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Lakewatch

Bluet Lake

The Alberta Lake Management Society
Volunteer Lake Monitoring Report

> *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*

A note from the Lakewatch Coordinator Preston McEachern

Lakewatch has several important objectives, one of which is to document and interpret water quality in Alberta Lakes. Equally important is educating lake users about their aquatic environment, encouraging public involvement in lake management, and facilitating cooperation and partnerships between aquatic scientists 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. Substantial additional information is generally available on the lakes that have participated in Lakewatch and readers requiring more information are encouraged to seek these.

Since 2002, Lakewatch Reports have undergone a substantial change in format from previous years. I am no longer the author as much as an editor including text and figures from others who have done an excellent job describing lakes throughout Alberta. I have attempted to give due credit to these outstanding people and apologize for blatant plagiarism where it occurs. As editor, feel free to castrate me for errors. I have included easily accessible information that is likely to have been updated in recent years and readers are encouraged to help update these reports by sending new information to me.

Another exciting event occurred in 2003. Laboratory analyses have been switched from the University of Alberta Limnology Lab to the Alberta Research Council lab in Vegreville. The ARCV has a very broad spectrum of analyses possible and their detection levels are very good. Thus, we have added metals to our suite of analyses in 2003.

I would like to thank all people who share my love for aquatic environments and particularly those who have helped in the Lakewatch program. These people prove that ecological apathy can be overcome and give us hope that water will not be the limiting factor in the health of our planet.

Acknowledgements

The Lakewatch program is made possible through the dedication of its volunteers and Alberta Environment employees. Shelley Manchur, Mike Bilyk, Brian Jackson, John Willis and Doreen LeClair from Alberta Environment were instrumental in funding, training and organizing data. Jean-Francois Bouffard was our summer field coordinator and was an excellent addition to the program. Our volunteers for Garnier Lake were Neil Guay from Canadian Natural Resources Ltd. and James Capjack of Petrovera Inc. Francine Forrest, Jean-Francois Bouffarc, and Théo Charette helped in report writing. Without the dedication of these people and the interest of cottage owners and local industry, Lakewatch would not have occurred. Financial support from Alberta Environment, the Lakeland Industry & Community Association (LICA) and the Summer Temporary Employment Program (STEP) were essential in 2003.

Bluet Lake

Bluet Lake, also known as Little Garnier, Garnier South, or Upper Garnier lies in the southern portion of Muriel Lake's sub – drainage basin of the Beaver River Watershed. Bluet Lake drains into Garnier Lake to the north, and then water flows into Muriel Lake and eventually, into the Beaver River. Bluet Lake is a small round lake with a surface area of 1.21 km^2 and a depth over 6.5 m deep (Fig. 2). Historically, the maximum depth of Bluet Lake has been recorded at 9.5 m but later sampling in the winter recorded 7 m (Alberta Government, 2002); the presence of Beaver dams can hold back as much as 1 to 1.5 m of water. For example, in the early 1980's a massive dam was located on the north end of the lake and it was noted that erosion and flooded trees covered most of the shoreline. Today, evidence of erosion still exists through much of the shoreline, but it was also evident that water levels have been decreasing. Unfortunately, no water level data records exist for Bluet Lake. Cattails fringe the bay area, most of the steeper western shoreline and near the outlet area.

