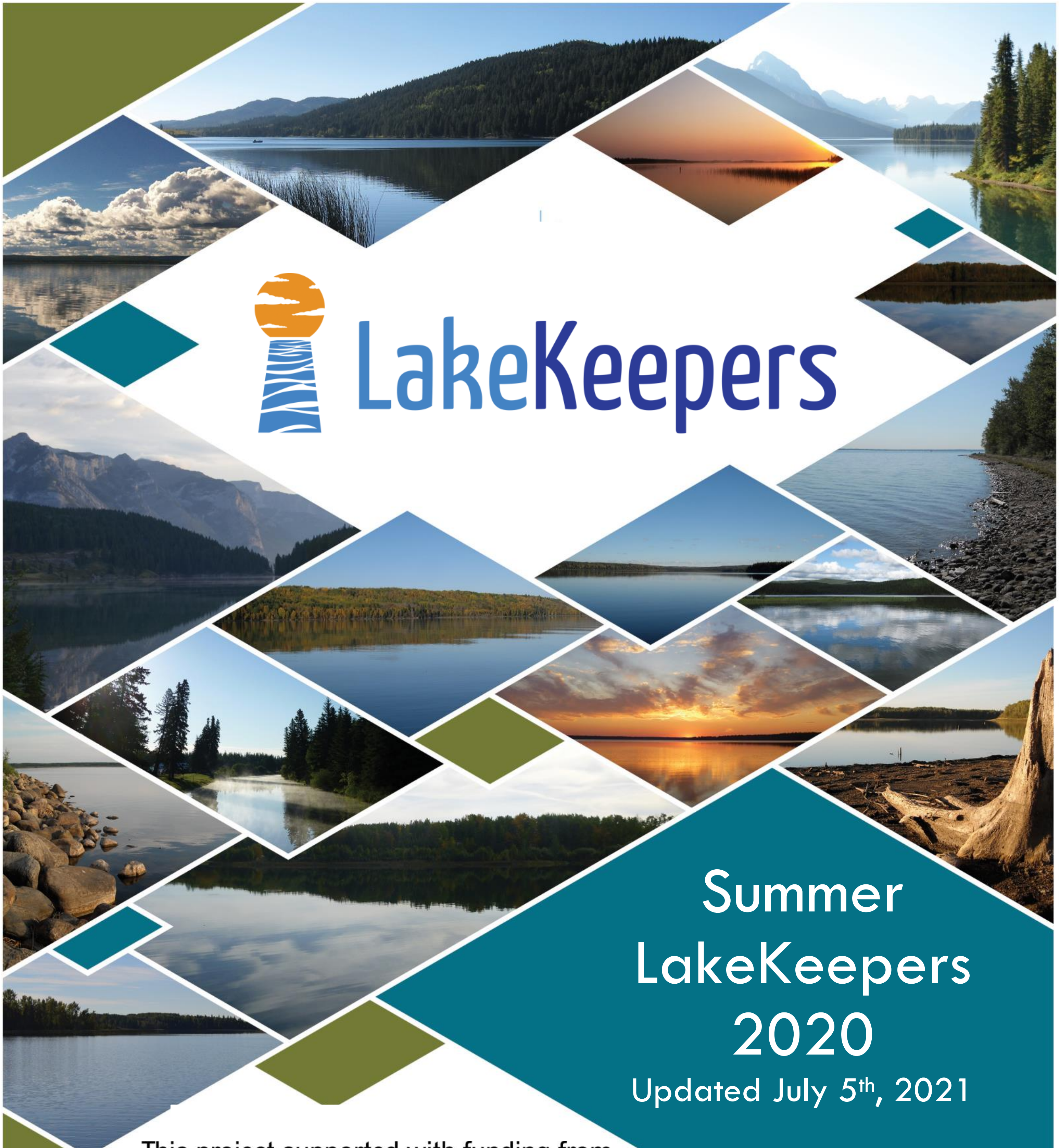


LakeKeepers

Summer LakeKeepers 2020

Updated July 5th, 2021

This project supported with funding from

alberta ecotrust

ALBERTA LAKE MANAGEMENT SOCIETY'S OBJECTIVES

The Alberta Lake Management Society (ALMS) has several 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.

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

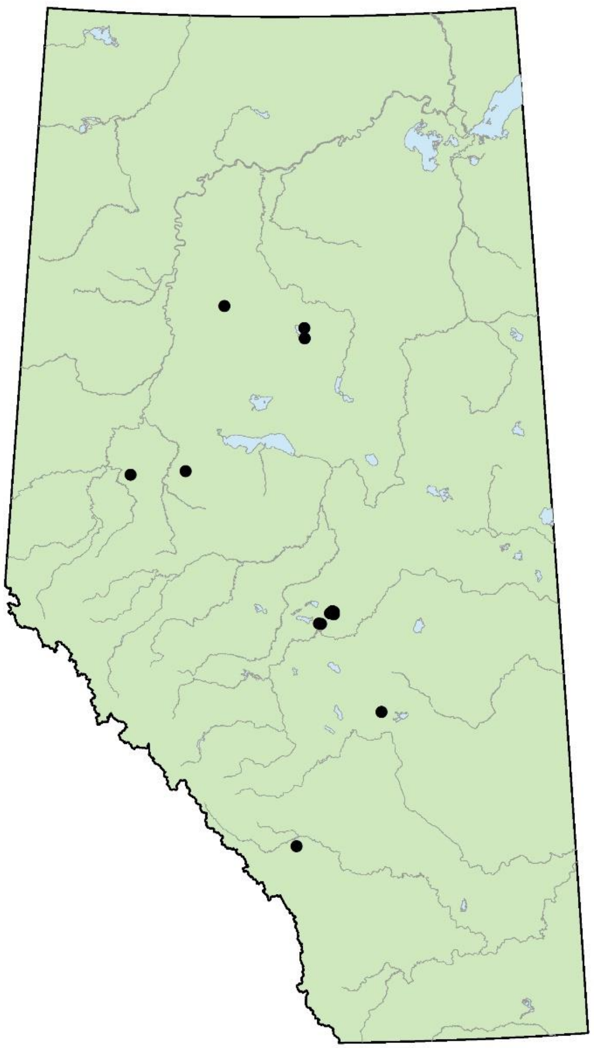
ACKNOWLEDGEMENTS

The LakeKeepers project was made possible with support from Alberta Ecotrust.

We would like to thank all of the volunteers who participated in sampling – without their commitment, this program would not exist. We would also like to thank the Mighty Peace Watershed Alliance for their assistance with coordinating volunteers and sample shipment. This report has been prepared by Bradley Peter and Caleb Sinn.

Report last updated: July 5th, 2021

Executive Summary



Map 1. Geographic spread of lakes sampled as part of the Summer LakeKeepers 2020 season.

In 2018, the Alberta Lake Management Society (ALMS), with financial support from Alberta Ecotrust, piloted the LakeKeepers program. This program was designed to enable volunteers to conduct lake monitoring by providing them with training and sampling equipment. Since the first Summer LakeKeepers season in 2018, 22 unique lakes have been sampled through the program including the summer of 2020, 5 of which have been sampled over multiple seasons since 2018. To see the results of past Summer LakeKeepers seasons, results and reports can be found on the ALMS website (https://alms.ca/summer-lakekeepers/).

The Summer LakeKeepers program in 2020 included seven lakes that followed the standard Summer LakeKeepers protocol: Graham Lake, Peerless Lake, Haig Lake, Snipe Lake, Swan Lake, Gadsby Lake, and Westover Lake. In total, 21 monitoring trips were completed by 10 volunteers across three different major watersheds – the Peace, Red Deer, and Bow River watersheds. Sampling began as early as June 3rd, and ended as late as October 10th.

The 2020 season also included nine lakes in the Carvel Pitted Delta, just west of Stony Plain in the North Saskatchewan River Watershed. These lakes are small, unnamed lakes surrounded by private property that were only sampled once each in mid-summer. These lakes are part of a greater research effort conducted by ALMS and the University of Alberta to understand the diversity of lakes in the Carvel Pitted Delta. Two volunteers, ALMS staff, and a post-doctoral student completed the sampling at these lakes, with the assistance of landowners who enabled access to these lakes.

