Hutchinson

Environmental Sciences Ltd.

Lac La Biche Sensitive Habitat Index Mapping and Shoreline Management Guidelines

Prepared for: Living Lakes Canada
Job #: J170009

June 16, 2017

1-5 Chancery Lane, Bracebridge ON P1L 2E3 | 705-645-0021
202-501 Krug Street, Kitchener ON N2B 1L3 | 519-576-1711
4482 97 Street NW, Edmonton AB T6E 5R9 | 587-773-4850

June 16, 2017 HESL Job #: J170009

Heather Leschied
Programs Director
Living Lakes Canada

Dear Ms. Leschied:

Re: Lac La Biche Sensitive Habitat Mapping and Shoreline Management Guidelines

Hutchinson Environmental Sciences Ltd. has completed the final version of the Lac La Biche Sensitive Habitat Inventory Mapping (SHIM) Project: the Lac La Biche Shoreline Management Guidelines. The report presents and describes information collected through 2016 field investigations and a background review (including land use, shore type, shoreline modifications, riparian vegetation, aquatic vegetation, phytoplankton, fisheries, wetlands, wildlife and birds), amalgamates the information through an Aquatic Habitat Index to measure the value of ecological habitat, assesses activity risk of proposed development activities, and recommends management practices and mitigation measures to avoid and minimize adverse environmental effects on Lac La Biche.

Lac La Biche is valued by residents and visitors alike for its natural beauty, abundant wildlife, good water quality, and the variety of recreational opportunities it offers. It is a large, moderately developed lake, which still retains a high degree of natural shoreline, but also contains numerous modifications associated with human activity, such as docks, retaining walls and boat launches, as well as removal of riparian, wetland and submerged vegetation. The lake has experienced recent declines in water quality and fish populations, leading to widespread and recurring algal blooms, as well as fishery closures.

Balancing shoreline development activities is paramount for the ongoing protection and restoration of Lac La Biche's ecological health. We have developed a tool to help landowners and regulators make environmentally sound land use decisions along the Lac La Biche shoreline. The SHIM tool offers a systematic, streamlined and science-based process for integrating information on ecological condition into shoreline development planning. We hope this tool will be a useful component of balancing shoreline development and environmental protection on Lac La Biche in the future.

Sincerely,
Per. Hutchinson Environmental Sciences Ltd.

Brent Parsons, M.Sc.
brent.parsons@environmentalsciences.ca

Signatures

Report Prepared by:

Brent Parsons, M.Sc.
Senior Aquatic Scientist

Andrea Smith, Ph.D.
Senior Scientist

Eric Dilligeard, Ph.D.
Geospatial Analyst

Report Reviewed by:

Dörte Köster, Ph.D.
Senior Aquatic Scientist

Acknowledgements

Fieldwork for this assessment was completed by Bruce MacDonald and Heather Leschied, Living Lakes Canada, with additional support from Lac La Biche County and Brian Deheer and Jason Ponto, Athabasca Watershed Advisory Council. Bruce MacDonald and Heather Leschied also provided invaluable technical support throughout report production.

Financial and in-kind support for this project was provided by Environment Canada EcoAction, Alberta EcoTrust, Alberta Conservation Association, Alberta Real Estate Foundation, Land Stewardship Centre, and Lac La Biche County.

List of Acronyms

AHI	Aquatic Habitat Index
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUE	Catch Per Unit Effort
GIS	Geographic Information Systems
GPS	Global Positioning System
HESL	Hutchinson Environmental Sciences Limited
SHIM	Sensitive Habitat Index Mapping
ZOS	Zones of Sensitivity

Executive Summary

Lac La Biche is appreciated by residents and visitors alike for its natural beauty, abundant wildlife, good water quality, and the variety of recreational opportunities it offers. Lac La Biche is a large, moderately developed lake, which still retains a high degree of natural shoreline, but also contains numerous modifications associated with human activity, such as docks, retaining walls and boat launches, as well as removal of riparian, wetland and submerged vegetation.

The lake has experienced recent declines in water quality (Schindler et al. 2008) and fish populations (Alberta Environment and Parks 2017a), leading to widespread and recurring algal blooms, as well as fishery closures. The lake supports mixed domestic and recreational fisheries, and a restoration program was established to address overfishing through reduction in catch limits, Walleye stocking, cormorant control, habitat protection and monitoring. The latest survey data (from 2014) indicate that Walleye populations appear to be recovering in the lake, but they are still considered vulnerable. Lac La Biche is naturally eutrophic and blue-green algal blooms are typically mid-summer, but cultural eutrophication in recent decades likely impacts the size and abundance of such blooms.

The Sensitive Habitat Inventory Mapping (SHIM) project for Lac La Biche was initiated in 2016 to respond to community concerns expressed by the Stewards of the Lac La Biche Watershed, over the health of the lake. This project characterizes the physical and biological features of the lake's foreshore so that sensitive areas can be identified and subsequently protected during shoreline development. The SHIM methodology was developed by Fisheries and Oceans Canada in British Columbia, and while it has been successfully incorporated into land use planning for several lakes there, the Lac La Biche SHIM project will be the first example of its use elsewhere in Canada.

The 167 km length of Lac La Biche shoreline was divided into 60 segments based on shore type, land use and vegetation. Most of the shoreline (85%) was natural, especially around the islands and along the northern side of the lake. The predominant shore type was rocky (65%), followed by wetland (19%) and sand (8%). Rocky shorelines were scattered throughout much of the lake, while wetlands were mainly concentrated along the north shore. The most common land use was natural area (65%).

Although most of the shoreline was characterized by natural habitat, numerous shoreline modifications were also recorded, including 229 docks, 248 boat lifts, 39 private boat launches and 5 retaining walls. Removal of riparian, wetland and submerged vegetation was also a common modification, as well as addition of substrate (such as gravel and sand) for boat launches and beaches.

The riparian zone was primarily characterized by forest (45% of shoreline was comprised of broadleaf forest and 39% of mixed forest). The remaining riparian habitat was made up of wetland (5%), shrubs (5%), landscaped habitat (4%), herbs/grasses (2%) and exposed soil (<1%). Wetland riparian habitat occurred mainly in the southeastern embayment and shrubs dominated areas around High, Black Fox, and Fox Islands. Forested riparian zones occurred throughout the lake's shoreline, while landscaped habitat was associated with developed areas, especially in the eastern basin.

The main types of substrate documented in the foreshore were sand (27%), cobble (23%), and gravel (22%). Boulders (17%), organic material (10%), and trace amounts of fine cobble, fine gravel, fines and coarse cobble were also recorded.

Submerged vegetation covered approximately 70% of the littoral zone, and had greatest coverage along the north shore of the western basin, adjacent to the La Biche River floodplain, as well as through most of the eastern basin. Emergent vegetation was less abundant, occupying 18% of the shoreline, typically associated with wetland areas.

Blue-green algal blooms occur annually in Lac La Biche during the summer, although coverage and abundance varies from year to year. The highest concentrations were typically reported in the eastern basin (due to westerly winds). Lac La Biche is naturally eutrophic and thus prone to blooms, although human activity has likely increased eutrophication of the lake over the last 30 to 50 years.

No fish surveys were conducted as part of the SHIM project. Lac La Biche is home to thirteen fish species and supports important sport, and domestic fisheries. A fisheries restoration program was initiated in 2005 in response to declines in fish populations due to overfishing, which includes catch limit reductions, protection of critical fish habitat, and monitoring of the fish community. Resident fish rely on a variety of aquatic habitats for spawning and rearing of young, including rocky substrates, flooded vegetation and the presence of macrophytes and woody debris.

Wildlife surveys were not conducted as part of the 2016 field work, but incidental observations were recorded. Wildlife species seen included beaver, fox and moose. Numerous bird species were also documented during field investigations, including waterfowl (e.g., ducks, geese), waterbirds (e.g., pelicans, herons), raptors (e.g., Bald Eagle) and songbirds (e.g., sparrows, chickadees). Lac La Biche is an important breeding and staging area for a wide variety of bird species. During the breeding season, the lake supports significant concentrations of several colonial waterbird species in offshore islands and marshes, and provides habitat for numerous migrating species during the non-breeding season.

An Aquatic Habitat Index (AHI) was developed for Lac La Biche using the foreshore inventory data collected in the 2016 field season, and based on approaches used in previous SHIM projects. The AHI ranked all shoreline segments by calculating their individual scores on parameters representing natural and disturbed or modified conditions. Shoreline segments were classified as follows:

- Red: Very High Habitat Value – 18 segments
- Orange: High Habitat Value – 24 segments
- Yellow: Moderate Habitat Value – 17 segments
- Grey: Low Habitat Value – 1 segment

Zones of Sensitivity were also identified on Lac La Biche because some sensitive features were not captured through the AHI but were identified instead either through background review or field observations. The Plamondon Wetland, La Biche River Fen, Spawning Shoal, and Bird Sanctuary were all identified as Zones of Sensitivity.

The Activity Risk Matrix was established which contains a list of common development activities that could occur in the foreshore of Lac La Biche. High, Medium and Low Activity Risks were determined for each development activity based on its anticipated environmental impacts and the value of ecological habitat found in each segment, as characterized by AHI-derived shore zone colours and Zones of Sensitivity. Lastly, a Decision-making Flowchart was created which outlines the process a proponent might take when

seeking project approval, including identifying AHI shore zone colour and Zones of Sensitivity, identifying activity risk, and determining required permitting, Best Management Practices and regulatory review.

The SHIM serves to protect natural features in the foreshore environment through conservation and as a development tool. Critical, sensitive and important habitats were identified that should be protected if the current fish and wildlife resources are to be sustained. Identification of habitats is the first step in conservation which we hope will be followed by education and stewardship. Balancing shoreline development activities is paramount for the ongoing protection and restoration of Lac La Biche's ecological health. The SHIM project was implemented to address concerns over the impacts of human activity on the lake's ecological integrity, and to offer ways to incorporate environmental considerations and guide future development decisions. The SHIM serves as a tool for landowners and regulators to make environmentally sound land use decisions along the Lac La Biche shoreline and offers a systematic, streamlined and science-based process for integrating information on ecological condition into shoreline development planning on Lac La Biche.

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1. Introduction

1.1 Project Overview

1.1.1 Sensitive Habitat Inventory Mapping

Sensitive Habitat Inventory Mapping (SHIM) is a method for characterizing the physical and biological features of a lake's foreshore[1] so that sensitive areas can be identified and protected during shoreline development. Habitat features are identified and mapped in shoreline segments along a lake, and the relative ecological value of each segment is determined (from very high to very low). This ranking process enables vulnerability zones to be highlighted along the shoreline which are most sensitive to being negatively impacted by development. A risk assessment evaluates the relative impact of common development activities on each ranked shoreline segment. The cumulative assessment of shoreline health is then used to develop management guidelines to facilitate informed land use planning around the lake, based on identified habitat sensitivities (e.g., fish spawning habitat, wetlands, breeding bird colonies).

The SHIM approach has been used to date in 15 British Columbia lakes (e.g., Kootenay Lake, Ktunaxa Nation Council et al. 2017; Monroe Lake, Schleppe 2009a; Moyie Lake, Schleppe 2009b; Windermere Lake, McPherson and Hlushak 2008), where results have been successfully incorporated into local and regional land use planning to develop appropriate mitigation measures and ultimately minimize impacts to sensitive features. In 2016 Living Lakes Canada and the Stewards of the Lac La Biche Watershed (in partnership with Lac La Biche County) initiated the Lac La Biche SHIM, which, when completed, will represent the first application of the method outside of British Columbia.

1.1.2 Project Objectives and Scope

Lac La Biche has recently experienced declines in water quality and fish populations (e.g., Walleye, *Sander vitreus*) leading to widespread blue-green algal blooms and fishery closures. The Lac La Biche Watershed Management Plan was developed in 2009 to address the impacts of development on the lake's ecology (Aquality 2009). The Plan evaluated the lake's water quality and quantity, and described riparian areas and wetlands, as well as fisheries, waterfowl and other wildlife. The Plan made a number of recommendations, which included mapping a variety of natural heritage features, determining the location and nature of sensitive features, and developing science-based guidance that could be incorporated into planning policy to protect these sensitive resources.

The Lac La Biche SHIM project was launched in 2016 in response to community concerns over the health of the lake, to act on the recommendations from the 2009 Watershed Management Plan, and to engage area residents in stewardship. The objectives of the project are as follows:

- To identify, inventory and map the foreshore of the lake, associated riparian habitats, as well as important fisheries and wildlife habitat features (in the Foreshore Inventory and Mapping Report);
- Develop an Aquatic Habitat Index to identify sensitive shoreline features and habitats surrounding the lake;

[1] *The foreshore is the area of the shore between the high and low water marks.*

- Prepare Shoreline Management Guidelines to help protect these sensitive shoreline features and habitats during development.

