KEEYASK PROJECT

Generating Station

December 2012

Report # 12-02

Terrestrial Habitats and Ecosystems in the Lower Nelson River Region: Keeyask Regional Study Area

E N V I R O N M E N T A L   S T U D I E S   P R O G R A M

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Environmental Studies Program
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Terrestrial Habitats and Ecosystems in the Lower Nelson River Region: Keeyask Regional Study Area

Report Prepared For Manitoba Hydro

by

ECOSTEM Ltd.

December 2012

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1 BACKGROUND

1.1 INTRODUCTION

The Keeyask Hydropower Limited Partnership is proposing to develop the Keeyask Generation Project (the Project), a 695 megawatt (MW) hydroelectric generating station and associated facilities, at Gull (Keeyask) Rapids on the lower Nelson River upstream of Stephens Lake in northern Manitoba. The Project includes an access road, permanent infrastructure, temporary borrow, camp and work areas, and approximately 45 km^2 of terrestrial flooding. An environmental impact statement for the Project (Keeyask Hydropower Partnership 2012) was submitted in July, 2012. If licensed, the current schedule has construction occurring from 2014 to 2022.

Manitoba Hydro is proposing to develop the Conawapa Generation Project (the Conawapa Project), a 1,485 MW hydroelectric generating station and associated facilities, on the lower Nelson River approximately 30 km downstream of the existing Limestone Generating Station and 70 km upstream of the Nelson River Estuary. This proposed project includes highway and access road upgrades, permanent infrastructure, temporary borrow, camp and work areas, and terrestrial flooding. Environmental assessment studies for the Conawapa Project are ongoing.

Both of these hydroelectric generation projects would have a variety of direct and indirect effects on terrestrial ecosystems. Studies to develop a better understanding of local terrestrial ecosystems and to help predict potential project effects have been underway since 2001. These studies were essential because little terrestrial ecosystem data was available for the project areas when the studies commenced.

This report describes and presents results from studies related to terrestrial habitat, ecosystems and plants in the project areas, which are referred to as the lower Nelson River (LNR) region. The LNR region follows the Nelson River, extending from the Thompson area to Hudson Bay, and is subdivided into Keeyask Regional Study Area and the preliminary Conawapa Regional Study Area (Map 1-1). The boundaries for each of the Regional Study Areas were delineated using ecological criteria (Section 2.5.2). Taking this broad area approach has various benefits such as better species and habitat distribution information, increased ability to infer causal factors, greater consistency in environmental assessment methodology and a stronger foundation for predicting potential project effects.

1.2 REPORT ORGANIZATION

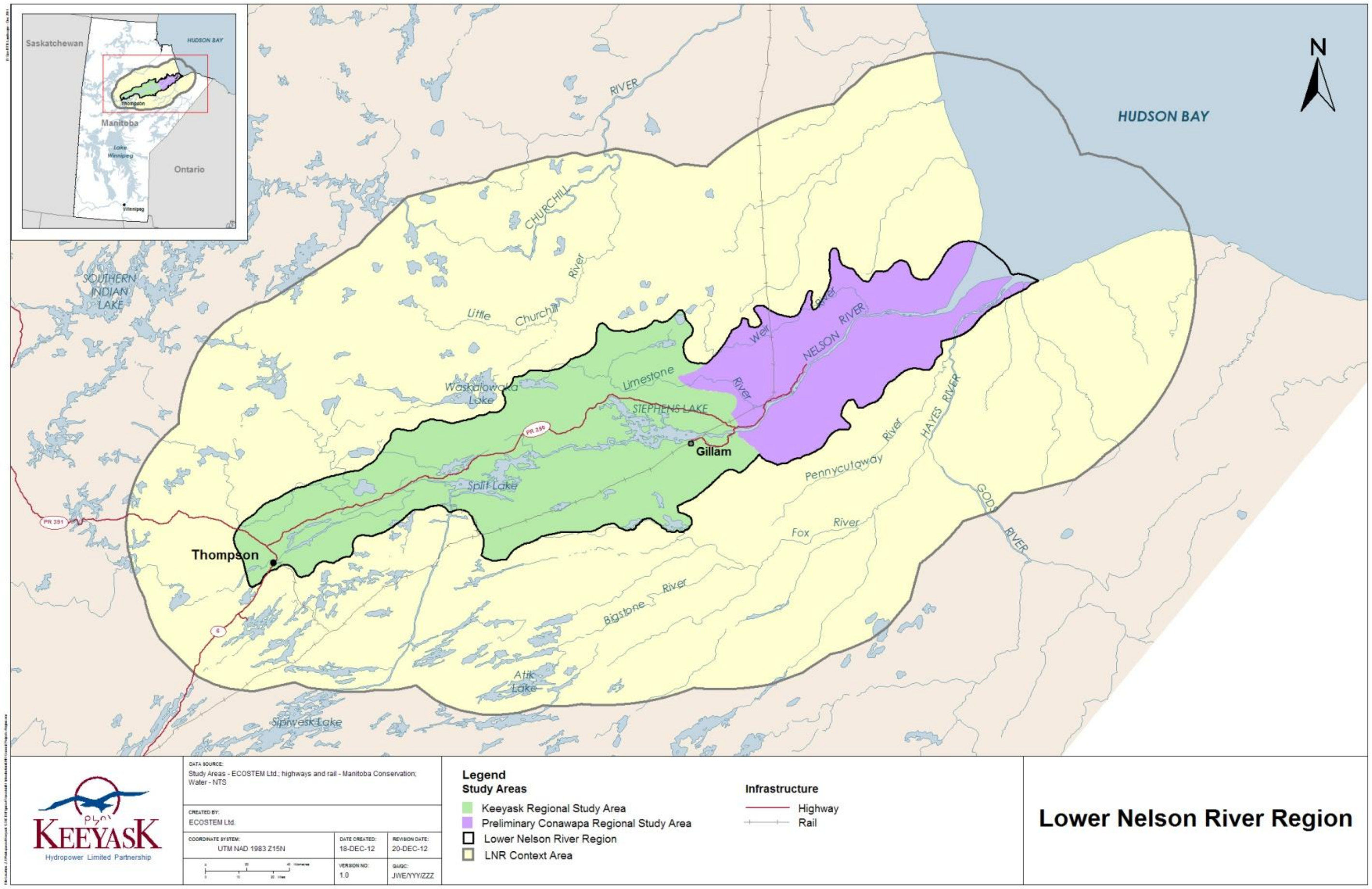
An ecosystem-based approach was used to describe and improve understanding of terrestrial ecosystems in the LNR region and to assess the potential effects of hydroelectric generating station developments on those regional ecosystems. This report begins by presenting this ecosystem-based methodology (Section 2). Components of the ecosystem-based methodology include the approach to selecting the most influential ecosystem drivers and key topics (e.g., valued environmental components), project scoping, key topic spatial and temporal scoping and use of thresholds and benchmarks. The remainder of Section 2 then provides an overview of the fundamental methods relevant for all of the terrestrial habitat and ecosystems studies and analyses (e.g., ecological zonation, habitat as a proxy for ecosystems, information sources). Within this methodological framework, Section 3 describes the overall design of the LNR region terrestrial habitat and ecosystems studies.

Section 4 describes the ecological context of the LNR region, which sets the stage for the remaining sections of the report that address various terrestrial ecosystem components and key topics. Each of these remaining sections begins with a description of the methods used for field studies, analysis and predictions. This is followed by results for the Keeyask study area. Results for the Conawapa study area will be provided in a subsequent report.

Since soils and ecosites are among the factors that have the strongest influence on stand level ecosystem patterns and dynamics, these are the first of the ecosystem components addressed by the report (Section 5).

The final two report sections address terrestrial habitat composition and relationships. As explained in Section 2.4, terrestrial habitat includes many of the key terrestrial ecosystem components and is used as a proxy for several ecosystem attributes. Section 6 describes the terrestrial habitat composition of the Keeyask study areas while Section 7 addresses terrestrial habitat relationships. Key terms are defined in the glossary (Section 8). Maps appear in a separate sub-section at the end of each main section.

1.3 MAPS



Map 1-1: **General location of the LNR region**

2 ECOSYSTEM-BASED APPROACH

2.1 INTRODUCTION

An ecosystem is a functional unit[1] comprised of the living and the non-living things in a geographic area, as well as the relationships between all of these things (Aber and Melillo 1991). Rowe (1961) argues that ecosystems are the only true level of biological organization beyond the organism.

An ecosystem has patterns (*e.g.*, a habitat mosaic), structures (*e.g.*, food web, trophic structure), dynamics (*e.g.*, cycling of energy, nutrients and matter) and performs functions (*e.g.*, converts carbon dioxide into plant material, creates soil, provides wildlife habitat). Ecosystems occur in different sizes, with the size being determined by the organism or process of interest. For example, the ecosystem for a bacterium may be a decaying log whereas the ecosystem for a squirrel may be portions of two adjacent forest stands.

The relativity of ecosystems raises the question: how do we define ecosystem boundaries for the purposes of terrestrial studies and project effects assessments? Ecosystems generally do not have well-defined, tangible boundaries. Nevertheless, causal linkages between ecological states and factors lead to natural functional breaks in spatial and temporal scales that facilitate the identification of an ecologically meaningful nested hierarchy of ecosystem levels (Allan and Starr 1982, King 1993 and Rowe 1961 for components or Ehnes 1998 and Waltner-Toews *et al*. 2008 for a synthesis). For a given phenomenon, a large process rate or frequency differential effectively isolates the fast manifestation of the phenomenon from its next slower level. For example, precipitation fluctuates on a daily basis around a long term mean. A plant's growth is affected by monthly or annual fluctuations in precipitation but not by changes in the long term mean. The latter dynamic occurs over a period that exceeds the life span of individuals for most species. On the other hand, long term change in average precipitation is associated with changes in the geographic distribution of the species that the individual represents.

Figure 2-1 provides an example classification of hierarchical ecosystem levels. Sites form stands, stands form landscapes, landscapes form subregions, subregions form regions and so on up to the biosphere (*e.g.*, Bailey 2009; Ehnes 2011). The various levels in an ecosystem hierarchy (*e.g.*, site, stand, region, the biosphere) are delineated by substantial differences in the rates or frequencies of change in the key ecosystem drivers (Allen *et al*. 1987; King 1993). Relative to the object of interest, higher ecosystem levels provide the context and constraints while the lower ecosystem levels are the components and mechanisms. As examples, climate and fire regime, which manifest spatial variation at the region or sub-region ecosystem level, constrain which plant species can survive and flourish within a site, stand or landscape.

[1] Following Allen and Starr (1982), any ecosystem object or hierarchy described herein is an epistemological construct that facilitates analysis, prediction and land-use management and may have no independent ontological basis.

The ecological perspective is that the components of an ecosystem are linked together in a web of feedback relationships. Likewise, aboriginal elders teach us that everything is connected to everything else. A change in one ecosystem attribute can change all other ecosystem attributes, to varying degrees. An ecosystem is a feedback system in the sense that effects from one component can eventually return to that same component after being altered by linkages with other ecosystem components. For example, although soil conditions are a key determinant of plant growth, subsequent plant growth affects soil properties which then leads to changes in soil conditions which then leads to changes in subsequent plant growth and so on.

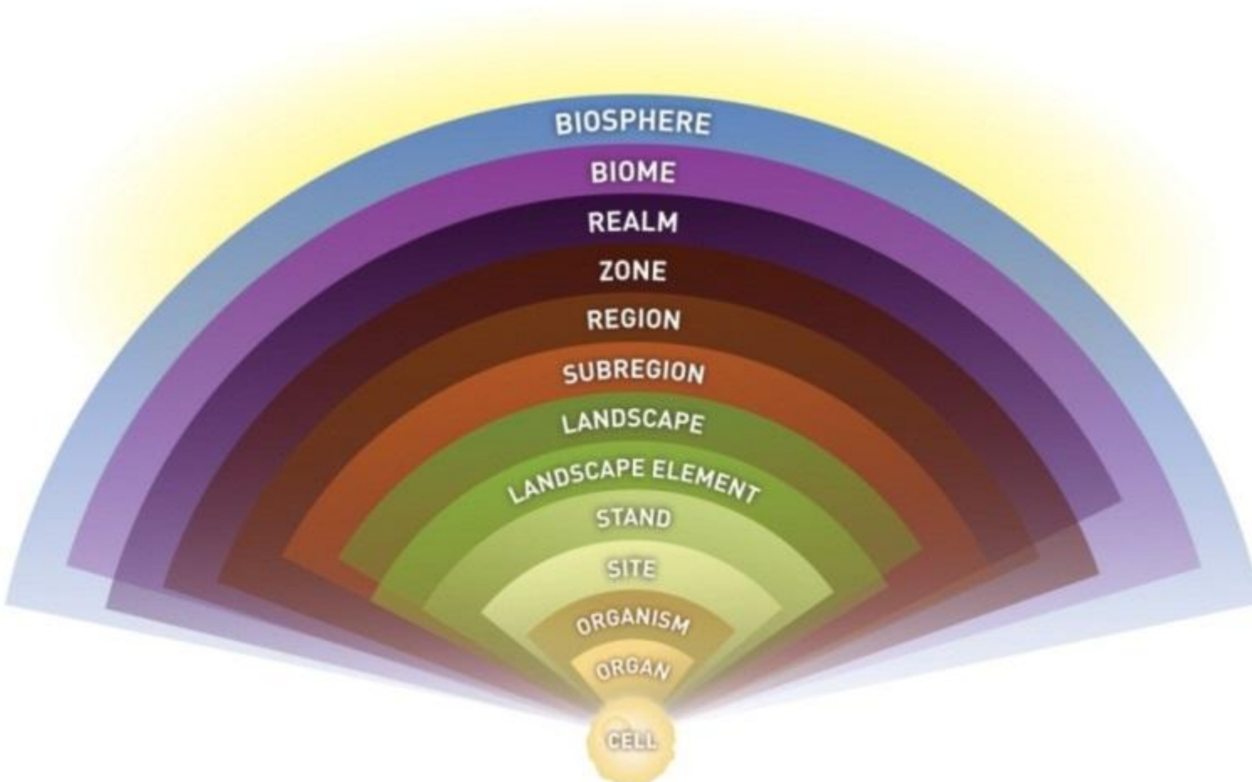
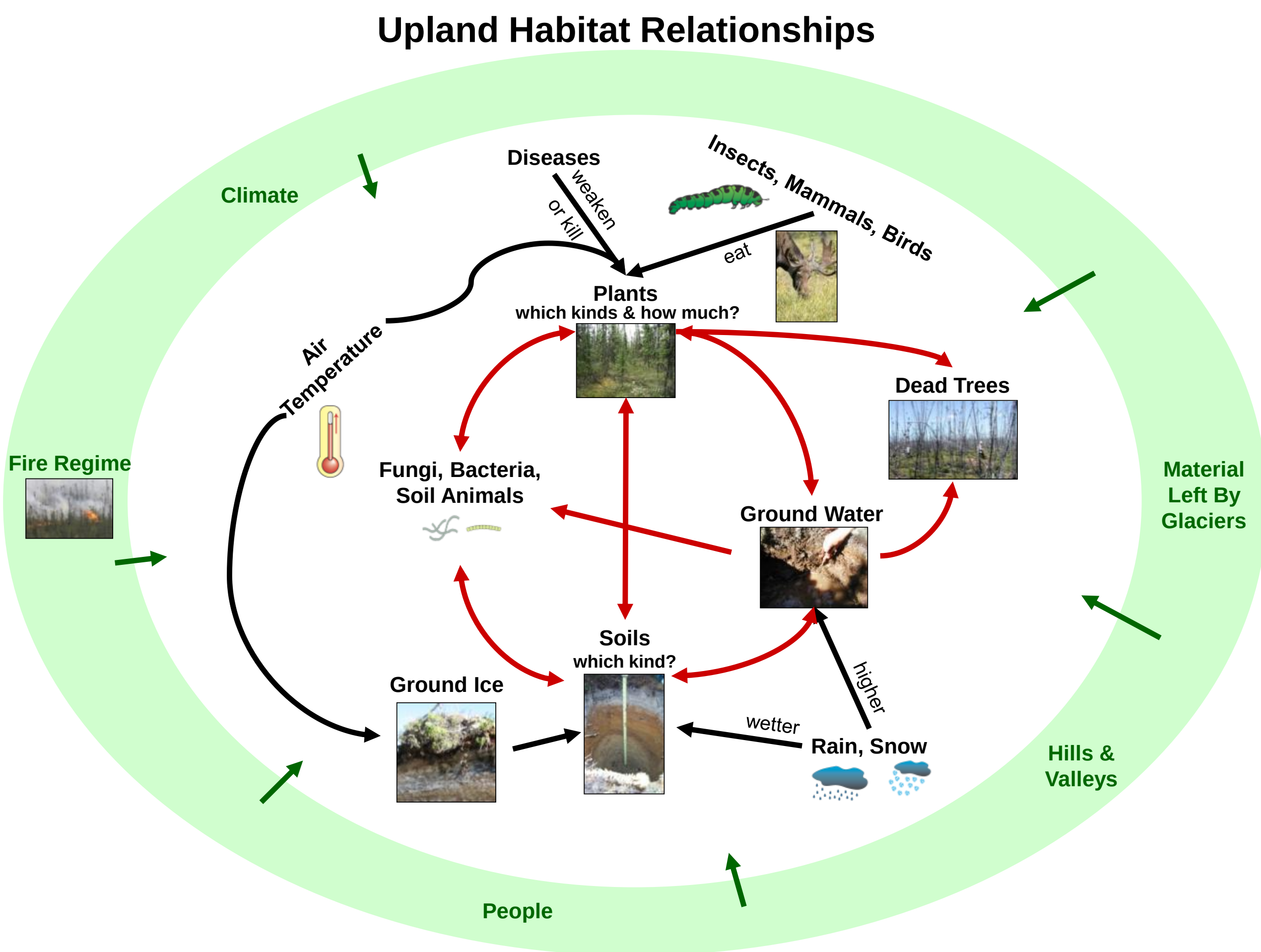


Figure 2-1: Hierarchical ecosystems levels (Ehnes 2011)

Figure 2-2 shows a portion of the web of relationships that exist between plants and soils in a stand level ecosystem, illustrating how a change in one ecosystem component can be transferred throughout the web of ecosystem relationships. These patterns and relationships were constrained by climate, fire regime, material left by glaciers and glacial lakes, topography and people (see green outer ring in figure), which were themselves patterns and processes that were produced at higher ecosystem levels such as the biome or biosphere.

Figure 2-3 provides an alternative representation of the complex web of relationships in the form of a network linkage diagram for the effects of project clearing on terrestrial vegetation composition and structure.



Arrows show linkages, or relationships, between ecosystem components. Red arrows are direct linkages while black arrows are indirect linkages. The outer green ring shows the factors that provide the context and constraints on site level patterns and processes.

Figure 2-2: Plant and soil relationships in a stand level ecosystem

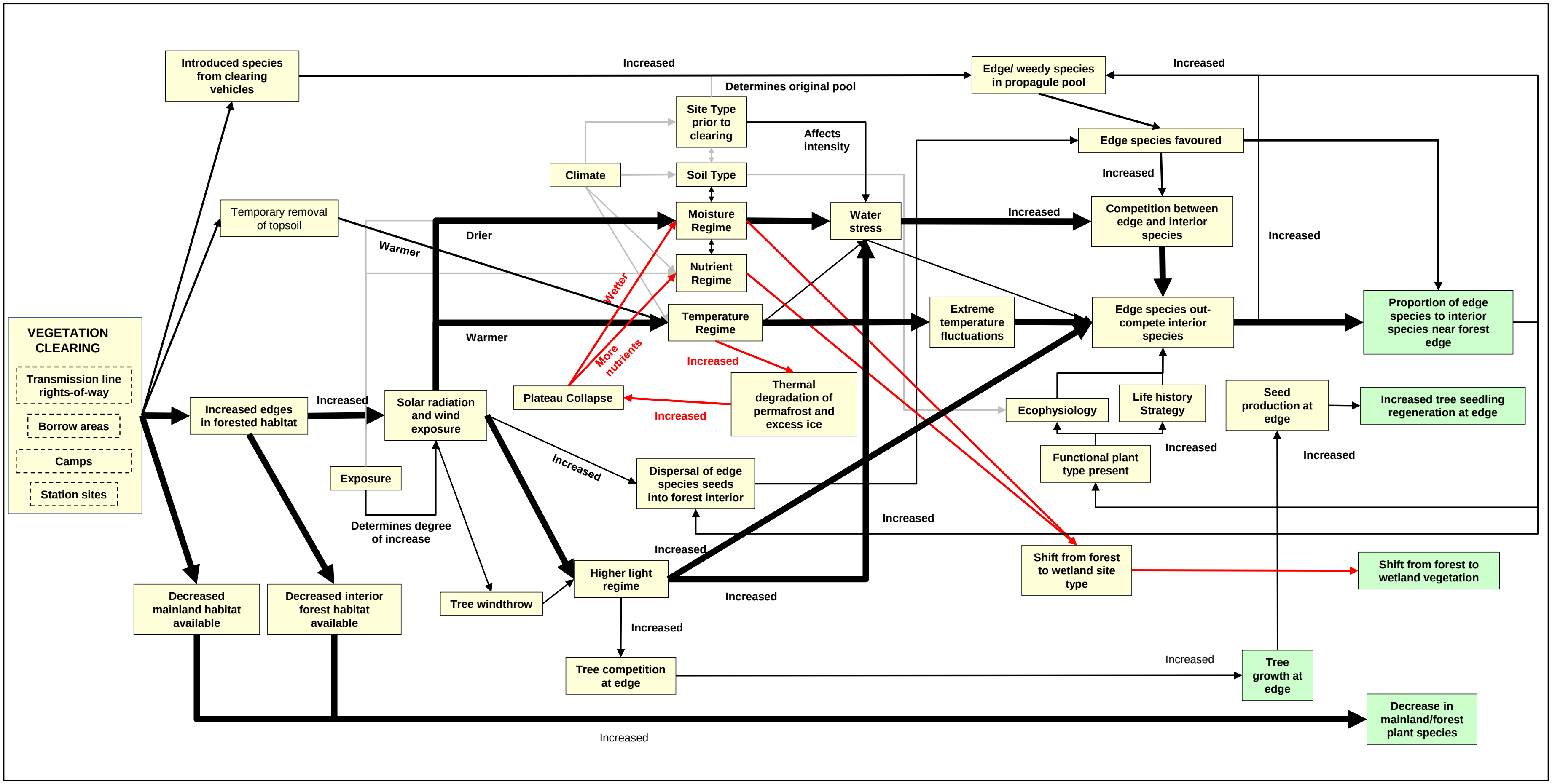


Figure 2-3: Network linkage diagram for terrestrial vegetation changes caused by project clearing

2.2 MOST INFLUENTIAL DRIVERS

The terrestrial ecosystems, habitat and plant studies, as well as the environmental assessments, used a key response – most influential driver conceptual approach. The objective of this conceptual approach was to elucidate the drivers that had the strongest influence on key ecosystem responses. By focusing jointly on the key ecosystem responses and the most influential drivers, ecosystem attributes were identified that best evaluated and monitored:

- the status of ecosystem condition;
- the factors that control ecosystem dynamics at particular levels;
- future trends in ecosystem condition; and,
- the likely effects of a project on ecosystems.

The key response – most influential driver approach, used to select key topics and associated indicators, was fashioned after other widely used cause-effect, stressor-response or controlling factors approaches developed to evaluate ecosystem condition for other purposes (e.g. Organization for Economic Cooperation and Development 2001; Young and Sanzone 2002; Millennium Ecosystem Assessment 2003; Bailey 2009). While the cause-effect, or driver-response theme, is common to all of these approaches, the approaches differ on where the emphasis is placed since they were all developed to meet different purposes. For example, the Millennium Ecosystem Assessment focuses on ecosystem services because this was thought to be the best strategy for influencing policy at the international level.

Bailey (2009) describes the key response – most influential driver conceptual approach in detail using the term controlling factors. He advocates using this approach as the basis for creating the ecosystem maps that become a tool to facilitate decision making, particularly ecosystem-based land use management. Bailey's Ecoregions of the Continents (Bailey 2009) is a practical implementation of the hierarchical ecosystems and controlling factors concepts.

There are many ecosystem attributes that could be selected as the key ecosystem responses. The responses of greatest interest are different when the question of interest is holistic (e.g., is the ecosystem healthy) than when it is elemental (e.g., why is the size of the beaver population changing). For holistic evaluations, the selected key ecosystem responses are the key emergent ecosystem properties (e.g., resilience, biodiversity), attributes that simultaneously integrate the outcomes of key patterns and processes (e.g., productivity or trophic structure are a manifestation of energy flow), represent critical functions for virtually all life (e.g., oxygen and biomass production by plants) and/or have a disproportionately high influence on many ecosystem responses (e.g., biodiversity, wetland functions).

For the LNR region studies, the key ecosystem response themes identified for the ecosystem condition evaluation included:

- native biodiversity at all levels;
- productivity;

- trophic structure;
- disturbance/ fluctuation regimes;
- resilience;
- resistance;
- intactness;
- contributions to global ecological cycles;
- soil quantity and quality;
- water quantity and quality; and,
- wetland function.

As described in Section 2.4, more specific key ecosystem responses were identified for each response theme (i.e., as a type of key topic).

There are many drivers that influence each of the key ecosystem responses. When the focus is on that portion of the web of relationships that relates to the ecosystem response of interest, it is apparent that many effects are indirect. In fact, the driver that initiates a change can be many steps removed from the ecosystem response of interest.

Some drivers have much higher influences on ecosystem responses than others. This generally arises because the driver either has a keystone or constraining effect. For example, fire is the keystone driver in the boreal forest (Payette 1992, Weber and Flannigan 1997) for the temporal scale that corresponds with forest stand dynamics. Relative to other global forest ecosystems, boreal vegetation is young due to frequent, large stand replacing fires. Fire rejuvenates the ecosystem at all spatial levels spanning from the site to the region.

Figure 2-4 illustrates the key response – most influential driver conceptual approach for the abundance and distribution of an animal species in an ecological region. This diagram can be generalized into a generic animal species diversity conceptual model or a generic model for ecosystem components.

The most influential medium to long-term drivers for ecosystem patterns and processes in the Canadian boreal forest are climate, fire regime, surficial materials and human activities (Section 4.2). Fire is the keystone driver in the boreal forest at the century time scale. The nature of fires within a large area over time can be characterized in terms of attributes such as their frequency, size, intensity, severity, patchiness, seasonality and type (*e.g.*, ground versus canopy), which are collectively referred to as the fire regime. A fire regime is largely a function of surficial materials (which determines the landscape level configuration of flammability) and climate. Surface material is an ultimate constraining driver for the fire regime because its composition changes very slowly relative to climate and the length of the fire cycle.

Relative to the response of interest, constraining drivers operate over much larger spatial scales or change extremely slowly. For example, most plants need soil to grow. Very different soils and vegetation will develop on clayey material than on sand. Soils develop from the surficial materials that were left by the last glaciation.

The chain of causality can be traced backwards to the origin of the universe. To include all orders of indirect effects this far back would have no utility for ecological questions relevant to evaluating changes to ecosystem condition in response to a proposed hydro-electric development. Referring to Figure 2-4, although glacial processes were what produced the landscape configuration and initial mosaic of surficial materials, glacial processes were not included because they operate at a much longer time scale than is relevant for ecosystem and species dynamics.

As Figure 2-4 illustrates, the ultimate most influential drivers depended on the question of interest.

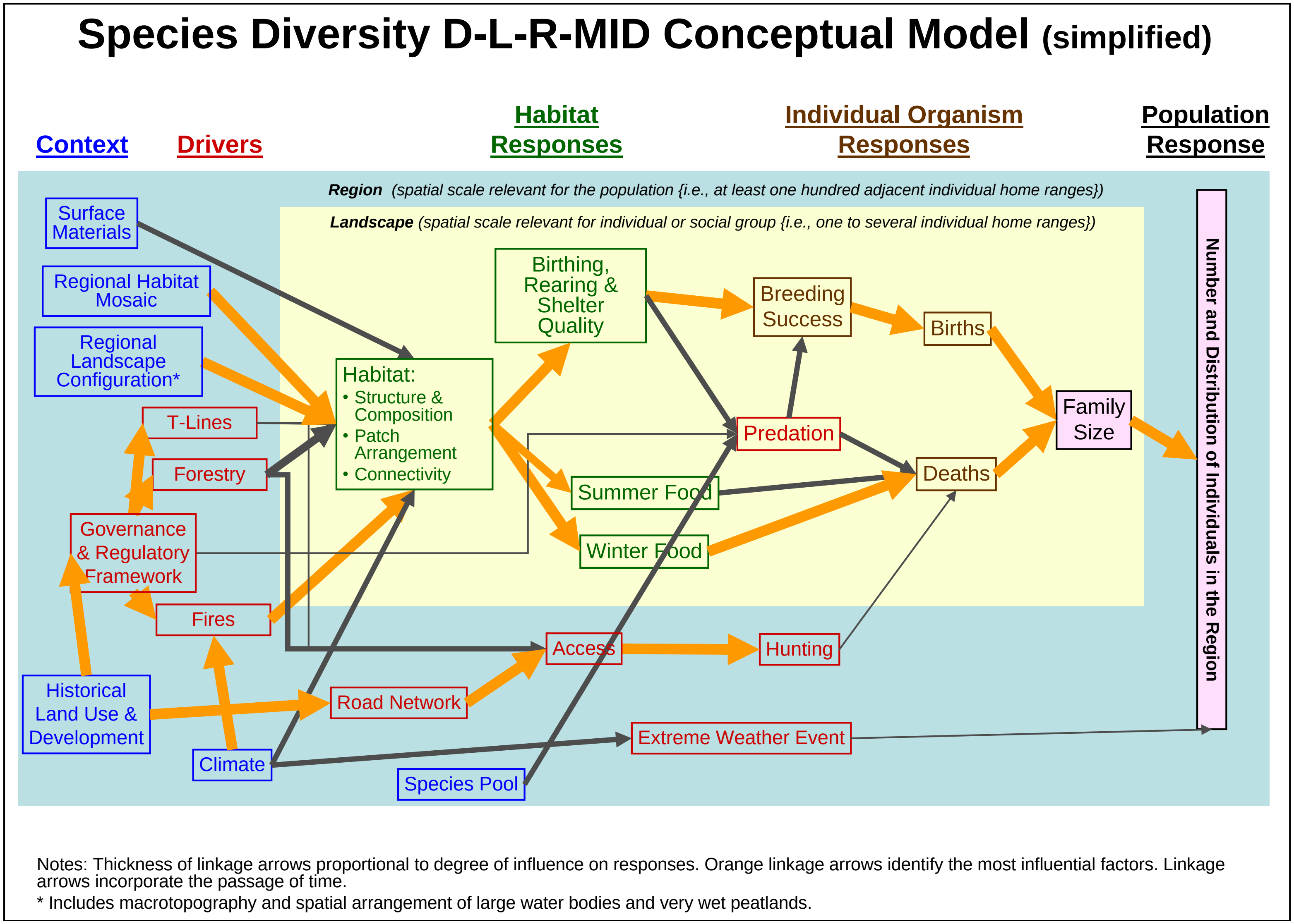


Figure 2-4: Drivers- Linkages- Responses- Most Influential Drivers (D-L-R-MID) generic pathway model for an animal species

2.3 OVERVIEW OF THE ECOSYSTEM-BASED APPROACH

An ecosystem-based approach was used to understand the terrestrial environment and to evaluate the potential effects of a hydroelectric generating station development on it. This approach recognized that the terrestrial environment is a complex, hierarchically organized system in which changes to one component directly and/or indirectly affect many other components (*i.e.*, elements, patterns, linkages, processes and functions).

The ecosystem-based approach used to scope and conduct the studies and environmental assessments included the following elements:

- Cause-effect linkages between the project and the terrestrial ecosystem were identified, including the direct and indirect effects of the project on the environmental components of interest, while considering the hierarchical structuring of ecosystem relationships. A key element of the ecosystem-based approach was identifying the components of ecosystems that are particularly important for maintaining terrestrial ecosystem health;
- The key topics selected to focus the studies and assessments (see Section 2.4) included representation for key emergent ecosystem properties (e.g., ecosystem diversity), for the primary controlling factors in the terrestrial ecosystem (e.g., wildfire regime) and for particularly important ecosystem functions (e.g., wetland function);
- The spatial scope of the studies and assessments reflected both the scales at which the project can affect species and ecosystems and the scales at which ecosystem components use the environment. Study areas for each key topic were nested to correspond with the project's local zone of influence on the topic (i.e., the local study area) and an ecologically appropriate regional comparison area (i.e., the regional study area);
- The temporal scope of the assessment considered seasonal, annual and inter-year variations and long-term changes in the environment that are relevant to species and ecosystems;
- Given the complexity of potential interactions within the ecosystem and between the project and the ecosystem, models were used to (i) improve the understanding of ecosystem patterns, processes and functions relevant to the assessment; (ii) predict potential changes caused by the project; and, (iii) evaluate uncertainty in the assessment;
- The evaluation of project effects used ecological benchmarks such as: i) degree of change from the existing environment, ii) degree of change from historical conditions, iii) the range of natural variability, and iv) comparison to established thresholds, benchmarks and guidelines; and,
- Uncertainties associated with the project effects predictions were described, as were potential measures for addressing these uncertainties. Monitoring, including adaptive management, was one measure used to address uncertainty.

Further details regarding how the ecosystem-based approach was used to undertake the studies and complete the assessments are provided below.

2.4 KEY TOPICS

Terrestrial ecosystems provide numerous benefits such as: food and shelter for all terrestrial animals; cultural, social, spiritual and economic benefits to people; and perform ecological functions such as cleaning the air and water for all people and animals. Some components of the terrestrial ecosystem are of particular interest because they are highly valued by people, are rare and are in danger of disappearing in some areas, are highly sensitive to disturbance or play a prominent role in ecosystem function.

The ultimate purpose of the LNR region studies was to provide the basis for understanding and predicting project effects on terrestrial ecosystems. As illustrated in Figure 2-3, there were many potential pathways for project impacts to lead to effects on terrestrial ecosystems. It was neither practical nor necessarily instructive to decision-making to investigate and assess the possible effects of a project on every component of terrestrial ecosystems. Consequently, the studies and analysis focused on the key terrestrial ecosystem issues of concern, i.e., the terrestrial key topics. The key topics collectively indicated how the project was expected to affect terrestrial ecosystem condition relative to an ecosystem health benchmark.

The development of a practical approach to identifying key topics, and associated indicators that are relevant for guiding land use management and predicting potential project effects on terrestrial ecosystems, has been evolving as a result of work conducted on several projects for Manitoba Hydro and other parties (Miller and Ehnes 2000; Manitoba Hydro 2003; ECOSTEM 2004b; Ehnes 2011). The approach was a practical synthesis of Canadian environmental assessment guidance literature with the land use sustainability framework developed by the Canadian Council of Forest Ministers (CCFM), industry and others (CCFM 1995) as a component of an international process (the Montreal Process) that culminated in the Santiago Declaration (Anonymous 1995). Due to its focus on maintaining regional ecosystem health, the approach is applicable to regions that have not already been dramatically altered by human activities (*i.e.*, it is not applicable to urban or agricultural areas).

The selection of key topics and ecosystem condition benchmarks, as well as the land use management decisions implicit in the licensing of a project, should be guided by an overall goal. In brief, the overall goal of the CCFM framework is to maintain long-term ecosystem health for present and future generations while conducting human activities and development. Ecosystem health is maintained when biodiversity, ecosystem condition and productivity, soil and water quantity and quality, and contributions to global ecological cycles are all maintained within their ranges of natural variability (after CCFM 1995). This framework is consistent with many environmental assessment regulations, policies and guidelines (*e.g.*, Canadian Environmental Assessment Agency 1996; *Federal Sustainable Development Act*) because it is a scientific approach developed by governments in partnership with stakeholder groups following extensive international, national and local consultation. The approach is also consistent with CSA Z809-08 (Canadian Standards Association 2008).

The practical approach to selecting project specific key topics and associated indicators included a sequence of filtering steps (Figure 2-5). In brief, the steps were to develop a generic checklist of ecological issues of concern by applying the CCFM land use sustainability framework to federal EIA guidance documents, CCFM criteria and indicator documents, scientific literature and ecological principles. Potential project specific issues of concern were selected from the generic checklist using input from local First Nations, observed effects from past hydroelectric developments in northern Manitoba, tools such as ecosystem linkage diagrams and local data. It was expected that some of the issues on the list of potential project issues of concern would actually experience very small project effects in the sense that effects would be well within the range of natural variability. As well, some ecological processes and interactions were more important than others in terms of their influences on ecosystem function (Aber and Melillo 1991). For these reasons, and because it is neither practical nor necessarily instructive to decision-making to investigate and assess the possible effects of a project on every component of the terrestrial ecosystem, the key terrestrial ecosystem health and/or social issues of concern were selected (i.e., the key topics) to focus the studies and assessments. That is, the ecosystem components (*i.e.*, patterns, processes and functions) that could potentially experience substantial project effects, and were especially important to maintaining overall ecosystem function, and the benefits that these functions provide to present and future generations. The key topics collectively indicated how the project is expected to affect terrestrial ecosystem health. Key topics of particularly high ecological and/or social interest became the valued environmental components (VECs) while the remaining key topics became the supporting topics. High importance to local First Nations was among the criteria used to select the key topics that became VECs.

The sequence of filtering steps in the practical approach used to identifying key topics, and associated indicators for the terrestrial studies and assessments, were as follows.

1. Define ecosystem health in a way that lends itself to practical application in land use management or a project effects assessment. That is, translate the overall goal of maintaining long-term ecosystem health into measurable criteria, indicators and benchmarks.
2. Develop a generic checklist of ecological issues of concern that would apply to any large project outside of the urban and agricultural zones. This was accomplished by relating

the components of ecosystem health to EIS guidelines, federal EIA guidance documents and ecological principles.

3. Scope the project (see Section 2.5).
4. Identify all impacts that could potentially affect terrestrial ecosystems.
5. Identify all potential project-specific ecosystem health issues of concern by selecting all of the generic issues of concern that have potential project linkages.
6. Identify the key project-specific ecosystem health issues of concern. These key issues, along with any other topics of high social interest, became the key topics for the studies and project effects assessments. The two types of key topics were VECs and supporting topics. VECs are often used to focus an environmental assessment (Hegmann et al. 1999). The VECs provided an overview of key project effects by directly or indirectly addressing the issues of highest concern. Supporting topics increased the reliability of the assessment by capturing the issues of moderately high concern and/or establishing how important influences on VECs would be affected by the project. The VECs and supporting topics were collectively used to indicate how the project was expected to affect terrestrial ecosystem health.
7. Identify generic indicators for each key topic.
8. Identify measurable indicators for each generic indicator.
9. Collect the local data needed to characterize the project area and to improve understanding of local cause-effect relationships to the degree needed to predict project effects with a reasonable level of uncertainty.
10. Develop project effects prediction models based on field data, ATK, experience from other locations experiencing similar impacts and relevant literature.
11. Continue to modify the indicators and models as new information from field studies and other sources improves the understanding of relevant terrestrial ecosystems.

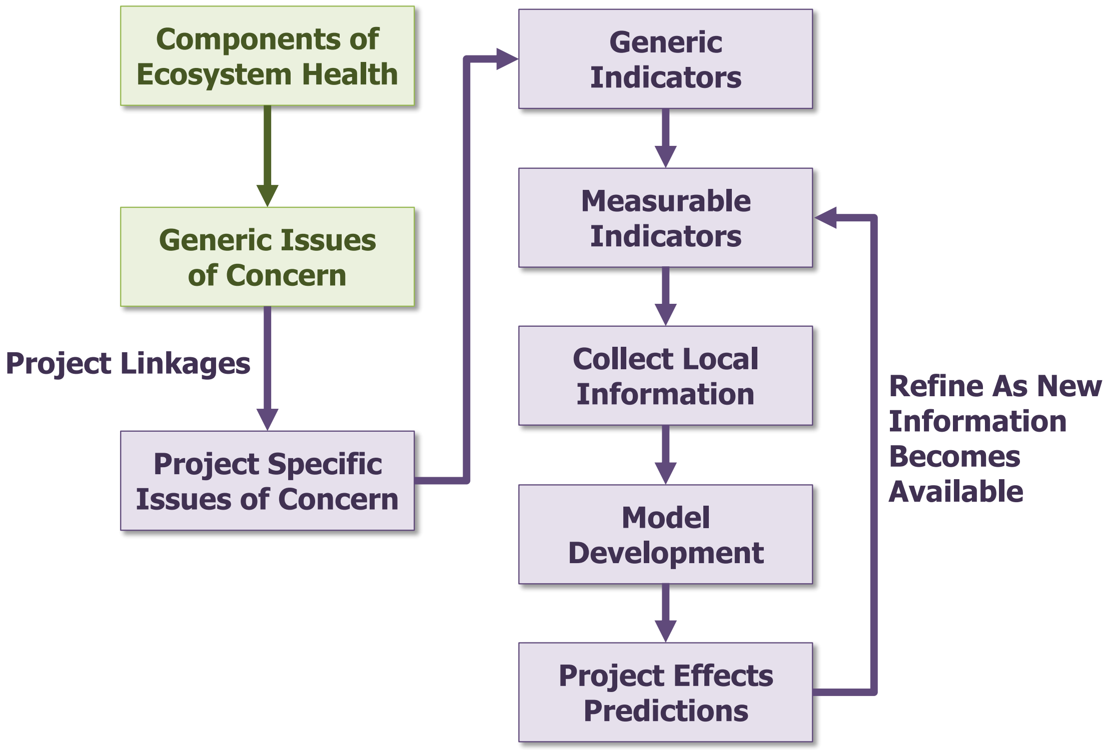


Figure 2-5: Key topic selection steps

Table 2-1 summarizes the outcome of Steps 1 to 5 for the biodiversity and ecosystem condition components, or criteria, for maintaining terrestrial ecosystem health applied to the Keeyask Generation Project. The following paragraphs explain the meaning of each column in the table and how the column responds to Steps 1 to 5.

Columns A and B address Step 1 by listing the two of the four major components of ecosystem health (Column A) and detailing the elements of each ecosystem health component (Column B). The major ecosystem health components, or criteria, defined by the outcome of the Montreal Process (CCFM 1995) are maintenance of native biodiversity, ecosystem condition and productivity, soil and water quantity and quality, and contributions to global ecological cycles. All four criteria need to be included when reporting on the status and trends in ecosystem condition and function. Each ecosystem health component is comprised of elements (Column B). For example, the biodiversity criterion includes maintenance of native ecosystem diversity, species diversity and genetic diversity.

Column C completes Step 2 by indicating why the element is a generic concern for project effects assessment or land use management. Some issues are of higher ecological and/or social concern than others, depending on the project and region. Column C also identifies the key drivers for the generic concerns. Anticipating changes in relevant drivers is often a reliable way of predicting project effects on issues of concern.

The key medium to long-term factors controlling ecosystem patterns and processes in the Canadian boreal forest are climate, fire regime, surficial materials and human activities (Ehnes 2012). As noted above, fire is the keystone controlling process (i.e., driving factor) in the boreal forest at the century time scale. Fire regime is largely a function of surficial materials (which determines the landscape configuration of flammability) and climate. The relevant spatial scale for mapping substantial differences in fire regime and climate corresponds with the subregion ecosystem level shown in Figure 2-1. Surficial materials strongly influence how fire regime, vegetation, soils and other ecosystem components respond to climate change. Surficial materials change very slowly relative to climate and fire regime. The initial step in identifying locations that do an outstanding job of representing regional level boreal shield ecosystem diversity is to focus on surficial materials.

Column D addresses Steps 3 and 4 for the Keeyask Generation Project by identifying the potential Project linkages and the Project-specific concerns for each generic issue of concern. Column D also identifies the key drivers for the Project linkages.

Column E is the first stage of addressing Step 5. Column E identifies the ideal conceptual indicators, or potential key topics, for each Project-specific concern. Bold blue font identifies the most frequently identified items in Columns E and F.

Column F identifies proxies for any potential key topics that would be difficult or impractical to measure. One such situation occurs when the scientific understanding of the associated processes may not be adequate to identify reliable measures that can be applied in the field (*e.g.*, soil microbial activity). Another of these situations occurs when the level of effort needed to collect adequate assessment data may be unreasonable given the potential Project effects. Potential Project effects on population size are an important example. Population size, which is a key concern for affected species, is either very difficult or extremely costly to estimate reliably for many species. Predicted changes in abundance indices, habitat composition, resource harvesting and other key influences on population size are collectively used as a proxy for potential Project effects on population size. In other words, the Project is not expected to affect population size for a particular species if the Project is not expected to change habitat availability, resource harvesting and the other key influences on population size for that species.

Column G is the final stage of responding to Step 5 by listing all of the potential key topics that could serve as indicators for each Project-specific issue of concern. That is, column G collates all of the topics in Columns E and F.

Some potential key topics appear many times in column G. A potential key topic may appear many times because it performs particularly important roles in ecosystem function and/or is a good proxy for a number of components of ecosystem health. Habitat composition, which appears 22 times in the table, is an example of a potential key topic that satisfies both criteria.

The key topics used for the terrestrial studies and environmental assessments were selected from the potential key topics listed in column G of Table 2-1 by dropping potential key topics that met either one of the following two conditions:

- The potential key topic had a high degree of overlap with one or more of the other potential key topics. If both potential key topics were retained, the EIS would contain considerable repetition and not contribute substantial additional information. The potential key topic that was dropped was the one that had weaker Project linkages; or,
- Currently there is no reliable way to measure the potential topic with a reasonable level of effort given the status of scientific methods and/or understanding of ecosystem relationships.

Table 2-2 lists potential key topics that were dropped and the reasons for doing so. The remaining potential key topics were carried forward as the key topics. The key topics used for the terrestrial studies and environmental assessments are listed in the first column of Table 2-3.

In short, the VECs were the key topics of highest ecological and/or social concern. The VECs were not adequate on their own to provide a reasonably reliable indication of potential Project effects on terrestrial ecosystem health. Consequently, the remaining key topics were included as supporting topics. In other words, the VECs and supporting topics collectively indicate how the Project is expected to affect terrestrial ecosystem health.

A potential key topic in Table 2-3 became a VEC if:

- There was potential for substantial Project effects (column A);
- It is feasible to compile suitable information with a reasonable level of effort (column B); **and**,
- **One** of the following was satisfied:
    - The high importance to local people identified in column D includes particularly high importance to local First Nations; or,
    - The potential for substantial Project effects in column A refers to a species group with numerous potentially affected species that are not adequately represented by another key topic; or,

- The regulatory requirement or guideline in column C considers the species as being at risk; or,
- It was thought to be especially important to terrestrial ecosystem function in the Keeyask study areas (two check marks in column E); or,
- It was thought to be a strong indicator for a number of species and/or ecosystem functions (i.e., an umbrella indicator) (two check marks in column F).

To illustrate application of the criteria, wolverine is listed as a species of Special Concern by COSEWIC but was not selected as a VEC because the potential for substantial Project effects is low (individuals have extremely large home ranges, their critical habitats would not be substantially affected by the Project and the Project is not expected to substantially increase mortality). The wolverine is addressed in the mammal section as a rare species under the other priority mammals supporting topic.

Priority species are the native species that are particularly important for ecological and/or social reasons, including importance to local First Nations (*e.g.*, for food and cultural importance; common nighthawk is a threatened species). Some priority species may be of sufficient interest to become VECs (*e.g.*, caribou is important both scientifically and to the local First Nations). The remaining priority species are grouped as topics.

Table 2-1: Ecosystem-based framework used to select the ecosystem health indicators that became the potential key topics for the Keeyask Generation Project (i.e., potential valued environmental components and supporting topics)[1]

Criterion	Element	Generic Concern/ Why is it Included?	Keeyask Linkages	Potential Key Topics Before Other Considerations (*i.e.*, potential conceptual indicators)	Proxies for Key Topic	Potential Key Topics
A	**B**	**C**	**D**	**E**	**F**	**G**
Biodiversity	Ecosystem	**Habitat Composition**: Changing the natural mixture of ecosystem/habitat types affects ecosystem functions and species within the ecosystem.	Flooding, clearing and other impacts would remove and indirectly alter upland and inland peatland habitat with potential effects on ecosystem diversity.	**Habitat composition**- upland and inland peatlands	Not needed	Habitat composition
			Construction of instream works, flooding and changes to water levels and flows and sedimentation remove and indirectly alter shore zone habitat. Indirect changes to water thermal regime, light availability, substrate composition, and adjacent upland/inland peatland habitat with potential effects on ecosystem diversity.	**Habitat composition**- shore zone wetlands	Not needed	Habitat composition (especially wetlands)
		Priority Habitat Types: Some habitat types are especially important for a variety of reasons.	Same as for **Habitat Composition**.	Rare habitat types (*i.e.*, a type of priority habitat type) such as broadleaf forest, jack pine forest, tall shrub uplands, high quality wetlands (*e.g.*, marsh); Rare enduring features.	Not needed	Priority habitat types (rare); Wetlands; Rare enduring features
				Habitat types that are critical for other species (*i.e.*, a type of priority habitat) such as caribou calving habitat, marsh wetlands for waterfowl.	Not needed	Priority habitat types (critical habitat for other species); Wetlands
				Habitat types that are sensitive to disturbance (*i.e.*, a type of priority habitat) such as dry jack pine forest.	Not needed	Priority habitat types (sensitive habitat); Wetlands
				Species rich or structurally diverse habitat types (*i.e.*, a type of priority habitat) such as broadleaf mixedwood forest.	Not needed	Priority habitat types (species rich and/or structurally diverse)
				Habitats that make disproportionate contributions to ecosystem functions (*i.e.*, a type of priority habitat) such as wetlands. High quality wetlands are particularly important for wetland function.	Not needed	Priority habitat types (important for ecosystem function); High quality wetlands; Wetland function
				Habitat types that are especially important to people (*i.e.*, a type of priority habitat).	Not needed	Priority habitat types (highly valued by people)
		Drivers:				
		Water Regime: water levels, flows and other water regime parameters are the	Project would: flood land; change the range and timing of water levels and flows;	Water regime	Habitat attributes (*e.g.*, tree mortality along shoreline) and wetland habitat composition	Water regime; Wetland habitat composition; Habitat attributes

Criterion	Element	Generic Concern/ Why is it Included?	Keeyask Linkages	Potential Key Topics Before Other Considerations (*i.e.*, potential conceptual indicators)	Proxies for Key Topic	Potential Key Topics
A	**B**	**C**	**D**	**E**	**F**	**G**
		dominant influence on shore zone habitat. Water regime changes can remove and/or alter some habitat types with potential effects on ecosystem diversity and priority habitats.	transport and deposition of materials such as organic sediment.			
		Ice Regime: Ice scouring and pressure can substantially alter shore zone habitat and adjacent inland areas. Ice regime changes can remove and/or alter some habitat types with potential effects on ecosystem diversity and priority habitats.	Project would change the nature, extent and distribution of ice scouring and other ice effects on the shore zone. Ice regime affects substrate composition and presence of plants in shore zone habitat.	Ice regime (*e.g.*, timing of ice formation and ice-off; thickness of ice, presence of ice cover)	Habitat attributes (*e.g.*, scoured vegetation along shoreline) and wetland habitat composition	Ice regime; Wetland habitat composition; Habitat attributes
		Intactness: Human features affect the movement of energy, materials and organisms can alter habitats.	Project features such as the dam/generation station; culverts; and dykes affect quantity and quality of material transported in surface and overland flows (*e.g.* transport and deposition of sediments, dissolved oxygen levels, transport and deposition of organic detritus).	Intactness; Groundwater; Hydrology	Not needed	Intactness; Groundwater; Hydrology
		Fire Regime: Large wildfires are a major influence on habitat composition in the boreal forest region. More fires and/or fires that are more severe and/or intense can dramatically change habitat composition.	Project features increase the risk that a large accidental fire will occur or that behaviour of a natural fire will be altered.	Fire regime	Habitat composition	Fire regime; Habitat composition
		Keystone Species: Some animal species can remove or alter habitat, sometimes over large areas (*e.g.*, beavers flood land, alter stream flows and take down trees).	Reservoir creation provides beaver with new access to poplar. Project water regime reduces mortality from winter lodge inundation.	Keystone species (*i.e.*, a type of priority animal species); Beaver	Habitat composition	Priority animal species; Beaver; Habitat composition
		Invasive Species: Can affect the abundance and distribution of other species.	Increased access brings more equipment, materials and people into the area, which could transport invasive plants into the area or spread them further.	Invasive species	Not needed	Invasive species
		Climate: Over the long-term, strongly influences the abundance and distribution of many species either directly or indirectly through fire regime.	Project is not expected to affect climate but rapid climate change increases uncertainty of Project effects predictions.	Future climate	Climate change predictions	Climate change predictions
	Species	**Species Number**: Slowing down the rate of species extinction due to human factors is key to the conservation of biodiversity.	Project features would directly and indirectly affect individuals, change habitat availability and change habitat effectiveness which can reduce abundance and, in extreme cases, lead to extirpation. Rare	Number of species. Number of rare species.	Habitat composition. Presence of key habitats	Number of species; Habitat composition

Criterion	Element	Generic Concern/ Why is it Included?	Keeyask Linkages	Potential Key Topics Before Other Considerations (*i.e.*, potential conceptual indicators)	Proxies for Key Topic	Potential Key Topics
A	**B**	**C**	**D**	**E**	**F**	**G**
			species are at highest risk.			
		Population size and distribution: Changes to population size and distribution can change species number. Changing the natural mixture of species affects ecosystem functions and other species within the ecosystem.	Project features would directly and indirectly affect individuals, change habitat availability and change habitat effectiveness, which can reduce abundance and change distribution.	Plant community composition; Animal community composition. Strong Project linkages with wetland and water species (*e.g.*, waterfowl, shore birds, ring-billed gull, northern waterthrush, tern, bald eagle, amphibians, boreal chorus frog, beaver, aquatic furbearers) and some neotropical migrants (*e.g.*, blue-headed vireo, olive-sided flycatcher).	Habitat composition. Presence of key habitats.	Plant community; Invertebrate community; Amphibian community; Bird community; Mammal community; Waterfowl; Bald eagle; Blue-headed vireo, Olive-sided flycatcher; beaver, aquatic furbearers; Habitat composition
		Priority Species: Some species are especially important for various reasons.	Same as for population size and distribution. Rare species are at highest risk.	Rare species (*i.e.*, a type of priority species), especially those species listed as endangered, threatened or special conservation concern.	Habitat composition. Presence of key habitats.	Priority plant species (rare); Priority animal species (rare); Caribou; Habitat composition
				Species that are highly sensitive to Project features for various reasons such as low reproductive capacity, intolerant of noise or have suffered large habitat losses throughout their range (*i.e.*, a type of priority species) such as caribou, migratory songbirds {*e.g.*, olive-sided flycatcher}, bald eagle.	Habitat composition. Presence of key habitats.	Priority plant species (sensitive); Priority animal species (sensitive); Caribou; Olive-sided flycatcher; Bald eagle; Habitat composition
				Species that can make disproportionate contributions to ecosystem functions (i.e., a type of priority plant species or priority animal species). Examples include Sphagnum mosses, predators, invertebrates, beaver, small mammals, perching birds (e.g., olive-sided flycatcher, palm warbler).	Habitat composition. Presence of key habitats.	Priority plant species (ecosystem function); Priority animal species (ecosystem function); Beaver; Olive-sided flycatcher; Habitat composition
				Species highly valued by people (i.e., a type of priority plant species or priority animal species). Examples are medicinal plants, berries, caribou, moose, waterfowl, ruffed grouse, bald eagle, furbearers, snowshoe hare, gray wolf, black bear.	Habitat composition. Presence of key habitats.	Priority plant species (highly valued); Priority animal species (highly valued); Caribou, Moose, Waterfowl; Habitat composition
		Drivers:				
		Resource Harvesting: Human activities (*e.g.*, harvest, noise) can affect species.	Project features may increase opportunities to harvest some species. Offset programs in adverse effects agreement increase	Resource harvesting; Offset programs.	Not needed	Resource harvesting; Offset programs

Criterion	Element	Generic Concern/ Why is it Included?	Keeyask Linkages	Potential Key Topics Before Other Considerations (*i.e.*, potential conceptual indicators)	Proxies for Key Topic	Potential Key Topics
A	**B**	**C**	**D**	**E**	**F**	**G**
			harvesting in other areas.			
		Invasive Species: Can affect the abundance and distribution of other species.	Increased access brings more equipment, materials and people into the area, which could transport disease or invasive species into the area or spread them further. Linear features may create migration corridors for invasive species.	Invasive species (*e.g.*, purple loosestrife); Disease.	Not needed	Invasive species; Disease
		Predation and Herbivory: Some species can create large changes in food availability or critical habitat attributes for other species or consume relatively large numbers of other animals or plants.	Species or processes that are important to other species.	Predators (*e.g.*, gray wolf); Herbivores (*e.g.*, beaver)	Professional judgement	Predators; Herbivores; Beaver
		Intactness: Features affecting the movement of organisms can alter species abundance and/or distribution. Some species require large core areas to maintain population levels.	Project features reduce core area. Features such as the reservoir and roads may be impediments to the movement of some animals and plants or reduce habitat effectiveness for animals.	Intactness (includes linear disturbance)	Not needed	Intactness (includes linear disturbance)
		Water Regime: water levels, flows and other water regime parameters are a strong influence on shore zone species and their habitats.	Project would flood land and change the water regime.	Water regime	Habitat attributes (*e.g.*, tree mortality along shoreline) and wetland habitat composition	Water regime; Wetland habitat composition; Habitat attributes
		Ice Regime: Ice scouring and pressure can substantially alter shore zone habitat and adjacent inland areas. Ice regime changes can remove and/or alter some habitat types with potential effects on ecosystem diversity and priority habitats.	Project would flood land and change the ice regime.	Ice regime	Habitat attributes (*e.g.*, scoured vegetation along shoreline) and wetland habitat composition	Ice regime; Wetland habitat composition; Habitat attributes
		Fire Regime: Changes to the fire regime can dramatically change habitat availability.	Project features increase the risk that a large accidental fire will occur or that behaviour of a natural fire will be altered.	Fire regime	Habitat composition	Fire regime; Habitat composition
		Climate: Strongly influences habitat availability over longer time frame.	Project is not expected to affect climate but rapid climate change increases uncertainty of predictions about Project effects on species.	Future climate	Climate change predictions	Climate change predictions
	Genetic	Evolutionary processes underlie adaptation to change. Maintain capacity for gene flow.	Some Project features can impede species movement and thereby reduce genetic interchange.	Intactness	None	Intactness
		Species at a range limit may adapt better to rapid climate change.	Some Project features may alter the distribution and/or abundance of range limit species.	Species at a range limit (*i.e.*, a type of priority plant species or priority animal species).	Habitat composition	Species at a range limit (*i.e.*, a type of priority plant species or priority animal species); Habitat composition

Criterion	Element	Generic Concern/ Why is it Included?	Keeyask Linkages	Potential Key Topics Before Other Considerations (*i.e.*, potential conceptual indicators)	Proxies for Key Topic	Potential Key Topics
A	**B**	**C**	**D**	**E**	**F**	**G**
		Some rare species may adapt better to rapid climate change.	Some Project features may alter the distribution and/or abundance of rare species.	Rare species (*i.e.*, a type of priority plant species or priority animal species).	Habitat composition	Rare species (*i.e.*, a type of priority plant species or priority animal species); Habitat composition
		Any species may contribute to adaptation to contextual change.	Some Project features will alter the distribution and/or abundance of rare species.	Number of species. Number of rare species.	Habitat composition	Number of species. Number of rare species; Habitat composition.
		Drivers:	Same as for Species Diversity.			All of the key topics for Species Diversity drivers
Ecosystem Condition and Productivity	**Productivity**	**Primary Productivity**: Critical to function of ecosystem. Plants capture energy from sun and convert the energy into biomass. Other **autotroph**s transform energy into biomass. Changes in primary production, detrital transport and habitat will affect secondary consumers.	Flooding and changes in water levels and flows and water quality will affect primary producers.	Primary Productivity	Habitat composition	Habitat composition
		Secondary Productivity: Some animal species are important food sources in the food web.	Project features may affect key food web animals, their habitat or habitat effectiveness.	Abundances of invertebrates, small mammals and perching birds.	Habitat composition	Invertebrates; Small mammals; Perching birds; Habitat composition
		Drivers:				
		Decomposition: Decomposition is critical for making nutrients and material in dead organisms or their parts available in the ecosystem.	Groundwater and other habitat changes will affect decomposers, affecting water quality (organic material, dissolved oxygen, nutrients, and resulting in the mobilization of methylmercury in the food web).	Decomposition	Habitat composition	Decomposition; Habitat composition
		Weather: Extremes of temperature, precipitation and other weather parameters can reduce productivity and resilience.	Not affected by the Project, but climate change could result in the frequency and/or severity of extreme weather events, which increases the uncertainty, associated with Project effects predictions.	Future weather	Climate change predictions	Climate change predictions
		Water Regime: Key driver affecting shore zone, species that use this zone and wetland function.	Increased wave energy in reservoir will affect survival of some shore zone species.	Surface water cover and ground water changes.	Post-project habitat composition and peatland disintegration models are based on ground water model predictions.	Habitat composition; wetland function
		Water Quantity: Surface and groundwater amounts and movement strongly affect soil development, substrate conditions for plants and animals and wetland functions. Depth to groundwater is one of the most important influences on the rate of decomposition in soil.	Reservoir creation and operation, roads, culverts and other Project features may affect surface and groundwater amounts and movements.	Surface water; Groundwater; Wetland function.	Habitat composition	Surface water; Groundwater; Wetland function; Habitat composition

Criterion	Element	Generic Concern/ Why is it Included?	Keeyask Linkages	Potential Key Topics Before Other Considerations (*i.e.*, potential conceptual indicators)	Proxies for Key Topic	Potential Key Topics
A	**B**	**C**	**D**	**E**	**F**	**G**
		Water Quality: Directly influences organisms. An important influence on microbial decomposition rates.	Affects shore zone, species that use this zone and wetland function.	Water quality; Wetland function.	Habitat composition	Water quality; Wetland function; Habitat composition
		Soil Quantity and Quality: One of the most important influences on primary productivity.	Project may create soil erosion and compaction, flooding.	Soil quantity and quality; enduring features.	Soil quantity and quality	Soil quantity and quality
		Substrate Quality	Project may cause erosion and subsequent sedimentation in shore zone.	Substrate quality	Organisms associated with specific substrate types or intolerant of sediment deposition: Benthic invertebrates, lake sturgeon, walleye, lake whitefish	Substrate quality, benthic invertebrates, lake sturgeon, walleye, lake whitefish
		Surface and Groundwater	Project may elevate groundwater along shorelines and some inland areas.	Surface water cover and ground water changes.	Habitat zone of influence indicated by studies along existing reservoir shorelines	Surface water cover; groundwater elevations
		Climate: Strongly influences productivity over longer time frame.	Project is not expected to affect climate but rapid climate change increases uncertainty of predictions about Project effects on species.	Future climate	Climate change predictions	Climate change predictions
	Incidence of disturbance and stress	**Disturbance/Fluctuation**: Species in relatively natural areas are adapted to the existing disturbance/fluctuation regime. Functional outcomes are dependent on the natural balance. Species and functions in altered areas are adjusting to the altered conditions.				

Notes: [1] Blue font identifies topics that appear multiple times in the table. Bold blue font identifies the most frequently identified items in Columns E and F.

Table 2-2: Reason for dropping potential key topics for the Keeyask Generation Project identified in Table 2-1

Potential Key Topics	Reasons for Dropping
Soil microbial activity	Not practical to measure for a project effects assessment
Enduring features	Covered by ecosystem diversity
Primary productivity	Covered by ecosystem diversity, wetland function and soil quantity and quality
Carbon storage	Covered by ecosystem diversity, wetland function and soil quantity and quality
Plant community (includes number of species)	Covered by ecosystem diversity/habitat composition, priority habitats, resource use and priority plant species (i.e., if these key topics are not affected then effects on the plant community are not expected

Table 2-3: Criteria used to elevate potential key topics identified in Table2-1 to the valued environmental components (VECs) for the Keeyask Generation Project

Key Topics (VECs and supporting topics)	Criteria to Elevate a Key Topic to a VEC: Potential for Substantial Project Effects	Suitable Information Can Be Compiled	Regulatory Requirement or Guideline	High Importance to Local People	Ecological: Key for Ecosystem Function	Ecological: Umbrella Indicator	Outcome: VEC	Outcome: Supporting Topic	Comments
	A	B	C	D	E	F	G	H	
Terrestrial Habitat and Ecosystems									
Fire regime		✓			✓✓			✓	
Ecosystem diversity/ habitat composition (includes habitat attributes)	✓	✓	✓		✓✓	✓✓	✓		
Soil quantity and quality	✓	✓			✓✓	✓✓		✓	
Wetland function (includes wetland habitat composition)	✓	✓	✓		✓✓	✓✓	✓		
Intactness	✓	✓	✓		✓	✓✓	✓		
Terrestrial Plants									
Priority plant species	✓	✓	✓	✓			✓		Includes the following groups: endangered or threatened; provincially rare; regionally rare; range limit; keystone species; and/or highly valued by people.
Plant community (includes number of species)	✓	✓	✓					✓	Covered by ecosystem diversity/habitat composition, priority habitats, resource use and priority plant species (*i.e.*, if these key topics are not affected then effects on the plant community are not expected).
Invasive non-native plant species	✓	✓	✓	✓				✓	

Notes: A priority species is a native species that is rare, ecologically sensitive in some way, near the outer limit of its range, a keystone species, critical to the survival or reproduction of another species and/or highly valued by people. A species is considered to be ecologically sensitive if it is has low reproductive capacity, dependent on an uncommon habitat type, dependent on uncommon environmental conditions, dependent on the natural disturbance regime or highly sensitive to disturbance.

Table 2-4 lists the eight VECs and supporting topics used to assess effects of the Keeyask Generation Project on terrestrial ecosystems.

Table 2-4: Valued environmental components (VECs) and supporting topics used for the Keeyask Generation Project

Key Topic	VEC	Supporting Topic
Soil quantity and quality		✓
Intactness	✓	
Fire regime		✓
Terrestrial habitat		✓
Ecosystem diversity	✓	
Wetland function	✓	
Invasive plants		✓
Priority plants[1]	✓	

Notes: [1] Priority plant species include those native species that are highly sensitive to human features, make high contributions to ecosystem function and/or are of particular interest to the local First Nations. A species was considered to be highly sensitive to human features if it is globally, provincially or regionally rare, near a range limit, has low reproductive capacity, depends on rare environmental conditions and/or depends on the natural disturbance regime. Rare species that are endangered or threatened are of particularly high concern.

2.5 SCOPING

2.5.1 Project Scoping

In general, project components that are relevant for the terrestrial studies and environmental assessments included:

- Physical components that could directly remove or alter terrestrial habitat and/or ecosystems, including effects on wildlife and/or their habitat;
- Components that could indirectly remove or alter terrestrial habitat and/or ecosystems, including effects on wildlife and/or their habitat;
- Components that could disturb animals and/or cause them to avoid habitat they would otherwise use;
- Improved access since it could increase disturbance, mortality or resource harvesting;
- Conditions that could increase the risk that diseases or invasive species are introduced or further spread; and,
- Conditions that increase fragmentation or otherwise reduce intactness.

For hydroelectric generation projects in northern Manitoba, construction and operation of roads and infrastructure, reservoir flooding, station operation and other associated works and activities would:

- remove vegetation, soil and parent material;
- alter vegetation, soil and parent material;
- convert terrestrial areas to water and shoreline wetlands;
- create activity, noise, emissions and dust;
- move equipment, material and people into the area;
- increase access to the area;
- alter water and ice regimes on the Nelson River; and,
- alter groundwater levels and hydrology.

2.5.2 Key Topic Spatial Scoping

2.5.2.1 Methodological Approach

Spatial scope was determined separately for each VEC and supporting topic (*i.e.*, each key topic) using a nested, cause-effect approach (FEARO 1994; CEAA 1996; Milko 1998a, 1998b; Hegmann *et al.* 1999; Manitoba Hydro 2003). The scoping approach considered the hierarchical structuring of ecosystems and the potential pathways of Project effects on the key topic, including where these pathways could interact with other past, current and reasonably foreseeable future projects. Figure 2-6 illustrates the approach using the potential effects of a hypothetical project on moose.

The rationale for the nested cause-effect approach was as follows. Project impacts such as vegetation clearing would have direct effects on the VEC or supporting topic being assessed. These Project impacts could also have indirect effects on the selected key topic through linkages such as those shown in Figure 2-3 (e.g., Project-related clearing leads to higher soil temperature, which eventually alters soils and vegetation). For each VEC and supporting topic, the spatial extent of potential direct and indirect effects defined a potential zone of influence on individuals (i.e., the local zone of influence), which became the local study area for the topic in question. In the case of a wildlife topic, individuals were the individual animals that would be affected (e.g., five moose are displaced). In the case of a non-species key topic, individuals were the relevant ecosystem elements (e.g., 10 jack pine stands will be cleared; two core areas will be fragmented).

Although effects on individuals were of interest, the question of ultimate concern for the Project effects assessments was how effects on individual animals would translate into long-term effects on population viability or how effects on individual ecosystem elements would translate into long-term effects on components of regional ecosystem health (which is a synthetic measure of all ecosystem functions). For example, how would removing the habitat that supports five moose affect the long-term viability of the moose population, or, how would removing ten jack pine stands affect regional ecosystem diversity? On this basis, an area that was large enough to capture the affected population or regional manifestation of the ecosystem attribute (i.e., the regional zone of influence) was used to assess the potential significance of Project effects (Miller and Ehnes 2000). The spatial extent of the regional zone of influence became the regional study area for the key topic.

The context area, a third area that surrounds the regional study area, was also used for some key topics. A context area was sometimes needed because ecological processes that operate over very large spatial scales or long time frames could influence the key topic and confound the interpretation of observed patterns and trends. For example, animals could migrate into the regional study area if there was an unusually large burn in the surrounding area that greatly reduced available habitat there. Failure to consider the ecological context could lead to the erroneous conclusion that some changes observed in the regional study area were caused by the Project, or conversely, Project effects could be obscured by broader changes.

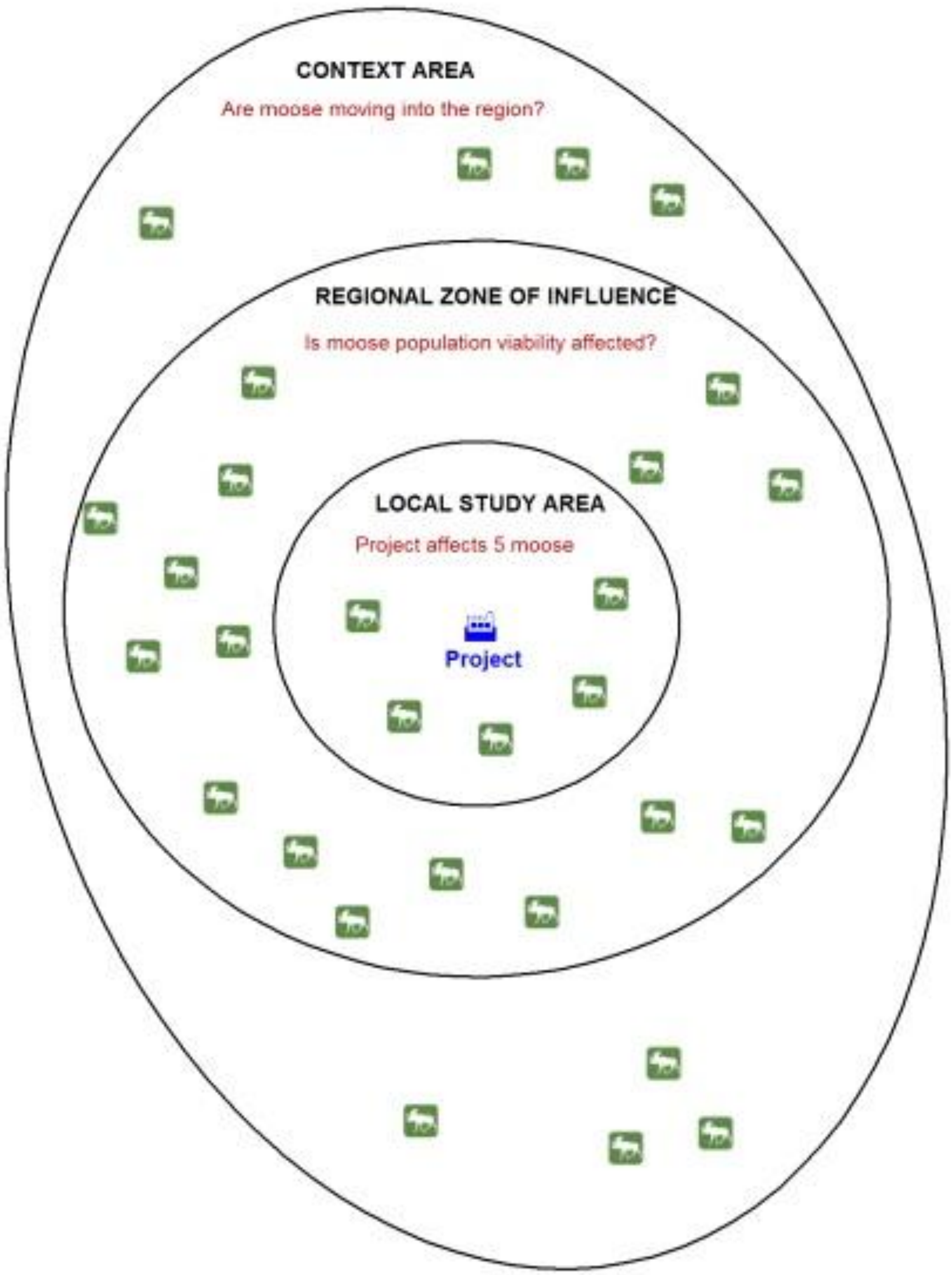


Figure 2-6: Nested study area methodology for a hypothetical project

2.5.2.2 Practical Steps to Determine Regional Study Area Boundaries

2.5.2.2.1 Background

Two of the key spatial scoping questions to be answered when terrestrial ecosystem health is the primary focus of the assessment are:

- What is the appropriate ecosystem level to evaluate ecosystem health?
- How are the spatial boundaries for the ecosystem level appropriate for ecosystem health evaluation delineated for a specific project?

Determining regional study areas separately for each VEC and supporting topic is appropriate when the question of interest is an ecosystem component. Does this change when the question of interest is holistic, that is, how is ecosystem health affected?

Conclusions from hierarchy, causal and systems theory (e.g., Rowe 1961; Cook and Campbell 1979; Allen and Starr 1982; Saris and Stronkhorst 1984; Allen et al. 1987; King 1993) suggest that the region ecosystem level (Figure 2-1) is the appropriate level to evaluate ecosystem health (Miller and Ehnes 2000). This is the ecosystem level that is large enough to capture the characteristic ecological patterns and processes for the broader area that a project is located in. In a relatively pristine area, process rates and ecosystem functions in the regional ecosystem are presumed to be occurring within their ranges of natural variability. Human projects and activities are ecologically sustainable when ecosystem functions are maintained within those ranges of natural variability. This conceptual approach is illustrated in Figure 2-7.

Wildfire is the keystone driver in the Manitoba boreal biome. A noteworthy characteristic of an area that is sufficiently large to support the regional fire regime would be the maintenance of relatively stable inland habitat composition in a shifting habitat mosaic over the century time frame (*i.e.*, period relevant for the life spans of species and where climate change is relatively small). In other words, the region should be sufficiently large so that one fire would not dramatically alter the proportions of any habitat type or the age class distribution of inland vegetation. Exceptions could occur if a fire larger than previously experienced were to occur or if a single fire or successive fires coincidentally extirpated a regionally rare habitat type. Another noteworthy characteristic of such a region is that it should be sufficiently large to support populations for most of the resident wildlife species (some species such as wolverine have extremely large population home ranges) since the resident species are adapted to cope with frequent large fires through various strategies. For example, many boreal plant species regenerate in situ by sprouting from roots or animals shift their home ranges to other places in the region (*e.g.*, an animal species that uses mature forest moving from a recently burned area to another area where the forest has shifted from the young to the mature age class).

Two possible approaches to establishing region size using the wildfire regime are statistical fire frequency distributions and rules of thumb. In the statistical fire frequency distribution approach, the region size is expanded until the age class distribution of the forest approximates a Weibull or a negative exponential distribution. In theory, the general shape of an age class distribution for the final geographic extents will be relatively stable over time, all other things being equal. A drawback of the statistical fire frequency distribution approach is that it requires age data for a very large geographic area. This approach was not pursued because these data were not available for the study area and could not be obtained with a reasonable level of effort.

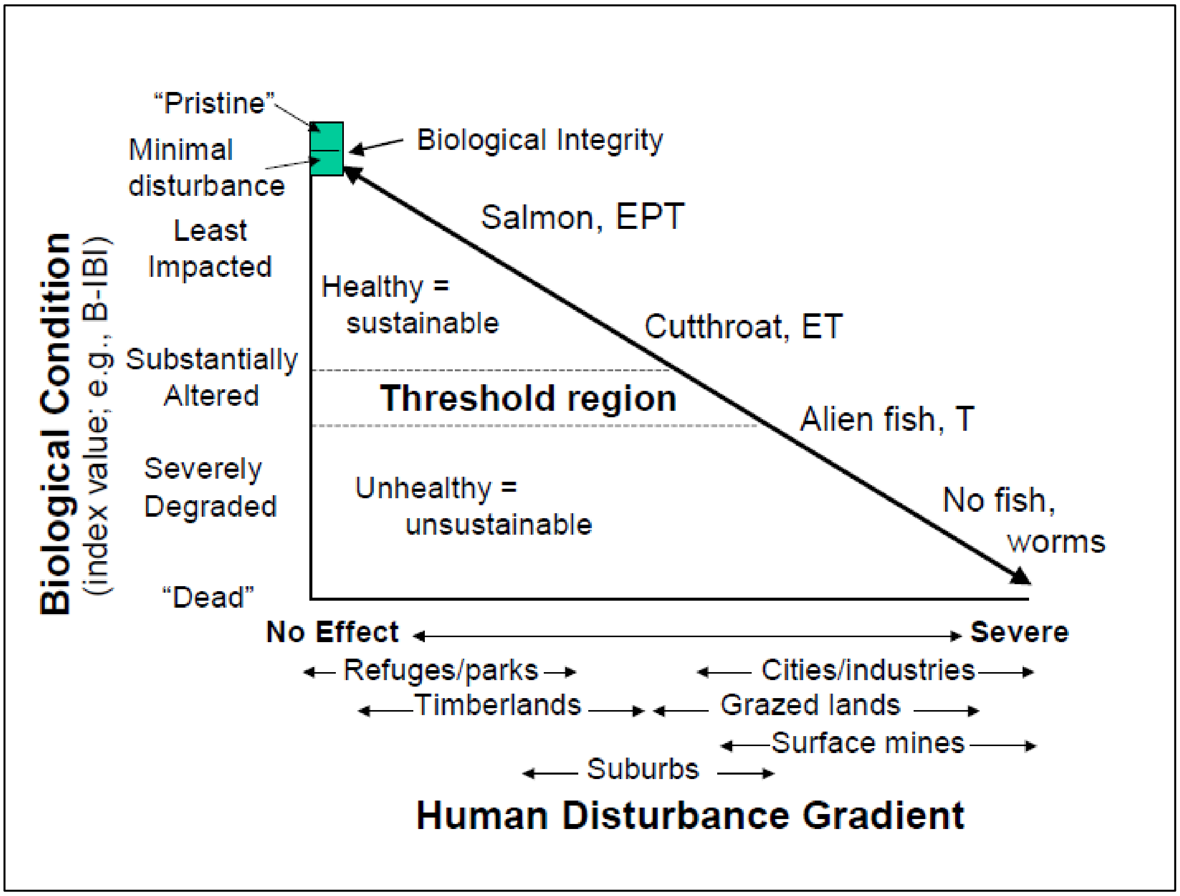


Figure 2-7: Relationship between biological condition and a hypothetical, synthetic measure of human activity, with examples (from Karr Undated)

The rule of thumb approach uses an area that is much larger than the size of the largest known wildfire. That is, an area sufficiently large that a single wildfire would not substantially alter the habitat composition of the region. There is no generally accepted rule of thumb for what constitutes an area that is much larger than the size of the largest known fire. An important consideration for region size determination, given that the region is used to assess the significance of a project's effects, is that the region not be so large that it is impossible or very difficult for a significant effect to occur. For this reason, a criterion used when determining region size was to select the minimum size required to support a relatively stable shifting habitat mosaic.

The objective used to determine study region size for a project effects assessment is analogous to that used to establish ecological reserves that maintain natural functioning ecosystems. Baker (1992) argues that reserves should be at least several times larger than the maximum disturbance size typical of the region. Johnson and Gutsell (1994) state that an area three times larger than the largest historic fire is of limited use for characterizing the wildfire regime. Mathematically, an area ten times larger than the largest fire would be adequate to absorb the effects of the largest fire in the sense that the proportions of the habitat types and age classes would generally not change dramatically. An exception would be the situation where all of a particular habitat type is concentrated in one location and all of it is burned in one or closely sequenced wildfires.

2.5.2.2.2 Methods

The region size rule of thumb selected for the Keeyask and Conawapa terrestrial habitat and ecosystems studies was that the region should be approximately ten times larger than the largest historic fire during the last century, recognizing that the application of this rule would be limited by available fire history data. In a region of this size, it is anticipated that it is unlikely that all occurrences of a particular plant species or habitat type would be burned even by the largest historic fire.

Study area delineation for the terrestrial ecosystem assessment began by identifying the boundaries of the region level ecosystem relevant for each project (*i.e.*, the regional ecosystem). Since wildfire and climate are the keystone drivers for variability in region level ecosystem functions over the century time frame in the boreal biome of central Canada, the first step was to determine the size and boundaries for an area surrounding each project that was sufficiently large to support the regional fire regime.

Surface material deposition mode changed considerably in the area northeast of Gillam (Map 2-1). Deposition mode to the southwest of Gillam was predominantly lacustrine whereas it was marine to the southeast (Nielsen et al. 1981). These differences were also quite apparent in the Soil Landscapes of Canada (SLC; Ecological Stratification Working Group 1996) mapping (Map 2-2), which also included information on peat development. The boundary between these two surface material regions also roughly coincided with two different climatic regions (Ecoregions Working Group 1989). Because surficial material composition and climate are key drivers for fire regimes, this also implied that there were different fire regimes in the regions on either side of the boundary line shown in Map 2-1. The most influential drivers for wildfire regime indicated a non-overlapping boundary between the regions on either side of the boundary line shown in Map 2-1. In this section, the region to the southwest is referred to as the Keeyask area while the region to the northeast is the Conawapa area.

Separate fire regime analyses were completed for the Keeyask and Conawapa areas.

Fire history data to determine the largest historic fire for the Keeyask and Conawapa areas were compiled from several sources including terrestrial habitat mapping, government datasets and satellite imagery.

Manitoba Conservation periodically produces a fire history dataset for all of Manitoba in GIS format (e.g., Manitoba Conservation 2010). The Canadian Forest Service has created the Canadian Large Fire Database (Stocks *et al.* 2003), which consists of database records with coordinates for a single point in each burn. At the time the region delineation analysis was completed, these records were available for the 1960 to 1999 period from the Canadian large fire database and for the 1976 to 2006 period from Manitoba Conservation.

Environmental impact assessment studies contributed additional, and in some cases, more detailed fire history information. Recent burns for Study Zone 4 were mapped as a component of the terrestrial habitat mapping (Section 6.2.2). Outside of this area and for older burns, composites created from Landsat 5 and Landsat 7 satellite imagery were used to verify the presence of a burn and its boundaries. Although coarser resolution, the Landsat 5 were helpful in confirming the presence of older burns since they were available from 1984 onward. However, due to the mapping scale and the nature of satellite data, they were only adequate to coarsely map boundaries. A limitation was that smaller areas that fires skipped over and left unburned by a fire were not detected thereby inflating burn size.

Once the approximate region size was determined from the largest historic burn, region boundaries were delineated by expanding outward from the project footprint over an ecologically homogenous area until the target region size was reached. The criteria for defining ecological homogeneity were the key controlling factors for the natural wildfire regime, which are climate and landscape level manifestations of surface materials, groundwater, surface water and topography (see Section 2.2). Different wildfire regimes are expected for large areas that have substantially different climate, dominant surface materials (*e.g.*, bedrock versus fen) or proportions of large waterbodies.

The polygons from SLC were used as the building blocks to create the Keeyask and Conawapa regions. SLC uses climate and landscape level manifestations of surface materials, groundwater, surface water and topography to subdivide Manitoba into relatively homogenous ecological units. As noted above, climate and surface materials are the key controlling factors for spatial differences in fire regimes.

To guide the selection of adjacent SLC polygons for the Keeyask region, the Project Footprint and PR 280 between Thompson and Gillam were buffered to produce a polygon that was approximately 12,000 km^2 in area, which was the target region size. The Keeyask region was formed by starting with the SLC polygons that overlapped the Project Footprint and PR 280 between Thompson and Gillam. Adjacent SLC polygons to these ones were added iteratively until the total area was large enough to meet the target size. For SLC polygons that were much too large to be included in their entirety, watershed and surface material polygon boundaries were used to truncate distant portions of these SLC polygons. The peripheral portions of SLC polygons were removed where surface materials were substantially different than the majority of the region. If area recalculations indicated that further reductions were still required, the Project Footprint buffers were used to make the final reduction.

2.5.2.2.3 Results

Fire history records indicated that the largest fire in the Keeyask Generation Project area during the 1960 to 2006 period was 1,160 km^2. On this basis, it was determined that the Keeyask region should be approximately 12,000 km^2 in size (keeping in mind the limitations of the data which include missing burned area and missing burns for the earlier portion of the study period).

Likewise, preliminary data indicated that the largest fire in the Conawapa Generation Project area for the 1960 to 2006 period was approximately 700 km^2 (second largest fire was 440 km^2) On this basis, the Conawapa terrestrial region should be approximately 7,000 km^2 in size.

As a cross-check against the region sizes derived from this approach, studies addressing one or more aspects of how minimum size contributes to ecosystem functioning or minimum ecological reserve size have derived values that range from approximately 2,000 km^2 to over 20,000 km^2, with most including ranges that exceed 10,000 km^2 (e.g. Baker 1992; Gurd *et al*. 2001; Ehnes 2000; Miller and Ehnes 2000; Rodrigues and Gaston 2001; Leroux *et al*. 2007). Minimum values vary with location in the boreal biome and the ecological attribute or attributes used to determine minimum size. The literature suggests that 10,000 km^2 is probably the minimum area needed to support a natural, boreal wildfire disturbance regime throughout much of the North American boreal shield (Ehnes 2011).

Map 2-3 shows the Keeyask region boundaries as delineated using the methods described in the previous section.

2.5.3 Key Topic Temporal Scoping

Temporal scope was determined separately for each key topic based on potential pathways of Project effects, including where these interactions could overlap with other past, current and reasonably foreseeable future projects. An important consideration for temporal scoping was the time required for key topic indicators to return to pre-disturbance conditions. This was closely related to life cycle length for animal key topics and the length of the natural post-disturbance recovery cycle for habitat and ecosystem key topics. Where potential Project effects differed by season (*e.g.*, nesting or calving periods) or by Project phase (*e.g.*, construction, operation), these were separated in the assessment.

In general, the temporal scope for each key topic was as follows:

- For historical conditions, as far into the past as needed to describe historical conditions and trends, subject to the availability of relevant historical information;
- For current conditions, the 2001 to 2011 period, which is when the majority of the studies were conducted; and,
- For future with and without the Project conditions, as far into the future as needed to capture potential Project effects, but no less than 100 years after Project operation commences since this is the assumed life of the Project.

2.5.4 <u>Benchmarks and Thresholds</u>

Currently there are no regulatory or generally accepted scientific thresholds or benchmarks for any of the selected VECs or supporting topics. Regulatory thresholds or benchmarks may be developed in the future for plants that are listed as endangered or threatened by the federal Species At Risk Act.

Given the lack of regulatory thresholds and generally accepted scientific standards specific to a key topic, the benchmarks used to assess Project effects varied depending on the key topic and included one or more of the following:

- Principles or recommendations from federal or Provincial policies and guidelines;
- Quantitative values or qualitative conditions proposed in the scientific literature;
- Conditions in areas relatively unaffected by human development;
- The range of natural variability;
- Comparison to conditions that existed in the past (i.e., has the key topic already experienced major stress or declines from events that occurred in the past?);
- Relative degree of change from current conditions; and/or
- Relative degree of change from relatively natural conditions.

2.6 METHODS

2.6.1 Overview

This section describes methods that were fundamental to all of the studies.

2.6.2 Ecological Zonation

Section 2.1 explained how substantial differences in the rates or frequencies of change for the key ecosystem drivers facilitated the spatial delineation of a terrestrial ecosystem hierarchy. For a particular key topic, differences in dominant drivers also strongly influenced the types of contextual information assembled, how field studies were designed and how field data were analyzed. Consequently, major ecological zones determined by major differences in the nature of the most influential drivers were used to structure the terrestrial ecosystems and habitat studies.

Wetlands and uplands were the two major types of terrestrial ecosystems. Wetlands are land areas where periodic or prolonged water saturation at or near the soil surface shapes ecosystem patterns and processes (National Wetlands Working Group 1997). Uplands were all land areas that were not wetlands. As is the case throughout Manitoba's boreal forest, large fires were the dominant natural driver (*i.e.*, controlling factor) in study area uplands. Groundwater, surface water and water nutrient regimes are the key drivers in most wetlands, and among the driving factors in the remaining ones (Keddy 2010).

According to hydrological connections criteria (National Wetlands Working Group 1997), the two major types of wetlands in the Keeyask regional ecosystem were shoreline and inland wetlands. Shoreline wetlands were located along the shorelines of a waterbody (*i.e.*, surface water areas larger than 0.5 ha) while inland wetlands were all remaining wetlands. The dominant drivers for inland wetlands were depth to groundwater and wildfire whereas water level fluctuations, water flows and waves were the dominant drivers for shoreline wetlands. Ice scouring was also important for Nelson River shoreline wetlands.

Keeyask terrestrial habitat and ecosystems were classified into three major ecological zones referred to as upland, inland wetland and shore zone (illustrated in Photo 2-1; note that only shoreline wetland portion of shore zone is labeled) because their dominant drivers, or controlling factors, were dramatically different. Dominant drivers were critical to understanding ecosystem dynamics and predicting potential Project effects.

At any given shoreline location, different plant species are typically arranged into bands that reflect a transition in the typical range of growing season water depths (Hellsten 2000; Cronk and Fennessy 2001; Keddy 2010; see Photo 2-2 for a Keeyask region example). To capture the strong influence that the water regime has on shoreline wetland ecosystems, the shore zone was subdivided into water depth duration zones (*i.e.*, littoral, lower beach, upper beach, inland edge and inland) using the number of days that growing season water depths exist over a particular depth range. Photo 2-2 illustrates the water depth duration zones and the dominant type of vegetation that is typically found within each duration zone. The shore zone also included areas where ice scouring extended into the upland ecological zone. It should be noted that some authors refer to the inland edge as the riparian zone.

Photo 2-2 also shows the wetland classes used to map Keeyask wetlands (see Section 6.2 for definitions of the wetland classes). Although water depth duration zone, dominant vegetation type and wetland class were strongly associated with each other, distinctions in how these attributes were distributed within the shore zone will be explained below.

An additional, higher level of ecological zonation occurred in the Conawapa region due to the high steep banks along the Nelson River and adjoining ravines. Plateau, ravine and the Nelson River bank above the shore zone were the three major upland ecological zones found in the Conawapa region. The plateau was exposed to much higher fire frequency and severity and higher winter wind abrasion than the ravines and the Nelson River banks. Nelson River banks were generally steeper, more exposed to wind and exhibited a higher rate of mass slumping than the ravines. Partial protection from fire and wind contributes to the higher biomass and plant diversity found in ravines.

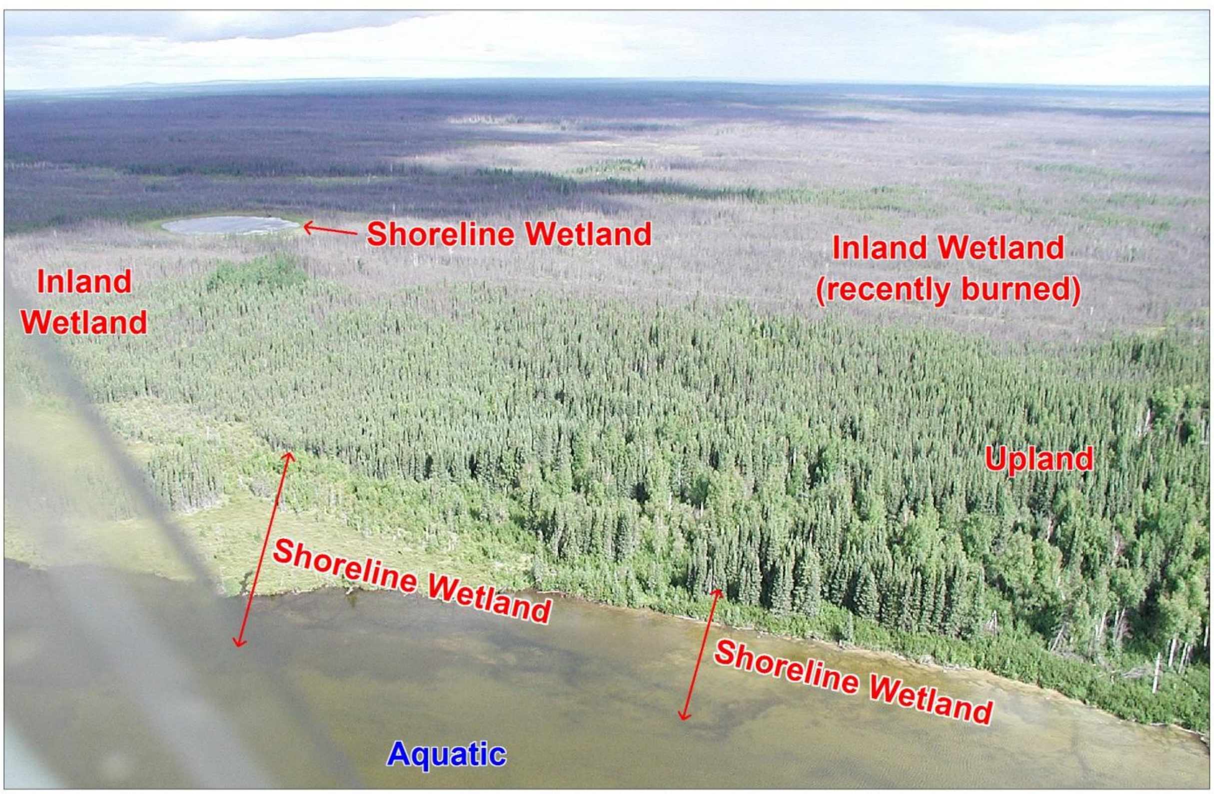


Photo 2-1: Broad ecological zones in the LNR region

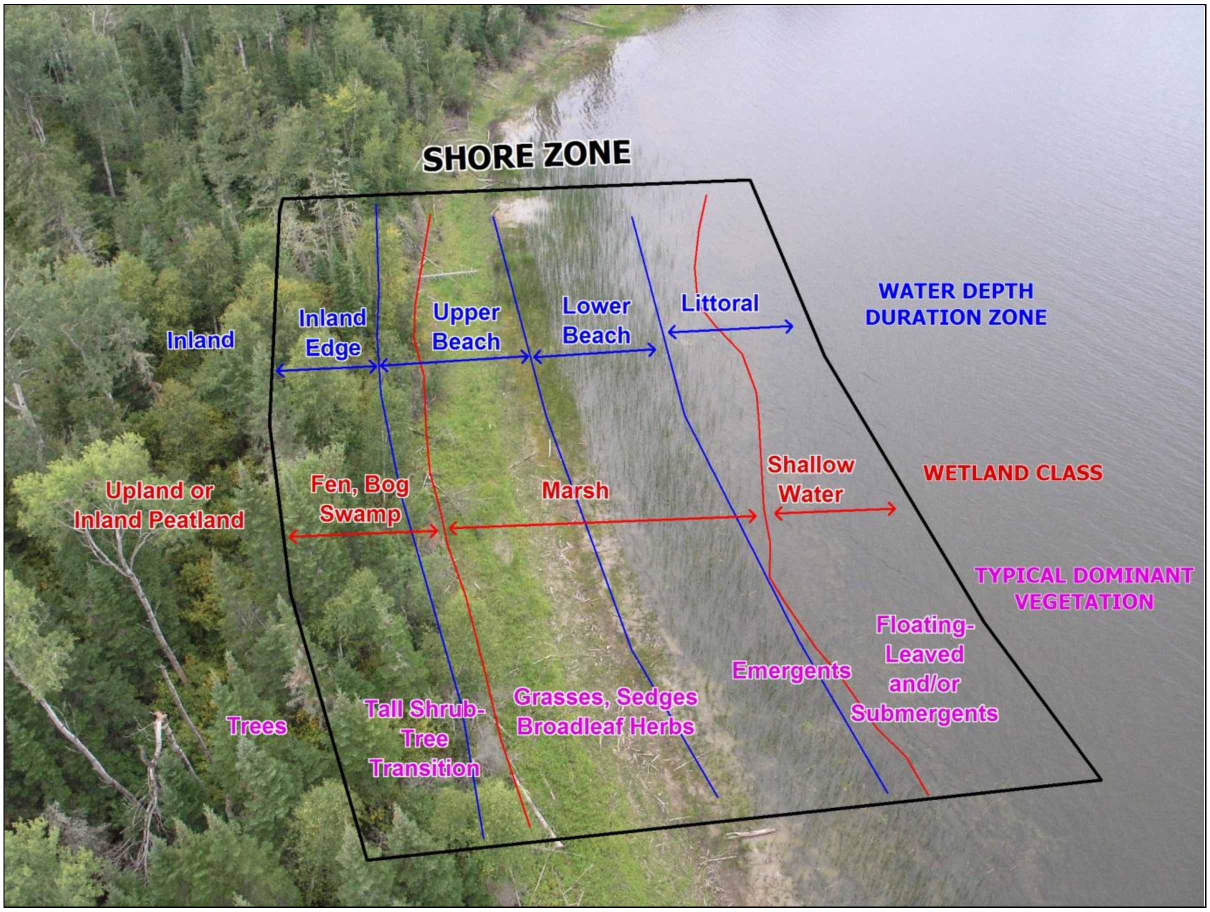


Photo 2-2: Photo illustrating shore zone water depth duration zones, vegetation bands and wetland classes in an off-system waterbody

2.6.3 Study Areas

Section 2.5.2 described the approach to spatial scoping for the Keeyask Generation Project key topics. In summary, each terrestrial VEC and key supporting topic had its own set of nested study areas referred to as the local study area, regional study area and context area. The local study area captured the potential zone of Project influence on individuals in the case of species and individual elements in the case of non-species topics. The regional study area captured the area needed to assess how local effects were expected to affect population viability in the case of species or the regional manifestation of the attribute for non-species key topics. The context area provided control for conditions or factors that could confound the interpretation of information, such as animals moving into the regional study area due to unusual conditions in the surrounding area.

Table 2-5 identifies the primary determinants of terrestrial study zone size. Study Zone 1 was the combined Project Footprint during construction and operation, including areas that are unlikely to be used and before considering mitigation, habitat rehabilitation and natural habitat regeneration.

Study Zone 2 boundaries were defined by the Project's maximum potential local zone of influence on terrestrial habitat composition, which were delineated as a 150 m buffer of Study Zone 1. Since Study Zone 2 was the maximum potential extent of altered habitat composition, this zone was used as the Terrestrial Habitat Local Study Area.

Study Zone 3 boundaries, which reflected the Project's maximum potential local zone of influence on landscape elements, were delineated as a 1,150 m buffer of Study Zone 1. Study Zone 3 was used as the regional study area for wildlife species with the smallest population home range sizes (*e.g.*, frogs, mice) and the local study area for species with small to moderate sized population home ranges (*e.g.*, olive-sided flycatcher, beaver).

Study Zone 4 was large enough to capture a repeating sequence of landscape types. Study Zone 4 was used as the regional study area for wildlife species with small to moderate sized population home ranges and as the local study area for species with large individual home range sizes.

Study Zone 5 was an area surrounding the Project that was large enough to capture a region level ecosystem. A region level ecosystem is a relatively homogenous area in terms of its ecological context (e.g., climate, surface materials) that was large enough to capture the populations of most of the resident wildlife species and the key ecological processes operating at the regional ecosystem level (such as the fire regime). In practical terms, the regional study area size was determined such that it was large enough to maintain a relatively stable habitat composition in response to the natural fire regime (Section 2.5.2.2). In other words, one large fire was unlikely to substantially change the proportion of any habitat type, thereby providing alternative habitat for species to move to when large fires occur.

An important consideration when delineating a regional study area is that it be large enough to capture the populations or regional ecosystem attributes of interest but not so large that it is virtually impossible for most projects to have significant effects. Another important consideration is that the regional study area size and boundaries are ecologically relevant for the topics being examined. Due to the manner in which it was derived, the regional study area selected for a key topic was also used as its cumulative effects assessment area.

Study Zone 6 was the area needed to characterize the fire regime. This zone was also used as the regional study area for wildlife species with very large population home ranges.

Table 2-5: Primary determinants for sizes of terrestrial study zones

Study Zone	Primary Determinant for Size	Size (hectares) [1]	
		Total	Land
1	Project Footprint	13,010	7,591
2	Potential local zone of influence on habitat (Terrestrial Habitat Local Study Area)	18,689	13,043
3	Potential local zone of influence on landscape elements (regional study area for species with small population home ranges, local study area for species with small to moderate population home ranges)	41,996	33,339
4	Area large enough to capture a repeating sequence of landscape types (regional study area for species with small to moderate population home ranges, local study area for species with large individual home ranges)	221,509	167,255
5	Area large enough to support the key boreal ecological processes and the population home ranges for most of the resident wildlife species	1,420,000	1,240,000
6	Area needed to fully characterize the fire regime	3,050,000	2,700,000

Notes: [1] Each of the study zones includes the smaller zones nested within it.

For most of the key topics, the ecologically appropriate local and regional study areas and context area were sufficiently similar that they were selected from six nested geographic areas referred to as the study zones. Using a common set of study zones for the key topic study areas facilitated linking results from different key topics. For example, habitat information developed for the terrestrial habitat supporting topic could be used for the terrestrial plant and wildlife assessments.

Map 2-3 shows the common study zones used for the Keeyask Generation Project (the Project) studies. Table 2-6 indicates which of the study zones were used as the local and regional study areas for the Keeyask terrestrial habitat, ecosystem and plant VECs and supporting topics. These same study zones were ultimately also used for most of the wildlife VECs and supporting topics.

The appropriate regional study areas were the same for six of the eight terrestrial habitat, ecosystems and plant VECs and supporting topics, reinforcing the notion that a single regional study area corresponding with the region ecosystem level in Figure 2-1 is appropriate for evaluating changes to ecosystem health. Consequently, this report refers to Study Zones 2 and 5 as the Local and Regional Study Areas, respectively, when discussing the Keeyask Project.

Table 2-6: Study zones from Map 2-3 that are used as the local and regional study areas for each of the Keeyask valued environmental components (bolded) and supporting topics for terrestrial ecosystems, habitat and plants

Report Section and Topic	Study Zone in Map 2-3				
	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Terrestrial Ecosystems and Habitat					
Intactness		LSA		RSA	
Fire regime		LSA			RSA
Terrestrial habitat	LSA			RSA	
Ecosystem diversity	LSA			RSA	
Soil quantity and quality	LSA			RSA	
Wetland function	LSA			RSA	
Terrestrial Plants					
Priority plants	LSA			RSA	
Invasive plants	LSA			RSA	

2.6.4 Proxy and Benchmark Areas

Two other types of study areas were developed for the terrestrial habitat and ecosystem studies. These were the proxy and benchmark study areas. Proxy areas were ecologically comparable areas that have already been exposed to impacts similar to those expected for the Project and the Conawapa Generation Project. The four proxy areas used to indicate the likely effects of flooding and water regulation on terrestrial ecosystems were Stephens Lake (*i.e.*, the reservoir for the Kettle generating station), Notigi reservoir, Wuskwatim Lake and Long Spruce reservoir. The terrestrial ecosystems assessments relied most heavily on Stephens Lake information because it was immediately downstream of the proposed Keeyask reservoir, was the most ecologically comparable proxy area and had the best time series of large-scale historical aerial photography.

Proxy areas for vegetation and soil recovery in cleared and excavated areas were selected from borrow areas developed for PR 280 and for the Kettle, Limestone and Long Spruce generating stations.

Benchmark areas, which were areas relatively unaffected by human development, were used to improve our understanding of natural, local ecosystem patterns and relationships. For example, off-system shoreline wetlands and portions of the Fox and Hayes Rivers were used to improve the understanding of which soil associations were favored by the plant species that grow on river shelves. Ecological information from benchmark areas was used for a number of other purposes such as recommending mitigation measures. Benchmark areas were not required for uplands and inland peatlands since most of Study Zone 6 has been relatively unaffected by large-scale human activities other than global change.

2.6.5 Habitat as a Proxy for Ecosystems

Two practical requirements for ecosystem study and analysis are ecosystem mapping and ecosystem descriptions. Habitat types and habitat mapping are often used as proxies for ecosystem types and ecosystem mapping (*e.g.*, Leitão *et al.* 2006; Noss *et al*. 2009).

Mapping and describing the visible ecosystem attributes that were not mobile (*e.g.*, vegetation, soils, surface water, topography, most recent disturbance type), and the disturbance regime associated with the location, corresponded with the definition for mapped terrestrial habitat. Mapped habitat was used as a proxy for stand level ecosystems because habitat includes most of the major ecosystem components, biomass and controlling factors. Mapped habitat was also the basis for measuring plant and wildlife habitat availability.

2.6.6 Habitat Classification and Mapping

A key broad objective of the terrestrial habitat and ecosystems studies was to develop integrated site and stand level hierarchical habitat classification systems. Among other things, the site level classification was used to classify plots into habitat types while the stand level classification was used for habitat mapping.

Reliable predictions of potential project effects on plants, habitat and ecosystems depend on an adequate understanding of local relationships between each of the components of habitat (e.g., vegetation, soils, permafrost, ground water) and between the factors that have a substantial influence on ecosystem composition, structure and dynamics (e.g., wildfire, water regime). One of the practical implementations of this understanding in a project effects assessment is a classification system that groups sample locations and map polygons into an ecologically meaningful classification system that can be linked to potential pathways of project effects. Consequently, site and stand level classification systems that reflected substantial differences in habitat composition and the factors that strongly influence ecosystem composition, structure and dynamics were developed for the project studies and effects assessments.

The dominant influences on habitat composition and ecosystem composition, structure and dynamics in the boreal region are ecosite type, disturbance type, time since stand replacing disturbance and climate (see Section 4.2). Ecosite type is a classification of soil, surficial material, surface water, groundwater and permafrost conditions that are associated with substantial differences in vegetation composition and/or structure.

A preliminary site level ecosite classification for use in the project studies, which was developed from a large number of plots sampled throughout the Manitoba Boreal Shield (Ehnes 1998, 2003; ECOSTEM and Calyx 2003), was adapted for field studies in the LNR region. Adaptations to the preliminary classification were made after each of the first few field seasons based on data collected to date. In 2009, the final LNR region classification was developed from project field data collected to date.

Plot data was the primary source of information used to improve our understanding of local ecological relationships and to develop the site level habitat classification. The stand level hierarchical habitat classification was ultimately developed from the site level habitat classification, the observed plot level habitat relationships, the observed range of vegetation and ecosite types in the preliminary habitat mapping, the Canadian Wetland Classification System (National Wetlands Working Group 1997) and patterns established by field data collected elsewhere in the Manitoba Boreal Shield (Ehnes 1998, 2003; ECOSTEM and Calyx 2003).

Hierarchical habitat and ecological land classifications were developed for use throughout the terrestrial habitat, ecosystems and plant assessment to provide a framework for characterizing terrestrial ecosystems and their interrelationships at multiple scales. The sequence of steps used to develop the site and stand level hierarchical habitat classification systems were:

(1) Develop a site level ecosite classification from an existing classification developed for the Manitoba Boreal Shield and the plot level field data;
(2) Develop a stand level ecosite classification by adapting the site level ecosite classification to capture all of the ecosite conditions observed in the preliminary

stand level habitat attribute mapping. To distinguish the site and stand level ecosite classifications from each other, site type refers to the site level ecosite type whereas ecosite type refers to the stand level ecosite type;

(3) Develop a site level hierarchical vegetation classification from the plot vegetation data.

(4) Develop a site level habitat classification through multivariate analyses of plant, site and environmental data from the LNR region inland habitat plots as well as the results from the site and stand level ecosite classifications. Site and other environmental data were used to determine which of the levels produced by the multivariate vegetation classification were retained and integrated with ecosite types to create the site level hierarchical habitat classification; and,

(5) Develop the stand level hierarchical habitat classification system by adapting the plot level hierarchical habitat classification system to capture the complete range of vegetation and ecosite types identified by the stand level habitat mapping.

There were some differences in the site and stand level hierarchical habitat classification systems due to several factors. First, there were differences in the scale of data collection and the type of data used to classify the plot or stand. The stand level mapping and classification was limited to those attributes that could be interpreted from air photos. It was primarily a classification based on overstorey attributes for the vegetation component. Second, the plots only represented a subset of the site level habitat types found in the LNR region because they were a sample. Since the habitat mapping is a census, the stand level habitat classification included every habitat type. Despite these differences, the site and stand level habitat classifications were designed to mirror each other to the extent appropriate for the different spatial levels. That way plot data could be used to describe the understorey and site characteristics of the stand level habitat types.

From most general to most detailed, the nested levels in the stand level habitat classification were land cover, coarse habitat, broad habitat and fine habitat. The habitat types within each classification level were combinations of vegetation type and ecosite type. Wetland habitat classes obtained from the Canadian Wetland Classification System (National Wetlands Working Group 1997) were enhanced to reflect dramatic differences in marsh water regimes along the Nelson River and between the Nelson River and off-system waterbodies.

The CWCS broadly classifies wetlands into the following classes: bog, fen, swamp, marsh and shallow open water. Bogs, fens and some swamps are peatlands. Peatlands are wetlands where organic material has accumulated on the surface because dead plant material production exceeds decomposition (National Wetlands Working Group 1997). Compared with bogs, fens have higher nutrient availability in the plant rooting zone and tend to have a water table that is closer to the surface. Swamps are tall shrub and/or treed wetlands with nutrient rich water and a water table that is generally deeper than in fens. Wetlands from all five wetland classes (National Wetlands Working Group 1988) can occur in the shore zone in the Keeyask region (Photo 2-3).

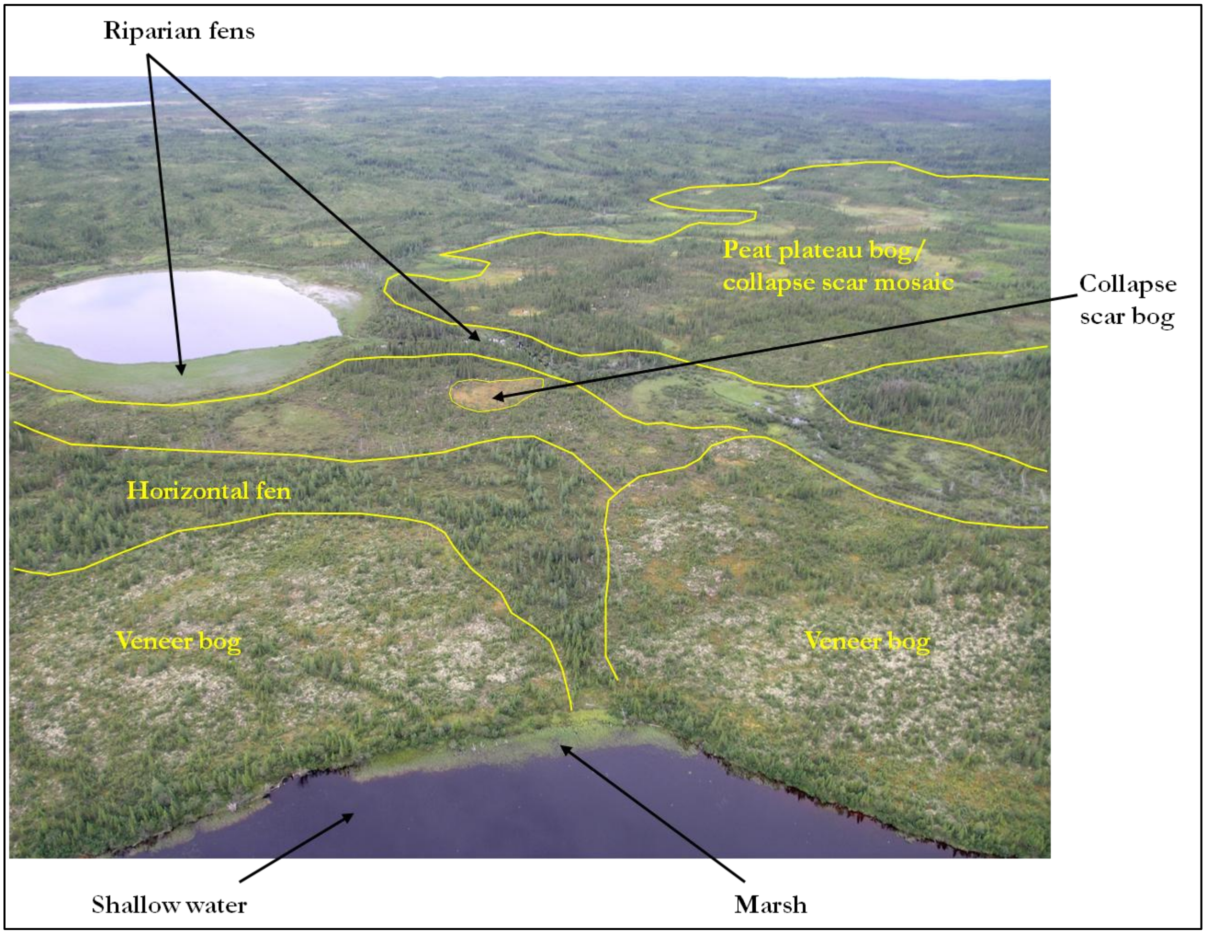


Photo 2-3: Photo from Study Zone 4 showing four of the five wetland classes

Table 2-7 provides the number of habitat types within each habitat classification level, an example of a habitat type and an example of how the classification level was used in this report. The attributes directly or indirectly used to classify and map terrestrial habitat types were vegetation type, vegetation age class (where this could be determined), ecosite type, topographic position and either recent disturbance type (*e.g.*, large fires, ice scouring) or water depth duration zone.

The characteristics of each habitat type, as well as relationships between habitat components (e.g., soils and vegetation) and drivers such as wildfire or permafrost melting, were derived from the analysis of vegetation, soil and environmental data collected at over 500 habitat plots, along over 540 km of habitat transects and at over 4,000 soil profile sample points.

Table 2-7: Hierarchical habitat classification and examples of its uses in the studies

Classification Level (number of habitat types)	Example of a Habitat Type	Examples of Uses in Terrestrial Studies	
		Habitat and Ecosystems	**Plants and Animals**
Land Cover Type (11)	Needleleaf treed on peatlands	Very general description of the study areas	Very general description of habitat use by a species
Coarse Habitat Type (23)	Black spruce treed on shallow peatland	Overview description of the study areas	Characterize the habitat preferences for a generalist species. Develop mixture types to relate to mammal 500m field transects.
Broad Habitat Type (65)	Black spruce mixture on ground ice peatland	Identify the regionally rare and uncommon habitat types	Characterize the general habitat preferences for a species
Fine Habitat Type (114)	Black spruce mixture/ Tall shrub on ground ice peatland	Distinguish the nature and degree of effects for different project linkages (e.g., groundwater versus vegetation clearing)	Identify patches satisfying specialized needs for some wildlife species (e.g., feeding habitat)

2.6.7 Information Sources

A limited amount of existing published information was available for the LNR region prior to commencement of the project studies. Most of this information originated from geotechnical investigations conducted by Manitoba Hydro and studies regarding the effects of hydroelectric development on the Nelson River aquatic environment. Reviews of the effects of hydroelectric development on the Nelson River aquatic environment (*e.g.*, Split Lake post-project environmental review; Split Lake Cree 1996a-f) provided some information on historical shoreline conditions.

Although some vegetation and soil mapping was available, its usefulness for these studies was limited because the mapping scale was too small and/or coarse, the information was outdated and/or only a small portion of the study areas was captured. For example, although Forest Resource Inventory mapping for Forest Management Unit 86 provided coverage for the southern half of the Regional Study Area, it was older mapping that very coarsely classified ecosite types and many broad habitat types. Landscapes and waterscapes of the Split Lake Resource Management Area are characterized in Cree Nation Partners Keeyask Environmental Evaluation Report

Appendix 1. Existing plant and habitat studies were not available except with regard to peatland responses to past climate change.

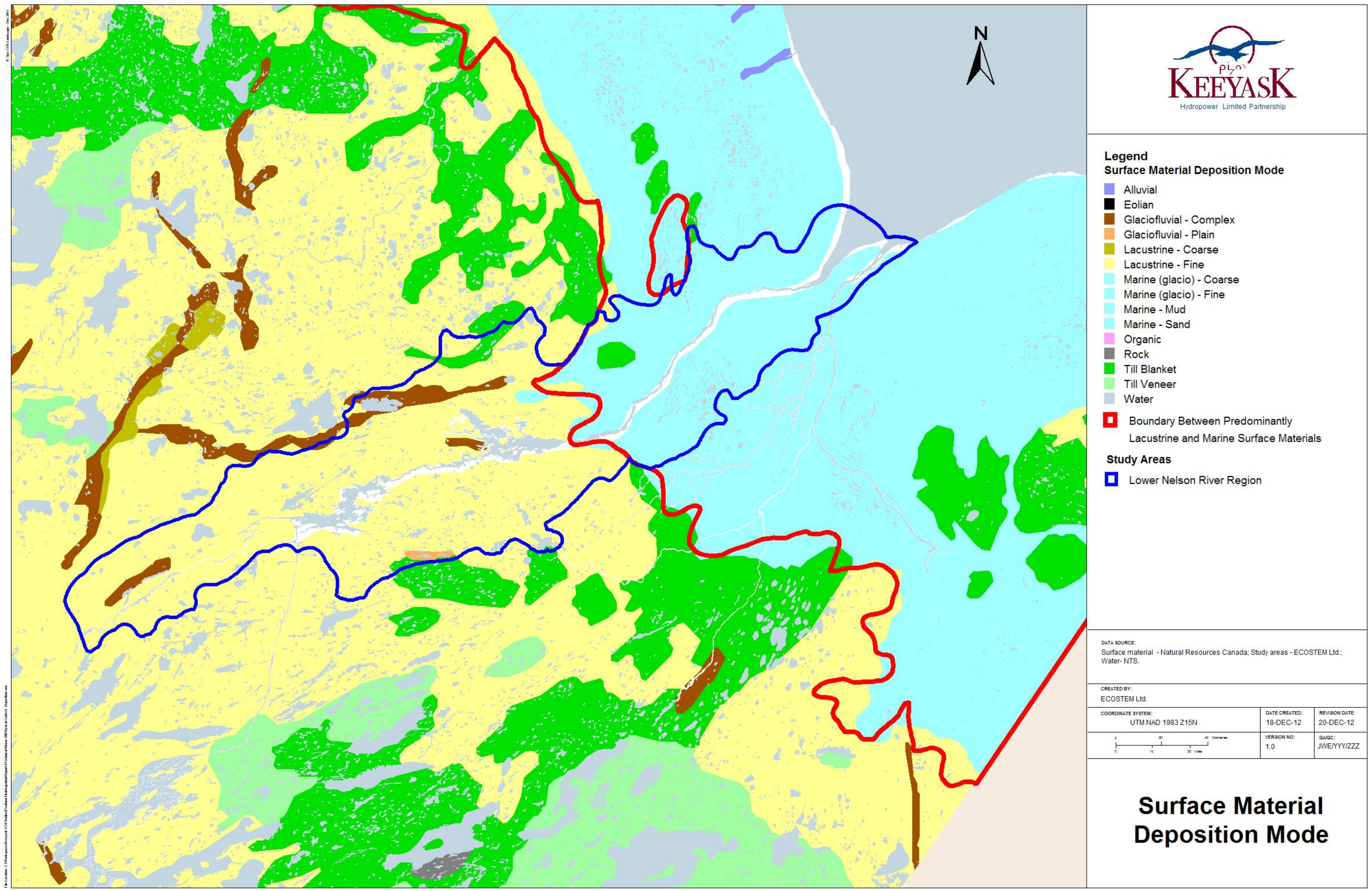
The majority of the information used for the terrestrial habitat and ecosystems assessment came from a wide range of project studies that included a large number of sample locations, which were initiated in 2001 and continued to 2011. Most field data for the Keeyask Project were collected from 2003 to 2009. While the majority of information was collected within the Regional Study Area, data collection efforts were highest in Study Zone 3 (Map 2-3) and decreased with distance from it. Stephens Lake (*i.e.*, the Kettle generating station reservoir) was the proxy area most commonly included in field studies.

Habitat mapping and habitat relationships were the two major types of information developed by project studies. Regardless of the terrestrial environment discipline, most effects predictions used models that require habitat maps as an input. Reliable predictions of potential project effects on habitat and ecosystems depended on a detailed terrestrial habitat map for the existing environment and on an adequate understanding of local relationships between each of the major habitat components (*e.g.*, vegetation, soils, permafrost, groundwater) and the factors that could have a substantial influence on ecosystem composition, structure and dynamics (*e.g.*, water regime).

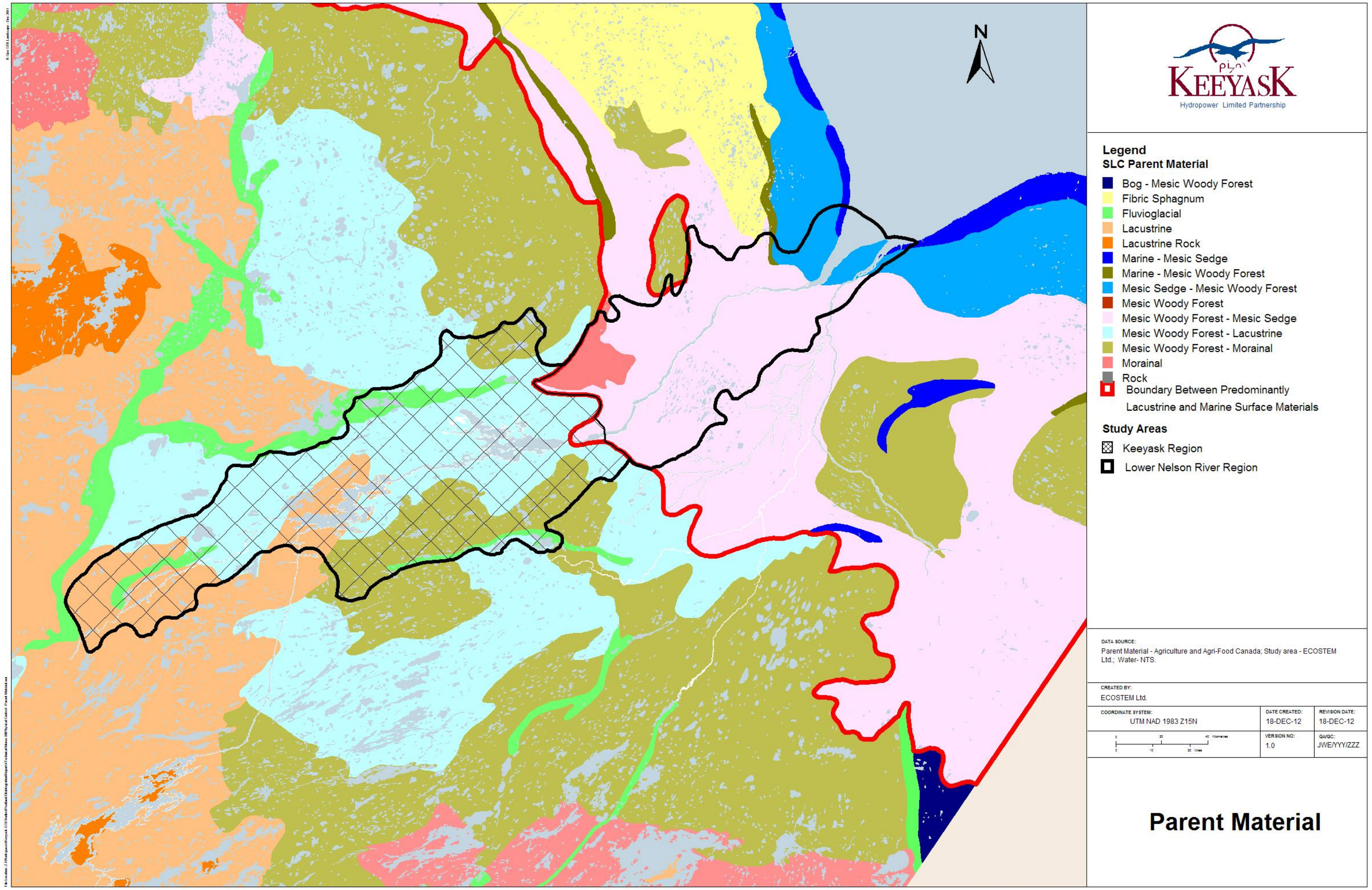
One of the practical implications of this for the habitat and ecosystems assessment was a hierarchical ecological land classification system that grouped sample locations and habitat map units into ecologically meaningful classes that could be linked to ecosystem drivers and potential pathways of project effects. Consequently, plot and stand level hierarchical habitat classification systems were developed to reflect substantial differences in habitat composition and the factors that were thought to strongly influence ecosystem composition, structure and dynamics.

Existing published information from ecologically comparable areas or areas that had experienced similar project impacts (*i.e.*, proxy areas) contributed to developing project effects predictions. Studies conducted at existing hydroelectric developments in northern Manitoba and northern Quebec, supplemented by field trips to some of these locations, were particularly helpful. Because Nelson River shoreline ecosystems have already been disrupted by human activities, field studies were also conducted in relatively pristine areas (*i.e.*, benchmark areas) that served to improve our understanding of natural ecosystems. For example, off-system lakes and portions of the Fox River were used to characterize natural shoreline wetlands, including habitat associations of shoreline wetland plant species.

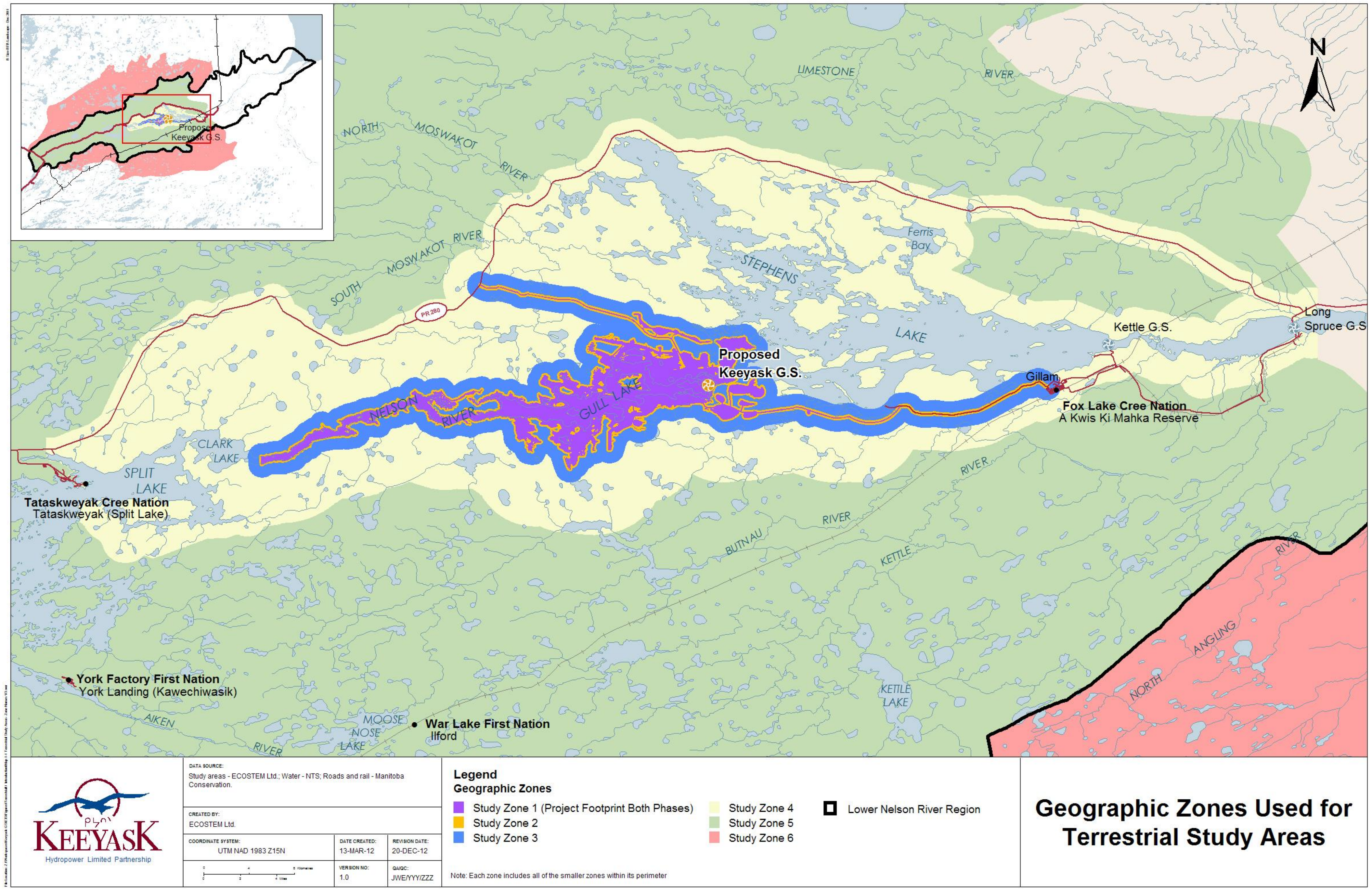
2.7 MAPS



Map 2-1: Surface materials for northeastern Manitoba from Geological Map of Manitoba



Map 2-2: Parent material for northeastern Manitoba from Soil Landscapes of Canada



Map 2-3: Geographic zones used for the Keeyask Terrestrial Study Areas

3 OVERALL STUDY DESIGN

3.1 INTRODUCTION

This section describes the overall study design for the LNR region studies.

