Riparian Area Assessment for the Lower McLeod River Watershed

FINAL REPORT

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Athabasca Watershed Council

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FIERA Biological Consulting

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The Athabasca Watershed Council would also like to acknowledge the financial assistance of the Government of Alberta. The Government of Alberta contributed to the delivery of this project through the Watershed Resiliency and Restoration Program, which aims to restore or enhance previously degraded natural habitats, including riparian habitat, within priority watersheds across Alberta. Additionally, the Government of Alberta provided spatial data that was essential for the successful completion of this project.

The AWC would also like to thank the many municipalities, industries, businesses, Indigenous communities, stewardship groups, and donors that support and contribute to the work of the watershed council.

Executive Summary

Riparian lands have substantial ecological, economic, and social value, Because of this, the effective management of riparian habitat is a critical component to the maintenance of watershed health. In an effort to better manage riparian habitats within the Lower McLeod River watershed, the Athabasca Watershed Council (AWS) retained Fiera Biological Consulting to assess riparian habitat along approximately 1,400 km of lake and river shoreline.

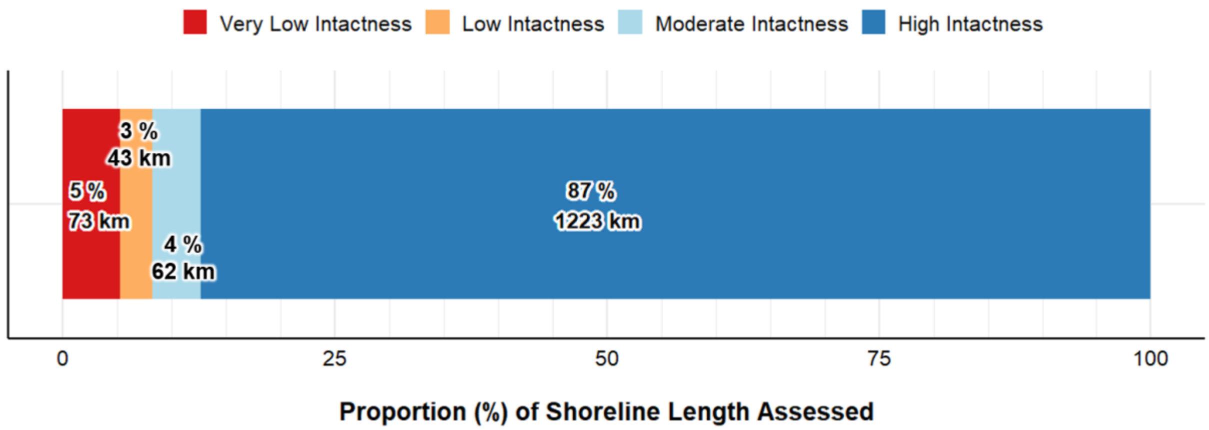
The Lower McLeod River is a large HUC 6 watershed that covers an area of ~4,770 km^2. It is located in the southwestern portion of the Athabasca River watershed, roughly between Edson and Whitecourt. This HUC 6 watershed is made up of four smaller (HUC 8) watersheds, including: Edson River, Lower McLeod River, Trout Creek, and Wolf Creek.

Riparian management areas (RMAs) located along shorelines of interest within the Lower McLeod watershed were evaluated using a desktop-based approach that utilizes a current land cover layer. An RMA is defined as an area adjacent the shoreline that typically includes the near-shore emergent vegetation zone, the riparian zone, and a riparian protective (buffer) zone. For the purpose of this study, RMAs had a fixed width of 50 m and a variable length that was determined based upon major breaks in the cover of natural vegetation.

Intactness was used as the measure of riparian condition because the relationship between an intact riparian zone and the health or function of the aquatic environment is well established. Intact riparian zones play a vital role in the exchange of inorganic and organic material between the terrestrial and aquatic ecosystems via the interception of sediments and nutrients that runoff from adjacent upland habitats, and through the supply of leaf litter and woody debris. Intact riparian vegetation also regulates water temperature and the instream light environment, thereby ensuring suitable habitat for a range of aquatic species. Further, riparian habitats stabilize the banks of waterbodies and help modulate water velocities and high water events, thereby improving water quality and protecting surrounding lands from flooding. Given the significant role that an intact riparian zone has on providing ecosystem services and supporting healthy and functional aquatic ecosystems, there is a need to effectively manage riparian areas. Understanding the distribution of intact riparian habitat across the landscape and identifying areas where riparian intactness has been degraded is essential to improving conservation and management outcomes.

As part of this riparian assessment, 13 waterbodies were evaluated, including 10 rivers and creeks and 3 lakes. Overall, 87%, (or 1,223 km) of the shoreline was classified as High Intactness. An additional 4% (62 km) of the shoreline was classified as Moderate Intactness. The remaining shoreline was classified as either Low (3%, 43 km) or Very Low (5%, 73 km) Intactness.

RIPARIAN INTACTNESS FOR WATERBODIES ASSESSED IN THE LOWER McLEOD RIVER HUC 6 WATERSHED



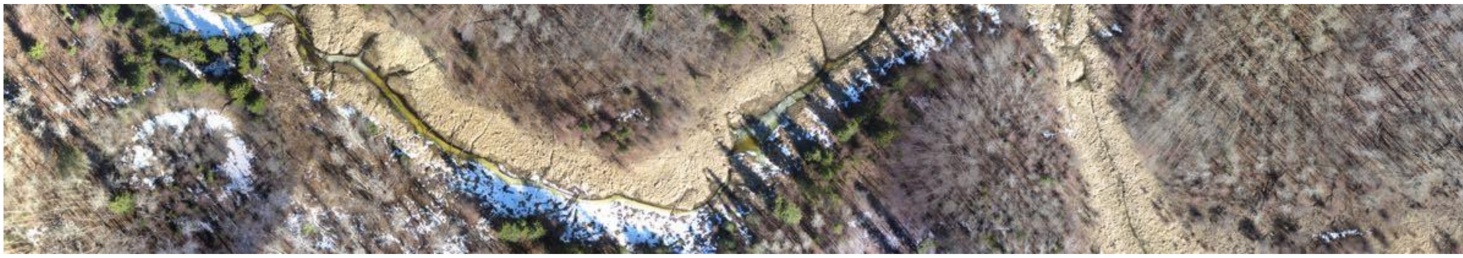
When intactness was compared by HUC 8 watershed, the Wolf Creek watershed had the greatest proportion (95%) of shoreline rated as High Intactness, while the Lower McLeod River watershed had the greatest length (642 km) of High Intactness shoreline. Conversely, the Edson River watershed had the greatest proportion of shoreline rated as either Very Low (12%, 31 km) or Low (4%, 12 km) Intactness.

When intactness was evaluated for municipalities that intersect the Lower McLeod River watershed, both Woodlands County and Yellowhead County had greater than 90% of their shorelines classified as Moderate or High Intactness. The towns of Edson and Whitecourt also had a substantial amount of shoreline (>80%) classified as either Moderate or High Intactness. Compared to other municipal jurisdictions, the Town of Edson had the greatest proportion of shoreline rated as Very Low Intactness.

		Proportion (%) of Shoreline within Intactness Category*					
Spatial Extent	**Length Assessed (km)**	**Very Low**	**Low**	**Very Low + Low**	**Moderate**	**High**	**Moderate + High**
Lower McLeod River HUC 6 Watershed	1,400	5	3	8	4	87	91
Edson River HUC 8 Watershed	264	12	4	16	7	77	84
Lower McLeod River HUC 8 Watershed	730	5	3	8	5	88	93
Trout Creek HUC 8 Watershed	144	4	4	8	3	89	92
Wolf Creek HUC 8 Watershed	261	1	1	2	2	95	97
Edson	25	14	3	17	19	63	82
Whitecourt	14	7	8	15	14	71	85
Woodlands County	159	3	3	6	1	93	94
Yellowhead County	1,201	5	3	8	4	87	91

*NOTE: The total sum of Very Low, Low, Moderate, and High may be > or < 100% due to the rounding of values.

This project has generated scientific information that can be used as the basis for the development and implementation of an evidence-based framework for adaptively managing riparian areas within the Lower McLeod River watershed. Through the commissioning of this study, the AWC and its stakeholders have added to their existing baseline of information about riparian habitat condition in the watershed. This information can be used to target restoration and conservation activities that will improve water quality, biodiversity, and drought and flood resilience throughout the watershed.



List of Terms

Abbreviations

AAFC: Agriculture and Agri-food Canada
ABMI: Alberta Biodiversity Monitoring Institute
AGS: Alberta Geological Survey
ARHMS: Alberta Riparian Habitat Management Society (Cows & Fish)
AWC: Athabasca Watershed Council
BMP: Best Management Practice
DEM: Digital Elevation Model
HUC: Hydrologic Unit Code
RMA: Riparian Management Area

Glossary

Aerial Videography: Video captured from a low flying aerial platform, such as helicopter or ultra light aircraft.

Hydrologic Unit Code (HUC): The Hydrologic Unit Code (HUC) Watersheds of Alberta represent a collection of nested hierarchically structured drainage basin feature classes that have been created using the Hydrologic Unit Code system of classification developed by the United States Geological Survey (USGS), with accommodation to reflect the pre-existing Canadian classification system. The HUC Watersheds of Alberta consist of successively smaller hydrologic units that nest within larger hydrologic units, resulting in a hierarchal grouping of alphanumerically-coded watershed feature classes. The hydrological unit codes include HUC 2, HUC 4, HUC 6, HUC 8, and HUC 10, with HUC 2 being the coarsest level and HUC 10 being the finest level of classification.

Indicator: A measurable or descriptive characteristic that can be used to observe, evaluate, or describe trends in ecological systems over time.

Intactness: In reference to the condition of natural habitat, intactness refers to the extent to which habitat has been altered or impaired by human activity, with areas where there is no human development being classified as high intactness.

Left Bank: The bank of a river, stream, or creek that is on the left when facing downstream.

Metric: A qualitative or quantitative aspect of an *indicator*; a variable which can be measured (quantified) or described (qualitatively) and demonstrates either a trend in an indicator or whether or not a specific threshold was met.

Resilience: The capacity of an ecosystem to resist, absorb, and recover from the effects of natural and human-caused disturbance to preserve ecological and hydrological services and functions.

Right Bank: The bank of a river, stream, or creek that is on the right when facing downstream.

Riparian Area, Riparian Habitat, Riparian Land, or Riparian Zone: Riparian lands are transitional areas between upland and aquatic ecosystems. They have variable width and extent both above and below ground. These lands are influenced by and/or exert an influence on associated waterbodies, which includes alluvial aquifers and floodplains, when present. Riparian lands usually have soil, biological, and other physical characteristics that reflect the influence of water and/or hydrological processes (Clare and Sass 2012).

Riparian Management Area: As per Teichreb and Walker (2008), and for the purpose of this report, a riparian management area is defined as an area along the shoreline of a waterbody that includes near-shore emergent vegetation zone, the riparian zone, and a riparian protective (buffer) zone.

Strahler Order: A method of classifying and assigning a numeric order to streams in a network based on the number of tributaries. First order streams are dominated by overland flow and have no upstream concentrated flow; whereas higher order streams have a greater number of upstream tributaries. Stream order increases when stream of the same order intersect.

Waterbody: Any location where water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during a flood. This includes, but is not limited to lakes, wetlands, aquifers, streams, creeks, and rivers.

Watercourse: A natural or artificial channel through which water flows, such as in creeks, streams, or rivers.

Watershed: An area that, on the basis of topography, contributes all water to a common outlet or drainage point. Watersheds can be defined and delineated at multiple scales, from very large (e.g., thousands of square kilometers, such as the Red Deer River watershed) to very small local watersheds (e.g., square metres, such as a small prairie wetland).

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1.0 Introduction

1.1. Background

Riparian areas are highly complex and dynamic “transitional habitats” that are found along the edge of waterbodies, including rivers, streams, lakes, wetlands, and springs. Riparian areas show steep hydrological and environmental gradients from the water’s edge to the adjacent uplands, and are critical for facilitating the transfer of energy and materials between terrestrial and aquatic ecosystems (NRC 2002). Hydrology (both groundwater and surface water) is the driving force behind the physical, chemical, and biological processes that characterize riparian habitats. Because riparian lands are under the influence of both terrestrial and aquatic processes (e.g. nutrient and sediment transfer), these areas tend to be more biologically productive and have higher levels of biodiversity than other habitats of comparable size (Ibid). From the perspective of human communities, riparian areas provide a multitude of beneficial ecosystem functions and services, including a wide range of provisioning, regulating, and cultural services.

The relationship between an intact riparian zone and the integrity of the aquatic environment is well established (Pusey and Arthington 2003). For example, intact riparian zones play a vital role in the exchange of inorganic and organic material between the terrestrial and aquatic ecosystems, via the interception of sediments and nutrients that runoff from adjacent upland habitats and through the supply of leaf litter and woody debris. Furthermore, intact riparian vegetation can modulate the transfer of solar energy to the aquatic ecosystem, regulating water temperatures and the instream light environment, ensuring suitable habitat for a range of aquatic species (Ibid). Riparian habitats stabilize the banks of waterbodies and help modulate water velocities and high water events, thereby improving water quality and protecting surrounding lands from flooding (Orewole et al. 2015; Olokeogun et al. 2020). Riparian vegetation also slows floodwater and increases floodplain residence times, which increases recharge to groundwater aquifers (Swanson et al. 2017). In turn, this allows water to seep back into streams during low water or drought periods (Blackport et al. 1995), thereby stabilizing base water flows (Caissie 1991; Blackport et al. 1995).

Despite the importance of these habitats, the loss and impairment of riparian lands in Alberta over the last century has been significant (Clare and Sass 2012). As a result, many of the current watershed management efforts throughout the province are focused on identifying priority areas for riparian restoration and habitat management. In order to efficiently target habitat restoration efforts and resources across large spatial extents, however, there first needs to be reliable information about the location, condition, and function of riparian habitats.

1.2. Methods for Assessing Riparian Areas

1.2.1. Field Assessment

The finest scale and most detailed evaluations of riparian condition come from “boots-on-the-ground” site-specific field assessments and/or inventories of riparian areas. In this type of assessment, such as the Alberta Riparian Habitat Management Society (ARHMS, also known as “Cows & Fish”) Riparian Health Assessment, detailed and local-scale traits of riparian areas are evaluated by trained practitioners, and a comprehensive and thorough assessment of riparian condition is made. Metrics evaluate a wide range of riparian attributes including: vegetation type, structure, and composition; bank characteristics; soil attributes; and land use and disturbance. The final compiled score provides a snapshot of whether a riparian area is “Healthy”, “Healthy, but with problems”, or “Unhealthy”, and gives a land-owner or other interested stakeholders an idea of where to focus management activities. To date, the vast majority of the field-based riparian assessments completed by Cows and Fish have been in central and southern Alberta, and while the site-specific detail offered by this approach cannot be matched, these assessments are limited in their ability to provide information for planning and management at municipal, regional, or larger scales.

Although existing ground-based assessment methods are useful for gathering information about the general condition of riparian habitat at small spatial extents, the site-specific delineation employed for these assessments cannot be scaled up to provide information about riparian condition across larger geographic areas. Further, the results of these assessments are typically not available publicly due to confidentiality agreements with landowners.

1.2.2. Aerial Videography

As an alternative to the highly detailed information required and the substantial time and cost investment associated with field assessments, alternative approaches that utilize recorded video have been applied to assess riparian areas over larger spatial extents. Aerial videography is a tool for assessing riparian habitat where a trained analyst uses spatially referenced continuous video to evaluate a hydrologic system. Instead of walking around and observing the site, the observation takes place through video images acquired from an oblique angle at altitudes of 60 m or less. Riparian condition is assessed within a “riparian management area” (RMA) polygon, and like the field-based Alberta Riparian Habitat Management Society Riparian Health Assessment, the evaluator answers a series of questions about the functional attributes of the riparian lands to derive a score that is then classified according to three health categories that are akin to the field-based approach.

Videography has been applied by various organizations across Alberta using a variety of airborne video platforms (e.g., Mills and Scrimgeour 2004, AENV 2010, NSWA 2015). The benefit of videography is that the entire riparian area of a lake or river can be assessed at one time, while providing a permanent geo-referenced video record of the current status of shoreline. It provides a relatively rapid method to produce a “coarse filter” assessment of riparian health. This approach is not intended to replace field-based assessments, but rather, complement them by allowing larger areas to be evaluated in an approximate fashion, to be followed by more detailed checks on the ground. The goal of the videography assessments is to provide information over larger areas at a lower cost, such that the management of riparian areas at larger scales (i.e. entire lake or river system) can be directed by standardized measurements.

In many cases, videography can be very cost-effective per kilometer of shoreline observed. At a certain scale, however, the size of the study area and the width of the stream or river make assessments by videography cost prohibitive. Compared to ground-based methods, aerial videography offers a broader scale and relatively coarse assessment of riparian condition; however, at larger scales, such as for entire watersheds, this method becomes limited in practicality and efficiency (i.e., time and cost).

1.2.3. Satellite Remote Sensing & GIS Assessment

In response to a growing need for an assessment method that could evaluate riparian condition at large spatial extents (i.e., entire watersheds), Fiera Biological developed a Geographic Information System (GIS) method to assess thousands of kilometers of shoreline in a reliable and cost-effective way. This method was developed using metrics comparable to existing ground-based and aerial videography methods, and the results have been validated using both aerial videography (Fiera Biological 2018a) and field data (Fiera Biological 2019).

The assessment method uses automated and semi-automated GIS techniques to quantify the intactness of riparian management areas using freely available or low cost spatial data. This method combines imagery from satellites with information about the terrain (e.g., relative differences in elevation, location of depressions, etc.,) to create a land cover dataset that is used to measure and quantify the amount of natural and human cover types present along the shorelines of a water body. The shoreline is then classified into condition categories along a gradient of how "intact" the vegetation is, with areas that are dominated by natural vegetation being considered highly intact, and areas dominated by human-created land cover types (e.g., roads, houses, agricultural crops) being considered to have very low intactness (Figure 1 and 2). To date, this method has been used to assess nearly 60,000 km of shoreline across Alberta (Fiera Biological 2018a-e, 2019, 2020a-b, 2021a-g, 2022a-c, 2023a-b). This includes just over 5,300 km of shoreline in the Athabasca River watershed.

Figure 1. Riparian intactness is a measure of how "natural" a shoreline is. Highly intact shorelines are dominated by natural vegetation and other natural cover types, while shorelines classified as very low intactness are dominated by human-build structures, roads, and manicured or disturbed vegetation.

Figure 2. Using a “bird’s eye view”, the satellite-based GIS riparian assessment method measures the type and amount of natural versus human-created land cover types present within 50 m of the shoreline. Shorelines classified as high intactness are almost entirely covered by natural cover. Shorelines that are considered to have very low intactness are dominated by human structures and modified or disturbed vegetation.

1.3. Study Objectives

The overall goal of this project is to contribute to the improvement of watershed health, including flood and drought resilience. In order to achieve this goal, this study had the following primary objectives:

1) Create a recent land cover within 50 m of selected shorelines and use this layer to assess the intactness of riparian areas along major waterbodies in the Lower McLeod River watershed.
2) Summarize intactness results at various scales (e.g., subwatershed, municipality, watercourse).
3) Provide guidance on how the results from the intactness assessment can be used to target conservation and restoration efforts for riparian areas.

The results of this study provide an overview of the status of riparian management areas within the Lower McLeod River watershed. This in turn allows for the targeting of conservation and/or restoration effort in areas of greatest need. Further, this approach has been adapted and applied in other watersheds in the Athabasca River basin and throughout the province, thereby allowing for a standardization of the methods used to conduct large-scale riparian assessments in Alberta.

