Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2015 Chestermere Lake Report

LAKEWATCH IS MADE POSSIBLE WITH SUPPORT FROM:

Beaver River Watershed Alliance

aemera.org

LICA
Lakeland Industry & Community Association

Ce projet a été réalisé avec l'appui financier de :
This project was undertaken with the financial support of:

Environnement Canada Environment Canada

Alberta Government

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.

This report has been published before the completion of the data validation process.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank Heather Davies and Jay & Kathy Speck. We would also like to thank Laticia McDonald, Ageleky Bouzetos, and Mohamad Youssef who were summer technicians with ALMS in 2015. Executive Director Bradley Peter was instrumental in planning and organizing the field program. Mike Bilyk was involved in the training aspects of the program. Lisa Reinbolt was responsible for data management. This report was prepared by Bradley Peter and Alicia Kennedy. The Beaver River Watershed Alliance (BRWA), the Lakeland Industry and Community Association (LICA), the Alberta Environmental Monitoring Evaluation and Reporting Agency (AEMERA), and Environment Canada, were major sponsors of the program.

CHESTERMERE LAKE:

Situated in the Town of Chestermere just minutes East of Calgary, Chestermere Lake is a popular recreational lake and a highly developed, urban, man-made reservoir.

Chestermere Lake was originally built by the Canadian Pacific Railroad (CPR) in the 1880's as a water-balancing reservoir, supplying water at 50 cents per acre to CPR land. In the 1940's, the CPR offered to forgive mortgages held on their land in return for settlers giving up their water rights. The irrigation system was turned over to the Western Irrigation District (WID), which currently owns and operates the structures feeding water to and from Chestermere Lake (Mitchell and Prepas, 1990). The drainage basin for the lake is only 7.65 km^2 including the 2.65 km^2 'reservoir' at its maximum capacity. Chestermere Lake is surrounded by urban development.

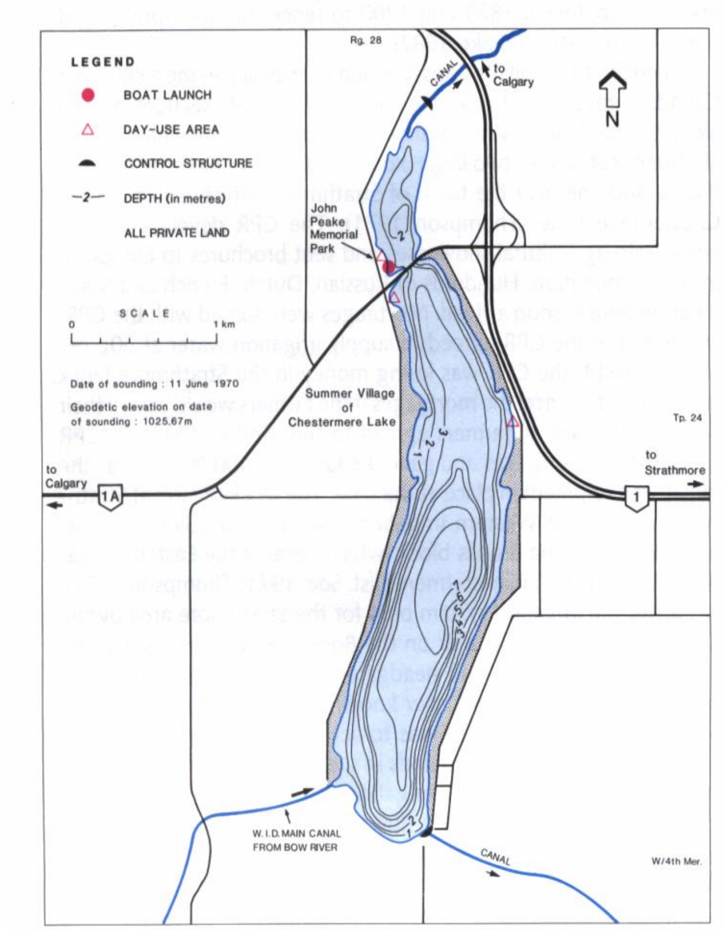

Figure 1 – Bathymetric map of Chestermere Lake (Mitchell and Prepas 1990).