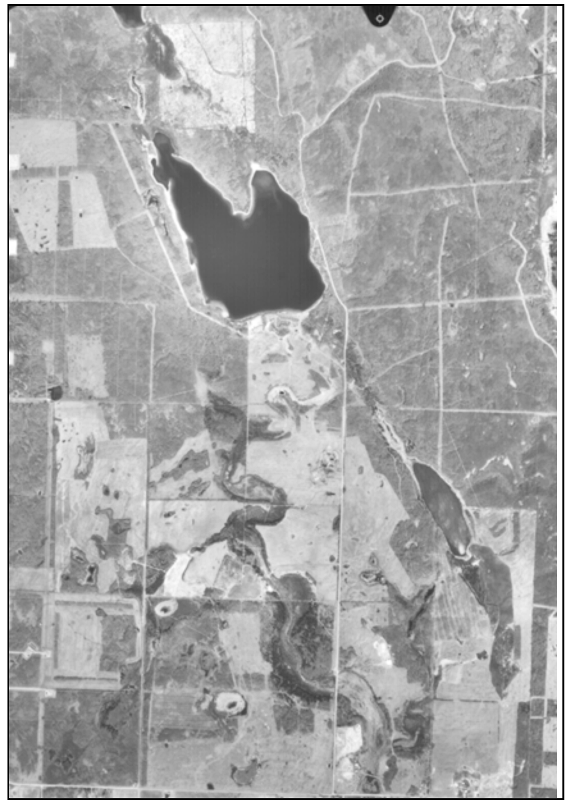


Fig. 1: Air photo of Bluet Lake and its surroundings. Source: Neil Guay.

Plains Cree and other nomadic tribes such as the Blackfoot Tribes once inhabited the area. There were many trading posts in the area to the north (Moose Lake and Cold Lake areas), east (Frog Lake), and southeast (along the North Saskatchewan River). Unsurprisingly, resources from hunting and trapping were very important trades to the area. Beaver activity is common around Bluet Lake, 30 to 50 pelts were still harvested annually from the region in the early-mid 1980's (AENV 1983, vol.5).

Bluet's drainage basin is moderately rolling hummocky morainal plain with irregular knob and kettle topography (Mitchell and Prepas, 1990). Vegetation in the area is mostly aspen forest. Agricultural land-use is primarily grazing with a small section of cleared land for hay. Other development includes oil and gas industries and it remains undeveloped for recreation and summer cottages. The lake's uses include livestock, trapping, hunting waterfowl, and fishing. Northern pike was the only sport fish found in previous surveys (Alberta Government, 2002), although it is likely that perch and burbot try to establish populations in some years, but are limited by beaver dam activity, erosion to the shoreline created by water level fluctuations and emergent vegetation development (AENV 1983, Vol.5).

Results

Water Temperature and Dissolved Oxygen

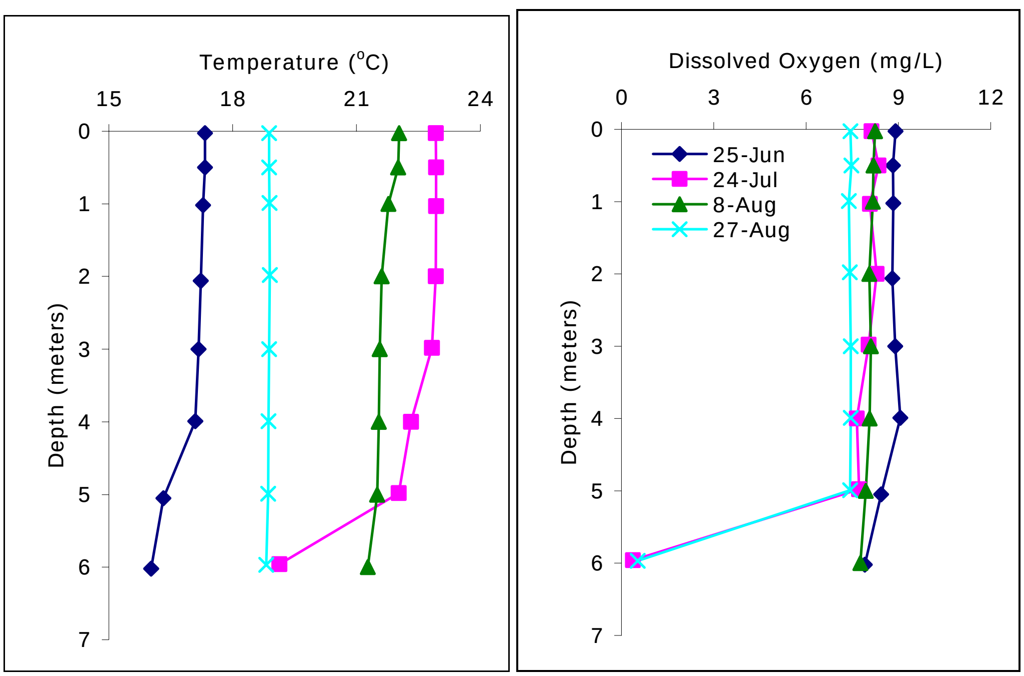
Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. Please refer to the end of this report for descriptions of technical terms.

