Soils Inventory of the Alberta Oil Sands Environmental Research Program Study Area

AOSERP Report 122

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ALBERTA OIL SANDS
ENVIRONMENTAL
RESEARCH PROGRAM

Soils Inventory of the Alberta Oil Sands Environmental Research Program Study Area

AOSERP Report 122

July 1982

ENVIRONMENT
Research Management Division
14th Floor, Standard Life Centre
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Edmonton, Alberta, Canada
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AOSERP Report 122

This report may be cited as:

Turchenek, L.W. and J.D. Lindsay. 1982. Soils inventory of the Alberta Oil Sands Environmental Research Program study area. Prep. for the Alberta Oil Sands Environmental Research Program by Alberta Research Council. AOSERP Report 122. 240 pp.

The Hon. J.W. (Jack) Cookson
Minister of the Environment
222 Legislative Building
Edmonton, Alberta

Sir:

Enclosed is the report "Soils Inventory of the Alberta Oil Sands Environmental Research Program Study Area".

This report was prepared for the Research Management Division through the Alberta Oil Sands Environmental Research Program.

Respectfully,

W. Solodzuk, P.Eng.
Deputy Minister, Alberta Environment

SOILS INVENTORY OF THE ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM STUDY AREA

by

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J.D. LINDSAY

Alberta Research Council
Soils Department

for

ALBERTA OIL SANDS
ENVIRONMENTAL RESEARCH PROGRAM

AOSERP Report 122

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ABSTRACT

A soil survey of the Alberta Oil Sands Environmental Research Program (AOSERP) study area was initiated in 1976 as part of the program objective to establish a data base for the area. The purpose of this report and accompanying soil maps is to provide data on the kinds, characteristics, location, and areal distribution of soils in the AOSERP study area.

The soil maps indicate types of soils and landforms within delineated areas. The mapping approach used is similar to the ecological method of classification in which land areas are mapped rapidly and at a small or reconnaissance scale by means of air photo interpretation and supporting field checks on 1:50 000 airphotos Recurring patterns of soils, landforms, and vegetation were delineated. The information was transferred first to 1:50 000 preliminary maps and then to eight 1:126 720 maps which accompany this report. General characteristics of vegetation are provided in this report, but more detailed information must be derived from AOSERP vegetation maps. In addition to airphoto interpretation, the information on soil maps is based on about four field checks per township and on analyses of samples from 130 soil profiles.

The predominant upland soils in the study area are Gray Luvisols, developed on loamy to clayey, morainal and glaciolacustrine deposits; and Dystric Brunisols, developed on sandy glaciofluvial and eolian materials. Gleysolic soils occupy a significant proportion of the landscape in many areas. Gleysols and Regosols occur on recently deposited fluvial materials which occur in stream channel, fan and apron, and delta landforms. Solonetzic soils are associated with Luvisols on some of the clayey glaciolacustrine plains. Soils of low-lying, poorly drained areas are mainly Organic. These soils, formed in bog and fen peats, occupy a considerable portion of the study area, and vary from less than 1 m to several metres in thickness. Soils formed in peat and which have permafrost layers in them, the Organic Cryosols, are extensive in the Birch Mountains

Upland and occur sporadically elsewhere. Miscellaneous land types mapped include Rock, Rough Broken, and Disturbed lands.

This report outlines methodology and systems of classification used in this soils inventory. This is followed by descriptions of ecological units and soils. The last part of the report outlines soil survey interpretations relating to forestry, agriculture, engineering, wildlife and recreational uses, and soil sensitivity to acidic deposition. Data for representative soil profiles are presented in RMD report L-80, "Soils Inventory of the Alberta Oil Sands Environmental Research Study Area: Appendix 9.4".

ACKNOWLEDGEMENTS

The authors wish to acknowledge several individuals for their contributions to this project: Graeme Spiers for field assistance during 1977 and 1978; Darrell Skinner for field and drafting assistance; Dan McCarthy, Judy Lorinczi, and Bill Grbavac for drafting assistance; and Pal Hooper, Connie Smith, and Debbie Ben-Oliel for assistance in report preparation and typing.

Haluk Yuksel is acknowledged for his work in initiating the project with J.D. Lindsay in 1976.

Charles Tarnocai, of the Land Resource Research Institute, Ottawa, and Matt Fairbarns, Alberta Parks and Recreation, Edmonton, are thanked for their discussions and ideas during field excursions.

Our colleagues in Alberta Soil Survey are thanked for discussions and information regarding various aspects of this project.

We are grateful to Dirk Hadler and staff of AOSERP, and to various helicopter pilots and engineers for their support in our field work.

The role of W.W. Pettapiece, Pedology Unit, Agriculture Canada, in correlation of soil mapping is gratefully acknowledged.

Special thanks are extended to Jarka Dlask and Zdenek Widtman for cartography of maps and figures in this and in the preliminary reports; to Joe Beres, Alex Schwarzer, and Wayne McKean for laboratory analysis of soil samples; and to Bettina Chong for preparation of the final draft of this report.

This research project LS 2.1 was funded by the Alberta Oil Sands Environmental Research Program, established to fund, direct, and co-ordinate environmental research in the Athabasca oil sands area of northeastern Alberta.

1. INTRODUCTION

The objective of this soils inventory is to provide baseline data with respect to the kinds, characteristics, location, and extent of soils and landforms in the Alberta Oil Sands Environmental Research Program (AOSERP) study area. The information provided by this inventory can be used to aid in identifying the nature of the interactions among some of the biotic and abiotic components of the environment; to predict the effect of oil sands development on the environment; to identify materials that may be useful in reclamation procedures; to aid selection of research sites; to provide information that will be useful in land use planning and development, both industrial and non-industrial; and to aid monitoring of changes in resources caused by disturbance. Among the users of this type of information are those involved in forestry, conservation, land use, engineering, industry, environmental research, reclamation, recreation, and wildlife. Some broad interpretations of soil capabilities and limitations are presented in the latter part of the report.

In this inventory, soils are considered in an ecological framework and the mapping system adopted is similar to the ecological, or biophysical, system of land classification. The conceptual framework of the ecological system facilitates differentiation and classification of the land surface rapidly and at a small (reconnaissance) scale, particularly in areas where little basic ecological knowledge is available. At the reconnaissance level of survey, recurring patterns of soils, landforms, vegetation, and water bodies are mapped primarily by use of aerial photographs. The ecological system provides an initial overview and inventory of wildlands and sets the stage for more detailed work on those areas that warrant closer attention. The soil survey approach is not greatly different from an ecological approach in that a study of the soil forming factors - climate, parent material, vegetation, and topography acting over time - is inherent in any survey of soil types and distribution. This report focuses on soils and the landforms in which they have developed. It can be used with other AOSERP reports and maps on vegetation, landforms, climate, fauna, hydrology, and others to obtain a more complete ecological description of the area.

2. GENERAL DESCRIPTION OF THE STUDY AREA

2.1 LOCATION AND EXTENT

The AOSERP study area (Figure 1) consists of those lands within Township 84 to 104, in Ranges 6 to 18 West of the Fourth Meridian, and Township 105 to 115, in Ranges 6 to 9, excluding Wood Buffalo National Park in the Province of Alberta (Smith 1979). The total land area is about 305 townships or 28 440 square kilometres. The area lies approximately between 56° and 59° north latitude and 111° and 113° west longitude, excluding Wood Buffalo National Park. Indian Reservations situated within the study area were not included in this soils inventory project.

The City of Fort McMurray, located in the southern part of the study area, is the major population centre. Small population centres include Fort Chipewyan, Fort MacKay, and Anzac. The Syncrude and Suncor oil sands extraction plants, located about 50 km north of Fort McMurray, are the major industrial centres. Other major geographical features of the study area are described in an AOSERP interim report (Smith 1979).

2.2 SOCIO-ECONOMIC HISTORY

The historic native people of the Athabasca oil sands region were of Chipewyan and Woodland Cree descent. Before contact with white fur traders and missionaries, the economy of these tribes was based on hunting and fishing. Resource development through private and government enterprise shaped the economy after the latter part of the eighteenth century while church missions had a considerable social influence. Since the eighteenth century, the resources which were utilized included furs, transportation, timber, commercial fishing and finally, oil (Smith 1979). The history of this development has been described by Parker (1980) and Parker and Tingley (1980), and more recent

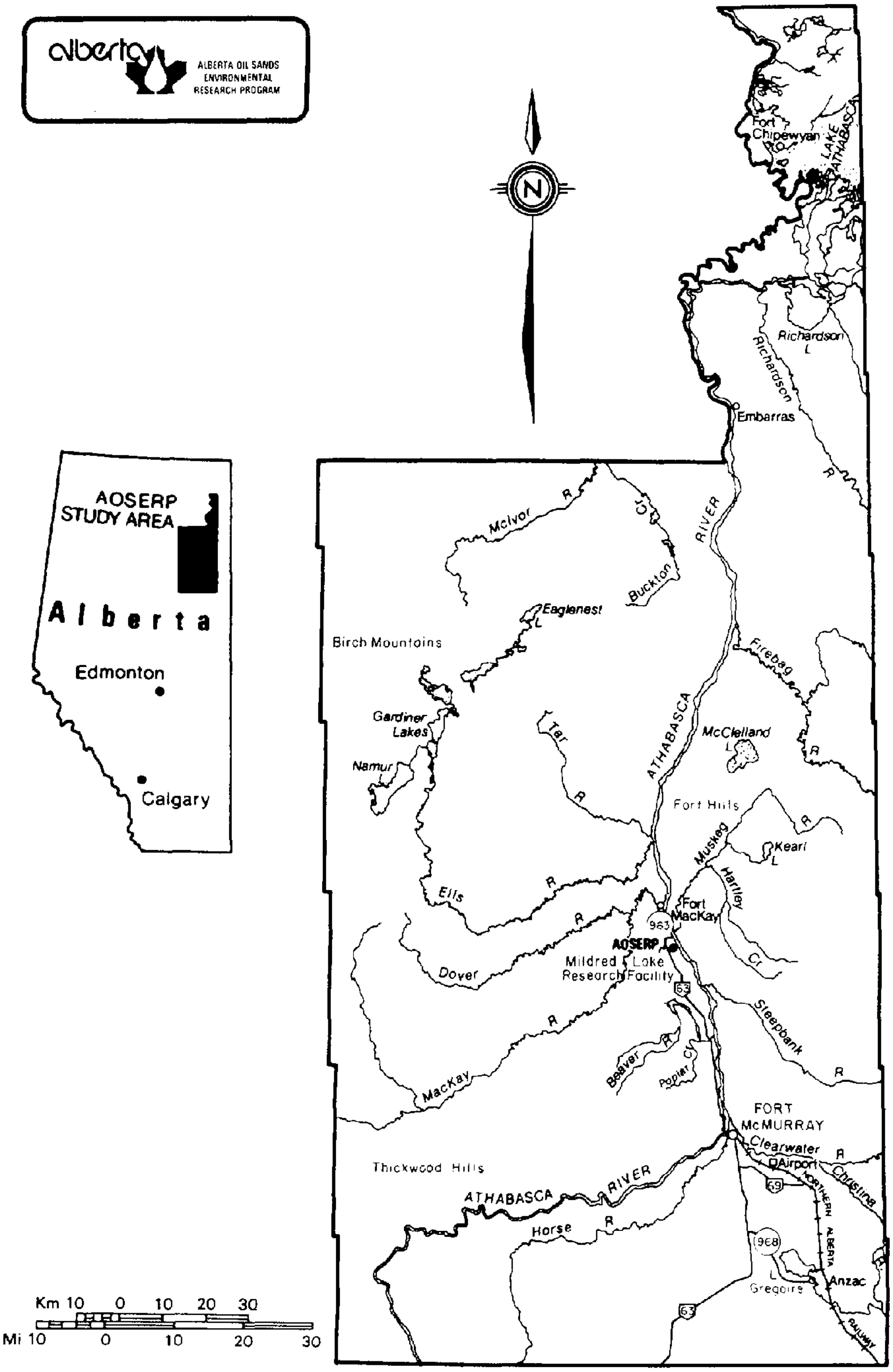


Figure 1. The Alberta Oil Sands Environmental Research Program study area.

economic trends have been summarized by P.C. Nichols and Associates Ltd. (1979).

2.3 CLIMATE

The climate of the AOSERP study area has been described by Longley and Janz (1978) and has been summarized in an AOSERP interim report (Smith 1979). Except as otherwise indicated, the following climatic summary is taken from these reports and they should be referred to for more complete information.

The climate in the oil sands region is continental, similar to that of central Alberta, except that it is generally cooler, especially in winter, and precipitation is lower. Winters are cold with relatively little snow. Heavy snowfalls are rare, while intense cold outbreaks can last up to several weeks. Summers are relatively short and cool, with temperatures only occasionally rising above 30°C. About two-thirds of the precipitation occurs in the summer months, much of it in the form of major rainstorms. High winds occur infrequently in the area. Topography does not have a major impact on weather patterns with the exception that certain terrain features may influence wind patterns. There is evidence that weather differences occur due to differences in elevation, but this is based on observations taken over only certain times of the year.

Long-term records are available only for the weather station at the Fort McMurray airport. Information from Fort Chipewyan is available from 1962, while data prior to 1962 was gathered at the Embarras airport. The temperature and precipitation data from these weather stations, as well as data available from forestry lookout towers and other stations in and near the area are presented in Tables 1 and 2.

