GroupeHemispheres

Terrestrial ecosystem mapping, Howse pit study area

HML
Howse Minerals Limited

Technical Report

Our file: PR185-18-13

Your order: 00000646

October 2014

info@hemis.ca
QUÉBEC : 13, rue Saint-Louis, suite 201, Lévis (Qc) G6V 4E2 418 903-9678
MONTRÉAL : 1453, rue Beaubien Est, suite 301, Montréal (Qc) H2G 3C6 514 509-6572
www.hemis.ca

PROJECT TEAM

GROUPE HÉMISPHÈRES

Hugo T. Robitaille	Project director, Biologist, M.Sc. Env, Terrain, Analysis and Report Drafting
Julie Tremblay	Biologist, B.Sc. Biol., DESS in Geomatics, Analysis and Mapping
Elissa Dickoum	Geograph, Master (France), Geomatic

Palmer Environmental Consulting Group Inc.

Robin McKillop	Geomorphologist, M.Sc., P.Geo., Analysis and Report Drafting

Recyclable and made of 100% recycled paper.
Paper made with wind energy and contributing to the responsible use of forest resources.

This report has been formatted for double-sided printing.

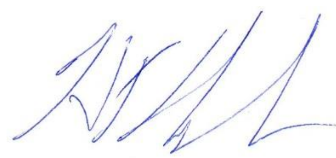
REVISION AND PUBLICATION		
Number	**Date**	**Modification or Publication Data**
00	2014-02-24	Preliminary Technical Report
01	2014-10-01	Technical Report, Final

V:\Contrat en cours\PR185-18-13_Howse Pit\Rapport\Rapport de terrain\CET\Hemis_PR185-18-13_Howse Pit_TEM Report_141003_VF.docx

Report prepared by:

Marie-Ève Dion
Biologist, M.Sc. Env

Report revised by:



Hugo Robitaille
Biologist, M.Sc. Env.

Julie Tremblay, B.Sc.
Biologist, DESS in Geomatics

This document should be cited as:

Groupe Hémisphères (2014) *Terrestrial ecosystem mapping, Howse pit study area.* Technical Report submitted to Howse Minerals Limited, 45 p. and 6 appendices.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND SYMBOLS

%	Percentage
ºC	Degrees Celsius
>	Larger than
<	Smaller than
asl	above sea level
CEAA	Canadian Environmental Assessment Agency
cm	Centimeter
ELC	Ecological Land Classification
ELCH	Ecological Land Classification Hierarchy
GIS	Geographic Information System
HST	High Subarctic Tundra
km^2	Square kilometer
LSA	Local Study Area
m	Meter
mm	Millimeter
n/a	Not applicable
n/av	Not available
MNR	Ministry of Natural Resources
MRNF	Ministère des Ressources naturelles et de la Faune
MSF	Mid Subarctic Forest
NOEGTS	Northern Ontario Engineering Geology Terrain Study
NTS	National Topographic System
RIC	Resources Inventory Committee
RSA	Regional Study Area
SMR	Soil Moisture Regime
SNR	Soil Nutrient Regime
TEM	Terrestrial Ecosystem Mapping

GLOSSARY

Abiotic:	Refers to non-living chemical and physical components in the environment, including light, temperature, water, atmospheric gases, wind, rock, soil and overall physiography.
Alluvial:	Pertaining to the sediments (commonly moderately- to well-sorted silt, sand, gravel and cobbles) eroded, transported and deposited by flowing water in contemporary streams.
ArcGIS™ TEM shapefile:	Digital geographic information system file containing all terrestrial ecosystem mapping polygon boundary and attribute data (available on CD-ROM, upon request).
Biotic:	Pertaining to any aspect of life, especially to characteristics of entire populations or ecosystems.
Bog:	A type of wetland characterized by the accumulation of acidic peat, a deposit of dead plant material (e.g., mosses).
Colluvial:	Pertaining to the sediments (commonly poorly-sorted rubble) deposited by gravitational mass movements.
Creep:	Slow downslope movement of surficial material or bedrock due to gravity.
Downwasting:	*In situ* disintegration of stagnant glacial ice through melting, evaporation, sublimation and erosion.
Drumlin:	An elongated "whaleback" or inverted, spoon-shaped hill of surficial material (commonly till) formed beneath a flowing glacier. The stoss (up-ice) side is typically steeper than the lee (down-ice) side, which tapers gradually. Drumlins are commonly used as indicators of ice flow direction.
Ecological Land Classification:	An approach used to identify terrestrial ecosystems and to classify them into a hierarchy of nested units at progressively smaller scales according to climate, physical land features and vegetation.
Ecoregion:	An area of the landscape with characteristic regional climate and landforms, as expressed in typical vegetation physiognomy and composition, soils and topography.
Ecotype:	The most detailed ecological classification units within ecoregions, which are used to delineate and describe terrestrial landscapes or, alternatively, ecosystems in this report. Ecotypes occur in predictable landscape positions and feature characteristic landform, site and soil characteristics that can be identified through stereoscopic interpretation of aerial photographs and described in detail during site visits.
Edatopic grid:	An arrangement of all ecotypes within an ecoregion into a two-way matrix of estimated soil moisture regime and soil nutrient regime.
Ericaceous:	Plant family including numerous plants from mostly temperate climates that normally grow in acidic soils.

Esker:	Sinuous ridge of sediment (generally sand, gravel, and cobbles) deposited by glacial meltwater in an ice-walled tunnel.
Fact sheet:	Technical section of the report describing in detail the nature of a particular landform type or terrestrial ecosystem (ecotype). Each fact sheet includes summary tables of key information
Fen:	A sedge-dominated, groundwater-fed type of wetland that accumulates peat, but is less acidic than a bog.
Gabbro:	A dark, coarse-grained igneous rock composed mainly of plagioclase and pyroxene.
Glacial debuttressing:	The removal of support once provided by glacial ice against a cliff through glacial retreat or downwasting. Recently exposed steep slopes may be prone to failure due to the increase in shear stress.
Glaciofluvial:	Pertaining to the sediments (commonly moderately- to well-sorted sand, gravel or cobbles) eroded, transported and deposited by glacial meltwater in ice-contact or proglacial environments.
Glaciolacustrine:	Pertaining to the sediments (commonly well-sorted fine sand, silt and clay) deposited through fall-out from suspension in ice-contact or proglacial lakes.
Gneiss:	A foliated, or banded, metamorphic rock with light-coloured layers, usually quartz and feldspar, alternating with dark-coloured layers of other minerals, usually hornblende and biotite.
Granitoid:	Resembling or having the texture of granite, a hard, coarse-grained, light-coloured igneous rock consisting chiefly of quartz, feldspar and mica.
High Subarctic Tundra:	One of the two ecoregions within the RSA. The HST Ecoregion has short, cool summers and long winters with severe winds in exposed landscape positions. Tundra vegetation covers more than 50% of this ecoregion.
Humus:	A brown or black organic substance consisting of partially or wholly decayed vegetation or animal matter that provides nutrients for plants and increases the ability of soil to retain water.
Hydric:	Soil condition that develops under states of water saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part.
Kettle:	A hole or pit within glacial deposits, formed by the melt-out of a block of glacial ice
Kame:	A ridge, mound or terrace of sediments deposited against glacial ice by meltwater. Given their ice-contact depositional setting, kames commonly exhibit complex internal structure and contain localized till deposits.
Lag deposit:	Residual accumulation of coarse material (e.g., cobbles or boulders) left behind by the winnowing of finer material. For example, boulder lag deposits exposed on a stream bed may be derived from underlying till through removal of surrounding fine sediments by stream flow.

Landform:	A distinct, three-dimensional feature on the earth's surface that has originated through a particular set of erosional and/or depositional processes and thus can be recognized wherever it occurs.
Late seral:	Final stage of a forest stand evolution in time (corresponding to an old growth forest).
Lithology:	The gross physical character of a rock or rock formation.
Lobate:	Having the shape of a lobe, a rounded projection.
Local Study Area:	Area where Howse Project infrastructure and activities will be located and in which detailed terrestrial ecosystem mapping was completed (see Figure 1).
Matrix:	Fine-grained portion of a deposit in which coarser rock fragments are embedded.
Mesic:	Soil condition referring to well drained soils that retain some water.
Mesoscale:	Pertaining to the middle, or intermediate, size of a phenomenon or process.
Metadata:	Information about data, including sources, types and format.
Metasedimentary:	Sedimentary rocks that have been partly metamorphosed.
Mid Subarctic Forest:	One of the two ecoregions within the RSA. Mean annual temperature for the ecoregion is between -5 and -2.5°C, and annual precipitation is around 800 mm, with 300 mm falling as snow. Summers in the MSF Ecoregion are cool and 4 to 5 months long; winters are cold and snowy (Meades, 1990). This combination of climatic factors inhibits continuous tree cover on upland sites, so forest cover becomes discontinuous, and subarctic forests occur that are transitional between the relatively productive, closed boreal forests to the south and the treeless subarctic tundra to the north.
Moraine:	Landform deposited directly by glacial ice, typically consisting of grains ranging in size from clay to boulders.
Periglacial:	Pertaining to processes, features and climates modified by their close proximity to the margin of a glacier or an ice sheet, or by cold, non-glacial environments.
Permafrost:	Perennially frozen soil and/or bedrock typically found in areas with arctic or subarctic climates.
Riparian:	Pertaining to the banks of, or area immediately adjacent to, a watercourse.
Sill:	A tabular, usually horizontal intrusion of igneous rock.
Soil moisture regime:	A scale, at the ecotype level, ranking the soil moisture level. SMR is estimated from site and soil properties, such as vegetation community and indicator plant species, as well as site (slope position, site shape and topography) and soil (drainage, humus form, texture, depth and coarse fragment content) characteristics.
Soil nutrient regime:	A scale, at the ecotype level, ranking the soil nutrient level. SNR is estimated from site and soil properties, such as vegetation community and indicator

	plant species, as well as site (slope position, site shape and topography) and soil (drainage, humus form, texture, depth and coarse fragment content) characteristics.
Stratum:	A layer of sedimentary rock with relatively homogeneous composition that can be visually distinguished from the rock layers above and below it.
Talus:	Accumulation of rock fragments at the base of a cliff, resulting from frost shattering and rock-fall.
Terrain:	An area of land with a distinctive assemblage of landforms, materials, topography and drainage.
Terrain mapping:	The process of dividing the landscape into polygons according to landform, material, topographic relief and variety and drainage characteristics, typically based on aerial photograph interpretation and limited field work.
Terrestrial ecosystem:	The environment in which terrestrial organisms live.
Terrestrial ecosystem mapping:	The process of classifying and delineating distinct terrestrial ecosystems, thereby providing a mapped inventory of terrestrial ecological resources that may be affected by a proposed development. The methodological approach used in this study is Ecological Land Classification.
Till:	Material deposited directly by glacial ice with grains ranging in size from clay to boulders.
Transect:	A path through a terrestrial ecosystem along which occurrences of the phenomenon of interest (e.g., plants) are counted and recorded.
Veneer:	A thin (typically <2 m), commonly discontiguous surficial deposit overlying another material or bedrock.
Xeric:	Soil condition that develops through lack of water in soils.

1 INTRODUCTION

In order to acquire a 51% share of the Howse Property, Tata Steel Mineral Canada Ltd. (TSMC) created Howse Minerals Limited (HML), a wholly-owned subsidiary based in Saint-John's, Newfoundland and Labrador. HML has acquired a 51% participating interest in the mineral licenses comprising the Howse property and is responsible to manage and operate the Howse Property.

An unincorporated Joint Venture was formed in August 2013 between Labrador Iron Mines Ltd (LIM), TSMC, HML and Labrador Iron Mines Holdings Limited for the purpose of developing the Howse Property. HML was appointed to be the operator and the legal owner of the Howse Property. Therefore, HML is considered as the proponent for this undertaking.

HML is planning on developing the iron ore deposit at the Howse Property with the support of adjacent mining infrastructures. The deposit is located in Newfoundland and Labrador along the Labrador Trough, between Irony Mountain, Pinette Lake and Timmins 4 (TSMC current site of operation) (Figure 1). A 3.5 km long haul road will need to be extended and upgraded to link the Howse Property to the existing road network. HML proposes to use a conventional open pit drill and blast operation mining method. The extracted iron ore will be crushed and screened, hauled by truck to the TSMC's DSO Project loading area (less than 5 km from the Project), which is currently under construction, and then shipped by train to Sept-Îles. Therefore, little additional infrastructure will need to be built.

1.1 Mandate and Objectives

The terrestrial ecosystem mapping (TEM) products produced for this project provide a baseline inventory of ecological communities, integrating landform, soils and vegetation in the project area. The information developed provides an ecosystem-based template for assessing potential project impacts and for developing effective mitigation approaches. The TEM maps also support many other aspects of the future assessment, including wildlife habitat models, rare plant surveys and general engineering applications. The map units are terrestrial ecosystems, so linkages are made between the terrestrial communities and the ecological processes that determine their composition, structure and function. This ecological approach provides a knowledge base for assessing the potential impacts of the proposed development on Environmental Components (ECs) and provides the possibility of including climate change effects on ECs over the life of the project.

The purpose of the TEM field survey conducted in summer 2013 was two-fold: to ground-truth preliminary mapping interpretations; and to collect additional site-specific data that cannot reasonably be interpreted from aerial photographs (e.g., soil grain size distributions, soil type, plants, root restricting layer, water table depth, site disturbances, etc.). Data collected from 2008 through 2010 surveys for the DSO projects were also used since some surveys were conducted in the Howse Project Study Area.

Fieldwork was carried out between August 29th to 31st 2013 in the Howse Project Study Area with a focus at the deposit location. Weather conditions were generally favourable – a mix of sun, cloud and infrequent showers – with no significant down-time due to weather-related delays.

This report provides four main products:

1. A regional overview of physiographic and terrestrial ecosystem features and processes;
2. The mapping and detailed description of distinct types of landforms;
3. The classification, mapping, detailed description, and management interpretations of terrestrial ecosystems following either RIC (1998) methods and;

4. A summary of the distribution and characteristics of terrain and terrestrial ecosystems within specific study area sub-units.

The *complete* map product is provided in digital format (ArcGIS™ 9.3 .mxd file) on CD-ROM, which is available upon request from Howse Minerals Limited (HML). However, *simplified* printed (paper) maps, which display the primary terrain and ecological information, are provided in this report, following their detailed coding definitions and metadata (Appendix I), in Appendices II and III.

1.2 Project Team

A core TEM team was created at the project's inception, comprising geoscientist Mr. Robin McKillop and terrestrial ecologists Mr. Hugo Robitaille. To complete this team, Julie Tremblay, an experienced GIS specialist working for Groupe Hémisphères, was responsible of the data management and map production. Each team member is experienced in terrain mapping and TEM, as indicated in the biographies provided below. The efforts of specialists in each discipline were combined to provide the highest level of interpretation and mapping accuracy. Inter-disciplinary communication throughout the project was seamless; the synergistic relationship added value to the mapping and helped provide continual quality checks.

Mr. Robin McKillop, M.Sc., P.Geo. is a geomorphologist with 10 years of nation-wide experience in fluvial, glacial, and hillslope geomorphology. Drawing on his expertise in Quaternary geology, Mr. McKillop has responsible for terrain mapping and soil characterization for proposed mining projects throughout northern Canada, including in Labrador, Quebec, Manitoba, Nunavut, Yukon, and northwestern British Columbia, as a basis for terrestrial ecosystem mapping and engineering and land use planning applications. For these projects, Mr. McKillop worked closely with terrestrial ecologists and engineers to conduct detailed literature reviews, complete 1:10,000- to 1:60,000-scale mapping, identify and describe sensitive soils, and evaluate the availability and suitability of soils for site reclamation. Through his northern project experience and his M.Sc. research in periglacial environments, Mr. McKillop has developed a comprehensive understanding of permafrost and its implications on slope processes and soil development. In recognition of his teaching capabilities and expertise in aerial photograph interpretation, Mr. McKillop twice instructed a senior undergraduate course, Applied Geomorphology, at the University of Waterloo.

Mr. Hugo T. Robitaille, M.Sc.Env., is a biologist, and has a Master of Sciences in environmental studies from Université du Québec à Montréal (UQAM). He has been working as a consulting biologist for more than 15 years with municipalities, governments, industry and individuals. He was involved with Hydro-Québec in sustainable management activities in the right-of-ways of the electricity distribution network. He has also acted as an advisor, coordinating the establishment of watershed management councils for the Richelieu and Yamaska rivers. Mr. T. Robitaille has done many projects characterizing and mapping sensitive ecosystems in which there were a number of flora and fauna species at risk, in Quebec, Labrador, British Columbia and Nepal. He recently carried out the terrestrial ecosystem mapping for the LabMag project (Groupe Hémisphères and Gartner Lee, 2007a, 2007b), for the DSO project (Groupe Hémisphères, 2011), and for the Taconite project, which included more than 1400 km of the right-of-ways of an energy transmission line and two pipelines potential corridors as well as the mine sites, the deep water port and pellet plant.

Mr. T. Robitaille has also working on a complex impact studies in the area of natural resources (mines, hydroelectricity and wind energy). He is coordinating for this purpose the biophysical surveys, evaluating the impacts and proposing measures to mitigate the impacts. Through his positions as director of the Conseil régional de l'environnement de la Montérégie and advisor to the Canadian Centre for International Studies and Cooperation, he has mastered the arts of water and watershed management, staff management, fund-raising, oral and written communication and collaboration with others working in the field.

Mr. T. Robitaille was the project leader for the ecosystem mapping for the Howse Project. He coordinated and took part in producing the different field surveys and ensured that methodologies and deadlines were respected. In collaboration with his team, Mr. Robitaille carried out the TEM and produced the technical report.

Julie Tremblay, B.Sc., is a biologist who also earned a certificate in geographic information systems and a diploma in graduate specialized studies in Geographic Information Systems. She has profound notions and superior expertise in mapping and spatial analysis. She masters Mapinfo and ArcGIS, as well as other GIS and programming softwares .

During her bachelor's degree studies, she worked during two summers as a research assistant on wildlife ecology in the northern regions, notably in the North of Québec and Canada, for the Chaire de recherche en sylviculture et faune et le Centre d'études nordiques, both affiliated to Laval University. During her studies and her different job activities, she has developed her expertise in wildlife population ecology, in wildlife conservation and management, in ornithology, in bontanic and in shoreline and marine geomorphology

1.3 Study Objectives

The principal objective of this study was to classify and map terrestrial ecosystemin the Howse Project Study Area to provide baseline information in support of an environmental assessment. Terrestrial ecosystems were classified and mapped at scales that facilitate reconnaissance-level inventories suitable for preliminary impact assessments and general project planning. The landform and terrestrial ecosystem characterizations and maps provide the basis for anticipating important engineering issues, e.g., locating bedrock, sources of gravel, and areas of organic terrain, and for ecological applications such as wildlife habitat suitability mapping, and for evaluating the potential impacts of the proposed project on valued environmental components, such as rare plant species, sensitive ecosystems, and ecological processes.

The production of fully integrated terrain-ecotype maps facilitates the identification and evaluation of constraints and opportunities for development, and provides a basis for recommending options for mitigation.

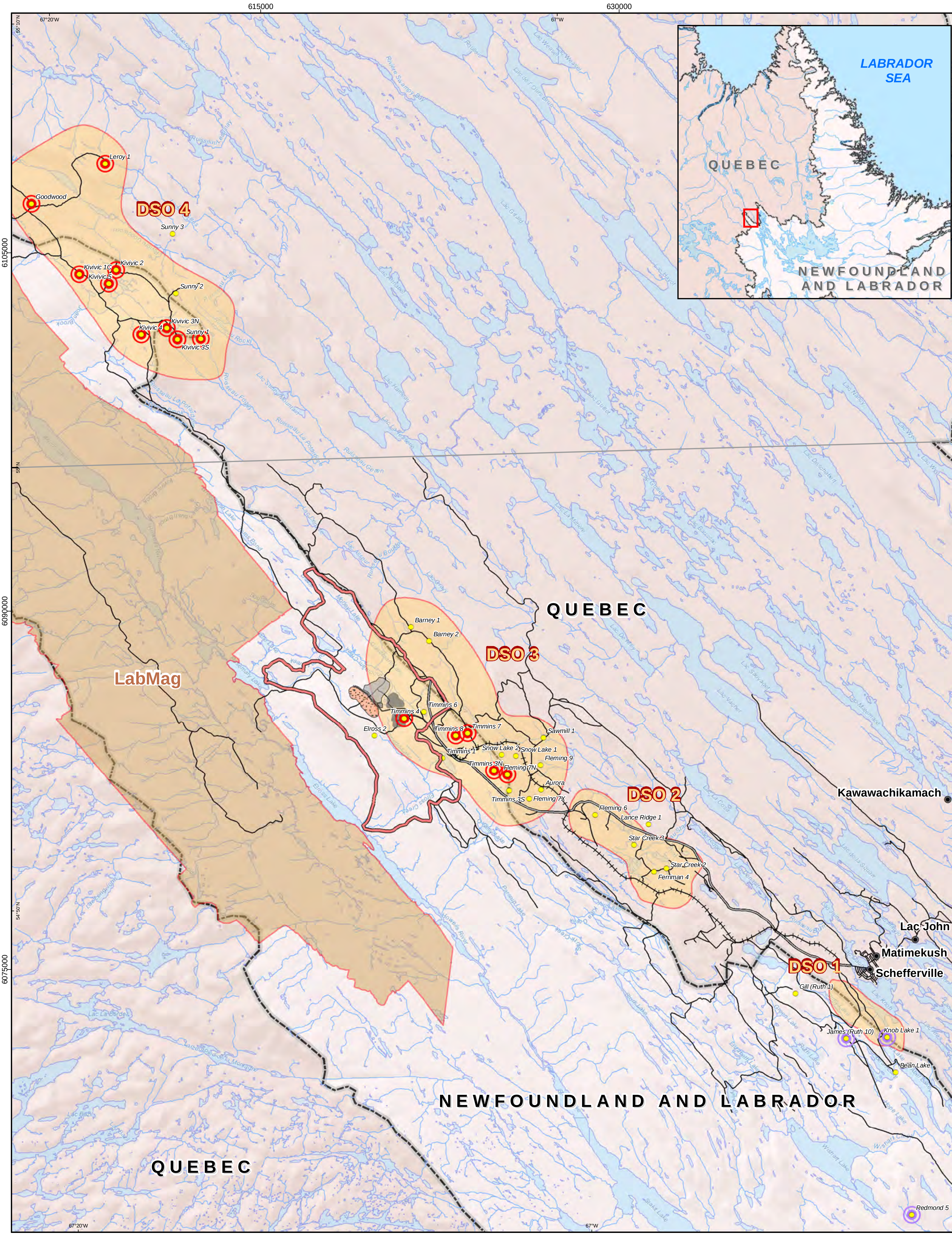
1.4 Report Organization

This report has been structured to provide the reader with a comprehensive understanding of both the biotic and abiotic components of each terrestrial ecosystem delineated within the Local Study Area (LSA). Following a brief background on terrestrial ecosystem characterization and mapping as it pertains to this study (Section 2), the methodological approach used to complete the terrain and ecosystem characterization and mapping is provided (Section 3). Section 4 provides a regional overview of the physiographic setting, to provide context for the sections that follow.

Sections 5 and 6 describe, in detail, the appropriate use, description, and interpretation of the terrain and terrestrial ecosystems. These sections and their associated appendices provide a detailed description of landform and ecotypes within the Howse LSA.

Section 7 provides summary descriptions of the dominant terrestrial ecosystems within the LSA. In addition to referencing particular landforms and ecotypes, Section 7 incorporates enough common descriptive terms that users with a basic understanding of ecosystem components should be able to grasp the most important points in the LSA.

All cited references are listed in Section 8. All printed terrain and terrestrial ecosystem maps have been included in separate appendices for practical reasons. Terrain map can be consulted in Appendix II and terrestrial ecosystem map can be consulted in Appendix III.



LEGEND

Infrastructure And Mining Components

- DSO - Deposit
- LIM Project
- TSMC Project
- Proposed Howse Pit
- Proposed Low Grade/Overburden Stockpile
- Proposed Crushing/Screening Facility
- Proposed Waste Rock Dump
- DSO Howse Local study area
- DSO - Other Site
- Taconite - LabMag

Basemap

- Town
- Railroad
- Road
- Watercourse
- Waterbody
- Provincial Boundary

Figure 1

Location

Howse Minerals Limited

0 2,5 5 7,5 10

Kilometers

SCALE:
1:150 000

UTM 19N Nad 83

FILE, VERSION, DATE, AUTHOR:
GH-0466, 03, 2014-02-25, E.D., J.T.

SOURCES:

Map base
Government of Canada, NTDB, 1:50,000, 1979
SNC Lavalin, Groupe Hémisphères, Hydrology update, 2013.

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
TATA Steel Minerals Canada Limited/ MET-CHEM, Howse Deposit Design for General Layout., 2013

GroupeHemispheres

2 BACKGROUND

2.1 The Ecosystem Context – Regional Scale Ecosystems

The proposed Howse Project is located in one major national-scale ecological zone (Wiken 1986) – the Sub-Arctic Forest Zone, where forest stands on zonal sites assume an open woodland structure. Within the LSA, these larger ecozones are represented by lower hierarchical levels – the Mid Sub-arctic Forest Ecoregion or MSF Ecoregion (Table 1 – following the Environment Canada Ecological Land Classification System or ELC [Lopoukhine et al., 1978]) and the High Subarctic Tundra Ecoregion or HST Ecoregion.

Table 1. Hierarchy of Ecosystem Classification Units Used in Ecological Land Classification (Wiken, 1986; Lopoukhine et al., 1978), and Classes for the Proposed Development Area

GENERAL CLASS	GENERAL DESCRIPTION	CLASS FOR PROPOSED DEVELOPMENT AREA
Ecozone (related mapping scale: 1:50,000,000)	An area of the earth's surface representative of large and very generalized ecological units, characterized by interactive and adjusting abiotic and biotic factors. Canada is divided into 15 terrestrial ecozones.	Subarctic Forest
Ecoprovince (related mapping scale: 1:10,000,000 – 1:5,000,000)	A subdivision of an ecozone characterized by major assemblages of structural or surface forms, faunal realms, vegetation, hydrology, soil and macro-climate.	Not mapped
Ecoregion (related mapping scale: 1:3,000,000 – 1:1,000,000)	A subdivision of an ecoprovince characterized by distinctive regional ecological factors, including climate, physiography, vegetation, soil, water and fauna.	Mid Subarctic Forest described in Section 7
Ecodistrict (related mapping scale: 1:500,000 – 1:250,000)	A subdivision of an ecoregion characterized by a distinctive assemblage of relief, landforms, geology, soil, vegetation, water bodies and fauna.	Not mapped
Ecosection (related mapping scale: 1:250,000 – 1:50,000)	A subdivision of an ecodistrict with recurring patterns of terrain, soils, vegetation, water bodies and fauna.	Not mapped
Ecosite (related mapping scale: 1:50,000 – 1:10,000)	A subdivision of an ecosection describing areas of the landscape uniform in landform and soils, with a characteristic chronosequence of vegetation communities	Described on Fact Sheets
Ecotype 1:50,000 – 1:10,000)	Ecosystems occurring within Ecosites having similar vegetation structure and composition	Described on Fact Sheets

Note: Ecological classification levels discussed in this study are shaded in light green.
Reference: http://sis.agr.gc.ca/cansis/nsdb/ecostrat/intro.html#references

2.2 Terrestrial Ecosystem Mapping (TEM) Approach

An ELC approach following the principles outlined in RIC (1998) was used to delineate ecosystems. TEM is the process of describing, classifying and mapping terrestrial ecosystems following accepted protocols and standards, and a complete description of the methods used in this study is presented in Section 3. Most Canadian provinces have some variant of TEM and, although mapping protocols may slightly differ among jurisdictions, all TEM systems are *ecological* in that they use the distribution of late seral communities to integrate abiotic and biotic environmental system components. Mapping was focussed at the ecotype or ecosite level, as these are the most relevant scales for assessing and mitigating the potential impacts of the Project. Higher levels of the ELC that are relevant to Labrador are provided at the ecozone level by

Wiken (1986), and at the ecoregion level by Lopoukhine *et al.* (1978), and, later, by Meades (1989). Characteristics of these ecological units are discussed in the report to provide a regional context for the project. In this baseline study, terrestrial ecosystems were mapped at the ecosite/ecotype level, at scales ranging from 1:50,000 to 1:60,000. The ecotype maps for the proposed Howse Project area are included in Appendix III.

2.3 Other Relevant TEM Projects in the Project Area

An assessment of other projects involving ecosystem mapping is important to ensure that mapping methods and classifications used by this Project are compatible with those of other projects so as to facilitate regional cumulative effects analyses. For the TEM based mapping, the team considered other Labrador TEM projects to ensure regional consistency. The Voisey's Bay TEM (CEAA, 2005) characterizes ecotypes within the Voisey's Bay development area. As in the Howse Project, ecotypes were developed through the integration of physical features of the environment and the identification and classification of vegetation communities. The Lower Churchill TEM (CEAA, 2011) used similar TEM approaches and is compatible with results for this Project. Where possible, the same descriptive ecotype names were used in this study as in the other projects. This consideration of other work in Labrador will ensure mapping consistency for other projects, and facilitate cumulative effects assessments, should they be required.

3 METHODOLOGY

Completion of the TEM required careful planning, particularly because the efforts of several team members required considerable co-ordination, so that a truly integrated product could be developed. Production of maps that accurately represent the distribution and characteristics of terrestrial ecosystems and provide a foundation for subsequent environmental impact assessment required completion of several main tasks, which correspond to the following subsections:

3.1.1 Selection of Mapping Methods

3.1.2 Aerial Photograph Preparation, Interpretation, and Preliminary Mapping

3.1.3 Digitization of Map Lines, and Preparation of Field Maps

3.1.4 Field Verification and Laboratory Analysis

3.1.5 Development of the Ecotype Classification

3.1.6 Mapping and Database Revisions

3.1.7 Data Analysis and Final Map and Report Preparation

3.1.8 Quality Assurance/Quality Control

A brief description of each task is provided below, so that the implications of the mapping and the basis for subsequent conclusions and recommendations are better understood.

3.1.1 Mapping Methods

The ecosystem mapping needed to be carried out at a scale large enough to permit the identification of the potential impacts of the Howse Project and of effective mitigation measures. The choice of the most appropriate scale, however, requires a compromise between the desired level of detail and the associated costs. A larger scale permits better mapping detail, but at a higher cost, while a smaller scale means less mapping detail, but at a lower cost.

Since the mine sites may be subjected to significant biophysical impacts, the level of mapping detail chosen had to be high in order to satisfy the requirements of the various government agencies involved and the Project Feasibility Study team.

Since TEM mapping has been carried out regionally over several years, the same mapping approach was used to complete the mapping for Howse LSA. The LSA was partly covered by the DSO mapping (Groupe Hémisphères, 2011). To ensure a continuity, the same mapping methods and Ecotype Classification was used. The Regional Study Area (RSA) includes the TEM for DSOP Project and Howse Project.

3.1.2 Aerial Photograph Preparation, Interpretation and Preliminary Mapping

Colour, 1:10,000 scale stereo-paired photos taken in September and October 2008 over the entire LSA were interpreted directly on-screen using a PurVIEW/ArcGIS™ 9.3 softcopy photographic interpretation system.

Terrain polygons were delineated while viewing the imagery in stereo at a scale of 1:5,000 to 1:8,000, so that the resultant polygon boundaries would be smooth when presented at the flight scale. Terrain polygons were described according to the NOEGTS (Gartner et al., 1981), so as to ensure consistency with previous mapping completed in the area. Along the margins of areas that had been mapped previously by the project team for the Direct Shipping Ore (DSO) project, terrain polygons were drawn to match the pre-existing polygon boundaries.

Terrain polygons were used as the foundational elements for interpreting terrestrial ecosystems, thus integrating landform, soils and plant communities in order to delineate unique terrestrial ecosystems. In many cases the ecosystem and terrain polygons were the same. In those cases, the ecological attributing components were simply added to the attribute table. Terrain and ecosystem polygons sharing the same boundaries reflect the fact that, for a uniform climate, terrain conditions (surficial deposit type and depth, slope, soil texture, topography) are by far the main predictors of ecosystem distribution. Some terrain polygons needed to be split into smaller polygons in order to capture important ecosystem variability within one single terrain polygon. In those cases, single attributing codes were given to each ecosystem. The metadata associated with the terrain and ecosystem mapping are included in Appendix I.

Field maps identifying streams, roads, trails and wetlands were prepared using basemaps at 1:50,000 scale from the federal Department of Natural Resources, photo-interpreted features with 1:10,000 aerial photos, previous sampled sites and terrain and ecosystem polygons.

3.1.3 Field Investigations

Field verification, or ground truthing, is an essential part of the TEM. In addition to permitting the verification of the preliminary interpretation of the aerial photos, field visits also made it possible to collect detailed information that cannot be inferred from aerial photos, such as the exact distribution of surface deposits, soils and drainage and the variety and percentage of the distribution of plant species. Time and financial constraints precluded visiting all the polygons in the LSA and those to be visited were selected on the basis of their representativity, their abundance, their ecological importance and their potential sensitivity to impacts from the Howse Project. It was assumed that the characteristics recorded in the polygons visited were the same as in the similar polygons that were not visited.

3.1.3.1 Field Work – Terrain

Field reconnaissance in support of the terrain mapping and descriptions was completed between August 29th to 31st 2013 by biologist Hugo T. Robitaille. In addition to prioritizing site visits according to the representativity of polygons, terrain types were selected for field investigation according to uncertainty of aerial photograph interpretations of terrain characteristics caused by such factors as forest canopy or indistinct surface expression. The sensitivity to impacts of particular terrain features was also considered. The sedimentological characteristics of natural or excavated exposures of surface materials were examined in detail. Evidence in soil pits and on the ground surface of cryoturbation, a likely sign of modern or relic permafrost, was recorded.

3.1.3.2 Field Work – Ecosystems

Ecosystems field work was carried out at the same time than terrain fieldwork. The primary focus during field investigations was on vegetation characteristics, including their relationship to drainage conditions and the moisture and nutrient regime of the underlying soil.

All the work characterizing ecosystems in the field was done using the Groupe Hémisphères computer program *Ecotype*, which supports ecosystem-based data entry and processing. Validation was done at three levels of detail in the field to provide a reliable description of the site, the soils and the vegetation composition and structure for each ecotype.

The 2013 campaign in the Howse Project LSA was carried out to ensure a maximum of ecosystem validation. Detailed samplings were less frequent since the four years of detailed terrain and vegetation communities sampling carried out regionally were considered. Results from the past surveys were used to present a better description of ecosystems within the Howse Project LSA.

Detailed sampling

The detailed sampling describes the environmental (elevation, slope, aspect, orientation of the slope and relief), soil (description of soil humus, texture, thickness and colour, drainage and classification by soil order according to the Canadian System of Soil Classification) and vegetation characteristics (percentage of cover occupied by vascular and non-vascular plant species, by stratum). A listed plant inventory was also done at this level of detail.

Quick sampling

The quick sampling collected the same environmental, soil and vegetation characteristics as the detailed sampling, but more briefly. A shorter list of environmental data is required, describing only the main properties of the soil and surface deposits. In order to do a more complete survey of listed plants, an exhaustive list of plot vegetation was always collected. The quick sampling verified the description of the ecosystem units and made it possible to visit a larger number of polygons.

Visual inspections

The visual inspections were carried out to confirm that the attributions of the polygons mapped were accurate. The visual inspection process is very important for the mapping and increases the reliability of the TEM products.

The field visits also made it possible to assess the sensitivity of certain ecosystems to the potential impacts of the Howse Project. For example, the ecosystems that contain rare species or unusual habitats for the region, or that have high sensitivity to variations in the hydrological regime, could be particularly sensitive to such impacts. Long transects were also done on sites where the ecotypes presented a higher probability of supporting listed plant species. The locations of these ecosystems were recorded and will be used as the basis for the preparation of the impact assessment and for the identification of mitigation measures.

3.1.4 Development of the Ecotype Classification

All data were tabulated, and basic statistical analyses were performed using the *Ecotype* computer program of Groupe Hémisphères.

Each ecotype describe characteristic combinations of vegetation communities and ecosites (Table 1) that recur across a given terrestrial landscape, and are the most detailed classification units within ecoregions.

Ecotypes occur in predictable landscape positions and present characteristic vegetation composition and structure, landform, site and soil features that can be identified on the ground, and on stereopairs of aerial photographs (Wiken, 1986). Within each ecosite, a number of successional ecotypes can occur after disturbance. We denote these changes in ecotypes within ecological sites by the seral stage assessment for each polygon, or polygon component. Each ecosite features a characteristic late seral vegetation community that results from the availability of soil moisture and nutrients, plant competition, and the nature, severity and timing recent and past disturbance on the site. The late seral ecotype is used to name the ecosite, and represents the potential vegetation for that unique set of ecological conditions in the project landscape. Ecotypes represent unique areas of the terrestrial landscape that have characteristic productivity, ecological processes and site-level biodiversity, and provide predictable habitat suitability for wildlife.

