TOWN OF CHESTERMERE

POLICY HANDBOOK

EFFECTIVE DATE: 7 October 2013	**POLICY: 311**
APPROVED BY: Council	**SUBJECT: Wetland Policy**
REVISED DATE:	**PAGE NO.: 1 of 8**
EXPIRY DATE: 7 October 2018	**POLICY TYPE: Town Policy**

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1.0 Introduction and Policy Context

1.1 Importance of Wetlands

Wetlands and their associated riparian lands are critically important habitats for a variety of aquatic and terrestrial organisms. Compared to upland habitats of equivalent size, wetlands and riparian lands support a higher level of biodiversity. Hydrologically, wetlands are important components of both local and regional watersheds, and provide important ecosystem services to human communities that include water filtration and water treatment. In addition, wetlands stabilization of water supplies through the amelioration of both floods and droughts (Mitsch & Gosselink 2007). Wetland ecosystems also provide a number of other less recognized regulating, provisioning, cultural, and supporting services that significantly contribute to human well-being, such as nutrient cycling, erosion control, pollination, and aesthetic appreciation (Millennium Ecosystem Assessment 2005).

1.2 Wetland Management in Alberta

Wetland loss in Alberta over the last 150 years has been significant, with up to 70% of the wetlands in central and southern Alberta having been lost to agricultural and urban development (Rubec 1994; Alberta Water Council 2008). Within rapidly urbanizing areas, wetland loss has been even more severe, with wetland loss in the Calgary region estimated to be in excess of 90% (City of Calgary 2004).

The responsibility for managing wetlands and riparian lands in Alberta is shared amongst jurisdictions, from local municipalities through to the provincial and federal governments.
Provincially, the Government of Alberta has jurisdiction under the *Water Act* to manage all water in the province and all activities that have the potential to impact a water body, including wetlands, requires an approval. In addition, the province has jurisdiction over "public lands" (regulated under the *Public Lands Act*), which includes the bed and shore of all permanent water bodies, regardless of whether these water bodies are located on private land.

The management of wetlands is also directed by the provincial government through a wetland policy that applies to both private and public land in the settled region of the province. The stated goal of this policy is to "sustain the social, economic, and environmental benefits that functioning wetlands provide, now and in the future" (Alberta Water Resources Commission 1993). In order to achieve this policy goal, the province has adopted a mitigation sequence: First, avoid impacts and conserve wetlands in a natural state; second, minimize unavoidable impacts; and third, compensate for irreducible impacts through the use of wetland restoration, enhancement, creation, or protection (Alberta Water Resources Commission 1993; Rubec & Hanson 2008). In addition, the government recently released best management practices for the management of riparian lands in the settled region of the province, which includes guidelines and recommendations for appropriate development setbacks on water bodies and watercourses (Government of Alberta 2012).

Municipal governments also play a critical role in the conservation and management of wetlands. Under the *Municipal Government Act,* each municipality is required to developstatutory planning documents that provide a framework and vision for land use and land development within their jurisdiction. Within these statutory documents, municipalities are required to provide specific direction for development requirements in or near wetlands and riparian lands, and can set forth minimum development setback widths on Environmental Reserve (ER), environmentally sensitive land, or water bodies and watercourses. Under the direction set out by the *Municipal Government Act* and the municipal Land Use Policies, many municipalities throughout the province have taken the initiative to enact policies that provide guidance on how wetlands and riparian lands should be managed within their jurisdictional boundaries. It is under this authority that Chestermere has developed a Wetland and Riparian Land Conservation Policy to manage wetlands within its municipal boundaries.

1.3 Wetlands in the Town of Chestermere

1.3.1 Wetland Inventory

An environmental resources inventory was undertaken in 2012 to identify and classify wetlands within the municipal boundaries of Chestermere (Fiera 2012; Figure A-1). The results of this inventory identified a total of 275 wetlands covering an area of approximately 324 ha (Figure A-2). This included 196 Class I and II wetlands, and 79 Class III to VI wetlands (Table 1; Figure A-3).

Table 1. Stewart and Kantrud classification for the types of wetlands found within the Town of Chestermere (Stewart and Kantrud 1971).

Wetland Class	Description	Defining Vegetation
I	Ephemeral	Wetland low-prairie
II	Temporary	Wet meadow
III	Seasonal	Shallow marsh
IV	Semi-permanent	Deep marsh
V	Permanent	Open water
VI	Alkali	Salt-tolerant

In 2013, Alberta issued a Wetland Policy that articulated an approach for rating the value of wetlands within the Province. Wetlands within future development areas will be assessed under this Provincial rating system. The rating of wetlands based on ecological and hydrologic significance gives decision- makers important information about the relative value of each wetland in the Town of Chestermere. These relative values can be used to prioritize wetland and riparian areas for conservation, such that the impacts of future land use and land development on wetlands of exceptional value can be avoided or minimized.

1.3.2 Ecosystem Services Provided by Wetlands in Chestermere

Wetland ecosystems provide a number of regulating, provisioning, cultural, and supporting services that significantly contribute to human well-being, with some of the most well-recognized services being water storage, flood control, and carbon storage (Millennium Ecosystem Assessment 2005).

In an effort to better understand the economic benefits provided by natural wetlands in Chestermere, the water and carbon storage potential of each wetland identified in the wetland inventory was calculated. In addition, the economic value of flood control and carbon storage provided by wetlands within the municipal boundaries was estimated. Combined, the estimated economic value of carbon storage and flood storage is approximately $11 million (Tables 2 and 3).

Table 2. Total carbon storage potential for wetlands, presented by wetland class, in the Town of Chestermere.

Wetland Class	Carbon Storage (MgC/ha)	Estimated Carbon Storage Value ($)
I	6864	$377,864
II	7463	$410,841
III	7993	$440,035
IV-VI	42,180	$2,321,991
TOTAL	**64,500**	**~$3.5 Million**

Table 3. Water and carbon storage potential for wetlands in the Town of Chestermere.

Wetland Class	Estimated Flood Control Value ($)
I	$1,089,961
II	$880,887
III	$935,732
IV-VI	$4,653,056
TOTAL	**~$7.5 Million**

2.0 Town of Chestermere Wetland and Riparian Land Conservation Strategy

In recognition of the ecological and economic importance of wetlands and riparian lands, and the need for orderly, fair, and transparent management and conservation of these habitats, the Town of Chestermere has developed a Wetland and Riparian Land Conservation Strategy to help direct future land use and land development within its municipal boundaries.

2.1 Policy Goal

This municipal policy follows the principals set out by the provincial wetland policy and the Town of Chestermere Municipal Development Plan (2009) by prioritizing wetland avoidance over impact minimization and compensation for habitat loss. Thus, the goal of this policy is to provide a policy framework to:

Promote the conservation of wetland and riparian land of exceptional value in order to sustain the ecological function of these habitats, such that they may be enjoyed by present and future residents and visitors of Chestermere.

2.2 Rationale for Policy

2.2.1 Conserving and enhancing wetlands and associated riparian lands is in the overall greater public interest, as these lands play a significant role in watershed management.

2.2.2 Wetlands and their associated riparian lands have the capacity to improve water quality, retain sediments, absorb nutrients, degrade pesticides, reduce flooding and soil erosion, recharge groundwater aquifers, moderate climate, and increase biodiversity by providing critical habitat for many species.

2.2.3 Wetlands and their associated riparian lands also contribute to aesthetic urban design and provide for recreational, educational, and economic opportunities for current and future generations.

2.3 Policy Objectives

2.3.1 Conserve Wetlands through Sustainable and Compatible Development

The ecological function of wetlands and riparian lands is inseparably linked to their surroundings. Thus, wetland conservation must be pursued through an integrated approach to environmental conservation and sustainable development

2.3.1.1 The first priority in land use planning is to avoid impacts to wetlands and associated riparian lands that have been rated as having Exceptional or High environmental significance.

2.3.1.2 Development will occur in a manner that maintains a conserved wetland's hydrology.

2.3.1.3 Wetland conservation will be achieved though the utilization of appropriate development setbacks, application of Low Impact Development principles, and adoption of other land use planning tools, such as conservation easements, transfer of development credits, tax incentives, and/or other applicable policy instruments.

2.3.1.4 To ensure the maintenance of water quality, only treated wastewater or stormwater will be discharged into a conserved wetland area.

2.3.1.5 Proponents of all developments within the Town of Chestermere must be compliant with existing requirements under the provincial *Water Act* and *Public Lands Act*, as well as other relevant provincial laws and policies as they relate to wetland and riparian land management.

2.3.2 Manage and Maintain Wetlands for Long-term Sustainability

Wetlands that are conserved as part of the Town's natural area network must be properly managed to ensure they remain viable and sustainable over the long-term.

2.3.2.1 This Policy and its associated implementation plan will be incorporated into all statutory planning documents and Land Use Bylaw provisions

2.3.2.2 Requirements for the long-term operation and maintenance of wetlands and riparian lands set aside for conservation in accordance with this Policy will be considered and incorporated into annual budgeting.

2.3.2.3 Consideration will be given to developing standardized methods and guidelines for preparing a Wetland and Riparian Assessment and developing a Wetland and Riparian Management Plan for all wetlands designated as Environmental Reserve. The purpose of such reports is to ensure that appropriate ecological design principles are being considered in neighbourhood design.

2.2.2.4 The Town of Chestermere will evaluate the effectiveness and review the goals and objectives of this Policy at five-year intervals

2.2.3 Increase Public Awareness and Promote Wetland Stewardship

Increasing public awareness about the critical ecological and economic functions of wetlands is a key component of successful wetland conservation and stewardship in the Town of Chestermere.

2.2.3.1 The Town of Chestermere will make available the best available wetland information to consultants, educational institutions, landowners, and the general public to encourage the protection and appreciation of wetlands and riparian lands

2.2.3.2 The sharing and exchange of information and expertise regarding wetland issues and management among government departments and other jurisdictions will be encouraged.

3.0 Implementation Strategy

3.1 Bylaw adoption

3.1.1 The Town will adopt a bylaw establishing:

3.1.1.1 The biophysical assessment submitted at time of Area Structure Plan or Outline Plan application shall identify the category of wetlands and associated plants and animals present within the plan area consistent with the Stewart and Kantrud classification system.

3.1.1.2 The biophysical assessment submitted at time of Area Structure Plan or Outline Plan application shall identify the value of wetlands within the plan area consistent with the Alberta Wetland Policy.

3.1.1.3 A report shall be provided at time of subdivision application that shall articulate the category and value of wetlands within the plan area and will articulate a plan for avoidance, minimization and / or replacement consistent with the Alberta Wetland Policy and Town of Chestermere wetland by-law provisions.

3.1.1.4 The criteria and process for Town decision-making in regards to submitted plans for avoidance, minimization and / or replacement of wetlands consistent with the Alberta Wetland Policy.

3.1.1.5 Buffers, setbacks, and / or other standard mitigation measures.

3.2 Environmental Reserve & Municipal Reserve Dedication

As authorized under the *Municipal Government Act,* the primary mechanism for conserving wetlands and riparian lands is through the dedication of these areas as Environmental Reserve.

3.1.1 Conserved and constructed wetlands and their associated buffers will be designated as Environmental Reserve at the time of subdivision.

4.0 Definitions

Avoidance is the prevention of impacts to a wetland and associated riparian land by designating lands as Environmental Reserve and applying stipulated development setbacks at the time of subdivision

Conservation is the planned management and wise use of wetlands and riparian lands to ensure they are available for future generations.

Buffers are planned and managed strips of land and vegetation located between wetlands and development sites, which are intended to protect the wetland and sustain its identified ecological functions. In some developing areas, the buffers may be the same as a setback. In others, as a result of detailed investigations, planning studies and site-specific environmental impact studies, the buffer can be a combination of topography, vegetation and soil in a relatively narrow area of land, designed to protect the wetland functions and values.

