Beaver Hills Initiative
Land Management Framework
Phase 2

Final Report

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BHI Land Management Framework
How to Use this Document

The Beaver Hills Initiative (BHI) is a multi-stakeholder collaboration comprising the five municipalities within the Beaver Hills moraine, federal and provincial protected areas agencies, plus other government and non-governmental organizations with interests in the area. In recognition of the moraine's essential landscape character, these partners have come together to promote a regional approach to land management in the moraine that will protect those elements that contribute to its character. The BHI emphasizes working together, through shared initiatives and coordinated action among all of its partner agencies. It also emphasizes voluntary participation, believing that sustainable management should be consensus and science-based, in order to succeed. The BHI is currently involved in several collaborative programs that provide research, support other jurisdictional initiatives and help raise awareness within the public and its own partner agencies. The Land Use/Management Framework is one of those recent projects. This document describes Phase 2 of the program.

Municipal governments manage the lands under their jurisdiction mainly by regulating land use at the local (parcel) and regional scale. Land use on the individual parcel is managed through the land development approval process; the regional context is managed through Municipal Development Plans and Land Use By-laws. To assist the partner municipalities in considering the natural features of the moraine in both scales of the planning process, the BHI developed the Common Land Use/Management Framework.

In essence, the Framework is a systematic approach to identify key environmental resources in an area under consideration for development, and to identify the means to manage those resources sustainably, should those lands be developed. The Framework is based on up-to-date information regarding the environmental resources that contribute to the essential landscape character of the moraine, described in this document in text and mapping. Electronic versions of the mapping will allow planners to determine the resources present at the local, parcel scale and at the broader regional scale. A checklist helps the planner identify from those maps potential concerns and the appropriate Best Management Practices to apply as approval conditions, to ensure development is sustainable. Together, these tools are intended to assist planners in applying the BHI Land Management Principles adopted by the partner municipalities in their regular planning duties.

The checklist, and the Best Management Practices list are attached here as an easy reference tool. They can be used to guide the reader through the background material and specific planning processes contained in this document. The checklist is based on the BHI Land Management Principles (Chapter 2.0), which identified critical components of the moraine landscape that the BHI wished to sustain. The natural resources within the principles could be mapped within Ecological Function Zones: those maps form the focus of the framework approach (Chapter 3.0). Understanding the types of resources occurring within the moraine, and their normal function provides the basis for their management, information provided in Chapter 3.0. The Best Management Practices list helps identify development conditions applicable to the resources identified in each Ecological Function Zone that would facilitate sustainable development at the parcel level (Chapter 4.0). Similar Best Management Practices recommendations for each of the Ecological Function Zones are provided within the document for consideration within regional level planning reviews (i.e., the MDP and LUB level; Chapter 5.0). Ultimately, the checklist is intended to be used with the framework mapping by the planner who understands the framework approach to assess a proposed parcel development application and recommend appropriate conditions that would allow sustainable development. Chapter 5.0 provides similar guidance for planners participating in land use policy reviews.

Also contained within the document are recommendations for the future steps of the framework implementation process, for the partner municipalities and for the BHI. Chapter 6.0 provides a summary of the framework project's findings and conclusions based on them. This chapter sets the stage for recommendations for immediate action by the municipalities and the BHI contained in Chapter 7.0. Policy recommendations in this chapter are based on sound environmental practice applied nationally and provincially, some of which are already currently applied by the partner municipalities themselves. If implemented, the recommendations proposed here would help the partner municipalities to achieve consistency in their policies with respect to natural resource management.

This section also includes a set of recommendations for the BHI itself. The BHI can play a key role in fostering a sustainable approach to development, by providing support to municipal initiatives through information gathering, program coordination and awareness raising activities. Most immediately, the BHI can take the next steps in implementing the framework, beginning with coordinating a pilot test period of the framework by the planners, to assess the ease and applicability of the process.

Together, the tools contained within this document, and application of the framework will help municipalities to make land use and management decisions within the moraine based on a consistent goal: to maintain the resources contributing to the essential landscape character of the moraine. This accomplishes the goal of the BHI partners, but ultimately, it ensures that the quality of life valued by residents and visitors to the area today, persists for future generations to enjoy. In this sense, successful implementation of the framework could be one of the most significant activities of the BHI partners, and a key step forward in sustainable management of the moraine.

BHI Land Management Framework
Subdivision/Development Application Review Checklist

Applicant Information

Applicant Name: ____________ **Date:** ____________

Parcel Legal Location: ____________ **Reviewer:** ____________

Parcel Area: ____________

Proposed Subdivision/Development: ____________

Referral Check *(check all that apply, refer proponent to AB ENV for additional permitting advice):*

Septic system / treatment lagoon	Stormwater management systems/outfalls
Water supply from new well or surface water source	Watercourse crossings (road or utilities pipeline)

Ecological Function Review	Parcel	Adjacent Lands (within 5 km)	***Potential Referrals*** *(see Reference Guide for additional information, note any specific referrals required on back)*			
Airphoto Review:			**AB ENV***	**ASRD* (Public Lands)**	**DFO* / Nav Waters**	**Migratory Birds Timing Restrictions**
Woodlands						x
Pasture *(possibility of native grasses?)*						
Streams wetlands, other waterbodies			x	x	x	x
Current development						

Surface Water Risk:			**Comments:**
GDA SW Risk Level (Map:Fig. 3.3 GDA SW Risk Map.pdf)			
Land Parcel SW Risk Level (Map: Fig. 3.4 SW Risk Map.pdf)			
Groundwater Risk:			
Groundwater Risk Level (Map: Fig. 3.5 GW Risk Map.pdf)			
Landscape Connectivity:			
Ecological Network Elements (Map: Fig 3.6 Eco Network Map.pdf) *(Any habitat patches or linkages present?)*			
Protected Areas (Map: Fig 3.7 PA Eco Network Map.pdf) *(Any lands already protected? Any NGO interest in area?)*			
Key Segments (Map:Fig 3.9 Segment Map.pdf) *(Part of a segment? Type?)*			
Functional Connections (Map: Fig. 3.10 Fxnal Cxn Map.pdf) *(Level of functional connection present?)*			
Biodiversity Core Areas:			
Biodiversity Core Areas (Map: Fig 3.11 Core Areas Map.pdf) *(Core Areas present? Type?)*			

* AB ENV = Alberta Environment, ASRD = Alberta Sustainable Resource Development, DFO = Fisheries and Oceans Canada, Nav Waters = Transport Canada

Recommended BMP's: *(check all that apply, based on EFZ assessment)*

Surface and Groundwater: *(see Pages 4-6 through 4-9 and 4-10 though 4-12 in Reference Guide for additional information)*	
Design Considerations	
	Encourage designs that minimize clearing of natural vegetation, particularly in floodplain areas
	Minimize or avoid watercourse and wetland disturbance, particularly those in or near environmentally significant areas or groundwater recharge/discharge areas
	Avoid creating access roads that will cross wetlands or watercourses
	Avoid watercourse alternations that may increase stream velocity or cause erosion
	Maintain a minimum vegetation buffer of 30 m along watercourses/wetland edges (may be wider if landscape connectivity or water quality protection is a concern)
	Confirm soil and groundwater conditions are suitable for proposed septic system
	Confirm shallow groundwater (water table) in area, particularly if basements, other excavations or septic fields are proposed
Planning Review Considerations	
	Proposed land use involving potential contaminants should not be located on or near groundwater recharge areas
	Ensure BMPs consider all associated infrastructure (e.g., waste transfer/collection point, haz mat storage facility)
	Ensure full ER and MR used to protect water features and associated riparian habitat
	Use a Conservation Easement to protect other adjacent uplands where a wider buffer will provide connectivity or where more protection of waterbody is required (e.g., large stream, lake).
	Ensure wastewater systems are:
	(a) appropriate for soil and groundwater conditions
	(b) sufficiently setback from waterbodies to prevent accidental release
	(c) a proven technology appropriate for the existing conditions
	Ensure stormwater management system provides sedimentation and contaminant filtration prior to release to waterbodies
	Minimize extent of impervious cover (e.g., paving, concrete), especially if groundwater recharge/discharge suspected
	Build up not out - encourage designs that minimize development footprint on lots
	Encourage low-impact surface runoff systems and overland drainage rather than redirection to stormwater systems
	Confirm sustainable water source is available (e.g., provide a Water License from AB ENV, or demonstrate access to commercial source like CU Water)
	Explore potential connection to municipal wastewater/drinking water systems where available, or innovative supply systems
Construction Conditions	
	Restrict clearing to construction area only - mark clearing limits before construction
	Appropriate controls must be used to minimize soil erosion by water and wind (e.g., sloped areas)
	Appropriate erosion and sediment controls must be in place for construction adjacent waterbodies/wetlands and within floodplain areas
	Prevent establishment of weedy or invasive (alien) species within riparian buffers through appropriate mitigation (e.g., weed control, equipment washing), particularly around waterbodies and wetlands
	Revegetate all disturbed areas as soon as possible (preferably with native species), but particularly where work is required within 30 m of a waterbody or in a floodplain
	Ensure wetland draining and clearing is completed before the spring restriction period (15 April - 31 July) to avoid harming or disturbing breeding migratory birds
	Proponent should prepare a Hazardous Materials Management Plan that addresses handling and storage of fuels, lubricants and other hazardous materials. Storage and handling of such materials within 100 m of a waterbody or wetland should be discouraged.

Landscape Connectivity / Biodiversity Core Areas: *(see Pages 4-13 through 4-14 and 4-15 though 4-17 in Reference Guide for additional information)*	
Design Considerations	
	Minimize development footprint to retain natural vegetation on lots (build up, not out)
	Design lots and associated infrastructure to avoid fragmentation of Key Segments and Core Areas within parcel
	Design lots and associated infrastructure (e.g., roads) to avoid disturbing other habitat patches and linkages that may provide access to Key Segments or Core Areas on or within 5 km of parcel
	In previously cleared lands, encourage landscaping with native species, especially where connectivity between habitat patches, Key Segments and Core Areas could be enhanced
	Confirm that no species at risk occur in proposed development area (referral to other agencies required if species are likely to be impacted)
	Ensure any potential impact to sensitive habitat of species at risk has been avoided or mitigated
	Incorporate landowner stewardship initiatives, such as native landscaping and wildlife habitat enhancement
Planning Review Considerations	
	Identify potential opportunities to restore or enhance connections between adjacent habitat patches (except where separated by major roads/railways)
	Ensure ER and MR dedication has been maximized to protect naturally vegetated areas within new subdivisions, particularly any Core Areas and Key Segments
	Consider use of Conservation Easements to protect other unprotected parts of Key Segments or Core Areas, or habitat supporting rare species
	Where development through a Key Segment cannot be avoided, require habitat replacement/enhancement of alternative detour
	Explore other means to direct development to less sensitive areas (e.g., lot bonusing, density trade-offs, cluster development)
Construction Conditions	
	Ensure vegetation and wetland clearing is completed before the spring restriction period (15 April - 31 July) to avoid harming or disturbing breeding migratory birds
	Minimize clearing of naturally vegetated areas by marking limits for vegetation removal
	Revegetated disturbed areas as soon as possible; use native species where possible, and particularly where disturbance is adjacent retained natural features
	Prevent establishment of weedy or invasive (alien) species within riparian buffers through appropriate mitigation (e.g., weed control, equipment washing), particularly around waterbodies and wetlands
Referrals Required? *(see Pages 4-8, 4-12, 4-14 and 4.63 in Reference Guide for additional information)*	
	AB ENV* - surface and groundwater permitting, watercourse crossings, outfall construction, stormwater/waste water permitting
	ASRD* (Public Lands) - wetlands/stream crossings, outfall construction
	DFO - watercourse crossings, outfall construction, any activity within or near fish-bearing waters
	Transport Canada (Navigable Waters Protection Program) - any activity within a navigable waterbody (note that this includes small streams)
	Environment Canada/ASRD - Species at Risk
	Natural Resources Conservation Board (NRCB) - intensive livestock operations (Note any special considerations requests that should be made re: local planning objectives)
	Environment Canada/AB ENV - activities with potential to contaminate soils, surface or groundwater (e.g., large sewage treatment facilities, certain industrial activities)
Follow-up/Additional Studies Required?	
	Soil percolation/groundwater study
	Rare species survey
	Wetland/habitat delineation
	Others?

* AB ENV = Alberta Environment, ASRD = Alberta Sustainable Resource Development, DFO = Fisheries and Oceans Canada

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1.0 INTRODUCTION

1.1 Background

1.1.1 The Beaver Hills Moraine

The Beaver Hills area lies east of Edmonton in the Beaver Hills/Cooking Lake moraine, a 1595 km^2 (616 mi^2) geomorphological feature that is a distinct regional landmark. The characteristic hummocky "knob and kettle" terrain of the moraine forms a patchwork of depressional areas, many of which support wetlands and small lakes. Terrain and soil conditions have limited past agricultural clearing and the area remains extensively forested with aspen and in some areas, spruce woodlands.

It is the combination of local geomorphology, hydrology, and climate that contributes to the unique landscape character[1] of the Beaver Hills. The natural greenspace and resulting biodiversity add to that character. Together, these biophysical features create a landscape in sharp contrast to the surrounding agricultural, urban and industrial lands, in which natural habitat has been reduced to smaller discontinuous patches. The Beaver Hills are truly a distinct feature on the regional landscape.

Land use in the area is administered by municipal, provincial and federal agencies. The Beaver Hills lie within five counties (Strathcona, Leduc, Beaver, Lamont and Camrose). There are several federal and provincial protected areas located entirely within the Beaver Hills, including Elk Island National Park (EINP), the Ministik Game Bird Sanctuary, the Cooking Lake - Blackfoot Recreational Area, Miquelon Lake Provincial Park and a number of smaller provincial natural areas. Nearby, there are other ecologically significant areas that are linked to the Beaver Hills. Beaverhill Lake, a designated RAMSAR site (a Wetland of International Importance), lies to the east and the North Saskatchewan River is within 5 km to the northwest. The moraine plays a key role in regional linkages with these areas, and at a broader scale, with the Dry Mixedwood Boreal Forest north of the North Saskatchewan River, and the Aspen Parkland to the south.

The natural feel to the moraine landscape is part of the quality of life valued by area residents and others in the region who enjoy the area for its recreational and aesthetic values. The area is under increasing pressure due to development and now the Beaver Hills ecosystem is at risk of fragmentation and degradation of its valued natural features. This pressure has potential to result in significant deterioration and loss of the natural capital of the area and the contribution that it makes to the social and economic well-being of local communities and their quality of life.

1.1.2 The Beaver Hills Initiative

The Beaver Hills Initiative (BHI) is a multi-stakeholder collaboration comprising the five municipalities within the Beaver Hills moraine, federal and provincial protected areas agencies, plus other government and non-governmental organizations with interests in the

[1] Definitions for this and other key terminology used in this report are provided in Appendix A.

area. In recognition of the moraine's essential landscape character, these partners have come together to promote a regional approach to land management in the moraine that will protect those elements contributing to that character.

The BHI's Vision and Mission identify both the elements of the landscape character that it wishes to protect and the means by which it hopes to accomplish that goal:

BHI Vision:
The Beaver Hills Initiative values the region for its natural beauty and quality of life and supports co-operative efforts to sustain its quality of water, land, air, natural resources and community development.

BHI Mission:
Working together for a sustainable region, through shared initiatives and coordinated action.

1.1.3 Benefits of Sustainable Land Management

Growth of the global human population has risen dramatically since the 1800s, increasing six-fold in that time (Ehrlich and Ehrlich 2004 in Hilty *et al.* 2006). To provide space and resources for that expanded population, landscapes have been progressively transformed over that time. While conversion of naturally vegetated lands to some form of human use is not new (Meffe *et al.* 1997), the dramatically increased rate of conversion in the past two centuries is a significant change. Human land use now covers 83 percent of the world's land area, and is thought to be one of the most serious threats to terrestrial biological diversity (biodiversity), along with climate change, nitrogen deposition and invasive species (reviewed in Hilty *et al.* 2006).

Globally, only 16 percent of the lands outside the polar regions are occupied by large, undeveloped wilderness areas (> 4000 km^2), which implies that the area remaining for those species that must use large ranges is becoming quite limited (reviewed in Hilty *et al.* 2006). The biodiversity contained within these large areas is similarly threatened, because large wilderness areas are often isolated within developed or even semi-developed landscapes. The same scenario is being played out at smaller scales. Clearing impacts are not restricted to large wilderness areas. Habitat loss and fragmentation is also occurring in agricultural and urban fringe landscapes, reducing the size of remnant natural areas, increasing their isolation from each other, and thus placing their biodiversity at risk.

Realization of the impact of past development on natural lands and the biodiversity they contain has created concern about the rate and extent of habitat and biodiversity loss, at all scales. Loss of species is not just an aesthetic or ethical issue. Increasingly, we are recognizing that the natural processes and natural goods and services on which we depend are critically linked to diverse ecosystems. The ecological processes responsible for air quality, water quality and abundance, soil production, nutrient cycling, climate moderation, pollination, breakdown of pollutants and waste and control of parasites and disease all rely, to some extent, on diverse plant and wildlife communities (reviewed in Hilty *et al.* 2006). Medicines, fresh water, fish and game are tangible products resulting from functioning and diverse ecosystems (Figure 1.1). The aesthetic and spiritual value gained from natural sites provides intangible, but no less valuable, benefits.

Together, the ecological goods and services and the aesthetic and spiritual values related to the landscape represent the *quality of life* for which our communities strive. Conservation efforts are required to ensure that these ecosystems, and their associated benefits, remain on the landscape. The link between natural goods and services and ecosystems suggests that conservation planning should be science-based. The BHI has taken this concept and its implications for quality of life to heart, and has consistently promoted a science-based approach to land-use planning.

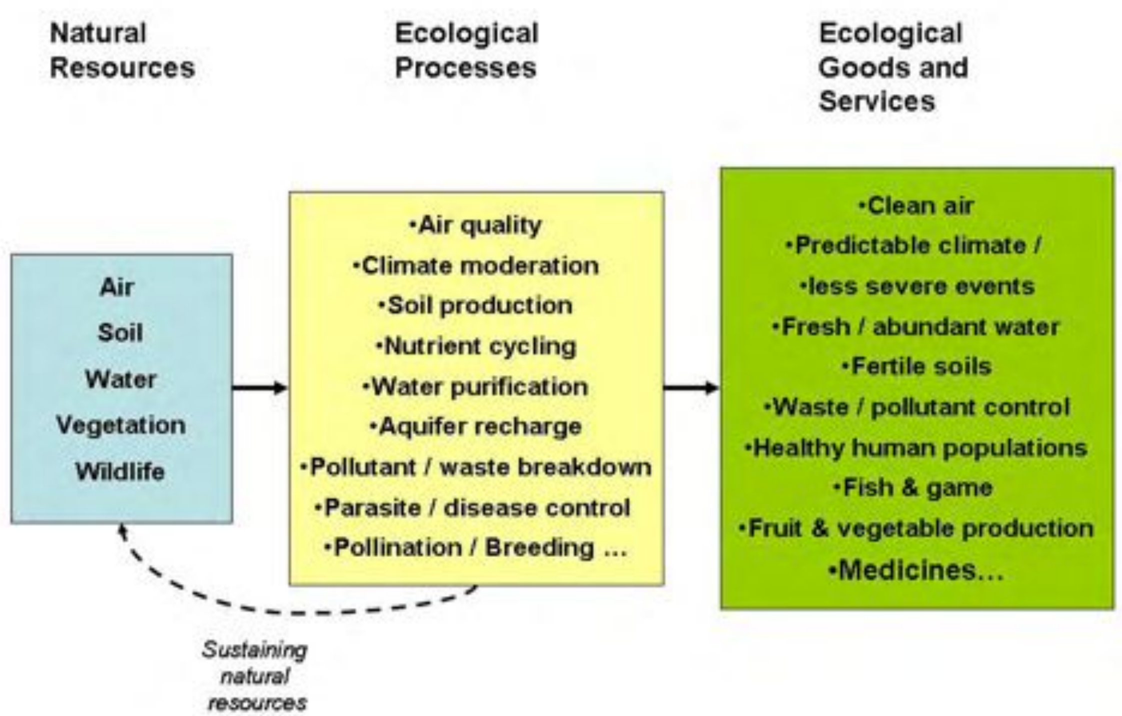


Figure 1.1. Relationship between ecological goods and services and ecological processes (Spencer Environmental 2006a)

1.2 The BHI Land Management Framework Project

Currently, the BHI wishes to foster regional cooperation through a common land use/management framework that will help to conserve the moraine now and into the future. They initiated preparation of that Land Management Framework as a two phase project in March 2006.

The common Land Management Framework envisioned by the BHI would provide a consistent approach to planning decision-making, intended to result in sustainable development. It will expand on the BHI Land Management Principles previously developed to guide development decisions in the moraine, to provide the detailed guidance necessary for practical application. The specific tools contained within the framework will help land use planners to manage the resources comprising the essential landscape character of the moraine consistently and sustainably.

The Land Management Framework Project is consistent with the many of the BHI's Guiding Principles, and indeed, the tools and information in the framework will allow many of these goals within these principles to be achieved throughout the moraine:

- Respect **appropriate use of land and water** and the **importance of our natural environment** in maintaining or improving our quality of life.
- Foster **long-term land use planning** with clear consistent goals and objectives.
- Promote **regional coordination** by reflecting the regional vision in all municipal land use policies, plans and actions.
- Success requires **community participation, input and support.**
- **Conserve, enhance, and monitor** improvements or monitor impacts to the environment.
- Success requires **commitment and leadership** from all levels of government.
- Strive for a **common level of data** (identify critical data needed, improve access and share where appropriate).
- Determine **habitat required** and strive to ensure that the **optimum amount** is maintained.
- Each partner area has a **responsibility to the environmental, social, economic well being** of the region. *(New -2006)*

The Framework steps beyond these principles, to 'operationalize' them and thereby provide the tools to implement the BHI's Principles and achieve regional coordination of land use planning. In that sense, it has the potential to be one of the most significant products provided to the BHI's municipal partners, the group's key client group (BHI Strategic Plan 2006-2009). Although the choice to utilize these tools will be left to the municipality, ultimately, the BHI hopes that the framework will be seen as a practical aid to planning, and adopted by each partner municipality as a consistent standard.

In July 2006, Spencer Environmental, IMI *strategics* and ISL Group completed Phase 1 of the Framework project, which assessed the current status of environmental policy among the partner municipalities, and the tools and jurisdiction available to them to manage environmental resources. Based on that information, Phase 1 concluded with a recommended process to move toward consistent policies within a Land Management Framework.

The Planners Working Group decided to proceed with implementation of the Phase 1 recommendations, working again, with Spencer Environmental and IMI *strategics*. In a series of meetings, the Planners Working Group, Spencer Environmental and IMI *strategics* refined the goals and objectives of Phase 2, and identified potential means to integrate Phase 2 with other related projects of the BHI currently underway. The key opportunity offered by other BHI activities is a council presentation proposed by the BHI in February 2007, which could serve to introduce the Framework to councilors and administrators.

The sections below outline the recommendations of Phase 1, which contained the approach now implemented in Phase 2.

1.2.1 Phase 1 Framework Approach Recommendations

1.2.1.1 Status of Existing Environmental Management Policy

Phase 1 began with a review of existing municipal policies to determine the level of consistency in environmental management among the partner municipalities. It also summarized environmental management jurisdiction of federal, provincial and municipal governments (under the Municipal Government Act (MGA)) to identify jurisdictional limits and tools currently used for environmental management. The two reviews identified gaps in policy that the municipalities might choose to fill in the context of a Land Management Framework.

The Phase 1 review found considerable variation in the approach and level of detail in environmental management among the five partner municipalities. All municipalities have environmental goals, objectives and policies but they are inconsistently incorporated in MDP, LUB and other non-statutory policies. Specific environmental protection measures are also variable in detail and force of law (in policy, vs. MDP or LUB). The environmental focus within the municipal context differed among the municipalities. This appeared to be driven, in part, by differences in the landbase administered by the municipality and the past land use pressures they have faced.

The types of statements included in the MDP and LUB documents also suggested that the inconsistent attention to environment is an artifact of the MGA. The MGA considers the environment in only three contexts:

- Environmental features that pose a threat to development and should be considered in development proposals ("hazard lands"),
- Lands that should be protected by the municipality for environmental reasons, typically those same hazard lands or lands suitable as park resources (Environmental and Municipal Reserve), and
- Lands of significance within the local environmental context that could be managed through landowner agreements (conservation easement provision, other management provisions within the Subdivision Regulation).

Although under the Subdivision Regulation, municipalities can consider any other factors that might be of concern in determining the most appropriate use of a parcel, no specific environmental issues are identified for consideration under that clause. As a result, most of the member municipalities have developed policies that address only the first two aspects of the environment listed in the MGA. Few have taken advantage of their authority under the MGA to manage environmentally significant lands, perhaps because of the limited definition of "environment" in the Act.

Phase 1 also assessed the extent to which the BHI's Blue and Yellow Landscape Management Areas (LMAs) are protected under current MDP and LUB policy and found that too, was variable. Older policies do not always protect the Blue LMAs, although some recently updated policies have extended protection through a designated zone or policy area. While some municipalities have identified specific zones for protection, others rely on general restrictions and conditions for development to protect key resources wherever they may occur. Both methods have their advantages, and Phase 1 concluded that the Framework should allow the flexibility to protect key resources through whichever method was most appropriate for the partner municipalities.

The LMA analysis identified the location of areas with abundant natural features of concern to the BHI. Ideally, the common Land Management Framework would capture within appropriate policy areas and land use zones the areas identified as Blue LMAs (containing several sensitive features). For the less clustered Blue and Yellow LMAs that cannot be easily grouped into such areas, a common set of policies with general management guidelines and criteria for development would provide a more workable mechanism for protection. In order for this approach to be implemented, however, the specific environmental resources contributing to a Blue or Yellow LMA (e.g., wildlife corridors, ground and surface water linkages) must first be identified.

Based on these background factors, Phase 1 recommended development and implementation of the common Land Management Framework in Phase 2 as a package of management practices that could be adopted by councils, according to their own circumstances and readiness. This acknowledges the varied distribution of sensitive resources among the municipalities and the level of awareness and political will related to their management. The proposed common Land Management Framework and the approach to its implementation in Phase 2 are explained more fully below.

1.2.1.2 The Land Management Framework, Phase 2

The BHI promotes informed decision-making that considers environmental, social and economic factors in land management, to achieve sustainable land management. The structure for the Land Management Framework recommended in Phase 1 was in keeping with that philosophy. The completed framework will provide an evidence-based foundation for land use decision-making that ideally, will result in sustainable development. This framework will be supportive to land use decision makers, because it follows a similar evidence-based approach to that used in developing land use policy. It will be successful because it provides a consistent, science-based foundation for land use decisions oriented toward determining the right land use in the right place.

The proposed framework arising from Phase 1 is envisioned as a reference guide consistent with the BHI's Landscape Management Principles that can support land use planning and promote environmentally-sustainable land management practices at the site-specific and landscape level. This will introduce a subtle change in land management approach, and to best implement that change, the Land Management Framework should be introduced gradually into municipal planning operations, at the individual municipality's discretion. The natural and manpower resources, knowledge, environmental issues and political context vary within each of the municipalities, and this integration process must acknowledge and allow for those differences. Accordingly, development and implementation of the Landscape Management Framework will be a bottom-up process, following the sequence outlined in Figure 1.2. This is a long-term plan. Phase 2 focused on only the first two steps, preparing materials that the municipalities and the BHI could use to promote internal and public awareness.

The products comprising the Land Management Framework have been packaged here as a reference manual that can be promoted within the planning departments of the municipal partners, and to the public. The material can be used to promote organizational (municipal) and public awareness of the necessity and means for action, an important preparatory step before attempting to adopt the framework into policy. Adoption of the Framework into formal LUB policy may follow later, at the discretion of each municipal partner. Later, the changes in policy created in the LUB could be captured in the broader MDP policy areas. All changes would be made by the individual municipality, incorporating the guidelines most suited to their landscape, and their political and public environment.

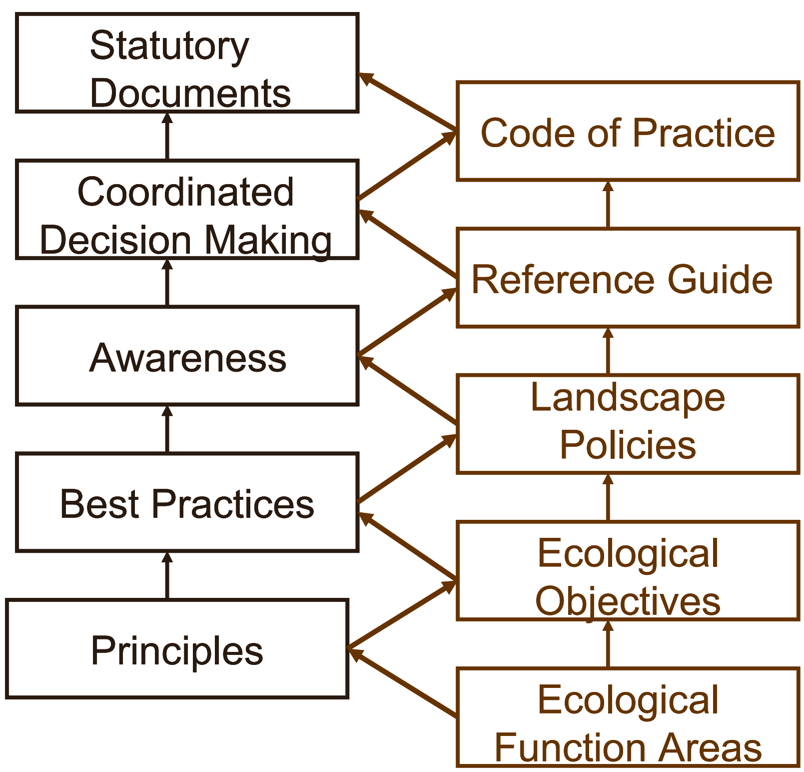


Figure 1.2. The Bottom-up Approach to the Land Management Framework
(Elements on the right side of the figure refer to specific deliverables of the framework)

1.2.1.3 Developing the Land Management Framework

Development of the Land Management Framework will follow a parallel process to that now used to create land use policy. Based on evidence collected during a research phase, planning zones will be created, supported by policy statements outlining criteria for development within those zones. The only difference is that with the Framework, the focus is on management of existing natural resources to sustain or enhance those features. Social and economic factors, the other components of a sustainable development approach, typically provide much of the background for land use policy development. It is the environment that is not typically addressed in land use planning, at least not as a comprehensive, functional system. Identification of Ecological Function Zones (EFZs) corresponding to each of the natural features addressed by the BHI Landscape Management Principles will provide the additional detail required to manage those resources. Development of ecological management objectives and supporting management practices (the Environmental Best Management Practices) for each of the EFZs will provide the partner municipalities with a practical reference manual that outlines where environmental sensitivities lie and how they can be sustainably managed.

The approach we have proposed to develop and implement the framework begins at the landscape scale. First, we have identified the areas in which resources occur. The larger Blue LMAs are critical to the moraine's ecology due to the concentration of resources that are critical for retaining the area's biodiversity value, ecological integrity, and natural capital outside designated protected areas (Green Area). Protecting landscapes such as the Blue LMAs from extensive development is a well-established tenet of landscape ecology. Similarly, the EFZs will identify areas where the more sensitive resources identified in the BHI's Landscape Management Principles occur on the landscape. The Environmental Best Management Practices (BMPs) can guide site-specific planning decisions regarding those natural resources or ecological functions. The combination of broad, landscape level analysis and site-specific, practical guidelines will provide the means for planners to identify appropriate land use and development for any given area.

These materials were compiled in this document, as a reference manual for sustainable land use planning/management that the BHI can provide to its member municipalities, or to others interested in the approach. Within this document, the link with the LMA Principles is clearly defined, through the Principles of Sustainable Land Use Management. The EFZs and supporting Environmental BMPs provide more specific description of the resources identified in the LMA Principles, and the Principles of Sustainable Land Use Management. The BMPs will also describe the desired outcome of management, which in turn, provides the basis for performance measurement. Guidelines and suggestions for performance monitoring have also been incorporated into the document.

1.2.2 Phase 2 Study Objectives

Phase 2 of the Land Management Framework project was to provide the following deliverables:

- Maps of the 5 EFZs and a set of Environmental BMPs specific to each EFZ.

- General Environmental BMPs applicable to key resources (identified in the LMA Principles) that can be incorporated into municipal policies.
- A Performance Measurement Implementation Strategy that identifies:
    - Performance Indicators,
    - potential means for monitoring each indicator from existing, BHI partner programs, and
    - any new monitoring initiatives that may be required.
- A list of future opportunities such as development of potential incentive and management policies, or involvement of BHI Working Groups in the implementation of the Framework.

1.3 Report Organization

This report summarizes the results of Phase 2, and provides the base elements of the Land Management Framework. It is intended primarily as a guide for land use planners, councilors and other interested agencies to provide the background information and tools required to manage the lands under their control in a sustainable manner. Accordingly, its organization reflects the various functions within municipal planning:

- Review of the site-specific development application,
- Development of broader municipal statutory policies (MDP's and LUB's), and
- Coordination and cooperation with other jurisdictions with similar management interests to promote appropriate land management practices.

The Framework is presented in 8 chapters. Chapter 1 provides background information related to the project, outlines the project objectives and describes the report structure. Chapter 2 reviews the original Landscape Management Principles adopted by the BHI, which were used to develop the Principles for Sustainable Land Management that form the basis for the framework. Chapter 3 describes the five EFZs, the importance of their management to the moraine, the methods used to quantify their current condition and their current state within the BHI boundaries. Chapters 4 and 5 outline Environmental Best Management Practices for each of the five ecological function zones, for two levels of planning. Chapter 4 provides site-specific considerations for review of development applications. Chapter 5 comprises broader recommendations appropriate for MDP/LUB planning activities. Broad management criteria for each EFZ that are intended to guide planning decisions are also provided in Chapter 4.

Chapter 6 identifies the performance indicators relevant to the EFZs and the recommended system to track them over time. Conclusions and recommendations arising from Phase 2 are provided in Chapter 7, and all references cited in the report follow in Chapter 8.

In addition, 7 appendices contain more detailed supporting information including:

Appendix A: a glossary of terms used in the report,

Appendix B: the original BHI Landscape Management Area Principles that accompanied the LMA mapping,
Appendix C: riparian buffer widths recommended in the literatures to protect various ecological functions,
Appendix D: the EFZ models,
Appendix E: GIS data used in the analyses, and
Appendix F: an example of application of the Environmental Best Management Practices for a typical development scenario.

2.0 BHI LANDSCAPE MANAGEMENT PRINCIPLES

2.1 BHI Principles and LMAs

The Beaver Hills is a unique area that is defined by a number of critical ecological aspects. In recognition of that fact and the value of the essential landscape character of the moraine landscape to its residents, the BHI has established and ratified a set of principles to guide decision-making on land use and land management practices within the moraine (Appendix B). Those principles were intended to provide guidance in five main areas, each of which may include several elements of the moraine:

1. Quality of Life
   - Essential Character
   - Property Rights
2. Biodiversity
   - Wetlands
   - Native Upland Habitat and Corridors
   - Species of Concern
3. Water
   - Watersheds
   - Water Quality
4. Land
   - Land Use
5. Air
   - Air Quality

The statements of principle were intended to serve as guidelines in land use planning and land management. They were linked to the LMA mapping zones (Green, Blue, Yellow and White Areas), through specific management guidelines reflective of the richness of resources within each LMA. The principles, while identifying the features of the moraine valued by its residents, provided only general guidance for their management. They lack the specific information required to support the eventual decisions required for land management. This Land Management Framework is intended to add more specific guidelines to the general principles, providing the information and tools required by the municipalities, as well as the various other partners, to manage the moraine in a sustainable manner.

To do that, we first needed to restate the Land Management Principles as more concise Principles of Sustainable Land Use Management that would more directly provide a link between the LMA Principles and the EFZs. Municipal land use planning is most concerned with the Blue and Yellow LMA areas. Green areas are managed as designated protected areas by the provincial or federal governments respectively. White areas have been highly modified, such that no natural features remain in them. It is those lands with some natural resource or function still present that require special management. The Principles of Sustainable Land Use Management, therefore, from a municipal standpoint, deal with those zones, which may be privately owned, but still contain resources of interest and value to a broader public. In the sections below, we have derived Principles of Sustainable Land Use Management from the original Landscape Management Principles, by focusing on the planning principles identified for the Blue and Yellow LMAs.

2.2 Principles for Sustainable Land Use Management

For each of the resources identified in the Landscape Management Principles, we have restated the original principle statement (in bolded italics) and in bullets below each statement, summarizing the common planning principles identified by the BHI for the Blue and Yellow LMAs. These Principles for Sustainable Land Use Management are intended to support and guide the framework, identifying the key features and means of achieving common land use planning and sustainable land management practices across the moraine.

1. Quality of Life

Essential character: ***The essential character of the Beaver Hills will be preserved in its natural beauty, clean and unspoiled environment, and quality of life.***

- Preserve the present character and quality of the moraine landscape, by protecting those aspects of the landscape valued by its residents and visitors for their distinctive natural or cultural configuration.
- Maintain patches of woodlands and wetlands that now form linkages between or surround, Green Areas, and support a variety of plant and animal species.
- Maintain natural areas that provide the aesthetic feel of abundant greenspace, and consider also those sites that if allowed, could return to a more natural state.

Property rights: ***We will respect existing land use designations. We will respect the rights and responsibilities of private and public landowners and enlist their voluntary cooperation to manage their lands and the resources of the Beaver Hills in a sustainable manner.***

- Allow current individual land management practices to continue, but promote sustainable practices where issues are identified.
- Provide incentives for rehabilitation of natural features damaged by past and current land use.
- Revise existing land uses proposed within planning documents if they are determined to pose a risk to sustainability of natural features.
- Maintain the distinctive aesthetics (character and quality) of the area associated with natural features.
- Engage in coordinated inter-agency land management strategies to manage broader issues (e.g., wetland restoration, weed and disease control).
- Encourage environmentally-friendly residential, industrial, recreational, and agricultural practices.

- Plan for future development consistent with the Land Management Principles of the BHI.

2. Biodiversity
Wetlands: ***Existing natural wetlands and their associated riparian upland margins will be conserved both in regard to their biodiversity and functional aspects.***

- Conserve intact wetlands where possible, and particularly those that are critical to the hydrology of the BH moraine.
- Focus development near less critical wetlands.
- Provide a riparian buffer on wetlands to preserve water quality and biodiversity.
- Abide by provincial Draft Wetland Policy (i.e., no-net-loss and restoration in compensation for loss).

Native Upland Habitat and Corridors: ***Development will retain native upland habitat (woodlands and grasslands) prominently featured within the Beaver Hills to maintain the majority of the existing greenspace and its associated biodiversity. Connectivity of habitat will also be retained so that continuous corridors remain within the Beaver Hills and between it and the surrounding region.***

- Maintain existing green spaces that provide habitat and wildlife corridors.
- Fill in gaps in wildlife corridors between Green Areas to form a band not less than 2 km wide.
- Focus restoration on fragmented or disturbed habitats that can support healthy natural ecosystems or provide linkages with other habitat in other landscape units.
- Focus expanded development on areas most suited to agricultural, industrial, recreational or residential land use.
- Direct new development to cleared, disturbed, isolated and fragmented areas with existing infrastructure to support development.
- Encourage environmentally sustainable development and land management practices.

Species of Concern: ***Promote land use and land management activities that will not compromise the ability of currently present rare and sensitive species or species important for human use to persist in the Beaver Hills.***

- Conserve habitat demonstrated to support species of concern and, where possible, adjacent habitat that could support other populations of such species.
- Retain habitat, including fragmented areas that will help sustain species of concern, on an opportunistic, site-by-site basis.
- Encourage education, awareness and voluntary action to conserve rare species and their habitat.

3. Water

Watersheds: ***Maintain function of local watershed to sustain regional surface and groundwater systems***

- Maintain intact watershed features that are critical to the hydrology of the BH moraine.
- Rehabilitate disturbed areas that are critical to natural hydrology.

Water Quality: ***Sustain ability of local watersheds to maintain the water quality of surface and groundwater systems***

- Manage wetlands and their riparian buffers to protect water quality.
- Permit those land uses that incorporate measures to protect water quality of waterbodies within and adjacent the property.
- Abide by letter and intent of federal and provincial legislation regarding surface and groundwater.

4. Land

Land Use: ***Support an appropriate mix of agricultural, industrial, recreational, and residential development in areas with lower environmental sensitivity and maximum potential for sustainable business operations, thus maintaining the character of the distinctive landscape.***

- Continue existing agricultural, residential and industrial land uses that complement the ecological integrity of adjacent natural areas, and particularly, protected areas.
- Focus future development in areas with existing infrastructure (e.g., roads, water & wastewater, schools, etc.) to minimize additional development requirements.
- Consider minimal impact designs for future developments.
- Encourage land use that supports quality of life goals held by residents in the more natural parts of the moraine.

5. Air

Air quality: ***Industrial growth in the region will maintain the clean air and current air quality valued by Beaver Hills residents***

- Maintain current air quality standards.