The mean daily temperatures for both Fort McMurray and Fort Chipewyan are 16.3°C in July, and -21.5 and -26.2 for the two centres in January. Average annual precipitation at Fort McMurray

Table 1. Mean temperature data (°C), 1941 - 1970, for stations within or near the AOSERP study area.[a,b]

Station	Month												
	J	F	M	A	M	J	J	A	S	O	N	D	Year
PART 1													
Embarras A[c]	-22.4	-19.2	-11.2	-0.4	8.6	13.9	17.3	15.5	9.3	2.4	- 9.0	-18.4	-1.1
Fort McMurray A	-21.5	-16.6	- 9.4	1.2	9.0	13.4	16.3	14.7	9.0	3.1	- 8.5	-17.0	-0.5
Fort Smith A	-27.0	-22.1	-14.6	-3.3	7.1	13.1	16.1	14.3	7.7	0.5	-11.9	-21.4	-3.5
Fort Vermilion	-23.4	-18.5	-10.6	0.9	9.6	14.1	16.6	14.7	8.7	1.8	-10.9	-19.7	-1.4
Uranium City	-27.5	-22.7	-15.8	-4.2	5.7	13.2	16.2	15.0	7.5	0.8	-11.5	-17.7	-3.4
Wabasca	-18.6	-14.5	- 8.2	2.0	9.7	14.3	16.9	15.4	9.7	4.2	- 6.4	-14.0	0.9
PART 2													
Algar Lo[c]					7.3	11.9	14.6	13.3	7.4				
Anzac	-19.9	-15.7	- 9.0	0.8	8.6	13.1	15.7	14.3		3.4	- 8.0	-15.5	
Birch Mtn. Lo					6.4	11.3	14.1	12.6	6.6				
Bitumount Lo					9.0	13.4	16.1	14.3					
Buckton Lo					5.7	10.6	13.5	12.2					
Edra Lo					6.0	11.1	13.8	12.1					
Ells Lo					8.4	12.7	15.4	13.5					
Fort Chipewyan	-26.2	-21.6	-13.7	-2.7	7.3	13.3	16.5	14.6	8.2	2.0	-10.5	-19.4	-2.8
Gordon Lake Lo					8.3	13.2	15.8	14.0					
Grande Lo					8.4	12.7	15.3	13.7					
Johnson Lake Lo					7.4	12.7	15.5	13.6					
Keane Lo					8.6	13.5	16.6	14.9					
Legend Lo					6.6	11.2	14.1	12.2	7.0				
Livock Lo						12.6	15.2	13.7					
Mildred Lake							16.6	15.1	9.0			-18.1	
Muskeg Lo					7.3	13.1	15.1	13.4	7.7				
Richardson Lo					8.6	14.3	17.1	15.4	8.8				
Seaforth Lo						11.7	14.1	12.6					
Stoney Mtn.	-18.8	-15.0	- 8.7	-0.2	8.1	12.8	15.8	14.5	8.4	2.4	- 8.1	-14.9	-0.3
Stoney Mtn. Lo					7.5	12.2	14.9	13.4	7.6				
Tar Island	-22.0	-18.0	-10.3	1.1	9.7	14.8	17.3	16.0	9.7	3.1	- 8.5	-17.0	-0.3
Thickwood Lo					8.4	12.5	15.2	13.6	8.1				

[a] Adapted from original tables in Longley and Janz (1978) and Environment Canada (1975a).

[b] Part 1 data are published normals. Part 2 data are adjusted values as described by Longley and Janz (1978).

[c] A - airport; Lo - lookout tower

Table 2. Mean precipitation data (mm), 1941 - 1970, for stations within or near the AOSERP study area.[a,b]

Station	Month J	F	M	A	M	J	J	A	S	O	N	D	Year
PART 1													
Fort McMurray A	21.1	17.3	18.3	20.3	33.0	61.5	73.7	64.0	53.1	24.1	24.9	24.1	435.4
Fort Smith A	17.5	15.5	14.5	17.5	24.6	33.8	52.8	37.8	37.6	28.7	27.7	23.1	331.1
Fort Vermilion	20.3	21.1	20.8	16.8	31.2	41.1	61.7	46.2	30.7	22.4	22.9	24.9	360.1
PART 2													
Algar Lo					48	84	103	82	66				
Anzac	21	19	20	22	41	64	82	50		17	27	33	
Birch Mtn. Lo					32	83	90	75	54	28			
Bitumount Lo					34	63	77	73					
Buckton Lo					39	99	100	59					
Edra Lo					28	81	89	65					
Ells Lo					34	68	74	64	38				
Embarras A	10	9	14	14	36	53	73	52	52	25	22	11	371
Fort Chipewyan A	23	15	22	21	26	45	59	45	42	26	23	21	368
Gordon Lake Lo					33	76	79	67					
Grande Lo					34	80	84	60					
Johnson Lake Lo					47	68	86	64					
Keane Lo					28	55	58	71	68				
Legend Lo					31	68	91	62	35				
Livock Lo					43	87	80	60					
Mildred Lake							63	48	41	13	13	22	
Muskeg Lo					35	69	85	75	62				
Richardson Lo					26	54	61	59	43	27			
Seaforth Lo					25	61	100	68	38				
Stoney Mtn.	17	25	25	38	56	99	109	81	102	18	33	25	628
Stoney Mtn. Lo					50	91	104	85	84	45			
Tar Island	19	12	12	13	30	62	57	44	59	21	28	25	382
Thickwood Lo					39	77	92	68	61				

[a]Source: Longley and Janz (1978) and Environment Canada (1975b).

[b]Part 1 data are published normals. Part 2 data are adjusted values as described by Longley and Janz (1978).

is 305 mm rainfall and 140 cm snowfall, or a total of 435 mm rainfall plus rainwater equivalent of the snow. Total precipitation decreases northward from Fort McMurray to Fort Chipewyan and Fort Smith, and is highest in the Stony Mountain area south of Fort McMurray.

Fort McMurray and Fort Chipewyan experience frost during an average of 223 and 226 days per year respectively. The average frost free period at Fort McMurray is 69 days, from 15 June to 24 August. However, the range is from 8 days to 115 days. In other areas, the occurrence or non-occurrence of frost is a function of topography and proximity of water. Stations at Fort Chipewyan and Embarras are influenced by their location next to major water bodies. There is evidence that winter temperatures are slightly higher and summer temperatures are cooler in the uplands as compared to the lowlands and plains in the study area. Due to the size of the study area and variations in topography, elevation, and proximity to water bodies, the climate varies somewhat throughout the study area. The variations are discussed further in the sections describing ecoregions and ecodistricts of the study area (Sections 5.1 and 5.2).

2.4 VEGETATION

The AOSERP study area is located in the Boreal Forest Region which is the only Forest Region recognized in Northern Alberta by Rowe (1972). Forest Regions should not be confused with Ecoregions described in this report. Rowe's Forest Regions are similar to Ecoprovinces and Forest Sections are generally similar to, but smaller than Ecoregions (Alberta Ecoregions Working Group 1980).

The principal tree species of the Boreal Forest Region are white spruce *(Picea glauca)*, black spruce *(Picea mariana)*, balsam fir *(Abies balsamea)*, jack pine *(Pinus banksiana)*, aspen *(Populus tremuloides)*, balsam poplar *(Populus balsamifera)*, and white birch *(Betula papyrifera)*. Four Forest Sections found within the study area are the Mixedwood, Upper MacKenzie, Athabasca South, and Northwestern Transition Sections (Rowe 1972).

Most of the study area lies within the Mixedwood Section which is characterized by forest associations of aspen, balsam poplar, birch species, white spruce, and balsam fir. Although white spruce is the climax species on relatively well-drained sites, aspen is the forest cover of greatest areal extent because of its ability to regenerate rapidly after disturbance, particularly by fire (Stringer 1976; Thompson et al. 1978). Jack pine is dominant in sandy areas, but occurs with other tree species on drier glacial till soils and mixes with black spruce in the uplands. Poorly drained, low-lying lands develop black spruce and tamarack *(Larix laricina)* bogs and sedge fens.

The Athabasca South Forest Section occurs in the north-east of the study area, and includes the Richardson Hills and Firebag Hills Uplands. This is an area of mainly sandy soils which support jack pine in upland areas and black spruce mixed with jack pine in the poorly drained areas.

The northern part of the study area is located in the Upper Mackenzie Forest Section which is characterized by white spruce and balsam fir on alluvial flats bordering rivers. Balsam fir and white birch are prominent south of Lake Athabasca. Upland communities are dominated by jack pine and trembling aspen, with black spruce and tamarack in moist to wet positions.

The portion of the study area lying north of Lake Athabasca in the Precambrian Shield is within the Northwest Transitional Forest Section. Areas of bog and barren rock interspersed with open stands of stunted trees characterize this area. Black spruce is dominant with white spruce occurring on well-drained soils.

The major vegetation types in the study area were studied by Stringer (1976) and these formed the basis for the classification scheme of Thompson et al. (1978). These references should be consulted for both an overview and more thorough discussions of types of understory species, succession, and other characteristics of the vegetation. The classification for vegetation community types of Thompson et al. (1978) was adopted in this study for characterization of the vegetation associated with different soil groups and ecological land units. The classification scheme is presented in Section 4.2.4.

2.5 PHYSIOGRAPHY

The AOSERP study area lies within two major physiographic provinces - the Interior Plains and the Precambrian Shield (Atlas of Alberta 1969). The physiographic provinces have been subdivided by Pettapiece (1981) into smaller units - regions, sections, and districts - as shown in Table 3. The physiographic districts have been adopted in this study as areas equivalent to ecodistricts in the ecological land classification system. General descriptions of physiographic sections and regions follow while districts are described in greater detail in Section 5.2. The distribution of physiographic units in the study area can be determined from the ecoregions and ecodistricts map which accompanies this report.

2.5.1 Methy Portage Plain Physiographic Section

The Methy Portage Plain is an undulating area of low relief extending from the Saskatchewan border along the Clearwater and Athabasca rivers to the sand plains south of the Thickwood Hills in the west and to the Fort Hills Upland in the north. The elevation range is about 300 to 550 m. On a broader physiographic scale, the Methy Portage Plain represents the northwestern extremity of the Saskatchewan Plains physiographic region.

2.5.2 Firebag Hills Upland Physiographic Section

The Muskeg Mountain Upland is the only district within this physiographic section which occurs in the study area. This upland and the Stony Mountain Upland represent the northernmost parts of the Eastern Alberta Plains physiographic region. Sandy

Table 3. Physiographic units in the AOSERP study area.[a]

Province	Region	Section	District
Interior Plains	Saskatchewan Plains	Methy Portage Plain	Garson Plain Hangingstone Plain Brule Plain McMurray Lowland Clearwater Plain Steepbank Plain Hartley Plain Dover Plain MacKay Plain Fort Hills Johnson Lake Plain
	Eastern Alberta Plains	Firebag Hills Upland	Muskeg Mountain Upland
		Stony Mountain Upland	Cheecham Hills Escarpment House Plain
	Northern Alberta Lowlands	Wabasca - Athabasca Lowland	Wabasca Plain Algar Plain Dunkirk Plain Thickwood Hills Upland
	Athabasca Plain	Richardson Hills Upland	Richardson Hills Upland
	Northern Plains	Great Slave Plain	Muskeg River Plain Embarras Plain Buckton Plain Athabasca Delta Plain
	Northern Alberta Uplands	Birch Mountains Upland	Birch Mountains Upland Birch Mountains Escarpment Gardiner Upland McIvor Plain
Precambrian Shield	Kazan Upland	Tazin River Plain	Flett Lake Plain

[a]Adapted from the original table in Pettapiece (In prep.)

surficial materials with Brunisolic soils characterize most of the area but the Muskeg Mountain Upland is differentiated on the basis of predominance of glacial till of the Kinosis type on which Luvisolic soils have developed. The elevation range of this section is about 400 to 650 m.

2.5.3 Stony Mountain Upland Physiographic Section

A prominent escarpment marks the northern edge of this area, but the main part of it lies south of the study area and consists of hummocky and undulating morainal plains. Kinosis till and colluviated ground moraine are the main surficial deposits. Elevation in this section ranges from 500 to 800 m.

2.5.4 Wabasca - Athabasca Lowland Physiographic Section

This section is in the southern part of the Northern Alberta Lowlands physiographic region. It is generally a plain with low relief and gradual elevation changes which forms a broad basin lying among different parts of the Northern Alberta Uplands physiographic region. Morainal and glaciolacustrine materials extensively overlain by organic deposits are the dominant surficial components. The elevation range is about 450 to 600 m.

2.5.5 Richardson Hills Upland Physiographic Section

The Richardson Hills are uplands within the Athabasca Plain physiographic region consisting mainly of glaciofluvial ice-contact deposits. They range in elevation from about 200 to 450 m. Within the study area, this section has not been subdivided into ecodistricts and, therefore, the description for the Richardson Hills ecodistrict (Section 5.2.1) also applies to the physiographic section as a whole.

2.5.6 Great Slave Plain Physiographic Section

The Great Slave Plain is at the southern end of the Northern Plains physiographic region and borders the Eastern

Alberta and Saskatchewan Plains. It generally consists of glaciofluvial and fluvial deposits occurring at elevations below 300 m, but with an overall range of about 200 to 350 m. Devonian and Precambrian bedrock underlies the area.

2.5.7 Birch Mountains Upland Physiographic Section

This area lies within the Northern Alberta Uplands physiographic region. Morainal deposits underlain by Cretaceous bedrock occur throughout the area. Prominant features include extensive areas of organic soils with permafrost, large areas of ice-contact deposits, and a strongly dissected escarpment on the east side. The elevation ranges from about 350 to 850 m.

2.5.8 Tazin River Plain Physiographic Section

The Tazin River Plain is a part of the Kazan Upland physiographic region in the Precambrian Shield. The part of the plain adjacent to Lake Athabasca consists of large areas of glaciofluvial outwash plains overlying bedrock. Granitic plutonic bedrock is generally predominant. The elevation ranges from about 200 to 400 m.

2.6 HYDROLOGY

The surface water hydrology in the study area is discussed in an AOSERP report by Neill and Evans (1979). The main drainage way is the Athabasca River which enters the study area from the southwest and runs into Lake Athabasca at the north end. Several small rivers and creeks drain into the Athabasca. The distribution of water bodies in the study area is shown on the ecoregion and ecodistrict map accompanying this report. A map of the surface water drainage system can be found in Neill and Evans (1979).

The main rivers, other than the Athabasca, include the Clearwater River which enters the study area from the east and joins the Athabasca at Fort McMurray. The large tributary streams south of Fort McMurray are the Hangingstone and Horse rivers. Part of the Christina River, which drains into the Clearwater, is within the study area. The MacKay, Beaver, and Ells rivers are the larger rivers draining into the Athabasca from the west. Several creeks drain the east slopes of the Birch Mountains. The Steepbank, Muskeg, and Firebag rivers drain into the Athabasca from the east. In the north, the Richardson River flows directly into Lake Athabasca while the Buckton and McIvor rivers flow into Lake Claire. The Rivière des Rochers drains Lake Athabasca and part of the Shield area and, joining with the Peace River, enters the Slave River at the north end of the study area.

Neill and Evans (1979) note other features of surface hydrology as follows: Runoff from within the study area contributes less than 10% of the average flow in the Athabasca River and about 60% of this occurs in the four month period from April to July. About 20% of the precipitation in the study area results in runoff, the remainder being returned to the atmosphere by evaporation and transpiration. Snowfall contributes about 30% of total precipitation, but its proportional contribution to runoff is much greater. Similar results were obtained by McGill et al. (1978) in studies of soil moisture relationships in the study area. Runoff from rainfall was found to be relatively low on the east slopes of the Birch Mountains. Over the study area, variability in runoff is high as is the year to year variability.

The hydrogeology of the Athabasca oil sands area has been described by Hackbarth and Nastasa (1979) for the area Township 77 to 100, Range 1 to 25, West of the Fourth Meridian. The hydrogeology of the Bitumount - Namur Lake area has been described by Ozoray et al. (1980). It was determined that high water yields could be found through most of the area, but the water in most cases is characterized by high salinity.