Sampling design, analytical methods and modeling techniques for the inland studies differed from those used for shoreline wetlands due to the dramatic differences in the most influential drivers and project linkages (Section 2.6.2). For example, inland habitat data were collected in plots located in relatively homogenous portions of stands whereas shoreline wetland data were collected along transects that spanned the entire water depth gradient in the shore zone.

3.2 STUDY AREAS

The study areas used for all of the key topics were delineated using the methods described in Section 2.5.2. The Keeyask study areas were identified in Section 2.6.3.

3.3 HABITAT MAPPING

Large scale habitat mapping was completed for all of Study Zone 4 using the methods described in Section 6.2. Section 2.6.6 provides an overview of the habitat mapping approach.

3.4 HABITAT RELATIONSHIPS STUDIES

Since ecosystems are organized hierarchically (Section 2.1), many of the observed stand level patterns were the outcomes of site level processes. Consequently, site level data were the primary sources of information used to improve our understanding of local ecological relationships and to develop the site and stand level hierarchical habitat classifications. The habitat relationship studies that provided the majority of the data used to address the wide range of issues were:

- Inland habitat relationships;
- Shoreline wetland relationships;
- Peatland disintegration processes; and,
- Soil characteristics.

Sections 5.3 and 7.2 describe the methods used for these studies.

3.5 HISTORICAL CHANGE

With the exception of flooding losses, the cumulative historical change in the size of the permanent human footprint in the Regional Study Area was estimated as follows. The current human footprint was derived for Study Zone 4 from the “human infrastructure” land cover type in the stand level habitat map (Section 6.2.2). NTS maps, developer datasets (*e.g.*, Manitoba Hydro transmission lines) and satellite imagery were used for the portion of Study Zone 5 outside of Study Zone 4. A further step needed to map historical land area was to identify land areas that had been converted to aquatic areas by flooding and associated shoreline erosion. Flooding and erosion losses were estimated by comparing maps of current conditions with historical aerial photos, NTS maps, other maps and reports such as the Split Lake post-project environmental review (Split Lake Cree – Manitoba Hydro Joint Study Group 1996).

The habitat composition of historical terrestrial habitat loss and alteration from human causes could be easily determined in areas where there were pre-disturbance air photos or land cover maps. For locations outside of these areas, several assumptions were made. For linear features and smaller human footprints, it was expected that human feature had the same habitat composition as the adjacent undisturbed areas. For the remaining area, it was assumed that their historical habitat composition was similar to Study Zone 4 habitat composition.

Historical changes in peat plateau bog area in Study Zone 4 were documented by mapping changes between 1962 and 2006, as shown on large-scale stereo air photos (or between 1962 and 2003 where 2006 photography was not available). This is the longest time period where photography of a suitable scale was available for most of the reservoir area.

Historical changes in Nelson River peat shore segments were detected using large scale aerial stereo photos acquired in 1962, 2003 and 2006. Nelson River peat shoreline locations in 1962 and 2003 were compared to determine if and to what extent peat bank recession had occurred due to peatland disintegration. Photography from 2006 was used for cross-checks and to validate the mapped 2003 shoreline location. Horizontal differences in 1962 and 2003 shore locations that were less than 10 m were considered to fall within the error margin related to photo-interpretation, differences in photo scales, geo-rectification and the horizontal positional accuracy of the digital ortho imagery (DOIs).

3.6 POTENTIAL PROJECT EFFECTS

An estimation of the potential Project zone of influence on each of the Keeyask Generation Project key topics was needed to define the local study areas. The effects of LNR generation projects on vegetation, soils, individual animals and key ecological flows were expected to generally decline with distance from the areas that are physically altered by the project (i.e., the Project Footprint). To account for this pattern, the habitat and ecosystems effects assessment used different local zones of influence for each topic. These zones of influence were also used in the spatial scoping for each key topic (Section 2.5.2).

Using terrestrial habitat as an example, the zone of influence was determined as follows. Direct project effects will include loss, alteration and disturbance of habitat and ecosystems in the areas that the project directly changes physically. Direct project effects will create indirect effects, both within and surrounding these areas. That is, a project impact will have a zone of influence surrounding its physical footprint. A particular indirect effect may be several stages removed from the direct project effect. For example, clearing trees on permafrost soils will generally lead to higher soil temperatures, both within the cleared area and in adjacent areas. Vegetation clearing that creates large openings on treed peatlands with thick ground ice will generally lead to permafrost melting, followed by collapse of the soil surface to form craters, and then by the development of very wet peatland habitat and/or open water in the craters (Figure 2-3 illustrates this pathway of effects). In this situation, the direct effect on habitat is vegetation clearing, an initial indirect effect is soil warming which leads to the secondary indirect effect, permafrost melting, followed by the tertiary indirect effect, peatland surface collapse, and finally the ultimate indirect habitat effect which is conversion to very wet peatland habitat and/or open water.

Indirect project effects on vegetation, soils, animals and key ecological flows were expected to generally decline with distance from the Project Footprint. The size and nature of the indirect zone of influence will be determined by how the particular project impact interacts with the ecosystem component of interest and local conditions. For example, tree clearing in dense, mature forest on permafrost soils will have a much larger habitat zone of influence than tree clearing on a bedrock outcrop. The nature and spatial extent of indirect habitat effects will range from not measurable to conversion to aquatic areas.

4 ECOLOGICAL CONTEXT OF THE PROJECT REGION

This section provides an overview of the ecological context for the LNR region, beginning with the processes and conditions that ultimately created the existing terrestrial ecosystems and ending with those that are relevant for the temporal scope. Unless otherwise noted, descriptions of the ecological context for the LNR region are based on the LNR context area shown in Map 1-1.

4.1 OVERVIEW

The LNR region was located along the lower section of Nelson River, extending from near Thompson to Hudson Bay (Map 1-1). It was confined within 55 to 58° N and 93°30" to 98° W. The LNR region was sub-divided into the Keeyask regional study area and the Conawapa regional study area as shown in Map 1-1 using the methods described in Section 2.6.3.

Most of Keeyask Regional Study Area was located within the Boreal Shield Ecozone (Map 4-1) and the Hayes River Upland Ecoregion (Ecological Stratification Working Group 1996). There was some overlap with the Taiga Shield Ecozone and the Selwyn Lake Upland Ecoregion in the northeast and with the Churchill River Upland Ecoregion in the northwest.

Most of the preliminary Conawapa Regional Study Area was located within the Hudson plains Ecozone and the Hudson Bay Lowland Ecoregion (Ecological Stratification Working Group 1996). A portion of the northeastern end of the Regional Study Area overlapped with the Coastal Hudson Bay Lowland Ecoregion.

The LNR region area lies within the Canadian Shield. The geological overburden is estimated as being up to 30 m deep over Precambrian bedrock, which is dominated by greywache gneisses, granite gneisses and granites (Betcher et al. 1995). Multiple glaciations have deposited four till units containing cobbles and boulders, which are overlain with sands and gravels (JDMA 2012). After the last glaciation, thin layers of silts and clays were deposited on the bottom of glacial Lake Agassiz, forming varved clay and silt deposits, which can be quite thick in low-lying areas and thin or locally absent on ridges and knolls (JDMA 2012). Peat veneer and peat blanket deposits developed on the poorly drained flatlands and depressions left after Lake Agassiz drained into the Hudson Bay and the Beaufort Sea (JDMA 2012).

Overall terrain is gently sloping. Ground surface elevations range between 275 and 150 masl in the Keeyask Regional Study Area and between 150 masl and sea level in the preliminary Conawapa Regional Study Area (Smith et al. 1998). Steep sloping drumlins and glaciofluvial ridges occur throughout the Keeyask Regional Study Area where peat of varying thicknesses overlay the fine-grained glaciolacustrine clay and silt which is found on the gently sloping terrain. On gentle slopes, veneer bogs are common, with shallow to deep peat plateau bogs and fens common in depressions and potholes. Veneer bogs, peat plateau bogs and fens generally overlay clayey glaciolacustrine sediments (JDMA 2012). Terrain in the preliminary Conawapa Regional Study Area is dominated by relatively flat, low relief terrain alternating with successive ridges of raised beaches (Smith et al. 1998). Flat terrain is overlain by a complex of patterned fens and peat plateau bogs comprised of sedge and brown moss peat, and fibric sphagnum peat, respectively.

Discontinuous permafrost is typical of the study area. Melting permafrost in peat plateaus has created collapse scar formations visible across the landscape (Smith et al. 1998). Lakes of various sizes are also common across the landscape and drainage is generally towards the north and east into the Hudson Bay through the Nelson and Hayes rivers (Smith et al. 1998). Keeyask reservoir shore zones are generally characterized by relatively low bluffs and gently sloping nearshore slopes (JDMA 2012, Stantec 2012).

Organic soils derived from woody forest and sedge peat dominate the study area (Section 5.4). The Cryosolic soil order is the most common followed by the Organic and Brunisolic orders. The remaining soil orders are uncommon. Fibrisols and Mesisols are dominant great groups in the area and are generally associated with very poorly drained fens and Sphagnum bogs (Section 5.4), and become more widespread in the Conawapa Regional Study Area. Mineral and organic soils in the study area frequently contain permafrost at varying depths. Cryosolic soils are mostly found in Sphagnum bogs, and to a lesser extent, feathermoss bogs and are generally very poorly drained (Section 5.4). Permafrost activity contributes to surface topography and deeper soil layer processes.

Mineral soils tend to occur on drumlins and glaciofluvial ridges and along the Nelson River. Brunisols tend to be found on gently to strongly rolling topography and are associated with deep dry sites. Brunisols are most commonly associated with glaciolacustrine and till deposition modes and moderately well drained soils (Section 5.4). Luvisolic soils are also present within the study area, especially on nearly level terrain. Luvisols are most commonly found on rapid to moderately well drained soils developed on till or glacio-fluvial deposits (Section 5.4).

4.2 TERRESTRIAL ECOSYSTEM PROCESSES AND DRIVERS

The most influential ecosystem drivers (Section 2.2) depend on the ecosystem level (Section 2.1) of interest, which determines the relevant temporal and spatial scales (Sections 2.5.2, 2.5.3). For the boreal biome to region ecosystem levels (the millennia and centuries temporal scales), the key drivers are climate, glaciation and soil formation (Bailey 2009) because they create the surface materials, topography, fire regime and peatlands. The processes and drivers for peatland formation are of particular interest for the LNR context area because most of it is covered by peatlands.

Peatlands have developed over millennia in the LNR region, through the processes of terrestrialization and paludification. Paludification is the process whereby vegetation (primarily *Sphagnum* mosses) on mineral soils progressively creates a wetter moisture regime that eventually leads to the formation of a surface organic layer that expands laterally over time (Figure 4-1). Paludification can be initiated outside of lacustrine basins or riverine valleys in lower slope areas. In upland areas, paludification can occur in wet depressions or in areas with a moist to wet moisture regime. Paludification can progressively blanket an area in an upslope direction. Factors that currently promote paludification in new areas include climate change, geomorphological change, beaver dams or forestry practices (Mitsch and Gosselink 2000).

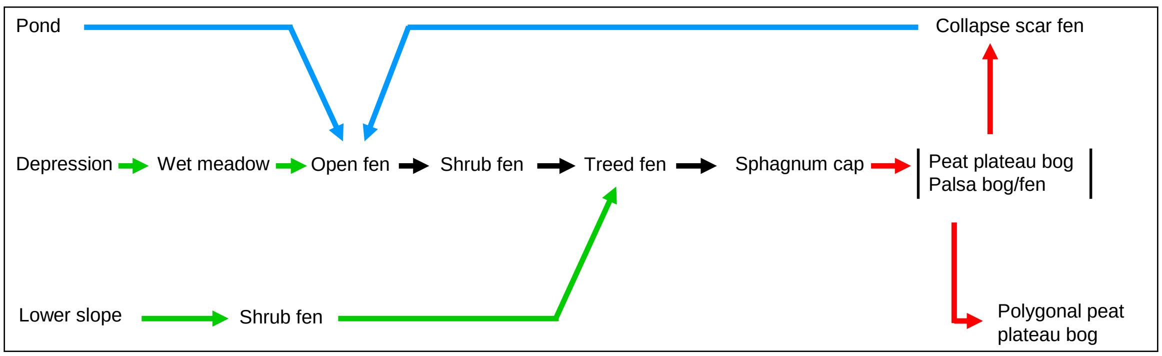


Figure 4-1: Pathways of wetland development in Northern Canada (after Zoltai et al. 1988a). Arrow legend: blue=terrestrialization; green=paludification; black=terrestrialization or paludification; red=permafrost dynamics.

Terrestrialization refers to the process whereby all or portions of a waterbody are filled in by the horizontal expansion of peat from the shore towards the center of the water body and by organic sediment deposition (Figure 4-1). A riparian peatland that was initiated through terrestrialization often expands inland and paludifies adjacent mineral ecosites.

Most inland peatland mosaics in the LNR region (e.g., Photo 2-3) are thought to be derived from a combination of terrestrialization and paludification. Paludification may or may not have been initiated by riparian terrestrialization. In the north, paludification usually commences once *Sphagnum* spp. have established. As organic material accumulates, the water table of peatlands can slowly elevate over time, causing peatland encroachment onto upland areas. The elevated water table can lead to forest flooding and eventual stunting or killing of trees (Keddy 2010).

In some shoreline wetlands (e.g., Photo 2-2), surface water level fluctuations, water flows, waves and ice scouring retard the natural tendency for terrestrialization to expand peatlands into the water. In some shoreline locations in large lakes and on the Nelson River, it appears that these counteracting factors were so strong that vegetation and peatlands were sparse or absent. For inland peatlands, the water table was typically below the surface and wildfire was a dominant driving factor.

Permafrost is an important factor in northern peatland development. Permafrost initially establishes in unfrozen peatlands in thin layers under small *Sphagnum* moss cushions (Zoltai and Tarnocai 1975) or under stands of black spruce (*Picea mariana*) (Zoltai 1972). As these pockets accumulate more permafrost, they eventually become small peat plateaus which may merge together to form peat plateau bogs (Zoltai 1972, Zoltai and Tarnocai 1975).

Typical successional pathways for peatlands in the discontinuous permafrost zone are shown in Figure 4-2. The pathways represented by connecting arrows A and C can be either a terrestrialization or paludification process. Pathway D is a permafrost aggradation process. Pathways E and G are natural permafrost degradation processes that follow climate warming or fire, respectively. Windthrow, which refers to a high wind event that blows down patches of trees, can also initiate pathway G. Pathways E and G generate thermokarst features known as collapse scars. Holocene peat plateau bog dynamics are viewed as cyclic in continental Canada (Zoltai and Tarnocai 1975, Chatwin 1981, Zoltai 1993, Englefield 1995) but this will probably end with climate warming (Camill 1999). Pathways F and I show a collapse scar redeveloping into a permafrost bog.

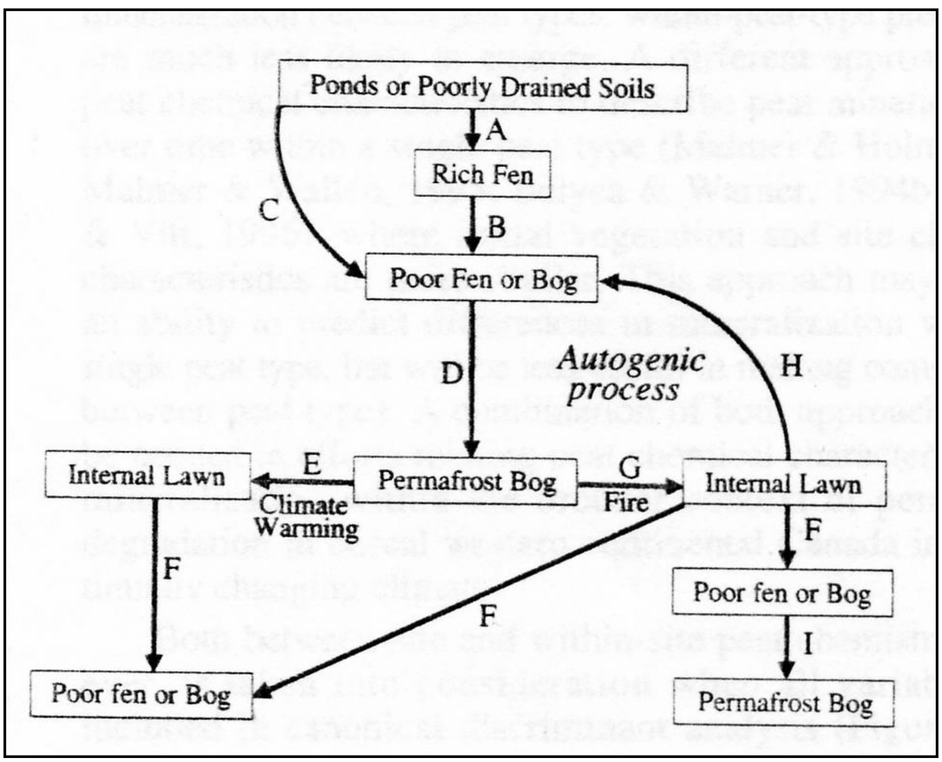


Figure 4-2: Historical development of peatlands in the discontinuous permafrost zone of boreal, Western Canada. (Source: Turetsky *et al.* 2000)

Climate is a key influence on permafrost distribution at the regional level. Wetlands began developing shortly after glacial Lake Agassiz drained. However, peatland development may have been delayed by up to 2000 years due to plant migration, unfavourable climatic conditions and/or other environmental factors (Zoltai *et al.* 1988a). It is thought that peat formation became possible in the northern part of the former Lake Agassiz basin between 4300 and 4800 years BP with the end of a warm and dry period, which had largely precluded prior peatland development (Zoltai *et al.* 1988b). Peatland initiation occurred later in the northern part of the former Lake Agassiz basin and much sooner in the Hudson Bay Lowlands.

Climate has an importance influence on the distribution and abundance of different peatland types. The southern edge of peat plateau bog distribution generally corresponds with the -1˚C isotherm (Vitt *et al.* 1994). Permafrost may have reached its maximum spatial extent during the Little Ice Age (1550-1850 AD; Turetsky *et al.* 2000).

Several studies document a reduction in the total area of permafrost peatlands since the end of the Little Ice Age (~ 150 years ago) with no evidence of subsequent aggradation (Thie 1974, Vitt *et al.* 1994, Halsey *et al.* 1995, Vitt *et al.* 2000). From aerial photography, Thie (1974) studied permafrost in peatlands at the southern edge of the discontinuous permafrost zone in an area north of Lake Winnipeg in Manitoba. Thie (1974) estimates that about 75% of the permafrost in peatlands in the study area degraded since the end of the Little Ice Age; many peat plateau bogs completely disappeared over a 20 year period (1947-1967). Over the same period, Vitt *et al.* (2000) estimate a net area loss of 9% of permafrost peatlands across boreal continental western Canada. Some locations across boreal continental Canada that once contained permafrost have had a complete melting of permafrost, moving the current southern limit of permafrost north by an average of 39 km, and in some locations, by as much as 200 km (Beilman *et al.* 2001).

Ongoing permafrost degradation and permafrost melting is thought to be a lagged response to the general warming trend that occurred at the end of the Little Ice Age (Vitt *et al.* 2000, Camill and Clark 1998). This climate change disequilibrium in permafrost melting may be attributed to the buffering capacity of local factors (*e.g.*, presence of insulating layer of *S. fuscum*) to mediate the effects of regional climate change (Camill and Clark 1998). Vitt *et al.* (2000) estimate that, of the permafrost that remains in boreal western Canada, 22% is still in disequilibrium with the climate.

The mean annual decrease in permafrost area of peatlands from western Canada appears to be around 1% or greater, while rates of permafrost retreat measured at the plateau-collapse scar edge have ranged from 0 to 2.8 m per year (Tarnocai 1972; Thie 1974; Reid 1977; Chatwin 1981; Englefield 1995; Camill and Clark 2000; Camill 2005). Camill and Clark (1998) show that the thaw rate increases linearly with mean annual temperature in Northern Manitoba, while Camill (2005) reports that thaw rates have significantly accelerated since 1950. “Current warming trends may eliminate most, if not all, peatland permafrost in the [sporadic and discontinuous permafrost] zones of Manitoba” (Camill 2005). However, it could still take centuries for permafrost peatlands to reach equilibrium with the current regional climate (Woo *et al.* 1992).

At the regional level, fire has been and remains the dominant natural driving factor shaping the habitat mosaic and ecosystem dynamics in the LNR region, which is why it is a supporting topic (Section 2.4). Although other disturbances such as windthrow or insect and disease infestations can also affect large areas elsewhere in the boreal forest, there is no evidence that stand-replacing disturbances of these types occurred in LNR region based on photo-interpretation and field surveys. Human developments and human-induced global change are the dominant human driving factors in the LNR region.

At the landscape and stand levels, research indicates that the overriding influence on boreal vegetation composition is usually stand and site level ecosite type. Of the ecosite attributes, moisture regime appears to be the most influential factor on vegetation composition (Ehnes 1998). Nutrient availability and light intensity gradients become influential when the focus narrows to variability among sites with a similar moisture regime or to temporal changes on particular sites. In contrast with the very different vegetation types created by moisture and nutrient availability gradients, wildfire typically initiates a succession of vegetation types with similar species composition. That is, boreal post-fire vegetation dynamics generally involve immediate regeneration of the vascular plants that were present prior to the fire, the rapid growth and demise of post-fire thrivers (*e.g.*, green-tongue liverwort (*Marchantia polymorpha*), Bicknell’s geranium (*Geranium bicknellii*), fireweed (*Chamerion angustifolium*)) and gradual changes in the moss and lichen community (Ehnes 1998; Ehnes 2003). Most herbaceous post-fire pioneers disappear within about ten years of the fire, leaving a group of plant species that is similar to what was there prior to fire.

Multivariate analysis of plot data from project studies confirmed that the largest differences in vegetation types were associated with dramatic differences in soil moisture, depth to groundwater and soil type (soil type is strongly influenced by moisture regime). These relative degrees of influence are demonstrated in Figure 4-3, which is from the Keeyask Regional Study Area. The habitats at the top of the hill are relatively dry. In contrast, the collapse scar bog in the lowest topographic location has no trees because there was too much water for trees to survive to maturity. Likewise, the habitat sequence in Photo 2-2 was created by large differences in depth to water table, groundwater flow and nutrient availability to plants.

Multivariate analysis of plot data also confirmed that spatial patterns in the LNR region were consistent with those reported in the scientific literature regarding the central Canadian boreal forest (Section 7.3).

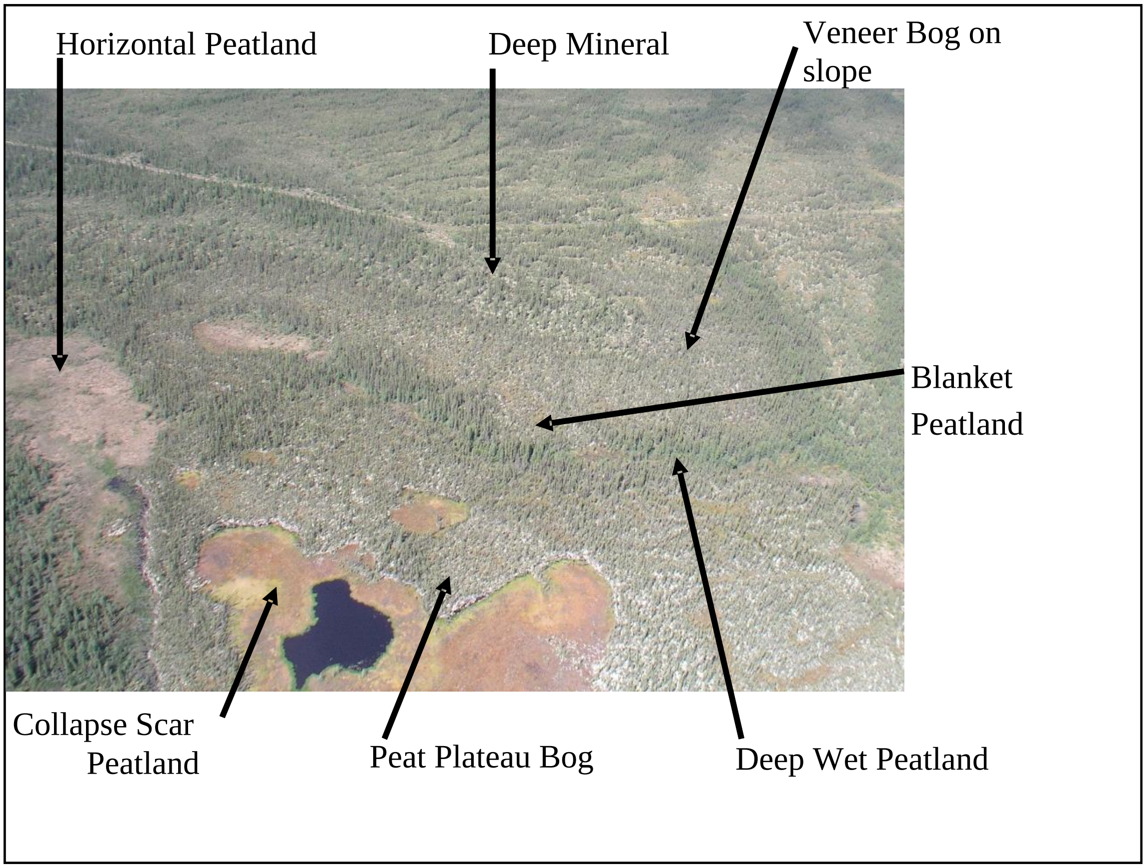


Figure 4-3: A common toposequence in the Regional Study Area, showing the sequence of ecosite types that occur when moving from a hilltop (deep mineral in the photo) to the lowest nearby elevation (Forefront)

4.3 Glacial Processes

The entire LNR region was glaciated during the glacial age. Most of the area was inundated by glacial Lake Agassiz during the ice retreat. Some portions of the area, like the lower Hudson Bay Lowland in the study area had been submerged by postglacial seas following deglaciation (Dredge 1992).

4.4 Physiography and Landform

The LNR region overlaps the Canadian Shield and Hudson Bay Lowland physiographic regions of Canada (Bostock 1970). For the Canadian Shield physiographic region, the north and northwest part of the LNR region is within the Kazan Upland Division. The southeast part of the LNR region is within the Severn Upland Division. The area extending from east of

Gillam to Hudson Bay is within the Hudson Bay Lowland. The physiographic descriptions below generally follow Klassen's (1986) descriptions of physiographic units in North-central Manitoba (Figure 4-4).

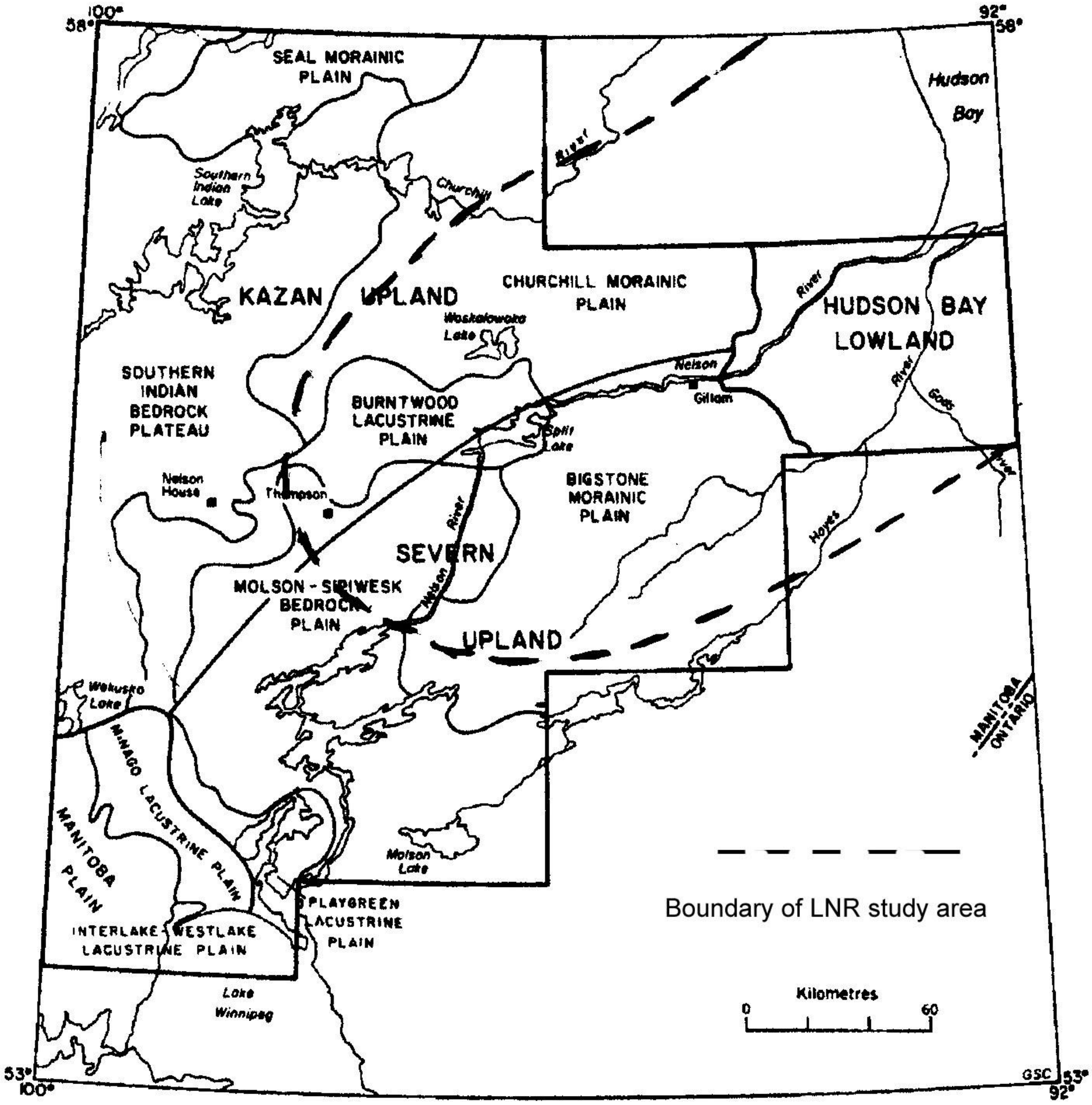


Figure 4-4: Klassen's (1986) physiographic units

4.4.1 Canadian Shield Physiographic Region

The Kazan Upland and Severn Upland portions of the LNR region are composed mainly of Precambrian granitic rocks interspersed with volcanic rocks and belts of gneisses and schists (Klassen 1986). The land surface is rolling and lake spotted, with considerable variation in relief and topography (Bostock 1970). The geological structural trends of the

Severn Upland are reflected by the alignment of large lakes roughly to the southwest, whereas on the Kazan Upland similar trends are not apparent (Klassen 1986).

The Kazan Upland Division is subdivided into the Churchill Morainic Plain and Burntwood Lacustrine Plain physiographic units. The Severn Upland is subdivided into Molson-Sipiwesk Bedrock Plain and Bigstone Morainic Plain physiographic units.

The Churchill Morainic Plain overlaps the north and northwest portions of the LNR region. In this physiographic unit, the land is nearly flat, gently irregular ground moraine with local relief generally less than 8 m. Wetlands cover the numerous shallow local depressions occurring between elevated till or clay blankets.

In the west-central portion of the LNR region that overlaps the Burntwood Lacustrine Plain, the surface is generally flat to gently irregular with local relief less than 5 m. Localized patches of hilly bedrock terrain have substantially higher relief. Bog and fen, underlain by glaciolacustrine silt and clay, are widespread.

Located in the west-central portion of the LNR region is the Molson-Sipiwesk Bedrock Plain. This is irregular to rolling bedrock plain with 8 m to 15 m of relief. Some hilly belts in the northwest portion have 15 m – 40 m of relief. Lakes are oriented southwest, which follows structure trends of bedrock.

The Bigstone Morainic Plain overlaps the south and southeastern portion of the LNR region. The plain is a great expanse of ground moraine marked by drumlins and drumloids oriented west and southwest. Terrain is gently irregular with local relief ranging from 1 m to 8 m.

4.4.2 Hudson Bay Lowland Physiographic Region

The Hudson Bay Lowland portion of the LNR region is underlain by nearly flat-lying Paleozoic carbonate rocks. It is a flat plain consisting of wetlands over a veneer of mostly marine sediments, separated from the underlying Paleozoic carbonate bedrock by thick till. Abandoned marine beach ridges are scattered throughout this physiographic region.

4.5 SURFICIAL MATERIALS

The surface materials of the LNR region were overprinted mainly with works by glaciers, lakes, and sea. The most common surficial deposits within this area are glaciolacustrine and marine (Klassen 1986). The glaciolacustrine deposits cover most of the eastern Hudson Bay Lowland, sparsely covering glaciofluvial ice contact deposits and glaciofluvial channel deposits. Morainal deposits are scattered throughout most of the region with a significant amount in the middle of the northern study area. Marine deposits cover most of the Hudson Bay Lowland portion of the study area, interspersed with alluvial deposits along rivers and occassional morainal deposits.

4.5.1 Glaciolacustrine Deposits

The thickest glaciolacustrine clay and silt deposits occur in west center of the LNR region, where it overlaps the Burntwood Lacustrine Plain. Two to three meter thick varved clays and silts are distributed throughout. In other portions of the LNR region such as the Molson-Sipiwesk Bedrock Plain, Bigstone Morainic Plain, and Churchill Morainic Plain, varved or massive clay or silt are discontinuously distributed in one to two meter thicknesses, and disrupted by hilly bedrock or till (Klassen 1986).

4.5.2 Marine Deposits

Marine deposits consist of clay, silt, sand, and fine gravel, which are generally less than 3 m thick. They cover most of the till plain in the Hudson Bay Lowland portion of the LNR region.

4.5.3 Glaciofluvial Deposits

Kame moraine, which is the main ice contact deposit, forms a continuous system of broad ridges across the study area. The main system is from north to south and is joined by several other segments trending southeast and west. The ridges are 15 to 90 m high and several kilometers wide, composed mainly of sand and gravel. Several low, discontinuous, sandy ridges are located in the south-central part of study area. These ridges are widely separated and aligned to the southeast.

Glaciofluvial channel deposits mainly occur in the Limestone River, Weir River, and Pilot Creek in the Kettle Rapids areas. They are composed of sand and gravel, which are well sorted and stratified.

4.5.4 Morainal Deposits

There is a ground moraine belt in the center-north portion of the LNR region. The surface is nearly flat or gently irregular with local relief less than 8 m. Scattered drumlins are oriented to the south or southwest. Although ground moraine forms a continuous blanket over bedrock, it is generally less than 3 m thick except in local depressions and valleys. Hummocky moraine has limited distribution within the region.

4.6 CLIMATE

The following description of climate in the LNR region is based on Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba: An Ecological Stratification Of Manitoba's Natural Landscapes (Smith et al. 1998) and mapping produced by Freemark et al. (1999) except where otherwise noted. The only climate station in the LNR region is located at the Gillam airport.

The LNR region lies within a cold, subhumid to humid, Cryoboreal climate and experiences short, cool summers and long, very cold winters.

The west half of the Lower Nelson River region straddles the north end of the Hayes River upland and the eastern end of the Churchill River Upland Ecoregions (Map 4-1). The Regional Study Area also overlaps the southern extent of the Selwyn Lake Upland Ecoregion in the Taiga Shield Ecozone. The eastern half of the Lower Nelson River region extends into the Hudson Plains Ecozone, through the northwest portion of the Hudson Bay Lowland Ecoregion, and the Coastal Hudson Bay Lowland before the Nelson River drains into the bay.

Throughout the LNR region, summers are generally cool and short while winters are cold and long, with annual precipitation ranging from 500 to 690 mm. The climate of the LNR region transitions from subarctic continental climate in the western portion of the Keeyask Regional Study Area, to subarctic marine in the eastern portion of the preliminary Conawapa Regional Study Area.

In the western portions of the study area, mean annual temperatures range from -3.4°C in the Orr Lake Ecodistrict northwest of Split Lake, to -4.1°C in the Knee Lake Ecodistrict (includes the Nelson River between Clark Lake and the Stephens Lake outlet; Map 4-2). Across these same areas, total mean number of growing season days ranges from 136 to 131 while growing degree days range from 930 to 880. Precipitation is variable, ranging from 500 mm in Knee Lake to 530 mm in the other Ecodistricts. Approximately one-third of the precipitation falls as snow.

In the eastern portions of the study area mean annual temperature ranges from -2.5°C in the Winisk River Lowland Ecodistrict of the Hudson Bay Lowland, to -4.9°C in the York Factory Ecodistrict of the Coastal Hudson Bay Lowland. However, Smith et al. (1998) indicated that there were no climate stations available within the former Ecodistrict. The number of growing season days ranges from 145 to 121 while growing degree days range from 1010 to 720. Precipitation is variable, ranging from 690 mm in Winisk River Lowland, to 510 mm in York Factory. A slightly higher proportion of the precipitation is snow in the latter.

Climate information in Smith et al. (1998) reflects climate normals for the 1961 to 1990 period. Historical climate trends using climate normals from the Gillam weather station indicate a warming of the local climate. Statistically significant upward temperature trends were identified for Gillam airport minimum, mean and maximum temperatures, though not for every month, season or annual data series (Manitoba Hydro 2012). The number of growing degree days above 0 °C and 5 °C has an upward trend in conjunction with the upward temperature trend.

Looking ahead, climate change scenarios, on average, project increasing temperatures and precipitation for the Keeyask Regional Study Area (Water Resources Engineering Department 2012). Winter is projected to experience the greatest change with annual temperature and precipitation changes increasing between the 2020s and the 2080s. A smaller subset of climate change scenarios also project increasing evapotranspiration for the same time periods, although climate modeling uncertainty is not well captured in the limited subset of scenarios.

4.7 PAST AND CURRENT HUMAN INFLUENCES

Human impacts, global change and fire regime changes have been the primary factors driving habitat and ecosystem changes in the LNR region over the past few hundred years. Other widespread human alterations such as spreading invasive plants and the airborne deposition of pollutants have also contributed to change. This section provides an overview of how changes in these driving and contextual factors are thought to have changed terrestrial habitat and ecosystems.

Aboriginal people have lived on the land for thousands of years. Although Europeans are thought to have first visited the Keeyask Regional Study Area in the 1600s, most of the cumulative historical change in the human footprint found in this region was derived from the settlements, infrastructure and hydroelectric projects developed over the past 50 to 100 years. Human influences on the fire regime such as fire suppression and accidentally started fires have also indirectly affected habitat and ecosystems.

Settlements first appeared in Northern Manitoba along the Hudson Bay coastal and inland region in late 1600's. York Factory was one of the first European settlements and was based around the Hudson Bay Company York Factory Fur Trade Post, which was built in 1684. Later, fur trade posts were established inland, creating a fur trade corridor to the south, with two documented posts along Split Lake. In 1886, a post was established at the north end of

Split Lake. This was followed by the construction of a permanent Anglican Mission house in 1906 (Split Lake Cree Nation 1996a). York Factory First Nation was moved from York Factory at the coast to a reserve at York Landing in 1957.

Ilford originated as a construction and service centre during the building of the Hudson Bay Railway and became one of the Bayline communities to service the route from The Pas to Churchill. War Lake First Nation Members (originally part of the Split Lake Band) had lived in the Ilford area to take advantage of railway employment and the fishery. In 1976, Cree leaders began efforts to obtain a reserve at Ilford and to form an independent First Nation; formal status was received in 1980.

The Fox Lake Cree have inhabited camps around Gillam, Fox Lake and Bird for many years. Prior to 1947, the Fox Lake Cree Nation (FLCN) Members were part of York Factory First Nation (YFFN). FLCN was unofficially recognized as an independent Band from YFFN in 1947. FLCN's reserve at Fox Lake (Bird), 53 km northeast of Gillam was formalized in 1985; however, FLCN Members and their families had been living in the Bird area for many years prior to that. The reserve community at Bird was renamed Fox Lake in 2010. In the same year, a small urban reserve was legally recognized at Kettle Crescent in Gillam.

Gillam became a formal settlement in the late 1960s associated with the development of the Kettle Generating Station; however, several families of Cree, Metis and others had lived in the vicinity of Gillam for several decades prior to the 1960s as it was a railway stop.

Terrestrial areas in the LNR region were flooded by water regulation related to Lake Winnipeg Regulation and the Churchill River Diversion, and by the reservoirs created for the Kelsey, Kettle, Long Spruce and Limestone hydroelectric generating stations.

4.7.1 Transportation and Access

Waterways have been the primary mode of transportation, communication and sustenance in the LNR region for many generations, with land-based trails and paths playing a more minor role. Many of these routes continue to be used to gain access to resources. In the Split Lake Resource Management Area alone, 899 km of waterways and trails have been identified (CNP 2010b). Use of the Nelson River has been reduced over the past decades because hydroelectric developments have modified water fluctuations and flows.

The three major provincial roadways in the Keeyask Regional Study Area include PR 391, PR 280 and PR 290. PR 391 and PR 280 extend from the City of Thompson to the Town of Gillam. PR 290 connects to PR 280 north of Long Spruce GS, and extends northeast to the Conawapa Project site (Keeyask GS EIS Socia-Economic Environment, Resource Use and Heritage Resources Supporting Volume (SE SV) Section 4). A new road is currently under construction, which intersects PR 280 and extends 25 km east to the Keeyask Generating

Station Project site on the north shore of the Nelson River at Gull Rapids. Seasonal winter road access in the Keeyask area includes a 32 km winter road connecting PR 280 to York Landing. This road typically is in service between mid-January and mid-March depending on weather conditions.

4.7.2 Historical Habitat Losses In the Keeyask Regional Study Area

Total historical terrestrial area loss to permanent human features was estimated to be approximately 39,200 ha, or 3.2%, of pre-development land area in the Keeyask Regional Study Area (Table 4-1). The settlement and infrastructure component of this change was approximately 8,000 ha, or 0.6% of the land area. Gillam and Split Lake have the largest settlement footprints. Flooding, reservoir expansion and water regulation have made the largest contribution to habitat loss at approximately 31,350 ha, or 2.5% of historical land area. The Kelsey reservoir flooded approximately 5,700 ha of land area (Split Lake Cree – Manitoba Hydro Joint Study Group 1996). Lake Winnipeg Regulation (LWR) and the Churchill River Diversion (CRD) decreased water levels on Split Lake by an average of 0.2 m during the summer and increased water levels by 0.8 m during the winter, with no associated flooding of land (Split Lake Cree – Manitoba Hydro Joint Study Group 1996). LWR and CRD up to 2005 did not remove any inlands in Study Zone 2 (Keeyask GS EIS Physical Environment Supporting Volume (PE SV) Section 6). The Kettle generating station reservoir (i.e., Stephens Lake), and its associated reservoir expansion area converted approximately 23,500 ha of uplands and peatlands to aquatic areas from the time of impoundment to 2003.

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Using a 50 m buffer of the mapped areas of loss as an estimate of the spatial extent of the indirect effects of these permanent human footprints on terrestrial habitat, it was estimated that an additional 22,000 ha, or 1.7%, of inland habitat alteration has occurred (Table 4-1). Approximately two-thirds of this total was associated with hydroelectric developments.

Human developments have affected a higher proportion of the central area of the Regional Study Area than the Regional Study Area as a whole because most of the developments are concentrated within the smaller study zones. Approximately 20% of pre-development land area in Study Zone 4 (Map 2-3) has been converted to human features or water (Table 4-1). It was estimated that the indirect effects of these losses may have increased the amount of affected inland terrestrial habitat land loss to more than 30% of Study Zone 4 pre-development land area.

Table 4-1: Historical terrestrial loss and alteration from large-scale human developments in the Keeyask Regional Study Area

Human Footprint	Size in Regional Study Area (ha)			Percentage of Regional Study Area Historical Land Area			Percentage of Study Zone 4 Historical Land Area		
	Loss	Alteration[4]	Total Change	Loss	Alteration4	Total Change	Loss	Alteration4	Total Change
PR 280 and connected borrow areas[1]	2,169	3,000	5,169	0.2	0.2	0.4	1.1	1.5	2.6
Other roads and "permanent" clearing (e.g., borrow areas)[1]	1,419	2,100	3,519	0.1	0.2	0.3	0.7	1.1	1.8
Settlements: Gillam, Split Lake, York Landing, Ilford[1]	951	956	1,907	0.1	0.1	0.2	0.5	0.5	1.0
Generating stations and dykes[1]	208	U	208	0.0	U	0.0	0.1	U	0.1
Transmission lines and converter stations[1]	3,070	6,383	9,453	0.2	0.5	0.7	1.6	3.2	4.8
Keeyask early infrastructure- unique borrow area[1]	771	302	28	0.1	0.0	0.0	0.4	0.2	0.5
Kelsey reservoir and Split Lake flooding[2]	5,700	5,400	11,100	0.4	0.4	0.9	2.9	2.7	5.6
Kettle flooding and reservoir expansion[3]	23,479	3,500	26,979	1.8	0.3	2.1	11.9	1.8	13.6
Long Spruce flooding and reservoir expansion[3]	1,400	300	1,700	0.1	0.0	0.0	0.7	0.2	0.9
Total	39,167	21,941	61,108	3.1	1.7	4.8	19.8	11.1	30.9

Notes: U = no estimate available. Column totals may not equal sum of rows due to rounding.
Data sources: [1] Terrestrial habitat mapping; [2] Split Lake Cree – Manitoba Hydro Joint Study Group 1996 (based on proportion of total area that is in Study Zone 5); [3] Historical terrestrial habitat mapping; [4] 50 m buffer of mapped area of loss.

4.7.3 Fragmentation

Past and existing linear features (*e.g.,* roads, railways, transmission lines) and other permanent infrastructure have reduced the intactness of the regional terrestrial ecosystem. Linear features have had a range of effects such as wildlife disturbance and increased wildlife mortality through improved access for people and predators. Improved access for people has also had a number of other effects such as more human-initiated fires and the spreading of invasive plants. Permanent human features have removed portions of core areas (*i.e.,* a large undisturbed area) and subdivided other core areas into smaller blocks. It was estimated that the total core area in the Keeyask Regional Study Area has been reduced to approximately 83% of land area.

4.7.4 Global Change

Global change refers to global-scale, human induced changes in environmental attributes such as climate warming, ground level ultra-violet radiation and ozone layer thickness. Global change has important direct and indirect influences on habitat and ecosystems. This section deals with climate change since this was the only attribute that had adequate historical information for the LNR region.

Over the 50-year period from 1967 to 2006, an overall trend in increasing temperature was observed in the study zones (Manitoba Hydro 2012). Mean temperature increases in Gillam were the highest in January (0.46°C increase per decade) and in April-June (0.32-0.43°C increase per decade). There were no statistically significant changes in precipitation at Gillam over this period. There was a significant downward trend in precipitation at Thompson annually, decreasing 3.13mm per year.

Climate has an importance influence on the distribution and abundance of different vegetation, soil and habitat types. For example, Bigelow *et al.* (2003) estimated that the northern treeline did not extend further north than 55°N following the last glacial maximum (18,000 yr BP). In the Keewatin area of central Canada, studies estimated that the northern treeline shifted approximately 240 km south since the end of the Mid-Holocene Warm Period (5,000 – 4,000 yr BP; Nichols 1976; Bigelow *et al.* (2003). Likewise, the southern limit of permafrost-affected peat landforms has shifted southward and then northward over the past 500 years (Tarnocai 2009).

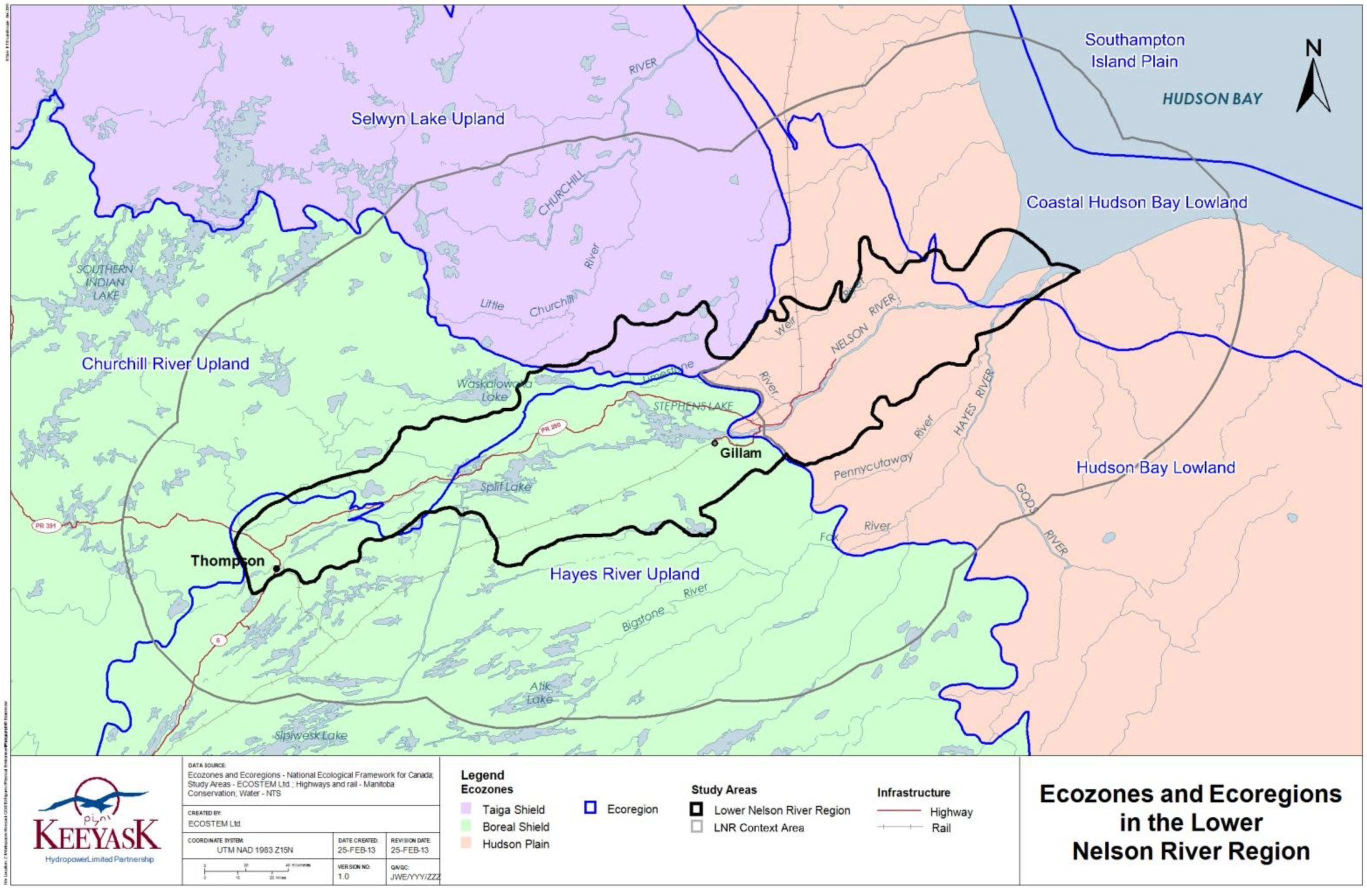
Peatlands cover most of Study Zone 5. Climate warming that occurred at the end of the Little Ice Age approximately 150 years ago has had a major effect on northern peatlands (Halsey *et al.* 1995), including those in the LNR region (Section 4.2). Several studies relevant to the LNR region report a reduction in the total area of permafrost peatlands since the end of the Little Ice Age (~150 years ago) with no evidence of subsequent aggradation (Thie 1974, Vitt *et al.* 1994, Halsey *et al.* 1995, Vitt *et al.* 2000). Ongoing permafrost melting is thought to be a lagged response to the climate warming that began at the end of the Little Ice Age.

Thie (1974) estimated that about 75% of the permafrost in peatlands in an area north of Lake Winnipeg in Manitoba has degraded since the end of the Little Ice Age. Many peat plateau bogs completely disappeared between 1947 and 1967. Over the same period, Vitt *et al.* (2000) estimate a net area loss of 9% of permafrost peatlands across boreal continental western Canada. Complete melting of permafrost has occurred in some of the continental boreal locations that once contained permafrost, moving the current southern limit of permafrost north by an average of 39 km, and in some locations, by as much as 200 km (Beilman *et al.* 2001). The mean annual decrease in permafrost area of peatlands in western Canada appears to be at least 1%, while rates of permafrost retreat measured at the plateau-collapse scar edge have ranged from 0.0 to 2.8 m per year (Tarnocai 1972; Thie 1974; Camill and Clark 2000; Camill 2005).

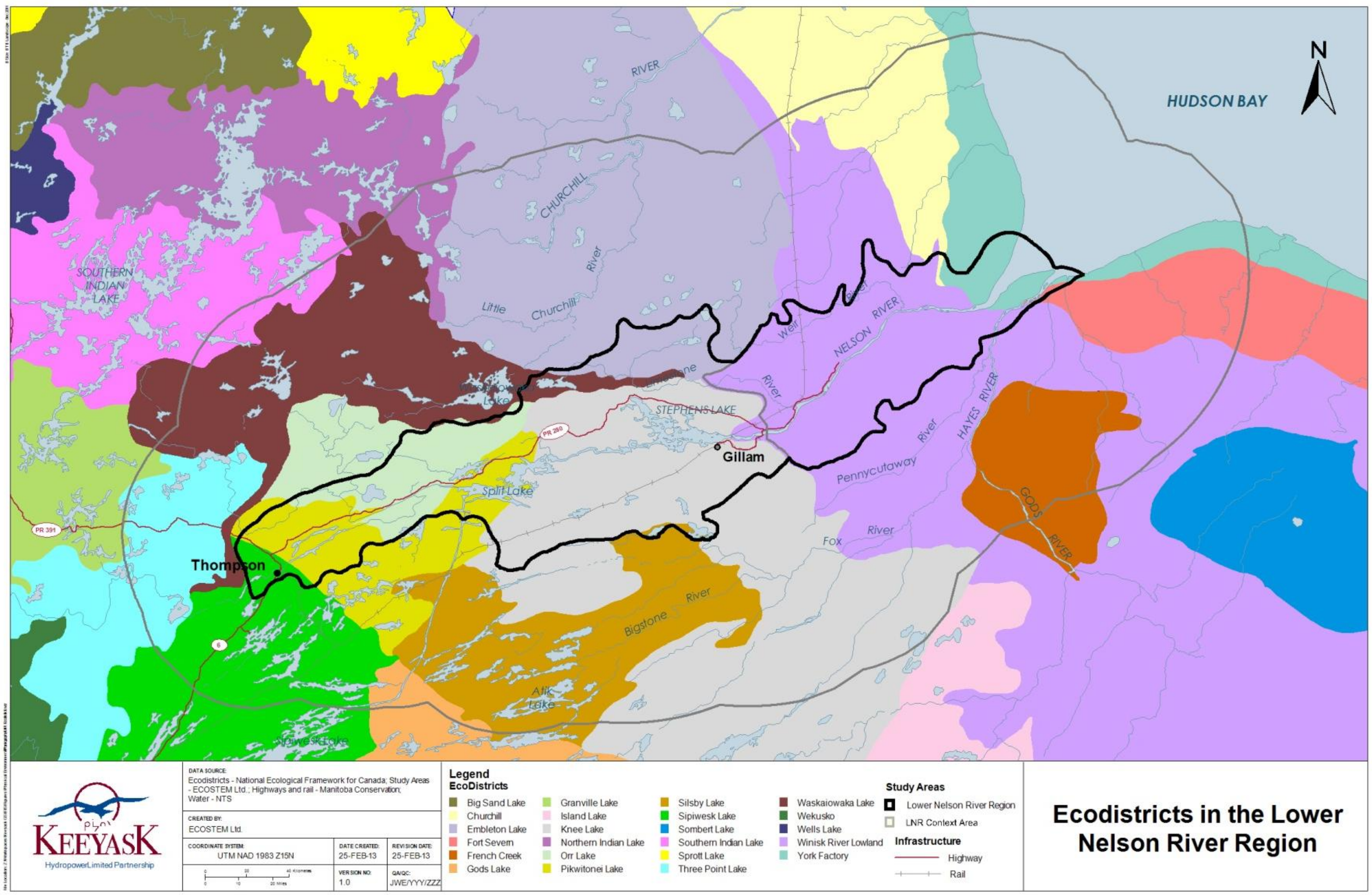
A study undertaken in Study Zone 4 confirmed these trends. Historical rates of permafrost peatland change were estimated using historical air photos from 1962, 2003 and 2006. Over the 44-year study period, peat plateau bog area declined by approximately 20%, or at a mean annual rate of loss of 0.5% per year. This mean annual rate was within the range reported in the scientific literature for northern Canada. Area losses for individual peat plateau bogs ranged widely from a minimum of 1% to a maximum of 48%. Recently burned peat plateau bogs shrank faster than unburned ones. Over 90% of the shrinking area became other peatland types; the rest became open water.

Fire is the keystone ecosystem process in the boreal forest (Rowe and Scotter 1973; Weber and Flannigan 1997), which is why fire regime is a key supporting topic. Section 6.3 describes the past and current fire regimes. In brief, the fire regime is highly dependent on climate. Climate change that increases evapotranspiration rates has been associated with higher fire frequency and total area burned (Girardin et al. 2009). Humans have altered the fire regime in several ways. Fire suppression and possibly roads have reduced the total area burned by natural and human caused fires. In contrast, the human contribution to fire starts and total burned area has likely increased.

4.8 MAPS



Map 4-1: Study zones relative to Ecozones and Ecoregions



Map 4-2: Study zones relative to Ecodistricts

5 SOILS AND ECOSITES

5.1 INTRODUCTION

Soil is the naturally occurring, unconsolidated, mineral or organic material at the earth's surface that is capable of supporting plant growth (Soil Classification Working Group 1998). Ecosite is the combination of soils, surficial material, surface water, groundwater and permafrost conditions that are associated with substantial differences in vegetation composition and/or structure. Ecosites are an important component of a natural ecosystem, having strong linkages with other ecosystem components. Changes to any aspect of ecosite properties, which includes soil properties, may profoundly affect other ecosystem components or even the entire ecosystem. Therefore, an understanding of local ecosite properties and dynamics are necessary to assess the effects of any human activity on an ecosystem.

Prior to initiation of the Keeyask and Conawapa environmental assessments, large mapping scale soil surveys such as those produced for southern Manitoba were not available for the LNR region. Soil and ecosite studies were conducted to support the terrestrial habitat and ecosystems studies related to the Keeyask and Conawapa Generation Project environmental assessments. This section of the report provides the soil and ecosite methods used for the LNR region, results for some soil and ecosite attributes relevant for the entire LNR region as well as soil and ecosite results for the Keeyask Regional Study Area.

5.2 BACKGROUND INFORMATION

5.2.1 <u>Most Influential Drivers for Soil and Ecosite Dynamics</u>

The five natural soil forming factors are climate, parent materials, biota, topography and time (Brady 1974). Some also consider groundwater and human activity as additional soil forming factors (Ellis 1938). Parent materials, topography and groundwater are elements of ecosite type because they strongly influence vegetation as well as soils.

Section 4 provided an overview of the key ecosystem drivers in the lower Nelson River (LNR) region as well as the current patterns created by those processes. These drivers and patterns are also relevant for soil and ecosites. The vegetation and permafrost conditions that have developed under the climate of the LNR region (Section 4.5) played important roles in soil forming processes. Also, the parent materials, which were deposited mainly by glacial, lacustrine and marine processes, influence soil forming processes greatly.

5.2.2 Existing Soil and Ecosite Information for the LNR Region

Soil surveys were completed for portions of the LNR region starting in the 1950s. Ehrlich et al. (1959) conducted engineering oriented soil surveys for a small portion of the region. During the 1970s, the Manitoba Department of Mines, Resources and Environmental Management initiated the Northern Resources Information Program (NRIP). This program completed reconnaissance level (1:125,000 scale) biophysical land classification mapping for North-Central Manitoba (Mills et al. 1976a, b), which encompassed the LNR region.

Soils information developed for the NRIP reports (Mills et al. 1976a, b) has been incorporated into Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba: An Ecological Stratification Of Manitoba's Natural Landscapes (Smith et al. 1998). The following background description of soils in the LNR context area (Map 1-1) was based on these documents, except where otherwise noted. See Section 4 for other components of the LNR region's ecological context.

Cryosolic, Organic, Luvisolic, Brunisolic, and Gleysolic orders are the dominant soil orders within the Lower Nelson River region. These soils are distributed within the LNR region in certain spatial patterns, which tend to correspond with the NRIP Biophysical Land Regions.

In the west of the Lower Nelson River region, the dominant soil orders are Luvisolic, Cryosolic and Organic. Brunisolic soils are more frequent to the north in the Waskaiowaka Lake Ecodistrict (Map 4-2), and the Embleton Lake Ecodistrict within the Selwyn Lake Upland Ecoregion (Map 4-1). Luvisolic soils are distributed throughout the Boreal Shield Ecozone portion of the Lower Nelson River region, but are most common in the southwest in the Pikwitonei Lake Ecodistrict, and the northwest in the Waskaiowaka Lake Ecodistrict. In the Orr Lake Ecodistrict, the Organic soil order is dominant, and in the Knee Lake Ecodistrict, which encompasses the largest portion of the Keeyask Study Zone 4, the Cryosolic order dominates. Cryosols also dominate in the Embleton Lake Ecodistrict to the north.

In the east, the Cryosolic soil order is co-dominant in the Hudson Bay Lowlands, with Organic soils, and in localized areas the Brunisolic order is present. In the Coastal Hudson Bay Lowlands, the Gleysolic order dominates along the coastline, while the Organic order is dominant inland, with localized patches of Cryosols and Regosols.

The Cryosolic order was discontinuous at the western extent of the Lower Nelson River region since it is near the fringe of the permafrost zone. Permafrost was more frequent there in organic deposits, but mineral deposits also show signs of former and present permafrost conditions. Permafrost becomes more widespread in the Knee Lake

Ecodistrict, and remains dominant to the east and north along with increasing Cryosol coverage.

Within the LNR region context area, Gray Luvisols are the dominant great group in the Luvisolic order, and Gleyed Gray Luvisol, peaty phased Orthic Gray Luvisol and Solonetzic Gray Luvisol are the dominant subgroups. Gleyed Gray Luvisols are distributed in very gently undulating to near-level lacustrine veneers and blankets, or inter drumlins. The parent materials are usually deep to shallow calcareous loam to clay textured lacustrine sediments, overlying loam textured till or Precambrian bedrock. Solonetzic Gray Luvisols are distributed in gently to strongly undulating lacustrine blankets and veneers. They develop in parent materials of shallow to deep calcareous lacustrine deposits overlying Precambrian bedrock. Peaty phased Orthic Gray Luvisols locally occur on hummocky terrain and ridged rock outcrops that are associated with thin, discontinuous veneers of clayey lacustrine sediments.

Brunisols occur on gently undulating lacustrine plains, marine beaches, and hilly glacial-fluvial eskers, ridges, and complexes. Eutric Brunisols are the dominant Brunisolic great group in the LNR region. Degraded Eutric Brunisols and Gleyed Degraded Eutric Brunisols are the dominant subgroups. Degraded Eutric Brunisols are distributed on moderately to highly rolling, and hummocky glaciofluvial ridges and marine beaches, usually deep calcareous, loamy to sandy and gravelly glaciofluvial deposits, or sandy marine deposits with well to imperfect drainage. Gleyed Degraded Eutric Brunisols can be found in gently rolling water-worked tills, and gentling undulating to nearly level lacustrine plains.

Terric Mesic Organic Cryosols and Mesic Organic Cryosols are the dominant subgroups from the Cryosolic Order in the Lower Nelson River region. Terric Mesic Organic Cryosols are usually associated with thin veneer bog on gently sloping terrain, underlain by lacustrine deposits. Mesic Organic Cryosols are located in level to depressional locations characterized by peat plateaus.

Soils belonging to the Organic order can be found throughout the LNR context area. The dominant great group is Mesisol, and the dominant subgroups include Typic Mesisols and Hydric Mesisols. Typic Mesisols usually form in patterned and horizontal fens, with extensive shallow to deep organic deposits that are widespread in the eastern half of the LNR region. Hydric Mesisols occur at small ice-block lakes ringed with floating fens. Fibrisols are also frequent in these areas.

Gleysols are dominant in the northeastern extent of the LNR region, along the Hudson Bay coast. The dominant subgroup is saline Rego Gleysol, associated with silty and clayey tidal flats. Regisols also occur further inland along sandy beach ridges and strandlines.

5.3 METHODS

5.3.1 Information Sources

5.3.1.1 Non-Project Studies

A reconnaissance level biophysical land inventory completed for the Churchill-Nelson Rivers area of north-central Manitoba (Beke et al. 1973) overlaps the western portion of the Keeyask Regional Study Area. This report includes soil stratigraphy and chemical data for five locations in the Keeyask Regional Study Area.

Although the Northern Resources Information Program produced some useful soil information for the LNR region, the information was too coarse to meet the requirements of environmental assessments, especially for the project footprint areas. The NRIP reports (Mills et al. 1976a, b) include soil type descriptions but no soil profile data from the ground truth sites.

5.3.1.2 Soil and Ecosite Data Collection

Soil profiles were sampled at over 3,000 locations in the LNR region from 2002 to 2012 using a variety of sampling protocols, depending on the question of interest. Other studies conducted for the Keeyask and Conawapa environmental assessments or for other purposes also provided useful data. This section describes the various soil and ecosite information sources. Since soils and ecosite are a component of terrestrial habitat, see Section 7.2 for further details regarding the overall approach to habitat sampling and the types of data collected.

5.3.1.2.1 Terrestrial Habitat and Ecosystems Sampling Protocols

Four main types of soil sampling protocols were employed for the LNR terrestrial habitat and ecosystems studies. These protocols are described below. The descriptions are then followed by a chronology of the studies conducted for each generation project, including the sampling protocols used and any variations needed to support study specific questions.

Soil Reconnaissance

Soil reconnaissance sampling provided data for key soil parameters using a rapid assessment sampling method. The sample locations varied by study, depending on the sampling design (see next section and Section 7.2 for sampling designs).

At each sample location, soil profile data were collected to a depth of 150 cm, where practicable. A pit was dug with a spade, digging as deep as possible within about five minutes. The rest of the profile was then sampled to the target depth using a dutch auger. Sampling depth tended towards 100 cm in stony or heavy clayey mineral soils due to the time required to hand auger to 150 cm. The actual sampling depth could be much lower when bedrock was encountered or when the auger was impeded by impenetrable frost.

Soil horizons were identified and classified using the Canadian System of Soil Classification criteria (CSSC; Soil Classification Working Group 1998). Depth to top of each soil layer was measured and recorded. Information recorded for each layer included horizon designations, depth, hand texture and stoniness. Pedon data recorded for each profile included depths to water table, frost and bedrock; and parent material, deposit type, site type, moisture regime and drainage regime. Moisture regime and drainage regime classes were determined using slightly modified versions of the classification keys in the Manitoba Forest Ecosystem Classification Guide (Zoladeski et al. 1995). Site type was determined from the LNR region classification developed from data collected by project studies (Section 7.3). During the latter study years when the ecosite classification was available, plots were classified into ecosite and site types.

Inland Habitat Plots

Inland habitat relationships studies (Section 7.2.2) collected soils, vegetation and other environmental attribute information in a hexagonal or rectangular plot that was generally 400 m^2 in size. The objective of these studies was to improve understanding of site level relationships between vegetation, soils, groundwater and other environmental factors. For that reason, the maximum soil profile sampling depth was the shallower of either bedrock contact, 110 cm or permafrost refusal. See Section 7.2.2 for a detailed description of the sampling protocol and data collected.

One soil profile was sampled in each inland plot. The sample was located in an area that was representative of the overall plot, but outside of the vegetation plot (centre 10 m x 10 m). Several test holes were augered throughout the entire habitat plot to find a location that was representative of soil and ecosite conditions in the plot. In organic ecosite plots, the sample location avoided the tops of hummocks and the bottoms of hollows.

A pit was dug to a minimum depth of 100 cm when practicable, with a deeper hole used for deep organic soils. Digging was difficult at many locations due to heavy clay, large stones or impenetrable ground frost. At these locations, a spade was used to dig a pit at least 20 cm into the C horizon or to 70 cm, whichever was deeper; a dutch auger was used to complete sampling to 100 cm. For pit locations where the surface organic layer was greater than 1 m thick and the water table was at or just beneath the surface, a dutch auger with multiple extensions was used to sample the profile. Sampling was continued until a mineral horizon was encountered. Augering was conducted in short vertical sections to capture the depth of individual organic horizons. For pits with frozen peat that could not be penetrated by the spade or dutch auger, a gas auger was often used to bore through the frozen peat or buried ice layer.

For each pit, all soil layers were identified and classified according to the CSSC. Depth to top of each horizon was measured and recorded. Mineral horizons were hand textured in the field. Stoniness information was recorded for each horizon, according to the CSSC. Soil pedon information, including the depth of the LFH layer, humus, and organic material were determined, as were depth to prominent mottling, gleying, water table, frost, and bedrock. The profile was also classified to CSSC soil order with the exception that soils were classified as organic if the depth of surface organic matter was greater or equal to 20 cm. During the latter study years when the ecosite classification was available, plots were classified into an ecosite type.

Ground frost was classified as seasonal if it was easily penetrable with the auger and the time of sampling was such that the frost could still be melting (*i.e.*, up to the beginning of September). Frost encountered in organic soils was often classified as permafrost because it was impenetrable (even with the power auger in some cases) in September or thick ground ice was clearly present.

Moisture regime and drainage regime classes were determined using slightly modified versions of the classification keys in the Manitoba Forest Ecosystem Classification Guide (Zoladeski et al. 1995) to provide finer delineation of some non-forested organic ecosite types.

Volumetric bulk density samples were taken from all mineral horizons where conditions allowed collecting a homogeneous sample using a 100 cm^3 cylindrical core sampler. When a homogeneous volumetric sample could not be taken (e.g., thin soil layer), a non-volumetric sample was collected from the side of the pit using a trowel. Starting in 2009, volumetric samples were no longer collected from soil profiles that were common in the area; collection from profiles continued for uncommon soil profile types.

Surface organic matter was volumetrically sampled at representative plot locations in the Keeyask study area during 2003. Samples were analyzed for physical and chemical properties. Two 1,825 cm^3 samples (approximately 7.5 cm deep, 22 cm long, and 14 cm wide) were collected in each organic ecosite plot. The first sample was taken at the surface going down the height of the container and the second sample was taken starting at 20 cm below the surface. Two 20.1 cm x 19.5 cm samples were collected in each mineral ecosite plot at a depth depending on the thickness of the surface organic layer. Volumetric peat samples were weighed immediately following collection to determine wet weight. Any large roots or debris in the samples were removed and weighed.

All soil samples (mineral and organic horizons) were air-dried in the field camp to the extent feasible and then fully dried at approximately 35° C in the office laboratory.

Shore Zone Inland Plots

A 10 m x 20 m inland plot oriented parallel to the shoreline was sampled at each shore zone sample location (Section 7.2.2.2.2). The plot was generally located between two transects that were 20 m apart, with the transect origins generally being placed one meter inland from the inland edge. The transect origins provided the two corners for one of the long sides of the plot, with the short sides continuing from the shore zone transect 10 m inland.

A soil profile was sampled in each plot using a dutch auger. The sample was located in an area that was representative of the overall plot (i.e. hummocks and hollows were avoided). For each profile, pedon information was recorded, including the depth of the LFH layer, humus, and organic matter, as were depth to prominent mottling, gleying, water table, and bedrock. If massive ice was encountered that could not be hand-augered, depth to ice from the surface was noted, and no further sampling was done. Soil texture for each mineral horizon was determined in the field by hand texturing.

Moisture regime and drainage regime classes were determined using slightly modified versions of the classification keys in the Manitoba Forest Ecosystem Classification Guide (Zoladeski et al. 1995). The soil profile was also classified to CSSC soil order with the exception that soils were classified as organic if the depth of surface organic matter was greater or equal to 20 cm.

Rapid Transects

Habitat data in inland areas where environmental conditions changed rapidly (e.g., on ravine banks) were collected along transects using the rapid transect sampling protocol. This inland habitat sampling protocol was only used in Conawapa studies. Transect origins were established 5 m back from the top of the slope or bank. The transect extended down-slope in a direction perpendicular to the river, or in the case of ravines, toward the opposite bank along a line perpendicular to the general ravine direction at that location. The end point of the transect was located at the base of the slope (ravine and river bank transects), the edge of the shelf (shelf transects), or at the water edge (shore zone transect).

Soil sampling along the transect was done using a screw auger, starting at the transect origin and continuing to the end of the transect. Soil was sampled every 5 m along the transect, or more often if a major change in vegetation structure, slope, texture or another attribute indicating a potential change in soil conditions was encountered. If major changes in soil texture were encountered between sample points, additional sampling was done between the points to locate where the change occurred. At each sample point, the distance along the transect, the organic matter and LFH thickness, the B horizon texture and the depth to impenetrable rock or frozen ground, where present, were recorded. The B horizon texture was a hand texture of the first 20 cm of mineral layer encountered by the screw auger. Additional notes were made on the depth of buried organic or mineral horizons, changes in soil texture, and ice hardness, when any of these cases were encountered. Surface stoniness was also recorded along the transect as a percentage cover in a moving square 1 m quadrat.

Detailed Ravine, Shore and Island Habitat Plots

Detailed habitat data were collected in 10 m x 20 m plots situated at strategic locations along the rapid transects, generally centered with the 20 m side perpendicular to the rapid transect direction. Data were collected using the detailed rapid transect plot habitat sampling protocol (Section 7.2.2.1), which was the same protocol as the inland habitat sampling protocol except that 200 m^2 plots were sampled instead of 400 m^2 plots. Soils were sampled using the inland habitat protocol. This protocol was only used in the Conawapa studies.

5.3.1.2.2 Data Collection Chronology

A number of studies were conducted to answer a variety of terrestrial habitat, ecosystems and plant questions. Some study designs were representative for Study Zone 4 as a whole while others were only representative for selected zones or conditions. Other studies conducted for the projects and studies conducted for other purposes also provided relevant data.

Keeyask

The Keeyask 2002 soil reconnaissance survey was the first field study conducted for the LNR region. The objective of the 2002 soil reconnaissance survey was to provide representative soil profile and ecosite data in the area using a rapid assessment protocol so that subsequent studies could be designed. Soil samples were located on a 500 m triangular grid in the portion of the reservoir that would undergo substantial flooding. The soil reconnaissance sampling protocol was initially developed for this study.

In 2003, sample points were located in peatlands where validation of peat type mapping was needed. The data collection protocol for each sample location was the same as for the 2002 reconnaissance survey with two exceptions. First, gleying and/or prominent mottling were recorded. Second, augering stopped after the first few cm of mineral soil were encountered (*i.e.*, deep enough to obtain a sample for texture and stoniness), permafrost refusal or bedrock. A total of 103 locations were established for peat sampling only. Volumetric peat samples were collected at 68 of the peat sampling locations. Surface samples were collected using a plastic container with a volume of 1,825 cm^3. The container was placed upside down on the organic surface and using a long knife the organic material was cut vertically around the container. Once the sample had been extracted, it was trimmed with a knife to create a complete volumetric sample. All new vegetation growth was also removed. Organic samples were collected using a Macaulay peat sampler, which captures a 500 cm^3 sample. The sampler was inserted into the organic surface up to a depth of 4 m. If a sample at 4 m deep was not entire, a sub-sample(s) was collected and the thickness of the sample was recorded.

Inland habitat plot sampling commenced in 2003 and continued to 2011 in the Keeyask Regional Study Area, and to 2012 in the Conawapa Regional Study Area. Habitat plots were located using a stratified, random cluster design (Section 7.2.2.1) to provide soil and ecosite data representative of Study Zone 4. The strata were geographic zones. A cluster included at least four of the following ecosite types: deep mineral soil, veneer bog, blanket peatland, peat plateau bog, collapse scar peatland or horizontal peatland. These ecosite types were thought to be the most common ones in the area based on reconnaissance soil surveys, helicopter surveys, air photos and existing maps. Once a cluster was randomly selected, additional less common ecosite types were added to the cluster if they occurred within a reasonable walking distance. In 2010 the emphasis on sampling shifted to filling data gaps, that is, to increase plot representation of the uncommon habitat types identified through mapping and preliminary data analyses.

Also in 2003, shore zone plot sampling commenced at replicate locations in the Keeyask and Stephens Lake reaches of the Nelson River. This study provided soil and ecosite data representative of the Nelson River shore zone wetland habitats. Nelson River shore zone sampling was continued in 2004, 2006 and 2011. In 2006, most of the shore zone sampling took place at a series of off-system lakes. In 2011, the primary goal of the shore zone sampling was to study the effects of recent, persistent increases in Nelson River water levels.

In 2004, the primary objective was to validate the preliminary predicted depth to non-disintegrating material, as predicted by the peatland disintegration model. A secondary objective was to validate soil type mapping. Soil profile sample points were systematically located along segments of the preliminary predicted non-disintegrating shoreline. The selected shoreline segments were in the portion of the reservoir where substantial flooding was expected. Most of the non-disintegrating shoreline in these areas was sampled. The data collection protocol for each sample location was the soil reconnaissance protocol except that: (a) if peat was frozen, and could not be penetrated by auger, attempts were made to find an alternate unfrozen location within 50 m of the original point (often in a collapse scar peatland); (b) if ground frost could be penetrated then augering stopped at bedrock contact or 30 cm into mineral soil; and, (c) gleying and/or prominent mottling were recorded.

In 2005, the primary objective of the soil sampling was to verify peat, water and excess ice thicknesses in areas that were difficult to photo-interpret or in areas that had the potential to substantially change peatland disintegration predictions if depths to non-disintegrating material were inaccurate. A secondary objective of this study was to validate the photo-interpreted ecosite mapping. Soil profile sample points were subjectively located within these general areas.

Soil reconnaissance protocol modifications were more extensive in 2005. Sampling extended into the first 20 cm of mineral. A gas soil auger was used in a pre-selected subset of the peat plots in an effort to penetrate any ground ice present in the soil. If ground ice was impenetrable at the sample location, then attempts were made to do so at up to four alternate points in the vicinity. If this was unsuccessful then information was collected only up to the depth of the impenetrable ice. Augering effort for ground ice was recorded.

Since much of the reservoir area burned in 2005, a new horizon modifier (B) was added to identify burned surface soil layers. For frozen horizons, notes were taken on the ice structure (similar to the peat disintegration ice descriptions; e.g. no visible ice but frozen peat), ice crystals, ice pores (small areas of solid ice), massive ice. Other information collected at each point included slope, presence of past fire disturbance, and landscape shape and position. Gleying and/or prominent mottling were also recorded.

Conawapa

Conawapa field sampling commenced in 2004 with soil reconnaissance and inland habitat plot sampling. Soil reconnaissance used the same methods as for Keeyask. The primary goal was to obtain data that would assist in photo-interpreting and validating ecosite mapping for the Conawapa area. Soil reconnaissance was conducted almost every field season from 2004 to 2012, except for 2006 and 2011. In 2012, the primary goal of soil reconnaissance was to develop more highly verified ecosite mapping in potential project footprint areas.

The Conawapa inland habitat plot sampling protocol was also the same as that used for the Keeyask area. As with Keeyask, in 2010 the emphasis on sampling shifted to filling data gaps identified through mapping and preliminary data analyses.

In 2005 a series of new protocols specific to the Conawapa study area began. These included detailed inland habitat plots along ravine, Nelson River island, and Nelson River shelf transects. These ecological zones were sampled differently than the inland habitat plots because they are subject to different ecological drivers than inland areas, for example ice scouring in the case of the shelf. Soils were sampled to gather soil and ecosite data representative of these areas using the same methods as for inland plots (see Section 5.3.1.2.1). Ravine sampling continued every year except 2008 until 2012. Island sampling continued every year until 2009, and shelf sampling occurred again from 2007 to 2009.

Also in 2005, a sampling protocol to support mammal studies (mammal dens and camera sites) was commenced. At each location a basic soil profile was obtained with a screw auger, recording the thickness of the organic matter, depth to the water table, depth to bedrock and depth to frost when present, as well as the first mineral soil horizon texture, moisture and drainage regimes, and site type. This sampling protocol was also implemented in 2007, 2008 and 2009.

5.3.1.3 Other Stratigraphy Data

5.3.1.3.1 Boreholes

Borehole data acquired by Manitoba Hydro supplemented field data collected by ECOSTEM. These borehole studies were conducted to provide information for engineering feasibility studies, primarily to locate permanent infrastructure (e.g., dam, dykes) and borrow material sources. Most boreholes were machine drilled to depths greater than 3 m, which is deeper than that typically used to classify and characterize soils and ecosites. Only those boreholes in terrestrial locations were used for the terrestrial habitat and ecosystems studies.

Because the boreholes were primarily located within potential infrastructure footprints and in potential borrow areas, they are a biased sample of the Study Zone 2 or broader areas. For this reason, their primary use was as corroborating or validation data for results developed from the soils and ecosite data.

Conawapa borehole data were not available when the analysis for this report was completed.

5.3.2 Ecosite and Site Classifications

Analogous ecosite and site classifications were developed for terrestrial habitat mapping and habitat sample locations, respectively. The ecosite classification was applied to map polygons while the site classification was used to classify transect segments or plots. The ecosite and site classifications were developed from classifications previously developed for the Manitoba Boreal Shield, and from soil data and photo-interpretation collected from the Keeyask and Conawapa Regional Study Areas. Section 6.2.2.1 describes the methods used to develop the site and ecosite classifications.

Table 5-1 provides the site types and criteria used to classify soil profiles. The primary dichotomy in this classification is the thickness of the surface organic layer. While many classifications use a surface organic layer thickness of at least 40 cm as the cutoff for an organic or peatland type (e.g., CSSC), results from Keeyask and Conawapa studies (Section 7.3.1) and elsewhere in the Manitoba Boreal Shield (Ehnes 1998; ECOSTEM and Calyx 2003) have shown that vegetation types change distinctly once the thickness of the surface organic layer reaches 20 cm.

The ecosite classes reflected important ecological differences in soil properties, hydrology and permafrost. The wetland ecosite classes were from the Canadian Wetland Classification System (CWCS; National Wetlands Working Group 1997), with enhancements to reflect dramatic differences in marsh water regimes along the Nelson

River and between the Nelson River and off-system waterbodies. Mitch and Gosselink (2000) point out that the CWCS and the U.S. hydrogeomorphic approach (Smith *et al.* 1995) use the same factors to classify wetlands.

The CWCS broadly classifies wetlands into the following classes: bog, fen, swamp, marsh and shallow open water. Bogs, fens and some swamps are peatlands. Peatlands are wetlands where organic material has accumulated on the surface because dead plant material production exceeds decomposition (National Wetlands Working Group 1997). Compared with bogs, fens have higher nutrient availability in the plant rooting zone and tend to have a water table that is closer to the surface. Swamps are tall shrub and/or treed wetlands with nutrient rich water and a water table that is generally deeper than in fens but shallower and less persistent than marshes.

Wetland classes were subdivided into wetland forms based on surface morphology, surface pattern, water type and underlying mineral substrate morphology. Because hydrology is a key driver for the development of these attributes, the type of hydrological connection is key to classifying wetland form. The two hydrological connection types in the CWCS are littogeneous and terrigenous which are referred to as shoreline and inland wetlands. Although all inland wetlands are peatlands or swamp, some peatland types were also found in shoreline wetlands.

Ecosites in the Project Study Zone 4 were photo-interpreted and mapped at a 1:15,000 scale from large scale stereo photos as a component of the terrestrial habitat mapping. See Section 6.2.2.1 for a detailed description of the habitat mapping methods. Table 5-2 provides the fine ecosite types and associated photo-interpretation criteria. Ecosite typing reflected the dominant conditions throughout a polygon.

Conflicts between the typing of a polygon and a soil sample location within that polygon could occur when the sample location was in a patch that was too small to map as a separate ecosite polygon. For example, a soil sample located in a blanket bog smaller than 2 ha that was surrounded by a veneer bog was classified as a blanket bog at the soil profile level but as a veneer bog at the mapped polygon level.

Table 5-1: Site types used to classify soil profiles and their associated criteria

Site Type	Site Code	Criteria*
Mineral types		Surface organic layer < 20 cm thick, water table below surface vegetation and soils not saturated during most of the growing season
Outcrop	1	Depth to bedrock < 5 cm
Thin mineral	2	Depth to bedrock 5-20 cm or O+LFH layers 10-20 cm thick
Moderately Deep Mineral	3	Depth to bedrock 21-100 cm
Deep dry mineral	4	Depth to bedrock > 100 cm, moisture regime 1 to 5
Deep wet mineral	5	Depth to bedrock > 100 cm, moisture regime 6-8
Organic types		Water table usually below surface, surface organic layer >= 20 cm thick
Sphagnum bog	6	Dominant soil materials are moderately decomposed Sphagnum and woody peat, may be underlain by sedge peat
Fen	7	Dominant soil materials are moderately decomposed sedge and/or brown peat moss, peat is nutrient enriched by groundwater or capillary movement in shallow peat
Feathermoss bog	8	Dominant soil materials is feathermoss
Swamp	9	Forest and/or tall shrub covered, soils organic or mineral
Meadow	10	Sedge, grass and/or tall shrub covered
Wetland types		Water table usually at or above the surface
Shallow, open water	12	Surface water 10 cm – 2 m deep, vegetation dominated by submergent, floating and/or floating-leaved aquatic species
Deep marsh	13	Surface water 10 cm – 2 m deep, seasonal water fluctuations, vegetation dominated by emergent species
Shallow marsh	14	Surface water < 10 cm deep, but fluctuating seasonally and exposing surface

Notes: * Criteria refer to dominant conditions throughout the polygon.

Table 5-2: Fine ecosite types used for ecosite mapping and associated photo-interpretation criteria

Fine Ecosite Type	Fine Ecosite Code	Criteria*
Mineral types		
Outcrop	1	Surface organic layer < 20 cm thick, and mineral soil < 4 cm thick
Shallow/ thin mineral	2	Surface organic layer < 20 cm thick, and mineral soil ≥ 4 cm and < 100 cm thick
Deep dry mineral	4	Surface organic layer < 20 cm thick; mineral soil > 100 cm thick; moisture regime very fresh or drier. Vegetation indicative of the moisture regime is present.
Deep wet mineral	5	Surface organic layer < 20 cm thick; mineral soil > 100 cm thick; moisture regime moderately moist or wetter. Vegetation indicative of the moisture regime is present.
Thin peatland types		
Veneer bog on slope	15	Surface organic layer ≥ 20cm and < 100 cm. Occurs on ridges and crests or sloped topography.
Organic or Mineral types		
Swamp	10	Mineral or organic soil; moisture regime is wet. Water table usually > 20 cm below surface; periodically flooded; woody vegetation cover ≥ 25%.
Shallow peatland types		
Veneer bog	21	Surface organic layer ≥ 20cm and < 100 cm, not occurring on crests, ridges or slopes
Blanket bog	22	Surface organic layer > 100 and ≤ 200 cm; surface is level and featureless; patchy ground ice may be present but does not form hummocks or banks taller than 1 m
Slope bog	24	Surface organic layer > 20 cm thick and mineral soil > 100 cm thick; surface sloped. Moisture regime moderately moist or wetter. On slopes. Usually in runnels. Slope and bog indicators.
Slope fen	25	Surface organic layer > 20 cm thick and mineral soil > 100 cm thick; surface sloped. Moisture regime moderately moist or wetter. On a slope. Usually in runnels. Vegetation indicative of mesotrophic or eutrophic conditions. Fen indicators. All polygons that could be slope swamps are included in this type.
Peat plateau bog	31	Surface organic layer ≥ 20 cm: massive ground ice at least 1 m thick; surface level. Banks obvious.
Peat plateau bog transitional stage	32	Surface organic layer ≥ 20 cm: massive ground ice patchy forming large, obvious hummocks and/ or banks shorter than 1m. Peat plateau bog in the formation or disintegration stage (build-up or melting of ground ice).
Peat plateau bog/ collapse scar peatland mosaic	33	Mixture of peat plateau bog and collapse scar peatlands

Fine Ecosite Type	Fine Ecosite Code	Criteria*
Blanket bog/ collapse scar peatland mosaic	35	Mixture of blanket bog and collapse scar peatlands
Wet peatland types		
Collapse scar bog	43	Thermokarst feature. Surface organic layer ≥ 20 cm, in a depression within a peat plateau bog. Bog indicators. Peat mat usually floating. Often a narrow band of water on the perimeter.
Collapse scar fen	44	Thermokarst feature. Surface organic layer ≥ 20 cm, in a depression within a peat plateau bog. Fen indicators. Peat mat usually floating. Often a narrow band of water on the perimeter.
Horizontal fen/ blanket bog mosaic	45	Mixture of horizontal fen (see type 55) and blanket bogs (see type 22)
Basin fen	52	Surface organic layer ≥ 20 cm, situated in a basin that has an essentially closed drainage, receiving water from the immediate surroundings. May have outlets but no inlets. Vegetation indicative of mesotrophic or eutrophic conditions.
Flat bog	54	Surface organic layer ≥ 20 cm. Depth to mineral material or bedrock typically greater than 2 m. Surface flat. Occurring in broad, poorly defined depressions. Open water absent or as small pools. Bog vegetation only.
Horizontal fen	55	Surface organic layer >= 20 cm, open water absent or as small pools; buried water layer usually present. Distinct water flow or vegetation indicative of mesotrophic or eutrophic conditions present. Patterning not visible.
String fen	62	Surface organic layer > 20 cm. Narrow, peaty ridges ("strings") that enclose open water pools or depressions of open water ("flarks") or wet fen surfaces. Strings are at right angles to the direction of surface water flow. Vegetation indicative of mesotrophic or eutrophic conditions.
Shore zone peatland types		
Riparian bog	67	Surface organic layer >= 20 cm: floating; open water present. No visible evidence of flowing water. Bog indicators.
Riparian fen	68	Surface organic layer >= 20 cm: floating; open water present, along lakes and waterways. Visible evidence of flowing water and/or fen indicator vegetation.
Shore zone types		
Ice scour on mineral above wet meadow zone	70	Along Nelson River banks above the shoreline wetland zone, disturbed by ice movement. Usually a terrace or steeply sloped mineral/ bedrock area.
Upper beach- regulated	72	Nelson River shoreline wetland. In main river channel. Infrequent to frequent flooding. Sloped transition between open water and upland. Herbaceous and/or tall shrub vegetation.

Fine Ecosite Type	Fine Ecosite Code	Criteria*
Upper beach- regulated	75	Nelson River shoreline wetland. In a shallow bay. Sloped transition between open water and upland. Herbaceous and/or tall shrub vegetation.
Upper beach on sunken, disintegrated peatland	74	Wet meadow on sunken, disintegrated peatland that is under water. Sloped transition between open water and upland. Herbaceous and/or tall shrub vegetation, snags often present in water.
Lower beach	76	Shallow water with emergent vegetation present adjacent to shoreline, usually above waterline in low water years.
Upper beach on sunken peat	77	Marsh on sunken fringes of floating peatlands. Generally along edges of lakes and streams.
Littoral	79	Marsh island, floating-leaved patch in permanently submerged of the shallow water zone
Other types		
Shallow water	80-85	Water covering at least 400 m^2 area and shallower than 2 m
Deep water	88	Water covering at least 400 m^2 area and deeper than 2 m
Nelson River deep water	89	Water covering at least 400 m^2 area and deeper than 2 m
Human	90	Human structures or semi-permanent clearings (e.g., borrow areas that are not regenerating)

Notes: * Criteria refer to dominant conditions throughout the polygon.

The accuracy of ecosite photo-interpretation for the Keeyask Study Zone 4 was verified using soil profile data from the Project studies. This was accomplished by assigning an ecosite type to each soil profile using the patch level ecosite photo-interpretation criteria for thickness of surface organic layer, permafrost presence and depth to water table criteria.

Soil profile attribute data were adequate to unambiguously determine whether the profile indicated that the patch was a mineral or an organic ecosite type. Profile data were adequate to determine whether or not a peat plateau bog was correctly classified. Most peat plateau bog/ collapse scar mosaics could also be unambiguously classified. The exception was collapse scars or similar features that were not fens.

Some soil profiles could not be unambiguously classified to an ecosite type because the profile was sampled either too early or too late in the season to reliably assess a criterion. Some profiles sampled early in the growing season had the surface organic portion truncated due to seasonal frost. Soil profiles sampled late in the growing season had water tables that had dropped below their typical growing season level due to the annual water elevation cycle. This was particularly problematic for profiles sampled in late summer 2003 because this and the previous year were unusually dry.

Each soil profile was assigned an ecosite classification accuracy of either correct, incorrect or uncertain by comparing the photo-interpreted ecosite type with that derived from soil profile data. If the profile was truncated before an ecosite thickness criterion was met, the profile ecosite was classified as uncertain.

Profiles that appeared to indicate that the polygon was incorrectly classified were extracted from the dataset. Legitimate conflicts between patch and profile ecosite type can occur for two reasons. First, the profile occurs in a small patch that is too small to map given the minimum polygon size of two ha. Second, the soil sample location may be near a map polygon boundary that occurs in the transition zone between two ecosite types.

Polygons that appeared to be incorrectly classified based on soil profiles were examined in a GIS and on stereo photos to determine whether there actually was a photo-interpretation error or the conflict was one of the legitimate situations described in the previous paragraph. A conflict between the polygon and soil profile ecosite types was considered legitimate if the hole was near a polygon boundary and the adjacent polygon had the same patch level ecosite type as the soil profile.

A total of 821 soil profiles were used to verify ecosite photo-interpretation accuracy. Consistency between the patch and soil profile ecosite types was uncertain for nine profiles. Of the remaining 813 holes, 88% were correctly classified before correcting for legitimate conflicts between patch and profile ecosite types. Corrections for legitimate conflicts between the patch and soil profile ecosite type increased the overall classification accuracy rate from 88% to 97% (Table 5-3). Over one-half of the corrections related to soil profiles located in the transitional zone between two ecosite types. Patches too small to be typed as a separate polygon, early season frost and late season drought were the reasons for the remaining reclassifications. For the misclassifications in the corrected dataset, photo-interpretation errors generally occurred in large flat areas outside of depressions with little internal relief or in areas that were recently burned.

Table 5-3: Percentage accuracy of ecosite typing using soil profile data after correcting for legitimate conflicts

Ecosite	After	Before	Change
Outcrop	100	100	0
Shallow mineral	100	100	0
Deep dry mineral	100	96	4
Thin wet peat	96	92	4
Deep wet peat	92	62	30
Veneer bog	98	92	6
Blanket bog	95	71	24
Peat plateau bog*	86	86	0
PPB forming or breaking down	94	84	0
Collapse scar	98	90	8
PPB/ collapse scar mosaic	98	73	25
Horizontal peatland	96	96	0
Aquatic peatland	97	95	2
Overall	97	88	9

Notes: As described in the text below, these accuracy rates were actually higher than shown because there was a transcription error on a subset of the polygons used for the calculations. The rates were expected to become higher than 90% once this error was corrected.

The corrected classification accuracy rates ranged from a low of 86% for peat plateau bogs to a high of 100% for the outcrop and mineral ecosite types. All but three of the thirteen types had classification accuracy rates of at least 95%. Deep wet peat, peat plateau bog/collapse scar mosaic and blanket bog had the largest improvements in accuracy rates.

Peat plateau bog (86% accuracy) was the only ecosite type with an adjusted accuracy rate less than 92%. The accuracy assessment revealed a GIS update error that occurred for peat plateau bogs in the Keeyask proposed reservoir area. During the development of the ecosite classification, ecosite types were added to the initial list as photo-interpretation progressed over a larger area. Two new codes were created for thin wet peat and deep wet peat, and the initial code for both of these types was assigned to PPB. Ecosite codes for some of the previously typed polygons were missed during the code update. It was expected that the peat plateau bog accuracy rate will increase to over 90% once the patch ecosite type transcription error is corrected.

5.3.3 Ecosite Descriptions

Ecosite type descriptions were developed for the ecosite mapping from the plot data. GIS location data from each plot was used to overlay the plot position onto the ecosite mapping (Section 6.2.2). Plot data was applied to mapped ecosite types by inheriting the fine ecosite type of the polygon in which the plot fell.

Once mapped ecosite types were associated with individual plots, mapped ecosite type was compared to the plot site type. This was done to identify unusual associations between mapped ecosite and field site type from cluster analysis. These situations may arise because of the differences in the scale of information used to classify ecosite and site between the two methods. Mapped ecosite types were assigned based on the average conditions within a polygon that is usually one to several hectares in size. Plot site types were based on more detailed information within an area no larger than 400 m^2. Consequently, a plot site type may differ somewhat from the mapped ecosite type due to microsite conditions that were not captured in the mapping. In this situation, the mapped ecosite type may be adjusted to reflect conditions in a smaller area, or the plot site type may be accepted as part of the natural variability within the mapped ecosite.

A second reason for differences arises from plots that were located close to the boundary between two mapped ecosite types, which is a transitional zone. Due to the scale of mapping, the boundary of the patch level ecosite type for the plot may actually be the ecosite type in the adjacent polygon. In this situation, the mapped ecosite type associated with the plot is changed to that of the adjacent polygon which truly represents the plot. If the boundary deviation was large enough, the polygon was adjusted in the mapping.

The third possible reason for differences is due to mistyped polygons. In this situation, the photo-interpretation was reviewed, and corrections were made to the ecosite mapping. The corrected ecosite type was then assigned to that plot.

Once the plot data and mapped ecosite associations were finalized, plot-based environmental data were used to generate descriptive statistics for each of the plot-represented mapped ecosite types.

5.3.4 Labwork

Physical and chemical properties of soils were measured from soil samples collected for the inland habitat relationships and the peat properties studies since the design of these studies provided data representative of the Project Study Zone 4.

Extraction and determination methods for chemical analysis varied somewhat depending on the intended uses of the results. More rigorous methods were used for samples collected to characterize chemical releases from flooded areas than for characterization of typical soil properties for the study area.

5.3.4.1 Peat and Plant Tissue Samples

As described in Section 5.3.4.2, peat and plant tissue samples were collected in the proposed Keeyask reservoir area to characterize the chemical properties of flooded peat, reindeer lichens and peat mosses. Peat tissue material types were surface peat, peat from a buried Of horizon, peat from a buried Om horizon and peat from a buried Oh horizon. Plant tissue material types were green reindeer lichen (*Cladina mitis)*, grey reindeer lichen (*Cladina rangiferina)*, *Sphagnum* moss collected from hummocks and *Sphagnum* moss collected from hollows.

Samples were sent to Norwest Labs for chemical analysis. A preliminary chemical analysis of peat material, lichen tissue and sphagnum moss tissue was conducted to select the most appropriate extraction and analytical methods for our samples. Once the extraction and analytical methods were selected, the remaining samples were submitted for chemical analysis.

The preliminary chemical analysis was conducted in two stages. In the first stage, up to five samples from each combination of ecosite type and material type were submitted, if available. The first batch included 35 samples while 121 samples were in the second batch for a total of 156 samples, 86 of which were peat samples.

Samples were oven-dried at 60°C prior to chemical analysis to ensure consistent moisture content. Quality control during chemical analyses was monitored by the use of duplicate samples, blanks, and standard reference materials (Markert 1988).

Element concentrations except for mercury were determined using inductively coupled atomic emission spectroscopy following EPA Method 6010B. Mercury was determined using cold-vapor atomic absorption following APHA Method 3112B. Samples were digested using EPA Method 3052. In this digestion process, nitric acid and hydrofluoric acid were added to a representative sample in a fluorocarbon digestion vessel and heated in a microwave unit prior to analysis.

Table 5-4 provides detection limits attained using these methods.

Analysis of results from the first batch indicated that two elements of environmental concern, arsenic and selenium, had detection limits (Table 5-4) that were higher than might be expected from typical background concentrations in some plant tissue types. Arsenic's detection limit was lower than but close to the 2002 Canadian environmental quality guideline of 5.9 μg/g for this element in freshwater sediment (but still far below the probable effect level concentration of 17 μg/g).

All 35 samples in the first batch (or approximately 22% of the total number ultimately analyzed), were then retested to determine arsenic and selenium concentrations using graphite furnace atomic absorption spectrophotometry, a technique with much lower detection limits for these elements (Table 5-4). Retesting evaluated whether using the optical ICP and EPA 3052 digestion method created a serious limitation. The graphite furnace detection limit for arsenic was 0.3 μg/g. All retested samples had arsenic concentrations less than 2.1 μg/g (including 13 with concentrations below the lower detection limit) and selenium concentrations less than 0.6 μg/g (including 25 with concentrations below the lower detection limit). On this basis it was decided that the additional cost of analyzing all samples using a method with a lower detection limit was not justified.

Following the second batch of chemical analyses, power tests were run to determine if more samples needed to be analyzed. Statistical analyses tested for differences in trace metal concentrations between different lichen species samples, between sphagnum hummock and hollow samples, and between peat samples from different organic horizons. These analyses were run for all samples together, as well as stratified by ecosite type.

Table 5-4: The elements and their respective detection limits (μg/g) in the different runs of the ICP scans (and CV-AA for mercury)

Element	Detection Limit	
	ICP-AES	Graphite A
Aluminum	1	-
Antimony	2	-
Arsenic	4	0.3
Barium	0.05	-
Beryllium	0.05	-
Bismuth	2	-
Cadmium	0.05	-
Calcium	1	-
Chromium	0.1	-
Cobalt	0.1	-
Copper	0.1	-
Iron	0.2	-
Lead	1	-
Lithium	0.6	-
Magnesium	1	-
Manganese	0.05	-
Mercury	0.01	-
Molybdenum	1	-
Nickel	0.2	-
Phosphorus	5	-
Potassium	100	-
Selenium	10	0.2
Silicon	5	-
Silver	0.2	-
Sodium	5	-
Strontium	0.5	-
Sulfur	100	-
Tin	1	-
Titanium	0.4	-
Uranium	6	-
Vanadium	0.1	-
Zinc	0.1	-
Zirconium	0.5	-

5.3.4.2 Habitat Plot Soil Samples

Physical and chemical analyses were conducted on a subset of the soil samples collected at the inland, detailed ravine, detailed shelf and detailed island habitat plots. Bulk density of volumetric samples was measured in the office lab. A subset of the mineral soil samples were sent to an external lab for analysis of particle size distribution, inorganic carbon, organic carbon, total carbon, total N, pH, electrical conductivity, available nitrate N, available sulfate S, plant available P and K, extractable cations and extractable Al, Fe and Mn. Analytical methods are provided in Appendix 5-A.

A subset of the samples were analyzed for total N, total C and trace metals. Total N and total C were determined by LECO combustion following AOAC Method 990.03, with detection limits for total N and total C being 0.03% and 0.02-0.05%, respectively.

A subset of the peat samples were also analyzed for available P and available N. Available P was determined by extraction with acetic acid followed by ICP, and total P was done in the metal scan. Available N was determined by extractable $CaCl_2$ and Cd reduction.

5.3.4.3 Peatland Disintegration

Additional lab analyses of the physical properties of peat and organic sediment settling rates were conducted to support Keeyask Project effects predictions regarding peatland disintegration and sedimentation modeling. Methods and results for these analyses are reported in ECOSTEM (2011a, b).

5.3.5 Data Analysis

5.3.5.1 Representative Samples

Terrestrial habitat and ecosystem studies used various soil sampling protocols, depending on the question of interest. For some of these studies, the sampling design was representative for the study area of interest as a whole while the designs for others were only representative for specific conditions or geographic areas. Data collected by study designs representative for a regional study area were used to calculate results applicable to the study areas as a whole.

Because the boreholes were primarily located within potential infrastructure footprints and in potential borrow areas, they were a biased sample of the Study Zone 2 or broader areas. For this reason, their primary use was to corroborate or validate results developed from the soils and ecosite data.

5.3.5.2 Substitution for Non-Detects

Concentration results from the chemical analysis of soil and plant tissue typically include values that are below the detection limit of the analytical methods used. This raises the question as to what values should be used for concentration values that are below the detection limit (referred to as non-detects for the chemical analysis or left-censored data for statistical analysis) when calculating statistics. There are several methods for selecting substitution values for non-detects. The most common methods described in the literature are to substitute:

1. Detection limit (DL) value;
2. Zero;
3. DL*0.5 or DL*0.7; and,
4. A statistical model to estimate a distribution of concentrations below the DL.

Method 1 is the most conservative in the sense that it produces the largest mean or median value because it assumes that a substance is present at the largest possible concentration at or below the DL (US EPA 2000; Pest Management Regulatory Agency 2003). This method is most commonly used in risk assessment situations where a conservative approach is desired, but it can positively bias results and bias standard deviations (Wendelberger and Campbell 1994; Corl *et al.* 2002; US EPA 2000). Standard deviations are biased since there is zero variability between the substituted values. The degree to which statistics are affected is determined by the proportion of non-detects in the calculation.

Method 2 is the least conservative approach, assuming that non-detect values represent absence of the substance (US EPA 2000; Pest Management Regulatory Agency 2003). This method is suitable for situations where it is reasonably certain that a substance is absent (Corl *et al.* 2002; US EPA 2000).

The third method is commonly employed in non-risk assessment situations, regulatory guidelines, and soil analysis studies (US EPA 2000; Pest Management Regulatory Agency 2003). This method either substitutes a value of 0.5 of the DL (which assumes the average concentration for non-detects is 50% of the DL) or a value of 0.7 of the DL. This method is useful for situations when the presence of a substance is possible, particularly when sampling along a gradient where it is present in higher concentrations elsewhere (Corl *et al.* 2002). This method has been shown to produce sufficiently accurate results in smaller datasets when compared to more complex statistical methods (Zhang *et al.* 2004). However, it biases estimates of variability statistics such as the standard deviation or standard error.

The fourth method is used in situations where bias should be minimized, and when dealing with very low concentrations of substances (Helsel 1987; US EPA 2000). This method is the most time consuming, and is most effective for datasets with large proportions of non-detect values (US EPA 2000).

There have been a number of comparisons of these approaches (e.g., Wendelberger and Campbell 1994; Clarke 1998; Corl *et al.* 2002; Zhang et al. 2004). Zhang et al. (2004) found that the DL*0.5 substitution method produces comparable results to more complex statistical models. Wendelberger and Campbell (1994) indicated that results from the non-parametric statistical methods for analysis are not strongly impacted by the choice of substitution method. The Pest Management Regulatory Agency (Pest Management Regulatory Agency 2003) generally recommends the use of a default value of half the Limit of Detection (LOD) or half the Limit of Quantitation (LOQ) for commodities which have been treated but for which no detectable residues are measured.

Ogden (2010) reports that the editorial board of the Annals of Occupational Hygiene journal considered Helsel's (2010) recommendation that journals reject papers that do not use a statistical model to replace non-detects. Their conclusion was that they should not necessarily reject papers not using this method arguing that. . .

> "the key principle as with all measurements and data treatments is that the conclusions must be justified by the evidence, or, to put it another way, approximations in the data treatment must not be so gross as to undermine the validity of the conclusions. So on substitution, researchers should be familiar enough with the problems to be able to justify their approximations and not just substitute because it is easy."

They go on to summarize the results of the studies that have examined the effects of substituting arbitrary values. If the percentage of non-detects is between 1% and 50% and the number of observations between 20 and 100, for a log-normal distribution with geometric standard deviation between 1.2 and 4, then a substitution of DL/2 or DL/2^.5 means that the average result shows fairly modest bias in the 95th percentile or the mean, and the imprecisions of these estimates are only slightly worse than the optimum method of data treatment.

On the basis that several studies have found that biases from using the DL/2 substitution method for non-detect values are limited, this was the method used.

5.4 RESULTS

Soil profiles were sampled at over 3,000 locations in the LNR region from 2001 to 2012 (Table 5-5). Map 5-1 shows the soil sample locations in the Keeyask Regional Study Area while Map 5-2 shows soil sample locations in the rest of the LNR region.

Table 5-5: Number of soil profile samples by regional study area, geographic zone, sampling protocol and year

Regional Study Area	Zone	Not Used for Inland Soil Character-ization[1]	Sampling Protocol	Year 2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	All
Keeyask	Keeyask	X	Fire effects	-	-	-	75	-	-	-	-	-	-	-	75
		X	Shore & wetland	-	-	-	-	68	-	-	-	-	-	-	68
			Inland	-	122	33	-	-	25	32	112	31	-	-	355
			Soil recon	136	-	-	-	-	-	-	-	-	-	-	136
			Peat plots	-	103	297	160	-	-	-	-	-	-	-	560
		X	Shore	-	56	-	-	-	-	-	-	-	71	-	127
	Long Spruce	X	Rail spur	-	-	12	-	-	-	-	-	-	-	-	12
			Soil recon	-	-	-	47	-	-	-	-	-	-	-	47
			Inland	-	-	2	-	-	-	-	-	1	-	-	3
		X	Shore	-	-	-	-	9	-	-	-	-	-	-	9
	Stephens Lake		Inland	-	-	-	-	12	-	-	-	-	-	-	12
		X	Shore	-	20	7	-	-	-	-	-	-	12	-	39
			Peat plots	-	-	-	-	-	-	-	-	-	149	-	149
	All			136	301	339	282	89	25	32	112	32	232	0	1,580
Cona-wapa	Conawapa		Soil recon	-	-	95	-	-	-	-	-	-	-	-	95
			Ravine detail	-	-	-	130	73	-	-	-	-	-	5	208
		X	Mammal dens/cameras	-	-	-	27	-	16	1	2	-	-	-	43
			Island detail	-	-	-	20	6	-	3	-	-	-	-	29
			Soil recon	-	-	-	74	-	81	-	9	-	-	27	191
			Inland	-	-	42	58	-	4	63	53	15	9	12	256
			Shelf detail	-	-	-	39	-	-	-	-	-	-	-	39
	Deer Island		Ravine detail	-	-	-	36	30	-	-	-	-	-	5	71
			Island detail	-	-	-	6	9	-	-	-	-	-	-	15
			Soil recon	-	-	-	-	-	-	72	20	23	-	-	110

Regional Study Area	Zone	Not Used for Inland Soil Character-ization[1]	Sampling Protocol	Year											
				2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	All
			Inland	-	-	-	-	14	17	-	6	7	-	5	49
			Shelf detail	-	-	-	-	-	12	-	-	-	-	-	12
	Limestone		Ravine detail	-	-	-	-	-	-	-	-	-	-	7	7
		X	Mammal cameras	-	-	-	-	-	4	-	-	-	-	-	4
			Soil recon	-	-	-	50	-	-	-	25	28	-	-	99
			Inland	-	-	3	17	-	8	-	-	8	-	4	40
	Estuary		Ravine detail	-	-	-	21	-	17	-	-	2	2	3	45
			Island detail	-	-	-	-	-	9	-	-	-	-	-	9
			Soil recon	-	-	-	-	-	-	-	8	-	-	-	8
			Inland	-	-	-	-	-	9	-	-	4	-	-	13
	Fox River		Ravine detail	-	-	-	-	-	15	-	-	-	-	-	15
			Island detail	-	-	-	-	-	16	-	-	-	-	-	16
			Shelf detail	-	-	-	-	-	10	-	-	-	-	-	10
	God's River		Island detail	-	-	-	-	-	-	7	-	-	-	-	7
			Shelf detail	-	-	-	-	-	-	6	-	-	-	-	6
	Hayes		Ravine detail	-	-	-	-	-	-	-	5	-	-	-	5
			Island detail	-	-	-	-	-	-	-	2	-	-	-	2
			Shelf detail	-	-	-	-	-	-	-	3	-	-	-	3
	All			0	0	152	478	132	218	152	133	87	11	68	1,431
Total				136	301	491	760	221	243	184	245	119	243	68	3,011

Notes: [1] "X" identifies protocols not used for inland soil characterization.

5.4.1 Soil Orders

As of 2007, when the majority of the data analysis to characterize soil orders in the LNR region was completed, 1,848 of the soil profiles were from sampling designs that were representative of the study areas.

The 1,848 soil profiles were from the Brunisolic, Cryosolic, Gleysolic, Luvisolic, Organic and Regosolic soil orders (Table 5-6). Six soil profiles were classified as non-soil because they were thin mineral over bedrock. The Organic order was the most common one in the LNR region (33% of locations), while the Cryosolic order was the second most common (27% of locations). The Gleysolic and Brunisolic orders were also common in the LNR region, with each accounting for around 15% of the locations. The Regosolic and Luvisolic orders comprised small percentages of the sampled locations.

Table 5-6: Frequencies and percentages of the soil profiles classified to soil order for the LNR region

Soil Order	N	Percent of Profiles
Brunisolic	266	14.4
Cryosolic	498	26.9
Gleysolic	282	15.3
Luvisolic	36	1.9
Organic	603	32.6
Regosolic	157	8.5
Non-soil	6	0.3
Total	1,848	100.0

5.4.1.1 Keeyask and Conawapa Regional Study Areas

All six soil orders appeared in the Keeyask and Conawapa Regional Study Areas (Table 5-7). The Organic order comprised 48% of the locations in the Keeyask Regional Study Area, which was substantially higher than for the LNR region as a whole. The rank order of the remaining soil orders was the same as for the LNR region.

The soil order composition of the Conawapa Regional Study Area was much more even than for the Keeyask Regional Study Area (Table 5-7), and the difference was statistically significant (Table 5-8). While the Cryosolic and Organic orders were still the two most common soil orders, each comprised only around 25% of the Conawapa Regional Study Area locations. The Brunisolic, Gleysolic and Regosolic orders were also important in the Conawapa Regional Study Area.

Table 5-7: Frequencies and percentages of the soil profiles classified to soil order by regional study area

Soil Order	Keeyask		Conawapa	
	N	Percent of Profiles	N	Percent of Profiles
Brunisolic	91	9.8	161	17.5
Cryosolic	241	26.0	255	27.7
Gleysolic	56	6.0	190	20.6
Luvisolic	13	1.4	23	2.5
Organic	442	47.7	216	23.4
Regosolic	77	8.3	77	8.4
Non-soil	6	0.6	0	0
Total	926	100%	922	100%

Table 5-8: Kruskal-Wallis test for differences in the frequency distributions of soil orders in the Keeyask and Conawapa Regional Study Areas

Parameter	Value
Chi-Square	52.8
DF	1
Asymptotic Significance	.000

The soil order composition results changed when only the inland habitat and sub-regionally representative soil reconnaissance profiles were used to compare soil order frequency distribution between the two regions. For the Keeyask Regional Study Area, the most common soil order became the Cryosolic order followed by Organic Order (Table 5-9). Other orders except for the Brunisolic Order each accounted for small percentages of the locations. For the Conawapa Regional Study Area, the Organic order became much more common while the remaining orders except for the Cryosolic Order became less common. The Kruskal-Wallis test showed that there was a significant difference in the Conawapa and Keeyask soil order frequency distributions derived from sub-regionally representative soil profiles (Table 5-10).

Table 5-9: Soil order frequencies and percentages calculated from the inland habitat and sub-regionally representative soil reconnaissance locations, by regional study area

Soil Order	Keeyask		Conawapa	
	N	Percent of Profiles	N	Percent of Profiles
Brunisolic	49	13.4%	28	7.4%
Cryosolic	163	44.4%	113	30.0%
Gleysolic	19	5.2%	39	10.3%
Luvisolic	11	3.0%	13	3.4%
Organic	102	27.8%	177	46.9%
Regosolic	23	6.3%	7	1.9%
Total	367	100%	377	100%

Table 5-10: Kruskal-Wallis test for differences in soil order frequency distributions between Keeyask and Conawapa Regional Study Areas for inland habitat and sub-regionally representative soil reconnaissance locations

Parameter	Value
Chi-Square	19.7
DF	1
Asymptotic Significance	.000

5.4.1.2 Keeyask Reservoir Area

A high proportion of the soil profiles sampled in Keeyask Regional Study Area were located in Keeyask reservoir area. Nearly half of these soil profiles belonged to the Organic order (Table 5-11). The difference in soil order frequency distribution between the Keeyask reservoir area and the remaining Keeyask locations was statistically significant (Table 5-12).

Table 5-11: Frequencies and percentages of soil orders in the Keeyask reservoir area compared with the rest of Study Zone 4

Soil Order	Keeyask Reservoir Area		Other Areas in Study Zone 4	
	N	Percent of Profiles	N	Percent of Profiles
Brunisolic	67	8.4	24	19.0
Cryosolic	208	26.0	33	26.2
Gleysolic	47	5.9	9	7.1
Luvisolic	4	0.5	9	7.1
Organic	395	49.4	46	36.5
Regosolic	72	9.0	5	4.0
Non-soil	6	0.8	-	0
Total	799	100%	126	100%

Notes: Cells with "0" values are values that round to 0, while "-" indicates a null value.

Table 5-12: Kruskal-Wallis test for differences in soil order frequency distributions for the Keeyask reservoir area and the remaining Keeyask locations

Parameter	Value
Chi-Square	13.3
DF	1
Asymptotic Significance	.00

5.4.1.3 Soil Order Distribution Over Site Types

Site type was an ecological classification of site level soil, surficial material, surface water, groundwater and permafrost conditions into types that were associated with substantial differences in vegetation composition and/or structure. Consequently, a high degree of correspondence between a soil profile's site type and soil order was expected.

The vast majority of the soil profiles were classified into the Deep Dry, Deep Wet. Sphagnum Bog, Fen, and Feathermoss Bog site types (Table 5-13). Six profiles were non-soils. Differences in the distribution of soil orders across site types were statistically significant.

The distribution of soil profiles by soil order and site type (Table 5-13) was as expected. Mineral soil orders were predominantly classified into mineral site types while organic soil orders were predominantly classified into organic site types. Exceptions related to the lower cutoff for the thickness of surface organic material and/or gleying in the site type classification system.

Table 5-13: Soil Order occurrences by site type

Site Type	Non-Soil	Soil Order						Total
		Regosolic	Brunisolic	Luvisolic	Gleysolic	Cryosolic	Organic	
Outcrop	6	0	0	0	0	0	0	6
Thin	0	4	0	0	0	0	0	4
Moderately Deep Mineral	0	2	2	0	1	0	0	5
Deep Dry	0	65	221	32	23	32	0	374
Deep Wet	0	21	10	2	152	42	0	227
Sphagnum Bog	0	36	10	0	32	266	360	704
Fen	0	1	0	0	13	18	234	266
Feathermoss Bog	0	25	9	2	22	138	53	248
Swamp	0	0	0	0	2	0	9	11
Deep Marsh	0	0	0	0	1	0	2	3
Total	6	154	252	36	246	496	658	1,848

5.4.2 Labwork

This section provides results of physical and chemical analyses of soil samples. Results for the physical properties of peat in addition to those included in this report are provided in other project reports (ECOSTEM 2011a, b).

Element concentrations (μg/g) were determined for a total of 86 peat samples and 70 plant tissue samples. Table 5-14 provides the number of samples analyzed by soil layer or plant species.

Of the 36 elements, non-detects (i.e., concentrations below the detection limit) occurred for 18 elements in peat samples and 16 elements in plant tissue samples (Table 5-15). The percentage of non-detects exceeded 50% for antimony, arsenic, beryllium, bismuth, lithium, molybdenum, selenium and silver in both peat and plant tissue samples (see Section 5.3.4 for additional arsenic and selenium results).

Table 5-14: Number of peat and plant tissue samples analyzed by soil layer or species

Type	Soil Layer or Plant Species[1]	Number or Samples
Peat	Surface peat	26
	Of	23
	Of1	1
	Of2	2
	Oh	12
	Om	19
	2Of	1
	2Om1	1
	2Om2	1
	Peat Total	86
Plant	*Cladina mitis*	19
	Cladina rangiferina	7
	Sphagnum spp.- hollow	22
	Sphagnum spp.- hummock	22
	Plant Total	70
All		156

Notes: [1] Of=fibric organic layer; Om=mesic organic layer; Oh=humic organic layer. A “2” prefix indicates a second buried Of or Om layer.

Table 5-15: Percentage of samples where concentration was below the detection limit by element for peat material and plant tissue

Element	Detection Limit (μg/g)	Percentage of Samples Below Detection Limit	
		Peat	Plant
Aluminum	1	0	0
Antimony	2	94	99
Arsenic	4	87	96
Barium	0.05	0	0
Beryllium	0.05	57	97
Bismuth	2	94	99
Cadmium	0.05	7	16
Calcium	1	0	0
Chromium	0.1	1	0
Cobalt	0.1	15	77
Copper	0.1	0	0
Iron	0.2	0	0
Lead	1	43	29
Lithium	0.6	63	99
Magnesium	1	0	0
Manganese	0.05	0	0
Mercury	0.01	1	10
Molybdenum	1	84	100
Nickel	0.2	1	0
Phosphorus	5	0	0
Potassium	100	9	11
Selenium	10	100	99
Silicon	5	9	21
Silver	0.2	66	99
Sodium	5	0	0
Strontium	0.5	0	0
Sulfur	100	0	4
Thorium	0.5	3	0
Tin	1	0	0
Titanium	0.4	0	0
Uranium	6	1	0
Vanadium	0.1	0	0
Zinc	0.1	0	0
Zirconium	0.5	0	3

5.4.2.1 Peat

Table 5-16 provides mean concentrations for each element in peat. In descending order of mean concentration, the elements that had the highest concentrations in peat were calcium, aluminum, iron, magnesium, sulfur, potassium, silicon, sodium and phosphorus.

Table 5-17 provides mean concentrations and standard errors of the mean for each element by soil layer with at least three replicate samples. Mean concentrations by soil layer differed significantly (α=1%) for at least one soil layer when compared with the others for 22 of the 27 elements that had less than 50% non-detects. Of the 22 elements, 20 had less than 10% non-detects. Elements whose concentrations did not vary significantly with soil layer and had less than 50% non-detects included manganese, phosphorus, potassium, tin and zinc.

Table 5-16: Mean and standard error of element concentrations (μg/g) measured in peat samples and detection limit

Element	Detection Limit (μg/g)	Percentage Below Detection Limit	Mean (μg/g)	Std. Error (μg/g)
Aluminum	1	0	4,291	932
Antimony	2	94	1.17	0.08
Arsenic	4	87	2.49	0.14
Barium	0.05	0	57.6	7.1
Beryllium	0.05	57	0.14	0.03
Bismuth	2	94	1.15	0.07
Cadmium	0.05	7	0.32	0.02
Calcium	1	0	13,874	1,596
Chromium	0.1	1	6.08	1.28
Cobalt	0.1	15	1.59	0.25
Copper	0.1	0	6.46	0.71
Iron	0.2	0	3,112	595
Lead	1	43	3.93	0.47
Lithium	0.6	63	2.91	0.74
Magnesium	1	0	2,065	220
Manganese	0.05	0	134.1	20.9
Mercury	0.01	1	0.11	0.01
Molybdenum	1	84	0.73	0.06
Nickel	0.2	1	4.50	0.59
Phosphorus	5	0	502	23
Potassium	100	9	1,283	268
Selenium	10	100	5.00	0.00
Silicon	5	9	1,217	385
Silver	0.2	66	0.33	0.05
Sodium	5	0	635	100
Strontium	0.5	0	37	4
Sulfur	100	0	1,454	114
Thorium	0.5	3	1.29	0.21
Tin	1	0	1.42	0.13
Titanium	0.4	0	143.3	28.5
Uranium	6	1	9.11	1.08
Vanadium	0.1	0	7.28	1.43
Zinc	0.1	0	17.91	1.97
Zirconium	0.5	0	7.32	1.23

Notes: N = 86

Table 5-17: Mean and standard error of element concentrations ($\mu g/g$) measured in peat samples by soil layer

Element	DL	Surface		Of		Om		Oh	
		Mean	S.E of Mean	Mean	S.E of Mean	Mean	S.E of Mean	Mean	S.E of Mean
Aluminum	1	2,769	716	757	181	7,014	2,607	11,787	4,299
Antimony	2	1.08	0.08	1.09	0.09	1.21	0.21	1.58	0.40
Arsenic	4	2.43	0.24	2.52	0.29	2.57	0.33	2.63	0.46
Barium	0.05	33.4	6.2	22.7	2.9	87.8	18.9	143.8	20.8
Beryllium	0.05	0.07	0.02	0.03	0.00	0.25	0.08	0.41	0.10
Bismuth	2	1.00	0.00	1.00	0.00	1.53	0.25	1.25	0.25
Cadmium	0.05	0.41	0.05	0.15	0.02	0.32	0.03	0.53	0.07
Calcium	1	8,642	2,678	9,131	1,678	21,408	4,187	23,823	4,683
Chromium	0.1	2.32	0.72	1.20	0.21	11.45	3.84	17.33	5.10
Cobalt	0.1	0.49	0.13	0.85	0.35	2.66	0.63	4.29	0.82
Copper	0.1	3.82	0.50	2.42	0.34	9.65	1.64	16.40	2.02
Iron	0.2	1,340	406	937	178	5,171	1,485	8,987	2,740
Lead	1	8.02	0.80	2.69	0.68	1.88	0.74	2.00	0.95
Lithium	0.6	1.00	0.44	0.44	0.08	5.42	2.08	9.12	3.45
Magnesium	1	1,046	149	1,679	210	2,725	511	4,297	983
Manganese	0.05	83.0	11.7	181.8	61.8	165.9	46.7	151.4	39.2
Mercury	0.01	0.15	0.01	0.09	0.01	0.09	0.01	0.11	0.01
Molybdenum	1	0.50	0.00	0.57	0.07	1.27	0.19	0.67	0.13
Nickel	0.2	3.14	0.52	1.73	0.20	5.94	1.43	11.69	2.37
Phosphorus	5	548	42	471	41	510	54	531	67
Potassium	100	1,563	471	917	107	895	332	2,434	1,533
Selenium	10	5.00	0.00	5.00	0.00	5.00	0.00	5.00	0.00
Silicon	5	1,430	907	805	655	890	421	2,609	1,324
Silver	0.2	0.15	0.02	0.11	0.01	0.54	0.14	0.91	0.18
Sodium	5	329	57	329	36	1,028	321	1,481	360
Strontium	0.5	14	2	22	3	63	8	80	9
Sulfur	100	893	56	887	143	2,314	287	2,213	292
Thorium	0.5	0.50	0.08	0.45	0.09	2.13	0.51	3.81	0.85
Tin	1	1.23	0.22	1.32	0.25	1.44	0.29	1.34	0.34
Titanium	0.4	60.35	16.02	24.01	5.26	260.35	83.45	422.47	109.50
Uranium	6	4.55	0.33	5.00	0.45	12.22	1.89	24.11	4.94
Vanadium	0.1	3.00	0.84	1.26	0.25	13.28	4.10	21.47	5.58
Zinc	0.1	18.39	1.76	16.07	1.63	16.48	4.40	25.26	11.38
Zirconium	0.5	2.31	0.66	1.55	0.29	13.05	3.37	22.46	3.84
N		26		23		19		12	

5.4.2.2 Plant Tissue

Mean concentrations for each element in plant tissue are provided in Table 5-18. In descending order of mean concentration, the elements that had the highest mean concentrations in plant tissue were calcium, potassium, magnesium, sulfur and phosphorus.

Table 5-18: Mean and standard error of element concentrations (μg/g), total carbon (% of D.W.) and total nitrogen (% of D.W.) measured in plant tissue samples

Element	Detection Limit (μg/g)	Percentage Below Detection Limit	Mean	S.E of Mean
Aluminum	1	0	284	17
Antimony	2	99	1	0
Arsenic	4	96	2	0
Barium	0.05	0	11.26	0.62
Beryllium	0.05	97	0.03	0.00
Bismuth	2	99	1	0
Cadmium	0.05	16	0.10	0.01
Calcium	1	0	2,820	349
Chromium	0.1	0	0.5	0.0
Cobalt	0.1	77	0.1	0.0
Copper	0.1	0	2.7	0.4
Iron	0.2	0	198.8	11.7
Lead	1	29	3	0
Lithium	0.6	99	0.3	0.0
Magnesium	1	0	735	83
Manganese	0.05	0	123.21	11.64
Mercury	0.01	10	0.04	0.00
Molybdenum	1	100	1	0
Nickel	0.2	0	1.9	0.1
Phosphorus	5	0	393	19
Potassium	100	11	2,107	174
Selenium	10	99	5	0
Silicon	5	21	69	16
Silver	0.2	99	0.1	0.0
Sodium	5	0	266	22
Strontium	0.5	0	5.4	0.9
Sulfur	100	4	511	61
Thorium	0.5	0	0.3	0.0
Tin	1	0	1	0

Element	Detection Limit (μg/g)	Percentage Below Detection Limit	Mean	S.E of Mean
Titanium	0.4	0	11.2	0.6
Uranium	6	0	4	0
Vanadium	0.1	0	0.6	0.0
Zinc	0.1	0	17.4	0.8
Zirconium	0.5	3	2.8	2.0
Total Nitrogen	0.03		0.43	0.02
Total Carbon	0.05		41.38	0.16
Notes: N = 70				

Table 5-19 provides mean concentrations and standard errors for each element by species. Compared with soil layers, there were fewer species based statistically significant differences even when the significance level was increased to α=1%. At this significance level, parameters with mean values that varied significantly by species and had less than 50% non-detects included barium, calcium, copper, lead, magnesium, manganese, mercury, nickel, potassium, sodium, sulfur, zinc and total nitrogen (Table 5-20) as a percentage of dry weight. For all of the situations where there was a significant difference, *Sphagnum* hollow species had the highest mean values followed by *Sphagnum* hummock species while *Cladina mitis* had the lowest values.

