Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2014 Laurier Lake Report

LAKEWATCH IS MADE POSSIBLE WITH SUPPORT FROM:

Beaver River Watershed Alliance

Alberta Government

LICA
Lakeland Industry & Community Association

Ce projet a été réalisé avec l'appui financier de :
This project was undertaken with the financial support of:

Environnement Canada
Environment Canada

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 2014 report.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers. We would like to thank volunteer Bev Smith for her assistance with and dedication to sampling Laurier Lake for their assistance with sampling Laurier Lake in 2014. We would also like to thank Jackson Woren, Brittany Kereliuk, and Kara MacAulay who were summer technicians with ALMS in 2014. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Mike Bilyk was involved in the training aspects of the program. Lisa Reinbolt was responsible for data management. This report was prepared by Jackson Woren and Bradley Peter. Alberta Environment, the Beaver River Watershed Alliance (BRWA), the Lakeland Industry and Community Association (LICA), and Environment Canada, were major sponsors of the program.

LAURIER LAKE:

Laurier Lake is one of four beautiful lakes that were left behind 10,000 years ago when glaciers carved a hummocky terrain of kettles, eskers, and lake basins. Archaeological evidence indicates that the area was inhabited 7000 years ago, with Europeans arriving in1754 by way of the nearby North Saskatchewan River.

Figure 1 – LakeWatch Coordinator Bradley Peter and volunteer Bev Smith at Laurier Lake. Photo by Pauline Pozsonyi, 2011.

The Whitney Lakes Provincial Park adjacent to Laurier Lake was established in 1982. It boasts a diverse setting of jack pine (*Pinus banksiana)* meadows, aspen (*Populus* spp.) groves, willow (*Salix* spp.) thickets, marshes, fens, and mixed wood forests. As many as 148 bird species have been observed in the park with an excellent viewing point on the west side of Laurier Lake. The land surrounding Laurier Lake includes a mixture of recreational cottage development, cleared agricultural land, and natural deciduous forest. Protected Crown Land makes up the north shore of the lake and the remainder is privately owned.

The lake is enjoyed through recreational activities including hiking, wildlife viewing, and water-based recreation such as wind surfing, water-skiing, sailing, swimming, and fishing. Yellow perch (*Perca flavescens*) and northern pike (*Esox lucius*) are the sport fish of Laurier Lake. Fish stocking occurred in 1953 with sport and forage fish transferred from Moose Lake to Laurier Lake. The lake has not been managed for commercial or domestic fisheries.

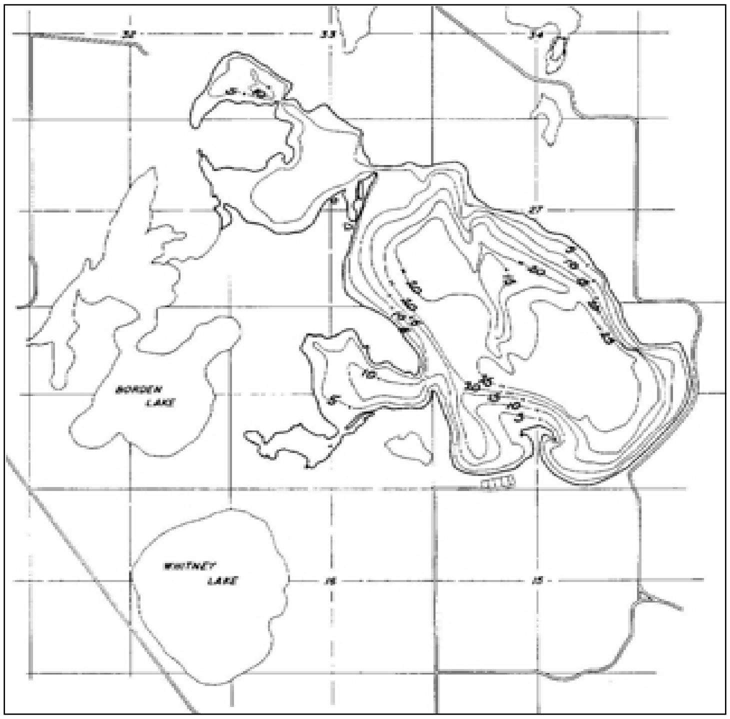

Figure 2 – Bathymetric map of Laurier Lake showing five-foot depth contour intervals.

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.

