Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

LICA
Lake Water Quality Summary Report 2015

COMPLETED WITH FINANCIAL SUPPORT FROM:

Beaver River Watershed Alliance

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LICA Lakeland Industry & Community Association

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.

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 2015.

Acknowledgements

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- **Crane Lake**: Ron Young
- **Elinor Lake**: Lisa & Trevor Byers
- **Lac Sante**: Terry Noble
- **Laurier Lake**: Bev Smith
- **Minnie Lake**: Garry Kissel
- **Moose Lake**: Grant Ferbey
- **Muriel Lake**: Lyle Kurtzman & Jeff Hlewka
- **Pinehurst Lake:** Megan Franchuk
- **Skeleton Lake North**: Orest Kitt
- **Skeleton Lake South**: Roy Nielsen

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Laurier Lake volunteer Bev Smith and LakeWatch Technician Ageleky Bouzetos

2015 Lake Water Quality Summary Report:

This report highlights the variability that exists within select parameters among the 2015 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 2015 BRWA lakes.

Lake	Drainage Basin Area (km^2)	Lake Area (km^2)	Drainage Basin Area/Lake Area
Crane	37.1	9.3	4:1
Elinor	37.63	9.58	3:1
Lac Sante	159	11.3	13:1
Laurier	92	6.4	14:1
Minnie	N/A	0.86	N/A
Moose	755	40.8	19:1
Muriel	306	64	5:1
Pinehurst	285	40.7	7:1
Skeleton Lake	31.7	7.9	4:1

In 2015, 10 lakes were sampled, with Skeleton Lake split into two basins which were sampled independently. Sampling was attempted five times throughout the summer for each lake. 2015 was an extremely successful sampling year, with 48 of 50 planned sampling trips completed (a 96% sample completion rate; Table 2). 2015 was the first time that Elinor Lake was included in the sampling program. Key water quality parameters have been highlighted in this report (Table 3).

Ageleky Bouzetos sampling Crane Lake in the rain.

Table 2 - Summary of the dates of five sampling trips in 2015 and the reasons for missed trips.

Lake	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5
Crane	10-Jun	8-Jul	5-Aug	18-Aug	4-Oct
Elinor	14-Jun	2-Jul	10-Aug	26-Aug	19-Sep
Lac Sante	26-Jun	15-Jul	30-Jul	13-Aug	10-Sep
Laurier	1-Jun	29-Jun	29-Jul	17-Aug	2-Sep
Minnie	9-Jun	8-Jul	4-Aug	18-Aug	8-Sep
Moose	23-Jun	7-Jul	12-Aug	2-Sep	18-Sep
Muriel	15-Jun	10-Jul	31-Jul	22-Aug	11-Sep
Pinehurst	24-Jun	24-Jul	7-Aug	27-Aug	30-Sep
Skeleton North	4-Jun	3-Jul	11-Aug	31-Aug	22-Sep
Skeleton South	4-Jun	3-Jul	Volunteer Absence	5-Sep	Volunteer Absence

Table 3 - Average Secchi depth and water chemistry values for ten BRWA lakes sampled from June-September of 2015.

Lake	Total Phosphorus (μg/L)	Chlorophyll-*a* (μg/L)	Secchi Depth (m)	TKN (mg/L)	pH	Conductivity (μS/cm)	Alkalinity (mg/L $CaCO_3$)
Crane	12	3.1	3.65	1.0	8.91	916	460
Elinor	15	3.7	4.09	1.2	8.56	400	206
Lac Sante	42	5.1	5.05	2.2	9.12	2000	952
Laurier	39	7.8	2.67	2.2	8.85	1100	524
Minnie	24	4.8	2.55	1.5	8.82	1400	370
Moose	33	14.6	2.60	1.6	8.80	990	344
Muriel	100	31.6	0.75	3.9	9.27	2475	1175
Pinehurst	16	7.2	2.45	0.9	8.59	286	154
Skeleton North	25	7.5	2.00	1.5	8.70	402	204
Skeleton South	27	14.1	2.50	1.4	8.70	413	220

