ALMS
Alberta Lake Management Society

Lakewatch

The Alberta Lake Management Society
Volunteer Lake monitoring report

Long Island Lake

* * *

2007 Report

Completed with support from:

LICA
Lakeland Industry & Community Association

Alberta Environment

Alberta Lake Management Society

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> *Water is integral to supporting and maintaining life on this planet as it moderates the climate, creates growth and shapes the living substance of all of Earth's creatures. It is the tide of life itself, the sacred source.* David Suzuki (1997). The Sacred Balance.

Alberta Lake Management Society's Lakewatch Program

Lakewatch has several important objectives, one of which is to collect and interpret water quality 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 these 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

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Long Island Lake

Figure 1. Long Island Lake, AB (Source:Heather Jones)

Long Island Lake is a beautiful spring fed lake (**Figure 1**), located north of Edmonton on Highway 44 to Westlock, Township Road 63 and Range Road 25.

Long Island Lake has an average depth of 7.4 m with a maximum depth of 14 m. (**Figure 2**). The lake is comprised of 2 basins encompassing an area of 216 hectares (2.16 km²) the north basin is larger and deeper than the south basin, and it is in the north basin that an island exists with a surface area of 16.2 hectares (0.16km^2). The shoreline length of Long Island Lake is 15.9 km. The south basin has a Summer Village and the North Basin has cottages and a campground.

