



*THE ALBERTA LAKE MANAGEMENT SOCIETY  
VOLUNTEER LAKE MONITORING PROGRAM*

## **2011 Calling 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.

### **Acknowledgements**

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank Avar Mann for coordinating the sampling of Calling Lake in 2011. We would also like to thank Jessica Davis and Pauline Pozsonyi who were summer interns with ALMS in 2011. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Technologists Shelley Manchur and Brian Jackson were involved in the training aspects of the program. Doreen LeClair, Chris Rickard, and Lisa Reinbolt were responsible for data management. Théo Charette, Ron Zurawell, Lori Neufeld, and Sarah Lord prepared the original report, which was updated for 2011 by Bradley Peter and Arin Dyer. Alberta Environment, the Beaver River Watershed Alliance (BRWA), and the Municipal District of Wainwright were major sponsors of the LakeWatch program.

## CALLING LAKE:

Calling Lake is located in the Municipal District of Opportunity No. 17, approximately 200 km north of the city of Edmonton in the Athabasca River watershed. The hamlet of Calling Lake and the St. Jean Baptiste Gambler Indian Reserve No. 183 are located on the lake's eastern shore (Figure 1).

The lake's name is a translation of the Cree words Kitow Sâkâhikan which refers to the loud noises heard when the lake freezes over<sup>1</sup>. The Calling Lake area has been inhabited for thousands of years; archaeological digs have discovered remnants of a hunter-gatherer band dating as far back as 6000 B.C.<sup>2</sup> In recent history, the area was inhabited by the Woodland Cree and early fur traders who used the lake to catch their winter supply of fish<sup>3</sup>. Calling Lake Provincial Park was established in 1971 on 741 ha of land on the southern shore of the lake. Today, the park is a popular summer vacation area used for camping, fishing, motor boating, swimming, and canoeing. The main sport fish are northern pike (*Esox lucius*), yellow perch (*Perca flavescens*), walleye (*Sander vitreus*), burbot (*Lota lota*), and lake whitefish (*Coregonus clupeaformis*).

Calling Lake has a large drainage basin covering an area of 1,092 km<sup>2</sup>, mostly to the north of the lake.<sup>4</sup> The main outlet, the Calling River, flows from the southeast end of the lake to the Athabasca River, approximately 25 km downstream. Calling Lake has a

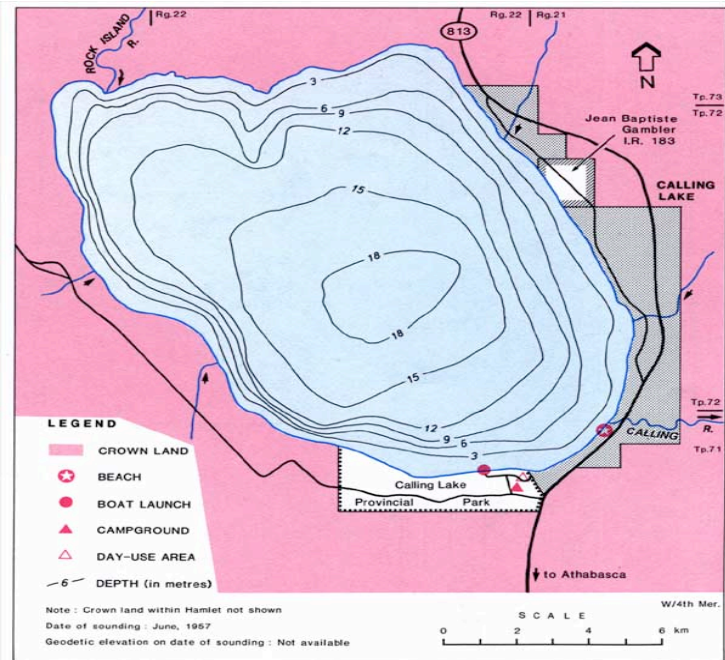


Figure 1 – Bathymetric map of Calling Lake obtained from Mitchell and Prepas, 1990.

<sup>1</sup> Aubrey, M. K. 2006. Concise place names of Alberta. Retrieved from <http://www.albertasource.ca/placenames/resources/searchcontent.php?book=1>

<sup>2</sup> Athabasca Historical Society, D. Gregory and Athabasca University. 1986. Athabasca Landing: An illustrated history. Athabasca Hist. Soc., Athabasca.

