Lakewatch

The Alberta Lake Management Society
Volunteer Lake Monitoring Program

Bluet (Garnier South) Lake

2005 Report

Completed with support from:

Alberta Lake Management Society
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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, 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 usually available for 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 Lakewatch Chairs, Théo Charette and Ron Zurawell, and the volunteers. James Capjack was the volunteer for Bluet Lake. He supplied the watercraft and made sampling possible through the dedication of his time. Our summer field technician and volunteer coordinator, Vien Lam, was a valuable addition and contributor to this year's program. Numerous Alberta Environment staff also contributed to successful completion of the 2005 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. Théo Charette, Ron Zurawell (Limnologist, AENV), and Lori Neufeld (ALMS Director) prepared this report. Alberta Environment and Lakeland Industry and Community Association (LICA) financially supported the Lakewatch program.

Bluet Lake

Bluet Lake, also known as Little Garnier, Garnier South, or Upper Garnier lies in the southern portion of Muriel Lake's sub – drainage basin of the Beaver River Watershed. Bluet Lake drains into Garnier Lake to the north, and then water flows into Muriel Lake and eventually, into the Beaver River. Bluet Lake (Fig. 1) is a small round lake with a surface area of 1.2 km^2 and a depth over 6.5 m deep. Historically, the maximum depth of Bluet Lake has been recorded at 9.5 m but later sampling in the winter recorded 7 m (Alberta Government, 2002); the presence of Beaver dams can hold back as much as 1 to 1.5 m of water. For example, in the early 1980's a massive dam was located on the north end of the lake and it was noted that erosion and flooded trees covered most of the shoreline. Today, evidence of erosion still exists through much of the shoreline, but it was also evident that water levels have been decreasing. Unfortunately, no water level data records exist for Bluet Lake. Cattails fringe the bay area, most of the steeper western shoreline and near the outlet area.

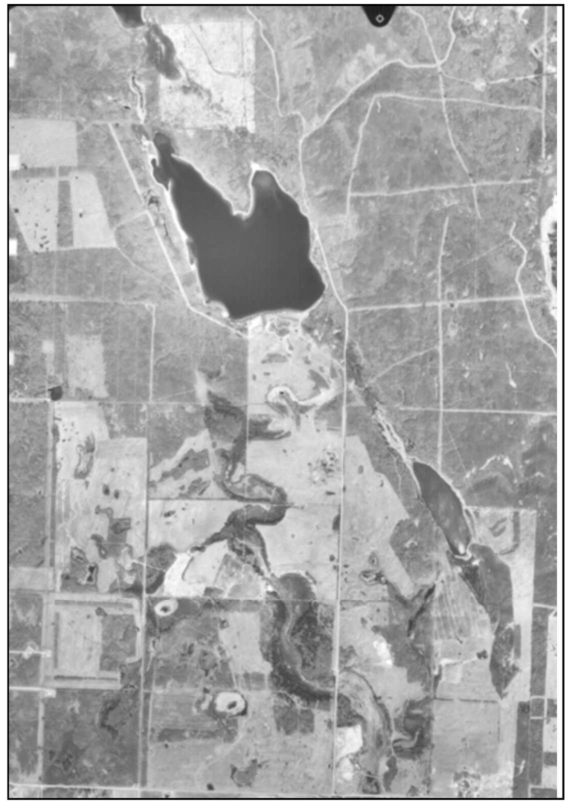

Figure 1. Air photo of Bluet Lake and its surroundings. Source: Neil Guay.

Plains Cree and other nomadic tribes such as the Blackfoot Tribes once inhabited the area. There were many trading posts in the area to the north (Moose Lake and Cold Lake areas), east (Frog Lake), and southeast (along the North Saskatchewan River). Unsurprisingly, resources from hunting and trapping were very important trades to the area. Beaver activity is common around Bluet Lake, 30 to 50 pelts were still harvested annually from the region in the early-mid 1980's (AENV 1983, vol.5).