Legal Bank means the bank of a permanent and naturally occurring wetland as determined by a surveyor in accordance with the Surveys Act, R.S.A. 2000, c.S-40

Minimize is reducing negative impacts on wetlands to the smallest practicable degree during the planning, design, construction, and operational stages of development, and when conducting activities that may harm wetlands.

Permanent Loss is the permanent elimination of wetland value resulting from a reduction / removal of wetland area.

Relative Value is the importance of a wetland from an ecological and human perspective. Using this approach, wetlands are compared across a common list of meaningful metrics and assigned a relative wetland value category.

Riparian refers to lands, habitat and vegetation found in the valley or floodplain of a stream or associated with flowing water

Setbacks are a physical distance separation between a wetland and a proposed building. Setbacks can include pathways, public and / or private green spaces, stormwater management facilities, and other uses as determined appropriate by the Subdivision Authority.

Temporary Wetland Impact is a negative effect on wetland function that can be restored to pre-disturbance conditions within a reasonable time frame, as established through regulatory mechanisms.

Wetlands are lands that are saturated with water long enough to promote wetland or aquatic processes as indicated by the poorly drained soils, hydrophytic vegetation, and various kinds of biological activity that are adapted to a wet environment

Wetland functions are the natural properties and processes (physical, chemical or biological) associated with wetland ecosystems. Wetland functions include the natural processes and derivation of benefits and values associated with wetland ecosystems including economic production (e.g. peat, agricultural crops, wild rice, peatland forest products), fish and wildlife habitat, organic carbon storage, water supply and purification (groundwater recharge, flood control, maintenance of flow regimes, shoreline erosion buffering), soil and water conservation, as well as tourism, heritage, recreational, educational, scientific and esthetic opportunities

Wetland Loss includes infilling, altering, or physically draining a wetland, any impact to the riparian area or buffer strips, and any type of interference with the hydrology to and from a wetland.

Wetland Replacement is compensation for wetland value that has been permanently lost due to human activity on the landscape. Replacement activities under the policy would include both restorative and non-restorative measures. Restorative measures may include wetland restoration, creation or enhancement. Non-restorative measures may include those activities that indirectly advance the goal of conserving wetlands and their value such as research, securement, or education programs.

Figure A-1

Figure A-2

1. **Related Documents:** Fiera 2012 Wetland Inventory (Exhibit A), Chestermere Municipal Development Plan, Alberta Public Lands Act, Alberta Water Act, Alberta Environment Wetland Policy, Municipal Government Act,

Alberta Water Council. 2008. Recommendations for a New Alberta Wetland Policy. Alberta Water Council, Edmonton, Alberta.

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Fiera (Fiera Biological Consulting Ltd. 2012. Environmental Resources Inventory. Report Prepared for the Town of Chestermere. Report #1222.

Government of Alberta. 2012. Stepping back from the water: A beneficial management practices guide for new development near water bodies in Alberta's Settled Region. Edmonton, AB. Available: http://environment.gov.ab.ca/info/library/8554.pdf. Accessed September 24, 2012.

Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: wetlands and water synthesis. Millennium Ecosystem Assessment. World Resources Institute, Washington, DC, USA.

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Rubec, C. D. A. 1994. Wetland policy implementation in Canada: proceedings of a national workshop. Winnipeg, MA, Can.

Stewart, RE and H.A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. Resource Publication 92. Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Washington, D.C. Northern Prairie Wildlife Research Center Home Page.

Adopted by Council: October 7, 2013

Resolution Number: 366-13

MAYOR

CAO

Environmental Resources Inventory

FINAL REPORT

Prepared for:

Town of Chestermere
Development Services Department
105 Marina Road
Chestermere, AB T1X 1V7

May 15, 2013

Report #1222

Prepared by Fiera Biological Consulting

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This report was prepared by Fiera Biological Consulting Ltd. in collaboration with Sassafras Consulting.

FIERA Biological Consulting

Sassafras consulting
Specializing in Landscape Analytics

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1.0 Introduction

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It is under the authority of the *Municipal Government Act* that Chestermere has undertaken the developed a Wetland and Riparian Land Conservation Policy to manage wetlands within its municipal boundaries. A key component of the development of this wetland and riparian policy is an Environmental Resource Inventory that was undertaken to help identify, evaluate, and prioritize wetlands for conservation in the Town of Chestermere. The following report outlines the methods that were used to identify, delineate, and classify wetlands, as well as methods for assessing and assigning relative condition scores for each wetland identified in the inventory. This report also describes and estimates the economic value of some of the important ecosystem goods and services that these wetlands provide to the residents of Chestermere. Finally, the methods used to rank wetlands based on an index of ecological and hydrological condition are outlined, and a final map of wetland significance is presented.

2.0 Study Area

The study area included approximately 2380 ha (5880 acres) of land that has recently been annexed by the Town Chestermere. These lands are located to the west, south, and east of the existing boundaries of the Town of Chestermere (Figure 1). Current land use within this annexed area consisted primarily of intensive agriculture, with smaller areas of low density residential.

3.0 Approach and Results

3.1 Wetland Mapping & Classification

Wetlands were mapped using a combination of methods, including: 1) on-screen digitization of wetland boundaries using high resolution colour aerial photographs; 2) an automated derivation of depressions using a terrain analysis; and 3) time-series mapping of ‘open water’ (standing water not obstructed by vegetation) over a three decade period using satellite imagery. It is important to note that this inventory provides only an estimate of wetland boundaries, as an accurate delineation of wetland area was not the focus of this assessment. Rather, the main objective of this mapping exercise was to identify the location and approximate extent of each wetland for planning purposes. In order to determine the exact extent and area of each wetland, delineation should be carried out using appropriate, standardized field methods.

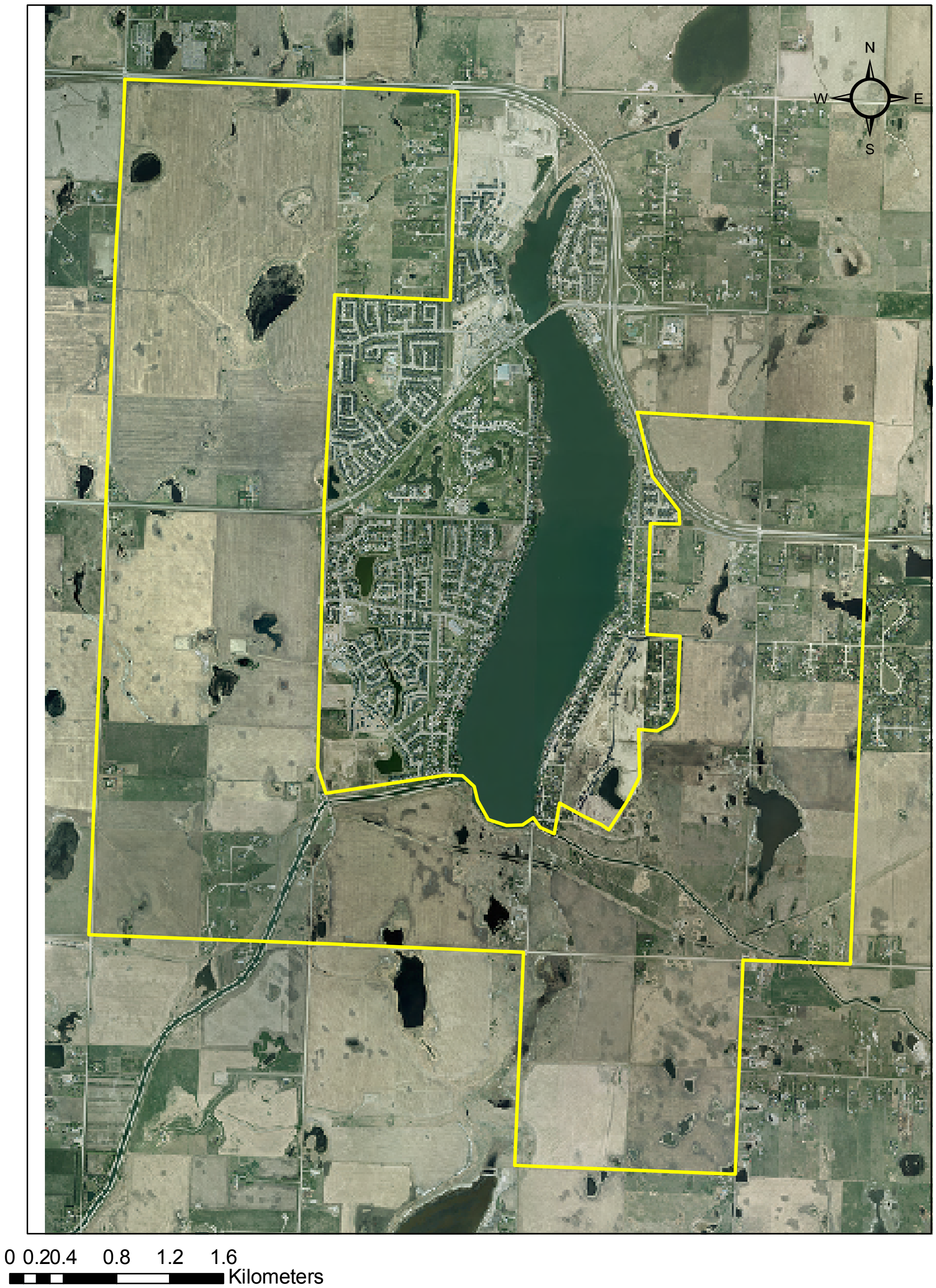

Figure 1. Study area for the Town of Chestermere Environmental Resources Inventory.

3.2 Wetland Location and Extent of Maximum Hydro-period

Two high spatial resolution (<50 cm) aerial photos provided by Town of Chestermere were used to map the location of wetland features. The photo taken in October of 2009 captured the end of a relatively dry year, whereas the 2012 photo, which was taken on April 26, captured conditions representative of average spring conditions. While the 2012 photo was used to represent the extent of the maximum hydro-period for this mapping exercise, an analysis of the hydro-climate history in this area suggests that the 2012 spring conditions do not represent the wettest year on record. Despite this, the 2012 photo was taken during the height of the spring melt, and are thus suitable for mapping maximum hydro-period (Figure 2).

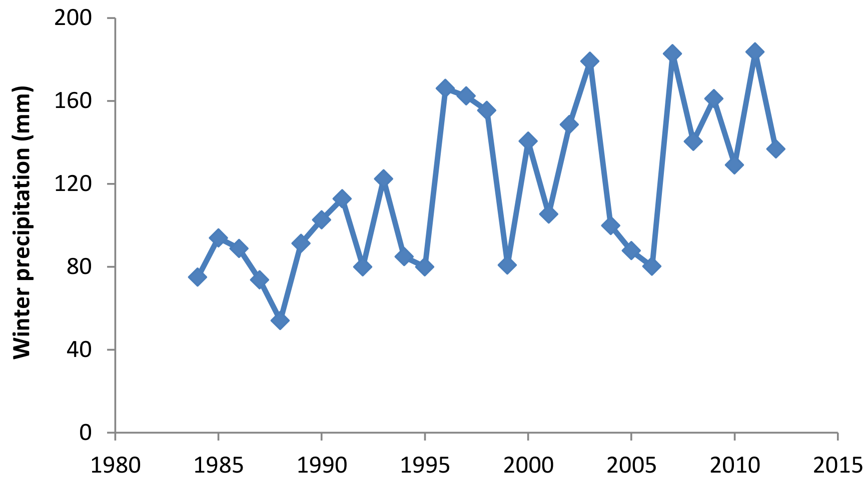

Figure 2. Winter precipitation (October 1 to April 30) recorded at Calgary International airport.

Using both the 2009 and 2012 aerial photos, the edge of open water and the extent of riparian vegetation were manually digitized on-screen. The 2012 photo also revealed wet areas (likely drained Class I and II wetlands) that were embedded within tilled agricultural fields. These areas were digitized and added as wetland features, despite an absence of open water or wetland vegetation. The end result of this classification procedure was a spatial layer that mapped the extent of both open water and riparian vegetation in 2009 and 2012, as well as boundaries for drained (tilled) wetlands identified in 2012.