<sup>3</sup> Finlay, J. and C. Finaly. 1987. Parks in Alberta: A guide to peaks, ponds, parklands & prairies. Hurtig Publ., Edmonton.

<sup>4</sup> Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press. Retrieved from <http://sunsite.ualberta.ca/projects/alberta-lakes/>

surface area of 138 km<sup>2</sup>, making it one of Alberta's larger lakes, with a moderate maximum depth of 18.3 m in the centre of the basin (Figure 1).

Calling Lake lies within the central mixedwood subregion of the boreal forest natural region<sup>5</sup>. A large portion of Calling Lake's drainage basin is covered by wetlands, with the remainder forested with a mixture of aspen, balsam poplar, white spruce, black spruce, and jack pine. Only a few small areas southwest of the lake are being farmed. The main human activities in the watershed include forestry and oil and gas exploration and extraction.

#### **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.*

The primary inflow into Calling Lake is the Rock Island River which drains Rock Island Lake to the north. Other smaller streams and run-off also contribute inflow to Calling Lake. In the past 40 years, water levels at Calling Lake have fluctuated at least 0.9 meters above sea level (m asl; Figure 3). In 1974, water levels at Calling Lake were at a historical maximum of 594.4 m asl. From there, water levels declined until a historical minimum of 593.5 m asl in 2002. After 2002, water levels increased and have fluctuated around 594.2 m asl. A high runoff year in 2011 brought water levels back up from 593.940 m asl in 2010 to 594.193 m asl.

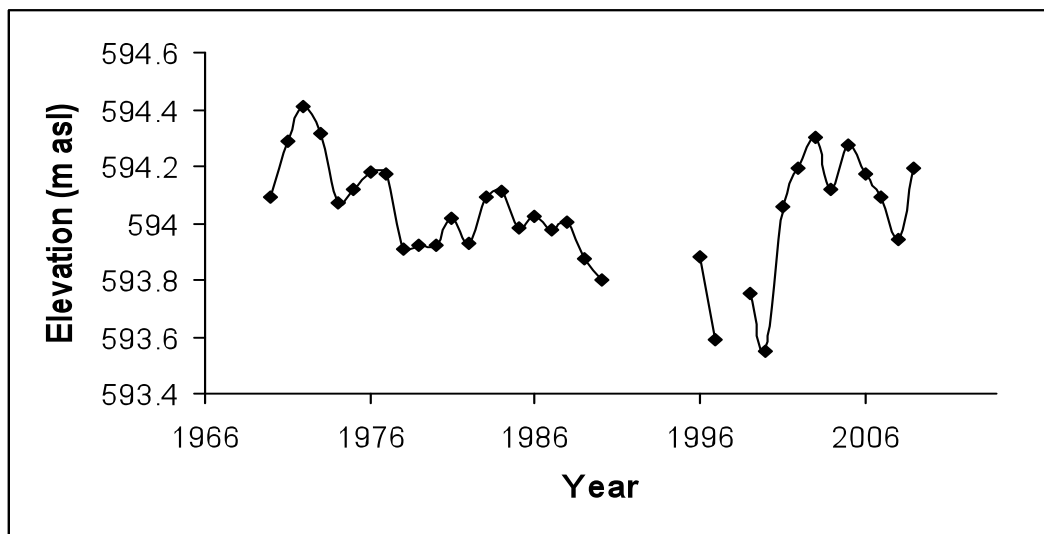


Figure 2 – Water levels measured at Calling Lake in meters above sea level (m asl) by Environment Canada. Measurements were taken from the Ranger Station on the lake.

<sup>5</sup> Strong, W.L. and K.R. Leggat. 1981. Ecoregions of Alberta. Alta. En. Nat. Resour., Resour. Eval. Plan. Div., Edmonton.

