PIGEON LAKE

watershed management plan 2017

draft for adoption

Pigeon Lake Watershed Management Plan Steering Committee
September 2017

Working Together for a Healthy Watershed, Healthy Lake, and Healthy Community

TECHNICAL SUPPORT

(RECOMMENDED CITATION)

Pigeon Lake Watershed Management Plan Steering Committee (plwmp.ca). September 2017.
The Pigeon Lake Draft Watershed Management Plan 2017 – Draft for Adoption.
Pigeon Lake Watershed Association (plwa.ca) and Alliance of Pigeon Lake Municipalities (aplm.org)

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ACKNOWLEDGEMENTS

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INTRODUCTION

Pigeon Lake is a popular beautiful prairie lake which has provided both livelihood and enjoyment for many generations of Albertans. Geologically, the lake is over 10,000 years old, left behind after retreating glaciers. The watershed and lake were part of Treaty 6 with First Nations. Pigeon Lake Reserve 138A was set aside to provide First Nation access to fishing. Early settlement activities were based on logging, farming and fishing. Today, in addition to farming, the watershed features several hamlets, acreages and cottage communities, IR 138A, campgrounds and business centers – all creating a significant regional economy.

The lake provides for many types of recreation and the simple pleasures of enjoying nature. All those who live, work and play in the watershed influence the health of the lake. This Pigeon Lake Watershed Management Plan ("Plan") provides guidance as to what we can accomplish together to improve the health of the lake and surrounding watershed.

The Plan incorporates input from the public received to date during 2017. Public Input was received through a survey plus comments at open houses and workshops held in 2017. A Consultation Summary may be found on-line at www.plwmp.ca/plan/.

PURPOSE

The purpose of the Pigeon Lake Watershed Management Plan ('Plan') is to develop a comprehensive, science-based strategy to coordinate action for the protection and improvement of Pigeon Lake, its shore lands, and its watershed.

VISION

Working together for a healthy watershed, healthy lake, and healthy community.

The Plan recognizes that a large-scale complex set of systems and processes influence the overall health of the lake. Many of these processes are nature-based and beyond human control. Similarly, the time frame for positive outcomes are difficult to predict. The Plan advocates for multiples management strategies that are within our collective control. The Plan sets out a road map for collective action in key areas to offset the effects of the past and to restore a better balance for the lake environment. To address the challenges facing the lake, action and commitment is needed by all parties.

GOALS

The Plan's goals are to:

- Reduce the frequency and intensity of algal blooms.
- Improve the health of the watershed and the lake.
- Improve the recreational value of the lake and economic health of the region.

COMMON GROUND

The Plan recognizes that a variety of perspectives and interests exist among the various municipalities and stakeholders of the Pigeon Lake watershed. The Plan focusses on topics and actions that are rooted in science, provide benefit, and represent common ground.

BACKGROUND

Pigeon Lake is a popular recreational lake in central Alberta.

Lake and watershed management planning is a means to address concerns and issues affecting Pigeon Lake and its surrounding watershed. The first two versions of watershed management plans for Pigeon Lake were completed in 1975 and 1985 respectively. In 2000, a Watershed Management Plan for the Pigeon Lake area was adopted by resolution by twelve municipalities (two counties and ten summer villages) with municipal boundaries abutting Pigeon Lake. Over time, this plan has become outdated.

Following significant algae blooms in 2006, the Pigeon Lake Watershed Association (PLWA) was formed to assist the watershed municipalities and stakeholders in addressing concerns and courses of action. Recognizing the need to plan and work collaboratively with community, municipal, traditional, and provincial partners, the PLWA began commissioning new scientific studies to determine the state of the lake, the shoreline area, and the surrounding lands.

In 2012, the PLWA began a renewed Pigeon Lake Watershed Management Plan that focused on education, beneficial practices and bylaws. This program was directed by a multi-stakeholder Steering Committee. By 2016, the PLWA, in partnership with the Alliance of Pigeon Lake Municipalities (APLM) and Alberta Environment and Parks (AEP), committed to prepare a comprehensive Pigeon Lake Watershed Management Plan (2017) that would combine the knowledge gained from research on the Pigeon Lake area with beneficial management practices for improved outcomes.

FIGURE 1: Aerial Photo of the Pigeon Lake Watershed (Outlined in Black)

The Plan promotes implementation by municipal partners through the statutory planning and bylaw adoption processes. The Plan also identifies actions that can be implemented by individuals, municipal governments, provincial government, First Nations, non-governmental organizations, and technical specialists.

PROGRESS TO DATE

This Plan is informed by considerable number of studies and prior initiatives already in place. These efforts have been spearheaded and funded by many organizations including the municipalities, the PLWA, the APLM, several non-governmental organizations, the Government of Alberta, The Government of Canada, the PLWMP Steering Committee, the University of Alberta, and the Alberta Biomonitoring Institute.

The following works are either underway (**u/w**) or completed (✓).

Scientific Studies

STATUS	DATE	TITLE
✓	2001+	Annual LakeWatch Reports (Water Quality) (2001, 2010, 2011, 2013, 2014, 2015, 2016, ongoing)
✓	2008	Pigeon Lake State of the Watershed Report
✓	2006/08	Shoreline Assessments
✓	2010	Hydrological Assessment and Water Balance Update
✓	2010+	Cyanobacteria Monitoring (Since 2010)
✓	2011	Water Quality Conditions & Long-Term Trends in Alberta Lakes
✓	2012	Options for the Control of Blue Green Algae.
✓	2012	Blue Green Algae Management: Review of work to date (PLWA)
u/w	2012+	Investigations of water importation, hydraulic dredging, and phosphorus inactivation
✓	2013	Overview of Pigeon Lake Water Quality, Sediment Quality, and Non-Fish Biota
✓	2013	Aquatic Invasive Species PVC monitoring
✓	2014	Pigeon Lake Phosphorus Budget 2014
✓	2015	PLWA Citizen Cyanobacteria Monitoring
✓	2016	Paleolimnology Sediments Study
✓	2016	Tropic Cascade Mesocosm Research
u/w	2016	Algae Harvesting
✓	2016	Sediment Sampling Study
✓	2016/17	Pigeon Lake Watershed Phosphorus Runoff Model
✓	2017	Pigeon Lake Summary of the Science
u/w	2017/18	Pigeon Lake Bloom Causal Factors
u/w	2017/18	Research on economic costs of blue green algae blooms

Social Research Studies

STATUS	DATE	TITLE
✓	2013	PLWMP Engagement Report "Are We on Track?"
✓	2014	Cosmetic Fertilizer Survey
✓	2015	Clean Runoff Survey

Legislation & Beneficial Practices Guidance

STATUS	DATE	TITLE
✓	2008	Law & Policy Framework Phase I Report
✓	2010	Regulatory and Policy Actions for a Healthy Pigeon Lake Watershed Phase II Report
✓	2012/13	PLWMP Terms of Reference
✓	2012/14	PLWMP Topic I – Cosmetic Fertilizers & Soil Management • Cosmetic Fertilizers Terms of Reference (2012) • Research on North AM Bylaws (2013) • Input from Soil Experts (2013) • Cosmetic Fertilizer & Soil Nutrients Guide (2014-15)

STATUS	DATE	TITLE
✓	2012/14	PLWMP Topic II – Model Land Use Bylaw • Model Land Use Bylaw: Lakeshore Environmental Development Provisions
✓	2012/14	PLWMP Topic III – Surface Water Runoff • Alberta Clean Runoff Action Guide

Stewardship Education and Advocacy

STATUS	DATE	TITLE
✓	2006+	Stewardship and Education Initiatives • Websites, Newsletters & Brochures • Information Booths, Speakers, Education Sessions • Himalayan Balsam Eradication Program • Grandview Creek Restoration • Tree Planting Program • Watershed 101 for new Councillors • Newcomers Packages • Love the Lake (Children's Event)

✓	2006+	Advocacy
		• Meetings and representation at APLM, Annual Information Meetings, Council Meetings, with First Nation Elders and committees when invited, and with all levels of Alberta Environment and Parks.
		• Representing Pigeon Lake & learning from others
		  • At Central Alberta Recreational Lake Forum
		  • At North America Lake Management Society

✓	2006-2016	Living by Water Shoreline Property Consultations
✓	2011+	Review of land development applications & municipal plans • Leduc County (2011 and 2016) • Watermere Resort (2012 & 2014) • County of Wetaskiwin (2013)
✓	2013+	Aquatic Invasive Species Prevention Efforts, Education & Monitoring
✓	2014+	Healthy-Lake Lawns Program • Brochure, 'How to create and maintain better lawns' spring and fall emails and native grass seed
✓	2015/16	Clean Runoff Action • Clean Runoff Introduction brochure • Three municipal demonstration sites installed • Two residential demonstration sites installed and another underway. • One shoreline pilot restoration and demonstration site installed • Watershed Rain Barrel Campaign (57 sold) • 25 Bird Houses & 10 Bat Boxes installed • Landscaper Clean Runoff workshops. • Sold 25 bags of PLWA native grass seed mix (225g)
✓	2017	• Clean Runoff workshop and native plant sale for everyone • Kids took 64 Bird Houses and 12 Bat Boxes home to install • 17 Rain Barrels sold • Two Clean Runoff Residential Demonstration Site Open Houses Shoreline Restoration Open House

SNAPSHOT OF THE LAKE AND WATERSHED

The Pigeon Lake Watershed Management Plan has a study area of 284 km^2; this includes an area of 96.7 km^2 for Pigeon Lake itself, and 187 km^2 for the surrounding drainage area (or 'Watershed'). The boundary of the Pigeon Lake Watershed Management Plan study area is illustrated in Figures 1 and 2. A list of physical properties of the lake and watershed are provided in Table A.

