Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Angling Lake

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2004 Report

Completed with support from:

Alberta Lake Management Society
Lakeland Industry & Community Association
Alberta Environment

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> *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, 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 Lakewatch Chairs, Théo Charette, Preston McEachern and Ron Zurawell, and the volunteers. Jeremy and Lori Neufeld were the volunteers for Angling Lake. They supplied the watercraft and made sampling possible through the dedication of there time. Our summer field technician and volunteer coordinator, Heather Jones, was a valuable addition and contributor to this year's program. Numerous Alberta Environment staff also contributed to successful completion of the 2004 program. Project Technical Coordinator, Shelley Manchur 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. Heather Jones and Ron Zurawell (Limnologist, AENV) prepared this report. Alberta Environment, Lakeland Industry and Community Association (LICA) and Lakeland County financially supported the Lakewatch program.

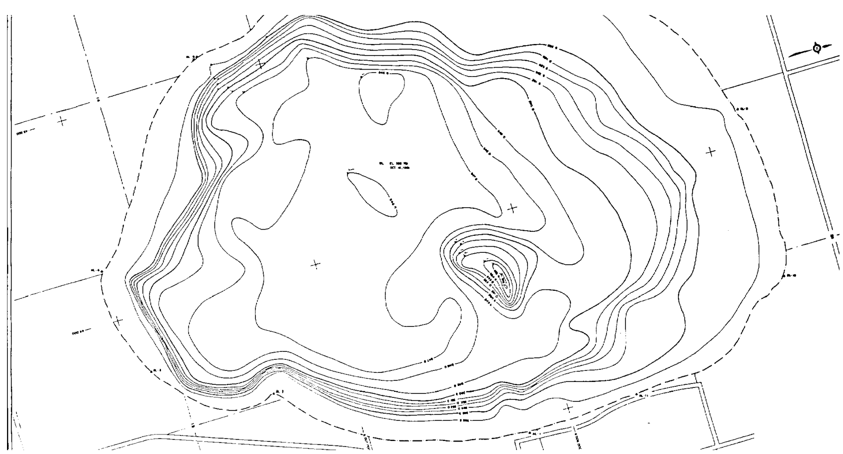
Angling Lake

Angling lake (**Figure 1**) is located 35 km southeast of Bonnyville, near the Hamlet of Beaverdam (20 km south on secondary road 897, from highway 28). The lake is part of the Cold Lake Beaver River Drainage basin, in an area with a rich history in fur trade, missionary, and European and Native North American settlement. Today, the region supports trade, agricultural, and oil and gas production.

Figure 1: Angling Lake (L. Kowalchuk).

Angling lake's origin is most likely the result of a Winsonsonian ice scour. It lies upon two types of morainal plains revealing a topography that is gently undulating to moderately rolling. Most of the shoreline is surrounded by agriculture fringed with aspen forest, though a large organic soil deposit along the north shore primarily supports shrub vegetation. The shoreline is very round and regular with a steep 1.5 m rounded bank, which can make boat launching difficult. According to a survey conducted by Alberta Environment, the lake receives minor recreational use, less than 30,000 users per year. Most of the recreation, such as camping, fishing and swimming, occurs during early summer because of "swimmer's itch" and poor water quality. (AENV 1983). Other reasons for its low usage are the lack of facilities and the poor road access and distance from major highways. Sport and forage fish include; northern pike (*Esox lucius)*, yellow perch (*Perca flavescens),* burbot (*Lota lota)* and spottail shiners (*Notropis hudsonius)*. Angling lake had supported a commercial pike fishery before 1983, but since 1992 the lake has not been commercially harvested (AENV, 1983; Bodden, 2002).

Figure 2: Bathemetry of Angling Lake



Angling lake is over 10 m deep (**Figure 2)** with a surface area of 5.85 km^2. Water levels in Angling Lake are maintained by surface inflow from Reita Creek and groundwater inputs from the Reita Creek sub watershed, which is 214 km^2. The water renewal or residence time is 1.7 years. Angling Lake's watershed area is about 40 times that of the lake's surface area.

The lake is eutrophic (productive) and has a moderate littoral (shallow) areas in relation to its surface area. The silty clay bottom support dense aquatic vegetation – bulrush (*Scirpus sp.)*, cattail *(Typha sp.),* and sedges (*Carex sp*) are common (AENV 1983). Due to the lakes naturally high fertility, algal blooms are known to occur during the late summer months.

