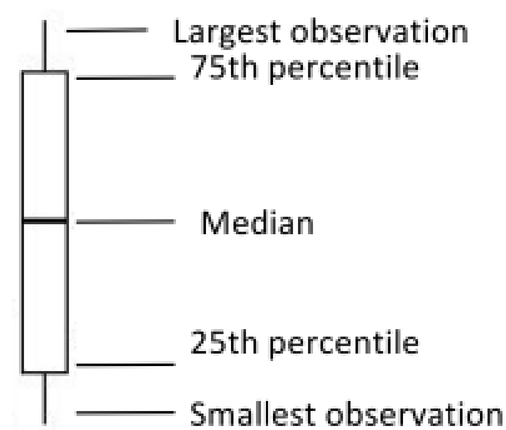
Median: the value in a range of ordered numbers that falls in the middle.

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)

Total phosphorus (TP) has decreased significantly over the course of data collection at Crane Lake (Tau = -0.49, *p* < 0.001).

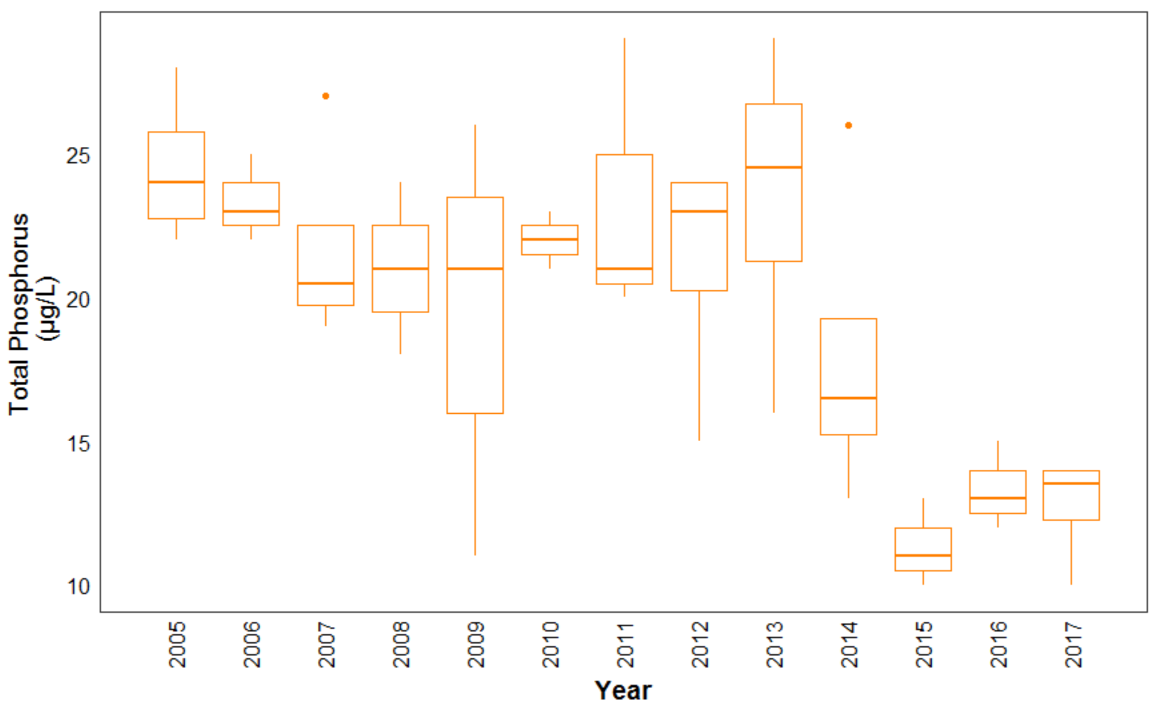


Figure 1- Monthly total phosphorus (TP) concentrations measured between June and September over the long term sampling dates between 2005 and 2017 (n = 44). The value closest to the 15^{th} day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Chlorophyll-*a*

Chlorophyll-*a* has not changed significantly since sampling began at Crane Lake (*p* = 0.52, Table 2). Chlorophyll-*a* trends follow TP trends with minor correlation over time (r = 0.31, *p* = 0.04).

