3.0 SOIL SURVEY AND SAMPLING

3.1 INTRODUCTION

It is important to understand the soil relationships in an area prior to preparation of a development plan in order to ensure adequate evaluation of the potential for reclamation. A soil survey with relevant interpretations is one of the first steps to be taken. The soil survey is planned and conducted to provide the level of information required for activities such as materials handling and soil reconstruction. The following section describes mapping and sampling techniques to be employed to conduct soil surveys.

3.2 SOIL SURVEY

3.2.1 Design

A soil survey is planned or designed on the basis of a sequence of decisions (Expert Committee on Soil Survey (ECSS) 1981). These decisions are listed and discussed below:

1. Establish the objectives of the survey. The objective of baseline soils mapping in this context is to provide information on the types of soil present, in sufficient detail, that decisions regarding materials handling and post disturbance soil reconstruction can be made. The information also provides a basis for formulating interpretations or predictions relative to post disturbance land use.

2. Determine the smallest area in the field that must be described and delineated to meet the objectives of the survey. The minimum size delineation is generally considered to be the smallest delineation inside which a simple symbol can be printed or the smallest area which can be discerned by a map user. The ECSS (1981) recommends that practical minimum size delineation on a soil survey map is one-half of a square centimetre.

3. Determine the survey intensity level (SIL). SIL is defined and controlled by the number of field inspections per unit area or other estimates of accuracy. Generally speaking, the number of field inspections increases with the detail of survey. The SIL involves implications of inspection densities, scale, survey techniques, levels of soil taxonomy used and accuracy of boundaries. Five survey intensity levels are proposed in Canada (ECSS 1981) but only Levels 1 and 2 are described in Table 1 as they reflect the amount of precision required for working with soils in the context of this report. On the basis of research conducted in Montana, Schafer (1979) suggests that order 2 (1:12 000 to 1:30 000) soil surveys are useful for general planning but must be supplemented by order 1 (1:10 000 scale) maps for purposes of cover-soil selection. For the purpose of this report it is suggested Level 2 surveys be conducted to provide a mechanism for general planning and that more detailed work be conducted where necessary depending upon the type of surface disturbing activity and the associated needs. Table 1 provides suggested scale limits for the two intensity levels defined and Table 2 provides recommended scales for mapping.

Table 1. Criteria for identifying survey intensity levels[1].

Survey Intensity Level (SIL)	Common Name	Definitive Characteristics		Associated Features		Appropriate Scale (Usual) [3]
		Inspection Intensity	Methods of Investigations	Main kinds of Soil Components	Map Units[2]	
SIL1	very detailed	At least one inspection in every delineation (1 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 and samples 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 (1 per 2-20 ha). Boundaries plotted by observations and interpretation of remotely sensed data verified at closely spaced intervals	Transects and traverses less than 1.5 km apart. Profile descriptions and analyses for all major soils	Series or phases or series	Simple and compound units	1:5 000 to 1:40 000 (1:20 000)

[1] Adapted from a Soil Mapping System for Canada: Revised (ECSS 1981).
[2] Simple units have over 80% or a single component or a nonlimiting inclusion. Compound units are complexes or associations of two or more components.
[3] Appropriate publication scale

Table 2. Guidelines for conducting soil surveys relative to development and reclamation.

Region	Purpose of Mapping	Level of Survey	Recommended Publication Scale	Min. Size Area Represented by 1 cm^2 on Map (ha)	Inspection Density (ha / Insp)	Sampling Density (Profile: Sites) ha/Sample	Overburden Sampling ha / Sample Site
Plains	Baseline	2	1:10 000	1	1 to 5	10 to 50	150 to 300
	Post Disturbance (Nonselective Handling)	1	1:5 000	0.25	0.25 to 1.25	1.25 to 6.25	
	Post Disturbance (Materials Handling)	1	1:10 000	1	1 to 5	10 to 50	
Eastern Slopes	Baseline	2	1:10 000	1	1 to 5	10 to 50	150 to 300
	Post Disturbance (Nonselective Handling)	1	1:5 000	0.25	0.25 to 1.25	1.25 to 6.25	-
	Post Disturbance (Materials Handling)	1	1:10 000	1	1 to 5	10 to 50	-
Northern Forest	Baseline	2	1:10 000	1	1 to 5	10 to 50	150 to 300
	Post Disturbance (Nonselective Handling)	1	1:5 000	0.25	0.25 to 1.25	1.25 to 6.25	-
	Post Disturbance (Materials Handling)	1	1:10 000	1	1 to 5	10 to 50	-

