THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2013 KEHEWIN LAKE REPORT

COMPLETED WITH SUPPORT FROM:

Government

Alberta Lake Management Society's LakeWatch Program

LakeWatch has several important objectives, one of which is to collect and interpret water quality data 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 those sources.

ALMS would like to thank all those 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.

Historical data has been re-queried and summarized for the 2012 report.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank volunteer Ken Dion for his assistance with sampling in 2013. We would also like to thank Jared Ellenor, Nicole Meyers, and Elynne Murray who were summer technicians with ALMS in 2013. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Technologists Trina Ball and Brian Jackson were involved in the training aspects of the program. Doreen LeClair, Chris Rickard, and Lisa Reinbolt were responsible for data management. Théo Charette, Ron Zurawell, Lori Neufeld, and Sarah Lord prepared the original report, which was updated for 2012 by Bradley Peter and Arin Dyer. Alberta Environment and the Beaver River Watershed Alliance (BRWA) were major sponsors of the program.

Values in this report may be skewed compared to historical values as only three of five planned trips were completed.

KEHEWIN LAKE:

Kehewin Lake is a long, beautiful lake located on Highway 41 north of Elk Point. The lake is surrounded by rolling pasture and hay lands. Kehewin Lake has two recreational facilities: one located on the southeast shore just off Highway 41, and the other located on the southwest shore.

Alternate spellings for Kehewin Lake are found in various literatures – spellings even differ on the two highway signs for the lake. "*Kehew*" is a Cree word meaning eagle, suggesting that "Kehewin" is the most appropriate spelling[1]. Kehewin Lake is named after the Indian Chief who signed treaty No.6 for The Kehewin Indian Reserve No.123 in 1876[2]. The Kehewin Indian Reserve is 8212.2 ha to the north of the lake, with 863 residents of 1,581 members in October 2002. The reserve is in the county of Bonnyville, but most of the lake is within the County of St. Paul.

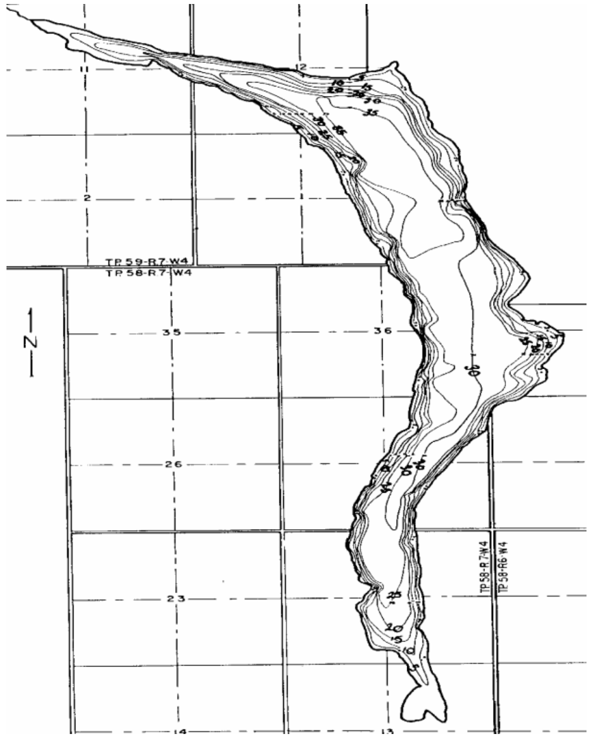

Figure 1 – Bathymetric map of Kehewin Lake. Contours in five foot intervals.

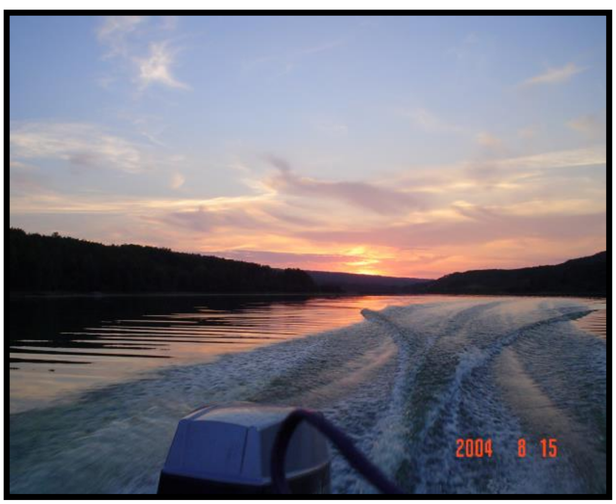

Figure 2 – Kehewin Lake sunset. Photo by Heather Jones, 2004.

