5.0 CRITERIA FOR EVALUATING THE SUITABILITY OF UNDISTURBED AND RECONSTRUCTED SOILS

5.1 INTRODUCTION

In attempting to establish criteria for evaluating soils and overburden materials, a number of factors must be considered. Invariably, the physical and chemical properties of the soil or overburden are the first to come to mind. However, there is more involved in the establishment and maintenance of vegetation than the properties of the soil. Whitaker (1975) suggests that water, light, carbon dioxide and soil nutrients are most critical to terrestrial production. Furthermore, to optimize plant production in a given environment the factors associated with the soil such as nutrients, water retention and availability must be in balance with all other factors.

Depth criteria are not spelled out in this report - not for unmined soils nor for reconstructed soils. However, occurrence and depth of master horizons (A, B, C) in the predisturbance state has a bearing or influence on how materials are salvaged, with respect to the different lifts involved and subsequently the manner of replacement. Replaced soil thickness should be no more limiting to plant growth than it was in the undisturbed state. Research pertinent to soil handling procedures for disturbed lands in Alberta and elsewhere has been and continues to be done to offer practical procedures and alternatives.

It must be emphasized the thickness replaced depends not only upon soil quality but the quality of the overburden, and other factors such as mean annual precipitation, topography, slope angle, and water table position.

This portion of the report will be organized on the basis of the three major regions of the province as described previously in this document. Each major region implies or suggests some things about climate and soil type. Therefore the materials handling procedures utilized would likely be expected to vary significantly

Some general procedures for materials handling for each of the regions must be defined in order that suitability criteria can be established or defined. For example, one must suggest topsoil and subsoil are handled separately where appropriate in the Plains Region in order to establish criteria for topsoil and subsoil.

It must be noted each individual area of disturbance has its own unique characteristics, problems and special requirements, therefore, materials handling techniques and soil replacement will be specific to each site. It is also worthwhile to reiterate the criteria which follow can be applied to the pre- and post-disturbance setting.

5.2 PHYSICAL AND CHEMICAL CRITERIA

To evaluate the suitability of soils and overburden materials in a given area one requires a soil survey in sufficient detail is available and that the soils and overburden have been adequately sampled and characterized. The requirement for evaluating reconstructed soil areas would be similar.

Evaluations of soil suitability are made by considering the interaction of various soil properties and characteristics to give an overall rating of the degree of suitability. Three categories of suitability and one category to indicate unsuitable areas are used. The four categories are as follow:

1. Good (G) - None to slight soil limitations that affect use as a plant growth medium.
2. Fair (F) - Moderate soil limitations that affect use but which can be overcome by proper planning and good management.
3. Poor (P) - Severe soil limitations that make use questionable. This does not mean the soil cannot be used, but rather careful planning and very good management are required.
4. Unsuitable (U) - Chemical or physical properties of the soil are so severe reclamation would not be economically feasible or in some cases impossible.

5.2.1 Plains Region

In agricultural areas the selective salvage of topsoil and subsoil and subsequent sequential replacement of these materials is commonly practiced. It is also useful to characterize the material below the subsoil in the predisturbance setting because this usually becomes the "spoil" upon which the reconstructed soils are built. In some instances these parent materials can and do become part of the reconstructed subsoil. To facilitate the identification of suitable sources of soil materials for replacement, it is recommended that the upper five metres be characterized to the level of detail outlined in Section 3.3: Soil Mapping and Sampling.

Topsoil is defined as the surface "A" (organo-mineral) horizons of the soil profile.
Subsoil is defined as the "B" horizon(s) and the upper portion of the parent material.

The criteria for evaluating the suitability of the soils for their use as topsoil and subsoil are listed in Tables 6 and 7.

Table 6. Criteria for evaluating suitability of topsoil in the Plains Region.