1.4. Purpose and Intended Use

This assessment synthesizes data from a variety of sources, with the goal of generally characterizing the current condition of riparian management areas within the Lower McLeod River watershed. Readers are asked to consider the following points regarding the scope of this assessment as they review the methods and interpret the results of this study:

- Assessments characterize the relative intactness of riparian areas using a collection of indicators and associated metrics that are measurable in a GIS environment at a pixel resolution of 6 m. These assessments do not provide a statement on the absolute condition of riparian areas and do not reflect the influence of factors that were not or cannot be included or considered for analysis. For example, this analysis cannot assess the occurrence or abundance of weeds within a riparian area, given that this type of cover cannot be resolved in a 6m resolution satellite image. Furthermore, because overhead satellite imagery is used to create the land cover layer used to assess intactness, this assessment is not able to evaluate impacts associated with structures or activities that are obscured by an extensive tree canopy (e.g., small structures, stormwater outfalls, etc.).
- In completing these assessments in a number of watersheds throughout Alberta, we have found that higher riparian intactness scores are more frequently associated with higher-order Strahler streams and rivers, whereas lower-order streams (many of which are unnamed) tend to have a much greater proportion of their shorelines assessed as Low or Very Low condition, particularly in agricultural landscapes. Thus, the overall intactness values for a watershed may be strongly influenced by the order of streams included in the assessment, as well as the dominant land use within the watershed.
- Intactness and pressure ratings are intended to support a screening-level assessment of management and/or conservation priorities across broad geographic areas (e.g., HUC 8 subwatershed, municipality, stream reach). *This assessment is not meant to replace more detailed, site-specific field assessments of riparian health or condition*. Instead, intactness ratings should be used to highlight smaller, more localized areas where field assessments and further validation may be required. Especially in areas of rough pasture, the level of impact on riparian vegetation by livestock can be difficult to conclusively determine using satellite imagery. We acknowledge that in these areas the decision between “natural” and “disturbed” is subjective, and thus, there may be some disagreement as to the level of impact and intactness of the riparian area.

- The provincial hydrography data for streams, creeks, rivers, and lakes was used to delineate the shoreline of the waterbodies included in this assessment. Because waterbodies are dynamic and their boundaries change seasonally and annually, the boundaries for the waterbodies included in this study had to be manually adjusted to ensure that the boundary was reflective of the current location of the shoreline, as well as consistent with the imagery that was used to complete the riparian assessment. Notably, the location of the boundaries used in this assessment may not be representative of the location of these same waterbodies in the future. Further, the spatial boundaries of waterbodies within the watershed that were not assessed as part of this study have not been updated.
- The jurisdictional summaries in this report were based on the boundaries available in the Alberta Base Features dataset and were generated using a spatial intersect rule in the GIS (i.e., if the riparian management area was within a municipality or touched the boundary of a municipality, then it was used to tabulate summaries for that municipality). It should be noted that where a watercourse defines the boundary between two jurisdictions, there is often a substantial spatial offset between the base feature jurisdictional boundary and the water boundary that is digitized as part of this riparian assessment. This is particularly an issue for municipal boundaries, and it is often unclear which municipality is responsible for the management of the left or right bank of a waterbody that defines the boundary of more than one municipality. Editing municipal boundaries to conform with the water boundaries applied in this project was beyond the scope of work, and as such, there may be instances where the spatial intersect rule applied to generate the summaries does not precisely reflect the riparian areas associated with a jurisdiction. Consequently, the jurisdictional summaries provide a *general estimate* of the amount of shoreline that was assessed in the study, as well as the condition of the associated riparian management areas identified for each jurisdiction.

2.0 Study Area

The Lower McLeod River watershed is a large (~4,770 km2) HUC 6 watershed that is located in west central Alberta, and within the southwestern portion of the Athabasca River watershed (Map 1). The Lower McLeod watershed has an extensive hydrological network that flows primarily through the Foothills Natural Region (Map 2), and is composed of four smaller (HUC 8) watersheds: Edson River, Lower McLeod River, Trout Creek, and Wolf Creek (Map 3).

Human settlement and agricultural activity is generally concentrated in the central and northern portions of the watershed, and is generally associated with the towns of Edson and Whitecourt. Approximately 11% of the watershed is classified as an anthropogenic land cover type (Map 4). Agriculture (cropland and pasture) make up the largest proportion of the lands modified by human activity (9%), with the remaining human land cover being composed of Built Up/Exposed (2%). Approximately 89% of the watershed consists of natural land cover types, such as wetlands, forests, open water, and other low and open natural vegetative cover. Land cover at the watershed scale was summarized using the 2022 Agriculture and Agri-Food Canada land cover data.

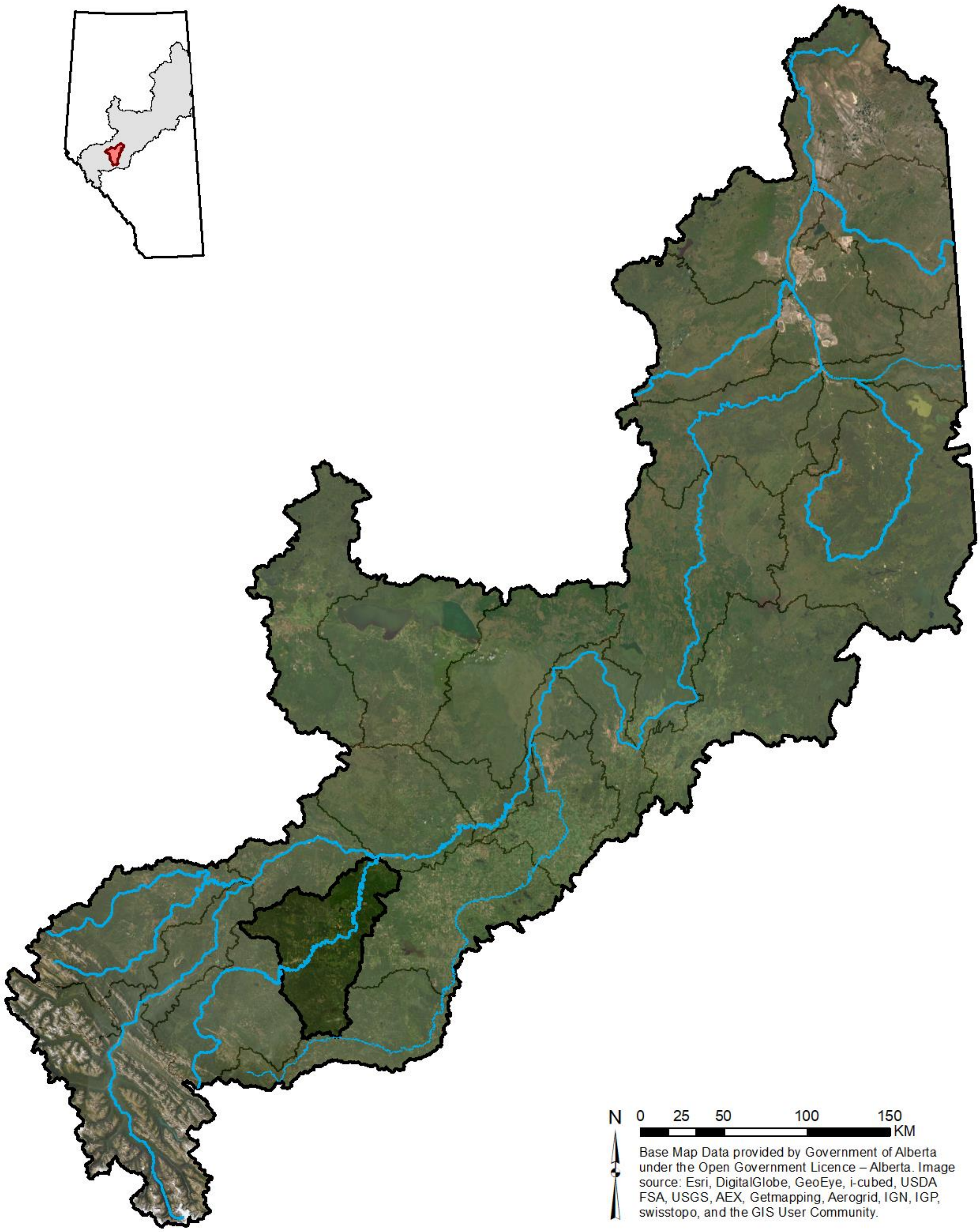
Resource extraction, including oil and gas, mining (open pit; gravel/sand), and forestry, is also a prominent human activity in the watershed. Based on ABMI Human Footprint data from 2021, the total footprint of oil and gas wells and facilities was 47.2 km^2 (~1% of the watershed), with mines covering an additional 7 km^2. In addition to the areal cover of these industrial facilities and operations, the density of pipelines and seismic lines in the watershed is very high (4.16 km/km^2; Map 5)Map 5. Historical and contemporary forestry activity in the watershed is also extensive. Prior to 1980, the majority of forestry activity was located in the northwest portion of the watershed, with more recent forestry activity (e.g., since 1980) being more concentrated in the northern and southern extents of the watershed (Map 6). In total, approximately 1,003 km^2 (21%) of the watershed has been harvested since 1922, with almost half of the total harvest (427 km^2) occurring since 2001.

Two rural counties intersect the Lower McLeod River watershed, including a large portion of Yellowhead County and a smaller portion of Woodlands County (Map 7). Additionally, the towns of Edson and Whitecourt are located within the watershed.

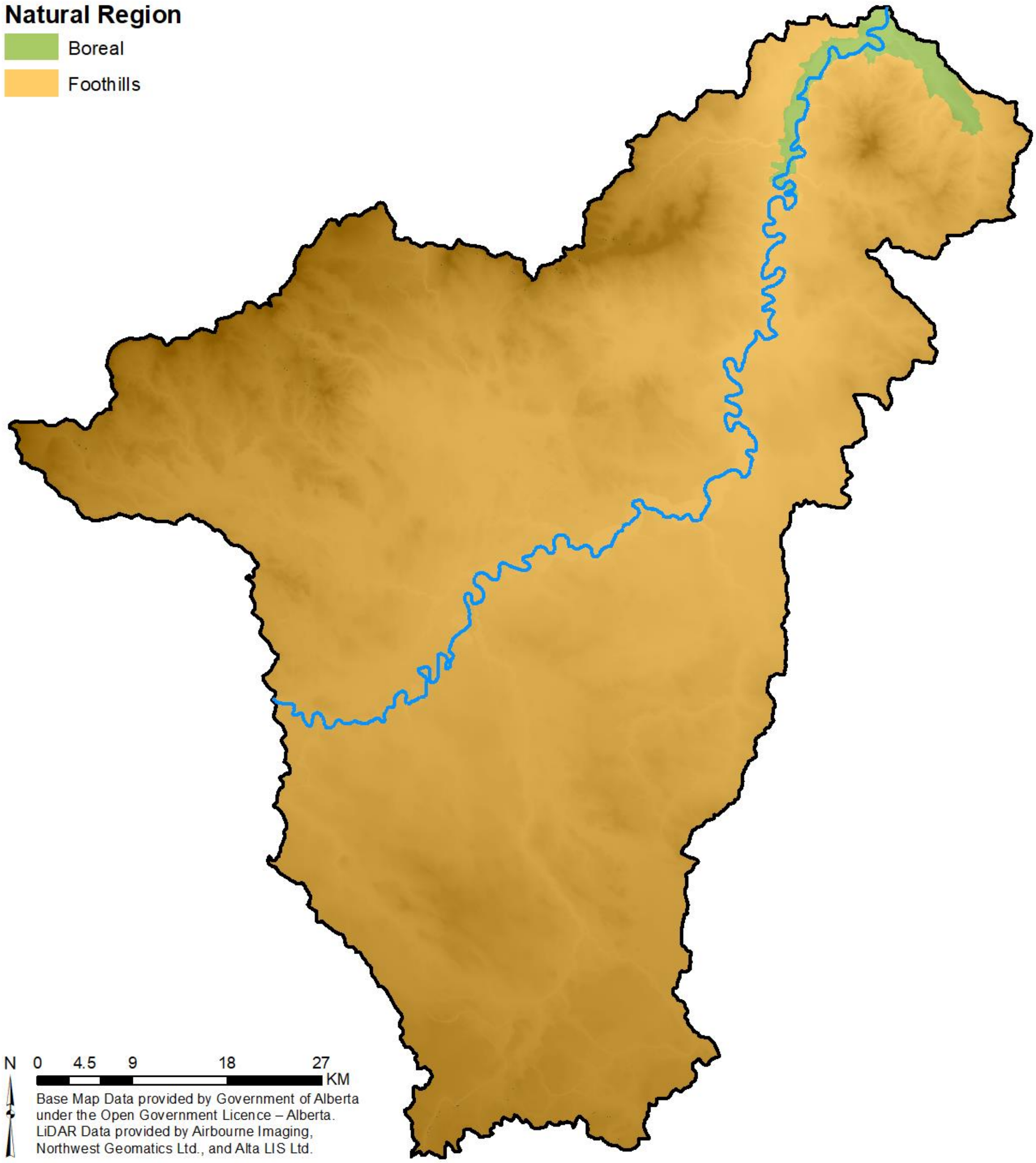
The riparian management areas that were assessed as part of this study were associated with left and right banks of 10 named watercourses. This included the McLeod River and its major tributaries. In addition, this study included two named lakes and one unnamed lake (Table 1; Map 8). In total, 1,400 km of shoreline was assessed.

Table 1. Waterbodies in the Lower McLeod River watershed that were assessed as part of this project. The shoreline length listed for each creek and river represents the total length of the shoreline that was assessed on both the left and right banks.

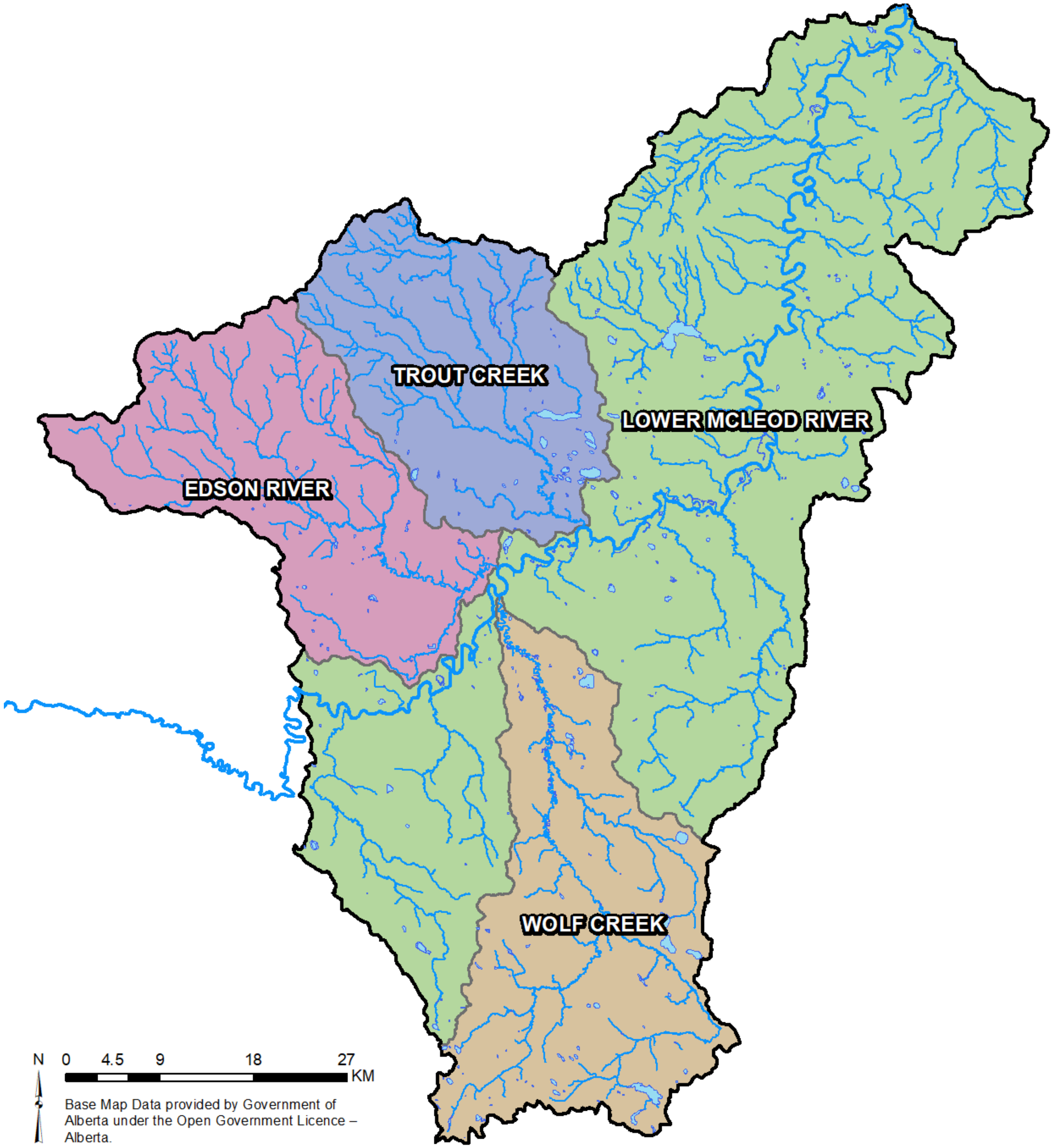
Waterbody Name	Length of Shoreline Assessed (km)
Creeks & Rivers	
Beaver Creek	68.5
Bench Creek	73.9
Carrot Creek	124.3
Edson River	189.2
January Creek	71.7
Lost Creek	30.0
McLeod River	368.9
Shiningbank Outlet Creek	53.8
Trout Creek	144.3
Wolf Creek	250.9
Lakes	
Shiningbank Lake	13.3
Wolf Lake	10.6
UL-170202-01	0.7
TOTAL	**1,400.0**



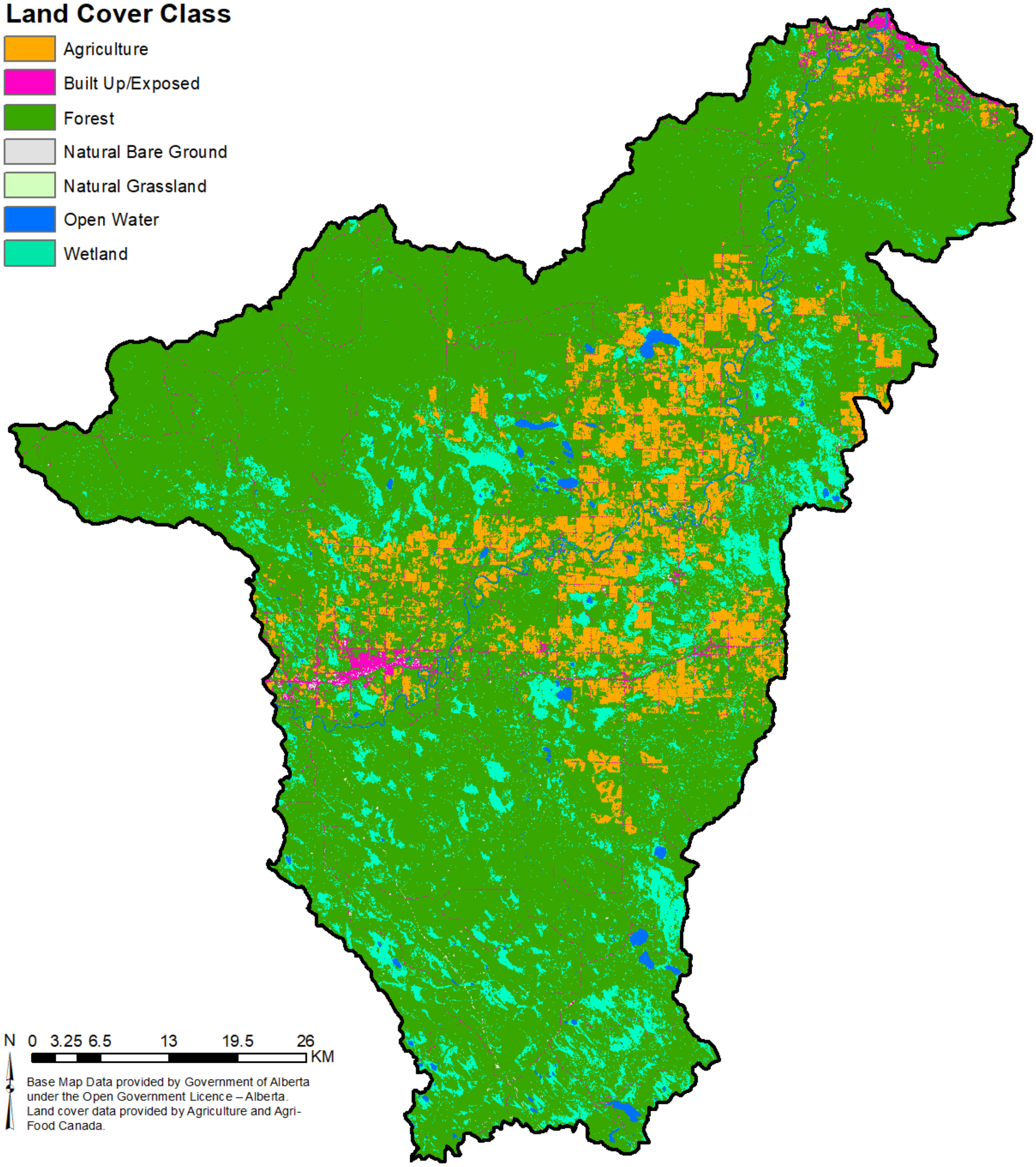
Map 1. The Lower McLeod River HUC 6 watershed located within in the Athabasca River watershed.



