PIGEON LAKE

Alberta
ENVIRONMENT

Lakes attract people. And people want to know why "their" lake is the way it is — why is it so green in July? Is the water quality really deteriorating? How do our activities affect the lake?

This brochure, one of a series on Alberta's lakes, attempts to answer these questions by presenting findings of water quality studies conducted by the Environmental Assessment Division of Alberta Environment.

As you read through the brochure, you may find that you have questions about the concepts and illustrations. At the end is a section called **Explanation of Lake Characteristics**. Refer to this for further interpretation.

Brochures are available for the following lakes:

Sandy Lake	Pine Lake	Lac la Biche
Lac la Nonne	Garner Lake	Nakamun Lake
Wizard Lake	Skeleton lake	Lac Ste. Anne
Pigeon Lake		

March 1989

Pigeon Lake is one of the most popular recreational lakes in central Alberta. It lies within easy driving distance from the cities of Edmonton, Red Deer, Leduc and Wetaskiwin. To reach Pigeon Lake from Edmonton, take Highway 2 south for 68 km to the Ma-Me-O Beach turnoff, then travel west on Highway 13 to the south end of the lake.

The lake was probably named for the Passenger Pigeon that was once abundant in the area. Settlement began in 1847, when Reverend Robert Rundle built Rundle Mission on the northwest shore where Mission Beach is now located.[1] The Summer Village of Ma-Me-O Beach was developed on land obtained from the Pigeon Lake Indian Reserve in 1924.

Pigeon Lake's shoreline has been extensively developed for private use. There are over 2300 cottage lots in ten summer villages and several subdivisions.[2] In addition, a number of institutional camps are located around the lake.

There are two provincial parks on Pigeon Lake. Ma-Me-O Beach Provincial Park is the smallest in the provincial park system. It offers day-use facilities only: picnic tables, a playground, pump water and a nearby swimming beach. Pigeon Lake Provincial Park includes a main campground on the southwest shore of the lake and Zeiner Campground on the northwest end. Facilities include 259 campsites, beaches, boat launches, a concession, toilets, sewage disposal, picnic shelters, tap water and walking trails.[3]

Fishing

Sport fishing is very popular at Pigeon Lake, particularly for northern pike (jackfish) and lake whitefish. Other species of fish in the lake include yellow perch, burbot, walleye and white sucker. Walleye disappeared from Pigeon Lake after 1964, but were stocked back into the lake in 1979 and for several years thereafter. They seem to be making a comeback. Commercial fishermen have fished the lake since 1918, and local Indian bands run a domestic fishery.[4]