Chestermere Lake is shallow over most of its depth (<2.0 m over 50% of its area). During the original survey conducted by the Alberta Government, Chestermere Lake was more than seven meters deep. The deepest areas of the lake have accumulated little sediment as maximum depth still remains between five to seven meters depending on water levels. Sediment accumulation has been heaviest at the WID canal inflow (south) where as much as two meters of sediment has accumulated. Likely due to its shallow depth, aquatic weeds are prevalent in Chestermere Lake (Figure 1). Chestermere is an important site for recreational use and mechanical removal of weeds using harvesters is maintained on a continuous basis.

Chestermere Lake receives a large volume of water during summer months, enough to replace the entire lake volume in eight days. Flushing of this magnitude may actually help to maintain the waters clarity and thus the success of weeds in comparison to other Alberta lakes of similar depth.

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.

Secchi depth at Chestermere Lake measured an average of 2.22 m in 2015. This average was comprised of a minimum observed water clarity of 1.25 m on August 12th and a maximum observed water clarity of 4.75 m on June 29th (Figure 2). An average value of 2.22 m is the lowest water clarity measurement observed when compared to Chestermere's historical measurements. It is likely that phytoplankton negatively impede water clarity measurements at Chestermere Lake, however, metal concentrations observed in 2015 (Table 2) indicate that there may be suspended sediments in the water column which are impeding clarity as well (Table 2).

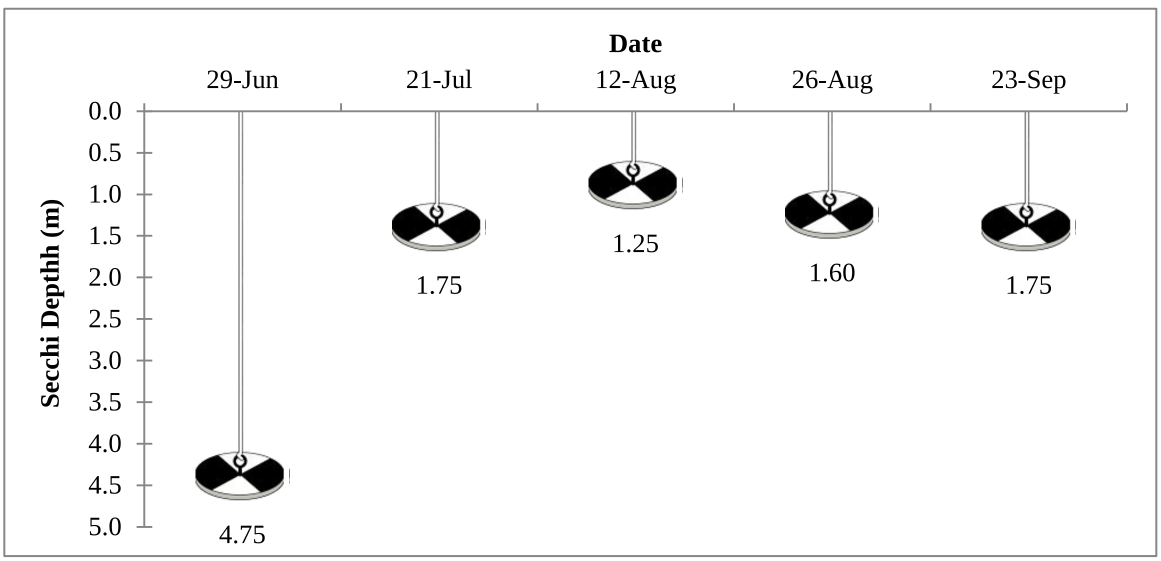

Figure 2 – Secchi depth values measured five times over the course of the summer at Chestermere Lake in 2015.

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.

Due to Chestermere Lake's shallow depth, Chestermere remained well mixed for most of the summer. This mixing action from wind and boat activity results in warm water temperatures throughout the water column. A maximum surface water temperature of 20.54°C was observed on June 29th - this coincided with the maximum temperature at the sediment of 18.48°C (Figure 3a). Slight stratification was observed on August 12th between 3.5-4.5 m, suggesting on warm, calm days Chestermere Lake may stratify intermittently. By September 23rd, temperatures had decreased dramatically, measuring only 13.73 °C at the lake's surface.

