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Lakewatch

Long Island Lake

Alberta Lake Management Society
Volunteer Lake Monitoring

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, 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 usually available for 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

The Lakewatch program is made possible through the dedication of its volunteers and Alberta Environment employees. Project Manager, Shelley Manchur, Technicians, Mike Bilyk, Brian Jackson, John Willis, and Doreen LeClair from Alberta Environment were instrumental in funding, training people and organizing with Lakewatch data. Heather Jones was our summer field technician and volunteer coordinator and was a valuable addition to the program. Heather Jones and Ron Zurawell prepared this report. Eric Herrinek and George Soctt were the volunteers for Long Island Lake and made sampling possible through the dedication of there time and of course watercraft. Financial support from Alberta Environment.

Long Island Lake

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

Figure 1. Long Island Lake (heather jones)

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 km^2) 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 (0.16$km^{2)}$. The shoreline length of Long Island Lake is 15.9 km (**Figure 2**). The south basin has a Summer Village, and the North Basin has cottages and a campground. Algae blooms are known to occur during the late summer months due to the lakes natural fertility. The lake is eutrophic having a moderate littoral area with relation to its surface area. A detailed algal composition has not been completed for the lake. The silty clay bottom does support 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, vol. 7), (AENV 1983, Main Report)

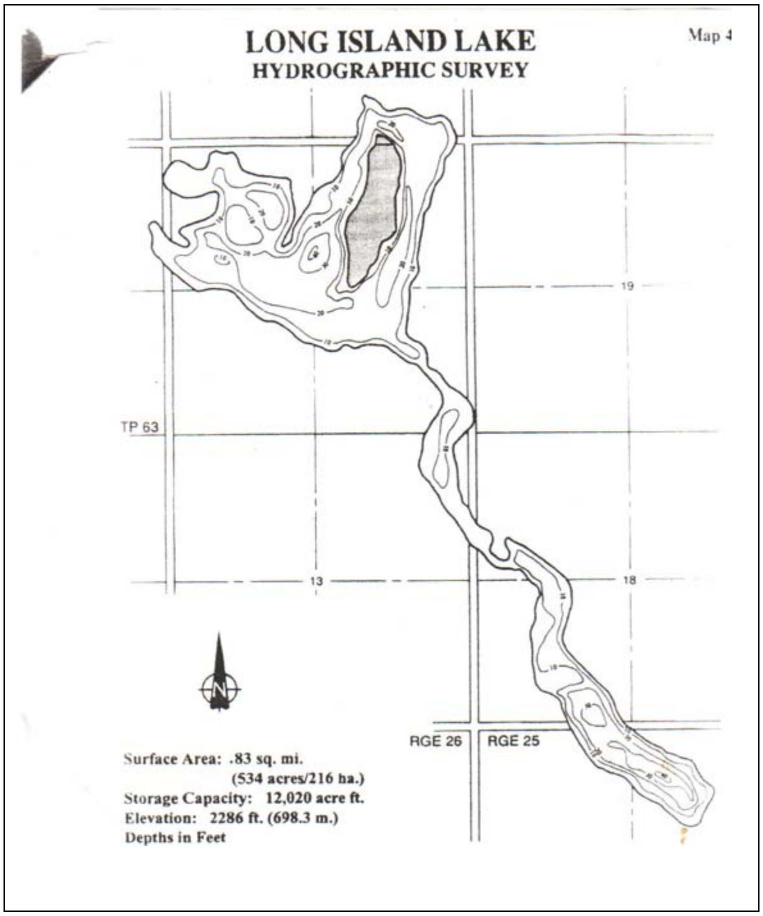


Figure 2. Bathymetry of Long Island Lake.

Water Levels

Lake levels in Long Island Lake have been monitored since 1961, where the lake showed its lowest levels at 696.7 m above sea level (**Figure 3**). Levels increased from 1963 to 1965, then in 1968 decreased until a major increase occurred in 1972 to 697.8 m above sea level. Lake levels remained fairly stable until 1998 where the highest levels in the lake