TABLE A: Physical Properties of the Lake and Watershed

PIGEON LAKE PHYSICAL FEATURES	PHYSICAL PROPERTIES
Lake Surface Area	96.7 km^2
Lake Water Volume	603,000,000 m^3
Maximum Depth	9.1 m
Mean Depth	6.2 m
Shoreline Length	46 km
Mean Annual Lake Evaporation	664 mm
Mean Annual Precipitation	534 mm
Mean Annual Inflow	17,000,000 m^3
Mean Residence Time	Greater than 100 Years
Lake Weir Sill Elevation	849.935 m (Above Sea Level)
Watershed Land Drainage Area	187 km^2
Watershed to Lake Area Ratio	2:1

Pigeon Lake is a relatively shallow large prairie lake. Relative to other Alberta lakes, studies of lake bed sediments show that the lake is moderately nutrient rich (eutrophic) and has always produced algae, which in turns supports a robust fishery. The mean residence time to replace the total volume of water in the lake is over 100 years.

Located in central Alberta, the entire Plan area is located within the Battle River Watershed, which is part of the even larger North Saskatchewan River Watershed.

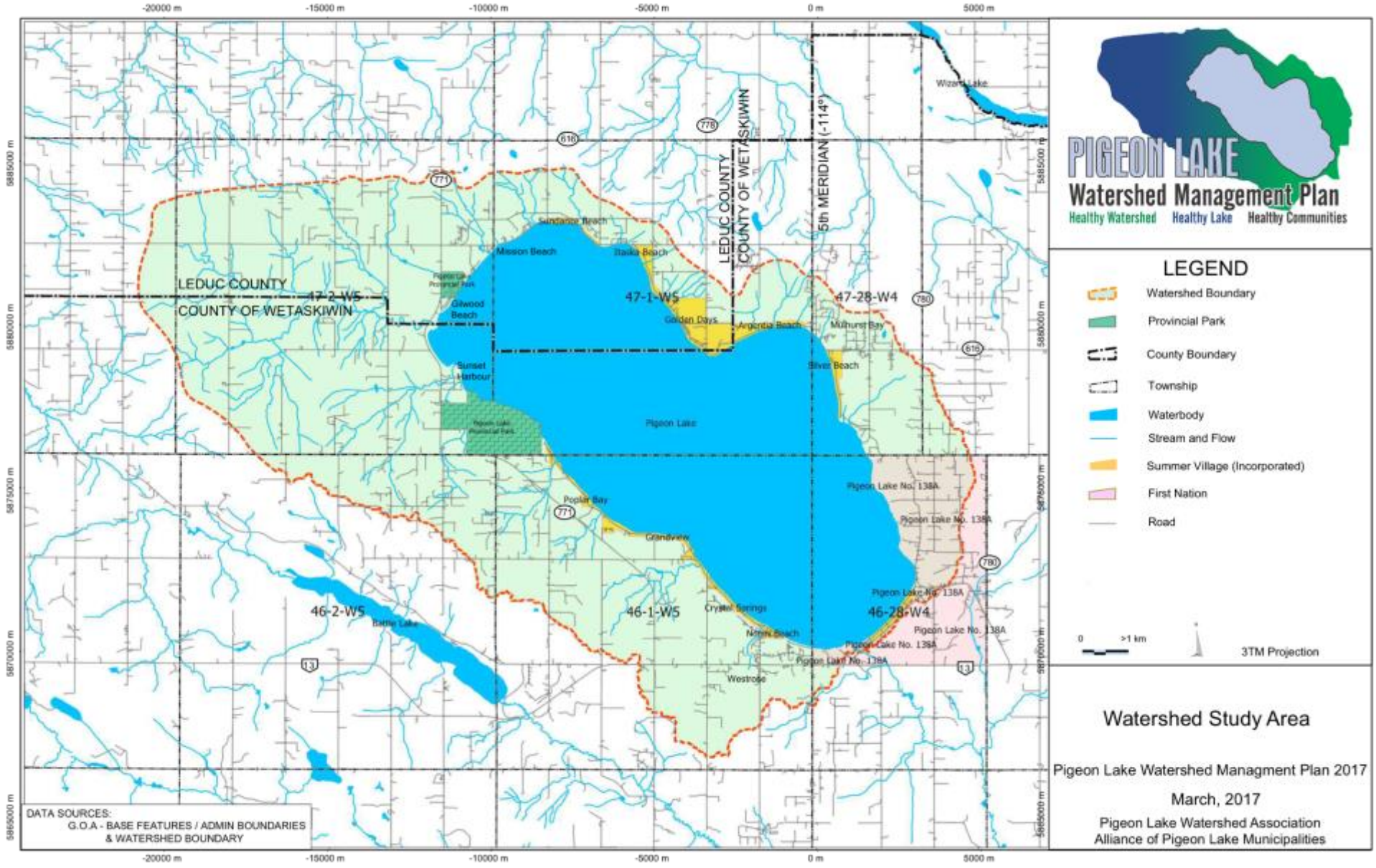
Lands within the Pigeon Lake watershed are administered by ten summer villages, two counties, First Nations (IR 138A), and the Government of Alberta (Provincial Parks).

A summary of the science has been prepared by a professional limnologist as a background to the development of the plan. Key factors affecting the overall strategy of the plan are presented below along with key implications.

ALGAE BLOOMS

An important driver of this Plan is that algal blooms have become noticeably more severe and frequent, especially since 2002. Algae are naturally present and are a foundation for the lake's food web and fishery. However, when algae are excessive, they form blooms. Blooms and related health advisories may have caused significant economic and social impacts. The costs of these impacts are being assessed. This Plan promotes a multi-pronged approach to reducing blooms and phosphorus levels.

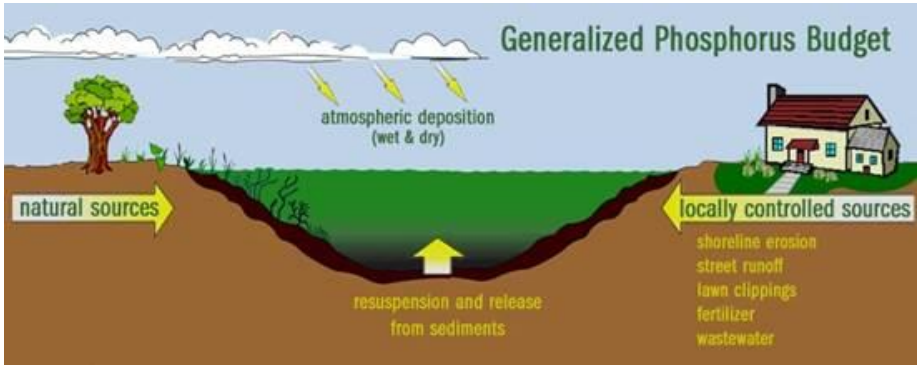
FIGURE 2: Pigeon Lake Watershed Management Plan Study Area



