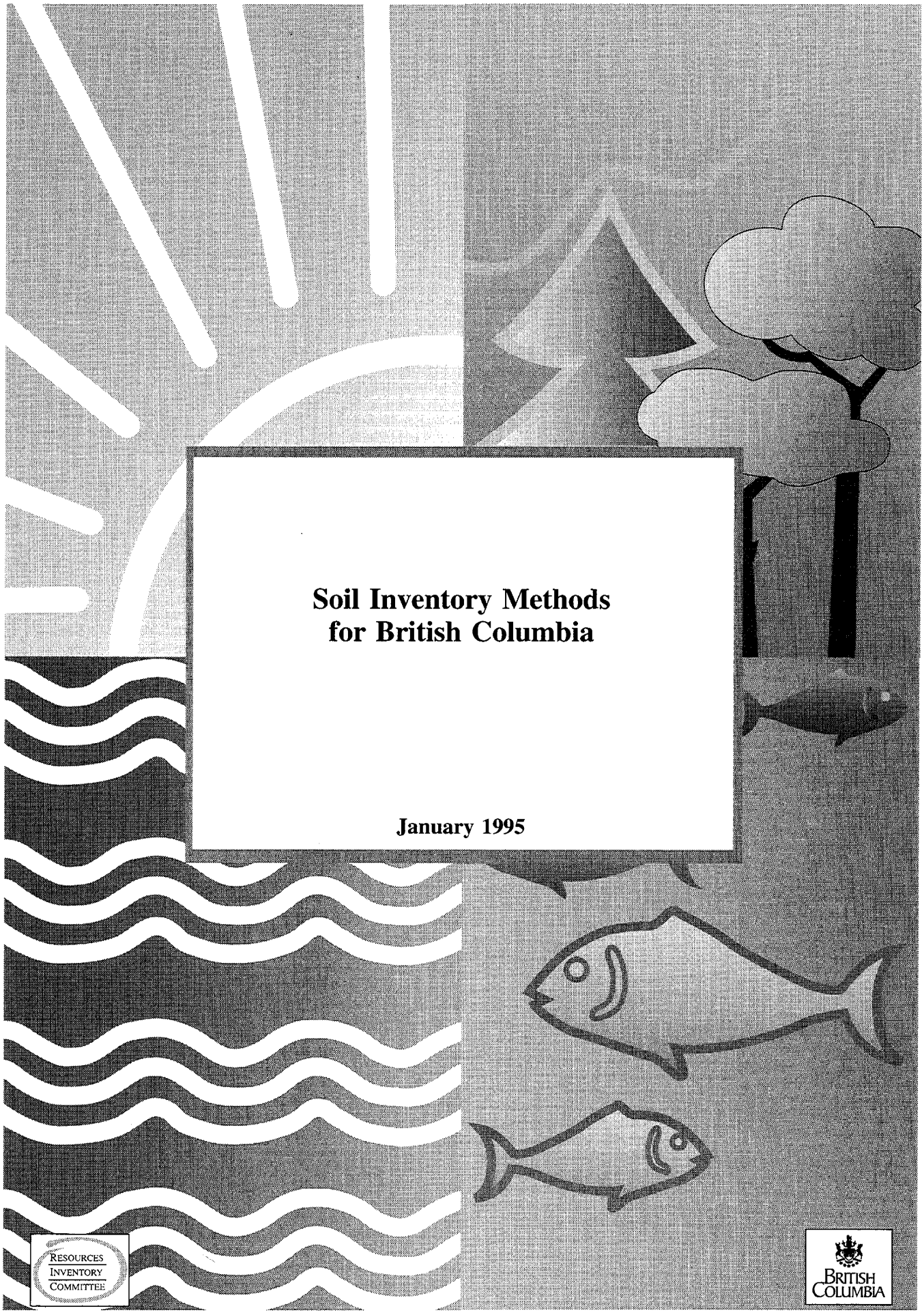

Soil Inventory Methods for British Columbia

January 1995

RESOURCES INVENTORY COMMITTEE

BRITISH COLUMBIA

Resources Inventory Committee

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FOR BRITISH COLUMBIA

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PREFACE

This report has been prepared as part of the Resources Inventory Committee (RIC) initiative to develop inventory standards to support integrated resource management and land use allocation processes in B.C.. The report was coordinated by the Terrestrial Ecosystems Task Force of RIC and follows earlier work undertaken by the Soils Task Group (Walmsley, 1992).

The methods and recommendations put forward in this report are intended to be applied and any changes resulting from this application will be incorporated into future editions of the report. The report provides common standards and methods that are proposed as Provincial requirements for all soil inventory conducted in the Province.

1.0 THE ESSENCE OF SOIL

1.1 Objectives and Purpose of the Manual

At the outset, it is important for the user to know that this is a **"how-to"** manual. The objective of the manual is to provide a discussion of soil inventory methodology and to define what soil inventory is, how it is conducted, and how it can be used for land management. The purpose is to provide a thorough description of the techniques used for field mapping, map unit definition and data interpretation. The manual is intended for use by those who are planning to undertake a soil inventory. It also provides those who wish to utilize existing soil maps and data the means of applying and understanding the consistent and scientifically valid methods used in soil survey. This manual is not a fully comprehensive document in the sense of duplicating other manuals and reports. Rather, it references and incorporates work done by others, and restricts itself to the basic "how-to" purpose.

There are seven publications that are most relevant for understanding how to conduct a soil inventory and which were referenced in the preparation of this document. These are listed below and the reader is encouraged to refer to them should further detail be required[1].

Soil inventories have been conducted in British Columbia for almost seventy years (Agriculture Canada, 1978). The first, in 1926, was undertaken by the B.C. Forest Service in the Central Interior for the purpose of establishing forest reserves. Soil inventories have progressed from this initial work in terms of both mapping scales and the taxonomy used to describe soils, as well as in the definition of map units and the provision of interpretations

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1 Agriculture Canada, Expert Committee on Soil Survey. 1987a. The Canadian System of Soil Classification. 2nd ed. Agriculture Canada. 1646. 164 pp.

Mapping Systems Working Group. 1981. A Soil Mapping System for Canada: Revised. Land Resource Research Institute, Contribution No. 142. Agriculture Canada, Ottawa. 94 pp.

Agriculture Canada Expert Committee on Soil Survey. 1987b. Soil Survey Handbook - Volume 1. Land Resource Research Centre, Contribution No. 85-30. Technical Bulletin 1987-9E. Agriculture Canada, Ottawa.

U.S. Department of Agriculture. 1975a. Revised Soil Survey Handbook. Agricultural Handbook No. 18, Revised. Soil Conservation Service. Washington, D.C.

U.S. Department of Agriculture. 1975b. Soil Taxonomy. Agricultural Handbook No. 436. Soil Conservation Service. Washington, D.C.

Luttmerding, H.A., D.A. Demarchi, E.C. Lea, D.V. Meidinger and T.Vold (eds.). 1990. Describing Ecosystems in the Field - 2nd. Edition. MOE Manual 11, Ministry of Environment and Ministry of Forests. Victoria, B.C. 213pp.

Canadian Society of Soil Science. 1993. M.R. Carton (ed). Soil Sampling and Methods of Analysis. Lewis Publisher. 823pp.

for land use planning and management. Today we find in B.C. a variety of maps, reports and data that collectively are referred to as soil surveys or soil inventories.

The terms "Soil Inventory" and "Soil Survey" are used interchangeably in this manual. They refer to the systematic examination, description, classification, mapping and specified use interpretations of the various soils in an area. The kind and frequency of field examinations defines the level (intensity) of soil survey. Five intensity levels are outlined in Mapping Systems Working Group (1981) and are discussed in following sections of this manual. In all cases, for a map to be called a soil map, the map units must be based largely on soil characteristics (pedons) (Figure 1.1). To say this another way, as long as the map legend (i.e. the map units) is defined in terms of soil parameters, then the map is a soils map. This does not diminish the role of soil scientists and the appreciation of soils information in the preparation of other forms of maps. Biophysical, Ecological and Vegetation maps, to name a few, generally all use some soils-related data in the definition of a map unit. While these maps should not be confused with or described as soils maps, they serve a specific purpose to which the soil scientist can offer input and guidance.

A brief discussion is provided in the following chapters with regard to soil survey intensity and purpose. Of all the conundrums facing the soil scientist who is responsible for the survey, these factors are perhaps the most difficult to resolve. In large measure, these result from the multitude of users who desire to use the information as well as the time and budget available for the work. Often, these are more or less mutually exclusive. It is up to the individual(s) designing the survey to make the appropriate decisions at the outset of the program and to ensure these decisions are adhered to throughout the completion of the workplan. The decisions do not reduce or alter the value of a **general purpose survey** or a **special purpose survey**, but instead point to the need for the soil inventory to have an objective. In all cases, the usefulness of a soil survey depends on the accuracy (regardless of level of intensity) of the mapping of soil properties and the relevance of the properties for the purpose or objective of the survey. A general purpose survey may satisfy many needs but fail to provide the specific requirements that only a special purpose survey can supply (e.g. land suitable for irrigation). On the other hand, special surveys will often concentrate on only a few specific soil parameters and thus may require the survey area to be re-mapped for other applications. Spending the time to fully define the purpose and objective of the soil survey at the planning stage is very important to the utility of the product provided to the user groups. It must also be recognized that land resources consist of a wide variety of natural elements such as hydrology, climate, vegetation, and geology as well as socio-economic factors such as land use, institutional and legislative factors, land ownership and political constraints. Soils constitute a part of this complex array and as such are not usually the sole basis for making decisions on land use and management.

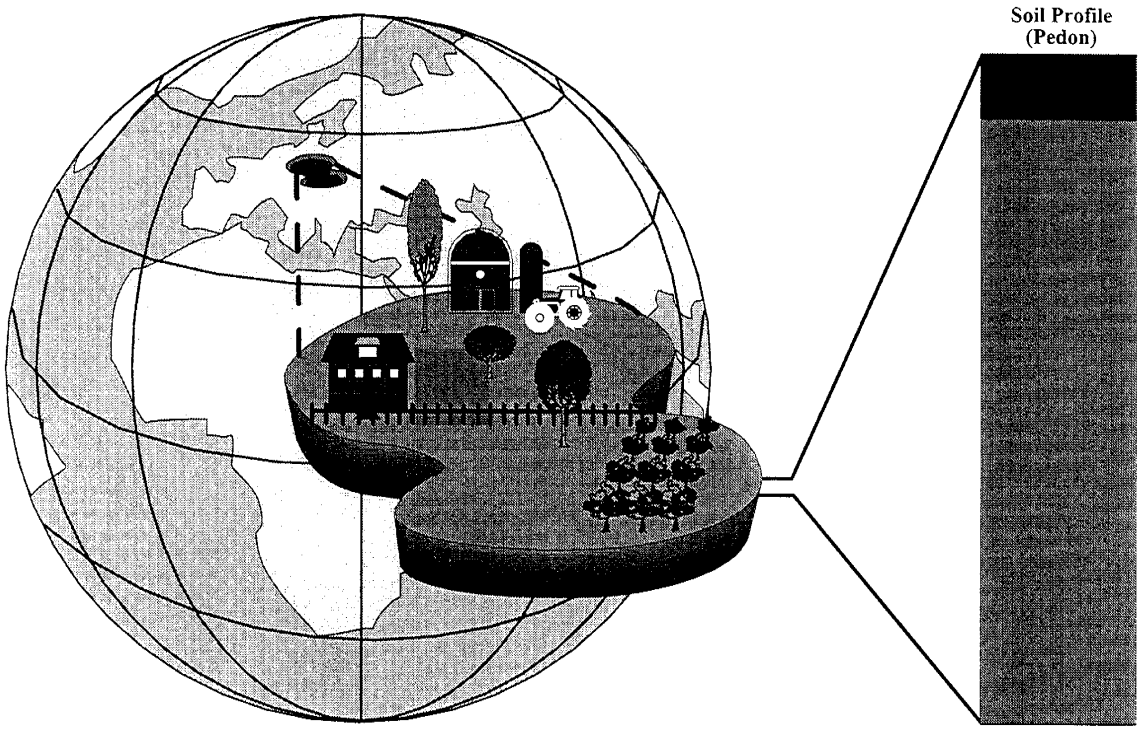

Figure 1.1 A Land unit and the soil profile that characterizes it

1.2 Definition of Soil Classification and Soil Inventory

Soil surveyors have a story to tell. Their science is the link between the animate and the inanimate world; that is, between the world of living things (man, plants, animals) and the physical world of geology, geomorphology, climate and time. The story deals with the character of the soil and soil-like materials that occur in the survey area, where they are located, how they function as part of the landscape and how they can be used. In essence, there are two main objectives of a soil survey:

1. the identification, description and classification of the different kinds of soils in a given area.
2. the identification, prediction and delineation of the different kinds or combinations of soils on a map in a consistent manner.

There are two central products that result from achieving these objectives:

1. a soil map and legend.
2. a soil report or similar related data base (used to describe, define, classify, and interpret for use, the different kinds of mapped soils).

In order for the soil surveyor to meet these objectives and provide these products to the user groups he[2] must have a number of specific definitions and means (or tools) available to him. First and foremost, he requires a definition of what soil is and also a **taxonomy** for classifying the different kinds of soils he encounters in the survey area. Perhaps the most comprehensive and useful definition of soil is that provided by the Soil Conservation Service of the U.S. Department of Agriculture (U.S.D.A, 1975b) which parallels that used in Canada and B.C. (Agriculture Canada, 1987a). That is:

> **"Soil is the collection of natural bodies on the earth's surface, in places modified or even made by man of earthy materials, containing living matter, and supporting or capable of supporting plants out-of-doors."**

In this context, the upper limit of soil is air or shallow water, the margins grade to deep water or barren areas (bedrock, ice, etc.) and the lower limit is the extent of main biologic activity (usually the common rooting depth of native perennial plants). The vertical dimension of soil is defined by what is termed the control section. For mineral soils this extends to a maximum depth of 2 metres and for organic soils to a maximum depth of 1.6 metres. The soil usually (but not always) contains soil horizons (more or less horizontal layers) that differ from each other and from the underlying soil parent material due to the independent and combined interactions among climate, living organisms, parent material and relief acting over a period of time. For the most part, soil is the natural medium for the growth of land plants.

Part of the definition of soil is that it is a "natural body" much like a plant or animal. Similar to these other natural populations, soils are identified by their shape and form (morphology) and are classified by a taxonomic system based on their observed and measured characteristics. In B.C., the Canadian System of Soil Classification (Agriculture Canada, 1987a) is used for this purpose. This system recognizes that soils with variable properties occur as a continuum on the earths surface and that it is necessary to define a basic unit of soil that can be described, sampled, analyzed and classified.

The basic soil unit is called a **Pedon** and it represents a 3-dimensional soil body that usually measures approximately 1 to 3 metres laterally and 1 to 2 metres vertically. It is the Pedon that is used to describe the 3-dimensional nature of soil. To adequately determine the characteristics of a soil, it is not enough to examine only the soil surface but, more importantly, the horizons or layers that make up the soil must be examined and studied as well.

To map soil distribution, it is necessary to classify a unit or area of soil that differs from adjoining units in the landscape due to the interactions of soil forming factors, singularly or collectively, (climate, parent materials, living organisms, time and relief). This recognition leads to the definition of a **Polypedon** which is a group of contiguous, similar pedons that are bounded by either nonsoil or by pedons of differing character (Figure 1.2). While the pedon defines a soil taxonomic unit, a soil map unit may contain more than one kind of pedon.

The Canadian System of Soil Classification provides the taxonomy for classifying soils and, like any classification system, it is an artificial arrangement of things, developed for the purpose of organizing knowledge. The system recognizes sets of soil properties and

---

[2] The term "he" is used only as a convenience; it is to be understood that it includes the feminine as well as the masculine.

provides names for specific soils that are similar, enabling recall of scientific facts and interpretive values about the soil. During the conduct of a soil inventory, the classification system helps to identify map units, to understand and define relationships among soils in the map area, and helps the surveyor remember soil properties that are used in the makeup of the soil map units. However, map units are not necessarily the same as soil taxa since the limits imposed by a soil taxonomic class rarely coincide precisely with a mappable area. The polypedon provides the means for expanding the concept of an individual taxa to the recognition of a map unit.

1.3 The Nature and Purpose of Soil

Soil scientists (pedologists) conduct a soil survey in order to learn what kinds of soils and soil-like material are in the survey area, where they are located, their ecological relationships and how they can be used. The purpose is to produce a soil map that is a 2-dimensional representation of a 3-dimensional landscape (Figure 1.3). This is perhaps the most profound attribute of a soil map in that it is not simply a series of points for which data has been collected but rather the extrapolation of this data to provide the areal extent of a landscape element that is represented by similar points. Hence, the "art" of soil surveying.

The principal intention of a soil survey is one of prediction. Data about soils is gathered and their distribution mapped, in order to predict or forecast their behaviour for various uses and their response to certain management practices. This aim is universal for all soil surveys, regardless of the landscape involved or the scale and intensity of mapping. By its very nature, a soil survey requires that many excavations be made in order to expose the soil profile (the sequence of horizons or layers that make up the soil) and examine it. The soil scientist makes comparisons among the profiles in the map area as well as with others that have been classified in surrounding areas. As well as gathering information on the steepness, length and shape of slopes, drainage patterns, the kinds of native plants, and the kind of bedrock, the soil surveyor groups those soils that have profiles that are similar or alike. These soil groupings are then used to differentiate map units. Depending on the scale and purpose of the survey, these may be as detailed as soil series or phases of soil series, or they may be soil associations where unique natural landscape units are mapped that have a distinctive pattern of soils, relief and drainage pattern. Once the soils of the area are basically understood, the pedologist prepares a legend that acts as a guide to naming and describing the soils that are to be mapped. On aerial photographs and/or base maps, the soil surveyor then draws the boundaries of the individual soil map units. During the progress of a soil survey, samples of soils are taken as needed for laboratory analysis of chemical and physical properties. All of this information, including observed, inferred and measured ratings of suitability and limitations, is then clearly organized in an understandable manner in a soil report and/or digital data base.

1.4 The Use of Soil Inventories

Soil inventories help to increase our knowledge about the natural world we live in but are usually undertaken for a more practical purpose. All soil inventories have objectives which can either be broad or site specific. Historically in B.C., soil inventories have usually been done to satisfy more than a single purpose. They often covered large areas that had more than one kind of important land use and the user groups often had varied interests and needs.

In B.C., soil surveys have been and continue to be used for four basic purposes (a number of examples are provided under each heading):

1. **Land Use Planning**
   - Land Capability and Suitability (e.g. Agriculture, Forestry)
   - Wildlife Habitat Identification
   - Environmental Protection (e.g. water supplies, sewage effluent disposal)
   - Agricultural Practices (e.g. cropping, grazing)
   - The development of new land (e.g. for agricultural purposes).
2. **Site Specific Land Evaluations**
   - On-site Sewage Disposal
   - Irrigation and Drainage
   - Land Reclamation
3. **Land Appraisal**
   - Use by taxation authorities and other organizations to help determine land value.
4. **Environmental Protection**
   - Hazardous Waste Disposal
   - Slope Stability and Soil Erosion

All of these uses of soil inventory information have one feature in common. The soil inventory provides scientific information regarding the potential of each soil for a specified land use, as well as limitations to this use. In addition, locations can be selected where the soil properties are favourable or practices can be planned that will overcome the limitations.

