

**Terrestrial Ecosystem Mapping (TEM) with
Wildlife Habitat Interpretations for the
Akie and Pesika Landscape Units of the
Mackenzie Timber Supply Area:**

Volume 1 - TEM

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Executive Summary

During 1996 to 2000, KTPW-Geo Consortium (composed of Bio-Geo Dynamics Ltd., Taiga-Pacific GIS Ltd., Taiga-Pacific Ltd., R.A. Sims and Associates Ltd., and Ray Wehr) completed a project on Terrestrial Ecosystem Mapping (TEM) with wildlife habitat interpretations for Slokan Forest Products–Mackenzie Division.

Work focused on the production of TEM and derivative wildlife suitability mapping for some fifty-three 1:20,000 mapsheets in the Akie, Pesika and Lower Ingenika Landscape Units. This 2-volume Final Report [TEM (Volume 1) and Wildlife Habitat Interpretations (Volume 2)] deals, in particular, with the Akie and Pesika Landscape Units.

TEM Mapping

TEM mapping was conducted in two stages. First bioterrain typing was completed. The bioterrain information then served as a basis for interpreting and typing ecosystems.

The bioterrain map was constructed using a two-step approach. First, terrain / landform units were identified, delineated and labelled onto 1:15,000 scale black and white photos. Terrain stability mapping was undertaken concurrently in portions of the Akie River and Pesika Creek drainages, and this initial terrain / landform layer was also used as a complementary base for that mapping. For the purposes of TEM and associated wildlife habitat suitability interpretations, bioterrain enhancements were then photo-interpreted and added, including drainage class, slope steepness class, bedrock subclass, geomorphological subclass and avalanche process subclass.

TEM depicts ecosystem (site series) patterns within different Biogeoclimatic units. Within the study area, there are six different Biogeoclimatic units ranging from a lower-elevation boreal forest unit to higher-elevation non-forested alpine tundra. Each Biogeoclimatic unit encompassed a number of site series, including site series that were previously unclassified non-forested units. As part of the current work, these unclassified units were sufficiently described so that they could be added into the provincial listings of site series. Each site series was further described using ecosystem site modifiers. Site modifiers are site-specific factors that can be directly related to management interpretations of different site series. These include factors such as aspect, soil texture, depth and certain specific soil terrain features.

Bioterrain and TEM databases and maps were produced through a sequence of :

- Initial field reconnaissance;
- Initial photo-typing, photo-to-map transfer, and GIS database / map production;
- Field verification sampling; and,
- Final photo-typing, photo-to-map transfer, and GIS database / map production.

Methods followed and other specifications are detailed in Volume 1. The work conforms to provincial standards for TEM mapping (RIC, 1996, 1997) and standard conventions were followed throughout the process. Final TEM products were prepared for hard-copy presentation, but are also completed in digital form, within a GIS.

Each stage of TEM map production was accompanied by a combination of internal and external quality control audits. The latter were conducted under the auspices of MELP Provincial Correlation staff for TEM, and formal approvals and sign-offs at milestones were obtained throughout the project.

There were two additional ecological studies supplementary to the TEM component: 1) Wetland description and stratigraphy and 2) Mensuration studies of Pacific Willow. These two projects provided in-depth investigation of two poorly-understood components of the study area.

Wildlife Habitat Interpretations

The goal of the wildlife component was to produce habitat suitability interpretations for eleven featured wildlife species: American marten, fisher, lynx, grizzly bear, elk, caribou, moose, Stone sheep, mountain goat, wolverine, and northern Goshawk. In addition to habitat suitability mapping, this project provides a synthesis of known wildlife values for the study area, including the results of aerial surveys, wildlife habitat assessments and incidental observations.

Wildlife habitat suitability ratings define the relative importance of mapped ecological units to wildlife populations. Habitat suitability mapping provides a basis to evaluate the effects of development on wildlife habitat. It identifies areas that provide regionally and/or provincially significant habitat and places the loss or modification of habitat into a local and regional context. When combined with current known animal distributions, interpretations can also be made on potential avenues or opportunities for range expansion.

We developed species-habitat models that relate each species' life requisites to the attributes of the ecosystem units present in the study area. Each model is based on scientific literature, previous studies in the region, our own field data collection, additional field observations, and expert opinion. Ratings tables were generated using a linear model that contains the key attributes of ecosystem units. An automated approach using a relational database was used to assign ratings to each possible ecosystem unit in the study area. Polygon ratings were generated by "looking-up" the ecosystem unit in the ratings table. A GIS algorithm was then constructed to apply spatial adjustments to the polygon ratings for some of the species.

Based on the 1:20,000 TEM outputs, wildlife habitat suitability mapping was produced mainly in digital form, although some selected sets of 1:20,000 mapsheets were produced, for demonstration purposes, in hard copy form.

The information derived from GIS map products and associated databases of the bioterrain, TEM and wildlife habitat suitability maps can all be used to direct and inform higher-level resource management planning and operational activities.

To better understand spatial patterns of wildlife movement in the study area, a separate study on the characterisation of wildlife trails was completed as a supplementary component to the wildlife habitat interpretations.

Acknowledgements

KTPW-Geo would like to acknowledge the following individuals for their contributions and support throughout the project:

Staff of Slocan-Mackenzie provided ongoing direction and input: Scott McNay, Leslie Yaremko, and Al Balisky. The summer field crews stayed at Slocan's field camps, and Slocan provided additional help with logistics and operational support that were critical to the success of the project.

Bob Maxwell (Bioterrain Specialist, MELP, Victoria), who correlated the bioterrain mapping and the digital database, Ted Lea (Vegetation Ecologist, MELP, Victoria) and Craig DeLong (Regional Ecologist, Ministry of Forests (MoF), Prince George Forest Region) who jointly correlated the ecosystem units and mapping, and Andy Stewart (Wildlife Specialist, MELP, Victoria) who correlated the wildlife habitat interpretations component.

Key external quality control auditors included Corey Erwin (TEM mapping), Barb Von Sacken (TEM mapping), Tim Brierley (spatial database), Terry Gunning (non-spatial database) and Wayne Blashill (field sampling and Venus database).

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We are pleased to acknowledge the following KTPW-Geo staff for their contributions towards the completion of the photo-typing, GIS database and support, fieldwork, final maps, wildlife interpretations, the preparation of the Final Reports:

- Angus McLeod (Project Manager) coordinated and supervised the project.
- Ecosystem mapping for the study was overseen by Ken Simonar (Bio-Geo Dynamics Ltd.).
- Summer field work was completed by several 2 and 3-person crews. Each crew provided field expertise in vegetation ecology, soil science and wildlife ecology. Vegetation ecologists were, Ken Simonar, Howard DeLong, Dan Bernier, Sharlene Becker, Wayne Lambkin, Michael Hochachka, Dr. Saphida Migabo, Marian McLellan and John Grods. Soil and terrain specialists were Dr. Zongyou Lu, Marc St. Arnaud, Ray Wehr, Tiffany Fraser, Brendan Miller, Ken Simonar and Joe Fitzpatrick. Wildlife ecologists were Jeff Matheson, Tim Janes, Rachelle Robitaille, Allister Mackenzie, Madeline Austen and Dr. Saphida Migabo
- In the office, photo-interpretation activities were undertaken by the following personnel: Bioterrain phototyping and ecosystem annotation work was undertaken by Ken Simonar, Dr. Zongyou Lu, Marc St. Arnaud, Ray Wehr, Howard DeLong, Dan Bernier, Sharlene Becker, Wayne Lambkin, Michael Hochachka, Dr. Saphida Migabo, Marian McLellan, Tiffany Fraser and Brendan Miller.

- Shudao Ni (Taiga-Pacific GIS Ltd.) coordinated the GIS portion of the ecosystem mapping component. He was ably assisted by Zhilli Wang, Ping Bai, Jing Shao, Chris Curry, and Karren Warrendorf.
- Richard Sims (RA Sims and Associates Ltd., EBA Engineering Consultants Ltd.) supervised the wildlife habitat interpretations component of the work. Jeff Matheson prepared wildlife habitat interpretations for the project. Habitat models were developed by Jeff Matheson, with the assistance of Tim Janes, Libor Michalak and Rachelle Robitaille. Christine Curry prepared and applied the GIS-based wildlife habitat algorithms. The final wildlife report was edited by Jeff Matheson and Richard Sims.
- The assembly of the final report was completed by Ken Simonar, Dan Bernier and Dr. Saphida Migabo edited the ecosystem unit description factsheets and the expanded ecosystem legend. Richard Sims, Ken Simonar, Angus McLeod and Shudao Ni supervised and edited the report production.

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1.0 INTRODUCTION

This Final Report was prepared by KTPW-Geo for Slocan Forest Products Ltd.-Mackenzie Division, and describes *Terrestrial Ecosystem Mapping (TEM) with Wildlife Habitat Interpretations for the Akie and Pesika Landscape Units of the Mackenzie Timber Supply Block (TSA)*¹.

This Final Report is contained in two volumes: Volume 1: TEM; and, Volume 2: Wildlife.

1.1. Background

KTPW-GEO Consortium undertook this project. KTPW-Geo is a consortium of consulting companies, composed of Bio-Geo Dynamics Ltd., Taiga Pacific (formerly Kuwani Forestry Consulting Ltd.), Taiga Pacific GIS Ltd., R.A. Sims and Associates (formerly Geomatics International Inc.), EBA Engineering Ltd. and Ray Wehr. This strong multidisciplinary group joined the talents of experts in ecology, terrain, wildlife and GIS mapping for a common purpose.

Project tasks were assigned among the member companies in KTPW-Geo as follows:

1. *Field Sampling, Ecosystem Analysis and Photo-Interpretation of Bioterrain and Ecosystem Units* was primarily undertaken by Bio-Geo Dynamics Ltd.. Field sampling was assisted by RA Sims and Associates Ltd. (formerly Geomatics International Inc.), Ray Wehr, and Taiga-Pacific Ltd.
2. *GIS and TEM Map Production* was directed by Taiga-Pacific GIS Ltd. with assistance from RA Sims and Associates Ltd.
3. *Wildlife Habitat Interpretations* were undertaken by RA Sims and Associates Ltd., and later, by the same personnel employed by EBA Engineering Consultants Ltd.'s Vancouver, BC office.

The project was conducted during Winter, 1996 to Spring, 2000, and was financially supported by Forest Renewal British Columbia (FRBC).

Scientific and technical direction of the work was provided by key staff within the Ministries of Forests (MOF), and Environment, Lands and Parks (MELP). Technical details of the approach were initially outlined in detail, in the project's original Technical Work Plan (KTPW-Geo, 1996).

Within BC, TEM is a standardized methodology and tool for identifying and mapping ecosystem units (Banner et al., 1996; Britton et al., 1996). TEM is based, in large part, upon the Biogeoclimatic Ecosystem Classification (BGC) system (e.g., see Meidinger and Pojar, 1991; DeLong et al. 1990,

¹ The Buffalohead Landscape Unit was identified under the original 1996 contract (with Timberwest) as a candidate area for TEM mapping, but it was later removed from the study area. Occasional reference will be made to the Buffalohead LU in parts of the reporting, since ecological conditions are closely associated to those within the study area's other Landscape Units.

1994). To date, nearly 100 separate TEM projects have been undertaken throughout the province, using standardized protocols and methodologies, including integrated quality assurance and project correlation components.

Volume 1: TEM is composed of four main sections. First, there is an overview section providing context related to the project's objectives, scope and organization, and the study area's physiographic and biotic components (Section 1). Section 2 describes the methodology and approach followed to complete TEM and wildlife interpretation deliverables. Section 3 documents symbols and conventions used in the mapping. Section 4 is an illustrated expanded legend for all ecosystems visited, described and classified within the study area. Additional appendices and a complete TEM map folio, in digital form, also accompany this volume.

1.2. Objectives

The project's principal objective was to undertake TEM and associated wildlife habitat mapping according to Resource Inventory Committee (RIC) standards (Resource Inventory Committee 1995, 1996; Anon., 1996). It was understood that the inventory outputs of the work would be directly incorporated into Slokan's resource management and planning activities within the Mackenzie TSA.

Operational forestry requires the best possible inventory data, so that informed management planning can be undertaken. Within the study area, there are some particular concerns about preserving critical caribou, bear, moose, Stone sheep and other wildlife habitat conditions. Consequently, the current TEM project provides valuable baseline information for some fifty-three 1:20,000 mapsheets within the Mackenzie TSA.

Several sub-objectives were also outlined at the outset of the project, and were summarized in KTPW-Geo's original Technical Plan for the project (KTPW-Geo, 1996). These include:

- Confirm or adjust locations of Biogeoclimatic (BGC) zonal/sub zonal/variant boundaries within the study area;
- Refine existing site series units and their descriptions, and define / describe previously unclassified ecosystem units, particularly within the Spruce Willow Birch (SWB), Parkland, and AT zones;
- Delineate, describe and map out poorly-known wetland ecosystem units within the study area;
- Develop spatially-referenced baseline biophysical information so that it can assist higher level management analysis and decision-making (such as, longer-term wildlife management scenarios, or spatial estimation of potential site productivity within the study area; and,
- Provide data and information that are directly applicable for operational planning (such as, planning for season of harvest, locating sources of aggregate, and identifying areas of potentially unstable or erosion-prone terrain).

The goal of the wildlife component was to produce habitat suitability interpretations for eleven featured wildlife species: American marten, fisher, lynx, grizzly bear, elk, caribou, moose, Stone sheep, mountain goat, wolverine, and northern Goshawk. In addition to habitat suitability mapping, the project provides a synthesis of known wildlife values for the study area, including the results of aerial surveys, wildlife habitat assessments, and incidental observations.

Results of this project provide valuable spatially-based data and fundamental information for Slokan – Mackenzie Division’s operational planning within a portion of the Mackenzie TSA. The project has also produced outputs that will directly address biodiversity conservation issues within the study area, which is known to have especially high wildlife values.

1.3. Study Area

The Mackenzie TEM study area is located in north-central British Columbia, north of Williston Lake. Figure 1 shows the extent of the approximately 476,000 ha study area, as well as those TRIM mapsheets involved in the project.

The study area is located within the Mackenzie TSA and includes a contiguous block composed of approximately 47 1:20 000 TRIM mapsheets (including partial sheets) located within the following UTM coordinates: 438,670E, 6,273,310N(SE corner); 440,230E, 6,384,620N(NE corner); 328,110E, 6,276,370N(SW corner); 332,680E, 6,387,630N (NW corner).

The study area is further divided into five different Landscape Units (LUs) shown on the map representing the major drainages (Figure 1). They are: The Upper and Lower Akie River, Pesika Creek, Lower Ingenika, and Buffalohead LUs. The study area is highly variable in terms of topography, and ranges in elevation from approximately 720m to 2600m.

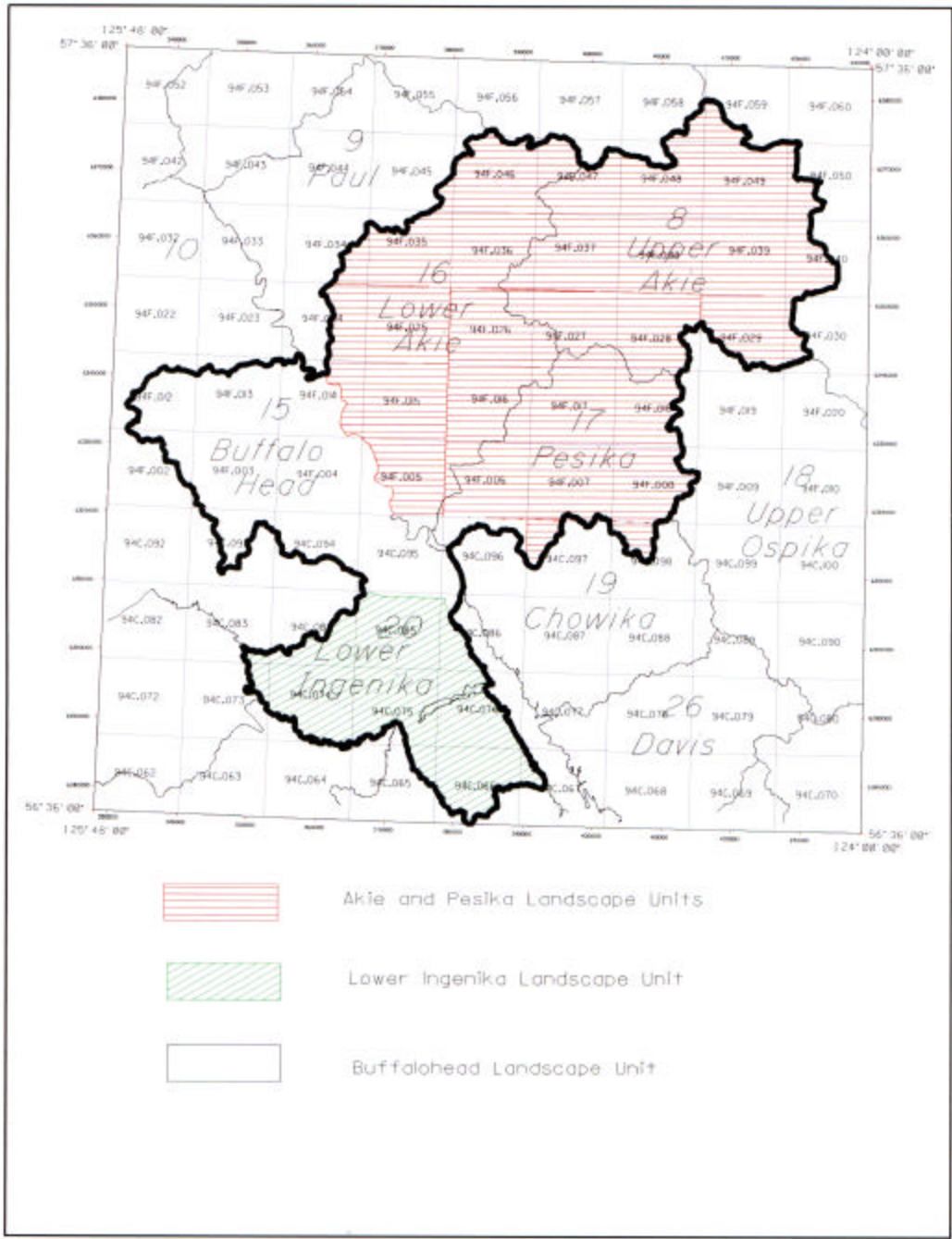


Figure 1. Mackenzie TEM Study Area.

1.4. Physiography and Soils

1.4.1. The Akie River and Pesika Creek Drainages

Almost all of the Akie and Pesika drainages on the eastern side of the study area occur within the Muskwa Range Section of the Rocky Mountain physiographic subdivision. Narrow valleys with valley bottom fluvial and glacio-fluvial deposits occur within both drainages. Elevations less than 900 meters within the lower halves of the main drainages feature significant glacio-lacustrine deposits. In the middle portion of the Akie River drainage, where the valley widens, there are substantial rolling, low relief morainal deposits (Figure 2).



Figure 2. Extensive low-relief rolling morainal deposits in mid-Akie River Valley at confluence of upper and lower forks. Young seral pine stands dominate the SWBmk1 foreground landscape. The Biogeoclimatic subzone variant boundary with the BWBSdk1 is approximately opposite the forested ridge in the upper left background.

Valley sides are dominated by a mixed coverage of both morainal and colluvial parent materials. Fluvial and colluvial fans formed primarily from debris flow deposits are a common feature emanating from steep valley side walls into the valley floors (Figure 3). Upper mountain slopes feature a mix of

weathered bedrock, bedrock and colluvium, and morainal veneers. The rivers and streams in this section of the study area flow through fairly narrow, confined valleys. These drainages form braided channels quite different from the broad meandering Finlay River into which they feed.



Figure 3. Colluvial fans formed from debris flow deposits in upper branch Akie Rivers within the SWBmk1. Note the fan shaped colluvial deposits jutting into pond and the dark green line of vegetation adjacent to ephemeral debris flow drainage.

During the last glaciation, the Fraser ice sheet did not penetrate into the Akie and Pesika River, therefore the surficial fine and coarse fragment materials are closely allied to the local bedrock types accumulated from local valley glaciers. Bedrock geology in the Muskwa Ranges section of the study area is comprised of a variety of sedimentary and slightly metamorphosed sedimentary rocks. Cambrian to Devonian age limestones, shales, phyllitic limestones, phyllites, schists and slates are very common in both Akie and Pesika drainages. Most of these materials are easily eroded into silts which are the source of the silty textured glacio-lacustrine and debris flow deposits which could be an operational constraint to road building activities at lower elevations within the valleys. Debris slides are a common occurrence along undercut glacio-lacustrine terraces (Figure 4). Igneous rock vein intrusions occur in faulted and folded metamorphosed to partly metamorphosed sedimentary rock formations in the Lower Akie River drainage. This has precipitated limited mineral exploration in the area.



Figure 4. Debris slide in undercut glacio-lacustrine deposits in Lower Akie. Note gray colored more erosion resistant basal till deposits underneath. Imperfectly drained BWBSdk1 Black Spruce Lingonberry-Coltsfoot site series occupies the glacio-lacustrine terrace above.

Because of the weak, easily weathered, nature of these rocks, the mountains are often quite rounded in profile. Very steep cliffs and scarps do occur, however, where bedrock bedding dips steeply (Figure 5).

Soils developed at medium to low elevations on medium-textured morainal and glacio-lacustrine materials are Brunisolic Grey Luvisols. Humo-Ferric Podzols and Brunisols have formed on variable materials at higher elevations and at lower to mid elevations on coarse-textured fluvial and glacio-fluvial materials. Because of the predominance of phyllitic limestones in this area of the Rocky Mountains, the soils typically exhibit a significant lime content. The high lime content, even in glacio-fluvial deposits, has formed distinctive eroded vertical cliff features adjacent to major creeks (Figure 6). Some remarkable lime/iron seepage deposits can be found emanating from the valley side-walls near the middle of the Akie River drainage.



Figure 5. Steep cliff formed at scarp face of steeply bedded toppling phyllitic limestone bedrock in mid-Akie River drainage.

The Dell Creek watershed to the North of the Lower Akie River watershed is very similar to that of the Akie and Pesika Rivers in that it shares the same geological frame. It is also similar to the Finlay River valley, in terms of the patterning of valley bottom wetlands, and the occurrence of distinctive marl-bottomed ponds and lakes

1.4.2. The Finlay River Drainage

Lower elevations of all drainages in the study area empty into the Finlay River or Williston Lake; this central portion of the study area is within the Rocky Mountain Trench Subdivision of the Interior Plateau Physiographic Unit (Holland, 1976). Lower elevations are dominated by extensive areas of rolling to level, glacio-fluvial and fluvial terrain. On the periphery of the broad fluvial valley of the Finlay River are extensive, low relief, strikingly patterned, basal till drumlin fields (Figure 7). A few scattered remnants of what were extensive glacio-lacustrine deposits occur along valley side walls. Extensive sandy loam textured eolian deposits are located south of Ed Bird Lake.

Bedrock geology of the Rocky Mountain Trench rock formations is primarily sedimentary but is covered, for the most part, by deep glacial and post glacial deposits. A low ridge of exposed

conglomerate is evident in the area of Ed Bird Lake. This portion of the study area was overridden, during the past glaciation, by the large Fraser Ice Sheet.



Figure 6. Strongly cemented, eroded glacio-fluvial deposits in mid-Akie River drainage.

The coarse fragment lithology consists of a mix of variable bedrock types that occurred to the south and east of the study area. There are high accumulations of lime in the parent materials brought in from side drainages, including the Akie and Pesika drainages. The high lime content manifests itself in marl lakes and ponds that are particularly distinctive in the pitted terrain found in the vicinity of Ed Bird Lake (Figure 8). The flat-bottomed, broad valley of the Finlay River supports many wetlands; in terms of total area, rich fens are the most abundant wetland. The low gradient and broad valley of the trench has influenced the widespread formation of extensive river meanders, and the development of oxbow ponds, shallow marshes, and swamps.