## 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 measured at Calling Lake in 2011 was 2.85 m (Table 1). This average is slightly higher than that recorded in previous years, though varies little from the historical average. A Secchi disk depth of 2.85 m suggests that enough light is available for photosynthesis in only the first 5.70 m of the water column, or ~30% of the water column. Throughout the summer, Secchi disk depth ranged from a minimum of 1.0 m on August 10<sup>th</sup> to 4.5 m on September 20<sup>th</sup>. Algae/cyanobacteria are likely the main factors affecting water transparency at Calling 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.*

Water temperature at Calling Lake varied greatly throughout the summer (Figure 3a). On September 20<sup>th</sup>, surface water temperature measured a seasonal minimum of 14.70 °C, while on August 10<sup>th</sup>, surface water temperature was 19.15 °C. Thermal stratification was present during three of the sampling trips, occurring quite deep in the water column. On June 13<sup>th</sup>, thermal stratification began at 12.0 m, and by August 24<sup>th</sup> stratification moved deeper to 15.5 m. By September 20<sup>th</sup>, the lake had mixed and temperature became uniform throughout the water column. At large round lakes it is easy for wind energy to mix greater amounts of water, often preventing the establishment of thermal stratification.

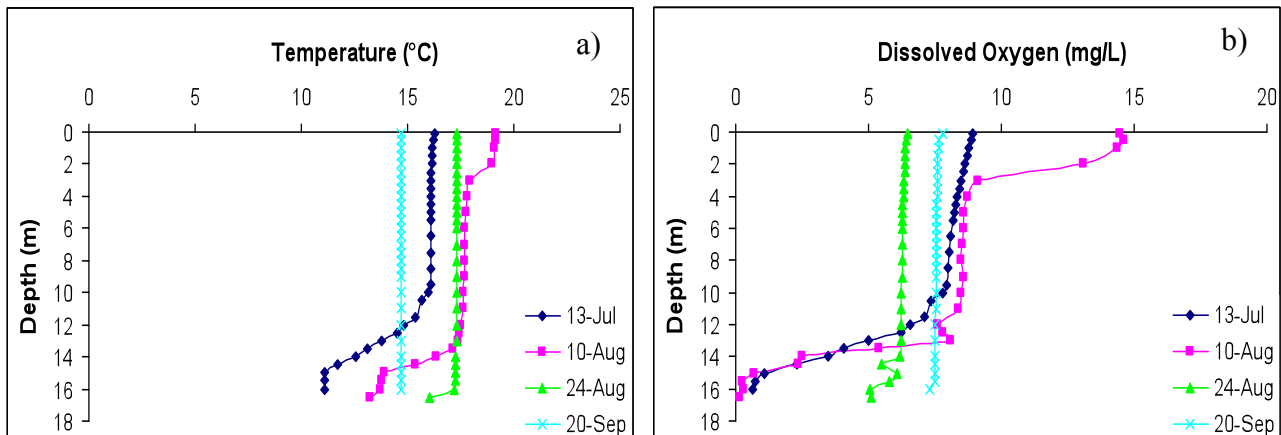


Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles measured four times during the course of the summer of 2011 at Calling Lake

Similar to temperature, dissolved oxygen also varied greatly throughout the summer (Figure 3b). On August 10<sup>th</sup>, during an algae/cyanobacteria bloom, dissolved oxygen was at a maximum, measuring 14.48 mg/L at the surface. In contrast, on August 24<sup>th</sup> after the collapse of the algae/cyanobacteria bloom, dissolved oxygen had dropped to 6.45 mg/L at the surface, leaving the entire water column below the Canadian Council for Ministers of the Environment recommendation for the Protection of Aquatic Life guideline of 6.5 mg/L. In each instance of thermal stratification, dissolved oxygen declined quickly below the thermocline. This is common in stratified lakes, as thermal stratification prevents the mixing of atmospheric oxygen to deeper depths, isolating the oxygen-consuming decomposition that occurs at the lakebed.

#### **WATER CHEMISTRY:**

*ALMS measures a suite of water chemistry parameters. Phosphorous, 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 Phosphorous (TP) in Calling Lake measured 76.2 µg/L during the summer of 2011, which falls into the eutrophic, or highly productive, classification (Table 1). This is much higher than previously recorded historical averages, and may be the result of high amounts of runoff. TP increased steadily throughout the summer, measuring a seasonal minimum of 34 µg/L on June 13<sup>th</sup> and 113 µg/L on September 20<sup>th</sup> (Figure 5).

Similarly, average Total Kjeldahl Nitrogen (TKN) in 2011 (966 µg/L) fell into the eutrophic classification and was higher than recorded in previous years. TKN measured a minimum of 650 µg/L on June 13<sup>th</sup> and July 13<sup>th</sup>, and a maximum of 1440 µg/L on August 10<sup>th</sup>.