The scope of work was based on the general approach used to complete other SHIM in British Columbia, with modifications to address site-specific features and sensitivities particular to Lac La Biche.

1.2 Lac La Biche

Lac La Biche is the seventh largest lake in Alberta (surface area = 234 km^2; 167 km of shoreline), located approximately 220 km northeast of Edmonton, in the Boreal Mixedwood Ecoregion (Figure 1; Mitchell and Prepas 1990). It is prized for its natural beauty, diverse wildlife and abundant recreational opportunities.

The landscape surrounding the lake includes coniferous and mixed forest, wetlands (marshes, bogs and fens), rivers, and streams. The drainage basin area is 4,040 km^2 and the major inflow is the Owl River, which in turn receives flow from tributaries, such as the Logan, Clyde and Piche Rivers, and Gull Creek. Lac La Biche drains to the Lac La Biche River, and is part of the Athabasca River watershed (Mitchell and Prepas 1990). Approximately 50% of the immediate catchment has been cleared for agriculture, primarily to grow hay or provide pasture for cattle. Agriculture makes up less than 5% of the entire watershed, however, which is mainly covered by forest and wetlands, as well as other lakes.

The lake consists of two distinct basins and numerous bays and rocky islands. The eastern basin contains most of the lake's islands and has a maximum depth of 12.2 m, while the western basin has a maximum depth of 21.3 m (McGregor 2014). Wide areas of shallow nearshore (also known as the littoral zone) are common throughout the lake, and support extensive patches of submerged and emergent vegetation. These areas provide critical habitat for a large diversity of wildlife, including fish, waterfowl and aquatic mammals.

Lac La Biche supports thirteen fish species: Walleye (*Sander vitreus*), Northern Pike (*Esox lucius*), Yellow Perch (*Perca flavescens*), Cisco (*Coregonus artedi*), Lake Whitefish (*Coregonus clupeaformis*), Burbot (*Lota lota*), White Sucker (*Catostomus commerconii*), Longnose Sucker (*Catostomus catostomus*), Ninespine Stickleback (*Pungitius pungitius*), Brook Stickleback (*Culea inconstans*), Spottail Shiner (*Notropis hudsonius*), Trout-Perch (*Percopsis omiscomaycus*), and Iowa Darter (*Etheostoma exile*) (McGregor 2014).

For many decades, the lake supported thriving fisheries for commercial (for Northern Pike, Cisco, and Whitefish), domestic (for Whitefish) and sport (for Walleye, Northern Pike, Whitefish and Yellow Perch) purposes. In recent years, however, several fish populations have experienced dramatic declines, which have been attributed to overfishing (Alberta Environment and Parks 2017a). Fishing restrictions and closures have been in effect on Lac La Biche since 2005 in an effort to protect and restore fish populations.

Lac La Biche represents an important nesting and staging area for many waterbird species. The lake and its islands are designated as a federal Migratory Bird Sanctuary, and recognized as an Important Bird Area internationally for their significance in bird and biodiversity conservation (Gammon 2001; Bird Studies Canada undated). During the breeding season, the lake supports large numbers of nesting colonial waterbirds. More than 2,000 California Gull (*Larus californicus*) nests have been recorded on the offshore islands, representing approximately 1% of the gull's global population. High concentrations of Western

Grebe (*Aechmophorus occidentalis*) nest in emergent marshes, where more than 500 nests (over 1% of the bird's global population) have been found. Double-crested Cormorant is abundant on the lake, with as many as 1,500 nests occurring on a single island. Other colonial waterbirds breeding on the lake include Herring Gull (*Larus argentatus*), Ring-billed Gull (*L. delawarensis*), Common Tern (*Sterna hirundo*) and Great Blue Heron (*Ardea herodias*). The lake provides important habitat for numerous bird species during the non-breeding season as well, including migrating waterfowl, and large numbers of Eared Grebe (*Podiceps nigricollis*) and American White Pelican (*Pelicanus erythrorhynchos*; Bird Studies Canada undated).

The riparian zones on the lake provide habitat for numerous wildlife species, including amphibians (e.g., Wood Frog, *Rana sylvatica*; Boreal Chorus Frog, *Pseudacris maculata*; Canadian Toad, *Bufo hemiophrys*), large mammals (e.g., White-tailed Deer, *Odocoileus virginianus*; Mule Deer, *O. hemionus*; Moose, *Alces alces*; Coyote, *Canis latrans*; Gray Wolf, *C. lupus*; Black Bear, *Ursus americanus*) and small mammals (e.g., American Mink, *Mustela vison*; Least Weasel, *M. nivalis*; Short-tailed Weasel, *M. ermina*; Common Muskrat, *Ondatra zibethicus*; and American Beaver, *Castor Canadensis*; Mitchell and Prepas 1990; Gammon 2001; Aquality 2009; Alberta Environment and Parks 2017b).

At least six species at risk are known to occur in the Lac La Biche area: Yellow Rail (*Coturnicops noveboracensis*; listed as special concern by COSEWIC federally[2]), Trumpeter Swan (*Cygnus buccinator;* listed as special concern in Alberta), Western Grebe (*Aechmophorus occidentalis*; listed as special concern by COSEWIC federally and threatened in Alberta), Bank Swallow (*Riparia riparia*; listed as threatened by COSEWIC federally), Monarch Butterfly (*Danaus plexippus*; listed as special concern under Schedule 1 of *SARA* federally) and Woodland Caribou boreal population (*Rangifer tarandus caribou*; listed as threatened under Schedule 1 of *SARA* federally and in Alberta). Of these, three bird species (Trumpeter Swan, Western Grebe, and Bank Swallow) have been recorded in association with the lake itself (Aquality 2009; HESL 2017).

Approximately two-thirds of the Lac La Biche shoreline is privately owned for cottages and permanent residences, with the remainder comprised of parkland, commercial, agricultural and recreational land uses. The Hamlet of Lac La Biche (population ~2,500) is located adjacent to the southeast part of the lake. Sir Winston Churchill Provincial Park encompasses the lake's largest island (Big Island), as well as Long, Current, Birch, Fox, Black Fox and High Islands. A causeway connects the park to the mainland to provide year-round access for visitors. Currently, the park has 72 campsites (available for use from May through October), as well as beaches and hiking/ski trails.

Lac La Biche is naturally eutrophic (i.e., nutrient-rich), which makes it prone to annual algal blooms in mid-summer. Increasing human activity in the watershed over the last 30 to 50 years, however, is believed to be contributing to increased lake eutrophication, raising the risk of more frequent and widespread blooms (Schindler et al. 2008). Algal blooms become a concern when their increased prevalence limits recreation, produces noxious odours, and, in the case of blue-green species (i.e., cyanobacteria), releases water-borne toxins which threaten the health of wildlife, pets and humans. Cyanobacteria monitoring in Lac La Biche

[2] *COSEWIC is the Committee on the Status of Endangered Wildlife in Canada. This scientific committee assesses the risk status of species in Canada based on the best available biological and Aboriginal Traditional Knowledge information. COSEWIC sends its assessment and supporting evidence to the Governor in Council, who makes the final decision on which species are officially listed at risk under Schedule 1 of the Species at Risk Act (SARA).*

has led to frequent blue-green algae advisories during recent summers (e.g., 2013, 2014, 2015, 2016), warning people to avoid contact with contaminated lakewater (Alberta Health 2014, 2015). Blue-green algal abundance in Lac La Biche is related to the high total phosphorus concentrations in the water column and low dissolved oxygen concentrations in the deep water during mid-summer, promoting sediment release of phosphorus (Trimbee and Prepas 1987).

Figure 1. Lac La Biche Study Area.

2. Methods

2.1 Foreshore Inventory and Mapping Methodology

Sensitive Habitat Inventory Mapping (SHIM) identifies sensitive foreshore ecosystems and critical habitats with a Geographical Information System (GIS) to provide an overall picture of the health of a lake's shoreline. The protocol has been used to characterize shoreline condition on 15 lakes in British Columbia; this is the first application of the methodology in Alberta. Modules describing tools to inventory, map and compile data for watercourses are provided in Mason and Knight (2001). The protocol has been adapted for different lakes based on site-specific features, including the unique characteristics of the particular lake, development pressures and study objectives.

2.2 2016 Field Work

Field information was collected by Bruce MacDonald and Heather Leschied in July and September 2016. The July field program was shortened due to logistical issues, and consequently served mainly as reconnaissance for the September field work, when most data were collected.

Field data was collected using a Trimble Global Positioning System (GPS) unit with SHIM Lake v. 2.4 software (FIM Data dictionary name), photos and video recording. Field personnel travelled by boat along the shoreline, collecting information from the boat or by land where possible while staying at sufficient water depth to ensure the boat could be operated safely. The study area stretched from approximately 100 m offshore (or approximately 3 m of water depth) to the high-water mark, with features assessed further inland via interpretation of aerial photography. Foreshore inventory details and mapping field code definitions are provided in Appendix A. Information collected included:

- Lake Reference
  - Lake name, date, time, weather, air temperature and water temperature
- Segment class
  - Shore modification, slope, land use and level of impact
- Shore type
  - Cliff, rocky, gravel, sand, stream mouth and wetlands
- Land use
  - Single family, natural area, park, commercial, agricultural, industrial, institution and recreation
- Substrates
  - Organic, fines, sand, gravel, fine gravel, coarse gravel, cobble, fine cobble, coarse cobble and boulder
- Littoral vegetation
  - Percent coverage of submerged vegetation, percent coverage of emergent vegetation
- Modifications
  - Number of docks, boat launches, retaining walls, marine railways
- Flora and fauna
  - Incidental observations.

Shoreline segments were delineated during field investigations by marking GPS break points. Segments were based on maximizing similarities of shore type, land use and vegetation within a segment, while maintaining a manageable total number of segments. All information was recorded and analyzed per shoreline segment. The assessment also included the establishment of 20 sample sites throughout the littoral environment where information on wildlife, shore type and general comments was recorded in more detail. Sample sites were established to confirm observations of shoreline segments and provide another layer of information when characterizing sensitive habitats.

Photographs were taken to depict shoreline conditions. Photograph numbers were sorted per segment number to allow for spatial analysis. Video recorded through aerial reconnaissance on August 26, 2004 was provided by Lac La Biche County and included audio commentary to provide spatial awareness. Review of photographs and video was conducted to clarify substrates, land use, and land cover, and to classify or validate shoreline segments where required.

Alberta Environment and Parks did not issue a fish collection permit because it indicated that ample fisheries information was already available for Lac La Biche. As a result, fish were not collected during field investigations.

2.3 Data Collection and Analysis

A background review was completed to summarize all available information on the physical and biological characteristics of the Lac La Biche foreshore. For this study, the foreshore included both the riparian and littoral environments stretching from approximately 30 m inland to 3 m of water depth (in general this depth extended out to approximately 100 m offshore). We reviewed provincial, federal and local wildlife, fish habitat and plant community data. Background review sources included:

- Bird monitoring data available through Ebird Canada, Alberta Bird Records, Canadian Wildlife Service's Marsh Monitoring Program, Alberta Breeding Bird Atlas (2000-2005), Ducks Unlimited, Lac La Biche Birding Society and the Prairie Shorebird Survey;
- Alberta Biodiversity Monitoring Institute (for invertebrates, plants, birds and mammals);
- Alberta Conservation Information Management System (for invertebrates, plants, and ecological communities);
- Fisheries and Wildlife Management Information System (for birds and fish);
- Lac La Biche County (for GIS layers on wetlands, transportation, legal description, cadastre, water features, depth contour line, aerial imagery);
- Cows and Fish Alberta Riparian Habitat Management Society for potential riparian health assessment data; and
- Peer-reviewed literature.

Fisheries information from Alberta Environment and Park's Fisheries and Wildlife Management Information System was also reviewed. Most fish surveys used gill net catches to inform sport fish management considerations, such as stocking of Walleye, and setting both recreational and commercial catch limits. To determine shoreline sensitivities, fisheries information needs to include habitat descriptions and collection methodologies that typify local populations so that results can be linked to characteristics of the shoreline

and littoral zone. Gill netting was typically completed in the pelagic zone and results cannot be used to inform microscale/shoreline segment conditions.

Data was collected and reviewed per shoreline segment. Data was interpreted by percent of total shoreline and length of shoreline, assessed spatially through a review of maps, and information was verified through review of photographs and field notes.

2.4 Aquatic Habitat Index

An Aquatic Habitat Index (AHI) is a tool to assess habitat value and environmental sensitivity of a shoreline (Schleppe 2009). An AHI was developed for Lac La Biche using the foreshore inventory data collected in the 2016 field season, and based on approaches used in previous SHIM projects (e.g., Interior Reforestation Co. Ltd. 2008; Schleppe 2009; Whelan Enns Associates Inc. 2012), with modifications to address specific characteristics of Lac La Biche.

