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Lakewatch

Angling 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 are the objectives of educating lake users about their aquatic environment; enhancing public involvement in lake management; and facilitating a link between aquatic scientists and lake users. The 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 sources.

The 2002 Lakewatch Report has 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 castigate 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.

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. Jeremy and Lori Neufeld were our volunteers at Angling Lake and made sampling possible through the dedication of their time and of course watercraft. Mike Bilyk and John Willis from Alberta Environment were instrumental in training people. Financial support from the Lakeland Industry and Community Association (LICA) and the Prairie Farm Rehabilitation Association (PFRA) was essential in 2002 as we lost a majority of our Alberta Government support following budget cuts. Sophie Lewin and Lucille Kowalchuk were our summer field coordinators and were excellent additions to the program.

Fig. 1: Angling Lake | Photo: L. Kowalchuk, ALMS

Angling Lake

Angling lake is located 35 km southeast of Bonnyville, near the Hamlet of Beaverdam. To get there you proceed 20 km on secondary road 897, south of highway 28. Located in the Cold Lake Beaver River Drainage basin, the area has a rich history in fur trade, missionary, and European and Native North American settlement. Today, the region supports trade, agricultural, oil and gas. Angling lake's origin is most likely the result of a Winsonsonian ice scour. It lies upon two types of physiographical morainal plains revealing a topography that is gently undulating to moderately rolling. A large organic soil deposit along the north shore provides an area of shrub, whereas most of the shoreline is surrounded by agriculture that is fringed with aspen forest. (AENV1983, vol.7) According to a survey conducted by Alberta Environment, the lake receives minor recreational use, less than 30,000 users per year. Partially, the reason for low usage is a lack of facilities. The shoreline is very round and regular with a steep 1.5 m rounded bank, which can make boat launching difficult. Another reason for its low use is the gravel road access and location from major highways. Much of the recreational activity that the lake receives; such as camping, fishing and swimming, occurs during early summer because of "swimmer's itch" and poor water quality. (AENV 1983, vol. 6) Sport and forage fish include; northern pike, yellow perch, burbot and spottail shiners. Angling lake has supported a commercial pike fishery before 1983, but since 1992 Angling Lake has not been commercially active and only one year in the last decade the lake was utilized for domestic fisheries. (Bodden, 2002), (AENV 1983, vol. 4)

Angling lake is over 10 m deep (Fig. 2) with a surface area of 5.85 km^2. The Rieta Creek sub watershed is 214 km^2, and maintains the water level in Angling Lake by receiving inflow from Rieta

Fig. 2: Bathymetry of Angling Lake

creek and groundwater that eventually drains to the Beaver River. It is fast flushing with a residence time of 1.7 yrs. (AENV 1983, vol. 7) 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 northwest *Scirpus sp*. (bulrush), *Typha sp.* (cattail), *and Carex sp*. (sedges) are common. (AENV 1983, vol. 7), (AENV 1983, Main Report)

