Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Fork Lake

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2005 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 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.

Acknowledgments

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Balmy summer sampling on Fork Lake

Fork Lake

As the name implies, Fork Lake (Figure 1) earns its name from its unique shape. Located off Highway 55 southeast of Lac La Biche, from above the lake looks like a large 'H' with a slight northwest-southeast angle. The lake is part of the Beaver River Basin and is situated in the low boreal mixedwood ecoregion (Table 1), characterized by rolling topography and dominated by aspen and spruce in wooded areas.

Figure 1. Fork Lake. Photo credit: Vien Lam

Table 1. Summary of details describing the low boreal mixedwood in which Fork Lake is situated (adapted from Strong and Leggat, 1992)

Low Boreal Mixedwood Characteristics*		
Vegetation	Aspen, succeeding to White Spruce	
Summer	Average Temp.	$13.8\ C^{0}$
	Average Min. Temp.	$7\ C^{0}$
	Average Max. Temp.	$20.4\ C^{0}$
	Month of Max. Precip.	July
	Total Summer Precip. (mm)	235.0
Winter	Average Temp.	-10.5
	Average Min. Temp.	-15.8
	Average Max. Temp.	-5.3
	Total Winter Precip. (mm)	61.0
Total Annual Precipitation (mm)		**380.0**

*precipitation numbers are median values

Fork Lake is remarkably unstudied. Prior to Lakewatch sampling in summer 2005, Alberta Environment has no records of any other water chemistry analyses. Drainage basin area is not known, although the lake has been sounded at least once in its history (Table 2). It is difficult to generalize with only a single season of available data, but Lakewatch numbers suggest that Fork Lake has an abundance of available nutrients and blooms readily in the right conditions. The 2005 averages classify the lake as eutrophic.

Table 2. Physical characteristics of Fork Lake (Anglers Atlas, 2006).

Lake surface area	$1.2\ km^2$
Drainage basin	n/a
Mean depth	6.1 m
Maximum depth	15.2 m

The lake supports a number of sport and associated fish, including Northern pike, yellow perch, lake whitefish, burbot, white sucker, spottail shiner and Iowa darter. A commercial fishery exits on the lake and runs at the end of September. The fishery is typically quite short, lasting only three days on average. Pike kept by angers on Fork

Lake have a minimum size requirement lower than that on other sport fish lakes: greater than 55 cm compared to >63 cm in other locations, as the fish do not seem to reach the larger sizes in this lake (D. Gullion, pers.com.).

Methods

Lakes monitored under the Alberta Lake Management Society's Lakewatch program are all monitored using standard Alberta Environment procedures: composite samples are collected from numerous sites around the lake and water is profiled at the deep water spot in each lake once per month through the warmer months. This usually results in 4 sampling trips per open-water season. On each trip, the deep-water profiles include measurements for temperature and dissolved oxygen recorded from lake surface to lake bottom, as well as maximum depth. A Secchi depth is also measured, from which the range of the euphotic zone is estimated. Once the euphotic zone depth is known, the composite samples are collected for lab analyses. After the water has been analyzed, results are examined for trends and summarized.

Water Levels

Monitoring for water levels has occurred on Fork Lake since 1973 (Figure 2). During this period, the lake's surface has ranged from a high of 588.517 m above sea level (asl) on January 22, 1974, to a low of 585.225 m asl on October 22, 2003. The average water level over this time was 586.834 m asl, which represents a mean depth of about 15 m at the deepest point in the lake. Fork Lake water levels appear to have dropped since monitoring began but may be starting to stabilize. The downward trend of water levels is similar