Rating/Property	Good (G)	Fair (F)	Poor (P)	Unsuitable (U)
Reaction (pH)	6.5 to 7.5	5.5 to 6.4 & 7.6 to 8.4	4.5 to 5.4 & 8.5 to 9.0	<4.5 and >9.0
Salinity (EC) (dS/m)	<2	2 to 4	4 to 8	>8
Sodicity (SAR)	<4	4 to 8	8 to 12	>12[1]
Saturation (%)	30 to 60	20 to 30, 60 to 80	15 to 20, 80 to 120	<15 and >120
Stoniness Class	S0, S1	S2	S3, S4	S5
Texture	FSL, VFSL, L, SL, Sil	CL, SCL, SiCL	LS, SiC, C[2], S, HC[3]	
Moist Consistency	very friable, friable	loose	firm, very firm	extremely firm
Organic Carbon (%)	>2	1 to 2	<1	
$CaC0_3$ Equivalent (%)	<2	2 to 20	20 to 70	>70

[1] Materials characterized by an SAR of 12 to 20 may be rated as poor if texture is sandy loam or coarser and saturation % is less than 100.

[2] C – May be upgraded to fair or good in some arid areas.

[3] HC – May be upgraded to fair or good in some arid areas.

Table 7. Criteria for evaluating suitability of subsoil material in the Plains Region.

Rating/Property	Good (G)	Fair (F)	Poor (P)	Unsuitable (U)
Reaction (pH)	6.5 to 7.5	5.5 to 6.4 & 7.6 to 8.5	4.6 to 5.4 & 8.6 to 9.0	<4.5 and >9.0
Salinity (EC) (dS/m)	<3	3 to 5	5 to 10	>10
Sodicity (SAR)	<4	4 to 8	8 to 12	>12[1]
Saturation (%)	30 to 60	20 to 30, 60 to 80	15 to 20, 80 to 120	<15 and >120
Stone Content (% Vol)	<3	3 to 25	25 to 50	>50
Texture	FSL, VFSL, L, SiL, SL	CL, SCL, SiCL	S, LS, SiC, C, HC	Bedrock
Moist Consistency	very friable, friable	loose, firm	very firm	extremely firm
Gypsum $CaC0_3$ Equivalent (%)	The suitability criteria for sodicity (SAR) may be altered by the presence of high levels of either lime ($CaC0_3$) or gypsum ($CaS0_4$) in excess of other soluble salts.			

[1] Materials characterized by an SAR of 12 to 20 may be rated as poor if texture is sandy loam or coarser and saturation % is less than 100.

5.2.2 Northern Forest Region

In the Northern Forest Region it is deemed practical to suggest that soil materials be salvaged in two lifts: The upper lift comprising a mixture of the organic and A horizons of the soil solum and perhaps a portion of the B horizon to a depth of about 30 cm depending upon site specific conditions. The second (lower lift) is comprised of the material below the upper lift to a depth deemed appropriate relative to specific site conditions. The second lift need not be salvaged in areas where the overburden material is rated as suitable for use as subsoil or lower lift material. Salvage of the top lift as a separate unit is important in that:

1. Organic matter levels as well as important soil macro and microorganisms are less diluted;
2. It generally has better growth support capability; and
3. It may serve as an excellent seed source for some native species.

The criteria for evaluating the soil properties are listed in Tables 8 and 9.

Some explanatory remarks are in order relative to the parameters of stoniness/rockiness and pH and the respective limits included in the suitability rating tables. In severely disturbed environments the presence of stones and coarse fragments can prove to be advantageous in some instances when end land use is anything other than cultivation for production of specific crops. Stones and coarse fragments can provide improved sites for seed germination. Their impact on seedling planting can be controlled to some extent in that seedling planting is generally done with hand tools and planting holes would normally be dug in the less stony spots. Stones and course fragments also play an important role in slope stabilization.

In regard to pH, the limits presented are pertinent to an end land use that involves production of trees, primarily conifers. Where the reclamation objective involves an end land use other than forestry, such as erosion control and where other plant species may be more important, then the limits presented in Table 6 are likely to be more applicable.