There are indications that the rivers and streams draining the Birch Mountains have very low or negative baseflow components (Hackbarth and Nastasa 1979). Neill and Evans (1979) indicated that there are few data to permit relating surface water and groundwater interactions. However, they indicated that low runoff in the area east of the Birch Mountains may be caused by substantial subsurface flow. Data from wells indicated that substantial recharge of groundwater followed snowmelt and rainstorms. It is possible that shallow subsurface flow or discharge on the plains east of the Birch Mountains has had a significant effect on soil properties and development, and on the types of ecosystems occurring there. Solonetzic soils occur in this area, but no studies have been conducted which would relate their development to groundwater features.

2.7 BEDROCK GEOLOGY

The bedrock geology in the study area is shown in Figure 2, which was derived from the bedrock geology map of Alberta (Green 1970). Most of the area is underlain by Cretaceous shales and sandstones. Precambrian granitic plutonic rocks underlie and outcrop in the area east of a line running south - southeast through the western end of Lake Athabasca. The area north of McClelland Lake is underlain by Devonian limestones and evaporites. Devonian limestones also outcrop along the Athabasca River and underlie the area in the vicinity of Fort MacKay. Additional descriptions of the bedrock geology are presented in the discussions of ecoregions and ecodistricts (Sections 5.1 and 5.2).

2.8 SURFICIAL DEPOSITS AND SOIL PARENT MATERIALS

Bayrock (1971, 1972a, 1972b, and 1972c) and Bayrock and Reimchen (1974) have mapped the surficial geology of National Topographic Series (NTS) sheets 74E, 74L, 74M, 74P, and 84I, at a scale of 1:250 000. McPherson and Kathol (1977) have reported on the surficial geology of potential mining areas in the Athabasca oil sands region (Township 91 to 98, Range 7 to 13, West of the Fourth Meridian). At a scale of 1:125 000, they provide more detail than the previous surficial geology maps and indicate the extent

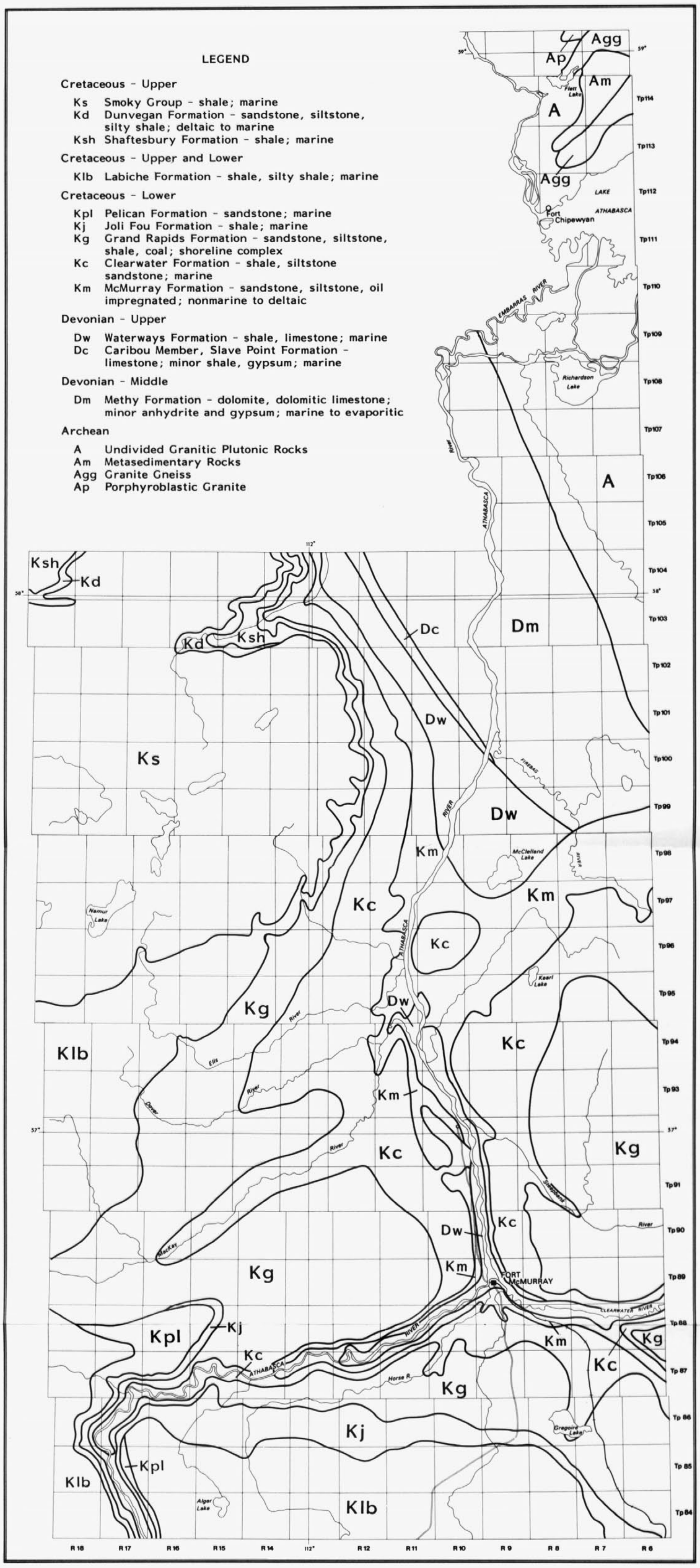


Figure 2. Bedrock geology of the AOSERP study area.
[Adapted from original map in Green (1970)]

and distribution of organic deposits. The surficial geology of the AOSERP study area has been mapped at a scale of 1:50 000 by Thompson et al. (1978); this report should be consulted for more detailed information on surficial deposits and landforms.

Soil classification and mapping is based on soil genetic types and on the type of material the soil has developed on. The distribution of soil parent materials found in the study area is shown on a map accompanying this report. The map shows that organic deposits overlie a considerable portion of the study area. The organic or peat category of deposits includes both shallow and deep sphagnum, fen, and forest peat deposits. For distribution of mineral materials that underlie the peat, reference should be made to the report of Thompson et al. (1978).

The majority of soils in the study area have developed on glacial and postglacial deposits. During the Pleistocene Period, northeastern Alberta was covered by a Continental ice sheet which advanced from the central region of the Keewatin district (Gravenor and Bayrock 1961). During deglaciation, glacial Lake McConnell was formed when the ice front retreated north beyond Fort McMurray (Craig 1965; Taylor 1960). The lake was fed by the Athabasca River and by waters of glacial Meadow Lake in Saskatchewan via the Clearwater and Athabasca spillways (Christiansen 1979). Major deltas were built where the rivers emptied into Lake McConnell. The deltaic deposits southwest of Fort McMurray along the Athabasca River were likely formed during a re-advance of the glacier which caused water to flow from the Athabasca River eastward through the Clearwater spillway (Christiansen 1979). Lacustrine sediments were deposited when waters of glacial Lake McConnell were impounded in front of the glacier for long periods of time. Relict beach ridges, identified at elevations from 312 to 511 m above mean sea level, indicate the extent of the former glacial lakes within the study area (Thompson et al. 1978).

In the uplands of the study area, the common surficial deposit is glacial till, an unsorted admixture of local bedrock and of rock material from more distant sources such as the Precambrian Shield. Most till material is locally derived and, therefore, its composition largely reflects that of underlying or nearby strata (Pawluk and Bayrock 1969). Bayrock and Reimchen (1974) have recognized different types of till based on matrix composition. Gipsy till, composed predominantly of sand derived from the Athabasca Formation, occurs mainly east of the AOSERP study area. Kinosis till has a loamy, gravelly, and stony composition and occurs mainly in the southeast part of the area, in the Muskeg Mountain and Stony Mountain uplands and surrounding areas. Horse River till has a clayey composition, occurs on the west flanks of the Stony Mountains Upland, and underlies glaciolacustrine deposits in the area. In this report, Horse River till is considered to include any calcareous tills found in the Methy Portage Plain and Wabasca - Athabasca Lowland physiographic sections (Map 10). Another till type recognized by Bayrock and Reimchen (1974) is colluviated ground moraine, which consists of till that has moved downslope and mixed with other materials, usually shales, but is now stable. In this study, the till found in the Birch Mountains is considered to differ from that found elsewhere. This till is fine-loamy to clayey and contains much shaly material which is probably locally derived. Till deposits occur in ground moraine, with low relief, and in hummocky moraine, which has local relief greater than 5 m. In the Birch Mountains, considerable areas of till deposits have been formed into flutings by glacial action.

Glaciofluvial outwash materials are the most widespread surficial deposits in the northeast part of the study area. They are composed predominantly of sand, with almost no silt and clay. Glaciofluvial meltwater channel deposits, which are sandy, gravelly, and stony, occur along the Athabasca and Clearwater rivers.

Eolian activity has reformed many of the glaciofluvial outwash and deltaic deposits in the area into sand sheets and dunes. Much of the area south of Lake Athabasca consists of eolian landforms in which veneers and blankets predominate and dunes occur commonly. The deltaic sediments southwest of Fort McMurray, which were referred to earlier, have been almost entirely developed into dunes. Dune forms are mainly U-shaped or longitudinal. Some aspects of formation and distribution of U-shaped dunes have been discussed by Odynsky (1958), while longitudinal and other eolian forms occurring south of Lake Athabasca have been described by Landals (1978). There are several areas of active dune fields south of Lake Athabasca, two of which occur within the study area.

Some glaciolacustrine deposits in the study area are similar to lacustro-till deposits recognized in other parts of northern Alberta (Scheelar and Macyk 1972). These are called mixed lacustrine deposits by McPherson and Kathol (1977) and were recognized mainly on the flanks of the Thickwood Hills and Muskeg Mountain Uplands. Various types of glaciolacustrine deposits were recognized by Bayrock and Reimchen (1974). Glaciolacustrine, bedded silts and clays are most widespread in the Dover and Hangingstone plains. They are mainly thin deposits which overlie southwestern margins of the study area, shallow glaciolacustrine deposits are not as clayey as the above and are composed of bedded sands and silts.

Ice-contact deposits such as kames, kame moraines, eskers, and crevasse fillings are also common in the study area. Deposits in areas such as the Richardson Hills and Fort Hills uplands are composed of sands with variable quantities of gravel, stones, and boulders. These uplands originated as kame moraines which marked ice-marginal positions during glacial retreat (Thompson et al. 1978). Kame and esker complexes also occur in the Birch Mountains and individual kames can be found in the Stony Mountain Upland.

Materials of recent origin include eolian, colluvial, fluvial, and organic deposits. Colluvial materials occur along creek and river banks and on the escarpments of the Birch Mountain and Stony Mountain uplands. Series of large rotational slump blocks have produced a ridged landform pattern on the upper slopes of the upland areas. A more gently sloping colluvial apron extends over much of the lower escarpment areas.

Three types of fluvial materials were distinguished in the study area. Fluvial channel deposits, or stream alluvium, occurs along creek and river channels and consists of variably textured materials. Fluvial fans and aprons have developed at the bases of the Birch Mountain and Stony Mountain uplands. The fans occur where streams' gradients are reduced when entering the valleys and lowlands below the uplands. This reduces the stream's carrying capacity and deposition takes place (Thompson et al. 1978). The deposits are thick near the hills and gradually decrease in depth with distance away from the hills. Their composition is mainly clayey and loamy. Deltaic materials comprise the third type of fluvial deposit. They occur in the Athabasca Delta, where several rivers enter Lake Athabasca. They consist of bedded point bar, levee, lakeshore, and backswamp deposits mainly of loamy composition (Dirschl et al. 1974).

Organic materials overlie glacial deposits over a considerable portion of the study area. The only areas with a relatively minor areal extent of organic accumulations are the sandy plains and uplands in the northeastern part of the study area. Organic deposits are characterized by an accumulation of peat, which, for soil classification purposes, exceeds a thickness of 40 cm. Three main types of organic material are recognized with respect to their mode of origin. The first is bog peat which is developed mainly from mosses of the Sphagnum species. Fen peat is derived from sedges and grasses and occurs in relatively treeless fen terrain. A third type is forest peat which is composed of tree and shrub remnants mixed with feathermosses and various other moss types. Forest peats are shallow and usually occur under a dense black spruce forest canopy. The different types of peat deposits are not distinguished on the parent material map.

3. SOILS

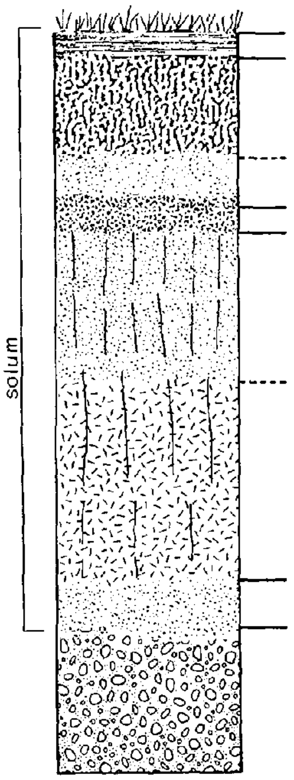
3.1 THE SOIL PROFILE

A soil profile is a vertical section of a soil extending downward through all its horizons (or layers) into the unweathered material. Soil horizons differ from one another in one or more of the following features: colour, texture, structure, consistence, reaction, and thickness as well as in chemical and biological composition. Major soil horizons are designated L, F, H, or O for organic horizons, and A, B, or C for mineral horizons. Lowercase letter suffixes are used to indicate the type of horizon and Arabic numeral suffixes are used when further division into sub-horizons is required. Roman numerals are prefixed to horizon and layer designations to indicate parent material discontinuities in the profile. The major horizon designations and lowercase suffixes are defined in the Glossary (Appendix Section 9.3). A diagrammatic representation of a soil profile showing various horizons is given in Figure 3.

3.2 SOIL FORMATION

Soil is the naturally occurring, unconsolidated, mineral or organic material at the earth's surface that is capable of supporting plant growth (Canadian Society of Soil Science 1976). Soil formation or genesis is the process or combination of processes responsible for the development of soil. At any particular location, soil genesis results in development of a particular type of soil with distinctive morphological and chemical characteristics. These characteristics are the result of the integrated effects of the soil forming factors: climate, parent material, biota, topography, and time (Jenny 1941). Soils do not cease to form, but are continually changing systems which respond to any changes in the environment.

Soils are multiphase systems consisting of varying mixtures of mineral and organic materials, air, and water. Soil



L,F,H -Organic horizon, which may be subdivided into: L(raw organic matter), F(partially decomposed organic matter), and H(decomposed organic matter).

A -A mineral horizon at or near the surface. It may be a dark coloured horizon in which there is an accumulation of humus (Ah), or a light coloured horizon from which clay, iron, and humus have been leached(Ae).

AB -Transition horizon.