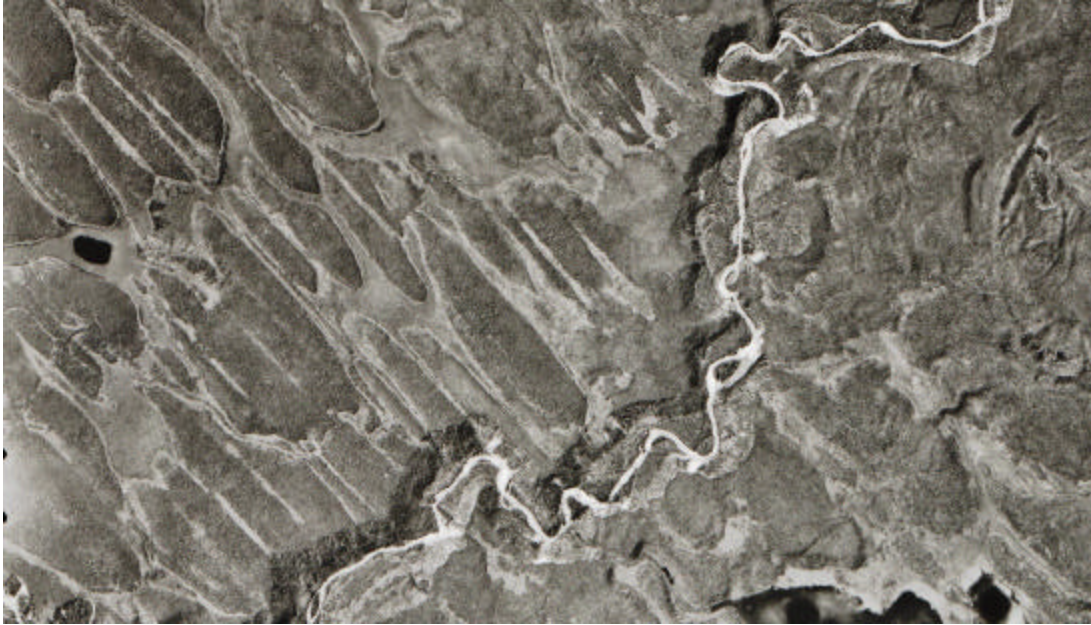


Figure 7. Aerial view of morainal drumlin fields adjoining glacio-fluvial and fluvial terraces near Finbow Camp near the Finlay River. Pole size pine, aspen and white spruce dominate the, low, flat topped drumlins primarily comprised of the well drained zonal Sw-Knight's plume-Step moss and Sw- Soopolallie - Twinflower site series within the BWBSdk1. Drumlins are separated broad expanses of Sedge-Asphodel saturated basin fen wetland site series.



Figure 8. Small marl lake in the area of Ed Bird Lake in the Rocky Mountain Trench.

Brunisols are the dominant soil subgroup associated with the relatively coarse textured fluvial and glacio-fluvial deposits, while Brunisolic Gray Luvisols have developed on medium-textured morainal materials.

1.4.3. The Ingenika River Drainage and the Omineca Mountains

The Ingenika River occurs within the Swanell and Finlay Range Physiographic Sections of the Omineca Mountains Subdivision of the Interior Plateau Physiographic Unit (Holland, 1976). Elevations of the mountains within this section of the study area are somewhat lower relative to those of the Upper Akie River and Pesika Creek drainages. The height of land to the south of Pelly Lake within the Finlay Range is the dividing point between the Lower Ingenika LU and the Buffalohead LU to the north of it. The Omineca Mountains and the Rocky Mountain Trench were strongly influenced by the Fraser Ice Sheet. Extensive areas of glacio-fluvial and fluvial material occur within the valley bottom of the Finlay River (Figure 9).



Figure 9. Extensive glacio-fluvial and fluvial terraces adjacent to Williston Lake. View from North of the Ingenika arm. Forests are a mosaic of different ages as a result of recent logging and fires.

The pattern and components of the surficial geology in the Finlay Ranges are somewhat similar to the Akie and Pesika drainages. Glacio-lacustrine deposits which occur as eroded terrace remnants above the Ingenika River are not as prominent as in the Akie and Pesika drainages. Weathering processes, and attendant features such as debris flows, are not as active as in the Muskwa Ranges to the east.

Morainal deposits are deeper and more widespread in the Finlay Ranges. Eolian deposits are a prominent feature on the valley sides above the Ingenika River (Figure 10). The remnants of an extremely large pre-glacial landslide on the north slope above the Lower Ingenika River is an outstanding feature in this portion of the study area. The Buffalohead area of the Omineca Mountains also features iron seepages similar to the Akie River drainage (Figure 11)



Figure 10. Eolian (fine sand) capping over a glacio-fluvial terrace on the north side of Ingenika Arm. Note active wind erosion in background. The BWBSdk1 Kinnikinick - Sage grassland ecosystem is typical of steep south facing scarp slopes in this area. These sites are important winter grazing areas for elk.

Bedrock geology of the Omineca Mountains Section of the study area is comprised of metamorphosed igneous rocks, dominantly shists and gneiss, and metamorphosed sedimentary rocks comprised dominantly of shists, quartzite, and metamorphosed limestone. These mountains tend to be more blocky than the more easily-eroded Rocky Mountains to the east, across the Trench.

Brunisols are the dominant soils on these parent materials on fluvial, glacio-fluvial and eolian deposits. Brunisolic Grey Luvisols and Brunisols both occur on lower to mid-elevation upland morainal sites. Humo-Ferric Podisols and Brunisols occur on materials at higher elevations.



Figure 11. Iron seep at toe of slope. This seep was located in the Buffalohead LU portion of the Omineca Mountains. The ecosystem below the seep is the Spruce- Scrub Birch-Bluejoint site series, with shrub carr in the cold air basin below that.

1.5. Ecoregions

The Ecoregion classification system is a hierarchical classification of physiographic units. These units are based on a five-level, nested, classification of landscapes which are relatively homogeneous or consistent for significant wildlife habitat features at each. (Demarchi, 1996). It has some commonality and overlap with the Biogeoclimatic Ecosystem classification (Meidinger and Pojar, 1991), but it is a broader, more physiographically-based classification. More than one BGC climatic unit is typically included within each of the lowest Ecoregion mapping units that exist within the study area.

The study area is located within the Northern Boreal Mountains Ecoprovince. Two Ecoregions comprise the study area; the Northern Boreal Ecoregion and the Northern Rocky Mountains Ecoregion. Within the study area, subdivisions (i.e., Ecosections) of Ecoregions exist. The Cassiar Mountain Ranges Ecosection (CAR) within the Northern Boreal Mountain Ecoregion comprises the Lower Ingenika and Buffalo Head LUs east of the Finlay River.

Most of the remainder of the study area, including much of the Upper and Lower Akie River, and Pesika Creek LUs, are located within the Western Muskwa Ranges (WMR) Ecosection of the Northern Rocky Mountains Ecoregion. The Eastern Muskwa Ecosection (EMR) of the Northern Rocky Mountain Ecoregion occurs in the headwaters of the Akie and Pesika drainages.

1.6. Biogeoclimatic Units

For TEM, ecosystem classification is conducted according to a three-level hierarchy of units. The two upper levels of classification – the “Ecoregion/Ecosection Classification” and “Biogeoclimatic Ecosystem Classification” (BGC) – together provide the broader ecological context for TEM. More locally-occurring ecosystem units are then delineated, described and mapped at finer levels.

The BGC system is a hierarchical ecosystem classification system in which units are delineated based upon an integrated treatment of climate, vegetation and site (topography). Broad Biogeoclimatic (BGC) units or zones are based on regional similarities determined under the classification system. British Columbia is divided into 14 BGC zones and four of these BGC zones are found within the Mackenzie TEM study, namely the Alpine Tundra (AT), Englemann Spruce (ESSF), Spruce Willow Birch (SWB), and Boreal White and Black Spruce (BWBS) zones (Meidinger, 1991).

Within each BGC climatic unit, distinct ecosystems called site series are defined based on soil/landscape characteristics.

1.6.1. Climatic Units

Local climates within BGC zones are somewhat variable along south to north gradients, from wetter coastal to drier interior situations and are also influenced by local terrain features. On this basis, they are further subdivided into subzones and variants. There are a total of six subzones within the study area, since both ESSF and SWB are represented by two subzones: AT, ESSFmvp4, SWBmks, ESSFmv4, SWBmk1 and BWBSdk1 (Table 1).

The Boreal White and Black Spruce (BWBS) zone occurs as an extension of the Great Plains (Alberta Plateau) continental climate into the northeastern corner of BC. The zone occupies the lower elevations of the main valleys west of the northern Rocky Mountains. The climate of this zone is characterised by short growing seasons, long, very cold winters with frequent outbursts of arctic air masses. Annual precipitation averages between 330 and 570 mm with 35-55% of this falling as snow. The ground freezes deeply for a large part of the year and discontinuous permafrost is common in the northeastern parts of the zone. White spruce, trembling aspen, lodgepole pine, black spruce, balsam poplar, tamarack, subalpine fir and paper birch are major tree species found in the BWBS. Forest fires are frequent, maintaining most of the forests in various structural stages (Meidinger and Pojar, 1991). True climax forests are largely unknown in the BWBS, as few stands have escaped fire for several hundred years (DeLong et al., 1991).

The BWBSdk1 occupies the lower elevations of all of the major river valleys within the study area, mostly below 1100m elevation. The BWBS disappears at a somewhat lower elevation within most upper drainages, since they are typically under the influence of cold air ponding.

Table 1. Biogeoclimatic zones, subzones and variants in the study area.

BGC Zone	Subzone/ Variant	Elevation (m)	Description
BWBS	dk1 – Stikine dry cool	600 to 1250 *	Climax zonal forests are comprised of White Spruce with a dominantly feathermoss understory. Seral stands containing pine and aspen are very common.
ESSF	mv4 – Graham moist very cold	1000 to 1600 *	Zonal climax vegetation is a mixed overstory of Engelmann spruce and Sub-alpine fir, frequently dominated by <i>Rhododendron</i> in the understory.
SWB	mk1 – moist cool	800 to 1600 *	Zonal climax forests consists of mixed White Spruce and Sub-alpine fir forests, with scrub birch and shrub willow present in the understory.
SWB	mks	1500 to 1900*	The parkland is transitional between high elevation forest zones and the non-forested alpine tundra zone. Characterized by lush forb-alpine grass communities, in association with shrub willow and krummholz vegetation (mostly Sub-alpine fir).
ESSF	mvp4,	1500 to 1900*	The parkland is transitional between high elevation forest zones and the non-forested alpine tundra zone. Characterized by lush forb-alpine grass communities, in association with shrub willow and krummholz vegetation (mostly Sub-alpine fir).
AT	(not applicable)	Above 1800*	AT is an upper-elevation treeless area characterized by a harsh climate and a very short growing season. Zonal vegetation is dominated by lush mixed forbs and alpine grasses at lower elevations, while at higher elevations, conditions for growth are more limiting and support a less vigorous mix of sedges, dwarf shrubs, forbs and alpine grasses.

* These are elevational ranges as determined for the Mackenzie TEM study area (i.e., as opposed to overall ranges for Subzones/Variants).

Generally, Alpine Tundra (AT) occurs above 1800 m. The climate in this zone is cold, windy, snowy and characterised by low growing season temperatures and a very short frost-free period. Most precipitation falls as snow. By definition, the AT is treeless. Alpine vegetation is dominated by shrubs, herbs, bryophytes, and lichens. Many areas in the AT are dominated by rock, snow and ice. Common shrubs in the study area are scrub birch and various willows (Pojar and Stewart 1991b). Figure 12 exemplifies a typical AT landscape.



Figure 12. Typical AT landscape on the northern edge of the Study area.

The Spruce – Willow – Birch (SWB) Zone is the most northerly subalpine zone in BC (Pojar and Stewart, 1991a). The climate is characterised by long, cold winters and brief, cool summers. Winter cold spells can be broken by Chinook winds. Mean annual precipitation is 460 to 700 mm, with 35-60% occurring as snowfall (Meidinger and Pojar, 1991). Generally open, low vigour, forests are dominated by white spruce, subalpine and lodgepole pine. Aspen and Black spruce occur occasionally at lower elevations. Figure 13 illustrates a typical SWBmk1 landscape.



Figure 13. Typical SWBmk1 forest near an upper branch of the Akie River.

The Engelmann Spruce – Subalpine Fir (ESSF) Zone is the uppermost forested zone in three-quarters of the interior of BC. In the Rocky Mountains, it occurs below the Alpine Tundra zone. Growing seasons are cool and short and winters are long and cold. Most precipitation falls as snow and snow depths are deep. The Graham Moist Very Cold ESSF (ESSFmv4) occurs primarily in the Muskwa Range of the Rocky Mountains. Climax forests are dominated by Engelmann spruce and subalpine fir. However, fire occurs more frequently in this variant and a large proportion of stands are dominated by lodgepole pine. Mixtures of lodgepole pine and black spruce also occur on poor sites at lower elevations (DeLong et al., 1994). Figure 14 illustrates a typical ESSFmv4 landscape.

The study area encompasses a transition zone from the ESSF to the colder more northern continental climate of the SWB. The southernmost extension of the SWB Biogeoclimatic zone appears in a widened level to undulating morainal/glacio-fluvial plain in the mid Akie LU. Cold air ponding is prevalent here. Traveling upstream and to the north, the SWBmk1 soon begins to replace the ESSFmv4 on north aspects as well as in valley bottoms until finally the ESSF disappears along the upper reaches of the Akie and its tributaries. On the other side of the study area, the SWB begins to appear within side valleys of the Finlay River, in the Buffalohead LU. Because of the transitional nature of the area, recognition of SWB/ESSF boundary can be problematic. For example, many ESSFmv4 sites within the study area support very sparse and sporadic *Rhododendron* cover, perhaps as a result of the soil's high lime content.



Figure 14. Typical ESSFmvp4 landscape in the upper Pesika Creek watershed.

This area of the ESSFmvp4 and the SWBmk1 appear to have significantly more precipitation – particularly high winter snow packs – than the same climatic subzones on the (eastern) lee side of the Rocky Mountains. The drying effect of the Chinook winds may also be significant on the east slopes. The seral pine and aspen forests are much more rare in mid to upper Akie-Pesika River Valleys than in the Sikanni Chief and other drainages flowing out of the east slopes. On west slopes, the lack of edaphic grasslands and high populations of large grazing ungulates is notable and evident.

1.6.2. Site Series

Site series are the most common units used to describe ecosystems within a BGC subzone. They are defined by the potential community of vegetation found at late seral or climax on a site. These unique vegetation assemblages characterize a relatively specific nutrient and moisture potential for each site. The nutrient and moisture potential, in turn, are determined by the examination and evaluation of a number of site parameters. Site series for each BGC subzone encountered within the study area are described in detail in the expanded legend (Section 4).

During the current project, ecologists undertaking the field work were required to adequately describe (i.e., in replicate sets of plots), and then classify new site series. Non-forested site series (especially wetlands, grasslands and a variety of non-forested units at high elevations where climate precludes tree growth) were known to be poorly described and were a focus of some parts of the field data collection.

As well, for the SWBmk1 and SWBmks subzones in particular, no ecosystem site series had yet been developed. In the course of their work, KTPW-Geo ecologists also identified and characterized some previously-unclassified forested ecosystem site series within the BWBSdk1 and ESSFmv4.

KTPW-Geo staff coordinated with the Ministry of Forests' Regional Ecologist and Provincial Ecologist to help define new ecosystem site series. In the project, as is the provincial convention, all previously-unclassified ecosystems were assigned a site series number designation of 00.

1.6.3. Disturbance and Edaphic factors

Within the study area, the present vegetation pattern, including seral stages and edaphic / disclimax stage, is a result of the pattern and periodicity of disturbance factors and the presence of edaphic site characteristics. Fire, avalanche, flooding, and landslides were the most common disturbance factors encountered. The prevalence of seral pine and aspen forests in various stages of development, in the BWBSdk1, is characteristic of a frequent fire history. Fire is much less common in the ESSFmv4 and SWBmk1 and parkland but it is still frequently encountered. Avalanches within high elevation forests are common and in some instances are frequent enough to maintain disclimax, herbaceous/shrub vegetation cover.

Two of the other key edaphic factors encountered which maintain non-forested edaphic ecosystems were cold air drainage and shallow soils. Cold air pondage conditions are frequently encountered in higher elevation areas, and help to perpetuate long-lived shrub/herbaceous plant communities. Similarly, shallow to bedrock areas and coarse fluvial/glaciofluvial terrace crest positions enable long lived herb/shrub communities to persist with the BWBSdk1. These ecosystems are generally not common and are small in area but may be important for wildlife.

1.7. Wildlife

The Mackenzie TEM study area contains a diverse array of habitats that support a range of vertebrate wildlife. High elevation alpine and parkland meadows, grasslands and shrublands provide high quality summer ranges for mountain goat, caribou, Stone sheep, elk and grizzly bear. Low elevation forests, wetlands and grasslands provide important winter ranges for moose, caribou, some elk and mule deer and year-round habitat for furbearers, such as marten, fisher and lynx. The construction of the W.A.C. Bennett Dam and the subsequent flooding of the Rocky Mountain Trench, now occupied by Williston Reservoir, has drastically changed the wildlife values in this portion of BC. Nevertheless, high quality low elevation winter ungulate habitat still exists. Outside of the Rocky Mountain Trench, deep snow and harsh winter conditions limit use by many ungulates, especially elk and mule deer.

In the following sections, wildlife habitat characteristics of each of the six BGC subzones/variants in the study area are described.

BWBSdk1

This zone provides important winter range for caribou and moose. A population of elk is also present along grassy south-slopes near the Ingenika River. In 1993, the existing elk herd population was supplemented with 50 translocated elk (Wood, 1993). Snowshoe hare, lynx, deer mice, ermine, black and grizzly bears and red squirrels are commonly found throughout the zone. South-facing slopes provide warm, lower snow depth habitats for most ungulates and thus for many predators like wolves and wolverine. Stone sheep and mountain goat may also be found in the BWBS where steep slopes provide escape terrain and where mineral licks are located.

In lowland areas, the BWBS contains numerous bogs, fens and riparian areas. These productive habitats play important roles for a variety of wildlife, including moose who use these lowlands for winter browse. The large number of snags associated with wet areas provide habitat for cavity-nesting/denning birds and small mammals such as three-toed woodpecker, red-breasted nuthatch, black-capped chickadee, boreal owl, boreal chickadee, red squirrel, American marten, fisher and lynx (DeLong et al., 1990).

ESSFmv4

Deep snowfalls in the ESSF make winter conditions for many species very difficult although mountain goat and caribou are well adapted and present throughout. In summer, the ESSF is widely used by grizzly bear, elk, mule deer, moose. Avalanche tracks are widespread in the ESSF and provide abundant forage for ungulates and bears. Extensive conifer forests provide habitat for marten, fisher, red squirrel, wolverine and lynx as well as for a variety of seed-eating birds, such as red and white-winged crossbills, Clark's nutcrackers and pine siskins (Coupé et al., 1991). Wetlands and riparian areas are typically not as productive as those at lower elevations.

SWBmk1

The SWB zone has the harshest climate of all the forested subzones in British Columbia and this has a profound effect on wildlife. The zone is composed of a mosaic of mostly open-canopied coniferous and mixed forests, willow-birch shrublands, grasslands, rugged, steep slopes and some wetlands, riparian areas and floodplains (Pojar and Stewart, 1991a). High elevation grassy southern aspects in the SWB are utilised by Stone sheep and mountain goats year-round and by grizzly bear, deer, elk and caribou in the growing season. In winter, they are windswept and heated by the sun reducing snow levels and exposing food during this critical time of year. Steep, rocky upper slopes are important escape terrain for both Stone sheep and mountain goats, golden eagles and gyrfalcons use this type of habitat for hunting.

Wetlands, riparian habitats and floodplains are not as abundant or as productive as in the BWBS but are used extensively by moose, bears, voles, ducks, songbirds, beaver, muskrat, various raptors like the eagles, northern harriers, and large mammals like bison. Cold-air drainage and ponding create open,

shrubby valley bottoms in many areas of the SWB. These habitats provide abundant browse year round although many areas are limited by snow depth in winter (Pojar and Stewart, 1991a).

Coniferous and mixed forests provide habitat for species such as northern Goshawk, northern hawk-owl, spruce grouse and three-toed woodpecker use this forest type extensively for foraging and nesting. Forested areas in the SWB also provide security and thermal protection in winter.

ESSFmvp4 and SWBmks

At high elevations, the ESSF and SWB have parkland variants that occupy the intergrading area between forest and alpine tundra. These variants are sparsely forested and much of the zones are characterised by herb, shrub and dwarf-shrub communities and by rugged, steep slopes. Windblown portions of these areas have low snow depths providing habitat for wintering caribou and Stone sheep. These areas are especially important when snow depths are high at low elevations. In summer, a number of birds, ungulates and bears feed in lush meadows and grasslands of the parkland zone.

AT

The harsh climate, rugged topography and low plant productivity in the AT result in low wildlife diversity and density. However, some wildlife species, such as mountain goat, pika, hoary marmot, willow and white-tailed ptarmigan, water pipits, caribou, Stone sheep and rosy finch are well-adapted to these conditions (Pojar and Stewart, 1991b). Grassland and scrub areas may be used extensively by ungulates during the summer months. In winter, these areas are utilised by goats, caribou and Stone sheep, which feed off lichens and dwarf shrubs, only where wind and solar radiation have reduced the snow depth. Grizzly bears use alpine meadows for food in the growing season. Other wildlife found seasonally in the AT include: snowshoe hare, voles, mule deer, black bear, wolverine, golden eagle, white-tailed ptarmigan, horned lark, golden eagle, golden-crowned sparrow and gyrfalcon (Pojar and Stewart, 1991b).

2. ECOSYSTEM MAPPING METHODOLOGY

In this Section, the project methodology is considered within two main phases:

1. Field sampling and photo-interpretation of bioterrain and ecosystem units; and,
2. GIS and TEM mapping production.

2.1. Field Sampling and Photo- Interpretation of Bioterrain and Ecosystem Units

The TEM mapping phase was comprised of several components:

1. Pre- typing of aerial photographs for bioterrain and ecosystem units;
2. Field sampling for terrestrial ecosystem mapping;
3. Data entry/classification of new ecosystems and;
4. Post-field edits of bioterrain and ecosystem labels on aerial photographs

These various components have been integrated in the flow chart shown in Figure 15 and elaborated on in the following sections.

2.1.1. Pre-Typing of Aerial Photos for Bioterrain and Ecosystem Units

Pre-typing of 1:20,000 black & white panchromatic stereo-photos was undertaken throughout the entire study area except for Buffalohead Landscape unit, but was first focussed within the Akie and Pesika LUs. This first phase of pre-typing was mainly conducted during the Winter/Spring of 1996/1997.

The initial step involved the “boxing” of alternate (odd-numbered) photos, and the set up of indexed sets of photo-flightline sets. Following this, stereoscopes were used to initially view photos so that the Alpine Tundra and Parkland Climatic Subzone lines could be delineated (as per RIC Standards). As this portion of the work proceeded, the marked-up photos showing these initial AT and Parkland lines were sent to MELP for TEM auditing; as required, any necessary modifications were then undertaken.

At an early stage in the photo interpretation work, a number of pre-typed photos were audited by Bob Maxwell (MELP’s Bioterrain Correlator for this project). This was undertaken in February, 1996, and this stage of review helped to clarify some details in terrain, bioterrain and ecosystem mapping methodologies. At a later date, after additional photo-interpretation and more field work had been

undertaken, Mr. Maxwell audited additional sets of photo-pairs, and provided additional useful review comments and inputs which then implemented during the post-field edits of pre-typed photos.

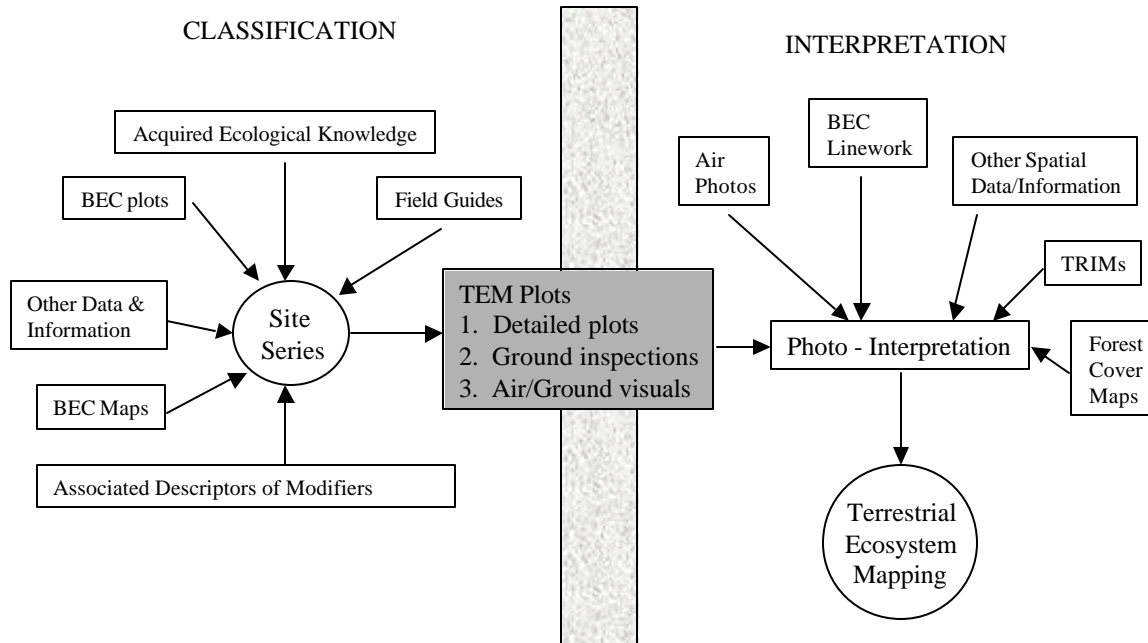


Figure 15. Flowchart summarizing the classification and photo-interpretation portions of the Mackenzie TEM project. Classification is based upon BGC principles to derive site series which are characterized via field programs and installed TEM plots. Using 1:20,000 scale stereo-photos and other associated data and information, TEM interpretation is conducted to produce typed photos for input into a GIS.