Kehewin Lake is very shallow in the north and south portions. The lake is situated within the Beaver River drainage basin, which is in the Moose Lake watershed, in the westernmost part of the Churchill River system. The outflow of Kehewin Lake drains into Bangs Lake to the north via Kehewin Creek, then joins with Yelling Creek and flows into Thin Lake, finally draining into Moose Lake via Thin Lake River.

Agriculture in Kehewin's drainage basin is limited to pasture and hay fields. The drainage basin overlies geological

[1] Ken Dion. 2002. Personal Communication.

[2] Mitchell, P. and E. Prepas. 1990. Atlas of Alberta Lakes, University of Alberta Press. Retrieved from http://sunsite.ualberta.ca/projects/alberta-lakes/

formations that are rich in heavy oils, thus oil extraction is common in the area. Kehewin Lake lies in a large melt-water channel predominated by glacial till and alluvial deposits[1]. It is surrounded by rough, broken land with steep slopes dominated by aspen (*Populus* spp.*)*. Extensive marshes on the north and south ends of the lake provide excellent habitat for waterfowl.

Marsh vegetation includes reed grass (*Calamagrostis* spp.), bulrush (*Scirpus* spp.), sedge (*Carex* spp.), cattail (*Typha latifolia),* and arrowhead (*Sagittaria cuneata).* Common submerged and floating aquatic plants include water smartweed (*Polygomum natans),* coontail (*Ceratophyllum demersum*), Richardson's pondweed (*Potamogeton richardsonii*), northern watermilfoil (*Myriophyllum exalbescens*), sago pondweed (*Potamogeton pectinatus*), large-sheath pondweed (*Potamogeton vaginatus*), and duckweed (*Lemna* spp.)[2]. Little is known about the phytoplankton community composition, though dense blue-green algal blooms have occurred in the past.

As a popular sport fishing lake, Kehewin is noted for its large northern pike. Also present are yellow perch (*Perca flavescens*), walleye (*Sander vitreus*), cisco (*Coregonus artedi)* burbot (*Lota lota*), and white suckers (*Catostomus commersonii*). Commercial and domestic fishing has been active in the last decade, and commercial fishing has been recorded as far back as 1945[2].

WATER QUANTITY:

There are many factors influencing water quantity. Some of these factors include the size of the lakes drainage basin, precipitation, evaporation, water consumption, ground water influences, and the efficiency of the outlet channel structure at removing water from the lake.

Water levels at Kehewin Lake have remained relatively stable since monitoring began in 1967. Fluctuations have ranged between a maximum of 540.4 meters above sea level (m asl) in 1997 to a minimum of 538.9 m asl in 1993. Kehewin Lake receives a steady inflow of water because its drainage basin is very large (156 km^2) as compared to its surface area (7.4 km^2).

