The Alberta Lake Management Society Volunteer Lake Monitoring Program

Sylvan Lake

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2006 Report

Completed with support from:

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

Alberta Lake Management Society's Lakewatch Program

Lakewatch has several important objectives, one of which is to collect and interpret water quality on Alberta Lakes. Equally important is educating lake users about their aquatic environment, encouraging public involvement in lake management, and facilitating cooperation and partnerships between government, industry, the scientific community and lake users. Lakewatch Reports are designed to summarize basic lake data in understandable terms for a lay audience and are not meant to be a complete synopsis of information about specific lakes. Additional information is available for many lakes that have been included in Lakewatch and readers requiring more information are encouraged to seek these sources.

ALMS would like to thank all who express interest in Alberta's aquatic environments and particularly those who have participated in the Lakewatch program. These people prove that ecological apathy can be overcome and give us hope that our water resources will not be the limiting factor in the health of our environment.

Acknowledgements

The Lakewatch program is made possible through the dedication of its volunteers and 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. Megan Mclean and Amanda Krowski were our summer field coordinators and were excellent additions to the program. Kent Lyle made sampling at Sylvan Lake possible, without his help Sylvan Lake would not have been included. Francine Forrest and Théo Charette helped write the original report, which was update with summer 2006 data by Zofia Taranu, Erika Brown and Jesse Vermaire 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 and the Lakeland Industry & Community Association (LICA) were essential in 2006.

Sylvan Lake

Sylvan Lake is a large (42.8 km^2), moderately deep lake (maximum depth 18.3 m), located west of the city of Red Deer (Fig. 1). The lake was first named “Snake Lake” from the Indian name *Kinabik*, which referred to the numerous garter snakes in the area. The name was officially changed to Sylvan Lake in 1903. “Sylvan” is from the Latin name *Sylvanus*, which means “of a forest”. Most of the surrounding land was originally forested with trembling aspen. However, approximately 90% of the watershed has been converted to agriculture.

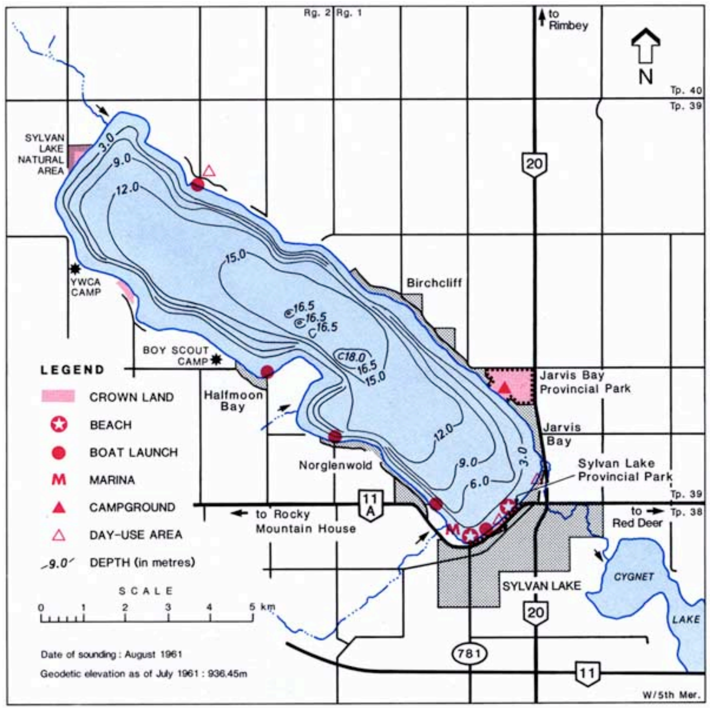


Fig. 1: Bathymetry of Sylvan Lake. From Mitchell and Prepas 1990.

Sylvan Lake was first settled in 1899 and within 5 years time (by 1904) it had become a summer resort area. Its popularity was due to the lake’s picturesque shoreline. Since this time, the shore of Sylvan Lake has undergone intensive development with four summer villages, the town of Sylvan Lake and six subdivisions. Two provincial parks also occupy the lakeshore, namely, Jarvis Bay and Sylvan Lake. Large sandstone banks, reaching up to 20 m above lake level, are located along the northeast shore. The lake’s shoreline is generally composed of sand or a mixture of rock and gravel.

Rooted aquatic plants occur in patches in sheltered areas around the lake and grow densely in the northwest end of the lake. The most common emergent species are bulrush (*Scirpus sp.*) and common cattail (*Typha latifolia*). Submergent macrophytes, which can grow up to a lake depth of 3.5 m, include pondweeds (*Potamogeton* spp.), water buttercup (*Ranunculus circinata*), Canada waterweed (*Elodea Canadensis*) and the macroalgae stonewort (*Chara* sp.). There are at least seven species of fish in Sylvan Lake: northern pike, yellow perch, walleye, burbot, spottail shiners, brook stickleback, and fathead minnows.