KTPW-Geo’s approach to bioterrain mapping was intended to maximize the multi-purpose utility of the bioterrain product. During the initial stage of bioterrain photo-interpretation, we assigned initial basic terrain labels using procedures and conventions outlined by Howes and Kenk (1997). Following this, bioterrain enhancement symbols (including drainage, slope, bedrock type and geomorphic process subclass descriptor) were added for each polygon on each photo and were differentiated from the standard terrain label by a different color (purple). This procedure allows the pure terrain mapping component of the photos to be more easily used in other terrain oriented studies at a later date. RIC standards (1995, 1996) for bioterrain mapping were followed for all bioterrain photo typing. We studied available geological, surficial geology and small scale soil maps with coverage of the study area prior to this work.

The next stage of air photo interpretation, involved designation of forested Climatic Subzones (or Climatic Subzone Variants) locations and the determination of Climatic Subzone (Variant), and

Ecodistrict boundary locations. These were delineated by studying available 1:250,000 scale ecosystem maps, in consultation with:

1. Prince George Forest Region ecosystem guides and other sources of published information;
2. Field observations including sample plots, ground and aerial transects; and,
3. Consultation with the MOF Regional Ecologist.

Changes to existing ecosystem climatic boundaries were thoroughly discussed and documented, and then applied following approval of the Regional Ecologist.

The final stage of photo interpretation involved the derivation and assignment of ecosystem unit labels. The main component of this stage involved the systematic delineation of site series assignments for delineated polygons. This step involved synthesizing and incorporating data and information from several sources including:

1. Published ecosystem field guides;
2. Other published and unpublished literature;
3. Available ecosystem field data; and,
4. In-house photo typing keys and other conceptual tools. Locations of all sample plots were precisely marked on air photos for transfer to the digital map base.

These point samples as well as other transect field notes were instrumental in calibrating / verifying photo-typing.

Schematic landscape/terrain/ecosystem profiles, a TEM “working legend” as well as and photo-typing keys were all developed to help guide the photo-typing. Examples of each of these are provided in Appendices A, B and C. Such “tools” are considered to be important and fundamental for a TEM project, in that they help in the development of “mental models” of the terrain/ecosystem relationships that exist within an area.

2.1.2. Field Sampling for Terrestrial Ecosystem Mapping

TEM field data collection was also coordinated with Terrain Stability Mapping (TSM). TSM was conducted within operable areas of the Akie and Pesika drainages. The overlap portion of the study area where both TEM and TSM was conducted totaled approximately 40,000 hectares.

Field sampling was initiated in August, 1996 following the formal award of the contract to KTPW-Geo. Project members participated in an initial familiarization visit to the study area. Impressions developed following this overview of the area, and augmented by our previous knowledge of the general ecology and landscape, and additionally based upon discussions with Slokan, MELP and MOF contacts, provided the foundation for the development of a preliminary field reconnaissance sampling plan.

A pre-typing field reconnaissance of the entire study area was carried out during September 1996. Based on the results of this pre-typing field reconnaissance and subsequent preliminary bioterrain mapping, a post typing field sampling plan for the Upper and Lower Akie and the Pesika LUs was developed during May, 1997 and also in May 1998 for the Ingenika Landscape Unit.

Post-typing field reconnaissance of the Akie and Pesika LUs along with supplemental field sampling in the Lower Ingenika and Buffalohead LUs was then undertaken between the beginning of July and the end of September, 1997. Post-typing field reconnaissance of the Ingenika Landscape unit took place between the end of July and the end of August 1998.

TEM data collection includes the judicious use and placement in the field of three different types of field point sample plots; this is also to be supplemented, according to RIC standards (1995, 1996), with ground and air based transect notes. The TEM field sample plot types used in this project have included:

- “Full Plots” (these are installed either as pre-type or post-type full plots, depending upon whether they are put in before photo-typing has occurred or after);
- ground-based “Visual Plots”; and,
- “Air / Ground Calls”.

“Full plots” are equivalent to research level ecosystem classification releve plots and contain detailed information, including site series designations, vegetational cover (% cover-abundance), tree cover, coarse woody debris, soils, geology and other landscape-site information. Pre-typing full plots have been used primarily as a mapping aid to very precisely confirm ecosystem site characteristics for bioterrain photo-typing and secondarily for classification of previously unclassified ecosystem units. Post-typing ecosystem plots are primarily sought and used for classification of new ecosystem units and secondarily for confirmation of detailed ecosystem site type characteristics.

“Visual plots” involve a somewhat less rigorous data collection effort; there is less detailed vegetation and soils information collected than a full plot and no coarse woody debris assessment. Visual plots were used both as a photo-typing pre-typing calibration aid and as a post-typing verification/editing aid. Because of the poorly known nature of BGC Subzone boundaries and the existence of large areas of unclassified ecosystem boundaries within the study area, these plots were usually positioned along transects; transect positions were determined during the pre-typing photo interpretation exercise. Visual plots installed during the pre-typing field reconnaissance (summer/fall, 1996) were instrumental in clarifying some fundamental ecosystem concepts at an early stage of the TEM project.

“Air/ground calls” are brief point or area sample descriptions that are made from the air, a vehicle or while in transit in the field, on foot. These plot types are used to record basic ecosystem sites series, vegetation or other very basic information, to aid in the delineation of polygon labels. During the installation of air /ground calls, as much information on terrain and soils is obtained as possible. During the Mackenzie TEM study, these plots were used primarily as a post-typing calibration of predefined air photo polygons. Table 2 lists the number of plots completed of each type.

Table 2. Numbers of full, visual and air/ground call plots completed.

Plot Type	Year 1 1996/97	Year 2 1997/98	Year 3 1998/99	Total
Visual Plots*	614	221	71	906
Air/Ground Call Plots*	0	1990	513	2503
Full (Pre-typing) Plots	16	248	0	264
Full (Post-typing) Plots	0	70	53	123
Total TEM Plots (all plot types) *	630	2529	637	3,796

* These numbers do NOT include several hundred additional air checks and ground visuals that were completed on terrain polygons for TSM mapping. These were acquired at lower elevations within the Akie and Pesika drainages, and provide additional information that was used during the TEM mapping within these areas.

Mr. Wayne Blashill audited KTPW-Geo’s field data collection and plot installation procedures. Mr Blashill was retained as a field auditor for TEM projects in the Prince George MoF Region starting in 1997, and he was responsible for quality control audits of TEM field plots for the Mackenzie TEM project. His assessment was that the work conducted in the field by KTPW-Geo staff was of excellent quality.

2.1.3. Data Entry and Classification Of New Ecosystem Units

The 1996 pre-typing plots were transferred to Excel spreadsheets, and these data were then analyzed in the winter of 1996/1997 to help target the sampling plan for post typing and ecosystem classification of full plots. Because of time constraints very few full plots were completed in the autumn of 1996. Most of the plots were ground visuals. Therefore, plots were only visually compared with field guide descriptions to test for goodness of fit to existing classified site series units. Concepts of how to sample and classify as yet unclassified BGC units (SWB, AT and parkland) were developed from these initial impressions.

Additionally, through our reconnaissance sampling, unclassified site series within previously classified BGC units (ESSFmv4 and BWBSdk1) were recognized. Initial plots were tabulated both by site series (for those ecosystems that were already classified), and by soil moisture regime and structural stage groupings (for any ecosystems that were not already classified within the BGC system as recognized ecosystem units). Initial findings and impressions were then discussed with Craig DeLong, Regional Ecologist Prince George Forest Region.

After the 1997 field season, the limited number of full pre-typing full plots from 1996 along with full plots from the 1997 field season were data entered into VENUS and underwent DECORANA and V-Tab multivariate analyses. From this, new site series were defined. Initial results for the SWBmk1 BGC Subzone were further refined by Craig DeLong. All newly-classified ecosystem units were subsequently reviewed and approved by Craig DeLong.

Data entry/classification of new units including wetland classification was completed in January, 1998. Finalization of units and unit codes was critical to editing of ESSF, SWB and AT units, and also involved re-editing of avalanche, wetland, grassland and oak fern units in the BWBS. Further refinement to codes and ecosystem modifiers to the ecosystems continued sporadically up to March 2000 with further input and modification by Craig DeLong, and MELP auditors.

Subsequent to entry and editing of all full plots into VENUS, Wayne Blashill carried out an audit of the full plot database which was subsequently approved.

More field plots were completed in the Lower Ingenika LU in the 1998 field season and were subsequently data entered.

An expanded legend, referenced to specific field plots, was created. This tabular output outlined the various seral and structural stages and typical site attributes of each ecosystem site series that was encountered during the course of the project. This information was used on an ongoing basis by the wildlife biologists involved with the project to help interpret wildlife habitat values.

2.1.4. Post-field Edits of Bioterrain and Ecosystem Labels on Aerial Photos

Following post-typing field sampling of the Akie-Pesika LUs, bioterrain and ecosystem photo-interpretations were completed from December 1997 to the end of February 1998 and the post-typing edits of Ingenika by December 31, 1999.

As already noted, photo-typing keys were developed to ensure consistent and accurate bioterrain and ecosystem photo-typing. Air photos were regularly audited internally by KTPW-Geo senior geoscientists and ecologists. As well, photos were frequently exchanged among photo interpreters to also achieve consistency throughout the typing process.

As the project proceeded, the relationships between ecosystems and the roles of BGC boundaries improved. During the post-field editing, general improvements to consistency were achieved. The most significant edits involved resolution of final BGC Subzone (Variant) boundaries, which had been poorly understood at the commencement of the project.

2.1.5. Transfer Of Typed Photos For GIS Mapping

The GIS mappers were provided with map legends for all bioterrain and ecosystem units so that they could develop editing checks for photo typing errors and for errors in the transfer of line work and polygon labels from aerial photographs.

Edited aerial photographs were photocopied and the original typed aerial photographs were sent for photo-to-map digital transfer, using a GIS (see next section for details of methods). Paper copies of maps and the original aerial photographs were sent back to the photo-interpreters for clarification /

cleanup as required, and any edits for photo-typing errors / inconsistencies were repaired prior to monorestitution line transfer and database creation.

Transcription errors in both line work and polygon labeling were then dealt with, in a final round of air photo reviews by the photo-interpreters. The most frequently encountered errors were line work that wasn't completely closed-off within polygons, and labeling errors associated with edge matching of aerial photos.

Final edited TEM maps were then submitted for approval, along with final map legends, and expanded legend. The approved map database underwent a spatial database audit by MELP using the Data Capture (DC) tool. The approved database was linked to the non-spatial plot databases. This linkage was then audited and approved.

2.1.5.1. Reliability and Limitations of Bioterrain and TEM maps

Map precision was generally quite high for most of the area since the air-photo scale was very close to the map scale. In the upper Akie in the upper Northeast corner and in the Dell Creek Drainage in the Northwest corner of the study area, lack of low-level photo coverage forced us to use a small number of 1:40,000 aerial photographs which somewhat diminished the precision of photo-typing in those locations.

Photo-typing consistency and accuracy were more difficult to achieve. This happened in part because of the huge area involved that required several different photo-typers to be involved. Many of the ecosystem units had never been classified or mapped before. Because the classification evolved and sometimes even changed over the course of the project, some simplifications and compromises were required. For example the forested wetland (complex) for the SWBmk1 was just developed and approved by the Ministry of Forests in early year 2000. This was much too late to be of use to our mapping project.

Because of the scale of mapping, it was often impossible to map very narrow or small ecosystems that were less than 10% of a polygon. For example, narrow subhygric-hygric streamside ecosystems on hillsides may be important to map from a wildlife habitat perspective but were often too small to map.

In general, as with other TEM mapping projects, complexing of well drained mesic to submesic was required since it was often difficult to distinguish between them. This reduced precision but probably increased accuracy of the photo typing.

Because of the variability and spatial complexity of wetlands, several site series were complexed into one mapping unit or mapping unit complex. The same problem was encountered in trying to differentiate discrete shrub carr and high meadow ecosystems from air photos that could be easily defined as unique on the ground.

We had to deal with a TRIM base that had some errors and inconsistencies. This was problematic and adversely affected the precision of TEM typing/mapping in the vicinity of watercourses on air photos. Our photo-typing in this instance was clearly more precise than the mapping result of having to fit our good typing into an existing imprecise database.

Accuracy of our use of correct ecosystem modifiers was also hampered by the necessity to conform to an established standard which did not apply to our study area and which was in some instances was probably erroneous. For example: analysis of soil textures within all our numerous AT plots revealed that every ecosystem we had defined should have a coarse soil as an assumed ecosystem modifier. To be consistent with other (accurate?) approved classification work, we were required to change modify several of our texture modifiers to the wrong ones.

The 1:20,000 scale TEM map and its Bioterrain map are best used for large area planning, and administration along wildlife habitat mapping. Because of limited ground control, this scale of map is not as suitable for detailed site specific management prescriptions.

Because the accuracy of the ecosystem map is strongly based on a good interpretation of the landscape, we concentrated in particular on insuring the highest precision and accuracy of our bioterrain maps. We tried to produce a terrain map base that could be used without modification for any type of earth science based usage. From what we have seen of other TEM projects in other venues, we are confident that you received the best possible product here.

2.2. GIS AND TEM MAP PRODUCTION

The next major phase of the Mackenzie TEM project involved the photo-to-map transfer and the Geographic Information System (GIS) setup of TEM mapping outputs, both in digital and hard copy formats. GIS treatment of TEM digital information was conducted to Resource Inventory Committee standards (RIC, 1998b).

GIS/Digital Mapping for the Mackenzie TEM project consisted of 5 components:

1. Data preparation;
2. Linework transfer (i.e., monorestitution);
3. Labeling and label generation;
4. Database development; and,
5. Map production.

Figure 16 illustrates the activities involved in each component.

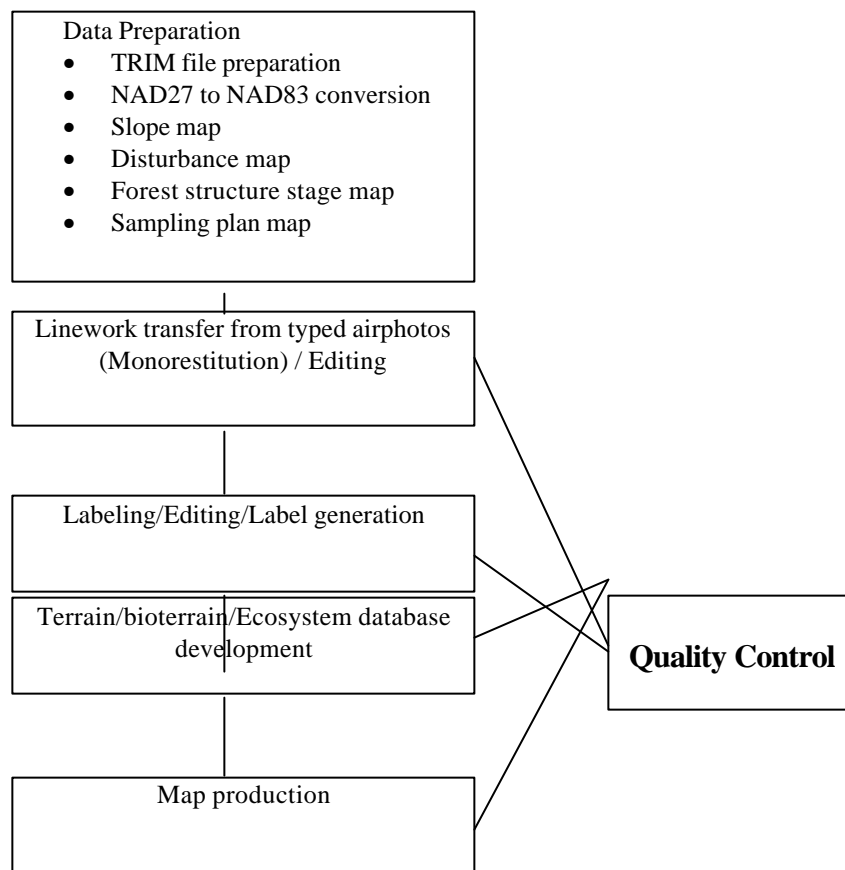


Figure 16. Flowchart of GIS/mapping stages.

2.2.1. Data Preparation

Data preparation involved two related components:

1. *Synthesis of existing data* to develop a number of interim map products; and,
2. *Conversion of input data* into common formats / projections.

Synthesis of existing data (from a variety of sources, and occurring in both digital and non-digital formats) was undertaken, in order to develop and provide integrated spatial data to other KTPW-Geo consortium team members. A particular emphasis with this part of the work was to aid air-photo interpretation and field sampling reconnaissance activities. These services included the production of:

- *Slope maps* based on DEM data in TRIM files;
- *Forest structural stage maps* based on FC1 files;
- *Disturbance maps* based on fire history data, silviculture opening data, recent PHSP data (as collected by Prince George Forest District (MoF) and Slocan - Mackenzie Division; and,
- *Sampling plan maps*, with field sampling plots located onto 1:50,000 scale maps.

Data preparation included converting TRIM digital file in binary compressed format to MELP ASCII format. The MELP files were then converted into IGDS format. Some TRIM map sheets were still based on a NAD27 projection, and it was necessary to convert these to a NAD83 datum.

2.2.2. Monorestitution

Transferring linework from typed airphotos to TRIM digital file was completed using a process of monorestitution. Monorestitution is a mathematical procedure that is used to ortho-correct air photo-based linework, correcting for elevational displacements, as well as effects of camera tip, tilt and crab. KTPW-Geo employed a Microstation-based (Bentley Systems Inc. 1994, 1995) software program called Mono-3D (Pacific International Mapping Corp., 1997). The program used ground control points (GCPs), a Triangular Irregular Network (TIN) surface, and a rigorous photogrammetric mathematical model to transfer photo coordinate to x,y,z ground coordinate in real time. The following six steps were involved in monorestitution:

1. Determine and obtain the required TRIM high-level (1:60,000 scale) photos;
2. Place control points on low-level airphotos (1:15,000) using the high-level TRIM photos. This procedure is referred to as cascade control, and as part of this process, x,y,z coordinates of each control point are recorded as an IGDS file;
3. Prepare the DEM for TIN generation;
4. Import the control IGDS file into the Mono-3D program;
5. Set up Mono-3D and register control points and fiducial marks. A minimum of 6 well-defined control points, evenly distributed around the perimeter of air photo, are required to ensure

acceptable Mono-3D set up. In the Mackenzie TEM mapping project, a minimum of 7 control points have been used to ensure high quality; and,

6. Digitally capture the linework from the typed airphotos.

2.2.3. Labeling And Label Generation

The method followed for polygon labeling and label generation was as follows:

1. Label polygons of terrain, bioterrain, and ecosystem layers in Microstation 95 following a set of rules that were developed for the project in-house;
2. Import digital label file from Microstation to ARC/INFO (cf. Environmental System Research Institute Inc., 1997);
3. Generate terrain/bioterrain database and ecosystem database based on the polygon labels in ARC/INFO; and,
4. Generate map polygon labels based on attributes contained in the database.

Software packages, including label-checking program, were written in ARC/INFO AML language for this purpose; processes are illustrated in Figures 17, 18 and 19.

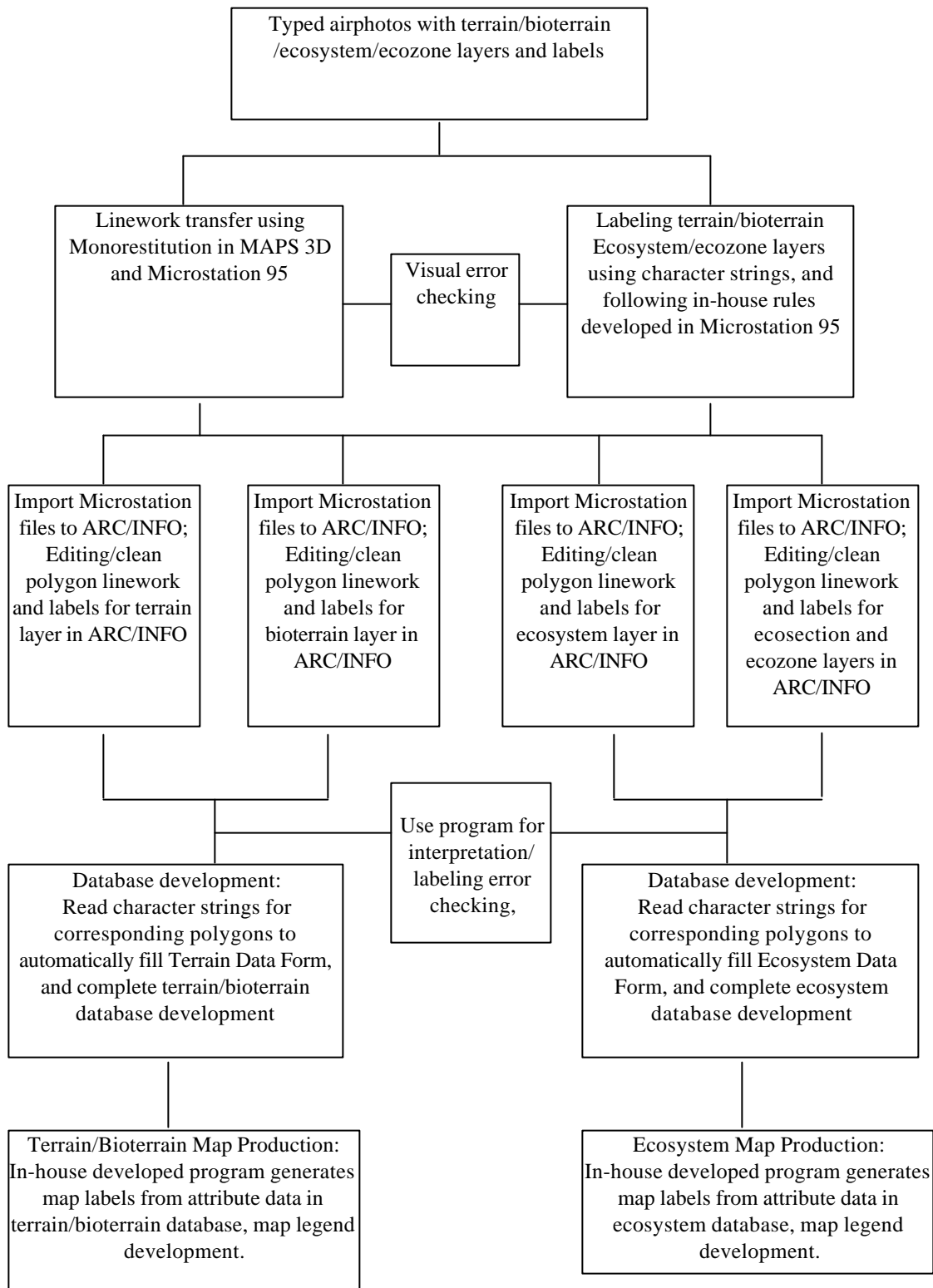


Figure 17. Processes of GIS Mapping for the Mackenzie TEM project.

Rules used for Terrain/Bioterrain map error checking:

- Percentiles should add to 100%.
- Surficial material symbols must be one capital letter and have limited options.
- Surface expression symbols must be lower case letters and have limited options.
- Material texture symbols must be lower case letters and have limited options.
- Terrain drainage symbols must be lower case letters and have limited options.
- Drainage separator symbols have limited options.
- Bedrock classification symbols must be lower case letters and have limited options.
- Geomorphologic process symbols must be capital letters and have limited options.
- Geomorphologic process subclass symbols must be lower case letters and have limited options.
- If bedrock type is known, the lower case letters in front of “R” are not soil texture, they are bedrock types.
- Avalanche process subclass must be lower case letters and have limited options.
- The order of terrain/bioterrain labels follow the rules.
- Some elements in terrain/bioterrain labels may be omitted.

Figure 18. Rules applied for terrain/bioterrain map error checking.

Rules used for Ecosystem map error checking:

- Percentiles should add to 100%.
- No polygon can miss Ecosection, Ecozone, and site series.
- Site series must with two capital letters and have limited options.
- Certain site series can only occur in certain Ecosection and Ecozone
- Site modifiers must be 1-4 lower case letters and have limited options.
- Forest structural stages must be number or number plus one lower case letter and have limited options.
- Stand type must be 1 lower case letter and have limited options.
- The order of ecosystem label follows the rules.
- Some elements in ecosystem labels may be omitted.
- If terrain label has a surface expression of ‘c’ and/or ‘f’, add ‘n’ modifier to all components in eco label. If terrain in complex, do not add ‘n’.
- If terrain label has a surface expression of ‘t’, add ‘t’ modifier to all components in eco label. If terrain in complex, do not add ‘t’.
- If terrain label has a qualifying descriptor of ‘A’, add ‘a’ modifier to all components in eco label. If terrain in complex, do not add ‘a’.
- If terrain label had geological expression ‘V’, add ‘g’ modifier to all components in eco label. If no geological expression ‘V’ in terrain label, remove ‘g’ modifier in eco label.