The scale of mapping is largely based on the minimum size of field delineation. For example, if soil units with different use potentials must be recognized down to a size of 4 ha then the scale should be at least 1:20 000. Table 2 indicates that Level 2 surveys are conducted for the purpose of providing baseline or general planning surveys in the three regions of the province. In these three major regions there are different factors which must be considered. For example, in the Plains Region one would probably concentrate on parameters such as depth of topsoil (Ah horizon) and the presence or absence of Solonetzic soils. In the Eastern Slopes Region parameters such as total depth of soil material overlying bedrock and coarse fragment content would be of concern. For post disturbance mapping a scale of 1:5000 is suggested for non-selectively handled areas or those areas where materials handling techniques were minimal. Where materials handling techniques (selection and salvage of materials) were employed a scale of 1:10 000 is recommended.

4. Determine the inspection density in relation to the scale and purpose of the survey. Inspection density is related to the amount of ground truth (digs or observations) that is required. An "observation" or "dig" can be defined as a ground truth that the pedologist can use as a control point to extrapolate his or her mapping. This usually means a soil exposure by shovel or auger, but could range up to a fly-past in the case of rock outcrop. Inspection density provides some measure of the reliability of a soil map. Generally speaking, for a reasonably reliable soils map there should be one dig or inspection per sq cm on the map (ECSS 1981). An acceptable range might be 0.2 to 2 inspections per sq cm. The concept of 1 inspection per sq cm is based on an average for the specific project. In areas where soils are easily interpreted from soil landscapes, or from aerial photographs, the inspection density could drop by a factor of 5 or 10 from the level of 1 per sq cm on the map.

   The number of inspections per area of land varies with the detail of the survey. Therefore, inspection density must be closely tied to and related to scale. Table 2 provides suggested inspection densities relative to recommended scales based on an inspection density of 1 to 5 ha per inspection.

   For linear disturbances such as pipeline rights of way in agricultural areas, the inspection density is the number of soil inspections made relative to the length of the right of way. For a soil evaluation done for problem (solonetzic or saline) soils or problem parent materials, the inspection density is between two to five inspections per kilometre. For ground truthing in areas where existing information from soil surveys and geology maps indicates there will be no problem soils or problem parent materials, the inspection density is one site per kilometer.

3.2.2 Soil Profile Characteristics and Landscape Features

Soil mapping involves the recognition of soil profile characteristics and landscape features. The profile characteristics normally observed and recorded include:

1. horizon thickness and sequence;
2. colour;
3. texture;
4. structure;
5. consistence;
6. effervescence and salt crystals;
7. coarse fragments;
8. field pH (not required for all observation sites);
9. presence of mottles; and
10. roots.

The parameters observed in completing a site description include the following:

1. slope class (topography);
2. aspect;
3. landform;
4. surface stoniness;
5. surface and internal drainage;
6. extent of erosion;
7. present land use (as related to delineating soil types); and
8. vegetation cover - trees, shrubs, herbs, grasses, and mosses (as related to delineating soil types).

Not all of the above parameters need be recorded for each site inspected, however, they should be documented for each profile sampling site. Furthermore, the parameters recorded will vary to some extent relative to the type of disturbance involved

3.2.3 Map Presentation

The soil survey information should be presented on an aerial photo mosaic base. With the relatively large scales involved, location and orientation are superior compared to line drawn or colour coded maps. Because the landscape is illustrated, interpretations are easier to make. Use of the photo mosaic base is particularly helpful in working with post disturbance landscapes.

3.3 SOIL SAMPLING

The methods of sampling vary with the purpose for which the samples are required. For example, sampling in conjunction with predisturbance mapping may involve emphasis on different parameters than sampling of disturbed areas.

Sampling intensity is largely dependent upon the scale of mapping employed and the variability of the soils encountered in the survey. A less intensive sampling program would be appropriate in areas where the materials are relatively homogeneous.

3.3.1 Sampling for Baseline Evaluation Purposes

The number of sampling sites selected should be determined primarily by the frequency of occurrence of the individual map units. Adequate numbers of samples should be collected to properly characterize the various map units (Table 2).

In the case of baseline mapping the samples are collected for purposes of characterization and classification. For this reason sampling intensity refers primarily to sampling of soil pits. However, some "grab" samples of surface materials may also be collected for characterization purposes and are included in the overall recommended number of sampling sites. It is suggested that for baseline purposes at least 50% of the sampling sites include sampling the entire soil profile.

Table 2 provides a range in the sampling density required for a particular scale. For example, for a Level 2 survey conducted at a scale of 1:10 000, a sampling density ranging from 10 to 50 ha per sampling site is recommended. In mapping for baseline or evaluation purposes an overall sampling density of 30 to 50 ha is probably adequate.

