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# Lakewatch

## Vincent Lake



*The Alberta Lake Management Society  
Volunteer Lake Monitoring Report*

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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*

## A note from the Lakewatch Coordinator

### Preston McEachern

Lakewatch has several important objectives, one of which is to document and interpret water quality in Alberta Lakes. Equally important are the objectives of educating lake users about their aquatic environment; enhancing public involvement in lake management; and facilitating a link between aquatic scientists and lake users. The 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. Substantial additional information is generally available on the lakes that have participated in Lakewatch and readers requiring more information are encouraged to seek these sources.

The 2002 Lakewatch Report has undergone a substantial change in format from previous years. I am no longer the author as much as an editor including text and figures from others who have done an excellent job describing lakes throughout Alberta. I have attempted to give due credit to these outstanding people and apologize for blatant plagiarism where it occurs. As editor, feel free to castigate me for errors. I have included easily accessible information that is likely to have been updated in recent years and readers are encouraged to help update these reports by sending new information to me.

I would like to thank all people who share my love for aquatic environments and particularly those who have helped in the Lakewatch program. These people prove that ecological apathy can be overcome and give us hope that water will not be the limiting factor in the health of our planet.

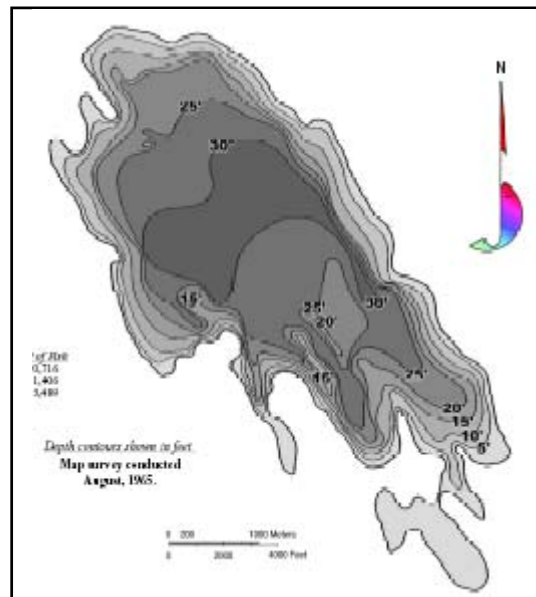
## Acknowledgements

The Lakewatch program is made possible through the dedication of its volunteers and Alberta Environment employees. Mike Bilyk, John Willis, Doreen LeClair and Dave Trew from Alberta Environment were instrumental in funding, training people and organizing with Lakewatch data. Comments on this report by Dave Trew were appreciated. Alberta Lake Management Society members and the board of directors helped in many facets of water collection and management. Sophie Lewin and Lucille Kowalchuk were summer field coordinators and were an excellent addition to the program. Without the dedication of these people and the interest of cottage owners, Lakewatch would not have occurred.