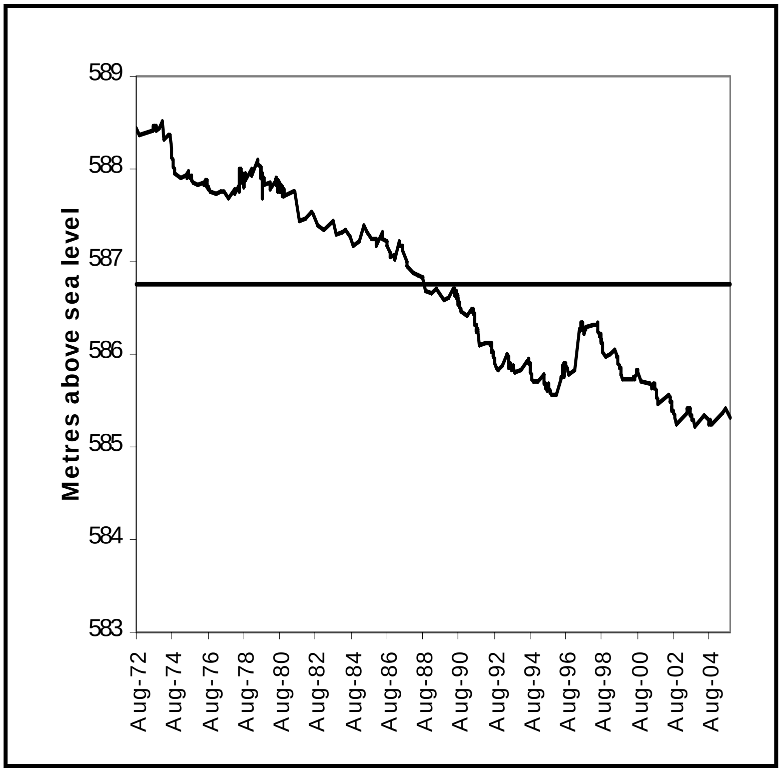

Figure 2. Historical water levels of Fork Lake near Lac La Biche. The heavier horizontal line indicates the average over the time period. Alberta Environment data.

to other lakes in the Beaver River Basin, which have been in a drying cycle over the past 20-30 years (Alberta Environment Report, 2006).

Temperature and Dissolved Oxygen Profiles

As for all Lakewatch lakes, sampling in Fork Lake occurred at the deepest point available. At this location, the dissolved oxygen (DO) profiles are showing very low oxygen levels near lake bottom for the entire sampling season (Figure 3). This indicates that incomplete mixing is occurring in Fork Lake over the summer months, regardless of wind action. The temperature numbers show that a weak thermocline is evident at the first sampling trip in June. This gradually disappears as surface waters warm. The almost straight line of temperature values in late September show that the water has mixed to the bottom thermally, although this has had little effect on oxygen levels at depth. The persistent lack of oxygen near the bottom in deeper water can lead to phosphorus being released from lake sediments through a process called internal loading. This can increase available nutrients even in a lake receiving no run-off, rainfall or other input sources.

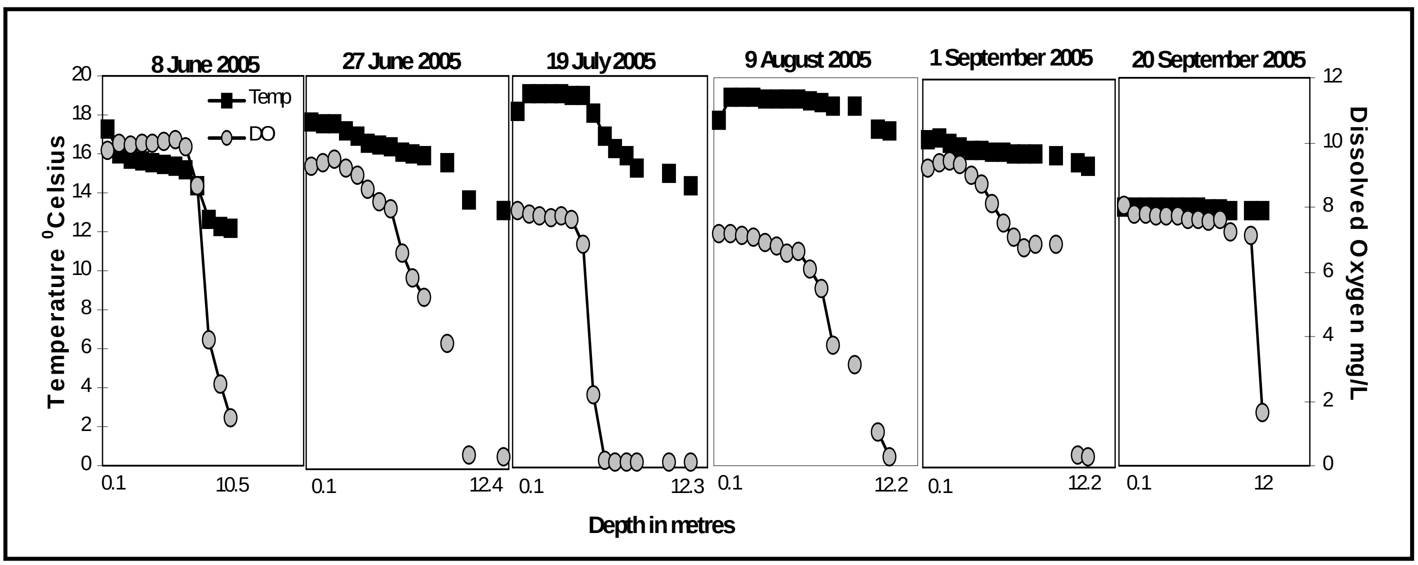

Figure 3. Temperature and dissolved oxygen profiles of Fork Lake for summer 2005. Alberta Environment data.