Organic soils should be considered for salvage and use as a soil conditioner. Origin, degree of decomposition and reaction will determine the suitability of these materials.

5.2.3 Eastern Slopes Region

In the Eastern Slopes Region salvage and replacement of one lift of material is commonly practiced. In this region, as for the Plains and Northern Forested Regions, the material handling procedures will reflect specific site conditions. Current research in Alberta indicates a minimum depth of 15 cm should be considered (Macyk 1982). To facilitate the identification of suitable sources of soil materials for replacement, it is recommended all of the unconsolidated materials be evaluated to the level of detail outlined in Section 3.3: Soil Survey and Sampling.

The criteria for evaluating the soil properties are listed in Table 10.

The comments made relative to stoniness/rockiness and pH in the section of the report dealing with the Northern Forest Region are also applicable to the Eastern Slopes Region.

Table 8. Criteria for evaluating the suitability of surface material (upper lift) for revegetation in the Northern Forest Region.

Rating/Property	Good (G)	Fair (F)	Poor (P)	Unsuitable (U)
Reaction (pH)[1]	5.0 to 6.5	4.0 to 5.0 6.5 to 7.5	3.5 to 4.0 7.5 to 9.0	<3.5 and >9.0
Salinity (EC)[2] (dS/m)	<2	2 to 4	4 to 8	>8
Sodicity (SAR)[2]	<4	4 to 8	8 to 12	>12[3]
Saturation (%)[2]	30 to 60	20 to 30, 60 to 80	15 to 20, 80 to 120	<15 and >120
Stoniness/ Rockiness[4] (% area)	<30/<20	30-50/ 20-40	50-80/ 40-70	>80/>70
Texture	FSL, VFSL, L, SiL, SL	CL, SCL, SiCL	LS, SiC, C, HC, S	
Moist Consistency	very friable, friable	loose, firm	very firm	extremely firm
$CaCO_3$ Equivalent (%)	<2	2 to 20	20 to 70	>70

[1] pH values presented are most appropriate for trees, primarily conifers. Where reclamation objective is for other end land uses, such as erosion control, and where other plant species may be more important, refer to Table 6.

[2] Limits may vary depending on plant species to be used.

[3] Materials characterized by an SAR of 12 to 20 may be rated as poor if texture is sandy loam or coarser and saturation % is less than 100.

[4] <25 cm diameter stones/rocks intercepting surface.

Table 9. Criteria for evaluating the suitability of subsurface material (lower lift) for revegetation in the Northern Forest Region.

Rating/Property	Good (G)	Fair (F)	Poor (P)	Unsuitable (U)
Reaction (pH)[1]	5.0 to 7.0[2]	4.0 to 5.0 7.0 to 8.0[2]	3.5 to 4.5 8.0 to 9.0	3.5 and >9.0
Salinity (EC)[3] (dS/m)	<3	3 to 5	5 to 8	>8
Sodicity (SAR)	<4	4 to 8	8 to 12	>12[4]
Saturation (%)[2]	30 to 60	20 to 30, 60 to 80	15 to 20, 80 to 100	<15 and >100
Coarse Fragments (% Vol)	<30[5] <15[6]	30 to 50[5] 15 to 30[6]	50 to 70[5] 30 to 50[6]	>70[5] >50[6]
Texture	FSL, VFSL, L, SiL, SL	CL, SiC, SiCL	S, LS, S, C, HC	bedrock
Moist Consistency	very friable, friable, firm	loose, very firm	extremely firm	Hard rock
$CaC0_3$ Equivalent (%)	<5	5 to 20	20 to 70	>70

[1] pH values presented are most appropriate for trees, primarily conifers. Where reclamation objective is for other end land uses, such as erosion control, and where other plant species may be more important, refer to Table 6.

