# Lakewatch

*The Alberta Lake Management Society*
*Volunteer Lake Monitoring Program*

# Pine Lake

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## 2004 Report

*Completed with support from:*

ALMS
Alberta Lake Management Society

Pine Lake Restoration Society

Alberta Environment

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> *Water is integral to supporting and maintaining life on this planet as it moderates the climate, creates growth and shapes the living substance of all of Earth's creatures. It is the tide of life itself, the sacred source.* David Suzuki (1997). The Sacred Balance.

# 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. Leah and John Cottam, with assistance from Lakewatch staff, sampled Pine Lake in 2004 and were instrumental in the success of the 2004 program. Our summer field technician and volunteer coordinator, Heather Jones, was a valuable addition and contributor to this year's program. Numerous Alberta Environment staff also contributed to successful completion of the 2004 program. Project Technical Coordinator, Shelley Manchur was instrumental in planning and organizing the field program. Technologists, Mike Bilyk, Brian Jackson and John Willis were involved in the logistics planning and training aspects of the program. Doreen LeClair was responsible for data management. Théo Charette (ALMS Director) was responsible for program administration and planning. Heather Jones and Ron Zurawell (Limnologist, AENV) prepared this report. Al Sosiak (Limnologist, AENV) provided critical review of the draft report and insight information contained in this report. The Lakewatch program received financial support from Alberta Environment and the Pine Lake Restoration Society.

# Pine Lake

Pine Lake is a small eutrophic lake southeast of Red Deer, Alberta. Pine Lake is subject to severe cyanobacterial blooms. Public concern over deteriorating water quality prompted the Alberta government to initiate a lake restoration program in 1991. The Pine Lake Restoration Program was designed as a pilot project for future lake and watershed projects in Alberta.

An advisory committee that represented all members of the community directed early planning and problem diagnosis by the Alberta government. A diagnostic study in 1992 (Sosiak and Trew, 1996) determined that approximately 61% of the total phosphorus (TP) loading was from sediment release and other internal sources, compared to about 36% from surface runoff and determined that algal growth in Pine Lake was mainly limited by the supply of phosphorus. Four critical areas for watershed restoration were identified on four streams affected by livestock operations and sewage release (Sosiak and Trew, 1996). These streams contributed 72% of the phosphorus loading from streams in 1992.