As a confirmation of wetland occurrence, terrain information from a high vertical resolution (LiDAR) digital elevation model was analyzed to provide an automatic delineation of all probable depressions (e.g., low lying areas such as wetlands and lakes, and low linear depressions such as coulees). Previous work has established the close link between a high probability of depression and wetland location (Lindsay et al 2004). All mapped wetlands within the study area were confirmed to lie within areas that were classified as having a high probability of depressions ([p_{dep}]> 0.4) (Figure 3). In order to identify individual wetlands, feature classes (open water, riparian vegetation, drained/tilled wetland) were combined into one 'wetland' class, for a total of 275 uniquely numbered wetland polygons (Figure 4). Wetlands divided by roads were considered separate wetlands and were assigned unique identifier numbers.

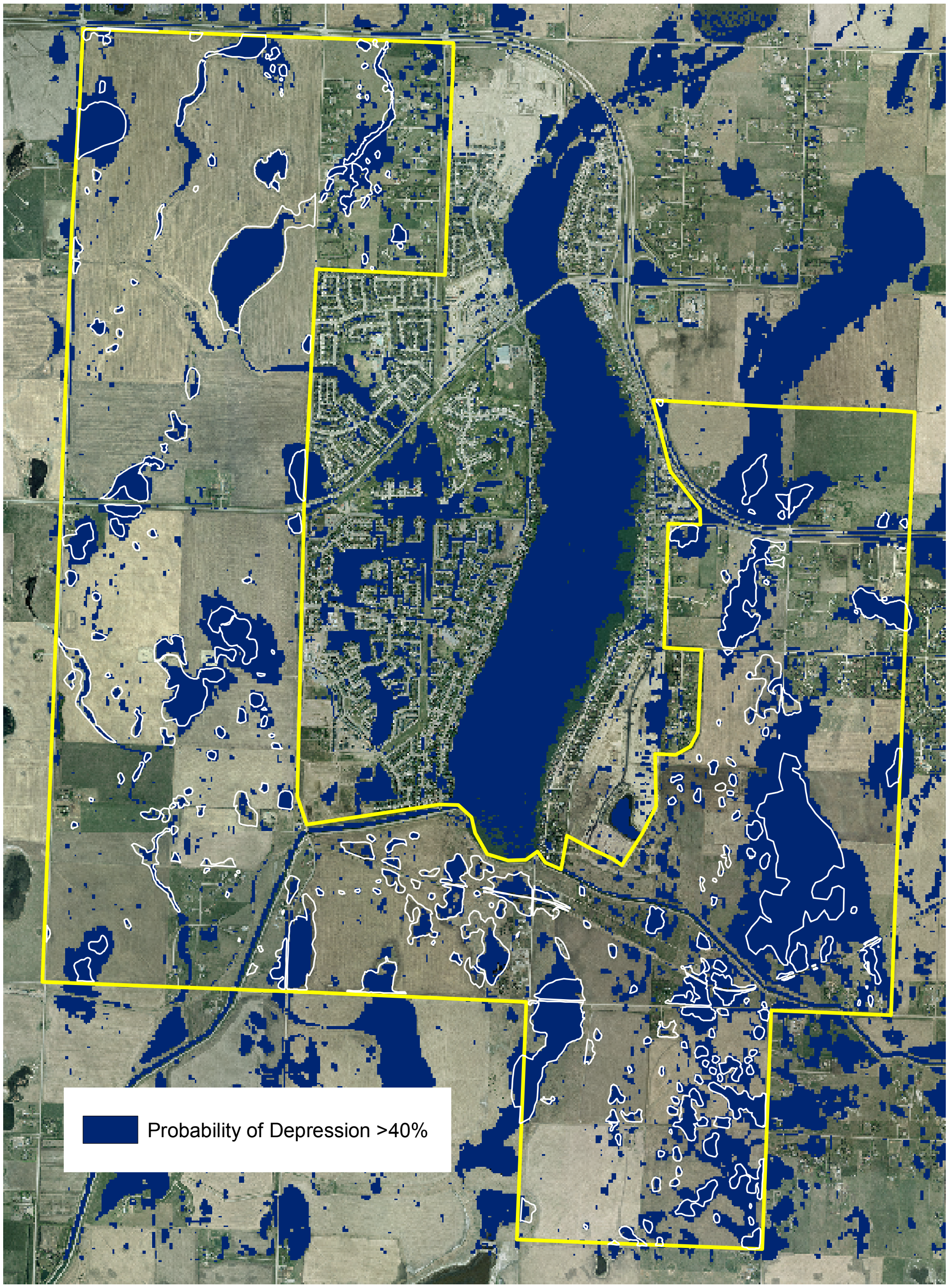

Figure 3: Probability of depression layer shown with transparency and edge of wetlands.

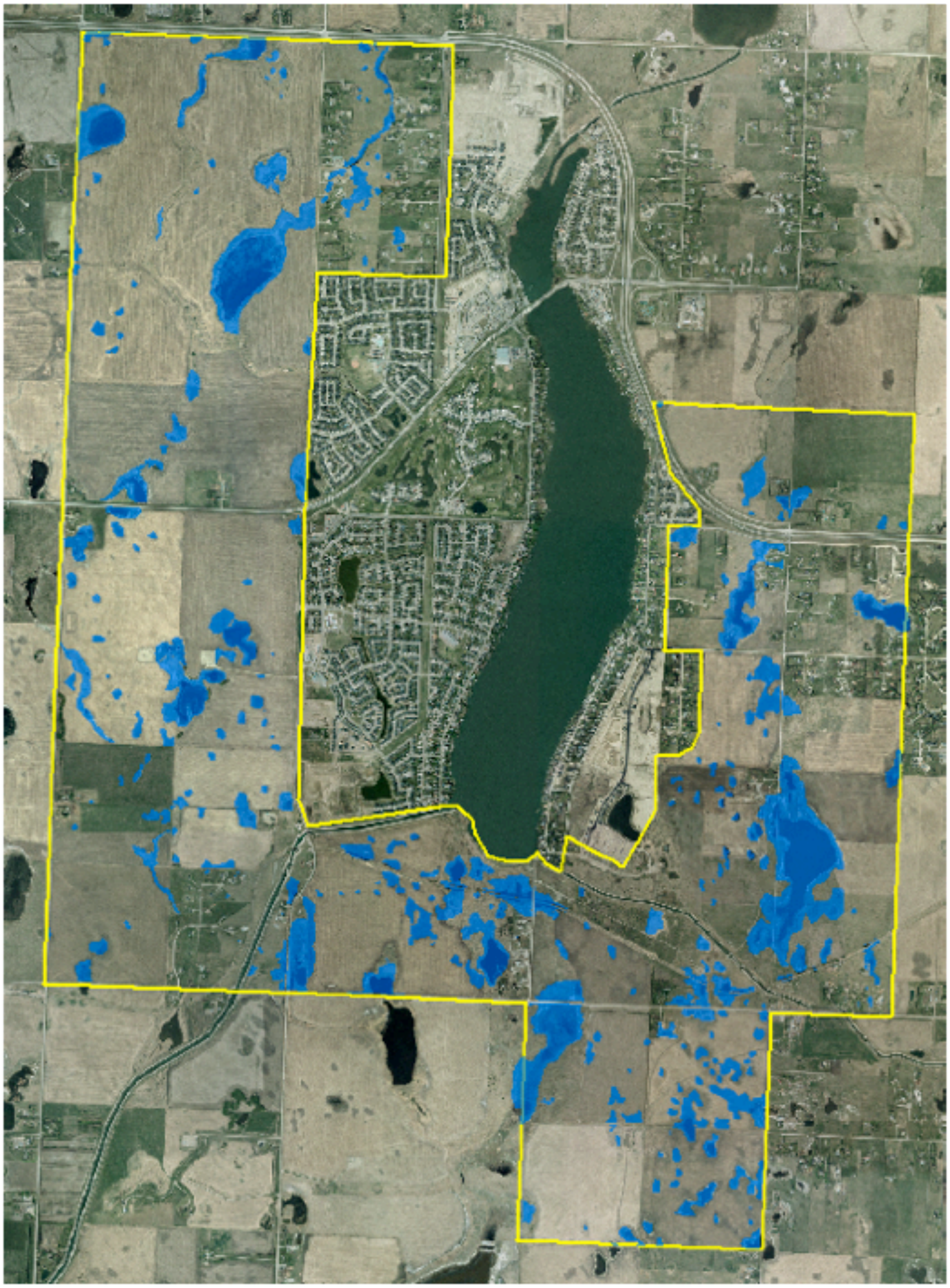

Figure 4: Distribution of wetlands (n=275) in the study area.

3.3 Wetland Classification

One of the main objectives of this assessment was to assign a wetland class to each wetland identified in the inventory. Remotely assigning wetland class using the Stewart and Kantrud (1971) classification method is highly dependent on (and influenced by) the frequency and timing of the hydrological information used in the assessment. For this assessment, we used two different sources of spatial information (in addition to field checking) to assign wetland class, including: 1) high-resolution aerial photos from 2009 and 2012 and 2) Landsat imagery from years ranging between 1984 and 2011.

As a first approximation, wetlands that contained open water in both the 2009 and 2012 aerial photos were assigned to Class V (permanent wetland). Large wetlands that had open water present in 2012, but no open water accompanied by the presence of abundant wetland vegetation in 2009 were assigned to Class IV (semi-permanent wetland). The smallest wetlands that did not contain any water in 2012 were assigned to Class I, as well as those wetlands with clear evidence of cultivation. The remaining wetlands – those small to medium sized wetlands with open water in 2012, but no open water accompanied by evidence of wetland vegetation in 2009 - were assigned into a combined Class II & III category.

To help confirm these initial wetland classifications, an 'open water' probability layer was derived by developing and combining 26 different 'open water' maps from 1984 to 2011. Mapping of open water using Landsat imagery is a very accurate technique (Lunetta and Balogh 1999), and permanence maps were created using spring (May to June) Landsat images acquired from the United States Geological Survey. An analysis of the historical climate record for the study area shows that the period between 1984 and 2011 is representative of the climatic conditions for any 25-year period since 1885 (Figure 5). In fact, the period between 1984 and 2011 is slightly drier than the historical average; thus, the probability of open water mapping layer provides reliable information about historical wetland hydrologic conditions in the study area.

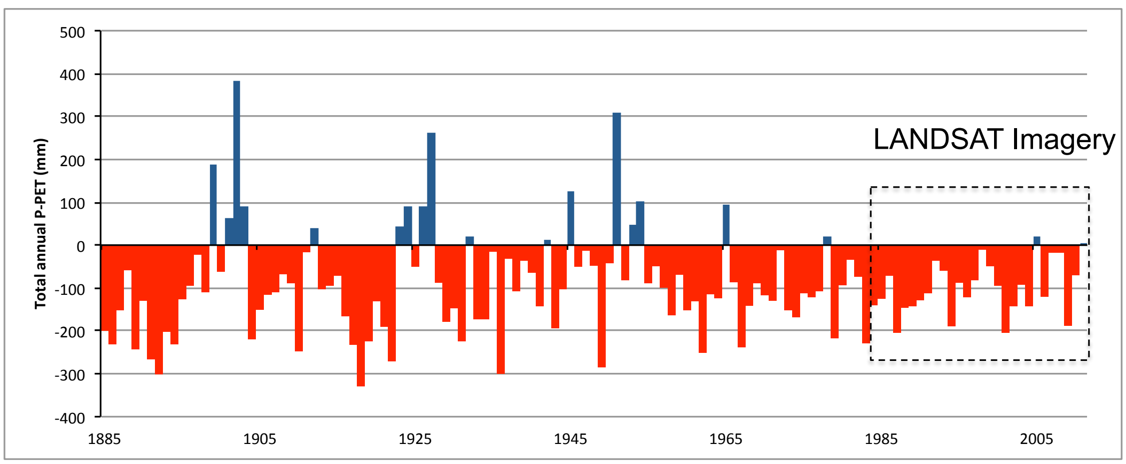

Figure 5. Historical climate analysis for the study area (data taken from the City of Calgary airport). Red bars represent years in which total annual precipitation was less than precipitation, minus potential evapotranspiration (PET) (i.e., "dry" years), while blue bars represent years in which precipitation exceeded PET (i.e., "wet" years).

