Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Hilda Lake

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2005 Report

Completed with support from:

Alberta Lake Management Society

LICA Lakeland Industry & Community Association

Alberta Environment

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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Don Harasimiuk and his grandson – making Lakewatch sampling a family affair

Hilda Lake

Figure 1. Hilda Lake. Photo credit: Vien Lam.

Hilda Lake (Figure 1) is located in the Beaver River Basin in the northeast corner of Alberta. It is fed by Moore Lake upstream and drains into Ethel Lake downstream eventually feeding the Beaver River, which then winds through Saskatchewan ultimately to Hudson Bay. The lake is accessed via Highway 897 connecting to a municipal road off the southeastern shore of the lake.

Hilda Lake is situated in rolling land characteristic of the low boreal mixedwood (Table 1): dominant trembling aspen, white spruce and jack pine occur on high ground, while black spruce and tamarack appear in low-lying areas. Birch and balsam poplar are also evident as well as many areas of muskeg (Trew, Yonge, and Kaminski, 1981). The lake supports some sport fish species including Northern pike and walleye, and to a lesser extent yellow perch and burbot. Lake cisco and white suckers are also present. A 1986 census showed breeding Northern pike ranging from 2 – 12 years of age and walleye from 4 – 6 years of age (R. L. and L. Environmental Services Ltd, 1986). Good to excellent permanent wetland habitat surrounds part of the lake as well as shorelines suitable for recreation. Much of the watershed is crown land, with most development near the lake itself. This includes two campsites and two multi-lot rural subdivisions (Alberta Environment Historical Library).

Table 1. Summary of details describing the low boreal mixedwood ecoregion in which Hilda 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

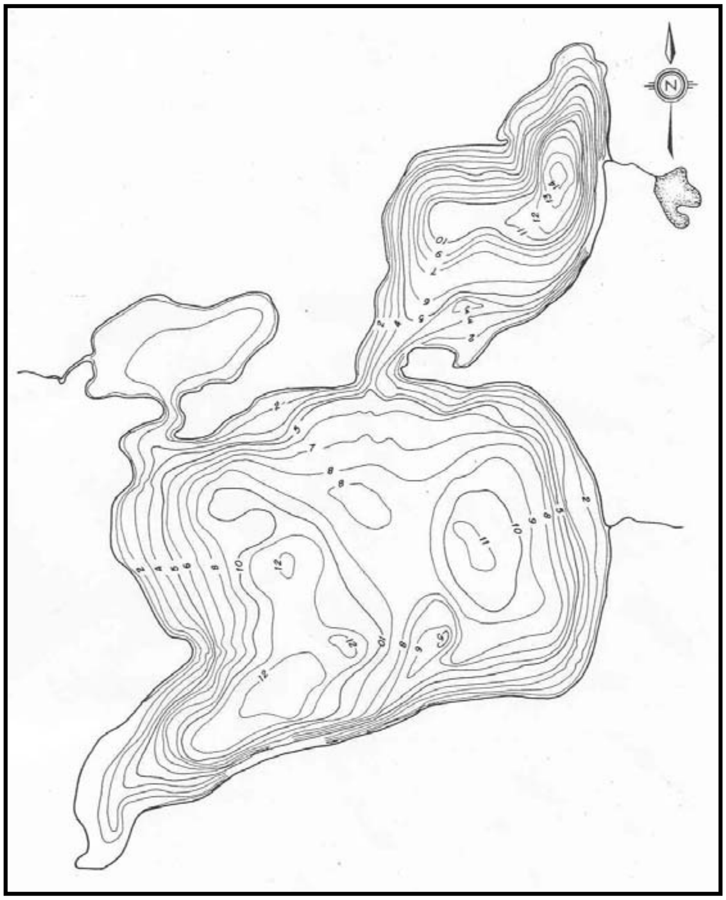

Figure 2. Bathymetric map of Hilda Lake. Alberta Environment Historical Library.