3.0 ECOLOGICAL FUNCTION ZONES

The BHI Land Management Principles and the new Principles of Sustainable Land Use Management list a consistent set of natural features that are the core biological elements representing the essential landscape character of the moraine, including:

- Air quality,
- Water abundance and quality of surface water,
- Water abundance and quality of groundwater,
- Biodiversity, and
- Habitat connectivity.

Just as the LMA mapping helped relate the Land Management Principles to specific areas of the moraine, the Ecological Function Zones (EFZs) will identify geographic areas requiring management under the Land Management Framework. These areas, and the sensitive resources contained within them, are the critical elements of the ecological system within the moraine. It is these elements that sustain the natural features and ecological processes, provide the ecological goods and services on which we rely, and ultimately, maintain the quality of life valued by residents and visitors to the moraine.

The Ecological Function Zones (EFZs) identify locations where the resources listed in these principles occur and are most sensitive to land use and management. Note that the EFZ's identify only the occurrence of resources known to be sensitive or at risk to land use and management in a general context. Identification of the specific factors contributing to that sensitivity were not part of the study scope, nor would such investigation be practical, as those factors would be site-specific and would vary considerably over the moraine landscape. Highlighting areas of concern raises the natural, follow-up question regarding causative factors. In instances where further investigation into the causes of resource sensitivity or confirmation of current resource quality would aid in future management, we have recommended additional investigation.

The EFZ zones were identified through Geographic Information System (GIS) analyses that isolated the geographic areas of highest sensitivity relevant to each resource. Sensitivities were based on the management considerations relevant to each resource: the value attached to the resource by government regulators, the public or resource managers; the role of the resource in the broader ecosystem; and, the element of risk that requires management.

The sections below outline for each EFZ the management considerations applicable to the resource, the GIS model methodology used to identify the EFZs, and finally, the critical locations identified through the modeling process. These locations indicate where the resource is most vulnerable to development and land management, and therefore, most in need of management in the planning context.

3.1 Air Quality

3.1.1 Management Considerations

The Beaver Hills moraine is generally considered to be a relatively natural setting, with aesthetics characteristic of country living. Fresh air, untainted by odors associated with more industrial or urban settings, was one of the elements of the essential landscape character of the moraine identified in the BHI Land Management Principles. The moraine lies within a developed context, with industrial and other urban elements adjacent to or within it. The release of potential airborne contaminants from these developed areas is of concern to moraine residents for both aesthetic and health reasons. Accordingly, we used air quality data compiled by the province to determine whether air quality in certain parts of the moraine may be at risk.

Air quality is regulated by the province, according to established provincial and national standards. Ideally, air quality should be such that air is odorless, tasteless, looks clear and has no measurable short- or long-term adverse effects on people, animals or the environment (CASA 2006). In Alberta, air quality is measured relative to standards for one-hour, 24-hour, and annual averaging periods. Occasionally, the underlying information requires that other averaging periods be used. These standards are based on an evaluation of scientific, social, technical, and economic factors (Alberta Environment 2006a and 2006b).

Locally, the companies operating within the Industrial Heartland, the industrial node east of Fort Saskatchewan and north of the moraine, are also interested in maintaining good air quality, in consideration of their proximity to large urban centers. The Fort Air Partnership, an industry association representing these heavy to medium industrial operations, regularly monitors and manages air quality issues within an area that includes the north part of the moraine (Figure 2.1).

The Fort Air Partnership operates eight continuous air monitoring stations, and 30 passive air sampling sites, which monitor compliance with the Alberta standards. Continuous air monitoring stations analyze the air for specific components, including ammonia, carbon monoxide, ethylene, ground-level ozone, hydrocarbons, hydrogen sulphide, methane, nitrogen oxides, particulates, sulphur dioxide, vinyl chloride monomer and volatile organic compounds. Weather conditions are also monitored continuously at these stations. These stations tend to be located in or near urban areas, which are considered to be most at risk to adverse air quality. There are two stations in Fort Saskatchewan and one in Lamont. A station has also been established in Elk Island National Park to monitor for potential ecological impacts. The Elk Island station is the only one within the moraine, but monitoring results there tend to be less frequently reported than for the urban sites. Continuous monitoring information for the moraine was, therefore, not available.

Passive samplers are much less expensive than continuous analyzers, and because they do not have any power requirements, they can be used in remote locations. Several of these stations have been established throughout the Fort Air Partnership area and some of those sites lie near or within the moraine (Figure 2.1). These stations monitor for ground-level ozone, sulphur dioxide and nitrogen dioxide. Nitrogen dioxide and sulphur dioxide are air pollutants that trigger adverse environmental impacts including acid rain and health issues, and ozone is related to aesthetic and ecological functions (e.g., global warming). We used data from those stations in and near the moraine to determine if certain areas of the moraine may be exposed to lower air quality.

3.1.2 Methods

The Fort Air Partnership established a network of 10 passive samplers in June 2006, monitoring for ozone, sulphur dioxide and nitrogen dioxide. In January 2006, 20 sites were added, monitoring for sulphur dioxide and hydrogen sulphide (Fort Air Partnership 2006). Passive samplers allow for the uptake of air through permeative or diffusive process. Passive samplers are collected on a monthly basis and the samplers are then sent for laboratory analysis.

To identify areas of the moraine that may be exposed to lower air quality, we compared the passive air monitoring data for ground-level ozone, sulphur dioxide and nitrogen dioxide from 10 stations to the recommended guideline of each air contaminant. Provincial standards for these elements are listed in Table 3.1. Ground-level ozone was compared to the Canadian 8-hour average guideline of 65 ppb. Both sulphur dioxide and nitrogen dioxide were compared to the Albertan annual average guidelines of 11 ppb and 32 ppb, respectively.

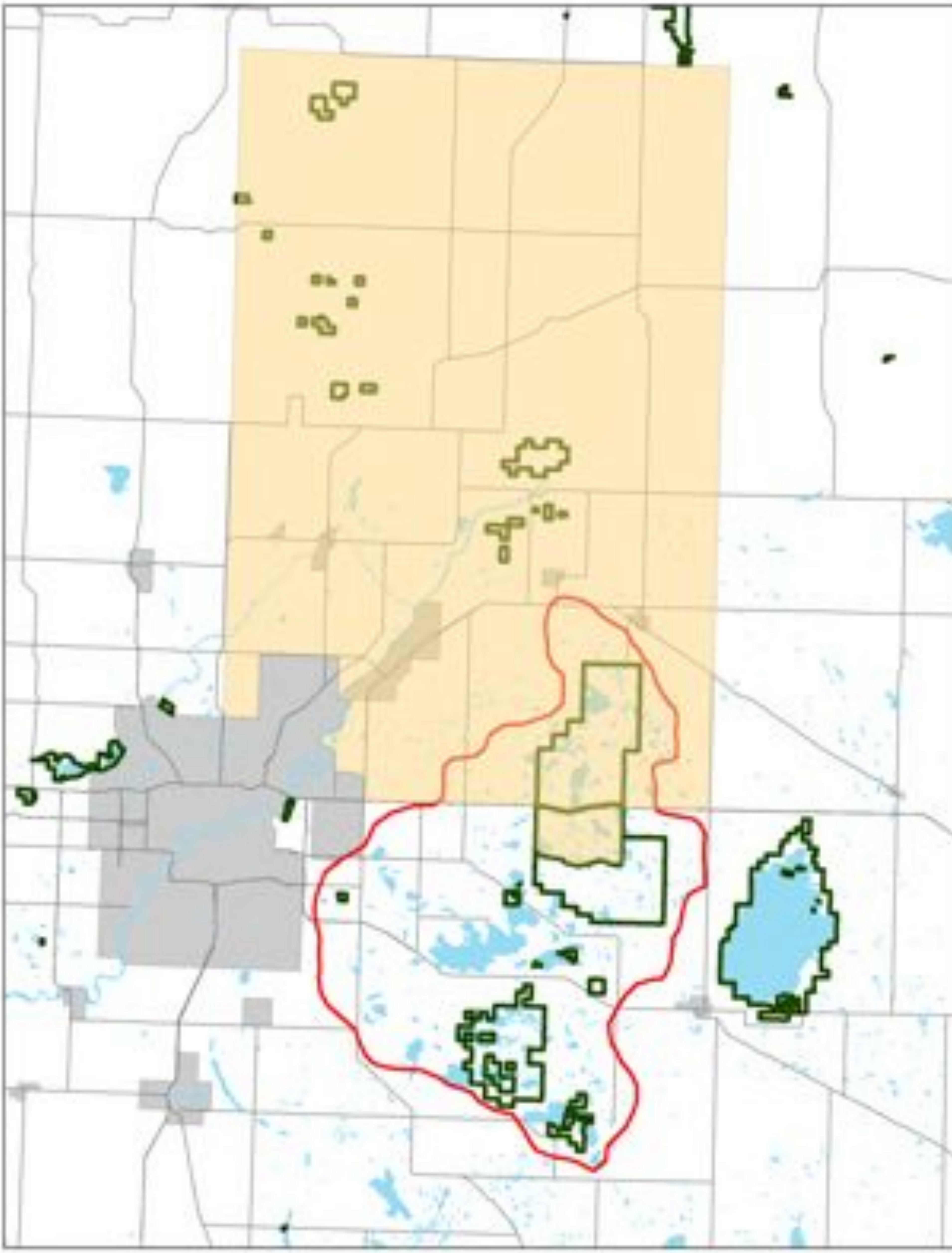
Table 3.1. Provincial Air Quality Standards for Selected Contaminants [a]

Substance	ug/m^3	ppbv [b]	Basis	Effective
Nitrogen dioxide				*1975*
1-hour average	400	212	Odor perception	
24-hour average	200	106		
Annual arithmetic mean	60	32		
Ozone (ground level)				*1975*
1-hour average	160	82	Lung function, sensitive receptors: tomato	
Sulphur dioxide				*1975, reviewed 1987*
1-hour average	450	172	Pulmonary function	
24-hour average	150	57	Sensitive receptors: begonia, bluegrass, aspen, forests	
Annual arithmetic mean	30	11	Sensitive receptors: natural forests, lichens	

[a] Alberta Environment (2006a and 2006b)
[b] Standard conditions of 25 C and 101.325 kPa are used as the basis for conversion from ug/m^3 to ppbv (parts per billion by volume).

3.1.3 Zone Characteristics

Fort Air Partnerships airshed boundaries include the northern part of the Beaver Hills Moraine (Figure 3.1). While this area represents less than half of the moraine, it does capture the area that would be most likely to have air quality concerns, given that it is nearest to the industrial areas within Fort Saskatchewan and east Edmonton. The prevailing wind direction blows towards the northeast (CASA 2006), suggesting that the areas most at risk due to airborne pollutants would be outside the moraine, a factor reflected in the Fort Air Partnership area of interest.



Legend

- Major Roads
- Municipal Boundary
- Protected Areas
- Beaver Hills Moraine
- Urban Areas
- FAP Airshed

Figure 3.1. Fort Air Partnership Airshed

N

1:425,000

Given the prevailing wind direction, which would carry any emissions from the key industrial areas in east Edmonton and the Industrial Heartland away from the moraine, one would perhaps expect good air quality within this area. In fact, none of the passive air monitoring stations recorded averages exceeding the provincial or national guidelines. The continuous monitoring stations in Fort Saskatchewan, Lamont and East Edmonton all report that air quality is "Good" (a relative index reflecting the frequency of exceedances of certain contaminants relative to provincial standards)(CASA, 2006). From an aesthetic and health perspective, air quality in the moraine does not appear to be at risk currently.

Ecologically, however, cumulative effects of long-term exposure may affect more sensitive natural resources. Certain lichens, for example are known to accumulate contaminants, and can be sensitive indicators of bioaccumulation. The Fort Air Partnership and Elk Island National Park initiated a study in 2006 that is examining air quality from this perspective. Results are not yet available, but may provide an additional and more sensitive assessment of air quality within the moraine.

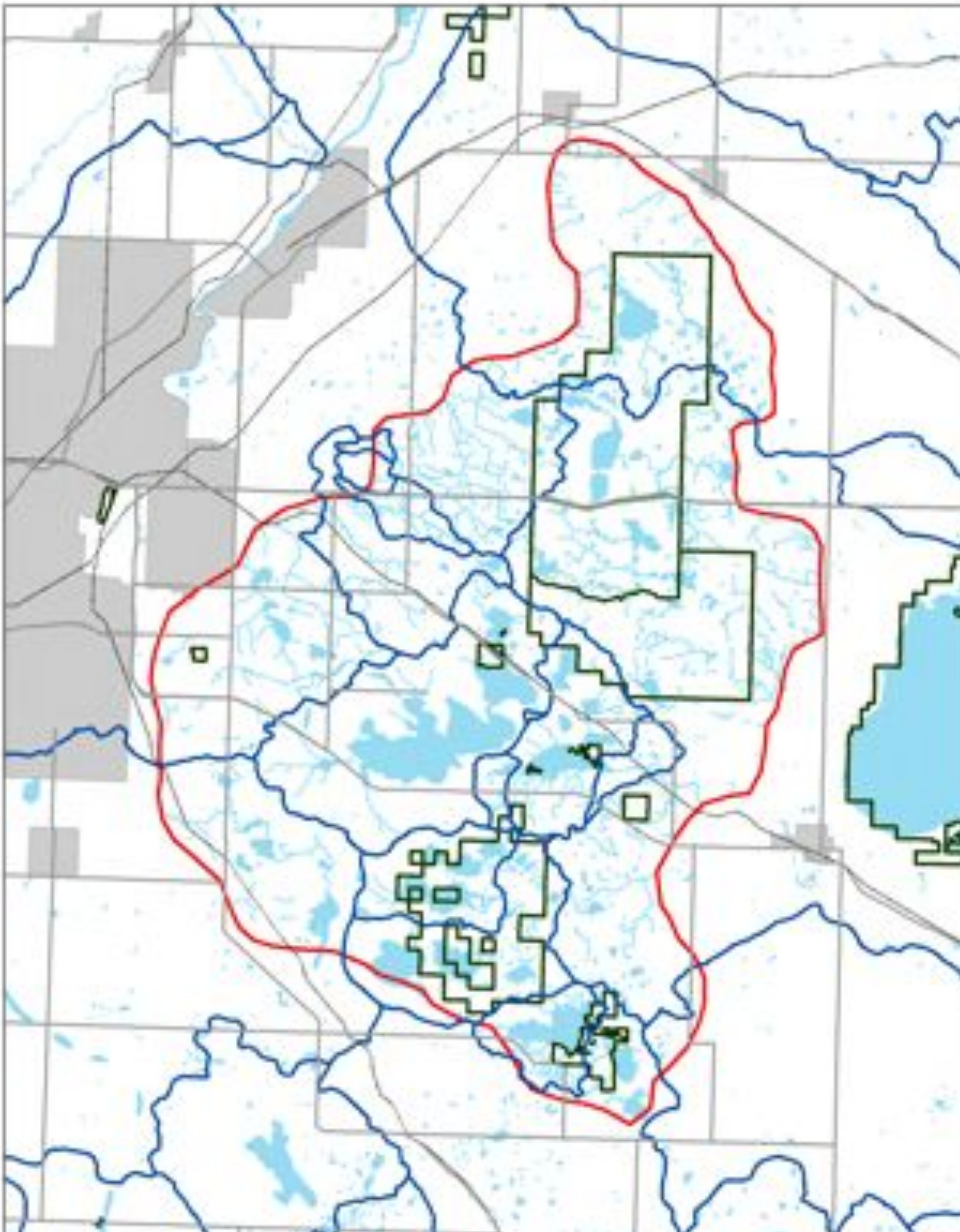
3.2 Surface Water Risks

3.2.1 Management Considerations

Hydrology within the moraine is complex, due to its elevation above the adjacent level plains, and its rugged, knob and kettle terrain. Surface water is abundant, and is captured in the form of wetlands and lakes within the moraine and at its edge, in streams. Cooking Lake is the largest waterbody within the moraine at approximately 36 km^2 (Mitchell and Prepas 1990). However, wetlands are far more numerous and are distributed across the whole of the moraine, with the greatest concentration in its eastern part. Their cumulative area represents 66.3 km^2, roughly twice the area of Cooking Lake.

No rivers run through the moraine, but there are a number of streams, which flow down the outer slopes of the moraine through various drainage systems into the North Saskatchewan River. Flows off the north and northwest edge of the moraine are collected in various larger order streams that release to the river near Fort Saskatchewan. The south-most part of the moraine drains into other sub-basins of the North Saskatchewan watershed, including the Battle River.

A river watershed consists of a number of drainage systems contained within progressively smaller areas. The Beaver Hills Moraine lies within the Beaver Hills Sub-basin of the North Saskatchewan watershed. The sub-basin can be more finely classified into Gross Drainage Areas corresponding to smaller drainage areas that ultimately release to the North Saskatchewan River (Figure 3.2). Some of these are closed systems, with no outflow connection to other higher order drainage systems. In total, nineteen Gross Drainage Areas lie within the Beaver Hills Moraine. A number of groundwater recharge and discharge sites exist within the moraine, so that surface water systems are closely linked to groundwater supply and protection. Surface water abundance and quality are, therefore, important locally, as well as regionally. For this reason, they were identified as critical elements of the moraine within the BHI Principles.



Legend

- Major Roads
- Rail Lines
- Regional Urban Areas
- Municipal Boundary
- Protected Areas
- Beaver Hills Moraine
- Gross Drainage Areas

Figure 3.2. Gross Drainage Areas within the Beaver Hills Moraine

N

1:250,000

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A healthy riparian system is capable of performing various ecological functions, including sediment trapping, bank building and maintenance, water storage, aquifer recharge, flow energy dissipation, maintenance of biotic diversity and primary production (Thompson et al. 1998). Collectively, wetlands provide additional ecological functions that benefit the watershed. Wetlands have been recognized as particularly useful areas because they:

- absorb the impact of hydrologic events such as large waves or floods;
- filter sediments and toxic substances;
- supply food and essential habitat for many species of fish, shellfish, shorebirds, waterfowl, and furbearing mammals;
- supply water for groundwater recharge;
- assist with erosion control (Cappiella et al. 2006, Environment Canada 2006).

Public and scientific concern over surface water quality and quantity is growing within the Beaver Hills Moraine. Recent droughts have lowered lake and wetland levels well below normal levels. Affected members of the public range from water-based recreational users, particularly those dependant on the larger waterbodies in the moraine, to farmers, who rely on surface water as a water source for livestock.

3.2.2 Model Objectives

Surface water quality is a concern of both provincial regulators and the public. Vegetated buffers and continuous aquatic linkages play a role in both water abundance and quality. Continued development within the moraine has also led to land conversion, which could affect water supply through altered drainage patterns and increased evapotranspiration. In addition, some forms of land use and management have the potential to affect water quality. Where development has been extensive, waterbodies may be at risk or require more management to ensure that impacts are minimized. Determining where development has been extensive within each the Gross Drainage Areas, and may be approaching a critical threshold with respect to its ecological functions, was the objective of this EFZ model.

3.2.3 Methods

The Surface Water Risk Model was designed to identify the sensitivity of each Gross Drainage Areas (GDAs) to additional development within the Beaver Hills Moraine. The GDA is defined as the area enclosed by a drainage divide, which might be expected to collect runoff from that area entirely (i.e., with no additional contribution from adjacent areas) under extremely wet conditions. The model identifies the relative proportion of land uses and land cover with negative and positive influence on water quality or quantity in each of the GDAs in the Beaver Hills Moraine. The model considers the relative impact of various land uses on water quality and water supply and the balance of developed to undeveloped lands within the GDA, to determine whether the GDA may be approaching some critical threshold where ecological function may be impeded. The detailed explanation of the model is provided in Appendix D. An overview of the model approach is provided here.

The GDA's within the moraine in some cases extend beyond the boundaries of the moraine. Because this current assessment wished to focus on the moraine lands only, those sections of GDA's beyond the moraine were clipped so that the analysis only considered the part of the GDA within the BHI area.

3.2.3.1 Model Scoring and Mechanics

The model relies on scores that classify each form of land use/land cover within the moraine, including undeveloped lands, in terms of positive and negative impact to surface water quality and quantity. The scoring is somewhat generalized, given the combined examination of water quality and quantity, but is sufficient for planning reviews, which seek to identify broader level concerns. The scores were based on documented functional relationships of land cover on surface water run-off, soil percolation, contaminant filtering, and evapotranspiration. The scores for each land use/cover element in the GDA model are listed in Table 3.2. For more detailed information on the modeling process, refer to the detailed model in Appendix D.

Within each GDA, the model assigns a score for each land cover type present. These land covers are explicit (i.e., they do not overlap), and, thus, the model is based on reclassification, rather than an additive approach. Next, the land cover data were classified as either Positive or Negative Land Cover Types as outlined in Table D1 in Appendix D. For each land parcel corresponding to a given land cover/use, a Land Cover Type Index was calculated according to the following formulae:

Positive Land Cover Type Index (PLT) = ($Score_i$ x $Area_i$)/ GDA Water Area,

where i = each positive land cover parcel.

Negative Land cover Type Index (NLT) = ($Score_i$ x $Area_i$)/ GDA Water Area,

where i = each negative land cover parcel.

The resulting Land Cover Type Index effectively provided a weighted index representing the contribution of that land cover area to surface water quality, relative to the extent of surface water present in the Gross Drainage Area. These indices were mapped for each land parcel within the moraine, to illustrate site-specific contributions to surface water risk.

Table 3.2. Scoring for Variables in the Surface Water Risk Model

Land cover Type	Variable	Element	Score	Influence	Datasets
Positive	*Land cover*	Natural vegetation (forest, shrub or grassland)	2	High positive	ASRD Native vegetation
		Protected Areas (where not overlapping native vegetation)	2	High positive	AB Community Development Protected Areas
		Forage and cropland	1	Moderately positive	New file created for analysis, to be replaced with PFRA Ag-Capture data in 2007
		Rural residential	0	Neutral	Land use zones
Negative		Commercial	-2	High negative	Land use zones
		Industrial	-2	High negative	Land use zones
		Urban residential	-2	High negative	Land use zones
		Developed urban areas	-2	High negative	Built-up areas file (BHI library)
	Transportation	Roads	-1	Moderate negative	NRCAN Roads
		Rail lines	-2	High negative	NRCAN Roads
	Water	Hydrology			NRCAN hydrology (1:50K)
		GDA			PFRA GDAs

We also wished to identify the risk at the GDA level. This analysis identified the net effect positive and negative influences on water quality and quantity relative to surface water area in each GDA. The net Land Cover Index within the GDA provided a final score used to map risk at the GDA level:

Final Score = $\sum PLT_i - \sum NLT_j$

Where *i* = all positive land cover parcels within the GDA, and *j* = all negative land cover parcels within the GDA.

The final mapping scores for the parcel-level and GDA analyses are then grouped into risk categories (low, medium, high) based on the distribution of final scores. These risk categories were then color-coded and mapped.

3.2.3.2 Model Limitations

Accurate and current forage and cropland data for the moraine do not currently exist. However, we used the Agricultural land use category identified in GIS land use layer provided by the 5 municipalities to create a layer for this analysis. Built-up areas, NRCAN roads and large waterbodies from the provincial hydrology data layers were erased from the agricultural land use layer to identify potential agricultural lands in crop or forage. Overlays with aerial photographs confirmed that this method had generally identified agricultural lands correctly. This new layer is a surrogate that will be replaced with more accurate data once it is available. PFRA's AG-capture project will be completed in early 2007, and can replace this interim dataset when available.

Land use data were also used to identify the various other land uses considered in this analysis. The original land use data provided by the municipalities were reclassified to identify industrial, country residential, commercial, and urban residential areas. Protected areas considered in the analysis were limited to large provincial protected areas, as the smaller conservation easements tended to overlap and duplicate the wetland and natural vegetation data.

3.2.4 Zone Characteristics

3.2.4.1 Higher Risk Zones

Across the moraine, the model identified several high risk GDAs (Figure 3.3). The Cooking Lake, Hastings Lake and Miquelon GDAs had low, negative final scores, indicating that the level of negative land uses/cover was high relative to the area of surface water. Each of these GDA’s contains a large lake; in the case of Miquelon, the majority of the GDA is occupied by water. The constituent land parcels in these areas tended to present only moderately low risk ratings (i.e., few negative land use/cover types), particularly Hastings Lake (Figure 3.4). The abundance of water appears to be the main factor driving risk in these GDAs.

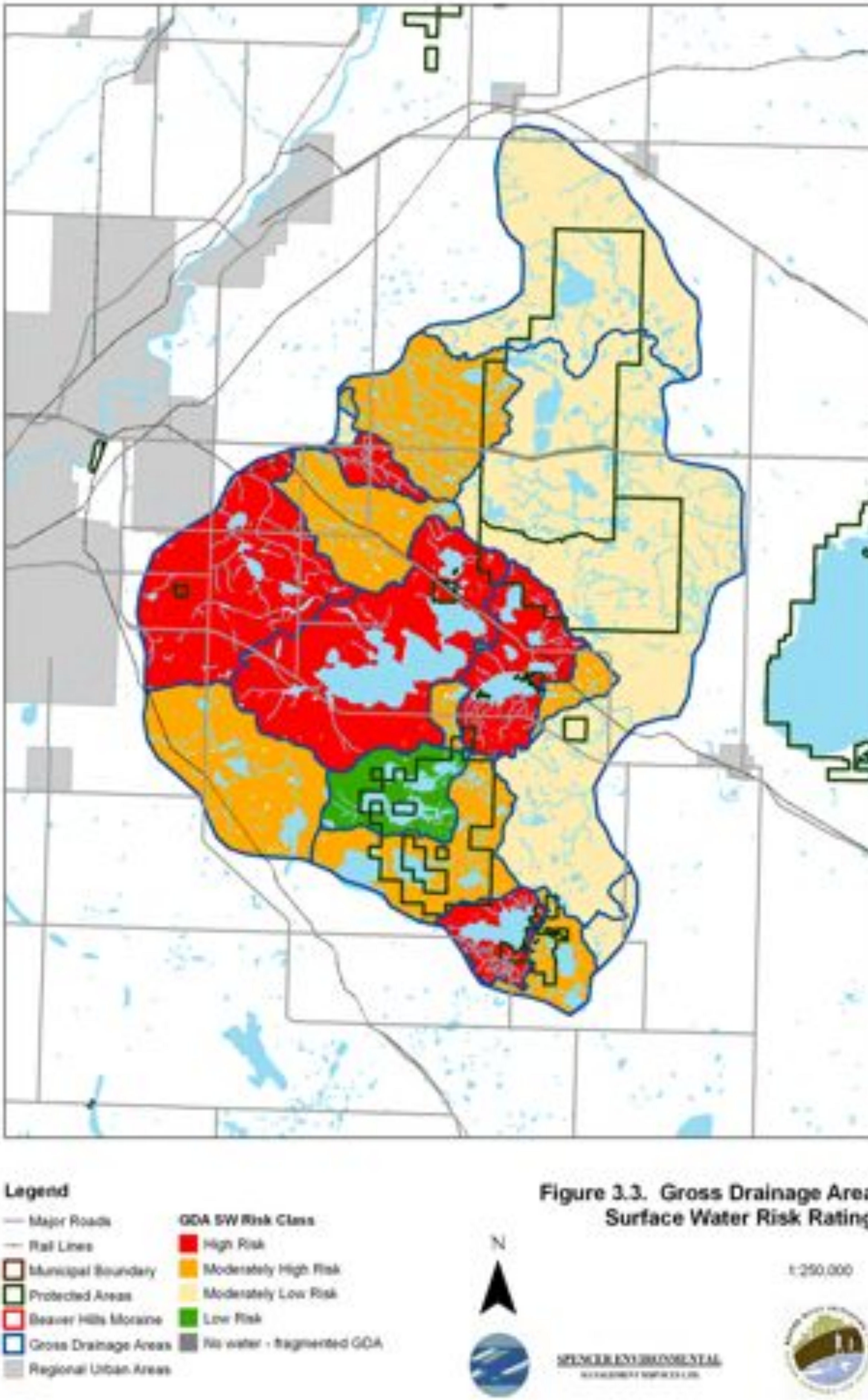

Figure 3.3. Gross Drainage Area Surface Water Risk Rating

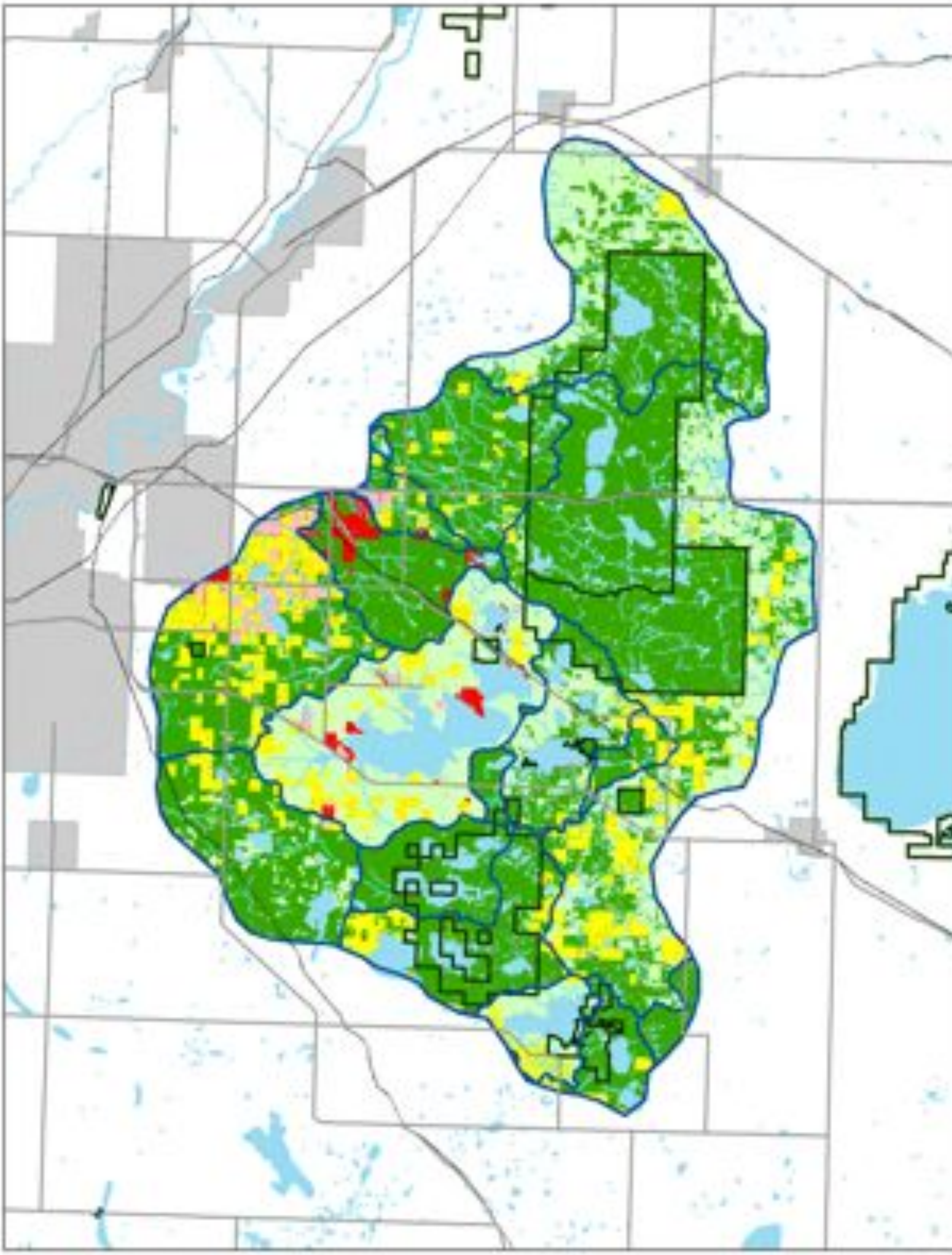

Figure 3.4. Surface Water Risk for Existing Land Use/Cover

The higher risk level in these circumstances is somewhat intuitive: where water is very abundant, even relatively low levels of negative land use/covers would increase the risk to water resources because exposure is higher, and, therefore, the potential to impact water quality is higher. Less obvious perhaps is the effect of a relatively small land base on surface water quantity. Although the presence of such a large waterbody suggests some supply from groundwater, surface water runoff from within the GDA will also provide an important source. Evaporative loss, impoundment or redirection of runoff before it reaches the large waterbodies in the drainage area could have a relatively significant cumulative effect within such a small drainage area.

The rating in the case of these GDAs is perhaps better termed as a higher sensitivity: development and land management must be sensitive here to avoid to potential impacts to water quality and quantity. Here, landowner cooperation to implement sustainable land management practices that will help protect for water quality and water quantity will be critical, particularly around the large lakes. Sensitive development that strives to minimize potential future water impacts will also be critical in these areas.

For the other two high risk areas, southeast of Sherwood Park and southeast of Highway 16, along the Pointe aux Pins drainage, water is not abundant, and the risk rating is more likely related to development (Figure 3.3). The parcel land use risk map confirms this assumption: higher risk negative land uses/covers occupy much of the land base in these two GDAs (Figure 3.4). Here, development may be near or at a threshold beyond which the positive landscape elements contributing to the water purification and supply functions may not be capable of sustaining water quality and quantity across the entire area.

Confirmation of site-specific conditions would be required to confirm whether such thresholds have been exceeded (e.g., for water quality parameters, eutrophication, drought impacts), a task outside the scope of this assessment. Provincial water quality standards provide a gauge against which to assess whether impact has crossed a sustainable threshold (Alberta Environment 1999), and data could readily be collected through lake management associations or land owner programs. Alberta Fish and Game Association sponsored such a program in 2005, which could be expanded to provide comprehensive assessment over the moraine. Regardless of such confirmation, this current assessment suggests that action is required now to avoid additional impacts that could drive ecological functions beyond a sustainable level. As with all of the models in this assessment, the intent is to indicate potential degradation that threatens the resource, before its associated ecological goods and services are severely affected. It raises awareness of potential concern, so that management of these areas can be adapted in a timely way to reduce the impact, rather than to confirm loss of essential function, and reduced quality of life.

Sustainable land management practices (e.g., minimizing pesticide and herbicide application around waterbodies, avoiding wetland disturbance and loss, appropriate waste management and stormwater treatment) will be critical in these high risk areas. Where lands have already been developed, adoption of such practices through landowner cooperation is probably the best option as it provides a long-term solution. In some cases, enforcement legislation might be required. Fortunately, provincial and federal enforcement legislation is already available. Implementing this measure would require increased inspection, reporting and enforcement, which, in turn would require cooperation between the municipalities and those agencies.

Sustainable practices are most efficiently applied by municipalities during the planning approval stage for new development, when innovative and current practices can be readily incorporated in development design. New developments within these GDA's should be reviewed carefully in light of their current risk rating.

3.2.4.2 Lower Risk Zones

Interestingly, the largest protected areas within the moraine (Elk Island National Park and the Cooking Lake - Blackfoot Recreation Area), which would be expected to have a low risk due to extensive vegetative cover, had a moderately low rating. In fact, the only low risk GDA was an area that encompassed and was dominated by the Ministik Bird Sanctuary area. The moderately low risk rating for three GDAs was, in part, due to the relatively abundant lakes and wetlands distributed across these areas. However, unlike the Ministik GDA, the three moderately low risk GDAs also contained lands with moderately low to moderate risk land use/cover parcel scores, which would have lowered the final score for the GDA (Figure 3.4).

Although not currently at risk, sustainable land management practices for new and existing land uses would be quite appropriate in these areas as well. The more positive balance implied in the lower ratings suggests that these lands are likely well below an ecological threshold and functioning reasonably well. Maintaining that low and moderately low risk level could help protect the ecological health not only of the protected areas, but also of a large component of the moraine itself. Together, these GDAs represent over one third of the moraine land base.

3.3 Groundwater Contamination Risk

3.3.1 Management Considerations

The Beaver Hills Moraine plays a significant role in groundwater supply and in particular, in recharge. Groundwater recharge areas are widespread through the moraine. These sites are located where the groundwater table is near the ground surface, and there is a hydraulic gradient supporting downward groundwater flow (Hydrogeological Consultants Ltd. 1999). Such sites are often associated with a waterbodies in the moraine. At recharge areas, surface water percolates through underlying sediment layers along that gradient to resupply shallow and deep aquifers. This is a slow process, and continual recharge is therefore a critical element of the water cycle.

Several discharge zones also exist within the moraine. Like recharge zones, groundwater is also near the ground surface at these sites, but the flow gradient is toward ground surface (Hydrogeological Consultants Ltd. 1999). As a result, these sites may supply waterbodies or occur as freely-flowing springs. Both types of discharge play important ecological roles, by providing habitat and consistent surface water sources.

The process of groundwater recharge and discharge also allows for some filtration as water flows through the intervening soil layers. In these circumstances, the contaminant is bound to the soil particles, where it may be retained or broken down by soil bacteria. Certain contaminants are not captured by the sediments, particularly if a large concentration of a contaminant is released (e.g., point-source contamination), in which cases contaminants are instead transported with water flow. Recharge and discharge sites and the aquifers underlying them are therefore vulnerable to land uses that could release contaminants into them. While point-sources, where large concentrations of contaminants may be released over a small area are an obvious risk, even more widely dispersed sources (e.g., herbicides, pesticides, air-borne pollutants) can pose a concern. Where such materials are deposited over the long-term, concentrations will accumulate, exposing potentially broad areas to a risk less readily managed than a point-source.

Groundwater is an important resource in Alberta and is managed by the province to protect both quantity and quality. Groundwater replenishes our rivers, stores water, and filters water through subsurface flows. Groundwater is also an important and bountiful source of fresh water for irrigation, industry, and communities. In Alberta, 90% of rural Albertans rely on groundwater for their household water supply (AAFRD, PFRA and Alberta Environment 2000). Ideally, groundwater intended for human consumption should be clear and free of taste and odor. Groundwater quality is directly impacted by the environmental state of the land base and the water bodies that feed groundwater recharge areas (Beaudry 2006).

Groundwater discharge can contribute significantly to surface water flow. In dry periods, the flow of some lakes, streams and wetlands fed by discharge may be supplied entirely by groundwater (McConnell 2006). Precipitation is a critical part of the water cycle; rainfall infiltrates through soil, sediment and permeable bedrock to reach the saturated soil zone and underlying aquifers (McConnell 2006). Obviously, the nature of the underlying sediments is also important in groundwater infiltration. Coarser textured soils will allow percolation much more readily than will fine textured soils. As a result, the balance between infiltration of surface runoff and the volume of water carried into streams and rivers depends on how much rainfall the subsurface sediments can absorb, and the rate at which precipitation falls. When there is more water on the surface than can be absorbed into the groundwater zone through the intervening sediments, it runs off into streams and lakes.

Development within the Beaver Hills Moraine includes several land uses with potential to release point-source contaminants. Intensive livestock operations and other medium to heavy land use industries have the potential to accidentally release highly concentrated contaminants to surface soils and water, which could then leach into groundwater. Where recharge and discharge sites occur, risk of contamination reaching the underlying aquifer may be higher, depending on soil conditions. Since ground water is used as a potable water source and such contamination is difficult to remediate, contamination can have serious ramifications.

Although industrial operations, as well as other land uses (e.g., urban and agricultural) also have the potential for more wide-spread release of contaminants, the risk of groundwater contamination is more difficult to assess than for point-sources. Risk may be spread over a broad area, and influenced by wind patterns, contaminant type and concentration, and duration of release. This model, therefore, focused on risk for point-source releases.

3.3.2 Model Objectives

Hydrogeological Consultants Ltd., in preparing groundwater supply studies for various municipalities in the province (a PFRA-sponsored project), conducted an optional groundwater contamination risk assessment for interested municipalities. Although those assessments provided a detailed assessment of groundwater contamination risk, they had not been done for all of the municipalities in the moraine. The optional assessment was not completed for either Strathcona County or Camrose County. Given the large area of the moraine covered by Strathcona County, a consistent analysis of groundwater risk was required to fill an important information gap.

We developed a model based on the approach of Hydrogeological Consultants Ltd., to provide a consistent assessment across the majority of the moraine. Groundwater recharge and discharge data were not available for Camrose County at the time of this assessment, precluding analysis of that area of the moraine. The intent of this assessment, although less specific than those conducted by Hydrogeological Consultants Ltd., was to provide information that could be used to identify appropriate locations for operations and land uses with potential for point-source release of contaminants. Because the model ties risk to recharge and discharge locations, it also identifies lands where those functions could be impaired by certain other land management activities (e.g., wetland infilling, placement of impervious surfaces). The model, therefore, could also be used to delineate areas where highly developed landscapes may be inappropriate.

This analysis was initially conducted for Strathcona County's recent MDP review process. The results of that original modeling run have been incorporated here. Methods and results provided here were originally reported in Spencer Environmental (2006b).

3.3.3 Methods

The Groundwater Contamination Risk Model run for the Strathcona MDP review process was designed to identify areas of high sensitivity, where potential for linkage between surface and groundwater was highest and most permeable. The primary environmental concern was the potential for contamination of groundwater, either through surface water or through percolation through soils. The groundwater mapping was conducted using a multi-stage process of data validation, manipulation, modeling, and mapping. For a full explanation of the model, refer to Appendix D; an overview of the model and its limitations are summarized here.

3.3.3.1 Model Scoring and Mechanics

The model assumed that groundwater sensitivity is higher where the surface lands and underlying groundwater are relatively well-connected. A contaminant released to surface water or on porous soils would encounter few barriers to movement. Where such features lie near a discharge or recharge zone, the potential for a contaminant to reach groundwater is likely high.

