



*THE ALBERTA LAKE MANAGEMENT SOCIETY  
VOLUNTEER LAKE MONITORING PROGRAM*

## **2011 Skeleton 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 Orest Kitts and Roy Nilson for their time and energy in sampling the north and south basins of Skeleton Lake, respectively, as well as Peter Sherman for arranging the sampling in the south basin. We would also like to thank Jessica Davis and Pauline Pozsonyi who were LakeWatch technicians 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.

## SKELETON LAKE:

Skeleton Lake is located in the western portion of the Beaver River watershed. The lake's name is a translation of the Cree *Cîpay Sâkâhikan*, which means "place of the skeletons". It is thought that a Cree chief is buried along the shores of the lake.<sup>1</sup>

The lake is located within the County of Athabasca, 160 km northeast of the city of Edmonton and 6.5 km northeast of the village of Boyle. Skeleton Lake has an extensively developed shoreline with the summer villages of Mewatha and Bondiss on the southern shore of the lake and additional cottage developments on the north shore. Since 1968, Skeleton Lake has been the main source of drinking water for the Town of Boyle.

The watershed is located in the Dry Mixedwood subregion of the Boreal Mixedwood natural region.<sup>2</sup> Several small intermittent streams flow into the lake and drain a watershed that is four times the size of the lake.<sup>3</sup> The outlet is a small creek located at the southeast end of the lake, and drains eastward into Amisk Lake. Beaver dams, however, often block the outlet. Tree cover in the watershed is primarily trembling aspen and secondarily white spruce, balsam poplar, and white birch. Peatlands are also significant, and most agricultural activities in the watershed take place in the southern and northwestern sections.

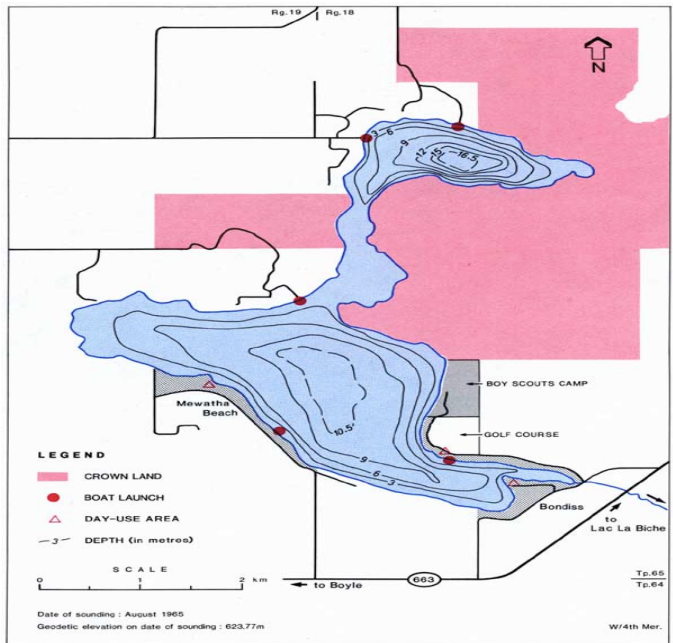


Figure 1 – Bathymetric map of Skeleton Lake obtained from Alberta Environment.



Figure 2 – A view of the north bay of Skeleton Lake. Photo: Pauline Pozsonyi.

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

<sup>3</sup> Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press. Retrieved from <http://sunsite.ualberta.ca/projects/alberta-lakes/>

Skeleton Lake is divided into two basins. The North basin (Figure 2) is nearly separated from the South basin by a shallow, weedy narrows. During the late 1940's, when lake levels were low, the two basins were separated by exposed land at the narrows. In 2008, the lake levels were again low enough that the narrows were dry and have remained dry to date. The North basin is small and deep, with steeply sloped sides that reach a maximum depth of about 17 m. The larger South basin slopes gradually to a maximum depth of 11 m. Skeleton Lake is very fertile and blooms of blue-green algae turn the water green in both basins during the summer months.<sup>3</sup> The average concentrations of algae in the South basin are higher than in the North basin. Because the basins are almost disconnected and the morphology and water quality characteristics of the two basins differ, the water quality of the North and South basins are reported separately for the 2010 LakeWatch Report.