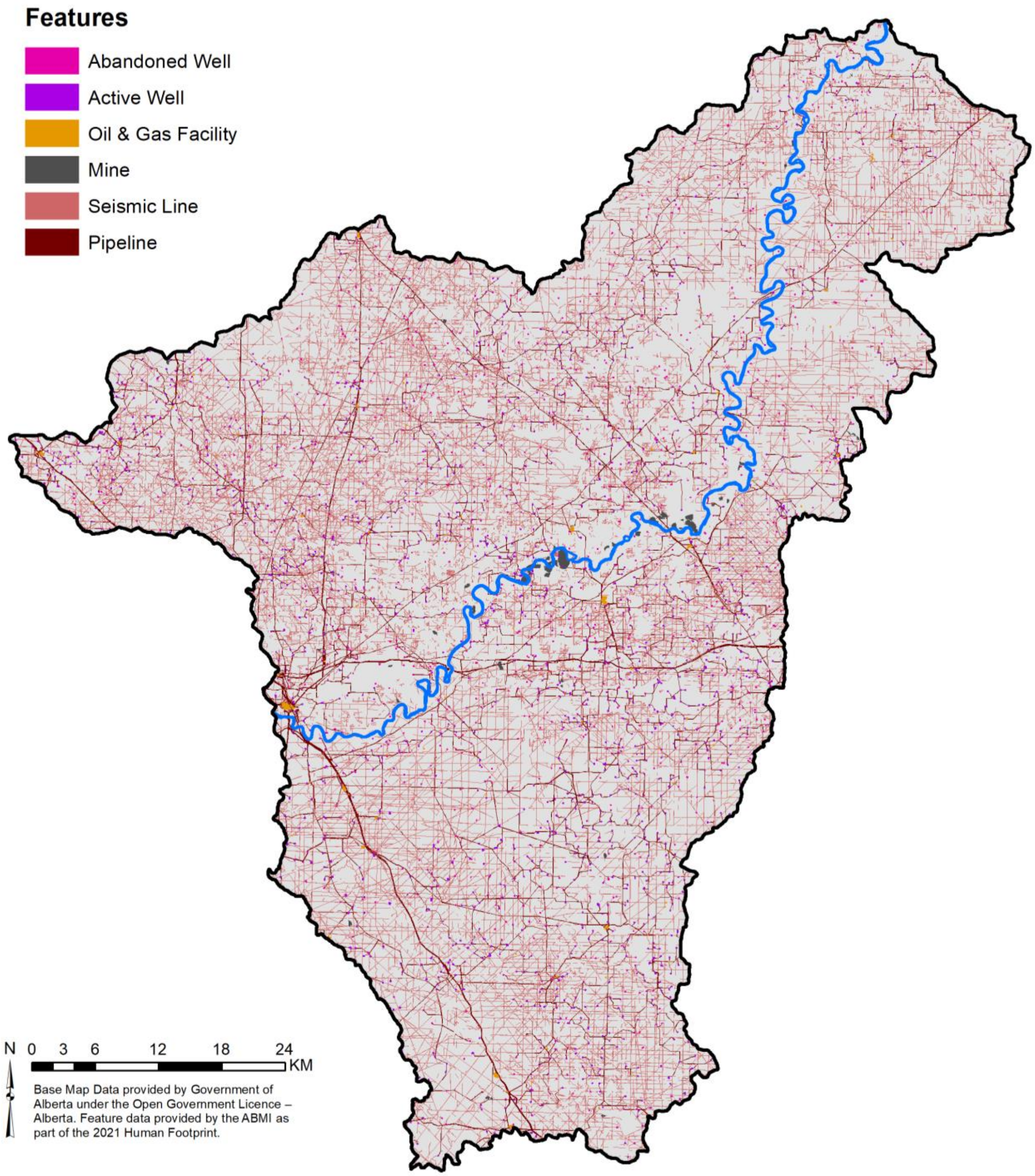
Map 2. The Lower McLeod watershed is located primarily within the Foothills Natural Region.



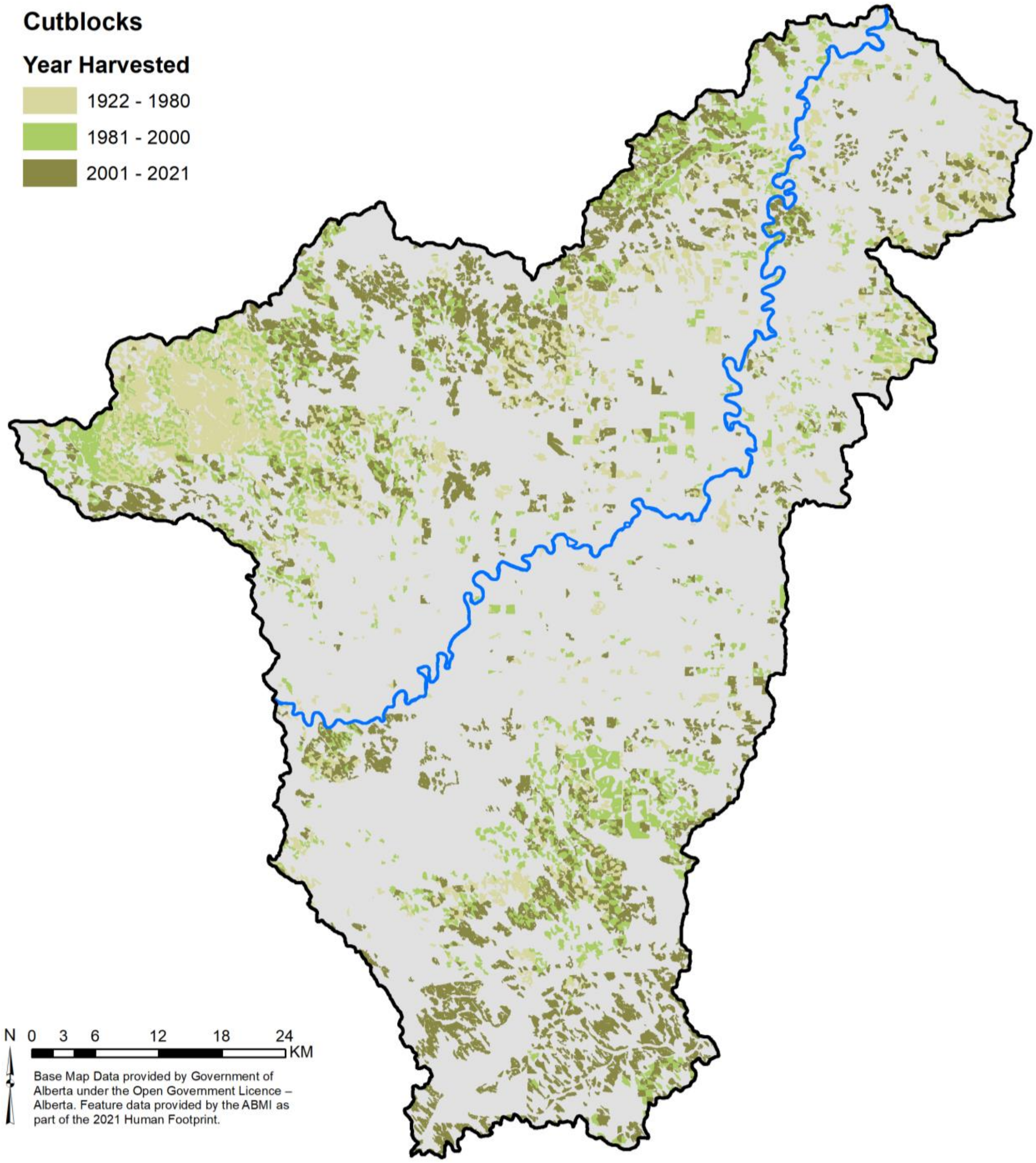
Map 3. The Lower McLeod watershed consists of four smaller (HUC 8) watersheds: Edson River, Lower McLeod River, Trout Creek, and Wolf Creek.



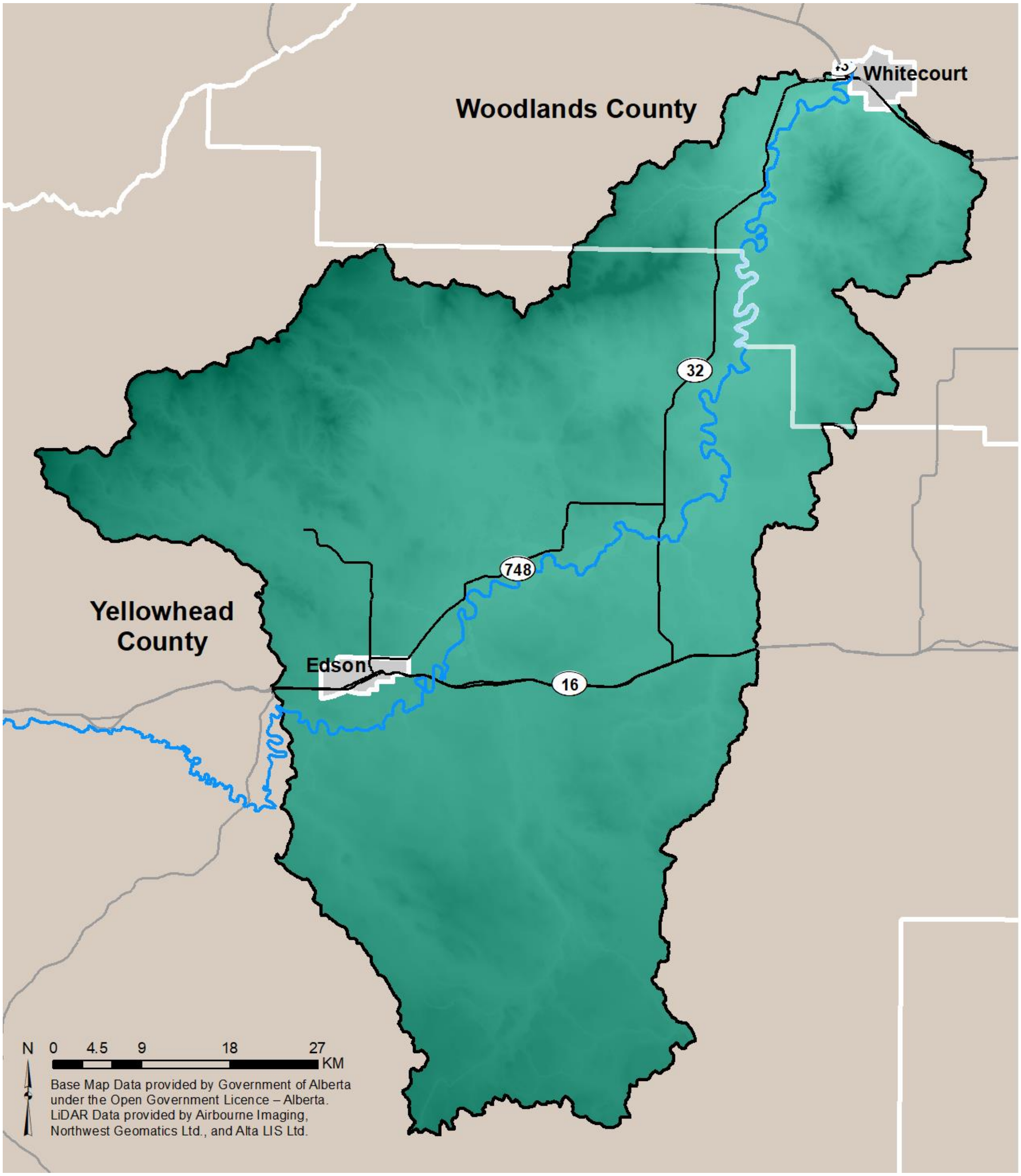
Map 4. Land cover in the Lower McLeod River watershed, based on the 2022 Agriculture and Agri-Food Canada land cover data.



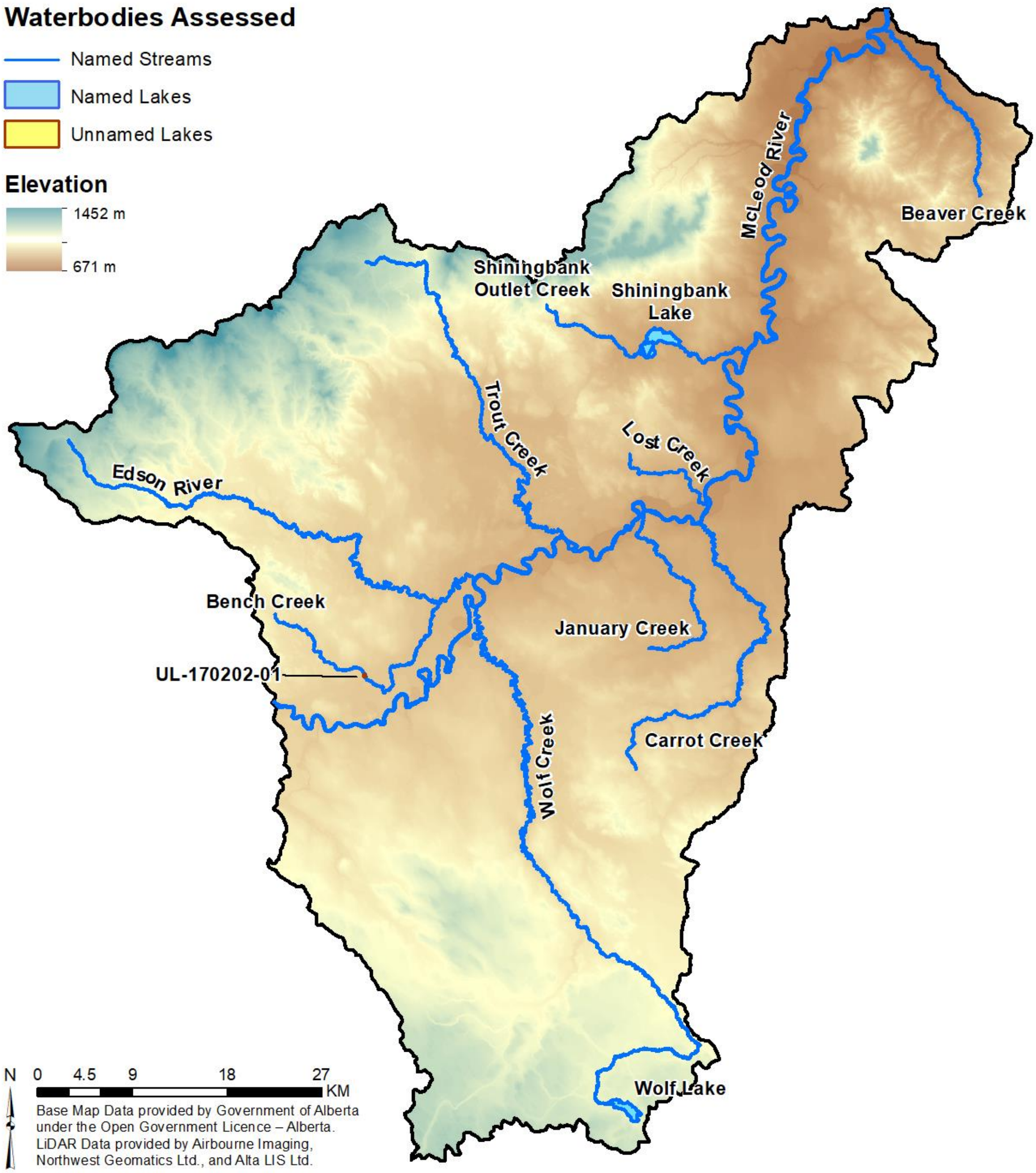
Map 5. Human footprint associated with oil and gas and mining activities in the watershed. Data is from the ABMI 2021 Human Footprint dataset.



Map 6. Human footprint associated with forestry in the watershed. Data is from the ABMI 2021 Human Footprint dataset.



Map 7. Major highways and municipalities located within the Lower McLeod River watershed.



Map 8. Location of the waterbodies that were assessed in this study.

3.0 Methods

3.1. Assessing Riparian Intactness

3.1.1. Land Cover Classification

To quantify riparian intactness in a GIS environment, several data sets are required, including a current land cover layer. While a freely available and current land cover layer is available from Agriculture and Agri-Food Canada (AAFC), the resolution of this data (30 m pixel size) is too coarse to accurately assess vegetation within riparian management areas. Consequently, a 6 m pixel resolution land cover layer was created using SPOT 6 and SPOT 7 satellite imagery from 2020, which was obtained by the AWC free of charge from the Government of Alberta.

To derive the land cover layer, seven separate satellite images were classified using a random forest classification. Random forest is a classification algorithm that is based on a set of decision trees derived using random subsets of training data to create predictive models from a "layer stack" that is composed of different spatial data layers (Ho 1995). Due to differences in the acquisition date and image quality, each satellite image was classified individually using the same methodology.

The layer stack for this classification was created using satellite imagery, LiDAR, and other ancillary data (Table 2). Band indices created from satellite imagery included Normalized Difference Vegetation Index (NDVI), Blue Normalized Difference Vegetation Index (BNDVI), Green Ration Vegetation Index (GRVI), and Iron Oxide Index (IOI). Additionally, satellite imagery was used to generate layers for the first four principal components of the four band image. A Digital Elevation Model (DEM) was created from 15m LiDAR products and was used to derive a Probability of Depression, Slope, and Deviation from Mean Elevation layers to account for terrain. As well, historic image analysis was performed in Google Earth Engine to generate mean and standard deviation maps of NDVI and Normalized Difference Water Index (NDWI) from Sentinel 2 imagery (Table 2).

Land cover classes were chosen and organized hierarchically into nested levels to facilitate training data selection and modelling (Table 3). Training data were manually selected for each SPOT 6/7 scene for the following classes: Coniferous; Deciduous; Shrub; Lowland Graminoid; Lowland Woody; Open Water; Pasture; Cropland; Human Built; Natural Bare Ground. For this classification, 70% of the training data was used to train the classifier and the remaining 30% of the data was held back to validate the preliminary results.

Following the first stage of the classification, decision rules and manual editing were used to fix general classification errors. During this stage, the Natural Grassland class was added to the classification to account for areas of natural, non-woody low cover vegetation, and the Disturbed Vegetation class was added to account for non-agricultural human impacted low vegetation cover and areas with managed or manicured vegetation. The Alberta Base features Roads layer was used to add in a Roads class. The classifications were then mosaicked together and clipped to within 50 m of the shorelines of the waterbodies included in this study. Quality control and editing for the buffer area was then completed, and the final 13-class "Level 2" land cover classification was used to assess riparian intactness (Table 3).

Table 2. Description of the spatial data obtained or derived for use in the assessment of riparian intactness.

Data Layer	Year	Source	Usage
SPOT 6/7 Satellite Imagery	2020	Government of Alberta	Derivation of land cover classification
6 m LiDAR DEM	n/d	Government of Alberta	Derivation of data products for classification
Normalized Difference Vegetation Index (NDVI)	2020	Fiera Biological. Layer was created using SPOT 6/7 satellite data provided by the Government of Alberta	Derivation of land cover classification
Blue Normalized Difference Vegetation Index (BNDVI)	2020	Fiera Biological. Layer was created using SPOT 6/7 satellite data provided by the Government of Alberta	Derivation of land cover classification
Green Ratio Vegetation Index (GRVI)	2020	Fiera Biological. Layer was created using SPOT 6/7 satellite data provided by the Government of Alberta	Derivation of land cover classification
Iron Oxide Index (IOI)	2020	Fiera Biological. Layer was created using SPOT 6/7 satellite data provided by the Government of Alberta	Derivation of land cover classification
Probability of Depression	n/d	Fiera Biological. Layer was created using LiDAR DEM data provided by the Government of Alberta	Derivation of land cover classification
Deviation from Mean Elevation	n/d	Fiera Biological. Layer was created using LiDAR DEM data provided by the Government of Alberta	Derivation of land cover classification
Roads	2014	Alberta Base Features	Derivation of land cover classification
Mean and Standard Deviation of NDVI and NDWI	2013-2019	Fiera Biological. Layers created using Sentinel 2 imagery	Derivation of land cover classification
ABMI Human Footprint	2021	Alberta Biodiversity Monitoring Institute	Semi-automated clean-up of classification
6 m Land Cover	2020	Fiera Biological. Layer was created using SPOT 6/7 satellite data provided by the Government of Alberta and derived layers	Derivation of RMAs and quantification of intactness metrics

Table 3. Land cover classes that were used to derive the land cover classification for the riparian intactness assessment.