Finally, average chlorophyll-*a* concentration was eutrophic at 20.67 µg/L. Chlorophyll-*a* concentration changed dramatically throughout the summer, measuring a maximum of 76.9 µg/L on August 10<sup>th</sup> and a minimum of 2.09 µg/L on August 24<sup>th</sup>. On August 12<sup>th</sup>, a blue-green algae advisory was



Figure 4 – A visual comparison of algae/cyanobacteria levels in Calling Lake in June and July of 2011. Photo by Pauline Pozsonyi.



posted at the lake by Alberta Health Services. Microcystin, a toxin produced by blue-green algae, is the primary reason for such advisories. This advisory was lifted on October 24<sup>th</sup> 2011. The absence of blue-green algae does not mean there is no longer a threat to health, as microcystin toxin can persist in the environment long after the algae is gone.

Average pH measured at Calling Lake in 2011 was 8.26, which is well above neutral (Table 1). Moderate alkalinity (92 mg/L CaCO<sub>3</sub>) and moderately high bicarbonate concentration (110.6 HCO<sub>3</sub> µg/L) may help to buffer the lake against changes to pH. Concentrations of all other ions were low and have not changed appreciably from previous years. Low ion concentration was reflected in a low conductivity (337 µS/cm).

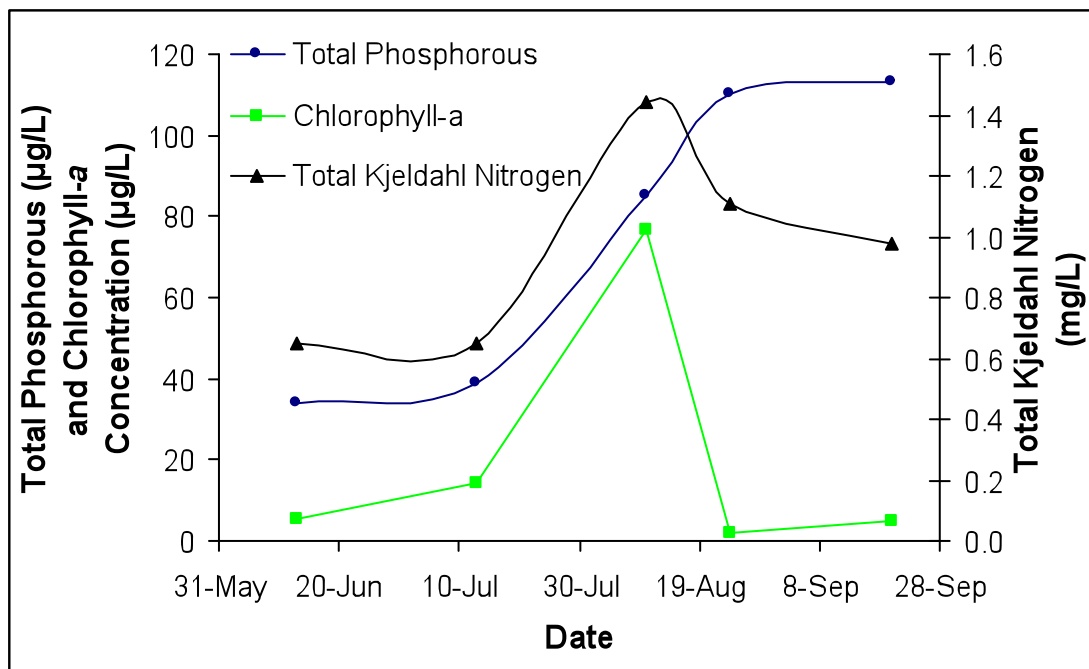


Figure 5 – Total phosphorous (µg/L), total Kjeldahl nitrogen (µg/L), and chlorophyll-*a* concentration (µg/L) measured five times throughout the course of the summer at Calling Lake.