TOTAL PHOSPHORUS:

Average total phosphorus (TP) is a measure of both inorganic and organic particulate and dissolved forms of phosphorus. While phosphates are not toxic to people or animals, they are an important determinant of the degree of biological production in a lake. Thus, phosphorus may directly influence the amount of algae and cyanobacteria in a lake, and, indirectly, water clarity. In Alberta, phosphorus levels tend to be naturally elevated due to phosphorus-rich sediments and soils, though human activities may increase the amount of phosphorus that enters a lake. In addition, the internal-cycling of nutrients within a lake is strongly influenced by factors such as dissolved oxygen concentrations.

In 2015, lakes fell into three categories based on TP concentration: mesotrophic (moderately productive), eutrophic (productive), and hypereutrophic (very productive) (Figure 1). Muriel Lake had the highest TP average of 2015 (101 ug/L) and was the only lake to fall into the hypereutrophic classification. A TP average of 101 µg/L is high for Muriel Lake based on historically measured values. In contrast, Crane and Elinor Lakes showed the lowest levels of TP, measuring 25.6 µg/L and 26.6 µg/L, respectively. As seen below, TP concentrations were closely associated with chlorophyll-*a* concentrations. In some lakes, high conductivity can inhibit the relationship between TP and chlorophyll-*a*.