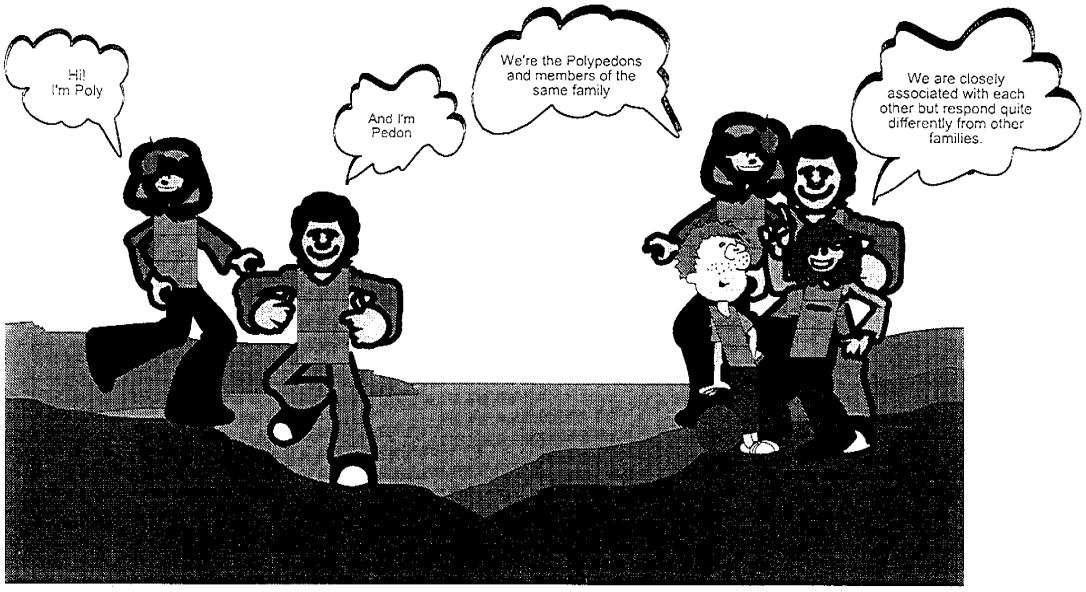

Figure 1.2 Polypedons as units of soil and landscape classification

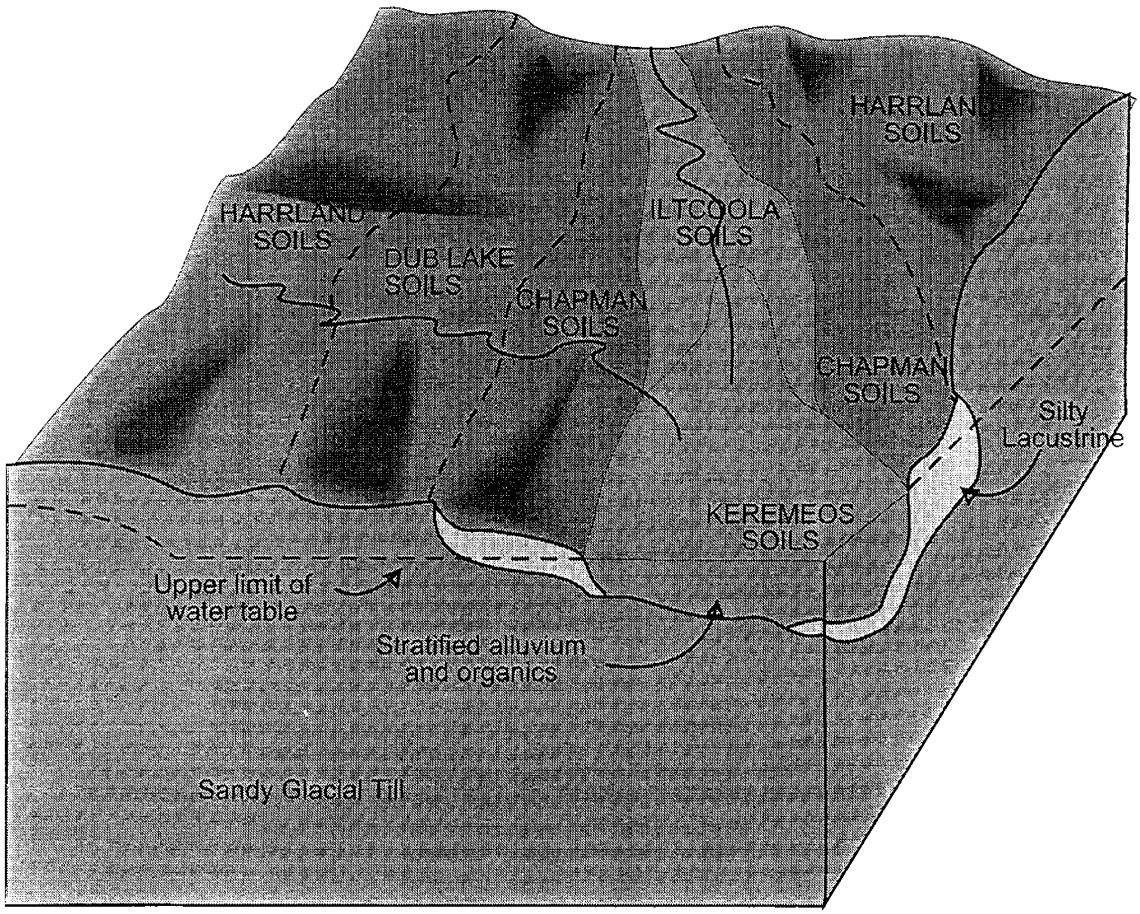

Figure 1.3 The 3-dimensional relationship of named soil units and landscape features

2.0 THE ORGANIZATION FOR A SOIL INVENTORY

2.1 Defining the Purpose and Objectives of the Soil Inventory

As discussed in more detail in other sections of this chapter, it cannot be overstressed that it is essential for the purpose or objective of the planned soil survey to be stated clearly at the outset. Far too often in the past, unclarity of purpose has resulted in confusion and misunderstanding during the conduct and utilization of the survey.

The purpose or objectives of the survey can be simple or complex. They vary according to the uses of soil for which predictions are needed. Essentially all of the decisions which must be made during the planning stage of the survey (e.g. scale, type of map unit) are based on the identification and determination of purpose. Although this may be difficult due to the variety of user groups who wish to use the information from the soil survey, this task must not be omitted or diluted.

2.2 Designing the Soil

The objectives of a soil survey dictate the design of the inventory and how the map is made. From the objective(s) the following decisions should be made:

1. The smallest size of map polygons to be differentiated.
2. Field inspection density required.
3. Map scale.
4. Differentiating criteria for the soil map units.
5. The type of legend to be formulated.

The size of the soil survey area, along with decisions regarding the above points, will determine the schedule for the project and the cost. The type of user groups will have an influence on the style of legend and map symbols as well as on the base maps used for final publication. For example, regional land use planning may require different forms of presentation than would applications for specific forestry land uses. In addition, it will be necessary to decide on the format of the final map and supporting data. For example, will there be an electronic data base and/or hard copy of the maps, legend and supporting data.

Organizational items requiring decisions are not independent; changes in any one usually affects the others, often in a profound manner. Lack of flexibility in any one factor will also influence the others.

2.2.1 Minimum Size Delineation

The minimum size delineation is the size of the smallest polygon on the soil map. It is not the average or usual size, but the smallest area to be shown as a map polygon. The determination is usually based on cartographic considerations related to the ability to print a

symbol inside the polygon, and map legibility. The recommended size is **0.5 cm²**. Some projects may require a minimum size delineation that is larger than 0.5 cm² but this value is generally used by most soil survey organizations. Table 2.1 provides an outline of the relationship between map scale and the size of map delineations. For example, if the objectives of the survey requires that soil areas as small as 2 hectares be differentiated, then the appropriate map scale should not be smaller than 1:20,000. Where specific small features need to be identified, **on-site symbols** (e.g. for excavations) can be used. These, however, should be standardized symbols for the soil survey area. Examples of standard on-site symbols are provided in Mapping Systems Working Group (1981). The use of Geographic Information Systems (GIS) and their associated cartographic methods provide the means of plotting maps at any scale and are a useful tool for displaying and recording soil data and improving map legibility.

Table 2.1 The Relationship Between Map Scale, Map Unit Area (cm²) and Area on the Ground (ha) *

Map Unit Area cm²	Map Scale				
	1:5,000	1:20,000	1:50,000	1:100,000	1:250,000
	(ha)	(ha)	(ha)	(ha)	(ha)
0.25	0.06	1	6.25	25	156
0.5	0.13	2	12.5	50	312
1.0	0.25	4	25	100	625
5.0	1.25	20	125	500	3125
10	2.5	40	250	1000	6250
100	25	400	2500	10000	62500

* From Mapping Systems Working Group, 1981.

Map legibility is important, and is a function of the average size of the map polygons. The use of colour for polygon differentiation aids in map legibility. With todays cartographic tools, legibility is usually not a significant issue unless the average size polygon approaches the minimum size delineation. In addition, the use of digital mapping can lessen concerns regarding legibility since it is possible to specify particular map units and other attributes when making use of the soil map.

2.2.2 Survey Intensity Level and Map

Given that the objective of a soil survey is to provide information on the soil resource to particular user groups for the purpose of predicting soil performance, it is important that the user be provided with an understanding of the **accuracy** and **precision** of the mapping and data gathering. This is fundamental, since interpretations of the soil data are only as useful as the basic information utilized for the interpretations.

While the objectives of the soil survey will determine the level of detail required, there are several terms that require definition in order to communicate these concepts to the user groups (Mapping Systems Working Group, 1981). They have profound implications in terms of the usefulness of the survey, map scale, schedule and cost.

Accuracy (Also referred to as Reliability)

The closeness with which the information portrayed on the map and in the data base conforms to the actual soil characteristics in the field.

Precision (Also referred to as Purity or Level of Detail)

An expression of the range of a soil or soil properties in a map unit. In other words, how much and what types of variability from a mean value for a particular soil characteristic is there within map units that are identified by the same symbol.

Scale

The unit of measurement on the map in relation to the unit of measurement on the ground. For example, a common scale such as 1:20,000 denotes 1 unit of measurement on the map equals 20,000 of the same unit of measurement on the ground. Soil mapping often makes a distinction between a working or compilation scale (for field work) and a publication scale.

For the purpose of soil mapping in B.C. and Canada, precision required in the mapping is determined by **Survey Intensity Level (SIL)**. This term is often used by soil surveyors when they discuss scale. Because precision and SIL are linked, the soil surveyor, when discussing the scale of the soil map with colleagues, is also implying a certain level of detail or precision. The five (5) usual SIL's are defined in Table 2.2.

In an indirect way, the reliability of soil map units can be evaluated by the density of field inspections. Table 2.3 provides examples of the number of inspections per square centimetre that have been commonly used. This table also shows that the use of aerial photography significantly reduces the density of inspections required to achieve the same level of reliability. This may also be the case with other forms of remote sensing such as data and imagery provided by satellites (e.g. LANDSAT and SPOT - the french acronym for Trial Earth Observation System).

Table 2.2 Criteria for Identifying Survey Intensity Levels[3]

Survey Intensity Level (SIL)	Common Name[4]	Definitive Characteristics		Associated Features		Appropriate scale (usual)
		Inspection Intensity	Methods of Investigation	Main Kinds of Soil Components	Map Units[5]	
SIL1	Very detailed	At least one inspection in every map delineation (one per 1-5 ha). Boundaries observed throughout entire length (over 50% in wooded area).	Transects and traverses less than 0.5 km apart. Profile descriptions, samples and laboratory analyses for all soils.	Series or phases of series.	Mainly simple units.	1:14,000 or larger (1:5,000).
SIL2	Detailed	At least one inspection in 90% of the delineations (one per 2-20 ha). Boundaries plotted through observations and interpretation of aerial photographs, verified at closely spaced intervals.	Transects and traverses less than 1.5 km apart. Profile descriptions, samples and laboratory analyses for all major soils.	Series or phases of series.	Simple and compound units.	1:5,000 to 1:40,000 (1:20,000).
SIL3	Reconnaissance	At least one inspection in over 60% of delineations (one per 20-200 ha). Boundaries plotted through observation and interpretation of aerial photographs, verified with some observations.	Traverses mainly by vehicle up to 3 km apart. Profile descriptions, samples and laboratory analyses for most major named soils.	Series or phases of subgroups.	Compound and some simple units.	1:20,000 to 1:200,000 (1:50,000).
SIL4	Broad reconnaissance	At least one inspection in over 30% of delineations (one per 100-1000 ha). Representative delineations studied, remainder spot checked or interpreted. Nearly all boundaries inferred from remotely sensed data and/or aerial photos.	Traverse mainly be vehicle up to 8 km apart. Helicopter may be used in some areas. Profile descriptions for major soils, samples and laboratory analyses for some.	Phases of subgroups.	Mainly compound.	1:50,000 to 1:300,000 (1:100,000).
SIL5	Exploratory	Descriptions in less than 30% of delineations. Mapping by widely spaced observations. Boundaries established by remotely sensed data and/or aerial photo interpretation.	Traverses 20 km or more apart. Use of helicopter common. Profile descriptions for major soils, samples and laboratory analyses for a few.	Phases of Soil subgroups, great groups or orders.	Mainly compound.	1:100,000 or smaller (1:250,000).

[3] Adapted from a Soil Mapping System for Canada: Revised (Mapping Systems Working Group, 1981).

[4] The term "small scale" is often used to refer to reconnaissance or exploratory surveys and "large scale" to detailed and very detailed surveys.

[5] Simple units consist of over 80% of a single component or a non limiting inclusion. Compound units are complexes or associations of 2 or more components, each less than 80%.

Table 2.3 Examples of Soil Survey Inspection Densities (From Vink, 1963)

Scale of map	1 cm^2 on map (ha)	Inspection/cm^2 on map				Hectares/Inspection			
		Grid Sampling	No Aerial Photos	Aerial Photos Used	FAO[8]	Grid	No Photo	Photo	FAO*
1:10,000	1	5	1-5	1-5	0.5	0.2	0.2-1	0.2-1	2
1:20,000	4	5	4-20	0.5-2	0.5	1	0.2-1	2-10	8
1:50,000	25	5	3-6	0.25-1	0.5	5	4-8	3-100	50
1:100,000	100	5	2-20	1	0.5	20	5-50	100	200

* Food and Agriculture Organization of the United Nations, Rome.

Level of detail, **precision**, or **purity** is also associated with the density of field inspections. It is usually taken for granted that greater detail requires a greater number of field inspections. This is usually the case since the need for more detail assumes that the soil map units should have greater purity or less variability. Putting large effort (and therefore cost) into excessive ground-truthing for reconnaissance level mapping may be unwarranted, while not providing enough inspection density for detailed mapping is untruthful and unprofessional. However, it is important to understand that increased precision does not necessarily improve map reliability and therefore inspection density is not always a direct reflection of accuracy. For example, having a large number of field inspections does not necessarily mean that the soil map is more accurate.

Mapping scale is determined as a function of the objectives of the project (implicit in this is Survey Intensity Level), the need for field control, and cartography related to map legibility. Figure 2.1 provides a number of examples of map scale. It is important to remember that a soil map is just that, and not a map of cultural, legal or political features or boundaries. The scale of mapping is a function of the intricacy of the soil pattern in relation to the intensity of soil use for which the survey is undertaken. In other words, where complex soil patterns exist, the potential for a unique soil use (as defined by the survey objectives) may be so low that it is not justified to differentiate the individual soils in detail. In such cases, the ability of the soil survey to define the individual rather than map its real extent may have to suffice. Table 2.4 provides, as a guide only, an outline of the interdependencies of SIL, scale and purpose of the survey. Characteristics such as rate-of-mapping (which are really schedule and cost variables) are very dependent on landscape complexity, prior knowledge about the study area, and experience of the survey team.

For the purposes of soil mapping in B.C., **one inspection per one square centimetre** (relative to the intended **publication scale** of the map) is a recommended guide and the acceptable range, depending on landscape complexity and surveyor experience, should be 0.2 to 2 inspections per cm^2 (Agriculture Canada Expert Committee on Soil Survey, 1987a). All soil surveys should be planned with this concept in mind and any significant deviation

that affects the quality control inherent in a particular SIL must be fully explained and justified.

2.2.3 Differentiating Criteria for the Map Units and Legend Formulation

During the initial design of a soil survey, it is important to establish the criteria, or soil properties and parameters, that will form the basis for recognizing soil map units and differentiating among them. These decisions greatly influence the structure of the map legend and in turn will affect the ease of application of the map by user groups. While this subject is dealt with more specifically in Chapters 3 and 4, some concepts are necessary to apply during the organization of the survey.

Perhaps the most important concept is that soil map units should be designed specifically to meet the needs of the user(s). A soil map can be called such as long as it depicts soils (i.e. the map units are based in a significant way on pedons). Ecological or Biophysical maps containing other differentiating criteria such as climate, physiography or vegetation may still be referred to as soil maps as long as the map unit differentiation recognizes pedons as central or differentiating mapping criteria. For the purpose of clarity, the following definitions should be used for map terminology (from Agriculture Canada, 1987b):

Soil Map

A soil map shows the geographical distribution of various soil classes. The definition does not include maps of single soil attributes such as texture, soil colour, or slope, though these may be derived from the former. They would be called single factor maps such as "soil texture maps".

Soil Survey Map

A soil map made from information collected by field procedures.

Interpretive Map

A map compiled for a particular purpose from information contained in the soils map (e.g. "Suitability For Vegetable Production").

Single Factor Map

A map depicting any one feature derived from the soil map. Interpretive and single factor maps may collectively be called derivative maps or extractive maps.

Generalized Soils Map

A map developed from the recompilation of more detailed published soils information.

Schematic Map

Essentially an interpretive "bestguess" map based on a combination of ancillary information such as aerial photo interpretation and vegetation maps.

Exploratory Soil Map

Differs only slightly from a schematic map and contains about the same level of information but is based on some actual field observations.

Soil/Landform Map

A soils map that combines the genesis of surficial materials, their relief, and form with soil (pedon) factors.

Biophysical or Ecological Map

A map that utilizes regional climate, physiography and plant ecology as differentiating characteristics for map units at broad scales; where soils are used to establish more detailed map units, then these maps may be referred to loosely as soil maps.

Table 2.4 Characteristics and Uses of Different Survey Intensity Levels (SIL)[6]

SIL	Range in Scale (usual)	Minimum-size Delineation[7] (usual)	Approximate Rates of Progress		Typical Objectives
			Mapping[8]	Map Support[9]	
SIL1	1:14,000 or larger (1:5,000)	0.4 ha (0.1 ha)	1250 ha/mo	50%	Very intensive planning that requires appraisal of the soil resource of very small areas. The map units are very refined and can provide soils data for such uses as defining experimental plots or predicting characteristics of septic fields.
SIL2	1:5,000 to 1:40,000 (1:20,000)	0.1 ha to 10 ha (2 ha)	5000 ha/mo	75%	Information for many purposes down to the level of local planning for groups of farms, stream catchments, small parks or irrigation management. It will not likely be used for specific site selection.
SIL3	1:20,000 to 1:130,000 (1:50,000)	2 ha to 80 ha (12.5 ha)	25 km^2/mo	100%	Information for a limited number of uses to the level of farming areas, county planning, major stream catchments, large parks, irrigation districts, or wildlife habitat differentiation.
SIL4	1:50,000 to 1:300,000 (1:100,000)	12.5 ha to 450 ha (50 ha)	200 km^2/mo	75%	Information for relatively generalized purposes to the level of large agricultural areas, regional plans, and wildlife habitat and ecological characteristics.
SIL5	1:100,000 to 1:1,000,000 (1:250,000)	50 ha to 5000 ha (300 ha)	700 km^2/mo	30%	Information for a few general purposes for broad regional or provincial plans, and regional wildlife habitat assessment.

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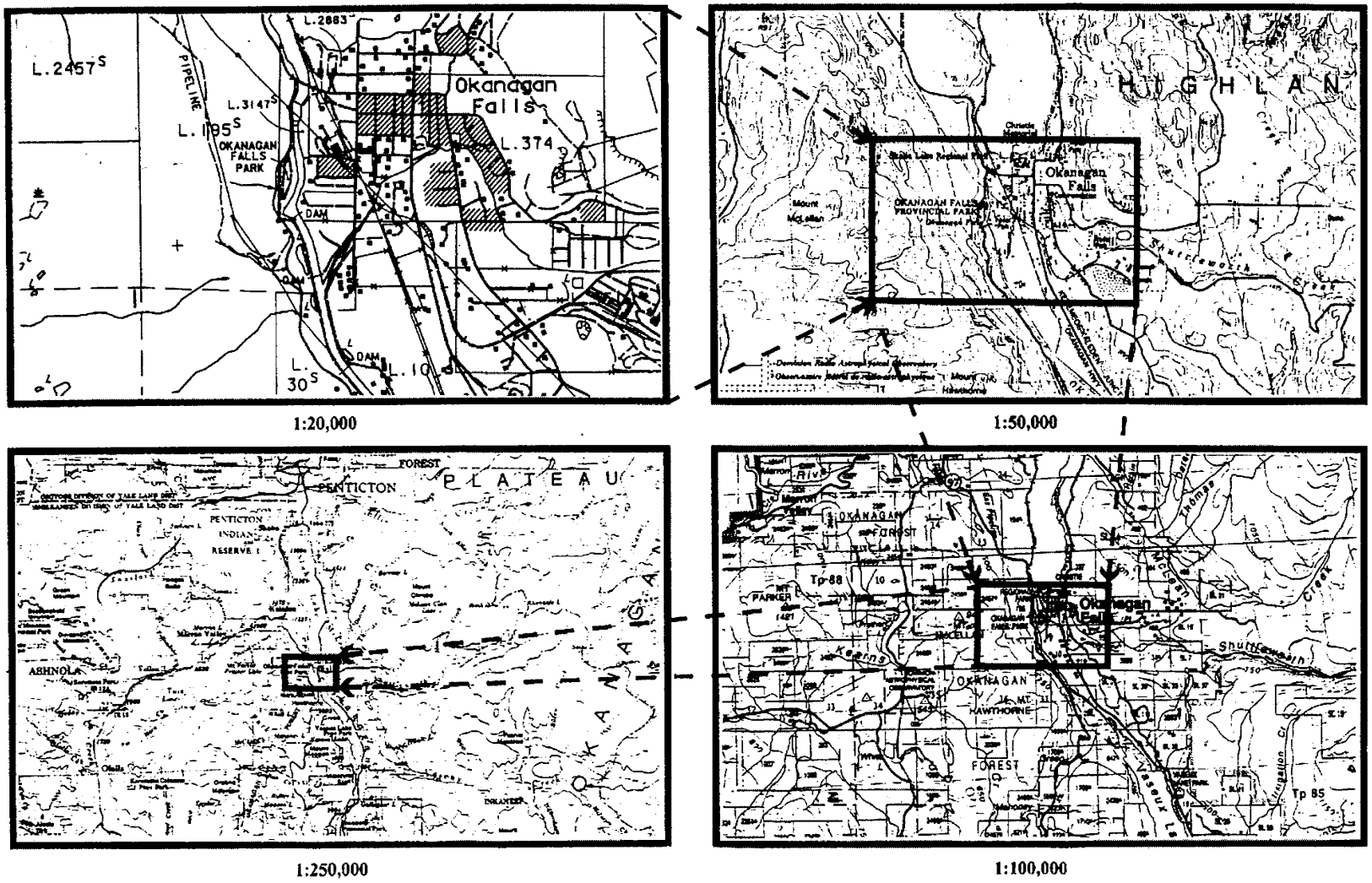
[6] Adapted from Agriculture Canada Expert Committee on Soil Survey, 1987a.

