The Alberta Lake Management Society
Volunteer Lake Monitoring Program

2010 Sylvan Lake Report

Completed with Support From:

Government of Alberta

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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SYLVAN LAKE

Sylvan Lake is a large (42.8 km^2), moderately deep (maximum depth = 18.3 m) lake located west of the city of Red Deer. The lake was first named "Snake Lake" from the First Nations 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 *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.

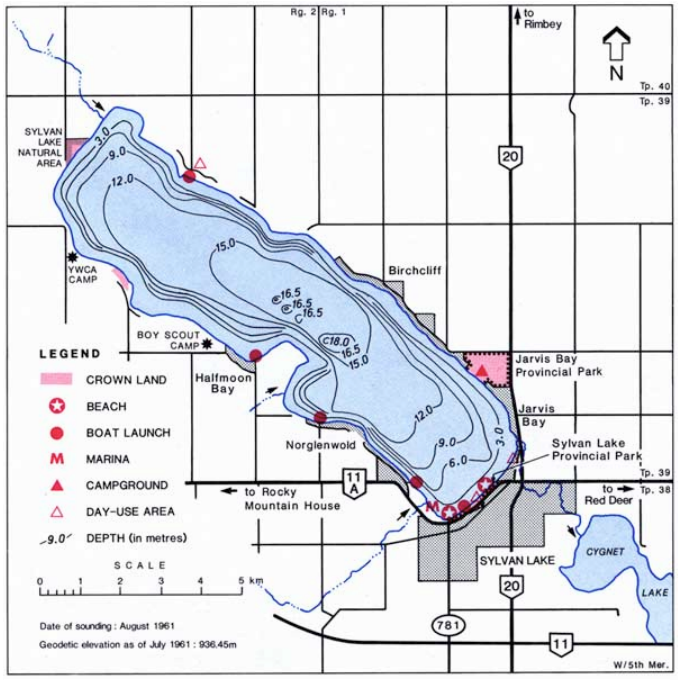


Figure 1 – Bathymetry of Sylvan Lake. From Mitchell and Prepas 1990.

Sylvan Lake was first settled in 1899 and within 5 years time (by 1904) 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 the 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 and 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 (*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.

WATER LEVELS:

From 1996-2004, the water levels in Sylvan Lake showed a general trend towards decline (Fig. 1). However, from 2004-2010 the water levels in Sylvan Lake have returned almost to the 1992 historical maximum of 937.0 meters above sea level (m asl). The lowest recorded lake level in Sylvan Lake was in 2004 when the water was 936.4 m asl.

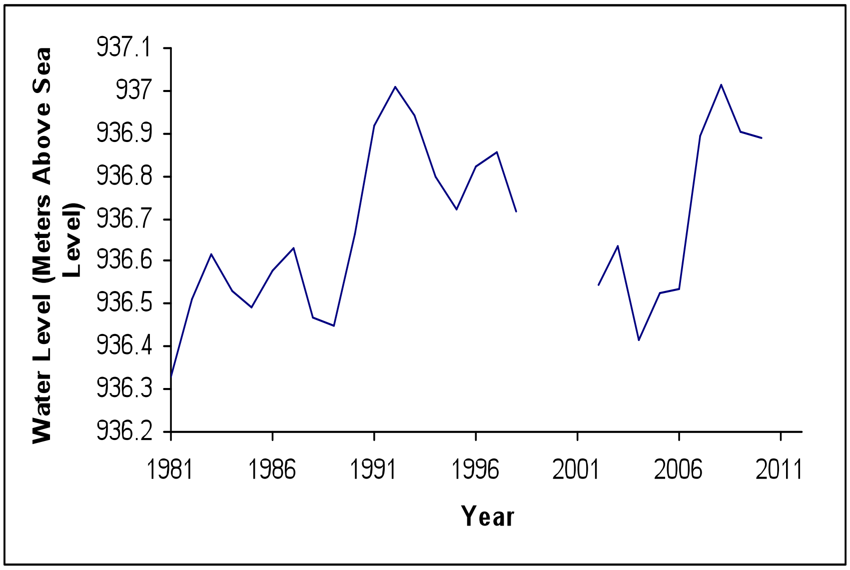


Figure 2 – Historical water levels in meters above sea level measured by Environment Canada and Alberta Environment from 1981-2010.

The catchment to lake surface area ratio of Sylvan Lake is small (only 2.5 times the lake 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 the three years. Thus, Sylvan Lake's water balance is primarily controlled by direct evaporation and precipitation at the lakes surface.

