Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY

VOLUNTEER LAKE MONITORING PROGRAM

2015 Elinor Lake Report

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Beaver River Watershed Alliance

aemera.org

LICA
Lakeland Industry & Community Association

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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 Lisa & Trevor Byers for their assistance with sampling Elinor Lake in 2015. 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.

ELINOR LAKE:

This large, clear, lake is located approximately 25 km southeast of Lac La Biche, in the Beaver River Basin. It is rumoured that, like many other lakes in this region with female names, this lake was named after a woman who was romantically involved with a French-Canadian voyager making his way up the Beaver River in the 1800s[1].

Figure 1 – The forested shore of Elinor Lake. Photo by Ageleky Bouzetos 2015.

Elinor Lake lies within the Central Mixedwood natural sub-region, and most of the shoreline is densely forested and remains undeveloped. The only development is along the southeast shore, where a collection of seasonal lots and the Elinor Lake Resort are located. The resort area is made up mostly of residential properties, and both the seasonal lots and the resort have access to a small boat-launch which provides recreational access to the lake. The lake is also just west of Lakeland Provincial Park and the Lakeland Provincial Park Recreation Area, which both provide opportunities to experience neighboring lakes and the surrounding environment.

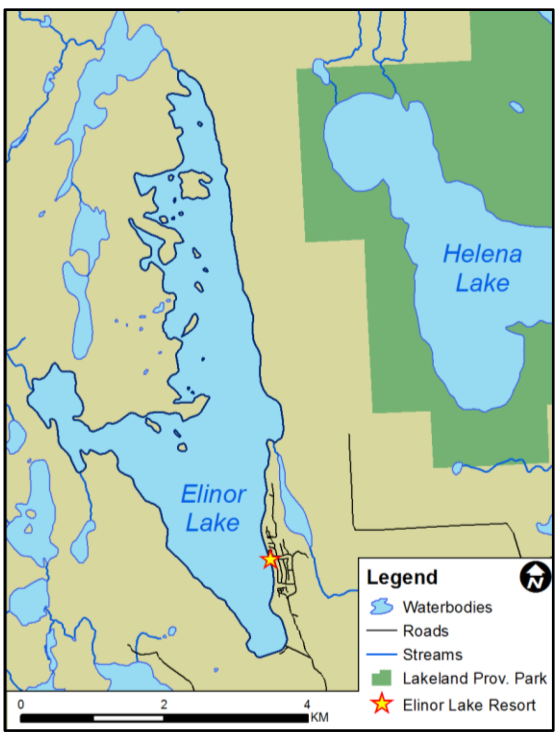

Figure 2 – Map of Elinor Lake. GIS data from GeoDiscover Alberta.

The drainage basin is only about 3 times the size of the lake, which is relatively small for a lake of this size. The lake itself has a surface area of 9.58 km^2, and its complex shape results in over 30 km of shoreline. The maximum depth of the lake has been recorded as 17.5 m, and according to bathymetric maps, the south end of the lake is deeper than the northern arm.

Fishing is a common activity here year-round, and sportfish species recorded here include burbot (*Lota lota*), lake whitefish (*Coregonus clupeaformis*), northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*). The lake is home to pelicans, grebes, loons, various shorebirds, and bald eagles. Other common recreational activities on the lake are swimming, paddle boarding, canoeing, and kayaking.

[1] Wayback archive-it place names of Alberta

A Level 2 Biological Nutrient Removal (BNR) sewage treatment plant exists on the southeast shore of Elinor Lake. This plant provides potable water and wastewater services to the Elinor Lake Resort. As well, many residents in the surrounding area collect potable water directly from the treatment plant. After passing through the plant, the treated wastewater enters a wetland, which connects via an unnamed creek to Matthews Lake which ultimately drains into Elinor Lake. Transit time of the treated water back to Elinor Lake is estimated at 7 years (pers. comm.).

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.

Elinor Lake has high water clarity which is reflected by its deep Secchi disk depths. Throughout the summer, Elinor Lake averaged a 4.09 m Secchi disk depth (Table 1). This average is comprised of a maximum observed water clarity of 5.00 m on July 2nd and a minimum observed water clarity of 2.50 m on September 19th. The minimum observed water clarity occurred alongside a small increase in chlorophyll-*a* concentration and a weakening of the thermocline which promoted mixing of surface waters with deeper waters.

