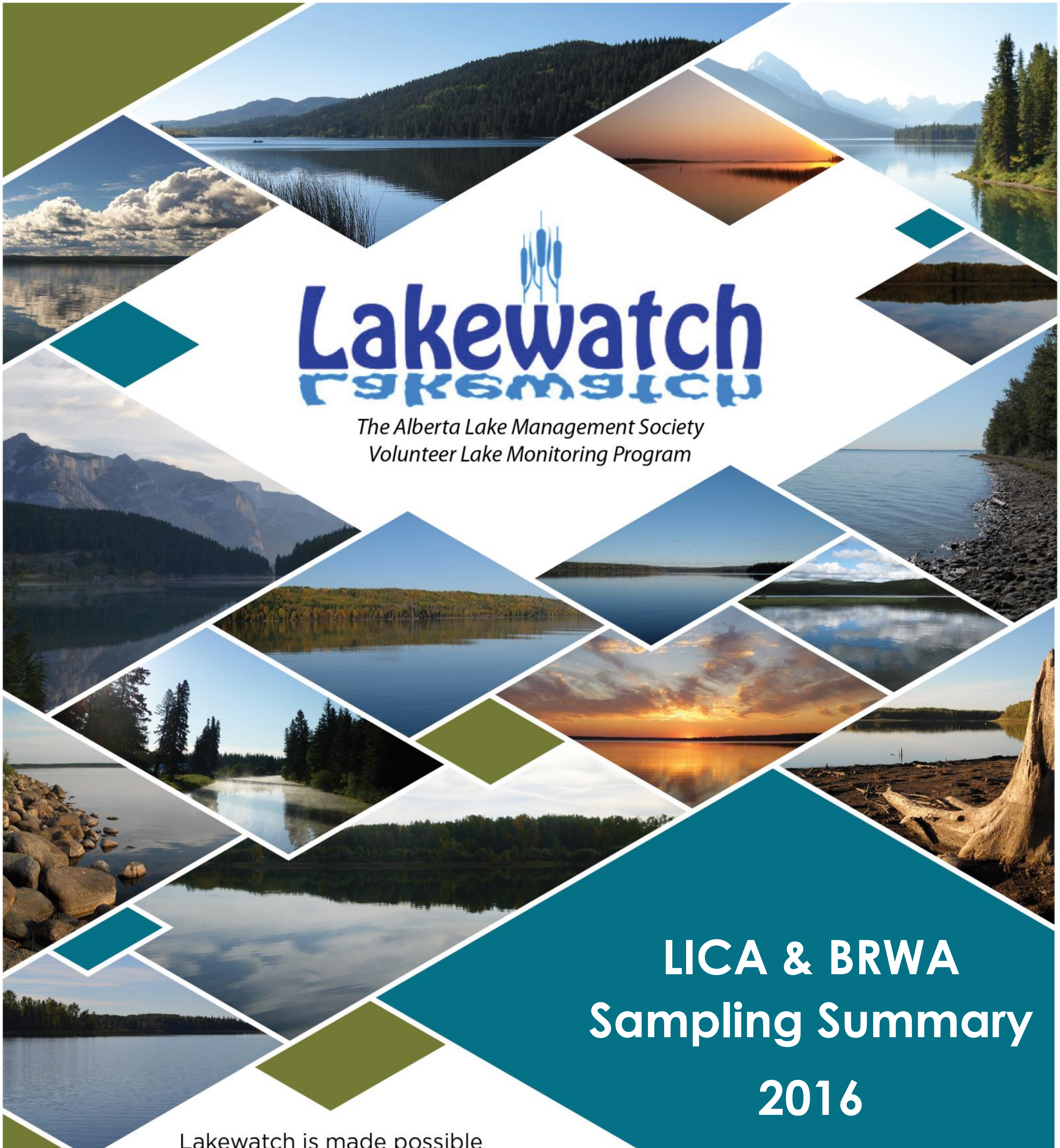

Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

LICA & BRWA Sampling Summary 2016

Lakewatch is made possible with support from:

Beaver River Watershed Alliance

Cargill

LICA Lakeland Industry & Community Association

Alberta

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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.

Each year, the Lakeland and Community Association (LICA) and the Beaver River Watershed Alliance (BRWA) contribute to have 10 lakes sampled by ALMS in the LICA region. The following report is a comparison of BRWA sponsored lakes sampled in 2016.

This report has been prepared with un-validated data.

ACKNOWLEDGEMENTS

The LakeWatch program is made possible through the dedication of its volunteers. We would like to extend a special thanks to:

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Marie Lake: Jim Ross, Marion & Lori Graca
Minnie Lake: Garry & Nadine Kissel
Pinehurst Lake: Megan Franchuk and Technicians Jordan and Brayden
Skeleton Lake: Orest Kitt
Touchwood Lake: Tom Hannan

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INTRODUCTION

This report highlights the variability that exists within select parameters among the 2016 lakes sponsored by LICA. The variation within these parameters does not necessarily reflect a degree of lake management, for many factors outside of human control also impact lake water quality. The depth of the lake, the size of the drainage basin (Table 1), lake order, and the composition of bedrock and sediment are just some of the factors which affect lake water quality and should be taken into consideration when reading this report.