WATER CLARITY AND SECCHI DEPTH:

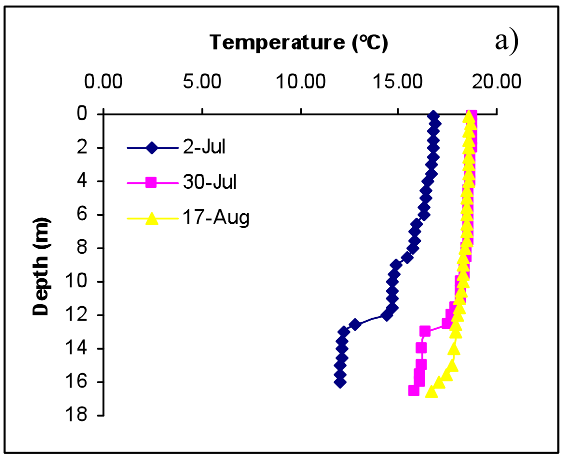
Water clarity is influenced by suspended materials, both living and dead, as well as dissolved colored compounds in the water column. During the melting of snow and ice in spring, lake water can become turbid (cloudy) from silt transported into the lake. Lake water usually clears in late spring but then 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.

Water clarity at Sylvan Lake was very good, with an average secchi disc depth of 7.0 meters (Table 1). The secchi depth value did not change greatly over the course of the summer, measuring 8.0 m on July 2nd, 6.5 m on July 30th, and 6.5 m on August 17th. The 2010 secchi depth average is much greater than that seen in previous years, and may be due to a mild-summer in 2010 which resulted in less-than-normal amounts of algae.

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 was measured three times over the course of the summer (Figure 3a). On July 2nd, surface temperatures were 16.79 °C and decreased to 12.07 °C at the lakebed. Small thermal stratification was observed between 12.0-13.0 m. On July 30th, surface water temperatures had increased to a seasonal maximum of 18.81 °C and decreased to 15.80 °C at the lakebed. A weak thermal stratification was still present between 12.0-13.0 m. Finally, on August 17th, surface temperatures were 18.62 °C and declined to 16.65 °C at the lakebed. No thermal stratification was observed on August 17th. This is an earlier turn-over than 2009, in which the lake still maintained a weak thermocline on August 20th.



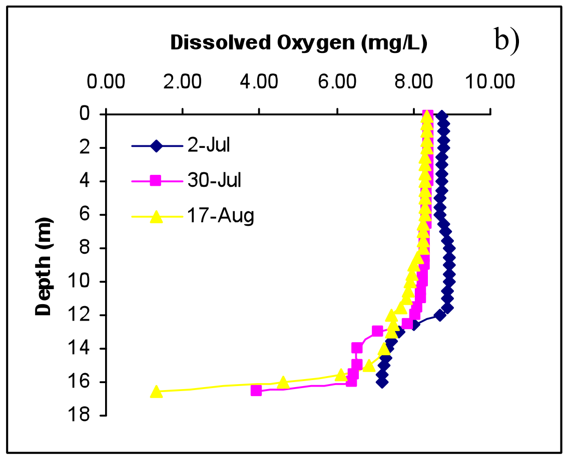


Figure 3 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles measured three times over the course of the summer of 2010.

The water column at Sylvan Lake remained well aerated throughout the summer (Figure 3b). On June 14th, dissolved oxygen reached a seasonal maximum of 8.72 mg/L and decreased to 7.17 mg/L at the lakebed, indicating that the water column was quite well mixed in mid-June. On July 30th, dissolved oxygen concentration was 8.39 mg/L at the surface, decreasing to 3.93 mg/L at the bottom. This reduced oxygen in comparison to June is evidence of algal decomposition at the lakebed and the effects of thermal stratification. Finally, on August 17th, dissolved oxygen concentration was 8.35 mg/L at the surface and dropped suddenly from 6.1 mg/L at 15.5 meters to a seasonal minimum of 1.33 mg/L at 16.5 meters. The small amounts of anoxia seen in Sylvan Lake are indicative of low algal biomass and the ability of the wind to mix the water column due to weak thermal stratification.

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 total phosphorous concentration measured in 2010, Sylvan Lake is considered mesotrophic, or moderately productive (Table 1). Total phosphorous concentration was the same in June, July, and August, consistently measuring 23 µg/L of phosphorous (Figure 4). The 2010 average phosphorous concentration showed very little change from the 2009 average of 20.0 µg/L. Similarly, nitrogen content changed very little throughout the summer. Nitrogen concentration was at a minimum of 0.68 mg/L in July and reached a maximum of 0.70 mg/L in August. On average, nitrogen concentration was 0.690 mg/L in 2010, very similar to the 2009 average of 0.630 mg/L. Finally, chlorophyll-a concentration in 2010 was at a minimum in June (1.30 µg/L) and reached its maximum in August (3.28 µg/L). On average, chlorophyll-a concentration was 2.14 µg/L, slightly lower than the 2009 average of 2.58 µg/L. Ultimately, the trophic status of the lake has not changed since 2009 based on phosphorous, nitrogen, or chlorophyll-*a*.