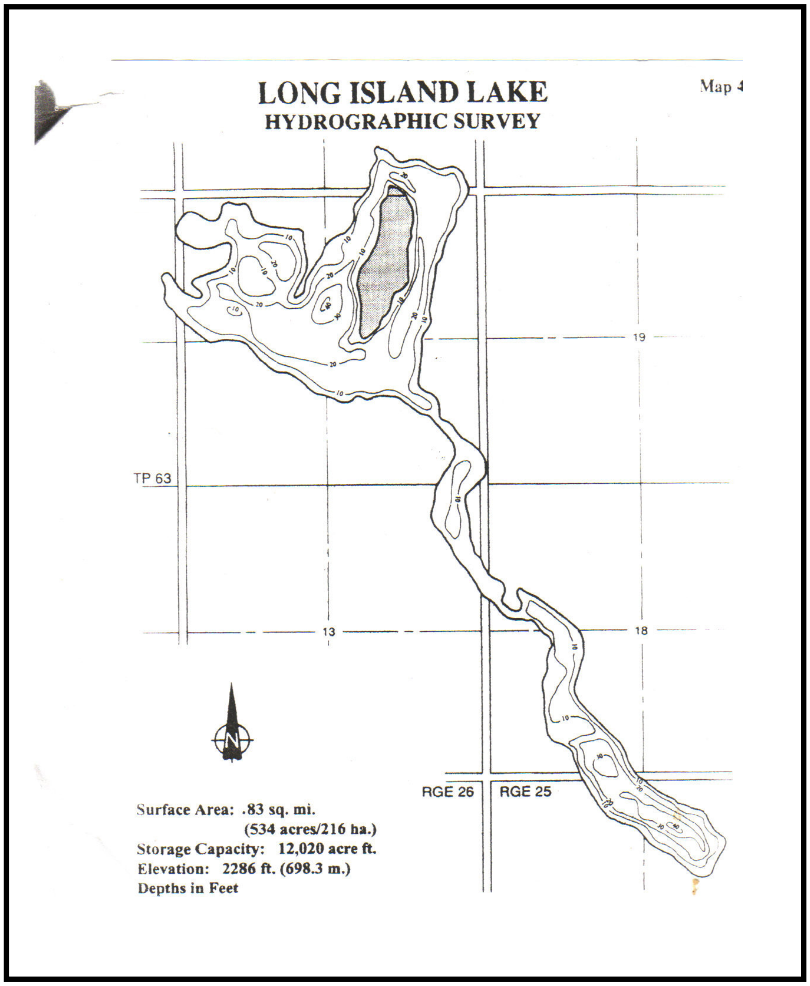

Figure 2. Bathymetry of Long Island Lake, AB

Algae blooms are known to occur during the late summer months due to the lakes natural productivity. The lake is eutrophic and has a moderate littoral area in relation to its surface area. A detailed algal composition has not been completed for the lake. The silt-clay lake bed supports dense aquatic vegetation. In the north and south basins bulrush (*Scirpus* spp.), cattail (*Typha* spp.) and sedges (*Carex* spp.) are common. Terrestrial vegetation is mainly spruce (*Picea* spp.), willow (*Salix* spp.) and balsam poplar (*Populus balsamifera*). The only reported sport fish in the lake is Northern pike (*Esox lucius*) (AENV, 1983).

Water Levels

Lake levels in Long Island Lake have been monitored since 1961. Minimum water level was 696.7 m above sea level (asl) in 1961 (**Figure 3**). Water levels increased from 1962 to 1964 and again from 1967 to 1972. Water level was 697.8 m asl in 1972. Lake levels remained fairly stable until 1998 when water level increased to 697.9 m asl in 1997, a wet year in Alberta. Water levels declined again between 1997 and 2003. Since 2003, lake water levels increased slightly. In 2007, the South Basin was deeper (e.g. total water depth) than the North Basin (**Figure 4** and **5**).

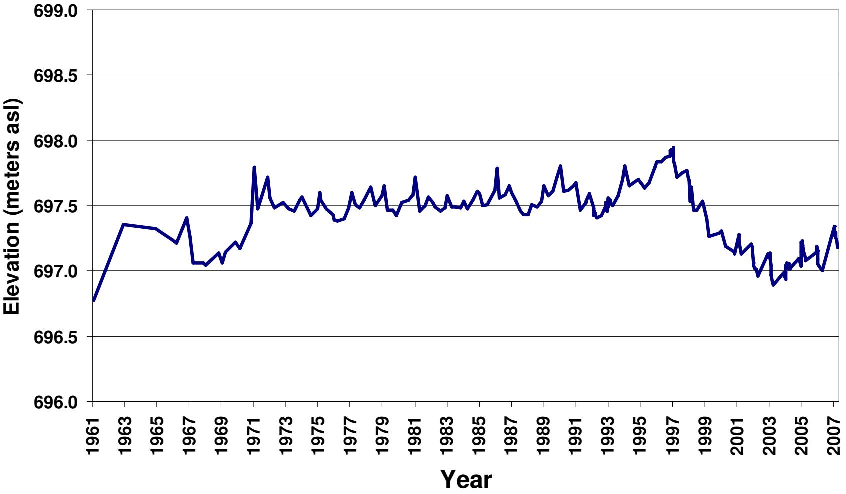

Figure 3. Water level elevation (meters above sea level (asl)) in Long Island Lake near Westlock, Alberta, 1961-2007.

Results

Water Temperature and Dissolved Oxygen

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. Please refer to the end of this report for descriptions of technical terms.

North Basin

Long Island Lake – North Basin was thermally stratified in June and July 2007 (**Figure 4**). The thermocline occurred at 3m depth on 5 June and at 4m on 25 July. Water temperature was similar from the water surface to 7.5m depth on 15 September, which suggests the north basin mixed prior to sampling. Since water depth increased by 2m between July and September, lake mixing may be related to water inputs or differences in sample location. Dissolved oxygen (DO) concentrations were highest in June (**Figure 4**). The north basin was stratified at 3m depth in June and 4m in July and September. DO concentration neared zero (e.g. anoxic) at the lake bed in July and September, due to decomposition.