The watershed of Hilda Lake is small and surface run-off is low, with most of the total annual inflow coming from direct rainfall. Areas of muskeg probably intercept the movement of surface water to the lake. Analysis of the lake water in the early 1980's suggest that groundwater plays an important role in lake inputs, as water chemistry results revealed high sodium and potassium levels typical of groundwater in the surrounding Sand River Formation. Hilda Lake is moderately productive (mesotrophic) and tends towards algal blooms in autumn.

Lake shape and depth result in water layers stratifying in warm summer months (Figure 2; Table 2). It is likely that factors including landscape position and a small surface area contribute to the water column never mixing completely throughout the deepest parts of the lake (Trew, Yonge, and Kaminski, 1981).

Table 2. Physical characteristics of Hilda Lake (Trew, Yonge and Kaminski, 1981).

Lake surface area	3.62 m^2
Drainage basin	37.2 km^2
Mean depth	6.2 m
Maximum depth	approx. 14 m

Concerns over low water levels led to the creation of the Hilda Lake Water Management Study in 1990. The steering committee sought to create long-term solutions meant to stabilize water levels in the lake. Proposed alternatives included controlling beaver populations, installing a structure at the outlet of upstream Moore Lake, temporary pumping of water from downstream Ethel Lake and improvements made to the existing structure on Hilda Lake. The lake was also included in a study of 23 lakes in the Beaver

River drainage basin throughout the 1980's, where mixing regimes and water quality were summarized from a 9-year sampling effort (Chow-Fraser, P. and D.O. Trew, 1990).

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

The water levels on Hilda Lake have been monitored from 1980 to present (Figure 3). Over this period, the lake's surface has ranged from a high of 547.173 m above sea level (asl) in the spring of 1981, to a low of 546.004 m asl in the autumn of 1995. The average water level during this time was 546.6 m asl. At the lake's deepest point, this translates into a depth range of about 12 to 14 m with an average depth of 12.6 m. Figure 3 suggests an overall drying trend characteristic of many lakes in the Beaver River Basin (Alberta Environment Report, 2006).

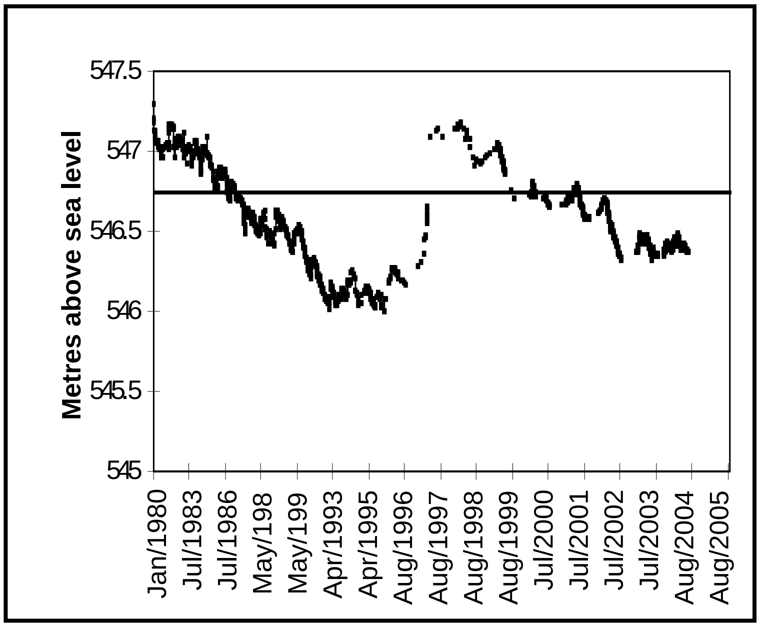

Figure 3. Historical water levels for Hilda Lake. The horizontal black line indicates the average water level for the sampling period. Alberta Environment data.

Temperature and Dissolved Oxygen Profiles

The movement of water within Hilda Lake reflects its shape and position in the landscape. Somewhat protected by wind and with a deeper basin pinched off to the north, the lake probably never mixes exceptionally well at its lowest points. Profiles taken at the deep water spot during the summer of 2005 reflect this (Figure 4). The lake was still stratified in June: surface water had started warming while deeper water remained cold. In July, the water column had started warming and August showed higher temperatures reaching into even the deepest water. By September, the surface water had begun to cool and the colder, denser water had started settling to the lake bottom.

