

Alberta Lake Management
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Lakewatch

*The Alberta Lake Management Society
Volunteer Lake Monitoring Program*

Garnier Lake

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2004 Report

Completed with support from:



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, Preston McEachern and Ron Zurawell, and the volunteers. James Capjack was the volunteer for Garnier Lake. He supplied the watercraft and made sampling possible through the dedication of his time. 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. Alberta Environment, Lakeland Industry and Community Association (LICA) and Lakeland County financially supported the Lakewatch program.

Garnier Lake

Garnier Lake is sometimes referred to as Big Garnier, Garnier North, or Lower Garnier. It lies in the southern portion of Muriel Lake's drainage basin. Garnier Lake is one of the biggest inflows into Muriel Lake (**Figure 1**).

Garnier Lake is a small (5.2 km²) and narrow lake that is fairly deep for its size. Historically, the maximum depth of Garnier Lake has been recorded at 9.5 m, a later sampling in the winter recorded 6.5 m (Alberta Government, 2002). The presence of Beaver dams on the outlet is thought to keep water levels more stable than Bluet Lake (AENV 1983, vol.5). Water levels have been decreasing due to the lack of precipitation in recent years.

Plains Cree and other nomadic tribes such as the Blackfoot Tribes historically inhabited the area. There were many trading posts in the area to the north, northeast, east and southeast. Unsurprisingly, resources from hunting and trapping were very important trades to the area. Beaver activity is very common, especially along the outflow to Muriel Lake (AENV 1983, vol.5).

Garnier Lake's drainage basin is rolling hummocky morainal plain with irregular knob and kettle topography (Mitchell and Prepas, 1990). The western shoreline has a very distinct ridge with rough irregular slopes. The east side is moderately rolling along in a north-south valley. Vegetation in the area is predominantly aspen (*Populus spp.*) forest. Within the forested areas are grazing pastures and oil and gas leases. Recreation and cottage developments do not exist. The lake is used as drinking water for cattle, and for trapping, hunting waterfowl, and fishing. Northern pike (*Esox lucius*), yellow perch (*Perca flavescens*) and burbot (*Lota lota*) were the only sport fish found in previous surveys (Alberta Government, 2002). There is no record of domestic or commercial fisheries for Garnier Lake (Bodden, 2002).

Cattails (*Typha latifolia*) and willow (*Salix spp.*) fringe the southern bay, and bulrushes (*Scirpus spp.*) dominate the west and northern shores (AENV 1983, vol.5).



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

Results

Lake Level

Water levels in Garnier Lake have been monitored since 1968 by Environment Canada under the joint federal-provincial hydrometric agreement. Water levels were quite stable during the 1970's and early 1980's reaching a maximum of 606.1 m above sea level in 1979 (**Figure 2**). Since then the water levels have steadily declined, except for an increase in 1997, one of the wettest years on record. The lowest water level occurred in 2004, where lake levels dropped to 602.84 m above sea level.

This decrease in lake water levels is a result of the drought conditions experienced in the area for the past 8 years.

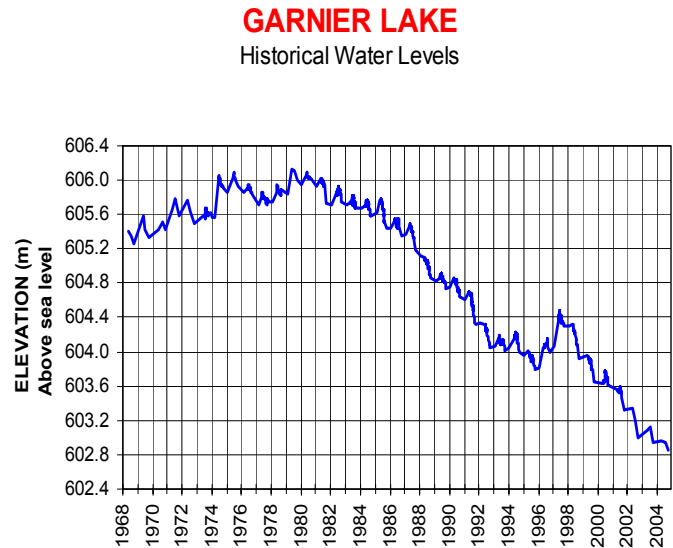


Figure 2. Historic water levels of Garnier Lake

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.

