Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY

VOLUNTEER LAKE MONITORING PROGRAM

2015 Hardisty 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 Ivan Lesmeister for his assistance with sampling Hardisty 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.

HARDISTY LAKE:

Figure 1 *- Aerial view of Hardisty Lake and the neighboring town of Hardisty. (Google Earth 2011)*

This small lake is located within the town limits of, and supplies drinking water to, the town of Hardisty, approximately 200 km southeast of Edmonton in Flagstaff County. Both the town and lake are named after Richard Hardisty, a former member of the Canadian Senate, and last chief factor of the Hudson Bay Company at Fort Edmonton[1].

The lake lies within the Central Parkland natural sub-region, and most of the shoreline borders grassland or private residential properties belonging to permanent or seasonal occupants. The lake has a teardrop-like shape, with the narrowest point in the northeast, and the larger section to the southwest. The surface area measures 0.26 km^2, and the maximum depth has been recorded at approximately 5 m. Turbidity is high in Hardisty Lake, causing the lake to appear shades of brown or dark red throughout the year.

Hardisty Lake Park, operated by the Hardisty Agricultural Society, is located on the north shore of the lake and provides camping facilities throughout summer months, as well as a sandy beach, large picnic area, and playground. Other facilities in the park include a public golf course, three baseball diamonds, and the rodeo grounds, which hosts the annual Hardisty Rodeo. Boats are banned within the park, however, there is a separate boat launch located on the opposite lakeshore. Motorized boating is permitted on the lake, but there are very specific restrictions, and a boating permit must first be obtained from the town[2].

The lake and its surrounding environment provide habitat for native upland birds, deer, and moose, as well as migrating ducks and geese[2]. No sportfish species are recorded for the lake, and the only fish observed have been small minnow and stickleback species. Northern milfoil (*Myriophyllum sibericum*) and Fries' pondweed (*Potamogeton fresii*) have been observed around the shores of Hardisty Lake.

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[1] Place Names of Alberta (2206) Edited by Merrily K Aubrey. Calgary, AB. University of Calg. Press.

[2] Hardisty Lake website – various pages (http://www.hardisty.ca/)

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.

Average Secchi depth at Hardisty Lake measured 0.58 m in 2015. This Secchi depth is low, and reflective of what would be considered a hypereutrophic lake. While phytoplankton (cyanobacteria and algae) tend to be the primary factor contributing to reduced water clarity across the province – Hardisty Lake also has high concentrations of total suspended solids (24 mg/L) and dissolved organic carbon (31 mg/L) which contribute to reduced water clarity. As Hardisty Lake is shallow, wave action caused by boating or wind activity will contribute to disturbance of bottom sediments and erosion of the lake shoreline which will decrease Secchi depth. Neither Secchi depth nor concentrations of phytoplankton (chlorophyll-*a*) changed appreciably throughout the summer.