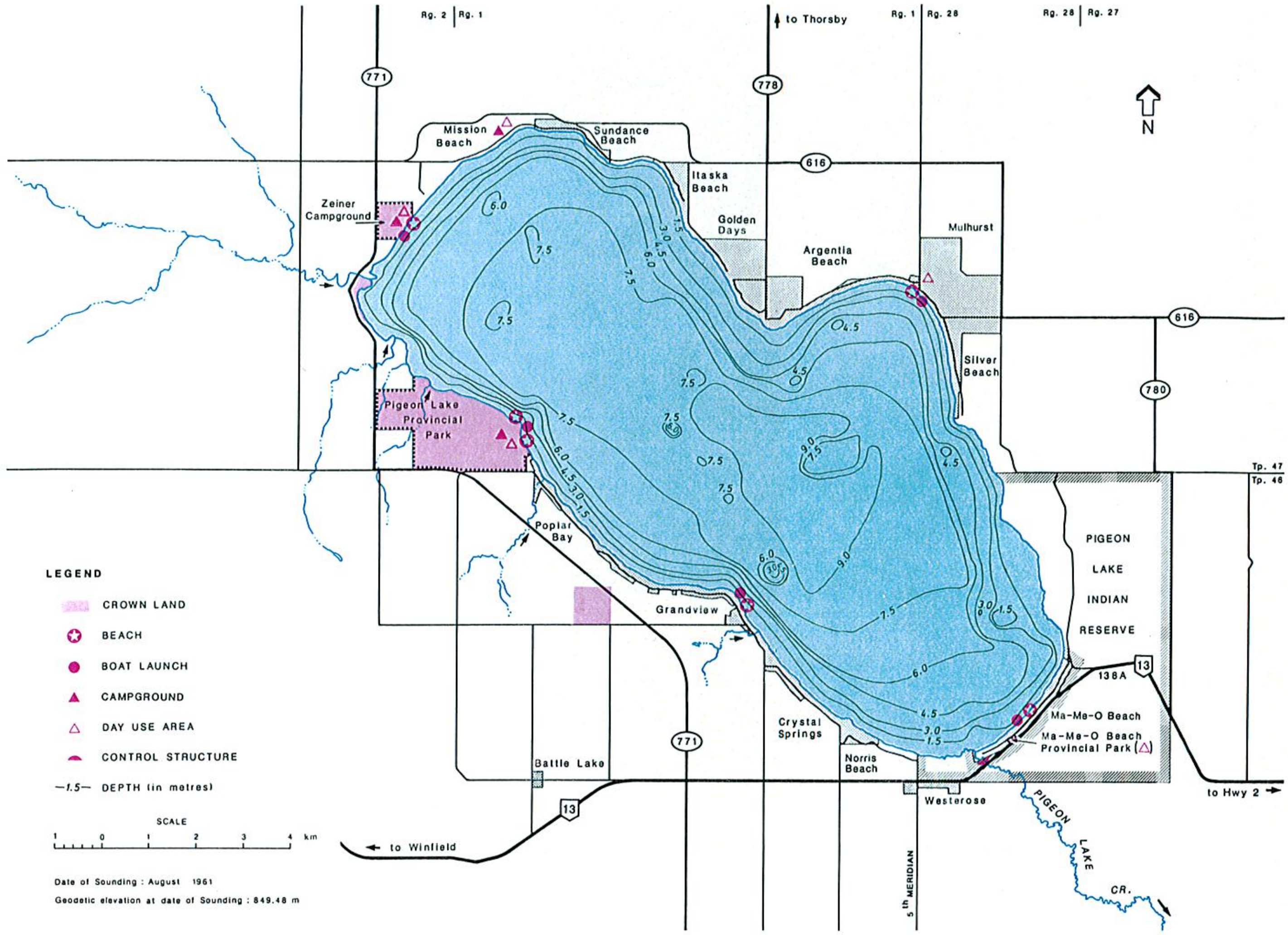
Physical Characteristics

Pigeon Lake is relatively large and roughly oval in shape. The Depth Contour map shows that it is made up of one simple, fairly shallow basin that reaches 9 metres at its deepest spot near the centre. Water flows into Pigeon Lake through several intermittent streams. The outflow, Pigeon Lake Creek, is situated at the south end of the lake. It runs south into the Battle River.

A weir built on Pigeon Lake in 1914 has provided some control of

1. Fryer, H. 1982. Stops of interest in central and northern Alberta. Heritage House Publishing Co. Ltd.
2. Battle River Regional Planning Commission. 1985. The Pigeon Lake management plan.
3. 1988 Alberta Campground Guide.
4. Alberta Forestry, Lands and Wildlife, Fish and Wildlife Division.

Depth Contours of Pigeon Lake



PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

LAKE AREA[a]	km²	96.7
DRAINAGE AREA (excluding lake)	km²	187
DRAINAGE AREA/ LAKE AREA		1.9
VOLUME[a]	m³	603 x 10⁶
MAXIMUM DEPTH[a]	m	9.1
MEAN DEPTH[a]	m	6.2
SHORELINE LENGTH	km	46
TOTAL INFLOW[b]	m³/yr	68.6 x 10⁶
EVAPORATION	m³/yr	64.2 x 10⁶
RESIDENCE TIME[b]	years	>100