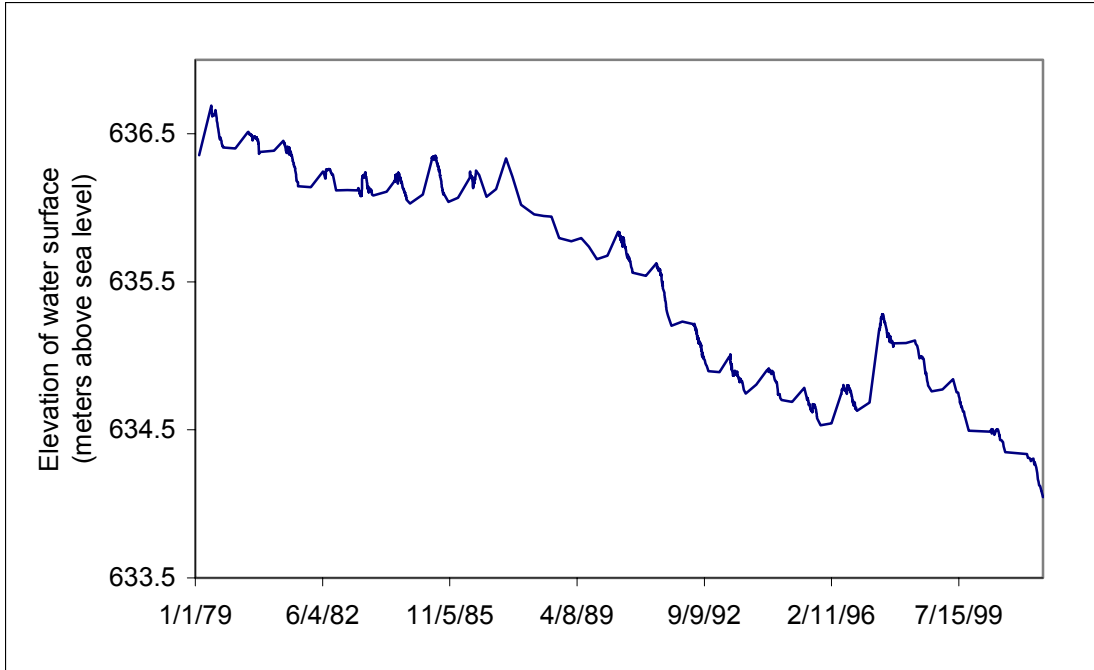
# Vincent Lake

Vincent Lake is a small (7.9 km<sup>2</sup>), and relatively shallow (mean and maximum depth 5.7 and 7.5 m, respectively) lake located approximately 17 km north of the town of St. Paul. The lake has a very abundant supply of nutrients and algae and is thus considered hyper-eutrophic. Algae regularly bloom, turning the water green and turbid, and surface clumps and mats of algae are common along the shoreline. Also, the lake is polymictic, meaning that its water column completely mixes periodically throughout the summer.

Lake Vincent has a sandy bottom with some excellent sandy beaches. Submergent aquatic plants are abundant near the shore and in shallow areas and consist mostly of northern watermilfoil (*Myriophyllum exalbescens*). Sport fish include northern pike, yellow perch, and walleye. The lake supports approximately 580 cottagers and about 130 farmers operate in its watershed (ACA, 2000). Farmers carry out a number of agricultural operations in the watershed including the production of forage, crops, and livestock. Agriculture occupies over half of Vincent Lake's drainage basin and contributes much of the nutrient inputs to the lake.



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



**Fig. 2:** Water levels in Vincent Lake from 1979 to 2001.

### *Water Levels*

The water level of Vincent Lake has been recorded regularly since 1979 and periodically from 1966. The maximum lake level throughout recorded history was 636.7 m in June 1974. The minimum lake level occurred recently in October 2001 when it reached 634.0 m. Water level of Vincent Lake has declined substantially (about 2.5 m) since 1979 and about 50 cm since 1999 (Fig 2). A very similar decline in water levels occurred in the nearby Muriel Lake. Declining water levels over the last two years is common in lakes between Edmonton and Cold Lake. As long as dry conditions persist, low water levels in Vincent Lake may continue. Such a decrease in water levels can concentrate dissolved substances and have negative impacts on water quality.