### **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.*

Water levels in Skeleton Lake have been monitored in the south basin since 1965 under the joint Federal-Provincial Hydrometric agreement (Figure 3). Consistent with other lakes in the area, water levels have decreased steadily by about 1.6 meters since the 1970s, with the exception of 1997, an extremely wet period, during which the water level increased to a historical maximum of 632.9 meters above sea level (m asl). Over the past 14 years, water levels in Skeleton Lake have declined to a historical minimum of 621.8 m asl in 2009. Declining water levels are a major stakeholder concern for this lake. In 2011, monitoring of water levels by Environment and Sustainable Resource Development began in the North basin of Skeleton Lake

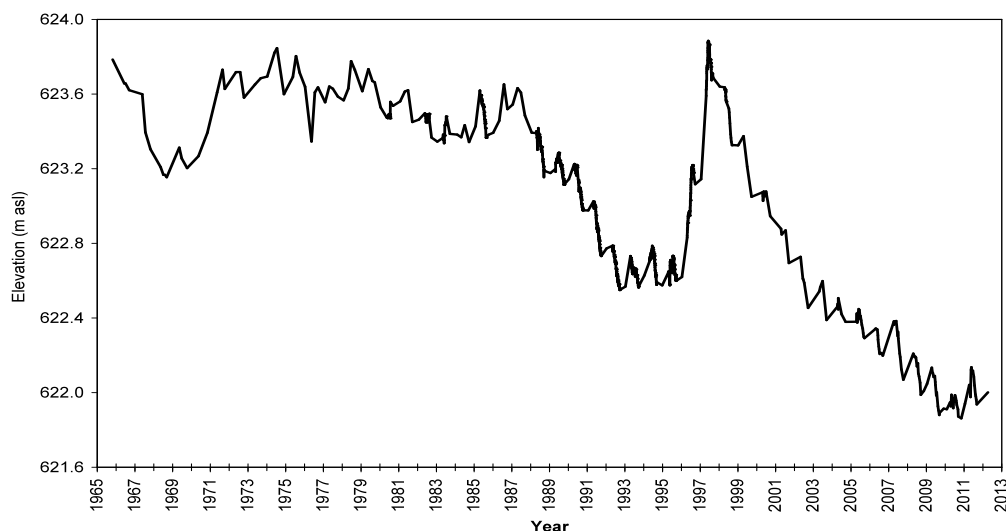


Figure 3 – Water levels at Skeleton Lake measured in meters above sea level (m asl). Data obtained from Alberta Environment.

## **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.*

**North:** Average Secchi disk depth measured 1.95 m during the summer of 2011 (Table 1). This value is less than the historical average, though given the high levels of run-off received in 2011, a lower-than-normal Secchi disk depth is not unexpected. Secchi disk depth ranged from a seasonal maximum of 3.75 m on June 21<sup>st</sup> to a seasonal minimum of 1.43 m on August 17<sup>th</sup>.

**South:** Average Secchi disk depth measured 1.44 m during 2011, slightly less than the historical average recorded at Skeleton Lake North (Table 1). This value is well within the range of variation previously measured at Skeleton South. Throughout the summer, Secchi disk depth changed very little in the South basin, measuring 1.5m on June 21<sup>st</sup>, July 5<sup>th</sup>, and July 27<sup>th</sup>, and 1.25m on August 27<sup>th</sup>.

## **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.*

**North:** Surface water temperature at Skeleton Lake North changed greatly throughout the summer, measuring a minimum of 14.35 °C on September 21<sup>st</sup>, and a maximum of 20.12 °C on July 27<sup>th</sup> (Figure 4). On each sampling trip, however, thermal stratification was observed, which resulted in a sudden decline in water temperature below the thermocline. The thermocline moved deeper throughout the summer, beginning at 4.5 m in July and at 10.0 m in September. It is unknown whether the lake became fully mixed later in the year (dimictic), or if the lake remains stratified year round (meromictic). Thermal stratification in the North basin is a product of both its deep depth and small size.

**South:** In the south basin of Skeleton Lake, no thermal stratification was observed (Figure 4). Surface water temperatures varied between 16.60 °C on June 21<sup>st</sup> and 19.34 °C on July 27<sup>th</sup>. Because of the absence of stratification, temperature remained relatively uniform throughout the water column for much of the summer in the South basin, measuring as high as 18.31 °C at the lakebed on August 27<sup>th</sup>.

