Tawatinaw River Watershed Riparian Area Assessment

FINAL REPORT

Project #2163
February 2022

Prepared for:

Athabasca
WATERSHED COUNCIL

Prepared by:

FIERA
Biological Consulting

Front Cover Photo Credit: Tawatinaw River, Athabasca Watershed Council

Suggested Citation:

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

Report Prepared by: Shari Clare and Shantel Koenig

Acknowledgements

The Athabasca Watershed Council acknowledges the financial assistance of the Government of Alberta, via the Watershed Resiliency and Restoration Program, without which this project would not have been possible. 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, Indigenous communities, non-government organizations, agricultural and industry groups, and private landowners working to conserve and restore riparian areas and other components of watershed health throughout the Athabasca watershed.

Executive Summary

Riparian habitats are critical components of healthy and functional aquatic ecosystems, and provide a wide range of ecological, economic, and social values to human communities. For example, intact 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. Intact riparian areas also play a vital role in the exchange of inorganic and organic material between terrestrial and aquatic ecosystems, and regulate water temperature and the instream light environment, thereby ensuring suitable habitat for a wide range of aquatic species. Given the important ecosystem functions and services that are supported by riparian habitats, effectively identifying areas where riparian habitat has been degraded is essential to improving conservation and management outcomes.

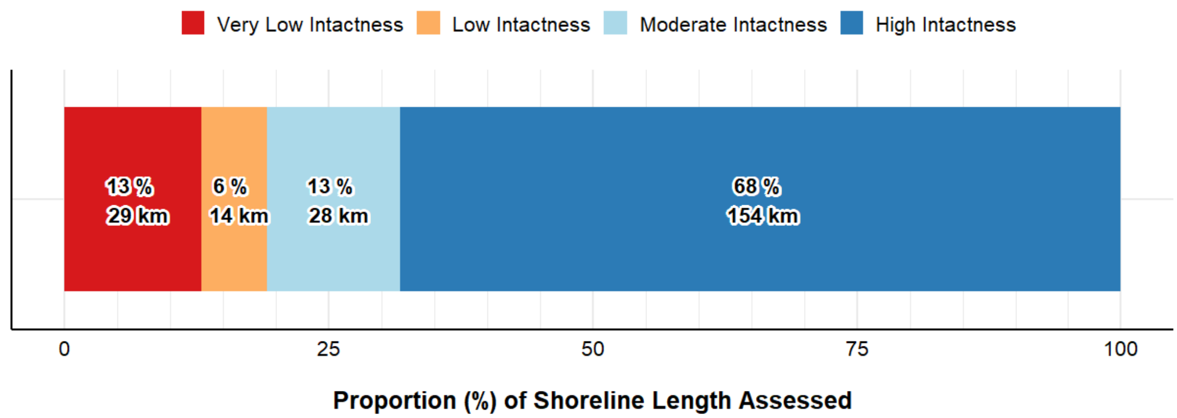
In an effort to better understand riparian condition at a watershed scale, the Athabasca Water Council (AWC) retained Fiera Biological Consulting to assess riparian habitat along approximately 226 km of shoreline within the Tawatinaw River HUC 8 watershed. As part of this work, five waterbodies were assessed within the watershed: Tawatinaw River, Tawatinaw Lake, Helliwell Lake, and two unnamed lakes (UL-170501-01, UL-170501-02).

Riparian vegetation intactness was assessed along the shorelines of each waterbody using a desktop-based assessment tool that utilizes a current land cover layer derived from satellite imagery. Intactness was assessed within riparian management areas (RMAs) that had a variable length, as determined by major breaks in the proportion of vegetation cover along the shoreline, and a fixed 50 m buffer that extended perpendicular to the shoreline. Within each RMA, intactness was assessed using a number of GIS metrics that determined the type and extent of vegetation and human disturbance present. 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.

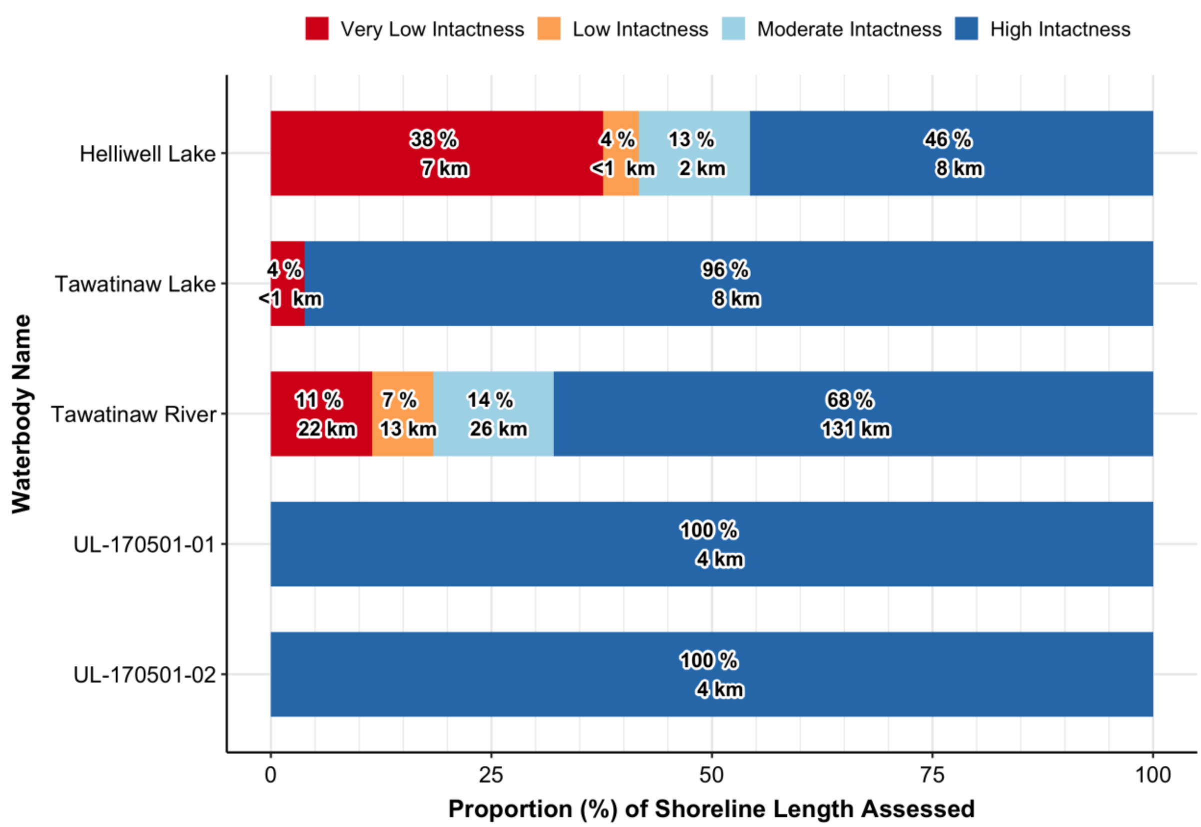
The majority of the shoreline assessed was classified as High Intactness (68%, or 154 km), with an additional 13% (28 km) classified as Moderate Intactness. The remaining shoreline was classified as either Low (6%, 14 km) or Very Low (13%, 29 km) Intactness.

Comparatively, riparian areas along the shorelines of the waterbodies that were assessed varied in condition, with the amount of shoreline assessed as High Intactness ranging from 46% for Helliwell Lake to 100% for the two unnamed lakes. Tawatinaw Lake also had most of its shoreline (96%) assessed as High Intactness. Helliwell Lake had the greatest proportion of shoreline assessed as Very Low Intactness (38%). When length of shoreline was considered, Tawatinaw River had the greatest length of shoreline assessed as High Intactness (131 km) and also the greatest length of shoreline assessed as Very Low Intactness (22 km).

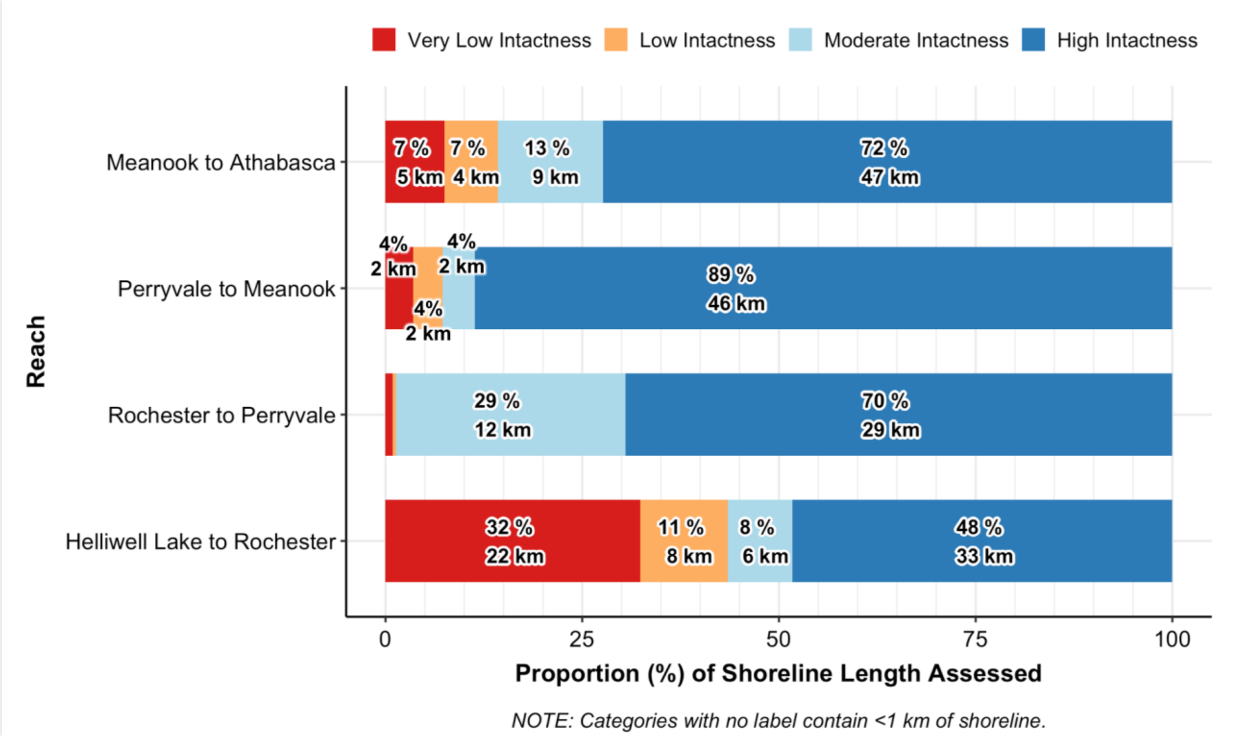
OVERALL RIPARIAN INTACTNESS FOR ALL SHORELINES ASSESSED IN THIS STUDY



RIPARIAN INTACTNESS BY INDIVIDUAL WATERBODY



RIPARIAN INTACTNESS BY LOCATION (REACH)



Riparian intactness was also summarized by location, with four distinct reaches being defined along the Tawatinaw River, including (from south to north): Helliwell Lake to the Hamlet of Rochester, Rochester to the Hamlet of Perryvale, Perryvale to the Hamlet of Meanook, and Meanook to the Town of Athabasca. The greatest proportion of shoreline classified as High Intactness (89%) was located within the Perryvale to Meanook reach. Conversely, the greatest proportion of shoreline assessed as Low (11%) and Very Low (32%) Intactness was located within the Helliwell Lake to Rochester reach. While the Rochester to Perryvale reach was the shortest in length, this reach contained the highest proportion of intact shoreline. with 99% of the riparian management areas being classified as either High or Moderate Intactness.

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 Tawatinaw River HUC 8 watershed. Through the commissioning of this study, the AWC and its stakeholders now have an important foundation of scientific evidence upon which to target restoration and conservation activities that will improve water quality, biodiversity, and drought and flood resilience in the watershed. The next step in the advancement of meaningful riparian management and conservation in the watershed will be to formalize a framework for action that includes a consideration of the current conditions and defining achievable outcomes and measurable targets that can be used by key stakeholders to inform management decisions. 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 management over time within 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)
BMP: Best Management Practice
DEM: Digital Elevation Model
ECCC: Environment and Climate Change Canada
HUC: Hydrologic Unit Code
IWMP: Integrated Watershed Management Plan
AWC: Athabasca Watershed Council
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 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, 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 of classification 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 through 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).

Table of Contents

List of Maps

List of Figures

List of Tables

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 essential 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, and 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, and 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 (Pusey and Arthington 2003). 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); consequently, recent watershed management efforts have been 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 characteristics 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 condition 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 also providing a permanent geo-referenced video record of the current status of shoreline. This method provides a relatively rapid and “coarse filter” assessment of riparian health, and is not intended to replace field-based assessments. Rather, the videography approach complements field assessment by allowing for the evaluation of larger areas in an approximate fashion, to be followed by a more detailed check on the ground. The goal of the videography assessment 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 evaluates 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 then 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 50,000 km of shoreline across central Alberta (Fiera Biological 2018a-e, 2019, 2020, 2021a-e).

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 in the Tawatinaw River HUC 8 watershed by generally assessing the intactness of major waterbodies, as well as providing guidance on how the results from the study can be used to prioritize conservation and restoration efforts within the watershed.

The results of this study provide stakeholders with an overview of the status of riparian management areas along the Tawatinaw River and associated lakes. This in turn allows organizations throughout the watershed to focus restoration, management efforts, and/or resources in areas of greatest need. Further, this approach has been adapted and applied in other watersheds 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 improving the understanding of the current condition of riparian areas within the Tawatinaw River HUC 8 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 or pressure within local catchments 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 ratings are intended to support a screening-level assessment of management and/or conservation priorities across broad geographic areas (e.g., HUC 8 watershed, municipality, stream reach). *The tool assessments are 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.
- 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 reach summaries in this report were based on locations along the Tawatinaw River that were identified in consultation with the Athabasca Watershed Council. Start and end of reach locations were selected where RMAs had a meaningful break at these locations. Consequently, the reach 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 reach.