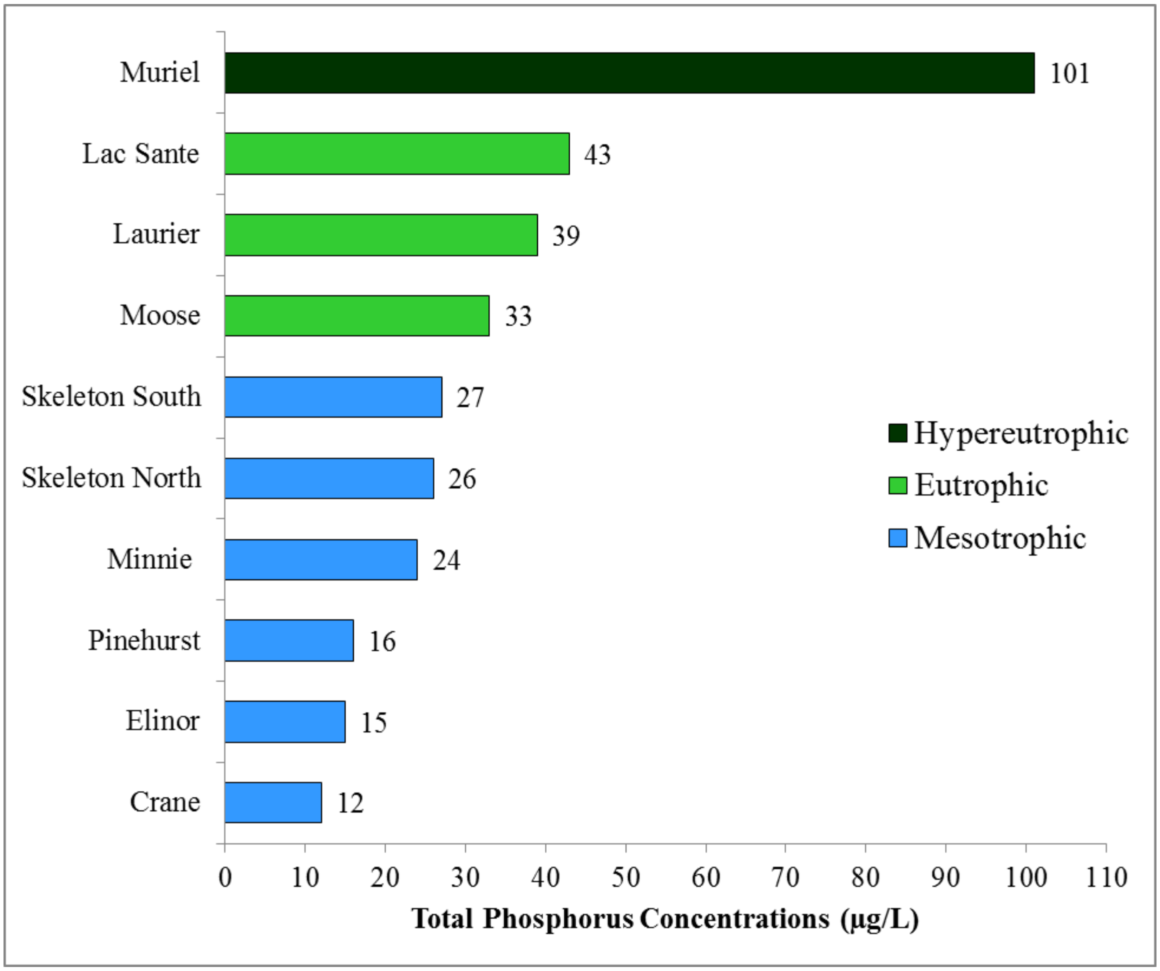

Figure 1 - Average total phosphorus (µg/L) concentrations measured at ten LICA lakes during the summer of 2015. Concentrations have been separated into trophic categories based on cut-offs identified in Table A of the appendix.

CHLOROPHYLL-A CONCENTRATION:

Chlorophyll-a is an important pigment used by algae and cyanobacteria for photosynthesis. Thus, the concentration of chlorophyll-a acts as an indirect measure of algal biomass or productivity. The concentration of chlorophyll-a can also act as an indirect measure of water clarity, as large algae/cyanobacteria blooms frequently diminish water clarity in Alberta's lakes.

In 2015, lakes sampled in the LICA area represented all major trophic levels based on chlorophyll-*a* concentrations (Figure 2). Muriel Lake was the only waterbody to fall into the hypereutrophic classification, measuring 31.7 µg/L in 2015 – this concentration is high for Muriel Lake based on historically measured values. Uncharacteristically, Lac Sante, which has historically fallen into the mesotrophic category, fell into the eutrophic category in 2015.This is likely due to a 'lake whitening' event (see Lake Whitening, below) caused by the precipitation of calcium onto the cell walls of autotrophic picoplankton. The rest of the lakes sampled fell into classifications of either eutrophic, mesotrophic, or oligotrophic.

