The Alberta Lake Management Society
Volunteer Lake monitoring report

Clairmont Lake

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2007 Report

Completed with support from:

Alberta Lake Management Society

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> *And you really live by the river? What a jolly life!"*
>
> *"By it and with it and on it and in it," said the Rat. "It's brother and sister to me. What it hasn't got is not worth having, and what it doesn't know is not worth knowing." Kenneth Grahame The Wind in the Willows*
>
> *"The world's supply of fresh water is running out. Already one person in five has no access to safe drinking water."*
>
> *BBC World Water Crisis Homepage*

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

The Lakewatch program is made possible through the dedication of its volunteers and the Lakewatch Chairs, Théo Charette and Ron Zurawell. We would like to thank Jill Henry for collecting field data in 2007. Numerous Alberta Environment staff also contributed to successful completion of the 2007 program. We would like to thank Jill Anderson and Wendy Markowski who were summer interns with ALMS in 2007. Project Technical Coordinator, Megan McLean was instrumental in planning and organizing the field program. Technologists, Mike Bilyk, Brian Jackson and John Willis were involved in the logistics planning and training aspects of the program. Doreen LeClair was responsible for data management. Théo Charette (ALMS Director) was responsible for program administration and planning. Théo Charette, Ron Zurawell (Limnologist, AENV), and Lori Nuefeld prepared the original report, which was updated by Heather Powell in 2007. The Lakewatch program was financially supported by Alberta Environment and Lakeland Industry and Community Association (LICA).

Clairmont Lake

Clairmont Lake is located at the intersection of Highway 2 and 43 (**Figure 1**) at ~685 m elevation. The hamlet of Clairmont (population 1367) is located on the west shore of Clairmont Lake. Population has increased 59% from 2000 to 2006. Concurrent with the increase in population, water and sewer treatment was established in 2005.

Figure 1. Clairmont Lake, Alberta. From Google Earth 2007.

Walter McFarlane, Dominion Land Surveyor, surveyed this area in 1909 and named Clairmont Lake after his hometown of Claremont Ontario. Clairmont Lake was previously called Twin Lakes.

Clairmont Lake is within the Peace River Parkland subregion and the surrounding landscape is dominated by agriculture. The lake is part of the Grand Prairie Important Bird Area Conservation Plan and is an important breeding ground for trumpeter swans (IBA 2004).

Clairmont Lake is a shallow, lake (**Figure 2**). Water depth did not exceed 1m in 2007.

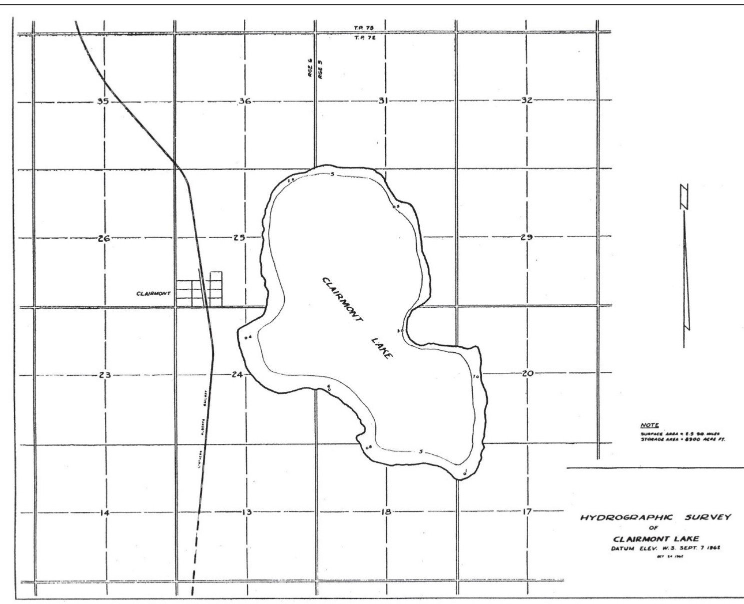

Figure 2. Bathymetry of Clairmont Lake, Alberta. From Angler's Atlas 2008.

Results

Water Levels

Water level elevation (meters above sea level (asl)) in Clairmont Lake have been monitored since 1976 (**Figure 3**). Maximum water level was 673.6 m asl in May 1977. Water level declined from 1977 to 1980. Water level fluctuated around an average 672.5 m asl from 1981 to 1989, and around 672.7 m asl from 1990 to 2000. In 2000, water levels increased to 673.4 m asl and then declined. The minimum water level elevation was 672.1 m asl in October 2001. Overall, there is a slight decline (<0.5 m) in the average water level of Clairmont Lake over the past 30 years.

