Associated Environmental

REPORT

Wizard Lake Watershed and Lake Stewardship Association

Wizard Lake Data Summary

JUNE 2021

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EXECUTIVE SUMMARY

The Wizard Lake Watershed and Lake Stewardship Association retained Associated Environmental Consultants Inc. to review reports, analyze water quality data and interpret what they mean for shoreline residents, Wizard Lake and watershed stewardship. This report summarizes existing knowledge about the health of Wizard Lake and its watershed (Section 2), evaluates the WLWLSA's creek sampling program and interprets the collected data (Section 3), presents a high-level breakdown of the sources of phosphorus to the lake to evaluate where most nutrients are coming from that feed lake algae (Section 4) and provides recommendations on next steps to improve understanding and management of Wizard Lake and its watershed (Section 5).

Overall, the water quality, shoreline, and watershed health of Wizard Lake are well understood. Wizard Lake has high nutrients and very high algae growth, as shown by the development of blue-green algae (cyanobacteria) blooms. This results in the detection of algal toxins in the water, but so far not at levels dangerous for swimmers. Another result of abundant algae is low oxygen under ice in winter, limiting the types of fish that can survive in Wizard Lake to tolerant species, such as Northern Pike. There has been a tendency for more algae in water over time from the late 1980s to recently, but more data are required to evaluate the significance of this trend.

The western portion of the lakeshore is very healthy due to the wetland and forests surrounding the lake there, while the eastern shores are strongly impacted by shoreline development. Half of the watershed is forested, which is beneficial for lake water quality and wildlife habitat, while about 38% of the watershed are used for agriculture and 10% is developed. The level of best management practice implementation in agricultural areas for water quality protection is unknown.

Our review of the WLWLSA's creek sampling program concluded that procedures were of good quality, providing meaningful data. Data from 2007, 2011, and 2018 indicate that the south-eastern portion of the watershed (Inflow 4) contributes most nutrients to the lake. This portion of the watershed is therefore the best candidate for stewardship actions to reduce nutrient inputs to Wizard Lake. Dissolved phosphorus, an important driver of algae growth, correlated with percent of agricultural land use in the sub-watersheds in the sampled creeks. Also, one individual farmyard has had a measurable effect on tributary water quality, indicating that best management practices such as riparian restoration on agricultural lands may be most suited to reduce nutrient inputs from creeks to Wizard Lake.

A preliminary phosphorus budget was completed to quantify the different sources of phosphorus to the lake. Once the relative importance of each source is known, the most effective ways to reduce phosphorus and thereby algae can be identified. Agricultural land contributes the largest amount of phosphorus to Wizard Lake from the watershed. Additional information of the flows into and out of the lake would help refine the phosphorus budget, as the relative importance of a potentially large phosphorus source, release from sediments, is not well understood.

To better understand the water quality of Wizard Lake, we recommend the following:

- Continue collecting water quality samples from the four inflows for another 2-3 years.
- Improve the phosphorus budget by developing a water balance and estimating internal load.
- Determine interest in people collecting information such as dates of algae blooms and weather conditions in the previous week.
- Participate annually in Alberta Health beach monitoring, if possible, to evaluate cyanobacteria abundance and the risk of cyanotoxin development at Wizard Lake.

To promote the health of the lake, we recommend the following:

- Determine which agricultural best management practices are most practical and most effective and work with farmers to implement them in the watershed to reduce nutrients in inflowing creeks.
- Set goals for riparian (shoreline) intactness and work with residents to achieve them.
- Ask residents to have their septic systems inspected; encourage pump-out systems.

ACKNOWLEDGEMENTS

We thank the board and members of the Wizard Lake Watershed and Lake Stewardship Association (WLWLSA) for their tireless efforts as stewards of Wizard Lake and for completing the creek sampling program. We thank in particular Blake and Linda Bartlett, who assembled the majority of information that was summarized in this report, provided a blissful and insightful boat tour of the lake and patiently assisted with our numerous information requests during the completion of this report.

We thank Alberta Environment and Parks for assisting in the early stages of the creek sampling program, providing water quality data for Wizard Lake and tributaries in organized form and for providing the watershed boundary spatial data for mapping. We are grateful to Arin MacFarlane-Dyer who facilitated the data access.

We thank Caleb Sinn and Bradley Peter from the Alberta Lake Management Society for providing up-to-date reports and data from the LakeWatch and LakeKeepers Programs on Wizard Lake as well as the Alberta Health beach monitoring program.

Last but not least, this project would not have been possible without the generous financial assistance of the Watershed Stewardship Grant Program from the Land Stewardship Centre and John Hrynkow, Bryan Mason, Linc Drynan, Richard Ipsen and Linda Bartlett.

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LIST OF ABBREVIATIONS

AEP	Alberta Environment and Parks
ALMS	Alberta Lake Management Society
NSWA	North Saskatchewan Watershed Alliance
P	Phosphorus
TDP	Total dissolved phosphorus
TP	Total phosphorus
WLWLSA	Wizard Lake Watershed and Lake Stewardship Association

GLOSSARY

Ammonia nitrogen concentrations - Ammonia is the preferred nitrogen-containing nutrient for plant growth.

Ammoniacal nitrogen - is a measure for the amount of ammonia, a toxic pollutant often found in waste products, such as sewage, liquid manure and other liquid organic waste products.

Atmospheric deposition - Process that removes gases and particles from the atmosphere.

Chlorophyll-a - is the primary pigment of photosynthesis for a majority of organisms such as plants, cyanobacteria, algae. In water quality analysis it is used to estimate the total biomass of all floating algae.

Creek – for the purposes of this report a creek could include creek, country road ditch, or man-made drainage canal.

Dimictic lake - A dimictic lake is a body of freshwater whose difference in temperature between surface and bottom layers becomes negligible twice per year (usually spring and summer), allowing all strata of the lake's water to circulate vertically.

Eutrophic - A eutrophic condition is a term describing a situation where a water body is "fed" too many nutrients, especially phosphorus and nitrogen. Elevated nutrients increase algae and plant growth, which, when decomposing, can result in loss of dissolved oxygen and negative effects to aquatic life.

Hypereutrophic lakes - are very nutrient-rich lakes characterized by frequent and severe nuisance algal blooms and low transparency.

Kjeldahl nitrogen - The Kjeldahl method is the quantitative determination of nitrogen contained in organic substances plus the nitrogen contained in the inorganic compounds ammonia and ammonium.

mg/L - milligram per liter.

Morphology - The shape and volume of a lake, which is determined by the lake's age and origins.

Nutrients in lakes are essential for the growth of algae and aquatic plants. The main nutrients come in the form of nitrogen (N) and phosphorus (P). However, only small amounts of each are required and any additional increase of these nutrients can quickly become a nuisance by causing excessive algae and plant growth. Increases in nutrients are nearly always as a result of land use activities or direct discharges from industry.

pH - a measure of how acidic/basic water is. The range goes from 0 to 14, with 7 being neutral. pHs of less than 7 indicate acidity, whereas a pH of greater than 7 indicates an alkaline environment.

Photosynthesis - a process used by plants and other organisms to convert light energy into chemical energy that, through cellular respiration, can later be released to fuel the organism's metabolic activities.

Specific Conductance - is a measure of how well water can conduct an electrical current, made at or corrected to 25°C. It is related to the amount of salts that are dissolved in water.

Stewardship - "the conducting, supervising, or managing of something; especially the careful and responsible management of something entrusted to one's care."

Sub-watershed - the area of land that a water course, e.g., a creek, flows over or through to drain into a larger body of water.

Total dissolved phosphorus - the phosphorus that remains in water after that water has been filtered to remove particulate matter.

Total phosphorus - a better way to measure phosphorus in lakes because it includes the phosphorus in plant and animal fragments suspended in lake water. TP levels are more stable and an annual mean can tell you a lot about the lake's water quality and the biological production of plant and animal life occurring in a lake.

Total suspended solids - these solids include anything drifting or floating in the water, from sediment, silt, and sand to plankton and algae.

Tributary – a water course that flows into another water body. In this report, this was also referred to as "inflow".

µg/L microgram per liter

Watershed – All lands that drain water to a water body. Used interchangeably with drainage basin or catchment.

1 INTRODUCTION

Community members around Wizard Lake interested in stewardship created a registered society called Wizard Lake Watershed and Lake Stewardship Association (WLWLSA) in 2006. The work of WLWLSA builds upon informal lake stewardship by residents since at least 1980, when the first lake management plan was created. The mission of the WLWLSA is to work toward enhancing and protecting the sustainability and enjoyment of Wizard Lake for the benefit of all users and watershed inhabitants (WLWLSA 2020). As part of this commitment and in consultation with Alberta Environment and Parks (AEP), the WLWLSA has collected water quality samples in tributaries that flow into Wizard Lake in 2007, 2010, 2011 and 2018. In addition, WLWLSA members have obtained lake water quality data from the TransAlta Biomonitoring Program (TransAlta 2017) and from the LakeWatch sampling completed by the Alberta Lake Management Society (2006, annually 2008-2011, 2013, 2016) (ALMS 2020) and other reports related to Wizard Lake. To date, there has been little to no integrated analysis and interpretation of these data and reports, thereby limiting the usefulness of the information for the WLWLSA in their efforts to advance lake stewardship.