Table 1– Drainage basin area (km^2), lake area (km^2), and the drainage basin to lake area ratio for the 2016 BRWA lakes.

Lake	Drainage Basin Area (km^2)	Lake Area (km^2)	Drainage Basin Area/Lake Area
Angling	217	5.89	37:1
Frog	553	58.36	9:1
Laurier	196	6.57	30:1
Marie	397	37.39	11:1
Minnie	4	0.67	7:1
Moore (Crane)	44	10.29	4:1
Moose	808	40.53	20:1
Pinehurst	299	39.56	8:1
Skeleton Lake	33	8.78	4:1
Touchwood	112	28.91	4:1

In 2016, 10 lakes were sampled. Sampling was attempted five times throughout the summer for each lake. 2016 was a successful sampling year, with 46 of 50 planned sampling trips completed (a 92% sample completion rate; Appendix Table 1). Key water quality parameters have been highlighted in this report (Appendix Table 2).

TOTAL PHOSPHORUS AND CHLOROPHYLL- A

ALMS measures a suite of water chemistry parameters. Phosphorus acts as one of the nutrients driving algae blooms in Alberta, while chlorophyll-a acts as an indicator of phytoplankton biomass, or how much algae is in the lake. These parameters together can help to identify the process of eutrophication, or excess nutrients, which can lead to harmful algae/cyanobacteria blooms. Taking these parameters together, lakes can be classified into oligotrophic (low nutrients), mesotrophic (moderately productive), eutrophic (productive) or hypereutrophic (highly productive).

In 2016, lakes fell into two categories based on TP concentration: mesotrophic (moderately productive) and eutrophic (productive; Figure 1). Laurier Lake had the highest TP average of 2016 (45 ug/L) - a TP concentration of 45 µg/L falls well within Laurier's historically measured values. In contrast, Touchwood and Crane Lakes showed the lowest levels of average TP, measuring 11 µg/L and 14 µg/L, respectively. As seen below, TP concentrations were closely associated with chlorophyll-*a* concentrations (cor= 0.95, df= 8, p-value= 2.07×10^{-5}). In some lakes, high conductivity can inhibit the relationship between TP and chlorophyll-*a*.

