Lakewatch

THE ALBERTA LAKE MANAGEMENT SOCIETY
VOLUNTEER LAKE MONITORING PROGRAM

2011 Upper Chain Lake Report

COMPLETED WITH SUPPORT FROM:

Alberta 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 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.

2011 data should be considered preliminary until the validation process is complete.

Acknowledgements

The LakeWatch program is made possible through the dedication of its volunteers and LakeWatch Chairs, Al Sosiak and Ron Zurawell. We would like to thank Ken Henkelman for his efforts in collecting data in 2011, and Cheryl Henkelman for contributing information for this report. We would also like to thank Jessica Davis and Pauline Pozsonyi who were summer interns with ALMS in 2011. Program Coordinator Bradley Peter was instrumental in planning and organizing the field program. Technologists Shelley Manchur and Brian Jackson were involved in the training aspects of the program. Doreen LeClair, Chris Rickard, and Lisa Reinbolt were responsible for data management. The 2011 report was prepared by Bradley Peter and Arin Dyer. Alberta Environment, the Beaver River Watershed Alliance (BRWA), and the Municipal District of Wainwright were major sponsors of the LakeWatch program.

UPPER CHAIN LAKE:

Figure 1 – Upper Chain Lake in July 2011. Photo by Jessica Davis.

Upper Chain Lake (Berdine Lake) is the northernmost section of three water bodies in the Buffalo Sub-Watershed collectively known as Chain Lakes. The northern-most lake is called Berdine, or Upper Chain, Lake; the middle lake is Middle Chain Lake; and the third, or southern-most water body, is called Magee, or Lower Chain, Lake. The Chain Lakes are connected by the north branch of Parlby Creek and ultimately drain into Mirror Bay to the South East, then to Buffalo Lake, and finally into the Red Deer River via Tail Creek. They are located just east of Ponoka and south of Highway 53 in the County of Ponoka. The lakes lie incised in a steep valley carved by an ice-marginal meltwater channel during the Pleistocene.[1] Because of the steep valley and lake bed, the marsh edge is generally narrow and discontinuous; however, because of two alluvial fans, Upper Chain Lake hosts fairly good marsh habitat. The lakes have a small collective surface area (~1.63 km^2)[2], though the area drained by streams entering the lake is 79.5 km^2, which results in a large lake area to drainage basin area ratio.[1] Sport fishing for northern pike (*Esox lucius*) is common in Chain Lakes.

In 2011, concerns over a proposal for a confined feeding operation (CFO) next to Upper Chain Lake prompted residents and the Friends of the Chain Lakes Society to initiate water quality data collection through the LakeWatch program. Data was collected four times throughout the summer from Upper Chain Lake. The CFO next to the lake was later denied, though many CFO's are present within Chain Lakes' watershed boundary.[2]

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.

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[1] Battle River and Red Deer Regional Planning Commissions. 1974. A study of the recreational potential of Chain Lakes. Wetaskiwin, Alberta.

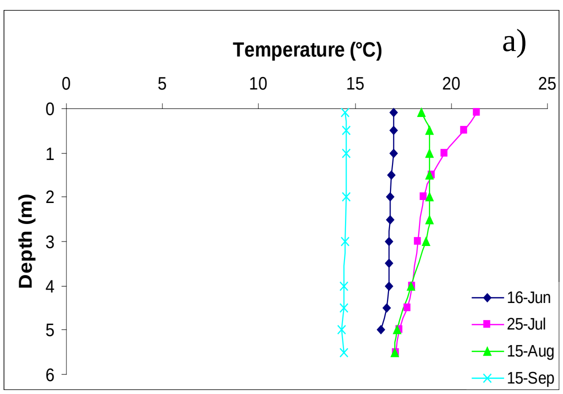
[2] Ponoka County. 2012. Chain Lakes Watershed Management Plan. Retrieved from: www.ponokacounty.com.

Average Secchi disk depth measured at Upper Chain Lake during 2011 was poor, measuring 1.19 m. An average value of 1.19 m falls into the eutrophic (nutrient rich) classification, and suggests that, on average, light was only available for photosynthesis for the first 2.20 m of the water column. While shallow lakes are subject to resuspension of sediments due to wind and boating activity, algae/cyanobacteria blooms are often the greatest factor impairing water clarity in Alberta lakes. Throughout the summer, Secchi disk depth ranged from a minimum of 0.5 m on September 15th to a maximum of 2.0 m on June 16th.

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 measured at Upper Chain Lake in 2011 ranged from a minimum of 14.49 °C on September 15th to a maximum of 21.35 °C on July 25th (Figure 2a). Thermal stratification was observed only once during the summer. This occurred on July 25th, when temperature dropped three degrees Celsius in the first two meters of the water column. Thus, Upper Chain Lake is likely polymictic, mixing and stratifying multiple times throughout the summer. Short stratification events may contribute to the decline of dissolved oxygen near the lakebed. By September 15th, the water column had become a uniform temperature.