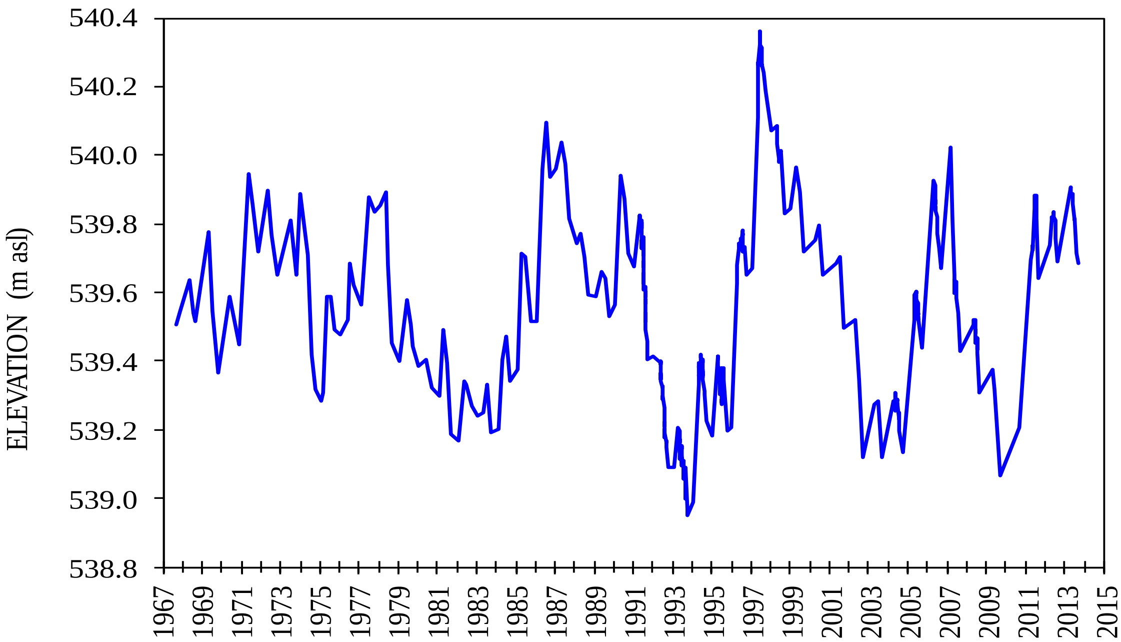

Figure 3 – Water levels measured in meters above sea level (m asl) for Kehewin Lake. Data obtained from Alberta Environment.

WATER CLARITY AND SECCHI DEPTH:

Water clarity is influenced by suspended materials, both living and dead, as well as dissolved colored compounds in the water column. During the melting of snow and ice in spring, lake water can become turbid (cloudy) from silt transported into the lake. Lake water usually clears in late spring but then becomes more turbid with increased algal growth as the summer progresses. The easiest and most widely used measure of lake water clarity is the Secchi disk depth.

Secchi disk depth at Kehewin Lake was poor during the summer of 2013, and fell on the low end of the natural variation previously measured. On average, Secchi disk depth was 1.1 m. Multiplying this value by two provides the euphotic depth (2.2 m): the depth to which enough light remains for photosynthesis. Thus, there is enough surface light remaining for photosynthesis for the first 1/5th of the water column at the lakes deepest location. Throughout the summer, Secchi disk depth ranged from a minimum of 0.9 m on July 19th to a maximum of 1.4 m on August 23rd. It is likely that algae/cyanobacteria blooms are the

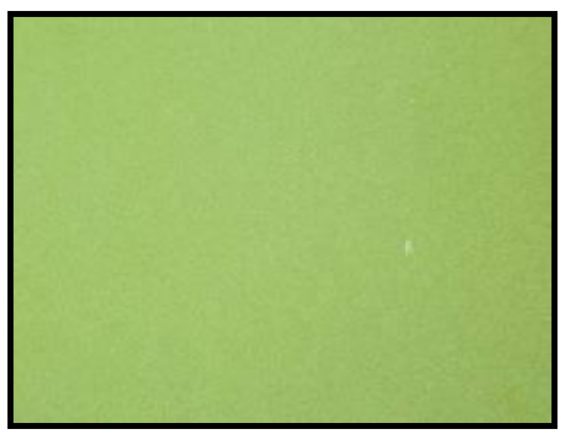

Figure 4 – A photograph of the lake's surface during a large surface bloom on July 19th. Photo by Pauline Pozsonyi.

primary factor affecting water transparency at Kehewin Lake (Figure 4).

WATER TEMPERATURE AND DISSOLVED OXYGEN

Water temperature and dissolved oxygen profiles in the water column can provide information on water quality and fish habitat. The depth of the thermocline is important in determining the depth to which dissolved oxygen from the surface can be mixed. Please refer to the end of this report for descriptions of technical terms.

Surface water temperatures measured during the summer of 2013 were quite high, ranging from 19.86 °C on August 8th to 20.85 °C on July 19th (Figure 5a). Weak and deep thermal stratification was observed on each sampling trip. This stratification likely has important implications for the concentrations of dissolved oxygen present in deeper locations of Kehewin Lake.