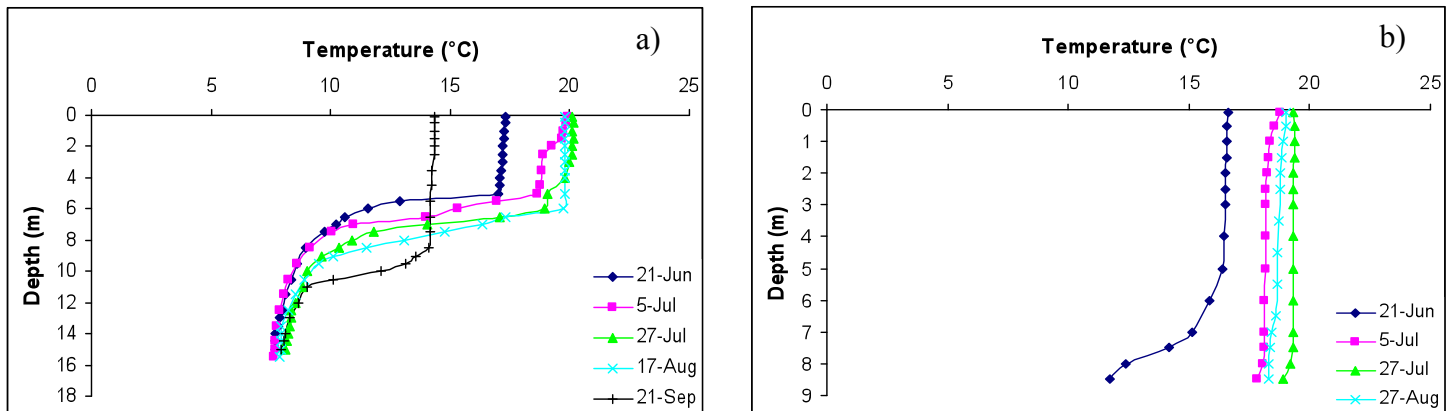


Figure 4 – Temperature (°C) profiles for the a) North basin and b) South basin of Skeleton Lake measured during the summer of 2011.

**North:** Because of thermal stratification, which separates bottom waters from atmospheric and sometimes photosynthetic oxygen, anoxia was observed in bottom waters of the North basin of Skeleton Lake (Figure 5). At the surface, the water was well oxygenated, ranging from a minimum of 8.30 mg/L on September 21<sup>st</sup> to a maximum of 9.81 mg/L on July 5<sup>th</sup>. Below the thermocline, oxygen quickly and consistently proceeded towards anoxia. Decomposition of organic matter, an oxygen-consuming process, also contributes to the decline of oxygen near the lakebed.

**South:** Unlike the north basin, the depth of the anoxic zone in the south basin of Skeleton Lake is much smaller, though still present due to the decomposition of organic matter (Figure 5). For most of its depth, the South basin remained well oxygenated and above the Canadian Council for Ministers of the Environment guideline of 6.5 mg/L for the Protection of Aquatic Life. At the surface, dissolved oxygen concentrations ranged from 10.18 mg/L on July 27<sup>th</sup> to 8.21 mg/L on July 5<sup>th</sup>.