[2] Higher values takes into consideration that in the lower lift the pH values of the soils are generally higher. Normally the pH rating should not be different from those shown in Tables 9 and 11.

[3] Limit may vary depending on plant species to be used.

[4] Materials characterized by an SAR of 12 to 20 may be rated as poor if texture is sandy loam or coarser and saturation % is less than 100.

[5] Matrix texture (modal) finer than sandy loam.

[6] Matrix texture (modal) sandy loam and coarser.

Table 10. Criteria for evaluating the suitability of root zone material in the Eastern Slopes Region.

Rating/Property	Good (G)	Fair (F)	Poor (P)	Unsuitable (U)
Reaction (pH)[1]	5.0 to 6.5	4.0 to 5.0 6.5 to 7.5	3.5 to 4.0 7.5 to 9.0	<3.5 and >9.0
Salinity (EC)[2] (dS/m)	<2	2 to 4	4 to 8	>8
Sodicity (SAR)[2]	<4	4 to 8	8 to 12	>12[3]
Saturation (%)[2]	30 to 60	20 to 30, 60 to 80	15 to 20, 80 to 100	<15 and >100
Coarse Fragments[4] (% Vol)	<30[5] <15[6]	30 to 50[5] 15 to 30[6]	50 to 70[5] 30 to 50[6]	>70[5] >50[6]
Texture	L, SiCL, SCL, SL, FSL,	CL, SiL, VFSL, SC, SiC	LS, S, Si, C, HC	Consolidated bedrock
Moist Consistency	very friable, friable	loose, firm	very firm	extremely firm
$CaC0_3$	<2	2 to 20	20 to 70	>70

[1] pH values presented are most appropriate for trees, primarily conifers. Where reclamation objective is for other end land uses, such as erosion control, and where other plant species may be more important, refer to Table 6.

[2] Limits may vary depending on plant species to be used.

[3] Materials characterized by an SAR of 12 to 20 may be rated as poor if texture is sandy loam or coarser and saturation % is less than 100.

[4] 0.2 to 25 cm diameter fragments in the soil material.

[5] Matrix texture (modal) finer than sandy loam.

[6] Matrix texture (modal) sandy loam and coarser.

5.3 USE OF THE CRITERIA TO DEVELOP RATINGS

The ratings (good, fair, poor, unsuitable) are determined by assessing the site factors and analytical data in terms of the limits presented in the criteria tables. Each horizon or layer is related relative to the individual parameters and an overall rating can be developed for each horizon or layer. The most limiting property (rating) determines the ultimate rating for each horizon or layer.

A number of the parameters assessed and used in developing ratings are interrelated. For example, sodicity, saturation percentage and texture are fairly closely related. Therefore, in the event a given soil horizon or layer had a fair rating assessed for each of these parameters and a fair or better rating for the remainder of the parameters considered, the overall rating for that horizon or layer should be fair.

It is important to note some parameters are more important than others in terms of assessing quality and there are those where management practices can overcome or compensate for some limitations. It is not the intent of this document, however, to suggest the extent to which management practice could impact ratings that are developed. Some pertinent comments can, however, be made. For example, a soil could be rated fair, poor, or unsuitable on the basis of degree of stoniness while the remaining parameters considered are not limiting. In this instance it would be reasonable to qualify the rating with a statement to the effect that management practice (stone picking) could be utilized to result in a better soil material.

Examples of how ratings can be developed from site description information and analytical data are presented in the following material. Examples 1 and 2 represent sites prior to disturbance in the Plains and Eastern Slopes Region, respectively. Example 3 represents a reconstructed soil site in the Plains Region.