Figure 19. Rules applied for ecosystem map error checking.

2.2.4. Database Development

Most TEM projects in the province use Microsoft Access as a database entry tool for terrain, bioterrain, and ecosystem map attribute data. Typed air-photo interpretation labels are placed into predefined fields to develop digital data forms. The method is not only time consuming, but also very easy to make mistakes in polygon labeling, and in typing to fill data forms. The mistakes made in database are also hard to error-check.

For the current project, Taiga-Pacific GIS Ltd. developed a set of in-house programs that combined polygon label generation and database development; in other words, polygon labels on the map were the same as that in polygon attribute form. Error sources were reduced because of the reduced data handling, and the ability to view on-screen and print-out check plots as map production proceeds.

2.2.5. Map Production

Map production included both map legend development and the preparation of hard-copy / digital maps.

Initially, interim 1:20,000 Terrestrial Ecosystem Maps and Bioterrain Maps (94F005, 94F014, 94F015, 94F024, 94F025) were printed out as interim samples of map data. Review and revision of these interim products was then made before final map products were submitted to MoF, MELP and Slokan – Mackenzie Division.

TEM product deliveries included digital data delivered to Ministry of Environment Lands and Parks and hard copies of maps delivered to Slokan.

Digital data delivery

Table 3 lists digital files delivered for the Akie/Pesika portion of the study area. Table 4 lists digital files delivered for the Lower Ingenika portion of the study area. Table 5 lists plotting files and annotation files for individual map sheets of the Akie/Pesika area. Table 6 lists plotting files and annotation files for individual map sheets of the Lower Ingenika area.

Table 3. Digital files (joined for the Akie/Pesika mapping area) delivered to MELP.

File Type	Files Name
Spatial Data File	Tecp_akie.e00 Teci_akie.e00
Non-Spatial Data File	Head_akie.csv Head_akie.dat.e00 Head_akie.mdb Tecp_akie.csv Tecp_akie.dat.e00 Tecp_akie.mdb
Sampling Plot Data File	Aircall_akie.xls Ground-full-akie.xls Ground-visual-akie.xls

Table 4. Digital files (joined for the Lower Ingenika mapping area) delivered to MELP.

File Type	Files Name
Spatial Data File	Tecp_ingenika.e00 Teci_ingenika.e00
Non-Spatial Data File	Head_ingenika.csv Head_ingenika.dat.e00 Head_ingenika.mdb Tecp_ingenika.csv Tecp_ingenika.dat.e00 Tecp_ingenika.mdb
Sampling Plot Data File	Aircall_ingenika.xls Ground-full-ingenika.xls Ground-visual-ingenika.xls

Table 5. Digital files for individual map sheets of the Akie/Pesika mapping area.

File Type	File Name			
Plotting File	Plt_94c097.rtl	Plt_94c098.rtl	Plt_94f005.rtl	
	Plt_94f006.rtl	Plt_94f007.rtl	Plt_94f008.rtl	
	Plt_94f014.rtl	Plt_94f015.rtl	Plt_94f016.rtl	
	Plt_94f017.rtl	Plt_94f018.rtl	Plt_94f024.rtl	
	Plt_94f025.rtl	Plt_94f026.rtl	Plt_94f027.rtl	
	Plt_94f028.rtl	Plt_94f029.rtl	Plt_94f030.rtl	
	Plt_94f034.rtl	Plt_94f035.rtl	Plt_94f036.rtl	
	Plt_94f037.rtl	Plt_94f038.rtl	Plt_94f039.rtl	
	Plt_94f040.rtl	Plt_94f045.rtl	Plt_94f046.rtl	
	Plt_94f047.rtl	Plt_94f048.rtl	Plt_94f049.rtl	
	Plt_94f050.rtl	Plt_94f058.rtl	Plt_94f059.rtl	
	Annotation File	Acp_94c097	Acp_94c098	Acp_94f005
		Acp_94f006	Acp_94f007	Acp_94f008
Acp_94f014		Acp_94f015	Acp_94f016	
Acp_94f017		Acp_94f018	Acp_94f024	
Acp_94f025		Acp_94f026	Acp_94f027	
Acp_94f028		Acp_94f029	Acp_94f030	
Acp_94f034		Acp_94f035	Acp_94f036	
Acp_94f037		Acp_94f038	Acp_94f039	
Acp_94f040		Acp_94f045	Acp_94f046	
Acp_94f047		Acp_94f048	Acp_94f049	
Acp_94f050		Acp_94f058	Acp_94f059	

Table 6. Digital files for individual map sheets of the Lower Ingenika mapping area

File Type	File Name		
Plotting File	Plt_94c065.rtl	Plt_94c066.rtl	Plt_94c067.rtl
	Plt_94c073.rtl	Plt_94c074.rtl	Plt_94c075.rtl
	Plt_94c076.rtl	Plt_94c083.rtl	Plt_94c084.rtl
	Plt_94c085.rtl	Plt_94c086.rtl	
Annotation File	Acp_94c065	Acp_94c066	Acp_94c067
	Acp_94c073	Acp_94c074	Acp_94c075
	Acp_94c076	Acp_94c083	Acp_94c084
	Acp_94c085	Acp_94c086	

Hard copy map delivery

The plotting files of individual map sheets were generated from the database. For smaller polygons, the textual labels were adjusted to fit the polygons or arrows were added to label the polygons. Table 7 lists map sheets delivered to Slocan for the Akie/Pesika mapping area. Table 8 lists map sheets to be

delivered to Slocan for the Lower Ingenika mapping area. Four copies of each ecosystem map were produced for each map sheet. A total of 33 map sheets for the Akie/Pesika mapping area, and 11 map sheets for Lower Ingenika mapping area. were produced

Table 7. List of Ecosystem Maps for the Akie/Pesika portion of the Study Area.

94c097	94c098	94f005	94f006	94f007	94f008
94f014	94f015	94f016	94f017	94f018	94f024
94f025	94f026	94f027	94f028	94f029	94f030
94f034	94f035	94f036	94f037	94f038	94f039
94f040	94f045	94f046	94f047	94f048	94f049
94f050	94f058	94f059			

Table 8. List of Ecosystem Maps for the Lower Ingenika portion of the Study Area.

94c065	94c066	94c067	94c073	94c074	94c075
94c076	94c083	94c084	94c085	94c086	

3. BIOTERRAIN AND ECOSYSTEM MAP SYMBOLS

This section of the Final Report summarizes conventions used in the mapping process. In general, standard procedures as outlined in the TEM Standards (RIC, 1998) were followed. In TEM, Bioterrain and Ecosystem Map Symbols are composed of a sequence of letters where each letter defines a specific characteristic. The position of the letters in the sequence typically augments the information described by the letter grouping (Figures 20, 21 and 22).

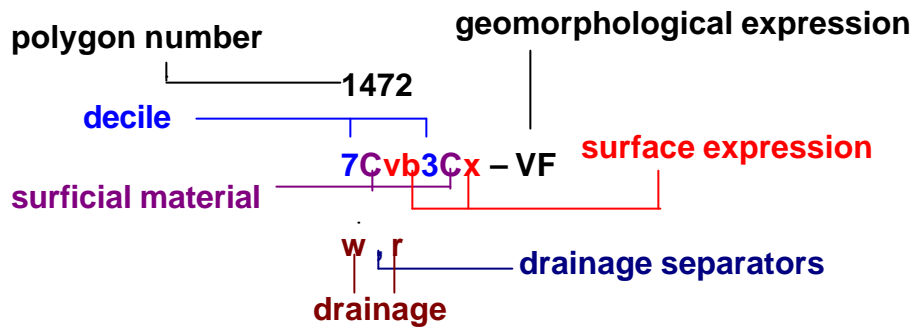


Figure 20. Bioterrain map symbols and map label format.

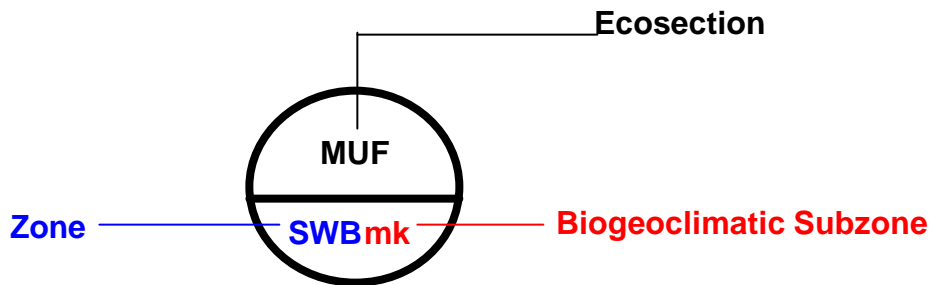


Figure 21. Ecosystem map Ecosection / BGC symbols.

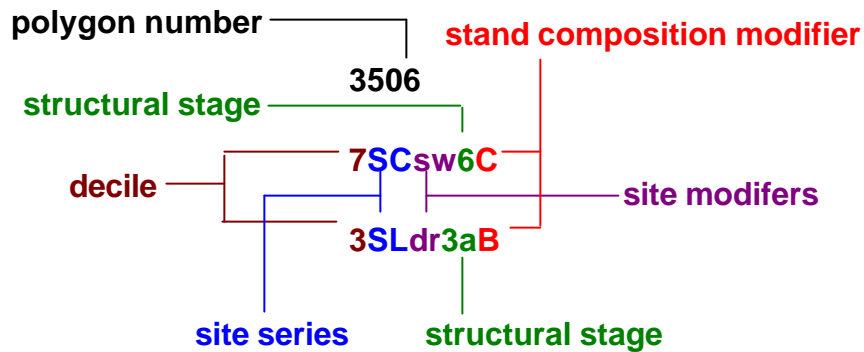


Figure 22. Ecosystem map symbols and map label format.

3.1. Bioterrain Map Symbols

The bioterrain terrain classification system was specifically developed to provide an inventory of terrain features in the landscape and to show their distribution, extent and location (Howes and Kenk, 1997). The data is described on maps by the use of symbols, which are conducive to computer digital storage, management and processing. The symbol sequence describes the following terrain characteristics: texture and type of surficial material, surface expression, geomorphological processes, and qualifiers.

3.1.1. Texture

Texture refers to the size, shape and sorting of particles in clastic sediments, and the proportion and degree of decomposition of plant fibre in organic sediments. Table 9 describes the letter codes that are used to define the texture of a polygon. The texture of surficial materials can vary both laterally and vertically within a polygon.

Table 9. Letter codes used to define terrain texture.

Code	Name	Description ¹
A	Blocks	Angular particles greater than 256 mm in size.
B	Boulders	Rounded particles greater than 256 mm in size.
K	Cobbles	Rounded particles between 64 and 256 mm in size.
P	Pebbles	Rounded particles between 2 and 64 mm in size.
S	Sand	Particles between 0.0625 and 2 mm in size.
Z	Silt	Particles between 2 µm and 0.0625 mm in size.
C	Clay	Particles less than 2 µm in size.
D	Mixed fragments	A mixture of rounded and angular particles greater than 2 mm in size.
X	Angular fragments	A mixture of angular fragments greater than 2 mm in size.
G	Gravel	A mixture of two or more size ranges of rounded particles greater than 2 mm in size; may include interstitial sand.
R	Rubble	Angular particles between 2 and 256 mm; may include interstitial sand.
M	Mud	A mixture of silt and clay; may also contain a minor fraction of fine sand.
E	Fibric	The least decomposed of all organic materials. It contains amounts of well-preserved fibre (40% or more) that can be identified as to botanical origin upon rubbing.
U	Mesic	Organic material at a stage of decomposition intermediate between fibric and humic.
H	Humic	Organic material at an advanced stage of decomposition; it has the lowest amount of fibre, the highest bulk density, and the lowest saturated water-holding capacity of the organic materials; fibres that remain after rubbing constitute less than 10% of the volume of the material.

¹ Howes and Kenk, 1997.

3.1.2. Surficial Materials

Surficial materials constitute the parent material of most soils. Howes and Kenk (1997) define surficial materials as non-lithified, unconsolidated sediments. These materials are produced by weathering, sediment deposition, biological accumulation, human and volcanic activity. Surface materials are classified by way they were formed. The most important fact to remember when describing surficial materials is that specific processes produce materials that have specific sets of physical characteristics (Howes and Kenk, 1997). Table 10 lists the letter codes that can be used to describe a polygon's surficial material.

Table 10. Letter codes used to define a polygons’ surficial materials.

Code	Name	Description ¹
C	Colluvium	Materials that have reached their present positions as a result of direct, gravity-induced movement involving no agent of transportation such as water or ice, although the moving material may have contained water and/or ice.
F	Fluvial	Materials transported and deposited by streams and rivers; synonymous with alluvium.
F ^G	Glaciofluvial	Materials that exhibit clear evidence of having been deposited by glacial meltwater streams either directly in front of, or in contact with, glacier ice.
I	Ice	Areas of snow and ice where evidence of active glacier movement is present.
L ^G	Glaciolacustrine	Lacustrine materials deposited in or along the margins of glacial (ice-dammed) lakes; includes sediments that were released by the melting of floating ice.
M	Morainal	Material deposited directly by glacier ice without modification by any other agent of transportation.
O	Organic	Sediments composed largely of organic materials resulting from the accumulation of vegetative matter. They contain at least 30% organic matter by weight (17% or more organic carbon).
R	Bedrock	Bedrock outcrops and rock covered by a thin mantle (up to 10cm thick) of unconsolidated or organic materials.

¹ Howes and Kenk, 1997.

3.1.3. Surface Expression

Howes and Kenk (1997) define surface expression as the assemblage of slopes and pattern of forms expressed by a surficial material at the land surface and also describe the manner in which unconsolidated surficial materials relate to the underlying substrate. Classification is according to slope, geometric shape and spatial pattern. Table 11 lists the letter codes used to describe a polygon’s surface expression.

Table 11. Letter codes that can be used when defining surface expression.

Code	Name	Description ¹
a	Moderate slope	An unidirectional (planar) surface with a slope 16° to 26° (27 to 50%), and a smooth, longitudinal profile that is either straight, or slightly concave or convex; local surface irregularities generally have a relief of less than 1 metre.
b	Blanket	A layer of unconsolidated material thick enough to mask minor irregularities of the surface of the underlying material, but still conforms to the general underlying topography. A blanket is greater than 1 metre thick and possesses no constructional forms typical of the materials genesis; outcrops of the underlying unit are rare.
c	Cone	A cone or sector of a cone with a relatively smooth surface, and mostly steeper than 15° (26%), and a longitudinal profile that is either straight, or slightly concave or convex.
f	Fan	A fan is a relatively smooth sector of a cone with a slope gradient from apex to toe up to and including 15° (26%), and a longitudinal profile that is either straight, or slightly concave or convex.
h	Hummock	Steep sided hillock(s) and hollow(s) with multidirectional slopes dominantly between 15° and 35° (26 to 70%) if composed of unconsolidated materials; bedrock slopes may be steeper. Local relief is greater than 1 metre. In plan, an assemblage of non-linear, generally chaotic forms that are rounded or irregular in cross-profile.
j	gentle slope	An unidirectional (planar) surface with slope gradient 4 to 15° (7 to 26%), and a smooth, longitudinal profile that is either straight, or slightly concave or convex; local surface irregularities generally have a relief of less than 1 metre.
k	Moderately steep slope	An unidirectional (planar) surface with slope gradient 27 to 35° (50 to 70%), and a smooth, longitudinal profile that is either straight, or slightly concave or convex; local surface irregularities generally have a relief of less than 1 metre.
m	Rolling	Elongate hillock(s) with slopes dominantly between 3 and 15° (5 to 26%) with local relief greater than 1 metre. In plan, an assemblage of parallel or sub-parallel linear forms with subdued relief.
p	Plain	A level or very gently sloping, unidirectional (planar) surface with gradients 0 to 3° (0 to 5%); local surface irregularities generally have a relief of less than 1 metre.
r	Ridge	Elongate hillock(s) with slopes dominantly between 15 and 35° (26 to 70%) if composed of unconsolidated materials; bedrock slopes may be steeper. Local relief greater than 1 metre. In plan, an assemblage of parallel or sub-parallel linear forms.
s	steep slope	An unidirectional (planar) surface with gradients greater than 35° (70%), and a smooth longitudinal profile that is either straight, or slightly concave or convex; local surface irregularities generally have a relief of less than 1 metre; bedrock slopes may be more irregular.
t	Terrace	A single or assemblage of step-like forms where each step-like form consists of a scarp face and a horizontal or gentle inclined surface (tread) above it.
v	Veneer	A layer of unconsolidated materials too thin to mask the minor irregularities of the surface of the underlying material. It is between about 10 cm and 1 m in thickness, and possesses no constructional form typical of the material genesis.
x	thin veneer	A very thin layer of unconsolidated material about 2-20 cm in thickness.

¹ Howes and Kenk, 1997.

3.1.4. Geomorphological Processes

Geomorphological expressions are natural mechanical processes that result in the modification of the surficial materials and landforms at the earth’s surface. The following are the natural mechanisms that create the expression: weathering, erosion and deposition. Table 12 lists the letter codes used to describe a polygon’s geomorphological processes.

Table 12. Letter codes that can be used when defining geomorphological expression.

Code	Name	Description ¹
B	Braiding	Active channel zone is characterized by many diverging and converging channels separated by unvegetated bars. Many channels are dry at moderate and low flows, but during major floods, the entire channel zone may be occupied by flowing water.
C	Cryoturbation	Movement of surficial materials by heaving and/or churning due to frost action (repeated freezing and thawing).
F	Slow Mass Movement	Slow downslope movement of masses of cohesive or non-cohesive surficial material and/or bedrock by creeping, flowing or sliding.
I	Irregular Channel	A clearly defined main channel displaying irregular turns and bends without repetition of similar features; backchannels may be common, and minor side channels and a few bars and islands may be present, but regular and irregular meanders are absent.
J	Anastomosing Channel	A channel zone where channels diverge and converge around many islands. The islands are vegetated and have surfaces that are relatively far above mean maximum discharge levels. Some channels are dry at moderate or low flows.
M	Meandering Channels	A clearly defined channel characterized by a regular and repeated pattern of bends with relatively uniform amplitude and wave length.
N	Nivation	Erosion of bedrock or surficial materials beneath and along the margin of snow patches by freeze-thaw processes (frost shattering and heave), meltwater action and snow creep.
R	Rapid Mass Movement	Rapid downslope movement by falling, rolling, sliding or flowing of dry, moist or saturated debris derived from surficial material and/or bedrock.
S	Solifluction	Slow gravitational downslope movement of saturated non-frozen overburden across a frozen or otherwise impermeable substrate.
U	Inundation	Terrain seasonally under standing water which results from high watertable.
V	Gully Erosion	The modification of unconsolidated and consolidated surfaces by various processes such as running water, mass movement and snow avalanching, resulting in the formation of parallel and sub-parallel long, narrow ravines.
X	Permafrost	Processes controlled by the presence of permafrost, and permafrost aggradation or degradation. “Permafrost” is earth material whose temperature remains below 0°C continuously for two years or longer.
Z	Periglacial Processes	Solifluction, cryoturbation and nivation occurring together within a single terrain unit.

¹ Howes and Kenk, 1997.

3.2. Ecosystem Map Symbols

Ecosystem maps contain three kinds of map units: ecoregion/ecosection map units, biogeoclimatic map units, and ecosystem map units. RIC (1998) defines ecosystem map units as derivatives of site series classification of BGC which are further differentiated by more specific site conditions and structural developmental stages.

3.2.1. Map and BGC Site Series

Map and BGC site series are related to a specific range of soil moisture and nutrient regimes within a subzone. Section 4 of this report describes the map and BGC site series symbols and definitions in detail. Table 13 lists the codes and definitions for non-vegetated, sparsely vegetated, and anthropogenic units.

Table 13. Sparsely vegetated, non vegetated, and anthropogenic units as defined by RIC (1998).

Ecosystem Unit	Definition	Site modifiers	Structural Stages
CL Cliff	A steep, vertical or overhanging rock face. ³	q, z	Sparse/Bryoid
GB Gravel Bar	An elongated landform generated by waves and currents and usually running parallel to the shore. It is composed of unconsolidated small rounded cobbles, pebbles, stones, and sand.	not applicable	Sparse/Bryoid
GL Glacier	A mass of perennial snow and ice with definite lateral limits. It typically flows in a particular direction. ²	not applicable	not applicable
LA Lake	A naturally occurring static body of water, greater than 2m deep in some portion. The boundary for the lake is the natural high water mark. ²	not applicable	not applicable
MO Moraine	An unvegetated landform consisting of unstratified glacial drift that is usually till and taking a variety of shapes, ranging from plains to mounds and ridges that are initial forms independent of underlying bedrock or older material. ⁴	k, w	Sparse/Bryoid
RO Rock Outcrop	A gentle to steep, bedrock escarpment or outcropping, with little soil development and sparse vegetative cover.	k, r, w	Sparse/Bryoid
RU Rubble	Rubble is common on the ground surface in and adjacent to alpine areas, on ridgetops, gentle slopes and flat areas due to the effects of frost heaving. ^{2,4}	k, r, w	Sparse/Bryoid
TA Talus	Angular rock fragments of any size accumulated at the foot of steep rock slopes as a result of successive rock falls. It is a type of colluvium	k, r, w	Sparse/Bryoid

¹ Dunster and Dunster (1996)

² Resources Inventory Committee (1997)

³ Sinnemann (1992)

⁴ Howes and Kenk (1997)

3.2.2. Site Modifiers

Each site series has been described by a “typical” set of environmental conditions. These conditions are focused on site, soil, and terrain characteristics. Compensating effects of different environmental characteristics can result in some site series having a wide range of physical site conditions. Site modifiers are descriptive terms for certain site conditions, to describe conditions outside those considered typical. Table 14 lists the site modifiers that were used when describing an ecosystem unit.

Table 14. Site series site modifiers used to describe atypical conditions.

Code	Name	Description ¹
a	active floodplain	Occurs on an active fluvial floodplain (level or very gently sloping surface bordering a river that has been formed by river erosion and deposition), where evidence of active sedimentation and deposition is present.
g	gullying occurring	Occurs within a gully, indicating a certain amount of variation from the typical, or the site series has gullying throughout the area being delineated.
h	hummocky terrain	Occurs on hummocky terrain, suggesting a certain amount of variability.
j	gentle slope	Occurs on topography less than 25% slope.
k	cool aspect	Occurs on cool, northerly or easterly aspects (285° - 135°), on moderately steep slopes (25% to 100%).
n	fan	Occurs on a fluvial fan (most common), or on a colluvial fan or cone.
q	very steep cool aspect	Occurs on very steep slopes (> 100%) with cool, northerly or easterly aspects (285° - 135°).
r	ridge	Occurs throughout an area of ridged terrain, or it occurs on a ridge crest.
t	terrace	Occurs on a fluvial or glaciofluvial terrace, lacustrine terrace, or rock cut terrace.
w	warm aspect	Occurs on warm, southerly or westerly aspects (135° - 285°), on moderately steep slopes (25% to 100%).
z	very steep warm aspect	Occurs on very steep slopes (> 100%) with warm, southerly or westerly aspects (135° - 285°).
c	coarse-textured soils	Occurs on soils with a coarse texture, including sand and loamy sand; and also sandy loam, loam and sandy clay loam with greater than 70% coarse fragment volume.
d	deep soil	Occurs on soils greater than 100 cm to bedrock.
f	fine-textured soils	Occurs on soils with a fine texture including silt and silt loam with less than 20% coarse fragment volume; and clay, silty clay, silty clay loam, clay loam, sandy clay and heavy clay with less than 35% coarse fragments volume.
m	medium-textured soils	Occurs on soils with a medium texture, including sandy loam, loam and sandy clay loam with less than 70% coarse fragment volume; silt loam and silt with more than 20% coarse fragment volume; and clay, silty clay, silty clay loam, clay loam, sandy clay and heavy clay with more than 35% coarse fragment volume.
p	peaty material	Occurs on deep organics or a peaty surface (15-60 cm) ³ over mineral materials.
s	shallow soils	Occurs where soils are considered to be shallow to bedrock (20-100 cm).
v	very shallow soils	Occurs where soils are considered to be very shallow to bedrock (less than 20 cm).

¹ RIC (1998)

3.2.3. Structural Stages

Structural stages describe the existing dominant stand appearance and structural features are emphasized over age criteria. Table 15 defines the various vegetation structural stages.

Table 15. Structural stage categories and modifiers used to describe ecosystem units.