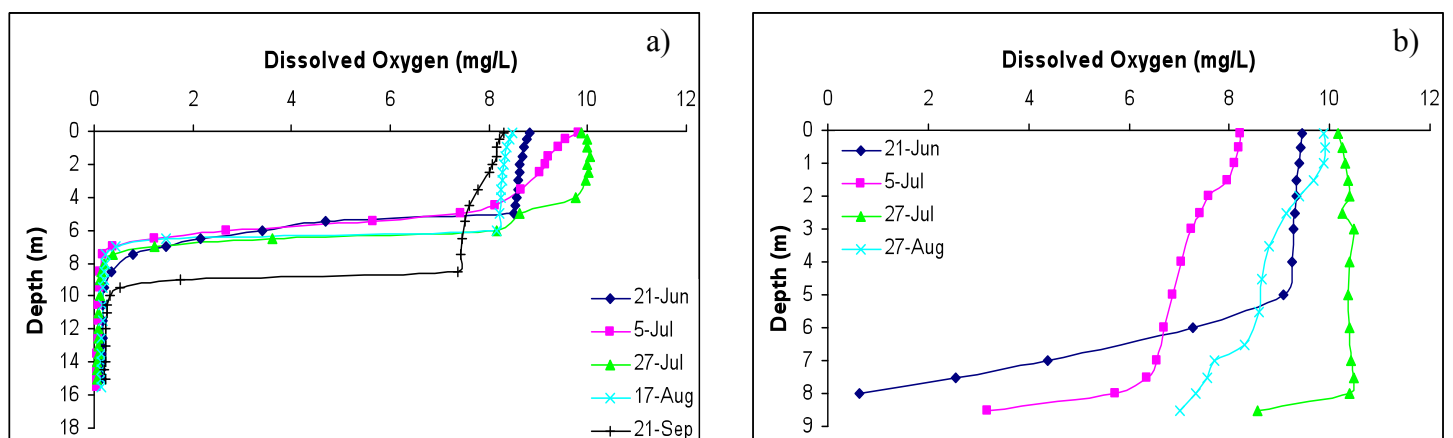


Figure 5 – Dissolved oxygen (mg/L) profiles for the a) North basin, and b) South basin, of Skeleton Lake measured during the summer of 2011.

## 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.*

**North:** Average Total Phosphorous (TP) measured in the north basin of Skeleton Lake during 2011 was 44.8  $\mu\text{g/L}$  (Figure 6). This value falls into the eutrophic, or nutrient rich, classification and is only slightly lower than that measured in 2010. Throughout the summer, TP ranged from a minimum of 36  $\mu\text{g/L}$  on July 27<sup>th</sup> and a maximum of 63  $\mu\text{g/L}$  on September 23<sup>rd</sup>. Average Total Kjeldahl Nitrogen (TKN) measured in the north basin was 1548  $\mu\text{g/L}$ . This falls into the hypereutrophic, or extremely productive, classification, and lies well within the variation previously measured in the North basin. Finally, chlorophyll-*a* concentration measured in the North basin of Skeleton Lake averaged to 9.44  $\mu\text{g/L}$ . This value falls on the low end of the eutrophic classification. Throughout the summer, chlorophyll-*a* concentration varied from 5.28  $\mu\text{g/L}$  on June 21<sup>st</sup> to 14.8  $\mu\text{g/L}$  on July 5<sup>th</sup>.

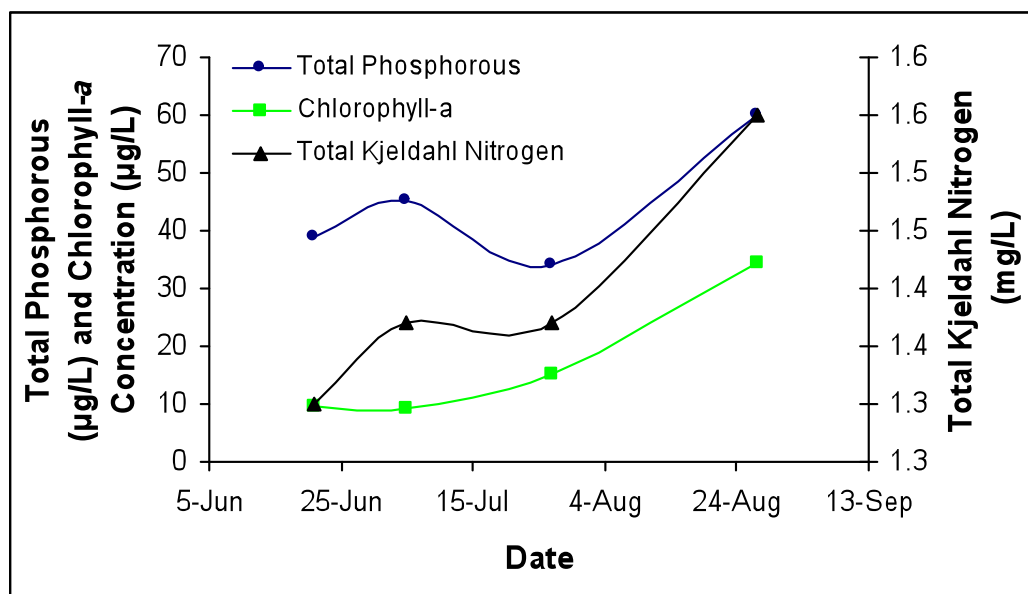


Figure 6 - Total phosphorous ( $\mu\text{g/L}$ ), chlorophyll-a concentration ( $\mu\text{g/L}$ ), and total Kjeldahl nitrogen ( $\text{mg/L}$ ), measured five times over the course of the summer in the north basin of Skeleton Lake.