Table 5-19: Mean and standard error of element concentrations (μg/g), measured in plant tissue samples by species

Element	DL	*Cladina mitis*		*Cladina rangiferina*		*Sphagnum*-hollow		*Sphagnum*-hummock	
		Mean	S.E of Mean	Mean	S.E of Mean	Mean	S.E of Mean	Mean	S.E of Mean
Aluminum	1	271	28	316	40	305	41	265	26
Antimony	2	1	0	1	0	1	0	1	0
Arsenic	4	2	0	2	0	2	0	2	0
Barium	0.05	7.13	0.60	11.90	1.10	13.15	1.18	12.73	1.09
Beryllium	0.05	0.03	0.00	0.03	0.00	0.03	0.00	0.04	0.01
Bismuth	2	1	0	1	0	1	0	1	0
Cadmium	0.05	0.08	0.01	0.10	0.02	0.10	0.01	0.13	0.03
Calcium	1	1,143	184	1,271	77	4,373	721	3,209	674
Chromium	0.1	0.5	0.1	0.5	0.0	0.5	0.1	0.5	0.0
Cobalt	0.1	0.1	0.0	0.1	0.0	0.2	0.0	0.1	0.0
Copper	0.1	1.4	0.1	2.0	0.2	4.4	1.2	2.5	0.2
Iron	0.2	168.3	14.4	217.4	27.1	230.8	30.3	187.1	14.0
Lead	1	1	0	3	0	4	1	3	0
Lithium	0.6	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0

Element	DL	*Cladina mitis*		*Cladina rangiferina*		*Sphagnum-hollow*		*Sphagnum-hummock*	
		Mean	S.E of Mean	Mean	S.E of Mean	Mean	S.E of Mean	Mean	S.E of Mean
Magnesium	1	333	51	301	10	1,116	161	837	165
Manganese	0.05	73.5	8.1	105.7	15.6	124.9	17.4	170.0	28.9
Mercury	0.01	0.02	0.01	0.04	0.01	0.05	0.00	0.05	0.00
Molybdenum	1	1	0	1	0	1	0	1	0
Nickel	0.2	2.0	0.2	3.0	0.5	1.7	0.1	1.8	0.1
Phosphorus	5	322	26	370	38	455	46	400	25
Potassium	100	1,076	79	1,181	94	2,811	360	2,589	303
Selenium	10	6	1	5	0	5	0	5	0
Silicon	5	20	7	17	12	97	27	101	41
Silver	0.2	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Sodium	5	90	15	83	14	381	36	361	31
Strontium	0.5	2.7	0.7	2.8	0.2	8.1	1.9	6.0	1.7
Sulfur	100	279	63	230	137	662	113	651	128
Thorium	0.5	0.4	0.0	0.4	0.0	0.3	0.0	0.3	0.0
Tin	1	1	0	1	0	1	0	1	0
Titanium	0.4	11.7	1.1	13.2	1.7	11.2	1.5	10.1	0.9
Uranium	6	4	0	4	0	4	0	4	0
Vanadium	0.1	0.4	0.1	0.6	0.1	0.6	0.1	0.6	0.1
Zinc	0.1	12.6	0.8	19.1	2.5	19.4	1.5	19.0	1.3
Zirconium	0.5	0.7	0.1	1.4	0.9	0.8	0.3	6.9	6.2

Total nitrogen and carbon as a percentage of dry weight is provided for each species in Table 5-20.

Table 5-20: Mean and standard error of total carbon (% D.W.) and total nitrogen (% D.W.) measured in plant tissue samples by species

Element	DL	*Cladina mitis*		*Cladina rangiferina*		*Sphagnum-hollow*		*Sphagnum-hummock*	
		Mean	S.E of Mean	Mean	S.E of Mean	Mean	S.E of Mean	Mean	S.E of Mean
Total Nitrogen	0.03	0.29	0.02	0.32	0.02	0.54	0.03	0.47	0.02
Total Carbon	0.05	41.2	0.2	42.0	0.4	41.5	0.3	41.2	0.4

5.4.2.3 Terrestrial Habitat Relationships Mineral Soil Samples

A total of 71 mineral soil samples were submitted for physical and chemical analyses. Measurement units, detection limits and percentage of non-detects for physical and chemical soil parameters measured in mineral soil samples are provided in Table 5-21.

Table 5-21: Measurement units, detection limits and percentage of non-detects for physical and chemical soil parameters measured in mineral soil samples

Parameter	N	Detection Limit	Units	% of Non-Detects
Aluminum	71	30	μg/g	0
Iron	71	30	μg/g	0
Manganese	71	2	μg/g	0
Available N	70	2	mg/kg	96
Available P	71	2	mg/kg	80
Available K	71	10	mg/kg	4
Available S	70	3	mg/kg	26
Extractable Calcium	70	2	meq/100g	20
Extractable Magnesium	70	1	meq/100g	47
Extractable Potassium	70	1	meq/100g	100
Extractable Sodium	70	1	meq/100g	100
Extractable CEC	70	1	meq/100g	1
Inorganic Carbon	71	0.1	% of D.W.	34
Total Carbon	71	0.1	% of D.W.	1
Total Carbon combust	71	0.1	% of D.W.	1
Total Nitrogen combust	71	0.02	% of D.W.	8
pH	63	0.1	pH	0
Conductivity	63	0.05	dS m-1	0
Calcium carbonates	71	0.7	% of D.W.	28
Percent Clay	71	0.1	% of D.W.	0
Percent Sand	71	0.1	% of D.W.	0
Percent Silt	71	0.1	% of D.W.	0

Sixteen of the 22 parameters had means that differed significantly (α=5%) for at least one soil horizon when compared with the other five horizons included in the analyses (Table 5-22). Four of the parameters with insignificant results had more than 50% non-detects (Table 5-21). For the chemical parameters with significant differences in means across soil horizons, the C horizon most often had the lowest mean values, and most of the exceptions were for Bfj samples developed in sandy parent material. Most of the highest means were from the Ae or Bh horizons.

Table 5-22: Mean values for physical and chemical soil parameters measured in mineral soil samples by soil layer

Parameter	All	Ae	Bfj	Bh	Bm	C	Cg
N	*66*	*4*	*9*	*7*	*27*	*10*	*9*
Aluminum	**1,369**	2,786	1,939	2,361	1,314	243	813
Iron	**1,463**	2,937	1,433	2,620	1,516	274	1,101
Manganese	**47.2**	63.3	25.4	123.5	51.6	12.2	28.1
Available N	1.18	1.25	1.00	1.46	1.29	1.00	1.00
Available P	1.47	1.55	2.24	1.46	1.43	1.18	1.13
Available K	59.7	84.3	30.6	74.4	76.8	24.3	54.2
Available S	**5.03**	6.70	1.76	8.77	6.01	3.59	3.31
Extractable Calcium	**10.8**	2.6	1.8	25.6	13.7	4.5	10.0
Extractable Magnesium	**1.76**	0.78	0.50	3.41	2.20	0.72	2.03
Extractable Potassium	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Extractable Sodium	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Extractable CEC	**12.7**	7.7	6.6	27.3	16.0	3.8	10.0
Inorganic Carbon	**1.73**	0.07	0.05	1.50	1.64	3.25	2.88
Total Carbon	**1.29**	0.87	0.73	3.56	1.50	0.45	0.58
Total Carbon combust	**3.00**	0.88	0.72	5.06	3.13	3.71	3.46
Total Nitrogen combust	**0.08**	0.06	0.04	0.21	0.10	0.03	0.04
pH	**7.27**	5.89	5.49	7.02	7.45	8.30	8.07
Conductivity	**0.21**	0.28	0.11	0.21	0.24	0.22	0.24
Calcium carbonates	**14.4**	0.5	0.4	12.5	13.7	27.1	24.0
Percent Clay	13.4	15.3	4.7	17.0	18.0	4.6	14.5
Percent Sand	**61.2**	68.3	82.8	47.1	52.9	79.9	51.1
Percent Silt	**25.5**	16.4	12.5	35.9	29.1	15.5	34.4

Notes: Bold font identifies parameter means with statistically significant differences between at least one soil layer compared with the others.

5.4.3 Ecosite Composition of the Keeyask Study Zone 4 and 2

From most general to most detailed, the ecosite levels in the hierarchical ecosite classification were land type, coarse ecosite type, broad ecosite type and fine ecosite type (see Section 6.2 for habitat classification methods). In 2010, the land type composition of Keeyask Study Zone 4 (Map 2-3) was approximately 12% mineral, 39% thin peatland, 45% other peatland, 3% shore zone peatland, and less than 1% other shore zone wetlands combined (Table 5-23).

Table 5-23: Land type composition of Study Zones 4 and 2, as a percentage of land area

Land Type	Study Zone 4	Study Zone 2
Mineral	11.7	18.7
Thin peatland	38.8	39.7
Other peatlands	45.5	34.3
Shore zone peatland	3.1	4.0
Nelson River shore zone	0.8	3.2
Off-system shore zone	0.1	0.1
Total land area (ha)	*167,255*	*13,043*

Notes: Reported areas are land area only.

Thin peatland was the most common coarse ecosite type (Table 5-24), covering approximately 39% of the area. Most of the remaining area was covered by shallow peatland (25%), ground ice peatland (16%) and mineral ecosites (12%).

Vegetation on the thin peatland coarse ecosite type was more similar to that found on mineral soils than the other peatland types. Thin peatlands typically formed the transition zone between mineral ecosites at higher elevations and other peatland types at lower elevations. Mineral ecosites occurred more frequently along the Nelson River including its islands and the elevated portions of eskers and moraines (Map 5-3). Thin peatlands are veneer bogs that occurred on slopes or crests. Bedrock outcrop patches that were large enough to map were found near the Nelson River to the north and south of Gull Lake.

Included in the other peatlands land type were the shallow and ground ice peatland coarse ecosite types. Shallow peatlands are well distributed on flat terrain throughout Study Zone 4 (Map 5-3). Most shallow peatlands were comprised of the blanket bog fine ecosite type, with a small amount of veneer bog and slope bog (Table 5-24). Ground ice peatland was most prevalent in the inland portions of Study Zone 4 (Map 5-3). Ground ice peatlands, which covered 16% of the total land area, were mostly composed of peat plateau bog and collapse scar mosaics and the transitional stages of peat plateau bog formation or breakdown.

The other peatlands land type also included the other permafrost peatland, deep peatland and wet deep peatland coarse ecosite types. Deep peatlands were the most common, and were almost entirely comprised of the horizontal fen fine ecosite type which was scattered in flat terrain and depressions throughout Study Zone 4. Large patches of deep peatlands occurred south of Stephens Lake, north of the Long Spruce reservoir and on the south side of PR 280 in the west of Study Zone 4 (Map 5-3). Collapse scar peatlands were more abundant than suggested by Table 5-24 because many collapse scars were very small so they were mapped as peat plateau bog and collapse scar mosaics.

Table 5-24: Coarse ecosite composition of Study Zones 4 and 2, as a percentage of land area

Land Type	Coarse Ecosite Type	Study Zone 4	Study Zone 2
Mineral	Mineral	11.7	18.7
Thin peatland	Thin peatland	38.8	39.7
Other Peatlands	Shallow peatland	24.7	20.0
	Ground ice peatland	15.9	11.8
	Permafrost peatland- other	0.4	0.3
	Deep peatland	4.4	2.3
	Wet deep peatland	0.0	-
Shore Zone Peatland	Riparian Peatland	3.1	4.0
Nelson River Shore Zone	Ice-Scoured Upland	0.1	1.0
	Nelson River Shoreline Wetland	0.8	2.2
Off-System Shore Zone	Off-System Shoreline Wetland	0.1	0.1
Total land area (ha)		*167,255*	*13,043*

Notes: Reported areas are land area only.
Cells with "0.0" values are areas that round to 0, while "-" indicates that the type is absent.

The shore zone peatland land type was comprised of riparian peatlands, and dominated by the riparian fen fine ecosite type (Table 5-24). Riparian peatlands tended to occur along small waterways and runnels, and were more frequent nearer the Nelson River.

Surface water was generally present throughout the growing season in riparian peatlands and many collapse scars. Small patches of open water occurred in many horizontal peatlands. Depth to groundwater generally increased with the following sequence of ecosite types: riparian and collapse scar peatland, horizontal peatland and wet deep peat. The remaining peatland ecosite types may have groundwater before mineral contact but the depth to occurrence was highly variable and somewhat dependent on slope position, season, and other conditions.

The Nelson River shore zone land type included the ice-scoured upland and Nelson River shoreline wetland types. Ice scoured upland ecosites occurred on sloping topography only along the Nelson River shoreline. This ecosite is located within the portion of the shore zone that is above the zone of fluctuating water levels. Nelson River shoreline wetland fine ecosite types included the upper beach, upper beach on sunken, disintegrated peatland and lower beach fine ecosite types, which reflected the shore zone water depth duration zones (Section 7.2.2.2.1). Sunken peat is the margin of a peatland whose surface has sunk below the water surface but is often suspended above the bottom. Emergent vegetation may occur on the coarse ecosite type. Because of Nelson River water level regulation and hydrodynamics, Nelson River shoreline wetlands are dramatically different than those found in the off-system shoreline wetlands.

Upper beach was the most common Nelson River shoreline wetland land type (0.6%), followed by the upper beach on sunken, disintegrated peatland and ice scoured upland broad ecosite types. Upper beach occurred in narrow bands within the fluctuating water zone on sloping topography along the Nelson River, while upper beach on sunken, disintegrated peatland were mostly scattered in Stephens Lake. Detailed discussion of Nelson River shoreline wetlands is provided in Section 6.3.2.3.

The off-system shoreline wetland land type was mostly comprised of the littoral island and upper beach fine ecosite types. Littoral island refers to off-shore areas with patches of emergent and/or floating-leaved vegetation, which was taken as an indicator that water depths may be shallower than adjacent areas. Off-system shoreline wetlands were scattered throughout Study Zone 4 but each made up less than 0.1% of the land area. Detailed discussion of off-system shoreline wetlands is provided in Section 6.3.2.3.

Study Zone 4 includes 29 fine ecosite types. Of these, five were upland/thin feathermoss peatland types, eight were shallow peatland types, seven were wet peatland types, and nine were shore zone types (Table 5-25). Peatlands covered over 87% of the area, the majority of which were thin and shallow peatland ecosite types.

Veneer bog on slope was the most common and widely distributed fine ecosite type in Study Zone 4 (Table 5-25), comprising nearly 39% of the land area. Deep dry mineral, the other common upland/thin feathermoss peatland ecosite type, comprised 11% of the land area, and was most frequent nearer the Nelson River and along eskers in the Study Zone 2. These fine ecosite types were primarily associated with ridges, crests and upper slopes, which were most frequent nearer the Nelson River and along eskers in the Study Zone 2.

Blanket bog was the most common shallow peatland ecosite type (21%), and the second-most common fine ecosite in Study Zone 4. Blanket bog was also widely distributed (Map 5-3), generally coinciding with the distribution of horizontal topography, as well as some lower slopes.

Table 5-25: Coarse and fine ecosite composition of Study Zones 4 and 2, as a percentage of land area

Coarse Ecosite Type	Fine Ecosite Type	Study Zone 4	Study Zone 2
Mineral Land Type		**11.7**	**18.7**
Mineral	Deep dry mineral	11.5	17.5
	Deep wet mineral	0.0	-
	Outcrop	0.0	-
	Shallow/ thin mineral	0.2	1.2
Thin Peatland Land Type		**38.8**	**39.7**
Thin Peatland	Veneer bog on slope or crest	38.8	39.7
Other Peatlands Land Type		**45.5**	**34.3**
Shallow Peatland	Blanket bog	20.6	18.2
	Slope bog	1.4	0.5
	Slope fen	0.2	0.2
	Veneer bog not on slope or crest	2.5	1.1
Ground Ice Peatland	Blanket bog/ collapse scar peatland mosaic	1.4	-
	Peat plateau bog	0.4	0.7
	Peat plateau bog transitional	4.4	3.3
	Peat plateau bog/ collapse scar peatland mosaic	9.9	8.0
Permafrost Peatland- Other	Horizontal fen/ blanket bog mosaic	0.2	-
Deep Peatland	Basin fen	0.0	-
	Flat bog	0.6	0.4
	Horizontal fen	3.8	1.9
Wet Deep Peatland	String fen	0.0	-
Shore Zone Peatland Land Type		**3.1**	**4.0**
Riparian Peatland	Riparian bog	0.2	0.1
	Riparian fen	2.9	3.9
Total Inland Area (ha)		*165,628*	*12,620*

Notes: Cells with "0.0" values are areas that round to 0, while "-" indicates that the type is absent.

All of the remaining fine ecosite types individually covered less than 10% of the land area. The most common ground ice peatland was the peat plateau bog/ collapse scar mosaic fine ecosite type, covering nearly 10% of Study Zone 4, followed by peat plateau bog in transitional stage at 4%, primarily associated with horizontal topography and depressions, respectively.

Horizontal and riparian fens, the most abundant wet peatland ecosite types, were uncommon, covering 7% of the land area combined. Riparian fens were widely distributed throughout Study Zone 4 (Map 5-3), generally along waterbody and waterway shorelines. Horizontal fens were somewhat more frequent in inland portions of Study Zone 4, and were associated with horizontal and depressed topography.

Together, the common and uncommon fine ecosite types comprised over 97% of the land area. Some of the rarest ecosite types included rock outcrops and string fens. Due to the limitations of photo interpretation, some fine ecosite types, such as deep wet mineral, were likely to be underestimated. Analysis of plot data (see Section 7.3) indicated that deep wet mineral soils made up a higher proportion of mineral ecosites. Collapse scar bogs and fens were also more abundant than apparent in Table 5-25, because many instances of these features were too small to be mapped, and were therefore incorporated in the peat plateau bog/ collapse scar mosaic polygons.

The coarse and fine ecosite composition of the Study Zone 2 was very similar to that of Study Zone 4. Study Zone 2 had a slightly higher proportion of mineral ecosites due to the proximity to the Nelson River, the presence of an esker and the higher proportion of ridges and crests there (see Section 6.3.2.1).

ECOSTEM (2011c) provides additional information for peatland ecosites.

Topography plays an important role in ecosite development. Considering topographical associations within each coarse ecosite type, virtually all of the minerals and thin peatlands in the study area occurred on crests or the upper portions of slopes because good water drainage has prevented thick peat development in these locations (Table 5-26; Map 5-4). Thicker peatlands develop in most other locations due to factors that reduce decomposition rates such as poorer drainage, permafrost and a longer period with impermeable shallow seasonal frost.

Most ground ice peatlands, wet and deep peatlands occurred in low-lying areas (88% of the depression area; Table 5-27). Wet peatlands and riparian peatlands were generally associated with areas where water collects and/or drains such as depressions, runnels and flat topography. Peat thickness in runnels tended to decrease with increasing runnel slope. Topography is described in detail in Section 6.3.2.1.

Table 5-26: Percentage distribution of coarse ecosite types across topography types in Study Zone 4

Coarse Ecosite Type	Topography Type									*Total area (ha)*
	Ridge/ Crest	Slope	Horizontal	Horizontal-raised	Dissected	Depression	Runnel	Ravine	Bank	
Mineral	89.4	5.8	1.6	0.0	-	0.0	0.0	1.5	1.2	*19,517*
Thin peatland	1.7	98.3	0.0	-	-	0.0	0.0	-	-	*64,857*
Shallow peatland	0.2	9.8	78.1	1.9	1.8	1.7	6.5	-	-	*41,388*
Ground ice peatland	-	0.0	75.1	3.0	-	20.7	1.2	-	-	*26,650*
Permafrost peatland- other	-	-	59.7	-	-	40.3	-	-	-	*598*
Deep peatland	0.0	0.0	37.1	0.6	0.0	45.1	17.1	0.0	-	*7,425*
Wet deep peatland	-	-	-	-	-	100.0	-	-	-	*20*
Riparian Peatland	0.0	0.1	49.5	0.3	-	10.9	39.1	-	-	*5,173*
Ice Scoured Upland	-	100.0	-	-	-	-	-	-	-	*129*
Shoreline Wetland	-	57.9	42.1	-	-	-	-	-	-	*193*
Shoreline Wetland- regulated	-	100.0	-	-	-	-	-	-	-	*1,276*

Notes: Cells with "0.0" values are areas that round to 0, while a blank cell indicates that the type is absent.

Table 5-27: Percentage distribution of coarse ecosite types within topography types in Study Zone 4

Coarse Ecosite Type	Topography Type								
	Ridge/ Crest	Slope	Horizontal	Horizontal-raised	Dissected	Depression	Runnel	Ravine	Bank
Mineral	93.6	1.6	0.5	0.4	-	0.0	0.1	98.9	100.0
Thin peatland	5.9	90.5	0.0	-	-	0.0	0.0	-	-
Shallow peatland	0.5	5.8	55.3	47.6	100.0	6.7	42.6	-	-
Ground ice peatland	-	0.0	34.3	48.2	-	53.1	5.0	-	-
Permafrost peatland- other	-	-	0.6	-	-	2.3	-	-	-
Deep peatland	0.0	0.0	4.7	2.8	0.0	32.2	20.2	1.1	-
Wet deep peatland	-	-	-	-	-	0.2	-	-	-
Riparian Peatland	0.0	0.0	4.4	1.0	-	5.4	32.1	-	-
Ice Scoured Upland	-	0.2	-	-	-	-	-	-	-
Shoreline Wetland	-	0.2	0.1	-	-	-	-	-	-
Shoreline Wetland- regulated	-	1.8	-	-	-	-	-	-	-
Total area (ha)	*18,643*	*70,474*	*58,393*	*1,657*	*738*	*10,399*	*6,300*	*291*	*228*

Notes: Cells with "0.0" values are areas that round to 0, while a blank cell indicates that the type is absent.

5.4.3.1.1 *Ecosite Type Descriptions*

The most common coarse ecosite types (Table 5-24) are characterized in the fact sheets presented in Figure 5-1 to Figure 5-9. The fact sheets are ordered from the driest upland type to the wettest wetland type.

Mineral Coarse Ecosite Type Sites with surface organic layers less than 20 cm thick.	
Deep Dry Mineral Fine Ecosite Type: Very fresh to dry sites with mineral soil greater than 100 cm thick	

Figure 5-1: Example and description of the mineral soil coarse ecosite type

Thin Peatland Coarse Ecosite Type

Sites with surface organic layer greater than 20 cm and less than 100 cm thick.

Veneer Bog On Slope Fine Ecosite Type:

Moist, sloping sites with thin organic soils, usually less than 50 cm thick, and occasional ground ice may be present.

Figure 5-2: Example and description of the thin peatland coarse ecosite type

Shallow Peatland Coarse Ecosite Type

Sites with a surface organic layer greater than 100 cm and less than 200 cm thick.

Blanket Bog Fine Ecosite Type:

Peatlands with a surface organic layer between 100 cm and 200 cm thick. Discontinuous ground ice permafrost present. Occurring on flat topography.

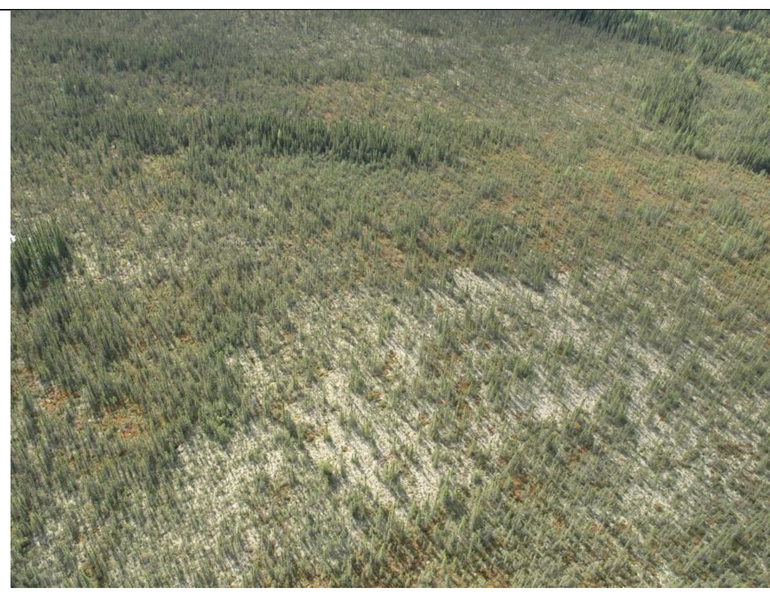


Figure 5-3: Example and description of the shallow peatland coarse ecosite type

<table>
<tr><td colspan="2">Ground Ice Peatland Coarse Ecosite Type
Sites with organic layers greater than 20 cm thick and either continuous or patchy ground ice at least one meter thick.</td></tr>
<tr><td>Peat Plateau Bog/Collapse Scar Mosaic Fine Ecosite Type:

A mixture of peat plateau bogs and small collapse scar peatlands. Peat plateaus are elevated relative to collapse scars and have distinct banks formed by continuous ground ice cores.

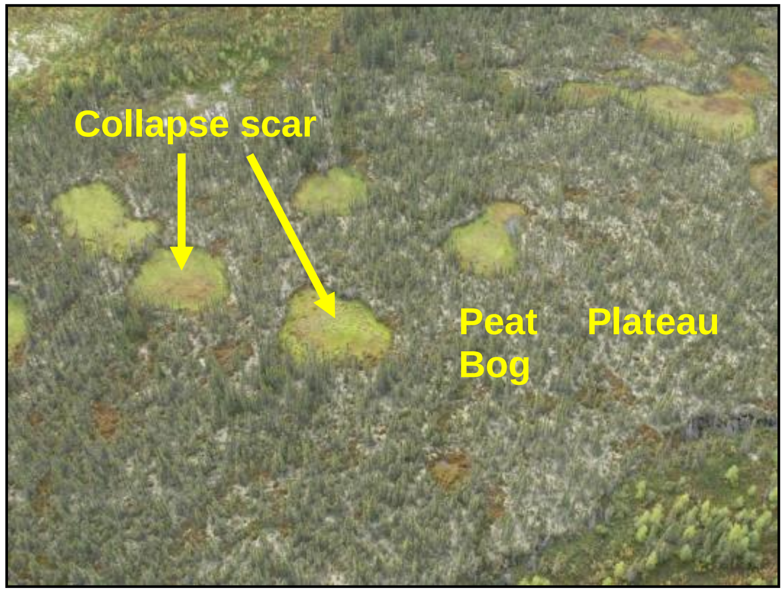
Collapse scar bogs or fens are depressed features formed when ground ice melts and the surface peat collapses. Larger features (>500m²) are classified under the Wet Peatland Coarse Type.</td><td>
</td></tr>
<tr><td>Side view of a peat plateau bog</td><td></td></tr>
</table>

Figure 5-4: Example and description of the peat plateau bog/collapse scar mosaic fine ecosite type included in the ground ice peatland coarse ecosite type

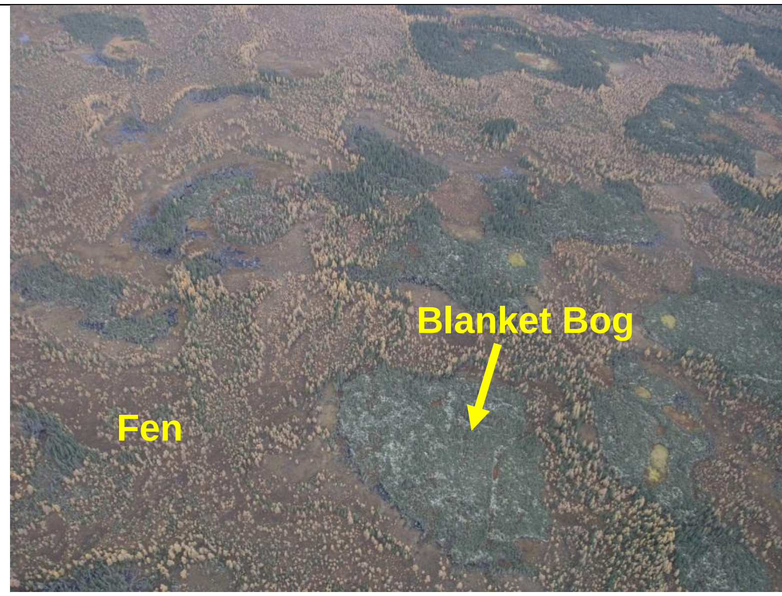
<table>
<tr><th colspan="2">Ground Ice Peatland Coarse Ecosite Type
Sites with organic layers greater than 20 cm thick and either continuous or patchy ground ice at least 1 m thick.</th></tr>
<tr><td>Peat Plateau Bog Transitional Fine Ecosite Type:

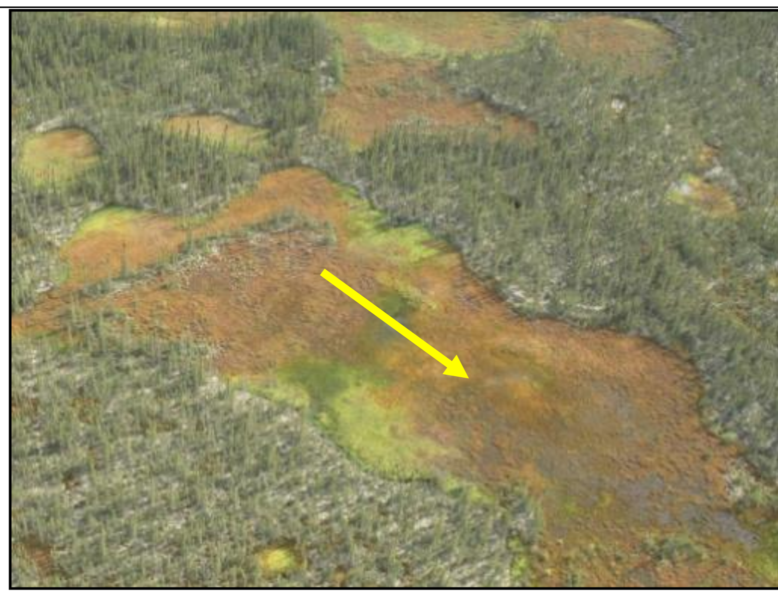
Peatlands where thick ground ice is obviously either forming or melting.</td><td></td></tr>
</table>

Figure 5-5: Example and description of the peat plateau bog transitional fine ecosite type included in the ground ice peatland coarse ecosite type

<table>
<tr><th colspan="2">Wet Peatland Broad Ecosite Type</th></tr>
<tr><td colspan="2"><u>Other Permafrost Peatland Coarse Ecosite Types:</u>
Sites with organic layer ≥ 20 cm with evidence of excess ice actively forming or melting. Hummocky surface due to patchy excess ice.</td></tr>
<tr><td>Other Permafrost Peatland Fine Ecosite Type:

Horizontal Fen/Blanket Bog Mosaic Fine Ecosite Type:

A mixture of horizontal fens and blanket bogs.</td><td>
</td></tr>
<tr><td>Collapse Scar Bog or Fen Fine Ecosite Type.

Depressed features formed in peat plateau bogs when ground ice melts and the surface peat collapses</td><td></td></tr>
</table>

<table>
<tr><td colspan="2"><u>Deep Peatlands Coarse Ecosite Type:</u>
Sites in depressional areas with sparse tree cover. Surface organic layer is greater than 20 cm thick.</td></tr>
<tr><td>Horizontal Fen Fine Ecosite Type:

Sites typically have buried water layers, occasionally with small pools at the surface. Sparse tree cover is primarily tamarack.</td><td></td></tr>
<tr><td colspan="2"><u>Wet Deep Peatlands Coarse Ecosite Types:</u>
Sites with organic layers greater than 200 cm. The surface is level and featureless, and the peatland is not confined and isolated by mineral or bedrock terrain.</td></tr>
<tr><td>String Fen Fine Ecosite Type:

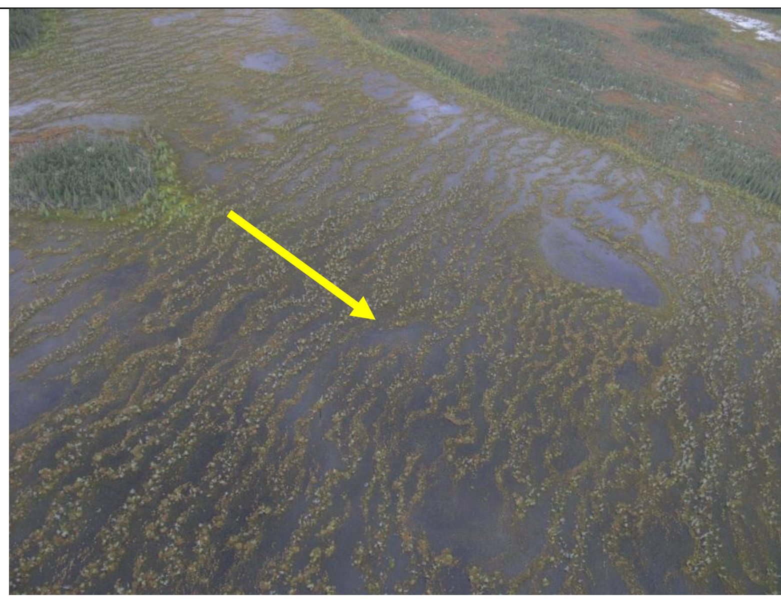
Sites with a pattern of peat ridges and water-filled depressions. Direction of water flow is perpendicular to the peat ridges.</td><td></td></tr>
</table>

Figure 5-6: Example and description of the wet peatland broad ecosite type

<table>
<tr><td colspan="2">Riparian Peatlands Coarse Ecosite Types
Peatlands occurring along lakes or waterways, with open water present. Edge of peatland along water is usually floating.</td></tr>
<tr><td>Riparian Fen Fine Ecosite Type:

These riparian peatlands are not landlocked. The water is nutrient-enriched by runoff from adjacent land areas and/or the stream flow.</td><td></td></tr>
</table>

Figure 5-7: Example and description of the riparian peatland coarse ecosite type

<table>
<tr><td colspan="2">Nelson River Shoreline Wetland Coarse Ecosite Types:
Wetlands occurring along the shorelines of the Nelson River where the water is less than 1.5 m deep.</td></tr>
<tr><td colspan="2"><u>Nelson River Upper Beach, Sunken Peat and Lower Beach Coarse Ecosite Types</u></td></tr>
<tr><td>Upper Beach Fine Ecosite Type:

Shore zone wet meadows occurring along the main body of lakes and the Nelson River. Gentle to steep slopes. Under water less than half of the growing season days over the past five years.</td><td></td></tr>
<tr><td>Upper Beach on Sunken, Disintegrated Peatland Fine Ecosite Type:

Shore zone wet meadows occurring on sunken, disintegrated peatlands, such as disintegrating peat plateau bogs. Usually associated with recently flooded and expanding zones of Stephens Lake. Under water less than half of the growing season days over the past five years.</td><td></td></tr>
</table>

<table>
<tr><td colspan="2">Nelson River Shoreline Wetland Coarse Ecosite Types:
Wetlands occurring along the shorelines of the Nelson River where the water is less than 1.5 m deep.</td></tr>
<tr><td>Lower Beach Fine Ecosite Type:

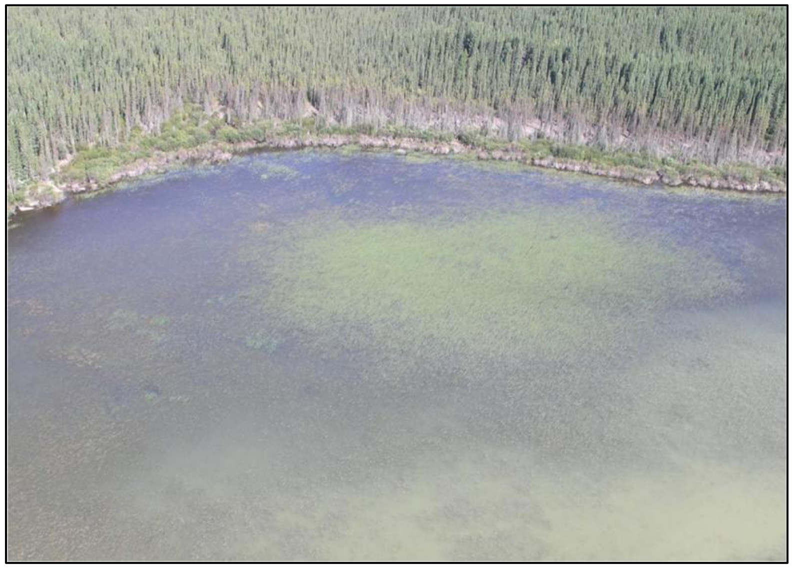
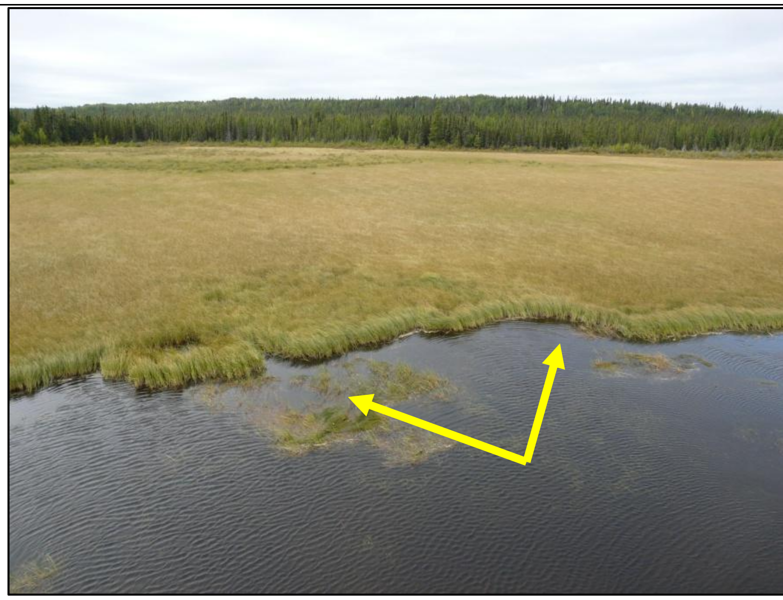
Portions of shore zone wet meadows that are under water for more than half of the growing season days over the past five years. Usually occurring in sheltered bays along Nelson River. May support emergent vegetation, but not native marsh due to water regulation.</td><td></td></tr>
</table>

Figure 5-8: Examples and descriptions of the Nelson River shoreline wetland coarse and fine ecosite types

Off-System Shoreline Wetland Coarse Ecosite Types:
Wetlands occurring either along the shorelines of lakes or waterways or as offshore islands where the water is less than 2.0 m deep.

<u>Off-System Upper Beach, Lower Beach and Littoral Broad Ecosite Types</u>

<table>
<tr><td>Upper Beach on Sunken Peat Fine Ecosite Type:

Sunken margins of floating peatlands along waterways and lake shores that are under water less than half of the growing season days over the past five years.</td><td></td></tr>
<tr><td><u>Lower Beach Fine Ecosite Type</u>:

Portions of shore zone wet meadows that are under water for more than half of the growing season days over the past five years.</td><td></td></tr>
</table>

<table>
<tr><td colspan="2">Off-System Shoreline Wetland Coarse Ecosite Types:
Wetlands occurring either along the shorelines of lakes or waterways or as offshore islands where the water is less than 2.0 m deep.</td></tr>
<tr><td>Littoral Fine Ecosite Type:

Rarely exposed sites in the shallow water zone of water bodies sometimes supporting emergent and floating-leaved vegetation.</td><td></td></tr>
</table>

Figure 5-9: Examples and descriptions of the off-system shoreline wetland coarse and fine ecosite types

5.5 APPENDICES

5.5.1 Appendix 5-A

Chemical Analysis Analytical Methods

Ecostem Ltd.
ATTN: DR. JAMES EHNES
495 - A Madison Street
Winnipeg MB R3J 1J2
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Date Received: 22-DEC-10
Report Date: 11-JAN-11 15:05 (MT)
Version: FINAL

Certificate of Analysis

Lab Work Order #: L965124
Project P.O. #: NOT SUBMITTED
Job Reference: LOWER NELSON RIVER SOILS
Legal Site Desc:
C of C Numbers:

Paul Nicolas
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

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Environmental www.alsglobal.com
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Reference Information

Sample Parameter Qualifier Key:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
AL,FE,MN-XTR-PYRO-SK	Soil	Sodium Pyrophosphate Al,Fe,Mn	CSSS (1993) 25.5
C-INORG-ORG-SK	Soil	Inorganic and Organic Carbon	SSSA (1996) P455-456

When carbonates are decomposed with acid in an open system, carbon dioxide is released to the atmosphere. The decrease in sample weight resulting from CO2 loss is proportional to the carbonate content of the soil.

Reference:
Loeppert, R.H. and Suarez, D.L. 1996. Gravimetric Method for Loss of Carbon Dioxide. P. 455-456 In: J.M. Bartels et al. (ed.) Methods of soil analysis: Part 3 Chemical methods. (3rd ed.) ASA and SSSA, Madison, WI. Book series no. 5

C-TOT-LECO-SK	Soil	Total Carbon by combustion method	SSSA (1996) P. 973-974

The sample is introduced into a quartz tube where it undergoes combustion at 900 C in the presence of oxygen.
Combustion gases are first carried through a catalyst bed in the bottom of the combustion tube, where oxidation is completed and then carried through a reducing agent (copper), where the nitrogen oxides are reduced to elemental nitrogen.
This mixture of N2, CO2, and H2O is then passed through an absorber column containing magnesium perchlorate to remove water. N2 and CO2 gases are then separated in a gas chromatographic column and detected by thermal conductivity.

Reference:
Nelson, D.W. and Sommers, L.E. 1996. Total Carbon, organic carbon and organic matter. P. 973-974 In: J.M. Bartels et al. (ed.) Methods of soil analysis: Part 3 Chemical methods. (3rd ed.) ASA and SSSA, Madison, WI. Book series no. 5

CAT-XTR-BACL2-SK	Soil	Barium Chloride Extractable Cations	CSSS (1993) 19.2

A 30 minute shaking extraction at a 1:10 soil to 0.1M BaCl2 ratio is used. Barium ions displace cations on the soil exchane sites and brings them into solution. These cations are then quantified by ICP-OES. The extracting solution is buffered to pH 8 to minimize the calcium or magnesium extracted from carbonates or free gypsum.

CEC-BACL2-SK	Soil	Cation Exchange Capacity (BaCl2 Extn)	CSSS 19.2 - 0.1M BaCl2 Extraction
ETL-ESP-SK	Soil	Exchangeable Sodium Percentage - Calc	Calculation
N-TOT-LECO-SK	Soil	Total Nitrogen by combustion method	SSSA (1996) p. 973-974

The sample is introduced into a quartz tube where it undergoes combustion at 900 C in the presence of oxygen.
Combustion gases are first carried through a catalyst bed in the bottom of the combustion tube, where oxidation is completed and then carried through a reducing agent (copper), where the nitrogen oxides are reduced to elemental nitrogen.
This mixture of N2, CO2, and H2O is then passed through an absorber column containing magnesium perchlorate to remove water. N2 and CO2 gases are then separated in a gas chromatographic column and detected by thermal conductivity.

Reference: Bremner, J.M. 1996. Nitrogen - Total (Dumas Methods). P. 1088 In: J.M. Bartels et al. (ed.) Methods of soil analysis: Part 3 Chemical methods. (3rd ed.) ASA and SSSA, Madison, WI. Book series no. 5

NO3-AVAIL-SK	Soil	Available Nitrate-N	CSSS (1993) 4.3

Available Nitrate and Nitrite are extracted from the soil using a dilute calcium chloride solution.
Nitrate is quantitatively reduced to nitrite by passage of the sample through a copperized cadmium column. The nitrite (reduced nitrate plus original nitrite) is then determined by diazotizing with sulfanilamide followed by coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. The resulting water soluble dye has a magenta color which is measured at colorimetrically at 520nm.

Reference:
Carter, Martin. Soil Sampling and Methods of Analysis. Can. Soc. Soil Sci.(1993) method 4.3

PH,EC-1:2-SK	Soil	pH and EC 1:2 Soil:Water Extraction	CSSS (1993) 16.2.2, 18.3.1

Soil Conductivity (1:2 soil:water extract)

1 part dry soil and 2 parts de-ionized water (by volume) is mixed. The slurry is allowed to stand with occasional stirring for 30 - 60 minutes. After equilibration pH of the slurry is measured using a pH meter. Conductivity of the filtered extract is measured by a conductivity meter.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**

Reference:
Carter, Martin R., Soil Sampling and Methods of Analysis, Can Soc. Soil Sci. method 16.2.2 and 18.3.1

ALS Test Code	Matrix	Test Description	Method Reference**
PO4/K-AVAIL-SK	Soil	Plant Available Phosphorus and Potassium	Comm. Soil Sci. Plant Anal, 25 (5&6)
PSA-1-SK	Soil	Particle Size Analysis: Mini-Pipet Metho	CSSS (1993) P.508-509

Dry, < 2 mm soil is treated with sodium hexametaphosphate to ensure complete dispersion of primary soil particles. The homogenized suspension is allowed to settle in accordance with Stoke's Law so that only clay particles remain in suspension.To determine the clay fraction, an aliquot of the clay suspension is removed, then dried and weighed. The sand fraction is determined by wet sieving the remaining suspension, then drying and weighing the sand retained on the sieve. The silt fraction is determined by calculation where % Silt = 100 - (%Sand+%Clay)

Reference:
Burt, R. (2009). Soil Survey Field and Laboratory Methods Manual. Soil Survey Investigations Report No. 5. Method 3.2.1.2.2. United States Department of Agriculture Natural Resources Conservation Service.

Kalra, Y.P., Maynard, D.G. 1991. Methods manual for forest soil and plant analysis. Forestry Canada. p. 42-45.

ALS Test Code	Matrix	Test Description	Method Reference**
PSA-3-SK	Soil	Particle size - Pipette removal OM & CO3	Forestry Canada (1991) p. 46-53

Dry, < 2 mm soil is treated hydrochloric acid top remove carbonates, then hydrogen peroxide to remove organic matter. The remaining soil is treated with sodium hexametaphosphate to ensure complete dispersion of primary soil particles. The homogenized suspension is allowed to settle in accordance with Stoke's Law so that only clay particles remain in suspension.To determine the clay fraction, an aliquot of the clay suspension is removed, then dried and weighed. The sand fraction is determined by wet sieving the remaining suspension, then drying and weighing the sand retained on the sieve. The silt fraction is determined by calculation where % Silt = 100 - (%Sand+%Clay)

Reference:
Burt, R. (2009). Soil Survey Field and Laboratory Methods Manual. Soil Survey Investigations Report No. 5. Method 3.2.1.2.2. United States Department of Agriculture Natural Resources Conservation Service.

ALS Test Code	Matrix	Test Description	Method Reference**
SO4-AVAIL-SK	Soil	Available Sulfate-S	REC METH SOIL ANAL - AB. AG(1988)

The soil is extracted with a weak calcium chloride solution. The calium chloride serves to reduce the extraction of organic materials and increases flocculation of the soil in the extract. Total S in the extract is then determined by ICP-AES, which is considered to be equivalent to the plant available S for mineral soils from the prairies.

Reference:
Recommended Methods of Soil Analysis for Canadian Praire Agricultural Soils.Alberta Agriculture(1988), p. 28

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS LABORATORY GROUP - SASKATOON, SASKATCHEWAN, CANADA

Chain of Custody Numbers:

LOWER NELSON RIVER SOILS

L965124 CONTD....
PAGE 61 of 61
Version: FINAL

Reference Information

Test Method References:

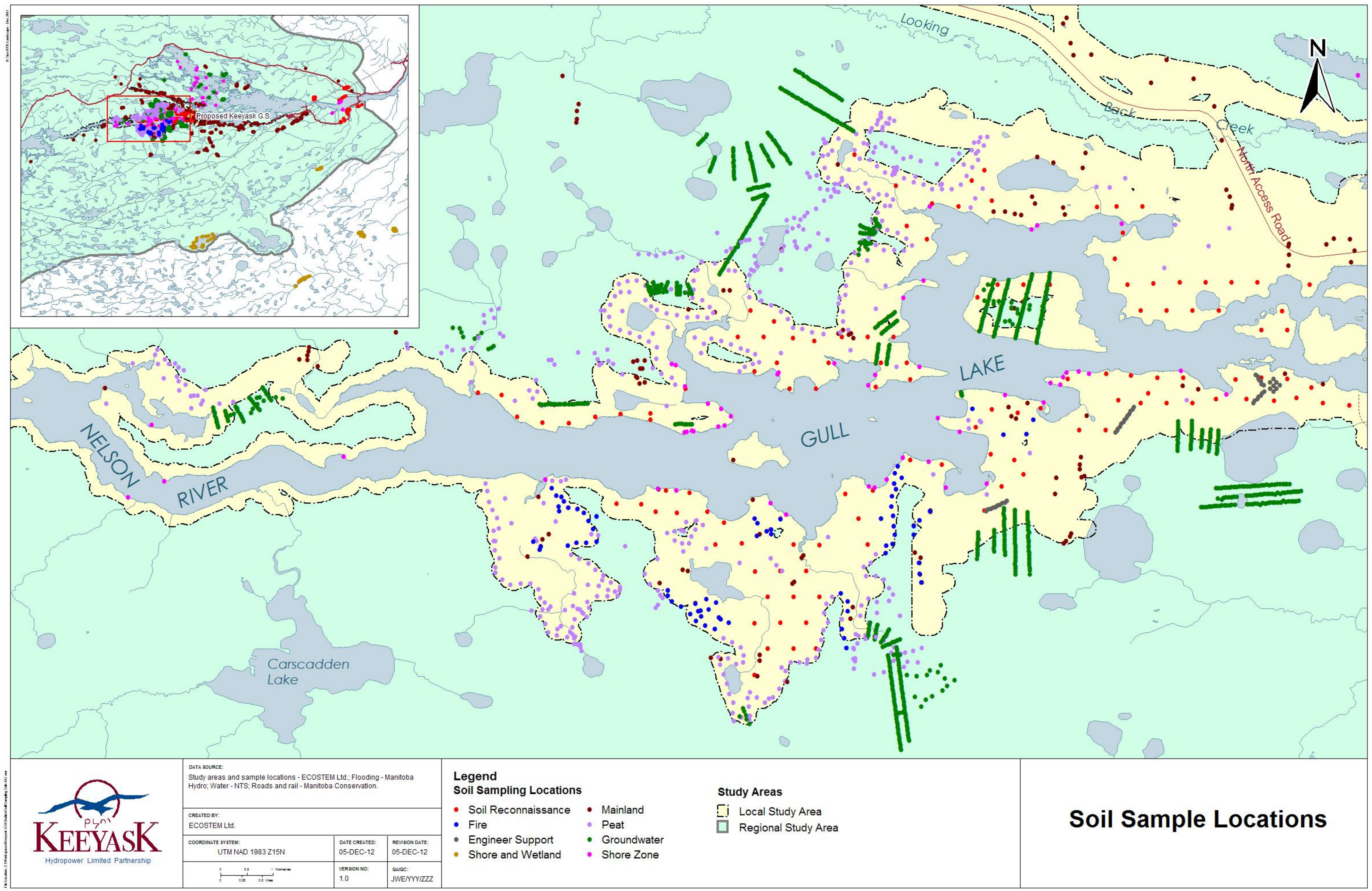
ALS Test Code	Matrix	Test Description	Method Reference**

GLOSSARY OF REPORT TERMS

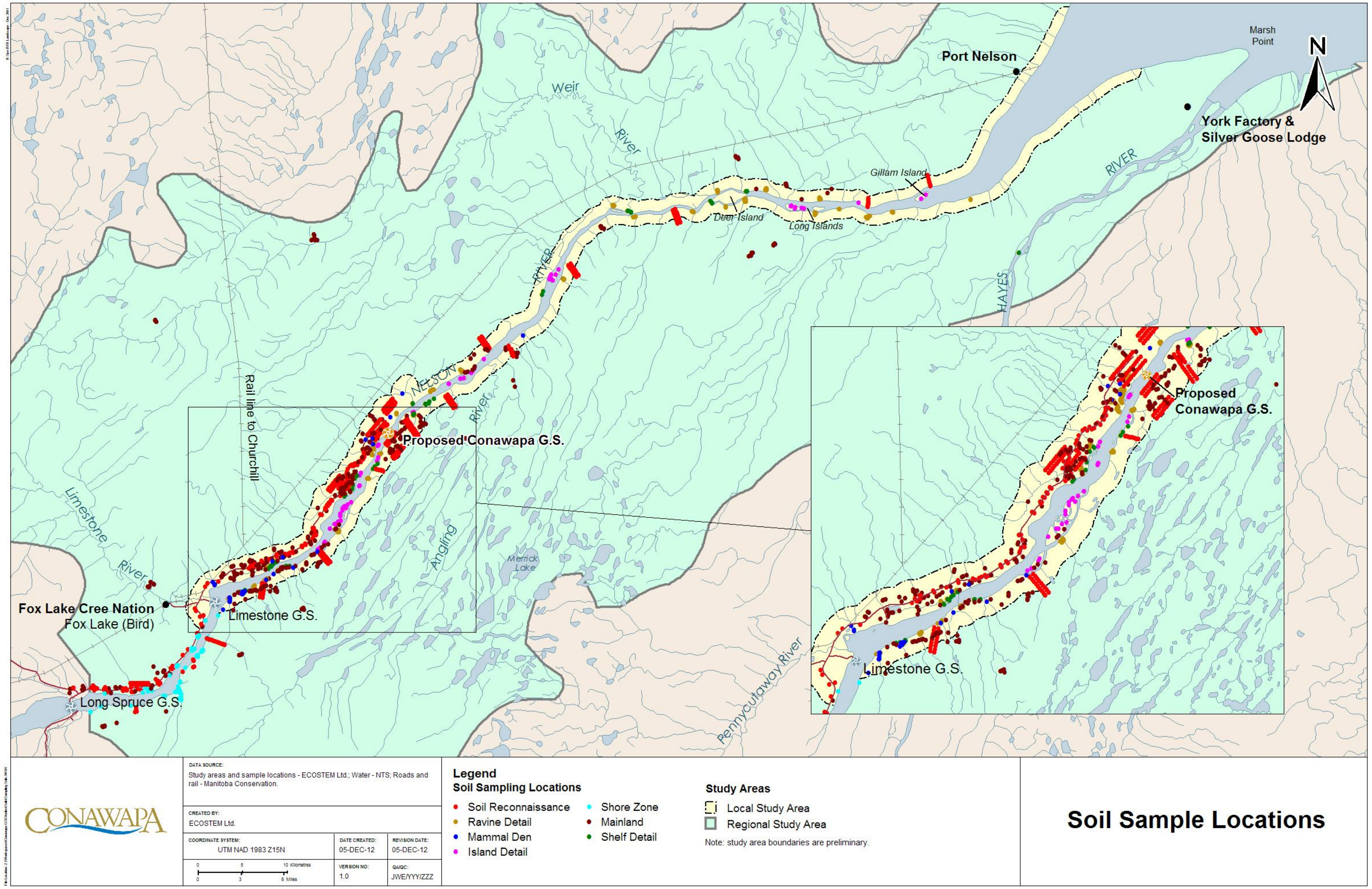
Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

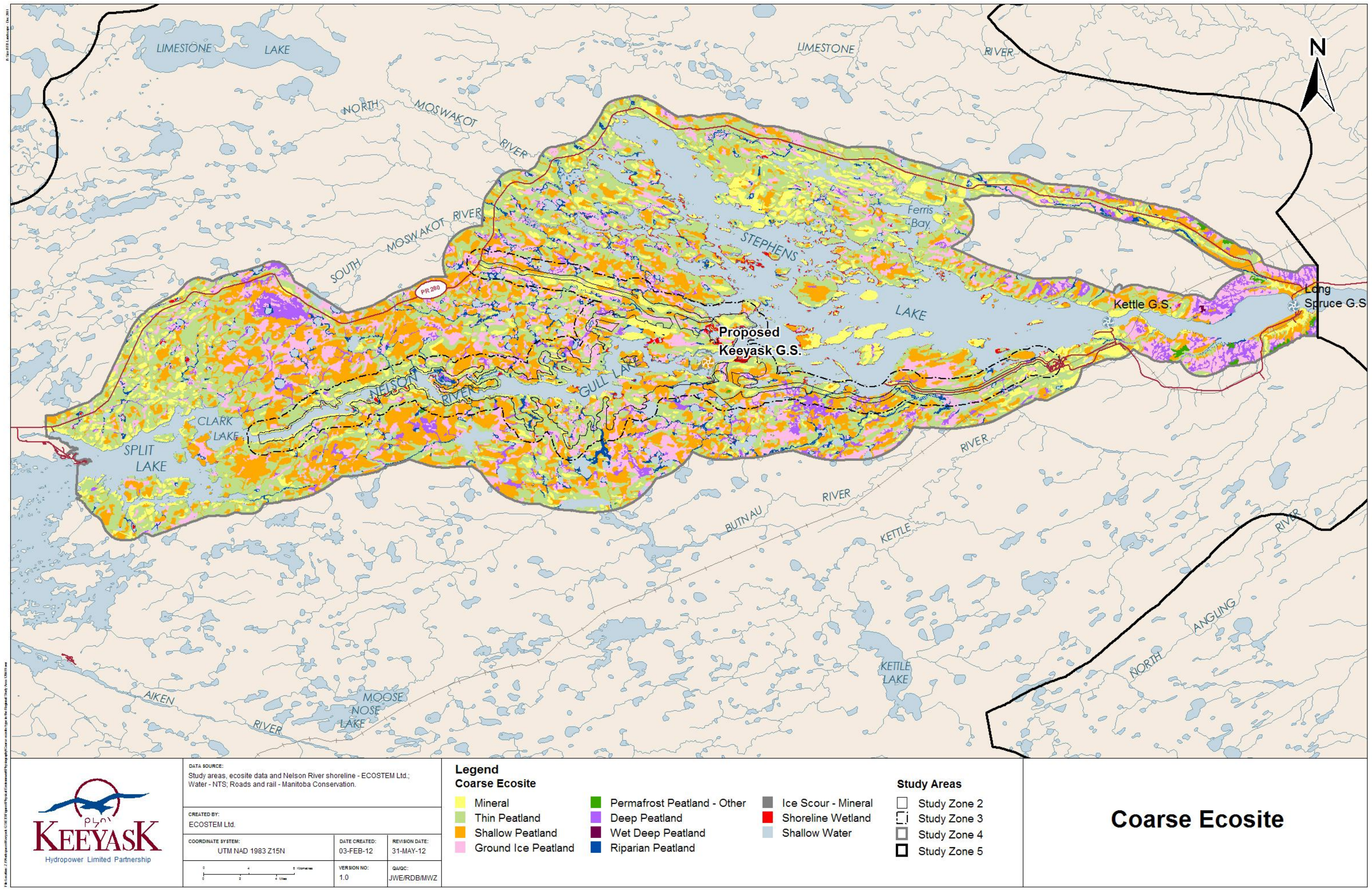
5.6 MAPS



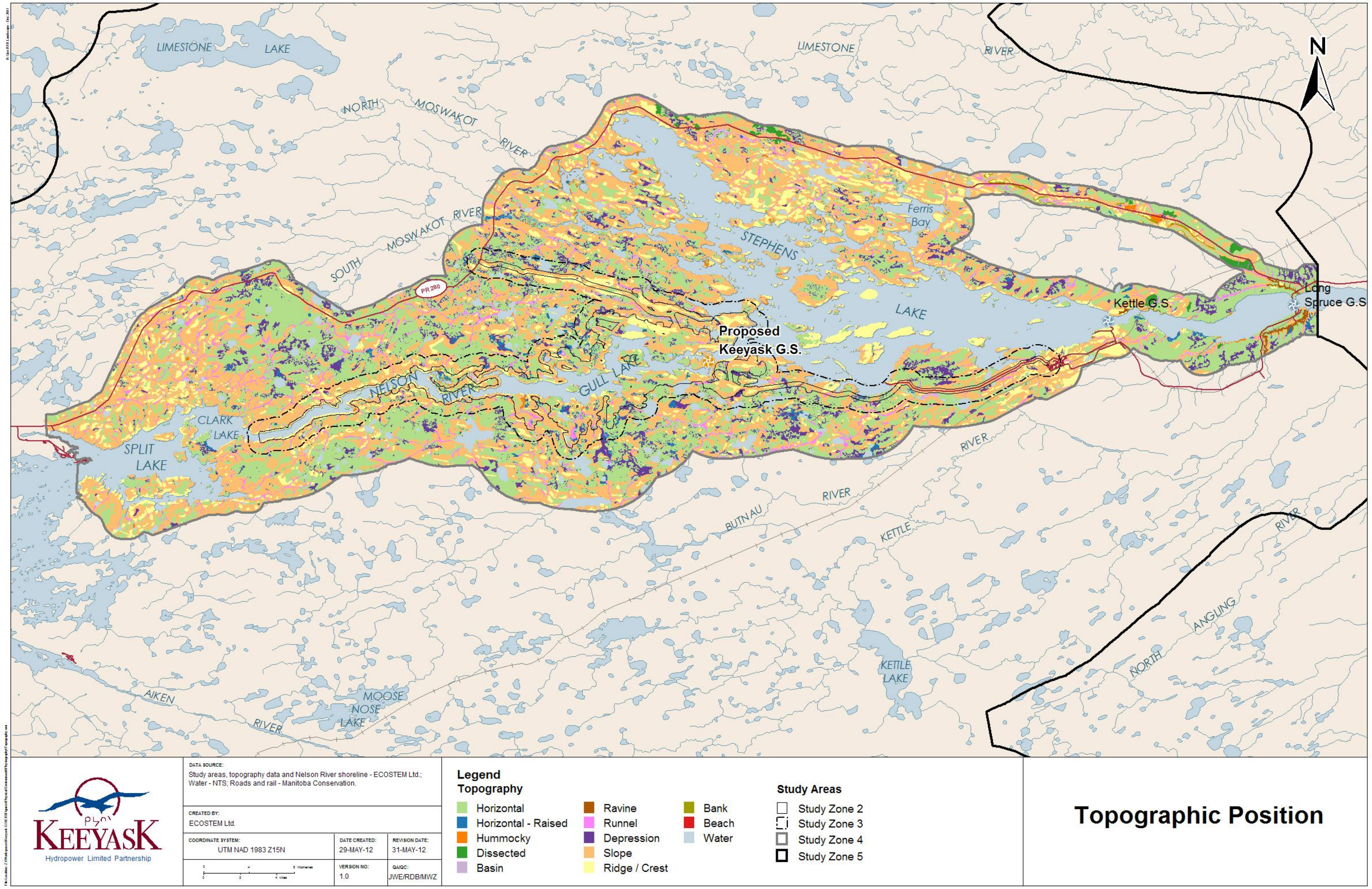
Map 5-1: **Soil sample locations in the Keeyask Regional Study Area**



Map 5-2: **Soil sample locations in the preliminary Conawapa Regional Study Area**



Map 5-3: **Coarse ecosite composition of the Keeyask Study Zone 4**



Map 5-4: Topographic form in the Keeyask Study Zone 4

6 HABITAT COMPOSITION

6.1 INTRODUCTION

This section presents the methods for creating the classification system used to map terrestrial habitat and ecosystems in the LNR region. Additionally, it describes the Keeyask fire regime and the terrestrial habitat composition of the Regional Study Area.

6.2 METHODS

6.2.1 Study Areas

The study areas used for habitat composition were those that were delineated in Section 2.6.3 using the spatial scoping methodology described in Section 2.5.2.

Additionally, the Nelson River in the Regional Study Area was sub-divided into the Gull, Stephens and Long Spruce study areas to reflect the different water regimes occurring in those river reaches (Map 6-1).

6.2.2 Habitat Mapping

6.2.2.1 Classification Systems

As described in Section 2.6.6, a key objective of the terrestrial habitat and ecosystems studies was to develop integrated site and stand level hierarchical habitat classification systems. Hierarchical habitat and ecological land classifications were developed for use throughout the terrestrial habitat and ecosystems assessment to provide a framework for characterizing terrestrial ecosystems and their interrelationships at multiple scales. Among other things, the site level classification was used to classify plots into habitat types while the stand level classification was used for habitat mapping.

Multivariate analyses of vegetation, soils and environmental data collected at the habitat plots and transects were used to develop ecologically relevant site and stand level habitat classifications. The site and stand level habitat classifications mirrored each other to the extent appropriate for the different spatial levels (see Section 7.2.3.1.3 for details). Cluster and ordination analyses were used to produce the site level habitat classification. The stand level habitat classification was developed from the site level habitat classification, the observed site level relationships between overstorey vegetation and site conditions, and the observed range of vegetation and ecosite types in the preliminary habitat mapping.

Section 2.6.2 described the ecological zonation system used by the studies. In brief, wetlands and uplands are the two major types of terrestrial habitats and ecosystems. Wetlands were classified into two major types, inland wetland and shoreline. Additionally, the shore zone was subdivided into five water depth duration zones (*i.e.*, littoral, lower beach, upper beach, inland edge and inland). Another higher level ecological zonation, consisting of plateau, river bank and ravine, was also used in the Conawapa Regional Study Area.

Regardless of whether it was a wetland or upland ecosystem, the attributes used to classify and map terrestrial habitat attributes were vegetation type, vegetation age class (where this could be determined), ecosite type, topographic position and either recent disturbance type (*e.g.*, large fires, ice scouring) or water depth duration zone. Ecosite type was a classification of soil, surficial material, surface water, groundwater and permafrost conditions that are associated with substantial differences in vegetation composition and/or structure.

Wetland habitat classes were derived from the Canadian Wetland Classification System (CWCS; National Wetlands Working Group 1997), with enhancements to reflect dramatic differences in marsh water regimes along the Nelson River and between the Nelson River and off-system waterbodies. Mitch and Gosselink (2000) point out that the CWCS and the US hydrogeomorphic approach (Smith *et al.* 1995) use the same factors to classify wetlands.

The CWCS broadly classifies wetlands into the following classes: bog, fen, swamp, marsh and shallow open water. Bogs, fens and some swamps are peatlands. Peatlands are wetlands where organic material has accumulated on the surface because dead plant material production exceeds decomposition (National Wetlands Working Group 1997). Compared with bogs, fens have higher nutrient availability in the plant rooting zone and tend to have a water table that is closer to the surface. Swamps are tall shrub and/or treed wetlands with nutrient rich water and a water table that is generally deeper than in fens but shallower and less persistent than marshes. Wetlands from all five wetland classes (National Wetlands Working Group 1988) can occur in the shore zone in the Keeyask region (Photo 6-1; Figure 6-1).

Wetland classes were subdivided into wetland forms based on surface morphology, surface pattern, water type and underlying mineral substrate morphology. Because hydrology is a key driver for the development of these attributes, the type of hydrological connection was key to classifying wetland form. The two hydrological connection types in the CWCS are littogeneous and terrigenous which correspond with the shoreline and inland wetland subdivision used by the Project studies. All inland wetlands were peatlands or swamp. Some peatland types were also found in the shore zone.

From most general to most detailed, the hierarchical levels in the stand level habitat classification system were land cover type, coarse habitat type, broad habitat type and fine habitat type (Table 6-1). The habitat types within each classification level were combinations of vegetation type and ecosite type. Land cover was used to provide very general study area descriptions and habitat use relationships for species. Vegetation on thin peatlands and mineral ecosites were grouped together at the land cover level because, although the vegetation on these two types were substantially different, the vegetation on thin peatlands was more similar to that found on mineral ecosite types than to the other peatland types.

The 11 land cover types, including permanent human features and water, were sub-divided into 23 coarse habitat types. Coarse habitat types were generally used to provide overview descriptions, characterize the general habitat requirements for the species of interest and/or to relate habitat mosaic information to field data.

The coarse habitat types were subdivided into 65 broad habitat types. Broad habitat types were generally used to characterize the habitat preferences for the species or species group of interest, to relate habitat mosaic information to field data and to describe certain areas of development from a wildlife perspective (*e.g.*, olive-sided flycatcher habitat in the south access road). The broad habitat classification level was also used to identify the regionally rare habitat types.

The broad habitat types were subdivided into 114 fine habitat types. Fine habitat type was generally used to address the specialized needs of VECs and supporting topics. For example, some types of high quality wildlife habitat were identified at the fine habitat level.

Table 6-1: Hierarchical habitat classification and examples of its uses in the EIS

Classification Level (number of habitat types)	Example of a Habitat Type	Examples of Uses in EIS	
		Habitat and Ecosystems	Plants and Animals
Land Cover Type (11)	Needleleaf treed on peatlands	Very general description of the study areas	Very general description of habitat use by a species
Coarse Habitat Type (23)	Black spruce treed on shallow peatland	Overview description of the study areas	Characterize the habitat preferences for a generalist species. Develop mixture types to relate to 500 m mammal transects.
Broad Habitat Type (65)	Black spruce mixture on ground ice peatland	Identify the regionally rare and uncommon habitat types	Characterize the general habitat preferences for a species
Fine Habitat Type (114)	Black spruce mixture/ Tall shrub on ground ice peatland	Distinguish the nature and degree of effects for different Project linkages (*e.g.*, groundwater versus vegetation clearing)	Identify patches satisfying specialized needs for some wildlife species (*e.g.*, feeding habitat)

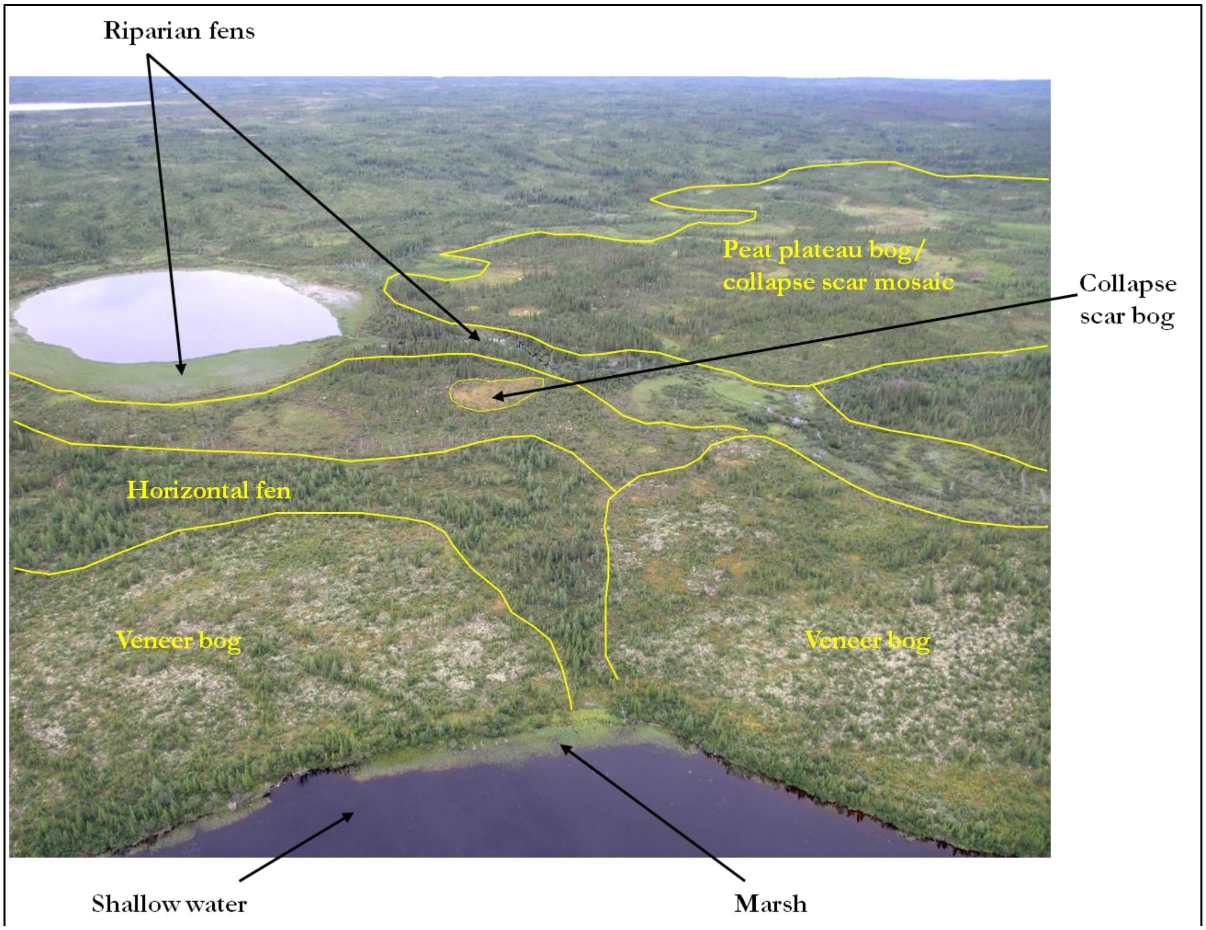


Photo 6-1: Photo from Study Zone 4 showing four of the five wetland classes

A)

B)

C)

Figure 6-1: Photos from off-system waterbodies showing: A) riparian fen and bog; B) marsh and floating-leaved plants in shallow water; and, C) shallow water wetlands

6.2.2.2 Inlands

The level of mapping detail varied with geographic scope. The most detailed Keeyask mapping was for Study Zones 2 and 4.

Preliminary approximations of Study Zones 2 and 4 were produced to plan habitat mapping and field studies. The first approximation of study areas was progressively refined as Project description information and data from mapping and field studies became available.

6.2.2.2.1 Keeyask Study Zone 4

Photo-Interpretation and Digital Polygon Creation

Most Study Zone 4 habitat attributes were mapped by photo-interpreting black and white stereo air photos. For most of Study Zone 4, the stereo photos were 1:15,000 scale taken on July 8, 2003. Stereo photos taken in 2006 (1:15,000), 1999 (1:20,000), 1991 (1:12,000) and 1986 (1:20,000) were used where 2003 photo coverage was not available. Polygon boundaries were traced on the air photos and then heads-up digitized on digital ortho-rectified imagery (DOI) or scanned photos that were georeferenced to the DOIs.

Photo-interpreted habitat attributes included vegetation structure, upper canopy species composition, lower canopy species composition, upper canopy closure, lower canopy closure (if visible), canopy complexity, burn extent, disturbed since 2003, ecological site type (ecosite coarse and ecosite fine) and topographic form type.

The minimum mappable polygon area for habitat attributes except for ecosite and topography was generally 5,000 m^2. A 1,000 m^2 cutoff was used for patches containing canopy species other than black spruce (*Picea mariana*) since these conditions were uncommon to rare in Study Zone 4. The minimum polygon size was 400 m^2 for water since this feature is important for distinguishing certain wetland types and it was extracted with a high accuracy rate using an automated digitization process (see below).

A larger minimum mappable polygon area was used for ecosite because the interpretation of where the boundaries between differences in sub-surface conditions was located was less discernible than vegetation cover mapping. That is, it was more straightforward to photo-interpret attributes such as vegetation structure, recent burn presence and overstorey species composition than ecosite attributes such as peat thickness, permafrost type or presence of a buried water layer.

The minimum polygon area for ecosite and topography was 20,000 m^2 (2 ha) with two exceptions. First, a 1,000 m^2 cutoff was used for collapse scars and peat plateau bogs in the potential Project reservoir area because these ecosite types play key roles in peatland disintegration (peatland disintegration is the largest indirect Keeyask Project effect; see Section

2.3.6 of Keeyask Hydropower Limited Partnership 2012 for details). Second, certain important and distinct ecosite types such as narrow runnels were usually smaller than 2 ha so the standard minimum mappable area was used for these features.

It should be noted that polygons slightly smaller than the stated minimum areas were present in the final habitat map for two reasons. The polygon areas were usually judged visually while tracing and digitizing. Additionally, ecosite typing sometimes sub-divided vegetation-based polygons into smaller polygons.

A mirror stereoscope was generally used to photo-interpret ecosite and topography. An Abrams stereoscope was also used for ecosite and topography in locations where higher magnification was needed. An Abrams stereoscope was used to photo-interpret all other habitat attributes.

GIS polygons for the photo-interpreted attributes were generated in several steps. The initial polygons were generated by a proprietary automated digitization program developed by ECOSTEM Ltd. The computer program generated preliminary vegetation structure polygons and assigned a vegetation structure type to each polygon. The input data used by the auto-digitization program were the 1999 digital orthorectified imagery (DOIs) provided by Manitoba Hydro (Manitoba Hydro, 2011). The auto-digitized polygons were overlaid on the DOIs in MapInfo (initially 7.5 and then 8.5). Errors in the automated polygon boundaries and vegetation structure were corrected by heads-up digitizing on the DOIs. Interpretations were reviewed by a second interpreter and further adjustments were made as necessary. Whenever possible, the same interpreter was used for review in order to maintain consistency throughout the mapping region.

Photo-interpreted boundaries traced on photos and not already incorporated by the auto-digitized polygons (i.e., ecosite type, topography, canopy species other than black spruce, recent disturbance boundaries) were heads-up digitized on the 1999 DOIs.

Year of polygon origin was assigned to recently disturbed polygons using available external information such as Manitoba Conservation fire mapping and dates of air photos or satellite imagery acquired before and after the disturbance. Burns occurring after 2003 were incorporated using either 2006 stereo photography or still camera photos acquired from a helicopter. An attribute was added to indicate that the polygon was burned since the 2003 stereo photography; polygons were split into burned an unburned sections as needed. Two versions of the habitat dataset were maintained, one as of 2003 and the other as of 2010. The former dataset represents conditions prior to the large 2005 burn on the south side of the Nelson River, which is when most of the field data were collected. The 2010 version represents current conditions in the existing environment.

Vegetation structure and overstorey species composition were mapped for recently burned areas (post-1993) by two different methods. For areas burned after 2003, it was assumed that the habitat would eventually regenerate to the pre-disturbance composition and structure. Vegetation attributes in these areas were set to the type that was photo-interpreted from the 2003 stereo photography. For recent burns since the air photo acquisition year (i.e. 1995, 1999 and 2001) and prior to 2003, low-level, overlapping oblique photos were obtained from a helicopter during the summers of 2010 and 2011, providing near-continuous photo coverage of the regenerating areas. The oblique photos were geo-referenced and used to identify vegetation structure and overstorey species composition, which were heads-up digitized on the DOIs.

After mapping was complete, the integrity of assigned polygon attributes was assessed by examining the associations among the different attributes within the polygons through a series of queries. Impossible or unlikely combinations of attributes within a polygon were flagged and examined in detail for validity, and errors were corrected.

Project study area boundaries, and impact areas were also incorporated into the habitat tables as additional fields once mapping was completed.

6.2.2.2.2 Validation

The photo-interpreted habitat mapping was validated using a combination of directed aerial validation surveys, still photos taken from a helicopter and ground data.

Directed aerial and ground validation surveys were completed for the uncommon to rare mapped habitat types. Location waypoints were generated from these map polygons and uploaded into a GPS receiver. The waypoints were visited in the field by helicopter and the actual canopy species composition and site conditions were recorded on a map. Additionally, waypoints were acquired in the field for any priority habitat types that were observed from the helicopter but not already in the habitat map. In the lab, mapped versus actual typing was compared and accuracy rates were calculated. Validated habitat attributes were adjusted if necessary in the GIS database, and any new priority habitat locations were incorporated.

Ecosite mapping was verified using soil profile data collected by Project studies and from the Manitoba Hydro borehole database. See Sections 5.3 and 5.4 for a description of methods and accuracy assessment results. Accuracy rates for all ecosite types were high.

A geo-referenced photo database was compiled to support photo-interpretation and to validate the habitat mapping. Still photos were taken from a helicopter during the 2001 – 2012 field seasons. Some photos were taken opportunistically while flying between ground sample locations while others were intentionally located in areas of interest. In addition, oblique, overlapping photos of stands and the landscape were taken at an altitude of approximately 150 m along a series of flight lines at selected locations in the LNR region.

6.2.2.2.3 Habitat Attributes

Photo-interpreted habitat attributes were vegetation structure, upper canopy species composition, lower canopy species composition, upper canopy closure, lower canopy closure, canopy complexity, year of origin where this could be determined, type of stand replacing disturbance where this could be determined, ecosite fine, and topographic form and hydrodynamics. Table 6-2 provides a summary description of each photo-interpreted habitat attribute. Where needed, further descriptions of the classes included within some of the attributes are provided in Table 6-3 to Table 6-7. Further details for each attribute are provided below.

Table 6-2: Habitat attributes in the GIS database acquired through photo-interpretation

Attribute Name	Description	Values
Veg_Structure	Current vegetation structure type: The growth form of the highest vegetation layer having at least 25% total cover.	F = Forest; D = Woodland; S = Sparsely Treed; M = Heterogeneous; TS = Tall Shrub; L = Low Vegetation; E = Emergent; R = Young Regeneration (See Table 6-3)
Veg_Structure_2003	Veg_Structure as of year 2003.	
Species_Upper	Species composition of canopy layer: All species with a minimum proportion of 10%, in 10% increment classes (e.g., BS6JP4 = 60% black spruce and 40% jack pine).	BS = Black Spruce, TL = Tamarack, JP = Jack Pine, TA = Trembling Aspen, BA = Balsam Poplar, WB = White Birch
Species_Upper_2003	Species composition of canopy layer as of year 2003.	
Species_Upper_Historical	Species composition of canopy layer prior to conversion to human infrastructure, if available.	
Species_Lower	Species composition of above-ground understorey layer (cannot be typed in polygons where understorey is obscured by canopy. i.e., forest or some woodland). Must be a distinct vegetation layer with at least 5m height difference between layers.	See Species_Upper
Species_Lower_2003	Species_Lower as of year 2003.	
Closure_Upper	Percent closure class of upper canopy layer: Classes are 10% increments where black spruce < 100%. Where black spruce = 100% there are 4 classes because of wide range of tree heights often in these stands (no true upper canopy).	0, 1, 2 . . . to 9 (1 = 10-19%; 2 = 20-29%; 3 = 30-39%;...; 9 = 90-100%)
Closure_Upper_2003	Closure_Upper as of year 2003.	
Closure_Lower	Percent closure of lower tree layer if present: Classes are 10% increments where lower canopy closure > 10%. Only applies to polygons where Species_Upper black spruce < 100%. Lower layer closure more difficult to interpret or underestimated with increasing upper canopy closure.	See Closure_Upper
Closure_Lower_2003	Closure_Lower as of year 2003.	
Canopy_Complexity	Indicates a complex canopy where there is a wide range of tree heights with no defined layer.	1 = Range of tree heights; 0 = Other

<table>
<tr><th>Attribute Name</th><th>Description</th><th>Values</th></tr>
<tr><td>Canopy_Complexity_2003</td><td>Canopy_Complexity as of year 2003.</td><td></td></tr>
<tr><td>Year_Origin</td><td>Most recent year of stand-replacing disturbance in polygon (where information is available).</td><td rowspan="2">Year</td></tr>
<tr><td>Year_Origin_2003</td><td>Most recent year of stand-replacing disturbance in polygon up to 2003 (where information is available).</td></tr>
<tr><td>Feature_Name</td><td>Identifies disturbance type if present.</td><td>Fire; Clearing- Linear, TLine, Railway etc.</td></tr>
<tr><td>EcoSite_Fine_Code</td><td>Fine ecosite type code.</td><td>See legend
Table 6-5</td></tr>
<tr><td>Topography</td><td>Topographic form: Combines surface shape and topographic position.</td><td>See legend</td></tr>
<tr><td>Hydrodynamics</td><td>Identifies main hydrological influence on a wetland.</td><td>See legend Table 6-7</td></tr>
</table>

Table 6-3: Vegetation structure types

Vegetation Structure Type	Code	Percent Cover
Forest	F	61% - 100% trees
Forest/ Tall Shrub	F/ TS	61% - 100% trees in upper canopy/ > 25% tall shrubs in lower canopy
Woodland	D	26% - 60% trees
Woodland/ Tall Shrub	D/ TS	26% - 60% trees in upper canopy / > 25% tall shrubs in lower canopy
Sparsely Treed	S	10% - 25% trees
Sparsely Treed/ Tall Shrub	S/ TS	10% - 25% trees in upper canopy / > 25% tall shrubs in lower canopy
Heterogeneous mixture of woodland and sparsely treed	M	Mixture of woodland and sparsely treed
Heterogeneous mixture of woodland and sparsely treed/ Tall Shrub	M/ TS	Mixture of woodland and sparsely treed with TS lower canopy
Tall Shrub	TS	<10% tree cover and > 25% tall shrub cover
Low Shrub and/or Graminoid and/ or Bryoid	L	<10% trees and < 25% tall shrub and > 10% ground cover
Emergent	E	> 25% emergent vegetation cover
Barren	B	< 10% vegetation cover
Unclassified Young Regeneration	R	Burned after 1992, insufficient information to classify into vegetation structure type

Table 6-4: Coarse and broad ecosite types and criteria

Broad Ecosite	Coarse Ecosite	Coarse Ecosite Code	Criteria*
Mineral land types			
Mineral Soil	Mineral Soil	1	Surface organic layer < 20 cm thick. (Fine_EcoSite_Code: 1 – 5)
Thin peatland land types			
Thin Peatland	Thin Peatland	15	Surface organic layer >= 20 cm and < 100 cm. Occurs on ridges and crests or sloped topography. (Fine_EcoSite_Code: 15)
Peatland land types			
Shallow Peatland	Shallow Peatland	20	Surface organic layer > 100 cm and ≤ 200 cm thick. (Fine_EcoSite_Code: 21 – 25)
Ground Ice Peatland	Ground Ice Peatland	30	Surface organic layer ≥ 20 cm; excess ice continuous. Level surface. (Fine_EcoSite_Code: 31 – 35)
Wet Peatland	Other Permafrost Peatland	40	Surface organic layer ≥ 20 cm; evidence of excess ice actively forming or melting (e.g., collapse scar peatlands). Hummocky surface due to patchy excess ice. (Fine_EcoSite_Code: 41 – 47)
	Deep Peatland	50	Surface organic layer > 200 cm; surface level and featureless. Excess ice usually absent and not confined by bedrock or mineral terrain. (Fine_EcoSite_Code: 51 – 57)
	Wet Deep Peatland	60	Surface organic layer > 200 cm; surface level and featureless. Evidence of very high water table. Excess ice usually absent and not confined by bedrock or mineral terrain. (Fine_EcoSite_Code: 62 – 65)
Shore zone peatland land types			
Riparian Peatland	Riparian Peatland	66	Surface organic layer ≥ 20 cm, floating. Open water present. (Fine_EcoSite_Code: 67 – 68)
Shore zone- regulated land types			
Ice Scoured Upland	Ice Scoured Upland	70	Along Nelson River banks, disturbed by ice movement. Usually a terrace or steeply sloped mineral/ bedrock area. (Fine_EcoSite_Code: 70)
Upper beach- regulated	Shoreline Wetland- regulated	75	Wet meadow, sloped transition between open water and upland. Herbaceous and/or tall shrub vegetation. (Fine_EcoSite_Code: 71 – 79)
Sunken peat- regulated			
Lower beach- regulated			
Shore zone marsh land types			
Upper beach	Shoreline Wetland	75	Wet meadow, sloped transition between open water and upland or along fringes of floating peat. Emergent, Herbaceous and/or tall shrub vegetation. (Fine_EcoSite_Code: 71 – 79)
Lower beach			
Littoral			

Notes: * Criteria refer to dominant conditions throughout the polygon.

Table 6-5: Fine ecosite types and criteria

Fine Ecosite Type	Fine Ecosite Code	Criteria*
Mineral types		
Outcrop	1	Surface organic layer < 20 cm thick, and mineral soil < 4 cm thick.
Shallow/ thin mineral	2	Surface organic layer < 20 cm thick, and mineral soil ≥ 4 cm and < 100 cm thick.
Deep dry mineral	4	Surface organic layer < 20 cm thick; mineral soil > 100 cm thick; moisture regime very fresh or drier. Vegetation indicative of the moisture regime is present.
Deep wet mineral	5	Surface organic layer < 20 cm thick; mineral soil > 100 cm thick; moisture regime moderately moist or wetter. Vegetation indicative of the moisture regime is present.
Thin peatland types		
Veneer bog on slope	15	Surface organic layer ≥ 20cm and < 100 cm. Occurs on ridges and crests or sloped topography.
Organic or Mineral types		
Swamp	10	Mineral or organic soil; moisture regime is wet. Water table usually > 20 cm below surface; periodically flooded; woody vegetation cover ≥ 25%.
Shallow peatland types		
Veneer bog	21	Surface organic layer ≥ 20cm and < 100 cm, not occurring on crests, ridges or slopes.
Blanket bog	22	Surface organic layer > 100 and ≤ 200 cm; surface is level and featureless; patchy ground ice may be present but does not form hummocks or banks taller than 1 m.
Slope bog	24	Surface organic layer > 20 cm thick and mineral soil > 100 cm thick; surface sloped. Moisture regime moderately moist or wetter. On slopes. Usually in runnels. Slope and bog indicators.
Slope fen	25	Surface organic layer > 20 cm thick and mineral soil > 100 cm thick; surface sloped. Moisture regime moderately moist or wetter. On a slope. Usually in runnels. Vegetation indicative of mesotrophic or eutrophic conditions. Fen indicators. All polygons that could be slope swamps are included in this type.
Peat plateau bog	31	Surface organic layer ≥ 20 cm: massive ground ice at least 1 m thick; surface level. Banks obvious.
Peat plateau bog transitional stage	32	Surface organic layer ≥ 20 cm: massive ground ice patchy forming large, obvious hummocks and/ or banks shorter than 1 m. Peat plateau bog in the formation or disintegration stage (build-up or melting of ground ice).
Peat plateau bog/ collapse scar peatland mosaic	33	Mixture of peat plateau bog and collapse scar peatlands.
Blanket bog/ collapse scar peatland mosaic	35	Mixture of blanket bog and collapse scar peatlands.
Wet peatland types		

Fine Ecosite Type	Fine Ecosite Code	Criteria*
Collapse scar bog	43	Thermokarst feature. Surface organic layer ≥ 20 cm, in a depression within a peat plateau bog. Bog indicators. Peat mat usually floating. Often a narrow band of water on the perimeter.
Collapse scar fen	44	Thermokarst feature. Surface organic layer ≥ 20 cm, in a depression within a peat plateau bog. Fen indicators. Peat mat usually floating. Often a narrow band of water on the perimeter.
Horizontal fen/ blanket bog mosaic	45	Mixture of horizontal fen (see type 55) and blanket bogs (see type 22).
Basin fen	52	Surface organic layer ≥ 20 cm, situated in a basin that has an essentially closed drainage, receiving water from the immediate surroundings. May have outlets but no inlets. Vegetation indicative of mesotrophic or eutrophic conditions.
Flat bog	54	Surface organic layer ≥ 20 cm. Depth to mineral material or bedrock typically greater than 2 m. Surface flat. Occurring in broad, poorly defined depressions. Open water absent or as small pools. Bog vegetation only.
Horizontal fen	55	Surface organic layer >= 20 cm, open water absent or as small pools; buried water layer usually present. Distinct water flow or vegetation indicative of mesotrophic or eutrophic conditions present. Patterning not visible.
String fen	62	Surface organic layer > 20 cm. Narrow, peaty ridges ("strings") that enclose open water pools or depressions of open water ("flarks") or wet fen surfaces. Strings are at right angles to the direction of surface water flow. Vegetation indicative of mesotrophic or eutrophic conditions.
Shore zone peatland types		
Riparian bog	67	Surface organic layer >= 20 cm: floating; open water present. No visible evidence of flowing water. Bog indicators.
Riparian fen	68	Surface organic layer >= 20 cm: floating; open water present, along lakes and waterways. Visible evidence of flowing water and/or fen indicator vegetation.
Shore zone types		
Ice scour on mineral above wet meadow zone	70	Along Nelson River banks above the shoreline wetland zone, disturbed by ice movement. Usually a terrace or steeply sloped mineral/ bedrock area.
Upper beach- regulated	72	Nelson River shoreline wetland. In main river channel. Infrequent to frequent flooding. Sloped transition between open water and upland. Herbaceous and/or tall shrub vegetation.
Upper beach- regulated	75	Nelson River shoreline wetland. In a shallow bay. Sloped transition between open water and upland. Herbaceous and/or tall shrub vegetation.
Upper beach on sunken, disintegrated peatland	74	Wet meadow on sunken, disintegrated peatland that is under water. Sloped transition between open water and upland. Herbaceous and/or tall shrub vegetation, snags often present in water.
Lower beach	76	Shallow water with emergent vegetation present adjacent to shoreline, usually above waterline in low water years.
Upper beach on sunken peat	77	Marsh on sunken fringes of floating peatlands. Generally along edges of lakes and streams.
Littoral	79	Marsh island, floating-leaved patch permanently submerged in the shallow water zone.
Other types		

Fine Ecosite Type	Fine Ecosite Code	Criteria*
Shallow water	80-85	Water covering at least 400 m^2 area and shallower than 2 m.
Deep water off-system	88	Water covering at least 400 m^2 area and deeper than 2 m.
Deep water Nelson River	89	Water deeper than 2 m.
Human	90	Human structures or semi-permanent clearings (e.g., borrow areas that are not regenerating).

Notes: * Criteria refer to dominant conditions throughout the polygon.

Vegetation Structure

Vegetation structural types were classified based on the structural type found in the tallest layer. Vegetation structure identifies the tallest growth form that has at least 25% total cover. The three treed classes were forest (F), woodland (D), sparsely treed (S), or woodland and sparsely treed mixtures (M). The treed classes were determined according to the average estimated percent cover. To be considered a treed polygon, a minimum 10% cover of trees taller than two metres was needed. Woodland and sparsely treed mixtures referred to areas with variable structure generally occurring in patches that were too small to be subdivided into separate polygons. Other areas were typed simply as “treed”. These were either woodland or sparsely treed areas located at the fringes of Study Zone 4 where less detailed mapping was conducted, and/or appropriate aerial photography was not available. A modifier was added to a treed class if a tall shrub understorey was visible through openings in the tree canopy (*e.g.*, F/TS).

The untreed classes were tall shrub, low vegetation and barren. Young regenerating burns were initially assigned to the recent burn class as a reflection of their short stature and general lack of a dominant growth form in photo-interpretation (i.e., often a mixture of shrubs and tree saplings). For a polygon to be assigned to the burned structure class, the fire must have been estimated to occur after 1993.

Table 6-3 provides the photo-interpretation criteria for each vegetation structure class.

Species Composition

Upper canopy species composition (Species Upper) of treed polygons was photo-interpreted. Polygons containing tree species other than black spruce, with at least 10% cover, were manually digitized (see Table 6-2 for tree species and codes). Tree species composition was estimated to the nearest 10%. All remaining treed areas were typed as 100% black spruce. If a secondary or lower canopy layer was distinguishable, the species composition of that layer was recorded separately (Species Lower).

For tall shrub polygons, species was identified where feasible.

Canopy Closure

Total canopy closure was estimated to the nearest 10% for all polygons with tree species other than black spruce. If more than one canopy layer was present, separate closure values were estimated for each layer. It should be noted that closure values for the lower canopy layer were biased, as lower cover estimates decreased with increasing upper canopy closure.

Canopy Complexity

For polygons with species other than black spruce, canopy complexity was indicated as “1” if there was no single distinct canopy layer present. This occurred in cases where there was a wide range of tree heights, with no single dominating height class.

Recent Disturbance

Recorded as “Year Origin”, this refers to the most recent year that stand replacing disturbance occurred in the polygon. For wildfires, this information was only generally available if they occurred after 1967.

Disturbance Type

Recorded as “Feature Name”, this identifies the type of stand replacing disturbance that occurred in the polygon up to and including the year 2003, and any stand replacing disturbances that occurred after 2003 (e.g., the 2005 fire). This includes natural disturbances as well as human infrastructure.

Ecosite

The ecosite classifications used for ecosystem and habitat mapping were described in Section 5.3.2.

Topographic Form

Topographic form combines surface shape and topographic position. Topographic form is closely related to ecosite type since it plays an important role in ecosite development, particularly with respect to its influence on water drainage and substrate. The photo-interpreted topographic form types and interpretation criteria are provided in Table 6-6. Twelve topographic form types were used. The topographic form type of a particular polygon was based on dominant conditions throughout the polygon. Due to the relationship between ecosite and topography, boundaries between different topographic form types usually corresponded to boundaries between ecosite types.

Table 6-6: Topographic form classes and criteria

Topographic Form	Criteria*
Ridge/ Crest	Long, narrow elevation of the surface, usually sharp crested with steep sides. The ridges may be parallel, subparallel, or intersecting.
Slope	Sloping, unidirectional surface with a generally constant slope not broken by marked irregularities. Slopes are 2-70% (1-35°).
Bank	Erosional slopes, greater than 70% (35°), on both consolidated and unconsolidated materials.
Beach	Open water zone shallower than 2 m.
Horizontal	Flat or very gently sloping (i.e., < 2%), unidirectional surface with a generally constant slope not broken by marked elevations and depressions.
Horizontal- raised	Horizontal areas that are higher than the surrounding areas and have banks or very steep slopes (e.g., peat plateau bog).
Hummocky	Very complex sequence of slopes extending from somewhat rounded depressions or kettles of various sizes to irregular to conical knolls or knobs. The surface generally lacks concordance between knolls or depressions. Slopes are generally 9-70% (5-35°).
Dissected	Many crevices or small runnels interspersed throughout.
Ravine	Band formed by steep, high banks on both sides; feature may or may not be distinctly sloped.
Runnel	Narrow band formed by (a) moderately to very short steep slopes on either side, or (b) large gentle slopes (e.g., two veneer bogs meeting); feature is often distinctly sloped.
Depression	Area is generally lower than all of the surrounding area but there may be surface water inlets and outlets.
Basin	Area is lower than all of the surrounding area.

Notes: * Criteria refer to dominant conditions throughout the polygon.

Hydrodynamics

The hydrodynamics attribute broadly classifies hydrological factors influencing wetlands. The type of water flow and hydrological inputs associated with a wetland affect its development and nutrient status, and ultimately the type of vegetation and habitat it is capable of supporting. This attribute represents the interpretation of open water into a waterbody type, such as a lake, stream, or the Nelson River, which determines the main hydrological influence on the adjacent peatland. The photo-interpreted hydrodynamic factors and interpretation criteria are provided in Table 6-7.

Table 6-7: Hydrodynamics classes and criteria

Hydrodynamics	Criteria
Inland	Inland wetlands, not adjacent to an open waterbody. Hydrological inputs received from precipitation or surface or groundwater flow.
Groundwater flow	Inland areas in transition ostensibly due to a recent change in depth to groundwater. Evidence of recent vegetation change, such as tree mortality in proximity to a waterbody that underwent a recent change in water flow or volume are criteria for this factor.
Lake	Lakes and ponds with no direct hydrological connection to the Nelson River system.
Stream	Open waterways with no direct input from the Nelson River system.
Nelson River	Any waterbody that is part of, or receives direct inputs from the Nelson River system (regulated).
Human	Human infrastructure
None	All other polygons that are not wetlands or human infrastructure.

A number of additional habitat attributes were derived from the photo-interpreted attributes. In general, derived attributes were broader categorizations of photo-interpreted attributes determined from quantitative or qualitative transformation of the photo-interpreted attribute classes. For example, land cover represents broad groupings of species composition and coarse ecosite type. Other derived attributes were mathematical calculations. For example, age at 2010 was 2010 minus year of polygon origin.

Derived attributes for each polygon included overall vegetation composition, vegetation class, broad vegetation type, dominant leaf type (needle or broadleaf), vegetation age as of 2003 and 2010, the leading six tree species, individual tree species contributions to upper canopy closure for each species in the polygon, broad habitat type and land type. Table 6-8 describes the derived attributes.

Table 6-8: Habitat attributes in the GIS database derived from photo-interpreted variables

Attribute Name	Description	Example Values
Priority_Concern	Indicates priority habitat criteria met, if any.	R=Rare; U=Uncommon; D=High Diversity; S=High potential for rare species
Land_Cover	Coarsest class in hierarchical ecological land classification. Generally a combination of Veg_Class and Land_Type for inland habitat.	Needleleaf treed on other peatlands; Nelson River shore zone
Land_Cover_2003	Land_Cover in 2003.	See Land_Cover
Coarse_Habitat	Second-coarsest class in hierarchical habitat classification. Identifies dominant conifer tree species; combination with ecosite types.	Black spruce treed on shallow peatland; Nelson River shrub and/or low vegetation on upper beach
Coarse_Habitat_2003	Coarse_Habitat in 2003	See Coarse_Habitat
Broad_Habitat	Second-finest class in hierarchical habitat classification. Priority habitat identified at this level. Identifies all dominant tree species and their degree of mixture in combination with ecosite.	Black spruce mixture on ground ice peatland; tall shrub on upper beach-regulated
Broad_Habitat_2003	Broad_Habitat in 2003	See Broad_Habitat
Fine_Habitat	Finest class in hierarchical habitat classification. Identifies all dominant tree species and their degree of mixture and tall shrub layer if present. Generally a combination of Veg_Broad and Broad_Ecosite.	BS Mixture/ tall Shrub on wet peatland; emergent on sunken peat
Fine_Habitat_2003	Fine_Habitat in 2003	See Fine_Habitat
Veg_Composition	Species composition of upper and lower strata. Combination of Species_Upper / Species_Lower.	JP8BS2/ BS10; TA10/ TS Unknown
Veg_Composition_2003	Veg_Composition as of year 2003.	See Veg_Composition.
Veg_Class	Aggregation of Veg_Broad classes into a small number of general types.	Needleleaf Treed; Broadleaf Treed
Veg_Class_2003	Veg_Class in 2003.	See Veg_Class
Veg_Broad	Leading species and degree of mixture with other types. Rules are: Needle mixedwood if broadleaf component >= 30% and <= 40%. Needle mixture if broadleaf component >= 10% and <= 20%. Broadleaf mixedwood if needle component >= 30% and <= 50%. Broadleaf mixture if needle component >= 10% and <= 20%. If there is a tie for leading species, then the following rules apply: BS always loses; where there are ties that involve a needle and a broadleaf species, the broadleaf species always wins; and, where there are ties that involve two broadleaf species, TA always loses.	BS Pure; TA Mixture
Veg_Broad_2003	Veg_Broad in 2003	See Veg_broad
Age_At_2003	Vegetation age in 2003. Equals 2003 minus "Year_Origin" where "Year_Origin" > 0.	Age (years)
Age_At_2010	Vegetation age in 2010. Equals 2010 minus "Year_Origin" where "Year_Origin" > 0.	Age (years)
Balsam_Fir, Balsam_Poplar, Black_Spruce, Jack_Pine,	Percentage of Closure_Upper contributed by the species. Information also available as of year 2003 (e.g. Balsam_Fir_2003)	1 to 10 (10% to 100%)

Attribute Name	Description	Example Values
Tamarack, Trembling_Aspen, White_Birch, White_Spruce		
Ecosite_Fine_Form	Adds a modifier to EcoSite_Fine_Code to distinguish between different wetland sub-forms and hydrodynamics within a fine ecosite type.	See Hydrodynamics and Wetland_Subform below.
EcoSite_Fine	Name of fine ecosite type, associated with EcoSite_Fine_Code.	See Table 6-4
EcoSite_Coarse_Code	Coarse ecosite type code. A more general grouping of EcoSite_Fine_Code.	See Table 6-4
EcoSite_Coarse	Name of coarse ecosite type, associated with EcoSite_Coarse_Code.	See Table 6-4
EcoSite_Broad	Broad ecosite type name. More general than coarse ecosite type for inland habitat.	See Table 6-4
Land_Type	Land type. The most general ecosite type classification.	See Table 5-23
Surface_Permafrost	Surface permafrost distribution in the polygon.	Continuous; Extensive Discontinuous; Sporadic Discontinuous; Isolated Patches; None
Water_Depth_Zone	Water depth duration zone: a generalized classification of shore zone polygons according to the amount of time spent submerged annually. See Section 7.2.2.2.1.	Littoral; Lower beach; Upper beach; Inland ice scour; None
Regulated	Indicates if shore zone wetland polygon is influenced by Nelson River regulation.	Yes; No
Wetland_Class	Wetland class. Coarsest wetland classification, based on Canadian Wetland Classification System (CWCS; National Wetlands Working Group 1997).	Bog; Fen; Marsh; Swamp; Shallow Water
Wetland_Form	Wetland form: subdivisions of each wetland class based on surface morphology, surface pattern, water type, vegetation and ecosite.	Riparian; Lacustrine,
Wetland_Subform	Wetland sub-form: a finer subdivision of some wetland forms reflecting more detailed site and hydrodynamic conditions.	Shore; Bay; Stream; Shore and floating; Shore and bay; Northern ribbed
ID	Unique identifying number for individual polygons. Integer.	1, 2, etc.
Area	Spherical area of polygon in square meters. Calculated by MapInfo.	Area (m^2)

Vegetation Composition

This attribute is derived from a combination of the upper and lower species composition obtained through photo-interpretation.

Vegetation Class

This attribute is derived from an aggregation of broad vegetation types (see below) into more general classes. For example, treed broad vegetation types with broadleaf species such as trembling aspen (*Populus tremuloides*) or white birch (*Betula papyrifera*) would be grouped into the vegetation class “Broadleaf Treed”.

Broad Vegetation Type

This derived variable identifies the leading vegetation species, and the degree of mixture with other types of species. For example, “black spruce mixedwood” refers to a treed stand with black spruce as the leading species, mixed with a broadleaf component greater than or equal to 30% of the canopy closure. Table 6-8 describes the rules for assigning broad vegetation types to each polygon.

Vegetation Age

Vegetation age is the age of the stand determined from the origin year in the “Recent Disturbance” attribute. Two stand age attributes are included: age in 2003 and age in 2010.

Individual Tree Species

This is a series of eight derived variables, each representing a species. If that species is present within a polygon, the percent canopy closure for that species is given.

Broad Habitat Type

This variable is derived by combining broad vegetation and coarse ecosite type. The resulting value indicates the vegetation composition of a polygon, along with the type of ecosite it occurs on (e.g., black spruce on shallow peatland).

Coarse Habitat Type

This derived variable combines broad habitat types into more general classes. It includes the specific dominant conifer species and identifies mixedwoods, and provides a more detailed ecosite association, such as “black spruce mixedwood on shallow peatland”.

Land Cover Type

This derived variable combines coarse habitat types into more general classes. It provides the general vegetation cover type (e.g. needleleaf treed or broadleaf treed) and the land type association, such as “peatland” or “mineral or thin peatlands”. This represents the most general habitat class in the ecological land classification.

Land Type

This attribute is derived from an aggregation of coarse ecosite into a few general classes. For example, all peatland ecosite types are combined into a single class called “Peatland”.

Water Depth Zone

This attribute applies to shore zone types occurring within either a fluctuating water zone or an ice scour zone. It identifies the general shore zone position of the polygon based on the amount of time the polygon would be under water during the growing season (See Section 7.2.2.2.1 for a description of water depth duration zones). Categories include “inland ice scour”, “upper beach”, “lower beach” and “littoral”. This attribute is derived from fine ecosite type.

Regulated

This category indicates whether or not a shore zone polygon is influenced by Nelson River water regulation. Values are set to “yes” if the polygon is adjacent to a water body with Hydrodynamics = “Nelson River”. Otherwise, values are “no”.

Wetland Class

Wetland class is the most general wetland type, representing a grouping of wetland fine ecosite types into general categories, such as “Bog” and “Fen”.

Wetland Form

Wetland form is a more detailed classification of wetland type, derived from fine ecosite type. For example the wetland class “Bog” is subdivided into forms of bog, such as “Veneer” or “Peat plateau”.

Wetland Subform

Wetland subform is a finer classification of wetland form that applies only to certain wetland types. Subform provided a more detailed subdivision for hydrodynamic or site conditions such as topographical situations and shoreline position as it relates to wave energy.

6.2.2.2.4 Areas Outside of the Study Zone 4

Land cover mapping for portions of Study Zones 5 and 6 (Map 2-3) were developed from classified satellite imagery. Landsat 7 imagery for tile 3221 was classified. This tile covered most of Study Zone 4 and approximately 80% of The Regional Study Area.

A number of different classification approaches were tested and evaluated for classification accuracy using the photo-interpreted terrestrial habitat dataset as the benchmark. The different classification approaches were also tested on Landsat imagery acquired on these dates: July 21, 2000, September 26, 2001, June 9, 2002 and July 11, 2002.

The main steps taken to classify the Landsat 7 imagery for the final version of the land cover map were:

1. Linear stretch bands 1 to 5 and 7.
2. Pan-sharpen the stretched bands using principal components analysis.
3. Isocluster the six pan-sharpened, stretched bands from the July 21, 2000.
4. Create water layer by combining water classes produced by step 3.
5. Create recent burn layer.
    a. Mask water obtained from step 4.
    b. Isocluster normalized burn ratio images from all four Landsat acquisition dates.
    c. Identify the classes that are recent burn.
6. Create the classified image from the July 21, 2000 imagery .
    a. Mask burn and water using images created in previous steps.
    b. Create an NDVI image.
    c. Isocluster the normalized burn ratio and NDVI images.
    d. Use correspondence with the photo-interpreted 1:15,000 scale terrestrial habitat dataset to assign classes to land cover types.

All of the classification steps were performed by IDRISI.

An accuracy assessment of the classified satellite imagery relative to the preliminary photo-interpreted habitat mapping found that the overall classification accuracy was 72% (76% commission; 69% omission). Accuracy rates were likely biased downwards due to several factors. First, imperfect georectification of the two datasets. Second, fires occurred between the dates that the satellite classification and the habitat mapping data were collected (2003 versus circa 2000).

The highest classification accuracy rates were for Recent Burn, Needle Dense and Needle Open (Table 6-9). These three types accounted for the majority of the land cover according to the photo-interpreted terrestrial habitat map (Table 6-10).

The lowest accuracy rates were for the Broadleaf class (34%; Table 6-9) and Tall Shrub & Low Veg class (41%). The majority of the Broadleaf misclassifications were to Needle Dense or Needle Open indicating that the combined accuracy rate for treed land cover types was high (i.e., 93%). Broadleaf land cover accounted for a small proportion of Study Zone 4 (Table 6-10).

For Tall Shrub & Low Veg, over 40% of the commission misclassifications were to Recent Burn. These Recent Burn misclassifications should not be considered complete misclassifications since they were primarily in areas that were previously identified as poorly regenerating burns that were approximately 20 years old. Over one-third of commission and most of the omission misclassifications were to Needle Open, which likely included some areas that were not misclassified in the sense that the vegetation was tree species at the sapling stage after a burn.

Even though the overall accuracy rate was not as high as the generally desired rate of 85% (Foody 2002), further refinement was not pursued because a comparison of the land cover composition of Study Zone 4 derived from the habitat mapping and the satellite classification yielded similar results (Table 6-10). The percentages of Needle Open, the most common land cover type, were identical in the two map datasets. The satellite classification over-represented the amount of Broadleaf and Needle Dense while under representing the amount of recent burn because fires occurred between the dates that the satellite classification and the habitat mapping data were collected (2003 versus circa 2000). Fires tend to burn higher proportions of upland than lowland areas which is where the overrepresented types were found.

Table 6-9: Commission and omission percentage accuracy rates for classified satellite imagery using the habitat mapping as the ground data

	Broadleaf	Needle Dense	Needle Open	Tall Shrub & Low Veg	Recent Burn	Human	Water	All
Commission Accuracy								
Broadleaf	56	29	10	4	0		1	100
Needle Dense	5	83	10	1	1		1	100
Needle Open	1	12	82	3	2		0	100
Tall Shrub/ & Low Veg	1	0	34	21	42	0	1	100
Recent Burn	0	0	5	3	91		0	100
Human						100		100
Water		0	0	1	0	0	98	100
All	2	16	47	5	20	2	8	100
Omission Accuracy								
Broadleaf	13	1	0	0	0		0	0
Needle Dense	38	64	3	1	0		1	13
Needle Open	40	34	84	25	4		0	48
Tall Shrub & Low Veg	9	0	12	63	34	0	2	16
Recent Burn	1	0	1	8	61		0	13
Human						99		2
Water		0	0	2	0	0	96	8
All	100	100	100	100	100	100	100	100

The land cover composition of Study Zones 4 and 5 from the classified satellite imagery were similar (Table 6-11). The Regional Study Area (Study Zone 5) had higher percentages of Broadleaf and Burn which were offset by a lower percentage of Needle Open.

The higher percentage of Broadleaf in the Regional Study Area was supported by Soil Landscapes of Canada (SLC; Agriculture and Agri-Food Canada 1996) mapping which indicated that mineral soils (Table 6-12, Table 6-13) and mineral surface deposits (Table 6-14) were more prevalent than organic materials in the Regional Study Area. This suggested that habitat types confined to or predominantly occurring on mineral soil should be more abundant in the Regional Study Area than in Study Zone 4. It should be noted that results based on SLC should be treated as approximations because the SLC polygons are very large and are mapped as complexes of different classes and because the study area boundaries did not fully coincide with the SLC polygon boundaries (especially for Study Zone 4).

Table 6-10: Land cover in the habitat mapping and classified satellite imagery

Land Cover	Area		
	Percentage of Land Area		ha
	Habitat Mapping	Classified Satellite Imagery	
Broadleaf	0.5	2.2	743
Needle Dense	15.8	20.2	25,633
Needle Open	59.2	59.2	96,103
Tall Shrub & Low Veg	6.2	5.6	10,049
Recent Burn	16.8	11.4	27,240
Human	1.5	1.3	2,481
All	100	100	162,250

Table 6-11: Land cover composition (percentage of total land area) of Study Zones 4 and 5, based on classified satellite imagery

Land Cover	Study Zone 4	Regional Study Area
Broadleaf	2	7
Needle Dense	20	19
Needle Open	59	51
Tall Shrub & Low Veg	6	8
Recent Burn	11	15
Human	1	0
All	100	100
Area (ha)	*152,798*	*991,895*

Table 6-12: Soil great group composition (percentage of total land area) of Study Zone 4 and Regional Study Area, based on Soil Landscapes of Canada

Development	Study Zone 4	Regional Study Area
Eutric Brunisolic	1	13
Gray Luvisolic	32	30
Organic Cryosolic	67	57
All	100	100

Table 6-13: Surface material composition (percentage of total land area) of Study Zones 4 and Regional Study Area, based on Soil Landscapes of Canada

Surface Material	Study Zone 4	Regional Study Area
Bedrock outcrop	0	0
Mineral soil	33	43
Organic soil	67	57
All	100	100

Table 6-14: Parent material mode of deposition composition (percentage of total land area) of Study Zones 4 and Regional Study Area, based on Soil Landscapes of Canada

Deposition Mode	Study Zone 4	Regional Study Area
Lacustrine	32	30
Morainal	1	7
Fluvioglacial	0	6
Mesic woody forest	67	57
All	100	100

6.2.2.2.5 Extrapolating Data From Study Zone 4 to The Regional Study Area

The terrestrial habitat composition of the Regional Study Area was estimated by extrapolating the detailed habitat mapping completed for Study Zone 4 using the proportions of each terrestrial habitat type in Study Zone 4. This approach was taken because the coarse land cover mapping derived from classified satellite imagery and the SLC map indicated that the land cover composition of these two areas was similar. When interpreting results based on this extrapolation, it should be kept in mind that mineral ecosites and mineral habitat types are expected to be more abundant in portions of The Regional Study Area that are outside of Study Zone 4.

6.2.2.3 Shoreline Wetlands

Shoreline wetlands were incorporated as polygons into the 1:15,000 terrestrial habitat mapping for Study Zone 4. Additional polygon attributes were added to the terrestrial habitat dataset to support the analysis of wetland relationships. Off-system water polygons were classified into one of three waterbody types:

- waterbodies (lakes and ponds),
- waterways (open rivers and streams), and
- pools (small, open pools in a wetland or runnel).

Waterbody type was determined from black and white stereo air photos, digital orthographic imagery (DOI) and digital elevation models (DEM). The scale and vintage of stereo photography varied by area. Current conditions for most of Study Zone 4 were interpreted from 1:15,000 photos taken on July 8, 2003. Photos for the balance of the area were as follows: 1:16,500 stereo photos taken in 1991 were used for the western extent of the area; 1:15,000 stereo photos taken in 2006 were used for areas immediately surrounding Stephens Lake; 1:20,000 stereo photos taken in 1999 were used for the southwest extent; 1:20,000 stereo photos taken in 2003 were used for the area south of Butnau Road; and 1:16,500 stereo photos taken in 1991 were used for areas south of Stephens Lake.

Waterbodies were further classified as to isolation and outflow presence. An isolated waterbody lacked inflow from one or more lakes via continuous open water channel, floating peatlands, or a combination of the two. Waterbody outflow was present if there was outflow to one or more other lakes via continuous open water channel, floating peatlands, or a combination of the two. Direction of surface water flow was determined using stereo-photography and DEMs.

The wetland polygon mapping incorporated in the 1:15,000 terrestrial habitat mapping was supplemented with more detailed shoreline wetland mapping for the Nelson River shoreline and selected off-system waterbodies. The selected off-system waterbodies were all of those within the proposed reservoir area as well as a sample of waterbodies elsewhere in the Keeyask portion of the LNR region. The more detailed wetland mapping was represented as segmented shorelines (i.e., segmented polylines in a GIS).

The first level of more detailed wetland mapping was created from oblique helicopter photography obtained during the summers of 2001 to 2011. This method captured more detail than the stereo photo interpretation, such as tree species composition and emergent vegetation cover. However, this mapping was only available for a small subset of the total shoreline length in the study area. This photography was also used to validate the stereo photo-interpretation.

The most detailed shoreline wetland mapping was completed for the subset of the off-system waterbodies where shoreline habitat data was collected along ground transects. This mapping was completed during boat-based shoreline surveys conducted in lakes and waterways (51 km of shoreline). Boat surveys provided another source of validation data for the stereo photo and oblique helicopter photo interpretations.

6.2.2.3.1 Nelson River Shoreline Detail

Nelson River shoreline wetlands were mapped from Clark Lake outlet to Stephens Lake inlet.

The first step in the shoreline wetland mapping was producing the terrestrial habitat shoreline, which was defined as the visible historical extent of water and ice regime effects. The 2006 Nelson River terrestrial habitat shoreline location was initially photo-interpreted from 1:15,000 stereo air photos taken on July 8, 2003 using a mirror stereoscope. An Abrams stereoscope was used in locations where higher magnification was needed. Changes in shoreline location that occurred between 2003 and 2006 were identified from 1:15,000 stereo air photos acquired in 2006. The photo-interpreted shoreline location was heads-up digitized from the traced photos onto digital ortho-images (DOIs) provided by Manitoba Hydro (created from 1999 stereo photography at a pixel size of 2 m).

The Nelson River terrestrial habitat shoreline generally coincided with the top of the bank in mineral soil segments with simple banks and no ice scouring. Delineating a shoreline location was more complex in riparian peatlands and shoreline segments with terraced mineral banks. When interpreting the shoreline location, terraces that appeared to be the result of post-glacial processes rather than more recent water and ice regime effects were ignored. For riparian peatlands, the approximate extent of water in the peat at the 99th percentile water elevation was photo-interpreted. Oblique helicopter-based photos obtained during summer 2005 when water levels were above the 99th percentile and 1:15,000 black and white stereo photos taken on August 22, 2006 were used to validate the 2003 shoreline location in riparian peatlands.

The Nelson River terrestrial habitat shoreline was segmented where changes in one or more of the following attributes occurred: wetland type, beach material type, bank material type, beach slope and bank height. The minimum shore segment length was 100 m. These attributes were generally mapped on a paper map of the shoreline while flying in a helicopter and then verified in the office using oblique still photos taken from a helicopter. The primary exception was the reach upstream of Birthday Rapids which was added in 2005. Extremely high water levels from 2005 to 2010 (Manitoba Hydro/WRE 2009) obscured the beach and most of the bank. Shoreline classification in this reach was based on photos and video acquired prior to 2005. The quality and completeness of these data were much lower than for the rest of the Gull Lake Study Area. Additional field data were collected during the summers of 2010 and 2011 to document the effects of very high flows and water levels that began in 2005.

The Nelson River classified shoreline map evolved over several years. During the first year of mapping (2002), the bank and the upper portion of the beach were exposed. Water levels dropped to the 1st percentile in 2003 exposing wide beaches along much of the shoreline. In 2005, water elevations were above the 99th percentile leaving only the upper portions of high banks exposed. This provided an excellent means to validate the mapped shoreline location in segments not subject to ice scouring.

Table 6-15 provides the classification used for beach and bank material types. In the bank material classification, heterogeneous material refers to material that was a heterogeneous mixture of size classes. A “prefix class” with heterogeneous indicates that one size class was dominant. For example, “Sand with Heterogeneous material” would be material where sand was dominant but had material from multiple size classes mixed in.

Table 6-15: Beach and bank material types

Material Type	Material Type
Bedrock	Fine textured with Boulders
Boulders	Fine textured with Cobbles
Cobbles	Fine textured with Gravel
Gravel	Fine textured with Heterogeneous material
Boulder till	Fine textured
Sand with Rock	Peat with Cobbles with Boulders
Sand with Cobbles	Peat with Cobbles
Sand	Peat with Rock
Sand with Heterogeneous material	Peat
Heterogeneous material	Unknown
Fine textured with Rock	

Bank height was typed into one of five classes (Table 6-16). Bank height was the vertical height from toe to top of bank.

Ecosite type of adjacent upland or peatland area was added to each segment from the terrestrial habitat map for Study Zone 4.

Table 6-16: Bank height classes

Class	Height Range
No bank	0 cm
Low	< ~ 1 m
Mixture of low and medium	See low and medium
Medium	~1 to ~3 cm
High	> ~ 3 cm
Unknown	N/A

The presence of a shoreline tall shrub band was also mapped during the helicopter-based aerial surveys. Wide tall shrub bands were identified from the 1:15,000 stereo photography and oblique helicopter photos. The tall shrub band types are provided in Table 6-17.

Table 6-17: Tall shrub band types

Code	Description	Criteria
1	None	
2	Present	Continuous but less than 10 m wide
3	Wide	Continuous and at least 10 m wide
4	Wide with graminoids	
5	Scattered patches along the shore segment	
9	Unknown	

6.2.2.3.2 Off-System Shoreline Detail

Shoreline Location

For the more detailed polyline mapping of shoreline wetlands in off-system waterbodies, the water surface edge was used to approximate the terrestrial habitat shoreline location because the shoreline position was often difficult to locate in air photos. The large peatlands in the flat terrain that often bordered off-system water bodies showed little evidence of where the high water mark occurred. As well, off-system waterbodies usually did not have visible water and ice regime effects, likely because most were too small for wave energy effects and water levels were thought to be considerably less variable than on the Nelson River.

The water surface area shorelines for off-system waterbodies were created by selecting the water polygons in the 1:15,000 terrestrial habitat dataset and then converting the polygons to polylines. Since this action was performed on a preliminary version of the terrestrial habitat dataset, there were places where the polyline and final terrestrial habitat polygon shoreline locations did not coincide.

Oblique Photo-Based Shoreline Mapping

The shoreline was segmented and classified using oblique aerial photos acquired from a helicopter flying at a low altitude. The helicopter flew over the water around the lake shoreline.

Off-system shorelines were segmented where there were changes in wetland type. Vegetation at the shoreline was used to classify the wetland type. In some situations a sub-dominant wetland type was identified. This was done where there were discontinuous mixtures of wetland types at the shoreline that could not be separated at the minimum segment length (e.g. a mixture of marshes and fens), or if there was a second wetland type behind the shoreline wetland that was not captured by the terrestrial ecosite classification. Additionally, for each marsh shoreline segment, the four species with the highest percent cover in the photos were identified in descending order (e.g. Veg1, Veg 2, Veg 3, Veg 4).

Boat-Based Shoreline Mapping

Boat-based shoreline wetland mapping was conducted by cruising along the entire lake or river shoreline and around emergent vegetation islands. The mapping protocol differs slightly for the mainland shoreline and emergent vegetation islands.

Mainland shoreline mapping was completed while cruising at a distance of approximately 5 m from the shoreline wherever possible. Shoreline wetland information that was recorded included vegetation (willow, emergent and floating-leaved), water depth and submerged substrate. The start and stop locations of wetland plant species were recorded on a map of the shoreline. Willow species along the shoreline were recorded if they were at least 25% of vegetation cover, and were given a density class (Table 6-18). Patches of emergent and/or floating-leaved vegetation adjacent to the shoreline were recorded if foliage cover was at least 10%. A patch was considered emergent if the vegetation was not growing on a floating peat island and was rooted in the lake substrate. Plant species were recorded to the species level whenever possible; otherwise the plants were identified to genus (see Table 6-19). If successive bands of vegetation occurred along the shoreline, these were identified on the map. If any known rare or any unusual unknown species were encountered, their presence and abundance was recorded regardless of percent cover and a picture was taken if possible.

Table 6-18: Willow density classes used in off-system shore zone mapping

Class	Description
Dense	A continuous band of vegetation of the noted type.
Sparse	A non-continuous band of vegetation either concentrated in clumps of close proximity and/or dispersed throughout the segment.

Table 6-19: Common wetland plant species encountered during off-system shore zone

Species Code	Scientific Name	Common name
ef,equisetfluv,Equifluv, Equisfluv	*Equisetum fluviatile*	Water horsetail
ep, eleopal	*Eleocharis palustris*	Creeping spike-rush
cxa,cxaqua	*Carex aquatilis*	Water sedge
cxu, cxutric	*Carex utriculata*	Bottle sedge
nv,nupharv	*Nuphar variegata*	Yellow pond-lily
spw	*Glyceria borealis*	Northern manna grass
sparg	*Sparganium* spp	Bur-reed species
sa	*Sparganium angustifolium*	Narrow-leaved bur-reed
potg, potgram, potgr	*Potamogeton gramineus*	Various-leaved pondweed
cxpelit,cxp	*Carex pellita*	Wooly sedge
utricvulag, utricvulgar	*Utricularia macrorhiza*	Common bladderwort
alnrug	*Alnus incana* ssp. *rugosa*	Speckled alder
myrica, myricag	*Myrica gale*	Sweet gale
sc, sagcun	*Sagittaria cuneata*	Arum-leaved arrowhead
pv	*Potamogeton vaginatus*	Sheathed pondweed
ta	*Typha angustifolia*	Narrow-leaved cat-tail
sv	*Schoenoplectus tabernaemontani*	Viscid great-bulrush
pr, potemrich	*Potamogeton richardsonii*	Clasping-leaved pondweed
betpap	*Betula papyrifera*	White birch
utricint	*Utricularia intermedia*	Flat-leaved bladderwort
sxb, sxbe, sxbeb	*Salix bebbiana*	Bebb's willow
sxpl,sxplan	*Salix planifolia*	Flat-leaved willow
betpum	*Betula pumila*	Swamp birch
sxpel, sxpelit, sxpe	*Salix pellita*	Satin willow
sxped	*Salix pedicellaris*	Bog willow
sxpseudo	*Salix pseudomonticola*	False mountain willow

Species Code	Scientific Name	Common name
sxa	*Salix arbusculoides*	Shrubby willow
sxm-cord	*Salix pseudomyrsinites*	Myrtle-leaved willow
hip	*Hippuris vulgaris*	Mare's-tail

Notes: Plant nomenclature followed Flora of North America where volumes currently exist for the genus and the Manitoba Conservation Data Centre elsewhere.

Water depth was recorded at the start of the mapping transect, and measured at intervals of approximately 20 m, and changes were indicated. Depth was recorded in 50 cm depth classes up to a depth of 2 metres (Table 6-20). The most abundant submerged substrate types (Table 6-21) were recorded for minimum distances of approximately 50 metres. Substrate types were recorded in order of relative abundance if they comprised at least 10% of the substrate within the minimum distance mapped.

Table 6-20: Water depth classes used in off-system shore zone mapping

Code	Depth Class (m)
0	< 0.5
1	0.5 to 1.0
2	1.0 to 1.5
3	1.5 to 2.0
4	> 2.0

Emergent vegetation islands were large patches of emergent wetland vegetation occurring in "islands" that were not adjacent to the shoreline. Emergent island mapping methods were somewhat different than that for the shoreline. Mapping was conducted from a boat travelling close along the edge of the emergent vegetation island. Additionally, due to the size and nature of emergent islands, information was recorded at a higher resolution for that protocol.

Plant species, water depth and submerged substrate were recorded. Plant species within the island were recorded if they comprised at least 25% cover. Additionally, satellite patches of vegetation (patches near, but not connected to the main island) were recorded if they had at least 10% foliage cover. Rare, or unusual unknown species were treated in the same way as in the shoreline mapping.

Water depth around the emergent island was recorded to the nearest decimetre at the start, and every 5 metres at three positions, including: the edge of the emergent island, 5 metres exterior to the edge, and 2 metres interior to the edge. Substrate type was recorded in the same manner as with shoreline mapping, but were identified for minimum distances of 5 metres.

Table 6-21: Submerged substrate types used in off-system shore zone mapping

Code	Class	Description
TS	Thin sedimentary peat	Thin peat that is not produced in-situ. Deposited by wave/wind action, erosion or slumping into water.
DS	Deep sedimentary peat	Deep peat that is not produced in-situ. Deposited by wave/wind action, erosion or slumping into water.
S	Sand	
C	Clay	
TO	Thin organic in place	Thin peat that is produced in-situ. Deposited in place by growth.
DO	Deep organic in place	Deep peat that is produced in-situ. Deposited in place by growth.
G	Gravel	
R	Cobble and stone	Cobbles or stones.

6.2.3 Fire Regime

Intermediate scale fire history data were developed for the LNR region. The year of origin attribute in the large scale mapping for Study Zone 4 identified recent burns for those areas. Recent fire history outside of Study Zone 4 was mapped using a combination of the Manitoba Conservation individual fire database, the federal Large Fire Database and Landsat 7 composites derived from bands 2, 4 and 7.

A fire history database capturing the 1979 to 2008 period was created for The Regional Study Area from the available information. Like most fire databases developed for remote regions, the Regional Study Area fire history database had two limitations. It was missing substantial portions of older burns because they have been hidden by more recent burns. In addition, areas that the fire skipped over often cannot be distinguished from the surrounding area in older burns. The first limitation underestimates total area burned while the second overestimates total area burned.

The annual burn rate, size class distribution of burns and other fire regime attributes were calculated from the Regional Study Area fire history database. The annual burn rate was the average area burned each year in the Regional Study Area over the 30-year period from 1979 to 2008.

Historical conditions and trends in the Regional Study Area fire regime were inferred from published literature that included this area in its geographic scope.

Additional information used for areas outside of Study Zone 4 included small scale GIS datasets for surface materials, deposition mode, soil order and soil great group. The data sources for these attributes were Soil Landscapes of Canada (Agriculture and Agri-Food Canada 1996) which was at a 1:1,000,000 map scale and Surface Materials of Canada (Fulton 1995) which was at a 1:5,000,000 map scale. These datasets were not consistent with each other in some locations because they were developed at different map scales and because they represented somewhat different attributes.

6.3 RESULTS

6.3.1 Fire Regime

6.3.1.1 Background

There are numerous scientific publications regarding the fire regime and its role in maintaining ecosystem health in the boreal forest of Canada (*e.g.*, Rowe and Scotter 1973; Bonan and Shugart 1989) and Manitoba's boreal shield (Ehnes 1998).

Fire is the keystone ecosystem process in the boreal forest (MacLean et al. 1983; Weber and Flannigan 1997; Burton et al. 2008). Large wildfires are the dominant type of stand-replacing natural disturbance throughout most of the Canadian boreal forest (Payette 1992). Although other disturbances such as windthrow or insect and disease infestations can also affect large areas, wildfire causes complete vegetation mortality over a much larger area. Large wildfires have played and continue to play critical roles in producing the vegetation mosaic that exists in the LNR region and maintaining regional ecosystem health.