Laurier Lake has a surface area of 6.42 km^2, a maximum of depth of approximately 7.5 m, and a drainage basin of 92.0 km^2 (which is shared with Ross, Borden, and Whitney Lakes; Figure 2). One intermittent and three permanent streams feed into Laurier Lake. The outflow, on the northwest end, drains into Borden Lake and subsequently into the North Saskatchewan River. Between 1968-2004 water levels at Laurier Lake have shown a general trend towards decline (Figure 3). Maximum water elevation was observed in 1974 at 567.2 meters above sea level (m asl), and a minimum of 564.0 m asl was observed in 2004. However, since 2004 water levels have shown an increasing trend, reaching 566.095 m asl in 2013 – a value this high has not been observed since 1990. High water levels have reconnected Laurier Lake to bays which were previously separated in dryer years (Bev Smith, pers. comm.).

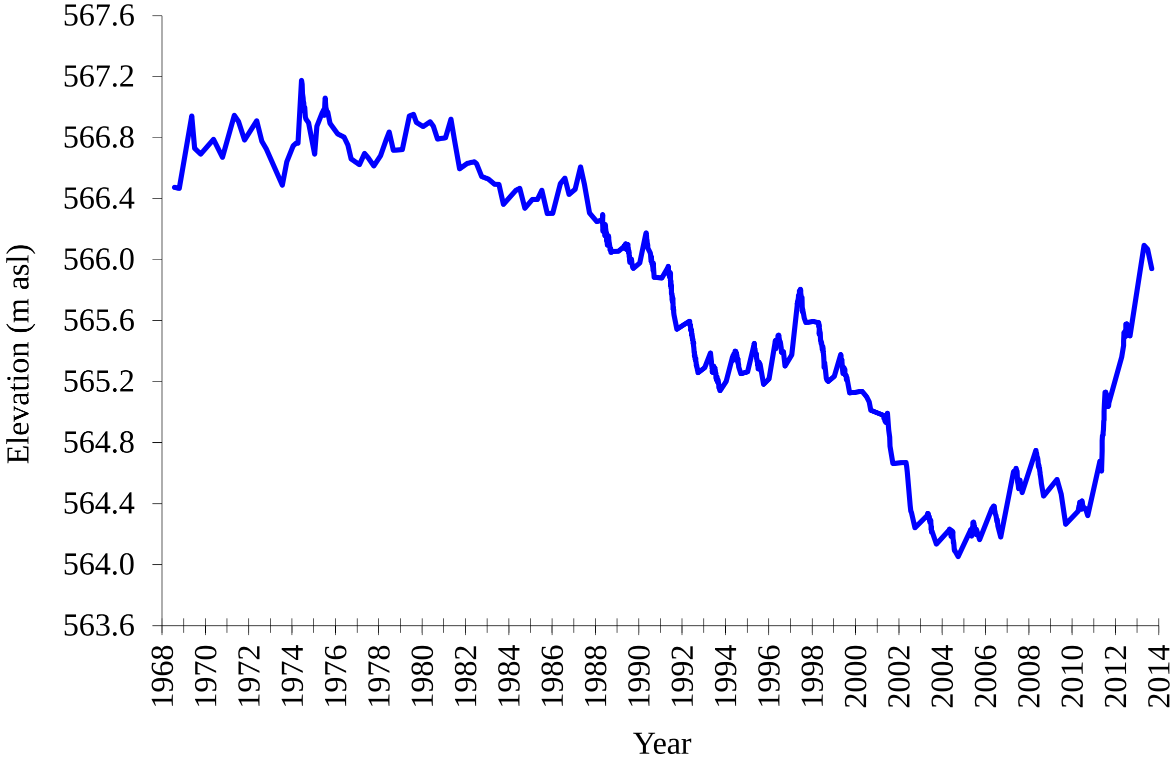

Figure 3 – Historical water levels for Laurier Lake recorded in meters above sea level (m asl) from 1968 to 2013. Data retrieved from Alberta Environment.

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.

As is typical in many of Alberta's lakes, Secchi disk depth at Laurier Lake decreased throughout the summer. On July 2nd, Secchi disk depth measured a maximum of 1.90 m, decreasing to an observed minimum of 1.15 m on September 5th. On average, Secchi disk depth at Laurier Lake measured 1.42 m during 2014 – this is on the low end of the historical observations and likely because chlorophyll-*a* concentration, a measure of algae/cyanobacteria biomass, was the highest concentration observed since 1980 (Table 2). This was also observed in 2013 when the chlorophyll-*a* concentration was 14.37 μg/L. Algae/cyanobacteria are one of the main factors impeding water clarity in Alberta's lakes.