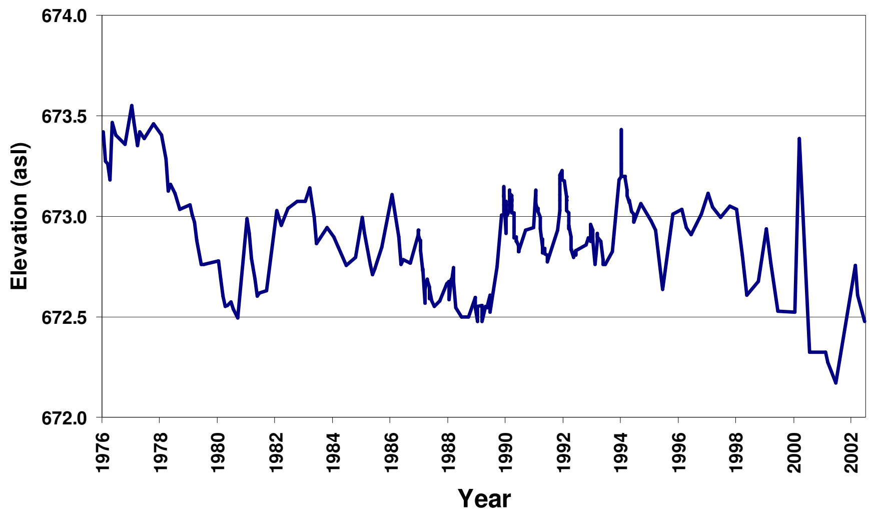

Figure 3. Water level elevation (meters above sea level (asl) at Clairmont Lake, Alberta, 1976-2002.

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.

Clairmont Lake is a shallow, polymictic lake, which means that the water column mixes many times throughout the summer. Because of frequent mixing, the water temperature and dissolved oxygen concentration is relatively the same at all water depths (**Figure 4**). Water temperature was ~18° C in June and declined to ~9 ° C in September.

Dissolved oxygen (DO) concentrations in Clairmont Lake during the summer 2007 were within the acceptable range for surface water quality, according to Alberta Environment guidelines (DO ≥ 5.0 mg/L) (**Figure 4**). Dissolved oxygen concentration was highest in September, which may indicate a phytoplankton bloom in late summer (prior to the September sample date).

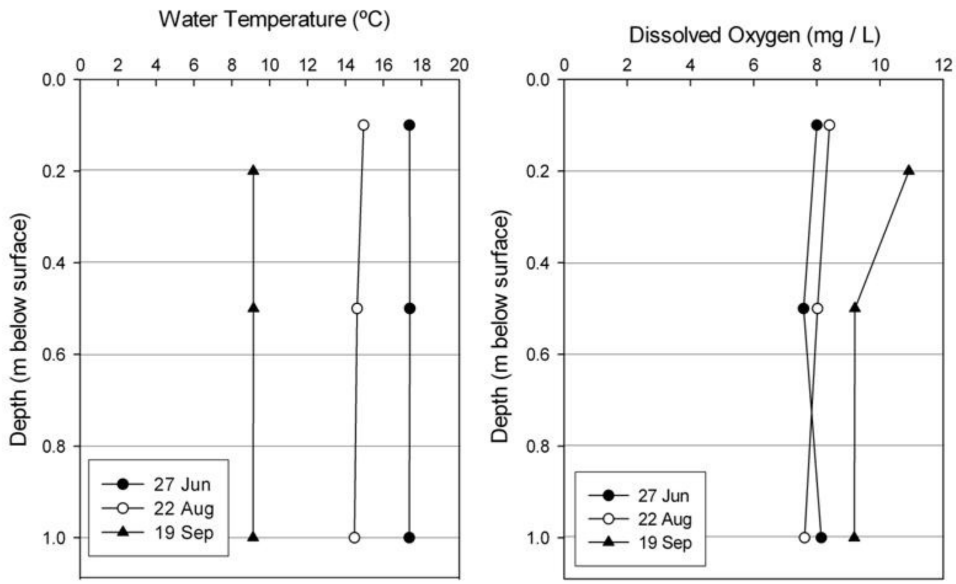

Figure 4. Water temperature (°C) and dissolved oxygen (mg /L) profiles for Clairmont Lake during the summer of 2007.