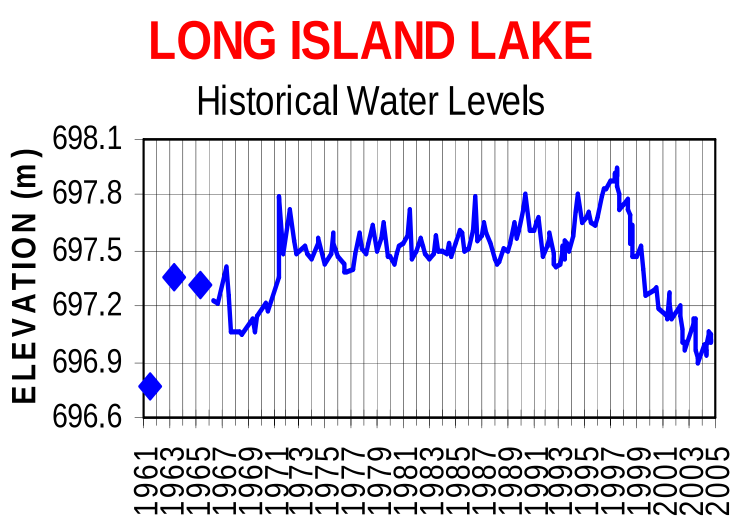


Figure 3. Historical water levels of Long Island Lake.

occurred at 697.9 m above sea level, this increase is likely due the highest precipitation recorded on record in 1998. However, lake levels continued to drop progressively since, possibly due to drought conditions in the area in the 1990's through to recent years. Lake levels for 2004 are at about the same levels recorded in the late 1960's (**Figure 3**).

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.

In 2004, thermal stratification in the south basin of Long Island Lake occurred in late June and late July at 4.5 m, in August stratification occurred at 7 m (**Figure 4**). The lake remained well oxygenated to 5 m for the beginning of the sample season, then increased to 7.5 m for the remainder of the sample season (**Figure 4**). Dissolved oxygen concentrations were within surface water quality guidelines for most of the water column throughout the summer.

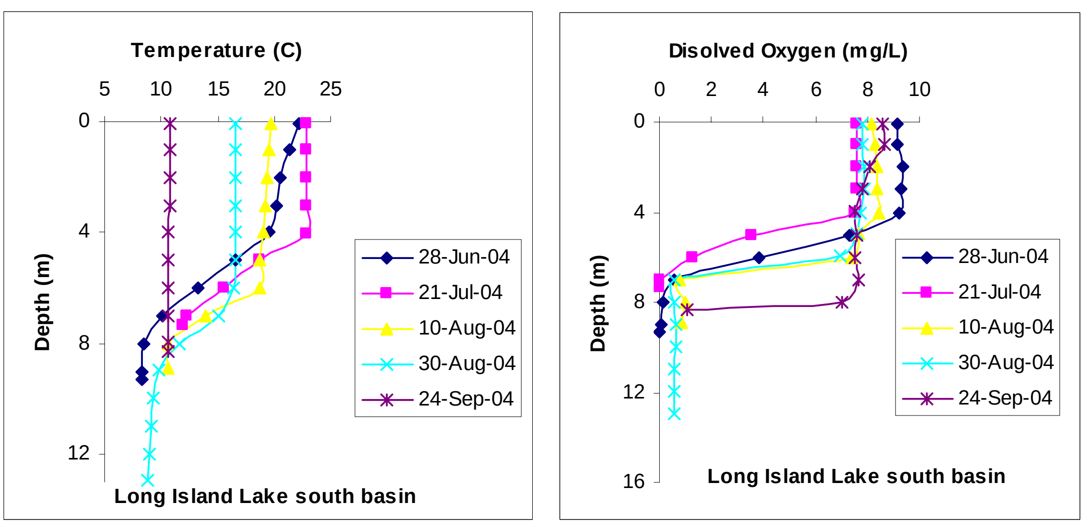
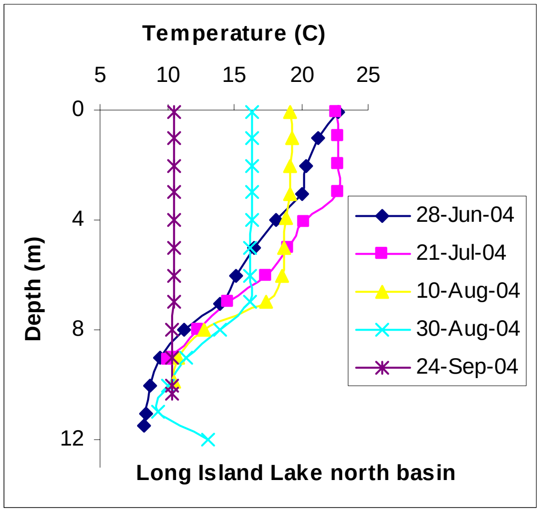


Figure 4. Temperature and dissolved oxygen profiles for Long Island Lake south basin.

