



*The Alberta Lake Management  
Society Volunteer Lake monitoring  
report*

# Blackfalds Lake

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## 2008 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 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 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 Lakewatch Chairs, Théo Charette and Ron Zurawell. We would like to thank Katie Calon, Claudia Cameron, Robert Anderson, Paddy Calon, and Richard Calon for their efforts in collecting data in 2008. We would also like to thank Lisa Brodziak and Sophie Damlencour who were summer interns with ALMS in 2008. Project Technical Coordinator, Jill Anderson was instrumental in planning and organizing the field program. Technologists, Shelley Manchur, Mike Bilyk, Brian Jackson and John Willis were involved in the logistics planning and training aspects of the program. Doreen LeClair and Chris Rickard were responsible for data management. Théo Charette (ALMS President) and Jill Anderson (Program Manager) were responsible for program administration and planning. Théo Charette, Ron Zurawell (Limnologist, AENV), Lori Neufeld, and Sarah Lord prepared the original report. Alberta Environment and the Beaver River Watershed Alliance (BRWA) were major sponsors of the Lakewatch program.

# Blackfalds Lake

Blackfalds Lake (**Figure 1**) is a small, shallow lake north of Red Deer, Alberta and east of the town of Blackfalds, Alberta. The lake shoreline is approximately 842 m above sea level. The lake itself is approximately 3.4 km long, and is less than 500 m wide at it's widest point. There is no indication that the lake has been sounded in the past, as no bathymetric data is available from Alberta Environment.

Land surrounding Blackfalds Lake has primarily been developed for agricultural use, but a 100 m treed strip buffers the southeast shore of the lake and scattered trees are visible on the west shore. Potential road access appears to be south of Township Road 400 at Range Road 265, but it is not clear whether the lake has a boat launch or if public access is permitted.

**Figure 1 (right).** Blackfalds Lake, Alberta. Satellite image retrieved from Google Earth®, from a satellite photo taken on June 24, 2002.



## *Water Level*

Water levels were not available for Blackfalds Lake in 2008. No obvious inflow channels are visible from the satellite image, which suggests Blackfalds Lake may be a spring-fed lake. This would mean there is no comparative lake in the area from which we can draw inference regarding trends in water levels. Spring-fed lakes tend to maintain stable water levels. If water levels decline, it may be due to 1) changes in the groundwater levels, 2) withdrawal of lake water, or a combination of the two. Water levels in Blackfalds Lake should be monitored in order to assess changes in lake levels and identify potential activities in the surrounding landscape that may contribute to changes in lake levels.

