Lac La Biche County
welcoming by nature.

2024 Water Quality Report
Elinor Lake

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Photo Credit: Jennifer Moore

Executive Summary

Elinor Lake is relatively small but scenic lake located within Lac La Biche County, Alberta ("County"), and is known for a variety of recreational activities such as swimming and boating. However, there is a concern that declining water quality in the lake is limiting the opportunities of recreational activities. Therefore, it is important that the lake water quality be monitored.

The County follows a regular program to monitor water quality of lakes located within its jurisdiction. In 2024, a volunteer for the Alberta Lake Management Society's LakeWatch program conducted water sampling events for Elinor Lake for the open water season. The data has been provided to The County for the purpose of this report. The water sampling events were conducted in the early spring by The County, and during the summer by the LakeWatch volunteer. The data collected includes water temperature, pH, specific conductivity, and dissolved oxygen which was collected in situ through a multi-probe and Kemmerer sampling device. Analytical data of nitrogenous compounds, heavy metals, and other inorganic parameters were provided by ALS Laboratory and Bureau Veritas (BV) Laboratory.

The water sampling events were conducted during spring and summer of 2024. Collected water samples were analyzed by ALS Laboratory and BV Laboratory. The laboratory results obtained were compared to the CCME Canadian Environmental Quality Guidelines for Protection of Aquatic Life and Protection of Agricultural Water; and Alberta Environment and Protected Areas Environmental Quality Guidelines for Alberta Surface Waters 2018.

Trophic State Index (TSI) is a classification system designed to rate lakes based on the amount of biological activity they sustain. The concentrations of nutrients (nitrogen and phosphorous) are the primary determinants of TSI. Increased concentrations of nutrients tend to result in increased plant growth, followed by an increase in subsequent trophic levels. Nurnberg (1996) used parameters including Secchi depth, chlorophyll, total nitrogen, and total phosphorus concentrations in lake waters to determine the trophic state of the lakes, which is provided as Table 1 in Appendix A. TSI is a useful tool for evaluation and management of lake health and setting objectives including sport and recreational activities related to the lake. Trophic classification of Elinor Lake based on Secchi depth and nutrients is presented in Table 2.

There are four classes of trophic states which include: Oligotrophic which would be the highest quality of water with low productivity, nutrients, and algae; Mesotrophic which is fair quality water with some productivity, nutrients and algae; Eutrophic which is relatively poor-quality water with high productivity, nutrients and algae; and Hypereutrophic which is the poorest quality water with excessive productivity, nutrients, and algae.

Elinor Lake would be considered Eutrophic based on the average of the four water parameters: Secchi depth, total nitrogen, total phosphorus, and total chlorophyll-a. The trophic status would be Mesotrophic based on Secchi depth, Hypereutrophic based on total nitrogen, Eutrophic based on total phosphorus, and Eutrophic based on total chlorophyll-a.

Results and Discussion

In 2024, Secchi depths in Elinor Lake were measured on June 24, July 22, and August 9, 2024. The average seasonal Secchi depth was observed to be 2.7 m which is similar to historical results. Based on the Secchi depths and in accordance with the classification provided in Table 1 (Appendix A), Elinor Lake is classified as Mesotrophic (some productivity, nutrients, and algae growth).

Dissolved oxygen data collected in 2024 shows that the average dissolved oxygen levels ranged from 3.35 mg/L to 6.86 mg/L. These concentrations are slightly under the regulatory guidelines of 9.5 mg/L for early life and 6.5 mg/L for all other life stages in cold-water lakes; however, Elinor Lake displays thermal stratification and has higher dissolved oxygen near the surface.

A temporal decrease in temperature was observed with an average summer water temperature of 15.47 ˚C. Stratified temperature profiles were observed during the summer.

In 2024, two types of lake water samples for analyses of nutrients were collected from Elinor Lake; composite samples and Kemmerer samples (obtained from different depths using a Kemmerer device). Kemmerer samples were taken only in March, as this sampling method is not included in the LakeWatch procedures for August. These samples were analyzed for total nitrogen and total phosphorus.

Total nitrogen concentrations in the composite samples collected from the lake in 2024 had an average of 1.13 mg/L of total nitrogen, while the Kemmerer samples collected had an average of 1.89 mg/L of total nitrogen; both of which exceeded the applicable regulatory guidelines and were consistent with historical results. The average nitrogen concentrations from composite and Kemmerer sampling methods classify Elinor Lake as Hypereutrophic (excessive productivity, nutrients, and algae growth).

Total phosphorus concentrations in the composite samples collected during the summer of 2024 had an average of 0.034 mg/L of total phosphorus, while the Kemmerer samples collected had an average of 0.067 mg/L. The average of both sampling methods is 0.051 mg/L of total phosphorus which exceeds the applicable regulatory guidelines of 0.05 mg/L and is higher than historical results. Total phosphorus concentrations from both sampling methods classify Elinor Lake as Eutrophic (high productivity, nutrients, and algae growth).

The average N:P ratio between composite and Kemmerer sampling events was 28:1, which is higher than the Redfield Ratio of 16:1. Therefore, the total phosphorus concentrations are considered low enough for phosphorus to be considered the main nutrient limiting growth in Elinor Lake.

Total chlorophyll-a concentrations in the composite samples collected during the summer of 2024 had an average of 18.73 µg/L of total chlorophyll-a, exceeding the standard of 3.5 µg/L for Oligotrophic lakes (low productivity, nutrients, and algae growth). This concentration classifies Elinor Lake as Eutrophic (high productivity, nutrients, and algae growth).

Routine water chemistry showed that Elinor Lake has an average pH of 8.02 in 2024 which is consistent with historical results.

Concentrations of metals analyzed from the composite and Kemmerer samples on March 12, 2024, and August 9, 2024, were generally below detection limits and/or below the applicable regulatory guidelines.

Elinor Lake would be considered Eutrophic based on the average of the four water parameters: Secchi depth, total nitrogen, total phosphorus, and total chlorophyll-a. The trophic status would be Mesotrophic based on Secchi depth, Hypereutrophic based on total nitrogen, Eutrophic based on total phosphorus, and Eutrophic based on total chlorophyll-a.

Recommendations:

It is recommended that Lac La Biche County continues to monitor the water quality of Elinor Lake on a regular basis. Continuous monitoring will help the County to determine how the lake management strategies and policies such as the Watershed Management Plan and Riparian Setback Matrix Model are impacting the lake water quality, and what the net effect on human and environmental health is.

Monitoring and sampling should continue to be conducted under a strategic plan and in a uniform manner to ensure that results produced are meaningful and are useful for establishing a correlation with the past results. This may include sampling at the same period of the year each time, recording the same parameters critical to lake health, obtaining samples from the same depths, and implementing a quality assurance program for the reliability of analytical results.

Nutrient loading is the main source of eutrophication in Elinor Lake, which is degrading the water quality, leading to algae growth, foul smells, and a reduction in water recreation. Therefore, action must be taken to slow down the eutrophication process and improve water quality. Best management practices would include education of the public on appropriate land use including restoration and protection of riparian areas (water buffers); and strengthening laws and regulations governing land use such as municipal sewer hookups and protection of environmental reserves.

Lac La Biche County updated the Lac La Biche Watershed Management Plan, which was adopted by Council in May 2021. This plan includes specific action items based on the recommendations that were formulated while drafting the plan. Although Elinor Lake is not within the Lac La Biche watershed, the recommended action items still apply.