2.4.1 Calculation of Aquatic Habitat Index Parameters

The AHI ranks all shoreline segments by calculating their individual scores on parameters representing natural and disturbed or modified conditions. Biophysical habitat parameters were selected for the AHI as proxies for overall ecological shoreline health, categorizing its condition (i.e., the extent to which the shoreline is in a natural vs. disturbed or modified condition). Each parameter was weighted based on its significance or contribution to the health of the aquatic habitat. All natural habitat features (e.g., biophysical and riparian parameters) were given positive scores, while all anthropogenic structures (e.g., retaining walls, boat launches etc.) received negative scores. Consequently, natural parameters add to habitat value, and anthropogenic structures subtract from habitat value.

Three types of parameters, reflecting different properties of the shoreline, were used to categorize shoreline condition: biophysical, riparian and modifications. Each of these parameters was measured or described through several variables:

- Biophysical: Shore Type, Percent Natural, Substrate Type, Percent Overhanging Vegetation; Percent Aquatic Vegetation;
- Riparian: Band 1 Vegetation (i.e., width and quality of riparian zone), Number of Veterans (i.e. large trees), and Number of Snags; and
- Modifications: Percent Retaining Walls, Numbers of Docks, Groynes, Boat Launches and Marinas.

Variables were chosen either because they represent an important ecological feature or function or because they can degrade or impair ecological features and function. All of the parameters and variables selected for this analysis have been used to develop AHI in other SHIM projects (e.g., in McPherson and Hlushak 2008, Schleppe a,b 2009). Two additional types of data used in other SHIM projects, however, could not be applied to this project due to insufficient data:

- Band 2 (Upland) vegetation scores and percent coverages were not collected during field work and air photo interpretation could not be completed with sufficient precision to estimate vegetation categories and coverages; and

- Fish habitat was not a standalone parameter because fisheries evaluations were not completed. Fish habitat was accounted for indirectly, however, through scoring of beneficial and non-beneficial features such as substrate, aquatic vegetation and shoreline modifications that are well known determinants of the health of resident fish populations.

The relative weighting of variables was based on approaches used in other SHIM (e.g., Schleppe 2009a, b).

2.4.1.1 Biophysical Variables

Shore Type: Shore type influences biodiversity, productivity and water quality. Stream mouths and wetlands were assigned the highest score because of their importance as habitat for fish and other wildlife (e.g., for foraging, breeding and shelter; wetlands also provide nutrient attenuation, flood control, shoreline stabilization and groundwater recharge), followed by gravel beach or rocky shore because of their importance for fish spawning and rearing. Sand beach or cliff/bluff were considered less suitable wildlife habitat and thus received lower scores.

Percent Natural: This is a direct measure of the amount of shoreline in natural condition.

Substrate Type: Substrate also influences productivity. Cobble and gravel were assigned the highest scores because of their importance for fish spawning.

Percent Overhanging Vegetation: Terrestrial vegetation along the shoreline can provide nutrients (litter or insects falling into water) and shade for aquatic organisms when it overhangs the nearshore.

Percent Aquatic Vegetation: Aquatic vegetation provides food and shelter for aquatic organisms, and food sources for various waterfowl.

2.4.1.2 Riparian Variables

Band 1 Vegetation: Band 1 Vegetation is situated directly adjacent to the lake (from high watermark up to 30 m inland) in the riparian zone. Native riparian vegetation provides wildlife habitat, stabilizes shorelines, filters stormwater runoff and provides a biological pathway for the uptake of nutrients. The greater the width of riparian vegetation the higher the score assigned. Vegetation quality was rated as well, with natural wetland, broadleaf forest and shrubs ranking highest, followed by coniferous and mixed forest, then herbs/grasses and unvegetated, then lawn, landscaped and row crops, and finally with exposed soil ranking lowest.

Number of Veterans: Veteran trees are trees which are considered to have significant ecological, landscape or cultural value because of their age, size or condition. In the riparian zone, they provide shade and nutrients (litter or insects falling into water) to the nearshore environment and provide wildlife habitat for various terrestrial species. This variable measures the abundance of such trees within the riparian zone along the shoreline.

Number of Snags: Dead standing snags increase structural diversity by providing coarse woody debris to the foreshore, which may be used as habitat by fish and aquatic invertebrates. Snags provide important

habitat for cavity nesting birds, as well as perching and nest sites for various bird species. This variable measures the abundance of this feature along the shoreline.

2.4.1.3 Modification Variables

Percent Retaining Wall: Retaining walls are constructed to prevent erosion along the shoreline but have negative consequences for aquatic biodiversity. The structures reduce aquatic habitat complexity, potentially reducing or eliminating sources of shelter, foraging, and breeding habitat for aquatic organisms. The diversity and abundance of the nearshore fish community, as well as the diversity of nearshore benthic macroinvertebrates are lower in the vicinity of retaining walls. In addition, retaining walls may actually increase erosion elsewhere in the lake, by transferring energy through wave action (Schleppe and Arsenault 2006).

Number of Docks: Docks can have both positive and negative effects on fish populations. They may provide refuge for prey fish, but at the same time may provide hiding areas for predatory fish. They offer shading, which can cool summer water temperatures, but also destroy existing aquatic vegetation. Docks may provide a substrate for periphyton growth (on their pilings), but reduce large woody debris entering the nearshore. In general, it seems that the intensity of dock development is key to whether they offer net benefits or net costs to the fish community, as fish density and diversity tends to decline with increasing dock density. Certain fish species (such as salmonids), are also more sensitive to docks than other species (such as perch; Schleppe and Arsenault 2006).

Number of Groynes: Groynes are structures built perpendicular to the shore to control the movement of sediment along shore. They are typically made of large boulders, concrete, stone or wood. Groynes reduce sediment drift by trapping it on one side of the structure, which can lead to increased embeddedness, and consequently less habitat availability, for small fish and invertebrates (Schleppe and Arsenault 2006).

Number of Boat Launches: Boat launches cause permanent habitat loss for fish and macroinvertebrates. They are usually made of concrete, which does not provide a suitable substrate for aquatic macrophytes to grow. They also extend below the high water mark, destroying habitat for foraging and shelter of fish and aquatic invertebrates (Schleppe and Arsenault 2006). Gravel and sand are typically added along the shoreline in the vicinity of boat launches to create traction for vehicles, which can cover up suitable habitat for aquatic plants and wildlife.

Number of Marinas: Marinas are a hub of human activity on the lake, and can have a variety of harmful effects on aquatic organisms. For example, marinas often have breakwaters, which can alter water circulation, wave action and sediment deposition. Marinas often lead to increased shading in the nearshore, which can reduce growth of aquatic macrophytes. Water quality may be adversely affected by boat cleaning, fueling stations and sanitary waste and bilge water disposal sites associated with marinas. The concentration of boat traffic in and around marinas can also cause significant disturbance to the nearshore, leading to reductions in the biodiversity of benthic invertebrates and fish assemblages, and the destruction of aquatic vegetation (Schleppe and Arsenault 2006). Boat activity can also stir up the underlying sediment, potentially releasing nutrients and metals into the water column.

Table 1 illustrates how the parameters and variables were applied to calculate the AHI.

Table 1. Calculation of the Aquatic Habitat Index for Lac La Biche.

Parameter	Variable	Maximum Score	Logic	Variable Weightings
Biophysical	Shore Type	20	(% of Segment) x (Shore Type Weighting)	Wetland or Stream Mouth (20) Gravel Beach or Rocky Shore (15) Sand Beach or Cliff/Bluff (10) Other (5)
	Percent Natural	15	(% Natural) x (Natural Score)	N/A
	Substrate	10	(% Substrate) x (Substrate Weighting)	Cobble (10) Gravel (8) Organic (6) Fines or Sands (4)
	Overhanging Vegetation	6	(% Overhanging Vegetation) x (Overhanging Vegetation Score)	N/A
	Aquatic Vegetation	12	(% Aquatic Vegetation) x (Aquatic Vegetation Score)	N/A
Riparian	Band 1 (riparian)	10	(Vegetation Bandwidth Category) x (Vegetation Quality x Vegetation Score)	Vegetation Bandwidth Category 0 - 4.9 m (0.2) < 5 - 9.9 (0.4) < 10 - 14.9 m (0.6) < 15 - 19.9 (0.8) < 20 m (1) Vegetation Quality Score Natural Wetland = Broadleaf = Shrubs (1) > Coniferous Forest = Mixed Forest (0.8) > Herbs/Grasses = Unvegetated (0.6) > Lawn = Landscaped = Row Crops (0.3) > Exposed Soil (0.05)

Parameter	Variable	Maximum Score	Logic	Variable Weightings
	Veterans	5	>25 (5), 5-25 (3), <5 (1)	>25 (5), 5-25 (3), <5 (1)
	Snags	5	>25 (5), 5-25 (3), <5 (1)	>25 (5), 5-25 (3), <5 (1)
Modifications	Retaining Wall	-3.5	% Retaining Wall x (5)	N/A
	Docks	-4	# Docks x (-0.1 per dock)	N/A
	Groynes	-0.25	# Groynes x (-0.5 per groyne)	N/A
	Boat Launch	-3	# Launches x (-1 per launch)	N/A
	Marina	-2	# Marina x (-1 per marina)	N/A

2.4.2 Calculation of Aquatic Habitat Index Values

Each shoreline segment was assessed for all parameters and the sum of all parameter scores were totaled per segment. The total range of summed AHI scores was then divided into four classes of index values, representing a gradient of habitat values, from 'Very High' to 'High', 'Moderate' and 'Low', and each segment was classified into one of the classes. A colour code was assigned to the different classes (red for Very High, orange for High, yellow for Moderate, and grey for Low habitat value) and the AHI values were mapped per segment around the lake.

2.4.3 Restoration Potential

The AHI analysis was also conducted without the modifications parameter to determine what the relative habitat index values would be around the lake in the absence of negative structures (i.e., retaining walls, docks, groynes, boat launches and marinas). This calculation provides a coarse measure of how habitat value could be improved along the shoreline through restoration efforts.

2.5 Zones of Sensitivity

Shoreline segments with very high and high habitat values are a good indication of environmentally sensitive areas. Another layer of information was required, however, to ensure that all sensitive habitats were included in the SHIM because:

- some sensitive features were not captured through the AHI, but were identified instead either through background review or field observations; and
- although the focus was on the foreshore, some sensitive features were more appropriately delineated as polygons extending beyond the foreshore.

These additional sensitive features (e.g., extensive wetlands, shoals, protected areas, colonial bird breeding habitat) were classified as Zones of Sensitivity (ZOS).

3. Results

3.1 Foreshore Inventory and Mapping Report

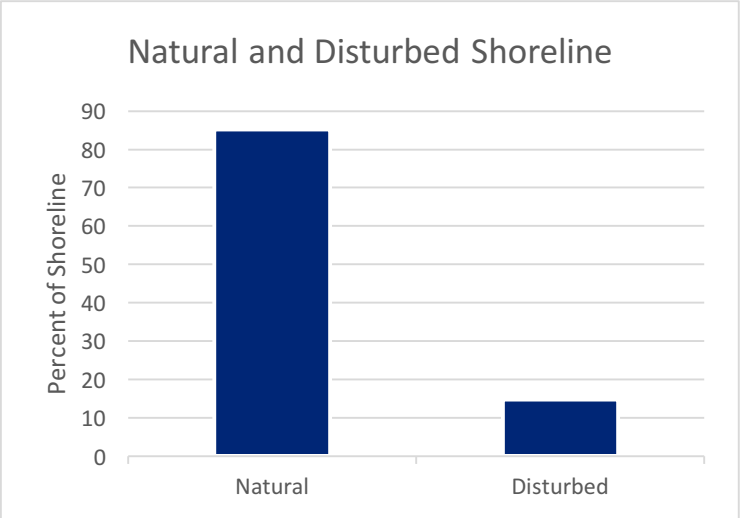
The entire 167 km shoreline of Lac La Biche was divided into 60 shoreline segments for the foreshore inventory and mapping (Figure 2).

3.1.1 Summary of Physical Features

Shoreline segments ranged from 100% natural to 100% disturbed depending on adjacent land use and level of impact. The total length of natural shoreline was 141.8 km (85%) and the total length of disturbed shoreline was 24.8 km (15%; Figure 3). The islands mainly had natural shoreline because most of them are protected areas. Natural shorelines were also prevalent throughout the northern shorelines of both the eastern and western basins. Modified shorelines were most abundant along the southern shoreline of the eastern basin near the hamlet of Lac La Biche (e.g., shoreline segments 1, 51) and adjacent to other areas of high density development, such as the Mystic Subdivision (segment 24).

Figure 2. Physical Landmarks and Shoreline Segments on Lac La Biche.