Level 1	Level 2	Description
Forest	Coniferous	Coniferous trees (needle-leaf) cover greater than 75% of treed area.
	Deciduous	Broadleaf trees covering greater than 75% of treed area.
	Shrub	Shrubs (<2 m tall) covering greater than 75% of area.
Natural Grassland	Natural Grassland	Naturally grassy areas with <1/3 shrub cover and <10% tree cover.
Open Water	Open Water	Any open water (lakes, permanent wetlands, standing water) and flowing water. Includes artificial waterbodies (e.g., dugouts and reservoirs).
Lowland	Lowland Graminoid	Low lying areas dominated by emergent or graminoid vegetation and depressional areas adjacent to streams/creeks and lakes, or areas dominated by graminoid vegetation where surface water flow is apparent.
	Lowland Woody	Depressional areas dominated by deciduous tree or shrub cover. Surface water flow may be apparent.
Natural Bare Ground	Natural Bare Ground	Naturally occurring bare soil, sand, sediment, banks, and beaches.
Agriculture	Pasture	Agricultural areas used primarily as pasture or hayland.
	Cropland	Agricultural areas used primarily as cereal crop. Tilled most years.
Disturbed Vegetation	Disturbed Vegetation	Non-agricultural human-impacted or managed non-woody vegetation.
Built Up/Exposed	Human Built	Human built features and human-caused exposed/bare areas.
	Roads	Paved and unpaved roads.

3.1.2. Land Cover Classification Accuracy Assessment

Accuracy of the land cover was assessed using traditional remote sensing techniques, which provide a measure of accuracy for each land cover class, as well as an overall accuracy for all classes combined. Accuracy of the land cover layer was assessed at Level 1 using a stratified validation dataset that was a combination of held back training data points (samples collected at the same time as training data was selected, but were not used to train the random forest model) and randomly selected points that were collected by a trained photo interpreter. A total of 360 samples were used to assess accuracy, with a minimum number of 10 samples validated for each class.

Overall accuracy at Level 1 for the classification was 96% with a Kappa statistic of 0.93 (Table 4). Class accuracies were high for all classes, with minor confusion between the Lowland (lowland graminoid) and Natural Grassland classes in areas where the boundary between lowland vegetation and upland vegetation is difficult to interpret and somewhat subjective. Some minor confusion also occurred between the Wetland (lowland woody) and Forest categories, which is expected given the difficulty discerning between these classes without confirmation from a field visit. Users of this buffer land cover classification should note that many riparian areas next to streams and rivers have been classified as the Lowland cover class (e.g., lowland graminoid, lowland woody) throughout many parts of the study area.

While the land cover and riparian assessment results for the three subwatersheds were not validated using field data, previous riparian assessments completed using this GIS method have been validated using aerial videography data (Fiera Biological 2018a), as well as high resolution imagery and data collected in the field (Fiera Biological 2019). In each case, the riparian assessment results were considered to be very robust when compared against the validation data. When compared to the aerial videography method, overall agreement between the GIS and videography scores was over 75% (Fiera Biological 2018a), and when compared to data collected in the field, the overall agreement between the GIS and field scores was 77% (Fiera Biological 2019). Disagreement between the GIS and field or videography scoring was often related to variability in the interpretation of somewhat “subjective” land cover classes, such as when deciding between natural grassland and pasture or disturbed vegetation.

Table 4. Accuracy assessment results for the Level 1 land cover classes.

	Agriculture	**Built Up / Exposed**	**Disturbed Vegetation**	**Forest**	**Lowland**	**Natural Bare Ground**	**Natural Grassland**	**Open Water**	**User Accuracy**
Agriculture	25	0	0	0	0	0	0	0	100%
Built Up / Exposed	0	10	0	0	0	0	0	0	100%
Disturbed Vegetation	0	0	10	0	0	0	0	0	100%
Forest	0	0	0	153	0	0	0	0	100%
Lowland	0	0	0	7	32	0	2	0	78%
Natural Bare Ground	0	0	0	0	0	10	0	0	100%
Natural Grassland	0	0	0	1	0	0	24	0	96%
Open Water	0	0	0	0	1	1	0	8	80%
Producer Accuracy	100%	100%	100%	95%	97%	91%	92%	100%	96%

NOTE: Producer accuracy measures errors of omission (exclusion) and assesses how well real-world land cover types have been classified. User accuracy measures errors of commission (inclusion), which represents the likelihood of a classified pixel matching the land cover type of its corresponding real-world location.

3.1.3. Editing Water Boundary Data

The provincial hydrography data for the waterbodies of interest were used to delineate the shorelines included in this assessment. Due to the dynamic nature of waterbodies and the vintage of the provincial dataset, the location of the hydrography feature does not always correspond well with shorelines in current satellite imagery. In order to ensure the generation of RMAs and quantification of the intactness metrics were accurate, the hydrography data was manually edited, where necessary, to ensure that the boundaries corresponded with the SPOT 6/7 imagery and the land cover classification.

For streams, the edited water boundary represents the approximate centreline of the watercourse. Where the width of a stream or creek was greater than 20 m for a distance of more than 50 m in the SPOT imagery, or the stream passed through an area of open water greater than 1.0 ha, the stream was split and edited to have a unique left and right bank. Lake and open water shorelines were edited to approximate the location of the boundary between the upland and riparian zone.

The edited water boundaries for assessed features have an approximate mean accuracy of +/- 5 m relative to their location in the SPOT imagery that was used to derive the land cover layer for this project.

Figure 3. Example of the spatial inaccuracies associated with stream boundaries, where the location of the stream center line does not match the actual location of the stream and exceeds the 5 m accuracy tolerance in the SPOT imagery. In this example, the yellow lines represent the location of the streamline from the provincial data and the blue line represents the manually edited location of the new stream center line.

3.1.4. Delineating Riparian Management Area Width and Length

In order to allow for comparisons between watersheds, the GIS methods that were developed to assess riparian areas in the Modeste watershed (Fiera Biological 2018a) were applied in this study. As per the GIS method, which was developed to closely match previously developed aerial videography methods (Teichreb and Walker 2008), riparian intactness was assessed within a "riparian management area" (RMA).

RMAs are areas along the shoreline of a waterbody that include the near-shore emergent vegetation zone, the riparian zone, and a riparian protective (buffer) zone (Figure 4). An RMA has two spatial components: width and length. For this assessment, riparian intactness was evaluated within RMAs that had a static 50 m wide buffer that was applied to the left and right banks of each watercourse. For lakes, a single 50 m wide buffer was applied to the shoreline. When assessing riparian condition using aerial videography, RMA length is determined by a change in the score of any single metric, and is thus variable. In order to replicate this approach, we chose to delineate the upstream and downstream extents of each RMA based upon major changes in the proportion of natural cover along the shoreline.

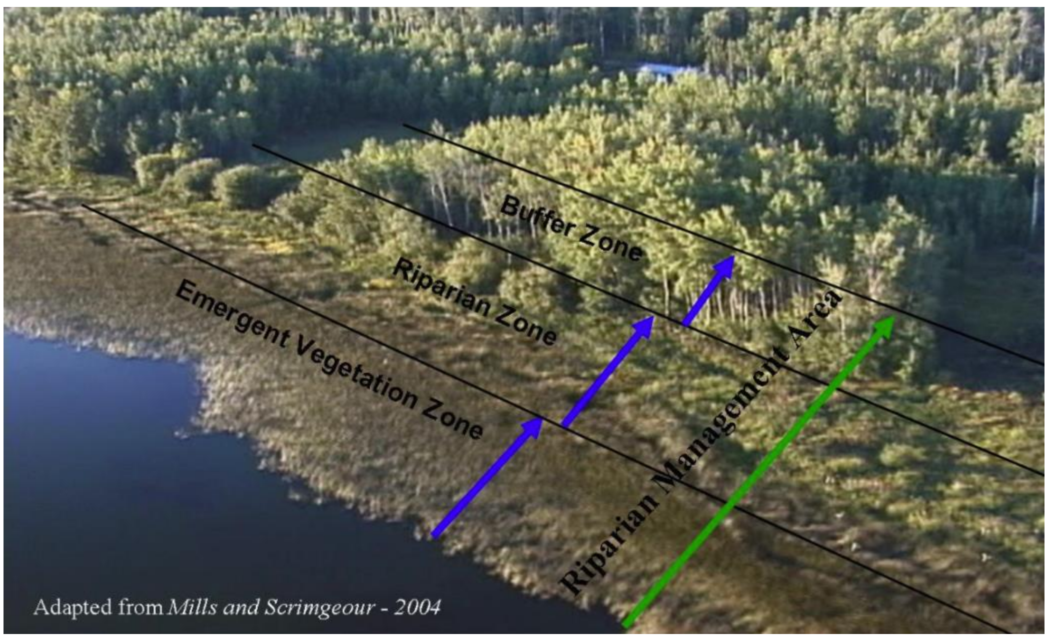


Figure 4. Schematic showing the different shoreline components included in a "riparian management area" (image taken from Teichreb and Walker 2008).

In order to determine the longitudinal extent of each RMA, the proportion of all natural cover types along the shoreline was evaluated, with the start and end points of each RMA corresponding with locations where there were major changes in the proportion of natural cover. To calculate the proportion of natural cover, all natural cover classes in the land cover (i.e., Lowland, Open Water, Natural Grassland, Natural Bare Ground, Forest) were selected and exported as a single layer. The stream layer was then divided into 10-meter segments on the left and right banks and the proportion of natural cover within a 25 m moving window was calculated for each segment. A threshold was used to identify locations along the shoreline within the moving window where there was greater than or less than 55% natural cover. All adjoining homogeneous segments of less than or more than 55% natural cover were then merged to became a single RMA. This threshold value was selected based upon an iterative threshold testing procedure to determine the percent of natural vegetative cover that best approximated the videography RMA boundaries (Fiera Biological 2018a). To reduce error associated with misclassification in the 6 m land cover, very small RMAs (≤10 m) were merged and dissolved with neighbouring segments.

3.1.5. Assigning Unique IDs to Edited Water Boundary Data

Many of the waterbodies in the provincial hydrography data are unnamed features with no unique identification code. Additionally, some names are duplicated several times for features across the province, which can result in confusion and also makes reporting results complicated. As part of this project, a naming schema for newly assessed waterbodies was developed and applied at the HUC 6-level to ensure each waterbody could be uniquely identified and summarized individually. Features were named using the following set of rules:

- **Named Streams** – Streams, creeks, or rivers with an existing name in the Alberta Base Features hydrography dataset or the FWMIS Hydro Arcs dataset retained their existing name. If a name was duplicated in a HUC 6 (e.g., two different streams both named Happy Stream), they were numbered sequentially from west to east (i.e., Happy Stream 1, Happy Stream 2).
- **Named Lakes** – Lakes with an existing name in the Alberta Base Features hydrography dataset or the FWMIS Hydro Arcs dataset retained their existing name. If a named was duplicated in a HUC 6 (e.g., two different lakes both named Pleasant Lake), they were numbered sequentially from west to east (i.e., Pleasant Lake 1, Pleasant Lake 2).
- **Unnamed Lakes and Reservoirs** – Lakes or reservoirs with no name in either of the provincial hydrography datasets were assigned a unique ID by combining “UL” or “UR” with the HUC 6 numeric ID code, along with a number starting at 01 and increasing sequentially moving north to south and west to east (e.g., for unnamed lakes assessed in the Frog HUC 6, the IDs are “UL-110302-01”, “UL-110302-02”, etc.).

3.1.6. Indicator Quantification and Riparian Intactness Scoring

Intactness with each riparian management area was quantified using the following metrics:

Metric 1: Percent cover of natural vegetation;
Metric 2: Percent cover of woody species;
Metric 3: Percent cover of all human impact and development (human footprint).

To quantify Metric 1, all natural cover classes were selected from the land cover layer and the proportion of the RMA covered by those cover classes was calculated. The natural classes used to quantify this metric included: Lowland (Lowland Woody and Lowland Graminoid), Forest (Coniferous, Deciduous, Shrub), and Natural Grassland.

To quantify Metric 2, the percent cover of Forest and Lowland Woody land cover classes was quantified for each RMA.

For Metric 3, the percent cover of the following land cover classes were used to calculate human footprint within each RMA: Cropland, Pasture, Disturbed Vegetation, and Built Up/Exposed (Human Built, Roads).

Once each metric was quantified, the values were range standardized and were aggregated using a weighting comparable to the aerial videography methods. The metrics were weighted as follows: Metric 1: 0.15; Metric 2: 0.25; Metric 3: 0.60. The weighted scores were aggregated to derive a final RMA score that ranged between 0 and 100, and these scores were converted into intactness categories using the following categorical breaks:

- High Intactness (≥75-100): Vegetation within the RMA is present with little or no human footprint.
- Moderate Intactness (≥50-75): Vegetation within the RMA is present with some human footprint.

- Low Intactness (≥25-50): Vegetation cover within the RMA is limited and human footprint is prevalent.
- Very Low Intactness (0-25): Vegetation cover within the RMA is mostly cleared and human footprint is the most dominant land cover.

3.2. Data Summaries

All municipal data summaries were generated using a spatial intersect rule in ArcGIS, where the results from each analysis (i.e., intactness, pressure, priority) were intersected with the municipal boundary layer. Summarizing the data in this way captures the assessed shorelines that fall within the municipal boundary; however, it should be noted that there are spatial discrepancies between the municipal boundary data and the provincial hydrography data that are freely available from AltaLIS.

For example, in many instances, municipal boundaries follow the boundary of a waterbody (e.g., the boundary between two Counties follows a creek or river) and often, the boundary topology of these two features do not match. In these instances, some minor edits may have been made to correct the intersection outputs and reassign results from one municipality to another, but in most cases, municipal boundary layers were not extensively edited to correct topological errors. As a result, the municipal summaries of shoreline length for intactness and priority are approximate and should be considered to be estimates that reflect relative differences between municipalities.

4.0 Results

4.1. Riparian Management Area Intactness

Riparian Intactness was calculated for approximately 1,400 km of shoreline in the Lower McLeod River watershed (Figure 5; Map 9and Map 10).

Overall, 87% (1,223 km) of the shoreline that was assessed was classified as High Intactness, with an additional 4% (62%) classified as Moderate Intactness. Approximately 8% of the shoreline was classified as either Low (3%, 43 km) or Very Low (5%, 73 km) Intactness.

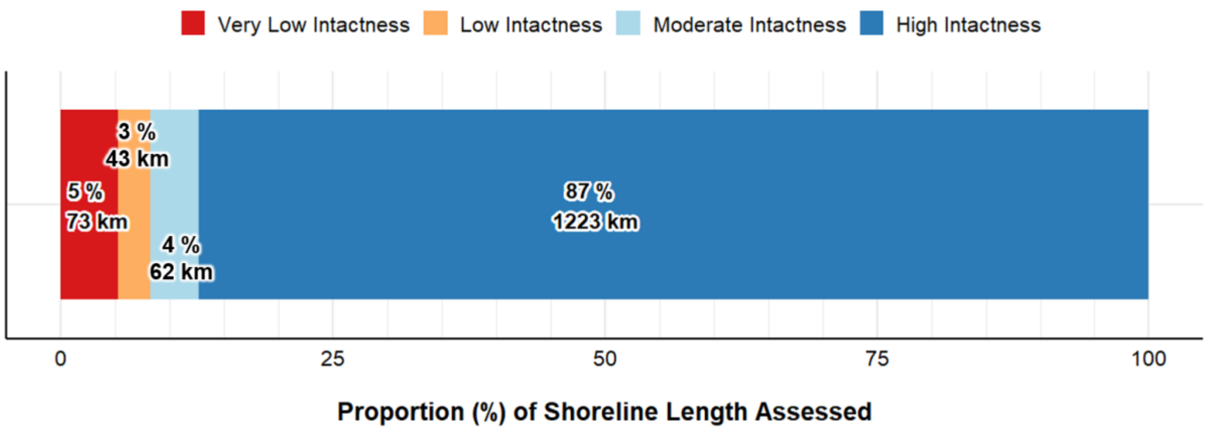
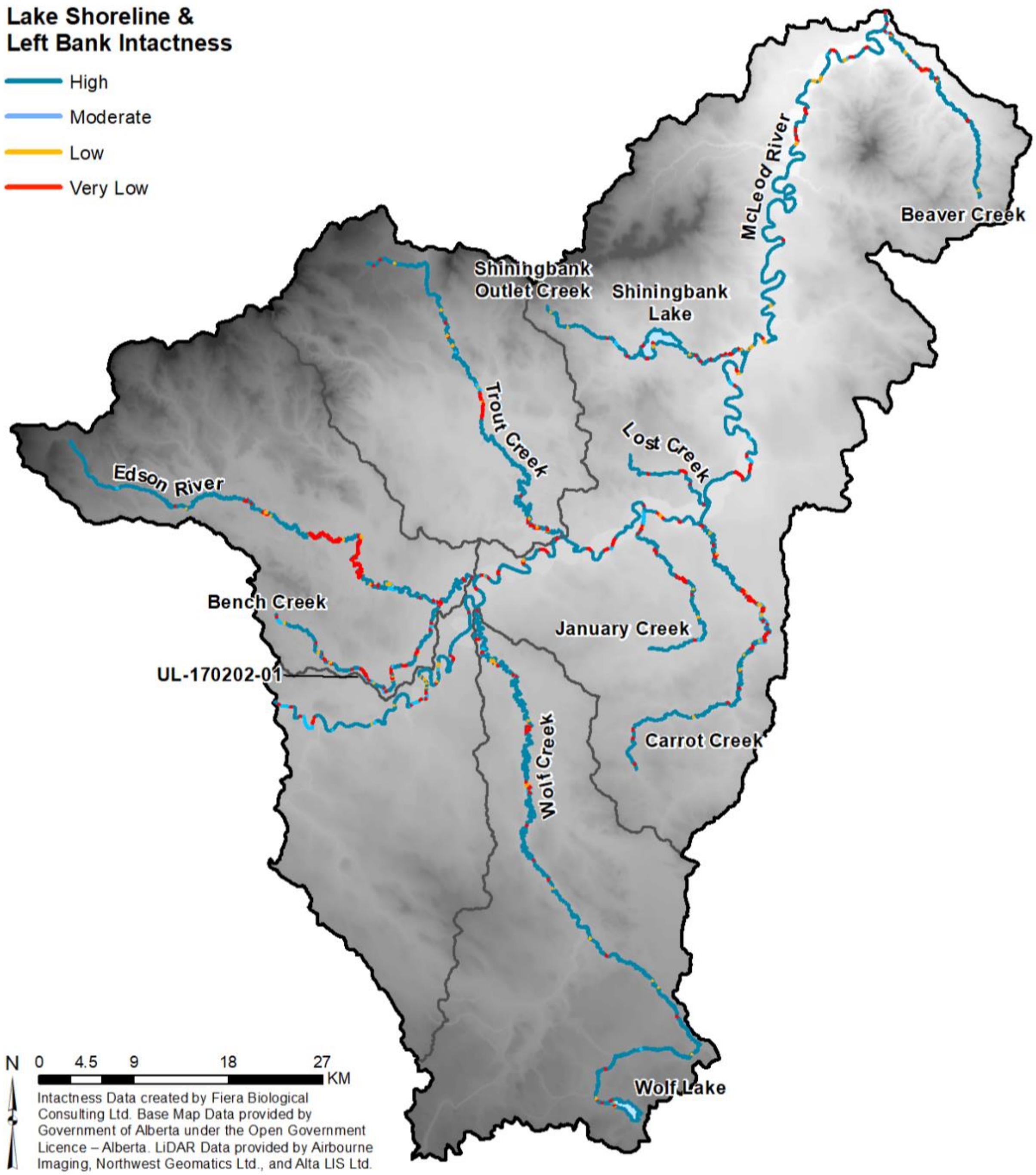
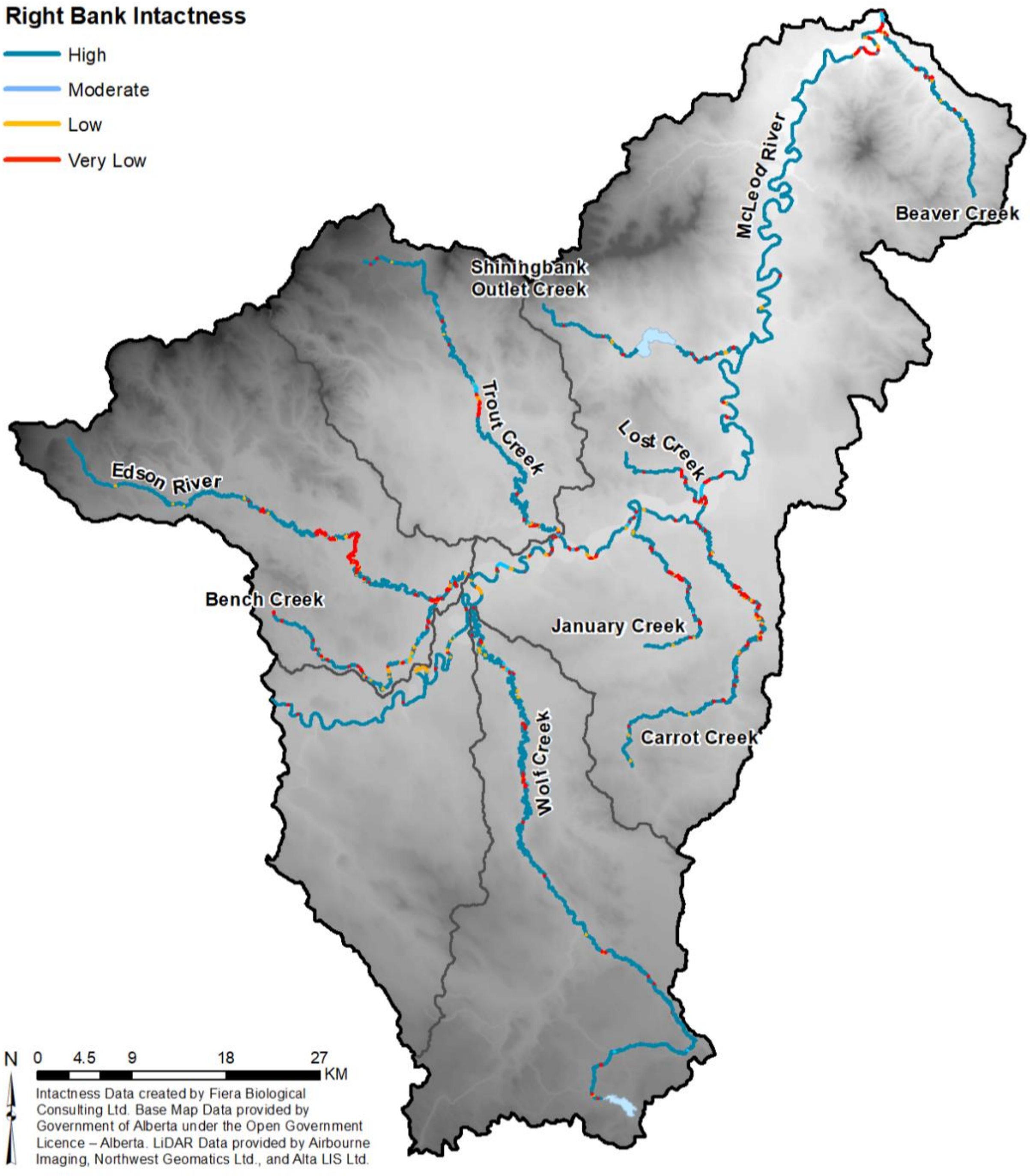