Water Clarity

Average chlorophyll *a* levels in Fork Lake classify it as eutrophic (Figure 4). Water in the lake begins the summer fairly clear and gradually decreases in clarity as algal growth (measured as chlorophyll *a*) increases (Figure 5). The chlorophyll *a* levels in Fork Lake rise steadily through the summer months, reaching levels above 25 ug/L. This implies that the lake has an abundance of available nutrients and the ability to produce dramatic algal blooms.

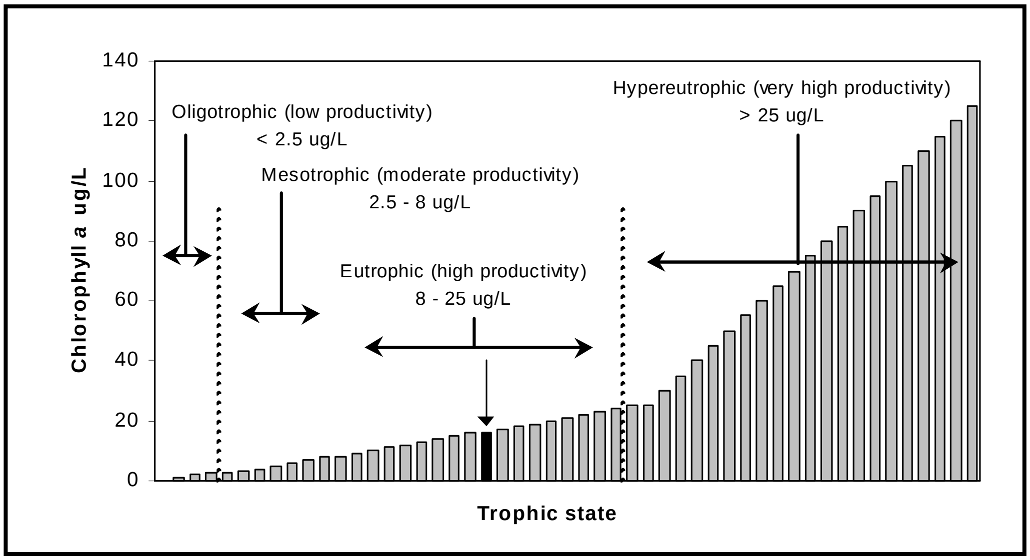

Figure 4. The black bar below the down arrow represents average chlorophyll a concentration for Fork Lake from summer 2005. Adapted from Mitchell, 1994.

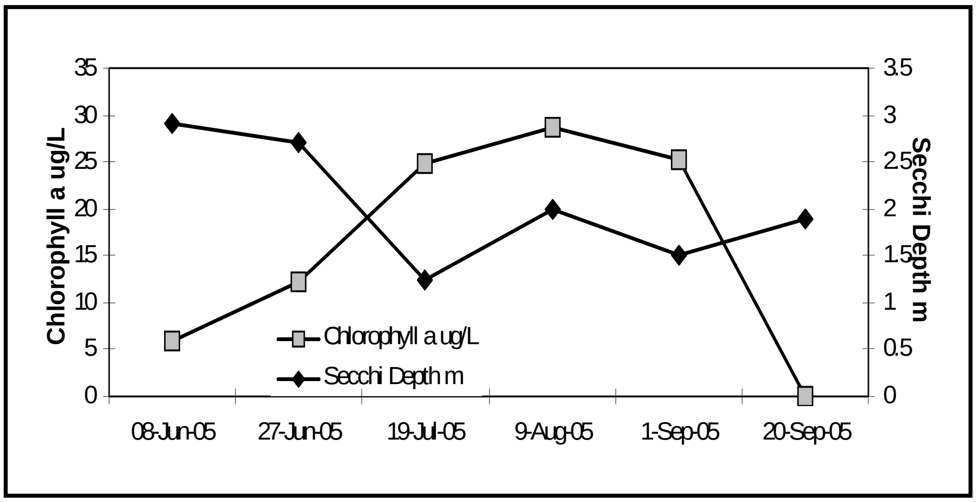

Figure 5. Lakewatch data from summer 2005. The increase of chlorophyll *a* over the summer months has a fairly rapid effect on Secchi depth, which starts to increase again after algal death in late summer/early autumn.

Water Chemistry

Since no historical data exist for Fork Lake, a comparison of Lakewatch values with previous measurements is not possible. Some generalizations can be made but the opportunity for developing a bigger picture for the lake is limited with only one season of solid sampling.

Salinity in Fork Lake is in the low range, as are total dissolved solids (Table 3). Alkalinity levels are moderate. The pH is slightly high but still within a normal range. Nutrient levels, however, are high. Summer chlorophyll *a* levels suggest the formation of a very noticeable algal bloom – despite this, nutrient levels do not show any serious depletion (Figure 6). This suggests that inputs including the process of internal loading are providing a persistent supply of nutrients from the lake sediments.