A classification of ecotypes is developed through a systematic field sampling of ecosites, selecting areas of the landscape uniform in vegetation composition and structure, landform properties, and soil and humus characteristics. The soil moisture regime (SMR) and soil nutrient regime (SNR) for the sample plots were assessed from plant community composition and structure, as well as site (slope position, site shape and topography) and soil (drainage, humus form, texture, depth and coarse fragment content) characteristics

(MoELP-MoF, 2010). After repeated sampling of a broad range of combinations of soil moisture, soil nutrient and vegetation communities, a pattern emerged: a similar group of seral vegetation communities occurred in similar soil moisture/nutrient positions. A relatively unique situation occurred regionally, where two very different late seral forest communities occurred in the same ecosite. The Black Spruce Feathermoss, and the disclimax Open Spruce Lichen Woodland Ecotypes occurred on mesic ecosites, due to repeated fire that reduces black spruce seed source and permanently interrupts 'normal' ecological succession to the Black Spruce Feathermoss Ecotype (Payette and Delwaide, 2003; Girard *et.al.,* 2008, 2009). This variation was encompassed in the classification by identifying two potential endpoints for ecological sucession on this ecosite. This Mesic Black Spruce Lichen Woodland Ecotype is distinguished from the (submesic to subxeric) Black Spruce Lichen Woodland that occurs as a successional endpoint on drier ecosites that develop on glaciofluvial outwash deposits. These two variants of the Black Spruce Lichen Woodland are mapped separately.

The soil moisture and soil nutrient ranges of characteristic ecosites within regional bioclimates are differentiated by the late seral vegetation communities that occur on them, and are interpreted to represent the ecological potential of that ecosite. They are displayed on an edatopic grid to represent a simplified representation of different combinations of soil moisture and soil nutrient regimes (Table 2) for the different ecological units with a regional climate. A relatively predictable suite of younger seral communities occur on each ecosite, providing an ecosystem basis for vegetation modelling and assessing habitat change. Edatopic grids for the MSF and HST Ecoregion are developed for the project and presented in Section 6 below.

Table 2. Example of an Edatopic Grid

SOIL MOISTURE REGIME	SOIL NUTRIENT REGIME					
		Very poor	**Poor**	**Medium**	**Rich**	**Very rich**
	Xeric					
	Subxeric					
	Submesic					
	Mesic					
	Subhygric					
	Hygric					
	Subhydric					
	Hydric					

3.1.5 Mapping and Database Revisions

In addition to properly characterizing the ecotypes present in the LSA, the field observations also made it possible to increase the precision of the TEM. The nature of the surface deposits could be confirmed, as well as that of the ecotypes present. All the boundaries of the polygons of the geological surface deposits were then plotted directly in the ArcGIS™ 9.3 software using PurView™, which makes it possible to view aerial photos in 3D. Each polygon of the geological surface deposits was then assigned using the codes presented in Appendix I (Table J to Table M).

The polygons representing the ecotypes were plotted on the basis of those for the geological surface deposits, which were divided into two or more polygons if necessary. The codes presented in Appendix I were then assigned.

3.1.6 Data Analysis, Final Map and Report Preparation

In order to respect the TEM objectives, data analyses were required after the mapping was done. Simple requests were performed in order to determine certain spatial statistics, such as the percentage of territory area occupied by the various geological surface deposits and ecotypes. These requests have also made it possible to identify the links that may exist between the topography and the plant communities, which can provide an overview of the preferences of certain plant species with respect to soil conditions and drainage.

The quantity of information that can be conveyed on a paper map is limited by the scale of the map and the format of paper on which it is printed. In the present case, more than 100 attributes were associated with certain polygons (see the GIS version of the TEM in shapefile format for ArcGIS™ 9.3). It was therefore impossible to represent all the attributes associated with the polygons at the scale chosen for the printing of paper maps. In order to remedy this situation, the maps of the geological surface deposits and the maps of the terrestrial ecosystems were produced separately. In spite of that, only simplified maps could be produced at the selected scales, showing the main characteristics of each polygon. The simplified maps nevertheless provide an appropriate level of detail for the assessment of environmental effects. If users want information not included on the paper maps, they have to refer to the complete description of each polygon available in the .mxd files of the TEM in ArcGIS™ 9.3 format (see the GIS version of the TEM in shapefile format for ArcGIS™ 9.3). The definition of each of the columns of the GIS database is available in the metadata in Appendix I. Even though the maps of the terrestrial ecosystems make it possible to assess the ecological sensitivity of the sites, the maps of the surface deposits also have important implications in terms of engineering and land-use planning.

Although the maps of the geological surface deposits and the terrestrial ecosystems were produced separately, they share the same polygon boundaries. Adjacent polygons sometimes share the same surface deposit characteristics, but they may still have different terrestrial ecosystem characteristics. In the same way, two contiguous polygons sharing the same terrestrial ecosystem characteristics can differ with respect to their surface deposits.

The scale used to produce the maps of the surface deposits and those of the terrestrial ecosystems is consistent with that used for the interpretation of the aerial photos.

A technical report was then produced to summarize the methodology and to present the various results associated with the ecological characterization and mapping.

3.1.7 Quality Assurance/Quality Control

Groupe Hémisphères has developed over the years a quality, health and safety system based on the ISO 9001:2008. Tasks assigned to Groupe Hémisphères are reviewed by the most qualified professionals. Furthermore, appropriate resources are always provided for the technical team depending on the technical and skill requirements of the task. Each responsible for an assigned task is accountable for ensuring that the task is completed on time and up to the high standards routinely provided by Groupe Hémisphères.

Quality control measures were applied at each step of the study, including planning, photo interpretation, modeling, the collection of data in the field, inputting the data and the production of maps, in order to obtain a useful, reliable and understandable mapping product.

Before undertaking the photo interpretation and field work, the team acquired a better understanding of the regional environment and the local biophysical environment through a detailed review of the literature and a summary of information relevant to the study site.

During the main interpretation phase, each polygon that was likely to be poorly interpreted was selected and verified by another interpreter. Throughout the interpretation process, senior field experts performed quality control checks of the interpretation of randomly selected polygons.

The field work carried out in August 2013 made it possible to do quality control and assess the accuracy of the photo interpretation by comparing the data with the field observations. The data collected were also compared to those collected for the DSO TEM.

All the plant species that could not be identified with certainty were sampled and pressed in a herbarium in order to be identified upon return by an experienced botanist.

An exhaustive check of the quality and consistency of the field data was carried out by the project team leader, and all necessary changes were made. All the digital data entered in *Ecotype* were verified by another member of the team in order to detect any systematic or sporadic data input errors.

Background information pertinent to the bedrock and surficial geology within the overall study area was reviewed. This included regional-scale surficial geology/terrain mapping from the Quebec government and Geological Survey of Canada, as well as geological publications from industry and academia.

4 REGIONAL OVERVIEW OF THE PROJECT AREA

The following sections provide an overview of regional geology (Subsection 4.1) and ecology (Subsection 4.2) within the proposed Project area. The descriptions provide an important regional context for the more detailed terrain and ecosystem mapping that was carried out for the Project.

4.1 Regional Geology

4.1.1 Bedrock Geology

The entire Project study area is underlain by bedrock of the Canadian Shield, which forms the core of North America. The Superior Province, located in westernmost Labrador, only several kilometres west of the Howells River, includes Archean rocks 2.5 to 4 billion years old.

Lithologies include cherty ironstone, underlain by quartzite, and their schistose to gneissic equivalents (Wardle et al., 1997). To the northeast, the Churchill Province comprises rocks 1.75 to 2.1 billion years old, including siltstone, shale, and greywacke sequences with turbiditic origins, and their schistose equivalents (Wardle et al., 1997). Most of the significant iron formations have been found in this province. The youngest rocks crossed by the proposed corridors are in the Grenville Province, which is located southeast of the Superior Province. These rocks, from the Proterozoic, are 950 million to 1.2 billion years old. Granitoid rocks have intruded otherwise metasedimentary gneisses, locally forming sills of gabbro (Wardle et al., 1997).

4.1.2 Glacial History and Distribution of Surficial Deposits

The main landscape elements of the Quebec/Labrador Peninsula, including ridges, valleys and the pattern of the major drainage network, are the result of deformation and erosion of Pre-Cambrian (up to 3 billion years old) bedrock. Continental glaciations during the Quaternary Period (<2 million years), however, have modified areas of the landscape to different degrees through the erosion of bedrock and deposition of sediment and soil materials.

During the Quaternary Period, continental glaciations repeatedly covered most of Canada, including the Quebec/Labrador Peninsula. The Laurentide Ice Sheet, which extended across mainland Canada from the foothills of the Rocky Mountains to Newfoundland, is believed to have had several centres, or ice divides, from which ice flowed outward. One of those ice divides, the Labrador Divide, appears to have been centred just several tens of kilometres northwest of Schefferville during the most recent, Late Wisconsin, glacial advance, which culminated locally about 8000 years ago (Andrews et al., 1986). The variable orientations of glacially-streamlined landforms (e.g., drumlins, roches moutonnées, striae) within the LSA are consistent with this theory.

Till deposited beneath actively flowing glaciers and through passive let-down by melting ice covers most of the ground surface. Its continuity and thickness, however, are highly variable. Only a thin, discontinous veneer overlies bedrock west of the Howells River, whereas comparatively thick ground moraine (up to several metres) blankets the uplands to the east. The till is bouldery, with a silty sand matrix. Large erratics are scattered across the rolling plains.

Deglaciation appears to have occurred through gradual concentric retreat of the ice sheet from the margin toward the centre, with isolated areas of in situ downwasting of ice. Kettles and low-relief, hummocky moraine are typical features of stagnant ice. Meltwater spillways and esker complexes radiate outward from the LSA in regional-scale Surface geology mapping (Klassen et al. 1992). Boulder fields in some valley bottoms are probably the result of meltwater erosion of fine-grained sediments. According to radiocarbon dating of peat, the LSA was not ice-free until 5000 to 6000 years ago (Nicholson, 1971).

Early in the post-glacial period, particularly before vegetation had become established, a variety of processes modified the regional landscape. Periglacial activity was concentrated along windswept ridges and plateaux at high elevations, where snow depth during the long winter was minimal. As a result of glacial debuttressing and weathering, cliffs were particularly susceptible to frost shatter and mass movements. Colluvium accumulated along the bases of prominent hills and knobs. Streams eroded channels through glacial drift and formed small fans and deltas where they flowed into broad valley bottoms and lakes. Strong winds deflated till-covered ridges, leaving behind a gravelly surface lag and redistributing fine sediments into sheltered, low-lying areas. In valley bottoms and depressions within rolling to undulating plains, vegetation began to colonize. Wetlands formed in the most poorly-drained areas, such as along bedrock fractures and at the confluence of headwater streams and shallow subsurface drainage pathways, where high groundwater tables slowed the decomposition of organic material.

4.2 Regional Ecological Context

The LSA is entirely within one ecozone, the Taiga Shield Ecozone, which extends from coastal Labrador to central Northwest Territories. The southern part of the Quebec-Labrador border is the boundary between the Taiga Shield Ecozone and the more forested Boreal Shield Ecozone to the south. The landscape of the Taiga Shield Ecozone, which is largely situated on Pre-Cambrian rocks of the Canadian Shield, is best characterized as a rough, rolling upland. Elevations change gradually from about 400 mASL near Churchill Falls to nearly 800 mASL along the ridges of the Howells River Basin, but localized rugged areas of cliffs and canyons exist. Surface deposits are usually thin, and extensive areas of very thin soils over exposed bedrock are common. The Taiga Shield Ecozone in Labrador is transitional between forested and tundra biomes. This ecozone is discontinuously forested where soils permit and, although productivity is considerably lower, includes most of the species found in the Boreal Ecozone. Sporadic to discontinuous permafrost and related periglacial features exist in high, windswept areas, especially in wetlands near ridge crests. Productive forest of white spruce can occur on active floodplains along larger rivers.

The LSA is contained within two ecoregions: the MSF and the HST Ecoregions. The MSF ecoregion includes the upland plateaux of central and western Labrador, where eskers and drumlin ridges are characteristic. Many low-lying areas have been inundated by hydroelectric reservoirs, however, so shoreline ecosystems are common. The area has a continental, subarctic climate, with short, cool summers and long, severe, cold winters. The growing season is 100 to 120 days. Black spruce is the dominant tree species, along with white spruce and tamarack. Trembling aspen reaches its northern limit here, and the only native population of jack pine occurs in this ecoregion (DFRA-Innu Nation, 2003). Open lichen woodlands are characteristic and are interspersed across the landscape by extensive ribbed fen-string bog complexes, which dominate depressions. The HST Ecoregion has short cool summers and long winters with severe winds in exposed areas. The growing season is only 80 to 100 days, and annual precipitation ranges from 700 to 1000 mm. Tundra vegetation, described as ‘alpine heath’ by Meades (1990), covers more than 50% of upland plateaux. The HST Ecoregion features shallow fens in depressions and along streamcourses, locally with discontinuous permafrost.

5 TERRAIN MAPPING AND DESCRIPTION OF THE PROJECT AREA

Terrain mapping is the process of dividing the landscape into polygons according to Surface geological and landform characteristics, typically based on aerial photograph interpretation and selective field work. It provides the foundation for, and is an integral component of, terrestrial ecosystem mapping (TEM). The national and international use of terrain mapping has resulted in the adoption of a variety of coding systems and legends. For consistency with the terrain mapping completed for the DSO Project (Groupe Hémisphères, 2011), the terrain mapping approach developed as part of the NOEGTS (Gartner et al., 1981) was applied to this study. This mapping system shares similar objectives to this study and was developed for terrain with a similar geological and geomorphological history.

Subsection 5.1 explains, using illustrative examples, the coding system used on the terrain maps. Subsection 5.2 describes in detail the types of landforms identified in the LSA. The summary description of the LSA (Section 7) contains enough detail that readers who have not read Subsection 5.2 will still understand the main points.

5.1 Description and Interpretation of Terrain Maps

Based on the NOEGTS (Gartner *et al*., 1981) system, each polygon is described by four key components: landform, material, topography and drainage. Each component influences to varying degrees soil development and soil moisture regime, and the type, diversity and structure of vegetation communities. Characterization of these four components also permits general inferences about the suitability of the terrain for infrastructure and activities. A brief rationale for characterizing each of these components is provided below.

5.1.1 Landform

Landforms are the result of a particular set of historical or modern erosional and/or depositional processes. The identification of a particular landform, combined with an understanding of the processes that created it, permits inference about its characteristics. For example, identifying an esker, which is a long, sinuous ridge of sediment deposited by flowing glacial meltwater in ice-walled channels or tunnels, permits the conclusion that it will be composed of stratified, well- to rapidly-drained sand and gravel. The landform is the prime mapping unit.

5.1.2 Material

The type and texture of the material comprising a landform can be inferred from an understanding of its origin. For example, ground moraine, which is deposited directly by glacial ice, is inferred to be composed of a wide range of grain sizes, from clay to boulders, based on the understanding that glaciers do not preferentially erode or deposit material according to size. The material characteristics of landforms provide a basis for inferring drainage conditions, which influence soil development and vegetation communities. The sensitivity of landforms and their associated ecosystems to disturbance is, in part, also inferred from material characteristics. Material is, therefore, a main mapping component.

5.1.3 Topography

The relative relief – low (<15 m), moderate (15 – 60 m) or high (>60 m) – and topographic variety, or surface expression, of a landform have important implications for ecosystems and habitat. For example, high points are likely better drained than intermediate depressions, where wetlands may develop, and hummocky relief may provide greater habitat diversity and shelter for animals. Relief and topographic variety collectively constitute an important mapping component.

5.1.4 Drainage

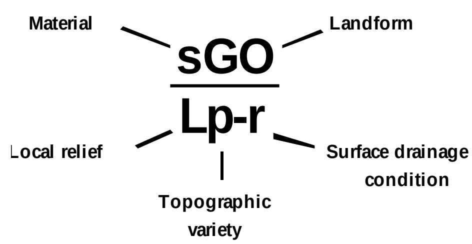
The surface drainage condition of a landform, namely the ease with which water infiltrates into and flows through it, has ecological significance. For example, poor drainage promotes the development of organic-rich soils and growth of moisture-tolerant vegetation. Each polygon was assigned to one of seven drainage classes used in MoELP-MoF (1998). The rare case of a high groundwater table within a landform whose surface is dry was also documented. Surface drainage condition is the final mapping component.

5.1.5 Terrain Code and Legend Format

Although the ArcGIS™ platform provides the flexibility to generate any type of terrain code label from the TEM attribute table, a simple, standardized format that contains the key information has been devised. For consistency, each of the four components has a fixed position in the legend format:

MATERIAL	LANDFORM
TOPOGRAPHY	DRAINAGE

Upper and lower case *letter symbols* represent particular values of each component (Appendix I). For example, the following terrain code describes rapidly-drained (r) sandy (s) glaciofluvial outwash (GO) with low-relief (L), planar (p) surface topography:



In the "numerator" of the terrain code, two upper-case letter symbols designate a particular landform (e.g., GO). The first letter symbol represents the basic origin of the landform, e.g., glaciofluvial (G); the second letter symbol represents the particular type of landform, e.g., outwash (O). A lower-case letter symbol, which always precedes the landform code, designates the dominant material comprising the landform, e.g., sand (s).

The topography and drainage are specified in the "denominator" of the terrain code. Local relief is indicated by one of three upper-case letters: L (low, <15 m), M (15 – 60 m) or H (high, >60 m). In the example above, relief is low (L). Because relief is interpreted from aerial photographs and base mapping, the values should be considered approximate. Topographic variety within one of the three categories of relief represents local shapes, forms or processes, which are mainly associated with recognizable erosional or depositional processes and may be glacial or post-glacial in age and origin (Gartner *et al*., 1981). Lower-case letter symbols, in this case p, for planar, specify topographic variety. The combined designation of relief and topographic variety above, Lp, describes low-relief (L) terrain with a planar (p), or level, surface. The surface drainage condition of the landform is indicated with a lower-case letter symbol, e.g., w, for well drained.

Although the terrain code described above may fully characterize some polygons, many polygons exhibit greater heterogeneity than can be represented with so few letter symbols. For such polygons, the *simplified* terrain code described above provides only the dominant values of each of the four main components. The headings of the columns within the TEM ArcGIS™ attribute table from which the dominant values of landform, material, relief and topographic variety and drainage originate are D1_Ov_Land, D1_Ov_mat3, Dom_relief and Dom_topog1 and Dom_drain respectively.

All terrain-related information can be represented, however, in a more complex, *complete* terrain code. The practicality of displaying complete terrain codes at the map scales used in this study (i.e., 1:20,000) is limited by constraints associated with label clarity and overlap. In addition, a script for generating *complete* labels from the attribute table is included within the TEM ArcGIS™ .mxd file for those users who may wish to display more detailed terrain-related information on enlarged portions of the maps. Indeed, it may be necessary to display the complete terrain codes on field maps to support planning or preliminary design investigations. One must remember, however, that the maps are only as accurate as the scales on which the interpretations are based. Detailed designs should always be based on site-specific field investigations, never just on interpretations of aerial photographs and reconnaissance field confirmation.

To facilitate reading the map and making spatial comparisons, standardized colours (based on federal and provincial surficial geology maps and on the NOEGTS mapping) have been assigned to each polygon (Terrain Map, Appendix II) according to the most dominant landform. For example, polygons dominated by morainal and glaciofluvial landforms are coloured green and yellow respectively. Colours do not differentiate polygons according to subordinate landforms; again, the digital file must be consulted to fully appreciate any intra-polygon variability.

5.1.6 Terrain Code Examples and Interpretation

The use and meaning of the terrain codes are best conveyed through examples. Therefore, the simplified terrain codes of two distinct terrain polygons are provided below, along with a brief explanation of their meaning and significance.

The most common simplified terrain code in the LSA is tMG/Lu-w. This code represents a well-drained (w), low-relief (L), rolling to undulating (u) ground moraine (MG) composed of till (t). Several adjacent polygons may have identical simplified terrain codes due to differences in subordinate terrain characteristics (recorded in the TEM ArcGISTM .mxd file), in addition to differences in terrestrial ecosystem characteristics. Polygons in which bedrock is inferred to be within about 2 m of the ground surface are indicated by a diagonal hatch pattern.

Another common simplified terrain code, which applies to wetlands, is pOT/Lp-v. This code describes very poorly-drained (v), low-relief (L), planar (p) or flat organic terrain (OT), mainly composed of peat (p).

Using this wetland code (i.e., pOT/Lp-v) as an example, the limitations of relying solely on the simplified terrain code for planning or preliminary design purposes must be emphasized. Most wetlands in the LSA are fairly shallow and many are punctuated by bouldery till mounds or bedrock knobs. While the TEM ArcGISTM .mxd file indicates the subordinate presence of bedrock knobs (RN), as would the complete terrain code, no indication of bedrock presence is provided in the simplified terrain codes. Terrain Maps, which convey the primary terrain characteristics of each polygon through the use of colour and simplified terrain codes, provide a valuable overview of general conditions, but the complete digital information should be consulted for determining the capacity of a particular site to support infrastructure of any kind.

5.2 Landform Type Descriptions

Landforms are the result of a particular set of erosional or depositional processes. Thus, landforms can be classified according to their origins. Given the interactions among the geological processes that create landforms, two landforms of the same type will never be identical and an individual landform may even exhibit considerable internal variability. In addition, post-formation modification of landforms by other processes can lead to considerable external variability. Nevertheless, most landforms are sufficiently distinct that their generic description reflects their primary characteristics reasonably well and can be used to predict soil conditions and engineering properties such as degree of compaction or consolidation.

The following "fact sheets" describe in detail the typical characteristics and variability of the landforms found in the LSA. The summary tables are intended to provide stand-alone descriptive summaries, highlighting each landform's key features, so they are not numbered or included in the List of Tables at the beginning of this report. Users who are interested in only one or two specific areas may prefer to consult the map (Appendix II) first and then to review only those summary tables within the following subsections that are relevant to their area of interest.

5.2.1 Bedrock Landforms

Areas of exposed bedrock are scattered throughout the LSA (about 4,2% of total areal coverage), most commonly on ridge and hill crests. Distinguishing bedrock lithology was beyond the scope of the TEM objectives, but such information is available on regional geological maps (e.g., Wardle et al., 1997).

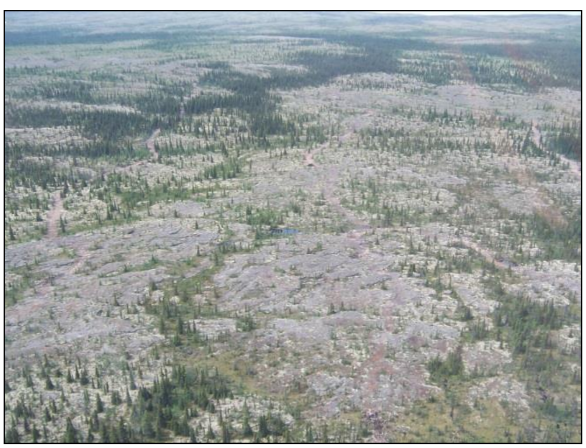
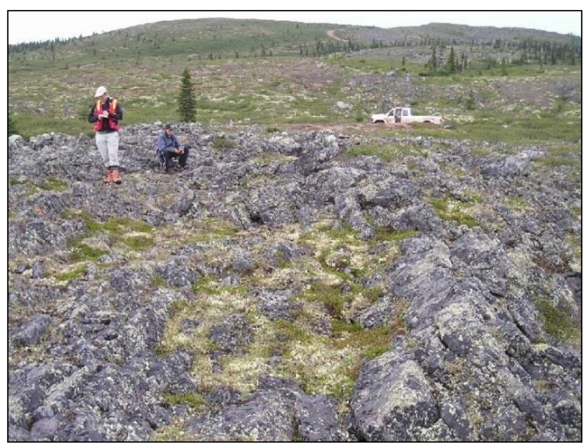
Two types of erosional bedrock landforms were mapped: knobs and ridges. Bedrock knobs (RN) are protruding, rounded to jagged hills of bedrock, and bedrock ridges (RR) are elevational crests of bedrock, commonly exhibiting linear continuity. Areas where bedrock underlies a drift veneer less than about 2 m thick have been diagonally hatched on the terrain maps (Appendix II).

The distribution of bedrock landforms across the LSA is related to past glacial activity and pre-existing topography. Bedrock is commonly exposed where it exhibits moderate to high local relief and on steep slopes. Ridge crests and abrupt knobs protruding from an otherwise low-relief landscape concentrated the erosive forces of flowing glaciers, and any overburden was easily stripped away. In addition, relatively steep slopes inhibited the accumulation of thick deposits and hastened the erosion of unconsolidated material. Subglacial meltwater activity also appears to have influenced the distribution of bedrock exposure. Particularly during deglaciation, when temperatures were warming and glaciers were melting, considerable volumes of meltwater flowed beneath the ice. Subglacial meltwater floods stripped away overburden in areas where sheetflow became concentrated, in some cases eroding several metres into bedrock.

Bedrock is recognized in aerial photographs by its sharp-edged appearance and systematic structural orientations (e.g., fractures). Where bedrock is overlain by a thin drift veneer (hatched polygons on terrain maps), its close proximity to the surface is inferred from distinct primary structural features and isolated bedrock outcrops.

The local relief of bedrock terrain differs across the RSA. In general, it is relatively low (<15 m), but several long ridges in the RSA exhibit local relief up to about 60 m. While till may be non-existent on high outcrops of bedrock, it can reach thicknesses of several metres in modest hollows. The simplified terrain code for such areas would indicate only bedrock presence, but the complete attribute table within the TEM ArcGISTM.mxd file would also list a subordinate till veneer.

Bedrock terrain is generally well to rapidly drained, depending on slope steepness and the type and distribution of any overburden. Where depressions and eroded fractures exist on the bedrock surface, however, surface runoff and groundwater may become trapped, over time forming wetlands. Depending on the relative proportions of bedrock and wetlands, such areas were mapped as RN (bedrock knob) or pOT (peaty organic terrain) respectively, with the subordinate presence of the other landform recorded in the TEM ArcGIS^{TM} .mxd file. Ecotypes MSF02, MSF03, MSF04, HST02 and HST03 are commonly associated with bedrock terrain.

Summary Table – Bedrock Landforms	
Distribution: Scattered throughout the LSA (4,2% of total areal coverage); most commonly exposed on ridge and hill crests	**Material Composition:** Bedrock, locally weathered into angular fragments
Landform Sub-types: RN, RR	**Sorting:** n/a
Depositional Origin: n/a – eroded, particularly by glacial ice	**Drainage:** Well to rapidly drained
Topographic Surface Expression: Knobby, ridged, planar	**Soil Types:** Folisol
Thickness: n/a, except where thin till or weathered bedrock veneers (<1 m) exist	**Associated Ecotypes:** Ecotypes MSF02, MSF03, MSF04, HST02 and HST03
Variability: Intact bedrock commonly overlain by weathered (frost shattered) fragments on high ridge and hill crests; patchy till veneers (<1 m) too small to be mapped; wetlands present in depressions	**Special Considerations:** Unpredictable groundwater flow, rugged topography, frost shattering of bluffs
Landform: 	**Material:** 

5.2.2 Morainal Landforms

Morainal landforms are accumulations of till, which may contain localized granular deposits. They are the most widespread landforms throughout the LSA (84% of total areal coverage). Ground moraine (MG), by far the most common morainal landform, originates through two main processes: active deposition of glacially-eroded material beneath a flowing glacier; or passive deposition of material from ablating glacial ice.

The thickness of ground moraine is highly variable across the LSA, and even within localized regions. Abandoned open pit mines and the associated test pits and trenches from several decades ago provide the rare opportunity to observe the lateral variability in overburden thickness. Discontinuous till veneers (<2 m) and uniformly thick till blankets (2-5 m) are most common, but erosional till slopes on some valleysides reveal local thicknesses in excess of 10 m. Isolated bedrock knobs commonly protrude through till veneers, in which case the complete polygon description would include subordinate presence of bedrock knobs (RN).

Morainal landforms can vary considerably in material composition, since different environments and modes of deposition from ice result in landforms with different sedimentological characteristics. The silty sand till matrix differs little across the LSA, but the stone content differs substantially. Areas characterized by distinctly bouldery till include the textural modifier b in the complete digital terrain description.

Post-depositional reworking of till has the potential to modify its characteristics significantly. For example, small boulder fields (bMG) occupying low-lying or valleyside areas are the result of meltwater washing away the fine till matrix sediment, leaving behind the largest boulders. Meltwater-dissected till blankets, which exhibit accordant surfaces separated by gullies, tend to have notably drier soil moisture regimes. A process that is still active on some till deposits, and influences the rate and distribution of tundra vegetation growth, is cryoturbation. Fresh frost boils, sorted stone polygons and contorted soil horizons, were observed on high, windswept, unvegetated to tundra-covered ground throughout the LSA. While permafrost undoubtedly underlies some of these high areas, on-site reports from drillers and existing literature (e.g., Nicholson and Lewis, 1976) indicate that the depth of the active layer is commonly around 10 m. The classification of a soil as a cryosol requires permafrost within 2 m of the surface in cryoturbated areas.

Due to its generally fine-grained matrix and density, till has a moderate to low permeability. Where exposed at surface, however, weathering increases its permeability. Most of the till in the LSA, given its sandy matrix, is moderately well to well drained, particularly on rolling topography. Ecotypes MSF01, MSF05, MSF06, HST01, HST03 and HST04 are commonly associated with till plains, in part due to moderate to good drainage and a moderately-rich soil nutrient regime.

Summary Table – Morainal Landforms	
Distribution: Widespread throughout the LSA (84% of total areal coverage)	**Material Composition:** Silty sand till; locally bouldery
Landform Sub-types: MG	**Sorting:** Very poor
Depositional Origin: Deposited directly by glacial ice	**Drainage:** Moderately well to well drained
Topographic Surface Expression: Planar to undulating; locally hummocky	**Soil Types:** Orthic Humo-Ferric Podzol, or Orthic Gleysol
Thickness: Thin veneers (<1 m) to locally >10 m	**Associated Ecotypes:** Ecotypes MSF01, MSF05, MSF06, HST01, HST03 and HST04
Variability: Washed/reworked till; boulder fields; cryoturbation features (frost boils, sorted stone polygons, contorted soil horizons)	**Special Considerations:** Density and thus permeability varies; interstitial lenses of granular material may be present; cryoturbation locally disturbs soil profile on some high, windswept ridges and hills
Landform: 	**Material:** 

5.2.3 Alluvial Lanforms

Alluvium is material that has been transported and subsequently deposited by modern (post-glacial) streams. Due to the scale of aerial photography used in this study, all alluvial landforms, including channel beds and banks, floodplains, fans and deltas, are collectively mapped as alluvial plains (AP). Active alluvial plains and relic terraces exist throughout the LSA (2,3% of total areal coverage). The floodplain deposits tend to consist of stratified sand and silt, but many channel beds in the LSA are armoured with cobble or boulder pavements. These stream pavements, actually lag deposits, are the result of long-term preferential erosion of fine sediment from the underlying substrate.

The most significant alluvial plains were mapped, but headwater streams were generally too small to map. Most streams in the LSA are confined by at least one valleyside and have discontinuous floodplains. Their planform configurations may be controlled by the fracture pattern within the underlying bedrock. In places, the longitudinal profile of the streams is controlled by bedrock in the channel bed.

Floodplains of many of the intermediate-sized channels are composed of a mixture of fine sediment and organic material. Some streams contain isolated wetlands in their riparian zone and, locally, banks composed predominantly of peat.

Although alluvium tends to be moderately to well sorted, it generally accumulates in valley bottoms, which have relatively high groundwater tables. As a result, most alluvial soils are imperfectly to poorly drained, especially if partially composed of moisture-retaining peat. Therefore, Ecotypes MSF07, MSF15 and HST05 tend to occur on imperfectly drained, rich alluvial soils.

Summary Table – Alluvial Landforms	
Distribution: Valleys throughout the LSA (2,3% of total areal coverage)	**Material Composition:** Silt, sand, gravel, cobbles, boulders, bedrock, peat
Landform Sub-types: AP	**Sorting:** Moderately to very well sorted
Depositional Origin: Deposited by modern stream flow	**Drainage:** Poorly to imperfectly drained
Topographic Surface Expression: Planar, channelled	**Soil Types:** Regosol and Gleysol
Thickness: Generally <2 m	**Associated Ecotypes:** Ecotypes MSF07, MSF15 and HST05
Variability: Cobble and boulder pavements armouring stream bed; silt and peat floodplain deposits; bedrock-controlled longitudinal profiles	**Special Considerations:** Prone to flooding and sedimentation; groundwater table near surface; susceptible to frost heave; commonly associated with organic veneer
Landform: 	**Material:** 

5.2.4 Colluvial Landforms

Colluvium is material that has been transported and subsequently deposited through the force of gravity. Therefore, all landforms that have originated through falls, topples, slides, avalanches or creep are classified as colluvial landforms. Less than 1% of the area of the LSA is classified as colluvium, partly because most colluvial landforms within it are of insufficient extent to be mapped using aerial photography. However, the presence of localized colluvial deposits in the LSA necessitates description of their landform characteristics.

The most common colluvial landform is a talus pile (CT). Talus is the accumulation of broken rock beneath a cliff prone to frost shatter. Talus piles may contain large boulders through fine sand. Most bedrock knobs with moderate to high relief, such as in the southern part of the LSA, have small talus piles at their bases. High cliffs with near-vertical slopes may have talus piles several metres thick, with surface slopes approximating the natural repose angle of 35°.

The drainage characteristics of colluvial landforms are largely dependent on the source material. Talus piles tend to be well to rapidly drained, given their coarse texture and steep slopes, whereas earth flow deposits, for example, which typically have a fine matrix, may be only moderately well drained. Over time, colluvial landforms may support Ecotypes MSF05 (coarse phase), MSF01 and HST03 (coarse phase).

Summary Table – Colluvial Landforms	
Distribution: Less than 1% throughout the LSA	**Material Composition:** Depends on source material: angular bouldery rubble to sand, silt and clay; permafrost may be present at depth
Landform Sub-types: CS, CT	**Sorting:** Poorly to very poorly sorted
Depositional Origin: Deposited by gravitational mass movements, in some cases related to movement of the active layer above relic or modern permafrost	**Drainage:** Moderately to rapidly drained
Topographic Surface Expression: Sloping, undulating, lumpy	**Soil Types:** Orthic Humo-ferric Podzol and Dystric Brunisol
Thickness: Thin veneers (<1 m) to approx. 5 m	**Associated Ecotypes:** Ecotypes MSF05 (coarse phase), MSF01 and HST03 (coarse phase)
Variability: Surface typically coarse rubble and boulders, but finer gravels and sand may exist beneath surface	**Special Considerations:** Talus piles generally have repose angle slopes of about 35˚ and may be locally unstable; relic or modern permafrost may be present within some masses
Landform: 	**Material:** 

5.2.5 Organic Terrain

Organic terrain, composed of peat and muck, is scattered throughout the LSA (3,7% of total areal coverage), largely due to low relief. It exists wherever organic material has accumulated, generally in confined depressions with very poor to poor drainage. All peatlands were initially delineated as organic terrain (OT), as shown on the terrain maps (Appendix II), regardless of their marsh, swamp, bog or fen classification. Subsequently, however, organic units were subdivided according to dominant plant species, soil nutrient regime and drainage characteristics, as shown on the terrestrial ecosystem maps (Appendix III).

Small wetlands are common, but most are punctuated by bedrock knobs or morainal hills, as indicated in the TEM ArcGIS™ .mxd file by the subordinate presence of RN (bedrock knob) or MG (ground moraine) respectively. Rolling to undulating till plains commonly contain poorly-drained peat-filled depressions, which are assigned subordinate presence within the complete digital attribute table.

The depth of organic terrain is highly variable. In many cases, boulders are visible at or beneath the stagnant water surface in wetlands, indicating that the organic material is relatively shallow. Most valley bottom wetlands appear to be less than 2 m deep. Where topography is undulating to hummocky, however, thicker accumulations of peat may exist.

The defining characteristic of organic terrain throughout the LSA is poor drainage. Perennially high groundwater tables inhibit the decomposition of organic material. Fens occupy valley bottoms, alongside streams and lakes, and fractures within bedrock that have a more or less constant groundwater supply. Many contain areas of open water, the extent and connectivity of which vary seasonally and in response to prolonged rainfall or snowmelt. A variety of moisture-tolerant ecosystems are associated with wetlands, including Ecotypes MSF10, MSF11, MSF12, MSF14 as well as HST06 and HST07.

<table>
<tr><th colspan="2">Summary Table – Organic Terrain</th></tr>
<tr><td>Distribution:

Scattered throughout the LSA (3,7% of total areal coverage), especially in valley bottoms</td><td>Material Composition:

Peat, muck</td></tr>
<tr><td>Landform Sub-types:

OT</td><td>Sorting:

n/a</td></tr>
<tr><td>Depositional Origin:

Accumulation of decomposing organic material</td><td>Drainage:

Very poorly to poorly drained</td></tr>
<tr><td>Topographic Surface Expression:

Planar</td><td>Soil Types:

Fibrisol and Mesisol (Organic Order), Fibric Organic Cryosol (one observation)</td></tr>
<tr><td>Thickness:

Generally <2 m, but locally up to several metres</td><td>Associated Ecotypes:

Ecotypes MSF10, MSF11, MSF12, MSF13, MSF14 as wel as HST06 and HST07</td></tr>
<tr><td>Variability:

Marsh, swamp, bog, fen; seasonally fluctuating groundwater table; areas of open water; boulder-paved wetlands</td><td>Special Considerations:

Groundwater table is at or near surface and flooding is common; relic permafrost may be present in high elevation wetlands, beneath areas of thick sphagnum moss</td></tr>
<tr><td>Landform:

</td><td>Material:

</td></tr>
</table>

6 TERRESTRIAL ECOSYSTEM MAPPING AND DESCRIPTION OF THE PROJECT AREA

Terrestrial ecosystems In the LSA have been classified, organized and mapped using a standard TEM mapping following RIC (1998). To provide a synoptic summary of map units and local terrestrial ecosystems, all ecotypes are described in a series of fact sheets in Appendix V. Depending on the reader's objectives, he or she may wish to skip directly to the map area of interest (Appendix III), and then review only those fact sheets that are relevant to their needs. Sufficient detail accompanies the references to ecotypes in the summary study area descriptions (Section 7) that readers who have not read the fact sheets in their entireties will still be able to understand the main points. The vast majority of ecotypes within the LSA are described in this section. However, ecotypes abundant within the RSA but marginally represented within the LSA are not described and shaded in light green in the tables (Table 3 and Table 4). The reader is invited to read the DSO TEM report (Groupe Hémisphères, 2011) if interested in having further information about ecotypes distribution at the RSA scale.