The WLWLSA retained Associated Environmental Consultants Inc. to review existing scientific papers, collected data and reports and interpret what they mean for shoreline residents and lake and watershed stewardship. This report summarizes existing knowledge about the health of Wizard Lake and its watershed (Section 2), evaluates the WLWLSA's creek sampling program and interprets the collected data (Section 3), presents a high-level breakdown of the potential sources of phosphorus that feed lake algae (Section 4) and provides recommendations on next steps to improve understanding and management of Wizard Lake and its watershed (Section 5).

2 WHAT DO WE KNOW?

This section summarizes existing information on Wizard Lake, including a general overview of physical setting and importance of the lake. Also provided is information on the three different but interconnected parts of the lake: the lake itself, the lakeshore (or riparian area) that is the immediate area surrounding the lake, and the watershed, which is all the land area from where rainwater drains into the lake. The information presented in this section was taken from materials provided by the WLWLSA (Appendix A), by ALMS or obtained from publicly available sources online.

2.1 Overview

Wizard Lake is located approximately 50 km southwest of Edmonton, Alberta. The lake provides important fish and wildlife habitat and is recognized as a regionally Environmentally Sensitive Area (Aquality 2012). Wizard Lake is a popular recreational lake for shoreline residents (Table 2-1) and visitors. Recreational activities include boating, swimming, scuba diving, waterskiing, canoeing, and fishing (ALMS 2018). A portion of the lake has reduced speed limits to provide a safe area for swimmers and people wanting to enjoy slower water sports. Shoreline residents enjoy the benefits of recreation and year-round beauty of the water and wildlife.

Wizard Lake has a unique narrow shape resulting from glacial meltwater channel landscape.

The lake's outflow, Conjuring Creek, flows about 35 km north and joins the North Saskatchewan River just upstream of the Town of Devon. Wizard Lake has a unique narrow shape that resulted from glacial meltwater channel landscape development. The lake is subdivided into a small west basin and the main body of the lake in the centre and east. A wetland occupies the west end of the lake. Water flows through the lake and drains at the east end into Conjuring Creek. The steeper shoreline slopes continue into the water to create deep spots, up to 11 m deep, that remain separated from the warm surface water in summer. This separation is called a stratified water column whereby deeper water will stay cool in summer and only mix vertically twice per year, in spring and fall (also called dimictic). Despite its total length of 11.5 km, the lake only covers 3.6 km^2, which is about 10 times smaller than the watershed (Table 2-1). This results in a relatively short duration to renew the lake's water (13-14 years). The deeply cut slopes and lake contours mean that groundwater enters the lake from the bottom. The groundwater assessment for Wetaskiwin County estimated a groundwater flow of 483 m^3/d in a northeast direction through Wizard Lake as part of the Upper Scolland Aquifer (Hydrogeological Consultants 2008) and based on the morphology of the lake, groundwater will enter the lake through the bottom.

Table 2-1
Key Facts about Wizard Lake

Parameter	Detail
Area of Wizard Lake Watershed (land only) (km^2)	36.4
Area of Wizard Lake including and excluding western wetland (km^2)	3.6 (2.48 excluding wetland)
Length of Wizard Lake including west basin (km)	11.5[1]
Maximum Depth of Wizard Lake (m)	11[1]
Watershed to Lake Area Ratio	10.2
Name of Larger Watershed	Within Strawberry Creek sub-basin which is within the North Saskatchewan Watershed
Volume of Wizard Lake (m^3)	14.8 million[2]
Residence Time	13 – 14 years[3]
Counties in the Watershed	Leduc and Wetaskiwin Counties
Population of Watershed	1173[3]
Number of Shoreline Residences	270[4]
Number of Residences in Watershed	391[2]
Number of Shoreline Campsites (Jubilee Park Campground)	111
Name of Outlet Stream	Conjuring Creek

Notes:

1. ALMS 2016
2. Mitchell 1998
3. Aquality Environmental Consulting Ltd. 2012
4. Personal communication with Blake Bartlett

2.2 Lake Health

2.2.1 Water Quality

Wizard Lake is rich in nutrients that support algae growth (i.e., phosphorus and nitrogen) (Aquality 2012). It is classified as a eutrophic lake based on total phosphorus (TP) concentrations and as hyper-eutrophic based on chlorophyll-a concentrations (ALMS 2020a). This means that Wizard Lake has high nutrients and very high algae growth, compared to lakes worldwide. Phosphorus concentrations in Wizard Lake typically increase throughout summer, after the period of main watershed runoff (ALMS 2020a). This indicates that a portion of the phosphorus is released from the sediments.

The ratio of nitrogen to phosphorus in Wizard Lake is relatively low (average molar ratio of 12), indicating that both phosphorus and nitrogen are important for algae growth in the lake (Guilford and Hecky 2000). This means that reducing inputs of both nutrients to the lake is important to control algal growth.

Phosphorus concentrations in Wizard Lake typically increase throughout summer. This indicates that phosphorus is released from the sediments.

During the summer months, oxygen levels are generally high in surface waters but lower in deeper waters (e.g., ALMS 2020a). In winter, oxygen remains generally low throughout the water column (ALMS 2020b). This is likely one key reason why the fish community consists of Northern Pike, a species that can tolerate low oxygen levels (Aquality 2012).

The TransAlta biomonitoring program evaluates if power generating stations that are located upwind (e.g., Wabamun, Sundance, Keephills and Genesee) have an impact on water quality in downwind water bodies, including Wizard Lake. The TransAlta program found that trace metals in water, sediment, and fish in Wizard Lake have not changed significantly in Wizard Lake since the start of monitoring in 2004.

2.2.2 Algae

The number and types of algae growing in a lake determines if there are aesthetic issues, such as scum, colours and smell, and health risks related to algae toxins. As part of the ALMS lake monitoring, total algae biomass is measured as chlorophyll-a in water. These data collected since the 1980s (with a gap during the 1990s) show that total algae biomass had a tendency to increase over time (Figure 2-1).

Alberta Health has monitored beach water quality at Jubilee Park to evaluate the risk of cyanobacteria (blue-green algae) toxins to swimmers. Cyanobacteria are part of the natural algae community in many Alberta lakes, but can produce harmful toxins (e.g., cyanotoxins) when blooming. The cyanobacteria and cyanotoxin data available online for 2014-2017 (Alberta Health 2021) showed an increase in the numbers of cyanobacteria and cyanotoxin concentrations at the beach throughout these years (Figure 2-2). The threshold of 100,000 cells/mL that Alberta Health uses to issue a blue-green algae advisory was exceeded each year from 2014-2017. The most common algae types were *Aphanothece* and *Microcystis*, which can produce microcystin, a type of cyanotoxin. Microcystin was detected in most samples, but the concentrations remained about ten times lower than the recreational objective of 20 µg/L, and therefore were not of concern for swimmer health. Still, it is always advisable to avoid surface scums and algae accumulations, as toxin concentrations in those can be much higher than in a composite water sample. To our knowledge, no beach cyanobacteria sampling was conducted at Wizard Lake in 2018-2020.

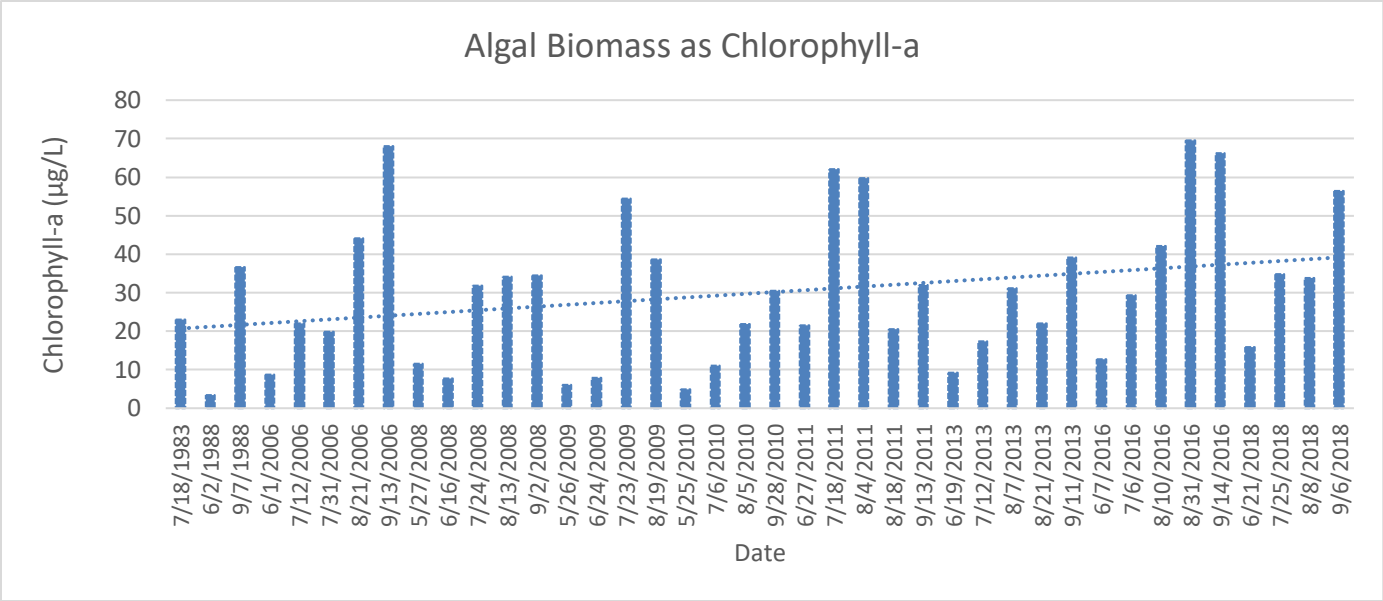

Figure 2-1
Total Algal Biomass as Chlorophyll-a in Wizard Lake over Time

Note: Chlorophyll-a data are from lake composite samples taken in summer (June-September). The dotted line is a linear trend line, but was not tested for statistical significance.