The north basin displayed a thermal stratification at 3.5 m in late June and late July, stratification occurred at 7.5 m in August (**Figure 5**). The north basin remained well oxygenated in June and July from 5.5 m to 6.5 m (**Figure 5**). The remainder of the sample season oxygen in the water column increased to a depth of 9 m, during complete mixing of the water column, when no thermal stratification occurs (i.e. September) oxygen mixes downward in the water column (**Figure 5**).



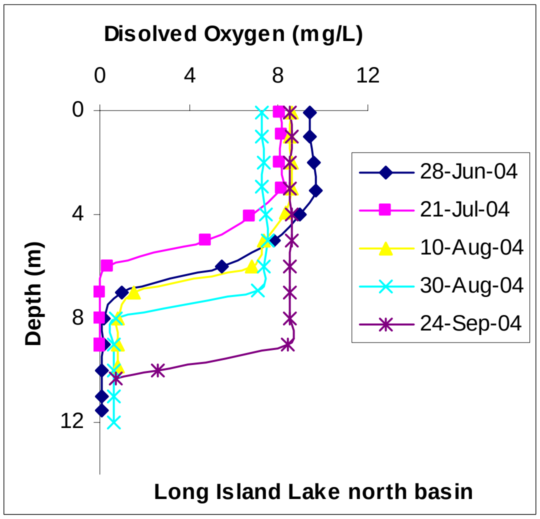


Figure 5. Temperature and dissolved oxygen levels for Long Island Lake north basin.

Water clarity and Secchi Depth

Water clarity is influenced by suspended material, both living and dead, as well as some coloured dissolved compounds in the water column. The most widely used measure of lake water clarity is the Secchi depth. After ice and snowmelt a lake can have low clarity due to spring runoff and suspended sediments in the lake. Lake water usually clears in the spring but then becomes less clear as algae grow through the summer.

In 2004, Long Island Lake north, and south basin's water was quite clear both basins had an average 2.95 Secchi disk depth. Secchi depth in mid June was very clear in the north basin at 3.5 m decreasing to 2.5 m by late September. The south basin's Secchi reading in late June was very clear at 5.5 m progressively declinging to 1.25 m by late September. These patterns in clarity followed trends in water greenness (**Figures 6, and 7**).

Water Chemistry

In summer 2004, algal biomass in Long Island Lake north and south basins mirrored patterns in phosphorus and nitrogen concentrations. Generally, total P, total N, and algal biomass were lowest in early summer and then rose progressively up to the end of summer (**Figures 6, and 7**).

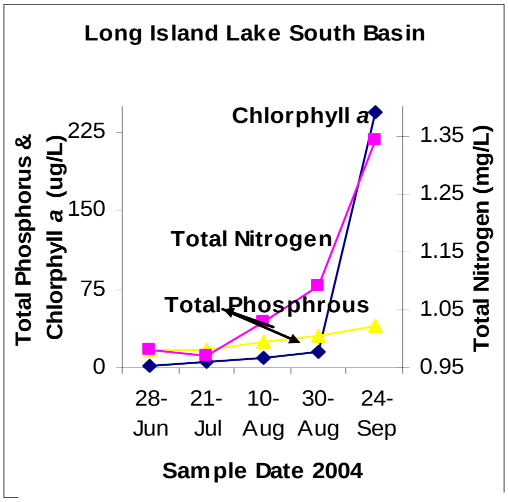


Figure 6. Total phosphorus, total nitrogen and chlorophyll-*a* (water greenness)concentrations in Long Island Lake south basin 2004.

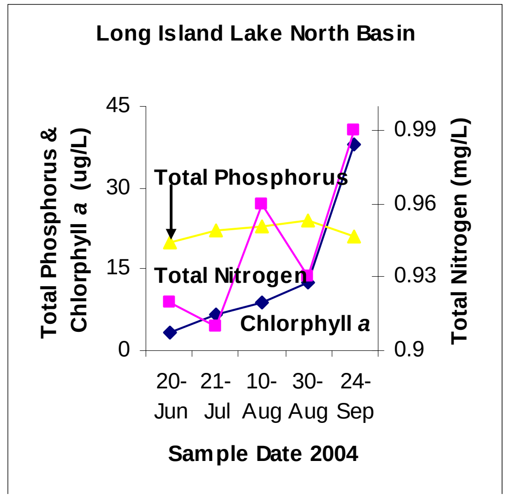


Figure 7. Total phosphorus, total nitrogen and chlorophyll-*a* (water greenness)concentrations in Long Island Lake north basin 2004.