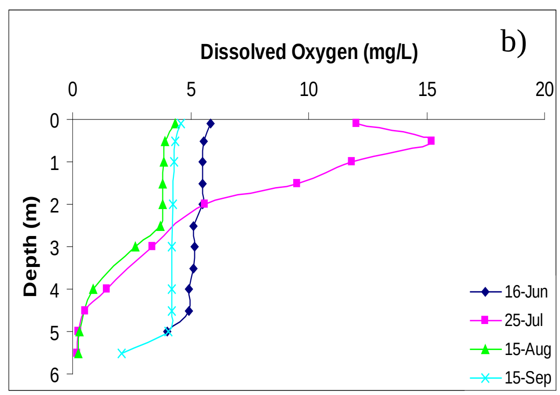


Figure 2 – a) Temperature (°C) and b) dissolved oxygen (mg/L) profiles for Upper Chain Lake measured four times during the summer of 2011.

Dissolved oxygen at Upper Chain Lake was poor, with three out of four sampling trips measuring below the Canadian Council for Ministers of the Environment guideline for the Protection of Aquatic Life of 6.5 mg/L (Figure 2b). On July 25th, however, dissolved oxygen near the surface was high, reaching 15.2 mg/L at 0.5 m. Such high dissolved oxygen levels near the lakes surface are indicative of large amounts of photosynthesizing algae/cyanobacteria. These algae/cyanobacteria eventually die and decompose on the lakebed, a process which consumes oxygen and further drives down dissolved oxygen concentrations. On both July 25th and August 15th, dissolved oxygen proceeded towards anoxia near the lakebed. Anoxic conditions near the lake sediments may contribute to the release of phosphorous from the lakebed.

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 at Upper Chain Lake during 2011 was 344.5 µg/L. This is very high, and falls into the hyper-eutrophic, or extremely nutrient rich, classification. Throughout the summer, TP ranged from a minimum of 263 µg/L on June 16th to 425 µg/L on September 15th. Run-off from the watershed acts as a large source of phosphorous, and 2011 showed particularly high amounts of run-off.

Similar to TP, total Kjeldahl nitrogen (TKN) was also very high and fell into the hyper-eutrophic classification with an average value of 2090 µg/L.

Finally, chlorophyll-*a* concentration measured an average of 94.95 µg/L, which also falls into the hyper-eutrophic classification. As seen in Figure 4, this value is dominated by a large algae/cyanobacteria bloom observed on July 25th, which measured 356 µg/L. This large bloom is reflected in both the dissolved oxygen pattern for that day (Figure 2) and the Secchi disk depth (Table 1), and may partly be related to the high surface water temperatures of July. Before and after this large bloom, chlorophyll-*a* values ranged between 4.89 µg/L and 9.94 µg/L.

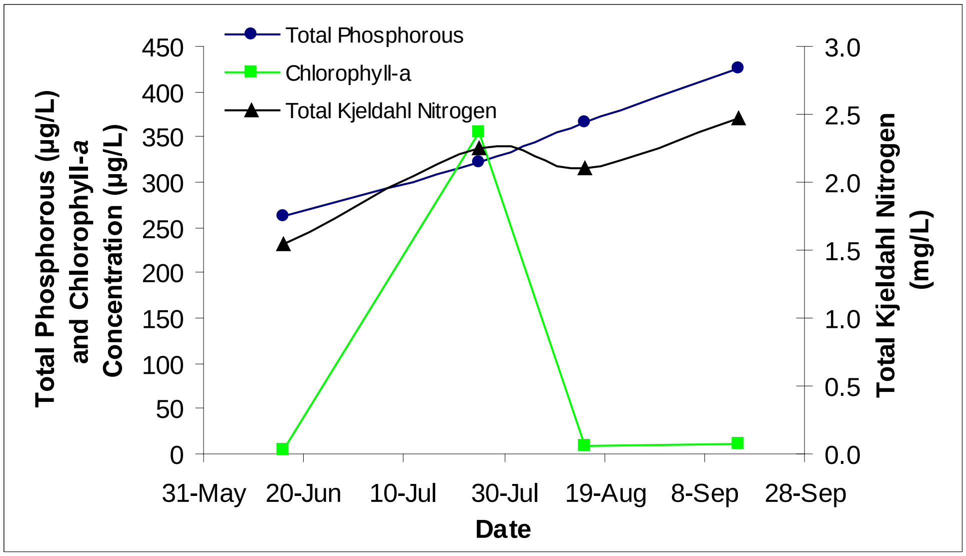


Figure 5 - Total phosphorous (µg/L), chlorophyll-a concentration (µg/L), and total Kjeldahl nitrogen (mg/L), measured five times over the course of the summer at Upper Chain Lake.