Bluet's drainage basin is moderately rolling hummocky morainal plain with irregular knob and kettle topography (Mitchell and Prepas, 1990). Vegetation in the area is mostly aspen forest. Agricultural land-use is primarily grazing with a small section of cleared land for hay. Other development includes oil and gas industries and it remains undeveloped for recreation and summer cottages. The lake's uses include livestock, trapping, hunting waterfowl, and fishing. Northern pike was the only sport fish found in previous surveys (Alberta Government, 2002), although it is likely that perch and burbot try to establish populations in some years, but are limited by beaver dam activity, erosion to the shoreline created by water level fluctuations and emergent vegetation development (AENV 1983, Vol.5).

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.

In 2005, Bluet Lake did not exhibit a strong thermal stratification. Weak stratification developed near the 3 meter mark during late June and July. Thermal stratification was not observed at other times during the summer. Dissolved oxygen concentrations were above 5 mg/L, the acute provincial guideline for the protection of aquatic life, throughout most of the water column, except at lake bottom. In general, Bluet Lake was well-airated during the 2005 sampling season (**Figure 2**).

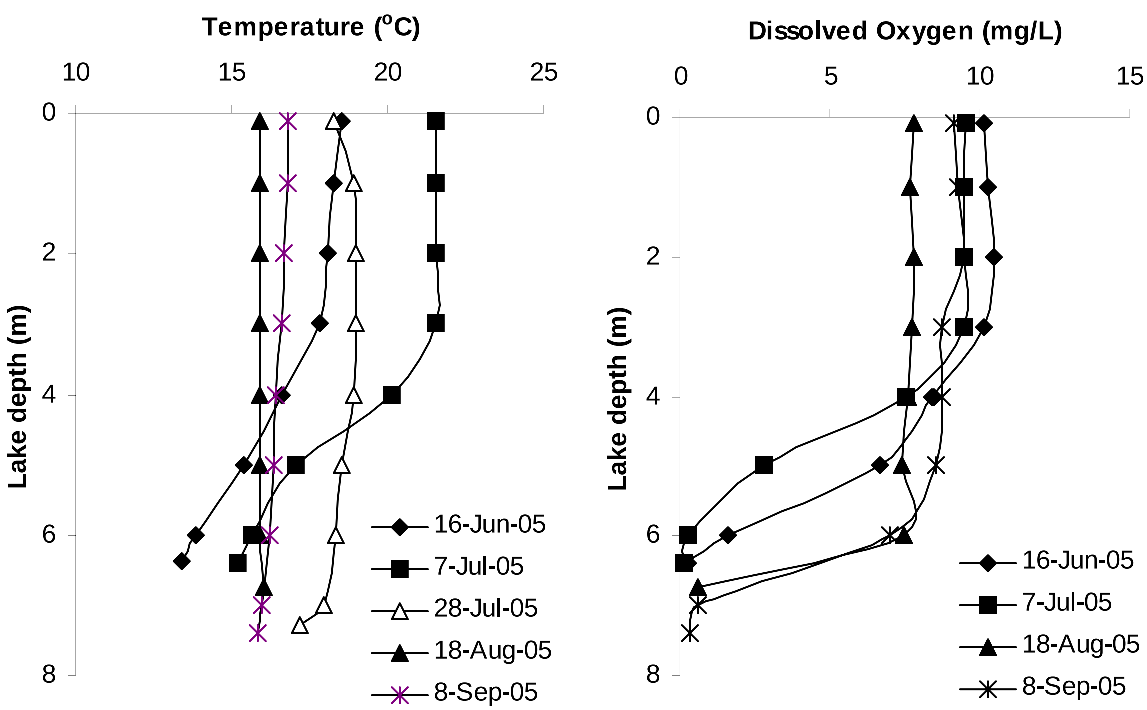

Figure 2. Temperature and oxygen concentration with depth of Bluet Lake (Garnier Lake South).

Water clarity and Secchi Depth

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.

In 2005, Bluet Lake's water was fairly clear with a mean Secchi disk depth of 2.36 meters. Water clarity followed patterns in algal biomass, or water greenness (**Figure 3**). Secchi disk depth in mid-June was quite shallow at 1.4 m, increasing through July and reaching a maximum of 3.2 m in late July. Clarity then dropped again to 2 meters by September.