2.0 Study Area

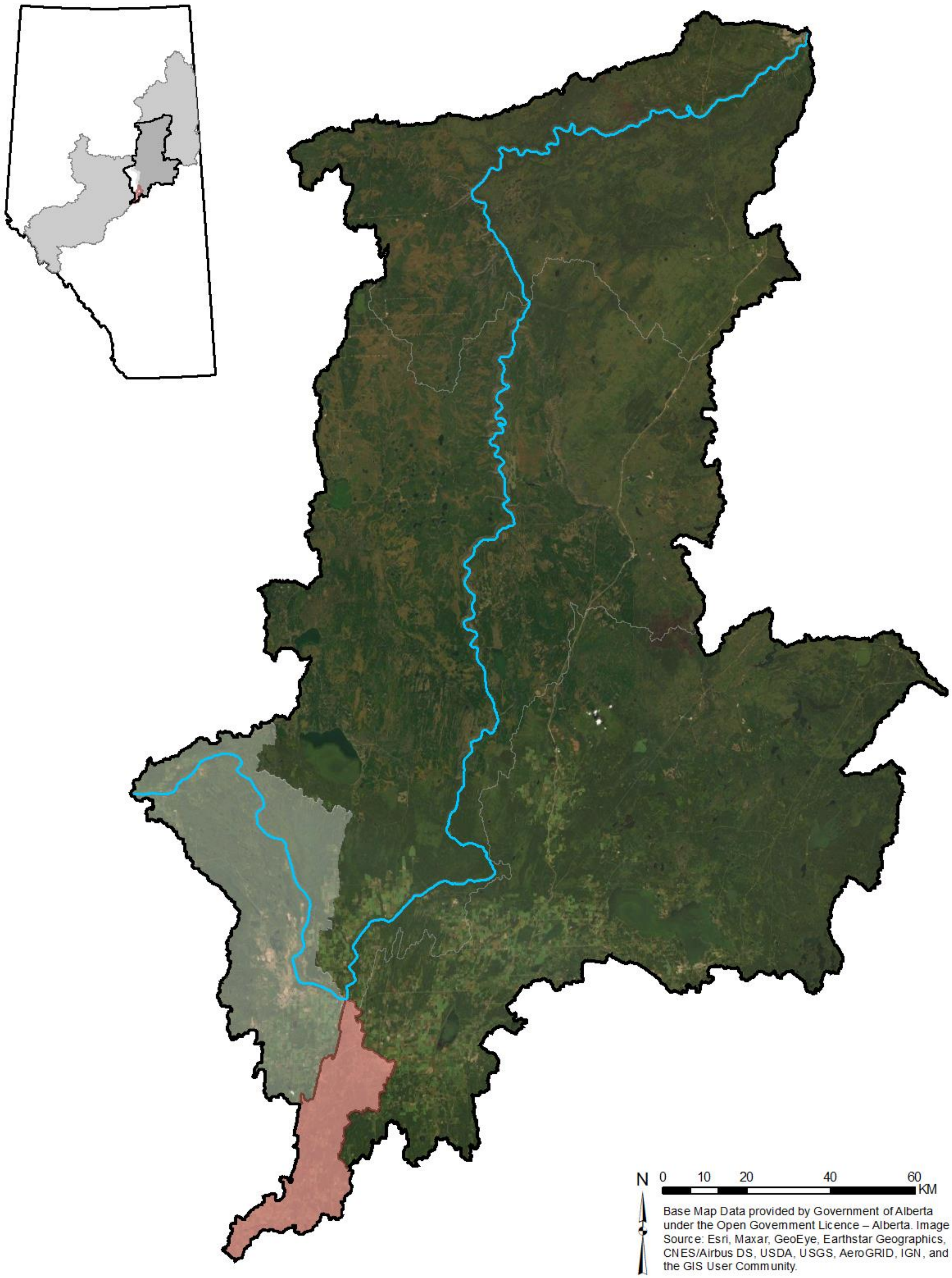
Located within the Athabasca River watershed, the Tawatinaw River HUC 8 watershed is nested within the larger Middle Athabasca HUC 4, and the Tawatinaw River HUC 6 watersheds (Map 1). Covering an area of approximately 746 km^2, the HUC 8 watershed is contained entirely within the Boreal Natural Region (Map 2). The Tawatinaw River is the major watercourse within the HUC 8 watershed, beginning at Helliwell Lake and flowing northward to its confluence with the Athabasca River, within the Town of Athabasca. The watershed is a mosaic of agricultural use and forest and wetland (Map 3). Agricultural use predominates in the south, with forest and wetland cover increasing in the central and northern parts of the watershed.

Three counties intersect the Tawatinaw River HUC 8 watershed, including Westlock County, Thorhild County, and Athabasca County; although only a very small portion of the watershed falls within Thorhild County (Map 4). The Town of Athabasca is located at the northernmost point of the watershed where the Tawtinaw River drains into the Athabasca River. Additionally, a number of hamlets are located along the Tawatinaw River, including Tawatinaw, Rochester, Perryvale, Meanook, and Colinton.

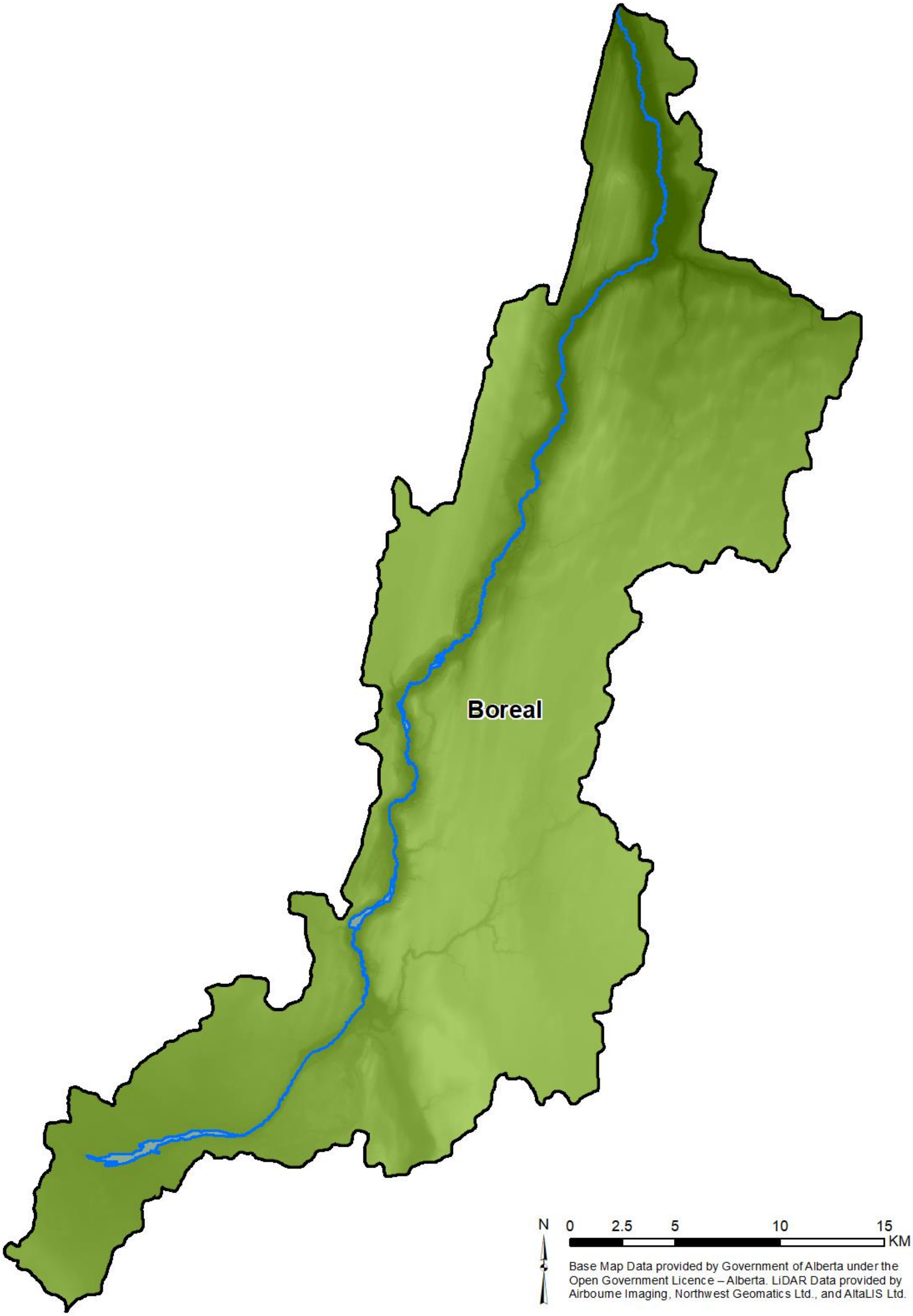
Approximately 226 km of shoreline was assessed as part of this study, including the left and right banks of the Tawatinaw River, as well as the shoreline of Helliwell Lake, Tawatinaw Lake, and two unnamed lakes associated with the Tawatinaw River (Table 1; Map 5).

Table 1. Watercourses in the Tawatinaw River HUC 8 watershed that were assessed as part of this project. The length of shoreline listed for the Tawatinaw River represents the total length assessed on both the left and right banks.

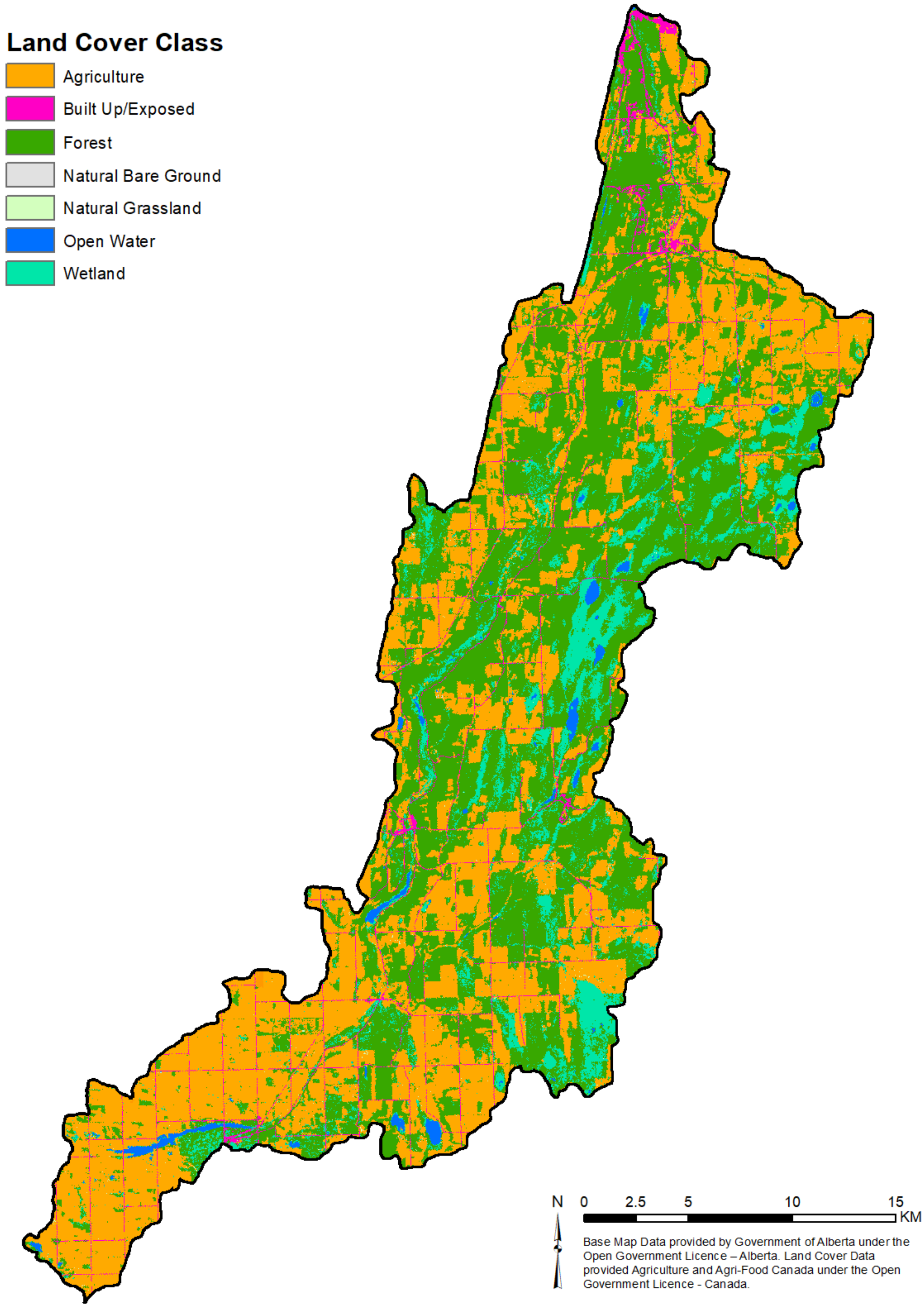
Waterbody Name	Length of Shoreline Assessed (km)
Rivers & Lakes	
Tawatinaw River	192.8
Helliwell Lake	18.0
Tawatinaw Lake	7.9
Unnamed Lakes (2)	7.6
TOTAL	**226.2**



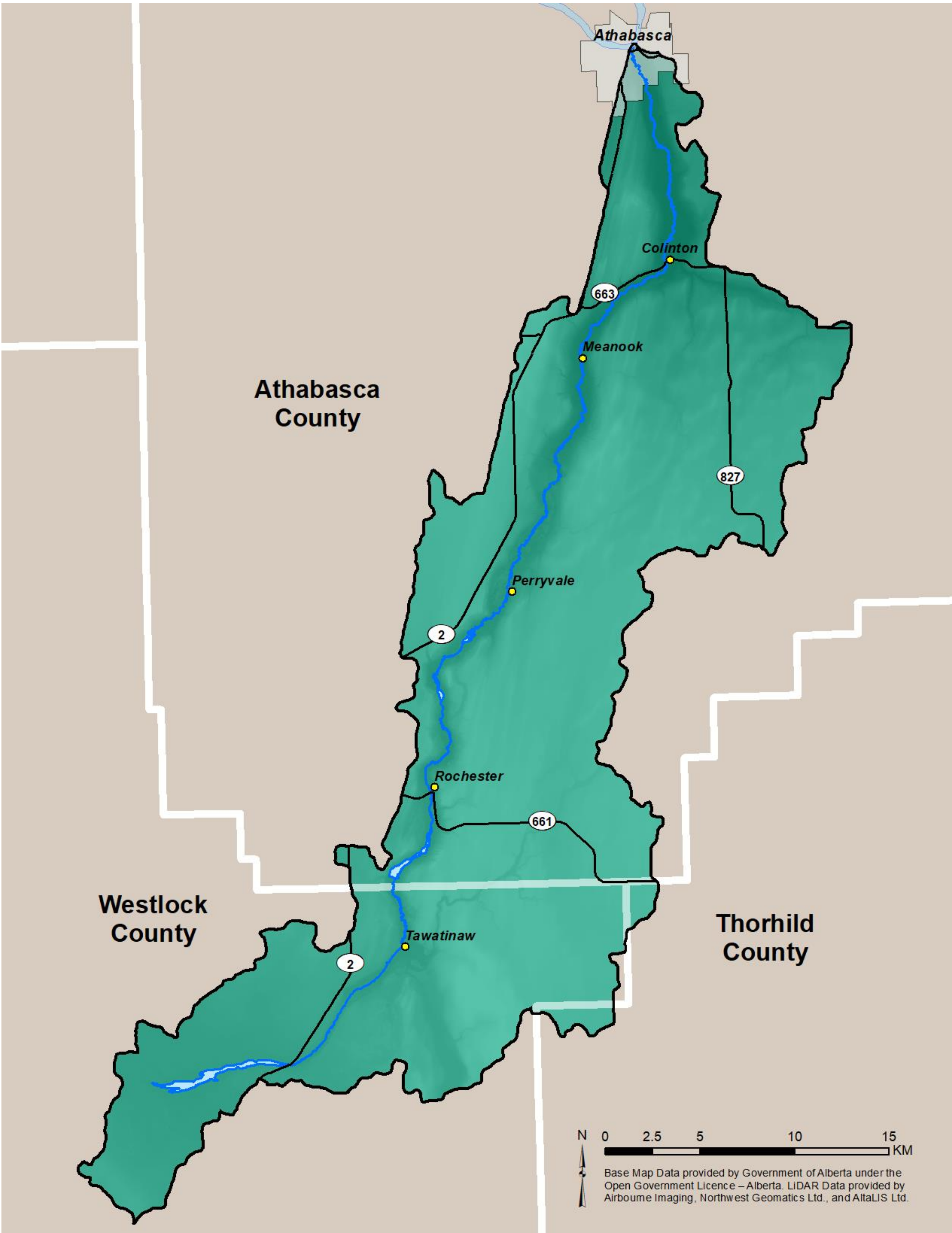
Map 1. The Tawatinaw River HUC 8 watershed (shaded in red) is nested within in the Middle Athabasca River HUC 4 watershed (shaded in white) and the Tawatinaw River HUC 6 watershed (outlined in black).