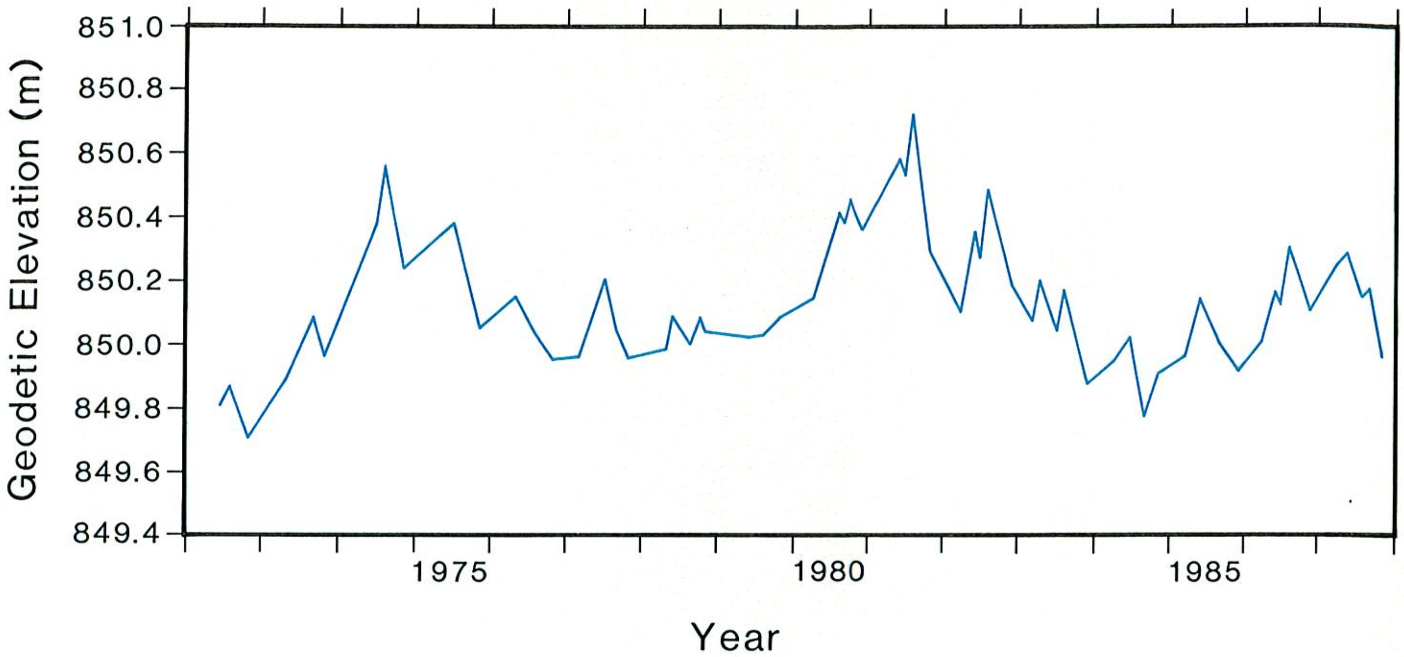
Reference: see footnote 6.

[a] on date of sounding, August 1961
[b] excludes groundwater

the flow of water out of the lake. Its original purpose was to prevent flooding of hay fields downstream.[5] Pigeon Lake has cycled through periods of high and low water levels, as most lakes do. This is shown on the Historical Water Level graph. During the 1980s the water level was very high and many cottage owners complained about erosion problems. Clearing of the outflow channel and the removal of silt from around the weir helped to ease the problem. A new weir was installed in 1986. It is usually operated with one stop log in place, at an elevation of 849.95m.[6]

5. Alberta Environment, Planning Division. 1982. Pigeon Lake regulation feasibility study - summary report.
6. Alberta Environment, Technical Services Division, unpublished, no date.