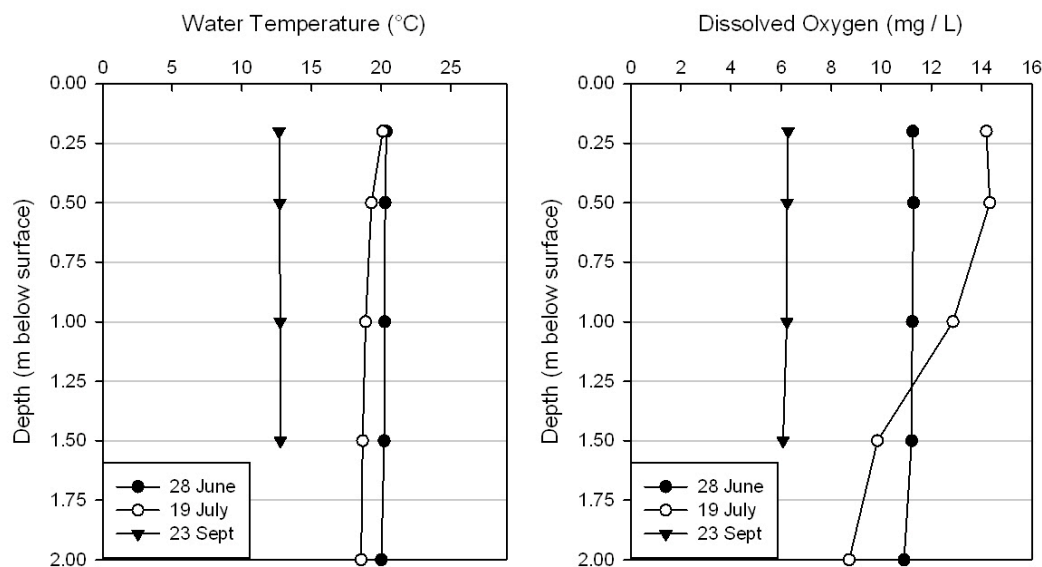
## Results

### *Water temperature and dissolved oxygen*

Blackfalds Lake is typical of many very shallow lakes; it is well mixed through the open water season and does not experience significant thermal stratification. On 28 June, surface water temperature was 20.4°C and declined less than 0.5°C at the lake bottom. On 19 July, surface waters cooled slightly to 20.1°C and declined to 18.6°C at the lake bottom. On 23 September, surface waters had cooled significantly to 12.7°C, and the hypolimnion was 0.1°C warmer than the epilimnion. Based on summer 2008 data,

Blackfalds Lake can be classified as a polymictic lake, as the completely isothermic water column on all sampling dates shows that the lake waters mixed frequently the sampling period.

Dissolved oxygen (DO) concentrations in upper layers of surface waters of Blackfalds Lake were  $\geq 6$  mg/L on all sampling dates through the summer, well within the acceptable range for surface water quality ( $\text{DO} \geq 5.0$  mg/L) (**Figure 2**). DO concentration was 11.3 mg/L throughout the water column on 28 June. Surface DO concentration increased to 14.1 mg/L on 19 July, while DO at the lake bed remained above 11 mg/L. On 23 September, surface waters had a much lower DO concentration of 6.3 mg/L, which declined by 0.2 mg/L at the lake bottom. On all sample dates, no part of the water column had DO concentrations near zero (e.g. anoxic). Deep-water anoxia is common in summer, and the lack of significant oxygen depletion in the hypolimnion is further evidence for frequent, complete mixing of lake water in Blackfalds Lake.



**Figure 2.** Water temperature ( $^{\circ}\text{C}$ ) and dissolved oxygen (mg/L) profiles for Blackfalds Lake during the summer of 2008.

#### *Water clarity and Secchi Disk Depth*

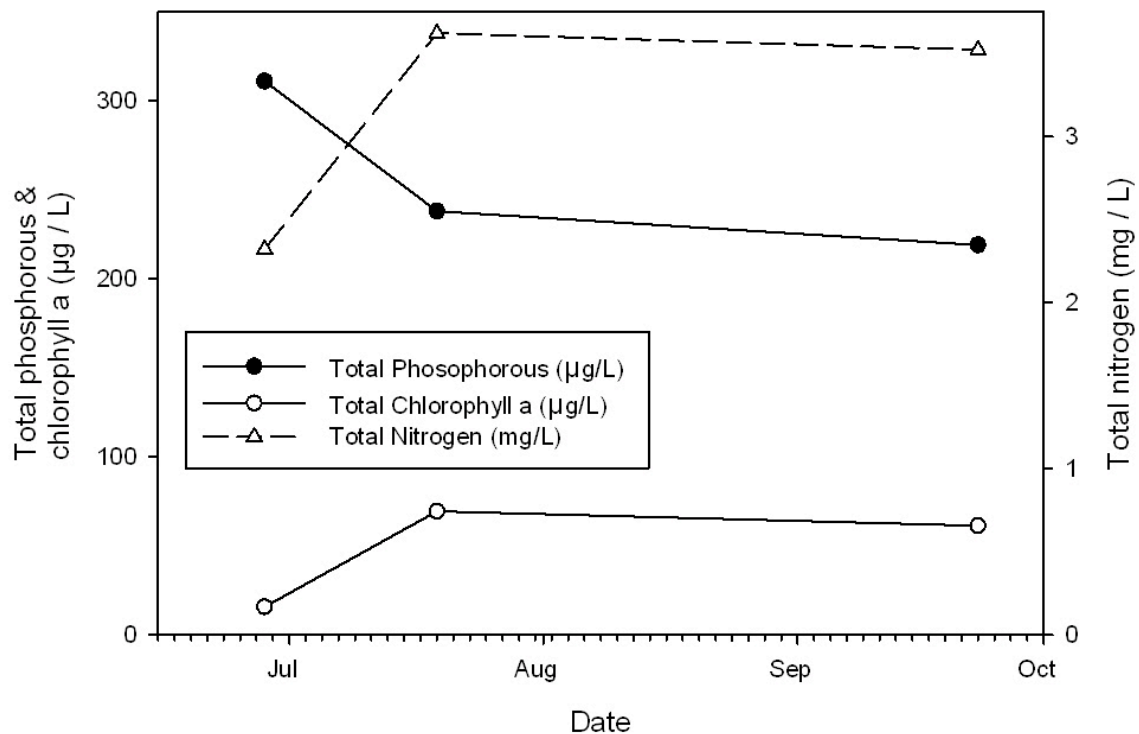
*Water clarity is influenced by suspended material, both living and dead, as well as some coloured dissolved compounds in the water column. The most widely used measure of lake water clarity is the Secchi disk depth. Following the period of ice and snowmelt, a lake can have low clarity due to spring runoff and the inflow of suspended sediments into the lake. Lake water usually clears in the spring but then becomes more turbid due to algal growth taking place throughout the summer open water season.*