**South:** The average TP measured in the south basin of Skeleton Lake in 2011 was 44.5  $\mu\text{g/L}$ , which falls in the eutrophic, or nutrient rich, classification (Figure 7). This is almost identical to the average measured in the North basin, and falls well within the variation previously recorded in the South basin. Throughout the summer, TP ranged from 39  $\mu\text{g/L}$  on June 21<sup>st</sup> to 60  $\mu\text{g/L}$  on August 27<sup>th</sup>. Average Total Kjeldahl Nitrogen

(TKN) measured in the South basin of Skeleton Lake was 1398  $\mu\text{g/L}$ . Similar to the North basin, this value falls into the hypereutrophic, or extremely productive, classification, and well within the historical variation observed at Skeleton Lake. Finally, chlorophyll-*a* concentration measured in the South basin of Skeleton Lake averaged to 17.20  $\mu\text{g/L}$ . This is much higher than that recorded in the North basin of Skeleton Lake, and is due mostly to a large algal/cyanobacterial bloom which was measured on August 27<sup>th</sup> and had chlorophyll-*a* concentrations as high as 34.4  $\mu\text{g/L}$ . The frequent mixing of the water column in the South basin may act to increase the availability of nutrients for algae/cyanobacteria. An average value of 17.2  $\mu\text{g/L}$  is typical for the South basin of Skeleton Lake.

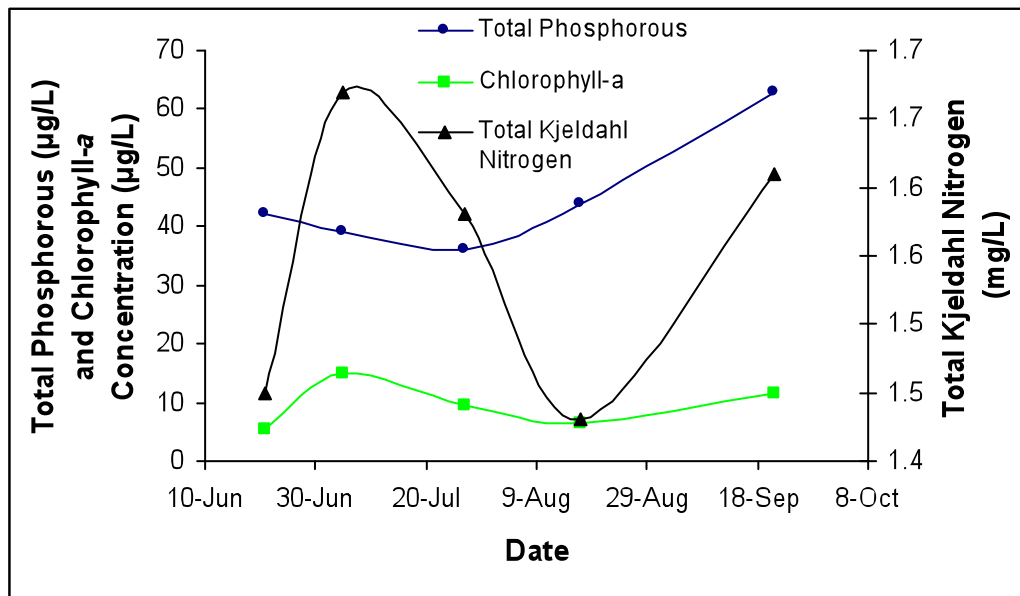


Figure 7 - Total phosphorous ( $\mu\text{g/L}$ ), chlorophyll-a concentration ( $\mu\text{g/L}$ ), and total Kjeldahl nitrogen ( $\text{mg/L}$ ), measured five times over the course of the summer in the south basin Skeleton Lake.



Table 1 – Average Secchi depth and water chemistry values for the north and south basins of Skeleton Lake. Previous years averages are provided for comparison.