Historical Water Level of Pigeon Lake



Nutrient Sources

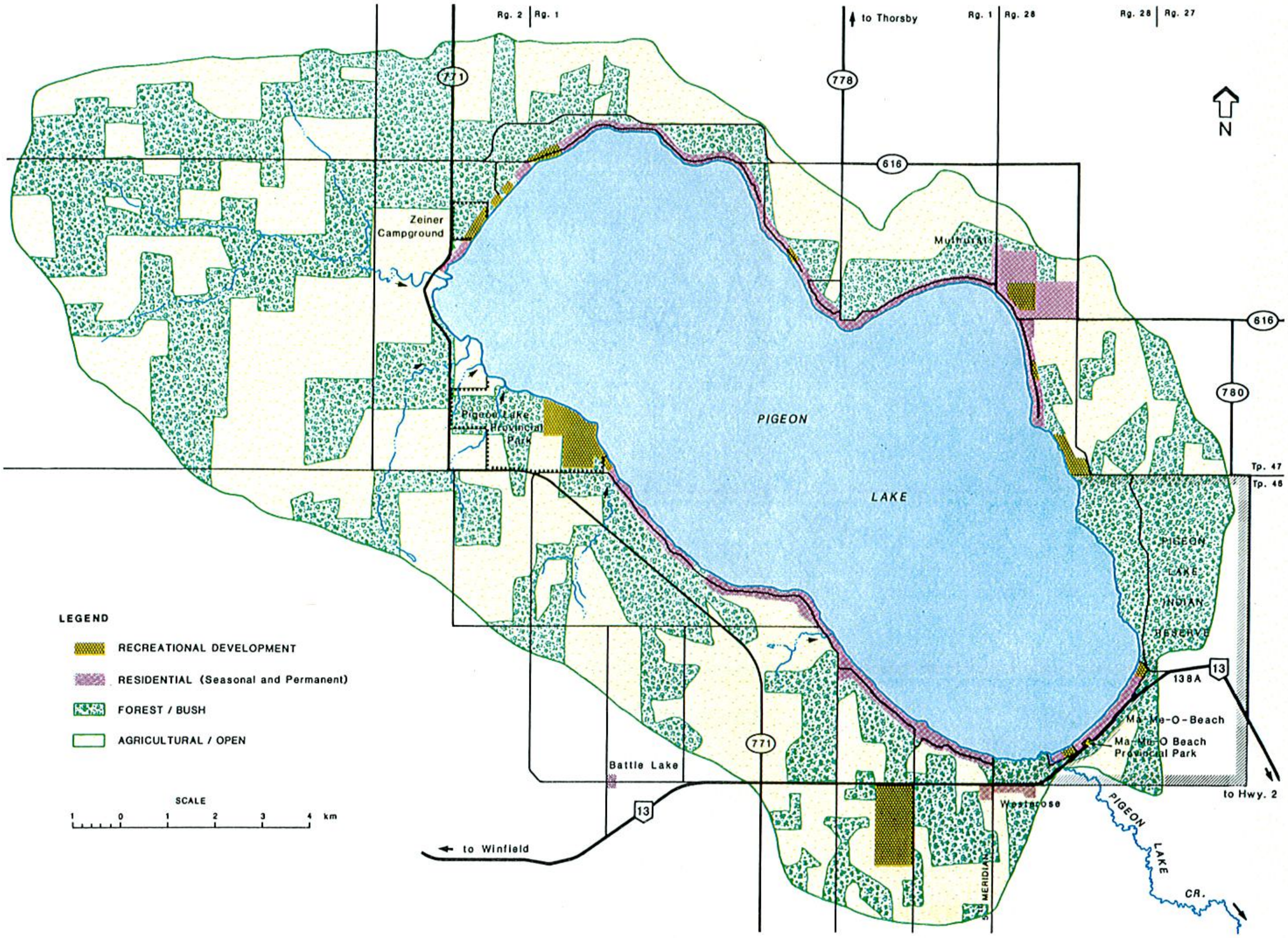
The amount of plant growth in a lake is related to the quantity of nutrients in the water. Phosphorus is the nutrient that is most directly related to water quality problems in Alberta lakes. Phosphorus may enter the lake water from the watershed or in precipitation ("external" sources) or it may be recycled from the bottom sediments ("internal" source).

The Theoretical Phosphorus Supply table shows the amount of phosphorus estimated to enter Pigeon Lake from external sources. Runoff from the watershed, particularly from agricultural land, is the largest external contributor of phosphorus. Because the watershed is so small (see the Watershed Map), this nutrient load is not very large for the size of the lake. A large proportion of the total phosphorus load comes from precipitation and dustfall directly onto the lake. A relatively small amount of phosphorus may come from sewage produced by residential and recreational developments. This has not been measured directly, but was estimated from studies on other lakes.

The areal loading figure at the bottom of the Theoretical Phosphorus Supply table is fairly small compared to that for other Alberta lakes. This means that the amount of phosphorus entering Pigeon Lake, compared to the size of the lake, is quite low, and the water quality should be good. The moderate algal blooms that occur occasionally during the summer may result from an 'internal load' of phosphorus that is recycled from the bottom sediment. The amount of recycled phosphorus has not been estimated, but it could be fairly large.

SEE EXPLANATION OF LAKE CHARACTERISTICS AT END OF BROCHURE.