In 2003, Bluet Lake did not exhibit strong thermal stratification. Weak stratification developed near the lake bottom and during the warmest time of the year (i.e., end of July). Thermal stratification was not observed at other times during the summer. Dissolved oxygen concentrations were above 5 mg/L, the acute provincial guideline for the protection of aquatic life, throughout most of the water column, except at lake bottom. In general, Bluet Lake was well-airated.

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.

In 2003, Bluet Lake's water was fairly clear with a mean Secchi disk depth of 3 meters. Water clarity followed patterns in algal biomass, or water greenness (Fig. 4). Secchi disk depth in late June was fairly shallow at 2.75 m increasing through July and reaching a peak of 4.5 m in early August. Clarity then dropped again by late august, to a depth of 2 m.



Figs. 2 & 3: Temperature and dissolved oxygen profiles for Bluet Lake, summer 2003.

Water chemistry

Bluet Lake had moderate nutrient concentrations and algal biomass compared to lakes throughout Canada, and therefore is considered mesotrophic (see details on trophic status classification at end of this report). In the Alberta context, Bluet Lake is about average in these characteristics. In 2003, total phosphorus concentrations were fairly stable and hovered about 25 µg/L for most of the summer. Chlorophyll *a*, a measure of algal biomass, stayed close to 5 to 10 µg/L and mirrored patterns in total phosphorus concentrations (Fig. 4). Bluet Lake does not follow the typical pattern in Alberta lakes of an increase in phosphorus and chlorophyll *a* concentrations over the summer. Total nitrogen concentrations also did not change much over the summer of 2003 and were more representative of hypereutrophic conditions. Annually, nutrient concentrations are similar to those found in 2002 (Table 1). However, there is a small increase in ammonia, a form of nitrogen readily available to algae. Ammonia is an end product of the decomposition of organic matter and can be released from the sediments under anoxic conditions (Wetzel, 1983). Metal concentrations were low and none surpassed provincial and federal Water Quality Guidelines for the Protection of Aquatic Life. In general, the water quality of Bluet Lake is relatively good and the water is clear.

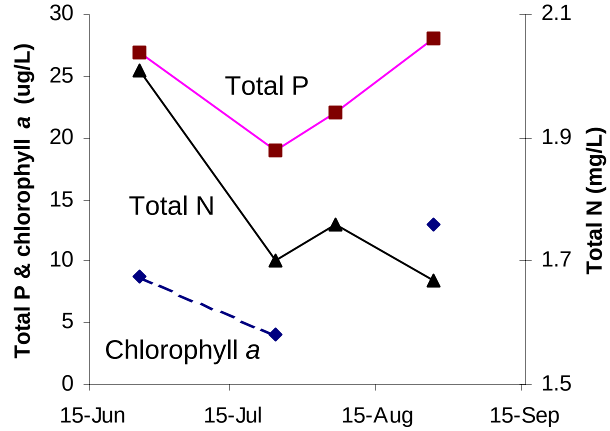


Fig. 4: Total phosphorus, algal biomass (as chlorophyll a), and total nitrogen in Bluet Lake, summer 2003.

Table 1: Average chemical characteristics of Bluet Lake, summers 2003 and 2002, and from a grab sample taken March 2, 1979.