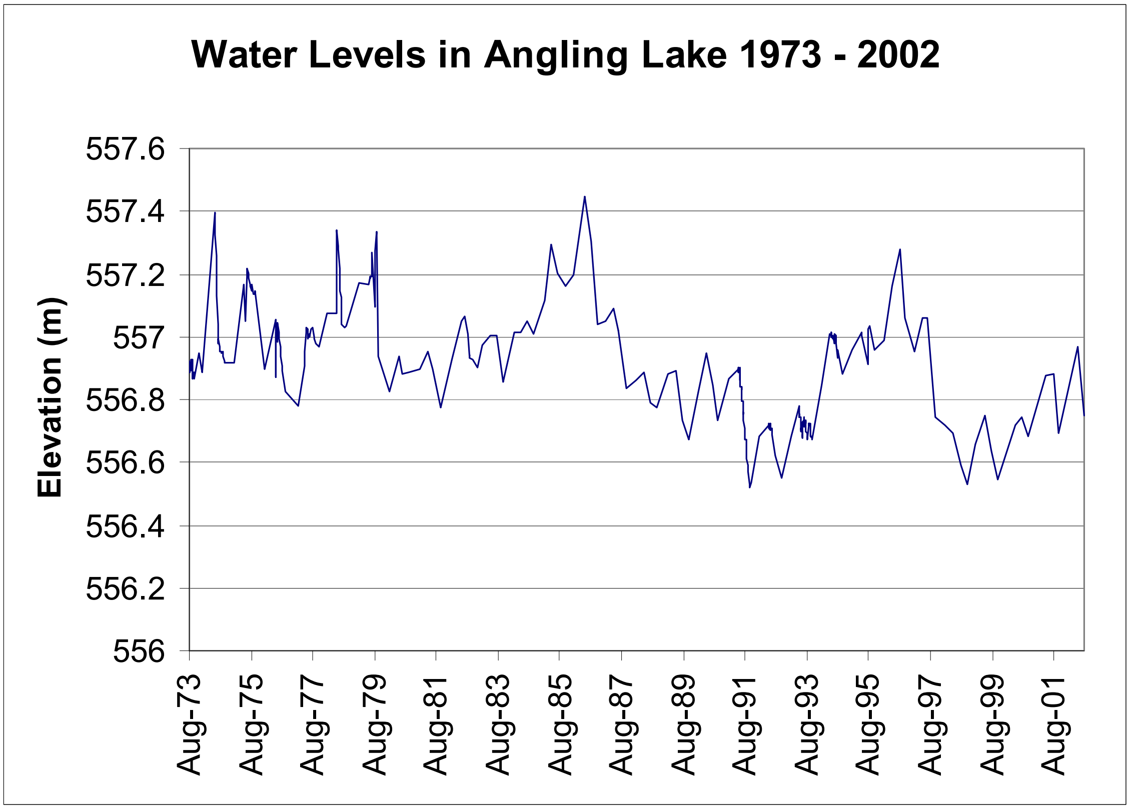

Fig. 3: Water level data for Angling Lake from 1973 through August 2002.

Water Levels

Water levels in Angling Lake have been monitored since 1973. Water levels rose to a maximum 557.25 m average in 1986; but dropped 0.6 m to a minimum 556.63 m average in 1988. Water levels from 1984 – 1987 were higher than the thirty - year mean of 556.93 m. Since the lowest year in 1988, water levels have been increasing steadily by about 0.04 m/year; except during 2001 where the water level rose 0.102 m, however, the levels are still below the average. In 2002, although not validated, the average water level from two sampling dates taken in May in August is 556.85 m above sea level. Unlike other lakes in Alberta, decreasing water levels are not a problem. Angling lake are increasing from the minimum low levels in 1988, likely due to the short residence time.