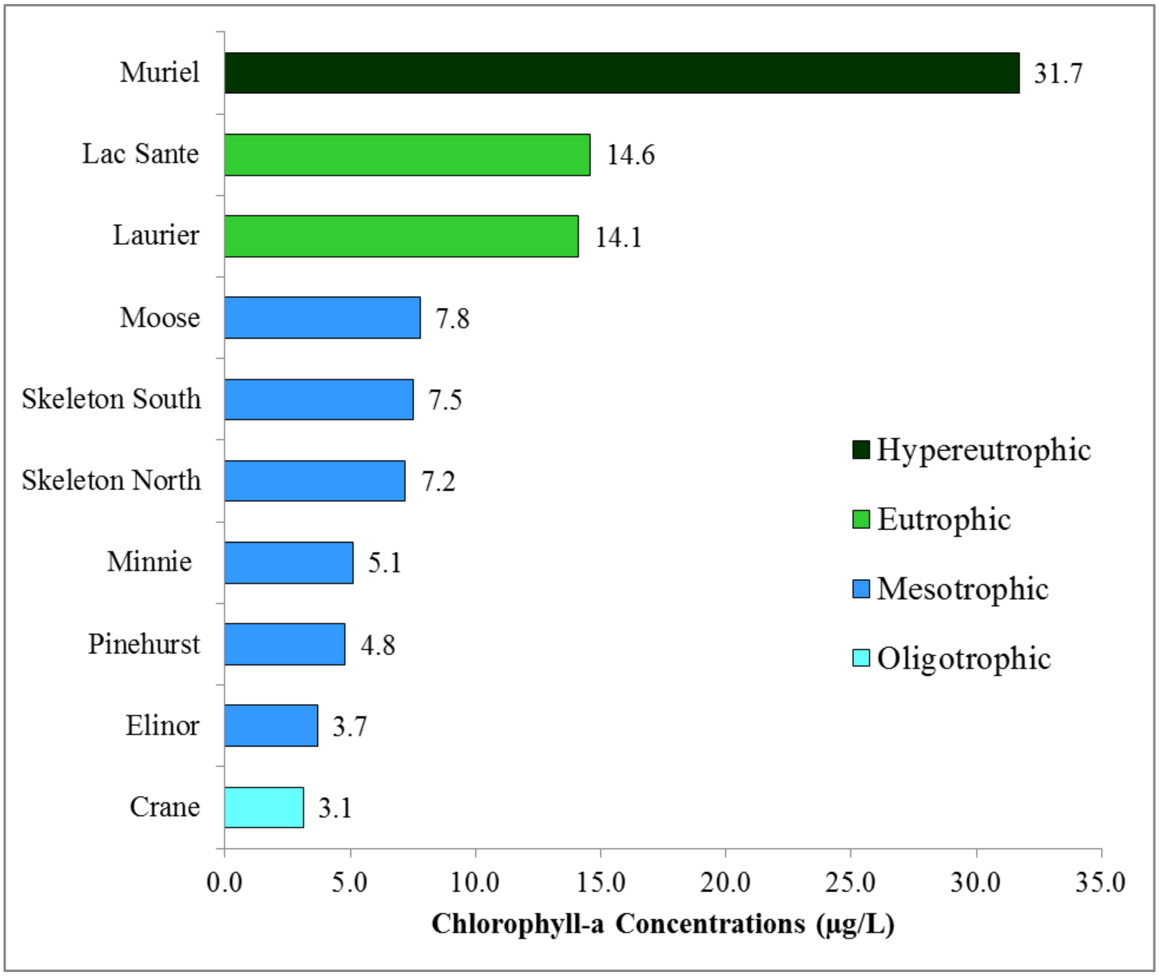

Figure 2 - Average chlorophyll-*a* (µg/L) concentrations measured at ten LICA lakes during the summer of 2015. Concentrations have been separated into trophic categories based on cut-offs identified in Table A of the appendix.

SECCHI DISK DEPTH:

Secchi disk depth is a measure of water clarity and can act as an indicator of suspended particles, such as algae or sediments, or of dissolved materials, such as dissolved organic carbon.

The greatest average water clarity in 2015 was measured at Lac Sante, with an average Secchi disk depth of 5.05 m (Figure 3). Water clarity was generally good throughout the Beaver River Watershed, as the majority of lakes fell within the mesotrophic and oligotrophic categories. Muriel Lake, which had the highest concentration of chlorophyll-*a* also had the lowest water clarity. It is likely that algae/cyanobacteria is the primary factor affecting water clarity in the Beaver River Watershed.