Under that assumption, at least two features must exist within a short distance of each other in order for a contaminant to reach an aquifer: porous soils and groundwater discharge/recharge sites. Waterbodies near or overlapping these features further increases the risk, as the groundwater table may be linked directly with the wetland in a discharge or recharge situation. As the risk of contamination is related to the rate and extent of spread of a contaminant carried in groundwater, we used the relative permeability of these natural features for water-borne contaminants in the model.

We scored surface water bodies with higher permeability (a lower score), due mainly to the speed at which contaminants could diffuse through water, versus soils (Table 3.3). Coarse soils would allow a faster rate of contaminant spread than would more finely textured soils, and these also were considered to be of higher permeability than finer-textured soils. Groundwater discharge and recharge areas, obviously, would also have high permeability. Although the direction of groundwater flow at a recharge and discharge location may influence the speed of contaminant spread within these groundwater zones, for the purposes of this assessment, we have assumed that the difference is minor relative to speed of spread through the various soil types and waterbodies.

The first step in preparing the model involved data buffering and scoring as outlined in Table 3.3. Waterbodies were buffered by 50 m to consider the risk of a release within that zone to enter the waterbody itself. The buffer was slightly wider than the minimum 30 m buffer often recommended as a water quality protection measure (Appendix C), to provide a conservative estimate of the risk zone. All buffer distances used in the analysis are listed with the corresponding variable in Table 3.3.

Table 3.3. Variables used in the Groundwater Contamination Risk Analysis

Variable	Score	Buffer Distance	Permeability to Contamination	Datasets
Wetlands	-2	50 meters	High permeability	ASRD Native vegetation
Hydrology	-2	50 meters	High permeability	NRCAN hydrology (1:50K)
Groundwater Discharge	-1	None	Medium permeability	PFRA groundwater discharge
Groundwater Recharge	-1	None	Medium permeability	PFRA groundwater recharge
Groundwater Transition	0	None	Limited permeability	PFRA groundwater transition zone
Fine Soils	0	None	Limited permeability	AGRASID soils
Moderately Fine Soils	0	None	Limited permeability	
Medium Soils	0	None	Limited permeability	
Moderately Coarse Soils	-1	None	Medium permeability	
Coarse Soils	-2	None	High permeability	
Organic Soils	-1	None	Medium permeability	

The Groundwater Contamination Risk Model is additive. The scores representing natural resource sensitivity that overlapped at any given location were summed, and that summed value indicated the relative risk due to simultaneous occurrence of highly permeable features at a given site. The juxtaposition of surface water, porous soils and a groundwater recharge or discharge site presents the worst-case scenario for contamination. Where these features overlap, the combined score would be lowest, indicating conversely, that risk is highest at that location. The resulting final summed scores were grouped into three classes as follows for mapping purposes:

Final Summed Score	Mapped Sensitivity Class
0	Low sensitivity
-1 to -2	Medium sensitivity
-3 or less	High sensitivity

In some urban areas, soil texture and groundwater data were unavailable. These areas were indicated as Unknown Sensitivity.

3.3.3.2 Model Limitations

The absence of groundwater data for the section of the moraine in Camrose County prevented comprehensive modeling in that area. For that part of the moraine, high risk areas were confined to lands with surface water and coarse-textured soils. The addition of the groundwater data for that area to the model will obviously improve the resulting analysis.

Groundwater data provided in the Hydrogeological Consultants Ltd. water assessments for each municipality incorporate groundwater well log data held in the Alberta Environment well database. Specific geographic coordinates are not typically reported in those data; often only the quarter section or section is reported. As a result, the discharge and recharge zones identified in these assessments do not have a high level of spatial accuracy. Risk zones that have been identified in this study should be interpreted as a broad scale estimate; additional site-specific confirmation would be required to inform planning decisions within these areas.

Few water wells have been drilled in Elk Island National Park, and the absence of groundwater data for that area may also have affected the accuracy of the model for that area.

3.3.4 Zone Characteristics

High sensitivity zones tend to occur where surface water, coarse soils and groundwater recharge and discharge zones coincide (Figure 3.5). Given the high density of wetlands within the moraine, these areas tend to be small and scattered throughout the moraine. The east side of the moraine, through the Cooking Lake - Blackfoot Recreation Area and between it and the Miquelon and Ministik protected areas have a particularly dense distribution of wetlands, and associated high risk zones. Similar conditions exist along the numerous streams in the moraine. Land developments around such water features should consider potential contaminant release and encourage design features that will avoid such incidents. Management of existing developed lands is just as important; again sustainable land management practices will play a key role in protecting groundwater resources. Chapters 4 and 5 provide Environmental Best Management Practices that should be considered for both existing and proposed developments.

Medium sensitivity zones are broadly distributed throughout the moraine and reflect mainly the overlap of groundwater recharge and discharge zones with coarse soil (Figure 3.5). Contaminants released in these areas could enter groundwater and travel relatively quickly through the coarse sediments, but not as quickly as through surface water in direct contact with a recharge/discharge zone. Development and land uses with potential to release contaminants may not necessarily be incompatible in these areas, but would require measures to prevent releases, or to swiftly contain and clean spills should they occur. Management of these zones may be best provided/implemented in broader MDP and LUB level planning, perhaps through conditions attached to land uses with potential for point-source release, given the size of these areas. Regardless, many Best Management Practices can be applied to site-specific developments and existing developed areas as well, that will ensure that impacts to groundwater resources are minimized.

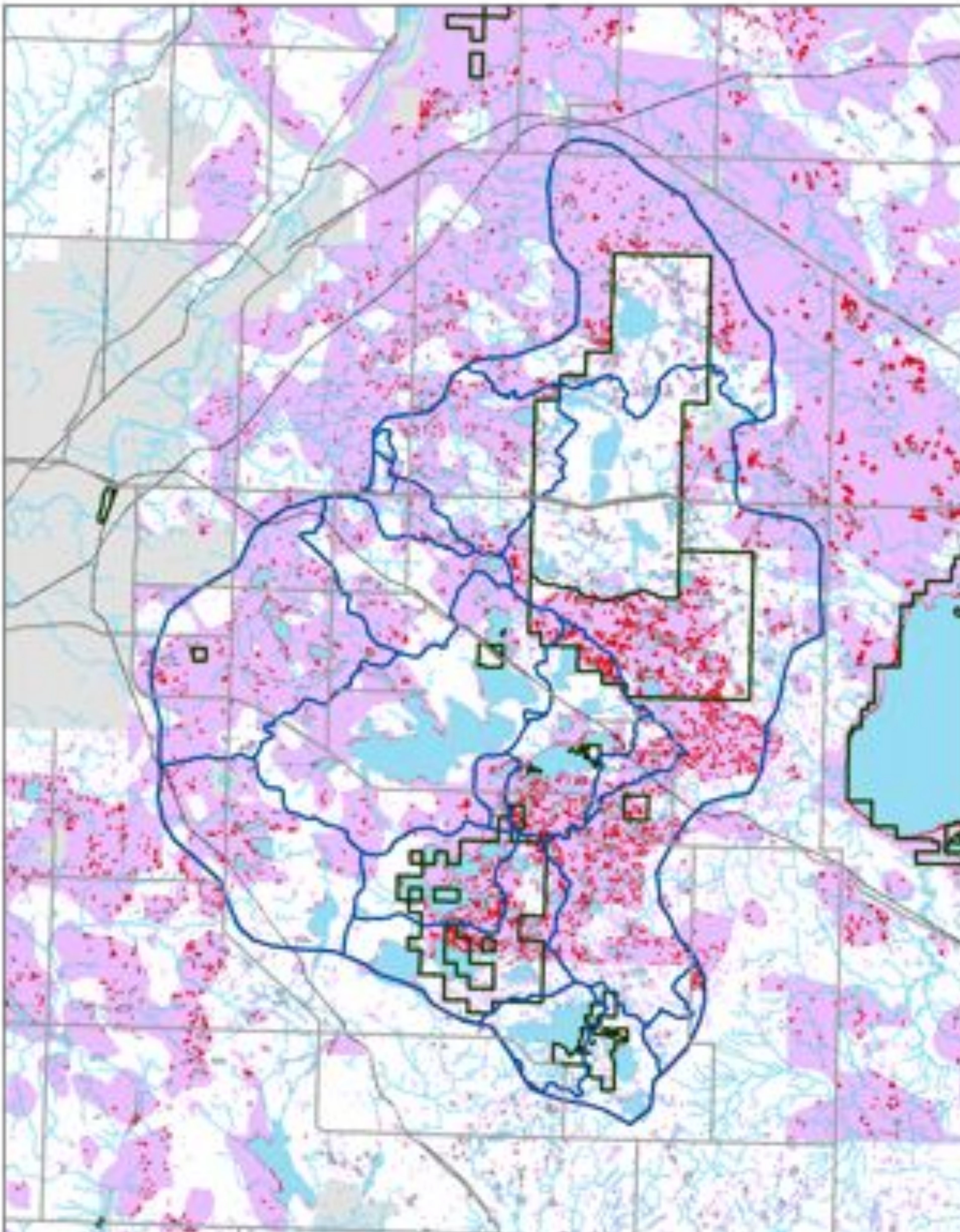

Figure 3.5. Groundwater Contamination Risk in the Beaver Hills Moraine

3.4 Landscape Connectivity

3.4.1 Management Considerations

The Beaver Hills Moraine is a visually distinct land feature in the Edmonton region, mainly because of extensive tree cover and other natural lands. The series of protected areas running the length of the moraine contain a central core of natural lands dominated by aspen forest. The rolling terrain of the Beaver Hills Moraine has discouraged large-scale clearing for agricultural fields. The surrounding level plains were much easier to convert to agricultural uses and typically have better soils for agricultural purposes. As a result, a large proportion of the moraine outside the protected areas has also retained natural cover in the form of forests, shrublands, grasslands and wetlands. The abundance of natural vegetation is one of the elements of the area's essential landscape character captured within the BHI Principles. This is in part because of their aesthetic value to local residents and visitors, but also because of the habitat it provides, which in turn, sustains a high level of biodiversity, including a variety of special status species.

Biodiversity has a value beyond its aesthetic character; it is the engine behind the ecological processes that provide the ecological goods and services on which we rely. Clean air and water, climate moderation, medicines, even our food sources rely on biological action, carried out by a wide array of microbial, plant, and animal species. We do not fully understand the species involved in all of these various processes; wise management dictates that we maintain as many of the participants as possible, in hope of retaining those most critical.

Biodiversity is sustained through a variety of means. Certainly, an adequate supply of habitat comprising a variety of forms is important. Size, shape and distribution of those habitat patches across the landscape are also very important, particularly in a developed landscape. This factor of biodiversity is addressed in Section 2.5 (Core Area Analysis).

The BHI Principles also recognized that habitat connectivity is critical in conserving biodiversity. Landscape patterns that promote connectivity for species, communities and ecological processes are a key element of nature conservation in environments modified by human impacts (Bennett 2003). Connectivity is a measure of the extent to which plants and animals can move between Habitat Patches (Hilty *et al* 2006). Put slightly differently, it is the degree to which the landscape facilitates or impedes movement among resources patches (Taylor *et al* 1993). Landscapes are perceived differently by different species and there is considerable variability in species requirements for movement, their abilities to move and the strategies employed to do so. Thus, what represents high connectivity for one species (or process such as dispersal) may be moderate or low connectivity for another species or process. In assessing connectivity, it is critical to acknowledge that connectivity is related to a particular process or species of focus (Hilty *et al* 2006).

There are two main components that influence potential connectivity for a particular species, community or process - a structural component and a behavioral, or functional, component (Bennett 1990a *in* Bennett 2003). The structural component is determined by the spatial arrangement of different types of habitat in a landscape. The functional component of connectivity relates to the behavioral response of individuals and species to the physical structure of the landscape. Ultimately, for animals, functional connectivity relates to the choices species make in selecting travel routes based on their unique behavioral requirements and physical abilities.

In a partly developed landscape like the moraine, the more suitable habitat patches are located within a Matrix of developed and agricultural land uses that offer varying degrees of resistance to animal and plant movement. In order to access suitable habitat, an animal must cross the Matrix, and where resistance is high, it will find alternative routes rather than cross through those areas (Hilty *et al.* 2006). In some instances, resistance may be completely barred by almost impenetrable Barriers that either discourage movement, or result in animal mortality (e.g., major roads). Where the distance between patches is too large with respect to the need of the species for security cover, that gap also functions as a form of Barrier. Linkage Habitats, vegetated areas not capable of supporting many resident species, but providing temporary resources and security cover, can play a significant role in these landscapes. Linkage Habitats can occur as either non-linear Stepping Stones, or linear Corridors.

3.4.2 Model Objectives

The habitat connectivity EFZ analyzed the moraine landscape to identify and map its ecological network, the landscape elements that facilitate movement by plants and animals. Our model addressed both structural and functional connections within the moraine. With respect to structural connections, contiguous segments of habitat and/or linkages provide the most connected form of landscapes and in that sense form the core of the network. Our functional connectivity model recognized that many wildlife species also tolerate small gaps of open space separating habitat and linkages that allows them to cross these areas to access suitable habitat. Together, these two analyses identified the key elements of the connected landscape within the moraine today, to identify management priorities to sustain biodiversity over the long-term. The connectivity model examines both structural and functional connectivity.

3.4.3 Methods

Structurally connected habitat refers to the geographic distribution of features across the landscape. It includes habitat patches, contiguous naturally vegetated habitat that would provide security cover and potential resources to animals as they move through the area. It also includes linkages barriers and the underlying matrix, the structural landscape through which an animal must navigate to access resources, mates and seasonally important habitat. Functional connectivity considers how a particular species will use habitats that are separated by particular gaps. For this analysis, we examined three different scales of functional connectivity, to examine functional connectivity that would support movement of a progressively smaller suite of animals.

Both structural and functional connectivity are important to land managers. Areas where structural connectivity is high (i.e. the spatial distribution of patches with respect to each other and to linkages), present few barriers to movement. Areas where habitat patches and linkages are contiguous represent large areas of accessible habitat that are critical for sustaining diverse plant and animal communities. Functional connections may link nearby but separate large areas, further enhancing the sustainability of biologically diverse communities on the landscape. The mapping resulting from these two analyses will allow planners to identify critical linkages within the Beaver Hills moraine that will help sustain its biodiversity, and through that, sustain the ecological processes responsible for the quality of life, and landscape character valued by residents and visitors to the moraine.

3.4.3.1 Structural Connectivity Mapping

Connectivity in a rural context depends on several factors:

- the distribution of **habitat patches** and potential **linkages**,
- the **matrix** in which they are located,
- the 'friction' to movement that organisms face within various parts of the matrix, and
- **barriers** relative to patches and linkages.

The structural connectivity component of this model identifies those landscape features in the BHI area that would contribute to each of those four main components of a structurally connected system. The first step involved classification of the land uses and cover types across the moraine to identify habitat patches, linkages and barriers within the matrix of developed lands. Land uses and cover types were assigned to each category as outlined in Table 3.4. These four categories provided the basis of analysis for structural and functional connectivity.

The BHI Principles aim to maintain habitat connectivity ultimately, to support the biodiverse communities now found in the moraine. Typically, larger intact areas that contain a variety of habitats tend to support higher biodiversity (Hilty *et al.* 2006, Forman 1995). Forested sites and wetlands that offer diverse vertical structure provide more resources and more niches than do grasslands, and so also tend to support high biodiversity. In order to model the ecological landscape elements necessary to sustain these higher biodiversity areas, we focused on connectivity from the perspective of the species most likely to occur in those areas. Although farmlands and human-inhabited lands can also support wildlife, it is those species less tolerant of human activity that comprise the main body of biodiversity in the moraine.

We selected deer and coyote as representative forest-dwelling species to score the various landscape features. These species offered several advantages for this modeling exercise. First, they both have large home ranges and must move through the landscape to access suitable habitat on a daily basis. Suitable habitat includes, for at least some life requirements, woodland habitat. Their movement habitat requirements and preferences are relatively well-studied, and although they will cross open areas, they prefer to move through forested lands offering security cover.

To identify the specific elements of the landscape that provide and prevent connection, habitat patches and linkages and barriers were next mapped, based on the classifications of land use/cover types outlined in Table 3.4. The resulting Ecological Network Map presents the distribution and size of habitat patches within the moraine and formed the basis of the Core Areas analysis described in the subsequent chapter.

To assess the friction inherent in the moraine landscape from the perspective of these species, we used an additive modeling approach that summed scores reflecting the direction and magnitude of influence on connectivity for land use/cover elements in that landscape (Table 3.4). The summed scores were mapped to illustrate relative permeability of the moraine landscape (the Landscape Connectivity Map).

The largest contiguous areas of habitat patches and linkages form key segments within that ecological network. The Key Segments Map identified those largest clusters of habitat patches that are directly connected through linkages. Through those direct linkages, the habitat patches create a much larger area that will likely contain higher levels of biodiversity and more abundant populations, and so may act as a source, similar to Core Areas.

Together, these three maps describe the distribution of habitat and level of structural connectivity across the moraine, essential information for land managers seeking to maintain biodiversity within the landscape.

3.4.3.2 Functional Connectivity Mapping

Functional connectivity is related to animal behavior, and an animal's comfort with crossing large gaps of a Matrix separating patches of more suitable habitat. Gap tolerance is a relatively new term, but the concept has been applied to the study of large mammal behavior for many years. In the course of daily movements through a home range, an animal will chose to travel within certain habitats, and avoid others, based in part on their need for security cover. Deer in particular, have been well assessed in terms of their security or escape cover requirements. Typically, deer tend to venture no further than 100 m from shrubby or forested escape cover or rough terrain (Thomas *et al* 1979). This is an average distance: as the gap width increases, the number of deer willing to cross it decreases. The 100 m gap distance also relates to other mobile species including weasels and urban deer populations (DeNicola *et* al 2000, Gehring and Swihart 2002). For our analysis, we assumed that at a gap width of 250 m (2.5 times the average deer gap tolerance) few to no deer would cross, and set this as the limit of functional connectivity. Beyond 250 m there would be very limited connectivity, and only for large highly-mobile species such as deer.

At certain times, large animals like deer and coyote may travel much greater distances (e.g., during the rut, or when young disperse), but this aspect of connectivity was not specifically examined in this analysis, as these movements can take place over a much broader regional scale. Dispersal, seasonal migration and other periodic, long-distance movements of smaller species would, however, be accommodated within the 100 m and 250 m gaps.

The tolerance of other wildlife species for crossing open spaces has also recently been examined, mainly in terms of the willingness to 'short-cut' across unsuitable areas to access other patches of suitable habitat. Various small songbird species, including the black-capped chickadee, have been found to avoid open gaps larger than 50 m (St. Clair *et* al 1998, St. Clair 2003). Amphibians have a similar tolerance limit for crossing unsuitable habitat, mainly dry areas (Roberts and Lewin 1979, Rothermel and Semlitsch 2002).

Landscape level assessments of connectivity for small mammals have also only recently been examined. We selected the red-backed vole as an indicator species that would be representative of species that have small territorial requirements and are thus likely to travel only relatively short distances. Red-backed voles prefer older forested sites and are generally thought to be less tolerant of habitat fragmentation (Pearson 1999, Silva *et al.* 2005). Silva *et al.* (2005) found that canopy forest gaps were important determinants of small mammal diversity within small woodlands, and tree density, a strong influence on red-backed vole population size in particular. Although the influence of specific gap width was not identified in their study, Slade and Crain (2006) found prairie voles were unwilling to cross a 15 m mowed gap separating more suitable habitat. Hilty *et al* (2006), in summarizing research by others, note that several species of voles (*Microtus spp.*) are reluctant to cross gaps of mowed grass that are between 4 and 9 m in width and only rarely will they travel across more than 9 m of inhospitable Matrix. We adopted a slightly wider gap of 20 m for red-backed voles to address the uncertainty related to perceptions of 'functional connectivity' for these and other species with similar small scale gap tolerances (see Rudd *et al* 2002).

The functional connectivity analysis was run three times, one each for the different scales at which we wished to assess the moraine's ecological network: 20 m, 100 m and 250 m. Variables used in the analysis are described in Table 3.5. Respectively, these scales were considered to indicate good, fair and weak functional connection, supporting movements of progressively fewer species. For each analysis run, we buffered the Habitat Patches and Linkages by widths corresponding to the gap width tolerance of the indicator species being used for a given scale (Table 3.5). The resulting polygons were merged together in areas where they overlapped, forming 'clusters' of functionally linked Habitat Patches and Linkages. The Barriers layer was then placed over the polygons and all large roads (i.e., roads with scores less than 0) were used to sever otherwise acceptable connections. This recognized that despite being within a reasonable gap distance, animals would likely avoid crossing large roads in most circumstances and seek other, less risky alternatives. The resulting map indicates areas of habitat that may be accessible to animals comfortable in crossing various scales of gaps. Such clusters of habitat effectively increase the area available to individuals, which in turn allows these areas to support larger populations than possible in the individual patches.

Table 3.4. Variables for the Landscape Structural Connectivity Model

Connection Component Type	Variable	Element	Score	Friction Level	Buffer (m)	Datasets
Habitat Patch	*Vegetation*	All native vegetation	3	Low		ASRD Native vegetation
	Protected Areas	Federal or provincial protected area	3	Low		AB Community Development Protected Areas
	Wetlands	wetlands	3	Low		NRCAN hydrology
Linkage	*Road Rights of Way*	Expressway/ Highway	0	Moderate	50	NRCAN Roads
		Ramp	0	Moderate	50	
		Collector	0	Moderate	50	
		Local/ Street	1	Moderately Low	35	
		Service	1	Moderately Low	35	
		Park Roads	1	Moderately Low	35	
		Rail Line	1	Moderately Low	35	
Matrix	*Land Use Zones*	Commercial	-2	High		Municipal Land Use Zoning for all 5 partner municipalities
		Industrial	-2	High		
		Agricultural	-1	Moderately High		
		Rural Residential	0	Moderate		
		Rural Recreation	1	Moderately Low		
		Urban Residential	-2	High		
		Conservation	3	Low		
Barriers	*Roads*	Highway/Freeway	-2	High	20	NRCAN Roads
		Ramp	-1	Moderately High	20	
		Collector	-1	Moderately High	10	
		Local/Street	0	Moderate	5	
		Service	0	Moderate	5	
		Park Roads	-1	Moderately High	15	
		Rail Line	0	Moderate	5	
Hydrology	*Large Waterbodies*	Rivers, lakes	-2	High		NRCAN hydrology (1:50K)
	Streams	Streams	-1	Moderately High	10	

Table 3.5. Variables in the Functional Connectivity Analysis

Connection Component Type	Variable	Element	Datasets
Functional Connectivity Analysis	*Good Functional Connection*	Gaps of <=20 m b/n patches/linkages	Patch and Linkage layers created in the Structural Connectivity Model, with roads and negative matrices erased from functional connections
	Fair Functional Connection	Gaps of >20 m, but <100 m between patches/linkages	
	Weak Functional Connection	Gaps of > 100 m or <250 m between patches/linkages	

3.4.4 Zone Characteristics

3.4.4.1 Beaver Hills Moraine Ecological Network

The protected areas provide the majority of habitat within the ecological network of the moraine, but habitat extends outside these protected lands as well (Figure 3.6). Particularly wide bands extend in a curve from the Cooking Lake - Blackfoot Recreation Area south through Beaver County, back toward Ministik Bird Sanctuary and Miquelon Provincial Park. Numerous, smaller habitat patches are distributed across the western part of the moraine. Near Elk Island, they are densely clustered, and although separated by road barriers, other clearing has been limited and the gaps separating these habitat patches are small. Further west, toward Sherwood Park, patches are more isolated, separated by cleared lands of the matrix. Roads associated with subdivisions are more abundant in these areas as well as along the CNR rail line. In particular, the habitat between Cooking Lake - Blackfoot and the northeast part of Cooking Lake is fragmented by several subdivision roads.

Habitat is quite limited around Cooking Lake; in many places only a narrow band of habitat remains. Hastings Lake has fared better, and almost its entire east side comprises habitat.

The key linkages are the road rights-of-way, which provide a widespread network across the moraine, but within narrow strips (hedgerows were identified as habitat, within the AB Sustainable Resource Development vegetation dataset). Functionally connected habitat patches may be more effective connections near the protected areas, where patches are larger and more densely distributed. Further away from these protected areas, at the edges of the moraine, such linkages likely play a more significant role.

Several significant barriers cross east to west through the moraine, effectively subdividing it into three subsections: Highway 16, the CNR rail line and Highway 14, although at the moraine scale, they are difficult to differentiate on the maps. None of these highways have incorporated animal crossings, and in the case of Highway 16 through Elk Island National Park, fencing provides an additional barrier for some species.

3.4.4.2 Landscape Connectivity

The habitat provided by the protected areas and the immediately adjacent lands provides a strong core of highly permeable lands, surrounded by developed lands of moderately low to low permeability (Figure 3.8). Highly permeable lands (corresponding to habitat patches) become smaller and more isolated from each other further away from the center of the moraine, where naturally-vegetated lands have been converted to other uses. Significant zones of low permeability include large lakes and highly developed urban centers, including Sherwood Park, which lies partly within the west side of the moraine, and Lamont, at the northern end of the moraine. Country residential lands east and west of Lamont form a moderately permeable land use along the northern edge of the moraine.

Not surprisingly, the natural areas within the protected areas in the moraine form the core connected landscapes and would offer the least resistance to movement for our reference animals (coyote and deer, Figure 3.6). Elk Island National Park and the Cooking Lake - Blackfoot Recreational Area form the largest block of connected lands. Although separated by Highway 16, the remaining areas still occupy a significant proportion of the moraine landscape. Both protected areas are fenced, and so access is blocked for some larger species, but not for our reference species[2] and the majority of plant and animal species comprising the biodiversity of the moraine. Ministik Bird Sanctuary and Miquelon Provincial Park are also highly permeable to movement, except where the large lakes form barriers. In Miquelon, this is particularly important, as waterbodies are relatively densely distributed in that area.

What is surprising, perhaps, is the extent to which connection extends beyond the boundaries of the protected areas. Although fragmented in some places by less permeable areas, a relatively wide connection exists between the Cooking Lake - Blackfoot Recreation Area and the Ministik and Miquelon protected areas, east of Hastings Lake (Figure 3.6). The private lands in the south part of the moraine, in particular, have a high permeability and very little fragmentation. They effectively create a connected area of potential habitat comparable in size to that of Elk Island National Park and the Cooking Lake - Blackfoot Recreation Area. Although its scale relative to the moraine is relatively small (and therefore difficult to map at the moraine scale), Highway 14 is a significant barrier bisecting this connection, as well as the connection between Cooking Lake - Blackfoot and the northeast end of Cooking Lake.

A band of connected lands also extends west from Elk Island National Park and the Cooking Lake - Blackfoot Recreation Area, but it becomes progressively more fragmented toward Sherwood Park (Figure 3.6). The fragmented connections form a convoluted network of potential routes through the western part of the moraine, but many may be constrained by narrow sections. Protection or enhancement of those areas of connection will be important to maintain biodiversity in the western and more developed part of the moraine. The need for protection has been addressed through various conservation agencies: conservation easements, environmental reserves and municipal reserves, which form a concentrated band between Elk Island National Park and Sherwood Park (Figure 3.6). The Cooking Lake area and a small lake south of Miquelon Provincial Park are focal areas for NCC and Ducks Unlimited and are shown as broad circles centering around these areas on Figure 3.6. Ducks Unlimited projects are ubiquitous through this area, and indeed, throughout the moraine lands outside the protected areas. Many of the smaller habitat patches southeast and south of Cooking Lake have also been protected under conservation easements.

The lands surrounding Cooking Lake are particularly fragmented, and in many places only a narrow band of connective habitat remains around the lake. As one of the largest waterbodies in the moraine, it forms a large barrier to movement. Even when frozen, the lake would be beyond the gap tolerance of most species found in the moraine (see the Functional Connectivity map below). The lack of upland connection around this large barrier, located so near the north and south protected areas, impacts not only movement

[2] Deer and coyote are able to move under the fence in some locations (e.g., at the edge of wetlands, where slope dips sharply down).

between those areas, but also movement into habitat in the western half of the moraine. Habitat enhancement should be a priority around the lake. This priority is strengthened when other ecological functions, including water purification, likely also affected by the limited natural vegetation in this area are considered.

3.4.4.3 Key Connected Segments

Key connected segments, contiguous habitat patches and linkages that together comprise a much larger area of accessible habitat, again center on the protected areas. Connected segments bisected by roads were not considered to be contiguous, which highlighted some interesting situations within the protected areas themselves. Highway 16 divides Elk Island National Park into two sections. The south section is contiguous with the Cooking Lake - Blackfoot Recreation Area, and together these protected lands are the largest connected segment in the moraine, at about 17,000 ha (Figure 3.9).

The north section of Elk Island is further subdivided by the Parkway, the north-south road through the park and the Administration Road around the south side of Astotin Lake (Figure 3.9). Although these roads have significantly less traffic than does Highway 16, and indeed, large animals cross them regularly (pers. obs., D. Patriquin), they may be a barrier to smaller animals, or plants. As a result, the north part of the park comprises a number of smaller connected segments. These are still among some of the largest segments in the moraine though, ranging from 2,500 ha to 16,000 ha.

Ministik and Miquelon also encompass fairly large contiguous areas of habitat (2,500 ha to 9,000 ha, Figure 3.9). In some cases, these segments extend beyond the boundaries of the protected area. The area of the key segment at Miquelon is largely dependant on the lands surrounding the adjacent lakes.

Private lands surrounding these protected areas also support relatively large connected segments, the smallest of which captures 500 ha. Notable locations include the lands east of the north section of Elk Island National Park and some locations around Cooking Lake. The habitat linking Cooking Lake - Blackfoot and the southern protected areas is also interesting. Although dominating the landscape in this area, roads create a series of smaller segments that may interrupt movements to some degree. Most of these roads do not receive heavy traffic, unlike the main highways.

3.4.4.4 Functional Connectivity

The functional connectivity model addressed daily movements by certain groups of animals (and by inference plants). The results indicate where movement might be expected at a fairly regular frequency for the given group of species. Smaller species that are comfortable crossing only narrow gaps may not cross the 100m and 250 m gaps often or at all. In fact, only during migration or dispersal might they attempt such crossings. Effectively then, the good, moderate and weak subjective classes of connectivity reflect the number of species likely to cross these gaps on a regular basis, but does not preclude more irregular journeys undertaken by dispersing young, or migrating individuals.

The functional connectivity map confirms that although parts of the moraine may have been fragmented by past development, the habitat in those areas is still accessible at certain levels of connectivity (Figure 3.10). Only the weak and good levels of connection are shown in the map (250 and 20 m gaps), as all three scales of functional connection could not be mapped at this scale. Additional larger scale maps and the GIS files will allow all three scales of connection to be used for site-specific assessments. At the weakest level, much of the moraine appears connected (i.e., at the 250 m gap distance). At this scale of connection, movement by larger, more mobile species would be supported, but migration and dispersal of smaller animals could also occur through these areas.

The habitat patches between the protected areas in the north and south part of the moraine are connected functionally, with a consistent weak level of connection throughout this area. This implies that these areas may provide a stronger link between the protected areas within the moraine than is evident in the structural connectivity analysis alone. Enhancement of connectivity through habitat management would ensure that this connection endures over the long-term.

The lands west of Elk Island National Park have weak connection that enhances the structural connectivity identified in the above assessment. Organisms could potentially travel across the moraine to Sherwood Park and potentially, beyond, through these weak functional connections, albeit infrequently. Generally, such gaps would only be regularly traveled by larger animals. The level of human activity in these areas may further reduce the value of this connection, as much of these lands are of lower permeability (Figure 3.8). Enhancement could play a role here as well, still, and provide routes for organisms more tolerant of human use through these more heavily used lands. Similar measures could be applied elsewhere on the fringes of the moraine, where habitat and functional connection are lower and friction higher, to maintain connections beyond the moraine.

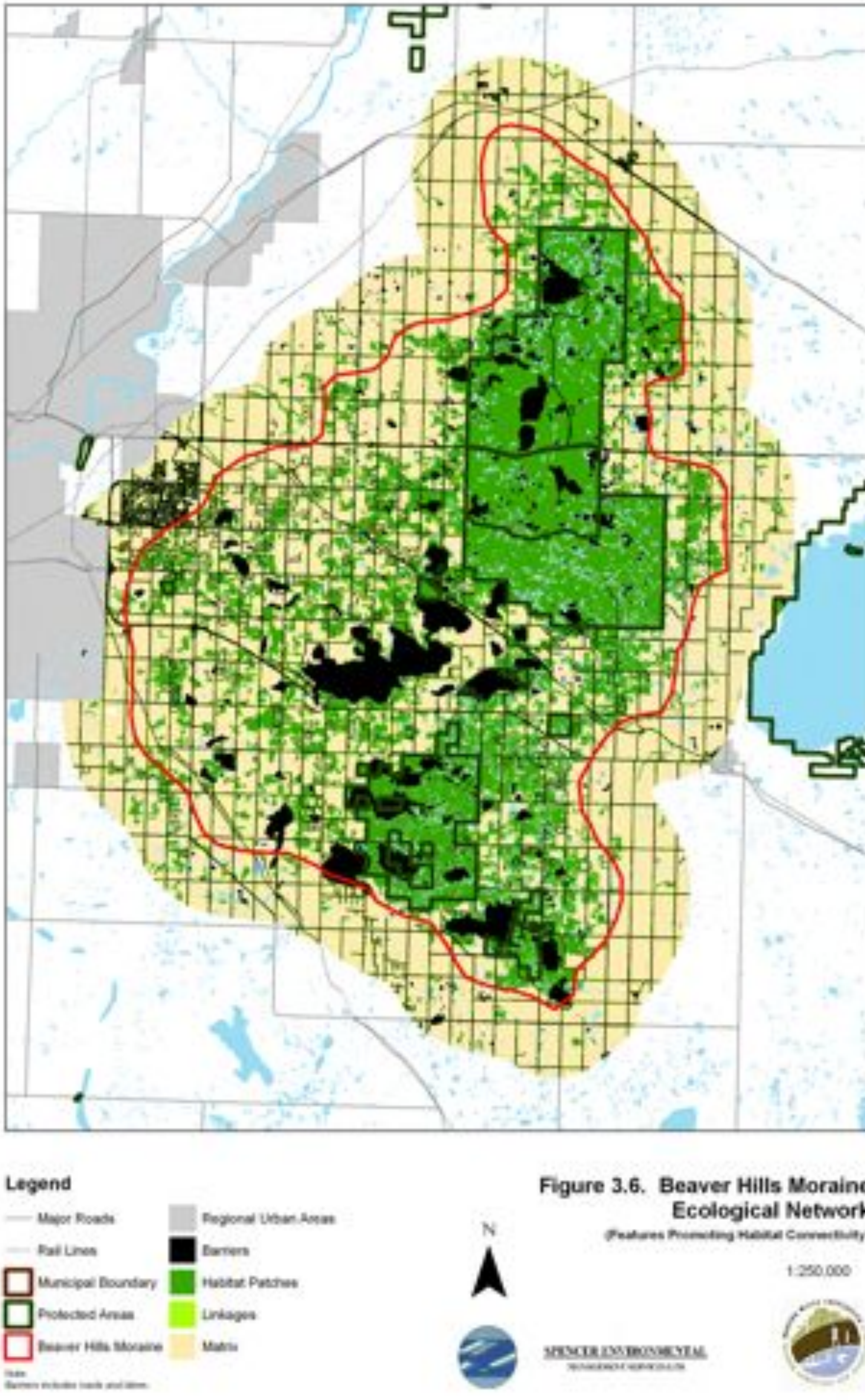

Figure 3.6. Beaver Hills Moraine Ecological Network

(Features Promoting Habitat Connectivity)

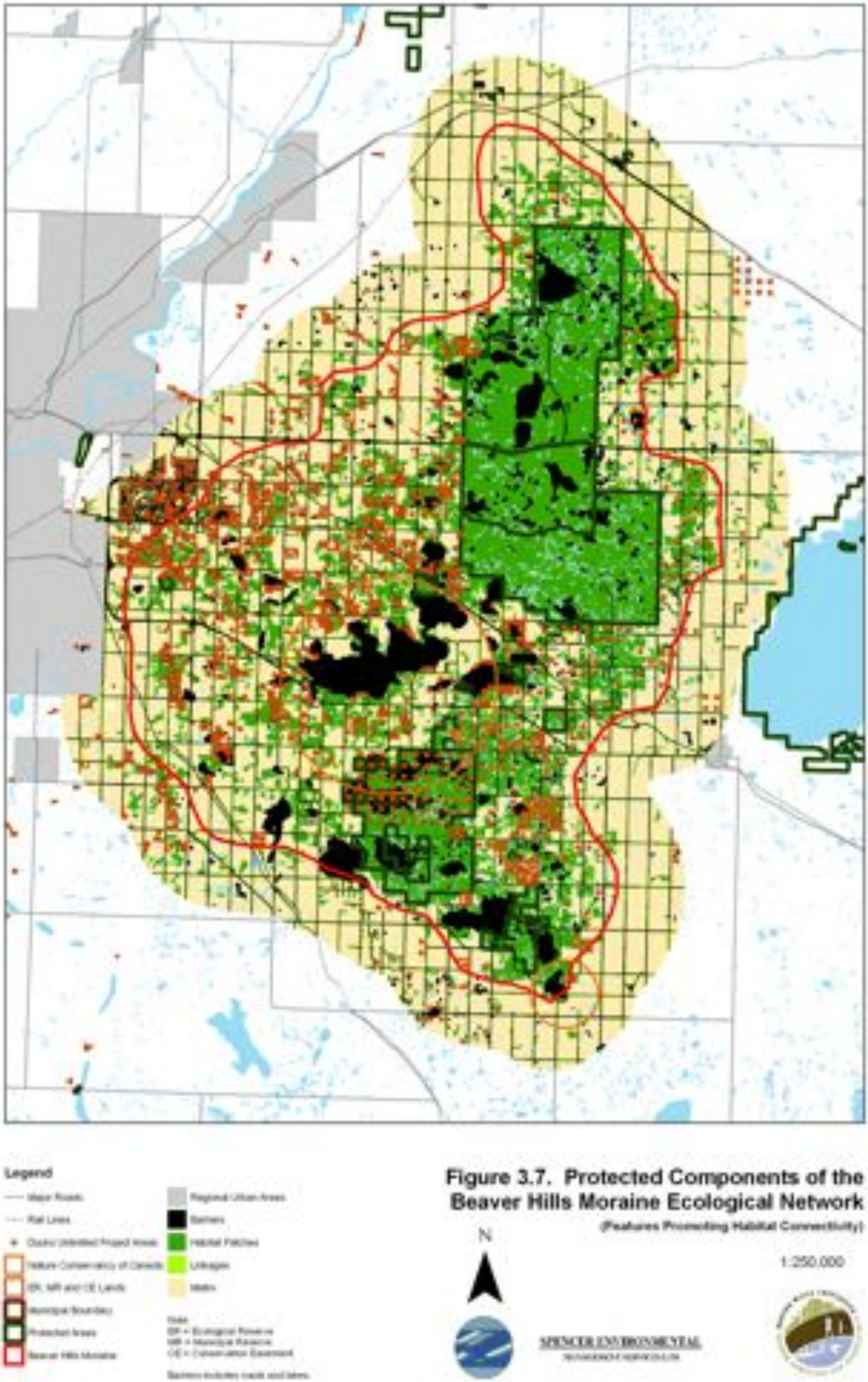

Figure 3.7. Protected Components of the Beaver Hills Moraine Ecological Network

(Features Promoting Habitat Connectivity)

