THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2012 Hastings Lake Report

COMPLETED WITH SUPPORT FROM:

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.

Historical data has been re-queried and summarized for the 2012 report.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank Dave McNeil and Matt and Zack McFadzean for their assistance with sampling Hastings Lake in 2012. We would also like to thank Randi Newton and Erin Rodger who were summer technicians with ALMS in 2012. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Technologists Trina Ball and Brian Jackson were involved in the training aspects of the program. Lisa Reinbolt was responsible for data management. This report was prepared by Bradley Peter and Arin Dyer. Alberta Environment and the Beaver River Watershed Alliance (BRWA) were major sponsors of the program.

If you are interested in becoming a volunteer with the LakeWatch program or having your lake monitored, please e-mail us at info@alms.ca or call us at 780-415-9785.

HASTINGS LAKE:

Figure 1 – Hastings Lake. Photo by Randi Newton, 2012.

Hastings Lake, with its natural shoreline and many islands, is a popular lake for boating and bird watching. It is a regionally significant nesting, moulting, staging, and migration area for diving ducks, and its islands provide nesting habitat for Canada Geese. The lake is located 40 km east of the city of Edmonton in the County of Strathcona. To reach the north side of the lake from Edmonton, take Highway 14 east to the hamlet of Sherwood Park, then continue east and southeast on Secondary Road 630, locally known as Wye Road. About 3 km southeast of the hamlet of Deville, turn south on Range Road 203 and drive 0.5 km to the lakeshore. Access is also available at the end of Range Road 204 on the north shore and in the hamlet of Hastings Lake on the south shore.[1]

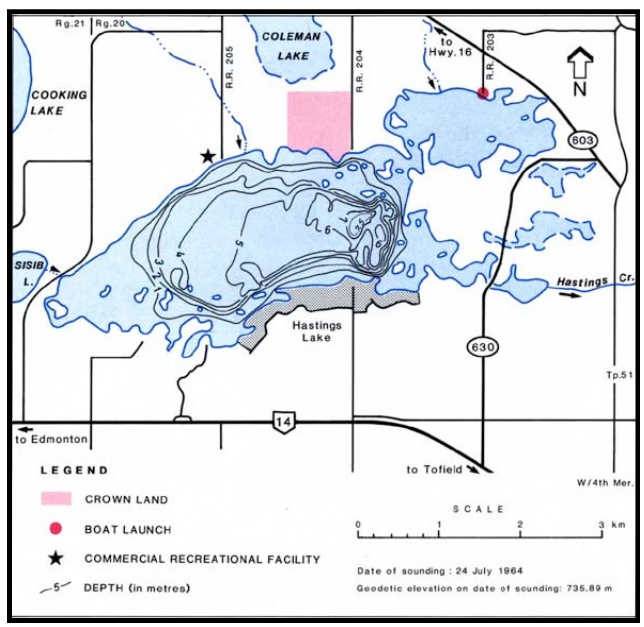

Figure 2- Bathymetric map of Hastings Lake, obtained from Alberta Environment.

The Cree name for the lake is a-ka-ka-kwa-tikh, which means "the lake that does not freeze". Apparently, springs that flow into the lake bottom prevent parts of the lake from icing over in the winter. In 1884, the lake and its outlet were renamed by J.B. Tyrell for Tom Hastings, a member of Tyrrell's geological survey party.[1]

Hastings Lake is a shallow, medium-sized water body that consists of two basins separated by a narrow channel. The small, northeast basin is known locally as Little Hastings Lake. The lake has more than 20 islands, mostly located in the main basin; their number and size vary with the water level. When the main

[1] Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press. Retrieved from http://sunsite.ualberta.ca/projects/alberta-lakes/

basin was surveyed in July 1964, its maximum depth was 7.3 m.

The first settlers at Hastings Lake were Jonas Ward and August Gladue, who arrived sometime during the late 1800's. A Grand Trunk Railway station was built in 1909 at the hamlet of Deville, 2.5 km north of the lake, and a post office was established there soon after. In 1912, the school district of Deville was created, and a school was built in the hamlet. By the late 1890s's, most of the virgin timber had been removed from the area surrounding Hastings Lake, either by fire or by timber cutting. In 1893, Alberta's first forest reserve, the Cooking Lake Forest Reserve, was opened. It included all of Hasting's Lake drainage basin as well as land north and south of the drainage basin.[1]