B -Mineral horizons that(1) may have an enrichment of clay(Bt), iron(Bf), or organic matter(Bh); or(2) may be characterized by a columnar structure and a significant amount of exchangeable sodium(Bn); or(3) may be altered to give a change in colour or structure(Bm). Usually lime and salts have been leached out of this horizon.(4) The symbol "j" is used with the above suffixes to denote a failure to meet the specified limits of the suffix.

BC -Transition horizon.

C -Mineral horizon comparatively unaffected by the soil forming process operative in the A and B horizons except for the process of gleying(Cg) and the accumulation of calcium or magnesium carbonates(Ck) and soluble salts(Cs).

Figure 3. Diagram of a soil profile showing various horizons.

air has the same constituents (but different proportions) as atmospheric air and is important to growth of plants and microorganisms. Soil water has important roles in plant growth and in the chemical and physical weathering reactions that occur in soils. Mineral matter consists of a wide variety of primary and secondary minerals. The particle sizes of these components range from clay (<0.002 mm), through silt (0.002 to 0.05 mm), sand (0.05 to 2 mm), gravel (2 to 75 mm), and cobbles (75 to 250 mm), to stones and boulders (>250 mm in diameter). The relative proportion of sand, silt, and clay (the fine-earth fraction) in a soil is called soil texture. Texture determines important soil properties such as nutrient status, water holding capacity, shrinking and swelling potential, and others. Organic materials in soil originate through accumulation of animal and plant residues added to the mineral soil. The residues undergo decomposition by soil fauna and flora to produce humus. Organic matter is important to plant growth and soil formation because it influences nutrient supplying power, water holding capacity, structure and many other soil properties.

The conditions of soil formation are set by the soil forming factors, but internal processes produce the soil profile. Horizon differentiation, forming a soil profile, has been ascribed by Simonson (1959) to additions, removals, transfers, and transformations of substances within the soil system. Climate and organisms are considered to be the driving forces for these processes, while parent material and topography are the passive factors. Additions, removals, and transfers involve movement which may occur laterally as well as vertically in a soil. Transformations involve the change of some soil constituents without any physical displacement. The active and passive factors of formation are interdependent and they act in different combinations and to different degrees to form many different types of soils over a period of time. The same processes occur to some extent in all soils. The characteristics of any one soil result from a particular balance among these processes. Different balances of the processes result in formation of different kinds of soil.

More detailed discussion of soil formation can be found in Buol et al. (1973). Properties and processes of forest soils have been discussed by Armson (1977).

3.3 SOILS OF THE STUDY AREA

Soils were classified according to the Canadian System of Soil Classification (1978). The classification system is a hierarchical organization of several categories. Classes at higher categorical levels (at the most general level of abstraction), the order, great group, and subgroup levels, reflect broad differences in soil environments that are related to differences in soil genesis and are expressed by major differences in morphological features exhibited by soil profiles. Classification in the lower categories of family and series is based on detailed soil features. The following are brief descriptions of the orders, great groups, and subgroups found in the study area.

3.3.1 Luvisolic Order

Luvisolic soils are well to imperfectly drained mineral soils that have developed under the influence of the growth and decomposition of forest vegetation in mild to cold climates. Soils of the Gray Luvisol great group, developed in cool climates under mixed deciduous and coniferous vegetation, are the typical mineral soils of the study area. The predominant soil forming process in Luvisolic soils is lessivage, a term used to describe the physical movement of clay, without destruction, from the upper portion of the solum to the lower solum (Duchaufour 1973; Howitt 1981). This process results in pronounced eluvial (Ae) horizons and illuvial, textural (Bt) horizons in which silicate clay is the main accumulation product. All Gray Luvisols in the map area have LF or LFH surface horizons (litter or duff layers) and absent or very thin Ah horizons. The Ae and Bt horizons are generally acidic in reaction while the parent material may be either acidic or calcareous. These soils can be classified further at the more detailed subgroup level on the basis of differences in horizon characteristics. Subgroups of the Gray Luvisol great group which are found in the study area are Orthic Gray Luvisol, Brunisolic Gray Luvisol, Solonetzic Gray Luvisol, Gleyed Gray Luvisol, and Gleyed Solonetzic Gray Luvisol.

3.3.2 Brunisolic Order

Soils of the Brunisolic order are rapidly to imperfectly drained mineral soils developed under the influence of varying types of forest, alpine, or tundra vegetation. They occur under climatic conditions varying from Mesic to Arctic in temperature and from perhumid to semiarid in moisture regimes. Brunisols are characterized mainly by the presence of brownish Bm horizons formed by in situ oxidation, hydrolysis, or solution resulting in significant changes in colour, structure, and composition from that of the A and C horizons, but with insufficient accumulations to produce textural (Bt) or sesquioxide (Bf) horizons.

Two great groups - Eutric Brunisol and Dystric Brunisol - occur in the study area. These are morphologically similar consisting of organic (LFH) surface horizons, weakly to strongly developed eluvial (Ae) horizons, and brown Bm or Bfj horizons. In the study area, these soils have developed in very sandy deposits in which the clay and sesquioxide contents are so low that processes such as lessivage and podzolization cannot occur to a great extent. Eutric Brunisols have a pH in a neutral salt solution of 5.5 or higher in any part of the solum while Dystric Brunisols have a pH less than 5.5 throughout the solum. A few subgroups are found within both of these great groups. The most common subgroups within the Eutric Brunisol great group are Eluviated Eutric Brunisol, Gleyed Eluviated Eutric Brunisol, Orthic Eutric Brunisol, and Gleyed Eutric Brunisol.

The latter two subgroups are generally rare in the study area but may be more common in certain locations as shown on the soil map of the Alsands lease (Hardy Associates Ltd. 1980).

Subgroups of the Dystric Brunisol great groups found in the study area are Eluviated Dystric Brunisol and Gleyed Eluviated Dystric Brunisol.

3.3.3 Gleysolic Order

Soils within the Gleysolic order are poorly drained mineral soils whose profiles reflect the influence of water-logging for significant periods. They develop under various climatic and vegetative conditions in the presence of a high or fluctuating water table which produces reducing conditions due to lack of aeration. Gleysolic soils are characterized throughout the profile by dull grayish colours frequently accompanied by prominent, usually rusty coloured mottles resulting from localized oxidation and reduction of hydrated iron oxides. In the study area, Gleysolic soils have developed in poorly drained areas in a variety of parent materials ranging from sandy to clayey in composition.

The Gleysol and Luvic Gleysol great groups occur most commonly in the study area. Both of these great groups lack well-developed Ah horizons. Subgroups within the Gleysol great group are Orthic Gleysol, which has a Bg horizon, and Rego Gleysol, which has no B horizon. The Orthic Luvic Gleysol is the only subgroup of the Luvic Gleysol great group commonly found in the study area. It is characterized by a weakly to strongly developed eluvial (Aeg) horizon and a textural (Btg) horizon.

Gleysols in the study area are almost everywhere overlain by a peaty (O) horizon. They are called peaty Gleysols where the O horizon consists of 15 to 60 cm of fibric peat or of 15 to 40 cm of peat composed partially or entirely of mesic or humic peat.

Determination of dominance of any one Gleysolic subgroup in a mapped area was not attempted in this soils inventory.

In many areas, all three subgroups are represented. They are, therefore, grouped and classified simply as peaty Gleysols and are referred to in this way in the legend and elsewhere in the report.

3.3.4 Regosolic Order

Soils in the Regosolic order are well- to imperfectly drained mineral soils with no or very weak profile development. They lack a B horizon but may have an organic surface (LFH) horizon or a weakly developed organo-mineral Ah horizon. Regosolic soils reflect essentially the characteristics of the C horizons or of the parent materials from which they are formed. Soil forming processes have not had sufficient time to form soil horizons. Whereas most soils in the study area had begun formation immediately after deglaciation about 10 000 years ago, Regosolic soils occur on more recently deposited sediments of fluvial, colluvial, and eolian origin. Only the Regosol great group is widely encountered in the study area, and within this, the following subgroups occur: Orthic Regosol, Cumulic Regosol, Gleyed Regosol, and Gleyed Cumulic Regosol.

Orthic Regosols occur in active and eroded sand dune areas and may or may not have a surface LFH horizon. Gleyed, Cumulic, and Gleyed Cumulic Regosols are typical soils on fluvial channel fan apron and deltaic deposits.

3.3.5 Solonetzic Order

Soils within the Solonetzic order are well- to imperfectly drained mineral soils having horizon features of distinctive physical and chemical characteristics believed to result from a combination of processes of salinization by alkaline salts, and desalinization and leaching within the soil. Salinization originates from a saline parent material or from saturation by external saline waters. Salinization is followed by solonization which involves leaching of salts by descending rainwater resulting in deflocculation of sodium-saturated colloidal organic matter and clay. These materials tend to concentrate in an alkaline, textural (Bnt) horizon and they produce a columnar structure which is dense and slowly permeable. With continued leaching, the process of dealkalization or solodization occurs in which there is removal of alkali bases and formation of an acidic, platy-structured (Ae) horizon followed by progressive structural breakdown of the Bnt horizon.

Solonetzic soils are mostly developed under grass and forb vegetation, but may also be found associated with tree cover, usually only in situations where solodization is well developed. This is the situation in the study area where Solodized Solonetz and Solod great groups occur. A Solodized Solonetz has a well developed, platy eluvial (Ae) horizon overlying a round-topped, columnar or prismatic, textural (Bnt) horizon which is very hard when dry. A Solod is similar to a Solodized Solonetz except that the upper Bnt horizon has been degraded to a platy or weak-blocky AB or BA horizon. Saline parent materials underlie the solum in these soils. Subgroups within the Solodized Solonetz great group are Gray Solodized Solonetz and Gleyed Gray Solodized Solonetz. Subgroups within the Solod great group are Gray Solod and Gleyed Gray Solod.

Solonetzic soils in the study area have developed mainly in glaciolacustrine sediments. These soils have likely formed were salts dissolved in groundwater were transported and concentrated at points of discharge (Pawluk 1982). In the study area, such discharge appears to have occurred most commonly in the Dover Plain.

3.3.6 Organic Order

Soils of the Organic order have developed predominantly from organic deposits derived from the decomposition of hydrophytic or mesohydrophytic vegetation. Three general types of peat recognized in the study area, based on mode of origin, are bog, fen, and forest peat (Section 4.2.3.1). By definition, Organic soils contain more than 17% organic carbon and they meet minimum specifications of depth and thickness within a control section. A control section is the vertical section of soil upon which classification is based. For Organic soils, it extends to a depth of 160 cm, or to a lithic contact, and is subdivided into surface (0 to 40 cm), middle (40 to 120 cm) and bottom (120 to 160 cm) tiers (Figure 4).

The Fibrisol and Mesisol great groups occur most commonly in the study area while Humisols are rare. Soils of the Fibrisol great group are composed largely of relatively undecomposed fibric organic material (Of horizons). More detailed classification into subgroups is based on proportions of mesic and humic organic material (Om and Oh horizons) in the control section, or on depth to mineral material (see Section 2.9.1 for definitions of Of, Om, and Oh horizons). Subgroups of the Fibrisol great group which are common in the study area are Typic Fibrisol, Mesic Fibrisol, Terric Fibrisol, and Terric Mesic Fibrisol.

Soils of the Mesisol great group are composed dominantly of peat which is mesic; that is, intermediate between fibric and humic peat in stage of decomposition. Subgroups found in the study area are Typic Mesisol, Fibric Mesisol, Terric Mesisol, and Terric Fibric Mesisol.

Soils of the Humisol great group consist of peat which is humic - an advanced stage of decomposition in which the material has few or no recognizable fibres. Subgroups which were recognized, but which occur rarely in the study area, are Terric Fibric Humisol and Terric Mesic Humisol.

Many soils developed on organic materials in the study area have frozen layers which are apparently of long-lasting or permanent duration. These soils were classified in the Cryosolic order.

3.3.7 Cryosolic Order

Cryosolic soils in the study area occur in organic deposits and have permafrost within 1 m of the surface. As with soils

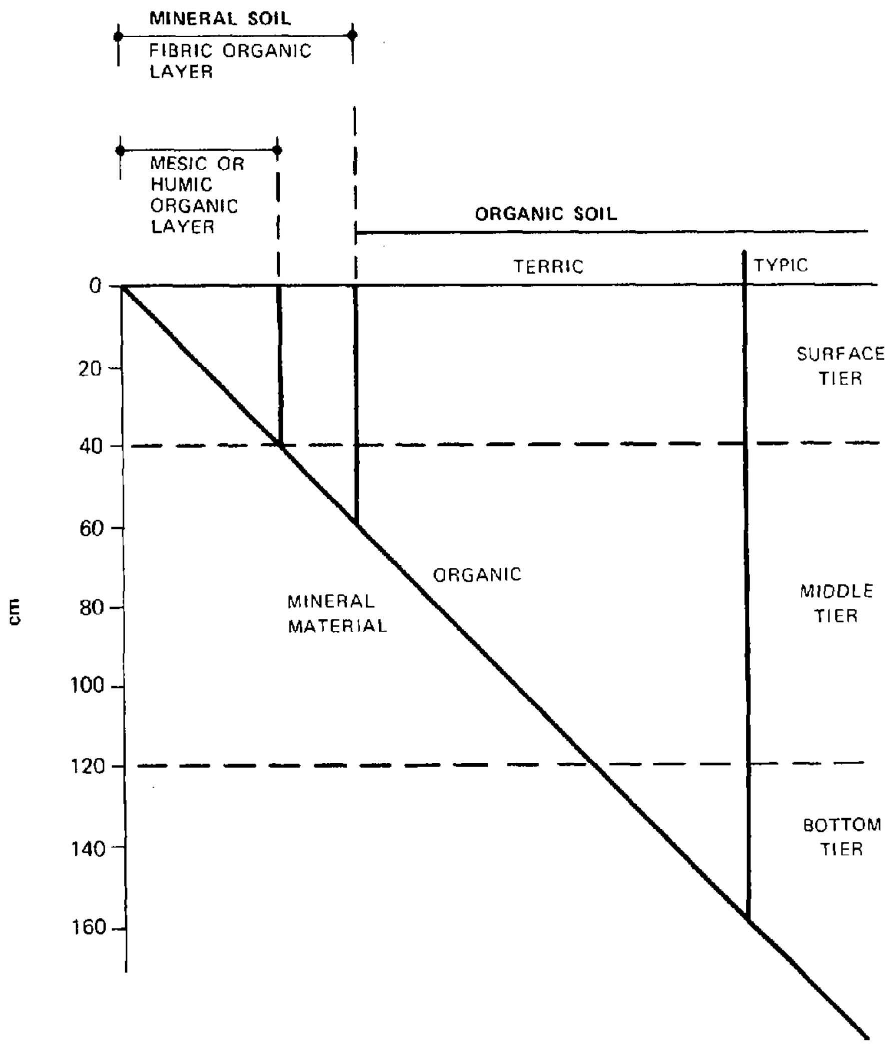


Figure 4. Diagrammatic representation of depth relationships involved in Organic soil classification (Source: Canada Soil Survey Committee 1978a).

of the Organic order, the Organic Cryosol great group is formed on materials containing more than 17% organic carbon which may be of bog, fen, or forest peat composition. Organic Cryosols are more than 40 cm thick, or more than 10 cm thick over a lithic contact or more than 10 cm thick over an ice layer that is at least 30 cm thick.