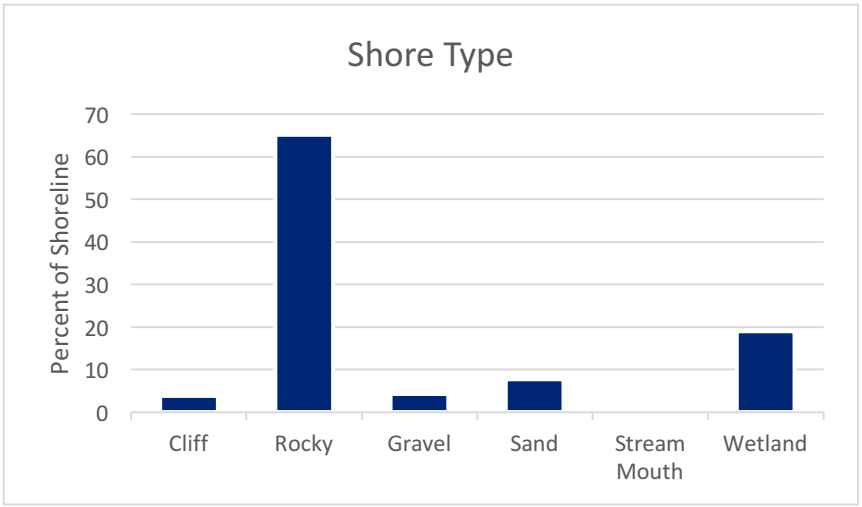
Figure 3. Percent of Natural and Disturbed Shoreline on Lac La Biche.



3.1.1.1 Shore Type and Land Use

The most abundant shore type was rocky, which occupied 65% of Lac La Biche's shoreline, followed by wetland (19%), sand (8%), gravel (4%), cliff (4%) and stream mouth (<1%) (Figure 4; Photographs 1-3). Rocky shorelines are scattered throughout much of Lac La Biche, wetlands are concentrated along the north shore of both the western and eastern basins and sand shore types are located adjacent to residential development at shoreline segments 8, 17 and 24 (Figures 5 and 6).

Figure 4. Percent of Shoreline Occupied by Various Shore Types.



Photographs 1-3. Common shore types along Lac La Biche were rocky (top left – shoreline segment 39), wetland (top right – shoreline segment 33) and sand (bottom left – shoreline segment 44).

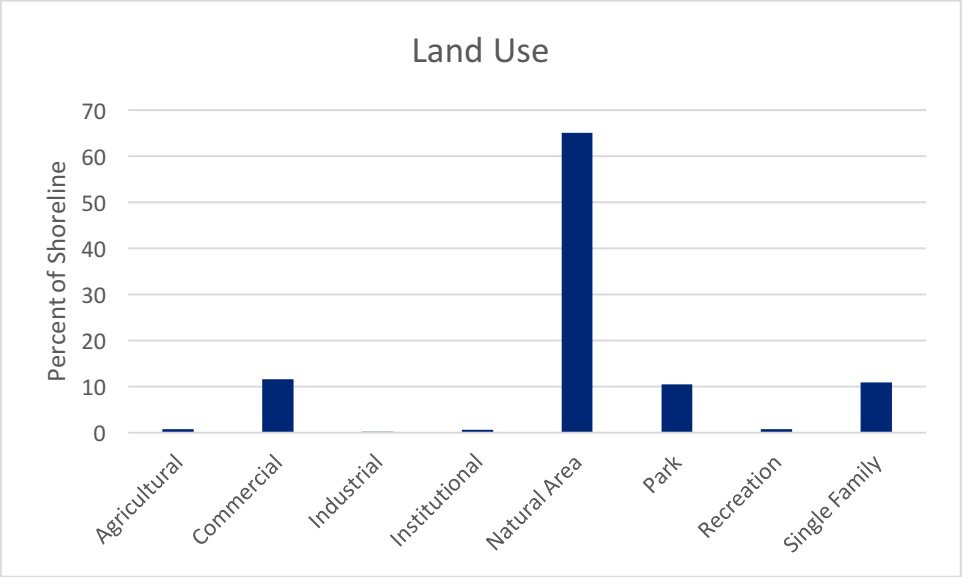
Figure 5. Physical Features of Lac La Biche – Western Basin.

Figure 6. Physical Features of Lac La Biche – Eastern Basin.

The most common land use around the lake was natural area, which occupied 65% of Lac La Biche's shoreline, followed by commercial (12%), single family (11%), and natural park (11%; Figure 7; Photographs 4 - 7). Agriculture (<1%), recreation (<1%) and industrial (<1%) land use proportions were minor. The relatively high proportion of commercial land use can be attributed to the presence of roads in segments 2, 36, 38, 38, 47, 48, 49 and 53, including the causeway to Winston Churchill Provincial Park, since roads were classified as commercial (see definitions provided in Appendix A).

Most single family homes were in segments 4, 7, 10, 13, 14, 16, 24, 27, 28, 29, 30, 35, 50, 51 and 52, associated with the Mystic Subdivision, Mission Subdivision, McGrane Subdivision, Lac La Biche West Subdivision, Golden Sands Subdivision and the hamlet of Lac La Biche (Figure 2).

Figure 7. Percent of Shoreline Occupied by Various Land Uses.



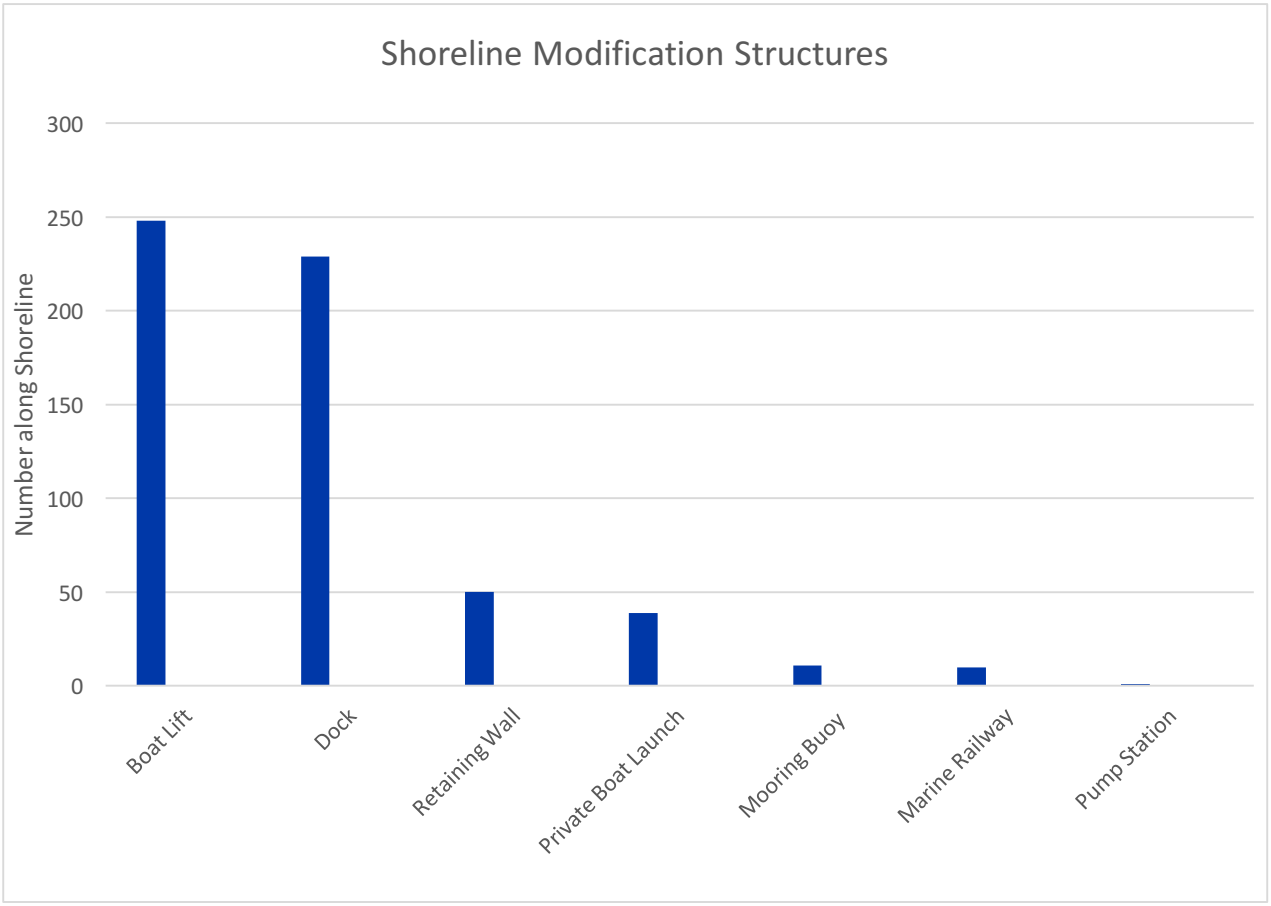
Photographs 4 – 7. Common land uses along the Lac La Biche shoreline included natural area (top left – shoreline segment 23), commercial (top right – causeway to Big Island, Sir Winston Churchill Provincial Park, shoreline segment 47), natural parkland (bottom right – shoreline segment 46) and single family (bottom left – shoreline segment 51).

3.1.2 Summary of Shoreline Modifications

A total of 597 shoreline structures were documented on the lake, comprised of 248 boat lifts, 229 docks, 50 retaining walls, 39 private boat launches, 9 public boat launches, 11 mooring buoys, 10 marine railways, and one pump station (Figure 8; Photographs 8 - 10). The retaining walls occupied approximately 1.5 km of shoreline and were made up of a range of materials including wood, stone and concrete. Heavily modified shorelines were observed in segments 24, 30, 51, 7, adjacent to single family residential development.

Removal of vegetation (i.e., riparian, wetland and submerged) and substrate addition were other modifications noted along the shoreline (although not quantified). Removal of aquatic vegetation is often conducted to improve conditions for swimming, to provide suitable areas for docks or to allow boat access. Shoreline vegetation, meanwhile, is often removed for landscaping purposes, and replaced with grass. Gravel and sand have also been added to portions of the shoreline to create solid traction for boat launches and beaches for recreation.

Figure 8. Types of Shoreline Modification Structures.



Photographs 8-10. Examples of shoreline modifications: ice road access (top left - shoreline segment 9), retaining wall (top right – shoreline segment 1) and docks within a nearshore wetland.

3.1.3 Summary of Biological Features

3.1.3.1 Riparian Zone

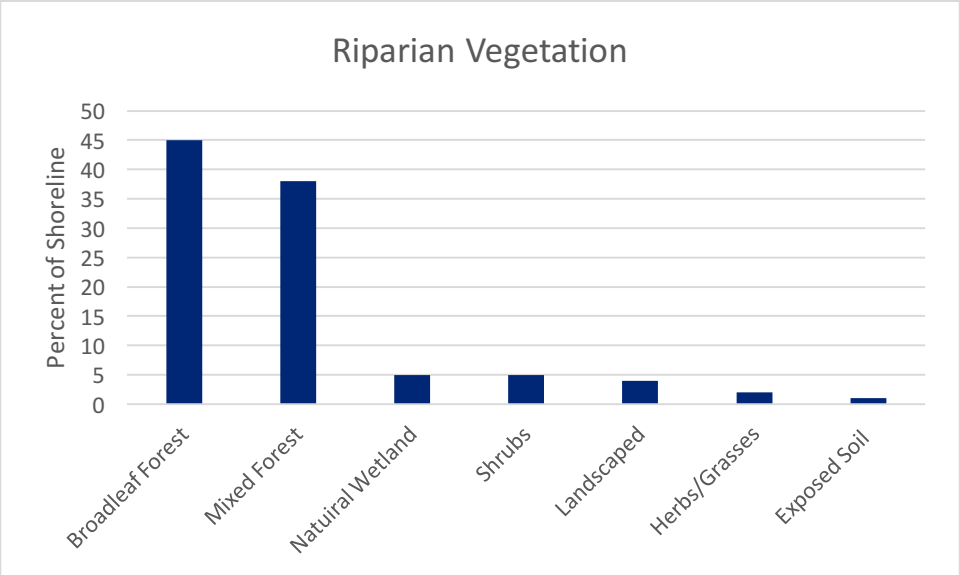
Vegetation with the B1 Zone (or riparian zone) was classified as Broadleaf Forest (45% of the shoreline), Mixed Forest (39%), Natural Wetland (5%), Shrubs (5%), Landscaped (4%), Herbs/Grasses (2%) and Exposed Soil (<1%; Figure 9; Photograph 11). Landscaped vegetation was located near developed areas (shoreline segments 1, 24, 51 and 53), wetland vegetation was concentrated in the southeastern embayment (shoreline segments 28, 33 and 34), and shrubs were most abundant around High Island (shoreline segment 54), Black Fox Island (shoreline segment 55) and Fox Island (shoreline segment 59). Broadleaf and mixed forests were scattered around much of the lake.