Results

Water Levels

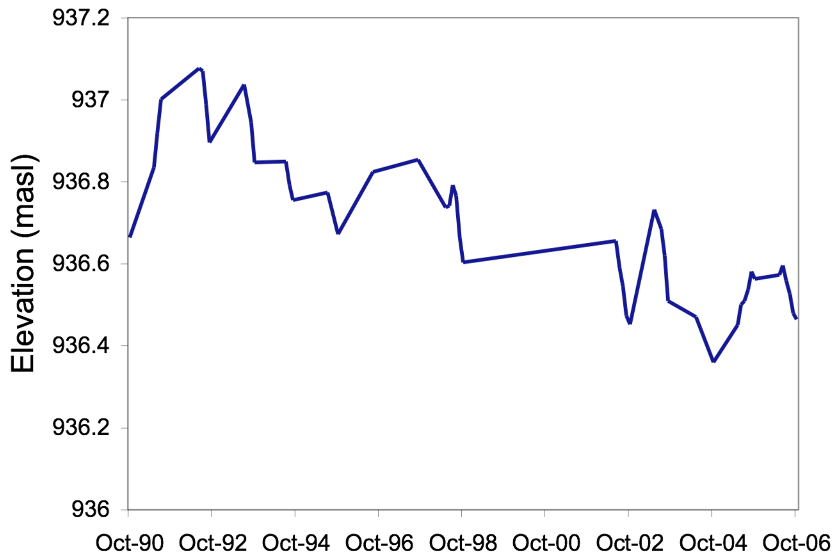


Fig. 2: Water levels in Sylvan Lake, 1990 to 2006.

The catchment to lake surface area ratio of Sylvan Lake is small (only 2.5 times the lake's surface area) and as such there is likely little incoming water from the drainage basin potentially contributing to changes in water level. This is further supported by the intermittent nature of the inflowing streams and the presence of numerous submerged springs. Evaporation from the large surface area of Sylvan Lake seems to be the primary outlet for water since very little water flows out of the lake. Between 1955 and 1976, the outlet stream flowed only during part of three years. Thus Sylvan Lake's water balance is controlled by direct evaporation and precipitation at the lake's surface.

There has been a general trend of water level decline in Sylvan Lake from 1990 to 2006. During this period the maximum lake elevation occurred in 1992, measuring 937.077 m above sea level. The lowest lake level since 1990 was experienced in 2004 recorded at 936.36 m above sea level. The water level in Sylvan Lake showed some recovery in 2005, but experienced a slight decline in 2006.

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.

Thermal stratification did not form in Sylvan Lake until July when a small thermocline developed at 8 meters. This thermocline reached 19 m by August, and was not present at any later time. Surface water temperatures started at approximately 17 °C in late June, reaching over 21°C by July and remained at 20 °C throughout August. Temperatures then dropped back down to 14 °C by late September. Dissolved Oxygen levels dropped rapidly below the thermocline when stratification was present. In all other cases, dissolved oxygen remained constant with depth, dropping only with proximity to bottom sediments.