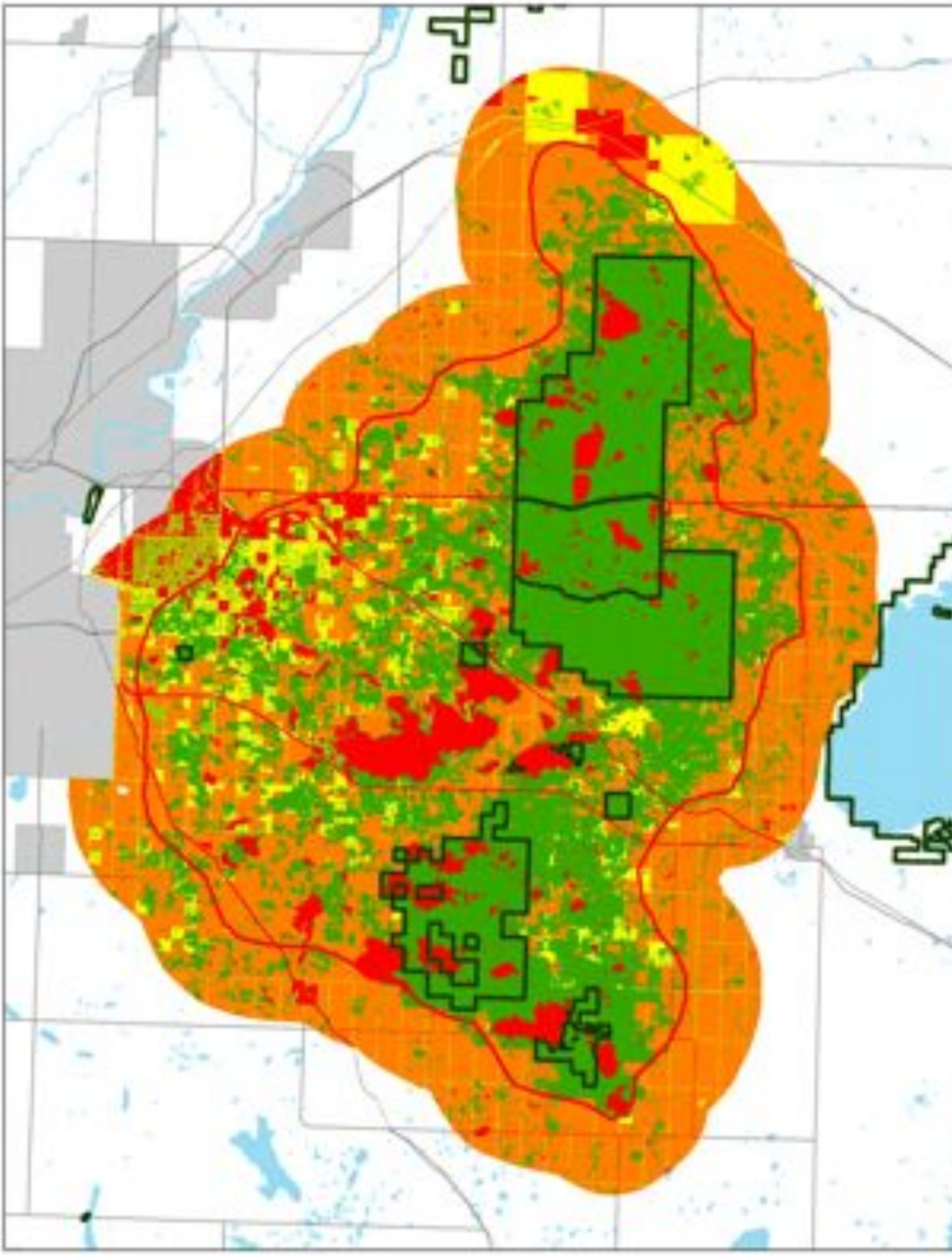

Figure 3.8. Relative Landscape Permeability in the Beaver Hills Moraine
(Relative permeability for movement of forest species)

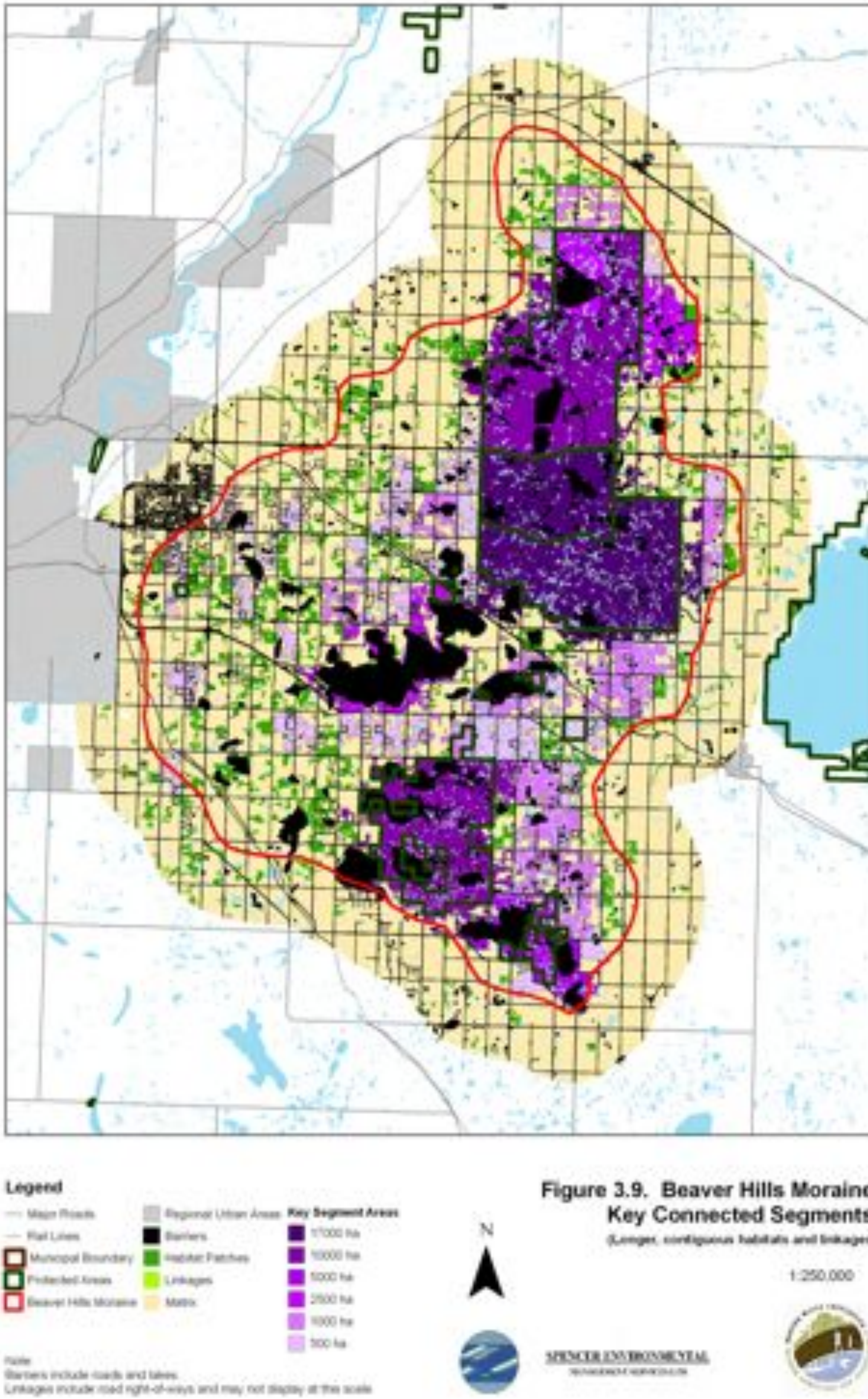

Figure 3.9. Beaver Hills Moraine Key Connected Segments

(Larger, contiguous habitats and linkages)

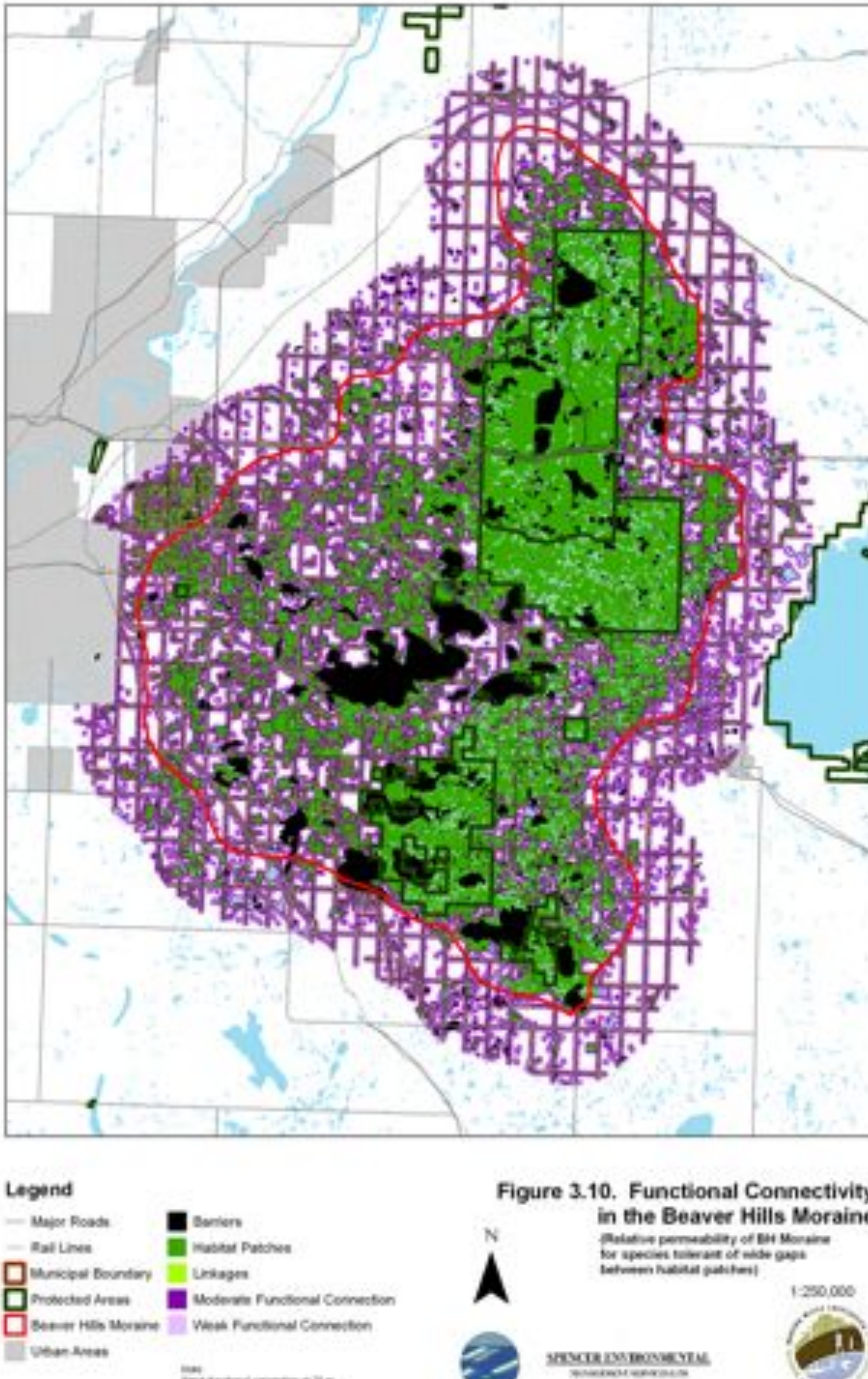

Figure 3.10. Functional Connectivity in the Beaver Hills Moraine

(Relative permeability of BH Moraine for species tolerant of wide gaps between habitat patches)

3.5 Biodiversity Core Area Analysis

3.5.1 Management Considerations

As noted in the previous section, the abundant greenspace within the Beaver Hills Moraine appears to support a high level of biodiversity. Biodiversity is maintained through several fundamental ecological factors: a sustainable metapopulation, genetic flow and redundancy. Core Areas provide one of the means to maximize the value of those fundamental factors, and ultimately, to ensure a well-functioning ecological landscape.

Core Areas are larger patches of habitat that can support high biodiversity and abundance of species, and whose populations are growing or stable (Forman 1995). As a result, they can serve as a source to repopulate areas more susceptible to local extinction (generally smaller, more fragmented areas). When distributed at several locations across a connected landscape, these areas can provide genetic flow, help sustain populations across the landscape, and through that, ensure that ecological processes continue to function throughout that landscape. The relationship between Core Areas and the fundamental ecological factors, and the relevance of that relationship to the Beaver Hills moraine is summarized below.

The metapopulation is a key concept in discussions on biodiversity conservation. Simply put, the metapopulation is the collection of smaller populations of a species across a landscape. For a species to be sustained within a given area, the metapopulation must be sufficiently large to persist through periodic declines in its constituent populations (Meffe and Carroll 1997, Akçakaya *et al.* 1999, Hilty *et al.* 2006). Although substantial populations provide a good buffer against stochastic events and associated mortality, genetic flow among the populations must also be maintained to ensure that populations continue to adapt through evolutionary change (Meffe and Carroll 1997, Hilty *et* al. 2006). Genetic flow, in this sense, provides the resilience required for the metapopulation to compensate for a dynamic environment, in which resource availability and environmental conditions continually change.

Within ecology, redundancy is considered one of the chief means by which species, ecosystems and ecological processes are sustained (Hilty *et al.* 2006). Although the understanding of ecological processes is still incomplete in many cases, in those systems that have been well-studied, several species often perform similar roles. That overlap provides assurance that the processes will continue to function, despite some subtle changes, provided the essential elements remain. The difficulty, of course, is that we often do not know which species or elements are essential. As a result, conservation managers now attempt to conserve as diverse an array of functional, intact habitat areas as possible.

Core areas are contiguous native habitats large enough to support both interior and edge species. They ideally would be large enough to support a minimum viable population for a given species. For many species, an effective (breeding) population of 50 individuals appears to allow a species to persist in the short term; 500 to 5000 individuals provide long term persistence (Franklin 1980, Soule 1980, Shaffer 1981, 1983; Samson 1983, Brussard 1985, Samson et al 1985, Lande 1987, Berger 1990, Thomas 1990, Henriksen 1997, Belovsky et al 1999; reviewed by Snaith and Beazley 2002).

Core areas vary with species, due to species-specific habitat requirements, thus discussion of the management of Core Areas must be tied to species of management concern, or indicators representative of a more diverse suite of species. Given the differences in range requirements among species, the area required to support a minimum viable population would vary depending on the species of interest. For this assessment, we selected a group of umbrella species representing a range of territory/home range size requirements. The assessment assumed that the habitat area required by a given umbrella species would also satisfy a suite of other species with similar habitat and area requirements. These "umbrella species" thus represent the level of biodiversity that can be sustained within the habitat available in a given landscape. The species requiring the largest area would, by default, also sustain viable populations of species with smaller area requirements, and thus indicate areas with the highest level of biodiversity.

Identification of Core Areas, which are likely to support the highest level of biodiversity within a landscape, provides essential information for biodiversity conservation efforts. To manage the moraine so that its current biodiversity is maintained, one of the BHI Principles, the Core Areas must be identified and protected through appropriate land management.

3.5.2 Analysis Objectives

The Core Areas Analysis was designed to identify habitat patches sufficiently large to sustain a range of levels of biodiversity and species abundance, and which could then sustain other nearby habitat patches. This assessment used as umbrella species those species that require native woodlands and wetlands for a significant part of their life history. Some of them may also use native grasslands and agricultural lands to some extent, but would not use those areas exclusively. This focused the assessment on native habitat, a key aspect of biodiversity implied within the BHI principles.

3.5.3 Methods

3.5.3.1 Umbrella Species Selection

In addition to representing a range of area requirements indicative of certain levels of biodiversity, we applied several additional criteria in selecting umbrella species for this analysis:

- relatively common distribution within the moraine,
- well documented habitat and life history requirements;
- availability of density or territory size data from the same ecoregion and ideally, the BH moraine area; and
- relatively abundant populations within the BH moraine.

Where possible, we used keystone species, those species known to regulate a broad plant and wildlife community, provided they met the other criteria. We also tried to include species of public concern or interest, to allow the assessment to be more readily understood and accepted by the public. Based on these criteria, we selected the umbrella species in Table 3.6 for our analysis, and calculated a Minimum Critical Area based on their documented density or territory size (see density sources provided in Appendix D).

Moose, white-tailed deer, and mule deer are common throughout the moraine, and elk also occur across the area, although at lower density. Coyotes are the largest predator and are also common throughout the moraine. Together, these species have the largest home range size of the suite of species regularly occurring in the BH moraine, and thus would require the largest Core Area to sustain their minimum viable populations. The Minimum Critical Area required for moose, deer and coyote, as the most common of these species, set the upper limit (representing high biodiversity) for the core area analysis.

We selected several other species with smaller area requirements as additional umbrellas species representing moderate and low levels of biodiversity. Unlike the species representing high biodiversity, these other species depend primarily on woodland or wetland habitat, and would typically remain entirely within such habitat patches, except during migration or dispersal. The Minimum Critical Areas of each set of umbrella species were averaged to provide a single value representative of Low, Moderate and High Biodiversity patch areas.

Where possible, we used density data from Elk Island National Park (EINP) and the Cooking Lake - Blackfoot Recreation Area. EINP is the largest protected area in the BH moraine and supports a variety of large mammal species including moose, deer, elk, and bison and a variety of medium sized carnivores, including coyote. The park is entirely fenced, however, and most of these large ungulates are confined to the park area. The Cooking Lake-Blackfoot Recreation Area is also fenced, and supports the same large mammal species as EINP, except bison. Ungulate populations in both areas are managed to maintain them within the ecological capacity of the landbase, and thus, are likely representative of the rest of the moraine. More importantly, Elk Island conducts annual censuses of their wildlife populations, which provided local and recent estimates of population densities for the analysis.

3.5.3.2 Analysis

Habitat patches identified in the Landscape Connectivity Model were the sole input into this analysis. To ensure that the habitat patches had no erroneous overlap with barriers (due to data quality in the vegetation dataset), we first erased from the GIS habitat patch layer any roads overlapping habitat. The resulting habitat patches larger than the Average Minimum Critical Area for a given level of biodiversity were identified as Core Areas for that level of biodiversity (see Table 3.6 for Minimum Critical Areas and Table 3.7 for data variables used in the analysis).

Table 3.6. Minimum Critical Areas Required by the Selected Core Area Analysis Umbrella Species

Core Area Type	Umbrella Species	Density/ Territory Size	Minimum Critical Area Required (sq. km.)	Level of Biodiversity Implied	Area Requirement Source	Rationale for Umbrella Species
Lower Biodiversity	Red-backed vole	20 voles/ha (200 voles/sq. km)	2.5	Low	Westworth et al (1984) and Boutin et al (1996)	Common woodland rodent, represents smallest level of mammalian biodiversity.
	Yellow warbler	156.4 birds/sq. km	3.2	Low	EINP 2000-2004 Roadside Count data	Common woodland species; density data available from EINP
		Average	***2.85***			
Moderate Biodiversity	Porcupine	7 porcupine/sq. km.	71	Moderate	Banfield (1974) published densities in North America	Common species in EINP and Blackfoot, dependant on woodlands for winter habitat, representative of mid-range area requirement
	Beaver	10.3 beavers/ sq. km.	48.5	Moderate	EINP 2005 and Cooking Lake - Blackfoot 2006 beaver census data	Keystone wetland species, densities and population trends known for EINP and can be estimated for outside park
		Average	***59.8***			
High Biodiversity	Great horned owl	1 bird/ sq km	500	High	EINP 2000-2004 Roadside Count data	Woodland specialist; density data available from EINP
	Moose	0.91 moose/sq. km	549	High	EINP 2005 census data	Common species in BH moraine woodland & wetlands; has large home range requirement
	Deer	0.91 moose/sq. km	549	High	EINP 2005 census data	Ubiquitous species found across BH moraine, with large home range size. EINP population can move outside park
	Coyote	0.87 coyotes/ sq. km.	575	High	Pruss (2002)	Common species in BH moraine, uses woodlands for denning and hunting; EINP population contiguous with outside lands
		Average	***543***			

Table 3.7. Core Area Analysis Variables

Connection Component Type	Variable	Element	Score	Datasets	File name
Habitat Patch	*Vegetation*	All native vegetation	1	ASRD Native vegetation	natural_veg.shp
	Lakes, Rivers and Wetlands	Lakes, manmade, reservoir, river, streams, wetlands	1	NRCAN hydrology	hydroline_project.shp; lakes_project.shp; wetlands.shp

The High Biodiversity Core Areas were those most likely to contain the most diverse populations of woodland/wetland dependant species. Moderately Biodiverse Core Areas would contain small and medium-sized species, and Low Biodiversity Core Areas would support only those species with smaller area requirements. Ideally, these areas would also support growing populations. Because we do not have population statistics for these specific areas in most cases, we do not know if these species are increasing (reproduction outweighs mortality). The analysis assumes only that based on area, these sites could provide a source population for other, adjacent habitat patches.

All types of Core Areas were identified in the final mapped output of the connectivity model to create the Core Areas Map. Together, the Core Areas and other elements of a connected system (particularly key connected segments) comprise the 'backbone' of the BH moraine, those components most critical to the ecological function of the entire area.

The High Biodiversity Core Areas were those most likely to contain the most diverse populations of woodland/wetland dependant species. Moderately Biodiverse Core Areas would contain small and medium-sized species, and Low Biodiversity Core Areas would support only those species with smaller area requirements. Ideally, these areas would also support growing populations. Because we do not have population statistics for these specific areas in most cases, we do not know if these species are increasing (reproduction outweighs mortality). The analysis assumes only that based on area, these sites could provide a source population for other, adjacent habitat patches.

All types of Core Areas were identified in the final mapped output of the connectivity model (the Ecological Network). Together, the Core Areas and other elements of a connected system (particularly key connected segments) comprise the 'backbone' of the BH moraine, those components most critical to the ecological function of the entire area.

3.5.4 Zone Characteristics

Of the 4369 habitat patches within the moraine, and adjacent 5 km radius, most were smaller than the Minimum Critical Area required to sustain the umbrella species representative of Low Biodiversity (Table 3.8). Several did meet the Minimum Critical Area limit for Low Biodiversity Core Areas (28 habitat patches, Figure 3.11). These included the north section of Elk Island National Park, which despite its large size is fragmented by access roads, including the Parkway and the Park Administration Road around Astotin. This effectively creates 3 separate Low Biodiversity Core Areas that include the private lands east of the park. Although these roads do not support the traffic volumes of Highway 16, for example, and so are not likely as significant a barrier as such large roads, they may prevent plants and smaller animals, less tolerant of wide gaps, from crossing. In that sense, these areas are separated and less accessible than other, contiguous areas of habitat within the park.

Other Low Biodiversity Core Areas included a series of sites south of the Cooking Lake – Blackfoot Recreation Area and within the arc of habitat linking Ministik and Miquelon protected areas (Figure 3.11). Smaller sites extend off the west edge of the Cooking Lake - Blackfoot area, and lie north and south of Cooking Lake. These sites are separated by range and township roads into the many smaller habitat patches comprising each Core Area.

Only 2 habitat patches had sufficient area to qualify as Moderate Biodiversity Core Areas: the contiguous habitat within and adjacent the Cooking Lake-Blackfoot Recreation Area and the south section of Elk Island National Park, and the Ministik Bird Sanctuary (Figure 3.11).

There were no High Biodiversity Core Areas in the moraine, single habitat patches with sufficient area to sustain the entire Minimum Viable Population for larger animals, with large home range requirements, and all species with smaller area requirements. The largest habitat patch (the combined areas of the Cooking Lake – Blackfoot Recreation Area and south Elk Island National Park) would provide only 30% of the area required to support the minimum viable populations for the larger species. And yet, ungulate populations continue to do well in those areas, and in the adjacent lands. Populations of deer and moose in particular, seem stable or growing, likely helped by a series of mild winters with limited snow and an absence of large predators. This suggests that the habitat in the moraine, most of which appears to be functionally connected at a scale appropriate for these animals (Figure 3.10), may provide sufficient area.

There is a total of 822.5 km^2 of habitat within the moraine alone (excluding the 5 km buffer shown on Figure 3.11), well beyond the area required for the Minimum Critical Area for the umbrella species representing high biodiversity[3]. Despite many of these areas being small (generally less than 1 ha), if they remain accessible, they can provide sufficient habitat to support the Minimum Viable Population required to sustain these species over the long-term.

This analysis highlights the importance of structural and functional connectivity within the moraine. Although the moraine has retained relatively abundant habitat (822.5 km^2 of the 1595 km^2 moraine, 52% of the landbase, is naturally vegetated), much of it within the protected areas, those areas alone cannot sustain the species currently present in the moraine over the long-term. Connections between the protected areas and to other smaller habitat patches within the moraine, particularly along the less developed, east side of the moraine will be essential if the current level of biodiversity, and associated values, are to be maintained for future generations.

[3] Note that this may be an underestimate of the habitat within the moraine, and therefore, an underestimate of Core Areas. The current vegetation dataset available for the moraine has a published accuracy rate of about 70 to 80% (AB SRD 2004). Rerunning this analysis with the updated vegetation data currently being compiled by the BHI is strongly recommended.

Table 3.8. Summary Core Area Analysis Statistics

Core Area	Minimum Critical Area (MCA) Required (km^2)	Number of Habitat Patches Meeting MCA
High Biodiversity	543.0	0
Moderate Biodiversity	59.8	2
Low Biodiversity	2.85	25
Smaller Habitat Patches	--	4342
Total Area of Habitat Patches in Moraine (km^2)	822.5	
Largest Patch area (km^2)	163.3	

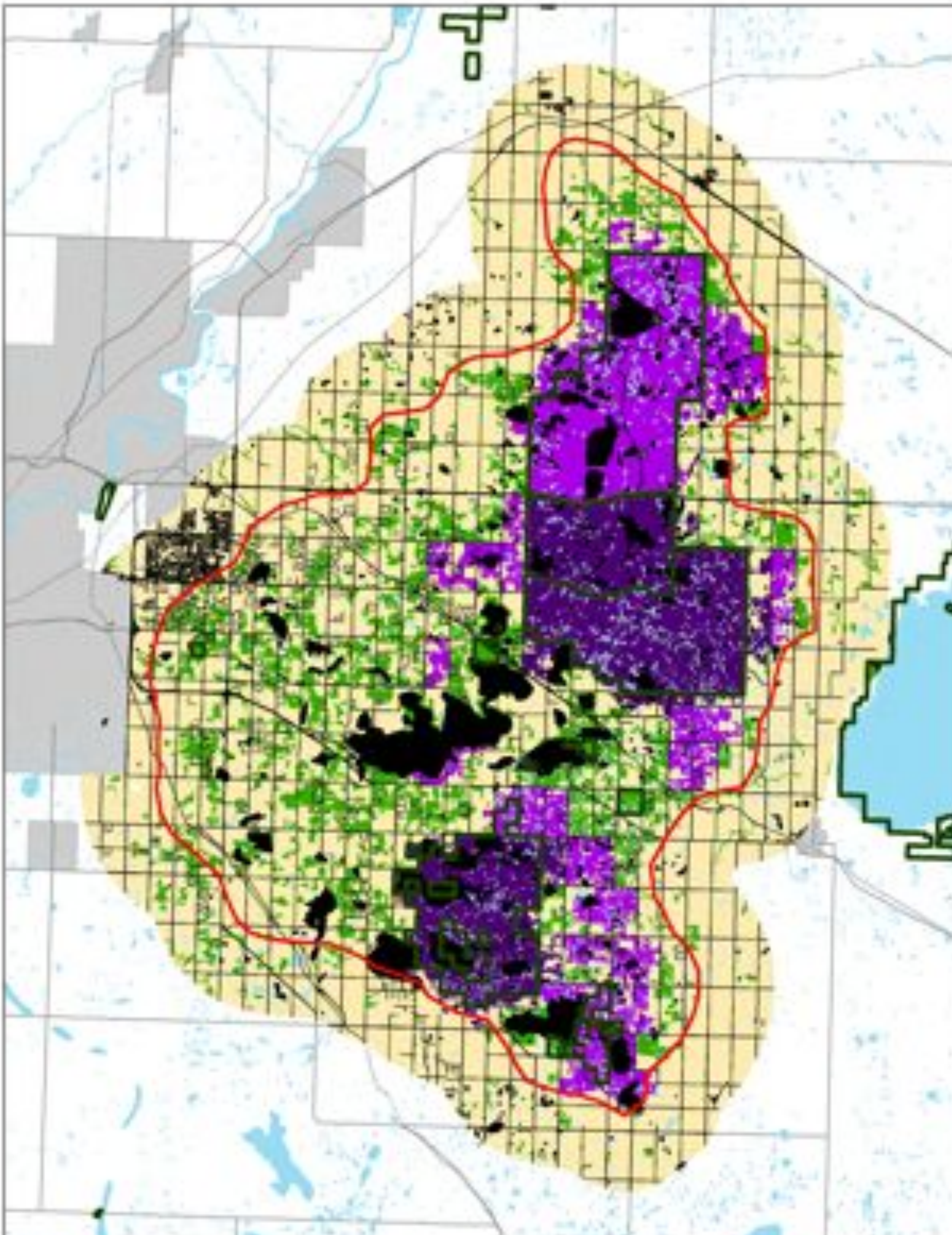

Figure 3.11. Core Areas within the Beaver Hills Moraine

4.0 APPLYING THE BHI PRINCIPLES WITHIN PLANNING REVIEWS

4.1 Introduction

The LMA mapping identified areas in the moraine where sensitive natural resources listed as critical elements in the BHI Principles were abundant, and therefore, potentially at risk. The Yellow and Blue Landscape Management Areas resulting from that mapping exercise identified areas potentially vulnerable to some forms of land use and management, where several or many sensitive resources (respectively) might occur. Loss of these natural resources will result in the decline in the natural capital of the Beaver Hills and the flow of economic and social benefits that are currently derived from this capital. They did not, however, present the underlying information regarding the individual resources themselves, essential information for future land management decisions. The Ecological Function Zone analyses filled that data gap, identifying the locations of these sensitive resources. In addition, the analyses identified the areas where critical ecological functions relative to those resources may occur (e.g., landscape connectivity). Knowledge of the location of key resources and functional elements of the ecological system is an important first step. Knowledge of the best means to manage those resources provides the tools to sustain them in perpetuity. In this section, we identify Environmental Best Management Practices (EBPs) for management of these resources: accepted management practices that will help sustain the key resources identified in the BHI Principles in a development context.

Land use and management decisions handled by municipal planning departments cover two very different scales. On one hand, planning departments review site-specific applications, evaluating the degree to which the development proposed meets land use guidelines and objectives outlined in policy. Periodically, they also revisit those policies themselves, to update the broader scale MDP policy areas and LUB land use zones and supporting policies. The EFZs could be considered within either planning context, but the best management options must be adapted to address the differences in scale. The specific management actions applicable for a proposed development would be impractical to incorporate into higher level policy. To achieve environmental management goals at the broader, municipal level, however, it may be appropriate to place certain general guidelines in a policy. In this document, we have separated recommendations for these two planning functions for ease of reference.

In the sections below, broad management objectives and Environmental Best Management Practices are described for each Ecological Function Zone. The broad management criteria describe the aspects that should be managed to sustain a given resource, with a description of what would constitute an acceptable threshold for effective management where such standards were available. These criteria also provided the basis for selection of performance indicators. Lastly, where referrals to other environmental jurisdictions might apply for the EFZ, we have provided a listing of the activities that might trigger environmental permitting, and the agency to which such a proposal should be referred by the municipality.

The Environmental Best Management Practices (BMPs) presented here are limited to those actions relevant to the land use permitting and approvals process for new development. Those best applied within a broader planning context are discussed in Section 5.0. Environmental BMPs may be best applied within specific stages of review for a proposed development. For each of the resources discussed below, relevant BMPs are presented for the design, planning review and eventual construction stage of the project, where applicable for that resource.

4.2 Air Quality

4.2.1 Broad Management Objectives

Maintain air quality

Substances such as carbon monoxide, ozone, sulphur dioxide and hydrogen sulphide are considered to be air pollutants when concentrations in the air are high enough to cause adverse effects. When air pollutants accumulate in the atmosphere, air quality is reduced and human health and the health of ecosystems can be affected. The cardiovascular system can be affected when pollutants are inhaled, absorbed into the bloodstream in the lungs and transported to the heart. The consequence can be degenerative necrosis, inflammatory reactions or changes in rhythmicity or contractility of the heart (Alberta Environment 2006a).

Vegetation can be affected when a substance enters the plant through the stomata or is absorbed directly into leaf tissue. Pollutants from the air can also be deposited in the soil then absorbed by the roots and transported to the leaves. Either way, vegetation can be adversely affected, resulting in chlorosis or necrosis of part of or entire leaves and reduced growth. Sensitive plant species can die if the exposure is for long periods or the concentration of the pollutant is high. In some cases sensitive species will be replaced by more resistant species, thereby reducing the biodiversity of the ecosystem (Alberta Environment 2006a).

It is also possible for certain substances to build up in vegetative tissue. Some of these substances have the potential to adversely affect the health of wildlife and animals if they use the vegetation as a food source. Substances in the air can also be deposited into water bodies, which could reduce the water quality and affect the health of organisms in that water body. All organisms in an ecosystem interact with one another to maintain a healthy ecosystem. If any of the organisms have been adversely affected by air pollution, the biodiversity of the ecosystem may be changed (Alberta Environment 2006a).

4.2.2 Environmental Best Management Practices

Maintain air quality

Air quality is managed by the province, and proposals for large industrial operations (with highest potential to impact air quality) would typically be coordinated through the Energy and Utilities Board and Alberta Environment and municipalities would be involved as a stakeholder. Permitting would be addressed during the development permitting process. Other developments with potential for air quality impacts include intensive livestock operations, which are regulated by the NRCB. Regardless, municipal concerns and land use policies must be addressed in the EUB and NRCB environmental review processes, and this provides an opportunity to avoid sensitive areas or highlight potential ecological concerns relevant to municipalities.

Best management practices can be applied to other land uses regulated solely by the municipality, including smaller farm operations (e.g., greenhouses, U-pick operations), commercial operations (e.g., trucking and storage areas), and municipal utilities (e.g., waste water management, waste disposal). Although these industries typically would release fewer airborne contaminants or toxins, minimizing releases from energy generation or materials storage would help reduce the cumulative impact on regional air quality.

- Establish best practice guidelines encouraging industries to adopt the most efficient technology for reducing air emissions.
- Minimize local odor and other air quality issues by managing potential land use conflicts. Investigate existing adjacent land uses and management, and future intended land uses, to determine whether a proposed development may eventually result in conflict. For example, many municipalities have recognized the potential conflict between certain agricultural operations and multi-lot subdivisions. Conditions to protect the existing land use may be appropriate in such circumstances, placing the onus on the new development to mitigate future impacts through vegetated buffers, odor controls or modified operations.
- Encourage natural vegetation retention where possible, to maximize the filtration and carbon sink functions provided by vegetation.

4.2.3 Potential Referrals

Where a development will cause air emissions, Alberta Environmental Protection and Enhancement Act approvals and Canadian Environmental Protection Act enforcement may apply. Municipalities should ensure that the proponent contacts Alberta Environment and Environment Canada, respectively, for approvals, advice and comment.

4.3 Surface Water

4.3.1 Broad Management Objectives

Maintain vegetation along watercourses/wetlands:

Riparian vegetation helps to stabilize banks, control nutrient cycling, trap contaminants, reduce water velocity, provide fish cover and food, trap sediments, reduce erosion and reduce the rate of evaporation (Platts et al. 1987). Sediments deposited along well-vegetated riparian areas build up, increasing the capability for water absorption and storage (Adams and Fitch 1995). Bare ground within a riparian zone caused by human activity, such as livestock grazing, recreation, roads and industrial activities, indicates a deterioration of riparian health (Thompson *et al*. 1998).

Vegetated buffers can support a variety of other ecological functions associated with riparian areas, including improving water quality, providing wildlife habitat and allowing for wildlife movement. Some functions require wide buffers, while others require relatively narrow buffers. Appendix C outlines typical widths recommended for riparian buffers to achieve specific management goals (e.g., to support wildlife movement or provide additional habitat). Recommended buffer widths typically vary between references and agencies. However, most of the research agrees that wider buffers are more effective in enhancing ecological functions. Accordingly, when determining an effective buffer width, it is generally wise to provide the widest buffer possible.

Maintain diverse, disturbance-free vegetation cover around watercourses/wetlands:
Many riparian woody species are browsed by livestock, which can prevent regeneration of these important species. Excessive browsing can eliminate them from the community and result in their replacement by undesirable invaders (Thompson et al. 1998). An abundance of disturbance-induced species, native or exotic, suggests displacement of other species from the natural community and a reduction in riparian health. These species are generally less productive, have shallow roots, and poorly perform most riparian functions. They usually result from some disturbance that removes more desirable species (Thompson et al. 1998). The presence of noxious weeds is also an indication of a degrading ecosystem (Thompson et al. 1998). In addition, a greater number of vegetative strata typically reflect better riparian condition (Cappiella et al. 2006). Diversity in both height and structure of vegetation assists in the capture and containment of sediments. Variety in vegetation types assists in capturing different contaminants, which can be reduced to a less hazardous form through phytoremediation (Rock 1997).

Avoid contamination of watercourses/ wetlands:
Point sources, such as intensive livestock operations and other heavy industry land uses, can release effluent or waste products into waterways, degrading the water quality. Non-point sources, such as golf courses and croplands, can diffusely release fertilizers or other chemicals into waterways through runoff. While these inputs may not be as concentrated, over a watershed the impact can accumulate to affect the water quality.

Maintain stable streambanks:
Streambank structural integrity is vital to good channel configuration and bank shape. Bank stability is linked to vegetation cover, as the roots bind the soil and prevent erosion (Adams and Fitch 1995). Impaired streambank structure can mobilize channel and bank materials, cause loss of fishery and wildlife habitat and lower the water table. Bank alteration can result from such causes as livestock hoof shear, recreation and resource extraction (Thompson et al. 1998).

Avoid wetland/watercourse loss, diversion or alteration from development, especially where part of an environmentally significant area:
Channeling or diverting watercourses can affect flow rates, potentially leading to slope down-cutting and loss of vegetation along watercourses. Down-cutting can lead to an incised channel, which can lower the water table enough to change existing vegetation (Thompson et al. 1998). Watercourse alteration can also result in increased stream flow velocities. A doubling of the speed of a stream's flow allows it to erode the channel four times as much and to carry 64 times the amount of material (Adams and Fitch 1995).

Increased stream flow speed also results in less retention time for water to soak into the soil and underlying substrate (Adams and Fitch 1995).

Removal of wetlands can result in the loss of habitat, filtration functions, ability of the land to attenuate floods and recharge groundwater. Wetlands that are environmentally significant may provide habitat to rare or sensitive species or comprise uncommon wetland or plant community types. Disturbance or removal of any wetland, including temporary spring-flooded ponds, is prohibited under the provincial *Water Act*. Although wetland impact can be approved where disturbance is unavoidable; the loss of wetland form and function must be compensated under the *Draft Wetland Policy.*

Manage storm water and other development wastewater, control runoff and sedimentation:
Storm water runoff can lead to erosion and subsequent sediment inputs into watercourses if not managed correctly. Runoff increases with increasing impervious cover such as when urban land uses are dominant, as water is unable to percolate into the ground surface. However, with management, storm water detention ponds can reduce the potential for erosion and improve water infiltration (Beaudry 2006). Such management can also assist in controlling sedimentation. Inputs of sediment into wetlands can result in wetland infilling and reduced capability for certain ecological functions. Sedimentation of watercourses can lead to physiological stress to aquatic fauna, including respiratory difficulty for fish.

Pollutant discharges from stormwater and other sources, such as septic systems, illicit discharges and spills are illegal under various provincial and federal legislation (Alberta *Environmental Protection and Enhancement Act (AEPEA)*, the Canadian *Environmental Protection Act* and the *Fisheries Act*). Where a proposed development has potential to release pollutants, the project would be in contravention of these Acts, and subject to later enforcement action. The *Subdivision and Development Regulation* under the MGA allows municipalities to request appropriate siting and selection of all design elements within a subdivision, including septic systems adjacent to sensitive surface or groundwater.

Manage water supply:
Surface water bodies often provide a water source for domestic or industrial use. If the volume of water withdrawn from the surface water source is greater than its typical input, its water level may be lowered, impacting the surrounding vegetation communities, aquatic organisms and wildlife. Due to the linkage between surface and groundwater, substantial withdrawals of surface water can also lower groundwater tables, contributing to drought conditions. Mismanaged surface water sources can also contribute to increased evaporation, as the exposed bed of affected waterbodies absorbs more heat, increasing the rate of evaporation relative to vegetated or water-covered areas. Increased evaporation can also result in areas of extensive vegetation removal, which leave bare soils. Lastly, areas bare of vegetation may have reduced infiltration of surface water into the soil, as flows run-off more quickly into drainage systems over such ground (Beaudry 2006).

4.3.2 Environmental Best Management Practices

The BMPs relevant to development design, planning review and construction stages are listed below. BMPs regarding surface water quality are widely available, often in a depth beyond the scope of this document. Taylor (1993), Taylor *et al.* (1995), Adams and Fitch (1995), Beaudry (2006) Cappiella *et al.* (2006) provide additional advice that may be useful to planners. We have summarized from those resources BMPs relevant to development design, planning review and construction stages of site-specific development proposal review. On review of the proposed development plan, supporting air photos and the Surface Water Risk Map, implement those BMPs applicable to the site.

Development Design Considerations:

- Minimize or avoid watercourse and wetland disturbance.
- Avoid watercourse alterations that may lead to increased stream flow velocities and subsequent erosion.
- Maintain a minimum vegetative buffer of 30m width along watercourses/ wetlands to:
    - provide vegetation that can capture and degrade potential contaminants to protect water quality and limit evaporation of moisture from bare soils,
    - stabilize banks and prevent their erosion, and
    - prevent sedimentation carried by overland water flow and deposition of wind-blown soils into waterbodies.
- Wider buffers may be appropriate to protect other functions. Check for concerns regarding other EFZs. Appendix C provides buffer widths for other management objectives (e.g., wildlife movement) that may be applicable.
- Construct within a minimal footprint, and minimize lot clearing to the area required for building.
- Development design should particularly avoid natural water features within environmentally significant areas and avoid removal, culverting, blocking or realignment of watercourses/wetlands within or associated with such features. Such watercourses/wetlands may perform a critical ecological function (e.g., supporting rare species, part of a recharge area). Clustered residential developments, that promote placement of higher density in less sensitive areas provides an effective planning alternative for such circumstances.
- Avoid creation of access roads that will cross watercourses or require filling of wetlands; design subdivision road networks with linkage to existing road networks as much as possible.