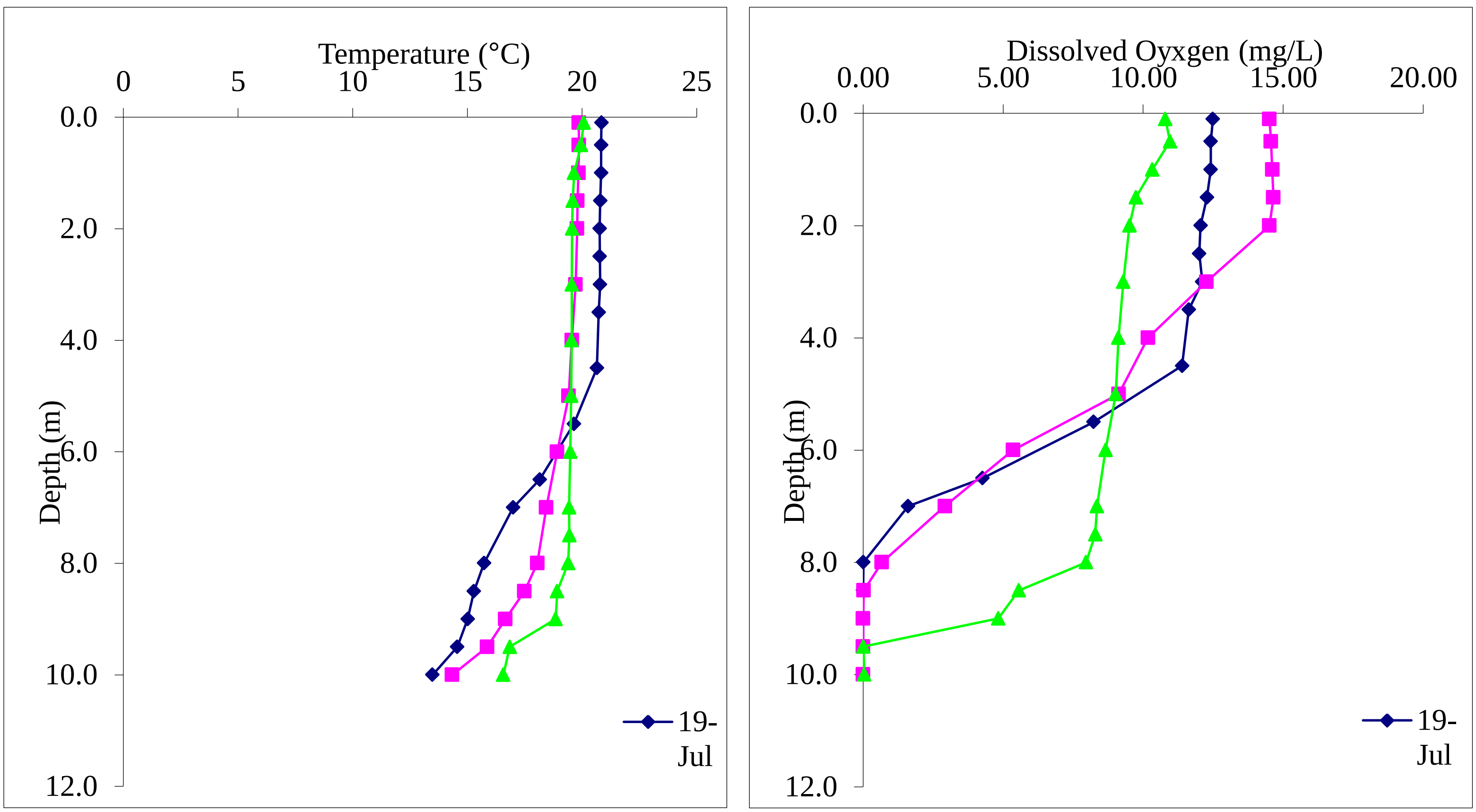

Figure 5 – a) Water temperature and b) dissolved oxygen measured three times at Kehewin Lake during the summer of 2013.

On the three sampling trips completed at Kehewin Lake, dissolved oxygen concentrations were supersaturated at the surface due to photosynthesis from cyanobacteria blooms. Surface concentrations ranged from 10.79 mg/L on August 23rd to a maximum of 14.51 mg/L on August 9th. While concentrations were supersaturated at the surface, dissolved oxygen concentrations proceeded towards anoxia on each sampling trip as early as 8.00 m. Low levels of oxygen are often due to high amounts of decomposition, in particular the decomposition of algae or cyanobacteria. In addition, the thermal stratification of the water column likely limits the amount of surface dissolved oxygen able to mix into deeper waters.