In following with current LakeKeepers report format, lake data are compared through major watershed groupings, along with summary figures comparing average levels of key lake parameters.

A variety of summer lake conditions were captured throughout the province, enabling greater understanding of how these lakes functioned in the summer of 2020.

Methods

Volunteer from the Peace River watershed collecting data from Haig Lake, Summer 2020.

Volunteers were provided with a protocol manual (available at www.alms.ca/summer-lakekeepers). Lakes were sampled three times during the ice-off period, between June 1st – October 31st. However, lakes sampled in the Carvel Pitted Delta in the North Saskatchewan River watershed were sampled once each, in mid-summer. Volunteers were assigned a sampling location, which is either the deepest part of the lake, or the historical sampling location for that lake.

Volunteers were provided with field sheets, a Secchi disk, a YSI ProODO dissolved oxygen (DO) and temperature meter, a nutrient sample bottle with preservative, a chlorophyll-a (ChlA) sample bottle and filtration kit, and a microcystin bottle. The sampling kits also included gloves to protect volunteers from the sulfuric acid preservative, and to keep the sample clean while filtering for chlorophyll-a.

The Secchi disk was used to measure Secchi depth, used as a proxy for lake water clarity. Profile measurements for DO and temperature were taken every meter starting at 1m, until lake bottom. The nutrient and ChlA grab samples were taken near the surface, at 0.5m depth. The nutrient sample was then preserved with the 2mL vial of sulfuric acid, and was submitted for total phosphorus and total kjeldahl nitrogen analysis. The ChlA sample was filtered on shore, and three separate filters were submitted for ChlA analysis, indicating the levels of algae and cyanobacteria. A microcystin grab sample was collected if a bloom was observed while sampling. Microcystin is a toxin produced by some species of cyanobacteria, and levels indicate the toxicity potential of a lake bloom. ALMS coordinated delivery of all samples to their respective analytical laboratories, and then also coordinated shipment of the sampling kits.

Data collected from the sampling events was compiled, then formatted for upload to the Gordon Foundation's DataStream (https://gordonfoundation.ca/initiatives/datastream), and for ALMS data visualization and reporting. Data analysis is done using the program R.[1] Data was reconfigured using packages tidyr [2] and dplyr [3], figures were produced using the package ggplot2 [4], and tables were produced using the package formattable [5]. Trophic status for each lake is classified based on lake water characteristics using values from Nurnberg (1996)[6].

[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] Ren, K. and Russell, K. (2016). formattable: Create 'Formattable' Data Structures. R package version 0.2.0.1. https://CRAN.R-project.org/package=formattable.
[6] 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.

Results

Volunteer Dave Trew collecting lake samples at PL6 Lake

Water column temperatures varied depending on the lake and sampling date. Generally, water temperatures were the greatest during the first sampling event, and lowest during the last sampling event. Whether lakes displayed temperature stratification, or distinct regions in the water column with different water temperatures, was most dependant on lake depth. Lake size, while not represented in this report, is also an important factor in water column temperature levels, as larger lakes compared to smaller lakes with similar depths will mix to a greater depth, as they are prone to greater wind-driven mixing. This is evident when comparing the temperature profiles of the large Graham Lake (Figure 6), to that of small lakes of similar depth within the Carvel Pitted Delta within the North Saskatchewan watershed (Figures 8, 9).

As expected, the dissolved oxygen levels in all lakes sampled were higher at the surface, and decreased towards the bottom. For lakes with multiple sampling events (Peace, Red Deer, Bow River watersheds), seasonal oxygen levels varied, but most often oxygen levels were highest during the first sampling event. Some lakes displayed complete water column hypoxia, or dissolved oxygen of less than 6.5 mg/L. This level of hypoxia is based on Alberta's chronic dissolved oxygen guideline for aquatic life[7], and The Canadian Council for Ministers of the Environment (CCME) guidelines for the protection of aquatic life in cold water for life stages other than early life stages[8]. Lakes that displayed complete water column hypoxia were Little Mere Lake, PL8 Lake, and PL6 Lake (Figures 7, 9) – all small lakes in the Carvel Pitted Delta.

Nutrient levels displayed high variation between lakes. Trophic classifications, or classes representing lake productivity based on total phosphorus (TP), varied between the oligotrophic (low), up to hypereutrophic (very high; Figure 1). Trophic classes for total Kjeldahl nitrogen (TKN) varied only between the mesotrophic (moderate) and hypereutrophic (very high; Figure 2). Chlorophyll-*a* levels varied between the four classes (Figure 3), while Secchi depth, or water clarity varied only between oligotrophic to eutrophic classes (Figure 4).

Microcystin values (collected only when there was visual confirmation of cyanobacteria) were always below 20 ug/L, or Alberta's recreational guideline. At Swan Lake and Gadsby Lake, values were about 6 ug/L at the sampling location, which may indicate that levels of microcystin, or other cyanobacteria toxins, could be in higher values in other locations where the bloom is more intense. For this reason, caution should be observed when recreating in visible cyanobacteria blooms.

[7] Shaw, J. (1997). Alberta water quality guideline for the protection of freshwater aquatic life: Dissolved oxygen. Standards and Guidelines Branch, Alberta Environmental Protection, Edmonton, Alberta.
[8] Canadian Council of Ministers of the Environment (1999). Canadian water quality guidelines for the protection of aquatic life: Dissolved oxygen (freshwater). Canadian environmental quality guidelines, Canadian Council of Ministers of the Environment, Winnipeg, Manitoba.

Results

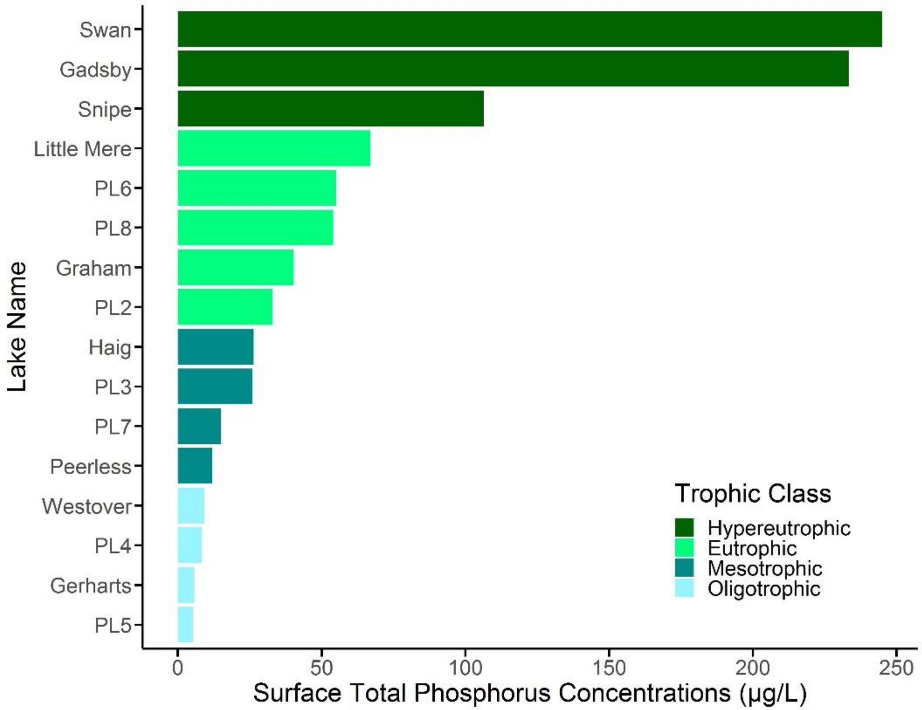


Figure 1. Average total phosphorus (ug/L) from lakes sampled in Summer LakeKeepers 2020. Average total phosphorus represents the average from across sample dates. Trophic class, or lake productivity level based on total phosphorus levels, is indicated by color. Samples were taken at 0.5m at the sampling location, between June and October 2020.