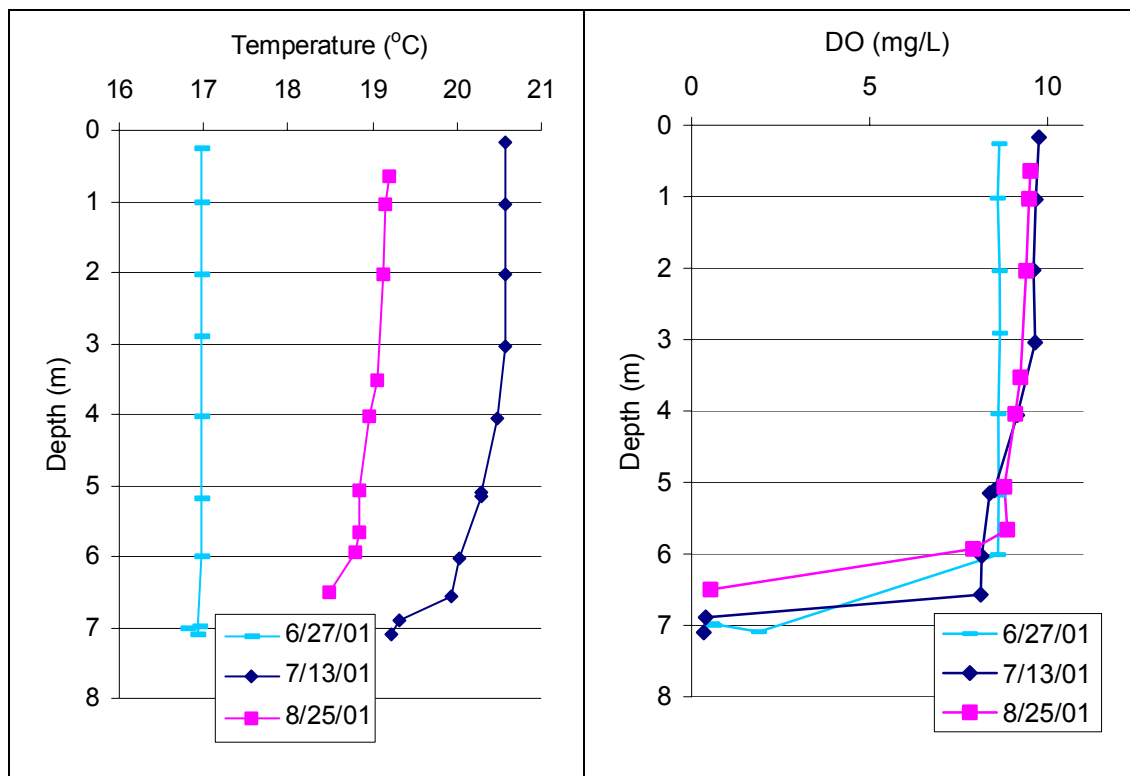


Fig. 3 & 4: Temperature and dissolved oxygen (DO) profiles for Vincent Lake for the summer 2001.

## Results

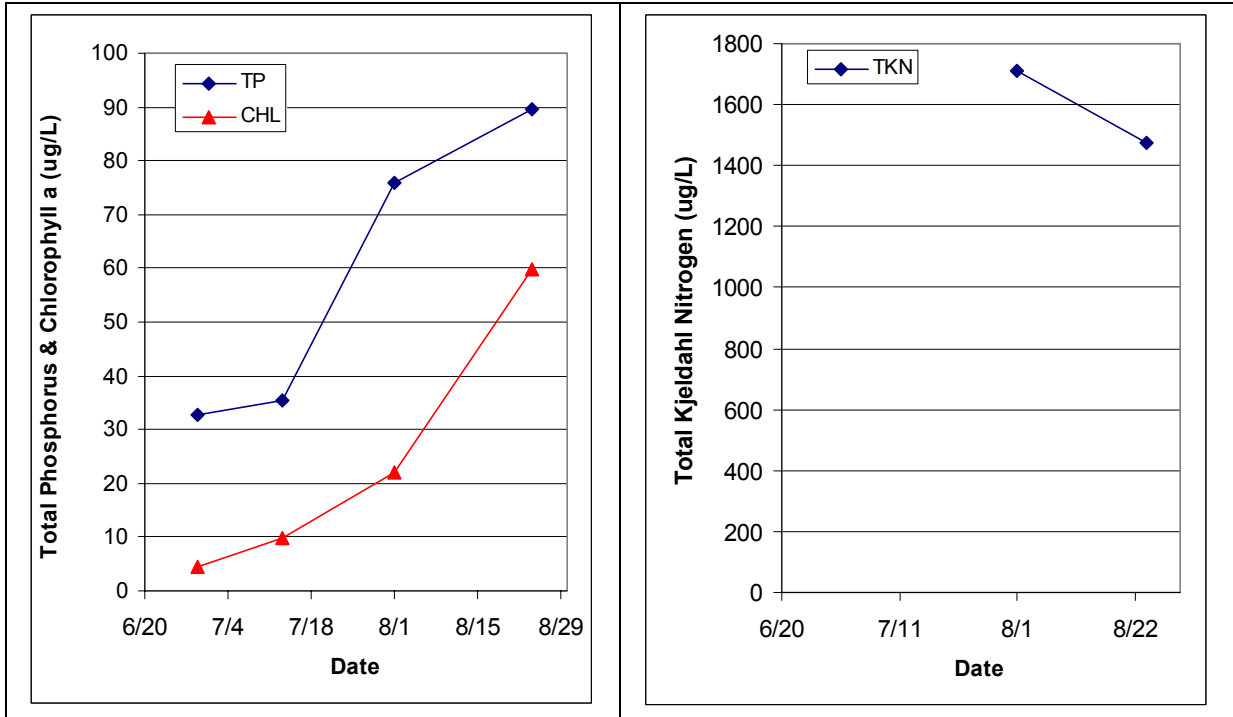
### *Water Temperature and Dissolved Oxygen*

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.

During 2001, thermal stratification was not detected in Vincent Lake and thus most of its water column was well mixed and oxygenated; dissolved oxygen concentrations were uniform to within 1 m of the lake bottom (Fig 4). Microbial decomposition of organic matter in the sediments at the lake bottom caused oxygen depletion in the bottom meter of the lake from late June to August. Vincent Lake does not have suitable habitat for fish species that require cold-water.

### *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.



**Fig. 5 & 6:** Total phosphorus and chlorophyll *a* and total Kjeldahl nitrogen for Vincent Lake during summer 2001. One nitrogen value from late June was lost by the lab.

Sylvan Lake’s water was clear in early summer of 2001. Secchi disk depth was over 4 m at the end of June but decreased substantially to 1 m by the end of August. This decrease in water clarity over the summer is consistent with an increase in algal biomass during this time (Fig 5).

