THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2010 Chestermere Lake Report

COMPLETED WITH SUPPORT FROM:

Alberta Lake Management Society's Lakewatch Program

Lakewatch has several important objectives, one of which is to collect and interpret water quality data 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 those 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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CHESTERMERE LAKE:

Chestermere Lake was originally built by the Canadian Pacific Railroad (CPR) in the 1880's as a water-balancing reservoir, supplying water at 50 cents per acre to CPR land. In the 1940's, the CPR offered to forgive mortgages held on their land in return for settlers giving up their water rights. The irrigation system was turned over to the Western Irrigation District (WID), which currently owns and operates the structures feeding water to and from Chestermere Lake (Mitchell and Prepas, 1990). The drainage basin for the lake is only 7.65 km^2 including the 2.65 km^2 'reservoir' at its maximum capacity.

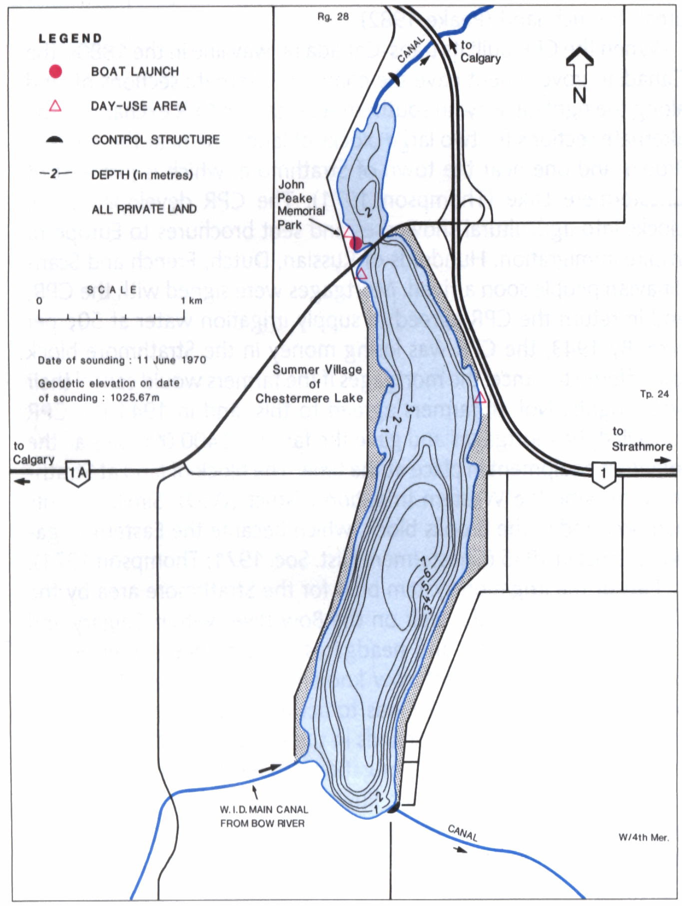

Figure 1 – Bathymetric map of Chestermere Lake (Mitchell and Prepas 1990).

Chestermere Lake is shallow over most of its depth. During the original survey conducted by the Alberta Government, Chestermere Lake was more than seven meters deep. The deepest areas of the lake have accumulated little sediment as maximum depth still remains between five to seven meters depending on water levels. Sediment accumulation has been heaviest at the WID canal inflow (south) where as much as two meters of sediment has accumulated.

Aquatic weeds are a problem in Chestermere Lake (Figure 1). Weed growth is extensive due to Chestermere Lakes shallow depth, which is less than two meters over 50% of its area. The prevailing theory on weed growth is that weeds dominate in shallow, clear water. Some shallow lakes have poor water clarity either because of excessive algae growth or suspended sediments; these lakes tend to have few weed problems no matter how shallow they are. Among shallow lakes, these two states (turbid and weed free vs. clear and weed dominated) exist as two stable possibilities for the same lake. The current evidence suggests that a lake can be pushed from weed dominated to weed free by a single event causing high sediment suspension. Turbid and algae dominated conditions will then persist because the stability of both the water column and bottom sediments provided by rooted-plants disappears. Chestermere Lake receives a large volume of water during summer months, enough to replace the entire lake volume in eight days. Flushing of this magnitude may actually help to maintain the waters clarity and thus the success of weeds in comparison to other Alberta lakes of similar depth.