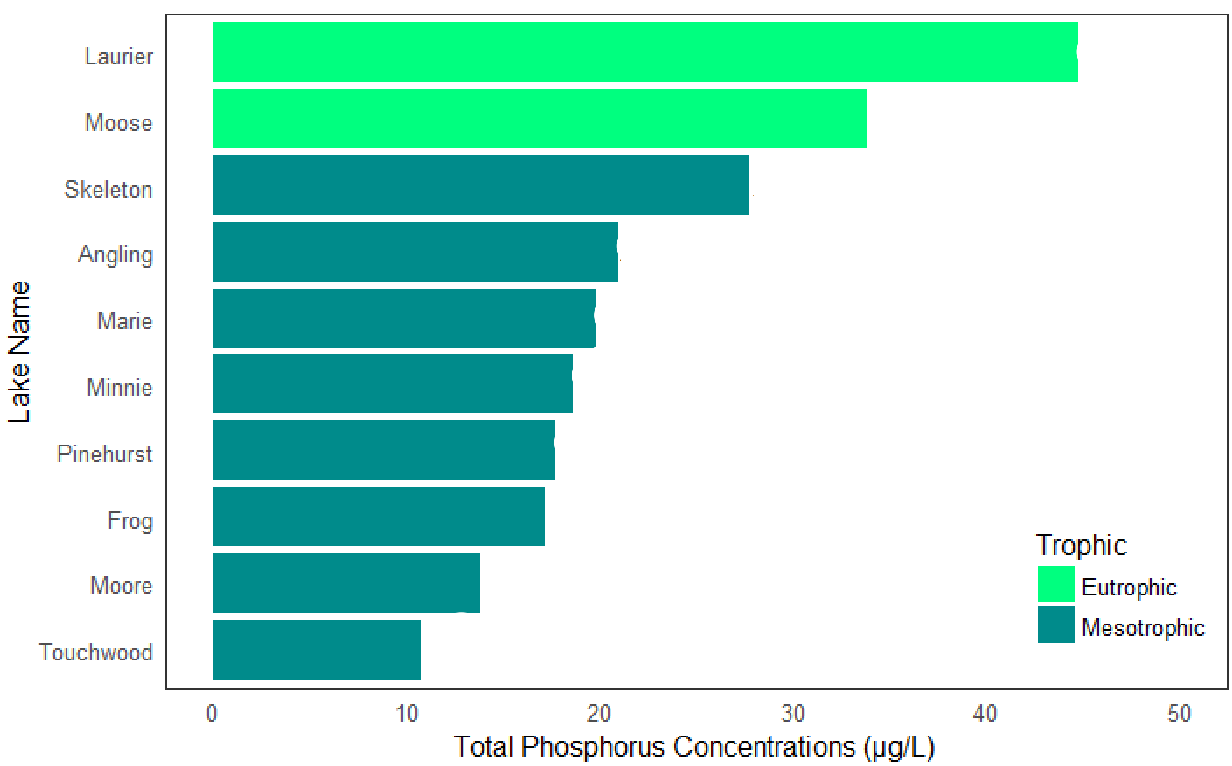

Figure 1 - Average total phosphorus (µg/L) concentrations measured at ten LICA lakes during the summer of 2016. Concentrations have been separated into trophic categories based on cut-offs identified in Table A of the appendix.

In 2016, lakes sampled in the LICA area represented all major trophic levels based on chlorophyll-*a* concentrations (Figure 2). Laurier and Moose Lakes were the only waterbodies to fall into the hypereutrophic classification, measuring 36.4 µg/L and 29.6 µg/L, respectively in 2016 – this concentration is high for Laurier Lake and above average for Moose Lake based on historically measured values. Touchwood Lake was the only lake to fall into the oligotrophic classification, measuring 3.42 µg/L. The rest of the lakes sampled fell into classifications of either eutrophic or mesotrophic.

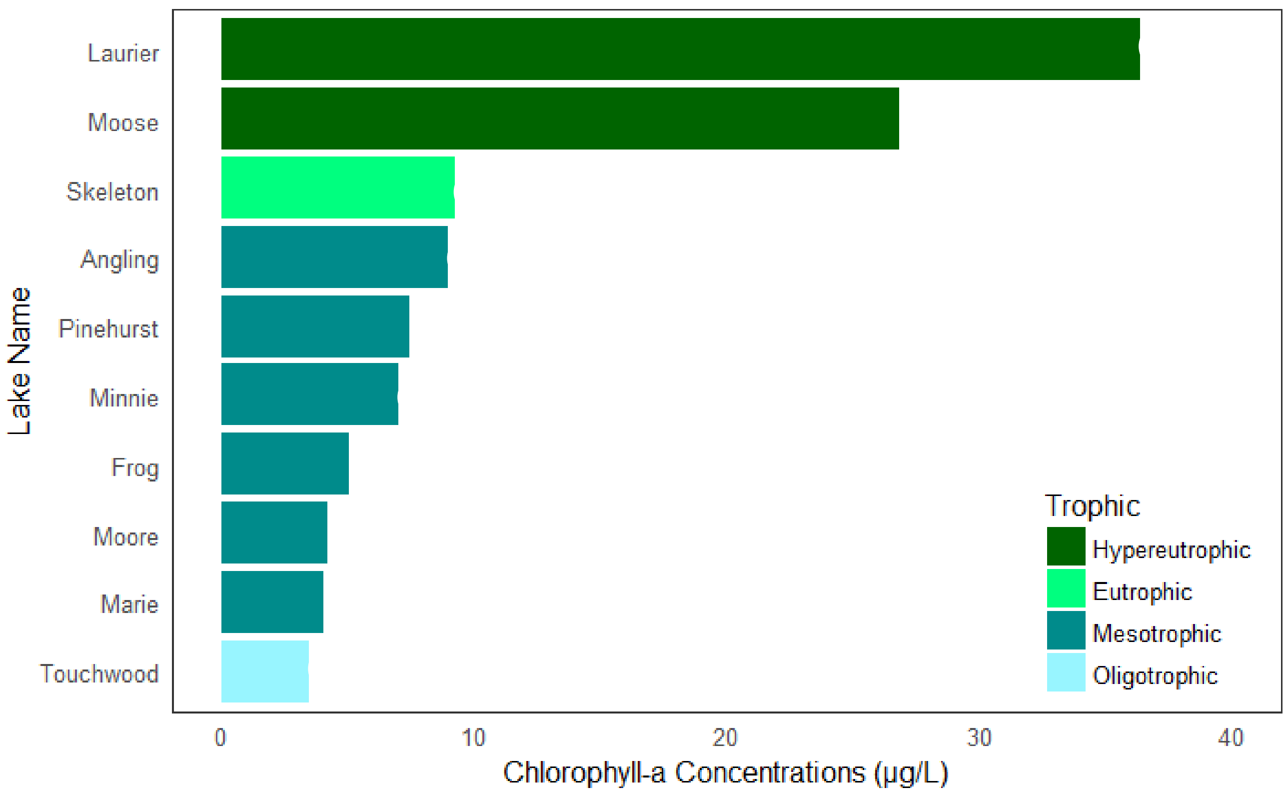

Figure 2 - Average chlorophyll-*a* (µg/L) concentrations measured at ten LICA lakes during the summer of 2016. Concentrations have been separated into trophic categories based on cut-offs identified in Table A of the appendix.