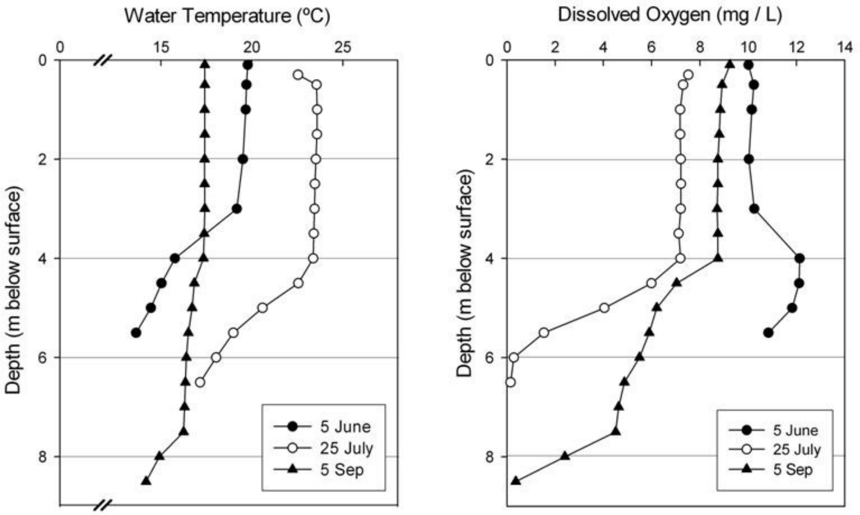

Figure 4. Water temperature (°C) and dissolved oxygen (mg /L) profiles for Long Island Lake- North Basin during the summer of 2007.

South Basin

Long Island Lake – South Basin was thermally stratified in June, July, and September 2007 (**Figure 5**). The thermocline occurred at 3m depth on 5 June and at ~5m in July and September. The thermocline in the south basin suggests that the basin does not fully mix during the summer. Dissolved oxygen (DO) concentrations in the south basin followed a similar pattern as in the north basin (**Figure 5**). The south basin was stratified at ~5m depth in summer 2007. DO concentration neared zero (e.g. anoxic) at 6m in July and 7.5 m in September, due to decomposition. While the south basin is ~4m deeper than the north basin, much of the lower 4m were anoxic in 2007.

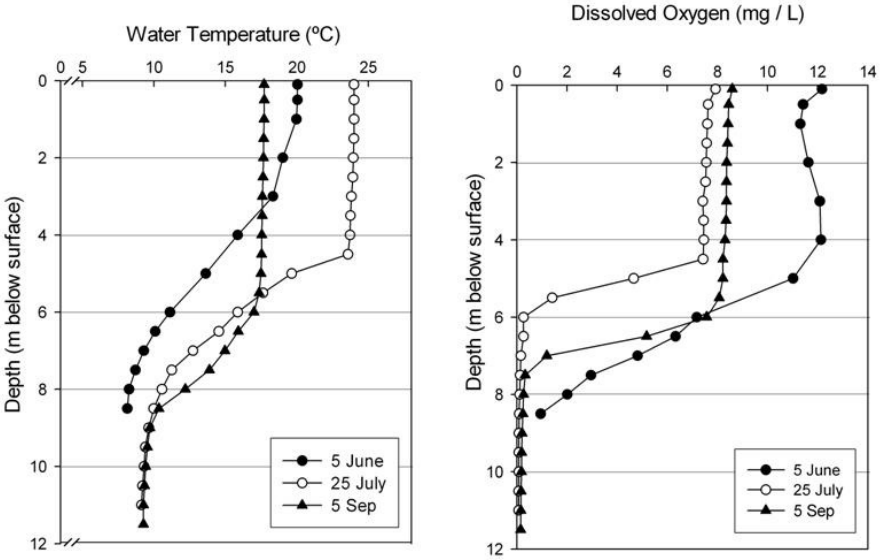

Figure 5. Water temperature (°C) and dissolved oxygen (mg /L) profiles for Long Island Lake- South Basin during the summer of 2007.

In the North and South Basins, oxygen levels in surface layers were within the acceptable range for surface water quality, according to Alberta Environment guidelines (DO ≥ 5.0 mg/L).