It is important to note that water bodies less than two meters deep are considered wetlands by Canadian and U.S. classification criteria. This is not to detract from the beauty of Chestermere Lake but simply to acknowledge the reality that Chestermere Lake should be dominated by aquatic plants. Chestermere is vital to local recreational use and requires a strong education drive to increase awareness that a fringe of weeds followed by floating-leaf and submerged vegetation may be unavoidable. At the same time, depth must be maintained in the lake to provide weed-free areas. Aggressive weed-removal by mechanical methods will provide respite from weeds but will be required on a continuous aggressive basis.

WATER LEVELS:

Because water levels in Chestermere Lake are controlled by a weir operated by Alberta Environment, water levels are predictable and change very little (Figure 2). Since the early 1990's, water levels in Chestermere Lake have fluctuated within a 0.3 meter range. In the winter, the water levels in Chestermere Lake are reduced drastically to protect the retaining walls around the lake.

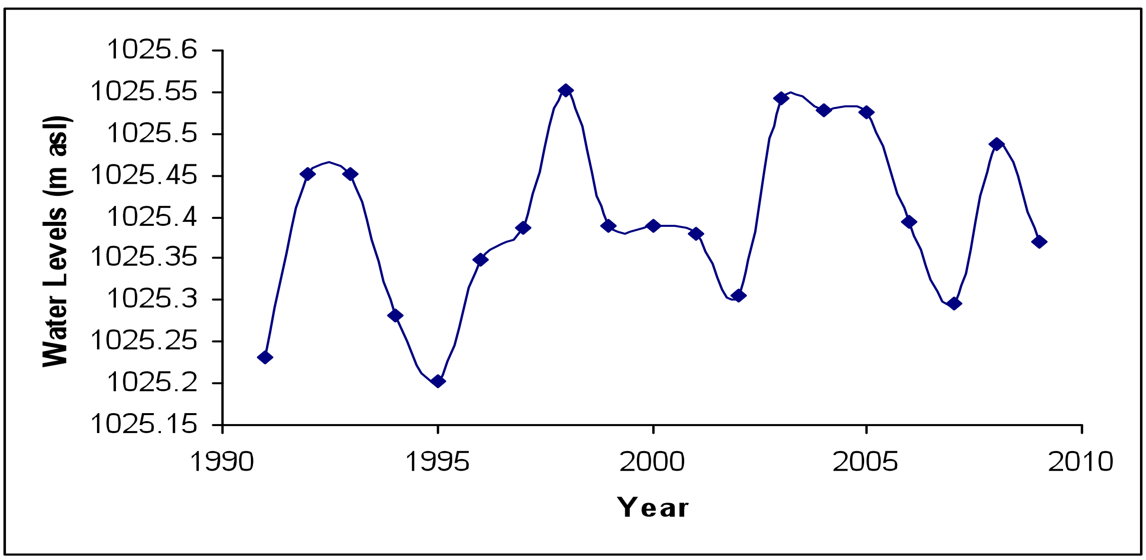

Figure 2 – Historical water levels for Chestermere Lake given in meters above sea level (m asl). Data retrieved from Environment Canada.

WATER CLARITY AND SECCHI DEPTH:

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

Secchi depth in Chestermere Lake was measured four times over the course of the summer and was an average of 4.25 meters (Table 1). A secchi depth of 4.25 indicates that enough light is available up to 8.50 meters to promote plant growth and is thus consistent with the large number of macrophytes (weeds) seen in Chestermere Lake. Maximum secchi depth was recorded in early July at 6.25 meters, and a minimum secchi depth of 2.00 meters was recorded in September.

WATER TEMPERATURE AND DISSOLVED OXYGEN:

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. The depth of the thermocline is important in determining the depth to which dissolved oxygen from the surface can be mixed. Please refer to the end of this report for descriptions of technical terms.