Water chemistry

Bluet Lake had moderate nutrient concentrations and algal biomass compared to lakes throughout Canada, and therefore is considered mesotrophic (see details on trophic status classification at end of this report). However, compared to other lakes in Alberta, nutrients and algae are low. In 2005, total phosphorus concentrations remained relatively constant throughout the summer, being highest in early summer. Chlorophyll *a*, which is a measure of algal biomass, mirrored patterns in total phosphorus and nitrogen concentration (**Figure 3**). Total nitrogen concentrations were more representative of hypereutrophic, or highly nutrient-rich conditions (**Refer to:** *Trophic status based on lake water characteristics: A brief introduction to Limnology at the end of this report).*

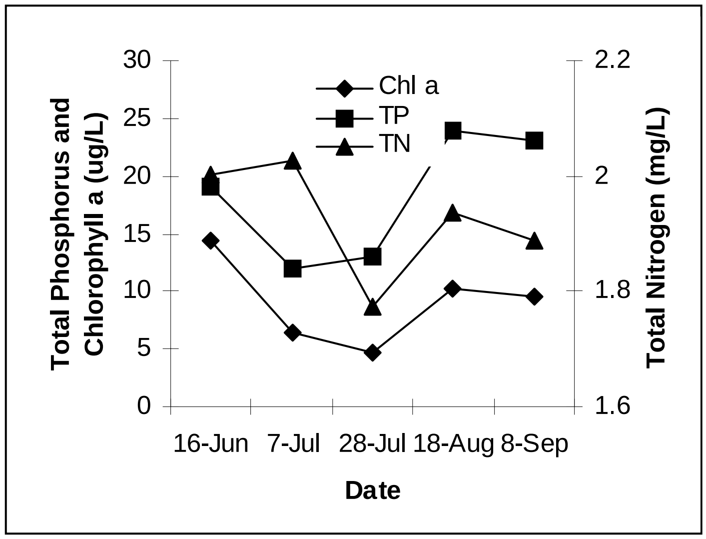

Figure 3. Total phosphorus (TP), total nitrogen (TN) and chlorophyll *a* (Chl a) concentrations 2005.

Like most lakes in Alberta, Bluet Lake is well buffered from acidification; its pH of 8.9 is well above that of pure water (i.e., pH 7). Bicarbonate, sulphate, calcium, and magnesium are the dominate ions in Bluet Lake (**Table 1**). The concentrations of most ions and nutrients remained constant over the last three sampling seasons, despite an important reduction in water levels. The increase in ion concentrations from 1979, such as magnesium and sodium are likely related to changing hydrology and decreased runoff, as groundwater is generally magnesium and sodium sulfate or chloride dominated. An increase in sodium, sulfate, and chloride in recent years indicate increased relative contribution from groundwater. Evaporative concentration could also play a role in the changing ion chemistry of Bluet Lake. Differences could also be partly attributed to seasonal differences between spring (March 1979) and summer (2002, 2003, and 2004) sampling.

Major nutrients (P, N) and water clarity has not changed over the past three summers, indicating no change in nutrient inputs to the lake. Ammonia (a form of nitrogen readily available to algae) concentrations have stabilized, after three years of steady increase. Ammonia is an end product of the decomposition of organic matter and can be released from the sediments under anoxic conditions (Wetzel, 1983). These observations are in-line with increased organic (algae) production during 2002 to 2004.

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. Further sampling of Bluet Lake is required to detect long-term trends in water quality.

Table 1: Average chemical characteristics of Bluet Lake, summers 2005, 2004, 2003 and 2002, and from a sample taken March 2, 1979.

Parameter	Mar 79	2002	2003	2004	2005
Total P (μg/L)	-	28	24	30	30
TDP (μg/L)		12	10	12	12
Chl *a* (μg/L)	-	4.2	8.6	9.0	9.0
Secchi (m)	-	2.9	3.0	2.7	2.4
Total N (mg/L)	-	1.8	1.8	1.8	1.9
NO_{2+3} (μg/L)	130	2.9	8.5	2.5	5.7
NH_4 (μg/L)	-	15	22	31	20
Ca (mg/L)	-	24	20	19	21
Mg (mg/L)	47	72	79	66	65
Na (mg/L)	32	57	57	62	62
K (mg/L)	11	21	20	20	20
SO_4 (mg/L)	57	69	108	126	132
Cl (mg/L)	3	7.4	7.5	8.6	8.1
CO_3 (mg/L)	-	39	42	39	34
HCO_3 (mg/L)	-	362	364	362	356
TDS (mg/L)	-	-	513	522	499
pH	-	9	9	8.9	8.9
Total Alkalinity (mg/L $CaCO_3$)	292	362	368	362	349

Note. TDP = total dissolved phosphorus, Chl *a* = chlorophyll *a*, Secchi = Secchi disk depth, 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, TDS = total dissolved solids.