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

<b>Parameter</b>	<b>1988</b>	<b>2000</b>	<b>2001</b>	<b>2010</b>	<b>2011</b>
TP (µg/L)	50.0	55.0	54.0	42.0	76.0
TDP (µg/L)	19.0	15.7	18.0	11.0	43.0
Chlorophyll- <i>a</i> (µg/L)	19.10	20.60	19.00	16.54	20.67
Secchi depth (m)	2.70	2.70	2.70	2.38	2.85
TKN (µg/L)	777.0	656.0	937.0	910.0	966
NO <sub>2</sub> and NO <sub>3</sub> (µg/L)	<7	2.2	6.0	4.3	17
NH <sub>3</sub> (µg/L)	33.0	14.2	31.0	14.0	127
DOC (mg/L)	/	/	/	10.9	11.27
Ca (mg/L)	22.0	22.0	23.0	17.1	22.6
Mg (mg/L)	6.0	6.0	6.0	5.6	6.3
Na (mg/L)	5.0	5.0	5.0	6.6	5.5
K (mg/L)	2.0	2.0	2.0	1.8	1.8
SO <sub>4</sub> <sup>2-</sup> (mg/L)	4.0	3.6	4.0	7.0	2.7
Cl <sup>-</sup> (mg/L)	1.0	0.6	1.0	1.2	1.2
CO <sub>3</sub> (mg/L)	/	/	/	/	1.4
HCO <sub>3</sub> (mg/L)	/	/	/	111	110.6
pH	7.4-8.5	8.6	9.0	8.2	8.26
Conductivity (µS/cm)	168.0	173.3	170.0	182.0	184
Hardness (mg/L)	/	/	/	65.6	82.07
TDS (mg/L)	/	/	/	93.9	95.27
Microcystin (µg/L)	/	/	/	0.71	0.078
Total Alkalinity (mg/L CaCO <sub>3</sub> )	82	84	85	91	92

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO<sub>2+3</sub> = nitrate+nitrite, NH<sub>3</sub> = ammonia, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO<sub>4</sub> = sulphate, Cl = chloride, CO<sub>3</sub> = carbonate, HCO<sub>3</sub> = bicarbonate. A forward slash (/) indicates an absence of data.



# 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:

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

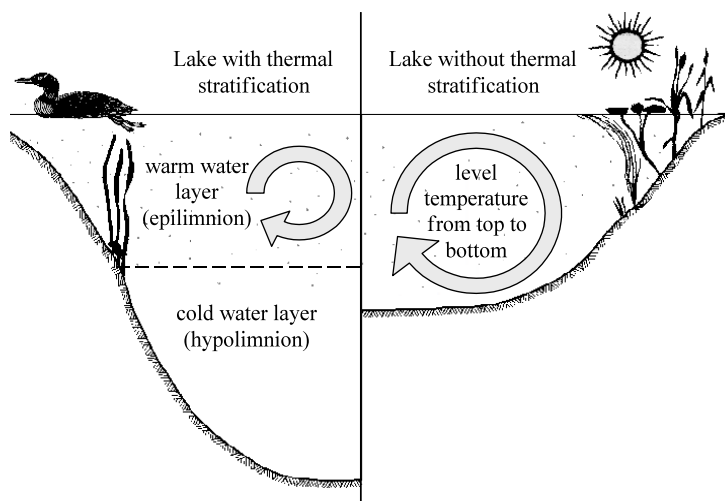


Figure A: Difference in the circulation of the water column depending on thermal stratification.

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•L<sup>-1</sup> and should not average less than 6.5 mg•L<sup>-1</sup> over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 mg•L<sup>-1</sup> in areas where early life stages of aquatic biota, particularly fish, are present.

#### **GENERAL WATER CHEMISTRY:**

Water in lakes always contains substances that have been transported by rain and snow or have entered the lake in groundwater and inflow streams. These substances may be dissolved in the water or suspended as particles. Some of these substances are familiar minerals, such as sodium and chloride, which when combined form table salt, but when dissolved in water separate into the two electrically charged components called **ions**. Most dissolved substances in water are in ionic forms and are held in solution due to the polar nature of the water molecule. **Hydrophobic** (water-fearing) compounds such as oils contain little or no ionic character, are non-polar and for this reason do not readily dissolve in water. Although hydrophobic compounds do not readily dissolve, they can still be transported to lakes by flowing water. Within individual lakes, ion concentrations vary from year to year depending on the amount and mineral content of the water entering the lake. This mineral content can be influenced by the amount of precipitation and other climate variables as well as human activities such as fertilizer and road salt application.