PHOSPHORUS

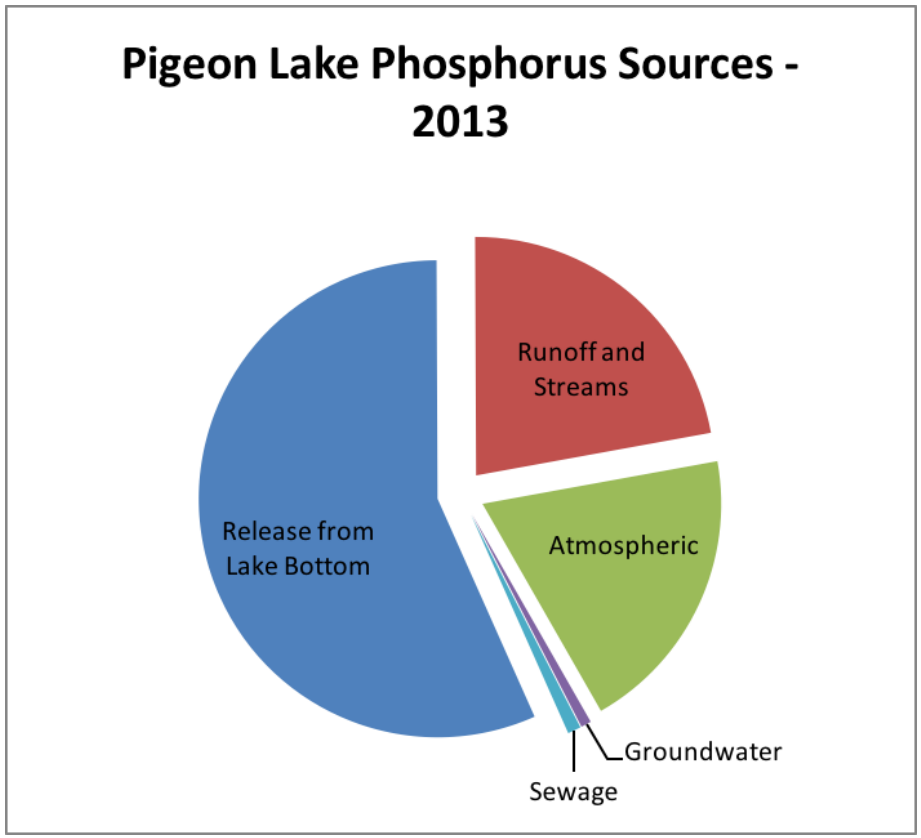
Algae levels are dependent on a variety of factors including climate cycles, sunlight, wind, and nutrient levels in the lake. Specifically, concentrations of phosphorus (a type of nutrient) greatly influence bloom formation. During ice-free conditions, phosphorus enters the lake from the surrounding watershed and the atmosphere (Figure 3) and is taken up by algae. During ice-covered conditions, the suspended sediment and algae (and the associated phosphorus) will settle out into the lakebed sediments, so that phosphorous returns to a low level during ice covered conditions. This cycle is repeated annually.

FIGURE 3: Generalized Phosphorous Budget



The movement of phosphorous into the lake from various sources can be calculated in a "phosphorus budget." During the open-water season of 2013, detailed measurements were taken of phosphorus movement into Pigeon Lake. From these measurements, a summation of annual phosphorus inflows and outflows was prepared in 2014.The phosphorous budget estimates that during the open water season, the lake gains on average 13,250 kg (13.2 metric tonnes) of total phosphorus from sources identified in Figure 4. Each winter, except for small amounts leaving the lake, this amount of phosphorus

FIGURE 4: Phosphorus Sources in 2013



is incorporated into the lakebed sediments, some of which get re-released to the lake in the following years.

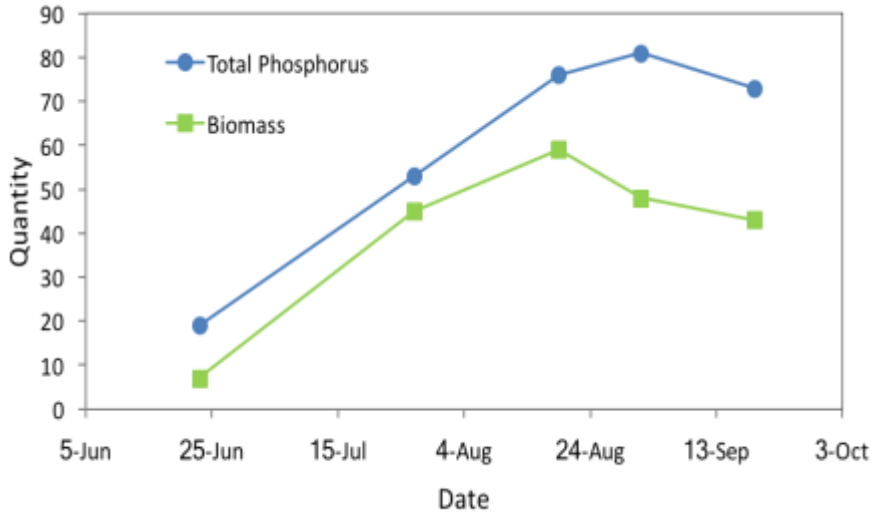
The five colored segments of the pie chart show the relative magnitude of the sources of internal and external loading. The sources of phosphorus that can potentially be managed include runoff, sewage, and release from lake bottom sediments. The Plan will include specific actions to address these sources of phosphorus.

The pie chart (Figure 4) represents only part of a typical year, is generalized and may not be typical of all years. Also, the chart may not fully differentiate

all sources nor all mechanisms and causes of phosphorous entering the lake. More research is needed. Phosphorus from internal sources (the sediments) is phosphorus from external sources deposited in prior years. Managing phosphorus sources from the watershed is a key priority of the Plan.

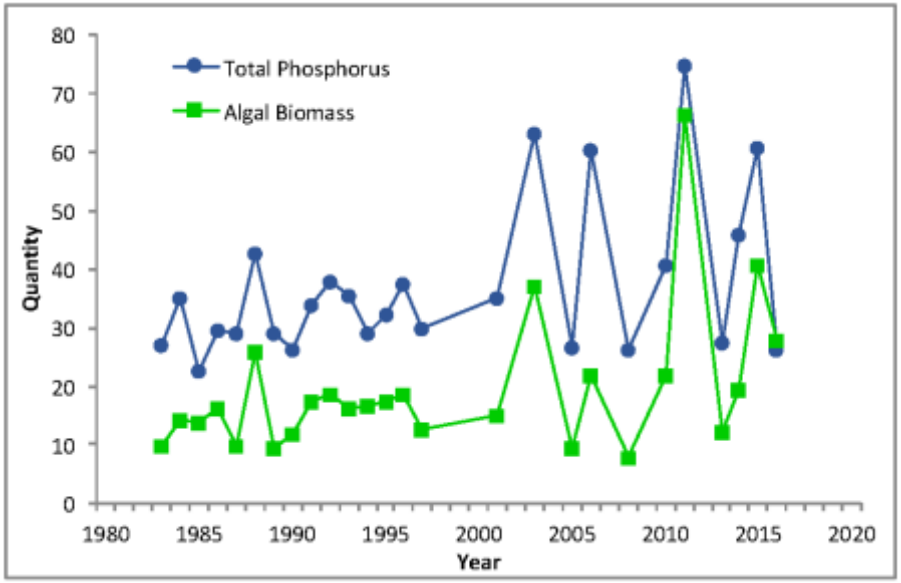
Each year, phosphorus levels in the lake vary from quite low during winter ice cover to higher levels, which in certain years coincide with bloom conditions. Figure 5 shows an example of phosphorus levels in 2015 relative to algal biomass during the open water season.

FIGURE 5: Seasonal Trends in Total Phosphorus and Algal Biomass



Trend lines in phosphorus and algae levels show considerable variations, from one year to the next. Figure 6 shows that since 2002 the pattern of peaks and lows has changed with larger fluctuations and specific years being much higher. There reasons are not fully understood and require more research.