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List of Abbreviations Used

CCME: Canadian Council of Ministers of the Environment
County: Lake La Biche County EQGASW-AGW: Environmental Quality Guidelines for Alberta Surface Waters 2018 for protection of Agricultural Water
EQGASW-FAL: Environmental Quality Guidelines for Alberta Surface Waters 2018 for protection of Fresh Water Aquatic Life
EQGASW-RA: Environmental Quality Guidelines for Alberta Surface Waters 2018 for Recreation and Aesthetics
QA/QC: Quality Assurance and Quality Control
Total N: Total Nitrogen
Total P: Total Phosphorous
TSI: Trophic State Index

1. INTRODUCTION

Elinor Lake is located in east-central Alberta, approximately 35 km southeast of the hamlet of Lac La Biche within the Beaver River drainage basin in the County (Figure 1). The lake covers a surface area of 9.33 km^2 with a mean depth of 5.2 m and a maximum depth of 18 m. The lake is one of the two main lakes that flows directly into Beaver Lake. The popular game fish of this lake are Yellow Perch (*Perca flavescens*), Northern Pike (*Esox lucius*), Walleye (*Sander vitreus*), and Lake Whitefish (*Coregonus clupeaformis*).

Figure 1: Location map of Elinor Lake

2. WATER QUALITY SAMPLING PROGRAM

Elinor Lake has been sampled by the County consistently every year from 2005 – 2024. Elinor Lake is sampled for various parameters using different techniques. Vertical profiles were taken using a multi-probe testing different depths (zones) of the lake for dissolved oxygen, pH, conductivity, and temperature. Composite samples are taken from 10 different locations throughout the lake, while Kemmerer sampling is used for discrete depth sampling; both the composite and Kemmerer samples are tested for nutrients such as phosphorus, nitrogen, ammonia, nitrates, nitrites, and metals. Elinor Lake sampling program for 2024 was completed as follows:

a) Secchi and Euphotic depths were measured on June 24, July 22, and August 9, 2024, using a Secchi Disk.
b) Composite samples were collected from the lake on June 24, July 22, and August 9, 2024, and were analyzed for nutrients, metals, and basic water chemistry parameters by BV laboratories. Lake water samples were also analyzed for chlorophyll-a by InnoTech Alberta Laboratories.
c) Kemmerer samples were collected on March 12 from depths of 0 m, 3 m, 6 m, 9 m, 12 m, and 15 m. Kemmerer samples were not taken during the August sampling date as Kemmerer sampling is not included in the LakeWatch sampling procedures.

d) Lake profiles were recorded to a maximum depth of 18.0 m using a multi-probe on March 12, June 24, July 22, and August 9, 2024.

2.1 Water Quality Parameters

Water samples collected during 2024 sampling events of Elinor Lake were analyzed for several parameters to characterize the lake water and identify potential issues associated with lake water quality. The water quality parameters measured/analyzed during 2024 are provided in the table below with a brief description.

Lake Water Quality Parameters

Water Quality Parameter	Description and Reason for Measuring
Secchi Depth	Secchi depth is a measure of the transparency of water and trophic state of a lake. A Secchi disk is generally a disk of 20 cm diameter with alternating black and white quadrants. It is lowered into the lake water until it can no longer be seen. This depth of disappearance is called the Secchi depth. A low Secchi depth (<4 m) is characteristic of a mesotrophic to hypereutrophic lake with turbid water. Whereas a high Secchi depth (>4 m) is characteristic of an oligotrophic lake with clear water.
Dissolved Oxygen	Dissolved oxygen is required by aquatic plants and animals for respiration. Survival of aquatic life such as fish, generally depends on an adequate amount of dissolved oxygen for respiration. As dissolved oxygen levels in the water drop below 5.0 mg/L, aquatic life is subjected to stress. Oxygen levels that consistently remain below 1-2 mg/L can result in the loss of large populations of fish.
Temperature	Temperature of water affects different physical, biological, and chemical characteristics of a lake and determines the behavior of many parameters responsible for water quality. The solubility of oxygen and other gases decrease as temperature increases. An increase in water temperature decreases the concentration of dissolved oxygen required for the survival of aquatic organisms.
Nutrients	Total nitrogen (N) and phosphorus (P) are principal nutrients in lake water and are representative of all forms of N and P present in the water. There are various sources of N and P both natural and anthropogenic. These nutrients are a major cause of eutrophication, decreasing dissolved oxygen concentrations and are detrimental to lake water quality.
Chlorophyll-a	Chlorophyll-a is a green pigment present in all green plants and is responsible for the absorption of light to provide energy for photosynthesis. It is associated with algae growth in a waterbody and affects the trophic status of a lake.
Metals	Metals enter the lake waters through natural (geological) and anthropogenic point and non-point sources. Certain metals such as lead and mercury is toxic to aquatic life and can bio-accumulate in the tissues and organs of aquatic organisms, becoming a part of the food chain. This may lead to loss of aquatic life and further affect human health.

3. REGULATORY FRAMEWORK

The protection of water quality in Canadian lakes is a federal, provincial, and territorial responsibility. Therefore, lake waters in Alberta are regulated by federal and provincial guidelines and fall under the jurisdiction of Canadian Council of Ministers of the Environment (CCME), Alberta Environment and Protected Areas (EPA), and Health Canada.

The regulatory criteria selection for lake waters in Alberta is subjected to CCME's Canadian Environmental Quality Guidelines (CEQG) and EPA's Environmental Quality Guidelines for Alberta Surface Waters 2018 (EQGASW). Protection of lake water is covered in CCME's CEQG and EPA's EQGASW chapters of water quality guidelines for Protection of Aquatic Life, Protection of Agricultural Water, and Protection of Recreation and Aesthetics. In addition, Health Canada's Guidelines for Canadian Recreational Water Quality for protection of lake waters have also been considered.

The analytical and monitoring results obtained for this report were compared to the above-mentioned regulations and are hereinafter referred to as regulatory guidelines or regulatory criteria.

4. SAMPLING ANALYSIS AND MONITORING RESULTS

4.1 Secchi Depth

The Secchi disk is a common method used to measure water clarity. The water clarity of a lake can be influenced by the amount of suspended materials such as phytoplankton, zooplankton, pollen, sediments, and dissolved compounds. The Secchi depth multiplied by 2 provides us with the euphotic depth of the lake. The euphotic depth is the maximum depth to which light can penetrate within a lake to facilitate growth.

In 2024, Secchi depths were measured on June 24, July 22, and August 9, 2024. A maximum Secchi depth of 3.4 m was recorded on July 22, while a minimum Secchi depth of 2.2 m was recorded on June 24, 2024 (Figure 2). The average Secchi depth of 2.7 m in Elinor Lake is indicative of a Mesotrophic (some productivity, nutrients, and algae growth) classification in accordance with the trophic status of lake water parameters (Nurnberg, 1996), provided in Table 1 of Appendix A.