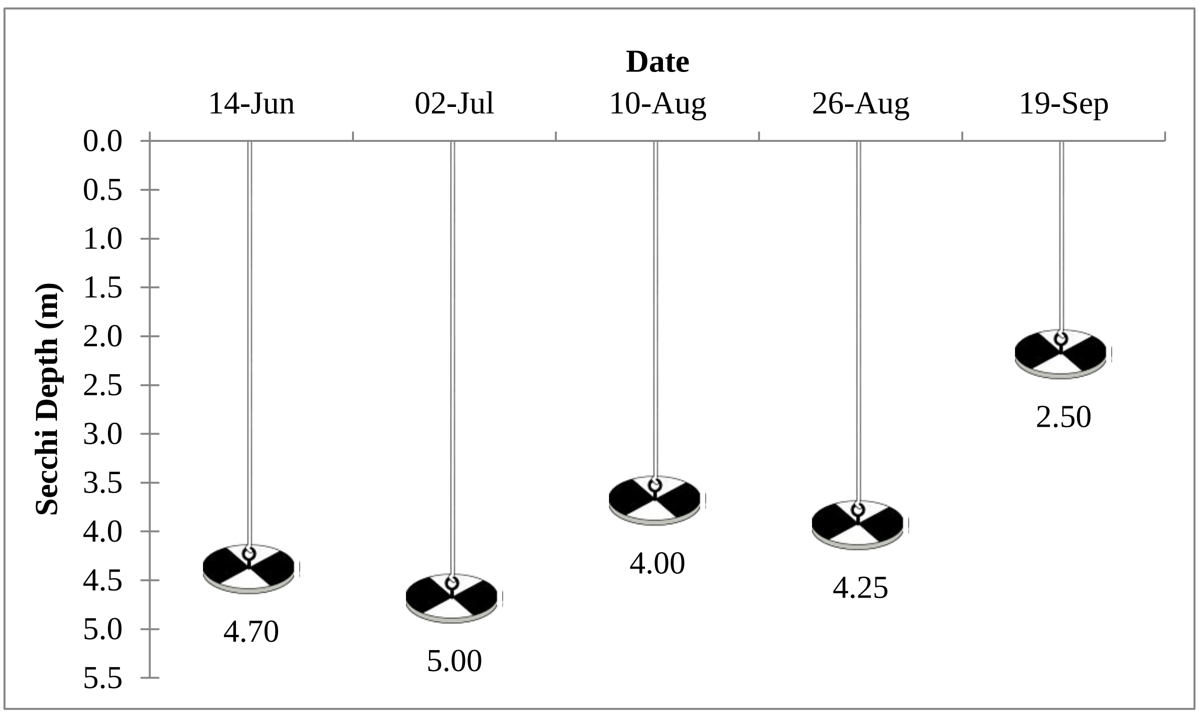

Figure 3 – Secchi depth values measured five times over the course of the summer at Elinor Lake in 2015.

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.

As is expected from a deep lake, Elinor Lake remained thermally stratified for the entirety of the summer. Thermal stratification was strong, and occurred as early as 3.00 m on July 2nd. By September 19th, thermal stratification weakened and began at 11.00 m. A maximum surface water temperature of 23.06 °C was observed on July 2nd. While this temperature is high, Elinor Lake's depth offers much refuge for fish species from warm waters. Below the thermocline, water temperature regularly proceeded to less than 10 °C.