For each image, every pixel in the image was assigned a value of zero (no water present) or one (water present), and the probability of that pixel being 'wet' was calculated for the period between 1984 and 2011 (Figure 6). This Landsat probability layer was used to confirm wetland class. Class II was assigned to those wetlands with a probability of open water ranging between 5-20%, and Class III was assigned to wetlands with a probability of open water between 20-45%. These wetland Class assignments were verified in the field using wetland vegetation and soil characteristics.

3.4 Field Assessment

The accuracy of the remotely sensed wetland inventory was assessed during a field assessment that was conducted between August 20 and 23, 2012. The main focus of the field assessment was to confirm the location and the class of each wetland as identified by the remote sensing inventory. A secondary objective of the field assessment was to provide a rapid assessment of wetland condition.

Wetland class was confirmed using a combination of criteria, including the presence or absence of open water, and the type and abundance of vegetation present in the wetland basin at the time of the field assessment. As per Stewart and Kantrud (1971), wetland class was confirmed based on the dominant vegetation community present in the central or deepest part of the wetland basin (Table 1). In addition to confirming wetland class, wetlands were assessed for condition using a rapid assessment method. This included a subjective assessment of the quality of the riparian vegetation and an estimate of the average width of the riparian zone. The condition of the wetland vegetation present in the wetland basin was also assessed using a qualitative cover score and a vegetation quality index that followed methods outlined by Mack (2001). Given the rapid nature of the assessment, as well as the timing of the survey, it was not appropriate to use this data as an input in the condition index (see Section 6); however, the final condition scores, as calculated by the index, generally corresponded to the data obtained through the rapid assessment.

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Wetland Class	Description	Defining Vegetation
I	Ephemeral	Wetland low-prairie
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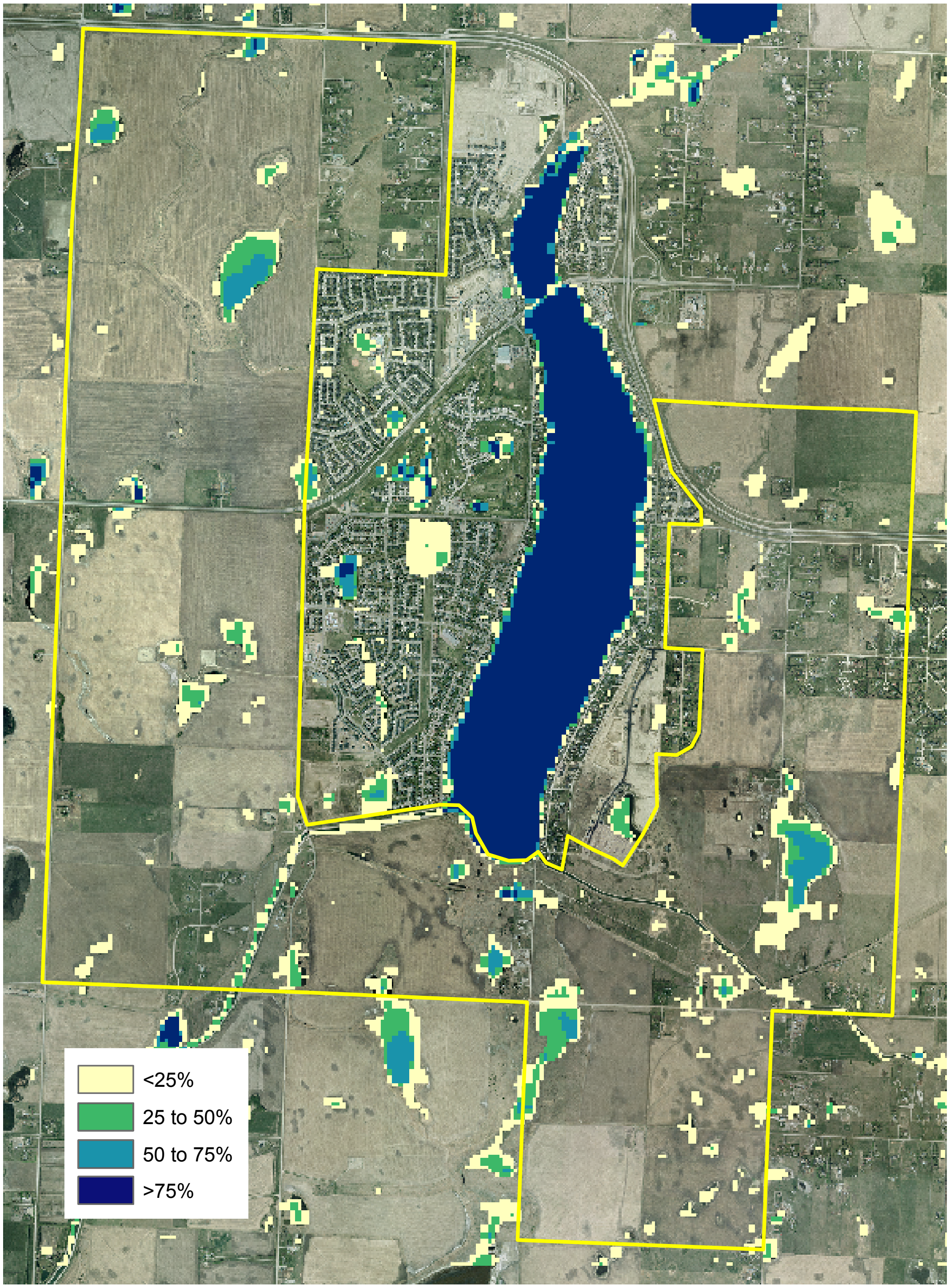

Figure 6. Map of probability of ‘open water’ derived from a time-series of Landsat images between 1984 and 2011. The smallest area represented in Landsat imagery is a 25m by 25m square (pixel); consequently, this permanence map does not capture wetlands that are less than 50m by 50m in size.

While every effort was made to visit each wetland identified in the remotely sensed wetland inventory, there were significant constraints that limited access to many of the wetlands of interest. A large number of wetlands were located on private land, and a number of landowners in the study area did not grant permission to access wetlands on their property. In addition, a significant number of wetlands could not be accessed because they were located on land that was being actively cultivated, and thus, these wetlands were not accessible on foot. In cases where access to the wetland was limited, every effort was made to observe the wetland from a distance (i.e., from adjacent roads or land where access permission had been granted). In total, 143 locations were visited during the field assessment. Of these, a total of 17 locations were confirmed to be non-wetland areas, the majority of which were small features less than 0.25 hectares in size. These areas were removed from the wetland inventory. If we assume a similar mapping accuracy for those wetlands not visited during the field assessment, the mapping accuracy is estimated to be 94% (1 - 17/275= 0.94).

A final class was assigned to each wetland based on a combination of information gathered from field assessments, aerial photographs, and the wetland permanence mapping (Figure 7). For the purposes of this assessment, Class IV, V, and VI wetlands have been combined and mapped together.

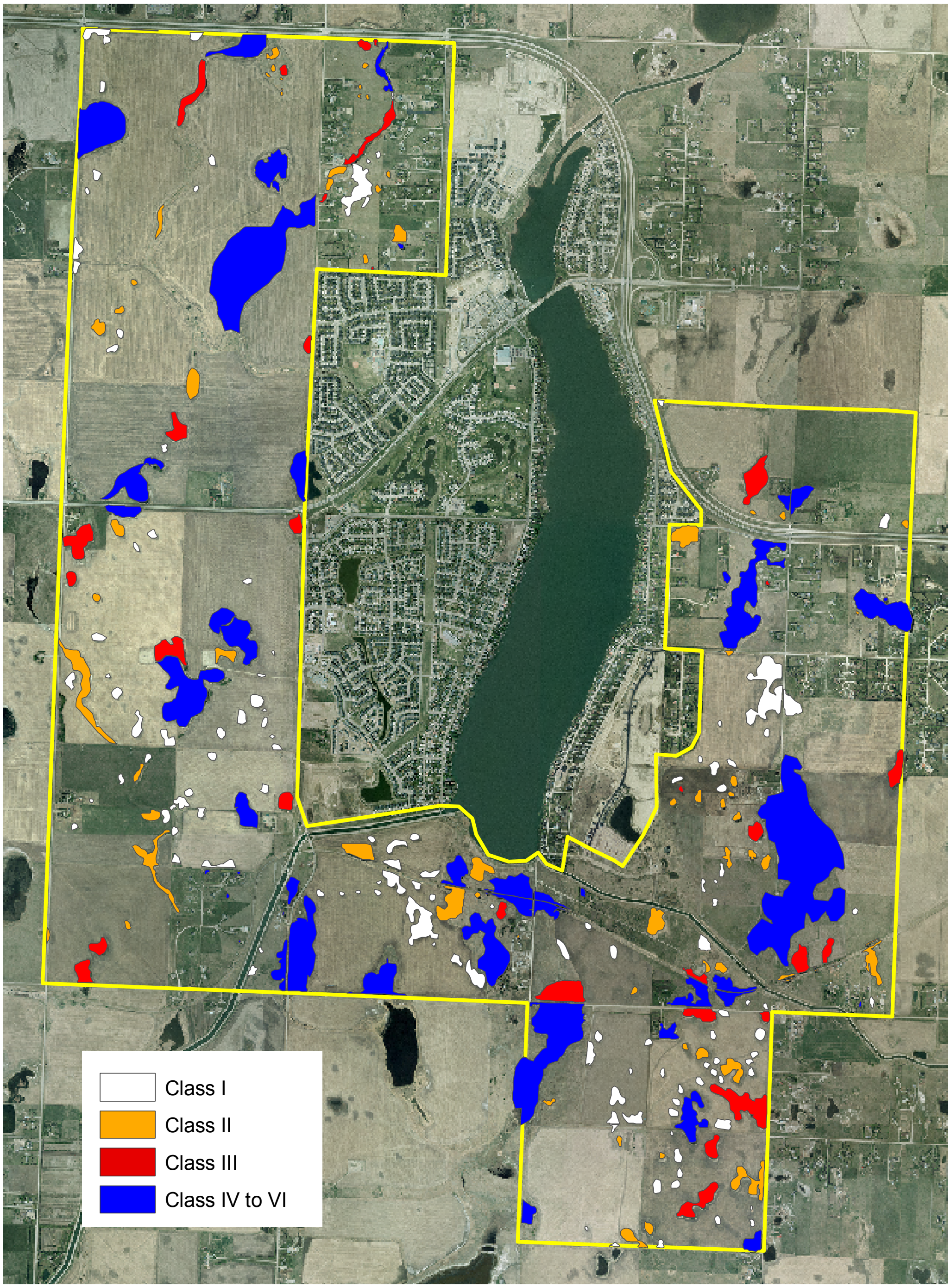

Figure 7. Wetland location and Stewart and Kantrud Class. For the purposes of this assessment, all Class IV, V, and VI wetlands have been combined and mapped together.

4.0 Wetland Ecosystem Service Assessment

Increasingly, municipalities are beginning to integrate information about the value of ecosystem services, such as the value of flood protection provided by wetlands, into land use decisions (Alberta Environment 2011). Recent advances in remote sensing, as well as progress in the field of ecosystem service assessment has made this kind of evaluation much more accessible and cost effective. Wetland ecosystems provide a number of regulating, provisioning, cultural, and supporting services that significantly contribute to human well-being, with some of the most well-recognized services being water storage, flood control, and carbon storage (Millennium Ecosystem Assessment 2005).

In an effort to better understand the economic benefits provided by natural wetlands in Chestermere, the water and carbon storage potential of each wetland identified in the wetland inventory was calculated. In addition, the economic value of flood control and carbon storage provided by wetlands within the municipal boundaries was estimated following methods from the Government of Alberta (2011) and Badiou et al (2011). In total, the estimated value of flood control and carbon storage provided by existing wetlands in Chestermere is approximately $11.5 million.