[7] Based on a minimum of 0.5 cm^2 on map (see Table 2.1). In practice the minimum sizes are generally larger than this.

[8] Based on experienced surveyors in areas of good access. Considering a 20 day month for 1 crew. (Usually 2 people).

[9] Values are given as a percentage of mapping rates and includes legend establishment, checking, correlation and sampling.

Figure 2.1 Maps of the Same Area at Different Scales



One other concept that is sometimes misunderstood is the relationship between soil taxonomy and soil map units. This is perhaps to be expected, since names like Chernozemic and Luvisolic tend to be foreign to most users. Map units represent real divisions of the land and as such will often contain more than one taxonomic group. Map units are established to meet the objectives of the soil survey and not necessarily the categories of the soil taxonomy. In other words, a change in soil taxa across the landscape does not necessarily result in a change in the map unit. The Canadian System of Soil Classification has five categorical levels within which numerous taxonomic groups occur (the **Soil Order**, **Soil Great Group**, **Soil Subgroup**, **Soil Family** and **Soil Series**). These taxonomic groups allow the soil surveyor to organize an understanding of the soils so that soil properties can be more easily defined and presented.

Each of the five categorical levels in the Canadian System of Soil Classification are briefly defined as follows. They are each subdivisions of the next higher category.

Soil Order	Differentiation on the basis of properties that reflect the nature of the soil environment and the effects of the dominant soil-forming process (e.g. time). There are nine Soil Orders defined in the Canadian System of Soil Classification (1987a).
Soil Great Group	Differentiation within the Soil Order on the basis of properties that reflect differences in the strengths of a dominant process or a major contribution of a process in addition to the dominant one. For example a Luvic Gleysol is differentiated on the basis of gleying (water saturation) but clay translocation is also a major process. There are 28 Great Groups defined in the Canadian System of Soil Classification (1987a).
Soil Subgroup	Differentiation within the Soil Great Group on the basis of the kind, arrangement and relative prominence of soil horizons; for example, the presence of an ortstein horizon in a Humo-Ferric Podzol soil. There are 193 Subgroups defined in the Canadian System of Soil Classification (1987a).
Soil Family	Differentiation within the Soil Subgroups on the basis of parent material characteristics such as texture and mineralogy, soil climate factors and soil reaction.
Soil Series	Differentiation within the Soil Families on the basis of detailed features of the pedons. Soil series have similar kinds and arrangements of horizons whose colour, texture, structure, consistence, thickness, reaction and composition all fall within a narrowly defined range.

In mapping, the soil surveyor distinguishes a limited number of soil groupings which are repetitive on similar landscapes and have attributes that vary within specific limits. In order to accomplish this, the surveyor makes use of the soil taxonomy as an aid. While map units are named for and correlated to the taxa, they are not the same thing. In other words, a pedon is a real unit of soil in the landscape, whereas a taxonomic category (e.g. Soil Series) is a conceptual class with defined limits. A pedon is not necessarily a soil series since the attributes of only one pedon may not encompass the complete range of attributes allowable within a series. However, a **polypedon** can accommodate this concept of the landscape and

therefore forms the link between the science of the pedon and the art or conceived nature of the taxonomic class.

2.3 Planning the Soil Inventory and the Preparation of a Workplan

Soil surveys consist of much more than a field mapping exercise. As illustrated in Figure 2.2, there are several component parts that make up a project and its work plan. These can be categorized as:

1. Initial Request for the Soil Survey and its Evaluation.
2. Preparation of Technical Project Plan.
3. Preparation of Management Plan.
4. Mapping Program.
5. Publication Plan.

Each of these component parts is essential for the soil survey to culminate in providing the desired end result. Failure to fully address them at the outset of the survey can greatly affect the outcome. Of all these components, the preparation of a clear and comprehensive statement of objectives and purpose is of utmost importance. This must be accomplished as a joint initiative of those who will be responsible for the survey (and their staff who will conduct the survey), the group or agency who is requesting the survey (as well as the group(s) or agency(ies) who are funding the project if they are separate), and where possible, the users of the soil survey information. As illustrated in Figure 2.2, if the objectives for the survey that are finalized as part of the Technical Project Plan cannot mesh with the schedule, funding and staffing criteria then either the objectives must change (e.g. area of survey; survey intensity level) or the project should not proceed.

Project management is an essential element in the project plan. It is the responsibility of the manager to ensure that the project plan is followed, and that technical, fiscal, staffing and scheduling responsibilities are assured. In most instances, it is not appropriate for the project leader (often referred to as the Party Chief) to also be the project manager since the duties and skills required are often quite different.

To assist in the preparation of a project plan, it is often useful to use a form or checklist to ensure that essential elements are not missed, and to aid in communication with other agencies or individuals involved in the survey. Forms of this type are also useful in formulating the management plan and in providing a record for periodic reference during the conduct of the survey for quality control purposes. Appendix A provides an example of forms for project planning that were developed by Agriculture Canada. While it may not be necessary to utilize such a comprehensive form for all soil inventory programs, any soil survey should include the preparation of similar forms, perhaps taking the essential elements from the one provided in Appendix A, in order to help ensure the success of the project.

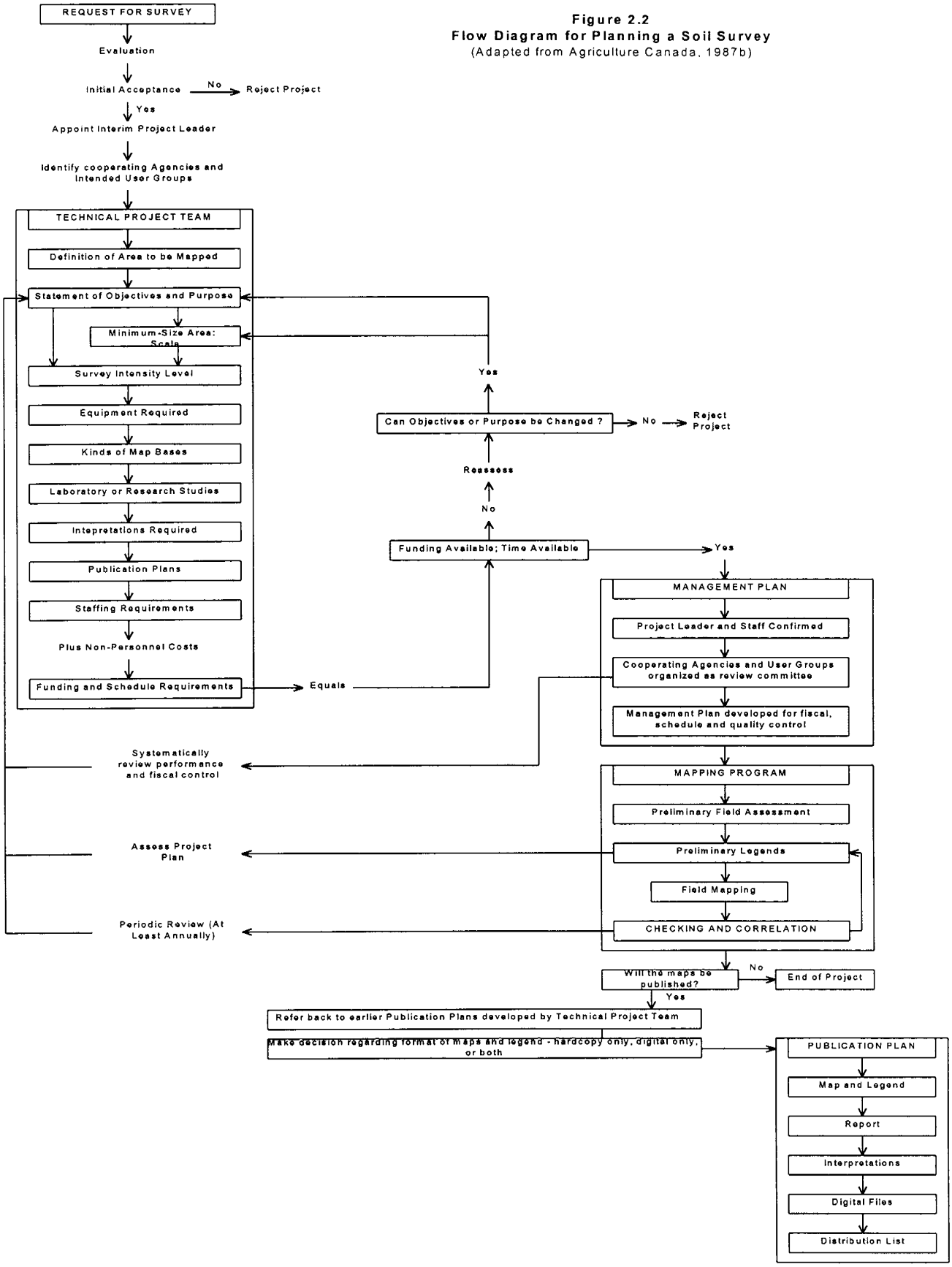
2.4 Qualifications of Soil Surveyors

As in any field of science or technology, it is necessary for the practitioner to have a basic set of skills, education, training, and accreditation.

For the purpose of conducting a soil survey in B.C. as the pedologist in-charge (party leader or party chief) and for undertaking interpretations of the information, the following qualifications are suggested as a minimum.

- at least 5 years of field soil mapping experience working under the direct supervision and guidance of a qualified soil surveyor.
- a technical school or university degree in natural resource sciences specializing in inventory methods; one of the major fields of study must be soil science.
- professional accreditation in a provincially recognized Institute or Association (e.g. B.C. Institute of Agrologists; Association of Professional Engineers and Geoscientists - as a geoscientist; Association of B.C. Professional Foresters).

Figure 2.2
Flow Diagram for Planning a Soil Survey
(Adapted from Agriculture Canada, 1987b)



3.0 PRE-FIELD ACTIVITIES

3.1 Confirming Purpose and Objectives

The initial phase of the planning process has been discussed in Chapter 2. At this juncture, it is presumed that the basic objective of the soil inventory and the user groups have been identified and adequate funding provided. It is important now to re-confirm these items and begin detailed planning for the project. These tasks are usually the responsibility of the Project Leader (or Party Chief) in close consultation with the Project Manager. At this point, the completed Project Plan should be referred to and amended where necessary to incorporate the detailed plans. For example, it is necessary to ensure that personnel and equipment are assembled to achieve the aims of the project, that necessary funding is allocated, and that the schedule for completion is understood and accepted by all agencies and individuals involved.

Factors that must be examined by the Project Leader and the Project Manager and, if necessary, more explicitly described, are discussed under the following sub-headings.

3.1.1 Schedule and Budget

A detailed schedule indicating key milestones, personnel allocation (person-days), tasks and costs should be prepared and agreed upon. At a minimum, the key milestones should include:

- Starting date of the field work.
- Completion date for the field work (multi-year projects should show this detail).
- The date when base maps and aerial photography will be required for field work and the production of the final map.
- The date when the manuscript maps will be ready for drafting (and/or digitizing) and when they are required to be completed.
- The date the draft report will be available for editing.
- The date for final publication.

3.1.2 Determination of Survey Area

In order to avoid any confusion regarding the area to be surveyed, a map (most often a National Topographic Series Map) should be prepared that clearly outlines the boundaries of the map area. The size of the map area (ha, acres or km^2) should be determined from this map.

3.1.3 Interpretations

The interpretations required from the soil survey should be specified and the methods to be employed in performing the interpretations should be documented. In addition, those individuals or agencies responsible for undertaking the interpretations should be specified.

Special studies, as well as data other than that provided by the soil inventory, should be identified and the responsibility assigned to an individual or agency. These requirements should be factored into the project schedule.

3.1.4 Relationship to Other Surveys

The soil inventory may be one component of an overall survey of the project area. There may be several other inventories taking place (e.g. Forest Inventory, Terrain, Wildlife Habitats, etc.) and the relationship and use of the soil inventory with respect to its integration with these other inventories must be fully described and understood.

3.1.5 Differentiating Criteria for Map Units and Format of Map Legend

The soil related criteria and parameters which will be used to differentiate map units such as wetness, texture, stoniness, slope, etc., and their class limits, must be decided upon and recorded. In most cases, these values will be determined by the interpretations that are required from the soil map and data base. The type of soil map legend (e.g. open, closed) should be determined.

The publication **Describing Ecosystems in the Field** (Luttmerding, et al, 1990) is an excellent source document for the definition of various criteria which are often used to describe soils and landscape characteristics and to differentiate map units. As an example, for detailed soil survey (SIL 1 or 2), ten classes of slope may be used ranging from 0% (level) to greater than 100% (very steep) whereas these classes can be grouped for less detailed survey (e.g. 5 classes for SIL 3).

3.1.6 Kind and Intensity of Field Procedures

The Survey Intensity Level (SIL) should be decided upon as a function of the accuracy required. Standards of accuracy and precision are fundamental requirements for the survey program and will be subject to critical review during the correlation phase of the project and any statistical testing of the survey results.

3.1.7 Minimum Size Delineation and Map

The individuals responsible for the soil survey and the user group(s) must decide on the minimum size for a map unit delineation as well as the map scale. As outlined in Chapter 2, the minimum size delineation should be approximately 0.5 cm^2. Map scale, and by corollary Survey Intensity Level, should be chosen so that the required legibility is not compromised and fits the needs of the map users.

3.1.8 Special Equipment

Depending upon the objectives of the soil survey and the nature of the landscape being examined, it may be necessary to assemble equipment that is not part of a normal soil survey. Such items might include backhoes for excavation, special equipment for measuring infiltration rates or helicopters for access to remote sites.

3.1.9 Soil Sampling, Laboratory Analysis and Research

Obtaining samples of soil within the map area, either prior to or during the conduct of the field mapping, is normally done to properly characterize the map units or support the interpretations to be made from the survey. Special sampling and analysis may also be done for research or purely scientific purposes but this is usually beyond the objectives of a standard soil survey. The publication **Soil Sampling and Methods of Analysis** (Canadian Society of Soil Science, 1993) provides a thorough description of recommended techniques.

The types of physical and chemical analysis required for characterizing the soils and map units should be specified and a laboratory selected to perform the work. An estimate of the number of samples and analytical procedures should be made and incorporated into the budget and schedule. Any research or special studies that are needed to support map unit characterization or interpretations of the data should also be identified and addressed in the budget and schedule.

Some of the more common analyses that are conducted for the purpose of verifying field estimates and providing information for taxonomic needs are listed as follows. Where a new soil is being defined (e.g. a new Soil Series), a minimum of three soil profiles should be sampled for analysis, and more comprehensive analytical work may be required. If the soil has been previously defined and characterized, including chemical and physical analyses, then sampling one soil profile is usually sufficient.

- pH (0.01M $CaCl_2$)
- particle size (% sand, silt and clay) and coarse fragment content
- organic matter (% organic carbon)
- iron and aluminum (sodium pyrophosphate extractable)
- electrical conductivity (mS/cm^2)
- available water storage capacity (cm H_2O/metre of soil)
- exchangeable cations (Ca, Mg, Na, K) and cation exchange capacity

3.1.10 Map and Report Publication and Dissemination

Since the map publication format affects the legend format and often the type of map unit symbol, it is important to decide on the scale and type of map bases that will be utilized for the manuscript and published (if required) maps. In this regard, decisions are required on:

- Type of base map (topographic, cadastral, photo mosaic, etc.).
- Digitizing the map polygons, symbols, sample site data, etc.
- Database characteristics: polygon numbers, acreage, statistics, etc.
- Colour or black and white; or combination of colour and black and white.
- Graphics and photos required for the report.
- How will the report and maps be reproduced (diazo; microfiche; printed by offset press; photocopied; computer plotted).
- How many copies are required, who will distribute them, who will receive them and where will copies be stored for future distribution.

3.2 The Use of Existing Information and Preliminary Field Studies

As in any orderly research program, it is necessary to assemble the existing information about the soil survey area that is pertinent to the objectives of the survey in order to save the time and money associated with duplicating previous work and to avoid costly errors. Accuracy and efficiency can be greatly aided by assembling background information, reviewing it for applicability and validity, and utilizing it in the survey program. In fact, the gathering and review of existing information should be undertaken early in the planning process since it can have impacts on scheduling and budgeting. The examination of such information should not be restricted to only that available for the intended survey area, but should also include surrounding areas for which soils and other information will be of benefit in understanding landscape relationships and during correlation activities. For example, many of the soils in the survey area may already be defined in adjacent areas.

In B.C., the most useful background data sources include, but are not limited to, the following:

- Previous soil survey and interpretive maps and data; these are usually from older surveys and often at smaller scales.
- Aerial photography, mosaics and remote sensing imagery; the age and scale of the photography should be considered in determining their usefulness for the survey and new aerial photography should be ordered well in advance of the survey if the quality, age, or scale of the existing photography is inadequate; LANDSAT and SPOT satellite images should be examined for their usefulness in meeting the survey objectives.
- Topographic (NTS), TRIM (Terrain Resource Information Management) and Cadastral/Planimetric map bases; these map bases and the digital files associated with the TRIM program, and some others, are available for parts of B.C. from Maps-BC and appropriate versions of them should be obtained for field use and perhaps final map production.
- Natural resource information (maps and reports) other than soil surveys are often valuable aids in understanding landscape relationships; these include: forest cover; terrain and surficial geology; bedrock geology; ecological/biophysical/biogeoclimatic; hydrological; and climatological maps and information.
- Research studies; often research institutes (e.g. Agriculture Canada; Canadian Forest Service; research branches of various provincial ministries) as well as Universities and Colleges have undertaken research studies (often as post-graduate thesis studies) within or adjacent to the survey area; these studies should be obtained and reviewed.
- Information gathered by the private sector; these include studies conducted by consultants, private companies (e.g. forestry and mining companies) and Crown Corporations for the purpose of land development or environmental impact assessment; where available, these studies should be obtained and reviewed.
- Cultural and land use information; maps of land use, zoning, land ownership and cultural features (e.g. highways, roads, airports, etc) are often of value in planning the soil survey and, in the case of Regional Districts and Municipalities, often contain information on landscape features that are valuable for understanding soil and land use relationships.

A critical review of these and perhaps other background information will enable the surveyor to determine where data gaps exist and allow sufficient time for the studies or tasks needed to fill the gaps to be undertaken. For example, these may include the requirement for new aerial photography to be flown or for new base maps to be prepared. Should specific studies be necessary that cannot be undertaken by the soil survey organization, they can be identified and a contract or funding mechanism organized for the work. These plans must be incorporated into the overall schedule and budget plan.

It is usually valuable to incorporate preliminary field studies into the project plan in order to supplement and verify the information available from existing sources and to enable the survey leader to gain a preliminary understanding of the landscape that is to be mapped. The purpose of the preliminary field studies is to gain a perspective on the broad patterns of soils and their relationship to soil landscapes (e.g. relief, aspect, parent materials, drainage), land use and vegetation. This examination, in addition to the background information (if any exists), enables the soil surveyor to prepare a preliminary or rough draft of a soil legend, and in some instances, to prepare a small scale, first-approximation of broad soil map units. In addition, it provides the soil surveyor with information on problems that may be encountered during the field survey such as complex soil patterns and access issues. All of the information gathered during this field examination should be recorded for future reference. One of the most important reasons for undertaking a preliminary field examination is to aid in the fine-tuning of the Project Plan in terms of schedule and cost. It is often of value to complete this exercise well in advance of the actual field mapping program so that necessary changes can be incorporated into the Project Plan and be discussed and agreed upon by the funding organization(s) and user group representatives.

3.3 Identifying and Designing Soil Mapping Units

As stated in Chapter 2, the classes of soil taxonomy as defined by the Canadian System of Soil Classification and the methods outlined in Describing Ecosystems in the Field (Luttmerding, et.al. 1990) provide the basic set of soil properties that help define the soil mapping units. The objectives of the soil survey, and hence the SIL, will, among other things, help define the level of soil taxonomy that should be applied to meet the needs of the project (e.g. Subgroup, Family or Series). The boundaries of a polypedon are sometimes difficult to precisely locate and therefore map units are identified by more than one taxa. This results in the use of the terms "complexes" and "associations" where there are two or more taxa and possibly nonsoil areas included in the map unit. Where it is necessary, due to project objectives, to recognize in the mapping procedures a soil property that is more refined than the soil taxon, then a phase can be used. For example, it is possible to recognize a *Ferro-Humic Podzol - very stony phase* if this is of importance to the interpretations to be made from the survey.

In B.C., it has been and is likely to continue to be common, to map **Soil Associations** and **Soil Series** and phases of them, depending on the intensity of the survey. Soil Series and Soil Associations are usually named for the geographic location (e.g. a mountain, lake, river, community, etc.) near where they are first described. The name is used to provide an easily recognizable description that implies a wealth of information about the soil in order to aid in communication. These concepts are discussed in more detail in Chapter 4. However, it should be remembered that the SIL will determine the kinds of map units and level of taxa to be used. Ranges of soil properties can be narrow or broad. The important point here is for the soil surveyor to design the map units that provide the greatest uniformity and usefulness

for the purposes of the survey. During the planning stage, it must be determined if the mapping unit:

- Can be mapped as a reasonably pure delineation of soil taxa.
- Is too narrowly defined to be useful for the survey purpose.
- Has properties that range too widely to serve the purposes of the survey.