Example 1 (Plains Region)

Soil Group: X
Soil Unit: X1
Classification: Solonetzic Dark Brown
Profile Location: Site 1
Topography: Nearly level
Drainage: Moderately well drained
Parent Material: Till

Description of Representative Profile:

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence	Roots	Stoniness
Ap	0 to 15	very dark grayish brown (10YR 3/2m)	sandy loam	weak fine granular	friable	abundant very fine	S1
Ahe	15 to 25	dark brown (10YR 4/3m)	sandy loam	moderate granular	friable	plentiful very fine	2%
Bnjtj	25 to 45	dark brown (10YR 3/3m)	sandy loam	moderate prismatic	friable	few very fine	2%
Csk	45 to 75	yellowish brown (10YR 5/4m)	loam	-	-	-	5%
Csk	75 to 100	-	loam	-	-	-	5%
Csk	100 to 150	-	loam	-	-	-	5%
Csk	150 to 200	-	loam	-			
Csk	200 to 250	-	loam	-			
Csk	250 to 300	-	loam	-			
Csk	300 to 350	-	silty clay	-			
Csk	350 to 400	-	clay	-			
Csk	400 to 500	-	silty clay	-			

ANALYTICAL DATA

Site: 1 **Soil Unit: X1**

Horizon	Depth (cm)	pH		Percent Saturation	EC dS/m	Soluble Cations (meq/L)					SAR
		H_2O	$CaC1_2$			NA	K	Ca	Mg	$S0_4$	
Ap	0 to 15	6.1	5.9	44.0	0.15	0.12	0.13	10.6	0.30	0.36	0.1
Ahe	15 to 25	6.6	6.3	38.5	0.31	1.96	0.05	0.84	0.42	0.72	2.5
Bnjtj	25 to 45	6.9	6.6	53.5	0.24	1.98	0.18	3.2	1.66	0.54	1.3
Csk	45 to 75	7.8	7.6	54.5	0.80	6.52	0.05	1.28	0.74	2.78	6.5
Csk	75 to 100	8.0	7.9	60.0	0.79	6.13	0.08	1.66	0.82	3.00	5.5
Csk	100 to 150	8.2	7.7	54.0	0.71	11.30	0.12	0.84	0.80	5.10	11.5
Csk	150 to 200	7.9	7.6	52.5	0.99	7.65	0.14	1.78	0.66	3.62	6.9
Csk	200 to 250	8.2	7.9	52.5	1.02	8.52	0.17	1.72	0.58	3.46	7.9
Csk	250 to 300	8.0	7.8	51.0	2.71	23.26	0.37	7.00	1.88	13.60	11.0
Csk	300 to 350	8.3	8.0	103.0	1.83	17.61	0.34	2.02	1.00	7.82	14.3
Csk	350 to 400	8.1	8.0	88.5	2.18	21.09	0.38	2.26	0.62	9.38	17.6
Csk	400 to 500	8.0	7.9	77.0	4.43	43.48	0.73	8.40	2.42	25.94	18.7

Horizon	Depth (cm)	Exchangeable Cations (me/100 g)				Cat Exch Capacity	$CaC0_3$ Equiv	Part Size Dist (%)			Texture
		Na	K	Ca	Mg	meg/100g	(%)	S	Si	C	
Ap	0 to 15	0.01	0.73	9.34	1.98	14.3	-	76	16	8	Sl
Ahe	15 to 25	0.17	0.35	8.69	2.19	13.7	-	69	17	14	SL
Bnjtj	25 to 45	1.83	0.45	5.83	8.68	14.1	-	57	24	19	SL
Csk	45 to 75	-	-	-	-	-	5.81	39	25	26	L
Csk	75 to 100	-	-	-	-	-	5.64	41	35	24	L
Csk	100 to 150	-	-	-	-	-	3.12	45	31	24	L
Csk	150 to 200	-	-	-	-	-	1.08	47	29	24	L
Csk	200 to 250	-	-	-	-	-	1.39	43	33	24	L
Csk	250 to 300	-	-	-	-	-	1.90	46	30	24	L
Csk	300 to 350	-	-	-	-	-	0.91	10	42	48	SiC
Csk	350 to 400	-	-	-	-	-	6.56	13	40	47	C
Csk	400 to 500	-	-	-	-	-	5.23	4	50	46	SiC