Figure 5. The total proportion and length of shoreline assigned to each riparian intactness category for waterbodies assessed in this study.



Map 9. Intactness for lakes and left banks of creeks and rivers that were included in this study.



Map 10. Intactness for the right bank of creeks and rivers that were included in this study.

Intactness was also summarized by HUC 8 watershed (Table 5; Figure 6). The Lower McLeod River watershed had the greatest length of shoreline assessed in the study (731 km), representing 52% of the shoreline that was assessed.

Overall, the Wolf Creek HUC 8 watershed had the greatest proportion (95%) of shoreline classified as High Intactness, while the Lower McLeod River watershed had the greatest length (642 km) of shoreline classified as High Intactness (Table 5; Figure 7).

The Edson River watershed had the greatest proportion of its shoreline assessed as Very Low (12%; 30.9 km) and Low Intactness (4%; 11.7 km) (Table 5; Figure 7).

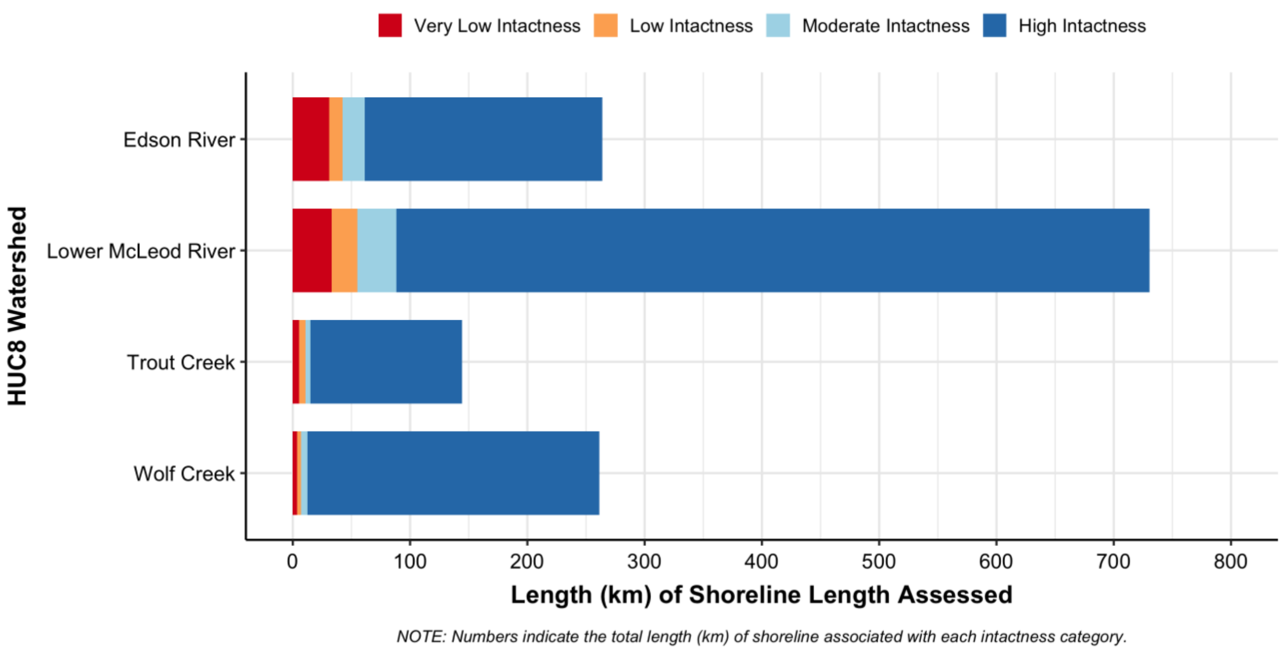


Figure 6. The total length of shoreline within the study area assigned to each riparian intactness category, summarized by HUC 8 watershed.

Table 5. Total length of shoreline assessed within each HUC 8 watershed, along with a summary of the length and proportion of shoreline assigned to each riparian intactness category.

HUC 8 Watershed Name	**Total Length Assessed (km)**	**Intactness**							
		Very Low		**Low**		**Moderate**		**High**	
		km	%	km	%	km	%	km	%
Edson River	263.8	30.9	12	11.7	4	18.6	7	202.6	77
Lower McLeod River	730.5	33.2	5	21.7	3	33.3	5	642.3	88
Trout Creek	144.3	5.2	4	5.5	4	4.4	3	129.1	89
Wolf Creek	261.4	3.5	1	3.6	1	5.4	2	248.9	95
Total	1,400.0	72.8	5	42.5	3	61.7	4	122.9	87

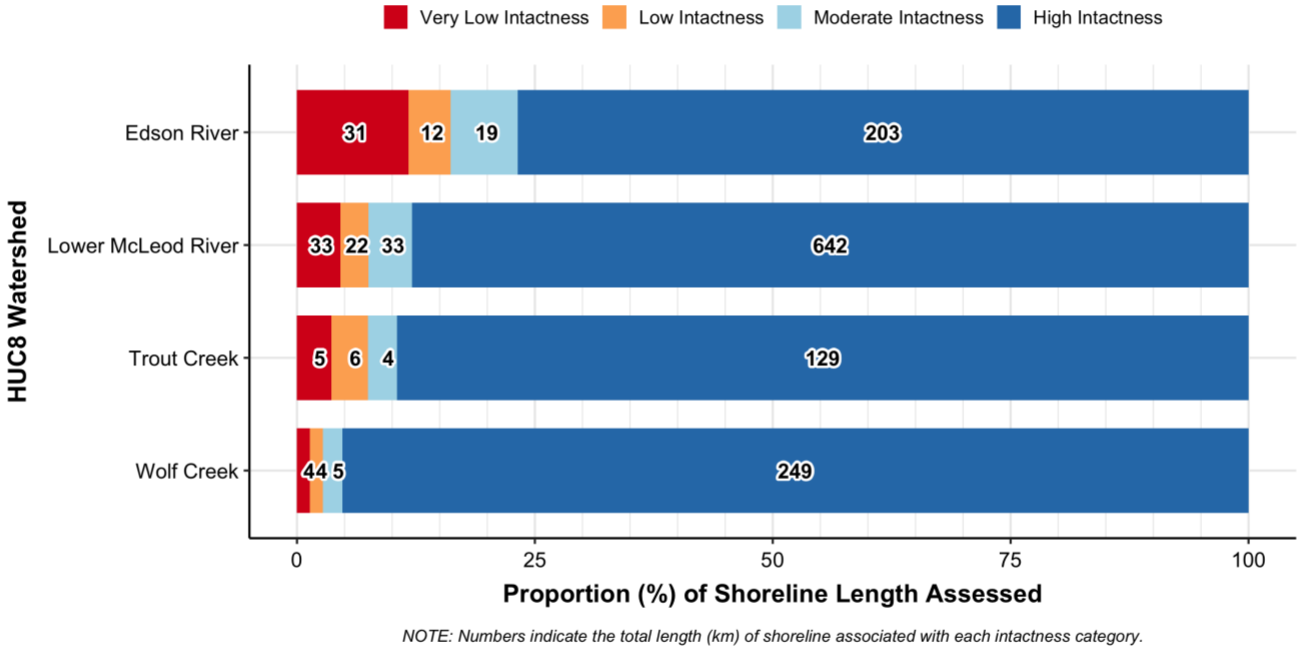


Figure 7. The total proportion of shoreline within the study area assigned to each riparian intactness category, summarized by HUC 8 watershed.

Seven out of the ten creeks and rivers in the watershed had more than 85% of their shorelines assessed as High Intactness (Figure 8). Wolf Creek had the greatest proportion of its shoreline assessed as Very High intactness (95%), while the McLeod River had the greatest length (325 km) of shoreline assessed as High Intactness. Conversely, the Edson River had the greatest proportion (13%) and length (25 km) of shoreline assessed as Very Low Intactness (Figure 8).

Of the three lakes that were assessed, Wolf Lake and Shiningbank Lake had the greatest proportion (95%) of their shorelines assessed as High Intactness (Figure 9). While the unnamed lake (UL-170202-01) had the greatest proportion (32%) of shoreline assessed as Very Low Intactness, this represented less that 1 km of shoreline. Overall, the lakes that were assessed as part of this study had a very high proportion (and length) of their shorelines assessed as either High or Moderate Intactness.

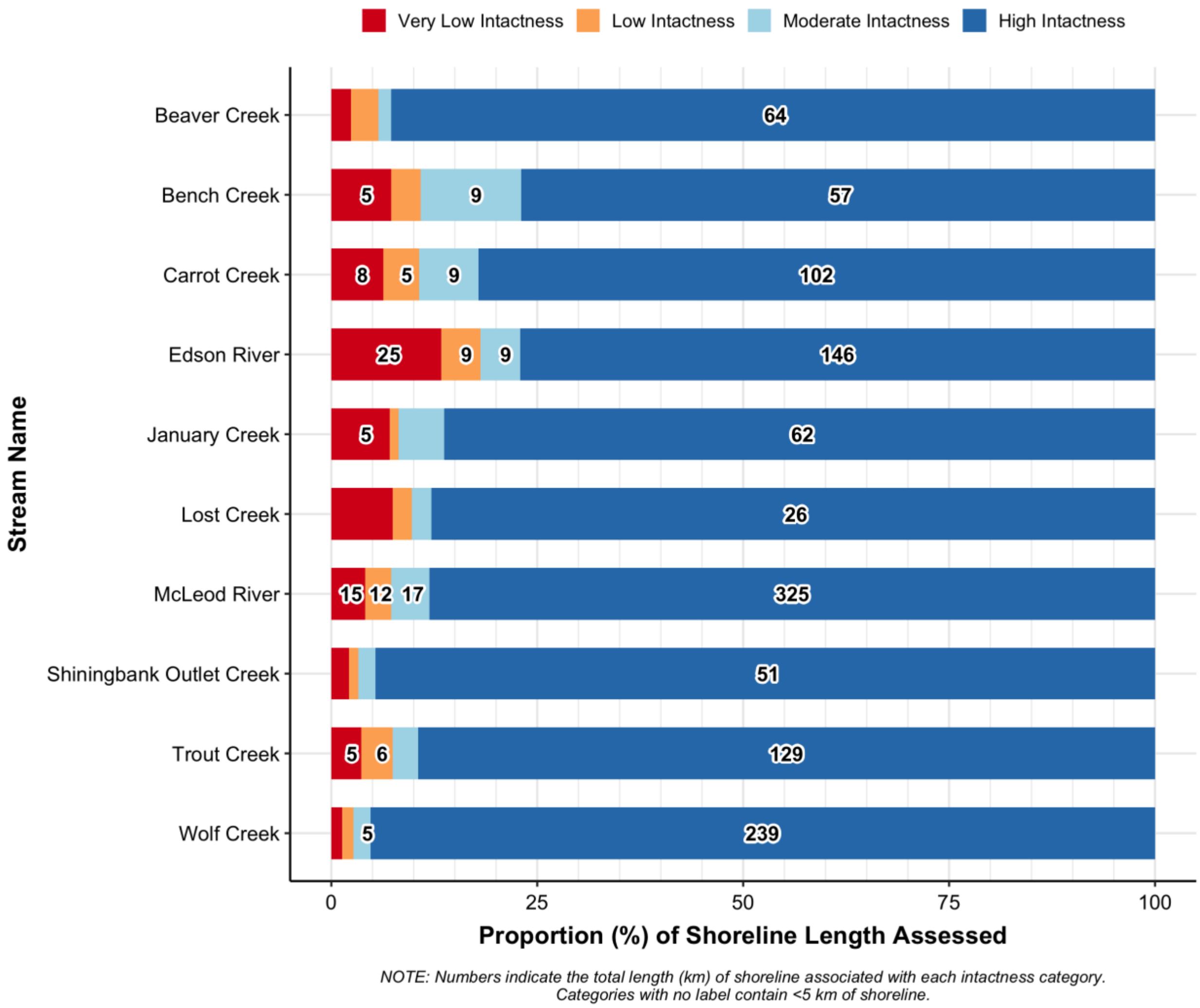


Figure 8. The total proportion of shoreline assigned to each riparian intactness category for rivers and creeks assessed in the Lower McLeod River watershed.

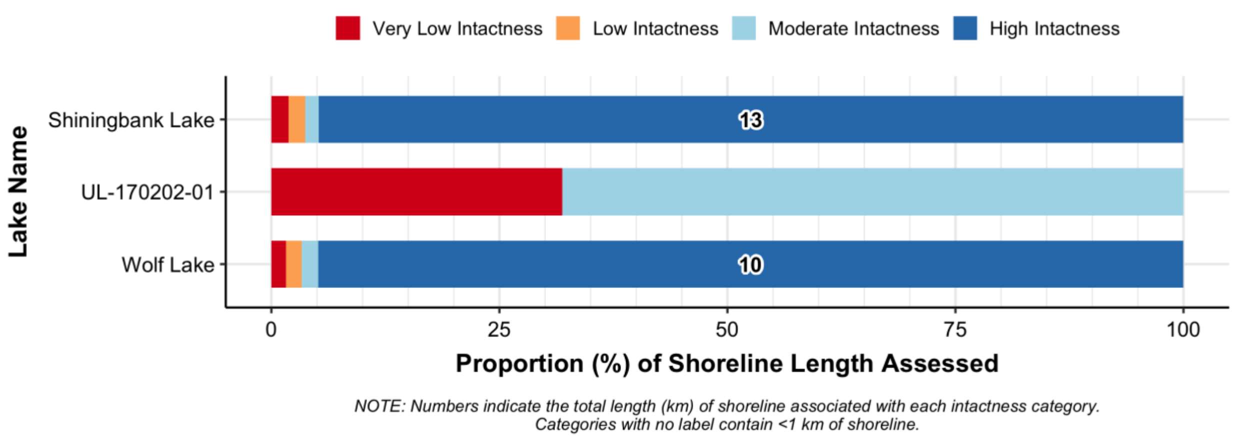


Figure 9. The total proportion of shoreline assigned to each riparian intactness category for lakes assessed in the Lower McLeod River watershed.

5.0 Jurisdictional Summary

In order to provide riparian assessment information that is relevant from a municipal planning and policy perspective, this section summarizes riparian intactness for municipal jurisdictions that intersect the Lower McLeod River watersheds. This includes the rural municipalities of Woodlands County and Yellowhead County, and the towns of Edson and Whitecourt (Map 7).

The total length of shoreline assessed as part of this study varied considerably by municipality (Figure 10). Roughly 1,200 km of shoreline was assessed in Yellowhead County, with an additional ~160 km assessed in Woodlands County. Less than 30 km was assessed in the towns of Edson and Whitecourt.

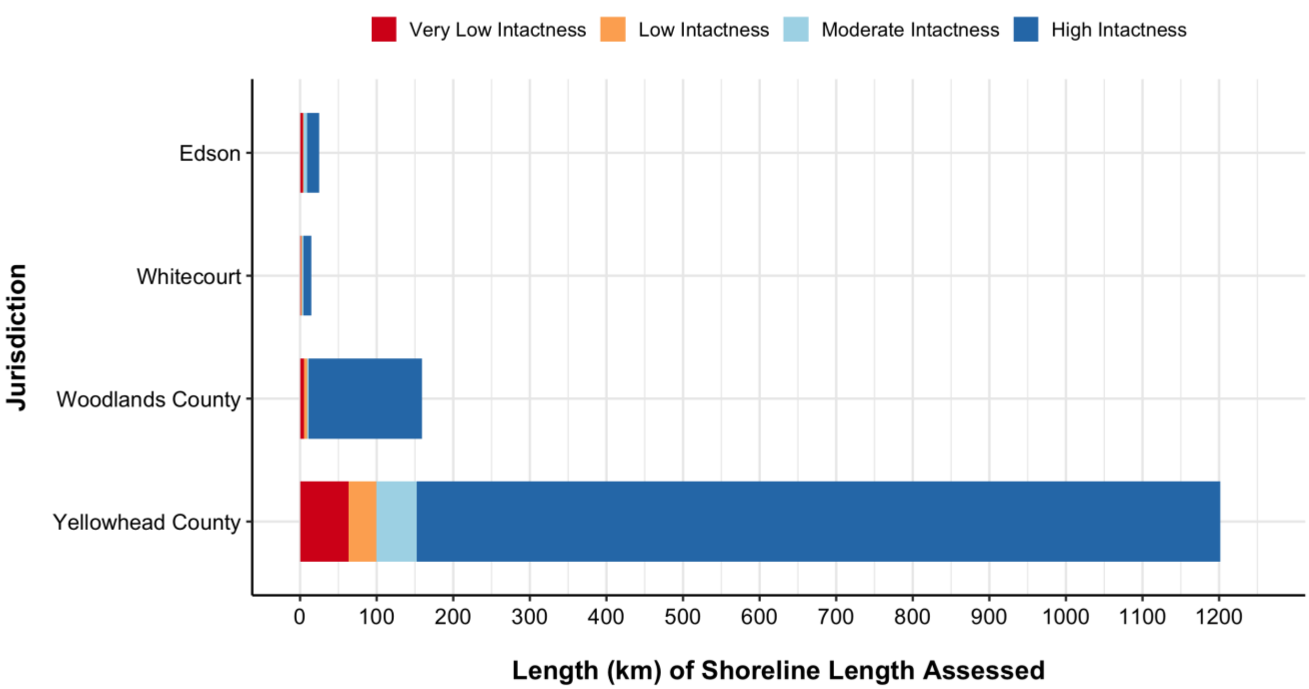


Figure 10. The total length of shoreline assessed by municipality.