This means soil surveyors must not just gather facts about the soil but must also focus their efforts on gathering relevant facts and presenting them so that they are readily identifiable and useable. At broad levels of soil inventory (SIL 3,4 and 5), the surveyor is faced with the difficult task of organizing map units that best reflect the complexity of soils found over large areas and what combinations or associations of soils are best to characterize useful and mappable units.

3.4 Initial Legend Formulation

During the examination of relevant background information and through initial field studies, it is usually possible to prepare a preliminary soil survey legend that broadly defines mapping units as well as characteristics of the soils and related landscape features within the survey area. Since it is not likely to have a complete legend at the start of a field survey, the preliminary legend will likely be modified and added to as the survey progresses (if available, a legend from an adjacent mapped area may be useful to use as a preliminary legend). However, by providing the preliminary legend to all of the field mappers it is possible to establish a number of tentative map units to which comparisons can be made in the field and to which additional mapping units can be logically and carefully added as the survey progresses.

3.5 Mapping Bases

Since one of the major end-products of a soil inventory is the soil map and legend, the appropriate selection of a base map to portray the soil map units is critical. The base map will influence accuracy and, due to factors such as the degree of ground control and age, the amount of field effort that must be applied in the survey, as well as the quality and usefulness of the final published or manuscript map. The term "**ground control**" or "**control**" implies the degree of accuracy which the base map portrays relative to actual ground conditions. Consequently, serious effort needs to be applied to the selection of not only the map bases used for field survey work but also those that will be used for the final soil map.

During the field survey, aerial photography of appropriate scale, backed up by topographic maps, are often used to assist the soil survey team. These tools allow for the stereoscopic interpretation of the ground surface from aerial photos and for ground-control and elevational relationships in the case of topographic maps. In many cases, soil surveyors will map directly on the aerial photographs during the course of the field survey. In addition, several types of remote sensing other than photography (e.g. satellite images) can prove useful.

For final map production, several choices of base maps are available such as topographic maps, controlled aerial photo mosaics and cadastral/planimetric maps. The choice of the

appropriate one will depend on cost, availability and the intended use of the survey information. In all instances, however, the base map must have accurate **horizontal ground control** so that there is little or no distortion or error throughout the entire map area. The degree of horizontal ground control will greatly influence the scale of the map, its accuracy, and its orientation and location relative to the surface of the earth. The Party Chief must be well aware of the degree of ground control and the location of permanent ground control stations (markers) relative to the base map being used for the soil survey. In the case of aerial mosaics, the use of digitally corrected images offer great potential, partic

4.0 FIELD MAPPING METHODOLOGY

4.1 Determination of the Map Unit

As stated in A Soil Mapping System for Canada: Revised (Mapping Systems Working Group, 1981) "map units are established by examining the range of soils or nonsoils that represent a real segment of the soil landscape whose size and properties are relevant to the objectives of the survey". Map units should have the following properties:

- They are usually repetitive.
- The level of taxonomy applied characterizes the aggregate of sites within the map unit.
- Individual delineations on the map are no smaller than 0.5 cm^2.
- They represent systematic and predictable changes of soil properties across the landscape and also reflect groupings of related properties.
- They have a minimum number of inclusions and unidentified features.
- Regardless of scale, the range of properties of the map unit should allow the entire area to be treated in the same manner for the kinds of management indicated by the purpose of the survey.

The two common types of map units are referred to as Simple and Compound. A simple map unit consists of predominantly one soil or nonsoil. A compound map unit contains predominantly two or more soils or nonsoils (or a combination of both) whose proportions within the map unit may vary depending upon the location of the map unit.

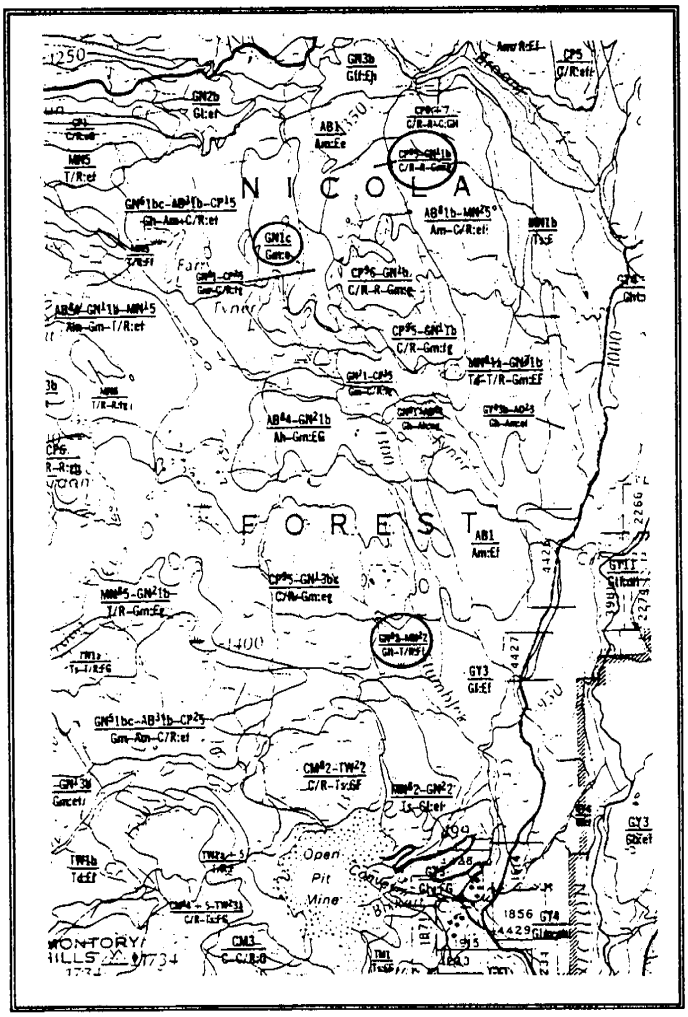
Figure 4.1 shows a portion of a soil survey map which contains both simple and compound map units. As can be seen, not all combinations of a map unit will contain exactly the same proportions of each component that makes up a compound map unit. While the proportions of each component may vary from delineation to delineation, it is the map unit as a whole (the aggregate of all delineations) that has these limits. For example, in the example shown in Figure 4.1, there are the following map units:

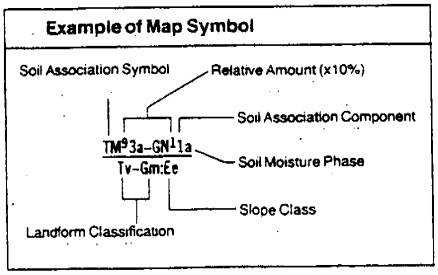
1. GN1c
   Gm:E

2. $GN^{8}2 - MN^{2}2$
   Gft - T/R: Ff

3. $CP^{9}b - GN^{1}b$
   C/R - R - Gm:g

Figure 4.1 Portion of a Soil Survey Map Illustrating Simple and Compound Map Units (From Young, et al. 1992 - Soils of the Ashcroft Map Area)





Example 1 is a simple map unit composed of soil association GN. Examples 2 and 3 are compound map units with dominant and minor proportions respectively of soil association GN in combination with soil association CP and soil association MN. In these examples, symbols in the denominator of the map unit designator refer to landform and slope, and numbers provided as superscripts in the numerator refer to relative decile percentages of the proportion of the soil association in the map unit.

Whether or not the map unit is simple or compound, the actual occurrence of soils in nature require the recognition of inclusions in the map unit. Inclusions are areas of soil or nonsoil that are not identified by the map unit name (or symbols) given to a map delineation. Inclusions usually occupy areas that are too small to be delineated as a different map unit. Inclusions that are named as part of the map unit reduce purity while unnamed inclusions reduce the precision of the map units.

At all times, it is important to design map units that can be consistently identified and delineated in the field and that meet the objectives of the survey. In the example above, if soil association GN, which is an Eluviated Dystric Brunisol, has inclusions of Orthic Humo-Ferric Podzol, then this may or may not be a problem for the user of the soil map. The similarities between these two taxa may be so close for the purpose of the survey that their separation doesn't matter. However, if a user of the map needs to recognize the pedological differences between a Brunisolic soil and a Podzolic soil due to perhaps differences in pH or organic matter content that may influence the plant community and wildlife habitat, then the map unit has important restrictions that must be recognized.

There are four terms used to describe and define map unit components. These are described below.

1. Similar Components

   Soils or nonsoils are alike in most properties. They may differ in some of their properties but they share a common class limit such as a pH or textural range. Interpretations for most common uses are alike.

2. Dissimilar Components

   Soils or nonsoils that have many contrasting properties or have one or two properties that differ widely and usually affect management differently.

3. Nonlimiting Components

   Soil and/or nonsoil components do not affect the management of the map unit in a significantly different way from other components. Similar soils are nonlimiting.

4. Limiting Components

   Soil and/or nonsoil components that require significantly different land use interpretations from the other components of the map unit.

When any population is classified and its distribution mapped, be it plants, animals or soils, it is necessary to provide a means of designating the oddities that always seem to occur and which occupy limited areas in the survey. There are three terms used to provide this flexibility and they are normally applied at the Series level.

1. Variant

   A soil which is dissimilar from all existing Series but comprises less than about 800 ha. in area. Should additional survey work reveal that there is greater than 800 ha. of this soil then it will form a new Series. Otherwise, it is referred to as a Variant of the most closely related series (e.g. Bankeir Variant).

2. Taxadjuncts

   A soil unclassified at the Series level but enough like a classified Series that it is identified as that Series by name. As the name implies, they are adjuncts to, but not part of, the Series for which they are named. In recognizing taxadjuncts, it is understood that they are outside of the range of properties established for a Series but that their behaviour and properties are such that little would be gained by recognizing a new series for them. However, because they are named after an established series, it is necessary for careful and complete notes to be kept about their characteristics that separate them from the named Series.

3. Phases

   A phase is a non-taxonomic subdivision of a taxonomic class. Phases generally recognized are as follows and are subdivided into appropriate levels:

   - Slope
   - Water Erosion
   - Wind Erosion
   - Soil Deposition
   - Stoniness
   - Rock Outcrop
   - Folic
   - Peaty

Phases are used to differentiate soils on the basis of predictions about use and management and as such are often a very useful mapping tool for separating soils for the purpose of interpretations. An example might be a **Howarth Soil, moderately eroded phase** which is differentiated from **Howarth Soil** due to 25 to 75% of the A horizon being lost from most of the area due to water erosion.

Soil mapping in B.C. has and should continue to utilize the concept of a Soil Series and Soil Association for the purpose of soil map units. The majority of the mapping in the Province has been at SIL 3 and 4, whereas some areas, due to the intensity of land use (e.g. the Fraser Valley and Okanagan Valley) have been mapped at SIL2.

A Soil Association is a map unit that is usually made up of components that are defined relative to a central concept for the identified soil (Table 4.1). In this way the central concept for the Soil Association is a Soil Series and the components of the Soil Association are Phases or Taxadjunts or Series that are the products of slightly different ecological and pedological variables (e.g. aspect, drainage, erosion, texture, etc.). A Soil Series, however, has a more narrowly defined set of properties that are outlined in the Canadian System of Soil Classification (1987a).

Table 4.1 Definition of Soil Association Components Recommended for Use

Soil Component	
1	This component consists only of the modal or most commonly occurring soil in the association. It is the central concept of the association and has usually developed on well drained, deep materials in a mid-slope position.
2	The less common soil is drier than the most common soil, due to either somewhat coarser textures, southern exposures, or being located in a slightly drier climate (e.g. south aspects). This component usually occurs at the lower elevation of the soil association elevation range.
3	The less common soil is moister than the most common soil, due to somewhat finer textures, northerly aspects, or being located in areas which receive slightly more moisture than component 1. The increased moisture often causes deeper soil weathering sufficient to produce a different taxonomic subgroup or order. Typically this soil component occurs at the upper parts of the elevational range of the soil association.
4	The less common soil varies from the modal due to ecological differences. The less common soil differs from the modal due to a historical alteration of vegetation (i.e. land clearing), or the present vegetation pattern is highly contrasting for the area. For example, clearings in some forested areas have developed Chernozemic-like soil profiles whereas the profiles under forest are Brunisolic.
5	The less common soil is shallow (lithic, less than 100cm thick) overlying bedrock.
6	Lithic soils (soils less than 100cm thick) overlying bedrock are most common and bedrock outcrops occupy a significant portion of the map unit.
7, etc.	Additional components of the Soil Association can be added and defined as a function of the survey objectives and the characteristics of the landscape being mapped.

The process of soil survey is one of landscape stratification, based on a number of pedological, ecological, and edaphic factors. This type of landscape stratification is recommended for use by all soil surveys. At SIL 3 and 4, the soil surveyor usually makes use of a number of landscape elements that can assist in broadly differentiating large areas of the landscape. In B.C., these landscape elements have usually been a **physiographic region** and a **vegetation zone** or **biogeoclimatic subzone**. The physiographic region provides broad differentiation of bedrock types and elements of landscape formation, and the vegetation zone and biogeoclimatic subzone is a surrogate used to reflect macro-climate.

Landform or terrain materials (soil parent materials) are also used to stratify the landscape. For example, the soil surveyor will determine the distribution of surficial geologic materials such as glacial till, fluvial and lacustrine sediments and their landform characteristics, and use them to define broad map units within the physiographic regions and vegetation or biogeoclimatic zones. Soil characteristics of these broad landscape units (such as

horizonation, drainage, texture) are determined in the field and used to finalize the map units. The soil mapping units (soil association or soil series) are then confined within these broad zones so that a named soil map unit does not occur outside of the defined area. For example, the **Allamore Soil** will only occur in the Engelmann Spruce-Subalpine Fir Biogeoclimatic Zone and not in the Interior Douglas-fir Zone.

The manner by which soil polygon boundaries are determined is usually a process of proceeding from the general to the specific, depending on the objectives of the survey. This process entails:

1. Delineate broad physiographic regions or bedrock types.
2. Delineate biogeoclimatic units within physiographic regions.
3. Delineate landform and soil parent material types within biogeoclimatic units.
4. Delineate soil map units that occur on the various landform and soil parent material types.

By proceeding from the general to the specific, the soil surveyor is able to put relevant bounds on the geographic distribution of the map unit and, as a result, provide a stratification of the landscape that is of value for land use and management interpretations. At larger scales (e.g. SIL 1 and 2) the soil survey area is often contained within one or perhaps two physiographic regions and vegetation zones such that there may not be a need to recognize them as differentiating landscape characteristics.

The process of soil mapping and hence the recognition of a soil body in nature is one of landscape stratification based on a number of defined variables with specific class limits. For the purpose of defining soil map units, and the field work that goes into recognizing them as segments of the earths surface that lines can be drawn around, it is necessary to define a number of terms that represent or contain units of soil that are classified. These are defined below and are illustrated in Figure 4.2.

Exposure

This is the exposed face of a soil pit or a cut-face of a soil exposed by a road cut or on an eroded terrace front. It is usually the smallest part of the soil landscape that the soil surveyor will recognize and describe during the process of field mapping and it represents a pedon or polypedon.

Site

The term site is used to define the characteristics of the external landscape that is associated with a soil exposure. Examples include a plant community, slope, aspect, and elevation.

Soil and Nonsoil

This is the concept of the "mapping individual". Through the process of examining many exposures and their associated sites, portions of the landscape are recognized as similar (depending on the purpose of the survey). A soil belongs to only one class of the Canadian System of Soil Classification (the level within the classification will depend on the purpose and intensity of the survey). Nonsoils are recognized and named (e.g. bedrock, gravel pits, water, made-land) according to the requirements of the survey. They are identified as polygons or through the use of on-site symbols. When on-site symbols are used, it is necessary to establish a convention in order for the map user to become familiar with the symbols. It is recommended that the same on-site symbols used in Terrain Mapping be employed wherever practical.

Map Units

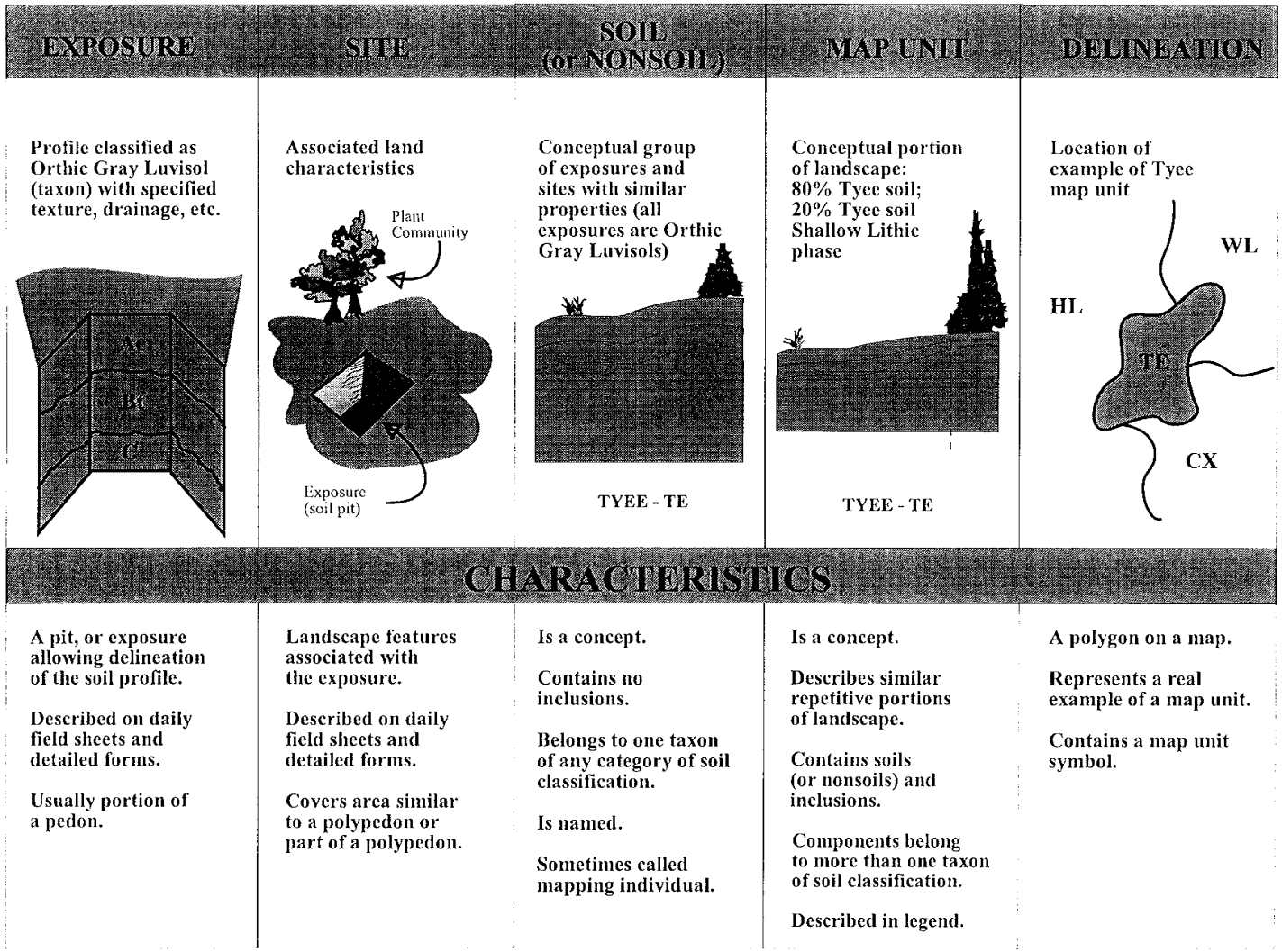
A soil map unit represents a grouping of recurring map delineations and is a conceptual portion (or area) of the soil landscape that is mappable and has attributes that vary within the limits established by the intensity and use of the survey. A map unit contains one or more soils and/or nonsoils plus sometimes a small proportion of inclusions. Map units are usually repetitive throughout the soil landscape that is being mapped. Symbols or names are given to map units by naming them for geographic locations at which the soil was first described.

For example, a map unit may be described as the **Espinoza 4** map unit which contains two soils: Duric Humo-Ferric Podzol and Orthic Humo-Ferric Podzol. These two soils are essentially the same except for the presence of a duric layer.

Map Delineation (polygon)

This is the soil map **polygon**. It is the line placed on the map that delineates the boundaries of a segment of the soil landscape that is recognized by the soil survey. A delineation is a real example of a map unit as denoted by the symbol placed in the polygon. A map unit, on the other hand is conceptual and comprises all delineations that contain exactly the same symbol.

Figure 4.2 The Building Blocks of Soil Mapping (after Agriculture Canada, 1981)



4.2 The Use of Aerial Photography and Remote Sensing

Prior to actual field work, and certainly during the conduct of the field survey, aerial photography and other forms of remote sensing are invaluable aids in understanding and mapping the soil landscape.

In most soil surveys, the mapper conducts what is commonly referred to as **"pretyping."** This is a process of examining aerial photography (stereoscopically) to delimit soil landscape patterns that are recognizable. Other remotely sensed information such as satellite images can also be used for this purpose but are not conducive to stereoscopic examination. These other remotely sensed images, and the digital data that comprises them, are often of value in determining broad landscape and cultural patterns.