SOIL SUITABILITY RATING

Site: 1 **Soil Unit: X1**

Horizon	Depth (cm)	pH (H_20)		EC		SAR		% Sat		$CaC0_3$ Equiv		Texture		Consistence		Stoniness		Rating	
		T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S
Ap	0 to 15	F	-	G	-	G	-	G	-	G	-	G	-	G	-	G	-	F	
Ahe	15 to 25	G	-	G	-	G	-	G	-	G	-	G	-	G	-	G	-	G	
Bnjtj	25 to 45	-	G	-	G	-	G	-	G	-	-	-	G	-	G	-	G	-	G
Csk	45 to 75	-	G	-	G	-	F	-	G	-	-	-	G	-	G	-	F	-	F
Csk	75 to 100	-	G	-	G	-	F	-	G	-	-	-	G	-	G	-	F	-	F
Csk	100 to 150	-	G	-	G	-	P	-	G	-	-	-	G	-	G	-	F	-	P
Csk	150 to 200		F		G		F		G	-	-	-	G	-	-	-	-	-	F
Csk	200 to 250	-	F	-	G	-	F	-	G	-	-	-	G	-	-	-	-	-	F
Csk	250 to 300	-	F	-	G	-	P	-	G	-	-	-	G	-	-	-	-	-	P
Csk	300 to 350	-	F	-	G	-	U	-	P	-	-	-	P	-	-	-	-	-	U
Csk	350 to 400	-	F	-	G	-	U	-	P	-	-	-	P	-	-	-	-	-	U
Csk	400 to 500	-	F	-	F	-	U	-	F	-	-	-	P	-	-	-	-	-	U

T - Suitability for use as topsoil material.
S - Suitability for use as subsoil material.
G - Good.
F - Fair.
P - Poor.
U - Unsuitable.

EXAMPLE 2 (EASTERN SLOPES REGION)

Soil Group: Y
Soil Unit: Y1
Classification: Eluviated Dystric Brunisol
Profile Location: 1
Topography: 15 degrees
Drainage: Moderately well drained
Parent Material: Till/Bedrock

Description of Representative Profile:

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence	Coarse Fragments (%/Vol)
L-H	0 to 15	-	-	partially decomposed litter	-	none
Ae	15 to 25	brown (l0YR 5/3m)	loam	weak platy	friable	< 5
Bm	25 to 42	dark yellowish brown (10YR 4/4m)	loam	moderate subangular blocky	friable	< 5
BC	42 to 60	olive brown (2.5Y 4/4m)	loam	weak subangular blocky	friable	8
C	60 to 97	very dark grayish brown (10YR 3/2m)	loam	-	friable	15
IIC	97+	very dark brown	sandy loam	-	-	25

ANALYTICAL DATA

Site: Dig 1 **Soil Unit: Y1**

Horizon	Depth	pH		Org C	$CaC0_3$ Equiv	EC	Exchangeable Cations (meq/100 g)				Cat Exch Capacity
	(cm)	H_20	$CaC1_2$	%	(%)	dS/m	Na	K	Ca	Mg	meg/100 g
L-H	0 to 15	6.3	6.0	38.61	0.0	0.2	0.04	5.43	114.58	10.86	107.0
Ae	15 to 25	5.1	4.2	-	0.0	0.1	0.01	0.38	6.38	2.56	15.9
Bm	25 to 42	5.9	5.2	-	0.0	0.1	0.02	0.17	8.25	2.91	13.0
BC	42 to 60	6.4	6.1	-	0.0	0.2	-	-	-	-	-
C	60 to 97	6.9	6.3	-	0.43	0.1	-	-	-		-
11C	97+	7.3	6.6	-	0.60	-	-	-	-	-	-