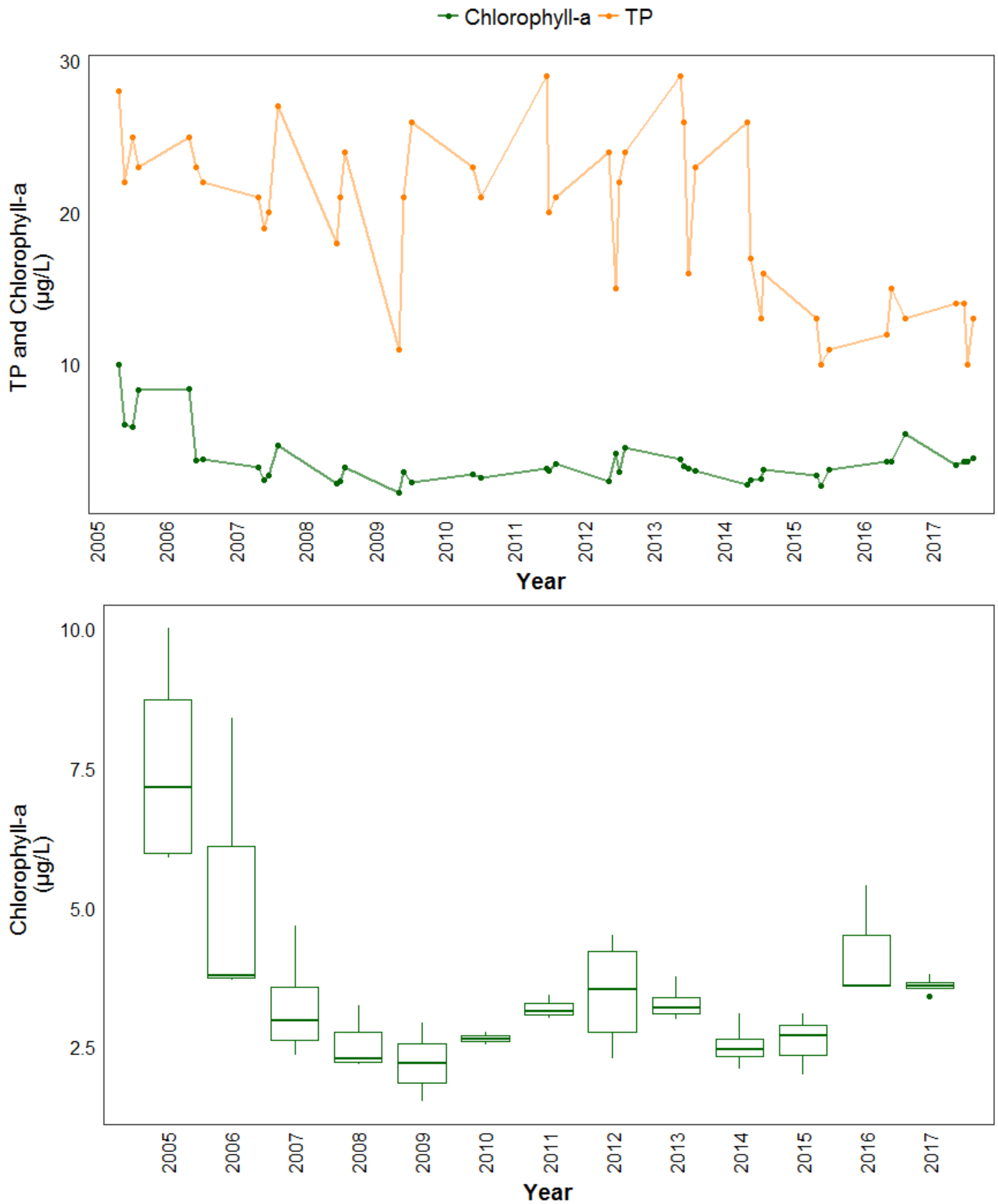
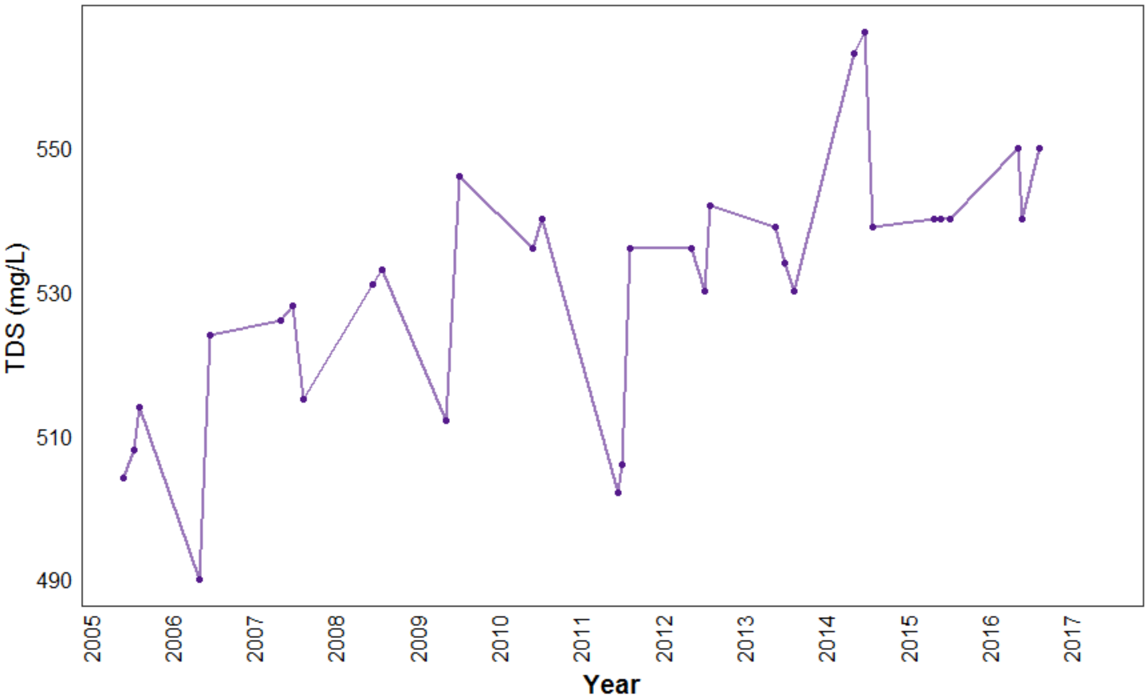