Throughout most of B.C., the most useful pretyping of aerial photography involves the recognition of landforms or terrain boundaries that can be drawn on the photo (depending on the study area, this information may already be available). The most useful system for this purpose is the **Terrain Classification System for British Columbia - Revised Edition** (B.C. Ministry of Environment, 1988). This system provides the means of recognizing and mapping surficial geological materials, landform, texture, stratigraphy and geomorphological processes that have or are affecting the landscape. For the purpose of the soil survey, it is also very useful to recognize other landscape elements during the pretyping process. These might be patterns of vegetation, drainage, aspect and cultural patterns. This process of landscape stratification enables the soil surveyor to recognize broad landscape or ecological parameters that can be used in separating and mapping soil landscape elements.

The pretyping of aerial photos is recommended for all soil surveys. However, the cluttering of the photos with lines and symbols that are only conjecture should be avoided. Once the aerial photos are pretyped, the soil surveyor has a preliminary understanding of the distribution of broad soil landscapes. This information greatly assists in the field mapping exercise by providing the delineation of areas that require intensive field checking and as a kind of map that assists in field location.

Aerial photography should be chosen that is recent and at a scale that is similar to the scale or intensity of mapping. New aerial photography should be flown if the scale, date and quality of the existing photos are not adequate to meet the needs of the survey.

All lines and symbols placed on the aerial photos must be matched between the edges of the adjacent photos in the same flight line and between flight lines. The soil mapper should "box" the aerial photos so that the area on the photo within which lines and symbols are placed contains minimal distortion.

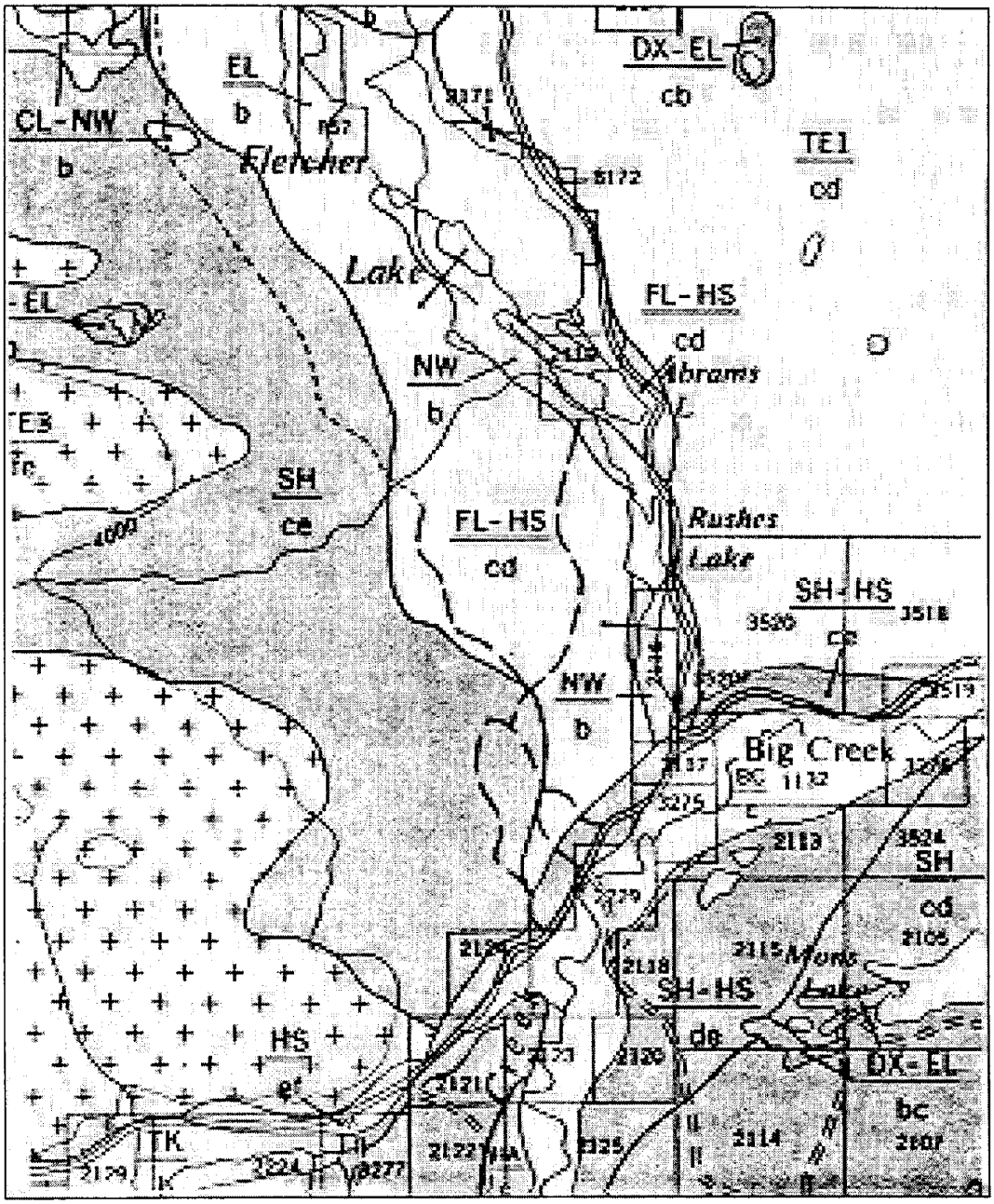
During the field mapping exercise, the pretyped map polygons provide a **first approximation** of the map units that will be recognized by the soil survey. Both the map polygons themselves and the boundaries between them are validated by exposing a number of soil pits and the boundaries are adjusted or new ones added to reflect the location of the soil map units. In addition, preliminary symbols are placed in the map unit to indicate the name of the soil that is being delineated. The location of soil exposure sites are marked on the photo and referenced to the field sheets that describe the soil and site at that location (An example of field sheets are contained in Appendix B).

4.3 Plotting Soil Boundaries

During the field mapping exercise, the soil mapper determines routes and transects that cross as many soil boundaries (as determined by the aerial photo interpretation) as possible. This work consists of a series of predictions and verifications as the route is traversed. The predictions are where the soil boundaries are and the sets of soil properties within them. The verification is the examination of soil pits and exposures used to confirm, modify or reject the prediction. Throughout this process, the mapper is constantly examining his field notes and aerial photography to refine the concept of the map unit. Preliminary (pre-typed) lines and symbols placed on the aerial photography are changed to reflect the information gathered in the field (Figure 4.3). Once in a preliminary map unit delineation, the soil is examined to verify the prediction, often in many locations within the delineation (Figure 4.4). This information is used to determine the map unit (based on the preliminary legend) which best identifies the area. If such a map unit is not currently recognized, then a new one should be defined. The soil mapper then selects a location within the map unit that is the best expression of the features that are being represented and describes the site and soil in detail. In addition, the surveyor determines inclusions within the map unit that must be expressed but are beyond the range of the taxon.

As this process proceeds, the soil mapper prepares lines and symbols on the aerial photography or other base maps that are close to the final lines and symbols that will be shown on the soil map (Figure 4.5). In addition, the soil map legend is altered to encompass the characteristics of the map units that are being depicted. The map unit boundaries are often transferred from the aerial photo to a topographic base map during the field mapping exercise in order to visualize the full extent of the soil distribution in the map area. Plotting the soil map unit boundaries is often accomplished by utilizing plotting devices such as a Zoom-Transferscope or Epidiascope, or can be done by hand. If TRIM aerial photography is used, the soil map units can be directly transferred (digitally) to a map polygon file and plotted since the photographs are digitally corrected for distortion. In many instances, these preliminary map units are re-examined in the field in order to confirm their position and characteristics after they have been tentatively drawn on the base map. However, final confirmation of the map unit boundaries and their characteristics must often wait for the completion of laboratory analysis of sampled soils and a more detailed examination of the data gathered in the field and recorded on the site and soil description forms. Figure 4.6 illustrates a completed soil map that is ready for publication.

Figure 4.6 Part of a Published Soil Map; Map Scale 1:100,000; from Soils of the Taseko Lakes Area; Soil Survey Report No. 36



Example Symbol

FL - HS
cd

Soil Symbol

Topographic Class

4.4 Sampling Design and Data Collection

During the conduct of a soil survey, it is necessary to examine all soils and their landscape characteristics in order to determine the nature and extent of the distribution of soil individuals and their variability. The soil surveyor must sample the population of soils that occur in the map area in order to determine their full range of properties and thereby organize classes of the population (**types of soil**) and delineate the areas containing those classes (**map units**). The **sampling design**, or the manner by which locations are chosen for sampling, will influence the quality of the final map. A sample may be simply a **soil inspection** where notes are taken on field data collection sheets or it may be an actual **sample**, where soil is taken from the soil excavation for laboratory analysis. The appropriate sampling design will depend on the purpose and intensity of the survey, the nature of the landscape, the amount of soil information already available from other sources and the experience of the surveyors. The sampling design will play a crucial role in determining the precision of the soil survey.

The majority of soil mapping in B.C. has been undertaken by what is referred to as **authoritative** or "**free survey**". This technique utilizes known and inferred soil-landscape relationships to predict soil characteristics. The soil surveyor chooses his sample site and then extrapolates the information gathered at this location to other nearby areas with the same soil-landscape relationships without necessarily examining the other areas in the field. By definition, the sample is biased and not random, thereby limiting the use of statistical methods to determine estimates of error and objective conclusions about the soil population.

The use of "free survey" sampling is appropriate for small scale surveys, particularly where large areas of inaccessible terrain must be covered in a short time within a limited budget. However, where detailed surveys are undertaken, the most appropriate techniques are those that employ a degree of randomness. The random transect method (Wang, 1980) is an example of this approach. For all soil surveys in B.C., it is important that a systematic sampling procedure be employed. The random transect method is recommended as the basic sampling technique. Depending on the type of landscape being mapped, this should take the form of the **line intercept method** or the **point intercept method** (these are described in Bartelli and De Ment, 1970). In the application of either method, each soil delineation should be adequately sampled with one or more transects in order to provide unbiased coverage. The number of observations (sample size) will be determined by the desired accuracy and the use of standard statistical methods.

Data collection at sample sites will vary with the survey objectives and purpose. However, for all soil surveys in B.C., the data forms contained in the manual **Describing Ecosystems in the Field: Second Edition** (Luttmerding, et.al. 1990) for recording site and soil characteristics can be utilized. The surveyor is able to choose those parameters that are most appropriate for the survey and the forms are organized for ease of input to digital data files. Examples of these data forms are contained in Appendix B.

The following minimum data set is recommended for all soil inventories regardless of scale or purpose. Definitions for all of these items are contained in Luttmerding, et al (1990).

Site Description Form

Project Identification
Date
NTS Sheet
Latitude and Longitude or UTM
Aspect
Slope
Elevation
Site Position (macro and meso)
Site Surface Shape
Microtopography
Exposure Type
Soil Drainage
Terrain Classification
Project Coordinator
Agency
Type of Soil Sample

Soil Description Form

Project Identification
Plot Number
Surveyor
Horizon
Horizon Depth (thickness)
Coarse Fragment Description
Soil Texture
Colour
Mottles
Consistence
Rooting
Organic Material Description (if applicable)
Salinity (if applicable)
Schematic Soil Profile

4.5 Map and Data Reliability

Previous sections of this manual have discussed the concept of reliability (accuracy). This term provides a measure of how close the information contained on the map and in associated data bases and reports conforms to actual soil conditions in the field. The users of the map and report require some expression of reliability in order for them to appropriately use and apply the information.

A recommended manner to generally convey reliability to the user is through the concept of a Survey Intensity Level. By having the survey conform to the precision inherent in each of the intensity levels, the user is assured a certain level of reliability.

In order to actually measure the degree of reliability, when required, it is recommended that the random transect method be used following completion of the survey. It is rarely possible to have a constant level of reliability throughout the map area. Consequently, it is often valuable to provide a discussion about this in the soil report or perhaps on the map. Often, this is best expressed by illustrating the degree of sampling, accessibility and landscape complexity on a small scale map that is contained in the soil report or on the soil map.

The reliability of laboratory data is usually well controlled by established procedures. However, it is recommended that some duplicate and/or standard samples be submitted for analysis in order to provide a check on quality control. The Manual on Soil Sampling and Methods of Analysis (CSSC, 1978) and Canadian Society of Soil Science (1993) provide methods and techniques for conducting most soil analyses.

4.6 Field Verification, Quality Control and Correlation

Quality control and quality assurance are two terms that are currently much in vogue. They are necessary elements of any soil survey program and require someone or some organization to assume the responsibility of maintaining consistency in the methods, terminology and conventions used for describing and defining soils.

In soil survey, this responsibility usually rests with the "**soil correlator**". This individual (or more than one person if necessary) is usually appointed to the soil survey team by the government agency responsible for the survey.

The correlation activity occurs throughout the survey, from the initial planning phase to the publication of the map and report. As a consequence, this requires both formal and informal meetings between the soil survey project leader and the soil correlator as well as field reviews at specified stages of the survey. The final correlation involves a review of the draft soil map and report in order to verify the precision with which the map and legend portray the soils and landscapes they represent and meet the objectives of the survey. The soil correlator compares the descriptions of the soils (including laboratory data) to ensure that the names used for the soil map units are correct if they have been previously defined and used, and to verify the taxonomic classification.

All systematic soil surveys require correlation prior to releasing the survey results to user groups. From a quality control perspective, it is recommended that this requirement not be over-looked.

5.0 POST-FIELD ACTIVITIES

5.1 Final Map and Legend Preparation

The report "**A Soil Mapping System for Canada: Revised**" (Mapping Systems Working Group, 1981) outlines several different forms of legends and symbols and some of the reasons why they are appropriate for specific uses. The final soil map legend is the culmination of a systematic process where the significant components of the soil landscape are combined into a finite number of soils and soil map units. This synthesis occurs from the start of the soil survey where the descriptions of soils at very many sites are amalgamated or synthesized in a process that reflects the objectives and purpose of the survey.

There are basically four forms of legends:

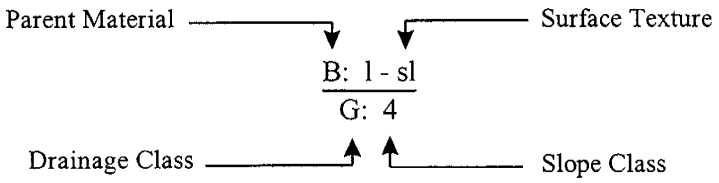
1. Open Legend

   An **open legend** is, as the name implies, structured so that a map unit is essentially that area for which the symbols are exactly the same. In other words, a change of a class of soil or landscape feature (e.g. slope) creates a new map unit.

   An open legend has the following characteristics:

   - various soil and landscape properties are assigned (different) letters or numbers.
   - each delineation is described by a composite symbol made up of these letters and symbols that are usually connotative.
   - the legend contains a definition for the classes of properties.
   - most delineations are unique.

   An example symbol would be:



2. Uncontrolled Legend

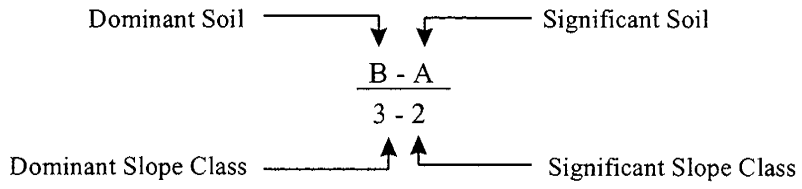
   An **uncontrolled legend** is one where all mapping individuals (soils and non-soils) are listed in the legend (e.g. names, symbols, colour) but the combination of the mapping individuals used to describe a map delineation are not listed or described. Symbols for Phases are usually put in the denominator portion of the symbol and described elsewhere in the legend.

   An uncontrolled legend has the following characteristics:

   - all recognized soils and non-soils are listed in the legend.
   - map delineations are indicated by soil or non-soil symbols.

- various combinations of soils are not listed and described.

An example of a compound map unit would be as follows; note that the user would have to refer to both Soil B and Soil A to gain sufficient information from the legend about this map delineation.



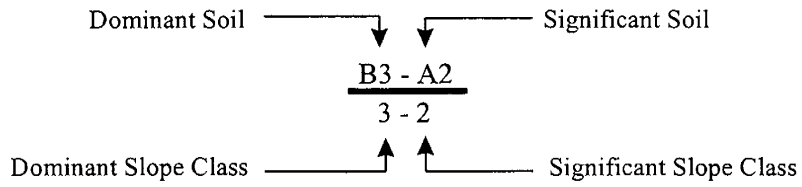
3. Controlled Legend

A **controlled legend** is similar to an uncontrolled legend with the important exception that all mapping individuals and their combinations are described in the legend. Symbols for Phases such as slope or stoniness are usually put in the denominator portion of the symbol and described elsewhere in the legend.

A controlled legend has the following characteristics:

- all soils and nonsoils, and all their combination are listed and described in the legend.
- soil phases are described in different portions of the legend.
- all delineations with exactly the same map symbol constitute a map unit.

An example symbol would be as follows; note that this compound map unit would be listed in the legend.



This symbol (map unit) would be described in the legend separately from the following symbol:

$$\frac{\text{A2 - B3}}{\text{3 - 2}}$$

4. Closed Legend

A **closed legend** is one where all combinations of symbols used to describe a map delineation, **including phases**, are listed and described in the legend.

A closed legend has the following characteristics:

- all combinations of soils, nonsoils and phases, including proportions (where used) are listed and described in the legend.
- all delineations with exactly the same symbol constitute a map unit.

In the example used above for a controlled legend, not only would the symbol $\frac{B3 - A2}{3 - 2}$ be

listed and described separately from $\frac{A2 - B3}{3 - 2}$, but so would $\frac{A2 - B3}{2 - 3}$ as well as $\frac{B3 - A2}{2 - 3}$.

The preliminary map legend used in the field for mapping purposes is usually an open form since this is the best way to organize and remember facts about the map area when little is known about the relationships among the soils and map units. As work progresses, from inspections (soil pits) to delineations and finally to a soil legend, it changes from a open form to an uncontrolled form. This working legend is useful for the surveyor since the characteristics of the area can be readily displayed by the symbol. However, the publication legend is different in that it is developed for the user who usually wishes to go from a symbol on the map to the legend that describes the symbol and hence the characteristics of the area and this is usually best provided by a closed legend.

An example of an uncontrolled legend is provided in Figure 5.1. The objectives of the soil survey and the user groups will determine the most appropriate legend. For example, it may be appropriate to use an expanded legend format when no soil report is to be prepared for the survey. The expanded legend provides a thorough description of the map unit in terms of definitive and accessory characteristics to aid the user in understanding the landscape relationships of the map unit.

5.2 Map Symbolization and Legibility

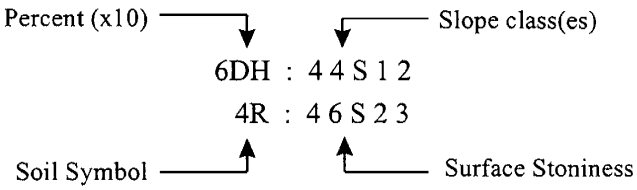
As discussed in section 3.1.7, the minimum size for a map delineation is recommended to be 0.5 cm^2 (on the published map). Where there are many delineations on the map which are near the minimum size or the map symbol is so large that many have to be printed outside of the delineation (and "arrowed-in" to the delineation), the map becomes difficult to read. This problem of **legibility** is often a major cause of soil map users becoming frustrated to the degree that they conclude the soil map cannot be used for their application.

As a guide, it is recommended that the average size delineation (total land area of the map divided by the total number of delineations) be about 20 times bigger than the minimum size delineation (Mapping Systems Working Group, 1981). Based on the following formula, this will result in a **map delineation density** of 5%. This is a constant regardless of the SIL.

$$\text{Map Delineation Density} = \frac{\text{Minimum Size Delineation}}{\text{Average Size Delineation}} \times 100$$

The type of map unit symbols used on the soil map are considered to be the choice of the soil surveyor reflecting the needs of the identified user groups. Consequently, it is not reasonable to recommend a specific type of symbol which will meet all circumstances. However, for soil survey maps in B.C. that will be entered into a digital file format, the

following type of symbol is recommended, where additional phase symbols can be added as required:



Map legibility must be of concern to the person responsible for preparing the soil map beginning at the project planning stage right through to the publication stage.

5.3 Computer Files and Geographic Information Systems for Maps and Data

The use of computers and computer software for the purposes of storing soil and map (polygon) data has greatly increased in B.C. over the past few years. The B.C. Soil Information System (BCSIS) has been developed over many years and became operational in 1983. An example of output from BCSIS is illustrated in Figure 5.2. BCSIS contains three types of data: site data; soil data; and laboratory data. The forms provided in Appendix B (and outlined in Describing Ecosystems in the Field - Luttmerding (ed), 1990), provided the means for the surveyor to enter this data into BCSIS. Laboratory data from the analysis of sampled soils is also contained in BCSIS. A parallel data base is available from the federal government and referred to as the Canadian Soil Information System (CanSIS). In addition to this, some soil maps have been digitized. That is, the boundaries of all polygons have been digitized and can be georeferenced through the use of a Geographic Information System (GIS).