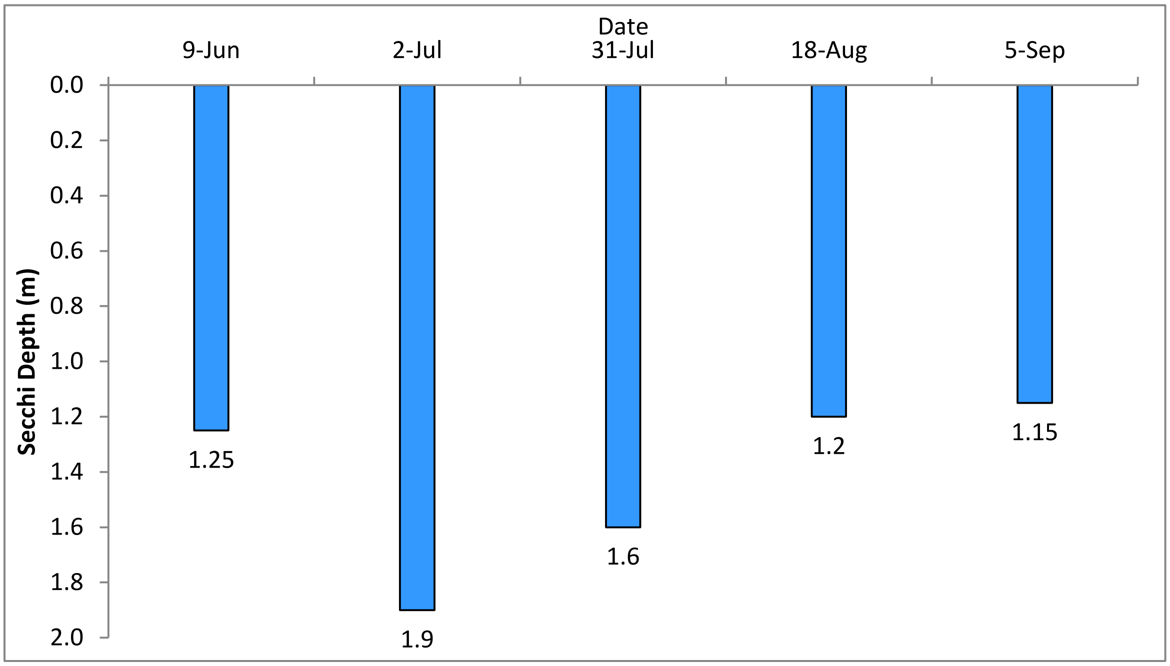

Figure 4 – Secchi disk depths obtained from the profile site on Laurier Lake in 2014.

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 temperature at Laurier Lake ranged from a minimum of 14.99 °C on June 9th to a maximum of 24.04 °C on July 31st (Figure 5a). The water column remained mainly isothermal all five trips. In previous years, thermal stratification events have been observed throughout the summer and it is possible that these events occurred on hot, calm days at Laurier Lake. A lake which mixes and stratifies many times throughout the year is referred to as polymictic.