Garnier Lake's water column showed a weak thermal stratification in late June at about 2 meters, and then again in late July at 5 meters (**Figure 3**). Dissolved oxygen concentrations dropped steadily below the thermocline, during June, but remained well oxygenated during periods of mixing (August and September; **Figure 3**). This decrease in oxygen concentrations below the thermocline occurs because oxygen from the atmosphere is prevented from reaching the lake bottom where microbial decomposition occurs. Despite this, the water column of Garnier Lake was within surface water quality guidelines for most of the water column throughout the summer.

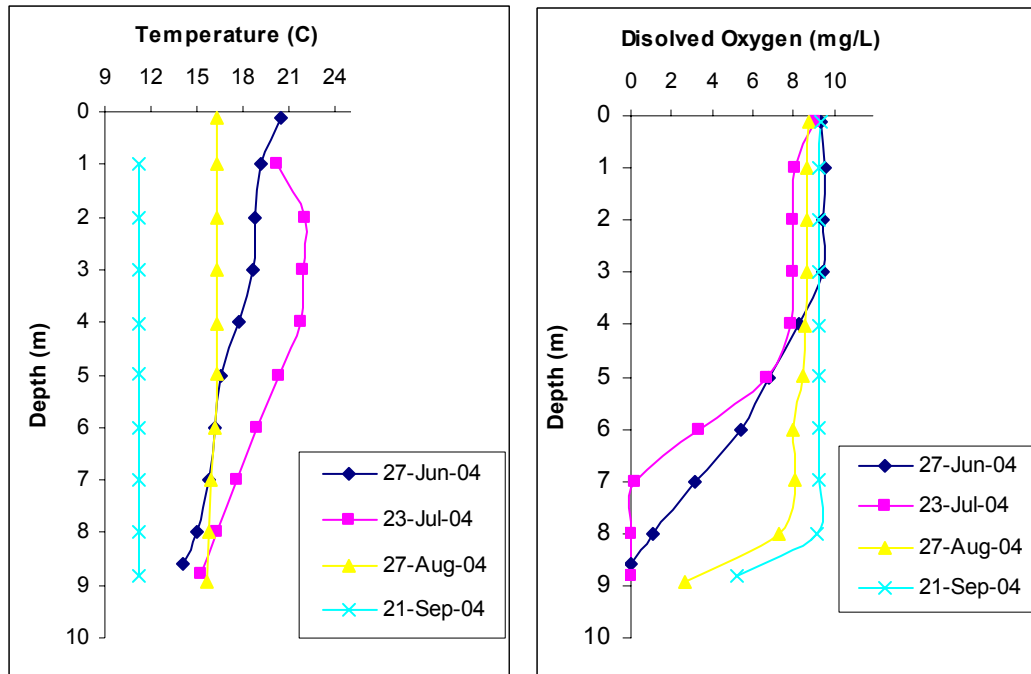


Figure 3: Temperature and oxygen profiles in Garnier Lake, summer 2004.

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 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.

Garnier Lake's water was clear during the summer of 2004 (average Secchi disk depth of 2.81m; **Table 1**). This is an increase of more than .5m from the average of 2003. Maximum water clarity was observed at the end of June when the Secchi disk depth reached 3.25m. Secchi disk depth decreased to 2.5m at the end of July and then increased to 3m in August decreasing again to 2.5 by the end of September. Based on the trophic status of lake water characteristics, Garnier Lake is considered to be mesotrophic (see *A Brief Introductory to Limnology* at the end of this report).

Water Chemistry

Because Garnier Lake had moderate nutrient concentrations and algal biomass compared to lakes throughout Canada, it is considered mesotrophic (see *A Brief Introduction to Limnology* at end of this report). Given that lakes in Alberta are productive, in the Alberta context, Garnier Lake is below average in nutrient

concentrations and algae. In 2004, total phosphorus concentrations were fairly stable showing an increase in late June and slightly decreasing during the rest of the summer. Chlorophyll *a*, a measure of algal biomass, hovered about 6 µg/L (**Figure 4**). Total nitrogen concentrations fluctuated over the summer and are representative of mesotrophic conditions. The quality and clarity of Garnier Lake during the 2004 Lakewatch sampling season is good.