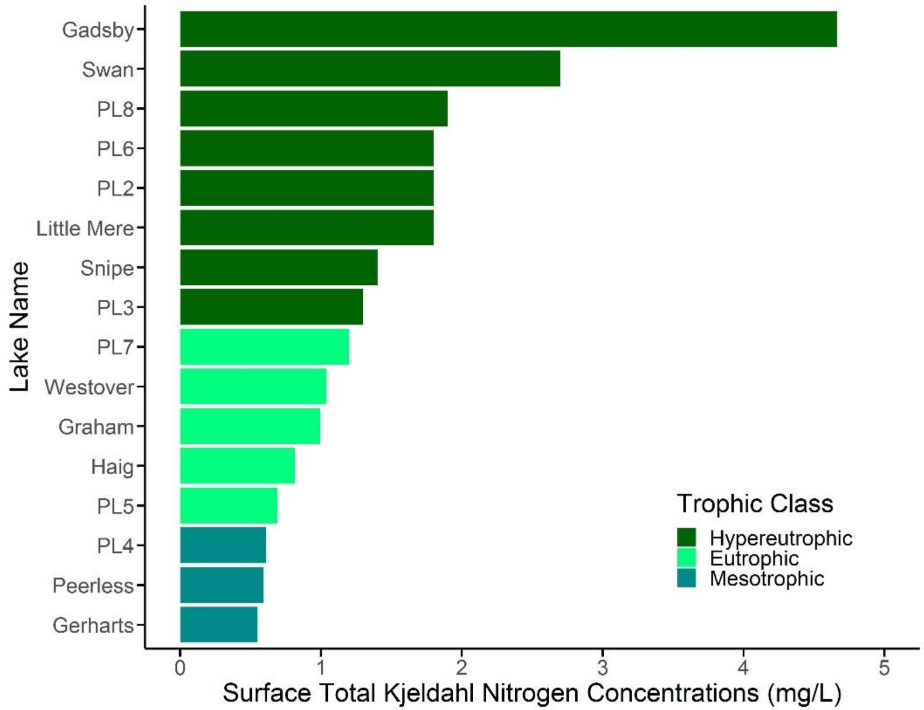


Figure 2. Average total Kjeldahl nitrogen (mg/L) from lakes sampled in Summer LakeKeepers 2020. Average total Kjeldahl nitrogen represents the average from across sample dates. Trophic class, or lake productivity level based on total Kjeldahl nitrogen levels, is indicated by color. Samples were taken at 0.5m at the sampling location, between June and October 2020.

Results

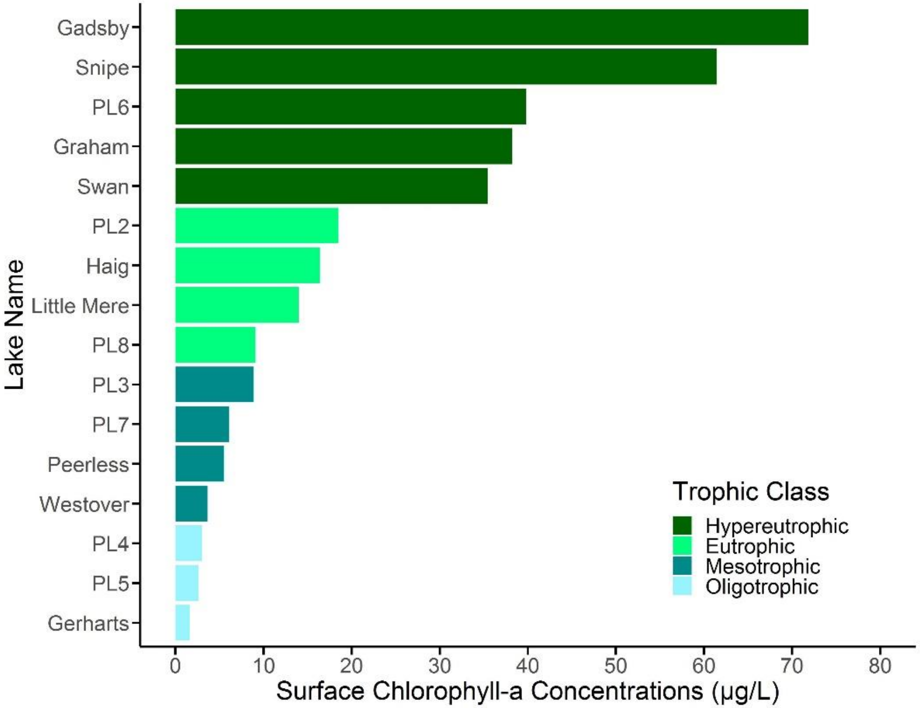


Figure 3. Average chlorophyll-*a*(ug/L) from lakes sampled in Summer LakeKeepers 2020. Average chlorophyll-*a* represents the average from across sample dates. Trophic class, or lake productivity level based on chlorophyll-*a* levels, is indicated by color. Samples were taken at 0.5m at the sampling location, between June and October 2020.

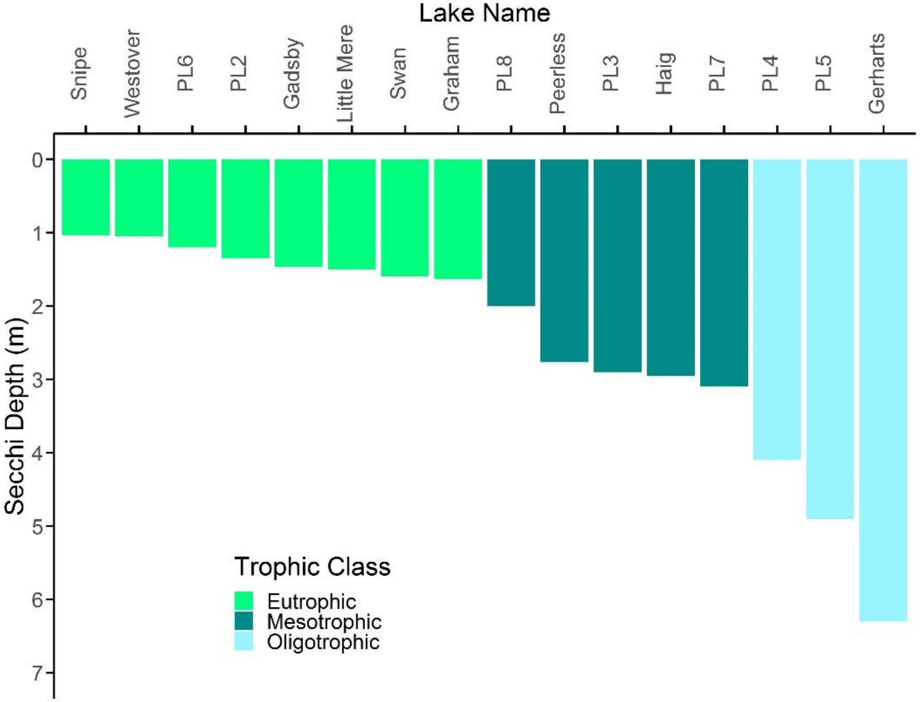
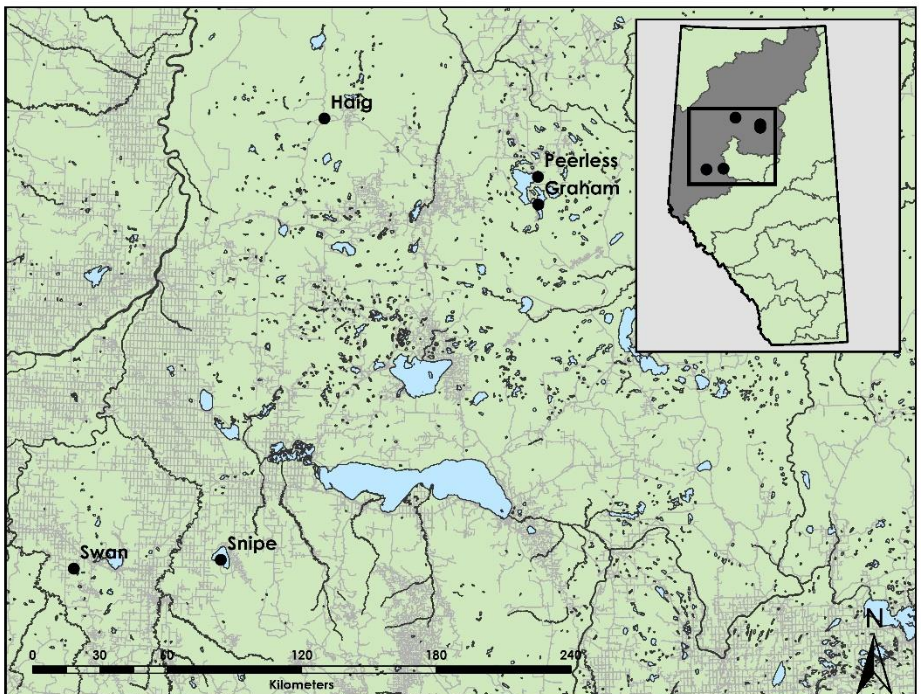


Figure 4. Average Secchi depth (m) from lakes sampled in Summer LakeKeepers 2020. Average Secchi depth represents the average from across sample dates. Trophic class, or lake productivity level based on Secchi depth, is indicated by color. Secchi depth measurements were taken at the sampling location, between June and October 2020.