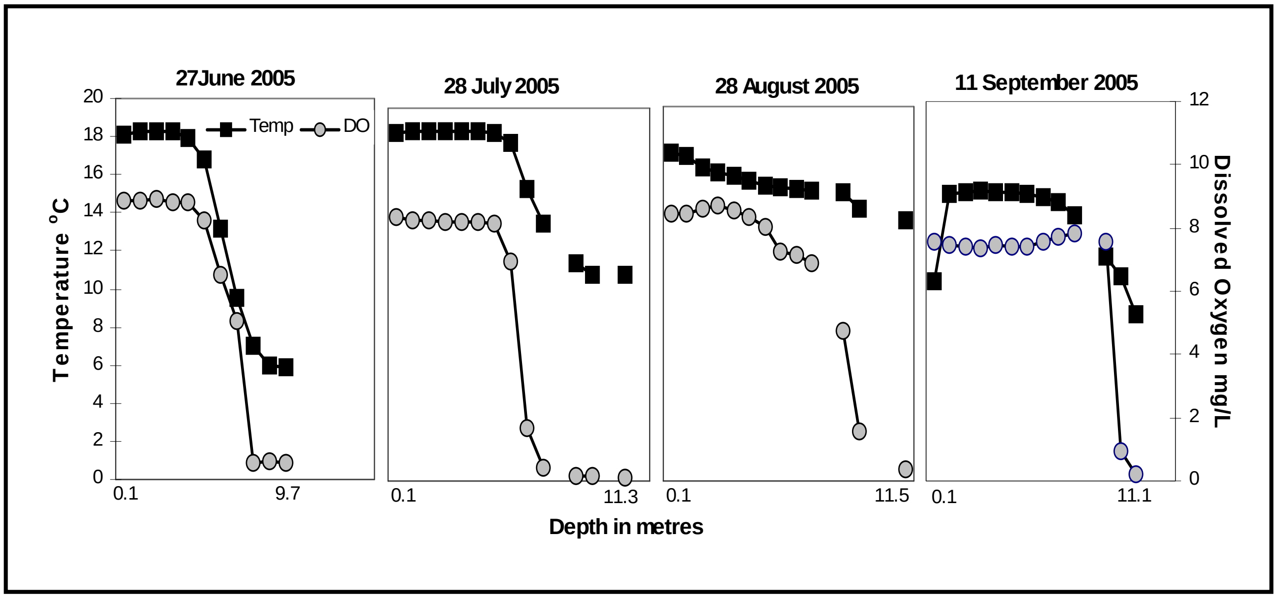

Figure 4. Temperature and dissolved oxygen profiles of Hilda Lake for summer 2005. Alberta Environment data.

Water Clarity

Since it is mesotrophic (Figure 5), the water in Hilda Lake remains clear for most of the open-water season. When blooms occur on this lake, they have historically formed during mid to late autumn (Trew, Yonge, and Kaminski, 1981). As such, the water clarity remains good through most of the summer months and only begins to decrease once algal growth (measured as chlorophyll *a* concentrations) increases in fall (Figure 6). In 2005, growth of algae over the warmer months was slow but steady. Low nutrient levels in the lake help to limit the seasonal growth of algae (Figure 7).