Figure 5.1 Example of a Controlled Legend (taken from soils of the Langley-Vancouver Map Area; Luttmerding, 1980)

MAP SYMBOL	SOIL NAME	SOIL MATERIAL	DRAINAGE	CLASS'N
AB	ALBION	Moderately fine to fine-textured glaciomarine deposits	Moderately poor to poor; perched water table	HU.LG
AD	ABBOTSFORD	20 to 50 cm of medium-textured eolian deposits over gravelly glacial outwash	Well to rapid	O.HFP
AG	ADDINGTON	15 to 40 cm of organic material over medium-textured, mixed floodplain deposits	Very poor; high groundwater table; susceptible to flooding	R.Gp
AL	ALOUETTE	15 to 40 cm of organic material over medium-textured, mixed flood-plain deposits	Poor to very poor; high groundwater table	O.Gp
AN	ANNIS	15 to 40 cm of organic material over moderately fine textured floodplain deposits	Poor to very poor; high groundwater table	R.Gp
AR	ARNOLD	Moderately fine textured, vertically accreted floodplain deposits	Moderately poor; fluctuating groundwater table	O.HG
AS	ANNACIS	More than 160 cm of well-decomposed organic material	Very poor; high to very high groundwater table	TY.H
B	BENSON	Moderately coarse textured deltaic deposits	Poor to very poor; high groundwater table	R.HGs
BB	BLACKBURN	Moderately fine textured, vertically accreted floodplain deposits	Poor to moderately poor; high groundwater table	O.HG
BD	BANFORD	40 to 160 cm of well-decomposed organic material over medium and moderately fine textured floodplain deposits	Poor to very poor; high groundwater table	T.H
BE	BLANEY	Moderately coarse to coarse-textured glacial till	Well to moderately well; telluric seepage	DU.FHP
BK	BUCKERFIELD	Moderately fine textured lacustrine deposits	Poor to moderately poor; high groundwater table	O.HG
BL	BEHARREL	Moderately fine textured,vertically accreted floodplain deposits	Moderately poor to poor; high groundwater table	HU.LG
BN	BONSON	Medium-textured floodplain deposits	Imperfect; fluctuating groundwater table	GL.SB
BO	BOSE	30 to 160 cm of gravelly lag or glacial outwash deposits over moderately coarse textured glacial till and some moderately fine textured glaciomarine deposits	Well to moderately well; telluric seepage	DU.HFP
BR	BERRY	Moderately fine to fine-textured marine deposits	Imperfect; perched water table	GLPZ.GL
BT	BATES	Medium-textured local stream deposits	Imperfect; fluctuating groundwater table	GLE.MB
BU	BLUNDELL	15 to 40 cm of organic material over medium-textured deltaic deposits	Poor to very poor; high groundwater table	R.Gsp
BW	BURWELL	Moderately coarse textured glacial till and some colluvium	Imperfect; telluric seepage	DU.FHP
BY	BOOSEY	30 to 160 cm of gravelly lag or glacial outwash deposits over moderately coarse textured glacial till and some moderately fine textured glaciomarine deposits	Poor; perched water table	R.HG
BZ	BUNTZEN	Moderately coarse to medium-textured glacial till	Moderately well; telluric seepage	DU.FHP
CC	CASCADE	Moderately coarse textured glacial till	Moderately well; telluric seepage	DU.FHP
CD	CLOVERDALE	Moderately fine to fine-textured marine deposits	Poor; perched water table	HU.LG
CE	CANNEL	10 to 50 cm of moderately coarse textured glacial till or colluvium over bedrock	Well to rapid	O.HFPI
CG	COGHLAN	Gravelly glacial outwash deposits	Imperfect; fluctuating water table	GLOT.HFP
CL	COLUMBIA	Gravelly glacial outwash deposits	Well to rapid	O.HFP
CM	CHEAM	Coarse-textured colluvial fan deposits	Well to rapid	O.HFP
CN	CALKINS	More than 20 cm of medium-textured eolian deposits over glacial outwash deposits or glacial till	Poor; perched water table	R.HG
CP	CAPILANO	Gravelly glacial outwash deposits	Well to rapid	OT.HFP
CS	CHEHALIS	Coarse-textured alluvial fan deposits	Well to moderately well	E.DYB
CT	CRESCENT	Medium to moderately fine textured deltaic deposits	Moderately poor to poor; high groundwater table	O.G
CV	CARVOLTH	Moderately fine textured local stream deposits	Poor to very poor; perched water table, susceptible to flooding	R.HG
DE	DENNET	More than 10 cm of organic material over bedrock	Well to moderately well	TY.FO
DN	DEAN	Coarse-textured alluvial fan deposits	Moderately well	OT.FHP
DR	DEFEHR	Sandy and gravelly glacial outwash deposits	Imperfect; perched water table	GL.HFP
DS	DEAS	Medium to moderately fine textured deltaic deposits	Poor; high groundwater table	R.HGs
DT	DELTA	Medium to moderately fine textured deltaic deposits	Poor; high groundwater table	O.HGs
DU	DURIEU	Medium to moderately fine textured glaciomarine deposits	Moderately well	O.FHP
DV	DEVIL	Moderately coarse textured glacial till deposits	Moderately well	O.FHP
DW	DEWDNEY	15 to 50 cm of medium-textured,laterally accreted floodplain deposits over sand	Imperfect; fluctuating groundwater table	GLE.MB
DX	DIXON	15 to 50 cm of moderately fine to fine-textured lacustrine deposits over sand	Poor to very poor; high groundwater table	R.G
EK	ELK	Medium to moderately coarse textured alluvial fan deposits	Poor; telluric seepage	R.HG
EM	EMBREE	Medium-textured deltaic deposits containing organic strata	Poor to very poor; high groundwater table	R.HGs
ER	ERROCK	Gravelly glacial outwash deposits	Imperfect; perched water table, telluric seepage	GLOTFHP
EU	EUNICE	More than 10 cm of organic material over bedrock	Well to rapid	TY.FO

MISCELLANEOUS LAND TYPES

MAP SYMBOL	DESCRIPTION	
GP	GRAVEL PIT	Active or inactive areas of gravel (or sand) extraction sufficiently large to be mapped.
RA	RECENT ALLUVIUM	Gravel and sand bars and other areas in or adjacent to rivers and streams. They are usually unvegetated and susceptible to regular flooding.
RO	ROCK OUTCROP	Areas of exposed bedrock or bedrock areas with less than 10 cm of mineral or organic cover.
TF	TIDAL FLAT	Areas lying outside the dykes which are subject to flooding by tidal action.

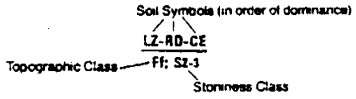
SOIL VARIANTS

:sv	SHALLOW VARIANT	Areas of soil which are similar in all respects to the named soil except that the depth of the soil profile is shallower than the modal. They occupy minor portions of the named soil area. For example, PE (Paige) is described as consisting of more than 50 cm of medium to moderately fine textured floodplain deposits over sand. PE:sv identifies those minor areas where the medium to moderately fine-textured overlay is less than 50 cm thick.
:an	ANTHROPOGENIC VARIANT	Man-made or man-modified materials, including those associated with mineral exploitation and waste disposal. Examples are areas of landfill and spoil heaps

PHASES

l	lithic
p	peaty
s	saline
sp	saline peaty

EXAMPLE OF MAP SYMBOL



TOPOGRAPHIC CLASSES

SIMPLE TOPOGRAPHY Single slopes (regular surface)		COMPLEX TOPOGRAPHY Multiple slopes (irregular surface)		Slope %
A	depressional to level	a	nearly level	0 to 0.5
B	very gently sloping	b	gently undulating	0.5 + to 2
C	gently sloping	c	undulating	2 + to 5
D	moderately sloping	d	gently rolling	5 + to 9
E	strongly sloping	e	moderately rolling	9 + to 15
F	steeply sloping	f	strongly rolling	15 + to 30
G	very steeply sloping	g	hilly	30 + to 60
H	extremely sloping	h	very hilly	over 60

STONINESS CLASSES*

S0 Nonstony land – Stones are not present or are so infrequent that they offer no hindrance to cultivation.

S1 Slightly stony land – There are some stones, but they offer only slight to no hindrance to cultivation.

S2 Moderately stony land – There are enough stones to cause some interference with cultivation.

S3 Very stony land – There are enough stones to constitute a serious handicap to cultivation and some cleaning is required.

S4 Exceedingly stony land – There are enough stones to prevent cultivation until considerable cleaning is done.

S5 Excessively stony land – This land is too stony to permit any cultivation (boulder or stone pavement).

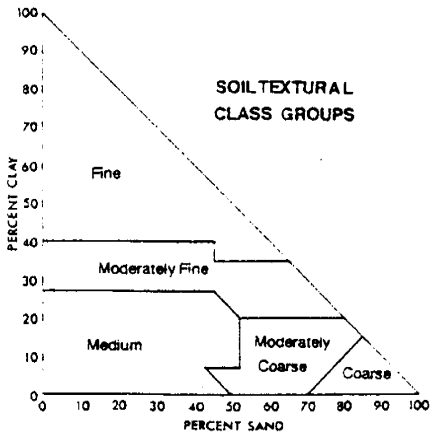
*In map units which contain no stoniness class, stones are not present.

REFERENCE

Main Highways 401 7
Railway .....
International boundary .....
Municipal boundary .....
Forest boundary .....
Bridge .....
Dykes .....
Soil boundary .....

CLASSIFICATION

GLE.MB	Gleyed Eluviated Melanic Brunisol
E.EB	Eluviated Eutric Brunisol
GL.SB	Gleyed Sombric Brunisol
E.DYB	Eluviated Dystric Brunisol
O.HG	Orthic Humic Gleysol
R.HG	Rego Humic Gleysol
O.G	Orthic Gleysol
R.G	Rego Gleysol
O.LG	Orthic Luvic Gleysol
HU.LG	Humic Luvic Gleysol
GL.GBL	Gleyed Gray Brown Luvisol
BR.GL	Brunisolic Gray Luvisol
PZ.GL	Podzolic Gray Luvisol
GL.GL	Gleyed Gray Luvisol
GLPZ.GL	Gleyed Podzolic Gray Luvisol
TY.F	Typic Fibrisol
TY.M	Typic Mesisol
T.M	Terric Mesisol
TY.H	Typic Humisol
T.H	Terric Humisol
TY.FO	Typic Folisol
O.FHP	Orthic Ferro-Humic Podzol
OT.FHP	Ortstein Ferro-Humic Podzol
DU.FHP	Duric Ferro-Humic Podzol
GL.FHP	Gleyed Ferro-Humic Podzol
GLOT.FHP	Gleyed Ortstein Ferro-Humic Podzol
O.HFP	Orthic Humo-Ferric Podzol
OT.HFP	Ortstein Humo-Ferric Podzol
DU.HFP	Duric Humo-Ferric Podzol
LU.HFP	Luvisolic Humo-Ferric Podzol
GL.HFP	Gleyed Humo-Ferric Podzol
GLOT.HFP	Gleyed Ortstein Humo-Ferric Podzol
GLSM.HFP	Gleyed Sombric Humo-Ferric Podzol
O.R	Orthic Regosol
CU.R	Cumulic Regosol
GL.R	Gleyed Regosol

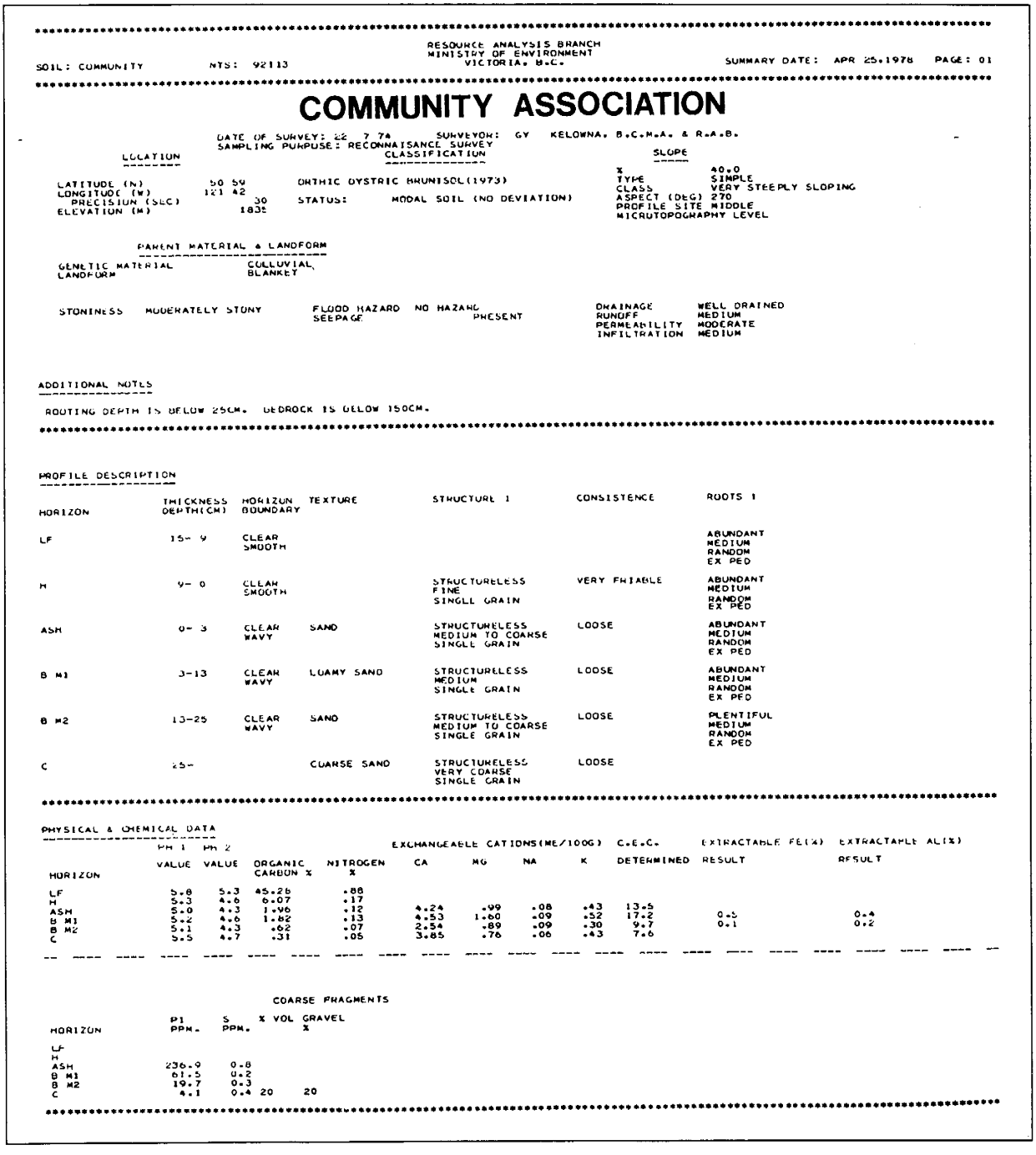


Soil textural class groups. Percentages of clay and sand in each group; the remainder of each class is silt.

Soil information by the Resource Analysis Branch, British Columbia Ministry of Environment in cooperation with the Land Resource Research Institute Research Branch, Agriculture Canada.

Compiled,drawn and published by the Cartography Section, Land Resource Research Institute, Research Branch, Canada Department of Agriculture Ottawa. Printed by the Directorate of Map Production, Department of Energy, Mines and Resources, 1978.

Figure 5.2 Example of Computer Output from BCSIS (from Agriculture Canada, 1980: Soils of the Lac La Hache - Clinton Area, BC)



RESOURCE ANALYSIS BRANCH
MINISTRY OF ENVIRONMENT
VICTORIA, B.C.

SOIL: COMMUNITY NTS: 92I13 SUMMARY DATE: APR 25,1978 PAGE: 01

COMMUNITY ASSOCIATION

DATE OF SURVEY: 22 7 74 SURVEYOR: GY KELOWNA, B.C.M.A. & R.A.B.
SAMPLING PURPOSE: RECONNAISSANCE SURVEY

LOCATION

LATITUDE (N) 50 59
LONGITUDE (W) 121 42
PRECISION (SEC) 30
ELEVATION (M) 1835

CLASSIFICATION

ORTHIC DYSTRIC BRUNISOL(1973)
STATUS: MODAL SOIL (NO DEVIATION)

SLOPE

% 40.0
TYPE SIMPLE
CLASS VERY STEEPLY SLOPING
ASPECT (DEG) 270
PROFILE SITE MIDDLE
MICROTOPOGRAPHY LEVEL

PARENT MATERIAL & LANDFORM

GENETIC MATERIAL COLLUVIAL
LANDFORM BLANKET

STONINESS MODERATELY STONY
FLOOD HAZARD NO HAZARD
SEEPAGE PRESENT

DRAINAGE WELL DRAINED
RUNOFF MEDIUM
PERMEABILITY MODERATE
INFILTRATION MEDIUM

ADDITIONAL NOTES

ROOTING DEPTH IS BELOW 25CM. BEDROCK IS BELOW 150CM.

PROFILE DESCRIPTION

HORIZON	THICKNESS DEPTH(CM)	HORIZON BOUNDARY	TEXTURE	STRUCTURE 1	CONSISTENCE	ROOTS 1
LF	15- 9	CLEAR SMOOTH				ABUNDANT MEDIUM RANDOM EX PED
H	9- 0	CLEAR SMOOTH		STRUCTURELESS FINE SINGLE GRAIN	VERY FRIABLE	ABUNDANT MEDIUM RANDOM EX PED
ASH	0- 3	CLEAR WAVY	SAND	STRUCTURELESS MEDIUM TO COARSE SINGLE GRAIN	LOOSE	ABUNDANT MEDIUM RANDOM EX PED
B M1	3-13	CLEAR WAVY	LOAMY SAND	STRUCTURELESS MEDIUM SINGLE GRAIN	LOOSE	ABUNDANT MEDIUM RANDOM EX PED
B M2	13-25	CLEAR WAVY	SAND	STRUCTURELESS MEDIUM TO COARSE SINGLE GRAIN	LOOSE	PLENTIFUL MEDIUM RANDOM EX PED
C	25-		COARSE SAND	STRUCTURELESS VERY COARSE SINGLE GRAIN	LOOSE	

PHYSICAL & CHEMICAL DATA

HORIZON	PH 1 VALUE	PH 2 VALUE	ORGANIC CARBON %	NITROGEN %	EXCHANGEABLE CATIONS(ME/100G) CA	MG	NA	K	C.E.C. DETERMINED	EXTRACTABLE FE(%) RESULT	EXTRACTABLE AL(%) RESULT
LF	5.8	5.3	45.28	.88							
H	5.3	4.6	6.07	.17							
ASH	5.0	4.3	1.96	.12	4.24	.99	.08	.43	13.5		
B M1	5.2	4.6	1.82	.13	4.53	1.60	.09	.52	17.2	0.5	0.4
B M2	5.1	4.3	.62	.07	2.54	.89	.09	.30	9.7	0.1	0.2
C	5.5	4.7	.31	.05	3.85	.76	.06	.43	7.6		

COARSE FRAGMENTS

HORIZON	P1 PPM.	S PPM.	% VOL GRAVEL %	
LF				
H				
ASH	236.9	0.8		
B M1	61.5	0.2		
B M2	19.7	0.3		
C	4.1	0.4	20	20

For all systematic soil surveys, it is recommended that the site, soil and laboratory data be entered into a digital file for the purpose of aiding the mapping effort, to help assure data is not misplaced and to provide a means of referencing the data for comparison purposes. While BCSIS may not be the most appropriate system for this purpose since it is not currently being up-dated and maintained, a data file of similar design could be used. Where applicable, polygon boundaries should be digitized and linked to the data files that contain the attributes of the soil that has been mapped. In addition, it is recommended that, where applicable, existing soil inventories be digitized in an appropriate system, along with all appropriate data.

Geographic Information Systems (GIS) and related technologies have become an essential component for the compilation and use of soils and soils-related data. Valuable information is provided to the soil mapping process since GIS can provide items such as digital elevation models, image processing and integration of multiple data sources. In addition, the spatial analysis capability of GIS is suited for modelling and monitoring soil related phenomena. However, it should be noted that there is an inherent level of accuracy and precision for the soil map and related data which is expressed by the Survey Intensity Level (SIL - see Section 2.2.2). Given that digital mapping can essentially reproduce the map at any scale, it is critical that the user be aware of the SIL for the soil map being utilized. Simply enlarging the soil map does not increase the accuracy or reliability of the information.

The fact that automated soils data (attribute files and polygon files) can be readily integrated with other data sets through polygon overlay is of significant importance to organizations like the Resources Inventory Committee (RIC). Other inventories such as terrain, geology and vegetation can use the same base maps and file structure as the soil survey in order for all of these data sets to be compatible. These tools enable the integration of these data sets to be undertaken with significant cost and time savings.

5.4 The Soil Survey Report

A soil survey is only partly completed when the soils have been named, described, interpreted, and delineated on a map, and when the laboratory data and other data has been assembled. The mass of detailed information then needs to be organized so it will be readily useful to different groups of users, among them landscape architects, gardeners, science teachers, engineers, planners, developers and builders, homebuyers, foresters, farmers, and those seeking recreation. Presenting the detailed information in an organized, understandable manner is the purpose of a soil survey report. In a practical way, the soil survey report supports the map(s) and enables the user to make greater use of the information. However, the need for a report will depend on the objectives of the survey. The decision whether or not to spend time and budget on its preparation should be decided early in the survey planning stage.