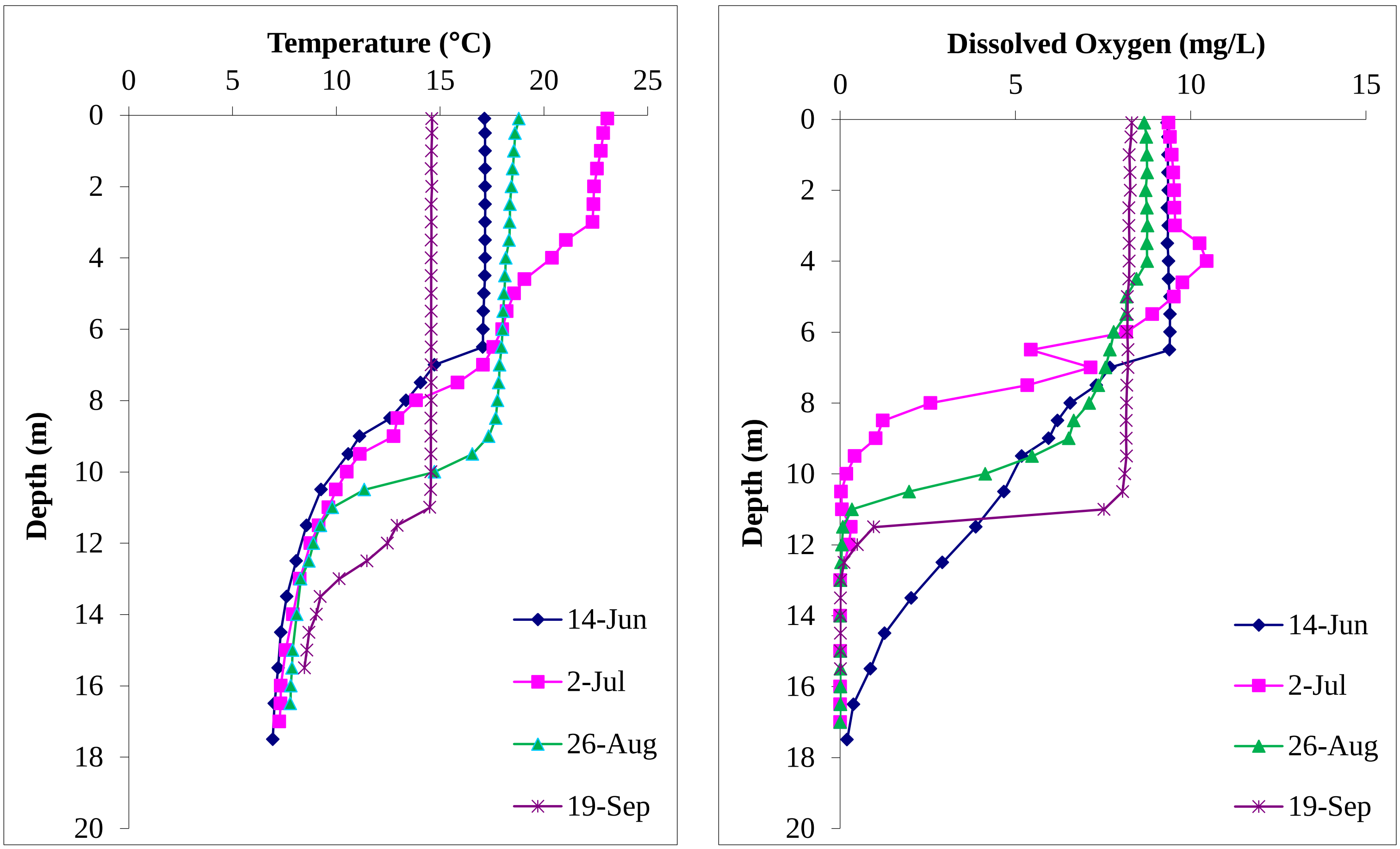

Figure 4 – Temperature (°C) and dissolved oxygen (mg/L) profiles for Elinor Lake measured four times over the course of the summer of 2015. An early August profile was missed due to probe malfunction.

Because of Elinor Lake's strong stratification, bottom waters are not able to mix with surface waters. This has important implications for oxygen concentrations in Elinor Lake. At the surface, Elinor Lake was well oxygenated, regularly measuring above the Canadian Council for Ministers of the Environment Guideline for the Protection of Aquatic Life of 6.5 mg/L. Below the thermocline, oxygen concentrations quickly proceeded to anoxia. Under anoxic conditions, phosphorus may be released from the lake sediments into overlying water – this process likely occurs in Elinor Lake. Due to the lack of lake mixing, these nutrients are not available at the surface of Elinor Lake. All of these processes are common in deep and stratified lakes.

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.

In 2015, average total phosphorus (TP) concentration measured 15 μg/L (Table 1). This value falls into the mesotrophic, or moderately productive, trophic classification. Throughout the summer, phosphorus fluctuated little, with a minimum observed concentration of 13 μg/L on July 2nd and August 10th and a maximum observed concentration of 23 μg/L on September 19th (Figure 5). The increase of phosphorus in September was likely due to the breakdown of stratification which occurred at that time - this allows for the mixing of top waters with deeper waters which were previously isolated by thermal stratification. Minimizing the input of phosphorus into Elinor Lake will be crucial for maintaining the lake's current water quality.

Chlorophyll-*a* concentrations were low in 2015. On average, chlorophyll-*a* concentration measured 3.7 μg/L (Table 1). This value falls into the mesotrophic, or moderately productive, trophic classification. Throughout the summer, chlorophyll-*a* concentrations were not reflective of nuisance cyanobacteria blooms, and fluctuated between an observed minimum of 3.1 μg/L on August 10th and an observed maximum of 6.0 μg/L on September 19th (Figure 5). More data is required to better understand the chlorophyll-*a* dynamics at Elinor Lake.