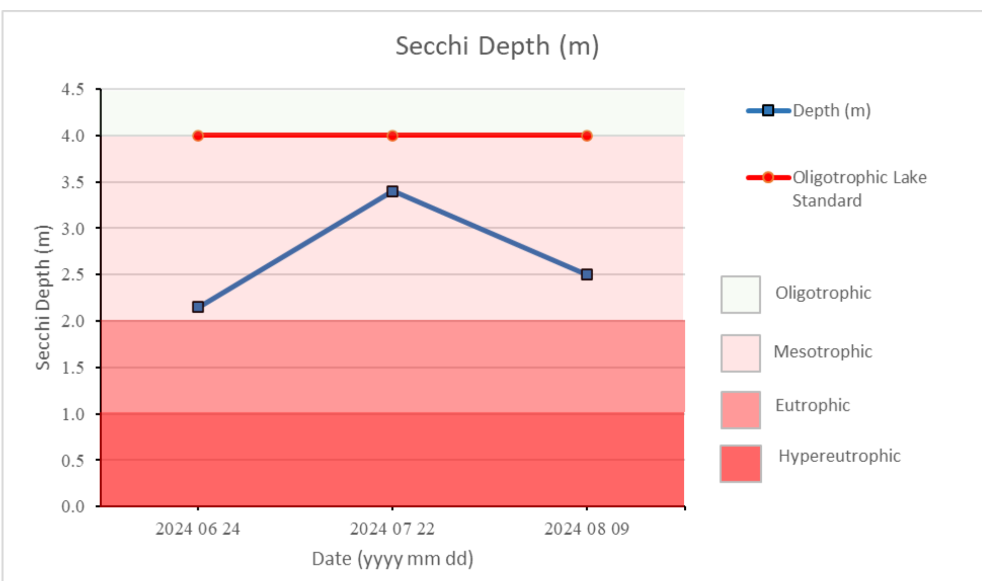

Figure 2: Secchi depth measurements in Elinor Lake – 2024

4.2 Dissolved Oxygen

Dissolved oxygen is the amount of gaseous oxygen dissolved in the water and is necessary for respiration and survival of aquatic life (e.g., fish, invertebrates, bacteria, and underwater plants). Dissolved oxygen is also needed for the decomposition of organic matter in the lakes. Oxygen enters the lake water by direct absorption from the atmosphere through rapid movement of water or as a product of plant photosynthesis. Therefore, the epilimnion zone (shallow layer of water) is relatively richer in oxygen than the hypolimnion zone (deeper layer of water), which is low in oxygen due to consumption by respiration.

There are several conditions necessary for fish survival in a lake including adequate water temperatures and available dissolved oxygen for respiration. The regulatory guidelines for dissolved oxygen in cold water lakes are 9.5 mg/L for early life stages and 6.5 mg/L for all other life stages (CCME, 1999). If dissolved oxygen levels are too low, fish will move to other depths in the water column, often where temperatures are conducive to sustain aquatic life.

The amount of dissolved oxygen in lakes usually decreases under winter ice-cover primarily due to respiration by organisms (particularly bacteria) and decomposition of organic matter. In shallow lakes, oxygen depletion can proceed rapidly under ice during the winter. If dissolved oxygen drops below 3.0 mg/L during the winter, many fish and invertebrate species will not survive.

In 2024, dissolved oxygen levels in Elinor Lake were recorded to a maximum depth of 18 m using a multi-probe on March 12, June 24, July 22, and August 9, 2024. The maximum recorded dissolved oxygen was 11.30 mg/L, observed on June 24 at a 1 m depth which declined gradually to 0.15 mg/L at a 17.5 m depth (Figure 3). The average dissolved oxygen concentration of 4.44 mg/L is slightly lower than the regulatory guidelines of 9.5 mg/L for early life and 6.5 mg/L for all other life stages in cold water lakes; however, Elinor Lake displays thermal stratification and has higher dissolved oxygen near the surface.

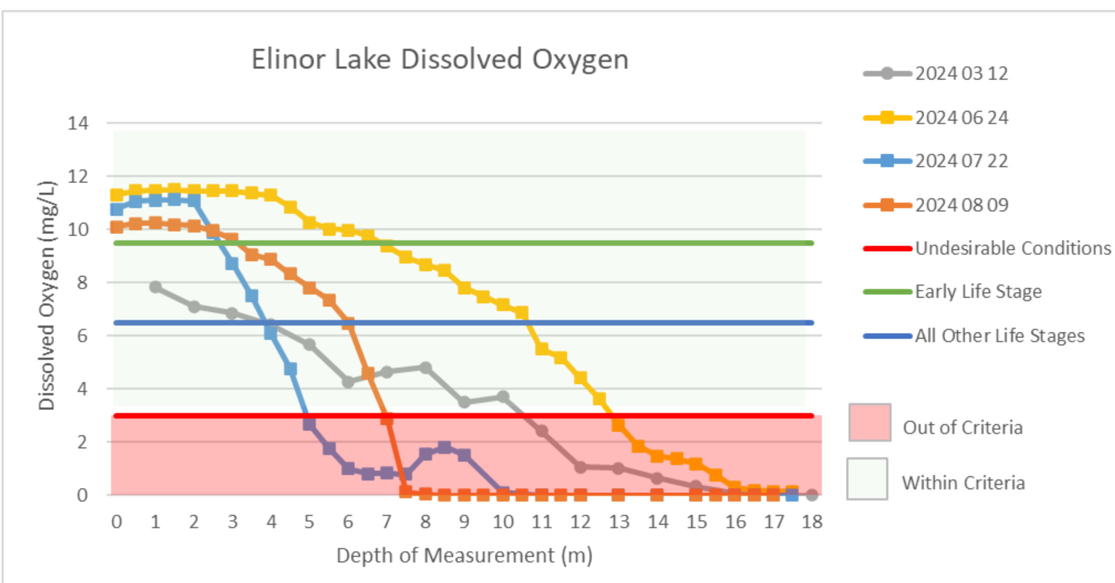

Figure 3: Dissolved oxygen in in Elinor Lake – 2024

4.3 Temperature

Water temperature in a lake determines the behavior of many parameters responsible for water quality. Thermal stratification occurs within a lake with a distinct difference in temperature between the surface water (epilimnion layer) and the deeper water (hypolimnion layer) separated by a thermocline. The thermocline is identified when the water changes by more than one degree Celsius per meter. Under winter conditions, ice covers the surface water, and a thermocline is formed with the colder water at the surface and the warmer water at the bottom of the lake. Lakes without thermal stratification mix from top to bottom and this mixing allows oxygen to distribute throughout the water column preventing hypolimnetic anoxia (lack of oxygen). In summertime, warmer surface water can facilitate cyanobacteria blooms at the lake surface (Wetzel, R. 2001).

Elinor Lake temperatures were recorded to a maximum depth of 18.0 m. A minimum temperature of 1.91 ˚C was recorded on March 12, 2024, at a 1 m depth, and a maximum temperature of 25.46 ˚C was observed on July 22, 2024, at a 0.1 m depth. An average summer water temperature of 15.47 ˚C was observed during the sampling period. Results of temperatures observed on different dates and depth are illustrated in Figure 4. Elinor Lake temperature sampling data showed a stratified temperature profile during the summer sampling events.