Water clarity and Secchi Depth

Water clarity is influenced by suspended materials, both living and dead, as well as dissolved coloured 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 biomass as the summer progresses. The easiest and most widely used measure of lake water clarity is the Secchi disk depth.

The water in Long Island Lake's north and south basins was relatively clear in the summer of 2007. Light penetrated to an average ~50% of the total lake depth in the north basin (Secchi depth = 3.4m) and ~36% in the south basin (Secchi depth = 3.7m, **Table 1**). Thus algae were able to grow throughout more than 1/3 of the water column in each basin. Maximum water clarity was measured on 25 July in both the north (Secchi disk depth= 3.9 m) and south (Secchi disk depth = 4.8 m) basins. Minimum water clarity was recorded on 8 August in the north basin (Secchi depth = 2.8 m) and on 5 June in the south basin (Secchi depth = 2.4 m). Water clarity also declined in the south basin on 8 August (to 3.5 m). The decline in water clarity in August in both basins may be the result of algal growth or partial mixing of upper layers. As water temperature and dissolved oxygen were not measured in August 2007, we cannot determine the underlying mechanism that resulted in decreased water clarity in late summer.

Overall, the change in depth to which light penetrated throughout the summer was 1.1 m in the north basin and 2.4 m in the south basin. . The larger change in water clarity in the south basin suggests that algal biomass was greater in the south basin. Dense algae growth can reduce water clarity. In the south basin, minimum water clarity was positively correlated with maximum Chl a content (**Figure 7**).

Water chemistry

Based on lake water characteristics, Long Island Lake is classified as mesotrophic (see *A Brief Introduction to Limnology* at end of this report). This is evidenced by moderate concentrations of total phosphorus (average TP = 21.8 and 28 µg/L in north and south basins, respectively) and algal biomass (average chl *a* =

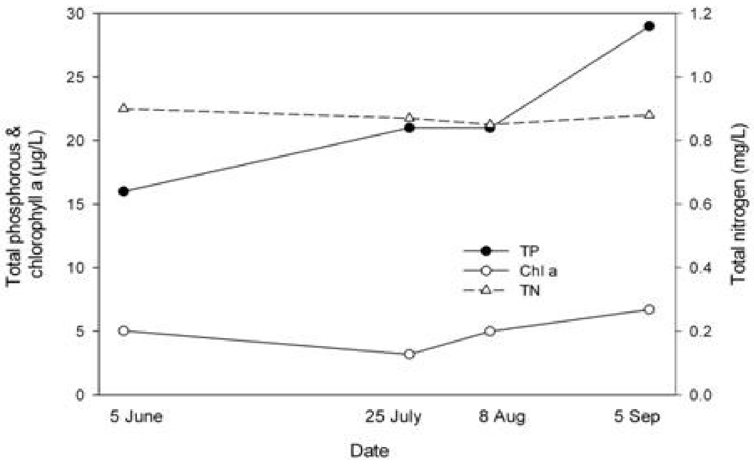

Figure 6. Total phosphorus, total nitrogen, and chlorophyll *a* (a measure of algae biomass) concentrations for Long Island Lake – North Basin during the summer of 2007.

5.0 and 5.3 µg/L in north and south basins, respectively), which fall within the mesotrophic range (**Figure 6,7**). Total Kjeldahl nitrogen (average TN = 0.88 and 0.97 mg/L in north and south basins, respectively) is within the hypereutrophic range, which suggest algal growth is phosphorous limited. (**Figure 6, 7**).