## **PHOSPHORUS AND NITROGEN:**

Phosphorus and nitrogen are important nutrients limiting the growth of algae in Alberta lakes. While nitrogen usually limits agricultural plants, phosphorus is usually in shortest supply in lakes. Even a slight increase of phosphorus in a lake can, given the right conditions, promote algal blooms causing the water to turn green in the summer and impair recreational uses. When pollution originating from livestock manure and human sewage enters lakes not only are the concentrations of phosphorus and nitrogen increased but nitrogen can become a limiting nutrient which is thought to cause blooms of toxic algae belonging to the cyanobacteria. Not all cyanobacteria are toxic, however, the blooms can form decomposing mats that smell and impair dissolved oxygen concentrations in the lake.

## **CHLOROPHYLL-*a*:**

Chlorophyll *a* is a photosynthetic pigment that green plants, including algae, possess enabling them to convert the sun's energy to living material. Chlorophyll *a* can be easily extracted from algae in the laboratory. Consequently, chlorophyll *a* is a good estimate of the amount of algae in the water. Some highly productive lakes are dominated by larger aquatic plants rather than suspended algae. In these lakes, chlorophyll *a* and nutrient values taken from water samples do not include productivity from large aquatic plants. The result, in lakes like Chestermere which are dominated by larger plants known as macrophytes, can be a lower trophic state than if macrophyte biomass was included. Unfortunately, the productivity and nutrient cycling contributions of macrophytes are difficult to sample accurately and are therefore not typically included in trophic state indices.

## **SECCHI DISK TRANSPARENCY :**

Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. A measure of the transparency or clarity of the water is performed with a Secchi disk with an alternating black and white pattern. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the disk disappears is recorded. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. However, low Secchi depths are not caused by algal growth alone. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly low Secchi depths despite low algal growth and nutrient concentrations.

The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Conversely, aquatic plants can ensure lakes have clear water by reducing shoreline erosion and stabilizing lake bottom sediments. In Alberta, many lakes are shallow and

bottom sediments contain high concentrations of nutrients. Without aquatic plants, water quality may decline in these lakes due to murky, sediment laden water and excessive algal blooms. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and insects, depend on aquatic plants for food and shelter.

#### TROPHIC STATE:

Trophic state is classification of lakes into four categories of fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass (as chlorophyll) concentrations, the trophic states are; **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic** (Table 2).

A majority of lakes in Alberta contain naturally high levels of chlorophyll *a* (8 to 25 µg/L) due to our deep fertile soils. These lakes are usually considered fertile and are termed eutrophic. The nutrient and algal biomass concentrations that define these categories are shown in the following table, a figure of Alberta lakes compared by trophic state can be found on the ALMS website.

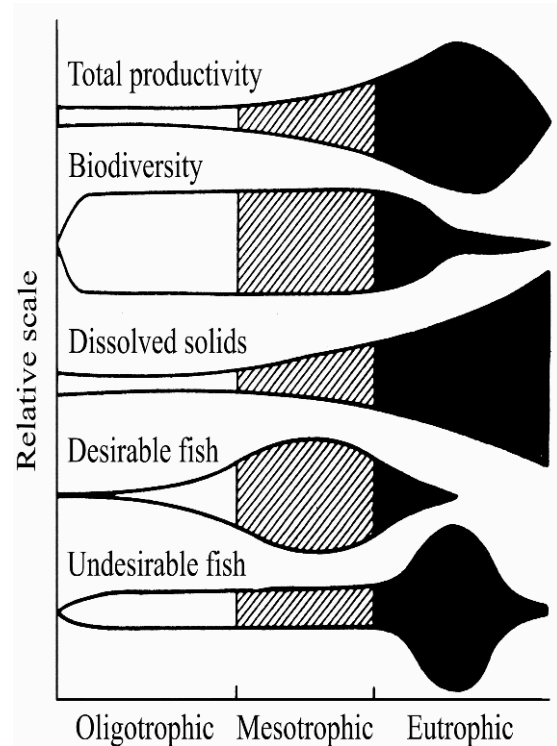


Figure B: Suggested changes in various lake characteristics with eutrophication.

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

Trophic state	Total Phosphorus (µg•L <sup>-1</sup> )	Total Nitrogen (µg•L <sup>-1</sup> )	Chlorophyll a (µg•L <sup>-1</sup> )	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