Most of the people who use Hastings Lake are local residents, and recreational facilities for visitors are limited. The only campground is Kawtikh Recreational Retreat on the north shore, a commercially operated facility that opened in 1988. There are 40 rustic campsites, a playground, a picnic area, and a boat launch. The area is used for picnicking, bird watching, and wildlife viewing. Grazing is permitted and the land is fenced, but access to the lakeshore is available and small boats can be launched at the end of the range road. The remainder of the shoreline, with the exception of some reserve land within the hamlet of Hastings Lake, is privately owned. West of the hamlet, there is a private camp owned by the Legion of Frontiersmen and a private sailing club, the Cutty Sark Club. Within the hamlet there is a summer camp operated by the Hastings Lake and Lutheran Bible Camp Association. The most popular recreational activities at Hastings Lake are bird watching, sailing, canoeing, rowing, and power boating.

WATER QUANTITY:

There are many factors influencing water quantity. Some of these factors include the size of the lakes drainage basin, precipitation, evaporation, water consumption, ground water influences, and the efficiency of the outlet channel structure at removing water from the lake.

Hastings Lake's water levels have fluctuated greatly throughout the past – an estimated minimum of 733.39 meters above sea level (m asl) was reached in 1949, while a measured maximum of 736.739 m asl was reached in 1997. Water levels have continued to decline since 1997, measuring an average of 734.617 m asl in 2012 (Figure 3). Concerns over water quantity in the past prompted Alberta Environment to conduct a study which concluded that precipitation patterns have the greatest influence on Hastings Lake's water levels. Further information regarding Hastings Lake's historical water levels can be found in the Atlas of Alberta Lakes.[1]

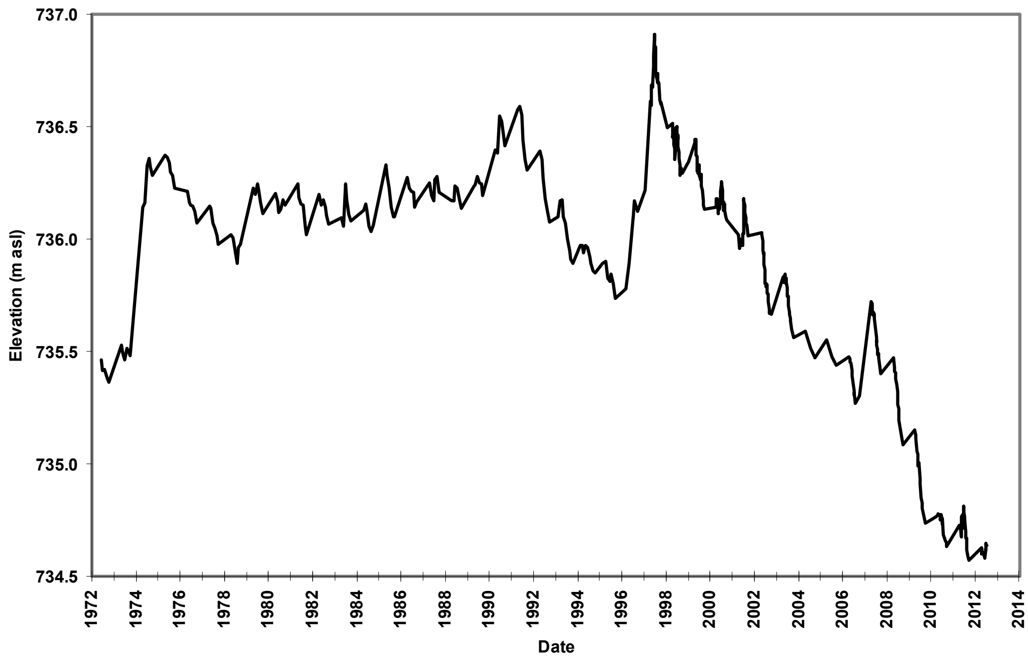

Figure 3 - Water levels measured at Hastings Lake in meters above sea level (m asl). Data retrieved from Alberta Environment.

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 disk depth in 2012 was low, measuring 0.59 m; this average is slightly lower than that measured in 2008 (Table 1). Throughout the summer Secchi disk depth changed very little, measuring a minimum of 0.50 m on August 28th and September 25th, and a maximum of 0.75 m on July 18th. Water clarity at Hastings Lake is influenced by both algae/cyanobacteria concentrations and total suspended solids. The concentration of total suspended solids remained high throughout the summer, averaging 19.04 mg/L. Because Hastings Lake is shallow, wind energy and boating activity are able to stir bottom sediments into the water column. Hastings Lake also has high concentrations of dissolved organic carbon (48.8 µg/L) which may colour the lake water, reducing transparency.