Watershed of Pigeon Lake



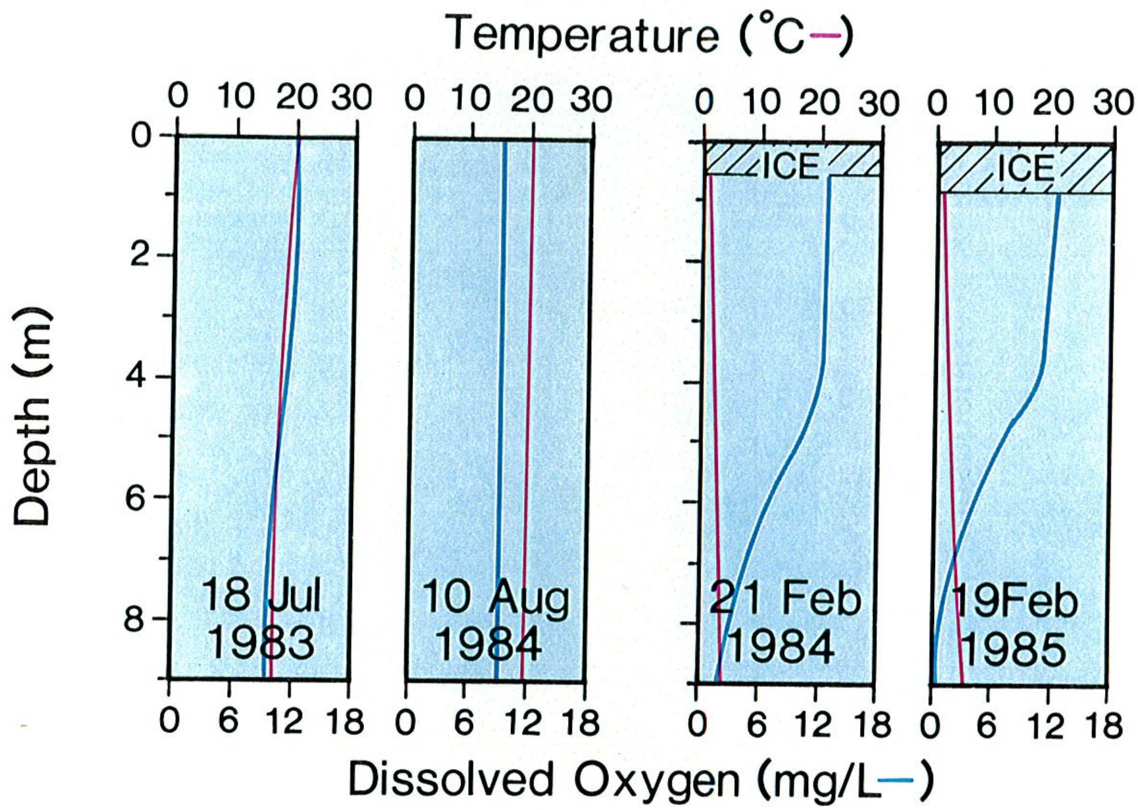
THEORETICAL PHOSPHORUS SUPPLY

	kg/year	Percentage
SURFACE RUNOFF:		
Forested/Bush	900	16
Cleared/Agricultural	1702	30
Urban/Cottage	770	14
PRECIPITATION, DUSTFALL	2127	38
SEWAGE FROM COTTAGES AND CAMPS	133	2
TOTAL	5632	100
AREAL LOADING (g/m² of lake surface)	0.06	

Temperature and Dissolved Oxygen

On most days during the summer months, winds mix the water in Pigeon Lake from the lake surface to the bottom, and there is plenty of dissolved oxygen throughout the lake. But, on warm, calm days the lake surface may warm faster than the deeper water, and the cool layer at the bottom resists mixing. Oxygen gradually declines near the bottom as organic matter decomposes and plants and animals respire. This decline is shown on the Temperature and Dissolved Oxygen graph for July 18, 1983. Even though there may be a

Temperature (°C) and Dissolved Oxygen (mg/L) in Pigeon Lake



lack of oxygen at the bottom at times, there is usually sufficient oxygen in the upper part of the water to maintain fish.