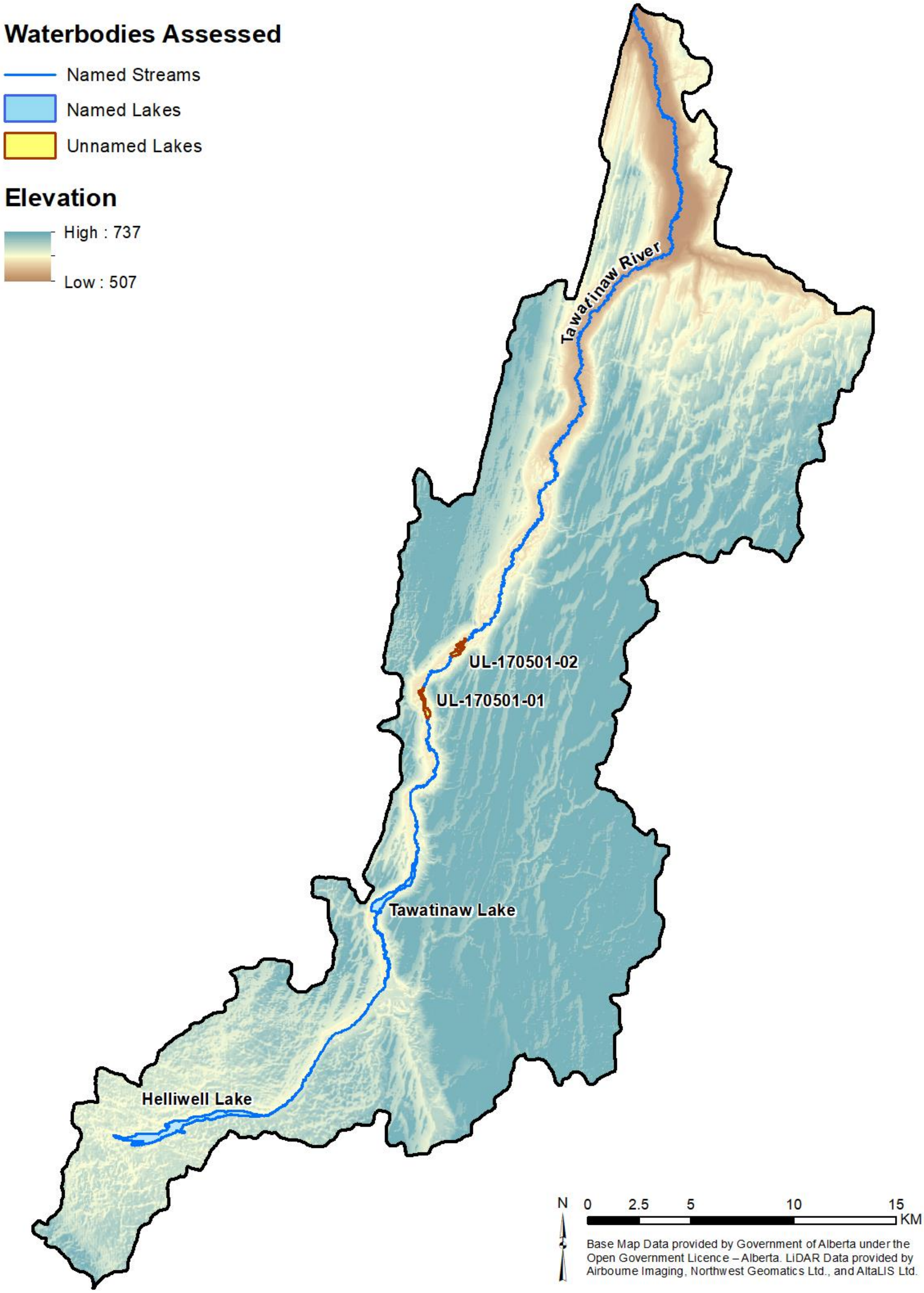
Map 2. The Tawatinaw River HUC 8 watershed falls entirely within the Boreal Natural Region.



Map 3. Land cover in the Tawatinaw River HUC 8 watershed, based on the 2020 Agriculture and Agri-Food Canada land cover.



Map 4. Major highways and municipal jurisdictions located within the watershed.



Map 5. 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) for this watershed, 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 satellite imagery from 2017, which was obtained by the AWC free of charge from the Government of Alberta.

The 6m land cover classification was created for the entire watershed and consisted of two separate SPOT 6 scenes. Because of differences in date of acquisition and image quality, each scene was classified individually, but using the same classification methodology. For each satellite image, the four SPOT 6 bands were combined with a set of ancillary raster data products that were specifically generated for use in the classification (Table 2). The SPOT 6 imagery was used to generate layers for the first four principal component layers of the four band image, Normalized Difference Vegetation Index (NDVI), Blue Normalized Difference Vegetation Index (BNDVI), Green Ratio Vegetation Index (GRVI), and Iron Oxide Index (IOI), and a 15 m LiDAR DEM was used to derive terrain layers including Probability of Depression, Cost Distance to Water, and Deviation from Mean Elevation. As well, historic image analysis was performed in Google Earth Engine to generate mean summer temperature maps from Landsat 8 imagery and mean and standard deviation maps of NDVI 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 scene for the following classes: Coniferous; Cropland; Deciduous; Open Water; Human Built; Marsh, Swamp, Graminoid Fen, Woody Fen, and Shrub. A random forest classification was performed on the SPOT 6 band stack, which included the four SPOT 6 bands and additional ancillary layers. Random forest is a classification algorithm that is based on a set of decision trees derived by repeatedly selecting random subsets of training data and applying them to the layers in the band stack to create predictive models. By creating multiple models of decision trees, the best model and combination of information from the information in the band stack is determined and better prediction performance is obtained (Ho 1995). 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, Natural Bare Ground was added to account for undisturbed bare areas, the Disturbed Vegetation class was added to account for non-agricultural human impacted low vegetation (e.g., managed or manicured vegetation), and the Agricultural Depression class was added to account for altered wetland basins in agricultural fields. Finally, the Alberta Base features Roads layer was used to add in a Roads class to complete the 16-class “Level 2” land cover classification (Table 3). The two classifications were then mosaicked together and clipped to within 50 m of the shoreline of assessed waterbodies. Quality control and editing for the 50m buffer area was then completed using ArcGIS Basemap imagery from 2020 to ensure the land cover was up to date, and this final buffer land cover classification was used to assess riparian intactness.

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

Data Layer	Year	Source	Usage
SPOT 6 Satellite Imagery	2017	Government of Alberta	Derivation of land cover classification
15 m LiDAR DEM	n/d	Government of Alberta	Derivation of data products for classification
Principal Component Layers 1-4	2017	Fiera Biological. Layers were created using SPOT 6 satellite data provided by the Government of Alberta	Derivation of land cover classification
Normalized Difference Vegetation Index (NDVI)	2017	Fiera Biological. Layer was created using SPOT 6 satellite data provided by the Government of Alberta	Derivation of land cover classification
Blue Normalized Difference Vegetation Index (BNDVI)	2017	Fiera Biological. Layer was created using SPOT 6 satellite data provided by the Government of Alberta	Derivation of land cover classification
Green Ratio Vegetation Index (GRVI)	2017	Fiera Biological. Layer was created using SPOT 6 satellite data provided by the Government of Alberta	Derivation of land cover classification
Iron Oxide Index (IOI)	2017	Fiera Biological. Layer was created using SPOT 6 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
Cost Distance to Water	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	2019	Alberta Base Features	Derivation of land cover classification
Mean Summer Temperature	2013-2018	Fiera Biological. Layers created using Landsat 8 imagery	Derivation of land cover classification
Mean and Standard Deviation of NDVI	2013-2018	Fiera Biological. Layers created using Sentinel 2 imagery	Derivation of land cover classification
ABMI Human Footprint	2018	Alberta Biodiversity Monitoring Institute	Semi-automated clean up of classification
6 m Land Cover	2020	Fiera Biological. Layer was created using SPOT 6 satellite data provided by the Government of Alberta and derived layers and edited using 2020 ERSI basemaps.	Derivation of RMAs and quantification of intactness metrics

Table 3. Land cover classes that were used to derive the land cover classification used to assess riparian intactness in the Tawatinaw River HUC 8 watershed.

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	Vegetation cover that is at least 1/3 shrub (low/short woody plants), with little or no presence of tress (<10% tree crown closure). Includes upland shrub and riparian shrub (e.g. shrub on gravel bars, shrub around marshes).
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).
Wetland*	Marsh	Low lying areas dominated by emergent or graminoid vegetation and depressional areas adjacent to streams/creeks and lakes.
	Swamp	Depressional areas dominated by deciduous tree or shrub cover.
	Woody Fen	Depressional areas dominated by woody vegetation cover (trees or shrubs) where surface water flow is apparent.
	Graminoid Fen	Depressional areas dominated by graminoid vegetation cover where surface water flow is apparent.
Agricultural Depression	Agricultural Depression	Human impacted/altered wetland basins in agricultural areas lacking intact emergent vegetation. In croplands these basins are typically cultivated and/or drained, and in pasture these low lying areas may be drained and/or utilized for agricultural purposes such as providing water for cattle.
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.

*NOTE: The wetland class names included in this land cover classification are similar to those used in the Alberta Wetland Classification System; however, this land cover classification should not be considered to be a wetland inventory.

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. The Natural Bare Ground and Agricultural Depression (Mineral – Disturbed Graminoid) classes were not included in the accuracy assessment because they each accounted for less than 0.1% of the land cover, and acquiring enough independent samples for the accuracy assessment was not feasible. A total of 123 samples were used to assess accuracy, with a minimum number of 5 samples for each validated class.

Overall accuracy at Level 1 for the classification was 91.1% with a Kappa statistic of 0.88 (Table 4). Class accuracies were high for all classes. Minor mixing occurred between the forest and wetland classes; however, upon review of the validation samples, the confusion was between upland woody cover and wetland woody cover, which does not impact the calculation of the riparian intactness scores. A qualitative review of the land cover classification was also performed. Users of this land cover classification may want to consider that many riparian areas next to streams and rivers are classified as wetland cover classes (e.g., Swamp, Marsh) throughout many parts of the study area.

While the riparian assessment results for this study 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.

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

	Agriculture	Built Up	Disturbed Vegetation	Forest	Natural Grassland	Open Water	Wetland	User Accuracy
Agriculture	17	0	1	0	0	0	0	94%
Built Up	0	5	0	0	0	0	0	100%
Disturbed Vegetation	0	0	4	0	0	0	0	100%
Forest	0	0	0	29	0	0	4	88%
Natural Grassland	0	0	0	1	7	0	1	78%
Open Water	0	0	0	0	0	5	0	100%
Wetland	0	0	0	4	0	0	45	92%
Producer Accuracy	100%	100%	80%	85%	100%	100%	90%	91.1%

NOTE: Producer accuracy measures errors of omission, which is a measure of how well real-world land cover types can be classified. User accuracy measures errors of commission, which represents the likelihood of a classified pixel matching the land cover type of its corresponding real-world location. For example, for the Agriculture class, all of the mapped areas classified as agriculture were agriculture when compared to "real life", which gives a Producer's Accuracy of 100%; however, when validation points were assessed to see if they matched the associated mapped class (e.g., Built Up, Disturbed Vegetation, etc.), some of these "real life" points were mapped as agriculture.

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 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 derived the land cover layer for this project.

Figure 3. Example of the spatial inaccuracies associated with stream boundaries, where the location of the stream centre 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 centre 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 watershed. 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).

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. 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.

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., Wetland, 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. As part of this project, a naming schema for newly assessed waterbodies was developed and applied to ensure that each waterbody could be identified uniquely and summarized individually. Features were named using the following set of rules:

- **Named Lakes and Streams** – Lakes, 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.
- **Unnamed Lakes** – Lakes with no name in either of the provincial hydrography datasets were assigned a unique ID by combining “UL” with the HUC 6 numeric ID code, along with a number starting at 01 and increasing sequentially.

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: Wetland (Mineral-Woody, Mineral-Graminoid, Peat-Woody, Peat-Graminoid), Forest (Coniferous, Deciduous, Shrub), and Natural Grassland. To quantify Metric 2, the percent cover of Forest (Coniferous, Deciduous, Shrub) and Treed Wetland (Mineral-Woody, Peat-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, Agricultural Depression (Mineral – Disturbed Graminoid), Disturbed Vegetation, and Built Up/Exposed.

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.

4.0 Results

4.1. Riparian Management Area Intactness

In this study, riparian intactness was calculated for approximately 226 km of shoreline. Overall, 68% of the shoreline that was assessed was classified as High Intactness, with a further 13% classified as Moderate Intactness (Figure 4; Map 6 and Map 7). Approximately 19% of the shoreline was classified as either Low (6%) or Very Low (29%) Intactness.

Spatially, areas of High Intactness were generally concentrated along the Tawatinaw River within the central portion of the watershed, where forest cover is more dominant. Areas of Low and Very Low Intactness were most concentrated in the southern part of the watershed, around Helliwell Lake and at the headwaters of the Tawatinaw River. Additionally, RMAs classified as Very Low Intactness become more frequent along the Tawatinaw River towards the Town of Athabasca. These areas of Very Low Intactness areas were generally associated with human settlements and with areas predominated utilized for agriculture (Map 6 and Map 7).