4.1 Carbon Storage Potential

Wetland soils typically store more carbon than upland soils; however, the rate of carbon accrual in wetland soils is greatly influenced by factors such as climatic regime and soil type. While accurate estimates of soil carbon storage require field sampling, the scope of this work did not allow for extensive soil sampling and analysis. Consequently, carbon storage potential for wetlands in the study area was estimated for each wetland by multiplying wetland area by soil organic carbon density values taken from Badiou et al. (2011).

Estimates of carbon storage potential were used to calculate an approximate dollar value for wetland carbon storage in the study area. Carbon storage potential (MgC/ha) for each wetland was converted into a CO_2 equivalent (CO_2eq) value (total carbon pool/wetland * 3.67), and this value was multiplied by $15/tonne CO_2eq to estimate the economic value of carbon storage. The multiplier of $15/tonne CO_2eq was used to estimate total economic value because this is the current price being paid for carbon emissions in Alberta as part of the provincial Greenhouse Gas Reduction Program (Government of Alberta 2011). Based on these estimates, the total value of carbon storage by wetlands in the study area is approximately $3.5 million (Table 2).

Table 2. Total carbon storage potential for wetlands, presented by wetland class, in the Town of Chestermere.

Wetland Class	Carbon Storage (MgC/ha)	Estimated Carbon Storage Value ($)
I	6864	$377,864
II	7463	$410,841
III	7993	$440,035
IV-VI	42,180	$2,321,991
TOTAL	**64,500**	**~$3.5 Million**

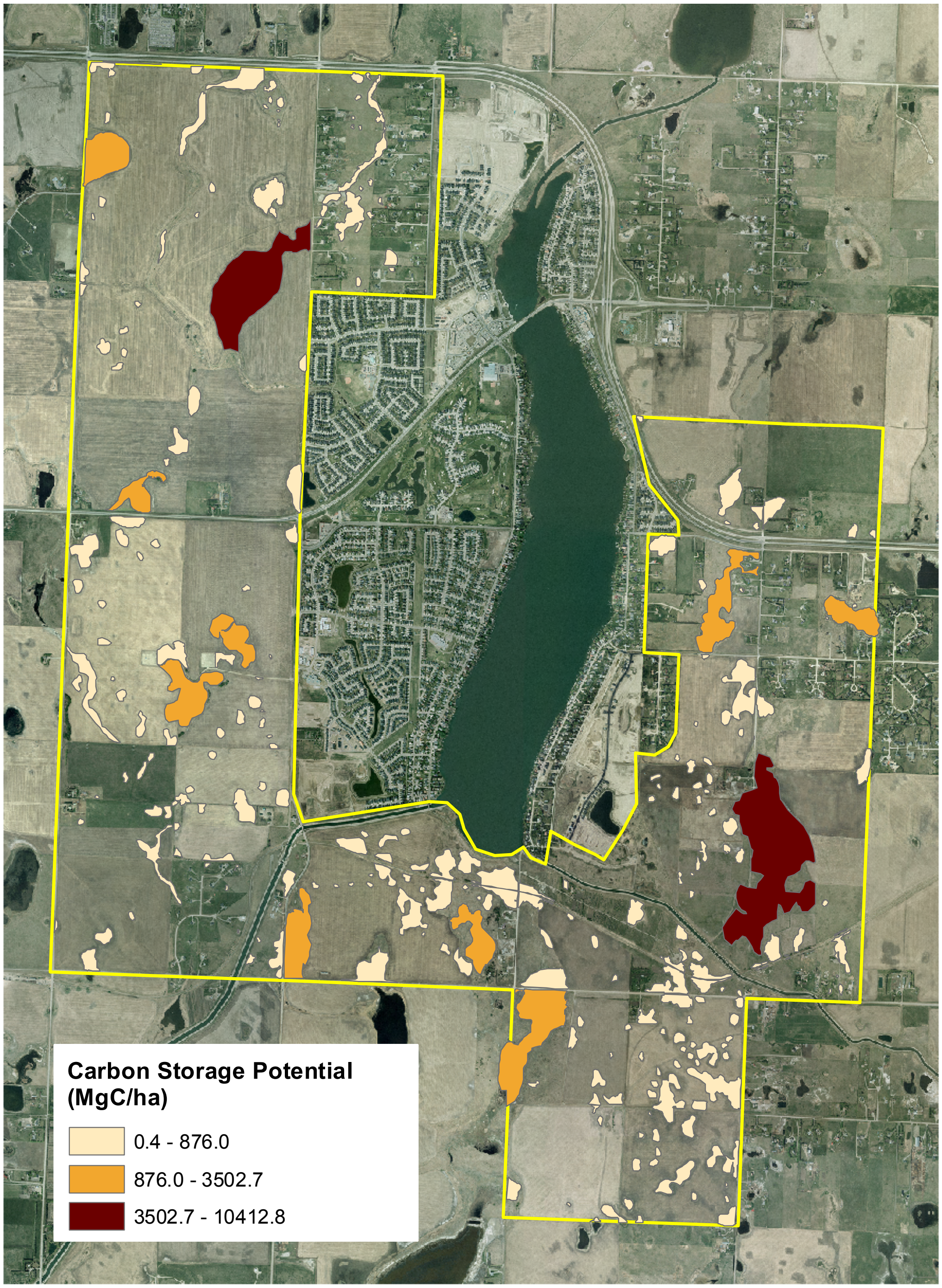

Figure 8. Carbon storage potential estimates for wetlands in the study area.

4.2 Flood Storage Potential

Flood storage potential is both a local and regionally important ecosystem service, particularly given the location of Chestermere within the Shepard Regional Drainage Corridor. Flood storage potential was estimated for wetlands in the study area by digitally ‘filling’ each wetland using a digital terrain analysis. The volume (m^3) of water that could be held before the water ‘spilled’ out of the wetland basin was calculated using ArcGIS and TAS (Lindsay 2005). In total, it is estimated that the wetlands in the study area have the potential to store over 3.2 million cubic meters of water (Table 3; Figure 9), which is equivalent to the volume of water contained in 1,311 Olympic sized swimming pools.

Table 3. Estimated water storage potential for wetlands in the Town of Chestermere.

Wetland Class	Water Storage Potential (m^3)
I	111,625
II	191,888
III	488,642
IV-VI	2,486,695
TOTAL	**3,278,850**

It is difficult to find volume-based dollar values for wetland water storage, as these values are typically related to local costs associated with managing stormwater runoff. Fortunately, a recent study conducted by the Government of Alberta (2011) examining the ecosystem services provided by wetlands in the Calgary region examined flood storage costs in the Shepard Drainage Corridor. The flood storage value that was calculated as part of the GOA study ($23,284/ha) was used to calculate the dollar value of flood storage in Chestermere. It is important to note that the dollar value used to calculate economic value for flood storage is based on wetland area (ha), rather than water storage potential volumes (m^3); thus, the estimated economic values do not correspond directly to the calculated flood storage volumes. In total, the estimated value of water storage in the study area exceeds $7 million (Table 4).

Table 4. Estimated flood control value for wetlands in the Town of Chestermere.

Wetland Class	Estimated Flood Control Value ($)
I	$1,089,961
II	$880,887
III	$935,732
IV-VI	$4,653,056
TOTAL	**~$7.5 Million**

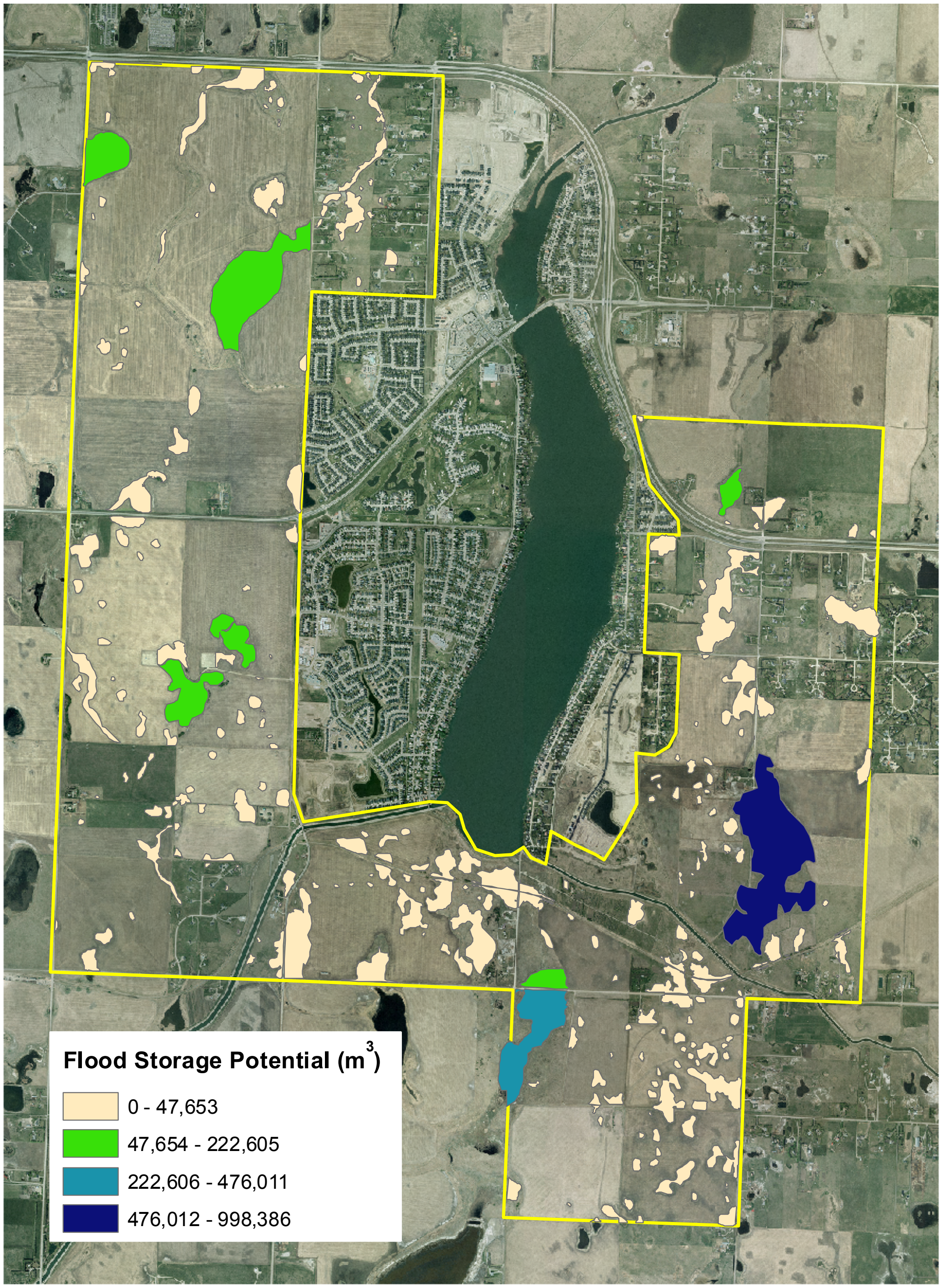

Figure 9. Flood storage potential for wetlands in the study area.

5.0 Wetland Condition Mapping

Making trade-off decisions between land development and wetland conservation is difficult without having objective information about the ecological condition of wetlands. Ideally, in areas where there is increasing land development pressure, those wetlands that are considered to be “key habitats”, whether from a hydrological or ecological perspective, should be prioritized for protection. This kind of prioritization is not possible without reliable and robust scientific information that allows for the comparison of relative wetland condition. Consequently, this assessment included an evaluation of wetland condition using a combination of hydrological and ecological criteria that were developed to help evaluate the relative condition of each wetland present in the study area.

5.1 Hydrological Condition

The emphasis of this assessment was on assessing the long-term availability of water in each wetland, as well as the hydrologic and ecological connectivity of wetlands through surface and sub-surface (groundwater) pathways.