Shrub and tree cover was categorized as Abundant (>50%), Moderate (10-50%) or Sparse (<10%; Figure 8). Abundant shrub coverage characterized 70% of the shoreline, followed by Moderate (19%), and Sparse (10%), with only <1% containing no shrubs. Tree coverage was similar: 79% Abundant, 12% Moderate, 7% Sparse and 2% without tree coverage in the riparian environment.

Rocky shorelines generally had shrubs and overhanging vegetation or emergent grasses and herbs beginning at the high-water mark and extending inland 1-3 m. Beyond this, shrubs and larger trees dominated.

Factors contributing to the difference in plant communities along the shoreline include shoreline ice development and heaving, prevalent wind/wave action, and substrate type, as these factors influence colonization and success of vegetation communities through the determination of nutrient availability and physical displacement resulting from erosion.

Figure 9. Types of Riparian Vegetation in the B1 Zone.

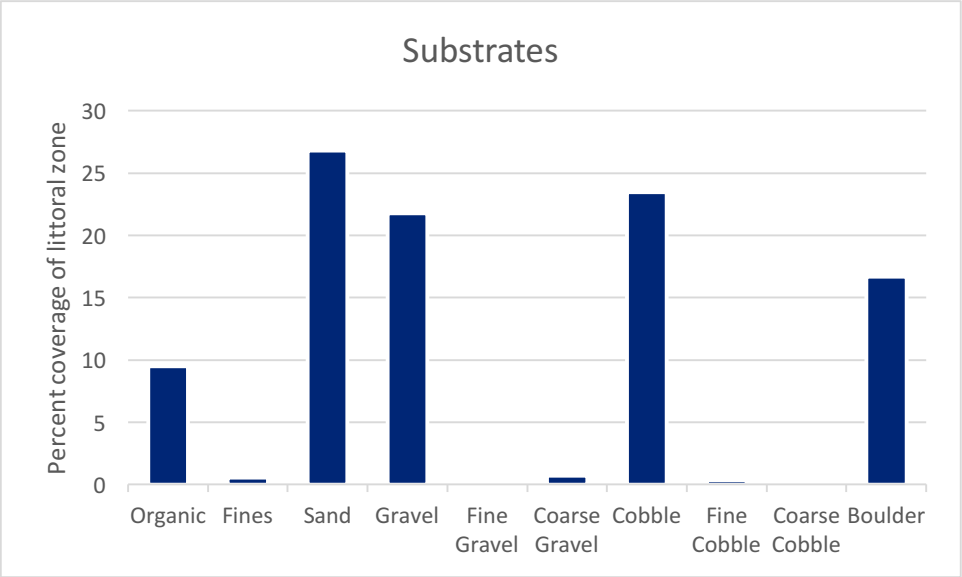


Photograph 11. Natural intact herbs/grasses riparian community observed adjacent to the lake.

3.1.3.2 Substrates

Substrates are important components of the aquatic ecosystem, providing habitat for fish spawning and egg development, benthic invertebrate colonization, aquatic vegetation and periphytic algae colonization. The Lac La Biche shoreline is composed of glacial till which is often blanketed with glaciolacustrine clays and sands (Mitchell and Prepas 1990). Sand was the most abundant substrate (27%), followed by cobble (23%), gravel (22%), boulder (17%) and organic (10%), with trace amounts of fine cobble (<1%), fines (<1%), fine gravel (<1%), and coarse cobble (<1%; Figure 10; Photographs 12-14).

Figure 10. Percent of Various Substrates in the Littoral Zone of Lac La Biche.



Photographs 12 – 14. Substrates observed in Lac La Biche included cobble (top left), sand (right) and boulders (bottom left).

3.1.3.3 Aquatic Vegetation

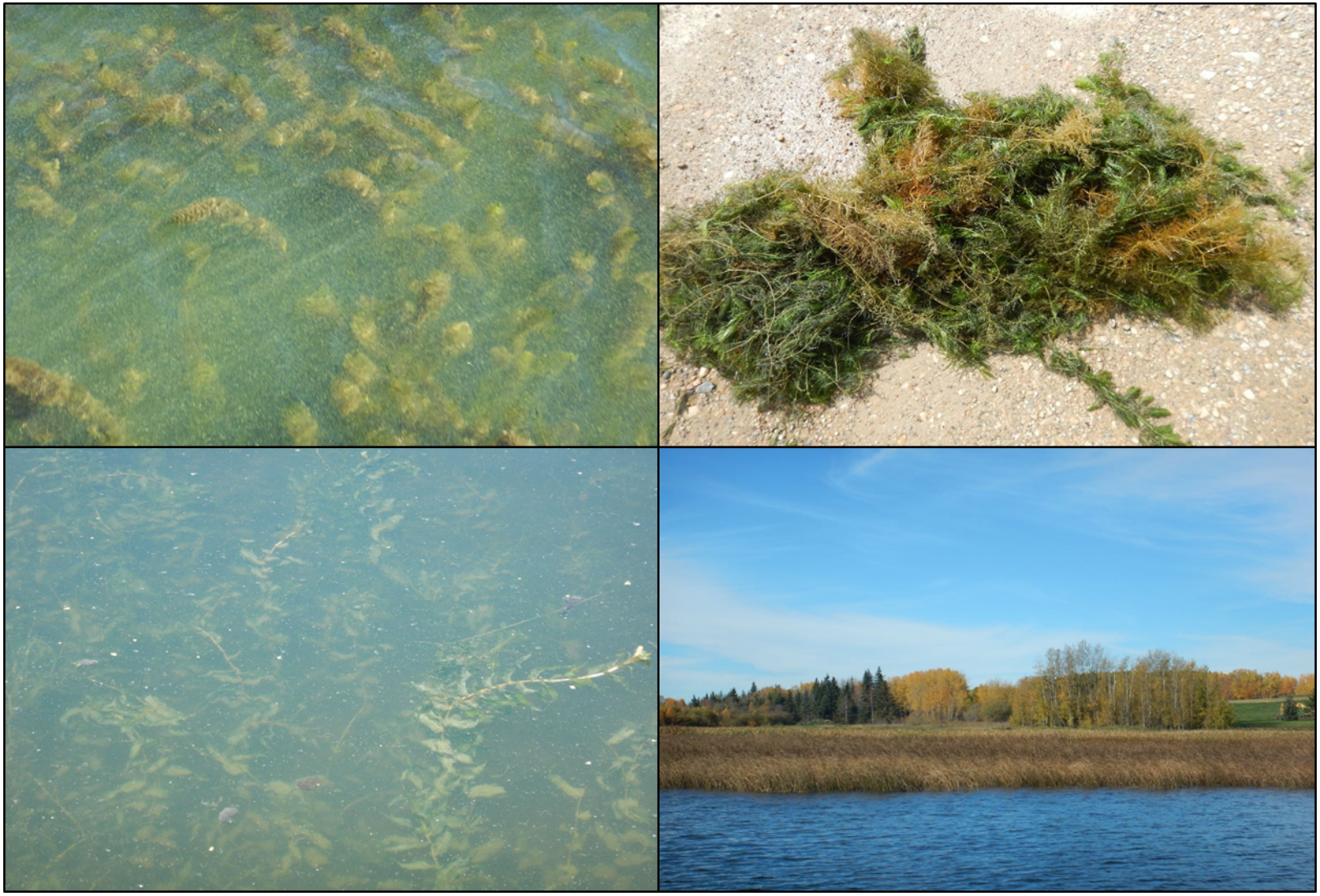
Submerged vegetation was abundant in the nearshore, covering approximately 70% of the littoral zone, varying between 0% to 100% coverage per segment (Figures 11 and 12). Coverage was typically highest along the north shore of the western basin adjacent to the floodplain of the La Biche River and throughout the majority of the eastern basin's shoreline (Table 2).

Table 2. Percent Coverage of Submerged Vegetation at all Shoreline Segments.

Percent Coverage	Number of Shoreline Segments	Shoreline Segments	
		East Basin	West Basin
81-100	39	1, 2, 4, 5, 6, 22, 24, 27, 29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40, 41, 43, 45, 46, 47, 48, 49, 50, 51, 52, 53, 56, 57, 58, 59	7, 14, 20, 54, 55
61-80	4	26, 34	9, 16
41-60	4	3	8, 12, 13
21-40	0	n/a	n/a
0-20	12	23, 25, 28, 42, 44, 60	10, 11, 17, 18, 19, 21

Most plants were not identified to species, but the presence of Milfoil (*Myriophyllum spp.*), Waterweed (*Elodea spp.*), and Pondweed (*Potamogeton spp.*) was noted. Surveys completed in 1967 included the following species: Canada Waterweed (*Elodea canadensis*), Northern Watermilfoil (*Myriophyllum exalbescens*), Sago Pondweed (*Potamogeton pectinatus*), Small-leaf Pondweed (*Potamogeton pusillus*), Richardson's Pondweed (*Potamogeton richardsonii*), and Flat-Stemmed Pondweed (*Potamogeton zosteriformis*; Pinsent 1967). Pinsent (1967) noted that distribution, species composition and abundance was influenced by substrates, water depth, and wind/wave action.

Emergent vegetation was less abundant than submerged vegetation in 2016, occupying 18% of the shoreline, with coverage ranging from 0% to 100% per segment. Pinsent (1967) noted the presence of Common Great Bulrush (*Scirpus validus*), especially along the north shore and in protected bays, and Common Cattail (*Typha latifolia*). In 2016, abundant coverage (>90%) often occurred adjacent to wetlands and was noted at shoreline segments 5, 8, 12, 15, 17, 19, 22, 25, 28, 33, 34, 42 and 56.



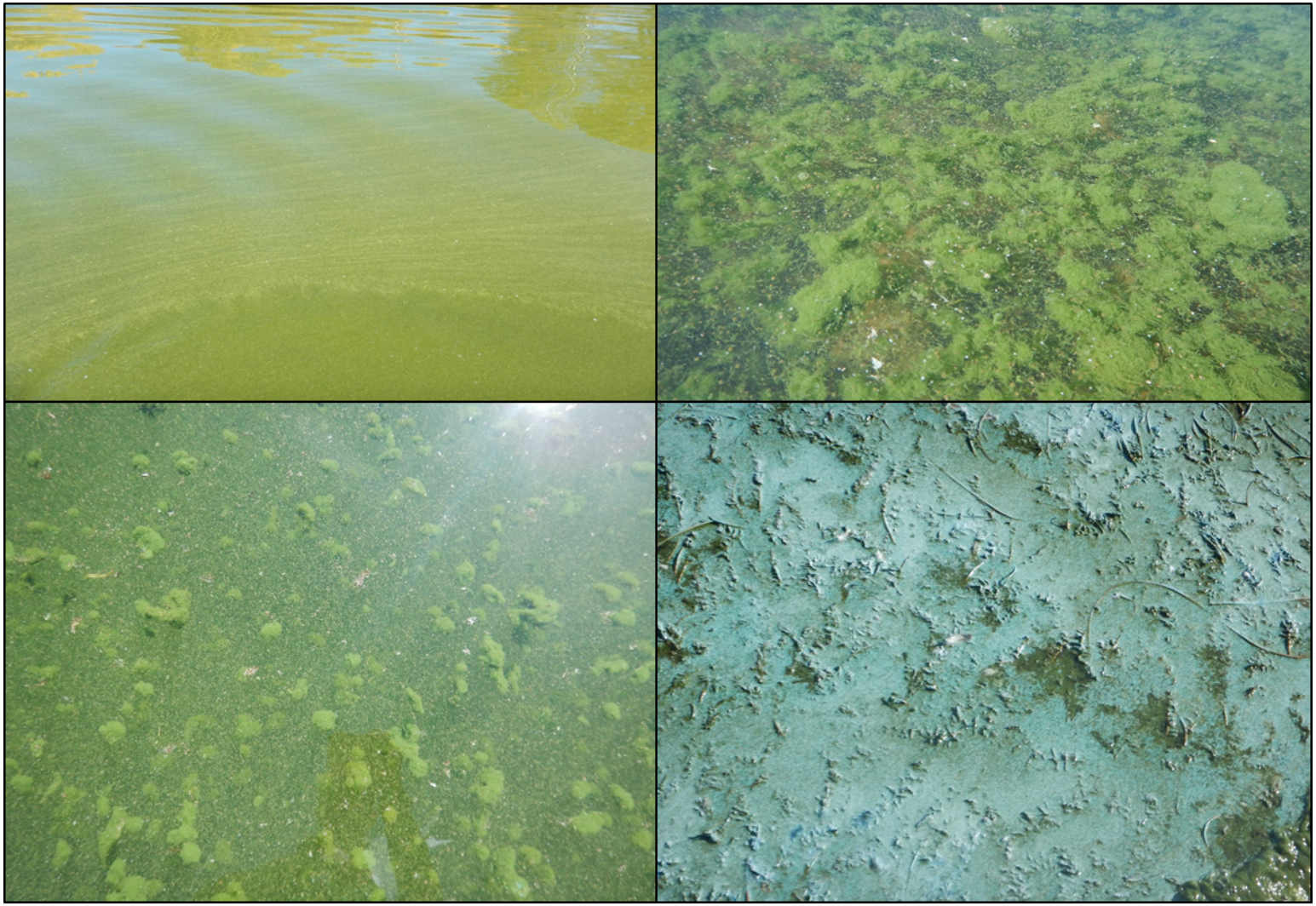
Photographs 15-18. Submerged aquatic vegetation (top left, top right and bottom left) and emergent aquatic vegetation (bottom right) were abundant in Lac La Biche.