Water temperature in Chestermere Lake was measured four times over the course of the summer (Figure 3a). On July 3rd, surface water temperature measured 17.78 °C and decreased to 15.57 °C at the lakebed. On July 30th, water temperature was at a seasonal maximum of 20.65 °C and decreased to 17.76 °C at the lakebed. On August 18th, surface water temperature had begun to decrease and was 18.86 °C at the surface, decreasing to 17.28 °C at the bottom. Finally, on September 6th, surface water temperature was at a seasonal minimum of 14.15 °C and decreased to 13.68 °C at the lakebed. None of the temperature profiles showed thermal stratification as Chestermere Lake is shallow enough that wind energy is able to mix the entire water column over the course of the summer.

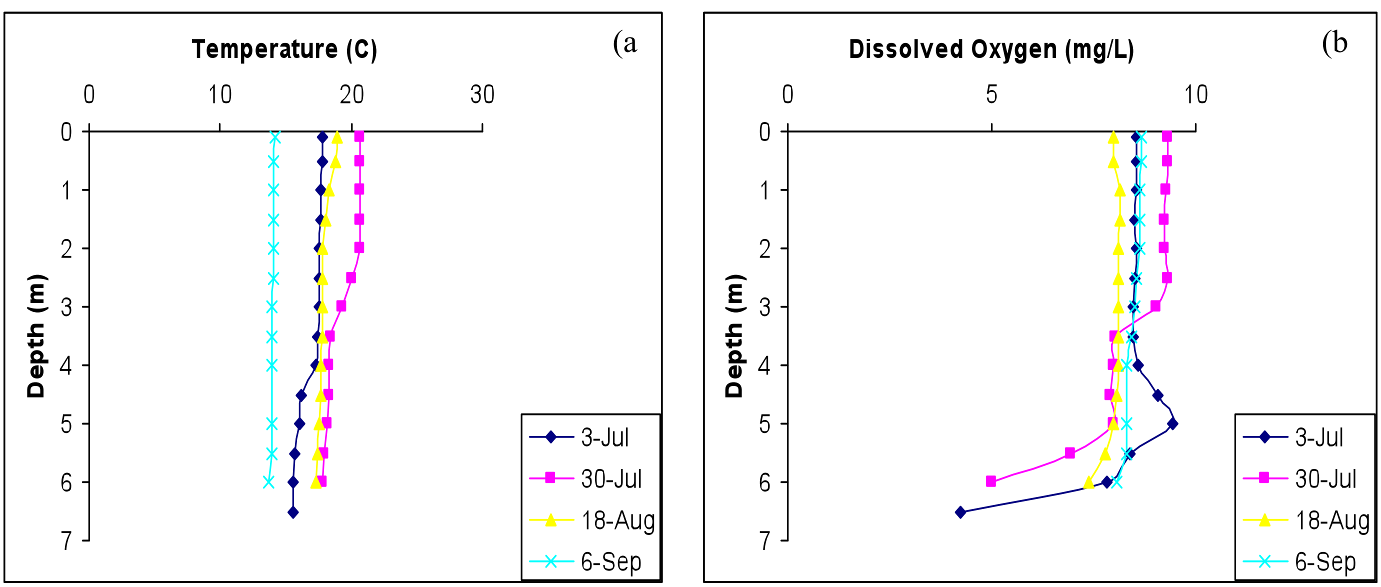

Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) measured four times over the course of the summer at Chestermere Lake.

Dissolved oxygen in Chestermere Lake was 8.56 mg/L at the surface on July 3rd and slowly decreased to 4.25 mg/L at the lake bottom (Figure 3b). On July 30th, dissolved oxygen had increased to 9.31 mg/L at the surface and 5.00 mg/L at the bottom. On August 18th, dissolved oxygen was quite uniform throughout the water column, measuring 7.99 mg/L at the surface and 7.39 mg/L at the lakebed. Finally, on September 6th, dissolved oxygen measured 8.68 mg/L at the lake surface and 8.06 mg/L at the lakebed.

WATER CHEMISTRY:

ALMS measures a suite of water chemistry parameters. Phosphorous, nitrogen, and chlorophyll-a are important because they are indicators of eutrophication, or excess nutrients, which can lead to harmful algal/cyanobacteria blooms. One direct measure of harmful cyanobacteria blooms are Microcystins, a common group of toxins produced by cyanobacteria. See Table 1 for a complete list of parameters.