Water clarity on Blackfalds Lake was measured three times during the summer of 2008. Blackfalds Lake was neither exceptionally turbid nor exceptionally clear compared to other lakes in Alberta, with average Secchi disk depth = 1.1 m (**Table 1**). On 28 June,

light penetrated 1.25 m or ~63% of the total lake depth, which allowed for algal growth throughout the entire water column of the lake. By 19 July, Secchi disk depth had decreased to 0.75 m, but then recovered to 1.25 m by mid-September. This pattern of water clarity dynamics is typical of highly productive Alberta lakes, when algal growth during July and August causes reduced water clarity. Water clarity recovers in September as lower temperatures limit growth, and dying algae fall out of the water column and settle on the lakebed where they are decomposed by anaerobic bacteria.

### Water chemistry

Based on lake water characteristics, Blackfalds Lake is considered hypereutrophic (see *A Brief Introduction to Limnology* at the end of this report). Average total phosphorus (TP = 256 µg/L) and total Kjeldahl nitrogen (TN = 3153 µg/L) concentrations were within the hypereutrophic range in 2008 (**Table 1**). Chlorophyll *a* (chl *a* = 48.8 µg/L) was also within the hypereutrophic range.



**Figure 3.** Total phosphorous, chlorophyll *a* (a measure of algal biomass), and total nitrogen concentrations for Blackfalds Lake during the summer of 2008.

Total phosphorous declined over the summer, from 311 µg/L on 28 June to a low of 219 µg/L on 23 September (**Figure 3**), as algal growth consumed nutrients in the water column. Total nitrogen increased from 2.32 mg/L on 28 June to a maximum of 3.62 mg/L on 19 July, decreasing only slightly to 3.52 mg/L by 23 September. Chlorophyll *a* (a measure of algal biomass) increased from 15.7 µg/L on 28 June to a maximum of 69.4 µg/L on 19 July, and then declined slightly to 61.3 µg/L by 28 September. As the

depletion of phosphorous during algal growth in late June – July was not accompanied by a significant decrease in nitrogen, algal growth in Blackfalds Lake is phosphorous-limited and not nitrogen-limited.

During the summer 2008, Blackfalds Lake was well buffered from acidification with an average pH = 8.9, which is well above that of pure water (i.e., pH 7). Dominant ions include bicarbonate, sodium, and sulphate (**Table 1**). Because there are no long-term records of ion concentrations from Blackfalds Lake it is not possible to assess possible changes in ion concentrations over time. The average concentrations of various heavy metals (as total recoverable concentrations) in Blackfalds Lake were not measured in the summer of 2008.

**Table 1.** Water chemistry values for Blackfalds Lake, summer 2008.

| <b>Parameter</b>                           | <b>2008</b> |
|--|-------------|
| TP (µg/L)                                  | 25.6        |
| TDP (µg/L)                                 | 18.8        |
| Chlorophyll- <i>a</i> (µg/L)               | 48.8        |
| Secchi disk depth (m)                      | 1.08        |
| TKN (µg/L)                                 | 3153        |
| NO <sub>2,3</sub> (µg/L)                   | 35          |
| NH <sub>4</sub> (µg/L)                     | 186         |
| Dissolved organic C (mg/L)                 | 31.3        |
| Ca (mg/L)                                  | 33.3        |
| Mg (mg/L)                                  | 28.9        |
| Na (mg/L)                                  | 81.0        |
| K (mg/L)                                   | 25.9        |
| SO <sub>4</sub> <sup>2-</sup> (mg/L)       | 74.5        |
| Cl <sup>-</sup> (mg/L)                     | 30.0        |
| TDS (mg/L)                                 | 452         |
| pH   | 8.94        |
| Conductivity (µS/cm)                       | 734         |
| Hardness (mg/L)                            | 202         |
| HCO <sub>3</sub> (mg/L)                    | 294         |
| CO <sub>3</sub> (mg/L)                     | 33.5        |
| Total Alkalinity (mg/L CaCO <sub>3</sub> ) | 298         |