Table 3. Fork Lake cation concentrations place the lake in the low salinity range overall. Adapted from Atlas of Alberta Lakes.

Salinity Range	**Average Cation Concentrations mg/L**			
(based on Total Dissolved Solids mg/L)	Sodium	Potassium	Calcium	Magnesium
Low salinity (<500)	20	5	29	15
Slightly saline (500-1000)	113	29	31	59
Moderately saline (1000-5000)	379	34	21	46
Fork Lake (183.3)	**16.6**	**20.3**	**34.4**	**30.1**

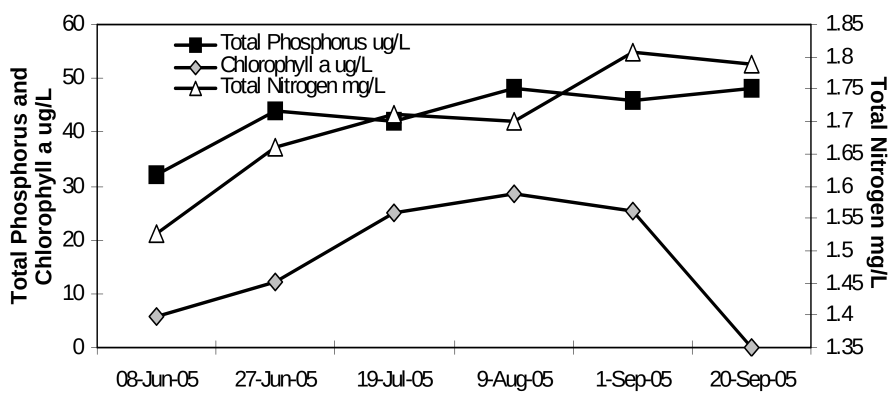

Figure 6. For summer 2005, Fork Lake did not appear to have much of an available nutrient shortage for algae - there is no rapid decline or recovery as the season progresses.

Results for other water quality measurements averaged from 2005 are summarized in Appendix I.

Works Cited

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Appendix 1. Summary of summer 2005 averages for various water quality parameters. No historical data exist for Fork Lake except the Lakewatch efforts.

Parameter	**2005**
Total Phosphorus ug/L	43.33
Total Dissolved Phosphorus ug/L	14.4
Total Dissolved Solids mg/L	288.67
Chlorophyll a ug/L	16.12
Secchi depth m	2.04
Total Nitrogen mg/L	1.699
Nitrate + Nitrite mg/L	0.0102
Ammonium mg/L	0.037
Calcium mg/L	34.4
Magnesium mg/L	30.1
Sodium mg/L	16.6
Potassium mg/L	20.27
Sulphate mg/L	73.33
Chloride mg/L	3.73
Alkalinity mg/L as $CaCO_3$	183.33
Carbonate mg/L	10
Bicarbonate mg/L	203.67
pH	8.62
Conductivity uS/cm	496.33
Fluoride mg/L	0.19
Iron mg/L	0.0045

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

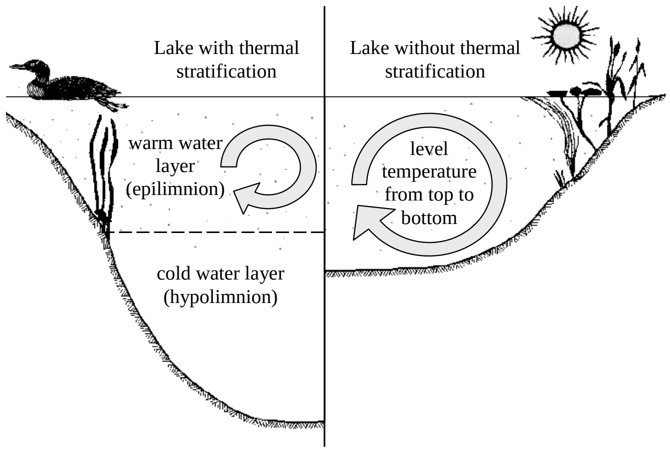

Fig. 1: Difference in the circulation of the water column depending on thermal stratification.

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 2.

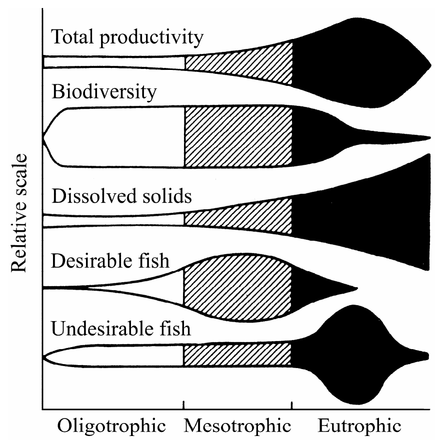

Fig. 2: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980

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.

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