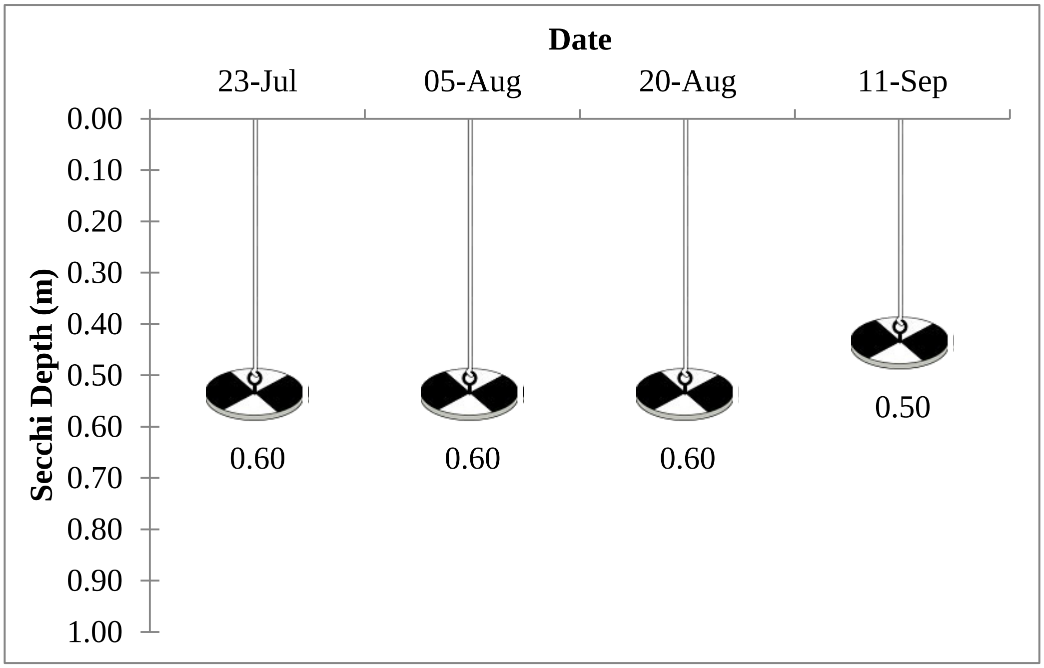

Figure 2 – Secchi disk depth measured four times over the course of the summer in 2015 at Hardisty Lake.

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.

Temperature was warm throughout the water column at Hardisty Lake in 2015. At the surface, a maximum temperature of 22.00 was observed on August 5th, and at the sediments, a maximum temperature of 19.45 °C was observed on July 23rd. Because of its shallow depth, Hardisty Lake is likely polymictic – experiencing weak periods of thermal stratification followed by periods of mixing. Weak thermal stratification was observed near the lake bed on both July 23rd and August 5th – these short periods of stratification may negatively impact dissolved oxygen concentrations. Shallow depth and high concentrations of suspended sediments lend themselves to warm water temperatures.