Water Levels

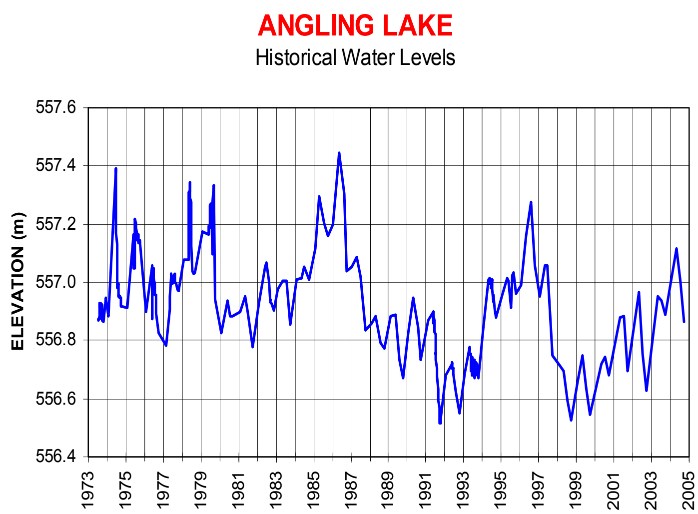


Figure 3: Historical water levels of

Water levels in Angling Lake have been fairly stable since monitoring began in 1973 (**Figure 3)**. Maximum water levels occurred in 1986, when they reached 557.4 m. Minimum levels were in 1991, when they dropped to 556.5. Water levels in Angling Lake seem to display a step pattern: levels dropped in the late 1980s and have remained about 0.3m lower than pre-1985 mean. Contrary to other lakes in the region that have experienced decreasing water levels, historical levels within Angling lake have been maintained in 2004 (557.1). This is likely due to the large watershed.

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, Angling Lake showed thermal stratification in early July and August, which caused a decline in oxygen below the thermocline (depth at which water temperature drops by at least 1 ºC over 1 meter) (**Figure 4**). When there was no thermal stratification, the water currents carried oxygen to the bottom of the lake and dissolved oxygen concentrations were within surface water quality guidelines for most of the water column.

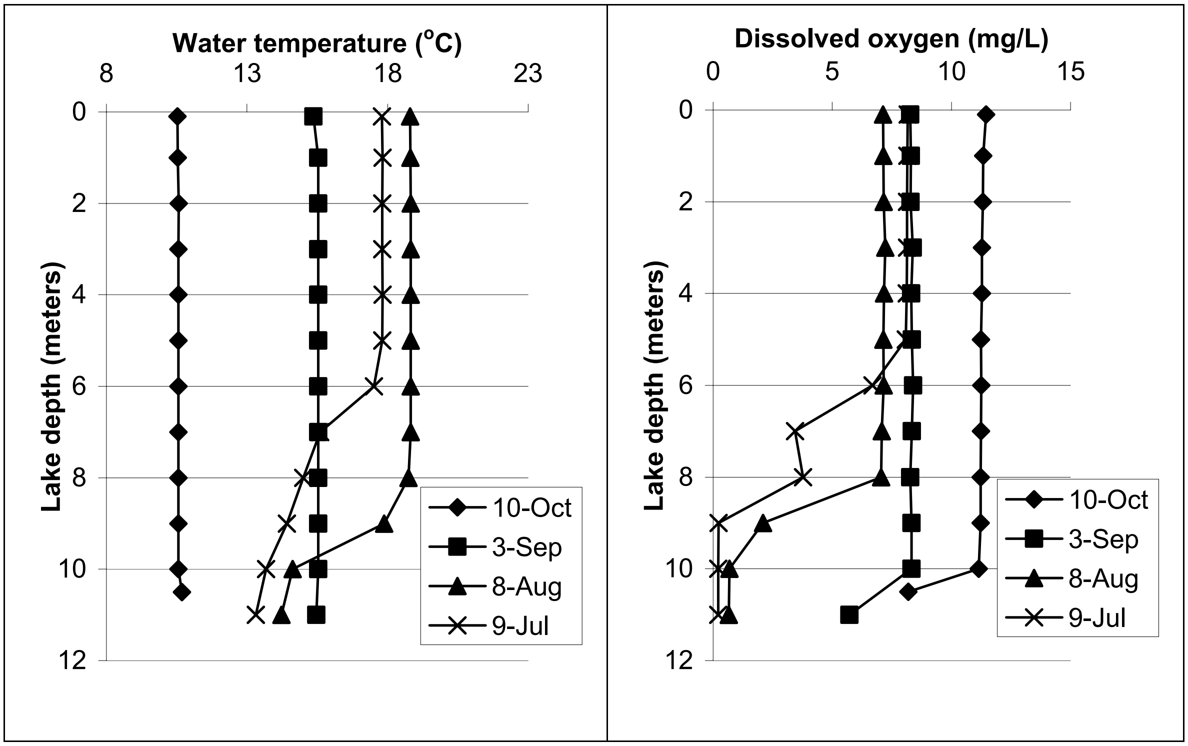


Figure 4: Temperature and dissolved oxygen profiles in the deepest spot of Angling Lake, summer 2004.