Average pH measured in Upper Chain Lake was 8.23 (Table 1). Slightly above neutral, Upper Chain Lake's pH is likely buffered against change due to high alkalinity (239 mg/L $CaCO_3$) and high bicarbonate concentration (287.25 mg/L HCO_3). Ion concentrations were generally low, which is reflected in a low conductivity (479 µS/cm). Dominant ions in the lake included calcium (38.8 mg/L) and sodium (39.5 mg/L). Microcystin, a cyanobacterial toxin, was also measured on each sampling trip and averaged 0.24 µg/L.

Table 1 – Average Secchi depth and water chemistry values for Chain Lakes. Historical data from the Lower and Middle basins are provided for comparison.

	Historical		**Recent**
	Lower	**Middle**	**Upper**
Parameter	**2001**	**2001**	**2011**
TP (µg/L)	112	105	345
TDP (µg/L)	41	40	27
Chlorophyll-*a* (µg/L)	51	66	94.9
Secchi depth (m)	1.6	2.1	1.18
TKN (µg/L)	1600	1547	2090
NO_2 and NO_3 (µg/L)	9	9	20.4
NH_3 (µg/L)	91	27	220
DOC (mg/L)	/	/	17.7
Ca (mg/L)	25	35	38.8
Mg (mg/L)	20	21	15.5
Na (mg/L)	62	68	39.5
K (mg/L)	5	5	9.3
SO_4^{2-} (mg/L)	15	20	7.5
Cl^- (mg/L)	3	3	7.73
CO_3 (mg/L)	/	/	2.13
HCO_3 (mg/L)	/	/	287.25
pH	9	8	8.23
Conductivity (µS/cm)	519	567	479
Hardness (mg/L)	/	/	157
TDS (mg/L)	/	/	256
Microcystin (µg/L)	/	/	0.24
Total Alkalinity (mg/L $CaCO_3$)	272	299	239

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.

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:

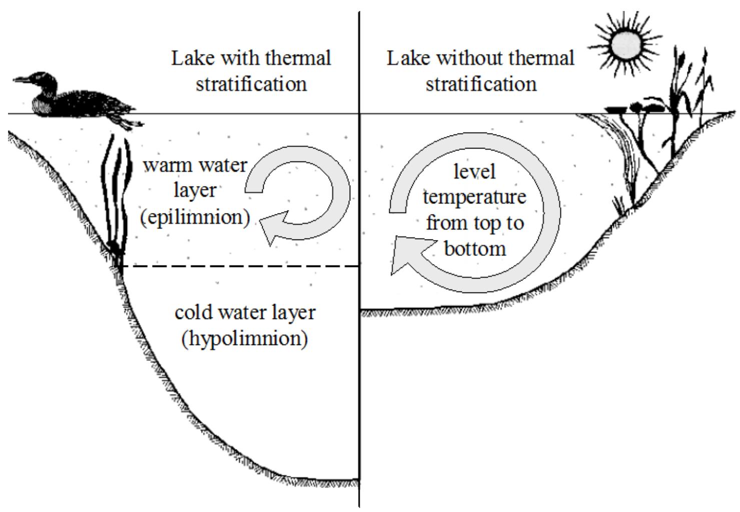


Figure A: Difference in the circulation of the water column depending on thermal stratification.

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.

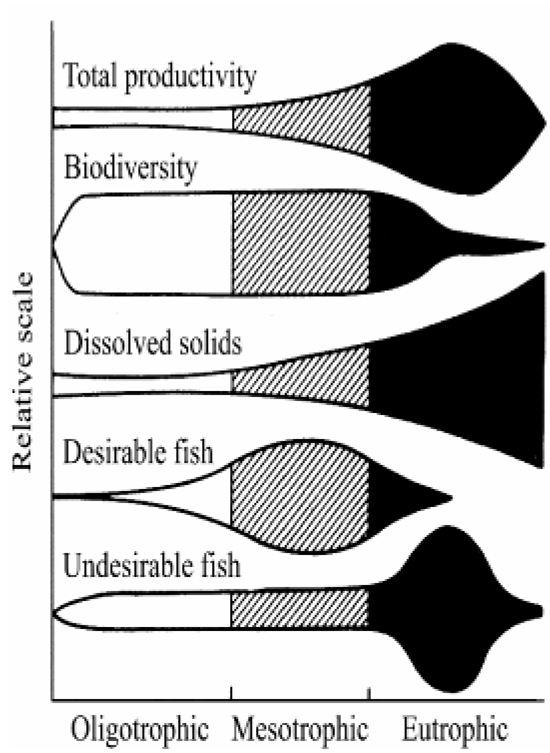


Figure B: Suggested changes in various lake characteristics with eutrophication.

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