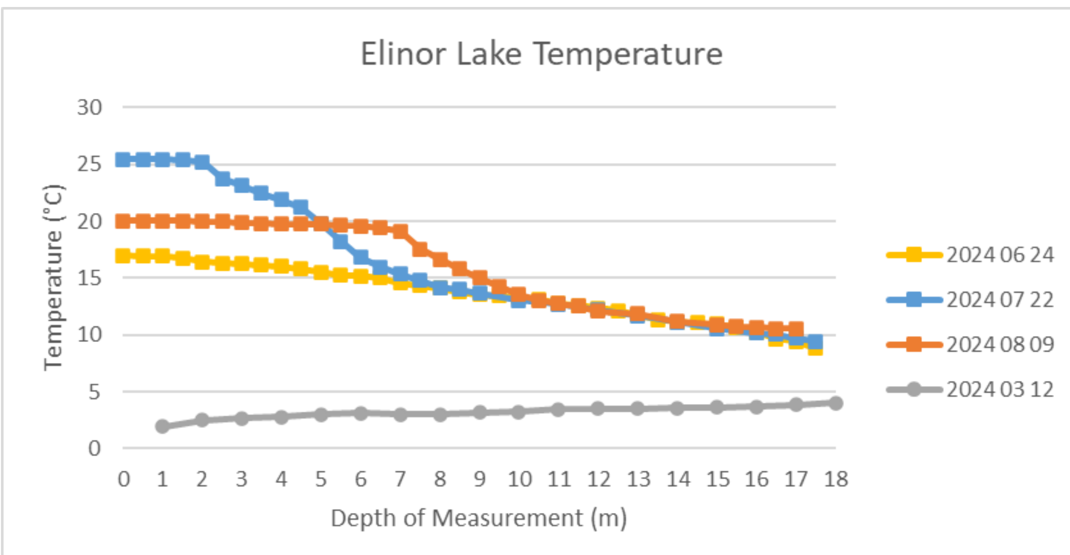

Figure 4: Elinor Lake temporal and spatial temperature measurements – 2024

4.4 Nutrients

Excessive levels of nitrogen and phosphorus are found in many lakes across Alberta leading to excessive growth of algae and aquatic plants. Decay of aquatic vegetation causes oxygen depletion in the water column and contributes to eutrophication. Consequently, the decreased levels of oxygen can suffocate fish and other aquatic organisms. High nutrient conditions foster algal blooms and can result in the proliferation of toxin-producing blue green algae (e.g., cyanobacteria). The input of nutrients into aquatic systems can occur naturally, but large amounts of nutrients typically originate from indirect, non-point anthropogenic sources, including improperly treated sewage, residential use of fertilizers and agricultural operations.

In 2024, two types of lake water samples for analyses of nutrients were collected from Elinor Lake; composite samples and Kemmerer samples (obtained from different depths using a Kemmerer device). These samples were analyzed for total nitrogen and total phosphorus.

Total Nitrogen

Total nitrogen is an essential nutrient for plants and animals; however, excessive amounts of nitrogen in lake water may lead to low levels of dissolved oxygen and negatively affect water quality and health of aquatic life within the lake. Nitrogen concentrations in the water are typically measured in three forms: ammonia, nitrates, and nitrites. Total nitrogen is the sum of total Kjeldahl nitrogen (ammonia, organic and reduced nitrogen), nitrate and nitrite. Nitrogen levels in lakes are also affected by atmospheric deposition and this refers to nitrogen in the air being deposited into the water system. Nitrogen oxides (NOx) are added to atmosphere due to the burning of fossil fuels, so emissions from motor vehicles and industrial facilities can also affect nitrogen levels in aquatic environments.

Composite Sampling

Composite lake water samples for total nitrogen analysis were collected on June 24, July 22, and August 9, 2024.

The minimum total nitrogen concentration of 1.10 mg/L was recorded on June 24 and August 9, while a maximum total nitrogen concentration of 1.20 mg/L was recorded on July 22, 2024 (Figure 5). The average total nitrogen concentration in the composite sampling was 1.13 mg/L of total nitrogen.

Lake water composite samples collected on June 24, July 22, and August 9, 2024, exceeded the regulatory guideline of 1.0 mg/L for total nitrogen. The average total nitrogen indicates that Elinor Lake is Eutrophic (high productivity, nutrients, and algae growth) based on total nitrogen from composite samples.

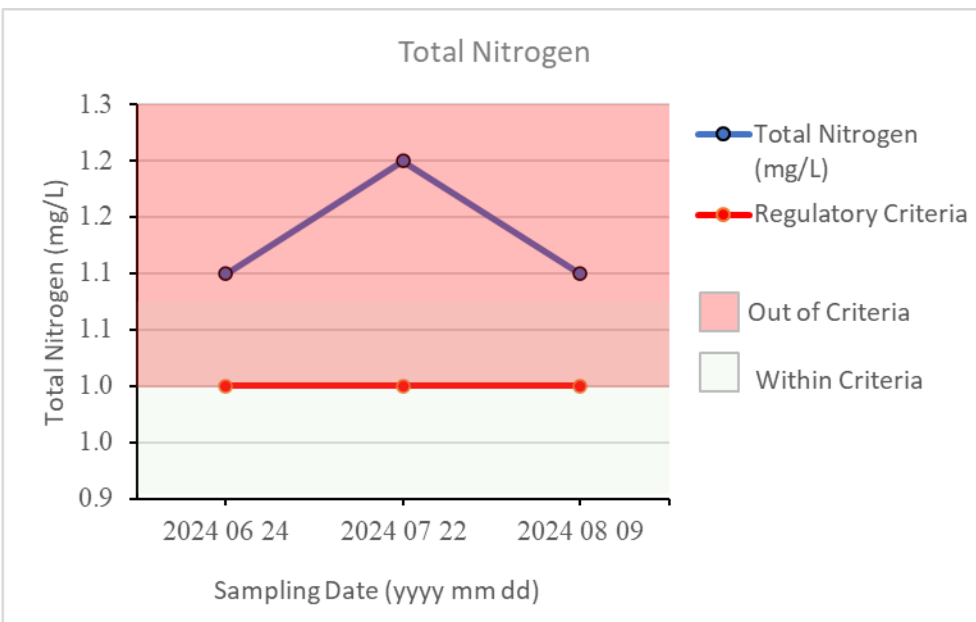

Figure 5: Total nitrogen from composite samples of Elinor Lake – 2024

Kemmerer Sampling

Kemmerer water samples are collected from different depths of the lake by using a Kemmerer device which makes it possible to obtain a sample of water from specific depths. Kemmerer samples were collected on March 12 from depths of 0 m, 3 m, 6 m, 9 m, 12 m, and 15 m. Kemmerer samples were not collected in August as Kemmerer sampling is not included in LakeWatch sampling procedures. These samples were analyzed for total nitrogen by ALS laboratories. Data regarding total nitrogen of Elinor Lake is illustrated in Figure 6.

A minimum total nitrogen concentration of 1.73 mg/L was found at a 9 m depth on March 12 and a maximum total nitrogen concentration of 2.27 mg/L was found at a 15 m depth on March 12, 2024. An overall average of 1.89 mg/L of total nitrogen was found in the Kemmerer samples. The total nitrogen concentrations in all samples exceeded the regulatory guideline of 1.0 mg/L. The results from the Kemmerer sampling resulted in a trophic state classification of Hypereutrophic (excessive productivity, nutrients, and algae growth) based on total nitrogen. The average total nitrogen concentration between both sampling types was observed to be 1.51 and would result in a classification of Hypereutrophic (excessive productivity, nutrients, and algae growth)

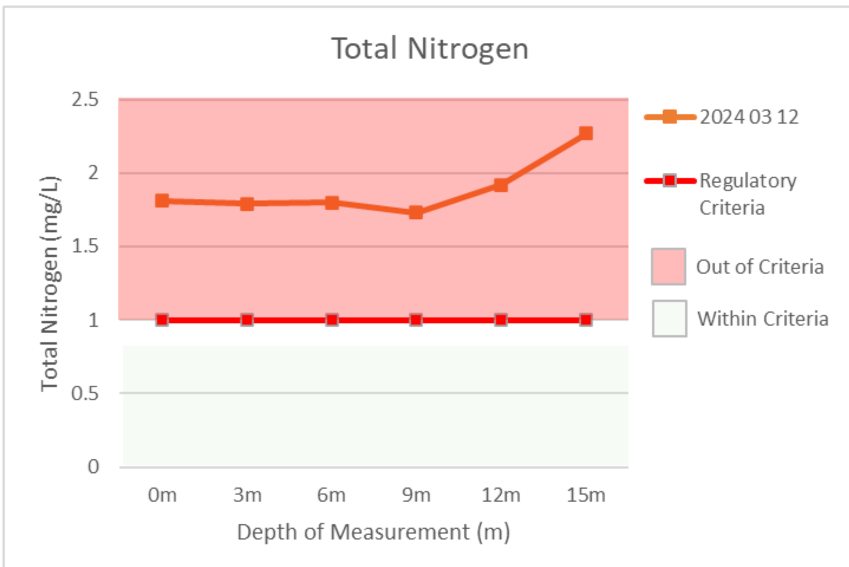

Figure 6: Total nitrogen from Kemmerer samples of Elinor Lake – 2024

Total Phosphorus

Increased phosphorus concentrations are the largest cause of degradation in water quality within lakes, causing 'dead zones', toxic algal blooms, a loss of biodiversity and increased health risks for plants, animals and humans that encounter polluted lake waters. Run-off from agriculture, human sewage and industrial practices results in increased phosphorus concentrations in lake water and lakebed sediments (Wetzel, 2001). Long-term monitoring activities following the control of phosphorus sources to lakes indicate that plants and animals do not recover from the effects of excessive phosphorus for several years.