FIGURE 6: Total Phosphorus and Algal Biomass 1983 to 2016

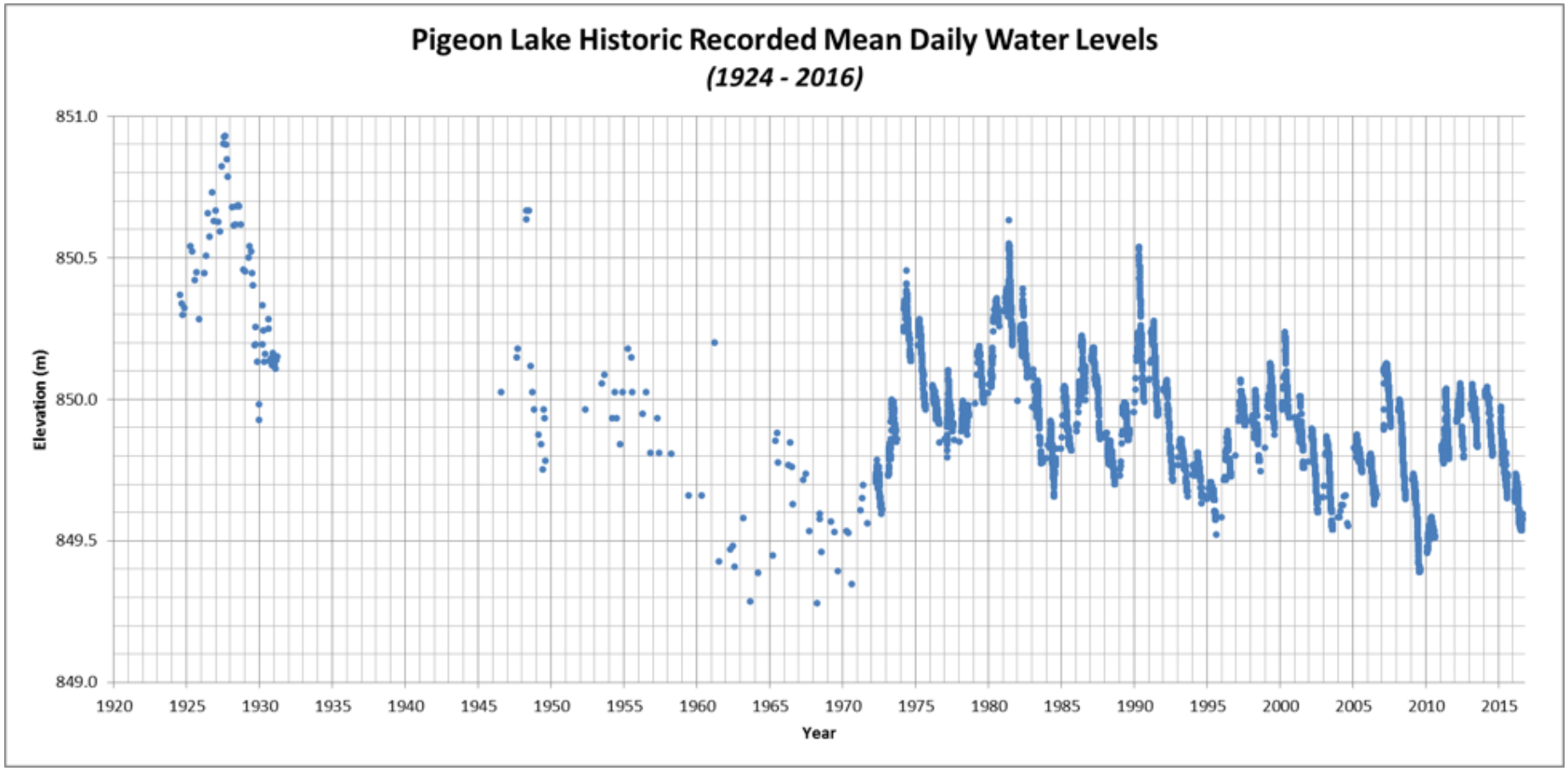


LAKE WATER LEVELS

Pigeon Lake is a permanent waterbody. It has a long residence time (the amount of time that water will remain in a basin) of greater than 100 years. The watershed of Pigeon Lake is small relative to the lake itself, with a surface area ratio of approximately 2:1 watershed (187 km^2) to lake (96.7 km^2). Compared to other Alberta lakes, the small drainage area and large evaporative area makes Pigeon Lake particularly sensitive to climatic variability, with changes to precipitation and/or evaporative rates having a considerable impact on lake water levels.

The lake does not have large water withdrawals. The outflow creek that drains Pigeon Lake into the Battle River is fitted with a weir with a crest elevation of 849.935 meters above sea level (masl). When water reaches this elevation, outflow occurs, including a small amount of nutrient release.

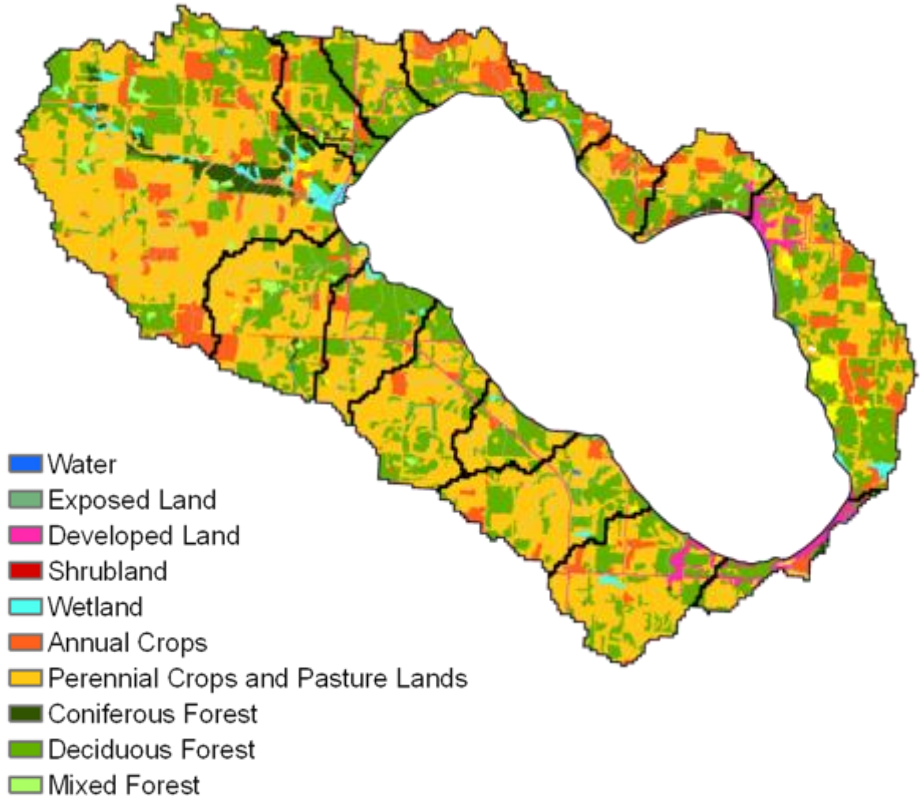
Pigeon Lake has lake level data available since the 1920s. The extensive historical water level data demonstrates that Pigeon Lake experiences ongoing water level cycles of both increasing and decreasing trends when considered over a longer time-period.



LAND COVER AND PHOSPHORUS

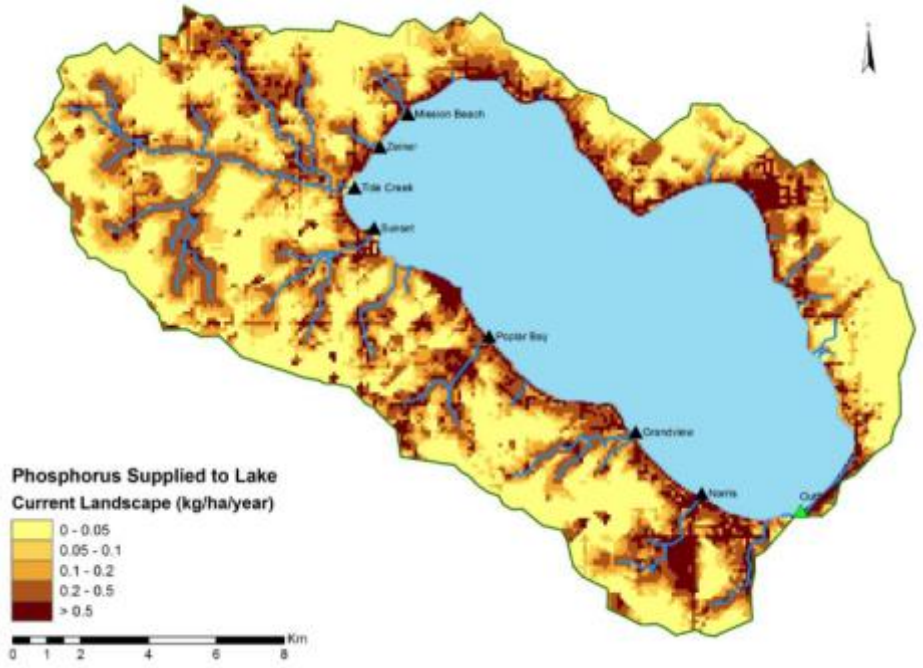
Historically, the watershed was naturally vegetated with forests, grasslands, and wetlands. Currently, the watershed is occupied by a mix of natural vegetation, farming, and developed lands (See Figure 7).