6.1 Mid Subarctic Forest Ecoregion

The general geology, topography and glacial history of the MSF Ecoregion are described in Section 4. This overview concentrates on climatic descriptors. Mean annual temperature is between -5° and -2.5°C, and annual precipitation is around 800 mm, with 300 mm falling as snow. Summers are cool and four to five months long, and winters are cold and snowy (Meades, 1990). The mean daily minimum temperature of the coldest month is -28.9°C, and the lowest recorded temperature is -49.4°C.

The severe climate inhibits continuous tree cover on upland sites, so forest cover is generally discontinuous – a transition between relatively productive closed boreal forests to the south and the treeless subarctic tundra to the north. Closed canopy forests occur only on moist sites with seepage, and there are very few deciduous trees (scattered and isolated stands of white birch do occur on some post-fire sites near the southern boundary with the BSM). To the north, Balsam fir almost disappears from the forest, leaving only black spruce, white spruce, and tamarack as forest tree species. Black spruce - lichen woodland stands are common on dry sites, and low-productivity, open stands of black spruce, mixed with white spruce and tamarack, occur on well-drained sites on deep morainal landforms. Forest fires are common and typically cover large areas, so many stands are in early successional stages. Extensive wetland complexes are common, and patterned or ribbed fens, interspersed with forested fens, characterize them.

The Table 3shows the late seral ecotypes present in the MSF ecoregion. Since they were not found in the study area, the ecotypes highlighted in dark green were classified, described and mapped in the MSF Ecoregion, but were not described in detail in the text. Ecotypes highlighted in light green are present within the LSA but are marginally represented and therefore not described. The edatopic grid for this Ecoregion is also presented at Figure 2.

Table 3. Late-Seral Ecotypes in the MSF Ecoregion

ECOSITE	MRN FOREST TYPE	LATE SERAL ECOTYPE COMPLETE NAME	LATE SERAL ECOTYPE COMMON NAME	DESCRIPTION
MSF01	RE12	Black Spruce / White Spruce - Labrador Tea-Feathermoss (Forested Ecosystem)	Mesic / Zonal Spruce Feathermoss	Black spruce and moss-lichen stand; thin-thick deposits; medium soil texture; well drained
MSF02	RO	Crowberry-Map Lichen Rock Outcrop (Non-Forested Ecosystem)	Rock Outcrop	Rock outcrop with low ericaceous species; no or little surficial deposits; variable soil texture; very rapidly drained
MSF03	DS	Glandular Birch - Crowberry-Lichen Very Thin Till Over Rock (Non-Forested Ecosystem)	Birch-Crowberry-Lichen	Low shrub communities on thin soils in crest positions; variable soil texture; rapidly drained
MSF04	RE10	Black Spruce-Lichen Rock (Forested Ecosystem)	Black Spruce Lichen Rock	Rock-dominated sites with scattered, stunted black spruce; very thin veneers; variable soil texture; rapidly drained
MSF05	RE11	Black Spruce - Lichen Woodland (Forested Ecosystem)	Black Spruce Lichen	Black spruce lichen stand; thin-thick deposits; coarse soil texture; well to rapidly drained
MSF06	RE25	White Spruce/Black Spruce - Feathermoss Seepage (Forested Ecosystem)	White Spruce/Black Spruce Seepage	Black spruce feathermoss-ericaceous stand; thin-thick deposits; fine soil texture; imperfectly drained with seepage
MSF07	RE25f	White Spruce-Alder / Willow-Sedges Streambank (Forested Riparian Ecosystem)	Fluvial White Spruce / Sedge	White spruce-moss stand; thin-thick deposits; fine soil texture; riparian; flooded sites imperfectly to poorly drained
MSF08	BS1	Black Spruce / Tamarack-Glandular Birch-Sphagnum Swamp (Forested Wetland Ecosystem)	Black Spruce/ Tamarack Forested Swamp	Forested bog; denser stand than Ecotype MSF10; organic deposits; Sphagnum-dominated; poorly drained
MSF09	BS1f	Tamarack / Black Spruce-Shrub Birch-Sedges Fluvial Fen (Forested Wetland Ecosystem)	Black Spruce/ Tamarack Fluvial Spruce Fen	Forested fen; fluvial or organic deposits; sedge-dominated; poorly drained
MSF10	Bbu	Black Spruce Forested Bog (Forested Wetland Ecosystem)	Black Spruce Bog	Uniform forested fen; organic deposits; forest floor dominated by sedge and grass; poorly drained
MSF11	Fns	Structured Herb Fen (or patterned/ribbed fens) (Non-Forested Wetland Ecosystem)	Structured Herb Fen	Structured non-forested herb fen; organic deposits; vegetation dominated by sedge and grass; very poorly drained
MSF12	Fnu	Uniform Herb Fen (Non-Forested Wetland Ecosystem)	Uniform Herb Fen	Uniform non-forested herb fen; organic deposits; vegetation cover dominated by sedge and grass; poorly drained

ECOSITE	MRN FOREST TYPE	LATE SERAL ECOTYPE COMPLETE NAME	LATE SERAL ECOTYPE COMMON NAME	DESCRIPTION
MSF13	Fnn	Non-Uniform Herb Fen (Non-Forested Wetland Ecosystem)	Non-Uniform Herb Fen	Random non-forested herb fen; organic deposits; vegetation cover dominated by sedge and grass; poorly drained
MSF14	Fau	Uniform Shrub Fen (Non-Forested Wetland Ecosystem)	Uniform Shrub Fen	Uniform non-forested shrub fen; organic deposits; vegetation cover dominated by sedge and grass; poorly drained
MSF15	Fauf	Uniform Fluvial Shrub Fen (Non-Forested Riparian Ecosystem)	Uniform Fluvial Shrub Fen	Uniform non-forested shrub fen; fluvial or rich organic deposits; vegetation cover dominated by sedge and grass; soil richer and more diverse plant community than Ecotype MSF14; imperfectly to very poorly drained

Marginally represented within the LSA

Absent from the LSA

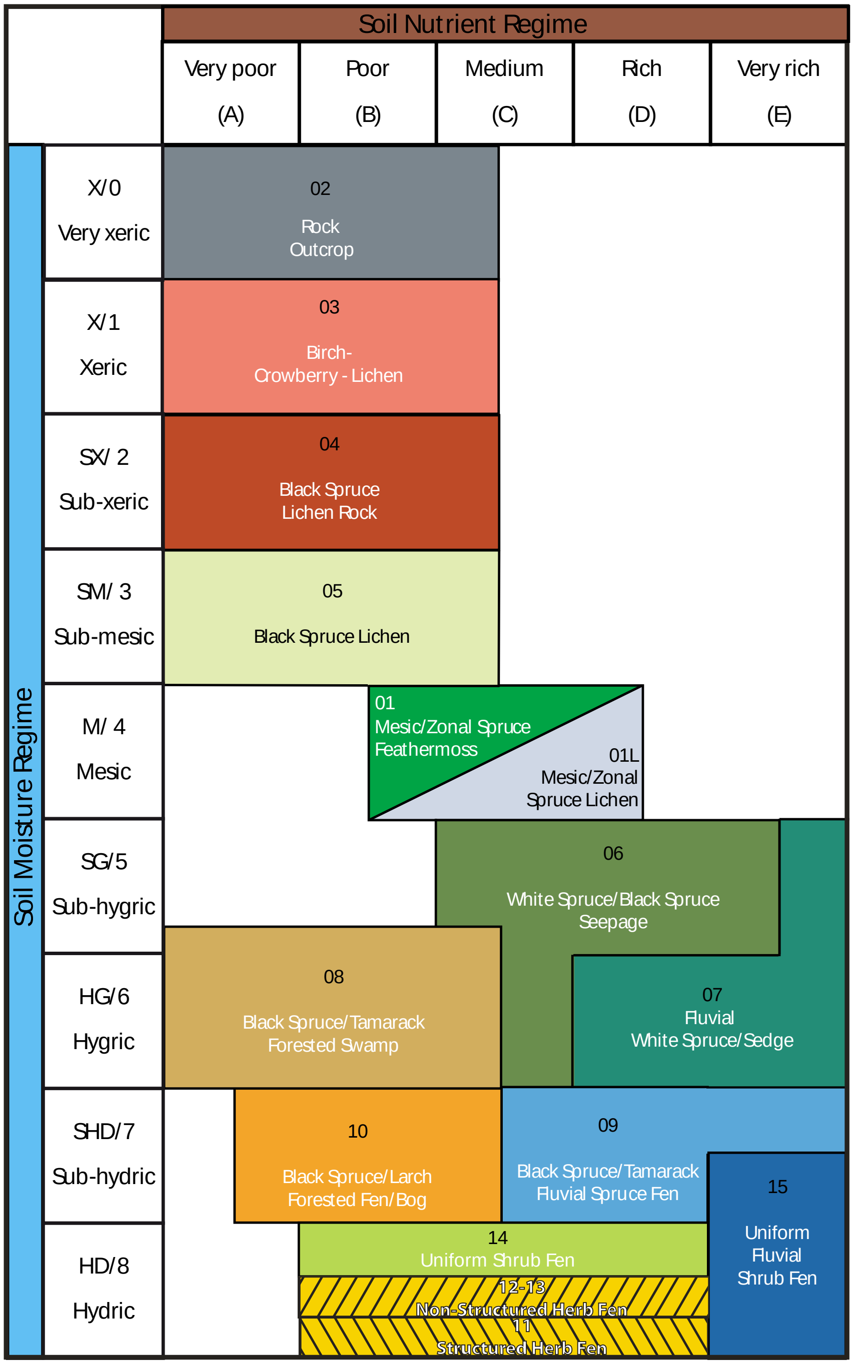


Figure 2 Edatopic Grid for the MSF Ecoregion

6.1.1 MSF Ecotype descriptions

MSF01: Black Spruce/White Spruce -Labrador Tea-Feathermoss (Forested Ecosystem)

Ecotype MSF01 is the 'zonal' or 'normal' late seral ecosystem for the MSF Ecoregion. Zonal or normal sites have a mesic SNR and medium SMR (neither too rich, nor too poor; neither too dry, nor too wet), support late seral ecosystems that best reflect the effects of regional climate, and thus can be used to characterize and map the spatial boundaries of the MSF Subzone. This ecotype also best represents changes in vegetation communities caused by climate change. Ecotype MSF01 occurs on deep to thin morainal soils throughout the study area. Compared to Ecotype MSF05, Ecotype MSF01 is less abundant, has a more closed canopy of black and white spruce and a higher shrub cover, especially Labrador tea. Feathermosses are more abundant than reindeer lichens in the moss layer. The MSF01 Ecotype can succeed to a disclimax Open Spruce Lichen Woodland Ecotype that also occurred on mesic ecosites, due to repeated fire that reduces black spruce seed source and permanently interrupts ‘normal’ ecological succession (MSF01L). Soils are typically Humo-ferric Podzols with Mor humus. In total, MSF01 covers 13% of the LSA.

MSF04: Black Spruce-Lichen Rock (Forested Ecosystem)

Ecotype MSF04 covers small areas, occurring on rocky sites with limited areas of very thin till. It is intermediate between Ecotype MSF02, which is almost entirely rock-dominated, and Ecotype MSF05, which is covered by a continuous mantle of thin till or deeper glaciofluvial deposits. Ecotype MSF04 is characterized by islands of stunted black spruce, with sparse shrub, herb and mosslichen layers in the understorey. Areas between tree islands feature crustose lichens on bare rocks and reindeer lichens on very thin soils. Soils are typically Folisols (organic humus layers over rock) or thin Humo-ferric Podzols, with Mor humus. In total, MSF04 covers around 2% of the LSA.

MSF05: Black Spruce - Lichen Woodland (Forested Ecosystem)

Ecotype MSF05 occurs primarily on coarse glaciofluvial deposits or on coarse moraine. This ecotype is highly visible from the air due to its distinctive light-coloured cover of reindeer lichens. Ecotype MSF05 is typified by a low cover (15 to 25%) of slowly growing black spruce, scattered shrubs dominated by Labrador tea, glandular birch (*Betula glandulosa*) and bog blueberry (*Vaccinium uliginosum*) and herbs and commonly continuous cover of reindeer lichen (*Cladina rangiferina*). Soils are typically Humo-ferric Podzols with Mor humus. In total, MSF05 covers around 21% of the LSA

MSF07: White Spruce-Alder/Willow-Sedges Streambank (Forested Riparian Ecosystem)

Ecotype MSF07 is, with Ecotype MSF06, the most productive forest ecosystems in the MSF Ecoregion. Ecotype MSF07 occurs on sites adjacent to streams and lakes that are enriched either by siltation and flooding, or subsurface seepage from adjacent streams or lakes. It occupies drainage courses, interspersed with Ecotypes MSF01 and MSF05, on level and rolling slope positions. Ecotype MSF07 features relatively large white and black spruce trees, a well-expressed shrub layer with willow species as well as abundant and diverse herb and moss layers. Soils are typically Regosol with Hemimor humus forms. In total, MSF07 covers around 1% of the LSA.

MSF08: Black Spruce/Tamarack-Glandular Birch-Sphagnum Swamp (Forested Wetland Ecosystem)

Ecotype MSF08 is common throughout the LSA, usually occuring in wetland complexes with forested (Ecotype MSF10) and non-forested (Ecotype MSF12) fens. As in other wetland ecotypes, this ecosystem occurs in depressions and lowlands, but on the margins of wetlands, where drainage is poor, but not very poor. This is a generally forested ecotype, with abundant herb, shrub and moss species. Although black spruce is the dominant tree, tamarack occurs more frequently in this ecotype than in any other and thus is used to name it. As in other wetland ecotypes, soils are commonly of the Organic Order, but gleyed mineral soils also occur. In total, MSF08 covers around 3% of the LSA.

MSF10: Black Spruce Forested Bog (Forested Wetland Ecosystem)

Ecotype MSF10 is found in complexes with ecotypes MSF08 and MSF12. As with other type of wetlands, Ecotype MSF10 is located in depressions that have poorly drained soils. This ecotype forms a gradient between the mesic ecosystems such as MSF01 and MSF05 and the non-forest wetlands such as ecotypes MSF12 and MSF14. The soils are always organic and the drainage poor. Forested bog surfaces are generally dome-shaped. The arboreous layer is entirely dominated by black spruce and tamarack. The shrub layer is diverse and abundant. The herbaceous layer is varied and dominated by sedge, while the moss layer is almost exclusively dominated by peatmoss. In total, MSF10 covers around 1% of the LSA.

MSF12: Uniform Herb Fen (Non-Forested Wetland Ecosystem)

Uniform Herb Fen (Ecotype MSF12), after forested swamps (Ecotype MSF08), is the most common wetland ecotypes in the LSA. They occur in depressions and lowlands. Like structured fens, Uniform Herb Fens are sedge-dominated ecosystems with scattered shrubs and other wetland herbs, but they lack the 'string' forms of structured fens. Their surfaces are flat to depressed, with a continuous vegetation cover. Black spruce and tamarack occur as scattered, stunted individuals on raised microsites. As in other wetlands, soils are organic, typically Mesisols and Fibrisols. Soil drainage is typically poor, and sites are very wet in the spring, with water tables declining as summer approaches. Ecotype MSF12 may occur in very large wetland complexes with Ecotypes MSF10 (forested bog) and MSF08 (swamp forest), or on its own in small, isolated depressions. In total, MSF12 covers around 2% of the LSA.

MSF15: Uniform Fluvial Shrub Fen (Non-Forested Riparian Ecosystem)

Uniform Fluvial Shrub Fens (Ecotype MSF15) are the most productive non-forested ecosystems in the MSF Ecoregion. A dense shrub layer is found with a rich and diverse herb layer. Ecotype MSF15 occurs on sites adjacent to streams that are enriched either by overbank flooding or subsurface seepage. MSF15 is found in complexes along stream banks with Ecotype MSF07 and features few trees, but it has a well-expressed shrub layer with alder and willow species and abundant and diverse herb and moss layers. Soils are typically Humic Regosols or Humic Gleysols. In total, MSF15 covers 1% of the LSA

6.2 High Subarctic Tundra (HST) Ecoregion

The climate of the HST Ecoregion is characterized by short, cool summers and long, windy winters. The growth period lasts only 80 to 100 days, and annual precipitation varies from 700 to 1,000 mm. Within the Project LSA, the various ecotypes of the HST Ecoregion are found in the vast majority of cases at elevations higher than 650 m. The ecotypes found inside the HST Ecoregion are all treeless and are similar to the alpine tundra that is described by Meades (1990), who mentions that more than 50% of the upland plateaus characteristic of the HST Ecoregion support vegetation dominated by shrubs, low shrubs and graminoids. The HST Ecoregion contains discontinuous permafrost and small areas of wetlands with thin organic soils, mostly located in depressions and around lakes.

Table 4 shows the late-seral ecotypes present in the MSF Ecoregion. Ecotypes highlighted in dark green are not present within the LSA but are common elsewhere within the HST Ecoregion. Ecotypes highlighted in light green are present within the LSA but are marginally represented and therefore not described. The edatopic grid for this ecoregion is also presented in Figure 3.

Table 4. Late-Seral Ecotypes in the HST Ecoregion

ECOSITE	LATE-SERAL ECOTYPE COMPLETE NAME	LATE-SERAL ECOTYPE COMMON NAME	DESCRIPTION
HST01	Alpine Shrub – Glandular Birch – Mesic	Alpine Shrub Mesic	Mesic ecosystem dominated by herbs and shrubs; thick till; silty texture; well to moderately well drained
HST01-P	Alpine Meadow – Shrub – Mesic	Shruby Alpine Meadow	Moist soil ecosystem dominated by shrubs and herbs; thick till deposits; rich soil with silty texture; good to moderate drainage
HST02	Rock Outcrop – Crowberry – Xeric	Rock Outcrop	Dry ecosystem dominated by lichen-covered rock outcrops; thin or no soil; medium texture; very rapid drainage
HST03	Low Alpine Shrub/Lichens – Subxeric	Alpine Shrub Subxeric	Subxeric ecosystem dominated by Ericaceae and lichen species; thin till on bedrock; medium to coarse texture; good to rapid drainage
HST04	Large-leaved Goldenrod	Alpine Shrub Seepage	Ecosystem with soils enriched by seepage and dominated by tall shrubs and a dense and diverse ground cover; thick till deposits; medium or fine texture; moderate to imperfect drainage
HST05	Alpine Shrub – Seepage	Uniform Riparian Shrub Fen	Riparian fen; fluvial or organic deposits; ground cover dominated by sedge and grass; imperfect to poor drainage
HST06	Uniform Herb Fen	Uniform Herb Fen	Uniform herb fen; organic deposits; ground cover dominated by sedge and grass; poor to very poor drainage
HST07	Uniform Shrub Fen	Uniform Shrub Fen	Uniform shrub fen; dominated by diverse shrub species of the Ericaceae family; ground cover dominated by sedge and grass; poor drainage

Marginally represented within the LSA

Absent from the LSA

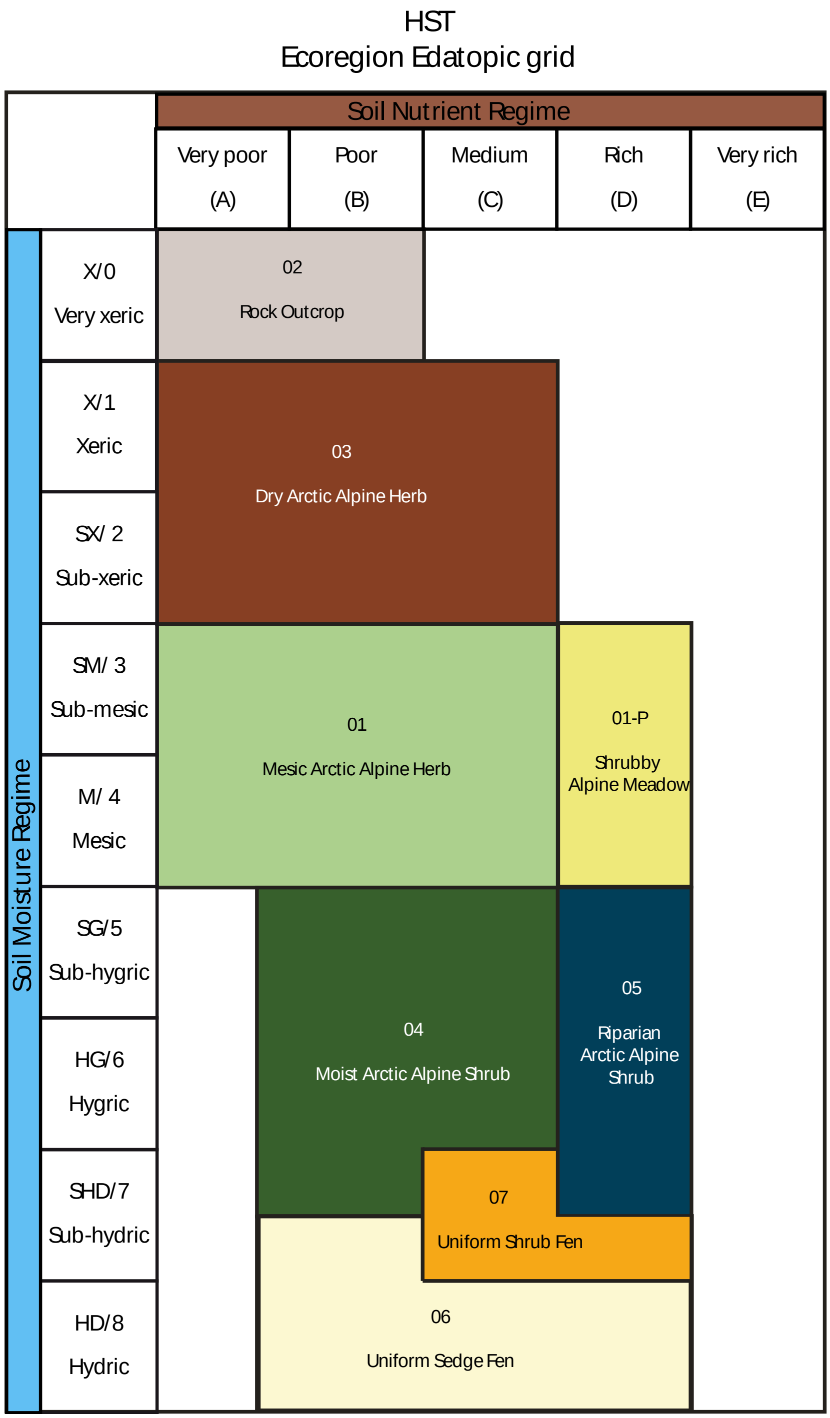


Figure 3 Edatopic Grid for the HST Ecoregion

6.2.1 HST Ecotype descriptions

HST01: Alpine Shrub – Glandular Birch – Mesic

Ecotype HST01 is found on till deposits of medium texture and variable thickness. This ecotype is considered to be the zonal, or normal, ecosystem of the HST ecoregion. The zonal or normal sites have one intermediate SMR and one intermediate SNR (neither too rich, nor too poor; neither too dry, nor too wet) and reflect the pressure from the climate of the ecoregion. They can be used to characterize and map the spatial boundaries of the ecoregion. The zonal sites indicate an important change in terms of regional climate and mark the boundary between the MSF and HST ecoregions. Trees are absent or infrequent (shrub forms only) within Ecotype HST01. However, sparce tree cover occurs at the boundary between HST and MSF ecoregions. The shrub layer is dominated by glandular birch, alpine billberry and mountain cranberry, while the herbaceous layer is diverse. Several lichens and mosses are also found scattered on the ground cover. The soils are mostly Melanic Brunisols and Eutric Brunisols with Mor type humus, indicating an average level of nutrients in the soil. Permafrost could occur within this ecotype, but the active layer (melting and freezing each year) is too thick (more than 2m) to consider the soil as a Cryosol. In total, HST01 covers around 17% of the LSA.

HST02: Rock Outcrop – Crowberry – Xeric

Ecotype HST02 is dominated by rock outcrops and is mostly without vegetation. The low shrub layer is dominated by alpine billberry and black crowberry. The herbaceous layer is not very developed. The lichens growing directly on the rocks, such as those of the Rhizocarpon genus, cover most of the surface. The drainage is very rapid, the SMR is very dry (0) and the SNR poor (A). This ecotype is generally found on summits. The thin soils (Cryosols), which are sometimes non-existent, show very little evidence of development. Ecotype HST02 covers around 3% of the LSA.

HST03: Low Alpine Shrub/Lichens – Subxeric

Ecotype HST03 supports a community of plant species suited to drought conditions and a harsh climate. The shrub layer is dominated by glandular birch, crowberry and bog blueberry. The herbaceous layer is not very developed and the bryophyte layer is dominated by lichens. Ecotype HST03 is usually supported by thin, or very thin, tills. The soils are thin and frequently dominated by turbic (cryoturbated) Cryosol or cryoturbated Melanic Brunisols and Eutric Brunisols if the active soil layer is too thick, with Mor type humus. This is the most common and widespread ecotype in the HST portion of the LSA. In total, HST03 covers around 22% of the LSA.

HST05: Uniform Riparian Shrub Fen

Ecotype HST05, the uniform riparian shrub fen, is found along watercourses, where the high humidity and strong concentrations of nutrients increase the productivity and diversity of plant species. Ecotype HST05 is characterized by a dense layer of shrubs mostly composed of glandular birch and satiny willow, as well as by a varied herbaceous layer mostly composed of bluejoint reedgrass and large-leaved goldenrod. Flooding is periodical and significant in the spring or after heavy precipitation. The drainage is moderate to imperfect. Sediment is deposited locally by floodwater, while the soils are enriched by underground irrigation from watercourses. The soils are mostly cumulic or gleyed regosols, where there is sedimentation. The SMR varies between submesic and subhydric, depending on periodical flooding, and the SNR is rich. In total, HST05 covers less than 1% of the LSA.

7 TERRESTRIAL ECOSYSTEMS OF LOCAL STUDY AREA

The following subsections summarize the general terrain and ecosystem characteristics of each sub-unit and illustrate the strong dependency of the identified ecotypes on terrain features. Table 5 and Table 6 summarize the approximate areal distributions of landforms and ecotypes in the LSA.

Table 5. Areal Distribution (%) of Landforms Within the LSA

LANDFORM CODE	LANDFORM	LSA TOTAL (%)
AP	Alluvial plain	2,3
CT	Talus pile, talus slope	0,2
MG	Ground moraine	84,1
OT	Organic terrain	3,7
RN	Bedrock knob	1,4
RR	Bedrock ridge	2,8
Other	Anthropogenic, waterbodies, etc.	5,5
Total:		**100**

Table 6. Areal Distribution (%) of Ecotypes within the LSA

ECOTYPE CODE	ECOTYPE (COMMON NAME)	LSA TOTAL (%)	RSA TOTAL (%)
PER/EAU	Anthropogenically Altered Landscapes or water surface	5,51	8,33
Mid Subarctic Forest			
MSF01	Mesic/Zonal Spruce Feathermoss	13,15	12,15
MSF02	Rock Outcrop	0,22	0,07
MSF03	Birch-Crowberry-Lichen	0,39	0,05
MSF04	Black Spruce Lichen Rock	1,94	0,48
MSF05	Black Spruce Lichen	21,38	13,53
MSF06	White Spruce/Black Spruce Seepage	2,43	3,99
MSF07	Fluvial White Spruce/Sedge	1,18	1,02
MSF08	Black Spruce/ Tamarack Forested Swamp	3,39	2,22
MSF09	Black Spruce/ Tamarack Fluvial Spruce Fen	0,07	0,02

ECOTYPE CODE	ECOTYPE (COMMON NAME)	LSA TOTAL (%)	RSA TOTAL (%)
MSF10	Black Spruce Bog	1,17	1,03
MSF11	Structured Herb Fen	0,01	0,02
MSF12	Uniform Herb Fen	2,39	1,81
MSF13	Non-Uniform Herb Fen	—	0,001
MSF14	Uniform Shrub Fen	0,90	1,17
MSF15	Uniform Fluvial Shrub Fen	0,95	0,73
High Subarctic Tundra			
HST01	Mesic Arctic Alpine Shrub	17,42	17,56
HST01-P	Shrubby Alpine Meadow	—	0,06
HST02	Rock Outcrop	3,30	6,32
HST03	Dry Arctic Alpine Shrub	22,21	26,36
HST04	Moist Arctic Alpine Shrub	1,04	1,58
HST05	Riparian Artic Alpine Shrub	0,63	1,04
HST06	Uniform Sedge Fen	0,30	0,42
HST07	Uniform Shrub Fen	0,02	0,05
Total:		**100**	**100**

7.1 Local study area presentation

The distribution and characteristics of landforms in the vicinity of the Project reflect a combination of ridges and valleys formed by folded, iron-rich, Pre-Cambrian metamorphic bedrock; glacial erosion and deposition from a generally northwestward flowing portion of the Laurentide Ice Sheet; deglacial meltwater processes; and post-glacial accumulation of organic matter. Irony Mountain, which is relatively resistant to glacial erosion, projects above the surrounding landscape as a prominent bedrock knob. Its silty sand soils are well to rapidly drained and support Ecotypes HST02 and HST03, and HST04 at the foothill of Irony Mountain. Bedrock is also exposed along the crests of lower ridges, and in some narrow valleys where meltwater has eroded surficial materials, supporting Ecotype HST02. Its weathered surface is a patchwork of angular blocks where frost heave has been most severe.

Silty sand till is the most widespread surficial material in the vicinity of the Project. Its thickness ranges from less than one metre in discontinuous veneers to a few metres in blankets and infilled hollows, which were more sheltered from glacial erosion. The till is generally moderately well to well drained, supporting sandy soils and Ecotypes HST01 and HST03 above 650 m or MSF05 and MSF01 below 650 m. In depressions, where the groundwater table is perched on underlying bedrock, the till may be imperfectly to poorly drained. Ecotype MSF08 is more common in such areas.

Conspicuous meltwater channels wrapping around the western flank of Irony Mountain and incised through till provide clear evidence of deglacial meltwater pathways. Depositional evidence of meltwater activity is less common in the region. One noteworthy exception occurs northeast of Irony Mountain, within the area encompassed by the Howse deposit itself. Here, trenching and drilling records indicate that a relatively uniform cover of till overlies buried glaciofluvial sand and gravel (Thiagarajan (BK) Balakrishnan, pers.

comm.). Its presence can only be inferred in aerial photography based on a distinct, radial drainage pattern interpreted to be centred on the thickest portion of sand and gravel. The landform is interpreted to be a buried kame overridden by a late glacial advance. The till cap is sufficiently thick and continuous that soil moisture and nutrient regime are relatively unaffected by the underlying glaciofluvial deposit. As in other areas of well drained till, Ecotypes MSF05 and MSF01 predominate.

Since the deglaciation of the region, organic material has accumulated in poorly to very poorly drained depressions and in areas of groundwater discharge. Organic mesic and fibric soils support Ecotypes MSF10, MSF12 and MSF14. In areas of greater regional slope, contemporary streams have eroded and redistributed glacially derived sediments in alluvial plains. The floodplains, comprising sand and silt, are typically imperfectly drained. Riparian ecosystems in such areas include Ecotypes MSF07 and MSF15. Goodream and Elross Creeks both show well developped alluvial plains supporting the most productive ecotypes of the LSA. The fluvial fan located at the mouth of Elross Creek supports, for example, very large white spruce trees growing on rich alluvial deposit.

7.1.1 Anthropogenically Altered Landscapes

A portion of the study area has been disturbed by previous mining activity, which ended in 1982, in some cases to such an extent that the original condition of the landscape is no longer recognizable. Mining related alterations to the landscape include numerous test pits and trenches, survey cut-lines, access roads and yards, and abandoned camps, infrastructure and equipment. In anthropogenically altered areas that have not been disturbed for several decades, pioneer species of vegetation have begun to colonize the surface. The rate of colonization has been slow, though, most likely due to the harsh climate, rocky soils and lack of organic matter. The following pioneer plant species were usually found on those sites: rough alder, bearberry willow, flatleaf willow and dwarf birch, as well as several grass species.

8 REFERENCES

Personal Communications

Thiagarajan (BK) Balakrishnan, Chief geologist, NML

Bibliography

Andrews, J.T., G.H. Miller, J.-S. Vincent and W.W. Shilts (1986) *Quaternary correlations in Arctic Canada*. Quaternary Science Reviews 5: 243-249.

Canadian System of Soil Classification (1998) *The Canadian system of soil classification*. Third edition. Soil Classification Working Group, Research Branch, Agriculture Agri-food Canada, Ottawa.

DFRA-Innu Nation (2003) *Forest Ecosystem Strategy Plan for Forest Management District No. 19*. Report prepared bythe Plamnning Team, Innu Nation and Dept. of Forest resources and Agrifoods. Website: http://www.env.gov.nl.ca/env/Env/EA2001/pdffiles/1062-CrownDistrict2019AForestPlan-GooseBay/StrategyPlan/Text.pdf.

Gartner, J.F., J.D. Mollard and M.A. Roed (1981) *Ontario Engineering Geology Terrain Study Users' Manual*. Ontario Geological Survey, Northern Ontario Engineering Geology Terrain Study 1, 51 pp.

Girard, F., S. Payette, and R. Gagnon (2008) *Rapid expansion of lichen woodlands within the closed-crown boreal forest zone over the last 50 years caused by stand disturbances in eastern Canada*. J. Biogeogr. (35): 529-537.

Girard, F., S. Payette, and R. Gagnon (2009) *Origin of the lichen–spruce woodland in the closed-crown forest zone of eastern Canada*. Global Ecol. Biogeogr. (18): 291-203.

Groupe Hémisphères (2011) *Mapping of terrestrial ecosystems and surface deposits : Direct-Shipping Ore Project.* Final technical report 2008-2010 produced on behalf of New Millennium Capital Corp., 157 p. et 10 annexes.

Groupe Hémisphères and Gartner Lee (2007a) *LabMag Iron Ore Project Study Area Terrestrial Ecosystem mapping*. Prepared for LabMag GP Inc. 131 pp + 16 appendices.

Groupe Hémisphères and Gartner Lee (2007b) *LabMag Iron Ore Project Pointe-Noire Study Area Terrestrial Ecosystem mapping.* Prepared for LabMag GP Inc. 54 pp + 10 appendices.

Klassen, R.A., S. Paradis, A.M. Bolduc and R.D. Thomas (1992) *Glacial landforms and deposits, Labrador, Newfoundland and eastern Québec*. Geological Survey of Canada, Map 1814A, scale 1:1 000 000.

Lopoukhine, N., D. Prout, and H. Hirvonen (1978) *Ecological Land Classification of Labrador – A Reconnaissance*. Ecological land Classification Series No. 4. Environment Canada, Hull, QC. 85 p.

Meades, W.J., (1989) *Ecoregions of Labrador*. [Unpublished report. Ecoregions Working Group. For inclusion in Ecoclimatic Regions of Canada, Forestry Canada, St. John's.]

Meades, S.J., (1990) *Natural Regions of Newfoundland and Labrador*. Protected Areas Association. 374 p.

MoELP-MoF (2010) *Field Manual for Describing Terrestrial Ecosystems – 2nd ed.* Land Management Handbook No. 25. ISSN 0229-1622. BC Ministry of Environment, Lands and parks and BC Ministry of Forests, Victoria, BC
http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh25/Lmh25_ed2_(2010).pdf

Payette, S., and A. Delwaide (2003) *Shift of conifer boreal forest to lichen-heath parkland caused by successive stand disturbances.* Ecosystems 6: 540-550.

RIC [Resources Inventory Committee] (1998) *Standard for Terrestrial Ecosystem Mapping in British Columbia*. Resource Inventory Committee, Province of British Columbia. Website: http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/tem/indextem.htm

Wardle, R.J., C.F. Gower, B. Ryan, G.A.G. Nunn, D.T. James and A. Kerr (1997) *Geological Map of Labrador, 1:1 million scale.* Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Map 97-07.

Wiken, E. (1986) *A National Ecological Framework for Canada - Overview*. Ecological Land Classifciation Series No. 19. Environment Canada, Hull, QC. 26 p. + map.