The control section for Cryosolic soils is 100 cm. Terric subgroups have a mineral material contact at less than 100 cm. Some of the subgroups within the Organic Cryosol great group which are found in the study area are Fibric Organic Cryosol, Mesic Organic Cryosol, Terric Mesic Organic Cryosol, Terric Fibric Organic Cryosol, Humic Organic Cryosol, and Terric Humic Organic Cryosol.

3.4 SOILS AND ECOLOGICAL SYSTEMS

The soil-forming factors - climate, parent material, topography, biota, and time - are also the major elements that compose an ecological system. Rowe (1961) defined an ecosystem as "a topographical unit, a volume of land and air plus organic contents extended areally over a part of the earth's surface for a certain time." The boundaries of ecosystems are transitional and, therefore, must be fixed by definition. The concept of land as stated by Jurdant et al. (1974) and derived from Christian and Stewart (1968) is that of all the natural resource attributes in a profile from the atmosphere above the land surface to some metres below the surface. Its attributes are climate, landform, soil, vegetation, fauna, and water. Land is an ecological system in which complex interrelationships exist between organisms and various components of the physical environment. The relationships of components can be regarded as independent basic components, such as time to produce dependent, manifest components, such as soils, landforms, and plant communities (Wendt et al. 1975). Soil is an integration of environmental characteristics and is thus a key to understanding complex environmental relationships.

It is apparent that, within a general climatic framework, distinct relationships occur among various soils, landforms, and plant communities. The type of soil and vegetation community may vary with parent material. On similar parent materials, there is an assemblage of soil types and plant communities which are dependent on topographical features such as slope, aspect, relief, length of slopes, and drainage.

There are some assemblages which occur very commonly in the study area. In undulating and hummocky areas of medium- to fine-textured morainal or glaciolacustrine deposits, Orthic Gray Luvisols typically occupy well- and moderately well-drained sites. White spruce-aspen forest community types are common on these sites. In imperfectly drained mesic to hydric sites of lower slope positions, Gleyed Gray Luvisol and mixed coniferous or deciduous shrub community types occur. Gleysolic soils, usually with a thin overlay of peat, occur in the poorly drained or hydric sites in depressional areas. Commonly, the peat accumulation is relatively thick, and Organic soils occur. Black spruce bog forest occurs in these sites, with semi-open black spruce bog and lightly forested tamarack and open muskeg occurring as well. The landscape thus consists of a recurring pattern of Luvisolic, Gleysolic, and Organic soils and associated upland and wetland community types.

Similar landscape relationships occur in undulating to hummocky areas of sandy eolian or glaciofluvial deposits. Brunisolic soils and jack pine communities occupy rapidly to well-drained sites. Gleyed Brunisols and mixtures or narrow bands of mixed coniferous and deciduous shrub communities occupy imperfectly drained sites. Gleysols or Organic soils and various wetland plant communities may occupy poorly drained, depressional areas.

In upland areas such as the Birch Mountains, soil-geomorphic relationships are similar to those described above for morainal deposits, except that the proportion of imperfectly and poorly drained soils may be higher. Mixed coniferous plant communities occur commonly in the upper slope positions. Cryosolic rather than Organic soils commonly occupy depressional areas, and fen peatlands are more common than in the lowlands.

The preceding discussion briefly describes some recurring soil-landform-vegetation relationships in the study area. The purpose of this report is to describe soils and their distribution in the study area, but it can be seen that soils, as integral components of ecosystems, can provide much information about the ecosystems in general. Nevertheless, soil maps are not ecosystem maps. Both more detailed and more general information on vegetation, landforms, and climate, as well as ecological components such as hydrology, fauna, limnology, and others can be found in other AOSERP reports.

3.5 RESUME OF SOILS INFORMATION PERTINENT TO THE AOSERP STUDY AREA

The soils of almost all of northern Alberta, including the Athabasca oil sands area, have been classified and mapped at an exploratory level by Lindsay et al. (1957, 1961, 1962). On maps at a scale of 1:750 000, separations were made mainly on the basis of soil parent materials. The large areas which were separated correspond closely, in this soil survey, to separations at the 'ecodistrict' level and they provided an indication of the major soils, materials, and topography that were likely to be encountered in different parts of the study area. The mineral soils recognized were Gray Wooded, Podzol Gray Wooded, and Podzol Great Groups. In the current classification system (Canada Soil Survey Committee 1978), these correspond to Gray Luvisol, Brunisolic Gray Luvisol, and Brunisolic Great Groups. The percent areal cover by Organic soils was also estimated in these surveys.

Crown and Twardy (1970) mapped an area of eight townships surrounding Fort McMurray. Maps produced at a scale of 1:126 720 provide information about soil materials, landforms, soil map units, drainage classes, and soil capability of agriculture at a semi-detailed level.

A soil survey of a portion of the Syncrude lease was conducted by Twardy (1978) at a scale of 1:24 000. Part of the Alsands has also been mapped at a scale of 1:20 000 by Hardy Associates Ltd. (1980). The soil group names used in this report differ from those used for similar soils in the soil survey of Syncrude Lease 17 by Twardy (1978). This may lead to confusion for users of both reports. In order to clarify the use of names, a list of the Syncrude and AOSERP soil survey names which were used for similar soil groups is presented in the Appendix (Section 9.2). In the soil survey of the Alsands area (Hardy Associates Ltd. 1980), soil names used were the same as in this report. Additional names and map units were required for their more detailed survey, however. A table of equivalent AOSERP and Alsands soil names is provided in that report.

Soil-vegetation-geomorphic relationships in the Athabasca delta area were described by Dirschl et al. (1974). Soil information is available for the Namur Lakes and McMurray-Gregoire Lake areas in the biophysical reports of Hanley (1973) and van Waas (1974). Soil parent material information was available for part of the AOSERP study area in the surficial geology maps of Bayrock (1971, 1972a, 1972b, 1972c) and Bayrock and Reimchen (1974), and in the report and maps of McPherson and Kathol (1977). Geomorphological and surficial geology information was also available upon completion of 1:50 000 maps of the AOSERP study area by Thompson et al. (1978). Additional geomorphological and parent material information was derived from the landform classification maps of the Resource Evaluation and Planning Division, Alberta Energy and Natural Resources. These were especially helpful for those portions of the study area within NTS sheets 84A and 84H for which relatively detailed geomorphological information was not otherwise available.

Information on properties of glacial tills in the study area is available from a publication on characteristics and physical properties of Alberta tills by Pawluk and Bayrock (1969). During the course of this soil survey, subsoil samples were collected by G. A. Spiers (see Acknowledgements) and the properties and distribution of macro- and microelements in soil parent materials was studied by use of various methods of statistical analysis (Spiers, M.Sc. Thesis, in preparation).

4. METHODOLOGY

4.1 CLASSIFICATION AND MAPPING SYSTEMS

4.1.1 Ecological Land Classification

Ecological land classification refers to an integrated approach to land survey in which areas of land are classified according to their ecological unit (Wiken and Ironside 1977). The classification recognizes land as an ecological system in which complex interrelationships exist between organisms and the various components of the physical environment. Ecological classification integrates a variety of information from climatology, geology, geomorphology, soil science, forestry, wildlife biology, and other areas. An ecological survey is an inventory of the land and its resources. The information obtained can be interpreted for a variety of land uses and interpretations.

The aim of most ecological land inventories in Canada has been to differentiate and classify ecologically significant segments of the land surface rapidly and at a small scale (Lacate 1969). A brief description of the divisions or levels of generalization within the classification system is given in Table 4. The basic mapping unit in most inventories is the land system (Wiken and Ironside 1977). The ecosystem map is a comprehensive inventory of the most stable biophysical characteristics of the environment which are significant to the potential production of the natural renewable resources and which determine its physical limitations to their management (Jurdant et al. 1974). Methodology for such an inventory relies on the use of airphotos and airphoto interpretation techniques supported by field checks. Emphasis is placed on classification and mapping of patterns of soils, landforms, vegetation, and water bodies.

Table 4. Outline of the ecological classification system.

Levels of generalization & common scales of maps	Current definitions
Ecoprovince	An area of the earth's surface characterized by major structural or surface forms, faunal realms, vegetation, hydrological, soil, and climatic zones.
Ecoregion 1:3 000 000 to 1:1 000 000	A part of an ecoprovince characterized by distinctive ecological responses to climate as expressed by vegetation, soils, water, fauna, etc.
Ecodistrict 1:500 000 to 1:125 000	A part of an ecoregion characterized by a distinctive pattern of relief geology, geomorphology, vegetation, soils, water, and fauna.
Ecosection (Ecosystem)[a] 1:250 000 to 1:50 000	A part of an ecodistrict throughout which there is a recurring pattern of landforms, soils, vegetation, water bodies, and fauna.
Ecosite 1:50 000 to 1:10 000	A part of an ecosection having a relatively uniform parent material, soil and hydrology, and a chronosequence of vegetation.
Ecoelement 1:10 000 to 1:2 500	A part of an ecosite having a fairly homogeneous combination of soil and vegetation; characterized by vegetation succession as expressed by the existing vegetation at the time of the survey.

[a] The older term 'ecosystem' is used in this report.

4.1.2 Soil Survey

Soil survey refers to the procedure involved in making a soil resource inventory. The main aspect of soil survey in soil mapping is the identification, description, and delineation on a map of contrasting segments of the landscape based on differentiating soil criteria from direct field observations or indirect inferences from sources such as airphotos (Canada Expert Committee on Soil Survey 1979). The actual differentiating characteristics depend on the detail required or the survey intensity level. Types of differentiating characteristics of soils are texture, depth of solum, mineralogy of the solum and underlying parent material, soil water regime, organic matter characteristics, horizon sequence, landform surface expression, slopes, erosion, and types and proportions of soil taxa.

Because the purpose of this survey is to provide a soils data base for broad regional planning, particularly environmental planning, a reconnaissance survey intensity level is appropriate. A working scale and preliminary map publishing scale of 1:50 000 was selected. The final map scale of 1:126 720(1 cm = 1.27 km; 1 inch = 2 miles) is the same as that of other reconnaissance soil surveys carried out in northern Alberta. Soil inspection density, however, is not as high as in other surveys and this inventory thus relies heavily on methodology as described for mapping ecosystems; that is, delineations are made on the basis of airphoto interpretation with limited supplemental field checking. Predicting soil type by airphoto examination is greatly dependent on consistent soil-landform-vegetation relationships and on recurring patterns of these.

This soils inventory is similar to ecological inventory insofar as soils and landforms are mapped at the ecosystem level and methodology is similar to ecological mapping. Vegetation communities were identified but were not used in descriptions of mapping units, except to the extent of predicting the probable plant community type to be found on a particular soil type.

Soils were mapped in this project within an ecological framework. In southern Alberta, major differences in soils resulting from climate, as expressed by vegetation, has resulted in soil zonation; as a result, soil mapping is carried out within the framework of soil zones. Because soil zones are conceptually very similar to ecoregions in the ecological classification system, ecoregions were identified in the study area. It was also apparent that the land surface in the study area could be subdivided into distinct physiographic areas or ecodistricts as defined in the ecological classification system. The soil maps, therefore, provide ecological information at the higher categories of the ecological system, as well as soils information.

4.2 DESCRIPTIVE METHODS AND TERMINOLOGY

4.2.1 Soil Classification System

Soils of the AOSERP study area were classified according to the Canadian System of Soil Classification (Canada Soil Survey Committee 1978). The soil orders, great groups, and subgroups recognized in the study area are described in Section 3.3.

4.2.2 Terminology for Describing Soils

Terminology for describing soils is fully described in publications of the Canada Soil Survey Committee (1978a, 1978b). Criteria for differentiating soil horizons and some of the descriptive terms used frequently in this report are defined in the Appendix (Section 9.3).

4.2.3 Landform Classification System

Landforms are classified according to the system adopted by the Canada Soil Survey Committee (1978). In this system, landforms are considered to represent two basic attributes, material, and form. Four groups are recognized in the material category: unconsolidated mineral, organic, consolidated mineral, and ice.

Textures of the unconsolidated mineral category and fiber content of the organic category are recognized by another category called Material Qualifiers.

Surface expression, or form, associated with a material or deposit is first considered on the basis of primary depositional form. Post depositional erosional forms and processes are recognized by a category called Modifying Processes. A category called Qualifying Descriptors makes possible further qualification of the kind of materials and the current states of processes, that is, whether they are active or inactive.

4.2.3.1 Genetic materials. The four groups of materials and the classes established within them are presented below.

Unconsolidated Group

The unconsolidated mineral component is composed of clastic sediments that may or may not be stratified but whose particles are not cemented together. They are mainly of glacial or post glacial origin, but include poorly consolidated and weathered bedrock. Classes which are encountered in the oil sands area are described below.

Anthropogenic: Man-made or man-modified materials, including those associated with mineral exploitation and waste disposal.

Colluvial: Massive to moderately well-stratified, non-sorted to poorly sorted sediments with any range of particle sizes from clay to boulders and blocks that have been deposited at the base of slopes due to direct, gravity-induced movement.

Eolian: Sediments that have been transported and deposited by wind action and which generally consist of medium to fine sand and coarse silt particle sizes. They are generally well sorted and poorly compacted, may show internal cross bedding or ripple structures, or may be massive.

Fluvial, Glaciofluvial: Sediments mainly composed of sand and gravel which have been transported and deposited by streams and rivers and which are commonly moderately to well sorted and stratified.

Lacustrine, Glaciolacustrine: Materials that either have settled from suspension in bodies of standing fresh water or have accumulated at their margins through wave action. The sediments are generally stratified fine sand, silt, and clay deposited on lake beds, or moderately well-sorted and stratified sand and coarser materials that are beach and other nearshore sediments transported and deposited by wave action.

Morainal: Sediment that is generally well compacted, nonstratified, and heterogeneous in particle size composition, and which has been deposited directly from glacial ice without modification by any intermediate agent.

Undifferentiated: A layered sequence of more than three types of genetic material outcropping on a steep erosional escarpment.

Organic Group

The organic group consists of peat deposits containing at least 30% organic matter (17% organic carbon) and which may be as thin as 10 cm if they overlie bedrock but are otherwise greater than 40 cm and generally greater than 60 cm thick. Classes in the group are bog, fen, organic (undifferentiated), and swamp. Their characteristics are as follows.