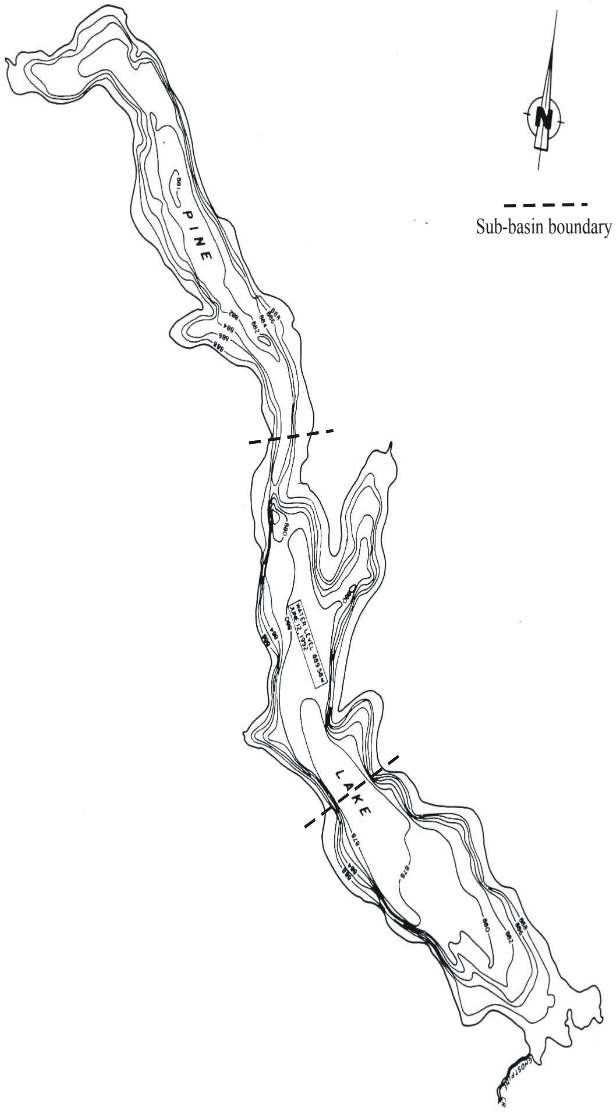

**Figure 1. Bathymetry of Pine Lake (Sosiak and Trew, 1996).**

The advisory committee later formed the Pine Lake Restoration Society, a non-profit organization with representatives from all stakeholders, which raised funds and worked with technical advisors from the Alberta government. The Pine Lake Restoration Society implemented a four-year work plan in 1995 that addressed phosphorus loading from all sources. The main objective of the restoration program was to restore Pine Lake to a “natural” level of algal productivity. The Pine Lake Restoration Society and other individuals in the basin completed beneficial management practices

(BMPs) projects at various agricultural sites. Other organizations also improved wastewater treatment at a resort and two camps near the shoreline of Pine Lake.

Following an evaluation of the different alternatives to remove or treat phosphorus released from lake sediments, hypolimnetic withdrawal was selected as the preferred method of treatment. Hypolimnetic withdrawal has been successfully used to reduce TP concentration in various lakes, mainly in Europe, but has never been attempted in Alberta. Two different designs for the Pine Lake system were prepared and evaluated and, following public notice and licensing, the system was installed in September 1998.

The system at Pine Lake consists of a weir that maintains head and regulates lake level, and a gravity-fed pipeline that withdraws cool, phosphorus-rich water from near the bottom of the lake (called the hypolimnion) of the south basin and discharges through a vault with control valves to a stilling basin on Ghostpine Creek. Locations and other details on the projects and results of water quality sampling to 2001 are in Sosiak (2002).

This report presents results of a volunteer sampling of Pine Lake in 2004. The Lakewatch sampling program is designed to monitor changes in water quality in Pine Lake following the completion of watershed and lake projects in 1998. In 2003 and 2004, Lakewatch volunteers collected a composite sample from the euphotic zone (i.e. the upper illuminated zone of water) on each sampling date during June to September. Accordingly, the composite samples, which comprise equal amounts of water collected from ten individual sites along the lake's length, represent the average conditions within individual basins. This report consists of a comparison of 2004 data with results collected by the Alberta government and Lakewatch since 1978.