APPENDICES

Appendix I

Metadata

List of Tables

Table A. Terrestrial Ecosystem Mapping ArcGISTM Shapefile Metadata for the Mine Site

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
OBJECTID	Unique ID given by database	Automatically generated by database		
Shape	Feature Type		Point, Line, Polygon	
D1_Ov_Mat1	Least dominant material comprising first dominant landform	Air photo interpretation, inference from understanding of landform origin, and representative field checks	See Table J	Gartner, J.F., Mollard, J.D., Roed, M.A. 1981. Ontario Engineering Geology Terrain Study Users' Manual. Ontario Geological Survey, Northern Ontario Engineering Geology Terrain Study 1, 51 p.
D1_Ov_Mat2	Middle dominant material comprising first dominant landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
D1_Ov_Mat3	Most dominant material comprising first dominant landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
D1_Ov_Land	First dominant landform (if two dominant landforms present, then this landform is slightly more prevalent than the second dominant landform)	Air photo interpretation and representative field checks	See Table K	Same as D1_Ov_mat1
D1_Un_Mat1	Least dominant material comprising landform that	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
	underlies first dominant landform			
D1_Un_Mat2	Middle dominant material comprising landform that underlies first dominant landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
D1_Un_Mat3	Most dominant material comprising landform that underlies first dominant landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
D1_Un_Land	Landform that underlies first dominant landform (only present if first dominant landform overlies another landform; if D1_Un_Land = R (bedrock), then first dominant landform thickness is <1-2 m)	Same as D1_Ov_Land	See Table K	Same as D1_Ov_mat1
D2_Ov_Mat1	Least dominant material comprising second dominant landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
D2_Ov_Mat2	Middle dominant material comprising second dominant landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
D2_Ov_Mat3	Most dominant material comprising second dominant landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
D2_Ov_Land	Second dominant landform (if two dominant landforms present, then this landform is slightly less prevalent than the first dominant landform)	Same as D1_Ov_Land	See Table K	Same as D1_Ov_mat1
D2_Un_Mat1	Least dominant material comprising landform that underlies second dominant landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
D2_Un_Mat2	Middle dominant material comprising landform that underlies second dominant landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
D2_Un_Mat3	Most dominant material comprising landform that underlies second dominant landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
D2_Un_Land	Landform that underlies second dominant landform (only present if second	Same as D1_Ov_Land	See Table K	Same as D1_Ov_mat1

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
	dominant landform overlies another landform; if D2_Un_Land = R (bedrock), then second dominant landform thickness is <2 m)			
S1_Ov_Mat1	Least dominant material comprising first subordinate landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
S1_Ov_Mat2	Middle dominant material comprising first subordinate landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
S1_Ov_Mat3	Most dominant material comprising first subordinate landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
S1_Ov_Land	First subordinate landform (if two subordinate landforms present, then this landform is slightly more prevalent than the second subordinate landform)	Same as D1_Ov_Land	See Table K	Same as D1_Ov_mat1
S1_Un_Mat1	Least dominant material comprising landform that underlies first	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
	subordinate landform			
S1_Un_Mat2	Middle dominant material comprising landform that underlies first subordinate landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
S1_Un_Mat3	Most dominant material comprising landform that underlies first subordinate landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
S1_Un_Land	Landform that underlies first subordinate landform (only present if first subordinate landform overlies another landform; if S1_Un_Land = R (bedrock), then first subordinate landform thickness is <2 m)	Same as D1_Ov_Land	See Table K	Same as D1_Ov_mat1
S2_Ov_Mat1	Least dominant material comprising second subordinate landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
S2_Ov_Mat2	Middle dominant material comprising second	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
	subordinate landform			
S2_Ov_Mat3	Most dominant material comprising second subordinate landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
S2_Ov_Land	Second subordinate landform (if two subordinate landforms present, then this landform is slightly less prevalent than the first subordinate landform)	Same as D1_Ov_Land	See Table K	Same as D1_Ov_mat1
S2_Un_Mat1	Least dominant material comprising landform that underlies second subordinate landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
S2_Un_Mat2	Middle dominant material comprising landform that underlies second subordinate landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1
S2_Un_Mat3	Most dominant material comprising landform that underlies second subordinate landform	Same as D1_Ov_mat1	See Table J	Same as D1_Ov_mat1

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
S2_Un_Land	Landform that underlies second subordinate landform (only present if second subordinate landform overlies another landform; if S2_Un_Land = R (bedrock), then second subordinate landform thickness is <2 m)	Same as D1_Ov_Land	See Table K	Same as D1_Ov_mat1
Dom_relief	Local topographic relief of first dominant landform	Same as D1_Ov_Land	See Table L	Same as D1_Ov_mat1
Dom_Topog1	Most dominant topographic variety (surface expression) of first dominant landform	Same as D1_Ov_Land	See Table L	Same as D1_Ov_mat1
Dom_Topog2	Middle dominant topographic variety (surface expression) of first dominant landform	Same as D1_Ov_Land	See Table L	Same as D1_Ov_mat1
Dom_Topog3	Least dominant topographic variety (surface expression) of first dominant landform	Same as D1_Ov_Land	See Table L	Same as D1_Ov_mat1
Sub_Relief	Local topographic relief of first	Same as D1_Ov_Land	See Table L	Same as D1_Ov_mat1

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
	subordinate landform			
Sub_Topog1	Most dominant topographic variety (surface expression) of first subordinate landform	Same as D1_Ov_Land	See Table L	Same as D1_Ov_mat1
Sub_Topog2	Middle dominant topographic variety (surface expression) of first subordinate landform	Same as D1_Ov_Land	See Table L	Same as D1_Ov_mat1
Sub_Ttopog3	Least dominant topographic variety (surface expression) of first subordinate landform	Same as D1_Ov_Land	See Table L	Same as D1_Ov_mat1
Dom_Drain	Surface drainage condition of first dominant landform	Same as D1_Ov_Land	See Table M	British Columbia Ministry of Forests and Range and British Columbia Ministry of Environment. 2010. Field manual for describing terrestrial ecosystems. 2nd ed. Forest Science Program, Victoria, B.C. Land Manag. Handb. No. 25. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh25-2.htm.
Sub_Drain	Surface drainage condition of first subordinate landform	Same as D1_Ov_Land	See Table M	Same as Dom_drain
WaterTable	Suspected high water table in first dominant landform	Air photo interpretation and representative field checks; inferred from surrounding landforms and water bodies	See Table M	Same as D1_Ov_mat1
Gr_Checking	Level of ground checking	Fieldwork plot cards	Codes (see report) V = Visual inspection	British Columbia Ministry of Forests and Range and British Columbia Ministry of Environment. 2010. Field manual for describing terrestrial ecosystems.

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
	(fieldwork observations)		from the ground or from low elevation G = Ground inspection, including general ecological data and complete plant inventory F = Full ecological inspection, including detailed ecological data and complete plant inventory	2nd ed. Forest Science Program, Victoria, B.C. Land Manag. Handb. No. 25. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh25-2.htm
EcoDistric	Related Ecoregion following Meades (1990) and MRNFP (2003)	Ecoregion boundaries from the Natural Regions of Newfoundland and Labrador maps and Ecoregions from Quebec from Ecological Land Classification Hierarchy	Codes HST = High Subarctic Tundra MSF = Mid Subarctic Forest	Meades, S.J. 1990. Natural Regions of Newfoundland and Labrador. Protected Areas Association. 374p. MRNFP [Ministère des Ressources naturelles, de la Faune, et des Parcs]. 2003. The Ecological Land Classification Hierarchy. http://www.mrn.gouv.qc.ca/english/publications/forest/publications/ecological/pdf
Toponym_1	First polygon component toponym code (for non terrestrial ecosystem polygon component)	Attributed by the air photo interpreter directly in the ArcGIS TEM database using Quebec Ecological Land Classification Hierarchy coding system	See Table C	Ministère des Ressources naturelles, de la Faune et des Parcs (MRNFP). 2003. Normes de cartographie écoforestière, troisième inventaire écoforestier. Direction des inventaires forestiers. 95 p.
Percent_1	First polygon dominant component percentage coverage	Attributed by the air photo interpreter directly in the ArcGIS TEM database	Refer directly to the Excel or ArcGIS TEM database for each of the LSA components	ArcGIS TEM database

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
Ecotype_1	First polygon component ecotype code (project ecosystem coding system)	TEM project ecotype coding system established by the project team	See Table B for the complete TEM project ecotype codes	Refer to the project report in ecotype description section
Cover_1	First polygon component tree cover type	Attributed by the air photo interpreter directly in the ArcGIS TEM database using Quebec Ecological Land Classification Hierarchy coding system	Codes: R = Coniferous M = Mixed stand (mix of hardwood and coniferous species)	Same as Toponym_1
Closure_1	First polygon component tree average crown closure	Attributed by the air photo interpreter directly in the ArcGIS TEM database using Quebec Ecological Land Classification Hierarchy coding system	See Table D for the average crown closure codes	Same as Toponym_1
Height_1	First polygon component tree stand average height	Attributed by the air photo interpreter directly in the ArcGIS TEM database using Quebec Ecological Land Classification Hierarchy coding system	See Table E for the tree stand average height codes	Same as Toponym_1
Struc_1	First polygon component	Attributed by the air photo interpreter	See	Same as Gr_checking

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
	ecosystem structural stage	directly in the ArcGIS TEM database using the Field Manual for Describing Terrestrial Ecosystems (section 1)	Table F for the ecosystem structural stage codes	
Moisture_1	First polygon component soil moisture regime	Attributed by the air photo interpreter directly in the ArcGIS TEM database using the Field Manual for Describing Terrestrial Ecosystems (section 1)	See Table G for the ecosystem soil moisture regime codes	Same as Gr_checking
Nutrient_1	First polygon component soil nutrient regime	Attributed by the air photo interpreter directly in the ArcGIS TEM database using the Field Manual for Describing Terrestrial Ecosystems (section 1)	See Table H for the ecosystem soil nutrient regime codes	Same as Gr_checking
Disturb_1	First polygon component disturbance type	Attributed by the air photo interpreter directly in the ArcGIS TEM database using Quebec Ecological Land Classification Hierarchy coding system	See Table I for the environmental disturbance codes	Same as Toponym_1

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
Toponym_2	Second polygon component toponym code (for non terrestrial ecosystem polygon component)	Same as Toponym_1	See Table C	Same as Toponym_1
Percent_2	Second polygon sub-dominant component percentage coverage	Same as Percent_1	Same as Percent_1	Same as Toponym_1
Ecotype_2	Second polygon component ecotype code (project ecosystem coding system)	Same as Ecotype_1	See Table B for the complete TEM project ecotype codes	Refer to the project report in ecotype description section
Cover_2	Second polygon component tree cover type	Same as Cover_1	Same as Cover_1	Same as Toponym_1
Closure_2	Second polygon component tree average crown closure	Same as Closure_1	See Table D for the average crown closure codes	Same as Toponym_1
Height_2	Second polygon component tree stand average height	Same as Height_1	See Table E for the tree stand average height codes	Same as Toponym_1
Struc_2	Second polygon component ecosystem structural stage	Same as Struc_1	See Table F for the ecosystem structural stage codes	Same as Gr_checking
Moisture_2	Second polygon component soil moisture regime	Same as Moisture_1	See Table G for the ecosystem soil moisture regime codes	Same as Gr_checking

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
Nutrient_2	Second polygon component soil nutrient regime	Same as Nutrient_1	See Table H for the ecosystem soil nutrient regime codes	Same as Gr_checking
Disturb_2	Second polygon component disturbance type	Same as Disturb_1	See Table I for the environmental disturbance codes	Same as Gr_checking
Toponym_3	Third polygon component toponym code (for non terrestrial ecosystem polygon component)	Same as Toponym_1	See Table C	Same as Toponym_1
Percent_3	Third polygon minor component percentage coverage	Same as Percent_1	Same as Percent_1	Same as Toponym_1
Ecotype_3	Third polygon component ecotype code (project ecosystem coding system)	Same as Ecotype_1	See Table B for the complete TEM project ecotype codes	Refer to the project report in ecotype description section
Cover_3	Third polygon component tree cover type	Same as Cover_1	Same as Cover_1	Same as Toponym_1
Closure_3	Third polygon component tree average crown closure	Same as Closure_1	See Table D for the average crown closure codes	Same as Toponym_1
Height_3	Third polygon component tree stand average height	Same as Height_1	See Table E for the tree stand average height codes	Same as Toponym_1

FIELD NAME (COLUMN HEADING)	DESCRIPTION	DATA SOURCE	CONTENT/CODE LIST	REFERENCE
Struc_3	Second polygon component ecosystem structural stage	Same as Stru_1	See Table F for the ecosystem structural stage codes	Same as Gr_checking
Moisture_3	Third polygon component soil moisture regime	Same as Moisture_1	See Table G for the ecosystem soil moisture regime codes	Same as Gr_checking
Nutrient_3	Third polygon component soil nutrient regime	Same as Nutrient_1	See Table H for the ecosystem soil nutrient regime codes	Same as Gr_checking
Disturb_3	Third polygon component disturbance type	Same as Disturb_1	See Table I for the environmental disturbance codes	Same as Gr_checking
Shape_Length	Longest axial length of polygon in metres	Automatically generated by database		
Shape_Area	Area of polygon in square metres	Automatically generated by database		

Table B. Ecotype (Terrestrial Ecosystem) Description and Codes

ECOTYPE	QUEBEC CODE	COMPLETE NAME	COMMON NAME	DESCRIPTION
Mid Subarctic Forest (MSF)				
01	RE12	Black Spruce/White Spruce -Labrador Tea-Feathermoss (Forested Ecosystem)	Mesic/Zonal Spruce Feathermoss	Black spruce and moss-lichen stand; thin-thick deposits; medium soil texture; well drained
01L		Black Spruce – Shrub - Lichen Woodland (Forested Ecosystem)	Mesic/Zonal Spruce Lichen	Open Black spruce stand with dense lichens and scattered shrubs; thin-thick deposits; medium soil texture; well drained; disclimax created by repeated disturbance (intense and repeated forest fires)
02	RO	Crowberry-Map Lichen Rock Outcrop (Non-Forested Ecosystem)	Rock Outcrop	Rock outcrop with low ericaceous species; no or little surficial deposits; variable soil texture; very rapidly drained
03	DS	Glandular Birch - Crowberry-Lichen Very Thin Till Over Rock (Non-Forested Ecosystem)	Birch-Crowberry-Lichen	Low shrub communities on thin soils in crest positions; variable soil texture; rapidly drained
04	RE10	Black Spruce-Lichen Rock (Forested Ecosystem)	Black Spruce Lichen Rock	Rock-dominated sites with scattered, stunted black spruce; very thin veneers; variable soil texture; rapidly drained
05	RE11	Black Spruce - Lichen Woodland (Forested Ecosystem)	Black Spruce Lichen	Black spruce lichen stand; thin-thick deposits; coarse soil texture; well to rapidly drained
06	RE25	White Spruce/Black Spruce - Feathermoss Seepage (Forested Ecosystem)	White Spruce/Black Spruce Seepage	Black spruce feathermoss-ericaceous stand; thin-thick deposits; fine soil texture; imperfectly drained with seepage
07	RE25f	White Spruce-Alder/Willow-Sedges Streambank (Forested Riparian Ecosystem)	Fluvial White Spruce/Sedge	White spruce-moss stand; thin-thick deposits; fine soil texture; riparian; flooded sites imperfectly to poorly drained
08	BS1	Black Spruce/Tamarack-Glandular Birch-Sphagnum Swamp (Forested Wetland Ecosystem)	Black Spruce/Tamarack Forested Swamp	Forested bog; denser stand than Ecotype MSF10; organic deposits; Sphagnum-dominated; poorly drained

ECOTYPE	QUEBEC CODE	COMPLETE NAME	COMMON NAME	DESCRIPTION
09	BS1f	Tamarack/Black Spruce-Shrub Birch-Sedges Fluvial Fen (Forested Wetland Ecosystem)	Black Spruce/Tamarack Fluvial Spruce Fen	Forested fen; fluvial or organic deposits; sedge-dominated; poorly drained
10	Bbu	Black Spruce Forested Bog (Forested Wetland Ecosystem)	Black Spruce/Larch Forested Fen/Bog	Uniform forested fen; organic deposits; forest floor dominated by sedge and grass; poorly drained
11	Fns	Structured Herb Fen (or patterned/ribbed fens) (Non-Forested Wetland Ecosystem)	Structured Herb Fen	Structured non-forested herb fen; organic deposits; vegetation dominated by sedge and grass; very poorly drained
12	Fnu	Uniform Herb Fen (Non-Forested Wetland Ecosystem)	Uniform Herb Fen	Uniform non-forested herb fen; organic deposits; vegetation cover dominated by sedge and grass; poorly drained
13	Fnn	Non-Uniform Herb Fen (Non-Forested Wetland Ecosystem)	Non-Uniform Herb Fen	Random non-forested herb fen; organic deposits; vegetation cover dominated by sedge and grass; poorly drained
14	Fau	Uniform Shrub Fen (Non-Forested Wetland Ecosystem)	Uniform Shrub Fen	Uniform non-forested shrub fen; organic deposits; vegetation cover dominated by sedge and grass; poorly drained
15	Fauf	Uniform Fluvial Shrub Fen (Non-Forested Riparian Ecosystem)	Uniform Fluvial Shrub Fen	Uniform non-forested shrub fen; fluvial or rich organic deposits; vegetation cover dominated by sedge and grass; soil richer and more diverse plant community than Ecotype MSF14; imperfectly to very poorly drained
High Subarctic Tundra (HST)				
01	Not classified	Alpine Shrub – Glandular Birch – Mesic	Mesic Arctic Alpine Herb	Mesic ecosystem dominated by herbs and shrubs; thick till; silty texture; well to moderately well drained.
01-P	Not classified	Alpine Meadow – Shrub - Mesic	Shrubby Alpine Prairie	Moist soil ecosystem dominated by shrubs and herbs; thick till deposits; rich soil with silty texture; good to moderate drainage
02	Not classified	Rock Outcrop – Crowberry – Xeric	Rock - Rhizocarpon	Dry ecosystem dominated by lichen-covered rock outcrops; thin or no soil; medium texture; very rapid drainage

ECOTYPE	QUEBEC CODE	COMPLETE NAME	COMMON NAME	DESCRIPTION
03	Not classified	Low Alpine Shrub/Lichens – Subxeric	Dry Arctic Alpine Herb	Subxeric ecosystem dominated by Ericaceae and lichen species; thin till on bedrock; medium to coarse texture; good to rapid drainage
04	Not classified	Large-leaved Goldenrod Alpine Shrub – Seepage	Moist Arctic Alpine Shrub	Ecosystem with soils enriched by seepage and dominated by tall shrubs and a dense and diverse ground cover; thick till deposits; medium or fine texture; moderate to imperfect drainage
05	Not classified	Uniform Riparian Shrub Fen	Riparian Arctic Alpine Shrub	Riparian fen; fluvial or organic deposits; ground cover dominated by sedge and grass; imperfect to poor drainage
06	Not classified	Uniform Herb Fen	Uniform Sedge Fen	Uniform herb fen; organic deposits; ground cover dominated by sedge and grass; poor to very poor drainage
07	Not classified	Uniform Shrub Fen	Uniform Shrub Fen	Uniform shrub fen; dominated by diverse shrub species of the Ericaceae family; ground cover dominated by sedge and grass; poor drainage

Table C. Ecosystem Toponyms

ECOSYSTEM TOPONYMS	CODES
Open water	EAU
Gravel pit	GR
Island (<1 hectare)	ILE
Unknown	INC
Flooded	INO
Transmission line	LTE
Rock outcrop	RO
Airport	AER
Dry bareland	DS
Agriculture	A
Anthropogenic/Disturbed	ANT

Table D. Tree Canopy Coverage Percentage Classes and Codes

TREE COVERAGE PERCENTAGES	CODE
More than 80 %	A
Between 60 % and 80 %	B
Between 40 % and 60 %	C
Between 25 % and 40 %	D
Between 15% and 25%	E
Less than 15%	F

Table E. Tree Height Classes and Codes

TREE HEIGHT CLASSES	HEIGHT CODES
More than 22 m	1
Between 17 m and 22 m	2
Between 12 m and 17 m	3
Between 7 m and 12 m	4
Between 4 m and 7 m	5
Between 2 m and 4 m	6

Table F. Ecosystem Structural Stage Names and Codes

ECOSYSTEM STRUCTURAL STAGE NAMES	STRUCTURE CODES
Sparse	SB
Herb	H
Shrubs	SH Low : SHa (< 2m)
	High : SHb (> 2m)
Pole Sapling	PS
Young forest	YF
Mature forest	MF

Table G. Soil Moisture Regime (SMR) Class Names and Codes

SOIL MOISTURE REGIME CLASS	CODES
Very xeric (VX)	0
Xeric (X)	1
Subxeric (SX)	2
Submesic (SM)	3
Mesic (M)	4
Subhygric (SHG)	5
Hygric (HG)	6
Subhydric (SHD)	7
Hydric (HD)	8

Table H. Soil Nutrient Regime (SNR) Class Names and Codes

SOIL NUTRIENT REGIME CLASS	CODES
Very poor	a
Poor	b
Medium	c
Rich	d
Very Rich	e
Saline	f

Table I. Ecosystem Disturbance Class Names and Codes

ECOSYSTEM DISTURBANCE CLASSES	CODES
Burned	br
Windfall	cht
Clearcut	ct
Cut with regeneration protection	crs, cpr
Serious epidemic	es
Fallow	fr
Inundated	in
Plantation	plr

Table J. Material Type Code Definitions

CODE	MATERIAL TYPE	DESCRIPTION
b	boulders, bouldery	Grain sizes >256 mm
c	clay, clayey	Grain sizes <0.004 mm, which have cohesive properties
g	gravel, gravelly	Grain sizes between 2 and 64 mm
p	peat, muck	Organic material
r	rubble	Angular rock fragments (e.g. talus)
s	sand, sandy	Grain sizes between 0.0625 and 2 mm
m	silt, silty	Grain sizes between 0.004 and 0.0625 mm
t	till	Mixture of grain sizes, from clay to boulders, due to deposition in contact with glacial ice

Table K. Landform Code Definitions

CODE	LANDFORM	DESCRIPTION
ME	End moraine	Discrete sharp-crested or hummocky ridge of sediment deposited at the margin of a glacier through a variety of processes, including direct deposition from ice and drop-out from meltwater
MG	Ground moraine	Sediment deposited beneath a flowing or down-wasting glacier, commonly in thick contiguous blankets
MH	Hummocky moraine	Sediment deposited beneath a glacier and/or during ablation of glacial ice with strongly undulating surface topography
GD	Ice contact delta, esker delta, kame delta, delta moraine	Accumulation of generally moderately to well sorted sediment that was transported by glacial meltwater and deposited in standing water against glacial ice
GE	Esker, esker complex, crevasse filling	Long, commonly sinuous ridge (or complex of ridges, which may be braided) of generally moderately to well sorted sediment deposited by a meltwater stream flowing on, in or under a glacier
GK	Kame, kame field, kame terrace, kame moraine	Mound or bench of generally moderately to well sorted sediment, which may be locally mixed with till deposits, that was transported by glacial meltwater and deposited on, in or under a glacier
GO	Outwash plain, valley train	Broad, flat to gently sloping accumulation of generally moderately to well sorted sediment that was transported and deposited by glacial meltwater in a proglacial setting
AP	Alluvial plain	A plain formed from the deposition of moderately to well sorted sediments transported by flowing water, usually adjacent to a stream that periodically overflows
ED	Sand dunes	Hill, mound or ridge of wind-blown fine sediments, with a grain size range almost exclusively between 0.05 and 0.5 mm
CS	Slope failure	Result of direct, gravity-induced movement involving no agent of transportation. Generally occurs in glaciolacustrine and glaciomarine sediments. Consists of massive to moderately well stratified, non sorted sediments with any range of particle size.
CT	Talus pile	Pile of sediment that accumulated at the base of a slope failure. Consists of massive to moderately well stratified, non sorted sediments with any range of particle size.
OT	Organic terrain	Accumulation of mainly organic material, including peat and muck, in a marsh, swamp, bog or fen
RL	Bedrock plateau	Elevated area, or upland, of bedrock with subdued relief
RN	Bedrock knob	Protruding rounded to jagged hills of bedrock
RP	Bedrock plain	Broad, mainly level expanse of bedrock
RR	Bedrock ridge	Elevational crest of bedrock, commonly having linear continuity
/R	Bedrock below a drift veneer (<2 m)	Bedrock of unspecified sub-variety exists at shallow depth (<2 m) beneath a sediment veneer
LP	Glaciolacustrine plain	Plain containing fine-grained sediments consisting of silts and clays, often layered into varves deposited in or along the margin of a glacial lake.
WP	Marine plain	Silts and clays that are commonly massive and seldom layered, deposited in a water body by settling from suspension and submarine gravity flows.
WD	Marine delta	Well sorted and well rounded sand and possibly gravel that have accumulated in the littoral zone through shoreline processes such as wave action and longshore drift.

Table L. Topography Code Definitions

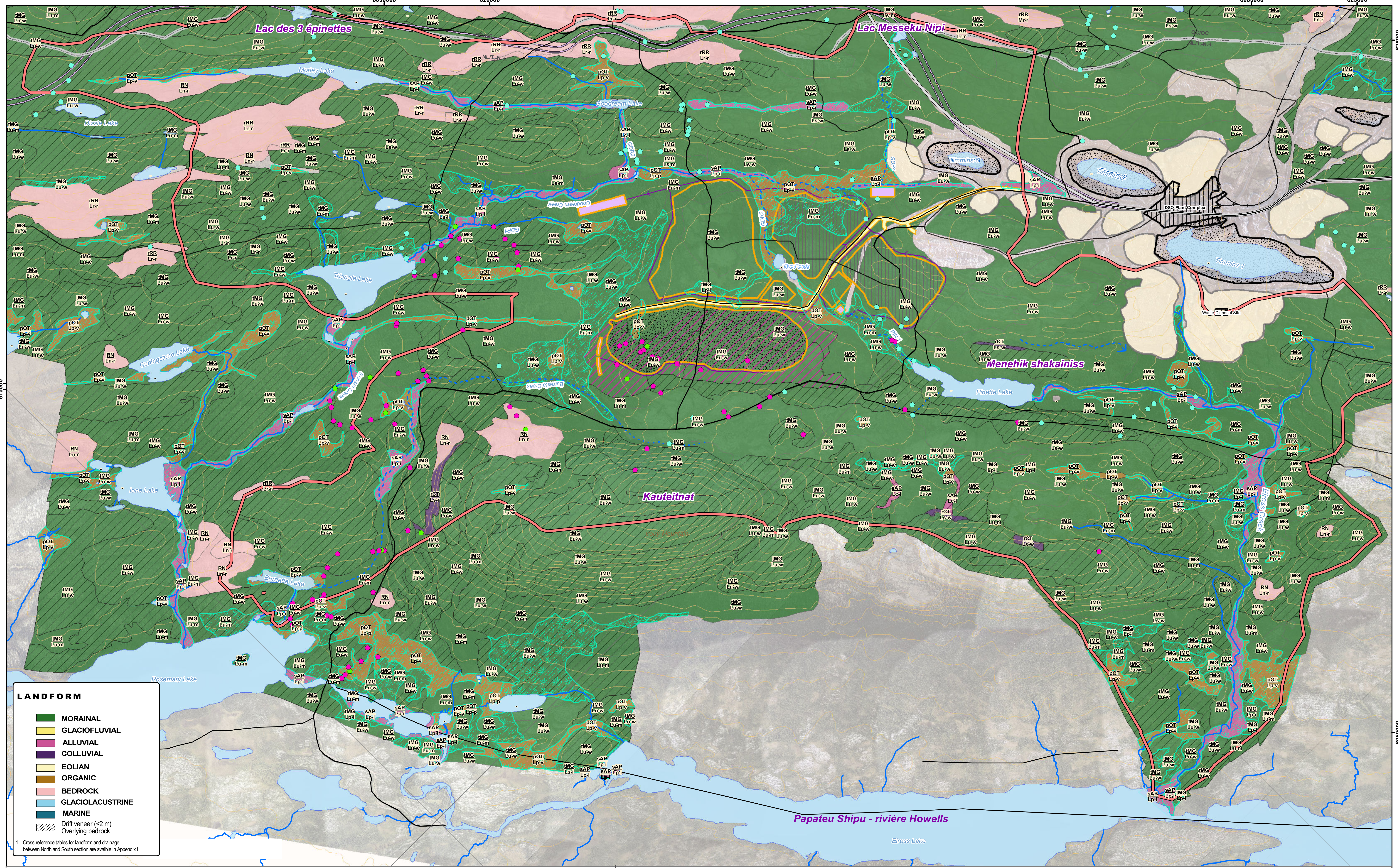
CODE	LOCAL TOPOGRAPHIC RELIEF	DESCRIPTION
L	Mainly low local relief (<15 m)	Area where local topographic relief is mainly less than 15 m
M	Mainly moderate local relief (15-60 m)	Area where local topographic relief is mainly between 15 and 60 m
H	Mainly high local relief (>60 m)	Area where local topographic relief is mainly more than 60 m
CODE	**TOPOGRAPHIC VARIETY (SURFACE EXPRESSION)**	**DESCRIPTION**
c	channelled	Terrain through which flowing water has recently, or in the past, eroded linear and/or sinuous depressions
d	dissected, gullied	Terrain that once exhibited a relatively uniform surface and has since become cut by fluvial and/or hillslope processes, which may form V-shaped incisions
j	jagged, rugged, cliffed	Terrain characterized by abrupt changes in slope, sharp-edged landforms and bluffs
k	kettled, pitted	Relatively uniform, level terrain with bowl-shaped concavities, or holes, in the surface
n	knobby, hummocky	Strongly undulating to ruggedly hilled terrain
p	plain	Broad, mainly level terrain
r	ridged	Terrain exhibiting linear, elevational crests
s	sloping	Mainly evenly sloping terrain with significant steepness
t	terraced	Level terrain edged by a steep slope
u	undulating to rolling	Terrain that has wave-like rises and falls
w	washed, reworked	Terrain through which flowing water, unrelated to the landform origin, has altered and/or redistributed sediment

Table M. Surface drainage condition definitions

CODE	SURFACE DRAINAGE CONDITION	DESCRIPTION
x	Very rapidly drained	Water is removed from the soil very rapidly in relation to supply
r	Rapidly drained	Water is removed from the soil rapidly in relation to supply
w	Well drained	Water is removed from the soil readily, but not rapidly
m	Moderately well drained	Water is removed from the soil somewhat slowly in relation to supply because of imperviousness or lack of gradient
I	Imperfectly drained	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season
p	Poorly drained	Water is removed so slowly in relation to supply that the soil remains wet for much of the time that it is not frozen
v	Very poorly drained	Water is removed from the soil so slowly that the water table remains at or near the surface for most of the time the soil is not frozen
h	Suspected high water table	Ground may be dry, but water table is likely near surface

Appendix II

Geological Surface Deposits Map



LEGEND

Data validation

- 2008/2009 Survey

2013 Survey

- Ground
- Visual
- Local Study Area
- Underlying glaciofluvial

Infrastructure and mining components

- Proposed Ditch
- Potential Road to DSO Area 4
- Proposed Railroad
- Elross Lake Area Iron Ore Mine (ELAIOM) Plant Infrastructure footprint
- Existing Pit
- Existing Dump
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Crushing/ Screening Facility
- Proposed Waste Rock Dump
- Proposed Sedimentation Pond
- Mine Haul Road

Basemap

- Permanent Watercourse
- Intermittent Watercourse
- Storm Runoff
- Disappearing Stream
- Artesian Spring
- Water Body
- Contour Line (50 ft)
- Existing Road
- Main Access Road
- Wetland

Components of Simplified Terrain Code

sGO / Lp-r: Material (D1_Ov_mat3); Landform (D1_Ov_Land); Local Relief (Dom_relief); Surface Drainage Condition (Dom_drain); Topographic Variety (Dom_topog 1)

*Hydronyms are oriented along the direction of water flow

FILE, VERSION, DATE, AUTHOR:
GH-0575-00, 2015-01-07, J.T., E.D.

0 500 1 000 1 500
Meters

UTM 19N NAD 83

SCALE: 1:20 000

SOURCES:
Basemap
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec,
Boundary used for claims
SLE, AMEC and GHI (October 2012). LabMag and Kémag Iron Ore Projects 2012 Mine Site Aquatic Program Field Report.
Groupe Hémisphères, Hydrology, Wetland, 2013.

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
TATA Steel Minerals Canada Limited/
MET-CHEM, Howse Deposit Design for General Layout, 2013

SURVEY:
Groupe Hémisphères (2011) Cartographie des écosystèmes terrestres et des dépôts de surface :
Projet de minerai de fer à enfournement direct.
Rapport technique 2008-2010 réalisé pour le compte de New Millennium Capital Corp., 159 p. et 10 annexes.

ENVIRONMENTAL IMPACT ASSESSMENT - HOWSE PROPERTY PROJECT

Terrain

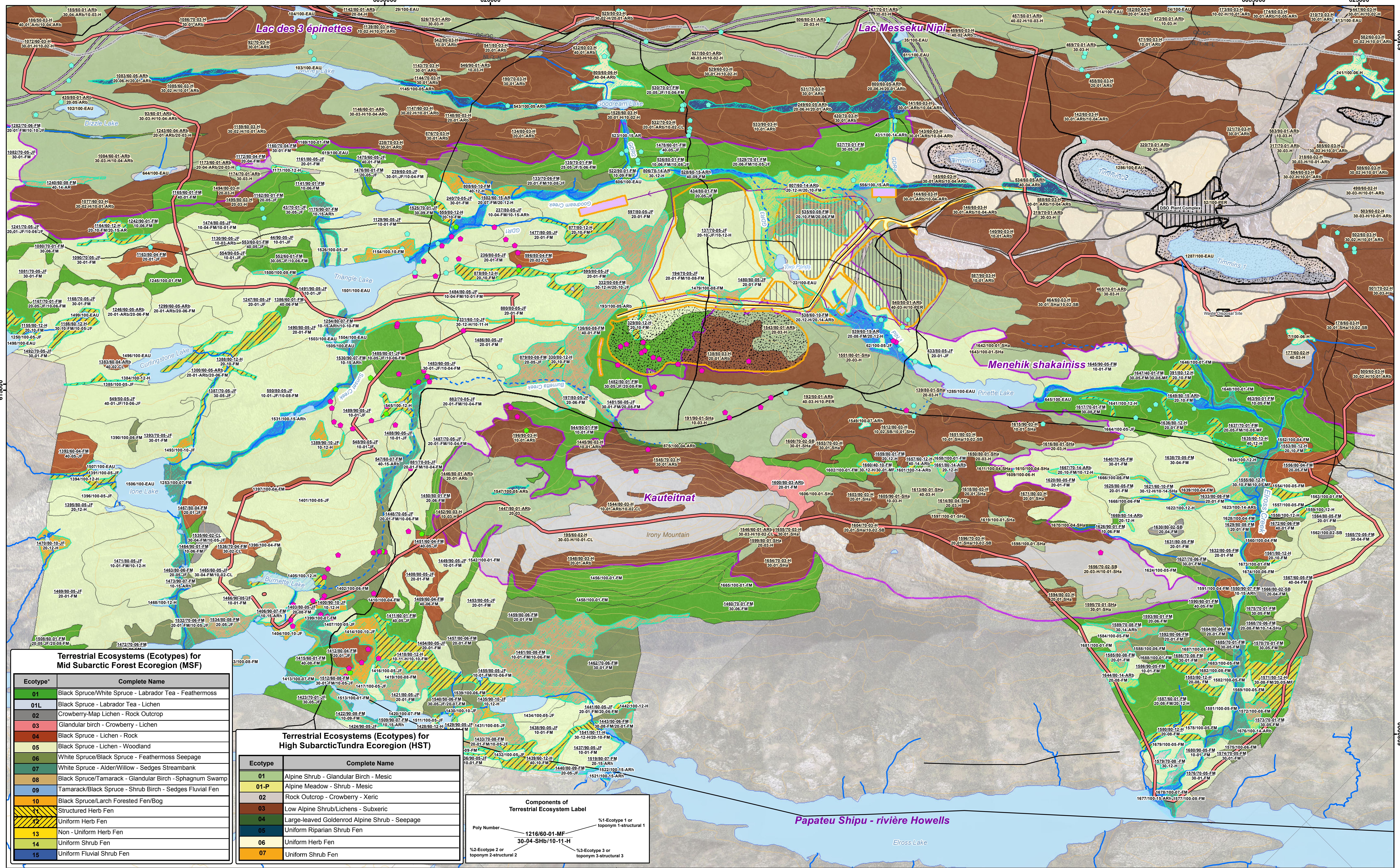
Howse Minerals Limited

GroupeHemispheres
13, rue Saint-Louis, Bureau 201, Lévis (QC) Canada, G6V 4E2
1453, rue Beaubien est, Bureau 301, Montréal (QC) Canada, H2G 3C6

Appendix II

Appendix III

Terrestrial Ecosystem Map



Terrestrial Ecosystems (Ecotypes) for Mid Subarctic Forest Ecoregion (MSF)

Ecotype*	Complete Name
01	Black Spruce/White Spruce - Labrador Tea - Feathermoss
01L	Black Spruce - Labrador Tea - Lichen
02	Crowberry-Map Lichen - Rock Outcrop
03	Glandular birch - Crowberry - Lichen
04	Black Spruce - Lichen - Rock
05	Black Spruce - Lichen - Woodland
06	White Spruce/Black Spruce - Feathermoss Seepage
07	White Spruce - Alder/Willow - Sedges Streambank
08	Black Spruce/Tamarack - Glandular Birch - Sphagnum Swamp
09	Tamarack/Black Spruce - Shrub Birch - Sedges Fluvial Fen
10	Black Spruce/Larch Forested Fen/Bog
11	Structured Herb Fen
12	Uniform Herb Fen
13	Non - Uniform Herb Fen
14	Uniform Shrub Fen
15	Uniform Fluvial Shrub Fen

Terrestrial Ecosystems (Ecotypes) for High SubarcticTundra Ecoregion (HST)

Ecotype	Complete Name
01	Alpine Shrub - Glandular Birch - Mesic
01-P	Alpine Meadow - Shrub - Mesic
02	Rock Outcrop - Crowberry - Xeric
03	Low Alpine Shrub/Lichens - Subxeric
04	Large-leaved Goldenrod Alpine Shrub - Seepage
05	Uniform Riparian Shrub Fen
06	Uniform Herb Fen
07	Uniform Shrub Fen

Components of Terrestrial Ecosystem Label

Poly Number — 1216/60-01-MF — %1-Ecotype 1 or toponym 1-structural 1

30-04-SHb/10-11-H — %2-Ecotype 2 or toponym 2-structural 2; %3-Ecotype 3 or toponym 3-structural 3

LEGEND

Data Validation

- 2008/2009 Survey

2013 Survey

- Ground
- Visual
- Local Study Area
- Ecoregion Boundary

Infrastructure and Mining Components

- Proposed Ditch
- Potential Road to DSO Area 4
- Proposed Railroad
- Elross Lake Area Iron Ore Mine (ELAIOM) Plant Infrastructure footprint
- Existing Pit
- Existing Dump
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Crushing/ Screening Facility
- Proposed Waste Rock Dump
- Proposed Sedimentation Pond
- Mine Haul Road

Basemap

- Permanent Watercourse
- Intermittent Watercourse
- Storm Runoff
- Disappearing Stream
- Artesian Spring
- Water Body
- Contour Line (50 ft)
- Existing Road
- Main Access Road
- Wetland

*Hydronyms are oriented along the direction of water flow

FILE, VERSION, DATE, AUTHOR:
GH-0575-00, 2015-01-07, J.T., E.D.