When the proportion of shoreline length assigned to each intactness category is considered, more than 80% of the shoreline in each municipality was classified as either Moderate or High Intactness; however, Edson and Whitecourt had a lower proportion of shoreline classified as High Intactness compared to Woodlands and Yellowhead County (Figure 11, Map 11 and Map 12).

Woodlands County had the highest proportion of shoreline classified as High Intactness (92%), while Yellowhead County had the greatest length (1,049 km) of shoreline assessed as High Intactness.

Conversely, Edson had the greatest proportion (17%) of its shorelines classified as either Low or Very Low Intactness. Yellowhead County had the greatest length (100 km) of shoreline assessed as either Low (37 km) or Very Low (63 km) Intactness.

A summary of shoreline intactness, summarized by waterbody and municipality, is provided in Table 6.

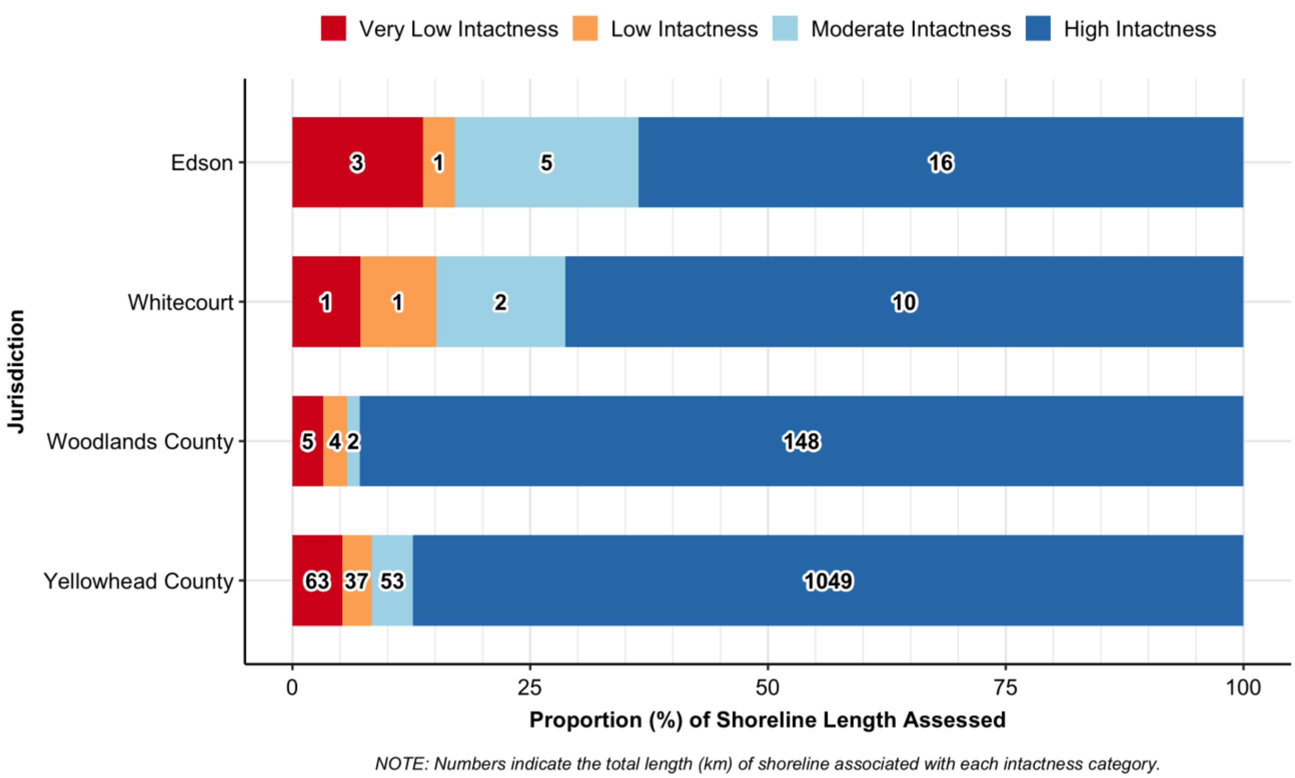
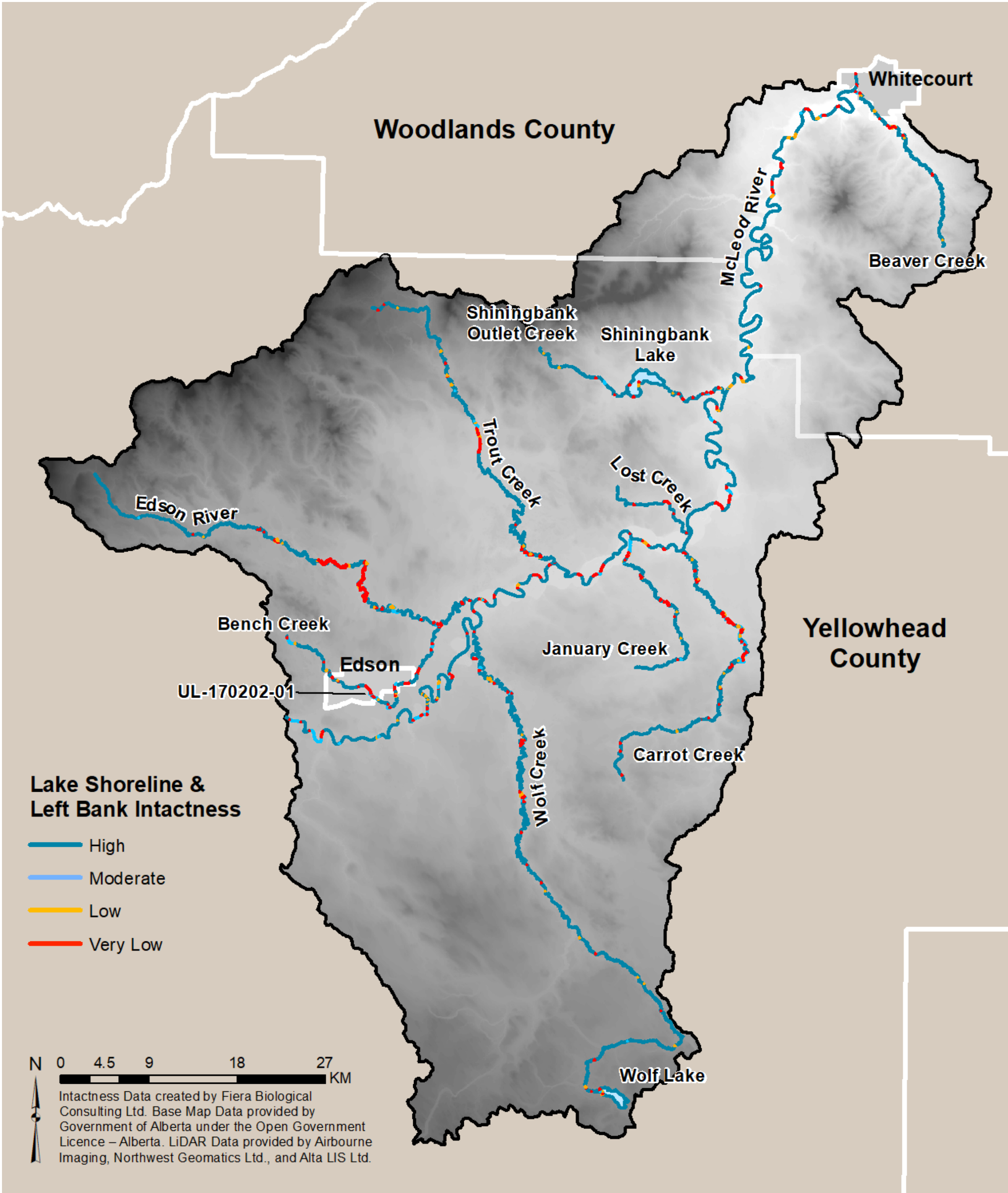


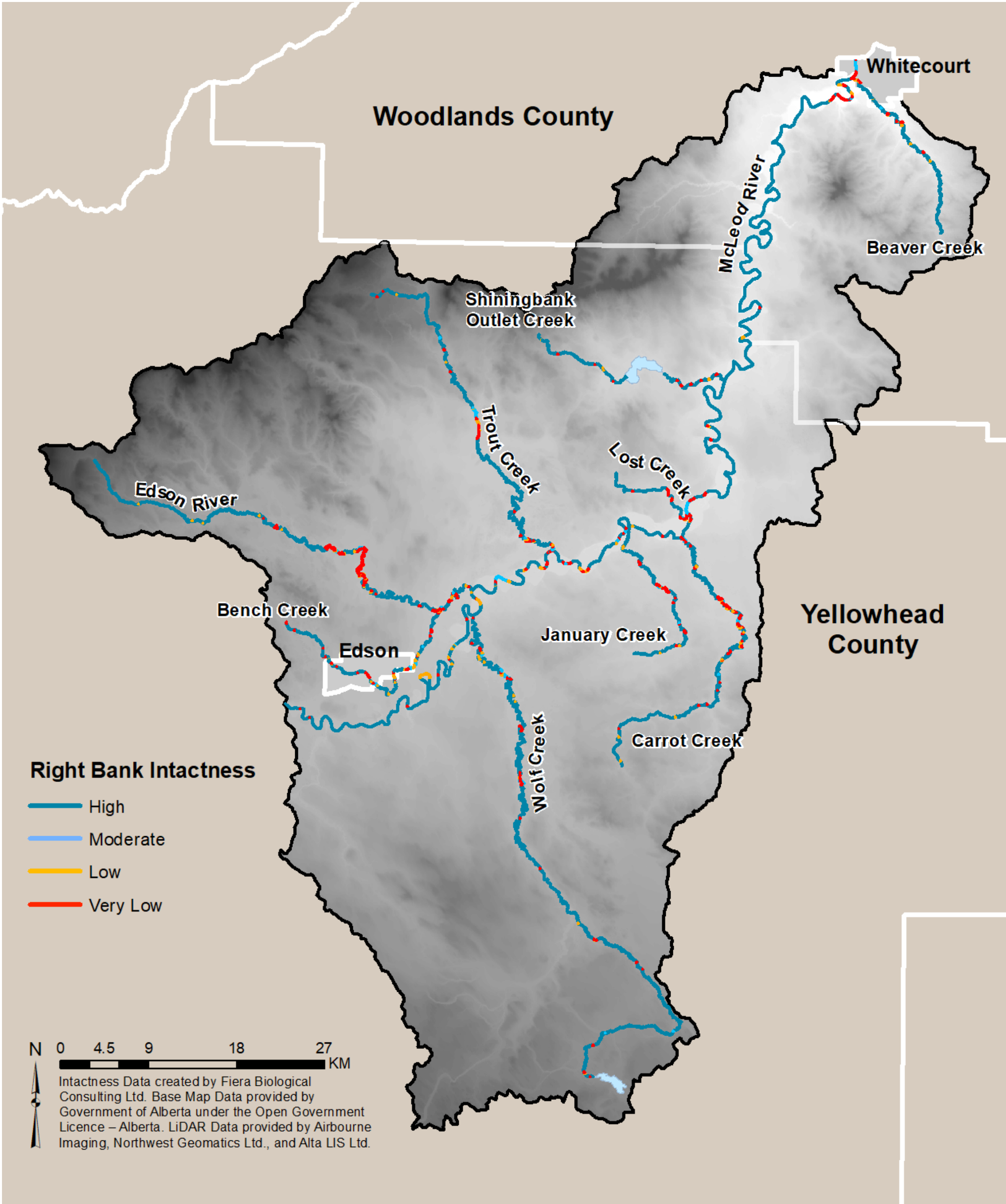
Figure 11. The proportion of shoreline length assigned to each riparian intactness category, summarized by municipality. Numbers indicate the approximate length (km) of shoreline associated with each intactness category.

Table 6. Shoreline intactness for each waterbody included in this assessment, summarized by municipality.

Municipality & Waterbody Name	Total Length Assessed (km)	Length of Shoreline (km) by Intactness Category			
		Very Low	Low	Moderate	High
Edson	**25.3**	**3.5**	**0.9**	**4.9**	**16.1**
Bench Creek	24.5	3.2	0.9	4.4	16.1
UL-170202-01	0.7	0.2	0.0	0.5	0.0
Whitecourt	**14.4**	**1.0**	**1.2**	**2.0**	**10.3**
Beaver Creek	0.7	0.2	0.0	0.5	0.0
McLeod River	3.4	0.8	0.1	1.4	1.2
Woodlands County	**159.1**	**5.2**	**4.0**	**2.2**	**147.8**
Beaver Creek	57.5	1.4	1.2	0.5	54.4
McLeod River	101.6	3.8	2.8	1.7	93.3
Yellowhead County	**1,201.3**	**63.2**	**36.6**	**52.7**	**1,048.8**
Bench Creek	49.3	2.1	1.8	4.6	40.8
Carrot Creek	124.3	7.8	5.4	8.9	102.1
Edson River	189.2	25.3	9.0	9.1	145.8
January Creek	71.7	5.1	0.8	4.0	61.8
Lost Creek	30.0	2.2	0.7	0.7	26.4
McLeod River	264.0	10.5	8.9	14.2	230.4
Shiningbank Lake	13.3	0.3	0.2	0.2	12.6
Shiningbank Outlet Creek	53.8	1.1	0.6	1.1	50.9
Trout Creek	144.3	5.2	5.5	4.4	129.1
Wolf Creek	250.9	3.3	3.4	5.2	238.9
Wolf Lake	10.6	0.2	0.2	0.2	10.0



Map 11. Intactness for lakes and left banks of creeks and rivers that were included in this study, by municipality.



Map 12. Intactness for the right bank of creeks and rivers that were included in this study, by municipality.

6.0 Riparian Land Management

Riparian intactness assessments are a screening-tool that can help to support a dialogue about riparian management and stewardship options. These assessments fill an essential data gap in watershed management by providing information about the intactness of riparian areas that can be used by a wide range of stakeholders, from Watershed Planning and Advisory Councils (WPACs) and stewardship groups, to municipalities and local landowners:

- **WPACs and local stewardship groups***:* Riparian intactness data can be used by a wide range of watershed groups to inform integrated watershed management planning, identify priority areas for potential restoration and/or conservation, and to understand the potential for riparian areas to contribute to key watershed outcomes (e.g., flood and drought resiliency, water quality). In particular, the data can be used to understand existing (baseline) conditions, which then allows for the identification of restoration or management targets, and the measurement of progress towards those targets. An example of how intactness data can be used by watershed groups to create a Riparian Habitat Management Framework is provided in Section 6.1.

- **Municipalities***:* Municipalities may use intactness data to set conservation or restoration targets, as well as to prioritize or guide programming decisions related to planning, conservation, restoration, and education. Section 7.0 outlines some of the existing tools for riparian management that may support this type of work. Areas with High or Moderate Intactness may be suitable for discussions regarding conservation options, whereas areas with Low or Very Low Intactness may be suitable areas to target for restoration and/or outreach.

- **Landowners***:* Local landowners may use intactness information to understand conditions on their land, which may lead them to explore the various riparian habitat management opportunities that may be available to them. For example, based on the intactness results, landowners may choose to request a site-specific assessment from an organization such as Cows and Fish. These site-specific assessments provide detailed information about the condition of riparian areas, and also provide information to landowners about best management practices and other management options for maintaining or improving the condition of riparian habitat on their land.

The collection and generation of scientific information is foundational to any conservation planning exercise because it is the basis for the development and implementation of an evidence-based adaptive management framework. Through the commissioning of this study, AWC and its stakeholders have objective information that they can use to build a framework for riparian habitat management.

6.1. Creating a Riparian Habitat Management Framework

In order to maintain or improve riparian habitat condition, a baseline of current condition is required. This baseline then becomes the benchmark against which achievable outcomes and measurable targets can be developed, and relevant collective action by key stakeholders can be identified. These actions can then be monitored on a regular basis to provide an evaluation of outcomes that feed into an adaptive and reflexive approach to riparian land management through time.

Central to the goal of improving riparian habitat outcomes is the development of a framework with specific objectives for riparian management and conservation. Objectives may address different types of goals, such as environmental (e.g., targets for amount of intact riparian area), social (e.g., increase in awareness), and/or programmatic (e.g., development of municipal policy or application of BMPs). Each defined objective should have associated measures, targets, and actions that are developed to ensure that the associated objective is achievable, and success towards achieving each objective can be measured. A definition for each of the key building blocks for the development of a riparian management framework is provided below:

Objective:	High-level statements of desired future conditions (outcomes).
Measure:	Specific metrics that can be quantified to assess the progress towards, and the degree to which, desired future conditions have been achieved.
Target:	Values of measurable items (metrics) that indicate the attainment of a desired condition. In the current context these may be expressed as a single value or as a range to acknowledge the inherent variability of ecosystems.
Action:	Management actions, plans, or policies for achieving stated objectives.

While the development of a riparian management framework and associated objectives should be undertaken collectively by stakeholders, we provide a number of key recommendations below that may be considered in the development of a riparian management plan.

6.1.1. Key Recommendations

The development of management objectives must consider ecological, social, and economic factors, and should acknowledge that maintaining functional and resilient ecological and hydrological systems is fundamental to maintaining healthy and vibrant human communities. Below we outline what we consider to be important riparian management objectives for the Lower McLeod River watershed, and offer considerations and suggestions for the selection of measures and targets for each objective. We also offer a list of high-level actions for each objective. Note that this list of management objectives is not exhaustive, and there may be other important riparian habitat management objectives identified by stakeholders.

Objective 1:

- Maintain or improve watershed resilience by conserving high quality riparian habitat.

Measure:

- Proportion (%) of shoreline assessed as Moderate and/or High Intactness.

This objective can include a measure of conservation at multiple and nested spatial extents. For example, a target for conservation of high quality riparian habitat can be developed for the Lower McLeod River watershed as a whole, and/or can also include measures and targets for riparian habitat conservation for individual HUC 8 watersheds, municipalities and/or individual waterbody. Measures for riparian habitat conservation may also be specific to the type (order) and the location (e.g., headwaters) of the stream. For example, riparian vegetation provides proportionately greater benefits to instream habitat along the headwaters of streams specifically as it relates to the regulation of temperature, flow, and sediment regimes (Wipfli and Musslewhite 2004; Anonymous 2007). Because of this, there may be a desire to preferentially target riparian habitat along headwater streams for conservation. Alternatively, retention of riparian habitats along higher order streams could be prioritized in areas where habitat connectivity and biodiversity conservation is a priority.

Targets:

There is no universally accepted scientific target for the total amount of riparian habitat that should be maintained within a watershed; however, there is scientific consensus that the higher the quality and the greater the amount of riparian habitat that is maintained on the landscape, the better the outcomes for biodiversity, water quality, and water quantity. Further, there is no universal consensus on the width of vegetation along streams that should be maintained; however, there is general scientific agreement that factors such as the size (order) of the stream, the steepness of the banks, and the specific management concerns of the local system (e.g., soils, type of adjacent land use and land cover) should all be factors considered when determining the amount (width) of vegetation retained adjacent to a stream. For example, Environment and Climate Change Canada suggests as a riparian management guideline that 75% of a stream's length should be naturally vegetated, and that both sides of a stream should have a minimum 30-meter-wide naturally vegetated zone, while also acknowledging that wider buffers may be appropriate in some circumstances (Government of Alberta 2012; Environment Canada 2014).