Composite Sampling

Composite lake water samples for total phosphorus analysis were collected on June 24, July 22, and August 9, 2024. The analytical results are illustrated in Figure 7. Total phosphorus concentrations in the composite samples had an average of 0.034 mg/L of total phosphorus which is below the applicable regulatory guideline of 0.05 mg/L. This average total phosphorus concentration classifies Elinor Lake as Eutrophic (high productivity, nutrients, and algae growth) based on total phosphorus from composite samples.

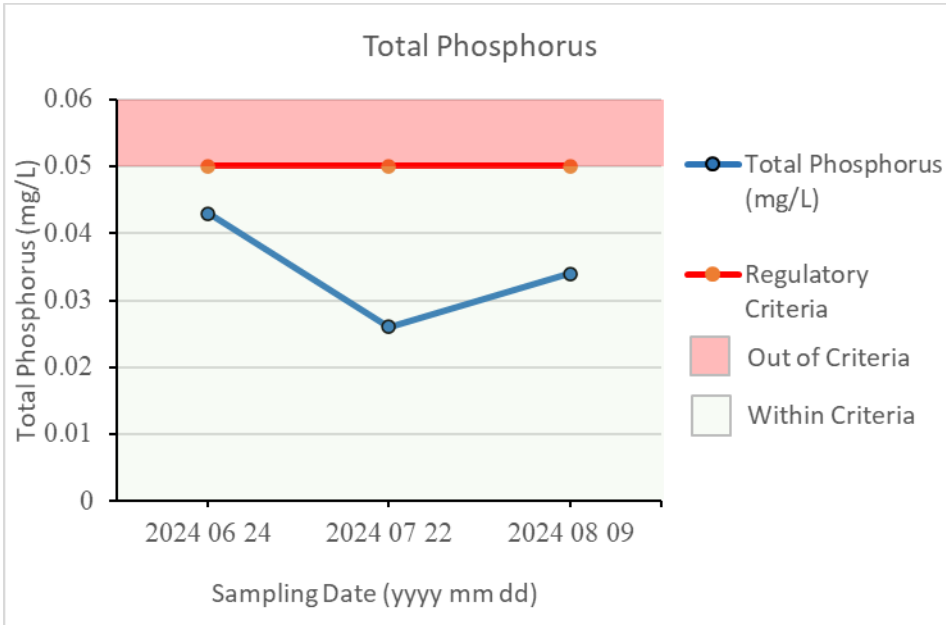

Figure 7: Total phosphorus from composite samples of Elinor Lake - 2024

Kemmerer Sampling

Kemmerer samples were collected on March 12 from depths of 0 m, 3 m, 6 m, 9 m, 12 m, and 15 m. Kemmerer samples were not collected in August as Kemmerer sampling is not included in LakeWatch sampling procedures. These were analyzed for total phosphorus by ALS laboratories. Analytical results are presented in Figure 8.

Total phosphorus concentrations displayed a spike in concentration at 15 m in depth. A minimum concentration of 0.051 mg/L was recorded at a 0 m depth, while a maximum concentration was recorded on the same sampling date at 15 m (lakebed). The average total phosphorus concentration was 0.067 mg/L from the Kemmerer samples, which is above the regulatory guideline of 0.05 mg/L. This average total phosphorus concentration classifies Elinor Lake as Eutrophic (high productivity, nutrients, and algae growth) based on total phosphorus from composite samples. Both composite and Kemmerer total phosphorous concentrations result in a trophic status of Eutrophic (high productivity, nutrients, and algae growth) based on total phosphorus.

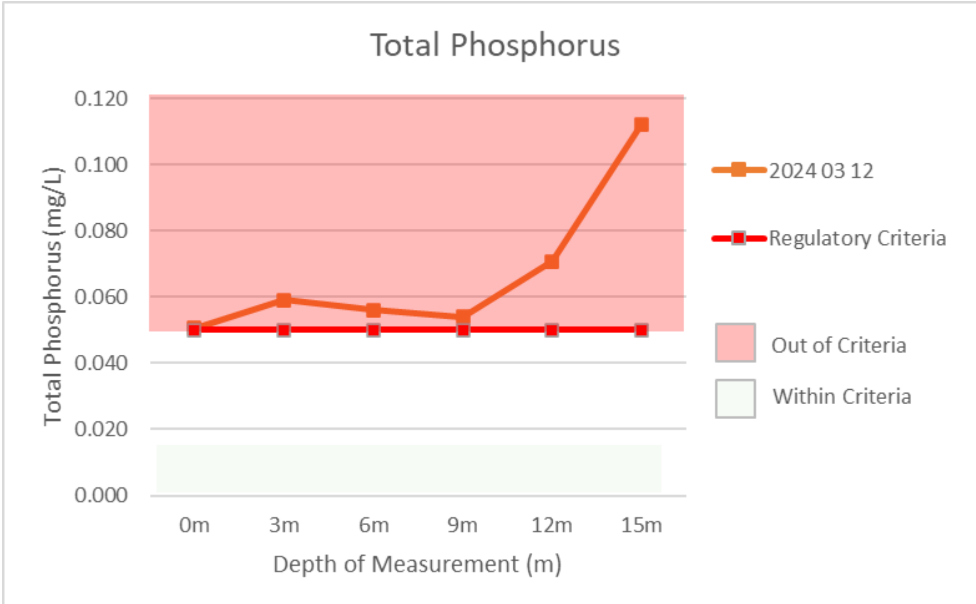

Figure 8: Total phosphorus from Kemmerer samples of Elinor Lake – 2024

N:P Ratio

The Redfield Ratio describes the optimal balance of total nitrogen to total phosphorus for aquatic plant growth and has an optimal value of 16:1 (Teubner and Dokulil 2002). If the ratio is lower than 16:1, phosphorus is no longer considered a limiting nutrient, and aquatic vegetation and cyanobacteria can use the dissolved and atmospheric nitrogen for growth by using the high amounts of phosphorus available in lake waters. If the ratio is higher than 16:1, it indicates that the phosphorus concentrations are occurring at levels much less than nitrogen and hence limits the growth within lakes.

The total nitrogen to total phosphorus ratio (N:P ratio) for composite and Kemmerer samples was 33:1 and 28:1, with an average of 30:1 between both sampling types. This is higher than the Redfield Ratio of 16:1, indicating that phosphorus is a limiting factor for growth in Elinor Lake.

4.5 Chlorophyll-a

Chlorophyll-a is used as a measurement of algal biomass present in lake water. It is a green pigment found in plants, algae, and cyanobacteria, which allows these organisms to photosynthesize. All algae and cyanobacteria produce chlorophyll-a, hence its usage as a proxy for algal biomass. High concentrations of chlorophyll-a indicate an elevated number of algae in the lake water. Due to the presence of chlorophyll-a in cyanobacteria, the measurement can be an underestimate of algae biomass when blue-green algae are present in the lake water.