Peace River Watershed

Five lakes were sampled within the Peace River watershed in Summer LakeKeepers 2020 (Map 2). All lakes appeared to be the coldest during the June sampling events. Swan, Snipe and Peerless Lakes were fairly well oxygenated and uniform in temperature throughout the water column, with the exception of Peerless Lake displaying weak temperature stratification during the early and mid-season sampling events (Figure 2, Figure 5). Graham and Haig Lakes had consistent temperatures during the mid and late-season sampling events, but displayed slight stratification during the early-season sampling event (Figure 6). Oxygen depletion was detected at Graham and Haig Lakes near the bottom of the lakes during the early and mid-season sampling events, but otherwise displayed high oxygen levels in the top half of the lakes in early and mid-season, and throughout the water column during the late sampling events.



Map 2. Lakes sampled in the Peace River watershed during Summer LakeKeepers 2020. Peace River watershed highlighted in Alberta inset map.

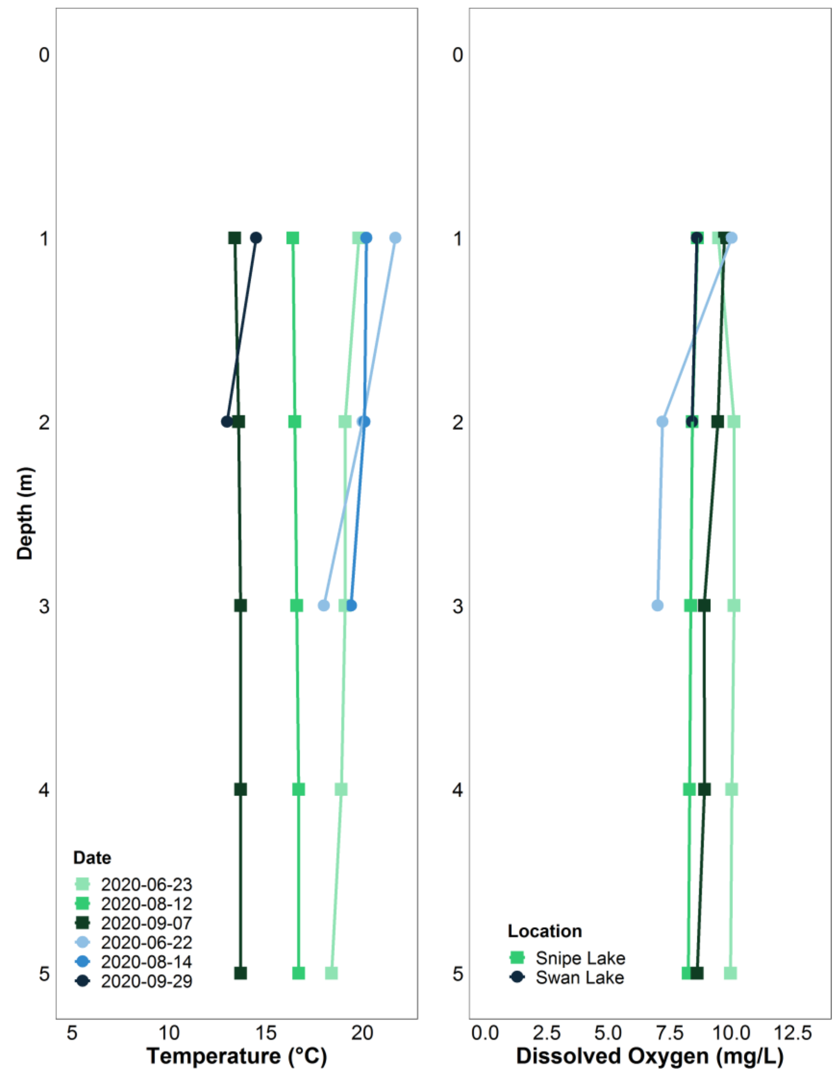


Figure 5. Temperature (°C) and dissolved oxygen (mg/L) measurements recorded at Snipe Lake and Swan Lake in Summer 2020. Measurements were taken every meter starting at 1 meter from water surface, until lake bottom. Note that dissolved oxygen data from the August 14th sampling event at Swan Lake is unavailable.

Peace River Watershed

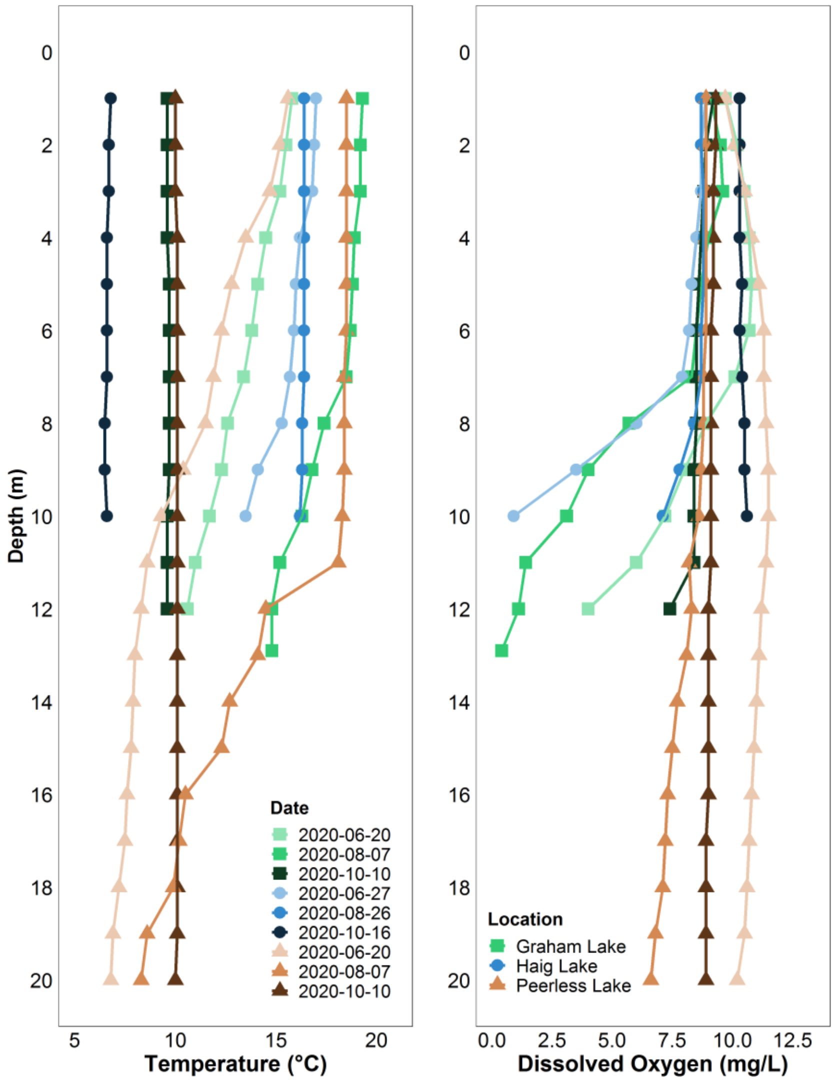


Figure 6. Temperature (°C) and dissolved oxygen (mg/L) measurements recorded at Graham Lake, Peerless Lake, and Haig Lake in Summer 2020. Measurements were taken every meter starting at 1 meter from water surface, until lake bottom. Note that Peerless Lake is ~30m deep; measurements are restricted to 20m due to the length of the YSI probe.