Bog: Sphagnum or other moss and forest peat materials formed under an ombrotrophic environment due to the slightly elevated nature of the bog tending to be disassociated from nutrient-rich groundwater or surrounding mineral soils.

Near the surface it is usually undecomposed (fibric), yellowish to pale brown in colour, loose and spongy in consistency with entire Sphagnum plants being readily identified. At depth it becomes darker in colour, compacted, and somewhat layered. These materials are dysic or extremely acidic (pH <4.5), of low bulk density (<0.1 g/cm^3), and very high fibre content (>85% unrubbed and 50% rubbed). These materials are associated with slopes or depressions with a water table at or near the surface in the spring, and slightly below during the remainder of the year. Bogs are usually covered with Sphagnum although sedges may also grow on them. They may be treed or treeless, and they are frequently characterized by a layer of ericaceous shrubs.

Fen: Sedge peat materials derived primarily from sedges with inclusions of partially decayed stems of shrubs formed in an eutrophic environment due to the close association of the material with mineral-rich waters.

The peat is usually moderately well to well decomposed, dark brown in colour with fine- to medium-sized fibers but may be well decomposed, black with fine fibers, decomposition often becoming greater at lower depths. Fen materials are euic (pH >4.5) with the range of pH 5.5 to 7.5 being most common. They are relatively low in fiber (20 - 80% unrubbed and 2 - 25% rubbed) and are relatively dense (0.1 - 0.2 g/cm^3). These materials are associated with relatively open peatlands having mineral-rich water tables that persist seasonally at or very near the surface. They are covered with a dominant component of sedges, although grasses and reeds may be associated in local pools. Sphagnum is usually subordinate or absent, with the more exacting mosses being common. Often there is much low to medium height shrub cover and sometimes a sparse layer of trees.

Swamp: A peat covered or peat filled area with the water table at or above the peat surface. The dominant peat materials are shallow to deep mesic to humic forest and fen peat formed in a eutrophic environment resulting from strong water movement from the margins or other mineral sources.

Swamps are of minor occurrence in the map area and are not mapped as such. The organic, undifferentiated category is treated similarly, bogs and fens being the only peatlands mapped.

Consolidated Group

The consolidated group consists of tightly packed, indurated materials of bedrock origin. These include igneous, metamorphic, sedimentary, and consolidated volcanic rocks. The only class is bedrock, which is undifferentiated.

Ice Component

This is the fourth material type, but occurs in mountain icefields and related features and, therefore, is not applicable to the study area.

4.2.3.2 Material modifiers. Material modifiers are used to further qualify unconsolidated mineral and organic deposits. Particle size classes are used to qualify mineral materials. The classes sandy, loamy, and clayey are most common and are used as defined in the Appendix (Section 9.3). Terms such as gravelly, cobbly, and bouldery may be used occasionally.

Organic material modifiers are fiber classes, reflecting degree of decomposition of material. The classes fibric, mesic, and humic are as described for Of, Om, and Oh horizons, respectively, in Table 4. A fourth class, woody, refers to any organic material which contains more than 50% of woody fibers.

4.2.3.3 Surface expression. The surface expression of genetic materials is their form (assemblage of slopes) and pattern of forms. Form, as applied to unconsolidated deposits refers to the product of the initial mode of origin of the materials, and as applied to unconsolidated materials refers to the product of their modification by geological processes. Surface expression also describes the manner in which unconsolidated genetic materials relate to the underlying unit. The classes of surface expression occurring in the study area are included in the map unit description in the map legend and are indicated in individual delineations by a symbol. The following definitions are taken from the system as presented by the Canada Soil Survey Committee (1978). Some symbols have been changed to avoid duplication.

Apron (a): A relatively gentle slope at the foot of a steeper slope, and formed by materials from the upper, steeper slope.

Fan (f): A fan-shaped form similar to the segment of a cone and having a perceptible gradient from the apex to the toe.

Hummocky (h): A very complex sequence of slopes extending from somewhat rounded depressions or kettles of various sizes to irregular and conical knolls or knobs. Slopes are in the range of 6 to 70% (usually 9 to 30%).

Inclined (i): A sloping, unidirectional surface with a generally constant slope not marked by irregularities. Slopes are 2 to 70%.

Level (l): A flat or very gently sloping, unidirectional surface with a generally constant slope not broken by marked elevations and depressions. Slopes are generally less than 2%.

Rolling (m): A very regular sequence of moderate slopes extending from rounded, sometimes concave depressions to broad, rounded convexities producing a wavelike pattern of moderate relief. Slope length is often 1.6 km or greater and gradients are greater than 5%.

Ridged (r): A long, narrow elevation of the surface usually sharp crested with steep sides. The ridges may be parallel, subparallel, or intersecting.

Steep (s): Erosional slopes, greater than 70%, on both consolidated and unconsolidated materials.

Terraced (t): Scarp face and the horizontal or gently inclined surface (tread) above it.

Undulating (u): A very regular sequence of gentle slopes that extends from rounded, sometimes confined concavities to broad rounded convexities producing a wavelike pattern of low local relief. Slope length is generally less than 0.8 km and the dominant gradient of slopes is 2 to 5%.

Two classes, veneer and blanket, are used in map unit descriptions in the legend but are not used to describe individual delineations.

Blankets: A mantle of unconsolidated materials thick enough to mask minor irregularities in the underlying unit but still conforming to the general underlying topography.

Veneer: Unconsolidated materials too thin to mask the minor irregularities of the underlying unit surface.

Many glaciofluvial, glaciolacustrine, and organic deposits in the study area are blankets or veneers overlying morainal or other materials. Classes described above which also apply to organic soils are 'level' and 'inclined'; these correspond to the 'horizontal' and 'sloping' classes as defined for organic materials (Canada Soil Survey Committee 1978). Additional classes which apply only to organic soils are 'plateau' and 'ribbed'. The classes 'bowl', 'domed', and 'floating' occur in the study area, but only to a small extent, and are not used in map unit descriptions.

Bowl: A bog or fen occupying concave-shaped depressions.

Domed: A bog with an elevated, convex, central area much higher than the margin.

Floating: A level organic surface associated with a pond or lake and not anchored to the lake bottom.

Plateau (p): A bog with an elevated, flat, central area only slightly higher than the margin.

Ribbed (r): A pattern of parallel or reticulate low ridges associated with fens.

4.2.3.4 Slope. Slopes are classified into ten categories which make possible a quantification of the dominant but not necessarily most abundant slopes within a mapped unit of a local landform (Canada Soil Survey Committee 1978). Because of the reconnaissance level of this survey, all delineated areas were not examined and slopes could be estimated only by examination of airphotos. Only broad ranges of slopes could be estimated and map units are described in the legend in terms of these. Slope classes are not indicated within delineated areas. Soil profile descriptions include a slope class for each site. Definitions of slope classes in terms of percent and degrees, and common terminology for these, are presented in the Appendix (Section 9.3).

4.2.3.5 Modifying Processes. The landform classification system includes a Modifying Process category which refers to terms that describe geological processes that have modified or are currently modifying genetic materials and their surface expression. Modifiers were used in on-site descriptions and in some of the map unit descriptions in the report and map legend. Those recognized in the map area are defined below.

Cryoturbated: Surface modified by processes of frost action. It includes stirring, churning, and other disturbances of soil resulting from frost action. It involves frost heaving, differential and mass movements, and it produces patterned ground. Assumed process status is active. However, the few cryoturbated areas examined in the AOSERP study area had no evidence of current frost action and, therefore, are either inactive or possibly intermittent in status.

Deflated: Modified by sorting out, lifting, and removal of loose, dry, fine-grained particles by the turbulent, eddy action of the wind.

Eroded (Channelled): Surface crossed by series of abandoned channels. The term applies to fluvial plains, terraces, and fans. Assumed process status is inactive.

Failing: Modification of surfaces by the formation of tension fractures or by large consolidated or unconsolidated masses moving slowly downslope. Process status is only active.

Kettled: Deposit or feature modified by depressions left by melting ice blocks. Depressions can be formed by the melting blocks of ice buried in glaciofluvial, glaciolacustrine, or glacial till materials. Kettle depressions usually have steep sides and are bound by an abrupt convex break of slope. They occur in a variety of shapes and sizes from round basins to branching valleys. Assumed process status is inactive.

Karst Modified: Modification of carbonate and other rocks by processes of solution, and of overlying unconsolidated materials by collapse resulting from that solution. Assumed process status is active.

Gullied: The modification of surfaces by fluvial erosion, resulting in development of parallel and sub-parallel, steep-sided and narrow ravines in both consolidated and unconsolidated materials.

4.2.3.6 Qualifying descriptors. Descriptors are used to qualify either the genetic materials or the modifying process terms. They supply additional information about the mode of formation, depositional environment, and the status of processes.

Glacial

This is used to qualify nonglacial genetic material or process modifiers where there is direct evidence that glacier ice exerted a strong but secondary or indirect control upon the mode of origin of the materials or mode of operation of the processes. In the list of classes of unconsolidated genetic materials, glaciofluvial and glaciolacustrine are used for materials that have been deposited in front of or in contact with glacier ice. In the study area, glaciofluvial deposits have been differentiated further into types such as outwash plains, ice-contact deposits, and meltwater channel deposits.

Active

This term is used to indicate a contemporary recurrent modifying process or process forming a genetic material.

Inactive

This term is used to indicate that a modifying process is not recurrent and that processes of formation of genetic materials have ceased.

Of the unconsolidated mineral material classes, 'anthropogenic' and 'colluvial' are considered to be active while the others are inactive. The assumed status of modifying processes is indicated in the description in Section 4.2.3.5. Exceptions to those do occur, an example being eolian activity, which, while having an assumed inactive process status, is active in the dune fields in the northern part of the study area.

4.2.4 Vegetation Classification System

During field mapping, notes on predominant and common plant species at soil inspection and sample sites were noted along with soils information. An attempt was made to classify the vegetation at first according to Stringer's (1976) vegetation types, and then according to the scheme of Thompson et al. (1978). In the soil group descriptions (Section 6), and the site descriptions (Appendix, Section 9.4), the terminology and symbols of Thompson et al. (1978) are used. The vegetation community types identified in the study area are described in Table 5. Some confusion may arise in use of the terms 'bog' and 'fen' in relation to vegetation type and to landform type. In this report, 'bog' and 'fen' are used mainly in their geomorphic sense. Plant community types which may be particularly confusing are 'black spruce forest' and 'semi-open black spruce bog'. These have been altered in this report to 'black spruce forest' and 'semi-open black spruce forest'.

It was indicated in Section 3.4 that soil and vegetation types vary with topographic position, mainly due to the influence of topography on drainage. The influence of drainage on community type is well recognized. The types of forest ecosystems occurring on different soil types and drainage classes have been documented for the mixedwood forest section of Saskatchewan by Kabzems et al. (1976). An attempt was made to relate soil types, drainage, and vegetation in the AOSERP study area as shown in Table 6. Probable vegetation community types that may be found on both dominant and

Table 5. Classification of vegetation in the AOSERP study area.

CLASS	SYMBOL	TYPE	COMPONENTS	SITUATION	DESCRIPTION
BOTTOMLAND AND RIPARIAN COMMUNITIES	1a	Bottomland and Riparian forest	balsam poplar aspen poplar white spruce willow	Found in floodplains and sideslopes along drainage courses, bordering lakes, ponds	Trees generally tall, white spruce in pure or mixed stands with subordinate species aspen and paper birch. Shrub layer of willow and alder often present, visible at the periphery of the stand.
	1b	Deciduous Shrub	willow alder, dwarf birch, immature aspen, immature paper birch	bordering rivers, ponds, lakes, occupying river sandbars, on and along drainage courses	Varies from patches too small to map along stream channels, to extensive willow and alder stands in association with fens. Height up to 6 m.
UPLAND COMMUNITIES	2	Undiffer-entiated	deciduous shrub on burned sites, shrub conifers, aspen poplar, willow, alder, balsam poplar balsam fir	moderately to well-drained, level or sloping upland sites	Upland communities of mixed species composition within which individual sites are too small to be resolved on a photograph.
	2a	White Spruce-Aspen Forest	white spruce aspen poplar jack pine balsam poplar balsam fir	moderately to well-drained	Upland forest, subdivided into three forest types dependent upon percentage composition of deciduous and coniferous species: aspen forest with less than 20% coniferous vegetation, mixed forest with 20% - 80% coniferous trees, and a coniferous forest with less than 20% deciduous trees.
	2aA	Aspen Forest	aspen poplar paper birch balsam poplar	most extensive on well- to moderately drained upland sites, but can be found in all but the wettest areas	Generally extensive stands of aspen poplar 30 m in height. Often forming a very dense canopy.
	2aM	Mixed Forest	white spruce aspen jack pine	moderately to well-drained upland sites	Extensive stands of mixed upland forest, having significant amounts of deciduous and coniferous vegetation, generally 20-30 m in height.

continued...

[a] Adapted from original table in Thompson (1979).

Table 5. Continued.

CLASS	SYMBOL	TYPE	COMPONENTS	SITUATION	DESCRIPTION
	2aC	Coniferous Forest	white spruce jack pine balsam fir	poorly to well drained upland sites	Stands of coniferous vegetation generally dominated by white spruce. Height of white spruce occasionally in excess of 35 m.
	2b	Mixed Coniferous	black spruce jack pine white spruce	poorly to moderately drained level or sloping upland sites, with inclusions of bog or covered by a thin discontinuous veneer of peat	Relatively tall, very dense, coniferous stands (over 6m), of fire origin, mostly pure black spruce with possible mixture of jack pine and white spruce, depending on site.
	2c	Jack Pine	jack pine black spruce	well drained sites including eolian deposits	Pure stands of jack pine, up to 15 m in height, on dry sandy sites, sometimes mixed with aspen or integrating with black spruce where sandy sites and poorly drained upland sites are mixed. Stand density may vary from very open to very dense.
	2d	Upland Open	grasses, forbs, shrubs	grassy open areas in White Spruce-Aspen Forest	Open area in upland white spruce-aspen communities, generally in pure aspen stands.
WETLAND COMMUNITIES	3	Undifferentiated (usually complex)			This community used where a variety of wetland forms exist that cannot be differentiated between bogs and fens or that are too small to type individually. Sometimes it is complexed with an upland type.
	3a	Fen Communities	sedges, rushes, semi-aquatic forbs and mosses, swamp birch, dwarf willow, alder	poorly drained, generally level to very gently sloped upland sites that are part of a slow moving drainage system; draws and low gradient streams and depressions	Very wet sites, composed mainly of sedges with a continuous or intermittent low shrub layer, consisting principally of swamp birch. Sometimes larger shrub species such as willow and alder are present.
	3aT	Fen community with ridges	same as 3a, with tamarack	poorly drained	Very wet fen sites with ridges of tamarack running perpendicular to direction of water flow.

continued...