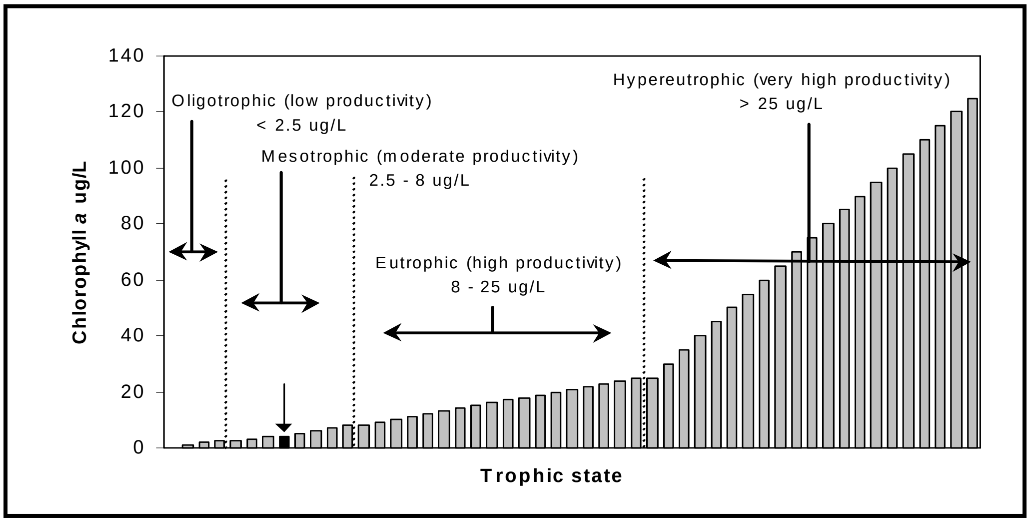

Figure 5. The black bar below the down arrow represents average chlorophyll *a* concentration for Hilda Lake from summer 2005. Adapted from Mitchell, 1994.

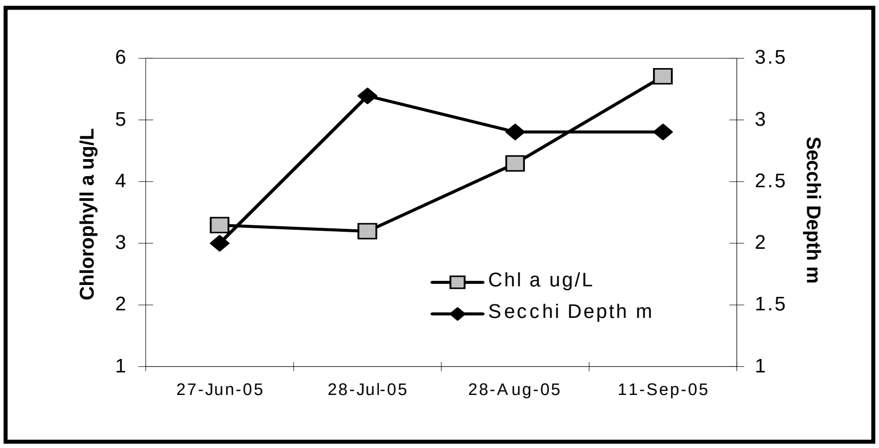

Figure 6. Lakewatch data from summer 2005. The gradual increase of chlorophyll *a* (chl *a*) over the summer months doesn't start to have an effect on Secchi depth until autumn.

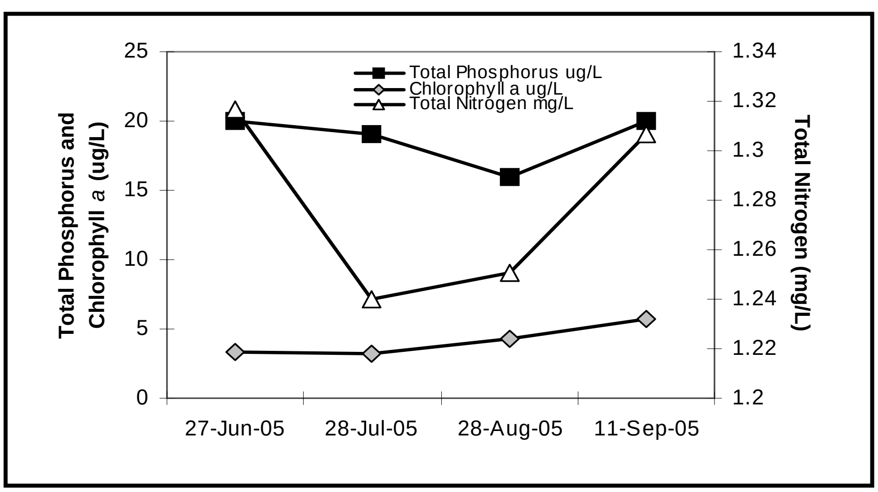

Figure 7. Decrease of nitrogen in the euphotic zone over summer can be due to many things, including surface temperatures, high winds and consumption by nitrogen-hungry algae.