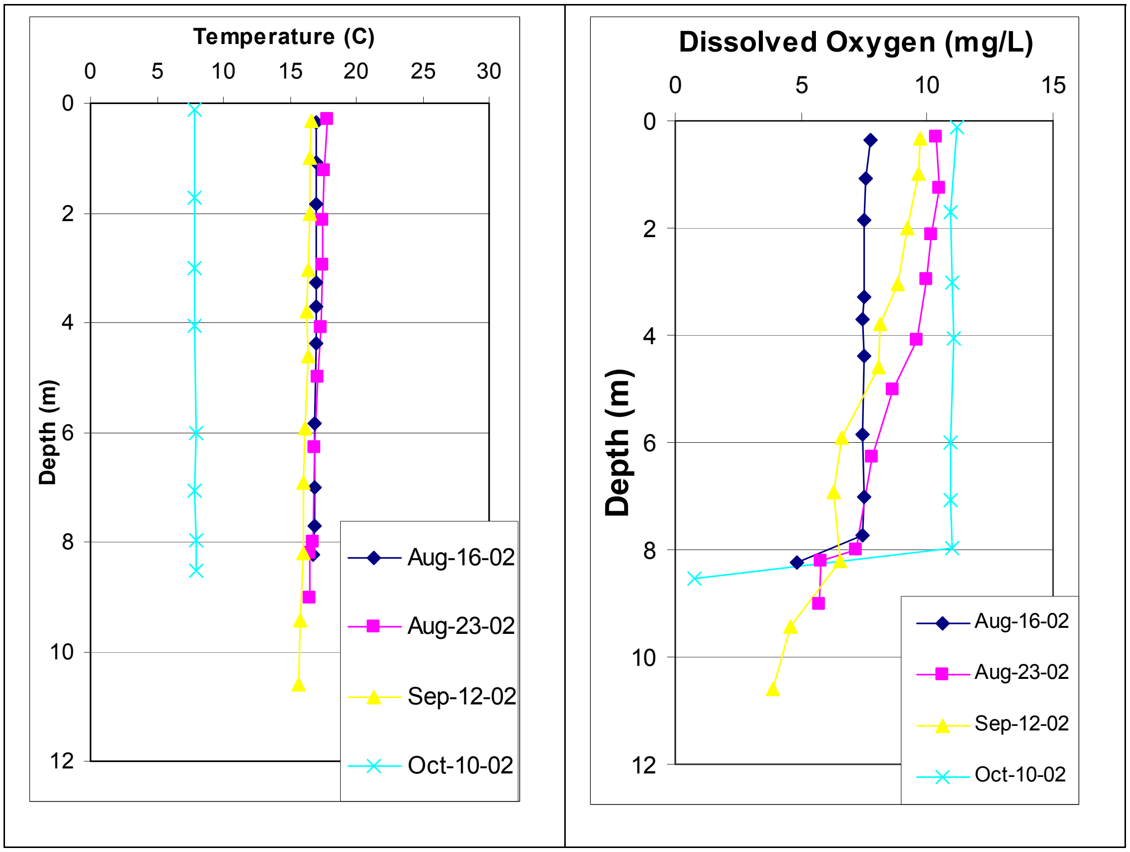

Fig. 4: Temperature and dissolved oxygen concentrations for Angling Lake.

Results

Water Temperature and Dissolved Oxygen

Thermal stratification was not apparent in Angling Lake through the summer of 2002 (Fig. 4). As a result, the lake remained well oxygenated. Low oxygen readings at 8 and 10.5 m depths were likely due to contact with sediments and represent conditions at the sediment water interface along the lake bottom. Dissolved oxygen concentrations were within surface water quality guidelines for most of the water column through the summer. Temperature and dissolved oxygen concentrations in Angling Lake are considered excellent for fish in the Alberta context.