In the Alberta context, Long Island Lake is about average in these characteristics. We are unable to assess if nutrient characteristics have changed in Long Island Lake due to lack of historical data. However, algal biomass, measured as chlorophyll *a*, seems to have increased somewhat, indicating that Long Island Lake is becoming more productive, since the last sampling conducted in 1992 (**Table 1**) . In general, metal concentrations were low and few surpassed provincial and federal Water Quality Guidelines for the Protection of Aquatic Life.

Both basins of Long Island Lake are well buffered, with a pH of 8.27 (north basin) and 8.33 (south basin) this is well above that of pure water (i.e., pH 7). Ion levels are high in both basins in 2004, and were dominated by bicarbonate, magnesium, and sodium. Magnesium, sodium, potassium, and sulfate concentrations appear to have remained stable with the exception of Sodium in the north basin increasing 3 fold since 1992 (**Table 1**). Excessive evaporation or changes in surface runoff that favor groundwater contributions or even problems with well injections of wastewater all result in changes in base cation concentrations. There are currently too few historic data to assess the sources of changed ion concentrations in Long Island Lake.

Parameter	1992 North	1992 South	2004 North	2004 South
Total P (mg/L)	0.021	0.025	0.03	0.03
TDP (mg/L)	0.008	0.011	0.009	0.011
Chla (µg/L)	7.18	8.9	13.68	48.77
Secchi (m)	3.9	4.6	2.95	2.95
Total N (mg/L)	0.818	0.92	0.94	1.08
NO_{2+3} (µg/L)	1.75	3.2	6.0	5.2
NH_4 (µg/L)	14.5	33.4	9.0	23
Ca (mg/L)	27.5	28.2	33	27.6
Mg (mg/L)	11.5	11.4	12.3	11.6
Na (mg/L)	2.8	2.8	6.6	3
K (mg/L)	4.1	4.1	5	5
SO_4 (mg/L)	-	-	3	3
Cl (mg/L)	0.45	0.567	0.6	0.7
Alkalinity (mg/L $CaCO_3$)	116	117.6	151	129
CO_3 (mg/L)	-	-	6	4
HCO_3 (mg/L)	124	125.2	154	162
pH	8.28	8.2	8.27	8.33
Conductivity (µS/cm)	234.5	237	244	253

Table 1. Historical water quality in Long Island Lake North and South Basins.

Note: TDP = total dissolved phosphorus, Chla = chlorophyll *a*, 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.

A brief introduction to Limnology

Indicators of water quality

Water samples are collected in Lakewatch to determine the water quality of lakes. 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

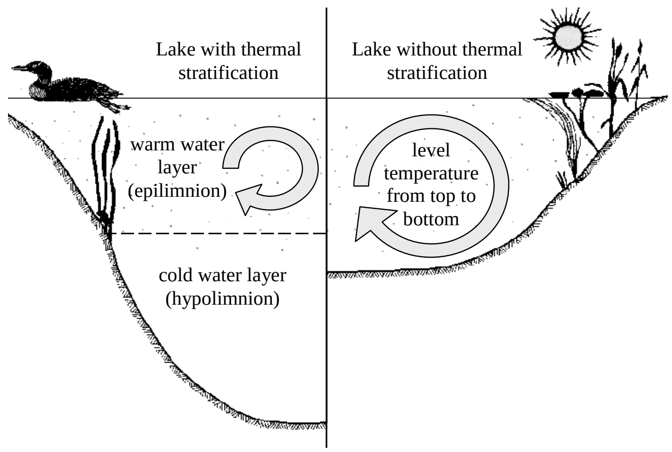


Fig. 6: Difference in the circulation of the water column depending on thermal stratification.

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 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 suggest 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 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, known as macrophytes, rather than suspended algae. 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 can be at 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 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 shallow. However, Secchi disk depth is not only affected by algae. 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 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.

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) concentrations, the trophic states are: **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic**. 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. 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 Fig. 7.

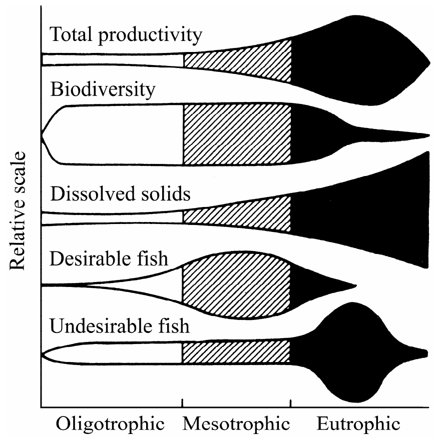


Fig. 7: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980

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 (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.