Parameter	South								North				
	1985	1986	2005	2006	2008	2009	2010	2011	1985	1986	2005	2010	2011
TP (µg/L)	/	47	29	41	45.4	40.3	58.8	44.5	/	36	33	48	44.8
TDP (µg/L)	/	11	8.4	12.5	13.4	13.5	14.8	11.8	/	10	11	16	15
Chlorophyll-a (µg/L)	16	24	12	17	19.3	12.4	22.32	17.2	9.2	11	11	8.62	9.44
Secchi depth (m)	2	1.6	2.3	1.4	1.65	1.63	1.4	1.4	2.5	2.5	2.6	1.75	1.95
TKN (µg/L)	1139	1318	1158	1290	1324	1135	1564	1398	1160	1140	1300	1612	1548
NO <sub>2</sub> and NO <sub>3</sub> (µg/L)	<3	<3	6.8	<5	<5	12.5	24.8	6	<3	<4	4	5.2	3.4
NH <sub>3</sub> (µg/L)	13	37	14	29	19.2	26.7	22	24.3	21	32	13	82.8	39
DOC (mg/L)	14	/	13	/	16.4	14.6	15.8	14.3	15	/	17	18.6	17.6
Ca (mg/L)	26	/	22	25	22.8	23.6	21.3	22.1	23	/	21	23	23.7
Mg (mg/L)	19	/	23	23	26.9	24.4	25.1	26.65	19	/	24	25.9	25.4
Na (mg/L)	14	/	19	20	20.2	21.3	21.7	19.6	13	/	18	18.7	18.1
K (mg/L)	9	/	11	11	11.5	12.5	11.9	11.6	8	/	11	10.8	11.2
SO <sub>4</sub> <sup>2-</sup> (mg/L)	<5	/	3	6	5	6	2.8	1.5	<5	/	5	6.3	6.8
Cl <sup>-</sup> (mg/L)	<2	/	3.1	3.4	3.8	4.2	4.7	4.4	<2	/	3.2	3.4	5.3
CO <sub>3</sub> (mg/L)	<6	/	11	15	13	12.7	13.3	11.75	<5	/	12	9.7	13.4
HCO <sub>3</sub> (mg/L)	208	/	226	231	223.6	231.3	229.3	229.25	198	/	204	217.7	210.8
pH	8.5-8.8	/	8.7	8.7	8.7	8.76	8.8	8.72	8.4-8.8	/	8.8	8.71	8.84
Conductivity (µS/cm)	/	/	/	389	374	381	391	388	/	/	/	372	374
Hardness (mg/L)	/	/	/	158	168	159	157	165	/	/	/	164	164
TDS (mg/L)	181	/	204	213	211.3	218.3	214	210	172	/	193	205	208
Microcystin (µg/L)	/	/	/	/	/	/	0.31	0.23	/	/	/	0.142	0.11
Total Alkalinity (mg/L CaCO <sub>3</sub> )	178	/	226	210	205.3	211	210	208	170	/	/	195	195

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.

Table 2 - Concentrations of metals measured at the north and south basins of Skeleton Lake. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	South				North		Guidelines
	2008	2009	2010	2011	2010	2011	
Aluminum µg/L	24.1	12.8	22.95	23.2	26.04	13.9	100 <sup>a</sup>
Antimony µg/L	0.033	0.032	0.03335	0.0326	0.03635	0.02885	6 <sup>e</sup>
Arsenic µg/L	1.01	0.983	1.065	0.948	0.8565	0.8685	5
Barium µg/L	55.8	57.3	55.55	56.2	48.95	50.85	1000 <sup>e</sup>
Beryllium µg/L	0.0045	<0.003	0.0015	0.0048	0.00585	0.0052	100 <sup>d,f</sup>
Bismuth µg/L	0.0036	0.004	0.002	0.0014	0.00195	0.00215	/
Boron µg/L	102.5	109.6	97	106	122.5	105.5	5000 <sup>ef</sup>
Cadmium µg/L	<0.002	0.0023	0.00695	0.0045	0.0057	0.001	0.085 <sup>b</sup>
Chromium µg/L	0.115	0.188	0.1395	0.15	0.242	0.0765	/
Cobalt µg/L	0.023	0.0203	0.01325	0.0171	0.01845	0.01115	1000 <sup>f</sup>
Copper µg/L	0.171	0.27	0.1303	0.181	0.1633	0.154	4 <sup>c</sup>
Iron µg/L	49.2	70.4	41	53.4	7.73	3.59	300
Lead µg/L	0.0285	0.0283	0.02505	0.0327	0.0151	0.0137	7 <sup>c</sup>
Lithium µg/L	30.6	36.1	28.05	33.2	31.7	33	2500 <sup>g</sup>
Manganese µg/L	44.5	62.1	49.75	58.1	35.4	43.9	200 <sup>g</sup>
Molybdenum µg/L	0.103	0.114	0.09395	0.103	0.0627	0.05335	73 <sup>d</sup>
Nickel µg/L	<0.005	0.204	0.0025	0.0025	0.0025	0.0025	150 <sup>c</sup>
Selenium µg/L	0.144	0.12	0.076	0.138	0.05	0.096	1
Silver µg/L	0.0036	0.0069	0.00255	0.00025	0.0013	0.003175	0.1
Strontium µg/L	185	185	188	186	176	187	/
Thallium µg/L	0.00115	0.00185	0.001	0.001	0.000725	0.0006	0.8
Thorium µg/L	0.0093	0.0017	0.0096	0.0066	0.008025	0.00625	/
Tin µg/L	0.0483	<0.03	0.03015	0.015	0.015	0.015	/
Titanium µg/L	1.21	0.762	0.904	1.1	0.336	0.676	/
Uranium µg/L	0.121	0.11	0.1145	0.12	0.1965	0.202	100 <sup>e</sup>
Vanadium µg/L	0.207	0.208	0.2095	0.217	0.214	0.1855	100 <sup>f,g</sup>
Zinc µg/L	0.373	0.996	0.5025	0.399	0.3085	0.41	30