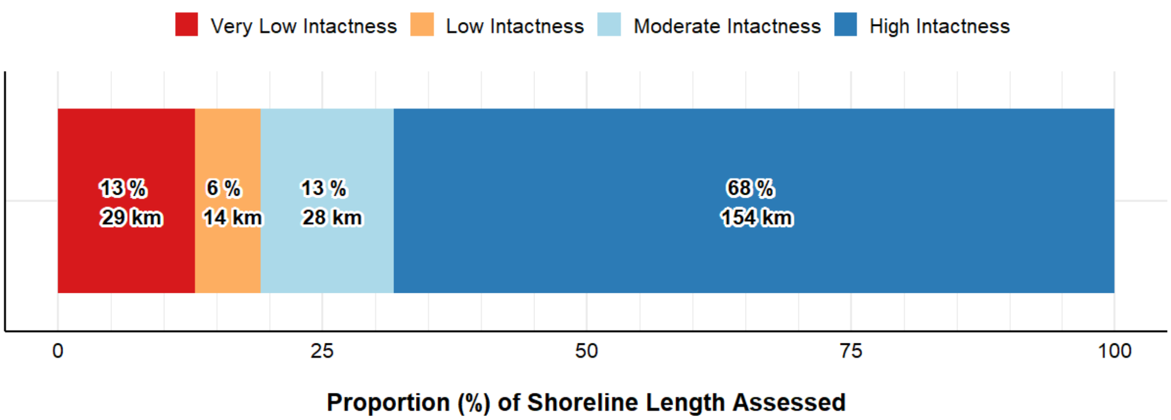
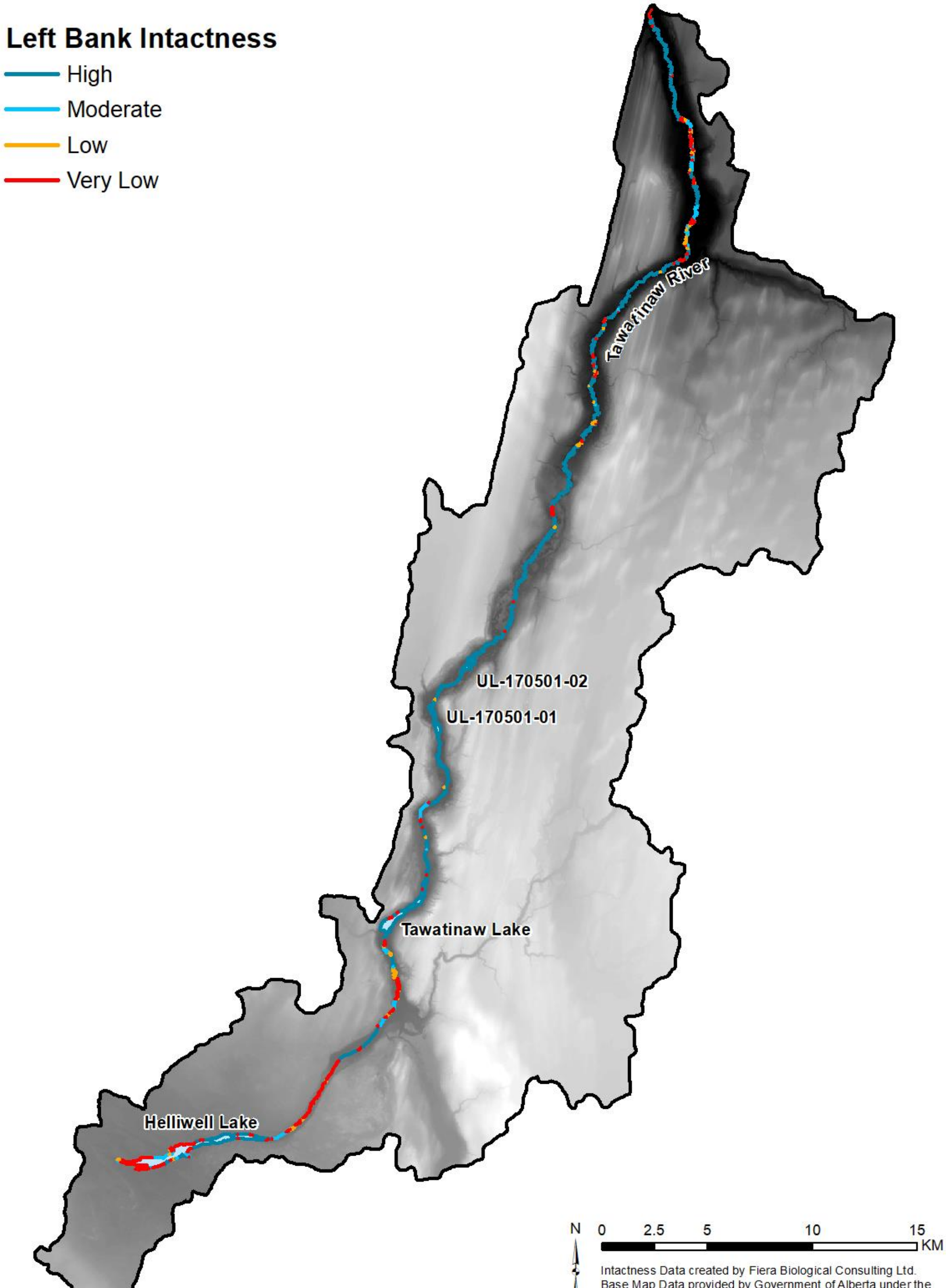
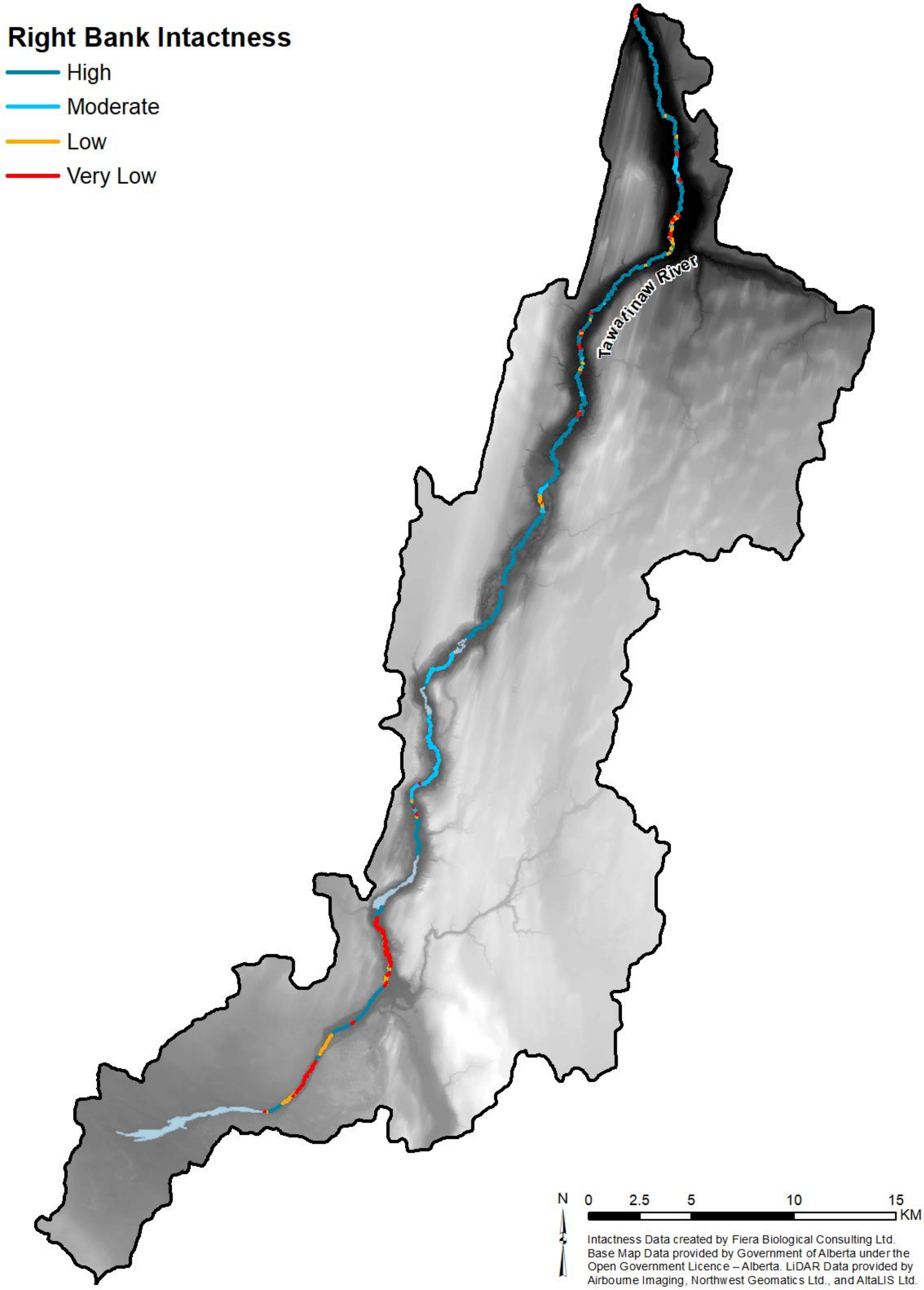


Figure 4. The total proportion of shoreline within the Tawatinaw River HUC 8 watershed assigned to each riparian intactness category.



Map 6. Intactness for the left bank of the Tawatinaw River and the lakes that were included in this study.



Map 7. Intactness for the right bank of the Tawatinaw River.

The amount of shoreline assessed, and the intactness of the shoreline varied for each of the waterbodies assessed (Figure 5). The greatest length of shoreline evaluated as part of this study was associated with the Tawatinaw River, which accounted for 193 km (or 85%) of the shoreline assessed. Originating at the south end of the watershed, the Tawatinaw River flows northward out of Helliwell Lake and towards the Town of Athabasca, where it discharges into the Athabasca River. The Tawatinaw River had just over two-thirds (68%) of its shoreline assessed as High Intactness (Figure 5), with the majority of this area being located within the central portion of the watershed between Rochester and Meanook. Conversely, river shoreline classified as Low or Very Low Intactness was associated with agricultural lands primarily located between Helliwell Lake and Tawatinaw Lake, with additional pockets of Low or Very Low Intactness shoreline occurring towards the Town of Athabasca (Map 6 and Map 7).

Located at the south end of the watershed, Helliwell Lake is the headwaters for the Tawatinaw River, and of the waterbodies assessed in this study, this lake had the greatest proportion of its shoreline assessed as Very Low Intactness (38%; Figure 5). Areas of Low or Very Low Intactness were concentrated along the west side of the lake, and were generally associated with agricultural land use (e.g., pasture areas). Conversely, just under half (46%) of the lake shoreline was classified as Very High Intactness, and these areas were concentrated around the eastern portion of the lake where more intact natural cover occurs.

The remaining lakes - Tawatinaw Lake and two unnamed lakes – were all associated with the Tawatinaw River and these waterbodies had a very high proportion of their shorelines assessed as High Intactness (Figure 5). Only 4% of the shoreline of Tawatinaw Lake, which accounts for less than a kilometer, was classified as Very Low Intactness. These areas were associated with rural yards that abut the lake shore, as well as areas that appear to be utilized as pasture.

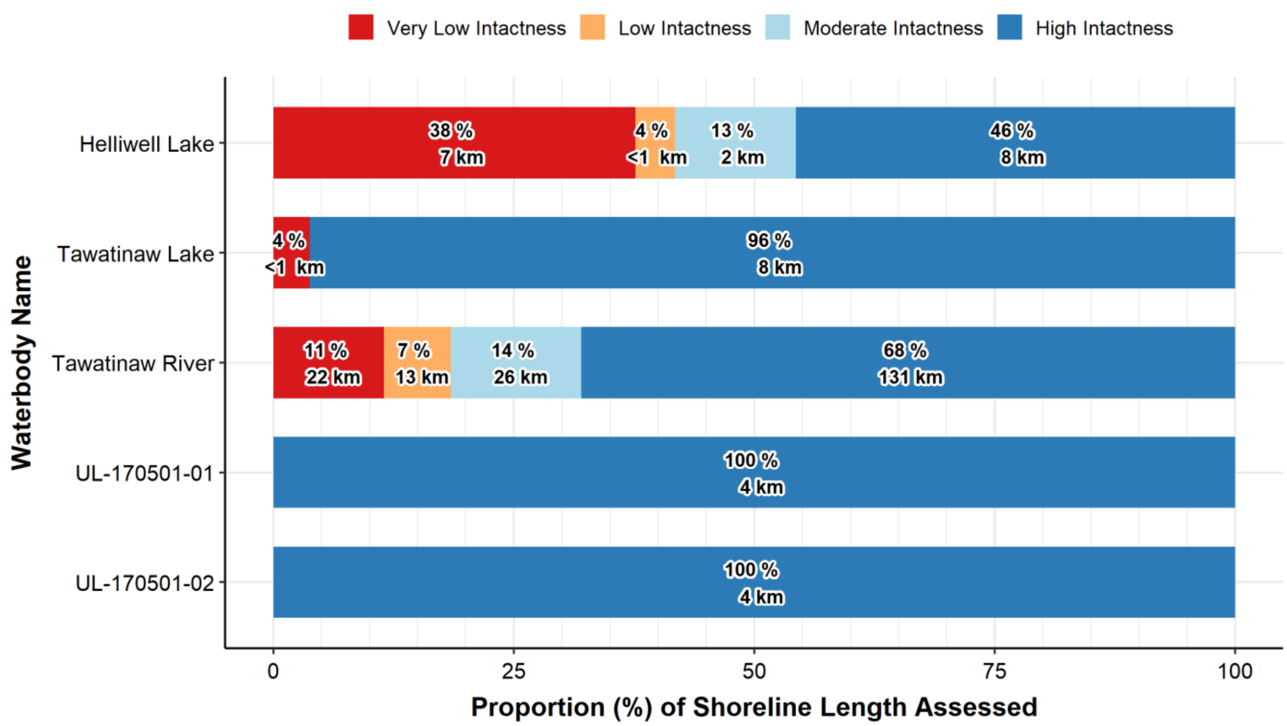


Figure 5. Proportion and length of shoreline assigned to each riparian intactness category for the waterbodies assessed in this study.

4.2. Intactness by Reach

Riparian intactness results were summarized at local scales along the Tawatinaw River by splitting the river into reaches. The start and end points of the reaches were based on locations of Hamlets along the river. The four reaches defined from south to north were: Helliwell Lake to Rochester, Rochester to Perryvale, Perryvale to Meanook, and Meanook to the Town of Athabasca (Map 4). The longest reach (69 km) was located between Helliwell Lake and Rochester, and this reach also had the greatest amount of shoreline (22 km) classified as Very Low intactness (Figure 6). Conversely, the Perryvale to Meanook, and Meanook to Athabasca reaches had the greatest length of shoreline assessed as High Intactness. A more detailed description of intactness within each of the four defined river reaches is provided below.