Figure 11. Wetland and Vegetation Features of Lac La Biche – Western Basin.

Figure 12. Wetland and Vegetation Features of Lac La Biche – Eastern Basin.

3.1.3.4 Phytoplankton

Widespread blue-green algal blooms have consistently appeared in recent years leading to blue-green algae advisories being issued on August 28, 2013, August 19, 2014, July 14, 2015 and July 15, 2016 based on cell count exceedances, complaints and/or visual confirmation (J. Graydon, Alberta Health, personal communication, June 1, 2017). Algal blooms were abundant and observed throughout the lake in 2016, with extensive blue-green algal mats noted in the northeastern embayment near the shore and around Red Fox Islands (Photographs 19 – 22). Blue-green algal blooms occur annually in the summer with coverage and abundance varying from year to year. The highest accumulations are typically found in the east basin due to the predominant western winds (Mitchell and Prepas 1990). Blue-green algae dominated the algal communities at two out of three sample sites in 1979 from June through September (Beliveau and Furnell 1980), and blue-green algae, particularly *Anabaena flos-aquae*, accounted for 49% of total biomass on July 4, 1983 (Trimbee and Prepas 1987). Blue-green algal abundance in Lac La Biche is related to the high total phosphorus concentrations in the water column and low dissolved oxygen concentrations in the deep water during midsummer, promoting sediment release of phosphorus (Trimbee and Prepas 1987). Lac La Biche is naturally eutrophic but further cultural eutrophication (due to human activity) has occurred during the last 30 to 50 years (Schindler et al. 2008).



Photographs 19 – 22. Phytoplankton blooms were observed in various locations throughout the lake in July and September 2016.

3.1.3.5 Fisheries

Populations of Walleye, Pike and Whitefish have experienced dramatic declines in Lac La Biche in recent decades due to overfishing (Alberta Environment and Parks 2017a). The lake has been managed for sport and domestic fisheries, and, until recently, a commercial fishery as well. The Alberta government closed all commercial fisheries across the province in 2014, because they are no longer considered viable and other fisheries required protection (Alberta Environment 2016).

A fisheries restoration program was initiated in Lac La Biche in 2005 to address fish declines. The program included a reduction in catch limits, Walleye stocking (from 2006 to 2011), Double-Crested Cormorant population control (since the species was believed to be hindering Walleye recovery), protection of critical fish habitat and monitoring to improve the Walleye population and improve the overall size and structure of the fish community (McGregor 2014). Fishing was closed in the Owl River, other tributaries and the lake outlet, and net fishing was closed from the Owl River embayment out to Birch and Current Islands to protect critical Walleye spawning habitat. In all other areas, Walleye fishing became catch and release only, while limits were set as follows for other species: one Pike, three Whitefish, ten Burbot, and 15 Perch (Alberta Environment and Parks 2017a).

Annual index netting surveys are conducted every fall by the province in Lac La Biche to evaluate the effectiveness of the restoration program. Walleye is the focus of the surveys, but other fish species are recorded as well. The latest data available (from the 2014 survey) indicate that Walleye appear to be recovering in the lake. The catch per unit effort (CPUE) for the species has continually increased since the initiation of stocking in 2006 (Government of Alberta 2015). In 2014 a total of 390 Walleye were caught, translating to a CPUE of 22.8 individuals/100 m^2/24 hours (95% confidence interval: 19.4-26.3), which is slightly above the provincial mean (18.6 individuals/100 m^2/24 hours). From this, it is estimated that there are now approximately 250,000 Walleye in the lake, compared to close to zero in 2005. The province currently classifies the population as vulnerable, since it is unclear whether it can now be sustained through natural reproduction (Government of Alberta 2015).

The availability of critical habitat (i.e., spawning and nursery habitat) is crucial for the ongoing recovery of Walleye and other fish species in Lac La Biche. Spawning habitat for sport fish species in Lac La Biche is described in Table 3. High quality nursery habitat for all fish typically includes an abundance of cover such as macrophytes, woody debris and coarse substrates. Walleye, Yellow Perch, Lake Whitefish and Burbot require mineral-based (typically rocky) substrates, while Northern Pike commonly spawn over flooded vegetation. Abundance of submerged and emergent vegetation and the presence of rocky substrates will be utilized to identify sensitive fisheries habitat during the development of the Aquatic Habitat Index and determination of shoreline sensitivities in the Shoreline Management Guidelines Report.

Table 3. Spawning Habitat Requirements of Resident Sport Fish (Scott and Crossman 1973).

Fish Species	Spawning Habitat
Walleye	Running water (0.3 – 1.2 m/sec.), cobble and gravel reefs
Northern Pike	Heavily vegetated floodplains of rivers and marshes
Yellow Perch	Shallows near vegetation, woody debris over sand or gravel
Cisco	1-3 m water depth over gravel or stony substrate
Lake Whitefish	Rocky substrates, typically in 1-3 m of water
Burbot	Sand, gravel or rocky substrates up to 3 m in water depth

3.1.3.6 Wetlands

Wetlands were characterized during field surveys as a shore type near the shoreline and as a category of riparian vegetation in the B1 zone from the high-water mark to 30 m inland. In addition, Lac La Biche County provided wetland mapping for the County lands surrounding Lac La Biche to allow for assessment of the B2 zone (30 m to 100 m inland). This layer included the following wetland types: bog, fen-graminoid, fen-shrub, fen-tree, fen-mixed type, marsh and shallow open water (Figures 11 and 12; Photograph 23). Wetlands were not constrained by these study areas and commonly stretched across all three environments.

Wetland was the second most abundant shore type and encompassed 19% of the shoreline, much of which was located along the northern shoreline of Lac La Biche in shoreline segments 16 and 22. Wetlands were noted in many adjacent terrestrial environments, with the largest accumulation of wetlands (predominantly fens), located within the floodplain of the La Biche River along the shoreline of the northwestern basin (Figures 11 and 12).

Three types of wetlands were observed during field investigations:

- Largely intact wetlands with rushes, cattails and shrubs at and above the high-water mark;
- Largely intact wetlands with patches of rushes and shrubs at the high-water mark separated by development or another shore type; and
- Altered wetlands with patches of rushes and/or cattails, manicured sandy substrates at the high-water mark, and gravel or sand substrate added to the foreshore with patchy shrubs or landscaped properties located further upland.

Wetlands provide numerous ecosystem services, including nutrient attenuation, flood control, wildlife habitat, shoreline stabilization and groundwater recharge. Many wetlands have been altered in Lac La Biche

due to human activity (e.g., construction of retaining walls, docks, boat launches, groynes, and marinas, landscaping), which reduces the effectiveness of these important wetland functions.

Photograph 23. Example of a Lac La Biche wetland which provides habitat for a variety of species in the quiescent backwaters.

3.1.3.7 Wildlife

Wildlife inventories were not conducted as part of the 2016 field work, but incidental observations of wildlife and evidence of wildlife presence (e.g., beaver lodge, moose scat) were noted during surveys (Table 4).

Table 4. Summary of Wildlife Observations from 2016 Field Season.

Wildlife Species	Evidence of Presence
American Beaver (*Castor canadensis*)	10 beaver lodges (one each in segments 3, 7, 20, 22, 26, 35, 37, 42, 47, and 49), 1 beaver dam (in segment 6), and beaver activity (in segments 19 and 27)
Red Fox (*Vulpes vulpes)*	1 individual (in segment 4)
Moose (*Alces alces*)	Moose scat (in segment 50)
Gopher species	Potential gopher burrows (in segment 24)

Wildlife habitat requirements vary by species and life stage but in general the highest quality habitat in Lac La Biche is in natural environments that have not been negatively impacted by development such as wetlands, accumulations of submerged and emergent vegetation, well-vegetated riparian environments and forests. Wildlife corridors which link various wildlife habitats are also important considerations because they provide routes for the movement of various wildlife species through otherwise developed lands.

3.1.3.8 Birds

Incidental observations of birds and nests were made during 2016 field surveys (Tables 5 and 6). Most observations were made during the September field visit, after the breeding season. The majority of birds recorded were waterbird species, including ducks, geese, gulls, cormorants, pelicans, and loons (e.g., Photograph 24). Many large congregations of waterfowl were observed on the lake, comprised of single species (e.g., 10-125 individuals of Bufflehead, *Bucephala albeola*; 3-200 individuals of Common Goldeneye, *B. clangula*; 40-100 individuals of Hooded Merganser, *Lophodytes cucullatus*) and mixed flocks (from 20-2000 individuals). Birds were recorded in all segments, except #5, 34, and 59.

Table 5. Summary of Bird Observations from 2016 Field Season.

Bird Species	When Observed	General Habitat
Waterbirds		
Bufflehead	September	Lakes, ponds, rivers
Common Goldeneye	September	Wooded lakes, rivers
Hooded Merganser	September	Wooded lakes, ponds, rivers
Mallard (*Anas platyrhynchus*)	September	Marshes, wooded swamps, ponds, rivers, lakes, grain fields
Grebe species	July and September	Lakes and ponds bordered by emergent vegetation, marshes
Merganser species	September	Wooded lakes, ponds, rivers
Scaup species	September	Lakes, rivers, marshes
Teal species	September	Rivers, marshes
Canada Goose (*Branta canadensis*)	July and September	Lakes, ponds, marshes, fields
American Coot (*Fulica Americana*)	September	Ponds, lakes, marshes
Common Loon (*Gavia immer*)	September	Wooded lakes
Double-crested Cormorant	July and September	Islands, lakes, rivers
American White Pelican	July and September	Islands, lakes, rivers, wetlands
Trumpeter Swan (*Cygnus buccinators*)	July	Ponds and lakes with abundant aquatic plants, marshes, bogs, rivers,
Ring-billed Gull	July	Lakes, farmland, dumps
Gull species	July and September	Lakes, farmland, dumps
Tern species	July and September	Lakes, beaches, marshes
Great Blue Heron	September	Marshes, swamps, lakeshore

Bird Species	When Observed	General Habitat
Belted Kingfisher (*Megaceryle alcyon*)	September	Streams, rivers, lakes
Raptors		
Bald Eagle (*Haliaeetus leucocephalus*)	September	Lakes and rivers
Northern Harrier (*Circus cyaneus*)	September	Marshes, fields
Passerines		
American Crow (*Corvus brachyrhynchos*)	September	Woodland, farmland, shoreline
Common Raven (*C. corax*)	September	Forest, beaches, farmland, islands
Black-billed Magpie (*Pica hudsonia*)	September	Meadows, grasslands, farmlands, streams
Bank Swallow	July and September	Fields, marshes, streams, lakes
Dark-eyed Junco (*Junco hyemalis*)	September	Coniferous or mixed woods
Red-winged Blackbird (*Agelaius phoeniceus*)	July and September	Marshes, swamps, farmland
Song Sparrow (*Melospiza melodia*)	July	Thickets, marshes
Swamp Sparrow (*M. georgiana*)	July	Marshes and swamps
White-throated Sparrow (*Zonotrichia albicollis*)	July	Thickets, woodlands
Chickadee species (Boreal or Black-capped)	July	Coniferous and mixed woods, thickets

Several bird nests were observed during 2016 field surveys, including five Bank Swallow (*Riparia riparia*) nests and an eagle nest (likely belonging to a Bald Eagle; Table 6).

Table 6. Summary of Bird Nest Observations from 2016 Field Season.

Wildlife Species	Evidence of Presence
Bank Swallow	5 nests (in segment 31)
Swallow species	1 nest (in segment 38), potential nests (in segment 58)
Eagle (presumed to be Bald Eagle)	2 nests (in each in segments 50 and 58)
Unidentified bird species	6 nests (in segment 56)
Swallow or kingfisher	Potential nests in bank (in segment 57)

Photograph 24. American White Pelican observed in Lac La Biche.