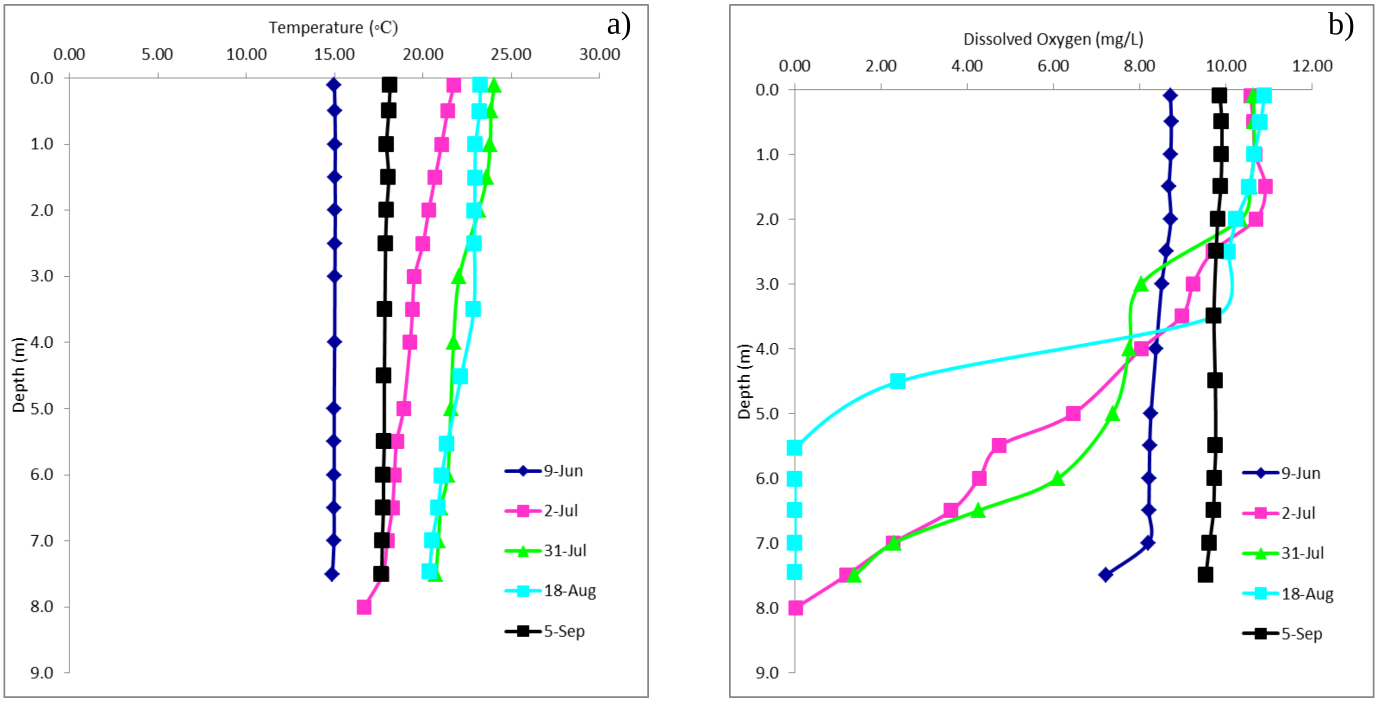

Figure 5 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles from Laurier Lake, 2014.

Despite isothermal temperatures at Laurier Lake, dissolved oxygen concentrations were depleted near the lakebed on three of five sampling trips (Figure 5b). The decomposition of algae/cyanobacteria which occurs at the lake sediments is an oxygen consuming process and acts to drive down dissolved oxygen concentrations. However, on each sampling trip more than half of the water column remained above the Canadian Council for Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life of 6.5 mg/L. In fact, on all trips past June 9th dissolved oxygen concentrations were supersaturated at the surface, all measuring at or above 9.86 mg/L; these elevated dissolved oxygen concentrations are the result of photosynthesis performed by algae/cyanobacteria in the water column.

WATER CHEMISTRY:

ALMS measures a suite of water chemistry parameters. Phosphorus, 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 2 for a complete list of parameters.

Average total phosphorus measured 48 µg/L in 2014 – this value falls into the eutrophic, or nutrient rich, classification (Table 2, Figure 6). Total phosphorus concentrations measured as high as 60 µg/L on June 9th and as low as 32 µg/L on August 18th (Figure 6). High concentrations of phosphorus may be due to increased run-off from the watershed or may be related to water levels, as the main portion of the lake is now reconnected to the once-separated smaller bays.

Chlorophyll-*a* concentrations in 2014 were the highest ever measured in Laurier Lake (Table 2, Figure 6). This follows a previous record year of chlorophyll-*a* concentrations which averaged 14.37 µg/L. Average chlorophyll-*a* concentration measured 19.6 µg/L, which falls into the eutrophic classification – a minimum concentration of 10 µg/L was observed on June 9th and a maximum concentration of 35 µg/L was observed on September 5th (Figure 6). Increases in chlorophyll-*a* concentrations may be related to increased nutrient concentrations or temperatures.

Finally, Total Kjeldahl Nitrogen measured an average of 2206 µg/L in 2014 (Table 2, Figure 6). While this value falls into the hypereutrophic classification, it is still well within the historical variation measured at Laurier Lake. TKN ranged from a maximum of 2670 µg/L on September 5th and a minimum of 1840 µg/L on July 31st.