Horizon	Depth (cm)	Macronutrients (ppm)[1]				Part Size Dist (%)			Texture	Sand Fractions (%)				
		N	P	K	S	S	Si	C		VCS	CS	MS	FS	VFS
L-H	0 to 15	0	4	68	4.9	-	-	-	-	-	-	-	-	-
Ae	15 to 25	0	11	80	4.1	41	46	13	L	0	3	3	16	20
Bm	25 to 42	0	3	69	-	44	46	10	L	0	4	4	18	18
BC	42 to 60	0	2	81	-	37	43	20	L	0	3	3	16	15
C	60 to 97	0	0	90	-	40	44	16	L	0	2	5	15	18
IIC	97+	0	0	85	-	67	26	7	SL	2	7	9	27	22

[1] These analyses are not required as part of the criteria for assessing suitability.

SOIL SUITABILITY RATING

Site: Dig 1 **Soil Unit: Y1**

Horizon	Depth (cm)	pH	EC	Course Fragments	Texture	Consistence	$CaCO_3$ Equiv	Rating
L-H	0 to 15	Good	Good	Good	-	-	Good	Good
Ae	15 to 25	Good	Good	Good	Good	Good	Good	Good
Bm	25 to 42	Good	Good	Good	Good	Good	Good	Good
BC	42 to 60	Good	Good	Good	Good	Good	Good	Good
C	60 to 97	Fair	Good	Good	Good	Good	Good	Fair
I IC	97+	Fair	-	Fair	Good	-	Good	Fair

EXAMPLE 3 (PLAINS REGION-RECONSTRUCTED SOIL)

Site: Z

Depth (cm)	pH		Percent Saturation	EC dS/m	Soluble Ions (meg/L)				SAR	$CaCO_3$ Equiv (%)	Particle Size (%)			Consistence	Stoniness
	H_2O	$CaCl_2$			Na	K	Ca	Mg			S	Si	C		
0 to 15	6.7	6.3	57.5	0.76	7.35	0.13	1.48	0.84	6.8	0.02	39	38	23	friable	S2
15 to 30	7.8	7.8	73.0	6.39	53.91	0.54	23.00	17.92	11.9	2.58	25	47	28	firm	5%
30 to 45	7.8	7.8	81.5	5.29	39.13	0.58	23.50	17.08	8.7	2.71	20	47	33	very firm	5%
45 to 60	7.6	7.5	69.5	5.16	34.35	0.51	23.75	20.42	7.3	3.73	20	52	28	very firm	5%
60 to 90	7.5	7.3	62.0	2.44	21.96	0.16	5.45	4.00	10.1	1.85	18	41	41	very firm	5%
90 to 120	7.8	7.7	61.0	4.58	36.52	0.37	21.00	9.75	9.3	4.16	39	32	29	firm	5%
120 to 150	8.0	7.7	85.0	4.30	42.61	0.42	11.25	3.63	15.6	2.32	37	32	31	firm	15%
150 to 180	8.2	8.2	165.5	1.59	21.52	0.07	4.10	0.50	43.5	2.16	17	43	40	1oose	20%

SOIL SUITABILITY RATING

Site: Z

Depth (cm)	pH (H_20)		EC		SAR		% Sat		$CaCO_3$ Equiv (%)		Texture		Consistence		Stoniness		Rating	
	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S	T	S
0 to 15	G	-	G	-	F	-	G	-	G	-	G	-	G	-	G	-	F	-
15 to 30	-	F	-	P	-	P	-	F	-	-	-	G	-	F	-	F	-	P
30 to 45	-	F	-	P	-	P	-	P	-	-	-	F	-	P	-	F	-	P
45 to 60	-	F	-	P	-	F	-	F	-	-	-	F	-	P	-	F	-	P
60 to 90	-	G	-	G	-	P	-	F	-	-	-	P	-	P	-	F	-	P
90 to 120	-	F	-	F	-	P	-	F	-	-	-	F	-	F	-	F	-	P
120 to 150	-	F	-	F	-	U	-	P	-	-	-	F	-	F	-	F	-	U
150 to 180	-	F	-	G	-	U	-	U	-	-	-	F	-	F	-	F	-	U

T - Suitability for use as topsoil material
S - Suitability for use as subsoil material
G - Good.
F - Fair.
P - Poor.
U - Unsuitable.