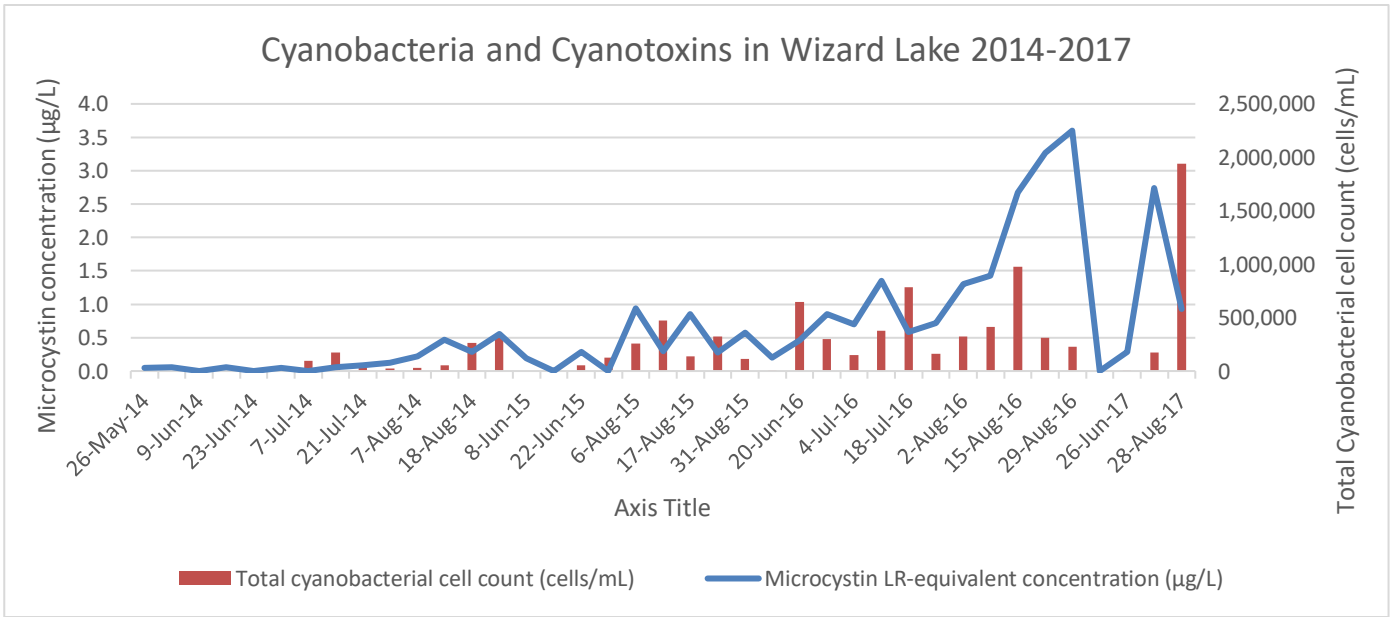

Figure 2-2
Cyanobacterial Cell Counts and Cyanotoxin Concentrations at Jubilee Beach, Wizard Lake, 2014-2017

Note: The data presented were collected using the algae beach monitoring protocol, where samples are taken at several locations along the beach and different depths and combined into one sample. Data from Alberta Health.

2.3 Lakeshore Health

Riparian zones, defined as areas with moisture-tolerant vegetation near natural water bodies (Government of Canada 2020), are important for the health of a lake.

Some benefits of intact riparian areas are as follows (Government of Canada 2020):

- Natural vegetation has a deep root system that helps maintain the shoreline and reduce erosion.
- Vegetation can help filter out sediment entering the water. Reducing sediment can reduce nutrients and improve spawning areas for fish.
- Riparian vegetation provides shade, which can limit photosynthesis and reduce algae.

Human activities that can damage riparian areas include clearing vegetation, using all-terrain vehicles, allowing heavy grazing, and building structures (NSWA 2016).

The NSWA assessed Wizard Lake to determine riparian condition. The majority (61%) of the Wizard Lake shoreline was highly intact with little to no human footprint. Eleven percent of the watershed shoreline was moderately intact with some human footprint. The remaining 28% of the shoreline was highly modified due to land development. In comparison to other lakes in that study, Wizard Lake was the only one with low pressure adjacent land-uses , such as forests, that do not create stress on the riparian areas (Fiera 2018).

2.4 Watershed Health

Almost half of the Wizard Lake watershed is covered in forest (see Section 4.2.1), which is beneficial to the lake's water quality and health. About 38% of the watershed area are used for agriculture. Anecdotally, oilseed, grain, pulse crops, and/or cattle production likely represent more than half of the agricultural activity in Wizard Lake watershed; however, precise statistics about agricultural activities are difficult to obtain (Aquality 2012).

Two campgrounds in the watershed offer campsites, picnic sites, and boat launches (Aquality 2012). The lake has periods of heavy boat traffic, and sometimes the number of boats exceeds the estimated carrying capacity of approximately 50 boats, which may have effects on both safety and the environment (Aquality 2012).

About half of the watershed is forest, which is beneficial for lake water quality. It is unknown, however, if best management practices are being implemented in the agricultural and developed areas of the watershed to protect lake water quality.

The watershed has no surficial pipelines but has nine petroleum wells in addition to some abandoned wells (Aquality 2012). Overall watershed health is generally not affected by abandoned wells (Aquality 2012).

We were not able to locate information on the level of best management practices in the Wizard Lake watershed. Local observations indicated that one property previously used as a cattle feedlot south of Wizard Lake has no water quality protection measures in place. Water runs through the farmyard where there is currently little to no vegetation, then flows into the ditch that joins Inflow 4A, which eventually drains into Wizard Lake (B. Bartlett, personal communication). This lack of protection has had measurable impacts on tributary water quality (Section 3.5).

3 CREEK SAMPLING PROGRAM

3.1 Why Was Sampling Done?

Volunteers of the WLWLSA have collected water samples in several creeks (tributaries) that flow into Wizard Lake (Table 3-1). This testing helps determine which areas are contributing the most nutrients and bacteria to the lake and assists in pinpointing areas to direct watershed stewardship activities. This section provides a summary of the sampling program to evaluate the quality of data, extract information on watershed health, and recommend sampling improvements.

3.2 Sampling Procedure

During the 2018 sampling, the following sampling practices were used:

- GPS was used to confirm that samples were always collected from the same location,
- Water sampler was rinsed three times prior to sample collection,
- Nitrile gloves were worn to prevent contamination,
- Samples were preserved in the field immediately after sampling, and
- Samples were placed on ice in coolers and delivered to the lab on the same day of collection.

These practices are standard steps for sample collection by aquatic scientists, ensuring good quality data.

Table 3-1
Sample Locations and Dates

Sample Site	2007	2010	2011	2018
Inflow 1	April 11	May 24	April 13	April 21
Inflow 2	April 16	Not sampled	April 26	April 21
Inflow 3	April 16	May 24	April 13	April 21
Inflow 4A	March 27	May 24	April 13	April 19
Inflow 4B[1]	Not sampled	Not sampled	Not sampled	April 19
Tributary A	March 27	Not sampled	April 13	April 19
Tributary B	March 27	May 24	April 13	April 19

Note 1: Sample was labelled Inflow 5 on laboratory report.

Samples sent to the laboratory were tested for nutrients, bacteria, or some physical parameters (Table 3-2). Additionally, pH, specific conductance, and temperature were sometimes measured in the field. For the most accurate data, these should always be measured in the field with a recently calibrated meter that can be either purchased or rented on a daily basis. A consistent naming scheme for sample locations should be used to simplify data comparison across years.