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 disk depth. Two times the Secchi disk depth equals the euphotic depth – the depth to which there is enough light for photosynthesis.

The greatest average water clarity in 2016 was measured at Touchwood, with an average Secchi disk depth of 4.25 m (Figure 3). Water clarity was generally good throughout the Beaver River Watershed, with no lakes falling into the hypereutrophic classification. Skeleton Lake, which had the third highest concentration of chlorophyll-*a* and total phosphorus also had the lowest water clarity (1.40 m). Secchi depth was positively correlated with chlorophyll-*a* (cor= 0.78, df=8, p-value= 0.007), so it is likely that algae/cyanobacteria is the primary factor affecting water clarity in the Beaver River Watershed, however, dissolved organic carbon (DOC) and suspended sediments may account for the discrepancies.

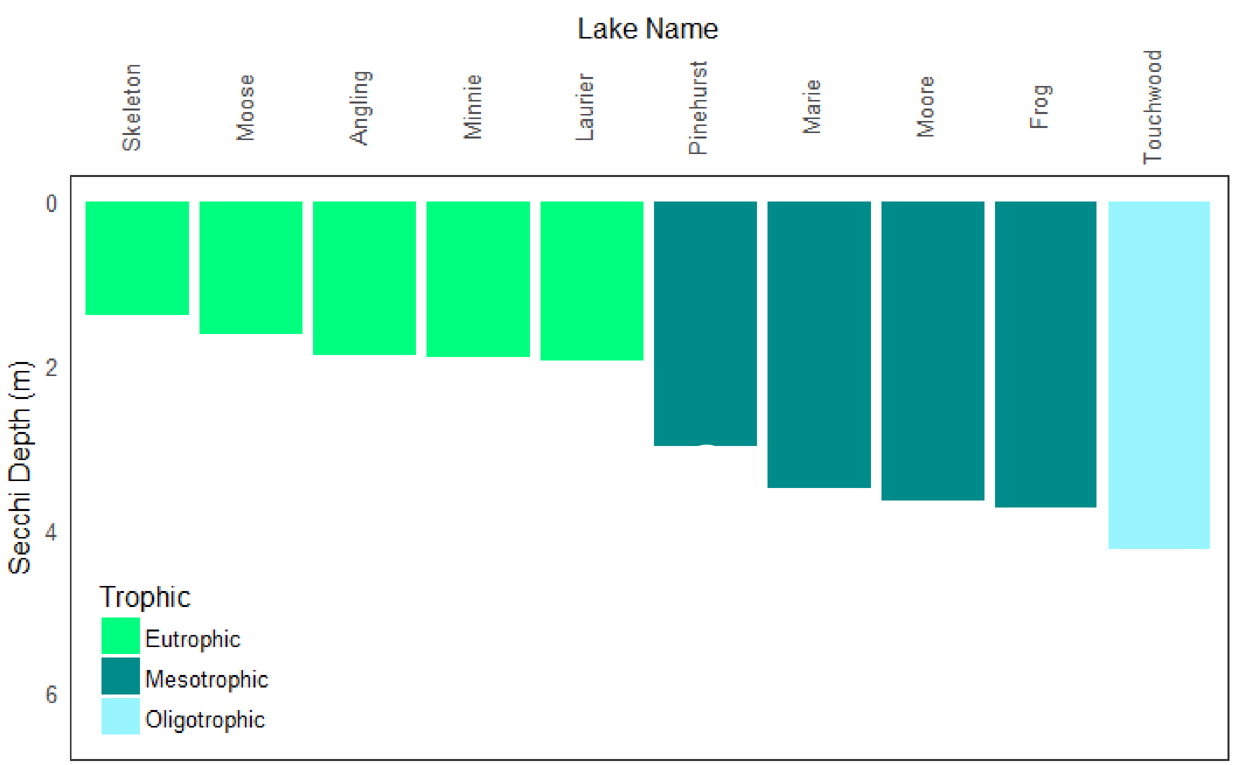

Figure 3 – Average Secchi disk depth (m) values measured at ten LICA sponsored lakes during the summer of 2016. Depths have been separated into trophic categories based on cut-offs identified in Table A of the appendix.

METALS

Samples were analyzed for metals twice throughout the summer (Table 4). In total, 29 metals were sampled for. In this report we will highlight the results of arsenic, cadmium, and lead as they are considered to be highly toxic. It should be noted that all are naturally present in aquatic environments due to the weathering of rocks and may only become toxic at higher levels.

Arsenic may be introduced to aquatic environments through industrial or municipal discharges or from the combustion of fossil fuels. Arsenic is known to be naturally elevated in the Beaver River Watershed, and in 2016, Minnie Lake (8.34 µg/L) exceeded the Canadian Council for Ministers of the Environment recommended guidelines for the Protection of Aquatic Life (5.0 µg/L) and nearly exceeded the Health Canada Drinking Water Quality Guidelines (10.0 µg/L; Table 4).