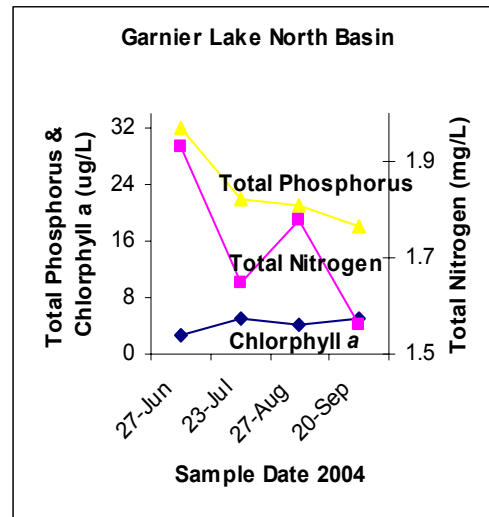


Figure 4. Total phosphorus, total nitrogen and Chlorophyll *a* (i.e., water greenness) concentrations, summer 2004.

Garnier Lake is well-protected from acidification; its pH of 9 is well above that of pure water (i.e., pH 7; **Table 1**). Garnier is a hardwater lake: ion concentrations are fairly high. Dominant ions include bicarbonate, carbonate, sulphate, sodium, and magnesium. Atmospheric deposition of acidifying pollutants from petroleum activities can often be seen in increasing sulphate and nitrate/nitrite concentrations. Sulphate concentrations have increased slightly over the past 2 years but nitrate/nitrite concentrations are low, indicating a non-industrial source of sulphate. Mineral ions are also supplied by weathering in the watershed and from groundwater inflows. High magnesium, bicarbonate, and sulphate indicate the potential for substantial groundwater inflows. Reduced water level can also cause a concentration of ions.

The most obvious change in water quality since the Lakewatch program has been conducted on Garnier Lake is a doubling in greenness, or algal biomass, in 2003. Usually, phosphorus is the most important nutrient limiting algal growth. However, because phosphorus concentrations remained unchanged, it is possible that algae in Garnier Lake benefited from a doubling in bioavailable nitrogen (i.e., ammonium and nitrate/nitrite). Overall, water quality in Garnier Lake was consistent with other mesotrophic lakes in Alberta.

Table1: Mean 2002, 2003, and 2004 chemical characteristics of Garnier Lake.

Parameter	2002	2003	2004
Total P (µg/L)	27	27	25
TDP (µg/L)	9.4	10	11
Chlorophyll <i>a</i> (µg/L)	4.7	7.8	4.2
Secchi disk depth (m)	2.8	2.2	2.81
Total N (mg/L)	1.6	1.6	1.7
NO ₂₊₃ (µg/L)	2.6	7.9	5
NH ₄ (µg/L)	10	23	22
Ca (mg/L)	16	18	18.7
Mg (mg/L)	76	80	75
Na (mg/L)	41	51	52
K (mg/L)	18	19	18
SO ₄ (mg/L)	82	96	107
Cl (mg/L)	3.7	7.1	8.0
CO ₃ (mg/L)	47	42	41
HCO ₃ (mg/L)	343	361	362
pH	9.0	9.0	9.0
Total Alkalinity (mg/L CaCO ₃)	357	366	364

Note. TDP = total dissolved phosphorus, NO₂₊₃ = nitrate+nitrite, NH₄ = ammonium, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO₄ = sulphate, Cl = chloride, CO₃ = carbonate, HCO₃ = bicarbonate

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.