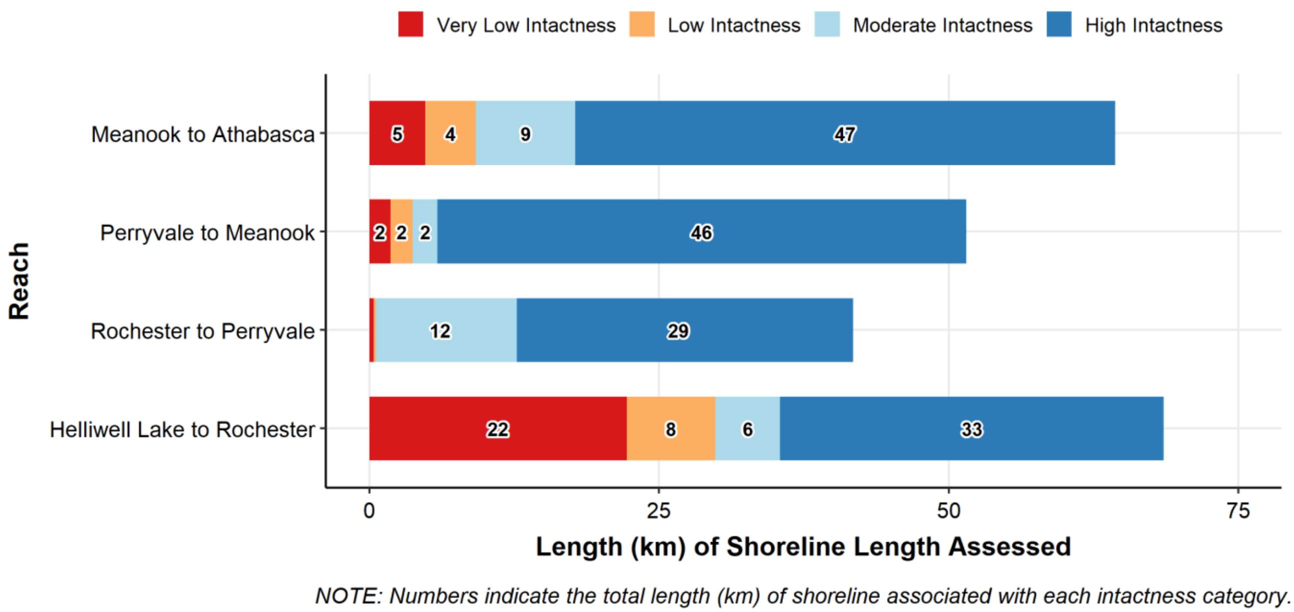


Figure 6. The length of shoreline assigned to each riparian intactness category, summarized by reach.

4.2.1. Helliwell Lake to Rochester

The reach from Helliwell Lake to Rochester is at the southern extent of the watershed and includes three waterbodies: Helliwell Lake, the Tawatinaw River, and Tawatinaw Lake (Map 8, Map 9). Of the four reaches that were assessed, this reach had the greatest proportion (32%) and length (22 km) of shoreline assessed as Very Low Intactness (Figure 7). The majority of the Very Low Intactness RMAs were associated with Helliwell Lake and the Tawatinaw River (Figure 7). Conversely, RMAs within the northernmost part of the reach were predominantly classified as Very High Intactness, including Tawatinaw Lake, which had 96% (8 km) of its shoreline assessed as Very High Intactness (Figure 7). Within this reach, RMAs classified as Very Low Intactness were associated with agricultural land use (primarily pasture lands), road crossings, and human settlements (Map 8, Map 9).

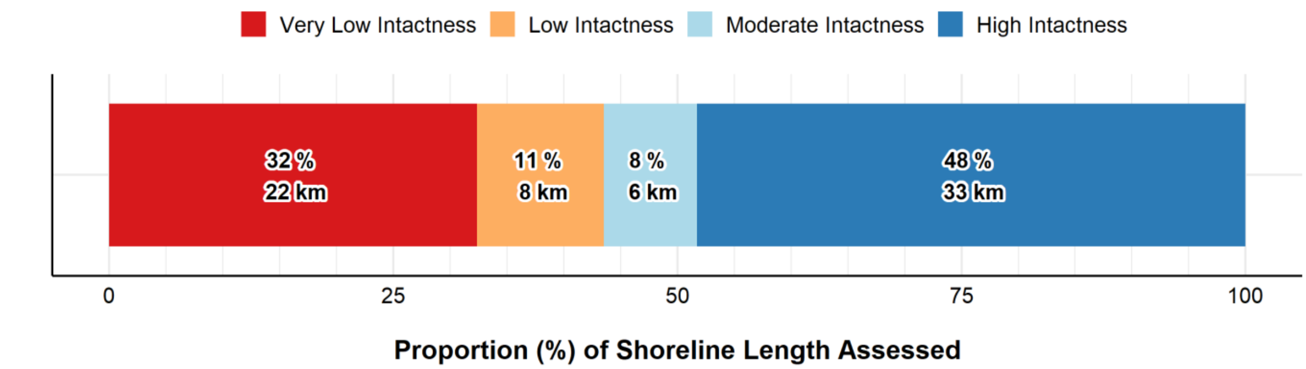


Figure 7. Proportion and total length of shoreline assigned to each riparian intactness category from Helliwell Lake to Rochester.

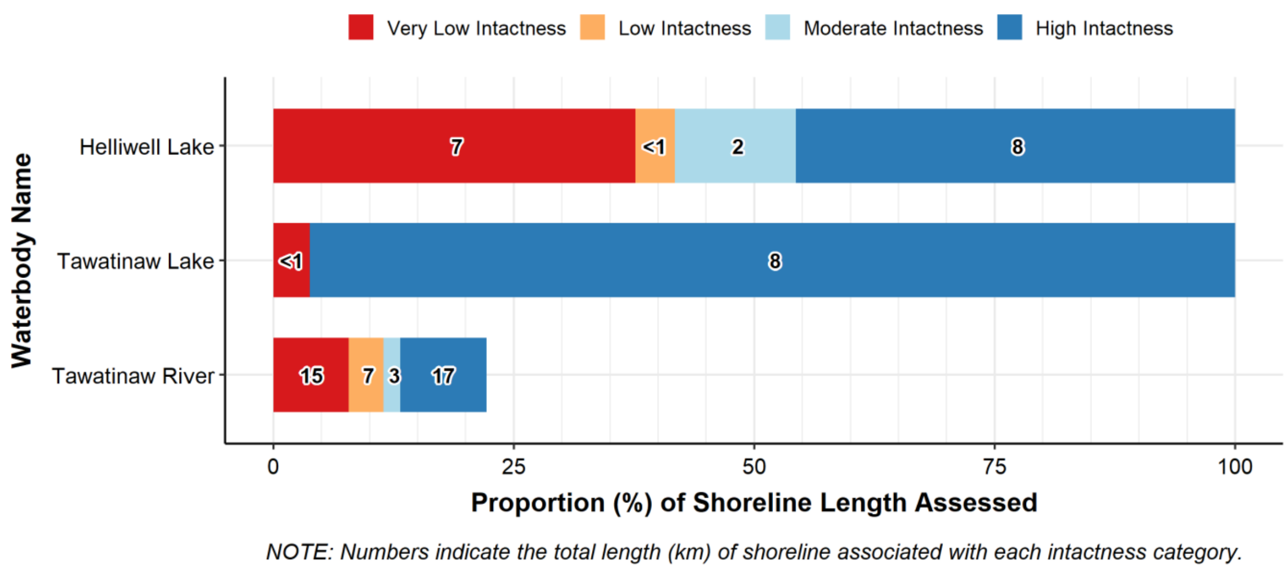
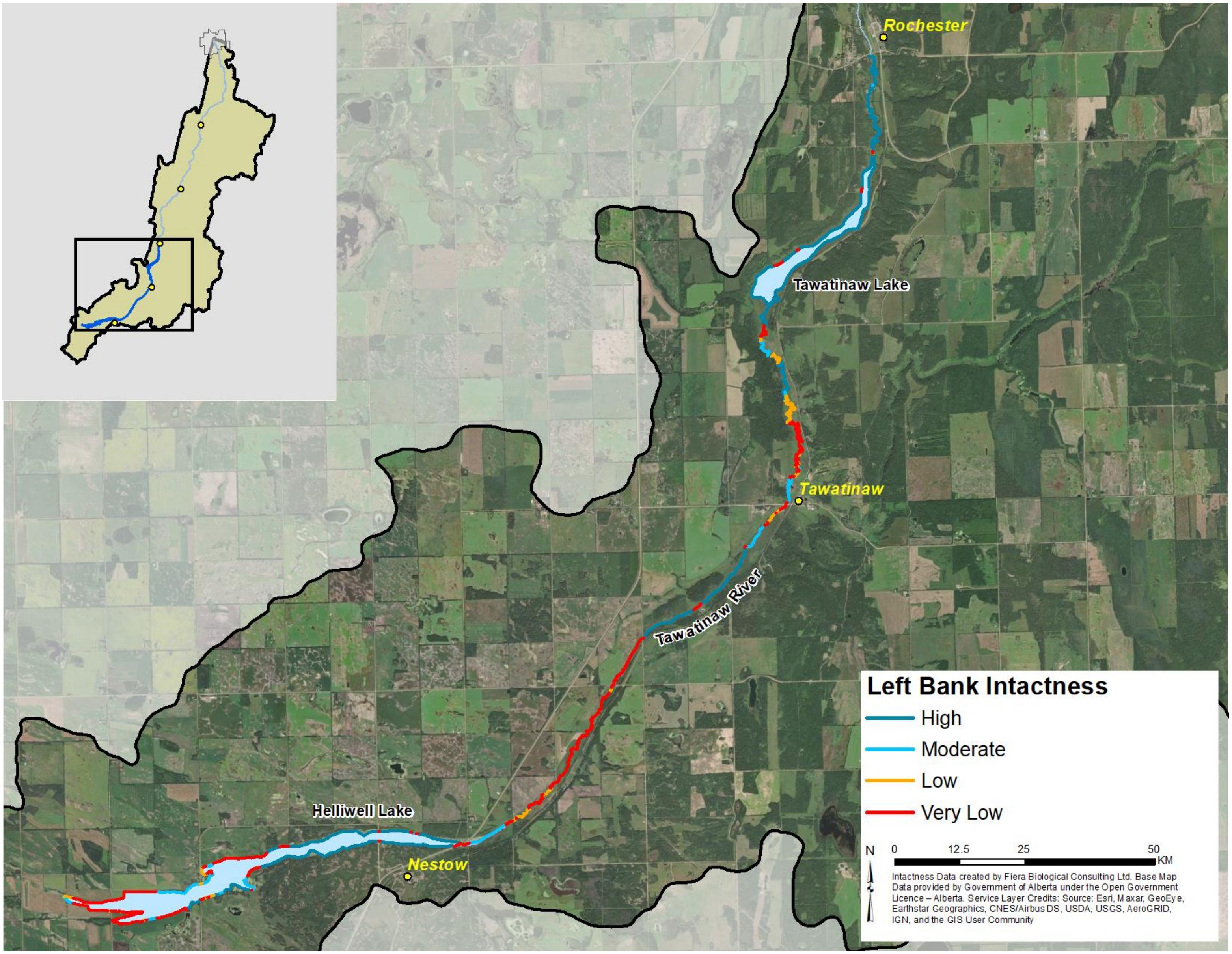
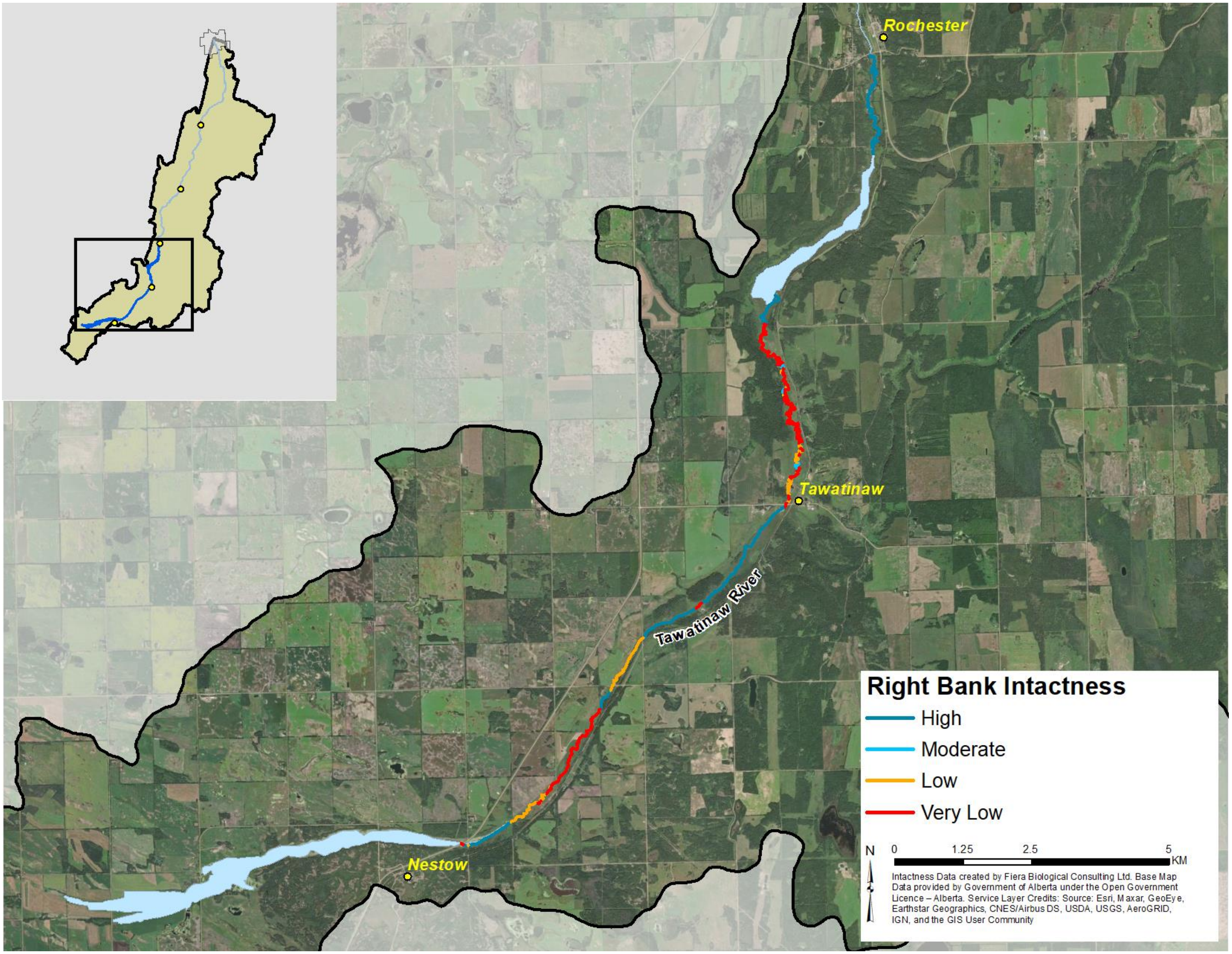


Figure 8. The length of shoreline assigned to each riparian intactness category in this reach, summarized by waterbody.