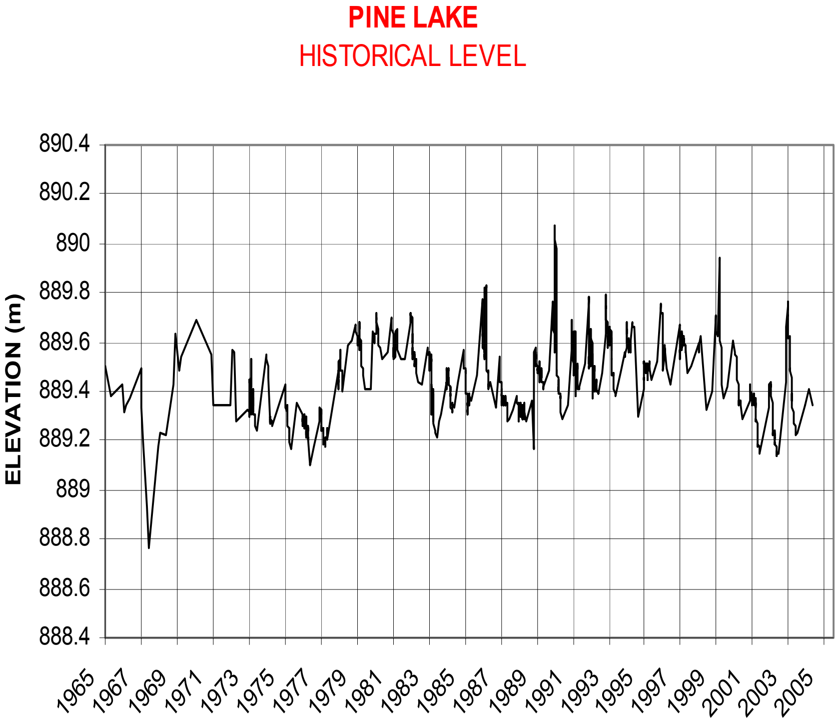

**Figure 2: Historical water levels for Pine Lake**

### *Water Levels*

Water levels in Pine Lake have been monitored since 1965 (Figure 2). Under the approval to operate the hypolimnetic withdrawal system, the Pine Lake Restoration Society tries to maintain water levels within a range that was recommended in the engineering report for the system. The weir operator for the Society accomplishes this by adding or removing boards to the weir at the lake outfall and by operating the control valves. There was sufficient water to operate the hypolimnetic withdrawal system in 1999, 2000, 2003, and briefly in 2001, but not during the drought of 2002 and 2004. Low water levels experienced in 2001 and 2002 may have resulted from below average rainfall (68 and 82%, respectively) compared to the long-term climate (precipitation) normals for the area. During project planning, it was assumed that there would be insufficient water to operate the system three years in 10 (Sosiak, 1997). With the control valves shut and all boards in the weir, lake levels declined to 889.147, which is the third lowest on record (Figure 2). Lake levels were lower at the start of the 2004-operating season, up to 889.23, but increased to 889.4 by the end of the 2004 monitoring season, most likely a result of the increase in precipitation received during the summer of 2004.