Results from this study provide a baseline that can be used to inform the selection of targets for this objective, as well as to measure improvement and progress towards achieving targets (Table 7). Individual targets for the desired amount of shoreline classified as High Intactness could be specified at the HUC 8 watershed scale, or as an alternative, overall targets could be set for each municipality. In this case, the Edson River HUC 8, as well as the towns of Edson and Whitecourt, are good candidates for riparain restoration programs or activities, given that these areas have a lower proportion of shoreline classified as Moderate or High Intactness.

Finer scale spatial targets can also be set for individual watercourses. For example, riparian habitat along creeks in the headwaters of each HUC 8 watershed could be prioritized for conservation, or as an alternative, riparian areas along creeks with important ecological values, such as threatened or sensitive fish populations, could be prioritized for conservation.

Table 7. Proportion and length of riparian areas that have been classified in each of the riparian intactness categories, summarized by various spatial extents. Grey columns are the sum total of the Very Low + Low and the Moderate + High categories.

Spatial Extent	Length Assessed (km)	Proportion and Length of Shoreline within Intactness Category*					
		Very Low	Low	Very Low + Low	Moderate	High	Moderate + High
Lower McLeod River HUC 6 Watershed	1,400	5% (73 km)	3% (43 km)	8% (116 km)	4% (62 km)	87% (1,223 km)	91% (1,285 km)
Edson River HUC 8 Watershed	264	12% (31 km)	4% (12 km)	16% (43 km)	7% (19 km)	77% (203 km)	84% (222 km)
Lower McLeod River HUC 8 Watershed	730	5% (33 km)	3% (22 km)	8% (55 km)	5% (33 km)	88% (642 km)	93% (675 km)
Trout Creek HUC 8 Watershed	144	4% (5 km)	4% (6 km)	8% (11 km)	3% (4 km)	89% (129 km)	92% (133 km)
Wolf Creek HUC 8 Watershed	261	1% (4 km)	1% (4 km)	2% (8 km)	2% (5 km)	95% (249 km)	97% (254 km)
Edson	25	14% (3 km)	3% (1 km)	17% (4 km)	19% (5 km)	63% (16 km)	82% (21 km)
Whitecourt	14	7% (1 km)	8% (1 km)	15% (2 km)	14% (2 km)	71% (10 km)	85% (12 km)
Woodlands County	159	3% (5 km)	3% (4 km)	6% (9 km)	1% (2 km)	93% (148 km)	94% (150 km)
Yellowhead County	1,201	5% (63 km)	3% (37 km)	8% (100 km)	4% (53 km)	87% (1, 049 km)	91% (1,102 km)

Actions:

There are a number of actions that could be taken to achieve conservation objectives, including (but not limited to):

- Incentivize voluntary conservation of riparian habitat on private land through payment for ecosystem services, changes to tax regimes, or other BMP programs.
- Develop education and outreach programs to encourage stewardship and conservation of riparian habitats on private land.
- Secure high conservation priority riparian habitats through purchase or through other land securement mechanisms available to conservation groups, land trusts, or municipalities.
- Develop provincial and/or municipal development setback and riparian land management policies.
- Create a municipal habitat conservation and restoration fund to allow for the securement of high priority riparian conservation areas.

Objective 2:

- Reduce flood risk by restoring riparian habitats that have been impacted or impaired.

Measure:

- Proportion (%) of shoreline assessed as Very Low and/or Low Intactness.

Similar to Objective 1, this measure can include multiple and nested spatial extents, and can also include finer scale spatial targeting of particular regions or high-priority waterbodies.

Targets:

Riparian habitats stabilize the banks of waterbodies and help modulate water velocities and high water events, thereby protecting surrounding lands from flooding (Orewole et al. 2015; Olokeogun et al. 2020). Consequently, limiting the amount and extent of riparian habitat that has been severely impacted and restoring these areas should be an important goal for riparian habitat management, particularly in areas that are prone to flooding.

At present, 5% (73 km) of the shoreline assessed in the Lower McLeod watershed has been classified as Very Low Intactness (Table 7). A target for this objective could include specifying a desire to reduce to zero the length of shoreline that has been classified as Very Low Intactness at the watershed, sub-watershed, and/or municipal scale. Alternatively, individual targets could be specified at a range of landscape scales.

As with Objective 1, finer scale targets can also be set for individual lakes or streams under this objective. For example, waterbodies with >10% of their shoreline classified as Low and Very Low Intactness could be targeted, and in this case, the focus would be on five of the waterbodies assessed in this study: Bench Creek, Carrot Creek, Edson River, Lost Creek, and UL-1702020-01 (Table A-1).

Actions:

There are a number of actions that could be taken to achieve the targets specified under Objective 2, including (but not limited to):

- Incentivize riparian habitat restoration on private land through payment for ecosystem services, changes to tax regimes, or other BMP programs.
- Develop education and outreach programs to encourage private land restoration, particularly for landowners located upstream of flood prone areas.
- Partner with conservation organizations to promote and encourage restoration on private lands.
- Create a municipal habitat conservation and restoration fund to pay for riparian habitat restoration on public lands, with a specific focus on restoring areas identified as Very Low or Low Intactness.

7.0 Existing Tools for Riparian Habitat Management

Riparian land management in Alberta falls under the jurisdiction of the federal, provincial, and municipal governments. While Alberta does not have legislation or policy that explicitly manages riparian lands, there are a number of laws, regulations, standards, policies, and voluntary programs that can be used to direct the management of riparian lands, or land that directly adjoins riparian lands.

The following sections highlights the key legislation, policies, and programs that are currently in place for riparian land management in the province of Alberta. Note that this is not intended to be an exhaustive list; rather, it is intended to highlight legislation, policy, and programs that are considered to be the most relevant and commonly employed to achieve riparian land conservation in the province.

7.1. Guidelines, Policies, and Legislation

Federal jurisdiction over riparian areas in Alberta is somewhat limited in scope. Exceptions to this include the authority to manage natural habitats and associated wildlife on federal land (e.g., First Nation Reserves, National Parks), as well as the authority to regulate migratory birds, fish and fish habitat, navigable waters, and species at risk. A summary of relevant federal laws and regulations that may apply to riparian management are listed in Table 8.

At the provincial level, there a number of statutory laws, regulations, and standards that directly or indirectly relate to the management of riparian habitat on both private and public land. The responsibility for managing riparian land falls to a number of provincial ministries and departments, and the mechanisms through which riparian lands are managed varies with respect to whether these habitats are located on private land (White Zone) or public land (Green Zone). In addition, the nature of the disposition and the activities associated with the land use(s) (e.g., forestry, oil and gas, agriculture, or urban development) influences how riparian lands are managed on both private and public land.

In instances of overlapping land use or activities (e.g., forest harvest operating together with oil and gas exploration), the manner in which riparian lands are managed is directed by the laws, regulations, and standards that are specific to that particular land use or activity. In these situations, coordination between the various government ministries responsible for enacting those laws, regulations, or standards is an important aspect of successful riparian management outcomes. Regardless of where the riparian land is located, or what the land use and associated activities may be, the provincial government has jurisdiction over the management of all water in the province under the *Water Act*, as well as all lands that are defined as “public” (regulated under the *Public Lands Act*), which includes the bed and shore of all permanent waterbodies, regardless of whether these waterbodies are located on private land.

In addition to provincial laws and regulations, the Government of Alberta has a wide range of policies, standards, or guidelines that provide direction for the management of natural areas, wildlife, and wildlife habitat. The majority of these policies are voluntary and require the application of best management practices to achieve the desired management goals. One exception to this is the provincial wetland policy. Wetlands are regulated as waterbodies under the *Water Act*, and as such, an approval is required to undertake any works that may impact a wetland. Thus, the principles and goals of the wetland policy and the associated wetland compensation guide are enforced through the *Water Act* application process.

A list and description of provincial laws, regulations, and policies that may apply to the management of riparian areas is provided in Table 9.

Table 8. List and description of Federal laws and regulations that may apply to the management of riparian areas in the Lower McLeod River watershed.

Federal Law or Regulation	Application to the Management of Riparian Areas
Migratory Bird Convention Act	This legislation is based on international treaty signed by Canada and the United States of America that aims to protect migratory birds from indiscriminate harvesting and destruction on all lands within Canada. Under this Act, efforts should be made to provide for and protect habitat necessary for the conservation of migratory birds, and to conserve habitats that are essential to migratory bird populations, such as nesting, wintering grounds, and migratory corridors.
Fisheries Act	Includes provisions for the protection of fish and fish habitat, and requires an authorization for activities that cause serious harm to fish.
Species At Risk Act	The Federal government has jurisdiction over all SARA-listed species on federally owned lands, including national parks, Department of National Defence lands, and First Nations Reserve lands. Management of SARA-listed species on provincial crown land, or on lands held by private citizens of Alberta, falls under the jurisdiction of the provincial government. In these cases, the provincial government is obligated to protect listed species to the same standards set forth by the Federal government. In cases where provincial governments do not meet these standards, the Federal Minister may issue an order in council to protect federally listed species that occur on provincial or private lands

Table 9. List and description of Provincial laws, regulations, and policies that may apply to the management of riparian areas in the Lower McLeod River watershed.

Legislation, Regulation, or Policies	**Application to the Management of Riparian Areas**
Agricultural Operation Practices Act	Regulates and enforces confined livestock feeding operations planning for siting, manure handling/storage, and environment standards.
Alberta Land Stewardship Act	Creates authority of regional plans and enables the development of conservation and stewardship tools that can be used to acquire and manage natural areas. These tools include conservation easements, conservation directives, conservation offsets, and transfer of development credits.
Alberta Wetland Policy & Wetland Mitigation Directive	Pursuant to the *Water Act*, the provincial wetland policy prohibits the unauthorized drainage or disturbance of wetlands. The stated goal of the policy is to "conserve, restore, protect, and manage Alberta's wetlands to sustain the benefits they provide to the environment, society, and economy". If wetland loss or impacts are authorized by the province under the *Water Act*, the permittee is responsible for the replacement of lost wetland habitat at the ratio stipulated by the province. While this policy does not explicitly manage riparian land, there is opportunity within the stated goals and intent of this policy to extend the policy to include riparian lands.
Environmental Protection and Enhancement Act (EPEA)	This legislation aims to protect air, land and water by regulating the process for environmental assessments, approvals, and registrations. In particular, stormwater drainage that is directed to any surface waterbody requires an EPEA approval. Further, the Environmental Code of Practice for Pesticides provides a standard for operating practices that restrict the deposition of pesticides into or onto any open waterbody.
Municipal Government Act (MGA)	Updated in June 2018, the modernized MGA provides municipalities with the authority to adopt statutory plans and bylaws that direct land use and development at subdivision. The MGA also grants limited rights to designate reserves at subdivision that can be used to conserve natural areas, and gives municipalities authority to regulate water on municipal lands, manage private land to control non-point source pollution, and adopt land use practices that are compatible with the protection of the aquatic environment, including development setbacks on waterbodies
Municipal Land Use Policies	Pursuant to Section 622 of the MGA, these Policies were established by Municipal Affairs to supplement planning provisions in the MGA and the Subdivision and Development Regulation, and to create a conformity of standard with respect to planning in Alberta. Section 5 of the Land Use Policies encourages municipalities to identify significant waterbodies and watercourses in their jurisdiction, and to minimize habitat loss and other negative impacts of development through appropriate land use planning and practices. In addition, Section 6 encourages municipalities to incorporate measures into planning and land use practice that minimizes negative impacts on water resources, including surface and groundwater quality & quantity, water flow, soil erosion, sensitive fisheries habitat, and other aquatic resources.

Continued …

Table 9 *continued …* List and description of Provincial laws, regulations, and policies that may apply to the management of riparian areas in the Lower McLeod River watershed.

Legislation, Regulation, or Policies	**Application to the Management of Natural Areas**
Public Lands Act	Regulates and enforces activities that affect the Crown-owned bed and shore of waterbodies, as well as Crown-owned riparian and upland habitats (e.g., forest and grazing leases).
Stepping Back from the Water: A Beneficial Management Practices Guide for New Developments Near Waterbodies	This document provides discretionary guidance to local authorities to assist with “decision making and watershed management relative to structural development near waterbodies”, and includes recommendations for development setbacks (buffers) on waterbodies to protect aquatic and riparian habitats.
Soil Conservation Act & Regulations	Regulates activities that may cause erosion and sedimentation of a waterbody.
Surveys Act	Definitions for the “legal bank” of a waterbody, upon which the Crown-owned “bed and shore” is defined. The legal boundary between the bed and shore and the adjacent lands is the naturally occurring high water mark, and may not extend to include the full extent of riparian lands adjacent to a waterbody.
Water Act	The stated purpose of this Act is to support and promote water conservation and management. Under the Act, any activity that causes or has the potential to cause an effect on the aquatic environment requires an approval. Regulations and Codes of Practice under this Act apply to water and water use management, the aquatic environment, fish habitat protection practices, in-stream construction practices, and storm water management.
Weed Control Act	Noxious and prohibited noxious weeds listed under Schedule 1 must be controlled (noxious weed) or destroyed (prohibited noxious weed) by the owner of the land on which the listed weed occurs.
Wildlife Act & Species at Risk Program	Regulates and enforces protection of wildlife species and their habitats, which may include riparian dependent species

While the provincial government holds the authority to regulate water and public land throughout the province, municipalities are given the authority to manage lands within their jurisdiction under the *Municipal Government Act* (MGA), which was modernized and revised in July 2018. Under Part 1, Section 3, the Act outlines the following purposes of a municipality:

1) To provide good governance and foster the well-being of the environment;
2) To provide services that are in the opinion of council to be necessary or desirable;
3) To develop and maintain safe and viable communities; and
4) To work collaboratively with neighbouring municipalities to plan, deliver, and fund intermunicipal services.

A primary power given to municipalities is land use planning and development, which allows municipalities to set the conditions under which lands are subdivided and developed. Further, each municipality must develop statutory planning documents that provide a framework and vision for development and land use within their jurisdictions. Statutory planning documents that are required include:

- Municipal Development Plans
- Intermunicipal Development Plans
- Area Structure Plans
- Area Redevelopment Plans

Within these planning documents, municipalities can provide specific direction for development requirements that may influence the conservation of riparian habitat. In addition to statutory planning documents, municipalities can influence the management of riparian areas by enacting Land Use Bylaws that set forth requirements for development setbacks on environmentally sensitive lands. For example, municipalities can provide specific direction for development requirements in or near riparian habitat, or set forth minimum development setback widths on Environmental Reserve (ER), environmentally sensitive land, or waterbodies and watercourses.

The MGA also gives municipalities the power to enact land use bylaws, as well as the authority to designate land as Environmental Reserve at the time of subdivision. Environmental Reserves are defined in Section 664 as waterbodies or watercourses, lands that are unstable or subject to flooding, and lands "not less than 6 metres in width abutting the bed and shore" of a waterbody or watercourse. While the Act allows municipalities to take a 6 metre (or more) setback on Environmental Reserve lands, the conditions under which this taking is permitted is limited to cases where the setback is required to prevent pollution or provide public access to the bed and shore of the waterbody or watercourse. In addition to the limited opportunities that are available for conserving riparian land as Environmental Reserve, Section 640(4)(l) of the Act allows municipalities to establish development setbacks on lands subject to flooding, low lying or marshy areas, or within a specified distance to the bed and shore of any waterbody.

7.2. Acquisition of Riparian Lands

It is important to note that while there is a wide range of different federal, provincial, and municipal laws and policies that regulate activities within or near riparian areas, these regulations by themselves to do not necessarily result in the conservation of riparian habitat. In many cases, existing laws regulate *activities* that may impact riparian habitats (e.g., the provincial *Water Act*), but do not regulate the habitats themselves. As a result, many of the existing laws result in approvals that allow for the removal or alteration of riparian areas under certain conditions outlined within the approval. In some cases, these regulations require compensation or replacement of impacted habitats (e.g., the Provincial wetland policy and the federal *Fisheries Act*), but typically, existing laws and policies do not prevent land development, and there is very little provision for riparian habitat conservation in existing laws and policies, particularly as it relates to federal and provincial regulation.

At the municipal level, most municipalities have environmental and land use legislation, policies, and guidelines that provide direction for how to target riparian habitats and other natural areas for conservation, as well as guidance for how to integrate these habitats into a neighbourhood post-development. However, there are only a small number of tools or mechanisms available that enable the *acquisition* of lands by the municipality (or a third party) for the purpose of conservation. In some cases, these tools are only available to municipalities at particular times during the development process (e.g., at subdivision). In other instances, there may be restrictions on the amount of land that municipalities can set aside for conservation, as natural area conservation must be considered alongside other land use demands, such as school and park sites. In many cases, municipalities may have undertaken an ecological inventory to identify high priority areas for conservation, and have the appropriate legislation or policies in place to manage these areas, but may lack the appropriate tools (or associated resources) to acquire high priority conservation areas.

One of the most effective conservation mechanisms for aquatic habitats within municipalities is the *Public Lands Act*. Pursuant to this legislation, the Province of Alberta owns the bed and shore of all permanent and naturally occurring waterbodies, including lakes, rivers, streams, and wetlands. Under this Act, all permanent and naturally occurring waterbodies are Crown land, and development must avoid these features. If development cannot be avoided, the Crown determines whether temporary construction or permanent occupation will be authorized, and in many cases, authorized activities that result in the loss of Crown land is subject to compensation. In the case of riparian habitats along streams and rivers and permanent wetlands, the determination of whether riparian areas are considered to be part of the Crown claimed waterbody is contingent on the existence of a legal survey, and the location of the water boundary that is determined by the surveyor, as per the Surveyors Act. In this regard there are known inconsistencies with respect to how surveyors determine the location of the water boundary, and this may or may not include riparian habitat.

The second provincial legislation that enables municipalities to develop and implement land conservation and stewardship tools is the *Alberta Land Stewardship Act* (ALSA). Under ALSA, the following tools may be utilized to conserve riparian areas in municipalities:

Conservation Easement:

A conservation easement is a voluntary contractual agreement between a private landowner and a qualified organization, such as a municipality, Land Trust organization, or conservation group. There are only three allowable purposes for a conservation easement under the *Alberta Land Stewardship Act*, and these include the protection, conservation and enhancement of 1) the environment, 2) natural scenic or aesthetic values, or 3) agricultural land or land for agricultural purposes. Under a conservation easement, the landowner retains title to the land, but certain land use rights are extinguished in the interest of conserving and protecting the land. The land use restrictions that apply to the property are negotiated and agreed to at the outset (for example, a restriction on subdivision), and the conservation easement (and the land use restrictions) are registered on title and are transferred to a new land owner if the land is sold. Conservation easements can be negotiated by a private land owner at any time, but the easement must be held by a qualified organization.

Conservation Directive:

A conservation directive allows the Alberta Government to identify private lands within a regional plan for the purpose of protection, conservation, or enhancement of environmental, natural scenic, or aesthetic values. Ownership of the lands is retained by the land owner, and the directive describes the precise nature and intended purpose for the protection, conservation, or enhancement of the lands. A conservation directive must be initiated by the provincial government, and to date, this tool remains largely untested (Environmental Law Centre 2015).

Conservation Offset:

A conservation offset is a tool that allows industry to offset the adverse environmental effects of their activities and development by supporting conservation activities and/or efforts on other lands. In order for conservation offsets to be effective, there must first be guidelines and rules for where offsets can be applied, and provisions for accountability, including monitoring and compliance. While conservation offsets are available as a tool for the conservation of natural areas in the Red Deer River watershed, work would first have to be done to create a proper framework to create eligibility rules, pricing and bidding rules for selling and buying offsets, and rules for combining buyers and sellers.

Transfer of Development Credits (TDCs):

Transfer of development credits is a tool that creates and incentive to redirect development away from specific landscapes in order to conserve areas for agricultural or environmental purposes. This tool allows land development and conservation to occur at the same time, while also allowing owners of the developed and undeveloped lands to share in the financial benefits of the development activity. A TDC program can be used to designate lands as a conservation area for one or more of the following purposes:

- The protection, conservation and enhancement of the environment;
- The protection, conservation and enhancement of natural scenic or aesthetic values;
- The protection, conservation and enhancement of agricultural land or land for agricultural purposes;
- Providing for all or any of the following uses of the land that are consistent with the following purposes: recreational use, open space use, environmental education use, or use for research and scientific studies of natural ecosystems; and
- Designation as a Provincial Historic Resource or a Municipal Historic Resource under the *Historical Resources Act*.