In winter, when ice covers the lake, the wind can no longer mix the water. The Temperature and Dissolved Oxygen graphs show that in February, the warmest water is at the bottom of Pigeon Lake. Because the water doesn't mix very well in winter, oxygen is gradually used up at the bottom. On February 19, 1985, dissolved oxygen at the surface was about 12 mg/L, whereas at the bottom it had dropped to 0 mg/L. It is likely that there is enough oxygen in Pigeon Lake to prevent winterkill of fish, but fish probably avoid the regions at the bottom of the lake where oxygen is low.

Chemistry

Pigeon Lake is a freshwater lake, with a low level of salinity (saltiness). The major ions, as shows on the Ionic Diagram, are bicarbonate (HCO_3) and calcium (Ca), which is a typical pattern for many Alberta lakes. With its moderately alkaline pH, Pigeon Lake's chemistry is well within the range suitable for fish and other aquatic life.

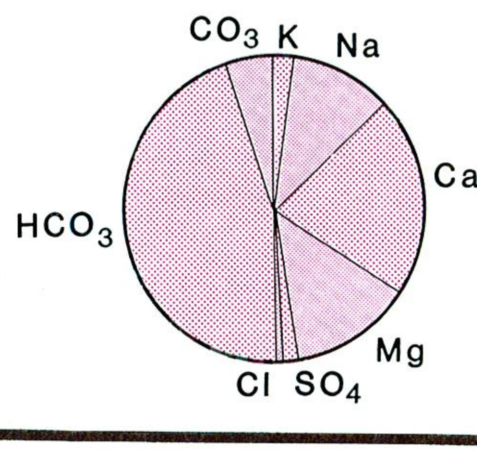
CHEMISTRY Ice-free season averages 1983-1984

TOTAL SALINITY	meq/L*	6
pH (RANGE)		8.2-8.6
ALKALINITY	mg/L**	152
TOTAL DISSOLVED SOLIDS	mg/L	155

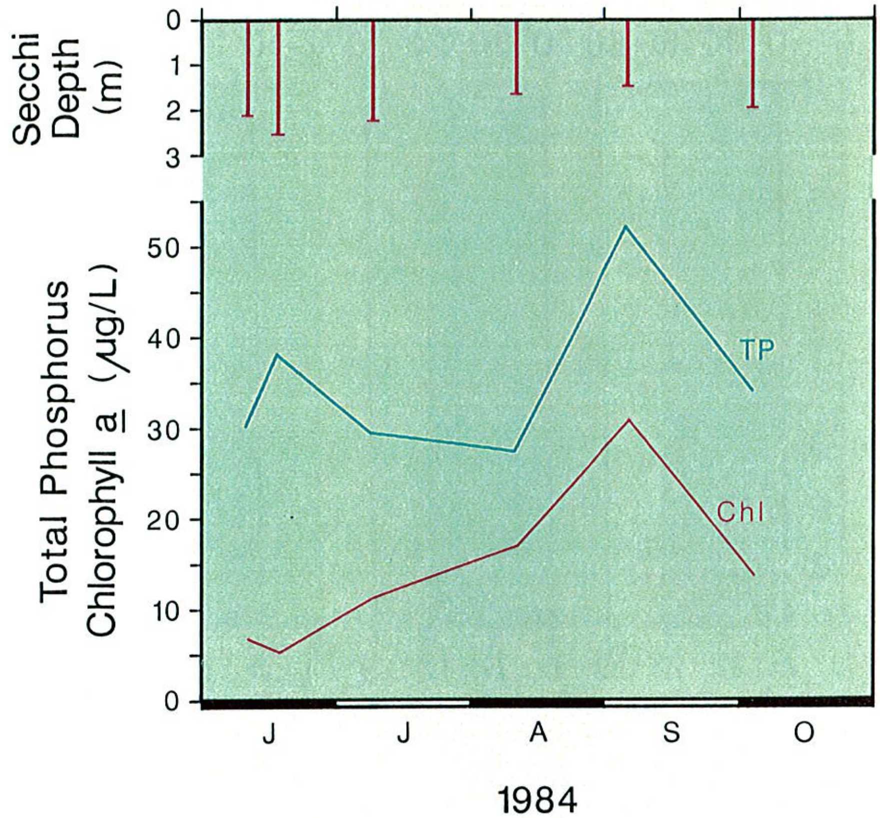
* milliequivalents per litre = 1/1000 of a chemical equivalent weight in a litre of water