FIGURE 7: Pigeon Lake Watershed Land Cover



The amount of phosphorus runoff from watershed lands is affected to the types of and proportions of land cover. Based on the current land cover types, (for example, forest, pasture, crops, and developed land), a phosphorus loading model was developed. Figure 8 illustrates the pattern of phosphorus intrusion into the lake from the surrounding watershed.

FIGURE 8: Phosphorus Entering Pigeon Lake from the Watershed



This model shows that areas near streams and the lake shore are the most abundant sources of phosphorus flowing into Pigeon Lake. Based on this information, the Plan will focus on addressing land uses and natural buffers along the streams and lake.

PLAN IMPLICATIONS

From the foregoing snapshot and the best available evidence, key considerations affecting the overall strategy and perspective of the plan are:

- Multiple strategies will be required to improve the health of Pigeon Lake. No one strategy (silver bullet) exists that will address the bloom problem.
- The sources of phosphorus that can potentially be managed include runoff, sewage, and release from lakebed sediments.
- The plan identifies three geographic areas where nutrient sources can be managed:
  - The Watershed Lands
  - The Shoreline
  - The Lake
- Managing nutrients, particularly phosphorus, in the watershed is a key priority.
- The state of science about Pigeon Lake continues to evolve. Significant knowledge gaps still remain, especially related to nutrient and blue-green algae behavior throughout each season of the year.
- While in-lake treatments have shown promise for smaller water bodies, there are no known examples of successful in-lake treatment interventions for a lake the size of Pigeon Lake. In-lake treatments are short term and require periodic reapplication. Addressing matters such as feasibility, environmental negative effects, regulatory approvals, organizational delivery, and financing means that decisions about in-lake treatment will take further investigation and time.

Photo: Clean Runoff Municipal Demonstration

A ROADMAP

The Plan is organized into four main sections:

- The Watershed Lands: Pigeon Lake watershed up to the height of land surrounding the lake
- The Shoreline: Pigeon Lake's shoreline, including the bank and near shore waters.
- The Lake: Pigeon Lake itself, and
- Working Together: improving our collaboration and organizational capacity

Each of the four key areas of the Plan (Pigeon Lake, Shoreline, Watershed Lands, and Working Together) is structured in the following manner (see diagram):

- Plan Area (e.g., Watershed, Shoreline, the Lake)
  - Plan Objectives: where we want to go.
    - Recommendations and Actions: How we will get there:
      - Policy: Statutory plans, bylaws, agreements
      - Technical: Science and monitoring
      - Community Action: Advocacy, education, and voluntary action

The recommendations and actions are presented in a tabular form to show how the Plan will be implemented. Alongside of each recommendation are listed:

- responsible parties
- time frame
- measures of success

WATERSHED LANDS

KEY FINDINGS

Reducing the amount of phosphorus pollution entering the
water of Pigeon Lake must be a key
goal for managing the lake.

The coverage and ecological condition of land cover types with low phosphorous runoff (e.g., forests grasslands and wetlands) should be maintained and/or improved.

Key natural lands such as wetlands
and forested lands next to streams and the lake itself should be targeted for restoration. Land use activities should also be restricted in these

OBJECTIVES

Increase land cover types (e.g. forest, wetlands) that have lower nutrient release rates, trap nutrients, and that promote biodiversity.

Improve phosphorous management for all land use activities to achieve a net reduction in nutrient runoff and promote biodiversity.

Promote clean runoff practices to reduce the transport of nutrients to Pigeon Lake.

Protect groundwater that feeds into Pigeon Lake.

LAND COVER & BIODIVERSITY

OBJECTIVE 1 Increase land cover types (e.g., forest, wetlands) that have lower nutrient release rates, trap nutrients, and promote biodiversity.

- Over 60% of the watershed has already been cultivated or converted for human uses, including urban development, pasture/perennial crops, and annual crops.
- Land cover is directly related to the sources and quantity of phosphorus that is entering the lake.
- Promoting land cover types that have low phosphorus runoff is one important watershed management strategy.
- Providing healthy vegetated buffers along water courses,
- Managing wetlands and natural areas as important nutrient traps.
- Promoting natural forest buffers will add to biodiversity (species diversity) important to the ecosystem health of the watershed.

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LAND COVER & BIODIVERSITY OBJECTIVE 1: Increase land cover types (e.g. forest, wetlands) that have lower nutrient release rates, trap nutrients, and that promote biodiversity				
RECOMMENDATIONS	Type	Roles	Time Frame	Success Measure
1a **Land Conservation:** Conserve watershed priority areas with protective designations, including: the Provincial Park, private land conservation purchases, conservation easements, environmental reserves, and land use districts.	Policy	Lead: PLWMP Support: NGO, GoA, Mun, PLWA	Ongoing	Additional 10% over entire watershed
1b **Statutory Plans & Land Use Bylaws:** Retain Natural Vegetation: Develop guidelines and implement policies and regulations within statutory planning documents and municipal land use bylaws to retain natural areas and wildlife corridor (e.g. 80% tree cover for 20-acre lots) within new subdivisions; and for the requirement for development permits for tree and natural vegetation removal on residential lots.	Policy	Lead: APLM Support: Mun, PLWMP	Short Term	100% municipal participation
1c **Statutory Plans & Land Use Bylaws:** Wetlands: Implement policies and regulations in municipal planning documents to retain all wetlands and peatlands as nutrient traps. Implementation tools may include: • Requiring the delineation and classification of wetlands as a component of statutory plan development, subdivision or development permit applications. • Implementing development setbacks from wetlands and peatlands based on their classification	Policy	Lead: APLM Support: Mun, PLWMP	Short Term	100% municipal participation
1d **Restoration:** Implement programs to encourage the restoration of natural vegetation on lands throughout the watershed including reforestation and restoration of wetlands using incentives such as the Alternative Land Use Services Program (alus.ca)	Community Action	Lead: PLWMP Support: Operators, Mun, GoA, PLWA, NGO	Ongoing	One project per year
1e **Mapping:** map watershed priority areas such as wetlands, wildlife habitat, environmentally significant areas	Technical & Scientific	Lead: PLWMP Support: Mun, GoA, PLWMP	Medium Term	Task Completed

LAND USE & PHOSPHORUS MANAGEMENT

OBJECTIVE 2 Improve phosphorus management for all land uses to achieve a net reduction in nutrient runoff and promote biodiversity.

- Work has begun on introducing beneficial management practices (BMPs) for residential land to achieve nutrient control. The initiatives include:
  - Lawn Fertilizer Ban
  - Model Land Use Bylaw
- Consultation with the agricultural community has been initiated to encourage and implement BMPs to reduce nutrient runoff and improve biodiversity.
- Voluntary adoption of these BMPs needs to be actively supported by the province, municipalities, and stewardship groups.
- Other sectors such as golf courses and the oil and gas industry have beneficial practices that need to be better promoted for local operators.

LAND USE & PHOSPHORUS MANAGEMENT OBJECTIVE 2: Improve phosphorus management for all land use activities to achieve a net reduction in nutrient runoff and promote biodiversity.				
RECOMMENDATIONS	Type	Roles	Time Frame	Success Measure
2a **Intensive Livestock Operations:** In consultation with the Government of Alberta, prohibit intensive livestock operations from establishing within the Pigeon Lake watershed.	Policy	Lead: APLM Support: Mun, GoA, PLWA	Ongoing	No Intensive Livestock Operations
2b **Statutory Plans & Land Use Bylaws:** Lakeshore Environmental Area: Adopt an 800 metre "Lakeside Environmental Area" as per the Model Land Use Bylaw, that gives priority to land uses, policies, and environmental provisions designed to protect the lake from nutrient runoff. Policy provisions to include: • Requiring construction management plans with new development permit applications. • Restricting land uses within riparian areas that may increase runoff, increase the potential for contamination of groundwater, and/or impede the effectiveness of important recharge areas • Restricting land uses within 800 metres of the lake where phosphorus and other nutrients, chemicals, or nutrient-rich sediment may pollute the waters of Pigeon Lake. • Requiring a development permit and providing guidelines for the stripping and grading of lands within 800 metres of the bank of Pigeon Lake. Where possible this activity should be discouraged and or sediment controls be implemented during and post construction to eliminate sediment loading of the lake during construction.	Policy	Lead: APLM Support: Mun, PLWMP, PLWA	Short Term	100% municipal participation