*Water chemistry*

Because Vincent Lake had high nutrient concentrations and algal biomass compared to lakes throughout Canada, it is considered eutrophic (see details on trophic status classification at end of this report). In the Alberta context, Vincent Lake is about average in these characteristics.

In 2001, total phosphorus concentrations increased from about 33 µg/L to 90 µg/L and averaged 58 µg/L. Chlorophyll *a*, a measure of algal biomass, mirrored changes in total phosphorus: it increased from about 4 µg/L in June to 60 µg/L in August and averaged 24 µg/L (Fig. 5). This pattern of increased phosphorus concentrations and algal biomass in Vincent Lake towards the end of summer is typical of most lakes in Alberta. Total nitrogen concentrations were elevated

**Table 1:** Average chemical characteristics of Vincent Lake, summer 2001.

Parameter	2001
Total phosphorus (µg/L)	58
TDP (µg/L)	26
Chlorophyll <i>a</i> (µg/L)	24
Secchi disk depth (m)	2.5
Total nitrogen (µg/L)	1601
NO <sub>2+3</sub> (µg/L)	8
NH <sub>4</sub> (µg/L)	20
Ca (mg/L)	28
Mg (mg/L)	37
Na (mg/L)	16
K (mg/L)	30
SO <sub>4</sub> (mg/L)	55
Cl (mg/L)	6
HCO <sub>3</sub> (mg/L)	224
CO <sub>3</sub> (mg/L)	21
Total Alkalinity (mg/L CaCO <sub>3</sub> )	218
Conductivity (µS/cm)	500
pH	9
Colour (mg/L Pt)	11
TSS (mg/L)	6

Note. TDP = total dissolved phosphorus, NO<sub>2+3</sub> = nitrate+nitrite, NH<sub>4</sub> = ammonium, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO<sub>4</sub> = sulfate, Cl = chloride, HCO<sub>3</sub> = bicarbonate, CO<sub>3</sub> = carbonate, TSS = total suspended solids.

(average 1601 µg/L) and more indicative of a hypereutrophic lake. In general, the water quality and clarity of Vincent Lake are fair.

Vincent Lake is well protected from acidification: its pH of 9 is well above that of pure water (=7). Its dominant ions are bicarbonate, sulfate, and magnesium. Total alkalinity, a measure of the ability of a lake to neutralize acidity, was fairly high at 218 mg/L CaCO<sub>3</sub>. Ion concentrations were about average for a eutrophic lake.

Access to historic data from Vincent Lake was very limited when preparing this report. Therefore, we cannot comment on changes in water chemistry that may have resulted from the decline in water level. However, water quality in Vincent Lake was consistent with other eutrophic lakes in Alberta.

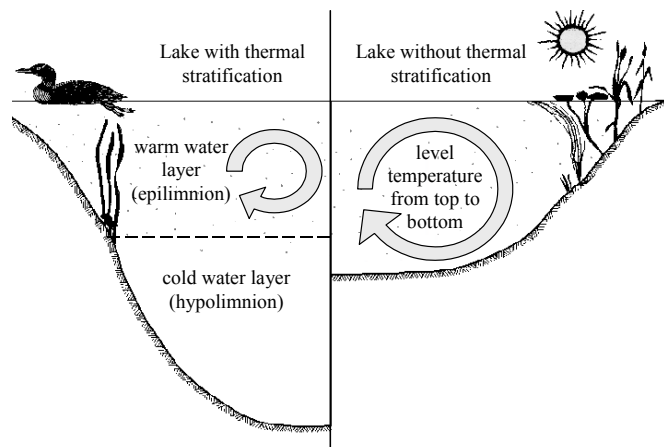
# A brief introduction to Limnology

## *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*

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.



**Fig. 7:** Difference in the circulation of the water column depending on thermal stratification.

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*

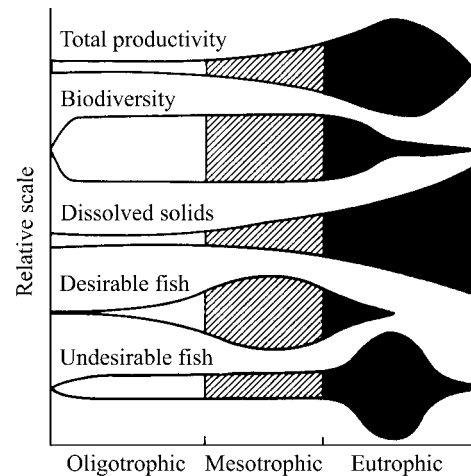
Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. Secchi disk depth is the oldest, simplest, and

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 8.



**Fig. 8:** 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.