0 500 1 000 1 500
Meters

UTM 19N NAD 83

SCALE: 1:20 000

SOURCES:
Basemap
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec,
Boundary used for claims
SLE, AMEC and GHI (October 2012). LabMag and Kémag Iron Ore Projects 2012 Mine Site Aquatic Program Field Report.
Groupe Hémisphères, Hydrology, Wetland, 2013.

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
TATA Steel Minerals Canada Limited/
MET-CHEM, Howse Deposit Design for General Layout, 2013

SURVEY:
Groupe Hémisphères (2011) Cartographie des écosystèmes terrestres et des dépôts de surface :
Projet de minerai de fer à enfournement direct.
Rapport technique 2008-2010 réalisé pour le compte de New Millennium Capital Corp., 159 p. et 10 annexes.

ENVIRONMENTAL IMPACT ASSESSMENT - HOWSE PROPERTY PROJECT

Terrestrial Ecosystems

Howse Minerals Limited

GroupeHemispheres

13, rue Saint-Louis,
Bureau 201, Lévis (QC)
Canada, G6V 4E2

1453, rue Beaubien est,
Bureau 301, Montréal (QC)
Canada, H2G 3C6

Appendix III

Appendix IV

Explanation of Factsheets

INTRUCTIONS TO READER

How to read and interpret fact sheets

Section 1: General Description of Ecotype

Section 2: Synthesis of Environmental Observations

Section 3: Synthesis of Plant Diversity

Section 1: General Description of the Ecotype

Ecotype : *Complete Name of the Ecotype*

This firs section provides an overview of the ecotype.

A summary text highlighting its distribution throug the LSA, and the surficial characteristics of geological deposits, soils and vegetation.
Then, the following description table includes the edatopic grid associated and photos.

General Description of Ecotype XXX	
Position of the ecotype on the edatopic grid of the ecoregion (Two-way matrix of estimated soil moisture and soil nutrient regime)	**Aerial View:** *Picture showing a view of from above or at a given altitude drop*
Ground View - Stand: *Picture showing a ground view of the representative stand ot the ecotype*	**Ground View - Vegetation:** *Picture showing a ground view of the representative vegetation of the ecotype*

Section 2: Synthesis of Environmental Observations

This section provides important environmental information on the ecotype, as presented below in the summary table of environmental observations of the Ecotype.

Synthesis of Environmental Observations Ecotype XXX (Continued)

Complete Name of the Ecotype

XX Inventories Numbers:

List of plot numberts (detailed and summary) associated with a specific field sampling site.

XX Validation Points:

List of validation plot numbers associated with a specific field sampling site.

General Location:

Overview of the geographical location of the ecotype within the study area.

Distribution within the Study Area:

General distribution of the ecotype within the study area

Elevation:

Elevation range observed for the ecotype and the average (m asl)

Typical Slope Position:

General slope position of the ecotype. Possibilities are: Crest, Upper, Middle, Lower, Toe slope or Depression. See Figure 1.

Topography:

Typical topography (Flat, Rolling, Undulating, Valley, Moutainous) associated with the ecotype.

Structural Stage:

Structural stage (Non-vegetated, Herb, Shrub, Pole Sapling, Young Forest, Mature Forest or Old Forest) of the ecotype.

Drainage:

Soil drainage (Very rapidly, Rapidly, Well, Moderately well, Imperfectly, Poorly, Very poorly) for the ecotype (follows the RIC Standards (1997)). Table 1 resumes the drainage classes.

Soil Types:

Soil subgroups (follows the Canadian System of Soil Classification, 1998) associated with the ecotype. The description of the various soil orders is presented in the Table 2.

Soil Humus Type:

Typical soil humus forms for the ecotype. Figure 2 shows soil humus types.

Roothing Depth:

Range and average roothing depth (cm).

Surficial deposits:

Surficial geology deposit associated with the ecotype (see subsection of the report about the surficial deposits for their detailed description).

Soil Moisture Regime:

Range of soil moisture regime encompassed by the ecotype. Table 3 presents the characterization of the various SMR.

Soil Nutrient Regime:

Range of soil nutrient regime encompassed by the ecotype. Table 4 presents characterization of the various SNR.

Natural/Anthropogenic Disturbance:

Main natural (Forest fire, Inundation, Insect infestation) and human-affected (Drilling, Road construction, Infrastructure) disturbance(s) of the ecotype.

Plant Species Diversity:

Number of plants species within an ecotype (Low = some common species of plants, Mean = several common species of plants, High = many species of plants, sometimes unusual for ecoregion).

Forest Productivity:

Natural ability of the ecosystem to capture energy and to produce forest resources (None, Low, Intermediate, High).

Organic Matter Cover Percentage:

Range and average (%) cover of organic matter.

Decaying Wood Cover Percentage:

Range and average (%) cover of decaying wood.

Rock Outcrop Cover Percentage:

Range and average (%) cover of bedrock outcrops.

Coarse Fragment Cover Percentage:

Range and average (%) of coarse fragments (pebbles to boulders).

Mineral Soil Cover Percentage:

Range and average (%) cover of mineral soil.

Open Water Cover Percentage:

Range and average (%) cover of open water.

Section 3: Synthesis of Plant Diversity

This third fact sheet section summarizez all the information related to the distribution of each plant species sampled for an ecotype.

For each species found within an ecotype, the frequency (% of plots in which species appear) and a mean cover class (grouped by vegetation layer, i.e. Tree, Shrub, Herb and Moss layer)

Figure 1. Topographic Classes

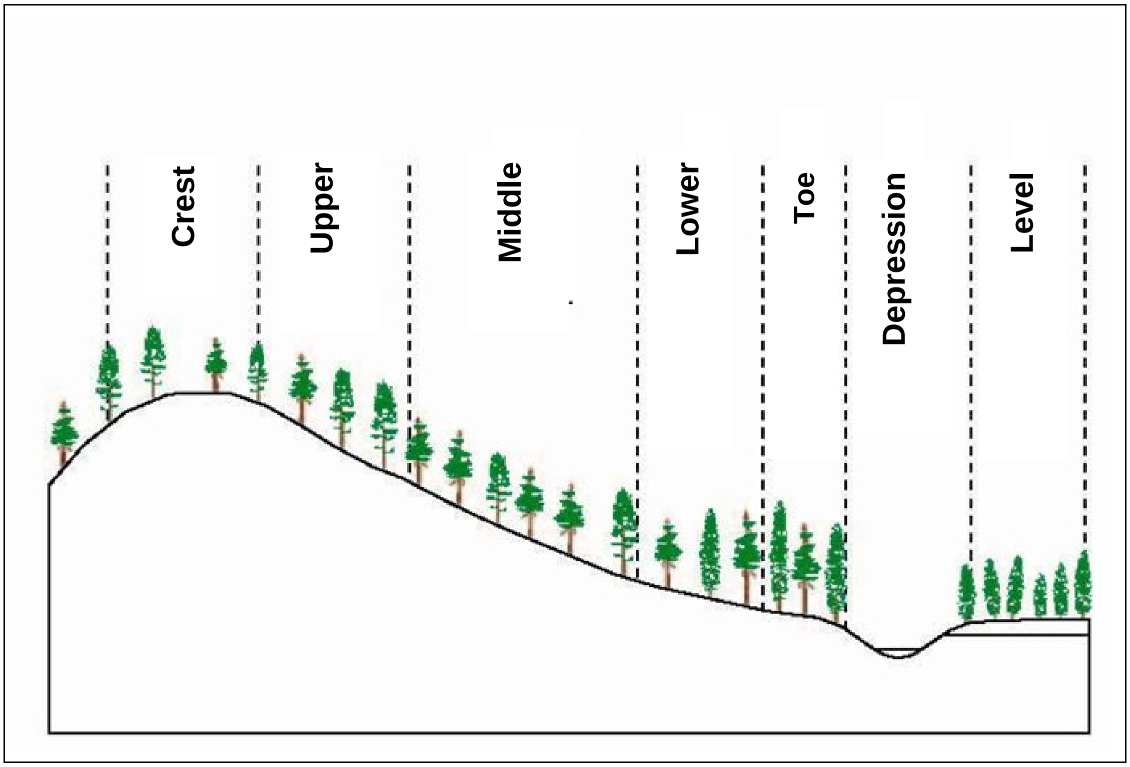


Table 1. Description of Soil Drainage

DRAINAGE CLASSES	DESCRIPTION
Very rapidly drained	Water is removed from the soil very rapidly in relation to supply. Excess water flows downward very rapidly if underlying material is pervious. There may be very rapid subsurface flow during heavy rainfall provided there is a steep gradient. Soils have very low available water storage capacity (usually less than 2.5 cm) within the control section and are usually coarse textured, or shallow, or both. Water source is precipitation
Rapidly drained	Water is removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep gradients during heavy rainfall. Soils have low available water storage capacity (2.5-4 cm) within the control section, and are usually coarse textured, or shallow, or both. Water source is precipitation.
Well drained	Water is removed from the soil readily but not rapidly. Excess water flows downward readily into underlying pervious material or laterally as subsurface flow. Soils have intermediate available water storage capacity (4-5 cm) within the control section, and are generally intermediate in texture and depth. Water source is precipitation. On slopes subsurface flow may occur for short durations but additions are, equaled by losses.
Moderately drained	Water is removed from the soil somewhat slowly in relation to supply. Excess water is removed somewhat slowly due to low perviousness, shallow water table, lack of gradient, or some combination of these. Soils have intermediate to high water storage capacity (5-6 cm) within the control section and are usually medium to fined textured. Precipitation is the dominant water source in medium to fine textured soils; precipitation and significant additions by subsurface flow are necessary in coarse textured soils.
Imperfectely drained	Water is removed from the soil sufficiently slowly in relation to supply, to keep the soil wet for a significant part of the growing season. Excess water moves slowly downward if precipitation is the major supply. If subsurface water or groundwater, or both, is the main source, the flow rate may vary but the soil remains wet for a significant part of the growing season. Precipitation is the main source if available water storage capacity is high; contribution by subsurface flow or groundwater flow, or both, increases as available water storage capacity decreases. Soils have a wide range in available water supply, texture, and depth, and are gleyed phases of well drained subgroups.
Poorly drained	Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen. Excess water is evident in the soil for a large part of the time. Subsurface flow or groundwater flow, or both, in addition to precipitation are the main water sources; there may also be a perched water table, with precipitation exceeding evapotranspiration. Soils have a wide range in available water storage capacity, texture, and depth, and are gleyed subgroups, Gleysols, and Organic soils.
Very poor drained	Water is removed from the soil so slowly that the water table remains at or on the surface for the greater part of the time the soil is not frozen. Excess water is present in the soil for the greater part of the time. Groundwater flow and subsurface flow are the major water sources. Precipitation is less important except where there is a perched water table with precipitation exceeding evapotranspiration. Soils have a wide range in available water storage capacity, texture, and depth, and are either Gleysolic or Organic.

Table 2: Canadian Soil Order Description

A. Soils that have permafrost within 1 m of the surface or 2 m if strongly cryoturbated.

Cryosolic order

B. Other soils that:

1. Have organic horizons (more than 17% organic C by weight) that extend from the surface to one of the following:
   - a) A depth of 60 cm or more if the surface layer is fibric material (Of) having a bulk density of less than 0.1 g/cm^3.
   - b) A depth of 40 cm or more if the surface layer consists of mesic or humic material (Om or Oh) having a bulk density greater than 0.1 g/cm^3.
   - c) A depth of more than 40 cm if only folic materials (L, F, and H) are present, or at least 10 cm if lithic or fragmentary materials are present. Folic materials must be more than twice the thickness of a mineral soil layer if the mineral layer is less than 20 cm thick.
2. Have at least one mineral horizon or layer within 40 cm of the surface in addition to the organic horizons (0) as follows:
   - a) If a mineral horizon thinner than 40 cm occurs at the surface, the organic horizon or horizons must have a total thickness of at least 40 cm.
   - b) If one or more mineral horizons or layers occur within 40 cm of the surface, the organic material must occupy more than 40 cm of the upper 80 cm of the control section.

Organic order

C. Other soils that have a podzolic B horizon and do not have a Bt horizon within 50 cm of the mineral surface.

Podzolic order

D. Other soils that are saturated with water and under reducing conditions either continuously or during some period of the year as indicated either by direct measurements of the water table and the oxidation-reduction status or by any of the following morphological features within 50 cm of the mineral surface:

1. Chromas of 1 or less, without mottles, on ped surfaces or in the matrix if peds are lacking in materials that develop higher chromas under oxidizing conditions.
2. Chromas of 2 or less, in hues of 10YR or redder, on ped surfaces or in the matrix if peds are lacking, accompanied by prominent mottles.
3. Chromas of 3 or less, in hues yellower than 10YR, on ped surfaces or in the matrix if peds are lacking, accompanied by prominent mottles.
4. Hues bluer than 10Y, with or without mottles, on ped surfaces or in the matrix if peds are lacking.

Gleysolic order

E. Other soils that have a solonetzic B horizon.

Solonetzic order

F. Other soils that have a chernozemic A horizon and any one of the following:

1. No Ae horizon.
2. A weakly expressed Ae horizon (Aej) with a dry color value lower than 5.
3. An Ae horizon thinner than an overlying Ah or Ap horizon that does not appear to be eluviated.
4. An Ae horizon not more than 5 cm thick if the chernozemic A is eluviated (Ahe) as indicated by gray streaks and splotches when the soil is dry.

Chernozemic order

G. Other soils that have a Bt horizon.

Luvisolic order

H. Other soils that have either Bm, Btj, or Bfj horizons at least 5 cm thick.

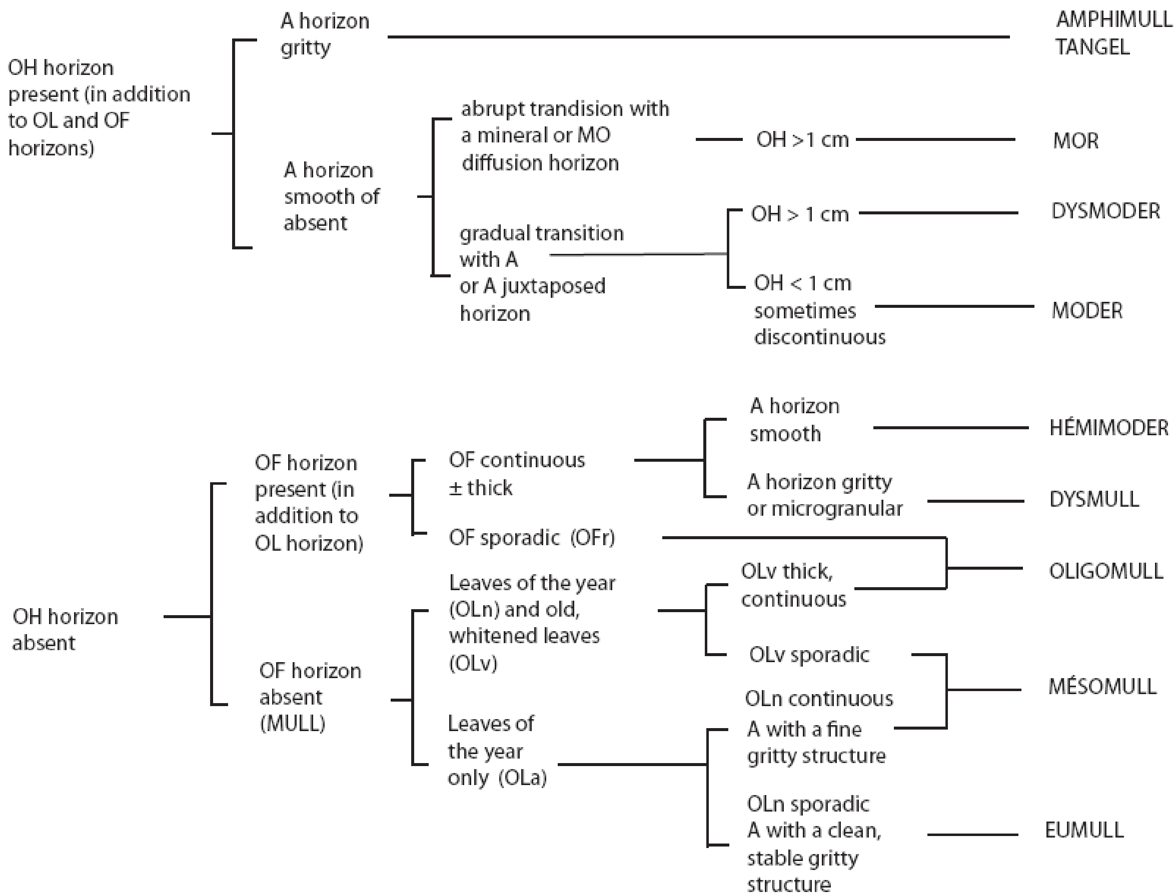
Brunisolic order

I. Other soils.

Regosolic order

Reference: *The Canadian System of Soil Classification*, 1987. Agriculture Canada Expert Committee on Soil Survey http://sis.agr.gc.ca/cansis/publications/manuals/cssc2.pdf

Figure 2 : Key to the Main Forms of Humus



Adapted from : *Les grands sols du monde*, Jean-Paul Legros, 2007, fig. 2.52.

Table 3. Soil Moisture Regime (SMR)

Code	Class	Description	Primary water source/ Typical Site Conditions	Code	Class	Description	Primary water source/ Typical Site Conditions
0	Very xeric	Water is removed from the soil very rapidly in relation to supply; the soil remains wet for a negligible amount of time following precipitations. Normally linked to a very rapid drainage, depending on the amount of precipitation.	Precipitation/ Summit of hill or mountain; surrounding cliffs	5	Sub-hygric	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season; temporary infiltrations and some mottling of the soil are possible. Linked to a moderate to imperfect drainage, depending on the amount of precipitation.	Precipitation and infiltration/ Ecosystem located on lower slope
1	Xeric	Water is removed from the soil very rapidly in relation to supply; the soil remains wet for a brief period of time following precipitations. Linked to a rapid to very rapid drainage, depending on the amount of precipitation.	Precipitation/ Ecosystem located on upper slope	6	Hygric	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season; permanent infiltrations (if on a gradient) and mottling in the soil are common. Link to imperfect or poor drainage, depending on the amount of precipitation.	Infiltration/ Natural ecosystem located at bottom of slope
2	Sub-xeric	Water is removed from the soil rapidly in relation to supply; the soil remains wet for short periods of time following precipitations. Linked to a rapid drainage, depending on the amount of precipitation.	Precipitation/ Ecosystem located on upper or mid-slope	7	Sub-hydric	Water is removed from the soil so slowly that the water table remains at or near the surface for most of the year; gleying mineral soils or organic soils; permanent infiltration < 30 cm under the surface. Linked to a poor or very poor drainage, depending on the amount of precipitation.	Permanent infiltration of the water table or continuous irrigation / Natural ecosystem located in a depression (often associated with wetlands)
3	Sub-mesic	Water is removed from the soil rapidly in relation to supply; water is available for moderately short periods following precipitations. Usually linked to a well-drained soil.	Precipitation/ Ecosystem located on upper or mid-slope.	8	Hydric	Water is removed from the soil so slowly that the water table remains at or near the surface all year long; gleying mineral soils or organic soils. Linked to very poor drainage.	Permanent water table from a natural source or irrigation / Wetlands
4	Mesic	Water is removed from the soil rather slowly in relation to supply; the soil can remain significantly wet, but sometime for short periods of the year. Soil wetness is directly linked to climate. Linked to a well to moderately well drained soil, depending on the amount of precipitation.	Precipitation and/or infiltration/ Ecosystem located on mid- or lower slope.				

Modified from *Field Manual for Describing Terrestrial Ecosystems*. MoELP-MoF (1998)

Table 4. Soil Nutrient Regime (SNR)

<table>
<tr><td rowspan="2">CODES</td><td>Oligotrophic</td><td>Submesotrophic</td><td>Mesotrophic</td><td>Permesotrophic</td><td>Eutrophic</td><td>Hypereutrophic</td></tr>
<tr><td>A
Very poor</td><td>B
Poor</td><td>C
Moderate</td><td>D
Rich</td><td>E
Very rich</td><td>F
Salted</td></tr>
<tr><td>Available nutrients</td><td>Very Low</td><td>Low</td><td>Moderate</td><td>Abundant</td><td>Very Abundant</td><td>Accumulation of Salt</td></tr>
<tr><td rowspan="3">Type of humus</td><td colspan="4">Mor</td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="3">Moder</td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Mull</td><td></td></tr>
<tr><td rowspan="3">Horizon A</td><td colspan="3">Horizon Ae present</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Horizon A absent</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Horizon Ah present</td><td></td></tr>
<tr><td rowspan="3">Proportion of organic matter</td><td colspan="3">Low (clear)</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Medium (colored)</td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="3">High (dark)</td><td></td></tr>
<tr><td rowspan="3">Growth rate</td><td colspan="2">Slow</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Moderate</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Rapid</td><td></td></tr>
<tr><td rowspan="2">Depth of the soil</td><td colspan="2">Extremely superficial</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="4">Very superficial to deep</td><td></td></tr>
<tr><td rowspan="2">Texture of the soil</td><td colspan="3">Coarse texture</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="3">Medium to fine texture</td><td></td></tr>
<tr><td rowspan="2">% coarse fragments</td><td colspan="2">High</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="3">Moderate to low</td><td></td></tr>
<tr><td rowspan="3">Mineralogy of parent materials</td><td colspan="2">Low base (low Ca content)</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="3">Medium base (medium Ca content)</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Strong base (high Ca content)</td><td></td></tr>
<tr><td rowspan="3">Soil pH</td><td colspan="2">Extremely to moderately acid</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="3">Moderately acid</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Lightly acid to moderately alkaline</td><td></td></tr>
<tr><td>Infiltration</td><td></td><td></td><td colspan="3">Temporary → Permanent</td><td></td></tr>
</table>

Modified from *Field Manual for Describing Terrestrial Ecosystems*. MoELP-MoF (1998).

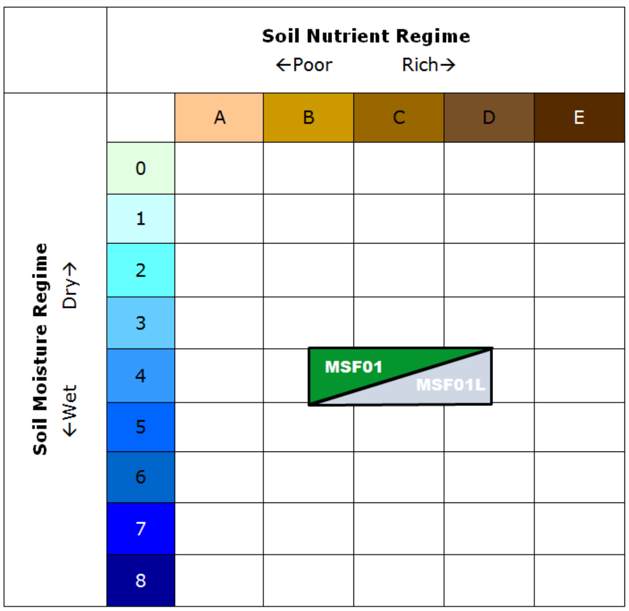
Appendix V

Ecotypes Factsheets

Ecotype: Black Spruce/White Spruce - Labrador Tea - Feathermoss (Forested Ecosystem)

Ecotype MSF01 is the 'zonal' or 'normal' late seral ecosystem for the MSF Ecoregion. Zonal or normal sites have a mesic SNR and medium SMR (neither too rich, nor too poor; neither too dry, nor too wet), support late seral ecosystems that best reflect the effects of regional climate, and thus can be used to characterize and map the spatial boundaries of the MSF Subzone. This ecotype also best represents changes in vegetation communities caused by climate change. Ecotype MSF01 occurs on deep to thin morainal soils throughout the study area. Compared to Ecotype MSF05, Ecotype MSF01 is less abundant, has a more closed canopy of black and white spruce and a higher shrub cover, especially Labrador tea. Feathermosses are more abundant than reindeer lichens in the moss layer. The MSF01 Ecotype can succeed to a disclimax Open Spruce Lichen Woodland Ecotype that also occurred on mesic ecosites, due to repeated fire that reduces black spruce seed source and permanently interrupts 'normal' ecological succession (MSF01L). Soils are typically Humo-ferric Podzols with Mor humus. In total, MSF01 covers 13% of the LSA.

General Description of Ecotype MSF01



Aerial View:

Ground View - Stand:

Ground View - Vegetation:

Synthesis of Environmental Observations Ecotype MSF01

Black Spruce/White Spruce -Labrador Tea - Feathermoss (Forested Ecosystem)

17 Inventories Numbers:

In 2008: DSO123; DSO137; DSO15; DSO24; DSO25; DSO317; DSO366; DSO57
In 2009: 178; 217; 260; 287; 373
In 2010: E12
In 2013: hg015, hv043, hv068

16 Validation Points:

hv005, hv006, hv013, hv014, hv019, hv020, hv028, hv029, hv052, hv053, hv054, hv055, hv056, hv071, hv073, hv074

General Location:

Widely distributed on flat or gently sloping sites with thin to thick tills; less common than Ecotype MSF05.

Distribution within the Study Area:

LSA : 13%

Elevation:

567-649 m (average of 625 m)

Typical Slope Position:

Mid-slope or lower slope, sometimes upper slope

Topography:

Generally on a gentle slope or undulating terrain

Structural Stage:

Mostly mature forest, except after forest fires where shrubs and regenerating forest dominate.

Drainage:

Mostly well to moderately well drained

Soil Types:

Humo-ferric Podzol or Orthic Dystric Brunisol

Soil Humus Type:

Hemimor or thick humimor
Mostly MOR, but also MODER and MULL

Roothing Depth:

10 to 35 cm (average of 23 cm)

Surficial deposits:

Typically on thick till with medium texture; sometimes on lower slopes on medium texture glaciofluvial deposits

Soil Moisture Regime:

4 (Mesic)

Soil Nutrient Regime:

B to C (poor and moderate)

Natural/Anthropogenic Disturbance:

Extensive forest fires, drill holes at future mine site

Plant Species Diversity:

Intermediate

Forest Productivity:

Intermediate

Organic Matter Cover Percentage:

75 to 90 % (average of 86 %)

Decaying Wood Cover Percentage:

N/A

Rock Outcrop Cover Percentage:

0 %

Coarse Fragment Cover Percentage:

0 to 10 % (average of 4 %)

Mineral Soil Cover Percentage:

N/A

Open Water Cover Percentage:

0 to 5 % (average of less than 1 %)

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF01				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ** **
Larix laricina	Tamarack	Tree	25	B
Picea glauca	White spruce	Tree	62	D
Picea mariana	Black spruce	Tree	75	C
Betula glandulosa	Glandular birch	Shrub	100	E
Betula pumila	Low birch	Shrub	12	A
Kalmia polifolia	Pale bog laurel	Shrub	12	A
Rhododendron groenlandicum	Common Labrador tea	Shrub	25	B
Salix pellita	Satiny willow	Shrub	12	B
Vaccinium angustifolium	Early lowbush blueberry	Shrub	12	E
Vaccinium uliginosum	Alpine bilberry	Shrub	62	B
Empetrum nigrum	Black crowberry	Low Shrub	50	D
Linnaea borealis	Twinflower	Low Shrub	25	D
Vaccinium boreale	Northern blueberry	Low Shrub	12	B
Vaccinium caespitosum	Dwarf bilberry	Low Shrub	25	D
Vaccinium vitis-idaea	Mountain cranberry	Low Shrub	50	A
Carex leptonervia	Leptonerved sedge	Herbaceous	25	D
Carex tribuloides	Blunt broom sedge	Herbaceous	12	C
Coptis trifolia	Goldthread	Herbaceous	25	A
Cornus canadensis	Bunchberry	Herbaceous	62	C
Deschampsia cespitosa	Tufted hairgrass	Herbaceous	62	D
Avenella flexuosa	Wavy hairgrass	Herbaceous	12	B
Diphasiastrum alpinum	Alpine clubmoss	Herbaceous	12	B
Lycopodium annotinum	Stiff clubmoss	Herbaceous	50	B
Petasites frigidus var. palmatus	Palmate coltsfoot	Herbaceous	25	B
Pyrola minor	Lesser pyrola	Herbaceous	12	A
Solidago macrophylla	Large-leaved goldenrod	Herbaceous	75	B
Trientalis borealis	Northern starflower	Herbaceous	50	A
Cladonia sp.	(none)	Bryophyte	12	B
Cladina rangiferina	Grey reindeer lichen	Bryophyte	62	B
Cladina stellaris	Star-tipped reindeer lichen	Bryophyte	75	D
Dicranum sp.	Dicranum	Bryophyte	12	C
Flavocetraria cucullata	(none)	Bryophyte	12	C
Peltigera sp.	Dog lichen	Bryophyte	12	A
Pleurozium schreberi	Schreber's big red stem moss	Bryophyte	100	F
Polytrichum sp.	Haircap moss	Bryophyte	38	D
Racodium sp.	(none)	Bryophyte	12	C

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF01				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ** **
Stereocaulon sp.	Foam lichen	Bryophyte	12	D

Species with Status : No plant species with status was encountered in Ecotype MSF01.

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

** : Plant cover

T = Trace (only few individuals)	A = less than 1%	B = 1 to 5%
C = 5 to 10%	D = 10 to 25%	E = 25 to 40%
F = 40 to 60%	G = 60 to 80%	H = 80 to 100%

Ecotype: Black Spruce-Lichen Rock (Forested Ecosystem)

Ecotype MSF04 covers small areas, occurring on rocky sites with limited areas of very thin till. It is intermediate between Ecotype MSF02, which is almost entirely rock-dominated, and Ecotype MSF05, which is covered by a continuous mantle of thin till or deeper glaciofluvial deposits. Ecotype MSF04 is characterized by islands of stunted black spruce, with sparse shrub, herb and mosslichen layers in the understorey. Areas between tree islands feature crustose lichens on bare rocks and reindeer lichens on very thin soils. Soils are typically Folisols (organic humus layers over rock) or thin Humo-ferric Podzols, with Mor humus. In total, MSF04 covers around 2% of the LSA.

General Description of Ecotype MSF04

Soil Moisture Regime (Dry ↑ / ↓ Wet)	Soil Nutrient Regime ←Poor Rich→				
	A	B	C	D	E
0					
1					
2	MSF04				
3					
4					
5					
6					
7					
8					

Aerial View:

Ground View - Stand:

Ground View - Vegetation:

Synthesis of Environmental Observations Ecotype MSF04

Black Spruce-Lichen Rock (Forested Ecosystem)

1 Inventories Numbers:
hg042

4 Validation Points:
hv040, hv044, hv046, hv088

General Location:
Located on crest or upper slope of low hills

Distribution within the Study Area:
LSA: 2%

Elevation:
From 590 to 590 m, Mean of 590 m

Typical Slope Position:
Level or Upper slope

Topography:
Hilly, flat or rolling

Structural Stage:
Mature Climax

Drainage:
Rapidly drained

Soil Types:
Dystric Brunisol and Humo-Ferric Podzol with some Eluviated Dystric Brunisol

Soil Humus Type:
Hemimor

Roothing Depth:
N/A

Surficial deposits:
Thin morainal deposit

Soil Moisture Regime:
Subxeric to Submesic

Soil Nutrient Regime:
Poor to Very poor

Natural/Anthropogenic Disturbance:
Infrequent forest fire

Plant Species Diversity:
Low (common species)

Forest Productivity:
Low

Organic Matter Cover Percentage:
N/A

Decaying Wood Cover Percentage:
N/A

Rock Outcrop Cover Percentage:
N/A

Coarse Fragment Cover Percentage:
N/A

Mineral Soil Cover Percentage:
N/A

Open Water Cover Percentage:
N/A

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF04				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Larix laricina	Tamarack	Tree	100	A
Picea mariana	Black spruce	Tree	100	A
Betula glandulosa	Glandular birch	Shrub	100	A
Rhododendron groenlandicum	Common Labrador tea	Shrub	100	B
Empetrum nigrum	Black crowberry	Low Shrub	100	A
Linnaea borealis	Twinflower	Low Shrub	100	A
Vaccinium vitis-idaea	Mountain cranberry	Low Shrub	100	A
Deschampsia cespitosa	Tufted hairgrass	Herbaceous	100	A
Cladina rangiferina	Grey reindeer lichen	Bryophyte	100	B
Cladina stellaris	Star-tipped reindeer lichen	Bryophyte	100	D

Species with Status: No plant species with status was encountered in Ecotype MSF04.

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

** : Plant cover

T = Trace (only few individuals)	A = less than 1%	B = 1 to 5%
C = 5 to 10%	D = 10 to 25%	E = 25 to 40%
F = 40 to 60%	G = 60 to 80%	H = 80 to 100%

Ecotype: **Black Spruce - Lichen Woodland (Forested Ecosystem)**

Ecotype MSF05 occurs primarily on coarse glaciofluvial deposits or on coarse and thin moraines. This ecotype is highly visible from the air due to its distinctive light-coloured cover of reindeer lichens. Ecotype MSF05 is typified by a low cover (15 to 25%) of slowly growing black spruce, scattered shrubs dominated by Labrador tea, glandular birch (*Betula glandulosa*) and bog blueberry (*Vaccinium uliginosum*) and herbs and commonly continuous cover of reindeer lichen (*Cladina rangiferina*). Soils are typically Humo-ferric Podzols with Mor humus. In total, MSF05 covers around 21% of the LSA

General Description of Ecotype MSF05

Soil Moisture Regime (← Wet / Dry →)	Soil Nutrient Regime (←Poor / Rich→): A	B	C	D	E
0					
1					
2					
3	MSF05	MSF05			
4					
5					
6					
7					
8					

Aerial View:

Ground View - Stand:

Ground View - Vegetation:

Synthesis of Environmental Observations Ecotype MSF05

Black Spruce - Lichen Woodland (Forested Ecosystem)

13 Inventories Numbers:

In 2008: DSO04; DSO185; DSO199; DSO316; DSO363; DSO400; DSO406
In 2009: 112; 127; 200; 221; E2-4
In 2013: hv037

12 Validation Points:

hv021, hv022, hv045, hv048, hv072, hv077, hv083, hv084, hv086, hv087, hv091, hv092

General Location:

Occupies extensive areas on upper slopes or on moderate slopes throughout the LSA

Distribution within the Study Area:

LSA: 21%

Elevation:

548-694 m (average of 609m)

Typical Slope Position:

Generally upper slope. Occasionally at middle or lower slope, toe of slope and on level ground

Topography:

Flat or gently rolling, sometimes with low relief.

Structural Stage:

Mostly young or mature forests, except where forest fires have occurred. Burned sites dominated by glandular birch and regenerating black spruce

Drainage:

Mostly well drained

Soil Types:

Humoferric Podzols

Soil Humus Type:

Mor (Humimor)

Roothing Depth:

5 to 40 cm (average of 20 cm)

Surficial deposits:

Typically thick; coarse glaciofluvial deposits or thin to thick tills

Soil Moisture Regime:

3 (4) (Submesic)

Soil Nutrient Regime:

B (A) (poor, sometimes very poor)

Natural/Anthropogenic Disturbance:

Extensive low-intensity fires; drill holes at future mine site

Plant Species Diversity:

Low

Forest Productivity:

Low

Organic Matter Cover Percentage:

50 to 97 % (average of 88 %)

Decaying Wood Cover Percentage:

N/A

Rock Outcrop Cover Percentage:

0 to 5% (average of 3%)

Coarse Fragment Cover Percentage:

1 to 40% (average of 9%)

Mineral Soil Cover Percentage:

N/A

Open Water Cover Percentage:

0 %

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF05				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Larix laricina	Tamarack	Tree	29	B
Picea glauca	White spruce	Tree	43	C
Picea mariana	Black spruce	Tree	86	C
Betula glandulosa	Glandular birch	Shrub	100	D
Rhododendron groenlandicum	Common Labrador tea	Shrub	57	C
Salix pellita	Satiny willow	Shrub	14	C
Vaccinium angustifolium	Early lowbush blueberry	Shrub	14	C
Vaccinium uliginosum	Alpine bilberry	Shrub	57	B
Empetrum nigrum	Black crowberry	Low Shrub	71	B
Vaccinium caespitosum	Dwarf bilberry	Low Shrub	14	D
Vaccinium vitis-idaea	Mountain cranberry	Low Shrub	71	B
Calamagrostis canadensis	Bluejoint reedgrass	Herbaceous	14	E
Cornus canadensis	Bunchberry	Herbaceous	29	A
Deschampsia cespitosa	Tufted hairgrass	Herbaceous	14	D
Avenella flexuosa	Wavy hairgrass	Herbaceous	29	B
Equisetum sylvaticum	Woodland horsetail	Herbaceous	14	C
Geocaulon lividum	Northern comandra	Herbaceous	14	B
Lycopodium annotinum	Stiff clubmoss	Herbaceous	86	B
Petasites frigidus var. palmatus	Palmate coltsfoot	Herbaceous	14	B
Solidago macrophylla	Large-leaved goldenrod	Herbaceous	29	C
Cladonia deformis	Lesser sulphur-cup	Bryophyte	14	A
Cladonia sp.	(none)	Bryophyte	14	B
Cladina rangiferina	Grey reindeer lichen	Bryophyte	29	C
Cladina stellaris	Star-tipped reindeer lichen	Bryophyte	71	G
Pleurozium schreberi	Schreber's big red stem moss	Bryophyte	57	D
Racomitrium sp.	(none)	Bryophyte	14	B
Sphagnum sp.	Peatmoss	Bryophyte	14	D
Stereocaulon sp.	Foam lichen	Bryophyte	29	B

Species with Status : No plant species with status was encountered in Ecotype MSF05.