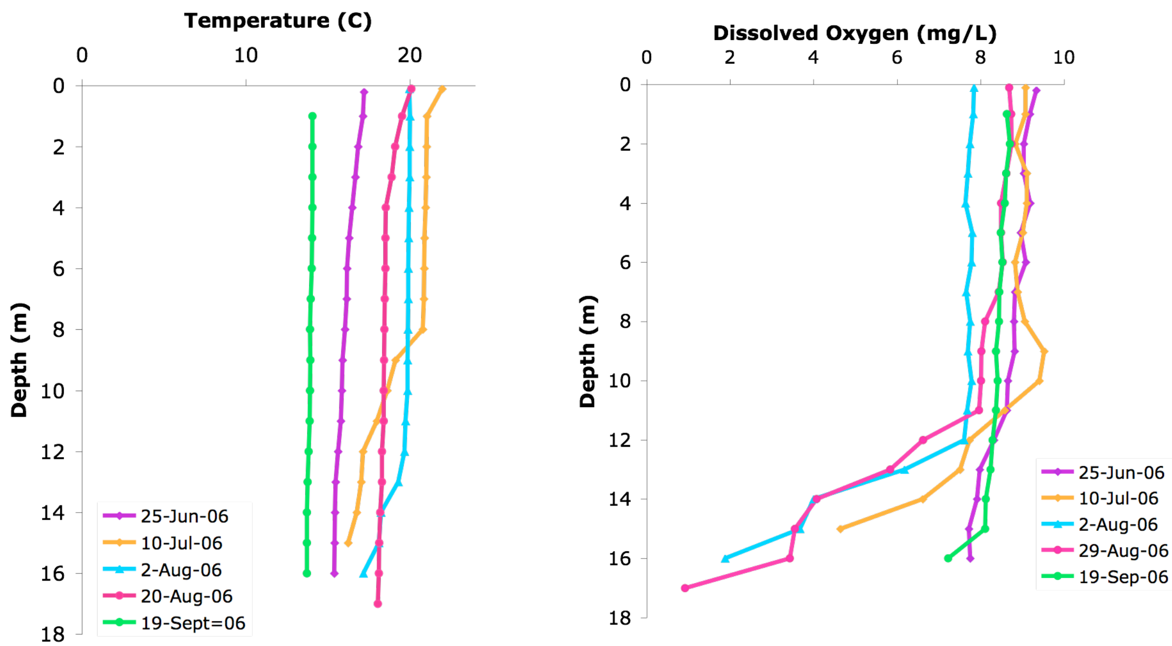
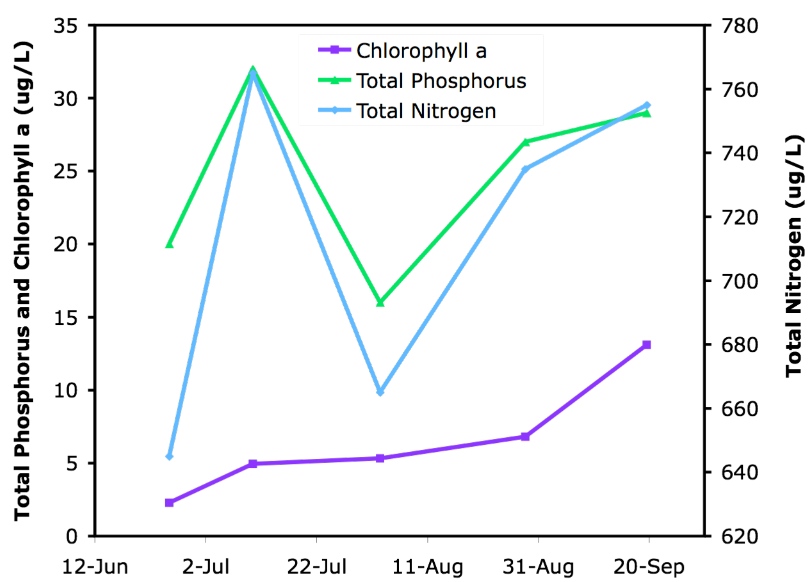


Fig. 3: Temperature and dissolved oxygen profiles for Sylvan Lake, summer 2006.

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.



Figures 5: Total phosphorus, Chlorophyll *a* and Total Nitrogen for Sylvan Lake, summer 2006.

Sylvan Lake's water was very clear during the summer 2006. Secchi disk depth was 4.25 m in the beginning of June, increased to 6 m by July, and decreased progressively to 2.2 m by September. The decrease in water clarity over the summer is expected as algal biomass increased continually throughout the open water season.

Water chemistry

Because Sylvan Lake had moderate nutrient concentrations and algal biomass compared to lakes throughout Canada, it is considered mesotrophic (see details on trophic status classification at the end of this report). In the context of the province of Alberta, Sylvan Lake is slightly below average in these characteristics. In 2006, total phosphorus concentrations varied from a high of 32 μg/L in early July to a low of 16 μg/L by early August, with an overall summer mean TP of 24.8 μg/L (**Figure 5**). The overall pattern of increasing phosphorus and chlorophyll *a* concentrations in Sylvan Lake towards the end of the summer is typical of most lakes in Alberta. Sylvan Lake was moderately concentrated in nitrogen with TN ranging from 640 to 760 μg/L and averaging 708 μg/L. In general, the water quality of Sylvan Lake was relatively good and the water was clear.

Sylvan Lake is well buffered from acidification; its pH of 8.9 is well above that of pure water (i.e., pH 7). Its dominant ions are bicarbonate, sodium, and magnesium. The relatively high sodium concentrations support the strong atmospheric influence on the lake. High magnesium and bicarbonate reflect substantial groundwater inflow. Ion concentrations were very similar to historic values from the Atlas of Alberta Lakes. In general, water quality did not change much over the last 20 years.

Table1: Mean water quality in Sylvan Lake, summer 2006.