Table 5. Concluded.

CLASS	SYMBOL	TYPE	COMPONENTS	SITUATION	DESCRIPTION
	3b	Black spruce Bog Forest	black spruce Labrador tea sphagnum mosses	poorly drained, generally level to gently sloped upland sites; wet depressions within well drained sites	Pure stands of even aged black spruce, generally low in height (up to 10 m). Crown cover is dense. Generally in association with organic soils covered with *Sphagnum* spp., *Ledum groenlandicum* and sometimes *Cladina* spp.
	3c	Semi-Open Black Spruce Bog	black spruce sphagnum mosses tamarack low shrubs sedges, rushes	poorly drained, generally level to gently sloped upland sites; wet depressions within well drained sites	Similar to 3b but stands are more open and tamarack is present. Often a heavy shrub layer of Labrador tea, bog laurel, willow, and swamp birch.
	3d	Lightly Forested Tamarack and Open Muskeg	sphagnum mosses wetland grasses sedges, willow, swamp birch tamarack, black spruce	poorly drained, generally level to gently sloped upland sites; wet depressions within well drained sites	Extensive bog areas as defined by Zoltai et al. (1977) with scattered tamarack and black spruce stands of low density.
BURN	4	Burn	dead vegetation	may occur anywhere	Recent burns up to several years old.
NON VEGETATED	5		occasional low herbs & grasses	recent slides, slumps	No vegetation or possibly very sparse vegetation.
AQUATIC VEGETATION	Q			lakes, ponds	

Table 6. Soil-drainage-vegetation relationships in the AOSERP study area.

Soil	Eluviated Dystric Brunisol/Eluviated Eutric Brunisol	Orthic Gray Luvisol	Cumulic Regosol Orthic Regosol	Gleyed[b] Subgroups	Peaty Gleysols	Terric Mesisol Terric Fibrisol	Typic Mesisol Typic Fibrisol Fibric Mesisol
Drainage / Land System	Very Rapid and Rapid	Well to Moderately Well	Moderately Well to Imperfect	Imperfect	Poor	Poor to Very Poor	Very Poor
Heart	2c[a]			1b 2b	3b		
Mildred	2c[a] 2aM 2aA			1b 2b	3b		
Firebag	2c[a] 2aM 2aA			1b 2b	3b		
Kearl	2c[a] 2aM 2aA			1b 2b	3b		
Ruth Lake	2c[a] 2aM 2aA	2aM[a] 2aA[a]		1b 2b	3b		
Kinosis		2aM[a] 2c 2aA		1b 2b	3b		
Surmont		2aM[a] 2b		1b 2b	3b		
Horse River		2aM[a] 2aA		1b 2b	3b		
Legend		2c[a] 2b 2aM[a]		1b 2b	3b		
Livock		2aM[a] 2aC		1b 2b	3b		
Dover		2cA[a] 2aM[a]		1a 1b	1b 3b		
Buckton		2cA 2aM	2aC[a] 2aM[a]	1b 2b	1b 3b		
Namur			2aC[a] 2aM	1b 2b	1b 3b		
McMurray			2aC[a] 1a 2aM	1a[a] 1b[a]	1b 3b		
Mamawi					1b		
Bitumount	2c 2aM			1b 2b	1b[a] 3b[a]		
Steepbank		2aM		1b 2b	1b[a] 3b[a]		
Algar		2aM		1a 1b	1b[a] 3b		
Kenzie						3b[a] 3c	3b 3d 3c
Eaglesham						3b 3c	3a[a] 3d

[a] dominant or one of dominant vegetation communities in ecosystem; see Table 5 for explanation of symbols.

[b] Gleyed subgroups of Brunisols, Luvisols, and Regosols.

significant soil types, and corresponding drainage classes within a soil group are indicated in the table. Evidence for these relationships consists of observations made at inspection sites in the field. No systematic study of this aspect of ecological characteristics of the study area was made. Thus, the tabulation of relationships is to be regarded as an approximation and in no way complete.

4.3 MAPPING PROCEDURE

Prior to examination of soils in the field, airphoto interpretation was carried out to delineate areas considered to have similar soils and to select sites for examination and sampling. Panchromatic black and white aerial photographs taken in 1974 at a scale of 1:50 000 were obtain from the National Air Photo Library in Ottawa. These photos were available for all of the study area to Township 100. North of Township 100, coverage was by 1:60 000 false colour infrared photos taken in 1977

With the aid of a stereoscope, delineations of different segments of the land surface were made directly on aerial photographs according to differences in vegetation and landform patterns. Available soil survey and surficial geology maps were then examined to aid prediction of parent materials and soil type in each delineated area. Possible sites were selected along seismic cutlines, the locations depending upon their suitability as helicopter landing sites.

Field work was carried out during the summers of 1976 to 1978. Only the highway and a few passable roads were traversed by land vehicle; most of the study area required survey by helicopter. Field inspection consisted of examining soils in pits at a single site or at a few sites along a transect. Site features such as slope, aspect, stoniness, and erosion were noted. The soil features recorded included sequence of horizons, colour, structure, thickness, roots, texture, drainage, and others. Species or groups of vegetation at a site were listed and the abundance or cover of both canopy and substrata components were visually estimated.

Preliminary soil maps were made by transferring information from aerial photographs to 1:50 000 National Topographic Series base maps, or, if these were not available, to Alberta Energy and Natural Resources forest cover base maps. These were then modified and reduced to produce the accompanying soils maps at a scale of 1:126 720(1 cm = 1.27 km; 1 in = 2 mi). All descriptive and laboratory data from sample sites are presented in Volume II of this report (Appendix, Section 9.4).

4.4 INSPECTION DENSITY AND RELIABILITY

The AOSERP study area was originally subdivided into high, medium, and low priority areas. The high priority area consisted of Township 88 to 100 and Ranges 6 to 12 inclusive as well as a strip along the Athabasca River to the Athabasca Delta. As well as being the first area mapped, this area was also field checked with a relatively higher inspection density than the rest of the area. The survey in this area corresponded to survey intensity level 4 in which nearly all traverses were by surface vehicle or helicopter, almost all boundaries were inferred, and most delineations were checked. The remainder of the study area was surveyed at intensity level 5 in which all traverses were by helicopter, all boundaries were inferred, and most delineations were checked (Expert Committee on Soil Survey 1979).

The rate of progress of field mapping using a helicopter for access was about fifteen site inspections through five or six townships per day. An average of about four sites per township or about one out of every 3.5 delineations was inspected. The average size delineation for the whole area is approximately 640 ha. Thus, there was an average of one inspection per 2000 to 2500 ha. As noted above, however, the inspection density was relatively higher in the high priority area. Figure 5 shows inspection sites which included all those examined and sampled on

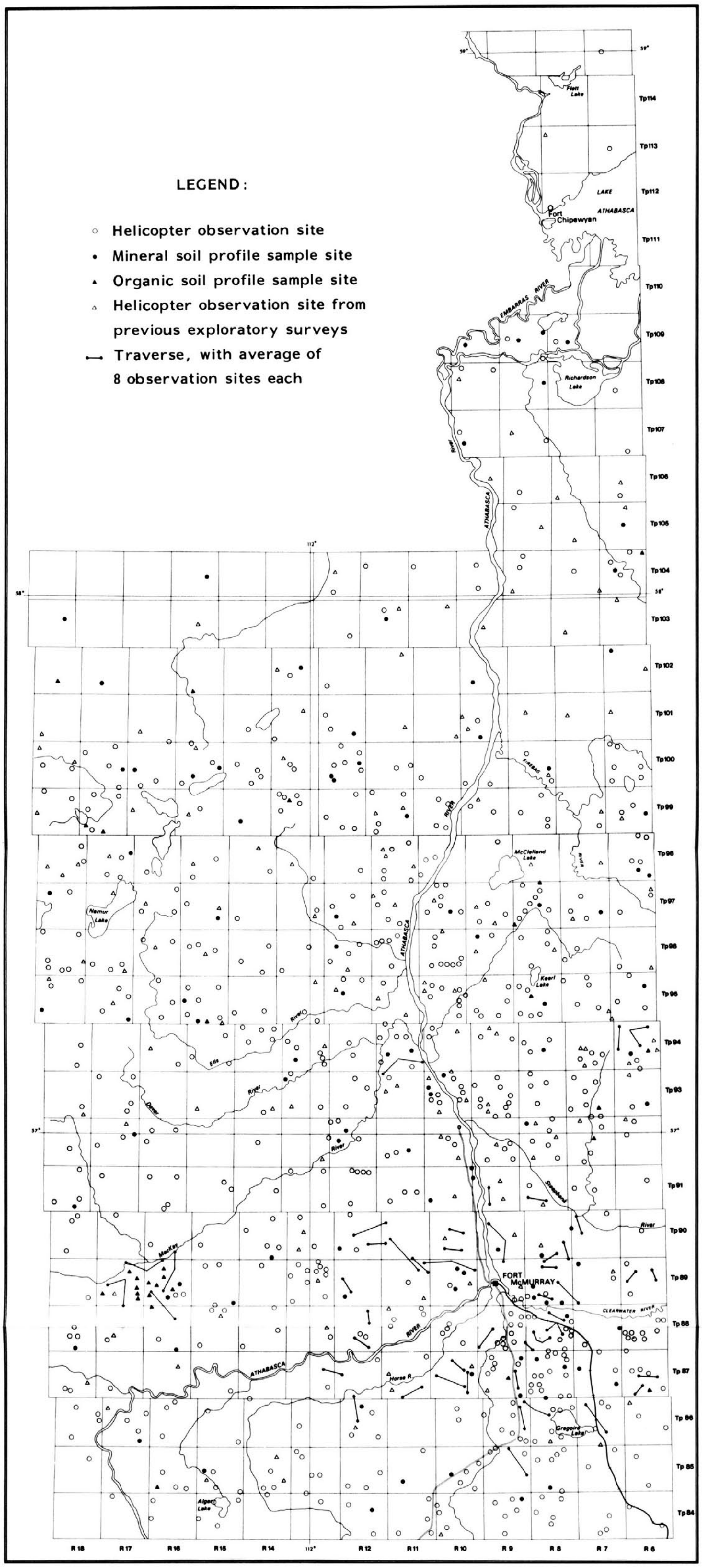


Figure 5. Soil observation sites, sampling sites, and traverses in the AOSERP study area (Scale 1:1,000,000).

traverses by foot, land vehicle, or helicopter; sites examined in previous surveys were also considered.

The figures above indicate the reliability of the soils maps. It is suggested that there should be one inspection per average size unit for a reliable soils map (Expert Committee on Soil Survey 1979). In this survey, most of the delineations of average or larger than average size were checked while most of the small ones were not inspected. The reliability of airphoto interpretation varies. Features such as organic and eolian soils and landforms can be quite accurately interpreted. However, extensive areas with young vegetation due to recent forest fires are difficult to interpret and such areas may be less accurately mapped. The areas which were most difficult to interpret were the glaciolacustrine plains on both sides of the Athabasca River both north and south of Fort McMurray. This area, however, had a relatively higher inspection density as well.

Level 4 and 5 soil surveys are reconnaissance level surveys conducted for the purpose of broad regional planning. The soil maps resulting from these surveys show certain ranges of soils and soil properties whose accuracy or reliability varies from one part of the map to another as shown above for the AOSERP study area. It is not the purpose of these maps to provide soils information for specific areas; site inspections or detailed soil surveys must be made to determine soil qualities at a particular location or in specific areas of interest.

4.5 MAPPING CONVENTIONS

In this section, an attempt is made to explain the presentation of information on the soils maps. Categories and terms employed in the descriptions of ecological units and soils in the text (Sections 5 and 6) and in the legend accompanying the soil maps are described below. Terminology not explained in this section is defined in the Appendix (Section 9.3).

Soil Group: A soil group is a group of closely related soils developed on similar parent materials under somewhat similar climatic conditions. This definition is adapted from Twardy and Corns (1980) as applied to the soil survey of the Wapiti area, Alberta. The soil group is strictly a mapping convenience used to bring together various collections of soils. Soil groups are named after the predominant soil in that group, the names being taken from geographic features in the study area. The names Heart, Kenzie, and Eaglesham were taken from previous soil survey projects. Names are changed at the soil order level of taxonomy, even if soils are developed on the same kinds of parent materials. For example, Algar consists predominantly of Gleysolic, Joslyn of Solonetzic, and Dover of Luvisolic soils, but all are developed on glaciolacustrine clays. A soil group will contain several soils, but the full range may not occur everywhere in the landscape. The soil groups are, therefore, subdivided into soil units which are found in predictable geographic association, but which have differing profile morphologies and drainage regimes.

Soil Unit: Soil units are areal subdivisions of soil groups such that within a given soil unit the component types are found in specified proportions. The symbols on the map representing these units identify both the group and the proportions of the soils within the unit, and also indicate the relative landscape and consequent drainage conditions (Twardy and Corns 1980). Because of the low intensity level of this survey, only one, two, or three soil units within a soil group were recognized. At more detailed levels of survey, more soil units would likely be identified.

Dominant Soils, Significant Soils, and Inclusions: These terms refer to the relative proportion of various soils as they are found in a natural soil unit. Within a soil unit, dominant soils occupy over 40% of the area, significant soils occupy 15 to 40% of the area, and inclusions occupy less than 15%. In most cases in the legend, only one soil is indicated as dominant, while two or three soils are commonly indicated as significant or as inclusions. Where two or more soils are listed as dominant or significant, it means that these soils together make up over 40% or 15 to 40% of the soil unit. This is a general guide only. There are exceptions to these which are indicated in the descriptions of soil units in the report but are not indicated in the legend.

Ecosystems and Soil Combinations: An ecosystem is an area of land throughout which there is a recurring pattern of landforms, soils, and vegetation. A delineation on a soils map can be regarded as an ecosystem with a recurring pattern of soils and landforms indicated by the symbols within that delineation. Vegetation type is not indicated but can be determined by use of AOSERP vegetation maps. In soil descriptions presented in Section 6, however, a subsection broadly describing soils, landforms, as well as characteristic vegetation is provided. The ecosystems may be simple, having basically one landform and soil group. In most parts of the AOSERP study area different soil groups were too intimately mixed to be shown separately on the map. Mixtures of groups of mineral soils with organic soil groups are particularly common. This resulted in the combination of soils from different soil groups within one delineated area on the map. Such combinations are shown with the first soil unit being predominant (occupying greater than 50% of an area) and the second unit being subdominant (occupying less than 50% of an area). For example, the symbol ALG1-KNZ2-u denotes an area of predominantly Algar soils, a peaty Gleysol, with a significant component of Kenzie soil, a Terric Mesisol on undulating topography. Combinations of three soil units are rare and occur only where it was necessary to show the presence of minor inclusions of bedrock, designated by the symbol 'R'.