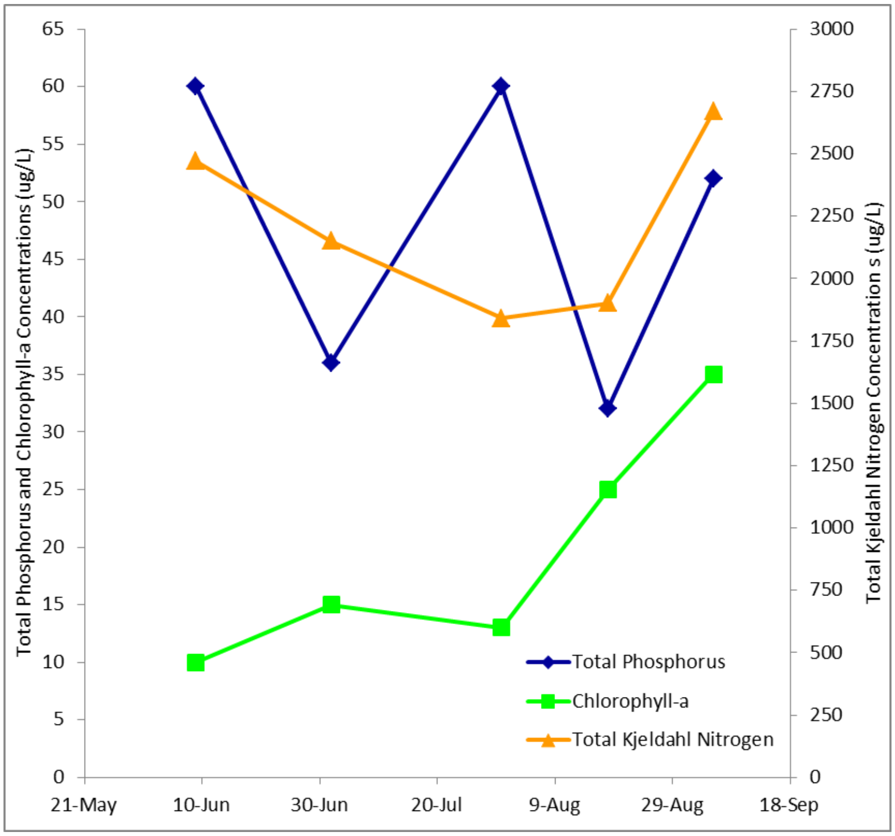

Figure 5 - Total phosphorus (µg/L), chlorophyll-*a* (µg/L), and total Kjeldahl nitrogen (µg/L) concentrations measured five times over the course of the summer of 2014.