Nutrient levels in three of the lakes were either eutrophic or hypereutrophic, or having total phosphorus (TP) levels of greater than 30 ug/L or 100 ug/L, respectively (Figure 3). Swan and Snipe Lakes had the highest seasonal average levels, both being hypereutrophic (very high TP levels), followed by Graham being eutrophic (high TP levels), and Haig and Peerless Lakes being mesotrophic (moderate TP levels). For all lakes, the highest TP levels were measured in either the mid or late-season sampling events (Table 1). Total Kjeldahl nitrogen (TKN) followed this same season trends, along with trophic categories for average seasonal TKN levels (Figure 2).

Chlorophyll-*a* (ChlA) levels tracked similarly to nutrient levels, with a few exceptions. Average levels of ChlA were the highest in Snipe, Swan and Graham Lakes – all three lakes had hypereutrophic ChlA levels (Figure 3). This indicates that for Graham Lake, considering the nutrient levels, the ChlA levels are proportionally high. Haig Lake also had proportionally high ChlA levels compared to nutrient levels, having eutrophic ChlA levels. The highest levels of ChlA were usually measured during the mid-season or late season sampling events, with the exception of Swan Lake, having the highest ChlA levels during the early season sampling event (Table 1). Notably, Snipe Lake also had very high variation in ChlA levels, ranging from 0.7 ug/L on the early season sampling event to 131.0 ug/L on the late season sampling event.

Secchi depth, or water clarity, followed similar trends as the ChlA levels, with the lowest levels being present when ChlA levels are high (Table 3). Snipe displayed the lowest average Secchi depth values, where Haig and Peerless displayed the highest Secchi depths, or highest water clarity (Figure 4).

A microcystin level of 6.09 ug/L from Swan Lake during the mid-season sample indicates levels at other locations on the lake may be above 20 ug/L, or above Alberta's recreational guideline for microcystin, a toxin produced by some species of cyanobacteria.

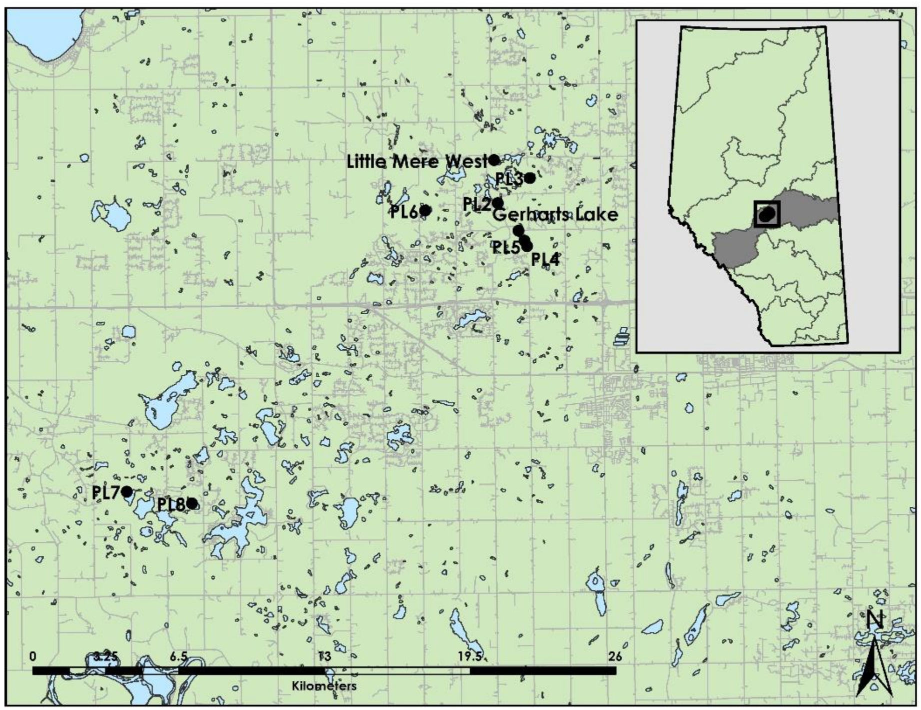
Peace River Watershed

Table 1. Surface water chemistry (TP = total phosphorus in ug/L, TKN = total Kjeldahl nitrogen, ChlA = chlorophyll-a), environmental measurements (Air Temp. = air temperature in °C), and observations recorded at lakes in the Peace River watershed in Summer LakeKeepers 2020. Note that TP and TKN data is not available at Swan Lake on September 29th, 2020.

Lake	Date	Surface TP (µg/L)	Surface TKN (mg/L)	Surface ChlA (µg/L)	Surface Microcystin (µg/L)	Secchi Depth (m)	Air Temp. (°C)	Wind (km/h)
Graham Lake	2020-06-20	16.0	0.77	3.9	-	1.8	17	9
Graham Lake	2020-08-07	70.0	1.30	80.1	0.57	1.0	14	17
Graham Lake	2020-10-10	35.0	0.91	30.7	0.14	2.0	3	0
Haig Lake	2020-06-03	19.0	0.77	1.3	-	3.5	11	18
Haig Lake	2020-08-26	35.0	0.96	37.7	1.54	1.4	8	10
Haig Lake	2020-10-16	25.0	0.71	10.2	-	3.9	-3	15
Peerless Lake	2020-06-20	7.1	0.56	2.0	-	3.0	24	8
Peerless Lake	2020-08-08	14.0	0.59	5.7	-	2.2	14	37
Peerless Lake	2020-10-10	15.0	0.62	8.9	-	3.1	5	15
Snipe Lake	2020-06-23	29.0	1.10	0.7	-	1.8	18	5
Snipe Lake	2020-08-12	120.0	1.40	52.7	-	0.7	7	8
Snipe Lake	2020-09-07	170.0	1.70	131.0	-	0.7	5	5
Swan Lake	2020-06-22	170.0	1.90	53.5	0.54	1.5	12	8
Swan Lake	2020-08-14	320.0	3.50	49.1	6.09	1.9	14	20
Swan Lake	2020-09-29	-	-	3.8	-	1.4	16	30

North Saskatchewan River Watershed

Nine lakes were sampled within the North Saskatchewan River watershed in Summer LakeKeepers 2020 (Map 3). All of the lakes displayed temperature stratification, regardless of depth (Figures 7, 8, 9). The thermoclines, or regions of the water column with the greatest change in temperature, ranged as low as 7m, to as shallow as near the surface. In general, the deeper the lake, the deeper the thermocline. Oxygen levels varied between the nine lakes, but all lakes displayed anoxia, or oxygen levels at 0 mg/L in some proportion in the water column. In some cases, rapid oxygen depletion occurred above the temperature thermocline (PL8 Lake, PL6 Lake Little Mere Lake), but more often observed was oxygen depletion at about the same depth as the thermocline. A slight increase in oxygen was observed at 6m in PL7 Lake, the approximate depth of the thermocline.



Map 3. Lakes sampled in the North Saskatchewan River watershed during Summer LakeKeepers 2020. North Saskatchewan River watershed highlighted in Alberta inset map.