A fire regime is the pattern, type, intensity, frequency and seasonality of fires that prevails in an area (Stocks *et al.* 2003). In the boreal forest, fires are generally large crown fires that occur infrequently and cause complete above ground vegetation mortality in the areas that they burn. Due to the conditions which favor them, large fires tend to be moderate to high intensity (*i.e.* "hot") fires that pass through rapidly and thus kill the aboveground but not the belowground parts of trees and understorey vegetation (Heinselman 1981; Rowe 1983; Cogbill 1985; Eberhart and Woodard 1987; Johnson 1992).

Many boreal plant species are adapted to a particular fire regime. Factors that change fire regime parameters (*e.g.*, average annual area burned, average time between large fires) can indirectly change the most abundant species (Weber and Flannigan 1997). For example, increases in fire frequency, severity and/or total area burned could create long-term effects on regional habitat composition and many ecosystem patterns and processes (*e.g.*, ecosystem diversity, species distributions and abundances, carbon storage). Some of the potential changes include:

- A higher percentage of area in young habitat and lower percentages of area in mature and old habitat;
- Increases in the abundances of post-fire pioneer plant species (e.g., Bicknell's geranium (*Geranium bicknellii*), fireweed (*Chamerion angustifolium*) or haircap mosses(*Polytrichum* spp)) and a reduction in the abundances of plant species found in mature to old vegetation (e.g., reindeer lichens); and,
- A higher percentage of area that is regenerating poorly relative to what was typically found there (e.g., the conversion of forests to shrublands and/or grasslands).

Prior to fire suppression, most of the area that burned in the boreal forest burned in a small proportion of years when weather events created conditions that favoured the spread of wildfires over large areas (Cogbill 1985; Johnson 1992; Hunter 1993). Consequently, infrequent large fires accounted for the majority of the area burned in the boreal forest. It has been estimated that 3% of the wildfires were responsible for 98% of the area burned under natural conditions (Weber and Stocks 1998) or that 5 % of the wildfires were responsible for 95 % of the area burned (Straus et al. 1989 cited in Johnson *et al.* 1995).

The fire regime is highly dependent on climate (Weber and Flannigan 1997). There are numerous scientific publications documenting the effects of past climate change and predicting future effects of climate change on the fire regime and ecosystem patterns and processes in the Canadian boreal forest (*e.g.*, Flannigan and Van Wagner 1991; Payette 1992; Bergeron *et al.* 2004; Tarnocai 2009; Gillet *et al.* 2004; Soja *et al.* 2007; Bond-Lamberty *et al.* 2007; Girardin and Mudelsee 2008). Many of these studies have included the LNR region in their geographic extents. The reported trends include higher fire activity in the LNR region.

Humans can alter the fire regime in several ways. Fire suppression has reduced the area burned in the commercial forestry zones and near communities. As well, roads may limit the spread of some fires (Lesieur *et al.* 2002). In contrast, improved access can increase the total area burned and change other fire regime attributes because humans are a major cause of fire ignitions. Fire ignition data for Manitoba indicates that humans started 56% of the forest fires that occurred in the 30 years from 1985 to 2004 (Table 6-22). Unsuppressed human-caused fires accounted for 15% of the total area burned (Table 6-23), which is substantial considering that the total area burned includes very large natural burns in remote areas.

Although there is evidence that humans can alter the fire regime, there is insufficient information to characterize the extent to which this has occurred in the LNR region.

Table 6-22: Number of human caused forest fires in Manitoba from 1985 to 2004

Year	Human		Lightning		Total
	Number	Percent of Total	Number	Percent of Total	Number
1985	211	61%	135	39%	346
1986	144	66%	73	34%	217
1987	314	61%	205	39%	519
1988	382	39%	600	61%	982
1989	513	42%	713	58%	1,226
1990	282	49%	288	51%	570
1991	388	57%	288	43%	676
1992	193	65%	105	35%	298
1993	171	72%	68	28%	239
1994	239	43%	316	57%	555
1995	264	40%	396	60%	660
1996	203	48%	221	52%	424
1997	188	51%	183	49%	371
1998	296	57%	220	43%	516
1999	330	54%	283	46%	613
2000	214	60%	140	40%	354
2001	234	43%	304	57%	538
2002	502	67%	252	33%	754
2003	685	56%	529	44%	1214
2004	110	47%	123	53%	233
Total	5,683	52%	5,442	48%	11,305

Table 6-23: Total area burned in human caused forest fires in Manitoba from 1985 to 2004

Year	Human		Lightning		Total
	Area (ha)	Percent of Total	Area (ha)	Percent of Total	Area (ha)
1985	1,967	17%	9,856	83%	11,823
1986	6,512	63%	3,830	37%	10,342
1987	15,224	9%	154,296	91%	169,520
1988	34,214	7%	451,439	93%	485,653
1989	634,763	18%	2,933,184	82%	3,567,947
1990	5,938	36%	10,427	64%	16,365
1991	23,835	18%	109,856	82%	133,691
1992	103,658	23%	353,796	77%	457,454
1993	3,117	5%	64,158	95%	67,275
1994	8,482	1%	1,420,272	99%	1,428,754
1995	10,532	1%	878,717	99%	889,249
1996	5,718	5%	111,006	95%	116,724
1997	3,656	9%	38,140	91%	41,795
1998	7,392	2%	401,525	98%	408,917
1999	59,442	51%	56,101	49%	115,543
2000	21,012	19%	89,912	81%	110,924
2001	4,972	6%	73,942	94%	78,914
2002	16,599	18%	77,964	82%	94,563
2003	89,859	10%	828,986	90%	918,845
2004	937	4%	25,066	96%	26,003
Total	1,057,829	12%	8,092,473	88%	9,150,301

6.3.1.2 Fire Regime Study Area

Available fire history data indicated that fires burned approximately 1,045,000 ha in the Keeyask Fire Regime Study Area (Map 6-2) between 1979 and 2008 (Table 6-24). Keeping in mind the limitations of these data described above (Section 6.2.3), the annual burn rate is roughly estimated to be nearly 35,000 ha/year, or 1.3% of the Fire Regime Study Area (Table 6-24). Using this burn rate, the recent fire cycle is roughly estimated to be nearly 78 years (note that some burned area for older burns is hidden by overlapping recent burns and a longer period is required to reliably estimate fire cycle length).

Approximately 39% (1,045,059 ha) of the Fire Regime Study Area and 34% (425,879 ha) of the Regional Study Area burned at least once between 1979 and 2008, with some locations burning more than once during this period. The years that had the largest area burned, in descending order, were 1989, 1992, 2003, 1998, 1994, 1981, 1995 and 2005 (Table 6-25).

Only 4% of the fires accounted for 58% of the area burned in the Fire Regime Study Area (Table 6-26). The latter percentage was much lower than the boreal forest historical value of approximately 98%, possibly due to the described data limitations and human intervention, among other reasons.

Large burns were distributed throughout the Fire Regime Study Area (Map 6-2). The most recent burns were near the Nelson River, encompassing a large proportion of the Keeyask Local Study Area (Study Zone 2). Most of the proposed reservoir area south of the Nelson River in the Gull Lake reach burned in 2005. The eastern portion of the north esker burned in 1999 and 2001 and the eastern portion of Caribou Island burned in 2003.

Much of the Fire Regime Study Area consists of young regenerating habitat. As of 2010, approximately 9% of the Fire Regime Study Area was less than 11 years old and 39% was 30 years old or younger.

Table 6-24: Area burned and annual burn rate for the 1979 to 2008 period in the Keeyask Study Areas

Study Area	Land Area (ha)	Area Burned (ha)	Annual Rate	
			Area (ha)	% of Area
Fire Regime Study Area (Study Zone 6)	2,700,000	1,045,059	34,835	1.29
Regional Study Area (Study Zone 5)	1,240,000	425,879	n/a	n/a
Study Zone 4	167,255	42,088	n/a	n/a
Local Study Area (Study Zone 2)	13,043	4,058	n/a	n/a

Table 6-25: Annual percentage of total area burned between 1979 and 2008 by most recent fire in the Keeyask study areas

Burn Year	Burn Age (years old)	Fire Regime Study Area (%)	Regional Study Area (%)	Local Study Area (%)	*Area Burned (ha) in Fire Regime Area*
2008	1	0	0	0	*0*
2007	2	0.1	0.0	-	*626*
2006	3	0.9	0.0	0.0	*9,415*
2005	4	7.7	9.2	32.2	*80,348*
2004	5	0.0	0.0	-	*80*
2003	6	8.0	8.8	1.6	*83,889*
2002	7	1.0	2.2	0.0	*10,452*
2001	8	1.0	0.4	1.7	*10,396*
2000	9	0.9	0.0	0.0	*9,286*
1999	10	3.0	2.0	20.2	*30,886*
1998	11	10.4	5.2	0.2	*108,637*
1997	12	0.0	0.0	0.0	*282*
1996	13	4.0	1.9	0.2	*42,121*
1995	14	8.7	16.4	13.2	*91,341*
1994	15	9.0	5.7	0.3	*93,824*
1993	16	0.0	0.0	0.1	*64*
1992	17	13.8	12.8	2.5	*143,779*
1991	18	0.4	0.0	-	*4,050*
1990	19	0.8	2.0	-	*8,444*
1989	20	17.3	19.8	8.1	*180,755*
1988	21	0.3	0.4	-	*3,187*
1987	22	0.1	0.1	0.0	*532*
1986	23	0.1	0.0	-	*757*
1985	24	0.2	0.3	0.0	*2,093*
1984	25	1.8	4.5	3.5	*19,125*
1983	26	0.0	0.0	0.0	*5*
1982	27	0.2	0.6	-	*2,510*
1981	28	8.7	3.8	16.0	*91,440*
1980	29	1.6	3.9	0.3	*16,727*
1979	30	0.0	0.0	0.0	*8*
All	All	100.0	100.0	100.0	*1,045,059*
Total Area (ha)		*1,045,059*	*425,879*	*42,088*	

Notes: Percentages that round to zero are shown as "0.0" while absences are shown as "-".

Table 6-26: Burned area attributes by size class in the Fire Regime Study Area

Size Class (ha)	Number of Burns	Total Area Burned (ha)	Percentage Of Total Number of Burns	Percentage Of Total Area of Burns
1-100	550	4,454	75	0
101-1,000	90	34,221	12	3
1,001-10,000	65	264,973	9	25
10,001-100,000	28	741,411	4	71
All sizes	733	1,045,059	100	100

6.3.2 Study Zone 4

6.3.2.1 Terrestrial Areas

Land accounted for 76% of Study Zone 4 in 2010 (Table 6-27). The Nelson River comprised 47,655 ha of the 54,254 ha of water area with the remaining area distributed amongst waterways and waterbodies (185 waterbodies were larger than five ha).

Land accounted for 70% of the Local Study Area total area in 2010 (Table 6-27). The Nelson River comprised 5,143 ha of the 5,418 ha of water area with the remaining area distributed amongst waterways, ponds and 19 waterbodies larger than five ha.

Table 6-27: Total land and water areas (ha) in the study zones

Study Zone[1]	Total Area (ha)	Land Area[2]	Water Area[2]
Study Zone 6 (Fire Regime Study Area)	3,050,000	2,700,000 (*89*)	350,000 (*11*)
Study Zone 5 (Regional Study Area)	1,420,000	1,240,000 (*87*)	180,000 (*13*)
Study Zone 4	221,509	167,255 (*76*)	54,254 (*24*)
Study Zone 3	41,966	33,339 (*79*)	8,627 (*21*)
Study Zone 2 (Local Study Area)	18,689	13,043 (*70*)	5,646 (*30*)
Study Zone 1	13,010	7,592 (*58*)	5,418 (*42*)

Notes: 1 Each Study Zone includes all of the study zones nested within it.
2 Areas for Study Zones 5 and 6 are rounded to the nearest 10,000 ha. Numbers in brackets are the percentage of total area.

6.3.2.2 Inlands

6.3.2.2.1 Current Conditions

Ecosite composition was described in Section 5.4.3.

Topography

Slopes and horizontal topography comprised most of the land area of Study Zone 4, comprising approximately 42% and 35% of the area, respectively (Table 6-28). Ridges and crests (11%), depressions (6%) and runnels (4%) accounted for most of the remaining area.

Table 6-28: Topography in Study Zone 4 and the Local Study Area as a percentage of total land area

Topography	Study Zone 4	Local Study Area
Ridge/ Crest	11.1	18.8
Slope	42.1	45.8
Horizontal	34.9	27.2
Horizontal- raised	1.0	2.1
Dissected	0.4	-
Hummocky	0.1	-
Depression	6.2	3.6
Basin (pit/ hole)	0.0	0.0
Runnel	3.8	2.5
Ravine	0.2	-
Bank	0.1	-
Total land area (ha)	*167,255*	*13,043*

Notes: Reported areas are land area only. Percentages that round to zero are shown as "0.0" while absences are shown as "-".

Sloping topography was distributed in a network throughout Study Zone 4, as this topography type occurred as a transition between the other topography types at different elevation levels (Map 5-4). Runnels were also distributed throughout the area, generally running from high to low elevation points within the sloping topography. Horizontal topography was distributed throughout the area, but was most extensive north and south of the Nelson River between Clark and Stephens Lakes, and to the south and east of Stephens Lake. This also generally coincided with the distribution of depressions, which often occurred adjacent to and within horizontal areas. Ridges and crests were concentrated near the banks of the Nelson River, along the esker north of Gull Lake and on the north side and southeast corner of Stephens Lake, and to the north and south of Split Lake (Map 5-4).

The topographic form composition of the Local Study Area and Study Zone 4 were similar. There was a higher proportion of rides and crests (19%), and a lower proportion of horizontal and depression topography, largely due to the increased influence of the Nelson River banks and esker (Table 6-28; Map 5-4).

Vegetation Structure

Approximately 98% of the land area in Study Zone 4 was vegetated. More than half of the land area in Study Zone 4 had either woodland, or a mixture of woodland and sparsely treed vegetation structure types (33% and 18%, respectively; Table 6-29). The other common vegetation structure types were forest and low vegetation (15% each), and sparsely treed (11%).

Tall shrub structural types were uncommon, at under 2% of the land area, but this type also occurred in combination with other treed and untreed structural types, increasing the estimated tall shrub cover to nearly 4% (Table 6-29). It should be noted that due to the limitations of photointerpretation, as canopy percent cover increased it became more likely that tall shrub cover was obscured. As a result, total tall shrub cover was likely to be underestimated in Table 6-29. Analysis of plot data suggested that tall shrub cover was high in many different treed habitat types (see Section 7.3.2.2).

The emergent and tall shrub/ low vegetation mixture structure types were the least common, covering less than 1% of the land area combined.

Just over 2% of the land area was classified as regenerating recent burns. These included recently burned areas (post-1993) that could not be classified into a structural type, usually because there was insufficient photo coverage. Regenerating recent burns usually were comprised of a mixture of treed, tall shrub and low vegetation structure types with scattered small patches of unburned vegetation.

The distribution of vegetation structure types in the Local Study Area was similar to that of Study Zone 4 (Table 6-29). There was a slightly higher proportion of forest structure and tall shrub in the Local Study Area, and somewhat less woodland and sparsely treed mixture. The overall proportion of vegetated land area was slightly less (94%) due to human infrastructure along the esker (Map 6-4).

Forest structure occurred most often on mineral and thin peatland ecosites (35% and 31% of forest area, respectively), and often on shallow peatland as well (Table 6-30). Woodland and sparsely treed structures, and mixtures of the two, were most common on thin peatland, shallow peatland and ground ice peatland (Table 6-30). Tall shrub structure usually occurred on riparian peatland (34%), regulated shoreline wetland (25%) and shallow peatland (16%). Tall shrub/ low vegetation mixtures and emergent vegetation structure types were primarily associated with the shoreline wetland ecosites. Subsequently, the distribution of these structure types largely corresponded to the distribution of their associated ecosites (Map 6-4 and Map 6-5).

In contrast, low vegetation was distributed more evenly, predominantly on thin, shallow and ground ice peatlands, and also on deep and riparian peatlands (Table 6-30). Low vegetation structure was often associated with recently burned areas, and older burns that were regenerating slowly. As a result, this distribution partially reflected the fire history and age structure of Study Zone 4 (see Map 6-2).

Table 6-29: Vegetation structure types in the sub-regional (Study Zone 4) and local study areas as a percentage of total land area

Vegetation Structure Type	Study Zone 4	Local Study Area
Forest	15.4	19.7
Forest/ Tall Shrub	0.1	0.0
Woodland	32.7	29.7
Woodland/ Tall Shrub	1.1	1.6
Sparsely Treed	10.5	11.8
Sparsely Treed/ Tall Shrub	0.6	1.1
Woodland & Sparsely Treed Mixture	18.2	12.1
Woodland & Sparsely Treed Mixture/ Tall Shrub	0.0	0.0
Tall Shrub	1.6	3.3
Low Vegetation	14.8	12.5
Tall Shrub/ Low Vegetation Mixture	0.3	1.9
Emergent Vegetation	0.1	0.2
Regenerating Recent Burn	2.4	0.0
Human	2.0	6.1
Total land area (ha)	*167,255*	*13,043*

Table 6-30: Vegetation structure type distribution across coarse ecosite types in Study Zone 4 as a percentage of total area in structure type

Vegetation Structure Type	Mineral	Thin peatland	Shallow peatland	Ground ice peatland	Permafrost peatland-other	Deep peatland	Wet deep peatland	Riparian Peatland	Ice Scoured Upland	Shoreline Wetland	Shoreline Wetland-regulated	*Total area (ha)*
Forest	35.2	31.2	21.5	9.1	0.2	2.1	0.0	0.7	-	-	-	*25,692*
Forest/ Tall Shrub	56.1	6.1	26.8	2.1	1.0	5.8	-	2.1	-	-	-	*89*
Woodland	10.4	49.3	22.1	15.3	0.2	2.1	-	0.6	-	-	-	*54,754*
Woodland/ Tall Shrub	52.0	35.3	10.7	0.6	-	0.7	-	0.7	-	-	-	*1,894*
Sparsely Treed	4.2	35.8	28.6	18.4	0.2	10.7	0.1	2.1	-	-	-	*17,604*
Sparsely Treed/ Tall Shrub	14.1	51.0	18.2	5.3	0.1	4.8	-	6.5	-	-	-	*964*
Woodland & Sparsely Treed Mixture	2.1	38.5	36.7	18.0	0.4	3.7	-	0.5	-	-	-	*30,463*
Woodland & Sparsely Treed Mixture/ Tall Shrub	-	10.8	45.2	4.9	-	36.7	-	2.3	-	-	-	*65*
Tall Shrub	2.4	9.6	16.3	5.1	0.1	8.0	-	33.7	-	-	24.8	*2,625*
Low Vegetation	2.6	27.6	21.6	24.6	1.1	9.2	0.0	12.2	-	-	1.0	*24,687*
Tall Shrub/ Low Vegetation Mixture	-	-	-	-	-	-	-	15.5	21.2	-	63.4	*577*
Emergent Vegetation	-	-	-	-	-	-	-	-	-	92.6	7.4	*209*
Regenerating Recent Burn	5.4	59.1	18.3	15.7	0.0	1.1	-	0.4	-	-	-	*4,075*

Notes: Percentages that round to zero are shown as "0.0" while absences are shown as "-".

Habitat Composition

Land Cover

Land cover in Study Zone 4 was dominated by open to dense needleleaf treed vegetation on uplands and inland peatlands (Table 6-31; Map 6-6). The needleleaf treed vegetation on mineral or thin peatlands and on other peatlands land cover types accounted for 43% and 36% of the land area, respectively (Table 6-31). Broadleaf treed on all ecosites cover comprised 1% of the land area. The distribution of needleleaf treed cover corresponds to the distribution of their coarse ecosite associations (Map 5-3). Broadleaf treed cover was primarily on mineral or thin peatland ecosite types, with more extensive cover adjacent to the north side of Gull Lake, and to the north of that in the areas corresponding to the 1999 and 2001 fires.

Table 6-31: Land cover composition of the study areas, as a percentage of land area

Land Cover Type	Study Zone 4	Local Study Area
Mineral and Thin Peatland Land Types		
Broadleaf Treed on All Ecosites	1.1	2.6
Needleleaf Treed on Mineral or Thin Peatland	43.2	47.3
Tall Shrub on Mineral or Thin Peatland	0.2	0.6
Low Vegetation on Mineral or Thin Peatland	4.5	3.6
Other Peatlands Land Type		
Needleleaf Treed on Other Peatlands	36.5	26.1
Shrub/Low Vegetation on Riparian Peatland	2.4	3.5
Tall Shrub on Other Peatlands	0.5	0.5
Low Vegetation on Other Peatlands	8.4	6.6
Shore Zone Land Types		
Nelson River Shore Zone	0.8	3.1
Off-system Shore Zone	0.1	0.1
Other Land Types		
Human Infrastructure	2.0	6.1
Unclassified	0.5	0.0
All	100.0	100.0
Total Land Area (ha)	*167,255*	*13,043*

Notes: Cells with 0 values are values that round to 0, while "-" cells indicate a value of 0. Reported areas are land area only.

Tall shrub on mineral or thin peatland, and tall shrub on other peatlands were relatively rare, comprising less than 1% of the land cover (Table 6-31). Low vegetation on mineral or thin peatland and low vegetation on other peatlands were more common, covering 4% and 8% of the land area, respectively. These tall shrub and low vegetation land cover types often corresponded with regenerating, recently burned areas (Map 6-7 and Map 6-2).

Shrub and low vegetation on riparian peatland made up over 2% of the land area. Nelson River and off-system shore zone vegetation cover made up nearly 1% of the land area combined, with most of that comprised of the former. Shore zone vegetation cover included mappable vegetation, usually emergent wetland species, within the fluctuating water zone of shorelines. These riparian peatland and shore zone cover types were distributed throughout Study Zone 4 along the shorelines of waterbodies and waterways (Map 6-7).

Human infrastructure accounted for 2% of the land area. Approximately 0.5% of the land area was not classified to a land cover or habitat type because there was insufficient information to classify vegetation type.

Land cover in the Local Study Area was similar to that of Study Zone 4, but there were slightly higher proportions of broadleaf treed on all ecosites, needleleaf treed on mineral or thin peatland, Nelson River shore zone and human infrastructure (Table 6-31). These increases, except for the last one, were largely due to the increased influence of the Nelson River and its banks in the Local Study Area.

Coarse and Broad Habitat

Land cover was subdivided into 30 coarse habitat types, which in turn were subdivided into 64 broad habitat types, not including human infrastructure. Coarse and broad habitat results are presented in detail in this section. A detailed list of broad habitat types, and their abundance, is provided in Table 6-32. A detailed list of coarse habitat types, and their abundance, is provided in Table 6-33.

Table 6-32: Broad habitat composition of the sub-regional (Study Zone 4) and local study areas, as a percentage of total land area

Coarse Habitat Type	Broad Habitat Type	Study Zone 4	Local Study Area
Broadleaf treed on all ecosites	Balsam poplar dominant on all ecosites	0.0	0.0
	Trembling aspen dominant on all ecosites	0.5	1.2
	White birch dominant on all ecosites	0.0	0.2
Broadleaf mixedwood on all ecosites	Balsam poplar mixedwood on all ecosites	0.0	-
	Trembling aspen mixedwood on all ecosites	0.4	0.9
	White birch mixedwood on all ecosites	0.0	0.3
Black spruce mixedwood on mineral or thin peatland	Black spruce mixedwood on mineral	0.2	0.2
	Black spruce mixedwood on thin peatland	0.1	0.0
Jack pine mixedwood on mineral or thin peatland	Jack pine mixedwood on mineral	0.2	0.3
	Jack pine mixedwood on thin peatland	0.1	0.3
Jack pine treed on mineral or thin peatland	Jack pine dominant on mineral	1.2	1.3
	Jack pine dominant on thin peatland	0.1	0.3
	Jack pine mixture on thin peatland	0.4	1.3
	Tamarack dominant on mineral	0.0	0.0
	Tamarack mixture on mineral	0.1	0.3
Black spruce treed on mineral soil	Black spruce dominant on mineral	7.5	8.5
	Black spruce mixture on mineral	0.7	3.5
Black spruce treed on thin peatland	Black spruce dominant on thin peatland	31.7	28.7
	Black spruce mixture on thin peatland	0.6	1.9
	Tamarack dominant on thin peatland	0.0	0.0
	Tamarack mixture on thin peatland	0.2	0.7
Tall shrub on mineral or thin peatland	Tall shrub on mineral	0.0	0.1
	Tall shrub on thin peatland	0.2	0.4
Low vegetation on mineral or thin peatland	Low vegetation on mineral	0.4	0.5
	Low Vegetation on thin peatland	4.1	3.0
Jack pine treed on shallow peatland	Jack pine dominant on shallow peatland	0.0	0.0
	Jack pine mixture on ground ice peatland	0.0	0.0
	Jack pine mixture on shallow peatland	0.0	0.2
Black spruce mixedwood on shallow peatland	Black spruce mixedwood on shallow peatland	0.0	0.0
	Jack pine mixedwood on shallow peatland	0.0	0.0
Black spruce treed on shallow peatland	Black spruce dominant on ground ice peatland	11.7	7.4
	Black spruce dominant on shallow	19.9	15.3

Coarse Habitat Type	Broad Habitat Type	Study Zone 4	Local Study Area
	peatland		
	Black spruce mixture on ground ice peatland	0.1	0.2
	Black spruce mixture on shallow peatland	0.4	0.7
Black spruce treed on wet peatland	Black spruce dominant on wet peatland	2.1	0.9
Tamarack- black spruce mixture on wet peatland	Black spruce mixture on wet peatland	0.1	0.1
	Tamarack mixture on wet peatland	0.7	0.2
Tamarack treed on shallow peatland	Tamarack dominant on ground ice peatland	0.0	0.0
	Tamarack dominant on shallow peatland	0.0	-
	Tamarack mixture on ground ice peatland	0.1	0.1
	Tamarack mixture on shallow peatland	0.3	0.6
Tamarack treed on wet peatland	Tamarack dominant on wet peatland	0.2	0.0
Black spruce treed on riparian peatland	Black spruce dominant on riparian peatland	0.7	0.4
Tamarack- black spruce mixture on riparian peatland	Tamarack- black spruce mixture on riparian peatland	0.0	0.0
Tamarack treed on riparian peatland	Tamarack dominant on riparian peatland	0.0	-
Tall shrub on shallow peatland	Tall shrub on ground ice peatland	0.1	0.0
	Tall shrub on shallow peatland	0.3	0.2
Tall shrub on wet peatland	Tall shrub on wet peatland	0.1	0.3
Low vegetation on shallow peatland	Low vegetation on ground ice peatland	3.6	3.3
	Low vegetation on shallow peatland	3.2	2.1
Low vegetation on wet peatland	Low vegetation on wet peatland	1.5	1.1
Tall shrub on riparian peatland	Tall shrub on riparian peatland	0.6	1.8
Low vegetation on riparian peatland	Low vegetation on riparian peatland	1.8	1.7
Nelson River shrub and/or low vegetation on ice scoured upland	Shrub/Low veg mixture on ice scoured upland	0.1	0.9
Nelson River shrub and/or low vegetation on upper beach	Tall Shrub on upper beach- regulated	0.4	0.5
	Low vegetation on upper beach- regulated	0.1	0.7
	Shrub/Low Veg Mixture on Upper beach- regulated	0.1	0.3

Coarse Habitat Type	Broad Habitat Type	Study Zone 4	Local Study Area
Nelson River shrub and/or low vegetation on sunken peat	Shrub/Low Veg Mixture on Sunken Peat-regulated	0.1	0.6
	Low vegetation on sunken peat-regulated	0.0	0.0
Nelson River marsh	Emergent on lower beach- regulated	0.0	0.1
	Emergent on sunken peat- regulated	0.0	-
Off-system marsh	Emergent on upper beach	0.1	0.1
	Emergent on lower beach	0.0	0.0
	Emergent island in littoral	0.0	0.0
Human infrastructure		2.0	6.1
Unclassified		0.5	0.0
Total land area (ha)		*167,255*	*13,043*

Notes: Cells with 0 values are values that round to 0, while "-" cells indicate a value of 0.

The needleleaf treed vegetation on mineral or thin peatlands land cover type included several black spruce and jack pine (*Pinus banksiana*) treed or mixedwood coarse habitat types (Table 6-33). Black spruce treed on thin peatland, the most abundant of these coarse habitat types, was also the most abundant coarse habitat type overall with nearly 33% of the land cover. This type was mostly comprised of the black spruce dominant on thin peatland broad habitat type, followed by black spruce mixtures. Jack pine treed and jack pine mixedwood on mineral or thin peatland covered only 2% of land area combined. On mineral soils, the most common broad habitat type was jack pine dominant, while jack pine mixture was most abundant on thin peatland. Although needleleaf treed vegetation was widely distributed, the mineral ecosite coarse habitat types tended to be more abundant near the Nelson River and along the north esker, as well as around Ferris Bay (Map 6-7).

Included in the needleleaf treed vegetation on other peatlands land cover type was a variety of black spruce, jack pine and tamarack (*Larix laricina*) coarse habitat types (Table 6-33). Black spruce treed on shallow peatland was the most abundant shallow peatland type by far, covering nearly an equal area as on thin peatland (32%). Within that coarse habitat type, black spruce dominant on shallow peatland and black spruce dominant on ground ice peatland were by far the most abundant broad habitat types. Jack pine treed on shallow peatland was rare (0.1% of land area), and concentrated in areas that were recently burned, including the jack pine dominant, and jack pine mixture (with black spruce) on shallow peatland broad habitat types. Black spruce and tamarack coarse habitat types made up most of the remaining area, of which black spruce treed on wet peatland was the most abundant at 2.1% of land area. Tamarack coarse habitat types were usually dominated by tamarack mixture (with black spruce) broad habitat types. Shallow peatland habitat was widely distributed throughout Study Zone 4, but wet peatlands were scattered in smaller patches in depressions and low flat areas (Map 6-7).

Table 6-33: Coarse habitat composition of Study Zone 4 and the Local Study Area, as a percentage of total land area

Land Cover	Coarse Habitat Type	Study Zone 4	Local Study Area
Mineral and Thin Peatland Types			
Broadleaf Treed on All Ecosites	Broadleaf treed on all ecosites	0.6	1.4
	Broadleaf mixedwood on all ecosites	0.5	1.2
Needleleaf Treed on Mineral or Thin Peatland	Black spruce mixedwood on mineral or thin peatland	0.3	0.3
	Jack pine mixedwood on mineral or thin peatland	0.3	0.5
	Jack pine treed on mineral or thin peatland	1.8	3.1
	Black spruce treed on mineral soil	8.2	12.0
	Black spruce treed on thin peatland	32.6	31.3
Tall Shrub on Mineral or Thin Peatland	Tall Shrub on Mineral or Thin Peatland	0.2	0.6
Low Vegetation on Mineral or Thin Peatland	Low Vegetation on Mineral or Thin Peatland	4.5	3.6
Other Peatland Types			
Needleleaf Treed on Other Peatlands	Jack pine treed on shallow peatland	0.1	0.2
	Black spruce mixedwood on shallow peatland	0.0	0.0
	Black spruce treed on shallow peatland	32.2	23.6
	Black spruce treed on wet peatland	2.1	0.9
	Tamarack- black spruce mixture on wet peatland	0.9	0.3
	Tamarack treed on shallow peatland	0.4	0.7
	Tamarack treed on wet peatland	0.2	0.0
	Black spruce treed on riparian peatland	0.7	0.4
	Tamarack- black spruce mixture on riparian peatland	0.0	0.0
	Tamarack treed on riparian peatland	0.0	-
Tall Shrub on Other Peatlands	Tall Shrub on Shallow Peatland	0.3	0.3
	Tall Shrub on Wet Peatland	0.1	0.3

Land Cover	Coarse Habitat Type	Study Zone 4	Local Study Area
Low Vegetation on Other Peatlands	Low Vegetation on Shallow Peatland	6.8	5.4
	Low Vegetation on Wet Peatland	1.5	1.1
Shrub/Low Vegetation on Riparian Peatland	Tall shrub on riparian peatland	0.6	1.8
	Low vegetation on riparian peatland	1.8	1.7
Shore Zone Types			
Nelson River Shore Zone	Nelson River shrub and/or low vegetation on ice scoured upland	0.1	0.9
	Nelson River shrub and/or low vegetation on upper beach	0.6	1.4
	Nelson River shrub and/or low vegetation on sunken peat	0.1	0.6
	Nelson River marsh	0.0	0.1
Off-system Shore Zone	Off-system marsh	0.1	0.1
Other Land Cover Types			
Human Infrastructure		2.0	6.1
Unclassified		0.5	0.0
All		100.0	100.0
Total Land Area (ha)		*167,255*	*13,043*

Notes: Cells with 0 values are values that round to 0, while "-" cells indicate a value of 0. Reported areas are land area only.

Broadleaf treed land cover captured a relatively even mixture of broadleaf dominant and broadleaf mixedwood coarse habitats. Trembling aspen dominant and mixedwood were the most abundant broad habitat types, followed by white birch (note that white birch was somewhat more abundant than the habitat mapping suggests, as it frequently occurred as scattered individuals too sparse to map in upland stands). Broadleaf treed habitat generally occurred in the infrequent areas where conditions were favorable, such as mineral and thin peatland ecosite types and, infrequently, in richer riparian areas such as on slope fens (Map 6-5). As a result, broadleaf treed land cover tended to be more abundant near the Nelson River and along the north esker (Map 6-6). The higher proportion of mineral surface materials in the Local Study Area compared with Study Zone 4 (Table 6-13) was associated with a higher proportion of broadleaf treed cover.

Tall shrub vegetation on mineral or thin peatland land cover consisted of only one coarse habitat type and two broad habitat types, comprising only 0.2% of land in Study Zone 4 (Table 6-31). Of the broad types, tall shrub on thin peatland was more abundant than tall shrub on mineral. This coarse habitat type most often occurred as early regenerating vegetation on recently burned thin peatlands. Consequently, the largest areas were distributed in the recent burns north of Gull Lake (compare Map 6-7 and Map 6-2).

Tall shrub on other peatlands land cover was a mixture of tall shrub on shallow peatland and tall shrub on wet peatland, making up only 0.5% of land combined in Study Zone 4 (Table 6-31). The more common tall shrub on shallow peatland coarse habitat type included the tall shrub on shallow peatland and tall shrub on ground ice peatland broad habitat types. They were usually associated with either recently burned shallow peatlands as early regeneration, or slope bogs in runnels and disintegrating peat plateau bogs. Due to the former case, many of the larger areas were located in the recently burned area north of Gull Lake (Map 6-2). Tall shrub on wet peatlands was scattered throughout Study Zone 4, usually in horizontal fens.

Low vegetation on mineral or thin peatlands consisted of only one coarse habitat type, comprising 4.5% of land in Study Zone 4 (Table 6-31), and two broad habitat types, including low vegetation on mineral and low vegetation on thin peatland. The latter broad habitat type was by far the more abundant one. Most of this area was associated with poorly regenerating burns on thin peatlands, while most of the remaining area is associated with cutlines and other human features. As a result, this coarse habitat type tended to be distributed in large concentrated areas that correspond with more recent burns (see Map 6-7 and Map 6-2 for a comparison of poorly regenerating burned areas).

Low vegetation on other peatlands covered 8.4% of land in Study Zone 4, and was mostly comprised of the low vegetation on shallow peatland coarse habitat type (6.8%), with low vegetation on wet peatland making up the remaining area (Table 6-31). The former was comprised of an even mixture of the low vegetation on shallow peatland, and low vegetation on ground ice peatland broad habitat types. As with tall shrub on shallow peatlands, most of the low vegetation on shallow peatlands were associated with poorly regenerating recently burned areas, with much of the remaining area in disintegrating peat plateau bogs. The distribution of this habitat is similar to that of low vegetation on mineral or thin peatland (Map 6-7). Low vegetation on wet peatland was scattered throughout Study Zone 4 in horizontal fens and collapse scar peatlands.

Shrub and low vegetation on riparian peatland land cover comprised 2.4% of land in Study Zone 4 (Table 6-31). Low vegetation on riparian peatland was the more common coarse and broad habitat type (1.8%). These coarse habitat types occurred in riparian fens along lake shores and waterways throughout Study Zone 4 (Map 5-3). They are also scattered in sheltered bays and at stream outlets along the Nelson River. Low vegetation on riparian peatland frequently forms wide areas along waterways and lakes surrounded by floating peatlands.

Human infrastructure such as PR 280, other roads, borrow areas, rail lines, transmission line rights-of way, towns and communities accounted for 2% of the land area. These features were concentrated around Stephens Lake, particularly within and surrounding the Town of Gillam and on the esker north of Gull Rapids (Map 6-7).

Shore zone land cover included shrub and/or low vegetation on ice scoured upland, on upper beach and on sunken peat, as well as Nelson River and off-system marsh wetland coarse habitat types. Shoreline wetlands with vegetation patches large enough to map were rare in Study Zone 4 (0.9% of land area; Table 6-31). Although Nelson River shrub and/or low vegetation on upper beach was the most abundant shore zone coarse habitat type, it only covered 0.6% of land area.

The nature of shore zone habitat in the Nelson River off-system waterbodies was considerably different, presumably due to the substantial differences in water and ice regimes (see KGS ACRES 2011, and Manitoba Hydro- WRE 2009 for Nelson River water and ice regimes). During the study period, the vegetated upper beach and vegetated ice scour upland habitat types were only observed on the Nelson River while virtually all of the littoral and lower beach marsh was in off-system waterbodies (Map 6-7). Additionally, the Nelson River upper beach peatlands were periodically flooded while those in off-system waterbodies appeared to float up and down with water fluctuations.

On the Nelson River, shrub and/or low vegetation on upper beach was the most abundant of the shore zone coarse types (0.6% of the land area). Nelson River marsh was virtually absent, comprising 15 ha of the 1,585 ha of Nelson River vegetated shore zone habitat. Vegetation in the Nelson River shrub/low vegetation on upper beach coarse habitat type was dominated either by tall shrubs or low vegetation mixed in with graminoids, with the characteristic plant species being different in the Keeyask and Stephens Lake reaches of the Nelson River (Map 6-1). For the tall shrub vegetation types, flat-leaved willow (*Salix planifolia*) and marsh reed-grass (*Calamagrostis canadensis*) occurred throughout the Nelson River, while bog billberry (*Vaccinium uliginosum*) and sweet gale (*Myrica gale*) cover occurred only in the Stephens Reach. For the low vegetation types, the vegetation cover commonly consisted of silverweed (*Argentina anserina*) and marsh reed grass in the Keeyask reach, while common horsetail (*Equisetum arvense*), marsh five-finger (*Comarum palustre*) and sedges (*Carex* spp.) were more common in the Stephens Lake reach.

Shoreline wetlands in off-system waterbodies were predominantly marshes occurring within shallow lacustrine environments and along the sunken margins of floating peatlands. Off-system littoral or lower beach marsh on mineral substrates tended to be dominated by either viscid great-bulrush (*Schoenoplectus tabernaemontani*) or creeping spike-rush (*Eleocharis palustris*) and spiked water-milfoil (*Myriophyllum sibiricum*). Water horsetail (*Equisetum fluviatile*) occurred in shallower water on organic and mineral substrates, while floating-leaved species such as small yellow pond-lily (*Nuphar variegata*) and narrow-leaved bur-reed (*Sparganium angustifolium*) often occurred in deeper water. Nelson River littoral or lower beach marsh was dominated by water horsetail.

Section 6.3.2.3 further describes shoreline wetlands.

Compared with Study Zone 4, the Local Study Area had higher proportions of broadleaf treed vegetation on all ecosites, jack pine treed on mineral or thin peatland and tall shrub vegetation on riparian peatlands (Table 6-21; Map 6-7). Conversely, there was a lower proportion of needleleaf treed on other peatlands, especially on shallow peatland. Broadleaf treed vegetation was concentrated adjacent and near to the Nelson River and regenerating in the recent burns on the esker, as were tall shrub on other peatlands.

Less common coarse habitat types that were more abundant in the Local Study Area included broadleaf treed and broadleaf mixedwood on all ecosites, jack pine treed on mineral or thin peatland and tall shrub on wet peatlands. Nevertheless, they still comprised a small percentage of the coarse habitat types. Black spruce treed on shallow peatland was more abundant outside of the Local Study Area, but this was primarily due to the impact of the fires occurring in the past 12 years north and south of Gull Lake.

Due to the presence of the Nelson River, shore zone habitat types were proportionately more abundant in the Local Study Area, increasing to a total of 3.1%. The proportion of shrub/ low vegetation on ice scour and on upper beach coarse habitat types were higher as well, nearly 1% and 1.4%, respectively. This was primarily because of the higher relative proportion of Nelson River shoreline in this area. Overall, the wetland habitat composition is similar to that of Study Zone 4 (Table 6-33).

Recent Fire History and Age Structure

Approximately 25% of the land cover in Study Zone 4 burned at least once during the past 30 years. Approximately 9% of Study Zone 4 burned recently (between the beginning of 2002 and end of 2011), and is currently covered with young regenerating vegetation. Habitat had regenerated in most of the areas burned prior to 2002. Some of the habitat that burned prior to 2002 was regenerating slowly, and had not yet recovered mappable tree cover, remaining as low vegetation or tall shrub cover in some areas. These poorly regenerating areas were usually found on thin, shallow, and ground ice peatland. Much of the poorly regenerating habitat corresponded to the 1999 and 2001 fires north of Gull Lake, and to older fires that occurred east of Split Lake, south of Stephens Lake, and adjacent to PR 280 near the proposed north access road.

Because of frequent large fires (Section 6.3.1), approximately one-quarter of the inland terrestrial habitat in Study Zone 4 was less than 30 years old in 2010. Most of the mature forest in the Local Study Area was approximately 70 years old.

Large burns were distributed throughout Study Zone 4 (Map 6-2). The most recent burns were near the Nelson River, encompassing a large proportion of the Local Study Area. Most of the proposed reservoir area south of the Nelson River in the Gull Lake reach burned in 2005. The eastern portion of the north esker burned in 1999 and 2001 and the eastern portion of Caribou Island burned in 2003.

6.3.2.2.2 Ellis Esker

An additional area outside of Study Zone 4 was mapped at 1:15,000 scale using the same methods. The Ellis Esker area was adjacent to the south ofStudy Zone 4 (Map 6-3) and encompassed a total area of 1,323 ha, of which 1,197 ha (90%) was land.

The Ellis Esker area was predominantly horizontal and sloped topography, which comprised 59% and 27% of the land area, respectively (Table 6-34). This supported a relatively even mixture of thin peatland (24%), shallow peatland (30%), primarily composed of blanket bogs, and ground ice peatlands (25%) dominated by peat plateau bog/ collapse scar mosaics (Table 6-35). Mineral ecosites were uncommon (4%), and almost entirely associated with the ridge/crest topography. Most of the remaining land area was comprised of horizontal and riparian fens (13%).

Table 6-34: Topography in the Ellis Esker area as a percentage of total land area

Topography	Ellis Esker Area
Ridge/ Crest	3.9
Slope	26.8
Horizontal	58.8
Horizontal- raised	2.4
Depression	4.4
Runnel	3.7
Total land area (ha)	*1,197*

Table 6-35: Ecosite composition of the Ellis Esker area as a percentage of total land area

Coarse Ecosite Type	Fine Ecosite Type	Ellis Esker Area
Mineral	Deep dry mineral	3.8
Thin peatland	Veneer bog on slope	24.3
Shallow peatland	Veneer bog	0.1
	Blanket bog	27.6
	Slope bog	2.5
	Slope fen	0.1
Ground ice peatland	Peat plateau bog	0.8
	Peat plateau bog/ collapse scar peatland mosaic	21.4
	Peat plateau bog transitional stage	2.8
Permafrost peatland- other	Collapse scar bog	1.5
Deep peatland	Flat bog	1.6
	Horizontal fen	9.4
Riparian Peatland	Riparian fen	4.1
Total land area (ha)		*1,197*

Low vegetation on shallow peatlands was the most abundant coarse habitat type in the Ellis Esker area (32%), followed by black spruce treed on shallow peatland (20%), with low vegetation on mineral or thin peatland and black spruce treed on thin peatland comprising the only other common habitat types in this area (Table 6-36). Tamarack dominated habitat types were uncommon in this area, and no broadleaf or tall shrub dominated habitat occurred in patches large enough to map.

Table 6-36: Habitat composition of the Ellis Esker area as a percentage of total land area

Land Cover Type	Coarse Habitat Type	Broad Habitat Type	Ellis Esker Area
Needleleaf treed on mineral or thin peatland	Black spruce mixedwood on mineral or thin peatland	Black spruce mixedwood on mineral	0.2
	Black spruce treed on mineral soil	Black spruce dominant on mineral	2.9
	Black spruce treed on thin peatland	Black spruce dominant on thin peatland	10.9
		Tamarack mixture on thin peatland	0.7
Low vegetation on mineral or thin peatland	Low vegetation on mineral or thin peatland	Low vegetation on mineral	0.7
		Low Vegetation on thin peatland	12.7
Needleleaf treed on other peatlands	Black spruce mixedwood on shallow peatland	Black spruce mixedwood on shallow peatland	0.1
	Black spruce treed on riparian peatland	Black spruce dominant on riparian peatland	0.4
	Black spruce treed on shallow peatland	Black spruce dominant on ground ice peatland	6.2
		Black spruce dominant on shallow peatland	13.8
		Black spruce mixture on ground ice peatland	0.1
		Black spruce mixture on shallow peatland	0.4
	Black spruce treed on wet peatland	Black spruce dominant on wet peatland	4.2
	Tamarack- black spruce mixture on riparian peatland	Tamarack- black spruce mixture on riparian peatland	0.1
	Tamarack- black spruce mixture on wet peatland	Black spruce mixture on wet peatland	0.1
		Tamarack mixture on wet peatland	0.9
	Tamarack treed on riparian peatland	Tamarack dominant on riparian peatland	0.1
	Tamarack treed on shallow peatland	Tamarack mixture on ground ice peatland	1.1
		Tamarack mixture on shallow	1.7

Land Cover Type	**Coarse Habitat Type**	**Broad Habitat Type**	**Ellis Esker Area**
		peatland	
Low vegetation on other peatlands	Low vegetation on shallow peatland	Low vegetation on ground ice peatland	17.7
		Low vegetation on shallow peatland	14.3
	Low vegetation on wet peatland	Low vegetation on wet peatland	7.3
Shrub/ low vegetation on riparian peatland	Low vegetation on riparian peatland	Low vegetation on riparian peatland	3.5
Total land area (ha)			*1,197*

6.3.2.2.3 Regional Study Area

As described in Section 6.2.2.2.5, the terrestrial habitat composition of the Regional Study Area was estimated by extrapolating the photo-interpreted mapping completed for Study Zone 4. Table 6-37 provides the estimated total areas of each coarse habitat type in the Sub-regional and Regional Study Areas.

Table 6-37: Area of the coarse habitat types in the Sub-regional (Study Zone 4) and the Regional Study Area

Coarse Habitat Type	Study Zone 4 (ha)	Regional Study Area (ha)
Broadleaf treed on all ecosites	979	7,398
Broadleaf mixedwood on all ecosites	810	6,123
Black spruce mixedwood on mineral or thin peatland	510	3,854
Jack pine mixedwood on mineral or thin peatland	458	3,464
Jack pine treed on mineral or thin peatland	3,013	22,771
Black spruce treed on mineral soil	13,779	104,151
Black spruce treed on thin peatland	54,455	411,604
Tall shrub on mineral or thin peatland	316	2,387
Low vegetation on mineral or thin peatland	7,462	56,399
Jack pine treed on shallow peatland	85	642
Black spruce mixedwood on shallow peatland	51	382
Black spruce treed on shallow peatland	53,838	406,942
Black spruce treed on wet peatland	3,431	25,930
Tamarack- black spruce mixture on wet peatland	1,460	11,036
Tamarack treed on shallow peatland	735	5,559
Tamarack treed on wet peatland	262	1,982
Black spruce treed on riparian peatland	1,091	8,245
Tamarack- black spruce mixture on riparian peatland	56	421
Tamarack treed on riparian peatland	10	79
Tall shrub on shallow peatland	562	4,245
Tall shrub on wet peatland	213	1,607
Low vegetation on shallow peatland	11,417	86,295
Low vegetation on wet peatland	2,563	19,374
Tall shrub on riparian peatland	974	7,358
Low vegetation on riparian peatland	3,007	22,731
Nelson River shrub and/or low vegetation on ice scoured upland	122	122
Nelson River shrub and/or low vegetation on upper beach	1,018	1,018
Nelson River shrub and/or low vegetation on sunken peat	237	237
Nelson River marsh	15	15
Off-system marsh	193	534
Human infrastructure	3,376	10,686
Unclassified	759	5,737
Total land area (ha)	*167,255*	*1,239,328*

6.3.2.3 Shoreline Wetlands

Wetlands accounted for approximately 90% of the land area in Study Zone 4 in 2010. Study Zone 4 was essentially one large wetland complex that was dotted with mineral-capped ridges and hills (Map 6-8). Bog accounted for approximately 91% of the wetland area in 2010, followed by fen (8% of wetland area) and marsh (1% of wetland area). Swamp was virtually absent, with none occurring in the Local Study Area (Table 6-38).

In descending order, the most abundant wetland forms were veneer bog, blanket bog and the various permafrost bog wetland forms (Table 6-38). The relatively abundant fen wetland forms were horizontal fen and riparian fen. Swamp is not considered further since it was virtually absent in patches large enough to map and none of the mapped patches were within the Local Study Area.

Marsh wetland forms included lacustrine marsh, stream marsh, riparian fen, riparian bog and shallow water (shallow water was only mapped for the Keeyask reach of the Nelson River where bathymetry data were available to separate shallow from deep water). As noted in Section 6.3.2.2, the nature and composition of Nelson River and off-system shoreline wetlands were considerably different. Nelson River shoreline wetlands were highly disrupted by water regulation and associated ice scouring, which presumably is why vegetation and plant species diversity in these wetlands were lower than in comparable environmental conditions in off-system wetlands. Virtually all of the littoral and lower beach marsh was in off-system waterbodies. Emergent vegetation islands were frequent in off-system waterbodies (Map 6-9 to Map 6-21) but were not observed in patches large enough to map in the Keeyask shoreline wetland study zone.

Focusing on shoreline wetlands, fen was by far the most abundant vegetated wetland class, accounting for approximately 74% of shoreline wetland area (Table 6-39), followed by marsh (22%) and bog (4%). The shallow water wetland class, which was not included in the shoreline wetland land type, was only mapped for the Keeyask shoreline wetland study zone (Map 6-1) where it accounted for 83% of the total wetland area. There was no natural marsh in the Nelson River, presumably due to the high degree of water fluctuations and ice scouring (Keddy 2010).

On a lineal kilometer of shoreline basis, the open water side of the shoreline was predominantly shallow water, with marsh occurring along only 3% of the shoreline. Regulated marsh was less frequent in the Keeyask shoreline wetland study zone (Map 6-1), occurring along 1% of Keeyask shoreline versus nearly 8% of the classified Stephens Lake shoreline (Table 6-40). This may have reflected the fact that Stephens Lake shorelines were still undergoing peatland disintegration from Kettle reservoir flooding whereas increased water levels in the Keeyask shoreline wetland study zone were within the historical range of variability (Manitoba Hydro- WRE 2009). Most of the regulated marsh in the Stephens Lake shoreline wetland study zone was shrub and/or low vegetation on sunken peat, primarily originating from disintegrating peatlands.

Tall shrub on riparian peatland and low vegetation on wet peatland were scattered in sheltered bays and at stream outlets along the Nelson River. Wetland classes other than shallow water were virtually confined to inlets and sheltered bays (Map 6-9 to Map 6-21).

Large herb and/or tall shrub meadows appeared during low to intermediate water levels in several bays. Based on detailed shoreline mapping (see Section 6.3.2.3.2), a tall shrub band was present at upper elevations along approximately 69% of the classified shoreline, becoming wide along about 24% of the shoreline. Most of the tall shrub vegetation occurred on peat banks. Willows were the most abundant tall shrub species by far. In Stephens Lake, marsh and fen were the only vegetated wetland classes occurring in the remainder of the classified shoreline. Emergent vegetation was more common in Stephens Lake, particularly in the bays. Although shoreline tall shrub vegetation occurred on a higher proportion of the classified shoreline, wide tall shrub bands were less common. Floating peat islands produced by peatland disintegration occurred in Stephens Lake.

On an area basis, regulated marsh made up two-thirds of the mapped Nelson River shoreline wetlands (Table 6-41). These regulated marshes occurred on the upper to lower beach water depth duration zones along the Nelson River, however due to water fluctuation and ice scour, these did not resemble off-system marshes. Most of the marsh area in Keeyask was regulated lacustrine shore marsh on upper beach (41%), and regulated lacustrine bay marsh on upper beach (12%). The 13% that included regulated upper beach shore and regulated bay marsh on sunken, disintegrated peatland was primarily found in Stephens Lake. Most of the remaining shoreline area (33%) was comprised of regulated riparian fens, which were generally scattered in sheltered bays and at stream outlets (Map 6-8).

On a lineal km of shoreline basis, regulated shallow water was the most frequent wetland type on the water side of the off-system shoreline, with regulated marsh occurring along 15% of the shoreline. These marshes were occurring within shallow lacustrine environments and along the sunken margins of floating peatlands. On the inland side of the shoreline, regulated riparian fens were most common, comprising 57% of the classified length, while regulated riparian bogs comprised only 3%. The remaining shoreline occurred along inland uplands and wetlands (Map 6-9 to Map 6-21).

Most of the vegetated off-system shoreline wetland area was comprised of riparian fen (90%) followed by riparian bog (6%), with marsh making up the remaining area (Table 6-42). Off-system waterbodies with relatively high amounts of marsh were located along waterways and tended to be situated in the valleys formed by pronounced drumlins, presumably receiving nutrient inputs captured by surface and groundwater flow from these landforms.

Approximately 75% of the 193 ha of off-system marsh in Study Zone 4 was lacustrine bay marsh while the rest was riparian stream marsh. This off-system marsh was predominantly located in the littoral rather than the lower beach water depth zone, typically growing as a narrow band along the shoreline. Off-shore marsh islands and patches of floating-leaved plants tended to occur in the littoral zone. Most of the remaining marsh was growing on the sunken fringes of floating riparian fens and bogs. Photo 6-2 and Photo 6-3 are photos of typical off-system marshes growing on the lake bottom.

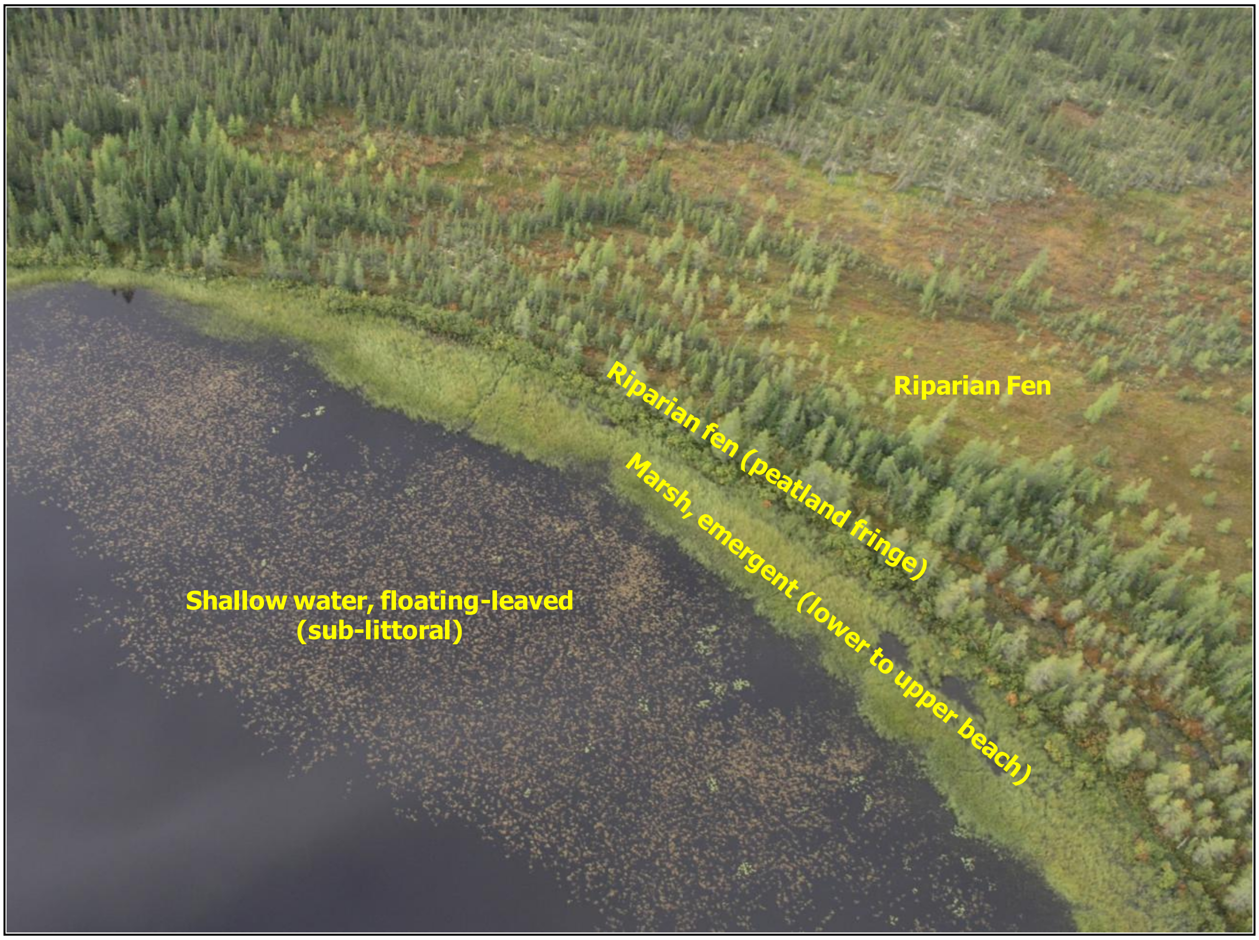


Photo 6-2: Aerial view of off-system marsh growing on the lake bottom next to a riparian peatland

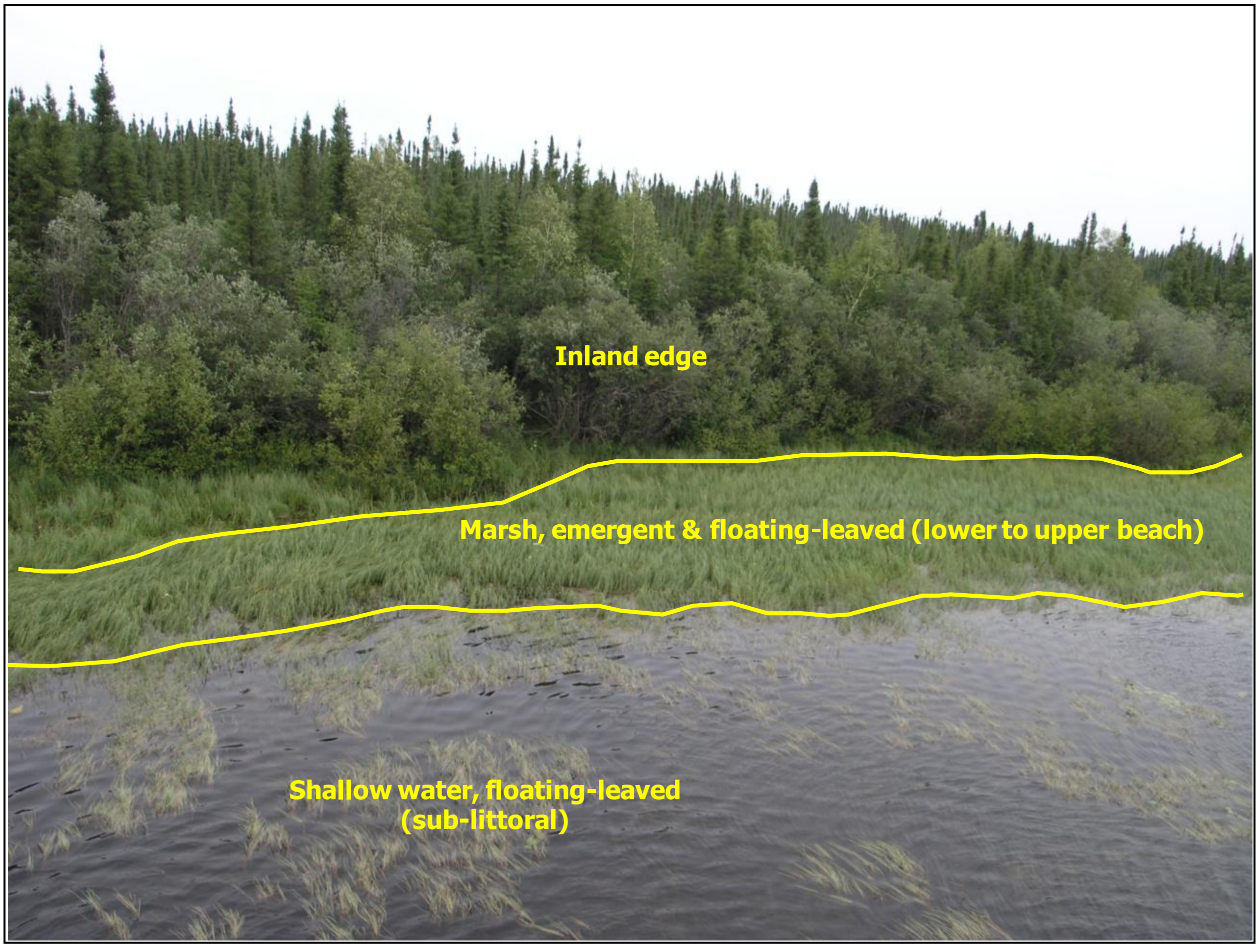


Photo 6-3: Close-up view of off-system marsh and floating-leaved vegetation growing on the lake bottom

Table 6-38: Composition of existing wetlands by wetland class and form as a percentage of total wetland area

Wetland Class	Wetland Form	Study Zone 4	Wetland Function Local Study Area
Swamp	Flat	0.0	-
Bog	Veneer	46.9	50.9
	Slope	1.6	0.6
	Blanket	23.3	22.7
	Peat plateau	5.5	5.0
	Collapse scar	0.2	0.3
	Peat plateau bog/collapse scar mixture	11.0	9.6
	Blanket bog/collapse scar mixture	1.6	-
	Flat	0.7	0.6
	Riparian	0.2	0.1
Fen	Basin	0.0	-
	Slope	0.2	0.2
	Collapse scar	0.0	0.1
	Horizontal	4.4	2.3
	String	0.0	-
	Riparian	3.3	4.9
Fen/Bog mixture	Horizontal fen and blanket bog	0.2	-
Marsh	Lacustrine and stream	1.0	2.8
All		100.0	100.0
Total Area (ha)		**147,566**	**10,461**

Notes: Cells with 0 values are values that round to 0, while "-" cells indicate a value of 0. Reported areas are land area only.

Table 6-39: Overall composition of existing shoreline wetlands on the Nelson River and off-system waterbodies in the Regional Study Area

Water Regime	Wetland Class	Wetland Form	Wetland Subform	Water Depth Duration Zone	Regional Study Area (%)	Local Study Area (%)
Off-system	Bog	Riparian	Shore and floating		4.1	1.4
	Fen	Riparian	Shore and floating		64.1	35.4
	Marsh	Lacustrine	Bay	Littoral	1.2	0.1
				Lower beach	0.3	0.3
				Upper beach on sunken peat	0.8	0.6
		Riparian	Stream	Lower beach	0.0	-
				Upper beach on sunken peat	0.6	0.4
Nelson River	Bog	Riparian	Shore and floating		0.0	0.1
	Fen	Riparian	Shore and floating		9.7	26.9
	Marsh	Lacustrine	Bay	Lower beach	0.2	1.3
				Upper beach	3.6	7.3
			Shore	Lower beach	0.0	-
				Upper beach	11.8	15.5
			Shore and Bay	Upper beach on sunken, disintegrated peatland	3.7	10.5
Both	All				100.0	100.0

Notes: Cells with 0 values are values that round to 0, while "-" cells indicate a value of 0.

Table 6-40: Composition of open water side of Nelson River of classified shoreline wetlands as a proportion of lineal shoreline length by reach in the Regional Study Area

Wetland	Gull Lake Study Area (%)	Stephens Lake Study Area (%)	All (%)
Marsh	1.1	7.6	3.2
Bog	0.0	0.1	0.0
Fen	10.0	27.2	15.5
Shrub Meadow	4.4	7.9	5.6
Wet Meadow	4.8	0.0	3.3
Shallow Water	79.7	57.2	72.4
Total classified shoreline length (km)	*254*	*121*	*374*

Table 6-41: Composition of existing shoreline wetlands on the Nelson River in the Regional Study Area as a percentage of total Nelson River wetland area

<table>
<tr><th>Wetland Class</th><th>Wetland Form</th><th>Wetland Subform</th><th>Water Depth Duration Zone</th><th>Regional Study Area</th><th>Local Study Area</th></tr>
<tr><td>Bog</td><td>Riparian</td><td>Shore and floating</td><td></td><td>0.1</td><td>0.1</td></tr>
<tr><td>Fen</td><td>Riparian</td><td>Shore and floating</td><td></td><td>33.5</td><td>43.7</td></tr>
<tr><td rowspan="5">Marsh</td><td rowspan="5">Lacustrine</td><td rowspan="2">Bay</td><td>Lower beach</td><td>0.6</td><td>2.2</td></tr>
<tr><td>Upper beach</td><td>12.3</td><td>11.9</td></tr>
<tr><td rowspan="2">Shore</td><td>Lower beach</td><td>0.0</td><td>-</td></tr>
<tr><td>Upper beach</td><td>40.7</td><td>25.2</td></tr>
<tr><td>Shore and Bay</td><td>Upper beach on sunken, disintegrated peatland</td><td>12.9</td><td>17.0</td></tr>
<tr><td colspan="4">Total Nelson River wetland area (ha)</td><td>1,920</td><td>502</td></tr>
</table>

Table 6-42: Composition of existing shoreline wetlands on the off-system waterbodies in the Regional Study Area as a percentage of total off-system wetland area

Wetland Class	Wetland Form	Wetland Subform	Water Depth Duration Zone	Regional Study Area	Local Study Area
Bog	Riparian	Shore and floating		5.8	3.7
Fen	Riparian	Shore and floating		90.1	92.4
Marsh	Lacustrine	Bay	Littoral	1.7	0.4
			Lower beach	0.4	0.8
			Upper beach on sunken peat	1.2	1.6
	Riparian	Stream	Lower beach	0.0	-
			Upper beach on sunken peat	0.8	1.0
Total off-system wetland area (ha)				*4,723*	*312*

Notes: Cells with 0 values are values that round to 0, while "-" cells indicate a value of 0.

6.3.2.3.1 Shoreline Wetland Habitat Type Descriptions

This section provides overview characterizations of the common shoreline wetland habitat types by water depth duration zone. Section 7.3.3.3.3 describes the inland wetland habitat types.

As noted above, typical growing season water depths at a particular shoreline location, which are classified into water depth duration zones, generally organize plant species into a sequence of vegetation and habitat types. Water horsetail and viscid great bulrush were the most common shoreline habitat types in the shallow water depth zone of the Nelson River and off-system waterbodies, followed by small yellow pond-lily and creeping spike-rush. The only shallow water habitat type found in the Nelson River was water horsetail, most of which was in the Gull Lake Study Area.

The water horsetail and viscid great bulrush habitat types were emergent, or marsh, habitat types. The water horsetail habitat type usually occurred on mineral substrates with bottle sedge and water smartweed (*Persicaria amphibia*) in the Nelson River and on a mixture of mineral and organic substrates with narrow-leaved bur-reed and small yellow pond-lily in the off-system waterbodies (Table 6-43). The viscid great bulrush habitat type, which included viscid great bulrush as its sole species, was associated with fine mineral substrates. These habitat types represented marsh habitat in the off-system and Nelson River waterbodies. Off-system marsh habitat tended to be more species-rich, include a wider range of marsh habitat types, and have a higher abundance of floating-leaved species (Table 6-43).

Table 6-43: Typical habitat types and species composition of marshes on off-system waterbodies and the Nelson River

Habitat Types		Species	
Off-System	**Nelson River**	**Off-System**	**Nelson River**
Water horsetail, Viscid great bulrush, Small yellow pond-lily, Creeping spike-rush	Water horsetail	Mineral substrates: Various-leaved pondweed (*Potamogeton gramineus*), Viscid great-bulrush (*Schoenoplectus tabernaemontani*), creeping spike-rush (*Eleocharis palustris*), water horsetail (*Equisetum fluviatile*) Organic substrates: Spiked water-milfoil (*Myriophyllum sibiricum*), Richardson's pondweed (*Potamogeton richardsonii*), narrow-leaved bur-reed (*Sparganium angustifolium*), needle spike-rush (*Eleocharis acicularis*), small yellow pond-lily (*Nuphar variegata*)	Mineral substrates: Water horsetail (*Equisetum fluviatile*), bottle sedge (*Carex utriculata*), water smartweed (*Persicaria amphibia*)

In the lower to middle beach water depth zone, small bedstraw (*Galium trifidum*)/creeping spike-rush/water smartweed was the most common habitat type, followed by the bottle sedge (*Carex utriculata*)/bladderwort (*Utricularia* spp) type, green reindeer lichen (*Cladina mitis*)/bladderwort type, and marsh five-finger /sedge type. The small bedstraw/creeping spike-rush/water smartweed habitat type was the most common lower to middle beach habitat type in the Nelson River but was not found in the off-system lakes. It was found primarily on organic substrates and often included water parsnip (*Sium suave*), smooth beggar-ticks (*Bidens cernua*) and water sedge. In contrast, the bottle sedge/bladderwort habitat type was one of the most common in the off-system lakes but was not found in the Nelson River. It typically occurred on organic substrates and often included marsh reed-grass and water horsetail.

In the upper beach and inland edge water depth zone, flat-leaved willow/marsh reed-grass was the most common habitat type, followed by the water sedge/marsh reed grass and silverweed/narrow reed-grass types. The former two habitat types were encountered in both the Nelson River and off-system waterbodies, while the latter was only found in the Nelson River. The flat-leaved willow/marsh reed-grass habitat type typically occurred on organic substrates and often included peat moss (*Sphagnum* spp), common horsetail (*Equisetum arvense*), three-leaved Solomon's-seal (*Maianthemum trifolium*), dewberry (*Rubus pubescens*) and water sedge. Bog bilberry also occurred in the Nelson River occurrences of this habitat type.

6.3.2.3.2 Nelson River Shoreline Detail

Detailed mapping of Nelson River shoreline attributes and wetlands was completed for just over 253 lineal km of terrestrial habitat shoreline in the Gull Lake Study Area of the Nelson River study areas (Map 6-22). Additionally, nearly 121 km (12.7%) of the Stephens Lake study area shoreline was mapped. The locations of the remaining shoreline in the Clark and Stephens Lake study areas were mapped for other studies but were not segmented and classified. The total shoreline lengths were 270 km in the Clark/ Split study area and 955 km in the Stephens Lake study area. The following shore zone descriptions apply to the Gull Lake Study Area and mapped portions of the Stephens Lake study area only.

Beach And Bank Characteristics

Gull Lake Study Area

The most common beach material type in the Gull Lake Study Area of the Nelson River was bedrock (22%), followed by peat, sand with cobbles, and cobbles (Table 6-44). Together these four types comprised 69% of the mapped shoreline beach. Clay and pure sand beaches were less common in this study area but, individually and in varying mixtures, these comprised most of the remaining beach materials. Approximately 5% of the mapped Gull Lake Study Area beach materials were unclassified.

In contrast to beach material, the most common bank material classified in the Gull Lake Study Area was peat (33%), followed by clay, bedrock and till, together comprising 74% of the mapped bank material (Table 6-45). Clay and till were much more common as a bank material rather than a beach material in this study area, while sand, cobbles, and generally coarser materials were much more common beach materials. Nearly 10% of the Gull Lake Study Area bank materials were unclassified. Beach and bank materials generally did not appear to be strongly associated with particular combinations. However, bedrock banks tended to be most strongly associated with bedrock beaches, and peat banks tended to be associated with peat beaches, with clay beaches as a secondary association (Table 6-46).

Table 6-44: Classified beach material types in the Nelson River study areas and off-system lakes as a percentage of total mapped shoreline length

Beach Type	Nelson River			Off-System
	Gull Lake Study Area	Stephens Lake Study Area	Total	
Bedrock	22	-	15	1
Boulders	2	0	2	12
Cobbles	10	-	7	19
Cobbles with Sand	1	-	1	-
Gravel	1	-	1	-
Till	1	-	0	0
Sand	5	3	4	1
Sand with Cobbles	16	-	11	-
Sand with Rock	1	-	0	-
Clay	6	21	11	1
Clay with Boulders	1	-	1	-
Clay with Cobbles	4	1	3	0
Clay with Gravel	1	-	1	-
Clay with Rock	1	-	1	-
Clay with Till	0	-	0	-
Unknown Mineral	-	-	-	23
Peat	21	61	34	38
Peat with Cobbles	2	0	2	-
Peat with Cobbles and Boulders	0	-	0	1
Unknown	5	14	8	3
Total mapped shoreline (m)	*253,500*	*120,591*	*374,091*	*98,741*

Notes: Cells with 0 values are values that round to 0 while "-"cells indicate a value of 0.

Table 6-45: Classified bank material types in the Nelson River study areas and off-system lakes as a percentage of total mapped shoreline length

Bank Type	Nelson River			Off-System
	Gull Lake Study Area	Stephens Lake Study Area	Total	
Bedrock	11	-	8	0
Boulders	-	-	-	1
Boulder till	1	-	0	-
Cobbles	-	0	0	1
Gravel	-	0	0	-
Till	10	1	7	0
Sand	7	3	6	1
Sand with Cobbles	0	1	0	-
Sand with Till	2	-	1	-
Clay	19	0	13	-
Clay with Boulders	0	-	0	1
Clay with Cobbles	0	-	0	-
Clay with Till	5	-	4	-
Unknown mineral	-	-	-	4
Peat	33	77	47	79
Peat with Cobbles	0	2	1	-
Peat with Cobbles and Boulders	-	2	1	12
Peat with Rock	1	-	1	-
Unknown	10	14	11	0
Total mapped shoreline (m)	*253,500*	*120,591*	*374,091*	*98,741*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-46: Distribution of common beach material types among common bank material types as a percentage of total mapped shoreline in beach type in the Nelson River Study Area?

Beach Type	Bank Type									Total shoreline in beach type (m)
	Bed-rock	Cobbles	Till	Sand	Sand with Cobbles	Clay	Clay with Till	Peat	Unknown	
Bedrock	45	-	7	4	-	23	4	6	11	*56,181*
Cobbles	2	-	17	5	-	20	9	15	24	*24,987*
Till	32	-	-	-	-	-	21	41		*1,271*
Sand	-	-	6	25	-	7	6	43	13	*16,080*
Sand with Cobbles	-	-	10	29	1	16	7	30	2	*40,467*
Clay	-	1	4	5	2	23	4	49	0	*40,838*
Clay with Till	-	-	-	-	-	34	-	14	-	*1,215*
Peat	1	-	1	0	-	0	0	95	-	*125,623*
Unknown	1	-	13	-	-	-	-	-	85	*30,018*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Bank height in the Gull Lake Study Area was most often low (< 1m) or a variable mixture of heights (< 1m – 3m; Table 6-47). Bank height was unknown for approximately 15% of the mapped Gull Lake Study Area shoreline. In the study areas, flat banks were exclusively associated with peat bank material, however peat material was most frequently associated with low banks (Table 6-48 and Table 6-49). Clay banks were associated with a range of bank heights, but primarily occur with a mixture of low to medium bank heights, although the highest banks (1 – 3m) are most commonly associated with clay. Bedrock, till and sand bank materials were also most frequent with the low to medium height mixtures, but are also frequent with low banks. There do not appear to be particularly strong associations between bank height and beach type, with the exception of peat and clay beach materials, which are the only beach materials associated with flat banks (Table 6-50 and Table 6-51).

Bedrock banks in the Gull Lake Study Area were primarily distributed toward the upstream end of the study area, near Clark Lake, and around William Smith Island (Map 6-23). Peat banks were concentrated around Gull Lake, and sheltered bays and inlets along the Nelson River. Till, and clay-till mixtures and clay banks occur primarily in alternating stretches along the central stretch of the study area, and there were also large stretches of clay banks at the east end of the study area near Gull Rapids.

Bedrock and mineral beach material types tend to be more frequent along the open channel of the Nelson River and Gull Lake (Map 6-23), occurring in alternating patches. Peat beach materials are generally confined to sheltered bays and inlets.

Low bank heights were most concentrated around the shores of Gull Lake and in sheltered bays and inlets along the River (Map 6-24). Shoe segments with a mixture of low and medium height banks were most frequent along the narrower channel upstream of Gull Lake, as well as around William Smith Island. Medium bank heights were primarily concentrated around Gull Rapids at the east end of the study area.

Table 6-47: Classified bank height in the Nelson River study areas and off-system lakes as a percentage of total mapped shoreline length

Bank Height Class	Nelson River study areas			Off-System
	Gull Lake Study Area	Stephens Lake Study Area	Total	
No bank present	0	40	13	38
Low (~< 1m)	50	17	39	61
Mixture of low & medium	29	30	29	1
Medium (~ 1 - 3m)	6	0	4	1
Unknown	15	14	14	-
Mapped shoreline length (m)	*253,500*	*120,591*	*374,091*	*98,741*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-48: Distribution of bank type among the different bank height classes as a percentage of the total classified shoreline length for the bank type in the Nelson River Study Area

Bank Type	Bank Height Class					*Total shoreline in bank type (m)*
	No bank present	Low (~< 1 m)	Mixture of low & medium	Medium (~ 1 - 3 m)	Unknown	
Bedrock	-	17	45	1	38	*28,759*
Boulder till	-	100	-	-	-	*1,624*
Cobbles	-	100	-	-	-	*312*
Gravel	-	-	100	-	-	*156*
Till	-	39	41	-	20	*26,543*
Sand	-	40	56	2	2	*22,259*
Sand with Cobbles	-	-	62	38	-	*1,497*
Sand with Till	-	94	6	-	-	*4,228*
Clay	-	24	46	26	3	*48,626*
Clay with Boulders	-	-	-	100	-	*217*
Clay with Cobbles	-	11	89	-	-	*735*
Clay with Till	-	43	31	2	24	*13,880*
Peat	27	51	21	0	0	*176,671*
Peat with Cobbles	-	100	-	-	-	*2,990*
Peat with Cobbles and Boulders	-	-	100	-	-	*2,364*
Peat with Rock	-	100	-	-	-	*2,292*
Unknown	-	9	11	-	80	*40,938*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-49: Distribution of bank height class among the different bank height classes as a percentage of the total classified shoreline length for the bank height class in the Nelson River Study Area

Bank Type	Bank Height Class				
	No bank present	Low (~< 1 m)	Mixture of low & medium	Medium (~ 1 - 3 m)	Unknown
Bedrock	-	3	12	1	20
Boulder till	-	1	-	-	-
Cobbles	-	0	-	-	-
Gravel	-	-	0	-	-
Till	-	7	10	-	10
Sand	-	6	11	3	1
Sand with Cobbles	-	-	1	4	-
Sand with Till	-	3	0	-	-
Clay	-	8	21	88	3
Clay with Boulders	-	-	-	2	-
Clay with Cobbles	-	0	1	-	-
Clay with Till	-	4	4	2	6
Peat	100	62	34	1	1
Peat with Cobbles	-	2	-	-	-
Peat with Cobbles and Boulders	-	-	2	-	-
Peat with Rock	-	2	-	-	-
Unknown	-	3	4	-	60
Total mapped shoreline (m)	*47,992*	*147,731*	*109,470*	*14,458*	*54,440*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-50: Distribution of beach type among the different bank height classes as a percentage of the total classified shoreline length for the beach type in the Nelson River Study Area

Beach Type	Bank Height Class					*Total shoreline in beach type (m)*
	No bank present	Low (~< 1m)	Mixture of low & medium	Medium (~ 1 - 3m)	Unknown	
Bedrock	-	16	53	5	26	*56,181*
Boulders	-	36	45	7	12	*5,996*
Cobbles	-	39	29	2	29	*24,987*
Cobbles with Sand	-	50	3	-	47	*3,639*
Gravel	-	19	72	9	-	*2,661*
Till	-	59	41	-	-	*1,271*
Sand	3	50	43	1	2	*16,080*
Sand with Cobbles	-	61	30	9	-	*40,467*
Sand with Rock	-	-	65	15	20	*1,565*
Clay	15	30	41	11	3	*40,838*
Clay with Boulders	-	96	4	-	-	*2,569*
Clay with Cobbles	-	54	46	-	-	*10,017*
Clay with Gravel	-	9	79	12	-	*2,554*
Clay with Rock	-	-	33	67	-	*2,039*
Clay with Till	-	14	69	18	-	*1,215*
Peat	33	50	17	-	-	*125,623*
Peat with Cobbles	-	100	-	-	-	*5,787*
Peat with Cobbles and Boulders	-	-	100	-	-	*584*
Unknown	-	5	-	-	95	*30,018*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-51: Distribution of bank height class among the different beach types as a percentage of the total classified shoreline length for the bank height class in the Nelson River Study Area

Beach Type	Bank Height Class				
	No bank present	Low (~< 1 m)	Mixture of low & medium	Medium (~ 1 – 3 m)	Unknown
Bedrock	-	6	27	19	27
Boulders	-	1	2	3	1
Cobbles	-	7	7	4	14
Cobbles with Sand	-	1	0	-	3
Gravel	-	0	2	2	-
Till	-	1	0	-	-
Sand	1	5	6	2	0
Sand with Cobbles	-	17	11	25	-
Sand with Rock	-	-	1	2	1
Clay	13	8	15	31	2
Clay with Boulders	-	2	0	-	-
Clay with Cobbles	-	4	4	-	-
Clay with Gravel	-	0	2	2	-
Clay with Rock	-	-	1	9	-
Clay with Till	-	0	1	2	-
Peat	86	43	19	-	-
Peat with Cobbles	-	4	-	-	-
Peat with Cobbles and Boulders	-	-	1	-	-
Unknown	-	1	-	-	53
Total mapped shoreline (m)	*47,992*	*147,731*	*109,470*	*14,458*	*54,440*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Stephens Lake Study Area

Beach and bank material in the mapped portions of the Stephens Lake study area were quite different than that in the Gull Lake Study Area. Peat was by far the most common beach type (61%), followed by clay beach (Table 6-44). Peat and clay beach comprise 82% of the classified shoreline, and other beach types were relatively scarce. Approximately 14% of the mapped beach materials in this study area were classified as unknown.

Approximately 81% of the classified Stephens Lake study area shoreline had peat bank materials, primarily pure, or occasionally in a mixture with cobbles and/or boulders (Table 6-45). Overall, with respect to beach and bank materials, there was much less variability here than in the Gull Lake Study Area.

Bank height characteristics were also quite different in the classified portions of the Stephens Lake study area. In this study area, flat banks were the most frequent at 40% of the classified shoreline (Table 6-47). Low and medium height mixtures, and low banks comprise the remaining classified shoreline. The dominance of flat banks in this area reflected the high prevalence of peat shorelines.

Peat beach materials occurred in long stretches along the classified Stephens Lake study area shoreline, occasionally broken by shorter stretches of clay beach, while peat banks were distributed continuously along the classified shoreline (Map 6-23). Two shorter stretches of sand bank occurred on an island at the south end of the classified shore zone.

Mixed low and medium bank heights classified in the Stephens Lake study area tended to occur in long stretches on the northeast-facing shorelines of Stephens Lake (Map 6-24). Flat and low shorelines were most frequent along an island and the long bay at the north end of the classified shoreline.

Shore Zone Vegetation

Gull Lake Study Area

Vegetation was mapped for just over 245 km of shoreline in the Gull Lake Study Area. The following percentage figures were based on that total.

Emergent vegetation islands (patches separated from shoreline by water ≥ 10m wide) were detected for just over 1% of the classified Gull Lake Study Area shoreline. Most of the emergent vegetation islands were distributed upstream of Gull Lake, along small stretches of shoreline near Birthday Rapids (Map 6-25). Approximately 66% of the emergent vegetation islands in the Gull Lake Study Area was associated with marsh wetlands (Table 6-52). All of this wetland type was associated with emergent vegetation islands. Small proportions of the emergent vegetation islands were found along fens and shallow water.

Table 6-52: The distribution of emergent vegetation patches in the Nelson River Study Areas and off-system waterbodies among the different wetland types, and as a percentage of each wetland type

Wetland Type	Nelson River				Off-System	
	Gull Lake Study Area		Stephens Lake Study Area			
	% of emergent	% of wetland type	% of emergent	% of wetland type	% of emergent	% of wetland type
Bog	-	-	-	-	1	26.3
Wet Meadow	-	-	-	-	-	-
Fen	7	1.5	12	7.4	6	26.1
Marsh	66	100.0	78	100.0	74	97.5
Swamp	-	-	-	-	-	-
Shallow Water	7	0.1	10	1.3	19	16.3
Unknown	20	1.4	-	-	-	-
*Total emergent shoreline (m)**	*2,833*	*1.2%*	*10,704*	*8.9%*	*45,341*	*45.9%*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.
* Percentage values given in totals represent percentages of entire mapped shoreline of the study area or zone where emergent vegetation is present.

Tall shrubs were present (≥ 5% cover) in various densities along approximately 63% of the Gull Lake Study Area classified shoreline (Table 6-53). About 27% of the classified shoreline supported a wide tall shrub band, and 18% supported scattered tall shrubs. Most of the tall shrubs occurred on peat banks, with a variety of beach types (Table 6-54 and Table 6-55). Continuous and wide tall shrub bands also occurred less frequently on other bank materials, but scattered tall shrubs tended to occur more frequently over a wider range of bank materials. Although most tall shrubs were associated with a range of beach types, the wider tall shrub bands tended to be more strongly associated with peat beach types in combination with peat banks. In the Gull Lake Study Area tall shrubs were primarily distributed along the north and south shores of Gull Lake, where they were almost continuous, and often occurring in wide bands (Map 6-25). Upstream of Gull Lake, tall shrubs were discontinuous, usually occurring along the south bank.

Table 6-53: The distribution of the different types of tall shrub bands in the Nelson River study areas and off-system waterbodies as a percentage of total classified shoreline

Tall Shrub Band Type	Nelson River			Off-System
	Gull Lake Study Area	Stephens Lake Study Area	Total	
None	33	24	30	35
Present	19	27	22	40
Wide	24	18	22	4
Wide with graminoids	2	1	2	-
Scattered	18	30	22	20
Unknown	3	0	2	1
Total mapped shoreline (m)	*253,500*	*120,591*	*374,091*	*98,741*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

The most abundant plant species identified along the Keeyask Zone shoreline was black spruce, followed by willow species (*Salix* spp.), occurring along 75% and 63% of the classified shoreline, respectively (Table 6-56). Trembling aspen was also common along the shoreline. Other tree species included tamarack, jack pine and balsam poplar (*Populus balsamifera*), but these were relatively rare. Most of the other classified vegetation included low shrubs, grasses and sedges (*Carex* spp.), all of which were identified for less than 10% of the shoreline.

The most abundant emergent species identified along the Gull Lake Study Area shoreline were sedges, occurring along 1% of the shoreline (Table 6-56). Water horsetail and cat-tail were also identified, but were rare.

Table 6-54: The distribution of the different types of tall shrub bands among the different bank types in the Nelson River Study Area as a percentage of total classified shoreline

Bank Type	Tall Shrub Band Type					
	None	Present	Wide	Wide with graminoids	Scattered	Unknown
Bedrock	10	8	6	10	3	28
Boulder till	0	1	-	2	1	-
Cobbles	-	-	-	-	0	-
Gravel	0	-	-	-	-	-
Till	12	8	2	4	6	-
Sand	4	6	6	-	10	-
Sand with Cobbles	0	-	1	-	1	-
Sand with Till	-	2	1	-	3	-
Clay	30	4	2	-	11	5
Clay with Boulders	0	-	-	-	-	-
Clay with Cobbles	1	-	-	-	0	-
Clay with Till	7	1	2	11	3	-
Peat	25	57	70	73	48	4
Peat with Cobbles	0	-	1	-	2	-
Peat with Cobbles and Boulders	0	-	1	-	1	-
Peat with Rock	0	0	2	-	-	-
Unknown	10	13	5	-	10	63
Total mapped shoreline (m)	*112,178*	*81,887*	*82,403*	*6,442*	*82,127*	*9,054*

Notes: Cells with 0 values are values that round to 0 while blank cells indicate a value of 0.

Table 6-55: The distribution of the different types of tall shrub bands among the different beach types in the Nelson River Study Area as a percentage of total classified shoreline

Beach Type	Tall Shrub Band Type					
	None	Present	Wide	Wide with graminoids	Scattered	Unknown
Bedrock	27	8	9	7	10	30
Boulders	3	2	1	-	1	-
Cobbles	8	9	4	-	3	21
Cobbles with Sand	2	-	0	-	1	-
Gravel	1	0	-	-	2	-
Till	1	-	-	8	0	-
Sand	4	6	5	-	3	0
Sand with Cobbles	7	17	6	-	16	-
Sand with Rock	1	0	0	-	0	-
Clay	10	12	9	16	13	9
Clay with Boulders	0	1	2	-	0	-
Clay with Cobbles	4	2	1	-	3	-
Clay with Gravel	1	1	-	7	1	-
Clay with Rock	1	0	-	-	-	-
Clay with Till	1	0	-	-	-	-
Peat	21	27	56	62	37	-
Peat with Cobbles	0	3	3	-	1	-
Peat with Cobbles and Boulders	-	1	-	-	-	-
Unknown	7	11	3	-	9	41
Total mapped shoreline (m)	*112,178*	*81,887*	*82,403*	*6,442*	*82,127*	*9,054*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-56: Species presence as a percentage of total classified shoreline on the Nelson River and off-system waterbodies as mapped from helicopter-based photos, by water depth zone

Water Depth Zone	Species or Vegetation Type	Nelson River			Off-System
		Gull Lake Study Area	Stephens Lake Study Area	Total	
Upper Beach/ Inland Edge	*Carex* spp	2	27	10	31
	Cladina spp	-	-	-	0
	Equisetum fluviatile	-	-	-	1
	Grass spp	3	-	2	-
	Chamaedaphne calyculata	-	-	-	3
	Herb rich	0	-	0	-
	Herb rich (burn)	-	0	0	-
	Low shrub	6	-	4	-
	Low shrub (burn)	2	24	9	-
	Salix spp	63	73	66	80
	Picea mariana	75	67	72	79
	Picea mariana snags	-	-	-	0
	Larix laricina	4	14	7	12
	Pinus banksiana	0	2	1	-
	Populus balsamifera	0	0	0	10
	Populus tremuloides	11	-	8	-
	Betula papyrifera	-	-	-	3
Emergent	*Calla palustris*	-	-	-	3
	Carex spp	1	9	4	27
	Eleocharis palustris	-	-	-	1
	Equisetum fluviatile	-	4	1	21
	Typha spp	0	1	0	-
	Potamogeton gramineus	-	-	-	1
	Schoenoplectus tabernaemontani	-	-	-	6
	Nuphar lutea ssp. *variegata*	-	-	-	11
Total mapped shoreline (m)		*245,468*	*120,589*	*366,057*	*98,739*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0. Nomenclature follows Flora of North America where volumes currently exist for the genus and the Manitoba Conservation Data Centre elsewhere.

Stephens Lake Study Area

Compared to the Gull Lake Study Area, emergent vegetation islands occurred more frequently along the classified portions of the Stephens Lake study area shoreline (nearly 9%; Map 6-25). Associations with different wetland types were similar in the Stephens Lake and Gull Lake Study Areas, with most of the emergent vegetation islands associated with marsh wetlands, 100% of which have emergent vegetation islands (Table 6-52). Fen and shallow water wetland types each had a larger proportion of their classified shoreline associated with emergent vegetation islands compared to the Gull Lake Study Area.

Tall shrubs were more frequent along the Stephens Lake study area shoreline, present in various densities along approximately 76% of the classified shoreline (Table 6-53). Wide tall shrub bands were not as abundant along the classified Stephens Lake study area shoreline compared to the Gull Lake Study Area, and scattered tall shrubs made up a higher proportion. Tall shrubs were distributed evenly along the entire classified shoreline of Stephens Lake study area (Map 6-25).

Along the classified Stephens Lake study area shoreline, willows were the most abundant species, followed by black spruce (73% and 67%, respectively; Table 6-56). Compared to the Gull Lake Study Area, tamarack was much more abundant along the shoreline, and there was more jack pine, while there was very little trembling aspen. Low shrub species and sedges were also far more abundant in the Stephens Lake study area compared to the Gull Lake Study Area. Large areas of low shrubs in recently burned areas occurred along the central portions of the classified shoreline. There were also large stretches of shoreline dominated by sedges in the long narrow bay in the north.

6.3.2.3.3 Off-System Shoreline Detail

Shore zone wetlands were classified for over 1,300 lineal km of shorelines in off-system waterbodies in the Regional and Study Zone 4. This included 457 lakes (503 km), and 814 km of waterways and small ponds (Table 6-57).

Over 98 lineal km, or 7.5% of the photo-interpreted terrestrial habitat shoreline was helicopter-photo mapped and classified in 14 off-system waterbodies within the Regional Study Area (Map 6-22). The three largest waterbodies comprised over 51% of the total off-system helicopter-photo classified shoreline, and the smallest waterbody had a total shoreline length of just under 2 km.

Nearly 38% of the helicopter-photo classified off-system shoreline (four lakes) also underwent detailed classification from boat surveys. A portion of the Fox River shoreline was also surveyed by boat, but was not classified by helicopter-photo. In total, nearly 51 lineal km of lineal shoreline underwent detailed classification.

Table 6-57: Photo-interpreted shore zone wetland types in the off-system lakes as a percentage of total classified shoreline length

Wetland Type	Waterbody Type			All
	Lake	Waterway	Small Pond	
Shallow Water	58	67	70	64
Bog	1	-	0	0
Fen	23	21	16	21
Marsh	18	12	15	15
Total Classified Shoreline (km)	*502.6*	*674.4*	*139.8*	*1,316.8*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Beach And Bank Characteristics

The proportion of peat beach materials in the off-system waterbodies was intermediate to that of the Keeyask and Stephens Lake reaches of the Nelson River (Table 6-44). Most of the remaining beach materials were comprised of mineral materials and cobbles. Compared to the Nelson River study areas, in the off-system waterbodies there was a much lower proportion of bedrock, and a higher proportion of cobbles and boulder beach materials. Approximately 3% of the beach materials were classified as unknown.

Peat materials comprised a much higher proportion of bank materials in the off-system waterbodies compared to the overall Nelson River study areas, but the proportion was very similar to that of the Stephens Lake study area (Table 6-45). Peat banks, and peat mixed with other materials comprise 91% of the off-system bank materials altogether. Unclassified mineral bank, and small amounts of other materials made up the remaining bank materials. Overall, mineral bank material types were scarce compared to the Nelson River study areas, particularly the Gull Lake Study Area.

The most common beach types were almost entirely associated with peat bank materials, largely due to the dominance of this bank type in the off-system waterbodies (Table 6-58). Mineral beaches tended to be somewhat more strongly associated with bank materials that were a mixture of peat, cobbles, and boulders. Conversely, all of the beaches of mixed peat, cobbles and boulders were associated with mineral banks. A large proportion of the till beaches were associated with till bank types. However, these latter two types were rare, and these associations should be interpreted with caution.

Table 6-58: Distribution of common beach material types among common bank material types as a percentage of total mapped shoreline in beach type in the off-system waterbodies

Beach Material	Bank Material						*Total shoreline in beach type (m)*
	Boulders	Cobbles	Mineral	Peat	Peat with Cobbles and Boulders	Unknown	
Boulders	-	-	-	83	-	-	*12,044*
Cobbles	-	-	-	87	-	-	*18,984*
Mineral	1	7	6	44	45	2	*23,013*
Peat	-	0	-	100	-	-	*37,183*
Unknown	-	-	51	49	-	-	*2,825*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Bank height was generally lower in the off-system waterbodies compared to the Nelson River study areas. Low banks (<1 m high) were the most frequent (61%), followed by flat banks, which together comprise over 98% of bank heights in the off-system waterbodies (Table 6-47). Nearly all of the bank material types were associated with low bank heights in the off-system waterbodies, with the exception of till materials, 100% of which was associated with flat banks, and peat, which occurred on both flat and low banks (Table 6-59). On the other hand, flat bank heights, mixed low and medium bank heights, and medium heights were almost always associated with peat banks in the off-system waterbodies (Table 6-60). This relationship was similar for beach materials, however some till beaches were associated with medium bank heights (Table 6-61 and Table 6-62).

Table 6-59: Distribution of bank type among the different bank height classes as a percentage of the total classified shoreline length for the bank type in the off-system waterbodies

Bank Material	Bank Height				*Total shoreline in bank type (m)*
	No bank present	Low (~< 1m)	Mixture of low & medium	Medium (~ 1 - 3m)	
Bedrock	-	80	20	-	*440*
Boulders	-	100	-	-	*581*
Cobbles	5	95	-	-	*1,473*
Till	100	-	-	-	*289*
Sand	-	100	-	-	*632*
Clay with Boulders	-	100	-	-	*642*
Mineral	-	100	-	-	*3,965*
Peat	45	53	1	1	*78,363*
Peat with Cobbles and Boulders	13	87	-	-	*11,964*
Unknown	-	100	-	-	*392*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-60: Distribution of bank height class among the different bank types as a percentage of the total classified shoreline length for the bank height class in the off-system waterbodies

Bank Material	Bank Height			
	No bank present	Low (~< 1 m)	Mixture of low & medium	Medium (~ 1 – 3 m)
Bedrock	-	1	9	-
Boulders	-	1	-	-
Cobbles	0	2	-	-
Till	1	-	-	-
Sand	-	1	-	-
Clay with Boulders	-	1	-	-
Mineral	-	7	-	-
Peat	95	69	91	100
Peat with Cobbles and Boulders	4	17	-	-
Unknown	-	1	-	-
Total mapped shoreline (m)	*37,137*	*59,821*	*981*	*802*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-61: Distribution of beach type among the different bank height classes as a percentage of the total classified shoreline length for the beach type in the off-system waterbodies

Beach Type	Bank Height				*Total shoreline in beach type (m)*
	No bank present	Low (~< 1 m)	Mixture of low & medium	Medium (~ 1 – 3 m)	
Bedrock	-	91	9	-	*948*
Boulders	4	95	-	1	*12,044*
Cobbles	8	90	-	1	*18,984*
Till	63	-	-	37	*459*
Sand	75	25	-	-	*1,424*
Clay	-	100	-	-	*755*
Clay with Cobbles	100	-	-	-	*341*
Mineral	9	91	-	-	*23,013*
Peat	84	13	2	1	*37,183*
Peat with Cobbles and Boulders	-	100	-	-	*765*
Unknown	-	100	-	-	*2,825*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-62: Distribution of bank height class among the different beach types as a percentage of the total classified shoreline length for the bank height class In the off-system waterbodies

Beach Material	Bank Height			
	No bank present	Low (~< 1 m)	Mixture of low & medium	Medium (~ 1 – 3 m)
Bedrock	-	1	9	-
Boulders	1	19	-	19
Cobbles	4	29	-	35
Till	1	-	-	21
Sand	3	1	-	-
Clay	-	1	-	-
Clay with Cobbles	1	-	-	-
Mineral	6	35	-	-
Peat	84	8	91	25
Peat with Cobbles and Boulders	-	1	-	-
Unknown	-	5	-	-
Total mapped shoreline (m)	*37,137*	*59,821*	*981*	*802*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Shore Zone Vegetation

Emergent vegetation islands were much more frequent in the off-system waterbodies than the Nelson River study areas, detected for nearly 46% of the classified shoreline (Table 6-52). Emergent vegetation islands in the off-system waterbodies were associated with the same types of wetlands, and distributed between these wetlands in similar proportions. However, a slightly larger proportion of open shallow water supported emergent vegetation islands in the off-system waterbodies. Similar to the Nelson River study areas, nearly all of the marsh wetlands were associated with emergent vegetation islands.

Tall shrubs were present in various densities along approximately 64% of the classified shoreline in the off-system waterbodies (Table 6-53). Characteristics of the tall shrub band here were very similar to that of the Stephens Lake study area in the Nelson River study areas. Tall shrubs in the off-system waterbodies were primarily associated with peat bank materials, but were evenly associated with a relatively wide range of beach materials, including peat, mineral, cobbles and boulders (Table 6-63 and Table 6-64).

Table 6-63: The distribution of the different types of tall shrub bands among the different bank types in the off-system waterbodies as a percentage of total classified shoreline

Bank Material	Tall Shrub Band Type				
	None	Present	Wide	Scattered	Unknown
Bedrock	-	1	2	0	-
Boulders	-	1	-	1	-
Cobbles	-	2	-	3	-
Till	1	-	-	-	-
Sand	-	2	-	-	-
Clay with Boulders	-	-	-	3	-
Mineral	8	1	-	4	-
Peat	82	75	98	79	100
Peat with Cobbles and Boulders	9	18	-	9	-
Unknown	-	1	-	-	-
Total mapped shoreline (m)	*34,846*	*39,667*	*3,693*	*19,738*	*797*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-64: The distribution of the different types of tall shrub bands among the different beach types in the Nelson River Study Area as a percentage of total classified shoreline

Beach Material	Tall Shrub Band Type				
	None	Present	Wide	Scattered	Unknown
Bedrock	1	1	-	0	-
Boulders	5	12	5	27	-
Cobbles	7	27	38	23	15
Till	1	-	-	-	-
Sand	-	2	7	1	-
Clay	-	2	-	-	-
Clay with Cobbles	0	-	5	-	-
Mineral	25	29	-	12	14
Peat	53	26	45	31	71
Peat with Cobbles and Boulders	-	-	-	4	-
Unknown	7	0	-	2	-
Total mapped shoreline (m)	*34,846*	*39,667*	*3,693*	*19,738*	*797*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

A total of 12 shore zone taxa were identified along the off-system waterbodies shoreline, and willow and black spruce were the most abundant species (Table 6-56). These species were somewhat more abundant in off-system waterbodies than along the Nelson River study areas shoreline. Balsam poplar was relatively common along the shoreline here, having the same proportion as trembling aspen in the Nelson River study areas, however trembling aspen was not identified along the off-system waterbodies shorelines. White birch was also identified in this zone, but was not frequent. Sedges were also frequent shore zone species in the off-system waterbodies, and occurred in slightly higher proportions than in the Stephens Lake study area of the Nelson River study areas.

Compared to the Nelson River study areas, more emergent taxa (8) were identified along the off-system waterbodies shoreline (Table 6-56). As in the Nelson River study areas, sedges and water horsetail were the most common species identified, but yellow pond-lily was also common.

All of the vegetated off-system wetlands were primarily associated with peat beach and bank materials (Table 6-65 and Table 6-66). Occasionally marshes were associated with mineral or cobble beach materials, and rarely sand bank types. Fens were occasionally associated with cobble beach types. Shallow water was distributed across all beach and bank materials.

All the vegetated wetland types were most frequent along shore segments without banks, and were also common with low bank heights (Table 6-67). A small proportion of fens also were associated with low and medium bank height mixtures. Very little open shallow water was associated with the absence of banks in the off-system waterbodies.

Table 6-65: Distribution of wetland types among the different beach types in the off-system lakes as a percentage of the total classified shoreline for each wetland type

Beach Material	**Wetland Type**			
	Bog	**Fen**	**Marsh**	**Shallow Water**
Bedrock	-	-	0	2
Boulders	-	-	3	21
Cobbles	-	2	7	32
Till	-	-	-	1
Sand	-	-	1	2
Clay	-	-	-	1
Clay with Cobbles	-	-	1	-
Mineral	-	-	17	33
Peat	100	98	68	2
Peat with Cobbles and Boulders	-	-	-	1
Unknown	-	-	3	4
Total mapped shoreline (m)	*1,473*	*11,254*	*34,470*	*51,544*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-66: Distribution of wetland types among the different bank types in the off-system lakes as a percentage of the total classified shoreline for each wetland type

Bank Material	Wetland Type			
	Bog	Fen	Marsh	Shallow Water
Bedrock	-	-	-	1
Boulders	-	-	-	1
Cobbles	-	-	0	3
Till	-	-	-	1
Sand	-	-	1	0
Clay with Boulders	-	-	-	1
Mineral	-	-	2	7
Peat	100	100	94	65
Peat with Cobbles and Boulders	-	-	2	22
Unknown	-	-	1	-
Total mapped shoreline (m)	*1,473*	*11,254*	*34,470*	*51,544*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-67: Distribution of wetland types among the different bank heights in the off-system lakes as a percentage of the total classified shoreline for each wetland type

Wetland Type	Bank Height				*Total shoreline in wetland type (m)*
	No bank present	Low (~< 1 m)	Mixture of low & medium	Medium (~ 1 – 3 m)	
Bog	80	20	-	-	*1,473*
Fen	78	19	3	-	*11,254*
Marsh	71	29	-	-	*34,470*
Shallow Water	6	92	1	2	*51,544*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Detailed Wetland Mapping

The results presented in this section were generally based on all waterbodies where detailed boat-based mapping was conducted. The exceptions were when comparisons were being made with attributes from helicopter-photo mapping; then only waterbodies where both were conducted were used.

Of the 50.9 km of off-system waterbody detailed mapping shoreline, the most common submerged substrate type was clay, where it was the dominant substrate type along 39% of the classified shoreline (Table 6-68). Deep sedimentary organic, sand and cobbles and stones were also common substrate types. When comparing submerged substrate to the remotely classified beach materials, mineral substrates tended to be strongly associated with mineral beach materials. Deep in-situ organic materials tended to be most strongly associated with peat beach materials, while thin in-situ organic were common with peat, clay and mineral beach materials (Table 6-69).

Table 6-68: Primary submerged substrate types along the off-system detailed mapping shoreline as a percentage of total mapped shoreline

Primary Submerged Substrate	Total Percentage
Cobble and stone	11
Gravel	9
Sand	12
Clay	39
Thin sedimentary organic	4
Deep sedimentary organic	18
Thin organic in place	3
Deep organic in place	2
Unknown	1
Total mapped shoreline (m)	*50,867*

Table 6-69: Distribution of primary submerged substrate types across beach material types as a percentage of total submerged substrate shoreline length

Primary Submerged Substrate	Beach Material							*Total shoreline in substrate type (m)*
	Boulders	Cobbles	Clay	Mineral	Peat	Peat with Cobbles and Boulders	Unknown	
Cobble and stone	8	13	1	71	3	3	-	*3,895*
Gravel	2	22	-	72	3	-	2	*1,665*
Sand	5	14	2	69	3	2	6	*4,386*
Clay	6	5		60	19	4	6	*14,163*
Thin sedimentary organic	-	-	-	60	31	-	9	*1,021*
Deep sedimentary organic	-	-	-	55	28	-	18	*8,365*
Thin organic in place	-	7	47	21	25	-	-	*1,752*
Deep organic in place	-	-	2	27	71	-	-	*1,185*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Measured near-shore water depth in the off-system lakes was most frequently in the 0.5 to 1.0 m depth class at an average distance of 5 m from the shoreline (Table 6-70). The maximum depth class recorded was 1.0 to 1.5 m, but was uncommon, and only occurred in the two largest lakes that were mapped by boat. Conversely, the <0.5 m depth class was most abundant in the smallest lake. Water depth class does not appear to be strongly associated with classified beach and bank materials, or bank height (Table 6-71, Table 6-72 and Table 6-73). Depth classes were distributed proportionately over the different material types and bank height classes. However, medium bank heights were primarily associated with the 1.0 to 1.5 m depth class (Table 6-73).

Table 6-70: Water depth classes 5 m off the shoreline of the different off-system detailed mapping lakes

Water Depth Class	Lake 59 (Cyril Lake)	Lake 60	Lake 61	Lake 62	Fox River	All
< 0.5 m	39	22	68	97	14	38
0.5 to 1.0 m	58	78	32	3	58	53
1.0 to 1.5 m	3	-	-	-	28	9
Total mapped shoreline (m)	*24,156*	*3,452*	*6,136*	*3,180*	*13,937*	*50,861*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 6-71: Distribution of water depth classes among associated beach material types in the off-system lakes

Beach Material	Water Depth Class		
	< 0.5 m	0.5 to 1.0 m	1.0 to 1.5 m
Boulders	3	5	3
Cobbles	5	6	33
Mineral	54	64	31
Clay	5	0	-
Peat	23	15	23
Peat with Cobbles and Boulders	1	3	10
Unknown	9	6	-
Total mapped shoreline (m)	*17,465*	*18,372*	*650*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0. Mapped portions of the Fox River are excluded due to lack of remote data for comparison.

Table 6-72: Distribution of water depth classes among associated bank material types in the off-system lakes

Bank Material	Water Depth Class		
	< 0.5 m	0.5 to 1.0 m	1.0 to 1.5 m
Boulders	1	2	-
Cobbles	1	4	33
Sand	4	-	-
Clay with Boulders	2	1	-
Mineral	15	4	10
Peat	57	43	23
Peat with Cobbles and Boulders	18	47	34
Unknown	2	-	-
Total mapped shoreline (m)	*17,465*	*18,372*	*650*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0. Mapped portions of the Fox River are excluded due to lack of remote data for comparison.

Table 6-73: Distribution of water depth classes among associated bank heights in the off-system lakes

Bank Height	Water Depth Class		
	< 0.5 m	0.5 to 1.0 m	1.0 to 1.5 m
No bank present.	33	17	26
Low (~< 1 m)	65	82	65
Mixture of low & medium	1	1	-
Medium (~ 1 – 3 m)	-	0	9
Total mapped shoreline (m)	*17,465*	*18,372*	*650*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0. Mapped portions of the Fox River are excluded due to lack of remote data for comparison.

Willows and/or herbaceous wetland vegetation species were identified for approximately 87% of the total detailed mapping shoreline overall. Seven willow species were identified along 72% of the detailed mapping shoreline (Table 6-74 and Table 6-75). The most common willow species included tea-leaved willow, Bebb's willow (*Salix bebbiana*) and satin willow (*Salix pelita*), identified along 66%, 41% and 28% of the detailed mapping shoreline, respectively. The remaining species were rarely encountered, with all but one identified along less than 1% of the shoreline. One species encountered, shrubby willow (*Salix arbusculoides*) is considered uncommon in Manitoba (CDC rank is S3). Approximately 44% of the willow that was classified in the detailed mapping was classified as dense (continuous), and the remaining was classified as sparse (discontinuous; Table 6-74).

Table 6-74: Vegetation types identified along the detailed mapping shoreline in the off-system lakes as a percentage of total classified shoreline

Shoreline Vegetation Type	Total Percentage
Dense willow	44
Sparse willow	28
Emergent	53
Other	1
None present	13
Total mapped shoreline (m)	*50,867*

Speckled alder (*Alnus incana* ssp. *rugosa*), bog birch (*Betula pumila*) and sweet gale (*Myrica gale*) were the other non-emergent species identified along the detailed mapping shoreline (Table 6-75). However, these species were rarely encountered, each occurring along less than 1% of the detailed mapping shoreline.

A total of 17 emergent and floating-leaved species were identified in the detailed wetland mapping (Table 6-75). The most common species included water horsetail, creeping spike-rush, yellow pond-lily and bottle sedge. No other species occurred along more than 10% of the mapped shoreline.

Most emergent and floating-leaved species were associated with a range of submerged substrate types (Table 6-76). However, it should be noted that the substrates were not necessarily classified at the exact location that the plant was rooted. Submerged substrates dominated by clay and deep sedimentary organic materials tended to support the largest proportions of emergent species; however these substrates were also the most common.

Table 6-75: Species identified during detailed shoreline mapping in the off-system lakes as a percentage of total mapped shoreline

Species Type	Species	Total Percentage
Willow	*Salix arbusculoides*	1
	Salix bebbiana	41
	Salix myrtillifolia var. *cordata*	0
	Salix pedicellaris	0
	Salix pellita	28
	Salix planifolia	66
	Salix pseudomonticola	0
Other	*Alnus incana* ssp. *rugosa*	0
	Betula pumila	1
	Myrica gale	0
Emergent	*Carex aquatilis*	1
	Carex pellita	1
	Carex utriculata	11
	Eleocharis palustris	16
	Equisetum fluviatile	18
	Glyceria borealis	2
	Hippuris vulgaris	0
	Nuphar variegata	11
	Potamogeton gramineus	0
	Potamogeton richardsonii	0
	Potamogeton vaginatus	3
	Sagittaria cuneata	2
	Schoenoplectus tabernaemontanii	6
	Sparganium spp.	4
	Typha angustifolia	0
	Utricularia intermedia	0
	Utricularia vulgaris	0
Total detailed mapping shoreline (m)		*50,867*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0. Nomenclature follows Flora of North America where volumes currently exist for the genus and the Manitoba Conservation Data Centre elsewhere.

Table 6-76: Distribution of different emergent species across submerged substrate types as a percentage of total shoreline length that the species was present

Species	Primary Submerged Substrate Type								*Total shoreline length with species (m)*
	Cobble and stone	Gravel	Sand	Clay	Thin sedimentary organic	Deep sedimentary organic	Deep organic	Thin organic	
Carex aquatilis	-	8	16	9	44	23	-	-	*301*
Carex pellita	-	-	-	-	8	92	-	-	*615*
Carex utriculata	7	2	8	26	14	32	2	9	*5,736*
Eleocharis palustris	12	3	18	47	10	9	-	1	*8,218*
Equisetum fluviatile	7	2	10	55	4	17	4	2	*9,230*
Glyceria borealis	3	-	29	59	9	-	-	-	*947*
Hippuris vulgaris	-	-	100	-	-	-	-	-	*51*
Nuphar variegata	7	3	6	25	3	51	2	4	*5,627*
Potamogeton gramineus	-	33	-	33	-	33	-	-	*75*
Potamogeton richardsonii	66	-	-	8	-	11	15	-	*253*
Potamogeton vaginatus	24	6	17	53	-	-	-	-	*1,619*
Sagittaria cuneata	9	-	6	74	2	-	3	6	*1,148*
Schoenoplectus tabernaemontanii	11	2	11	70	-	-	-	5	*2,817*
Sparganium spp.	-	1	1	13	3	67	13	2	*1,843*
Typha angustifolia	-	-	-	80	-	-	-	20	*203*
Utricularia intermedia	-	-	-	-	-	100	-	-	*94*
Utricularia vulgaris	-	-	-	-	-	-	100	-	*31*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0. Only shoreline where substrate was classified is shown in species totals.

Emergent species were almost entirely confined to water depths of less than 1 metre (Table 6-77). Only two species were encountered in the 1.0 to 1.5 m depth class, including creeping spike-rush (*Eleocharis palustris*) and sheathed pondweed (*Potamogeton vaginatus*). Again, it should be noted that water depth was not necessarily measured at the exact location that the plant was rooted.

Table 6-77: Distribution of different emergent species across water depth classes as a percentage of total shoreline length that the species was present

Species	Water Depth Class			*Total shoreline length with species (m)*
	< 0.5 m	0.5 to 1.0 m	1.0 to 1.5 m	
Carex aquatilis	90	10	-	*325*
Carex pellita	8	92	-	*615*
Carex utriculata	39	56	5	*5,736*
Eleocharis palustris	38	58	5	*8,218*
Equisetum fluviatile	51	47	3	*9,230*
Glyceria borealis	12	88	-	*947*
Hippuris vulgaris	49	51	-	*51*
Nuphar variegata	54	46	-	*5,627*
Potamogeton gramineus	100	-	-	*75*
Potamogeton richardsonii	-	100	-	*253*
Potamogeton vaginatus	15	81	5	*1,619*
Sagittaria cuneata	54	46	-	*1,148*
Schoenoplectus tabernaemontanii	51	49	-	*2,817*
Sparganium spp.	29	71	-	*1,843*
Typha angustifolia	61	39	-	*203*
Utricularia intermedia	100	-	-	*94*
Utricularia vulgaris	-	100	-	*31*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

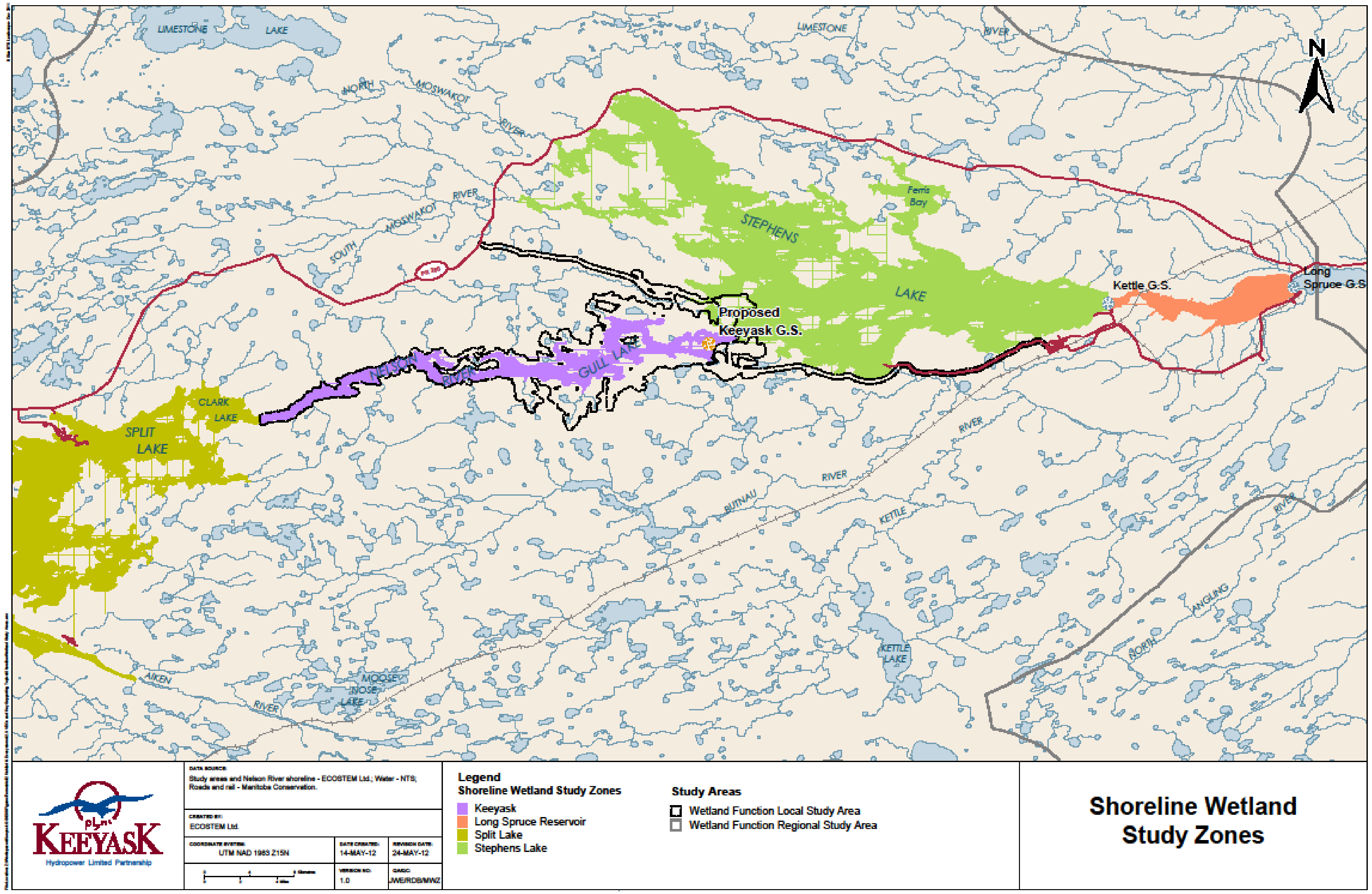
Individual species also tended to be associated with a range of wetland classes, but there were differences in the proportions of species within each wetland type. Bebb's and satin willow were more abundant in the marsh and shallow water wetland types, compared to fens. Water horsetail, viscid great-bulrush and bottle sedge were more abundant in the marsh wetlands, while yellow pond-lily was more abundant in the fen wetland type. Yellow pond-lily and bottle sedge were the only species recorded for the bog wetland type.