Water Clarity and Secchi Depth

Water clarity is influenced by suspended materials, both living and dead, as well as some coloured dissolved compounds in the water column. During the melting of snow and ice in spring, lake water can become 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.

Clairmont Lake is a shallow, polymictic lake, and as such has turbid water (e.g. murky). During the summer of 2007, light penetrated to an average 70% of the total lake depth (average Secchi disk depth of 0.7 m, **Table 1**). While Secchi disk was visible throughout much of the lake, it does not imply that the lake was clear. Rather, the lake was very shallow and algae were able to grow throughout much of the water column.

In 2007, maximum water clarity was observed on 22 June (Secchi disk depth = 0.9 m). Minimum water clarity was observed on 22 August (Secchi disk depth = 0.45 m). While dense algal growth can increase water clarity via the removal of suspended particles in the water column, Clairmont Lake mixes too frequently for the pattern to be observed. Compared to other lakes in the Lakewatch program, Clairmont Lake is very turbid due its shallow, polymictic nature.

Water Chemistry

Based on lake water characteristics, Clairmont Lake is classified as hypereutrophic (see *A Brief Introduction to Limnology* at end of this report). This is evidenced by high concentrations of total phosphorus (average TP = 251 μg/L) and total Kjeldahl nitrogen (average TN = 2.4 mg/L) and high algal biomass (average chl *a* = 37.7 μg/L) (**Figure 5**). Phosphorous and nitrogen concentrations peaked in late-August 2007.

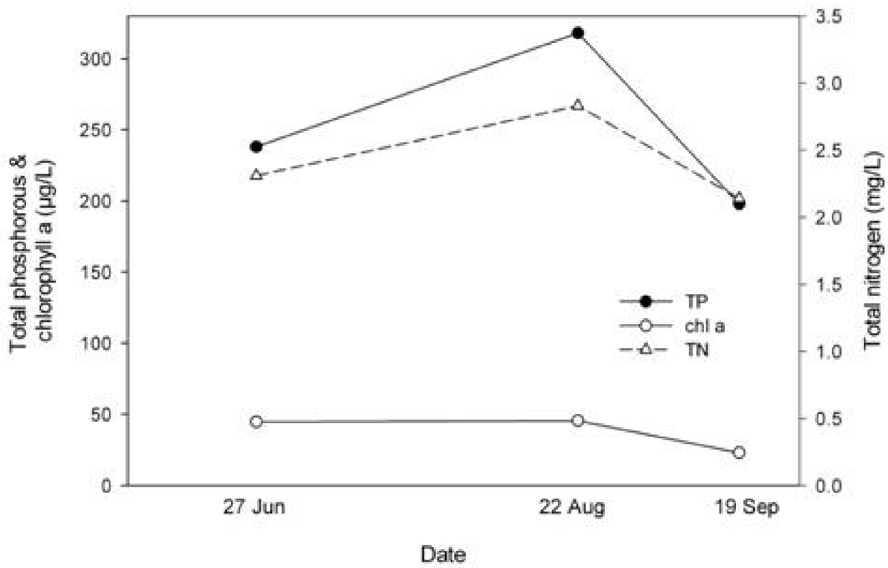

Figure 5. Total phosphorus, total nitrogen, and chlorophyll *a* (a measure of algae biomass) concentrations for Clairmont Lake during the summer of 2007.

Clairmont Lake is well-buffered from acidification. In 2007, lake pH = 8.0 is well above that of pure water (i.e., pH 7). Dominant ions are bicarbonate, chloride, and sodium (**Table 1**).

The average concentrations of heavy metals were not available for Clairmont Lake, except for iron, which was higher than the CCME guidelines for the Protection of Freshwater Aquatic Life (**Appendix 1**).

Table 1. Mean water chemistry in Clairmont Lake, summer 2007.