Based on the average total phosphorous measured in 2010 (23.75 μg/L), Chestermere Lake would be classified as a mesotrophic, or moderately productive, lake. Over the course of the summer, phosphorous concentration fluctuated slightly, with a seasonal maximum on July 2nd of 28 μg/L and a seasonal minimum on July 30th of 18 μg/L. Average total nitrogen in 2010 was 0.315 mg/L and fluctuated between a seasonal maximum of 0.37 mg/L on July 2nd and a seasonal minimum of 0.29 mg/L on July 30th. Average chlorophyll-*a* concentration (3.365 μg/L) in Chestermere Lake was low, within the oligotrophic classification level for lakes. Such low chlorophyll-*a* levels are consistent with the high water clarity observed in Chestermere Lake.

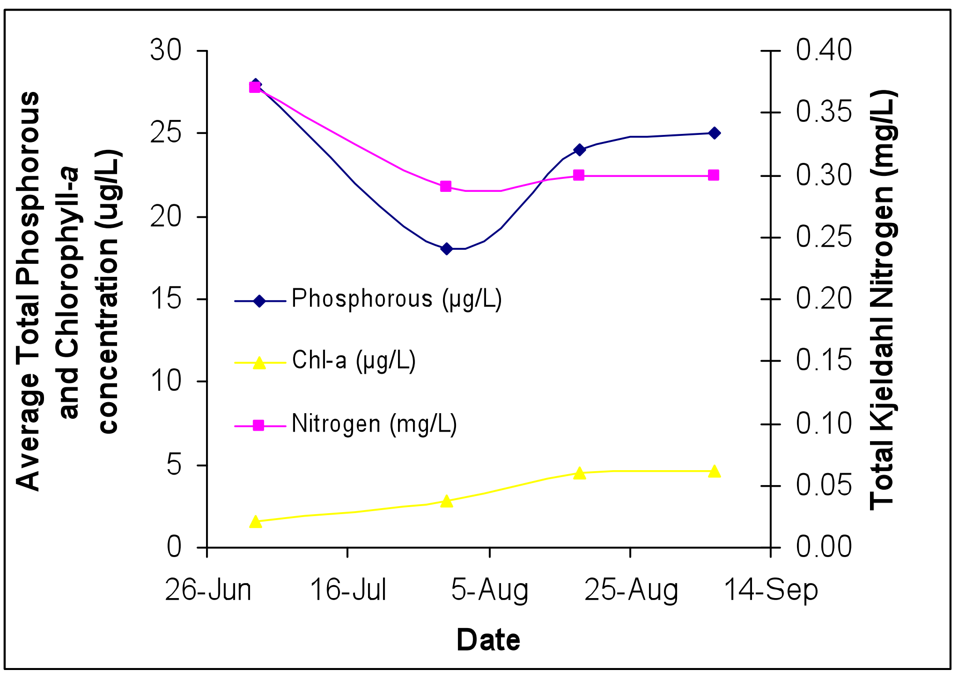

Figure 4 – Total phosphorous (μg/L), chlorophyll-*a* concentration, and total Kjeldahl nitrogen (mg/L) measured five times over the course of the summer at Chestermere Lake.

The pH in Chestermere Lake is above-neutral, with an average of 8.57 in 2010. The high alkalinity measured in Chestermere Lake (120 mg/L $CaCO_3$) helps to buffer the water from changes to pH. Dominant ions include sodium, magnesium, calcium, and bicarbonate. As an urban lake, concerns have been raised in the past regarding levels of sodium and chlorine due to urban runoff. While both parameters have increased in comparison to historical levels, neither of these parameters were appreciably high.

Table 1 – Average secchi depth and water chemistry values for Chestermere Lake measured from 1983 to 2010.