## 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.

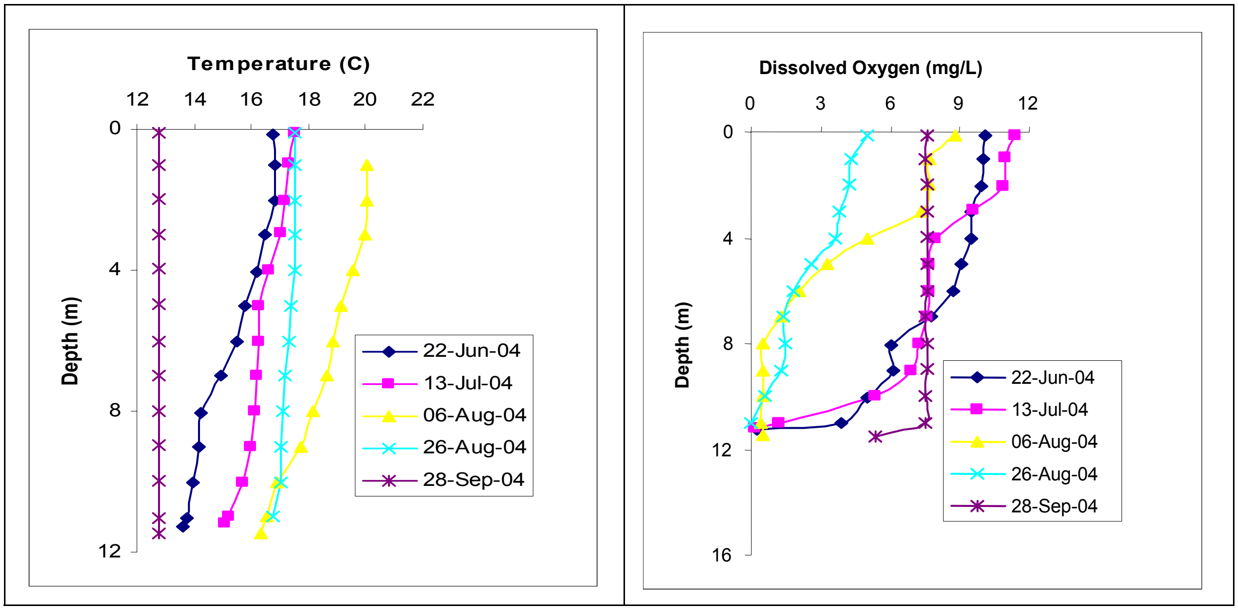

**Figure 3: Temperature and dissolved oxygen concentrations with depth in Pine Lake, summer 2004**

As in previous years thermal stratification occurred in Pine Lake (Figure 3). A weak thermal stratification formed in early and mid-summer. In late August to late September, no thermal stratification was observed; water temperature remained constant from top to bottom and resulted in a mixing of the water column. Dissolved oxygen concentrations were highest in July where oxygen concentrations were at 11 mg/L at the surface but declined to 7 mg/L at 4 m depth. Surface oxygen concentrations were lowest at the end of August at 5mg/L (Figure 3). Anoxic conditions (containing little or no oxygen) were observed in August at a depth of 8 m, whereas this condition was observed at the bottom of the lake in June, and July. The lake remained well oxygenated in September due to the complete mixing of the lake (Figure 3). The sharp drop in dissolved oxygen in August corresponds with the period of greatest bacterial decomposition of organic matter at the lake bottom. Dissolved oxygen concentrations were within surface water quality guidelines for most of the water column throughout the summer.

### *Water clarity and Secchi Depth*

Water clarity is influenced by suspended materials, both living and dead, as well as dissolved coloured 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 biomass as the summer progresses. The easiest and most widely used measure of lake water clarity is the Secchi disk depth.

In Pine Lake, water clarity, as measured by Secchi disk depth, followed patterns in algal biomass, or how green the water becomes (Figure 4). Water clarity was highest in late June (Secchi 2.6 m), and was lowest in July (Secchi 1.25). Late September showed an increase in water clarity (Secchi disk depth of 2.0 m) as algal biomass decreased.

Average Secchi depth measurements collected by volunteers of Pine Lake in 2004 (1.74 m) were lower than in 2003. This indicates the lake had a decrease in water clarity in 2004, compared to the 2003 average Secchi readings (Table 1). However, the 2004 average value was similar to that recorded in 2002 and the minimum and maximum measurements were within the range that has occurred in recent years.

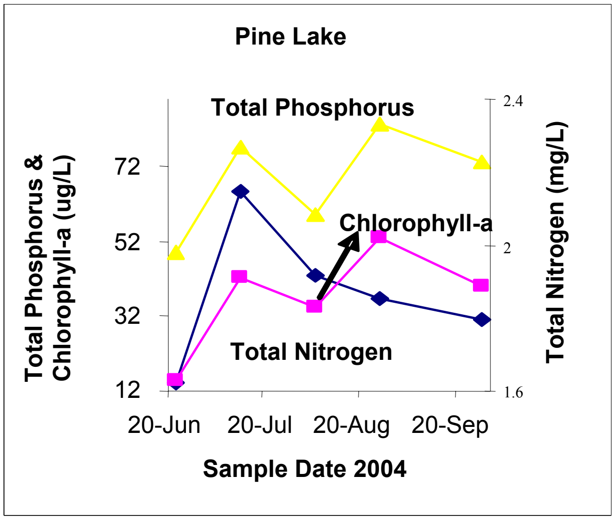

**Figure 4: Total phosphorus, total nitrogen and chlorophyll-*a* concentrations (i.e., amount of algae), summer 2004.**

### *Water chemistry*

The average total phosphorus concentrations reported for Pine Lake in 2004 (79µg/L, Table 1) was higher than in 2003, though concentrations remained lower than prior to completion of the lake restoration program in 1998. Average chlorophyll-*a* concentrations were also higher in 2004 (average 37.8 µg/L, Table 1) compared to recent years (2002 and 2003). The high total phosphorus and chlorophyll-*a* concentrations could reflect the effects of external phosphorus loadings due to an increase in surface runoff. This may be a direct result of the increased precipitation experienced during the 2004-sampling season, compared to past years. Total annual precipitation at Red Deer was 525.9 mm, about 9% above the climate normal of 482.7 mm. Increased precipitation and external phosphorus loading (than during the drought) could partially account for higher total phosphorus levels in the lake in 2004 and may explain the occurrence of algal blooms during the late summer. Alternatively, blooms of the cyanobacteria *Gleotrichia*, may be partly responsible for high average total phosphorus concentrations in 2004. This species begins its annual growth and reproduction on the sediment where phosphorus is often in abundant supply. When the water warms, large populations migrate to the euphotic zone, the upper zone of water with enough sunlight to permit photosynthesis, where the cyanobacteria continue its growth cycle. This process reflects an important, albeit, indirect transfer of sediment phosphorus to the water column.