Composite lake water samples for filtering and analyses of chlorophyll-a were collected on June 24, July 22, and August 9, 2024. The analytical results of these samples are presented in Figure 9 below. A minimum concentration of 10.8 µg/L was observed on July 22, 2024. The highest concentration of chlorophyll-a was observed on June 24, 2024, at 26.6 µg/L. Total chlorophyll-a concentrations in the samples collected during the summer of 2024 had an average of 18.73 µg/L of total chlorophyll-a, which classifies Elinor Lake as Eutrophic (excessive productivity, nutrients, and algae growth).

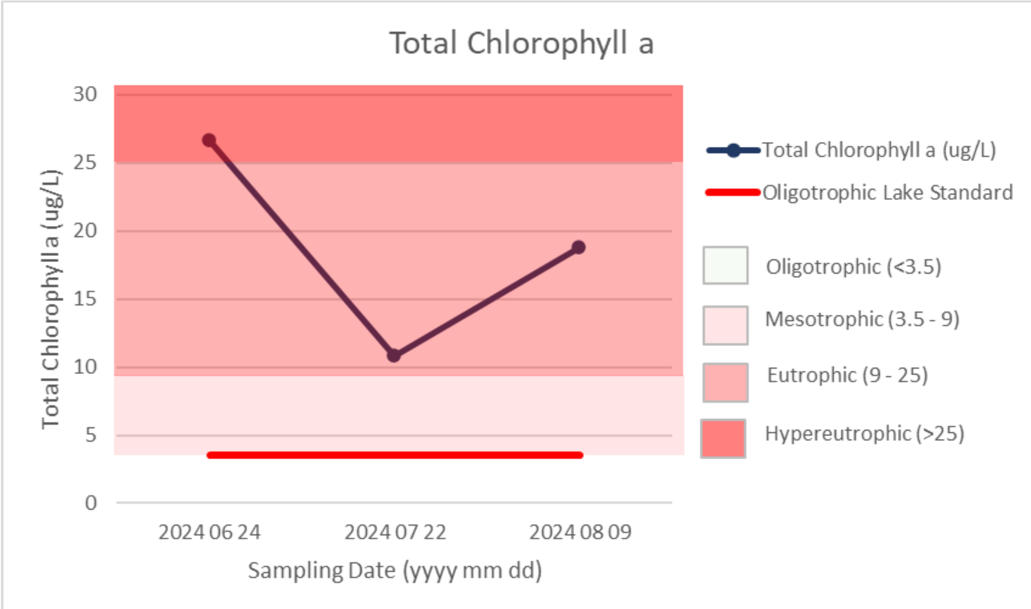

Figure 9: Total Chlorophyll-a from Composite samples of Elinor Lake – 2024

4.6 Routine Water Chemistry

Results of routine water chemistry of composite and Kemmerer samples are presented in Table 4 in Appendix A.

The average measured pH for Elinor Lake was 8.02 which was consistent with the average of past years. The pH of water determines the solubility and biological availability of chemical constituents such as nutrients and heavy metals. The ability of a lake to neutralize these hydrogen ions is referred to as buffering capacity. Any lake with a total alkalinity of more than 100 mg/L is considered to have high buffering capacity (Mitchell and Prepas 1990). The pH in Elinor Lake is likely buffered against change by its high alkalinity. The high alkalinity in Alberta lakes is derived from the rich calcareous glacial till over which the lakes have formed.

4.7 Metals

Metals enter the water naturally through the weathering of rocks and soil and are generally non-toxic and in low concentrations. However, metals can also come from a wide variety of anthropogenic and non-point pollution sources including runoff from urban areas, wastewater discharge, improperly managed sewage treatment, industrial activities, and agricultural runoff. The analytical results of total dissolved metals in the Kemmerer and composite water samples collected from Elinor Lake are presented in Table 5.

Concentrations of all metals analyzed from the composite and Kemmerer samples were generally below detection limits and/or below the applicable regulatory guidelines.

5 HISTORICAL TREND ANALYSIS

The objective of the historical trend analysis is to provide an overview of water quality conditions in a lake with time, and to evaluate the impact of watershed management practices on lake water quality.

Three parameters are significant in trend analyses for lake water quality: Secchi depth, total nitrogen, and total phosphorus; all of which are used for trophic classification of lakes.

5.1 Secchi Depth

Historical data shows that Secchi Depth in Elinor Lake ranged from 2.5 m – 4.25 m and has been less than the standard Oligotrophic Secchi Depth of 4 m except in 2009, 2018, and 2019 as illustrated in Figure 9. The historical Secchi depth shows that the clarity of Elinor Lake is relatively good, although the overall trend is declining. The Secchi depth of Elinor Lake in 2023 had the lowest measurement at 1.8 m. However, the Secchi depth readings may not provide an exact measure of the water transparency, as there can be errors due to the sun's glare on the water, and eyesight of the observer.

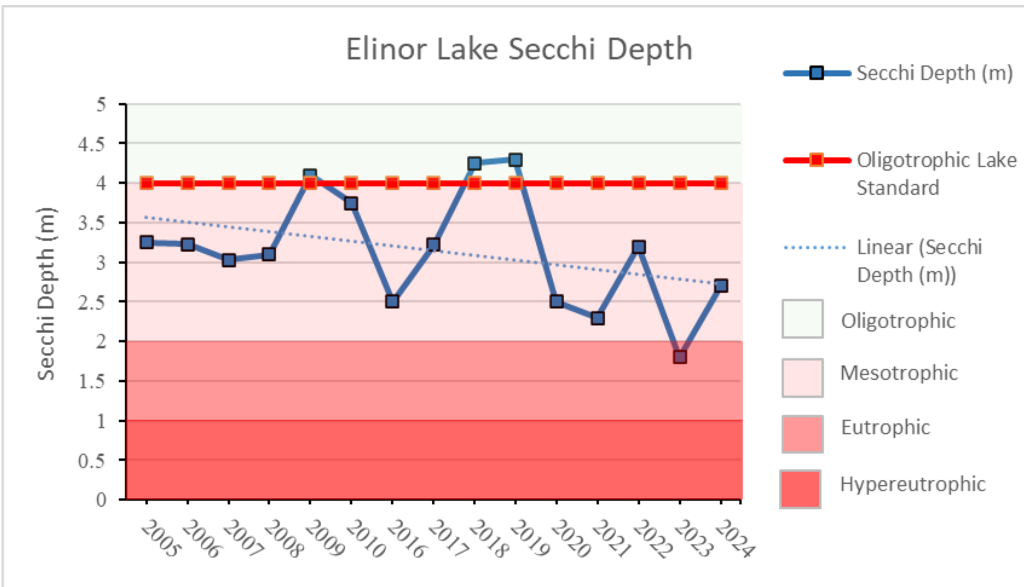

Figure 10: Historical trend for Secchi Depth in Elinor Lake

5.2 Total Nitrogen

Historical data shows that total nitrogen concentration in Elinor Lake ranged from 1.12 mg/L to 1.54 mg/L of total nitrogen and consistently exceeded the regulatory guideline of 1.0 mg/L. A maximum total nitrogen concentration of 1.69 mg/L was measured in 2023, resulting in an increasing trend in total nitrogen concentration which had previously been decreasing. However, improved water conditions in 2024 have stabilized these concentrations. Total nitrogen concentrations have historically been classified as Hypereutrophic (excessive productivity, nutrients, and algae growth).