Finally, total Kjeldahl nitrogen (TKN) averaged 1.2 mg/L in 2015 (Table 1). This average falls into the eutrophic, or productive, trophic classification. Most lakes across Alberta have elevated levels of nitrogen. Little variation was observed in TKN concentrations throughout the summer – values ranged between 1.1 mg/L and 1.3 mg/L.

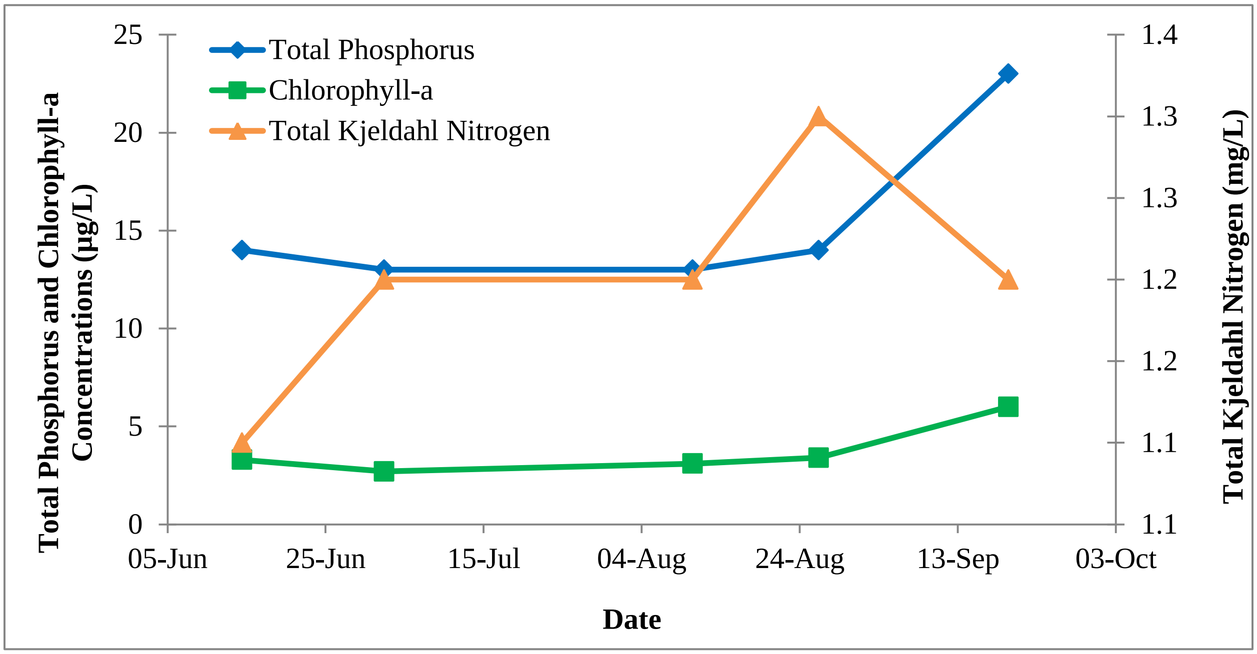

Figure 5 – Total Phosphorus (TP), Total Kjeldahl Nitrogen (TKN), and Chlorophyll-*a* concentration measured five times over the course of the summer at Elinor Lake.

Average pH at Elinor Lake measured 8.56 – this value is well above neutral. Elinor Lake is well buffered against changes to pH due to its alkalinity (206 mg/L $CaCO_3$) and bicarbonate (236 mg/L $HC0_3$) concentrations (Table 1). Elinor Lake has moderate conductivity (400 µS/cm) with magnesium (26 mg/L), calcium (23 mg/L), and sodium (17 mg/L) as dominant contributing ions.

Metals were collected twice at Elinor Lake and all concentrations fell within their respective guidelines (Table 2).

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 microcystin values fell below the laboratory 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.

No invasive zebra or quagga mussels were detected in 2015.

Table 1 - Average Secchi disk depth and water chemistry values for Elinor Lake.