Table 3-2
Parameters Tested by Laboratory

Parameter Group	Interpretation	Parameters Tested
Nutrients	Nutrients (especially phosphorus) feed lake algae. If excessive, they can cause algal blooms. Elevated ammonia and nitrate can be toxic to aquatic life	• Ammonia nitrogen • Nitrate + nitrite nitrogen • Total Kjeldahl nitrogen • Total phosphorus • Total dissolved phosphorus
Bacteria	Excessive bacteria numbers can cause digestive illness in swimmers	• *E. coli* • Fecal coliforms
Physical	Physical parameters are important for fish habitat quality Elevated temperature and pH can increase ammonia toxicity	• Total suspended solids • pH • Temperature • Specific conductance

3.3 Timing

Flows in prairie creeks like those around Wizard Lake are usually highest during spring melt and large storms in summer and minor or absent during the rest of the year. Therefore, most watershed substances, such as nutrients and bacteria, enter the lake during the peak creek flows in spring, which is ideal for creek water quality sampling. Associated checked the sample dates against stream flows from a nearby water station (Water Survey of Canada station Weed Creek 05DF008) to verify if sampling captured this critical flow period. In 2007, 2011, and 2018, water was sampled during high flows, which is ideal. Spring 2010 was very dry overall, so there was no ideal sample time. In 2018, the sampling was completed on two dates (April 19 and 21) that coincided with a peak inflow. In the future, creeks should be sampled close together (within a couple of days), as it was successfully done in 2018, for best comparison among creeks.

3.4 Sampling Locations

Water samples were collected from four tributaries that flow into Wizard Lake from the south (Inflows 1-4) and a creek that flows into Inflow 4 (Tributary A and B, Figure 3-1). For data from Inflow 4, most of the sampling occurred at Inflow 4A; referred to as Inflow 4 in this report. Inflow 4A has three 36” culverts and drains the majority of water from lands upslope. An additional 48” culvert was installed at Inflow 4B to the west because the other culverts were not sufficient to handle excessive flows. Inflow 4B was only sampled once in 2018; therefore, the data were not included. The sampling locations were on the south side of the lake because that is where most of the watershed water drains into the lake. Tributary B is just upstream of a farm (previous feedlot), and Tributary A is just downstream of the same farm. The purpose of this pair of samples was to understand if farm runoff has an impact on creek water quality.

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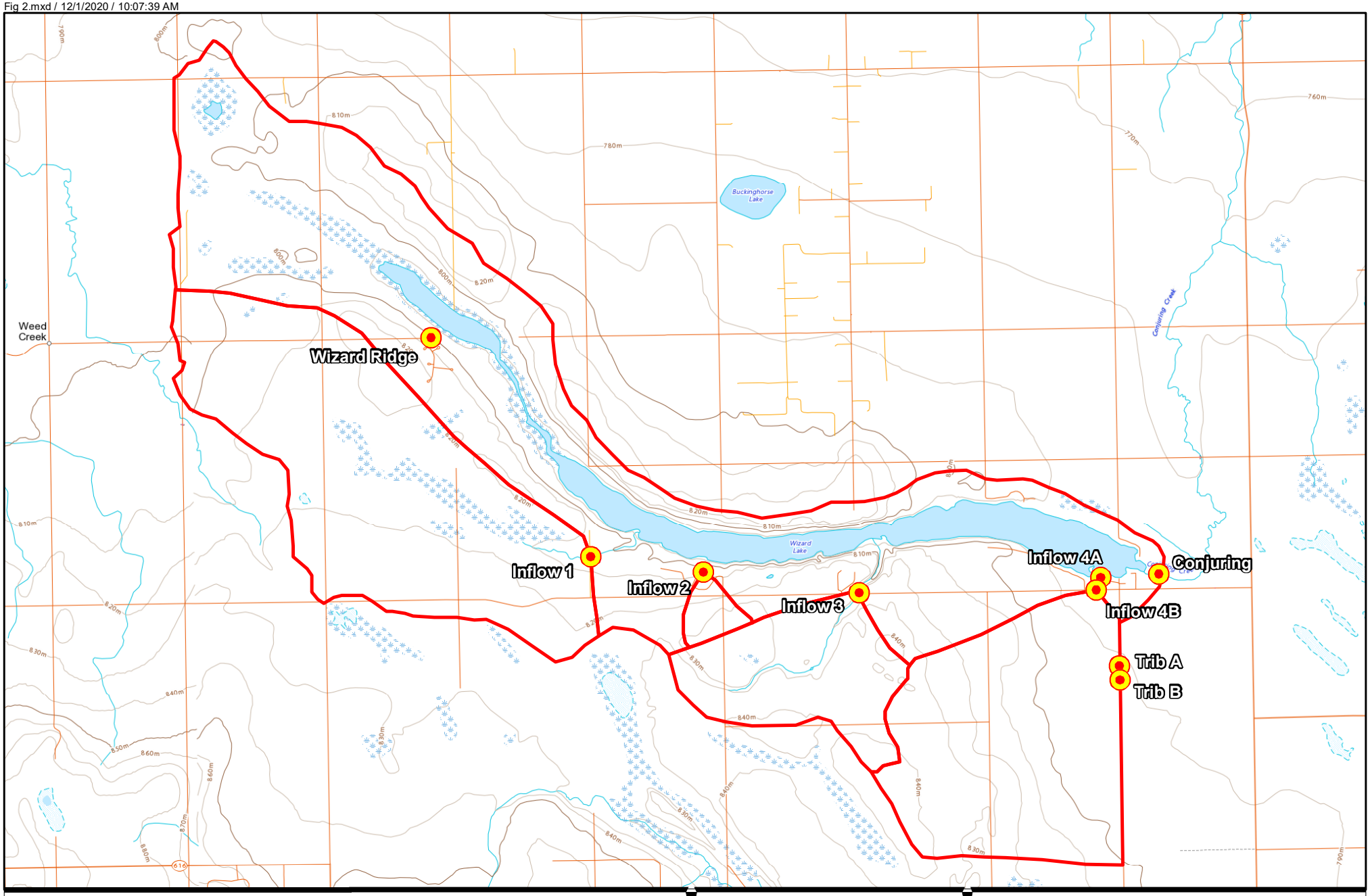


Associated Environmental

Sample Sites

Wizard Lake Watershed

PROJECT NO.: 2020-8649.000.000

DATE: December 2020

DRAWN BY: DA

0 2 km

N

FIGURE3-1WATERSHEDS FOR TRIBUTARY SAMPLING LOCATIONS

Wizard Lake Watershed & Lake Stewardship Association

Wizard Lake Data Summary

Overall, these sampling locations represent the surface water that flows into Wizard Lake from the majority of the watershed. In addition, targeted sampling allows evaluating the impact of an individual property, which is informative. The only area where water quality is unknown is the west end of the lake; however, the extensive wetlands at the west end may act as a filter which improves the quality of water that enters the lake from that portion of the watershed.

3.5 What Does Sampling Tell Us?

The assessment was based on water quality data from 2007, 2011, and 2018, which determined any consistent differences between the sites and any concerns related to water quality. The data from 2010 were excluded because it was a very low flow year and did not appear to be representative.

3.5.1 Does Water Quality Differ between Creeks and Why?

Levels of nutrients, such as total ammonia nitrogen (Figure 3-2), total and dissolved phosphorus (Figure 3-3, Figure 3-4) were consistently highest at Tributary A, followed by Inflow 4 and Tributary B, which are all located in the Inflow 4 subwatershed. Tributary A also had the highest concentration of nitrate whenever nitrate was analyzed (2011 and 2018). These data indicate that the Inflow 4 portion of the watershed is the best candidate for stewardship actions to reduce nutrient inputs to Wizard Lake.

Ammonia and phosphorus levels doubled from upstream of one farm property (Tributary B) to downstream of the farm (Tributary A). Total ammonia nitrogen exceeded guidelines for the protection of aquatic life in 2007 at Inflow 4 and at Tributary A (AEP 2018)[1], but not in 2011 and 2018. These results likely indicate that runoff from the then-active cattle operation contained animal wastes which are rich in ammonia, nitrate and phosphorus. The majority of samples from the other inflows were well below surface water quality guidelines (Figure 3-2).

[1] The guideline for ammonia depends on pH and water temperature, which are not available. Based on a worst-case assumption of pH of 8 and a temperature of 10°C, the total ammonia guideline would be 0.88 mg/L.