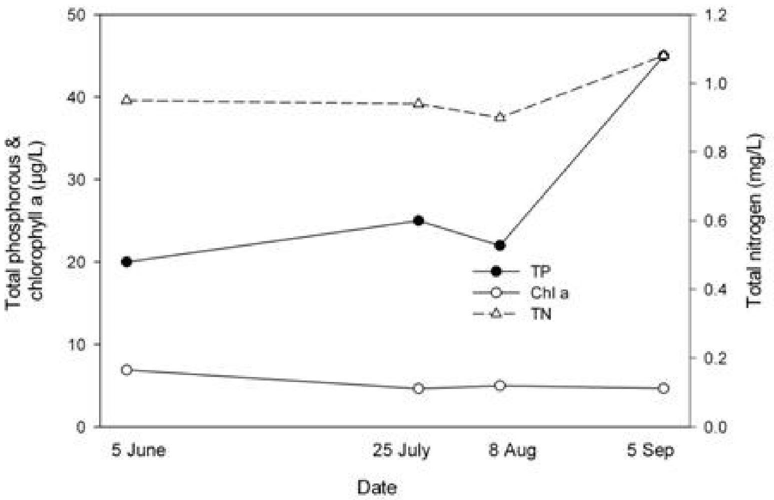

Figure 7. Total phosphorus, total nitrogen, and chlorophyll *a* (a measure of algae biomass) concentrations for Long Island Lake – South Basin during the summer of 2007.

The nutrient regime in Long Island Lake has not changed, over the three years of data collection (**Table 1**).

The north and south basins of Long Island Lake are well buffered, with a pH of 8.2, which is well above that of pure water (i.e., pH 7). Ion concentrations are moderate in both basins in 2007 (**Table 1**). Dominant ions are bicarbonate and calcium. Chloride concentrations doubled from 1994 to 2007. Excessive evaporation or changes in surface runoff and groundwater inputs to the lake may contribute to changes in base cation concentrations. There are currently too few data to assess the mechanisms by which ion concentrations have changed in Long Island Lake.

Metal concentrations were not measured in Long Island Lake in 2007, except for iron (**Appendix 1**).

Table 1. Mean water chemistry values for Long Island Lake north (N) and south (S) basins, summer 2007, 2004 and 1992.

PARAMETER	1992 N	1992 S	2004 N	2004 S	2007 N	2007 S
TP (µg/L)	21	25	30	30	21.8	28
TDP (µg/L)	8	11	9	11	11	13.3
Chla (µg/L)	7.18	8.9	10.3	15.7	5.0	5.3
Secchi (m)	3.9	4.6	2.95	2.95	3.4	3.7
TKN (mg/L)	0.818	0.92	0.94	1.08	0.88	0.97
NO_{2+3} (µg/L)	1.75	3.2	6.0	5.2	<6	<5
NH_4 (µg/L)	14.5	33.4	9.0	23	21.5	21
Dissolved organic C (mg/L)	-	-	-	-	14.8	16.0
Ca (mg/L)	27.5	28.2	33	27.6	31.4	30.3
Mg (mg/L)	11.5	11.4	12.3	11.6	13.1	12.6
Na (mg/L)	2.8	2.8	6.6	3	4.8	4.4
K (mg/L)	4.1	4.1	5	5	4.7	4.7
SO_4 (mg/L)	-	-	3	3	<3	<3
Cl (mg/L)	0.45	0.567	0.6	0.7	1.1	1.1
Alkalinity (mg/L $CaCO_3$)	116	118	151	129	138.8	134.3
CO_3 (mg/L)	-	-	6	4	25.5	6
HCO_3 (mg/L)	124	125	154	162	163.5	160
pH	8.28	8.2	8.27	8.33	8.2	8.2
Conductivity (µS/cm)	234	237	244	253	258	318
Total dissolved solids (mg/L)	-	-	-	-	140.3	135.7

Note: TP = total phosphorus, TDP = total dissolved phosphorous, Chla = chlorophyll *a*, TKN = total Kjeldahl nitrogen, NO_{2+3} = nitrate+nitrite, NH_4 = ammonium, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate.

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Appendix 1

Mean concentrations of metals in Long Island Lake north (N) and south (S) basis in 2007 and 2004, compared to CCME Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated).