Structural Stage	Code	Definition^{1,2}
Sparse/ Bryoid	1 (NS)	Initial stages of primary and secondary succession; bryophytes and lichens often dominant; time since disturbance < 20 yrs for normal forest succession, may be prolonged (50-100+ years) where there is little or no soil development.
Sparse	1a (SP)	Less than 10% vegetation cover.
Bryoid	1b (BR)	Bryophyte and lichen-dominated communities; total shrub and herb cover < 20% and total tree cover < 10%.
Herb	2 (H)	Early successional stage or restricted development Because of environmental conditions or disturbance; dominated by herbs (forbs, graminoids, ferns); some invading or residual shrubs and trees may be present; tree cover < 10%, shrubs <20% or < 33% of total cover, herb-layer cover > 20%, or > 33% of total cover; time since disturbance < 20 yrs for normal forest succession; many non-forested communities are perpetually maintained in this stage.
Forb-dominated	2a (FO)	Includes non-graminoid herbs and ferns.
Graminoid-dominated	2b (GR)	Includes grasses, sedges, reeds, and rushes.
Dwarf shrub-dominated	2d (DS)	Dominated by dwarf woody species such as <i>Arctostaphylos alpina</i> , <i>Salix reticulata</i> , <i>Cassiope tetragona</i> .
Shrub/Herb	3 (SH)	Early successional stage or restricted development Because of environmental limitations or disturbance; dominated by shrubby vegetation; seedlings and advance regeneration may be abundant; tree cover < 10%, shrub cover > 20% or > 33% of total cover.
Low shrub	3a (LS)	Dominated by shrubby vegetation < 2m tall; time since disturbance < 20 yrs for normal forest succession; may be perpetuated indefinitely by environmental conditions or disturbance.
Tall shrub	3b (TS)	Dominated by shrubby vegetation that is 2 – 10 m tall; time since disturbance < 40 yrs for normal forest succession; may be perpetuated indefinitely.
Pole/Sapling	4 (PS)	Trees > 10m tall, typically densely stocked, have overtopped shrub and herb layers; younger stands are vigorous; older stagnated stands are also included; self-thinning and vertical structure not yet evident in the canopy; time since disturbance < 40 yrs for normal forest succession; up to 100+ years for dense stagnant stands.
Young Forest	5 (YF)	Self-thinning has Become evident and the forest canopy has begun to differentiate into distinct layers; vigorous growth and a more open stand than in PS stage; begins as early as age 30 and extends to 50 – 80 yrs; time since disturbance generally 40 – 80 years, depending on tree species and ecological conditions.
Mature Forest	6 (MF)	Trees established after the last disturbance have matured; a second cycle of shade-tolerant trees may have Become established; understories Become well developed as the canopy opens up; time since disturbance generally 80 – 140 years for BGC BWBSmw and 80 – 250 for BGC SWBmk.
Old Growth Forest	7 (OF)	Old , structurally complex stands comprised mainly of shade-tolerant and regenerating tree species, although older seral and long lived trees from a disturbance such as fire may still dominate the upper canopy; snags and coarse woody debris in all stages of decomposition and patchy understories typical; time since disturbance generally > 140 yrs for BGC BWBSmw and > 250 yrs for SWBmk.

¹ RIC (1998)

² Modifiers for stand composition (Structural Stages 3-7 only): **C** = coniferous (> 75% of total tree cover is coniferous); **B** = broadleaf (> 75% of total tree cover is broadleaf); **M** = mixed (neither coniferous or broadleaf account for > 75% of total tree cover)

4. DESCRIPTION OF ECOSYSTEM UNITS

Each ecosystem unit that was mapped within the Mackenzie study area is listed in one or more of the following tables. The tables are organized by BGC Zone, and include detailed ecosystem unit descriptions.

The site series name appears as a header at the top of each of the two descriptive tables. Site series name descriptions include the subzone (variant), full ecosystem name plus the two letter mapping code name based on the common name of two key plant indicator species.

Site series numbers are listed in the header for all correlated sites series. Site series which have not been correlated have not been assigned a number and are assumed to have 00 designation.

The first table outlines the typical habitat of the ecosystem and makes comments on its distribution. Included in this first table is a list of map modifiers. A typical landscape view of the ecosystem is provided below the first table.

The second table lists: the structural stages mapped, plant indicators and plots sampled within each site series and structural stage. Where no plots were encountered for a structural stage that was likely to have occurred, then a plant list was extrapolated based on our best ecological knowledge.

In the plant list description, plant indicator species have been broken down into "dominant" and "indicator" species. Dominant plant species dominate and typify the plant cover. Dominant indicator species are species which occur in fifty to hundred percent of sample plots and also have a high cover, usually 20% or greater. In some ecosystems, no one species may have a high cover and in these circumstances the highest cover constant indicator species with 2%+ cover may be listed as a dominant species. Indicator plant species were plants that had been listed which either occur in low to moderate cover (usually less than 5%) but are constantly (50%+) present or occur sporadically but usually exhibited high cover values when present.

4.1. Summary Listing of Ecosystem Units

Table 16 is an index of all ecosystems encountered. Several site series occur within multiple BGC zones. However, the same site series in different BGC units often have different vegetation characteristics. Therefore, a separate description has been produced for most site series in each each BGC unit. Ecosystems occurring in the BWBSdk1 are introduced first, followed by ecosystems in the SWBmk1, SWBmks, ESSFmv4, ESSFmvp4 and AT.

Table 16. List of site series and the BGC unit(s) in which each occurs.

Map Code	Site Series	BWBSdk1	SWBmk1	SWBmks	ESSFmv4	ESSFmvp4	AT
AD	00 – Mountain arnica - Subalpine daisy meadow		∴	127	175	∴	197
AW	00 – Mountain avens- Dwarf willow		∴	131	179	∴	199
BB	00 – Scrub Birch - Beaked edge fen	79					
BC	07 – Sb - Lingonberry - Coltsfoot	63					
BH	09 – Sb - Horsetail - Sphagnum	67					
BJ	00 – Bluejoint - Avens high meadow		115		169		
BL	04 – Sb - Lingonberry - Knight’s plume	57					
BP	00 – Bluejoint - Cow parsnip avalanche track	75	∴		∴		
BT	03 – B1Sb - Labrador tea				155	189	
FB	00 – Scrub birch - Sedge fen	87	∴		∴		
FF	00 – B1 - Feathermoss avalanche track		117	∴	165	183	
FH	00 – B1 - Heather mesic krumholtz					∴	
FH	05 – B1 - Alder - Horsetail				159	∴	
FL	00 – Alpine fescue - Lichen dry meadow				181	∴	201
FR	01 – B1 - Rhododendron - Feathermoss				151	185	
FS	00 – Slender sedge - Fen moss fen	85	∴		∴		
FW	00 – B1 - Rhododendron - Wildrye				161	193	
HG	00 – Horsetail - Giant water moss fen	83					
HS	00 – Horsetail - Sedge fen			135		∴	∴
KR	00 – Kalm's Lobelia - Rush marl flat	77			∴		
KS	00 – Kinnikinnik - Sage	73					
LC	02 – B1P1 - Crowberry - Cladina				153	187	
LG	00 – Labrador tea - Glow moss sloping fen		123		∴		
LL	02 – P1 - Lingonberry - Feathermoss	53					
ME	00 – Horsetail – Giant water moss – oxbow marsh				171		
MW	00 – Water sedge - Fen moss fen		119		∴		
PL	00 – Sw - Scrub birch - Cladina		97	139			
PW	00 – Pacific willow - Dogwood low riparian bench	79					
RH	04 – B1 - Rhododendron - Horsetail				157	191	
RS	00 – Rush - Sedge marsh	93			∴		
SA	00 – Scrub birch - Atai fescue		∴	133			
SB	00 – Sw - Scrub birch		95	137			
SC	08 – Sw - Currant - Horsetail	67					
SC	00 – Sw - Scrub birch - Bluejoint		107	149			
SD	00 – Sedge dwarf - Willow moist meadow		∴	125	173	∴	195
SE	00 – Sedge - Asphodel fen	91	∴		∴		
SH	00 – Sw - Shrubby cinquefoil - Horsetail		109				
SK	00 – Sw - Juniper - Wildrye		99	141			
SL	00 – Sw - Willow - Crowberry		103	145			
SM	01 – Sw - Knight’s plume - Step moss	51					
SO	00 – Sw - Oak fern	69					
SO:ao	00 – At - Oak fern	71					
SR	06 – Sw - Scouring rush - Step moss	61					

Map Code	Site Series	BWBSdk1	SWBmk1	SWBmks	ESSFmv4	ESSFmvp4	AT
SS	05 – Sw - Sooploallie - Twinflower	59					
SS	00 – Sw - Willow - Stepmoss		105	147			
SW	03 – Sw - Wildrye - Feathermoss	55					
SW	00 – Sw - Arctic lupine – Step moss		101	143			
VH	00 – Sitka valerian - Indian hellebore avalanche track		111	∣	163	∣	203
WA	00 – Willow - Mountain arnica moist meadow		∣	129	177	∣	∣
WE	00 – Scrub birch - Willow fen edge	81	∣		∣		
WG	00 – Willow - Groundsel shrub carr		113		167		
WP	00 – Water sedge - Bristle stalked sedge perched fen		121		∣		

4.2. Detailed Expanded Legend

The following pages contain the detailed descriptions of each site series. An abbreviated version is found in Appendix E.

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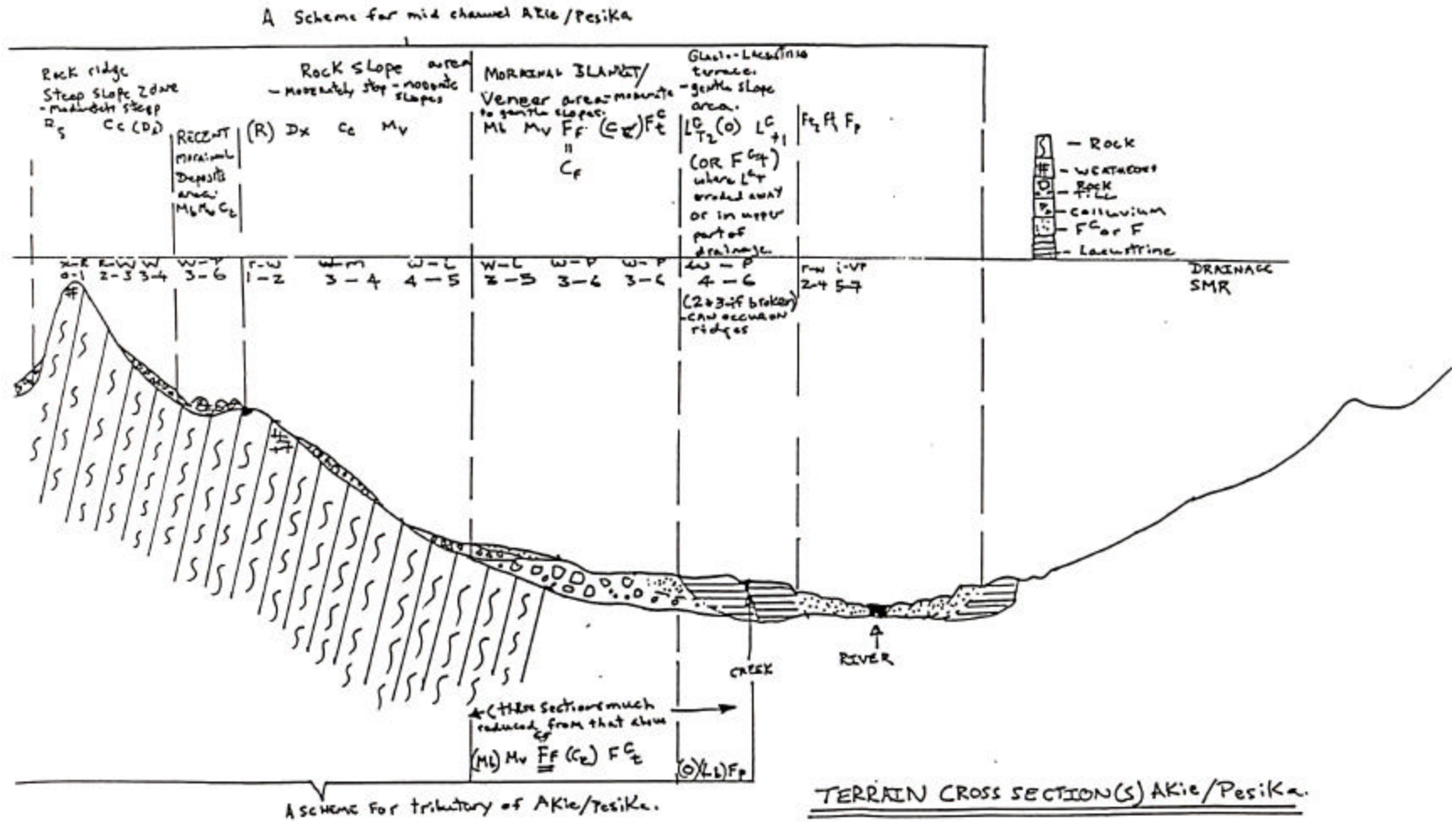
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APPENDIX A: TERRAIN CROSS-SECTION

Terrain cross-section and the Akie/Pesika. This was used to gain an initial understanding of landscape features and their positions.



APPENDIX B: WORKING LEGEND

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION	
	5.2. LANDSCAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT				
BWBSdk1	Level	Glaciofluvial terrace	shallow (bedrock)	also deep very coarse medium - coarse	02	LL	Pl – Lingonberry - Feathermoss	
					03	SW	Sw – Wildrye - Feathermoss	
					04	BL	Sb – Lingonberry – Knight’s plume	
			deep	medium - coarse	01	SM	Sw – Knight’s plume Step moss	
					03	SW	Sw – Wildrye - Feathermoss	
					05	SS	SwPl – Soopalallie - Twinflower	
			Fluvial	low bench	medium - coarse	06	SR	Sw – Scouring-rush – Step moss
						07	BC	Sb - Lingonberry - Coltsfoot
						08	SC	Sw – Currant - Horsetail
				med. bench	medium - coarse	01	SM	Sw – Knight’s plume – Step moss
						05	SS	SwPl – Soopalallie - Twinflower
				high bench	medium - coarse	01	SM	Sw – Knight’s plume – Step moss
					05	SS	SwPl – Soopalallie - Twinflower	
					04	BL	Sb – Lingonberry – Knight’s plume	
		fen	medium - coarse	09	BH	Sb – Horsetail - Sphagnum		
				11	SG	Sw - Willow – Glow moss		
				32	BG	Bog		
		Morainial	shallow (bedrock)	medium - coarse	03	SW	Sw – Wildrye - Feathermoss	
					04	BL	Sb – Lingonberry – Knight’s plume	
					07	BC	Sb - Lingonberry - Coltsfoot	
			deep	medium - coarse	01	SM	Sw – Knight’s plume – Step moss	
					04	BL	Sb – Lingonberry – Knight’s plume	
Glaciolacustrine	shallow (bedrock)	medium	03	SW	Sw – Wildrye - Feathermoss			
			04	BL	Sb – Lingonberry – Knight’s plume			
		fine	01	SM	Sw – Knight’s plume – Step moss			
	deep	medium	01	SM	Sw – Knight’s plume Step moss			
			04	BL	Sb – Lingonberry – Knight’s plume			

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES			SITE SERIES	ECO-UNIT	DESCRIPTION	
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT					
				fine		06	SR	Sw – Scouring-rush – Step moss	
	Organic	bog	forested		10	BS	Sb – Labrador tea - Sphagnum		
					31	BG	Bog		
					07	BC	Sb - Lingonberry - Coltsfoot		
					fen		08	SC	Sw – Currant - Horsetail
							09	BH	Sb – Horsetail - Sphagnum
							09	BH	Sb – Horsetail - Sphagnum
							11	SG	Sw - Willow – Glow moss
					32	FN	Fen		
Toe slopes			(Glacio) fluvial	all			06	SR	Sw – Scouring-rush – Step moss
							08	SC	Sw – Currant - Horsetail
	Morainal	all			06	SR	Sw – Scouring-rush – Step moss		
					08	SC	Sw – Currant - Horsetail		
	(Glacio) lacustrine	all			06	SR	Sw – Scouring-rush – Step moss		
					08	SC	Sw – Currant - Horsetail		
	Colluvium	all			01	SM	Sw – Knight’s plume – Step moss		
					06	SR	Sw – Scouring-rush – Step moss		
					08	SC	Sw – Currant - Horsetail		
	Organic	all			07	BC	Sb - Lingonberry - Coltsfoot		
					08	SC	Sw – Currant - Horsetail		
					09	BH	Sb – Horsetail - Sphagnum		
Lower Slopes	(Glacio) fluvial mostly on scarps	shallow (bedrock)	coarse	northerly	04	BL	Sb – Lingonberry – Knight’s plume		
				southerly	02	LL	Pl – Lingonberry - Feathermoss		
				03	SW	Sw – Wildrye - Feathermoss			
			medium	northerly	01	SM	Sw – Knight’s plume – Step moss		
				southerly	05	SS	SwPl – Soopalallie - Twinflower		
			deep	coarse	northerly	01	SM	Sw – Knight’s plume – Step moss	
		04				BL	Sb – Lingonberry – Knight’s plume		
					06	SR	Sw – Scouring-rush – Step moss		

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES			SITE SERIES	ECO-UNIT	DESCRIPTION		
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT						
				medium	southerly	03	SW	Sw – Wildrye - Feathermoss		
					northerly	06	SR	Sw – Scouring-rush – Step moss		
						07	BC	Sb - Lingonberry - Coltsfoot		
					southerly	01	SM	Sw – Knight’s plume – Step moss		
						05	SS	SwPl – Soopalallie - Twinflower		
				Morainal	shallow (bedrock)	coarse	northerly	04	BL	Sb – Lingonberry – Knight’s plume
							southerly	02	LL	Pl – Lingonberry - Feathermoss
								03	SW	Sw – Wildrye - Feathermoss
						medium	northerly	01	SM	Sw – Knight’s plume – Step moss
								01	SM	Sw – Knight’s plume – Step moss
								04	BL	Sb – Lingonberry – Knight’s plume
		(Glacio) lacustrine	all	northerly		01	SM	Sw – Knight’s plume – Step moss		
						06	SR	Sw – Scouring-rush – Step moss		
						07	BL	Sb – Lingonberry – coltsfoot		
				southerly		01	SM	Sw – Knight’s plume – Step moss		
						07	BL	Sb – Lingonberry – coltsfoot		
						05	SS	SwPl – Soopalallie - Twinflower		
		Colluvium	shallow (bedrock)	northerly		03	SW	Sw – Wildrye - Feathermoss		
				southerly		02	LL	Pl – Lingonberry - Feathermoss		
			deep	northerly		01	SM	Sw – Knight’s plume – Step moss		
				southerly		05	SS	SwPl – Soopalallie - Twinflower		
		Middle Slopes	(Glacio) fluvial mostly scarps	shallow (bedrock)	coarse	northerly	01	SM	Sw – Knight’s plume – Step moss	
							04	BL	Sb – Lingonberry – Knight’s plume	
southerly	02					LL	Pl – Lingonberry - Feathermoss			
	03				SW	Sw – Wildrye - Feathermoss				

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES			SITE SERIES	ECO-UNIT	DESCRIPTION	
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT					
				medium	northerly	01	SM	Sw – Knight’s plume – Step moss	
						05	SS	SwPl – Soopalallie - Twinflower	
					southerly	02	LL	Pl – Lingonberry - Feathermoss	
						03	SW	Sw – Wildrye - Feathermoss	
					deep	northerly	01	SM	Sw – Knight’s plume – Step moss
							04	BL	Sb – Lingonberry – Knight’s plume
				coarse	southerly	01	SM	Sw – Knight’s plume – Step moss	
						03	SW	Sw – Wildrye - Feathermoss	
					medium	northerly	01	SM	Sw – Knight’s plume – Step moss
							06	SR	Sw – Scouring-rush – Step moss
					southerly	01	SM	Sw – Knight’s plume – Step moss	
						03	SW	Sw – Wildrye - Feathermoss	
			Morainal	shallow (bedrock)	coarse	northerly	04	BL	Sb – Lingonberry – Knight’s plume
						southerly	02	LL	Pl – Lingonberry - Feathermoss
						03	SW	Sw – Wildrye - Feathermoss	
					medium	northerly	01	SM	Sw – Knight’s plume – Step moss
						southerly	01	SM	Sw – Knight’s plume – Step moss
						03	SW	Sw – Wildrye - Feathermoss	
				deep	coarse	northerly	01	SM	Sw – Knight’s plume – Step moss
							04	BL	Sb – Lingonberry – Knight’s plume
					southerly	01	SM	Sw – Knight’s plume-step moss	
						03	SW	Sw – Wildrye - Feathermoss	
					medium	northerly	01	SM	Sw – Knight’s plume – Step moss
							06	SR	Sw – Scouring-rush – Step moss
			southerly	01	SM	Sw – Knight’s plume – Step moss			
				03	SW	Sw – Wildrye - Feathermoss			
			(Glacio) lacustrine	all	northerly		01	SM	Sw – Knight’s plume – Step moss
							06	SR	Sw – Scouring-rush – Step moss
southerly		01			SM	Sw – Knight’s plume – Step moss			

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION			
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT						
		Colluvium	shallow (bedrock)	northerly	01	SM	Sw – Knight’s plume – Step moss			
					02	LL	Pl – Lingonberry - Feathermoss			
				southerly	02	LL	Pl – Lingonberry - Feathermoss			
					01	SM	Sw – Knight’s plume – Step moss			
			deep	northerly	01	SM	Sw – Knight’s plume – Step moss			
				southerly	03	SW	Sw – Wildrye - Feathermoss			
				Upper Slopes	(Glacio) fluvial on scarps	shallow (bedrock)	northerly	04	BL	Sb – Lingonberry – Knight’s plume
								02	LL	Pl – Lingonberry - Feathermoss
		03	SW				Sw – Wildrye - Feathermoss			
		81	GB				Grassland			
		82	SB			Scrub				
	deep	northerly	01			SM	Sw – Knight’s plume – Step moss			
			04			BL	Sb – Lingonberry – Knight’s plume			
		southerly	03			SW	Sw – Wildrye - Feathermoss			
		Morainal	shallow (bedrock)	northerly	04	BL	Sb – Lingonberry – Knight’s plume			
				02	LL	Pl – Lingonberry - Feathermoss				
				81	GB	Grassland				
				82	SB	Scrub				
	deep			northerly	01	SM	Sw – Knight’s plume– Step moss			
					05	SS	SwPl – Soopalallie – Twinflower			
					04	BL	Sb – Lingonberry – Knight’s plume			
		southerly	03	SW	Sw – Wildrye - Feathermoss					
	Colluvium	shallow (bedrock)	northerly	02	LL	Pl – Lingonberry - Feathermoss				
			southerly	02	LL	Pl – Lingonberry - Feathermoss				
			deep	northerly	01	SM	Sw – Knight’s plume – Step moss			
				southerly	02	LL	Pl – Lingonberry - Feathermoss			
				(Glacio) Lacustrine	all	northerly	01	SM	Sw – Knight’s plume – Step moss	
						05	SS	SwPl – Soopalallie – Twinflower		
southerly	03	SW	Sw – Wildrye - Feathermoss							

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION	
	5.2. LANDSCAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT				
					81	GB	Grassland	
					82	SB	Scrub	
	Crests	(Glacio) fluvial headscarps	shallow (bedrock)	medium - coarse	02	LL	Pl – Lingonberry - Feathermoss	
					03	SW	Sw – Wildrye - Feathermoss	
			deep	medium - coarse	02	LL	Pl – Lingonberry - Feathermoss	
					03	SW	Sw – Wildrye - Feathermoss	
		Morainial	shallow (bedrock)	medium - coarse	02	LL	Pl – Lingonberry - Feathermoss	
					03	SW	Sw – Wildrye - Feathermoss	
					04	BL	Sb – Lingonberry – Knight’s plume	
					81	GB	Grassland	
			deep	medium - coarse	02	LL	Pl – Lingonberry - Feathermoss	
					03	SW	Sw – Wildrye - Feathermoss	
					05	SS	SwPl – Soopalallie - Twinflower	
					81	GB	Grassland	
			(Glacio) lacustrine	all		02	LL	Pl – Lingonberry - Feathermoss
						03	SW	Sw – Wildrye - Feathermoss
			Bedrock	all		02	LL	Pl – Lingonberry - Feathermoss
						03	SW	Sw – Wildrye - Feathermoss
	81					GB	Grassland	
	82					SB	Scrub	
	Depression	organic	all		09	BH	Sb – Horsetail - Sphagnum	
					10	BS	Sb – Labrador tea - Sphagnum	
					11	SG	Sw - Willow – Glow moss	
					31	BG	Non-forested bog	
					32	FN	Non-forested fen/marsh	
					33	MH	Marsh	