Map 8. Intactness for the left bank and lake shorelines within the Helliwell Lake to Rochester reach.



Map 9. Intactness for the right bank within the Helliwell Lake to Rochester reach.

4.2.2. Rochester to Perryvale

The reach from Rochester to Perryvale is located within the central portion of the watershed and includes three assessed waterbodies: the Tawatinaw River and two unnamed lakes (UL-170501-01 and UL-170501-02). This reach had 70% (29 km) of shoreline assessed as Very High Intactness, with an additional 29% (12 km) assessed as Moderate Intactness (Figure 9). Less than 1% of the shoreline in this reach was classified as Low or Very Low Intactness. When considered by waterbody, all three waterbodies had the majority of their shorelines assessed as Very High Intactness (Figure 10). RMAs classified as Moderate, Low, or Very Low Intactness were associated with the Tawatinaw River and were concentrated near the Hamlet of Rochester (Map 10, Map 11). The majority of the shoreline classified as Moderate Intactness was associated with the right bank of the Tawatianw River, as this bank had less woody cover within RMAs compared to the left bank (Map 11).

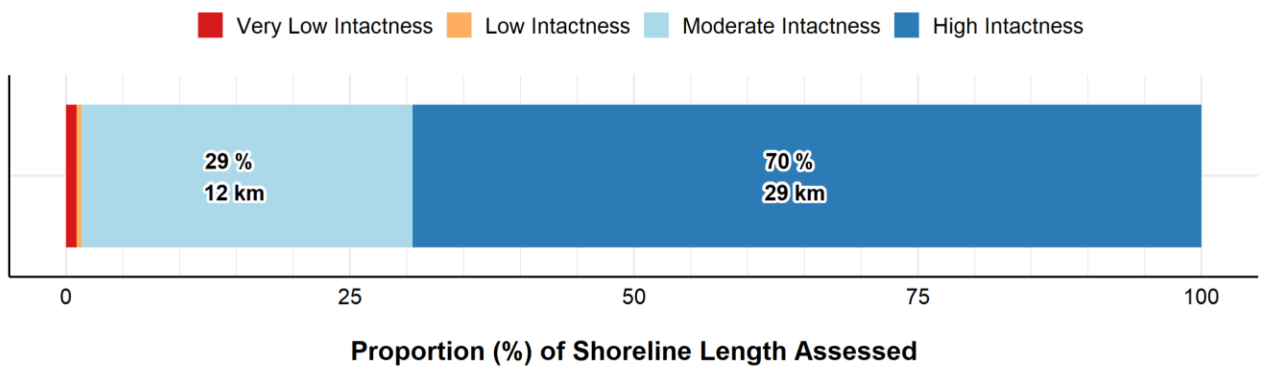


Figure 9. Proportion and total length of shoreline assigned to each riparian intactness category from Rochester to Perryvale.

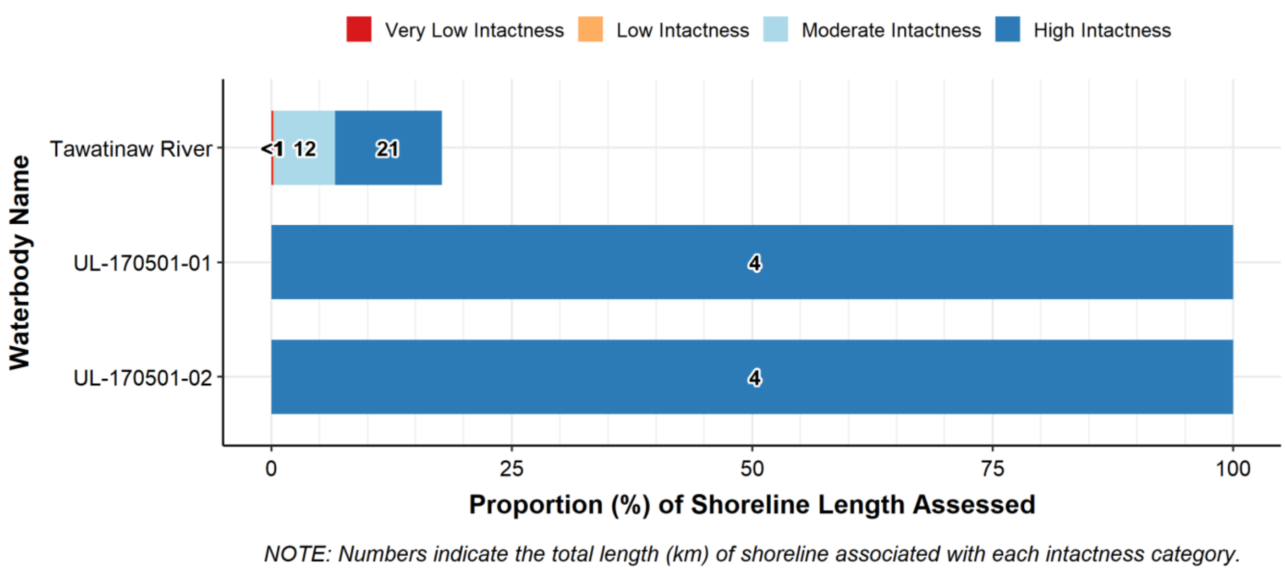
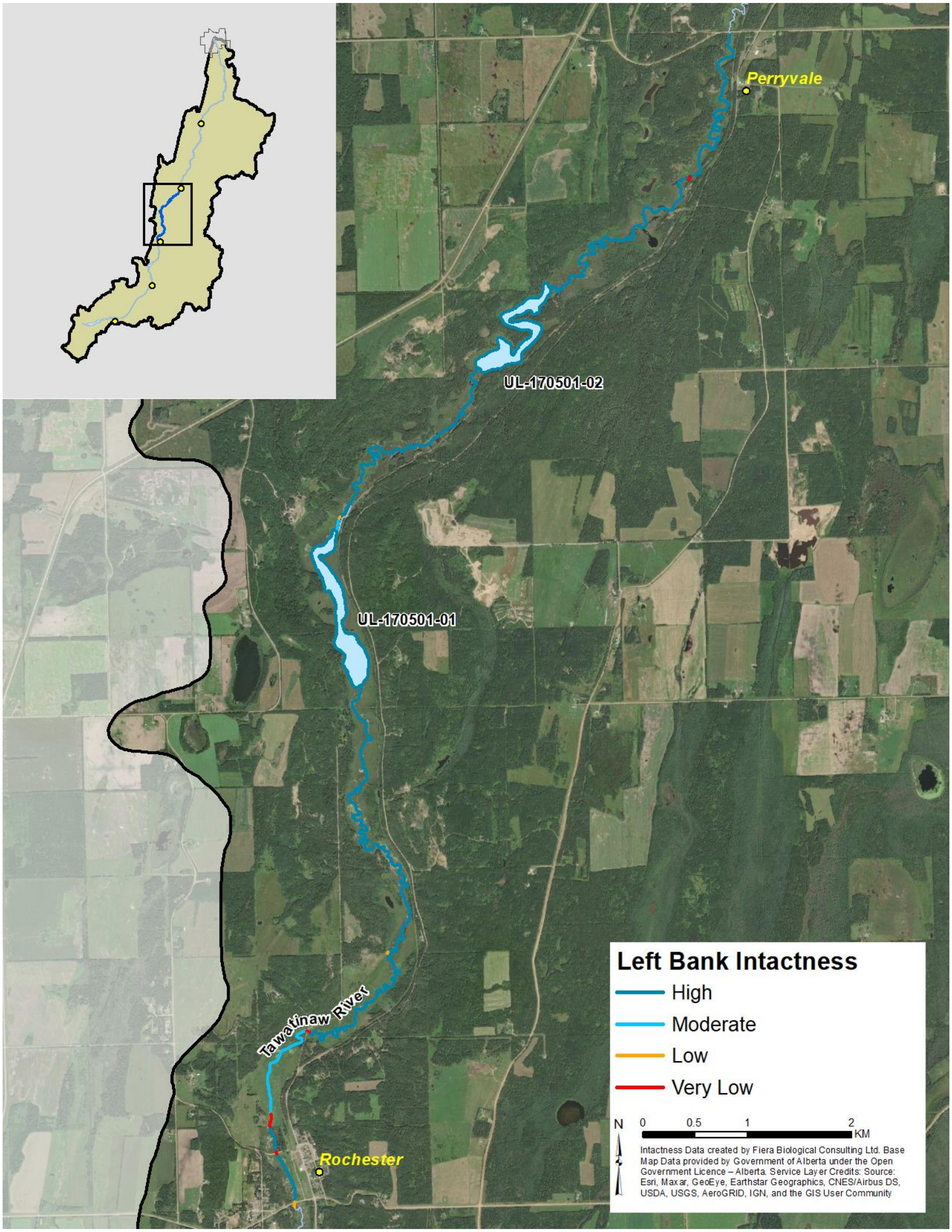
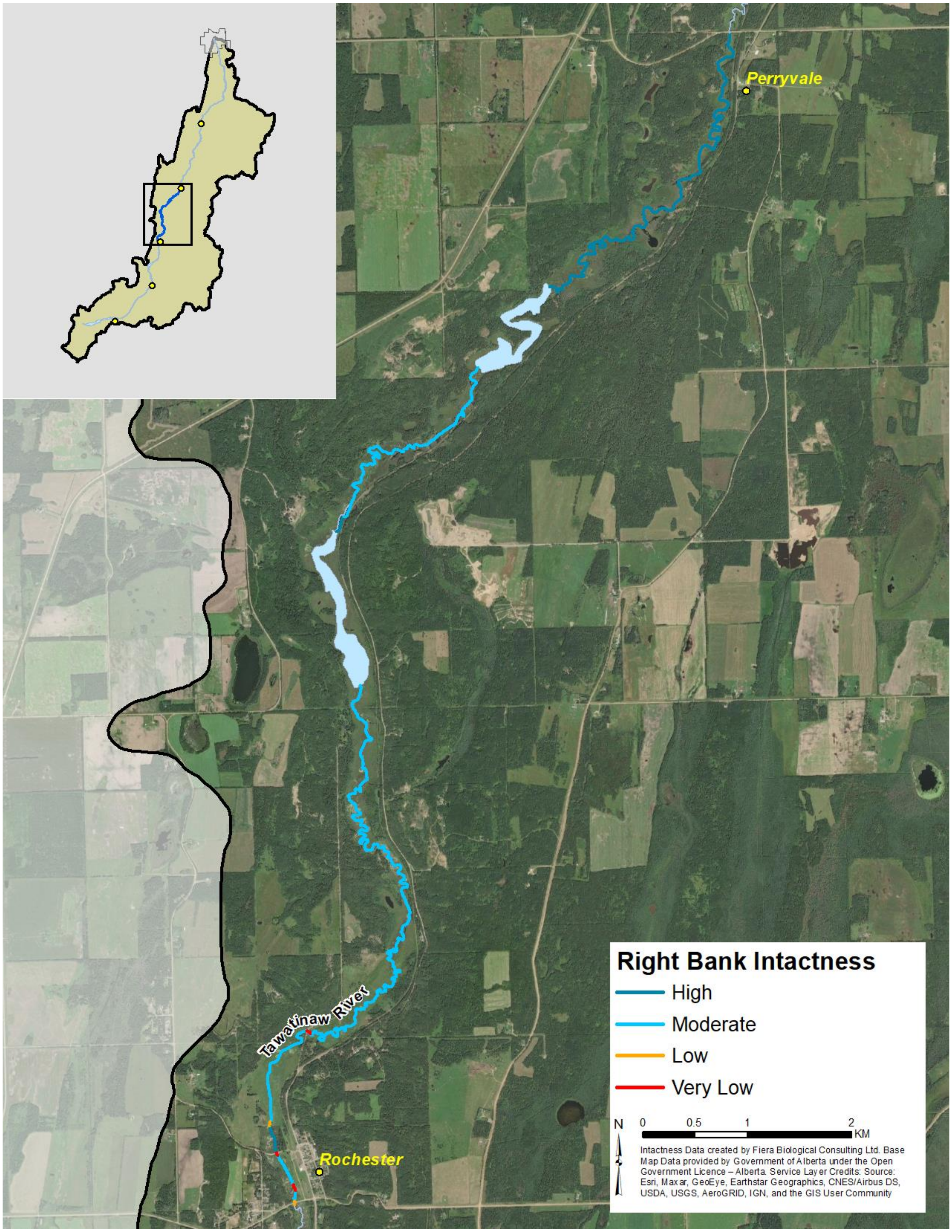


Figure 10. The length of shoreline assigned to each riparian intactness category in this reach, summarized by waterbody.



Map 10. Intactness for the left bank and lake shorelines within the Rochester to Perryvale reach.



Map 11. Intactness for the right bank within the Rochester to Perryvale reach.

4.2.3. Perryvale to Meanook

The Perryvale to Meanook reach includes 52 km of shoreline, all of which is associated with the Tawatinaw River, and accounts for 27% of the river's shoreline (Figure 11and Figure 12). Within this reach, 89% (46 km) of the river's shoreline was assessed as Very High Intactness, with 4% (2 km) being classified as Moderate, Low, or Very Low Intactness (Figure 11). The locations of RMAs classified as Low and Very Low Intactness within this reach were generally associated with agricultural land use and were located near the Hamlet of Meanook where settlement and clearing has occurred (Map 12, Map 13).

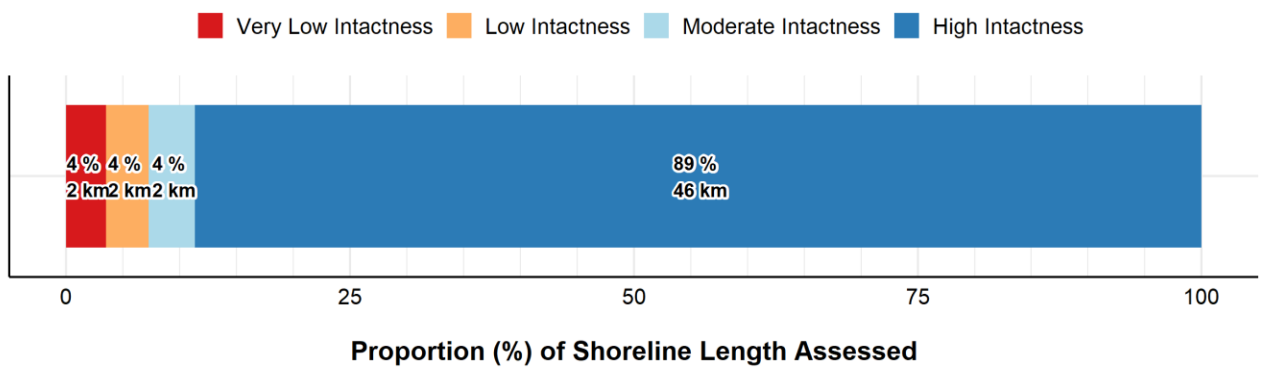


Figure 11. Proportion and total length of shoreline assigned to each riparian intactness category from Perryvale to Meanook.