While there are no specific established guidelines for a soil survey report, the data included in the report must always be accurate and scientifically valid. The reports organization and content usually varies with the characteristics of the landscape being mapped, the recognized user groups and the agency or individuals responsible for the survey. Some soil surveys are conducted and maps produced that do not have a supporting soil survey report but rather an expanded legend with supporting data available from other sources (e.g. data files).

At a minimum, the soil survey report should contain the following chapters for it to be considered complete and of the greatest use to the user groups:

1. **Index to the Map Units** (page reference to the description of the map units).
2. **General Description of the Map Area** (location of the map area; history and development; climate; physiography and drainage; vegetation; geology and parent materials of the soils).
3. **How the Survey was Conducted** (outline of methods and techniques used).
4. **The Mapped Soils** (general descriptions of all soil map units often supported by cross-sectional diagrams).
5. **Formation, Morphology and Classification of the Soils** (factors of soil formation; morphology of the soils; processes of soil horizon differentiation; landscape relationships among soils).
6. **Interpretations, Use and Management of the Soils** (capability classification; engineering uses; etc.).
7. **Descriptions and Analysis of the Soils** (profile descriptions of typical pedons; laboratory data); these can be included in the main body of the report or in an Appendix.
8. **Literature Cited**
9. **Appendices** (as required); Soil Map(s) and Legend (bound in report or in map pocket).

5.5 Maintenance and Access of Data Collected

When a soil survey is undertaken by a government agency or by a consultant paid by a government agency, it is considered public property. The same cannot be said for soil surveys that are undertaken by private organizations. However, it is hoped that these organizations would cooperate in making their information available for the common good of the community.

Regardless of who undertakes the soil survey, they have an obligation to make the accurate information available in a timely manner and to ensure that the data and information is maintained in an easily accessible and up-to-date manner. All data should be archived in an appropriate fashion for future applications.

6.0 USE OF THE SOIL MAP AND DATA

6.1 Planning the Use and Management of Soil

The soil survey is an analysis and evaluation of the most basic resource of the survey area - the soil. It may be used to fit the use of the land to the limitations and potentials of the natural resources and the environment, and help to avoid soil-related errors in uses of the land. However, it must be remembered at all times that no interpretation of a soil survey is complete without due consideration of interactions among all components of an ecosystem. In this regard, it is very important for the soil surveyor to consult and work with other professionals when developing interpretations. This will help ensure that the most appropriate techniques and data are used to make the interpretations and that the soil maps and data are of widespread use.

During a soil survey extensive notes are kept, not only about the nature of the soils but also about unique aspects of behaviour of these soils in the field. These notes include observations of erosion, damage to plants, flooding, soil failures, wildlife habitat, and other factors relating to the kinds of soil and their productivity, potentials and limitations under various uses and management. In this way, field experience incorporated with measured data on soil properties and performance can be used as a basis for predicting soil behaviour. Information from these field notes should be incorporated into the soil survey report where applicable.

Information from the soil survey can be used in applying basic facts about the soils to plans and decisions for use and management of the soils for many farm and non-farm uses (e.g.highways, sanitary facilities, parks, wildlife habitat, etc.). From the data provided by the soil survey, the potential of each soil for specified land uses may be determined, soil limitations to those land uses may be identified and costly failures avoided. A site can be selected where the soil properties are favourable, or a practice can be planned that will overcome the soil limitations. Planners and others using the soil survey can evaluate the impact of specific land uses on the environment. Plans can be made to maintain or create a land use pattern in harmony with the natural soil.

6.2 The Kinds of Interpretations

In B.C., to-date, the most extensive interpretation of soil survey information have been by the Canada Land Inventory (CLI) and B.C. Land Inventory (BCLI) programs. These programs provided a series of maps outlining capability classes for agriculture and forestry and these applications should continue in the future. In addition to these, several soil survey map areas have provided interpretations for a variety of other uses to which soil and other natural resource information (e.g. climate) have been applied. Table 6.1 provides an example of these interpretations for forestry, agriculture and grazing. Table 6.2 provides an example for engineering and related land uses.

Methods for undertaking these interpretations are outlined in several publications. These publications are listed in Appendix C and while the list of interpretation references is not exhaustive, it is important to note that whatever interpretive methodology is chosen, it must be applied in a consistent manner throughout the project or survey area.

Table 6.1 Example of Agriculture and Forestry Interpretations from a Soil Survey (From Biophysical Resources of the East Kootenay Area: Soils, Lacelle, 1990)

Soil Association Component	Agriculture		Forestry			
	Climate Capability for Agriculture	Soil Capability for Agriculture	Land Capability for Forestry	Natural Forest Regeneration Potential	Windthrow Hazard	Relative Susceptibility of Soils to Damage by Disturbance
AS1,3,9,10	3G	5IP	2S	high	low	low
AS11,12	3G	6WI	6WI	low	moderate	low
AZ1-3	3GF	4X	2S	high	moderate	high
AZ7	3GF	6ED	3ED	high	moderate	high
BB1-6	6G	7TR	6ER	moderate	high	high
BB7,8	6G	7ER	7ER	low	high	high
BC1-6; B01-6; BP1-6; RF1-6; RG1-6; RT1-6	6GH	7TR	5HR	moderate	high	moderate
BC7; BO7; BP7; RF7	6GH	7ER	6ER	moderate	high	moderate
BC8; BO8; BP8; RF8; RG8; RT8	6GH	7ER	7ER	low	high	moderate
BF1-6; RC1-6; RP1-6; RS1-6	5G	7TR	5MR	moderate	high	moderate
BH1-6; BK1-6; RS8	6G	7TR	5HR	moderate	high	moderate
BH7; BK7	6G	7ER	6ER	low	high	moderate
BH8; BK8	6G	7ER	7ER	low	high	moderate
BK - see BH						
BN1-6	5G	7TR	5R	moderate	high	moderate
BN7	5G	7ER	6ER	low	high	moderate
BN8	5G	7ER	7ER	low	high	moderate
BO - see BC						
BP - see BP						
BS1-6; RH1-6	6G	7TR	5R	moderate	high	moderate
BS7; RH7	6G	7ER	6ER	low	high	moderate
BS8; RH8	6G	7ER	7ER	low	high	moderate
CA1-4	3GF	3C	1	high	high	high
CA7	3GF	5TE	2ED	moderate	high	high
CAI1-4; CE1-4	5G	6T	4M	high	low	low
CAI7; CE7	5G	6TE	4ME	moderate	low	low
CB1-4; CW1-4	6G	6T	4M	high	low	low
CB7; CW7	6G	6TE	5ME	moderate	low	low
CB8; CW8	6G	6TE	7E	low	low	low
CC1-4	5G	6T	2S	high	high	high
CC7	5G	6TE	3ED	moderate	high	high
CD1-4	3G	4TDs	2S	high	high	high
CD%	3G	5TR	3RD	high	high	high
CD7	3G	5TE	3ED	moderate	high	high
CE - see CAI						
CE8	5G	6TE	7E	low	low	low

Table 6.2 Example of Geological Hazards and Terrain Capability for Residential Settlement Interpretations from a Soil Survey

Soil Parent Material Groups	Soil Associateion Components	Constraints Affecting Use For*							Geological Hazards**
		Septic Tank Disposal Fields	Foundations for Low Rise Dwellings	Road and Street Subgrade	Ease of Excavation	Sites for Sanitary Landfill	Source of Topsoil	Source of Sand and Gravel	
Floodplain deposits (Regosolic soils)	AS1,9-11; CN1,3; FA1,3; FD1,2; FE1,2; FF1,3; FJ1,2; FK1,2; FM1,3,9; FQ1,2; FR10; FS1,3; FT10; FU1,3; FV1,2; FZ1,3; GN10; KO10; L10; NW1,2; S1,2	severe	severe	severe	moderate	severe	moderate	moderate	inundation; shifting channels; bank erosion
Floodplain deposits (Gleysolic soils)	AS3,11,12; CN10,11; FA10,11; FD10,11; FE10,11; FF10,11; FJ10,11; FK10,11; FM10,11; FQ10,11; FS10,11; FU10,11; FV10,11; FZ10,11; KO11; L11; MA10; NW3,11; S3,10,11	severe	severe	severe	severe	severe	severe	severe	inundation; shifting channels; bank erosion
Fluvial fans (relatively fine texture)	CA1-4; F01-4,9; FP1-4; GE1-4; GZ1-4; MA1-3	moderate	moderate	moderate	slight	moderate	slight	moderate	inundation; shifting channels; bank erosion; debris, mud or earth flows
Fluvial fans (relatively coarse texture)	FR1-4; FT1-3	moderate	slight	slight	slight	slight	moderate	slight	inundation; shifting channels; bank erosion; debris, mud or earth flows
Fluvial terraces and fluvioglacial terraces, plains and fans (coarse texture)	FX1,2,9; GB1-4; GC1-4; GL1-4; GN1-4; GR1-4; GT1-4; GY1-4; KA1-4; KG1-4; KR1-4	severe	slight	slight	slight	moderate	moderate	slight	--
Fluvial, fluvioglacial and eolian deposits (sandy surface texture)	E1,2,4,9; F1,2,9; GD1-4; H1,3; KE1-4; KO1-4; L1-3; MY1-4; SA1,3,9,10	severe	slight	slight	slight	moderate	slight	slight	wind erosion

6.3 Quality Control and Correlation

The need to maintain quality throughout the process of preparing interpretive maps and information is as equally important as **quality control** is during the conduct of the soil survey itself. With the increased use of computers and sophisticated software for preparing interpretive maps and summary tables, it is of vital importance to undertake checking and other quality control procedures prior to the release of the information. Methods used for the interpretation must be fully documented for the user and limitations inherent in the results must be explained.

Perhaps the most useful way to provide quality control is to have periodic reviews of the interpretive information conducted by the Soil Correlator. In this manner, the soil scientist is provided with a peer review of his work and inconsistencies and errors can be detected and corrected.

6.4 The Use of Other Data

It is unlikely that all interpretations can be undertaken solely with the data provided by the soil survey. A soil survey provides information about soils and should not be considered as the only data source required for land use planning and management. Other than derivations from the map and laboratory data (e.g. drainage, depth to bedrock, pH) it is often necessary to include information from other disciplinary studies for the interpretation to be complete and of most value to the user. For example, the preparation of an Agriculture Capability Map cannot be completed without climatic information such as freeze - free period and growing degree - days. Equally, it is not feasible to prepare interpretations regarding wildlife habitat without information on plant ecology and the specific requirements of the wildlife being considered. Where computers are used to prepare interpretations from the soil map and related data, augmented by other data sets (e.g. climate, terrain), it is important for the individual who is responsible for the interpretations to be aware of any inconsistencies among the data sets (e.g. accuracy of the information) prior to performing the interpretations.

The need for additional studies to support the objectives of the soil survey must be identified and planned for during the initial organization of the soil survey. It is not satisfactory to discover at the end of the survey that a vital piece of information is missing. Scheduling and budgeting for these studies must be considered an essential part of the soil survey workplan.

The use of data from other sources must be fully acknowledged by the soil surveyor. Those individuals who have contributed their time and effort in providing information and professional opinion should be referenced in the soil survey report.

6.5 Distribution and Format of Interpretive Information

The largest number and greatest geographical coverage by interpretive maps based on soil survey are those produced by the Canada Land Inventory and B.C. Land Inventory (e.g. Agriculture Capability). In addition, many recent soil surveys have not actually produced interpretive maps, but have provided "interpretive tables" in the soil survey report that the users can apply in the construction of their own interpretive map.

With the increased application of digital files for both the map polygon as well as attribute data regarding the properties of the map unit, it is possible to prepare interpretive maps very quickly and efficiently upon request. Consequently, it is not usually necessary to prepare a multitude of interpretive maps waiting for the user to request them, but rather to respond to the request when it is made. Regardless of the method used, it is important that the soil surveyor, or his colleagues, who were responsible for the survey, to undertake and perform quality control checks on the interpretive maps and data.

For all future systematic soil surveys, it is assumed that they will be supported by computer-based cartographic and data handling tools. In one form or another, these will be Geographic Information Systems that will be linked to other geographic data bases such as TRIM. By providing soil survey maps and data in this manner to the user, it is redundant to prepare a series of interpretive maps since they can be provided on demand to the user or the user himself can undertake the work. Regardless of this, it is recommended that specific, well documented methods be utilized for the interpretations and that the results of the interpretations be checked by the soil surveyor. The most important aspect is for the soil surveyor and his support agency to maintain an organized, up-to-date, and easily accessible data base for user groups to utilize.

7.0 REFERENCES AND BIBLIOGRAPHY

Agriculture Canada. 1978. History of Soil Survey in Canada. Historical Series No. 11. Soil Research Institute. Ottawa, Ontario. 30pp.

Agriculture Canada. 1980. Soils of the Lac La Hache-Clinton Area, British Columbia. B.C. Soil Survey Report No. 25. Research Branch, Agriculture Canada. Vancouver, B.C.

Agriculture Canada. 1987. Soils of the Taseko Lakes Area, British Columbia. Soil Survey Report No. 36. Research Branch. Ottawa, Ontario. 13pp.

Agriculture Canada Expert Committee on Soil Survey. 1987a. The Canadian System of Soil Classification. 2nd ed. Agriculture Canada Publication 1646. 164pp.

Agriculture Canada Expert Committee on Soil Survey. 1987b. Soil Survey Handbook - Volume 1. Land Resource Research Centre, Contribution No. 85-30. Technical Bulletin 1987 - 9E. Agriculture Canada. Ottawa.

Bartelli, L.J. and J.A. DeMent. 1970. Soil Survey - A Guide for Forest Management Decisions in the Southern Appalachians *in* Youngberg, C. and C.B. Davey (eds) Tree Growth and Forest Soils, Oregon State University Press. Corvallis, Oregon. pp. 427-434.

B.C. Ministry of Environment. 1988. Terrain Classification System for British Columbia - Revised Edition. Ministry of Environment Manual 10, Recreational Fisheries Branch and Resource Mapping Branch. Victoria, B.C. 90pp.

Block, J. and V. Hignett. 1982. Outdoor Recreation Classification for British Columbia. APD Technical Paper 8. British Columbia Ministry of Environment. Victoria, B.C.

Canada Land Inventory. 1972. Soil Capability Classification for Agriculture. The Canada Land Inventory Report No. 2. Lands Directorate. Department of the Environment. Ottawa, Ontario.

Canada Soil Survey Committee. 1978. Manual on Soil Sampling and Methods of Analysis. Canadian Society of Soil Science. Ottawa. 212pp.

Canadian Society of Soil Science. 1993. M.R. Carter (ed). Soil Sampling and Methods of Analysis. Lewis Publisher. 823pp.

Kenk, E. 1983. Land Capability Classification for Agriculture in British Columbia. Manual 1. B.C. Ministry of Environment and Ministry of Agriculture and Food. Victoria, B.C. 62pp.

Kenk, E. 1979. Recommended Logging System Based on Soil Information. RAB Working Report. British Columbia Ministry of Environment. Kelowna, B.C.

Kowall, R.C. 1971. Methodology, Land Capability for Forestry in British Columbia. British Columbia Department of Agriculture. Kelowna, B.C.

Lacelle, L.E.H. 1990. Biophysical Resources of the East Kootenay Area: Soils. B.C. Soil Survey Report No. 20. B.C. Ministry of Environment, Lands and Parks, Wildlife Branch. 359pp.

Luttmerding, H.A. 1980. Soils of the Langley-Vancouver map area. Volume 1, Soil map mosaics and legend, Lower Fraser Valley. Report No. 15. British Columbia Soil Survey. Ministry of Environment. Victoria, B.C.

Luttmerding, H.A., D.A. Demarchi, E.C. Lea, D.V. Meidinger, T. Vold (eds). 1990. Describing Ecosystems in the Field - 2nd Edition. Ministry of Environment Manual 11. Ministry of Environment and Ministry of Forests. Victoria, B.C. 213pp.

Mapping Systems Working Group. 1981. A Soil Mapping System for Canada: Revised. Land Resource Research Institute. Contribution No. 142. Agriculture Canada. Ottawa. 94pp.

Maynard, D. 1979. Terrain Capability for Residential Settlements: Summary Report. RAB Working Report. British Columbia Ministry of Environment. Victoria, B.C.

McCormack, R.J. 1972. Land Capability Classification for Forestry. The Canada Land Inventory Report No. 4. Department of the Environment. Ottawa, Ontario.

Montgomery, P.H. and F.C. Edminster. 1966. Use of Soil Surveys in Planning for Recreation. L.J. Bartelli et al. Pages 104-112 in Soil Surveys and Land Use Planning. Soil Science Society of America and American Society of Agronomy. Madison, Wisconsin.

Runka, G.G. 1973. Methodology, Land Capability for Agriculture. British Columbia Department of Agriculture. Kelowna, B.C.

U.S. Department of Agriculture. 1975a. Revised Soil Survey Handbook. Agricultural Handbook No. 18. Revised. Soil Conservation Service. Washington, D.C.

U.S. Department of Agriculture. 1975b. Soil Taxonomy. Agriculture Handbook No. 436. Soil Conservation Service. Washington, D.C. 754pp.

U.S. Department of Agriculture. 1971. Guide for interpreting Engineering Uses of Soils. Washington, D.B. 87pp.

Vink, A.P.A. 1963. Planning of Soil Surveys in Land Development. Int. Institute for Land Reclamation and Improvement., Publ. 10, Wageningen, The Netherlands. 55p.

Walmsley, M.E. 1992. Report of the Soils Task Group to the Resources Inventory Committee. 34pp plus appendices.

Wang, C. 1980. Transect Mapping and its Application. **in** Day. J.H. (ed). Minutes of second annual meeting of Expert Committee on Soil Survey. Land Resource Research Inst. Ottawa. p197-212.

Young, G., M.A. Fenger and H.A. Luttmerding. 1992. Soils of the Ashcroft Map Area. B.C. Soil Survey Report No. 26. B.C. Ministry of Environment. Victoria, B.C. 233pp.

APPENDIX A

Soil Survey Project Plan Summary

(from Agriculture Canada, 1987b)

PREAMBLE

The portion of the Soil Survey Project Plan contained in this appendix is contained in full in the publication **Soil Survey Handbook - Volume I** (Agriculture Canada, 1987b). This appendix provides only the summary format in order to provide the reader with a guide to the type of information which should be incorporated into the plans for a soil survey. The reader is encouraged to reference the publication in order to review the full project planning framework. However, since the actual project plan for a soil survey will vary due to differences in survey objectives and jurisdictions, it may be appropriate to develop a plan that is specific to those needs.

SOIL SURVEY PROJECT PLAN

Part I - Summary

A. IDENTIFICATION

A1 **Title & project no.**:

A2 **Originator**:

A3 **Location & geographical situation**:

A4 Summary statement (<100 words on objectives, area extent, agencies, resources py per yr & for each coop agency, staff, dates, cost, i.e., highlights of following material, abstracted last).