Water Chemistry

Historical records for water quality measurements exist for Hilda Lake. Looking at available summer averages from 1981 to present, Hilda Lake shows no dramatic trends in terms of chlorophyll levels (Figure 8).

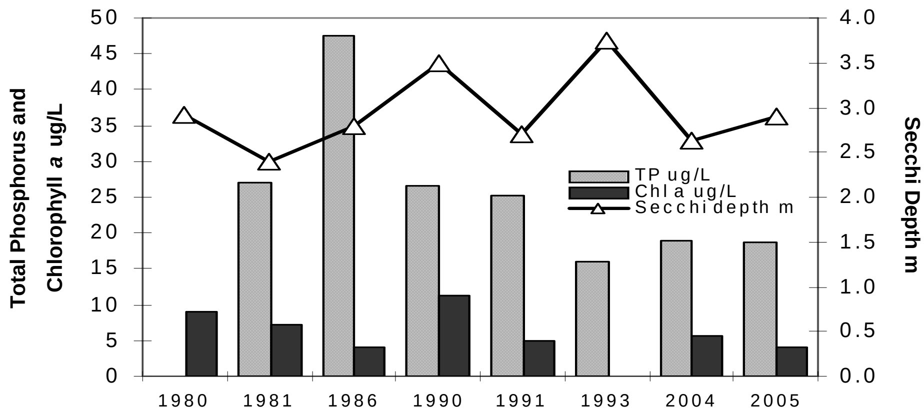

Figure 8. Summer averages for TP, chl a and Secchi depth. No dramatic trends are evident although 1986 was certainly a banner year for phosphorus levels. Note that 1990 and 1993 values are based on single samples.

Sampling efforts from 2005 show an average alkalinity of 431 as mg/L $CaCO_3$. This represents high alkalinity since this value must be 100 mg/L as $CaCO_3$ or less to be considered low. This is a common situation for most Alberta lakes and usually implies that the lake water is hard. However, in the case of Hilda Lake the water is actually somewhat soft, indicated by higher values for sodium and potassium relative to those of calcium and magnesium (Table 3). This implies strong inputs from local groundwater, which also shows these characteristics. A drying effect, supported by the downward trend in water levels, is probably responsible for the increase in alkalinity and in the concentrations of the major ions and zinc.

Table 3. Hilda Lake cation concentrations place the lake in the slightly saline range. 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
Hilda Lake (526)	**113.7**	**9.9**	**16.2**	**52.8**

Results for other water quality measurements averaged from 2005 are summarized in Appendices I and II, as well as historical values where available.

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Appendix 1. Summary of historical and summer 2005 averages for various water quality parameters. Years 1990 and 1993 represent a single sampling effort.

Parameter	1979	1980	1981	1986	1990	1991	1993	2004	2005
Total Phosphorus ug/L	40.0		27.0	47.6	26.6	25.2	16.0	19.0	18.8
Total Dissolved Phosphorus ug/L			12.6	28.9	9.8	17.2		6.8	6.5
Total Dissolved Solids mg/L								534.5	526.0
Chlorophyll a ug/L	18.2	9.0	7.2	4.1	11.2	5.0		4.8	4.1
Secchi depth m	2.3	2.9	2.4	2.8	3.5	2.7	3.8	2.8	2.9
Total Nitrogen mg/L	1.5	1.6	1.2	1.2	1.4		1.3	1.4	1.3
Nitrate + Nitrite mg/L	< 0.005	< 0.005		< 0.005	< 0.005		< 0.005	< 0.005	0.012
Ammonium mg/L	0.0	0.1	0.1	0.0	0.1		0.0	0.0	0.0
Calcium mg/L	18.0	20.3	19.9	20.0	20.0		19.0	17.0	16.2
Magnesium mg/L								55.3	52.8
Sodium mg/L								115.5	113.7
Potassium mg/L	5.3	6.8	7.0	7.5	8.3		8.7	10.2	9.9
Sulphate mg/L	14.0	15.3	19.6	20.0	30.0		24.0	38.5	34.7
Chloride mg/L	21.0	21.5	21.1	23.0	25.3		27.5	33.5	31.8
Alkalinity mg/L as $CaCO_3$	330.0	332.9	328.4	359.0	393.0		418.0	442.5	431.0
Carbonate mg/L				29.0	25.0		37.0	47.0	41.7
Bicarbonate mg/L				379.0	428.0		471.0	444.0	440.7
pH	8.5		7.9	8.9	8.8		8.9	9.0	8.9
Conductivity uS/cm								891.5	882.7