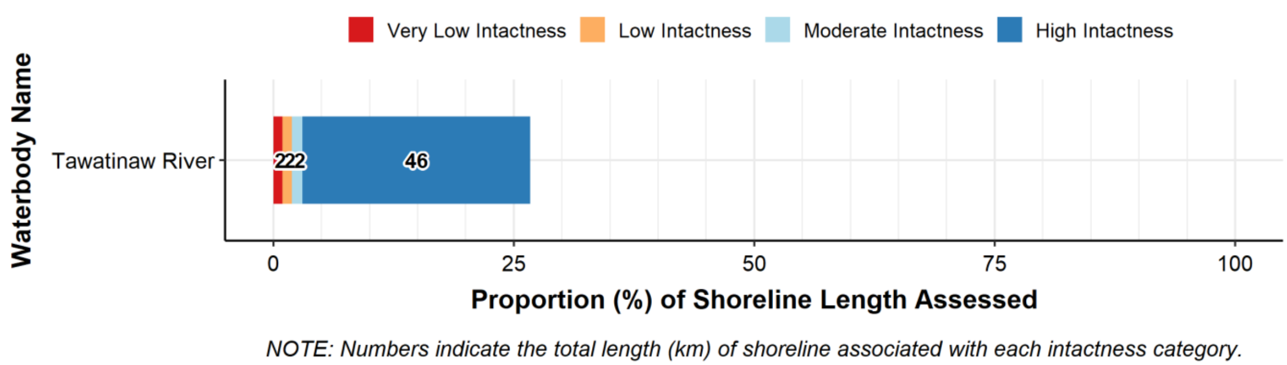
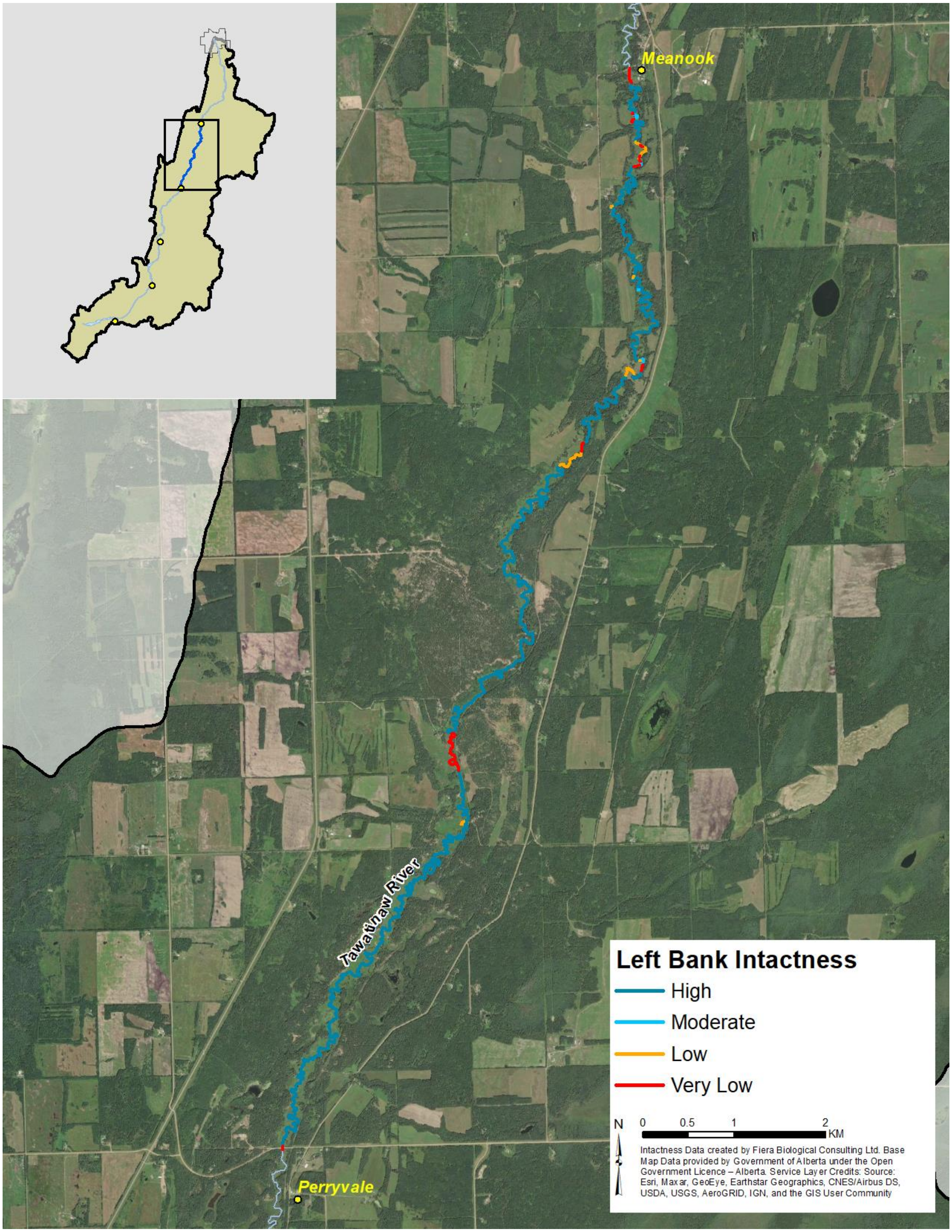
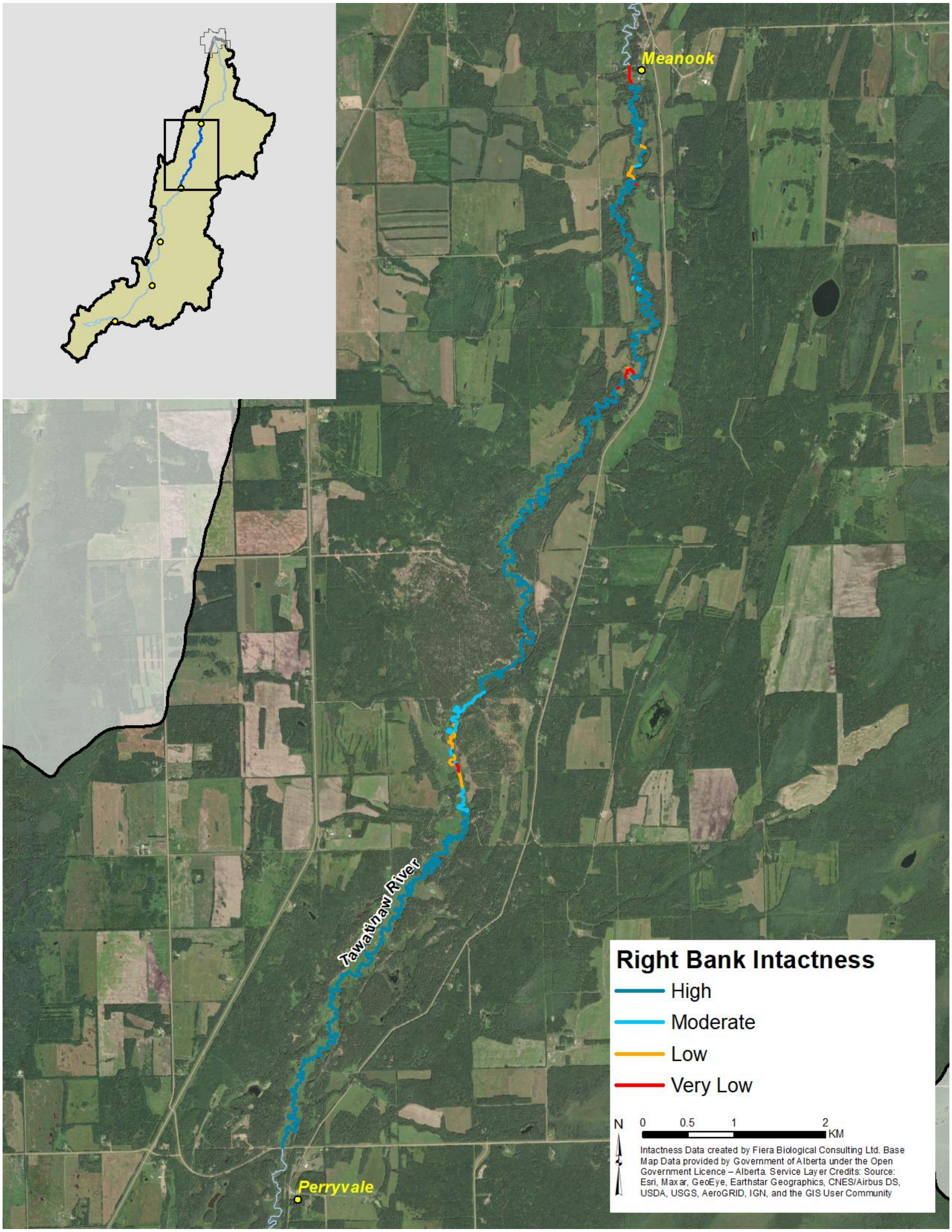


Figure 12. The length of shoreline assigned to each riparian intactness category in this reach, summarized by waterbody.



Map 12. Intactness for the left bank within the Perryvale to Meanook reach.



Map 13. Intactness for the right bank within the Perryvale to Meanook reach.

4.2.4. Meanook to the Town of Athabasca

The reach from Meanook to the Town of Athabasca is located within the northernmost portion of the watershed, and includes 64 km (33%) of shoreline that is associated with the Tawatinaw River (Figure 13 and Figure 14). Within this reach, 72% (47 km) of the river's shoreline was assessed as Very High Intactness, with an additional 13% (9 km) being assessed as Moderate Intactness. The remaining 14% of shoreline was assessed as Low or Very Low Intactness (4 km and 5 km, respectively). RMAs classified as Low and Very Low Intactness were primarily located near the Hamlet of Colinton, and north towards the Town of Athabasca, where human settlements and agricultural land use occur close to the shoreline (Map 14 and Map 15).

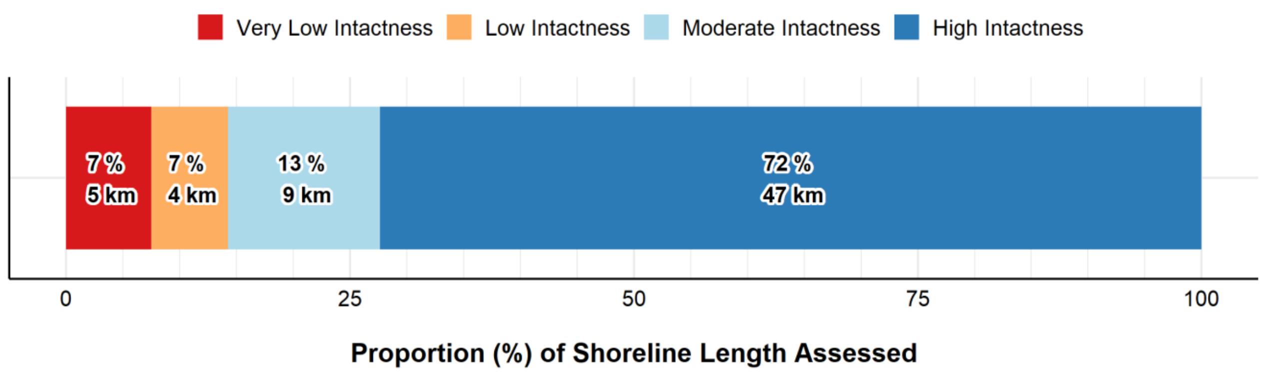


Figure 13. Proportion and total length of shoreline assigned to each riparian intactness category from Meanook to Athabasca.