Before TDCs can be used by municipalities as a conservation tool, they must be established through a regional plan, or they must be approved by the Provincial Government.

Outside of the conservation tools that have been created through the *Alberta Land Stewardship Act*, there are other mechanisms through which municipalities may acquire lands for conservation, most of which rely on voluntary conservation action taken by private land owners. These tools may be utilized at any time during the municipal planning and development process, and include:

Land Purchase:

Municipalities can purchase land from a private land owner at any time for the purpose of conservation. For example, the City of Edmonton established a Natural Areas Reserve Fund in 1999, with the purpose of using these funds to purchase and protect natural areas. While land purchase for conservation is an option that is available, many municipalities do not have the financial resources available to purchase lands within their municipal boundaries, as the market value for these lands can be very high.

Land Swap:

In some cases, a land developer may be willing to “swap” or exchange natural areas for other developable lands that are owned by the municipality. In this case, the municipality and the developer would enter into an agreement to exchange the lands, such that the natural areas can be conserved.

Land Donation:

Land donation involves the transfer of ownership from a private land owner to the municipality, or to a conservation organization or land trust, who would hold the land for conservation in perpetuity. Lands that are donated to a conservation organization or land trust are eligible for the federal government’s Ecological Gifts program which provides donors with significant tax benefits.

The final set of conservation tools are directly available to municipalities, and are the most common and frequently used tools for acquiring riparian areas as part of land development and planning. However, these tools are enabled through the *Municipal Government Act*, which only gives municipalities the authority to use these tools at the time of subdivision. Thus, municipalities can only utilize these tools through formal land development and planning processes.

Environmental Reserve (ER):

Environmental Reserves are defined in the Act as waterbodies, watercourses, lands that are unstable or subject to flooding, and lands "not less than 6 metres in width abutting the bed and shore" of a waterbody or watercourse. While the Act allows municipalities to take a *minimum* of a 6 metre setback on Environmental Reserve lands (with no stated maximum), the conditions under which this taking is permitted is limited to cases where the setback is required to prevent pollution or provide public access to the bed and shore of the waterbody or watercourse. In addition, Section 640(4)(l) of the Act allows municipalities to establish development setbacks on lands subject to flooding, low lying or marshy areas, or within a specified distance to the bed and shore of any waterbody.

Environmental Reserve Easement:

In instances where the municipality and the landowner agree, Environmental Reserve lands may be designated as an Environmental Reserve Easement. An ER Easement serves the same purpose as ER, but differs in that the title of the reserve lands remains with the land owner; however, ER easements are registered on title by caveat in favour of the municipality.

Conservation Reserve:

Under Section 664.2(1), municipalities may designate an area as a Conservation Reserve if the area contains significant environmental features that are not required to be provided as Environmental Reserve. Under the Act, the purpose of taking the Conservation Reserve is to protect and conserve the significant environmental features in a manner that is consistent with other statutory planning documents. In designating a Conservation Reserve, the municipality must compensate the landowner in an amount that is equal to the market value at the time of the subdivision approval application.

7.3. Public Engagement

Public engagement is a critical component to the successful conservation and management of riparian areas. Without the support of the public, successful implementation of restoration and management programs are not possible. Further, many of the acquisition tools outlined above rely on voluntary participation by the public (e.g., land donations and conservation easement). Thus, ensuring that the public are aware of the various voluntary programs that exist for riparian habitat conservation, as well as formulating active partnerships that can capitalize on the public's willingness to participate in such programs, is critical to the conservation and restoration of riparian habitats. Public engagement can take several forms, including the following:

Education, Extension and Outreach:

Increasing public awareness and appreciation for natural areas is a critical component to effective conservation and management. Thus, creating educational opportunities and programs, as well as supporting local conservation and stewardship groups is critical to achieving desired riparian conservation and restoration objectives in the Lower McLeod River watershed.

Partnerships:

Given the limited number of tools available to municipalities for the acquisition of riparian areas on private lands, engaging in strategic partnerships to promote voluntary land conservation and management activities is essential. Central to this is developing partnerships with land trusts and conservation organizations, developing strong inter-municipal policies, and partnerships with the provincial government to promote and enhance collaboration and improve conservation outcomes

All of the tools outlined in this section are currently available to stakeholders in the Lower McLeod River watershed for the purpose of conserving and managing riparian habitats; however, in order to focus management action in the watershed, it is essential that the AWC and its partners first define objectives and targets for the conservation, restoration, and management of riparian habitats. Once these objectives and targets have been outlined, specific action and the relevant tools associated with those actions can be identified. In some cases, there may be existing tools in place to achieve the desired management outcomes. In other cases, there may be gaps in the available tools, and new policies, partnerships, or programs may need to be developed in order to achieve the desired management objectives.

8.0 Conclusion

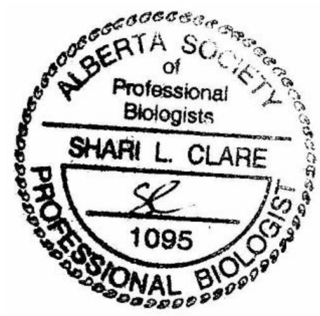
The overall goal of this project was to quantify and characterize the intactness of riparian management areas in the Lower McLeod River watershed. Approximately 1,400 km of shoreline was assessed as part of this study, with 91% being evaluated as either High (87%, 1,223 km) or Moderate (4%, 62 km) Intactness. The remaining ~8% was classified as Low (3%, 43 km) or Very Low (5%, 73 km) Intactness. The greatest length of shoreline that was classified as Very Low or Low Intactness was located within the Lower McLeod River HUC 8 watershed, as well as within the towns of Edson and Whitecourt.

The intactness ratings provided in this report are intended to support a screening-level assessment of management and/or conservation priorities across the Lower McLeod River watershed, and are not meant to replace more detailed, site-specific field assessments of riparian health or condition. Instead, this information should be used to highlight smaller, more localized areas where field assessments and further validation may be required. Ultimately, the results of this work provide the AWC, local municipalities, stewardship groups, and other partners with an overview of the status of riparian areas within the Lower McLeod River watershed, and provides a foundation of scientific evidence that can be used to support stewardship and management efforts throughout the region.

The next step in the advancement of meaningful riparian management and conservation within the Lower McLeod watershed will be to formalize a framework for action that includes defining achievable management outcomes and measurable targets, which can be used to inform relevant collective action by key stakeholders. These actions can be monitored on a regular basis to provide an evaluation of outcomes that feed into an adaptive and reflexive approach to riparian management through time.

8.1. Closure

This report was written by:



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9.0 Literature Cited

Adams, P.W. and M. Taratoot. 2001. Municipal water supplies from forest watersheds in Oregon: Fact book and catalogue. Oregon Forest Resources Institute, Portland. 100 p.

Alberta Biodiversity Monitoring Institute (ABMI). 2017. Wall-to-wall Human Footprint Inventory. Available: http://www.abmi.ca/home/data-analytics/da-top/da-product-overview/GIS-Land-Surface/HF-inventory.html.

Alberta Environment (AENV). 2010. Using Aerial Videography to Assess Riparian Areas in Southern Alberta: a Pilot Study. Alberta Environment, Calgary. 40 pp.

Alberta Environment and Sustainable Resource Development (AESRD). 2012. Guide to Reporting on Common Indicators Used in State of the Watershed Reports. Government of Alberta, Edmonton, Alberta.

Anonymous. 2007. The technical basis of zone of sensitivity determinations under the detailed assessment procedure of the Riparian Areas Regulation. B.C. Ministry of Environment and Fisheries and Oceans Canada, Pacific Region. 55pp. Available: https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/riparian-areas-regulations/rar_zone_of_sensitivity__rational_2007.pdf?bcgovtm=2free

Blackport R, R. MacGregor, and J. Imhof. 1995. An approach to the management of groundwater resources to protect and enhance fish habitat. Canadian Manuscript Report of Fisheries and Aquatic Sciences, No. 2284, Ontario, Canada.

Caissie D. 1991. The importance of groundwater to fish habitat: Base flow characteristics for three Gulf Region Rivers. Canadian Data Report of Fisheries and Aquatic Sciences, No. 814, Ontario, Canada.

Clare and Sass. 2012. Riparian lands in Alberta: Current state, conservation tools, and management approaches. Report prepared for Riparian Land Conservation & Management Team, Alberta Water Council, Edmonton, Alberta. Fiera Biological Consulting Ltd. Report #1163.

Deegan, B.M., Ganf, G., and Brookes, J.D. 2010. Assessment of Riverine Ecological Condition in the Fleurieu Peninsula, South Australia: Implications for Restoration. Transactions of the Royal Society of South Australia 134: 228-242.

Environment Canada. 2014. How Much Habitat is Enough? Third Edition. Environment Canada, Toronto, Ontario. Pp. 130.

Environmental Law Centre. 2015. Conservation directives: Alberta's unknown and untested conservation tool. Available: http://elc.ab.ca/media/103996/ConservationDirectivesELCRecommendations.pdf. Accessed: December 30, 2016.

Fiera Biological Consulting Ltd. 2018a. Modeste Watershed Riparian Area Assessment. Report prepared for the North Saskatchewan Watershed Alliance, Edmonton, Alberta. Fiera Biological Consulting Report Number 1652. Pp. 101.

Fiera Biological Consulting Ltd. 2018b. Sturgeon Riparian Area Assessment. Report prepared for the North Saskatchewan Watershed Alliance, Edmonton, Alberta. Fiera Biological Consulting Report Number 1762. Pp. 113.

Fiera Biological Consulting Ltd. 2018c. Strawberry Riparian Area Assessment. Report prepared for the North Saskatchewan Watershed Alliance, Edmonton, Alberta. Fiera Biological Consulting Report Number 1773. Pp. 110.

Fiera Biological Consulting Ltd. 2018d. Riparian Assessment for North Saskatchewan Region Lakes. Fiera Biological Consulting Report #179910. Prepared for the Alberta Environment and Parks, Policy and Planning Division, Edmonton, Alberta. Pp. 65.

Fiera Biological Consulting Ltd. 2018e. Blindman River Riparian Assessment. Fiera Biological Consulting Report #1834. Prepared for Agroforestry & Woodlot Extension Society (AWES), Edmonton, Alberta. Pp. 39.

Fiera Biological Consulting Ltd. 2019. Riparian Assessment Validation for North Saskatchewan Region Lakes. Fiera Biological Consulting Report #1853. Prepared for the Alberta Environment and Parks, Policy and Planning Division, Edmonton, Alberta. Pp. 45.

Fiera Biological Consulting Ltd. 2020a. Riparian Area Assessment for the Medicine-Blindman Rivers Watershed. Fiera Biological Consulting Report #2011. Prepared for the Red Deer River Watershed Alliance, Red Deer, Alberta. Pp. 104.

Fiera Biological Consulting Ltd. 2020b. Mid-Pembina Watershed Riparian Area Assessment. Fiera Biological Consulting Report #2012. Prepared for the Athabasca Watershed Council, Athabasca, Alberta. Pp. 80.

Fiera Biological Consulting Ltd. 2021a. West Prairie River Watershed Riparian Area Assessment. Fiera Biological Consulting Report #2014. Prepared for the Lesser Slave Watershed Council, High Prairie, Alberta. Pp. 69.

Fiera Biological Consulting Ltd. 2021b. Upper Pembina Watershed Riparian Area Assessment. Report #2012c. Prepared for the Athabasca Watershed Council, Athabasca, Alberta. Pp. 74.

Fiera Biological Consulting Ltd. 2021c. Lower Pembina Watershed Riparian Area Assessment. Report #2012b. Prepared for the Athabasca Watershed Council, Athabasca, Alberta. Pp. 77.

Fiera Biological Consulting Ltd. 2021d. Riparian Area Assessment of the North Saskatchewan and Battle River Watersheds. Report #1987c. Prepared for the North Saskatchewan Watershed Alliance and the Battle River Watershed Alliance. Pp. 56 + Appendices.

Fiera Biological Consulting Ltd. 2021e. Jackfish-Muriel Creeks Watershed Riparian Area Assessment. Report #2044. Prepared for the Lakeland Industry & Community Association, Athabasca, Alberta. Pp. 128.

Fiera Biological Consulting Ltd. 2021f. Upper Beaver Watershed Riparian Area Assessment. Fiera Biological Consulting Report #2132. Prepared for the Lakeland Industry & Community Association, Athabasca, Alberta. Pp. 157

Fiera Biological Consulting Ltd. 2021g. Upper Fish Creek Watershed Riparian Area Assessment. Fiera Biological Consulting Report #2137. Prepared for the Fish Creek Watershed Association, Alberta. Pp. 45.

Fiera Biological Consulting Ltd. 2022a. Tawatinaw River Watershed Riparian Area Assessment. Fiera Biological Consulting Report #2163. Prepared for the Athabasca Water Council. Pp. 53.

Fiera Biological Consulting Ltd. 2022b. Riparian Area Assessment for the Buffalo, Kneehills, Little Red Deer, and Threehills Subwatersheds. Fiera Biological Consulting Report #2153. Prepared for the Red Deer River Watershed Alliance, Red Deer, Alberta. Pp. 124

Fiera Biological Consulting Ltd. 2022c. Jumpingpound Creek Watershed Riparian Area Assessment. Fiera Biological Consulting Report #2180. Prepared for the Jumpingpound Creek Watershed Partnership, Alberta. Pp. 51

Fiera Biological Consulting Ltd. 2023a. Nose Creek Watershed Riparian Area Assessment. Fiera Biological Consulting Report #2181. Prepared for the Nose Creek Watershed Partnership, Alberta. Pp. 58.

Fiera Biological Consulting Ltd. 2023b. Sounding Creek Watershed Riparian Area Assessment. Fiera Biological Consulting Report #2170. Prepared for Battle River Watershed Alliance, Alberta. Pp. 103.

Flotemersch J.E., Leibowitz S.G., Hill R.A., Stoddard J.L., Thoms M.C., Tharme R.E. 2015. A Watershed Integrity Definition and Assessment Approach to Support Strategic Management of Watersheds. River Research and Applications 32: 1654–1671.

Government of Alberta. 2012. Stepping Back from the Water: A Beneficial Management Practices Guide for New Development Near Water Bodies in Alberta's Settled Region. Her Majesty the Queen in right of the Province of Alberta. Available: https://open.alberta.ca/dataset/1c70eb43-a211-4e9c-82c3-9ffd07f64932/resource/6e524f7c-0c19-4253-a0f6-62a0e2166b04/download/2012-steppingbackfromwater-guide-2012.pdf

Ho, T.K. 1995. Random decision forests. Proceedings of the 3rd International Conference on Document Analysis and Recognition, Montreal, QC, 14–16 August 1995. pp. 278–282.

Mills, B. and Scrimgeour, G. 2004. The Effectiveness of Aerial Videography to Characterize Lakeshore Condition. Data Report (D-2005-017) produced by Alberta Conservation Association, Alberta, Canada. 52 pp. + App.

North Saskatchewan Watershed Alliance (NSWA). 2015. Riparian Health Assessment of Wabamun Lake: An Aerial Assessment Using an Unmanned Air Vehicle (UAV). Prepared for the Wabamun Watershed Management Council, Edmonton, AB. 20pp + Appendix.

NRC (National Research Council). 2002. Riparian Areas: functions and strategies for management. National Academy Press, Washington, D.C. 428 pp.

Olokeogun, O. S., A. Ayanlade, and O.O. Popoola. 2020. Assessment of riparian zone dynamics and its flood-related implications in Eleyele area of Ibadan, Nigeria. Environmental Systems Research, 9(1), 1-11.

Orewole, M. O., D.B. Alaigba, and O. Oviasu. 2015. Riparian corridors encroachment and flood risk assessment in Ile-Ife: A GIS perspective. Open Transactions on Geosciences. 2(1): 17-32.

Pusey, B.J. and A.H. Arthington. 2003. Importance of the riparian zone to the conservation and management of freshwater fish: a review. Marine and Freshwater Research 54: 1-16.

Swanson, S., D. Kozlowski, R. Hall, D. Heggem, and J. Lin. 2017. Riparian proper functioning condition assessment to improve watershed management for water quality. Journal of Soil and Water Conservation. 72(2): 168–182. doi:10.2489/jswc.72.2.168.

Teichreb C. and Walker G, 2008. Aerial Videograhic Health and Integrity Assessment of the Riparian Management Area for Selected Reaches of the Battle River. Alberta Environment Technical Report. Available: https://www.battleriverwatershed.ca/sites/default/files/2007_Battle_River_H_and_I_Final_Report_George_24_Mar_08.pdf.

Appendix A: Intactness Summary Tables

Table A- 1. Length (km) and proportion (%) of shoreline classified into each Intactness category, summarized by waterbody and municipality.

Waterbody Name & Intersecting Municipality	Length Assessed (km)*	Intactness Category							
		Very Low		Low		Moderate		High	
		km*	%	km*	%	km*	%	km*	%
Beaver Creek	**68.5**	**1.7**	**2**	**2.3**	**3**	**1.1**	**2**	**63.5**	**93**
Whitecourt	11.0	0.3	2	1.1	10	0.6	5	9.1	83
Woodlands County	57.5	1.4	2	1.2	2	0.5	1	54.4	95
Bench Creek	**73.9**	**5.4**	**7**	**2.7**	**4**	**9.0**	**12**	**56.8**	**77**
Edson	24.6	3.2	13	0.9	3	4.4	18	16.1	65
Yellowhead County	49.3	2.1	4	1.8	4	4.6	9	40.8	83
Carrot Creek	**124.3**	**7.8**	**6**	**5.4**	**4**	**8.9**	**7**	**102.1**	**82**
Yellowhead County	124.3	7.8	6	5.4	4	8.9	7	102.1	82
Edson River	**189.2**	**25.3**	**13**	**9.0**	**5**	**9.1**	**5**	**145.8**	**77**
Yellowhead County	189.2	25.3	13	9.0	5	9.1	5	145.8	77
January Creek	**71.7**	**5.1**	**7**	**0.8**	**1**	**4.0**	**6**	**61.8**	**86**
Yellowhead County	71.7	5.1	7	0.8	1	4.0	6	61.8	86
Lost Creek	**30.0**	**2.2**	**7**	**0.7**	**2**	**0.7**	**2**	**26.4**	**88**
Yellowhead County	30.0	2.2	7	0.7	2	0.7	2	26.4	88
McLeod River	**369.0**	**15.1**	**4**	**11.7**	**3**	**17.3**	**5**	**324.9**	**88**
Whitecourt	3.4	0.8	23	0.1	2	1.4	41	1.2	34
Woodlands County	101.6	3.8	4	2.8	3	1.7	2	93.3	92
Yellowhead County	264.0	10.5	4	8.9	3	14.2	5	230.4	87
Shiningbank Lake	**13.3**	**0.3**	**2**	**0.2**	**2**	**0.2**	**2**	**12.6**	**95**
Yellowhead County	13.3	0.3	2	0.2	2	0.2	2	12.6	95
Shiningbank Outlet Creek	**53.8**	**1.1**	**2**	**0.6**	**1**	**1.1**	**2**	**50.9**	**95**
Yellowhead County	53.8	1.1	2	0.6	1	1.1	2	50.9	95
Trout Creek	**144.3**	**5.2**	**4**	**5.5**	**4**	**4.4**	**3**	**129.1**	**89**
Yellowhead County	144.3	5.2	4	5.5	4	4.4	3	129.1	89
UL-170202-01	**0.7**	**0.2**	**32**	**0.0**	**0**	**0.5**	**68**	**0.0**	**0**
Edson	0.7	0.2	32	0.0	0	0.5	68	0.0	0
Wolf Creek	**250.9**	**3.3**	**1**	**3.4**	**1**	**5.2**	**2**	**238.9**	**95**
Yellowhead County	250.9	3.3	1	3.4	1	5.2	2	238.9	95
Wolf Lake	**10.6**	**0.2**	**2**	**0.2**	**2**	**0.2**	**2**	**10.0**	**95**
Yellowhead County	10.6	0.2	2	0.2	2	0.2	2	10.0	95

*NOTE: All municipal data summaries were generated by using a spatial intersect rule in ArcGIS. Summarizing the data in this way captures the assessed shorelines that fall within the municipal boundary; however, it should be noted that there are spatial discrepancies between the municipal boundary data and the provincial hydrography data that are freely available from AltaLIS. As a result, the municipal summaries of shoreline length for intactness and priority are approximate and should be considered estimates that reflect relative differences between municipalities.