3.3.2 Methodology of Sampling for Baseline Purposes

The following provides a suggested procedure for sampling as part of a soil survey for baseline or evaluation purposes:

1. select sample sites typical of the soils that the samples are intended to represent (McKeague 1978);
2. the sites should be away from fences, roads, and other features that may cause atypical properties;
3. samples should be collected from freshly dug pits and not from roadcuts. The pit should be deep enough to expose part of the C horizon, or to the bottom of the control section (CSSC 1978), whichever is deeper.
4. sample on a horizon or "homogeneous layer" basis and from a face about 50 cm wide for laterally uniform soils. If horizons are discontinuous, vary greatly in thickness or degree of expression, collect samples from different locations on the pit face to ensure a representative sample of each horizon is obtained. Some discontinuous horizons may not be significant enough in amount or characteristics to warrant sampling and analysis; and
5. if possible, start sampling at the bottom of the pit.

3.3.3 Overburden Sampling (2 m + Depth)

The preceding section dealt with sampling the soil control section which in the case of mineral soils generally involves a depth of 1 to 2 m. The material below the control section and above the resource to be extracted can be referred to as overburden.

Overburden sampling should be based on the lithology of the area. Selection of appropriate sites should be based on soils and geologic information. Surficial and bedrock geologic information is available for most areas of the province.
Overburden samples should be collected in increments:

1. not exceeding 0.5 m in the 2 to 5 m depth; and
2. not exceeding 1.5 m in the 5 m depth to the top of the resource except in areas where the formations or materials are known to be relatively uniform. A less intensive sampling would be appropriate when geologic conditions are generally known and especially in areas where the overburden is known to be unsuitable.

3.3.4 Sampling Post-Disturbance Areas

Guidelines in the literature vary widely with regard to the number of samples to be collected in order to adequately characterize reconstructed soils. As noted for baseline sampling programs, frequency of sampling also depends on the purpose for the sampling. Table 2 offers guidelines with regard to sampling frequency for nonselectively handled areas and areas where materials handling was employed. The values in the table indicate a greater frequency of sampling for nonselectively handled areas as compared to those where selective materials handling was employed because of the more heterogeneous nature of the former. The sampling frequency includes site sampling down to the depths described later in this report as well as grab samples of the surface material.

Sampling of reconstructed soils should be done on the basis of layers or materials such as topsoil, subsoil, and spoil and on depth intervals within each of these discrete layers.
Table 3 provides an indication of the total depth and intervals that should be sampled in reconstructed soil areas. The depth of sampling is wholly dependent on the type of material encountered. For example, in the Eastern Slopes Region the shallow layer of soil material over rocky spoil will, in some instances, limit the sampling procedures.

3.3.5 Transporting and Processing Samples

There are a number of factors to be considered when transporting and processing soil samples.

1. Polyethylene plastic bags should be used for transporting samples from the field. Paper bags are not recommended.
2. Galvanized equipment should be avoided if zinc is to be determined.
3. Moist samples to be analysed for nitrate or ammonium nitrogen cannot be stored under warm conditions.

4. For best results moist or wet samples are immediately frozen or spread to dry on waterproof material. Once dry they are ground to 2 mm sized fragments and stored in closed, watertight containers.

Table 3. Sampling depth intervals for reconstructed soils in the three regions.[1]

Region	Depth Interval (cm)		Notes
Plains	0 to 15	or	The topsoil layer should be taken in one sample. If topsoil depth is less than 15 cm then that depth of material should be segregated from material below. If topsoil is greater than 15 cm then first sample can exceed 15 cm in thickness. If topsoil layer is greater than 20 cm in thickness topsoil should be split into two sample intervals. Sample should be collected to and including one depth increment of spoil if depth to spoil is greater than 1.5 m.
	15 to 30		
	30 to 45		
	45 to 60		
	60 to 90		
	90 to 120		
	120 to 150		
Northern Forest	0 to 15		If the upper lift is less than 30 cm in thickness it could be sampled in one or two intervals. For example, if 20 cm thick then one sample interval would be appropriate, if greater than 20 cm thick it should be split into two samples. Samples should be collected to and including one depth increment of spoil if depth to spoil is greater than 1.2 m.
	15 to 30		
	30 to 60		
	60 to 90		
	90 to 120		
Eastern Slopes	0 to 15		If the thickness of replaced soil material is less than 30 cm then sampling could be done in one or two intervals. For example, if 20 cm thick then one sample interval would be appropriate, if greater then 20 cm thick the recommended intervals should be utilized.
	15 to 30 then 30 cm increments where possible to 120 cm		

[1] Sampling should be conducted on the basis of the layers replaced and depth intervals within these layers.