LAND USE & PHOSPHORUS MANAGEMENT OBJECTIVE 2: Improve phosphorus management for all land use activities to achieve a net reduction in nutrient runoff and promote biodiversity.					
	• Requiring the application of local topsoil and native plants to be included in landscaping plans for new development and redevelopment areas. • Prescribing a maximum site coverage percentage for non-permeable surfaces on new development and re-development sites within 800 metres of Pigeon Lake. • Prescribing site coverage guidelines for natural vegetation cover that is compatible with FireSmart development principals • Discouraging the compaction of soils during stripping and grading activities that may interfere with natural groundwater recharge and increase surface water runoff. • Prohibiting the excavation or filling in or clearing of all wetlands and stream courses and their associated riparian lands within 800 metres of the legal bank of Pigeon Lake.				
2c	**Lawn Fertilizers and Pesticides:** Continue to provide education and support for watershed residents to eliminate lawn fertilizers and pesticides on residential properties and to promote alternative practices.	Community Action	Lead: PLWA Support: Mun	Largely Completed	Annual Programs,
2d	**Watershed Stewardship Advocacy & Education:** Encourage landowners (residential, business, recreational and agricultural) to adopt proactive lake-friendly environmental management practices, landscaping and activities. Support land use policies and regulatory measures with public awareness and education.	Community Action	Lead: PLWA Support: Mun, NGO, GoA	Ongoing	Increased Participation
2e	**Agricultural Operations:** Encourage agricultural operators to participate in whole farm reductions in phosphorus runoff using the Alberta Agriculture and Forestry Phosphorus Management Tool and the Environmental Farm Program, and to adopt beneficial management practices that reduce nutrient runoff. Promote agricultural erosion and sediment control practices (e.g. low tillage).	Community Action	Lead: Counties Support: PLWA, PLWMP, APLM, GoA	Ongoing	Sector Participation
2f	**Recreational Operations:** Encourage recreational land uses (e.g. golf courses, campgrounds) to adopt beneficial management practices (e.g. Audubon Certification) that reduce nutrient run off and promote biodiversity.	Community Action	Lead: PLWA Support: PLWMP, Mun, NGO, GOA	Ongoing	Sector Participation
2g	**Oil and Gas Operations:** Encourage all oil and gas operations to adopt a best management practices on all well sites, batteries, and processing operations to reduce contaminants and phosphorous rich runoff. Encourage future operations to minimize land disturbances.	Community Action	Lead: PLWA, Support: PLWMP, NGO, GOA	Medium to Long Term	Sector Participation

CLEAN RUNOFF

OBJECTIVE 3 Promote clean runoff practices to reduce the transport of nutrients to Pigeon Lake.

The movement of water across the watershed carries nutrients to the lake.

- Suspended sediment with attached phosphorus is also entering waterbodies within the watershed and Pigeon Lake itself.
- Suspended sediment negatively impacts the health of waterbodies by: transporting nutrients to the lake, burying important spawning grounds and impeding the flow of water.

- Low-Impact Development Practices are promoted in the Alberta Clean-Runoff Action Guide for individual lot owners and municipalities.
- Drainage management needs to have phosphorus as the target water quality criteria for the Pigeon Lake basin.

CLEAN RUNOFF OBJECTIVE 3: Promote clean runoff practices to reduce the transport of nutrients to Pigeon Lake				
RECOMMENDATIONS	Type	Roles	Time Frame	Success Measure
3a **Roads:** Eliminate salt and pesticide applications for all road allowances within 800 metres of the lake.	Policy	Lead: APLM Support: Mun, PLWMP, PLWA	Short Term	100% Participation
3b **Statutory Plans & Land Use Bylaws: New Subdivision Stormwater:** Require all new developments to: • provide a storm water quality management plan that is net neutral or better in phosphorus release rates and incorporates low impact development drainage practices. • Regulating post development storm drainage flow to no net increase in amount or rate of water flow offsite. • When applicable, requiring developers to submit and follow Stormwater Site Implementation Plans (SSIPs) that comply with a Master Drainage Guidelines for the Watershed.	Policy	Lead: APLM Support: Mun, PLWMP, PLWA	Short Term	100% Participation
3c **Statutory Plans & Land Use Bylaws: Sediment and Erosion Control:** all new developments and redevelopment to institute a construction erosion and sediment control plan.	Policy	Lead: APLM Support: Mun, PLWMP, PLWA	Short Term	100% Participation
3d **Beaver Management:** Manage beaver populations and natural structures in tributaries to promote nutrient trapping while adequately protecting infrastructure and property.	Policy	Lead: PLWA Support: PLWMP, Mun, GOA	Ongoing	100% Participation
3e **Clean Runoff:** Promote clean runoff practices on private and public properties as per the Alberta Clean Runoff Action Guide.	Community Action	Lead: PLWA. Support: Mun, NGO, GoA	Ongoing	Increased Participation
3f **Water Quality Guideline:** Develop a drainage water quality guide with quality and release rates guidelines for new major developments and proposed retrofits for existing drainage systems. Phosphorus is to be recognized as the water quality parameter of greatest concern for Pigeon Lake.	Technical & Scientific	Lead: PLWMP Support: APLM, Mun	Medium Term	Task Completion

GROUNDWATER QUALITY

OBJECTIVE 4 Protect Groundwater that feeds into Pigeon Lake.

- Phosphorus from wastewater is identified in the phosphorus budget as contributing 0.9% of the total phosphorus budget and as a potential source to be managed. Phosphorus from wastewater may be accompanied with fecal coliforms.
- Local municipalities have policies to regulate and minimize potential contamination from private waste water disposal systems. Where private systems still exist near the lake, most are provincially approved pump-out tanks and a small percentage are septic fields.
- Septic fields are a source of nutrient release into groundwater and the nearby lake.
- The Northeast portion of the lake is served with a communal wastewater sewer system (gravity collection system and lagoon). Currently under development is a trunk collection line for the south shore.

GROUNDWATER QUALITY
OBJECTIVE 4: Protect groundwater that feeds into Pigeon Lake.

	RECOMMENDATIONS	Type	Roles	Time Frame	Success Measure
4a	**Statutory Plans & Land Use Bylaws: Groundwater Conservation:** Incorporate water conservation guidance tools into municipal statutory plans and development requirements.	Policy	Lead: APLM Support: Mun, PLWMP, PLWA	Medium Term	Task Completion
4b	**Statutory Plans & Land Use Bylaws:** Groundwater Impact Assessments: Require new major developments in the watershed to demonstrate no negative impacts on existing groundwater users or the lake water supply.	Policy	Lead: APLM Support: Mun, PLWMP, PLWA	Medium Term	Task Completion
4c	**Wastewater Collection:** Support the extension of a regional waste water system to lakeside communities including the two Pigeon Lake Provincial Park campsites.	Policy	Lead: APLM Support: PLWA Mun, Local Authorities, GOA	Medium Term	Completion of system
4d	**Septic Fields:** Eliminate septic fields for residential lots within the Lakeside Environmental Area	Policy	Lead: APLM Support: PLWA Mun, Local Authorities, GOA	Medium Term	Elimination of remaining fields
4e	**Wastewater System Inspections:** Promote regular inspections of both private and communal wastewater systems for integrity and leakage. Systems that fail are to be reported and repaired.	Policy	Lead: APLM Support: Mun, Local Authorities	Ongoing	100% Participation
4f	**Water Wells:** Encourage home owners to adopt water conservation and well maintenance practices (e.g. GoA Working Well program)	Community Action	Lead: PLWA Support: Mun, NGO, GOA	Ongoing	Consistent Program
4g	**Industrial Groundwater Extraction:** Monitor permit applications and Intervene where warranted on behalf of the watershed to maintain groundwater flows to the lake.	Community Action	Lead: PLWA Support: Mun, NGO,	Ongoing	Effective Monitoring

THE SHORELINE

Healthy shorelines (or riparian areas) are critically important for the health and protection of aquatic ecosystems. Thus, these areas should be targeted for protection and restoration efforts.

KEY FINDINGS

Natural lands such as wetlands and forested lands next to streams and the lake itself should be targeted for restoration. Land use activities should also be restricted in these areas.

Ongoing monitoring is necessary to prevent the infestation of aquatic and riparian invasive species.