Figure 2-Monthly chlorophyll-*a* concentrations measured between June and September over the long term sampling dates between 2005 and 2017 (N=44). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples. Line graph is overlain by TP concentrations.

Total Dissolved Solids (TDS)

Total dissolved solids have increased significantly since sampling began in 2005 (Tau= 0.6, $p < 0.001$). This is likely not due to evaporative losses as Crane Lake's water levels have not declined in recent years.



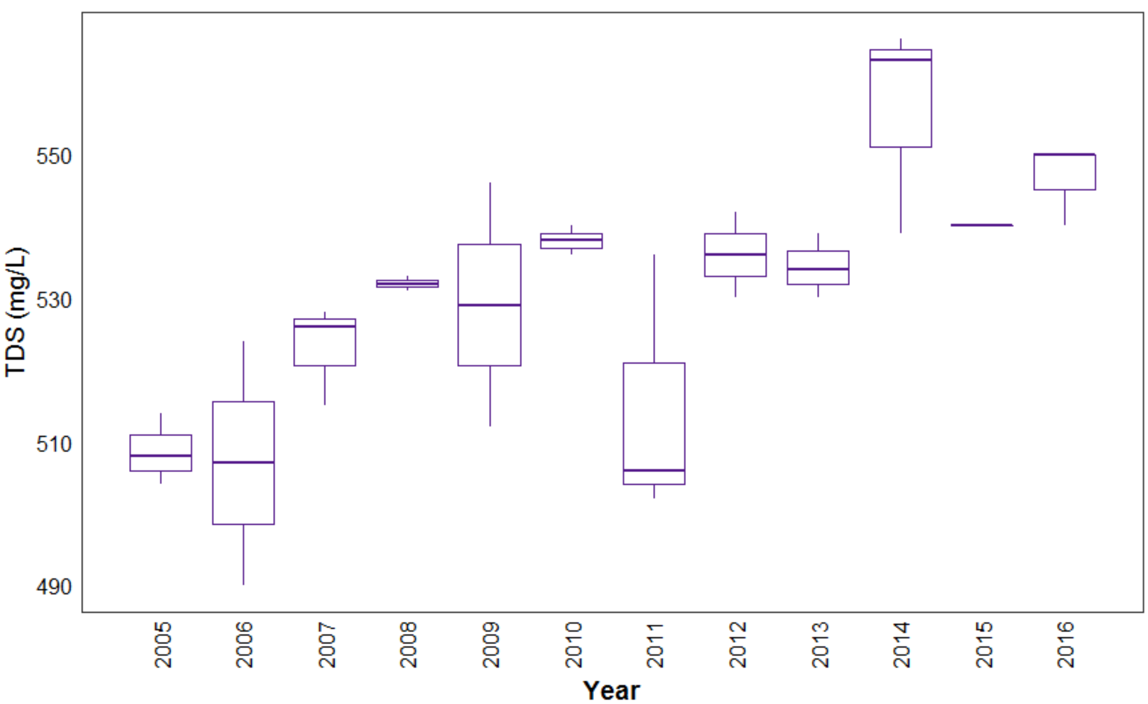


Figure 3-Monthly TDS values measured between June and September over the long term sampling dates between 2005 and 2017 (n = 32). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Secchi Depth

Trend analysis found that water quality measured as Secchi depth has increased (become more clear) over the sampling period (Tau = 0.3, *p* = 0.014).