Planning Review Considerations:

- Ensure that the full Environmental and Municipal Reserve is utilized to protect sensitive water features. This basic tool, permitted under the MGA, allows municipalities to conserve lands due to environmentally sensitivity and for municipal benefit, both of which apply to surface water bodies.
- Consider including the vegetated riparian buffer as part of the Environmental Reserve taken around wetlands and other watercourses. Particularly wide buffer

areas in good condition could be protected under a Conservation Easement or as MR, an option that should be considered where other ecological functions may be present (e.g., wildlife corridors). Lot bonusing systems and cluster design, such as that used by Strathcona County, may be another useful incentive to increase conserved lands.

- Ensure the appropriate buffer required for protection /promotion of other relevant ecological functions at watercourses/wetlands has been included in the design (e.g., to enhance habitat connectivity).
- Because pollutant discharges from stormwater and other sources, such as septic systems, illicit discharges and spills, are illegal under various provincial and federal legislation, assuring that proposed developments would not pose a contravention would be due diligence on the part of the municipality. Ensure that wastewater collection systems are located, constructed and can be maintained to avoid impacts to surface and groundwater quality:
    - ensure appropriate setback from waterbodies to prevent release (particularly septic fields),
    - ensure that the septic system is appropriate for the local soil conditions, and
    - encourage applicants to select systems that have proven long-term performance.
- Require new developments to provide a storm water management system that provides some form of sedimentation and contamination filtration prior to release to natural waterbodies (e.g., forebays, oil and grit separation).
- Discourage replacement of existing natural areas (areas of relatively undisturbed native vegetation) and wetlands with impervious cover, particularly where groundwater recharge or discharge is suspected. Consider adding a condition to re-development approvals to rehabilitate areas of extensive impervious cover where groundwater recharge or discharge is known to occur.
- Encourage developers to build up rather than out to reduce the area of impermeable surface within lots.
- Encourage use of “low-impact” surface runoff systems (e.g., release roof run-off into vegetated areas, rather than collecting in storm systems).
- For proposals that will require large volumes of surface water withdrawal to support the development, confirm that the water source can sustain such use. Confirm that a withdrawal license under the *Water Act* has been obtained from Alberta Environment. Farmers and residents adjacent to surface waters who remove small volumes are exempt from Alberta *Water Act* licenses for withdrawal.

Construction Conditions:

- Minimize sedimentation from soils disturbed during the construction process by minimizing clearing, requiring erosion and sediment controls within the construction area and enforcing these regulations (Cappiella et al. 2006). The City of Calgary’s Wetland Policy contains excellent suggestions for development standards designed to minimize the amount of sediment carried in run-off to local waterbodies.

- Prevent the establishment of noxious, invasive or weedy species within riparian buffers through appropriate construction mitigation measures (weed control, washing of equipment prior to entering riparian areas).
- Require remedial measures as a condition of approval for projects around watercourses or wetlands where noxious, invasive or weedy vegetation has become established within a riparian buffer.
- Revegetate cleared areas as soon as possible with native species to prevent the establishment of noxious, invasive or weedy species and minimize potential erosion.
- Where construction is necessary within the 30 m riparian buffer, require revegetation of the disturbed areas adjacent watercourses and wetlands as soon as possible. Require that adequate erosion and sedimentation controls be in place for any such work, to mitigate potential release into surface waters.
- Require that appropriate erosion and sedimentation protection measures are in place for any construction works within floodplain areas to prevent potential sediment release to adjacent waterbodies.

4.3.3 Potential Referrals

- Where in-stream activities in fish-bearing waters are proposed, the Canadian *Fisheries Act* approval process applies. Such projects may also trigger review under the *Canadian Environmental Assessment Act.* Refer the proposal to the Canadian Department of Fisheries and Oceans for advice.
- Where construction would occur in or on the shores of navigable waters, the *Navigable Waters Protection Act* approval processes apply. Such projects may also trigger review under the *Canadian Environmental Assessment Act.* Refer proposals to Transport Canada.
- Where water resources, including all wetland types, could be impacted by diversion, draining or filling, the Alberta *Water Act* approval process applies. Refer such proposals to Alberta Environment
- Where development occurs on the bed or shores of permanent, naturally occurring waterbodies, including work within wetlands or watercourse realignments, the Alberta *Public Lands Act* approval processes applies. Refer such proposals to Alberta Sustainable Resource Development, Public Lands Branch.
- Where stormwater management is necessary, the Alberta *Environmental Protection and Enhancement Act* and the *Water Act* Code of Practice for Outfall Structures applies. Refer proposals to Alberta Environment.
- Where road crossings over waterbodies are proposed, the *Water Act* Code of Practice for Watercourse Crossings applies. Refer proposals to Alberta Environment.
- Alberta's *Wildlife Act*, the federal *Migratory Birds Convention Act* and the federal *Species at Risk Act* prohibit disturbance to nesting birds, select (listed) species, and dens or hibernation sites of certain other wildlife species. Ensure that construction plans will comply with requirements by these Acts. Proposals could be referred to Alberta Environment and Environment Canada for comment, if uncertainty exists regarding potential impact.

- In the Edmonton area, Alberta Sustainable Resource Development recommends avoiding clearing activities in vegetated areas between 15 April and 15 July to avoid mortality to migratory birds. Environment Canada and Strathcona County recommend an extended clearing restriction between 15 April and 31 July.
- Where contamination of watercourses/wetlands has potential to occur, the Alberta *Environmental Protection and Enhancement Act* applies. Refer such proposals to Alberta Environment for advice on appropriate design controls to prevent accidental leaks or spills.
- Where intensive livestock operations are planned, the *Agricultural Operation Practices Act* approval process applies. Refer to the Natural Resource Conservation Board.

4.4 Groundwater

4.4.1 Broad Management Objectives

Maintain vegetation in floodplains:
Well-vegetated, healthy floodplains slow the overland flow of water run-off, reducing its erosive capacity, providing for settling of finer sediments and allowing ample time for water percolation into soils (Adams and Fitch 1995). Conversely, floodplains with sparse vegetation or channelized areas shed water quickly and consequently have little infiltration into the soils. Soils in such areas tend to be drier as a result, which in turn affects vegetation productivity.

Floodplains often also have a groundwater recharge function; reduced infiltration can impact groundwater supply (Adams and Fitch 1995). Watersheds with poor groundwater storage capability will more quickly exhibit low stream flows in times of low precipitation. Stream flow may become intermittent during dry periods and water may become unavailable for livestock, wildlife and fish. Typically, water tables in well-vegetated riparian areas are higher, often within the plant rooting zone and thus available to plants. The combination of lower soil moisture and a lowered groundwater table can reduce vegetation productivity, including forage production for livestock and wildlife (Adams and Fitch 1995).

Avoid draining wetlands:
Wetlands can serve as recharge zones for groundwater supply, providing the retention time necessary for water to soak into the soil and underlying substrate (Beaudry 2006). Wetlands also function as a filtration system for water seeping through the substrate into the underlying aquifers.

Avoid contamination of groundwater recharge zones:
As groundwater flows through surficial sediments toward underlying aquifers, it is naturally filtered. This filtering, combined with the long residence time underground, means that groundwater is usually free from disease-causing microorganisms. Other contaminants that can either be dissolved or carried in water may not always be filtered out, however, and if such contaminants reach the underlying aquifer, removal or remediation can be difficult or impossible. Where groundwater is near or exposed to the

ground surface, such as recharge or discharge zones or groundwater well shafts, the potential to encounter such contaminants is higher. Placing a source of concentrated contaminants such as fuel storage areas, septic systems or manure storage areas close to such zones further increases that risk.

Contaminants can enter groundwater through wells, recharge areas or even through surface soils. Releases entering shallow groundwater can spread contaminants far beyond the site of the source, further complicating remediation, or threatening critical sources. Contaminants released into surface water or even onto the soil surface can leach into groundwater reservoirs. This not only leads to aquifer contamination but also can lead to re-circulation, through the hydrological cycle, into distant surface waters. Groundwater contamination is extremely difficult and sometimes impossible to clean up and often is present for long periods.

Contamination of groundwater is prohibited under the Alberta Environmental Protection and Enhancement Act (AEPEA), and could result in prosecution. More importantly though, such contamination can be extremely difficult and expensive to remove from groundwater, and treatment often requires many years for successful removal. The *MGA's Subdivision and Development Regulation* allows municipalities to regulate septic system locations, which provides a mechanism for municipalities to manage this particular risk.

Avoid concentrating high-demand groundwater users:
Intensive withdrawal of groundwater can lead to lowered groundwater tables, affecting the ability for vegetation to persist on the surface. Obviously, as the density of water wells increases, their collective demand on local groundwater resources also increases and may ultimately exhaust the source, if use is not managed. During groundwater shortages, surface waters levels may also fall as the discharge of groundwater sources to surface water bodies may be reduced. A high density of groundwater wells also increases the risk of groundwater contamination, as direct access allowing contaminant entry also becomes more available.

4.4.2 Environmental Best Management Practices

The BMPs relevant to development design, planning review and construction stages are listed below. On review of the proposed development plan, supporting air photos and the Ground Water Risk Map, implement those BMPs applicable to the site.

Development Design Considerations

- Encourage use of designs/landscaping that will limit clearing and retain maximum vegetation within floodplain areas.
- Avoid covering extensive areas with impervious surfaces (e.g., paving, concrete surfacing), instead, choose chose gravel surfacing or vegetation.
- Design developments around natural water features to avoid wetland impact, as described for surface water in the preceding section (e.g. clustered residential developments, minimizing or avoiding water crossings by roads).

- Maintain a minimum 30 m wide vegetated buffer around wetlands, other waterbodies and particularly known groundwater recharge zones to protect both surface and groundwater quality.
- Septic systems should be appropriate to the soil and groundwater conditions. Where recharge or discharge zones are suspected to occur, particularly in areas with coarse soil textures or surface waterbodies, septic systems that prevent potential release to surface water or subsoils should be incorporated into the proposed development design.
- Developments should also consider high water table levels. Construction within the water table presents a potential risk of groundwater contamination, and basements may also be inappropriate in such areas.

Planning Review Considerations

- Where wetland impacts cannot be avoided and choices are available, discourage disturbance of wetlands on or near groundwater recharge areas (Beaudry 2006).
- Do not allow land uses associated with potentially harmful contaminants on or near groundwater recharge areas (Beaudry 2006).
- Where intensive livestock operations are planned, the *Agricultural Operation Practices Act* approval process applies. Such proposals must be referred to the Natural Resource Conservation Board, but the municipality can request that special considerations consistent with local planning objectives be addressed within the NRCB approval process. Consider if conflict with other management objectives may apply to these proposals (e.g., existing density of ILOs, proximity to locally sensitive waterbodies or groundwater recharge/discharge areas).
- Consider other facilities associated with the proposed development, such as landfills or hazardous material storage facilities, in the proposal review. Ensure such facilities are in locations where leachates will not contaminate underlying groundwater or surface waters overlying recharge areas.
- Allocation of groundwater resources falls under the Alberta *Water Act*. Confirm that sufficient groundwater supply exists to support proposals that will require large volumes of water for operation (e.g., subdivisions, industrial developments). All such proposals require licensing approval from Alberta Environment. Require the proponent to provide documentation from Alberta Environment confirming a license would be granted for the proposed development as a condition of development approval. (A formal referral process would also provide this confirmation.)
- To minimize groundwater use in areas with higher groundwater demand, country residential and small holdings can be linked to municipal water systems, or use water storage systems (e.g., cisterns). Adequate sources must still be available; confirmation of a reliable and sustainable source should be sought from Alberta Environment.
- Recommend seeking other sources of potable water, or innovative approaches to water use, if there is a threat of groundwater overuse (Beaudry 2006).
- Require that any new drilled wells are reported to Alberta Environment as a condition of development approval to support these other jurisdictional requirements.

Construction Conditions

- Revegetate floodplain areas disturbed during construction as soon as possible, as this will enhance infiltration and capture of surface run-off, and groundwater recharge.
- Require applicants to prepare Hazardous Materials Management Plans for proposed construction and for operation of industrial developments. Storage and use of hazardous materials within 100 m of any waterbody should be discouraged.

4.4.3 Potential Referrals

- Where water resources could be impacted by diversion, draining or filling, the Alberta *Water Act approval process applies*. Where development occurs on the bed or shores of a water body the Alberta *Public Lands Act* approval processes also apply. Refer such proposals to Alberta Environment and Alberta Sustainable Resource Development (Public Lands), respectively.
- Where wetlands may be impacted by proposed developments by draining, filling or other disturbance, the Alberta *Draft Wetland Policy* and Alberta *Water Act* approval processes apply. In some cases, the Alberta *Public Lands Act* may also apply. Refer proposals with such potential impacts to Alberta Environment and Public Lands, respectively.
- Contamination of groundwater (or surface water) is prohibited under the Alberta *Environmental Protection and Enhancement Act*. Depending on the contaminant, a release may also be administered under the Canadian *Environmental Protection Act*. Proposals with potential to impact groundwater resources (including certain sewage treatment systems and industrial activities) should be referred to Alberta Environment and Environment Canada, respectively for advice on potential for the design to contravene these regulations.
- Where intensive livestock operations are planned, the *Agricultural Operation Practices Act* approval process applies. Such proposals should be referred to the Natural Resource Conservation Board.

4.5 Landscape Connectivity

4.5.1 Broad Management Objectives

Maintain corridors between habitat patches

In a developed landscape, even a rural landscape such as the moraine, suitable habitat patches are located in a Matrix of other land uses that discourage animal movement. The quality of habitat within a land use may provide insufficient security cover or resources to support movement, or, the width of the gap in an otherwise permeable land use may be too large. In such a landscape, “corridors”, which may comprise Linkage Habitats (Linear Corridors, Stepping Stones) or more permeable forms of land use, allow animals to seek mates and new habitat, and allow for effective plant and animal dispersal. Ultimately, these functions sustain biodiversity within that landscape.

4.5.2 Environmental Best Management Practices

The BMPs relevant to development design, planning review and construction stages are listed below. On review of the proposed development plan, supporting air photos and the various Landscape Connectivity EFZ Maps, implement those BMPs applicable to the resources present at the site. Note that to address regional connectivity, review should also consider the adjacent lands (within a minimum radius of 5 km), as corridors and Key Segments may lie near the proposed property and may be affected by the proposed development.

Development Design Considerations

- Minimize the development footprint to retain natural vegetation within lots.
- Encourage the designation, location, and management of Environmental Reserves (ER) and Municipal Reserves (MR) to establish and/or maintain connectivity between habitat patches.
- Protect naturally vegetated areas on lots within new subdivisions using the maximum Environmental Reserve and Municipal Reserve dedication and consider additional protection through conservation easements or covenants on the land title. This will be particularly important in areas that provide a buffer between human use areas and retained environmental features (e.g., wetlands, riparian areas).
- Where species at risk are known to occur within the proposed development area, ensure that connection between retained habitat within the parcel and any adjacent movement corridors are maintained. Development restrictions may also apply to habitat supporting federal Endangered and Threatened and provincial At Risk and May Be At Risk species. BMPs regarding these species are described in the Core Areas section below.
- If trails are planned as part of a subdivision, avoid bisecting otherwise intact natural areas, and instead, route trails around their perimeter.
- Encourage developments that incorporate landowner stewardship initiatives, such as native species landscaping or wildlife viewing, to enlist future residents in local management.

Planning Review Considerations

- Encourage restoration of narrow corridors linking adjacent protected areas, or buffering protected areas as a condition of new developments that would remove vegetative cover (i.e., resulting in no-net loss).
- Encourage conservation easements as a means of protecting connective habitat, particularly where such habitat links or buffers protected areas. Consider development bonuses as an incentive for conservation easements.
- Consider the relationship of the proposed parcel in the context of regional level wildlife corridors and ensure that development avoids blocking such corridors. Corridors linking protected areas are particularly vulnerable, and may extend over long distances (e.g., between Blackfoot-Cooking Lake, Ministik and Miquelon protected areas). Incremental loss within key corridors, particularly narrow sections of connected habitat, could cause some species to avoid travel through those areas. In such areas, maintain a threshold width of about 600 m of naturally

vegetated woodland habitat within key segments of connected habitat between protected areas (see Appendix C for other relevant minimum width thresholds).

- Similar buffers may also be appropriate where species at risk are known to occur, in order to protect critical habitat for the species or to ensure its habitat is not isolated from other suitable habitat and populations. Because the degree of sensitivity will vary with the species and the proposed development, such mitigation measures should be applied on a situation-specific basis. Advice of a biologist would be useful in evaluating the risk to the sensitive species, and in developing appropriate mitigation. Alberta Sustainable Resource Development or Environment Canada can provide such advice for species under their jurisdiction. Alternatively, professional advice from a consultant may be requested by the planning officer, at the developer's expense. Other BMPs regarding species at risk are provided in the Core Areas section below.
- Where development within a key corridor (e.g., within a key segment of connective habitat) cannot be avoided, require restoration or enhancement of alternative routes that would provide a detour around the disturbance area.

Construction Conditions

- Minimize clearing of naturally vegetated areas to the area required by clearly marking limits for vegetation removal.
- Revegetate disturbed areas adjacent retained natural features using native species where possible.

4.5.3 Potential Referrals

- Alberta's *Wildlife Act*, the federal *Migratory Birds Convention Act* and the federal *Species at Risk Act* prohibit disturbance to select, listed species, nesting birds, and dens or hibernation sites of certain other wildlife species. Ensure that construction plans will comply with these Acts, by requiring confirmation of the presence of any rare species on the development parcel. Proposals could be referred to Alberta Environment and Environment Canada for comment, if uncertainty exists regarding potential impact.
- If species at risk will certainly be impacted by a proposed development, under the federal *Species At Risk Act*, an environmental assessment is required to meet the *Canadian Environmental Assessment Act (CEAA)*. Consult with the Canadian *Environmental Assessment Agency* if such potential is identified in studies supporting the proposed design.

4.6 Core Areas

4.6.1 Broad Management Objectives

Maintain large contiguous patches of native vegetation

Biodiversity is sustained within a landscape largely in two ways: by maintaining pockets of high diversity that may exist, and by maintaining healthy source populations that can help repopulate other, smaller habitat patches. Generally, larger patches of habitat support higher diversity and abundance of species. As a result, they play a key role in the regional ecological landscape, because they can serve as a source to repopulate areas more susceptible to extirpation (generally smaller, more fragmented areas). In this assessment, we have identified Core Areas as large, contiguous patches of habitat that can support higher diversity communities and abundant populations. Core areas vary with respect to species, due to species-specific habitat requirements, thus discussion of management of Core Areas must be tied to species of management concern, or indicators representative of a more diverse suite of species. In this assessment, we have identified several categories of Core Areas that can sustain different levels of biodiversity within the moraine. Maintaining a range of such Core Areas across the landscape will provide multiple sources, representing different communities of wildlife and plant species. Maintaining such sites, distributed across the moraine, avoids concentrating that investment in one, potentially vulnerable location, and allows dispersal to a wider range of smaller habitat patches.

4.6.2 Environmental Best Management Practices

The BMPs relevant to development design, planning review and construction stages are listed below. On review of the proposed development plan, supporting air photos and the Core Areas Map, implement those BMPs applicable to the resources present at the site. Note that to address concerns related to High Biodiversity Core Areas in particular, the review should also consider the adjacent lands (within a minimum radius of 5 km). Buffering may be required to protect Core Areas, and some forms of development may not be appropriate immediately adjacent to these areas.

Development Design Considerations

- Encourage development that avoids or minimizes loss of naturally-vegetated areas. In particular, avoid clearing within identified Moderate Biodiversity Core Areas, associated Linkage Habitat and key corridor segments.
- In parcels containing Low and Moderate Biodiversity Core Areas, locate development along the perimeter of the habitat patch and avoid clearing with the naturally-vegetated areas themselves. If development within such areas cannot be avoided, locate infrastructure within the edge of the area, rather than its interior.
- Use Environmental Reserve or Municipal Reserve dedication where possible to protect these areas. Consider Conservation Easements if these tools cannot protect the entire Core Area.
- Avoid access that will cross Core Areas, associated Linkage Habitat or key corridor segments. Alternatively, locate such infrastructure along the disturbed edge of such areas. For higher volume roads, locate within adjacent lands that will provide some separation from Core Areas by a buffer of low vegetation (e.g., grass or low shrubs) to discourage crossings.
- Proposals that provide a buffer of lower intensity land use (e.g., low density housing, non-intensive agricultural operations) adjacent to Core Areas will minimize human disturbance impacts in these areas and should be promoted where possible.
- Avoid sensitive or critical habitat of species of federal or provincial concern. Where such species may be present, provide mitigation to ensure that such species

or their critical habitat are not harmed by the development's construction or operation. This is particularly important for species considered Endangered or Threatened federally, or At Risk or May Be At Risk provincially. Because the risk to these species can vary with the species and the type of development, mitigation should be developed on a situation-specific basis. Seek advice from qualified biologists to incorporate appropriate mitigation into the proposed design.

Planning Review Considerations

- Ensure that Environmental Reserve, Municipal Reserve, conservation easements and other tools permitted under the *MGA* and the *Subdivision and Development Regulation* have been used to maximize protection of Core Areas within a proposed development parcel.
- Provide incentives such as lot bonusing for other innovative approaches to protect Core Areas (e.g., cluster design, land title covenants, resident stewardship programs, habitat enhancements).
- Explore other means to direct development to other, less sensitive areas:
    - Encourage innovative designs that trade off high density development in other less sensitive areas, to avoid development in Core Areas (e.g., cluster development).
    - Consider establishing a Transfer Development Credit system, which would grant development rights in other, less sensitive areas in order to protect areas with significant environmental function, including Core Areas (see Beaudry 2006).
- Ensure that no species at risk are known to occur in any proposed development area. This will require the developer to undertake an inventory, which at a minimum, should include a search for past records from the Alberta Sustainable Resources Wildlife Information Management System (FWMIS) and the Alberta Natural Heritage Information Center's (ANHIC) database. Such requirements can be incorporated within a Biophysical Review or Environmental Impact Assessment, if the municipality has established such a review within the planning process.
- Where species considered Endangered or Threatened federally, or At Risk or May Be At Risk provincially have been identified within the development area, work with Environment Canada and Alberta Sustainable Resource Development to ensure that all applicable legislative requirements are fulfilled by the developer.

Construction Conditions

- Minimize vegetation clearing within and adjacent Core Areas as much as possible. Clearly mark the limits of the area to be cleared before construction begins to avoid accidental removal of additional vegetation.
- Implement measures to limit the spread of noxious, invasive or weedy species when working near Core Areas:
    - wash equipment before moving to new sites to remove seeds captured in soil or grease,
    - provide weed control for soils stockpiled over long periods to limit establishment of undesirable species, and

- revegetate disturbed areas with suitable native seed mix as soon as possible and follow-up to ensure sufficient establishment of new vegetation

4.6.3 Potential Referrals

- Alberta's *Wildlife Act*, the federal *Migratory Birds Convention Act* and the federal *Species at Risk Act* prohibit disturbance to rare species, nesting birds, and dens or hibernation sites of certain other wildlife species. Ensure that construction plans will avoid disturbance or mortality to these species. Proposals could be referred to Alberta Environment and Environment Canada for comment, if uncertainty exists regarding potential impact.
- If rare species will certainly be impacted by a proposed development, under the federal *Species At Risk Act*, an environmental assessment is required to meet the *Canadian Environmental Assessment Act (CEAA)*. Consult with the Canadian *Environmental Assessment Agency* if such potential approach.
- Where wetlands may be impacted by proposed developments by draining, filling or other disturbance, the Alberta *Draft Wetland Policy* and Alberta *Water Act* approval processes apply. In some cases, the Alberta *Public Lands Act* may also apply. Refer proposals with such potential impacts to Alberta Environment and Alberta Sustainable Resource Development (Public Lands Branch), respectively.

5.0 APPLYING THE BHI PRINCIPLES WITHIN MUNICIPAL POLICY

In the previous section, site-specific considerations for development applications were provided as a reference guide in reviewing such applications. Over the longer term, a municipality may wish to incorporate some of those considerations into statutory or non-statutory policy.

To implement a Land Management Framework that outlines a sustainable land use approach, the environmental goals, objectives and force of such policies should ideally be consistent and mutually reinforcing across all municipal authorities within the Beaver Hills. In the course of the policy review in Phase 1 of this project, we identified areas in which a minimum of consistency is required in order to set the stage for a comprehensive sustainable management approach. Phase 1 also identified the tools currently provided for in the MGA, and the gaps in environmental legislation that municipalities might choose to fill to maintain the key elements of the moraine. By achieving maximum consistency and utilizing all the tools available to it, the BHI municipalities could most efficiently and effectively manage the natural resources that comprise the essential landscape character of the moraine. In doing so, they could serve as a model for sustainable land management for others.

In this section, we review the authority and tools provided by the MGA for management of the environment by municipal governments. We also review the limits of federal and provincial jurisdiction, and the means by which municipalities can use those government agencies to help manage their own resources more effectively. Next, we review the basic, minimal policy changes required to achieve a consistent base among the municipal partners that were identified in Phase 1. Lastly, for each of the EFZs, we have recommended actions and alternative land use approaches to sustain the specific resource that could be encouraged within policy. All of these recommendations are provided for consideration by the member municipalities during reviews of their MDP, LUB and other policy documents, for incorporation as appropriate to their specific circumstances.

5.1 Environmental Tools within Policy

Currently, the MGA defines environmental aspects for municipal management in the following contexts:

- Environmental features that pose a threat to development and should be considered in development proposals (“hazard lands”),
- Lands that should be protected by the municipality for environmental reasons, typically those same hazard lands or lands suitable as park resources (Environmental and Municipal Reserve), and
- Lands of significance within the local environmental context that could be managed through land owner agreements (conservation easement provision, other management provisions within the Subdivision Regulation).

The Subdivision Regulation provides a broad clause that also allows municipalities to consider any other factors that might be of concern in determining the most appropriate use of a parcel. This could include specific environmental concerns, but few municipalities have used this clause to protect critical natural features within their boundaries. As a result, most of the member municipalities have developed policies that address only the first two aspects of the environment listed in the MGA. Few have taken advantage of their authority under the MGA to manage environmentally significant lands, perhaps because of the limited definition of "environment" in the Act.

Notwithstanding these past approaches to environmental management, the MGA provides considerable room to manage environmental issues beyond these definitions, through the authority granted to protect the safety, health and welfare of people and community. That authority allows any resource or issue considered critical to the broader community to be managed through specific by-laws or policies, provided their justification is clear and apparent and their implementation would not be perceived as an unfair limitation. At a minimum, the BHI municipalities should consider revising policies to incorporate all three aspects of the environment defined under the MGA:

- Ensure all potential environmental hazards to the development, or to the environment, are considered within a development proposal, or broader policy area or land use zone. This may require a broader definition of environmental hazards to include threats to water resources, habitat and species of concern. Because such aspects have not typically been identified as environmental hazards in statutory documents, confirmation of the most appropriate means of incorporating such a definition should be obtained from municipal legal counsel.
- Ensure all opportunities to protect lands defined as environmentally significant within the municipality, or the broader region, are implemented (e.g., through Municipal Reserve or Environmental Reserves). This requires a definition of what will comprise environmental significance for the municipality, and related management objectives.
- Ensure the means to secure and manage conservation easements are in place and implemented to protect lands of environmental significance to the municipality. This also requires definitions of 'environmental significance' and related management objectives, as noted above.

In addition to utilizing these basic tools provided within the MGA to their maximum effectiveness, municipalities can also draw on the resources of provincial and federal resource managers. Federal and provincial governments are directly responsible for management of water, wildlife, fish, rare species, historical resources and air quality. The Historical Resources Act is particularly powerful and is by no means restricted to cultural features within the landscape. The federal *Fisheries Act* and supporting policies require no-net loss of fish habitat due to development. That element and habitat degradation clauses give it considerable strength as well. Provincially, management also extends to natural resources traded as commodities (e.g., oil, gas, aggregates and minerals) and to industries with potential to impact natural resources (e.g., agriculture, petrochemical extraction and refining). Management is applied either through permitting or enforcement. An understanding of which agencies manage which resources, and how, allows the municipality the opportunity to access expertise for review of development proposals that may not be available locally. It also provides assurance that a proposed development will meet all applicable regulatory requirements. An environmental impact assessment (EIA) process that ensures that all relevant aspects of the environment and the applicable regulatory considerations have been considered in the design of a proposed development provides an excellent means of involving those agencies as reviewers. Yet, few municipalities have established such a policy, or at a minimum, a requirement for proposals potentially covered under such legislation to be referred to the appropriate agency.

In federal and provincial environmental legislation, the onus for referrals and preparation of the environmental assessment report has been given to the developer (the "developer pays" concept). A similar approach should be employed here, to require, at a minimum, that the proponent has consulted all relevant federal and provincial regulatory authorities. Again, awareness of the environmental legislation applicable to a given proposal would help municipal administrators ensure that this step has been complete. The referrals recommended for each EFZ in the preceding section provide a basis for such awareness.

Incorporating a requirement for the referrals in the preceding section within policy would provide clear guidance to municipal administration, and better integration with the resource management processes of federal and provincial agencies. Ideally, each municipality would adopt a consistent environmental assessment process within the same form of policy. This would provide the mechanism for referral, but it also would ensure that all environmental and regulatory concerns were addressed at the initial design stage, before the developer or the municipality had invested many resources in a project. Such a process requires the municipality to have the resources and environmental background available to support that process, however, and may not be feasible immediately.

5.2 Recommendations for Base Policies

The policy review conducted during Phase 1 of the Land Management Framework project identified inconsistencies in the approach and level of detail within the MDP, LUB and non-statutory policies of the BHI partner municipalities. Specific environmental protection measures are also variable in detail and force of law (in policy, vs. MDP or LUB). Definitions of the environmental aspects of interest within the municipal context are also inconsistently addressed among the policies of the five municipalities. Figure 5.1 summarizes the gaps currently existing among the BHI municipalities. Filling in these gaps with consistent policy should be a longer-term goal of the Land Management Framework, as it is in the definitions, objectives and goals of the MDP and LUB documents in which the overall direction of land management is established.

Figure 5.1. Land Use Provision Summary Checklist

Legend: **Yes** (shaded) **No** (unshaded)

Municipal Development Plan	Nature of Provision	Strathcona	Beaver	Leduc	Lamont	Camrose
Goals and Objectives	Environmental (General)	Yes	Yes	Yes	Yes	Yes
	Beaver Hills (Specific)	Yes	Yes	No	No	No
Agriculture/Country Residential	Environmental Protection Provisions	Yes	Yes	Yes	Yes	No
	Beaver Hills (Specific)	Yes	No	No	No	No
Environment/Wildlife Policies	General	Yes	Yes	Yes	Yes	Yes
	Beaver Hills (Specific)	Yes	No	No	No	No
Riparian Protection	Environmental Reserve Provisions	Yes	Yes	Yes	Yes	Yes
	Riparian Area Protection (Specific)	Yes	Yes	Yes	No	Yes
Implementation Policies	Environment (Specific)	Yes	No	Yes	No	No
Definitions	Environmental	Yes	No	Yes	No	No

Land Use Bylaw	Nature of Provision	Strathcona	Beaver	Leduc	Lamont	Camrose
Application Requirements	EIA/ESA/Other Specific Requirement	Yes	No	Yes	Yes	No
	Additional Information (Non-Specific)	No	Yes	No	No	No
Application Referrals	General Requirement	Yes	Yes	No	No	No
	Environment (Specific)	No	No	Yes	Yes	No
General Regulations	Environmental Standards	Yes	No	Yes	Yes	No
Land Use Districts	Environment/Conservation	Yes	No	Yes	No	No
	Other District	No	No	No	No	Yes
	Tree Removal or Other Restriction	No	Yes	Yes	Yes	Yes
Definitions	Environment or Related Terms	Yes	Yes	Yes	No	No

Non-Statutory Requirements	Environmental Protection	Yes	No	No	No	No

At a minimum, consider establishing a consistent definition of the environment within the statutory documents of all 5 municipalities. That definition should recognize the environment as a complex system that is composed of natural features whose existence depends on the retention of the features as well as the processes that allow them to interact and whose natural capital provides the basis for a sustainable flow of environmental, social and economic benefits. Recognition of the environment as a comprehensive entity possessing both form and function, (i.e., moving away from a management approach that views each resource in isolation) is essential for a sustainable development approach. The definition used in the Canadian Environmental Assessment Act provides a good model, and if adopted, would maintain consistency with federal and provincial environmental legislation:

"Environment" means the components of the Earth, and includes:

(a) land, water and air, including all layers of the atmosphere,
(b) all organic and inorganic matter and living organisms, and
(c) the interacting natural systems that include components referred to in paragraphs (a) and (b).

Ensuring that the environmental management tools provided under the MGA are fully exercised within municipal policies is critical, as it will provide planners with the means to manage environmental concerns. A definition of the specific resources that are considered critical, or environmentally significant to the municipality, and establishing management goals to sustain those critical elements within the MDP and LUB are also essential, and currently missing in most municipal policies. The broader definition of environment, recommended above, will help establish a context for such additional definitions and objectives. Recommendations for such specifics have been provided in the discussion below, regarding suggested policies for the EFZs. A broader definition of the environmental features that might be taken as Environmental Reserve, to include certain critical features such as wetlands on recharge zones, or Core Areas, might be possible as well. The potential for this under the MGA and the Subdivision Regulation should be investigated.

With these definitions as a base, MDP policies addressing the Beaver Hills moraine specifically should be consistently adopted across all municipalities. These include general goals and objectives as well as policy area provisions, and any critical environmental elements that the municipality may feel are relevant. We would recommend that the critical environmental resources defined as recommended above be specifically addressed in such provisions. Incorporating in the LUB document a specific policy identifying the process for assessing potential impact at these environmentally significant or sensitive areas is required for continuity within the municipality's statutory documents, at a minimum. Ideally, an EIA process would also be listed as a requirement. This has certain advantages as it can be combined with a requirement for referrals to other jurisdictions to maximize efficiency of environmental review.

As discussed above, the LUB should also identify the requirement to refer applications that deal with resources under provincial and federal jurisdiction to the appropriate agency. Clearly stating the activity triggering such referral (e.g., work within a fish-bearing stream, or disturbance of a wetland) would clarify the jurisdictional requirements for the developer as well as administrators. Ideally, such referrals would be consolidated within a broader environmental assessment process that would be coordinated under one responsible authority. This sort of requirement is probably best applied within the LUB, as Leduc has done for environmentally sensitive areas. Strathcona County has established a similar non-statutory policy, however the environmental review can only provide guidance to development approval. A policy providing a stronger role in the approval process would give more force to the recommendations resulting from such a review.

Other specific policies dealing with the EFZ resources follow below, and could be incorporated either as LUB policy or non-statutory policy, as appropriate to the municipality's resources, interests and political context.

5.3 Environmental Best Management Practices for MDP and LUB Review

Section 4.0 provided specific considerations for review of site-specific development applications for each of the EFZs. These guidelines were based on current science and industry standards for environmental practice, with an implied goal of sustaining the resource in question. At some point, the BHI municipalities may wish to formalize the goals relative to the EFZs, and adopt policies regulating the management of the resources in question. The sections below provide for each EFZ recommendations of points that could be incorporated in policy. We have not recommended the level and form of policy, as that would be more appropriately established by each municipality, with consideration for the relative importance and abundance of that resource within the municipality.

Air Quality

- Although air quality is currently considered to be good across the Edmonton region, areas close to industrial zones may be susceptible to other, longer-term ecological impacts of airborne contaminants. The lichen study by Fort Air Partnership and Elk Island National Park will shed some light on that issue. On-going air quality monitoring and lichen study results should be considered in future MDP and LUB policy reviews.
- Most municipalities are sensitive to public perception of air quality near industrial areas and impacts on quality of life, and attempt to buffer industrial areas from more densely populated zones with other types of land use (e.g., agriculture). Yet, the public is also increasingly wary of potential impacts of airborne contaminants on food products. Consider other alternative forms of agriculture that may be compatible with industry for use as buffers (e.g., landscaping businesses, woodlots). Such land uses may also act as carbon sinks, countering other impacts of industry.
- Although not a legislated aspect of air quality, odiferous operations such as poultry and pig farms, can cause future conflict with densely populated rural residential or urban areas. Buffers of vegetated land, preferably wide, treed

buffers, could help minimize adjacent impacts, but providing an intermediary land use between such land uses would also help defuse potential issues. Consider less dense, non-residential or recreational land uses for these areas.

Surface Water

- Consider a water protection policy that would provide a minimum vegetated buffer of 30 m width around waterbodies. A minimum width of 30 m is sufficient to protect water quality; wider buffers offer other benefits and could be considered where multiple management objectives may apply (e.g., habitat connectivity; see Appendix C for examples of functions and buffer widths).
- Identify land use zones for intensive livestock operations or heavy industrial land use outside GDAs with abundant water, particularly those in closed systems. Reference provincial guidelines regarding separation from watercourses in land use policies for these zones. For particularly sensitive surface waterbodies in the local context, consider a wider buffer requirement (e.g., recreational lakes, larger lakes with significant wildlife habitat).
- Avoid development in environmentally sensitive areas, particularly those containing waterbodies.
- Consider potential watershed level impacts in decisions regarding the location, type and intensity of land uses in a municipality, considering the balance of development relative to surface water cover.
- Adopt a wetland protection policy that references the provincial *Draft Wetland Policy* discouraging activities causing wetland loss.
- Discourage introducing impervious cover (such as asphalt) in existing natural areas, particularly where groundwater recharge or discharge are suspected. Rehabilitate areas already constructed with impervious materials, replacing such cover with more permeable materials (e.g., gravel) on an opportunistic basis.
- Avoid watercourse alterations that may lead to increased stream flow velocity that may cause subsequent erosion.
- Encourage rural landowners to increase natural vegetation buffers surrounding waterbodies on their properties through incentive programs or as conditions to new developments within their property.
- Encourage agricultural best management practices, including conservation tillage and irrigation water management. Refer to Agricultural Management Practices for Water Quality Protection (USEPA 2006).
- Consider re-zoning areas to lower the densities of future water users where water supplies appear to be declining or sparse. For example, avoid concentrating industries with high water supply demands in areas without ready access to water.
- Encourage water conservation by residents, businesses and industry through demand management (see Beaudry 2006). For example, a by-law might address:
    - sewer and metered water rates.
    - lawn watering.
    - A requirement (or provision of incentives such as rebates) for low flow fixtures in new building developments.

Groundwater

- Most municipalities do not allow building development within the 1:100 year floodplain, but may allow other structures. Considering the impact of evaporation of cleared areas on the water cycle, minimizing extensive clearing within floodplains would also help retain soil moisture, and ultimately, surface and groundwater supply. Consider reviewing floodplain development policies adjacent major waterbodies, at a minimum, to discourage extensive clearing or replacing natural surfaces with impervious materials.
- During MDP and LUB planning reviews, designate areas for intensive livestock operations or heavy industries away from recharge zones.

Habitat Connectivity

- Establish explicit management goals within MDP policy for habitat connectivity. For example, determine the key areas between which each municipality wishes to retain or enhance connections. At a minimum, connections should be retained between the 4 main protected areas of the moraine, and their broader regional connections (for example, with the North Saskatchewan River valley) in order to sustain the biodiversity that now exists within these areas, and the rest of the moraine.
- Ensure an appropriate level of protection is provided in MDPs and LUBs for critical habitat:
    - Identify the habitat contiguous with and surrounding protected areas as key conservation areas. Linkage Habitat (Linear Corridors or Stepping Stones) that connects the main protected areas within the moraine (Elk Island National Park, Cooking Lake - Blackfoot Recreation Area, Ministik and Miquelon) to each other, and to other regionally significant core areas outside the moraine should also be identified as key conservation areas. Encourage lower density development in these areas within MDP and LUB policies.
    - Strive for a minimum level of functional connectivity in these key conservation areas through sensitive development (e.g., limiting cleared, developed gaps to a maximum of 100 m), and encouraging restoration of natural habitats and retention of existing natural vegetation. Provide incentives within policy to limit lot clearing or to restore previously cleared areas or degraded, weedy habitat within these areas.
- Consider protecting Linkage Habitats between other smaller Habitat Patches throughout the moraine so that at least a minimum level of functional protection is maintained (e.g., gaps of a maximum 250 m), with a particular focus on those Linkage Habitats separating Core Areas from other smaller Habitat Patches. This could be accomplished through zoning for more permeable types of land use, or by encouraging extension of Linkage Habitat within largely cleared areas, or restoration of narrow, impaired Linkages, such as stream edges as a condition of future development.

- Develop policies that will encourage use of conservation easements to protect Linkage Habitat and large Habitat Patches, particularly where such habitat links or buffers protected areas. Consider development bonuses as an incentive for conservation easements.
- Seek partnerships with ENGO's or conservation land trusts that will manage conservation easements, so that a capable land manager is available for easement lands.
- Establish a policy for habitat retention to address natural vegetation that may not provide a connective or other habitat function, but may still be valued by area residents (e.g., a Tree Policy).