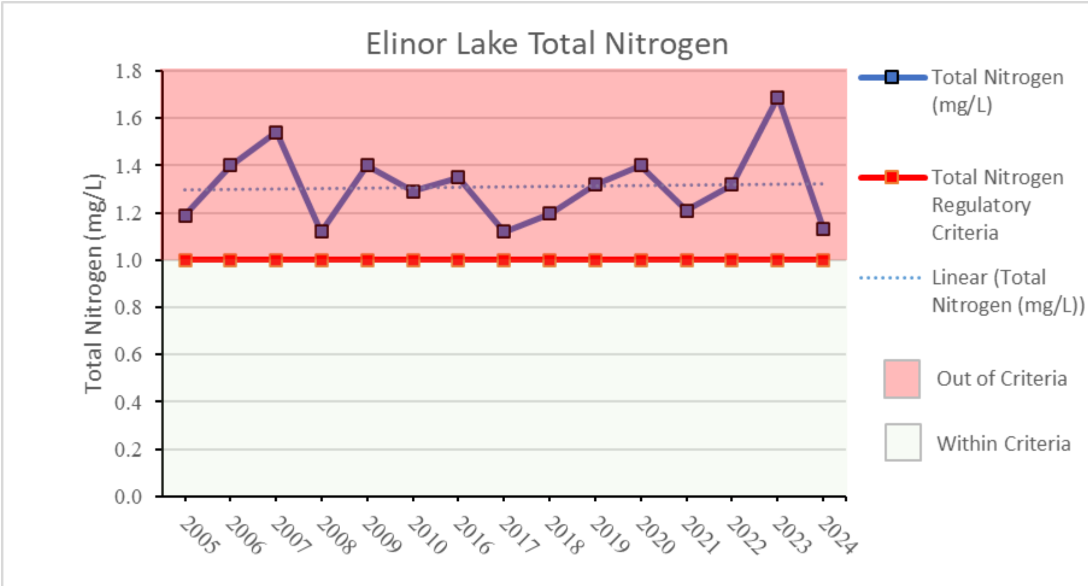

Figure 11: Historical trend of total nitrogen concentrations in Elinor Lake

5.3 Total Phosphorus

Historical data shows that the total phosphorus concentration has been without significant variation since testing began in 2005. Overall variation of total phosphorous concentrations ranged from 0.014 mg/L in 2005 to 0.036 mg/L in 2021. Total phosphorus concentrations in Elinor Lake did not exceed the regulatory guideline of 0.05 (Figure 11) since monitoring began in 1986. However, the overall trend shows that total phosphorus concentrations are increasing with time. Total phosphorus concentrations have historically been classified as Mesotrophic (some productivity, nutrient, and algae growth), Though concentrations in recent years have resulted in a classification of Eutrophic (high productivity, nutrients, and algae growth).

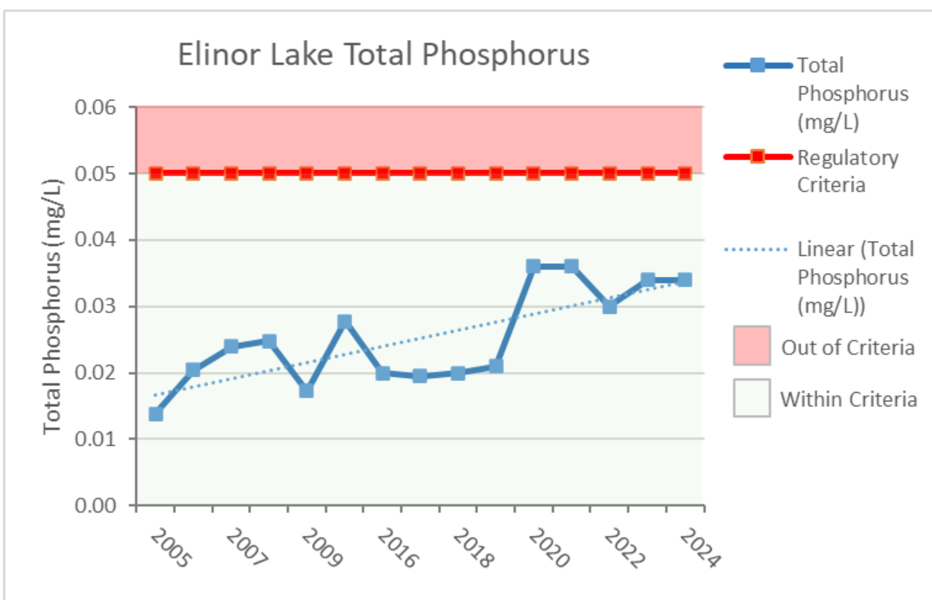

Figure 12: Historical trend of total phosphorus concentrations in Elinor Lake

6 DISCUSSION

Trophic State Index (TSI) is a classification system designed to rate lakes based on the amount of biological activity they sustain. The concentrations of nutrients (nitrogen and phosphorous) are the primary determinants of TSI. Increased concentrations of nutrients tend to result in increased plant growth, followed by an increase in subsequent trophic level. Nurnberg (1996) used parameters including Secchi depth, chlorophyll, total nitrogen, and total phosphorus concentrations in lake waters to determine the trophic state of the lakes, which is provided as Table 1 in Appendix A. TSI is a useful tool for evaluation and management of lake health and setting objectives including sport and recreational activities related to the lake. Trophic classification of Elinor Lake based on Secchi depth and nutrients is presented in Table 2.

There are four classes of trophic states which include: Oligotrophic which would be the highest quality of water with low productivity, nutrients and algae; Mesotrophic which is fair quality water with some productivity, nutrients and algae; Eutrophic which is relatively poor-quality water with high productivity, nutrients and algae; and Hypereutrophic which is the poorest quality water with excessive productivity, nutrients, and algae.

Elinor Lake would be considered Eutrophic based on the average of the four water parameters: Secchi depth, total nitrogen, total phosphorus, and total chlorophyll-a. The trophic status would be Mesotrophic based on Secchi depth, Hypereutrophic based on total nitrogen, Eutrophic based on total phosphorus, and Eutrophic based on chlorophyll-a.

7 RECOMMENDATIONS

It is recommended that Lac La Biche County continues to monitor the water quality of Elinor Lake on a regular basis. Continuous monitoring will help the County to determine how the lake management strategies and policies such as the Watershed Management Plan and Riparian Setback Matrix Model are impacting the lake water quality, and what the net effect on human and environmental health is.

Monitoring and sampling should continue to be conducted under a strategic plan and in a uniform manner to ensure that results produced are meaningful and are useful for establishing a correlation with the past results. This may include sampling at same period of the year each time, recording the same parameters critical to lake health, obtaining samples from the same depths, and implementing a quality assurance program for reliability of analytical results.

Nutrient loading is the main source of eutrophication in Elinor Lake which is degrading the water quality, leading to algae growth, foul smells and a reduction in water recreation. Therefore, action must be taken to slow down the eutrophication process and improve water quality. Best management practices would include the education of the public on appropriate land use including restoration and protection of riparian areas (water buffers) and strengthening laws and regulations governing land use such as municipal sewer hookups and protection of environmental reserves.

Lac La Biche County updated the Lac La Biche Watershed Management Plan, which was adopted by Council in May 2021. This plan includes specific action items based on the recommendations that were formulated while drafting the plan. Although Elinor Lake is not within the Lac La Biche watershed, the recommended action items may still apply.