**Table 1: Mean values from summer 2004 samples compared to values reported previously.**

| Parameter | *1979 | *1984 | 1992 | 1996 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|
| TP ($\mu g{\bullet}L^{-1}$) | - | 56 | 84.7 | 104.0 | 49.3 | 55 | 79 |
| Chl ($\mu g{\bullet}L^{-1}$) | 11.3 | 26.3 | 50.4 | 22.1 | 15.6 | 17.9 | 37.8 |
| Secchi (m) | 3.4 | 1.8 | 1.8 | 2.1 | 1.7 | 3.1 | 1.74 |
| TKN ($\mu g{\bullet}L^{-1}$) | 1293 | 1302 | 2052 | 1360 | 1442 | 1474 | 1880 |
| TN ($\mu g{\bullet}L^{-1}$) | - | - | 2088 | 1385 | 1445 | 1484 | 2020 |
| $NO_2$+$NO_3$N ($\mu g{\bullet}L^{-1}$) | 13 | <10 | 36 | 11 | 3 | 10 | 9.7 |
| $NH_4^+$ N ($\mu g{\bullet}L^{-1}$) | - | 59 | 146 | 120 | 11 | 98 | 136 |
| Ca ($mg{\bullet}L^{-1}$) |  | 23 | 25 | 28 | 20 | 21 | 21.7 |
| Mg ($mg{\bullet}L^{-1}$) |  | 25 | 25 | 24 | 26 | 24 | 24.8 |
| Na ($mg{\bullet}L^{-1}$) |  | 108 | 99 | 103 | 112 | 124 | 132 |
| K ($mg{\bullet}L^{-1}$) |  | 10 | 9 | 10 | 11.5 | 10 | 10 |
| $SO_4^{2-}$ ($mg{\bullet}L^{-1}$) |  | 84 | 69 | 63 | 90 | 79 | 85 |
| $Cl^-$ ($mg{\bullet}L^{-1}$) |  | 6 | 7 | 8 | 11 | 10 | 10.6 |
| Total Alkalinity ($mg{\bullet}L^{-1}$ $CaCO_3$) |  | 319 | 308 | 313 | 321 | 331 | 341 |
| pH | - | - | - | - | - | - | 8.77 |
| $HCO_3$($mg{\bullet}L^{-1}$ ) | - | - | - | - | - | - | 374 |

Note: TP = total phosphorus, Chla = chlorophyll *a*, $NO_{2+3}$ = nitrate+nitrite, $NH_4$ = ammonium, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, $SO_4$ = sulphate, Cl = chloride, $CO_3$ = carbonate, $HCO_3$ = bicarbonate.

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

Alkalinity, chloride, and sodium levels have increased slightly since 2003, and most forms of nitrogen have slightly increased as well. However, other variables have changed little over time (Table 1). Pine Lake is well-buffered from acidification; its pH of 8.77 is well above that of pure water (i.e., pH 7). Bicarbonate, sulphate, calcium, and magnesium are the dominant ions in Pine Lake, and have remained relatively constant over the past two decades.

The average concentrations of various heavy metals (as total recoverable concentrations) were below CCME guidelines for the Protection of Freshwater Aquatic Life. Results of the metal analyses, compared to guideline values, are listed in Appendix 1.

The results of the 2004 volunteer sampling of Pine Lake provide a valuable ongoing assessment of changes since the initiation of the lake restoration program. Pine Lake serves as a model for future lake management programs in Alberta, and some of the lake and watershed methods implemented at Pine Lake are unique within the province. It would be valuable to continue this monitoring program, to evaluate the operation of the hypolimnetic withdrawal system and the response of the lake to normal variations in precipitation and runoff.