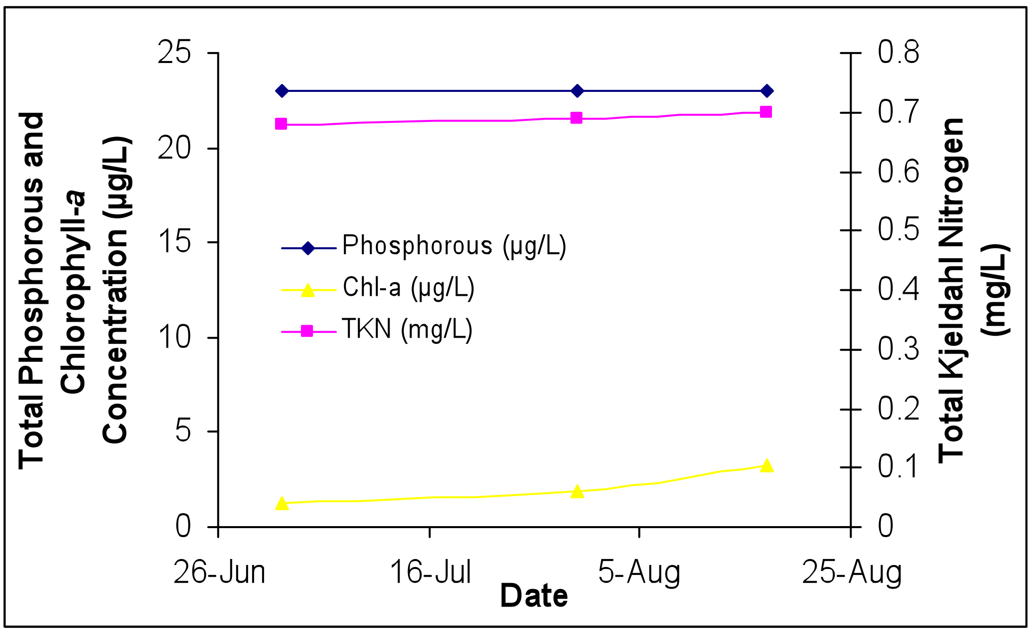


Figure 4 – Total phosphorous (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (mg/L), measured three times during the summer at Sylvan

Sylvan Lake's pH in 2010 was 8.81, and has changed little over the past years, fluctuating between 8.7 and 9.0 in the seven times that ALMS has monitored the lake since 1989 (Table 1). This may be due to the high alkalinity in Sylvan Lake (339 mg/L $CaCO_3$) which helps to buffer the lake against changes in pH. The high alkalinity can be attributed to magnesium, bicarbonate, and calcium, all of which are dominant ions in Sylvan Lake and have changed little over the past years. Ultimately, all parameters measured in Sylvan Lake have shown little change since ALMS first monitored the lake in 1986.

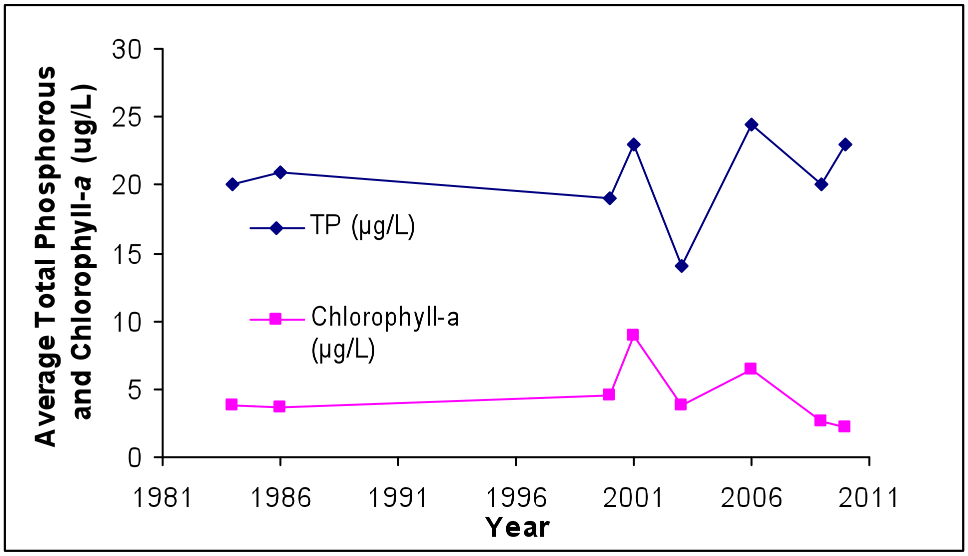


Figure 5 – Historical average total phosphorous (µg/L) and chlorophyll-*a* (µg/L) from Sylvan Lake.

Table 1 – Average secchi disc depth values and water chemistry values for Sylvan Lake. Previous years data is provided for comparison.