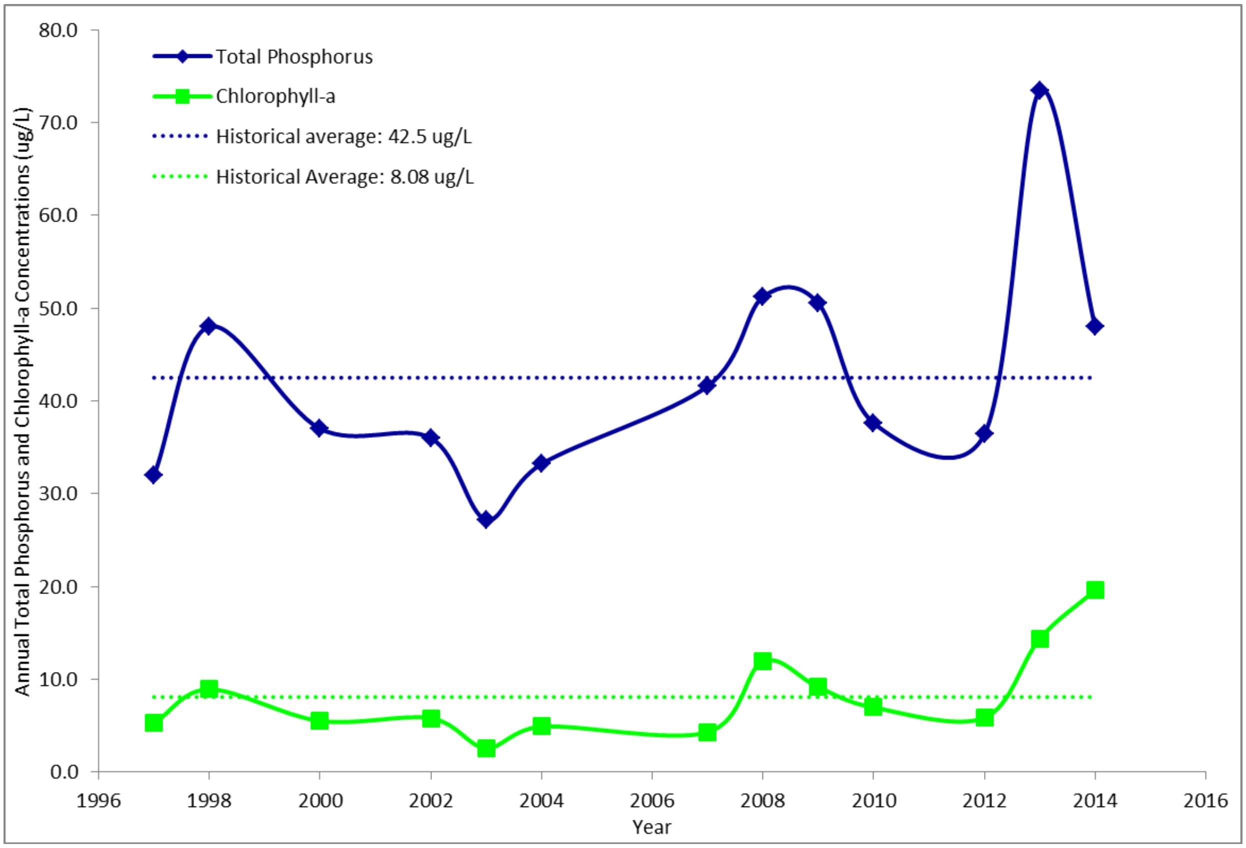

Figure 6 - Historical trends for total phosphorus and chlorophyll-*a* concentrations. Dotted lines mark historical averages.

Average pH in Laurier Lake measured 8.896, well above neutral. Laurier Lake consistently has a high pH, and is well buffered against changes to pH due to its high alkalinity (504 mg/L $CaCO_3$) and bicarbonate concentration (614.6 mg/L HCO_3; Table 2). With increased water levels, concentrations of major ions in Laurier Lake have showed slight decreases since 2004 as they become more dilute. In 2014, major ions in Laurier Lake were sodium (108.3 mg/L), magnesium (71.6 mg/L), sulphate (102.6 mg/L), and potassium (32.5 mg/L). Overall, concentration of dissolved solids measured an average of 709.67 mg/L and conductivity measured 1100 µS/cm.

In 2014, microcystin concentrations averaged 3.514 µg/L – this is well below the recreational guidelines of 20 µg/L (Table 2). Concentrations of microcystin progressed throughout the summer with chlorophyll-*a* concentrations suggesting the cyanobacteria community at Laurier Lake is was likely dominated by microcystin producing species (Table 1). A maximum concentration of 7.11 µg/L was observed on September 5th.

Metal concentrations were measured twice at Laurier Lake and all values fell within their respective guidelines (Table 3).

MICROCYSTIN:

Microcystins are toxins produced by cyanobacteria (blue-green algae) which, when ingested, can cause severe liver damage. Microcystins are produced by many species of cyanobacteria which are common to Alberta's Lakes, and are thought to be the one of the most common cyanobacteria toxins. In Alberta, recreational guidelines for microcystin are set at 20 μg/L.

In 2014, concentrations of microcystin reached an observed maximum of 7.11 μg/L on July 29th (Table 1). This is a high concentration of microcystin based on a 10-point composite sample. The seasonal average of microcystin concentration was 3.514 μg/L. It was not determined what species of cyanobacteria is dominant at Laurier Lake. Caution should always be taken when recreating in waters experiencing 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 2014, no zebra or quagga mussels were detected in Laurier Lake.

Table 1 – Microcystin concentrations (μg/L) measured at Laurier Lake during the summer of 2014. Values represent samples taken as whole-lake composites.

Date	Microcystin (μg/L)
9-Jun	0.19
2-Jul	1.53
31-Jul	2.49
18-Aug	6.25
5-Sep	7.11

Table 2 – Average Secchi disk depth and water chemistry values for Laurier Lakes. Previous year averages from all basins are provided for comparison.