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chla = chlorophyll *a*, TKN = total Kjeldahl nitrogen, NO<sub>2+3</sub> = nitrate+nitrite, NH<sub>4</sub> = ammonium, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO<sub>4</sub> = sulphate, Cl = chloride, CO<sub>3</sub> = carbonate, HCO<sub>3</sub> = bicarbonate.

\*Atlas of Alberta Lakes (Mitchell and Prepas, 1990).



## References

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- Vollenweider, R.A., and J. Kerekes, Jr. 1982. Eutrophication of Waters. Monitoring, Assessment and Control. Organization for Economic Co-Operation and Development (OECD), Paris. 156p.
- Welch, E.B. 1980. Ecological Effects of Waste Water. Cambridge University Press.

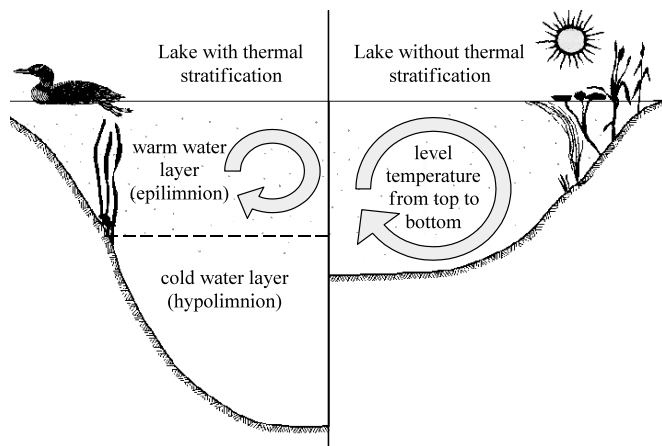
# A brief introduction to Limnology

## *Indicators of water quality*

The goal of **Lakewatch** is to collect water samples necessary to determine the water quality of lakes. Though not all encompassing, the variables measured in **Lakewatch** are sensitive to human activities in watersheds that may cause impacts to 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 affected (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 fish habitat and production of noxious odors. Large increases in nutrients over time may also indicate sewage inputs, which in turn, may result in other human health concerns such as harmful bacteria or protozoans (e.g. *Cryptosporidium*).

## *Temperature and mixing*

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality (Figure 6). 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.



**Figure 6: 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. Larger aquatic plants, known as macrophytes, rather than algae, dominate some highly productive lakes. 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 exist 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*

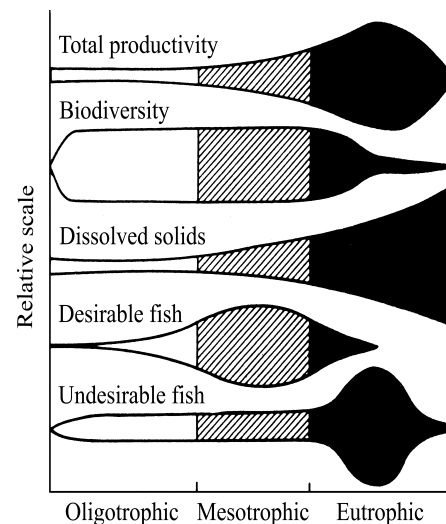
Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. Secchi disk depth is the oldest, simplest, and quickest quantitative measure of water clarity. A Secchi disk is a black and white disk that is lowered 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-*a*) concentrations, the trophic states are: **oligotrophic**, **mesotrophic**, **eutrophic** and **hypereutrophic**. The nutrient and algal biomass concentrations that define these categories are shown in table 2 and a graph 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 Figure 7.



**Figure 7: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.**

**Table 2: 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.