Parameter	2007
TP (µg/L)	251.3
TDP (µg/L)	147.7
Chlorophyll *a* (µg/L)	37.7
Secchi disk depth (m)	0.7
TN (mg/L)	2.4
NO_{2+3} (µg/L)	<0.09
NH_4 (µg/L)	0.07
Dissolved organic C (mg/L)	19.5
Ca (mg/L)	25.0
Mg (mg/L)	7.9
Na (mg/L)	38.2
K (mg/L)	14.3
SO_4 (mg/L)	14.3
Cl (mg/L)	49.3
CO_3 (mg/L)	-
HCO_3 (mg/L)	134.7
Total Alkalinity (mg/L $CaCO_3$)	110.4
pH	8.0
Conductivity (µS/cm)	408
Total dissolved solids (mg/L)	216

Note: TP = total phosphorus, TDP = total dissolved phosphorus, Chla = chlorophyll *a*, TN= 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.
From *Atlas of Alberta Lakes* (Mitchell and Prepas, 1990).

References

Angler's Atlas. 2008. Last accessed February 2008. http://www.anglersatlas.com/

IBA Canada. 2004. Important Bird Areas of Canada. Last accessed March 2008. http://www.bsc-eoc.org/iba/site.jsp?siteID=AB107

Mitchell, P. and E. Prepas, eds. 1990. *Atlas of Alberta Lakes*. University of Alberta Press.

Appendix 1

Mean concentrations of metals, Clairmont Lake 2007, compared to CCME Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated).

Metals (total)	2007	Guidelines
ALUMINUM µg/L	-	100[a]
ANTIMONY µg/L	-	6[e]
ARSENIC µg/L	-	5
BARIUM µg/L	-	1000[e]
BERYLLIUM µg/L	-	100[d,f]
BISMUTH µg/L	-	
BORON µg/L	-	5000[e,f]
CADMIUM µg/L	-	0.085[b]
CHROMIUM µg/L	-	
COBALT µg/L	-	1000[f]
COPPER µg/L	-	4[c]
IRON µg/L	351.3	300
LEAD µg/L	-	7[c]
LITHIUM µg/L	-	2500[g]
MANGANESE µg/L	-	200[g]
MOLYBDENUM µg/L	-	73[d]
NICKEL µg/L	-	150[c]
SELENIUM µg/L	-	1
SILVER µg/L	-	
STRONTIUM µg/L	-	
THALLIUM µg/L	-	0.8
THORIUM µg/L	-	
TIN µg/L	-	
TITANIUM µg/L	-	
URANIUM µg/L	-	100[e]
VANADIUM µg/L	-	100[f,g]
ZINC µg/L	-	30
FLUORIDE mg/L	-	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

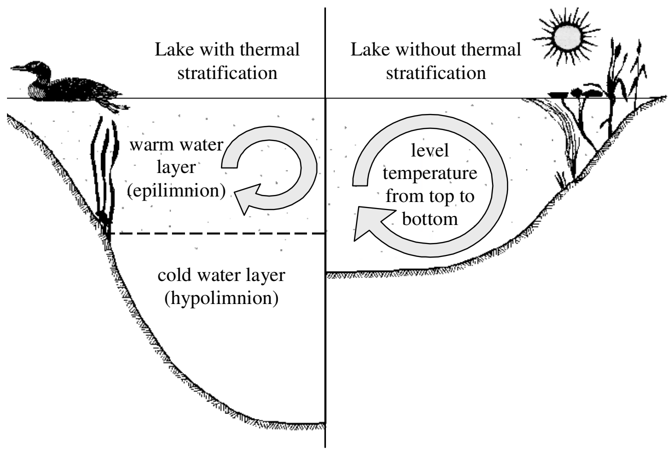

Figure 6: Difference in the circulation of the water column depending on thermal stratification.

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality (Figure 6). 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. 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, can exist 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-*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. 7.

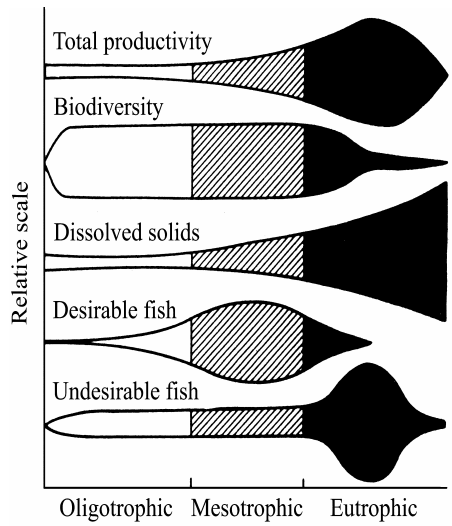

Figure 7: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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 (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.