WATER CHEMISTRY:

ALMS measures a suite of water chemistry parameters. Phosphorous, nitrogen, and chlorophyll-a are important because they are indicators of eutrophication, or excess nutrients, which can lead to harmful algal/cyanobacteria blooms. One direct measure of harmful cyanobacteria blooms are Microcystins, a common group of toxins produced by cyanobacteria. See Table 1 for a complete list of parameters.

Average Total Phosphorous (TP) measured 89.3 μg/L, which falls into the hypereutrophic, or extremely productive, classification (Figure 5). Throughout the summer, TP ranged from 64.0 μg/L on July 19th to 122 μg/L on August 23rd. Compared to previous years, a value of 89.3 μg/L falls at the low end of the historical variation observed at Kehewin Lake (however, this may be skewed due to only three samples being collected).

Average Total Kjeldahl Nitrogen (TKN) measured 1650 μg/L in 2013. Throughout the summer, TKN ranged from 1570 μg/L on July 19th to 1730 μg/L on August 23rd.

Finally, average chlorophyll-*a* concentration measured at Kehewin Lake was 38.37 μg/L. Over the three sampling trips the chlorophyll-*a* concentration changed very little, measuring a minimum of 32.2 μg/L on August 23rd to a maximum of 41.7 μg/L on August 9th.

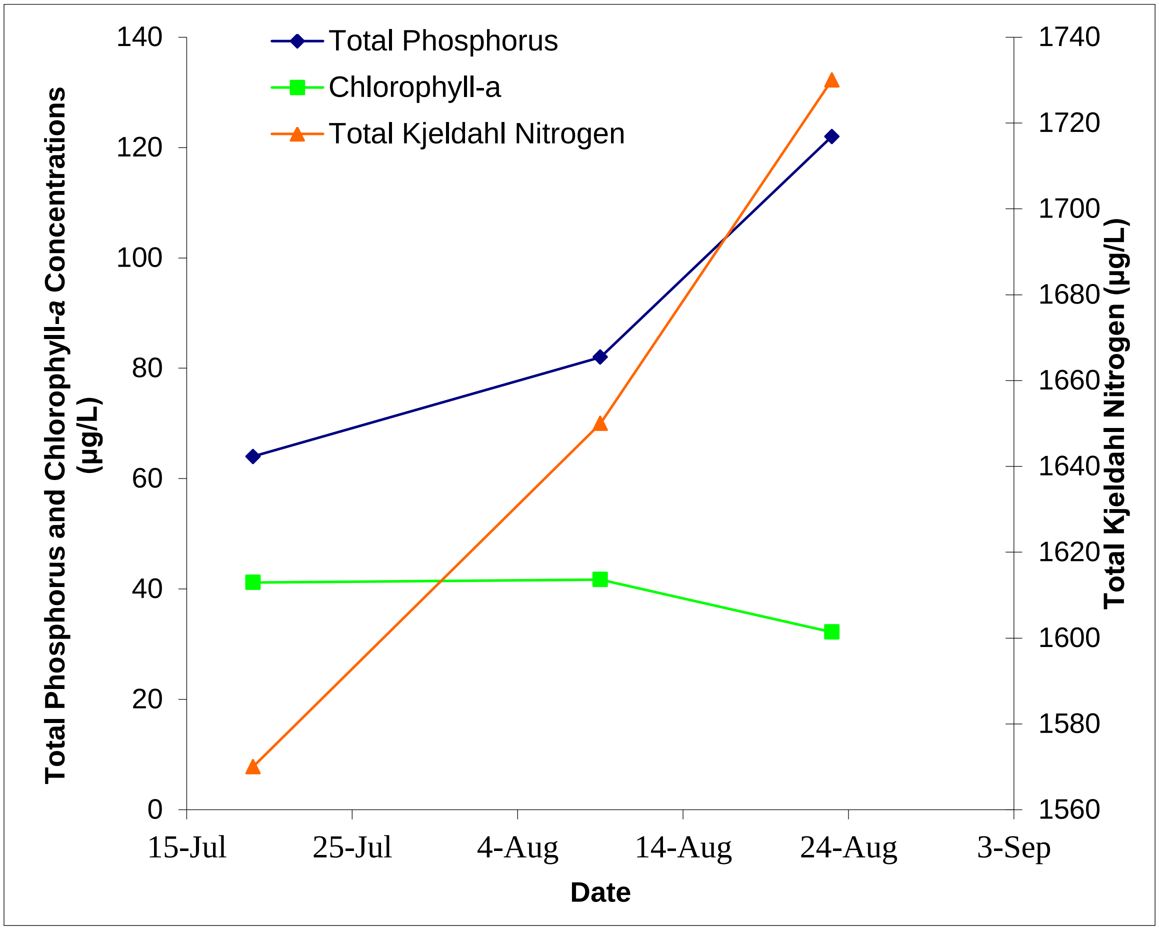

Figure 6 – Total phosphorous (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (µg/L) measured at Kehewin Lake during the summer of 2013.