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.

Surface water temperatures changed dramatically throughout the summer at Hastings Lake (Figure 4). On September 25th surface water temperature measured a minimum of 15.50 °C, while on August 8th surface water temperature reached a maximum of 23.34 °C. Despite its shallow depth, thermal stratification was observed during three of the five sampling trips. The presence of thermal stratification has important implications for both nutrient dynamics and dissolved oxygen concentrations.

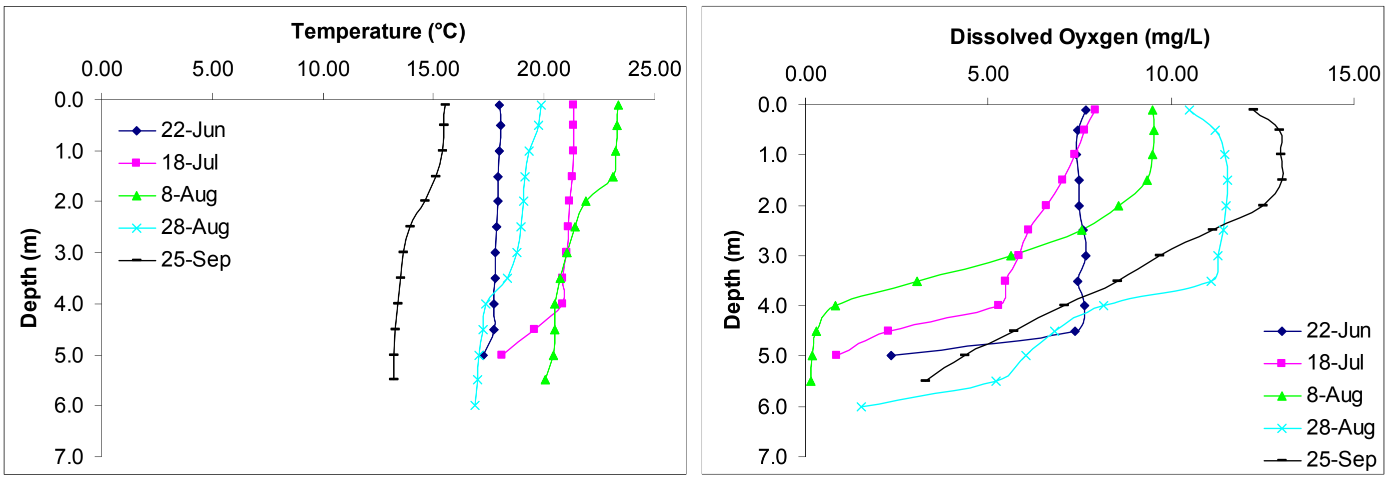

Figure 4 – a) Temperature and b) dissolved oxygen profiles measured five times over the course of the summer at Hastings Lake.

Surface dissolved oxygen concentrations fluctuated throughout the summer, measuring a minimum of 7.65 mg/L at the surface on June 22nd and a maximum of 12.23 mg/L on September 25th. Sharp declines in dissolved oxygen concentrations near the lakebed are caused in part by the thermocline which separates bottom waters from atmospheric oxygen, and by the oxygen-consuming process of decomposition which occurs on the lakebed. On both June 22nd and July 18th, approximately half the water column fell below the Canadian Council for Ministers of the Environment recommended guidelines of 6.5 mg/L for the Protection of Aquatic Life.

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.

Average Total Phosphorus (TP) measured 88 μg/L during the summer of 2012 – this value falls at the high end of the eutrophic, or nutrient rich, classification (Table 1). When compared to previous years' measurements, a value of 88 μg/L falls at the low end of Hastings Lake's historical variation.

Chlorophyll-*a* measured an average of 32.02 μg/L in 2012 (Table 1). This value falls into the hypereutrophic, or extremely productive, classification, which is the same classification that Hastings Lake has fallen into in the past. Throughout the summer, chlorophyll-*a* concentrations ranged from a minimum of 20.8 μg/L on August 8th to a maximum of 41.0 μg/L on August 28th (Figure 5). Frequent stratification and mixing events may serve to redistribute nutrients throughout the water column during the summer

Finally, total Kjeldahl nitrogen (TKN) measured an average of 4740 μg/L in 2012. This value falls well above the hypereutrophic classification, which is typical of nitrogen levels in Hastings Lake (Table 1). Levels of nitrogen changed dramatically throughout the summer, measuring a minimum of 2430 μg/L on June 22nd to a maximum of 10300 μg/L on September 25th (Figure 5).