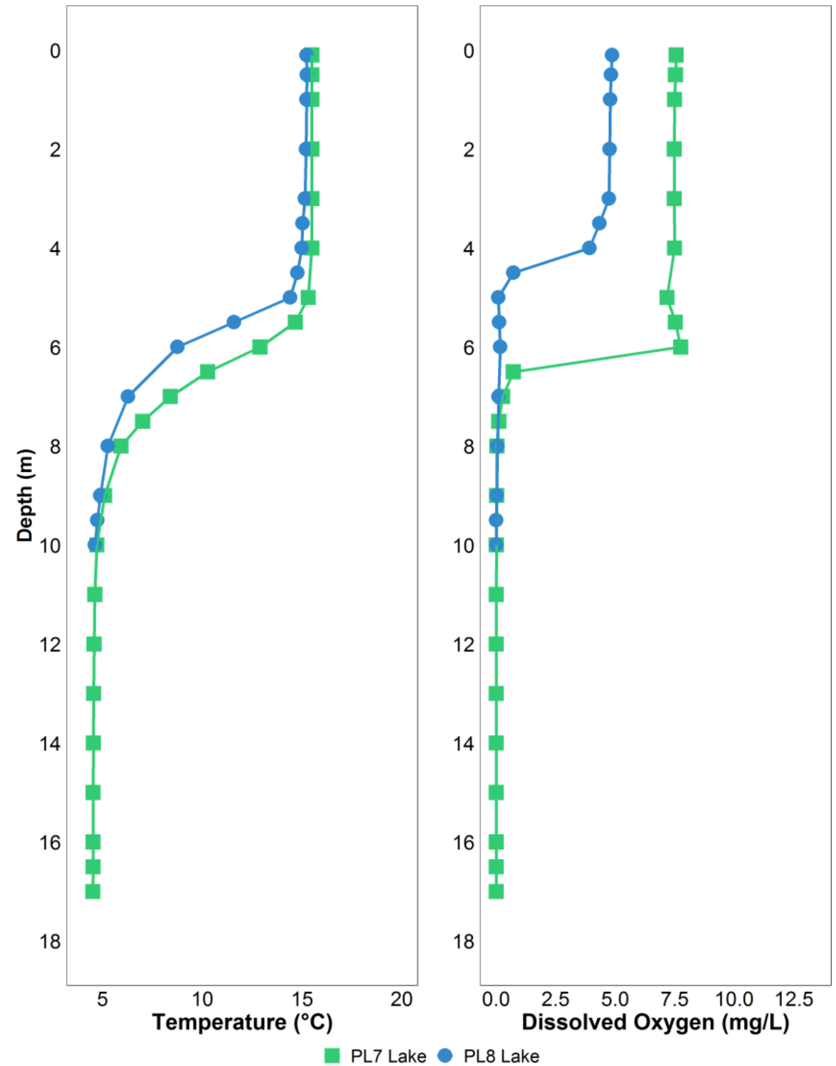


Figure 7. Temperature (°C) and dissolved oxygen (mg/L) measurements recorded at PL7 Lake and PL8 Lake, in Summer 2020. Measurements were taken every meter starting at 1 meter from water surface, until lake bottom.

North Saskatchewan River Watershed

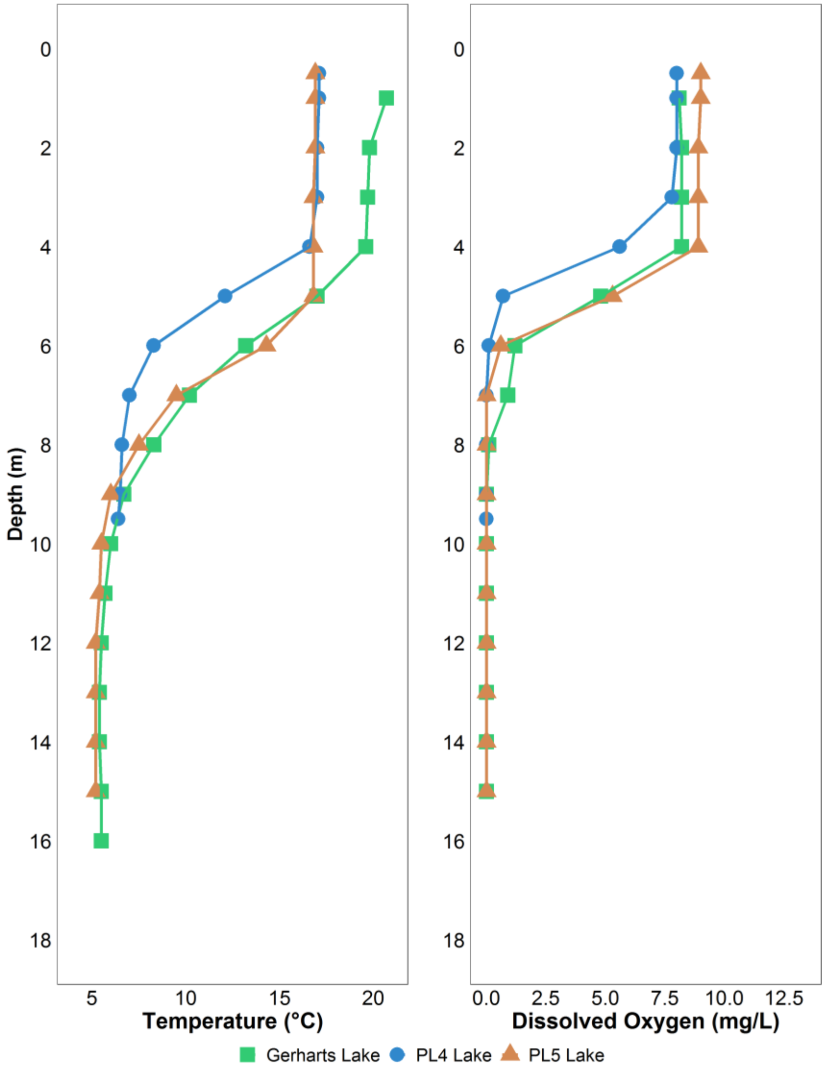


Figure 8. Temperature (°C) and dissolved oxygen (mg/L) measurements recorded at Gerharts Lake, PL4 Lake, and PL5 Lake in Summer 2020. Measurements were taken every meter starting at 1 meter from water surface, until lake bottom.

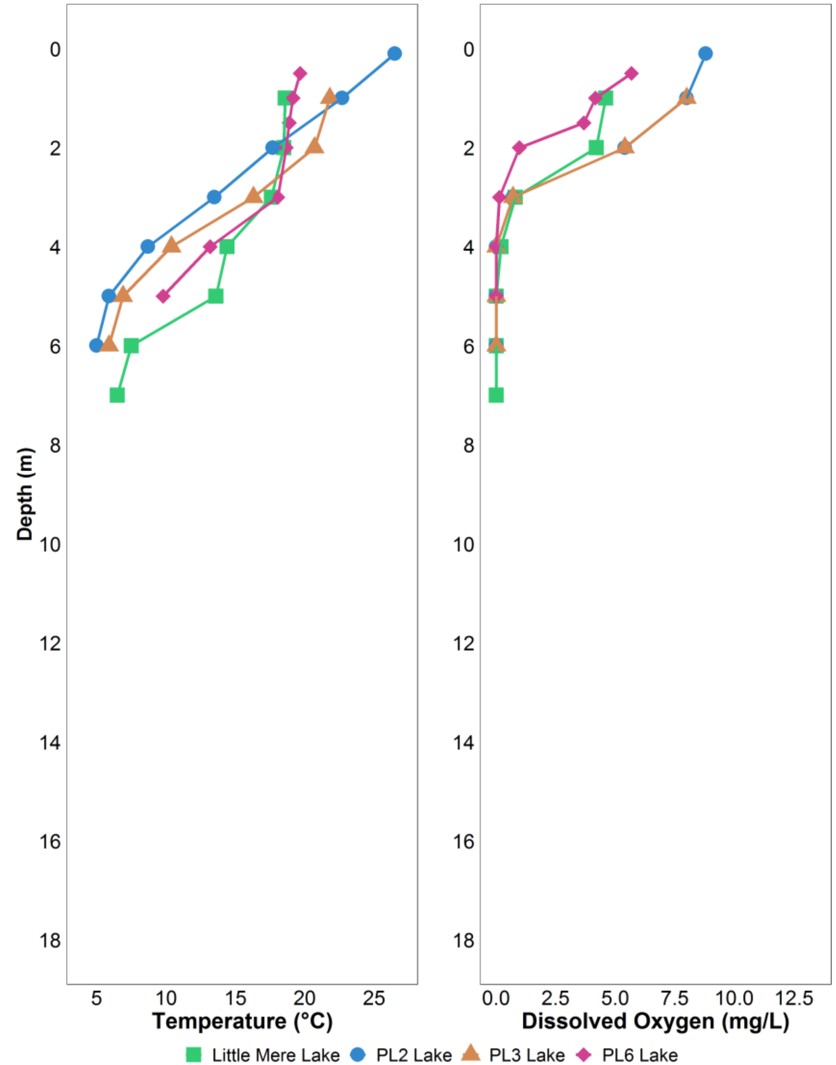


Figure 9. Temperature (°C) and dissolved oxygen (mg/L) measurements recorded at Little Mere Lake, PL2 Lake, PL3 Lake, and PL6 Lake in Summer 2020. Measurements were taken every meter starting at 1 meter from water surface, until lake bottom.