Appendix 1

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

Metals (total)	2003	2004	2005	Guidelines
ALUMINUM ug/L	42	36	16	100[a]
ANTIMONY ug/L	0.04	0.09	0.06	6[e]
ARSENIC ug/L	1.3	1.3	1.3	5
BARIUM ug/L	28	24	24	1000[e]
BERYLLIUM ug/L	0.02	0.002	<0.003	100[d,f]
BISMUTH ug/L	0.007	0.002	0.002	
BORON ug/L	119	117	123	5000[e,f]
CADMIUM ug/L	0.034	0.004	0.002	0.085[b]
CHROMIUM ug/L	0.5	0.24	0.31	
COBALT ug/L	0.05	0.05	0.06	1000[f]
COPPER ug/L	0.35	0.57	0.48	4[c]
IRON ug/L	9	6	18	300
LEAD ug/L	0.06	0.05	0.04	7[c]
LITHIUM ug/L	48	62	62	2500[g]
MANGANESE ug/L	4.9	8.9	13	200[g]
MOLYBDENUM ug/L	0.25	0.23	0.30	73[d]
NICKEL ug/L	0.03	0.05	0.13	150[c]
SELENIUM ug/L	0.25	0.28	0.26	1
SILVER ug/L	0.0025	0.0014	0.0095	0.1
STRONTIUM ug/L	156	125	133	
THALLIUM ug/L	0.06	0.0005	0.019	0.8
THORIUM ug/L	0.002	0.005	0.007	
TIN ug/L	0.05	0.02	0.04	
TITANIUM ug/L	1.0	1.4	0.9	
URANIUM ug/L	0.88	0.98	1.2	100[e]
VANADIUM ug/L	0.5	0.49	0.38	100[f,g]
ZINC ug/L	8.8	1.5	1.6	30
FLUORIDE mg/L		0.26	0.26	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 $[Ca^{+2}]$ ≥ 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

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

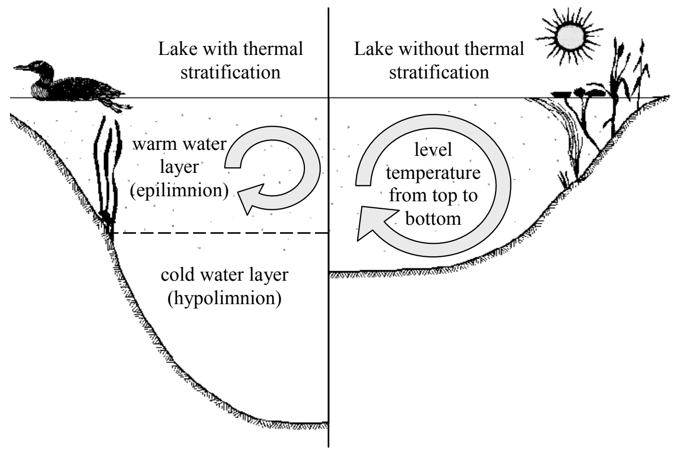

Fig. 1: Difference in the circulation of the water column depending on thermal stratification.

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.

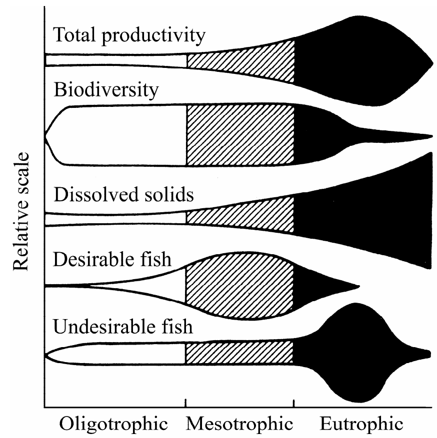

Fig. 2: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980

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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