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT			
SBSwk2	Level	Glaciofluvial terrace	shallow (bedrock)	medium - coarse	02	LH	Pl – Huckleberry - Cladina
					03	SC	Sxw – Huckleberry - Highbush-cranberry
					04	BF	SbPl - Feathermoss
			deep	medium - coarse	01	SO	Sxw – Oak fern
					03	SC	Sxw – Huckleberry - Highbush-cranberry
				02	LH	Pl – Huckleberry - Cladina	
		Fluvial	low bench	medium - coarse	05	SD	Sxw – Devils Club
					06	SH	Sxw - Horsetail
			med. bench	medium - coarse	03	SC	Sxw – Huckleberry - Highbush-cranberry
					04	BF	SbPl - Feathermoss
			high bench	medium - coarse	02	LH	Pl – Huckleberry - Cladina
					03	SC	Sxw – Huckleberry - Highbush-cranberry
		Morainal	shallow (bedrock)	medium - coarse	02	LH	Pl – Huckleberry - Cladina
					03	SC	Sxw – Huckleberry - Highbush-cranberry
			deep	medium - coarse	01	SO	Sxw – Oak fern
					03	SC	Sxw – Huckleberry - Highbush-cranberry
		Glaciolacustrine	shallow (bedrock)		04	BF	SbPl - Feathermoss
					03	SC	Sxw – Huckleberry - Highbush-cranberry
			deep		01	SO	Sxw – Oak fern
					03	SC	Sxw – Huckleberry - Highbush-cranberry
			05	SD	Sxw – Devils Club		
	Organic	bog			BG		
		forested fen		06	SH	Sxw - Horsetail	
					FN		
	Toe slopes	(Glacio) fluvial	all		05	SD	Sxw – Devils Club
					06	SH	Sxw - Horsetail
		Morainal	all		05	SD	Sxw – Devils Club
				06	SH	Sxw - Horsetail	
	(Glacio) lacustrine	all		05	SD	Sxw – Devils Club	

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES			SITE SERIES	ECO-UNIT	DESCRIPTION
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT				
						06	SH	Sxw - Horsetail
		Colluvium	all			01	SO	Sxw – Oak fern
						05	SD	Sxw – Devils Club
		Organic	all			05	SD	Sxw – Devils Club
						06	SH	Sxw - Horsetail
Lower Slopes	(Glacio) fluvial	shallow (bedrock)	coarse	northerly	01	SO	Sxw – Oak fern	
				southerly	04	BF	SbPl - Feathermoss	
					01	SO	Sxw – Oak fern	
			medium	northerly	03	SC	Sxw – Huckleberry - Highbush-cranberry	
				southerly	05	SD	Sxw – Devils Club	
				northerly	01	SO	Sxw – Oak fern	
		deep	coarse	northerly	05	SD	Sxw – Devils Club	
				southerly	01	SO	Sxw – Oak fern	
					05	SD	Sxw – Devils Club	
			medium	northerly	05	SD	Sxw – Devils Club	
				southerly	01	SO	Sxw – Oak fern	
					05	SD	Sxw – Devils Club	
	Morainal	shallow (bedrock)	coarse	northerly	01	SO	Sxw – Oak fern	
				southerly	04	BF	SbPl - Feathermoss	
					01	SO	Sxw – Oak fern	
			medium	northerly	03	SC	Sxw – Huckleberry - Highbush-cranberry	
				southerly	01	SO	Sxw – Oak fern	
					05	SD	Sxw – Devils Club	
		deep	coarse	northerly	01	SO	Sxw – Oak fern	
				southerly	05	SD	Sxw – Devils Club	
					01	SO	Sxw – Oak fern	
			medium	northerly	03	SC	Sxw – Huckleberry - Highbush-cranberry	
				southerly	01	SO	Sxw – Oak fern	
					05	SD	Sxw – Devils Club	

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION	
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT				
				southerly	01	SO	Sxw – Oak fern	
					05	SD	Sxw – Devils Club	
		(Glacio) lacustrine	all	northerly	05	SD	Sxw – Devils Club	
				southerly	01	SO	Sxw – Oak fern	
					05	SD	Sxw – Devils Club	
		Colluvium	shallow (bedrock)	northerly	01	SO	Sxw – Oak fern	
				southerly	03	SC	Sxw – Huckleberry - Highbush-cranberry	
			deep	northerly	01	SO	Sxw – Oak fern	
					05	SD	Sxw – Devils Club	
				southerly	01	SO	Sxw – Oak fern	
	Middle Slopes	(Glacio) fluvial	shallow (bedrock)	coarse	northerly	01	SO	Sxw – Oak fern
						04	BF	SbPl - Feathermoss
				southerly	02	LH	Pl – Huckleberry - Cladina	
					03	SC	Sxw – Huckleberry - Highbush-cranberry	
				medium	northerly	01	SO	Sxw – Oak fern
					southerly	02	LH	Pl – Huckleberry - Cladina
					03	SC	Sxw – Huckleberry - Highbush-cranberry	
			deep	coarse	northerly	01	SO	Sxw – Oak fern
					04	BF	SbPl - Feathermoss	
				southerly	01	SO	Sxw – Oak fern	
					03	SC	Sxw – Huckleberry - Highbush-cranberry	
				medium	northerly	01	SO	Sxw – Oak fern
					southerly	01	SO	Sxw – Oak fern
					03	SC	Sxw – Huckleberry - Highbush-cranberry	
		Morainial	shallow (bedrock)	coarse	northerly	01	SO	Sxw – Oak fern
					04	BF	SbPl - Feathermoss	
				southerly	02	LH	Pl – Huckleberry - Cladina	
					03	SC	Sxw–Huckleberry-Highbush-cranberry	
				medium	northerly	01	SO	Sxw – Oak fern

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION		
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT					
			deep	coarse	northerly	01	SO	Sxw – Oak fern	
						04	BF	SbPl - Feathermoss	
					southerly	01	SO	Sxw – Oak fern	
						03	SC	Sxw – Huckleberry - Highbush-cranberry	
				medium	northerly	01	SO	Sxw – Oak fern	
						01	SO	Sxw – Oak fern	
					southerly	03	SC	Sxw – Huckleberry - Highbush-cranberry	
						03	SC	Sxw – Huckleberry - Highbush-cranberry	
				(Glacio) lacustrine	all	northerly	01	SO	Sxw – Oak fern
							01	SO	Sxw – Oak fern
						southerly	04	BF	SbPl - Feathermoss
					shallow (bedrock)		northerly	01	SO
			04					BF	SbPl - Feathermoss
			Colluvium		shallow (bedrock)	southerly	01	SO	Sxw – Oak fern
				02			LH	Pl – Huckleberry - Cladina	
				deep		northerly	01	SO	Sxw – Oak fern
					03		SC	Sxw – Huckleberry - Highbush-cranberry	
					southerly	01	SO	Sxw – Oak fern	
				02		LH	Pl – Huckleberry - Cladina		
			Upper Slopes	(Glacio) fluvial Terrace scarps	shallow (bedrock)	northerly	02	LH	Pl – Huckleberry - Cladina
							03	SC	Sxw – Huckleberry - Highbush-cranberry
							04	BF	SbPl - Feathermoss
						southerly	02	LH	Pl – Huckleberry - Cladina
							04	BF	SbPl - Feathermoss
							deep	northerly	01
					03	SC			Sxw – Huckleberry - Highbush-cranberry
					southerly	01		SO	Sxw – Oak fern
						03		SC	Sxw – Huckleberry - Highbush-cranberry

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION	
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT				
	Morainal	shallow (bedrock)	northerly	02	LH	Pl – Huckleberry - Cladina		
				03	SC	Sxw – Huckleberry - Highbush-cranberry		
				04	BF	SbPl - Feathermoss		
			southerly	02	LH	Pl – Huckleberry - Cladina		
				04	BF	SbPl - Feathermoss		
				deep	01	SO	Sxw – Oak fern	
		03	SC		Sxw – Huckleberry - Highbush-cranberry			
		Colluvium	shallow (bedrock)	northerly	02	LH	Pl – Huckleberry - Cladina	
					03	SC	Sxw – Huckleberry - Highbush-cranberry	
					04	BF	SbPl - Feathermoss	
			southerly	02	LH	Pl – Huckleberry - Cladina		
				04	BF	SbPl - Feathermoss		
	deep			01	SO	Sxw – Oak fern		
		03	SC	Sxw – Huckleberry - Highbush-cranberry				
	(Glacio) Lacustrine	all	northerly	01	SO	Sxw – Oak fern		
				03	SC	Sxw – Huckleberry - Highbush-cranberry		
				04	BF	SbPl - Feathermoss		
				03	SC	Sxw – Huckleberry - Highbush-cranberry		
		southerly	02	LH	Pl – Huckleberry - Cladina			
			03	SC	Sxw – Huckleberry - Highbush-cranberry			
			Crests	(Glacio) fluvial	shallow (bedrock)	02	LH	Pl – Huckleberry - Cladina
						04	BF	SbPl - Feathermoss
	deep	03			SC	Sxw – Huckleberry - Highbush-cranberry		
	Morainal	shallow (bedrock)		medium - coarse	02	LH	Pl – Huckleberry - Cladina	
					04	BF	SbPl - Feathermoss	
	(Glacio) lacustrine	all		medium - coarse	03	SC	Sxw – Huckleberry - Highbush-cranberry	
			02		LH	Pl – Huckleberry - Cladina		
	Bedrock	all	medium - coarse	03	SC	Sxw – Huckleberry - Highbush-cranberry		
02				LH	Pl – Huckleberry - Cladina			

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION	
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT				
	Depression	organic	all		06	SH	Sxw - Horsetail	
ESSFmv4	Level	Glaciofluvial terrace	shallow (bedrock)	medium - coarse	02	LC	BIPl – Crowberry - Cladina	
					03	BT	BISb – Labrador tea	
			deep	medium coarse	01	FR	B1 – Rhododendron - Feathermoss	
					03	BT	BISb – Labrador tea	
						02	LC	BIPl – Crowberry - Cladina
		Fluvial	low bench	medium - coarse	04	RH	B1 – Rhododendron - Horsetail	
					05	FH	B1 – Alder – Horsetail	
			med. bench	medium - coarse	01	FR	B1 – Rhododendron - Feathermoss	
					03	BT	BISb – Labrador tea	
			high bench	medium - coarse	01	FR	B1 – Rhododendron - Feathermoss	
					02	LC	BIPl – Crowberry - Cladina	
		Morainal	shallow (bedrock)	medium - coarse	02	LC	BIPl – Crowberry - Cladina	
					03	BT	BISb – Labrador tea	
			deep	medium - coarse	01	FR	B1 – Rhododendron - Feathermoss	
		Glaciolacustrine	shallow (bedrock)		03	BT	BISb – Labrador tea	
					02	LC	BIPl – Crowberry - Cladina	
			deep		01	FR	B1 – Rhododendron - Feathermoss	
					04	RH	B1 – Rhododendron - Horsetail	
					03	BT	BISb – Labrador tea	
	Organic	bog			BG	fen		
					FN	bog		
		forested		05	FH	B1 – Alder – Horsetail		
	Toe slopes	(Glacio) fluvial	Coarse		01	FR	B1 – Rhododendron - Feathermoss	
medium - coarse				04	RH	B1 – Rhododendron - Horsetail		
Morainal		all		05	FH	B1 – Alder – Horsetail		
				04	RH	B1 – Rhododendron - Horsetail		
(Glacio) lacustrine		all		05	FH	B1 – Alder – Horsetail		
				04	RH	B1 – Rhododendron - Horsetail		
Colluvium		all		01	FR	B1 – Rhododendron - Feathermoss		

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION				
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT							
BGC		Organic	all		04	RH	B1 – Rhododendron - Horsetail				
					04	RH	B1 – Rhododendron - Horsetail				
					05	FH	B1 – Alder – Horsetail				
					Lower Slopes	(Glacio) fluvial	shallow (bedrock)	northerly	01	FR	B1 – Rhododendron - Feathermoss
								southerly	03	BT	B1Sb – Labrador tea
							deep	northerly	04	RH	B1 – Rhododendron - Horsetail
	southerly	01	FR	B1 – Rhododendron - Feathermoss							
		04	RH	B1 – Rhododendron - Horsetail							
	Morainal	shallow (bedrock)	northerly	01			FR	B1 – Rhododendron - Feathermoss			
			southerly	03		BT	B1Sb – Labrador tea				
	deep	northerly	04	RH		B1 – Rhododendron - Horsetail					
		southerly	01	FR		B1 – Rhododendron - Feathermoss					
		04	RH	B1 – Rhododendron - Horsetail							
	(Glacio) lacustrine	all				01	FR	B1 – Rhododendron - Feathermoss			
						03	BT	B1Sb – Labrador tea			
					04	RH	B1 – Rhododendron - Horsetail				
	Colluvium	shallow (bedrock)			01	FR	B1 – Rhododendron - Feathermoss				
					03	BT	B1Sb – Labrador tea				
					deep	01	FR	B1 – Rhododendron - Feathermoss			
						04	RH	B1 – Rhododendron - Horsetail			
	Middle Slopes	(Glacio) fluvial	shallow (bedrock)	northerly	01	FR	B1 – Rhododendron - Feathermoss				
					03	BT	B1Sb – Labrador tea				
				southerly		02	LC	B1P1 – Crowberry - Cladina			
						03	BT	B1Sb – Labrador tea			
			deep	northerly		01	FR	B1 – Rhododendron - Feathermoss			
						04	RH	B1 – Rhododendron - Horsetail			
			southerly		01	FR	B1 – Rhododendron - Feathermoss				
				01	FR	B1 – Rhododendron - Feathermoss					
Morainal		shallow (bedrock)	northerly		01	FR	B1 – Rhododendron - Feathermoss				
					03	BT	B1Sb – Labrador tea				

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES			SITE SERIES	ECO-UNIT	DESCRIPTION	
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT					
				southerly		02	LC	BIPI – Crowberry - Cladina	
						03	BT	BISb – Labrador tea	
			deep	northerly		01	FR	B1 – Rhododendron - Feathermoss	
						04	RH	B1 – Rhododendron - Horsetail	
				southerly		01	FR	B1 – Rhododendron - Feathermoss	
		(Glacio) lacustrine	all	northerly		01	FR	B1 – Rhododendron - Feathermoss	
						03	BT	BISb – Labrador tea	
						04	RH	B1 – Rhododendron - Horsetail	
				southerly		01	FR	B1 – Rhododendron - Feathermoss	
						02	LC	BIPI – Crowberry - Cladina	
		Colluvium	shallow (bedrock)	northerly		02	LC	BIPI – Crowberry - Cladina	
						03	BT	BISb – Labrador tea	
						01	FR	B1 – Rhododendron - Feathermoss	
				southerly		02	LC	BIPI – Crowberry - Cladina	
			deep	northerly		01	FR	B1 – Rhododendron - Feathermoss	
						04	RH	B1 – Rhododendron - Horsetail	
				southerly		01	FR	B1 – Rhododendron - Feathermoss	
	Upper Slopes	(Glacio) fluvial Terrace scarps	shallow (bedrock)	northerly		02	LC	BIPI – Crowberry - Cladina	
						03	BT	BISb – Labrador tea	
				southerly		02	LC	BIPI – Crowberry - Cladina	
				deep	northerly		01	FR	B1 – Rhododendron - Feathermoss
				southerly		02	LC	BIPI – Crowberry - Cladina	
		Morainal	shallow (bedrock)	northerly			01	FR	B1 – Rhododendron - Feathermoss
							03	BT	BISb – Labrador tea
					southerly		02	LC	BIPI – Crowberry - Cladina
				deep	northerly		01	FR	B1 – Rhododendron - Feathermoss
					southerly		01	FR	B1 – Rhododendron - Feathermoss
						03	BT	BISb – Labrador tea	
		Colluvium	shallow (bedrock)	northerly		01	FR	B1 – Rhododendron - Feathermoss	

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT			
	(Glacio) Lacustrine		deep	southerly	03	BT	BISb – Labrador tea
				southerly	02	LC	BIPI – Crowberry - Cladina
				northerly	01	FR	B1 – Rhododendron - Feathermoss
				southerly	03	BT	BISb – Labrador tea
			northerly	01	FR	B1 – Rhododendron - Feathermoss	
				03	BT	BISb – Labrador tea	
				02	LC	BIPI – Crowberry - Cladina	
			southerly	01	FR	B1 – Rhododendron - Feathermoss	
				02	LC	BIPI – Crowberry - Cladina	
				01	FR	B1 – Rhododendron - Feathermoss	
	Crests	(Glacio) fluvial Head of scarp	shallow (bedrock) deep		02	LC	BIPI – Crowberry - Cladina
					02	LC	BIPI – Crowberry - Cladina
					03	BT	BISb – Labrador tea
		Morainal	shallow (bedrock) deep		02	LC	BIPI – Crowberry - Cladina
					02	LC	BIPI – Crowberry - Cladina
					03	BT	BISb – Labrador tea
		Colluvium	shallow (bedrock) deep		02	LC	BIPI – Crowberry - Cladina
					02	LC	BIPI – Crowberry - Cladina
					03	BT	BISb – Labrador tea
		Bedrock	all		02	LC	BIPI – Crowberry - Cladina
				03	BT	BISb – Labrador tea	
Depression	organic	all			BG	Bog	
					FN	Fen	
				05	FH	B1 – Alder – Horsetail	
SWBmk1?	Level	Glaciofluvial terrace	shallow (bedrock)		02		SxPI – Lichen
					05		SxSb – Labrador Tea – Crowberry
			deep		01		Sx – Bearberry – Fuzzy-spiked wildrye
					03		Sx – Bluebell – Horsetail
		Fluvial	low bench		03		Sx – Bluebell – Horsetail
					04		SxSb – Willow - Horsetail
					06		Sb – Labrador Tea – Sphagnum
					01		Sx – Bearberry – Fuzzy-spiked wildrye
	med. bench						

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES			SITE SERIES	ECO-UNIT	DESCRIPTION		
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT						
Toe slopes			high bench			03		Sx – Bluebell – Horsetail		
			fen			01		Sx – Bearberry – Fuzzy-spiked wildrye		
						05		SxSb – Labrador Tea – Crowberry		
						04		SxSb – Willow - Horsetail		
						06		Sb – Labrador Tea – Sphagnum		
		Morainal	shallow (bedrock)				02		SxPl – Lichen	
			deep				05		SxSb – Labrador Tea – Crowberry	
							01		Sx – Bearberry – Fuzzy-spiked wildrye	
							05		SxSb – Labrador Tea – Crowberry	
		Glaciolacustrine	shallow (bedrock)				02		SxPl – Lichen	
			deep				05		SxSb – Labrador Tea – Crowberry	
							01		Sx – Bearberry – Fuzzy-spiked wildrye	
					03		Sx – Bluebell – Horsetail			
	(Glacio) fluvial	Organic	bog			04		SxSb – Willow - Horsetail		
						06		Sb – Labrador Tea – Sphagnum		
		forested					03		Sx – Bluebell – Horsetail	
							04		SxSb – Willow - Horsetail	
							06		Sb – Labrador Tea – Sphagnum	
							01		Sx – Bearberry – Fuzzy-spiked wildrye	
							03		Sx – Bluebell – Horsetail	
			all					01		Sx – Bearberry – Fuzzy-spiked wildrye
								03		Sx – Bluebell – Horsetail
			Morainal	all				01		Sx – Bearberry – Fuzzy-spiked wildrye
						03		Sx – Bluebell – Horsetail		
	(Glacio) lacustrine	all				01		Sx – Bearberry – Fuzzy-spiked wildrye		
						03		Sx – Bluebell – Horsetail		
	Colluvium	all				01		Sx – Bearberry – Fuzzy-spiked wildrye		
						03		Sx – Bluebell – Horsetail		
	Organic	all				03		Sx – Bluebell – Horsetail		
						04		SxSb – Willow - Horsetail		
Lower Slopes	(Glacio) fluvial	shallow (bedrock)	Coarse - medium	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye			

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION			
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT						
				southerly	05		SxSb – Labrador Tea – Crowberry			
					02		SxPl – Lichen			
					deep	coarse	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye
							03		Sx – Bluebell – Horsetail	
					southerly	medium	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye
							03		Sx – Bluebell – Horsetail	
				04		SxSb – Willow - Horsetail				
				southerly	medium	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye	
						03		Sx – Bluebell – Horsetail		
				Morainal	shallow (bedrock)	Coarse - medium	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye
							southerly	05		SxSb – Labrador Tea – Crowberry
							02		SxPl – Lichen	
			deep			coarse	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye
							03		Sx – Bluebell – Horsetail	
			southerly			medium	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye
					03			Sx – Bluebell – Horsetail		
			04			SxSb – Willow - Horsetail				
			southerly		medium	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye	
						03		Sx – Bluebell – Horsetail		
			(Glacio) lacustrine		all	northerly	03		Sx – Bluebell – Horsetail	
							04		SxSb – Willow - Horsetail	
				southerly		01		Sx – Bearberry – Fuzzy-spiked wildrye		
						03		Sx – Bluebell – Horsetail		
			Colluvium	shallow (bedrock)	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye		
						southerly	05		SxSb – Labrador Tea – Crowberry	
				deep	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye		

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION		
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT					
Middle Slopes	(Glacio) fluvial		shallow (bedrock)	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye		
				southerly	02		SxPl – Lichen		
				deep	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye	
					southerly	01		Sx – Bearberry – Fuzzy-spiked wildrye	
				Morainal	shallow (bedrock)	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye
					southerly	02		SxPl – Lichen	
			deep	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye		
				southerly	01		Sx – Bearberry – Fuzzy-spiked wildrye		
			(Glacio) lacustrine	all	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye	
				southerly	01		Sx – Bearberry – Fuzzy-spiked wildrye		
			Colluvium	shallow (bedrock)	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye	
				southerly	02		SxPl – Lichen		
					deep	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT			
BGC				southerly	03		Sx – Bluebell – Horsetail
					01		Sx – Bearberry – Fuzzy-spiked wildrye
					02		SxPl – Lichen
					05		SxSb – Labrador Tea – Crowberry
	Upper Slopes	(Glacio) fluvial	shallow (bedrock)	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye
					02		SxPl – Lichen
				southerly	02		SxPl – Lichen
					05		SxSb – Labrador Tea – Crowberry
			deep	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye
					01		Sx – Bearberry – Fuzzy-spiked wildrye
				southerly	02		SxPl – Lichen
					05		SxSb – Labrador Tea – Crowberry
		Morainal	shallow (bedrock)	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye
					02		SxPl – Lichen
				southerly	02		SxPl – Lichen
					05		SxSb – Labrador Tea – Crowberry
			deep	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye
					01		Sx – Bearberry – Fuzzy-spiked wildrye
				southerly	02		SxPl – Lichen
					05		SxSb – Labrador Tea – Crowberry
	Colluvium	shallow (bedrock)	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye	
				02		SxPl – Lichen	
			southerly	02		SxPl – Lichen	
				05		SxSb – Labrador Tea – Crowberry	
		deep	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye	
				01		Sx – Bearberry – Fuzzy-spiked wildrye	
			southerly	02		SxPl – Lichen	
				05		SxSb – Labrador Tea – Crowberry	
(Glacio) Lacustrine	all	northerly	01		Sx – Bearberry – Fuzzy-spiked wildrye		
			01		Sx – Bearberry – Fuzzy-spiked wildrye		
	southerly	02		SxPl – Lichen			
		05		SxSb – Labrador Tea – Crowberry			

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION	
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT				
BGC					02		SxPl – Lichen	
					05		SxSb – Labrador Tea – Crowberry	
	Crests	(Glacio) fluvial	shallow (bedrock)		02		SxPl – Lichen	
			deep		02		SxPl – Lichen	
		Morainal		shallow (bedrock)		02		SxPl – Lichen
				deep		02		SxPl – Lichen
		(Glacio) lacustrine		all		02		SxPl – Lichen
						05		SxSb – Labrador Tea – Crowberry
		Bedrock		all		02		SxPl – Lichen
						05		SxSb – Labrador Tea – Crowberry
	Depression	organic	all		03		Sx – Bluebell – Horsetail	
					04		SxSb – Willow - Horsetail	
	AT	level	Morainal	Shallow		Moist- Wet herb		Very rare exist only as small units in the basin of a limited number of high elevation circs
						Dry herb / shrub		Very rare exist only as small units in the basin of a limited number of high elevation circs
			Deep		Moist - Wet herb		Very rare exist only as small units in the basin of a limited number of high elevation circs	
Weathered bedrock			shallow		Dry herb / shrub		Very rare exist only as small units in the basin of a limited number of high elevation circs	
Toe slopes / benches / drainages		Morainal, weathered bedrock, colluvium	all		Moist – Wet herb		All very rare except moist to wet areas along drainages	

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION
	5.2. LANDSCAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT			
					Tall willow		Only found as isolated pockets in favorable micro-sites close to the AT and Atp boundaries
					Krummholz		Only found as isolated pockets in favorable micro-sites close to the AT and Atp boundaries
	Lower Slopes	Morainal, weathered bedrock, colluvium	all		Moist – Wet herb		Very rare exist only as small units in the basin of a limited number of high elevation circs
					Tall willow		Only found as isolated pockets in favorable micro-sites close to the AT and Atp boundaries
					Krummholz		Only found as isolated pockets in favorable micro-sites close to the AT and Atp boundaries
	Middle Slopes, upper slopes and crests	All			Dry herb / shrub		
					Tall willow		Only found as isolated pockets in favorable micro-sites close to the AT and Atp boundaries
					Krummholz		Only found as isolated pockets in favorable micro-sites close to the AT and Atp boundaries
					Fell Fields		Most common at higher elevations
	ATp	level	Morainal	Shallow		Moist-Wet herb	Very rare exist only as small units in the basin of a limited number of high elevation circs And upper river and creek basins

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION
	5.2. LANDS CAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT			
						Dry herb / shrub	Very rare exist only as small units in the basin of a limited number of high elevation circs And upper creek and river basins
				Deep		Moist - Wet herb	Very rare exist only as small units in the basin of a limited number of high elevation circs And upper river and creek basins
			Weathered bedrock	shallow		Dry herb / shrub	Very rare exist only as small units in the basin of a limited number of high elevation circs And upper river and creek basins
			All			Forest Units	dry to mesic forested units ecologically equivalent to site series of ESSF or SWB just below.
		Toe slopes / benches / drainages	Morainal, weathered bedrock, colluvium	all		Moist – Wet herb	Rare except moist to wet areas along drainages
						Tall willow	
						Krummholz	
						Forest units	subhygric forested units ecologically equivalent to site series of ESSF or SWB just below. Rare and small in area
		Lower Slopes	Morainal, weathered bedrock, colluvium	All		Moist – Wet herb	rare
						Tall willow	Rare
						Krummholz	Rare

BGC	BIOTERRAIN		5.1. SITE SPECIFIC FEATURES		SITE SERIES	ECO-UNIT	DESCRIPTION
	5.2. LANDSCAPE POSITION	2.0 SURFICIAL MATERIAL	5.3. SOIL DEPTH	5.4. SOIL TEXTURE/ ASPECT			
			All			Forest units	Mesic - subhygric forested units ecologically equivalent to site series of ESSF or SWB just below. Rare and small in area
		Middle Slopes, upper slopes and crests	All			Dry herb / shrub	
						Krummholz	
						Fell Fields	
						Forest units	Mesic - xeric forested units ecologically equivalent to site series of ESSF or SWB just below.