Metals	2004 N	2004 S	2007 N	2007 S	Guidelines
ALUMINUM µg/L	29	26.6	-		100[a]
ANTIMONY µg/L	1.325	0.824	-		6[e]
ARSENIC µg/L	0.81	0.83	-		5
BARIUM µg/L	55.4	59.1	-		1000[e]
BERYLLIUM µg/L	<0.003	<0.003	-		100[d,f]
BISMUTH µg/L	0.002	0.002	-		
BORON µg/L	30.3	32.9	-		5000[e,f]
CADMIUM µg/L	0.0024	0.0044	-		0.085[b]
CHROMIUM µg/L	0.16	0.13	-		
COBALT µg/L	0.041	0.042	-		1000[f]
COPPER µg/L	0.399	0.813	-		4[c]
IRON µg/L	163	85.4	63.9	39.1	300
LEAD µg/L	0.057	0.044	-		7[c]
LITHIUM µg/L	8.55	8.3	-		2500[g]
MANGANESE µg/L	87.4	23.7	-		200[g]
MOLYBDENUM µg/L	0.23	0.24	-		73[d]
NICKEL µg/L	0.009	0.03	-		150[c]
SELENIUM µg/L	0.067	<0.04	-		1
SILVER µg/L	0.053	0.004	-		0.1
STRONTIUM µg/L	121.5	125.5	-		
THALLIUM µg/L	0.072	0.044	-		0.8
THORIUM µg/L	0.014	0.009	-		
TIN µg/L	0.048	<0.03	-		
TITANIUM µg/L	0.88	0.7	-		
URANIUM µg/L	0.1925	0.3975	-		100[e]
VANADIUM µg/L	0.152	0.183	-		100[f,g]
ZINC µg/L	7.45	6.66	-		30
FLUORIDE mg/L	0.15	0.15	-		1.5

With the exception of fluoride (which reflects the mean concentration of dissolved fluoride only), values represent means of total recoverable metal concentrations.

[a] Based on pH ≥ 6.5; calcium ion concentration [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 > 180 mg/L (as $CaCO_3$).

[d] CCME interim value.

[e] Based of Canadian Drinking Water Quality guideline values.

[f] Based of CCME Guidelines for Agricultural Use (Livestock Watering).

[g] Based of CCME Guidelines for Agricultural Use (Irrigation).

A Brief Introduction to Limnology

Indicators of water quality

The goal of **Lakewatch** is to collect water samples necessary to determine the water quality of lakes. Though not all encompassing, the variables measured in **Lakewatch** are sensitive to human activities in watersheds that may cause impacts to 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 affected (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 fish habitat and production of noxious odors. Large increases in nutrients over time may also indicate sewage inputs, which in turn, may result in other human health concerns such as harmful bacteria or protozoans (e.g. *Cryptosporidium*).

Temperature and mixing

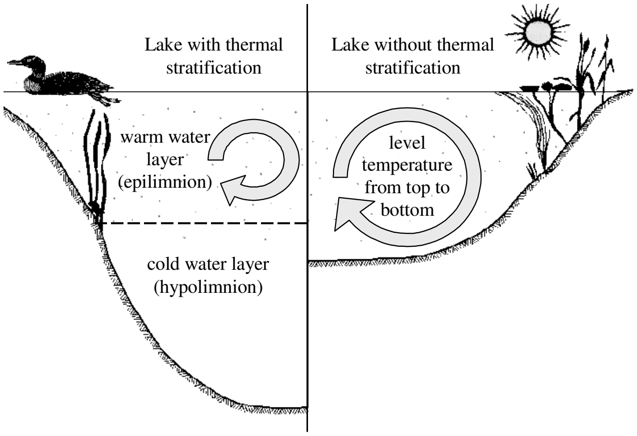

Figure 8: Difference in the circulation of the water column depending on thermal stratification.