Biodiversity Core Areas

- Establish explicit management goals within MDP policy for the various types of Core Areas identified in this framework. At a minimum, the largest Core Areas should remain unfragmented by development. Ideally, they should be connected to each other, and to the smaller Habitat Patches in the moraine through Linkage Habitat (Linear Corridors and Stepping Stones) and permeable forms of land use. Designating land uses and promoting land management practices that minimize impacts to the Core Areas within the lands adjacent these areas would provide an additional measure of protection for these areas.
- Create explicit policy that prioritizes the types of habitat that should be retained through the planning process and identifies the means for conservation action. At a minimum, portions of the largest Core Areas (i.e., the protected areas) not currently contained within a federally or provincially protected area, and other medium-sized Core Areas and Linkage Habitats associated with the protected areas should be identified as conservation priorities. Identify specific planning tools, including the full range of options permitted under the MGA, to manage these conservation priorities. This could include Environmental Reserves or conservation easements. Consider also, covenants on the land title that would limit the extent of clearing of naturally vegetated lands considered a conservation priority, limit building footprints or provide other development conditions that could manage natural habitat in perpetuity. In the longer term, the municipalities as a group may wish to advocate the application of market based approaches that will encourage more environmentally friendly land management practices within agriculture and other land-using sectors.
- Ensure that locations identified for development in MDP and LUB plans avoid critical habitat areas through the following measures:
    - Define critical natural areas (i.e., Core Areas and Linkage Habitat) in policy and provide some measure of conservation for these areas.
    - Direct future development, particularly intensive forms of development (industrial and commercial land uses, high density residential areas), to already developed areas with supporting infrastructure and less critical habitat.
    - Designate lower density forms of development in areas with abundant greenspace and provide policies that encourage retention of natural vegetation, or restore natural vegetation.

  - Set urban growth boundaries that focus development on lands without critical habitat, or on lands already cleared of natural habitat (e.g., the White LMAs).
  - Relieve development pressures on all natural areas at the urban fringe by promoting infill development and urban redevelopment.
  - Consider developing a Tree Policy that encourages retention of treed habitat for aesthetic purposes, in addition to the protection offered to critical habitat.
  - Consider amendments to MDPs and LUBs for the protection of environmentally sensitive and significant natural areas through the application of a natural areas designation.
- Consider defining a restricted construction period to avoid the critical nesting period for migratory birds, and to avoid possible contravention of the federal *Migratory Birds Convention Act* and the Alberta *Wildlife Act*. Environment Canada and Strathcona County recommend avoiding clearing between 15 April and 31 July. Alberta Sustainable Resource Development promotes a slightly different period (15 April to 15 July). Typically, these timing restrictions recommend avoidance first, but if construction cannot be avoided during that period, they require a survey for nesting birds be completed by a qualified wildlife biologist.

6.0 SUMMARY AND CONCLUSIONS

6.1 Summary

The Beaver Hills Initiative (BHI) has consistently promoted a science-based approach to land use planning and land management, and has worked to provide the information required to support sustainable development in municipal decision-making. The Land Management Area mapping and the accompanying principles developed by the BHI provided guidance for broad level planning, but did not have sufficient detail to be applied directly to planning applications. Part of that difficulty was the LMA mapping itself, which summarized environmentally sensitive features on the landscape, to indicate where several concerns occurred.

In the Land Management Framework, the BHI sought to provide specific guidance and more detailed information describing the natural features in the moraine, identifying for each resources, sites of high management priority. Ideally, this framework would be adopted consistently across all partner municipalities of the BHI. Considering the differences in natural and labor resources, political context and environmental concerns within each municipality, the BHI recognizes that adoption must be at the discretion of each municipality to be successfully implemented. Accordingly, the implementation process proposed for the framework depends on voluntary adoption of the framework, and the ultimate goal of adoption into statutory policy is projected over the long-term.

6.1.1 Ecological Function Zone Mapping

The Ecological Function Zone analysis refined the LMA mapping, identifying for each resource, sites of potential sensitivity within the moraine landscape. This analysis reported only on the status of the resources across the moraine; it did not specifically address the causative factors related to that status. Such work was not within the scope of this study, and indeed, would have been impractical to address at the moraine scale, given the variation of possible causes and site-specific nature required of the assessment. Where further investigation to confirm resource quality and the threats facing those resources would aid in management of a particular area or issue, we recommended additional studies.

Surface water risk was identified at two scales: the parcel level, based on land use and land cover; and the Gross Drainage Area level, a finer subdivision of local watershed sub-basins. High risk areas identified in the analysis highlighted two main factors associated with that risk: the extent of existing and proposed development, and the extent of surface water present in the GDA. In some areas, Cooking Lake being a notable example, surface water covers much of the landbase of the GDA. In such areas, any development must be approached carefully, as a limited landbase contributes run-off to those waterbodies, and in turn, protects their water quality and supply.

Groundwater risk is tied to locations where surface water, coarse soils and groundwater recharge and discharge overlap. Within the moraine, such overlap is common around many of its waterbodies. With the abundance of water within the moraine, wise management would dictate sensitive development near any waterbody; contaminants can spread quickly through water, and the water table is often high near waterbodies - spread to shallow groundwater can occur quickly. Once into groundwater, contaminants can be difficult to remove, and underlying aquifers may be at risk. Other, moderate risk areas associated with recharge and discharge zones and coarse soils are widespread through the area. There is some potential error in this assessment, given the broad scale of the groundwater data, and potential inaccuracies acknowledged within this dataset. Development proponents should confirm groundwater risk through site-specific investigation, and incorporate appropriate mitigation where required.

Landscape connectivity modeling and the core areas analysis confirmed the critical role of the protected areas and the habitat linking them in supporting biodiversity within the moraine. These areas had the largest Key Segments and largest Core Areas within the ecological network of the moraine, and generally have experienced the least fragmentation. As a result, they offer little resistance to movement of our reference animals (deer and coyote) and presumably also other less mobile organisms, particularly through the contiguous Key Segments. The private lands that link these areas also supported habitat, and in some cases were sizable areas. Conserving the Key Segments and Core Areas within the moraine would, for the most part, ensure a continuous linkage between the protected areas, and with other significant habitat in the region (e.g., the North Saskatchewan River valley). These elements of the moraine's Ecological Network should be identified as priorities for conservation in land use planning.

Although habitat patches tend to become smaller and more isolated further away from the protected areas, they still appear capable of supporting connection across the moraine. In particular, the lands east of Hastings Lake provide a relatively wide and contiguous corridor linking the Cooking Lake – Blackfoot Recreation Area and Elk Island National Park with Ministik and Miquelon protected areas. Habitat at the north and south ends of the moraine provides linkage beyond the moraine, to the North Saskatchewan River valley and boreal forests to the north, and south into the parkland. As a result, the moraine provides a critical regional link between these ecoregions and a detour route around more developed and urban areas surrounding the moraine.

6.1.2 Best Management Practices for Sustainable Development

Appropriate best management practices for both site-specific development application review and broader scale planning for MDPs and LUBs are based on sustainable land management practices. Implementation of these practices follows a similar process, regardless of scale:

- Identify specific natural resource concerns within a site or broader area;
- Identify impacts resulting from proposed development or land management likely to disturb, degrade or remove those resources;
- Identify mitigative measures that will reduce the severity of those impacts, either within the design or through specific management actions; and
- Identify monitoring needs to ensure management is successful.

A variety of Best Management Practices appropriate to site-specific development were provided in Chapter 4. In some cases, federal or provincial jurisdiction may also apply, and referral of the proponent to these agencies can ensure due diligence for responsible development in the decision-making process. Many municipalities coordinate this referral process internally, requesting comments on the proposed project from the other jurisdictions as part of an environmental assessment process. In this sense, it can provide the municipality with additional expertise and regulatory advice not available in-house, and the assurance that all potential regulatory authorities are involved in the project. In general, the municipalities had inconsistent referral references in their land use policies. The framework provides a guide to the referrals required under current legislation. These requirements could be easily incorporated into statutory policy to formally recognize the areas of jurisdiction and the supporting role other jurisdictions can provide for sustainable management.

The most effective means to implement the review system outlined above is through an environmental assessment process. Although federal and provincial legislation requires environmental assessment of proposed development, it applies mainly to large projects with potential to impact regional resources. Smaller projects that may affect local resources valued by municipal residents may not be assessed by these agencies, as comprehensive review of such projects is beyond their scope. To address this gap in regulatory attention, several of local municipalities have already adopted their own environmental review processes, either as a condition of development approval (e.g., Leduc County, City of Edmonton) or to inform other planning decisions (e.g., ER, MR and conservation easement dedication, Strathcona County). At the broader policy level, adoption of a consistent environmental assessment process across all municipalities, ideally one that is a pre-condition of development approval, would ensure review for all proposed development within the moraine. Such review would provide an opportunity to incorporate best management practices in the design of the project, or to incorporate additional mitigation to minimize impact. A definition of environment that is consistent with federal and provincial legislation is also a priority, as that would provide the necessary legal basis for broader environmental management within the municipalities.

Managing existing developed lands sustainably requires a different approach. Landowner cooperation and voluntary adoption of sustainable land management practices is the best means of achieving management goals at the landscape level. The alternative of enforcement may be necessary to ensure conformance, but should not be the first choice. Convincing landowners of the need and benefit of sustainable management offers a better chance for long-term success. The variety of partner organizations involved in the BHI provides an important opportunity for municipalities to raise awareness through existing programs, or to propose partnership on new initiatives to deal with specific concerns. Such options are discussed further in the sections below.

6.2 Conclusions

The Ecological Function Zone mapping confirmed, dramatically, the natural capital contained within the Beaver Hills moraine. Greenspace and water are abundant in this area, and highlights the role that those natural features play in sustaining biodiversity and surface and groundwater supply and quality. Conserving biodiversity will involve conservation of the necessary habitat for those species. Such conservation does not mean development cannot occur. It does mean that development must be wisely planned and managed, so that where it is allowed to occur, it is done in the most environmentally-sensitive manner possible.

Conservation of biodiversity is not simply a moral or aesthetic option; indeed it is not an option at all, but a necessity. The ecological goods and services on which we rely, and which support our quality of life, are created and sustained by diverse species that drive a variety of ecological processes. The benefits are several, and essential. Clean air and water, a moderate and stable climate, and abundant water sources have a critical role in our survival, and in our economic well-being. These goods and services cannot be readily or cheaply replaced. Plant and animal species provide food and medicines and degrade waste materials, cleansing waters and soils and regenerating soil fertility. Even for domestic crops and produce, pollination by insects and other animals is responsible for healthy, propagating and productive systems. The intangible benefits of aesthetic and spiritual value of natural areas cannot be tallied in dollars, but has no less importance in the quality of life appreciated by residents and visitors to the Beaver Hills. It is that essential landscape character that the BHI wishes to protect. This framework provides the first step in comprehensive management toward that end. It is a living document that will be updated and modified to incorporate new information and new practices, and in that sense, will provide on-going and adaptive management that will be invaluable to the partner municipalities.

7.0 RECOMMENDATIONS

In the course of preparing this framework, a number of recommendations with broad application became apparent. In this section, we summarize those recommendations applicable to the municipalities and to the BHI.

7.1 Municipalities

7.1.1 General Recommendations

Effecting changes within municipal policy is one option for adopting sustainable management practices. In some cases, change may also be required at the provincial level, to enhance or provide new tools for management. One such area is broadening the definition of environment within the MGA. The current definition focuses mainly on geotechnical and flooding concerns: the potentially negative interactions of the environment on development. A definition of the environment that encompasses not only the specific resources but also the interactions between them, provides a definition comparable to other levels of government. That expanded scope of management sets the stage for a sustainable management approach, because it acknowledges the interactions between resources, which can also be affected by development. Such an expanded definition would allow municipalities to manage resources of local importance, in a manner comparable to the sustainable approach now taken by other levels of government. Importantly, it would also fill a gap not currently addressed by higher levels of government, which necessarily must focus on concerns at the provincial or national scale.

The benefit of a broader definition of the environment would help support another change currently being promoted by municipalities across the province. Presently, under the MGA, the features that can be taken as Environmental Reserve are restricted to environmental limitations to development: geotechnically unstable areas, ‘wet areas’ and floodplain lands. Expanding the definition of Environmental Reserve lands to include natural features that may serve a critical ecological function, such as wetlands on recharge zones, or Core Areas, would provide a legislative tool not currently available to municipal planners.

There are several provincial committees currently examining the need for such changes to the MGA. As partners in an initiative promoting sustainable development, the municipalities and the BHI should take full advantage of this opportunity, and participate in these discussions. Provincially, there is an openness to change in the MGA and in the approach to land use in general that could create the changes necessary to provide more flexibility for the municipality to manage its local resources sustainably.

7.1.2 EFZ-specific Recommendations

Municipalities exercise considerable control over land use through the land use planning process. Controlling existing land management practices is more difficult, as there is no direct, regulatory control, other than enforcement of regulatory requirements, many of which lie outside municipal jurisdiction for natural resources. Municipalities can, however, foster sustainable land management practices through more subtle means:

leading through example, promoting alternatives, and providing incentives. Recommendations relevant to each of the EFZ zones follow in the sections below. While not all of these may be of interest or appropriate for all of the partner municipalities, these options are provided to stimulate discussion and perhaps future consideration, as local circumstances allow.

Air Quality

- Encourage the use of clean energy, such as solar and wind power. If possible, investigate means of incorporating such systems into municipal operations.

Surface Water

- Retain or plant native species adjacent to waterbodies in municipally-owned areas.
- Consider providing grants to landowners who help municipalities achieve watershed goals by restoring lost vegetation buffers and aquatic linkages disturbed by past land management.
- Encourage landscaping using native vegetation in developed areas, particularly drought tolerant species that will require limited water.
- Establish restrictions on activities that have high potential for pollutant discharge in areas draining to wetlands and other waterbodies (Cappiella et al. 2006). This might include pump-out septic systems, water transfer stations). The NRCB has established manure storage guidelines for intensive livestock operations that will apply to those land uses. A reference to those guidelines may be appropriate, if not already included in relevant policies.
- Consider an Aesthetic Herbicide and Pesticide Bylaw to regulate use of these chemicals on landscaped areas, where over-use can result in release to waterbodies through run-off. Review municipal use of these chemicals to minimize use where possible (e.g., naturalized rights-of-ways and parkland may not require chemical treatments).
- Pollutant discharges from existing, older septic systems can impact surface and groundwaters. Such releases, although difficult to identify, are illegal under various provincial and federal legislation (Alberta Environmental Protection and Enhancement Act (AEPEA) and the Canadian Environmental Protection Act and the Fisheries Act). Consider incorporating conditions for redevelopment of existing properties to upgrade existing, non-compliant systems.
- Encourage rural landowners to increase vegetation buffers around waterbodies on their properties to a 30 m *minimum* width.
- Establish erosion and sediment control regulations.
- Implement Off Highway Vehicles Bylaw to protect sensitive watershed areas from OHV use.
- Implement Sewer Use Bylaw to define regulations regarding the discharge of pollutants in a wastewater or stormwater system.
- Monitor surface water users to ensure that quantities withdrawn do not exceed the capacity of the system.

Groundwater

- Rehabilitate degraded floodplains to restore natural vegetation cover and natural water cycles, where possible.
- Identify wetlands that may lie on or near groundwater recharge areas and discourage draining, filling or other disturbance of these wetlands (Beaudry 2006).
- Do not allow activities (land uses or land management) associated with potentially harmful contaminants on or near groundwater recharge or discharge areas (Beaudry 2006).
- Establish restrictions on activities (land uses or land management) that have high potential for pollutant discharge in areas draining to wetlands (Cappiella et al. 2006).
- Encourage replacement of leaking underground storage tanks by tanks that will not corrode.
- Work with the provincial government to assess the quantity of groundwater available in the community.

Habitat Connectivity and Biodiversity Core Areas

- Seek partnerships with ENGO's or conservation land trusts that will manage conservation easements, so that a capable land management system is available for easement lands.
- Consider providing grants to landowners who help municipalities achieve habitat connectivity goals (e.g., through habitat restoration programs).
- Lobby the provincial government for an expanded definition of Environmental Reserve under the MGA to allow areas of significant ecological function (Core Areas, Linkage Habitats) to be retained through the development approval process.
- Enforce weed control bylaws in Core Areas to prevent invasion of these aggressive species and elimination of native species in these critical areas.

7.2 BHI

BHI is well positioned to facilitate and coordinate joint actions that would support the municipalities in implementing the Best Management Practices at a broader scale. For example, the BHI, through its ENGO and government partnerships, could help promote public awareness initiatives addressing specific land management issues of common concern. Priority initiatives should be identified through discussions with the ENGO's and the municipalities and incorporated into annual business plans. Some suggestions arising from this current project, that we would recommend following up immediately include the following:

- Rerun the model with data missing at the time of this assessment, but to be available soon:
    - Updated vegetation data (BHI project),
    - Ag-capture data (PFRA project), and

    - Groundwater recharge-discharge data for Camrose (available through PFRA).
- Confirm surface water quality in those GDAs identified as high risk to test the model outcome, and investigate whether water conditions are approaching some ecological threshold.

Other longer-term initiatives include:

- Establish additional air monitoring stations to monitor ambient air quality.
- Rehabilitate degraded sections of streams.
- Develop an awareness program regarding best management practices for grazing near waterbodies to help protect water quality and abundance (e.g., in conjunction with the provincial Cows and Fish program).
- Work with Ducks Unlimited to identify critical wetland habitats that could be conserved, enhanced or restored, particularly wetland complexes and areas where connectivity with adjacent upland habitat areas could easily be restored (Cappiella et al. 2006).
- Establish a wetland monitoring program that will record the losses or gains in wetlands across the moraine (part of the performance monitoring system).
- Promote agricultural best management practices in conjunction with Environment Canada, PFRA and Alberta Agriculture, Food and Rural Development. This should include crop nutrient management, pest management and irrigation water management. Refer to Agricultural Management Practices for Water Quality Protection for additional resource materials (USEPA 2006).
- Educate and encourage people to improve storm water quality through pollution prevention (see Beaudry 2006).
- Outline special criteria to protect downstream wetlands from storm water runoff (Cappiella et al. 2006).
- Decrease demands for impermeable road infrastructure by promoting public transportation and community walkability.
- Educate the public on water supply and the value of water.
- Facilitate partnerships between municipalities and ENGO's or regional conservation land trusts to ensure land managers are available for easement lands.
- Identify species of management concern to determine appropriate goals for a range of core area sizes.
- Establish monitoring programs for species of management concern to determine appropriate goals for core area size.
- Identify important natural areas and areas for restoration before development pressures grow.

7.3 Framework Next Steps

Initial review of the Framework and a trial implementation during a Planners Workshop highlighted the fact that this is a new approach that will take some time to be effectively incorporated into municipal function. A roll-out of the framework assisted by additional awareness-raising activities and Board discussion, as well as a longer trial period for the

Planners would help fine-tune the Framework to the specific interests and capabilities of the partner municipalities. Accordingly, our recommendations for the next steps of implementation of the Common Land Use/Management Framework include the following:

- Conduct a 3 month trial period during which the Planners would agree to use the framework on current development applications and document their reactions to the Framework's ease of use and application within their specific planning context. At the end of this review period, the BHI Planners Working Group should meet to review those comments and if appropriate, adjust the Framework to address concerns. Key questions to consider might include:
    - Ease of use of the Framework document: What worked? What didn't? Can you see areas for improvement?
    - Applicability of Best Management Practices: What worked? What didn't? Can you see areas for improvement?
    - Incorporation of this process within your standard review process: What worked? What didn't? Can you see areas for improvement?
- Address the concerns raised by BHI Board members regarding the Framework through a facilitated discussion aimed to inform, resolve conflicts and create solutions or alternatives.
- Continue awareness-raising activities within the partner municipalities to address specific concerns with the Framework with individual councils and administrations. This could include merely providing additional support to assist the Planners in using the Framework, or more direct interaction with councilors and staff, where opportunities arise.

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Appendix A. Glossary of Terms Used in This Report

Glossary of Terms Used in This Report

Aquatic organism: Fish, invertebrate animal species and microbial organisms (e.g., bacteria) that reside exclusively in and are dependant on water.

Biophysical Assessment: A form of environmental assessment that focuses on the potential impact to the biophysical features present in or adjacent to the proposed location by a proposed development. Typically such assessments would be applied to smaller developments, where other social and cultural features are assessed through other means, or thought to be negligible. Assessed features would include, but are not limited to geology, landform (terrain), soils, surface and groundwater, vegetation, wildlife, fish and aquatic habitat. Results of the assessment may provide assurance that development follows sustainable practices and significant regulatory issues have been addressed, or it may inform other related permitting processes. For example, Strathcona County uses the Biophysical Assessment process to recommend areas for potential Environmental and Municipal Reserve dedication or Conservation Easements.

Connectivity: The concept of connectivity is used to describe how the spatial arrangement and quality of other elements in the landscape affect the movement of organisms among habitat patches (Merriam 1984, 1991; Taylor et al. 1993; Forman 1995 in Bennett 2003). In an urban context, connective landscapes are described in terms of relatively permeable habitat patches and linkages, separated by a less permeable matrix and barriers.

Core area: A patch of habitat that contains a large, growing sub-population from which species could disperse to other smaller habitat patches, thus contributing to a sustainable population at the landscape scale (Forman 1995). Core areas vary with species, due to species-specific habitat requirements, thus discussion of management of Core Areas must be tied to species of management concern, or indicators representative of a more diverse suite of species.

Corridor: Any space, usually linear in shape, that improves the ability of organisms to move among patches of their habitat (Hilty *et. al 2006)*. Although naturally-vegetated linear strips can also be corridors (Bennett 2002), for this assessment we identified only disturbed grass corridors, primarily transportation rights-of-way (i.e., linear greenspace, such as hedgerows, were not identified as corridors in this assessment).

Ecological Network: A means of achieving connectivity within a landscape through a linked system of habitat suitable for residence and/or movement (patches, linkages and permeable matrix types)(Forman 1995, Hilty *et al*. 2006).

Edge: The portion of an ecosystem near its perimeter, where influences of the surrounding lands prevent development of interior environmental conditions. Instead, the perimeter contains a distinctive species composition or abundance created through a process termed “edge effect” (Forman 1995).

Environment: "Environment" means the components of the Earth, and includes:
(d) land, water and air, including all layers of the atmosphere,
(e) all organic and inorganic matter and living organisms, and
(f) the interacting natural systems that include components referred to in paragraphs (a) and (b). (from the *Canadian Environmental Assessment Act*)

Environmental Assessment: A review of a proposed development to identify and quantify the potential impact on the biophysical, social and/or cultural environment. Where negative impacts may result from the project, the assessment should recommend mitigative measures that will eliminate or minimize those impacts. Such assessments are usually used by government agencies responsible for development approval to determine whether the proposal will result in sustainable development, or will reduce the quality or function of a valued component of the environment. The scope may be adjusted to focus on specific environmental resources of concern to the regulatory agency, or relevant to the type of development. Development permits are usually contingent on approval of these reviews by the regulatory agency, which in turn depends on the extent of environmental impact predicted to result from the project.

Environmental Impact Assessment: A form of environmental assessment applied as a condition of development under statutory legislation. Although these reviews may be conducted at a general or very detailed, comprehensive level, they always consider potential impacts to a broadly defined "environment" that includes biophysical, social and cultural elements. Federal and provincial level EIA processes are legislated under the *Canadian Environmental Assessment Act* and *Alberta Environmental Protection and Enhancement Act*, respectively and apply to larger infrastructure projects. Some municipalities have also adopted EIA processes applicable to specific geographic areas (e.g., Leduc County, the City of Edmonton).

GIS: Geographic Information System, computer software that allows spatial analysis and display of the qualities and characteristics of a landscape.

Habitat: The ecosystem in which a given species lives, or the conditions within that ecosystem that provide resources suitable for a given species (modified from Forman 1995).

Habitat Patch: A relatively homogenous, unfragmented, nonlinear area of habitat that differs from its surroundings (Forman 1995). Within this assessment, habitat patches are all considered capable of sustaining populations of plants and wildlife over the longer term. Such sites included naturally-vegetated lands identified in an inventory by Alberta Sustainable Resource Development, provincial parks and protected areas, which included regionally significant natural areas.

Linkage: Arrangements of vegetated areas that enhance connectivity for species, communities or ecological processes (modified from Bennett 2003). In a developed environment, linkage is typically provided by Stepping Stones or Corridors (defined elsewhere in this glossary). In the context of our assessment, we have considered Stepping Stones and Corridors as distinct forms of linkage habitat.

Landscape: An area (usually large and at a regional scale) where a cluster of local ecosystems is repeated in similar form (Forman 1995). In the context of a developed area such as the Beaver Hills Moraine, the landscape can further be defined as a zone or area perceived by local people or visitors, whose visual features and character are the result of the action of natural and /or cultural (human-influenced) factors (European Landscape Convention, Article 1). In this analysis, we considered the Beaver Hills moraine to comprise a landscape, from an ecological and human perception perspective.

Landscape Character: The recognizable and consistent pattern of natural and cultural elements that differentiate landscapes from each other. Such patterns (for example, in geology, soils, landform, land use, vegetation, field boundaries, settlement patterns and building styles) can be described for landscapes of any scale. Landscape character reflects the combination of biophysical and cultural factors that create a distinct and unique sense of place perceived by local residents and visitors (modified from the European Landscape Character Assessment Initiative, 2005).

Landscape Protection: Measures to preserve the present character and quality of a landscape that is greatly valued because of its distinctive natural or cultural configuration. Such protection must be active and involve maintenance measures to preserve significant features of the landscape (European Landscape Convention, Article 1). Protection in the context of this document includes formal measures to control future land management, either through a change in ownership (e.g., conservation easement, Environmental Reserve) or through implementation of protection by jurisdictions responsible for specific environmental features (e.g., provincial control of surface waters).

Landscape Management: Any measure introduced under the principle of sustainable development, to guide changes brought about by economic, social or environmental necessity. Those measures may be concerned with organization of the landscape (e.g., within a Municipal Development Plan) or its components (e.g., specific planning guidelines). The goal of those measures, however, is to sustain environmental functions and features in the context of development, such that the landscape evolves to meet economic and social needs without disrupting critical ecological processes. Because the underlying ecological processes and societal needs are dynamic, the management approach must also be adaptive, seeking always to improve landscape quality on the basis of the population's expectations (European Landscape Convention, Article 1). Management in the context of this document includes measures implemented on a voluntary or statutory basis that guide activities on developed and undeveloped parts of the moraine landscape.

Landscape Planning: The formal process of study, design and construction, by which landscapes are modified to meet the goals of stakeholders. Deciding which landscapes should be modified to accommodate economic or social needs involves a balance between planning for development, protection and on-going management that is ultimately dependant on the natural character of the area, and the agreed objectives for its future character (European Landscape Convention, Article 1). Planning in the context of this document includes the research and discussion of objectives guiding future development of the moraine.

Matrix: The matrix is the background ecosystem or land use in which habitat patches lie on a landscape (Forman 1995, Hilty et al 2006). The matrix in a developed landscape can be quite complex given the variety of land uses present and is best thought of as comprising a gradient of permeability that can range from very permeable to a complete barrier (Hilty et al 2006). Permeability is related to the quality of the matrix and the distance separating more suitable habitat patches, and is therefore, species-specific. In this assessment, we defined relative permeability of the matrix from the perspective of two large mammals (deer and coyote).

Metapopulation = a population of sub-populations, or a system of local populations (demes) connected by movements of individuals (dispersal) among the population units (Hilty et al 2006).

Minimum Viable Population = population at or above which the probability of extinction is reduced to an acceptable level over a given period of time (Schaffer 1981, Samson 1983, Lemkhul 1984, Gilpin and Soule 1986, Lacy 1993/94, Henriksen 1997).

Natural Capital: The ecological goods and services provided by natural ecosystems, which sustain the ecosystems themselves as well as human populations. Although natural capital can include non-renewable resources such as oil, coal, and minerals; this document focused on renewable resources contained within ecosystems. Those resources are in turn involved in a broad range of ecosystem processes and functions that provide tangible benefits to people, including air quality, climate moderation, maintenance of the water cycle and water quality, waste assimilation, nutrient cycling, soil regeneration, pollination and provision of foods and other useful natural products. Aesthetic and spiritual values are additional intangible benefits associated with natural capital (Folke *et al.* 1994.

Natural Vegetation: Plant species composition and cover comprising predominantly native species not planted by humans. Human impacts and exotic species may be present, but native species are usually dominant (Forman 1995).

Riparian: The lands immediately adjacent a waterbody. Due to high soil moisture, such areas typically have more productive vegetation development and growth, which in turn support abundant and diverse wildlife communities. As the buffer between aquatic and terrestrial ecosystems, they can support other important ecological processes, including water quality protection, groundwater recharge and habitat connectivity.

Restoration: Efforts to restore or re-establish habitat in lands degraded by past land use to improve connectivity or other ecological processes. Restoration can be either passive (relying on succession to replace natural vegetation) or active (planting or managing habitat to restore natural vegetation)(Hilty *et al.* 2006).

Source: A growing or stable population in which reproduction is greater than mortality, such that individuals must disperse to new habitat.

Stepping stone: A vegetated area that may provide resources to sustain an organism for some time, but is generally used as a temporary stop while moving through the matrix toward more suitable habitat patches (modified from Forman 1995). Stepping stones are separated by short gaps from each other, corridors or habitat patches and are most useful for mobile, relatively disturbance-tolerant species (Bennett 2002).

Sustainability: The ability of a site to continue to exist as a vigorous, biologically diverse site that will continue along a natural trajectory of change, regulated by natural process and dominated by native species, even when future conditions on surrounding lands have changed.

Viable Population: A population that will continue to exist and to function naturally so that, over the long term, reproductive rates remain higher than or equal to rates of loss (Salwasser et al 1984, Newmark 1985).

Wildlife: Vertebrate and invertebrate animal species.

Appendix B. BHI Planning Principles for Landscape Management Areas (LMAs)

Beaver Hills Initiative
Statement of Landscape Management Principles

The Beaver Hills is a unique area that is defined by a number of critical ecological aspects. In order to proceed with specific initiatives that support cooperative efforts that lead to a sustainable region, a framework of principles is required that provide guidance for decision making on land use and land management practices. These principles will provide guidance in five areas:

1. Quality of Life
   - Essential Character
   - Property Rights
2. Biodiversity
   - Wetlands
   - Native Upland Habitat and Corridors
   - Species of Concern
3. Water
   - Watersheds
   - Water Quality
4. Land
   - Land Use
5. Air
   - Air Quality

These are proposed statements of principle that serve as guidelines. It is the mandate of Municipalities and other governments to make decisions on land use regulations. The role of the Beaver Hills Initiative is to provide a consistent framework for planning decisions, information and awareness for the public, and a forum for decision makers where issues of mutual concern to be discussed. In our activities, we will endeavor to meet the intent of these principles, recognizing the complexities and realities of this initiative.

1. Quality of Life

Essential character: ***The essential character of the Beaver Hills will be preserved in its natural beauty, clean and unspoiled environment, and quality of life.***

Rationale: The attractiveness of the Beaver Hills to residents and visitors alike is the green rolling hills dotted with small lakes and wetlands harboring an abundance of plants and wildlife. The heavily treed boreal landscape is a distinct change from the surrounding prairies and parklands. It provides an ideal backdrop for those who want to live in a rural setting not far from the amenities of urban life, together with a rich economy built upon industry, agriculture, recreation and tourism, and business services.

It is these essential characteristics of the Beaver Hills that must be preserved for the use and enjoyment of residents and visitors. The broad expanses of green uplands, the wetlands filled with waterfowl and songbirds, the occasional glimpse of a coyote, fox, moose or deer. These cannot continue to exist unless the robust balance of natural systems is sustained amid the demands of a growing and vital metropolitan community. Through the principles of sustainable development, the natural beauty and unique visual landscape of the Beaver Hills will be maintained as our communities and our economy grows.

Objectives:

- To ensure that the principles of sustainable communities are better understood
- To assist residents and visitors to be better stewards of the natural environment.

Property rights: ***We will respect existing land use designations. We will respect the rights and responsibilities of private and public landowners and enlist their voluntary cooperation to manage their lands and the resources of the Beaver Hills in a sustainable manner.***

Rationale: Top-down regulation is rarely effective in managing natural resources within settled areas where the perception is of lost control of one's land and livelihood. Effective natural resource management enlists the assistance of informed, supportive stakeholders to help determine common goals, establish the guidelines for appropriate resource use and finally, implement those guidelines on their lands.

Objectives:

- To use education as our primary tool
- To use methods from the conservation tool box to remove incompatible land uses and land management practices
- To focus attention on clearly deleterious land uses, land management practices, and priority rehabilitation sites
- To cooperate with other levels of government and NGOs to develop tools and incentives to shift or adapt incompatible land use to more appropriate sites

2. Biodiversity

Wetlands: ***Existing natural wetlands and their associated riparian upland margins, will be conserved both in regard to their biodiversity and functional aspects***

Rationale: The knob and kettle terrain of the Beaver Hills captures and holds water in numerous wetlands scattered across the area. Compared to the adjacent plains, a greater amount of precipitation falls within the Beaver Hills, meaning wetland habitat is also more abundant here than in the surrounding lands. In the past, wetlands in the province were actively filled or modified to accommodate other land use. The critical role of wetlands in maintaining water supply, water quality, and biological diversity (including rare and sensitive species) is now better understood and conservation of wetlands has become a provincial priority as part of an overall water management strategy. The recently released provincial Draft Wetland Policy stresses a no-net-loss of wetland habitat: where loss cannot be avoided, habitat must be replaced through wetland compensation or mitigation banking.

Both wetlands and the upland habitat surrounding them are important. The adjacent uplands help filter contaminants from surface water supplying the wetland and provide essential habitat for wetland species (e.g., nesting ducks), among other functions. The lush growth around wetlands and the associated riparian habitat and the activity of constituent wildlife species provide an aesthetic sense of nature readily accessible to and valued by area residents. Including wetlands as a valued resource recognizes not only their abundance and their regional hydrological and ecological roles, but their value to residents as part of the natural quality of life that draws many to the area.

***Objectives**:*

- To assist planners and landowners to have a better understanding of wetland abundance and hydrology in the Beaver Hills
- To ensure that planning in the Beaver Hills will be consistent with the Water Act and proposed Alberta Environment Draft Wetlands Policy, June 2003
- To ensure that processes are in place for monitoring loss of wetlands and changes to biodiversity and function in the individual wetland and cumulative effect over the landscape

Native Upland Habitat and Corridors: ***Development will retain native upland habitat (woodlands and grasslands) prominently featured within the Beaver Hills to maintain the majority of the existing greenspace and its associated biodiversity. Connectivity of habitat will also be retained so that continuous corridors remain within the Beaver Hills and between it and the surrounding region.***

Rationale: The Beaver Hills stand in contrast to the adjacent agriculturally developed plains mainly because of the significant amount of greenspace remaining within the area. The abundance and continuity of woodlands in the Beaver Hills is part of the aesthetic appeal valued by its residents. Those same features provide habitat that support a diverse community of plant and wildlife species valuable to area residents and other Albertans. The isolated pocket of boreal habitat comprising the Beaver Hills is unique for this region, which is dominated by aspen parkland. Most of province's boreal forest and its associated plant and wildlife species are concentrated further north.

The string of municipal, provincial and federally protected areas that runs north-south through the Beaver Hills offers a core area of upland habitat that has experienced relatively little modification for human land use. Although some development has occurred in the lands immediately adjacent to these protected areas, for the most part, activity has focused on the outer edge of the Beaver Hills. Agricultural capability is higher there and cleared croplands are more common in than in the heart of the Beaver Hills. The proximity of the western edge of the Beaver Hills to the larger urban centers of the Edmonton capital region has also favored more dense residential subdivision development.

The relatively less disturbed central areas offer abundant natural habitat that supports not only high species diversity, but more individuals of each species. Larger population size offers protection from mortality caused by chance random events like drought, flooding or poor growing seasons that could drive a species to localized extinction. Larger areas of habitat can support a minimum viable population that remains stable, countering potential sources of mortality.

The distribution of protected lands in a length-wise band through the middle of the Beaver Hills, surrounded by less developed natural areas, facilitates animal movement across the landscape - an important functional feature of viable habitat. Habitat with limited fragmentation, few roads and other barriers to animal use offers secure habitat for animals to move between areas of suitable habitat, providing access to seasonal, breeding and over-wintering habitat, and potential mates, all critical to the long-term survival of species on the landscape.

Objectives:

- To identify key wildlife corridor locations and constraints
- To define location, zoning and land uses in buffer areas that support habitat and mobility
- To ensure that fragmentation and loss of upland habitat does not occur without confirmation that both abundance and continuity of the woodlands valued by residents, wildlife and plants is maintained.

Species of Concern: ***Promote land use and land management activities that will not compromise the ability of rare and sensitive species or species important for human use now present to persist in the Beaver Hills.***

Rationale: The relatively undisturbed natural habitat within the Beaver Hills supports a variety of rare and sensitive species. While many of these species occur on the protected lands, they have also been observed on the adjacent unprotected lands. These species contribute to the overall biodiversity of the area, as many are not found in the surrounding region. Most of these species are at risk due to habitat loss or disturbance of key habitat. Although some are considered rare at the federal or provincial level, others may be locally rare, have declining provincial populations but no official status as rare species, or simply be sensitive to disturbance at some point in their life cycle (e.g., heron breeding colonies, snake hibernacula). Land use decisions must balance the value of conserving these species against the economic gains of development.

The Beaver Hills, as a disjunct pocket of the northern boreal forest, supports species with economic as well as aesthetic and scientific value. Large game, upland game birds and waterfowl are relatively abundant in this area and are hunted recreationally. Sustaining viable populations to support such recreational uses is important to local residents as well as visitors.

Objectives:

- To identify habitat supporting species at risk, locally rare and sensitive species requiring specific management, along with the location, zoning and land uses in buffer lands that offer habitat to species at risk
- To ensure that the planning in the Beaver Hills will be consistent with the Species At Risk Act (SARA), the provincial Wildlife Act, and the status of Alberta species listings describing species at risk provincially.

3. Water

Watersheds: ***Maintain function of local watershed to sustain regional surface and ground water systems***

Rationale: The Beaver Hills play an important link in the local, and possibly also the regional water cycle. The knob and kettle terrain collects surface water and precipitation (about 20% more than that falling on the surrounding plains). In most years, the collected water supplies small streams that flow out onto the surrounding plains and eventually, into the larger river systems. During very wet years, flow from these wetlands floods channels connecting to larger lakes within the Beaver Hills, and helps recharge those water bodies (e.g., Cooking Lake). Other wetlands are groundwater recharge sites, where the accumulated surface water percolates through the underlying sediments into local and regional aquifers. Together, these wetlands form the basis of water supply both within the Beaver Hills area and in the surrounding lands. The BHI recognizes the critical role these wetlands play in the water cycle and seeks to maintain a functional network of wetlands over the entire watershed.

Objectives:

- To ensure that decision-makers have a better understanding of local hydrological function
- To ensure that developments minimize impacts on surface and ground water resources
- To ensure that surface water drainage patterns are maintained to reduce seasonal flooding and encourage longer retention times to retain reliable and clean ground water supplies

Water Quality ***Sustain ability of local watersheds to maintain the water quality of surface and ground water systems***

Rationale: Water quality is important to human residents as well as the various plant and wildlife species found within the Beaver Hills. The abundant surface water bodies in this area provide an important source of water for agricultural and industrial uses; they also support diverse and abundant wetland and riparian communities. Potability of those water sources is just as important as their availability. Excessive sedimentation or contamination by high levels of nutrients, heavy metals or other chemicals can reduce water quality for human use. It also reduces habitat suitability for wetland and riparian plants and wildlife, so that species abandon the area or gradually die off, reducing biodiversity at the regional level.

Alberta's Water for Life policy released in 2003 stresses the importance of water quality to all Albertans, and the vulnerability of our water resources, both groundwater and surface water. Under that policy, provision of 'safe' water for people as well as natural biological communities was identified as a critical priority: a number of action items are to be implemented over the short to long term to maintain sustainable sources of high quality water.

With a role in both local and regional water cycles, the Beaver Hills can impact water quality over a wide area. Maintaining sufficient vegetative buffers to protect water quality, carefully designing developments to minimize the potential contribution of contaminants to water bodies, and managing storm water quality can all help reduce impacts on a local level. Cumulatively, impact can be reduced at the watershed level.

Objectives:

- To ensure that decisions-makers have a better understanding of the potential impact of development on water quality, for both surface water bodies and groundwater sources
- To ensure that the implications of watershed management and all disturbances are evaluated to ensure that water quality of water bodies on or near proposed developments is not negatively impacted
- To ensure that vegetative buffers are retained or restored around water bodies to provide for water quality objectives when evaluating development proposals

4. Land

Land Use: ***Support an appropriate mix of agricultural, industrial, recreational, and residential development in areas with lower environmental sensitivity, maximum potential for sustainable business operations, and maintaining the character of the distinctive landscape.***

Rationale: The Beaver Hills also support a variety of existing agricultural and industrial operations and there is the potential for growth. The area is a favored market for rural residential development. Opportunity for economic development is critical to a healthy regional economy, and for sustainable communities. Wise land use decisions will be necessary to balance growth with conservation of the natural resources that provide the quality of life that local residents value within the Beaver Hills.

Objectives:

- To increase awareness and sensitivity of landowners and potential landowners about the real potential for agricultural use of the Beaver Hills
- To identify and evaluate appropriate zones for industrial and rural residential development within the buffer lands.