3.2 Aquatic Habitat Index

3.2.1 Summary of Habitat Index Values of Shoreline Segments

Index values ranged from 24.95 to 70.56, with a mean of 51.22.Values greater or equal to 45 represented high or very high habitat value, while values less than or equal to 30 represented low habitat value (Table 7). Most of the Lac La Biche shoreline was classified as having high habitat value (40%), followed by very high habitat value (30%), and moderate habitat value (28%). Only one shoreline segment, located adjacent to the hamlet of Lac La Biche, was classified as low habitat value (<2%). The highest valued, and therefore most sensitive, shoreline segments were concentrated along the northern shoreline of both east and west basins. This area of Lac La Biche shoreline remains largely undeveloped because of the presence of wetlands (Figures 13 and 14).

Table 7. Summary of Aquatic Habitat Index Values for Lac La Biche.

AHI Categories	Range	# Segments
Red – Very High Habitat Value	>60-75	18
Orange – High Habitat Value	>45-60	24
Yellow – Moderate Habitat Value	>30-45	17
Grey – Low Habitat Value	15-30	1
	Total	60

Shoreline modification index values ranged from 0 to -9.05. Boat launches had the greatest impact on AHI scores (representing 60% of negative scores) followed by docks (35%); both of these structures were abundant along the Lac La Biche shoreline. In comparison, retaining walls and groynes were less common, and thus had relatively minor impacts on AHI scores (5% and <1% respectively). No marinas were recorded along the shoreline.

Figure 13. Aquatic Habitat Index for Lac La Biche – Western Basin.

Figure 14. Aquatic Habitat Index for Lac La Biche – Eastern Basin.

3.2.2 Summary of Restoration Potential of the Lac La Biche Shoreline

The simulated removal of the modifications parameter (i.e., retaining walls, docks, groynes, boat launches and marinas) from the AHI resulted in changes to the index values of 33 shoreline segments, but their increased scores did not change the overall index category in which these segments were classified (Appendix B). The restored index values ranged from 27 to 71.26, with a mean of 52.31. The lack of a significant change in index values with the removal of modifications reflects two important factors about shoreline condition on Lac La Biche. First, most of the shoreline is in relatively good condition with little to no impact from these types of modifications (particularly along the north shore of both basins). Second, the segments that are heavily impacted by these modifications likely exhibit other forms of ecological degradation as well due to human activity, such as low natural cover, lack of overhanging vegetation, and reduced and poor quality riparian vegetation. Thus, even if existing modifications were to be removed in these areas, additional restoration work that increases ecological value would be necessary to measurably improve the ecological health of these degraded areas in terms of the AHI.

The analysis of restoration potential is a coarse measure of the influence of human modifications on the aquatic health of the shoreline. It may not provide a particularly realistic picture of restoration options, however, if the public is not willing to actually remove these modifications to improve ecological conditions. For example, removing the retaining wall, docks and boat launch in the hamlet of Lac La Biche may not be a practical solution to increasing the habitat value of the shoreline in this area. Furthermore, removal of shoreline modifications alone is not sufficient to restore the ecological health of degraded habitat.

There are other restoration/stewardship activities apart from removal of shoreline modifications that would improve the condition of Lac La Biche such as planting native species in the riparian environment, widening and improving natural shoreline buffers, avoiding the use of fertilizers on lawns, maintaining septic systems through regular pumping and inspection, and reducing stormwater through various Low Impact Designs (e.g. French drains or rain gardens). Restoration/stewardship activities are encouraged as they have the potential to improve a variety of natural heritage features in the foreshore environment such as water quality, fish and wildlife habitat and improve the overall ecological value.

3.3 Zones of Sensitivity

Zones of Sensitivity (ZOS) are mapped in Figure 15. A description of each ZOS is presented in Table 8. Zones of Sensitivity are treated separately than AHI shore zone colours in the Activity Risk Matrix presented in Section 4.1.1.

Figure 15. Zones of Sensitivity along the Lac La Biche Shoreline.

Table 8. Description of Zones of Sensitivity Identified Along the Lac La Biche Shoreline.

Feature Identification Number	Feature	Rationale
A	Plamondon Wetland	A predominantly natural (98% according to shoreline survey) wetland with mixed substrates (organic, sand and gravel) and abundant riparian, emergent and submerged vegetation. Abundant waterfowl (560+) observed in the wetland on September 26, 2016 including: 60 Canada Geese, 26 Bufflehead, 10 Gulls, 2 Mallards and 1 Raven.
B	La Biche River Fen	The La Biche River Fen transitions to an open water wetland containing abundant submerged and emergent vegetation along the majority of segment 16. Abundant waterfowl (500+) observed along the shoreline segment on September 26, 2016 including: 100+ Gulls, 2 Goldeneye, 120+ Bufflehead, 4 Raven, and 4 Canada Geese. The eastern portion of segment 16 was also identified as Grebe nesting habitat.
C	Spawning Shoal	An approximately 1 km long shoal is located off the northwestern part of Birch Island. The shoal is located in shallow water depths (0-8 m), contains relatively clean, wave swept rocky substrates, and provides spawning opportunities for resident fish species such as Cisco and Lake Whitefish.
D	Bird Sanctuary	All of the islands are designated as bird sanctuary. In addition, segments 54 and 55 have been identified as nesting habitat for Great Blue Herons (Alberta Environment and Parks 2017c).

4. Discussion

4.1 Overview of Management Guidelines

The final step in the SHIM process is the development of Shoreline Management Guidelines to facilitate informed land use planning based on the habitat sensitivities identified through the Foreshore Inventory and Mapping Report and the Aquatic Habitat Index. The Guidelines adopt a risk-based approach to shoreline management, in which the risk of proposed development activities is determined based on the environmental sensitivity of the shoreline. The decision-making process to determine whether an activity should proceed or not, or under which conditions it can proceed, will depend on a number of factors, including the location of the proposed activity along the shoreline (i.e., the relative habitat value of the segment where the proposed activity is located and whether ZOS are present in the vicinity), its calculated activity risk, existing legislation and policy governing shoreline development, and available best management practices and mitigation measures recommended to minimize or avoid negative impacts on the natural environment.

4.1.1 Activity Risk Matrix

The Activity Risk Matrix contains a list of common development activities that could occur in the foreshore of Lac La Biche (Table 9). This list was compiled based on activities included in other SHIM projects and in consultation with the County of Lac La Biche. High (H), Medium (M) and Low (L) Activity Risks were determined for each development activity based on its anticipated environmental impacts and the value of ecological habitat found in each segment, as characterized by AHI-derived shore zone colours and ZOS (Table 9). Where multiple activities are proposed at the same site, there is potential for increased and cumulative project risk; such projects should be assessed on a case-by-case basis.

High risk development activities (e.g. beach creation below the high water mark) have high potential to negatively impact the foreshore environment and measures to fully mitigate impacts are very challenging or impossible to implement. These activities do not typically adhere to other relevant legislation such as the *Fisheries Act*, and should be avoided. If proponents wish to proceed with high risk activities, an Environmental Impact Study (EIS) should be completed. An EIS should consider all relevant policy or policies and include characterization of natural heritage features, description of the proposed works and rationale for their undertaking, an impact assessment, development of mitigation measures and monitoring. The EIS should be completed by a qualified professional, such as a Professional Biologist designated by the Alberta Society of Professional Biologists, prior to issuance of relevant permits and/or completion of the work.

Medium risk development activities (e.g. beach creation above the high water mark in moderate habitat value) have potential to negatively impact the foreshore environment but mitigation measures can often be implemented to minimize impacts to appropriate levels. Proponents should try to reduce the project risk by altering or moving the project activity to lower value ecological habitat. If the proponent wishes to proceed with the project they should review and adhere to relevant legislation, implement appropriate mitigation measures and seek project approval from a regulatory agency. Some landowners will be capable of gaining approval for these types of activities while others will require advice from a qualified professional.

Low risk development activities (e.g. public beach maintenance) have limited potential to negatively impact the foreshore environment and mitigation measures are easily implemented to minimize impacts associated with the activity. These projects require review and adherence with relevant legislation and implementation of appropriate mitigation measures but can generally proceed without regulatory review.

It should be noted that the Activity Risk Matrix provides guidance for both residents and regulatory agencies but does not constitute all relevant policy. Relevant legislation such as that outlined in 4.1.2 should be reviewed by residents/developers and regulatory agencies to ensure that all applicable policies are accounted for in the planning process. Also, the process of delineating habitat values and activity risks based on shoreline segments results in an amalgamation of features, some of which way be much more sensitive (e.g. remnant marsh) than what is indicated by the segment as a whole (e.g. low ecological value/grey shore zone colour). The AHI and Activity Risk Table provide a planning tool but individual features and functions still need to be characterized and assessed as required by appropriate policy.

Table 9. Activity Risk Matrix Relating Development Activities with AHI Categories and ZOS to Determine the Activity Risk as High (H), Medium (M) or Low (L).

Activity	Shore Zone Colour and Activity Risk				Modifier
	Red	Orange	Yellow	Grey	Zone of Sensitivity
Aquatic vegetation removal	H	H	H	M	H
Beach creation above HWM	H	H	M	M	H
Beach creation below HWM	H	H	H	H	H
Boat house (below HWM)	H	H	H	M	H
Boat launch upgrade	H	H	H	H	H
Boat lift - temporary	M	M	L	L	H
Docks	Refer to DFO Guidance, dock type, etc.				
Dredging	H	H	H	H	H
Dredging - maintenance/previously approved	H	H	H	H	H
Elevated boardwalk below HWM	H	M	M	M	H
Erosion protection (hard engineered)	H	H	H	M	H
Erosion protection (soft bioengineered)	H	M	L	L	H
Foreshore sediment disturbance and removal of lakebed substrates	H	H	M	M	H
Infill	H	H	H	H	H
New boat launch	H	H	H	H	H
Over water-piled structure (i.e. building, house, etc.)	H	H	M	M	H
Public beach maintenance	M	L	L	L	M
Septic application	Refer to residential permitting requirements				

Activity	Shore Zone Colour and Activity Risk				Modifier
	Red	Orange	Yellow	Grey	Zone of Sensitivity
Installation of treated effluent discharge pipe	H	H	M	M	H
Upland vegetation removal	H	M	M	M	H
Waterline drilled	H	M	L	L	H
Waterline trenching	H	H	H	M	H

4.1.2 Legislation and Policy

A variety of legislation and policy at the federal, provincial and municipal levels relate to shoreline development and activity. The following list summarizes some important acts and guidelines to consider, but proponents are encouraged to consult with relevant government agencies to ensure all applicable acts, regulations, and policies are followed when submitting planning applications.

Table 10. Legislation and Policy Relating to Shoreline Development and Activity on Lac La Biche.

Legislation/Policy	Government Agency	Description
Federal		
Fisheries Act	Department of Fisheries and Oceans	Prohibits any activity that causes harmful alteration, disruption or destruction of fish habitat, prohibits the deposit of deleterious substances into waters frequented by fish, prohibits importation, possession, transportation or release of regulated invasive species. Self-assessment to determine DFO review: (http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html)
Provincial		
Agricultural Operations Practices Act	Natural Resources Conservation Board	Regulates manure management and sets environmental standards for livestock operations
Environmental Protection and Enhancement Act	Alberta Environment and Parks	Protects air, land and water through management of contaminated sites, landfills, hazardous waste, storage tanks, and wastewater discharges