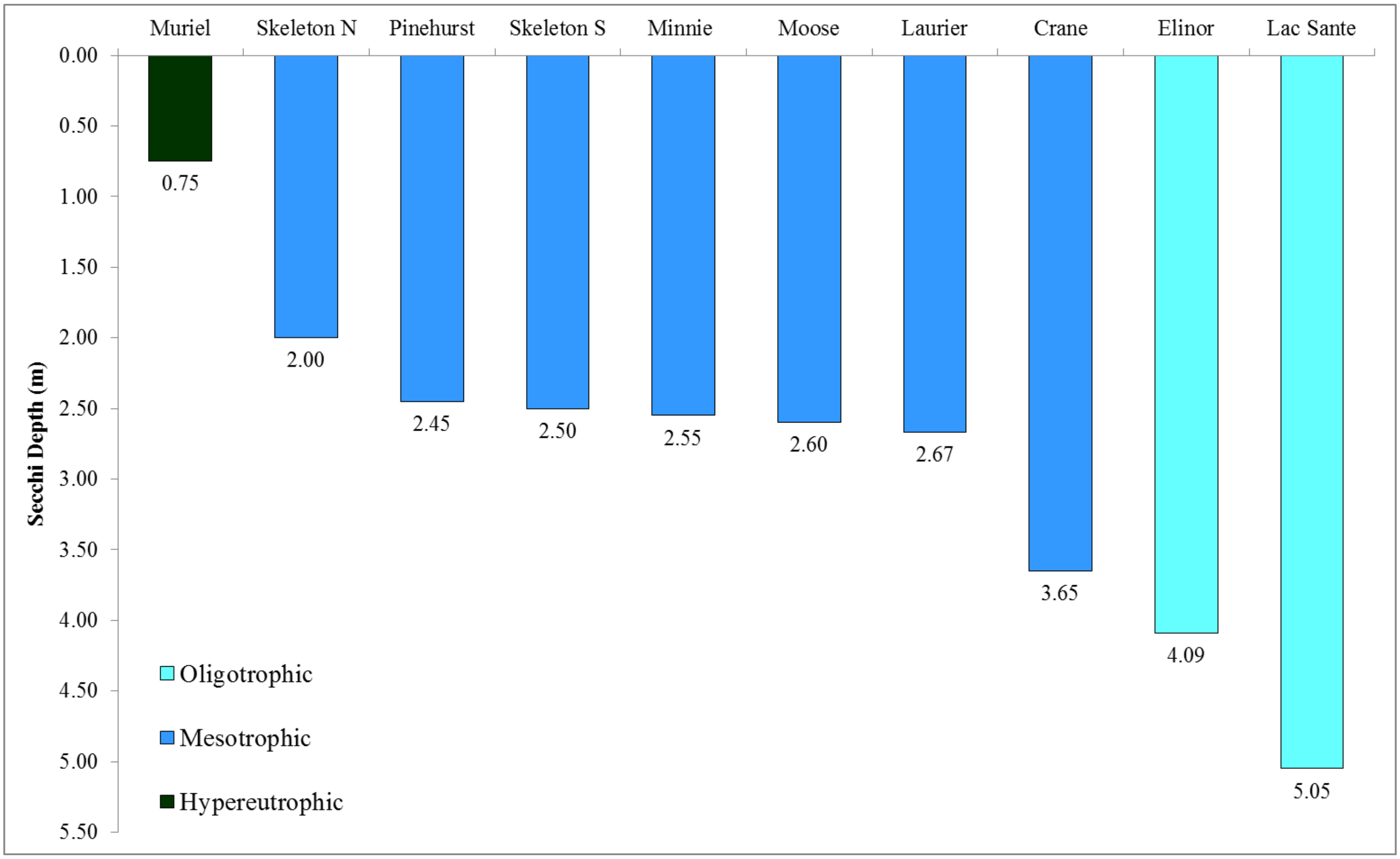

Figure 3 – Average Secchi disk depth (m) values measured at ten LICA sponsored lakes during the summer of 2015. Depths have been separated into trophic categories based on cut-offs identified in Table A of the appendix.

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 2015, two lakes, Muriel (10.7 μg/L) and

Minnie (10.36 µg/L), exceeded both Canadian Council for Ministers of the Environment recommended guidelines for the Protection of Aquatic Life of 5 µg/L and the Health Canada Drinking Water Quality Guidelines (10.0 µg/L).

Cadmium may be introduced to aquatic environments through mining, agriculture, and the burning of fossil fuels. In 2015, 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.

Volunteer of the Year award recipient Ron Young and technician Ageleky Bouzetos at Crane Lake.

Table 4 – Average concentrations of arsenic, cadmium, and lead measured in August and September of 2015. 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]
Crane	4.56	0.005	0.0375
Elinor	0.755	0.0045	0.0235
Lac Sante	4.06	0.0035	0.077
Laurier	3.89	0.0015	0.043
Minnie	10.36	0.002	0.029
Moose	1.93	0.001	0.0145
Muriel	10.7	0.006	0.1005
Pinehurst	0.6055	0.001	0.0345
Skeleton North	0.828	0.002	0.0275
Skeleton South	N/A	N/A	N/A

[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 2015, 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.