Water clarity and Secchi Depth

The most widely used measure of lake water clarity is the Secchi depth. 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 2004, Angling Lake's water was clear (average Secchi disk depth of 2.5 m. Secchi depth in early July was 2.5 m and this to 2.75 m by early August. By early September, Secchi depth decreased to 1.5 m due to increased algal growth before increasing again

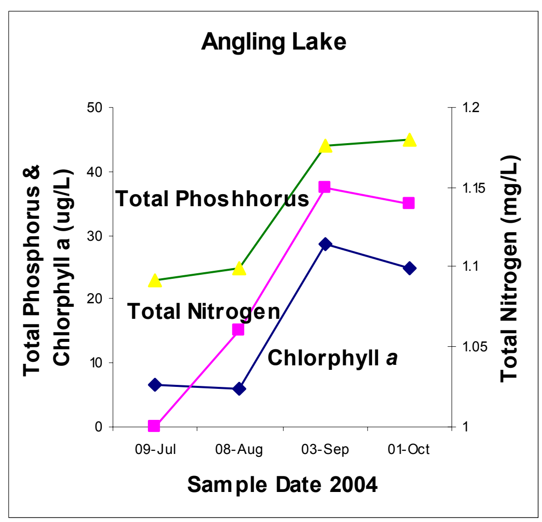


Figure 5: Total phosphorus, total nitrogen and chlorophyll-a (water greenness) concentrations, summer 2004.

at the beginning of October to 2.25. In general, patterns in water clarity followed trends in algal growth as measured by the concentration of chlorophyll-*a* (**Figure 5**).

Water chemistry

Angling Lake is eutrophic (*Refer to tropic status of Alberta lakes in A Brief Introduction to Limnology at the end of this report*) based on high nutrient concentration and algal biomass compared to lakes throughout Canada. In context to other lakes in Alberta, productivity of Angling Lake is about average. Due to lack of historical data, however, we are unable to assess if nutrient characteristics are changing in Angling Lake. According to algal biomass, measured as chlorophyll *a*, which has decreased somewhat, Angling Lake appears to be becoming less productive (**Table 1**). During the summer of 2004, algal biomass in Angling Lake followed patterns in phosphorus (P) and nitrogen (N) concentrations. Generally, total P, total N, and algal biomass were lowest in early summer increasing progressively to the end of summer, and then decreasing again during early October (**Figure 5)**.

Table 1: Historical water quality in Angling Lake.

Parameter	1985	2002	2003	2004
Total P (µg/L)	-	48	42	49
TDP (µg/L)	-	16	14	12
Chla (µg/L)	27	23	19	19
Secchi (m)	-	1.9	3.4	2.2
Total N (mg/L)	-	1.1	1.1	1.1
NO_{2+3} (µg/L)	0.4	2.4	3.1	3.6
NH_4 (µg/L)	-	10	26	63
Ca (mg/L)	22	26	25	23
Mg (mg/L)	33	45	46	41
Na (mg/L)	19	36	38	39
K (mg/L)	4.8	14	10	10
SO_4 (mg/L)	< 1	14	14	14
Cl (mg/L)	3	4.1	3.2	3.6
Alkalinity (mg/L $CaCO_3$)	260	314	327	318
CO_3 (mg/L)	-	25	27	27
HCO_3 (mg/L)	-	333	344	334
pH	8.8	8.8	8.8	8.8
Conductivity (µS/cm)	350	584		

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.

The average concentrations of most heavy metals measured (as total recoverable concentrations) were below CCME guidelines for the Protection of Freshwater Aquatic Life. However, minor exceedances to guidelines occurred for total arsenic in both 2003 and 2004. Results of the metal analyses, compared to guideline values, are listed in Appendix 1.