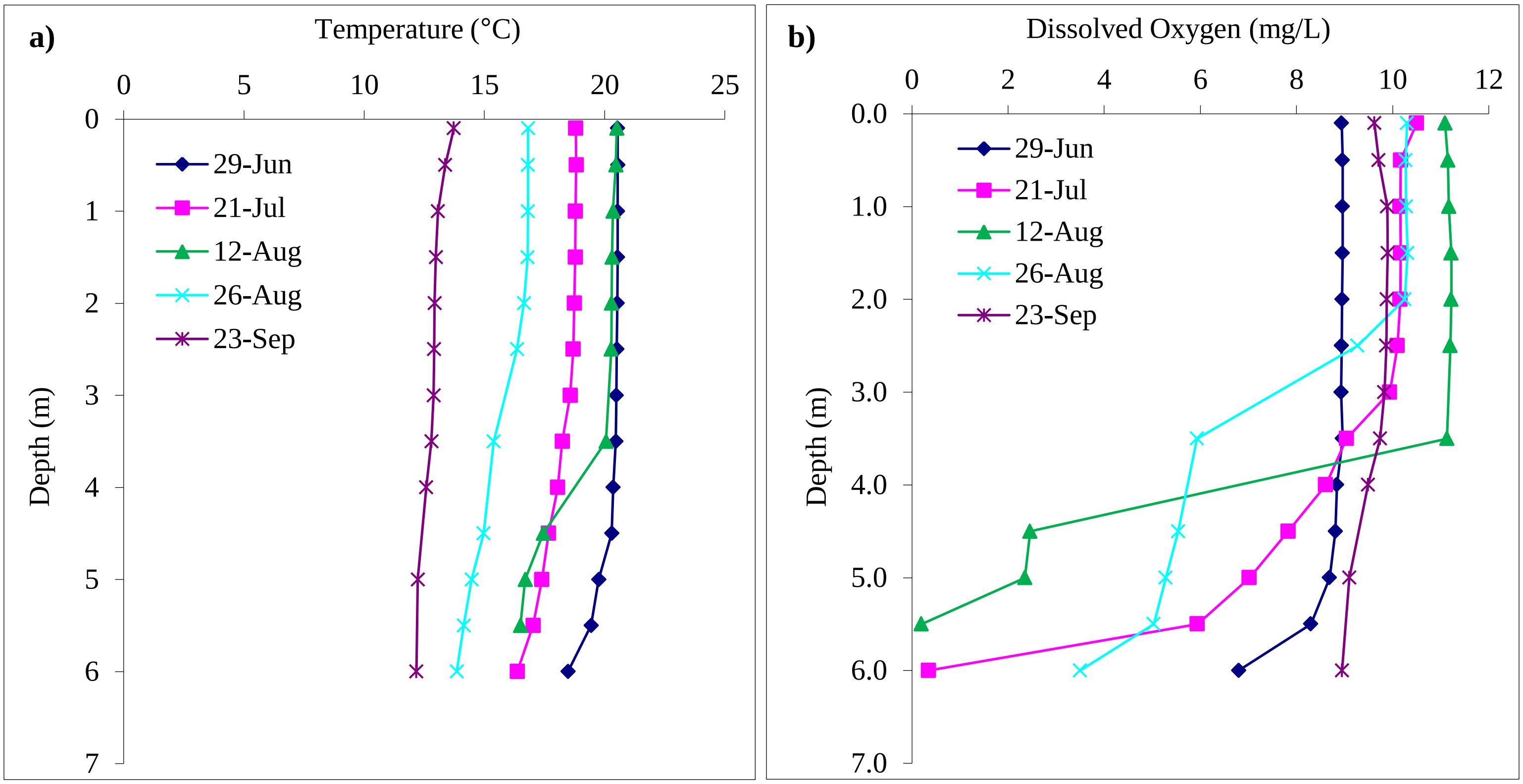

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Chestermere Lake measured five times over the course of the summer of 2015.

Dissolved oxygen concentrations varied throughout the summer at Chestermere Lake. While most of Chestermere Lake's water column fell above the Canadian Council for Ministers of the Environment guideline for the Protection of Aquatic Life of 6.5 mg/L, hypoxic, and even anoxic conditions, were observed in the waters overlying the sediment on multiple sampling trips (Figure 3b). Decomposition occurring at the lake sediment will contribute to the depletion of oxygen in deeper waters.