5.1.1 Surface Water & Ecological Connectivity

The critical importance of surface hydrologic connections to prairie wetlands has historically been a blind spot for prairie hydrologists; however, recent academic literature highlights how ‘isolated’ wetlands are much more connected, even on the surface, than formerly acknowledged (Leibovitz and Vining 2003; Cook and Hauer 2007; Shaw et al. 2012). This finding has important implications for water chemistry, gaseous exchange with the atmosphere, and the ecology of prairie wetlands (Cook and Hauer 2007; Pennock et al. 2010). Given this, surface water and ecological connectivity was considered and important metric of wetland condition.

Surface water connectivity was evaluated by assessing the potential for surface connections as derived from an analysis of a digital elevation model (DEM). The provincial 15m LiDAR DEM was used to identify channel segments by classifying all pixels as belonging to a channel that had a specific contributing area of at least 5000 m^2. Channel connections were assessed for each wetland by counting the number of potential stream channels entering and exiting each wetland (Figure 10). The channels represent the potential for surface water connectivity, rather than actual observed water flow, and these channels are expected to contain water during the wettest hydrological conditions.

Wetlands that were part of a wetland complex (surface connection to other wetlands) or wetlands that were connected to larger ecological corridors (e.g., connected to other wetlands through a vegetated coulee) were also identified. This hydrological connectivity is important for the transfer of water, but also for providing ecological connectivity by providing moist upland habitat for those species that require such conditions to facilitate movement between wetlands (e.g., amphibians and reptiles). Wetlands with a greater degree of ecological and hydrologic connectivity were assigned higher condition scores than more isolated wetlands (Table 5).

Table 5. Surface water connectivity scores for wetlands located in the study area.

Surface Water & Ecological Connectivity Score	Description
1	No Inlet, Outlet, or Wetland Complex
2	Potential Outlet or Wetland Complex
3	Potential Inlet AND Outlet
4	Potential Inlet (multiple) AND Outlet
5	Potential Inlet AND Outlet AND Vegetated Corridor

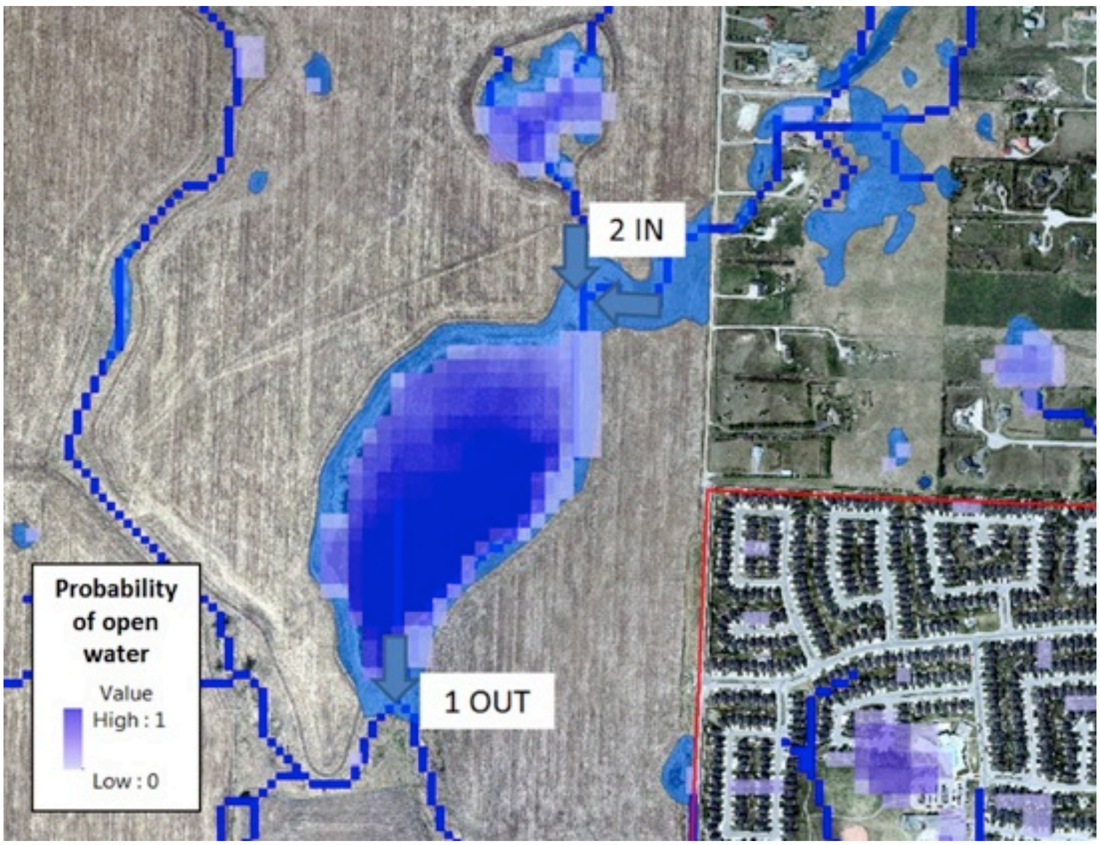

Figure 10. Surface hydrological indicators (probability of open water and potential stream channel connections) shown for a wetland in the western part of study area.

5.1.2 Sub-Surface Water Connectivity

Hydrologic connections to sub-surface hydrologic systems were assessed at two scales: regional and local. Given that warmer areas on the landscape have been shown to correspond to areas of strong groundwater discharge (Bobba et al. 1992; Sass et al. 2012), we used Landsat Thermal Imagery acquired during the winter months to assess regional groundwater conditions. The satellite imagery did not detect any strong areas of discharge within the study area (Figure 11). Given that the Town of Chestermere sits on a watershed divide, there is a much higher potential for regional recharge; however, underlying till and sandstone makes water transmission very slow, thus reducing recharge potential.

At a local scale, the potential for groundwater recharge (areas where water moves downward from surface water to groundwater) and discharge (areas where water moves out from an aquifer through saturated soils) was classified and mapped based on topography (Table 6; Figure 12). Those wetlands on higher ground (western part of study area) have limited potential to recharge water into local flow systems that discharge into Chestermere Lake and low lying areas south of the lake. Given the fairly homogenous distribution of surficial and deeper geological materials, the effect of different substrate affecting recharge rates was not considered. Higher spatial resolution surficial geological substrate maps might reveal local heterogeneities of high conductivity materials such as sand and gravel lenses, which might be important to consider in terms of wetland hydrologic connectivity for some of the wetlands in the area.

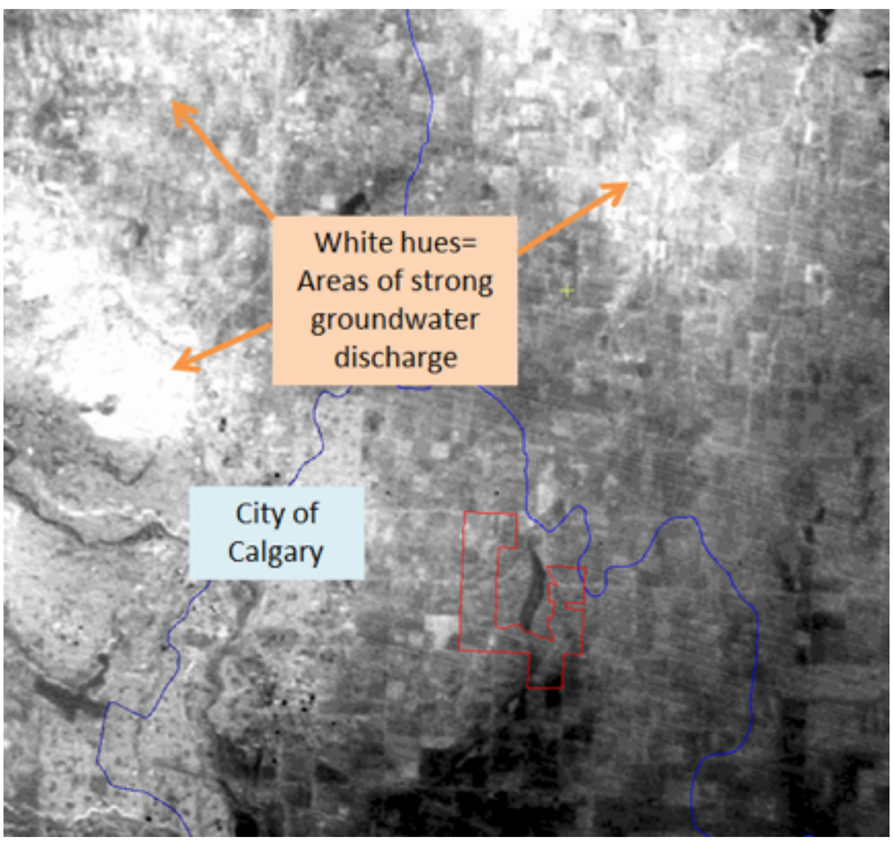

Figure 11. Landsat satellite imagery shows no regional areas of groundwater discharge near the Town of Chestermere.

Table 6. Local recharge/discharge potential scores for wetlands located in the study area.

Sub-surface Connectivity Score	Description	Elevation (m)
1	High Local Discharge Potential	<1020
2	Low Local Discharge Potential	1020-1030
3	Low Local Recharge Potential	1030-1045
4	High Local Recharge Potential	>1045

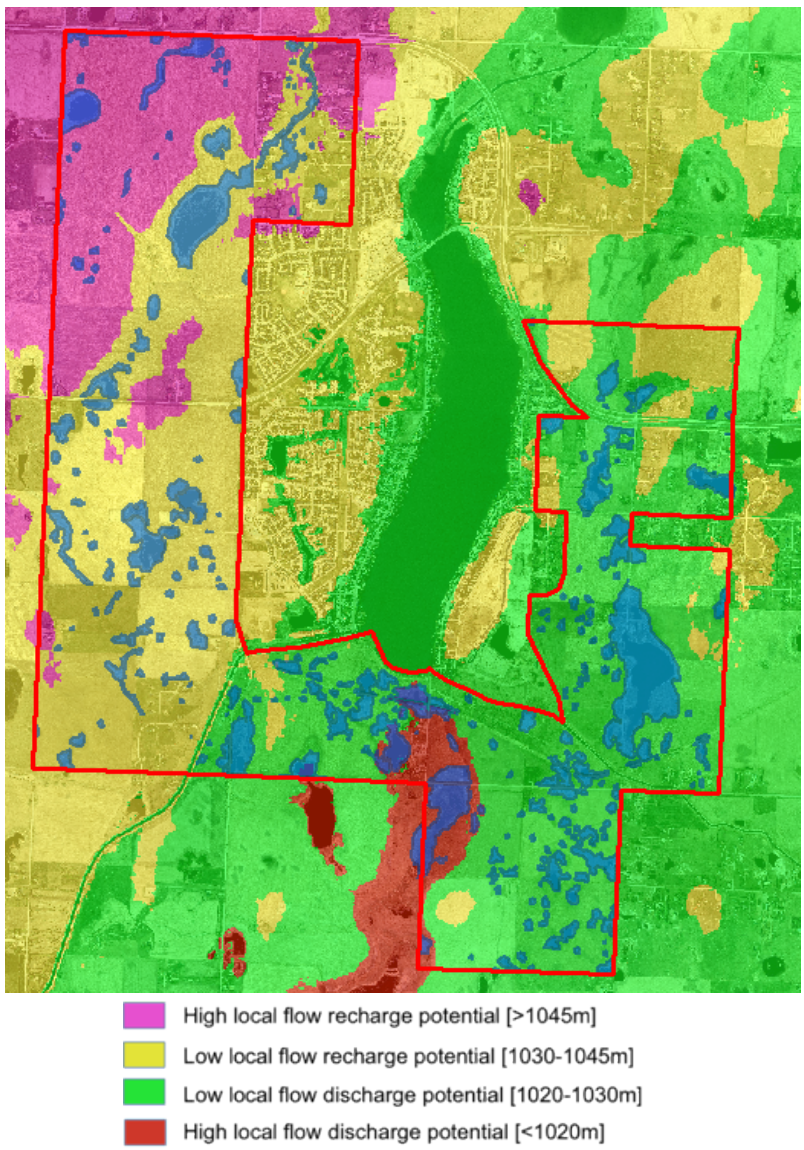

Figure 12. Local flow groundwater recharge and discharge potential. Higher elevations have higher recharge potential, while lower elevations, especially those near larger bodies of water, have a higher potential for groundwater discharge.