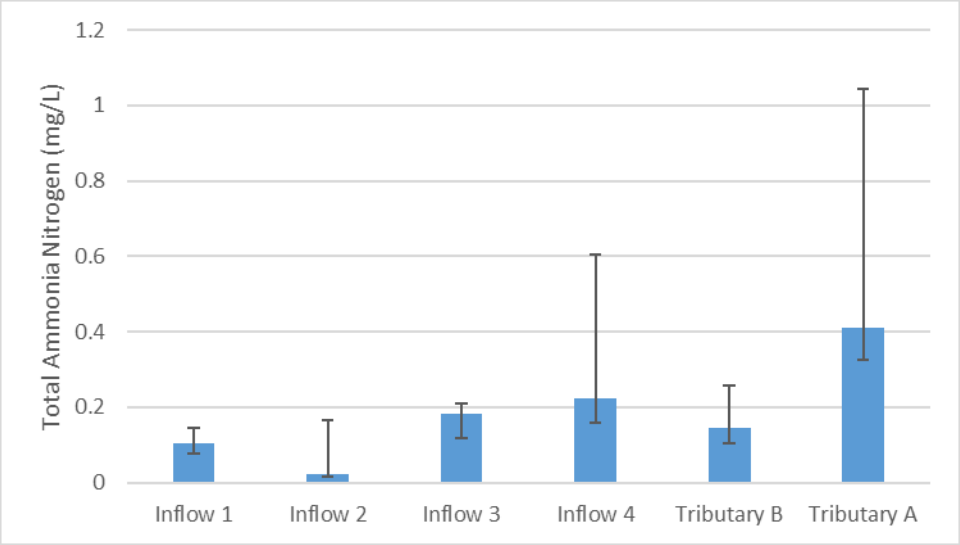


Figure 3-2
Total Ammonia Nitrogen Concentrations in Wizard Lake Watershed

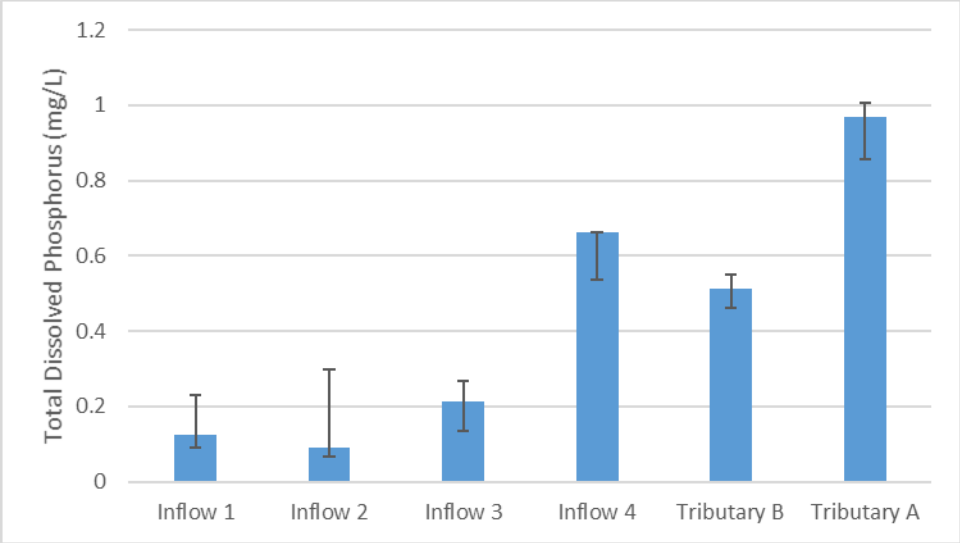


Figure 3-3
Total Dissolved Phosphorus Concentrations in Wizard Lake Watershed

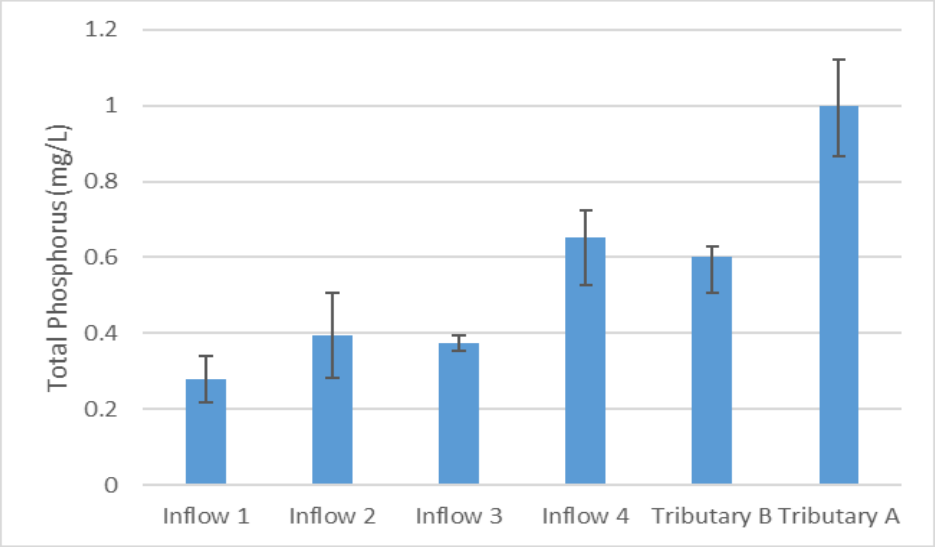


Figure 3-4
Total Phosphorus Concentrations in Wizard Lake Watershed

Total dissolved phosphorus (TDP) concentrations in the inflows were correlated with the percent of agricultural land use in the sub-watersheds of each inflow location (Figure 3-5). The watershed of Inflow 4 has the largest proportion of agricultural land use (84%) and highest TDP concentrations, watersheds of Inflows 1 and 3 have about 40% of agricultural land use, and Inflow 2 watershed has the smallest proportion of agricultural land use in the watershed (5%) and the lowest dissolved phosphorus concentrations. Inflow 2 has, however, the largest development footprint among the sampled watersheds (24%) (Appendix C).

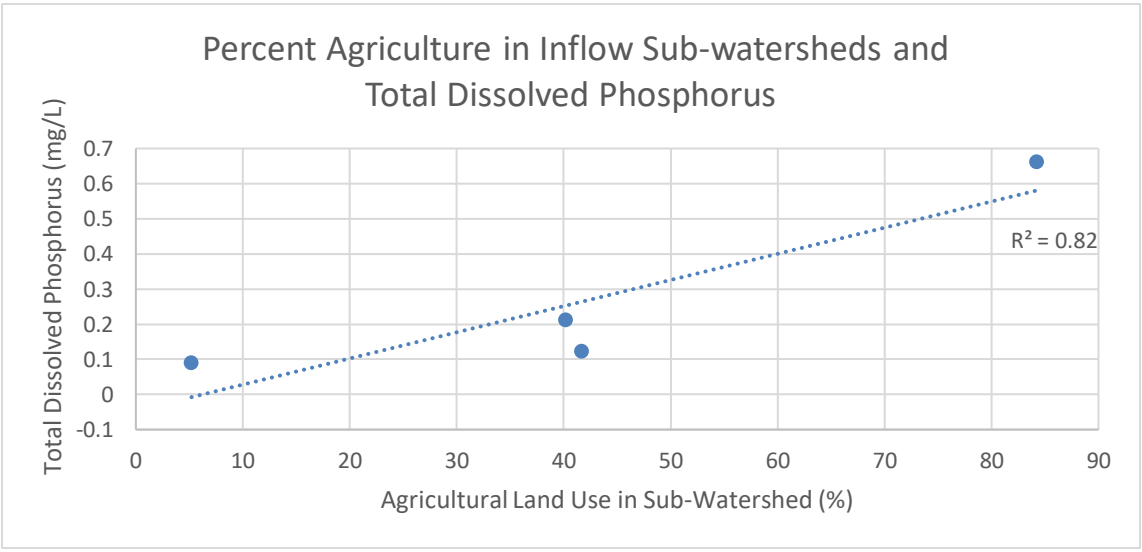


Figure 3-5
Correlation of Inflow Total Dissolved Phosphorus with Percent Agricultural Land Use in the Sub-watershed

3.5.2 What Parameters Are of Concern?

Ammonia levels exceeded guidelines for the protection of aquatic life at Tributary A, which is of concern for aquatic life in that stream. The sampling at the Tributary A and B locations should be repeated to verify if this concern persists, now that the cattle operations on the property have ceased (B. Bartlett, personal communication).

Phosphorus concentrations were elevated in many samples, particularly at Inflow 4, but also at Inflow 3. The majority of phosphorus was in dissolved form, which is the most bioavailable form of phosphorus for algae and plants. In excessive concentrations within a lake, it can lead to algal blooms that impair recreational water quality and reduce oxygen, which can harm fish.

There is no numerical guideline for phosphorus in Alberta, so it is difficult to assess if the phosphorus concentrations in creeks around Wizard Lake are acceptable. An extensive study by Environment Canada proposed a performance standard of 0.087 mg/L TP for Alberta agricultural streams, but this is not a regulatory standard (Chambers et al. 2008). All inflows to Wizard Lake exceeded that standard. Government of Alberta studies found that typical (flow-weighted) TP concentrations were 0.51–0.62 mg/L for streams in high-intensity agriculture, 0.28–0.33 mg/L for medium-intensity agriculture and 0.14–0.19 mg/L for low-intensity agricultural watersheds in Alberta (Anderson et al. 1998, Lorenz et al. 2008). This means that phosphorus levels in Inflow 4 are similar to those in streams that drain high-intensity agricultural lands elsewhere in Alberta. TP concentrations in Inflows 2 and 3 were slightly above values associated with medium intensity agricultural watersheds, and TP in Inflow 1 was within values reported for medium intensity agriculture, despite significant forested portions in these watersheds. Based on these comparisons, phosphorus levels in Wizard Lake tributaries are elevated due to medium to high agricultural intensity in the farmed portions of the watershed. The implementation of best management practices specific to the types of agriculture in the watershed would help to reduce phosphorus inputs to Wizard Lake.