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

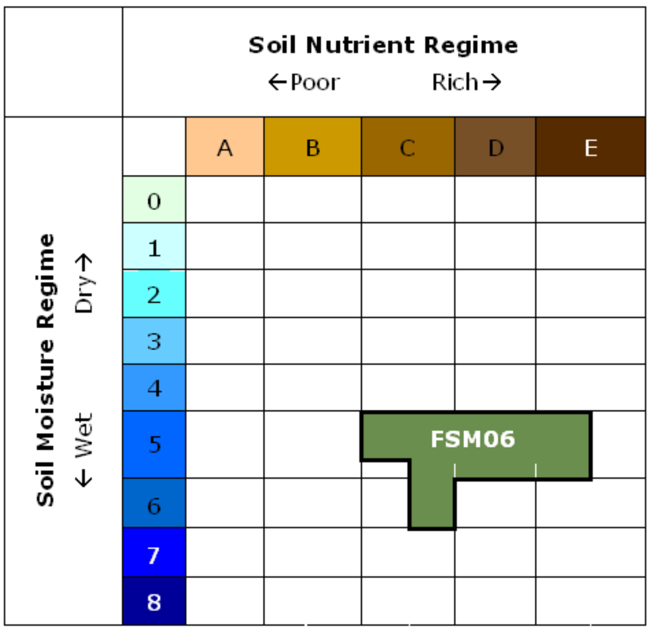
** : Plant cover

T = Trace (only few individuals)	A = less than 1%	B = 1 to 5%
C = 5 to 10%	D = 10 to 25%	E = 25 to 40%
F = 40 to 60%	G = 60 to 80%	H = 80 to 100%

Ecotype: White Spruce/Black Spruce - Feathermoss Seepage (Forested Ecosystem)

Ecotype MSF06 is one of the most productive forest ecosystems in the MSF Ecoregion, occurring on sites affected by nutrient-rich subsurface seepage. Ecotype MSF06 occurs on deep morainal soils with seepage throughout the LSA. It is often distributed within an ecotype complex in which it occupies linear drainage courses. As an example, Ecotypes MSF01 and MSF05 are interspersed with it on level and rolling slope positions. Ecotype MSF06 features relatively large white and black spruce trees, a well-expressed shrub layer with willow species and Labrador tea as well as an abundant and diverse herb and moss layers. Soils are typically Humo-ferric Podzols with Mormoder humus. In total, MSF06 covers around 2% of the LSA.

General Description of Ecotype MSF06



Aerial View:

Ground View - Stand:

Ground View - Vegetation:

Synthesis of Environmental Observations Ecotype MSF06

White Spruce/Black Spruce - Feathermoss Seepage (Forested Ecosystem)

12 Inventories Numbers:

In 2008: DSO06; DSO32; DSO358: DSO72
In 2009: 170; 222; AR-BO2; AR-GB2; B01
In 2010: E08, E09 and E13

2 Validation Points:

hv033, hv070

General Location:

Distributed throughout the LSA, on lower slopes and in shallow depressions where seepage increases forest productivity.

Distribution within the Study Area:

LSA: 2 %

Elevation:

533-734 m (average of 630 m)

Typical Slope Position:

Mid-slop to depression

Topography:

Gentle slope (average of 5,8 %)

Structural Stage:

Mostly mature forests

Drainage:

Moderately well to imperfect

Soil Types:

Gleyed Eutric or Melanic Brunisol or Humic Gleysol

Soil Humus Type:

Mormoder

Roothing Depth:

11-30 cm and deeper (average 22 cm)

Surficial deposits:

Morainal or glaciofluvial

Soil Moisture Regime:

5 (Subhydric), sometimes 4 (Mesic), 6 (Hygric) and 7 (Subhydric)

Soil Nutrient Regime:

Mostly C (Moderate)

Natural/Anthropogenic Disturbance:

Forest fires are rare because of wet soils and lower slope position.

Plant Species Diversity:

High

Forest Productivity:

High

Organic Matter Cover Percentage:

85 to 98 % (average of 93 %)

Decaying Wood Cover Percentage:

N/A

Rock Outcrop Cover Percentage:

0 %

Coarse Fragment Cover Percentage:

0 to 5 % (average of 3 %)

Mineral Soil Cover Percentage:

N/A

Open Water Cover Percentage:

0 to 10 % (average of 3 %)

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF06				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Larix laricina	Tamarack	Tree	50	C
Picea glauca	White spruce	Tree	50	D
Picea mariana	Black spruce	Tree	25	D
Salix bebbiana	Bebb's willow	Tree	50	C
Alnus incana subsp. rugosa	Speckled alder	Shrub	25	D
Amelanchier bartramiana	Mountain serviceberry	Shrub	25	C
Betula glandulosa	Glandular birch	Shrub	100	D
Juniperus communis	Common juniper	Shrub	25	B
Kalmia polifolia	Pale bog laurel	Shrub	25	C
Rhododendron groenlandicum	Common Labrador tea	Shrub	50	C
Salix glauca	Grey-leaved willow	Shrub	25	A
Salix pellita	Satiny willow	Shrub	25	D
Salix planifolia	Tea-leaved willow	Shrub	25	C
Salix pyrifolia	Balsam willow	Shrub	25	B
Salix vestita	Hary willow	Shrub	25	D
Salix sp.	Willow	Shrub	25	B
Vaccinium uliginosum	Alpine bilberry	Shrub	50	B
Empetrum nigrum	Black crowberry	Low Shrub	25	B
Linnaea borealis	Twinflower	Low Shrub	50	B
Rubus canadensis	Canada blackberry	Low Shrub	25	A
Vaccinium vitis-idaea	Mountain cranberry	Low Shrub	25	A
Calamagrostis canadensis	Bluejoint reedgrass	Herbaceous	25	C
Carex leptonervia	Leptonerved sedge	Herbaceous	25	D
Carex sp.	Sedge	Herbaceous	25	D
Coptis trifolia	Goldthread	Herbaceous	50	A
Cornus canadensis	Bunchberry	Herbaceous	50	B
Deschampsia cespitosa	Tufted hairgrass	Herbaceous	25	C
Equisetum sp.	Horsetail	Herbaceous	25	A
Equisetum sylvaticum	Woodland horsetail	Herbaceous	25	B
Eriophorum angustifolium	Narrow-leaved cottongrass	Herbaceous	25	F
Eriophorum gracile	Slender cottongrass	Herbaceous	25	A
Eriophorum russeolum	Russet cottongrass	Herbaceous	25	B
Luzula sp.	Woodrush	Herbaceous	50	A
Lycopodium annotinum	Stiff clubmoss	Herbaceous	25	C
Diphasiastrum complanatum	Northern ground-cedar	Herbaceous	25	A
Petasites frigidus var. palmatus	Palmate coltsfoot	Herbaceous	75	B

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF06				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Bistorta vivipara	Alpine bistort	Herbaceous	25	A
Rubus pubescens	Dewberry	Herbaceous	25	B
Solidago macrophylla	Large-leaved goldenrod	Herbaceous	75	B
Streptopus amplexifolius	Clasping-leaved twisted-stalk	Herbaceous	25	A
Trichophorum cespitosum	Tufted clubrush	Herbaceous	25	F
Vaccinium oxycoccos	Small cranberry	Herbaceous	25	A
Pleurozium schreberi	Schreber's big red stem moss	Bryophyte	25	F
Polytrichum sp.	Haircap moss	Bryophyte	25	D
Sphagnum sp.	Peatmoss	Bryophyte	50	F

Species with Status : No plant species with status was encountered in Ecotype MSF06.

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

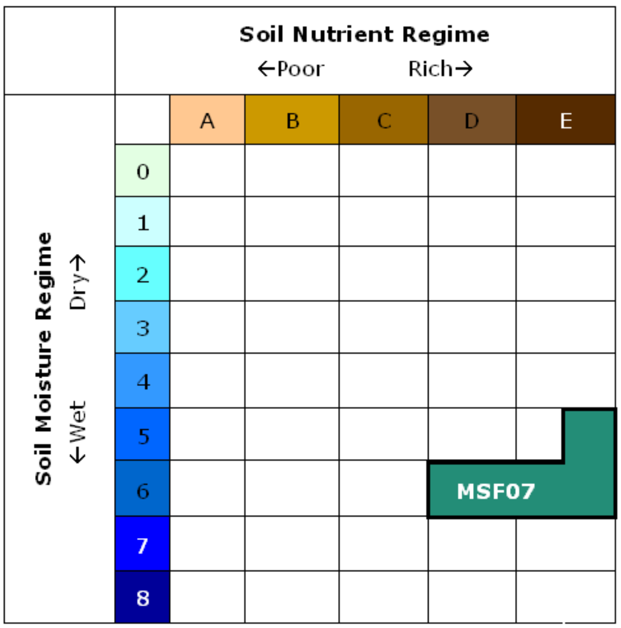
** : Plant cover

T = Trace (only few individuals)	A = less than 1%	B = 1 to 5%
C = 5 to 10%	D = 10 to 25%	E = 25 to 40%
F = 40 to 60%	G = 60 to 80%	H = 80 to 100%

Ecotype: White Spruce-Alder/Willow-Sedges Streambank (Forested Riparian Ecosystem)

Ecotype MSF07 is, with Ecotype MSF06, the most productive forest ecosystems in the MSF Ecoregion. Ecotype MSF07 occurs on sites adjacent to streams and lakes that are enriched either by siltation and flooding, or subsurface seepage from adjacent streams or lakes. It occupies drainage courses, interspersed with Ecotypes MSF01 and MSF05, on level and rolling slope positions. Ecotype MSF07 features relatively large white and black spruce trees, a well-expressed shrub layer with willow species as well as abundant and diverse herb and moss layers. Soils are typically Regosol with Hemimor humus forms. In total, MSF07 covers about 1% of the LSA.

General Description of Ecotype MSF07



Aerial View:

Ground View - Stand:

Ground View - Vegetation:

Synthesis of Environmental Observations Ecotype MSF07

White Spruce-Alder/Willow-Sedges Streambank (Forested Riparian Ecosystem)

11 Inventories Numbers:

In 2008: DSO183; DSO318; DSO409
In 2009: 145; 189; 259; 400; AR-GB1
In 2010: E10 and E11
In 2013: hg069

4 Validation Points:

hv075, hv078, hv081, hv082

General Location:

Restricted to the banks of certain streams located in the LSA.

Distribution within the Study Area:

LSA: about 1 %

Elevation:

552-669 m (average of 609 m)

Typical Slope Position:

Mid-slope to flat and depression

Topography:

At the bottom of valleys, along streams or on lake shores.

Structural Stage:

All stands sampled or mapped were mature forest.

Drainage:

Imperfectly to poorly drained

Soil Types:

Humic Gleysol

Soil Humus Type:

Mormoder

Roothing Depth:

Approximately 20 cm

Surficial deposits:

Fluvial or lacustrine

Soil Moisture Regime:

6 (Hygric)

Soil Nutrient Regime:

D or C (rich or moderate), but sometimes E (very rich)

Natural/Anthropogenic Disturbance:

Episodic and seasonal flooding

Plant Species Diversity:

High

Forest Productivity:

High

Organic Matter Cover Percentage:

70 to 100 % (average 83 %)

Decaying Wood Cover Percentage:

N/A

Rock Outcrop Cover Percentage:

0 %

Coarse Fragment Cover Percentage:

0 %

Mineral Soil Cover Percentage:

N/A

Open Water Cover Percentage:

0-20 % (average 11 %)

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF07				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Larix laricina	Tamarack	Tree	100	C
Picea glauca	White spruce	Tree	100	D
Betula glandulosa	Glandular birch	Shrub	100	B
Salix pellita	Satiny willow	Shrub	100	B
Salix planifolia	Tea-leaved willow	Shrub	100	D
Salix vestita	Hary willow	Shrub	100	D
Achillea millefolium	Common yarrow	Herbaceous	100	A
Symphyotrichum puniceum	Purple-stemmed aster	Herbaceous	100	A
Bromus sp.	Brome	Herbaceous	100	A
Calamagrostis canadensis	Bluejoint reedgrass	Herbaceous	100	B
Carex aquatilis	Water sedge	Herbaceous	100	F
Carex vaginata	Sheathed sedge	Herbaceous	100	A
Cornus canadensis	Bunchberry	Herbaceous	100	A
Equisetum sylvaticum	Woodland horsetail	Herbaceous	100	C
Geum rivale	Water avens	Herbaceous	100	D
Glyceria sp.	Mannagrass	Herbaceous	100	A
Luzula parviflora	Small-flowered woodrush	Herbaceous	100	A
Bistorta viviparia	Alpine bistort	Herbaceous	100	A
Comarum palustre	Marsh cinquefoil	Herbaceous	100	A
Pyrola minor	Lesser pyrola	Herbaceous	100	A
Solidago macrophylla	Large-leaved goldenrod	Herbaceous	100	A
Mnium sp.	Star moss	Bryophyte	100	B
Pleurozium schreberi	Schreber's big red stem moss	Bryophyte	100	B
Sphagnum sp.	Peatmoss	Bryophyte	100	F

Species with Status : No plant species with status was encountered in Ecotype MSF07.

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

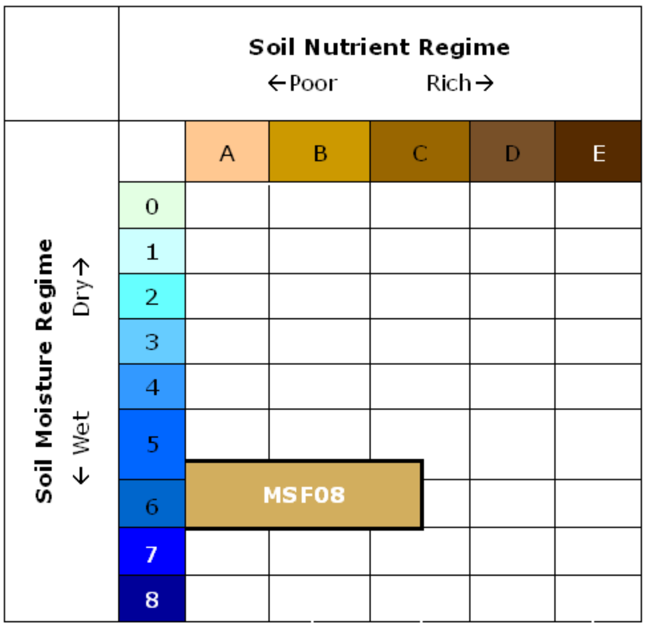
** : Plant cover

T = Trace (only few individuals) A = less than 1% B = 1 to 5%
C = 5 to 10% D = 10 to 25% E = 25 to 40%
F = 40 to 60% G = 60 to 80% H = 80 to 100%

Ecotype: Black Spruce/Tamarack-Glandular Birch-Sphagnum Swamp (Forested Wetland Ecosystem)

Ecotype MSF08 is common throughout the LSA, usually occuring in wetland complexes with forested (Ecotype MSF10) and non-forested (Ecotype MSF12) fens. As in other wetland ecotypes, this ecosystem occurs in depressions and lowlands, but on the margins of wetlands, where drainage is poor, but not very poor. This is a generally forested ecotype, with abundant herb, shrub and moss species. Although black spruce is the dominant tree, tamarack occurs more frequently in this ecotype than in any other and thus is used to name it. As in other wetland ecotypes, soils are commonly of the Organic Order, but gleyed mineral soils also occur. In total, MSF08 covers around 3% of the LSA.

General Description of Ecotype MSF08



Aerial View:

Ground View - Stand:

Ground View - Vegetation:

Synthesis of Environmental Observations Ecotype MSF08

Black Spruce/Tamarack-Glandular Birch-Sphagnum Swamp (Forested Wetland Ecosystem)

9 Inventories Numbers:

In 2008: DSO181; DSO328; DSO331
In 2009: 135; 157; 231; 411
In 2010: E07
In 2013: hg010

9 Validation Points:

hv007, hv008, hv009, hv011, hv012, hv016, hv026, hv027, hv034

General Location:

Widely distributed over the entire LSA, but mostly concentrated where soil drainage is imperfect to poor.

Distribution within the Study Area:

LSA : 3 %

Elevation:

537-633 m (average of 595 m)

Typical Slope Position:

Bottom of slope, depression and flat ground.

Topography:

Flat

Structural Stage:

Mature forest

Drainage:

Mostly imperfect

Soil Types:

Fibrisol or Humic Gleysol

Soil Humus Type:

Mor or Moder

Roothing Depth:

10 to 40 cm (average of 30 cm)

Surficial deposits:

Mostly organic deposits over till

Soil Moisture Regime:

6 (Hygric) sometimes 5 (Subhygric)

Soil Nutrient Regime:

C to B (moderate to poor)

Natural/Anthropogenic Disturbance:

Episodic and seasonal (spring) flooding caused by fluctuations in the water table

Plant Species Diversity:

Intermediate

Forest Productivity:

Low

Organic Matter Cover Percentage:

50 to 100 % (average of 86 %)

Decaying Wood Cover Percentage:

N/A

Rock Outcrop Cover Percentage:

0 %

Coarse Fragment Cover Percentage:

0 to 30 % (average of 18 %)

Mineral Soil Cover Percentage:

N/A

Open Water Cover Percentage:

0 to 10 % (average of 7.5 %)

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF08				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Larix laricina	Tamarack	Tree	67	B
Picea glauca	White spruce	Tree	33	E
Picea mariana	Black spruce	Tree	100	D
Amelanchier bartramiana	Mountain serviceberry	Shrub	33	A
Betula glandulosa	Glandular birch	Shrub	67	D
Kalmia polifolia	Pale bog laurel	Shrub	67	B
Rhododendron groenlandicum	Common Labrador tea	Shrub	100	B
Myrica gale	Sweet gale	Shrub	33	B
Salix pellita	Satiny willow	Shrub	67	B
Vaccinium angustifolium	Early lowbush blueberry	Shrub	33	B
Vaccinium uliginosum	Alpine bilberry	Shrub	100	D
Empetrum nigrum	Black crowberry	Low Shrub	67	B
Gaultheria hispidula	Creeping snowberry	Low Shrub	33	B
Linnaea borealis	Twinflower	Low Shrub	33	B
Rubus chamaemorus	Cloudberry	Low Shrub	33	C
Calamagrostis canadensis	Bluejoint reedgrass	Herbaceous	33	B
Carex canescens	Silvery sedge	Herbaceous	33	C
Carex limosa	Mud sedge	Herbaceous	33	C
Carex pauciflora	Few-flowered sedge	Herbaceous	33	A
Carex trisperma	Three-seeded sedge	Herbaceous	33	D
Carex sp.	Sedge	Herbaceous	33	A
Coptis trifolia	Goldthread	Herbaceous	67	A
Cornus canadensis	Bunchberry	Herbaceous	67	B
Deschampsia cespitosa	Tufted hairgrass	Herbaceous	33	B
Avenella flexuosa	Wavy hairgrass	Herbaceous	33	A
Chamerion angustifolium	Fireweed	Herbaceous	33	A
Equisetum sylvaticum	Woodland horsetail	Herbaceous	100	C
Eriophorum angustifolium	Narrow-leaved cottongrass	Herbaceous	33	A
Geocaulon lividum	Northern comandra	Herbaceous	33	B
Lycopodium annotinum	Stiff clubmoss	Herbaceous	33	A
Petasites frigidus var. palmatus	Palmate coltsfoot	Herbaceous	100	C
Platanthera dilatata	Tall white bog orchid	Herbaceous	33	A
Solidago macrophylla	Large-leaved goldenrod	Herbaceous	67	B
Trichophorum cespitosum	Tufted clubrush	Herbaceous	33	B
Vaccinium oxycoccos	Small cranberry	Herbaceous	33	A
Vahlodea atropurpurea	Mountain hairgrass	Herbaceous	33	D

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF08				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Cladina stellaris	Star-tipped reindeer lichen	Bryophyte	33	B
Pleurozium schreberi	Schreber's big red stem moss	Bryophyte	100	F
Polytrichum sp.	Haircap moss	Bryophyte	33	B
Sphagnum compactum	Compact peatmoss	Bryophyte	67	E
Sphagnum sp.	Peatmoss	Bryophyte	100	D

Species with Status : No plant species with status was encountered in Ecotype MSF08.

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

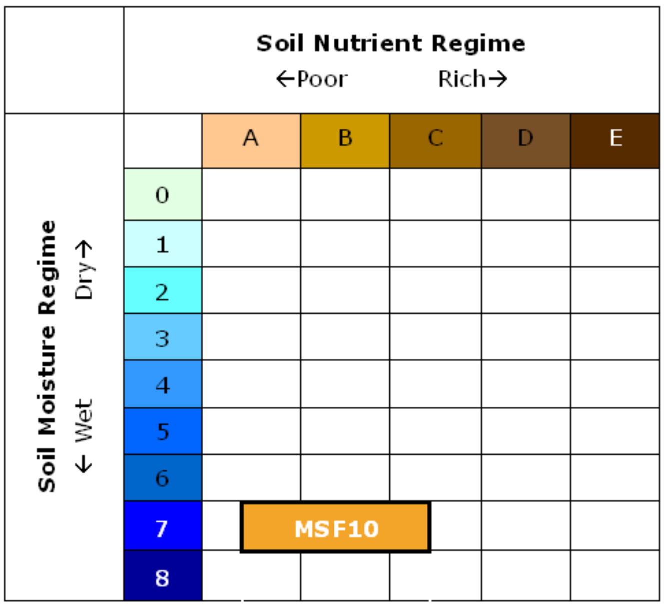
** : Plant cover

T = Trace (only few individuals)	A = less than 1%	B = 1 to 5%
C = 5 to 10%	D = 10 to 25%	E = 25 to 40%
F = 40 to 60%	G = 60 to 80%	H = 80 to 100%

Ecotype: Black Spruce Forested Bog (Forested Wetland Ecosystem)

Ecotype MSF10 is found in complexes with ecotypes MSF08 and MSF12. As with other type of wetlands, Ecotype MSF10 is located in depressions that have poorly drained soils. This ecotype forms a gradient between the mesic ecosystems such as MSF01 and MSF05 and the non-forest wetlands such as ecotypes MSF12 and MSF14. The soils are always organic and the drainage poor. Forested bog surfaces are generally dome-shaped. The arboreous layer is entirely dominated by black spruce and tamarack. The shrub layer is diverse and abundant. The herbaceous layer is varied and dominated by sedge, while the moss layer is almost exclusively dominated by peatmoss. In total, MSF10 covers around 1% of the LSA.

General Description of Ecotype MSF10



Aerial View:

Ground View - Stand:

Ground View - Vegetation:

Synthesis of Environmental Observations Ecotype MSF10

Black Spruce Forested Bog (Forested Wetland Ecosystem)

4 Inventories Numbers:

In 2008: DSO177; DSO401
In 2009: 181
In 2013: hg036

6 Validation Points:

hv035, hv038, hv041, hv076, hv079, hv080

General Location:

Concentrated where wetland complexes are most abundant. Ecotype MSF10 is almost always found in complexes with Ecotypes MSF12 and MSF14.

Distribution within the Study Area:

LSA : 1 %

Elevation:

539-579 m (average of 555 m)

Typical Slope Position:

Depression

Topography:

Always associated with flat topography

Structural Stage:

Mostly mature forest (sometimes young forest)

Drainage:

Poor

Soil Types:

Organic soil: Fibrisol, sometimes Mesisol

Soil Humus Type:

Organic

Roothing Depth:

10 to 50 cm (average of 30 cm)

Surficial deposits:

Thin layer of organic deposits aver till

Soil Moisture Regime:

6 (Hydric)

Soil Nutrient Regime:

B (poor) to C (moderate)

Natural/Anthropogenic Disturbance:

Episodic and seasonal flooding

Plant Species Diversity:

Intermediate

Forest Productivity:

Low

Organic Matter Cover Percentage:

69 to 99 % (average of 90 %)

Decaying Wood Cover Percentage:

N/A

Rock Outcrop Cover Percentage:

0 %

Coarse Fragment Cover Percentage:

0 to 10 % (average of 1.25 %)

Mineral Soil Cover Percentage:

N/A

Open Water Cover Percentage:

0 to 20 % (average of 14 %)

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF10				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Larix laricina	Tamarack	Tree	100	B
Picea mariana	Black spruce	Tree	100	D
Betula glandulosa	Glandular birch	Shrub	100	C
Kalmia polifolia	Pale bog laurel	Shrub	100	A
Rhododendron groenlandicum	Common Labrador tea	Shrub	50	B
Lonicera villosa	Mountain fly-honeysuckle	Shrub	50	A
Myrica gale	Sweet gale	Shrub	100	D
Salix pedicellaris	Bog willow	Shrub	50	B
Vaccinium uliginosum	Alpine bilberry	Shrub	50	A
Linnaea borealis	Twinflower	Low Shrub	50	B
Rubus chamaemorus	Cloudberry	Low Shrub	50	C
Eurybia radula	Low rough aster	Herbaceous	50	B
Calamagrostis canadensis	Bluejoint reedgrass	Herbaceous	50	D
Carex aquatilis	Water sedge	Herbaceous	100	D
Carex echinata	Star sedge	Herbaceous	50	A
Carex leptonervia	Leptonerved sedge	Herbaceous	50	D
Carex limosa	Mud sedge	Herbaceous	50	B
Carex pauciflora	Few-flowered sedge	Herbaceous	100	B
Coptis trifolia	Goldthread	Herbaceous	50	A
Deschampsia cespitosa	Tufted hairgrass	Herbaceous	50	A
Equisetum sylvaticum	Woodland horsetail	Herbaceous	50	B
Eriophorum sp.	Sheathed cottonsedge	Herbaceous	50	B
Eriophorum russeolum	Russet cottongrass	Herbaceous	50	A
Eriophorum virginicum	Tawny cottongrass	Herbaceous	50	A
Maianthemum trifolium	Three-leaved false Solomon’s seal	Herbaceous	50	A
Rubus pubescens	Dewberry	Herbaceous	50	B
Maianthemum trifolium	Three-leaved false Solomon’s seal	Herbaceous	50	A
Solidago sp.	Goldenrod	Herbaceous	50	B
Euthamia graminifolia	Narrow-leaved goldenrod	Herbaceous	50	B
Solidago uliginosa	Bog goldenrod	Herbaceous	50	A
Trichophorum cespitosum	Tufted clubrush	Herbaceous	100	D
Vaccinium oxycoccos	Small cranberry	Herbaceous	100	A
Sphagnum compactum	Compact peatmoss	Bryophyte	50	G
Sphagnum sp.	Peatmoss	Bryophyte	100	F

Species with Status : No plant species with status was encountered in Ecotype MSF10.

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

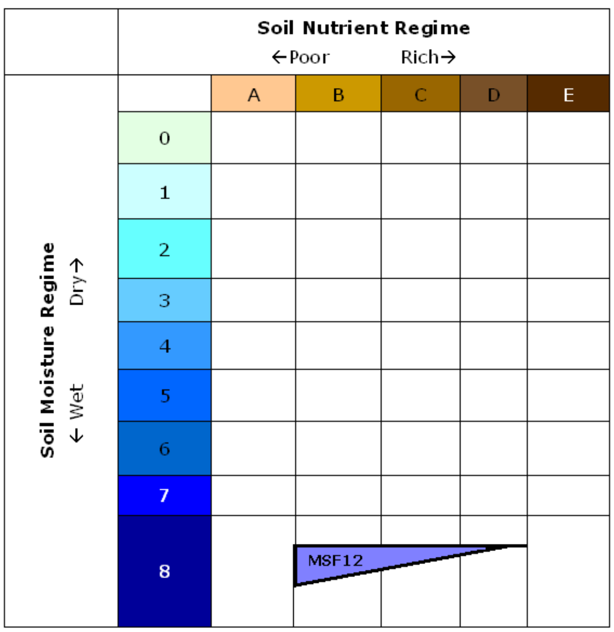
** : Plant cover

T = Trace (only few individuals)	A = less than 1%	B = 1 to 5%
C = 5 to 10%	D = 10 to 25%	E = 25 to 40%
F = 40 to 60%	G = 60 to 80%	H = 80 to 100%

Ecotype: **Uniform Herb Fen (Non-Forested Wetland Ecosystem)**

Uniform Herb Fen (Ecotype MSF12), after forested swamps (Ecotype MSF08), is the most common wetland ecotypes in the LSA. They occur in depressions and lowlands. Like structured fens, Uniform Herb Fens are sedge-dominated ecosystems with scattered shrubs and other wetland herbs, but they lack the 'string' forms of structured fens. Their surfaces are flat to depressed, with a continuous vegetation cover. Black spruce and tamarack occur as scattered, stunted individuals on raised microsites. As in other wetlands, soils are organic, typically Mesisols and Fibrisols. Soil drainage is typically poor, and sites are very wet in the spring, with water tables declining as summer approaches. Ecotype MSF12 may occur in very large wetland complexes with Ecotypes MSF10 (forested bog) and MSF08 (swamp forest), or on its own in small, isolated depressions. In total, MSF12 covers around 2% of the LSA.

General Description of Ecotype MSF12



Aerial View:

Ground View - Stand:

Ground View - Vegetation:

Synthesis of Environmental Observations Ecotype MSF12

Uniform Herb Fen (Non-Forested Wetland Ecosystem)

16 Inventories Numbers:

In 2008: DSO129; DSO14; DSO150; DSO151; DSO314; DSO333; DSO367
In 2009: 104; 113; 162; 224; 253; 408; AR-REA4; E2-5
In 2013: hg031, hg090

3 Validation Points:

hv032, hv039, hv089

General Location:

Found in depressions where soil drainage is poor; ; represented by either extensive wetlands or small isolated pockets.

Distribution within the Study Area:

LSA : 2 %

Elevation:

551-666 m (average of 623 m)

Typical Slope Position:

Depression

Topography:

Flat

Structural Stage:

Cover dominated by herbaceous species and plant communities comprised mostly of sedges and mosses.

Drainage:

Poor to very poor

Soil Types:

Organic soil: mostly Fibrisol; sometimes Mesisol.

Soil Humus Type:

Organic

Roothing Depth:

20 to 40 cm (average of 30 cm)

Surficial deposits:

Organic deposits

Soil Moisture Regime:

7 (8) (Subhydric, sometimes Hydric)

Soil Nutrient Regime:

B (poor)

Natural/Anthropogenic Disturbance:

Episodic and seasonal flooding caused by fluctuations in the water table

Plant Species Diversity:

High

Forest Productivity:

None

Organic Matter Cover Percentage:

55 to 100 % (average of 85 %)

Decaying Wood Cover Percentage:

N/A

Rock Outcrop Cover Percentage:

0 %

Coarse Fragment Cover Percentage:

0 to 30 % (average of 2.7 %)

Mineral Soil Cover Percentage:

N/A

Open Water Cover Percentage:

5 to 50 % (average of 20 %)

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF12				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Picea mariana	Black spruce	Tree	50	C
Betula glandulosa	Glandular birch	Shrub	100	C
Kalmia polifolia	Pale bog laurel	Shrub	50	A
Picea mariana	Black spruce	Shrub	100	C
Salix pedicellaris	Bog willow	Shrub	50	D
Salix pellita	Satiny willow	Shrub	50	C
Vaccinium uliginosum	Alpine bilberry	Shrub	50	C
Rubus canadensis	Canada blackberry	Low Shrub	50	C
Rubus chamaemorus	Cloudberry	Low Shrub	50	A
Eurybia radula	Low rough aster	Herbaceous	50	A
Calamagrostis canadensis	Bluejoint reedgrass	Herbaceous	50	A
Carex bigelowii	Bigelow's sedge	Herbaceous	50	D
Carex brunnescens	Brownish sedge	Herbaceous	50	A
Carex limosa	Mud sedge	Herbaceous	50	C
Coptis trifolia	Goldthread	Herbaceous	50	A
Deschampsia cespitosa	Tufted hairgrass	Herbaceous	50	D
Chamerion angustifolium	Fireweed	Herbaceous	50	A
Equisetum sylvaticum	Woodland horsetail	Herbaceous	50	C
Eriophorum gracile	Slender cottongrass	Herbaceous	100	B
Torreyochloa pallida var. fernaldii	Fernald's false mannagrass	Herbaceous	50	D
Juncus filiformis	Thread rush	Herbaceous	50	C
Maianthemum trifolium	Three-leaved false Solomon's seal	Herbaceous	50	A
Petasites frigidus var. palmatus	Palmate coltsfoot	Herbaceous	50	C
Platanthera dilatata	Tall white bog orchid	Herbaceous	50	A
Trichophorum cespitosum	Tufted clubrush	Herbaceous	50	D
Vaccinium oxycoccos	Small cranberry	Herbaceous	50	B
Pleurozium schreberi	Schreber's big red stem moss	Bryophyte	50	D
Polytrichum sp.	Haircap moss	Bryophyte	50	D
Sphagnum sp.	Peatmoss	Bryophyte	100	G

Species with Status : No plant species with status was encountered in Ecotype MSF12.

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

** : Plant cover

T = Trace (only few individuals)	A = less than 1%	B = 1 to 5%
C = 5 to 10%	D = 10 to 25%	E = 25 to 40%
F = 40 to 60%	G = 60 to 80%	H = 80 to 100%

Ecotype: Uniform Fluvial Shrub Fen (Non-Forested Riparian Ecosystem)

Uniform Fluvial Shrub Fens (Ecotype MSF15) are the most productive non-forested ecosystems in the MSF Ecoregion. A dense shrub layer is found with a rich and diverse herb layer. Ecotype MSF15 occurs on sites adjacent to streams that are enriched either by overbank flooding or subsurface seepage. MSF15 is found in complexes along stream banks with Ecotype MSF07 and features few trees, but it has a well-expressed shrub layer with alder and willow species and abundant and diverse herb and moss layers. Soils are typically Humic Regosols or Humic Gleysols. In total, MSF15 covers 1% of the LSA

General Description of Ecotype MSF15

Soil Nutrient Regime (←Poor Rich→); Soil Moisture Regime (Dry→ ← Wet)

Soil Moisture Regime	A	B	C	D	E
0					
1					
2					
3					
4					
5					
6					
7					MSF15
8					

Aerial View:

Ground View - Stand:

Ground View - Vegetation:

Synthesis of Environmental Observations Ecotype MSF15

Uniform Fluvial Shrub Fen (Non-Forested Riparian Ecosystem)

19 Inventories Numbers:

In 2008: DSO136; DSO149; DSO175; DSO191; DSO197; DSO27; DSO28; DSO354; DSO356; DSO362; DSO74
In 2009: 106; 207; 226; 424; AR-GB3; AR-REA5a
In 2013: hg024, hg050

4 Validation Points:

hv025, hv049, hv051, hv085

General Location:

Limited to the banks of various types of streams.

Distribution within the Study Area:

LSA : 1 %

Elevation:

444-688 m (average of 607 m)

Typical Slope Position:

Toe of slopes to depression

Topography:

Flat terrain or gentle slope

Structural Stage:

Low shrubs were dominant at all sites.

Drainage:

Moderately well to poorly drained

Soil Types:

Humic regosol and Humic Gleysol

Soil Humus Type:

Mostly Moder (Mullmoder)

Roothing Depth:

12 to 30 cm (average of 21 cm)

Surficial deposits:

All surveyed deposits were fluvial or thin organic deposits covering fluvial deposits.

Soil Moisture Regime:

Mostly 7 (Subhygric), in places 6 or 5 (Hygric or Subhydric).

Soil Nutrient Regime:

Mostly D (rich), in places C (moderate).