5.2 Ecological Condition

The focus of this assessment was to select ecologically meaningful metrics that could be reliably measured and evaluated using Geographic Information Systems, and which could be combined to develop an index of condition to assess relative wetland value in the study area.

5.2.1 Wetland Size

It is generally accepted that larger habitat patches support a greater diversity of species than smaller habitat patches, and for this reason, single large habitats are generally prioritized over several small patches in the design of conservation networks. This relationship between size and species persistence is less straightforward in the case of wetland habitats, as many of the species that occur in wetlands are limited in their ability to move between habitats (e.g., amphibians); thus, the density and distance between wetlands should also be considered in conservation network design (Gibbs 2000). Other studies have shown strong links between wetland hydroperiod and biodiversity (Babbitt 2005), with hydroperiod and wetland size being highly correlated (Naugle et al. 2001). These larger wetlands typically have longer hydroperiods (i.e., water persists for a longer period of time) than smaller wetlands, and as a result, are important habitats for species that require open water throughout the spring and summer months (Naugle et al. 2001).

Given that larger wetlands are more likely to support a greater number of species per unit area than smaller wetlands, and given that these larger wetlands are more likely to persist on the landscape for longer periods of time, wetland size was used as a metric of ecological condition. Wetlands were divided into three size categories according to percentile distributions. Those wetlands that fell into the 90th percentile (largest 10% of wetlands) were assigned a score of 3, while those that fell into the 10th percentile (smallest 10% of wetlands) were assigned a score of 1. All remaining wetlands were assigned a score of 2 (Table 7).

Table 7. Size and percentile ranges, as well as wetland size scores, for wetlands located in the study area.

Wetland Size Score	Size Range	Percentile Range
1	≤0.052 ha	≤10
2	0.053 to 2.42 ha	>10 to <90
3	2.43 to 49.9 ha	≥90

5.2.2 Rarity

In 2010, the provincial government released a report that identified Aquatic Environmentally Significant Areas (AESAs) in the province (Fiera 2010). These AESAs were identified according to seven criteria that were developed in consultation with the Alberta Water Council. These criteria included the following:

1. Presence of aquatic focal species, species groups, or their habitat
2. Presence of species of conservation concern
3. Presence of rare or unique aquatic ecosystems
4. Key areas that contribute to water quality
5. Key areas of biological connectivity
6. Key areas of intact complexity and/or biodiversity
7. Key areas that contribute to water quantity.

Previously identified AESAs were used to help identify ecologically important wetlands in the study area, including areas of critical habitat for rare species (for a complete description of methods used to identify AESAs, please see Fiera 2010). Those wetlands that were contained within a previously identified AESA were assigned a score of 2, while those wetlands that were not contained within a previously identified AESA were assigned a score of 1 (Table 8).

Table 8. Wetland rarity score, as determined by wetland overlap with previously identified Aquatic Environmentally Significant Areas (AESAs).

Wetland Rarity Score	Description
1	Wetland does not overlap with an AESA
2	Wetland overlaps with an AESA

5.2.3 Anthropogenic Disturbance

Wetland condition is highly influenced by the amount and type of anthropogenic disturbance adjacent to a wetland (Rooney et al. 2012). Consequently, five metrics were selected to measure anthropogenic disturbance within 500m of the edge of the wetland, including: the percent cover of open water; percent cover of impermeable surfaces (e.g., roads, buildings, etc.); percent cover of agricultural lands; percent cover of native vegetation; and road density (Table 9).

The percent cover of open water, impermeable surfaces, and agricultural land was derived from a land use/land cover layer that was developed using the 2012 high-resolution (30cm) colour air photo. Land cover classes were delineated on-screen using visual clues of colour, texture and contextual information. Six major land cover categories were identified, including: water, wet meadow, grass/pasture, trees, agricultural, and impervious surfaces (buildings/roofs, paved/unpaved roads) (Figure 13). Percent cover of native vegetation was calculated using the Alberta Grassland Vegetation Inventory (Government of Alberta 2009) and road density was calculated using the provincial road layer. A 500m buffer was applied from the edge of each wetland and the percent cover or density of each land use was calculated in ArcGIS 10.0 (ESRI 2011). Wetlands were assigned a score of 1 through 3 based on percentile ranks for each land cover metric. For each individual wetland, the scores for each metric were summed, and an average condition score (1 to 3) was assigned.

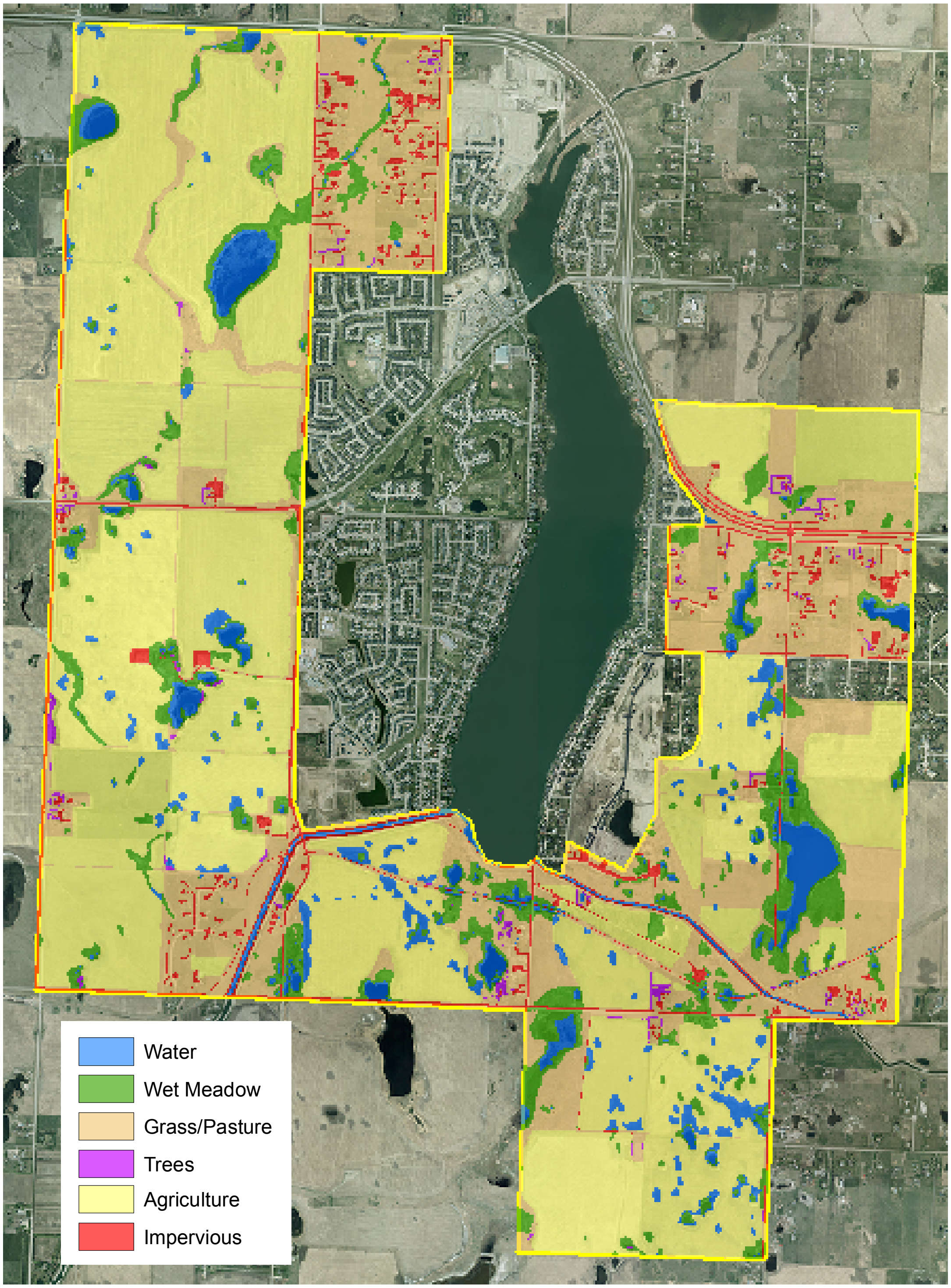

Figure 13. Land cover mapping of the study area, derived through on-screen digitization of the 2012 high-resolution air photo.

Table 9. Scores, value ranges, and percentile ranges for anthropogenic disturbance in the study area.

Metric	Score	Value Range	Percentile Range
Cover of Open Water within 500m	1	≤0.02%	≤10
	2	>0.02 to <6.3%	>10 to <90
	3	≥6.3%	≥90
Cover of Impermeable Surfaces within 500m	1	≥9.2%	≥90
	2	>0.3 to <9.2%	>10 to <90
	3	≤0.3%	≤10
Cover of Agricultural Land within 500m	1	≥83.8%	≥90
	2	>9.7 to <83.8%	>10 to <90
	3	≤9.7%	≤10
Cover of Native Vegetation within 500m	1	0%	≤10
	2	>0 to <30.3%	>10 to <90
	3	≥30.3%	≥90
Density of Roads within 500m	1	≥3.5 km/km^2	≥90
	2	>0.3 to <3.5 km/km^2	>10 to <90
	3	≤0.3 km/km^2	≤10

6.0 Index of Ecological and Hydrologic Condition

The rating of wetlands based on ecological and hydrologic significance gives decision-makers important information about the relative value of each wetland in the Town of Chestermere. There is no accepted standard for constructing an index of wetland condition; however, a good index should include metrics that are relevant to local conditions and are supported by the scientific literature. The index of Ecological and Hydrologic Condition that was constructed to identify important wetlands in the Town of Chestermere included metrics that were selected for their sensitivity to local conditions, as well as their general acceptance in the literature as being important indicators of wetland condition. While both ecosystem services and sub-surface connectivity were evaluated as part of the wetland condition mapping (see Section 5), these metrics were not included in the final index of condition. Ecosystem services were excluded because the focus of the index was strictly on the biophysical characteristics of the wetlands in the study area, while sub-surface connectivity was excluded because we felt that this metric warranted further field investigation.

The metrics included in the Index of Ecological and Hydrologic Condition included:

1. Size
2. Surface Water & Ecological Connectivity
3. Rarity
4. Anthropogenic Disturbance

The scores from each of the four metrics were combined to derive a single condition index score, ranging from a minimum score of 4 to a maximum score of 13 (Figure 14).