Parameter	**1984**	**1986**	**2000**	**2001**	**2003**	**2006**	**2009**	**2010**
TP (µg/L)	20	21	19	23	14	24.5	20	23
TDP (µg/L)	/		7.4	8	5	7.6	10.8	13
Chlorophyll-*a* (µg/L)	3.8	3.7	4.5	9	3.8	6.5	2.58	2.14
Secchi depth (m)	5	4.7	5		4.8	4.1	4.7	7
TKN (µg/L)	/	/	618	836	610	713	630	690
NO_2 and NO_3 (µg/L)	/	/	1.2	2	5	<5	6.75	9
NH_3 (µg/L)	/	/	6.9	9	8	12	9.5	12.3
DOC (mg/L)	/	/	/	/	/	/	6.93	7.55
Ca (mg/L)	/	18	17	17	17	17	16.2	14.15
Mg (mg/L)	/	37	37	36	37	36	34.1	38.9
Na (mg/L)	/	64	63	60	71	73	70.2	73.5
K (mg/L)	/	7	8	7	8	8	7.77	7.8
SO_4^{2-} (mg/L)	/	16	13	14	14	14	16.3	23
Cl^- (mg/L)	/	<1	2.8	3	2	2.7	3.26	3.75
CO_3 (mg/L)	/	21	18	22	26	26.3	22	22.5
HCO_3 (mg/L)	/	354	348	343	359	361.7	366	367.5
pH	/	8.9	8.7	9	8.8	8.86	8.79	8.81
Conductivity (µS/cm)	/	597	585	572	611	606	608	584.5
Hardness (mg/L)	/	/	/	/	193	190.7	181	195.5
TDS (mg/L)	/	/	/	/	350	353	350.3	353
Microcystin (ug/L)	/	/	/	/	/	0.04	0.11	0.07
Total Alkalinity (mg/L $CaCO_3$)	/	325	316	318	337	340	337.3	339

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:

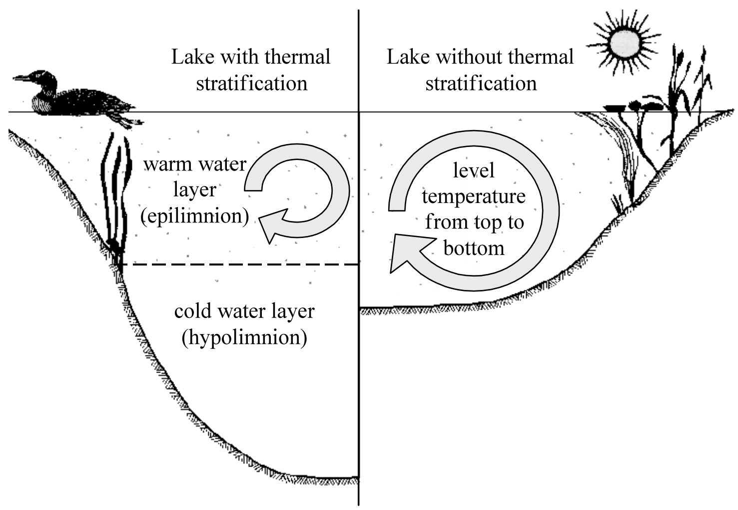


Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

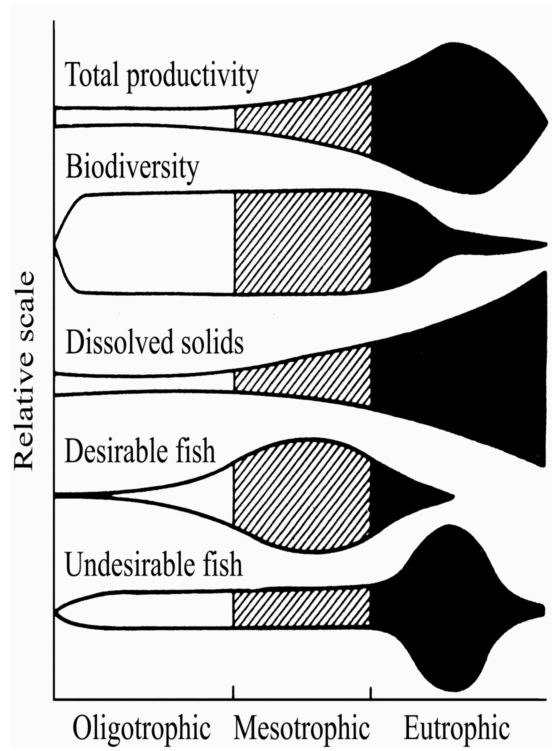


Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

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

Trophic state	Total Phosphorus (µg•L^{-1})	Total Nitrogen (µg•L^{-1})	Chlorophyll *a* (µg•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.

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