Parameter	**1978**	**1980**	**1987**	**1997**	**1998**	**2000**	**2002**	**2003**	**2004**	**2007**	**2008**	**2009**	**2010**	**2012**	**2013**	**2014**
TP (µg/L)	/	/	/	32.0	48.0	37.0	36.0	27.2	33.2	41.6	51.2	50.5	37.6	36.4	73.4	48
TDP (µg/L)	/	/	/	/	/	/	15	15	18	22	18.8	20.5	16.4	19.4	31	26.2
Chlorophyll-*a* (µg/L)	/	/	/	5.3	8.9	5.5	5.8	2.56	4.9	4.29	11.93	9.13	6.96	5.85	14.37	19.6
Secchi depth (m)	/	1.30	1.20	4.60	1.30	1.80	2.50	4.36	3.17	2.40	1.30	2.00	1.80	3.10	1.72	1.42
TKN (µg/L)	/	/	/	/	/	/	2500	2434	2646	2212	2714	2755	2614	2152	2268	2206
NO_2 and NO_3 (µg/L)	<50	50	<1	/	/	/	3.8	211	6.7	5	6	5.75	9.6	3.4	2.5	24
NH_3 (µg/L)	/	/	/	/	/	/	23	40.8	74.4	46.2	39.2	39.3	33.2	33	26.4	32.8
DOC (mg/L)	/	/	/	/	/	/	/	/	44.3	37.9	37.9	39	37.5	32.2	34.1	35.17
Ca (mg/L)	23	27	19	20	21	13	12	10.3	10.6	16.3	14.5	12.1	12.2	20.2	23.13	23.13
Mg (mg/L)	48	54	52	73	81	83	99	106	105.1	97.8	92.9	88.1	98.6	84.6	83.3	71.67
Na (mg/L)	49	45	59	86	92	98	77	127.5	130.3	122.7	120.7	132.3	136	101.9	100.9	108.33
K (mg/L)	14	14	17	24	25	25	26	31.25	33.87	32.83	31.9	38	34.47	31.3	35.2	32.57
SO_4^{2-} (mg/L)	36	40	41	62	66	73	94	99	103.7	111.7	121.3	135.7	148.7	118.3	107.3	102.67
Cl^- (mg/L)	5	6	9	12	13	15	12	18.4	20.1	19.5	20.2	21.2	22.7	18.7	16.6	18.23
CO_3 (mg/L)	/	/	/	39	62	66	102	112	83.7	86	84.7	70	85	45	55.6	63.66
HCO_3 (mg/L)	/	/	/	493	468	469	515	522	601.3	535.7	544.3	582.3	568	546.8	500.2	614.6
pH	/	/	/	8.8	8.9	8	9.2	9.24	9.06	9.11	9.03	9	9.1	8.84	8.88	8.90
Conductivity (µS/cm)	/	/	/	/	/	/	/	/	1196.7	1163.3	1196.7	1246.7	1257	1143.6	1098.6	1100
Hardness (mg/L)	/	/	/	351	387	376	/	462.5	459	443.3	418.7	392.7	436.3	399	401	353
TDS (mg/L)	/	/	/	562	598	602	/	764.5	783.7	750.3	754.3	784.3	817	690.7	669	709.6667
Microcystin (µg/L)	/	/	/	/	/	/	/	/	/	0.53	0.236	0.39	0.174	0.4692	0.40	3.514
Total Alkalinity (mg/L $CaCO_3$)	310	329	360	470	488	493	592	615	633	583	588	594	607.7	523.8	503	504

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

Table 3 - Concentrations of metals measured in Laurier Lake on July 31st and September 5th 2013. Values shown for 2013 are an average of those dates. The CCME heavy metal Guidelines for the Protection of Freshwater Aquatic Life (unless otherwise indicated) are presented for reference.