Average pH measured at Kehewin Lake in 2013 was 8.95. This is well above neutral, which is common in many Alberta lakes. The high pH is likely maintained by high alkalinity (220.3 mg/L $CaCO_3$) and high bicarbonate concentration (222 mg/L HCO_3) which help to buffer the lake against changes to pH. The concentration of other ions in the lake is low, resulting in a moderate conductivity (512.7 µS/cm). Metals were also measured twice during the summer, and all values fell within their respective guidelines (Table 2).

Microcystin concentrations were low in 2013 – on average, microcystin concentration measured 0.40 µg/L – well below the recreational guideline of 20 µg/L (Table 1). Though microcystin concentrations were low, it is possible that other cyanotoxins were present in the water. Thus, caution should always be observed when recreating in waters with cyanobacteria blooms.

INVASIVE SPECIES:

Quagga and Zebra mussels are invasive species which, if introduced to our lakes, will have significant negative ecological, economical, and recreational impacts. ALMS collects water samples which are analyzed for mussel veligers (juveniles) and monitors substrates for adult mussels. In order to prevent the spread of invasive mussels, always clean, drain, and dry your boat between lakes. To report mussel sightings or mussel-fouled boats, call the confidential Alberta hotline at 1-855-336-BOAT.

In 2013, no zebra or quagga mussels were detected in Kehewin Lake.

Table 1 – Average Secchi depth and water chemistry values for Kehewin Lake. Previous years averages are provided for comparison.

Parameter	**2002**	**2003**	**2004**	**2004**	**2005**	**2007**	**2008**	**2009**	**2011**	**2013**
TP (μg/L)	106	105	36	123	98	170.8	162.3	130	117	89.3
TDP (μg/L)	65	62	31	67	33	116.3	126.7	52.5	45.3	17.3
Chlorophyll-*a* (μg/L)	30	49	1.3	45	40	50.7	19.58	32.9	131.9	38.4
Secchi depth (m)	2.1	1.9		1.9	1.9	1.1	2.9	1.13	1.5	1.1
TKN (μg/L)	1400	1382.5	1300	1474	1386.667	1877.5	1620	1800	2070	1650
NO_2 and NO_3 (μg/L)	20	19	270	35	14	101	19	5	7.5	2.5
NH_3 (μg/L)	149	69	67	65	15	89	261	23.5	90.3	35.3
DOC (mg/L)	/	/	/	/	/	13.6	13.9	13.9	14.45	17.15
Ca (mg/L)	25	26	29	24	26	24.2	25.2	25.3	22.2	24.8
Mg (mg/L)	29	29	33	25	30	28.3	26.8	29	28.1	27.45
Na (mg/L)	32	35	39	36	35	36.2	34.1	35.4	34.5	37.3
K (mg/L)	14	12	14	12	13	13.1	13.5	11.9	13.05	16.45
SO_4^{2-} (mg/L)	20	27	33	28	26	22.7	26	17	14	20
Cl^- (mg/L)	16	16	18	17	17	18.9	19.2	19.7	20.65	20.8
CO_3 (mg/L)	6.2	14	6.7	14	17	14	20	21	19.75	22.67
HCO_3 (mg/L)	189	245	284	238	234	226.3	228.5	228	221	222
pH	8.5	8.7	8.4	8.7	8.8	8.7	8.9	8.93	8.99	8.95
Conductivity (μS/cm)	/	/	/	/	/	481	499	485	480	512.67
Hardness (mg/L)		184		166	191	177	173	/	171	175
TDS (mg/L)	/	/	/	/	/	269.3	277.5	272	262	280
Microcystin (μg/L)	/	/	/	/	0.28	0.54	0.56	/	0.16	0.4
Total Alkalinity (mg/L $CaCO_3$)	165	224	243	218	220	209	221	222	215	220.3

Note: TP = total phosphorous, TDP = total dissolved phosphorous, Chl-*a* = chlorophyll-*a*, TKN = total Kjeldahl nitrogen. NO_{2+3} = nitrate+nitrite, NH_3 = ammonia, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, SO_4 = sulphate, Cl = chloride, CO_3 = carbonate, HCO_3 = bicarbonate. A forward slash (/) indicates an absence of data.