OBJECTIVES

Improve the health and resilience of the shoreline and near-shore areas

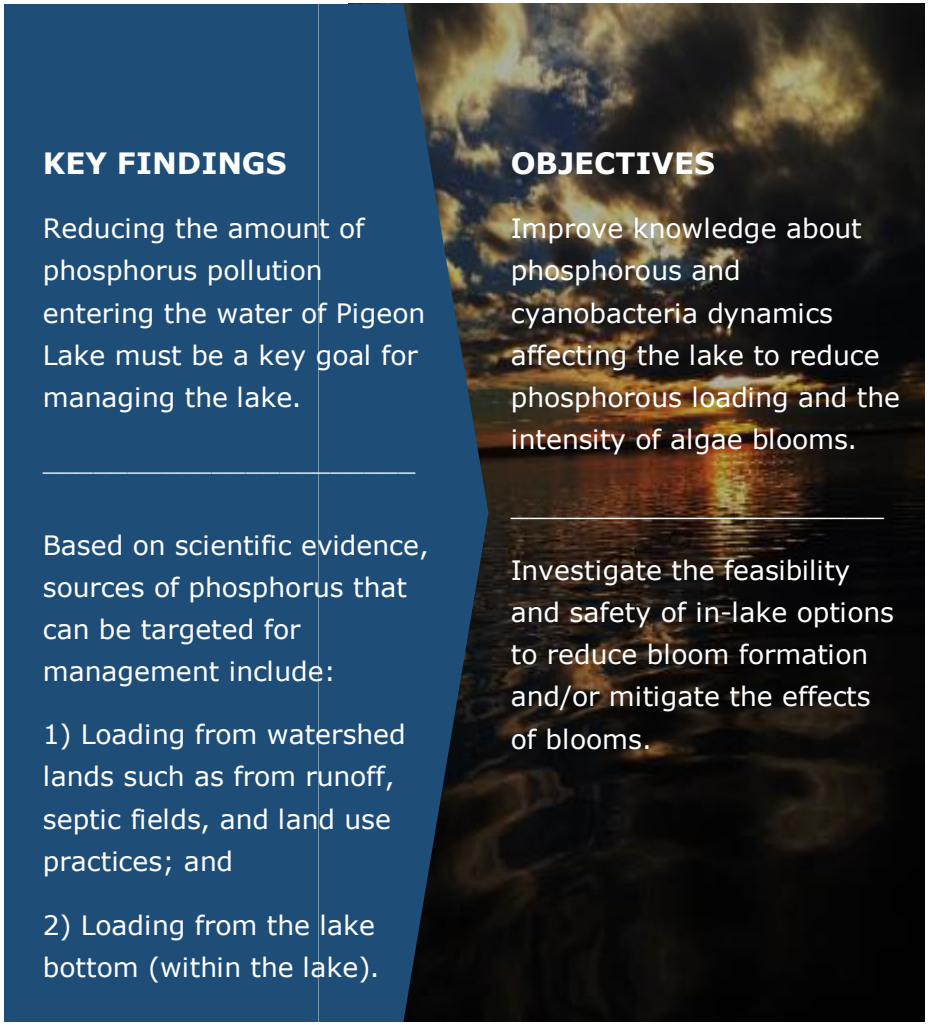
Riparian Beneficial Management Practices (BMPs) involve actions that can be taken by land owners and users within the Pigeon Lake watershed to improve the water quality of the lake and streams. These may include:

- Avoiding the removal of riparian vegetation such as mowing, trimming, or land clearing, if possible. Maintaining natural vegetation cover on shores is preferred to artificial armoring and modification of shorelines.
- Educating watershed property owners and lake visitors about the importance of near-shore vegetation. The current perception of many is that most aquatic plants are all "weeds" and, as such, are a nuisance to lake users. However, educating the public of the ecological value of aquatic vegetation is hugely important to maintenance and improvement of these areas.
- Educating lake users and residents on how to recognize aquatic invasive species is critical for early detection and eradication.
- Developing and encouraging the use of community-based lake access and beaches instead of individual ones. Concentrating the traffic in a few spots around the lake will help to reduce shoreline degradation and destruction.
- Ensuring adequate naturalized setbacks for upland activities such as residential development, cropping, or livestock grazing. This may include leaving a natural vegetation buffer around waterbodies, reducing grazing intensity and access within riparian areas, and planting additional riparian vegetation.
- Eliminating the use of fertilizers and herbicides along the lakeshore.
- Limiting the use of salts on shoreline roads to limit the increase in lake salinity via runoff.

SHORELINES OBJECTIVE 5: Improve the health and resilience of the shoreline and near-shore areas				
RECOMMENDATIONS	Type	Roles	Time Frame	Success Measure
5a **Statutory Plans & Land Use Bylaws: Shoreline and Tributary Setbacks:** • For Sensitive shore lands: implement restrictive land use designations that preserve natural buffers • For new subdivisions: implement development setbacks from the surveyed shoreline of the Lake for new development, based on riparian setback guidelines with a minimum of 30 m, including restrictions for tree and vegetation clearing. At time of subdivision, where existing development would not make the provision of an environmental reserve inappropriate, require the provision of a 30-metre-wide environmental reserve adjacent to the shoreline of the lake. • For existing lot redevelopment: establish a minimum building setbacks as per guidelines set out in the Model Land Use Bylaw.	Policy	Lead: APLM Support: Mun, PLWMP, PLWA	Short Term	Task Completed 100% municipal participation
5b **Statutory Plans & Land Use Bylaws:** Shoreline Modification: Require bylaw provisions consistently across the watershed that any shoreline modification requires a development permit lines for lands abutting the legal bank and provincial permits for shore land below the legal bank. Except for reasonable access shore lines are to be kept in a natural state. Modifications include regrading, natural vegetation clearing, drainage modifications	Policy	Lead: APLM Support: Mun, PLWMP, PLWA	Ongoing	No shoreline modifications without approvals
5c **Restoration of Aquatic Vegetation:** Retain and re-establish cattail and reed beds to support fish habitat, provide erosion protection and filter nutrients.	Policy	Lead: GoA Support: Mun PLWA	Ongoing	Increased compliance
5d **Lake Shoreline Property Management Guidelines:** Develop a checklist and reference guide to assist development officers and lot owners in addressing the special development requirements for shore line lots. (e.g. On the Living Edge Update)	Community Action	Lead: PLWMP Support: PLWA, APLM, PLWMP	Short Term	Task Completion
5e **Shoreline Practices and Restoration:** Provide guidance documents, incentive programs, technical information, and support to shoreline landowners to implement healthy shoreline practices, shoreline restoration, and lake-friendly landscaping.	Community Action	Lead: PLWA Support: Mun, NGO, GOA	Short Term	50% Participation
5f **Algal Biomass:** Provide guidance and support for landowners on addressing algal biomass accumulation along shorelines.	Community Action	Lead: PLWA, Support: GoA	Ongoing	Consistent information
5g **Noxious Weeds:** Continue invasive species eradication programs, including education, monitoring, and eradiation of prohibited noxious weeds.	Community Action	Lead: MUN, PLWA, Support: NGO	Ongoing	Outbreaks under control
5h **Shoreline Health Assessment:** update the Pigeon Lake shoreline and tributary shoreline health (riparian) assessment	Technical & Scientific	Lead: PLWMP Support: PLWA GOA	Short Term	Task Completion
5i **Mapping:** Undertake a comprehensive inventory of critical fish and wildlife habitat (such as Sensitive Habitat Inventory Mapping)	Technical & Scientific	Lead: PLWMP Support: PLWA	Medium Term	Task Completion

THE LAKE

High nutrient levels contribute to the growth of blue-green algae. Blue-green algae advisories have been applied to the lake since 2010, which is when the Alberta Health Services (AHS) program was implemented. Recent algae blooms have impacted the use and enjoyment of the lake by residents and visitors and affected recreational property values within the watershed. Since blue-green algae can be affected by many climatic and other environmental factors, information gaps about the causal factors for blooms and the behavior of blue-green algae need to be filled.



KEY FINDINGS

Reducing the amount of phosphorus pollution entering the water of Pigeon Lake must be a key goal for managing the lake.

Based on scientific evidence, sources of phosphorus that can be targeted for management include:

1) Loading from watershed lands such as from runoff, septic fields, and land use practices; and

2) Loading from the lake bottom (within the lake).

OBJECTIVES

Improve knowledge about phosphorous and cyanobacteria dynamics affecting the lake to reduce phosphorous loading and the intensity of algae blooms.

Investigate the feasibility and safety of in-lake options to reduce bloom formation and/or mitigate the effects of blooms.