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# Appendix 1

Mean concentrations of metals, Pine Lake, 2004 compared to CCME Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated).

| Metals | 2004 | Guidelines |
|---|---|---|
| ALUMINUM ug/L | 30.55 | 100[a] |
| ANTIMONY ug/L | 0.078 | 6[e] |
| ARSENIC ug/L | 1.145 | 5 |
| BARIUM ug/L | 58.6 | 1000[e] |
| BERYLLIUM ug/L | <0.003 | 100[d,f] |
| BISMUTH ug/L | 0.0018 | |
| BORON ug/L | 80.3 | 5000[e,f] |
| CADMIUM ug/L | 0.0037 | 0.085[b] |
| CHROMIUM ug/L | 0.33 | |
| COBALT ug/L | 0.0.063 | 1000[f] |
| COPPER ug/L | 1.57 | 4[c] |
| IRON ug/L | 9 | 300 |
| LEAD ug/L | 0.127 | 7[c] |
| LITHIUM ug/L | 43.6 | 2500[g] |
| MANGANESE ug/L | 10.5 | 200[g] |
| MOLYBDENUM ug/L | 0.7 | 73[d] |
| NICKEL ug/L | 0.2 | 150[c] |
| SELENIUM ug/L | <0.1 | 1 |
| SILVER ug/L | <0.0005 | 0.1 |
| STRONTIUM ug/L | 283.5 | |
| THALLIUM ug/L | 0.0007 | 0.8 |
| THORIUM ug/L | 0.006 | |
| TIN ug/L | <0.03 | |
| TITANIUM ug/L | 1.32 | |
| URANIUM ug/L | 0.76 | 100[e] |
| VANADIUM ug/L | 0.38 | 100[f,g] |
| ZINC ug/L | 7.69 | 30 |
| FLUORIDE mg/L | 0.30 | 1.5 |

With the exception of fluoride (which reflects the mean concentration of dissolved fluoride only), values represent means of total recoverable metal concentrations.

[a] Based on pH ≥ 6.5; calcium ion concentration $[Ca^{+2}] \geq 4$ 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

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

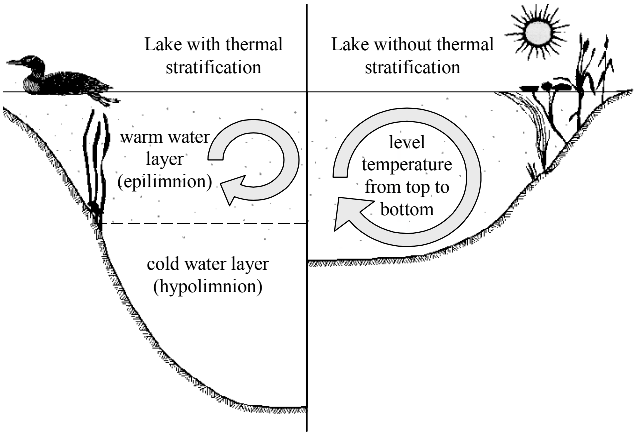

**Figure 5: Difference in the circulation of the water column depending on thermal stratification.**

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality (Figure 5). 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. A third layer, known as the metalimnion, provides an effective barrier between the epi- and hypolimnion**.** The metalimnion reflects a rapid transition in water temperature known as the **thermocline**. A thermocline typically occurs when water temperature changes by several degrees within one-meter of depth. The thermocline acts as an effective physico-chemical barrier to mixing between the hypolimnion and epilimnion, restricts downward movement of elements, such as oxygen, from the surface 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 state 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 terrestrial plants and plants and algae of tropical lakes, phosphorus is usually in shortest supply in temperate 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, reflect lower-nutrient trophic states than would otherwise result if macrophyte-based chlorophyll were 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 low. Secchi disk depth, however, is not only affected by algae, high concentrations of suspended sediments, particularly fine clays or glacial till common in plains or mountain reservoirs of Alberta, also impact water clarity. 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.

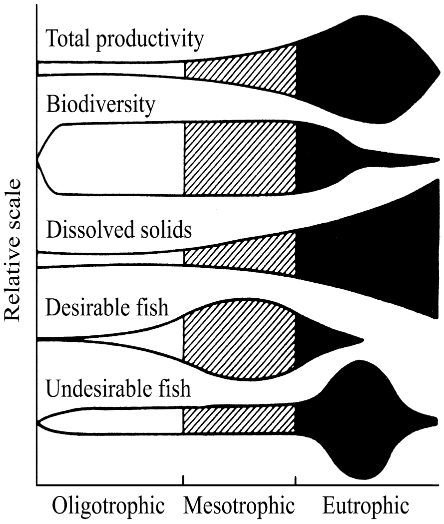

**Figure 6: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.**

## 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. 6.

**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 and Kerekes (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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