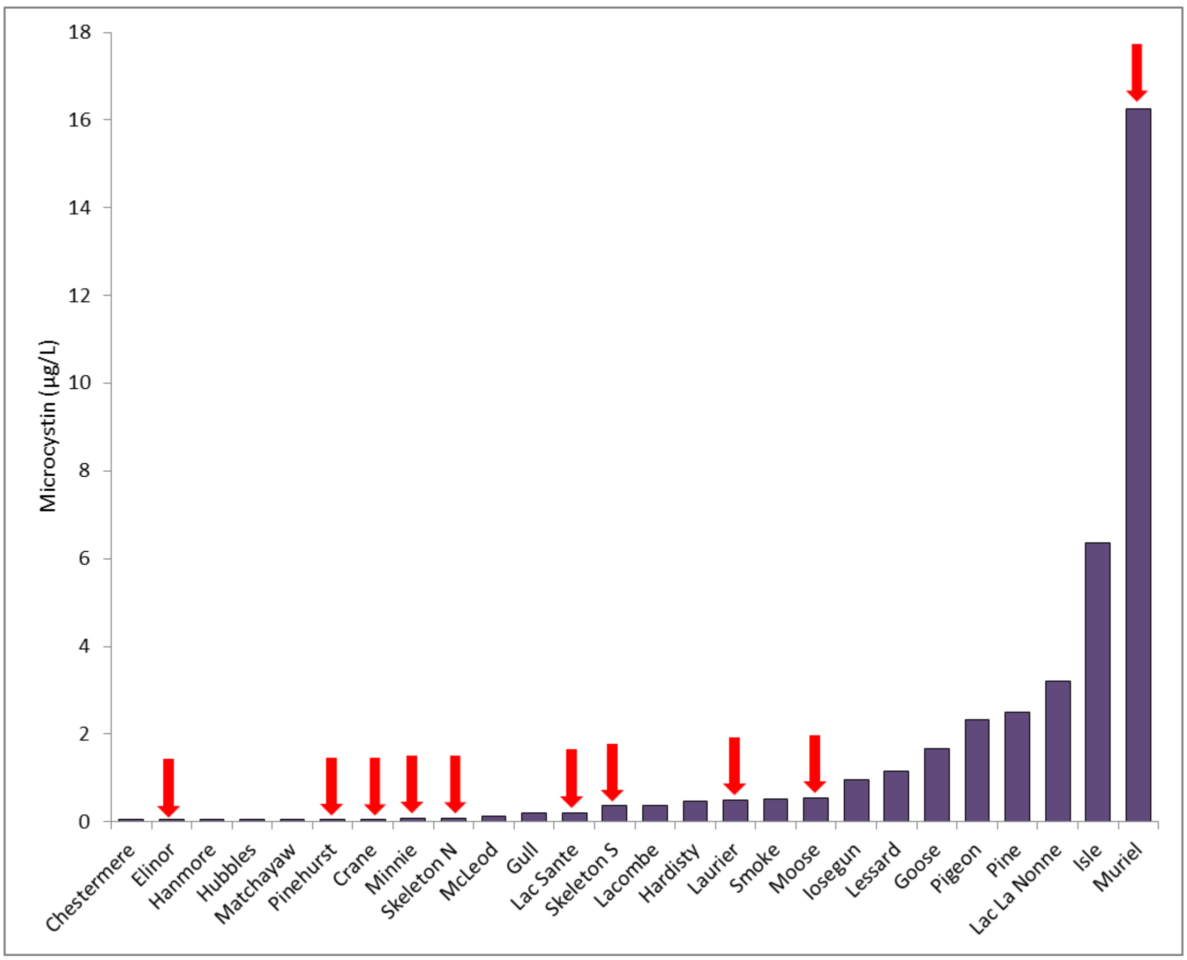

Figure 4 – Average microcystin concentrations observed for ten LICA lakes in 2015.