Cadmium may be introduced to aquatic environments through mining, agriculture, and the burning of fossil fuels. In 2016, all lakes sampled were below the CCME PAL guideline (0.085 µg/L).

Finally, lead may be introduced to lakes through urban runoff and industrial or municipal discharges. All lakes sampled were below the CCME PAL guidelines (7 µg/L). All other metals sampled for also fell below their respective CCME PAL guidelines

For the results of all metals analyzed, please view the individual LakeWatch reports.

Table 4 – Average concentrations of arsenic, cadmium, and lead measured in August and September of 2016. Concentrations have been compared to CCME Guidelines for the Protection of Aquatic Life. Values in red indicate measurements which have exceeded their guideline.

Lake	Arsenic[a]	Cadmium[b]	Lead[c]
Angling	4.77	0.001	0.02
Frog	0.59	0.001	0.03
Laurier	1.93	0.001	0.01
Marie	2.20	0.001	0.01
Minnie	8.34	0.001	0.03
Moore/ Crane	4.01	0.140	0.16
Moose	1.78	0.001	0.01
Pinehurst	0.75	0.005	0.20
Skeleton Lake	0.75	0.001	0.01
Touchwood	15.2	0.003	0.12

[a]Guideline: 5.0 µg/L
[b]Guideline: 0.085 µg/L. Based on water Hardness of 300 mg/L ($CaCO_3$)
[c]Guideline: 7.0 µg/L. Based on water Hardness of >180 mg/L ($CaCO_3$)

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. In 2016, no mussels were detected in the 10 BRWA lakes sampled.

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. It is advised that the public avoid recreating in cyanobacteria blooms.

Microcystin concentrations collected by ALMS are not suitable for advisory purposes: samples collected by ALMS are compiled from ten points around the lake and results may be diluted compared to a single grab sample collected at a recreational beach. Average microcystin concentrations fell below the minimum detection limit of 0.1 μg/L at Marie, Pinehurst, and Touchwood Lakes (Figure 4). Microcystin was detected at every other lake, with the highest average concentration observed at Moose Lake, measuring 1.9 μg /L. None of the 10-point composite samples measured higher than the recreational guideline of 20 μg /L at any time throughout the summer of 2016.

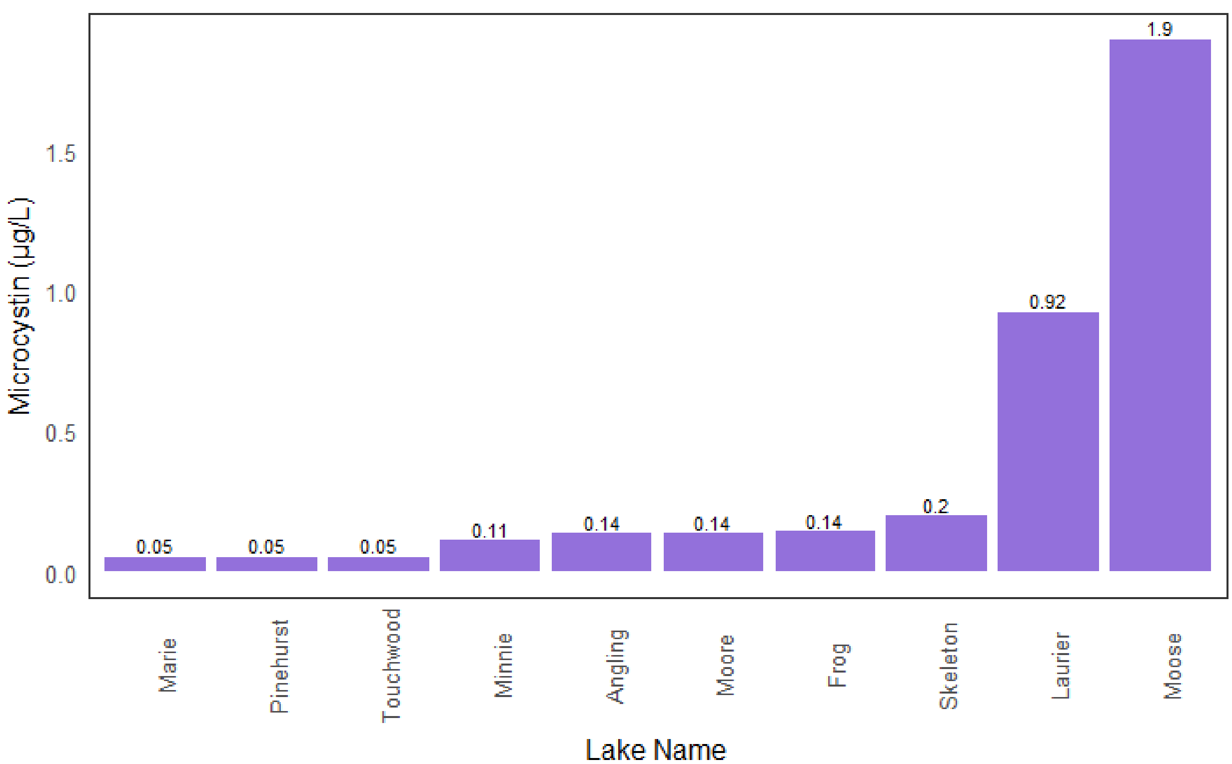

Figure 4 – Average microcystin concentrations observed for ten LICA lakes in 2016.