Angling Lake is slightly alkaline and hence well buffered against acidic deposition (rain and snowfall). The pH of its water was 8.75, well above that of pure water (i.e., pH 7). Dissolved ion levels were high in 2004 and were dominated by bicarbonate, magnesium, and sodium. Magnesium, sodium, potassium, and sulfate concentrations appear to have increased since 1985. Despite this increase, these concentrations are not particularly high. Excessive evaporation or changes in surface runoff that favour groundwater contributions may have resulted in changes in dissolved ion concentrations. Changes in the hydrologic regime (i.e. the proportions of direct atmospheric deposition as rain and snowfall, groundwater inputs and surface runoff and stream flow to a lake) have contributed to increased ion concentrations in other lakes within and the approximate one-third increase in most ions in Angling Lake may also reflect reduced surface runoff to the lake.

Angling Lake does not appear to be impacted by the problems common to other lakes in Alberta such as decreasing water levels. From the limited chlorophyll-*a* data, it appears that Angling Lake may be becoming less productive, indicating a reduction in nutrient loads to the lake.

Appendix 1

Mean concentrations of total metals, Angling Lake, 2004 compared to CCME Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated).

Metals (total)	2003	2004	Guidelines
ALUMINUM ug/L	26.8	11.9	100[a]
ANTIMONY ug/L	0.03	0.028	6[e]
ARSENIC ug/L	6.4	5.6	5
BARIUM ug/L	69.2	65.8	1000[e]
BERYLLIUM ug/L	0.18	0.0015	100[d,f]
BISMUTH ug/L	0.004	0.00125	
BORON ug/L	105	112	5000[e,f]
CADMIUM ug/L	0.01	0.0033	0.085[b]
CHROMIUM ug/L	0.39	0.28	
COBALT ug/L	0.01	0.0134	1000[f]
COPPER ug/L	2.2	0.734	4[c]
IRON ug/L	9	6.9	300
LEAD ug/L	0.11	0.031	7[c]
LITHIUM ug/L	39.8	48.4	2500[g]
MANGANESE ug/L	10.9	10.4	200[g]
MOLYBDENUM ug/L	1.8	1.48	73[d]
NICKEL ug/L	0.48	0.0025	150[c]
SELENIUM ug/L	0.25	0.085	1
SILVER ug/L	0.0025	0.0025	0.1
STRONTIUM ug/L	245	248	
THALLIUM ug/L	0.033	0.000825	0.8
THORIUM ug/L	0.003	0.00745	
TIN ug/L	0.05	0.015	
TITANIUM ug/L	1.03	0.66	
URANIUM ug/L	0.86	0.723	100[e]
VANADIUM ug/L	0.26	0.154	100[f,g]
ZINC ug/L	4.32	3.98	30
FLUORIDE mg/L		0.215	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

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

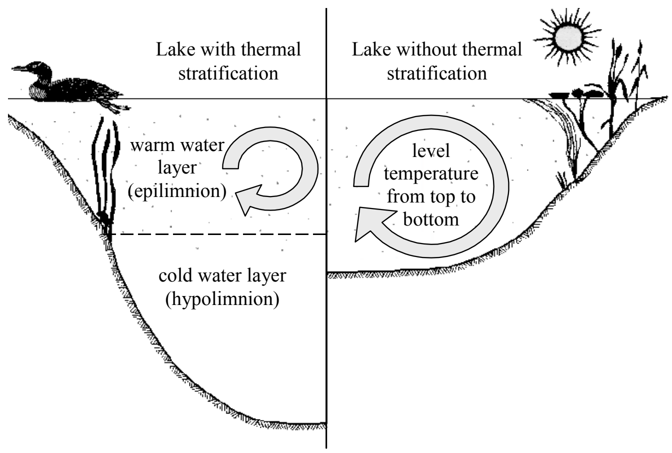


Fig. 6: Difference in the circulation of the water column depending on thermal stratification.

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.

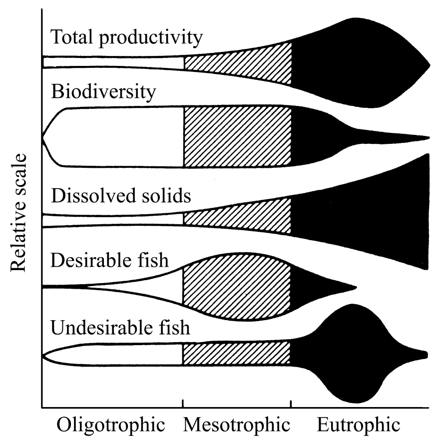


Fig. 7: Suggested changes in various lake characteristics with eutrophication. From

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.

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