In 2015, microcystin was detected in all BRWA lakes except for Pinehurst and Crane Lakes (detection limit: 0.1 ug/L). The highest microcystin concentrations observed were in Muriel Lake, where concentrations exceeded 20 ug/L on three of four sample trips. See individual reports for the microcystin concentrations observed at each lake.

LAKE WHITENING:

Lake whitening is a phenomenon which results in lakes appearing a glacial blue or green colour. This event is most likely caused by blooms of autotrophic picoplankton (APP) – microscopic photosynthesing algae and bacteria. Blooms of APP cause calcium precipitation on their outer walls which results in a 'lake whitening' effect. These events are most common in mesotrophic lakes.

In 2015, lake whitening was observed at Crane Lake (Figure 5) and Lac Sante. It is likely that autotrophic picoplankton (APP) was the cause of these whitening events as spikes in dissolved oxygen concentrations partway through lake profiles or high chlorophyll-*a* concentrations are indicative of high photosynthetic activity. It is yet unknown what results in these seemingly harmless blooms.

Figure 5 – The glacial colour indicative of a lake whitening event observed at Crane Lake in 2015.

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:

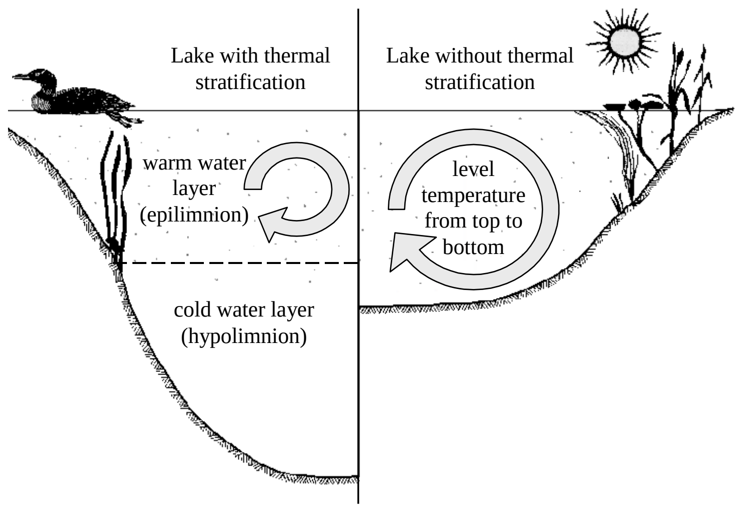

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

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.

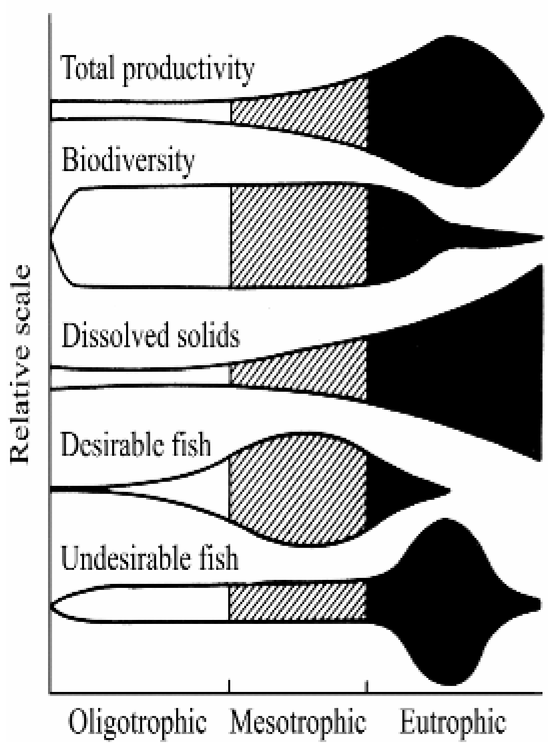

Figure B: Suggested changes in various lake characteristics with eutrophication.

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