5. Air

Air quality ***Industrial growth in the region will maintain the clean air and current air quality valued by Beaver Hills residents***

Rationale: Air quality is important to the residents of the Beaver Hills. The Fort Air Partnership Airshed, which is part of the provincial Clean Air Strategic Alliance, monitors air quality in the Fort Saskatchewan area and plays an active role in encouraging responsible industrial use of the local airshed. The BHI partners will support economic growth that respects the quality of life enjoyed by local residents, including clean air.

Objectives:

- To enhance cooperation with industry
- To conduct further research on relationships between water and air quality

PROPOSED PLANNING PRINCIPLES FOR LANDSCAPE MANAGEMENT AREAS

	PRINCIPLE	GREEN AREA	BLUE AREA	YELLOW AREA	WHITE AREA
DESCRIPTION		***Protected Landscapes***	***Natural Water & Wildlife Linkage Landscapes***	***Country Landscapes***	***Multiple Use Landscapes***
Purpose	*The Beaver Hills Moraine is valued for its natural beauty, quality of life, and supports cooperative efforts to sustain the quality of water, land, air and natural resources and community development.*	➢ Conservation of the most significant natural features ➢ Retention of representative natural habitats in relatively large areas with a reduced human footprint; ➢ Link protected areas together in a relatively continuous band through the BH	➢ Retention or restoration of habitat to complete a network of wildlife corridors connecting the Green Areas and maintaining continuity of surface and ground water hydrology	➢ Management of existing residential, agricultural, recreational, and industrial land uses within the principles of the BHI. ➢ Restoration or replacement of habitat encouraged on an opportunistic basis, particularly where continuity of habitat is a priority	➢ Integration with existing land use within areas surrounding the BH, and with existing natural areas offering linkages with those in the BH including connectivity and opportunities for restoration.
Quality of Life ***Essential Character***	 *The essential character of the Beaver Hills will*	 ➢ Management of landscape	 ➢ Maintain patches of woodlands and	 ➢ Maintain natural areas that provide	 ➢ Subject to existing land use policies

	PRINCIPLE	GREEN AREA	BLUE AREA	YELLOW AREA	WHITE AREA
	be preserved in its natural beauty, clean and unspoiled environment, and quality of life.	components with the objective of maintenance or restoration of the ecological integrity of the area, subject to existing land use regulations applicable in each. ➢ Protected areas include Elk Island National Park, Blackfoot/ Cooking Lake Recreation Area, and Miquelon Lake Provincial Park, Ministik Bird Sanctuary, and Provincial natural Areas.	wetlands that now form linkages between Green Areas, or surrounding them, and support a variety of plant and animal species ➢ Maintain the aesthetic appeal of the distinctive landscape of the Blue Area	the aesthetic feel of abundant greenspace, or if allowed, could return to a more natural state ➢ Maintain the aesthetic appeal of the distinctive landscape of the Yellow Area	with recognition of the Land Management Principles of the BHI
Property Rights	*We will respect and maintain existing land use designations. We will respect the rights and responsibilities of private and public landowners and enlist their voluntary*	➢ Subject to the appropriate management plans for each protected area	➢ Current individual land use practices continue ➢ Incentives for rehabilitation ➢ Some prohibition of existing land	➢ Current individual land use practices continue ➢ Encouragement of environmentally friendly residential,	➢ Raise sensitivity and awareness of environmentally sustainable land use and land management practices

	PRINCIPLE	GREEN AREA	BLUE AREA	YELLOW AREA	WHITE AREA
	cooperation to manage their lands and the resources of the Beaver Hills in a sustainable manner.		uses where deleterious to sustainability ➢ Maintain the distinctive aesthetics of the area ➢ Coordinated land management strategies (e.g., wetland restoration, weed and disease control)	industrial, recreational, and agricultural practices ➢ Maintain the distinctive aesthetics of the area ➢ Future development must be consistent with the Land Management Principles of the BHI	
Biodiversity ***Wetlands***	*Existing natural wetlands and their associated riparian upland margins, will be conserved both in regard to their biodiversity and functional aspects*	➢ Subject to the appropriate management plans for each protected area	➢ Conserve intact wetlands that are critical to the hydrology of the BH ➢ Identify riparian buffer on wetlands to preserve water quality and biodiversity ➢ Abide by	➢ Conserve intact wetlands where possible ➢ Focus development near less critical wetlands ➢ Abide by provincial draft wetland policy (i.e., no-net-loss)	➢ Raise sensitivity and awareness of environmentally sustainable land use and land management practices ➢ Abide by provincial draft wetland policy (no-net-loss)

	PRINCIPLE	GREEN AREA	BLUE AREA	YELLOW AREA	WHITE AREA
			provincial draft wetland policy (i.e., no-net-loss)		
Native Upland Habitat and Corridors	*Development will retain native upland habitat (woodlands and grasslands) prominently featured within the Beaver Hills to maintain the majority of the existing green space and its associated biodiversity. Connectivity of habitat will also be retained so that continuous corridors remain within the Beaver Hills and between it and the surrounding region.*	➢ Subject to the appropriate management plans for each protected area	➢ Maintain existing green spaces that provide habitat and wildlife corridors ➢ Fill in connectivity gaps in wildlife corridors between Green Areas in a band no less than 2 km wide ➢ Focus restoration on fragmented or disturbed habitats that can support healthy natural ecosystems or provide linkages with other habitat in other landscape units on a no-net-loss basis	➢ Focus expanded development on areas most suited to agricultural, industrial, recreational or residential land use ➢ Direct new development to cleared, disturbed, isolated and fragmented areas with infrastructure to support development ➢ Encourage environmentally sustainable development and land management practices	➢ Raise sensitivity and awareness of environmentally sustainable land use and land management practices
Species of Concern	*Promote land use and land management activities that will not compromise the ability*	➢ Subject to the appropriate management plans for each protected	➢ Conserve habitat required by species of concern, or which could	➢ Retain habitat, including fragmented areas that will help	➢ Raise sensitivity and awareness of environmentally sustainable land

	PRINCIPLE	GREEN AREA	BLUE AREA	YELLOW AREA	WHITE AREA
	of rare and sensitive species or species important for human use now present to persist in the Beaver Hills.	area	support adjacent populations of such species	sustain species of concern, on an opportunistic, site-by-site basis ➢ Conserve areas demonstrated to support species of concern ➢ Encourage education, awareness and voluntary action to conserve habitat	use and land management practices
Water ***Watersheds***	*Maintain function of local watershed to sustain regional surface and ground water systems*	➢ Subject to the appropriate management plans for each protected area	➢ Maintain intact watershed features that are critical to the hydrology of the BH ➢ Rehabilitation of disturbed areas that are critical to natural hydrology	➢ Maintain intact watershed features that are critical to the hydrology of the BH	➢ Raise sensitivity and awareness of environmentally sustainable land use and land management practices ➢ Abide by provincial draft wetland policy (no-net-loss) ➢ Link to North Saskatchewan

	PRINCIPLE	GREEN AREA	BLUE AREA	YELLOW AREA	WHITE AREA
					Watershed Alliance
Water Quality	*Sustain ability of local watersheds to maintain the water quality of surface and ground water systems*	➢ Subject to the appropriate management plans for each protected area	• Both wetlands and the riparian buffers surrounding them are managed to protect water quality. • Permitted land uses that incorporate measures to protect water quality of water bodies within and adjacent the property. • Abide by letter and intent of federal and provincial legislation	• Both wetlands and the riparian buffers surrounding them are managed to protect water quality. • Permitted land uses that incorporate measures to protect water quality of water bodies within and adjacent the property. • Abide by letter and intent of federal and provincial legislation	➢ Raise sensitivity and awareness of environmentally sustainable land use and land management practices
Land ***Land Use***	*Support an appropriate mix of agricultural,*	➢ Subject to the appropriate	➢ Continue existing agricultural,	➢ Continue existing agricultural,	➢ Raise sensitivity and awareness of

	PRINCIPLE	GREEN AREA	BLUE AREA	YELLOW AREA	WHITE AREA
	industrial, recreational, and residential development in areas with lower environmental sensitivity, maximum potential for sustainable business operations, and maintaining the character of the distinctive landscape.	management plans for each protected area	residential and industrial land uses that complement the ecological integrity of the adjacent Green Area ➢ Future development should consider minimal impact design ➢ Encourage land use supporting quality of life goals of Blue Area residents	residential, recreational and industrial uses ➢ Focus future development in areas with existing infrastructure, e.g., roads, water & wastewater, schools, etc. ➢ Encourage land use supporting quality of life goals of Yellow Area residents	environmentally sustainable land use and land management practices ➢ Link to existing municipal jurisdictions and cooperative efforts such as the North East Industrial Heartland
Air ***Air Quality***	*Industrial growth in the region will maintain the clean air and current air quality valued by Beaver Hills residents*	➢ Subject to the appropriate management plans for each protected area	➢ Current air quality standards maintained	➢ Current air quality standards maintained	➢ Link to the Fort Air Partnership

APPENDIX C. RIPARIAN BUFFER DISTANCES

Riparian Buffer Distances

Riparian buffers perform a variety of ecological functions. Among the many accepted functions, some of the most commonly recognized include improving water quality, providing wildlife habitat and allowing for wildlife movement. Some functions require wide buffers, while others require relatively narrow buffers. Regardless, there is no universally accepted buffer width recommended for any given function. Instead, recommended buffer widths typically vary between references and agencies. Most of the research agrees that wider buffers are more effective in performing ecological functions. Accordingly, when determining an effective buffer width, it is generally wise to provide the widest buffer possible.

To develop the Landscape Management Areas and Confined Feeding Operation models used in this assessment, we required buffer widths suitable for the intended management goals. For the Land Management Areas analysis, water quality protection, wildlife habitat and wildlife movement were the key management factors. Ideally, a policy would protect sufficient land to provide all three functions. For the Confined Feeding Operation analysis, water quality was the chief concern. Accordingly, a smaller buffer would be appropriate.

We reviewed a variety of references to identify the range of buffer widths recommended for these different ecological functions (Table 1). Based on these data, and the principle that a wider buffer would provide maximum protection, we selected appropriate buffer widths for each model, according to the ecological function of interest. To a certain extent, our decisions were based on the minimum mappable unit – generally speaking, buffers less than 50 m were not distinguishable at the map scales used for this assessment. Accordingly, a 50 m buffer was the minimum unit feasible for these analyses.

Much of the research on wildlife corridors has focused on wilderness areas (e.g., the Bow Valley system in Banff National Park). As a result, the buffer widths recommended by those studies is much wider than would be feasible in a rural environment. We selected a buffer of 200 m for the Landscape Management Area analysis, which represented a compromise between sufficient wildlife habitat and a minimum width for wildlife connectivity. For the Confined Feeding Operation analysis, we selected 50 m as a water quality function buffer, which recognized the 30 to 36 m buffer recommended by most authors, and acknowledged our mapping limitations.

Table C1. Comparison of Recommended Riparian Buffer Widths to Achieve Different Ecological Functions

Ecological Function	Buffer Width*	Description	Reference
Water Quality	30 m	Protect water quality in wetlands by filtering sediment, contaminants, nutrients and pesticides	Fischer et al 2000, Connecticut River Joint Commissions 2000
	36 m	Reduces the concentration of nutrients and microorganisms to acceptable levels in feed lot runoff from summer storms	Young et al 1980
Wildlife Habitat	100 m	Accommodate resident populations of all three locally common amphibian species	Spencer Environmental 2004
	100 m	Provide for increased avian diversity in natural vegetation surrounding wetlands	Fischer et al 2001
	100 m	Provides habitat for wetland and riparian species	Fischer and Fischenich 2000, Alberta Sustainable Resource Development 2001
	10-200 m	Provide habitat for all life stages of wildlife dependent on wetlands or watercourses	Connecticut River Joint Commissions 2000
Wildlife Connectivity	600 m	Minimum corridor width for white-tailed deer	Nelson and Mech 1987 *in* Meffe and Carroll1994
	1000 m+	Corridors several kilometers in width may be necessary for use by large mammal species	Paquet et al 1994

* buffer widths listed are *minimums*; it is widely accepted that wider buffers are more effective

APPENDIX D. MODEL DOCUMENTATION

Surface Water Risk Model

Background

The Surface Water Risk Model is designed to identify the sensitivity of land parcels within Gross Drainage Areas (the smaller drainage systems comprising a watershed sub-basin) to sediments and contaminants potentially introduced by existing development within the Beaver Hills Moraine. Clearing of natural vegetation for development in areas with extensive surface water removes a natural filtration system that can capture and degrade sediments and contaminants before they reach waterbodies. The loss of natural vegetation also exposes the soil to sun, increasing the rate of evapotranspiration, and ultimately, reducing the amount of surface water retained on the landscape.

Where clearing has extended to the edge of wetlands, lakes and stream banks, activities in the cleared areas are separated from the waterbody by only a limited vegetated buffer, which has a correspondingly limited capacity to protect water quality. Certain forms of development not only remove or modify vegetation, they also leave bare soils that can potentially be eroded into waterbodies, or use potential contaminants as part of their operation, which further increases the risk to surface water quality.

In this model, we have assumed that where certain types of development have been extensive relative to the amount of surface water, the risk of contamination is higher. In those cases, natural processes that help protect water quality and quantity may potentially be approaching the limits of sustainability. Further development of operations with high potential for contaminant release may be less suitable in such areas, if water quality and quantity are to be protected.

The model is based on the relative influence of different types of land use and management on water quality and water supply, applied first within the individual parcels, and then summed over each gross drainage areas (GDA) in the Beaver Hills Moraine. The model assigns scores to each form of land use (identified from land use mapping) in terms of positive and negative influence on surface water. The areas of the positive and negative land covers within the GDA are then weighted using the model scores, and standardized by dividing by the area of surface water represented in the GDA. This index represents the proportional contribution of that land cover to overall surface water health relative to water coverage in the GDA. The indices of positive and negative land covers for a given GDA are next summed to derive a single net estimate of the positive and negative land cover impact on surface water within the GDA.

We decided to use the GDA unit as the geographic area for analysis with consideration of proposed future provincial watershed initiatives. The province is moving toward a watershed planning system in which municipalities will be responsible for planning land use on a watershed basis (e.g., by incorporating watershed level management into the MDP process). This analysis method provides the information that the municipalities will need for their planning activities, should that system be implemented.

Dataset Scoring System

Scores reflect the direction and magnitude of a land cover class's potential influence on water quality or water volume retained on the landscape. Each land cover type within the SW Risk Model was scored according to the following system:

Score	Influence
-2	Highly negative
-1	Moderately negative
0	Neutral
1	Moderately positive
2	Highly positive

Data Scoring and Model Mechanics

Within each GDA, the model assigns a score for each land cover type present based on their influence on water quality and supply. These land covers are explicit (i.e., they do not overlap), and, thus, the model is based on reclassification, rather than an additive approach. The land cover data were classified as either Positive or Negative Land Cover Types as outlined in Table D1 below. For each area, a Land Cover Type Index was calculated according to the following formulae:

Positive Land Cover Type Index (PLT) = $(Score_i \times Area_i)$/ GDA Water Area,

where i = positive land cover type.

Negative Land cover Type Index (NLT) = $(Score_i \times Area_i)$/ GDA Water Area,

where i = negative land cover type.

The resulting Land Cover Type Index effectively provided a weighted index representing the contribution of that land cover area to surface water quality, relative to the extent of surface water present in the Gross Drainage Area. These indices were mapped for each land parcel within the moraine, to illustrate site-specific contributions to surface water risk.

The final score used to map risk at the GDA level was calculated as the net Land Cover Index for all land cover types within the GDA:

Final Score = $\sum PLT_i - \sum NLT_j$

Where i = all positive land cover indices within the GDA, and j = all negative land cover indices within the GDA.

Final Mapping

Mapping was provided in two forms:

- Parcel level, showing the Positive and Negative Land Cover Indices for individual parcels of land to show distribution across the moraine, and
- GDA level, the Final Scores within each GDA.

The first map is applicable to assessment of individual land development proposals, while the second is applicable to broader scale planning (e.g., MDP review).

The mapped scores were grouped into 4 classes for the individual parcels and 5 classes for the GDA, based on the distribution of scores. The classes ranged from low to high levels risk to surface water from land-based activities. These risk categories were then color-coded and used to map the relative risk of surface water contamination for the individual parcels and GDAs.

Variable Assumptions

Each land cover category used as a variable in the analysis was scored relative to its potential contribution (positive or negative) to either surface water quality or volume. That scoring was somewhat generalized, given the combined examination of these two aspects of surface water, but the individual scores were based on documented functional relationships of land cover on surface water run-off, soil percolation, contaminant filtering, and evapotranspiration. See the model documentation for the rationale and literature associated with the scoring.

Accurate and current forage and cropland data for the moraine do not currently exist. However, we used the Agricultural land use category identified in GIS land use layer provided by the 5 municipalities to create a layer for this analysis. Built-up areas, NRCAN roads and large waterbodies from the provincial hydrology data layers were erased from the agricultural land use layer to identify potential agricultural lands in crop or forage. Overlays with aerial photographs confirmed that this method had generally identified agricultural lands correctly. This new layer is a surrogate that will be replaced with more accurate data once it is available. PFRA's AG-capture project will be completed in early 2007, and can replace this interim dataset when available.

Land use data were also used to identify the various other land uses considered in this analysis. The original land use data provided by the municipalities were reclassified to identify industrial, country residential, commercial, and urban residential areas. Protected areas considered in the analysis were limited to large provincial protected areas, as the smaller conservation easements tended to overlap and duplicate the wetland and natural vegetation data.

Table D1. Surface Water Risk Model Variables

Land cover Type	Variable	Element	Score	Influence	Datasets	File name
Positive	*Land cover*	Natural vegetation (forest, shrub or grassland)	2	High positive	ASRD Native vegetation	natural_veg.shp
		Protected Areas (where not overlapping native vegetation)	2	High positive	AB Community Development Protected Areas	ena_pa_UTM.shp
		Forage and cropland	1	Moderately positive	New file created for analysis, to be replaced with PFRA Ag-Capture data in 2007	bhi_forage-cropland_final_SW-1.shp
		Rural residential	0	Neutral	Land use zones	Camrose_LU.shp; Lamont_LU.shp; Leduc_LU.shp; Strath_LU.shp; Beaver_LU.shp
Negative		Commercial	-2	High negative	Land use zones	Camrose_LU.shp; Lamont_LU.shp; Leduc_LU.shp; Strath_LU.shp; Beaver_LU.shp
		Industrial	-2	High negative	Land use zones	Camrose_LU.shp; Lamont_LU.shp; Leduc_LU.shp; Strath_LU.shp; Beaver_LU.shp
		Urban residential	-2	High negative	Land use zones	Camrose_LU.shp; Lamont_LU.shp; Leduc_LU.shp; Strath_LU.shp; Beaver_LU.shp
		Developed urban areas	-2	High negative	Built-up areas file (BHI library)	Built_up_Areas_UTM.shp
	Transportation	Roads	-1	Moderate negative	NRCAN Roads	NRCAN_ROADS_project.shp; Park roads.shp
		Rail lines	-2	High negative	NRCAN Roads	NRCAN_ROADS_project.shp
	Water	Hydrology			NRCAN hydrology (1:50K)	hydroline_project.shp; lakes_project.shp; wetlands.shp
		GDA			PFRA GDAs	Watershed_project.shp

Buffers for Roads and Right-of-Ways:
Note: buffers were derived from measurements of typical road widths from aerial photography. Because this analysis is based on the GDA area, and provides an assessment of risk level due to previous development within that broad unit, accurate road and rail widths can be used (i.e., the buffers do not need to be scaled up to ensure they can be displayed).

Variable	Element	Buffer (m)
Transportation	Expressway/ Highway	35
	Ramp	40
	Collector	15
	Local/ Street	20
	Service	20
	Rail Line	25
	Park roads	15
Hydrology	Streams	10

Groundwater Risk Model

Background

The Groundwater Contamination Risk Model was originally designed to identify areas of high sensitivity to water-borne contamination for the Strathcona County MDP review in 2006. The model identifies areas within the Beaver Hills Moraine that may require special management when considering applications for development with high potential for contaminant release, such as industrial development, intensive livestock operations or subdivision septic treatment systems.

The environmental concern with such activities, with respect to groundwater, is the potential for contaminants related to or produced by them to enter groundwater reserves, percolating either through surface water or through permeable soils. The model scored soil texture, surface water sites and groundwater recharge and discharge sites relative to the risk of a contaminant release spreading through that feature and into groundwater. Because these data can overlap in space, this is an additive model. The scores assigned to each feature are summed for all overlapping polygons to produce a final summed score. A higher summed score reflects the overlap of permeable soils, surface water and discharge or recharge zones, where risk of potential contamination would be highest.

Note that this analysis was run previously for the entire BHI area, during the Strathcona MDP analysis. The data presented in this document are those originally created for that project; the model documentation is provided simply as a reference.

Dataset Scoring System

Waterbodies were buffered by 50 m to consider the risk of a release within that zone to enter the waterbody itself. The buffer was slightly wider than the minimum 30 m buffer often recommended as a water quality protection measure (Appendix C), to provide a conservative estimate of the risk zone. All buffer distances used in the analysis are listed in the column beside the variable scores.

After buffering of features, all data were reclassified to reflect the relative permeability of the natural feature to water-borne contaminants. The relative permeability to water was assumed to indicate the potential speed and extent of spread of a contaminant accidentally released at the feature. Scores assigned to the various features followed the range listed below:

Score	Permeability
-2	High permeability
-1	Medium permeability
0	Limited permeability

Data Scoring and Model Mechanics

The Groundwater Contamination Risk Model is additive and, therefore, the scores representing natural resource sensitivity overlapping at any given location were summed to indicate the risk due to simultaneous occurrence of highly permeable features at a given site. The resulting final summed scores were grouped into three classes: low, medium and high sensitivity as follows:

Final Summed Score	Mapped Sensitivity Class
0	Low sensitivity
-1 to -2	Medium sensitivity
-3 or less	High sensitivity

Variable Assumptions

The model assumed that groundwater sensitivity is higher where the surface lands and underlying groundwater are relatively well-connected. A contaminant released to surface water or on porous soils would encounter few barriers to movement. Where such features lie near a discharge or recharge zone, the potential for a contaminant to reach groundwater is likely high.

The model assumes that at least two components must exist within a short distance of each other in order for a contaminant to reach an aquifer: porous soils and groundwater near the ground surface. The presence of waterbodies in addition to these factors further increases the risk, as the groundwater table may be linked directly with the wetland in a discharge or recharge situation. For that reason, we have identified surface water bodies as having higher sensitivity (a lower score), due mainly to the speed at which contaminants could diffuse through water, versus soils. Coarse soils would allow a faster rate of contaminant spread than in more finely textured soils, and these also were considered to be of higher sensitivity (lower score).

Although the direction of groundwater flow at a recharge and discharge location may influence the speed of contaminant spread within these groundwater zones, for the purposes of this assessment, we have assumed that the difference is minor relative to speed of spread through the various soil types and waterbodies. Thus, the juxtaposition of surface water, porous soils and a groundwater recharge or discharge site presents the worst-case scenario for contamination. Where these features overlap, the combined score would be lowest, indicating that risk is highest at that location.

Table D2. Groundwater Contamination Risk Model Variables

Variable	Score	Buffer Distance	Permeability to Contamination	Datasets	File name
Wetlands	-2	50 meters	High permeability	ASRD Native vegetation	wetlands.shp
Hydrology	-2	50 meters	High permeability	NRCAN hydrology (1:50K)	hydroline_project.shp; lakes_project.shp
Groundwater Discharge	-1	None	Medium permeability	PFRA groundwater discharge	Discharge_Select.shp
Groundwater Recharge	-1	None	Medium permeability	PFRA groundwater recharge	Recharge_Select.shp
Groundwater Transition	0	None	Limited permeability	PFRA groundwater transition zone	Transisiton_Select.shp
Fine Soils	0	None	Limited permeability	AGRASID soils	83hsoils_Clip.shp
Moderately Fine Soils	0	None	Limited permeability		
Medium Soils	0	None	Limited permeability		
Moderately Coarse Soils	-1	None	Medium permeability		
Coarse Soils	-2	None	High permeability		
Organic Soils	-1	None	Medium permeability		

Landscape Connectivity Model

Background

Connectivity of habitat in a developed landscape depends on several factors:

- the distribution of **habitat patches** and potential **linkages**,
- the **matrix** in which they are located,
- the 'friction' to movement that organisms face within various parts of the matrix, and
- **barriers** relative to patches and linkages.

Model Objectives

This model identifies those landscape features in the Beaver Hills moraine that would contribute to a connected system. By classifying the landscape in terms of habitat patches, linkages, barriers and the remaining matrix (i.e., the ecological network), we can identify critical components that require management. By rating the degree of resistance to movement by organisms presented by each of those components, we can also map the level of connectivity across that landscape (landscape connectivity). Lastly, by examining the combined areas resulting from habitat patches contiguous with linkages, we can identify the largest segments of the network, where movement would theoretically be unimpeded (key segments). Together, these data identify the most sensitive ecological features within this landscape.

Movement across a landscape by an animal is not random: the choice of a travel route depends on the animal's requirements for security cover to avoid perceived threats (human or predators), and the energy required to negotiate that landscape. These behavioral responses are predictable and species-specific, which allows identification of likely movement paths. Ideally, most species would travel through parts of the landscape offering security cover (i.e., habitat patches, linkages, and permeable forms of matrix) and no barriers. In the best case, habitat patches and linkages would be contiguous. Where less hospitable lands (e.g., sparsely vegetated lands) separate desirable habitat patches, many animals have been shown to adapt their path of travel to avoid crossing the intervening gap. Reluctance increases with gap width, and so movement at the landscape level is best provided by a densely distributed network of habitat patches and linkages that are “functionally connected” by tolerable gaps. Gap-crossing tolerance varies with the species, and thus, functional connectivity can be said to apply at different scales. Generally, smaller animals that are less mobile or more vulnerable to predators seem to avoid crossing broad gaps. Larger, more mobile species will cross wider gaps, but still have a limit beyond which they will rarely travel. The landscape connectivity model also assessed functional connection, at three different scales (20 m, 100 m and 250 m gaps).

Plants also require connected habitat in order to propagate across the landscape. Plant seeds are carried by wildlife in some cases, and by wind. Ensuring that wildlife connectivity is maintained within a landscape will also help sustain those species that are carried by wildlife. Wind-borne seed dispersal is less readily modeled, but is addressed at least partially through the various scales of functional connectivity. As gap distance increases, fewer species are likely to be dispersed to adjacent habitat.

In essence, the connectivity model examines two different types of connection: structural connection and functional connection. Structurally connected habitat is contiguous naturally vegetated habitat that would provide security cover and potential resources to animals as they move through the area. Functionally connected habitats are those separated by a gap that an animal will attempt to cross in most cases. For this analysis, we examined three different scales of connectivity, which would support movement of a progressively smaller suite of animals. Both structural and functional connectivity are important to land managers. Areas where structural connection exists and creates large areas of accessible habitat are critical for sustainability of a diverse plant and animal community. Functional connections may link adjacent, large areas, further enhancing the sustainability of biologically diverse communities on the landscape. The mapping resulting from these two analyses will allow planners to identify critical linkages within the BH moraine that will help sustain its biodiversity.

The analysis focuses on native habitat rather than human-modified habitats such as agricultural areas. Native habitat tends to support higher biodiversity, and therefore, best provides the means to address the BHI principle of conservation of biodiversity.

Dataset Scoring System

Scores reflecting the direction and magnitude of friction associated with each land use/cover element within the connectivity model are listed in the column beside the model element in Table D3. Individual friction scores reflect the degree to which a forest-dwelling animal would perceive a given feature as facilitating or resisting movement, as outlined below:

Score	Friction Level
-2	High
-1	Moderately high
0	Moderate
1	Moderately low
2	Low

We selected deer and coyote as representative forest-dwelling species to score the various landscape features. These species offered several advantages for this modeling exercise. First, they both have large home ranges and must move through the landscape to access suitable habitat on a daily basis. Suitable habitat includes, for at least some life requirements, woodland habitat. Their movement habitat requirements and preferences are relatively well-studied, and although they will cross open areas, they prefer to move through forested lands offering security cover.

Data Scoring and Model Mechanics

As mentioned above, connectivity reflects the ease of potential travel over terrain, and the spatial distribution of vegetative cover that provides security cover and possible habitat. Terrain in the Beaver Hills moraine is rolling to undulating and lacks steeply sloped areas that would discourage movement. Accordingly, the model identified habitat that would facilitate movement (**linkages**) between **habitat patches** with sufficient resources to sustain plants or wildlife for some time. Habitat patches are considered to have minimal resistance to movement, and so have the highest, positive scores. Linkages may not be as permeable, due to human use or narrow width, and had scores of variable magnitude, but were still positive. The land use of the m**atrix** also had varied potential friction, ranging from positive to negative values. Differences were dependant on the degree to which natural vegetation might be retained in the land use zone, the level of human use and the extent of infrastructure development within such areas. B**arriers** **(**roads and rail lines**)** had negative or neutral scores that ranged in magnitude according to their width and the volume and frequency of traffic, which in turn determine the extent of deterrence to animal movement.

Landscape Connectivity – Structure and Friction

The model first classifies data contributing to each of the connected landscape elements (patches, linkages, matrix and barriers) to identify where they occur on the landscape (Table D3). Those elements are mapped to illustrate where habitat patches and linkages are structurally connected. The connected elements of the landscape represent the backbone of the ecological network - the main routes linking habitat inside and potentially, outside the moraine. The longest of those connected segments are identified as part of a separate analysis, to locate the key areas of connection within the network.

Next, the relative degree of friction presented by those features is assigned as outlined in Table D3 and summed to provide a total (additive) score reflecting the level of connectivity of all overlapping landscape features. The total scores are then mapped to illustrate landscape connectivity. Friction in this model reflects the degree to which a forest-dwelling animal would perceive a given feature as facilitating or resisting movement. Our hypothetical animal will chose to avoid crossing lands with high friction levels, but may cross other areas with a smaller or more positive friction level.

Functional Connectivity

Lastly, the proximity of the connected elements to each other was considered in the functional connectivity analysis. The functional connection analysis describes the frequency of movement likely to occur between clusters of habitat and linkages: as separation increases, movements between habitat patches would be less. Where such connectivity exists among densely distributed habitat patches, the clustered habitat may be able to support higher levels of biodiversity than in more isolated patches in the ecological network.

The functional connectivity analysis identified connected habitat at 3 spatial scales corresponding to the gap crossing tolerance for mice (20 m), songbirds and deer (100 m), and a theoretical maximum gap crossing distance of 2.5 times that for deer (250 m) (see Table D4 for variables and buffers used in the analysis). Mapping of these results identified key areas of clustered patches and small gaps where connectivity might be improved. The three scales of connection were stated as functional classes, as follows:

- Good Connected Habitat = 20 m gaps separation
- Fair Functional Connected Habitat = 100 m gap separation
- Poor Functional Connected Habitat = 250 m gap separation

Variable Scoring Assumptions

ROWs were all assumed to be moderately effective as a linkage due to limited tree cover and other use for transportation.

Patches and Linkage Connections: Connected habitat can be considered in terms of structural and functional connections. Contiguous patches and linkages are structurally connected. Patches and linkages separated by 20 m or less were assumed to have a Good Functional Connection (i.e., the small gap was not sufficient to isolate the patches/linkages for most animals, Rudd et al 2002). Larger gaps discourage some animals from crossing: 100 m is an effective limit for large animals like deer to cross open areas (Thomas et al 1979, DeNicola et al 2000, Gehring and Swihart 2002). Smaller animals such as birds and amphibians tend to avoid gaps wider than 50 m (Roberts and Lewin 1979, St. Clair et al 1998, Rothermel and Semlitsch 2002, St. Clair 2003). The Fair Functional Connection class identifies the patches and linkages separated by gaps between 20 m and 100m; those clusters of suitable habitat accessible to many of the medium to larger species found in the moraine. For mapping purposes, we combined both scales of gap tolerance within this category, as separate 50 m and 100 m gaps would not be distinguishable on a map of the moraine.

Gaps of more than 100 m, and up to 250 m (2.5 times the average gap tolerance for deer and other large animals), would have Poor Functional Connection. Gaps wider than 250 m would effectively represent a barrier to movement that would be crossed by smaller animals infrequently (e.g., by dispersing or migrating animals that will travel longer distances than under normal circumstances), or only occasionally by larger animals.

Matrix of Land Use: We assumed that the more intensive the land use, the higher the level of resistance to movement through that matrix. Rural residential lands tend to be more extensively landscaped and thus offer moderate levels of friction to movement. Habitat alienation due to human activity will still influence animal use of these areas, another factor contributing to the moderate score for this landscape class. Rural recreational facilities are also often more landscaped than other intensively developed lands, and were given a moderate connectivity score based on that, and habitat alienation potential. Industrial, commercial and urban residential lands, in contrast, tend to support more infrastructure, more open space and more human activity that may deter animals from moving through them. Agricultural lands fall between these more intensive land uses and the less developed land uses. Although human activity is typically lower than in more developed areas, vegetative cover is typically also limited, providing little security cover.

Roads: Traffic and road width have both been found to influence road crossing behavior of animals ranging from deer to amphibians and birds. Generally, smaller roads are crossed more easily, and larger highways are almost a complete barrier for most species. Although the right-of-way is converted to non-vegetated (or non-naturally vegetated) cover, and trains travel at speeds that would cause mortality to crossing animals, trains are generally much less frequent than road traffic. As a result, rail lines were assumed to act as only a moderate barrier.

Dataset Manipulation

Land use datasets of each municipality were reclassified into the broad land use categories indicated above.

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Table D3. Landscape Connectivity Model Variables

Connection Component Type	Variable	Element	Score	Friction Level	Buffer (m)	Datasets	File name
Habitat Patch	*Vegetation*	All native vegetation	3	Low		ASRD Native vegetation	natural_veg.shp
	Protected Areas	Federal or provincial protected area or ER/MR/CE	3	Low		AB Community Development Protected Areas + Municipal and ENGO conservation data	ena_pa_UTM.shp
	Wetlands	wetlands	3	Low		NRCAN hydrology	wetlands.shp
Linkage	*Road Rights of Way*	Expressway/ Highway	0	Moderate	50	NRCAN Roads	NRCAN_ROADS_project.shp; Park roads.shp
		Ramp	0	Moderate	50		
		Collector	0	Moderate	50		
		Local/ Street	1	Moderately Low	35		
		Service	1	Moderately Low	35		
		Park Roads	1	Moderately Low	35		
		Rail Line	1	Moderately Low	35		
Matrix	*Land Use Zones*	Commercial	-2	High		Municipal Land Use Zoning for all 5 partner municipalities	Camrose_LU.shp; Lamont_LU.shp; Leduc_LU.shp; Strath_LU.shp; Beaver_LU.shp
		Industrial	-2	High			
		Agricultural	-1	Moderately High			
		Rural Residential	0	Moderate			
		Rural Recreation	1	Moderately Low			
		Urban Residential	-2	High			
		Conservation	3	Low			
Barriers	*Roads*	Highway/Freeway	-2	High	20	NRCAN Roads	NRCAN_ROADS_project.shp; Park roads.shp
		Ramp	-1	Moderately High	20		
		Collector	-1	Moderately High	10		
		Local/Street	0	Moderate	5		
		Service	0	Moderate	5		
		Park Roads	-1	Moderately High	15		
		Rail Line	0	Moderate	5		
Hydrology	*Large Waterbodies*	Rivers, lakes	-2	High		NRCAN hydrology (1:50K)	hydroline_project.shp; lakes_project.shp
	Streams	Streams	-1	Moderately High	10		

Table D4. Functional Connectivity Analysis

Connection Component Type	Variable	Element	Datasets
Functional Connectivity Analysis	*Good Functional Connection*	Gaps of <=20 m b/n patches/linkages	Patch and Linkage layers created above, with roads and negative matrices erased from functional connections
	Fair Functional Connection	Gaps of >20 m, but <100 m between patches/linkages	
	Poor Functional Connection - Poor	Gaps of > 100 m or <250 m between patches/linkages	

Buffers for Roads and Right-of-Ways

Connection Component Type	Element	Buffer Distance (m)	Rationale
Linkage	Expressway/ Highway	50	Average ROW (and adjacent lands)
	Ramp	50	
	Collector	50	
	Local/ Street	35	
	Service	35	
	Rail Line	35	
	Park roads	35	
Barrier	Highway/Freeway	20	Typical lane width
	Arterial	20	
	Ramp	20	
	Collector	10	
	Local/Street	5	
	Service	5	
	Rail line	5	
	Park roads	10	
Hydrology	Streams	10	Must buffer as this is a line feature, as data is not in polygon form

BHI Core Area Assessment

Background

Biodiversity plays a critical in many ecosystem processes, and as a result, is responsible for the ecological goods and services on which human populations rely (Hilty et al. 2006). Water quality, soil fertility, air quality, climate moderation, pollination and the range of plant and animals that are used as foods and medicines provide tangible benefits of biodiverse, functional ecosystems. The spiritual and aesthetic value of healthy, functional and biodiverse natural systems are an intangible, but no less valuable benefit. Protecting biodiversity and managing landscapes (even developed ones) to sustain the highest level of biodiversity possible is not simply an ethical matter: our quality of life and in the extreme, our survival, depends on it.

Biodiversity centers on several fundamental ecological factors: a sustainable metapopulation, genetic flow and redundancy. Core Areas provide the one of the means to maximize the value of those fundamental factors, and ultimately, ensure a well-functioning ecological landscape. Core Areas are larger patches of habitat that can support high biodiversity and abundance of species, and whose populations are growing or stable (Forman 1995). As a result, they can serve as a source to repopulate areas more susceptible to local extinction (generally smaller, more fragmented areas). When distributed at several locations across a connected landscape, these areas can provide genetic flow, help sustain populations across the landscape, and through that, ensure that ecological processes continue to function throughout that landscape. The relationship between Core Areas and the fundamental ecological factors, and the relevance of that relationship to the Beaver Hills moraine is summarized in the sections below.

Role of Metapopulation, Genetic Flow and Redundancy in Conserving Biodiversity

The metapopulation is a key concept in discussions on biodiversity conservation. Simply put, the metapopulation is the collection of smaller populations of a species across a landscape. For a species to be sustained within a given area, the metapopulation must be sufficiently large to persist through stochastic changes in size of its constituent populations (Meffe and Carroll 1997, Akçakaya *et al.* 1999, Hilty *et al.* 2006). Population size is not static and typically fluctuates over time (Akçakaya *et al.* 1999). There may be periods of high mortality due to unpredictable climatic conditions, food shortages or other disturbances. Small populations do not have the capacity to recover from such downturns, and very small populations run the risk of local extinction (Meffe and Carroll 1997, Akçakaya *et al.* 1999, Hilty *et al.* 2006). To sustain a species across a landscape, the metapopulation must be sufficiently large to persist through and recover from stochastic events that cause higher than normal mortality.

Although substantial populations provide a good buffer against stochastic events and associated mortality, genetic flow among the populations must also be maintained to ensure that populations continue to adapt through evolutionary change (Meffe and Carroll 1997, Hilty *et* al. 2006). Genetic flow, in this sense, provides the resilience required for the metapopulation to compensate for a dynamic environment, in which resource availability and environmental conditions continually change.

Within ecology, redundancy is considered one of the chief means by which species, ecosystems and ecological processes are sustained (Hilty *et al.* 2006). Although the understanding of ecological processes is still incomplete in many cases, in those systems that have been well-studied, several species often perform similar roles. That overlap provides assurance that the processes will continue to function, despite some subtle changes, provided the essential elements remain. The difficulty, of course, is that we often do not know which species or elements are essential. As a result, conservation managers now attempt to conserve as diverse an array of functional, intact habitat areas as possible.

Habitat at the landscape scale is rarely contiguous and populations comprising a metapopulation reside in smaller patches within a matrix of varied permeability (and connection). Because the smaller populations reside in habitat patches, the patches themselves can be used to represent the populations comprising the metapopulation. Generally, the size of a habitat patch indicates the number of individuals of a given species that can be sustained within them: larger patches tend to support more abundant populations and higher biodiversity (Meffe and Carroll 1997, Hilty *et al.* 2006). To maintain genetic flow among the populations in these habitat patches, individuals must be able to negotiate the intervening matrix to access other habitat. To provide redundancy, replicate ecosystems (habitat patches) should be distributed across the landscape. The extent to which the landscape is connected was addressed in the Landscape Connectivity Model. The Core Area analysis focuses instead on the size of habitat patches within the moraine, the abundance of large habitat patches and their distribution across the landscape. Distribution of the larger patches relative to each other, and to other smaller patches, indicates the accessibility of the core areas, and their capacity to bolster smaller populations across that landscape.

Core Areas

For the purpose of this analysis, we defined core areas as patches of contiguous native woodland, grassland and wetland habitats large enough to support both interior and edge species. Although agricultural areas may also support wildlife species, the moraine's natural habitats, and particularly patches containing a variety of habitat types, will have much higher biodiversity. Our analysis also assumes the moraine is an ecologically distinct area with better connectivity within its boundaries than with other natural features beyond the moraine (i.e., the populations in the habitat patches within the moraine function as a metapopulation). Because the moraine contains several large protected areas, it was reasonable to expect that the protected areas and possibly other contiguous natural habitat could serve as core areas. The question is, what other core areas may exist, and what level of biodiversity might they (and the protected areas) support?