Appendix II. Summary of metals, non-metals and metallic elements analyses. Guideline values are those listed for the Protection of Freshwater Aquatic Life unless otherwise noted. Concentrations represent total recoverable fractions except fluoride, which is for the dissolved fraction only.

Parameter	**2005**	**Guideline Values**	**Parameter**	**2005**	**Guideline Values**
Aluminum ug/L	7.303	100	Lithium ug/L	65.100	2500 [3]
Antimony ug/L	0.046	6 [1]	Manganese mg/L	5.903	200 [3]
Arsenic ug/L	2.240	5	Molybdenum ug/L	0.666	73
Barium ug/L	20.833	1000 [1]	Nickel ug/L	L0.005	150
Beryllium ug/L	L0.003	100	Selenium ug/L	0.230	1
Bismuth ug/L	0.004		Silver ug/L	0.002	0.1
Boron ug/L	255.333	5000 [1]	Strontium ug/L	105.467	
Cadmium ug/L	0.014	0.085	Thallium ug/L	0.010	0.8
Chromium ug/L	0.428		Thorium ug/L	0.100	
Cobalt ug/L	0.017	1000 [2]	Tin ug/L	0.049	
Copper ug/L	0.363	4	Titanium ug/L	0.688	
Fluoride mg/L	0.232	1.5	Uranium ug/L	0.173	100 [1]
Iron mg/L	6.200	300	Vanadium ug/L	0.302	100 [2]
Lead ug/L	0.081	7	Zinc ug/L	**3.463**	1.5

[1] Canadian Drinking Water Quality Guidelines
[2] Canadian Guidelines for Agricultural Use (Livestock Watering)
[3] Canadian Guidelines for Agricultural Use (Irrigation)

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

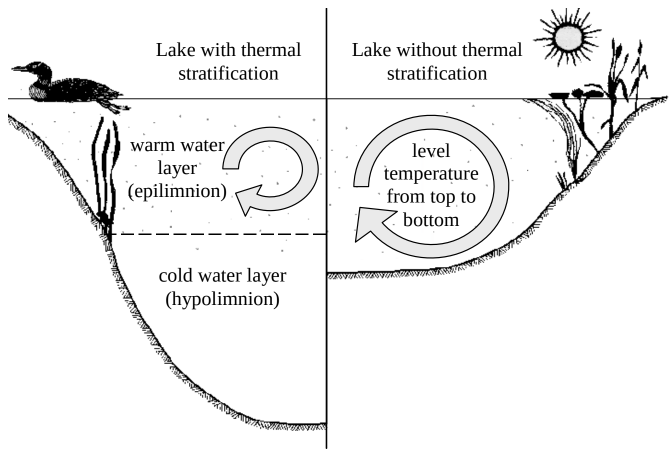

Fig. 1: Difference in the circulation of the water column depending on thermal stratification.

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.

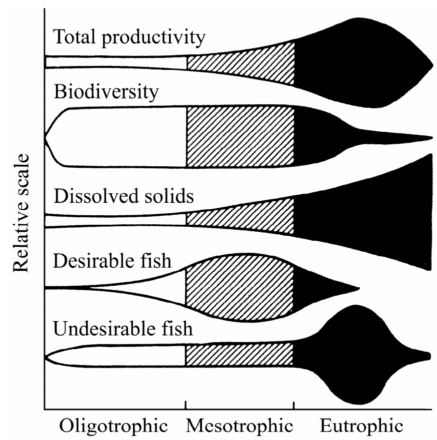

Fig. 2: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980

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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