Metals (Total Recoverable)	**2007**	**2008**	**2010**	**2011**	**2012**	**2013**	**2014**	**Guidelines**
Aluminum µg/L	29.4	9.69	20.65	17.2	7.61	7.265	16.05	100[a]
Antimony µg/L	0.137	0.117	0.131	0.1245	0.115	0.0931	0.094	6[e]
Arsenic µg/L	2.6	3	3.185	2.825	2.435	2.35	2.165	5
Barium µg/L	20.2	16.95	17.8	19.15	29.6	35.8	37.85	1000[e]
Beryllium µg/L	<0.003	<0.003	0.0015	0.00275	0.00975	0.0015	0.004	100[d,f]
Bismuth µg/L	<0.005	0.0051	0.00205	0.0028	0.0067	0.00075	0.0005	/
Boron µg/L	175.5	182	188.5	189	221.5	163	171	5000[ef]
Cadmium µg/L	0.008	0.0038	0.00425	0.00345	0.00325	0.0019	0.002	0.085[b]
Chromium µg/L	0.611	0.56	0.441	0.465	0.2955	0.526	0.695	/
Cobalt µg/L	0.099	0.058	0.07075	0.081	0.05905	0.0482	0.0255	1000[f]
Copper µg/L	0.613	0.555	0.278	2.9	0.6815	0.373	0.2425	4[c]
Iron µg/L	37.1	15.8	16.855	21.05	9.5	17.15	13.4	300
Lead µg/L	0.057	0.023	0.0208	0.05535	0.01625	0.02645	0.00975	7[c]
Lithium µg/L	102.9	100.2	114	114.5	111.5	87.05	75.8	2500[g]
Manganese µg/L	5.15	7.97	4.125	8.335	13	19.9	20.3	200[g]
Molybdenum µg/L	0.661	0.587	0.8645	0.7775	0.5875	0.4565	0.316	73[d]
Nickel µg/L	0.275	0.127	0.12845	0.199	0.0025	0.2175	0.004	150[c]
Selenium µg/L	0.547	0.372	0.416	0.312	0.302	0.2395	0.49	1
Silver µg/L	<0.003	0.0086	0.001425	0.043125	0.00235	0.02525	0.018	0.1
Strontium µg/L	84.5	62.9	58.85	72.35	114.5	134	145	/
Thallium µg/L	<0.001	0.0024	0.00115	0.001275	0.000425	0.00015	0.002975	0.8
Thorium µg/L	<0.01	0.017	0.01245	0.0379	0.01295	0.0067	0.002225	/
Tin µg/L	<0.06	<0.03	0.015	0.015	0.0337	0.015	0.01475	/
Titanium µg/L	1.24	1.36	1.38	0.7535	0.69	1.4	1.935	/
Uranium µg/L	0.811	0.808	1.085	0.875	0.6825	0.677	0.5495	100[e]
Vanadium µg/L	0.742	0.512	0.807	0.563	0.4275	0.3265	0.44	100[f,g]
Zinc µg/L	1.53	0.916	0.326	1.0925	1.031	0.6225	1.1	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:

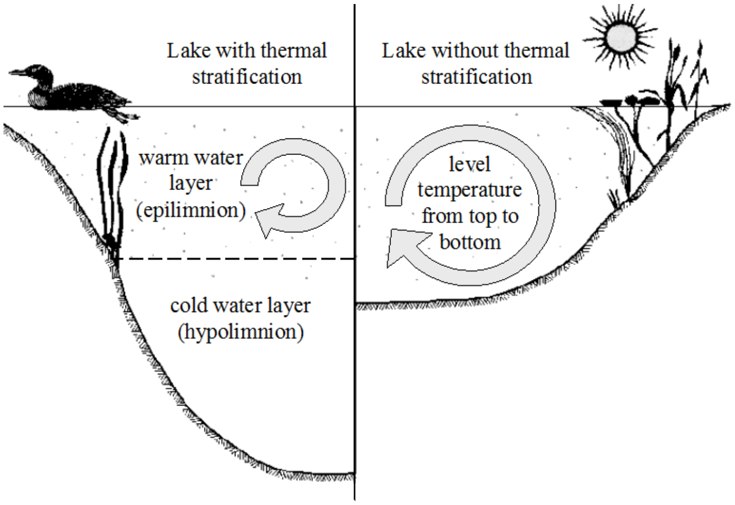

Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

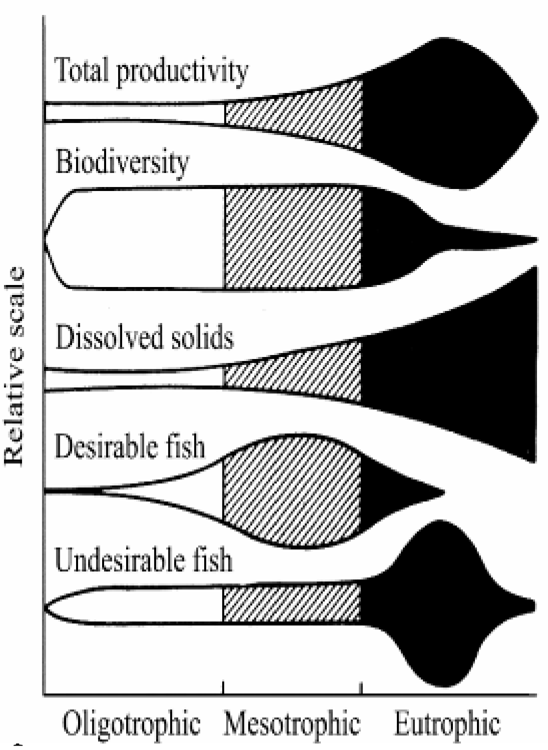

Figure B: Suggested changes in various lake characteristics with eutrophication. From “Ecological Effects of Wastewater”, 1980.

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