Values represent means of total recoverable metal concentrations.

<sup>a</sup> Based on pH  $\geq$  6.5; calcium ion concentrations  $[\text{Ca}^{+2}] \geq 4$  mg/L; and dissolved organic carbon concentration  $[\text{DOC}] \geq 2$  mg/L.

<sup>b</sup> Based on water Hardness of 300 mg/L (as  $\text{CaCO}_3$ )

<sup>c</sup> Based on water hardness  $> 180$ mg/L (as  $\text{CaCO}_3$ )

<sup>d</sup> CCME interim value.

<sup>e</sup> Based on Canadian Drinking Water Quality guideline values.

<sup>f</sup> Based on CCME Guidelines for Agricultural use (Livestock Watering).

<sup>g</sup> 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:

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

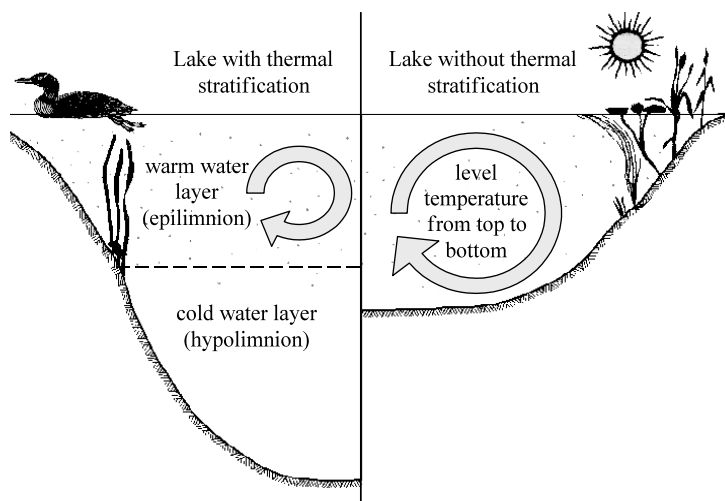


Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

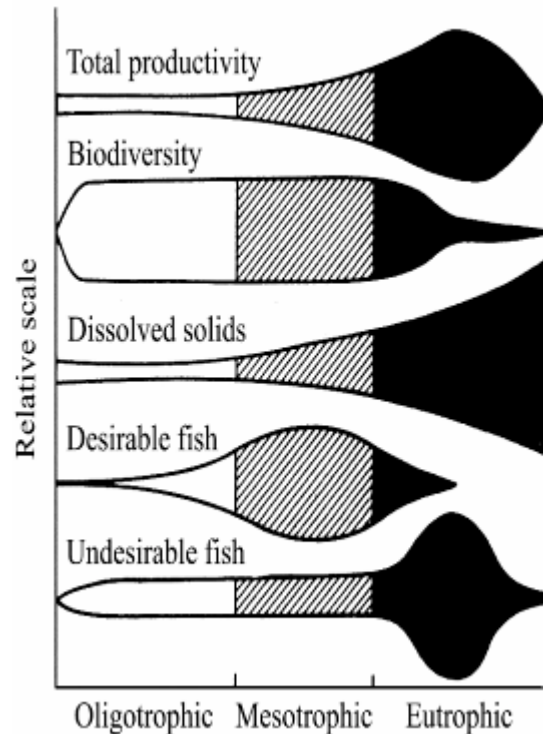


Figure B: Suggested changes in various lake characteristics with eutrophication.

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