Bacteria (*E. coli)* do not appear to be a concern because they met the aesthetic guideline (100# CFU/100 mL) in all but one sample. Nitrate and nitrite concentrations were always below the water quality guidelines for the protection of aquatic life. These parameters could be omitted from the sampling program to save costs.

3.6 Summary and Recommendations

Community-based monitoring conducted in creeks around Wizard Lake was successful and resulted in important and useful data. The data indicate the following:

- Water contains most nutrients in tributaries that flow through agricultural lands;
- Individual farm operations in the watershed had a measurable impact on creek water quality;
- Phosphorus was elevated at Inflows 3 and 4, and the majority of phosphorus in creeks is in the dissolved form, which is readily available for algae growth and can lead to algae blooms in the lake; and
- Bacteria, nitrate and nitrite levels are not of concern.

The data gaps are as follows:

- Long-term trends are unknown; and
- Field pH and temperature measurements are lacking that would improve interpretation of ammonia data.

We recommend the following for future creek monitoring.

- Gather samples for 2 to 3 more years.
- Collect all samples in one day during peak flow.
- Collect samples at the same locations as before for consistency (Inflows 1-3, 4A).
- Omit Inflow 4B because 4A provides information on what enters the lake in this area.
- Omit Tributary A and B for now if no changes are made to the farm. If any erosion and sediment control measures will be implemented at this property, these sites can be re-added later to monitor the success of improvements.
- Add sampling at the western inflow to characterize water quality in the western part of the watershed.
- Pathogen sampling is optional and if completed, only requires *E. coli*, as it is very similar to fecal coliforms.
- Measure pH and temperature in the field instead of at a laboratory for accurate interpretation of ammonia.
- There are opportunities to reduce the parameter suite to save costs. Testing for ammonia, total and total dissolved phosphorus should be maintained; while testing for fecal coliforms, *E. coli*, nitrate, nitrite, total Kjeldahl nitrogen, total suspended solids/residue non-filterable can be considered optional.

4 PHOSPHORUS BUDGET

4.1 What Was Done and Why?

Phosphorus is one of the main nutrients controlling algae growth in Wizard Lake (Section 2.2). Therefore, reducing phosphorus input to the lake is an effective means to reduce algae. A phosphorus budget can quantify the different sources of phosphorus to the lake. Once the relative importance of each source is known, the most effective ways to reduce phosphorus and thereby algae can be identified.

A high-level assessment of local inputs of phosphorus was completed. A complete phosphorus budget estimates three components: the sources of phosphorus entering the lake (inputs); the ways that it leaves the lake (outputs); and the amount of phosphorus in the lake water at any given time. There is not enough information on outputs (specifically, flow data at the outflow), so this piece of the budget is currently missing. We estimated the major external inputs of phosphorus, including atmospheric deposition, watershed runoff, and septic seepage from shoreline residences and preliminary internal loads (loads from sediments). The methods used to quantify these phosphorus sources are explained below.

4.1.1 Watershed Runoff

Published estimates of phosphorus export per unit area from different land uses in Alberta were used to estimate phosphorus load from the watershed to Wizard Lake (Donahue 2013). The phosphorus export coefficients from Parkland and Boreal Forest Natural Regions were averaged because Wizard Lake is near the border of the two regions. For developed areas, the coefficient for rural residential acreage yards were used. The export coefficients for soft roads with light use and drainage structures were selected for roads as the best fit for the area. The watershed land

use areas were mapping using the Alberta provincial layer from the Alberta Biodiversity Monitoring Institute (ABMI n.d.).

4.1.2 Atmospheric Deposition

Phosphorus enters lakes from the air through dry and wet deposition of dust that is in the atmosphere. Dust can be emitted from roads and through agricultural practices. Atmospheric deposition has previously been estimated for the neighbouring Pigeon Lake. The Pigeon Lake atmospheric P load number was multiplied by the surface area of Wizard Lake.

4.1.3 Septic seepage

Phosphorus loads from septic systems around Wizard Lake were estimated using the same approach used for the Pigeon Lake phosphorus budget (Teichreb 2014). The per-person contribution of 0.93 kg P/yr was multiplied by an estimated percent of the sewage actually making it to the lake (10%) and the number of shoreline residences, which was provided by the WLWLSA.

4.1.4 Internal Loads

Release from sediment is a major source of phosphorus to many lakes, in particular in the Canadian Prairies (Orihel et al. 2017). A preliminary estimate was based on summer lake outflow volumes (11.6 ML over 3 months) provided by Dave Trew (personal communication). The increase in phosphorus mass over the summer was estimated from ALMS water quality data for available years (2006, 2008-2011, 2013, 2016, 2018) and an assumed stable lake volume. Summer contributions from the watershed, atmosphere and sewage as well as losses to outflow and sedimentation were taken into account. The remaining term in the phosphorus budget was attributed to phosphorus release from sediment, as described in Teichreb (2013). Again, since the lake outflows and changes in lake volume over the summer were not measured in the years for which lake water quality data were available, the resulting internal load value is only a preliminary estimate (requiring further validation).

4.2 What Does the Phosphorus Budget Tell Us?

4.2.1 External Phosphorus Load

Different types of land use introduce varying amounts of phosphorus to the water. The primary land use in the Wizard Lake watershed is broadleaf forest (46.5%) (Figure 4-1). The second most common land use is agriculture (30.7%). Agricultural land, however, contributes almost twice the amount of phosphorus compared to the various forest types because its per-hectare phosphorus contribution is much larger. This is consistent with previous external phosphorus load estimates for Wizard Lake that also resulted in the highest watershed loads from agriculture (Table 4-1).

Agricultural land contributes almost twice the amount of phosphorus compared to the various forest types.

Roads only cover a small percentage of the land in the Wizard Lake watershed; however, combined with the acreages, developed land contributes approximately 14% of the external phosphorus to Wizard Lake (Figure 4-2). Approximately 109 kg of phosphorus enters Wizard Lake each year from septic seepage, representing about 8% of the total external phosphorus load. The atmospheric deposition of phosphorus in Wizard Lake is about 67 kg annually or approximately 5% of the external input of phosphorus. Grassland only contributes 1% of the external phosphorus load to Wizard Lake.