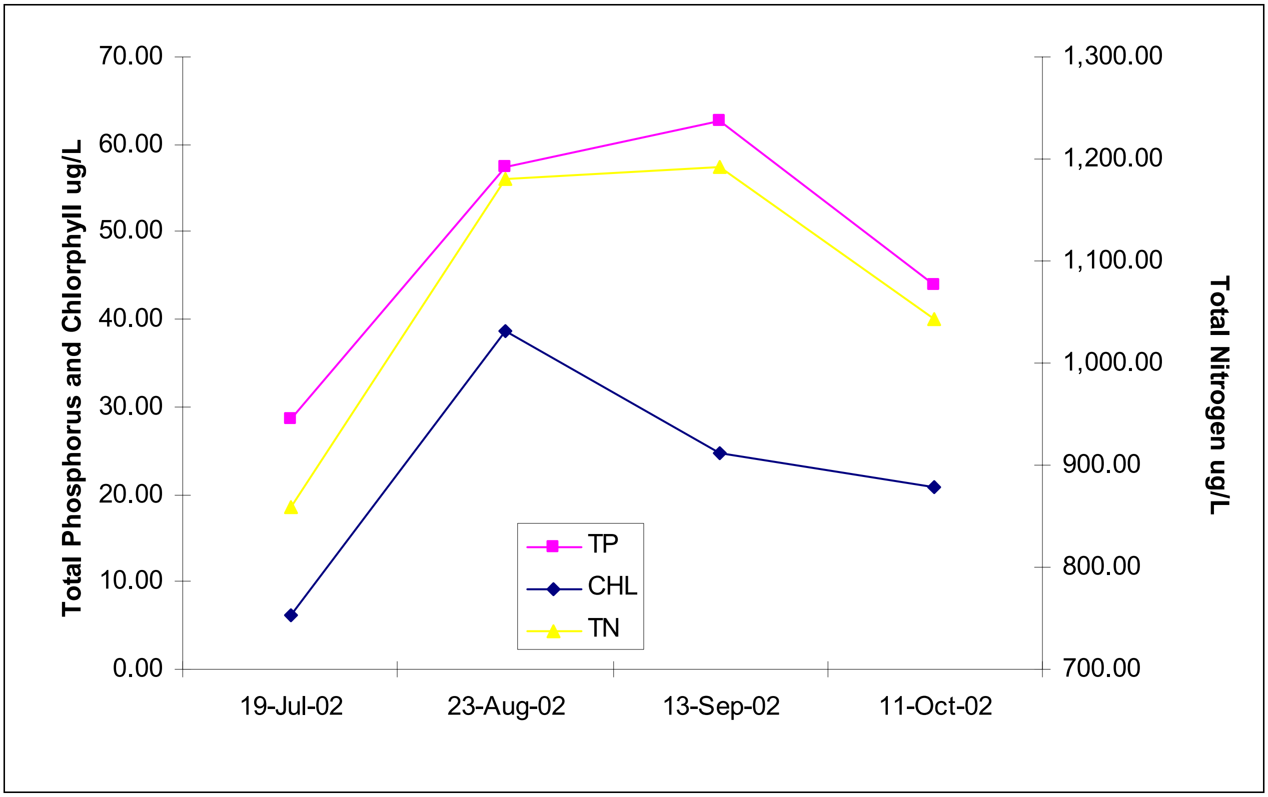

Fig. 5: Total phosphorus, chlorophyll *a* and Kjeldahl nitrogen for Angling Lake, summer 2002.

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 Angling Lake, the Secchi depth averaged 1.9 m. Secchi depth values were not available for May or June, however the lake was clear during July with a Secchi depth of 3.5 m. By mid-August the Secchi depth declined to 1.5 m continued to decline through September (1.25 m) and rose slightly in October (1.5 m). These patterns in clarity were consistent with seasonal chlorophyll values which increased through the summer through to peak concentrations in September (Fig. 5). Historic Secchi depth data were not available for Angling Lake on which to compare trends in water clarity.

Table 1: Mean values from summer 2002 samples compared to values from April 1981 and 1985 for chlorophyll *a* collected by AENV.

Parameter	1981	1985	2002
TP ($\mu g \bullet L^{-1}$)	-	-	48
TDP ($\mu g \bullet L^{-1}$)	-	-	16
Chl ($\mu g \bullet L^{-1}$)	30	27	23
Secchi (m)	-	-	1.9
TN ($\mu g \bullet L^{-1}$)	-	-	1069
$NO_{2+3}N$ ($\mu g \bullet L^{-1}$)	-	0.4	2.38
NH_4^+ N ($\mu g \bullet L^{-1}$)	-	-	7.2
Ca ($mg \bullet L^{-1}$)	-	21.9	26
Mg ($mg \bullet L^{-1}$)	-	33	45
Na ($mg \bullet L^{-1}$)	-	19.2	36
K ($mg \bullet L^{-1}$)	-	4.8	14
SO_4^{2-} ($mg \bullet L^{-1}$)	-	< 1	14
Cl^- ($mg \bullet L^{-1}$)	-	3	4.06
Total Alkalinity ($mg \bullet L^{-1}$ $CaCO_3$)	-	260	314
pH	-	8.88	8.84
Conductivity	-	350	584

Water chemistry

Ion concentrations in Angling Lake are high in monovalent cations, sodium and potassium. Groundwater contributions may be the source of sodium, however, sulfate and chloride concentrations are relatively low. Mineral ions such as calcium and bicarbonate or sodium and sulfate are supplied by weathering in the watershed and from groundwater inflows. Magnesium, sodium, potassium, bicarbonate and sulfate concentrations appear to have increased since 1985. Atmospheric deposition of acidifying pollutants from petroleum activities can often be seen in increasing sulfate concentrations. 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 data to assess the sources of changed ion concentrations in Angling Lake. Changes in the hydrologic regime have contributed to increased ion concentrations in other lakes in the region and the approximate one-third increase in most ions in Angling Lake may also reflect reduced surface runoff. However, the large increase in sulfate is a potential concern if sources of atmospheric deposition exist in the watershed.