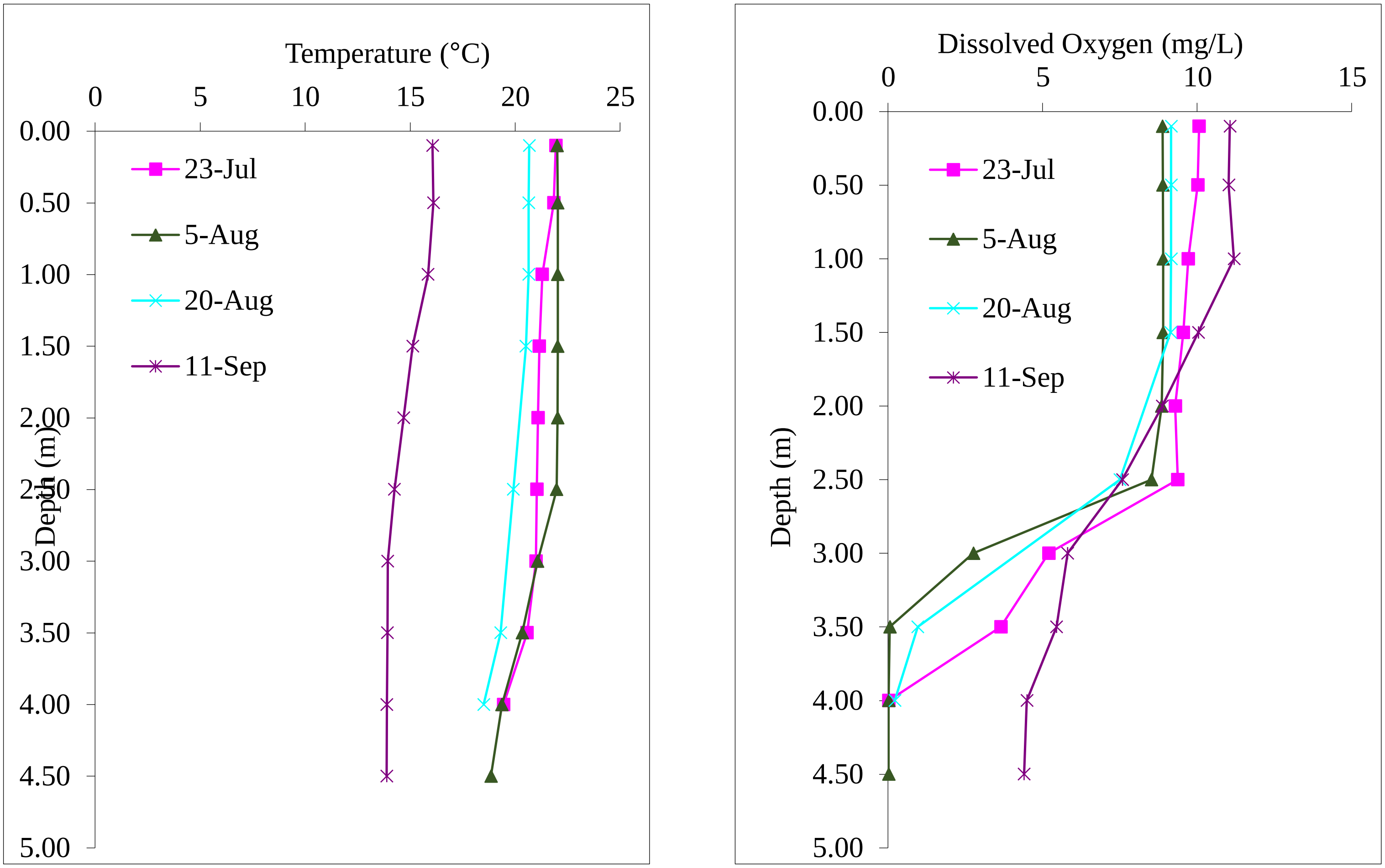

Figure 3 – Temperature (°C) and dissolved oxygen (mg/L) measured four times over the course of the summer at Hardisty Lake in 2015.

Dissolved oxygen concentrations were elevated at the surface of Hardisty Lake, but decreased rapidly with depth. Phytoplankton populations at the surface of the lake can elevate oxygen concentrations due to photosynthetic rates. Below the phytoplankton populations and in zones where thermal stratification may establish, oxygen concentrations rapidly declined. Anoxia (no oxygen) was observed as early as 3.50 m on August 5th. On each trip, oxygen proceeded to concentrations below the Canadian Council for Ministers of the Environment recommended guidelines of 6.5 mg/L for the Protection of Aquatic Life. Warm temperatures combined with low oxygen concentrations can result in a stressful environment for sport fish species. Low oxygen concentrations can also contribute to the release of nutrients from bottom sediments.

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 43 ug/L in 2015. This value falls into the eutrophic, or nutrient rich, classification. TP also increased steadily throughout the summer, measuring a minimum of 41 ug/L on July 23rd and a maximum of 45 ug/L on September 11th. Although this is only a small increase in nutrients, the pattern is typical of lakes which have a polymictic mixing pattern. More data is required to better understand the nutrient dynamics of Hardisty Lake.

Chlorophyll-*a* concentration remained steady throughout the summer and measured an average of 44.0 ug/L. Cyanobacteria (blue-green algae) contributed to the phytoplankton community at Hardisty Lake as colonies of these bacteria were observed in ALMS' zooplankton samples. The phytoplankton community remained dense throughout the summer – it is possible this bloom collapsed in late fall. This biomass would contribute to the depletion of winter oxygen concentrations in the lake as decomposition occurs under ice.