Table 2 - Concentrations of metals measured in Kehewin Lake on August 23rd. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2003**	**2004**	**2005**	**2007**	**2008**	**2009**	**2011**	**2013**	**Guidelines**
Aluminum μg/L	24	13	8.8	23.4	12.3	13.2	11.8	5.21	100[a]
Antimony μg/L	0.072	0.1	0.105	0.09	0.088	0.092	0.0812	0.0683	6[e]
Arsenic μg/L	2.1	2	1.84	2.17	2.5	2.84	2.14	1.76	5
Barium μg/L	54	56	58	50.9	51.7	52.3	55.5	51.7	1000[e]
Beryllium μg/L	0.037	0.0015	0.0015	<0.003	<0.003	/	0.0015	0.0034	100[d,f]
Bismuth μg/L	0.0037	0.0005	0.054	0.002	<0.001	0.0273	0.0005	0.0005	/
Boron μg/L	84	87	81	79	89	88	100	95.4	5000[ef]
Cadmium μg/L	0.02	0.0016	0.0043	0.017	0.0071	0.0137	0.0064	0.0022	0.085[b]
Chromium μg/L	0.18	0.25	0.21	0.244	0.324	0.261	0.269	0.161	/
Cobalt μg/L	0.04	0.037	0.04	0.056	0.0379	0.0525	0.0532	0.0432	1000[f]
Copper μg/L	0.43	0.52	0.47	1.31	0.675	0.439	0.351	0.261	4[c]
Iron μg/L	27	7.7	3.4	19.2	10.55	9.3	24.6	24.3	300
Lead μg/L	0.11	0.042	0.354	0.07	0.0467	0.0708	0.0275	0.0022	7[c]
Lithium μg/L	26	29	26	26.5	27.3	29.3	36.8	31.2	2500[g]
Manganese μg/L	30	26	32	23.9	25.6	32.5	14.5	12.9	200[g]
Molybdenum μg/L	0.8	0.83	0.82	0.77	0.748	0.767	0.647	0.49	73[d]
Nickel μg/L	0.15	0.16	0.18	0.27	0.373	0.182	0.283	0.358	150[c]
Selenium μg/L	0.42	0.05	0.2	0.35	0.183	0.214	0.327	0.221	1
Silver μg/L	/	/	/	0.005	<0.0005	0.00115	0.00025	0.0213	0.1
Strontium μg/L	229	235	226	214	208	222	226	217	/
Thallium μg/L	0.093	0.001	0.022	0.002	0.0005	0.0131	0.0006	0.00015	0.8
Thorium μg/L	0.012	0.004	0.06	0.005	0.0014	0.0033	0.0105	0.00015	/
Tin μg/L	0.05	0.026	0.015	<0.03	<0.03	0.0358	0.015	0.015	/
Titanium μg/L	1.23	1.33	0.98	1.8	0.878	1.42	0.777	0.983	/
Uranium μg/L	0.57	0.6	0.64	0.56	0.617	0.678	0.6	0.489	100[e]
Vanadium μg/L	0.66	0.56	0.4	0.45	0.426	0.458	0.369	0.24	100[f,g]
Zinc μg/L	2	11.8	2.8	1.03	0.646	0.148	0.386	0.274	30

Values represent means of total recoverable metal concentrations.
[a] Based on pH ≥ 6.5; calcium ion concentrations [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 > 180mg/L (as $CaCO_3$)
[d] CCME interim value.
[e] Based on Canadian Drinking Water Quality guideline values.
[f] Based on CCME Guidelines for Agricultural use (Livestock Watering).
[g] Based on CCME Guidelines for Agricultural Use (Irrigation).
A forward slash (/) indicates an absence of data or guidelines.