North Saskatchewan River Watershed

Table 2. Surface water chemistry (TP = total phosphorus in ug/L, TKN = total Kjeldahl nitrogen, ChlA = chlorophyll-a), environmental measurements (Air Temp. = air temperature in °C), and observations recorded at lakes in the North Saskatchewan River watershed in Summer LakeKeepers 2020. Note that TKN data is not available for PL2 Lake and PL3 Lake at the sampling location – view Appendix Table 1 for shore TKN values for PL2 Lake and PL3 Lake.

Lake	Date	Surface TP (µg/L)	Surface TKN (mg/L)	Surface ChlA (µg/L)	Surface Microcystin (µg/L)	Secchi Depth (m)	Air Temp. (°C)	Wind (km/h)
Gerharts Lake	2020-08-25	5.7	0.55	1.6	-	6.3	20	0.0
Little Mere Lake	2020-08-25	67.0	1.80	14.0	0.05	1.5	18	7.5
PL2 Lake	2020-07-29	33.0	-	18.5	-	1.4	26	0.0
PL3 Lake	2020-07-27	26.0	-	8.9	0.05	2.9	20	0.0
PL4 Lake	2020-09-06	8.4	0.61	3.0	-	4.1	13	10.0
PL5 Lake	2020-09-06	5.2	0.69	2.6	-	4.9	13	10.0
PL6 Lake	2020-08-27	55.0	1.80	39.8	0.05	1.2	19	23.0
PL7 Lake	2020-09-15	15.0	1.20	6.1	-	3.1	8	13.0
PL8 Lake	2020-09-15	54.0	1.90	9.1	0.49	2.0	11	16.0

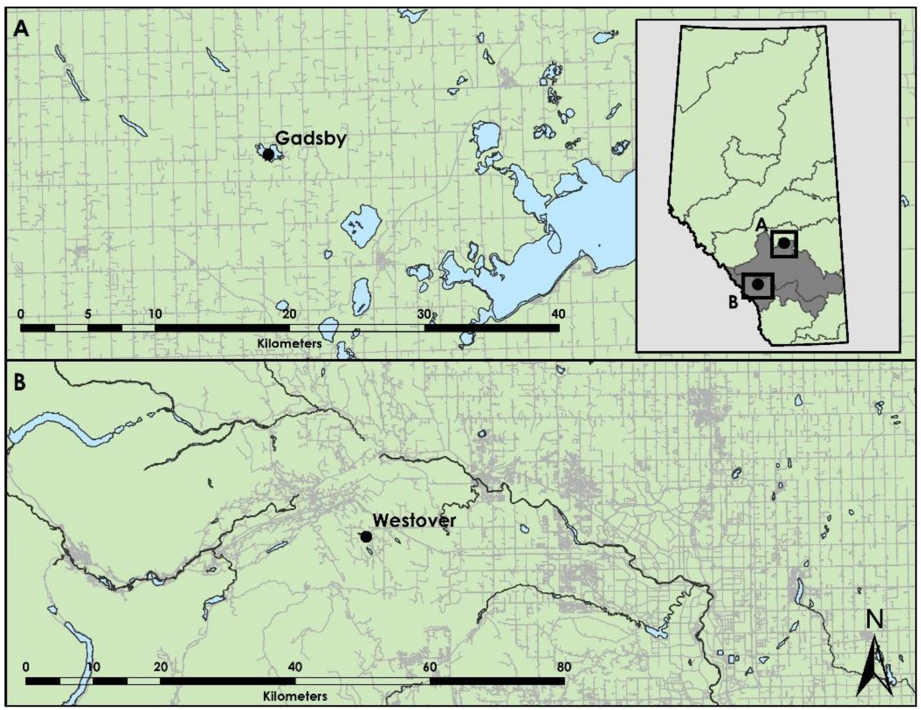
Nutrient levels of the nine lakes sampled in the Carvel Pitted Delta varied significantly. When considering total phosphorus (TP) levels, none of the lakes were hypereutrophic (very high TP), but ranged from oligotrophic (low TP) to eutrophic (high TP; Figure 1, Table 2). It is unique to see oligotrophic levels of TP in lakes within central Alberta – oligotrophic lakes are most often present in alpine, montane, and some foothills lakes. Also of note is that the three oligotrophic lakes (Gerharts, PL4, and PL5 Lakes) are part of the same watershed. Generally, total Kjeldahl nitrogen (TKN) levels in the lakes followed the same distribution as TP levels – TKN was proportionally lower in lakes also with low TP levels (Figure 2, Table 2). However, considering the trophic classes based on TKN, the range was between hypereutrophic and mesotrophic (moderate TKN levels).

Chlorophyll-*a* (ChlA) levels in terms of trophic classes ranged from hypereutrophic to oligotrophic (Figure 3, Table 2). Surprisingly, nutrient levels did not track closely to the ChlA levels present. For instance, the lake with the highest ChlA (PL6 Lake) had ChlA levels nearly double the next highest lake (PL2 Lake), even though PL6 Lake did not have the highest TP levels present. In addition, lakes with proportionally higher TP levels displayed ChlA levels lower than would otherwise be anticipated (Little Mere Lake, PL8 Lake). As expected, lakes with the lowest TP levels also had the lowest levels of ChlA (Gerharts Lake, PL4 Lake, PL5 Lake).

Secchi depth values, or water clarity, tracked very similarly to ChlA levels. The lakes with the lowest ChlA had the deepest Secchi depths, or greatest water clarity, and vice versa. Microcystin levels, a toxin produced by some species of cyanobacteria, were low in all lakes where bloom conditions were observed. Additional lake water chemistry information for the nine lakes sampled in the Carvel Pitted Delta is present in Appendix Tables 1 and 2.

Red Deer & Bow River Watersheds

One lake was sampled within each of the Red Deer and Bow River watersheds in Summer LakeKeepers 2020 (Map 4). Westover Lake, in the Bow River watershed, is very shallow, and thus only has one profile reading at 1m depth. For both lakes, lake water column temperature was coolest in the late sampling event, and warmest in the earlier or mid sampling events (Figure 10). Water column temperatures were consistent throughout Gadsby Lake across all three sampling events – no temperature stratification was observed. Oxygen levels were high during all sampling events at Westover Lake. Oxygen levels were high at the surface of Gadsby Lake, but approached anoxia (dissolved oxygen levels of 0 mg/L) towards the bottom of the lake. Dissolved oxygen levels for Gadsby Lake during the mid-season sampling event are not available.



Map 4. Lakes sampled in the Red Deer River and Bow River watersheds during Summer LakeKeepers 2020. Red Deer River and Bow River watersheds highlighted in Alberta inset map.