B. PROJECT DEFINITION AND OBJECTIVES

B1 **Requirement**. 1. Requested by:
or 2. Part of long-term plan of:

B2 **Relevant background** of the requirement, including reasons for the originator (<100 words):

B3 **Purpose and objectives**: Define the information requirement (<100 words):

B4 **Output** (summary of details in E9, E10, E11)

Interim maps - number: SIL: Scale:

Final maps - number: SIL: Scale:

Interpretive maps - approximate number of categories:

Kind of report(s): internal ( ), provisional/interim ( ), final ( ),
expanded legend ( ), wide readership, both ( )

Interpretive pamphlets: open-file data

C. SCHEDULE AND RESOUCE REQUIREMENTS

C1 **Date of initiation:** Date of completion:

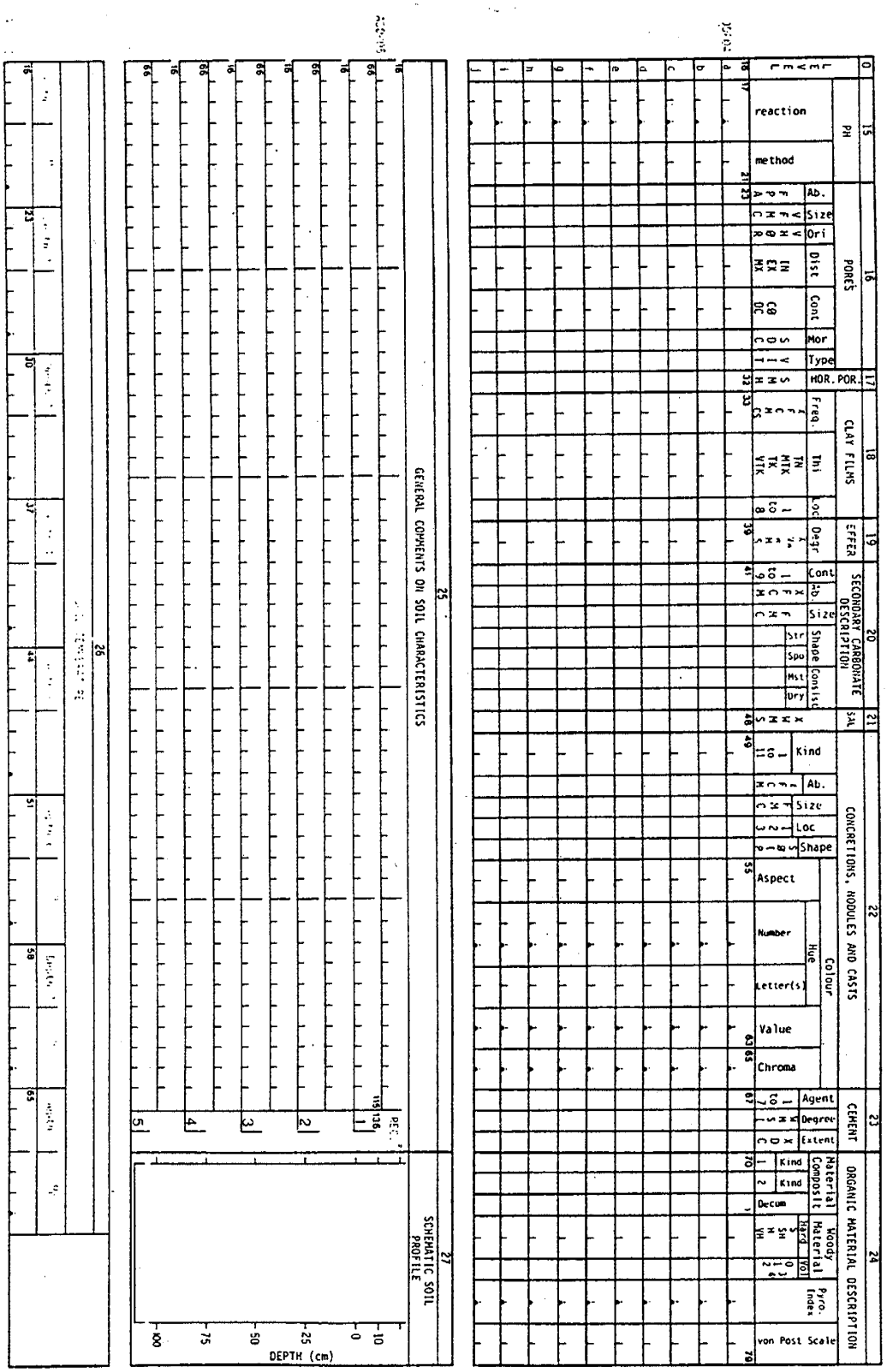
C2 **Costs:**

		Agency 1	Agency 2
Identity			
Person-years	Total		
	Annual		
Non-pay	$ Total		
	$ Annual		
Exceptional items $			

APPENDIX B

Site and Soil Description Forms

(from Luttmerding, et al. 1990)

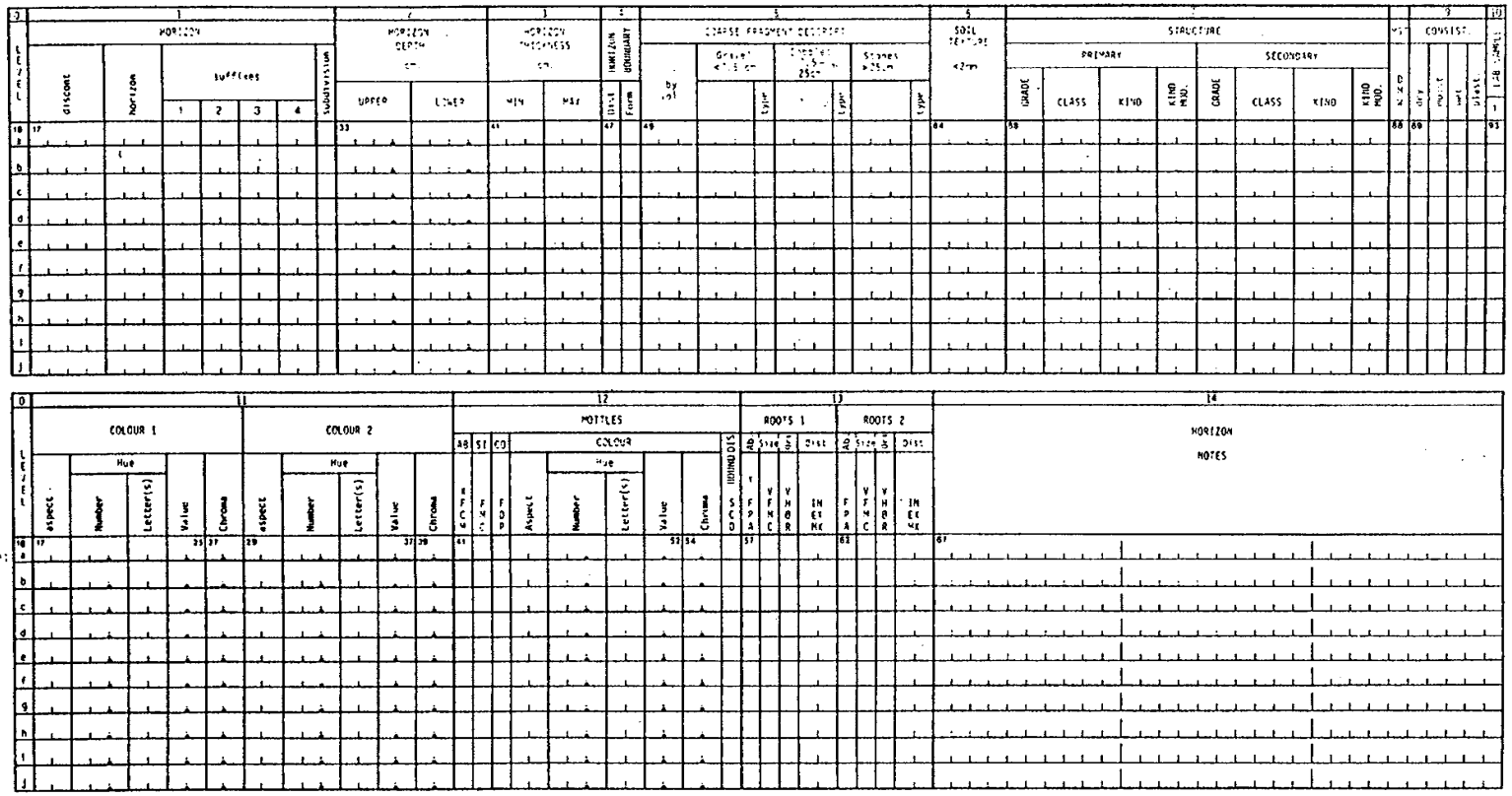


(if continuation then put # over 30BP09)

SERIES ☐☐ FORM ☐☐☐☐☐

SOIL DESCRIPTION FORM

PROJECT I.D. _____ PLOT NO. _____ SURVEYOR _____ PAGE ___ OF ___



Province of British Columbia Ministry of Environment and Parks Ministry of Forests and Lands Ministry of Agriculture and Fisheries

ENV. 1895

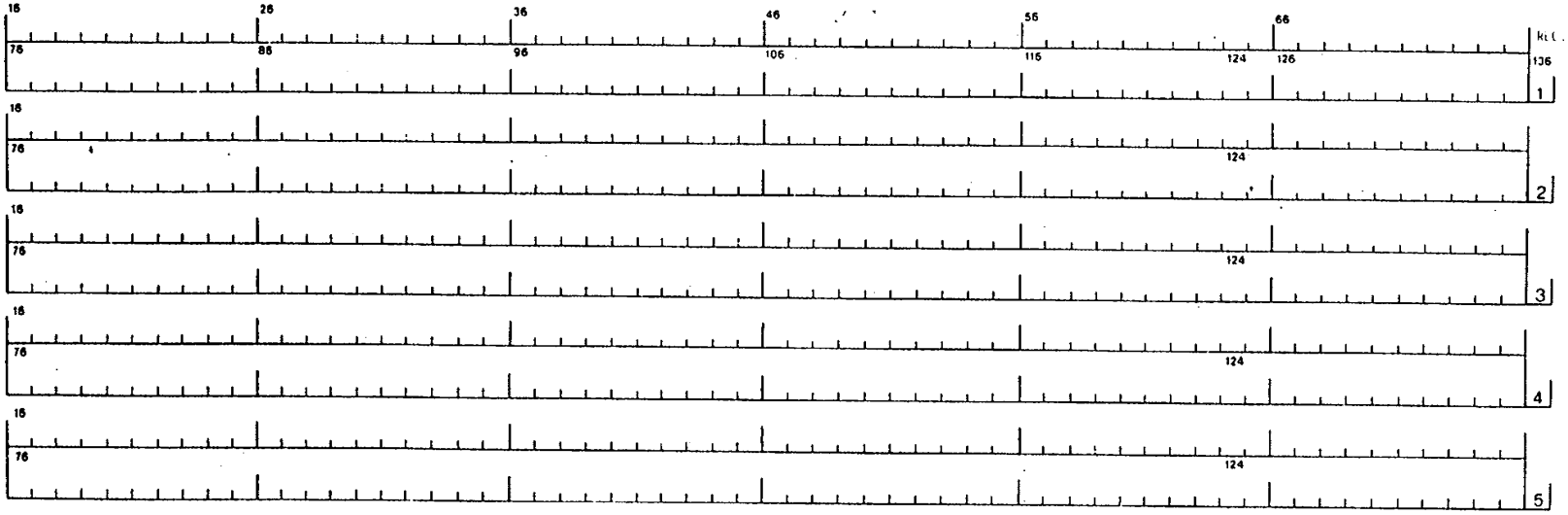
SERIES ☐☐ FORM ☐☐☐☐

SITE DESCRIPTION FORM

PAGE ____ OF _____

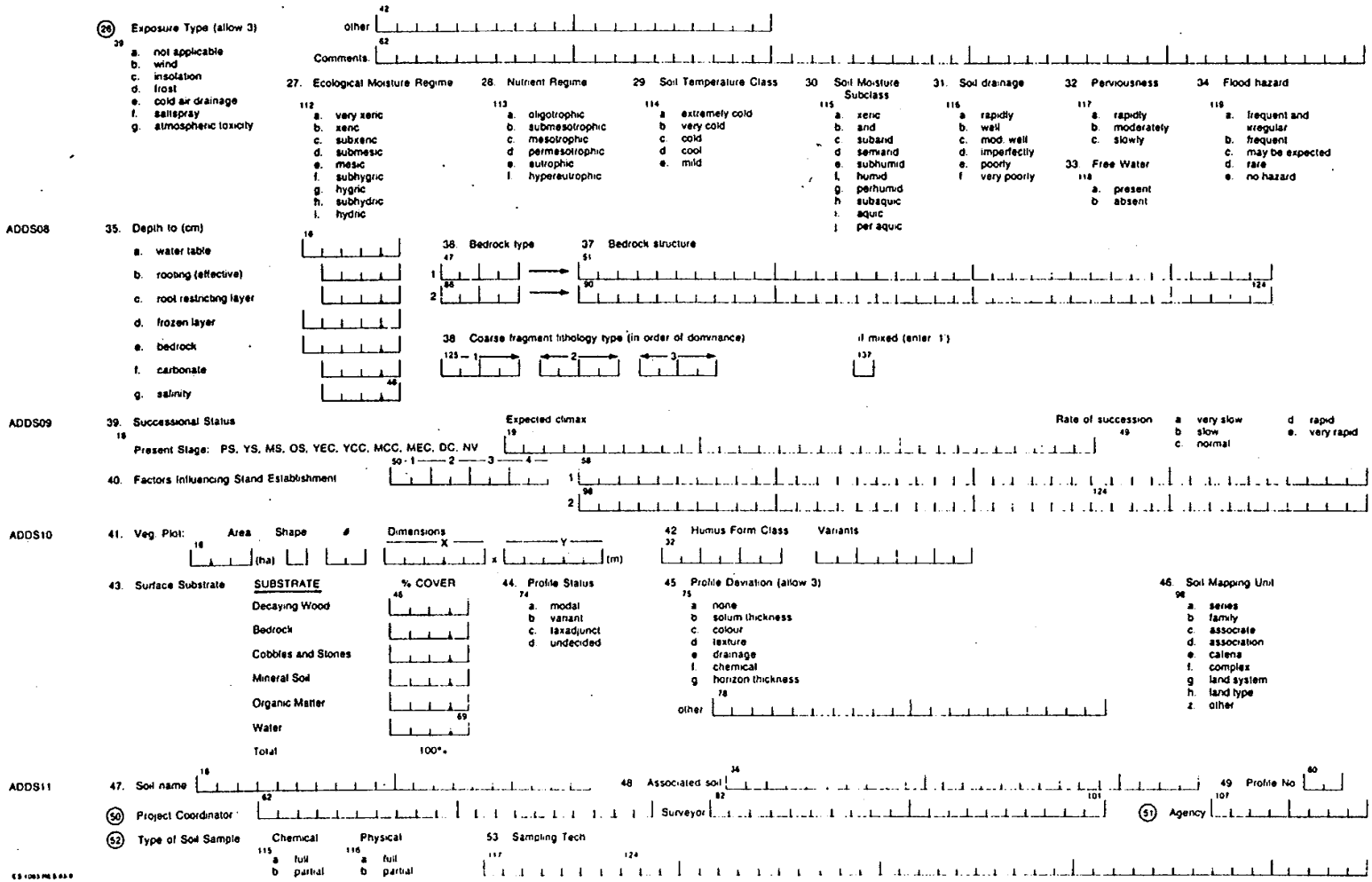
54. Notes on Site Description

ADDS12



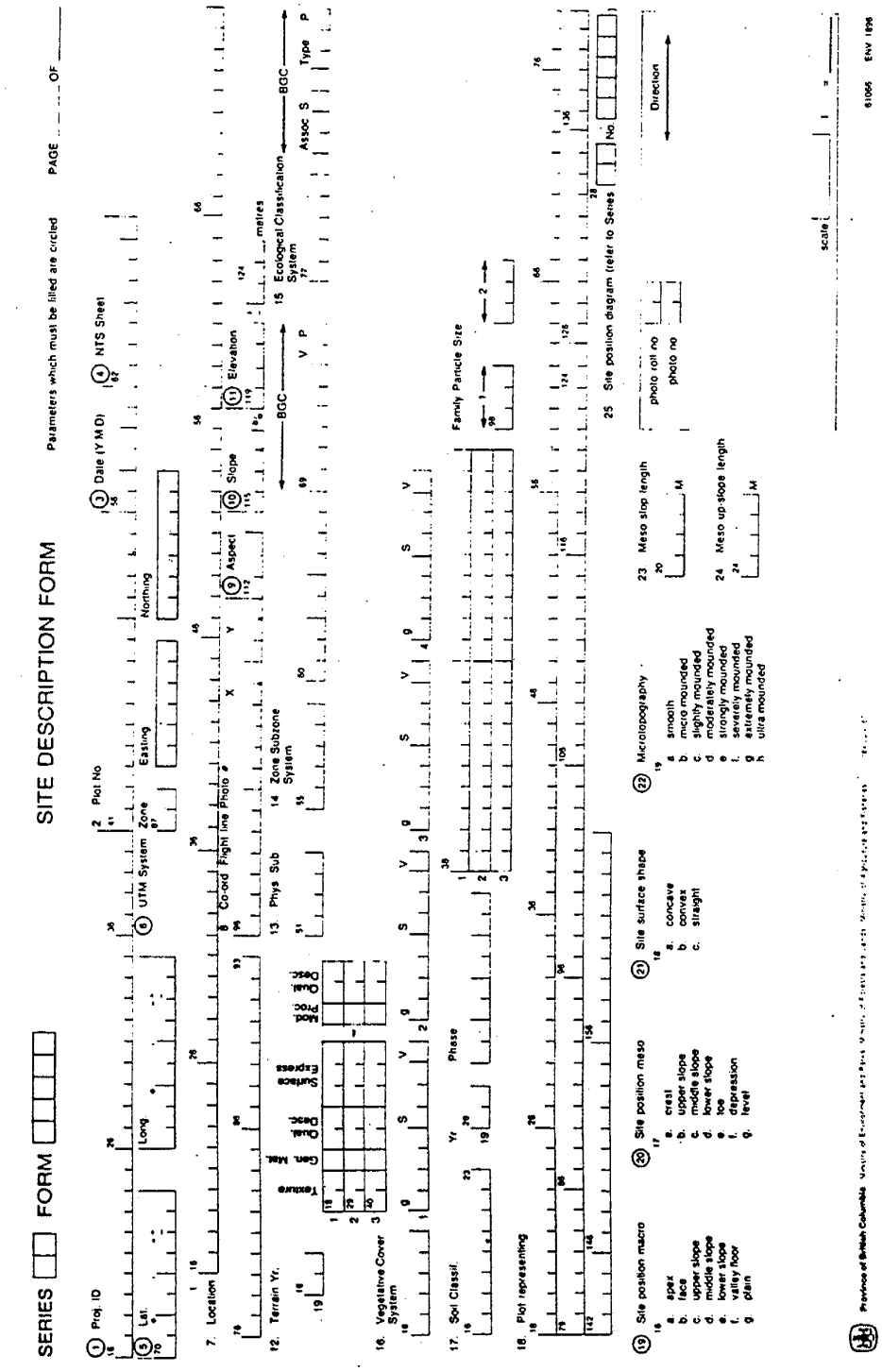
Province of British Columbia Ministry of Environment and Parks Ministry of Forests and Lands Ministry of Agriculture and Fisheries rev. Oct. 87

ENV. 1897


(28) Exposure Type (allow 3)
a. not applicable
b. wind
c. insolation
d. frost
e. cold air drainage
f. saltspray
g. atmospheric toxicity
other
Comments:
27. Ecological Moisture Regime
a. very xeric
b. xeric
c. subxeric
d. submesic
e. mesic
f. subhygric
g. hygric
h. subhydric
i. hydric
28. Nutrient Regime
a. oligotrophic
b. submesotrophic
c. mesotrophic
d permesotrophic
e. eutrophic
f hypereutrophic
29 Soil Temperature Class
a extremely cold
b very cold
c cold
d cool
e. mild
30 Soil Moisture Subclass
a. xeric
b. arid
c subarid
d semiarid
e. subhumid
f. humid
g. perhumid
h subaquic
i. aquic
j per aquic
31. Soil drainage
a rapidly
b. well
c. mod. well
d. imperfectly
e. poorly
f very poorly
32 Perviousness
a. rapidly
b. moderately
c. slowly
33. Free Water
a. present
b absent
34 Flood hazard
a. frequent and irregular
b. frequent
c. may be expected
d. rare
e. no hazard
ADDS08
35. Depth to (cm)
a. water table
b. rooting (effective)
c. root restricting layer
d. frozen layer
e. bedrock
f. carbonate
g. salinity
36. Bedrock type
37 Bedrock structure
38 Coarse fragment lithology type (in order of dominance)
If mixed (enter 1)
ADDS09
39. Successional Status
Present Stage: PS, YS, MS, OS, YEC, YCC, MCC, MEC, DC, NV
Expected climax
Rate of succession
a very slow
b slow
c. normal
d rapid
e. very rapid
40. Factors Influencing Stand Establishment
ADDS10
41. Veg. Plot: Area (ha) Shape # Dimensions X x Y (m)
42 Humus Form Class
Variants
43. Surface Substrate
SUBSTRATE
% COVER
Decaying Wood
Bedrock
Cobbles and Stones
Mineral Soil
Organic Matter
Water
Total
100%
44. Profile Status
a. modal
b variant
c. taxadjunct
d. undecided
45 Profile Deviation (allow 3)
a none
b solum thickness
c. colour
d texture
e drainage
f. chemical
g horizon thickness
other
46. Soil Mapping Unit
a. series
b family
c. associate
d. association
e. catena
f. complex
g land system
h. land type
z. other
ADDS11
47. Soil name
48 Associated soil
49 Profile No
(50) Project Coordinator
Surveyor
(51) Agency
(52) Type of Soil Sample
Chemical
a full
b partial
Physical
a full
b partial
53 Sampling Tech

APPENDIX C

List of References for Soil Interpretation Methods



Engineering Uses - Urban Development

Septic Tank Absorption Fields (Maynard, 1979; USDA, 1971)

Foundations for Low-Rise Buildings (Maynard, 1979; USDA, 1971)

Subgrade for Roads and Streets (Maynard, 1979; USDA, 1971)

Ease of Excavation (Maynard, 1979; USDA, 1971)

Solid Waste Disposal Sites (Maynard, 1979; USDA, 1971)

Source of Topsoil (Maynard, 1979 a and b; USDA, 1971)

Sewage Lagoons (USDA, 1971)

Potential Frost Action (USDA, 1971)

Flood Hazard (Maynard, 1979)

Forestry

Forest Capability (McCormack, 1972; Kowall, 1971)

Erosion Hazard (Kenk, 1979)

Geomorphic Hazard (Kenk, 1979)

Forest Harvesting Limitations (Kenk, 1979)

Suitability for Sand and Gravel (Maynard, 1979)

Recreation

Suitability for Playgrounds (Montgomery and Edminster, 1966)

Suitability for Camp Areas (Montgomery and Edminster, 1966)

Suitability for Picnic Areas (Montgomery and Edminster, 1966)

Suitability for Paths and Trails (Montgomery and Edminster, 1966)

Recreation Carrying Capacity (Block and Hignett, 1982)

Agriculture

Agriculture Capability (CLI, 1972; Runka, 1973)

Land Capability Classification for Agriculture in British Columbia (Kenk, 1983)

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