Parameter	**2015**
TP (µg/L)	15
TDP (µg/L)	7.6
Chl-*a* (µg/L)	3.7
Secchi depth (m)	4.09
TKN (µg/L)	1.2
NO_2 and NO_3 (µg/L)	2.5
NH_3 (µg/L)	25
DOC (mg/L)	17.7
Ca (mg/L)	23
Mg (mg/L)	26
Na (mg/L)	17
K (mg/L)	12
SO_4^{2-} (mg/L)	9.0
Cl^- (mg/L)	2.0
CO_3 (mg/L)	6.9
HCO_3 (mg/L)	236
pH	8.56
Conductivity (µS/cm)	400
Hardness (mg/L)	162
TDS (mg/L)	214
Microcystin (µg/L)	<0.1
Total Alkalinity (mg/L $CaCO_3$)	206

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. A forward slash (/) indicates an absence of data.

Table 2 - Average concentrations of metals measured in Elinor Lake on August 10th and September 19th. 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)	**2015**	**Guidelines**
Aluminum µg/L	6.95	100[a]
Antimony µg/L	0.0225	6[e]
Arsenic µg/L	0.755	5
Barium µg/L	39.1	1000[e]
Beryllium µg/L	0.004	100[d,f]
Bismuth µg/L	0.00425	/
Boron µg/L	58.65	5000[ef]
Cadmium µg/L	0.0045	0.085[b]
Chromium µg/L	0.26	/
Cobalt µg/L	0.0135	1000[f]
Copper µg/L	0.25	4[c]
Iron µg/L	8.5	300
Lead µg/L	0.0235	7[c]
Lithium µg/L	26.45	2500[g]
Manganese µg/L	37.4	200[g]
Molybdenum µg/L	0.0195	73[d]
Nickel µg/L	0.004	150[c]
Selenium µg/L	0.06	1
Silver µg/L	0.001	0.1
Strontium µg/L	129	/
Thallium µg/L	0.00045	0.8
Thorium µg/L	0.006575	/
Tin µg/L	0.026	/
Titanium µg/L	0.445	/
Uranium µg/L	0.05	100[e]
Vanadium µg/L	0.095	100[f,g]
Zinc µg/L	0.35	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:

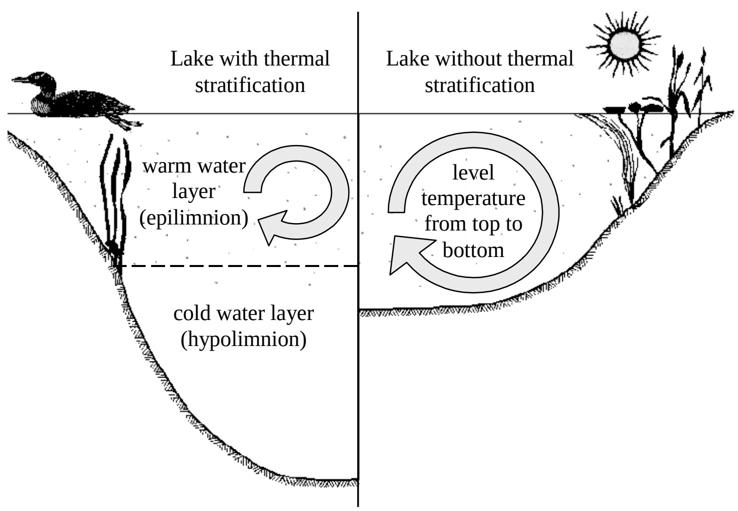

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

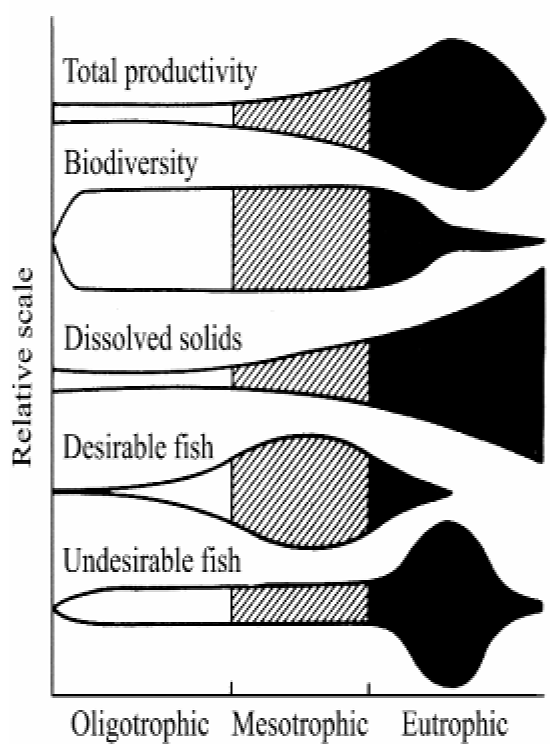

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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