** milligrams per litre = parts per million

IONIC DIAGRAM Relative proportions of ions in Pigeon Lake 1983 - 1984



Trophic Status of Pigeon Lake



Algae and Trophic Status

The level of chlorophyll is a measure of how much algae is in the lake water. Because Pigeon Lake has moderate levels of nutrients and chlorophyll it is classified as a mildly eutrophic (fertile) lake. Eutrophic lakes may have blooms of algae that make the water murky and give the surface a scummy appearance. Average quantities of phosphorus, nitrogen and chlorophyll in Pigeon Lake for 1983 and 1984 are shown in the Trophic Characteristics table. The average values of phosphorus and chlorophyll in 1984 were slightly higher than those in 1983, but this is natural year-to-year variation rather than a sign that the lake is deteriorating.

The Trophic Status graph shows how phosphorus and chlorophyll (algae) change during the year. In 1984 a bloom of algae developed in late summer; the water would have been quite green at that time. This pattern commonly occurs in many Alberta lakes when phosphorus moves from the lake sediments up into the water. Algae respond to this 'fertilization' by developing blooms. The transparency of the water (Secchi Depth) declines when there is a lot of algae in the lake.

Even though the lake appears green at times, the water quality of Pigeon Lake is quite acceptable for recreational pursuits. Its eutrophic condition may be caused in part by recycling of nutrients from the bottom sediments during summer.

TROPHIC CHARACTERISTICS Ice-free season averages

		1983	1984
PHOSPHORUS	µg/L*	29	35
NITROGEN	µg/L	910	**
CHLOROPHYLL	µg/L	12	14
SECCHI TRANSPARENCY	m	2.9	2.0

* micrograms per litre = parts per billion

** Data not available

Explanation of Lake Characteristics

PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

Drainage Area or the watershed of a lake is the land surface from which a lake receives its water. As rain water or snowmelt gathers in streams, it picks up soil particles, nutrients and other materials and carries them to the lake.

A study of more than 30 Alberta lakes shows that when drainage areas are large compared to lake areas, (i.e. when the **Drainage Area/Lake Area** ratio is large), lakes have more algae (are more eutrophic) (see TROPHIC CHARACTERISTICS).

Mean Depth is the volume of the lake divided by the surface area. Shallow lakes are often more eutrophic than deeper lakes of a similar surface area.

Inflow is the total volume of water entering the lake in a year. It is related to **Residence Time**, which is the time it would take the inflow to completely fill the empty lake basin.

The **Geodetic Elevation** on the water level graph indicates the level or elevation of the lake above mean sea level.

TEMPERATURE

Alberta lakes show two basic annual patterns of temperature distribution through the water.

Deep lakes, or those protected from strong winds, form layers with the coldest water near the bottom in summer. Because this colder water is denser, it resists mixing into the warmer, lighter, upper layer.

For much of the summer, the bottom portion of water is isolated from the top portion. In spring and fall, these lakes usually mix from top to bottom by wind action as the water becomes uniform in temperature and density. In winter, under ice, the warmest water (about 4^{0}C) is on the bottom, because water is most dense at this temperature.

Shallow lakes mix throughout the summer or layer only temporarily. In winter, the temperature pattern of these lakes is similar to that of deep lakes.

DISSOLVED OXYGEN

Oxygen is essential to the life in lakes. Oxygen from the air dissolves readily in water, especially on windy days when waves break up the lake surface. The photosynthesis of small aquatic plants also supplies a large amount of oxygen to the lake water.

Oxygen is consumed by respiration of animals and plants, and by the decomposition of dead organisms by bacteria. A great deal can be learned about the "health" of a lake by studying its patterns and quantity of oxygen.

Lakes that are unproductive (oligotrophic) will have sufficient oxygen throughout the year at all depths. But as a lake becomes more eutrophic, and increasing quantities of plants and animals respire and decay, the balance shifts towards consumption — especially near the lake bottom where dead organisms accumulate.

In deep productive lakes (see TEMPERATURE), the oxygen in the isolated bottom layer may deplete rapidly, forcing fish to move into the upper layer (fish are stressed when oxygen falls below about 3 mg/L). Fish kills occur when decomposing or respiring algal populations use up the oxygen. In summer, this usually happens when an algal bloom "collapses" or dies suddenly.