Appendix

Table 1 - Summary of the dates of five sampling trips in 2016 and the reasons for missed trips.

Lake	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5
Angling	Jun 27	Jul 20	Aug 8	Volunteer absence	Sep 16
Frog	Jun 30	Jul 19	Aug 16	Sep 7	Sep 28
Laurier	Jun 1	Jul 4	Aug 3	Aug 30	Volunteer absence
Marie	Jun 28	Jul 25	Aug 13	Sep 5	Sep 25
Minnie	Jun 27	Jul 18	Aug 8	Aug 24	Sep 26
Moore/Crane	Jun 16	Jul 7	Jul 28	Sep 1	Sep 20
Moose	Jun 16	Jul 6	Jul 27	Aug 24	Sep 21
Pinehurst	Jun 29	Jul 22	Aug 5	Unsafe Weather	Sep 29
Skeleton Lake	Jun 7	Jul 5	Jul 26	Aug 22	Sep 9
Touchwood	Jun 13	Jul 14	Aug 4	Volunteer absence	Sep 22

Table 2 - Average Secchi depth and water chemistry values for ten BRWA lakes sampled from June-September of 2016.

Lake	Total Phosphorus (µg/L)	Chlorophyll-*a* (µg/L)	Secchi Depth (m)	TKN (mg/L)	pH	Conductivity (µS/cm)	Alkalinity (mg/L $CaCO_3$)
Angling	20	9.0	1.88	0.92	8.79	570	315
Frog	20	5.0	3.75	1.10	8.95	950	400
Laurier	48	36.4	1.94	2.40	8.90	1100	505
Marie	20	4.0	3.50	0.73	8.26	266	142
Minnie	18	7.0	1.90	1.48	8.86	1400	356
Moore/Crane	15	4.5	3.56	0.91	8.95	925	465
Moose	34	29.6	1.75	1.52	8.79	994	342
Pinehurst	18	7.5	3.00	0.90	8.56	293	160
Skeleton Lake	28	9.2	1.40	1.46	8.70	392	200
Touchwood	13	3.4	4.25	0.54	8.50	275	148

A BRIEF INTRODUCTION TO LIMNOLOGY

INDICATORS OF WATER QUALITY

Water samples are collected in LakeWatch to determine the chemical characteristics that characterize general water quality. Though not all encompassing, the variables collected in LakeWatch are sensitive to human activities in watersheds that can cause degraded water quality. For example, nutrients such as phosphorus and nitrogen are important determinants of lake productivity. The concentrations of these nutrients in a lake are impacted (typically elevated) by land use changes such as increased crop production or livestock grazing. Elevated nutrient concentrations can cause increases in undesirable algae blooms resulting in low dissolved oxygen concentrations, degraded habitat for fish and noxious smells. A large increase in nutrients over time may also indicate sewage inputs which in turn may result in other human health concerns associated with bacteria or the protozoan *Cryptosporidium*.

TEMPERATURE AND MIXING

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality. Heat is transferred to a lake at its surface and slowly moves downward depending on water circulation in the lake. Lakes with a large surface area or a small volume tend to have greater mixing due to wind. In deeper lakes, circulation is not strong enough to move warm water to depths typically greater than 4 or 5 m and as a result cooler denser water remains at the bottom of the lake. As the difference in temperature between warm surface and cold deeper water increases, two distinct layers are formed. Limnologists call these layers of water the epilimnion at the surface and the hypolimnion at the bottom. The layers are separated by a transition layer known as the metalimnion which contains the effective wall separating top and bottom waters called a thermocline. A thermocline typically occurs when water temperature changes by more than one degree within one meter depth. The hypolimnion and epilimnion do not mix, nor do elements such as oxygen supplied at the surface move downward into the hypolimnion. In the fall, surface waters begin to cool and eventually reach the same temperature as hypolimnetic water. At this point the water mixes from top to bottom in what is often called a turnover event. Surface water cools further as ice forms and again a thermocline develops this time with 4° C water at the bottom and near 0° C water on the top.