Core areas ideally would be large enough to support a minimum viable population for a given species (the population size sufficient to persist through periodic population declines caused by unexpected events). For many species, an effective (breeding) population of 50 individuals appears to allow a species to persist in the short term; 500 to 5000 individuals provide long term persistence (Franklin 1980, Soule 1980, Shaffer 1981, 1983; Samson 1983, Brussard 1985, Samson et al 1985, Lande 1987, Berger 1990, Thomas 1990, Henriksen 1997, Belovsky et al 1999; reviewed by Snaith and Beazley 2002). In this analysis, we compared the size of habitat patches (contiguous native habitat, comprising combinations of native woodlands, grasslands and wetlands) in the moraine to the area required for a minimum viable population of 500 individuals for selected species (the Minimum Critical Area, Snaith and Beasley (2002)). In this way, we could identify habitat patches likely to support a given species, and others with similar habitat requirements.

Given the differences in range requirements among species, the area required to support a minimum viable population would vary depending on the species of interest. For this assessment, we selected a group of umbrella species representing a range of territory/home range size requirements. The assessment assumed that the habitat area required by a given umbrella species would also satisfy a suite of other species with similar habitat and area requirements. These "umbrella species" thus represent the level of biodiversity that can be sustained within the habitat available in a given landscape. The species requiring the largest area would, by default, also sustain viable populations of species with smaller area requirements, and thus indicate areas with the highest level of biodiversity.

Analysis Objectives

The Core Areas Analysis was designed to identify habitat patches sufficiently large to sustain a range of levels of biodiversity and species abundance, and which could then sustain other adjacent habitat patches. This assessment used as umbrella species those that require native woodlands and wetlands for a significant part of their life history. Some of them may also use native grasslands and agricultural lands to some extent, but would not use those areas exclusively. This focused the assessment on native habitat, a key aspect of biodiversity implied within the BHI principles.

Umbrella Species Selection

In addition to representing a range of area requirements indicative of certain levels of biodiversity, we applied several additional criteria to selecting umbrella species for this analysis:

- relatively common distribution within the moraine,
- well documented habitat and life history requirements;
- availability of density or territory size data from the same ecoregion and ideally, the BH moraine area; and
- relatively abundant populations within the BH moraine.

Where possible, we used keystone species, those species known to regulate a broad plant and wildlife community, provided they met the other criteria. We also tried to include species of public concern or interest, to allow the assessment to be more readily understood and accepted by the public. Based on these criteria, we selected the umbrella species in Table D5 for our analysis, and calculated a Minimum Critical Area based on their documented density or territory size (see density sources provided below).

Moose, white-tailed deer, and mule deer are common throughout the moraine, and elk also occur across the area, although at lower density. Coyotes are the largest predator and are also common throughout the moraine. Together, these species have the largest home range size of the suite of species regularly occurring in the BH moraine, and thus would require the largest Core Area to sustain their minimum viable populations. The Minimum Critical Area required for moose, deer and coyote, as the most common of these species, set the upper limit (representing high biodiversity) for the core area analysis.

We selected several other species with smaller area requirements as additional umbrellas species representing moderate and low levels of biodiversity. Unlike the species representing high biodiversity, these other species depend primarily on woodland or wetland habitat, and would typically remain entirely within such habitat patches, except during migration or dispersal.

Where possible, we used density data from Elk Island National Park (EINP) and the Cooking Lake - Blackfoot Recreation Area. EINP is the largest protected area in the BH moraine and supports a variety of large mammal species including moose, deer, elk, and bison and a variety of medium sized carnivores, including coyote. The park is entirely fenced, however, and most of these large ungulates are confined to the park area. The Cooking Lake-Blackfoot Recreation Area is also fenced, and supports the same large mammal species as EINP, except bison. Ungulate populations in both parks are managed to maintain them within ecological capacity of the landbase, and thus, are likely representative of the rest of the moraine. More importantly, both parks conduct annual censuses of their wildlife populations, which provided local and recent estimates of population densities for the analysis.

Data Scoring and Model Mechanics

The Minimum Critical Area for each umbrella species was derived from the density (animals per unit area) or home range/territory requirement of the species. For some animals, individual territory/home ranges can overlap, so in these cases, density is the better estimate of the required area (Snaith and Beazley 2002). The Minimum Critical Areas of those umbrella species were next averaged to provide a single value representative of Low, Moderate and High Biodiversity patch areas.

Habitat Patches larger than the Average Minimum Critical Area for a given level of biodiversity were identified as Core Areas for that level of biodiversity (see Table 4 for Minimum Critical Areas and Table 5 for data variables used in the analysis). The High Biodiversity Core Areas are those most likely to contain most diverse populations of woodland/wetland dependant species. Moderately Biodiverse Core Areas would contain small and medium-sized species, and Low Biodiversity Core Areas would support only those species with smaller area requirements. Ideally, these areas would also support growing populations. Because we do not have population statistics for these specific areas in most cases, we do not know if these species are increasing (reproduction outweighs mortality). The analysis assumes only that based on area, these sites could provide a source population for other, adjacent habitat patches.

All types of Core Areas are identified in the final mapped output of the connectivity model (the Ecological Network). Together, the Core Areas and other elements of a connected system comprise the 'backbone' of the BH moraine, those components most critical to the ecological function of the entire area.

Umbrella Density References

Coyote:

- Pruss, S.D. 2002. Reported coyote densities of between 0.87 and 1.05 coyotes/sq km

Ungulates:

- EINP aerial survey spring 2006: Moose 321 animals/196 km^2 = 1.64 moose/km^2; Deer = 0.93 deer/km^2
- Moose density elsewhere: AB Parkland Region, 1996 surveys average density of 0.18 moose/km^2, Rochester (ctrl AB) =0.64 moose/km^2
- Moose density used for analysis = average of Ctrl AB Parkland (0.18/km^2) and current EINP density (1.64 /km^2) = 0.91/km^2. EINP density is apparently quite high, and with no hunting or predators, it would not be consistent with typical populations. The Central Parkland data likely represents a landscape most consistent with the Beaver Hills moraine.

Beaver:

- EINP has conducted annual surveys to estimate beaver populations within the park since the 1950s. The 2005 data indicate a stable to declining population, at lower density than in past years due to drought and prescribed fire (G. Hood, EINP). This data may be similar to density in the surrounding agricultural lands, which have also been subject to drought.
- 153 active lodges in EINP (194 sq. km), each lodge typically supports 6 individuals, for a total estimate of 918 beaver in the park, or 4.73 beaver/km^2.
- Blackfoot – Cooking Lake conducted a beaver occupancy survey in the fall of 2006, which found 249 lodges within the 94 km^2 protected area (G. Hood, EINP). Based on the same average lodge occupancy, the park likely supports about 1494 beaver, or 15.9 beaver/km^2.
- Given the broad range of densities within the moraine, we used the average of these two current population estimates in our assessment (10.3 beaver/km^2).

Great horned owl:

- Data from EINP point count survey data collected between 2000 through 2004. Average density over that period was 0.01/ha, or 1 bird/km^2.

Yellow warbler:

- Data from Forrest (2001) study of breeding bird densities in Edmonton's river valley parks. Density in that study was 0.54/ha, or 156.4/km^2.

Red-backed vole:

- Data for local densities of red-backed vole were not available. Westworth et al. (1984) and Boutin et al (1996) both reported densities of 20 voles/ha in aspen forest of Alberta and the Yukon (respectively)

Porcupine:

- Banfield (1974) reported densities ranging from 7.7-10.8/km^2 in Maine and 2.3-3.0/km^2 in New Brunswick. More recent or local data was not available; however this species represents a common animal of the moraine, known to be abundant in EINP and the Blackfoot.
- We used the lower density estimate from Maine for the purposes of this analysis, although its accuracy for our area is less certain than others in our analysis.

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Table D5. Minimum Critical Areas Required by the Selected Core Area Analysis Umbrella Species

Core Area Type	Umbrella Species	Density/ Territory Size	Minimum Critical Area Required (sq. km.)	Level of Biodiversity Implied	Area Requirement Source	Rationale for Umbrella Species
Lower Biodiversity	Red-backed vole	20 voles/ha (200 voles/sq. km)	2.5	Low	Westworth et al (1984) and Boutin et al (1996)	Common woodland rodent, represents smallest level of mammalian biodiversity.
	Yellow warbler	156.4 birds/sq. km	3.2	Low	EINP 2000-2004 Roadside Count data	Common woodland species; density data available from EINP
		Average	***2.85***			
Moderate Biodiversity	Porcupine	7 porcupine/sq. km.	71	Moderate	Banfield (1974) published densities in North America	Common species in EINP and Blackfoot, dependant on woodlands for winter habitat, representative of mid-range area requirement
	Beaver	10.3 beavers/ sq. km.	48.5	Moderate	EINP 2005 and Cooking Lake - Blackfoot 2006 beaver census data	Keystone wetland species, densities and population trends known for EINP and can be estimated for outside park
		Average	***59.8***			
High Biodiversity	Great horned owl	1 bird/ sq km	500	High	EINP 2000-2004 Roadside Count data	Woodland specialist; density data available from EINP
	Moose	0.91 moose/sq. km	549	High	EINP 2005 census data	Common species in BH moraine woodland & wetlands; has large home range requirement
	Deer	0.91 moose/sq. km	549	High	EINP 2005 census data	Ubiquitous species found across BH moraine, with large home range size. EINP population can move outside park
	Coyote	0.87 coyotes/ sq. km.	575	High	Pruss(2002)	Common species in BH moraine, uses woodlands for denning and hunting; EINP population contiguous with outside lands
		Average	***543***			

Table D6. Core Area Analysis Variables

Connection Component Type	Variable	Element	Score	Datasets	File name
Habitat Patch	*Vegetation*	All native vegetation	1	ASRD Native vegetation	natural_veg.shp
	Lakes, Rivers and Wetlands	Lakes, manmade, reservoir, river, streams, wetlands	1	NRCAN hydrology	hydroline_project.shp; lakes_project.shp; wetlands.shp

APPENDIX E. Beaver Hills Initiative GIS Analysis Datasets

Data Category	Feature	File Name	Comments	Licensing	Base Map	Analysis	SW Risk Parcels	SW Risk GDA	Landscape Connection	GW Risk Map
Base Features										
Transportation										
	Roads and Railways (for analysis)	NRCAN_ROADS_project.shp		Unlicensed		x	x	x	x	x
	Regional Roads and Railways (for mapping)	rva_nrcan_roads-and-rails_3tm.shp		Unlicensed	x		x	x	x	x
	Major Regional Highways/freeways	nrcan_major_roads_3tm.shp	selected from rva_nrcan_roads-with-rails_3tm.shp	Unlicensed	x		x	x	x	x
	Regional rail lines	nrcan_rails-3tm.shp	selected from rva_nrcan_roads-with-rails_3tm.shp	Unlicensed	x		x	x	x	x
	Park roads	Park roads.shp			x	x	ArcReader	ArcReader	ArcReader	ArcReader
Urban										
	Municipalities	ab_muni_02.shp		Unlicensed	x		x	x	x	x
	Built_up_Areas	Built_up_Areas_UTM.shp		Unlicensed	x	x	x	x	x	x
	Towns	BHI_towns_UTM.shp		Unlicensed	x		ArcReader	ArcReader	ArcReader	ArcReader
Other										
	Beaverhills Moraine	BHMoraine_project.shp		Unlicensed	x	x	x	x	x	x
Quarter Section Fabric	Quarter section boundaries	fab01_bhi.shp	Clipped to BHI area	Unlicensed	x		ArcReader	ArcReader	ArcReader	ArcReader
Biophysical Features										
Soils										
	83hsoils_Clip	83hsoils_Clip.shp		Unlicensed		x				
	agrisoils_Clip	agrisoils_Clip.shp		Unlicensed		x				
	Coarse Soils	ab_soiltext_coarse.shp		Unlicensed		x				
	Moderately Coarse Soils	ab_soiltext_modcoarse.shp		Unlicensed		x				
	Medium Textured Soils	ab_soiltext_medium.shp		Unlicensed		x				
	Moderately Fine Soils	ab_soiltext_modfine.shp		Unlicensed		x				

Data Category	Feature	File Name	Comments	Licensing	Base Map	Analysis	SW Risk Parcels	SW Risk GDA	Landscape Connection	GW Risk Map
	Fine Soils	ab_soiltext_fine.shp		Unlicensed		x				
Vegetation										
	natural_veg	natural_veg.shp		Licensed		x				
Wildlife										
	ANHIC Rare Species	species_risk_Clip.shp				x				
	BHI_Query_Results	BHI_Query_Results.shp				x				
Planning										
Statutory Plans										
	Beaver County Land Use	Beaver_LU.shp		Licensed		x				
	Camrose County Land Use	Camrose_LU.shp		Licensed		x				
	Strathcona County Land Use	Strath_LU.shp		Licensed		x				
	Lamont County Land Use	Lamont_LU.shp		Licensed		x				
	Leduc County land Use	Leduc_LU.shp		Licensed		x				
Significant Natural Areas Inventories										
	Provincial Protected Areas (for analysis)	ena_pa_UTM.shp		Unlicensed		x				
	Provincial Protected Areas (for mapping)	pashape_ocsites_10tm.shp		Unlicensed	x		x	x	x	x
	Ministik Bird Sanctuary (for mapping)	ministik.shp		Unlicensed	x		x	x	x	x
	Camrose County Protected Areas	Camrose_PAs.shp		Project			x		x	x
	Ducks Unlimited projects	duc_proj_project.shp		licensed			x		x	x
	bhi_qtrs	bhi_qtrs_project.shp		licensed			x		x	x

Data Category	Feature	File Name	Comments	Licensing	Base Map	Analysis	SW Risk Parcels	SW Risk GDA	Landscape Connection	GW Risk Map
	Leduc County Protected Areas	LC_Reserves_project.shp		Project			x		x	x
	Strathcona County conservation_easements	STRATH_cons_ease_project.shp		Project			x		x	x
	Strathcona County Environmental_Reserve	STRATH_Enviro_res_project.shp		Project			x		x	x
	Strathcona County ERE	STRATH_ERE_project.shp		Project			x		x	x
	Strathcona County Municipal_Reserve	STRATH_Muni_Res_project.shp		Project			x		x	x
	Strathcona County Restrictive_Covenant	STRATH_Res_Cov_project.shp		Project			x		x	x
	ENGO Protected_Areas	ENGO_Protected_Areas.shp		Project			x		x	x
	NCC Protected Areas	NCC_BHI_project.shp		Project			x		x	x
Water Features										
Surface Water										
	Streams and rivers	hydroline_project.shp		Unlicensed	x	x				
	Streams and rivers	hydroline_clip.shp		Unlicensed	x	x	x	x	x	x
	Streams and rivers	Buffer_of_hydroline_clipSW.shp		Unlicensed		x	x			
	Lakes	lakes_project.shp		Unlicensed	x	x	x	x	x	x
	Wetlands	wetlands.shp		Unlicensed	x	x	ArcReader	ArcReader	ArcReader	ArcReader
Groundwater										
	Discharge_Select	Discharge_Select.shp		Unlicensed		x				
	Recharge_Select	Recharge_Select.shp		Unlicensed		x				
	Transition Select	Transition_Select.shp		Unlicensed		x				

Data Category	Feature	File Name	Comments	Licensing	Base Map	Analysis	SW Risk Parcels	SW Risk GDA	Landscape Connection	GW Risk Map
Watershed										
Watershed	Gross Drainage Area	Watershed_project_SWclip.shp		freeware	x	x	x	x		
Model Analyses										
Surface Water Risk	Surface water risk model output	bhi_sw-1_final.shp		Project			x	x		
Groundwater Contamination Risk	Groundwater contamination risk model output	TBA		Project						x
Connection Model	Landscape connectivity model output	bhi_friction-3_final.shp		Project					x	
Key Segments	Key (largest) segments of contiguous habitat patches and linkages	TBA		Project					X	
Core Areas	High, Moderate and Low Core Ares identified through size analysis	TBA		Project					x	

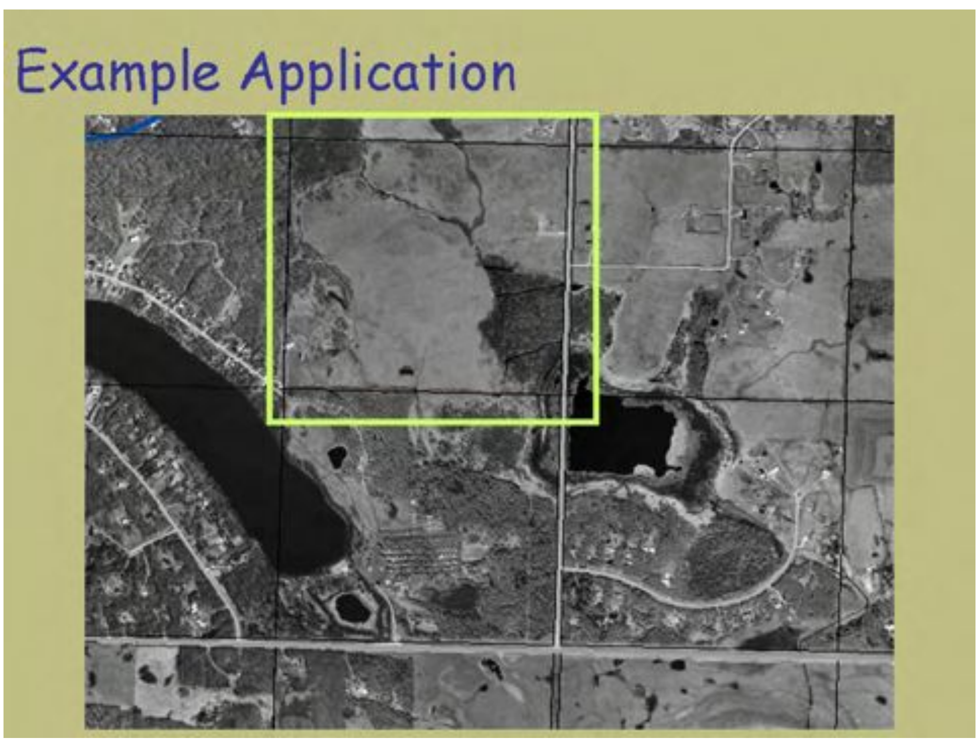
Appendix F. Application of the Environmental BMPs in a Typical Development Scenario

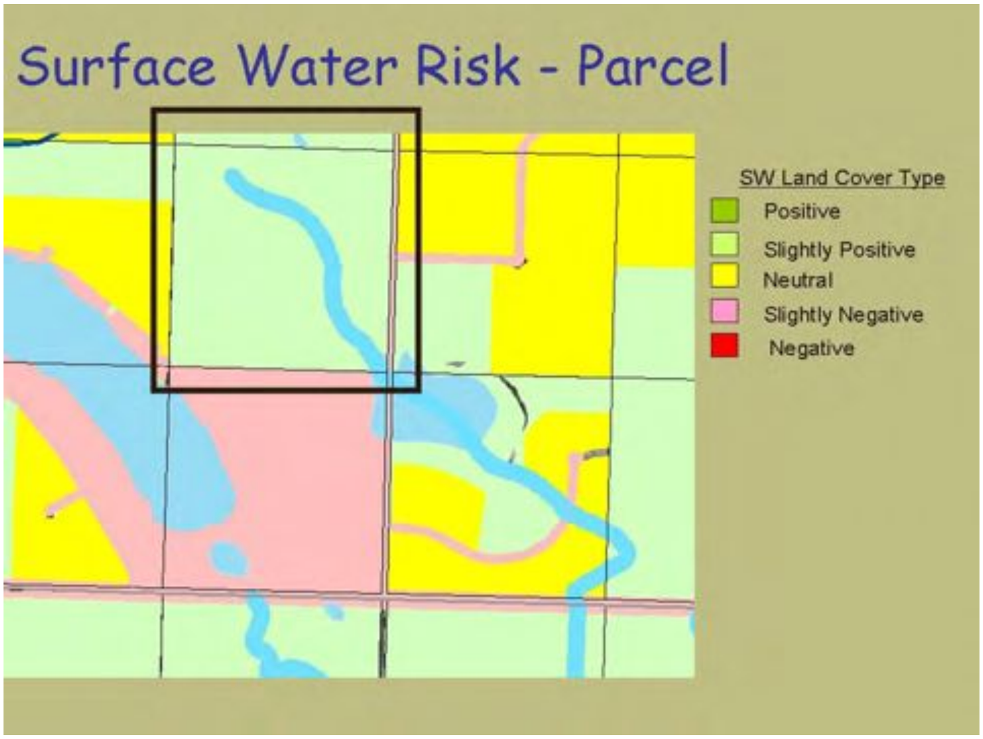
Subdivision Example

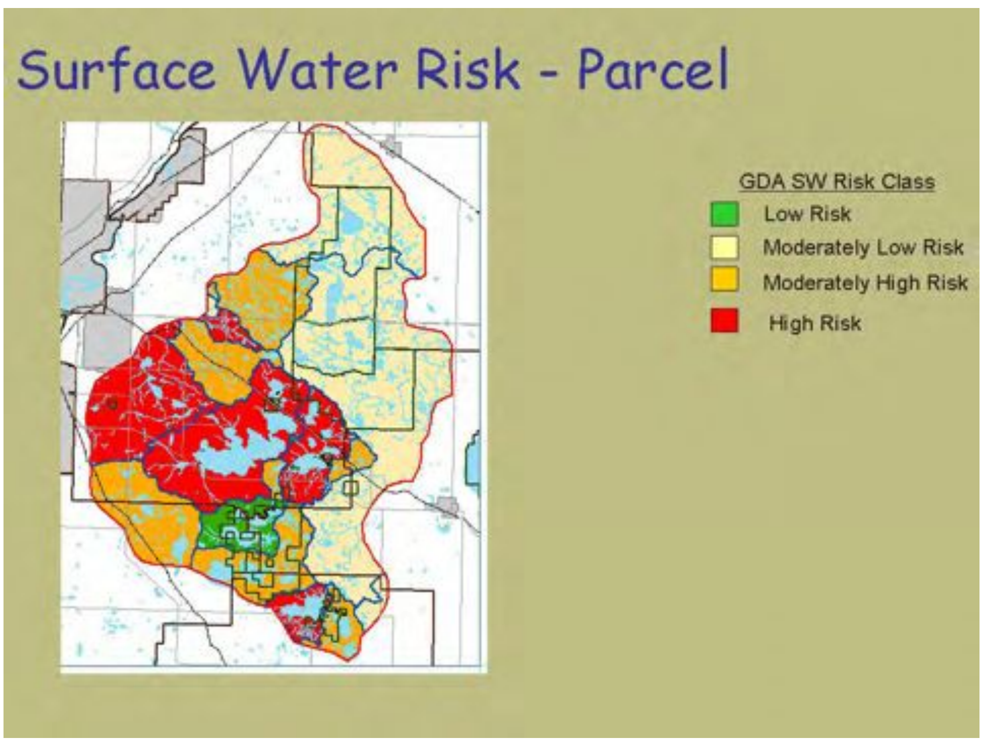
Often planners asked to review a new application for subdivision are faced with limited information: an air photo of the site, and depending on the stage of design, perhaps a proposal. It is actually easier to identify concerns that should be mitigated before design begins, so that the proponent can address these concerns early in the design process. Now, with the EFZ mapping, and accompanying BMPs, planners can provide guidance to proponents, and request additional, site-specific information that may be required.

In this example, a hypothetical application for subdivision of the quarter section marked on the air photo to the left is submitted by the proponent. This site is located just east of Half Moon Lake, Strathcona County. Consulting the Parcel Land Use Type, Surface Water Risk Model Map, the planner finds that lands in this area have a slightly positive impact on surface waters, likely due to the predominant pasture land use, and small patches of woodland on the parcel, and the relatively limited water area within the parcel. One stream channel runs perpendicularly through the parcel, and is linked to a wetland and associated drainage southeast of the parcel.

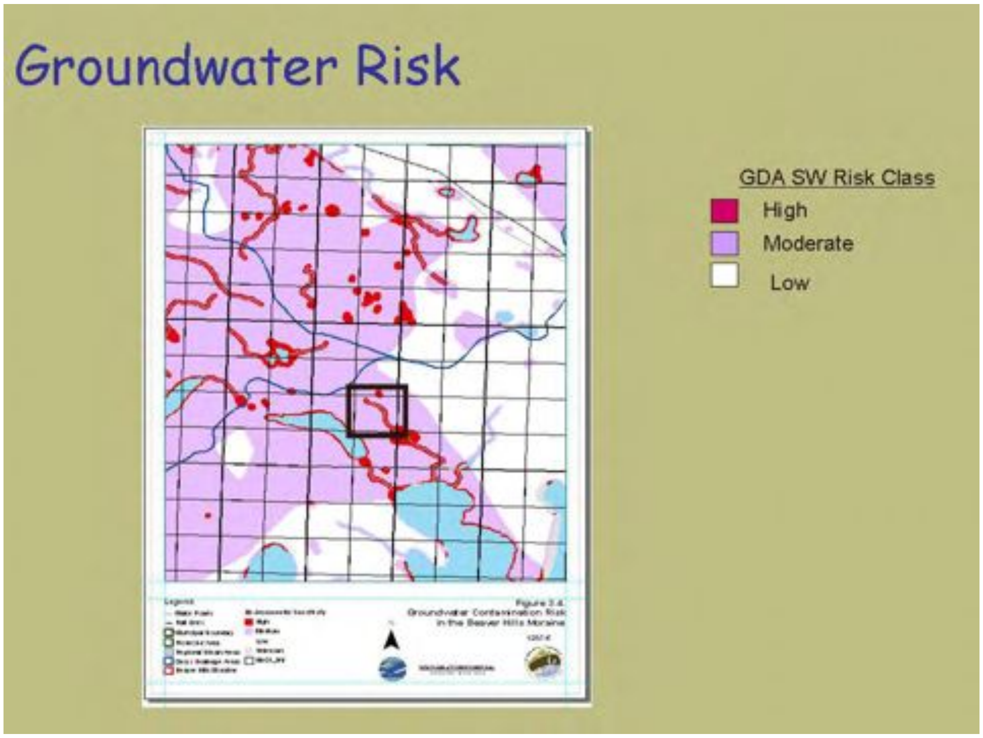
Immediately south, and around Half Moon Lake, the adjacent lands have slightly negative rating. This lake is used for recreational purposes, and is linked to Cooking Lake through a drainage channel south of the lake. It lies in the Cooking Lake GDA, which was rated as high risk, due to the abundance of water in the area, and a relatively limited landbase. Potential surface water concerns are flagged as a potential issue for development at this site.







On examining the Groundwater Risk Model Map, the planner finds that the stream running through the property has a high potential contamination risk that lies within an area of moderate risk. This suggests either a recharge or discharge area underlies the parcel, and possibly also coarse surficial sediments.

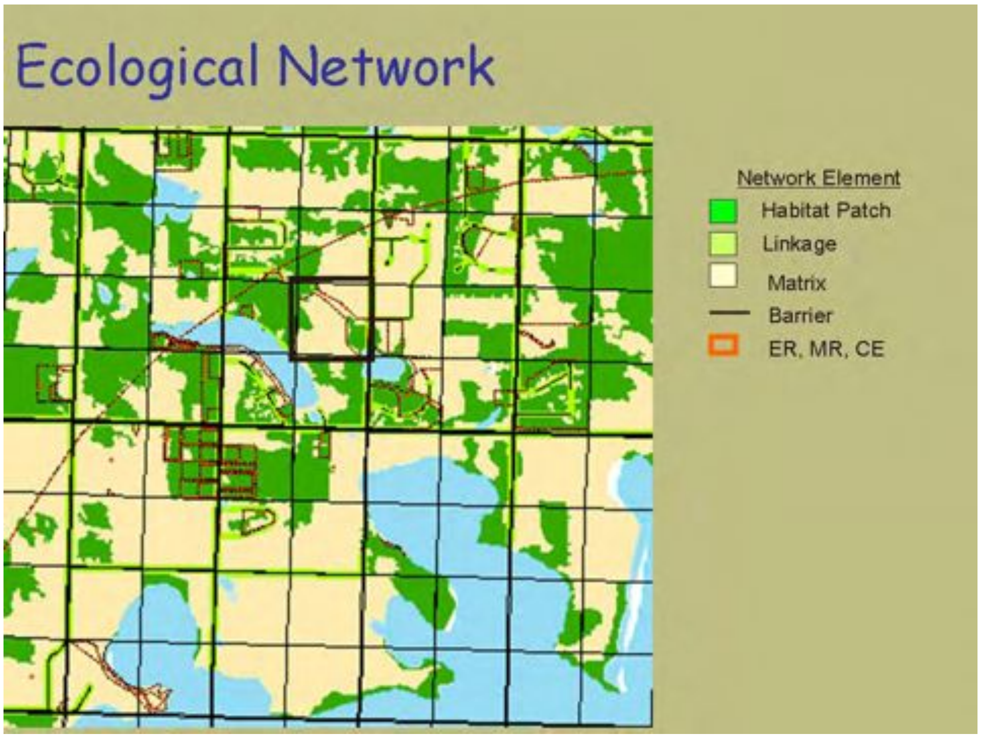


The Planner suggests the following BMPs for surface water and groundwater concerns:

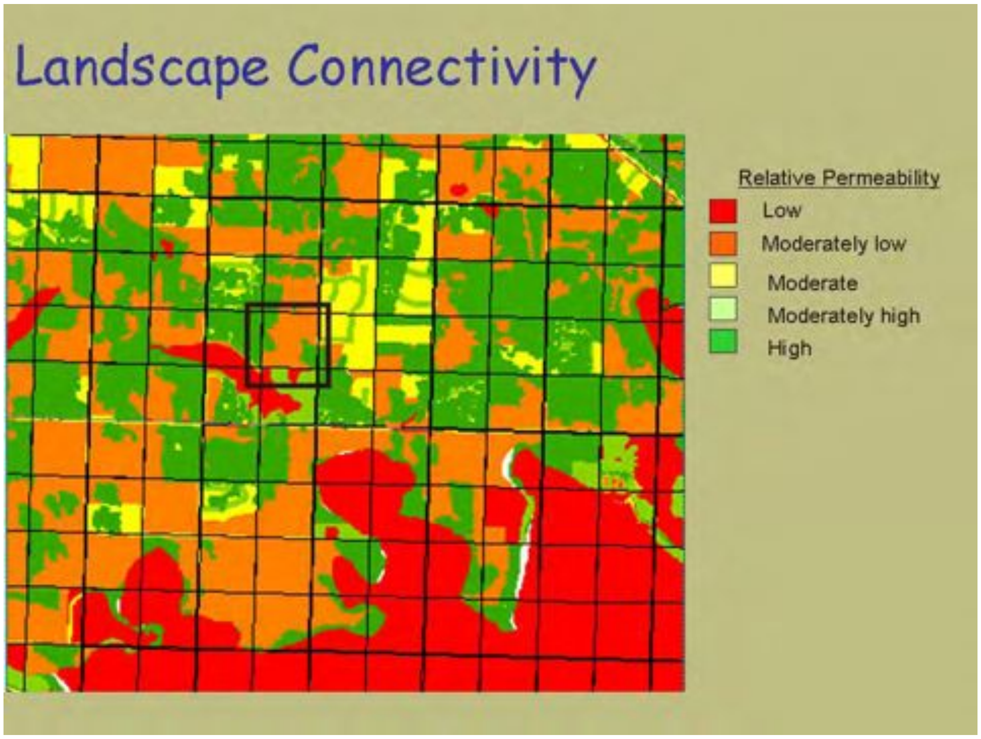
- Maintain vegetated buffers around all waterbodies
- Maintain natural drainage as much as possible by limiting hard surfacing and development footprints within lots and directing collected roof runoff from houses overland through vegetated areas.
- Treat all stormwater prior to release to natural waterbodies.
- Where possible, avoid stream crossings, realignments or other in-stream disturbances. If a road crossing is required for access, locate such access in the upper reaches of the stream, and provide adequately sized culverts to avoid back-flooding.
- Ensure proposed septic system is appropriate to soils and set-back sufficiently from surface waters. To confirm that the design is appropriate, the planner requests the proponent to undertake an assessment of the site that addresses potential groundwater and issues (actually completed by a qualified professional).

The proponent is also directed to provide confirmation from Alberta Environment that sufficient water supply is available on the property for groundwater wells, and for any work proposed within the stream channel or wetland. In addition, the proponent must ensure that all other approvals are in place before development begins. (If a formal environmental assessment process was in place, this referral would occur as part of the review process.)

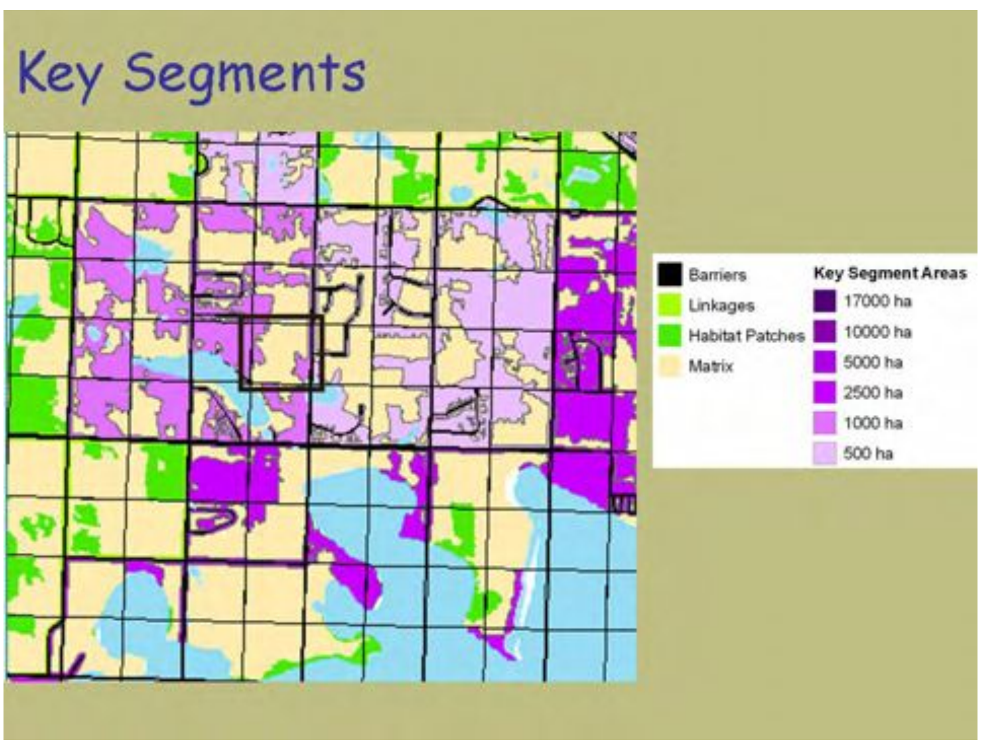
Next, the planner examines the Landscape Connectivity map series, including the Ecological Network, Landscape Connectivity, Key Segments and Functional Connectivity Maps. There are few habitat patches on the parcel, but the adjacent lands support large patches, which appear to form a connected ring around the parcel. The habitat with the parcel has already been protected under either an MR, ER or conservation easement, likely in recognition of that fact. The proponent must consider those protected areas within their design.



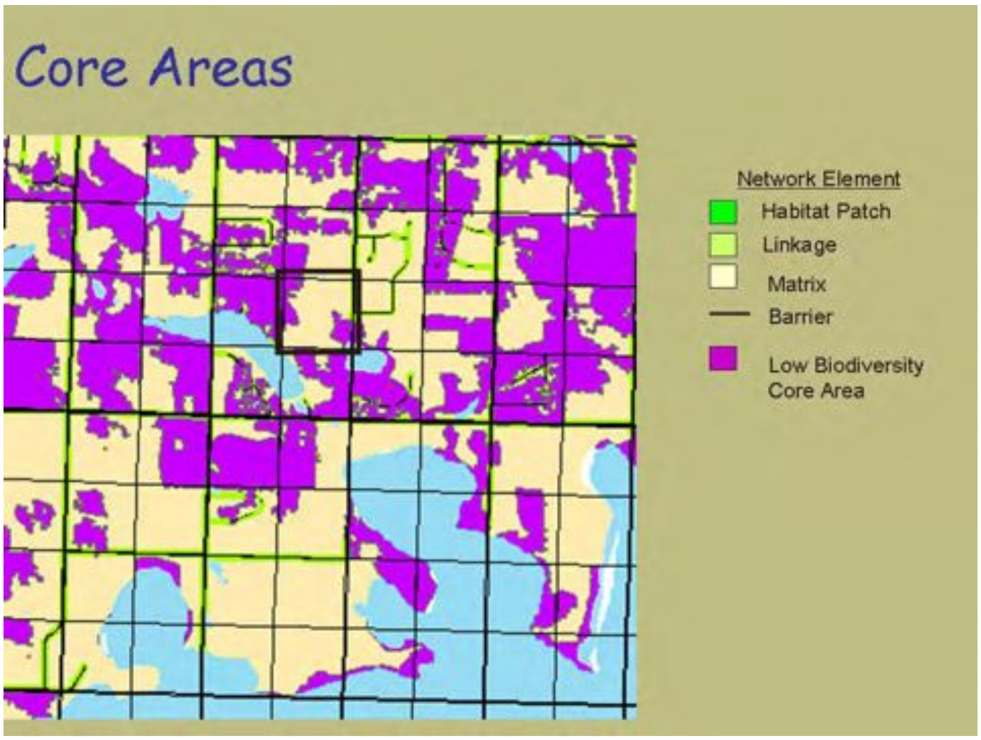
Examining the Landscape Connectivity Map, the planner finds that indeed, the lands around the parcel are highly permeable, and provide some linkage with the limited habitat around Cooking Lake. The planner checks the Key Segments map to ensure that the linkages around and partly within the parcel are not part of a segment of some size.



The habitat within the parcel is part of two key segments, but one of the smaller ones with a total area between 1000 and 2499 ha. The habitat patch west of the parcel is the larger of the two. Sensitive development that retains as much of the treed land on the property, and particularly within the larger patch will be important in this assessment.



Lastly, the planner checks the Core Areas Map to determine whether any of the habitat patches within or adjacent the parcel were considered Core Areas. Many of the patches around the parcel, and those sections partly within it were identified as Low Biodiversity Core Areas. Absolute protection is not necessary within these patches, but minimizing loss of habitat should be encouraged if possible. The planner investigates options for lot bonusing or cluster designs to retain as much of the natural habitat as possible.



BMPs related to Landscape Connectivity and Core Areas recommended by the planner include the following:

- The proponent is encouraged to minimize building footprints as much as possible and to encourage landscaping with native species to enhance connections through the parcel.
- ER and MR have already been claimed on this parcel; the proponent is reminded that their design must respect those areas already designated.
- The planner confirms that cluster design is permitted in this area and recommends the proponent pursue such options to minimize clearing of woodland habitat.
- Where lots may lie within naturally vegetated areas, the proponent is encouraged to provide additional protection of these parts of the lots through innovative means (e.g., covenants on land titles, land owner stewardship programs, or additional planting elsewhere on the property). The currently unvegetated sections of the stream channel might be candidate area for replanting, perhaps in exchange for a lot bonus.

- To confirm that no species at risk occur within the parcel, the proponent is directed to conduct a rare plant and wildlife assessment for the property, containing at a minimum, a request of past records from ANHIC or BSOD.
- If trails are proposed, the proponent is encouraged to place them on the perimeter of the wooded areas and beyond a set-back buffer along the stream.

No approvals are required, although federal and provincial agencies could advise if any enforcement legislation was likely to be triggered by the legislation. (If a formal environmental assessment process was in place, this referral would occur as part of the review process.)

The planner provides the following, additional advice to the proponent to minimize potential impacts during construction:

- The proponent is requested to prepare a Hazardous Materials Management Plan for proposed construction. Storage and use of hazardous materials within 100 m of any waterbody should be discouraged within that plan, to avoid surface and groundwater contamination.
- Minimize vegetation clearing within and adjacent Core Areas as much as possible. Clearly mark the limits of the area to be cleared before construction begins to avoid accidental removal of additional vegetation.
- Ensure that any vegetation clearing does not affect nesting birds by asking that vegetation be cleared during the period 15 April and 31 July (Strathcona County recommends an extended clearing restriction period for wetlands, from 15 April to 1 September). If that is not possible, the proponent is directed to conduct a nest search to confirm that no nesting birds are present before clearing. (Note that Strathcona County also requests surveys to confirm that no nesting owls are present, to be address these late winter breeding species.
- Minimize sedimentation from soils disturbed during the construction process by minimizing clearing and providing erosion and sediment controls within the construction area (Cappiella et al. 2006).
- Where construction is necessary within the 30 m riparian buffer, require revegetation of the disturbed areas adjacent watercourses and wetlands as soon as possible. Require that adequate erosion and sedimentation controls be in place for any such work, to mitigate potential release into surface waters.
- Revegetate disturbed areas adjacent retained natural features using native species where possible.
- Implement measures to limit the spread of noxious, invasive or weedy species when working near Core Areas:
    - wash equipment before moving to new sites to remove seeds captured in soil or grease,
    - provide weed control for soils stockpiled over long periods to limit establishment of undesirable species, and
    - revegetate disturbed areas with suitable native seed mix as soon as possible and follow-up to ensure sufficient establishment of new vegetation