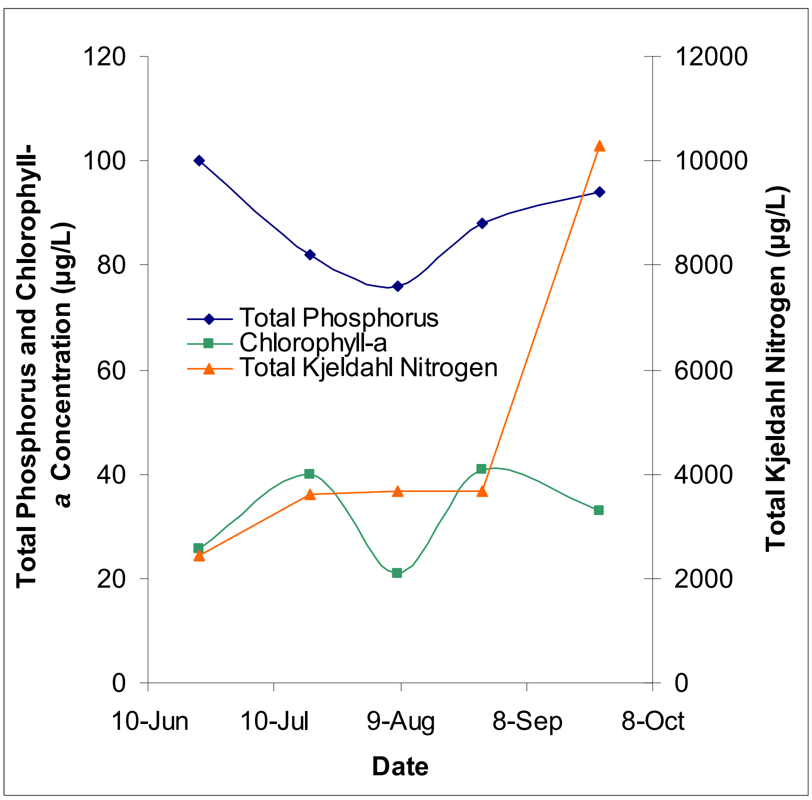

Figure 5 – Total Phosphorus (μg/L), total Kjeldahl nitrogen (μg/L), and chlorophyll-*a* (μg/L) concentrations measured five times over the course of the summer of 2012.

Average pH at Hastings Lake in 2012 measured 9.07, which is well above neutral (Table 1). Moderately high bicarbonate (349.6 mg/L HCO_3) concentration and alkalinity (357.4 mg/L $CaCO_3$) may help to protect the lake from changes to pH. Conductivity in Hastings Lake is high, with sulphate (382 mg/L) and sodium (168 mg/L) acting as the dominant ions in the lake. Microcystin, a toxin produced by cyanobacteria, measured 0.582 µg/L, which is well below the recreational guidelines of 20 µg/L. Throughout the summer, microcystin concentration measured a maximum of 1.66 µg/L on July 18th.

Metals were measured twice throughout the summer, and all concentrations fell within their respective guidelines (Table 2). Arsenic levels were high (4.12 µg/L), though still fell below the Canadian Council for Ministers of the Environment guidelines of 6.5 mg/L for the Protection of Aquatic Life.

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

Parameter	1987	1999	2008	2012
TP (µg/L)	116	96	77.5	88
TDP (µg/L)	/	/	20	30.8
Chlorophyll-*a* (µg/L)	72.5	44	30.4	32.02
Secchi depth (m)	0.90	2.10	0.85	0.59
TKN (µg/L)	3730	2514	3578	4740
NO_2 and NO_3 (µg/L)	/	171	19	2.5
NH_3 (µg/L)	/	/	43.3	34.2
DOC (mg/L)	36	/	40.75	48.8
Ca (mg/L)	29	36	28.6	28.6
Mg (mg/L)	46	/	61.3	72
Na (mg/L)	98	/	139	168
K (mg/L)	29	/	37.9	44.8
SO_4^{2-} (mg/L)	221	/	275	382
Cl^- (mg/L)	10	/	21.8	25.9
CO_3 (mg/L)	26	/	29.5	42.2
HCO_3 (mg/L)	238	/	323.5	349.6
pH	8.8-9.0	/	8.9	9.07
Conductivity (µS/cm)	917	/	1165	1424
Hardness (mg/L)	258	/	323.5	937
TDS (mg/L)	573.19	/	752	368
TSS	11.5	/	/	19.04
Microcystin (µg/L)	/	/	0.215	0.582
Total Alkalinity (mg/L $CaCO_3$)	238	/	315	357.4