Parameter	1984	1986	2000	2001	2003	2006
TP (µg/L)	20	21	19	23	14	245
TDP (µg/L)	NA	NA	7.4	8	5	7.6
Chl a (µg/L)	3.8	3.7	4.5	9	3.8	6.5
Secchi (m)	5.0	4.7	5	-	4.8	4.1
TN (µg/L)	-	-	618	836	610	713
NO_{2+3} (µg/L)	-	-	1.2	2	5	<5
NH_4 (µg/L)	-	-	6.9	9	8	12
Ca (mg/L)	-	18	17	17	17	17
Mg (mg/L)	-	37	37	36	37	36
Na (mg/L)	-	64	63	60	71	73
K (mg/L)	-	7	8	7	8	8
SO_4 (mg/L)	-	16	13	14	14	14
Cl (mg/L)	-	<1	2.8	3	2	2.7
HCO_3 (mg/L)	-	354	348	343	359	361.7
CO_3 (mg/L)	-	21	18	22	26	26.3
Alkalinity (mg/L $CaCO_3$)	-	325	316	318	337	340
Hardness (mg/L)	-	-	-	-	193	190.7
Conductivity (µS/cm)	-	597	585	572	611	606
pH	-	8.9	8.7	9	8.8	8.86
TDS (mg/L)	-	-	-	-	350	353

Note. TDP = total dissolved phosphorus, Chla = chlorophyll *a*, TKN = total kjehldahl nitrogen, NO_{2+3} = nitrate+nitrite, NH_4 = ammonium, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, HCO_3 = bicarbonate, CO_3 = carbonate, TDS = total dissolved solids.

Appendix 2

Metals (total)	2003	2006	Guidelines
ALUMINUM ug/L	-	-	100[a]
ANTIMONY ug/L	0.103	-	6[e]
ARSENIC ug/L	-	-	5
BARIUM ug/L	-	-	1000[e]
BERYLLIUM ug/L	0.14	-	100[d,f]
BISMUTH ug/L	0.009	-	
BORON ug/L	65.4	-	5000[e,f]
CADMIUM ug/L	<0.02	-	0.085[b]
CHROMIUM ug/L	0.32	-	
COBALT ug/L	0.044	-	1000[f]
COPPER ug/L	0.58	-	4[c]
IRON ug/L	8	7.56	300
LEAD ug/L	0.102	-	7[c]
LITHIUM ug/L	18.5	-	2500[g]
MANGANESE ug/L	2.49	-	200[g]
MOLYBDENUM ug/L	2.6	-	73[d]
NICKEL ug/L	0.09	-	150[c]
SELENIUM ug/L	0.9	-	1
STRONTIUM ug/L	256	-	
SILVER ug/L	-	-	
THALLIUM ug/L	-	-	0.8
THORIUM ug/L	0.005	-	
TIN ug/L	<0.1	-	
TITANIUM ug/L	1.07	-	
URANIUM ug/L	1.5	-	100[e]
VANADIUM ug/L	0.89	-	100[f,g]
ZINC ug/L	1.78	-	30

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

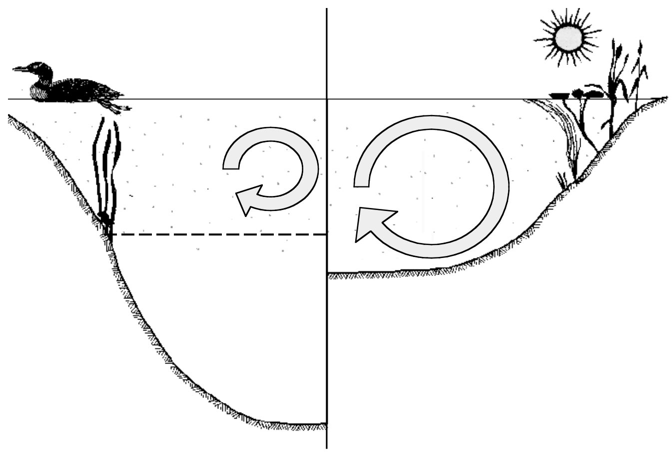


Fig. 6: Difference in the circulation of the water column depending on thermal stratification.

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.

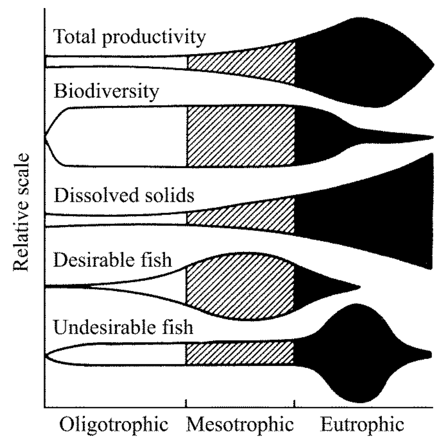


Fig. 7: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980

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.