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~A Special Thank you to the Alberta Lake Management Society and their LakeWatch volunteer for providing us with the 2024 summer data for Elinor Lake~

APPENDIX A

Table 1: Trophic status classification based on lake water parameters (Nurnberg 1996)

Trophic State	**Total Phosphorus (mg/L)**	**Total Nitrogen (mg/L)**	**Secchi Depth (m)**	**Chlorophyll-a (µg/L)**
Oligotrophic	<0.01	<0.35	>4	<3.5
Mesotrophic	0.01 – 0.03	0.35 – 0.65	4 - 2	3.5 – 9
Eutrophic	0.03 – 0.10	0.65 – 1.20	2 - 1	9 – 25
Hypereutrophic	>0.10	>1.20	<1	>25

Table 2: Trophic status of Elinor Lake based on lake water parameters 2024

Trophic State	**Secchi Depth**	**Total Nitrogen**	**Total Phosphorus**	**Total Chlorophyll-a**
	(m)	(mg/L)		(µg/L)
Oligotrophic	>4	<0.35	<0.01	<3.5
Mesotrophic	4 – 2	0.35 – 0.65	0.01 – 0.03	3.5 – 9
Eutrophic	2 – 1	0.65 – 1.2	0.03 – 0.1	9 – 25
Hypereutrophic	<1	>1.2	>0.1	>25
Elinor Lake 2024	2.7	1.13	0.034	18.73
Trophic State of Elinor Lake in 2024	Mesotrophic	Hypereutrophic	Eutrophic	Eutrophic

Table 3: Average lake water N:P ratios for composite and Kemmerer samples from Elinor Lake

Sampling Event	**Total Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**N:P**
Composite Sampling	1.13	0.034	33:1
Kemmerer Sampling	1.89	0.067	28:1

Table 4: Routine water chemistry analysis from Elinor Lake composite samples – 2024

	June 24, 2024	**July 22, 2024**	**August 9, 2024**
	mg/L		
pH	8.10	8.01	8.02
Temperature (°C)	13.64	17.00	16.14
Ammonia, Total (as N)	0.016	0.048	0.075
Nitrate (as N)	0.0075	0.0045	0.0015
Nitrite (as N)	0.0005	0.0005	0.0005
Nitrate and Nitrite (as N)	0.0075	0.0045	0.0015

* Based on average pH and temperature of 8.02 and 15.47 °C of Elinor Lake in 2024

1: CCME C Guidelines, de-minimis criteria for Protection of Aquatic Life and Agricultural Water Uses

2 - Environmental Quality Guidelines for Alberta Surface Waters 2018

a: CCME Canadian Environmental Quality Guidelines for water for the Protection of Aquatic Life

b: CCME Guidelines for Protection of Agricultural Water

Table 5: Dissolved metals in Elinor Lake– 2024

Date of Sampling	**Kemmerer Sampling (9 m depth) March 12, 2024**	**Criteria[1]**	**Criteria[2]**
Parameters	-------------(mg/L)--------------		
Aluminum (Al)-Total	0.0043	0.1[a]	0.1
Arsenic (As)-Total	0.00102	0.005[a]	0.005
Barium (Ba)-Total	0.0584	NS	NS
Beryllium (Be)-Total	<0.000020	100[b]	NS
Boron (B)-Total	0.06	1.5[a]	1.5
Cadmium (Cd)-Total	<0.0000050	0.00009[a]	0.00033
Chromium (Cr)-Total	0.00062	NS	NS
Cobalt (Co)-Total	<0.00010	0.05[a]	0.0012
Copper (Cu)-Total	<0.00050	0.0040[a]	0.022
Iron (Fe)-Total	<0.010	0.3[a]	0.3
Lead (Pb)-Total	<0.000050	0.007[a]	0.007
Lithium (Li)-Total	0.0279	2.5[b]	NS
Manganese (Mn)-Total	32.3	0.2[b]	NS
Mercury (Hg)-Total	<0.0000050	0.000026[a]	NS
Molybdenum (Mo)-Tot	0.000107	0.073[a]	0.073
Nickel (Ni)-Total	0.00076	0.150[a]	0.11
Selenium (Se)-Total	<0.000050	0.001[a]	NS
Silver (Ag)-Total	<0.000010	0.00025[a]	0.00025
Thallium (Tl)-Total	<0.000010	0.0008[a]	0.0008
Tin (Sn)-Total	<0.00010	NS	NS
Titanium (Ti)-Total	<0.00030	NS	NS
Uranium (U)-Total	0.000123	0.01[b]	0.015
Vanadium (V)-Total	<0.00050	0.1[b]	NS
Zinc (Zn)-Total	<0.0030	0.007[a]	0.03

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Table 6: Historical trend of water chemistry parameters from the Elinor Lake

	Year														
Parameter	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
pH	8.36	8.26	8.26	8.13	8.60	8.33	8.15	8.35	7.79	8.11	8.11	7.52	7.5	7.76	8.02
Secchi Depth (m)	3.25	3.23	3.03	3.10	4.10	3.75	2.50	3.22	4.25	4.30	2.5	2.3	3.2	1.8	2.7
Total Nitrogen (mg/L)	1.19	1.40	1.54	1.12	1.40	1.29	1.35	1.12	1.20	1.32	1.4	1.21	1.32	1.69	1.13
Total Phosphorus (mg/L)	0.014	0.020	0.024	0.025	0.017	0.028	0.020	0.020	0.020	0.020	0.036	0.036	0.030	0.034	0.034
Specific Conductivity (µS/cm)	347	359	380	392	402	379	407	331	572	357	569	636	825	435	580.5

Table 7. Historical trend of dissolved metals from the Elinor Lake

Dissolved Metals	2020	2021	2022	2023	2024*	Criteria[1]	Criteria[2]
	-------------------(mg/L) -----------------						
Aluminum (Al)	<0.0030	0.005	0.00445	0.0049	0.0043	0.1a	0.1
Arsenic (As)	0.00083	0.00095	0.001	0.00149	0.00102	0.005a	0.005
Barium (Ba)	0.0483	0.0514	0.05655	0.05095	0.0584	NS	NS
Beryllium (Be)-Total	<0.00010	<0.00010	<0.000020	<0.000020	<0.000020	100b	NS
Boron (B)	0.057	0.053	0.0575	0.037	0.06	1.5a	1.5
Cadmium (Cd)	<0.0000050	<0.000005	0.0000178	<0.0000050	<0.0000050	0.0037a	0.00025
Chromium (Cr)	<0.00010	0.00043	<0.00050	<0.00050	0.00062	-	NS
Cobalt (Co)-Total	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.05a	0.0012
Copper (Cu)	<0.000645	<0.00050	0.001735	0.00186	<0.00050	0.0038a	0.028
Iron (Fe)	<0.010	0.013	0.02	0.0325	<0.010	0.3a	0.3
Lead (Pb)	<0.000050	<0.000050	0.0001315	0.000802	<0.000050	0.0065a	0.0065
Lithium (Li)-Total	0.0232	0.0231	0.0257	0.01045	0.0279	2.5b	NS
Manganese (Mn)	0.0839	0.0554	0.14236	0.1241	32.3	0.2b	NS
Mercury (Hg)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.000026a	NS
Molybdenum (Mo)-Total	<0.000050	<0.000050	<0.000050	0.0003995	0.000107	0.073a	0.073
Nickel (Ni)	<0.00050	<0.00050	<0.00050	0.00087	0.00076	0.147a	0.084
Selenium (Se)	<0.000050	<0.000050	<0.000050	0.000053	<0.000050	0.001a	NS
Silver (Ag)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.00025a	0.00025
Thallium (Tl)-Total	<0.000010	<0.000010	0.000018	<0.000010	<0.000010	0.0008a	0.0008
Tin (Sn)-Total	<0.00010	<0.00010	<0.00010	0.0001	<0.00010	NS	NS
Titanium (Ti)-Total	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	NS	NS
Uranium (U)	0.0000585	<0.00050	0.000116	0.0000575	0.000123	0.01b	0.015
Vanadium (V)-Total	<0.00050	<0.00050	0.00056	<0.00050	<0.00050	0.1b	NS
Zinc (Zn)	<0.0030	<0.0030	0.00555	0.0031	<0.0030	0.007a	0.03

*: Concentrations are based off the March 12 sampling event and are not a seasonal average

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