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 - Concentrations of metals measured in Hastings Lake on August 8th and September 25th 2012. Values shown for 2012 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)	2012	Guidelines
Aluminum µg/L	44.35	100[a]
Antimony µg/L	0.2615	6[e]
Arsenic µg/L	4.12	5
Barium µg/L	63.45	1000[e]
Beryllium µg/L	0.01395	100[d,f]
Bismuth µg/L	0.0005	/
Boron µg/L	167.5	5000[ef]
Cadmium µg/L	0.0055	0.085[b]
Chromium µg/L	0.529	/
Cobalt µg/L	0.111	1000[f]
Copper µg/L	1.195	4[c]
Iron µg/L	19.95	300
Lead µg/L	0.0624	7[c]
Lithium µg/L	141	2500[g]
Manganese µg/L	49.4	200[g]
Molybdenum µg/L	0.2315	73[d]
Nickel µg/L	0.14125	150[c]
Selenium µg/L	0.255	1
Silver µg/L	0.00025	0.1
Strontium µg/L	282.5	/
Thallium µg/L	0.00015	0.8
Thorium µg/L	0.00015	/
Tin µg/L	0.015	/
Titanium µg/L	1.4	/
Uranium µg/L	0.684	100[e]
Vanadium µg/L	0.8215	100[f,g]
Zinc µg/L	1.545	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:

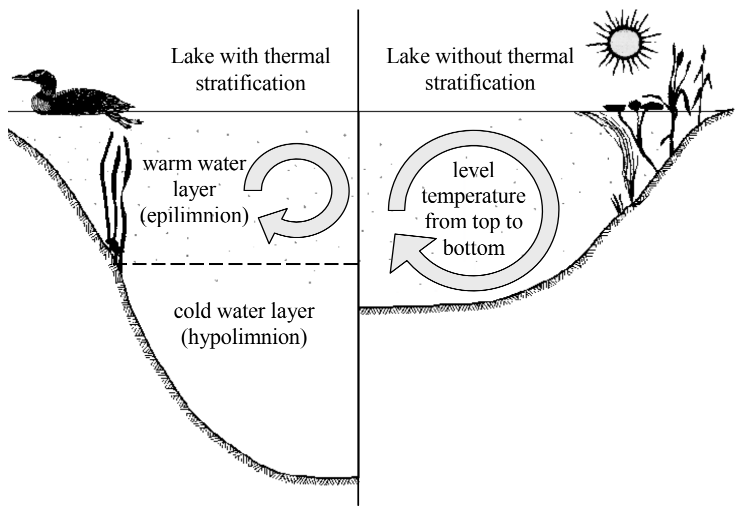

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

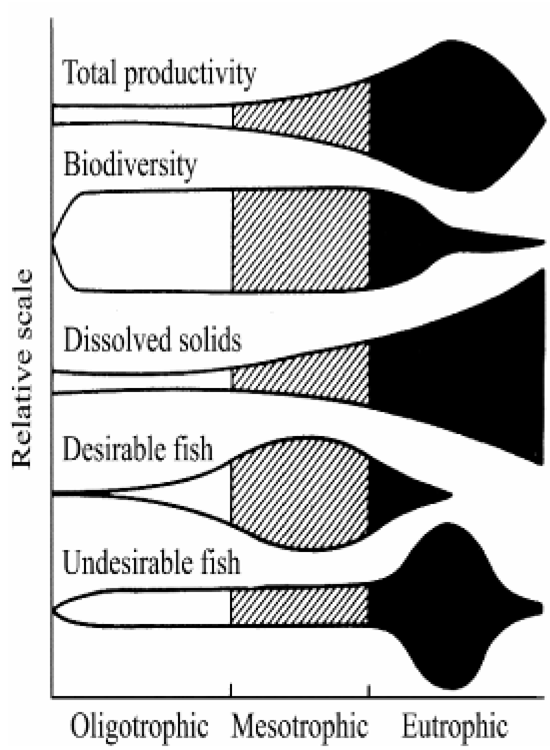

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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