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 1 for a complete list of parameters.*

Total phosphorus (TP) measured an average of 16 µg/L in 2015 – this average falls into the mesotrophic, or moderately productive, trophic classification (Table 1). An average value of 16 µg/L falls on the low end of the historical measurements previously observed at Chestermere Lake. TP increased throughout the summer, ranging from a minimum of 6 µg/L on June 29th to a maximum of 26 µg/L on September 23rd (Figure 4). Lakes which experience mixing throughout the open water season tend to have increasing phosphorus concentrations as the summer progresses.

Average chlorophyll-*a* concentration measured 6.4 µg/L in 2015 - this concentration falls well within the historical concentrations previously observed at Chestermere Lake and falls into the mesotrophic, or moderately productive, classification. This average is comprised of a minimum concentration of 2.2 µg/L observed on June 29th and a maximum of 9.6 µg/L observed on August 12th (Figure 4).

Total Kjeldahl nitrogen (TKN) concentrations are low in Chestermere Lake. In 2015, average TKN measured 0.30 mg/L. Concentrations of TKN increased throughout the summer, measuring 0.20 mg/L on June 29th and 0.38 mg/L on September 23rd (Figure 4).

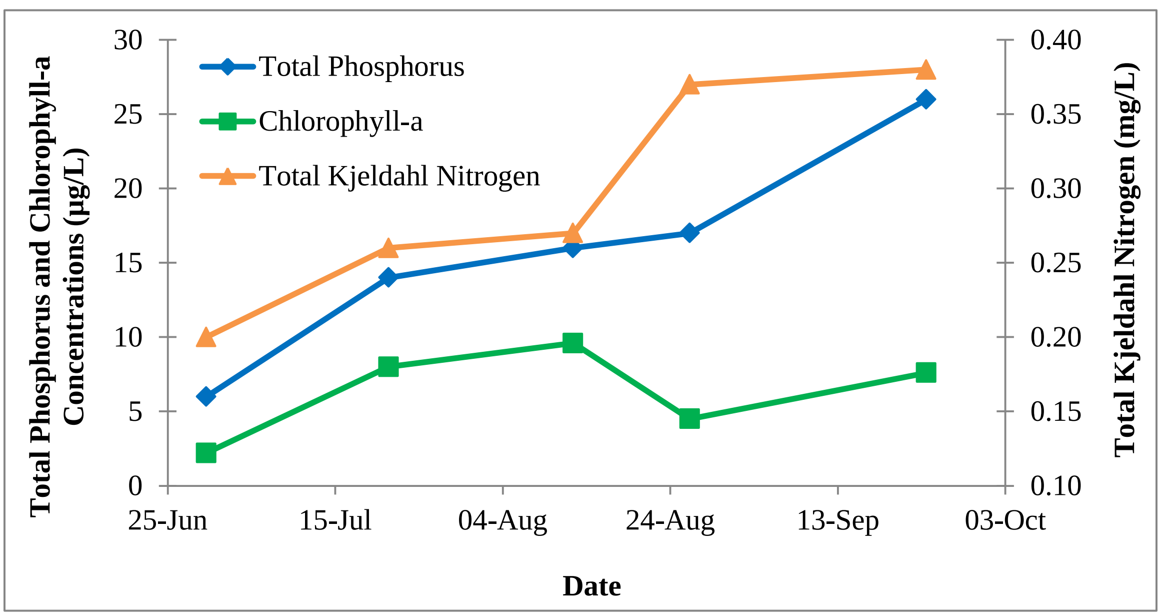

Figure 4 – Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentration measured five times over the course of the summer at Chestermere Lake.

Average pH measured 8.31 in 2015 – this value is well above neutral. Chestermere Lake maintains some buffering capacity due to its alkalinity (116 mg/L $CaCO_3$) and bicarbonate (142 mg/L HCO_3) concentration (Table 1). Chestermere Lake has low conductivity (392 µS/cm) with dominant contributing ions as sulphate (60 mg/L), calcium (39 mg/L), and magnesium (16 mg/L).