Angling Lake is eutrophic with what is considered high nutrient concentration and algal biomass compared to lakes throughout Canada. In the Alberta context, Angling Lake is about average in these characteristics. There are currently no historic nutrient data available from Alberta Environment for Angling Lake. We are therefore unable to assess if nutrient characteristics have changed in Angling Lake. However, algal biomass concentrations do not appear to have changed since 1981 indicating that nutrient concentrations, particularly phosphorus also may not have changed.

Chlorophyll *a* (CHL) concentrations in Angling Lake were consistent with the phosphorus concentration. The lake is eutrophic and therefore can appear very green with algal growth. Concentrations rose through to late summer then declined through September, consistent with the phosphorus and nitrogen concentrations in the lake and other lakes in Alberta.

Angling Lake does not appear to be impacted by the problems common to other lakes in Alberta such as loss of water level. Ion concentrations do appear to have increased which may be a result of changes in hydrology not reflected in water levels. From the limited chlorophyll data it appear that Angling Lake is not experiencing any changes in regards to nutrient inputs from cottages or landuse practices.

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A brief introduction to Limnology

Indicators of water quality

Water samples are collected in Lakewatch to determine the chemical characteristics that characterize general water quality. Though not all encompassing, the variables collected in Lakewatch are sensitive to human activities in watersheds that can cause degraded water quality. For example, nutrients such as phosphorus and nitrogen are important determinants of lake productivity. The concentrations of these nutrients in a lake are impacted (typically elevated) by land use changes such as increased crop production or livestock grazing. Elevated nutrient concentrations can cause increases in undesirable algae blooms resulting in low dissolved oxygen concentrations, degraded habitat for fish and noxious smells. A large increase in nutrients over time may also indicate sewage inputs which in turn may result in other human health concerns associated with bacteria or the protozoan *Cryptosporidium*.

Temperature and mixing

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality. Heat is transferred to a lake at its surface and slowly moves downward depending on water circulation in the lake. Lakes with a large surface area or a small volume tend to have greater mixing due to wind. In deeper lakes, circulation is not strong enough to move warm water to depths typically greater than 4 or 5 m and as a result cooler denser water remains at the bottom of the lake. As the difference in temperature between warm surface and cold deeper water increases, two distinct layers are formed. Limnologists call these layers of water the **epilimnion** at the surface and the **hypolimnion** at the bottom. The layers are separated by a transition layer known as the **metalimnion** which contains the effective wall separating top and bottom waters called a **thermocline**. A thermocline typically occurs when water temperature changes by more than one degree within one meter depth. The hypolimnion and epilimnion do not mix, nor do elements such as oxygen supplied at the surface move downward into the hypolimnion. In the fall, surface waters begin to cool and eventually reach the same temperature as hypolimnetic water. At this point the water mixes from top to bottom in what is often called a **turnover** event. Surface water cools further as ice forms and again a thermocline develops this time with 4° C water at the bottom and near 0° C water on the top.

In spring another turnover event occurs when surface waters warm to 4° C. Lakes with this mixing pattern of two stratification periods and two turnover events are called **dimictic** lakes. In shallower lakes, the water column may mix from top to bottom most of the ice-free season with occasional stratification during periods of calm warm conditions. Lakes that mix frequently are termed **polymictic** lakes. In our cold climate, many shallow lakes are **cold monomictic** meaning a thermocline develops every winter, there is one turnover event in spring but the remainder of the ice free season the lake is polymictic.

Dissolved Oxygen

Oxygen enters a lake at the lake surface and throughout the water column when produced by photosynthesizing plants, including algae, in the lake. Oxygen is consumed within the lake by respiration of living organisms and decomposition of organic material in the lake sediments. In lakes that stratify (see temperature above), oxygen that dissolves into the lake at the surface cannot mix downward into the hypolimnion. At the same time oxygen is depleted in the hypolimnion by decomposition. The result is that the hypolimnion of a lake can become **anoxic**, meaning it contains little or no dissolved oxygen. When a lake is frozen, the entire water column can become anoxic because the surface is sealed off from the atmosphere. Winter anoxic conditions can result in a fish-kill which is particularly common during harsh winters with extended ice-cover. Alberta Surface Water Quality Guidelines suggest dissolved oxygen concentrations (in the epilimnion) must not decline below 5 $mg \bullet L^{-1}$ and should not average less than 6.5 $mg \bullet L^{-1}$ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 $mg \bullet L^{-1}$ in areas where early life stages of aquatic biota, particularly fish, are present.