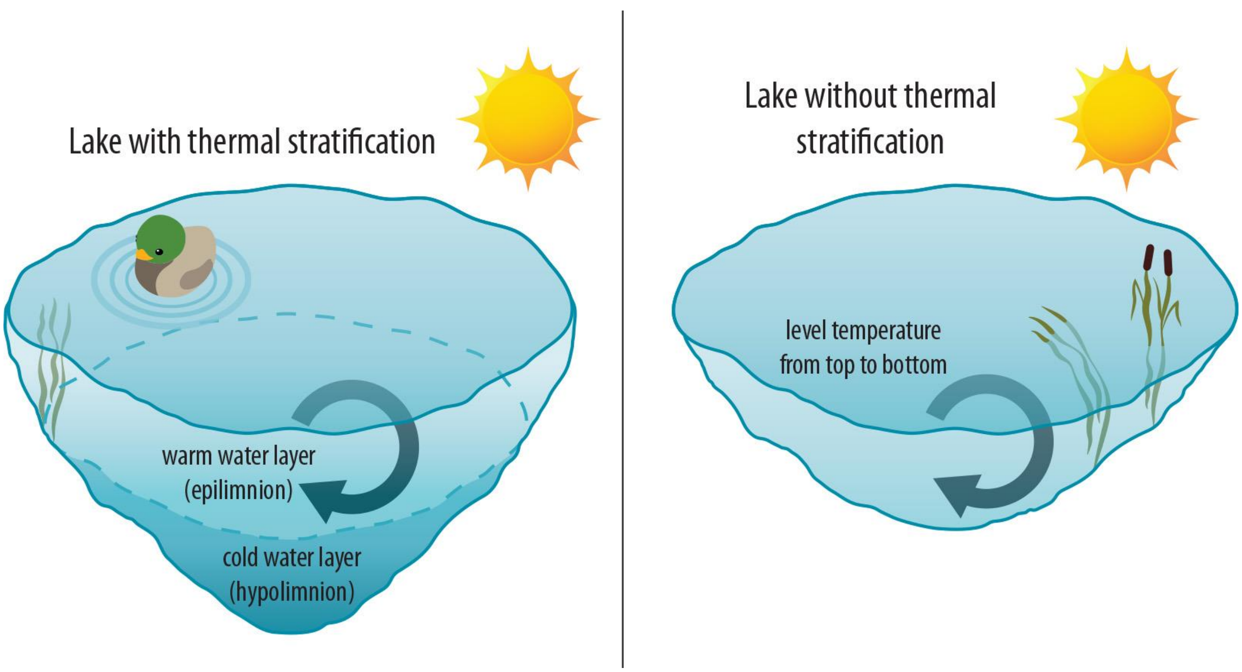

Figure A: Difference in the circulation of the water column depending on thermal stratification.

In spring another turnover event occurs when surface waters warm to 4° C. Lakes with this mixing pattern of two stratification periods and two turnover events are called **dimictic** lakes.   In shallower lakes, the water column may mix from top to bottom most of the ice-free season with occasional stratification during periods of calm warm conditions. Lakes that mix frequently are termed **polymictic** lakes. In our cold climate, many shallow lakes are **cold monomictic** meaning a thermocline develops every winter, there is one turnover event in spring but the remainder of the ice free season the lake is polymictic.

DISSOLVED OXYGEN

Oxygen enters a lake at the lake surface and throughout the water column when produced by photosynthesizing plants, including algae, in the lake. Oxygen is consumed within the lake by respiration of living organisms and decomposition of organic material in the lake sediments. In lakes that stratify (see temperature above), oxygen that dissolves into the lake at the surface cannot mix downward into the hypolimnion. At the same time oxygen is depleted in the hypolimnion by decomposition. The result is that the hypolimnion of a lake can become **anoxic**, meaning it contains little or no dissolved oxygen. When a lake is frozen, the entire water column can become anoxic because the surface is sealed off from the atmosphere. Winter anoxic conditions can result in a fish-kill which is particularly common during harsh winters with extended ice-cover. Alberta Surface Water Quality Guidelines suggest dissolved oxygen concentrations (in the epilimnion) must not decline below 5 $mg \bullet L^{-1}$ and should not average less than 6.5 $mg \bullet L^{-1}$ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 $mg \bullet L^{-1}$ in areas where early life stages of aquatic biota, particularly fish, are present.

GENERAL WATER CHEMISTRY

Water in lakes always contains substances that have been transported by rain and snow or have entered the lake in groundwater and inflow streams. These substances may be dissolved in the water or suspended as particles. Some of these substances are familiar minerals, such as sodium and chloride, which when combined form table salt, but when dissolved in water separate into the two electrically charged components called **ions**. Most dissolved substances in water are in ionic forms and are held in solution due to the polar nature of the water molecule. **Hydrophobic** (water-fearing) compounds such as oils contain little or no ionic character, are non-polar and for this reason do not readily dissolve in water. Although hydrophobic compounds do not readily dissolve, they can still be transported to lakes by flowing water. Within individual lakes, ion concentrations vary from year to year depending on the amount and mineral content of the water entering the lake. This mineral content can be influenced by the amount of precipitation and other climate variables as well as human activities such as fertilizer and road salt application.