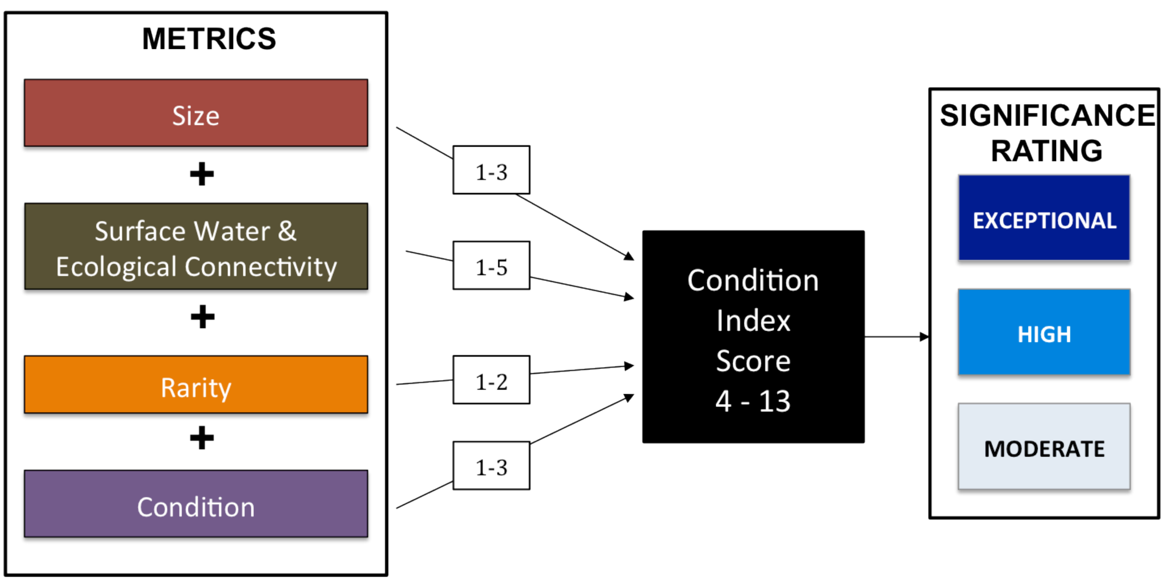

Figure 14. The metrics and scores that made up the Index of Ecological and Hydrologic Condition for rating wetlands in the study area. Significance rating scores were derived using area-based targets in consultation with Chestermere Town Council.

The Surface Water and Ecological Connectivity metric was given a slightly higher weighting because this metric combined two important components of wetland connectivity. The Rarity metric was down-weighted because Aquatic Environmentally Significant Areas were modeled at the provincial scale, and there is sufficient uncertainty as to how representative this provincial model represents rarity at the local scale to warrant a lower metric score. The scores from each of the four metrics were summed and the overall combined scores for each wetland were used to assign a significance rating of Exceptional, High, or Moderate to each wetland in the study area.

Index score boundaries for each of the wetland categories were first determined using a Jenks classification analysis. A Jenks classification is a statistical analysis that identifies natural groupings inherent in the data, such that similar values are grouped together to maximize the differences between classes (i.e., identifies breaks in the ordered distribution of values that minimizes within-class sum of squared differences) (Jenks 1977). Using this statistical approach, all wetlands with an index score of >8.6 fell into the Exceptional category. Using this statistically derived category boundary, 226 ha of wetland fell into the Exceptional category, which accounted for approximately 70% of the total wetland area. This was not considered a realistic management target for the town of Chestermere; thus, the category scores derived using the Jenks classification were adjusted using area-based conservation targets that were developed in consultation with Town Council.

An overall conservation target of 15% was selected for the study area. This conservation target included both wetland area and riparian lands, as captured through a development setback. In order to be consistent with other wetland policies in the greater Calgary region, a development setback of 10m was selected for Class I and II wetlands, while a 30m development setback was selected for Class III to VI wetlands. These development setbacks were applied to each wetland in the study area, and the total area and percent cover of wetlands and development setback was calculated. A conservation target of 8% was selected for wetlands and associated riparian areas with the highest condition scores (i.e., the “best” wetlands). In order to define Exceptional wetlands, those wetlands initially assigned to the Exceptional category using the Jenks analysis were reviewed, and only the top 8% of wetlands, as measured by coverage of both wetland and development setback area, were included in the Exceptional category. As such, the index score cut-off between the High and Exceptional categories was revised from >8.6 to ≥10, meaning that fewer wetlands fell into this category than assigned through statistical analysis. The remaining conservation target (7%) was captured by wetlands and associated development setback areas that were assigned to the High significance category (index scores ranging between 8.2 and 9.9). All remaining wetlands were assigned to the Moderate significance category (index scores <8.2) (Table 10).

Overall, 28 of the 275 wetlands were considered Exceptional, covering an estimated 138 ha (5.8%) of the study area (Table 10). Once development setbacks were applied to these Exceptional wetlands, they accounted for a total area of ~203 ha, or 8.5% of the study area (Table 11). The High significance category included 45 wetlands, covering approximately 94 ha, or 4% of the study area. With development setbacks, High significance wetlands account for 175 ha, or approximately 7% of the study area (Table 11). Together, Exceptional and High significance wetlands, along with their associated development setbacks, account for approximately 15.8% of the study area (Figure 15). All remaining wetlands were placed in the Moderate significance category.

Table 10. Condition scores, area of wetlands, and area of associated riparian development setbacks by condition category.

Significance Rating	Condition Score	Number of Wetlands	Wetland Area (ha)	% Study Area
Exceptional	≥10	28	138.2	5.8
High	8.2-9.9	45	94.4	4.0
Moderate	<8.2	202	92.0	3.9
	TOTAL	**275**	**324.6**	**13.7**

Table 11. Conservation targets by wetland condition category. Development setbacks included 10m on Class I and II wetlands, and 30m on Class III to VI wetlands.

Significance Rating	Wetland Area (ha)	Development Setback Area (ha)	Total Area (ha)	Study Area Coverage (wetland + setback) (%)
Exceptional	138.2	65.2	203.4	8.5
High	94.4	80.6	175.0	7.3
TOTAL	**232.6**	**145.8**	**378.4**	**15.8**

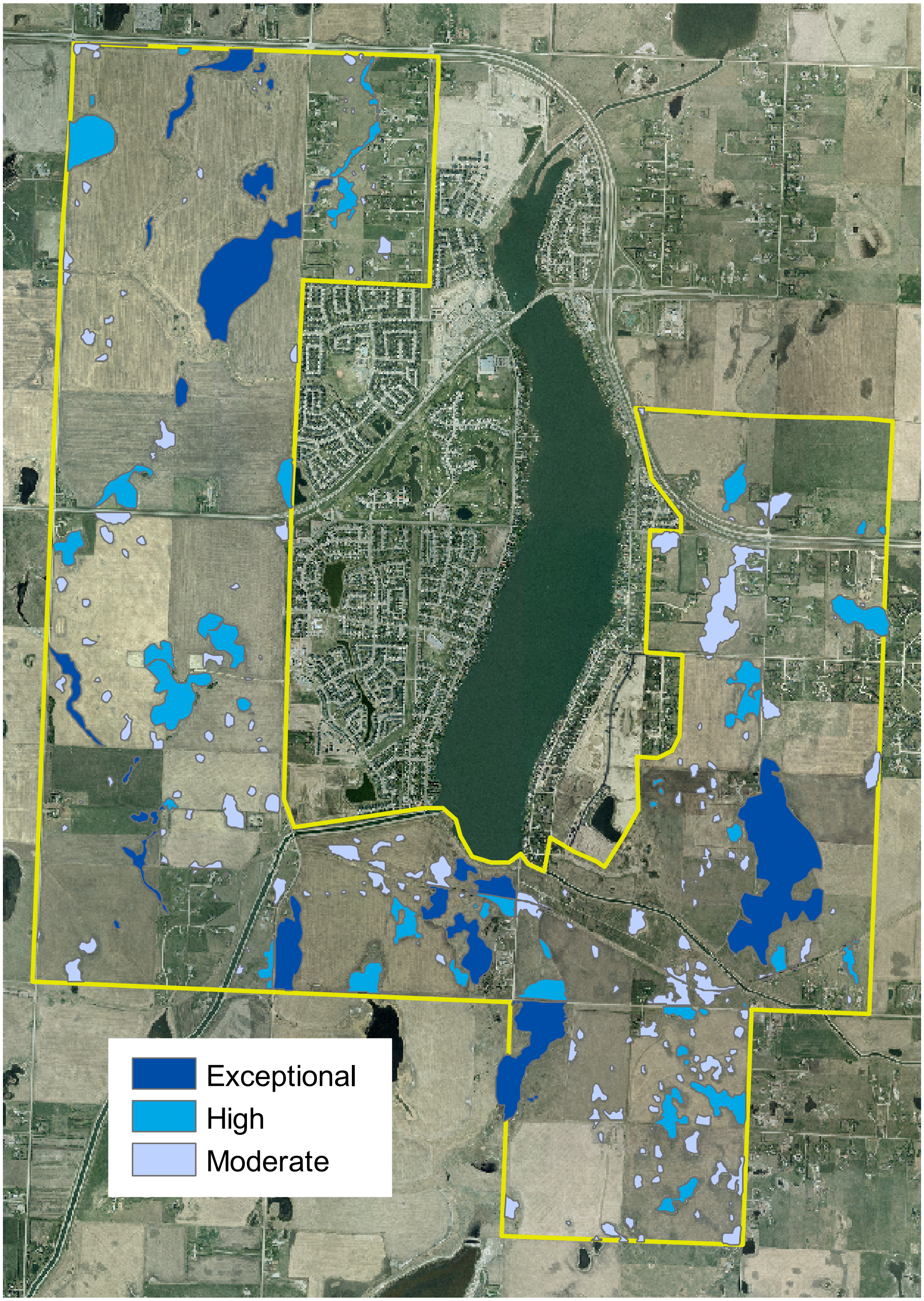

Figure 15. Final classification of wetlands according to the Index of Ecological and Hydrologic Condition. Wetlands of Exceptional and High condition combine to comprise approximately 15.8% of the study area.

7.0 Study Limitations & Recommendations

While this assessment was carried out using advanced and accepted scientific methods, the information presented in this report was developed to address specific needs for the Town of Chestermere. As such, the information and results should be considered in this context. Specifically, the following limitations should be considered when evaluating the information presented in this report:

1. This inventory provides only an estimate of wetland boundaries, as an accurate delineation of wetland area was not the focus of this assessment. Rather, the main objective of this study was to identify the location and approximate extent of each wetland for planning purposes. In order to determine the exact extent and area of each wetland, boundary delineation should be carried out using appropriate, standardized field methods.
2. Wetland class was assigned using the best available spatial and climate data, and the results of this classification were ground truthed for accuracy. However, due to land access issues, not all wetlands identified as part of this inventory could be visited in the field. While the accuracy assessment suggested a high level of correspondence between the remotely sensed and the field assessment, wetland class should be confirmed in the field by a qualified professional using standardized and accepted classification methods.
3. The Environmental and Hydrologic significance of each wetland identified in the inventory was assessed using the best available spatial data, and the metrics that were selected to evaluate wetland condition reflect the most recent and up to date information from the scientific literature regarding wetland condition modeling. While modeling is a generally accepted approach to informing ecological planning, the model developed for wetlands in the Town of Chestermere has not been corroborated with ecological or hydrologic data collected in the field.
4. Prior to making any final management or policy decisions based on the condition scores presented here, the Town of Chestermere should require land development proponents to provide information to corroborate wetland condition scores. This should be done using standardized field assessment methods that would produce standardized condition scores, allowing for direct comparisons of wetlands throughout the study area. Developing a standardized wetland assessment method for use by all organizations conducting wetland field assessments is critical to this corroboration process.

8.0 Conclusion

The Town of Chestermere initiated an Environmental Resources Inventory to assess and prioritize ecologically and hydrologically significant wetlands that are located on lands that have recently been annexed by the town. This report details the methods used to identify, delineate, and rank wetlands in the Town of Chestermere.

This inventory identified a total of 275 wetlands that cover approximately 325 ha, or 14% of the study area. These wetlands provide an abundance of important ecosystem goods and services to the citizens of Chestermere, including carbon storage and flood storage potential, which together have an estimated economic value of $11 million. Based on area-based conservation targets, a total of 28 wetlands in the study area were ranked as

Exceptional ecological and hydrological significance, with another 45 wetlands being ranked as High significance. The remaining 202 wetlands were ranked as Moderate significance. When development setbacks (10m on Class I and II; 30m on Class III to VI) were applied to wetlands within the study area, Exceptional and High significance wetlands and riparian areas comprise approximately 16% of the study area.

The information contained in this report has been used to inform the development of a wetland and riparian policy for the Town of Chestermere. The intent of this policy is to help direct future land use decisions and development, such that impacts to significant wetlands can be minimized or avoided, and the important ecological and social values of these wetlands can be conserved for the present and future benefit of the residents and visitors of the Town of Chestermere.

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