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality (Figure 8). 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. A third layer, known as the metalimnion, provides an effective barrier between the epi- and hypolimnion**.** The metalimnion reflects a rapid transition in water temperature known as the **thermocline**. A thermocline typically occurs when water temperature changes by several degrees within one-meter of depth. The thermocline acts as an effective physico-chemical barrier to mixing between the hypolimnion and epilimnion, restricts downward movement of elements, such as oxygen, from the surface 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 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 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 state dissolved oxygen concentrations (in the epilimnion) must not decline below 5 mg/L and should not average less than 6.5 mg/L over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 mg/L 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 terrestrial plants and plants and algae of tropical lakes, phosphorus is usually in shortest supply in temperate 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. Larger aquatic plants, known as macrophytes, rather than algae, dominate some highly productive lakes. In these lakes, chlorophyll-a and nutrient values taken from water samples do not include productivity from large aquatic plants. As a result, lakes like Chestermere, which are dominated by macrophytes, reflect lower-nutrient trophic states than would otherwise result if macrophyte-based chlorophyll were 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 Depth

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. Secchi disk depth is the oldest, simplest, and quickest quantitative measure of water clarity. A Secchi disk is a black and white disk that is lowered down through the water column until it can no longer be seen. Secchi disk depth is the midpoint between the depth at which it disappears when lowered and reappears when it is pulled up again. The Secchi disk depth in lakes with high algal biomass will generally be low. Secchi disk depth, however, is not only affected by algae, high concentrations of suspended sediments, particularly fine clays or glacial till common in plains or mountain reservoirs of Alberta, also impact water clarity. Mountain reservoirs may have exceedingly shallow Secchi disk depths despite low algal growth and nutrient concentrations.

The euphotic zone, calculated as twice the Secchi disk depth, is the portion of the water column that has sufficient light for aquatic plants to grow. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Aquatic plants are important because they ensure clear lake water by reducing shoreline erosion and stabilizing lake bottom sediments. Many lakes in Alberta are shallow and have bottom sediments with 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 fish, depend on aquatic plants for food and shelter.

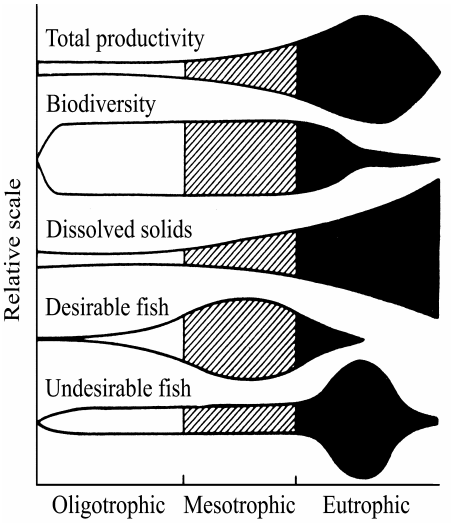

Figure 9: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

Trophic State

Trophic state is a classification system for lakes that depends on fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass (as chlorophyll-a) concentrations, the trophic states are: oligotrophic, mesotrophic, eutrophic and hypereutrophic. The nutrient and algal biomass concentrations that define these categories are shown in Table 2 and a graph of Alberta lakes compared by trophic state can be found on the ALMS website. A majority of lakes in Alberta are meso- to eutrophic because they naturally contain high nutrient concentrations due to our deep fertile soils. Thus, lakes in Alberta are susceptible to human impacts because they are already nutrient-rich; any further nutrient increases can bring about undesirable conditions illustrated in Figure. 9.

Table 2: Trophic status based on lake water characteristics

Trophic state	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Chlorophyll a (µg/L)	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

Note: These values are from a detailed study of global lakes reported in Nurnberg, 1996. Alberta Environment uses slightly different values for TP and CHL based on those of the OECD reported by Vollenweider and Kerekes (1982). The AENV and OECD cutoffs for TP are 10, 35 and 100; for CHL are 3, 8 and 25. AENV does not have TN or Secchi depth criteria. The corresponding OECD exists for Secchi depth and the cutoffs are 6, 3 and 1.5 m.