APPENDIX C: AIR-PHOTO TYPING KEYS.

AT/Parkland Photo typing Key

1) Herbaceous ecosystems

1a) Light toned herbaceous, very shallow soils mostly on crest or flat bedrock table Xeric-Very xeric, or colluvium on Northerly aspect usually now shrub present FL

1b) Moderate to darker toned herbaceous not extremely shallow to bedrock, less rarely talus on north aspect, slopes variable moisture usually moister than xeric.

2a) moderate to dark toned herbaceous, **moderate to steep active talus slopes, usually upper slope, subxeric to submesic not crest not, very shallow to bedrock AW**
- normally not associated with shrub willow
- often fairly dark texture associated with high heather component in vegetation.

2b) moderate to dark toned herbaceous, **depressional, level to gentle slopes or steep slope with some influence from up-slope seepage, mesic or wetter, usually not active talus slope, not steep upper.**

3a) Moderate to dark toned vegetation, mesic to subhygric sites, soils usually fairly deep most often on level to moderately steep slopes

4a) Not higher than 100-200 meters of AT boundary and occurring within the parkland, commonly in complex with shrub willow AD

4b) Always at least 100m above AT boundary or else cold air drainage basin at lower elevation within the parkland SD
- often lighter tone than the DM

3b) Dark toned vegetation, depression area in circ - Hygric or wetter FH

2) Avalanche Track – (Herbaceous, and Deciduous Shrub) - VH

- This unit is initiation zone for avalanche tracks descending into lower Climatic Subzones
- Willow shrub and herbaceous units are differentiated by structural stage designation
 - *Tall shrub to pole size units are classified as a structural stage of a treed unit*

3) Avalanche Track – (Mixed conifer and deciduous shrub) - FF

- This unit only in parkland has a darker texture than the VH unit because of conifer abundance

4) Tree islands or discontinuous forested parkland units (eg., FR)

- Take the designation from the appropriate equivalent forested ecosystem from the adjoining forested climatic unit below.

5) (Willow) Krumholtz – FH

- Prostrate, low shrub, alpine fir mats (not tree islands)
- Always very dark texture
-

6) Shrub Willow Meadow - WA

- Fuzzy light textured

Photo-typing Key for ESSFmv4

1a. Canopy dominated by open to moderately closed canopy forest, lodgepole pine, lodgepole pine and black spruce or stunted alpine fir and white spruce on either very wet or very dry conditions. Variable SMR.

2a Cool aspects upper to toe other wise adjacent in depression or adjacent to wetlands. Very open to moderately open canopy of poor pine and black spruce in mid to lower Akie/ Pesika and trench otherwise in headwaters pine can replaced by small alpine fir and stunted white spruce BT (03).

- material variable but dominantly talus and moraine of variable depth.
- SMR (subxeric) submesic to hygric

**Comments: this unit is predominates and is very common on many Northerly aspects.
Within the transition area to SWB this unit will also contain some willow and Birch.**

2b Non-cool aspects SMR always drier than mesic, materials variable. Stands either very poor and open to moderate growth and fairly good crown closure. Black spruce low cover or absent. At lower elevations - up to 1400m - aspen may be present in the stand.

3a Submesic, always warm aspect. Fairly open to moderately closed stands of pine with moderate to good growth. Variable amounts of aspen (normally low cover) can occur up to 1400m. within the trench side walls and closer to the trench FW.

- materials variable but mostly talus and moraine
- almost always on upper to mid-slope
- Elymus inovatus is normally always significant cover

Comments: in the upper drainages this ecosystem is replaced by a more closed canopy alpine fir or alpine fir/spruce forest which is the submesic phase of the FR (01)

3b Subxeric or drier, always crest to upper, always shallow to bedrock or colluvium of variable depths. Most often warm aspects. Very open to open stunted Pine and/or aspen in trench side wall and lower to mid drainages up to 1400m., or stunted open alpine fir and Englemann spruce in upper drainages LC (02)

- ground vegetation often sparse herbaceous, lichen cover highly variable
- at lower elevation stunted aspen is often indicative and dominant on these sites

1b Moderately vigorous to vigorous stands dominated by Englemann spruce and /or alpine fir sites. Not dominated by pine or aspen, black spruce usually not present. Soil moisture regime varies from submesic to hygric. Mostly non-cool aspects.

4a Good to excellent growth often dominated by spruce rather than alpine fir, stands usually not closed canopy. Pine not common. Generally occurring on lower to toe slopes or adjacent to either standing water or moving water (seepage).

5a Occurring on level or depressions or toe of slopes or along significant drainages primarily in valley bottoms - (hygric) trees medium to large and scattered dominantly spruce FH (05)

- materials variable but often include fluvial materials and organic veneers.
- Shrubs are often prominent in the understory

5b Occurring mostly on mid to lower slopes where some seepage adjacent to water courses on significant slopes (subhygric). Canopy not closed usually fairly open or patchy RH (04).

- materials variable though often not shallow soils
- not as common on cool aspects

4b Mid to upper slopes and level (submesic - mesic). Moderate growth, closed canopy forest. At lower elevations pine and aspen may appear in stand. May occur on warm lower slopes. Note pine may dominate warm lower slopes (mesic sites) close to the trench but spruce will usually be noticeably present. FR (01)

- Materials variable but not fluvial or organic.
- Mesic/submesic phases greatly dominate landscape, especially in the upper drainages.

Photo typing key for forested BWBSdk1

1a. Canopy dominated by black spruce, sometimes stunted white spruce, lower slope to toe and depression

2a. Pure stunted Sb and sometimes white spruce, always sparse, tree covered wetland often in wetland complex -BH (09)

- Depressions (level) only, either forested wetlands and/or adjacent to open wetlands
- SMR poor to very poor (hygric to subhygric)
- Material often organic otherwise variable

Comments: fairly common in depressions throughout study area but mostly in trench

2b. Abundant Sb often with variable amounts short Sw and variable amounts of Pl, usually at least moderately low to moderate (20-30%) tree cover, trees short, is not a treed wetland often occurs as narrow ring around forested/non-forested wetlands or in a complex with them, - BC (07)

- Depressions mostly (often level) *but can occur lower slope to toe (subhygric) – often moderately dense with high pine cover*
- SMR imperfect to poor (subhygric to hygric)
- Materials variable, sometimes organic veneer

Comments: fairly common mostly in trench. Has been identified in depressions and also on lower slope seepage areas in mid Akie on unstable glacio-lacustrine deposits

1b. Canopy not dominated by stunted to short black spruce and not in depressions immediately adjacent to tree/untreed wetlands. (otherwise if black spruce abundant always with high Pl). *note that low levels of black spruce and black spruce regeneration can occur in almost all the site series units.*

3a. Dominated by moderately vigorous to vigorous Sw and not adjacent to depression with stagnant water. Sometimes aspen or cottonwood leading with spruce present

4a. Quite open stands Wetter than mesic sites, pine less common than aspen

5a. Streamside/riverside – major drainage - almost always active fluvial or low fluvial bench or (rarely) Toe (hygric), Large open pure spruce or Spruce with cottonwood or Pure cottonwood (aspen and black spruce sometimes present on) - SC (08)

- SMR Hygric or occasionally on “subhygric” low fluvial terrace under influence of high water table
- Fluvial - rarely other materials

Comments: found along Finlay, Ingenika, Akie, Pesika and their major Tributaries

5b. Lower slope to toe also streamside (minor stream usually on gentle to steep hillslope), Moderately open to occasionally open usually with deciduous (aspen and birch) mixed in. Subhygric to hygric.

6a Streamside, lower and toe (subhygric) common throughout BWBSdk1 – SR (06)

Materials variable

Comments: Also on “level” terrain adjacent to wetter ecosystems or on long low gradient seepage slopes: for example on inactive low fluvial terraces and Upper glacio-fluvial terraces of major drainages - immediately adjacent to uplands and on fluvial fans of minor streams exiting steeper ground.

6b Mostly streamside and toe, more rarely lower. Found in trench ,Dell, Lower Akie and Lower to Mid Pesika – Most common on fluvial (hygric to subhygric)

deposits, almost always quite open aspen and/or birch always present. Aspen and Birch can form pure seral stage in this site series. Usually wetter and richer than the SR (06) – seepage water usually obvious. Always 20-30% mapping complex with the SR (06) unit – **SO - spruce oak fern (devils club)**

Comments: uncommon and small in area and always in complex with the SR.
Can sometimes differentiate from SR, on lower slopes, by prominence of deciduous tree cover and less uniform canopy with numerous small openings

4b.(mixed stand) Closed canopy stand dominated by White spruce but pine and aspen both present and often abundant. Moderately vigorous growth, sites generally well to moderately well drained (mesic). Stands have somewhat uneven texture. Normally good crown closure (30%+). **SM (01)**

- SMR: Well drained mesic
- Materials variable

- Dominates medium textured mid slope to level terrain. But also found: Upper slopes on North aspects, on inactive lower fluvial terraces of river valleys - Ingenika and Finlay. High glacio-fluvial terraces under the influence of minor seepage from up-slope. Upper slopes of glacio-lacustrine terraces in Akie and Pesika. Very common on lower colluvial slopes and on mid-slope morainal deposits.

3b. Site not dominated by white spruce. Site dominated by pine, aspen or dwarf shrubs, herbs and grasses. Always mesic or drier (moderately well to very rapidly drained)

7a. Non-treed ecosystem “Climax” species are dwarf shrubs and herbs. Dwarf sages are always present. **KS – Kinnikinnick – Sage “grassland”**

7b. Treed; not dominated by white spruce. Site dominated by pine or aspen with White spruce sometimes present, often low levels. Black spruce may be present.

8a. Canopy dominated by pure pine, tight closed canopy, growth fair, texture of stand very homogeneous - submesic ecosystems. Sometimes abundant aspen, if so, usually level or northerly and pine rather than spruce as minor species **SS (05)**.

- SMR: Well drained, submesic sites
- Materials variable but very dominant on upper fluvial and on glacio-fluvial terraces where no influence of creeks or up-slope seepage.

Comments: may have very minor amounts of black spruce, white spruce or aspen but key photo feature distinguishing this unit from other pine types is dense homogeneous texture.

8b. Canopy dominated by pine either open irregular and/or mixed with other tree species which form important component of stand. Sometimes aspen leading.

9a. Pure Pine, poor growth, very open almost always level inactive high fluvial terraces or glacio-fluvial terraces – rare. **LL (09) or BL (04)**

- SMR: Rapidly drained 0-2 (LL) or 1-2 (BL)
- Material normally always coarse fluvial or glacio-fluvial however occasionally very shallow to bedrock crests – very rare.

9b. Pine with aspen, white spruce or black spruce, irregular canopy

10a Dominant Pine with significant black spruce cover stands have somewhat irregular small tops and very dense canopy. (BL 04)

- level terrain normally coarse (high fluvial bench or glacio-fluvial terrace) most common or rarely level fine textured (glacio-lacustrine terrace).

- SMR: well drained 3-4

10b. Irregular canopy, either pine or aspen dominant but usually some aspen or White spruce in stand.

11a. Fairly open, irregular short Pine or aspen dominated stands, always warm dry exposure, spruce rare or absent (SW 03).

- always steep southerly slope, never level, crest to upper fluvial or glacio-fluvial terraces or crest to mid - shallow to bedrock slopes

- SMR: well to rapidly drained (2-3)

Comments: sometimes in complex with KS unit, rarely with LL unit never cool aspect.

11b. Closed, irregular canopied forest, good to moderate growth. Pine or aspen leading with white spruce usually always present. (SM 01)

- aspect variable but if warm aspect usually lower than mid-slope.

- SMR: mesic (4) – Zonal

- Materials variable, most common on morainal materials, but also on inactive fluvial terraces above influence of groundwater (possible complex with SR unit) or on glacio-fluvial terraces which have seepage effect of small active drainages or pooling in relict stream scars or general seepage from adjoining uplands. Also found on level glacio-lacustrine terraces in Akie-Pesika.

Comments: very common

APPENDIX D: BACKGROUND TO WETLAND ECOSYSTEMS.

This table shows the relationship between the wetland subcategories of wetland units described by Mackenzie and Banner (1997) with the wetland ecosystem mapping units used in this project.

FEN type²	Site Association	Proposed Site Series Code
BB (BWBSdk1) (FA-fen in standing water)	Slender sedge-buckbean-fen moss Scrub birch-slender sedge-fen moss Scrub birch-water sedge-fen moss Beaked sedge-giant water moss	FB (fen moss-buckbean) BP (birch-panicked sedge) BB (Scrub birch-beaked sedge) GS (giant water moss-beaked sedge)
MW (SWBmk1) (FA)(ESSFMv4) (fen in standing water)	Short-fruited willow-water sedge-glow moss Water sedge-fen moss Beaked sedge	SG (short-fruited willow- glow moss) MW (Water sedge-Fen moss) HF (horsetail-fen moss)
WE (FE-fen edge)	Spruce-willow-bog birch-fen moss Spruce-scrub birch- fen moss Spruce-willow-horsetail-sphagnum Spruce-sedge-sphagnum	WE (Willow- Scrub birch) FC (fen moss-crow berry) BF (Bebb willow-feather moss) MF (Maccall's willow-sphagnum)
WP (FP - perched fen)	Barclay's willow-fen moss Water sedge-fen moss	BH (Barclay's willow-horsetail) WP (Water sedge-Bristle stalked sedge)
LG (FS- sloping fen)	Labrador tea-Glow moss	LG (Labrador tea-glow moss)
HG ME- oxbow Marsh)	Swamp horsetail-giant water moss	HG (Horsetail-Giant water moss)
KR (MJ – marl flat)	Marl Flats	KR (Kalms Lobelia- Rush)
RS (MS- shallow lake marsh)	Shallow Lake Margin	RS (Rush - Sedge)
FS (FR- ribbed fen)	Slender sedge-buckbean-fen moss	SF (Slender sedge-Fen moss)
FB (FB- dry basin fen)	Scrub birch-sedge-fen moss Scrub birch-willow-sedge-fen moss	FB (Scrub birch-Sedge) WS (willow-sedge)

² FEN types derived from: Will Mackenzie and Allen Banner. 1997. Classification of Wetland and Riparian Ecosystems in British Columbia. Working draft.

SE Beaked sedge-water sedge
(*FD- saturated* Willow-sedge-sphagnum
basin fen)

SE (Sedge-Asphodel)
DS (drummond's willow-sphagnum)

PW Sandbar willow
(*FL- low bench*) Pacific willow

SG (willow-dogwood)
PW (Pacific willow-Dogwood)

NOTE: Fen types occur as plant associations or complexes of site series. These are not mappable at medium scale (10,000-1:20,000). Fen type is a wetland ecosystem complex mapping unit based on physiographic and drainage characteristics. For the purposes of TEM mapping fen types take the two letter code from the most common site series within the plant association grouping. Because of complex water drainage patterns, mapped fen types designations, in turn, often represent the dominant fen type of a complex of fen types not mappable at present mapping scale. For example: the FE (Fen Edge) type is composed primarily of one or more of 4 FE ecosystems (not mappable at our mapping scale) along with smaller amounts of ecosystems from FA and FD fen types. The FA and FD ecosystems can not be separated as a separate at our mapping scale.

APPENDIX E: LIST OF SITE SERIES.

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
AT			SD	2	Sedge-Dwarf willow moist meadow	Sedges, herbs , grasses and dwarf shrubs including dwarf salix and aven species	variable	Mostly above 1900m, level, lower to upper meso gentle slopes, deep coarse textured soil	cdj	Mesic - subhygric	fsvkw
AT			AD	2	Mountain arnica - Subalpine daisy meadow	Dominated by lush moisture loving herbs including alpine daisy, mountain sagewort, lupine, meadow rue along with mixed grasses.	variable	Lower to upper meso slopes & level coarse textured soils, usually deep, found below 1900m.	djm	Mesic - subhygric	fsvkw
AT			WA	3ab	Willow-Mountain arnica moist meadow	Shrub willow and moisture loving herbs as in DM unit	variable	Lower to upper meso slopes & level coarse textured soils, usually deep usually below 1900m.	cdj	Subhygric - submesic	fsvkw
AT			AW	2	Mountain avens-Dwarf willow	Dry herb-grass, dwarf willows, dwarf shrub typically including avens, heathers, altai fescue, arctic poas, alpine bistort, gentians	Dx, Mv,C	Crest - upper slopes, shallow soils, significant slopes coarse textured soils	jms	Subxeric - submesic	fjkvw
AT			FL	2	Alpine fescue - Lichen dry meadow	Dominated by alpine grasses altai fescue, arctic poas and high mixed lichen cover	Dx,Cv	shallow soils, gentle slopes - rapidly drained coarse textured	jms	very xeric - subxeric	dmkw
AT			HS	2	Horsetail-Sedge fen	Sedges & horsetail	O, Fb	depression, peaty gentle slopes deep soils	pjd	Hygric - subhydric	md
AT			FH	3a	B1-Heather mesic krumholtz	Alpine fir mats under which dwarf willow , heathers and assorted herbs including mountain sagewort may also occur	Variable	rapidly to moderately well drained, shallow coarse textured soils	sc	Subxeric - mesic	fvdkw
AT			VH	2,3ab	Sitka valerian - Indian hellebore avalanche track	Moist herbs and grasses including indian hellebore, Sitka valerian, cow parsnip, arrow leaved groundsel and grasses. Shrub willow dominated phase also recognized which has same herbaceous understory	Variable	Well to imperfectly drained . Avalanche tracks, significant slopes, deep, medium textured soils	dc	Hygric - subhygric	kwcs
AT			GL	N/A	glacier	no vegetation					
AT			PS	N/A	permanent snow	no vegetation					

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
AT			PG	1a	patterned ground	variable invader species chiefly annual herbs	M	mostly level to gentle slopes		mesic-subhygric	f,m
AT			SO	1a	soluflection	variable invader species chiefly annual herbs	M,C	gentle slope or greater		mesic-subhygric	f,m
AT			MO	1a	moraine	variable	M			variable	c,f,m,k,w,s ,d
ESSF	mvp4		SD	2	Sedge - Dwarf willow moist meadow	Sedges, herbs , grasses and dwarf shrubs including dwarf salix and aven species	variable	Mostly above 1900m, gentle level, lower to upper meso slopes, deep, medium textured soil	djm	Mesic - subhygric	cfsvkw
ESSF	mvp4		AD	2	Mountain arnica-Subalpine daisy meadow	Dominated by lush moisture loving herbs including alpine daisy, mountain sagewort, lupine, meadow rue along with mixed grasses.	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	djm	Mesic - subhygric	cfsvkw
ESSF	mvp4		WA	3ab, 3am, 3bb	Willow-Mountain arnica moist meadow	Tall willow and moisture loving herbs as in DM unit	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	djm	Subhygric - submesic	cfsvkw
ESSF	mvp4		AW	2	Mountain aven-Dwarf willow	Dry herb-grass, dwarf willows, dwarf shrub typically including avens, heathers, altai fescue, arctic poas, alpine bistort, gentians	Dx, Mv, C	Crest - upper slopes, shallow soils	sc	Subseric - submesic	fjkvw
ESSF	mvp4		FL	2	Alpine fescue-Lichen dry meadow	Dominated by alpine grasses altai fescue, arctic poas and high mixed lichen cover	Dx, Cv	Gentle slopes, medium-textured, shallow soils	jms	Subseric - submesic	vdmkw
ESSF	mvp4		HS	2	Horsetail-Sedge fen	Sedges & horsetail	O, Fb	depression	pjd	Hygric - subhydric	md
ESSF	mvp4		FH	3a, 3am	BL-Heather krumholtz	Alpine fir mats under which dwarf willow , heathers and assorted herbs including mountain sagewort may also occur	variable	rapidly to moderately well drained, gentle shallow medium textured soils	jms	Subseric - mesic	vkwcf
ESSF	mvp4		FF	3a, 3am, 3ab, 3b	Bl-feathermoss avalanche track	Bl, bog birch feathermosses assorted high elevation herbs	C, M	significant slope, deep medium textured soils	dm	mesic - subseric	wkvsc

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
ESSF	mvp4		VH	2,3ab	Sitka valerian - Indian hellebore avalanche track	Moist herbs and grasses including indian hellebore, Sitka valerian, cow parsnip, arrow leaved groundsel and grasses. Willow dominated phase also recognized which has same herbaceous understory	variable	significant slope, deep medium textured soils	dm	subhygric - hygric	kw
ESSF	mvp4		FR	3a-7 - same as ESSFmv4	BI-Rhododendron - Feathermoss	Se-BI-white-flowered rhododendron black huckleberry, bunchberry, mountain sagewort, feathermosses	variable	upper-mid level, deep medium textured soils	dmj	Mesic	wkcfsv
ESSF	mvp4		FW	3a-7 - same as ESSFmv4	BI-Rhododendron - Wildrye	Se-BI-PI-White flowered rhododendron, black huckleberry, soopolallie, altai fescue, feathermosses	variable	significant slopes, warm aspect, deep, medium textured soils	wdm	submesic	kcfsv
ESSF	mvp4		LC	3a-7 - same as ESSFmv4	BIPI-Crowberry - Cladina	PI-Se-white flowered rhododendron, black huckleberry, twinflower, crowberry, feathermosses, lichens	coarse, shallow soils or F ^G	coarse textured shallow ridged , gentle slope	csrj	subxeric-xeric	dvfwk
ESSF	mvp4		BT	3a-7 - same as ESSFmv4	BISb - Labrador tea	PI-Sb-BI- white-flowered rhododendron, black huckleberry, Labrador tea, twinflower, lingonberry, feathermosses	variable	deep medium textured soils, gentle slope	djm	subxeric-subhygric	svfc
ESSF	mvp4		RH	3a-7 - same as ESSFmv4	BL - Rhododendron - Horsetail	Se-BI-white-flowered rhododendron black huckleberry, bunchberry, bluebells, dwarf scouring rush feathermosses	variable	deep mdium textured soils, gentle slope	djm	subhygric	cfwkvs
ESSF	mvp4		GL	N/A	glacier	no vegetation					
ESSF	mvp4		PS	N/A	permanent snow	no vegetation					
ESSF	mvp4		PG	1a	patterned ground	variable invader species chiefly annual herbs	M	mostly level to gentle slopes		mesic-subhygric	f,m
ESSF	mvp4		SO	1a	solifluction	variable invader species chiefly annual herbs	M,C	gentle slope or greater		mesic-subhygric	f,m
ESSF	mvp4		MO	1a	moraine	variable	M			variable	c,f,m,k,w,s .d