PHOSPHORUS AND NITROGEN

Phosphorus and nitrogen are important nutrients limiting the growth of algae in Alberta lakes. While nitrogen usually limits agricultural plants, phosphorus is usually in shortest supply in lakes. Even a slight increase of phosphorus in a lake can, given the right conditions, promote algal blooms causing the water to turn green in the summer and impair recreational uses. When pollution originating from livestock manure and human sewage enters lakes not only are the concentrations of phosphorus and nitrogen increased but nitrogen can become a limiting nutrient which is thought to cause blooms of toxic algae belonging to the cyanobacteria. Not all cyanobacteria are toxic, however, the blooms can form decomposing mats that smell and impair dissolved oxygen concentrations in the lake.

CHLOROPHYLL-A

Chlorophyll *a* is a photosynthetic pigment that green plants, including algae, possess enabling them to convert the sun's energy to living material. Chlorophyll *a* can be easily extracted from algae in the laboratory. Consequently, chlorophyll *a* is a good estimate of the amount of algae in the water. Some highly productive lakes are dominated by larger aquatic plants rather than suspended algae. In these lakes, chlorophyll *a* and nutrient values taken from water samples do not include productivity from large aquatic plants. The result, in lakes like Chestermere which are dominated by larger plants known as macrophytes, can be a lower trophic state than if macrophyte biomass was included. Unfortunately, the productivity and nutrient cycling contributions of macrophytes are difficult to sample accurately and are therefore not typically included in trophic state indices.

SECCHI DISK TRANSPARENCY

Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. A measure of the transparency or clarity of the water is performed with a Secchi disk with an alternating black and white pattern. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the disk disappears is recorded. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. However, low Secchi depths are not caused by algal growth alone. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly low Secchi depths despite low algal growth and nutrient concentrations.

The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Conversely, aquatic plants can ensure lakes have clear water by reducing shoreline erosion and stabilizing lake bottom sediments. In Alberta, many lakes are shallow and bottom sediments contain high concentrations of nutrients. Without aquatic plants, water quality may decline in these lakes due to murky, sediment laden water and excessive algal blooms. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and insects, depend on aquatic plants for food and shelter.

TROPHIC STATE

Trophic state is classification of lakes into four categories of fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass (as chlorophyll) concentrations, the trophic states are; **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic (Table 2)**.

A majority of lakes in Alberta contain naturally high levels of chlorophyll *a* (8 to 25 µg/L) due to our deep fertile soils. These lakes are usually considered fertile and are termed eutrophic. The nutrient and algal biomass concentrations that define these categories are shown in the following table, a figure of Alberta lakes compared by trophic state can be found on the ALMS website.

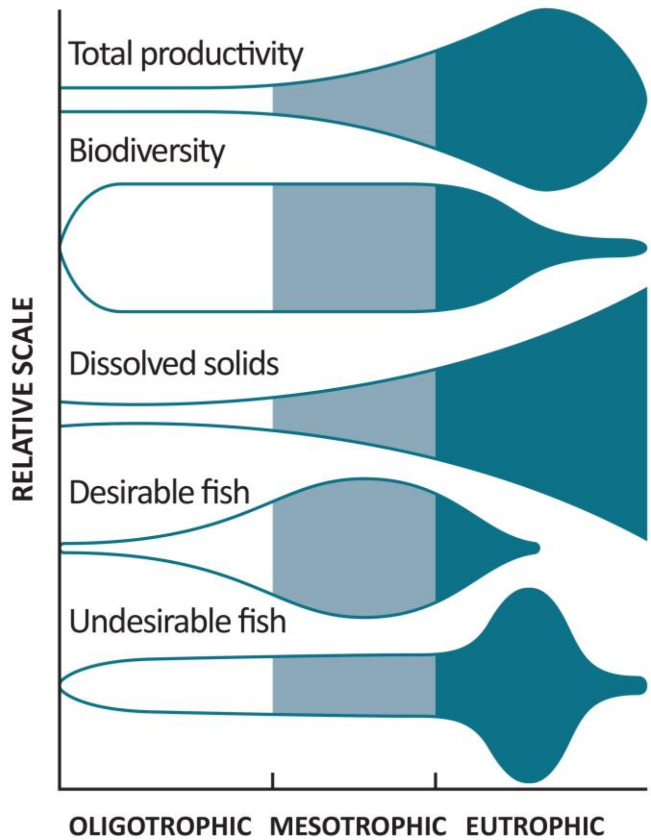

Table A - Trophic status classification based on lake water characteristics.

TROPHIC STATE	TOTAL PHOSPHORUS (µg•L-1)	TOTAL NITROGEN (µg•L-1)	CHLOROPHYLL A (µg•L-1)	SECCHI DEPTH (m)
Oligotrophic	< 10	< 350	< 3.5	> 4
Mesotrophic	10 – 30	350 - 650	3.5 - 9	4 - 2
Eutrophic	30 – 100	650 - 1200	9 - 25	2 - 1
Hypereutrophic	> 100	> 1200	> 25	< 1