5.4 BIOLOGICAL CONSIDERATIONS

As a result of classic and continually developing knowledge in soil biology, there presently exists a well-recognized general appreciation for the importance of the diverse and extensive activities of soil organisms. Tens of thousands of species of bacteria, actinomycetes, fungi, protozoa, nematodes, algae and microfauna have been described and all are known to play critical roles in soil genesis, cycling and conservation of energy and nutrients and organism/plant associations (Cole et al. 1977; Jones and Woodmansee 1979; McGill and Christie 1981; Fessenden et al. 1981; Silvester 1977). These organisms are not randomly distributed but found in distinct patterns or communities. Such communities vary in degree of complexity and interrelationship, depending upon characteristics of the soil environment and period of undisturbed development.

Soil biological activity is largely concentrated in the surface horizons of soil as exemplified in Table 11.

Table 11. Variation in plate count numbers of selected soil microorganisms with soil profile depth[1].

	Organisms in Dry Soil (Numbers/Grams)		
Soil Profile Depth (cm)	**Bacteria (10^6)**	**Actinomycetes (10^6)**	**Fungi (10^3)**
0 to 15	150.0	35.0	18
15 to 30	62.0	11.0	10
30 to 60	2.5	1.0	4
60 to 90	0.8	0.5	4

(Cook 1968)

[1] Site: Black Chernozem (Malmo Series).

This observed decrease in biological activity with increasing soil profile depth closely parallels a similar gradation in soil temperature and moisture as well as availability of 0_2 and nutrients. The total biomass of soil organisms in a given soil sample is significant, ranging from 0.06 to 0.2% of sample weight, depending upon sampling site, i.e., semi-arid grassland vs. decomposing forest litter (Domsch et al. 1979, Visser).[1] While some of the fundamental principles in soil biology are now understood, overall comprehension has not reached the point where soil quality criteria, in a biological sense, can be addressed meaningfully or quantitatively. It is very clear, however, that soil chemical and physical properties have a profound influence in determining the composition of a microbial community. In turn, the metabolism of the biological community may dramatically alter the former dynamic equilibrium. Provision of a soil environment meeting suitable chemical/physical soil quality criteria, therefore, will ensure, in large measure, establishment of balanced, functional populations of soil organisms.

In considering soil organisms within the context of surface reclamation, it is important to recognize that soil organisms will respond to changes in the soil environment resulting in subsequent shifts in the diversity of organisms, population numbers and biochemical activity. The response by soil organisms is relatively immediate and is a sensitive index to change. Thus, potential differences in soil biota existing in a balanced, undisturbed soil versus that found in a drastically disturbed soil are generally acknowledged (Cundile 1977; Curry 1975; Miller 1976; Sindelar et al. 1974). Definitive information in this regard is limited.

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[1]Visser (Personal Communication).

Multidisciplined research in soil microbial synecology is currently in progress at a number of locations, for example at the University of Calgary, University of Saskatchewan, Saskatoon, Colorado State University, University of Alberta (Parkinson 1978; Cole et al. 1978; Elliot et al. 1979; McGill and Christie 1981). Such work should prove valuable in attempts to characterize the effects of surface disturbances on soil microbial populations, particularly with respect to the:

1. nature and extent of change in soil microbial populations, for example, the hierarchy of microbial communities and patterns of microbial predation;
2. effect of disturbance on
   - decomposition potential;
   - cycling of trace elements and plant nutrients, particularly C, N, P; and
   - soil development; and
3. effect of disturbance on specialized plant root, microbial relationships such as;
   - rhizosphere, rhizoplane associations and
   - mycorrhizal associations.