Table 6-78: Distribution of the five substrate classes among the shore zone replicate locations sampled in the Nelson River study areas and off-system lakes as a percentage of total number of replicates

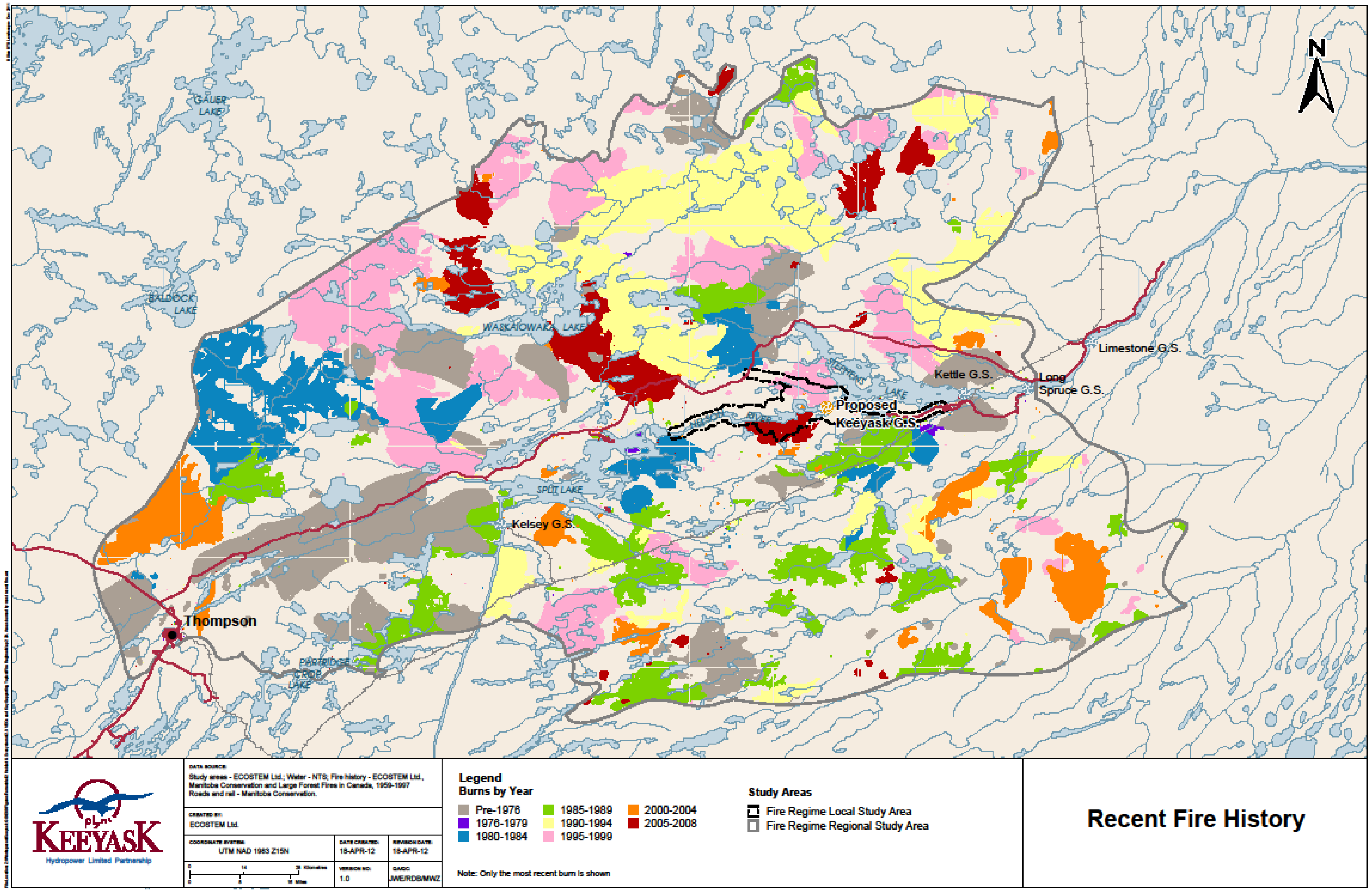
Substrate Class	Nelson River study areas			Off-System
	Gull Lake Study Area	Stephens Lake Study Area	Total	
Organic	18	56	36	47
Organic-mineral mix	35	38	36	44
Fine mineral	12	-	6	1
Mineral mixture	32	6	20	7
Coarse mineral	3	-	2	-
Total replicates	*34*	*32*	*66*	*68*

Notes: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

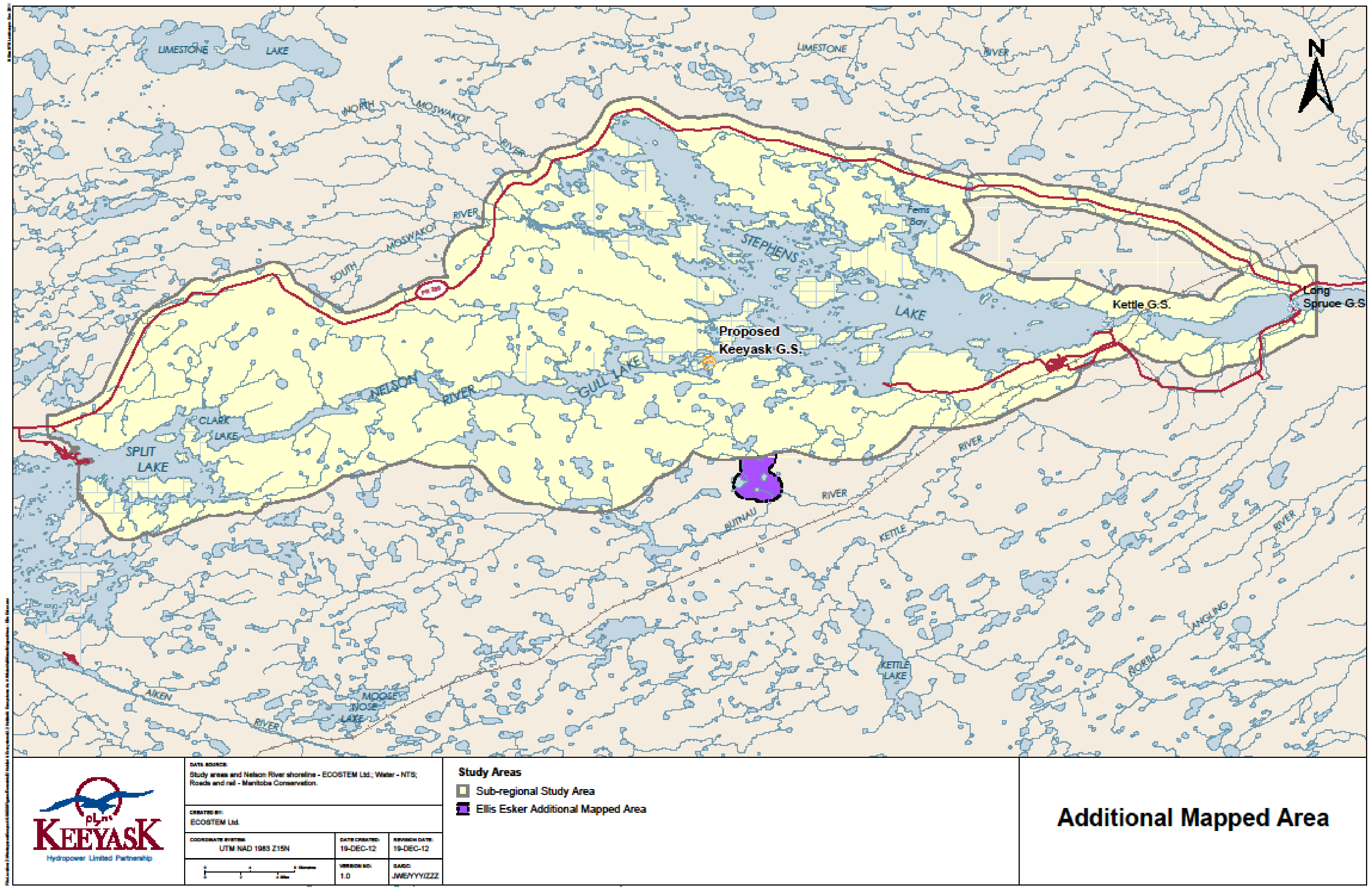
6.4 MAPS



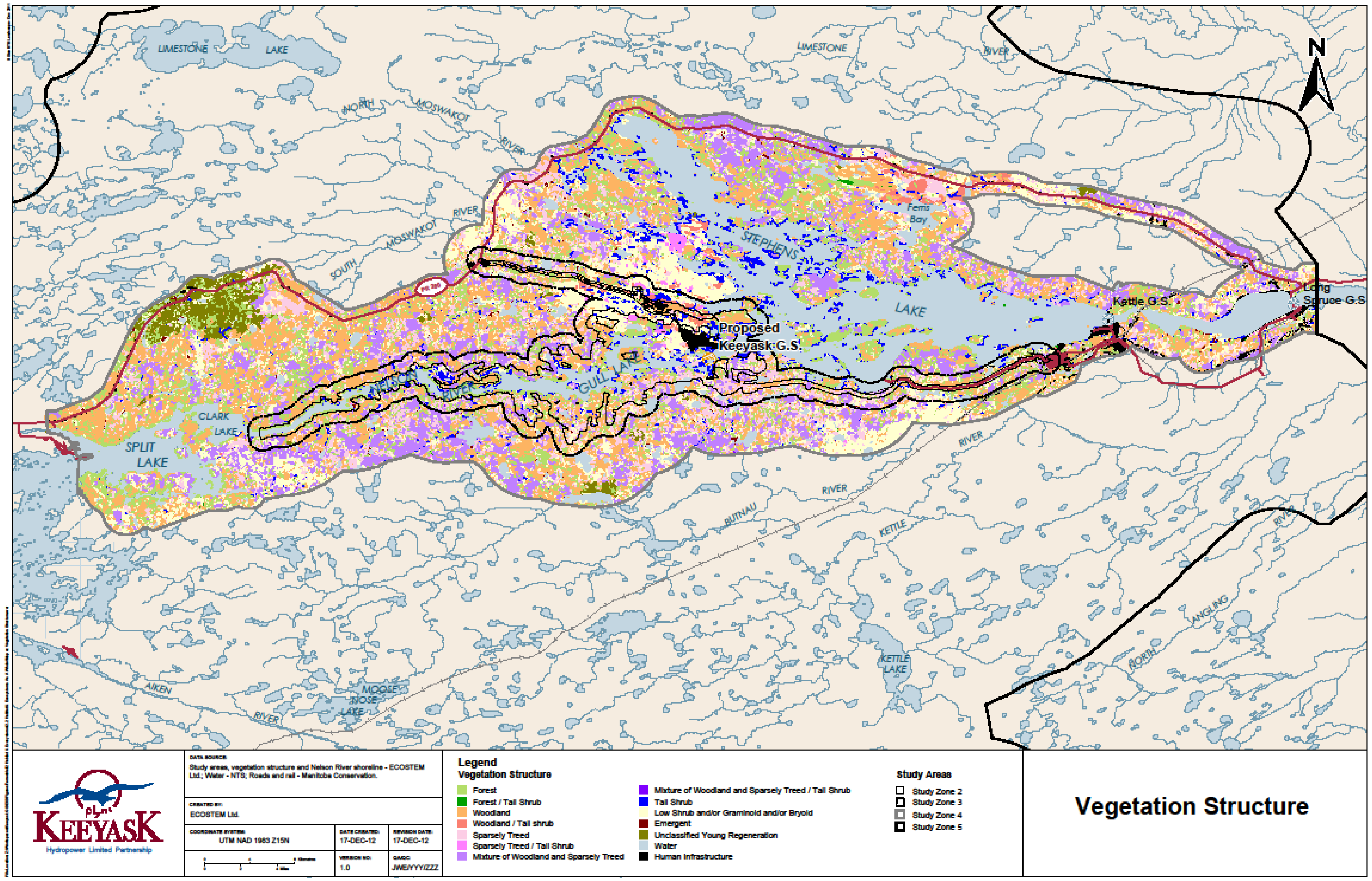
Map 6-1: Nelson river shore zone study zones



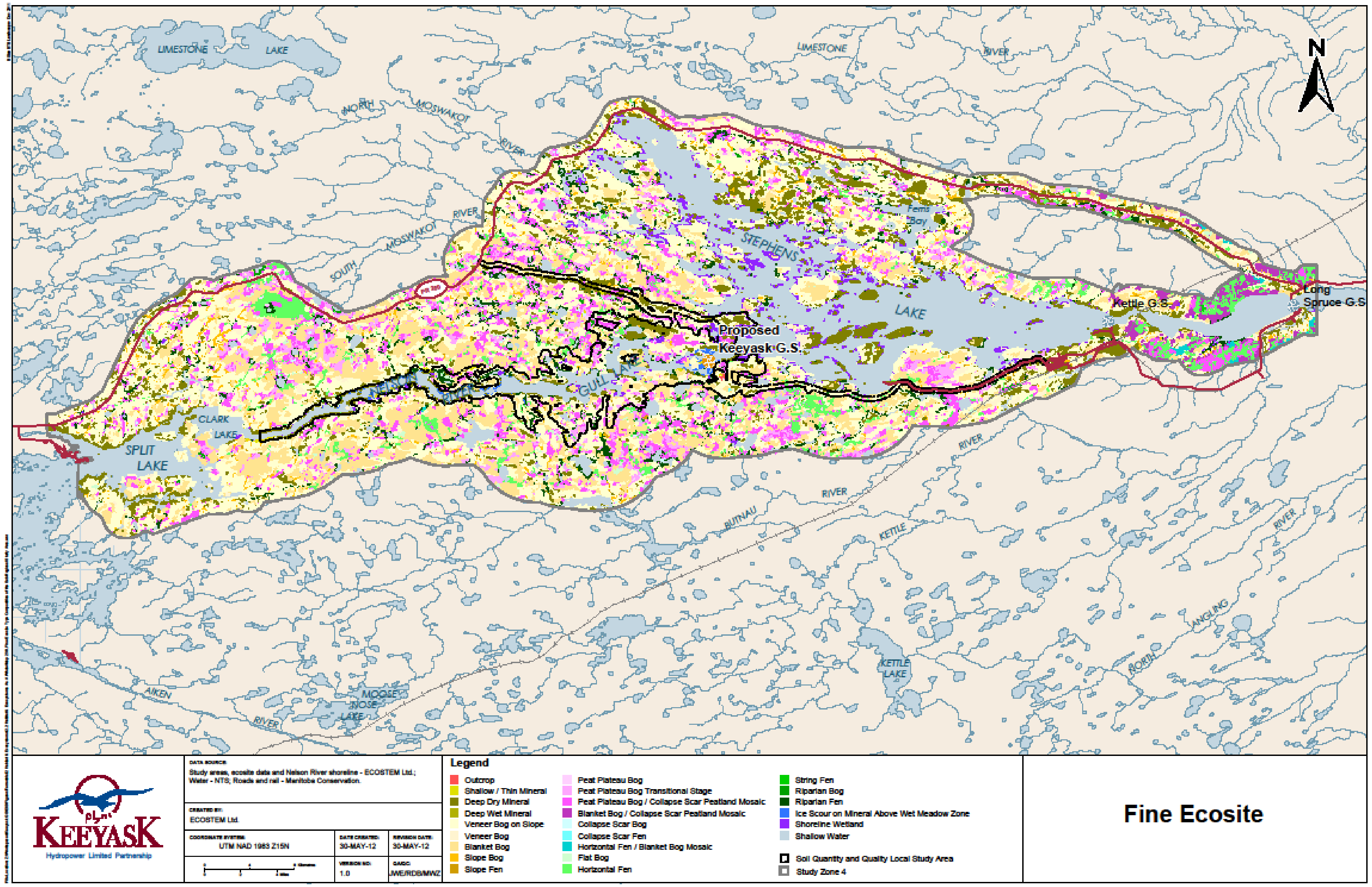
Map 6-2: **Areas burned by most recent fire in the Keeyask Fire Regime Study Area**



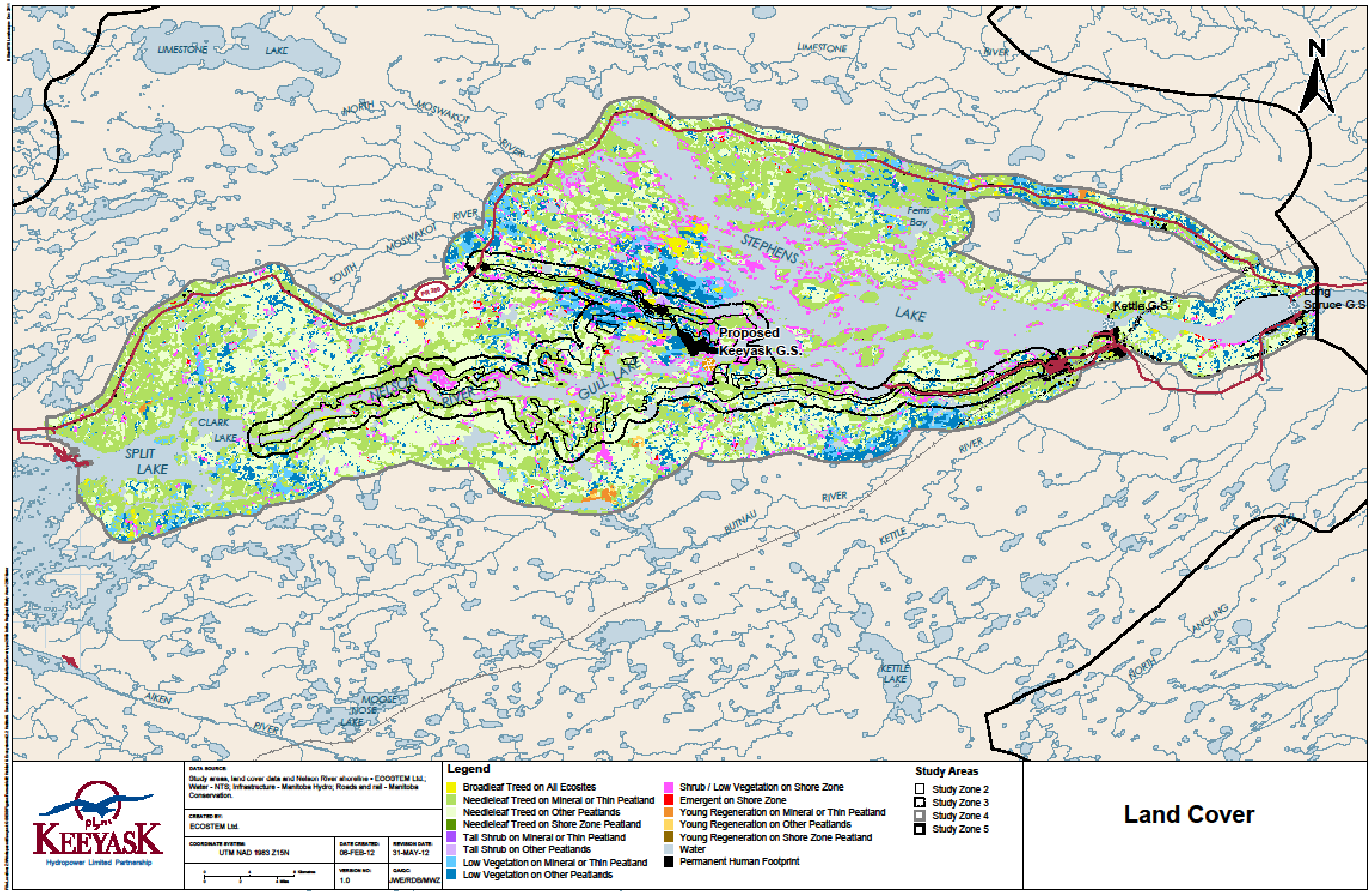
Map 6-3: **Ellis Esker mapping area**



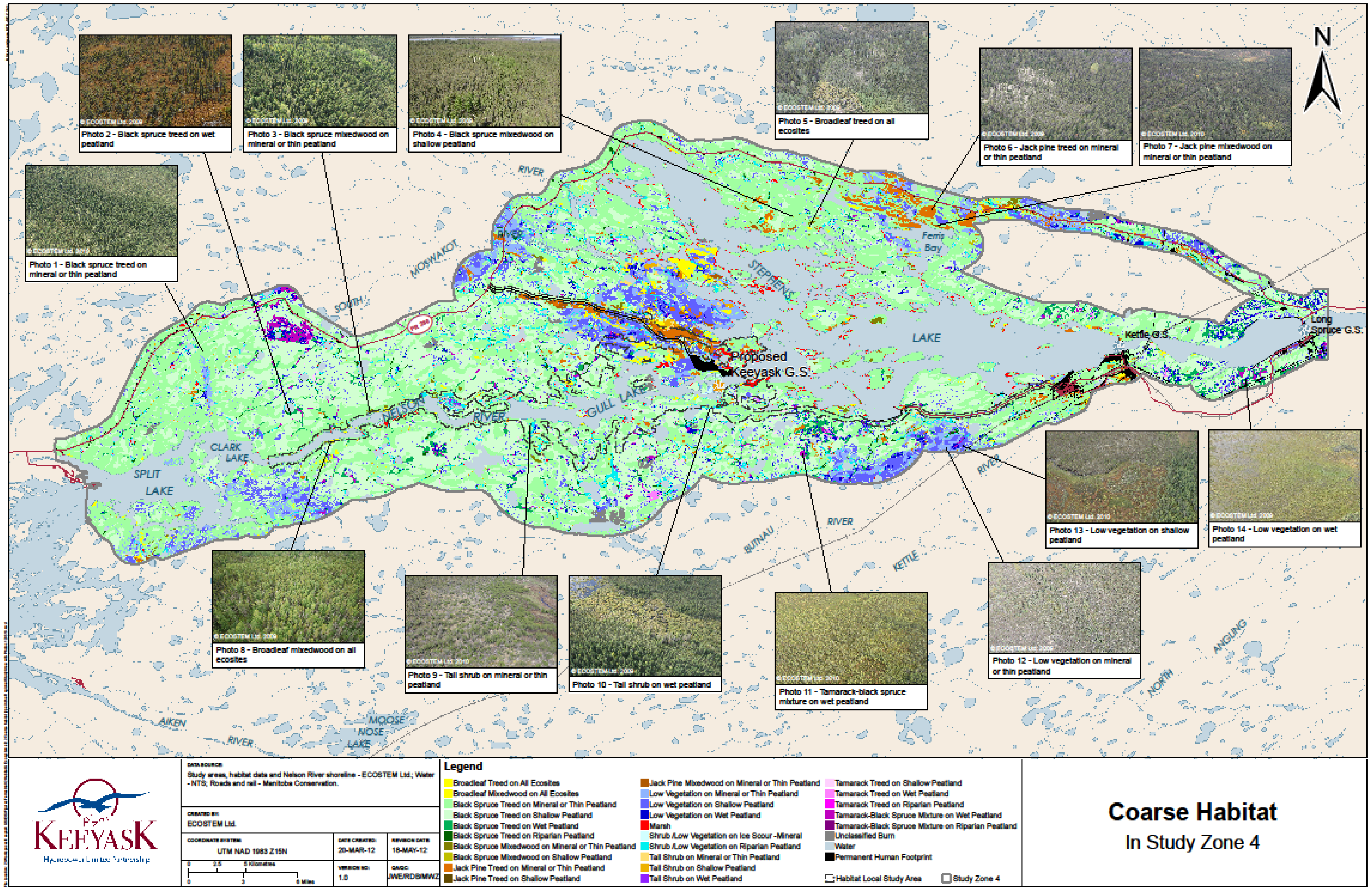
Map 6-4: **Vegetation structure composition of Keeyask Study Zone 4**



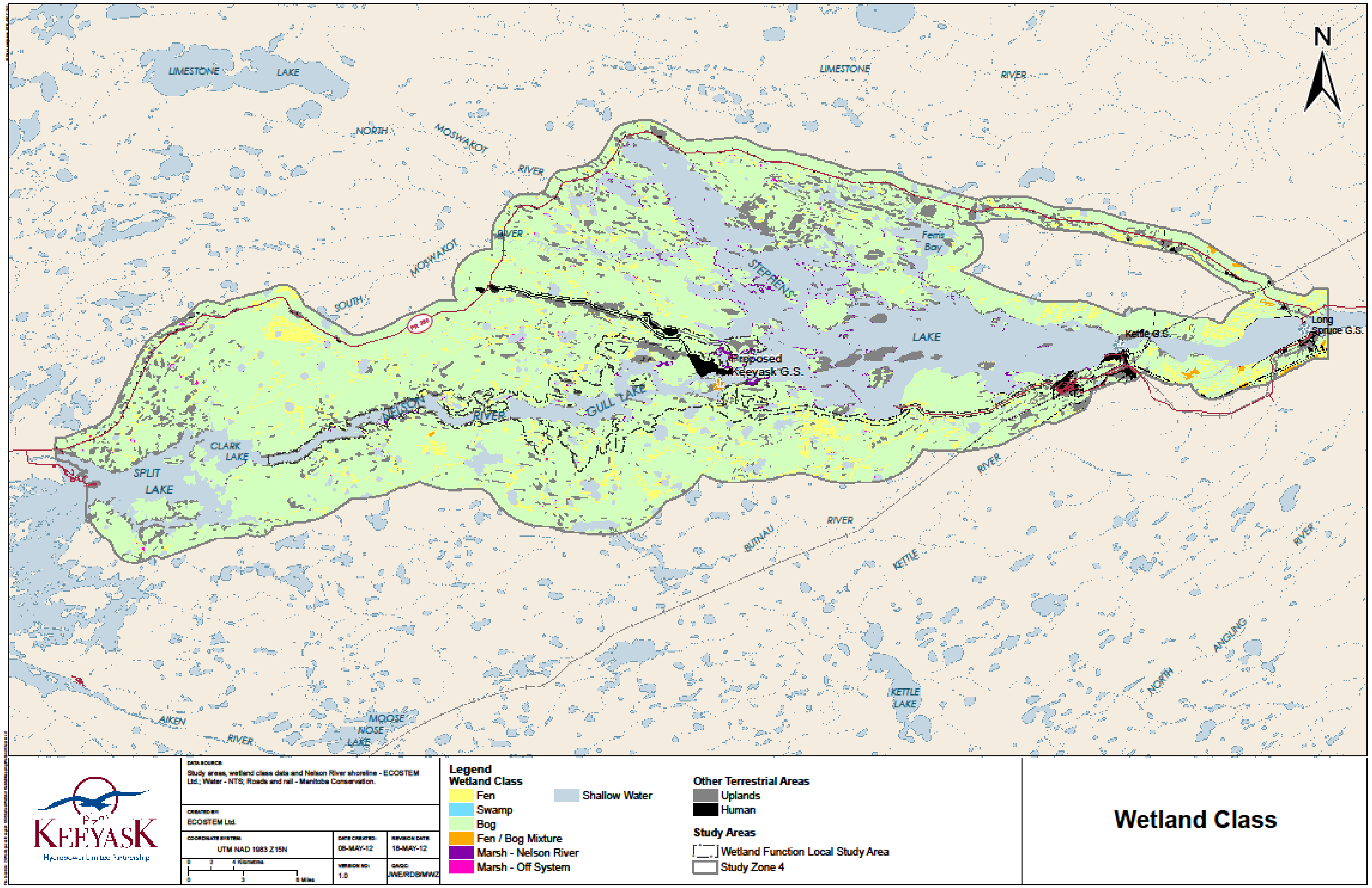
Map 6-5: Fine ecosite composition of Keeyask Study Zone 4



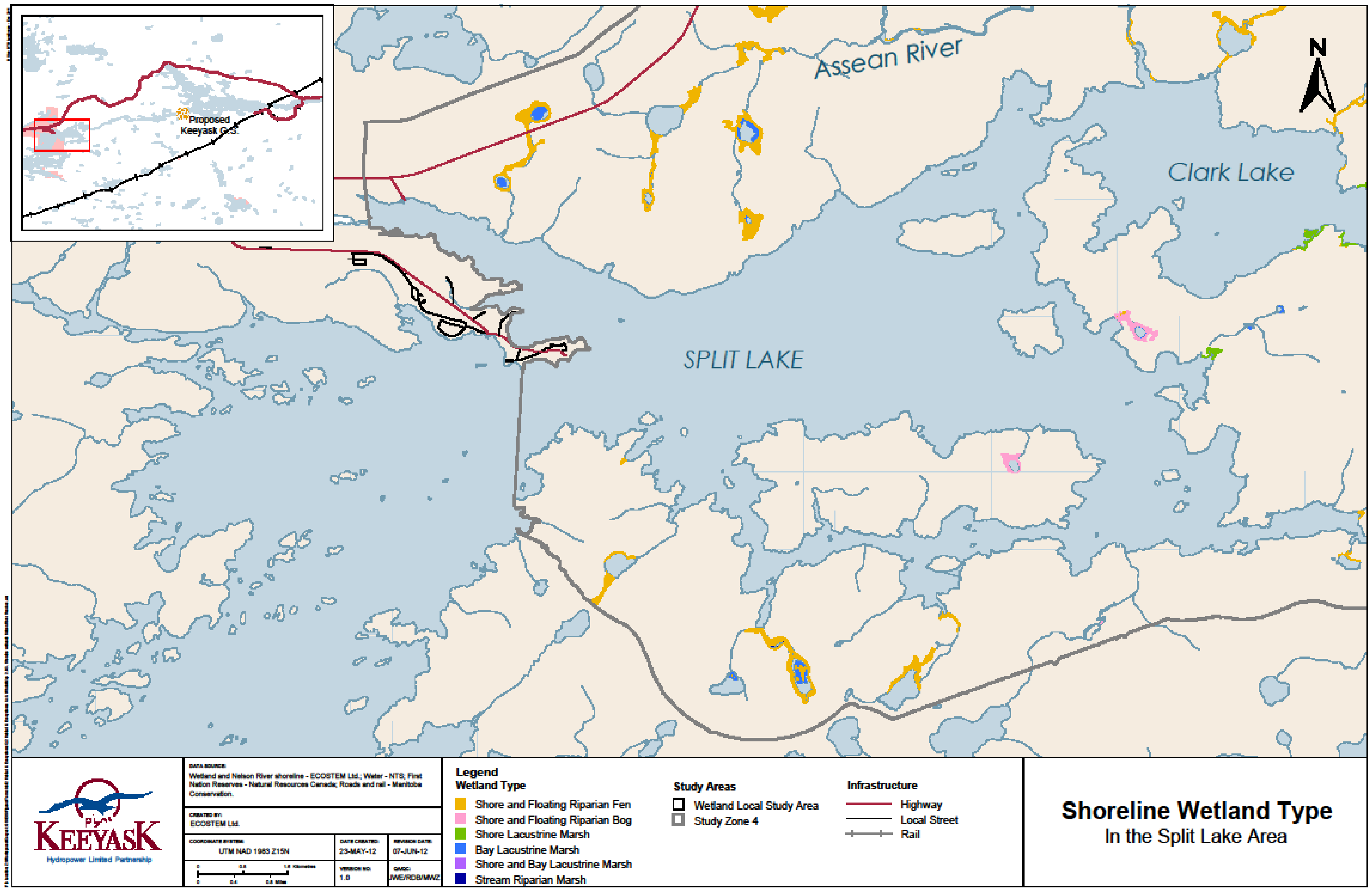
Map 6-6: Land cover composition of Keeyask Study Zone 4



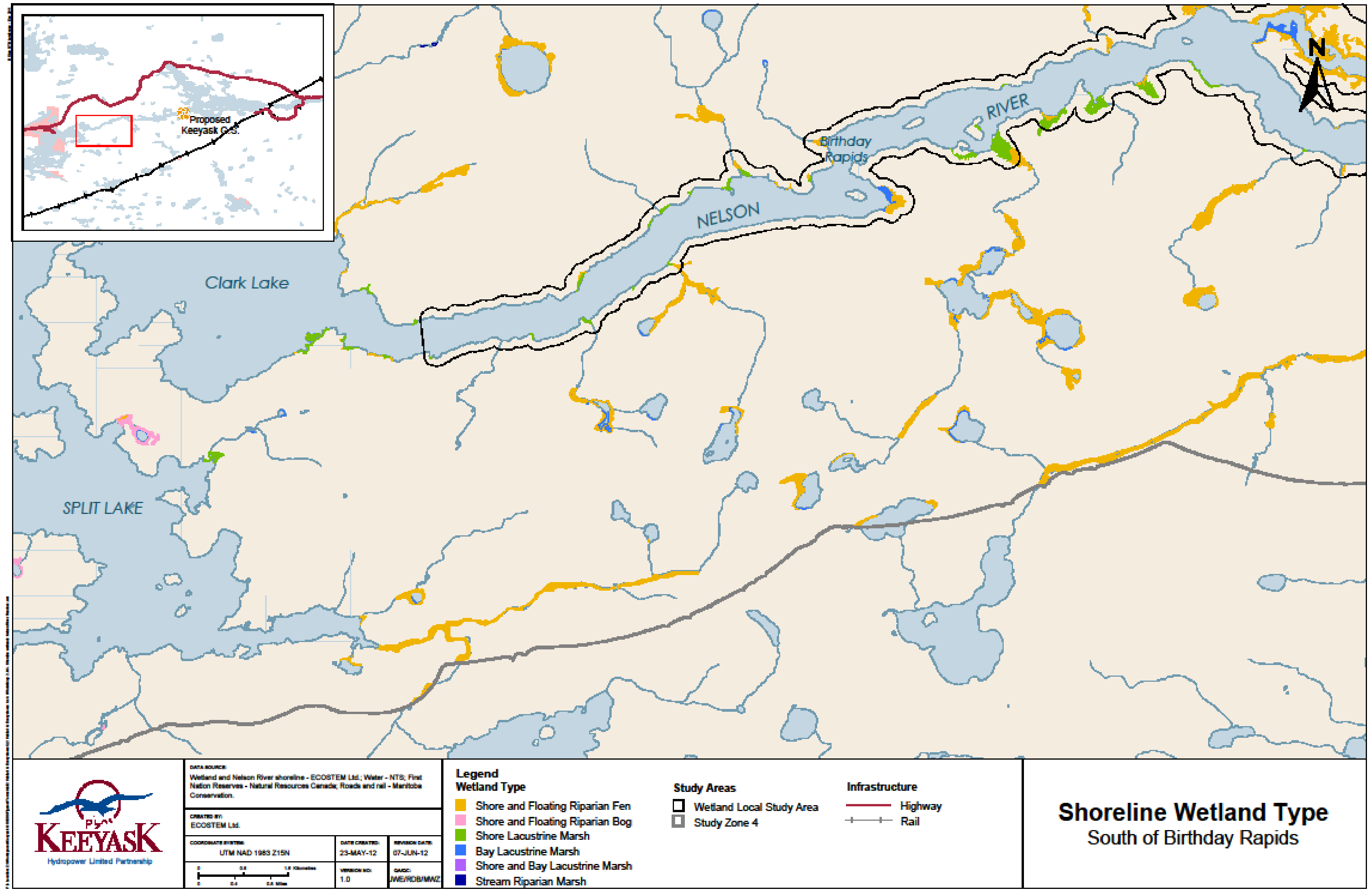
Map 6-7: **Coarse habitat composition of Keeyask Study Zone 4**



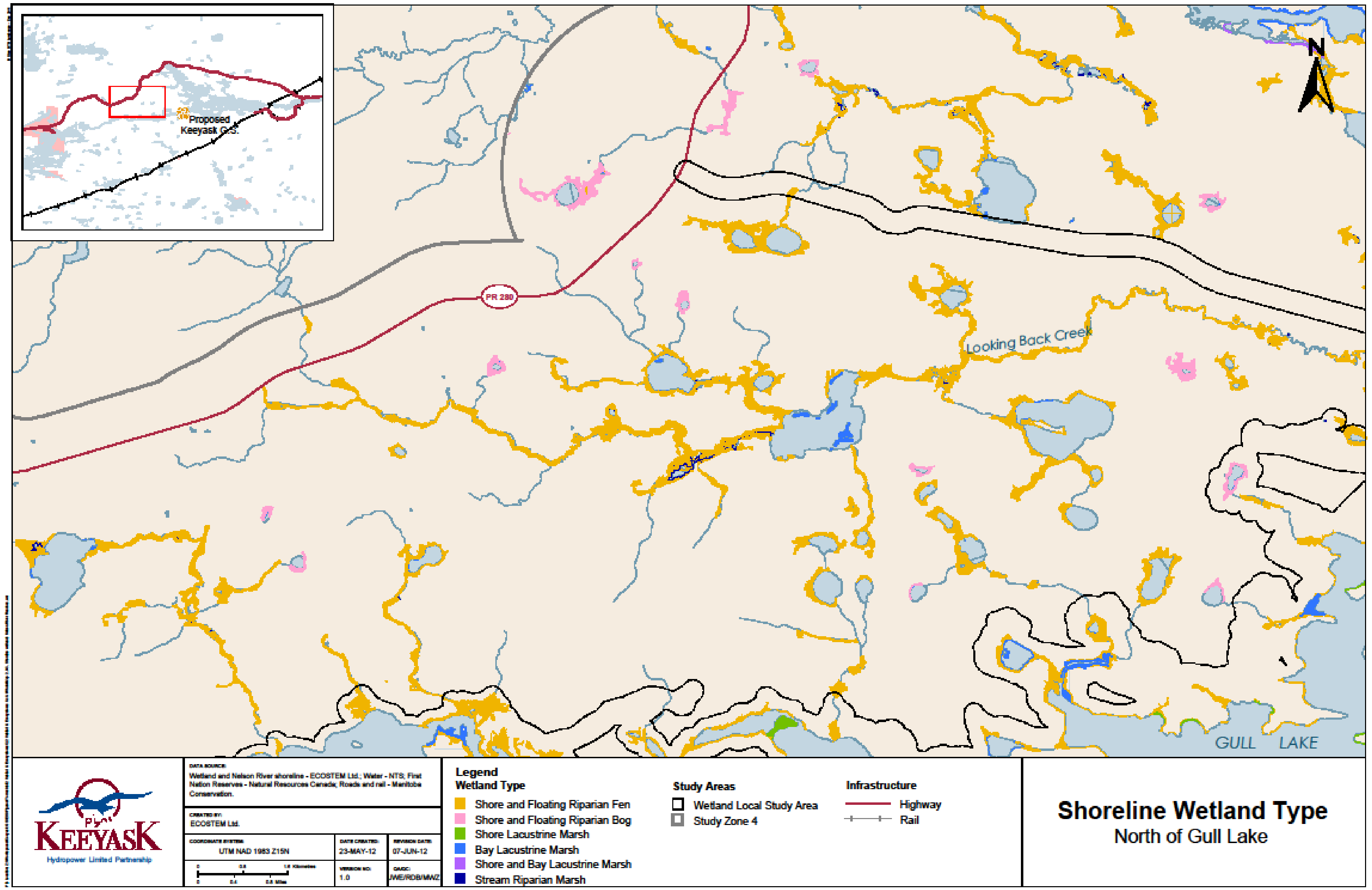
Map 6-8: Wetland class composition of Keeyask Study Zone 4



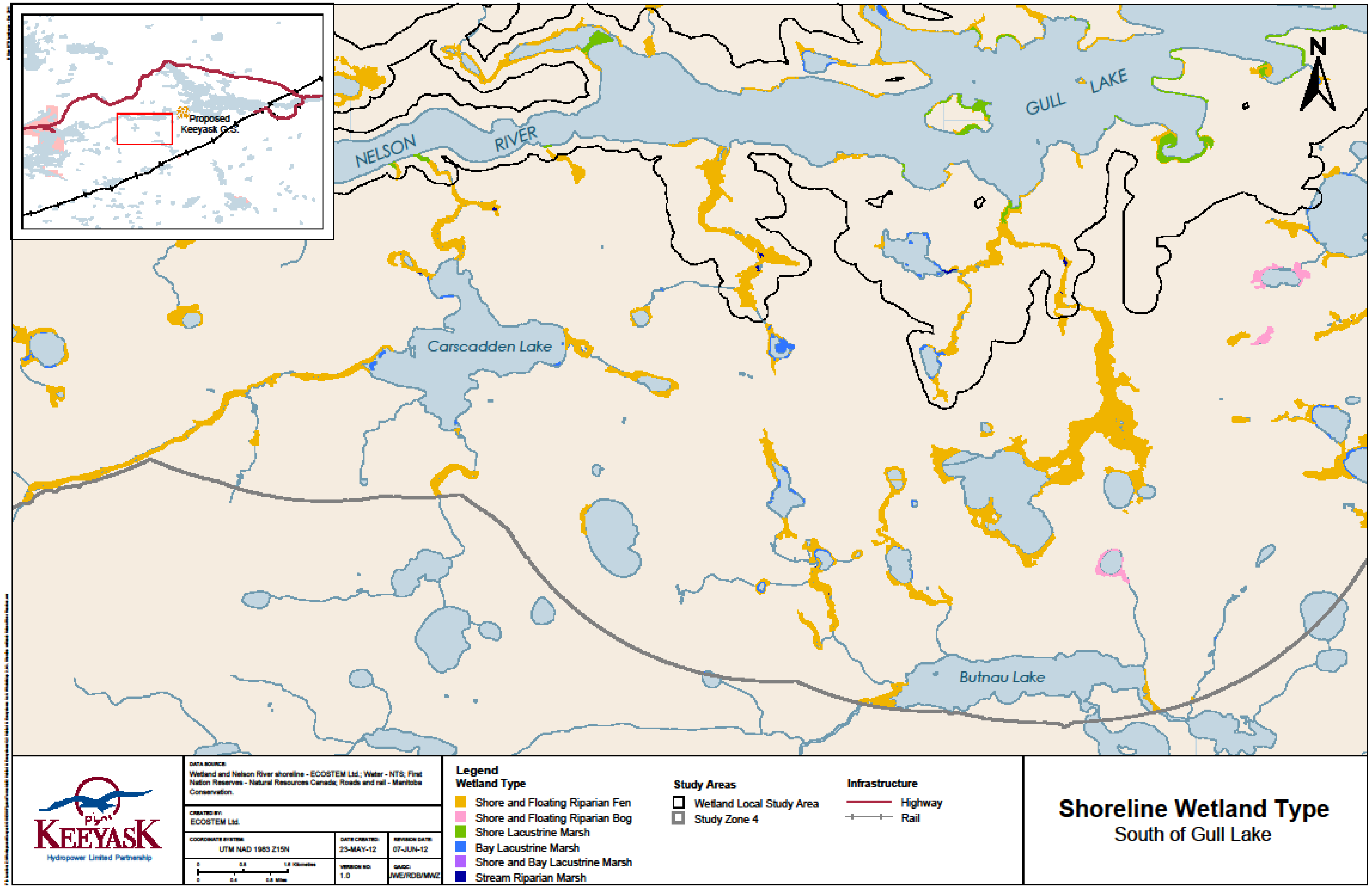
Map 6-9: Shoreline wetland type – Split Lake



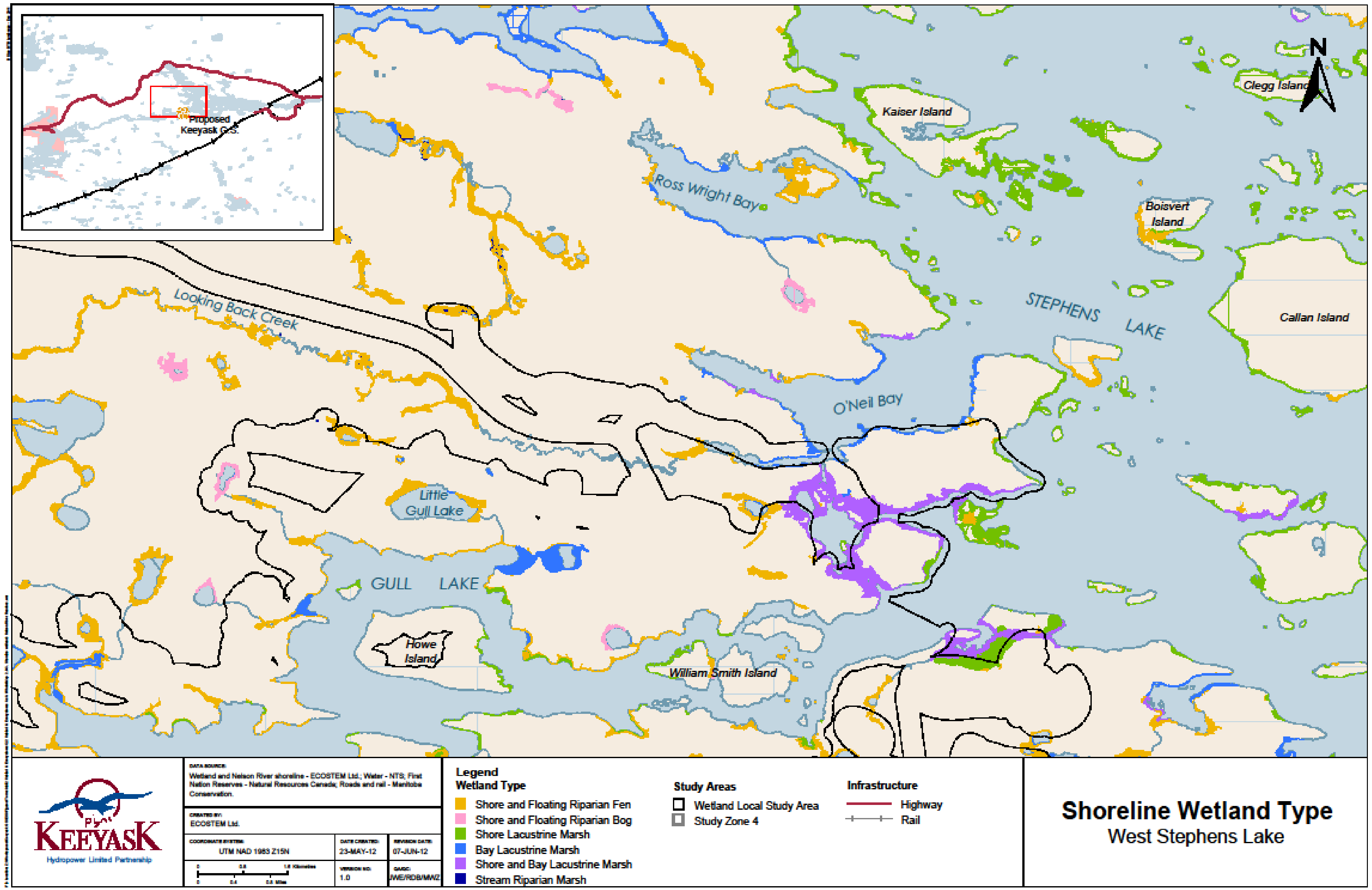
Map 6-10: Shoreline wetland type – Birthday Rapids South



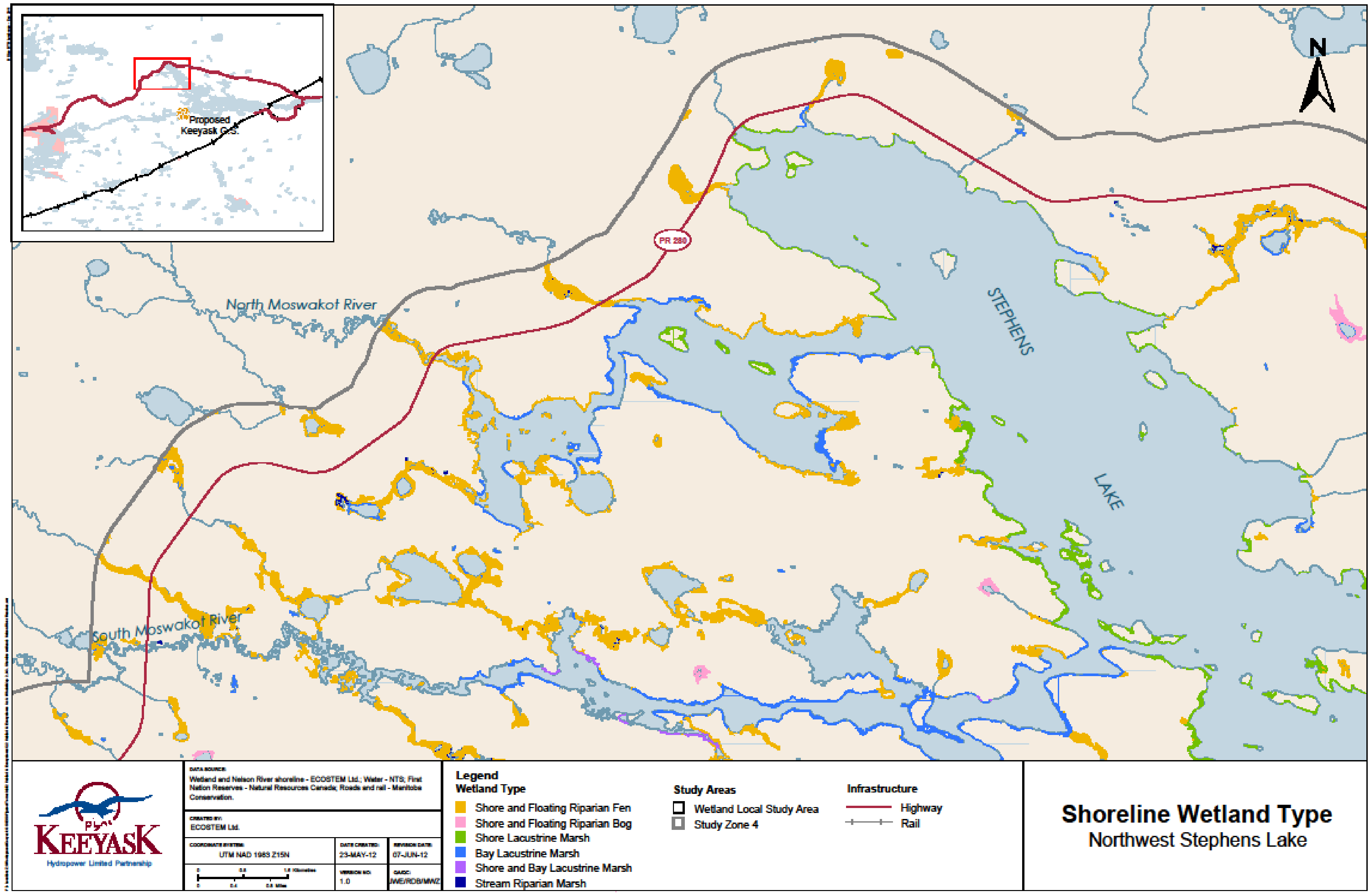
Map 6-11: Shoreline wetland type – Gull Lake North



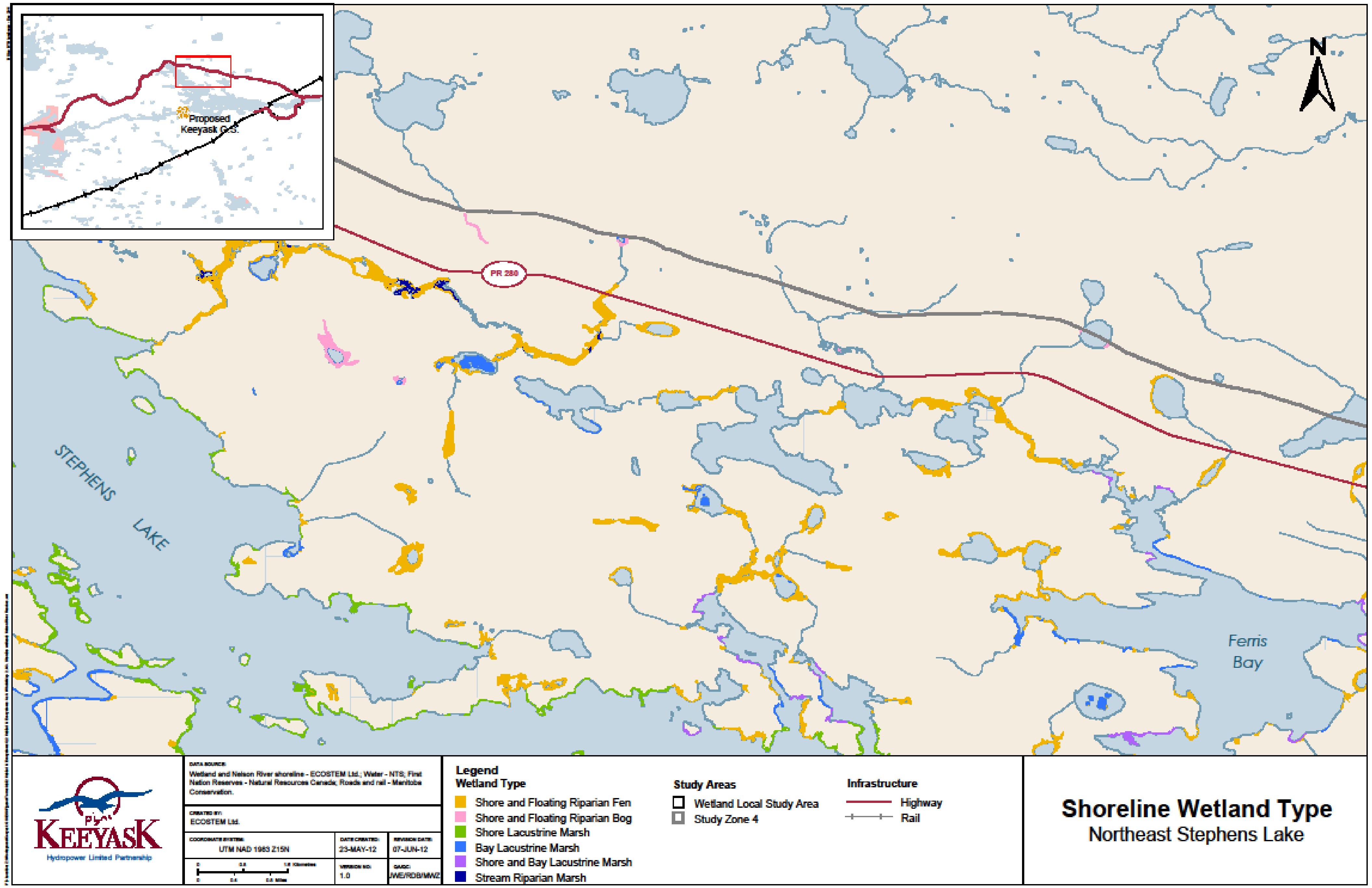
Map 6-12: Shoreline wetland type – Gull Lake South



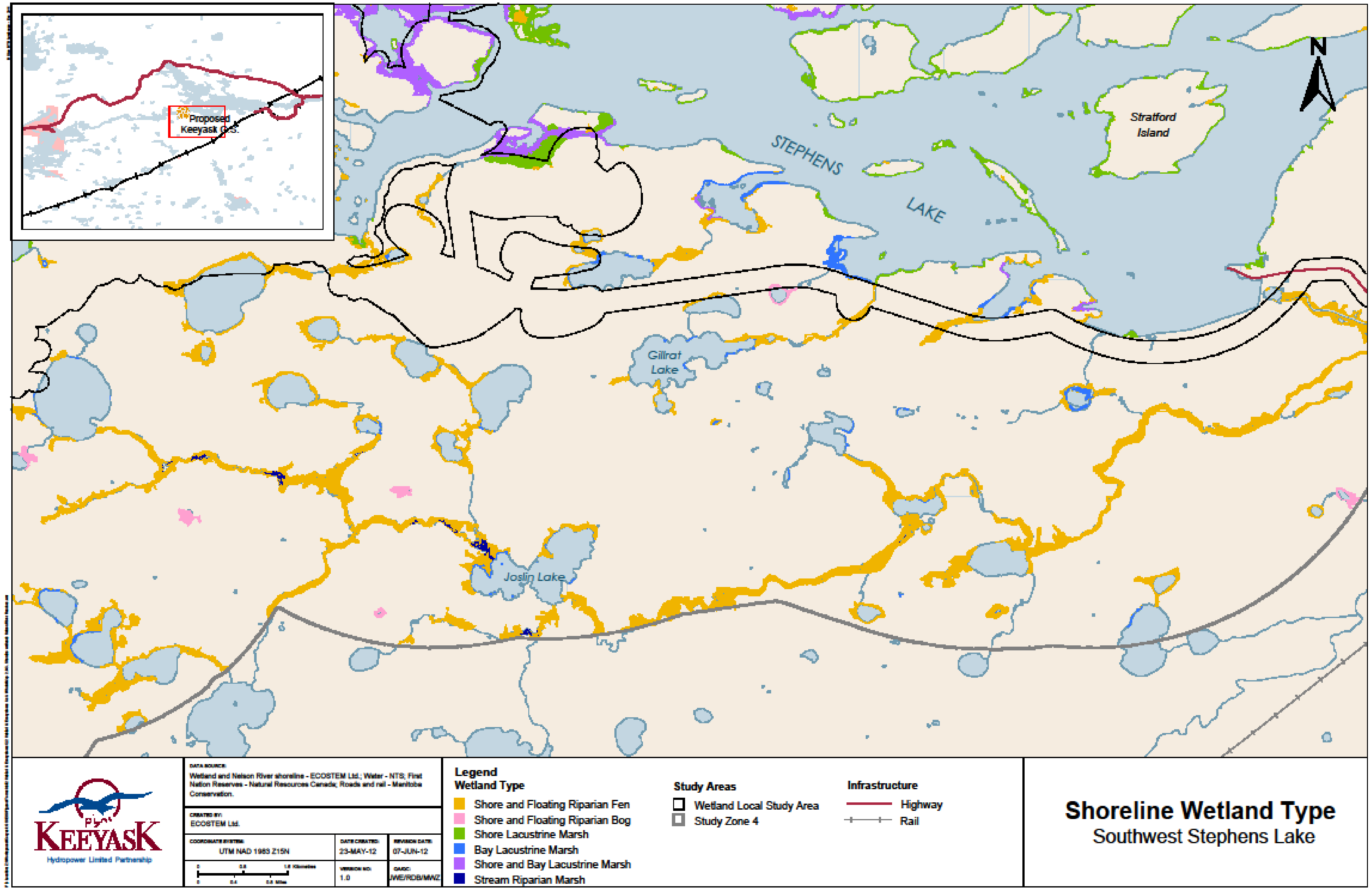
Map 6-13: Shoreline wetland type – Stephens Lake West



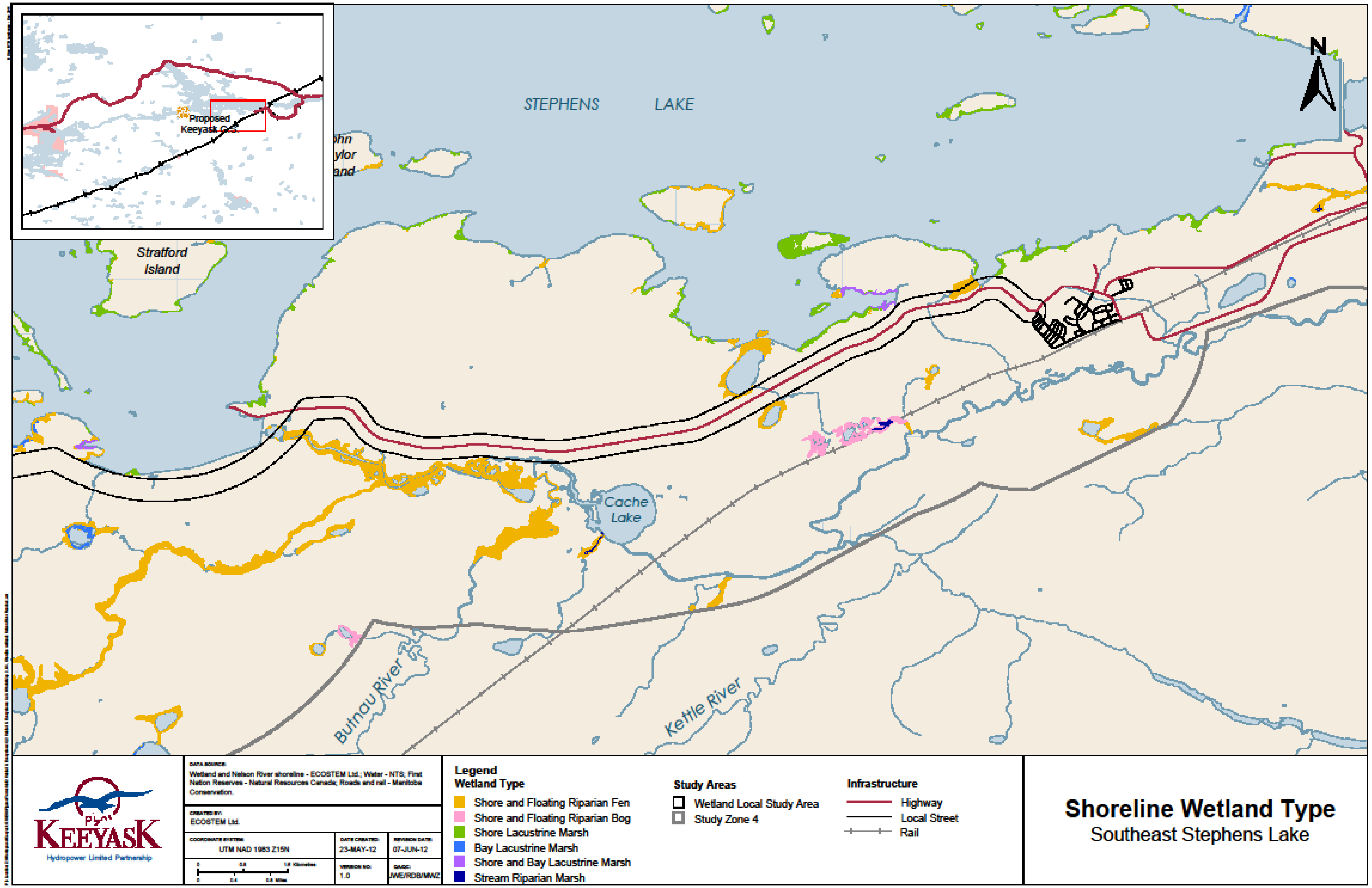
Map 6-14: **Shoreline wetland type – Stephens Lake Northwest**



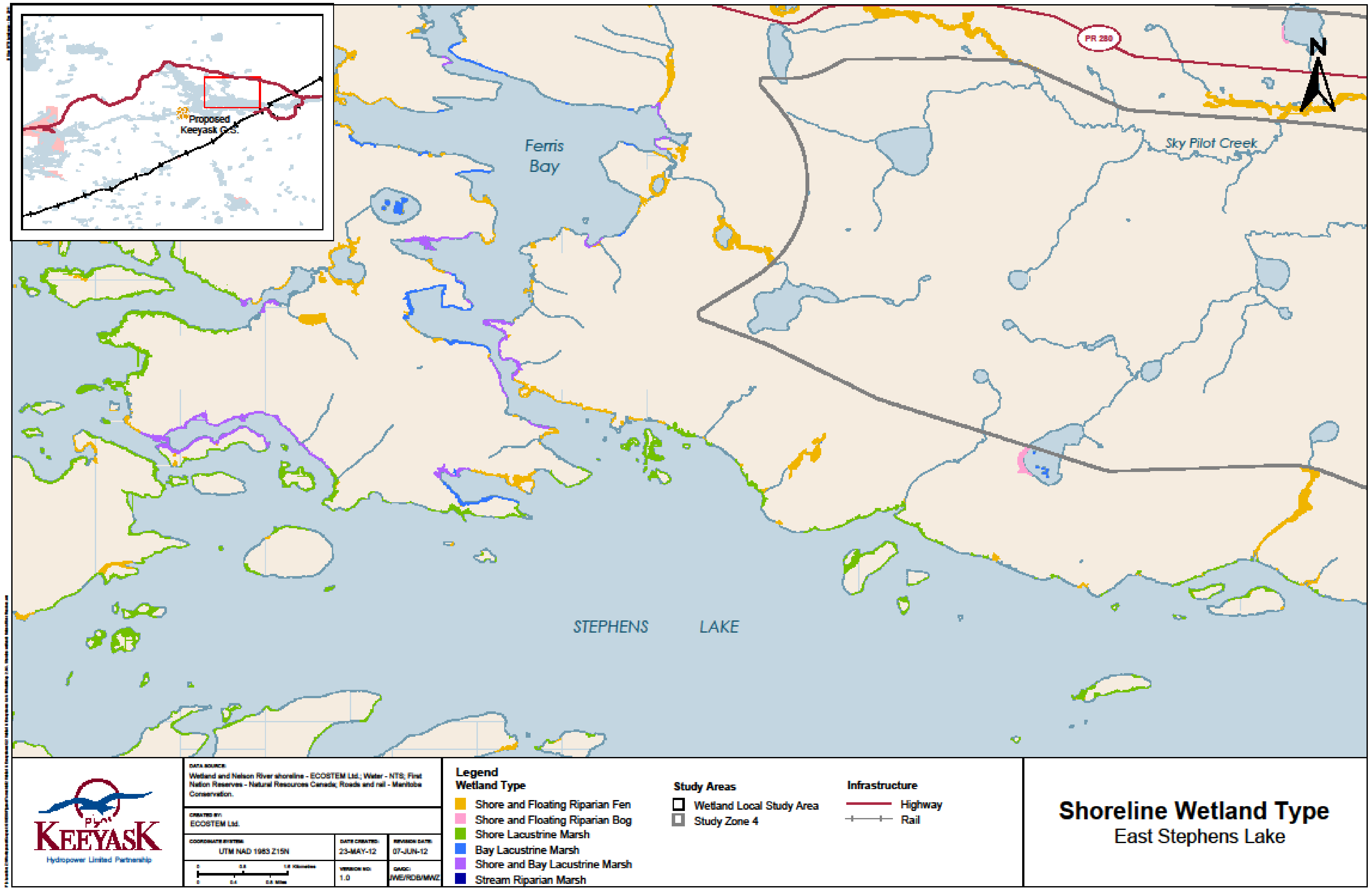
Map 6-15: Shoreline wetland type – Stephens Lake Northeast



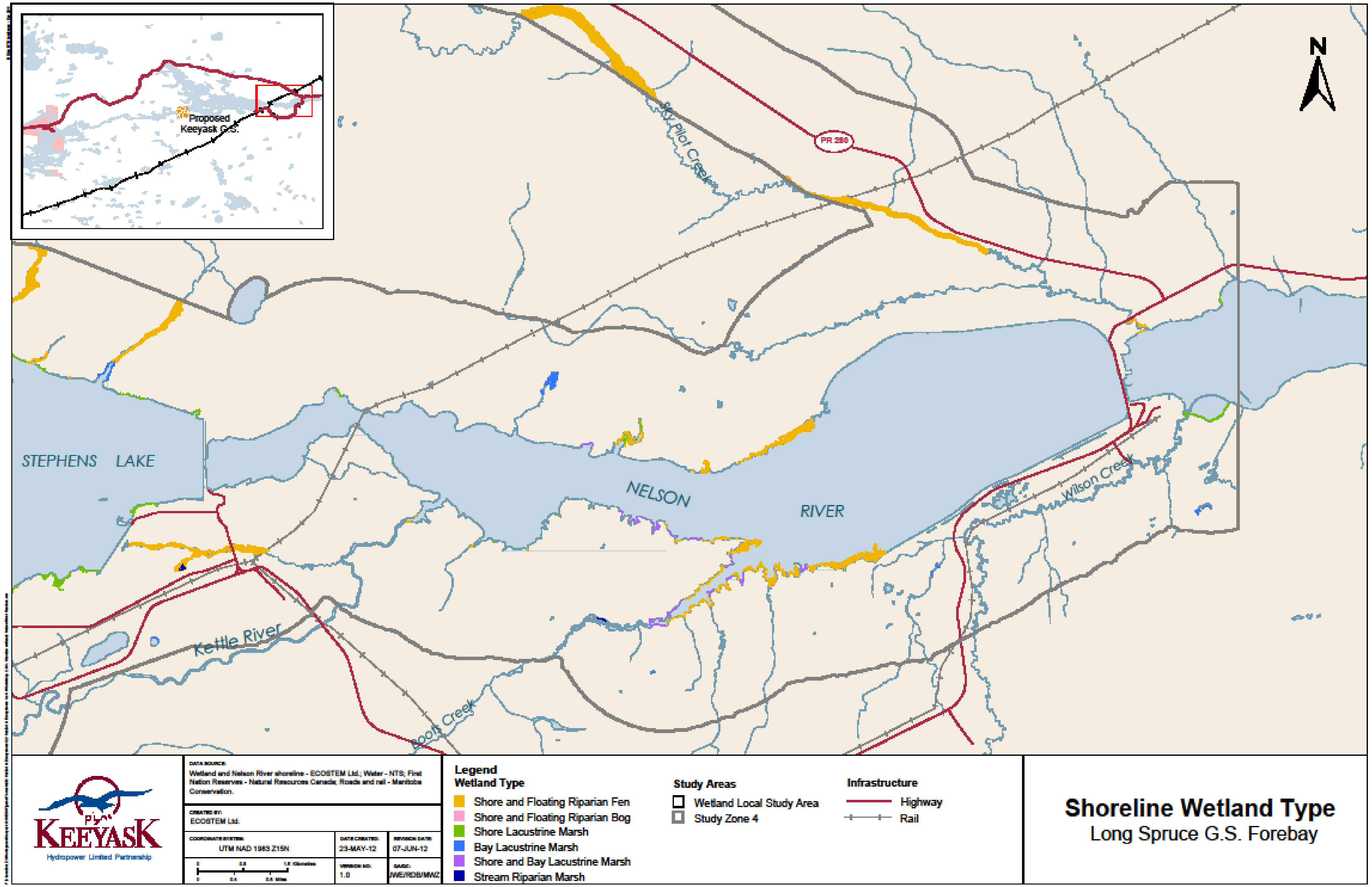
Map 6-16: Shoreline wetland type – Stephens Lake Southwest



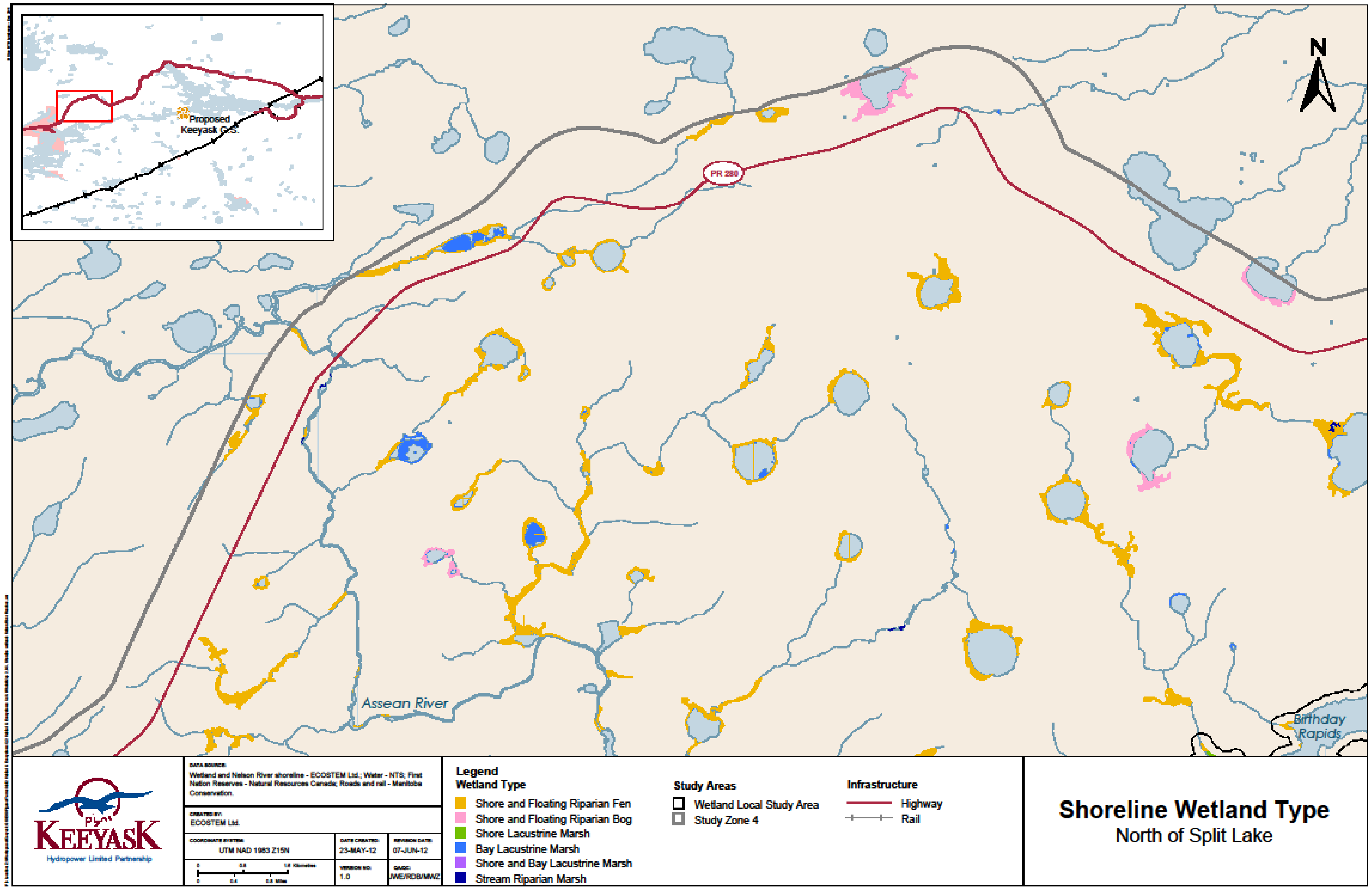
Map 6-17: Shoreline wetland type – Stephens Lake Southeast



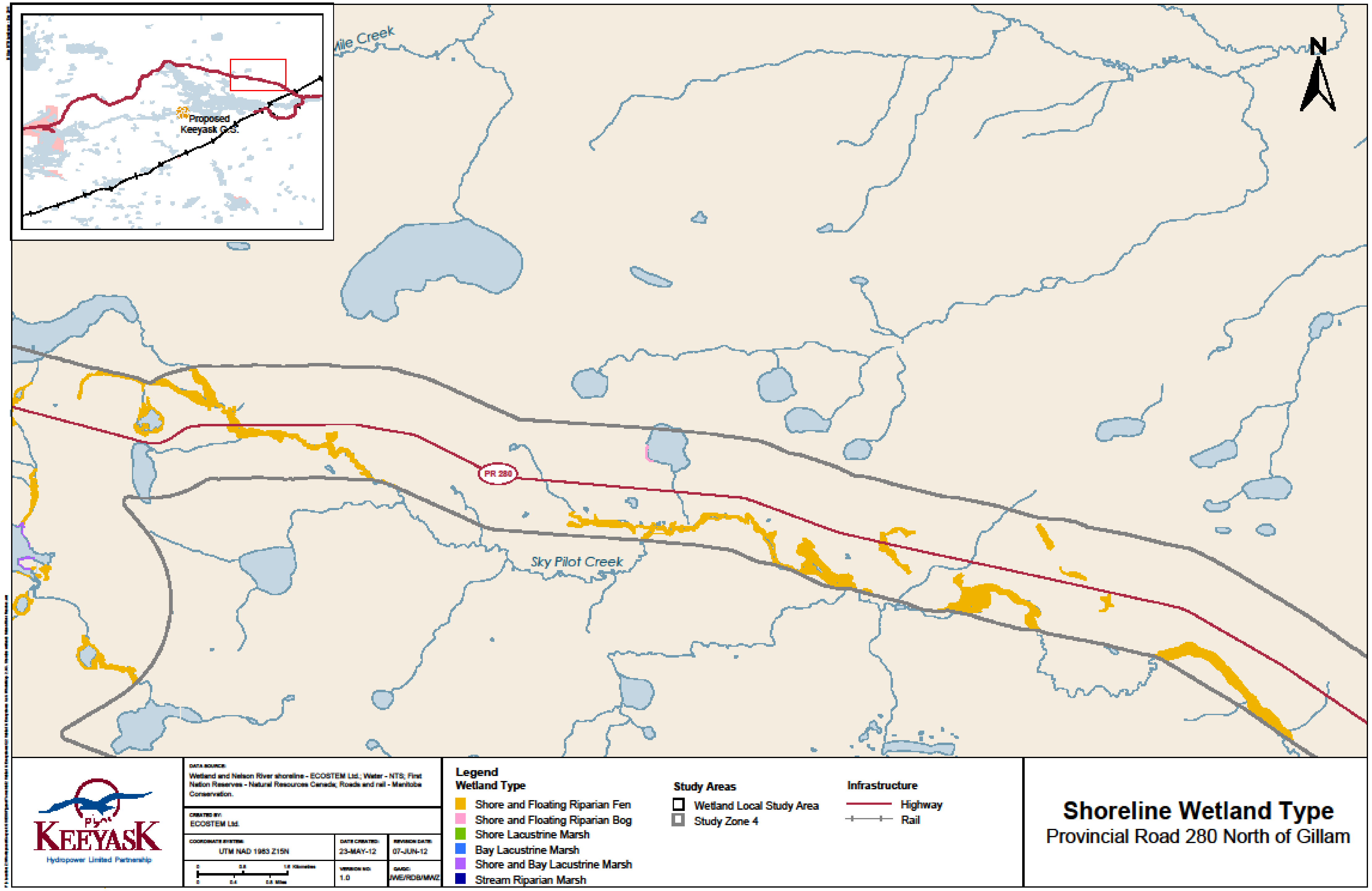
Map 6-18: Shoreline wetland type – Stephens Lake East



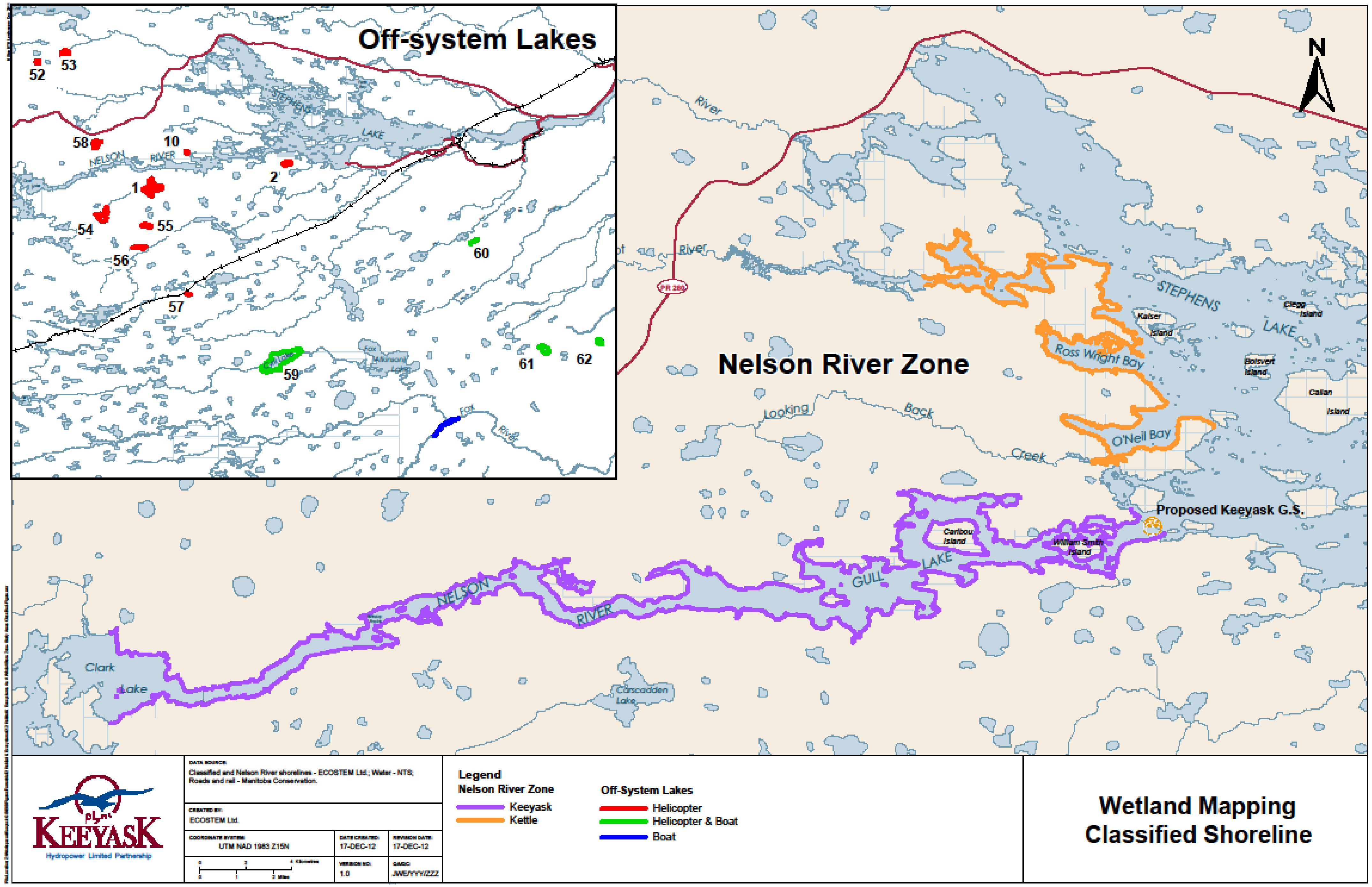
Map 6-19: Shoreline wetland type – Long Spruce Forebay



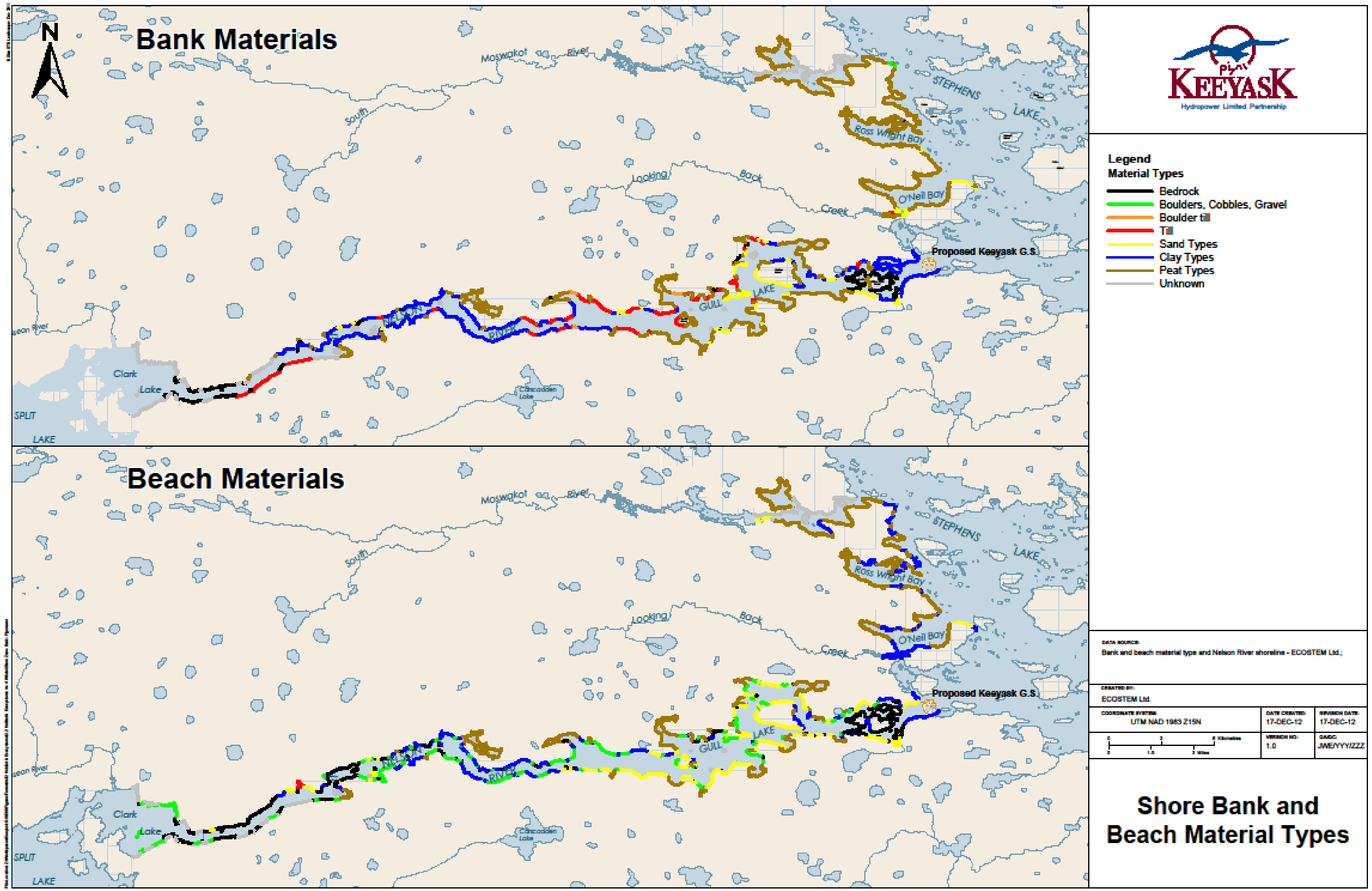
Map 6-20: **Shoreline wetland type – Split Lake North**



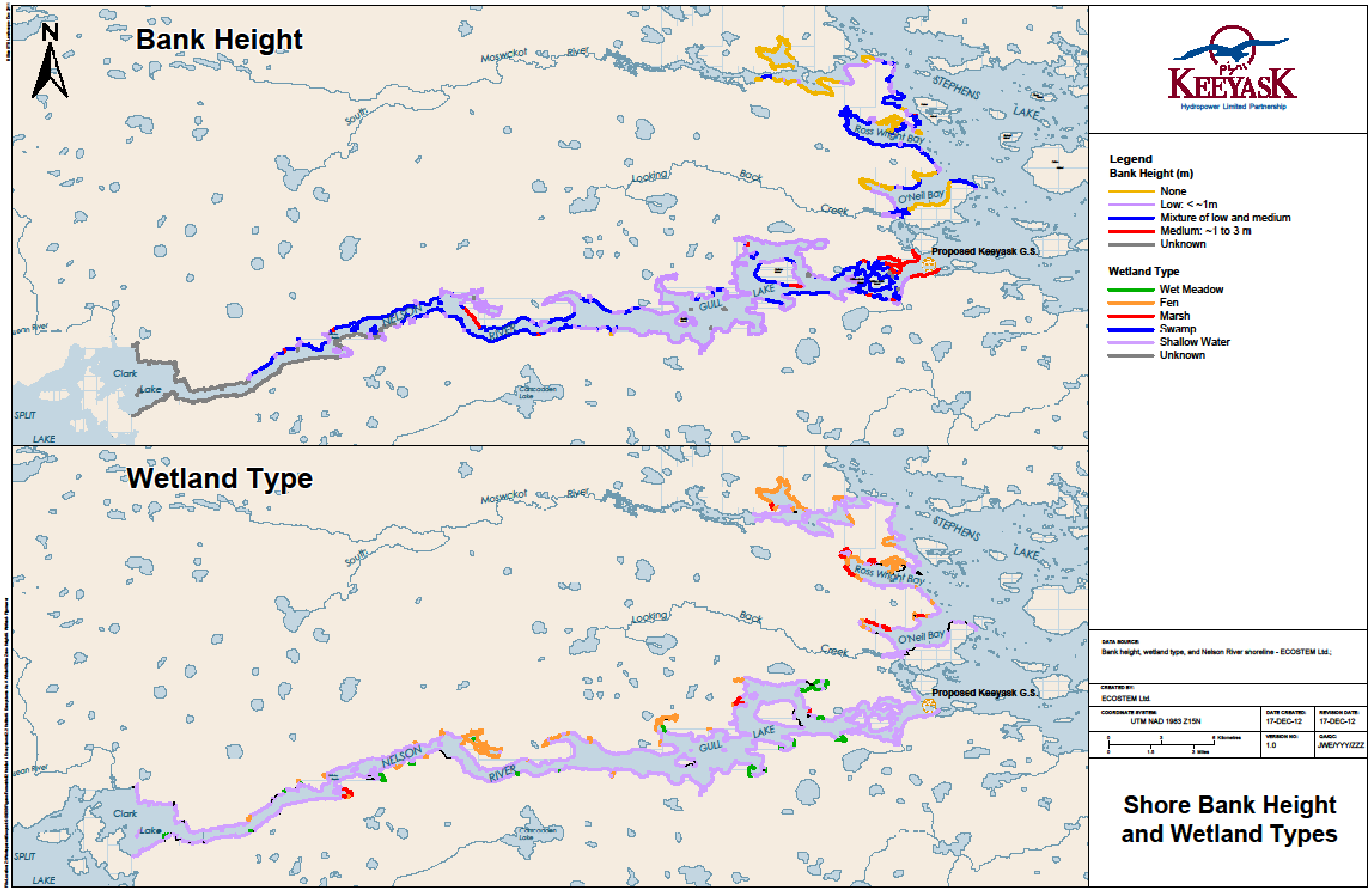
Map 6-21: Shoreline wetland type – PR 280



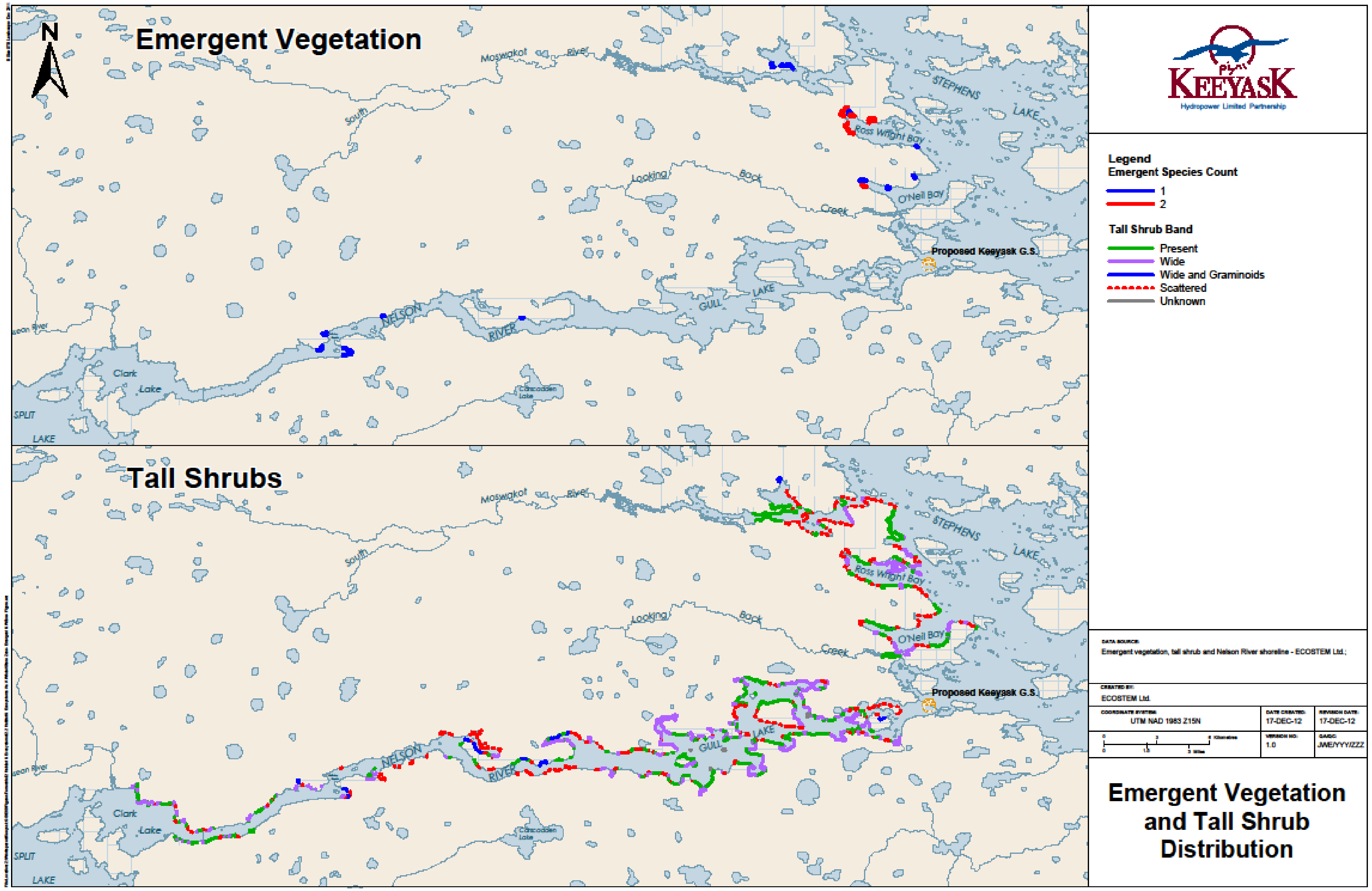
Map 6-22: **Extent of terrestrial habitat shoreline mapping**



Map 6-23: Shoreline bank and beach material types for the Nelson River Study Areas



Map 6-24: Shoreline bank height and wetland types for the Nelson River Study Areas



Map 6-25: Shoreline emergent vegetation islands and tall shrubs for the Nelson River Study Areas

7 HABITAT RELATIONSHIPS

7.1 INTRODUCTION

Predicted changes to terrestrial habitat, ecosystems and plants were the foundation for understanding and predicting many potential Project effects on the terrestrial environment. Habitat effects were of interest in their own right. Plants and animals use habitat for survival and reproduction. Indicators for some components of ecosystem health were derived from habitat maps and descriptions. Habitat changes also served as a proxy for many terrestrial ecosystem effects.

Reliable predictions of potential Project effects on ecosystems depended on an adequate understanding of the linkages, or relationships, between each of the components of habitat (e.g., vegetation, soils, permafrost) and the factors that had a substantial influence on habitat composition and structure (e.g., wildfire, water regime).

Habitat relationships studies were conducted to better understand how various ecosystem components in the Regional Study Areas were connected together; what were the most influential factors that determined the patterns and dynamics of ecosystem attributes such as vegetation, soils and surface layer permafrost; and how changes in natural and human drivers could change terrestrial ecosystem patterns and dynamics. Results from habitat relationships studies were used to develop models to predict how the Project could potentially affect terrestrial ecosystems and habitat, if it proceeds. Study results also provided information needed to recommend potential mitigation measures to avoid or reduce potential Project effects.

Ecosystems contain a very large number of components and relationships. A challenge for Project assessment studies was to undertake these studies with a reasonable level of effort given the nature of local ecosystems and the scope of the Project. Habitat relationships studies focused on issues that were expected to be of high ecological, social and/or economic concern since it was neither necessary nor reasonable to attempt to predict effects on every single component of the ecosystem (Section 2.4 explained how indicators representing multiple topics were selected). Studies focused on ecosystem health indicators or key topics such as habitat composition, rare plant distribution and abundance, soil quantity and quality, frequency of large fires and fragmentation.

Many habitat and ecosystem issues of concern were addressed through predictions of how the common habitat types will change since they accounted for most of the area. Habitat relationships studies focused primarily on the common habitat types and broad groupings of the uncommon habitat types. Other habitat and ecosystem issues of concern were addressed by focused studies such as rare plant surveys and ecosystem diversity studies.

This section describes the field, lab and statistical methods used for the various studies. Since ecosystems are organized hierarchically (Section 2.1), many of the observed stand and landscape level patterns were the outcomes of site level processes. Site level data were the primary sources of information used to develop our understanding of local ecological relationships and to develop the site level habitat classifications. Collecting the site level data needed to develop this understanding was a broad objective of the terrestrial habitat and ecosystems assessment studies.

Another broad objective for the studies was to develop site and stand level hierarchical terrestrial habitat and ecosystem classifications applicable to both of the LNR region Regional Study Areas. Consequently, one of the detailed objectives for the overall study design was to provide the data required to develop these classifications. The site level terrestrial habitat and ecosystem classification was applied to sample plots and transect segments while the stand level classification was used for the terrestrial habitat and ecosystem mapping.

7.2 METHODS

Section 3 described the overall study design for all of the Project studies. This section describes methods used in the LNR region as a whole as well as methods specific to the Keeyask Regional Study Area.

Sampling design, analytical methods and modeling techniques for the inland habitat studies differed from those used for the shore zone due to the dramatic differences in the most influential drivers and Project linkages (Section 2.6.2). For example, inland habitat data were typically collected in plots located away from transition zones near stand edges whereas shore zone data were typically collected along transects that spanned the entire transition of surface water depth in the shore zone.

7.2.1 Study Areas

The study areas used for the terrestrial habitat relationships studies were those that were delineated in Section 2.6.3 using the spatial scoping methodology described in Section 2.5.2. The Keeyask Local and Regional Study Areas were Study Zones 2 and 5, respectively, in Map 2-3.

Additionally, the Nelson River in the Keeyask Regional Study Area was sub-divided into the Gull, Stephens and Long Spruce study areas to reflect the different water regimes occurring in those river reaches (Map 6-21).

7.2.2 Data Collection

7.2.2.1 Inlands

7.2.2.1.1 Inland Habitat Relationships

Sampling Design

The inland habitat relationships study collected data in plots. Inland habitat sample locations were selected using a two-phased, two-staged sampling design. During the first phase, the more common inland habitat types were sampled using a representative design. In the second phase, stands representing priority habitat types not adequately sampled to date were selected from those available, which generally meant most of the available stands due to the rarity of the habitat types.

The first phase of the inland habitat relationships sampling design employed a stratified, random cluster design. Since ecosite is typically the primary driver for spatial differences in vegetation composition on the Boreal Shield (Ehnes 1998), clusters of the most common ecosite types (Section 5.4.3) were located on a preliminary ecosite map. Each cluster included at least four of the following ecosite types: deep mineral soil, veneer bog, blanket peatland, peat plateau bog, collapse scar peatland or horizontal peatland. These ecosite types were thought to be the most common ones in the area based on reconnaissance soil surveys, helicopter surveys, air photos and existing maps. From the map of cluster locations, clusters were randomly selected from geographic zones (*i.e.*, the strata in the sampling design). Once the clusters were selected, additional less common ecosite types were added to the cluster if they occurred within a reasonable walking distance.

Plots were typically located near the center of the habitat patch to minimize the variability introduced by edge effects and the potential biases of subjective placement. GPS coordinates for the plot location were either extracted in a GIS or were waypointed while flying over the stand in a helicopter. In the event that the pre-selected plot coordinates placed the plot so that it overlapped a stand edge transition zone, the plot was shifted to be at least 10 m from the transition zone.

Plot Layout

Habitat data were generally collected in 400 m^2 hexagonal plots. The plot was subdivided into several nested sub-plots, in which different habitat components were sampled. These habitat components included: vegetation structure; surface substrate; downed woody material; small trees and snags, saplings and tall shrubs; large trees and snags; understorey vegetation; detailed soil and ecosite; and plant tissue sampling.

The first step in plot layout was to establish a 10 m x 20 m rectangular plot, which was then sub-divided lengthwise into two 5 m x 20 m sections (Figure 7-1). The 20 m sides were further separated into 5 m sections, creating a 5 m x 5 m grid across the rectangular plot. The 400 m^2 hexagon was formed by extending the plot 10 m out perpendicularly from the middle of each 20m side (the 10 m x 20 m center rectangle with two 100 m^2 triangles). Only the 10 m x 20 m rectangular plot was sampled if there were at least 30 large diameter trees in the rectangular plot or if the hexagon would extend the plot into a non-homogenous habitat (some habitat types such as riparian peatland types are typically long and narrow).

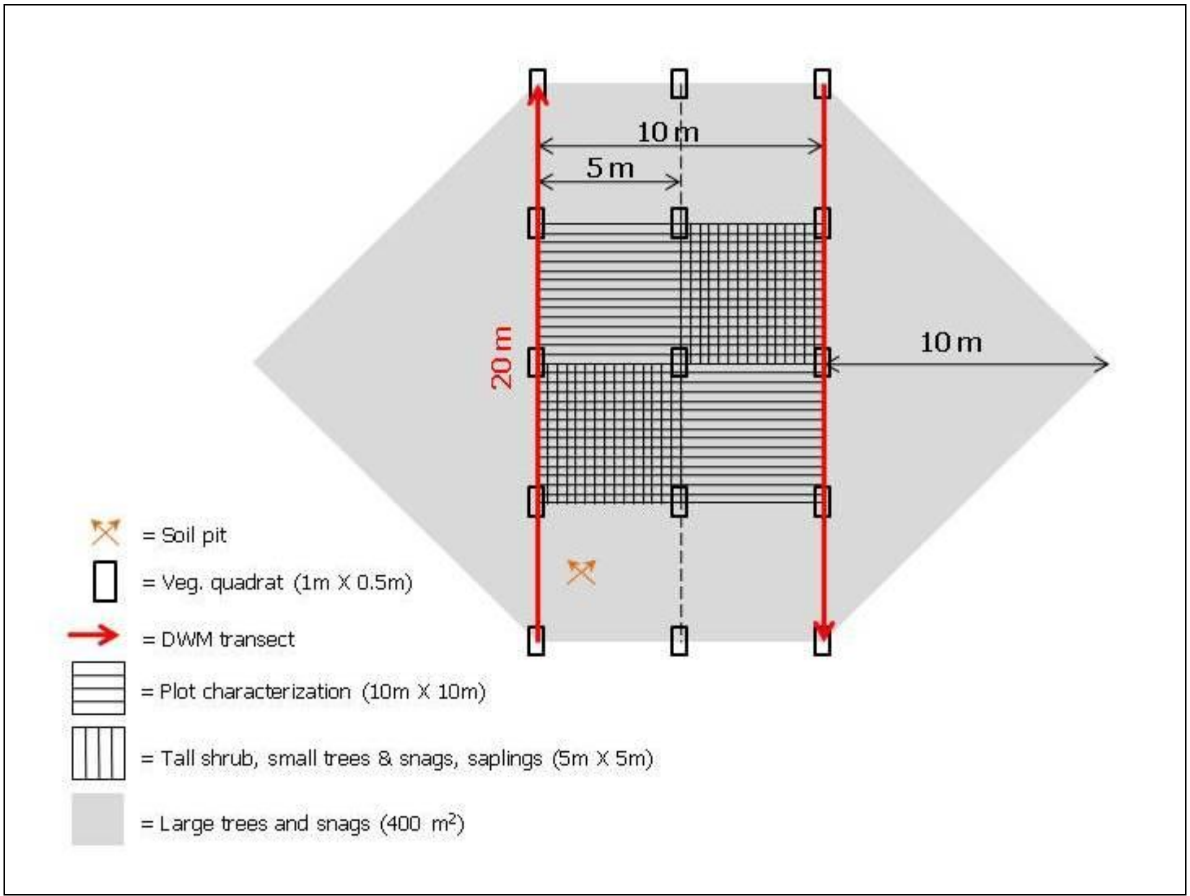


Figure 7-1: Inland habitat plot layout

Data Collection

Tree and tall shrub enumeration and plant tissue collection were completed as the last sampling steps to avoid trampling understorey vegetation and small woody debris. In addition, soil sampling was done outside of the center 10 m X 10 m plot to avoid disturbing understorey vegetation and small woody debris.

Vegetation Structure

Percent cover was estimated in the center 10 m x 10 m of the rectangular plot for the following vegetation strata:

- Dominant and co-dominant canopy layers;
- Sub-dominant canopy layer;
- Tall shrub layer;
- Low shrub (includes low shrubs, herbs);
- Ground layer (mosses, lichens, hepatics).

Dominant/co-dominant and sub-dominant layer heights were also recorded. The height of the tall shrub layer was only recorded in 2003 and 2004.

A minimum of three photos were taken at each plot to visually record understory vegetation structure and site conditions. Photos were taken to provide a view along each of the 20 m sides of the rectangular plot while standing at the origin point and shooting towards the corner diagonally across from the origin. A third photo was taken from one side of the plot, at approximately the midpoint of the 20 m side, far enough back from the plot to provide a general view of the entire plot. This photo was taken from the side that offered the best view of the plot. Voice recordings were made for each photo with the camera, identifying the plot and view in the photo.

Surface Substrate

Percent cover was estimated in the center 10 m x 10 m of the plot for the following components of ground cover: organic (including dead and living organic matter), buried wood, decaying wood, bedrock, rocks/cobbles/stones, mineral soil, and water. The percentages of all components added to a total of 100% substrate cover.

Downed Woody Material

Downed woody material was sampled in two 20 m transects corresponding to each 20 m side of the 10 m X 20 m rectangular plot, with the zero point for each line occurring at diagonal corners. Pieces of woody debris were tallied along each transect: for 0 - 10 m, all pieces with a diameter above one centimeter were counted; for 10 – 20 m, only pieces with a diameter greater than 7 cm were counted. Pieces greater than 7 cm in diameter were tallied according to their size class: 1.1 - 3.0 cm, 3.1 - 5.0 cm, and 5.1 - 7.0 cm. Pieces greater than 7 cm in diameter were tallied individually according to species, diameter, length and decay stage.

Small Snag, Small Tree, Saplings and Tall Shrubs

Two diagonal 5 m x 5 m squares were used in the center of the 10 m x 20 m rectangular plot (the corner of these squares met in the center of the rectangular plot). All small snags (dead trees that were still standing, and were > 1.3 m tall but had a DBH < 9 cm) and stumps (dead trees < 1.3 m tall with a circumference > 10 cm at a height of 20 cm) were tallied, and recorded to species if possible. All trees with a DBH < 9 cm were tallied by species. All saplings (tree species with no DBH, but taller than 0.5 m) and tall shrubs (stems taller than 0.5 m) were tallied by species. For tall shrubs, all individual stems were counted.

Large Tree And Large Snag Plot

Large trees and snags were sampled in the 400 m^2 hexagon plot, unless it extended the plot into a non-homogenous habitat, or if the number of large trees in the rectangular plot was sufficient (> 30 stems in the 10 m X 20 m rectangular plot). Otherwise, trees were only sampled in the rectangular plot. All trees or snags with a DBH greater than or equal to 9 cm were tallied according to species and size class (9-15 cm DBH, 16-20 cm DBH, and >20 DBH). Snags were tallied only if their angle from the ground was greater than 45 degrees, otherwise they were considered to be downed woody material.

Vegetation Plot: 7.5 m^2 sub-sample of 200 m^2

The vegetation sample area was located along the perimeter of the 10 m x 20 m rectangular plot. It was sub-sampled with fifteen 0.5 m x 1.0 m quadrats totaling 7.5 m^2. Quadrats were placed along a 5 m grid centered on the 10 m x 20 m rectangular plot, with 5 quadrats occurring along each of the three 20 m lines.

All plants with leaf cover overhanging a quadrat were recorded. All tree species were recorded as pseudo-species by stratum (i.e. tree, sapling, seedling). The presence of a trunk (all tree stems with a DBH) or snag (all standing snags with an angle to the ground >45°) was also recorded for each quadrat. All plants occurring in a quadrat were enumerated. If it was not possible to identify a plant due to their immaturity and/or lack of flowering parts, a voucher specimen was taken, for later identification. For bryophytes, red-stemmed feathermoss (*Pleurozium schreberi*), stair-step moss (*Hylocomium splendens*), and knight’s plume moss (*Ptilium crista-castrensis*) were recorded, although all sphagnum mosses (*Sphagnum* spp.) were grouped together. Other mosses were grouped together under a general moss (moss spp.) category. The lichens recorded were green reindeer lichen (*Cladina mitis*), grey reindeer lichen (*Cladina rangiferina*), and northern reindeer lichen (*Cladina stellaris*), while cup lichens (*Cladonia spp*.) and pelt lichens (*Peltigera* spp.) were grouped to the level of genus only.

In addition to live plant cover, inanimate ground cover in each quadrat was also recorded, including rock, water, mineral soil, bare peat or woody debris. Fallen snags were counted as woody debris only where there was contact with the ground. Litter was recorded in the quadrat where cover was greater than 25%.

Soils

One soil pit was sampled in a representative location, determined after sampling several test holes located outside of the center 10 m X 10 m plot. Where possible, a soil pit depth of 100 cm was sampled. In the case of an organic soil, the soil pit was extended 20 cm into the first mineral layer unless frozen soil was encountered. In the case of frozen soil, as much data was recorded as possible, and the plot was revisited later in the season to determine if the frost was seasonal or permafrost. If the plot was not frozen upon revisiting, the soil pit was sampled normally.

At each soil pit, pedon information was recorded, including thickness of the LFH layer and organic matter, depth to permanent mottling, depth to gleying, depth to water table, depth to bedrock, depth to frost, deposit type, site type, drainage regime and moisture regime. Soil horizon data, including depth, texture and stoniness, were also recorded. Soil samples were collected for all soil horizons, and where possible, volumetric samples were collected for each mineral soil horizon.

Plant Tissue Samples

Plant tissue samples were collected from within the 10 m X 20 m rectangular plot at the end of sampling in each plot. Collections included ground and arboreal lichens, sphagnum and moss from hummocks and hollows (where present) and arboreal mosses. Ground moss samples were taken back to the lab for identification using a microscope.

Tree Aging

An increment borer was used to collect tree cores, which were collected from 3 dominant trees and 2 sub-dominant trees. Trees were bored at a height lower than 50 cm where possible. Tree cores were taken back to the lab for processing.

Nomenclature

7.2.2.1.2 Priority and Invasive Plant Transects

Rare and invasive plant data were collected along transects. Priority plant transects were done by foot along transects through habitats that were likely to support rare, uncommon or invasive species. When encountered, a species' position was marked, the abundant plant species in the vicinity, including ground cover type, were recorded, along with site conditions such as habitat attributes, plant community phenology and presence of recent burn signs. A count of the number of individuals present was recorded, or in the case of a large population, an estimate of the number of individuals was made, or the size and cover of the species was recorded. Priority plant transects were also done by boat along major shorelines. Priority plant locations along the shore were marked and the number of individuals, or an estimate similar to the one done during foot surveys was also recorded. Along highway 280 and the Conawapa road, 300m and 200m long invasive plant surveys were done every 5 km and 2 km, respectively, by foot on either side of the road. Invasive plant cover in the Right Of Way was estimated for each species and the adjacent habitat composition was noted.

7.2.2.1.3 Soil and Ecosite Protocols

Section 5 described studies that focused on soils and ecosites. Relevant data and results from these studies was used for the terrestrial habitat relationships studies.

7.2.2.2 Shore Zone

Shore zone habitat along the Nelson River and off-system waterbodies are often addressed in separate sections of this report since their water and ice regimes were quite different. Water flows and levels in the Nelson River were regulated by Manitoba Hydro whereas the off-system waterbodies were natural systems. Off-system wetland data provided benchmarks for natural wetland composition and relationships.

Within each of these broad hydrodynamic zones (i.e., Nelson River versus off-system), shore zone habitat studies and analysis were further stratified by water depth duration zone (Section 2.6.2). For this reason, this section begins with an explanation of water depth duration zones.

Ice effects were an additional factor in the shore zone. Because ice scouring can affect uplands, the shore zone includes uplands as well as shoreline wetlands.

7.2.2.2.1 Water Depth Duration Zones

At any given shoreline location, different plant species are typically arranged into bands that reflect a transition in typical growing season water depths (e.g., Photo 7-1, Photo 7-2, Photo 7-3). The dominant mechanism in creating these vegetation bands are different plant tolerances to flooding duration (Hellsten 2000; Keddy 2010). Species that can only survive under water for a relatively short period (*e.g.* tall shrubs) grow in the higher elevations of the shore zone because this area is rarely under water. Species that cannot survive out of the water for very long grow in the lower elevations of the shore zone (*e.g.* pondweeds (*Potamogeton* spp.)). In other words, a sequence of vegetation bands forms because day-to-day water fluctuations constantly change water depths and the amount of the shore zone area that is exposed/flooded. Labeled photos show shore zone vegetation bands at a location on the Nelson River shoreline (Photo 7-1) and a location in an off-system lake (Photo 7-3) in the Keeyask Regional Study Area.

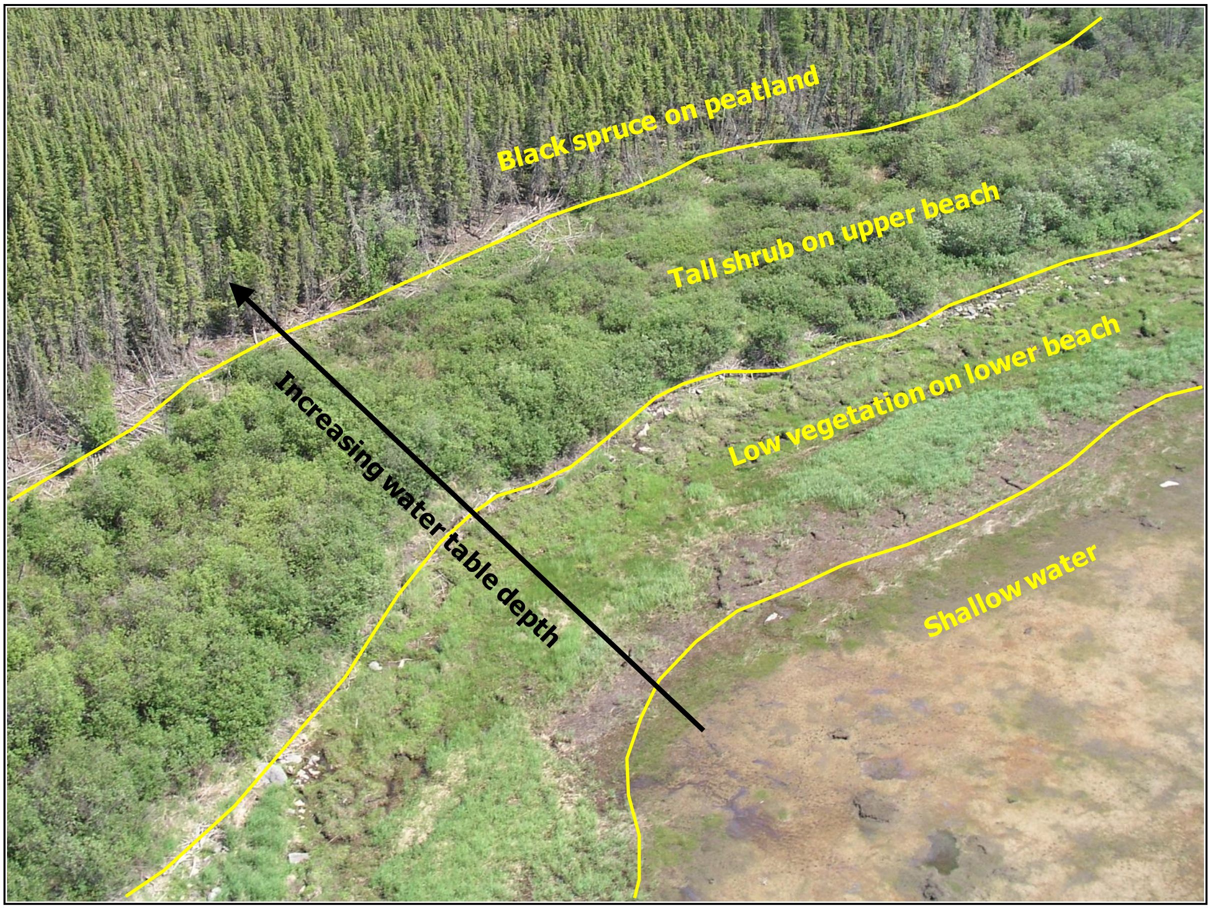


Photo 7-1: Photo illustrating vegetation bands that reflect a water depth gradient in a back bay on the Nelson River during very low water

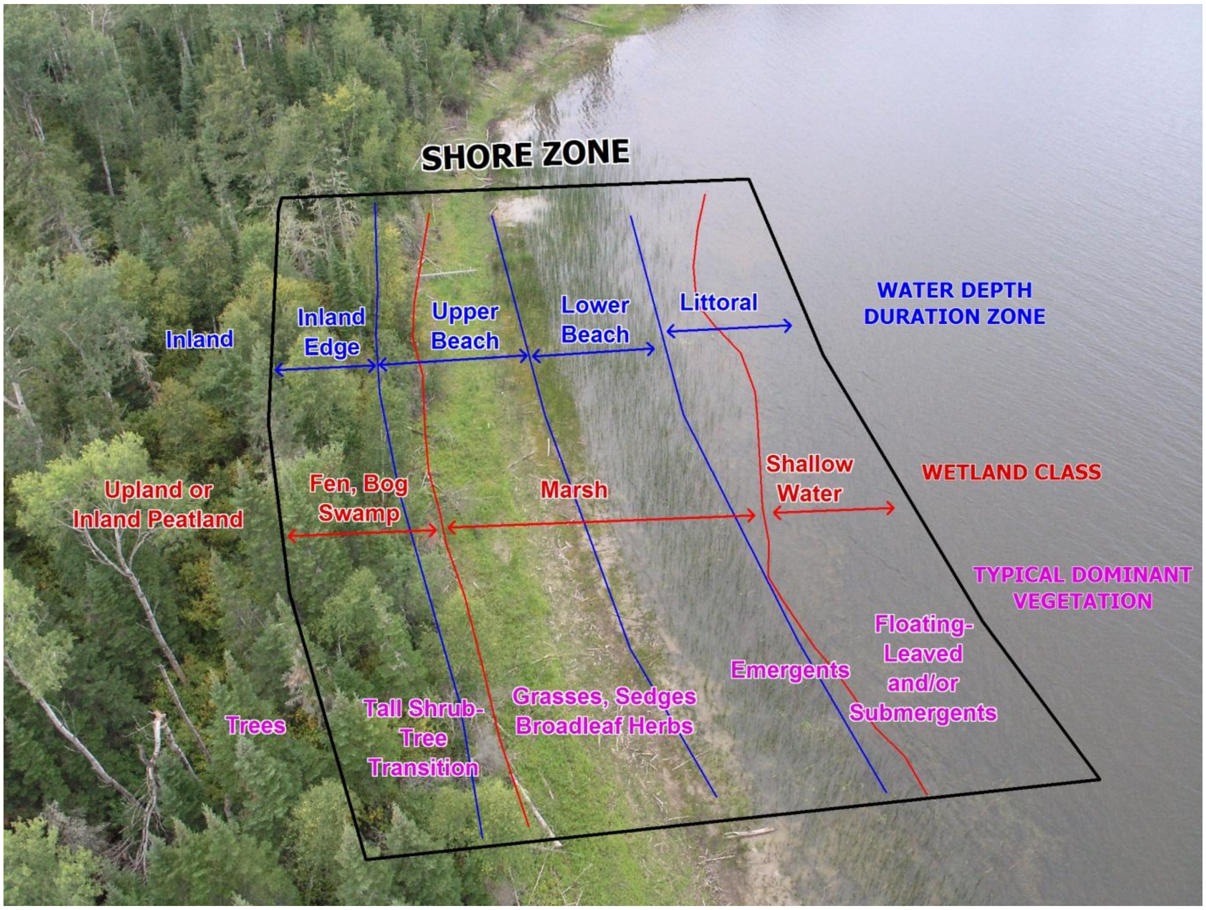


Photo 7-2: Photo illustrating shoreline wetland water depth duration zones, vegetation bands and wetland classes in an off-system waterbody

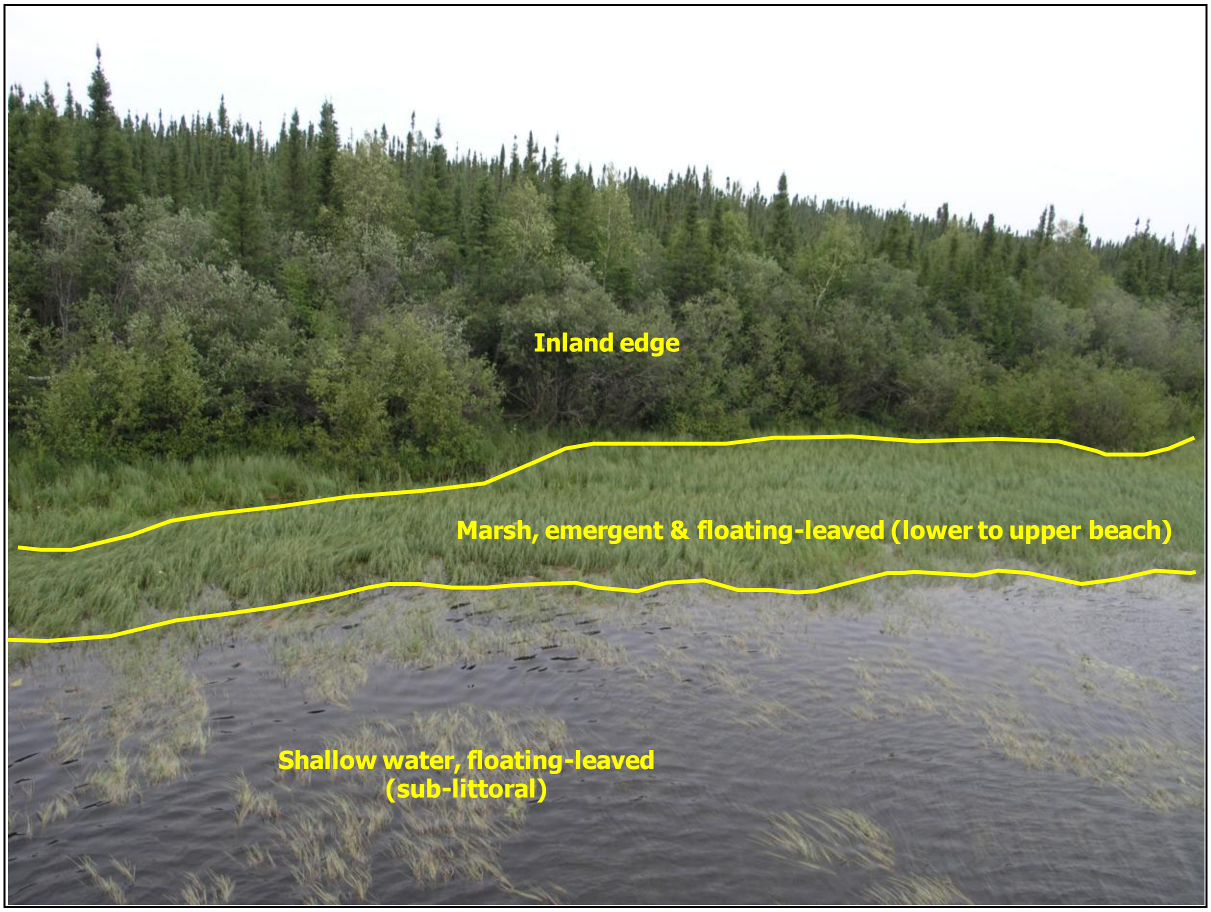


Photo 7-3: Typical off-system marsh growing on the lake bottom

The width of the beach (*i.e.* the exposed organic or mineral substrate that is the lake bottom on some days) varies from day-to-day in accordance with water level changes. The beach is at its widest when water levels are at their lowest elevation. Also, on any given day, the width of the exposed beach is different at various places along the shoreline because the slope and shape of the lake bottom varies. A low slope area will have a much wider beach than a high slope area at a given water elevation.

Plant species distributions along the shore zone water depth gradient are best understood when a plant's location within the shore zone is related to standardized growing season water depths rather than water depths on the day of sampling (Rorslett 1984; Wilcox and Meeker 1991; Hellsten 2000; Keddy 2010). A standardized water depth is the water elevation on a given day minus the median growing season water elevation calculated over the 3–5 years prior to shore zone sampling (Hellsten 2000). The frequency of standardized daily water depths is a key water regime parameter for plant species.

Standardized growing season water depths can be usefully grouped into standardized water depth duration zones (U.S. Army Corps of Engineers 1987; Hellsten 2000). The

LNR studies used Hellsten's (2000) water depth duration zones because they were specifically developed to address the effects of hydroelectric water regulation. The water depth duration zones going from driest to wettest are inland edge, supra-littoral, upper eu-littoral, middle eu-littoral, lower eu-littoral, upper sub-littoral and lower sub-littoral. Every day names used for this sequence were inland edge, upper beach/inland edge transition (supra-littoral), upper beach (upper eu-littoral), middle beach (middle eu-littoral), lower beach (lower eu-littoral), very shallow water (upper sub-littoral) shallow water (lower sub-littoral) and deep water/aquatic Figure 7-2. Table 7-1 describes the water duration zones and the types of species that typically grow in each zone.

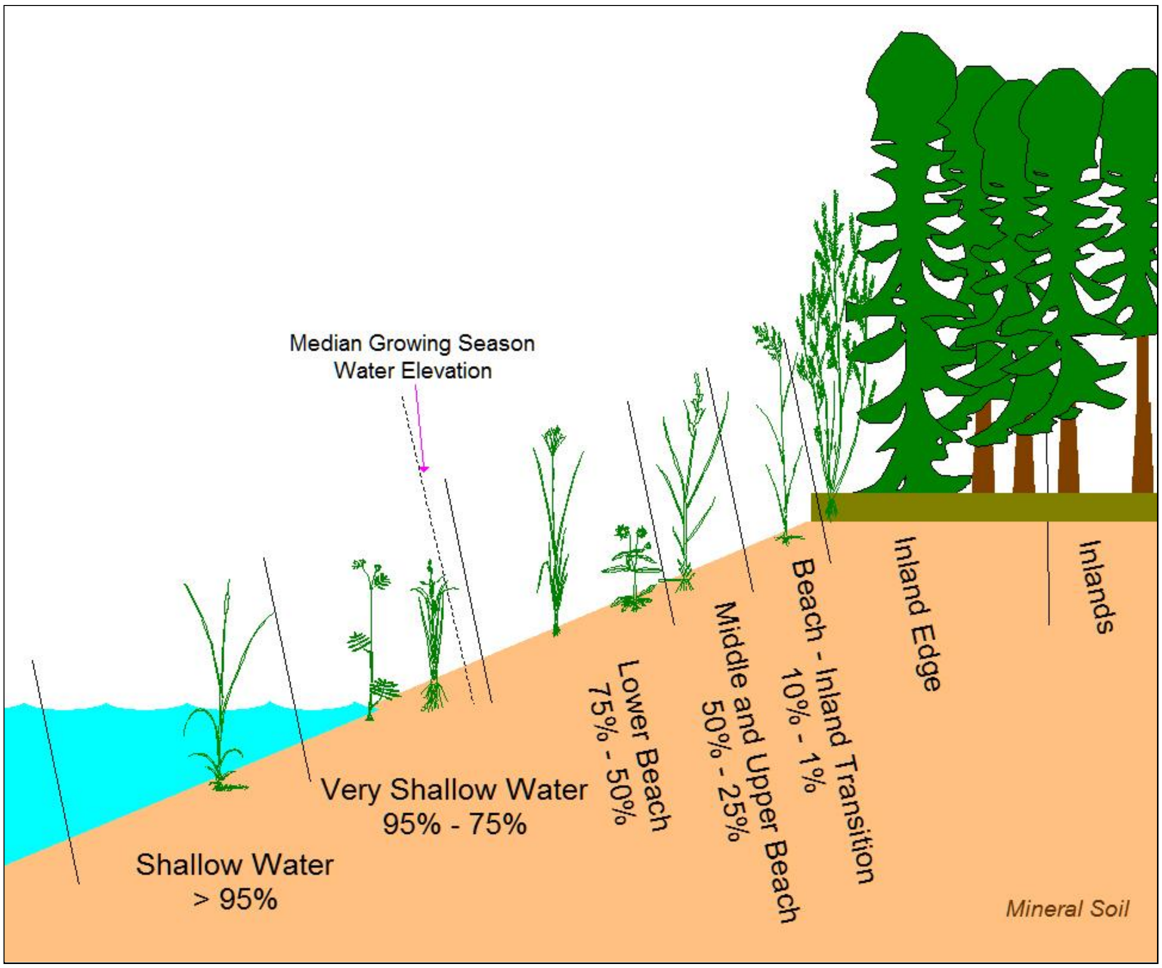


Figure 7-2: Water depth duration zones and the types of plants found in each zone

Different water regimes produce water depth duration zones with different horizontal widths. Consequently, water regime can lead to shore zone vegetation zonation at two spatial levels: the site and the waterbody (or river reach). Site level zonation refers to the shore zone vegetation bands described above. Zonation at the waterbody level refers to reaches of a river or large portions of a lake. Even in a natural river, the elevation ranges of the duration zones will vary in reaches where the flow passes through more constricted areas. A given flow passing through a more constricted reach will have more variable water levels than the same flows passing through a less constricted reach. Consequently, different river reaches can have different water regimes.

When examining an entire waterbody or when different waterbodies are compared, shoreline wetlands with similarly sloped substrates, water regimes and ice regime can exhibit different vegetation types due to the secondary factors that structure wetlands (Keddy 2010). Secondary factors influencing shore zone vegetation zonation at the site and waterbody levels include light regime, erosion, sediment deposition, depth to bottom freezing, ice pressure, bottom slope, bottom shape and soil type (Hellsten 2000; Keddy 2010). Broad differences in these factors were the primary basis for identifying zones at the waterbody level. Some proxies for these factors are wave energy, turbidity, bottom slope, bottom shape and type of surface materials. These broad differences provide the context for vegetation and soils at a particular location and constrain which types of shore zone vegetation sequences can develop.

The primary sub-division of a waterbody into zones is often based on water regime since this is generally the most important influence on the overall composition of shore zone vegetation sequence types in a study area. This was the primary reason why Nelson River and off-system waterbody shoreline wetlands were addressed differently, as well as for treating the Split Lake, Keeyask and Stephens Lake reaches as separate shoreline wetland study areas. A secondary sub-zonation was based on broad differences in other influential factors such as wave energy, current, sedimentation or surface materials, to the extent they were apparent within each waterbody zone. These latter factors were considered for the stratification component of field studies and when analyzing field data.

The preceding generalizations regarding shoreline wetland relationships and drivers have been confirmed for areas subjected to water regulation (Keddy and Fraser 2000; Keddy 2010).

Table 7-1: Water duration zones, associated water conditions and types of species found in each zone

Water Duration Zone	Water Conditions[1]	Typical Species[2]
Deep Water	Under water at least 95% of the time	Addressed by aquatic studies
Upper and Lower Sub-littoral	Under water more than 75% but less than 95% of the time. Bottom freezing occurs in most or all of this zone.	Plants which cannot tolerate desiccation but which can tolerate bottom freezing and ice pressure. Hydrophytes ("true" aquatic plants according to some authors)
Lower Beach	Under water more than 50% but less than 75% of the time	Plants which can tolerate alternating periods of inundation and desiccation during a season between years where the condition may persist for more than about 45 days. Tall emergents. Most are monocots. These species also expand their distribution into the higher portion of the sub-littoral zone when water levels drop for a prolonged period.
Middle & Upper Beach	Under water more than 10% but less than 50% of the time	Plants which can tolerate alternating periods of inundation and desiccation during a season between years where the condition may persist for more than about 30 days. Tall to short emergents. Most are graminoids and ruderal herbs.
Beach/Inland Edge Transition	Under water more than 1% but less than 10% of the time	Plants which grow poorly in wet soil but can survive periodic short-term flooding. Graminoids, ruderal herbs, shrubs.
Inland Edge- Mineral Ecosite	Under water less than 1% of the time & surface organic layer < 20 cm deep	Plants which will die if their roots are under water for extended periods during the growing season. Most woody plants, many herbs.
Inland Edge- Peatland Ecosite	Under water less than 1% of the time & surface organic layer >= 20 cm deep	Fen or bog plants. Substrate edge may be a floating or expandable mat which moves up and down with moderate water level fluctuations thereby protecting plant roots from submergence. Most woody plants, ericaceous plants, many herbs.

Notes: [1] Based on the number of growing season days over past three to five years.
[2] References include Rorslett 1984, Mark and Johnson 1985, Wilcox and Meeker 1991, Hellsten 2000 and Keddy 2010

7.2.2.2.2 Shore Zone Habitat Relationships

The two shore zone studies that provided shore zone terrestrial habitat and ecosystems data were the shore zone habitat relationships and muskrat pond studies.

Sampling Design

For the shore zone habitat relationships study, sample locations were selected using a stratified, random sampling design. Stratification provided representation for the factors thought to influence wetland composition and dynamics at the site and waterbody levels (see Section 7.2.2.2.1). Some of these factors were synthesized by the waterbody sub-zones while others were captured by shore material type. For example, the Nelson River in the Keeyask Regional Study Area was sub-divided into the Gull, Stephens and Long Spruce study areas to reflect the different water regimes occurring in those river reaches.

Shore segments within each stratum were randomly selected from a preliminary classified shoreline map. The shore zone sample location was centered in the selected shore segment to avoid edge effects and the potential bias of subjective location selection.

Sampling occurred during the summers of 2003, 2004 and 2006.

Data Collection

The shore zone habitat relationships data collection methods used on the Nelson River and generally used on the off-system waterbodies were as follows.

At each pre-determined sampling location, data were collected along two parallel transects, in a willow zone plot and in an inland plot (Figure 7-3). The two parallel transects were established 20 m apart and perpendicular to the shoreline. In general, sampling began in the inland edge zone and extended to the deep end of the sub-littoral zone. The origin of each transect was generally set 1 m inland from the tree line, if present, or at what appeared to be the elevation along the shore at which the surface was expected to be under water less than 5% of the open water days. The water end of the transect was positioned to capture all of the water depth duration zones described in Section 7.2.2.2.1 except for the shallow water/aquatic zone. On the Nelson River, this depth was 1.6 m for the Gull study area, 1.4 m for Stephens Lake and 1.0 m for the Long Spruce reservoir. Because daily or weekly water elevation data were not available for the off-system waterbodies, transects extended into the water to the further of 1 meter deep or to 5 m past any patches of emergent or floating-leaved vegetation having at least 5% cover.

At each location, data regarding plant species, surface substrate, substrate at depth, woody debris, slope and water depth were collected along the two transects. Vegetation structure, plant species composition and soil stratigraphy data were collected in the inland plot (Figure 7-3). In off-system locations, additional soil stratigraphy data was gathered at the end of each transect.

Once the measuring tapes were laid out along the transects, a string was attached to a survey pin placed firmly in the ground. The string was attached at the other end to a pole located at the pre-established water depth or distance determined by the water regime for that waterbody zone. A line level was used to level the string. The height from the ground to the leveled string was measured at the origin, the waterline, at each substantial change in substrate slope and at the end of the transect if it was not in the water. The distance along the transect was recorded wherever height was measured. In cases where the transect ended in the water (water levels were extremely low in the Gull study area during 2003), a survey rod was used to measure water depths from the waterline to the end of the transects. In some cases where the depth from the origin to the end of the transect was too large, or where vegetation or some other factor did not allow the string method to be used, a clinometer and survey rod were used to measure the slope heights. The height and distance data were used to calculate water depth and substrate slope.

Plant species presence was recorded in contiguous 20 cm x 50 cm quadrats centered on the transect. The long side of the quadrat was positioned perpendicular to the tape.

The surface substrate in the contiguous 20 cm X 50 cm quadrats was classified into one of the following categories: organic (all living and/or dead organic material), water, clay, sand, gravel (rocks up to 8 cm in size), cobble (rocks 8 - 25 cm in size), and stones (rocks > 25 cm in size). Each substrate category was given an estimated percent cover value. Substrate at depth was classified by inserting a survey pin into the ground.

Debris cover and size was recorded in the 20 cm X 50 cm quadrats. Percent cover classes and size classes were used to record woody debris. Woody debris was also recorded where possible under the water in off-system transects.

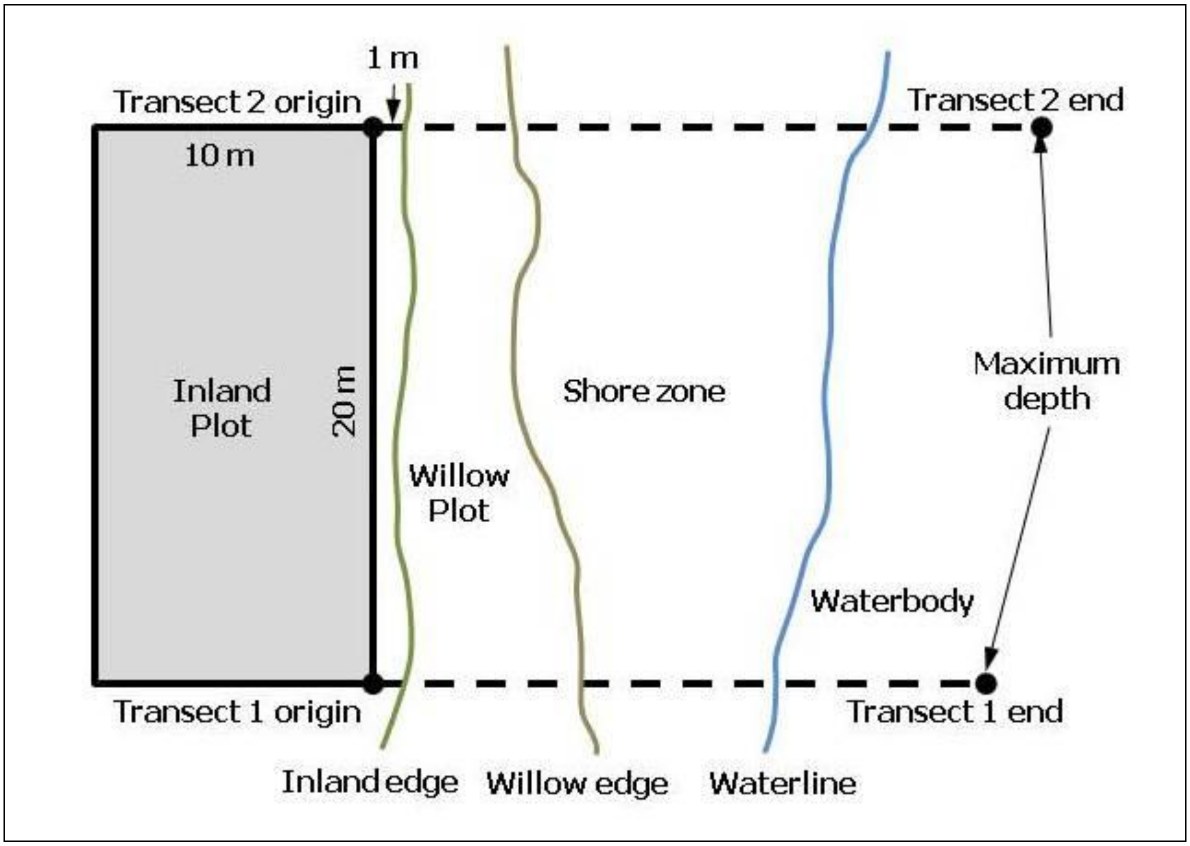


Figure 7-3: Shore zone habitat relationships transect and plot layout

A willow zone plot was established if a band of willows (*Salix* spp.) was present along the shore transects. The willow zone plot was established between the two transects and was as deep as the willow band at the location, the width of the plot therefore differed within and between sample locations. The percent cover of the tall shrub community and its species composition were estimated. Soil was sampled using a dutch auger in a representative location that was selected by testing multiple locations in the plot. Recorded pedon data included: thicknesses of the LFH layer, humus, and organic matter; depths to prominent mottling, gleying, water table and bedrock; and, soil texture for each mineral horizon as determined in the field by hand texturing. If ground ice that could not be hand-augered was encountered, depth to ice was noted.

An inland edge habitat plot was established to provide the context for the shore zone and potential influences on it. Overview rather than detailed data were collected in this plot. Generally, a 10 m x 20 m plot was established running a line between the origins of the transects and by moving 10 m inland along each transect (Figure 7-3). The origin points of the two transects therefore acted as two of the plot corners. Tapes were laid out along each of the four sides. In cases where a very large willow zone was encountered, the transect origins were established within the willow zone, and the inland plot was moved back to the inland area.

Vegetation structure cover and stratum height was estimated for the dominant, sub-dominant, tall shrub, low shrub, and ground strata within the plot. Large diameter trees were tallied by DBH class (9-15 cm, 16-20 cm and >20 cm). The most frequent plant species were recorded. Frequency was estimated based on an imaginary grid using the length marks on the side tapes. Figure 7-4 shows an example of species frequency estimation. A small diagram of the layout of the plot, the willow zone and the transects was then made.