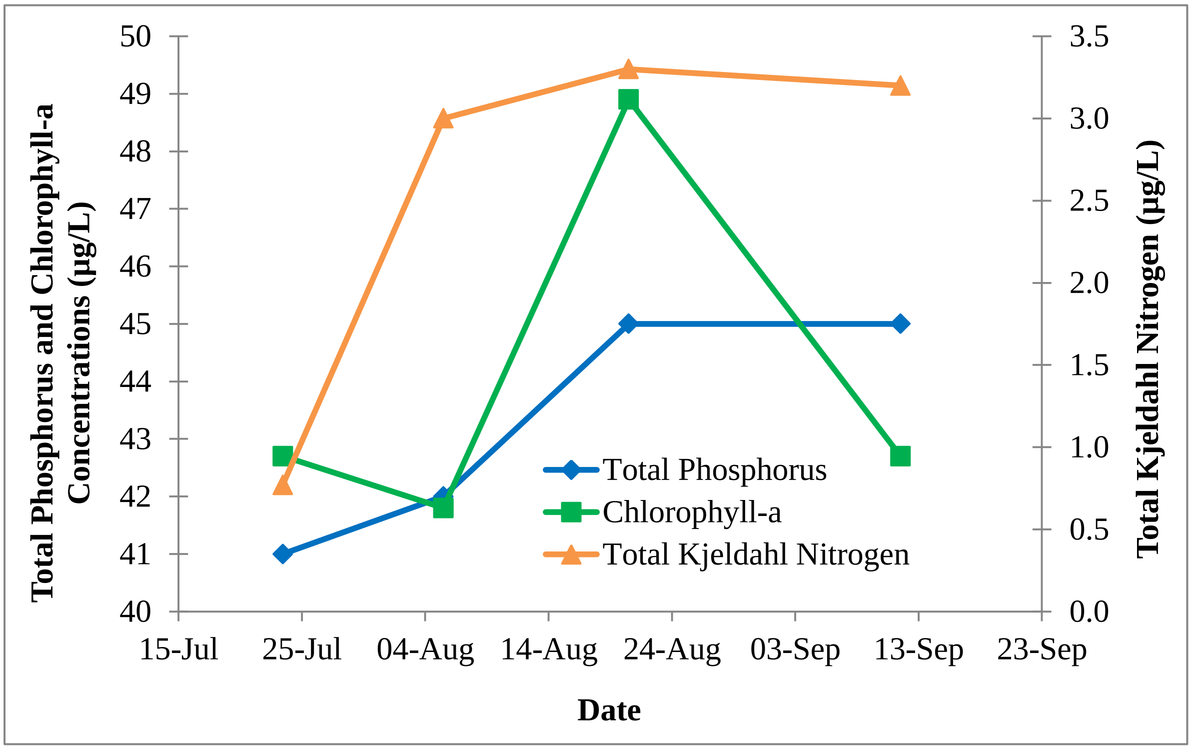

Figure 4 – Average total phosphorus (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (mg/L) concentrations measured four times over the course of the summer at Hardisty Lake.

Total Kjeldahl Nitrogen (TKN) was high in Hardisty Lake, measuring an average of 2.6 mg/L in 2015. Phosphorus is likely the limiting nutrient driving phytoplankton growth in Hardisty Lake, as nitrogen can be obtained from the atmosphere by some species of cyanobacteria.

Average pH in Hardisty Lake measured 9.09 in 2015 – this is well above neutral and contributing factors may include high alkalinity (555 mg/L) and bicarbonate (495 mg/L $CaCO_3$) which help to buffer the lake water against changes to pH. Conductivity in Hardisty Lake is also high, measuring 1175 uS/cm. Dominant ions contributing to conductivity include magnesium (99 mg/L) and sodium (97 mg/L).

Metals were analyzed for three times over the course of the summer. All metals with the exception of arsenic (12.1 ug/L) fell within their respective guidelines. Arsenic exceeds the CCME PAL guidelines (5 ug/L) and narrowly exceeds the World Health Organization’s drinking water guidelines (10 ug/L). Arsenic is elevated in the groundwater and lakes in some regions of Alberta due to the natural geology of the area.

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 Hardisty Lake.

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, average microcystin concentrations measured 0.48 ug/L. These concentrations are well below the recommended recreational guidelines (20 ug/L), though recreating in cyanobacteria blooms should still be avoided to due risk of skin irritation and toxins other than the commonly detected microcystin. Not all species of cyanobacteria, notably *Aphanizomenon* spp., are capable of producing microcystin toxin.

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

Parameter	**2015**
TP (μg/L)	43
TDP (μg/L)	8
Chlorophyll-*a* (μg/L)	44
Secchi depth (m)	0.58
TKN (mg/L)	2.6
NO_2 and NO_3 (μg/L)	2.5
NH_3 (μg/L)	25
DOC (mg/L)	31
Ca (mg/L)	15
Mg (mg/L)	99
Na (mg/L)	97
K (mg/L)	28
SO_4^{2-} (mg/L)	53
Cl^- (mg/L)	69
CO_3 (mg/L)	89
HCO_3 (mg/L)	495
pH	9.09
Conductivity (μS/cm)	1175
Hardness (mg/L)	445
TDS (mg/L)	698
Microcystin (μg/L)	0.48
Total Alkalinity (mg/L $CaCO_3$)	555