Parameter	Mar 79	2002	2003
Total P (µg/L)	-	28	24
TDP (µg/L)		12	10
Chla (µg/L)	-	4.2	8.6
Secchi (m)	-	2.9	3.0
Total N (mg/L)	-	1.8	1.8
NO_{2+3} (µg/L)	130	2.9	8.5
NH_4 (µg/L)	-	15	22
Ca (mg/L)	-	24	20
Mg (mg/L)	47	72	79
Na (mg/L)	32	57	57
K (mg/L)	11	21	20
SO_4 (mg/L)	57	69	108
Cl (mg/L)	3	7.4	7.5
CO_3 (mg/L)	-	39	42
HCO_3 (mg/L)	-	362	364
pH	-	9	9
Total Alkalinity (mg/L $CaCO_3$)	292	362	368

Note. TDP = total dissolved phosphorus, Chla = chlorophyll *a*, Secchi = Secchi disk depth, 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

Bluet Lake is well-protected from acidification; its pH of 9 is well above that of pure water (i.e., pH 7). Bicarbonate, sulfate, sodium, and magnesium are the dominant ions in Bluet Lake. Ion concentrations were fairly high in 2003 and 2002, about double those measured in 1979. Since precipitation in recent years has been quite low in Alberta, groundwater inflows and evaporation are possibly responsible for the doubling in ion concentrations between 1979 and 2003. The increase in ion concentrations such as magnesium and sodium is likely related to changing hydrology and decreased runoff, as groundwater is generally magnesium and sodium sulfate or chloride dominated. Evaporative concentration could also play a role in the changing ion chemistry of Bluet Lake. Atmospheric deposition of acidifying pollutants from petroleum activities is another possibility for the increasing sulfate concentrations. However, since other ions not generated by the petroleum industry also doubled during this time, the petroleum activities are not likely solely responsible for the differences. Differences could also be attributed to seasonal differences between spring (March 1979) and summer (2002 & 2003) sampling. Speculations can unfortunately only be made at this time as limited historical water chemistry and no water level data exist.

Declines in water levels are a problem common to many lakes in the Cold Lake area due to our recent dry climate. Ion concentrations are rising in many of these lakes and we expect this trend to continue as long as the water deficit continues to occur. As levels decline, the potential for internal loading of nutrients from bottom sediments can increase and could result in declines in water quality that include the occurrence of algal blooms.

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

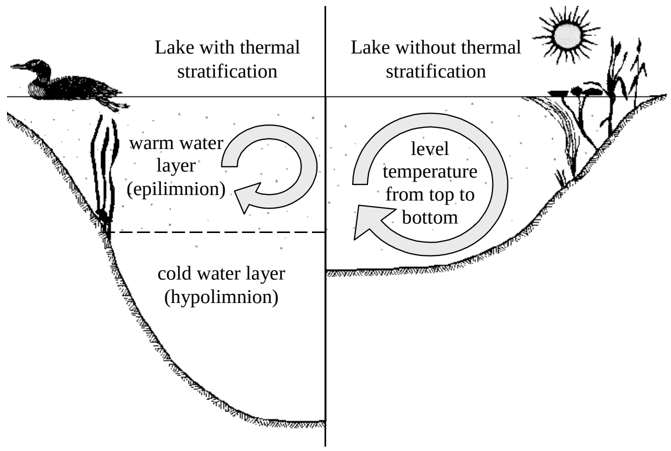


Fig. 5: Difference in the circulation of the water column depending on thermal stratification.

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 6.

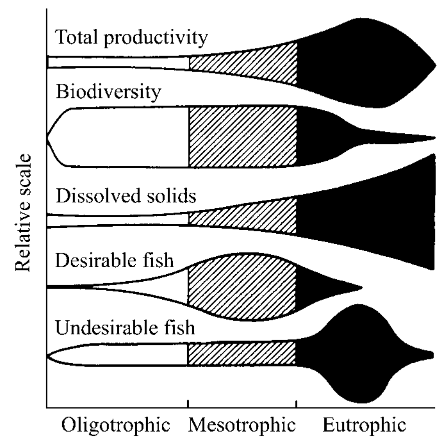


Fig. 6: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980

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.