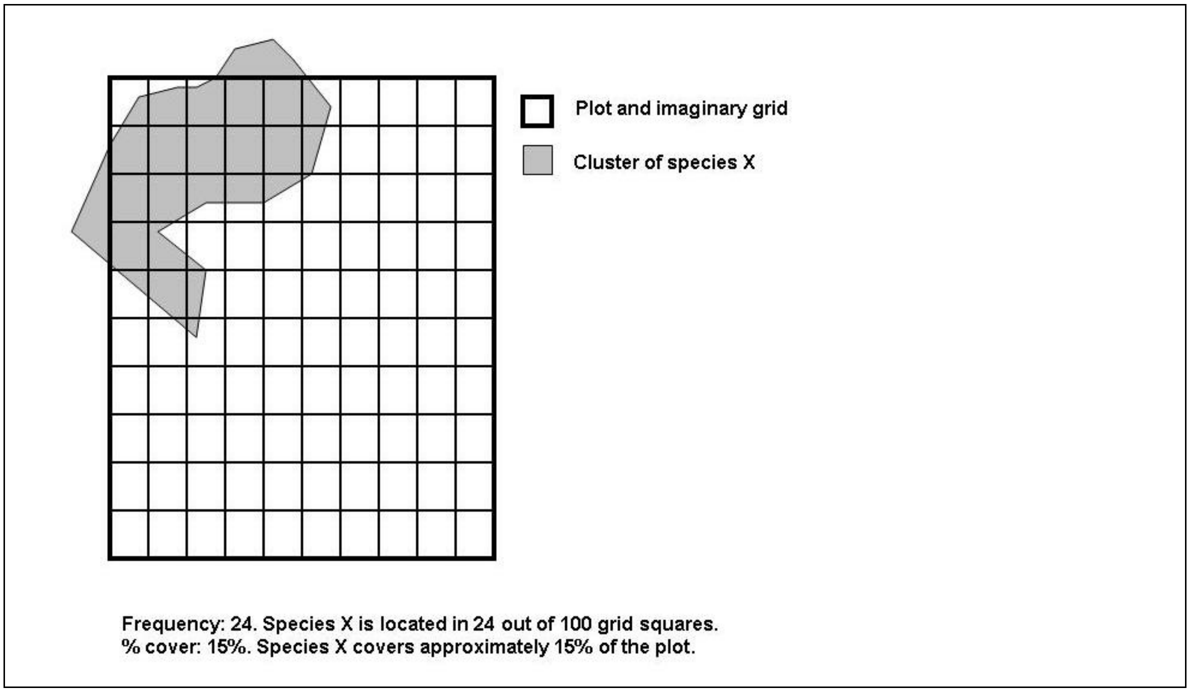


Figure 7-4: Example of plant frequency estimation method for inland edge habitat plot

Soil was sampled in a representative location using a dutch auger (hummocks and hollows were avoided). Recorded pedon information was the same as for the willow plot. In addition, moisture regime and drainage regime were determined based on the soil texture of the C horizon (for mineral soils), depth of organic horizons (for organic soils), depth to the water table and the presence of mottling and/or gleying in mineral horizons. Soil was also identified to soil order according to the CSSC (1988), with the exception that soils were classified as organic if the depth of surface organic matter was greater or equal to 20 cm.

Differences in the off-system shore zone sampling relative to the Nelson River were:

- Any beaver, muskrat or otter sign was recorded;
- Start and stop locations of submerged vegetation were recorded for species with a minimum of 25% cover;

- A rake was used to detect and record submerged species every 5 m along the transect in the water section;
- An inland habitat plot was not established because many locations had inland peatlands that extended a considerable distance. In its place, general notes were made on the vegetation and soil characteristics.

7.2.2.2.3 Muskrat Ponds

The primary objective of the muskrat pond study was to characterize muskrat habitat quality while the secondary objective was to provide additional shore zone habitat relationships data.

A map of ponds and lakes in the Keeyask Sub-regional Study Area was created. The quality of these waterbodies for muskrats was classified by the mammalogist. Four high quality and four low quality lakes were selected from the muskrat habitat quality map.

Within each waterbody, the shoreline was sub-divided into segments based on the following four classes. Major classes were optimal and unsuitable habitat for muskrats. The optimal quality segments were sub-divided into creeks and non-creek. The unsuitable quality segments were sub-divided into shallow and deep water based on helicopter photos.

For each lake, two shore segments were selected from each of the above four classes, if present. A sample location was located in the center of each shore segment that was sampled.

At each sample location, two replicate transects were established using the shore zone protocol with the following exceptions:

- The transect origin was located 3 m inland from the mainland edge or tall shrub band, but not more than 50 m from the water edge. The transects extended a distance of 25 m into the water from the water's edge;
- Terrestrial vegetation and substrate were recorded using the shore zone protocol, and aquatic vegetation was recorded according to the off-system shore zone methodology;
- Willow zone and inland habitat plots were not established;
- Soil texture was sampled with a dutch auger at the start of the transects and at the water's edge, as well as any location along the transect where there was a change in vegetation. Beyond the water line, soils were sampled to a maximum depth of 50 cm, or 20 cm into the mineral layer. Soil samples were taken every 5 m until 25 m (transect end) was reached.

7.2.2.2.4 Other Studies that Provided Relevant Information

Other project studies provided information that was relevant for improving the understanding of shore zone habitat relationships. These studies were conducted to better understand the historical effects of flooding and water regulation on shore zone ecosystems in northern Manitoba. These studies are presented in separate reports (ECOSTEM 2011c, 2012a, b).

7.2.3 Data Analysis

7.2.3.1 Inlands

7.2.3.1.1 Descriptive Statistics

Preliminary data analysis included descriptive statistics and exploratory analyses to examine data structure and identify potential outliers for plot datasets. Stem and leaf plots and box plots were among the techniques used were for variables measured on interval or ratio scales.

Descriptive statistics were calculated for trees, snags, tall shrubs, understorey species, substrate cover, vegetation cover and height and downed woody debris for the entire LNR region and by Regional Study Area. Descriptive statistics were calculated following each field season starting in 2003 to guide subsequent field studies, identify data gaps and support the development of the stand level terrestrial habitat classification that was used to map terrestrial habitat.

Plot species richness was measured as species density (i.e., the number of species identified within the plot).

7.2.3.1.2 Species Distribution and Abundance

Species distribution and abundance was determined from the inland sample plots.

The distribution of a species was calculated based on the percentage of all sample plots that the species occurred in, with percentages calculated over the relevant grouping variable (e.g., LNR region, Regional Study Area, ecosite type). The distribution of a species was considered very widespread if it was found in more than 90% of the plots, widespread if it was found in 75% to 90% of the plots, scattered if it was found in 25% to 75% of plots and localized if it was found in less than 25% of plots (Table 7-2).

Species abundance was calculated based on the mean quadrat frequency of each species within a plot, with means calculated over the relevant grouping variable (e.g., Regional Study Area, ecosite type). Maximum abundance was 15 per plot, as there were 15 quadrats per plot. Species were considered very abundant if the mean frequency was

12 or higher; abundant if the mean frequency was 8 to 12, moderate if the mean frequency was 5 to 8 and sparse if it was less than 5 (Table 7-2).

Table 7-2: Species distribution and sbundance classes

Distribution (D) (% of plots)		Abundance (A) (mean quadrat frequency; max = 15)	
Very Widespread	D ≥ 90%	Very Abundant	A ≥ 12
Widespread	75% ≤ D < 90%	Abundant	8 ≤ A < 12
Scattered	25% ≤ D < 75%	Sporadic	5 ≤ A < 8
Localized	0 < D < 25%	Sparse	0 < A < 5
Absent	0%	Absent	0

7.2.3.1.3 Habitat Classification

A primary objective for the terrestrial habitat and ecosystem studies was to develop site and stand level hierarchical terrestrial habitat and ecosystem classifications applicable to both of the LNR region Regional Study Areas (Section 7.1).

A preliminary site level terrestrial habitat classification was developed in 2004 to guide subsequent field studies and support the development of the stand level terrestrial habitat classification that was used to map terrestrial habitat. Preliminary analyses determined that the most suitable approach for vegetation classification was to combine the understorey frequency data and standardized tree and tall shrub density data into a single dataset.

Tree and tall shrub density data (stems/ha) was standardized to a 15-point abundance scale for consistency with the understory species quadrat data. This was accomplished by calculating the stem densities for the two datasets, and standardizing to an overall maximum density value as follows:

$$SA = D_{spp} / MA \times 15$$

Where *SA* was the standardized abundance, D_{spp} was the species stem density in a particular plot, and *MA* was an upper percentile maximum density of pooled plot data.

For tall shrub data, *MA* was the 85th percentile tall shrub density from all plots. For tree data, *MA* was the 95th percentile tree density for the sapling, 0 to 9 cm, and >9 to 15 cm DBH classes. The larger DBH classes were adjusted to emphasize the relative importance of larger diameter classes. Any resulting *SA* values above 15 were reset to a value of 15 in a second step.

The terrestrial habitat classification was updated in 2009 before it was finalized in 2011. Plots sampled after 2011 were assigned to a terrestrial habitat type from the final classification.

The steps taken to develop the site level terrestrial habitat classification evolved somewhat over the years. The steps used for the final classification were:

1. Calculate descriptive statistics and complete exploratory data analysis;
2. Determine which plant species will be retained for the analyses since species that only occur in one or a few plots can heavily influence multivariate results;
3. Produce the first iteration classification using cluster analysis;
4. Corroborate the preliminary cluster analysis using other multivariate techniques and descriptive statistics;
5. Refine classification; and,
6. Choose the cluster solution group levels that will be used as the coarse and fine site level terrestrial habitat classifications.

The sections below describe the methods for those steps where methods may not be obvious from viewing the results.

Species To Retain

McCune and Grace (2002) recommend dropping infrequent species because they can distort results, depending on the question being addressed. Their rules of thumb for selecting which species to drop range from dropping species that occur in less than three plots to dropping species that occur in less than 5% of the plots. The latter rule of thumb can remove a high percentage of species when the study includes sampling along multiple ecological gradients. McCune and Grace (2002) also caution that the 5% rule of thumb will not be valid for some study objectives.

The terrestrial habitat relationships study intentionally sampled rare habitats. It was decided that species occurring in these habitat types should be retained unless they were substantially distorting the multivariate results. Consequently, the 5% rule was not used.

The cutoff for infrequent species removal was determined by a two-step process that evaluated the sensitivity of multivariate results to the species inclusion cutoff (i.e., minimum number of plots that a species must occur in to be included in the clustering). In step one, the number of cluster groups to use for the species inclusion sensitivity analysis was selected using cluster analysis and indicator species analysis. Using PC-ORD 6 software (McCune and Mefford 2011), a Ward’s clustering was performed using the Sorensen resemblance measure. The plots were the objects and all species were included. A group membership was assigned to each plot for each solution level from 3 to 40. A candidate number of groups was chosen using an indicator species analysis method adapted as follows, from that outlined in McCune and Grace (2002). Indicator species analysis was performed using the group membership at each solution level. The cluster solution level (i.e., number of groups) used for the species inclusion sensitivity analysis was the one that generated the best combination of average P-value and total number of significant P-values, provided that it had a sound ecological interpretation.

In step two, an iterative process was conducted to assess the sensitivity of the cluster solution to the species inclusion cutoff. In the first iteration, species occurring in less than three plots were excluded from the dataset and then a cluster analysis was performed. Group membership at the solution level determined in step one was then assigned to each plot. In the second iteration, species occurring in less than four plots were removed and plot group membership was assigned for this species inclusion level. After successive iterations, the number of plots changing group membership was calculated. Iterations continued until the first zone of group membership stability was identified. That is, the cluster solution was virtually insensitive to changing the number of species dropped. The cluster solution where species in less than approximately 5% of plots were dropped was also generated to demonstrate the effect of using this “rule-of-thumb” cutoff criterion.

Site level Habitat Types

After the number of species to be retained for analysis was determined using the method described above, a second cluster analysis was performed on the reduced species dataset. Ward’s Cluster Analysis using the Sorensen (Bray-Curtis) distance measure in PC-ORD 6.05 was performed, and plot group memberships were retained for the 60 group solution. Sixty groups was chosen as a maximum because preliminary analyses indicated that this number of groups was higher than that required to capture the variation along the different ecological gradients in the study area. The indicator species analysis used in step one was also used to identify a series of candidate pruning levels (i.e., group solutions) for the coarse and fine site level habitat types. Candidate pruning levels were tested for group distinctiveness using multi-response permutation procedures (MRPP) analysis in PC-ORD (using Sorensen distance measure).

Coarse to fine site level habitat types were chosen from the candidate pruning levels by analyzing and comparing both site and vegetation characteristics for each group solution. Groups with the most distinctive and ecologically interpretable combinations of site and vegetation characteristics were used to define the coarse and fine site level habitat types.

After the final groups were chosen, the plot habitat types were named using the following naming convention as a guideline:

- Leading tree species if present (highest # sites [minimum 75%], then highest mean density) *or* canopy type (i.e. “Needleleaf”, “Broadleaf”, “Mixedwood”) +
- Secondary tree species if present (highest # sites [minimum 70%], highest mean density) *or* canopy type +

- Distinguishing understorey characteristics if applicable (abundant species, indicator species) +
- Typical site type, if applicable

A naming term was only used if it characterized the habitat type. For example, "Small-Diameter Black Spruce, Low Shrub, Horsetail Feathermoss Bog" is distinguished from "Small-Diameter Black Spruce, Low Shrub, Horsetail Sphagnum Bog" on the basis of the dominant moss ground cover. If a particular type of ground cover did not characterize or distinguish the habitat type, then it is not mentioned in the habitat type name. Additional descriptive adjectives at the beginning of the name were also used if required to distinguish the type from others in the group or subgroup, for example "Moist Black Spruce…" and "Dry Black Spruce…", or "Young Jack Pine…".

Ordination of Plot Vegetation

Nonmetric multidimensional scaling (NMS) was the primary analysis method used for ordination of species data because it does not assume normality or linear relationships in the dataset (McCune and Grace 2002). This method was suitable for this dataset because this study sampled across a wide range of ecological gradients. NMS ordinations were performed on all of the available LNR region plots, as well as subsets corresponding to broad ecological groups (e.g. mineral and peatland sites). The ecological groups were determined by the hierarchical relationships between coarse site level habitat types from the cluster analysis (See Section 7.3.2.2).

NMS ordinations were performed in PC-ORD 6.05 using the same dataset used for the cluster analysis of vegetation data and the Sorensen distance measure. Dimensionality was determined by stepping down from six to one dimension, choosing the number of dimensions where reductions in stress to the next step was low (McCune and Grace 2002). Thirty runs were performed with real data, and 35 runs with randomized data constrained by a maximum of 300 iterations. Ordination scores were saved to a file to produce species biplots. For interpretive purposes, the plots in the ordinations were grouped according to coarse site level habitat types.

The ordination results were used to identify associations among species, and between the plots and quantitative environmental variables. Associations among species was assessed quantitatively using a plexus diagram (McCune and Mefford 2011). The plexus diagram was obtained by PC-ORD through the calculation of a standardized association value obtained from a chi-square 2 x 2 contingency table of presence-absence for each species. Positive associations that exceeded value thresholds of 0.3 and 0.5 were considered to be weakly and strongly associated, respectively. Species with strong or weak positive associations were connected by lines on the ordination diagram. Method details are available in McCune and Mefford (2011).

The relationship between the vegetation ordination and the Ward's clustering coarse habitat types and the environmental variables was assessed by calculating Kendall's tau-b correlation coefficients between the ordination axis scores and quantitative environmental variables. Environmental variables were then overlain on the species biplot to produce a joint plot. The joint plot is produced by plotting vectors, where the vectors radiate from the ordination centroid, to scaled coordinates determined from the correlation scores for each axis.

Because sampling occurred over numerous long ecological gradients, some important relationships could be masked by ordinations performed on the entire dataset. To investigate these potential species-environment relationships, NMS ordinations were repeated on subsets of the vegetation dataset that were grouped along the dominant gradient in the ordination of the full dataset.

Due to the inclusion of tree pseudo-species in the vegetation data, there was a possibility that structural characteristics could influence the ordination and mask some of the environmental associations with understorey species. For interpretation and Ward's clustering and verification purposes during the preliminary analyses, the above ordinations were repeated using the understorey species dataset with the tree pseudospecies removed. The results of this analysis were compared with the results of the cluster analysis with tree pseudospecies included.

7.2.3.2 Shoreline Wetlands

7.2.3.2.1 Preliminary Descriptive Statistics

Each shore zone transect was classified into an overall substrate type based on both the substrate found on the surface and at depth for all the quadrats along the transect. Because substrate at surface likely played a larger role in determining the community structure of the vegetation, the "surface substrate" scores were given a higher weighting. This was done as follows for each of the substrate types:

0.7*(# Quadrats Type 1 Surface) + 0.3*(# Quadrats Type 1 Depth) = Total Quadrats for Type 1

This was repeated for each type for the transect. The classification of a given replicate location was then calculated from these new values.

Most classifications were based on a 70/30 rule. For example, if any type contained greater than 70% of the total quadrats within that location, the location was classified as that substrate class. (e.g., if more than 70% of the quadrats were classified as "Organic", the location as a whole is given an "Organic" classification). Criteria for the five substrate classes are given as follows:

Class 1 (Organic): If % organic quadrats is greater than 70%

Class 2 (Organic dominated mixture, which was coded as Org-Min Mix): Following conditions must be met:

a. Org-Min mixture class > 70%

OR

b. % plots with organic material /% plots without organic material >0.5<2

(plots with organic material = organic + organic mineral mix)

(plotswithout organic material = mixed mineral + Fine Mineral + Coarse)

Class 3 (Fine Mineral): Fine mineral > 70

Class 4 (Mineral dominated mixture, which was coded as Min-Org Mix): If following conditions were met:

a. no single class is greater than 70%

b. The ratio of % organic material to % mineral material is <0.429

OR

c. If the % mineral mix > 70%

Class 5 (Coarse Mineral): If % Coarse mineral > 70

7.2.3.2.2 Species Distribution and Abundance

Descriptive summaries of the understory data from the Shore, Muskrat and Wetland Protocols (2003-2006) in this section include trees, tall shrubs, low shrubs, herbaceous and ground cover layers. The data were summarized over the entire Regional Study Area, by location on- or off- system and by geographic zone (*i.e.*, Keeyask, Stephens, Long Spruce, Limestone). As well, the data were summarized by substrate class (organic, organic-mineral mix, fine mineral, mineral mix, and coarse mineral).

For each data stratification, four species lists are presented: the least conservative estimate of species distribution by location, whereby a species must have occurred in at least one quadrat in one of the two transects at a location, followed by species which occurred in at least three quadrats in one of the two transects, species which occurred in at least one quadrat in both transects and the most conservative estimate of species distribution, whereby a species must have occurred in at least 3 quadrats in both transects. For reporting purposes, the estimation using species occurring in at least one quadrat in both transects was retained. Species distribution (Table 7-2) was determined for all locations combined, for locations on- and off-system separately, and for locations separated by sampling area (Keeyask, Stephens Lake, Long Spruce and Limestone)

7.2.3.2.3 Habitat Classification

Cluster analysis was used to determine shore zone habitat types along a gradient from the shallow water to the inland edge zone. Vegetation data from paired transects at each of the wetland habitat locations were subdivided into two datasets. The first dataset included Transect 1 data, and was used for the primary cluster analysis and descriptive analysis. The second dataset included data from Transect 2 at each location, and was retained to later verify results from the analyses of Transect 1 data.

Species to retain

Habitat mapping and exploratory analysis indicated that shore zone habitat in the Nelson River and off-system waterbodies differed considerably. Subsequently, the shore zone transect locations were subdivided into Nelson River and off-system datasets for separate analyses.

To reduce the confounding effect of outliers on the cluster analysis, species occurring in a very small percentage of transects were removed from the dataset. A different approach to determining species to retain was used for the wetland transect data than for the inland plot data. Due to the number of long ecological gradients sampled along each shore zone transect, and the need to retain sufficient numbers of species to represent the entire gradient as well as the study area stratification factors, the iterative indicator species selection method used for the inland habitat plot analyses (Section 7.2.3.1.3), which was efficient for the inland analysis, would have involved considerably more effort than required to address the questions of interest.

The cut-off number of transects that a species must occur in order to be retained was determined by running a series of cluster analyses using different cut-off levels. Candidate cut-off levels were determined by assessing the number of species remaining while increasing the cut-off level from zero, up to 5% of the transects. Candidates were chosen where a sufficient percentage of species was retained to capture the long ecological gradients sampled, while removing very rare species that were distorting the multivariate results and obscuring the ecological gradients.

Ward’s cluster analysis was then performed on each of the candidate datasets, and the results were compared. The species to retain cutoff used for further analyses was the one that produced groups with the best interpretability as determined by descriptive statistics and professional judgment.

Shore Zone Habitat Types

Within each of the two shore zone datasets (*i.e.*, Nelson River and off-system), a Ward's Cluster Analysis using the Sorensen (Bray-Curtis) distance measure in PC-ORD 6.05 (McCune and Mefford 2011) was performed on the presence data from all of the 0.1 m^2 quadrats. Quadrat group memberships were retained up to the 50 group solution. This number was chosen because it was judged to be a number higher than the possible number of ecologically distinctive wetland types based on the environmental gradients in the study area.

A PC-ORD indicator species analysis (McCune and Mefford 2011) was performed on each cluster solution level from 3 to 50. Changes in indicator species and species composition were assessed at each step in the clustering as the number of groups was increased. The grouping level(s) judged to show the best combination of group distinctiveness and ecological interpretability was chosen as a candidate solution. Environmental characteristics for each of the candidate groups were then analyzed, and further refinement to the grouping level was made if necessary.

After the final cluster solution was chosen for each data subset, the cluster analysis groups were further grouped into general water depth duration zones if possible using standardized water depth data for each transect. This analysis established apparent associations between vegetation composition and the water depth duration zone.

Transect depth data for the Nelson River and off-system datasets were standardized differently to reflect differences in hydrological conditions and sampling methods. For off-system locations, the transect depth at the water edge was set to zero, with depths inland from the water edge becoming negative depths, and shallow water depths became positive depths. Nelson River locations were sampled during a low-water year, and water depth varies over a much larger range annually. Because a typical water edge position could not be established, transect depth at the bottom of the inland/upper beach bank was set to zero. Depths inland of the upper beach/inland edge bank were negative depths, while upper beach to shallow water depths were positive.

Inter-quartile depth ranges were calculated for each of the vegetation groups in the final cluster solution. Based on analysis of the depth ranges and vegetation composition of the groups, they were placed where possible into general water duration zones.

7.2.4 Stand Level Coarse Habitat Type Descriptions

Stand level coarse and fine habitat descriptions were developed for the habitat mapping from the plot data. GIS location data from each plot was used to overlay the plot position onto the habitat mapping (Section 6.2.2). Plot data was applied to stand level mapped habitat types by inheriting the coarse habitat type of the polygon in which the plot fell.

Once mapped habitat types were associated with individual plots, coarse mapped habitat type was compared to the plot habitat type. This was done to identify unusual associations between mapped and plot habitat type from cluster analysis. These situations arose because of the differences in the scale of information used to classify habitat between the two methods. Mapped habitat types were assigned based on the average conditions within a polygon that is usually one to several hectares in size. Plot habitat types were based on more detailed information within an area no larger than 400 m^2. Consequently, some plot habitat types differed from the mapped habitat type due to microsite conditions that were not captured in the mapping. In this situation, either the mapped coarse habitat type was adjusted to reflect conditions in a smaller area, or the plot habitat type was accepted as legitimate due to the natural variability within the mapped polygon.

A second reason for differences arises from plots that were located close to the boundary, or transitional zone between two mapped habitat types. Due to the scale of mapping, the boundary may have captured part of an adjacent habitat type that the plot occurred in. In this situation, the mapped habitat type associated with the plot was changed to that of the adjacent polygon that the plot truly occurred in. If the boundary deviation was large enough, the polygon was adjusted in the mapping.

The third possible reason for differences was due to mistyped polygons. In this situation, the photo-interpretation was reviewed, and corrections were made to the habitat mapping. The corrected coarse habitat type was then assigned to that plot.

Once the plot data and mapped habitat associations were finalized, plot-based species, environmental and structural data were used to generate descriptive statistics for each of the mapped coarse habitat types.

7.3 RESULTS

Soils and ecosites were described in Section 5.4. This section describes plant species, vegetation types, habitat types and habitat relationships. Unless otherwise stated, all of the results in this section are for the Keeyask Regional Study Area only.

Terrestrial habitat was sampled at 377 inland plots and 262 shore zone locations, including 69 locations in the Limestone reservoir (Map 7-1). Table 7-3 provides the number of samples by major ecological zone (inland, shore zone) and sampling protocol.

Table 7-3: Number of Keeyask Regional Study Area sample locations by major ecological zone (inland, shore zone) and sampling protocol

Sampling Protocol	Ecological Zone		
	Inland	Shore	Total
Inland	377	n/a	377
Muskrat pond	n/a	59	59
Shore	n/a	135*	135
Shore & wetland	n/a	68	68
Total	377	262	632

* Notes: Shore protocol includes 69 Limestone reservoir locations.

7.3.1 Plant Species

The plant species found in the Regional Study Area were typical of the central Canadian boreal forest, consisting primarily of species that are tolerant of the cold, harsh climate and can grow in peatlands.

Manitoba Conservation Data Center (MBCDC) information, floras and herbarium records indicated that at least 750 vascular plant species could potentially occur in the Regional Study Area. Of this total, 350 taxa consisting of 304 species and 46 broader taxa (*e.g.*, species only identified to the genus level in the field) were recorded during field studies in the Regional Study Area. The 377 Inland plots included 221 of these taxa; the 193 shoreline wetland transects included 253 taxa.

All of the 11 bryophytes and lichens that were to be identified to either species or genus during field studies were encountered. An additional 85 moss, lichen and liverwort species were identified to either species or genus in the lab from ground layer samples collected in the Inland plots (Project studies only attempted to identify the most common and abundant ground mosses and lichens in the field). Based on field data and ground layer samples collected at the terrestrial habitat plots, 88 mosses, six lichens and two liverworts were identified to either a species or a broader taxon.

Appendix 7-A provides a list of vascular plant species that could potentially occur in the Regional Study Area, along with common names, scientific names, MBCDC conservation concern ranking (*i.e.*, S-Rank) as of 2011 and the number of locations where the species was found during the terrestrial habitat and plant studies. Appendix 7-A also includes the list of non-vascular plants identified from ground vegetation samples collected at the inland habitat plots and the number of plots where the species was found.

In descending order, the most widespread and abundant plant taxa were black spruce (*Picea mariana*), green alder (*Alnus viridis* ssp*. crispa*), willows (*Salix bebbiana, S. myrtillifolia, S. planifolia, S. pedicellaris*), swamp birch (*Betula pumila*), Labrador tea (*Rhododendron groenlandicum*) and rock cranberry (*Vaccinium vitis-idaea*) in the inland habitat plots (stem density was the abundance measure for trees and tall shrubs; quadrat frequency was the abundance measure for low shrubs, herbs and ground cover). Marsh reed-grass (*Calamagrostis canadensis*), common horsetail (*Equisetum arvense*) and water sedge (*Carex aquatilis*) were the most widespread species in the shoreline wetland transects.

Based on the species distribution and abundance classes (Table 7-2), no species were very widespread and very abundant in the inland plots while 158 species were localized and sparse (Table 7-4). No species were widespread or very widespread in the shoreline wetland transects while 17 species were scattered.

Table 7-4: Number of plant species that occurred in each of the distribution and abundance classes based on the field data

Abundance Class	Distribution Class			
	Very Widespread	Widespread	Scattered	Localized
Inland Plots				
Very Abundant	0	0	0	0
Abundant	0	1	0	0
Sporadic	1	1	1	0
Sparse	0	1	23	158
Shoreline Wetland Transects				
Total	0	0	11	210

Notes: See Table 7-2 for class ranges.

7.3.2 <u>Inlands</u>

7.3.2.1 Overview

Of the 304 species and 46 broader taxa recorded during field studies in the Regional Study Area, 186 of these taxa were found in inland sample locations.

7.3.2.1.1 Trees

Black spruce was the most commonly recorded tree species (81% of plots; Table 7-5), followed by tamarack (*Larix laricina*), white birch (*Betula papyrifera*), jack pine (*Pinus banksiana*), trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*) and white spruce (*Picea glauca*). Black spruce also had the highest mean stem density across all plots (6,488 stems/ha). White spruce and balsam poplar had the lowest overall mean stem densities (7 stems/ha and 21 stems/ha, respectively). When considering only the plots where the species was present, black spruce still had the highest mean stem density by far. Snag density was higher in plots than all tree species except black spruce, but was less dense than all species in plots where present, except for white spruce and balsam poplar.

Tree species distribution and relative abundance patterns were generally the same across all six vegetation structure types (*i.e.*, forest, woodland, sparsely treed, tall shrub, low shrub, bryoid and sparse; Table 7-6). Prominent exceptions were that black spruce and tamarack were predominant in the tall shrub, low shrub and bryoid plots. As well, tamarack was not recorded in forest plots. Snag density was highest in the sparse and low shrub vegetation types.

Black spruce had the highest mean stem density in all of the five site types that had adequate replication in the Regional Study Area, except for fen (Table 7-7). Fen and sphagnum bog had fewer tree species than the other site types. White spruce was only recorded on the deep dry mineral site type and once in the feathermoss bog site type. Snags were the most dense in deep moist sites, but had a relatively consistent density across all site types.

Tree species distribution and relative abundance patterns were similar among the Regional and Local Study Areas (N= 237 and 98, respectively). White birch was observed in only 18% of Regional Study Area plots compared to 32% of Local Study Area plots and had a lower mean stem density (119 stems/ha compared to 387 stems/ha in Regional Study and Local Area, respectively). Differences in species frequencies in the study areas were attributed to the higher proportions of mineral soils and rare habitat plots in the Local Study Area portion of the Regional Study Area.

Table 7-5: Tree and snag density statistics by diameter class for the inland habitat plots

Tree Species[1]	Number of Plots (max= 377)	Stems per hectare				
		All Plots				Where Present
		Mean	SD	Min	Max	Mean
All Size Classes						
trembling aspen	46	135	647	0	6,800	1,104
balsam poplar	21	21	118	0	1,200	382
white birch	101	312	1,118	0	10,200	1,165
jack pine	77	399	2,322	0	27,600	1,953
white spruce	5	7	71	0	900	500
black spruce	306	6,488	7,198	0	47,800	7,994
tamarack	109	392	1,002	0	7,400	1,356
snags	252	704	1,154	0	32,000	1,054
By Diameter Class						
trembling aspen sapling	8	28	260	0	3,400	1,325
trembling aspen 0-8	27	65	434	0	6,800	904
trembling aspen 9-15	24	25	166	0	2,075	395
trembling aspen 16-20	22	11	69	0	800	197
trembling aspen > 20	15	5	35	0	500	133
balsam poplar sapling	3	2	25	0	400	267
balsam poplar 0-8	12	12	90	0	1,200	383
balsam poplar 9-15	9	6	55	0	700	269
balsam poplar 16-20	5	1	6	0	100	40
balsam poplar > 20	0	0	0	0	0	0
white birch sapling	24	50	263	0	2,600	783
white birch 0-8	60	220	916	0	9,000	1,380
white birch 9-15	56	34	129	0	1,200	232
white birch 16-20	28	7	36	0	350	94
white birch > 20	6	1	15	0	275	79
jack pine sapling	3	6	76	0	1,200	800
jack pine 0-8	29	325	2,306	0	27,600	4,221
jack pine 9-15	57	41	152	0	1,500	273
jack pine 16-20	43	17	64	0	500	152
jack pine > 20	33	9	41	0	400	105
white spruce sapling	1	2	31	0	600	600
white spruce 0-8	1	1	21	0	400	400
white spruce 9-15	4	2	27	0	400	231
white spruce 16-20	4	1	16	0	300	100
white spruce > 20	4	0	6	0	100	44

Tree Species[1]	Number of Plots (max= 377)	Stems per hectare				
		All Plots				Where Present
		Mean	SD	Min	Max	Mean
black spruce sapling	267	2,715	3,414	0	18,800	3,834
black spruce 0-8	259	3,556	4,734	0	31,800	5,176
black spruce 9-15	188	193	370	0	2,100	387
black spruce 16-20	65	20	62	0	475	116
black spruce > 20	28	4	17	0	150	54
tamarack sapling	64	109	351	0	3,000	641
tamarack 0-8	77	268	793	0	7,000	1,312
tamarack 9-15	35	13	62	0	700	138
tamarack 16-20	12	3	21	0	300	83
tamarack > 20	0	0	0	0	0	0
snags 0-8	217	647	1,127	0	6,200	1,124
snags 9-15	109	49	137	0	900	169
snags 16-20	40	8	34	0	400	73
snags >20	11	1	10	0	150	45

Notes: [1] Numbers next to tree species is the DBH class range in cm. DBH= diameter at breast height; SD= standard deviation; Min= minimum; Max= maximum

Table 7-6: Tree and snag density statistics by vegetation structure type for the inland habitat plots

Vegetation Structure Type	Forest			Woodland			Sparsely Treed			Tall Shrub			Low Shrub			Bryoid			Sparse		
Number of Plots	18			100			137			25			30			58			9		
		Stems per hectare			Stems per hectare			Stems per hectare			Stems per hectare			Stems per hectare			Stems per hectare			Stems per hectare	
Tree Species[1]	Number of Plots Present	All Plots	Where Present	Number of Plots Present	All Plots	Where Present	Number of Plots Present	All Plots	Where Present	Number of Plots Present	All Plots	Where Present	Number of Plots Present	All Plots	Where Present	Number of Plots Present	All Plots	Where Present	Number of Plots Present	All Plots	Where Present
		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean
trembling aspen	11	803	1,314	25	210	838	6	57	1,300	0	0	0	0	0	0	2	76	2,200	2	356	1,600
balsam poplar	2	26	238	11	53	484	7	13	261	1	16	400	0	0	0	0	0	0	0	0	0
white birch	9	586	1,172	49	492	1,003	31	280	1,235	5	224	1,120	4	367	2,750	3	53	1,025	0	0	0
jack pine	10	401	723	26	1,073	4,125	35	224	875	0	0	0	1	93	2,800	4	38	550	1	33	300
white spruce	1	6	100	3	15	500	1	7	900	0	0	0	0	0	0	0	0	0	0	0	0
black spruce	14	3,454	4,441	97	9,204	9,489	133	8,682	8,943	7	524	1,871	13	1,567	3,615	38	3,589	5,478	4	636	1,431
tamarack	0	0	0	25	399	1,596	46	392	1,167	8	440	1,375	7	453	1,943	22	504	1,330	1	44	400
snags	17	689	729	81	791	977	94	496	723	9	333	925	16	1,035	1,941	28	739	1,530	7	2,656	3,414
trembling aspen sapling	1	33	600	3	22	733	1	23	3,200	0	0	0	0	0	0	2	66	1,900	1	89	800
trembling aspen 0-8	7	300	771	14	126	900	2	25	1,700	0	0	0	0	0	0	2	10	300	2	267	1,200
trembling aspen 9-15	8	363	816	12	25	204	4	4	125	0	0	0	0	0	0	0	0	0	0	0	0
trembling aspen 16-20	7	93	239	13	22	169	2	3	225	0	0	0	0	0	0	0	0	0	0	0	0
trembling aspen > 20	2	14	125	10	15	150	3	2	83	0	0	0	0	0	0	0	0	0	0	0	0
balsam poplar sapling	0	0	0	1	4	400	1	1	200	1	8	200	0	0	0	0	0	0	0	0	0
balsam poplar 0-8	1	22	400	6	30	500	4	7	250	1	8	200	0	0	0	0	0	0	0	0	0
balsam poplar 9-15	1	4	75	5	18	360	3	4	183	0	0	0	0	0	0	0	0	0	0	0	0
balsam poplar 16-20	0	0	0	2	1	63	3	1	25	0	0	0	0	0	0	0	0	0	0	0	0
balsam poplar > 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
white birch sapling	1	11	200	9	58	644	7	48	943	3	120	1,000	2	47	700	2	31	900	0	0	0
white birch 0-8	7	433	1,114	25	328	1,312	18	210	1,600	4	104	650	4	320	2,400	2	21	600	0	0	0
white birch 9-15	7	118	304	33	84	254	16	18	155	0	0	0	0	0	0	0	0	0	0	0	0
white birch 16-20	4	24	106	16	17	108	7	3	57	0	0	0	0	0	0	1	1	75	0	0	0
white birch > 20	0	0	0	5	5	90	1	0	25	0	0	0	0	0	0	0	0	0	0	0	0
jack pine sapling	0	0	0	1	6	600	0	0	0	0	0	0	1	40	1,200	1	10	600	0	0	0
jack pine 0-8	4	89	400	10	988	9,880	10	137	1,880	0	0	0	1	53	1,600	3	24	467	1	22	200
jack pine 9-15	9	140	281	19	51	268	27	58	293	0	0	0	0	0	0	2	1	25	0	0	0
jack pine 16-20	8	115	259	12	18	150	21	18	117	0	0	0	0	0	0	1	2	125	1	11	100
jack pine > 20	8	57	128	12	10	79	12	11	123	0	0	0	0	0	0	1	0	25	0	0	0
white spruce sapling	0	0	0	0	0	0	1	4	600	0	0	0	0	0	0	0	0	0	0	0	0
white spruce 0-8	0	0	0	1	4	400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
white spruce 9-15	1	3	50	2	6	300	1	2	275	0	0	0	0	0	0	0	0	0	0	0	0
white spruce 16-20	1	1	25	2	4	175	1	0	25	0	0	0	0	0	0	0	0	0	0	0	0

Vegetation Structure Type	Forest			Woodland			Sparsely Treed			Tall Shrub			Low Shrub			Bryoid			Sparse		
Number of Plots	18			100			137			25			30			58			9		
Tree Species[1]	Number of Plots Present	Stems per hectare: All Plots Mean	Stems per hectare: Where Present Mean	Number of Plots Present	Stems per hectare: All Plots Mean	Stems per hectare: Where Present Mean	Number of Plots Present	Stems per hectare: All Plots Mean	Stems per hectare: Where Present Mean	Number of Plots Present	Stems per hectare: All Plots Mean	Stems per hectare: Where Present Mean	Number of Plots Present	Stems per hectare: All Plots Mean	Stems per hectare: Where Present Mean	Number of Plots Present	Stems per hectare: All Plots Mean	Stems per hectare: Where Present Mean	Number of Plots Present	Stems per hectare: All Plots Mean	Stems per hectare: Where Present Mean
white spruce > 20	1	1	25	3	2	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
black spruce sapling	12	1,556	2,333	79	2,924	3,701	118	3,780	4,388	6	400	1,667	13	1,273	2,938	36	2,310	3,722	3	356	1,067
black spruce 0-8	10	1,800	3,240	84	5,900	7,024	121	4,626	5,238	3	120	1,000	8	287	1,075	31	1,214	2,271	2	267	1,200
black spruce 9-15	6	67	200	71	326	460	94	257	374	2	4	50	2	7	100	12	59	288	1	8	75
black spruce 16-20	5	31	110	31	44	141	26	16	86	0	0	0	0	0	0	2	6	163	1	6	50
black spruce > 20	1	1	25	19	10	54	8	3	59	0	0	0	0	0	0	0	0	0	0	0	0
tamarack sapling	0	0	0	7	58	829	27	109	556	6	152	633	7	120	514	17	221	753	0	0	0
tamarack 0-8	0	0	0	17	302	1,776	32	269	1,150	7	288	1,029	5	333	2,000	15	283	1,093	1	44	400
tamarack 9-15	0	0	0	15	34	223	18	10	79	0	0	0	0	0	0	2	1	25	0	0	0
tamarack 16-20	0	0	0	6	6	92	6	3	75	0	0	0	0	0	0	0	0	0	0	0	0
tamarack > 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
snags 0-8	11	600	982	71	712	1,003	82	454	759	7	320	1,143	14	973	2,086	26	693	1,546	6	2,467	3,700
snags 9-15	11	67	109	43	67	155	31	37	165	5	13	65	6	48	242	9	34	219	4	186	419
snags 16-20	6	13	38	18	12	64	10	4	55	0	0	0	2	13	188	3	10	192	1	3	25
snags >20	2	10	88	4	1	25	3	1	33	0	0	0	1	1	25	1	2	100	0	0	0

Notes: [1] Numbers next to tree species is the DBH class range in cm. DBH= diameter at breast height

Table 7-7: Tree and snag density statistics by site type for the inland habitat plots

Site Type	Deep Dry			Deep Moist			Feathermoss Bog			Sphagnum Bog			Fen		
Number of Plots Total	133			34			38			115			53		
Tree Species[1]	Number of Plots	Stems per hectare: All Plots Mean	Stems per hectare: Where Present Mean	Number of Plots	Stems per hectare: All Plots Mean	Stems per hectare: Where Present Mean	Number of Plots	Stems per hectare: All Plots Mean	Stems per hectare: Where Present Mean	Number of Plots	Stems per hectare: All Plots Mean	Stems per hectare: Where Present Mean	Number of Plots	Stems per hectare: All Plots Mean	Stems per hectare: Where Present Mean
trembling aspen	37	330	1,203	7	161	736	1	14	525	1	5	600	0	0	0
balsam poplar	14	37	357	5	66	420	2	24	463	0	0	0	0	0	0
white birch	68	650	1,290	11	175	509	7	97	525	9	163	2,083	5	28	300
jack pine	56	924	2,226	11	309	898	6	191	1,213	3	38	1,475	0	0	0
white spruce	4	13	438	0	0	0	1	20	750	0	0	0	0	0	0
black spruce	119	6,589	7,474	29	5,509	6,079	35	9,632	10,458	96	8,273	9,911	26	782	1,594
tamarack	21	101	649	9	264	939	16	624	1,483	38	491	1,486	25	860	1,823
snags	103	765	988	25	961	1,307	30	766	970	71	723	1,171	21	351	887
trembling aspen sapling	6	73	1,633	1	13	400	0	0	0	1	3	400	0	0	0

Site Type	Deep Dry			Deep Moist			Feathermoss Bog			Sphagnum Bog			Fen		
Number of Plots Total	133			34			38			115			53		
		Stems per hectare			Stems per hectare			Stems per hectare			Stems per hectare			Stems per hectare	
Tree Species[1]	Number of Plots	All Plots	Where Present	Number of Plots	All Plots	Where Present	Number of Plots	All Plots	Where Present	Number of Plots	All Plots	Where Present	Number of Plots	All Plots	Where Present
		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean
trembling aspen 0-8	22	163	1,000	4	69	550	0	0	0	1	2	200	0	0	0
trembling aspen 9-15	19	53	375	4	66	525	1	7	250	0	0	0	0	0	0
trembling aspen 16-20	18	27	203	3	14	150	1	6	225	0	0	0	0	0	0
trembling aspen > 20	14	14	139	0	0	0	1	1	50	0	0	0	0	0	0
balsam poplar sapling	1	1	200	0	0	0	2	16	300	0	0	0	0	0	0
balsam poplar 0-8	9	22	333	2	44	700	1	5	200	0	0	0	0	0	0
balsam poplar 9-15	5	12	330	3	20	217	1	3	125	0	0	0	0	0	0
balsam poplar 16-20	3	1	50	2	2	25	0	0	0	0	0	0	0	0	0
balsam poplar > 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
white birch sapling	16	104	875	2	69	1,100	1	5	200	2	16	900	2	8	200
white birch 0-8	41	446	1,468	4	81	650	3	68	867	8	144	2,075	3	11	200
white birch 9-15	46	80	236	4	16	131	3	22	283	1	3	350	2	8	200
white birch 16-20	21	17	107	5	8	50	1	1	25	0	0	0	1	2	100
white birch > 20	5	3	90	1	1	25	0	0	0	0	0	0	0	0	0
jack pine sapling	1	4	600	1	19	600	1	32	1,200	0	0	0	0	0	0
jack pine 0-8	20	770	5,200	3	194	2,067	3	105	1,333	2	38	2,200	0	0	0
jack pine 9-15	42	90	288	8	49	197	5	40	305	1	0	25	0	0	0
jack pine 16-20	34	38	150	6	31	167	3	12	150	0	0	0	0	0	0
jack pine > 20	28	21	103	4	16	125	1	3	100	0	0	0	0	0	0
white spruce sapling	1	4	600	0	0	0	0	0	0	0	0	0	0	0	0
white spruce 0-8	0	0	0	0	0	0	1	11	400	0	0	0	0	0	0
white spruce 9-15	3	5	242	0	0	0	1	5	200	0	0	0	0	0	0
white spruce 16-20	3	3	117	0	0	0	1	1	50	0	0	0	0	0	0
white spruce > 20	3	1	25	0	0	0	1	3	100	0	0	0	0	0	0
black spruce sapling	98	2,416	3,329	19	1,875	3,158	33	4,047	4,661	96	4,000	4,792	20	355	940
black spruce 0-8	93	3,887	5,643	25	3,175	4,064	33	5,258	6,055	89	4,158	5,373	18	370	1,089
black spruce 9-15	78	239	413	22	412	599	26	312	456	56	114	233	6	46	408
black spruce 16-20	42	38	123	10	41	130	6	14	88	4	1	38	3	8	133
black spruce > 20	22	8	48	3	7	75	1	1	50	0	0	0	2	4	100
tamarack sapling	3	6	267	4	94	750	9	189	800	29	155	614	19	230	642
tamarack 0-8	12	83	933	6	144	767	9	416	1,756	33	323	1,127	17	608	1,894
tamarack 9-15	12	11	119	4	24	194	6	13	83	10	12	135	3	15	258
tamarack 16-20	5	1	40	2	2	38	2	6	113	1	1	100	2	8	200
tamarack > 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
snags 0-8	83	641	1,027	21	929	1,505	25	711	1,080	70	715	1,174	17	332	1,035
snags 9-15	67	105	208	10	25	85	11	44	152	10	7	85	9	18	108

Site Type	Deep Dry			Deep Moist			Feathermoss Bog			Sphagnum Bog			Fen		
Number of Plots Total	133			34			38			115			53		
		Stems per hectare			Stems per hectare			Stems per hectare			Stems per hectare			Stems per hectare	
Tree Species[1]	Number of Plots	All Plots	Where Present	Number of Plots	All Plots	Where Present	Number of Plots	All Plots	Where Present	Number of Plots	All Plots	Where Present	Number of Plots	All Plots	Where Present
		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean
snags 16-20	29	17	78	4	4	38	4	10	94	2	1	38	1	1	50
snags >20	7	3	54	2	2	38	2	1	25	0	0	0	0	0	0

Notes: 1 Numbers next to tree species is the DBH class range in cm. DBH= diameter at breast height

7.3.2.1.2 Woody Debris

Fine woody debris density varied considerably in the inland plots while mean coarse piece density had much smaller variation (Table 7-8). Mean woody debris piece densities by vegetation structure type and site type are provided in Table 7-9 and Table 7-10, respectively.

Table 7-8: Downed woody debris density statistics for the inland habitat plots

Downed woody debris diameter class	Number of Plots (Max = 377)	Pieces per meter				
		All Plots				Where Present
		Mean	SD	Min	Max	Mean
Coarse (> 7 cm)	185	0.1	0.1	0.0	0.6	0.1
Fine (0-7 cm)	254	0.5	0.7	0.0	3.2	0.8

Notes: SD= standard deviation; Min= minimum; Max= maximum

Table 7-9: Downed woody debris density statistics by vegetation type for the inland habitat plots

Vegetation Structure	Forest			Woodland			Sparsely Treed			Tall Shrub			Low Shrub			Bryoid			Sparse		
Number of Plots	18			100			137			25			30			58			9		
Downed woody debris classes	Number of Plots	Pieces per meter		Number of Plots	Pieces per meter		Number of Plots	Pieces per meter		Number of Plots	Pieces per meter		Number of Plots	Pieces per meter		Number of Plots	Pieces per meter		Number of Plots	Pieces per meter	
		All Plots	Where Present		All Plots	Where Present		All Plots	Where Present		All Plots	Where Present		All Plots	Where Present		All Plots	Where Present		All Plots	Where Present
		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean
Coarse (> 7 cm)	10	0.1	0.1	66	0.1	0.1	67	0.0	0.1	9	0.0	0.1	7	0.0	0.1	20	0.0	0.1	6	0.1	0.3
Fine (0-7 cm)	11	0.7	0.9	82	0.7	0.9	101	0.6	0.7	13	0.3	0.9	13	0.3	0.6	26	0.2	0.6	8	0.4	1.1

Table 7-10: Downed woody debris density statistics by site type for the inland habitat plots

Site Type	Deep Dry			Deep Moist			Feathermoss Bog			Sphagnum Bog			Fen		
Number of Plots Total	133			34			38			115			53		
Species	Number of Plots	Pieces per meter		Number of Plots	Pieces per meter		Number of Plots	Pieces per meter		Number of Plots	Pieces per meter		Number of Plots	Pieces per meter	
		All Plots	Where Present		All Plots	Where Present		All Plots	Where Present		All Plots	Where Present		All Plots	Where Present
		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean
Coarse (> 7 cm)	99	0.1	0.1	17	0.1	0.0	20	0.0	0.1	39	0.0	0.1	7	0.0	0.1
Fine density (0-7 cm)	112	0.8	0.9	24	0.6	1.0	27	0.5	0.6	71	0.2	0.4	18	0.2	0.8

7.3.2.1.3 Tall Shrubs

Green alder and willows were the most widely distributed tall shrubs in the Regional Study Area, occurring in 29% and 50% of inland plots, respectively (Table 7-11). The most frequently recorded willows were Bebb's, myrtle-leaved, flat-leaved and bog willow (Table 7-12).

Based on mean values, green alder was the most abundant tall shrub across all plots and in the plots where it occurred (Table 7-11). Willows were the second most abundant tall shrub across all of the plots but only the fifth most abundant in the plots where it occurred.

Although willow was more widespread than green alder, swamp birch and speckled alder (*Alnus incana* ssp*. rugosa*), it was less abundant where it was present (Table 7-11). Alder-leaved buckthorn (*Rhamnus alnifolia*), saskatoon (*Amelanchier alnifolia*), Canada buffalo-berry (*Shepherdia canadensis*) and low bush-cranberry (*Viburnum edule*) had low abundances in the Regional Study Area. Red-osier dogwood (*Cornus sericea*) was rarely recorded.

Green alder and willow were the most abundant tall shrubs in the three treed vegetation structure types. Swamp birch and willows were most abundant in the untreed types (Table 7-13). Red-osier dogwood was only recorded in tall shrub plots while Canada buffalo-berry was only recorded in the three treed structure types and the sparse type. Although speckled alder, low bush-cranberry and alder-leaved buckthorn were not widespread, they had relatively high densities in the sparsely treed and tall shrub types.

Green alder was the most abundant tall shrub on the deep dry and deep moist site types. Willow and swamp birch were the most abundant tall shrubs on the feathermoss bog, Sphagnum bog and fen site types (Table 7-14). Red-osier dogwood was only found on the deep dry mineral site type. Canada buffalo-berry was only found on the mineral site types. Overall, plots in the feathermoss bog and Sphagnum bog site types had lower mean tall shrub densities than the other site types.

Shrub species distribution and relative abundance patterns were similar in the Local and Regional Study Areas, with a few exceptions. Green alder was slightly more widespread than swamp birch in the local study area, while in the Regional study area, swamp birch was more abundant. Willow (3,330 stems/ha compared to 5,316 stems/ha) and green alder (3,480 stems/ha compared to 6,424 stems/ha) had lower mean densities overall in Regional Study Area plots.

Table 7-11: Shrub density statistics for the inland habitat plots

Tree Species and Diameter Class	Number of Plots (Max = 377)	Stems per hectare				
		All Plots				Where Present
		Mean	SD	Min	Max	Mean
swamp birch	92	3,203	9,639	0	69,000	13,126
green alder	108	4,886	10,692	0	58,800	17,056
speckled alder	33	900	4,399	0	37,600	10,279
alder-leaved buckthorn	4	100	1,196	0	19,800	9,450
low bush cranberry	8	48	555	0	8,600	2,250
Saskatoon	3	2	25	0	400	267
Canada buffalo-berry	13	149	1,169	0	15,800	4,323
red-osier dogwood	2	168	3,075	0	59,600	31,600
willow	189	4,432	12,955	0	90,800	8,840

Notes: SD= standard deviation; Min= minimum; Max= maximum

Table 7-12: Willow species density statistics for the inland habitat plots

Species	Distribution		Abundance
	Number of plots	Percent plots	Mean
shrubby willow (*Salix arbusculoides*)	10	3	0.1
Bebb's willow (*Salix bebbiana*)	104	28	0.8
hoary willow (*Salix candida*)	6	2	0.1
grey-leaved willow (*Salix glauca*)	21	6	0.1
myrtle-leaved willow (*Salix myrtillifolia*)	90	24	1.2
bog willow (*Salix pedicellaris*)	34	9	0.6
satin willow (*Salix pellita*)	5	1	0.0
flat-leaved willow (*Salix planifolia*)	61	16	0.8
false mountain willow (*Salix pseudomonticola*)	1	0	0.0
tall blueberry willow (*Salix pseudomyrsinites*)	15	4	0.1
willow (*Salix* spp.)	50	13	0.5
rock willow (*Salix vestita*)	8	2	0.1

Table 7-13: Shrub density statistics by vegetation structure type for the inland habitat plots

Vegetation Structure	Forest			Woodland			Sparsely Treed			Tall Shrub			Low Shrub			Bryoid			Sparse		
Number of Plots	18			100			137			25			30			58			9		
Species	Number of Plots	Stems per hectare All Plots Mean	Stems per hectare Where Present Mean	Number of Plots	Stems per hectare All Plots Mean	Stems per hectare Where Present Mean	Number of Plots	Stems per hectare All Plots Mean	Stems per hectare Where Present Mean	Number of Plots	Stems per hectare All Plots Mean	Stems per hectare Where Present Mean	Number of Plots	Stems per hectare All Plots Mean	Stems per hectare Where Present Mean	Number of Plots	Stems per hectare All Plots Mean	Stems per hectare Where Present Mean	Number of Plots	Stems per hectare All Plots Mean	Stems per hectare Where Present Mean
swamp birch	0	0	0	17	1,240	7,294	26	1,785	9,408	15	16,864	28,107	8	4,753	17,825	24	4,590	11,092	2	956	4,300
green alder	15	25,144	30,173	49	7,048	14,384	37	4,679	17,324	1	472	11,800	2	927	13,900	4	69	1,000	0	0	0
speckled alder	0	0	0	10	1,102	11,020	7	382	7,486	10	6,424	16,060	3	367	3,667	3	86	1,667	0	0	0
alder-leaved buckthorn	0	0	0	1	8	800	2	201	13,800	1	376	9,400	0	0	0	0	0	0	0	0	0
low bush cranberry	1	33	600	1	4	400	4	115	3,950	1	32	800	0	0	0	0	0	0	1	44	400
Saskatoon	0	0	0	2	6	300	0	0	0	0	0	0	0	0	0	1	3	200	0	0	0
Canada buffalo-berry	1	11	200	4	94	2,350	6	245	5,600	0	0	0	0	0	0	0	0	0	2	1,444	6,500
red-osier dogwood	0	0	0	0	0	0	0	0	0	2	2,528	31,600	0	0	0	0	0	0	0	0	0
willow	7	378	971	59	1,906	3,231	66	1,969	4,088	24	39,656	41,308	11	4,907	13,382	19	986	3,011	3	867	2,600

Table 7-14: Shrub density statistics by site type for the inland habitat plots

Site Type	Deep Dry			Deep Moist			Feathermoss Bog			Sphagnum Bog			Fen		
Number of Plots Total	133			34			38			115			53		
		Stems per hectare			Stems per hectare			Stems per hectare			Stems per hectare			Stems per hectare	
Species	Number of Plots	All Plots	Where Present	Number of Plots	All Plots	Where Present	Number of Plots	All Plots	Where Present	Number of Plots	All Plots	Where Present	Number of Plots	All Plots	Where Present
		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean		Mean	Mean
swamp birch	6	358	7,933	6	2,524	14,300	16	3,600	8,550	35	3,251	9,383	29	11,491	21,000
green alder	75	9,800	18,163	19	12,465	19,211	8	2,532	12,025	4	55	1,400	1	11	600
speckled alder	4	262	8,700	4	1,118	9,500	4	1,563	14,850	10	176	1,780	10	3,457	18,320
alder-leaved buckthorn	1	6	800	1	582	19,800	0	0	0	0	0	0	2	325	8,600
low bush cranberry	5	63	1,680	0	0	0	0	0	0	1	2	200	2	177	4,700
Saskatoon	1	2	200	1	12	400	1	5	200	0	0	0	0	0	0
Canada buffalo-berry	11	418	5,055	2	18	300	0	0	0	0	0	0	0	0	0
red-osier dogwood	1	27	3,600	0	0	0	0	0	0	0	0	0	0	0	0
willow	82	2,567	4,202	17	1,447	2,706	21	4,826	8,733	35	2,671	7,709	30	12,894	22,780

7.3.2.1.4 Understorey

Labrador tea, rock cranberry, moss species and black spruce seedlings were the only widespread to very widespread understorey taxa in the inland plots (Table 7-15). The 27 scattered taxa included 16 vascular plants, six bryophytes and five lichens.

Labrador tea, and black spruce seedlings were abundant and scarce, respectively, while other moss species and rock cranberry were sporadic. All scattered species were sparse in the Regional Study Area plots, except for green reindeer lichen, which was sporadic.

Mosses not identified to a genus or species were very widespread or widespread in all six vegetation structure types (Table 7-16). Two vascular (Labrador tea and rock cranberry) and two bryophyte (stair-step moss and big red stem moss) species were very widespread in one or more of the structure types. Very widespread species ranged from sparse to abundant. Seven vascular and five bryophyte species were widespread in one or more of the structure types. Of these taxa, four were sporadic in more than one type, but none was abundant in more than one type, except for peat mosses (*Sphagnum* spp.) which were abundant in the low shrub and bryoid types. Bunchberry (*Cornus canadensis*) and Labrador tea were abundant in the forest and woodland type, respectively. Rock cranberry, Labrador tea and green reindeer lichen were abundant in the sparsely treed type. Among the untreed structure types, four vascular and one bryophyte species were widespread in one or more type. Small bog cranberry (*Vaccinium oxycoccos*) and peat mosses were sporadic and abundant, respectively, in both the low shrub and bryoid types. Three of the species were widespread in only one of the structure types. There were no species that occurred in only one vegetation structure type.

Thirteen taxa were widespread to very widespread in one or more of the site types (Table 7-17). Mosses not identified to a genus or species and Labrador tea were very widespread and either sporadic or abundant in all site types, with the exception of Labrador tea which was widespread in the sphagnum bog type and neither very widespread or widespread in the fen type. Three vascular and one bryophyte species were very widespread in one or more site type. Additionally, two vascular and four bryophyte species were widespread in one or more site type. Of these species, four were abundant in more than one of the site types, including Labrador tea which was also very abundant in the sphagnum bog sites. Three species were sporadic in more than one of the site types. None of the species were abundant on deep dry mineral sites, but Labrador tea and rock cranberry were abundant in the deep moist mineral type. Labrador tea, rock cranberry and other moss species were abundant in the feathermoss bog type. In addition to Labrador tea, rock cranberry, sphagnum mosses and green reindeer lichen were abundant in the sphagnum bog site type. Sphagnum moss was also abundant in the fen type, where it was the only widespread species aside from other moss species and three-leaved Solomon's-seal (*Maianthemum trifolium*). Four Understorey species were widespread in only one of the site types. Four species occurred exclusively in one site type in the Regional Study Area. Trembling aspen seedlings, pink corydalis (*Corydalis sempervirens*) and jack pine seedlings were only recorded on deep dry mineral sites.

Understorey species distribution and relative abundance patterns were similar between the Local and Regional Study Areas, with a few exceptions. Green reindeer lichen was widespread in the Regional Study Area, while it was scattered in the Local Study area (in 82% in Regional plots compared to 63% in Local Study Area plots). The Local Study Area had fewer species with a scattered distribution than the Regional Study Area.

Table 7-15: Abundance of widespread and scattered understorey species in the inland habitat plots

Species	Distribution		Abundance (mean)	
	N	Percentage of Plots	All Plots	Where Present
Very Widespread and Widespread				
Rhododendron groenlandicum	333	88	8.5	9.6
Picea mariana seedling	291	77	3.3	4.3
Vaccinium vitis-idaea	288	76	7.0	9.2
Moss species	360	95	7.2	7.6
Scattered				
Carex aquatilis	100	27	1.7	6.5
Carex spp.	110	29	1.6	5.6
Chamaedaphne calyculata	102	27	2.1	7.6
Chamerion angustifolium	133	35	1.3	3.8
Cornus canadensis	130	34	2.2	6.4
Equisetum arvense	96	25	1.3	4.9
Equisetum scirpoides	124	33	1.5	4.5
Equisetum sylvaticum	113	30	1.5	5.0
Geocaulon lividum	99	26	1.1	4.2
Kalmia polifolia	108	29	1.3	4.4
Linnaea borealis	114	30	1.7	5.7
Maianthemum trifolium	120	32	1.7	5.3
Rosa acicularis	145	38	2.2	5.8
Rubus chamaemorus	122	32	2.3	7.1
Vaccinium oxycoccos	172	46	3.3	7.2
Vaccinium uliginosum	175	46	2.8	5.9
Dicranum spp	82	33	1.9	5.9
Hylocomium splendens	196	52	3.1	5.9
Pleurozium schreberi	248	66	4.5	6.8
Sphagnum capillifolium	73	29	2.3	8.0
Sphagnum fuscum	94	38	3.4	8.9
Sphagnum spp	206	55	4.4	8.1
Cladina mitis	264	70	5.8	8.3
Cladina rangiferina	159	42	2.6	6.1
Cladina stellaris	117	31	1.5	4.8
Cladonia spp.	248	66	3.5	5.3
Peltigera spp.	144	38	1.2	3.1

Table 7-16: Mean abundance of widespread understorey and scattered understorey species in the inland habitat plots by vegetation structure type

Structure Type	Forest			Woodland			Sparsely Treed			Tall Shrub			Low Shrub			Bryoid			Sparse		
Number of Plots	18			100			137			25			30			58			9		
Species	Number of Plots	Abundance All Plots Mean	Abundance Where Present Mean	Number of Plots	Abundance All Plots Mean	Abundance Where Present Mean	Number of Plots	Abundance All Plots Mean	Abundance Where Present Mean	Number of Plots	Abundance All Plots Mean	Abundance Where Present Mean	Number of Plots	Abundance All Plots Mean	Abundance Where Present Mean	Number of Plots	Abundance All Plots Mean	Abundance Where Present Mean	Number of Plots	Abundance All Plots Mean	Abundance Where Present Mean
Cornus canadensis	16	8.8	9.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chamerion angustifolium	14	3.2	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	6.3	7.1
Rhododendron groenlandicum	18	4.8	4.8	98	8.2	8.4	132	11.4	11.8	0	0	0	0	0	0	0	0	0	9	8.3	8.3
Linnaea borealis	16	7.4	8.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picea mariana seed	0	0	0	87	3.5	4.0	117	4.0	4.7	0	0	0	0	0	0	0	0	0	8	2.8	3.1
Rosa acicularis	15	6.6	7.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vaccinium oxycoccos	0	0	0	0	0	0	0	0	0	0	0	0	24	7.8	9.7	48	7.1	8.6	0	0	0
Vaccinium vitis-idaea	15	6.3	7.5	91	7.9	8.7	126	9.9	10.8	0	0	0	0	0	0	0	0	0	7	6.9	8.9
Hylocomium splendens	17	7.3	7.8	83	6.0	7.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moss spp.	17	5.0	5.3	100	7.8	7.8	133	6.9	7.1	25	9.5	9.5	25	6.5	7.8	51	6.7	7.6	9	9.1	9.1
Pleurozium schreberi	17	5.8	6.1	86	6.7	7.8	116	5.9	6.9	0	0	0	0	0	0	0	0	0	0	0	0
Sphagnum spp.	0	0	0	0	0	0	0	0	0	0	0	0	26	9.2	10.6	52	8.8	9.8	0	0	0
Cladina mitis	0	0	0	78	5.7	7.3	123	8.6	9.6	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia spp.	0	0	0	78	4.1	5.2	115	4.5	5.4	0	0	0	0	0	0	0	0	0	0	0	0

Table 7-17: Mean abundance of widespread understorey species for all plots in the inland habitat plots by site type

Site Type	Deep Dry			Deep Moist			Feathermoss Bog			Sphagnum Bog			Fen		
Number of Plots Total	133			34			38			115			53		
Species	Number of Plots	Abundance All Plots Mean	Abundance Where Present Mean	Number of Plots	Abundance All Plots Mean	Abundance Where Present Mean	Number of Plots	Abundance All Plots Mean	Abundance Where Present Mean	Number of Plots	Abundance All Plots Mean	Abundance Where Present Mean	Number of Plots	Abundance All Plots Mean	Abundance Where Present Mean
Rhodendron groenlandicum	126	6.5	7.0	31	9.4	9.7	38	12.7	12.7	103	11.6	13.0	0	0	0
Maianthemum trifolium	0	0	0	0	0	0	0	0	0	0	0	0	40	5.1	6.8
Picea mariana seedling	0	0	0	25	2.8	3.5	36	4.7	4.9	103	4.9	5.4	0	0	0
Rubus chamaemorus	0	0	0	0	0	0	0	0	0	87	6.2	8.3	0	0	0
Vaccinium oxycoccos	0	0	0	0	0	0	0	0	0	104	7.1	7.8	0	0	0
Vaccinium vitis-idaea	118	7.7	8.8	30	8.3	8.8	35	9.4	10.2	93	8.2	10.1	0	0	0
Hylocomium splendens	0	0	0	28	5.3	6.1	29	5.0	6.6	0	0	0	0	0	0
Moss spp.	132	6.7	6.8	32	7.2	7.2	37	8.4	8.6	107	7.3	7.8	48	7.8	8.6
Pleurozium schreberi	105	6.2	7.9	27	6.7	7.9	32	6.6	7.8	0	0	0	0	0	0
Sphagnum fuscum	0	0	0	0	0	0	0	0	0	73	7.2	8.9	0	0	0
Sphagnum spp.	0	0	0	0	0	0	0	0	0	109	8.6	9.0	46	8.5	9.8
Cladina mitis	0	0	0	26	6.3	7.7	31	7.7	9.4	98	8.4	9.9	0	0	0
Cladonia spp.	0	0	0	25	3.2	4.1	0	0	0	91	4.4	5.5	0	0	0

7.3.2.2 Habitat Classification

7.3.2.2.1 Species To Retain

When all species in at least three plots were retained, the cluster solution that generated the best combination of average P-value and number of significant P-values was eight groups (Figure 7-5). This seemed to be a reasonable number of coarse groups given the range and number of ecological gradients included in the sampling. Group associations with site type and canopy vegetation indicated that the groups generally separated along ecological gradients (Table 7-18). Consequently, eight groups were used for the species inclusion sensitivity analysis.

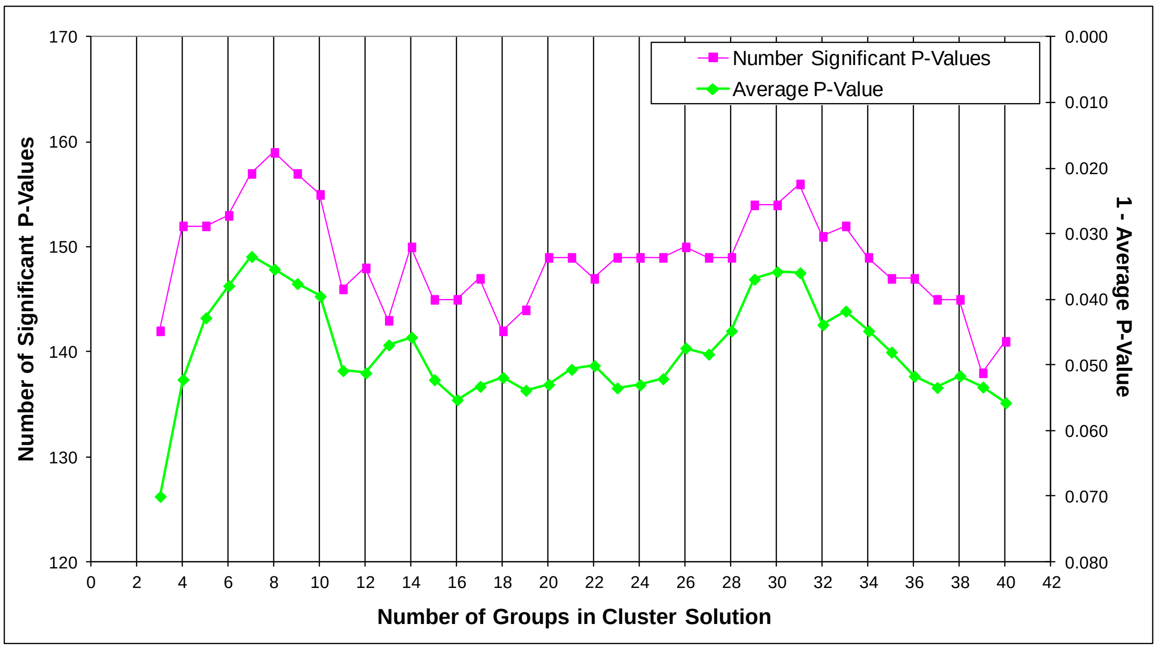


Figure 7-5: Number of significant P-values and average P-value from indicator species analysis at various levels of Ward's cluster analysis (Sorensen resemblance measure) group membership when all species in at least three plots are included

Table 7-18: Site type associations with the eight Ward's cluster groups used for species inclusion sensitivity analysis

Site Type	Cluster Group ID								
	1	2	3	5	6	9	15	16	Total
Moderately Deep	-	-	-	2	-	-	-	-	2
Deep Dry	79	1	-	49	62	-	13	9	213
Deep Moist	25	3	-	9	21	-	1	12	71
Feathermoss Bog	22	18	-	4	5	-	3	22	74
Sphagnum Bog	7	132	16	1	-	34	1	25	216
Fen	2	1	57	-	-	28	21	8	117
Swamp	-	-	1	-	-	-	3	-	4
Deep Marsh	-	-	1	-	-	-	-	-	1
Total	135	155	75	65	88	62	42	76	698

Notes: Cells with 0 values are values that round to 0, while "-" cells indicate a value of 0.

The iterative "species dropping" process identified a zone of plot group membership stability for the range of dropping species occurring in 12 to 15 or less plots (Table 7-19). Species found in less than 13 plots were dropped for subsequent cluster analyses, resulting in a final vegetation matrix of 123 species and 698 plots. As a demonstration of the sensitivity of cluster analysis to rare species inclusion, note that increasing the number of plots a species needs to occur in from 6 to 7 caused 86, or 12%, of the 698 plots to change group membership (Table 7-19).

Table 7-19: Effect of removing infrequent species on the 8 group cluster solution. Number of plots changing group membership as species are removed based on the number of plots they occurred in

Step[1]	# species dropped in step	Cumulative # of species dropped	# species remaining	Plots changing group membership	
				Total number	% of all plot[2]
2	-	58	182	-	-
2 vs 3	9	67	173	0	0
3 vs 4	9	76	164	16	2
4 vs 5	6	82	158	0	0
5 vs 6	4	86	154	43	6
6 vs 7	8	94	146	86	12
7 vs 8	11	105	135	36	5
8 vs 9	5	110	130	9	1
9 vs 10	1	111	129	21	3
10 vs 11	2	113	127	142	20
11 vs 12	4	117	123	135	19
12 vs 13	3	120	120	0	0
13 vs 14	3	123	117	7	1
14 vs 15	0	123	117	0	0
15 vs 16	2	125	115	273	39
16 vs 17	4	129	111	209	30
17 vs 34[3]	24	153	87	188	27

Notes: [1] Each step represents the change in the total number of plots a given species needs to occur in, to be excluded from analysis.
[2] Grey cells identify the zone of plot group membership stability referred to in the text.
[3] 34 is the number of plots representing less than 5% of the total 698 plots. Cells with 0 values are values that round to 0, while "-" cells indicate a value of 0.

7.3.2.2.2 Cluster Analysis Results

The Ward's clustering of the 123 species and 698 plots produced 60 vegetation groups at its highest cluster solution. Analysis of the average significance, and number of significant indicator species from the various cluster solutions identified ten candidate cluster solutions where there were peaks in the number and average significance of indicator species (Figure 7-6). Candidate solutions were at the 6, 9, 14, 16, 22, 27, 35, 50, 54 and 60 group levels. The Multi-response permutation procedures (MRPP) analysis indicated that the groups, and all pairwise comparisons between groups, were significantly different from one another. Chance-corrected within-group agreement continued to increase to the 60 group solution, suggesting that group distinctiveness increased with each increase in candidate group number (Table 7-20).

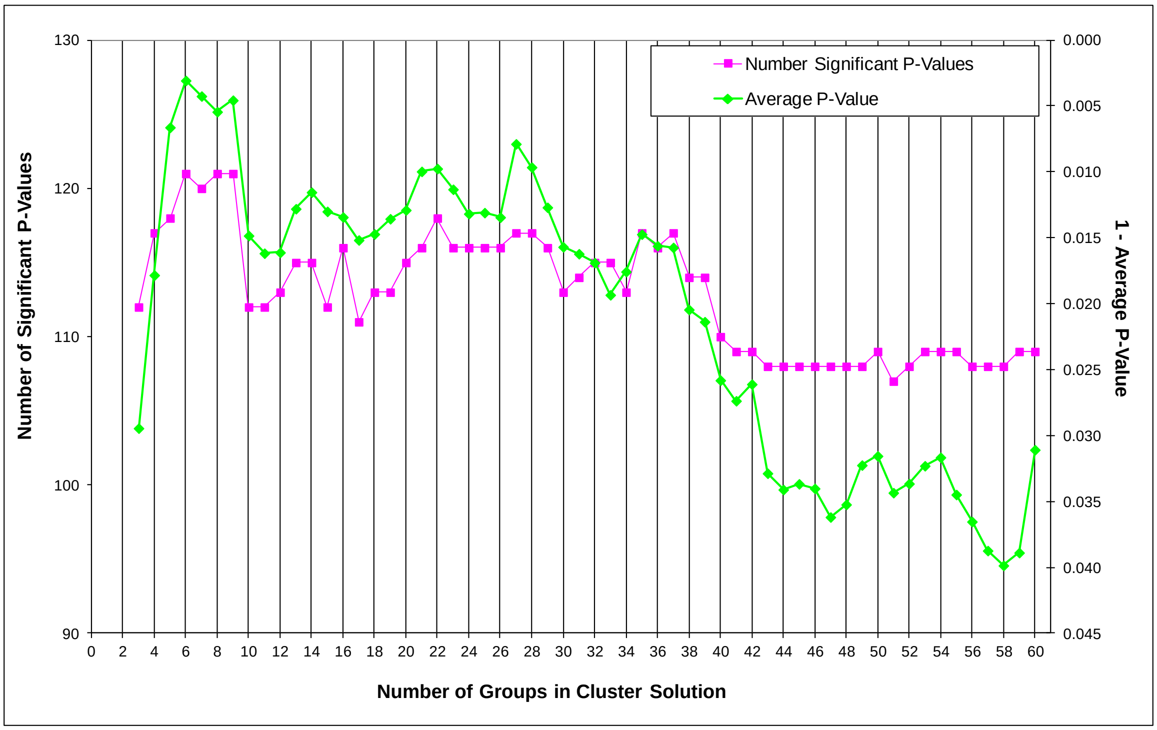


Figure 7-6: Number of significant P-values and average P-value from indicator species analysis at various levels of Ward's cluster analysis (Sorensen resemblance measure) group membership when all species in at least 13 plots are included

Table 7-20: Results of the MRPP analysis of the candidate group solutions, including within-group agreement (*A*)* and significance of differences (*P*)

Group Solution	*A*	*P*
6 groups	0.262	<0.001
9 groups	0.300	<0.001
14 groups	0.338	<0.001
16 groups	0.349	<0.001
22 groups	0.383	<0.001
27 groups	0.403	<0.001
35 groups	0.423	<0.001
50 groups	0.449	<0.001
54 groups	0.457	<0.001
60 groups	0.465	<0.001

7.3.2.2.3 Interpretation of Group Solutions

The Ward's clustering of the 123 species separated the 698 plots into the following three, very broad groups that reflected very coarse site conditions: uplands (i.e., mineral soil or thin feathermoss peatland); shallow peatlands; and, wet peatlands. In other words, vegetation on thin feathermoss peatland was more similar to mineral sites than to other peatland types. According to the multivariate analyses, the main subdivisions of the very broad upland group related to overstorey tree leaf type (i.e., broadleaf versus needleleaf) and whether or not the plot was recently burned. The very broad wet peatland group strongly separated into three sub-groups based on vegetation structure.

The final group solutions for the coarse, intermediate and fine habitat classifications were chosen out of ten candidate solutions by comparing the subdivision of vegetation, structure and site characteristics from one solution to the next, starting with the six group solution. Detailed descriptive results for vegetation composition, structural and site characteristics were produced. The dendrogram in Figure 7-7 (page 7-63) illustrates the grouping process from the 60 group to the two group level.

Based on the interpretation of vegetation and site, the final group solutions chosen were 6, 22 and 60 groups. The six group solution represented general cover types (i.e. needleleaf, broadleaf, tall shrub) occurring on different general site types (e.g., mineral, feathermoss and sphagnum bogs, and wet, deep sphagnum bogs and fens). The 22 groups from the cluster analysis were comparable to the mapped coarse habitat types (Section 6.2.2) in both characteristics and number of groups. Therefore, the 22 group solution was the best choice for an intermediately detailed terrestrial habitat classification. The 60 group solution was chosen as a third level of classification detail, primarily used to describe the variation in habitat within the groups of the 22 group solution, particularly with respect to mineral and wet peatland habitat types.

The following describes the stages in selecting the group solutions used for the broad, coarse and detailed site level inland habitat classifications.

Six group solution

In the six group solution, groups differed with respect to site type and general vegetation cover. The six group solution included:

G5. Forest to sparsely treed broadleaf, needleleaf and mixedwood canopies with a variety of tall shrub species, a herb-rich understorey, on deep dry to moist mineral sites.

G1. Woodland to sparsely treed needleleaf dominated canopies on dry to moist mineral and feathermoss bogs.

G16. Woodland and sparsely treed, smaller-diameter black spruce on sphagnum and feathermoss bogs.

G2. Sparsely treed smaller-diameter black spruce with reindeer lichen on sphagnum bogs.

G6. Tall shrub and low shrub dominated cover on mineral and peatland sites.

G3. Sparsely treed tamarack dominated and untreed on deep wet fens and bogs.

Based on the dendrogram, at a high level these six groups appeared to cluster into three coarser groupings based on ecosite. At the three group level, groups G5, G1 and G16 formed a larger grouping generally associated with mineral and thin peatland ecosites. Group G2 remained distinct, associated primarily with shallow peatland ecosites, while groups G6 and G3 were generally associated with wetter peatlands and riparian ecosites (Figure 7-7).

Solutions with 6 vs. 9 groups

Increasing the number of groups from six to nine resulted in the subdivision of two groups. The needleleaf dominated mineral group (G1) split into three groups, including a jack pine black spruce canopy group (G84), a black spruce dominant canopy often with broadleaf (G1), and a denser black spruce canopy group on moist sites (G4). Average thickness of soil organic layers increased respectively with each group.

The sparsely treed tamarack and untreed group (G3) divided into two groups. These included a sparsely treed tamarack group (G3) and an untreed, bryoid and low shrub dominated group (G18).

This step resulted in the subdivision of some groups on the basis of canopy composition and dominant vegetation cover. At the 9 group level, some of the other groups remained more general with respect to canopy composition. At the 6 group level, canopy composition was uniformly general, while still reflecting the site conditions that distinguished each group. On this basis, the 6 group solution was the best candidate for the coarse plot habitat types. Classes at this level are comparable to the land cover classification from the habitat mapping (Section 6.2.2).

Solutions with 9 vs. 14 groups

Increasing the number of groups from 9 to 14 resulted in the subdivision of four groups. The broadleaf, needleleaf and mixedwood group on mineral (G5) divided into two groups, including a larger group of broadleaf and needleleaf canopies (G5), and a smaller white spruce, broadleaf canopy group (G31).

The sparsely treed small diameter black spruce, reindeer lichen bog group (G2) divided into two groups. The larger group was more densely treed black spruce (G2), while the smaller group was untreed and sparsely treed and often associated with recently burned sites (G36).

The tall shrub group (G6) divided into three groups. The first group was a willow type occurring on mineral soils, sometimes with balsam poplar (G6). The second was a willow and bog birch group on organic fens with shallow water tables, occasionally sparsely treed (G25). The third group was willow-dominated and generally untreed on deeper organic fens with shallow water tables (G30).

The sparsely treed tamarack group (G3) divided into two groups based in canopy composition. The first group was a tamarack, black spruce mixture (G3), and the second group was tamarack dominated with a somewhat shallower water table on average (G9).

At this step, some groups were further subdivided into more distinctive canopy composition and structure types, however some more general types remain, particularly in the mineral coarse habitat types. The tall shrub group divided according to site conditions, as well as shrub composition. Because some general types remained, the 14 group solution was not considered as a finer habitat type classification.

Solutions with 14 vs. 16 groups

Increasing the number of groups from 14 to 16 resulted in the subdivision of two groups. The broadleaf and needleleaf canopy on mineral group (G5) divided into a larger and smaller group. The larger group remained a mixture of needleleaf and broadleaf, dominated by jack pine and trembling aspen, respectively (G5). The smaller group had a white spruce-dominated canopy (G37).

The black spruce dominant on mineral group (G1) divided into a smaller and larger group. The first was more sparsely treed trembling aspen, white birch, jack pine group on drier coarse mineral sites (G1), and the second was a black spruce-dominated group with more tall shrub cover on moister mineral and feathermoss bog sites with thicker organic layers (G10).

The 16 group solution further refined some of the more general groups with respect to canopy composition, and distinguished between different mineral site conditions with respect to G1 and G10. This group solution was considered as a candidate for a finer habitat type classification.

Solutions with 16 vs. 22 groups

Increasing the number of groups from 16 to 22 resulted in the subdivision of five groups. The needleleaf and broadleaf on mineral group (G5) subdivided into a broadleaf, black spruce, and mixedwood group (G5) and a jack pine dominant and mixedwood group (G348).

The jack pine, black spruce canopy group on mineral (G84) divided into three groups. One group was a small-diameter black spruce and broadleaf group, associated with recently burned sites (G84). Another was a dense small-diameter black spruce dominant group with a taller canopy on average (G112). The third was a small-diameter jack pine dominant group (G226).

The denser black spruce canopy on moist sites group (G4) divided into two groups, including a denser black spruce dominant with white birch on fresher sites (G4), and a moist black spruce dominant group with deeper organic layers (G8).

The woodland and sparsely treed small-diameter black spruce on sphagnum and feathermoss (G16) divided into two groups, including a moist black spruce dominant group (G16), and a wetter black spruce dominant with tamarack and willow (G44).

The more densely treed small diameter black spruce, reindeer lichen bog group (G2) subdivided into a more densely black spruce dominant group (G2) and a less densely treed black spruce dominant with tamarack group (G7).

The 22 group solution further subdivided some more general groups into more distinctive groups based on dominant canopy species and structure, particularly with respect to needleleaf species. The 22 group solution was more comparable to the mapped coarse habitat type classification than the 16 group solution with respect to the range and detail of canopy composition among the groups. Therefore the 22 group solution was a better candidate for a plot habitat type classification.

Solutions with 22 vs. 27 groups

The 22 group solution produced groups that were more distinctive with respect to dominant canopy species composition within the overall broad site types that were distinguished at the six group level. The 22 group solution provided more distinctive groups than the 16 group solution, and the 27 group solution produced some groups that were distinguished at a much finer scale than the other groups at that level.

Beyond the 22 group solution, new groups distinguished themselves more often on structural and finer-scale site differences, particularly for the shallow and thin peatland types. The mineral types continued to form more distinctive groups based on canopy composition beyond the 22 group solution. This suggested a higher degree of species variability in the mineral site types, as well as more community associations and more sensitive responses to differences in finer-scale site conditions. The cluster analysis continued to form relatively distinctive groups up to the 60 group solution, although some groups, particularly in the shallow peatland types appeared to show very subtle differences.

Increasing the number of groups from 22 to 27 resulted in the subdivision of five groups. The broadleaf, black spruce, and mixedwood group (G5) divided into a trembling aspen dominant, black spruce group (G5), and a trembling aspen, white birch with black spruce group on moister mineral sites (G99).

The moist black spruce-dominated, tall shrub cover on mineral and feathermoss bog group (G10) divided into a group with a black spruce-dominated canopy (G10), and a group with black spruce and white birch canopies (G14).

The moist black spruce dominant group on feathermoss and sphagnum bogs (G16) divided into two groups based on tree structure, including a larger diameter black spruce dominant group (G16), and a smaller-diameter black spruce dominant group often associated with recently burned sites (G82).

The recently burned untreed and sparsely treed small diameter black spruce, reindeer lichen bog group (G36) divided into a more frequently treed group, and a mostly untreed group (G80).

The willow and bog birch group on organic fens with shallow water tables group (G25) divided into a willow, bog birch group on wetter, deeper fens (G25), and a very dense willow group on moist mineral or fens with shallower organic layers on average (G243).

The 27 group solution divided some groups further with respect to canopy species dominance and composition, particularly with respect to the broadleaf mineral groups. Needleleaf groups on deeper organic sites were subdivided into groups distinguished primarily by structural differences, such as tree density. Compared to the 22 group solution, this solution did not produce any new distinctive combinations of species and site conditions, therefore the 22 group solution was the best candidate for an intermediate classification of plot habitat types.

Solutions with 27 vs. 35 groups

Increasing the number of groups from 27 to 35 resulted in the subdivision of eight groups. The jack pine dominant and mixedwood group (G348) divided into two groups based on canopy composition, including a trembling aspen, jack pine mixedwood group (G348), and a jack pine dominant group (G557). The small-diameter jack pine dominant group (G226) divided into a jack pine, black spruce mixture (G226) and a dense jack pine dominant group (G439).

The moist black spruce, tall shrub cover on mineral and feathermoss bog group (G10) divided into two groups based on canopy structure, including a sparser black spruce group (G10) and a denser black spruce group with occasional broadleaf trees (G102). The moist black spruce and white birch, tall shrub cover on mineral and feathermoss bog group (G14) divided based primarily on canopy composition, creating a black spruce dominated, white birch group (G14) and a white birch dominated, black spruce group (G187).

The recently burned smaller-diameter black spruce dominant group on feathermoss and sphagnum bogs (G82) divided into two groups based on vegetation structure and site. One group was more sparsely treed, and occurred on deeper organic, sphagnum sites (G82), and the other was denser, and was associated with moist mineral sites (G151).

The sparsely treed willow, bog birch group on wetter, deeper fens group (G25) divided into a very dense willow-dominated group on shallower organic soil (G25), and a dense bog birch-dominated group on deeper organic soil (G32). The usually untreed willow-dominated on deeper organic fen group (G30) divided into a willow-dominated group with occasional sparse trees (G30), and an untreed bryoid and low shrub-dominated group (G41).

The tamarack-dominant group (G9) divided into an open, sparser tamarack group with lower bog birch cover (G9) and a sparse, but more densely treed tamarack group with very dense bog birch cover (G47).

The 35 group solution resulted in the creation of new groups based on vegetation composition and/or structure. Additionally, some groups at this level showed associations with finer-scale site conditions, such as organic soil depth.

Solutions with 35 vs. 50 groups

Increasing the number of groups from 35 to 50 resulted in the subdivision of 14 groups. The trembling aspen dominant, black spruce group (G5), and the trembling aspen, white birch with black spruce group on moister mineral sites (G99) each divided into two groups based on canopy composition, structure and fine site characteristics. The former divided into a smaller-diameter black spruce mixtures with broadleaf group, occasionally recently burned (G5), and a larger-diameter trembling aspen dominant and mixedwoods group (G13). The latter divided into a moister black spruce dominant and mixedwood group with trembling aspen or balsam poplar (G99), and a drier white birch dominant group (G128).

The smaller white spruce, broadleaf canopy group (G31) also divided according to canopy composition and fine site characteristics. One group was a balsam poplar, trembling aspen dominant, white spruce group on drier sites (G31), and the other was a more open white spruce dominant group with white birch on moister sites (182).

The small-diameter black spruce and broadleaf group, associated with recently burned sites (G84) divided into two groups distinguished by structure, and canopy composition to a lesser degree. The first group was recently burned, with smaller trees and a higher proportion of black spruce (G84), while the other had somewhat taller trees and had a higher proportion of trembling aspen (G341). On a similar basis, the jack pine, black spruce mixture group (G226) divided into a jack pine black spruce mixture with a more sparsely treed understorey (G226), and a jack pine dominant canopy with a more densely treed black spruce understorey on somewhat moister sites (G340).

The trembling aspen, white birch, jack pine group on drier coarse mineral sites (G1) divided into a more densely treed group dominated by trembling aspen, white birch or balsam poplar (G1), and a sparser black spruce, jack pine group (G68). The moist white birch-dominated, black spruce, tall shrub on mineral and feathermoss bog group (G187) was further refined into two groups distinguished by canopy composition and fine site characteristics. One group was a moister black spruce-dominated group occasionally mixed with white birch or other broadleaf on flatter terrain (G65), and the other was a white birch-dominated canopy on more sloping terrain (G187).

The denser black spruce dominant with white birch on fresher sites (G4) divided into two groups distinguished by structure, including a more densely treed group with less white birch (G4), and a less densely treed group with more frequent white birch and occasional jack pine (G460).

The moist, larger-diameter black spruce dominant group on feathermoss and sphagnum bogs (G16) divided into a very moist, more densely treed and smaller black spruce group with occasional tamarack (G16), and a moist black spruce group with somewhat larger trees (G109). The wetter small-diameter black spruce dominant with tamarack and willow on sphagnum and feathermoss (G44) divided into a more densely treed group with somewhat more willow than bog birch (G44), and a more sparsely treed group with somewhat more bog birch than willow, and more frequently with ground ice (G158).

The less densely treed black spruce dominant with tamarack group, reindeer lichen bog group (G7) divided into two groups that appear very similar, except for some differences in canopy species proportions. One group (G39) had a higher black spruce stem density, and more frequent tamarack than the other group (G7).

The willow tall shrub on mineral group (G6) divided into three groups with distinctive vegetation composition. One group had a balsam poplar canopy, with abundant willow (G6), another group was untreed, usually with dense bog birch (G100), and the third group was untreed with abundant willow (G244). The willow-dominated on deeper organic fen group (G30) divided into a very dense willow group with more mesic organic soils (G30), and a less dense bog birch group with more fibric-dominated organic soils (G41).

The untreed, bryoid and low shrub dominated group (G18) divided into an untreed bryoid sphagnum bog type (G18), and an occasionally sparsely treed group on fens or sphagnum bogs (G57).

The 50 group solution produced more refined groups with respect to canopy species composition, particularly in the needleleaf and broadleaf mixtures and mixedwoods on mineral, and tall shrub groups. New groups in the needleleaf-dominated types tended to be most distinguishable with respect to structure, and relative abundance of canopy species. Many of the groups at this level were exhibiting differences in finer-scale site conditions.

Solutions with 50 vs. 54 groups

Increasing the number of groups from 50 to 54 resulted in the subdivision of four groups. The moist black spruce dominant feathermoss and mineral group with deeper organic layers (G8) divided into a moist mineral and feathermoss group with occasional white birch (G8), and a wetter sphagnum and feathermoss group with occasional tamarack (G202).

The more densely treed small diameter black spruce-dominant, reindeer lichen bog group (G2) divided into two similar groups, but with different structure. One group had denser black spruce (G2), and the other group was less dense, and occasionally had a tamarack component (G11).

The dense bog birch-dominated group on deeper organic fens group (G32) divided into a dense bog birch-dominated mixture with willow group, more often with sparse trees (G32), and a dense willow-dominated mixture with bog birch group, less frequently with trees (G48). Similarly, the tamarack, black spruce mixture group (G3) divided into a black spruce dominated, tamarack mixture (G3), and a tamarack-dominated, black spruce mixture (G282).

Most of the groups created in the 54 group solution were more subtle, with differences in relative species abundance and structure. However, in the case of G8, the new groups were distinctive with respect to finer-scale site conditions and secondary canopy species.

Solutions with 54 vs. 60 groups

Increasing the number of groups from 54 to 60 resulted in the subdivision of six groups. The white spruce-dominated on mineral group (G37) divided into two equal sized groups based on structure. One group had a denser black spruce understorey with a less dense tall shrub layer on gentler slopes (G37), and the other had a sparser black spruce understorey with more abundant tall shrubs on steeper and upper slopes (G106).

The dense small-diameter black spruce dominant group (taller canopy) on mineral (G112) also divided into two groups with different structure. These included a less dense canopy occasionally with white birch (G112) and a very dense, usually shorter canopy occasionally with jack pine (G359).

The moister black spruce-dominated, tall shrub on mineral and feathermoss bog group on flatter terrain (G65) divided into a black spruce dominated group (G65) and a black spruce, white birch group on moist sloping mineral, bog and fen sites (G247). The denser black spruce dominant with less white birch on fresher sites (G4) divided into a dense black spruce group (G4), and a dense black spruce, white birch mixture (G320).

The sparser tamarack group with lower bog birch cover (G9) divided into a frequently treed sparse tamarack group with denser bog birch cover (G9), and an untreed group with slightly less bog birch cover (G20). The occasionally sparsely treed group on fens or sphagnum bogs (G57) also divided into groups distinguished by the presence of tree cover, as well as different site types. One group often had scattered black spruce or tamarack occurring on sphagnum bogs or fens (G57), and the other was untreed and occurred only on fens (G312).

The 60 group solution made some further refinement to groups based on the relative abundance of canopy species, canopy structure, and finer scale site characteristics. Subdivisions at this level were confined to the mineral and thin peatland groups, and the deep, wet peatland groups. Groups with shallow peatland associations remained stable between the 54 and 60 group solutions.

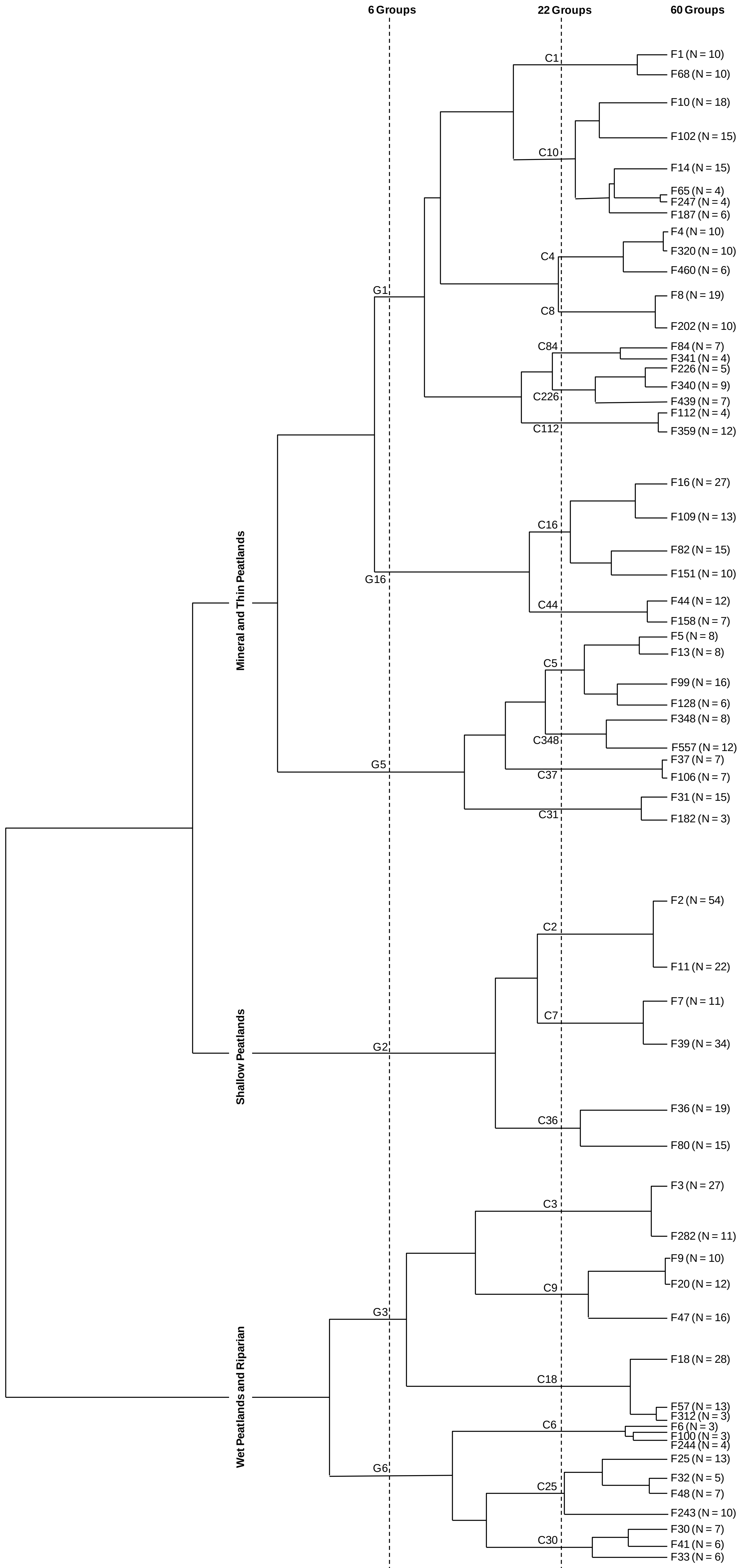


Figure 7-7: Dendrogram illustrating plot grouping from the Ward's cluster analysis to the 60 group solution. Dashed lines represent the group levels chosen to represent general (G), coarse (C), and fine (F) plot habitat types

7.3.2.2.4 Ordination of Plot Vegetation

Ordinations corroborated and elucidated the cluster analysis results. Nonmetric multidimensional scaling (NMS) of the 123 species and 698 LNR region inland habitat plots resulted in a two dimensional ordination solution (Figure 7-8). Final stress and instability for the solution after 97 iterations was 16.27 and 0.00047, respectively. Of the total variation in the dataset, 81.1% was explained by the first two ordination axes, including 42.7% explained by axis two. The two ordination axes were significantly stronger than expected by chance ($P = 0.0278$).

Species separated into groups along both the first and second ordination axes. Plots containing broadleaf tree species, including balsam poplar and trembling aspen grouped toward the lower right, and white spruce, white birch and jack pine grouped toward the lower center side of the ordination. Conversely, leather-leaf (*Chamaedaphne calyculata*) and wetland herbs such as sedges, round-leaved sundew (*Drosera rotundifolia)*,cotton-grass (*Eriophorum* spp) and bogbean (*Menyanthes trifoliata)* were grouped with plots at the upper-left side of the ordination.

The plexus diagram indicated a few strong species associations (Figure 7-9). Some associations included wetland species such as marsh five-finger (*Comarum palustre)*, water horsetail (*Equisetum fluviatile)*, bogbean, and bog willow, myrtle-leaved willow, alpine bearberry (*Arctuous alpina)*, and dwarf scouring rush (*Equisetum scirpoides)*; and fireweed (*Chamerion angustifolium)*, Green alder, prickly rose (*Rosa acicularis)*, bunchberry (*Cornus Canadensis)* and twinflower (*Linnaea borealis)* associations.

The six coarsest plot habitat types separated into relatively distinctive clusters on the ordination, with some degree of overlap (Figure 7-8). Group separation occurred along both the first and second axis, with the largest gradient occurring from the upper-right to lower-left of the ordination diagram.

The Broadleaf, Needleleaf and Mixedwood on Mineral group (G5) and Needleleaf Dominated on Mineral and Feathermoss group (G1) were located at the lower-right of the ordination, and to the left and right of each other, respectively. The Sparse Black Spruce Dominated, Reindeer Lichen on Bogs group (G2) and Small Black Spruce Dominated Sphagnum and Feathermoss Bogs group (G16) were located at the centre of the ordination, to the left and right of each other, respectively. The Tall Shrub on Mineral and Peatlands group (G6) and Sparsely Treed to Low Vegetation on Deep Wet Peatlands group (G3) were located at the top of the ordination, to the right and left of each other, respectively. The Tall Shrub on Mineral and Peatlands group was not clustered together as strongly as the other groups, suggesting a larger degree of species variability in this group.

The first axis in the NMS ordination was most strongly correlated with total and fibric organic substrate thickness, moisture and drainage regimes, and canopy closure and canopy height (Table 7-21). The species most strongly correlated with this axis were *Sphagnum* spp., small bog cranberry, prickly rose, twinflower, leather-leaf and bunchberry. Organic substrate thickness increased in plots toward the left of the ordination, as did the moisture regime, along with the abundance of *Sphagnum* spp, small bog cranberry and leather-leaf. Plots toward the right of the ordination were drier, and better drained with thinner organic substrates, and tended to have greater canopy cover and height, and more abundant prickly rose, twinflower and bunchberry.

The second axis was most strongly correlated with depth to water table, canopy height and total organic substrate thickness (Table 7-21). These variables were also correlated to the first axis, but the former two were more strongly correlated to the second axis. The species most strongly correlated with the second axis were *Carex* spp., big red stem, rock cranberry, bog rosemary (*Andromeda polifolia)*, three-leaved Solomon's-seal and bogbean (Table 7-21). All but three-leaved Solomon's-seal were more strongly correlated to the second axis than the first. As a result, plots at the bottom of the ordination had the deepest water tables (>1.2m deep) and highest canopies, as well as higher abundances of big red stem and rock cranberry. Those at the top tended to have water tables closer to the surface and shorter canopies, along with more abundant sedges, bog rosemary, three-leaved Solomon's-seal and bogbean.

Figure 7-8: Vegetation biplot from a nonmetric multidimensional scaling ordination of 698 LNR Region inland habitat plots and species[1], shaded by general plot habitat type

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1 Only species with Kendall tau *b* correlation coefficients of 0.3 or higher are shown in ordination. Species names displayed are abbreviations. Percentages following the axis labels are percent species variability explained by the axis.

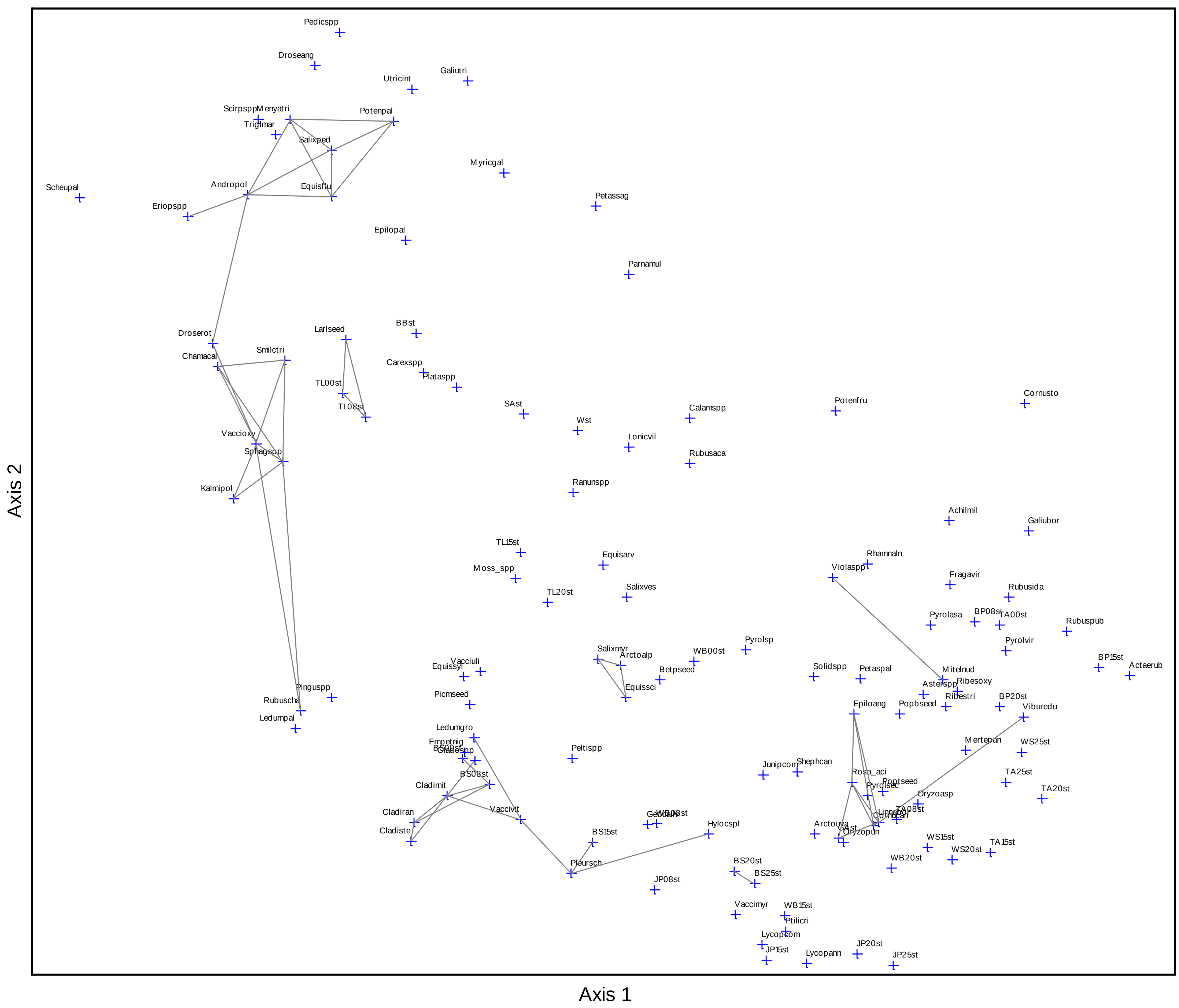


Figure 7-9: Species[2] plot and plexus association diagram from a nonmetric multidimensional scaling ordination of 698 inland habitat plots. Species with plexus scores of at least 0.5 are connected by a line

[2] Species are abbreviated in the plexus diagram as a combination of the first five letters of the genus, and first three letters of the species (e.g. *Drosera anglica* = Droseang).

Table 7-21: Kendall tau *b* correlation coefficients of species and environmental variables with the two NMS ordination axes of the 698 inland habitat plots

Species	tau *b*	Environment	tau *b*
Axis 1			
Sphagnum spp	-0.65	Peat depth class	-0.64
Vaccinium oxycoccos	-0.65	Fibric OM thickness	-0.60
Chamaedaphne calyculata	-0.53	OM thickness	-0.58
Kalmia polifolia	-0.49	Drainage regime	-0.51
Drosera rotundifolia	-0.47	Moisture regime	-0.50
Rubus chamaemorus	-0.46	% cover <0.1m strata	-0.41
Maianthemum trifolia	-0.42	Mesic OM thickness	-0.39
Andromeda polifolia	-0.37	Slope position	-0.26
Eriophorum spp	-0.36	Depth to mottling	-0.21
TA > 15-20cm	0.31	% cover 0.5-1.3m strata	0.22
Rubus pubescens	0.32	% slope	0.26
Viola spp	0.33	Dom. mineral particle size	0.30
Fragaria virginiana	0.35	C-horizon particle size	0.31
Mertensia paniculata	0.35	LFH thickness	0.38
Petasites frigidus var. *palmatus*	0.35	Depth to water table	0.38
Orthillia secunda	0.35	Canopy height	0.40
Mitella nuda	0.40	Canopy closure	0.42
Hylocomium splendens	0.42	Mineral thickness in pit	0.46
Viburnum edule	0.42		
Alnus viridis ssp. *crispa*	0.46		
Chamerion angustifolium	0.49		
Cornus canadensis	0.50		
Linnaea borealis	0.55		
Rosa acicularis	0.58		
Axis 2			
Pleurozium schreberi	-0.55	Depth to water table	-0.53
Vaccinium vitis-idaea	-0.52	Canopy height	-0.50
Hylocomium splendens	-0.39	Canopy closure	-0.42
BS > 9-15 cm	-0.38	Depth to gleying	-0.25
Cladina mitis	-0.36	% slope	-0.24
Cladina rangiferina	-0.33	LFH thickness	-0.20
Cladina stellaris	-0.33	Humic OM thickness	0.23
BS 0-9 cm	-0.30	Fibric OM thickness	0.31
Larix laricina seed	0.31	Mesic OM thickness	0.33
Drosera rotundifolia	0.33	Slope position	0.34

Species	tau *b*	Environment	tau *b*
Eriophorum spp	0.35	Drainage regime	0.40
Salix pedicellaris	0.35	Moisture regime	0.40
Vaccinium oxycoccos	0.36	OM thickness	0.42
Betula pumila	0.36	Peat depth class	0.45
Chamaedaphne calyculata	0.37		
Sphagnum spp	0.38		
Equisetum fluviatile	0.40		
Potentilla palustris	0.40		
Menyanthes trifoliata	0.41		
Maianthemum trifolia	0.41		
Andromeda polifolia	0.42		
Carex spp	0.59		

Notes: Only species and environmental variables with a minimum tau *b* of 0.3 and 0.2, respectively, are shown.

Based on the separation of the six coarse plot habitat types on the ordination, and their site characteristics, NMS ordinations were performed on three ecological subsets of the 698 plots, each comprised of two coarse plot habitat types. These included the broadleaf and needleleaf mineral and feathermoss bog groups (G5 and G1), the black spruce feathermoss and sphagnum bog groups (G16 and G2), and the tall shrub and deep wet peatland group (G6 and G3).

Broadleaf and Needleleaf on Mineral and Feathermoss Bog

Nonmetric multidimensional scaling ordination of the 275 plots in this subset resulted in a three dimensional ordination solution (Figure 7-10). Final stress and instability for the solution was 16.51 and 0.00047, respectively. A total of 79.8% of the variation in the dataset was explained by the first three ordination axes, with 41.3% and 23.8% explained by axis 2 and axis 1, respectively. The two ordination axes were significantly stronger than expected by chance ($P = 0.0278$).

In the ordination diagram of the first two axes, plots in the Broadleaf, Needleleaf and Mixedwood on Mineral group (G5) tended to cluster together on the lower-right of the ordination, and plots in the Needleleaf Dominated on Mineral and Feathermoss group (G1) tended to cluster on the upper-left (Figure 7-10).

Plots differentiated on ordination axis 2 along a gradient most strongly correlated with vegetation structure and total organic substrate thickness. Species and environmental correlations with ordination axis 2 indicated that plots clustered at the top of the ordination were associated with higher abundance of rock cranberry, big red stem and *Cladina* spp., and higher percent cover of low vegetation (<50 cm) and deeper fibric organic layers (Table 7-22). Plots clustered toward the bottom of the ordination were associated with higher abundances of fireweed, prickly rose, low bush-cranberry, bishop's-cap (*Mitella nuda*) and twinflower and a thicker LFH layer.

On ordination axis 1, plots appeared to differentiate along a gradient most strongly correlated with canopy structure. Correlations with axis 1 indicated that plots clustered to the right were associated with higher abundance of bishop's-cap, twinflower, one-sided pyrola (*Orthilia secunda)* and larger-diameter trembling aspen, along with taller, more closed canopies (Table 7-22). Plots clustered on the left were associated with more abundant green reindeer lichen, cup lichens and black spruce trees under 9 cm in diameter, along with shorter more open canopies.

The gradient along axis 3 was most strongly associated with site characteristics (Table 7-22). Plots near the top of the ordination diagram were associated with higher abundances of black spruce trees and stair-step moss, along with deeper organic substrates, higher moisture regimes, poorer drainage and frozen soils. Plots toward the bottom of the ordination were associated with more abundant jack pine trees, velvet-leaf blueberry (*Vaccinium myrtiloides)* and prickly rose, along with shallower organic substrates and drier, better-drained sites.

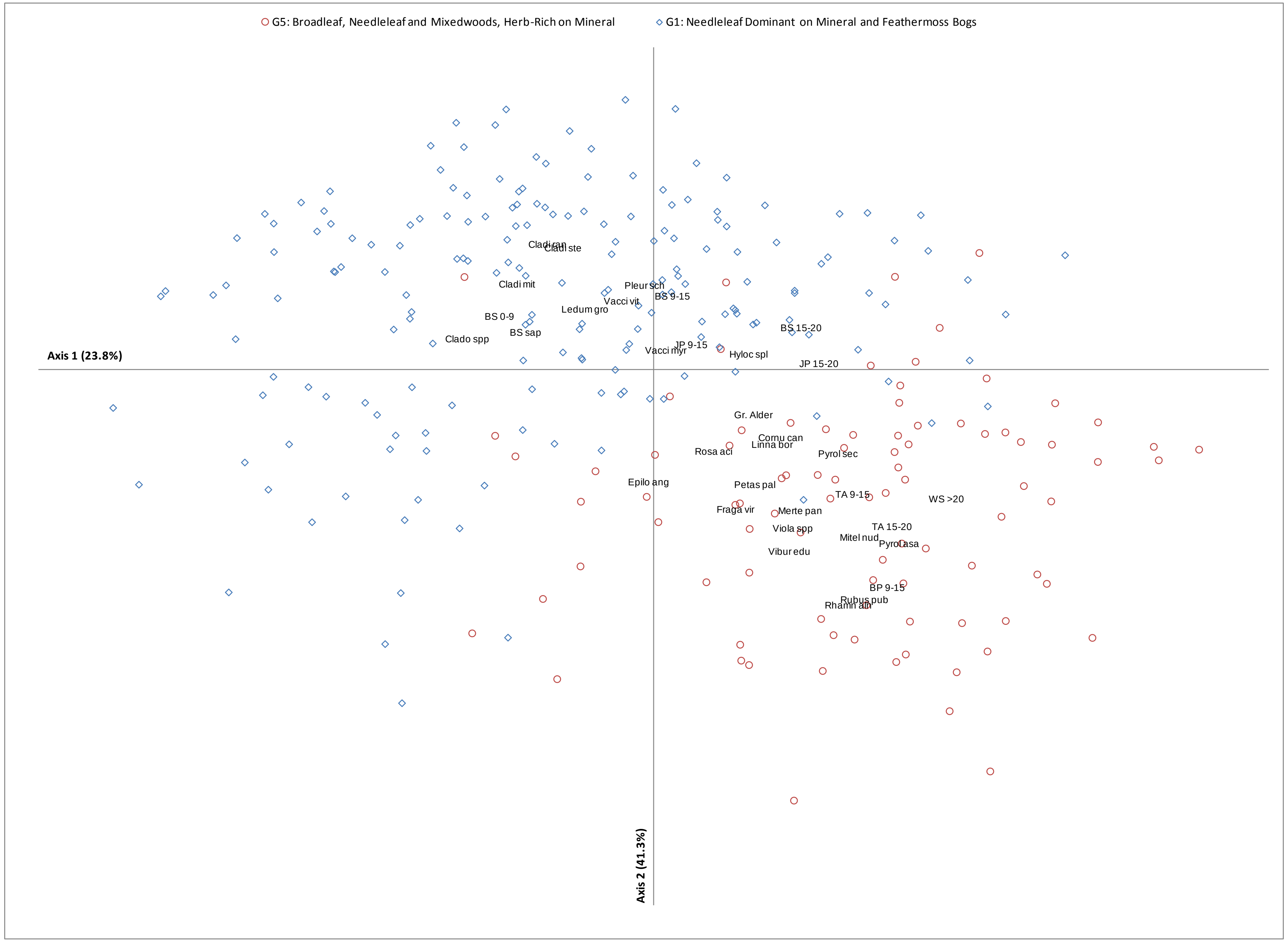


Figure 7-10: Vegetation biplot from nonmetric multidimensional scaling ordination of 275 LNR Region inland habitat plots and species[3], shaded by general plot habitat types G5 and G1

[3] Only species with Kendall tau *b* correlation coefficients of 0.3 or higher are shown in ordination. Species names displayed are abbreviations. Percentages following the axis labels are percent species variability explained by the axis.

Table 7-22: Kendall tau *b* correlation coefficients of species and environmental variables with the three NMS ordination axes of the 275 inland habitat plots in general plot habitat types G5 and G1

Species	tau *b*	Environment	tau *b*
Axis 1 (23.8%)			
Cladina mitis	-0.45	LFH thickness	0.27
Cladonia spp	-0.43	Canopy closure	0.27
BS 0-9 cm	-0.42	Canopy height	0.48
BS sapling	-0.32		
TA > 9-15 cm	0.31		
BP > 9-15 cm	0.31		
WS > 20 cm	0.31		
Alnus viridis ssp. *crispa*	0.31		
BS > 15-20 cm	0.33		
Pyrola asarifolia	0.34		
Hylocomium splendens	0.35		
Cornus canadensis	0.36		
Orthillia secunda	0.37		
TA > 15-20 cm	0.37		
Linnaea borealis	0.38		
Mitella nuda	0.42		
Axis 2 (41.3%)			
Chamerion angustifolium	-0.53	LFH thickness	-0.32
Rosa acicularis	-0.49	Depth to frost	-0.20
Viburnum edule	-0.48	Fibric OM thickness	0.32
Mitella nuda	-0.48	% cover <0.1 m strata	0.51
Linnaea borealis	-0.44		
Viola spp	-0.43		
Rubus pubescens	-0.39		
Mertensia paniculata	-0.37		
Fragaria virginiana	-0.36		
Pyrola asarifolia	-0.35		
BP > 9-15 cm	-0.34		
Rhamnus alnifolia	-0.34		
Cornus canadensis	-0.33		
Petasites frigidus var. *palmatus*	-0.33		
TA > 15-20 cm	-0.32		
BS > 9-15 cm	0.35		
Cladina stellaris	0.41		
Rhododendron groenlandicum	0.42		

Species	tau *b*	Environment	tau *b*
Cladina mitis	0.43		
Cladina rangiferina	0.47		
Pleurozium schreberi	0.53		
Vaccinium vitis-idaea	0.54		
Axis 3 (14.7%)			
JP > 9-15 cm	-0.32	Depth to frost	-0.32
Rosa acicularis	-0.31	LFH thickness	-0.23
JP > 15-20 cm	-0.30	Dom. mineral particle size	-0.21
Vaccinium myrtilloides	-0.30	Mesic OM thickness	0.24
BS > 9-15 cm	0.35	Humic OM thickness	0.25
		Fibric OM thickness	0.28
		Moisture regime	0.32
		Drainage regime	0.35
		OM thickness	0.36

Notes: Only species and environmental variables with a minimum tau *b* of 0.3 and 0.2, respectively, are shown.

Black Spruce Feathermoss and Sphagnum Bog

Nonmetric multidimensional scaling of the 239 plots in this subset resulted in a three dimensional ordination solution (Figure 7-11). Final stress and instability for the solution was 13.40 and 0.00044, respectively. A total of 89.0% of the variation in the dataset was explained by the first three ordination axes, with 49.0% and 23.6% explained by axis 1 and axis 2, respectively. The two ordination axes were significantly stronger than expected by chance (P = 0.0278).

In the ordination diagram of the first two axes, plots in the Small Black Spruce Dominated Sphagnum and Feathermoss Bogs group (G16) clustered toward the left of the ordination, and the plots in the Sparse Black Spruce Dominated, Reindeer Lichen on Bogs group (G2) clustered toward the right of the ordination diagram. There was little to no separation along the third axis, although group G2 plots separated along a wider range with axis 3 and toward the lower end of axis 3 (Figure 7-11).

The gradient along axis 1 was most strongly associated with site characteristics (Table 7-23). Correlations with axis 1 indicated that plots clustered to the right of the ordination were associated with a higher abundance of cloudberry (*Rubus chamaemorus)* and leather-leaf, as well as thicker fibric and total organic substrate thickness, wetter, more poorly drained sites and finer soil textures. Plots clustered on the left were associated with a higher abundance of myrtle-leaved willow and other willows, dwarf scouring rush, alpine bearberry, *Peltigera* spp, sedges, prickly rose and bog bilberry; along with coarser soil textures and higher percent slope.

The gradient along axis 2 was most strongly associated with structural characteristics (Table 7-23). Plots clustered toward the top of the ordination were associated with a higher abundance of reindeer lichen (*Cladina* spp.), big red stem, small black spruce trees (<9 cm DBH) and rock cranberry; along with a higher percentage of low vegetation cover (<50 cm). Plots clustered toward the bottom of the ordination were associated with more abundant three-leaved Solomon's-seal, other moss species, swamp birch and sedges; along with a lower proportion of low vegetation cover.

The gradient along axis 3 was most strongly associated with structural characteristics (Table 7-23). Correlations indicated that plots clustered toward the top of the ordination were associated with more abundant stair-step moss, larger black spruce trees (9-15 cm DBH), willows and *Rubus arcticus*; as well as taller canopies. Plots clustered toward the bottom of the ordination were associated with more abundant cup lichens and cloudberry, and shorter canopies.

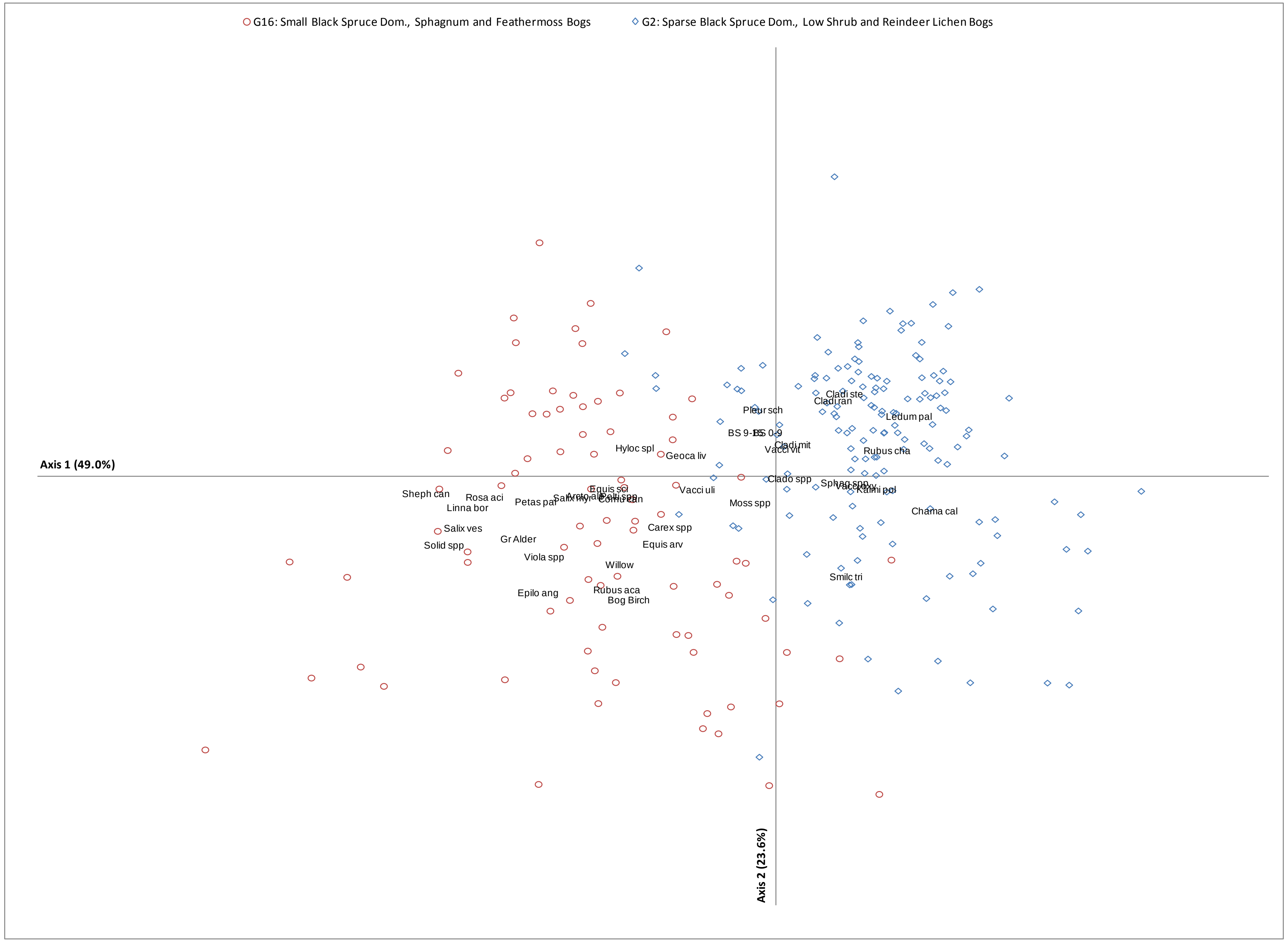


Figure 7-11: Vegetation biplot from nonmetric multidimensional scaling ordination of 239 LNR Region inland habitat plots and species[4], shaded by general plot habitat types G16 and G2

[4] Only species with Kendall tau *b* correlation coefficients of 0.3 or higher are shown in ordination. Species names displayed are abbreviations. Percentages following the axis labels are percent species variability explained by the axis.

Table 7-23: Kendall tau *b* correlation coefficients of species and environmental variables with the three NMS ordination axes of the 239 inland habitat plots in general plot habitat types G16 and G2

Species	tau *b*	Environment	tau *b*
Axis 1 (49.0%)			
Salix myrtillifolia	-0.64	Mineral thickness in pit	-0.40
Equisetum scirpoides	-0.60	C-horizon particle size	-0.37
Arctuous alpina	-0.55	Dom. mineral particle size	-0.36
Peltigera spp	-0.52	% slope	-0.29
Carex spp	-0.51	Slope position	0.22
Rosa acicularis	-0.49	Depth to mottling	0.32
Salix spp	-0.49	Moisture regime	0.37
Linnaea borealis	-0.45	Drainage regime	0.38
Hylocomium splendens	-0.44	OM thickness	0.48
Solidago spp	-0.42	Peat depth class	0.51
Vaccinium uliginosum	-0.42	Fibric OM thickness	0.54
Equisetum arvense	-0.41		
Rubus arcticus	-0.39		
Petasites frigidus var. *palmatus*	-0.37		
Alnus viridis ssp. crispa	-0.35		
Chamerion angustifolium	-0.35		
Viola spp	-0.33		
Geocaulon lividum	-0.32		
Cornus canadensis	-0.31		
Salix vestita	-0.31		
Shepherdia canadensis	-0.30		
Kalmia polifolia	0.32		
Rhododendron tomentosum	0.36		
Sphagnum spp	0.40		
Vaccinium oxycoccos	0.40		
Chamaedaphne calyculata	0.45		
Rubus chamaemorus	0.63		
Axis 2 (23.6%)			
Maianthemum trifolia	-0.43	Depth to frost	-0.20
Moss spp	-0.36	Depth to water table	0.21
Betula pumila	-0.34	Canopy closure	0.21
Carex spp	-0.33	Canopy height	0.27
Rubus arcticus	-0.31	% cover <0.1m strata	0.38
Cladina mitis	0.31		
Vaccinium vitis-idaea	0.34		

Species	**tau *b***	**Environment**	**tau *b***
BS 0-9cm	0.38		
Pleurozium schreberi	0.43		
Cladina stellaris	0.54		
Cladina rangiferina	0.56		
Axis 3 (16.4%)			
Cladonia spp	-0.39	Fibric OM thickness	-0.26
Rubus chamaemorus	-0.38	Peat depth class	-0.24
Cladina mitis	-0.35	OM thickness	-0.23
Pleurozium schreberi	0.32	Canopy closure	0.24
Equisetum scirpoides	0.34	Mineral thickness in pit	0.25
Carex spp	0.37	C-horizon particle size	0.25
Equisetum arvense	0.37	Dom. mineral particle size	0.26
Rubus arcticus	0.39	Canopy height	0.36
Salix spp	0.39		
BS > 9-15 cm	0.41		
Hylocomium splendens	0.51		

Notes: Only species and environmental variables with a minimum tau *b* of 0.3 and 0.2, respectively, are shown.

Tall Shrub and Deep Wet Peatland

Nonmetric multidimensional scaling of the 184 plots in this subset resulted in a two dimensional ordination solution (Figure 7-12). Final stress and instability for the solution was 15.00 and 0.00045, respectively. A total of 85.3% of the variation in the dataset was explained by the two ordination axes, with 52.1% and 33.3% explained by axis 1 and axis 2, respectively. The two ordination axes were significantly stronger than expected by chance (P = 0.0278).

In the ordination diagram, plots in the Tall Shrub on Mineral and Peatlands group (G6) were clustered to the top of the diagram, while plots in the Sparsely Treed to Low Vegetation on Deep Wet Peatlands group (G3) were more tightly clustered at the bottom-right of the ordination (Figure 7-12). The looser clustering of plots in group G6 suggest a greater degree of variation within that group.

The gradient along both axis 1 and 2 were associated with a combination of site and structural characteristics (Table 7-24). Plots clustered toward the left of the ordination had increasing abundance of Willow, reed grass (*Calamagrostis* spp), common horsetail and stemless raspberry (*Rubus arcticus)*; as well as thinner total and fibric organic substrate, higher percent cover in the 0.5 to 1.3 m stratum and greater canopy closure. Plots clustered toward the right of the ordination were associated with increasing abundance of bogbean, bog rosemary, cotton grasses, sundew (*Drosera* spp), and sedges; with deeper organic substrates, lower 0.5 to 1.3 m stratum cover, and lower canopy closure.

Plots clustered toward the top of the ordination were associated with increasing abundance of reed grass, Willow, common horsetail and stemless raspberry, along with lower fibric and total organic substrate thickness, higher percent cover in the 0.5 to 1.3 m stratum and drier, better-drained sites. Plots clustered toward the bottom of the ordination were strongly associated with an increasing abundance of *Sphagnum* spp., small bog cranberry and leather-leaf, along with higher percent cover in the <50 cm vegetation stratum and deeper organic substrates.