SALINITY AND TOTAL DISSOLVED SOLIDS

Lake water contains a multitude of dissolved substances. These can be seen by allowing a dish of lake water to evaporate. If the water is filtered to remove living organisms and other particles, and then allowed to evaporate, the residue is called **Total Dissolved Solids**.

The ions* that make up most of this residue can be measured individually, giving a value for **Total Salinity** when added together. The **Ionic Diagram** presents all of the major ions in a lake in proportion to each other.

Salinity is controlled by the types of rock or soil in the watershed and by the amount of evaporation relative to precipitation. Lakes of high salinity, such as many of those found in southeastern Alberta, have fewer species of plants and animals than freshwater lakes; many are too saline to support fish.

* Ions: Chemical form in water of constitutents such as sodium and carbonate.

pH AND ALKALINITY

The **pH** of lake water refers to its concentration of hydrogen ions on a scale that runs from 0 (extremely acidic) to 14 (extremely alkaline). A pH of 7 is neutral - neither acidic nor alkaline.

Most Alberta lakes fall between pH 6 to 9, with the majority on the alkaline side. **Alkalinity** refers to the capacity of water to neutralize an acid, and is a measure of the alkaline materials present in the water.

Alberta lakes that were formed in sedimentary bedrock have a large capacity to neutralize acids entering them, such as from acid rain.

THEORETICAL PHOSPHORUS SUPPLY

Lake scientists know that for most lakes, the amount of algae in the water is related directly to the amount of phosphorus. This is because phosphorus is usually in shortest supply relative to all the nutrients that lake plants need. When it runs out, the algal population can no longer increase. A larger phosphorus supply usually results in more algae.

Based on studies from all over North America, the quantity of phosphorus contributed by a hectare of forest during runoff is remarkably similar no matter where the lake is located. Similarly, agricultural or cleared land overlying sedimentary bedrock contributes fairly similar quantities of phosphorus per hectare in most lake watersheds. This was confirmed for Alberta by measuring quantities of phosphorus supplied by various land uses in several lake watersheds.

In all studies, the phosphorus supply from cleared or agricultural lake was greater than that from forest, averaging 2 to 5 times more.

The **Theoretical Phosphorus Supply** is estimated by multiplying phosphorus supply factors for each type of land use by the area of that land use, and then summing the products.

Similar factors are used for the supply from precipitation. The supply from sewage is estimated based on a percentage of the total amount that could be generated by cottages and camps on the particular lake.

It might be expected that a large phosphorus supply would produce a eutrophic lake. But the size of the lake is also important. If the total phosphorus supply is divided by the surface area of the lake, the resulting **Areal Loading** figure can be compared with other lakes, and can be used as an indication of trophic status.

TROPHIC CHARACTERISTICS

The word "trophic" literally means nourishment.

Mountain lakes usually are "poorly nourished" or **oligotrophic**. Levels of nutrients such as phosphorus and nitrogen are low, plant life is sparse, and the water is clear. Fish production is low.

On the other end of the scale are well-nourished or fertile lakes called **eutrophic**. In these lakes, aquatic plants, including tiny suspended algae, flourish because the water contains abundant nutrients.

Mesotrophic lakes, those intermediate in fertility, often combine the best features of the other two types.

In some lakes, the nutrient supply is so high that plant growth inhibits certain recreational uses of the lake. Lake users may consider such a lake to have poor water quality. One of the purposes in studying lakes is to determine whether fertility is increasing.

There are several ways to measure a lake's fertility or **Trophic Status**.

Phosphorus and **nitrogen** can be measured directly. Phosphorus in lakes of the Boreal Forest/Parkland areas of Alberta ranges between 10 and 200 micrograms per litre* (μg/L) (oligotrophic to highly eutrophic), and nitrogen ranges between 500 and 3500 μg/L.

Transparency of the water declines as a lake becomes more fertile. It is measured with a black and white plate called a **Secchi Disk**, which is lowered through the water on a line marked at metre intervals. The depth at which it can no longer be seen is the **Secchi Transparency**.

The quantity of algae in the water can be determined by measuring its content of **Chlorophyll a**, the green photosynthetic pigment.

* equivalent to parts per billion

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