Natural/Anthropogenic Disturbance:

Episodic and seasonal (in spring and following heavy rains) flooding caused by fluctuations in stream water level

Plant Species Diversity:

High

Forest Productivity:

None

Organic Matter Cover Percentage:

40 to 100 % (average of 75 %)

Decaying Wood Cover Percentage:

N/A

Rock Outcrop Cover Percentage:

0 %

Coarse Fragment Cover Percentage:

0 to 15 % (average of 2 %)

Mineral Soil Cover Percentage:

N/A

Open Water Cover Percentage:

5 to 50 % (average of 26 %)

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF15				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Larix laricina	Tamarack	Tree	9	B
Picea glauca	White spruce	Tree	27	B
Picea mariana	Black spruce	Tree	9	C
Alnus incana subsp. rugosa	Speckled alder	Shrub	18	E
Betula glandulosa	Glandular birch	Shrub	64	D
Kalmia polifolia	Pale bog laurel	Shrub	9	B
Lonicera villosa	Mountain fly honeysuckle	Shrub	18	A
Myrica gale	Sweet gale	Shrub	27	D
Ribes glandulosum	skunk currant	Shrub	27	C
Salix pedicellaris	Bog willow	Shrub	9	D
Salix pellita	Satiny willow	Shrub	64	E
Salix planifolia	Tea-leaved willow	Shrub	18	E
Salix vestita	Hary willow	Shrub	9	A
Salix sp.	Willow	Shrub	9	A
Vaccinium vitis-idaea	Mountain cranberry	Low Shrub	9	B
Achillea millefolium	Common yarrow	Herbaceous	27	B
Elymus repens	Quackgrass	Herbaceous	9	B
Agrostis scabra	Rough bentgrass	Herbaceous	9	A
Alchemilla filicaulis	Thin-stemmed lady's mantle	Herbaceous	18	B
Symphyotrichum puniceum	Purple-stemmed aster	Herbaceous	36	B
Eurybia radula	Low rough aster	Herbaceous	9	B
Bromus ciliatus	Fringed brome	Herbaceous	9	C
Calamagrostis canadensis	Bluejoint reedgrass	Herbaceous	82	D
Carex aquatilis	Water sedge	Herbaceous	36	D
Carex leptonervia	Leptonerved sedge	Herbaceous	9	D
Carex pauciflora	Few-flowered sedge	Herbaceous	9	A
Carex rariflora	Loose-flowered alpine sedge	Herbaceous	9	A
Carex tribuloides	Blunt broom sedge	Herbaceous	9	A
Coptis trifolia	Goldthread	Herbaceous	27	B
Cornus canadensis	Bunchberry	Herbaceous	45	C
Deschampsia cespitosa	Tufted hairgrass	Herbaceous	9	B
Avenella flexuosa	Wavy hairgrass	Herbaceous	9	B
Elymus trachycaulus	Slender wildrye	Herbaceous	9	A
Chamerion angustifolium	Fireweed	Herbaceous	45	B
Equisetum palustre	Marsh horsetail	Herbaceous	9	B
Equisetum sylvaticum	Woodland horsetail	Herbaceous	36	B

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE MSF15				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Fragaria virginiana	Wildstrawberry	Herbaceous	27	C
Galium sp.	Galium	Herbaceous	9	B
Geocaulon lividum	Northern comandra	Herbaceous	9	C
Geum rivale	Water avens	Herbaceous	27	B
Torreyochloa pallida var. fernaldii	Fernald's false mannagrass	Herbaceous	9	C
Lolium sp.	Ryegrass	Herbaceous	9	D
Luzula parviflora	Small-flowered woodrush	Herbaceous	9	A
Nuphar variegata	Variegated pond-lily	Herbaceous	9	C
Petasites frigidus var. palmatus	Palmate coltsfoot	Herbaceous	55	B
Platanthera dilatata	Tall white bog orchid	Herbaceous	9	A
*Bistorta vivipari*a	Alpine bistort	Herbaceous	9	A
Comarum palustre	Marsh cinquefoil	Herbaceous	9	B
Rhinanthus minor	Little yellow rattle	Herbaceous	18	A
Rubus pubescens	Dewberry	Herbaceous	36	B
Solidago sp.	Goldenrod	Herbaceous	9	A
Solidago macrophylla	Large-leaved goldenrod	Herbaceous	73	D
Sparganium sp.	burreed	Herbaceous	9	B
Streptopus amplexifolius	Clasping-leaved twisted-stalk	Herbaceous	9	B
Trichophorum cespitosum	Tufted clubrush	Herbaceous	18	D
Trientalis borealis	Northern starflower	Herbaceous	9	A
Vaccinium oxycoccos	Small cranberry	Herbaceous	9	A
Viola iblanda	Sweet white violet	Herbaceous	9	D
Climacium dendroides	Tree climacium moss	Bryophyte	9	B
Hepatica sp	Hepatic	Bryophyte	18	C
Mnium sp.	Star moss	Bryophyte	9	D
Pleurozium schreberi	Schreber's big red stem moss	Bryophyte	36	C
Polytrichum sp.	Haircap moss	Bryophyte	9	E
Ptilidium ciliare	(none)	Bryophyte	9	D
Ptilium crista-castrensis	Knights plume moss	Bryophyte	9	B
Sphagnum sp.	Peatmoss	Bryophyte	45	F
Tomentypnum nitens	Shining feather moss	Bryophyte	18	D

Species with Status : No plant species with status was encountered in Ecotype MSF15

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

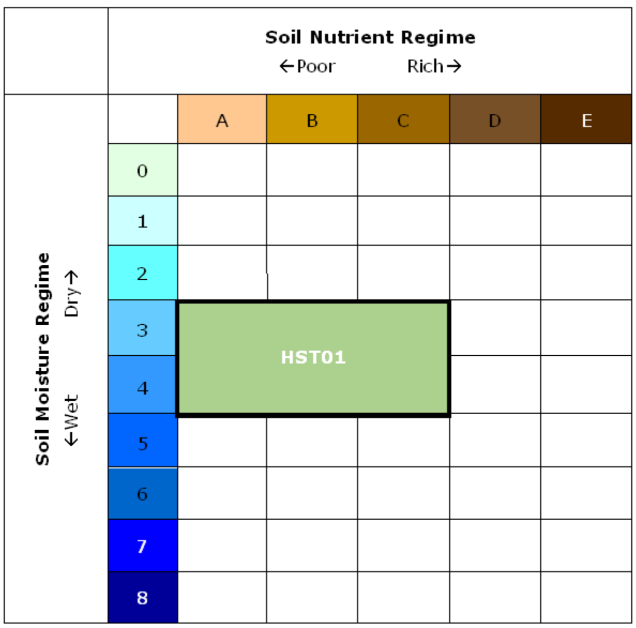
** : Plant cover

T = Trace (only few individuals)	A = less than 1%	B = 1 to 5%
C = 5 to 10%	D = 10 to 25%	E = 25 to 40%
F = 40 to 60%	G = 60 to 80%	H = 80 to 100%

Ecotype: **Alpine Shrub – Glandular Birch – Mesic**

Ecotype HST01 is found on till deposits of medium texture and variable thickness. This ecotype is considered to be the zonal, or normal, ecosystem of the HST ecoregion. The zonal or normal sites have one intermediate SMR and one intermediate SNR (neither too rich, nor too poor; neither too dry, nor too wet) and reflect the pressure from the climate of the ecoregion. They can be used to characterize and map the spatial boundaries of the ecoregion. The zonal sites indicate an important change in terms of regional climate and mark the boundary between the MSF and HST ecoregions. Trees are absent or infrequent (shrub forms only) within Ecotype HST01. However, sparce tree cover occurs at the boundary between HST and MSF ecoregions.The shrub layer is dominated by glandular birch, alpine billberry and mountain cranberry, while the herbaceous layer is diverse. Several lichens and mosses are also found scattered on the ground cover. The soils are mostly Melanic Brunisols and Eutric Brunisols with Mor type humus, indicating an average level of nutrients in the soil. Permafrost could occur within this ecotype, but the active layer (melting and freezing each year) is too thick (more than 2m) to consider the soil as a Cryosol. In total, HST01 covers around 17% of the LSA.

General Description of Ecotype HST01



Aerial View:

Ground View - Stand:

Ground View - Vegetation:

Synthesis of Environmental Observations Ecotype HST01

Alpine Shrub – Glandular Birch – Mesic

32 Inventories Numbers:

In 2008: DSO10; DSO110; DSO118; DSO128; DSO380; DSO41; DSO42; DSO45; DSO75; DSO77; DSO87; DSO91; DSO97
In 2009: 246; 273; AR-BA2; AR-JO1; AR-JO3; E1-3; E2-2
In 2010: Cr01; Cr03; E05; E06; E25; E27; E29; E31; E34; E35 and E63
In 2013: T7-02

10 Validation Points:

hv001, hv002, hv003, hv017, hv018, hv058, hv059, hv060, hv061, hv062

General Location:

Develops where till is thick enough to support a continuous and diverse plant cover.

Distribution within the Study Area:

LSA : 17 %

Elevation:

651-854 m (average of 735 m)

Typical Slope Position:

Mostly mid-slope, sometimes in depression or on upper slope.

Topography:

Undulating

Structural Stage:

Low-shrub or herbaceous species were dominant at all sites visited.

Drainage:

Mostly well drained, moderately well drained in places

Soil Types:

Melanic or Eutric Brunisol, sometimes turbic Cryosol

Soil Humus Type:

Mor

Roothing Depth:

10 to 30 cm (average of 18.6 cm)

Surficial deposits:

Medium to thick till

Soil Moisture Regime:

Mostly 4 (Mesic) and in places 3 (Submesic)

Soil Nutrient Regime:

B (C) (poor to moderate)

Natural/Anthropogenic Disturbance:

No natural disturbance observed; drill lines at future mine site

Plant Species Diversity:

High (in comparison with other HST ecotypes)

Forest Productivity:

None

Organic Matter Cover Percentage:

15 to 100 % (average of 73 %)

Decaying Wood Cover Percentage:

N/A

Rock Outcrop Cover Percentage:

0 to 5 % (average of 0.5 %)

Coarse Fragment Cover Percentage:

0 to 85 % (average of 21 %)

Mineral Soil Cover Percentage:

N/A

Open Water Cover Percentage:

0 %

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE HST01				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Populus balsamifera	Balsam poplar	Tree	8	H
Amelanchier bartramiana	Mountain serviceberry	Shrub	8	A
Betula glandulosa	Glandular birch	Shrub	77	D
Rhododendron groenlandicum	Common Labrador tea	Shrub	38	B
Salix glauca	Grey-leaved willow	Shrub	8	A
Salix pedicellaris	Bog willow	Shrub	15	B
Vaccinium macrocarpon	large cranberry	Shrub	8	D
Vaccinium uliginosum	Alpine bilberry	Shrub	77	B
Arctous alpina	Alpine bearberry	Low Shrub	31	A
Empetrum nigrum	Black crowberry	Low Shrub	38	B
Kalmia procumbens	Alpine azalea	Low Shrub	8	B
Phyllodoce caerulea	Purple mountain heather	Low Shrub	15	B
Vaccinium caespitosum	Dwarf bilberry	Low Shrub	8	C
Vaccinium vitis-idaea	Mountain cranberry	Low Shrub	77	C
Agrostis scabra	Rough bentgrass	Herbaceous	8	A
Calamagrostis canadensis	Bluejoint reedgrass	Herbaceous	31	B
Carex bigelowii	Bigelow’s sedge	Herbaceous	69	C
Carex brunnescens	Brownish sedge	Herbaceous	15	C
Carex rariflora	Loose-flowered alpine sedge	Herbaceous	8	B
Carex vaginata	Sheathed sedge	Herbaceous	8	A
Carex sp.	Sedge	Herbaceous	8	A
Deschampsia cespitosa	Tufted hairgrass	Herbaceous	8	C
Avenella flexuosa	Wavy hairgrass	Herbaceous	23	C
Chamerion angustifolium	Fireweed	Herbaceous	8	A
Eriophorum angustifolium	Narrow-leaved cottongrass	Herbaceous	8	A
Eriophorum gracile	Slender cottongrass	Herbaceous	8	B
Eriophorum russeolum	Russet cottongrass	Herbaceous	8	H
Graminea sp.	Graminaceous	Herbaceous	15	B
Anthoxanthum monticola subsp. alpinum	Alpine sweetgrass	Herbaceous	8	B
Juncus effusus	Soft rush	Herbaceous	8	D
Juncus trifidus	Highland rush	Herbaceous	8	C
Juncus sp.	Rush	Herbaceous	8	B
Luzula confusa	Northern woodrush	Herbaceous	8	B
Lycopodium annotinum	Stiff clubmoss	Herbaceous	31	B
Huperzia selago	Northern firmoss	Herbaceous	15	A
Pedicularis groenlandica	Elephant’s-head lousewort	Herbaceous	8	A

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE HST01				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Petasites frigidus var. palmatus	Palmate coltsfoot	Herbaceous	8	B
Poa arctica	Arctic bluegrass	Herbaceous	8	A
Bistorta viviparia	Alpine bistort	Herbaceous	8	A
Pyrola sp.	Pyrola	Herbaceous	8	B
Pyrola minor	Lesser pyrola	Herbaceous	15	C
Solidago macrophylla	Large-leaved goldenrod	Herbaceous	38	B
Trichophorum cespitosum	Tufted clubrush	Herbaceous	8	D
Alectora sp	Alectora	Bryophyte	8	B
Bryocaulon divergens	Bryocaulon	Bryophyte	8	A
Cladonia crispata	(none)	Bryophyte	8	B
Cladina sp.	Reindeer lichen	Bryophyte	23	D
Cladonia sp.	(none)	Bryophyte	15	B
Cladina rangiferina	Grey reindeer lichen	Bryophyte	38	C
Cladina stellaris	Star-tipped reindeer lichen	Bryophyte	77	E
Pleurozium schreberi	Schreber's big red stem moss	Bryophyte	31	E
Polytrichum sp.	Haircap moss	Bryophyte	15	C
Ptilidium ciliare	(none)	Bryophyte	38	D
Sphagnum compactum	Compact peatmoss	Bryophyte	8	C
Sphagnum sp.	Peatmoss	Bryophyte	15	F
Stereocaulon sp.	Foam lichen	Bryophyte	15	C

Species with Status : No plant species with status was encountered in Ecotype HST01.

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

** : Plant cover

T = Trace (only few individuals)	A = less than 1%	B = 1 to 5%
C = 5 to 10%	D = 10 to 25%	E = 25 to 40%
F = 40 to 60%	G = 60 to 80%	H = 80 to 100%

Ecotype: **Rock Outcrop – Crowberry – Xeric**

Ecotype HST02 is dominated by rock outcrops and is mostly without vegetation. The low shrub layer is dominated by alpine billberry and black crowberry. The herbaceous layer is not very developed. The lichens growing directly on the rocks, such as those of the Rhizocarpon genus, cover most of the surface. The drainage is very rapid, the SMR is very dry (0) and the SNR poor (A). This ecotype is generally found on summits. The thin soils (Cryosols), which are sometimes non-existent, show very little evidence of development. Ecotype HST02 covers around 3% of the LSA.

General Description of Ecotype HST02

Soil Nutrient Regime (←Poor Rich→); Soil Moisture Regime (←Wet Dry→)

Soil Moisture Regime	A	B	C	D	E
0	HST02	HST02			
1					
2					
3					
4					
5					
6					
7					
8					

Aerial View:

Ground View - Stand:

Ground View - Vegetation:

Synthesis of Environmental Observations Ecotype HST02

Rock Outcrop – Crowberry – Xeric

24 Inventories Numbers:

In 2008: DSO319; DSO320; DSO369; DSO377; DSO38; DSO82
In 2009: 265, 349, 389, 396, AR-REA3
In 2010: E19, E20, E22, E23, E24, E30, E36, E37, E38, E39, E40, E69, E70

1 Validation Points:

hv063

General Location:

On rocky outcrops and rocky till deposits.

Distribution within the Study Area:

LSA : 3 %

Elevation:

668-761 m (average of 735 m)

Typical Slope Position:

Summits and crests

Topography:

Undulating

Structural Stage:

Initial, dominated by rock and lichen

Drainage:

Very rapid to rapid

Soil Types:

Folisol

Soil Humus Type:

Mor (if any)

Roothing Depth:

Maximum 10 cm

Surficial deposits:

Rocky outcrop

Soil Moisture Regime:

0 and 1 (Xeric and Subxeric)

Soil Nutrient Regime:

A (B) (Very poor to poor)

Natural/Anthropogenic Disturbance:

No natural disturbance observed

Plant Species Diversity:

Low

Forest Productivity:

None

Organic Matter Cover Percentage:

2 to 35 % (average of 20 %)

Decaying Wood Cover Percentage:

N/A

Rock Outcrop Cover Percentage:

0 to 10 % (average of 60 %)

Coarse Fragment Cover Percentage:

30 to 98 % (average of 71 %)

Mineral Soil Cover Percentage:

N/A

Open Water Cover Percentage:

0 %

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE HST02				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Betula glandulosa	Glandular birch	Shrub	50	B
Rhododendron groenlandicum	Common Labrador tea	Shrub	17	B
Rhododendron tomentosum	Northern Labrador tea	Shrub	17	A
Vaccinium uliginosum	Alpine bilberry	Shrub	100	B
Arctous alpina	Alpine bearberry	Low Shrub	17	B
Empetrum nigrum	Black crowberry	Low Shrub	100	C
Kalmia procumbens	Alpine azalea	Low Shrub	67	B
Salix uva-ursi	Bearberry willow	Low Shrub	17	B
Phyllodoce caerulea	Purple mountain heather	Low Shrub	33	B
Vaccinium vitis-idaea	Mountain cranberry	Low Shrub	100	B
Arctous rubra	Red bearberry	Herbaceous	17	B
Carex bigelowii	Bigelow's sedge	Herbaceous	67	A
Carex saxatilis	Russet sedge	Herbaceous	17	A
Juncus trifidus	Highland rush	Herbaceous	33	A
Lycopodium annotinum	Stiff clubmoss	Herbaceous	17	A
Alectora sp.	Alectora	Bryophyte	33	B
Cladonia crispata	(none)	Bryophyte	17	B
Cladina sp.	Reindeer lichen	Bryophyte	33	C
Cladonia sp.	(none)	Bryophyte	33	C
Cladina rangiferina	Grey reindeer lichen	Bryophyte	67	C
Cladina stellaris	Star-tipped reindeer lichen	Bryophyte	33	D
Flavocetraria nivalis	Crinkled snow lichen	Bryophyte	33	B
Ptilidium ciliare	(none)	Bryophyte	17	B
Racomitrium sp.	(none)	Bryophyte	17	D
Rhizocarpon sp.	Map lichen	Bryophyte	100	F

Species with Status : No plant species with status was encountered in Ecotype TSS02

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

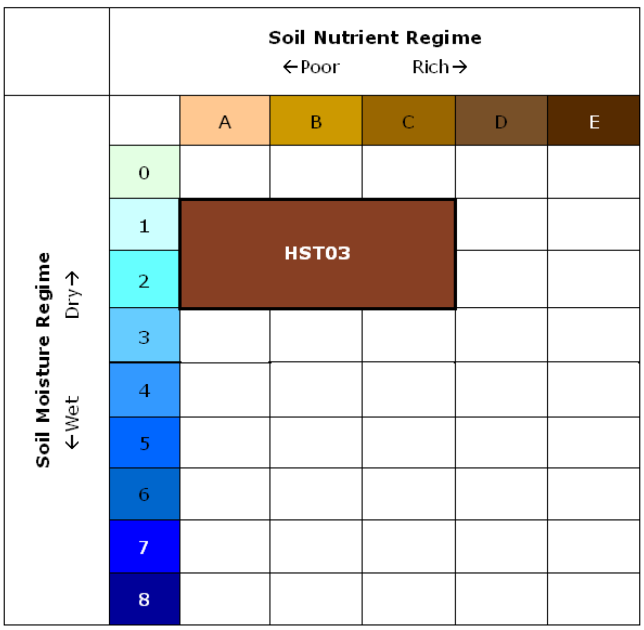
** : Plant cover

T = Trace (only few individuals)
A = less than 1%
B = 1 to 5%
C = 5 to 10%
D = 10 to 25%
E = 25 to 40%
F = 40 to 60%
G = 60 to 80%
H = 80 to 100%

Ecotype: **Low Alpine Shrub/Lichens – Subxeric**

Ecotype HST03 supports a community of plant species suited to drought conditions and a harsh climate. The shrub layer is dominated by glandular birch, crowberry and bog blueberry. The herbaceous layer is not very developed and the bryophyte layer is dominated by lichens. Ecotype HST03 is usually supported by thin, or very thin, tills. The soils are thin and frequently dominated by turbic (cryoturbated) Cryosol or cryoturbated Melanic Brunisols and Eutric Brunisols if the active soil layer is too thick, with Mor type humus. This is the most common and widespread ecotype in the HST portion of the LSA. In total, HST03 covers around 22% of the LSA.

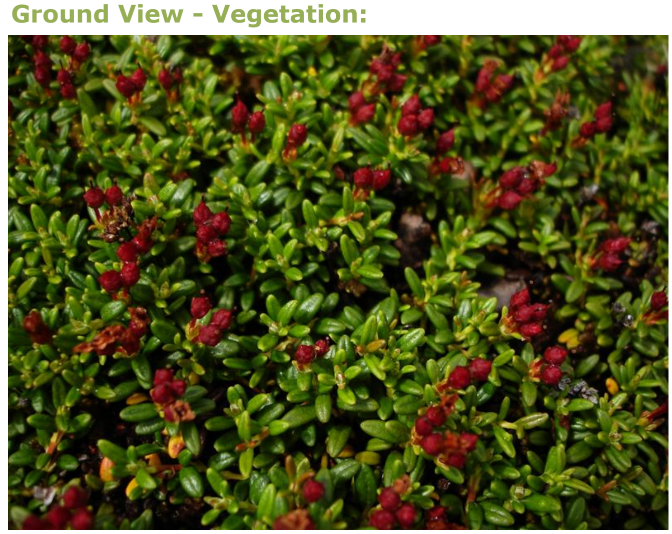
General Description of Ecotype HST03



Aerial View:

Ground View - Stand:

Ground View - Vegetation:



Synthesis of Environmental Observations Ecotype HST03

Low Alpine Shrub/Lichens – Subxeric

38 Inventories Numbers:	**4 Validation Points:**
In 2008: DSO01; DSO11; DSO124; DSO300; DSO36; DSO37; DSO376; DSO40; DSO49; DSO54; DSO61; DSO96; DSO99 **In 2009: 141; 237; 251; 271; 323; 360; AR-JO2; E1-1** **In 2010: E01, E03, E17, E18, E21, E26, E28, E32, E41, E45, E58, E66, E68, E71, E73, E74.** **In 2013: T7-01**	**hv004, hv057, hv064, hv065**
General Location:	**Distribution within the Study Area:**
In a mosaic with ecotypes of the MSF Ecoregion. Exposure to wind is very high, especially in winter.	**LSA : 22 %**
Elevation:	**Typical Slope Position:**
625-806 m (average of 713 m)	**Mostly on upper slope, sometimes at mid-slope or at summit**
Topography:	**Structural Stage:**
Rolling or gentle slope	**All sites visited were dominated by low-shrub vegetation.**
Drainage:	**Soil Types:**
Mostly rapid and well drained	**Melanic Brunisol, thin Eutric Brunisol or turbic Cryosol.**
Soil Humus Type:	**Roothing Depth:**
Mor	**6 to 25 cm (average of 18 cm)**
Surficial deposits:	**Soil Moisture Regime:**
Fine matrix tills with a low percentage of rock outcrop	**Mostly 3 and 2 (Submesic and Subxeric)**
Soil Nutrient Regime:	**Natural/Anthropogenic Disturbance:**
B (A) (poor, in places very poor)	**No disturbance was observed at any of the visited sites; drill lines at future mine site**
Plant Species Diversity:	**Forest Productivity:**
Low to intermediate	**None**
Organic Matter Cover Percentage:	**Decaying Wood Cover Percentage:**
20 to 83 % (average of 49 %)	**N/A**
Rock Outcrop Cover Percentage:	**Coarse Fragment Cover Percentage:**
0 to 30 % (average of 4.4 %)	**15 to 80 % (average of 37 %)**
Mineral Soil Cover Percentage:	**Open Water Cover Percentage:**
N/A	**0 to 10 % (average of 1.1 %)**

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE HST03				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Betula glandulosa	Glandular birch	Shrub	100	D
Rhododendron groenlandicum	Common Labrador tea	Shrub	8	C
Vaccinium angustifolium	Early lowbush blueberry	Shrub	8	A
Vaccinium uliginosum	Alpine bilberry	Shrub	100	C
Arctous alpina	Alpine bearberry	Low Shrub	54	B
Empetrum nigrum	Black crowberry	Low Shrub	100	C
Kalmia procumbens	Alpine azalea	Low Shrub	62	B
Phyllodoce caerulea	Purple mountain heather	Low Shrub	15	B
Vaccinium vitis-idaea	Mountain cranberry	Low Shrub	46	A
Arctous rubra	Red bearberry	Herbaceous	8	C
Carex bigelowii	Bigelow's Sedge	Herbaceous	46	A
Deschampsia cespitosa	Tufted hairgrass	Herbaceous	15	B
Diapensia lapponica	Lapland diapensia	Herbaceous	8	A
Harrimanella hypnoides	Moss heather	Herbaceous	8	A
Juncus trifidus	Highland rush	Herbaceous	15	A
Lycopodium annotinum	Stiff clubmoss	Herbaceous	38	B
Huperzia selago	Northern firmoss	Herbaceous	54	A
Pyrola minor	Lesser pyrola	Herbaceous	15	A
Cladina sp.	Reindeer lichen	Bryophyte	46	C
Cladonia sp.	(none)	Bryophyte	23	B
Cladina rangiferina	Grey reindeer lichen	Bryophyte	69	D
Cladina stellaris	Star-tipped reindeer lichen	Bryophyte	77	E
Flavocetraria nivalis	Crinkled snow lichen	Bryophyte	8	C
Polytrichum sp.	Haircap moss	Bryophyte	15	B
Ptilidium ciliare	(none)	Bryophyte	23	D
Racomitrium sp.	(none)	Bryophyte	31	C
Rhizocarpon geographicum	Map lichen	Bryophyte	8	D
Salix uva-ursi	bearberry willow	Bryophyte	15	B
Stereocaulon sp.	Foam lichen	Bryophyte	15	C

Species with Status : No plant species with status was encountered in Ecotype HST03.

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

** : Plant cover

T = Trace (only few individuals)	A = less than 1%	B = 1 to 5%
C = 5 to 10%	D = 10 to 25%	E = 25 to 40%
F = 40 to 60%	G = 60 to 80%	H = 80 to 100%

Ecotype: **Uniform Riparian Shrub Fen**

Ecotype HST05, the uniform riparian shrub fen, is found along watercourses, where the high humidity and strong concentrations of nutrients increase the productivity and diversity of plant species. Ecotype HST05 is characterized by a dense layer of shrubs mostly composed of glandular birch and satiny willow, as well as by a varied herbaceous layer mostly composed of bluejoint reedgrass and large-leaved goldenrod. Flooding is periodical and significant in the spring or after heavy precipitation. The drainage is moderate to imperfect. Sediment is deposited locally by floodwater, while the soils are enriched by underground irrigation from watercourses. The soils are mostly cumulic or gleyed regosols, where there is sedimentation. The SMR varies between submesic and subhydric, depending on periodical flooding, and the SNR is rich. In total, HST05 covers less than 1% of the LSA.

General Description of Ecotype HST05

Soil Nutrient Regime ←Poor Rich→

Soil Moisture Regime ←Wet Dry→

	A	B	C	D	E
0					
1					
2					
3					
4					
5				HST05	
6					
7					
8					

Aerial View:

Ground View - Stand:

Ground View - Vegetation:

Synthesis of Environmental Observations Ecotype HST05

Uniform Riparian Shrub Fen

20 Inventories Numbers:

In 2008: DSO103; DSO104; DSO122; DSO381
In 2009: 103; 245; 249; 362; 367; 368; AR-REA1; AR-REA2; E2-3
In 2010: E04, E14, E46, E54, E61, E64
In 2013: hg067

1 Validation Points:

hv066

General Location:

Restricted to parts of the LSA located above 625 m. Exclusively along watercourses.

Distribution within the Study Area:

LSA: less than 1 %

Elevation:

675- 757 (average of 680 m)

Typical Slope Position:

Toe of slope; depression.

Topography:

Gentle slope, bottom of valley

Structural Stage:

All sites visited were dominated by shrubs.

Drainage:

Moderately to imperfectly drained

Soil Types:

Humic Regosol, Cumulic Regosol or Gleyed Brunisol

Soil Humus Type:

Mormoder or absent

Roothing Depth:

15 to 35 cm (average of 22 cm)

Surficial deposits:

Fluvial

Soil Moisture Regime:

5 (6) (Subhygric (Hygric), but variable throughout the year depending on flooding)

Soil Nutrient Regime:

B to D (poor to rich)

Natural/Anthropogenic Disturbance:

Occasional flooding

Plant Species Diversity:

High

Forest Productivity:

None

Organic Matter Cover Percentage:

40 to 97 % (average of 71 %)

Decaying Wood Cover Percentage:

N/A

Rock Outcrop Cover Percentage:

0 %

Coarse Fragment Cover Percentage:

0 to 50 % (average of 15 %)

Mineral Soil Cover Percentage:

N/A

Open Water Cover Percentage:

0 to 30 % (average of 10 %)

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE HST05				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Betula glandulosa	Glandular birch	Shrub	75	D
Kalmia polifolia	Pale bog laurel	Shrub	25	B
Rhododendron groenlandicum	Common Labrador tea	Shrub	25	B
Myrica gale	Sweet gale	Shrub	25	C
Salix arctophila	Northern willow	Shrub	25	C
Salix pellita	Satiny willow	Shrub	50	D
Vaccinium macrocarpon	Large cranberry	Shrub	25	C
Vaccinium uliginosum	Alpine bilberry	Shrub	25	B
Empetrum nigrum	Black crowberry	Low Shrub	25	B
Phyllodoce caerulea	Purple mountain heather	Low Shrub	25	A
Sibbaldia tridentata	Three-toothed cinquefoil	Low Shrub	75	B
Vaccinium caespitosum	Dwarf bilberry	Low Shrub	25	B
Vaccinium vitis-idaea	Mountain cranberry	Low Shrub	25	B
Achillea millefolium	Common yarrow	Herbaceous	50	C
Elymus repens	Quackgrass	Herbaceous	25	A
Agrostis scabra	Rough bentgrass	Herbaceous	25	B
Alchemilla filicaulis	Thin-stemmed lady's mantle	Herbaceous	25	B
Calamagrostis canadensis	Bluejoint reedgrass	Herbaceous	25	B
Carex aquatilis	Water sedge	Herbaceous	25	C
Carex gynocrates	Ridged sedge	Herbaceous	25	A
Carex leptonervia	Leptonerved sedge	Herbaceous	25	D
Carex limosa	Mud sedge	Herbaceous	25	B
Carex rariflora	Loose-flowered alpine sedge	Herbaceous	25	A
Carex saxatilis	Russet sedge	Herbaceous	25	B
Carex vaginata	Sheathed sedge	Herbaceous	25	B
Danthonia spicata	Poverty oatgrass	Herbaceous	25	C
Deschampsia cespitosa	Tufted hairgrass	Herbaceous	75	B
Avenella flexuosa	Wavy hairgrass	Herbaceous	50	B
Elymus trachycaulus	Slender wildrye	Herbaceous	25	D
Equisetum sylvaticum	Woodland horsetail	Herbaceous	25	C
Geum rivale	Water avens	Herbaceous	25	B
Juncus trifidus	Highland rush	Herbaceous	25	D
Luzula parviflora	Small-flowered woodrush	Herbaceous	25	A
Diphasiastrum alpinum	Alpine clubmoss	Herbaceous	25	C
Packera indecora	Rayless mountain groundsel	Herbaceous	25	A
Pedicularis groenlandica	Elephant's-head lousewort	Herbaceous	100	B

SYNTHESIS OF PLANT DIVERSITY IN ECOTYPE HST05				
Latin name	**Common name**	**Plant form**	**Frequency (%)***	**Cover Class ****
Petasites frigidus var. palmatus	Palmate coltsfoot	Herbaceous	50	B
Phegopteris connectilis	Northern beech fern	Herbaceous	25	A
Phleum alpinum	Alpine timothy	Herbaceous	25	A
Comarum palustre	Marsh cinquefoil	Herbaceous	25	A
Pyrola minor	Lesser pyrola	Herbaceous	25	D
Packera paucflora	Alpine groundsel	Herbaceous	50	A
Solidago macrophylla	Large-leaved goldenrod	Herbaceous	100	C
Trichophorum cespitosum	Tufted clubrush	Herbaceous	50	B
Cladina rangiferina	Grey reindeer lichen	Bryophyte	25	C
Pleurozium schreberi	Schreber's big red stem moss	Bryophyte	50	C
Sphagnum sp.	Peatmoss	Bryophyte	75	E

Species with Status : No plant species with status was encountered in Ecotype HST05.

* : Frequency in %:(presence of plant in surveyed ecosystem/total number of samples for this ecosystem) X 100

** : Plant cover

T = Trace (only few individuals)	A = less than 1%	B = 1 to 5%
C = 5 to 10%	D = 10 to 25%	E = 25 to 40%
F = 40 to 60%	G = 60 to 80%	H = 80 to 100%

Appendix VI

List of plants surveyed during the 2013 campaign in the Howse LSA

Total Plant Richness for Howse Pit Study Area					
				Species Status	
Latin Name	**English Name**	**French Name**	**WA***	**Canada**	**Province**
TREE					
Larix laricina	Tamarack	Mélèze laricin	FMH		
Picea glauca	White spruce	Épinette blanche			
Picea mariana	Black spruce	Épinette noire	FMH		
SHRUB					
Arctous rubra	Red bearberry	Busserole rouge			
Betula glandulosa	Glandular birch	Bouleau glanduleux	FMH		
Empetrum nigrum	Black crowberry	Camarine noire			
Kalmia polifolia	Pale bog laurel	Kalmia à feuilles d'Andromède	OMH		
Myrica gale	Sweetgale	Myrique baumier	OMH		
Phyllodoce caerulea	Purple mountain heather	Phyllodoce bleue			
Rhododendron groenlandicum	Common Labrador tea	Thé du Labrador	OMH		
Ribes glandulosum	Skunk currant	Gadellier glanduleux	FMH		
Rubus chamaemorus	Cloudberry	Chicouté	FMH		
Rubus pubescens	Dewberry	Ronce pubescente	FMH		
Salix arctophila	Northern willow	Saule arctophile			
Salix bebbiana	Bebb's willow	Saule de Bebb	FMH		
Salix pellita	Satiny willow	Saule satiné	OMH		
Salix planifolia	Tea-leaved willow	Saule à feuilles planes			
Vaccinium angustifolium	Early lowbush blueberry	Bleuet à feuilles étroites			
Vaccinium corymbosum	Highbush blueberry	Bleuet en corymbe	FMH		
Vaccinium oxycoccos	Small cranberry	Canneberge commune	OMH		
Vaccinium uliginosum	Alpine bilberry	Airelle des marécages			
Vaccinium vitis-idaea	Mountain cranberry	Airelle rouge			
Viburnum edule	Squashberry	Viorne comestible	FMH		
HERB					
Achillea millefolium	Common yarrow	Achillée millefeuille			
Agrostis sp.	Bentgrass	Agrostide			
Bromus ciliatus	Fringed brome	Brome cilié	FMH		
Calamagrostis canadensis	Bluejoint reedgrass	Calamagrostide du Canada	FMH		
Carex aquatilis	Water sedge	Carex aquatique	OMH		
Carex bigelowii	Bigelow's sedge	Carex de Bigelow	FMH		
Carex grayii	Gray’s sedge	Carex de Gray	FMH		
Carex leptalea	Bristlystalked sedge	Carex à tiges grêles	OMH		
Carex limosa	Mud sedge	Carex des bourbiers	OMH		
Carex oligosperma	Few-feeded sedge	Carex oligosperme	OMH		
Carex rostrata	Swollen beaked sedge	Carex rostré	OMH		
Carex sp.	Sedge	Carex			
Carex trisperma	Three-seeded sedge	Carex trisperme	OMH		
Chamerion angustifolium	Fireweed	Épilobe à feuilles étroites			
Coptis trifolia	Goldthread	Savoyane			
Cornus canadensis	Bunchberry	Quatre-temps			
Danthonia spicata	Poverty oatgrass	Danthonie à épi			
Deschampsia cespitosa	Tufted hairgrass	Deschampsie cespiteuse	FMH		
Eleocharis sp.	Spikerush	Éléocharide			
Equisetum sylvaticum	Woodland horsetail	Prêle des bois	FMH		
Eriophorum russeolum	Russet cottongrass	Linaigrette rousse			
Eurybia radula	Low rough aster	Aster rude	OMH		
Geum rivale	Water avens	Benoîte des ruisseaux	OMH		
Heracleum maximum	Common cow parsnip	Berce laineuse			
Huperzia selago	Northern firmoss	Lycopode sélagine			
Lycopodium annotinum	Stiff clubmoss	Lycopode innovant			

*WA= Wetland Affinity (OMH=Obligatory, FMH=Facultative) (MDDEP, 2010)

Total Plant Richness for Howse Pit Study Area					
				Species Status	
Latin Name	English Name	French Name	WA*	Canada	Province
Petasites frigidus var. palmatus	Palmate coltsfoot	Pétasite palmé			
Rhinanthus minor	Little yellow rattle	Petit rhinanthe			
Solidago altissima	Tall goldenrod	Verge d'or très élevée			
Solidago macrophylla	Large-leaved goldenrod	Verge d'or à grandes feuilles			
Symphyotrichum puniceum	Purple-stemmed aster	Aster ponceau	FMH		
Trichophorum cespitosum	Tufted clubrush	Trichophore cespiteux			
Viola sp.	Violet	Violette			
BRYOPHYTE					
Cladina rangiferina	Grey reindeer lichen	Cladonie des rennes			
Cladina stellaris	Star-tipped reindeer lichen	Cladonie étoilée			
Pleurozium schreberi	Schreber's big red stem moss	Hypne de Schreber			
Polytrichum sp.	Hollyfern	Polytric			
Scorpidium scorpioides	Scorpion feather moss	Scorpidie scorpion			
Sphaerophorus sp.	Coral lichen	Shérophore			
Sphagnum compactum	Compact sphagnum	Sphaigne compacte			
Sphagnum sp.	Sphagnum	Sphaigne	FMH		

*WA= Wetland Affinity (OMH=Obligatory, FMH=Facultative) (MDDEP, 2010)

GroupeHemispheres

Pinette Lake Water Regime

HML
Howse Minerals Limited

Technical Report

Our file: PR185-22-15

Your order: HPP-LD-20150604-1

September 30, 2015

PROJECT TEAM

GROUPE HÉMISPHÈRES

Mariana Trindade	Geographer, PhD, Director, Review and Quality Control
Daniel Néron	Geographer, M.Sc., Project Manager, Fieldwork and Drafting
Simon Barrette	Biologist, M.Sc., Fieldwork
Samuel Denault	Biologist, M.Sc., Fieldwork
Elissa Dickoum	Geomatician, M.Sc. in Earth Science and Geography, Mapping
Christian Corbeil	Professional Technologist, Reviewer

Collaborators (Howse Minerals Limited)

Loïc Didillon	Manager – Environment and permitting
Lisa Clancey	Environment Technician
Jean-François Dion	Environment Technician

Cover page photographs
Left: Gauging ruler installed in Pinette Lake
Right: Hydrometric station at the Pinette Lake outflow

Recyclable and made of 100% recycled paper.
Paper made with wind energy and contributing to the responsible use of forest resources

This report has been formatted for double-sided printing.