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

Table 2 - Average concentrations of metals measured in Hardisty Lake on August 5th, August 20th, and September 11th. 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	15.7	100[a]
Antimony µg/L	0.142	6[e]
Arsenic µg/L	12.1	5
Barium µg/L	240	1000[e]
Beryllium µg/L	0.004	100[d,f]
Bismuth µg/L	0.012	/
Boron µg/L	209	5000[ef]
Cadmium µg/L	0.006	0.085[b]
Chromium µg/L	0.19	/
Cobalt µg/L	0.090	1000[f]
Copper µg/L	1.17	4[c]
Iron µg/L	20.4	300
Lead µg/L	0.063	7[c]
Lithium µg/L	114	2500[g]
Manganese µg/L	18.8	200[g]
Molybdenum µg/L	2.01	73[d]
Nickel µg/L	0.488	150[c]
Selenium µg/L	0.07	1
Silver µg/L	0.003	0.1
Strontium µg/L	581	/
Thallium µg/L	0.003	0.8
Thorium µg/L	0.047	/
Tin µg/L	0.019	/
Titanium µg/L	1.63	/
Uranium µg/L	2.70	100[e]
Vanadium µg/L	0.47	100[f,g]
Zinc µg/L	1.2	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:

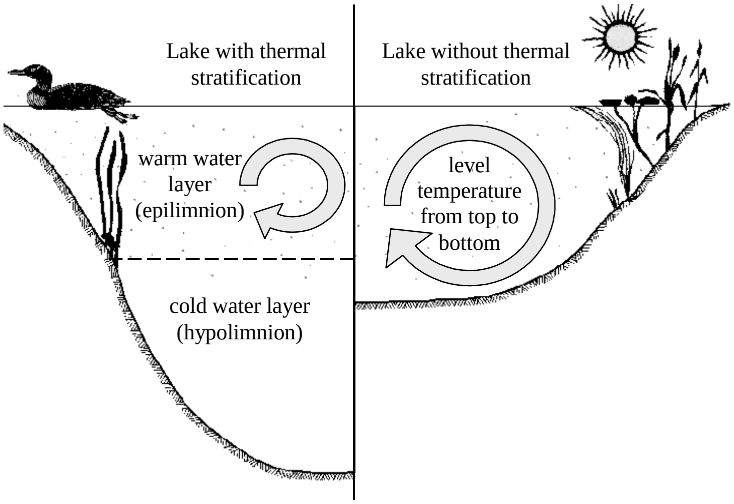

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

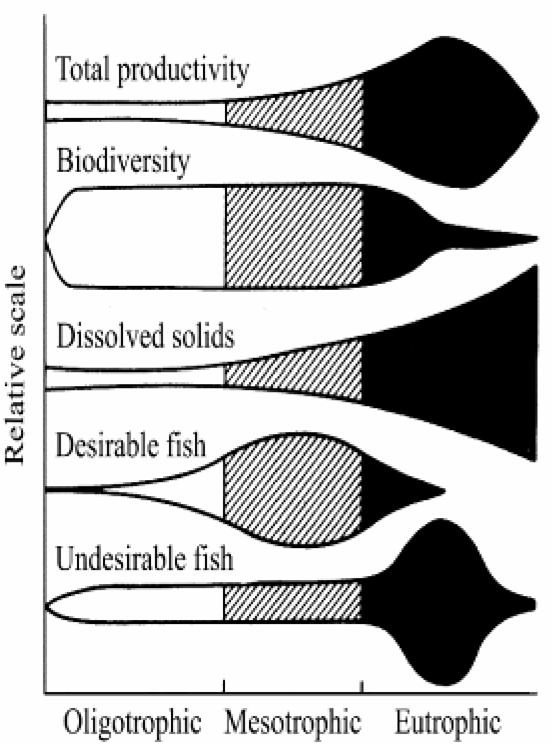

Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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

Trophic state	Total Phosphorus ($\mu g \bullet L^{-1}$)	Total Nitrogen ($\mu g \bullet L^{-1}$)	Chlorophyll a ($\mu g \bullet L^{-1}$)	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