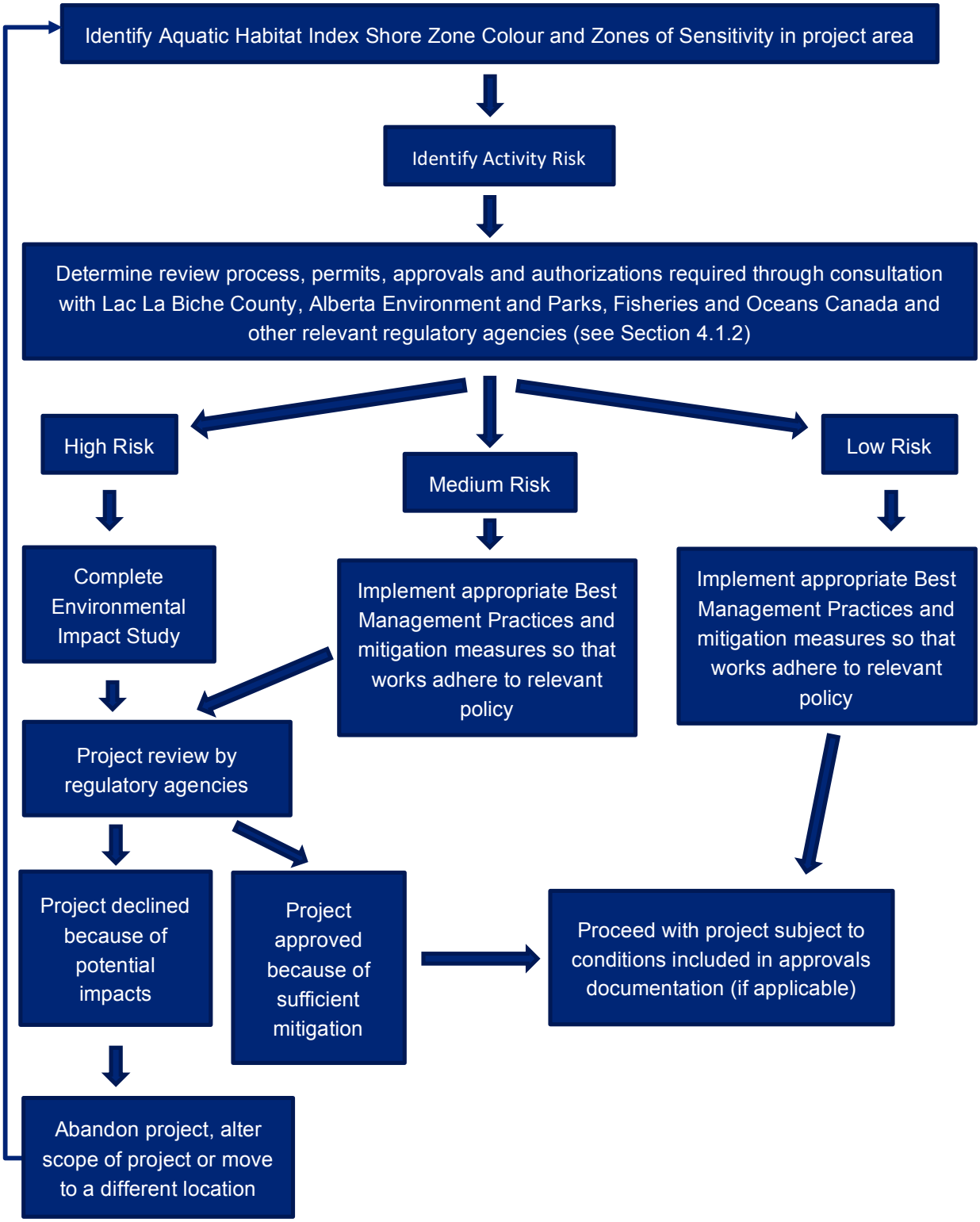
Legislation/Policy	Government Agency	Description
Municipal Government Act	Municipal Affairs	Provides the governance framework for municipal operations, including the authority to regulate water on municipal lands, manage private land to control non-point sources, and ensure land use planning that is compatible with the protection of the aquatic environment
Provincial Parks Act	Alberta Environment and Parks	Regulates land use activities in and adjacent to parks and protected areas to protect water quality and aquatic resources
Public Lands Act	Alberta Environment and Sustainable Resource Development	Governs activities on the shorelands (beds and shores) of waterbodies on provincial Crown land
Safety Codes Act	Municipal Affairs	Regulates septic system management
Water Act	Alberta Environment and Sustainable Resource Development	Governs water management and protection, including water use, stormwater management, and protection of the aquatic environment and fish habitat
Wilderness Areas, Ecological Reserves, Natural Areas and Heritage Rangelands Act	Alberta Environment and Parks	Regulates land use activities in and adjacent to parks and protected areas to protect water quality and aquatic resources
Alberta Wetland Policy	Alberta Environment and Parks	Aims to conserve, restore, protect and manage wetlands through determination of relative wetland value, mitigation, monitoring and stewardship
Municipal		
Lac La Biche County Land Use Bylaw	Lac La Biche County Planning and Development Department	Governs what kind of development can occur in the County
Lac La Biche Area Structure Plan		Provides a framework for future development and land use practices for a particular area

Legislation/Policy	Government Agency	Description
Lac La Biche West Area Structure Plan		
Lac La Biche County Municipal Development Plan		Provides a framework for future growth and development in the County
Lac La Biche Environmental Reserve Encroachment		A procedure that details types of encroachment on Environmental Reserves, access and associated procedures
Lac La Biche Riparian Setback Matrix		Details setback requirements for subdivisions based on vegetative cover, slope of land, height of bank and groundwater influence
Lac La Biche Residential Permits		Various permits required for development, including some which are related to activities in the foreshore environment: building permit application, deck building application, private sewage disposal system permit, and residential garage permit

4.1.3 Decision-making Flowchart

The Decision-Making Flowchart enables users to scope project requirements in accordance with activity risk. Project scope is determined by activity risk, the requirement for Environmental Impact type studies and adherence to other relevant legislation and policy such as those outlined in Section 4.1.2. The intent of the flowchart is to provide a preliminary understanding of study requirements and constraints for proponents and a communication tool to guide environmentally-sensitive planning for regulatory agencies.

Table 11. Decision-Making Flowchart



4.2 Recommendations for Lake Management and Conservation

Recommendations are focused on improving the nearshore environment, with an emphasis on water quality and fisheries, since both have been degraded through the presence of algal blooms and declines in fish stocks in recent years. Recommendations are based on observations made during field work and a thorough understanding of stressors on Lac La Biche and range from typical lake stewardship to scientific study recommendations.

- Maintain a predominantly natural shoreline buffer stretching from the high water mark to 30 m upland. Shoreline buffers with native, dense vegetation are effective at mitigating the impacts of stormwater and septic effluent through filtering, infiltration and attenuation.
- Limit the construction of beaches, especially in rocky shore and wetland shore types. A number of constructed beaches located below the high water mark were observed around the lake. Imported sand and other materials typically wash away and cover native sediment, which affects lower trophic level organisms such as benthic invertebrates and reduces spawning opportunities for fish species. Future SHIM studies should focus on inventorying information on beach creation and habitat affected.
- Protect aquatic vegetation. Aquatic vegetation is often removed in recreational areas or damaged on the lake through boat use as boaters travel through vegetation to access their docks. The aquatic vegetation provides habitat, moderates algal growth and dampens wave energy along eroding shorelines and should be strongly discouraged. Consider the implementation of speed limits, educate boat owners and landowners on the importance of aquatic vegetation and ensure landowners comply with appropriate legislation (e.g. Fisheries Act) and mitigation (e.g. time activities to avoid spawning) when removing aquatic vegetation.
- Develop standard Environmental Impact Study terms of reference to assess impacts of activities in the foreshore and implement requirements in municipal policy.
- Initiate a study to assess the causes of algal blooms on Lac La Biche. Typical drivers of algal blooms should be characterized such as nutrient, iron and oxygen concentrations throughout the open-water season, and identifying point-source and non-point sources of nutrients to increase understanding and allow for the development of management options.
- Map the extent of submerged vegetation and wetland marshes within the nearshore environment.
- Acquire better wildlife and fish data in the foreshore environment, including delineation of critical habitats for fish spawning and rearing and a detailed inventory of bird nesting areas.
- Assess potential spawning habitat around High Island, Black Fox Island and Pelican Island through a habitat assessment and spawning surveys to determine if other locations shoals should be lumped into the Zones of Sensitivity – C – Spawning Shoal.
- Consider splitting segment 14 into multiple segments in a future SHIM because the Plamondon Wetland may be better treated as its own segment. Much of the wetland is in a natural state compared with the surrounding developed area.
- Complete another SHIM in the future to determine temporal trends, and to fill in data gaps (e.g., consider including systematic fish and wildlife surveys).
- Implement recommendations of the 2009 Lac La Biche Watershed Management Plan, with the support of Lac La Biche County

4.2.1 Mitigation Measures to Minimize Negative Impacts on the Foreshore during Project Activities

Determination of ecological habitat quality of the foreshore through calculation of AHI scores and mapping ZOS should be used to avoid, minimize or mitigate impacts of development and human activity. Residents, proponents and regulatory agencies should use the AHI shore zone colours and ZOS to prevent impacts by avoiding sensitive areas or features by choosing an alternative project, project design, or location, or by avoiding the activity altogether. When impacts are unavoidable, they should be minimized to acceptable levels through implementation of mitigation measures. Determination of appropriate mitigation measures are project and activity-specific. It is the responsibility of the proponent to contact regulating agencies such as Lac La Biche County and Alberta Environment and Parks to determine the required mitigation measures. Examples of mitigation can be found in Caring for Shoreline Properties (Alberta Conservation Association 1999) which includes several mitigation measures associated with common activities completed in the foreshore environment, and measures to avoid causing harm to fish and fish habitat by Fisheries and Oceans Canada at http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/measures-mesures-eng.html related to project planning, erosion and sediment control, shoreline/bank re-vegetation and stabilization, fish protection, and operation of machinery.

Fisheries and Oceans Canada also requires habitat offsets when project impacts are considered likely to result in “serious harm to fish” and are unavoidable despite implementation of mitigation measures. Habitat offsets are rare, especially in conjunction with typical activities included in the Activity Risk Matrix, but in those cases the permitting process will include a detailed assessment of project impact and consideration of suitable offsets based on resident fish species, habitat and the proposed impacts so guidance regarding offsets is therefore not discussed here; such guidance can be found at http://www.dfo-mpo.gc.ca/pnw-ppe/offsetting-guide-compensation/index-eng.html

4.3 Data and Analysis Limitations

The SHIM process is useful for characterizing the physical and biological features of a lake’s shoreline so that sensitive habitats can be identified and protected. Nonetheless, it is important to recognize the limitations of this approach as it applies to the Lac La Biche study. The field work which formed the foundation for the foreshore inventory and mapping, as well as the AHI, was conducted in a single year, over six visits. The short duration of field investigations means that natural variations in physical and biological features over longer periods (e.g., semi-annual or annual) would not be captured in the data. Instead, the data should be considered as a snapshot of shoreline conditions, which can serve as a baseline to track future changes if monitoring is continued on a regular basis. In addition, several logistical challenges prevented systematic collection of some types of data (e.g., access to portions of the shoreline, lack of permits for fish sampling etc.), which could result in an incomplete picture of current conditions that might hinder subsequent interpretation. To overcome this potential problem, the field data were supplemented with information from additional sources gathered through a desktop review. This third-party information is assumed to be accurate and reliable, but in some cases may not be current. Nonetheless, data were collected consistently as planned and enabled a relatively thorough assessment of habitat conditions.

5. Conclusions

Lac La Biche is appreciated by residents and visitors alike for its natural beauty, abundant wildlife, good water quality, and the variety of recreational opportunities it offers. Lac La Biche is a large, moderately developed lake, which still retains a high degree of natural shoreline, but also contains numerous modifications associated with human activity, such as docks, retaining walls and boat launches, as well as removal of riparian, wetland and submerged vegetation.

The lake has experienced recent declines in water quality and fish populations, leading to widespread and recurring algal blooms, as well as fishery closures. The lake supports mixed domestic and recreational fisheries, and a restoration program was established to address overfishing through reduction in catch limits, Walleye stocking, cormorant control, habitat protection and monitoring. The latest survey data (from 2014) indicate that Walleye populations appear to be recovering in the lake, but they are still considered vulnerable. Lac La Biche is naturally eutrophic and blue-green algal blooms are typically mid-summer, but cultural eutrophication in recent decades may impact the size and abundance of such blooms.

The SHIM serves to protect natural features in the foreshore environment through conservation and as a development tool. Critical, sensitive and important habitats were identified that must be protected if the current fish and wildlife resources are to be sustained. Identification of habitats is the first step in conservation which we hope will be followed by education and stewardship.

The SHIM also serves as benchmark to assess compliance of applicable legislation, and the rate of change of shoreline habitat over time. It is recommended to revisit SHIM five years following the initial assessment to determine if natural shoreline habitat is being lost, if habitat values are decreasing, or if restoration measures are effective and increasing natural shoreline and habitat values.

Balancing shoreline development activities is paramount for the ongoing protection and restoration of Lac La Biche's ecological health. The SHIM project was implemented to address concerns over the impacts of human activity on the lake's ecological integrity, and to offer ways to incorporate environmental considerations into future development decisions. The SHIM serves as a tool for landowners and regulators to make environmentally sound land use decisions along the Lac La Biche shoreline. The SHIM provides background information on the ecological condition of the lake's foreshore, classifying all shoreline segments into colour zones according to habitat quality and thus sensitivity to development. Additional sensitive habitat features not captured through this classification (e.g., shoals, bird sanctuaries) are also included as ZOS. The SHIM then evaluates the risk of common development activities in each of the colour zones and ZOS, and provides a framework for decision-making on development activities based on the calculated activity risk, relevant legislation and policy, and potential for best management practices and mitigation measures to avoid and minimize adverse impacts on the environment. The SHIM offers a systematic, streamlined and science-based process for integrating information on ecological condition into shoreline development planning on Lac La Biche.

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Appendix A. Foreshore Inventory and Mapping Field Code Definitions

Source: Ecoscape Environmental Consultants 2009

Appendix B. Restoration Potential Results