REVISION AND PUBLICATION		
Number	**Date**	**Modification or Publication Data**
00	2015-09-30	Preliminary Technical Report
01	2015-10-22	Final Technical Report

V:\Contrat en cours\PR185-22-15_Impacts_Pinette Lake\Rapport\Hemis_PR185-22-15_Lake Pinette Water Regime_151022_VF.docx

Report prepared by:

Daniel Néron, M.Sc
Geographer, Project Manager

Report revised by:

Mariana Trindade, PhD
Geographer, Project Director

Christian Corbeil,
Professionnal Technologist

This document should be cited as:

Groupe Hémisphères (September 2015) *Pinette Lake Water Regime*. Technical Report submitted to Howse Minerals Limited., 13 pp. and 1 appendix

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

GLOSSARY

Bankfull stage

Stage at which a stream just overflows its natural banks.

Channel

The longitudinal boundary surface consisting of the bed and banks or sides within which water flows with a free surface.

Creek

Natural stream of water, normally smaller than, and often tributary to, a river.

Hydraulic radius

The ratio of the wetted area divided by the wetted perimeter.

Hydrometric station

A station in a water channel where water depth and discharge rate are measured.

Wetted area

Transversal area of a water course where flowing water is visible.

Wetted perimeter

Transversal perimeter of a water course where water flows above it.

Wetland

Area saturated with water or flooded over a sufficiently long period to influence the soil and vegetation components. More closely resembling an aquatic environment during floods and becoming almost terrestrial during droughts, wetlands are colonized by a specialized plant cover that is used as an indicator to delineate them.

1 INTRODUCTION

Howse Minerals Limited (HML) is currently studying the development of the Howse Project in Labrador, located about 25 km north-west of Schefferville, Quebec. In March 2015, Environment Canada raised concerns over the Pinette Lake water regime after the review of the first draft of the Howse EIS. Concern was based on the possible reduction of 25% of Pinette Lake's drainage basin. After optimization to reduce the effect toward this waterbody, the proposed reduction is now only 3%. The layout of the mining project is the one received in August 2015.

Additional information was therefore necessary to better portray the hydrology for Pinette Lake. The main inflow at Pinette Lake has been monitored for several years now for water quality (Groupe Hémisphères, 2014a). Since 2012, HML samples at least four times a year this tributary.

Groupe Hémisphères was mandated by HML to complete the hydrological program for the Howse Project, namely the water regime of Pinette Lake. The program was structured to identify the basic hydrological properties of this water body, enough to calculate a possible stage drawdown, in order to be able to apply for the necessary environmental certificate of authorization.

2 SITE DESCRIPTION

2.1 Physiography

The Howse Project sits on the Labrador geosyncline (or Labrador Trough), which is an arcuate belt of sedimentary, volcanic and intrusive rocks, over 1,200 km long and up to 100 km wide.

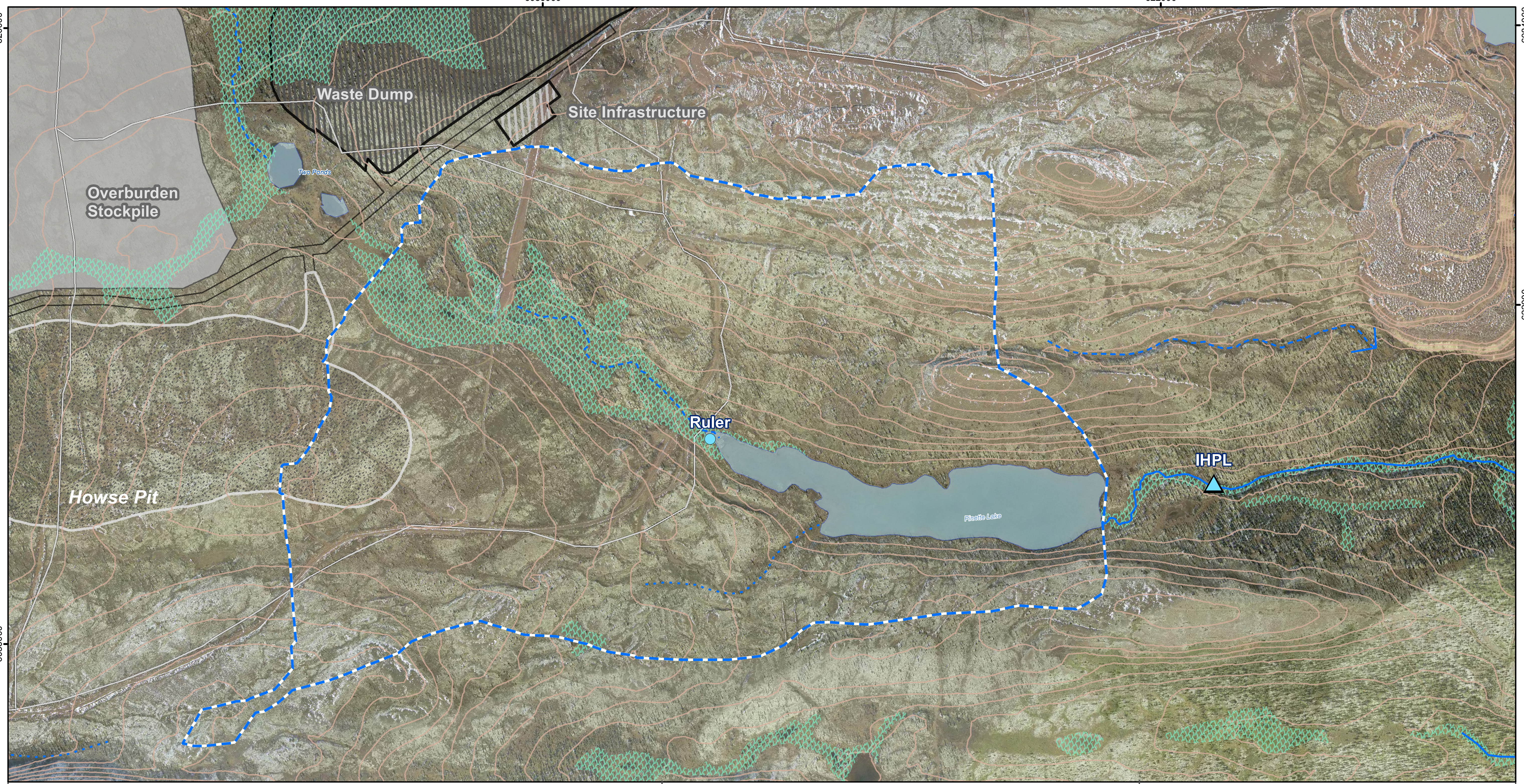
Two distinct ecoregions are present: areas below about 680 m asl are part of the Mid Subarctic Forest ecoregion dominated by forested ecosystems; and areas above 680 m asl are classified as High Subarctic Tundra ecoregions (Groupe Hémisphères, May 2010). Most of the Howse sector is located in the High Subarctic Tundra. Although punctuated by isolated bedrock outcrops, till has by far the greatest areal coverage of any landform within the area. Some streams, which tend to follow the roughly northwest-southeast oriented bedrock fractures and fold axis, exist within the Timmins sector (Groupe Hémisphères, May 2010).

2.2 Hydrography

Knowledge about the surface flow pattern in the area was updated through field observations and an interpretation of 2008 aerial photographs taken by New Millennium Limited (NML) at a scale of 1:10,000.

The Pinette Lake is a headwater lake of 15 ha fed by two tributaries. The main one is PIN1, a very small creek coming from the north and mostly intermittent over time. The second one has no name and is a torrent in the west and never observed flowing.

Pinette Lake does have an outlet, unofficially named Pinette Creek, which discharges into Elross Creek. At the outlet, his drainage basin covers 229 ha, waterbody included. Figure 1 presents the Pinette Lake Hydrology and Hydrography.



LEGEND

Survey
- Hydrometric Station
- Ruler

Infrastructure and Mining Components
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Site Infrastructure
- Proposed In-Pit Dump /Waste Dump

Basemap
- Permanent Watercourse
- Intermittent Watercourse
- Storm Runoff
- Disappearing Stream
- Artesian Spring
- Water Body
- Contour Line (16 ft)
- Provincial Border
- Existing Road
- Main Access Road
- Wetland
- Watershed Boundary

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0660 , PR185-22-14, 2015-10-22, edickoum

N

0 500
Meters

UTM 19N NAD 83

SCALE: 1:10 000

SOURCES:
Basemap
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and Government of Quebec, Boundary used for claims
Groupe Hémisphères, Hydrology, 2013.

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
TATA Steel Minerals Canada Limited/ MET-CHEM, Howse Deposit Design for General Layout, 2013

LAKE PINETTE WATER REGIME - TECHNICAL REPORT

Pinette Lake Hydrology

Howse Minerals Limited

GroupeHemispheres
5731, rue Saint-Louis, Bureau 201, Lévis (QC) Canada, G6V 4E2
1453, rue Beaubien est, Bureau 301, Montréal (QC) Canada, H2G 3C6

Figure 1

3 METHODOLOGY

3.1 Field Program Chronology

Field logistics were managed by Groupe Hémisphères in collaboration with Loïc Didillon (HML). The first fieldwork was conducted in April 19, 2015 by Daniel Néron in order to assess the feasibility of the project.

The second field campaign was conducted in May 16 by Simon Barrette, with the help of Lisa Clancey for some installations and gauging. A third visit, conducted in June 25 by Samuel Denault, with the help of Jean-François Dion, completed the installation while allowing another gauging of the hydrometric station. The same team returned in July 15 for gauging and a first download. A second download was achieved by Jean-François Dion in August 20. At last, Simon Barrette and Samuel Denault completed the measurements needed at the outlet and at the hydrometric station in September 1.

3.2 Water Regime

To be able to estimate the drawdown of Pinette Lake from any change in the water supply, a relation stage/discharge needs to be known. To do so, stage measurements in conjunction with outflow measurements has to be repeated in order to establish the rating curve. Last, the stage/volume relationship for the lake needs to be established.

3.3 Stage Measurements and Monitoring of the Waterbody

A standard enameled gauging ruler was installed in Pinette Lake and was equipped with a hydrostatic pressure probe, brand Heron Instruments® model DipperLog. This automatic water-level data logger was programmed to take stage measurements at 15-minutes intervals. For convenience, this ruler is based near the main inflow were an access road passes nearby. One of the photographs of the cover shows the ruler. As an arbitrary reference, the invert of the nearby culvert stands at 176 cm with respect to the ruler.

3.3.1 Pressure Monitoring

An automatic air pressure data logger already installed near the mine site, a Heron Instruments® model BaroLog, was used. The barometric pressure variations are used to compensate water level readings recorded by the water level monitoring probe.

3.3.2 Water Level Monitoring

To obtain the water head (H), the raw data obtained from the probe loggers were corrected for barometric pressure variations using the following equation:

$$H = \text{Water level recorded (m)} - \text{Barometric pressure (m)} \pm \text{Altitude correction (m)} \qquad (1)$$

An altitude correction was also applied to the barometric data for hydrometric stations that stand at a significantly different elevation.

3.4 Outflows Measurements

3.4.1 Hydrometric Station

The station IHPL was installed in a straight and uniform section of the stream with a D50 of 120 mm and a bankfull width and height of 1.90 m and 0.70 m respectively. This station was installed at the outlet of Pinette Lake, at a point where the velocity is appropriate for the apparatus (>0.01 m/s) and the flow is substantially laminar. The relationship between water depth and velocity was established by repeatedly measuring the speed of the water going through the stream section under various flow conditions using a velocimeter (see next section for details).

3.4.2 Instant Flow

All flows are calculated using the relationship between the average water velocity and the wetted area, according to the following formula:

$$Q = VA \qquad (2)$$

Where Q = flow (m^3/s)
V = average velocity (m/s)
A = wetted area (m^2)

The average water velocity was measured by dividing the wet area in several columns. At the center of each column, the average value was measured by slowly moving the velocimeter up and down for 20 seconds. A velocimeter brand Swoffer® model 2100 was used. The flow was obtained by multiplying the wetted area by the weighted average velocity of the water.

The flow was then measured several times in order to establish the rating curve, a relationship with the water depth. The rating curve takes the following exponential form:

$$Q = aH^b \qquad (3)$$

Where Q = flow rate (m^3/s)
H = water head over the probe (m)
a and ^{b} = proportionality constants

3.4.3 Average Flood Flow

At the hydrometric station, a geodesic field survey was carried out in order to obtain a detailed cross-sectional profile of the area along with the longitudinal slope (S) of the section. On the basis of the high water mark obtained from the field observation of physical criteria, the maximum wetted area (A) and perimeter (P) was determined for a channel at least 30 m long.

The average flood flow is estimated using formula (4) and Manning's equation to estimate the velocity:

$$V = 1/n\ R^{2/3}\ S^{1/2} \qquad (4)$$

Where V = velocity (m/s)
n = Manning's roughness coefficient
R = hydraulic radius (m)
S = stream gradient (m/m)

The hydraulic radius (R) is the ratio of the wetted area (A) divided by the wetted perimeter (P). Manning's roughness coefficient represents the resistances for water to flow in open flow stream channels. This value is selected by taking the local stream bed and flood plain composition into account.

3.4.4 Precipitation

Precipitation data was obtained from Environment Canada (Station no 7117823 - Schefferville A) to visualize flow fluctuations with precipitations.

3.5 Water Level Prediction

The last activity consists of fluctuating inflow and outflow lake levels iteratively. The routing model is used and takes into account the lake stage/volume and the stage/discharge relationship. Evaporation was not considered since the goal was not to reproduce a certain event but to discriminate a possible reduction of 4% of the drainage basin, and therefore will not change between scenarios. The natural flow and modified flow that enter the model come from the Water Management Plan developed by SNC-Lavalin (August 2015). Table 1 show the monthly variation of the estimated outlet flow between scenarios.

Table 1. Pinette Lake Estimated Outlet Natural (237 ha) and Modified Flow (228 ha)

MONTH	NATURAL FLOW (L/s)	MODIFIED FLOW (L/s)
Jan	0.0	0.0
Feb	0.1	0.1
Mar	0.3	0.3
Apr	4.4	4.2
May	340.1	327.9
Jun	0.0	0.0
Jul	5.5	5.3
Aug	12.3	11.9
Sep	18.4	17.7
Oct	25.1	24.2
Nov	2.4	2.3
Dec	0.1	0.1

Source: SNC-Lavalin (August 2015)

4 RESULTS AND DISCUSSIONS

4.1 Observed Water Level Variation

Figure 2 shows the water level fluctuations of Pinette Lake during the study period. Little water-level variation was observed during this period. The stage over this two month period is shown along with precipitation. Daily precipitation from the Schefferville A weather station can be found in Appendix I. Between maximum level (53 cm) and minimum level (43 cm), a difference of only 10 cm was recorded between June 25 and August 20, 2015. Even in the spring, when a gage ruler was installed on May 16, the water level was as low as 54 cm.

The water level of this water body showed a rapid increase to 53 cm on July 8 following two days of precipitation totaling 41.4 mm of rain. The same phenomena appears July 15 after 25.9 mm of rain. A gradual decline in the levels between those peaks were then observed.

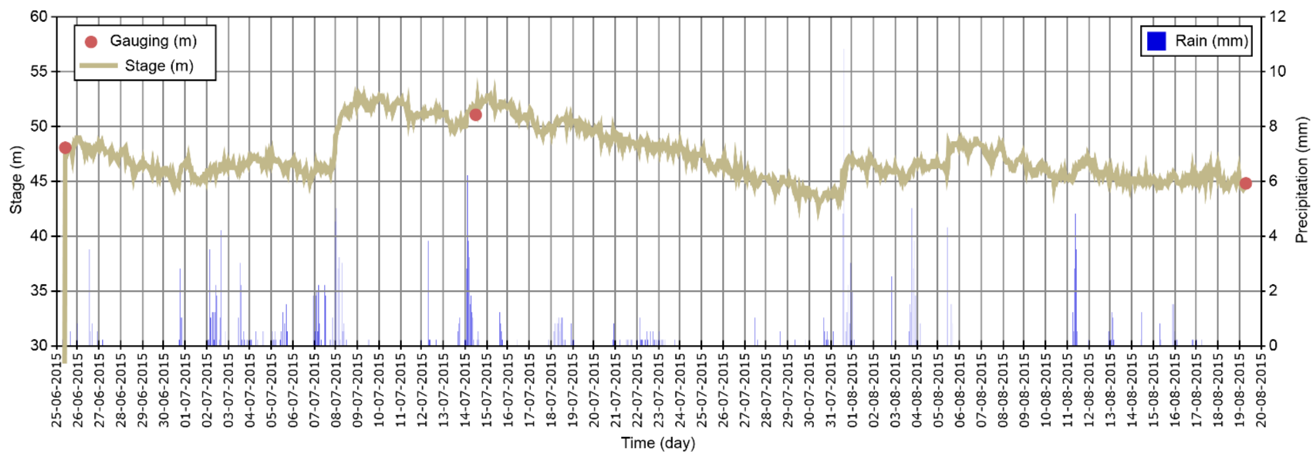


Figure 2. Water Level of Pinette Lake – June 25 to August 20, 2015

4.2 Surface Flow Measurements and Relation to Morphometry

4.2.1 Hydrometric Station IHPL

The IHPL hydrometric station was installed on May 16, 2015. Given its location and geology, the flow channel theoretically offers a good level of variation. For example, the April reconnaissance visit of this stream yielded a dry bed, and therefore a stream classification of intermittent.

Details of the cross-section surveying can be found in Figure 3. At the time of installation in May, water level were well under the high water mark (HWM). From the morphometry of the bed for the HWM condition, the wet area covers 0.730 m^3 while the wet perimeter is 4.90 m, with a slope of 1.5% (measured as the difference in elevation 15 m downstream and upstream). Considering that the bed is mainly composed of cobbles and boulders, a Manning's roughness coefficient of 0.055 is associated with that channel.

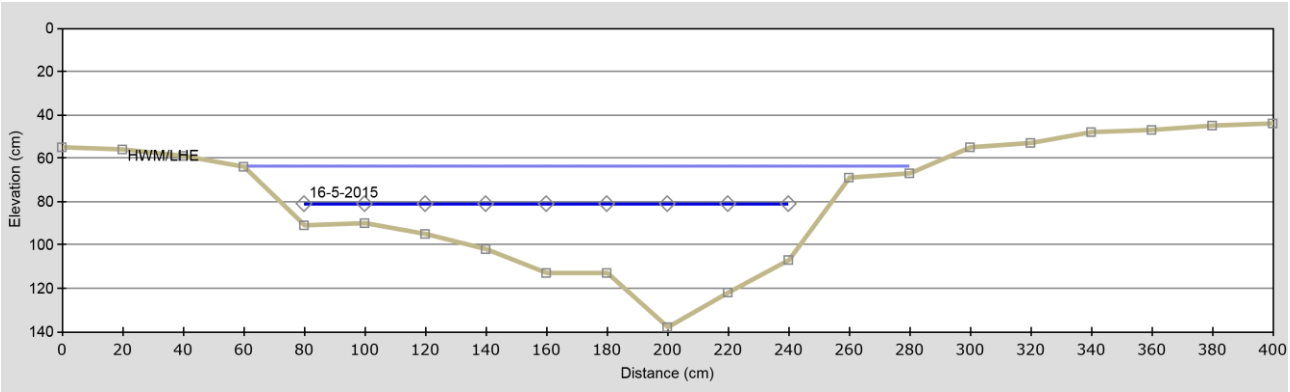
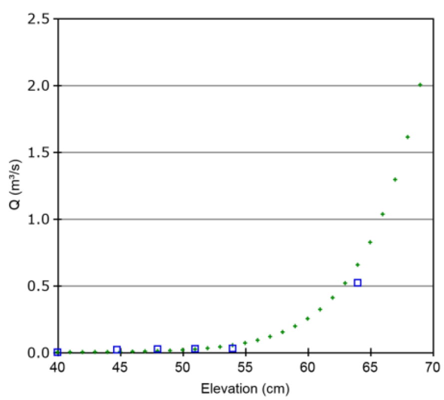


Figure 3. Cross-Section Drawing of Station IHPL

4.2.2 Stage-Discharge Relationship

The stage-discharge calibration curve was obtained from 3 gauging events in 2015 and 2 theoretical events which enable the interpolation of the outflow of Pinette Lake from any given water level. The visit in September at the outlet of the lake allows to estimate the zero discharge level at 32 cm and a normal flood level at 64 cm. At this location that largely control the lake level, the outlet is 36 m large and have a rectangular notch 0.5 m depth, 0.2 m wide.

Because of the peculiarity of spring 2015 (few precipitation and lot of sublimation), the freshet was weak and we were unable to observed and measure the flow at bankfull or normal flood. For this reason, this high flow was evaluated using the Manning's equation. Figure 4 show this relationship that have a strong goodness of fit.



Formula

$Q = 9.23782E\text{-}28 \ Stage^{14.8656}$

Goodness of fit

$R^2 = 0.9881$

Figure 4. Stage-discharge relationship of Pinette Lake

4.2.3 Stage-Volume relationship

The bathymetric maps from Groupe Hémisphères (2014b) give the area of each isobath. Using the Simpson equation, the cumulative volume can be evaluated. Figure 5 shows the stage-volume relationship for Pinette Lake. It takes the form of polynomial trend line and have a strong goodness of fit.

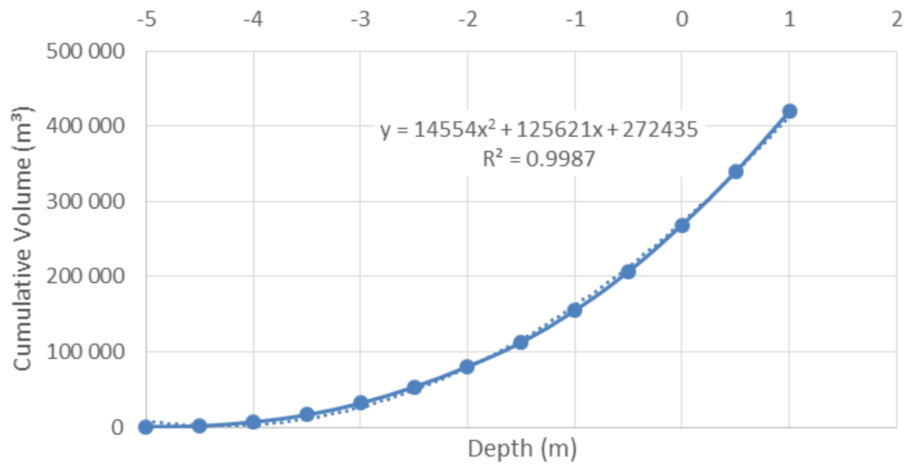


Figure 5. Stage-Volume relationship of Pinette Lake

4.3 Water Level Prediction

The use of the routing model for Pinette Lake give stage with daily variability. The starting level for the first day of January was set to 43 cm. Table 2 shows the mean water level prediction for Pinette Lake between natural and modified flow. It can be seen that the maximum expected difference between those scenarios is a 2 mm drawdown during the spring freshet.

Table 2. Mean Water Level Prediction for Pinette Lake between Natural and Modified Flow

MONTH	NATURAL STAGE (cm)	MODIFIED STAGE (cm)	EXPECTED DIFFERENCE (cm)
Jan	42.3	42.3	0.0
Feb	40.6	40.6	0.0
Mar	39.9	39.9	0.0
Apr	42.5	42.4	-0.1
May	61.3	61.1	-0.2
Jun	41.6	42.6	0.0
Jul	43.7	43.7	0.0
Aug	48.5	48.4	-0.1
Sep	50.2	50.1	-0.1
Oct	51.3	51.2	-0.1
Nov	46.1	46.0	-0.1
Dec	42.8	42.8	0.0

5 CONCLUSIONS

5.1 Observations and Calculations

In mid-May 2015, a ruler was installed on the littoral of Pinette Lake. Since that time, no more than 11 cm in level variations were noted during the three-month period of observation. A hydrostatic pressure probe installed in June subsequently possible to follow in detail the change in lake level. Although precipitation influenced the water level, it need to be substantial and for a duration of several days to do so.

The hydrometric station IHPL was setup in spring 2015 and provided the Stage-Discharge relationship. High flow was evaluated by using the Manning's formula rather than a field observation because spring climatic conditions did not lead to that occurrence. The morphometry of the outlet corroborates the exponential curve used. Nonetheless, a very strong goodness (R^2 = 0.9881) allow confidence on this relationship.

Relationship between the stage and the cumulative lake volume demonstrates a very strong goodness of fit using a polynomial curve (R^2 = 0.9987).

Together with a routing model, the expected difference between the mean natural flow and the expected modified one is a drawdown of 2 mm during May and no more than 1 mm for summer and autumn. That small difference for a lake is understandable with regard to a reduction in the size of the catchment area not exceeding 4 %.

5.2 Recommendations

The limnimetric ruler installed near a road is a simple tool that offers adequate monitoring. For reliability over time, we suggest that surveyor take ASL altitude of the zero of the ruler and also the invert of the nearby culvert.

6 REFERENCES

Database Consulted

Schefferville A weather station 2015 database. Environment Canada, Meteorological department.

Bibliography

DeWalle, D.R. and Rango, A. (2008) *Principles of Snow Hydrology*. Cambridge University Press, Cambridge, United Kingdom, 410 p.

Groupe Hémisphères (2015) *Environmental Impact Statement for the DSO – Howse Property Project*. Submitted to Howse Minerals Limited, Preliminary version of February, 2015, 569 pp. and 14 appendices

Groupe Hémisphères (2014a) *2013-2014 Hydrological Campaign for the Howse Property*. Technical Report submitted to Tata Steel Minerals Canada Ltd., 6 p. and 2 appendices

Groupe Hémisphères (2014b) *Aquatic Survey - Howse Pit Study Area*. Technical Report Submitted to TSMC, 35 pages and 7 appendices

Groupe Hémisphères (May 2010) *Mapping of Terrestrial Ecosystems and Surface Deposits: Direct Shipping Ore Project. Unofficial Translation*. Final technical report 2008-2009 produced on behalf of New Millennium Capital Corp., 144 p. and 10 appendices

Llamas, J. (1985) *Hydrologie générale : principes et applications*. Gaëtan Morin Éditeur, Chicoutimi, Québec, Canada, 469 p.

NML and PFWA [New Millennium Capital Corp. and Paul F. Wilkinson & Associates] (December 2009) *Elross Lake Area Iron Ore Mine. Environmental Impact Statement Submitted to Government of Newfoundland and Labrador*, Montréal, QC

Rollings, K.P. (1997) *The Hydrology of Labrador*. Government of Newfoundland and Labrador, Department of Environment and Labour, Water Resources Management Division, 105 p. and 19 appendices

SNC-Lavalin (August 2015) *Conceptual Engineering for Howse Water Management Plan*. Preliminary Report Number: 622834-4000-40ER-0005_01, 58 p. and 4 appendices

APPENDICES

Appendix I

Meteorological Data

Government of Canada Gouvernement du Canada

Canada

Climate

Daily Data Report for June 2015

SCHEFFERVILLE A QUEBEC					
Latitude:	54°48'19.000" N	Longitude:	66°48'19.000" W	Elevation:	520.90 m
Climate ID:	7117823	WMO ID:	71921	TC ID:	YKL

	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days	Cool Deg Days	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's deg	Spd of Max Gust km/h
DAY											
01 ‡	8.3	-1.6	3.4	14.6	0.0	M	M	1.8		24	50
02 ‡	18.0	7.0	12.5	5.5	0.0	M	M	0.0		26	39
03 ‡	19.4	8.5	14.0	4.0	0.0	M	M	0.0		26	67
04 ‡	12.9	0.7	6.8	11.2	0.0	M	M	0.3		28	54
05 ‡	11.1	-1.1	5.0	13.0	0.0	M	M	0.0		33	35
06 ‡	6.8	-0.3	3.3	14.7	0.0	M	M	1.5		32	44
07 ‡	8.9	0.4	4.7	13.3	0.0	M	M	9.8		18	35
08 ‡	19.5	6.3	12.9	5.1	0.0	M	M	0.0		23	32
09 ‡	14.8	5.5	10.2	7.8	0.0	M	M	0.3		11	35
10 ‡	12.7	7.0	9.9	8.1	0.0	M	M	5.8			<31
11 ‡	14.6	7.3	11.0	7.0	0.0	M	M	0.6			<31
12 ‡	9.3	4.9	7.1	10.9	0.0	M	M	7.8			<31
13 ‡	5.7	2.2	4.0	14.0	0.0	M	M	3.8		2	33
14 ‡	14.0	1.1	7.6	10.4	0.0	M	M	0.0		31	33
15 ‡	22.6	1.6	12.1	5.9	0.0	M	M	1.5		26	57
16 ‡	12.3	2.2	7.3	10.7	0.0	M	M	0.8		31	57
17 ‡	10.9	0.7	5.8	12.2	0.0	M	M	0.0		24	56
18 ‡	21.6	1.2	11.4	6.6	0.0	M	M	4.6		24	67
19 ‡	8.7	0.8	4.8	13.2	0.0	M	M	0.8		30	67
20 ‡	16.1	0.7	8.4	9.6	0.0	M	M	5.8		21	61
21 ‡	18.5	2.0	10.3	7.7	0.0	M	M	0.0		27	35
22 ‡	23.7	7.5	15.6	2.4	0.0	M	M	0.0		28	41
23 ‡	25.4	10.3	17.9	0.1	0.0	M	M	0.0		15	57
24 ‡	14.2	8.0	11.1	6.9	0.0	M	M	9.1		14	61
25 ‡	19.4	5.8	12.6	5.4	0.0	M	M	M		7	41
26 ‡	17.4	4.9	11.2	6.8	0.0	M	M	6.1		30	35
27 ‡	21.2	5.5	13.4	4.6	0.0	M	M	0.3		29	50
28 ‡	23.8	5.2	14.5	3.5	0.0	M	M	0.0		33	44
29 ‡	24.2	11.9	18.1	0.0	0.1	M	M	0.0		20	41
30 ‡	23.6	7.4	15.5	2.5	0.0	M	M	5.0		16	39
Sum				237.7	0.1	M	M	65.7^			
Avg	16.0	4.1	10.1								
Xtrm	25.4	-1.6								30	67S
Summary, average and extreme values are based on the data above.											

Legend

- A = Accumulated
- C = Precipitation occurred, amount uncertain
- E = Estimated
- F = Accumulated and estimated
- L = Precipitation may or may not have occurred
- M = Missing
- N = Temperature missing but known to be > 0

Climate

Daily Data Report for July 2015

SCHEFFERVILLE A QUEBEC					
Latitude:	54°48'19.000" N	**Longitude**:	66°48'19.000" W	**Elevation**:	520.90 m
Climate ID:	7117823	**WMO ID**:	71921	**TC ID**:	YKL

DAY	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days	Cool Deg Days	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's deg	Spd of Max Gust km/h
01 ‡	18.0	6.3	12.2	5.8	0.0	M	M	0.3			<31
02 ‡	14.4	10.4	12.4	5.6	0.0	M	M	18.8		9	37
03 ‡	17.8	10.0	13.9	4.1	0.0	M	M	8.1			<31
04 ‡	13.9	9.1	11.5	6.5	0.0	M	M	2.9			<31
05 ‡	15.9	10.2	13.1	4.9	0.0	M	M	6.1			<31
06 ‡	22.6	9.2	15.9	2.1	0.0	M	M	0.5		18	43
07 ‡	20.4	14.5	17.5	0.5	0.0	M	M	24.6		20	35
08 ‡	14.5	7.2	10.9	7.1	0.0	M	M	16.8		33	50
09 ‡	22.0	8.3	15.2	2.8	0.0	M	M	0.6		28	54
10 ‡	17.5	8.6	13.1	4.9	0.0	M	M	0.0			<31
11 ‡	18.6	7.8	13.2	4.8	0.0	M	M	0.3			<31
12 ‡	13.3	6.6	10.0	8.0	0.0	M	M	4.6		31	52
13 ‡	M	M	M	M	M	M	M	M		17	37
14 ‡	18.4	8.8	13.6	4.4	0.0	M	M	23.1		26	61
15 ‡	13.0	6.4	9.7	8.3	0.0	M	M	2.8		25	56
16 ‡	11.8	5.7	8.8	9.2	0.0	M	M	0.3		27	44
17 ‡	18.6	3.5	11.1	6.9	0.0	M	M	0.0		13	32
18 ‡	11.7	9.3	10.5	7.5	0.0	M	M	9.6		17	35
19 ‡	14.3	9.0	11.7	6.3	0.0	M	M	0.5		17	37
20 ‡	14.5	9.2	11.9	6.1	0.0	M	M	1.0		16	48
21 ‡	11.6	9.3	10.5	7.5	0.0	M	M	2.1		15	44
22 ‡	12.9	10.3	11.6	6.4	0.0	M	M	4.9		14	39
23 ‡	16.7	10.1	13.4	4.6	0.0	M	M	2.9			<31
24 ‡	17.4	9.2	13.3	4.7	0.0	M	M	0.0			<31
25 ‡	21.3	8.4	14.9	3.1	0.0	M	M	0.0		20	35
26 ‡	21.1	9.3	15.2	2.8	0.0	M	M	0.0		24	43
27 ‡	20.9	12.6	16.8	1.2	0.0	M	M	1.3		23	35
28 ‡	21.9	9.2	15.6	2.4	0.0	M	M	0.5			<31
29 ‡	24.2	8.6	16.4	1.6	0.0	M	M	0.3			<31
30 ‡	27.7	13.4	20.6	0.0	2.6	M	M	2.3		23	48
31 ‡	21.1	13.8	17.5	0.5	0.0	M	M	25.9		17	37
Sum				140.6^	2.6^	M	M	161.1^			
Avg	17.6^	9.1^	13.4^								
Xtrm	27.7^	3.5^								26	61

Summary, average and extreme values are based on the data above.

Legend

- A = Accumulated
- C = Precipitation occurred, amount uncertain
- E = Estimated
- F = Accumulated and estimated
- L = Precipitation may or may not have occurred
- M = Missing
- N = Temperature missing but known to be > 0

Government of Canada Gouvernement du Canada

Canada

Climate

Daily Data Report for August 2015

SCHEFFERVILLE A QUEBEC					
Latitude:	54°48'19.000" N	**Longitude:**	66°48'19.000" W	**Elevation:**	520.90 m
Climate ID:	7117823	**WMO ID:**	71921	**TC ID:**	YKL

	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days	Cool Deg Days	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's deg	Spd of Max Gust km/h
DAY											
01 ‡	19.8	9.3	14.6	3.4	0.0	M	M	2.5		25	39
02 ‡	20.3	9.0	14.7	3.3	0.0	M	M	0.0		33	32
03 ‡	20.7	11.5	16.1	1.9	0.0	M	M	17.3		11	44
04 ‡	21.6	12.7	17.2	0.8	0.0	M	M	3.0		14	35
05 ‡	20.5	9.5	15.0	3.0	0.0	M	M	9.6		18	37
06 ‡	14.1	9.0	11.6	6.4	0.0	M	M	0.0			<31
07 ‡	15.3	6.4	10.9	7.1	0.0	M	M	0.0		3	37
08 ‡	21.5	6.2	13.9	4.1	0.0	M	M	0.0		30	41
09 ‡	22.9	6.8	14.9	3.1	0.0	M	M	0.0			<31
10 ‡	24.2	10.1	17.2	0.8	0.0	M	M	0.0			<31
11 ‡	18.1	10.1	14.1	3.9	0.0	M	M	13.3			<31
12 ‡	12.3	8.1	10.2	7.8	0.0	M	M	0.3			<31
13 ‡	16.8	10.9	13.9	4.1	0.0	M	M	3.8		14	32
14 ‡	18.6	12.5	15.6	2.4	0.0	M	M	1.5		21	37
15 ‡	17.4	12.3	14.9	3.1	0.0	M	M	4.0		31	37
16 ‡	17.4	11.6	14.5	3.5	0.0	M	M	4.5		34	35
17 ‡	23.2	6.9	15.1	2.9	0.0	M	M	0.6		24	89
18 ‡	17.6	6.2	11.9	6.1	0.0	M	M	0.0		29	37
19 ‡	20.3	6.5	13.4	4.6	0.0	M	M	0.0			<31
20 ‡	24.0	11.5	17.8	0.2	0.0	M	M	12.6		21	46
21 ‡	22.8	12.9	17.9	0.1	0.0	M	M	0.0		25	61
22 ‡	19.1	11.1	15.1	2.9	0.0	M	M	3.5		25	43
23 ‡	22.1	11.9	17.0	1.0	0.0	M	M	0.0		29	37
24 ‡	25.1	12.8	19.0	0.0	1.0	M	M	0.0			<31
25 ‡	25.3	13.8	19.6	0.0	1.6	M	M	M		15	33
26 ‡	21.9	13.9	17.9	0.1	0.0	M	M	7.3		20	43
27 ‡	19.4	8.5	14.0	4.0	0.0	M	M	3.5		23	35
28 ‡	17.9	6.7	12.3	5.7	0.0	M	M	2.6		23	59
29 ‡	12.8	5.6	9.2	8.8	0.0	M	M	0.5		25	32
30 ‡	13.1	6.0	9.6	8.4	0.0	M	M	2.3			<31
31 ‡	11.3	2.1	6.7	11.3	0.0	M	M	0.0		6	39
Sum				114.8	2.6	M	M	92.7^			
Avg	19.3	9.4	14.4								
Xtrm	25.3	2.1								24	89
Summary, average and extreme values are based on the data above.											

Legend

- A = Accumulated
- C = Precipitation occurred, amount uncertain
- E = Estimated
- F = Accumulated and estimated
- L = Precipitation may or may not have occurred
- M = Missing
- N = Temperature missing but known to be > 0

- S = More than one occurrence
- T = Trace
- Y = Temperature missing but known to be < 0
- [empty] = No data available
- ^ = The value displayed is based on incomplete data
- † = Data for this day has undergone only preliminary quality checking
- ‡ = Partner data that is not subject to review by the National Climate Archives

Date modified: 2015-02-11