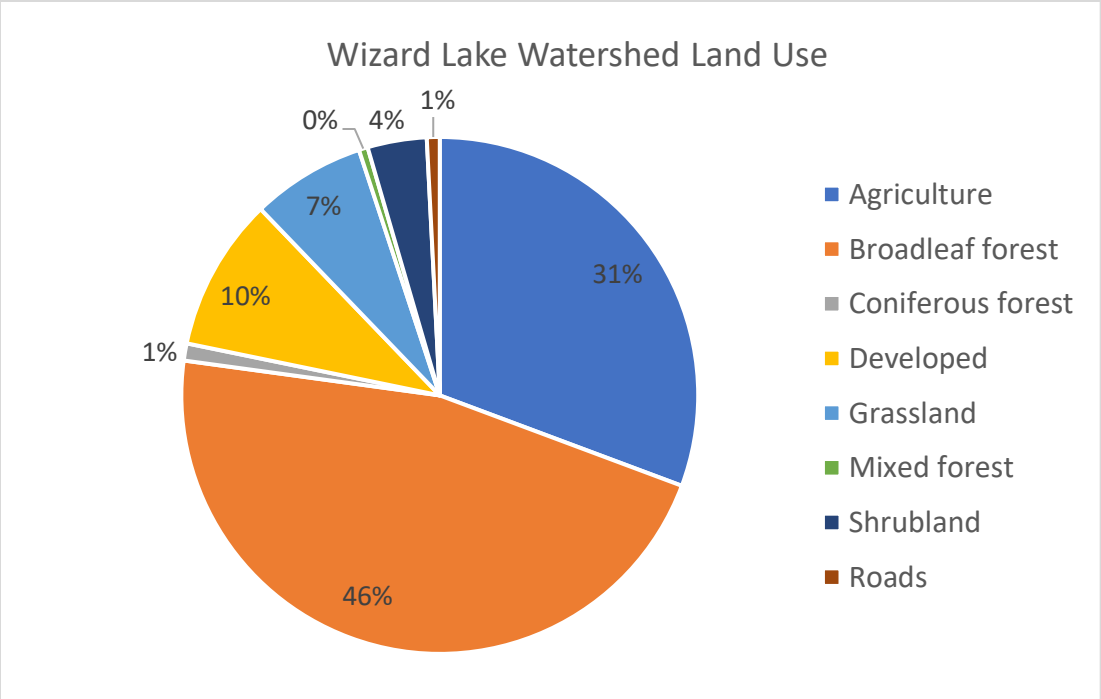


Figure 4-1
Proportion of Land Use Types in Wizard Lake Watershed

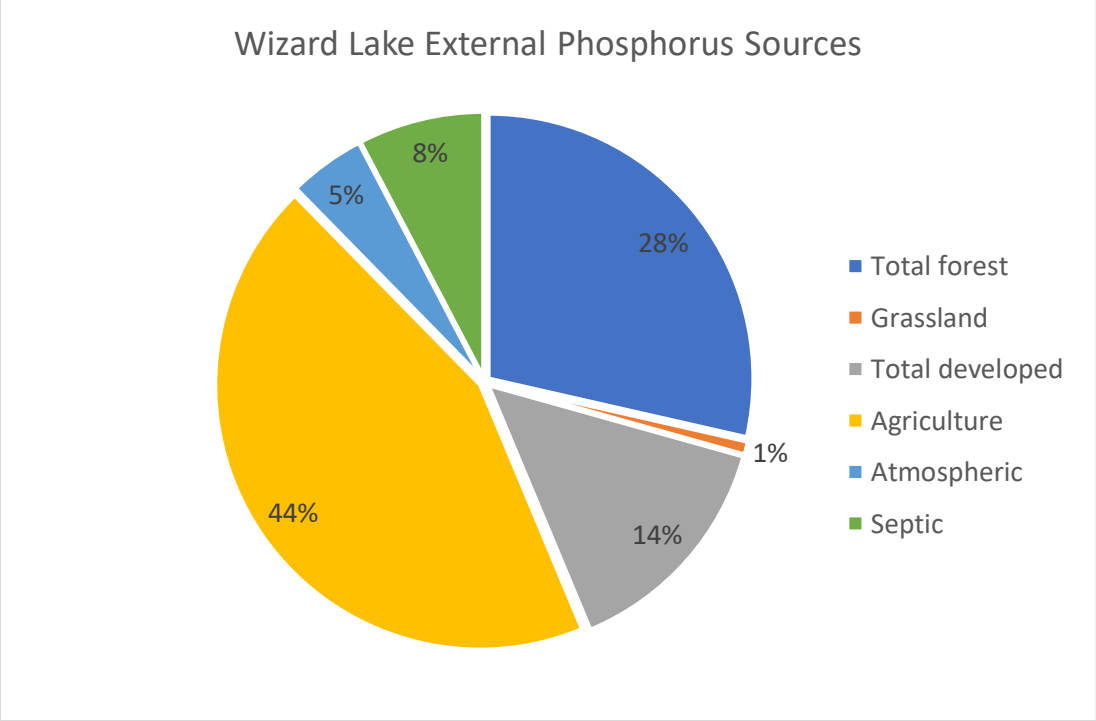


Figure 4-2
Annual Phosphorus Load to Wizard Lake for External Sources

4.2.2 Internal Phosphorus Load and Total Loads

Early work in the 1980s and 1990s estimated internal load contribution to Wizard Lake at 67% (2133 kg/yr) (Mitchell and Prepas 1990) or 45% (581 kg) (Alberta Environmental Protection 1998). The preliminary internal P load was estimated at 20% (362 kg). The total external load estimates range from 680 kg/yr to 1424 kg/yr and the total phosphorus load estimates to Wizard Lake range from 1261 kg/yr to 3173 kg/yr. Given the large variation in estimates, the relative importance of internal P loads to Wizard Lake and total load estimates remain uncertain.

Table 4-1
Estimates of External and Internal P Loads to Wizard Lake

Phosphorus Source		Annual Phosphorus Load to the lake (kg/yr)		
		Mitchell & Prepas 1990	Mitchell 1998	Associated 2021
Watershed	Forest/shrubs	111	164	407
	Cleared/agriculture	313	184	637
	Urban: cottage lots, roads	228	89	205
Sewage		286	193	109
Precipitation		61	50	67
Inflow from upstream slough		52	-	-
Total external load		1051	680	1424
Internal load (summer sediment release)		2133	581	362
Percent internal of total load		67%	46%	20%
Total load (external + internal)		3173	1261	1786

5 RECOMMENDATIONS

Overall, the water quality, shoreline, and watershed health of Wizard Lake are well understood, while some gaps remain with respect to key phosphorus sources (e.g., internal phosphorus loads). Tributary data collected by Wizard Lake stewards were reliable and provided important information on watershed health.

To better understand the water quality of Wizard Lake, we recommend the following:

- Continue collecting water quality samples at the four inflow locations for at least another 2 to 3 years (detailed recommendations for sampling are provided in Section 3.6):
- Further refine and develop the phosphorus budget:
    - Internal phosphorus loads were based on old water balance data in this report and historical estimates varied widely. To improve the internal load estimate, measurement of the amounts of water entering and leaving the lake will greatly refine the results.
- Determine interest in people collecting information such as dates of algae blooms and weather conditions in the previous week.
- Participate annually in Alberta Health beach monitoring, if possible, to evaluate cyanobacteria abundance and the risk of cyanotoxin development at Wizard Lake.

To promote the health of the lake, we recommend the following:

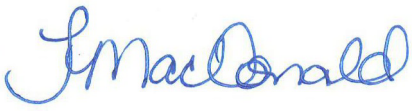
- Determine which agricultural best management practices are most practical and most effective and work with farmers to implement them in the watershed.
- Set goals for riparian intactness and work with residents to achieve them:
    - Aim to elevate the 9% or 1.7 km of Wizard Lake shoreline that currently have a “low intactness” to moderate intactness through restoration activities around Wizard Lake.
    - Maintain current levels of intactness in areas with higher ratings by encouraging residents to protect areas of high intactness.
    - Improve public awareness about the importance of riparian intactness through education outreach.
- Ask residents to have their septic systems inspected; encourage pump-out systems.

CLOSURE

This report was prepared for the Wizard Lake Watershed and Lake Stewardship Association to summarize information and lake and watershed health, assess the sampling conducted by WLWLSA, and update the phosphorus budget and to provide recommendations.

The services provided by Associated Environmental Consultants Inc. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,
Associated Environmental Consultants Inc.