A Brief Introduction to Limnology

Indicators of Water Quality:

Water samples are collected in LakeWatch to determine the chemical characteristics that characterize general water quality. 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:

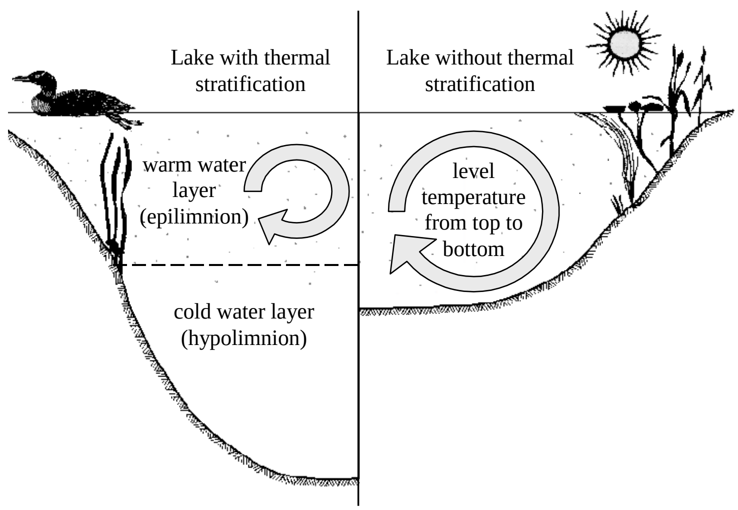

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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 often 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 near 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 $mg \bullet L^{-1}$ and should not average less than 6.5 $mg \bullet L^{-1}$ over a seven-day period. However, the guidelines also require that dissolved oxygen concentrations remain above 9.5 $mg \bullet L^{-1}$ 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 rather than suspended algae. In these lakes, chlorophyll *a* and nutrient values taken from water samples do not include productivity from large aquatic plants. The result, in lakes like Chestermere which are dominated by larger plants known as macrophytes, can be 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 TRANSPARENCY:

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. A measure of the transparency or clarity of the water is performed with a Secchi disk with an alternating black and white pattern. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the disk disappears is recorded. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. However, low Secchi depths are not caused by algal growth alone. 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 low Secchi depths despite low algal growth and nutrient concentrations.

The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Conversely, aquatic plants can ensure lakes have clear water by reducing shoreline erosion and stabilizing lake bottom sediments. In Alberta, many lakes are shallow and bottom sediments contain 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 insects, depend on aquatic plants for food and shelter.

TROPHIC STATE:

Trophic state is classification of lakes into four categories of 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 (Table 2)**.

A majority of lakes in Alberta contain naturally high levels of chlorophyll *a* (8 to 25 µg/L) due to our deep fertile soils. These lakes are usually considered fertile and are termed eutrophic. 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.

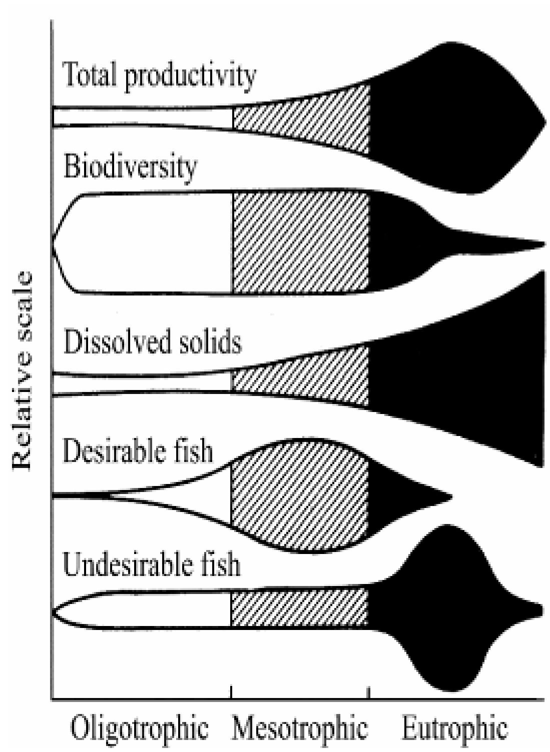

Figure B: Suggested changes in various lake characteristics with eutrophication. From "Ecological Effects of Wastewater", 1980.

Table A - Trophic status classification based on lake water characteristics.

Trophic state	Total Phosphorus (µg•L^{-1})	Total Nitrogen (µg•L^{-1})	Chlorophyll a (µg•L^{-1})	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