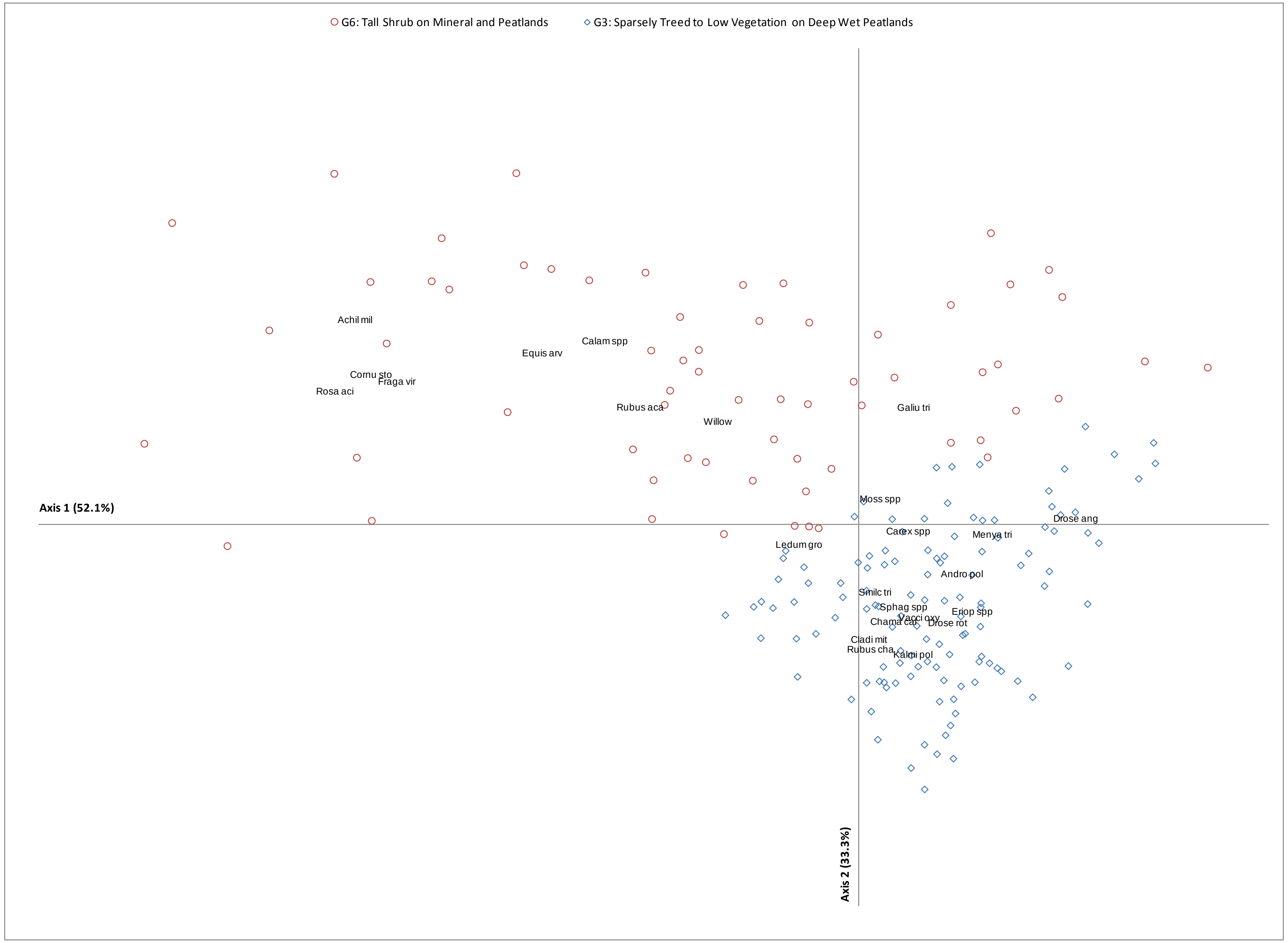


Figure 7-12: Vegetation biplot from nonmetric multidimensional scaling ordination of 184 LNR Region inland habitat plots and species[5], shaded by general plot habitat types G6 and G3

[5] Only species with Kendall tau *b* correlation coefficients of 0.3 or higher are shown in ordination. Species names displayed are abbreviations. Percentages following the axis labels are percent species variability explained by the axis.

Table 7-24: Kendall tau *b* correlation coefficients of species and environmental variables with the three NMS ordination axes of the 184 inland habitat plots in general plot habitat types G6 and G3

Species	tau *b*	Environment	tau *b*
Axis 1 (52.1%)			
Salix spp.	-0.56	% cover 0.5-1.3 m stratum	-0.45
Calamagrostis spp.	-0.50	Canopy closure	-0.34
Equisetum arvense	-0.45	Depth to water table	-0.32
Rubus arcticus	-0.45	Mineral thickness in pit	-0.28
Rosa acicularis	-0.35	Canopy height	-0.26
Rhododendron groenlandicum	-0.35	LFH thickness	-0.25
Fragaria virginiana	-0.34	% slope	-0.23
Cornus sericea	-0.31	% cover 0.1-0.5 m stratum	-0.22
Achillea millefolium	-0.31	Mesic OM thickness	0.27
Drosera rotundifolia	0.32	Moisture regime	0.33
Carex spp.	0.36	Drainage regime	0.33
Drosera anglica	0.37	Fibric OM thickness	0.41
Eriophorum spp.	0.40	Peat depth class	0.47
Andromeda polifolia	0.43	OM thickness	0.48
Menyanthes trifoliata	0.46		
Axis 2 (33.3%)			
Sphagnum spp	-0.74	% cover < 0.1 m stratum	-0.49
Vaccinium oxycoccos	-0.67	Peat depth class	-0.44
Chamaedaphne calyculata	-0.63	Fibric OM thickness	-0.42
Kalmia polifolia	-0.57	OM thickness	-0.38
Drosera rotundifolia	-0.48	Drainage regime	-0.35
Rubus chamaemorus	-0.42	Moisture regime	-0.35
Maianthemum trifolia	-0.36	Slope position	-0.24
Cladina mitis	-0.34	Mesic OM thickness	-0.20
Eriophorum spp	-0.31	% slope	0.25
Moss spp	0.30	LFH thickness	0.26
Galium trifidum	0.30	Mineral thickness in pit	0.29
Rubus arcticus	0.35	% cover 0.5-1.3 m stratum	0.35
Equisetum arvense	0.36		
Salix spp.	0.43		
Calamagrostis spp.	0.49		

Notes: Only species and environmental variables with a minimum tau *b* of 0.3 and 0.2, respectively, are shown.

7.3.2.2.5 Summary

A primary objective for the terrestrial habitat and ecosystem studies was to develop site and stand level hierarchical terrestrial habitat and ecosystem classifications applicable to the entire LNR Region (Section 7.1). Habitat types produced by the 22 group solution from a cluster analysis of plot data (Figure 7-7) corresponded well with mapped coarse habitat types (Table 6-32). Other statistical techniques corroborated the ecological meaningfulness of the cluster solutions selected for use as the coarse and fine site level habitat classifications, and identified associations between the habitat types and environmental factors.

The following section provides descriptions for the site level coarse inland habitat types, which can be used to infer the attributes of the mapped coarse habitat types.

7.3.2.2.6 Site Level Inland Habitat Type Descriptions

The following site level coarse habitat type descriptions are based on the 377 inland habitat plots sampled in the Keeyask study areas. The descriptions are grouped by the six general groups produced from the cluster analysis. A summary of the characteristics of each of the habitat types is provided in Table 7-25 (p. 7-96) to Table 7-31 (p. 7-102). The general habitat types are identified with codes that start with “G” (*e.g.*, G5 is the Broadleaf, Needleleaf and Mixedwoods, Herb-Rich on Mineral general site level habitat type) while the coarse and fine plot level habitat codes start with “C” and “F”, respectively. These tables also identify which of the mapped coarse habitat types are associated with each plot scale coarse habitat type.

Broadleaf, Needleleaf and Mixedwoods, Herb-Rich on Mineral (G5)

This group was comprised of a mixture of forest to sparsely treed canopy types ranging from broadleaf-dominated to needleleaf-dominated, and various mixtures of the two (Table 7-25). The most common canopy tree species included trembling aspen, white birch, black spruce and jack pine, usually ranging from 13 to 18 m in height. The broadleaf species and jack pine tended to make up the largest diameter classes in the stand. The dominant understorey tree species was usually black spruce, often occurring at high stem densities.

This group usually had a well developed, and often dense tall shrub layer, which was dominated by green alder, occasionally occurring with willow. Widespread low shrubs included prickly rose and rock cranberry, and widespread herb and ground cover includes bunchberry, twinflower, stair-step moss and other moss species (species other than sphagnum and feathermosses).

This group was associated with a flat to sloping topography, and fresh to moist mineral soils. The organic substrate is 8 cm on average for the group, often with an LFH layer.

Plots in this group most frequently occurred on the deep dry mineral mapped fine ecosite type, and occasionally on veneer bog on slope.

Black Spruce, Broadleaf and Mixedwoods on Mineral (C5)

This group included a mixture of forest to sparsely treed black spruce and broadleaf-dominated and mixedwood canopies. The dominant needleleaf component was black spruce, and broadleaf trees including white birch and trembling aspen, usually ranging from 11 to 17 m in height. Broadleaf trees usually comprised most of the largest-diameter stems. When present, understorey trees were most often dominated by black spruce.

This group had a dense tall shrub layer dominated by green alder, and occasionally some willow was present. Prickly rose was the dominant low shrub species, and widespread herbs and mosses included twinflower, bunchberry, stair-step moss and other moss species. Several species were indicators for this group, including palmate-leaved colt's-foot (*Petasites frigidus* var. *palmatus*), tall lungwort (*Mertensia paniculata*), bishop's-cap and *Aster* spp.

This group was associated with flat to sloping terrain and crests with fresh to moist mineral soil. The organic substrate was 9 cm thick on average, usually with an LFH layer averaging 3 cm.

Plots in this group occurred primarily on deep dry mineral, and sometimes on veneer bog on slope ecosite types. They were typically found within a variety of mapped coarse habitat types, including broadleaf treed on all ecosites, black spruce treed on mineral soil, broadleaf mixedwood on all ecosites, black spruce mixedwood on mineral or thin peatland, and black spruce treed on thin peatland.

The finer classification of plots in this group produced four distinctive canopy types. The first was a younger (smaller-diameter), sparse black spruce and jack pine type with a lower canopy, rich tall shrub layer, and an understorey dominated by prickly rose (F5). This was a fresh type occurring on crests and slopes with clayey mineral soil. The second type was a woodland to forest trembling aspen dominant and mixedwood canopy with black spruce on dry to moist clayey mineral with a thicker LFH layer, 5 cm on average (F13). The third was a black spruce dominant and mixedwood type, usually occurring on silty and loamy dry to moist mineral with a thicker organic substrate, 11 cm on average (F99). The fourth type was an often tall white birch dominant canopy with understorey trees that were a mixture of white birch, black spruce and/or trembling aspen, predominantly on fresh silty clay soil with a thick, 6 cm LFH layer (G128).

Large Jack Pine Dominant and Mixedwoods on Mineral (C348)

This group included forest to sparsely treed jack pine dominated canopies and mixedwoods, and broadleaf mixedwoods with jack pine. Broadleaf canopy species included trembling aspen and white birch. Canopies usually ranged from 14 to 18 m tall, and when present, understorey trees are dominated by black spruce saplings.

This group usually had a dense tall shrub layer comprised of green alder. Widespread low shrubs included rock cranberry and prickly rose, with widespread bunchberry, twinflower, stairstep moss and big red stem moss making up the herbaceous and moss ground cover. Larger-diameter jack pine and trembling aspen (>15 cm DBH) were both indicators of this group, as was one-sided pyrola.

The group was associated with flat and sloping terrain and fresh to moist mineral soil. The organic substrate was thin on average (5 cm), with an LFH layer often present.

Plots in this group almost all occurred on the deep dry mineral mapped ecosite type. They were typically found within the jack pine treed on mineral or thin peatland, jack pine mixedwood on mineral or thin peatland and broadleaf treed on all ecosites mapped coarse habitat types.

The finer classification of plots within this group produced two distinctive canopy types. The first was a trembling aspen dominated and mixedwood canopy type with jack pine on silty mineral soil (F348). The second was a jack pine dominated canopy often with white birch on fresh mineral soil (F557).

Needleleaf Dominant on Mineral Soil and Feathermoss Bogs (G1)

This general group was usually comprised of woodland and sparsely treed needleleaf-dominated canopies, sometimes with broadleaf trees (Tables 7-26 and 7-27). Canopies usually ranged in height from 8 to 14 m. The needleleaf trees included black spruce and jack pine, while the most common broadleaf tree was white birch.

The tall shrub layer was usually comprised of green alder when present, and occasionally willow. Widespread low shrubs included rock cranberry and Labrador tea, and feathermosses and green reindeer lichen were the most widespread ground cover.

This group was associated with flat to sloping terrain, and site types ranged from deep dry to moist mineral and feathermoss bogs. The organic substrate was 13 cm deep on average.

Most plots in this group occurred on the deep dry mineral fine ecosite type, and often occurred on veneer bog on slope as well.

Regenerating Broadleaf and/or Black Spruce on Mineral (C84)

This group was comprised of regenerating young, sparsely treed small-diameter trembling aspen with black spruce (F341) and very sparse white birch or black spruce dominated cover (F84). Canopy heights in this group ranged from 0 to 5 m, with trembling aspen or white birch having the highest stem densities. Black spruce seedlings were also widespread.

The tall shrub layer was comprised of abundant willow and buffalo-berry when associated with the trembling aspen canopies, and often bog birch when associated with white birch or black spruce. Widespread low shrubs included prickly rose and Labrador tea, and fireweed was the most abundant herbaceous ground cover, along with moss species and bunchberry. Fireweed, red raspberry (*Rubus idaeus*) and trembling aspen saplings and seedlings are indicator species for this group.

This group was associated with crests, upper slopes and flat terrain, often on moderately fresh, well-drained coarser mineral soil of fluvial deposits. Average organic substrate thickness was 3 cm.

Plots in this group mostly occurred on the deep dry mineral mapped ecosite type, and young regenerating habitat on mineral or thin peatlands, which may include broadleaf treed, black spruce treed, or low vegetation mapped habitat types.

Young Black Spruce Dominant and Mixedwoods, Green Alder on Mineral (C112)

This group was comprised of woodland to sparsely treed, small-diameter black spruce dominant to mixedwood canopies usually ranging from 8 to 10 m in height. White birch was the most common broadleaf canopy species, occasionally forming the dominant species (F112), and occasionally jack pine or tamarack would also occur on moister sites (F359). Black spruce stem density was often relatively high in this group.

This group had an abundant to dense tall shrub layer dominated by green alder with some willow. Widespread low shrubs included Labrador tea and prickly rose, and herbaceous and bryoid ground cover included moss species, cup lichens, dwarf scouring rush and green reindeer lichen. No species were strongly indicative of this group. Labrador tea comprised the more abundant low shrub species on moister sites (F359), while prickly rose was more abundant on drier sites (F112).

This group occurred on sloping to flat terrain with very fresh mineral soils. The organic substrate was 6 cm thick on average, usually with an LFH layer, which in some cases comprised the entire organic substrate (F112).

Plots in this group usually occurred on the deep dry mineral fine ecosite type, and occasionally on the outcrop ecosite type. This group primarily occurred within the black spruce treed on mineral coarse habitat type from mapping.

Young Jack Pine Dominant, Black Spruce and Mixedwoods on Mineral (C226)

This group was comprised of woodland to sparsely treed, smaller-diameter jack pine canopies, usually with a black spruce component, and sometimes in mixedwoods with white birch. The canopy generally ranged 6 to 14 m tall, and in taller stands, there may be an understorey layer of black spruce (F340).

The tall shrub layer was sparse to abundant, usually dominated by green alder, occasionally with willow on drier sites (F226 and F439). Widespread low shrubs included rock cranberry and Labrador tea, and herbaceous and bryoid ground cover included big red stem moss, bunchberry, other moss species and cup lichens. Velvet-leaf blueberry and jack pine trees 15 cm DBH and less were indicators for this group.

This group occurred on sloping to flat terrain, with moderately to very fresh and well drained mineral soils. The organic substrate was 7 cm thick on average, often with a thin LFH layer (1 cm).

Plots in this group occurred on the deep dry mineral and veneer bog on slope mapped fine ecosite types, and primarily occurred in the jack pine treed on mineral or thin peatland coarse habitat type from mapping.

The finer classification of plots in this group produced three distinct canopy types primarily based on structure. The first two were associated with moderately fresh mineral sites, and included a young, dense jack pine dominated group with a 5 to 7 meter tall canopy, occasionally with willow (F439); and a jack pine dominated mixture with black spruce and occasional white birch, with a 8 to 10 meter tall canopy, willow, and occasional green alder (F226). The third type occurred on very fresh mineral sites and feathermoss bogs, with a sparser jack pine dominated canopy 13 to 16 m tall, often mixed with black spruce and/or white birch and denser black spruce in the understorey. The tall shrub layer was comprised of denser green alder (F340).

Dry Black Spruce, Jack Pine Mixture, Lichen, on Coarse Mineral (C1)

This group had a sparsely treed canopy comprised of black spruce or jack pine dominated mixtures, occasionally with trembling aspen (F1) or white birch (F68). Canopy height usually ranged from 10 to 16 m, and black spruce and/or jack pine made up most of the largest-diameter stems. Understorey trees were dominated by black spruce.

This group had a scarse to abundant tall shrub layer of green alder. Widespread low shrubs included abundant rock cranberry, and prickly rose. Ground cover was dominated by abundant green, grey and northern reindeer lichen, and twinflower was also widespread. Northern reindeer lichen was an indicator of this group.

This group was associated with crests and upper slopes, and moderately dry, rapidly drained sandy mineral soil. The organic substrate was thin, 4 cm thick on average, often with an LFH layer.

Plots in this group occurred on deep dry mineral, veneer bog on slope and shallow or thin mineral fine ecosite types, and within the black spruce on mineral and black spruce on thin peatland coarse habitat types from mapping.

Finer classification of plots in this group indicated that on steeper, moderately dry slopes the canopy tended to be black spruce or trembling aspen dominated, with more abundant green alder (F1). On gentler, moderately fresh slopes, there tended to be a more open jack pine dominated canopy up to 20 m tall with a black spruce and white birch component, and a scarce tall shrub layer (F68).

Moist Black Spruce Dominant and Mixedwoods, Green Alder on Mineral and Feathermoss (C10)

This group had a woodland to sparsely treed canopy of black spruce dominated mixtures and mixedwoods with white birch. Occasionally white birch forms the dominant canopy species. The canopy generally ranged from 10 to 16 m tall. Black spruce seedlings were also widespread in the understorey.

This group had a sparse to dense tall shrub layer dominated by green alder, occasionally with willow. Widespread low shrubs included rock cranberry and Labrador tea. Widespread and abundant feathermosses dominated the ground cover.

This group was associated with flat and sloping terrain, on deep dry to moist mineral soil, as well as feathermoss bogs. The average organic substrate thickness was 12 cm, with 1 cm of LFH.

Plots in this group occurred predominantly on deep dry mineral ecosites, with some veneer bog on slope. Plots also occurred occasionally on slope bogs. The mapped coarse habitat types these plots coincided with included black spruce treed on mineral soil, black spruce treed on thin peatlands, and broadleaf mixedwood on all ecosites.

Finer classification of plots within this group indicated several distinct canopy structure types coinciding with variation in site conditions. On moister mineral sites, canopies tended to be shorter and more open, often with willow (F10) or speckled alder (F102) mixed in the tall shrub layer. Very fresh mineral sites had taller, more closed canopies, forming either black spruce dominated mixedwoods on more fibric-dominated organic substrates (F14), and white birch dominated mixedwoods on more mesic-dominated organic substrates (F187). On sloping, very moist sites with deeper organic substrates, canopies often had denser white birch, and frequently tamarack was present with a willow tall shrub layer (F247).

Black Spruce Dominant with White Birch, Willow on Mineral (C4)

This group had a woodland to sparsely treed canopy of black spruce dominated mixtures with white birch, and occasional mixedwoods. In smaller diameter classes (<9 cm DBH) black spruce often had very high stem densities, while stems greater than 15 cm DBH were generally absent in this group. The canopy height usually ranged from 7 to 12 m.

The tall shrub layer in this group was comprised of willow, which ranged in abundance. Widespread low shrubs included abundant Labrador tea and rock cranberry, with the remaining widespread ground cover including green reindeer lichen, cup lichen, big red stem moss and other moss species.

This group was associated with slopes, crests and flat terrain, often on till deposits, with fresh to moist mineral soil. The organic substrate was 14 cm deep on average with a 1 cm LFH layer.

Plots in this group most often occurred on the deep dry mineral fine ecosite type, and occasionally veneer bog on slope. Associated coarse habitat types from mapping included black spruce treed on mineral, black spruce treed on thin peatland, and black spruce treed on shallow peatland.

The finer classification of this group produced three structural variations of the canopy and tall shrub layer associated with different organic substrate thicknesses. These groups increased in white birch density and willow, and decreased in black spruce density with decreasing organic substrate thickness.

Moist Black Spruce Dominant on Feathermoss and Mineral (C8)

This group had a sparsely treed to woodland canopy dominated by black spruce, usually ranging from 8 to 13 m tall.

The tall shrub layer was sparse, comprised of willow when present. Low shrubs were abundant, with widespread rock cranberry and Labrador tea, while the remaining ground cover was dominated by abundant big red stem moss, and widespread green and grey reindeer lichen and other moss species.

This group is associated with gentle slopes and flat terrain on moist feathermoss bogs and mineral sites. The organic substrate is 30 cm thick on average, and often ground ice was present in deeper organic substrates.

Plots in this group usually were located on veneer bog on slope ecosites, and occasionally blanket bogs or deep dry mineral. This group was associated with the black spruce on mineral soil and black spruce on thin peatland coarse habitat types from mapping.

Finer group classification indicated that on moderately moist sandy to loamy mineral with shallower organic substrates the canopy was taller and more closed, with occasional white birch (F8). On wetter sites with deeper organic substrates, the canopy was shorter and more open, with occasional tamarack (F202).

Small Black Spruce Dominated, Sphagnum and Feathermoss Bogs (G16)

This general group was comprised of sparsely treed to woodland canopies dominated by smaller-diameter black spruce (Table 7-28). Tamarack is also often present as a secondary canopy species. Canopy height generally ranges from 4 to 8 m.

The tall shrub layer was dominated by willow, often with bog birch. Speckled alder was also occasionally present. Labrador tea was widespread and abundant in this group, along with rock cranberry, bog bilberry and myrtle-leaved willow. Moss species and green reindeer lichen were widespread ground cover.

This group was associated with flat to sloping terrain, primarily on sphagnum and feathermoss bogs as well as some moist mineral sites. The organic substrate was 33 cm deep on average, and over half of the plots in this group had ground ice.

Very Moist Black Spruce Dominant, Low Shrub on Sphagnum and Feathermoss (C16)

This group was comprised of sparsely treed to woodland canopies dominated by small-diameter black spruce, occasionally with tamarack. Canopy height ranged from 3 to 8 m in general.

The well-developed tall shrub layer in this group was generally a mixture of bog birch and willow. Widespread low shrubs included Labrador tea, bog bilberry, rock cranberry and myrtle-leaved willow. Moss species and green reindeer lichen made up the remaining widespread ground cover. Indicator species for this group included bog bilberry, myrtle-leaved willow, alpine bearberry and dwarf scouring rush.

This group was associated with flat and sloping terrain, on sphagnum and feathermoss bogs as well as some very moist mineral soils. The organic substrate was 28 cm deep on average, and ground ice was often present.

Plots in this group were usually located on mapped veneer bog on slope, as well as some blanket bog and deep dry mineral fine ecosite types. This group was primarily associated with the black spruce treed on thin peatland coarse habitat type from mapping.

Finer plot classification produced four sub-groupings distinguishable by structure and canopy species relative abundance. One was a tamarack, black spruce mixture, often with some trembling aspen and dense bog birch with willow type, associated with moist mineral sites with thinner organic substrates (F151). Another was a black spruce dominated canopy with a dense willow layer mixed with green alder (F109), and another occurred on slightly wetter sites with a black spruce canopy and occasional tamarack (F16). The last was a recently burned, very sparsely treed canopy 0 to 4 m tall (F82).

Wet Black Spruce Dominant, Willow on Bogs and Fens (C44)

This group had a woodland black spruce dominated canopy, often with tamarack and white birch. Canopy height ranged from 6 to 14 m. Small black spruce trees under 9 cm DBH and saplings often occurred at relatively high densities in this group, with other species occurring at much lower densities on average.

This group had abundant tall shrubs dominated by willow, and scarce to abundant speckled alder and bog birch. Widespread low shrubs included abundant Labrador tea, and the remaining bryoid and herbaceous cover was sphagnum and other moss species, three-leaved Solomon's-seal, common horsetail and wood horsetail. Arrow-leaved colt's-foot (*Petasites frigidus* var*. sagittatus*) was an indicator species for this group.

This group was associated with flat terrain, on wet sphagnum bogs and fens. The organic substrate was 52 cm deep on average, occasionally with ground ice, and often with a shallow water table, 26 cm deep on average.

Plots in this group were usually located on the veneer bog on slope fine ecosite type, as well as slope bogs and fens. Mapped coarse habitat type associations included black spruce treed on thin peatland, black spruce treed on shallow peatland and black spruce mixedwood on shallow peatland.

Finer classification of plots produced two sub-groupings. One group was more sparsely treed on average and associated with shallow water table sites and more humic organic substrate (F44). The other group was denser, and had more white birch and feathermoss. It was associated with more frequent ground ice (F158).

Sparse Black Spruce Dominated, Low Shrub and Reindeer Lichen Bogs (G2)

This general group was comprised of sparsely treed, small-diameter black spruce canopies, usually under 9 cm DBH, often mixed with some scattered tamarack stems (Table 7-29). Canopy height usually ranged from 5 to 10 m.

The tall shrub layer was generally scarce, but scattered willow or bog birch may occur. Low shrubs, including Labrador tea and rock cranberry, were widespread and abundant throughout plots in this group. Other widespread ground cover included green reindeer lichen, cloudberry, sphagnum and other moss species.

This group was usually associated with flat terrain, but also occasionally on some gentle slopes. This group occurred on moderately wet sphagnum bogs, usually with ground ice at a depth of 37 cm on average.

Black Spruce Dominant, Low Shrub on Sphagnum Bog (C2)

This group had a sparsely treed to woodland, small-diameter black spruce dominated canopy. Black spruce stem density on average was relatively high (>12,000 stems/ha), with an even mixture of trees less than 9 cm DBH, and saplings. Canopy height usually ranged from 6 to 11 m.

Tall shrubs in this group were scarce, but occasionally scattered bog birch or speckled alder stems may occur. The low shrub layer was comprised of abundant Labrador tea and rock cranberry. The bryoid and herbaceous ground cover was dominated by green and grey reindeer lichen, cloudberry and sphagnum mosses. Abundant cloudberry was indicative of this group.

This group was associated with flat to gently sloping terrain, on wet sphagnum bogs with ground ice at a depth of 36 cm on average. Unfrozen organic substrate depth was 63 cm on average.

Plots in this group most often occurred on the peat plateau bog fine ecosite type, and occasionally on veneer bog on slope and blanket bog as well. The mapped coarse habitat types associated with this group included black spruce treed on shallow peatland, and black spruce treed on thin peatland.

Finer classification of plots did not produce very distinctive sub-groups for this coarse habitat type. One fine type had somewhat lower black spruce stem density and more frequent, although still very sparse tamarack (F11) than the other (F2).

Sparse Black Spruce Dominant and Mixture on Sphagnum Bog (C7)

This group had a sparsely treed, small-diameter black spruce dominated canopy, often in a mixture with small-diameter tamarack. Black spruce formed by far the higher overall stem densities in this type (>10,000 stems/ha), with tamarack stems being more scattered (~1,000 stems/ha). Most stems of both species were less than 9 cm DBH.

Tall shrubs were scattered in this group, with occasional sparse willow and/or bog birch. Low shrubs included widespread and abundant Labrador tea and rock cranberry, with widespread bog bilberry and small bog cranberry as well. The remaining widespread ground cover included green reindeer lichen and sphagnum mosses.

This group was associated with flat to gently sloping terrain, on wet sphagnum bogs usually with ground ice at a depth of 34 cm on average. Unfrozen organic substrates average depth was 44 cm.

Plots in this group most often occurred on the veneer bog on slope fine ecosite type, and occasionally on veneer bog as well. The mapped coarse habitat types associated with this group included black spruce treed on thin peatland, and black spruce treed on shallow peatland.

As with group C2, finer classification of plots within this group did not produce very distinctive subgroups. One fine group had somewhat higher black spruce and tamarack stem density, and occurred more frequently on gentle slopes (F39) than the other fine group (F7).

Regenerating Black Spruce, Low Shrub on Sphagnum Bog (C36)

This group included untreed to sparsely treed, low, regenerating canopies dominated by black spruce seedlings, saplings and small trees. The canopy typically ranged from 0 to 5 m in height.

The tall shrub layer was sparse, but occasionally scattered stems of bog birch may be present. Widespread and abundant Labrador tea dominated the low shrub layer, as well as rock cranberry. Widespread herbaceous and bryoid cover included cloudberry, green reindeer lichen, other moss species and cup lichens.

This group was associated with wet sphagnum bogs on flat to gently sloping terrain. Ground ice was often present at an average of 51 cm deep, and unfrozen portions of the organic substrate were 122 cm deep on average.

Plots in this group occurred most often on transitional peat plateau bog, as well as peat plateau bog and veneer bog on slope fine ecosite types. Mapped coarse habitat type associations included black spruce treed on shallow peatland, low vegetation on shallow peatland, and young regeneration on shallow peatland (including black spruce and low vegetation types).

Finer classification of plots in this group did not produce very distinctive subgroups. One group was more frequently treed, and was associated with fibric sites often with a shallower water table (F36). The other group was more sporadically treed, and associated with occasionally gently sloped, fibric and mesic sites with more frequent ground ice (F80).

Tall Shrub on Mineral and Peatlands (G6)

In this general group the tall shrub layer was dominant, although occasionally sparse smaller-diameter black spruce, tamarack and/or white birch may be present (Table 7-30). The dominant vegetation layer in this group generally ranged from 0 to 2 m in height.

The usually dense tall shrub layer was most often dominated by willow, but varying densities of bog birch and speckled alder were also common. The only widespread ground cover for this general group was other moss species.

This group was associated with very moist to wet fens and mineral sites with a range of organic substrate depths, averaging 80 cm. Often there was a shallow water table an average of 9 cm deep.

Willow and Bog Birch Mesic Fen and Mineral (C25)

This group had a dense tall shrub layer dominated by willow, often with sparse to dense bog birch and speckled alder. Occasionally sparse, small-diameter black spruce, tamarack and/or white birch stems were present. The canopy ranged from 0 to 2 m tall.

Labrador tea was the only widespread low shrub in this group, with a low average abundance. Other moss species were the only other widespread ground cover. Reed grasses and dense willow were indicative of this group.

This group was primarily associated with very moist to wet fens on flat terrain. The organic substrate was mesic-dominated, and 57 cm deep on average, sometimes with an LFH layer. Often there was a shallow water table at a depth of 9 cm on average.

Plots in this group occurred on a number of fine ecosite types, including riparian fen, veneer bog on slope, deep dry mineral, horizontal fen and blanket bog. Mapped coarse habitat type associations included tall shrub on riparian peatland, tall shrub on mineral or thin peatland, tall shrub on wet peatland and tall shrub on shallow peatland.

Finer classification of plots within this group resulted in four fine groups distinguished by shrub composition and fine site characteristics. The first was a moist willow, bog birch, speckled alder group on very moist, flat to sloping mesic-dominated organic substrates (F25). The second was a wet bog birch dominated group with sparse tamarack on deeper wet, fibric-dominated fens with a shallow water table (F32). The third was a wet, willow-dominated group on deeper wet, mesic dominated fens (F48). The fourth was a moist willow-dominated group with abundant marsh reed grass on flat to sloping moist mineral or humic-dominated fens (F243).

Willow and Low Shrub Fibric Fen (C30)

This group was characterized by a scattered to dense tall shrub layer dominated by willow. Occasionally the low shrub or bryoid layers formed the dominant vegetation strata. Widespread ground cover included other moss species, marsh-five-finger and small bedstraw, the latter were indicative of this group.

This group was associated with wet fens on flat terrain. The fibric and mesic-dominated organic substrate was 144 cm deep on average. Often there was a shallow water table present at a depth of 8 cm on average.

Plots in this group usually occurred on the riparian fen and horizontal fen ecosite types. Mapped coarse habitat type associations included low vegetation on riparian peatland, tall shrub on riparian peatland and low vegetation on wet peatland.

Finer classification of plots produced three groups with distinctive vegetation structure associated with increasing mean organic substrate depth. These included a very dense willow group on wet fens and marshes with an average organic substrate depth of 70 cm (F30); a sparse willow, bog birch, green alder group on wet, fibric-dominated fens with an average organic substrate depth of 180 cm (F41); and a low shrub and bryoid group, rarely with scattered willow, on wet fens with an average organic substrate depth of 206 cm (F33).

Sparsely Treed to Low Vegetation on Deep Wet Peatlands (G3)

This general group included a range of vegetation structure, from untreed to sparsely treed canopies of small-diameter tamarack and/or black spruce (Table 7-31). Canopy height generally ranged from 0 to 3 m.

The tall shrub layer was often dense and dominated by bog birch, occasionally with willow. Widespread low shrubs included abundant small bog cranberry and leather-leaf. Widespread herbaceous and bryoid cover included sphagnum moss and other moss species, and three-leaved Solomon’s-seal.

This group was associated with flat, deep wet fens and bogs. The average organic substrate depth was 180 cm overall and fibric-dominated. There was generally a shallow water table at an average depth of 8 cm.

Sparse Tamarack and Black Spruce, Bog Birch Fen (C3)

This group usually had a sparsely treed canopy with an even mixture of small-diameter tamarack and black spruce, usually less than 9 cm in diameter. Canopy height generally ranged from 0 to 3 m.

The tall shrub layer was dense, dominated by bog birch often mixed with some willow. Widespread and abundant leatherleaf and small bog cranberry made up the low shrub layer. Widespread herbaceous and bryoid cover included sphagnum mosses and other mosses, three-leaved Solomon’s-seal and water horsetail. Water horsetail and bog willow were indicator species for this group.

This group was associated with flat, wet, fibric-dominated fens with an average organic substrate depth of 104 cm. Usually the water table was shallow, at a depth of 11 cm.

Plots in this group were associated with the horizontal fen, transitional peat plateau bog and peat plateau bog ecosite types. Mapped coarse habitat type associations included low vegetation on wet peatland, tamarack-black spruce mixture on wet peatland, and tamarack treed on wet peatland.

Finer plot classification divided this group into two fine sub-groups based on relative canopy species abundance and fine site characteristics. One group was a slightly drier black spruce-dominant, tamarack mixture more often on sphagnum bogs (F3), and the other was a slightly wetter tamarack-dominant, black spruce mixture more often on fens (F282).

Open, Wet Tamarack Dominant and Untreed, Bog Birch Fen (C9)

This group had a sparse canopy dominated by small-diameter tamarack, occasionally with some sparser black spruce. Stem diameter generally did not exceed 9 cm DBH in this group. Canopy height ranged from 0 to 3 m.

The tall shrub layer was usually dense, comprised of bog birch, often with sparse willow. Bog rosemary and small bog cranberry were the only widespread low shrubs. Bog bean was widespread and abundant in this group, and other widespread ground cover included sphagnum and other moss species, and water horsetail. Bog bean and bog rosemary were both indicator species for this group, as well as sea-side arrow-grass (*Triglochin maritima*) and cotton-grass species.

This group was associated with wet, deep fibric-dominated fens on flat topography. The organic substrate was 218 cm deep on average, and the water table was at or near the surface, with a depth of 5 cm on average.

Plots in this group usually occurred on the riparian fen, horizontal fen and transitional peat plateau bog fine ecosite types. Mapped coarse habitat associations included low vegetation on wet peatland, tamarack treed on wet peatland, tamarack treed on riparian peatland, black spruce treed on riparian peatland and low vegetation on riparian peatland.

Finer classification of plots within this group produced two sub-groups based on canopy composition and structure. One group was a sparse tamarack fen with black spruce and a less dense tall shrub layer of bog birch (F9). The other was a tamarack fen with a higher tamarack stem density and less black spruce, with a very dense tall shrub layer of bog birch and scattered willow (F47).

Untreed, Deep Sphagnum Bog and Fen (C18)

This group was generally untreed, but scattered small-diameter black spruce or tamarack stems may occur. The tall shrub layer in this group was scarce. The dominant vegetation strata in this group were comprised of low shrubs and bryoid vegetation. Small bog cranberry and leatherleaf were widespread and abundant in this group, as was sphagnum moss. Other widespread species included bog-laurel (*Kalmia polifolia*) and three-leaved Solomon’s-seal. Leatherleaf and bog-laurel were indicator species for this group.

This group was associated with deep, wet fibric-dominated sphagnum bogs and some fens on flat terrain. The organic substrate was 224 cm thick on average, with a shallow water table at an average depth of 7 cm.

Plots in this group occurred on the collapse scar bog, transitional peat plateau bog, horizontal fen and collapse scar fen fine ecosite types. These plots were primarily associated with the low vegetation on wet peatland coarse habitat type from mapping.

Finer classification of plots sub-divided this group into three fine groups with more distinctive vegetation cover and site conditions. One group was a low shrub and bryoid bog, rarely with scattered black spruce and/or tamarack, associated with the sphagnum bog site type (F18). Another group was a low shrub and bryoid bog or fen with scattered black spruce and/or tamarack stems, associated with sphagnum bog or fen site types (F57). Another group was an untreed bryoid and sedge fen, with occasional sparse bog birch and willow, associated with the fen site type (F312).

Table 7-25: Characteristics of the Broadleaf, Needleleaf and Mixedwood, Herb-rich on Mineral general site level habitat type (G5), and its subgroups in the Keeyask region

General Plot Habitat Type	G5: Broadleaf, Needleleaf & Mixedwood, Herb-rich on Mineral					
Canopy Composition	Forest to Sparsely treed Broadleaf dominated canopy (TA, WB, BP), & Conifer (BS, JP) Canopy 13-18 m					
Tall Shrub Composition	Often abundant GA, also W, SC, VE, RA - diverse					
Widespread Understory Composition (Mean Abundance)	(9) *Cornus canadensis*, (8) *Linnaea borealis*, (8) *Hylocomium splendens*, (7) *Rosa acicularis*, (6) Moss spp, (5) *Vaccinium vitis-idaea*					
Site Characteristics	Flat terrain & Upper to Mid slopes V. Fresh, Deep dry to moist, TOM = 8 with LFH					
Coarse Plot Habitat Type	**C5: Black Spruce, Broadleaf & Mixedwood on Mineral**				**C348: Jack Pine Dominant & Mixedwoods on Mineral**	
Canopy Composition	Forest to Sparsely treed Needleleaf (BS dom) and/or Broadleaf canopy, BS understorey Canopy 11-17 m				Forest to Sparsely treed JP canopy often w/TA or WB, BS understorey Canopy 14-18 m	
Tall Shrub Composition	Dense GA, Occ. W				Dense GA	
Understory Composition (Mean Abundance) Indicator species	(11) *Linnaea borealis*, (10) *Rosa acicularis*, (8) *Hylocomium splendens*, (7) Moss spp, (7) *Cornus canadensis*, (6) *Petasites frigidus var palmatus*, *Mertensia paniculata*, *Mitella nuda*, Aster spp				(12) *Cornus canadensis*, (7) *Linnaea borealis*, (7) *Hylocomium splendens*, (6) *Vaccinium vitis-idaea*, (5) *Rosa acicularis*, (4) *Pleurozium schreberi*, JP25&20, TA20, *Orthillia secunda*	
Site Characteristics	Flat to Sloping terrain & Crests V. Fresh, Deep dry to moist mineral, TOM = 9 w/LFH (3 cm)				Flat terrain & Upper Slopes V. Fresh, Deep dry to moist mineral, TOM = 5 w/LFH (1 cm)	
Typical Mapped Fine Ecosite Types	Deep dry mineral (70%), Veneer bog on slope (30%)				Deep dry mineral (95%)	
Typical Mapped Coarse Habitat Types, Descending Dominance	Broadleaf treed on all ecosites, Black spruce treed on mineral soil, Broadleaf mixedwood on all ecosites, Black spruce mixedwood on mineral or thin peatland, Black spruce treed on thin peatland				Jack pine treed on mineral or thin peatland, Jack pine mixedwood on mineral or thin peatland, Broadleaf treed on all ecosites	
Fine Plot Habitat Type	**F5: Young BS & JP Mixture, Shrub Rich**	**F13: TA Dominant and Mixedwood (with BS)**	**F99: BS Dominant and Mixedwood**	**F128: WB Dominant**	**F348: TA Dominant and Mixedwood (with JP)**	**F557: JP Dominant and Mixedwood (with WB)**
Number of plots	*2*	*2*	*11*	*5*	*8*	*12*
Canopy Composition (CC = canopy closure)	Sparsely treed Sm dia. BS w/JP, TL, BP Canopy 10 m CC 10 - 25 %	Woodland to Forest TA dom. & BS, BS understorey Canopy 14-17 m CC 30 - 70 %	Forest to Sparsely treed BS dom. (JP) w/broadleaf canopy, BS dom understorey Canopy 11-15 m CC 15 - 70 %	Woodland to Forest WB dom (TA) canopy, BS, TA, WB understorey Canopy 13-21 m CC 38 - 63 %	Woodland to Forest TA dom. Canopy often w/JP, usually BS understorey Canopy 15-18 m CC 41 - 74 %	Forest to Sparely treed JP dom. Canopy often w/WB, often BS understorey Canopy 14-18 m CC 26 - 79 %
Tall Shrub Composition	Dense GA, w/W, Oft. SC, VE	Dense GA	Dense GA, Occ. W	Dense GA, occ. BB	Dense GA	Dense GA
Understory Composition (Mean Abundance) Indicator species	(14) *Rosa acicularis*, (12) *Vaccinium vitis-idaea*, (10) *Linnaea borealis*, (8) *Cornus canadensis*, (8) *Cladonia* spp, (7) *Viburnum edule*	(15) Linnaea borealis, (10) *Orthillia secunda*, (9) *Cornus canadensis*, (8) *Vaccinium vitis-idaea*, (8) *Hylocomium splendens*, (8) *Geocaulon lividum*	(11) Linnaea borealis, (9) *Hylocomium splendens*, (8) *Petasites frigidus* var *palmatus*, (8) Moss spp, (6) *Chamerion angustifolium*, (5) *Pleurozium schreberi*, Aster spp.	(10) *Cornus canadensis*, (9) *Linnaea borealis*, (9) *Hylocomium splendens*, (8) *Rosa acicularis*, (7) *Petasites frigidus* var *palmatus*, (6) Moss spp, *Mertensia paniculata*, WB20*	(12) *Cornus canadensis*, (7) *Rosa acicularis*, (7) *Linnaea borealis*, (7) *Hylocomium splendens*, (6) Moss spp, (5) *Vaccinium vitis-idaea*, TA25,20&15	(12) *Cornus canadensis*, (7) *Vaccinium vitis-idaea*, (7) *Linnaea borealis*, (7) *Hylocomium splendens*, (6) *Pleurozium schreberi*, (4) *Vaccinium myrtilloides*, JP25&20, *Lycopodim annotinum*
Site Characteristics	Crest & Slope Fresh, Mod. well drained Clayey mineral TOM = 4 w/LFH (1 cm)	Flat & Crest Dry to Moist Clayey mineral, TOM = 5 w/LFH (5 cm)	Flat & Slope Silty & Loamy, Deep dry to moist mineral, TOM = 11 w/LFH (1 cm)	Flat & Lower slope Silty Clay, Fresh Deep dry mineral, TOM (LFH)= 6	Deep dry to moist silty mineral soil, TOM = 7 w/LFH (3 cm)	Fresh, well drained deep dry to moist mineral soil, TOM = 4
Typical Mapped Fine Ecosite Types	Deep dry mineral, Veneer bog on slope	Deep dry mineral, Veneer bog on slope	Deep dry mineral, Veneer bog on slope	Deep dry mineral	Deep dry mineral	Deep dry mineral

*Notes: TA = trembling aspen; BP = balsam poplar; WB = white birch; BS = black spruce; WS = white spruce; JP = jack pine; TL = tamarack; GA = green alder; SA = speckled alder; W = willow; BB = bog birch; SC = buffaloberry; RA = alder-leaved buckthorn; VE = low bush-cranberry; CS = red-osier dogwood. Tree abbreviations followed by a number represent the diameter class pseudospecies: 08 = 0-9 cm; 15 = > 9-15 cm; 20 = > 15-20 cm; 25 = > 20 cm. TOM = thickness of organic material, and LFH = the folic organic layer.

Table 7-26: Characteristics of the Needleleaf Dominant on Mineral and Feathermoss Bogs general site level habitat type (G1), and its drier, shallower organic subgroups in the Keeyask region

General Plot Habitat Type	**G1: Needleleaf Dominant on Mineral and Feathermoss Bogs**								
Canopy Composition	Woodland & Sparsely treed Conifer dominated (BS, JP) & some Broadleaf (WB) Canopy 8-14 m								
Tall Shrub Composition	GA, some W								
Widespread Understory Composition (Mean Abundance)	(9) *Vaccinium vitis-idaea*, (9) *Rhododendron groenlandicum*, (8) *Pleurozium schreberi*, (7) Moss spp, (6) *Cladina mitis*, (5) *Hylocomium splendens*								
Site Characteristics	Upper to mid slopes, crests & flat terrain, V. Fresh, Deep dry to Feathermoss bog, TOM = 13								
Coarse Plot Habitat Type	**C84: Regnerating Broadleaf and/or Black Spruce on Mineral**		**C112: Young Black Spruce Dominant and Mixedwoods, Green Alder on Mineral**		**C226: Young Jack Pine Dominant, Black Spruce and Mixedwoods on Mineral**			**C1: Dry Black Spruce, Jack Pine Mixture, Lichen on Coarse Mineral**	
Canopy Composition	Sm. Dia TA, WB and/or BS regeneration Canopy 0-5 m		Woodland to Sparsely treed Dense Sm. Dia BS, often w/WB Canopy 8-10 m		Woodland to Sparsely treed Smaller JP w/BS, often w/WB Canopy 6-14 m			Sparsely treed BS, JP canopy, BS understorey Canopy 10-16 m	
Tall Shrub Composition	Often SC and/or W		Dense GA, w/W		Sparse to Abundant GA, some W			Sparse GA, occ. W	
Understory Composition (Mean Abundance) Indicator species	(10) *Chamerion angustifolium*, (9) *Rosa acicularis*, (8) Moss spp, (5) *Rhododendron groenlandicum*, (5) *Cornus canadensis*, (1) *Picea mariana* seed, *Rubus idaeus*, TA00&seed		(10) Moss spp, (8) *Rhododendron groenlandicum*, (7) *Cladonia* spp, (5) *Rosa acicularis*, (5) *Equisetum scirpoides*, (5) *Cladina mitis*		(10) *Pleurozium schreberi*, (10) *Vaccinium vitis-idaea*, (9) *Rhododendron groenlandicum*, (8) *Cornus canadensis*, (7) Moss spp, (6) Cladonia spp, *Vaccinium myrtilifolia*, JP08&15			(12) *Cladina mitis*, (11) *Vaccinium vitis-idaea*, (9) *Cladina stellaris*, (8) *Linnaea borealis*, (8) *Cladina rangiferina*, (7) *Rosa acicularis*	
Site Characteristics	Crests, Upper Slopes & Flat terrain Mod. fresh, well drained deep dry coarser mineral, Fluvial deposits, TOM = 3 Recently burned		Slopes & Flat Terrain V. Fresh deep dry mineral, TOM = 6 w/LFH (2 cm)		Slopes & Flat Terrain Fresh, well drained deep dry mineral, TOM = 7 w/LFH (1 cm)			Crests & Upper slopes, Mod. dry & rapidly drained fluvial deposits, deep sandy mineral soil, TOM = 4 w/LFH (1 cm)	
Typical Mapped Fine Ecosite Types	Deep dry mineral (89%)		Deep dry mineral (67%), Outcrop (13%)		Deep dry mineral (53%), Veneer bog on slope (47%)			Deep dry mineral (50%), Veneer bog on slope (38%), Shallow/thin mineral (13%)	
Typical Mapped Coarse Habitat Types, Descending Dominance	Young regeneration on mineral or thin peatland (includes low vegetation, broadleaf and black spruce on the same ecosites)		Black spruce treed on mineral soil		Jack pine treed on mineral or thin peatland			Black spruce treed on mineral soil, Black spruce treed on thin peatland	
Fine Plot Habitat Type	**F84: Recent Burn and Regenerating WB or BS**	**F341: Regenerating TA mixture with BS**	**F112: Young BS or WB**	**F359: Young Dense BS Dominant and Mixedwoods**	**F226: Young JP Mixture with BS and/or WB**	**F340: Young JP Mixture, Moist**	**F439: Young, Dense JP Dominant**	**F1: Dry BS or TA Dominant, Green Alder**	**F68: Open Mature JP Mixture with WB and BS**
Number of plots	*5*	*4*	*3*	*12*	*2*	*8*	*7*	*4*	*4*
Canopy Composition (CC = canopy closure)	Untreed to Scarcely treed Sm. WB or BS Canopy 0-6 m CC 0 - 3 %	Sparsely treed Sm TA dom. w/BS Canopy 2-6 m CC 1 - 16 %	Woodland to Sparsely treed Sm dia BS dom, occ WB Canopy 8-12 m CC 20 - 40 %	Woodland to Sparsely treed V. dense sm dia BS, occ TL, JP Canopy 7-10 m CC 20 - 54 %	Forest to Sparsely treed JP dom. BS mixture, Occ WB, sparse understorey Canopy 8-10 m CC 20 - 65 %	Sparsely treed to Woodland JP dom canopy (BS, WB), denser BS understorey Canopy 13-16 m CC 15 - 34 %	Woodland Young, dense JP, often w/BS Canopy 5-7 m CC 30 - 50 %	Sparsely treed to Forest BS or TA dom w/JP, BS dom understorey Canopy 9-16 m CC 13 - 63 %	Sparsely treed Lg JP dom w/BS & WB, BS dom understorey Canopy 10-20 m CC 11 - 24 %
Tall Shrub Composition	Often BB, W	Abundant W & SC	Dense GA, w/W	Dense GA, w/W	W, sometimes GA	Often Dense GA	Occ W	Often abundant GA, occ SC	Scarce
Understory Composition (Mean Abundance) Indicator species	(9) Moss spp, (8) *Rhododendron groenlandicum*, (7) *Vaccinium vitis-idaea*, (7) *Rosa acicularis*, (5) *Cornus canadensis*, (10) *Chamerion angustifolium*, *Rubus idaeus*	(11) *Rosa acicularis*, (11) *Chamerion angustifolium*, (9) *Solidago* spp, (8) Moss spp, (7) *Fragaria virginiana*, (6) *Cladonia* spp, TA00&seed, TA08, *Oryzopsis pungens*, *Solidago spp.*, *Achillia millefolium*	(9) Moss spp, (5) *Rosa acicularis*, (5) *Cladonia* spp, (4) *Chamerion angustifolium*, (4) *Cladina mitis*, (3) *Equisetum scirpoides*	(9) *Rhododendron groenlandicum*, (7) Cladonia spp, (6) *Cladina mitis*, (5) *Picea mariana* seed, (5) *Equisetum scirpoides*, (4) *Vaccinium uliginosum*	(15) *Vaccinium vitis-idaea*, (14) *Cornus canadensis*, (9) *Cladonia* spp, (8) *Rosa acicularis*, (8) *Chamerion angustifolium*, (7) *Linnaea borealis*	(13) *Pleurozium schreberi*, (12) *Vaccinium vitis-idaea*, (12) *Rhododendron groenlandicum*, (8) *Cornus canadensis*, (6) Moss spp, (5) *Rosa acicularis*, JP15	(9) Moss spp, (7) *Rhododendron groenlandicum*, (7) *Cladina mitis*, (6) *Vaccinium vitis-idaea*, (6) *Cornus canadensis*, (4) *Rosa acicularis*, JP08	(12) *Linnaea borealis*, (11) *Cladina mitis*, (10) *Vaccinium vitis-idaea*, (8) *Rosa acicularis*, (8) *Pleurozium schreberi*, (6) *Hylocomium splendens*	(13) *Vaccinium vitis-idaea*, (12) *Cladina mitis*, (11) *Cladina stellaris*, (10) *Cladina rangiferina*, (7) *Pleurozium schreberi*, (6) *Rosa acicularis*
Site Characteristics	Slopes & flat terrain TOM = 5 Recently burned	Crests TOM = 1	Deep Dry TOM = 3 (all LFH)	Deep Dry to Moist, TOM = 7 w/LFH (1 cm) Occ w/Frost @ 65 cm	Slopes Mod Fresh, deep dry mineral, TOM = 5 w/LFH (3 cm)	Flat to Sloping V. Fresh mineral & Feathermoss bog, TOM = 9 w/LFH (1 cm)	Slightly steeper Slopes to Flat, Mod. Fresh, TOM = 5 w/LFH (1 cm)	Steeper, Mod. Dry	Mod. Fresh
Typical Mapped Fine Ecosite Types	Deep dry mineral	Deep dry mineral	Deep dry mineral, Blanket bog	Deep dry mineral, Outcrop	Deep dry mineral, Veneer bog on slope	Deep dry mineral, Veneer bog on slope	Deep dry mineral, Veneer bog on slope	Veneer bog on slope, Deep dry mineral, Shallow/thin mineral	Deep dry mineral, Veneer bog on slope

Notes: TA = trembling aspen; BP = balsam poplar; WB = white birch; BS = black spruce; WS = white spruce; JP = jack pine; TL = tamarack; GA = green alder; SA = speckled alder; W = willow; BB = bog birch; SC = buffaloberry; RA = alder-leaved buckthorn; VE = low bush-cranberry; CS = red-osier dogwood. Tree abbreviations followed by a number represent the diameter class pseudospecies: seed = seedling; 00 = sapling; 08 = 0-9 cm; 15 = > 9-15 cm; 20 = > 15-20 cm; 25 = > 20 cm. TOM = thickness of organic material, and LFH = the folic organic layer.

Table 7-27: Characteristics of the Needleleaf Dominant on Mineral and Feathermoss Bogs general site level habitat type (G1), and its moister, deeper organic subgroups in the Keeyask region

General Plot Habitat Type	**G1: Needleleaf Dominant on Mineral and Feathermoss Bogs**									
Canopy Composition	Woodland & Sparsely treed Conifer dominated (BS, JP) & some Broadleaf (WB) Canopy 8-14 m									
Tall Shrub Composition	GA, some W									
Widespread Understory Composition (Mean Abundance)	(9) *Vaccinium vitis-idaea*, (9) *Rhododendron groenlandicum*, (8) *Pleurozium schreberi*, (7) Moss spp, (6) *Cladina mitis*, (5) *Hylocomium splendens*									
Site Characteristics	Upper to mid slopes, crests & flat terrain, V. Fresh, Deep dry to Feathermoss bog, TOM = 13									
Coarse Plot Habitat Type	**C10: Moist Black Spruce Dominant and Mixedwoods, Green Alder on Mineral and Feathermoss**					**C4: Black Spruce Dominant with White Birch, Willow on Mineral**			**C8: Moist Black Spruce Dominant on Feathermoss and Mineral**	
Canopy Composition	Woodland to Sparsely treed, BS dom. often w/WB Canopy 10-16 m					Woodland to Sparsely treed, Dense BS dom, often w/WB Canopy 7-12 m			Sparsely treed to Woodland Less Dense BS dom., Canopy 8-13 m	
Tall Shrub Composition	Sparse to Dense GA, some W					W			Scarce W	
Understory Composition (Mean Abundance) <u>Indicator species</u>	(10) *Hylocomium splendens*, (10) *Pleurozium schreberi*, (10) *Vaccinium vitis-idaea*, (7) *Rhododendron groenlandicum*, (6) Moss spp, (3) *Picea mariana* seed					(12) *Rhododendron groenlandicum*, (11) *Cladina mitis*, (10) *Vaccinium vitis-idaea*, (9) *Cladonia* spp, (7) Moss spp, (6) *Pleurozium schreberi*			(14) *Pleurozium schreberi*, (13) *Vaccinium vitis-idaea*, (11) *Rhododendron groenlandicum*, (7) *Cladina rangiferina*, (7) *Cladina mitis*, (5) Moss spp	
Site Characteristics	Flat terrain & slopes Deep dry & moist mineral to feathermoss bogs, TOM = 12 w/LFH (1 cm)					Upper to Mid Slopes, crests & flat terrain Till deposits Fresh, deep dry to moist mineral, TOM = 14 w/LFH (1 cm)			Gentle Slopes & flat terrain Moist feathermoss bogs to deep dry mineral, TOM = 30, often Frost @ 41 cm ave.	
Typical Mapped Fine Ecosite Types	Deep dry mineral (74%), Veneer bog on slope (16%), Slope bog (6%)					Deep dry mineral (67%), Veneer bog on slope (17%)			Deep dry mineral (45%), Veneer bog on slope (40%)	
Typical Mapped Coarse Habitat Types, Descending Dominance	Black spruce treed on mineral soil, Black spruce treed on thin peatland, Broadleaf mixedwood on all ecosites					Black spruce treed on mineral soil, Black spruce treed in thin peatland, Black spruce treed on shallow peatland			Black spruce treed on mineral soil, Black spruce treed on thin peatland	
Fine Plot Habitat Type	**F10: Sparser BS Dominant and Mixedwoods Moist Mineral**	**F102: Denser BS Dominant and Mixedwoods Moist Mineral**	**F14: Large BS Dominant and Mixedwoods Mineral**	**F247: BS Mixedwood and Dominant on Moist Mineral and Shallow Peatland**	**F187: WB Mixedwood and Dominant on Mineral and Feathermoss**	**F4: Dense BS Dominant**	**F320: Dense BS Mixture**	**F460: BS Dominant and Mixedwood, WB and JP**	**F8: Larger BS Dominant with WB, Moist**	**F202: Smaller BS Dominant with TL, Frozen Peat**
Number of plots	*7*	*6*	*10*	*3*	*5*	*8*	*10*	*6*	*15*	*5*
Canopy Composition (CC = canopy closure)	Sparsely treed to Woodland Sparser BS dom., occ. WB Canopy 10-13 m CC 11 - 40 %	Woodland Dense BS, occ. WB Canopy 7-14 m CC 33 - 51 %	Sparsely treed to Forest BS dom, oft w/WB Canopy 14-17 m CC 25 - 60 %	Sparsely treed to Woodland BS oft w/denser WB, frequent TL Canopy 8-21 m CC 25 - 30 %	Woodland to Forest WB dom BS canopy, BS adv regen Canopy 11-18 m CC 40 - 75 %	V. dense BS Canopy 7-12 m CC 20 - 53 %	V dense BS mixture w/WB, oft w/TL Canopy 9-12 m CC 29 - 43 %	Sparsely treed Sm dia BS and WB, occ w/JP, BS saplings Canopy 8-11 m CC 14 - 25 %	Woodland to Sparsely treed BS dom occ w/WB Canopy 10-14 m CC 20 - 30 %	Sparsely treed BS dom occ w/TL Canopy 7-9 m CC 9 - 15 %
Tall Shrub Composition	Dense GA, often W	Usually GA, often SA	Often dense GA	W	Often GA, W	Often W	W	Abundant W	Occ Scattered W	Occ Scattered W
Understory Composition (Mean Abundance) <u>Indicator species</u>	(14) *Rhododendron groenlandicum*, (10) *Vaccinium vitis-idaea*, (9) *Pleurozium schreberi*, (7) Moss spp, (6) *Vaccinium uliginosum*, (5) *Rosa acicularis*	(13) *Pleurozium schreberi*, (12) *Vaccinium vitis-idaea*, (12) *Hylocomium splendens*, (8) *Cornus canadensis*, (7) *Rosa acicularis*, (7) *Geocaulon lividum*	(13) *Hylocomium splendens*, (12) *Pleurozium schreberi*, (10) *Vaccinium vitis-idaea*, (5) Moss spp, (4) *Picea mariana* seed, (3) *Rhododendron groenlandicum*, <u>BS25,20</u>, *Ptilium crista-castrensis*	(11) *Hylocomium splendens*, (10) *Equisetum sylvaticum*, (10) *Cornus canadensis*, (9) Moss spp, (8) *Vaccinium vitis-idaea*, (5) *Rhododendron groenlandicum, Ribes triste, Pyrola asarifolia*	(10) *Pleurozium schreberi*, (8) *Vaccinium vitis-idaea*, (7) *Hylocomium splendens*, (5) Moss spp, (5) *Rhododendron groenlandicum*, (4) *Picea mariana* seed, WB15&08	(13) *Vaccinium vitis-idaea*, (13) *Rhododendron groenlandicum*, (13) *Cladina mitis*, (9) *Pleurozium schreberi*, (7) Moss spp, (6) *Cladonia* spp	(11) *Cladonia* spp, (8) Moss spp, (8) *Rhododendron groenlandicum*, (8) *Cladina mitis*, (6) *Vaccinium vitis-idaea*, (6) *Pleurozium schreberi, Cladonia* spp.	(15) *Rhododendron groenlandicum*, (13) *Vaccinium vitis-idaea*, (12) *Cladina mitis*, (11) *Cladonia* spp, (5) Moss spp, (3) *Pleurozium schreberi*	(14) *Pleurozium schreberi*, (13) *Vaccinium vitis-idaea,* (10) *Rhododendron groenlandicum*, (9) *Cladina mitis*, (6) Moss spp, (6) *Hylocomium splendens*	(14) *Pleurozium schreberi*, (14) *Rhododendron groenlandicum*, (12) *Vaccinium vitis-idaea*, (12) *Cladina rangiferina*, (5) *Sphagnum* spp, (4) *Vaccinium oxycoccos, Empetrum nigrum*
Site Characteristics	Deep moist mineral, TOM = 10	Mod. Moist, Moist to deep dry mineral, TOM = 8, occasionally frost @ 44cm	V. Fresh deep dry mineral sites, TOM = 11, fibric dom.	Sloping V. Moist mineral, bog and fen, TOM = 32 fibric dom.	V. Fresh Deep dry mineral and feathermoss bogs, TOM = 11, mesic dom.	V. Fresh Upper slopes, crests & flat terrain TOM = 21	Fresh Upper slopes, crests & flat terrain TOM = 12 w/LFH (1cm)	Fresh Crests & upper slopes TOM = 7 w/LFH (1cm)	Sloping to Flat Mod. Moist Deep dry sandy/loamy mineral to feathermoss bog, TOM = 19	Flat to Sloping Wet Sphagnum & Feathermoss bogs, TOM = 63 Frost @ 38cm
Typical Mapped Fine Ecosite Types	Deep dry mineral	Deep dry mineral	Deep dry mineral, Veneer bog on slope	Deep dry mineral, Veneer bog, Slope bog	Deep dry mineral, Veneer bog on slope	Deep dry mineral, Veneer bog on slope	Deep dry mineral	Deep dry mineral, Veneer bog on slope	Deep dry mineral, Veneer bog on slope	Veneer bog on slope

Notes: TA = trembling aspen; BP = balsam poplar; WB = white birch; BS = black spruce; WS = white spruce; JP = jack pine; TL = tamarack; GA = green alder; SA = speckled alder; W = willow; BB = bog birch; SC = buffaloberry; RA = alder-leaved buckthorn; VE = low bush-cranberry; CS = red-osier dogwood. Tree abbreviations followed by a number represent the diameter class pseudospecies: seed = seedling; 00 = sapling; 08 = 0-9 cm; 15 = > 9-15 cm; 20 = > 15-20 cm; 25 = > 20 cm. TOM = thickness of organic material, and LFH = the folic organic layer.

Table 7-28: Characteristics of the Small Black Spruce Dominated Sphagnum and Feathermoss Bogs general site level habitat type (G16) and its subgroups in the Keeyask region

General Plot Habitat Type	**G16: Small Black Spruce Dominated Sphagnum and Feathermoss Bogs**					
Canopy Composition	Woodland & Sparsely treed Smaller BS dom. TL, Canopy 4-8 m					
Tall Shrub Composition	W, often BB, some SA					
Widespread Understory Composition (Mean Abundance)	(13) *Rhododendron groenlandicum*, (12) Moss spp, (9) *Vaccinium vitis-idaea*, (9) *Vaccinium uliginosum*, (9) *Cladina mitis*, (7) *Salix myrtillifolia*					
Site Characteristics	Flat terrain & Mid to Upper slopes, Sphagnum & Feathermoss bog to Deep dry, TOM = 33, 56% with frost					
Coarse Plot Habitat Type	**C16: Very Moist Black Spruce Dominant, Low Shrub on Sphagnum and Feathermoss**				**C44: Wet Black Spruce Dominant, Willow on Bogs and Fens**	
Canopy Composition	Sparsely treed to Woodland Sm. Dia. BS dom. Occ. TL Canopy 3-8 m				Woodland BS often w/TL, WB Canopy 6-14 m	
Tall Shrub Composition	Usually BB & W				Abundant W, scarce to Abund. SA, BB	
Understory Composition (Mean Abundance) Indicator species	(14) *Rhododendron groenlandicum*, (12) Moss spp, (11) *Vaccinium uliginosum*, (10) *Vaccinium vitis-idaea*, (10) *Cladina mitis*, (8) *Salix myrtillifolia*, *Arctostaphylos alpina*, *Equisetum scirpoides*				(12) *Rhododendron groenlandicum*, (11) Moss spp, (7) *Sphagnum* spp, (7) *Maianthemum trifolium*, (7) Equisetum arvense, (6) *Equisetum sylvaticum*, *Petasites frigidus var. sagittatus*	
Site Characteristics	Flat & Sloping terrain V. Moist sphagnum & feathermoss to mineral soils TOM = 28, often Frost @ 49 cm ave.				Flat terrain Wet Sphagnum bogs & fens TOM = 52, occasional Frost @ 38 cm, often Water table (26 cm)	
Typical Mapped Fine Ecosite Types	Veneer bog on slope (71%), Blanket bog (14%), Deep dry mineral (14%)				Veneer bog on slope (75%), Slope bog (13%), Slope fen (13%)	
Typical Mapped Coarse Habitat Types, Descending Dominance	Black spruce treed on thin peatland				Black spruce treed on thin peatland, Black spruce treed on shallow peatland, Black spruce mixedwood on shallow peatland	
Fine Plot Habitat Type	**F16: BS Dominant, TL, Bog Birch, Willow**	**F109: BS Dominant, TA, BP, Willow**	**F82: Small Regenerating BS Dominant**	**F151: Tamarack, Black Spruce Mixture on Moist Mineral**	**F44: BS Dominant, Shallow Water Table**	**F158: BS Dominant, Frozen**
Number of plots	*17*	*3*	*11*	*4*	*6*	*2*
Canopy Composition (CC = canopy closure)	Sparsely treed to Woodland Denser BS dom occ w/TL Canopy 5-8 m CC 10 - 35 %	Woodland to Sparsely treed BS dom Canopy 7-10 m CC 25 - 60 %	Sparsely treed, Low shrub & Bryoid BS dom. Occ. w/JP or TL Canopy 0-4 m CC 0 - 5 %	Woodland to Tall shrub TL or BS dom. Oft. w/TA Canopy 4-8 m CC 5 - 40 %	Woodland to Sparsely treed BS, occ. TL Canopy 6-11 m CC 10 - 36 %	Woodland Denser BS, occ TL, more WB Canopy 11-16 m CC 35 - 60 %
Tall Shrub Composition	Usually BB, W, occ GA	Often Dense W, w/GA, occ SC	W & BB	Often dense BB, W, occ SC	Dense W, oft dense BB & SA	W, oft. Dense SA, occ BB
Understory Composition (Mean Abundance) Indicator species	(14) *Rhododendron groenlandicum*, (12) *Vaccinium uliginosum*, (11) Moss spp, (10) Vaccinium vitis-idaea, (10) *Cladina mitis*, (8) *Salix myrtillifolia*	(14) *Vaccinium vitis-idaea*, (14) *Hylocomium splendens*, (11) *Rhododendron groenlandicum*, (9) Moss spp, (7) *Cladina mitis*, (5) *Salix myrtillifolia*	(15) *Rhododendron groenlandicum*, (13) Moss spp, (11) *Vaccinium uliginosum*, (10) *Cladina mitis*, (9) *Equisetum arvense*, (9) *Cladonia* spp, BSseed	(12) *Salix myrtillifolia*, (12) Moss spp, (11) *Vaccinium uliginosum*, (11) *Rhododendron groenlandicum*, (8) *Salix vestita*, (8) *Petasites frigidus* var *palmatus*	(13) *Rhododendron groenlandicum*, (9) *Sphagnum* spp, (8) *Equisetum arvense*, (7) *Maianthemum trifolium*, (7) *Equisetum sylvaticum*, (7) *Carex aquatilis*	(14) Moss spp, (10) *Rhododendron groenlandicum*, (6) *Hylocomium splendens*, (5) *Equisetum sylvaticum*, (5) *Cladonia* spp, (5) *Calamagrostis canadensis*
Site Characteristics	V. Moist Feathermoss, Sphagum & Mineral TOM = 29 65% Frozen (51 cm)	Moist Feathermoss bog & Mineral TOM = 21	V. Moist Sphagnum & Feathermoss bog, TOM = 36 64% Frozen (39 cm) Recently burned	Moist mineral, TOM = 11 50% Frozen (66 cm)	Wet Sphagnum bogs & fens, TOM = 55 Fibric/Mesic/Humic 83% Water table (26 cm)	Wet Feathermoss, & Sphagnum bogs TOM = 42, Frost @ 38 cm, Fibric/Mesic
Typical Mapped Fine Ecosite Types	Veneer bog on slope	Deep dry mineral, Veneer bog on slope	Veneer bog on slope, Blanket bog	Veneer bog on slope, Deep dry mineral	Veneer bog on slope, Slope fen	Veneer bog on slope, Slope bog

Notes: TA = trembling aspen; BP = balsam poplar; WB = white birch; BS = black spruce; WS = white spruce; JP = jack pine; TL = tamarack; GA = green alder; SA = speckled alder; W = willow; BB = bog birch; SC = buffaloberry; RA = alder-leaved buckthorn; VE = low bush-cranberry; CS = red-osier dogwood. Tree abbreviations followed by a number represent the diameter class pseudospecies: seed = seedling; 00 = sapling; 08 = 0-9 cm; 15 = > 9-15 cm; 20 = > 15-20 cm; 25 = > 20 cm. TOM = thickness of organic material, and LFH = the folic organic layer.

Table 7-29: Characteristics of the Sparse Black Spruce Dominated, Low Shrub and Reindeer Lichen Bogs general site level habitat type (G2) and its subgroups in the Keeyask region

General Plot Habitat Type	**G2: Sparse Black Spruce Dominated, Low Shrub and Reindeer Lichen Bogs**					
Canopy Composition	Sparsely treed Smaller BS dom. TL and untreed, Canopy 5-10 m					
Tall Shrub Composition	Scarce					
Widespread Understory Composition (Mean Abundance)	(14) *Rhododendron groenlandicum*, (11) *Vaccinium vitis-idaea*, (11) *Cladina mitis*, (8) *Sphagnum* spp, (8) *Rubus chamaemorus*, (7) Moss spp					
Site Characteristics	Flat terrain, some slopes, Mod. Wet, Sphagnum bog, TOM = 66, Usually w/Frost @ 37 cm					
Coarse Plot Habitat Type	**C2: Black Spruce Dominant, Low Shrub on Sphagnum Bog**		**C7: Sparse Black Spruce Dominant and Mixture on Sphagnum Bog**		**C36: Regenerating Black Spruce, Low Shrub on Sphagnum Bog**	
Canopy Composition	Sparsely treed to Woodland Sm. Dia. BS dom. Canopy 6-11 m		Sparsely Treed Sm. Dia. BS dom., often TL Canopy 6-10 m		Untreed to Sparsely treed Often sparse Sm. Dia. BS Canopy 0-5 m	
Tall Shrub Composition	Scarce		Occ. Sparse W, BB		Occ. Sparse BB	
Understory Composition (Mean Abundance) Indicator species	(14) *Rhododendron groenlandicum*, (12) *Cladina mitis*, (11) *Vaccinium vitis-idaea*, (11) *Rubus chamaemorus*, (9) *Cladina rangiferina*, (8) *Sphagnum* spp		(14) *Rhododendron groenlandicum*, (11) *Vaccinium vitis-idaea*, (11) *Cladina mitis*, (8) *Vaccinium uliginosum*, (8) *Sphagnum* spp, (7) *Vaccinium oxycoccos*		(14) *Rhododendron groenlandicum*, (11) *Rubus chamaemorus*, (9) *Cladina mitis*, (8) Moss spp, (7) *Vaccinium vitis-idaea*, (7) *Cladonia* spp	
Site Characteristics	Flat to gently sloping terrain Wet Sphagnum Bog, TOM = 63 cm 94% w/Frost (36 cm)		Flat to gently sloping terrain Wet Sphagnum Bog, TOM = 44 cm 79% w/Frost (34 cm)		Flat to gently sloping terrain Wet Sphagnum bog, TOM = 122 cm (67%) w/Frost (51 cm) 50% are recently burned	
Typical Mapped Fine Ecosite Types	Peat plateau bog (59%), Veneer bog on slope (18%), Blanket bog (9%)		Veneer bog on slope (74%), Veneer bog (12%)		Transitional peat plateau bog (40%), Peat plateau bog (27%), Veneer bog on slope (20%)	
Typical Mapped Coarse Habitat Types, Descending Dominance	Black spruce treed on shallow peatland, Black spruce treed on thin peatland		Black spruce treed on thin peatland, Black spruce treed on shallow peatland		Black spruce treed on shallow peatland, Low vegetation on shallow peatland, Young regeneration on shallow peatland	
Fine Plot Habitat Type	**G2: Denser BS**	**G11: Sparser BS, TL**	**G7: Flat Bog Birch**	**G39: Flat to Sloping W**	**G36: More treed**	**G80: Less treed**
Number of plots	*26*	*8*	*4*	*30*	*6*	*9*
Canopy Composition (CC = canopy closure)	Sparsely treed to Woodland Denser Sm dia BS Canopy 6-10 m CC 10 - 25 %	Sparsely treed to Woodland Sm dia BS, occ w/TL Canopy 8-14 m CC 10 - 15 %	Sparsely treed & Bryoid Canopy 6-12 m CC 5 - 14 %	Sparsely treed Somewhat denser BS and more TL Canopy 6-10 m CC 5 - 13 %	Bryoid & Sparsely treed Frequently treed, BS dom. Sm dia. Canopy 3-6 m CC 1 - 6 %	Untreed to Sparsely treed Sporadically treed, BS dom. Sm dia. Canopy 0-5 m CC 0 - 18 %
Tall Shrub Composition	Rarely sparse BB	Rarely scattered SA	BB, Often W	Often W	Often BB	Often sparser BB
Understory Composition (Mean Abundance) Indicator species	(14) *Rhododendron groenlandicum*, (13) *Cladina mitis*, (11) *Vaccinium vitis-idaea*, (11) *Rubus chamaemorus*, (8) *Cladina rangiferina*, (7) *Sphagnum* spp	(15) *Rhododendron groenlandicum*, (14) *Vaccinium vitis-idaea*, (11) *Sphagnum* spp, (11) *Rubus chamaemorus*, (11) *Cladina rangiferina*, (10) *Pleurozium schreberi*	(14) *Rhododendron groenlandicum*, (13) *Vaccinium uliginosum*, (13) *Cladina mitis*, (10) *Cladina rangiferina*, (9) *Vaccinium vitis-idaea*, (9) *Cladina stellaris*	(15) *Rhododendron groenlandicum*, (12) *Vaccinium vitis-idaea*, (11) *Cladina mitis*, (9) *Sphagnum* spp, (8) *Vaccinium uliginosum*, (7) *Vaccinium oxycoccos*	(12) *Rhododendron groenlandicum*, (12) *Cladina mitis*, (9) *Vaccinium oxycoccos*, (9) *Rubus chamaemorus*, (9) Moss spp, (8) *Chamaedaphne calyculata*	(15) *Rhododendron groenlandicum*, (12) *Rubus chamaemorus*, (9) *Vaccinium vitis-idaea*, (8) Moss spp, (6) *Picea mariana* seed, (3) *Vaccinium oxycoccos*
Site Characteristics	TOM = 66 frost (36 cm)	TOM = 53 88% frost (34 cm)	Flat TOM = 31 75% frost (34 cm)	Flat to mid slopes, TOM = 46 80% frost (34 cm)	Flat, wet sphagnum bogs, fibric dom TOM = 132, may be water table @ 25 cm 33% recently burned	Flat to gently sloped terrain Wet sphagnum bogs, Fibric/Mesic dom. TOM = 115, 89% frost (56 cm) 44% recently burned
Typical Mapped Fine Ecosite Types	Peat plateau bog	Peat plateau bog, Veneer bog on slope, Blanket bog	Veneer bog on slope, Veneer bog	Veneer bog on slope	Transitional peat plateau bog, Veneer bog on slope, Blanket bog, Horizontal fen	Peat plateau bog, Transitional peat plateau bog, Veneer bog on slope

Notes: TA = trembling aspen; BP = balsam poplar; WB = white birch; BS = black spruce; WS = white spruce; JP = jack pine; TL = tamarack; GA = green alder; SA = speckled alder; W = willow; BB = bog birch; SC = buffaloberry; RA = alder-leaved buckthorn; VE = low bush-cranberry; CS = red-osier dogwood. Tree abbreviations followed by a number represent the diameter class pseudospecies: seed = seedling; 00 = sapling; 08 = 0-9 cm; 15 = > 9-15 cm; 20 = > 15-20 cm; 25 = > 20 cm. TOM = thickness of organic material, and LFH = the folic organic layer.

Table 7-30: Characteristics of the Tall Shrub on Mineral and Peatlands general site level habitat type (G6) and its subgroups in the Keeyask region

General Plot Habitat Type	**G6: Tall Shrub on Mineral and Peatlands**						
Canopy Composition	Tall shrub and low shrub, Occasional Sm. Diam. BS, TL and/or WB, Canopy 0-2 m						
Tall Shrub Composition	Dense W, often BB and SA						
Widespread Understory Composition (Mean Abundance)	(8) Moss spp						
Site Characteristics	Flat terrain, V. Moist to Wet, Fens & some Deep dry, TOM = 80, 67% gleyed 57% with water table ave. 9 cm						
Coarse Plot Habitat Type	**C25: Willow and Bog Birch Mesic Fen and Mineral**				**C30: Willow and Low Shrub Fibric Fen**		
Canopy Composition	Tall Shrub Occasional sm. BS, TL and/or WB Canopy 0-2 m				Tall shrub, Low Shrub & Bryoid		
Tall Shrub Composition	Dense W, BB, SA				Usually Dense W		
Understory Composition (Mean Abundance) Indicator species	(8) Moss spp, (4) *Rhododendron groenlandicum*, *Calamagrostis* spp., Willow				(8) Moss spp, (5) *Potentilla palustris*, *Galium trifidum*		
Site Characteristics	Flat terrain V. Moist to Wet Fens, TOM = 57, Mesic dom., w/some LFH (1 cm) 52% w/shallow water table (9 m).				Flat terrain Wet Fens, TOM = 144 cm, Fibric/Mesic dom 50% w/shallow water table (8 cm).		
Typical Mapped Fine Ecosite Types	Riparian fen (43%), Veneer bog on slope (14%), Deep dry mineral (14%), Horizontal fen (10%), Blanket bog (10%)				Riparian fen (58%), Horizontal fen (17%)		
Typical Mapped Coarse Habitat Types, Descending Dominance	Tall shrub on riparian peatland, Tall shrub on mineral or thin peatland, Tall shrub on wet peatland, Tall shrub on shallow peatland				Low vegetation on riparian peatland, Tall shrub on riparian peatland, Low vegetation on wet peatland		
Fine Plot Habitat Type	**F25: Moist Willow, Bog Birch, Alder, Mesic**	**F32: Wet Bog Birch with Tamarack, Fibric**	**F45: Wet Willow Fen, Mesic**	**F243: Moist Willow Dominant, Marsh Reed Grass, Humic**	**F30: Dense Willow Fen**	**F41: Deep Wet Tall Shrub and Low Shrub Fen**	**F33: Low Vegetation Deep Fen**
Number of plots	*7*	*2*	*3*	*9*	*4*	*3*	*3*
Canopy Composition (CC = canopy closure)	Tall shrub Occ. Scattered BS, TL, WB, BP Canopy 0-2 m CC 0-30%	Tall Shrub Sparse TL Canopy 0-3 m CC 5%	Tall & Low shrub Occ sparse BS and/or scattered WB Canopy 0-6 m CC 0-3%	Tall shrub Occasional sm. scattered WB & BS Canopy 0-2 m CC 0-30%	Tall shrub & Low shrub Rarely sparse BS or WB	Bryoid & Low shrub Rarely sparse TL	Untreed Bryoid & Low shrub
Tall Shrub Composition	V dense W, Dense BB & SA	Dense BB often w/W	V dense W oft w/BB & SA	V. dense W, often dense SA, occ CS	V dense W	Sparse W, BB, GA	Rarely some scattered W
Understory Composition (Mean Abundance) Indicator species	(11) Moss spp, (9) *Rubus arcticus*, (9) *Carex aquatilis*, (6) *Rhododendron groenlandicum*, (5) *Sphagnum* spp, (4) *Maianthemum trifolium*	(14) Moss spp, (12) *Carex aquatilis*, (11) *Potentilla palustris*, (6) *Salix pedicellaris*, (4) *Vaccinium oxycoccos*, (4) *Rubus arcticus*	(11) *Sphagnum* spp, (8) *Carex* spp, (7) *Maianthemum trifolium*, (6) *Potentilla palustris*, (6) Moss spp, (5) *Rhododendron groenlandicum*	(10) *Calamagrostis canadensis*, (6) Moss spp	(11) Moss spp, (7) *Potentilla palustris*, (4) *Sphagnum* spp, (4) *Chamaedaphne calyculata*, (2) *Galium trifidum*	(9) *Salix pedicellaris*, (9) Moss spp, (10) *Potentilla palustris*	(6) Moss spp
Site Characteristics	Flat, some lower slopes V. Moist, TOM = 51, Mesic dom. 57% water table (9cm)	Wet Fens TOM = 98, Fibric dom. Water Table (8cm)	Wet Fens & Sphagnum Bogs TOM = 90, Mesic dom. 67% water Table (13cm)	Flat, some Lower slopes Moist mineral or fens, Humic dom. TOM = 43, 33% water table (9cm)	Wet Fen and Marsh TOM = 70, Mesic/Fibric dom. 50% water table (13cm)	Wet Fen TOM = 180, Fibric dom. Water table (3cm)	Wet Fen TOM = 206, Mesic/Fibric dom 33% water table (10cm), 66% frost (39cm)
Typical Mapped Fine Ecosite Types	Riparian fen, Veneer bog on slope	Riparian fen, Blanket bog	Riparian fen, Blanket bog	Riparian fen, Deep dry mineral, Horizontal fen	Riparian fen, Horizontal fen	Riparian fen, Horizontal fen	Riparian fen, Collapse scar fen

Notes: TA = trembling aspen; BP = balsam poplar; WB = white birch; BS = black spruce; WS = white spruce; JP = jack pine; TL = tamarack; GA = green alder; SA = speckled alder; W = willow; BB = bog birch; SC = buffaloberry; RA = alder-leaved buckthorn; VE = low bush-cranberry; CS = red-osier dogwood. Tree abbreviations followed by a number represent the diameter class pseudospecies: 08 = 0-9 cm; 15 = > 9-15 cm; 20 = > 15-20 cm; 25 = > 20 cm.

Table 7-31: Characteristics of the Sparsely Treed to Low Vegetation on Deep Wet Peatlands general site level habitat type (G3) and its subgroups in the Keeyask region

General Plot Habitat Type	G3: Sparsely Treed to Low Vegetation on Deep Wet Peatlands						
Canopy Composition	Untreed to Sparsely treed Sm. Dia. TL and/or BS, Canopy 0-3 m						
Tall Shrub Composition	Often Dense BB, some W						
Widespread Understory Composition (Mean Abundance)	(13) *Sphagnum* spp, (11) *Vaccinium oxycoccos*, (10) *Chamaedaphne calyculata*, (7) *Maianthemum trifolium*, (6) Moss spp						
Site Characteristics	Flat to sloping terrain, Deep wet Fens and Bogs, TOM = 180, Gleyed mineral with shallow water table (8 cm)						
Coarse Plot Habitat Type	**C3: Sparse Tamarack and Black Spruce, Bog Birch Fen**		**C9: Open, Wet Tamarack Dominant and Untreed, Bog Birch Fen**		**C18: Untreed, Deep Sphagnum Bog and Fen**		
Canopy Composition	Sparsely treed to Bryoid Sm. TL and BS Canopy 0-6 m		Bryoid to Sparsely treed Sm. TL dom w/BS Canopy 0-3 m		Bryoid & Low shrub Scarcely treed		
Tall Shrub Composition	Dense BB, often w/W		Dense BB, sparse W		Scarce		
Understory Composition (Mean Abundance) Indicator species	(13) *Sphagnum* spp, (12) *Chamaedaphne calyculata*, (10) *Vaccinium oxycoccos*, (10) *Maianthemum trifolium*, (9) *Equisetum fluviatile*, (8) Moss spp, *Salix pedicillaris*		(13) *Menyanthes trifoliata*, (11) *Andromeda polifolia*, (10) *Sphagnum* spp, (10) Moss spp, (9) *Vaccinium oxycoccos*, (7) *Equisetum fluviatile*, *Triglochin maritima*, *Eriophorum* spp.		(14) *Sphagnum* spp, (13) *Vaccinium oxycoccos*, (12) *Chamaedaphne calyculata*, (7) *Maianthemum trifolium*, (7) *Kalmia polifolia*		
Site Characteristics	Flat Wet Fens, TOM = 104, Fibric dom., 89% shallow water table (11 cm).		Flat Wet Fens, TOM = 218, Fibric dom. Water table (5 cm).		Flat bogs, some fens, Wet, TOM = 224, Fibric dom. Water table 7 cm.		
Typical Mapped Fine Ecosite Types	Horizontal fen (44%), Transitional PPB (22%), Peat plateau bog (11%)		Riparian fen (36%), Horizontal fen (36%), Transitional PPB (27%)		Collapse scar bog (32%), Transitional PPB (32%), Horizontal fen (18%), Collapse scar fen (9%)		
Typical Mapped Coarse Habitat Types, Descending Dominance	Low vegetation on wet peatland, Tamarack-black spruce mixture on wet peatland, Tamarack treed on wet peatland		Low vegetation on wet peatland, Tamarack treed on wet peatland and on riparian peatland, Black spruce treed on riparian peatland, Low vegetation on riparian peatland		Low vegetation on wet peatland		
Fine Plot Habitat Type	**F3: Drier BS Dominant, TL Mixture**	**F282: Wetter TL Dominant, BS Mixture**	**F9: Sparse TL Fen with BS**	**F47: Sparse TL Fen, Tall Shrub**	**F18: Low Shrub Bog**	**F57: Low Shrub Bog or Fen Scattered Trees**	**F312: Bryoid and Sedge Fen**
Number of plots	*8*	*10*	*4*	*6*	*15*	*4*	*3*
Canopy Composition (CC = canopy closure)	Sparsely treed to Bryoid BS dom w/TL Canopy 0-6 m CC 0-13%	Sparsely treed to Shrub & Bryoid TL dom w/BS Canopy 2-5 m CC 3-18%	Sparse Sm dia. TL, oft BS Canopy 1-2 m CC 0-6%	Sparsely treed to Bryoid Small dia. TL dom. Canopy 0-5 m CC 0-6%	Bryoid & Low shrub Rarely scattered small BS and/or TL	Often w/scattered small BS occ TL	Untreed
Tall Shrub Composition	Abundant BB, oft w/W	Dense BB w/W	BB	V dense BB w/W	None	None	Occ BB, W
Understory Composition (Mean Abundance) Indicator species	(14) *Sphagnum* spp, (13) *Chamaedaphne calyculata*, (11) *Vaccinium oxycoccos*, (10) Moss spp, (9) *Equisetum fluviatile*, (8) *Maianthemum trifolium*	(13) *Sphagnum* spp, (11) *Maianthemum trifolium*, (11) *Chamaedaphne calyculata*, (9) *Vaccinium oxycoccos*, (9) *Equisetum fluviatile*, (7) *Salix pedicellaris*	(14) *Andromeda polifolia*, (11) *Menyanthes trifoliata*, (8) *Trichophorum alpinum*, (8) *Carex* spp, (6) *Chamaedaphne calyculata*, (5) *Maianthemum trifolium*, *Drosera anglica*, *Triglochin maritima*	(14) *Menyanthes trifoliata*, (12) *Sphagnum* spp, (10) Moss spp, (10) *Andromeda polifolia*, (8) *Vaccinium oxycoccos*, (8) *Salix pedicellaris*	(15) *Sphagnum* spp, (14) *Vaccinium oxycoccos*, (13) *Chamaedaphne calyculata*, (7) *Maianthemum trifolium*, (7) *Kalmia polifolia*, (6) *Drosera rotundifolia*	(15) *Sphagnum* spp, (15) *Chamaedaphne calyculata*, (14) *Vaccinium oxycoccos*, (12) *Kalmia polifolia*, (8) *Eriophorum vaginatum*, (7) *Rubus chamaemorus*, *Sheuchzeria palustris*	(11) *Sphagnum* spp, (6) *Vaccinium oxycoccos*, (6) *Maianthemum trifolium*, (6) *Carex magellanica*, (5) Moss spp, (5) *Rhododendron groenlandicum*
Site Characteristics	Sphagnum Bog and Fen TOM = 104	Fen & Sphagnum Bog TOM = 104	TOM = 274 Water table (9 cm) 50% Frost (17 cm)	TOM = 186 Water table (3 cm)	Sphagnum bogs, TOM = 224 Water tabe (9 cm)	Sphagnum bog or Fen TOM = 281 Water table (8 cm)	Fens TOM = 144 Water table (5 cm)
Typical Mapped Fine Ecosite Types	Transitional peat plateau bog, Collapse scar fen, Flat bog, Horizontal fen, Riparian fen, Peat plateau bog	Horizontal fen	Horizontal fen, Riparian fen, Transitional peat plateau bog	Riparian fen, Horizontal fen	Collapse scar bog, Transitional peat plateau bog, Collapse scar fen, Horizontal fen	Transitional peat plateau bog, Collapse scar bog, Horizontal fen	Blanket bog, Transitional peat plateau bog, Horizontal fen

Notes: TA = trembling aspen; BP = balsam poplar; WB = white birch; BS = black spruce; WS = white spruce; JP = jack pine; TL = tamarack; GA = green alder; SA = speckled alder; W = willow; BB = bog birch; SC = buffaloberry; RA = alder-leaved buckthorn; VE = low bush-cranberry; CS = red-osier dogwood. Tree abbreviations followed by a number represent the diameter class pseudospecies: 08 = 0-9 cm; 15 = > 9-15 cm; 20 = > 15-20 cm; 25 = > 20 cm.

7.3.3 Shoreline Wetlands

A total of 262 shore zone locations were sampled in the Regional Study Area and Limestone reservoir during the summers of 2003 to 2006 (Map 7-2). Included in this total were 68 locations in four off-system lakes and along the Fox River during the summers of 2005 and 2006 and 59 locations were sampled in eight off-system muskrat ponds in 2006. On the Nelson River, 57 locations were sampled in Gull Lake and Stephens Lake, nine were sampled in the Long Spruce reservoir, and 69 locations were sampled in the Limestone reservoir (Table 7-3).

7.3.3.1 Substrates

Of the 262 shore zone locations, 134 were utilized for the substrate analysis (muskrat pond locations did not include comparable substrate data, and were dropped for this analysis). Locations downstream of the Long Spruce GS were also dropped because there were no off-system waterbodies sampled in that region, and retaining them would potentially bias the substrate results. In total, 66 Nelson River locations and 68 off-system locations were retained for substrate analysis.

7.3.3.1.1 Nelson River

Gull Lake

Five shore zone substrate classes were identified in the Keeyask Regional Study Area. These were used to broadly describe the overall substrate composition of each replicate location in the Gull Lake study area of the Nelson River. The most frequent substrates were organic dominated mixtures and mineral dominated mixtures, occurring at 35% and 32% of the replicate locations, respectively (Table 7-32). Organic, fine mineral and coarse mineral substrate types were substantially less frequent.

Mineral mixtures were most frequent at locations along the south shore of Gull Lake, but were also found at scattered locations along the north bank of the Nelson River (Map 7-3). Organic mineral mixtures were distributed throughout the Gull Lake study area, while organic substrates were generally confined to the sheltered bays of Gull Lake. Fine substrates were scattered among three locations in Gull Lake.

Table 7-32: Distribution of the five substrate classes among the shore zone replicate locations sampled in the Nelson River study areas and off-system waterbodies as a percentage of total number of replicates

Substrate	Nelson River Zone			Off-System
	Keeyask	Stephens	Total	
Organic	18	56	36	47
Organic dominated mixture	35	38	36	44
Mineral dominated mixture	32	6	20	7
Fine mineral	12	-	6	1
Coarse mineral	3	-	2	-
Total replicates	*34*	*32*	*66*	*68*

Notes: Cells with "-" values indicate an absense.

Stephens Lake

Substrates at the replicate locations sampled in the Stephens Lake study area were distinctive from the Gull Lake study area. Three substrate classes described the locations in that area, the most frequent of these by far was organic substrates (56%), followed by organic dominated mixtures (Table 7-32). Mineral mixtures were also present at a couple of locations.

Organic substrates were distributed among locations throughout the Stephens Lake study area (Map 7-3). The organic dominated mixtures tended to be distributed at the southwest extent of Stephens Lake, and in the Long Spruce reservoir. Mineral dominated mixtures were found only at two locations on an island and peninsula in the central portion of the lake.

7.3.3.1.2 Off-System Waterbodies

Organic and organic dominated mixtures were the most frequent substrates in the off-system waterbodies, occurring at 47% and 44% of the replicate locations, respectively (Table 7-32), and distributed across all sampled off-system waterbodies (Map 7-3). Mineral dominated mixtures occurred at a few off-system locations, but were relatively uncommon, and occurred only at a few locations on Cyril Lake, and on the Fox River.

7.3.3.2 Plant Species

There were a total of 221 plant species recorded in the shore zone. Using the most conservative estimate of species distribution (only those species occurring within at least three quadrats in both transects within a location), only two species were found in greater than 30% of the sample locations. These included Labrador-tea and marsh reed grass. For the results that follow, the estimation based on species which occurred in at least one quadrat in both transects was retained because the substrate in some transects was steep and depths increased rapidly over short distances.

No taxa were widespread or very widespread in the shoreline wetland transects. Marsh reed-grass, Labrador tea, common horsetail, moss species, water sedge and rock cranberry were the only species that were scattered (Table 7-33). The 169 localized taxa included 160 vascular plants, four bryophytes and five lichens. Black spruce, flat-leaved willow and fireweed were the most common localized species.

No taxa were widespread or very widespread in the off-system transects, or the on-system transects. Marsh reed-grass and Labrador tea were scattered in both the on- and off-system transects (Table 7-34). Water sedge, speckled alder and leather-leaf were also scattered in the off-system transects. Common horsetail, black spruce tree, flat-leaved willow and rock cranberry were scattered in on-system transects.

Labrador tea, moss species and black spruce were widespread in wetland transects sampled in the Long Spruce reservoir (Table 7-35). Bog bilberry was widespread in transects sampled on Stephens lake. Labrador tea was also scattered in all other regions. Twenty-nine species were scattered in at least one of the four study regions (Keeyask, Stephens, Long Spruce and Limestone). Flat-leaved willow, marsh reed-grass and water sedge were scattered in all but the Limestone area. Rock cranberry was scattered in all but the Keeyask area and common horsetail was scattered in all but the Long Spruce Study Area. Fifteen species were scattered in the Long Spruce transects, while only seven were scattered in the Keeyask transects.

No taxa were widespread or very widespread on any of the substrate classes. Seventeen taxa were scattered in one or more of the substrate classes (Table 7-36). Labrador tea, marsh reed-grass, water sedge and flat-leaved willow were the most common species found on organic substrates. Labrador tea, common horsetail and moss species were the most common on organic-mineral substrates, whereas marsh reed-grass, common horsetail and moss species were the most common on fine-coarse mineral substrates. Labrador tea, common horsetail, moss species and rock cranberry were common on fine mineral substrates. Thirteen of the seventeen taxa were scattered on organic plots, more species than any other substrate type

Table 7-33: Distribution of scattered understorey species in Regional Study Area wetland transects

Species	Percent of Locations
Calamagrostis canadensis	43
Carex aquatilis	31
Equisetum arvense	32
Rhododendron groenlandicum	40
Moss spp	32
Vaccinium vitis-idaea	26

Table 7-34: Distribution of scattered understorey species in off-system versus Nelson River Regional Study Area wetland transects

Species	Off-System	Nelson River
	Percent of Locations	Percent of Locations
Alnus incana ssp. rugosa	36	-
Calamagrostis canadensis	58	28
Carex aquatilis	43	-
Chamaedaphne calyculata	27	-
Equisetum arvense	-	41
Rhododendron groenlandicum	32	47
Moss spp	36	28
Picea mariana tree	-	26
Salix planifolia	-	26
Vaccinium vitis-idaea	-	39

Notes: Cells with "-" value indicate the species does not qualify for category.

Table 7-35: Distribution of widespread and scattered understorey species in Nelson River wetland transects by study area

Species	Keeyask	Stephens Lake	Long Spruce Reservoir	Limestone Reservoir
	Percent of Locations	Percent of Locations	Percent of Locations	Percent of Locations
Widespread				
Rhododendron groenlandicum	-	-	89	-
Moss spp	-	-	78	-
Picea mariana tree	-	-	78	-
Vaccinium uliginosum	-	78	-	-
Scattered				
Alnus incana ssp. rugosa	29	-	-	-
Alnus viridis ssp. crispa	-	-	-	32
Calamagrostis canadensis	57	48	67	-
Carex aquatilis	39	57	67	-
Carex canescens	-	-	33	-
Carex chordorrhiza	-	-	33	-
Carex diandra	-	-	44	-
Carex gynocrates	-	35	-	-
Carex magellanica	-	-	56	-
Chamaedaphne calyculata	-	-	44	-
Cladina mitis	-	-	67	-
Cladina rangiferina	-	-	33	-
Chamerion angustifolium	-	-	-	46
Comarum palustris	-	48	56	-
Equisetum arvense	28	52	-	38
Galium trifidum	-	48	-	-
Hylocomium splendens	-	-	-	39
Rhododendron groenlandicum	28	70	-	52
Moss spp	29	-	-	45
Myrica gale	-	30	-	-
Picea mariana sapl	-	-	56	-
Picea mariana seed	-	-	44	-
Picea mariana tree	-	30	-	28
Pleurozium schreberi	-	26	-	-

Rubus arcticus	-	30	-	-
Rubus chamaemorus	-	-	44	-
Salix myrtillifolia	-	57	-	-
Salix planifolia	27	65	44	-
Vaccinium vitis-idaea	29	26	56	57

Notes: Cells with "-" value indicate the species does not qualify for category.

Table 7-36: Distribution of scattered understorey species in Nelson River wetland transects by substrate type

Species	Organic	Organic Dominated Mixture	Fine Mineral	Fine-Coarse Mineral Mixture
	Percent of Locations	Percent of Locations	Percent of Locations	Percent of Locations
Argentina anserina	-	-	-	27
Calamagrostis canadensis	52	41	-	45
Carex aquatilis	51	-	-	-
Carex utriculata	30	-	-	-
Chamaedaphne calyculata	33	-	-	-
Chamerion angustifolium	-	34	32	-
Comarum palustris	40	-	-	-
Cornus canadensis	-	-	-	27
Equisetum arvense	27	51	37	52
Galium trifidum	27	-	-	-
Hylocomium splendens	-	25	-	-
Rhododendron groenlandicum	62	53	37	36
Moss spp	33	47	37	45
Picea mariana tree	35	29	26	-
Salix planifolia	46	28	-	-
Vaccinium uliginosum	32	-	-	-
Vaccinium vitis-idaea	30	38	37	30

Notes: Cells with "-" value indicate the species does not qualify for category.

Table 7-37: Composition of vegetation bands in water duration zones (*i.e.*, vegetation sequences) on mineral or organic substrates.

Water Duration Zone	**Core Vegetation Sequence** (Species most commonly observed in all conditions)	**Species More Common and/ or Abundant In Shore Zone Habitat Type Relative to the Core Vegetation Sequence** (*i.e.*, each vegetation sequence includes the species from the core vegetation sequence plus species modifications listed)			
		Nelson River	**Keeyask**	**Stephen's Lake**	**Off-System**
Lower Beach	water horsetail *(Equisetum fluviatile)*	Mineral Substrates: water horsetail *(Equisetum fluviatile),* bottle sedge *(Carex utriculata*), water smartweed *(Persicaria amphibia)*	Mineral Substrates: water horsetail *(Equisetum fluviatile)*, bottle sedge *(Carex utriculata)*, Water smartweed *(Persicaria amphibia)*	N/A	Mineral Substrates: various-leaved pondweed *(Potamogeton gramineus)*, viscid great-bulrush *(Schoenoplectus tabernaemontani*), creeping spike-rush *(Eleocharis palustris)*, water horsetail *(Equisetum fluviatile)* Organic Substrates: spiked water-milfoil *(Myriophyllum sibiricum),* Richardson's pondweed *(Potamogeton richardsonii),* narrow-leaved bur-reed *(Sparganium angustifolium*), needle spike-rush *(Eleocharis acicularis*), small yellow pond-lily *(Nuphar variegata*)
Upper Beach	water sedge *(Carex aquatilis*), reed-grass *(Calamagrostis* spp*)*	Mineral Substrates: sweet gale *(Myrica gale),* bog bilberry *(Vaccinium uliginosum)* Organic Substrates: water sedge *(Carex aquatilis)*	Organic Substrates: small bedstraw *(Galium trifidum*), smartweed *(Persicaria spp),* creeping spike-rush *(Eleocharis palustris)*	Mineral Substrates: sweet gale *(Myrica gale*), bog bilberry (*Vaccinium uliginosum)* Organic Substrates: flat-leaved willow *(Salix planifolia*), water sedge	Organic Substrates: bog sedge *(Carex magellanica),* water sedge *(Carex aquatilis),* leather-leaf *(Chamaedaphne calyculata),* marsh reed-grass *(Calamagrostis canadensis)*

Water Duration Zone	**Core Vegetation Sequence** (Species most commonly observed in all conditions)	**Species More Common and/ or Abundant In Shore Zone Habitat Type Relative to the Core Vegetation Sequence** (*i.e.*, each vegetation sequence includes the species from the core vegetation sequence plus species modifications listed)			
		Nelson River	**Keeyask**	**Stephen's Lake**	**Off-System**
				(Carex aquatilis)	
Inland Edge	black spruce *(Picea mariana),* willows *(Salix* spp*),* Labrador tea *(Rhododendron groenlandicum*), marsh reed-grass (*Calamagrostis canadensis*)	Mineral Substrates: black spruce (*Picea mariana*), green alder *(Alnus viridis ssp. crispa*), fireweed (*Chamerion angustifolium*) Organic Substrates: flat-leaved willow (*Salix planifolia*),myrtle-leaved willow *(Salix myrtillifolia),* bog bilberry *(Vaccinium uliginosum)*	Mineral Substrates: black spruce (*Picea mariana*), green alder *(Alnus viridis ssp. crispa),* prickly rose *(Rosa acicularis),* rock cranberry *(Vaccinium vitis-idaea*) Organic Substrates: flat-leaved willow *(Salix planifolia)*, bog bilberry *(Vaccinium uliginosum),* marsh reed-grass *(Calamagrostis canadensis)*	Mineral Substrates: black spruce *(Picea mariana),* green alder *(Alnus viridis ssp. crispa*), prickly rose *(Rosa acicularis*), rock cranberry *(Vaccinium vitis-idaea)* Organic Substrates: leather-leaf *(Chamaedaphne calyculata)*, Labrador tea *(Rhododendron groenlandicum*), water sedge (*Carex aquatilis*)	Mineral Substrates: fireweed *(Chamerion angustifolium)* Organic Substrates: Bebb's willow *(Salix bebbiana*), leather-leaf *(Chamaedaphne calyculata),* peat mosses (*Sphagnum* spp*)*

Note: N/A = Either no specific association found, or insufficient data available for the area/zone.

7.3.3.3 Habitat Classification

7.3.3.3.1 Species to Retain

After assessing the number of species remaining while increasing the cut-off level from zero to 13 (5%) of the 261 transects, the candidate cut-off levels for the number of transects a species must be in to be retained for analysis included species occurring in fewer than three, and fewer than four transects. A total of 253 species were recorded among the locations sampled. At the fewer than three transects cut-off, 88 species were removed leaving 165 species. At the fewer than four transects cut-off, 111 species were removed leaving 142 species. At higher cut-off levels it was judged that there was a higher risk of removing species that were important for capturing the range of ecological gradients present in the overall dataset.

7.3.3.3.2 Cluster Analysis Results

It was determined from preliminary examination of the Ward's cluster analysis dendrograms and indicator species analysis results for the two candidate cut-off levels, that dropping species in fewer than four transects produced the most ecologically interpretable cluster results and the most distinctive vegetation groups. Therefore, this cutoff was used for the remaining analyses.

Interpretation of the cluster dendrogram and indicator species analysis of species from the 7,337 quadrats sampled along transects at 134 Nelson River shore zone locations resulted in the selection of the 15 group solution as a candidate for shore zone habitat types (Figure 7-13). The same analysis of the 12,654 quadrats sampled along transects at 127 off-system locations resulted in the selection of the 21 group solution as a candidate for shore zone habitat types (Figure 7-14). Five groups from the off-system candidate solution were ultimately dropped from further analysis. Three of these, O4416, O3862 and O4443 were represented by a very low number of quadrats (<10 each). The other two groups, O10151 and O7475, were dropped because they corresponded with locations that were missing transect depth data.

Analysis of substrate type and standardized transect depth data indicated that some shore zone habitat types for both Nelson River and off-system locations were distinguishable with respect to standardized transect depth and substrate characteristics (Table 7-38). Based on ecological interpretation of vegetation composition and standardized water depths, the Nelson River and off-system shore zone habitat types were assigned to one of three general water depth duration zone groups. These include an inland edge/upper beach group, a lower beach group, and a shallow water group.

Comparing the Nelson River and off-system wetlands revealed that more than half of all habitat types occurred only in one of the two zones. That indicates that habitat within the three water depth duration zones were often different in species composition when comparing Nelson River to the off-system (Table 7-38). However, seven of the 15 Nelson River types were compositionally similar to types in the off-system, and were subsequently lumped into single shared habitat types.

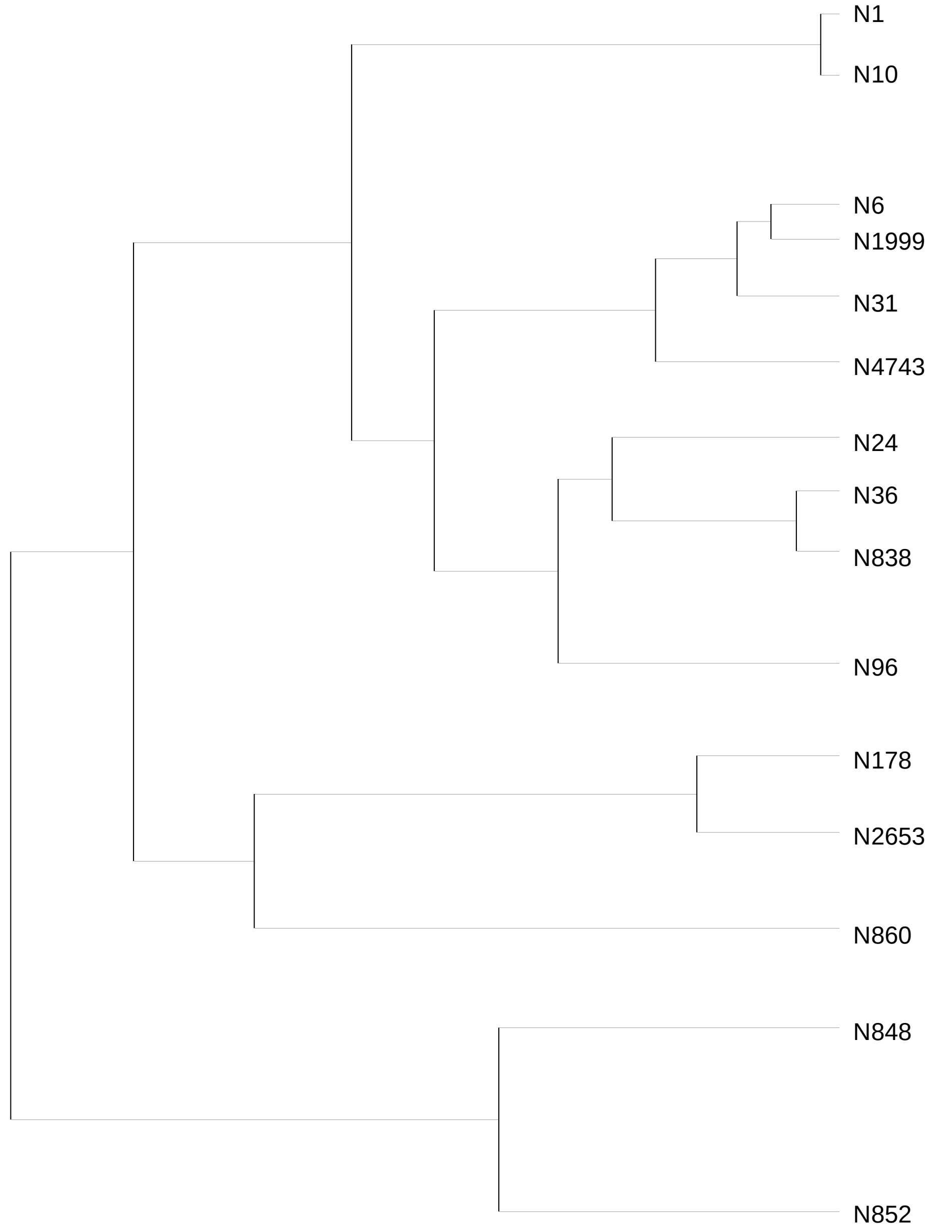


Figure 7-13: Ward's cluster dendrogram of species from the 134 Nelson River shore zone locations

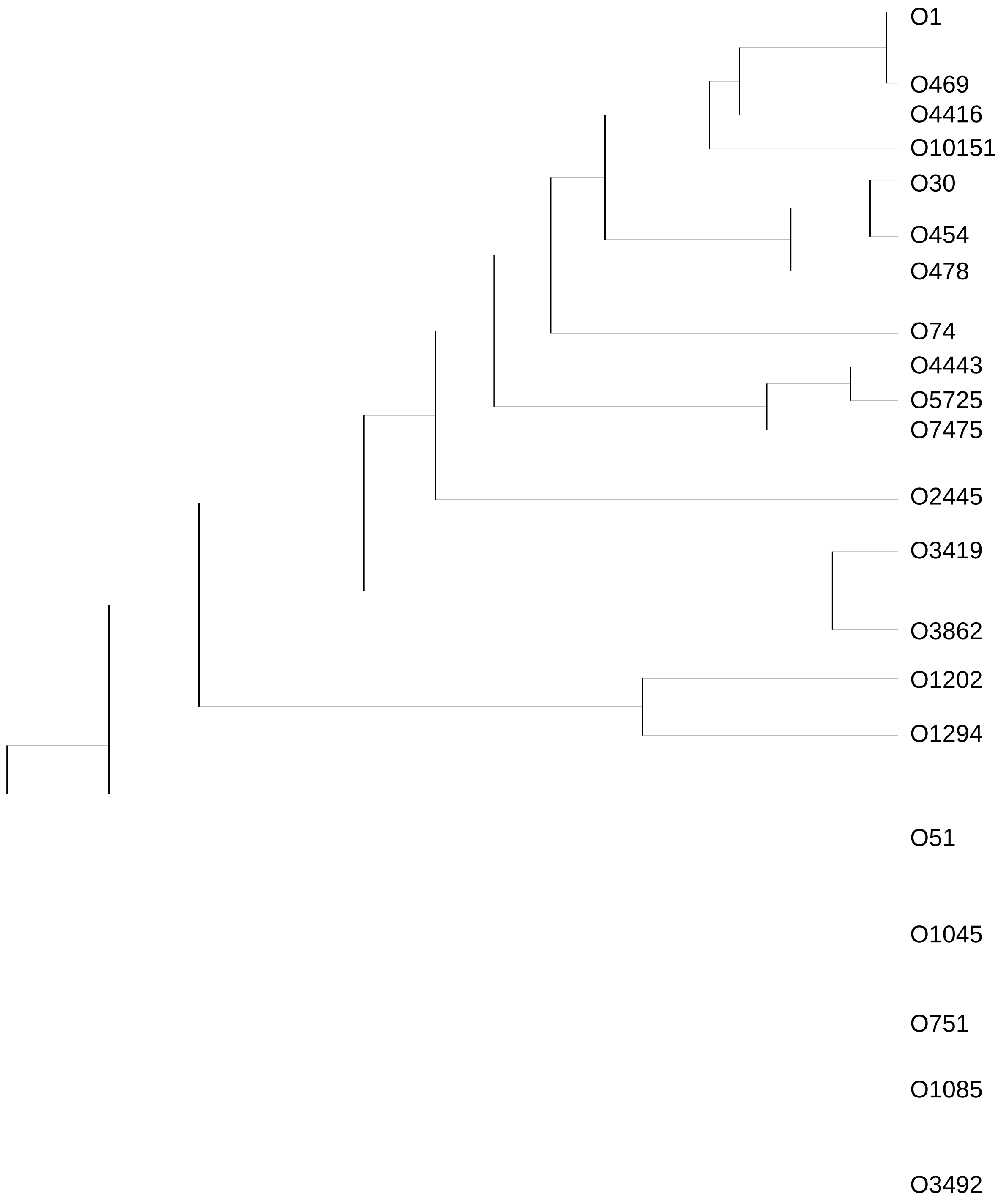


Figure 7-14: Ward's cluster dendrogram of species from the 127 off-system shore zone locations

Table 7-38: Characteristics of the 15 Nelson River and 16 off-system shore zone habitat types

Water Depth Duration Zone	Shore Zone Habitat Type	Group ID	Indicator Species	Plant Species With Highest Quadrat Occurrence (descending order)	Depth Range (waterline; off-system)		% Slope Off-system	Depth Range (inland edge; Nelson R.)		% Slope Nelson R.	Substrate	Number Quadrats	Number of Locations			
					Range	Median	Mean (St. dev.)	Range	Median	Mean (St. dev.)			Off-system	Keeyask	Stephens Lake	All
Shallow Water	Creeping Spike-Rush	O1045	*Eleocharis palustris*, *Myriophyllum sibiricum*	*Eleocharis palustris* (98%), *Myriophyllum sibiricum*, *Carex utriculata*	22 to 56 cm	41	2 (3.0)	-	-	-	Organic, fine mineral	832	13			13
	Water Horsetail	O1294, N1999	*Equisetum fluviatile*, *Sparganium angustifolium*, *Nuphar variegata*	*Equisetum fluviatile* (96%), *Sparganium angustifolium*, *Nuphar variegata*	32 to 62 cm	50	2 (2.6)	7 to 26 cm	16	0 (1.3)	Organic, fine mineral and mixtures (O1294); Fine mineral (N1999)	767	15	5	1	21
	Small Yellow Pond-Lily	O1202	*Nuphar variegata*	*Nuphar variegata* (100%)	26 to 87 cm	67	2 (1.7)	-	-	-	Organic, fine mineral	454	16			16
	Viscid Great-Bulrush	O74	*Schoenoplectus tabernaemontani*	*Schoenoplectus tabernaemontani* (100%)	61 to 74 cm	67	1 (2.3	-	-	-	Fine mineral	487	21			21
Lower Beach	Bottle Sedge/Bladderwort	O51	*Carex utriculata, Utricularia* spp	*Carex utriculata* (96%), *Utricularia* spp, *Calamagrostis canadensis*, *Equisetum fluviatile*	-19 to 9 cm	-10	4 (8.1)	-	-	-	Organic	1,091	34			34
	Green Reindeer Lichen/Bladderwort	O2445	*Cladina mitis, Utricularia* spp	*Cladina mitis* (81%), *Utricularia* spp	-1 to 1 cm	0	38 (181.2)	-	-	-	Organic	769	34			34
	Marsh-Five-Finger/Sedge	O1085, N2653	*Potentilla palustris, Carex diandra, Carex utriculata, Carex aquatilis* (21), *Equisetum fluviatile, Eleocharis palustris*	*Potentilla palustris* (98%), *Carex utriculata* (98%), *Carex aquatilis* (85%), *Equisetum fluviatile, Eleocharis palustris, Carex diandra* Moss spp	-3 to 3 cm	-1	1 (7.6)	2 to 21 cm	7	3 (4.2)	Organic	463	8	3	16	27
	Sedge/Alpine Cotton-Grass/Water Horsetail	O5725	*Carex leptalea, Trichophorum alpinum*, Moss spp, *Equisetum fluviatile, Carex magellanica* (31), *Carex aquatilis*	*Carex aquatilis* (100%), *Carex leptalea* (100%), *Equisetum fluviatile* (100%), *Trichophorum alpinum* (100%) Moss spp (100%), *Carex magellanica* (99%), *Betula pumila* (10%)	-29 to 69 cm	40	2 (4.0)	-	-	-	Organic	270	1			1
	Small Bedstraw/Creeping Spike-Rush/Water Smartweed	N848	*Eleocharis palustris, Galium trifidum, Bidens cernua, Persicaria amphibian, Sium suave, Eleocharis* spp	*Galium trifidum* (48%), *Eleocharis palustris, Persicaria amphibian, Carex aquatilis, Sium suave, Bidens cernua, Eleocharis* spp	-	-	-	8 to 39 cm	15	0 (3.4)	Organic	877		24	12	36
Inland Edge/Upper Beach	Black spruce/Rock Cranberry/Feathermoss	N1	*Vaccinium vitis-idaea, Hylocomium splendens* (32), *Rhododendron groenlandicum, Pleurozium schreberi, Cladina mitis, Cladina rangiferina, Geocaulon lividum, Picea mariana* tree	*Vaccinium vitis-idaea* (74%), *Rhododendron groenlandicum, Hylocomium splendens, Picea mariana* tree, *Pleurozium schreberi, Cladina mitis, Geocaulon lividum,* Moss spp, *Picea mariana* sapling, *Alnus viridis* ssp. *crispa, Cladina rangiferina, Picea mariana* seedling, *Cornus canadensis*	-	-	-	-272 to -60 cm	-149	41 (39.1)	Organic, fine mineral	782		21	68	89
	Black spruce/Willow	N6		*Picea mariana* tree (25%), *Salix bebbiana, Rosa acicularis, Cornus Canadensis, Alnus viridis* ssp. *crispa, Salix arbusculoides, Chamerion angustifolium, Salix pellita*	-	-	-	-124 to 3 cm	-48	30 (43)	Organic or fine mineral	790		2	18	20

Water Depth Duration Zone	Shore Zone Habitat Type	Group ID	Indicator Species	Plant Species With Highest Quadrat Occurrence (descending order)	Depth Range (waterline; off-system)		% Slope Off-system	Depth Range (inland edge; Nelson R.)		% Slope Nelson R.	Substrate	Number Quadrats	Number of Locations			
					Range	Median	Mean (St. dev.)	Range	Median	Mean (St. dev.)			Off-system	Keeyask	Stephens Lake	All
	Green Alder/Stair-step moss	N10	*Alnus viridis* ssp. *crispa*, *Hylocomium splendens* (16)	*Alnus viridis* ssp. *crispa* (99%), *Hylocomium splendens, Vaccinium vitis-idaea, Rhododendron groenlandicum*	-	-	-	-159 to 8 cm	-49	42 (29.8)	Organic, fine mineral	129		4	45	49
	Fireweed	N31	*Chamerion angustifolium*, Moss spp, *Rubus idaeus*	*Chamerion angustifolium* (63%), Moss spp, *Equisetum arvense, Alnus viridis* ssp. *crispa, Rubus idaeus, Linnaea borealis*	-	-	-	-298 to -42 cm	-108	46 (37.4)	Organic, fine mineral	469		3	48	51
	Bog Bilberry/Sweet Gale	N838	*Myrica gale, Vaccinium uliginosum*	*Vaccinium uliginosum* (70%), *Carex aquatilis, Myrica gale, Salix planifolia*	-	-	-	-1 to 29 cm	7	2 (5.7)	Fine to coarse mineral, organic	362		1	20	21
	Speckled Alder/White Birch	O469	*Alnus incana* ssp. *rugosa*, *Betula papyrifera* tree	*Alnus incana* ssp. *rugosa* (86%), *Calamagrostis canadensis, Equisetum arvense, Betula papyrifera* tree, *Salix bebbiana,* Moss spp, *Myrica gale*	-99 to -32 cm	-60	28 (37.2)	-	-	-	Organic	343	42			42
	Labrador Tea/Black Spruce	O1, N36	*Rhododendron groenlandicum*	Moss spp (24%), *Rhododendron groenlandicum, Picea mariana* tree, *Chamerion angustifolium, Equisetum arvense, Calamagrostis canadensis*, *Carex aquatilis, Chamadaphne calyculata, Myrica gale*	-93 to -22 cm	-58	17 (29.4)	-52 to -1 cm	-19	19 (28.9)	Organic	1,919	100	2	71	173
	Flat-Leaved Willow/Marsh Reed Grass	O454, N96, N860	*Salix planifolia, Calamagrostis canadensis*	*Salix planifolia* (96%), *Calamagrostis canadensis* (60%), *Sphagnum* spp, *Equisetum arvense*, *Maianthemum trifolium*, *Carex aquatilis,* Moss spp, *Betula papyrifera* tree, *Alnus incana* ssp. *rugosa*	-86 to -48 cm	-68	15 (22.6)	-55 to -2 cm (N96) -12 to 25 cm (N860)	-14 (N96) 0 (N860)	4 (12.9) N96 4 (11.1) N860	Organic	408	24	23	35	82
	Common Horsetail	N24	*Equisetum arvense*	*Equisetum arvense* (93%), *Carex aquatilis, Vaccinium uliginosum*, *Salix planifolia*, *Argentina anserina, Salix myrtillifolia*, *Rhododendron groenlandicum, Myrica gale*	-	-	-	-12 to 17 cm	0	11 (28.7)	Organic	396		18	29	47
	Satin Willow/Marsh Reed Grass	O478	*Salix pellita, calamagrostis canadensis*	*Salix pellita* (98%), *Calamagrostis Canadensis, Chamerion angustifolium*	-60 to -23 cm	-41	13 (21.3)	-	-	-	Organic, mineral and mixtures	321	18			18
	Marsh Reed Grass/Bebb's Willow	O30	*Calamagrostis canadensis, Salix bebbiana*	*Calamagrostis canadensis* (93%), *Salix bebbiana* (37%), *Cornus sericea*, Moss spp, *Galium trifidum*	-83 to -39 cm	-62	11 (22.5)	-	-	-	Organic	507	47			47
	Sphagnum/Leather-leaf	O3419, N4743	*Sphagnum spp, Vaccinium oxycoccos, Rubus chamaemorus, Chamadaphne calyculata*	*Sphagnum* spp (100%), *Chamadaphne calyculata* (72%), *Vaccinium oxycoccos*, *Rubus chamaemorus*, *Carex magellanica,* *Rhododendron groenlandicum,* *Maianthemum trifolium*, *Vaccinium uliginosum*	-48 to -28 cm	-39	10 (15.7)	-242 to 35 cm	-162	12 (44.7)	Organic	304	11		6	17
	Water Sedge/Marsh Reed Grass	O751, N178	*Carex aquatilis* (22), *Calamagrostis canadensis*	*Carex aquatilis* (86%) *Calamagrostis canadensis, Chamadaphne calyculata, Potentilla palustris,* *Sphagnum* spp, Moss spp, *Carex magellanica, Carex utriculata*	-53 to -11 cm	-23	5 (18.2)	5 to 28 cm	18	3 (5.8)	Organic	858	59	2	19	80

Water Depth Duration Zone	Shore Zone Habitat Type	Group ID	Indicator Species	Plant Species With Highest Quadrat Occurrence (descending order)	Depth Range (waterline; off-system)		% Slope Off-system	Depth Range (inland edge; Nelson R.)		% Slope Nelson R.	Substrate	Number Quadrats	Number of Locations			
					Range	Median	Mean (St. dev.)	Range	Median	Mean (St. dev.)			Off-system	Keeyask	Stephens Lake	All
	Water Sedge/Wooly Sedge	O3492	*Carex pellita*, *Carex aquatilis*	*Carex aquatilis* (96%), *Carex pellita*, *Carex chordorrhiza*, *Carex magellanica, Ribes triste*	-86 to -3 cm	-8	16 (21.7)	-	-	-	Organic	1,011	35			35
	Silverweed/Narrow reed-grass	N852	*Argentina anserina*, *Calamgrostis stricta*, *Epilobium ciliatum*, *Persicaria lapathifolia, Ranunculus flammula*, *Galium trifidum*	*Argentina anserina* (80%), *Calamgrostis stricta*, *Galium trifidum, Epilobium ciliatum*, *Persicaria amphibian, Persicaria lapathifolium*, *Eleocharis acicularis*, Grass spp, *Ranunculus flammula*, *Eleocharis palustris*, *Agrostis scabra, Mentha arvensis*	-	-	-	11 to 55 cm	27	1 (4)	Organic	893		31	7	38
				Maximum possible number of quadrats or locations								**15502**	**127**	**34**	**100**	**261**

7.3.3.3.3 Shore Zone Habitat Type Descriptions

Shallow Water Vegetation Zone

Plants in the shallow water vegetation zone were predominantly aquatic and semi-aquatic plants that were at least partially submerged during the growing season most years. Species in this zone were either submergent, emergent, or floating-leaved. The following shallow water vegetation types were encountered in the shore zone wetlands.

Creeping Spike-Rush (O1045)

This emergent vegetation type was comprised of creeping spike rush (*Eleocharis palustris*), sometimes mixed with bottle sedge (*Carex utriculata*). Spiked water-milfoil (*Myriophyllum sibiricum*), a submergent species, also occurred often and was indicative of this community. Water smartweed (*Persicaria amphibia*) was also encountered in the Nelson River system. This type most often occurred at shallower water depths, and was most often associated with fine mineral substrates, but occasionally occurred on organic substrates as well.

Water Horsetail (O1294, N1999)

This vegetation type was dominated by emergent water horsetail. This species often occurred with floating-leaved species, including narrow-leaved bur-reed (*Sparganium angustifolium*) and small yellow pond-lily (*Nuphar variegata*). All three species were indicative of this vegetation type. This type most often occurred at moderate water depths, and was most often associated with organic substrates, but also occurred on mineral and organic-mineral mixtures.

Small Yellow Pond-Lily (O1202)

This was a floating-leaved vegetation type usually comprised only of small yellow pond-lily. This was one of the deeper vegetation types, occurring at the widest range of water depths. This type was usually more often associated with organic substrates, but also occurred on fine mineral substrates.

Viscid Great-Bulrush (O74)

This was an emergent vegetation type comprised of viscid great-bulrush (*Schoenoplectus tabernaemontani*). This type usually occurred in relatively deep water, and was associated only with fine mineral substrates.

Lower Beach Zone

Plants in the Lower Beach/Shallow Water vegetation zone were dominated by sedges, usually spending parts of the growing season partially submerged, and not submerged in the fluctuating water zone. The following lower beach to shallow water vegetation types were encountered in the shore zone wetlands.

Bottle Sedge/Bladderwort (O51)

This vegetation type was dominated by bottle sedge, occasionally with bladderwort species (*Utricularia* spp.), both of which were indicative of this type. Marsh reed-grass and water horsetail also occasionally occurred in this type. This type usually occurred on dry land, and occasionally in water to 9 cm deep. This type was almost always associated with organic substrates.

Green Reindeer Lichen/Bladderwort (O2445)

This vegetation type was transitional, dominated by green reindeer lichen, and often mixed with bladderwort species. This type typically occupied a very narrow elevation range along the waterline, occasionally in very shallow water, and was encountered only on organic substrates.

Marsh-Five-Finger/Sedge (O1085, N2653)

This vegetation type was a mixture of marsh-five-finger, and sedge species including bottle sedge, water sedge and two-stamen sedge (*Carex diandra*). Water horsetail, creeping spike-rush and some moss species also sometimes occurred. This vegetation type usually occurred over a narrow elevation range near the water's edge, occasionally in shallow water, and was encountered only on organic substrates.

Sedge/Alpine Cotton-Grass/Water Horsetail (O5725)

This vegetation type was a mixture of several species, including water sedge, bristle-stalked sedge (*Carex leptalea*), bog sedge (*Carex magellanica*), water horsetail, alpine cotton-grass (*Trichophorum alpinum*) and some moss species. Bristle-stalked sedge and alpine cotton-grass were both indicators for this type. This type had the highest elevation range in the off-system wetlands, and was the type in this zone closest to the shallow water zone. It was only associated with organic substrates and encountered at one location.

Small Bedstraw/Creeping Spike-Rush/Water Smartweed (N848)

This vegetation type was comprised of small bedstraw (*Galium trifidum*), creeping spike-rush and/or water smartweed. Other species included water parsnip (*Sium suave*), smooth beggar-ticks (*Bidens cernua*) and water sedge. This type occurred on flat topography in the lower beach, occasionally occurring in water. It was encountered primarily on organic substrates in the Nelson River shore zone.

Inland Edge/Upper Beach

The inland edge/upper beach zone contained a wide range of plants, including trees, often dense tall shrubs, and graminoids. Plants in this zone spend most of the growing season on dry land, and only occasionally are flooded. The following inland edge/upper beach vegetation types were encountered in the shore zone wetlands.

Black spruce/Rock Cranberry/Feathermoss (N1)

This vegetation type was dominated by rock cranberry, Labrador tea and stair-step moss, which were indicators of this type. Other species included black spruce, big red stem moss and green reindeer lichen. This vegetation type formed the inland edge, and occurred over a wide range of elevations (2.5 m) on steeper upper banks along the Nelson River. It was usually encountered on organic substrates.

Black spruce/Willow (N6)

This vegetation type was comprised of a range of species, most commonly black spruce, Bebb's willow, prickly rose, bunchberry, green alder and shrubby willow. This type usually occurred on steeper upper banks over a wide range of elevations (2m) at the Nelson River locations. This vegetation type was associated mostly with organic substrates, as well as fine mineral substrates at some locations.

Green Alder/Stair-step moss (N10)

This vegetation type was dominated by green alder, often occurring with stair-step moss, both of which were indicative of this type. Occasionally rock cranberry and Labrador tea also occurred. This vegetation type formed the inland edge, and occurred over a wide range of elevations (2m) on steeper upper banks along the Nelson River. This vegetation type was encountered on both organic and fine mineral substrates.

Fireweed (N31)

This vegetation type was comprised of fireweed and various moss species. These, as well as red raspberry were indicative of this type. Common horsetail and green alder also occurred. This vegetation type occurred at the inland edge, and over the widest elevation range along the Nelson River banks. This type was associated with steep slopes on average, and was encountered on both organic and mineral substrates.

Bog Bilberry/Sweet Gale (N838)

This vegetation type was comprised of bog bilberry and sweet gale (*Myrica gale*), which were indicative of this type. Water sedge and flat-leaved willow also occur. This vegetation type usually occurred at the toe of the Nelson River bank and on the upper beach. This type was associated with gentle or no slopes, and was almost always encountered on organic substrates.

Speckled Alder/White Birch (O469)

This vegetation type was dominated by speckled alder, often occurring with white birch, both of which were indicative of this group. Other species included marsh reed-grass, common horsetail, Bebb's willow and moss species. This vegetation type usually occurred along the inland edge, and had the steepest slopes on average. This type was usually associated with organic substrates, but also occasionally with coarse mineral substrates.

Labrador Tea/Black Spruce (O1, N36)

This vegetation type was comprised of a variety of species, most commonly moss species, Labrador tea and black spruce. Labrador tea was indicative of this vegetation type. This vegetation type was associated with the widest range of elevation in this zone for the off-system wetlands, usually forming or extending up to the inland edge, and was associated with a range of slopes. This type was usually associated with organic substrates.