Parameter	1983	1999	2000	2001	2007	2010
TP (μg/L)	36	32	25	19	30.5	23.75
TDP (μg/L)	/	/	/	/	11	7.25
Chlorophyll-*a* (μg/L)	5.5	9.0	7.6	3.4	2.725	3.365
Secchi depth (m)	2.9	2.6			3.9	4.25
TKN (μg/L)	443	335	200	724	537.5	315
NO_2 and NO_3 (μg/L)	/	/	229	739	226.25	29.5
NH_3 (μg/L)	/	/	/	/	/	18.25
DOC (mg/L)	/	/	/	/	4.275	2.23
Ca (mg/L)	35	37	37	37	41.875	32.23
Mg (mg/L)	12	15	13	14	15.1625	16.63
Na (mg/L)	7	15	8	5	46.225	19.03
K (mg/L)	1	1	1	1	2.5	1.13
SO_4^{2-} (mg/L)	38	/	43	38	100	58
Cl^- (mg/L)	4	7	5	3	37.425	12.7
CO_3 (mg/L)	/	/	/	/	1.85	0.5
HCO_3 (mg/L)	/	/	/	/	158	146
pH	/	/	/	/	8.31	8.42
Conductivity (μS/cm)	/	/	/	/	563	149
Hardness (mg/L)	/	/	/	/	185	375
TDS (mg/L)	/	/	/	/	329.75	212
Total Alkalinity (mg/L $CaCO_3$)	111	/	116	110	132	120

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO_{2+3} = nitrate+nitrite, NH_3 = ammonia, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate. A forward slash (/) indicates an absence of data.

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:

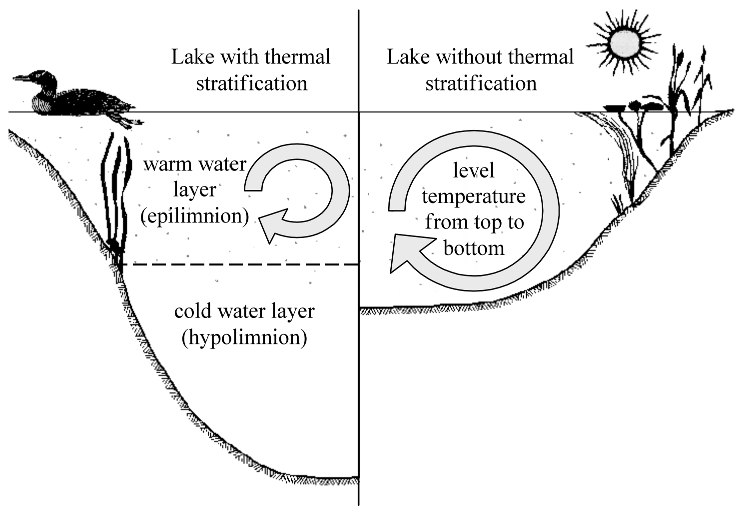

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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 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 (Table 2)**.

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.

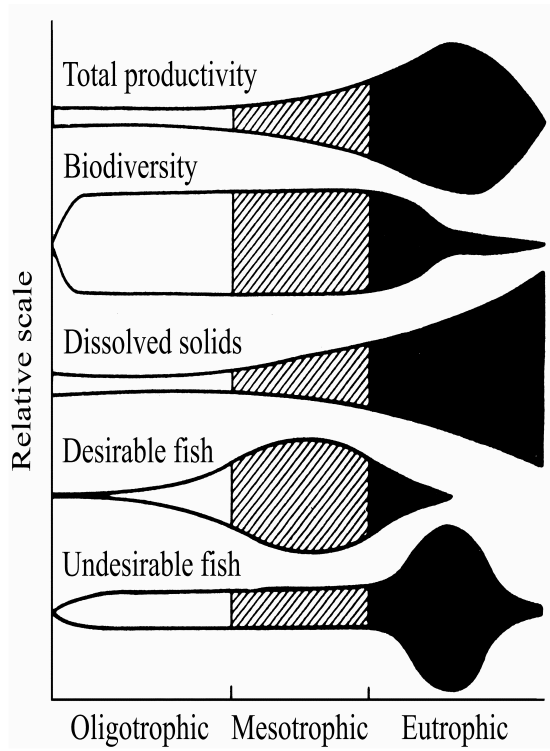

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

Table A - Trophic status classification based on lake water characteristics.

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

References

Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes. University of Alberta Press. Available at: http://alberta-lakes.sunsite.ualberta.ca/

Nürnberg, G.K. 1996. Trophic state of clear and colored, soft and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. Lake and Reservoir Management 12(4):432-447.