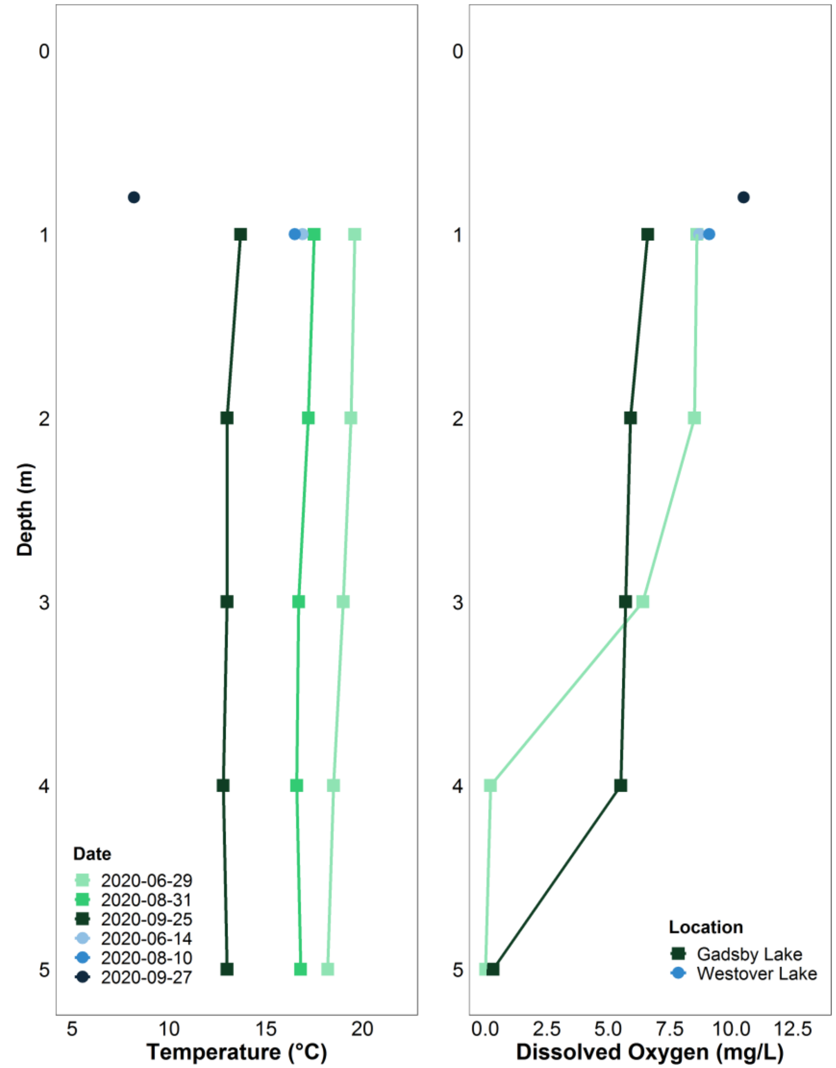


Figure 10. Temperature (°C) and dissolved oxygen (mg/L) measurements recorded at Gadsby Lake and Westover Lake in Summer 2020. Measurements were taken every meter starting at 1 meter from water surface, until lake bottom. Note that dissolved oxygen data from the August 31st sampling event at Gadsby Lake is unavailable.

Table 3. Surface water chemistry (TP = total phosphorus in ug/L, TKN = total Kjeldahl nitrogen, ChlA = chlorophyll-a), environmental measurements (Air Temp. = air temperature in °C), and observations recorded at lakes in the Red Deer River and Bow River watersheds in Summer LakeKeepers 2020.

Lake	Date	Surface TP (µg/L)	Surface TKN (mg/L)	Surface ChlA (µg/L)	Surface Microcystin (µg/L)	Secchi Depth (m)	Air Temp. (°C)	Wind (km/h)
Gadsby Lake	2020-06-29	150.0	3.50	22.2	0.87	3.2	14.0	0
Gadsby Lake	2020-08-31	150.0	5.50	122.0	6.47	0.4	13.0	15
Gadsby Lake	2020-09-25	400.0	5.00	71.3	3.77	0.8	24.7	10
Westover Lake	2020-06-14	11.0	0.82	2.5	-	1.3	19.5	19
Westover Lake	2020-08-10	6.7	0.99	3.3	-	0.8	18.0	15
Westover Lake	2020-09-27	10.0	1.30	5.2	-	1.0	13.6	9

Nutrient levels, or levels of total phosphorus (TP) and total kjeldahl nitrogen (TKN) were very high for Gadbsy Lake. The average levels of TP and TKN were among the highest of any lake sampled through Summer LakeKeepers 2020, both being in the hypereutrophic, or very high nutrient level classification (Figure 1, 2). Nutrient levels remained high throughout the season, but TP levels were especially high during the late-season sampling event (Table 3). Westover Lake had among the lowest nutrient levels, with oligotrophic (low) levels of TP, and eutrophic (high) levels of TKN. Nutrient levels remained quite consistent at Westover Lake through each sampling event.

Chlorophyll-*a* (ChlA) levels, an indicator of levels of algae and cyanobacteria, in Gadbsy Lake were higher than any other lake sampled through Summer LakeKeepers 2020 (Figure 3). The average level through the season indicates Gadsby as having hypereutrophic, or very high nutrient levels. Levels did fluctuate greatly through the season, with the highest level present during the mid-season sampling event, but being proportionally lower in the early-season sampling event (Table 3). Westover Lake also had among the lowest ChlA levels, having a mesotrophic (moderate) level of ChlA. Levels of ChlA remained very consistent throughout the three sampling events.

At Gadsby Lake, Secchi depth, or water clarity, was surprisingly high during the first sampling event, considering the level of ChlA (Table 3). However, Secchi depth decreased through the season, and was lowest when ChlA was highest during the mid-season sampling event. While the average Secchi depths of Westover appear low, and even indicate Westover as a eutrophic (high productivity) based on the average seasonal Secchi depth (Figure 4), the lake is so shallow that the Secchi depth hits the bottom of the lake before it disappears, or the depth to which the measurement is taken. This demonstrates the limitation of measuring water clarity in shallow and high water clarity lakes using a Secchi disk.

A microcystin level of 6.47 ug/L from Gadsby Lake during the mid-season sample indicates levels at other locations on the lake may be above 20 ug/L, or above Alberta's recreational guideline for microcystin, a toxin produced by some species of cyanobacteria.

Appendix

Appendix Table 1. Water chemistry (TP = total phosphorus in ug/L, TKN = total Kjeldahl nitrogen, ChlA = chlorophyll-a), and observations recorded at lakes in the North Saskatchewan River watershed in Summer LakeKeepers 2020. Sampling location also indicated.

Lake	Bottom Depth (m)	Sample Location	Sample Date	Top TP (ug/L)	Bottom Sample Depth (m)	Bottom TP (ug/L)	TKN (mg/L)	ChlA (ug/L)	Secchi Depth (m)
Gerharts Lake	16	Profile	2020-08-25	5.7	16	230	0.55	1.6	6.3
Little Mere Lake	7	Profile	2020-08-25	67	6	800	1.8	14	1.5
PL2 Lake	6	Profile	2020-07-29	33	6	840	1.8*	18.5	1.35
PL3 Lake	6	Profile	2020-07-27	26	6	1200	1.3*	8.9	2.9
PL4 Lake	9.5	Profile	2020-09-06	8.4	9	350	0.61	3	4.1
PL5 Lake	15	Profile	2020-09-06	5.2	14	700	0.69	2.6	4.9
PL6 Lake	5	Profile	2020-08-27	55	4	430	1.8	39.8	1.2
PL7 Lake	17	Profile	2020-09-15	15	16	280	1.2	6.1	3.1
PL8 Lake	10	Profile	2020-09-15	54	9	450	1.9	9.1	2

*TKN data for PL2 Lake and PL3 Lake is from a shore sampling on a different sampling data; 2020-09-07 for both lakes.

Appendix Table 2. Routine water chemistry (TDS = total dissolved solids, Cond. = Conductivity), from lakes sampled in the North Saskatchewan River watershed in Summer LakeKeepers 2020. Sampling location also indicated. If less than (<) present, value is below laboratory detection limit.

Lake	Sample Location	Sample Date	TDS (mg/L)	Hardness (mg/L)	Cond. (uS/cm)	pH	Alkalinity (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Calcium (mg/L)	Iron (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Potassium (mg/L)	Sodium (mg/L)
Gerharts Lake	Shore	2020-08-27	330	290	550	8.33	180	220	<1.0	5.8	98	66	<0.06	31	<0.004	4	18
Little Mere Lake	Shore	2020-09-07	250	200	440	7.96	150	180	<1.0	19	50	50	<0.06	18	<0.004	17	9.5
PL2 Lake	Shore	2020-09-07	99	55	200	7.16	44	54	<1.0	30	<1.0	14	<0.06	4.6	<0.004	11	12
PL3 Lake	Shore	2020-09-07	41	23	78	7.03	31	38	<1.0	1.8	<1.0	5.4	<0.06	2.3	<0.004	12	0.62
PL4 Lake	Profile	2020-09-06	420	350	670	8.05	210	260	<1.0	3.8	150	82	<0.06	35	<0.004	3.9	16
PL5 Lake	Profile	2020-09-06	410	330	640	8.21	190	230	<1.0	3.9	170	71	<0.06	37	<0.004	4.2	17
PL6 Lake	Profile	2020-08-27	260	220	430	8.05	110	140	<1.0	3.2	93	57	<0.06	18	<0.004	13	4.7
PL7 Lake	Profile	2020-09-15	300	250	510	8.48	220	260	5.5	1	56	31	<0.06	43	<0.004	19	14
PL8 Lake	Profile	2020-09-15	650	480	910	7.04	140	180	<1.0	1.8	360	98	<0.06	56	0.007	25	16