General Water Chemistry

Water in lakes always contains substances that have been transported by rain and snow or have entered the lake in groundwater and inflow streams. These substances may be dissolved in the water or suspended as particles. Some of these substances are familiar minerals, such as sodium and chloride, which when combined form table salt, but when dissolved in water separate into the two electrically charged components called **ions**. Most dissolved substances in water are in ionic forms and are held in solution due to the polar nature of the water molecule. **Hydrophobic** (water-fearing) compounds such as oils contain little or no ionic character, are non-polar and for this reason do not readily dissolve in water. Although hydrophobic compounds do not readily dissolve, they can still be transported to lakes by flowing water. Within individual lakes, ion concentrations vary from year to year depending on the amount and mineral content of the water entering the lake. This mineral content can be influenced by the amount of precipitation and other climate variables as well as human activities such as fertilizer and road salt application.

Phosphorus and Nitrogen

Phosphorus and nitrogen are important nutrients limiting the growth of algae in Alberta lakes. While nitrogen usually limits agricultural plants, phosphorus is usually in shortest supply in lakes. Even a slight increase of phosphorus in a lake can, given the right conditions, promote algal blooms causing the water to turn green in the summer and impair recreational uses. When pollution originating from livestock manure and human sewage enters lakes not only are the concentrations of phosphorus and nitrogen increased but nitrogen can become a limiting nutrient which is thought to cause blooms of toxic algae belonging to the cyanobacteria. Not all cyanobacteria are toxic, however, the blooms can form decomposing mats that smell and impair dissolved oxygen concentrations in the lake.

Chlorophyll a

Chlorophyll *a* is a photosynthetic pigment that green plants, including algae, possess enabling them to convert the sun's energy to living material. Chlorophyll *a* can be easily extracted from algae in the laboratory. Consequently, chlorophyll *a* is a good estimate of the amount of algae in the water. Some highly productive lakes are dominated by larger aquatic plants rather than suspended algae. In these lakes, chlorophyll *a* and nutrient values taken from water samples do not include productivity from large aquatic plants. The result, in lakes like Chestermere which are dominated by larger plants known as macrophytes, can be a lower trophic state than if macrophyte biomass was included. Unfortunately, the productivity and nutrient cycling contributions of macrophytes are difficult to sample accurately and are therefore not typically included in trophic state indices.

Secchi Disk Transparency

Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. A measure of the transparency or clarity of the water is performed with a Secchi disk with an alternating black and white pattern. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the disk disappears is recorded. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. However, low Secchi depths are not caused by algal growth alone. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly low Secchi depths despite low algal growth and nutrient concentrations.

The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Conversely, aquatic plants can ensure lakes have clear water by reducing shoreline erosion and stabilizing lake bottom sediments. In Alberta, many lakes are shallow and bottom sediments contain high concentrations of nutrients. Without aquatic plants, water quality may decline in these lakes due to murky, sediment laden water and excessive algal blooms. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and insects, depend on aquatic plants for food and shelter.

Trophic state

Trophic state is classification of lakes into four categories of fertility and is a useful index for rating and comparing lakes. From low to high nutrient and algal biomass (as chlorophyll) concentrations, the trophic states are; **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic**. A majority of lakes in Alberta contain naturally high levels of chlorophyll *a* (8 to 25 µg/L) due to our deep fertile soils. These lakes are usually considered fertile and are termed eutrophic. The nutrient and algal biomass concentrations that define these categories are shown in the following table, a figure of Alberta lakes compared by trophic state can be found on the ALMS website.

Trophic status classification based on lake water characteristics.

Trophic state	Total Phosphorus ($\mu g \bullet L^{-1}$)	Total Nitrogen ($\mu g \bullet L^{-1}$)	Chlorophyll a ($\mu g \bullet L^{-1}$)	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.