Metals were monitored twice at Chestermere Lake. All average concentrations fell within their respective guidelines with the exception of aluminum (227 μg/L) and copper (4.30 μg/L) (Table 2). These concentrations likely exceeded guidelines due to sediment contamination in the water quality samples.

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.

In 2015, all concentrations of microcystin monitored fell below the laboratory's minimum detection limit of 0.1 μg/L.

INVASIVE SPECIES:

Quagga and Zebra mussels are invasive species which, if introduced to our lakes, will have significant negative ecological, economical, and recreational impacts. ALMS collects water samples which are analyzed for mussel veligers (juveniles) and monitors substrates for adult mussels. In order to prevent the spread of invasive mussels, always clean, drain, and dry your boat between lakes. To report mussel sightings or mussel-fouled boats, call the confidential Alberta hotline at 1-855-336-BOAT.

In 2015, no zebra or quagga mussels were detected in Chestermere Lake.

Table 1 - Average Secchi disk depth and water chemistry values for Chestermere Lake. Previous years averages are provided for comparison.

Parameter	1983	1999	2000	2001	2007	2010	2011	2013	2015
TP (μg/L)	36	32	25	19	31	24	24.3	18	16
TDP (μg/L)	/	/	/	/	11	7	8.1	4.625	4
Chlorophyll-*a* (μg/L)	5.5	9.0	7.6	3.4	2.725	3.365	8.01	3.09	6.38
Secchi depth (m)	2.9	2.6			3.9	4.25	3.43	2.98	2.22
TKN (mg/L)	0.44	0.34	0.20	0.72	0.54	0.32	0.35	0.28	0.30
NO_2 and NO_3 (μg/L)	/	/	229	739	226.25	29.5	86.8	84.75	26.6
NH_3 (μg/L)	/	/	/	/	/	18.25	18.25	13.75	25
DOC (mg/L)	/	/	/	/	4.275	2.23	3.1	2.7	2.38
Ca (mg/L)	35	37	37	37	41.875	32.23	43.1	43.3	38.6
Mg (mg/L)	12	15	13	14	15.1625	16.63	17.9	15.9	15.8
Na (mg/L)	7	15	8	5	46.225	19.03	22.9	17.7	18
K (mg/L)	1	1	1	1	2.5	1.13	1.77	1.47	1.23
SO_4^{2-} (mg/L)	38	/	43	38	100	58	65.7	49.3	60.4
Cl^- (mg/L)	4	7	5	3	37.425	12.7	16	10.8	13.78
CO_3 (mg/L)	/	/	/	/	1.85	0.5	1.5	2.25	0.84
HCO_3 (mg/L)	/	/	/	/	158	146	162	175.25	142
pH	/	/	/	/	8.31	8.42	8.34	8.38	8.31
Conductivity (μS/cm)	/	/	/	/	563	149	432	420.75	392
Hardness (mg/L)	/	/	/	/	185	375	181	173.3	162
TDS (mg/L)	/	/	/	/	329.75	212	251	226.7	220
Microcystin (μg/L)	/	/	/	/	/	0.025	0.0786	0.05	<0.1
Total Alkalinity (mg/L $CaCO_3$)	111	/	116	110	132	120	135	147.25	116

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO_{2+3} = nitrate+nitrite, NH_3 = ammonia, DOC = dissolved organic carbon, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate, TDS = total dissolved solids, TSS = total suspended solids. A forward slash (/) indicates an absence of data.