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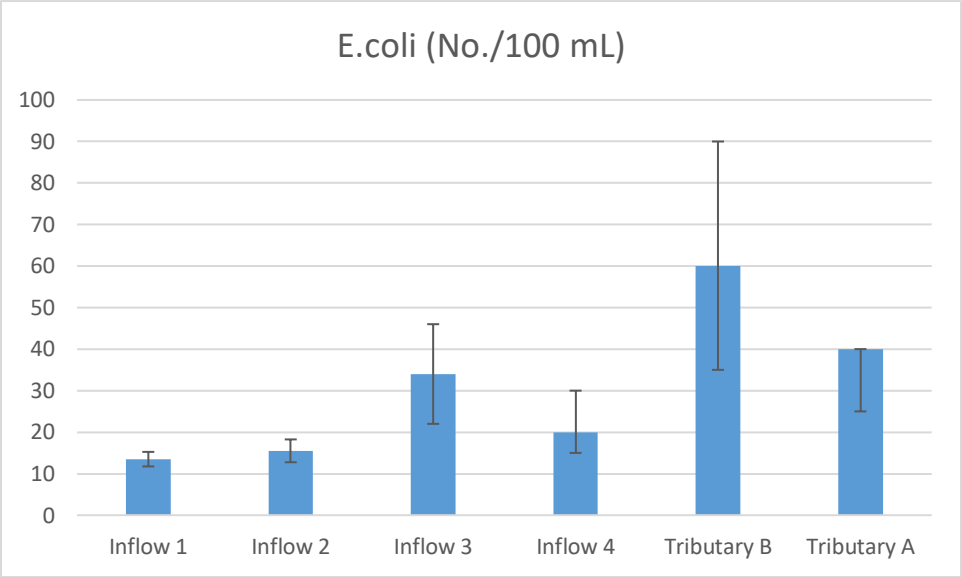
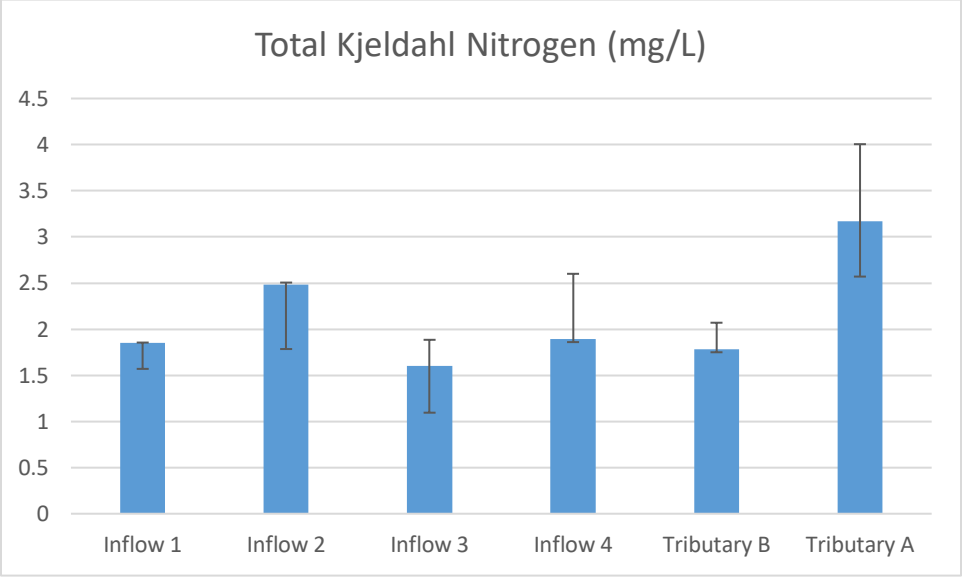
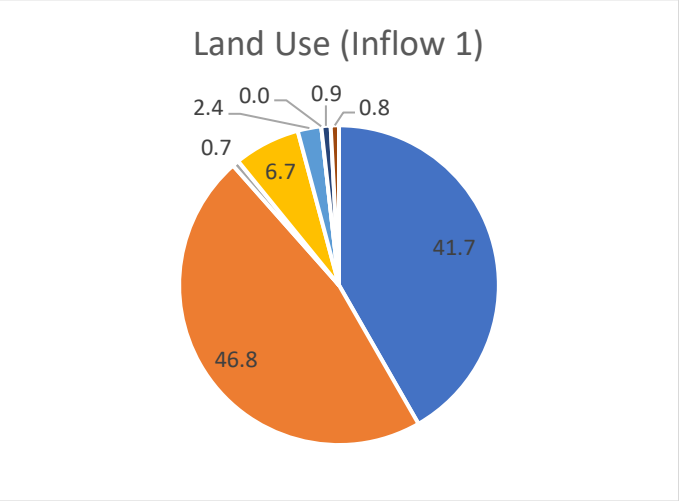
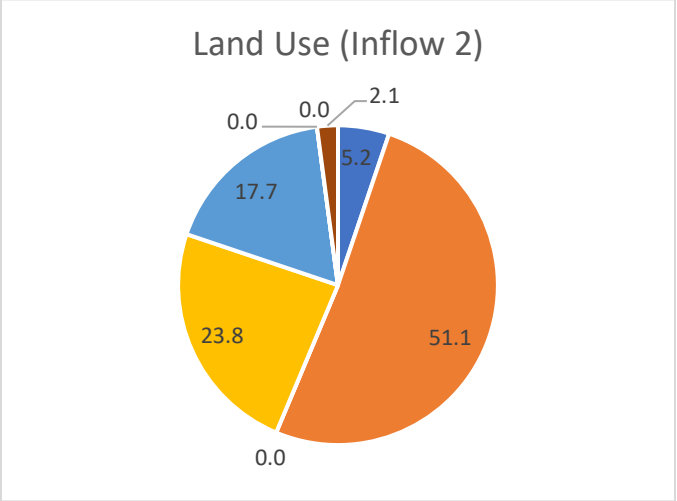
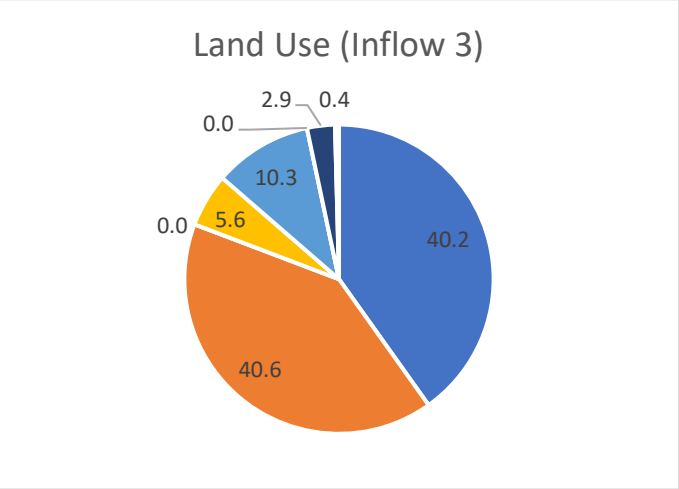
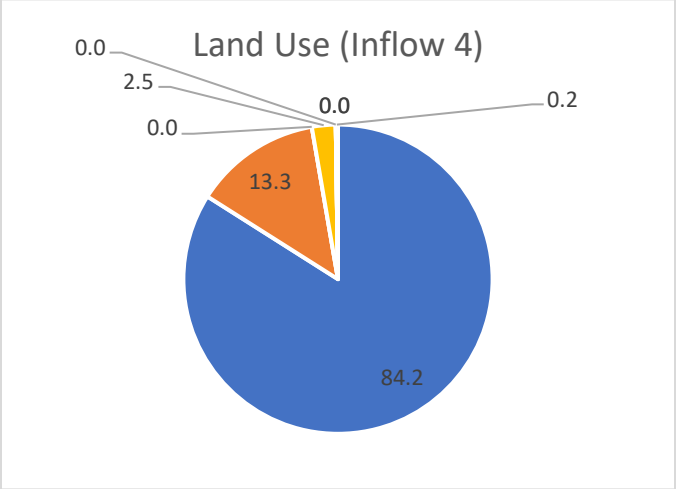
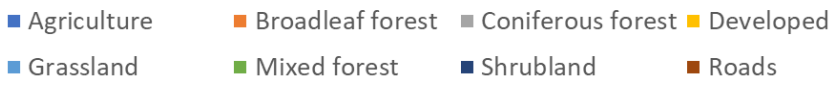
APPENDIX A – REVIEWED REPORTS

Years of Data in Report	Name of Report	Who Produced Report	Scope	Notes
2006, 2008, 2009, 2010, 2011, 2013, 2016, 2018	The Alberta Lake Management Society Volunteer Lake Monitoring Program: Wizard Lake	ALMS	Summary report on water quality	One report for each year listed
2020	ALMS: LakeWatch Summary report	ALMS	compares water quality among all lakes sampled by ALMS	Wizard Lake eutrophic based on TP and Secchi depth, but hypereutrophic based on chlorophyll-a
2010	Wabamun–Genesee Area Biomonitoring Program - 2010 REPORT	TransAlta	Summary of aquatic monitoring program (WQ, sediment quality (0-5 cm, metals, particle size, TOC), fish tissue (trace metals), plant tissue and community), WQ data available 2004 (baseline), 2006, 2007, 2010	lake water naturally elevated in fluoride, manganese and iron sediment exceeded arsenic sediment quality guidelines in 2/3 samples fish tissue metals did not change and were below consumption guidelines
2015	Wabamun–Genesee Area Biomonitoring Program - 2015 REPORT	TransAlta	Surface and groundwater quality, fish tissue data, vegetation, benthic community info, human health risk assessment	-fish tissue mercury was higher than 2006 but not than 2004 or 2010 - part of natural variability -iron and manganese concentrations in lake water were highest at the deep spot (2010, 2015), possibly indicating the influence of sediment release under anoxia and/or stronger influence from groundwater at the deep spot
2016, 2017	Wabamun–Genesee Area Biomonitoring Program - 2016 REPORT	TransAlta	Summary of aquatic monitoring program	Didn't report on Wizard Lake
1999	Regional Groundwater Assessment Leduc County	Hydrogeological Consultants Ltd	Summary of groundwater resources and characteristics in Leduc County	Leduc County is on the northside of the lake. Groundwater flow direction is towards the north-east, so this assessment is not as relevant to Wizard Lake as is the Wetaskiwin County one
2008	Regional Groundwater Assessment Wetaskiwin County	Hydrogeological Consultants Ltd	Summary of groundwater resources and characteristics in Wetaskiwin County	Estimated a groundwater flow of 483 m^3/d in northeast direction through Wizard Lake as part of the Upper Scolland Aquifer

Years of Data in Report	Name of Report	Who Produced Report	Scope	Notes
2016	Shoreline Assessment - Wizard Lake	NSWA	1pg summary of intactness rating	
2006 - 2011?	Wizard Lake State of the Watershed Report 2012	Aquality	Summary of many water quality, water quantity, biological indicators, land use, and data gaps	eutrophic based on chl-a, algal blooms, some bacteria exceedances in beach monitoring, estimated high manure production, but based on surrounding region (likely overestimated), lake is at or over capacity for boating
2000 - 2018	Strawberry Watershed Riparian Area Assessment	Fiera	Summary of riparian intactness, function, conservation prioritization results	summarized in report
1968 - 1998	WATER QUALITY OF WIZARD LAKE	Alberta Environmental Protection	Summary of water quality; table 4 phosphorus loading	hypereutrophic based on chlorophyll-a, internal load at least 50% of total annual P load
2007	Tracking changes in water quality due to catchment land-use and lake morphometry across spatial and temporal scales	Zofia Taranu, McGill University	Thesis; one mention of Wizard lake (TP, depth, % agriculture development, surface area)	When looking at many AB lakes together, internal is load more important in controlling nutrient concentrations in polymictic lakes than in dimictic lakes such as Wizard Lake. Watershed land use has a stronger influence on dimictic lake nutrient levels than it does on polymictic lake nutrient levels.
Unknown	trophic State of Alberta Lakes	AEP	trophic state classification based on TP and Chlorophyll-a	Wizard Lake eutrophic based on TP and hypereutrophic based on chlorophyll-a

APPENDIX B – WATER QUALITY GRAPHS





APPENDIX C - LAND COVER IN INFLOW SUBWATERSHEDS