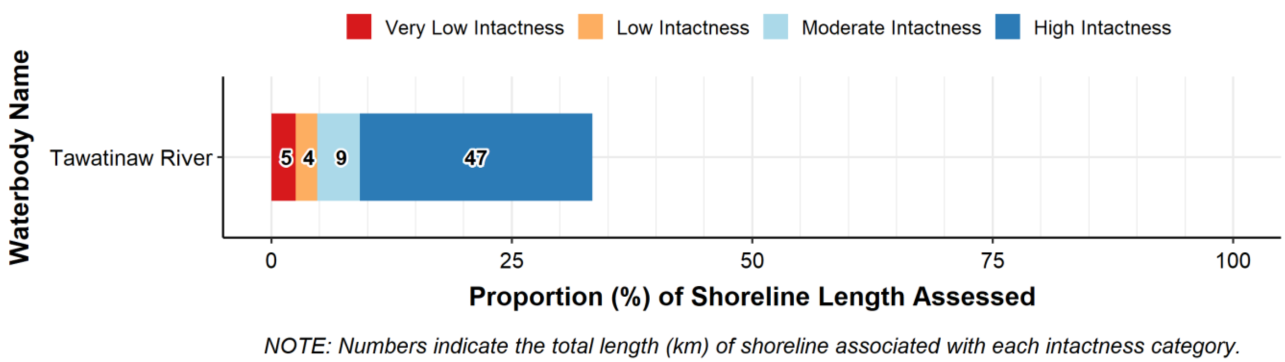
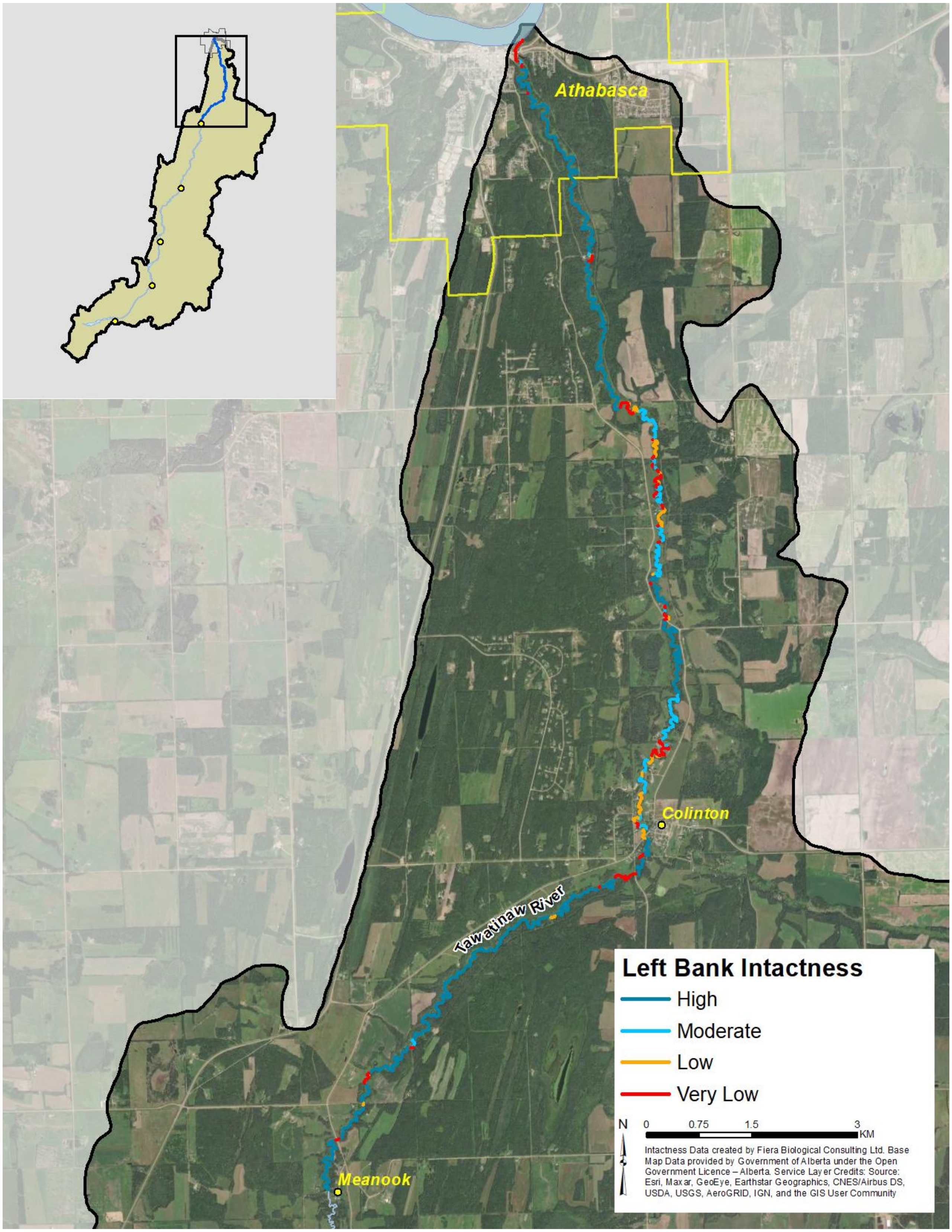
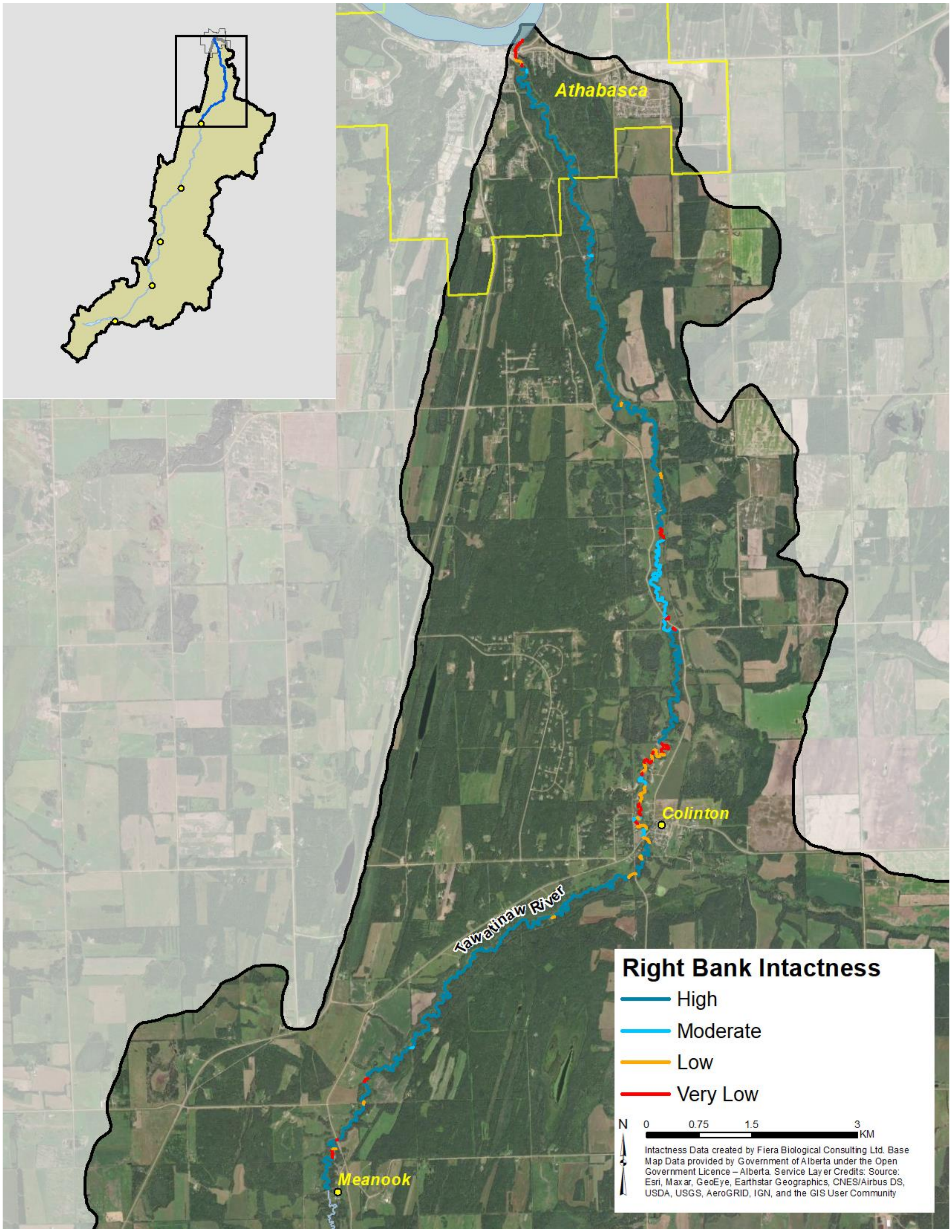


Figure 14. The length of shoreline assigned to each riparian intactness category in this reach, summarized by waterbody.



Map 14. Intactness for the left bank within the Meanook to Athabasca reach.



Map 15. Intactness for the right bank within the Meanook to Athabasca reach.

5.0 Creating a Riparian Habitat Management Framework

Foundational to any conservation planning exercise is the collection and generation of scientific information that can be used as the basis for the development and implementation of an evidence-based adaptive management framework. Through the commissioning of this study, the AWC and its stakeholders have an important foundation of scientific evidence upon which to build a systematic and adaptive framework for riparian habitat management in the Tawatinaw River HUC 8 watershed.

Importantly, the next step in the advancement of meaningful riparian management and conservation in the watershed will be to formalize a framework for action that includes a consideration of the current conditions (baseline) and defining achievable outcomes and measurable targets, which can then be used to inform relevant collective action by key stakeholders. 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 management and conservation outcomes in the watershed is the development of a framework with specific objectives for riparian land management. 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 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 for the watershed 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 with stakeholders, we provide a number of recommendations below that may be considered in the development of a riparian management plan.

5.1. Recommendations for Management

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 and economies. Below we outline some general riparian management objectives that could be adopted, 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; further discussion about potential actions that can be undertaken to improve riparian habitat management is provided in Section 6. Note that this list of management objectives is not exhaustive, and there may be other important riparian habitat management objectives defined by stakeholders in the watershed.

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 watershed as a whole, and/or could include measures and targets for riparian habitat conservation at the scale of individual waterbodies, or along the specific reaches defined in this report. For example, riparian vegetation provides proportionately greater benefits to aquatic 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). Thus, there may be a desire to preferentially target riparian habitat along the headwaters of the Tawatinaw River for conservation. Measures for riparian habitat conservation may also be specific to a particular reach where overall intactness values may be below the desired target.

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.

Results from this study provide an important 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. For example, currently, 13% of the shorelines assessed have been classified as Moderate Intactness, with an additional 68% classified as High Intactness, for a combined total of 81% (Table 5). A realistic target could be to increases the total amount of shoreline classified as Moderate or High Intactness to 85%, or alternatively, to increase the proportion of shoreline classified as High Intactness to 75%. Targets could also be set for each individual waterbody. For example, setting a target of having >85% of the shoreline classified as either Moderate or High Intactness would focus restoration efforts on the Tawatinaw River and Helliwell Lake, since these waterbodies do not currently meet this target. As similar target could be applied at the reach scale, which would focus restoration efforts on the Helliwell Lake to Rochester reach.

Table 5. Proportion of riparian areas that have been classified in each of the riparian intactness categories, summarised by various spatial extents (HUC 8 watershed, reach, named streams).

Spatial Extent	Name	Length Assessed (km)	Proportion (%) and length (km) of Shoreline within Intactness Category					
			Very Low	Low	Sum of Very Low + Low	Moderate	High	Sum of Moderate + High
Watershed	Tawatinaw River	226	13% (29.2)	6% (14.1)	19% (43.3)	13% (28.5)	68% (154.4)	81% (182.9)
Reach	Helliwell Lake to Rochester	69	32% (22.2)	11% (7.6)	43% (29.8)	8% (5.6)	48% (33.1)	56% (38.7)
	Rochester to Perryvale	42	1% (0.4)	0.4% (0.2)	1% (0.6)	29% (12.2)	70% (29.0)	99% (41.2)
	Perryvale to Meanook	52	4% (1.8)	4% (1.9)	8% (3.7)	4% (2.1)	89% (45.7)	93% (47.8)
	Meanook to Athabasca	64	7% (4.8)	7% (4.4)	14% (9.2)	13% (8.6)	72% (46.6)	85% (55.2)
Waterbody	Tawatinaw River	193	11% (22.2)	7% (13.4)	18% (35.6)	14% (26.2)	68% (131.0)	82% (157.2)
	Helliwell Lake	18	38% (6.8)	4% (4.1)	42% (10.9)	13% (2.3)	46% (8.2)	59% (10.5)
	Tawatinaw Lake	8	4% (0.3)	0% (0)	4% (0.3)	0% (0)	96% (7.6)	96% (7.6)
	UL-170501-01	4	0% (0)	0% (0)	0% (0)	0% (0)	100% (3.7)	100% (3.7)
	UL-170501-02	4	0% (0)	0% (0)	0% (0)	0% (0)	100% (3.8)	100% (3.8)

Actions:

There are a number of actions that could be taken to achieve conservation targets specified under this objective, 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.
- Continue implement existing setbacks (oil and gas, forestry, agriculture, urban development) and establish new setbacks where none exist. Consider evaluating the effectiveness of existing setbacks using scientific evidence to inform the development of new or the refinement of existing 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 reaches or individual 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). Thus, 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 in the watershed, particularly in areas that are prone to flooding.

At present, 13% of the shoreline assessed in the watershed has been classified as Very Low Intactness, with an additional 6% classified as Low Intactness, for a combined total of 19% (or 43 km; Table 5). As with Objective 1, a target for this objective could include specifying a desire to reduce the length of shoreline that has been classified as Very Low and/or Low Intactness to 15% (34 km). Alternatively, individual targets could be set for each reach and/or waterbody.

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.

6.0 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.

6.1. 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 in the watershed are listed in Table 6.

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 in the watershed is provided in Table 7.

Table 6. List and description of Federal laws and regulations that may apply to the management of riparian areas in the Tawatinaw River HUC 8 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 7. List and description of Provincial laws, regulations, and policies that may apply to the management of riparian areas in the Tawatinaw River HUC 8 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 7 *continued …* List and description of Provincial laws, regulations, and policies that may apply to the management of riparian areas in the Tawatinaw River HUC 8 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, provide public access to the bed and shore of the waterbody or watercourse, prevent development of land that presents a significant risk to persons or property if developed, or to preserve natural features that in the opinion of the subdivision authority should be preserved. 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.

6.2. 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 Tawatinaw River HUC 8 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.

6.3. 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 Tawatinaw River HUC 8 watershed.
>
> **Partnerships:**
>
> Engaging in strategic partnerships to promote voluntary land conservation and management activities on private lands is essential. Central to this is developing partnerships with landowners, 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 Tawatinaw River HUC 8 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.

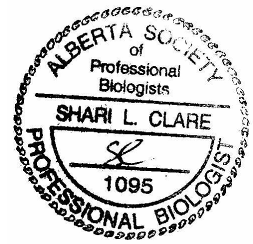
7.0 Conclusion

The overall goal of this project was to quantify and characterize the intactness of riparian management areas along approximately 226 km of shoreline in the Tawatinaw River HUC 8 watershed. The majority of the shoreline (81%, or 182 km) was classified as either High or Moderate Intactness, with the remaining 19% (43 km) of the shoreline classified as Very Low or Low Intactness. The greatest amount of shoreline classified as Low and Very Low Intactness was associated with Helliwell Lake and the Tawatinaw River, within the Helliwell Lake to Rochester reach.

The results of this study provides the AWC and its stakeholders with a foundation of scientific evidence upon which to build a systematic and adaptive framework for riparian habitat management in the Tawatinaw River HUC 8 watershed. A recommended next step for advancing riparian habitat restoration and conservation in this watershed is the establishment of a framework that includes achievable management outcomes and measurable targets, which can then be used to inform relevant collective action by key stakeholders. 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 management through time. Importantly, this study contributes to a larger riparian assessment initiative across central Alberta that has included a number of other Watershed Planning and Advisory Councils, as well as the Government of Alberta, that has assessed nearly 50,000 km of shoreline across Alberta to-date. Combined, these riparian assessments will significantly advance watershed planning and stewardship activities within Alberta.

7.1. Closure

This report was written by:



Shari Clare, PhD, PBiol
Director, Sr. Biologist

Shantel Koenig, MGIS, PhD
Sr. Landscape Ecologist and GIS Specialist

8.0 Literature Cited

Alberta Biodiversity Monitoring Institute (ABMI). 2018. 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.

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.

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 #1762. Prepared for the North Saskatchewan Watershed Alliance, Edmonton, Alberta. Pp. 113.

Fiera Biological Consulting Ltd. 2018c. Strawberry Riparian Area Assessment. Report #1773. Prepared for the North Saskatchewan Watershed Alliance, Edmonton, AB. Pp. 110.

Fiera Biological Consulting Ltd. 2018d. Riparian Assessment for North Saskatchewan Region Lakes. 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. 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. 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. 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. 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.

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.

Palliser Environmental Services Ltd. (PESL). 2021. Tawatinaw River State of the Watershed Report. Prepared for the Fish Creek Watershed Association, Priddis, Alberta. 59 pp. + Appendices..

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.

Wipfli, M.S., and Musslewhite, J. 2004. Density of red alder (Alnus rubra) in headwaters influences invertebrate and detritus subsidies to downstream fish habitats in Alaska. Hydrobiologia 520: 153-163