Flat-Leaved Willow/Marsh Reed Grass (O454, N96, N860)

This vegetation type was dominated by flat-leaved willow and was often mixed with marsh reed-grass, which together were indicative of this type. Other species included *Sphagnum* spp., common horsetail, three-leaved Solomon's seal, dewberry (*Rubus pubescens*) and water sedge. This vegetation type usually occurred along the inland edge over a range of elevations and slopes. This type was associated primarily with organic substrates. On the Nelson River, this type often occurred as a separate group with very dense flat-leaved willow mixed with water sedge, and was associated more often with the upper beach side of the inland edge.

Common Horsetail (N24)

This vegetation type was usually dominated by common horsetail, which was indicative of the type, and often mixed with water sedge, silverweed and a mixture of low shrubs. Low shrubs included bog bilberry, flat-leaved willow, myrtle-leaved willow, Labrador tea and sweet gale. This type usually occurred along the inland edge, and was associated with organic substrates on a range of slopes and elevations.

Satin Willow/Marsh Reed Grass (O478)

This vegetation type was dominated by satin willow and was often mixed with marsh reed-grass, which together were indicative of this type. Fireweed also occasionally occurred. This vegetation type usually occurred along the inland edge over a range of elevations and slopes. This type was usually associated with organic substrates, but was also encountered on organic-mineral mixtures, fine mineral, and coarse mineral substrates.

Marsh Reed Grass/Bebb's Willow (O30)

This vegetation type is dominated by marsh reed grass, often mixed with Bebb's willow, which together are indicative of this type. Red-osier dogwood, moss species and small bedstraw also occasionally occurred. This vegetation type usually occurs at higher elevations along the beach, and extending into the inland edge. This type was associated with a range of slopes, and primarily organic substrates.

Sphagnum/Leather-leaf (O3419, N4743)

This vegetation type was comprised of sphagnum moss cover, usually with leather-leaf. Small bog cranberry and cloudberry often occurred, and occasionally bog sedge and Labrador tea. This vegetation type usually occurred at the inland edge, often extending into the upper beach. It was associated with moderate to gentle slopes and encountered only on organic substrates.

Water Sedge/Marsh Reed Grass (O751, N178)

This vegetation type was dominated by water sedge, often mixed with marsh reed grass which were together indicative of this type. Leather-leaf, marsh-five-finger and *Sphagnum* mosses may also occur. This vegetation type usually was located along the upper beach, extending into the inland edge. This type was associated with gentler slopes on average, and was only encountered on organic substrates.

Water Sedge/Wooly Sedge (O3492)

This vegetation type was comprised of a mixture of sedges, dominated by water sedge and wooly sedge, which were indicators of this type. Other sedges included prostrate sedge (*Carex chordorrhiza*) and bog sedge. This vegetation type occurred over a wide range of elevations within the upper beach zone, and was associated with a range of slopes. This vegetation type was usually encountered on organic substrates.

Silverweed/Narrow reed-grass (N852)

This vegetation type was comprised primarily of silverweed (*Argentina anserina*) and narrow reed-grass (*Calamagrostis stricta*), both of which were indicative of this type. Other species included northern willowherb (*Epilobium ciliatum*), small bedstraw, water smartweed and pale persicaria (*Persicaria lapathifolia*). This vegetation type usually occurred over a narrow elevation range at the base of the Nelson River banks along the upper beach, and extending into the inland edge. It was associated with a mixture of substrate types, including fine and coarse mineral, as well as organic.

7.3.3.4 Comparison of Nelson River and Off-System Shoreline Wetlands

The nature of shore zone habitat in the Nelson River and off-system waterbodies was considerably different, presumably due to the substantial differences in water and ice regimes. During the study period, the vegetated upper beach and vegetated ice scour upland habitat types were only observed on the Nelson River while virtually all of the littoral and lower beach marsh was in off-system waterbodies (Section 6.3.2.2). Additionally, the Nelson River upper beach peatlands were periodically flooded while those in off-system waterbodies appeared to float up and down with water fluctuations.

On the Nelson River, shrub and/or low vegetation on upper beach was the most abundant of the shore zone coarse types (Section 6.3.2.2). Nelson River marsh was virtually absent. Vegetation in the Nelson River shrub/low vegetation on upper beach coarse habitat type was dominated either by tall shrubs or low vegetation mixed in with graminoids, with the characteristic plant species being different in the Keeyask and Stephens Lake reaches of the Nelson River. For the tall shrub vegetation types, flat-leaved willow and marsh reed-grass occurred throughout the Nelson River, while bog billberry and sweet gale cover occurred only in the Stephens Reach. For the low vegetation types, the vegetation cover commonly consisted of silverweed and marsh reed grass in the Keeyask reach, while common horsetail, marsh-five-finger and sedges were more common in the Stephens Lake reach.

In contrast, shoreline wetlands in off-system waterbodies were predominantly marshes occurring within shallow lacustrine environments and along the sunken margins of floating peatlands (Section 6.3.2.2). Off-system littoral or lower beach marsh on mineral substrates tended to be dominated by either viscid great-bulrush or creeping spike-rush and spiked water-milfoil. Water horsetail occurred in shallower water on organic and mineral substrates, while floating-leaved species such as small yellow pond-lily and narrow-leaved bur-reed often occurred in deeper water. Nelson River littoral or lower beach marsh was dominated by water horsetail.

Off-system wetlands also had higher habitat diversity within both the shallow water and lower beach water depth zones (Table 7-38). Cluster analysis identified four types in each zone for the off-system wetlands, versus one per zone for the Nelson River. Although the inland edge/upper beach zone had slightly more habitat types on the Nelson River (11) than on off-system waterbodies (8), this was likely an artificact of starting the transect on riparian peatlands in off-system wetlands and not extending them into the inland edge (i.e., considerably fewer upland ecosite types were captured by the off-system transects). This was supported by further examining the inland edge/upper beach zone in Table 7-38, which showed more diversity with respect to habitat types in the highest elevation ranges on the Nelson River, while the number of vegetation types was comparable between the two systems in the lower elevation ranges.

The higher wetland diversity in the lower beach and shallow water zones in off-system waterbodies was likely due to a much lower range of water level fluctuations and flows compared to the Nelson River. This would allow for a higher potential to develop marshes with a variety of emergent wetland species establishing in the lower beach and shallow water zone. This is generally supported by the habitat mapping (Section 6.3.2.2), which showed true emergent vegetation being much more widely distributed in off-system lakes than on the Nelson River, where it was rare and confined to more sheltered bays and inlets.

7.3.4 Stand Level Coarse Habitat Type Descriptions

Section 6.3 described the stand level terrestrial habitat composition of the Keeyask Sub-regional Study Area. This section provides brief characterizations of the most common coarse habitat types occurring in the Sub-regional Study Area (Map 6-7 includes aerial photo examples of selected coarse habitat types). These characterizations are followed by a fact sheet for each of the coarse habitat types (Figure 7-15 to Figure 7-34). The fact sheets are ordered from structurally diverse upland to structurally simple wetland. It should be noted that some stands may have a very different composition than described in the fact sheets because the descriptions represent typical conditions. Between-stand variability within a habitat type results from natural variability for all habitat types, and from a small sample size for a few habitat types.

7.3.4.1 Most Common Inland Coarse Habitat Types

The black spruce on mineral soil or thin peatland coarse habitat types typically occurred on sloped or elevated well drained mineral deposits. The surface organic layer thickness was 23 cm on average but highly variable, and was derived from peat mosses and feathermosses. The vegetation was characterized by a black spruce dominated overstorey with occasional tamarack on moister sites and occasional jack pine, white birch and/or trembling aspen on drier sites. Green alder usually occurred in the tall shrub layer, often accompanied by willows. Typical species in the lower understorey were Labrador tea, rock cranberry, big red stem , stair-step moss, knight's plume moss, reindeer lichens and cup lichens. Reindeer lichen cover was more abundant in the northern portion of the Regional Study Area where the tree canopy was more open (Cree Nation Partners 2011).

The black spruce on shallow peatlands coarse habitat type typically occurred on flat to gently sloping areas with very moist or poorly drained peatlands. The surface organic layer thickness was highly variable, averaging 71 cm, and was derived from peat mosses. Compared with black spruce on mineral soil or thin peatlands habitat type, the vegetation generally had a shorter, more open overstorey and tall shrubs were scarce. The lower understorey layer had more small cranberry, reindeer lichen, peat mosses and feathermosses.

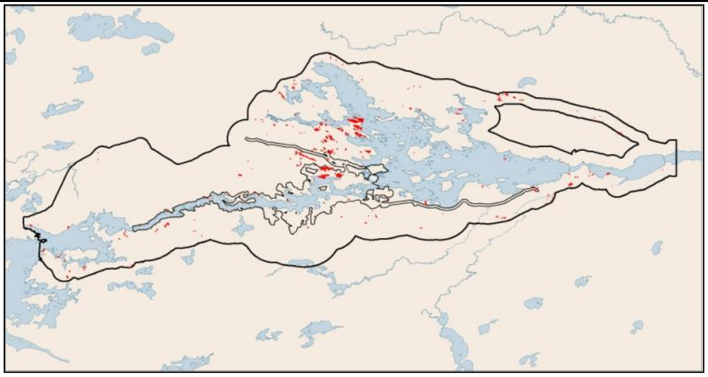
7.3.4.2 Most Common Shoreline Coarse Habitat Types

As noted in Section 7.3.3.3.3, shoreline wetland types are related to water depth zones. Based on the 212 shoreline wetland transect locations that were sampled, water horsetail and viscid great bulrush were the most common broad habitat types in the littoral water depth zone of off-system waterbodies, followed by small yellow pond-lily and creeping spike-rush. Water horsetail was the only shallow water broad habitat type found in the Nelson River and most of its area was located in the Keeyask reach. The water horsetail and viscid great bulrush habitat types were emergent, or marsh, habitat types. The water horsetail habitat type usually occurred on mineral substrates with bottle sedge and water smartweed in the Nelson River and on organic substrates with narrow-leaved bur-reed and small yellow pond-lily in the off-system waterbodies. The viscid great bulrush habitat type, which included viscid great bulrush as its sole characteristic species, was associated with fine mineral substrates.

In the lower beach water depth zone, small bedstraw/creeping spike-rush/water smartweed was the most common habitat type, followed by the bottle sedge/bladderwort type. The small bedstraw/creeping spike-rush/water smartweed habitat type was the most common lower to middle beach habitat type in the Nelson River but was not found in the off-system lakes. It primarily occurred on organic substrates and often included water parsnip , smooth beggar-ticks and water sedge. In contrast, the bottle sedge/bladderwort habitat type was one of the most common in the off-system lakes but was not found in the Nelson River. It typically occurred on organic substrates and often included marsh reed-grass and water horsetail.

In the upper beach and inland edge water depth zone, flat-leaved willow/marsh reed-grass was the most common habitat type, followed by the water sedge/marsh reed grass and silverweed/narrow reed-grass types. The former two habitat types were encountered in both the Nelson River and off-system waterbodies, while the latter was only found in the Nelson River. The flat-leaved willow/marsh reed-grass habitat type typically occurred on organic substrates and often included peat moss, common horsetail, three-leaved Solomon's-seal, dewberry and water sedge. Bog bilberry also occurred in the Nelson River occurrences of this habitat type.

The Nelson River vegetated ice scoured upland coarse habitat type supported a mixture of shrub and low vegetation that was scoured by moving ice in areas of strong current along the Nelson River banks (KGS ACRES 2011).



Sub-regional Study Area Distribution

A regionally rare coarse habitat type (0.6% of land area).

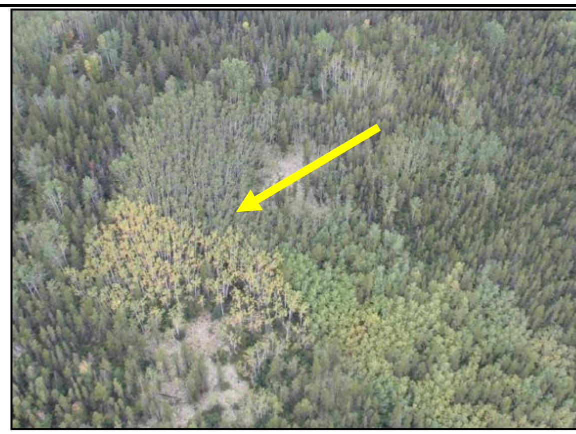
Scattered stands, more frequent nearer the Nelson River banks and along eskers.

Characteristic Site Conditions

Upland flat terrain, ridges and upper slopes with moderately well drained mineral sites.

Thin organic substrate averages 6 cm, mostly derived from LFH.

Mineral soil varied in texture from sandy to clayey, and formed on a range of deposit types. Range of pH, neutral to ~5. Total B-horizon organic carbon ~0.6% Total B-horizon combustible nitrogen ~0.06% Available B-horizon phosphorus/potassium ~ 148/<10 mg/kg



Aerial View

Characteristic Vegetation Composition

Structure: Forest and woodland stand types, often closed canopies 13 m – 18 m tall.

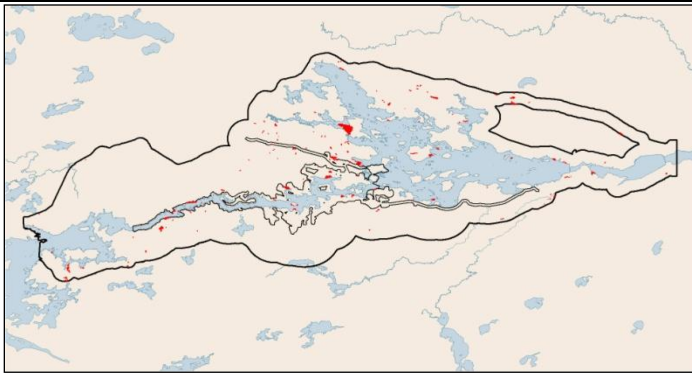
Canopy composition: Trembling aspen or white birch dominated, some black spruce or jack pine may occur. Understorey trees and seedlings dominated by black spruce.

Tall shrubs: Usually dense, dominated by green alder.

Understorey: Often rich with low shrubs including prickly rose, rock cranberry, and Labrador tea; herbs including bunchberry and twinflower, and mosses.

Ground View

Figure 7-15: Broadleaf treed on all ecosites coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally rare coarse habitat type (0.5% of land area).

Scattered stands, more frequent nearer the Nelson River banks and along eskers.

Characteristic Site Conditions

Upland flat terrain, ridges and slopes.

Moderately well to well drained mineral sites.

Thin organic layer averages 5 cm, mostly derived from LFH.

Mineral soils with a range of textures developed on glaciofluvial and glaciolacustrine mineral deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Forest and woodland stand types, often closed canopies 14 m – 19 m tall.

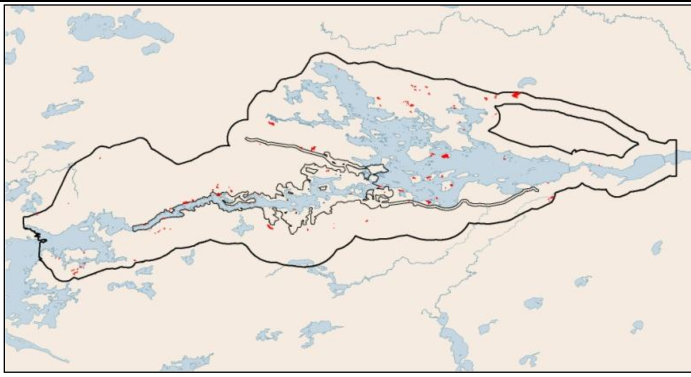
Canopy composition: White birch or trembling aspen mixed with jack pine or black spruce. Understorey trees are often a mixture of black spruce, white birch or trembling aspen.

Tall shrubs: Green alder, denser on fresh sites, sparser on drier sites.

Understorey: Often rich with low shrubs including prickly rose and rock cranberry; herbs including bunchberry and twinflower; and mosses with feather-mosses more widespread on drier sites.

Ground View

Figure 7-16: Broadleaf mixedwood on all ecosites coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally rare coarse habitat type (0.3% of land area).

Scattered stands, more frequent nearer the Nelson River banks and on islands in the south of Stephens Lake.

Characteristic Site Conditions

Upland flat terrain, ridges and slopes.

Mineral ecosites and some thin peatlands.

Variable organic substrate thickness, 14 cm deep on average.

Range of mineral textures, silty to clayey, derived from glaciofluvial and lacustrine deposits.

Aerial View

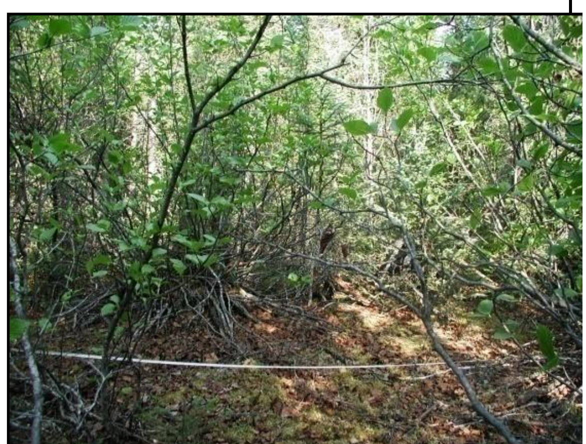
Characteristic Vegetation Composition

Structure: Forest and woodland stand types, often closed canopies 8 m – 14 m tall.

Canopy composition: Black spruce mixed with trembling aspen, sometimes with tamarack. Occasionally white spruce may be present. Understorey trees mostly black spruce, occasionally with hardwoods and tamarack.

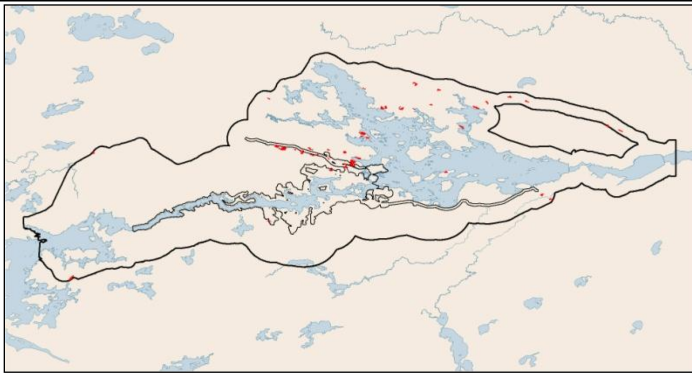
Tall shrubs: Often dense green alder, some speckled alder, willow, buffaloberry and or bog birch may be present.

Understorey: Often rich in species, composed primarily of low shrubs including rock cranberry and Labrador tea, herbs including palmate-leaved coltsfoot and twinflower, and feathermosses.



Ground View

Figure 7-17: Black spruce mixedwood on mineral or thin peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally rare coarse habitat type (0.3% of land area).

Scattered stands, more frequent along eskers and nearer the Nelson River banks.

Characteristic Site Conditions

Upland flat terrain, ridges and upper slopes.

Fresh, moderately well drained mineral sites.

Thin organic layer averages 7 cm mostly derived from mosses, including a thin LFH layer.

Mineral soil textures vary, but are often sandy, derived from glaciofluvial and glaciolacustrine mineral deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Sparsely treed to forest stand types, with open to closed canopies 13 m – 18 m tall.

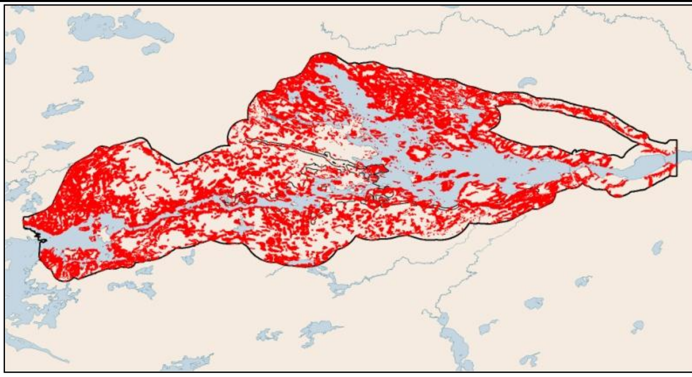
Canopy composition: Jack pine mixed with trembling aspen or white birch and black spruce. Understorey trees are usually black spruce.

Tall shrubs: Usually dense, dominated by green alder.

Understorey: Abundant low shrubs including rock cranberry, Labrador tea and velvet-leaf blueberry; herbs including bunchberry, twinflower and fireweed; and abundant feather-mosses.

Ground View

Figure 7-18: Jack pine mixedwood on mineral or thin peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

The most common coarse habitat types (41.6% of land area).

Widespread throughout the Sub-regional Study Area.

Characteristic Site Conditions

Upland flat and sloping terrain, with moderately moist, imperfectly drained thin peatlands and fresher, well drained mineral sites.

Organic layer varies in thickness averaging 23 cm (lower on mineral, and higher on thin peatland), and is derived from mosses.

Organic deposits are derived from sphagnum or forest peat. Mineral soils vary in texture and are derived from a range of glacial deposit types. Upper horizon (A and B) soils average: 64% sand, 21% silt, 15% clay. pH range from 5.4 – 7.3. Total organic carbon ~0.9%. Total combustible nitrogen ~0.06%. Available phosphorus/potassium ~ 62/<10 mg/kg

Aerial View

Characteristic Vegetation Composition

Structure: Sparsely treed to woodland stand types, with open to partially closed canopies 7 m – 12 m tall.

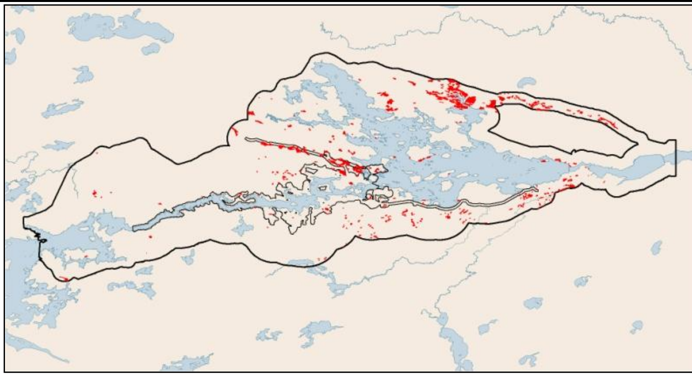
Canopy composition: Black spruce dominated, with occasional tamarack (moister) or jack pine and broadleaf (drier). Understorey trees are predominantly black spruce.

Tall shrubs: Green alder in varying densities, often with some willow. Occasionally bog birch.

Understorey: Occasionally rich, dominated by low shrubs including Labrador tea and rock cranberry; and abundant lichens and feather-mosses.

Ground View

Figure 7-19: Black spruce treed on mineral soil or on thin peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally rare coarse habitat type (1.8% of land area).

Scattered primarily in north-central and eastern Sub-regional Study Area. Large stands occur along north-central esker and north of Stephens Lake.

Characteristic Site Conditions

Slopes, ridges and upland flat terrain, usually with fresh, well drained mineral sites.

Thin organic layer 9 cm thick on average, mostly derived from mosses, thin LFH layer may be present.

Mineral soils vary in texture but silty to sandy soils are more common with this habitat. Soils are derived from a range of glacial deposit types. Upper horizon (B) soils average:
66% sand, 24% silt, 10% clay.
pH range from 5.4 – 7.7
Total organic carbon ~2.1%
Total combustible nitrogen ~0.11%
Available phosphorus/potassium ~ 52/<10 mg/kg

Aerial View

Characteristic Vegetation Composition

Structure: Forest to sparsely treed stand types, with open to closed canopies 5 m – 16 m tall.

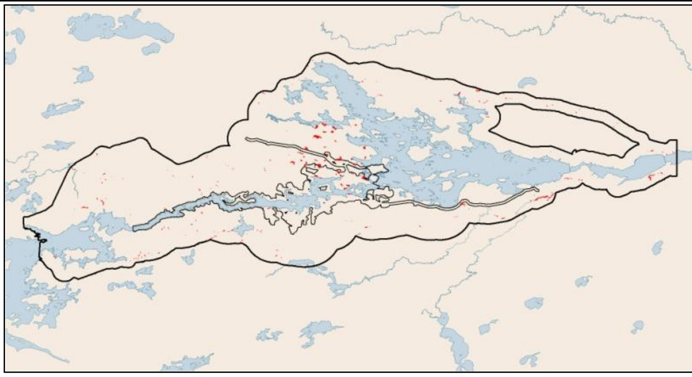
Canopy composition: Jack pine dominated, sometimes with some black spruce. Understorey trees are predominantly black spruce.

Tall shrubs: Dominated by green alder at highly variable densities.

Understorey: Often rich, dominated by low shrubs including rock cranberry, Labrador tea and prickly rose; herbs include bunchberry, twinflower and fireweed; and feather-mosses are common.

Ground View

Figure 7-20: Jack pine treed on mineral or thin peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally rare coarse habitat type (0.2% of land area).

Most widespread along the Nelson River shoreline, also scattered along inland riparian areas.

Characteristic Site Conditions

Slopes, ridges, upland flat topography adjacent to waterways, and ravines.

Occurring on thin peatlands to swampy mineral sites with very fresh, imperfectly drained regimes on average.

The organic layer is variable, 27 cm on average, usually with an LFH layer.

Mineral soils are usually silty clays, and derived primarily from lacustrine or fluvial deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed or very sparsely treed areas with dense tall shrub layer.

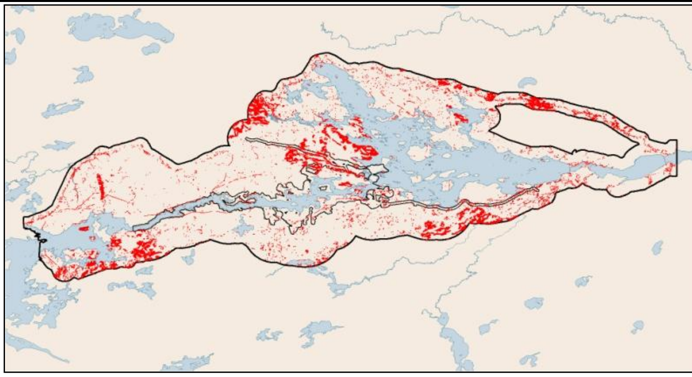
Canopy composition: Scattered stems of black spruce or white birch may be present.

Tall shrubs: Dense willow, often mixed with bog birch and speckled alder of varying densities.

Understorey: Rich in species, dominated by herbs including marsh reed grass, common horsetail and stemless raspberry. Labrador tea is widespread, and various moss species usually are present.

Ground View

Figure 7-21: Tall shrub on mineral or thin peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally uncommon coarse habitat type (4.6% of land area).

Distributed throughout the Sub-regional Study Area, associated with old poorly regenerating burns and cutlines.

Characteristic Site Conditions

Slopes, ridges and upland flat terrain, and river banks.

Usually on thin peatlands, occasionally on mineral sites. Variable moisture and drainage regimes.

Highly variable organic layer thickness, 30 cm on average, derived from mosses.

Mineral soil textures vary and are derived from a range of deposit types.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed areas, scattered tree stems may be present.

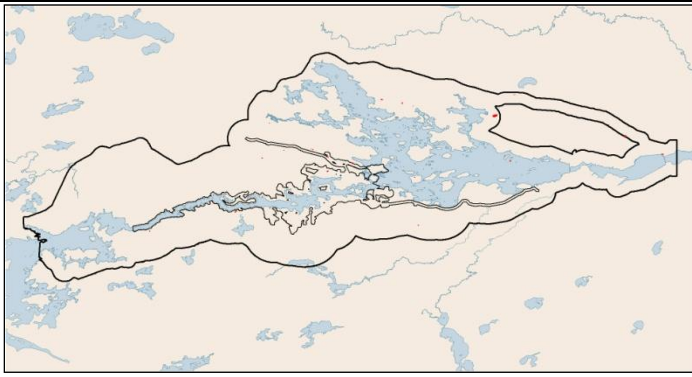
Canopy composition: Scattered seedlings or small black spruce or white birch up to three metres tall may be present.

Tall shrubs: Scarce, often may be scattered willow.

Understorey: Dominated by low shrubs such as Labrador tea; Lichens and mosses are also widespread.

Ground View

Figure 7-22: Low vegetation on mineral or thin peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A rare coarse habitat type (<0.1% of land area).

A few scattered locations in the Sub-regional Study Area with suitable microsite conditions.

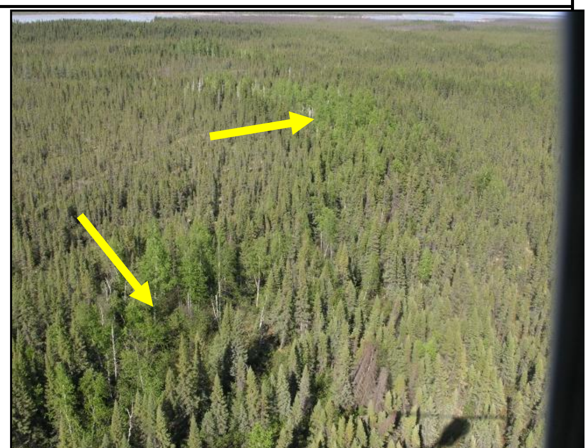
Characteristic Site Conditions

Most often located in runnels, gently sloping or flat topography on slope bog and veneer bog peatlands.

Associated with very moist, poorly drained sites on average.

The organic layer is 36 cm thick on average, mostly derived from mosses; usually with an LFH layer.

Ground ice is occasionally present at varying depths. Soils are primarily derived forest peat deposits.



Aerial View

Characteristic Vegetation Composition

Structure: Woodland to sparsely treed areas, open to partially closed canopies, 8 m – 11 m tall.

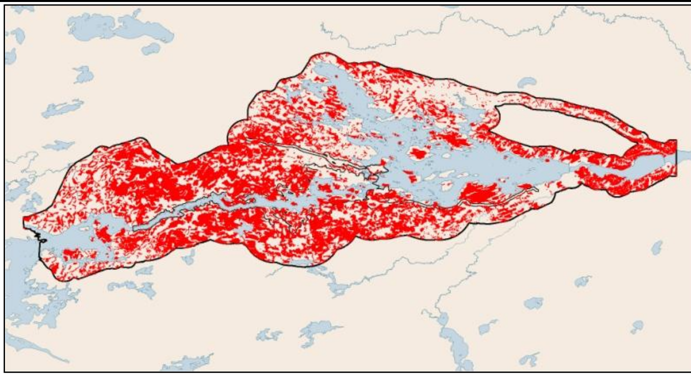
Canopy composition: Black spruce, mixed with white birch or balsam poplar. Understoreys dominated by black spruce, often mixed with white birch.

Tall shrubs: Often dense, with speckled alder or green alder. Usually mixed with willow, and occasionally bog birch.

Understorey: Usually rich, with widespread low shrubs including Labrador tea and rock cranberry; herbs including wood horsetail and bishop's cap; and stair-step moss.

Ground View

Figure 7-23: Black spruce mixedwood on shallow peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A common coarse habitat type (32.8% of land area).

Widespread throughout the Sub-regional Study Area.

Characteristic Site Conditions

Flat to gently sloping terrain.

Very moist, poorly drained peatlands, including blanket and veneer bogs, and peat plateau bogs.

The organic layer is variable, averaging 71 cm thick, and ground ice is often present.

The organic substrate is primarily composed of fibric and mesic sphagnum deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Sparsely treed to woodland areas, with open canopies up to 8 m tall.

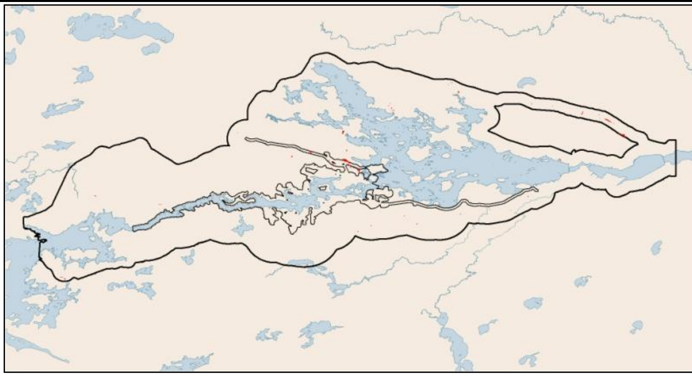
Canopy composition: Black spruce dominated. Understorey trees also black spruce.

Tall shrubs: Scarce.

Understorey: Dominated by low shrubs, including Labrador tea, rock and small cranberry; cloudberry and reindeer lichens are widespread, and sphagnum and feather-mosses comprise the remaining ground cover.

Ground View

Figure 7-24: Black spruce treed on shallow peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A rare coarse habitat type (0.1% of land area).

A few scattered locations in the Sub-regional Study Area.

Aerial View

Characteristic Site Conditions

Most often located on horizontal or gently sloping terrain, often adjacent to upland areas.

Moderately wet, very poorly drained peatlands, including blanket bogs.

The organic layer is greater than 20 cm, averaging 24 cm thick; primarily composed of fibric and mesic feathermoss over lacustrine deposits.

Ground View

Characteristic Vegetation Composition

Structure: Sparsely treed areas with short, open canopies 3 m tall on average.

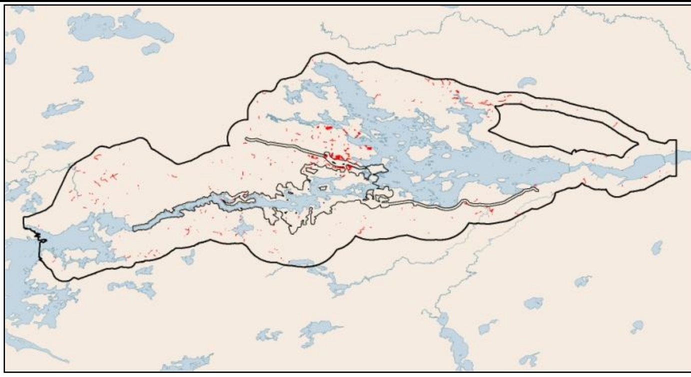
Canopy composition: Jack pine in mixture with black spruce, and occasionally tamarack. Understorey dominated by dense black spruce regeneration.

Tall shrubs: Predominantly willow and/or bog birch.

Understorey: Rich, with widespread low shrubs, including Labrador tea, bog bilberry and rock cranberry; herbs including alpine bearberry, dwarf scouring rush and sedges, as well as feather-mosses and lichens.

* Habitat type has low plot representation. Understorey and microsite characteristics are estimated.

Figure 7-25: Jack pine treed on shallow peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally rare coarse habitat type (0.3% of land area).

Distributed throughout the Sub-regional Study Area. Often regenerating in recent burns.

Characteristic Site Conditions

Along runnels and on horizontal and depressed topography usually near waterways.

Wet, very poorly drained peatlands, including slope fens, blanket and veneer bogs.

The organic layer is variable, averaging 90 cm thick, and the water table is near the surface.

The organic substrate is composed of fibric, mesic and humic fen peat deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed, or very sparsely treed areas.

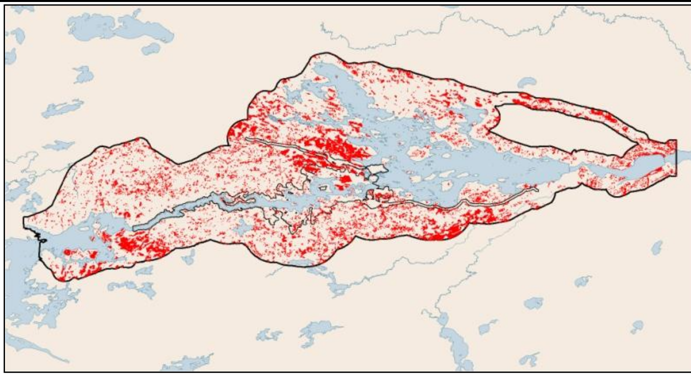
Canopy composition: Scattered tamarack, white birch or black spruce may occur.

Tall shrubs: Dense willow, speckled alder and bog birch.

Understorey: Rich, dominated by sphagnum and other mosses. Low shrubs include Labrador tea and leatherleaf; herbs include three-leaved false Solomon's-seal, sedges, swamp horsetail and marsh five-finger.

Ground View

Figure 7-26: Tall shrub on shallow peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally uncommon coarse habitat type (7% of land area).

Distributed throughout the Sub-regional Study Area, often in cutlines, and forming some extensive areas corresponding to old, poorly regenerating burns.

Characteristic Site Conditions

Horizontal topography and depressions.

Wet, very poorly drained peatlands, including blanket bogs and permafrost peatlands.

The organic layer is variable, averaging 122 cm thick, often with ground ice, or a water table at variable depths.

The organic substrate is primarily composed of fibric and mesic fen peat deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed, or very sparsely treed areas.

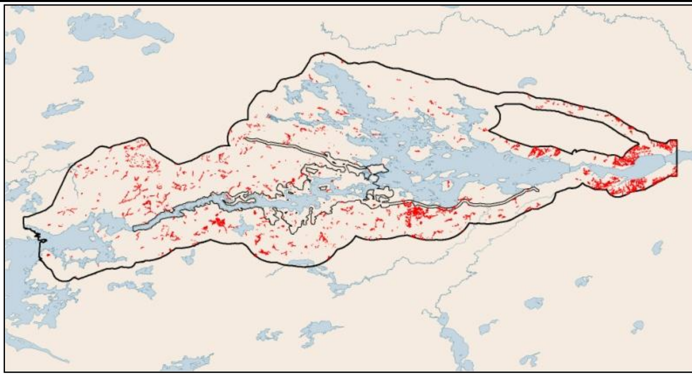
Canopy composition: Scattered black spruce may occur.

Tall shrubs: Sparse willow and bog birch.

Understorey: Low shrubs including Labrador tea; herbs including cloudberry and three-leaved false Solomon's-seal; and widespread sphagnum mosses and cup lichens.

Ground View

Figure 7-27: Low vegetation on shallow peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally uncommon coarse habitat type (2.1% of land area).

Distributed throughout the Sub-regional Study Area, extensive areas occur at the eastern extent and south of Stephens Lake.

Characteristic Site Conditions

Horizontal and depressed terrain and runnels.

Very moist to wet, very poorly drained horizontal and riparian fens and flat bogs.

The organic layer is variable but deep, more than 1.3 m thick on average, and the water table is often near the surface.

The organic substrate is primarily composed of fibric-dominated sphagnum, feathermoss or fen deposits.

Aerial View

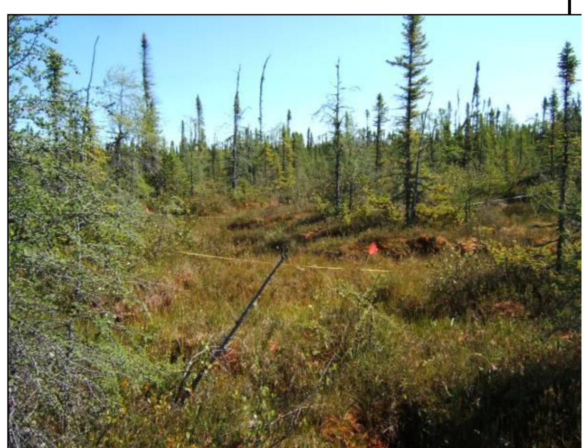
Characteristic Vegetation Composition

Structure: Sparsely treed to woodland areas, with open to partly closed, short, complex canopies; trees heights range from 3 m on poor, up to 13 m on richer sites.

Canopy composition: Small diameter black spruce, scattered tamarack often present.

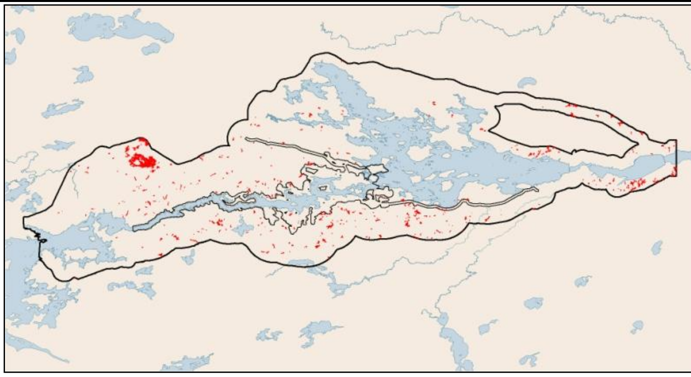
Tall shrubs: Composed of bog birch and willow in varying densities.

Understorey: Rich; low shrubs including leather-leaf, small bog cranberry, Labrador tea, rock cranberry and bog bilberry; herbs including sedges, three-leaved false Solomon's-seal, cloudberry and wood horsetail; ground cover dominated by sphagnum and other moss species.



Ground View

Figure 7-28: Black spruce treed on wet peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally rare coarse habitat type (0.9% of land area).

Scattered throughout the Sub-regional Study Area, one extensive area occurs near the northwest extent adjacent to PR 280.

Characteristic Site Conditions

Horizontal and depressed terrain.

Wet, very poorly drained horizontal and riparian fens, and flat bogs.

The organic layer is deep, 78 cm on average, water table depth is variable, often near the surface.

The organic substrate is primarily composed of fibric and mesic dominated sphagnum deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Sparsely treed areas, with open, short complex canopies and trees up to 7 m tall.

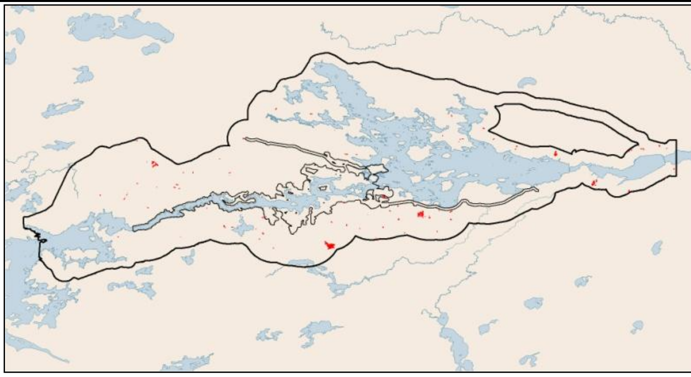
Canopy composition: Small diameter black spruce and tamarack.

Tall shrubs: Usually dense, comprised of bog birch and willow.

Understorey: Ground cover dominated by sphagnum mosses; low shrubs including leather-leaf, small bog cranberry and Labrador tea; herbs including swamp horsetail, three-leaved false Solomon's-seal and marsh-five-finger.

Ground View

Figure 7-29: Tamarack- black spruce mixture on wet peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally rare coarse habitat type (0.2% of land area).

Scattered stands and a few large areas in the Sub-regional Study Area, more common south of the Nelson River.

Characteristic Site Conditions

Flat and depressed terrain.

Wet, very poorly drained horizontal and riparian fens.

The organic layer is deep, 1.3 m thick on average, and the water table is near or at the surface.

The organic substrate is primarily composed of fibric dominated fen peat deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Sparsely treed to woodland areas, with short complex canopies and trees up to 5 m tall.

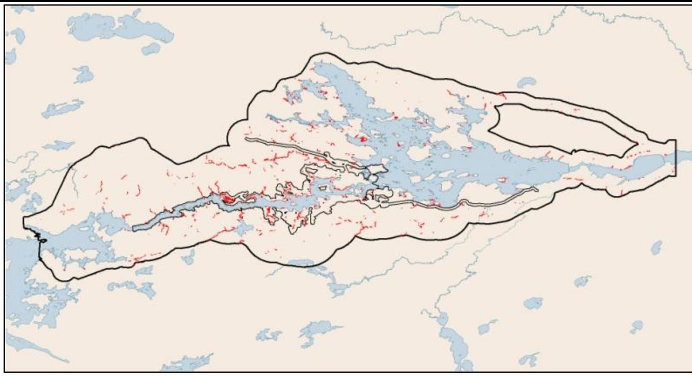
Canopy composition: Small diameter tamarack, often with scattered black spruce.

Tall shrubs: Often dense, comprised mostly of bog birch.

Understorey: Ground cover dominated by sphagnum mosses; low shrubs including leather-leaf and small bog cranberry; herbs include bog bean, bog rosemary, three-leaved false Solomon's-seal, water horsetail, marsh-five-finger and round-leaved sundew.

Ground View

Figure 7-30: Tamarack treed on wet peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

Regionally rare coarse habitat types (0.7% of land area).

Scattered areas throughout the Sub-regional Study Area along waterways and lake shores, less frequent northeast of Stephens Lake.

Characteristic Site Conditions

Usually in runnels, as well as flat and depressed terrain.

Very moist, poorly drained riparian and horizontal fens.

The organic layer is quite variable, 78 cm thick on average, often with a shallow water table.

The organic substrate is primarily composed of humic dominated fen peat deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed or very sparsely treed areas.

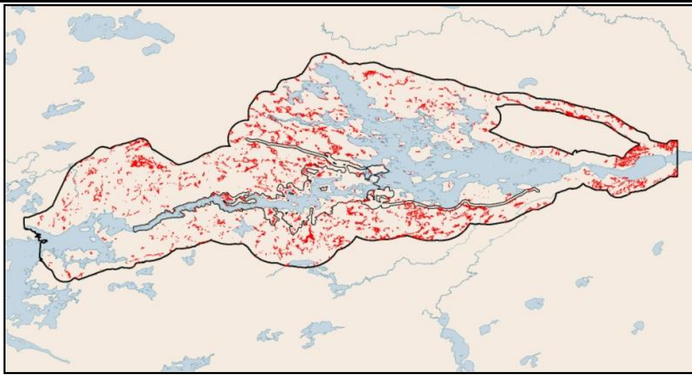
Canopy composition: Occasionally scattered short black spruce or white birch.

Tall shrubs: Dense, dominated by willow, sometimes with speckled alder or bog birch.

Understorey: Primarily moss species; Other scattered species include leather-leaf, sedges, three-leaved false Solomon's-seal and marsh-five-finger.

Ground View

Figure 7-31: Tall shrub on riparian or wet peatlands coarse habitat fact sheet



Sub-regional Study Area Distribution

Regionally uncommon coarse habitat types (3.3% of land area).

Distributed throughout the Sub-regional Study Area in very small to extensive areas.

Characteristic Site Conditions

Flat and depressed terrain.

Wet, very poorly drained collapse scars, horizontal fens and transitional peat plateau bogs, and riparian peatlands.

The organic layer is variable but deep, often more than 2 m thick with a shallow water table.

The organic substrate is composed of fibric dominated fen and sphagnum peat deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed or very sparsely treed areas.

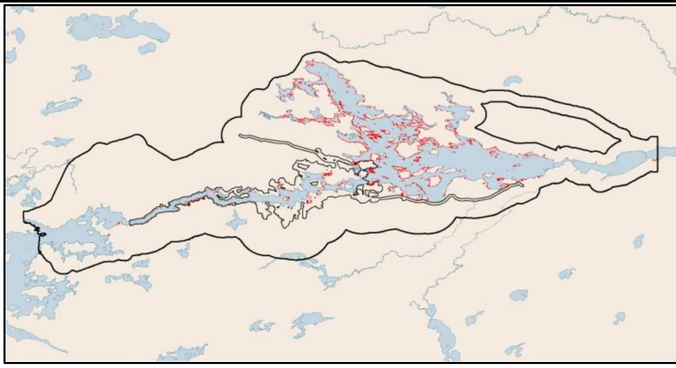
Canopy composition: Occasionally small scattered black spruce or tamarack usually less than two m tall.

Tall shrubs: Occasionally sparse willow.

Understorey: Primarily sphagnum mosses; low shrubs including leather-leaf and small bog cranberry; herbs include three-leaved false Solomon's-seal.

Ground View

Figure 7-32: Low vegetation on riparian or wet peatland coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally rare coarse habitat type (0.7% of land area).

Primarily distributed along the regulated Nelson River Shoreline.

Characteristic Site Conditions

Sloping topography.

Within the intermittently flooded shore zone.

Occurring on thin organic, and fine to coarse mineral substrates.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed, tall shrub and/or low vegetation.

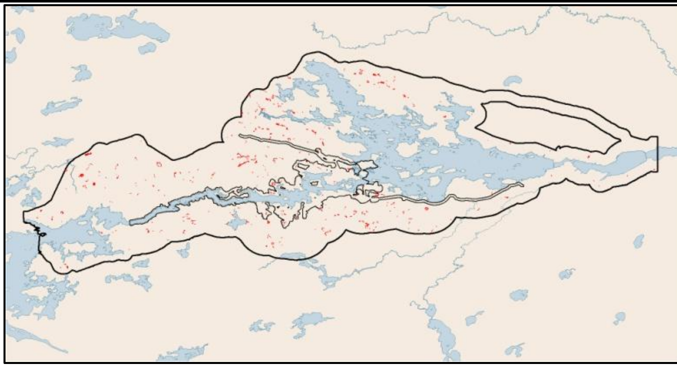
Canopy composition: Untreed.

Shrubs: Often dense flat-leaved willow when present, bog bilberry and sweet gale frequent in the Stephens reach.

Low vegetation: Silverweed and narrow reed grass and water sedge frequent in the Keeyask reach, and common horsetail, marsh-five-finger and sedge species more common in the Stephens reach.

Ground View

Figure 7-33: Shrub/low vegetation on upper beach coarse habitat fact sheet



Sub-regional Study Area Distribution

A regionally rare coarse habitat type (0.1% of land area).

Scattered along shorelines of off-system lakes and waterways, rarely in sheltered bays of Nelson River.

Characteristic Site Conditions

Shallow water, depths usually ranging up to 1.7m.

Submerged margins of floating peatlands and lake bottoms.

Substrates include submerged, floating fibric peat, and mineral, organic and littoral lake bottoms.

Aerial View

Characteristic Vegetation Composition

Structure: Emergent, floating-leaved and submerged low vegetation.

Canopy composition: Untreed.

Shrubs: None.

Emergent & vegetation: Water horsetail and needle spike-rush, with creeping spike-rush on mineral substrates.

Floating-leaved vegetation: Various-leaved pondweed and yellow pond-lily, narrow-leaved bur-reed, large-leaved white water-crowfoot and arum-leaved arrowhead.

Submerged vegetation: Pondweeds, spiked water-milfoil and common bladderwort.

Ground View

Figure 7-34: Off-system marsh coarse habitat fact sheet

7.4 APPENDICES

7.4.1 Appendix 7-A

Plant Species Lists for the Keeyask Regional Study Area

Table 7A-7-39: Vascular plant species encountered during field studies in the LNR Region, including MBCDC S-Rank and number of locations in the Keeyask and Conawapa Regional study areas

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Achillea millefolium L. var. *borealis* (Bong.) Farw.	Common yarrow	S5	26	199	
Actaea rubra (Ait.) Willd.	Baneberry	S5	5	35	
Agrostis scabra Willd.	Rough hair-grass	S5	55	38	
Agrostis stolonifera L.	Redtop	SNA	1	2	
Alnus incana (L.) Moench. ssp. *rugosa*	Speckled alder	S5	203	525	
Alnus viridis (Vill.) de Candolle ssp. *crispa*	Green or mountain alder	S5	208	1179	
Alopecurus aequalis Sobol.	Short-awned foxtail	S5	8	1	
Amerorchis rotundifolia (Banks ex Pursh) Hulten	Small round-leaved orchis	S5	5	5	
Andromeda polifolia L.	Bog Rosemary	S5	62	102	
Anemone canadensis L.	Canada anemone	S5	8	173	
Anemone multifida Poir.	Cut-leaved anemone	S5	6	20	
Anemone parviflora Michx.	Northern anemone	S4	2	28	Near range limit

Scientific Name[1]	**Common Name**	**MBCDC S-Rank[2]**	**Number of Sample Locations in Keeyask RSA**	**Number of Sample Locations in Conawapa RSA[3]**	**Comments**
Anemone richardsonii Hook.	Yellow anemone	S3	0	2	
Antennaria pulcherrima (Hook.) Greene	Showy pussytoes	S4	1	26	
Antennaria rosea Greene ssp. *rosea*	Rosy pussytoes	SU	0	1	
Anthoxanthum hirtum (Schrank) Schouten & Veldkamp	Common sweet grass	S5	0	9	
Aquilegia brevistyla Hook.	Blue columbine	S4	3	36	
Aralia nudicaulis L.	Wild sarsaparilla	S5	3	2	Near range limit
Arctuous alpina (L.) Niedenzu	Alpine Bearberry	S5	69	546	
Arctuous rubra (Rehd. & Wilson) Nakaj	Bearberry	S5	0	1	Difficult to ID without mature berries
Arctostaphylos uva-ursi (L.) Spreng.	Common bearberry	S5	49	238	
Argentina anserina (L.) Rydb.	Silverweed	S5	66	159	
Argentina egedii (Wormsk.) Rydb.	Egede's cinquefoil	S2	0	1	
Arnica angustifolia Vahl	Narrowleaf arnica	S4	0	1	
Artemisia biennis Willd.	Biennial wormwood	S5	4	1	
Artemisia tilesii Ledeb.	Mountain sagewort	S2	0	105	
Astragalus agrestis Dougl. ex G. Don	Milkvetch	S5	0	7	
Astragalus alpinus L.	Alpine milk-vetch	S5	0	1	
Astragalus americanus (Hook.) M. E. Jones	American milk-vetch	S3	9	48	
Astragalus eucosmus B. L. Robins.	Pretty milk-vetch	S4	0	6	

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Beckmannia syzigachne (Steud.) Fern	Slough grass	S5	14	5	
Betula glandulosa Michx.	Dwarf birch	S5	0	1	
Betula neoalaskana Sarg.	Alaskan birch	S5	1	1	Included with *Betula papyrifera*, not differentiated in field due to difficulty in doing so
Betula occidentalis Hook.	Water birch	S4S5	0	2	
Betula papyrifera Marsh.	White birch	S5	197	181	
Betula pumila L.	Swamp Birch	S5	236	505	
Bidens cernua L.	Smooth beggar-ticks	S5	17	0	
Bistorta vivipara (L.) S. F. Gray	Alpine bistort	S4	0	5	
Botrychium lunaria (L.) Sw.	Moonwort	S4	0	1	
Bromus inermis Leyss.	Smooth brome grass	SNA	6	1	Introduced species
Calamagrostis canadensis (Michx.) Nutt.	Marsh reed-grass	S5	342	694	
Calamagrostis stricta ssp. *inexpansa* (Gray) C. W. Greene	Northern reed-grass	S5	2	8	
Calamagrostis stricta (Timm) Koeler ssp. *stricta*	Narrow reed-grass	S5	45	7	
Calla palustris L.	Wild calla	S5	25	4	
Callitriche hermaphroditica L.	Northern water-starwort	S5	2	0	

Scientific Name[1]	**Common Name**	**MBCDC S-Rank[2]**	**Number of Sample Locations in Keeyask RSA**	**Number of Sample Locations in Conawapa RSA[3]**	**Comments**
Callitriche palustris L.	Vernal water-starwort	S5	3	1	
Caltha palustris L.	Marsh-marigold	S5	18	11	
Calypso bulbosa (L.) Oakes	Venus'-slipper	S4	3	3	Near range limit
Campanula rotundifolia L.	Harebell	S5	2	34	
Cardamine pensylvanica Muhl. ex Willd.	Bitter-cress	S5	8	0	
Carex aquatilis Wahl.	Water sedge	S5	331	419	
Carex atherodes Spreng.	Awned sedge	S5	2	15	
Carex aurea Nutt.	Golden sedge	S5	1	9	
Carex bebbii Olney ex Fern.	Bebb's sedge	S5	4	1	
Carex brunnescens (Pers.) Poir.	Brownish sedge	S5	3	0	
Carex buxbaumii Wahlenb.	Brown sedge	S4S5	5	0	
Carex canescens L.	Hoary sedge	S5	37	10	
Carex capillaris L.	Hair-like sedge	S5	10	29	
Carex chordorrhiza Ehrh. ex L.	Prostrate sedge	S5	53	61	
Carex concinna R. Br.	Beautiful sedge	S4S5	42	257	
Carex deflexa Hornem.	Bent sedge	S5	2	1	
Carex diandra Schrank	Lesser panicled sedge	S5	25	6	
Carex disperma Dewey	Two-seeded sedge	S5	13	19	
Carex eburnea Boott	Bristleleaf sedge	S4S5	0	10	
Carex foenea Willd.	Silvery-flowered sedge	S5	4	4	
Carex gynocrates Wormsk. ex Drej.	Northern bog sedge	S5	27	52	

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Carex houghtoniana Torr.	Sand sedge	S5	1	0	
Carex interior Bailey	Inland sedge	S4?	0	2	
Carex lacustris Willd.	Lakeshore sedge	S5	2	0	
Carex lenticularis Michx.	Lens-fruited sedge	S5	3	0	
Carex leptalea Wahlenb.	Bristle-stalked sedge	S5	10	12	
Carex limosa L.	Mudge sedge	S5	0	5	
Carex magellanica Lam.	Bog Sedge	S5	94	87	
Carex media R. BR.	Closedhead sedge	S5	0	1	
Carex pauciflora Lightf.	Few-flowered sedge	S3	0	1	
Carex pellita Muhl. ex Willd.	Wooly sedge	S5	14	3	
Carex sartwellii Dewey	Sartwell's sedge	S4	6	0	
Carex saxatilis L.	Rock sedge	S4	0	3	
Carex scirpoidea Michx.	Rush-like sedge	S5	13	49	
Carex sychnocephala Carey	Long-beaked sedge	S4?	4	0	
Carex tenuiflora Wahlenb.	Thin-flowered sedge	S5	1	4	
Carex trisperma Dew.	Three-seeded sedge	S5	1	1	
Carex utriculata Boott	Bottle sedge	S5	101	18	
Carex vaginata Tausch	Sheathed sedge	S5	65	217	
Castilleja raupii Pennell	Purple paintbrush	S4	0	27	
Ceratophyllum demersum L.	Coontail	S5	3	0	
Chamaedaphne calyculata (L.) Moench	Leather-leaf	S5	268	257	
Chamerion angustifolium (L.) Holub	Fireweed	S5	223	912	

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Chamerion latifolium (L.) Holub	Broad-leaved willowherb	S3	0	8	
Chenopodium album L.	Lamb's-quarters	SNA	2	3	Introduced species
Chenopodium capitatum (L.) Ambrosi var. *capitatum*	Strawberry-blite	S5	2	2	
Chenopodium glaucum L. var. *salinum* (Standl.) Boivin	Oakleaf goosefoot	SNA	11	0	Introduced species
Cicuta bulbifera L.	Bulb-bearing water-hemlock	S5	33	4	
Cicuta maculata L.	Spotted cowbane	S5	7	5	
Cicuta virosa L.	Mackenzie's water-hemlock	S4	1	0	
Cirsium arvense (L.) Scop.	Canada thistle	SNA	1	0	Introduced species
Coeloglossum viride (L.) Hartman	Bracted bog-orchid	S5	0	1	
Comarum palustre L.	Marsh-five-finger	S5	146	54	
Coptis trifolia (L.) Salisb.	Goldthread	S5	2	3	
Corallorhiza trifida Chat.	Early coral-root	S5	6	10	
Cornus canadensis L.	Bunchberry	S5	216	278	
Cornus sericea L.	Red osier dogwood	S5	46	557	
Corydalis aurea Willd.	Golden corydalis	S5	0	4	
Corydalis sempervirens (L.) Pers.	Pink corydalis	S5	4	1	
Crepis elegans Hook.	Elegant hawk's-beard	S1S2	9	2	Near range limit

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Crepis tectorum L.	Narrow-leaved hawk's-beard	SNA	6	0	Introduced species
Cypripedium parviflorum Salisb. var. *pubescesns* (Willd.) Knight	Yellow lady's-slipper	S5?	1	0	
Cypripedium passerinum Richards.	Sparrow's-egg lady's-slipper	S4	0	30	
Danthonia intermedia Vasey	Poverty oat-grass	S2?	0	1	
Danthonia spicata (L.) Beauv. Ex Roemer & J. A. Schultes	Poverty oat-grass	S5	3	4	
Dasiphora fruticosa (L.) Rydb. ssp. *floribunda* (Pursh) Kartesz	Shrubby cinquefoil	S5	5	328	
Delphinium elatum L.	Candle larkspur	SNA	0	1	
Deschampsia cespitosa (L.) Beauv.	Tufted hair grass	S5	0	2	
Descurainia sophia (L.) Webb ex Prantl	Flixweed	SNA	0	1	
Diphasiastrum complanatum (L.) Holub	Ground-cedar	S5	24	24	
Dracocephalum parviflorum Nutt.	American dragonhead	S5	1	0	
Drosera anglica Huds.	Oblong-leaved sundew	S3	5	22	
Drosera linearis Goldie	Slender-leaved sundew	S2	0	2	
Drosera rotundifolia L.	Round-leaved sundew	S5	89	101	
Elaeagnus commutata Bernh. ex Rydb.	Wolf-willow	S4	10	104	
Eleocharis acicularis (L.) Roemer & J. A. Schultes	Needle spike-rush	S5	87	11	

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Eleocharis palustris (L.) Roemer & J. A. Schultes	Creeping spike-rush	S5	79	13	
Eleocharis quinqueflora (F.X. Hartmann) Schwarz	Few-flowered spike-rush	S4	1	3	
Elodea canadensis Michx.	Canada waterweed	S5	2	0	
Elymus repens (L.) Gould	Quack grass	SNA	2	1	Introduced species
Elymus trachycaulus (Link) Gould ex Shinners ssp. *trachycaulus*	Slender wheat-grass	S5	12	95	
Empetrum nigrum L.	Black crowberry	S5	65	159	
Epilobium ciliatum Raf.	Northern willowherb	S5	8	1	
Epilobium ciliatum ssp. *glandulosum* (Lehm.) Hoch & Raven	Northern willowherb	S5	48	1	
Epilobiuim ciliatum ssp. *watsonii* (Barbey) Hoch & Raven	Northern willowherb	SU	0	2	
Epilobium leptophyllum Raf.	Marsh willow-herb	S5	1	1	
Epilobium palustre L.	Marsh willow-herb	S5	30	13	
Equisetum arvense L.	Common or Field horsetail	S5	260	1311	
Equisetum fluviatile L.	Water horsetail	S5	166	115	
Equisetum palustre L.	Marsh horsetail	S4S5	1	0	
Equisetum pratense Ehrh.	Meadow horsetail	S4S5	3	2	
Equisetum scirpoides Michx.	Dwarf scouring rush	S5	154	465	

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Equisetum sylvaticum L.	Wood horsetail	S5	175	134	
Equisetum variegatum Schleich. ex F. Weber & D. M. H. Mohr	Variegated scouring-rush	S5	9	10	
Erigeron elatus (Hook.) Greene	Tall fleabane	S4	1	0	
Erigeron hyssopifolius Michx.	Wild daisy	S4	2	21	
Erigeron philadelphicus L.	Philadelphia fleabane	S5	0	4	
Eriophorum angustifolium Honckeny	Tall cotton-grass	S5	1	2	
Eriophorum chamissonis C. A. Mey.	Russet cotton-grass	S5	2	1	
Eriophorum gracile W.D.J Koch	Slender cotton-grass	S5	2	2	
Eriophorum vaginatum L.	Sheathed cotton-grass	S5	14	31	
Eriophorum viridicarinatum (Engelm.) Fern	Thin-leaved cotton-grass	S4	1	2	
Erysimum cheiranthoides L.	Wormseed-mustard	SNA	0	1	
Eschscholzia californica Cham.	California poppy	(blank)	0	1	
Euphrasia arctica Lange ex Rostrup	Northern eyebright	SU	1	7	
Euthamia graminifolia	Flat-topped goldenrod	S5	0	4	
Eutrochium maculatum (L.) Lamont var. bruneri	Spotted joe-pye weed	S5	0	3	
Festuca rubra L.	Red-fescue	S5	2	24	
Festuca saximontana Rydb.	Rocky mountain fescue	S5	2	0	
Fragaria vesca L.	Woodland strawberry	S4S5	1	1	
Fragaria virginiana Dcne.	Smooth wild strawberry	S5	44	344	

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Galium boreale L.	Northern bedstraw	S5	3	194	
Galium labradoricum (Wieg.) Wieg.	Ladies' bedstraw	S5	22	4	
Galium palustre L.	Common marsh bedstraw	SU	1	0	
Galium trifidum L.	Small bedstraw	S5	96	34	
Galium triflorum Michx.	Sweet-scented bedstraw	S5	1	2	
Gentianella amarella (L.) Boerner	Northern gentian	S5	5	23	
Geocaulon lividum (Richards.) Fern.	Northern comandra	S5	111	523	
Geranium bicknellii Britt.	Bicknell's geranium	S5	1	1	
Glaux maritima L.	Sea-milkwort	S4S5	2	0	
Glyceria borealis (Nash) Batchelder	Small floating manna-grass	S5	26	1	
Glyceria grandis S. Wats.	Tall manna-grass	S5	3	0	
Glyceria striata (Lam.) A. S. Hitchc.	Fowl manna grass	S5	3	2	
Goodyera repens (L.) R. Br. ex Ait.	Lesser rattlesnake-plantain	S5	1	4	
Halenia deflexa (Sm.) Griseb.	Spurred gentian	S5	0	3	
Hedysarum boreale Nutt.	Northern hedysarum	S4	0	3	
Heracleum maximum Bartr.	Cow-parsnip	S5	0	15	
Hieracium umbellatum L.	Canada hawkweed	S5	0	6	
Hippuris tetraphylla L. f.	Four-leaved mare's-tail	S3S4	0	4	
Hippuris vulgaris L.	Mare's-tail	S5	24	3	

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Hordeum jubatum L.	Wild barley	S5	28	28	Invasive species
Isoetes echinospora Durieu	Quillwort	S4?	7	0	
Juncus alpinoarticulatus Chaix	Alpine rush	S5	2	10	
Juncus arcticus Willd. var. *balticus* (Willd.) Traut.	Wire rush	S5	13	87	
Juncus bufonius L.	Toad rush	S5	12	2	
Juncus castaneus Sm.	Chestnut rush	S3?	0	2	
Juncus dudleyi Wieg.	Dudley's rush	S5	14	0	
Juncus filiformis L.	Thread rush	S5?	2	0	
Juncus nodosus L.	Knotted rush	S5	14	6	
Juniperus communis L.	Common juniper	S5	39	277	
Juniperus horizontalis Moench	Creeping juniper	S5	7	7	
Kalmia polifolia Wang.	Bog-laurel	S5	143	123	
Larix laricina (Du Roi) Koch	Tamarack	S5	220	439	
Lathyrus ochroleucus Hook.	Cream-coloured vetchling	S4S5	0	7	
Lathyrus palustris L.	Marsh vetchling	S5	15	137	
Lathyrus venosus Muhl. ex Willd.	Wild peavine	S5	3	2	
Lemna minor L.	Duckweed	SNA	2	0	
Lemna trisulca L.	Star-duckweed	S5	4	0	
Leucanthemum vulgare Lam.	Ox-eye Daisy	SNA	1	3	Introduced species

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Leymus innovatus (Beal) Pilger	Hairy wild rye	S5	0	73	
Limosella aquatica L.	Mudwort	S4S5	5	0	
Linnaea borealis L.	Twinflower	S5	140	609	
Listera borealis Morong	Northern twayblade	S2	0	3	
Listera cordata (L.) R. Br. var. cordata	Heart-leaved twayblade	S4?	2	5	
Lobelia kalmii L.	Kalm's lobelia	S5	2	0	
Lonicera dioica L.	Twining honeysuckle	S5	2	25	Near range limit
Lonicera dioica L. var. *glaucescens* (Rydb.) Butters	Twining honeysuckle	S5	0	2	
Lonicera involucrata Banks ex Spreng.	Black twinberry	S4	0	2	
Lonicera oblongifolia (Goldie) Hook.	Swamp -fly-honeysuckle	S4	0	1	
Lonicera villosa (Michx.) J. A. Schultes	Fly honeysuckle	S5	23	4	
Luzula parviflora (Ehrh.) Desv.	Small-flowered wood-rush	S5	1	2	
Lycopodium annotinum L.	Stiff club-moss	S5	31	10	
Lycopodium clavatum L.	Running club-moss	S4	12	1	
Lycopodium dendroideum Michx.	Ground-pine	S5	1	8	Near range limit
Lycopus americanus Muhl. ex W. Bart.	Water-hore-hound	S5	37	0	
Lycopus uniflorus Michx.	Water-hore-hound	S5	27	2	
Lysimachia thyrsiflora L.	Tufted loosestrife	S5	18	7	
Maianthemum stellatum (L.) Link	Star-flowered Solomon's-seal	S5	1	44	

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Maianthemum trifolium (L.) Sloboda	Three-leaved Solomon's-seal	S5	162	150	
Matricaria discoidea DC.	Pineappleweed	SNA	1	0	Introduced species
Medicago sativa L.	Alfalfa	SNA	0	1	Introduced species
Melampyrum lineare Desr.	Cow-wheat	S5	0	1	
Melilotus albus Medik.	White sweet clover	SNA	30	6	Introduced species
Melilotus officinalis (L.) Lam.	Yellow sweet clover	SNA	4	1	Introduced species
Mentha arvensis L.	Common mint	S5	40	12	
Menyanthes trifoliata L.	Bogbean	S5	49	88	
Mertensia paniculata (Ait.) Don	Tall lungwort	S5	45	301	
Mitella nuda L.	Bishop's-cap	S5	77	259	
Moehringia lateriflora (L.) Fenzl	Grove-sandwort	S5	3	14	
Moneses uniflora (L.) Gray	One-flowered wintergreen	S5	0	16	
Muhlenbergia glomerata (Willd.) Trin.	Bog muhly	S4	1	1	Near range limit
Muhlenbergia richardsonis (Trin.) Rydb.	Mat muhly	S4	0	1	
Myrica gale L.	Sweet gale	S5	78	63	
Myriophyllum sibiricum Komarov	Spiked water-milfoil	S5	92	0	

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Najas flexilis (Willd.) Rostk. & Schmidt	Slender naiad	S4	2	0	
Nuphar variegata Dur.	small yellow pond-lily	S5	67	0	Near range limit
Orthilia secunda (L.) House	One-sided pyrola	S5	74	321	
Oryzopsis asperifolia Michx.	White-grained mountain-rice grass	S5	6	15	
Oxytropis borealis DC.	Locoweed	SU	0	1	
Oxytropis campestris (L.) DC. var. varians (Rydb.)	Field locoweed	SU	5	5	
Oxytropis splendens Dougl. ex Hook.	Showy locoweed	S4	0	2	
Packera paupercula (Michx.) A. & D. Love	Balsam groundsel	S5	3	31	
Parnassia kotzebuei Cham. ex Spreng.	Small grass-of-parnassus	S4	1	0	
Parnassia palustris L. var. *tenuis* Wahlenb.	Grass-of-Parnassus	S4	26	54	
Pedicularis lapponica L.	Lapland lousewort	S2S3	0	1	
Pedicularis macrodonta Richards.	Swamp lousewort	S2	0	12	
Persicaria amphibia (L.) Gray	Water smartweed	S5	69	26	
Persicaria lapathifolia (L.) S. F. Gray	Pale persicaria	S5	36	3	
Petasites frigidus (L.) Fries var. *palmatus* (Ait.) Cronq.	Palmate-leaved colt's-foot	S5	106	183	
Petasites frigidus (L.) Fries var. *sagittatus* (Banks ex Pursh) Cherniawsky	Arrow-leaved colt's-foot	S5	11	25	

Scientific Name[1]	**Common Name**	**MBCDC S-Rank[2]**	**Number of Sample Locations in Keeyask RSA**	**Number of Sample Locations in Conawapa RSA[3]**	**Comments**
Petasites frigidus (L.) Fries var. x *vitifolius* (Greene) Cherniawsky	Vine-leaved colt's-foot	SNA	0	3	
Phacelia franklinii (R. Br.) Gray	Franklin's scorpionweed	S5	0	1	
Phalaris arundinacea L.	Reed-canary-grass	S5	27	9	Introduced species
Picea glauca (Moench.) Voss	White spruce	S5	16	520	
Picea mariana (Mill.) BSP	Black spruce	S5	638	1610	
Pinguicula villosa L.	Hairy butterwort	S3S4	41	21	
Pinguicula vulgaris L.	Common butterwort	S5	1	8	
Pinus banksiana Lamb.	Jack pine	S5	104	56	
Piptatherum pungens (Torr. ex Spreng.) Dorn	Northern rice grass	S5	17	41	
Plantago major L.	Common plantain	SNA	24	2	Introduced species
Platanthera aquilonis Sheviak	Northern green bog-orchid	SNA	5	17	
Platanthera dilatata (Pursh) Lindl. ex Beck	Tall white bog-orchid	S4	0	2	
Platanthera obtusata (Banks ex Pursh) Lindl.	Blunt-leaf orchid	S5	0	22	
Poa glauca Vahl	Glaucous poa.	S5	0	3	
Poa palustris L.	Fowl bluegrass	S5	17	54	
Poa pratensis L.	Kentucky bluegrass	S5	0	7	

Scientific Name[1]	**Common Name**	**MBCDC S-Rank[2]**	**Number of Sample Locations in Keeyask RSA**	**Number of Sample Locations in Conawapa RSA[3]**	**Comments**
Polygonum aviculare L. ssp. *depressum* (Meisner) Arcangeli	Common knotweed	SNA	8	0	Introduced species
Populus balsamifera L.	Balsam-poplar	S5	62	947	
Populus tremuloides Michx.	Trembling aspen	S5	58	302	
Potamogeton gramineus L.	Various-leaved pondweed	S5	78	1	
Potamogeton praelongus Wulfen	White-stemmed pondweed	S5	1	0	
Potamogeton pusillus L. ssp. *tenuissimus* (Mert. & W.D.J. Koch) Haynes & C. B. Hellquist	small pondweed	S2	27	0	
Potamogeton richardsonii (Benn.) Rydb.	Richardson's pondweed	S5	81	0	
Potamogeton robbinsii Oakes	Robbin's pondweed	S2	20	0	
Potamogeton zosteriformis Fernald	Flatstem pondweed	S5	24	0	
Potentilla norvegica L.	Rough cinquefoil	S5	26	0	
Primula egaliksensis Wormsk. ex Hornem.	Greenland primrose	S4	0	1	
Primula incana M. E. Jones	Mealy primrose	S4	0	4	
Primula mistassinica Michx.	Bird's-eye primrose	S5	7	8	
Primula stricta Hornem.	Erect primrose	S3	0	1	
Prunus pensylvanica L.	Pin-cherry	S5	4	20	
Puccinellia nuttalliana (Schultes) Hitchc.	Nuttall's alkali grass	S5	1	0	

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Puccinellia phryganodes (Trin.) Scribn. & Merr.	Salt-meadow grass	S3	0	3	
Pyrola asarifolia Michx.	Pink pyrola	S5	41	223	
Pyrola chlorantha Sw.	Greenish-flowered wintergreen	S5	6	68	
Pyrola grandiflora Radius	Arctic wintergreen	S4	3	21	Near range limit
Ranunculus aquatilis L.	Large-leaved white water-crowfoot	S5	46	0	
Ranunculus cymbalaria Pursh	Seaside buttercup	S5	5	2	
Ranunculus flammula L.	Creeping spearwort	S5	23	1	
Ranunculus gmelinii DC.	Yellow water-crowfoot	S5	2	1	
Ranunculus hyperboreus Rottb.	Boreal buttercup	S1	0	3	
Ranunculus lapponicus L.	Lapland buttercup	S5	7	12	
Ranunculus pensylvanicus L.	Bristly crowfoot	S5	5	0	
Ranunculus sceleratus L.	Cursed crowfoot	S5	6	0	
Rhamnus alnifolia L'Her.	Alder-leaved buckthorn	S5	20	294	
Rhinanthus minor L. ssp. *groenlandicus* (Ostenf.) L. Neum.	Arctic rattlebox	S4	0	18	
Rhinanthus minor L. ssp. *minor*	Little yellow rattle	S4	0	3	
Rhododendron groenlandicum (Oeder) Kron & Judd	Labrador-tea	S5	627	1523	
Rhododendron tomentosum (Harmaja) G. Wallace	Northern labrador-tea	S4	7	221	Near range limit

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Rhynchospora alba (L.) Vahl	White beak-rush	S3?	0	6	
Ribes americanum P. Mill.	Wild black currant	S5	0	12	
Ribes glandulosum Grauer	Skunk currant	S5	15	6	
Ribes hudsonianum Richards.	Northern black currant	S5	31	74	
Ribes lacustre (Pers.) Poir.	Bristly black currant	S4	3	70	
Ribes oxyacanthoides L.	Northern gooseberry	S5	11	112	
Ribes triste Pall.	Red currant	S5	66	285	
Rorippa palustris (L.) Besser	Bog yellowcress	S5	46	8	
Rosa acicularis Lindl.	Prickly rose	S5	199	936	
Rubus arcticus L.	Stemless raspberry	S5	121	310	
Rubus chamaemorus L.	Cloudberry	S5	178	304	
Rubus idaeus L.	Red raspberry	S5	30	123	
Rubus pubescens Raf.	Dewberry	S5	55	356	
Rubus x *paracaulis* Bailey		SNA	0	6	
Rumex crispus L.	Curly-leaf dock	SNA	1	0	Introduced species
Rumex fueginus Phil.	Golden dock	S5	14	0	
Sagina nodosa (L.) Fenzl	Knotted pearlwort	S4	1	1	
Sagittaria cuneata Sheldon	Arum-leaved arrowhead	S5	34	0	
Salix arbusculoides Anderss.	Shrubby willow	S3	39	744	Near range limit
Salix bebbiana Sarg.	Bebb's willow	S5	213	780	
Salix candida Fluegge ex Willd.	Hoary willow	S5	14	23	

Scientific Name[1]	**Common Name**	**MBCDC S-Rank[2]**	**Number of Sample Locations in Keeyask RSA**	**Number of Sample Locations in Conawapa RSA[3]**	**Comments**
Salix discolor Muhl.	Pussy-willow	S5	0	1	
Salix exigua Nutt.	Sandbar willow	S5	0	39	
Salix glauca L.	Grey-leaved willow	S4?	34	602	
Salix lucida Muhl. ssp. *lasiandra* (Benth.) E. Murr.	Shining willow	S5	0	3	
Salix myrtillifolia Anderss.	Myrtle-leaved willow	S5	150	563	
Salix pedicellaris Pursh	Bog willow	S5	63	43	
Salix pellita Anderss.	Satin willow	S4	73	457	
Salix planifolia Pursh.	Flat-leaved willow	S5	241	230	Includes S. discolor and hybrids of S. planifolia and S. discolor
Salix pseudomonticola Ball	False Mountain Willow	S4S5	6	566	
Salix pseudomyrsinites Anderss.	Tall blueberry willow	S5	26	646	
Salix reticulata L.	Net-veined willow	S3	0	1	
Salix serissima (Bailey) Fern.	Autumn willow	S4	4	2	
Salix vestita Pursh.	Rock willow	S3	28	397	Near range limit
Sarracenia purpurea L.	Pitcher-plant	S5	1	12	
Scheuchzeria palustris L.	Podgrass	S4?	16	12	
Schoenoplectus tabernaemontani K. C. Gmel.	Viscid great-bulrush	S5	73	0	
Scirpus atrocinctus Fern.	Wool-grass	S5	0	7	

Scientific Name[1]	**Common Name**	**MBCDC S-Rank**[2]	**Number of Sample Locations in Keeyask RSA**	**Number of Sample Locations in Conawapa RSA**[3]	**Comments**
Scirpus microcarpus J. & K. Presl	Small-fruited bulrush	S5	0	2	
Scutellaria galericulata L.	Common skullcap	S5	22	1	
Selaginella selaginoides (L.) P. Beauv. ex Mart.& Shrank	Club spikemoss	S2	0	19	
Shepherdia canadensis (L.) Nutt.	Canada buffalo-berry	S5	48	600	
Sibbaldiopsis tridentata (Ait.) Rydb.	Three-toothed cinquefoil	S5	2	11	
Silene csereii Baumg.	Smooth catchfly	SNA	4	0	
Sisyrinchium montanum Greene var. *montanum*	Blue-eyed grass	S5	0	1	
Sium suave Walt.	Water-parsnip	S5	74	3	
Solidago canadensis L.	Canada goldenrod	S5	0	27	
Solidago hispida Muhl.	Hairy goldenrod	S5	30	36	Near range limit
Solidago multiradiata Ait.	Northern goldenrod	S5	9	116	
Solidago simplex Kunth	Mt. Albert goldenrod	SU	2	67	
Sonchus arvensis L.	Perennial sow thistle	SNA	8	11	
Sparganium angustifolium Michx.	Narrow-leaved bur-reed	S5	71	2	
Sparganium natans L.	Small bur-reed	S5	1	0	
Spiranthes romanzoffiana Cham.	Hooded ladies'-tresses	S5	8	2	
Stachys palustris L.	Marsh hedge-nettle	S5	10	2	
Stellaria crassifolia Ehrh.	Fleshy stitchwort	S4	19	1	
Stellaria longifolia Muhl. ex Willd.	Long-leaved stitchwort	S5	14	6	
Stellaria longipes Goldie ssp. *longipes*	Long-stalked stitchwort	S5	5	25	

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Stuckenia pectinata (L.) Boerner	Sago pondweed	S5	1	0	
Stuckenia vaginata (Turcz.) Holub	Sheathed pondweed	S5	1	0	
Symphoricarpos albus (L.) Blake	Snowberry	S5	1	0	
Symphyotrichum boreale (Torr. & Gray) A. & D. Love	Rush aster	S5	3	14	
Symphyotrichum ciliatum (Ledeb.) G.L.Nesom	Rayless aster	SU	6	0	
Symphyotrichum ciliolatum (Lindl.) A. & D. Love	Lindley's aster	S5	32	23	
Symphyotrichum lanceolatum (Willd.) G. L. Nesom var. *hesperium* (A. Gray) G. L. Nesom	Willow aster	S4	0	4	
Symphyotrichum lanceolatum (Willd.) G. L. Nesom var. *lanceolatum*	Small blue aster	S5	0	11	
Symphyotrichum puniceum (L.) A. & D. Love var. *puniceum*	Purple-stemmed aster	S5	6	40	
Tanacetum bipinnatum (L.) Sch. Bip.	Lake Huron tansy	S3	0	27	
Taraxacum officinale Weber.	Common dandelion	S5	32	78	Introduced species
Thalictrum venulosum Trel.	Veiny meadow-rue	S5	15	345	
Tofieldia pusilla (Michx.) Pers.	Scotch false asphodel	S4	1	9	
Triantha glutinosa (Michx.) Baker	Sticky asphodel	S5	0	9	
Trichophorum alpinum (L.) Pers.	Alpine cotton-grass	S5	30	59	

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Trichophorum cespitosum (L.) Hartman	Tufted bulrush	S4	4	8	
Trifolium hybridum L.	Alsike clover	SNA	5	0	
Trifolium pratense L.	Red clover	SNA	0	5	
Triglochin maritima L.	Sea-side arrow-grass	S5	14	31	
Triglochin palustris L.	Marsh arrow-grass	S5	0	4	
Trisetum spicatum (L.) K. Richt.	Spike trisetum	S4	0	1	
Typha latifolia L.	Common cat-tail	S5	9	0	
Urtica dioica L.	Stinging nettle	S5	0	4	
Utricularia cornuta Michx.	Horned bladderwort	S3	0	1	
Utricularia intermedia Hayne	Flat-leaved bladderwort	S5	25	11	
Utricularia macrorhiza Le Conte	Common bladderwort	S5	43	1	
Vaccinium myrtilloides Michx.	Velvet-leaf blueberry	S5	98	16	
Vaccinium oxycoccos L.	Small bog cranberry	S5	202	198	
Vaccinium uliginosum L.	Bog bilberry	S5	309	986	
Vaccinium vitis-idaea L.	Rock cranberry	S5	392	844	
Veronica peregrina (L.)	Neckweed	S5	19	0	
Veronica scutellata L.	Marsh-speedwell	S4S5	0	1	
Viburnum edule (Michx.) Raf.	Low bush-cranberry	S5	90	487	
Vicia americana Muhl. ex Willd.	American vetch	S5	0	72	
Vicia cracca L.	Tufted vetch	SNA	0	227	Introduced species

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Viola adunca Sm.	Early blue violet	S5	1	0	
Viola canadensis L.	Western Canada violet	S5	0	1	
Viola palustris L.	Marsh violet	S4S5	3	0	
Viola renifolia Gray	Kidney-shaped white violet	S5	16	23	
Zannichellia palustris L.	Horned pondweed	S3?	3	0	

Notes: [1] Nomenclature follows Flora of North America (FNA) where volumes currently exist for the genus and the Manitoba Conservation Data Centre elsewhere.
[2] Species S-Rank source: MBCDC, personal communication.
[3] Preliminary Regional Study Area boundaries for Conawapa.

Table 7A-7-40: Bryophytes and lichens recorded to species or genus during field studies in the LNR Region and number of locations in the Keeyask and Conawapa Regional Study Areas

Scientific Name[1]	Common Name	MBCDC S-Rank[2]	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[3]	Comments
Cladina mitis (Sandst.) Hustich	green reindeer lichen	Not ranked	350	587	
Cladina rangiferina (L.) Nyl.	grey reindeer lichen	Not ranked	189	379	
Cladina stellaris (Opiz) Brodo	northern reindeer lichen	Not ranked	128	283	
Cladina stygia (Fr.) Ahti	reindeer lichen	Not ranked	0	4	
Hylocomium splendens (Hedw.) Schimp.	stair-step moss	S4S5	347	1415	
Marchantia polymorpha L.	green-tongue liverwort	SNA	6	68	
Pleurozium schreberi (Brid.) Mitt.	big red stem	S4S5	494	959	
Ptilium crista-castrensis (Hedw.) De Not.	Knight's plume	S4S5	47	122	
Sphagnum spp.	peat mosses		379	572	
Moss spp.	other mosses		584	1413	
Cladonia spp.	cup lichens		282	500	
Peltigera spp.	leaf lichens		150	370	

Notes: [1] Nomenclature follows Flora of North America (FNA) where volumes currently exist for the genus and the Manitoba Conservation Data Centre elsewhere.
[2] Species S-Rank source: MBCDC, personal communication.
[3] Preliminary Regional Study Area boundaries for Conawapa.

Table 7A-7-41: Moss taxa identified in the lab from samples collected at inland plots in the LNR region, and number of locations in the Regional and Local study areas

Scientific Name*	Common Name	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[1]
Abietinella abietina (Hedw.) Fleisch.	wiry fern moss	0	11
Aulacomnium palustre (Hedw.) Schwagr.	tufted moss	52	108
Brachythecium albicans (Hedw.) Schimp.	brachythecium moss	0	1
Brachythecium spp.	brachythecium mosses	6	65
Bryhnia spp.	bryhnia mosses	0	1
Bryum argenteum Hedw.	silvergreen bryum moss	0	1
Bryum pseudotriquetrum (Hedw.) G. Gaertn., B. Mey. & Scherb.	common green gryum moss	1	0
Bryum spp.	bryum mosses	1	4
Callicladium haldanianum (Grev.) H.A. Crum	callicladium moss	1	0
Calliergon giganteum (Schimp.) Kindb.	giant water moss	5	9
Calliergon spp.	calliergon mosses	0	1
Calliergon stramineum (Brid.) Kindb.	straw-coloured water moss	2	2
Calliergon trifarium (F. Weber & D. Mohr) Kindb.	three-ranked feather moss	0	1
Campylium hispidulum (Brid.) Mitt.	hispid campylium moss	0	1
Campylium spp.	campylium mosses	0	1
Campylium stellatum (Hedw.) C.E.O. Jensen	yellow star moss	10	18
Catascopium nigritum (Hedw.) Brid.	catascopium moss	0	1
Ceratodon purpureus (Hedw.) Brid.	purple horn-toothed moss	2	46
Chara spp.		44	0

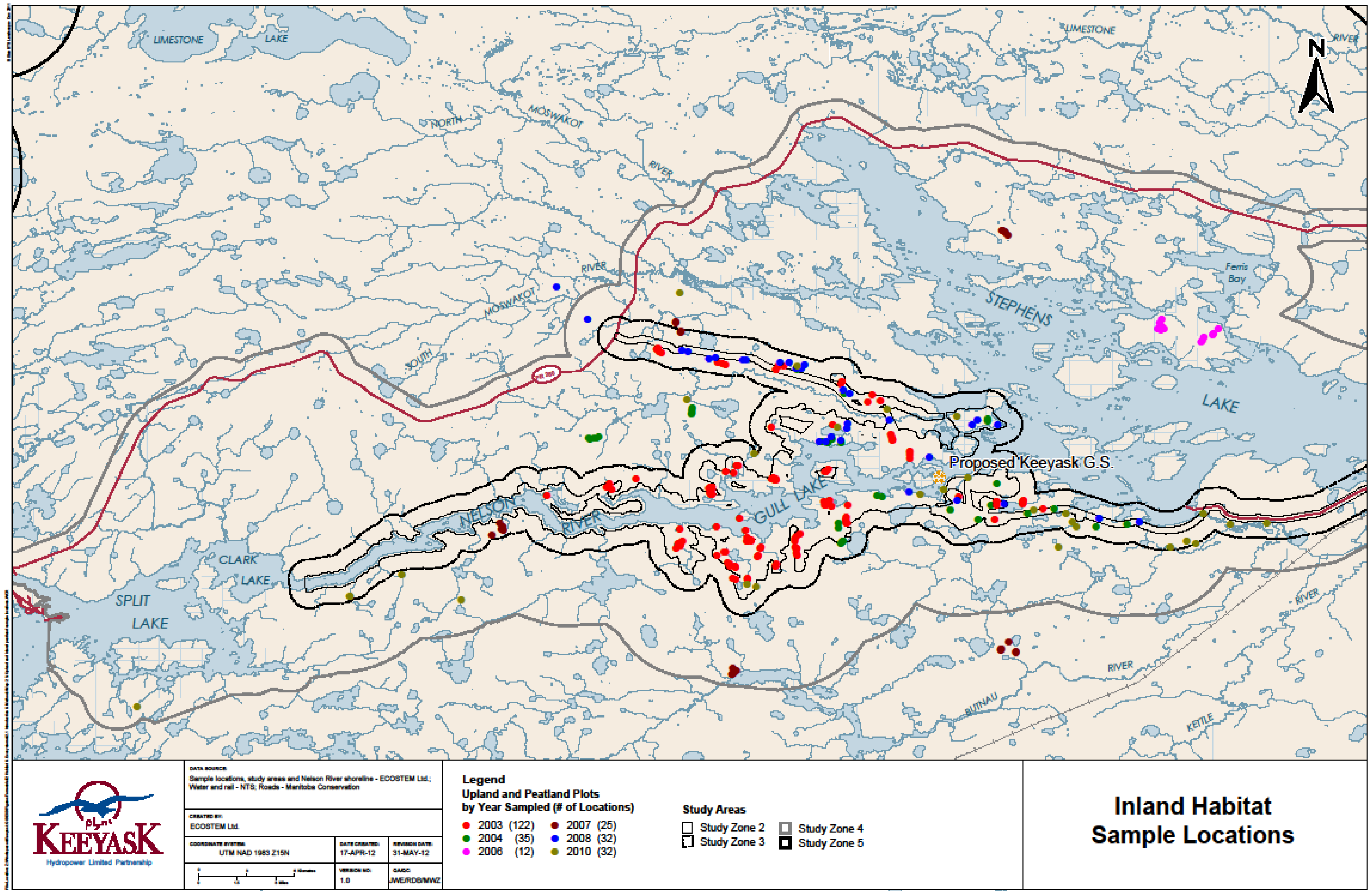
Scientific Name*	Common Name	Number of Sample Locations in Keeyask RSA	Number of Sample Locations in Conawapa RSA[1]
Climacium dendroides (Hedw.) F. Weber & D. Mohr	common tree moss	0	3
Dicranella spp.	dicranella mosses	0	1
Dicranum ontariense Peters	Ontario dicranum moss	0	1
Dicranum polysetum Sw.	electric eels	8	19
Dicranum scoparium Hedw.	dicranum moss	1	0
Dicranum spp.	dicranum mosses	94	137
Dicranum undulatum Brid.	wavy dicranum	4	8
Ditrichum flexicaule (Schwagr.) Hampe	ditrichum moss	1	0
Ditrichum spp.	ditrichum mosses	4	7
Drepanocladus aduncus (Hedw.) Warnst.	common hook moss	1	0
Drepanocldus revolvens (Sw.) Warnst.	limprichtia moss	9	5
Drepanocladus spp.	hook mosses	2	28
Eurhynchium pulchellum (Hedw.) Jenn.	eurhynchium moss	0	2
Funaria hygrometrica Hedw.	funaria moss	3	1
Funaria spp.	funaria moss	0	1
Hamatocaulis vernicosus (Mitt.) Hedenas	hamatocaulis moss	3	2
Helodium blandowii (F. Weber & D. Mohr) Warnst.	Blandow's feather moss	2	4
Hypnum lindbergii Mitt.	Lindberg's hypnum moss	1	2
Hypnum pratense (Rabenh.) Koch ex Spruce	hypnum moss	0	1
Hypnum spp.	hypnum mosses	1	19
Isopterygium spp.	isopterygium mosses	0	1
Leskea spp.	leskea mosses	1	0
Liverwort spp.	liverworts	2	7
Mniaceae spp.	mniaceae	0	1
Paludella squarrosa (Hedw.) Brid.	angled paludella moss	4	6
Peltigera spp.	peltigera lichens	150	370

Scientific Name*	**Common Name**	**Number of Sample Locations in Keeyask RSA**	**Number of Sample Locations in Conawapa RSA[1]**
Plagiomnium cuspidatum (Hedw.) T. Kop.	toothed plagiomnium moss	1	7
Pohlia nutans (Hedw.) Lindb.	copper wire moss	3	11
Pohlia spp.	pohlia mosses	5	10
Polytrichum juniperinum Hedw.	juniper hair-cap	12	13
Polytrichum spp.	polytrichum mosses	9	29
Polytrichum strictum Brid.	slender hair-cap	11	12
Pseudobryum cinclidioides (Hub.) T. Kop.	pseudobryum moss	1	0
Pylaisiella polyantha (Hedw.) Grout	stocking moss	0	1
Rhytidium rugosum (Hedw.) Kindb.	rhytidium moss	0	3
Sanionia uncinata (Hedw.) Loeske	sanionia moss	12	37
Sarmentypnum exannulatum (Schimp.) Hedenas	ringless hook-moss	1	1
Scorpidium scorpioides (Hedw.) Limpr.	sausage moss	3	9
Sphagnum angustifolium (C.E.O. Jensen ex Russow) C.E.O. Jensen	poor fen peat moss	33	41
Sphagnum capillifolium (Ehrh.) Hedw.	acute-leaved peat moss	82	143
Sphagnum cuspidatum Ehrh. ex Hoffm.	toothed peat moss	2	5
Sphagnum fallax (Klinggr.) Klinggr.	peat moss	1	0
Sphagnum fimbriatum Wilson	peat moss	1	0
Sphagnum flexuosum Dozy & Molk.	peat moss	0	1
Sphagnum fuscum (Schimp.) Klinggr.	rusty peat moss	111	96
Sphagnum lindbergii Schimp.	Lindberg's peat moss	1	6
Sphagnum magellanicum Brid.	midway peat moss	6	10

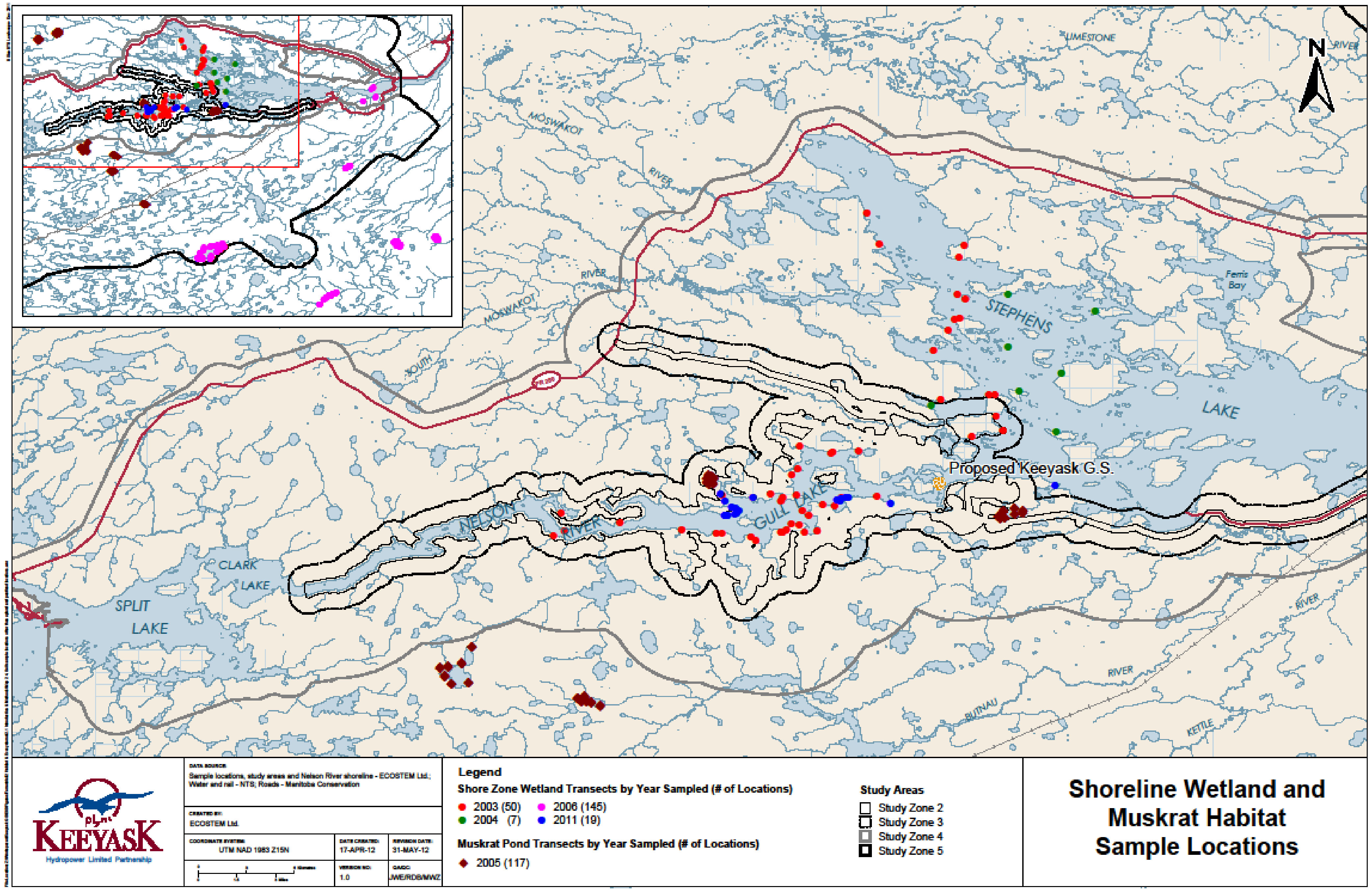
Scientific Name*	**Common Name**	**Number of Sample Locations in Keeyask RSA**	**Number of Sample Locations in Conawapa RSA[1]**
Sphagnum majus (Russow) C.E.O. Jensen	greater peat moss	1	2
Sphagnum pulchrum (Lindb. ex Braithw.) Warnst.	peat moss	0	1
Sphagnum riparium Angstr.	shore-growing peat moss	8	8
Sphagnum rubellum Wilson	peat moss	2	11
Sphagnum russowii Warnst.	wide-tongued peat moss	6	5
Sphagnum subsecundum Nees	peat moss	2	6
Sphagnum subtile (Russow) Warnst.	peat moss	0	1
Sphagnum tenellum (Brid.) Bory	peat moss	0	3
Sphagnum teres (Schimp.) Angstr.	thin-leafed peat moss	0	4
Sphagnum warnstorfii Russow	Warnstorf's peat moss	25	37
Thuidium delicatulum (Hedw.) Schimp.	thuidium moss	0	1
Thuidium recognitum (Hedw.) Lindb.	thuidium moss	0	2
Tomenthypnum falcifolium (Renauld ex Nicols) Tuom.	sickleleaf tomentypnum moss	0	2
Tomenthypnum nitens (Hedw.) Loeske	golden fuzzy fen moss	38	80
Tortella fragilis (Hook. & Wilson) Limpr.	fragile tortella moss	1	0
Torella spp.	tortella moss	0	2
Tortella tortuosa (Hedw.) Limpr.	twisted moss	0	1
Tortula ruralis (Hedw.) G. Gaertn., B. Mey & Scherb.	tortula moss	0	2
Ulota spp.	ulota moss	0	2
Warnstorfia fluitans (Hedw.) Loeske	warnstorfia moss	1	0

[1] Preliminary Regional Study Area boundaries for Conawapa.

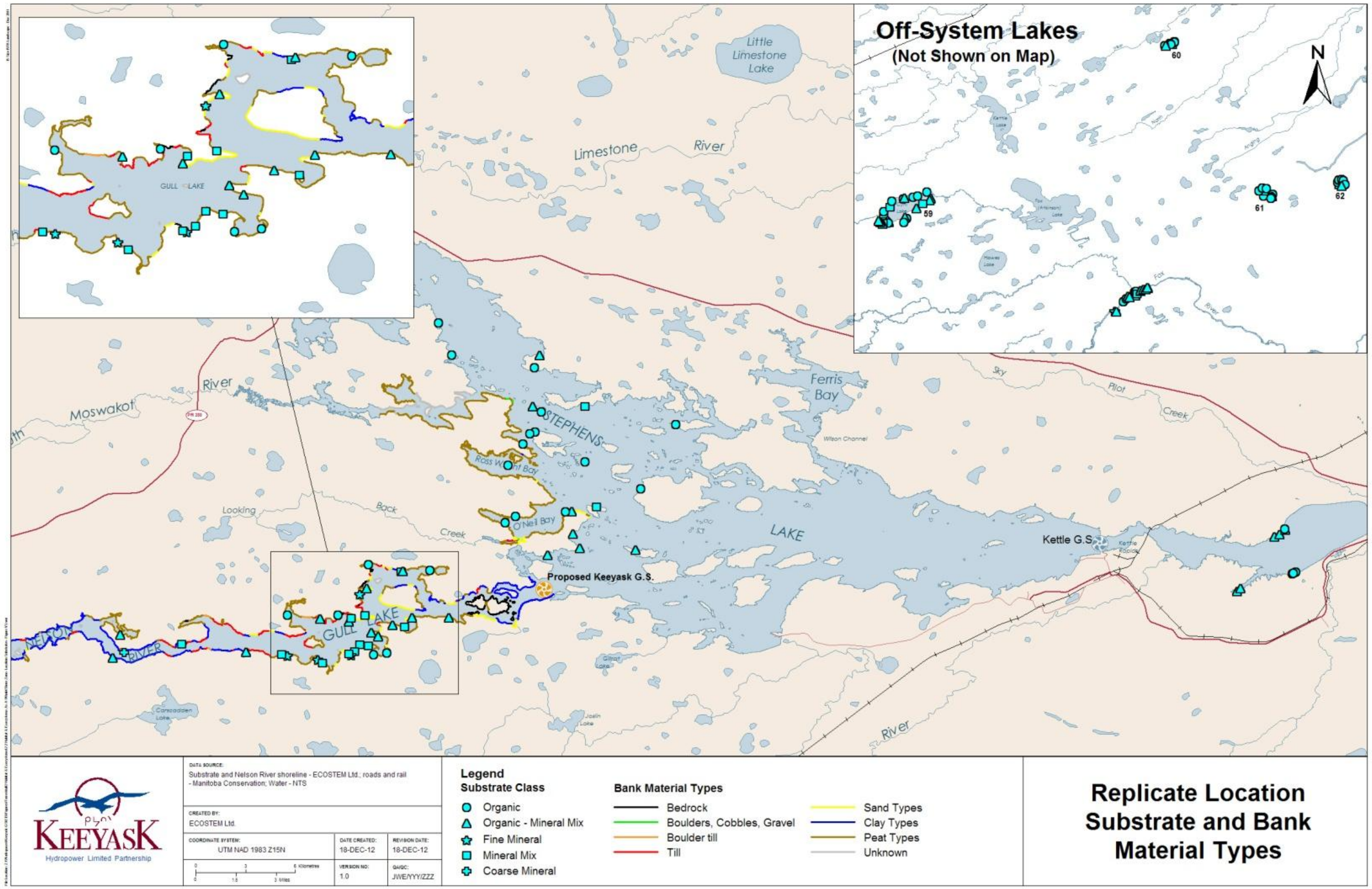
7.5 MAPS



Map 7-1: **Inland habitat sample locations**



Map 7-2: **Shore zone habitat sample locations**



Map 7-3: Substrate classes for each of the replicate locations in the Nelson River study areas and off-system waterbodies

8 GLOSSARY

Adaptive management: Involves the implementation of new or modified mitigation measures over the life of a project to address its unanticipated environmental effects (*Canadian Environmental Assessment Act*).

Aquatic environment: All organic and inorganic matter and living organisms and their habitats that are related to or are located in or on the water, beds, or shores of a water body.

Aquatic plant: Any plant adapted to grow in water or aqueous habitats.

Attribute: A readily definable and inherent characteristic of a plant, animal, or habitat.

Autotroph: An organism capable of synthesizing its own nutritional organic substances from inorganic compounds, such as CO_2, green plants, algae, and certain bacteria.

Bedrock: A general term for any solid rock, not exhibiting soil-like properties, that underlies soil or other surficial materials.

Benchmark: A reference or target condition or range of conditions that is used to evaluate the state or trend of an attribute of interest.

Benchmark area: A geographic area that has not been substantially affected by human activities. Benchmark areas were used to improve our understanding of local natural ecosystem patterns, processes and linkages.

Biomass: Total mass of living matter, within a given unit of area or volume.

Bio-physical land classification: A delineation of distinct areas on a map based on soil, surficial deposits, landforms, permafrost and water.

Blanket peatland: Bog, fen or mixtures of these types with peat of intermediate thickness (*i.e.*, up to approximately 2 m thick) and a featureless surface that cover gentle slopes.

Bog: One of five classes in the Canadian Wetland Classification System. A type of peatland that receives nutrient inputs from precipitation and dryfall (particles deposited from the atmosphere) only. Sphagnum mosses are the dominant peat forming plants. Commonly acidic and nutrient poor.

Boreal: Of or relating to the cold, northern, circumpolar area just south of the tundra, dominated by coniferous trees such as spruce, fir, or pine. Also called taiga.

Broad habitat type: The third coarsest level in the hierarchical habitat classification used for the terrestrial assessment. From coarsest to finest, the levels in the habitat classification system are land cover, coarse habitat type, broad habitat type and fine habitat type.

Brunisol: A soil order in the Canadian System of Soil Classification which includes soils that are not well developed but are more developed than regosols (must include a Bm, Btj, or Bfj horizon).

Bryophyte: A division of the plant kingdom that includes non-flowering plants characterized by rhizoids rather than true roots and having little or no organized vascular tissue and showing alternation of generations between gamete-bearing forms and spore-bearing forms. Includes mosses, liverworts and hornworts.

Buffer: An area surrounding a defined geographic area, usually created by locating a line a fixed distance around the area of interest.

Cause-effect linkage: The relationship between an event (the cause) and a second event (the effect) or subsequent event (an indirect effect), where the second event or subsequent event is a consequence of the first.

Churchill River Diversion (CRD): The diversion of water from the Churchill River to the Nelson River and the impoundment of water on the Rat River and Southern Indian Lake as authorized by the CRD Licence.

Coarse habitat type: The second coarsest level in the hierarchical habitat classification used for the terrestrial assessment. From coarsest to finest, the levels in the habitat classification system are land cover, coarse habitat type, broad habitat type and fine habitat type used for the terrestrial assessment.

Context area: The spatial area surrounding the regional comparison area for the ecosystem component of interest. Used to consider conditions and trends occurring at very large spatial and temporal scales that could influence the ecosystem component of interest and confound the interpretation of Project effects.

Core area: A natural area that meets a minimum size criteria after applying an edge buffer on human features. Two minimum sizes (200 ha, 1,000 ha) after applying a 500 m buffer on human features were used in the intactness effects assessment.

Cryosol: A soil order in the Canadian System of Soil Classification which includes soils that have permafrost within 1m of the surface, or 2m if highly disturbed by cryoturbation.

Cumulative effect (impact): The effect on the environment, which results when the effects of a project combine with those of the past, existing, and future projects and; the incremental effects of an action on the environment when the effects are combined with those from other past, existing and future actions.

Deposit type: Mode of surface material deposition. Refers to the dominant form of development in the case of organic deposits developed in situ.

Disturbance regime: The frequency, size, intensity, severity, patchiness, seasonality and sub-type of a particular type of disturbance or continual fluctuation.

Drainage regime: A classification of the typical speed at which water inputs drain from the soil.

Driver: Any natural or human-induced factor that directly or indirectly causes a change in the environment.

Driving factor: Any natural or human-induced factor that directly or indirectly causes a change in the environment.

Ecodistrict: A subdivision of Ecoregions from the National Ecological Framework for Canada into areas characterized by distinctive assemblages of relief, geology, landforms and soils, vegetation, water, fauna and land use.

Ecological land classification: A process of delineating and classifying ecologically distinctive areas of the earth's surface based on surficial geology, landforms, soils, vegetation, climate, wildlife, water and human features. The dominance of any one or more of these factors varies with the given ecological land unit. This holistic approach to land classification can be applied incrementally on a scale-related basis from site-specific ecosystems to very broad ecosystems.

Ecoregion: A subdivision of Ecozones from the National Ecological Framework for Canada into areas characterized by distinctive regional ecological factors including climate, physiography, vegetation, soil, water, fauna and land use.

Ecosite type: A **stand level** classification of soil, slope, groundwater and other environmental conditions that have important influences on ecosystem patterns and processes. Attributes that were directly or indirectly used for terrestrial habitat classification included moisture regime, drainage regime, nutrient regime, surface organic layer thickness, organic deposit type, mineral soil conditions, permafrost conditions, groundwater conditions and surface water conditions.

Ecosystem: A dynamic complex of plant, animal and micro-organism communities and their non-living components of the environment interacting as a functional unit.

Ecosystem diversity: The number of different ecosystem types and the distribution of area amongst them, at various ecosystem levels.

Ecosystem function:The outcomes of ecosystem patterns and processes viewed in terms of ecosystem services or benefits. Examples include producing oxygen to breathe, habitat for animals, purifying water and storing carbon.

Ecozone: A classification system that defines different parts of the environment with similar land features (geology and geography), climate (precipitation, temperature, and latitude), and organisms.

Edge effect: The effect of an abrupt transition between two different adjoining ecological communities on the numbers and kinds of organisms in the transition between communities as well as the effects on organisms and environmental conditions adjacent to the abrupt transition.

Effect: Any change that the Project may cause in the environment. More specifically, a direct or indirect consequence of a particular Project impact. The impact-effect terminology is a statement of a cause-effect relationship (see **Cause-effect linkage**). A terrestrial habitat example would be 10 ha of vegetation clearing (*i.e.*, the impact) leads to habitat loss, permafrost melting, soil conversion, edge effects*, etc*. (*i.e.*, the direct and indirect effects).

Effective habitat: An estimate of the percentage of habitat available to support individuals within a wildlife population after subtracting habitat alienated by human influences (*e.g.*, sensory disturbances). Human influences do not include physical habitat losses.

Emergent: A plant rooted in shallow water and having most of its vegetative growth above water.

Environmental assessment: Process for identifying project and environment interactions, predicting environmental effects, identifying mitigation measures, evaluating significance, reporting and following-up to verify accuracy and effectiveness leading to the production of an Environmental Assessment report. EA is used as a planning tool to help guide decision-making, as well as project design and implementation (Canadian Environmental Assessment Agency).

Esker: A narrow ridge of sand or gravel, usually deposited by a stream flowing in or under glacial ice.

Eutric: A qualifier for classifiying soils that have a relatively high degree of base saturation as indicated by their pH.

Evapotranspiration: The process by which water is transferred to the atmosphere through evaporation, such as plants emitting water vapour from their leaves.

Existing environment: The present condition of a particular area; generally included in the assessment of a project or activity prior to the construction of a proposed project or activity.

Fen: One of five classes in the Canadian Wetland Classification System. Includes peatlands in which the plants receive nutrients from mineral enriched ground and/or surface water. Water chemistry is neutral to alkaline. Sedges, brown mosses and/or Sphagnum mosses are usually the dominant peat forming vegetation.

Fibric: The least decomposed of organic soil materials. Fibers are readily identifiable as to their botanical origin.

Fine habitat type: The most detailed level in the hierarchical habitat classification used for the terrestrial assessment. From coarsest to finest, the levels in the habitat classification system are land cover, coarse habitat type, broad habitat type and fine habitat type.

Fire regime: The frequency, size, intensity, severity, patchiness, seasonality and type (*e.g.*, ground versus canopy) of fires in the Fire Regime Area.

Fire regime area: The terrestrial study area used to characterize the regional **fire regime**.

Floating-leaved: A plant rooted in shallow to deep water and having leaves that float at or on top of the water surface.

Flooding: The rising of a body of water so that it overflows its natural or artificial boundaries and covers adjoining land that is not usually underwater.

Fragmentation: Refers to the extent to which an area is broken up into smaller areas by human features and how easy it is for animals, plant propagules and other ecological flows such as surface water to move from one area to another. Fragmentation can isolate habitat and create edges, which reduces habitat for interior species and may reduce habitat effectiveness for other species. *OR* The breaking up of contiguous blocks of habitat into increasingly smaller blocks as a result of direct loss and/or sensory disturbance (*i.e.*, habitat alienation). Eventually, remaining blocks may be too small to provide usable or effective habitat for a species.

Generating station: A complex of structures used in the production of electricity, including a powerhouse, spillway, dam(s), transition structures and dykes.

Glaciofluvial: Pertaining to streams fed by melting glaciers, or to the deposits and landforms produced by such streams.

Glaciolacustrine: Pertaining to lakes fed by melting glaciers, or to the deposits forming therein

Gleying: A soil condition that develops under long-term anaerobic, reducing conditions. These soils are generally grayish, bluish, or greenish in color and are characteristic of many water-logged soils.

Gleysol: A soil order in the Canadian System of Soil Classification which includes soils that formed under saturated, reducing conditions and appear gleyed or mottled

Global change: Large-scale changes in environmental attributes such as climate, ground level ultra-violet radiation and ozone layer thickness.

Graminoid: Grasses and grasslike plants such as sedges and rushes.

Groundwater: The portion of sub-surface water that is below the water table, in the zone of saturation.

Habitat: The place where a plant or animal lives; often related to a function such as breeding, spawning, feeding, etc.

Habitat attribute: A readily definable and inherent characteristic of a habitat patch.

Habitat effect: Regarding terrestrial habitat, any change in a habitat attribute that results from the Project.

Habitat effectiveness: see **Effective habitat.**

Habitat loss: Conversion of terrestrial habitat into human features or aquatic areas.

Habitat patch: A defined geographic area where habitat attributes are relatively homogenous (*e.g.*, a map polygon).

Herbaceous: A plant that has leaves and stems that die down to the soil level at the end of the growing season and does not develop persistent woody tissue. Can also refer to the parts of a plant that die and are shed at the end of a growing season.

Hierarchical habitat classification: A habitat classification in which the categories at each level are subdivisions of the categories at the next more general level.

Horizontal peatland: Large, flat, featureless peatland; peat depth is generally intermediate to deep. May have a buried water layer.

Humic: Partially decomposed organic material that occurs on the soil surface (also **humus**) or has been incorporated into the soil profile by physical and biological processes.

Hydroelectric: Electricity produced by converting the energy of falling water into electrical energy (*i.e.*, at a hydro generating station).

Ice regime: A description of ice on a water body (*i.e.*, lake or river) with respect to formation, movement, scouring, melting, daily fluctuations, seasonal variations, *etc.*

Impact: Essentially, a statement of what the Project is in terms of the ecosystem component of interest while a project effect is a direct or indirect consequence of that impact (*i.e.*, a statement of the cause-effect relationship). A terrestrial habitat example would be 10 ha of vegetation clearing (*i.e.*, the impact) leads to habitat loss, permafrost melting, soil conversion, edge effects, etc. (*i.e.*, the direct and indirect effects). Note that while *Canadian Environmental Assessment Act* requires the proponent to assess project effects, Manitoba legislation uses the terms impact and effect interchangeably. See also Effect.

Impact area: The geographic area encompassed by a particular Project impact.

Impermeable: Relating to a material through which substances, such as liquids or gases, cannot pass.

Impoundment: The containment of a body of water by a dam, dyke, powerhouse, spillway or other artificial barrier.

Indicator species: A species that is closely correlated with a particular environmental condition or habitat type such that its presence, absence, or state of well-being can be used as indicator of environmental conditions. A species whose population size and trend is assumed to reflect the population size and trend of other species associated with the same geographic area and habitats.

Infrastructure: Permanent or temporary structures or features required for the construction of the principal structures, including access roads, construction camps, construction power, batch plant and cofferdams.

Inland peatland: A peatland that is beyond the direct influence of a water body's water regime and ice regime.

Inland wetland: A wetland that is beyond the direct influence of a water body's water regime and ice regime.

Invasive plant: A plant species that is growing outside of its country or region of origin and is out-competing or even replacing native organisms.

Intactness: The degree to which an ecosystem remains unaltered by human features that remove habitat and increase fragmentation.

Invasive species: A plant species that is growing outside of its country or region of origin and is out-competing or even replacing native organisms.

Key topic: A topic selected to focus the terrestrial effects assessment. Includes valued environmental components and key supporting topics.

Keystone species: A species that indirectly creates essential habitat attributes for another species. For example, cavities excavated by pileated woodpeckers are used by other species that cannot excavate cavities.

Lacustrine: Of or having to do with lakes, and also used in reference to soils deposited as sediments in a lake.

Land cover type: The most general level in the hierarchical habitat classification used for the terrestrial assessment. From coarsest to finest, the levels in the habitat classification system are land cover, coarse habitat type, broad habitat type and fine habitat type.

Landscape: The ecological landscape as consisting of a mosaic of natural communities; associations of plants and animals and their related processes and interactions.

LFH: A surface organic soil horizon primarily developed from the accumulation and decomposition of leaves, twigs and woody materials. LFH refers to the progressive stages of decomposition that typically increase from surface to depth, with the L layer being the least decomposed and the H layer being highly decomposed.

Local study area: The spatial area within which potential Project effects on individual organisms, or individual elements in the case of ecosystem attributes, may occur. Effects on the populations to which the individual organisms belong to, or the broader entity in the case of ecosystem attributes, were assessed using a larger regional study area; the spatial area in which local effects are assessed (i.e., within close proximity to the action where direct effects are anticipated.

Luvisol: A soil order in the Canadian System of Soil Classification which includes soils that have a light-colored, eluvial horizon and an accumulation of clay in the B horizon.

Marsh: One of five classes in the Canadian Wetland Classification System. Includes non-peat wetlands having at least 25% emergent vegetation cover in the water fluctuation zone.

Mesic: Characterized by, relating to, or requiring a moderate amount of moisture. Regarding soils, organic material in an intermediate stage of decompositon. Intermediate amounts of fiber are identifiable as to their origin.

Mineral soil: Naturally occurring, unconsolidated material that has undergone some form of soil development as evidenced by the presence of one or more horizons and is at least 10 cm thick. If a surface organic layer (*i.e.*, contains more than 30% organic material or 17% organic carbon by weight) is present, it is less than 20 cm thick.

Mitigation: A means of reducing adverse Project effects. Under the *Canadian Environmental Assessment Act*, and in relation to a project, mitigation is "the elimination, reduction or control of the adverse environmental effects of the project, and includes restitution for any damage to the environment caused by such effects through replacement, restoration, compensation or any other means."

Model: A description or analogy used to help visualize something that cannot be directly observed. Model types range from a simple set of linkage statements or a conceptual diagram to complex mathematical and/or computer model.

Moisture regime: The usual amount of water available for plant growth during the growing season.

Monitoring: Measurement or collection of data to determine whether change is occurring in something of interest. The primary goal of long term monitoring of lakes and rivers is to understand how aquatic communities and habitats respond to natural processes and to be able to distinguish differences between human-induced disturbance effects to aquatic ecosystems and those caused by natural processes; a continuing assessment of conditions at and surrounding the action. This determines if effects occur as predicted or if operations remain within acceptable limits, and if mitigation measures are as effective as predicted.

Moraine: An accumulation of boulders, stones, or other debris carried and deposited by the toe of a glacier.

Mottling: A soil condition soil that develops under periodic anaerobic, reducing conditions as indicated by irregular spots of different colors than the soil matric and vary in number and size. Mottling generally indicates impeded drainage.

Multivariate techniques: Statistical or modeling techniques that capture the interrelationships between two or more factors.

Network linkage diagram: A schematic diagram that shows the states, driving factors, relationships and direction of flows in a complex system such as an ecosystem; a simple diagrammatic representation of a cause-effect relationship between two related states or actions that illustrates an impact model.

Off-system: Water body or waterway outside of the Nelson River hydraulic zone of influence.

On-system: Waterbody or waterway inside the Nelson River hydraulic zone of influence.

Organic: The compounds formed by living organisms.

Organism: An individual living thing.

Paludification: Peat-forming process whereby vegetation (primarily sphagnum mosses) on mineral soils progressively creates a wetter moisture regime that eventually leads to the formation of a surface organic layer that expands laterally and vertically over time. It is the process whereby peatlands form on mineral uplands.

Parameter: Characteristics or factor; aspect; element; a variable given a specific value.

Parent material: The unconsolidated mineral or organic material from which the soil develops.

Peatland: A type of wetland where organic material has accumulated at the surface.

Peat plateau bog: Ice-cored bog with a relatively flat surface that is elevated from the surroundings and has distinct banks.

Pedon: The smallest volume that can be called a soil, with a depth that reaches the lower limit of the active soil horizons and is 1m by 1m wide or more, depending on the variability of the soils horizons.

Permafrost: Ground area where the temperature remains below 0°C for two or more consecutive years.

Plexus association: A strong positive association between plant species within an ordination diagram, as calculated by PC-ORD (McCune and Mefford 2011).

Polygon: An area fully encompassed by a series of connected lines.

Population: A group of interbreeding organisms of the same species that occupy a particular area or space.

Post-project: The actual or anticipated environmental conditions that exist once the construction of a project has commenced.

Primary productivity: The rate at which organic compounds are produced from atmospheric or aquatic carbon dioxide, principally through the process of photosynthesis, with chemosynthesis being much less important. All life on earth is directly or indirectly reliant on primary production.

Priority habitat: A native broad habitat type that is regionally rare or uncommon, highly diverse (*i.e.*, species rich and/or structurally complex), highly sensitive to disturbance, highly valued by people and/or has high potential to support rare plant species.

Priority plant: A native plant species that is rare, plays a highly disproportionate role in ecosystem function, is highly sensitive to Project features, or is highly valued by people.

Priority species: A species or group of species that is particularly important for ecological/social reasons.

Project feature: Any Project physical impact or activity that changes the environment. Synonymous with "action" in the *Canadian Environmental Assessment Act*.

Project Footprint: The maximum potential spatial extent of clearing, flooding and physical disturbances due to construction activities and operation of the Project, including areas unlikely to be used.

Project linkage: A causal linkage where a Project feature is the event. See also **causal linkage**.

Proxy area: Ecologically comparable areas previously exposed to impacts similar to those expected for the Keeyask Generating Station.

Rapids: A section of shallow, fast moving water in a stream made turbulent by totally or partially submerged rocks.

Rare habitat type: A broad habitat type that covers less than 1% of land area in the regional study area. See also **uncommon habitat type**.

Reach: A section, portion or length of stream or river.

Regime: The frequency, size, intensity, severity, patchiness, seasonality and sub-type of a periodic event or continual fluctuation.

Regional comparison area: The spatial area used to assess the potential significance of Project effects for the ecosystem component of interest.

Regionally rare habitat type: A broad habitat type that covers less than 1% of regional study area land area.

Regional study area: The regional comparison area used for a particular key topic. Alternatively, the spatial area within which cumulative effects are assessed (*i.e.* extending a distance from the project footprint in which both direct and indirect effects are anticipated to occur).

Regosol: A soil order in the Canadian System of Soil Classification which includes soils that are relatively young and poorly developed and lack a B horizon.

Relative abundance: The number of individuals of one species compared to the number of individuals of another species. The number of individuals at one location or time compared to the number of individuals at another location or time. Generally reported as an index of abundance.

Reservoir: A body of water impounded by a dam and in which water can be stored for later use. The reservoir includes the forebay.

Riparian: Along the banks of rivers and streams.

Riparian peatland: Peatland that borders a water body or waterway. The portion adjacent to the water is usually floating.

Riverine: Of or having to do with rivers.

Runnel: A narrow channel found where two slopes meet.

Scope: An activity that focuses the assessment on relevant issues and concerns and establishes the boundaries of the environmental assessment (Canadian Environmental Assessment Agency).

Semi-aquatic plant: Any plant adapted to grow in partially in water or in both aqueous and terrestrial habitats.

Shallow water: One of five classes in the Canadian Wetland Classification System. Includes open water areas that are typically less than 2 m deep, that may be periodically dewatered, and having less than 25% emergent vegetation cover.

Shallow peatland: A broad ecosite type which includes peatlands that typically have peat that is at least 100 cm thick, lack continuous or extensive discontinuous ground ice and have a water table that is typically more than 20 cm below the surface.

Shoreline wetland: A wetland where surface water level fluctuations, water flows and ice scouring are the dominant driving factors.

Shore zone: Areas along the shoreline of a waterbody including the shallow water, beach, bank and immediately adjacent inland area that is affected by the water body.

Site level: An ecosystem level used for classification purposes that refers to a relatively uniform area in terms of vegetation, soils and other key environmental conditions, ranging from 1 m^2 to approximately 250 m^2 in size.

Site type: A **site level** classification of environmental conditions that have important influences on ecosystem patterns and processes. Site attributes that were directly or indirectly used for habitat classification included moisture regime, drainage regime, nutrient regime, surface organic layer thickness, organic deposit type, mineral soil conditions and permafrost conditions.

Soil order: The highest level of soil classification in the Canadian System of Soil Classification. Soil orders group soils based on soil forming processes.

Stand level: An ecosystem level used for classification purposes that refers to a relatively uniform area in terms of other key environmental conditions, ranging from approximately one to one hundred hectares in size

Stratigraphy: Scientific study of rock strata, especially the distribution, deposition, correlation and age of sedimentary rocks. Also can refer to the layering of materials or soil horizons at a location.

Study area: The geographic limits within which effects on a VEC (valued environmental component) or supporting topic is assessed.

Study zones: A common set of six nested geographic areas used for key topic study areas.

Submergent: Plants that normally have all of their photosynthetic tissues under water.

Supporting topic: A Project assessment topic of concern that is of lesser focus than a VEC.

Swamp: One of five classes in the Canadian Wetland Classification System. Includes treed or tall shrub dominated wetlands, on either mineral or organic soil with a water table that is typically at least 20 cm below the surface.

Taxa: Plural of taxon.

Taxon: A group of organisms that are treated as a classification unit. Usually a taxon is given a name and a rank, although neither is a requirement.

Terrestrial: Belonging to, or inhabiting the land or ground.

Terrestrial habitat: Terrestrial habitats include forests and grasslands (among others). They are typically defined by factors such as plant structure (trees and grasses), leaf types (*e.g.*. broadleaf and needleleaf), plant spacing (forest, woodland, savannah) and climate.

Terrestrial habitat shoreline: The visible historical extent of water and ice regime effects on vegetation and overburden.

Terrestrial plant: Any plant adapted to grow on the land or areas with water that is typically shallower than 2 m.

Terrestrialization: A peat-forming process whereby all or portions of a waterbody or waterway are filled in by organic sediment deposition and the horizontal expansion of peat from the shore towards the center of the waterbody or waterway.

Thin peatland: A fine type in the hierarchical ecosite classification that includes veneer bogs that occur on slopes or crests.

Threshold: A limit or level which if exceeded likely results in a noticeable, detectable or measurable change or environmental effect that may be significant. Example thresholds include water-quality guidelines, acute toxicity levels, critical population levels and wilderness criteria. See also benchmark. Or A limit of tolerance of a VEC to an effects, that if exceeded, results in an adverse response by that VEC..

Till: An unstratified, unconsolidated mass of boulders, pebbles, sand and mud deposited by the movement or melting of a glacier.

Topography: General configuration of a land surface, including its relief and the position of its natural and manmade features.

Transect: A line located between points and then used to investigate changes in attributes along that line.

Transmission line: A conductor or series of conductors used to transmit electricity from the generating station to a substation or between substations.

Trophic: In ecology, **trophic level** describes an organism's position in the food chain.

Trophic level: one of the hierarchical strata of a food web characterized by organisms that are the same number of steps removed from the primary producers.

Umbrella indicator: An indicator for which changes represent changes for a broad group of species, several ecological pathways and/or an indicator of one or more other topics.

Uncertainty: For the purpose of the EIS, the lack of certainty or a state of having limited knowledge where it is difficult or impossible to exactly describe an existing state or a future outcome, or there is more than one possible outcome. In environmental assessment, uncertainty is not knowing, with high confidence, the nature and magnitude of environmental effects or the degree to which mitigation measures would prevent or reduce adverse effects.

Uncommon habitat type: A broad habitat type that covers between 1% and 10% of land area in the regional study area. See also rare habitat type.

Upland: A land ecosystem where water saturation at or near the soil surface is not sufficiently prolonged to promote the development of wetland soils and vegetation.

Valued environmental component:Any part of the environment that is considered important by the proponent, public, scientists and government involved in the assessment process. Importance may be determined on the basis of cultural values or scientific concern.

Vascular plant: Any plant which has specialized tissues for transporting sugar, water and minerals within the plant.

Vegetation structure type: Classification of the uppermost dominant vegetation layer within a defined area. The vegetation structure types used in the upland and inland peatland habitat assessment are forest, woodland, sparsely treed, tall shrub, low vegetation, sparse and barren.

Veneer bog: Bogs with thin peats (*i.e.*, generally less then 1.5 m thick) that generally occurs on gentle slopes and contain discontinuous permafrost.).

Waterbody: An area with permanent surface water

Wetland: A land ecosystem where periodic or prolonged water saturation at or near the soil surface is the dominant driving factor shaping soil attributes and vegetation composition and distribution. **Peatland**s are a type of wetland.

Wetland function: Can either refer to one of the functions performed by a wetland or be a collective term for all of the wetland functions. See also **Ecosystem function**.

Zone of influence: Relative to a particular attribute, the spatial areas outside of the Project Footprint where direct and indirect effects occur. The location and size of the zone of influence varies for each ecosystem component of interest.

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