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
SWB	mks		SD	2	Sedge - Dwarf willow	sedges, herbs , grasses and dwarf shrubs including dwarf salix and aven species	variable	Mostly above 1900m, level, lower to upper meso slopes, medium textured soil	dmj	Mesic - subhygic	cfsvkw
SWB	mks		AD	2	Mountain arnica - Subalpine daisy meadow	dominated by lush moisture loving herbs including alpine daisy, mountain sagewort, lupine, meadow rue along with mixed grasses.	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	dmj	Mesic - subhygic	cfsvkw
SWB	mks		WA	3ab,3am 3bb, 3bm	Willow - Mountain arnica moist meadow	Willow - Mountain arnica moist meadow	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	dmj	Subhygic - submesic	cfsvkw
SWB	mks		AW	2	Entire leaved mountain avens - Dwarf willow	dry herb-grass, dwarf willows, bog birch, dwarf shrub typically including avens, heathers, altai fescue, arctic poas, alpine bistort, gentians	Dx, Mv, C	Crest - upper slopes, shallow soils	jms	Subzeric - submesic	fkvw
SWB	mks		SA	3ab, 2	Scrub birch - Altai fescue	dominated by alpine grasses altai fescue, bog birch, arctic poas and high mixed lichen cover, crowberry, lingonberry	Dx, Cv	gentle slopes, deep , medium textured soils	djm	Subxeric - submesic	dsmkw
SWB	mks		HS	2	Horsetail - sedge fen	Horsetail - Sedge fen	O, Fb	depression, organic	pjd	Hygic - subhydic	
SWB	mks		FH	3a	BL-Heather krumholtz	alpine fir mats under which dwarf willow , bog birch, heathers and assorted herbs including mountain sagewort may also occur	variable	significant slope, shallow, medium textured soils	sm	Subxeric - mesic	vkwc
SWB	mks		FF	3a, 3am, 3b	B1-Feathermoss avalanche track	B1, bog birch, willow, feathermosses assorted high elevation herbs	C, M	significant slopes, deep, medium textured soils	dm	mesic - subxeric	wk
SWB	mks		VH	2,3am,3ab	Sitka valerian - Indian hellebore avalanche track	moist herbs and grasses including indian hellebore, Sitka valerian, cow parsnip, arrow leaved groundsel and grasses. Willow dominated phase also recognized which has same herbaceous understory	variable	significant slopes, cool aspect shallow coarse textured soil	cks	subhygic-hygic	w

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
SWB	mks		SB	all SWB st. stages	Sw-Grey-leaved willow-Scrub birch	Sw - Bl, bog birch, shrub willows, mountain sagewort, Sitka valerian, feathermosses	variable	mid-upper, level, gentle slope, deep medium textured soils	dmj	Mesic - subhygric	wkscsv
SWB	mks		SC	all SWB st. stages	Sw-Scrub birch-Bluejoint	At - Sw,-Sb Labrador tea, shrub willow, crowberry, lingonberry, feathermoss	variable	level, upper-lower, significant slope, cool aspect, deep medium textured soils	kdm	subhygric	svfc
SWB	mks		SK	all SWB st. stages	Sw-Juniper-Wildrye	Sw-Bl, juniper, soopolallie, shrubby cinquefoil, bog birch, red bearberry, death camus, northern goldenrod,	Cv,F, F ^G	warm aspect significant slope deep, medium textured soils, warm aspect	dmw	subxeric	s
SWB	mks		SL	all SWB st. stages	Sw-Willow-Crowberry	Sw - Labrador tea, bog birch, willow, lingonberry, feathermoss	variable	significant slope, cool aspect, deep medium textured soils	kdm	submesic-subhygric	svfc
SWB	mks		SS	all SWB st. stages	Sw - Willow-Stepmoss	Sw- Bl shrub willow, Labrador tea, bog birch, lingonberry, bluebells, feathermoss	M,F	deep , medium textured soils, gentle slope	djm	Subhygric	vscwk
SWB	mks		SW	all SWB st. stages except 2	Sw-Arctic lupine-Stepmoss	Sw- shrub willow, soopolallie, Labrador tea, fuzzy wildrye, lingonberry, feathermoss	F ^G ,C,M	crest - upper warm aspect	djm	Xeric - Subxeric	svc
SWB	mks		PL	all SWB st. stages	Pl - Scrub birch - Cladina	Sw - Bl - Pl Soopolallie, Salix, fuzzy wildrye, lichens, feathermosses	shallow to bedrock	significant slope , warm aspect, shallow soils	sw	very xeric - xeric	k
SWB	mks		GL	N/A	glacier	no vegetation					
SWB	mks		PS	N/A	permanent snow	no vegetation					
SWB	mks		PG	1a	patterned ground	variable invader species chiefly annual herbs	M	mostly level to gentle slopes		mesic-subhygric	f,m
SWB	mks		SO	1a	solifluction	variable invader species chiefly annual herbs	M,C	gentle slope or greater		mesic-subhygric	f,m
SWB	mks		MO	1a	moraine	variable	M			variable	c,f,m,k,w,s,d
SWB	mk1		SB	all	Sw-Grey-leaved willow - Scrub birch	Sw - Bl, bog birch, shrub willows, feathermoss	variable	mid-upper, level, gentle slope, deep medium textured soils	mdj	mesic	svfcwk
SWB	mk1		PL	all	Pl - Scrub birch - Cladina	Sw - Bl - Pl Soopolallie, Salix, fuzzy wildrye, lichens, feathermosses	shallow to bedrock	significant slope , warm aspect, shallow soils	sw	very xeric - xeric	k
SWB	mk1		SK	all	Sw-Juniper-Wildrye	Sw-Bl, juniper, soopolallie, shrubby cinquefoil, bog birch, red bearberry, death camus, northern goldenrod,	Cv,F, F ^G	crest upper, warm aspect	dmw	subxeric	s

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
SWB	mk1		SW	all	Sw-Arctic lupine - Step moss	Sw- shrub willow, soopolallie, Labrador tea, fuzzy wildrye, lingonberry, feathermoss	F ^G ,C,M	gentle , deep, medium textured	djm	Xeric - Subxeric	svc
SWB	mk1		SL	all	Sw-Willow-Crowberry	Sw - Labrador tea, bog birch, willow, lingonberry, feathermoss	variable	upper-lower, significant slope, cool aspect, deep medium textured soils	kdm	submesic-subhygric	svfc
SWB	mk1		SC	all	Sw- Scrub birch - Bluejoint	Sw,-Sb Labrador tea, shrub willow, crowberry, lingonberry, feathermoss	variable	upper-lower on northerly aspect, significant slope, deep medium textured soils	kdm	subhygric	svfc
SWB	mk1		SS	all	Sw - Willow - Step moss	Sw- Bl shrub willow, Labrador tea, bog birch, lingonberry, bluebells, feathermoss	M,F	lower toe, gentle slope, deep medium textured soils	djm	Subhygric	vscwk
SWB	mk1		SH	all	Sw - Shrubby ciquefoil - Horsetail	Sw- shrub willow, bog birch, , horsetail, bluebells, coltsfoot, northern sweet-vetch, blue stem, polar grass, feathermoss	F	toe, depression, gentle slope, deep coarse textured soils	cdj	Hygric	vsmwk
SWB	mk1		SD	2	Sedge - Dwarf willow moist meadow	sedges, herbs , grasses and dwarf shrubs including dwarf salix and aven species	variable	Mostly above 1900m, level, lower to upper meso slopes, medium textured soil	dmj	Mesic - subhygric	cfsvkw
SWB	mk1		AD	2	Mountain arnica-Subalpine daisy meadow	Dominated by lush moisture loving herbs including alpine daisy, mountain sagewort, lupine, meadow rue along with mixed grasses.	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	djm	Mesic - subhygric	cfsvkw
SWB	mk1		WA	3ab, 3am, 3bb	Willow-Mountain arnica moist meadow	Tall willow and moisture loving herbs as in DM unit	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	djm	Subhygric - submesic	cfsvkw
SWB	mk1		AW	2	Mountain aven-Dwarf willow	Dry herb-grass, dwarf willows, dwarf shrub typically including avens, heathers, altai fescue, arctic poas, alpine bistort, gentians	Dx, Mv, C	Crest - upper slopes, shallow soils	sc	Subseric - submesic	fjkvv
SWB	mk1		SA	2	Scrub birch - Altai fescue	Dominated by alpine grasses altai fescue, arctic poas and high mixed lichen cover	Dx, Cv	Shallow coarse textured soils - rapid drained	jms	Subxeric - submesic	vdmkw

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
SWB	mk1		BJ	2	Bluejoint - Avens high meadow	Mixed grasses, sedges, tall larkspur, large leaf aven, dwarf nagoonberry, meadow rue	variable	lower, depression, cold air ponding, gentle slopes, deep, medium textured soils	mdj	mesic - hygric	cvfwk
SWB	mk1		WG	3ab,3am, 3bb,3bm	Willow - Groundsel shrub carr	Shrub willow, bog birch, mixed grasses, sedges, Sitka valerian, arrow leaved groundsel, large leaf geum	variable	lower, depression, cold air ponding, gentle slopes, deep, medium textured soils	mdj	mesic - hygric	cvfwk
SWB	mk1		VH	2,3ab,3a m 3bb,3bm	Sitka valerian - Indian hellebore avalanche track	moist herbs and grasses including indian hellebore, Sitka valerian, cow parsnip, arrow leaved groundsel and grasses. Willow dominated phase also recognized which has same herbaceous understory	variable	Well to imperfectly drained. Avalanche tracks, significant slopes slopes	dm	Hygric - subhygric	kw
SWB	mk1		BP	2,3ab	Bluejoint - Cow parsnip avalanche track	Blue joint, bluebells, cow parsnip, white geranium, stinging nettle, tall larkspur, meadowrue, Canada violet, wild strawberry, trailing raspberry. Willow dominated phase also recognized with the same herbaceous understory	variable	Well to imperfectly drained. Avalanche tracks, significant slopes	dm	Hygric - subhygric	kw
SWB	mk1		MW	2,3ab	Water sedge - Fen moss fen	carex lasiocarpa, carex aquatilis	O	Depression, organic	pjd	Hydric	
SWB	mk1		SE	2,3ab+E1 55	Sedge - Asphodel fen	carex, Trichorum caespitosum	O	Depression, organic	pjd	Hydric	
SWB	mk1		WE	3a,3ab,3b ,3bb,4,etc to 7	Willow - Scrub birch fen edge	Stunted spruce, willow, Labrador tea	O	Depression, organic	pjd	Hydric	
SWB	mk1		FS	2	Slender sedge - Fen moss fen	Sedges, trichophorum caespitosum	O	Depression, organic	pjd	Hydric	
SWB	mk1		WP	2,3ab	Water sedge - Bristle stalked sedge perched fen	Sedges, willow, bog birch, horsetail	O	Depression, organic	pjd	Hydric	
SWB	mk1		LG	2,3ab, 3b	Labrador tea - Glow moss sloping fen	Sedges, willow, bog birch, Labrador tea, horsetail	O	Depression, organic	pd	Hydric	wk
SWB	mk1		FB	2,3ab	Scrub birch - Sedge fen	Bog birch, willows, carex, fen edge	O	Depression, organic	pjd	Hydric	

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SWB	mk1		FF	3a, 3b, 3am	Bl-Feathermoss avalanche track	Bl, bog birch feathermosses assorted high elevation herbs	C, M	significant slopes, deep, medium textured soils	dm	mesic - subxeric	wk
BWBS	dk1	01	SM	all	Sw -Knight's plume - Step moss	Sx-Pl - highbush cranberry, prickly rose, soopolalie, one-sided wintergreen, bunchberry, feathermosses	variable	deep, coarse textured soils, gentle slopes	cdj	submesic - subhygric	svfwk
BWBS	dk1	02	LL	all	Pl- Lingonberry - Feathermoss	Pl-Sw- soopolallie, lingonberry, kinnickinik, dwarf blueberry, lichens,	Dx, Cv, F ^G b	deep, coarse textured soils, gentle slopes	cdj	subxeric - xeric	svfwk
BWBS	dk1	03	Sw	all	Sw- Wildrye - Feathermoss	Pl-Sw- soopolallie, fuzzy spiked wildrye, twinflower, feathermosses	variable	significant slope, warm aspect, deep, medium textured soils	dmw	Submesic - subxeric	svfc
BWBS	dk1	04	BL	all	Sb - Lingonberry - Knight's plume	Pl-Sw-Sb- Labrador tea, soopolallie, lingonberry, crowberry, feathermosses	F ^G ,M	north or level, gentle slopes, deep, medium textured soils	dmj	xeric-mesic	ksvfc
BWBS	dk1	05	SS	all	Sw - Soopolallie - Twinflower	Pl- soopolallie, prickly rose, twinflower, kinnickinick, bastard toadflax, feathermoss	variable	upper, north or level, gentle slopes, deep, coarse textured soils	cdj	Submesic - mesic	ksvfm
BWBS	dk1	06	SR	all	Sw - Scouring rush - Step moss	Sw-black current, highbush cranberry, dwarf scouring rush, bluebells, feathermosses	variable	lower - toe receiving sites, gentle slopes, deep, medium textured soils	djm	Subhygric	cvfwk
BWBS	dk1	07	BC	all	Sb - Lingonberry - Coltsfoot	Pl-Sw-Sb- Labrador tea, prickly rose, willow, lingonberry, feathermosses	Mb, F, O	Lower, toe, level - depression, gentle slopes, deep, medium textured soils	djm	Subhygric - hygric	kpcf
BWBS	dk1	08	SC	all	Sw - Currant - Horsetail	Sw-black current, mountain alder, highbush cranberry, horsetails, common mitrewort, bluebells, feathermosses	F,O	level - toe, streamside, gentle slope, deep medium textured soils	dm	Subhygric - hygric	cvfwkj
BWBS	dk1	09	BH	all	Sb - Horsetail - Sphagnum	Sb-Labrador tea, willows, horsetails, sedges, bog cranberry, sphagnum mosses, step moss, glow moss	O	level - toe - depression, organic	pj	subhydric - hygric	
BWBS	dk1		SO	all	Sw- Oak fern	Sw-Devils club, currants, high bush cranberry, oak fern, bluebells, common mitrewort, feather mosses	variable	lower, toe, gentle slope, deep medium textured soils	dmj	subhygric	vfcwk
BWBS	dk1		SO:ao	all	At - Oak fern	At-Bi-Sw-Devils club, currants, high bush cranberry, oak fern, bluebells, common mitrewort, feather mosses	variable	lower, toe, gentle slope, deep medium textured soils	dmj	subhygric	vfcwk

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BWBS	dk1		KS	2	Kinnikinnik - Sage grassland	Common juniper, kinnikinnick, sages, spikelike goldenrod, cut leaf anemone, grasses	shallow soils or F ^G	crest, significant slope, warm aspect, sometimes shallow soils	w	very xeric - subxeric	vscd
BWBS	dk1		BP	2, 3ab	Bluejoint - Cow parsnip avalanche track	Blue joint, bluebells, cow parsnip, white geranium, stinging nettle, tall larkspur, meadowrue, Canada violet, wild strawberry, trailing raspberry. Willow dominated phase also recognized with the same herbaceous understory	variable	Well to imperfectly drained. significant slopes, deep, medium textured soils	dm	subhygric - hygric	kw
BWBS	dk1		BB	2,3ab	Scrub birch - Beaked sedge fen	Carex lasiocarpa, carex aquatilis or utricularis	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		SE	2,3ab	Sedge- Asphodel fen	Carex, Trichohorum caespitosum	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		WE	3ab,3b	Scrub birch - Willow fen edge	Stunted spruce, willow, Labrador tea	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		FS	2	Slender sedge - Fen moss fen	Carex	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		FB	2,3ab	Scrub birch - Sedge fen	Birch willow carex	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		HG	2	Horsetail - Giant water moss oxbow marsh	Equisetum fluvitale	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		RS	2	Rush - Sedge marsh	Scirpus lacustris	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		KR	2	Kalm's lobelia - Rush marl flats	Lobelia kalmii, sedges, rushes	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		PW	3ab,3b	Pacific willow - Dogwood low bench riparian	Salix lasiandra, Equisetum pratense	O	depression, organic	pjd	hydric	n/a
ESSF	mv4	01	FR	all	B1-Rhododendron - Feathermoss	Se-B1-white-flowered rhododendron black huckleberry, bunchberry, feathermosses	variable	mid-upper or level, gentle slopes, deep, medium textured soils	dmj	mesic-submesic	wkvsc
ESSF	mv4	02	LC	all	BIPl - Crowberry - Cladina	Pl-Se- white-flowered rhododendron, black huckleberry, twinflower, crowberry, feathermosses, lichens	coarse, shallow soils or F ^G	crest-upper, ridge or gentle slope, deep medium textured soils	djmr	subxeric-xeric	vfwk

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ESSF	mv4	03	BT	all	BISb - Labrador Tea	Pl-Sb-BI- white-flowered rhododendron, black huckleberry, Labrador tea, twinflower, lingonberry, feathermosses	variable	upper - lower, often northerly, gentle slope, deep medium textured soils	djm	subxeric-subhygric	svfc
ESSF	mv4	04	RH	all	BL - Rhododendron - Horsetail	Se-BI-white-flowered rhododendron black huckleberry, bunchberry, bluebells, dwarf scouring rush feathermosses	variable	mid-toe, gentle slope, deep medium textured soils	djm	subhygric	cfwkvs
ESSF	mv4	05	FH	all	BI - Alder - Horsetail	Se-BI- - Sitka alder, willows, Labrador tea, currants, common horsetail, bluebells, arrow leaved groundsel, leafy mosses	F, O	level - depression, gentle slope, deep medium textured soils	dmj	hygric	cfvs
ESSF	mv4		FW	all	Rhododendron - Wildrye	Se-BI-Pl-White flowered rhododendron, black huckleberry, soopolallie, fuzzy spiked wildrye, feathermosses	variable	upper slopes, significant slopes, warm aspects, deep, medium textured soils	wdm	subxeric-submesic	cfvs
ESSF	mv4		FF	3a, 3am, 3b	BI-Feathermoss avalanche track	BI, rhododendron, feathermosses assorted high elevation herbs	C, M	significant slopes, deep, medium textured soils	dm	mesic - subxeric	wk
ESSF	mv4		AD	2	Mountain arnica-Subalpine daisy meadow	Dominated by lush moisture loving herbs including alpine daisy, mountain sagewort, lupine, meadow rue along with mixed grasses.	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	djm	Mesic - subhygric	cfsvk
ESSF	mv4		WA	3ab, 3am, 3bb	Willow-Mountain arnica moist meadow	Tall willow and moisture loving herbs as in DM unit	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	djm	Subhygric - submesic	cfsvk
ESSF	mv4		AW	2	Mountain aven-Dwarf willow	Dry herb-grass, dwarf willows, dwarf shrub typically including avens, heathers, alai fescue, arctic poas, alpine bistort, gentians	Dx, Mv, C	Crest - upper slopes, shallow soils	sc	Subxeric - submesic	fjkvv
ESSF	mv4		FL	2	Alpine fescue-Lichen dry meadow	Dominated by alpine grasses alai fescue, arctic poas and high mixed lichen cover	Dx, Cv	Shallow coarse textured soils - rapid drained	jms	Subxeric - submesic	vdmkw

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ESSF	mv4		BJ	2	Bluejoint - Avens high meadow	Mixed grasses, sedges, tall larkspur, large leaf aven, dwarf nagoonberry, meadow rue	variable	lower, depression, cold air ponding, gentle slopes, deep, medium textured soils	mdj	mesic - hygric	cvfcwk
ESSF	mv4		WG	3ab	Willow - Groundsel shrub-carr	Shrub willow, bog birch, mixed grasses, sedges, Sitka valerian, arrow leaved groundsel, large leaf guen	variable	lower, depression, gentle slopes, deep, medium textured soils	mdj	mesic - hygric	cvfcwk
ESSF	mv4		VH	2,3ab	Sitka valerian - Indian hellebore avalanche track	moist herbs and grasses including indian hellebore, Sitka valerian, cow parsnip, arrow leaved groundsel and grasses. Willow dominated phase also recognized which has same herbaceous understory	variable	Well to imperfectly drained. significant slopes, deep medium textured soils	dm	Hygric - subhygric	kw
ESSF	mv4		BP	2,3ab	Bluejoint - Cow parsnip avalanche track	Blue joint, bluebells, cow parsnip, white geranium, stinging nettle, tall larkspur, meadowrue, Canada violet, wild strawberry, trailing raspberry. Willow dominated phase also recognized with the same herbaceous understory	variable	Below 1200m Well to imperfectly drained, significant slopes, deep medium textured soils	dm	Subhygric - hygric	kw
ESSF	mv4		SD	2	Sedge - Dwarf willow moist meadow	sedges, herbs, grasses and dwarf shrubs including dwarf salix and aven species	variable	Mostly above 1900m, level, lower to upper meso slopes, medium textured soil	dmj	Mesic - subhygric	cfsvkw
ESSF	mv4		MW	2,3ab	Water sedge - Fen moss fen	Slender sedge, water sedge or beaked sedge	O	depression, organic	pjd	hydric	n/a
ESSF	mv4		SE	2,3ab	Sedge - Asphodel fen	carex, tuft clubrush	O	depression, organic	pjd	hydric	n/a
ESSF	mv4		WE	3ab,3b	Scrub birch - Willow fen edge	Stunted spruce, willow, Labrador tea	O	depression, organic	pjd	hydric	n/a
ESSF	mv4		FS	2	Slender sedge - Fen moss fen	Carex	O	depression, organic	pjd	hydric	n/a
ESSF	mv4		FB	2,3ab	Scrub birch - Sedge fen	Birch willow carex	O	depression, organic	pjd	hydric	n/a
ESSF	mv4		WP	2,3ab,3b	Water sedge - Bristle stalked sedge, perched fen	Sedges, willow, bog birch, horsetail	O	depression, organic	pjd	hydric	n/a

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ESSF	mv4		LG	2,3ab,3b	Labrador tea - Glow moss, sloping fen	Sedges, willow, bog birch, Labrador tea, horsetail	O	depression, organic	pd	hydic	n/a
ESSF	mv4		ME	2	Horsetail - Giant water moss, oxbow marsh	Swamp horsetail	O	depression, organic	pjd	hydic	n/a
ESSF	mv4		RS	2	Rush - Sedge marsh	Common great bulrush	O	depression, organic	pjd	hydic	n/a
ESSF	mv4		KR	2	Kalm's lobelia - Rush marl flats	Kalm's lobelia, sedges, rushes	O	depression, organic	pjd	hydic	n/a
All			BA	1a	barren	variable invader species chiefly annual forbs	variable				w,k
All			CL	1a	cliff	variable but includes mosses and lichens	R	very steep rock scarps		very xeric	w,k
All			ES	1a	exposed soil	variable	variable				c,f,m
All			LB	1a	lava bed	variable, usually high lichen	R	recent lava flows		xeric-very xeric	w,k
All			MU	1a	mudflat sediment	pioneer herbs, possible sparse willow	F	on margin of active streams or delta	a	hygric-hydric	
All			RG	1a	rock glacier	dominated by lichen and mosses	C	slow or rapid mass movement	c	xeric-very xeric	
All			RP	N/A	road surface	pioneer herbs dominate	variable	level to gentle slopes	j	mesic or drier	
All			UR	N/A	urban/suburban	variable	variable	usually not on steep slopes		mesic or drier	
All			BE	1a	beach	variable	L,F	mostly margin of lake or pond	a,j	mesic-suhydric	
All			CB	1a	cutbank	variable	C	unconsolidated materials-steep		mesic-xeric	c,f,m,k,w
All			GB	1a	gravel bar	pioneer herbs, possible sparse willow	F	active watercourses	c,a	subhygric-hygric	
All			GP	1a	gravel pit	variable	F	fluvial or glacio-fluvial materials	c,j,d	sumesic-very xeric	
All			OW	N/A	shallow open water	N/A	N/A	shallow pond			
All			RI	N/A	river	N/A	N/A	not include non-mapable stream			

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All			RU	1a	rubble	variable, often dominated by moss or lichen	C	colluvium usually moderate-steep	c	mesic-very xeric	k,w,
All			TA	1a	talus	variable	C	usually moderate slope or greater	c		k,w,s,d
All			BF	1a	blockfields, blockslopes	variable, usually high lichen	M,C	often at high elevation	c	xeric-very xeric	k,w
All			LA	N/A	lake	N/A	N/A	lake			
All			MS	1a	rubby mine spoils	variable	A		c	mesic-very xeric	k,w
All			PD	N/A	pond	N/A	N/A	pond			
All			RE	N/A	reservoir	N/A	N/A	man made pond or lake			
All			RO	1a	rock outcrop	variable	R	normally steep to very steep		xeric-very xeric	w,k
All			TS	1a	mine tailings	variable	A		c	mesic-very xeric	w,k

APPENDIX F: SAMPLE AIR-PHOTO WITH BIOTERRAIN AND ECOSYSTEM LINEWORK AND LABELS.