Appendix 1

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

Metals (total)	2003	2004	Guidelines
ALUMINUM ug/L	19.5	26.8	100 ^a
ANTIMONY ug/L	0.04	0.085	6 ^e
ARSENIC ug/L	1.31	1.28	5
BARIUM ug/L	18.5	17.5	1000 ^e
BERYLLIUM ug/L	0.08	0.0015	100 ^{d,f}
BISMUTH ug/L	0.006	0.0011	
BORON ug/L	92	92	5000 ^{e,f}
CADMIUM ug/L	0.04	0.0029	0.085 ^b
CHROMIUM ug/L	0.47	0.22	
COBALT ug/L	0.03	0.039	1000 ^f
COPPER ug/L	0.41	0.54	4 ^c
IRON ug/L	10	3	300
LEAD ug/L	0.064	0.087	7 ^c
LITHIUM ug/L	43	58.3	2500 ^g
MANGANESE ug/L	11.6	12.5	200 ^g
MOLYBDENUM ug/L	0.31	0.261	73 ^d
NICKEL ug/L	0.03	0.0025	150 ^c
SELENIUM ug/L	0.25	0.27	1
SILVER ug/L	0.025	0.001	0.1
STRONTIUM ug/L	58	57.3	
THALLIUM ug/L	0.06	0.0004	0.8
THORIUM ug/L	0.008	0.0054	
TIN ug/L	0.1	0.032	
TITANIUM ug/L	0.5	0.59	
URANIUM ug/L	1.03	1.06	100 ^e
VANADIUM ug/L	0.33	0.337	100 ^{f,g}
ZINC ug/L	5.74	2.97	30
FLUORIDE mg/L		0.27	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 \geq 6.5; calcium ion concentration $[Ca^{+2}] \geq 4$ mg/L; and dissolved organic carbon concentration $[DOC] \geq 2$ 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

Water temperature in a lake dictates the behavior of many chemical parameters responsible for water quality. Heat is transferred to a lake at its surface and slowly moves downward depending on water circulation in the lake. Lakes with a large surface area or a small volume tend to have greater mixing due to wind. In deeper lakes, circulation is not strong enough to move warm water to depths typically greater than 4 or 5 m and as a result cooler denser water remains at the bottom of the lake. As the difference in temperature between warm surface and cold deeper water increases, two distinct layers are formed. Limnologists call these layers of water the **epilimnion** at the surface and the **hypolimnion** at the bottom. The layers are separated by a transition layer known as the **metalimnion** which contains the effective wall separating top and bottom waters called a **thermocline**. A thermocline typically occurs when water temperature changes by more than one degree within one meter depth. The hypolimnion and epilimnion do not mix, nor do elements such as oxygen supplied at the surface move downward into the hypolimnion. In the fall, surface waters begin to cool and eventually reach the same temperature as hypolimnetic water. At this point the water mixes from top to bottom in what is called a **turnover** event. Surface water cools further as ice forms and again a thermocline develops this time with 4° C water at the bottom and 0° C water on the top.

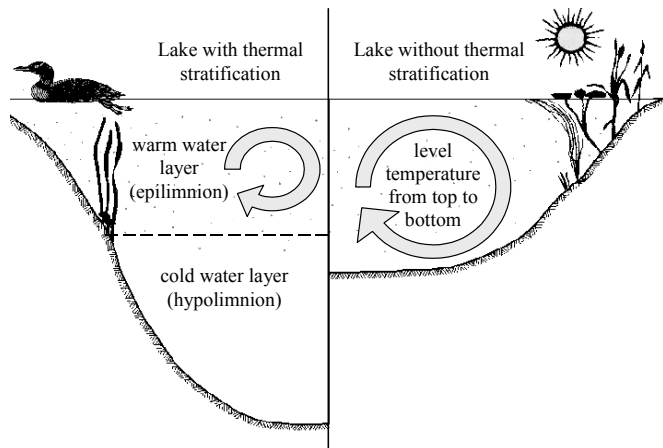


Fig. 5: Difference in the circulation of the water column depending on thermal stratification.

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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 6.

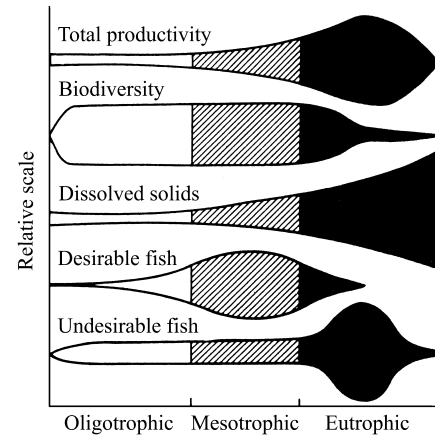


Fig. 6: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980

Trophic status based on lake water characteristics.

Trophic state	Total Phosphorus ($\mu\text{g/L}$)	Total Nitrogen ($\mu\text{g/L}$)	Chlorophyll a ($\mu\text{g/L}$)	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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