Table 2 - Average concentrations of metals measured in Chestermere Lake on August 26th and September 23rd. Values shown for 2015 are an average of those dates. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2013**	**2015**	**Guidelines**
Aluminum µg/L	95.6	227	100[a]
Antimony µg/L	0.1165	0.148	6[e]
Arsenic µg/L	0.5775	0.6335	5
Barium µg/L	54.45	51.25	1000[e]
Beryllium µg/L	0.0015	0.0065	100[d,f]
Bismuth µg/L	0.0077	0.00225	/
Boron µg/L	14.2	18.65	5000[ef]
Cadmium µg/L	0.0226	0.033	0.085[b]
Chromium µg/L	0.317	0.57	/
Cobalt µg/L	0.06575	0.1055	1000[f]
Copper µg/L	1.303	4.295	4[c]
Iron µg/L	90.15	298.5	300
Lead µg/L	0.136	0.338	7[c]
Lithium µg/L	4.89	5.125	2500[g]
Manganese µg/L	7.185	19.9	200[g]
Molybdenum µg/L	0.9945	1.08	73[d]
Nickel µg/L	0.438	0.3875	150[c]
Selenium µg/L	0.9035	0.58	1
Silver µg/L	0.0255	0.0055	0.1
Strontium µg/L	237	225.5	/
Thallium µg/L	0.0057	0.0094	0.8
Thorium µg/L	0.0208	0.025025	/
Tin µg/L	0.02805	0.057	/
Titanium µg/L	1.35	4.875	/
Uranium µg/L	1.065	1.16	100[e]
Vanadium µg/L	0.5045	0.655	100[f,g]
Zinc µg/L	1.58	3.35	30

Values represent means of total recoverable metal concentrations.
[a] Based on pH ≥ 6.5; calcium ion concentrations [Ca^{+2}] ≥ 4 mg/L; and dissolved organic carbon concentration [DOC] ≥ 2 mg/L.
[b] Based on water Hardness of 300 mg/L (as $CaCO_3$)
[c] Based on water hardness > 180mg/L (as $CaCO_3$)
[d] CCME interim value.
[e] Based on Canadian Drinking Water Quality guideline values.
[f] Based on CCME Guidelines for Agricultural use (Livestock Watering).
[g] Based on CCME Guidelines for Agricultural Use (Irrigation).
A forward slash (/) indicates an absence of data or guidelines.

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:

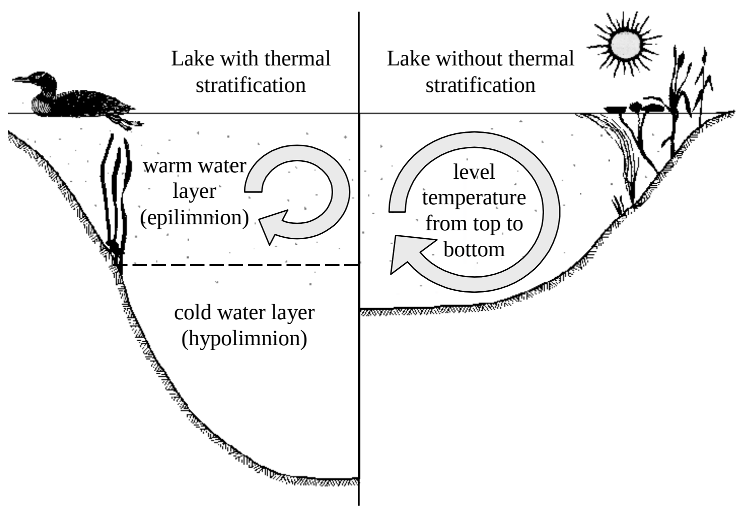

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

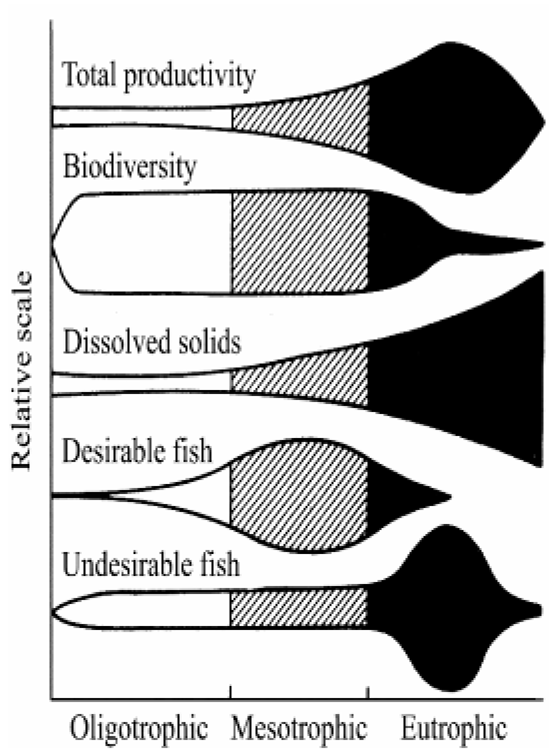

Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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