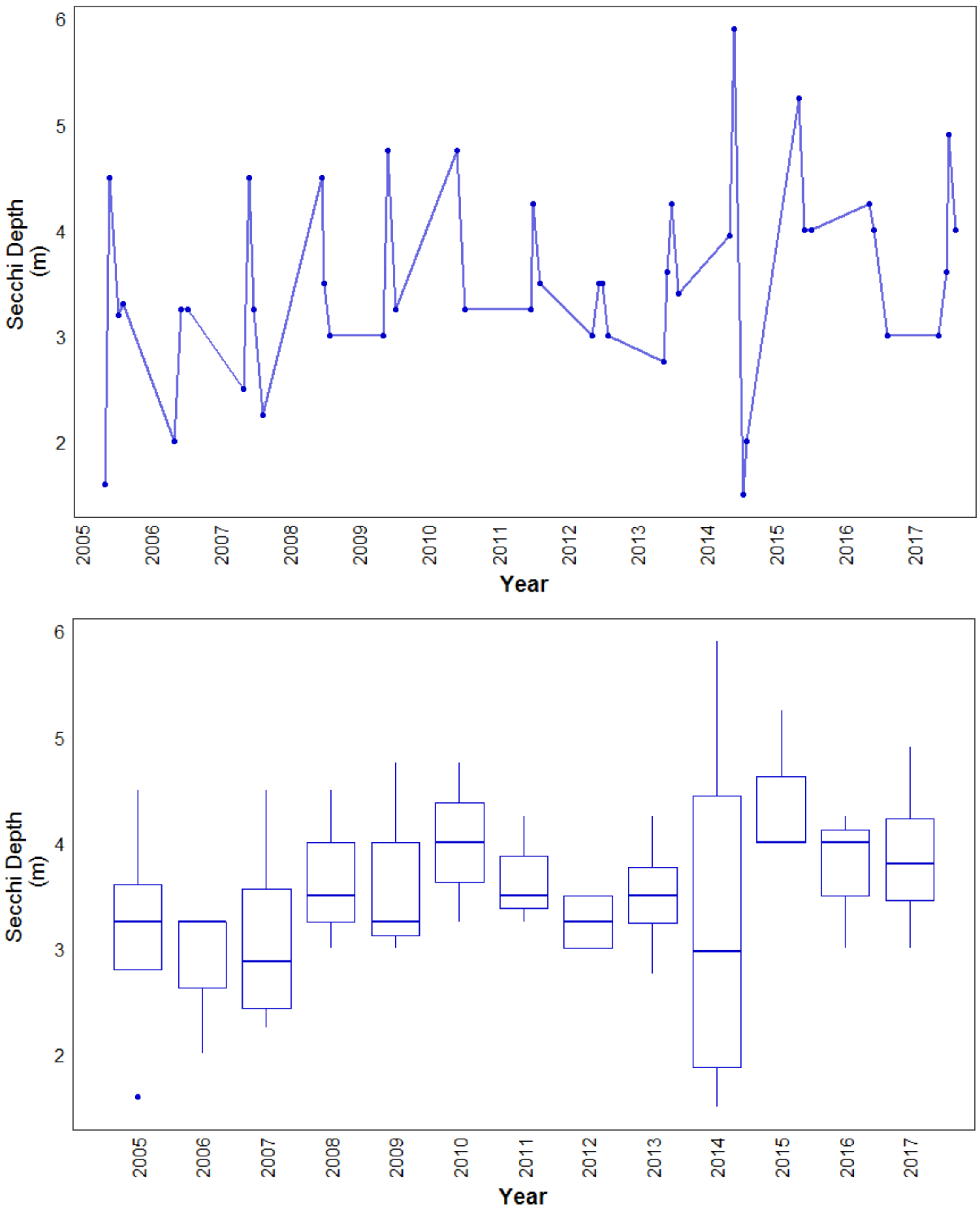


Figure 4-Monthly Secchi depth values measured between June and September over the long term sampling dates between 2005 and 2017 (n = 44). The value closest to the 15th day of the month was chosen to represent the monthly value in cases with multiple monthly samples.

Table 2- Results of Seasonal Kendall Trend test using monthly total phosphorus (TP), chlorophyll-*a* 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	Seasonal Kendall
The strength and direction (+ or -) of the trend between -1 and 1	Tau	-0.49	-0.094	0.60	0.30
The extent of the trend	Slope	-1.00	-0.031	3.25	0.075
The statistic used to find significance of the trend	Z	-4.15	-0.64	4.11	2.47
Number of samples included	n	44	44	32	44
The significance of the trend	*p*	3.35×10^{-5}*	0.52	3.85×10^{-5}*	0.014*

*$p < 0.05$ is significant within 95%