Pigeon Lake Technical Committees have reviewed several methods that have been implemented in other jurisdictions to address excess lake nutrient levels and harmful algal blooms. Treatment options under consideration include:

PIGEON LAKE & IN-LAKE MANAGEMENT

- Removal of algae:
  - Manipulation of the lake food web to control Blue Green Algae
  - Harvesting algae from the water surface and shorelines and exporting the biomass out of the watershed
- Removal of nutrients:
  - Chemical inactivation of P in the water column via addition of aluminum, calcium, iron and/or lanthanum-enriched bentonite clay (e.g., Phoslock®)

These approaches are currently being reviewed to determine their viability to treat the current water quality problems; however, the circumstances supporting their efficacy at one lake may not be true when applied to another. Review of these strategies requires lake-specific research, environmental and socio-economic risk assessments (including evaluation of potential risks to the

lake, financial costs, and overall efficacy), formal stakeholder consultation, and regulatory approval prior to implementation. Before moving forward with any in-lake treatment, professionally prepared feasibility studies with costs, risks, and benefits are needed and should be made available to the public. Any in-lake engineered treatment will require Provincial Government regulatory approval and should not be undertaken without public consultation and the implementation of a program for on-going scientific monitoring.

The following table provides recommendations and actions for achieving the identified Pigeon Lake and In-Lake Management objectives.

PIGEON LAKE & IN-LAKE MANAGEMENT

OBJECTIVE 6: Improve knowledge about phosphorus and cyanobacteria dynamics affecting the lake to reduce phosphorus loading and the intensity of algae blooms.

OBJECTIVE 7: Investigate the feasibility and safety of in-lake options to reduce bloom formation and/or mitigate the effects of blooms and also to build local defences against harmful invasive species.

	RECOMMENDATIONS	Type	Roles	Time Frame	Success Measure
6a	**Advancement of Science:** Identify knowledge gaps relating to the formation of cyanobacteria blooms and techniques for meaningful reductions. Prioritize specific investigations and research projects. Fund and implement ongoing research for Pigeon Lake.	Technical & Scientific	Lead: PLWMP Support: APLM, Technical Specialists, PLWA, GoA	Ongoing	Coordinated Published program.
7a	**Invasive Species:** Complement the Government of Alberta's province-wide efforts with local initiatives to improve education and build local defenses to keep out aquatic invasive species. Measures include monitoring, public education, signage, and other initiatives	Community Action	Lead: PLWA Support: APLM, Mun, Technical Specialists, PLWMP, GoA	Ongoing	Effective local program
7b	**In-Lake Management:** Evaluate potential management options including project description, costs and financing; effectiveness in reducing phosphorus and algal blooms; reapplication frequency; environmental, social, and economic risks; and regulatory concerns. Implement where feasible.	Technical & Scientific	Lead: APLM. Technical Specialists	Ongoing	Coordinated published program.

WORKING TOGETHER

OBJECTIVE 8 Improve regional collaboration, partnerships and organizational effectiveness to promote collective action for a healthy watershed, healthy lake and healthy community.

- People and different jurisdictions have different and sometimes conflicting perspectives on the nature and scale of Pigeon Lake's problem, the likely effectiveness of proposed solutions,
- The Plan provides an opportunity to coordinate implementation, and assess the organizational assets to implement the plan and its policies

WORKING TOGETHER

OBJECTIVE 8: Improve regional collaboration, partnerships and organizational effectiveness to promote collective action for a healthy watershed, healthy lake and healthy community.

	RECOMMENDATIONS	Type	Roles	Time Frame	Success Measure
8a	**Statutory Regional Plans:** Work toward a watershed-wide Intermunicipal Development Plan (IDP), Regional Collaboration Framework and a sub-regional plan under the North Saskatchewan Regional Plan that all align with the Pigeon Lake Watershed Management Plan.	Policy	Lead: APLM Support: PLWMP, Mun, PLWA, GoA	Short Term	Task Completion
8b	**Municipal Development Plans:** Work toward consistent municipal development plans for all Summer Villages, that incorporate the environmental protection policies of the Watershed Management Plan and the Model Land Use Bylaw	Policy	Lead: APLM Support: SV, PLWMP, PLWA, GoA, TS	Short Term	Task Completion
8c	**First Nations:** Engage the First Nations of IR 138A Pigeon Lake Reserve in the Watershed Management Plan.	Policy	Lead: PLWMP/ First Nations Support: APLM, PLWA, GoA	Short Term, Ongoing	Ongoing
8d	**Watershed Management Plan Updates:** Revisit and update the Watershed Management Plan every five years and rewrite the Plan every ten years to accommodate the changing condition of the lake, success of current recommendations, new scientific knowledge, new legislation, and new stakeholder and organizational assets and interests.	Policy	Lead: PLWMP Support: APLM, PLWA, GoA	Medium to Long Term	Task Completion
8e	**Assess Organizational Assets:** Investigate organizational options to increase effectiveness, staff resources, financing, risk management, and accountability in undertaking watershed and lake management tasks, including coordination of scientific inquiry, action by municipalities, and community action.	Policy	Lead: PLWMP Support: APLM. PLWA, GoA	Short to Medium Term	Task Completion
8f	**Incentives to Promote Voluntary Action:** Develop non-monetary and monetary incentive programs to promote voluntary action for individuals, municipalities and organizations	Community Action	Lead: PLWA Support: PLWMP, APLM, GoA, NGO	Ongoing	Program of Incentives
8g	**Communication and Engagement Plan:** Establish a communications and engagement plans for disseminating and reporting Plan progress to and amongst stakeholders.	Community Action	Lead: PLWA Support: PLWMP, APLM, PLWA, GoA	Short Term, Ongoing	Consistent Program
8h	**Monitoring Plan:** Develop an monitoring plan for environmental trends including lake and tributary water quality and for plan performance including fulfillment of success measures.	Technical & Scientific	Lead: PLWMP Support: PLWA APLM GoA	Medium Term, Ongoing	Effective Monitoring Program
8i	**Phosphorous Budget:** Continue to update and refine the phosphorus budget.	Technical & Scientific	Lead: GoA Support: PLWA APLM	Medium Term	Task Completion

PUTTING THE PLAN INTO MOTION

The following provides a summary of the Plan is to be put into action.

POLICY

Policy and statutory plans are how governments can collaborate to improve the health of the lake and watershed. Recently enacted changes in the Municipal Government Act (MGA) provide a significant opportunity to harmonize regional plans and land use policies. The MGA now requires that all Summer Villages prepare a Municipal Development Plan. Watershed Management Plan objectives and policy recommendations have an opportunity to become common to all Summer Villages. Similarly, all adjacent municipalities will be required to have an Intermunicipal Development Plan (IDP) and a Regional Collaboration Framework (RCF). A common IDP or RCF for all municipalities bordering Pigeon Lake should provide common senior land use policy for the watershed including a Lakeshore Environmental Area Planning Zone. Land Use Bylaws are being updated by each municipality and this Plan and Model Land Use Bylaw provide guidance to improve their environmental provisions.

The Province may recognize this Plan under the North Saskatchewan Regional Plan. This status will promote coordination between departments on key objectives and reinforce land use policy through the Alberta Land Stewardship Act (ALSA) and ALSA provisions in the Municipal Government Act.

Addressing the resources and effective organizational structures monitoring progress, updating the plan and developing detailed guidelines is an ongoing role of the Plan Steering Committee, which is a joint initiative of the Pigeon Lake Watershed Association and the Alliance of Pigeon Lake Municipalities.

COMMUNITY ACTION

The volunteer actions of individual property owners, business, recreation, farm and oil & gas operators are very important. Organizations such the Pigeon Lake Watershed Association, Municipalities and agriculture extension and industry associations play a key role in promoting beneficial practices and providing information, education and support. The Plan asks all individuals and organizations to:

- Seek out information and beneficial practices relevant to their situation.
- Assess their own properties and operations
- Make beneficial changes incrementally.
- Encourage others and councils to make appropriate changes.
- Support volunteer watershed groups such as the PLWA

TECHNICAL / SCIENCE

Moving forward will require the engagement of experts to provide guidance in a variety of areas including:

- Planning and Land Use Controls including Statutory Planning, Drainage/water quality guidelines.
- Research Ongoing basic and applied research and monitoring to address information gaps to help make better management decisions
- In-lake management options feasibility and actions
- Mapping and Plan Monitoring

CONCLUSION

The Pigeon Lake Watershed Management Plan provides a comprehensive, science-based strategy to coordinate action for the protection and improvement of Pigeon Lake, its shore lands, and its watershed.

The roadmap provided by the Plan will enable improved coordinated action of all parties concerned about the health the Pigeon Lake and its watershed. The Plan enables all of us to be "Working together for a healthy watershed, healthy lake, and healthy community".

NOTES