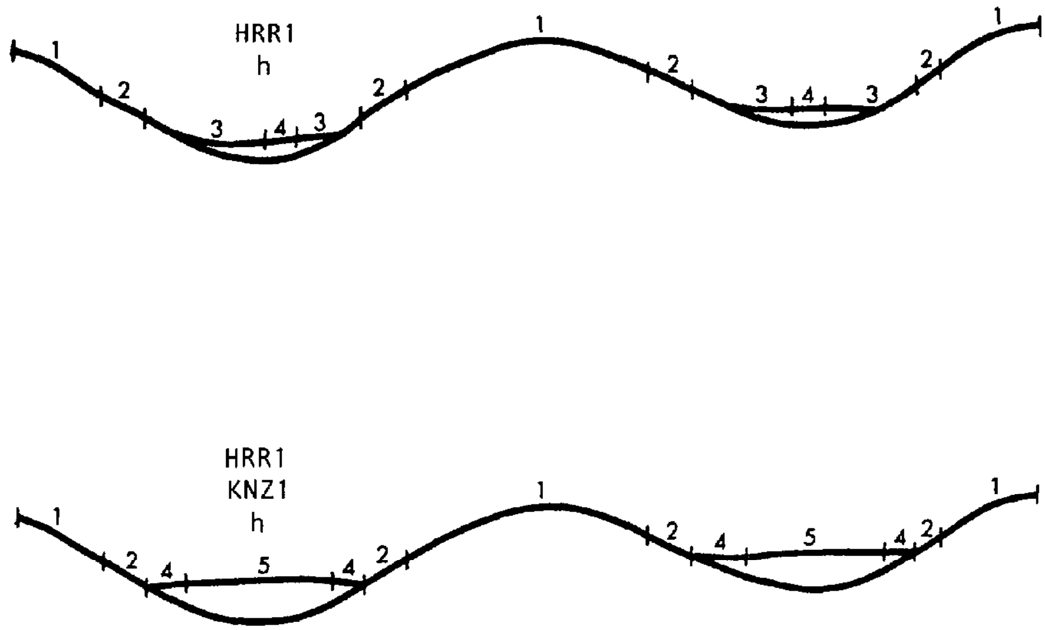
A problem arises in determining the composition of combinations in which component map units are already a complex of soil types. As previously stated, the most common soil combinations are those of mineral and organic soil groups. An example of interpreting soil combinations and comparison with a single soil unit is shown in Figure 6. The HRR1 (Horse River) unit is composed dominantly of well drained Orthic Gray Luvisols with a significant proportion of Gleyed Gray Luvisols and peaty Gleysols, and with minor inclusions of Organic soils. If poorly drained depressions are occupied predominantly by Organic soils, as in HRR1-KNZ1, the proportion of Gleyed Gray Luvisols and peaty Gleysols in the landscape becomes relatively small (commonly less than 20%). The KNZ1 (Kenzie) soil unit is defined as being composed mainly of Fibric Mesisols with significant proportions of other Organic subgroups. All of these subgroups might not be represented in any one area. Thus, KNZ1 in soil combinations should be interpreted as consisting mainly of Fibric Mesisols with a few similar associated subgroups possibly occurring as well. This way of interpreting mineral and Organic soil combinations is applicable to most of the soil units mapped, and these same factors apply in combinations in which Organic soils predominate (e.g., KNZ1-HRR1).

Soils Map Symbols: Each delineation on the soils map is identified by a collection of symbols which are always arranged as shown below.

$$\frac{\text{Soil Group} \qquad \text{Soil Unit}}{\text{Landform Surface Expression}}$$

For example, the soil map symbol $\frac{\text{MIL1}}{\text{u}}$ denotes an area characterized by the Mildred soil group which is composed of dominantly Eluviated Dystric Brunisols with a significant component of Eluviated Eutric Brunisols and inclusions of peaty Gleysols (Soil Unit 1). The topography in this particular example is undulating.

In a soil combination, the subdominant soil group and unit is shown directly below the dominant soil group and unit. The landform surface expression may be a single symbol or a



Symbol	Land Type	Soils	Vegetation
1	Mid slope, upper slope, and crest; very gentle to moderate slopes	Orthic Gray Luvisol; well drained	Upland white spruce-aspen forest
2	Lower and toe slopes	Gleyed Gray Luvisol; imperfectly drained	Mixed coniferous, and bottomland and riparian deciduous forest and shrub
3	Toe slopes and depressions	Peaty Gleysols; poorly drained	Black spruce forest and mixed coniferous forest
4	Depressions	Peaty Gleysols and Terric Mesisols	Black spruce forest
5	Depressions	Fibric Mesisol, Mesic Fibrisol, Typic Fibrisol; very poorly drained	Black spruce forest and semi-open black spruce-tamarack forest

Figure 6. Diagrammatic cross-section of a landscape comparing a mineral soil unit such as HRR1 (Horse River) and a combined mineral-organic soil unit such as HRR1 - KNZ1 (Horse River - Kenzie).

combination of two or three symbols. The symbols are arranged in decreasing order of dominance within a delineation. In soil combinations, the dominant surface expression is not necessarily related to the dominant soil; the surface expression refers to an area as a whole and its component parts cannot always be related to the component soil unit. Both single and combined soil units can have either single or complex landform surface expressions. A key to the landform surface expression symbols is provided on the soils maps.

Land Units: This is a general expression referring to either a physiographic area or ecological unit delineated on the map. Thick lines are used on the map to separate different ecodistricts. From the land unit legend, the physiographic sections and ecoregions within which ecodistricts occur can be determined.

5. DESCRIPTION OF ECOLOGICAL UNITS

5.1 ECOREGIONS

The AOSERP study area was subdivided into ecoregions and ecodistricts on the basis of recently published reports and maps and on information gathered during this inventory project. As discussed in Section 4.1.1, an ecoregion is an area of land characterized by a distinctive regional climate as expressed by vegetation. Boundaries on land regions cannot be identified on climatic data alone because data collecting stations are too sparse and the time period over which data has been collected is insufficient in many areas. Therefore, vegetation is used to indicate climatic conditions because it reflects climate and can be observed more easily. Differences in the composition and function of an ecological unit can be traced to differences in drainage, aspect, slope, and soil texture as well as climate. These factors can be controlled, and climate can be assessed by comparing sites which are equivalent and recurrent with respect to edaphic and landform characteristics. Two recent reports describe the ecoregions of Alberta. Strong and Leggat (1981) analyzed the vegetation that occurred on medium-textured substrates which were moderately well drained to establish the 'modal condition' of an ecoregion. The Alberta Ecoregions Working Group (1980) considered 'reference sites' with well-drained, medium-textured soils and without strong slopes. Once boundaries were established, climatic data from stations within ecoregions were used to characterize the ecoregions and differentiate them from others.

Land regions were described as being equivalent to the forest regions of Rowe (1972) in the 1978 interim report for this project (Turchenek and Lindsay 1978). Similarly, land subregions were seen as being equivalent to Rowe's forest sections. Similarities in these do exist, but the more recent descriptions of ecoregions, or land regions, were adopted in this report.

5.1.1 Boreal Mixedwood Ecoregion

The AOSERP study area lies mainly in the Boreal Mixedwood Ecoregion (Alberta Ecoregions Working Group 1980; Strong and Leggat 1980). Characteristic climatic features of this ecoregion are presented in Table 7.

In the study area, the Boreal Mixedwood Ecoregion includes all but the Birch Mountains and the area north of Lake Athabasca. It consists predominantly of undulating plains with some upland areas, the highest being the Stony Mountain Upland. Elevations range from about 225 m in the Athabasca Delta Plain to 750 m in the Stony Mountain Upland. Surficial materials are predominantly loamy morainal and clayey glaciolacustrine deposits in the western and southeastern parts of the study area. About 50% of these materials are overlain by organic deposits. Sandy glaciofluvial and eolian deposits are dominant in the northeastern part of the area. Loamy fluvial deposits occur in the large Athabasca Delta area.

Gray Luvisolic soils supporting aspen-white spruce mixedwood forests are characteristic of this ecoregion. The Northern Boreal (or Boreal Northlands) ecoregion differs by having a greater abundance of white spruce.

The climate of the Boreal Mixedwood Ecoregion is classified as cold, humid to subhumid with marked continentality in all months. The mean annual precipitation is 440 mm with the study area ranging from about 370 mm at Fort Chipewyan and Embarras to 628 mm at Stony Mountain. Precipitation at Fort McMurray, at 435 mm, is near the mean for the ecoregion (Longley and Janz 1978). About 300 mm, or about 70% of the total precipitation, occurs during the May - September period. Moisture deficit is approximately 75 mm. The winters are dry with a long period of snow cover.

The mean annual temperature in the Boreal Mixedwood ecoregion is 0.5°C, the May - September mean is 12.0°C. These means correspond with data for Fort McMurray. The mean annual

Table 7. Characteristics of ecoregions in the AOSERP study area.[a]

	Boreal Mixedwood Ecoregion	Northern Boreal Ecoregion
Modal Vegetation	Aspen	Aspen-White Spruce
Modal Soil	Gray Luvisol	Gray Luvisol
Dominant Climatic Regime	Boreal	Boreal-Arctic
Mean May to September		
Temperature (°C)	12.0	11.0
Precipitation (mm)	300	250
Precipitation, % of annual	72	55
Growing Degree Days above 5°C	1190	1050
Mean Freeze Free Period (days)	85	85
No. Days 0°C or less	20	25
Month of Maximum Precipitation	July	July
Mean Climatic Moisture Deficit	-190	
Mean December to February		
Temperature (°C)	-15.5	-24.0
No. Days with Chinooks	10	
No. Days with Continuous Snow Cover	150	185
Maximum Depth of Snow Cover (cm)	55	55
Mean October to April		
Precipitation (mm)	170	160
Mean Annual Temperature (°C)	0.5	-3.5
Mean Annual Precipitation (mm)	440	340

[a]Source: Strong and Leggat 1981.

temperature at Embarras, near the boundary with the Northern Boreal ecoregion, is -1.1°C. The frost free period ranges between about 50 to 90 days. The mean at Fort McMurray is 69 days, but periods as short as 8 days have been recorded. These and other climatic data for the area can be found in Longley and Janz (1978).

Characteristics of soil temperature classes typical of the AOSERP study area are presented in Table 8. The soil climate of the Boreal Mixedwood ecoregion is mainly Cryoboreal. Soil moisture regimes are variable, although much of the area is Humid (showing slight moisture deficit) with a large proportion of Aquic areas (saturated for moderately long periods). Large areas with predominantly poorly drained soils, such as the MacKay, Buckton, and Athabasca Delta Plains, are Aquic and Peraquic (saturated for very long periods). The sandy soils near Lake Athabasca have a Humid to Subhumid regime (showing slight to significant moisture deficit). Soils of the Athabasca Delta Plain are Aquic to Perhumid (having no significant water deficits).

The characteristic vegetation of the Boreal Mixedwood ecoregion is white spruce and aspen forest with lesser amounts of balsam poplar, paperbirch, and balsam fir. Jack pine forests occur on sandy soils while black spruce occurs in poorly drained areas. The vegetation is described in greater detail in the reports of Strong and Leggat (1981) and the Alberta Ecoregions Working Group (1980). The vegetation is described in terms of community types by Thompson et al. (1978) and elsewhere in this report. The above reports also discuss fauna typical of this ecoregion.

Strong and Leggat (1981) have subdivided the Boreal Mixedwood ecoregion into subregions based primarily on summer precipitation. The Moist Mixedwood subregion has a summer precipitation range of 300 to 380 mm with a mean of 320 mm. The modal ecosystem of this region is characterized by aspen and balsam poplar vegetation and by moderately well-drained Gray Luvisols. Most of the study area lies within this ecoregion.

Table 8. Characteristics of soil temperature classes.[a]

Characteristics	Subarctic (very cold)	Cryoboreal (cold to moderately cold)
Mean annual soil temperature[b]	-7 to <2°C	2 to <8°C
Mean summer soil temperature	5 to <8°C	8 to <15°C
Growing season ($\geq$ 5°C)	< 120	120-220 days
Growing season degree-days ($\geq$ 5°C)[c]	< 555	555 to <1250
Thermal period ($\geq$ 15°C)	none	No significant days
Thermal period degree-days ($\geq$ 15°C)[d]	none	<33

[a]Source: Clayton et al. 1977.

[b]Measured at 50 cm depth.

[c]Excess of daily mean temperature above 5°C accumulated through the growing season.

[d]Excess of daily mean temperature above 15°C accumulated through the growing season.

The Wet Mixedwood Subregion has summer precipitation between 380 and 440 mm. Its modal ecosystem consists of aspen-balsam poplar- white spruce vegetation and moderately well-drained Gray Luvisols. In the study area, the Cheecham Hills Escarpment and the House Plain are ecodistricts which lie within this ecoregion.

The Dry Mixedwood Subregion has mean summer precipitation in the 200 to 300 mm range. Aspen and well- to moderately well-drained Gray Luvisols comprise the modal ecosystem of this subregion. In the study area, jack pine on rapidly to well-drained Eutric (and Dystric) Brunisols occurs extensively. The Muskeg River, Embarras, Buckton, and Athabasca Delta plains, and the Fort Hills Upland, are ecodistricts in the study area which lie within the Dry Mixedwood Subregion.

5.1.2 Northern Boreal Ecoregion

The Northern Boreal Ecoregion extends across northern Alberta, borders the Boreal Mixedwood ecoregion on the south, and includes outliers of relatively high elevation. Within the study area, the Birch Mountains and the area north of Lake Athabasca occur in this ecoregion. In the report of Strong and Leggat (1981), this ecoregion is referred to as the Boreal Northlands ecoregion; Zoltai (1979) has referred to it as the High Boreal ecoregion.

The elevation of the Flett Lake Plain, north of Lake Athabasca, is between 200 and 300 m. The elevation of the Birch Mountain plateau is between 750 and 825 m. The Birch Mountains Escarpment lies between 350 and 750 m elevation. Relief is generally low with some hills reaching up to about 50 m. The surficial materials are loamy and clayey morainal deposits in the Birch Mountains. In some areas, these are shallow overlying shales and shaly basal till. On the Flett Lake Plain, Precambrian rock outcrops predominate, but glaciofluvial sand plains are fairly extensive as well. Large areas of organic deposits with permafrost characterize the Birch Mountains Uplands, but organic soils are of limited extent in the Flett Lake Plain.

Climatic conditions for the Northern Boreal ecoregion are presented in Table 6. The climate is cold, humid to subhumid, and is dominated by continental air masses throughout the year. It is drier and colder than the Boreal Mixedwood climate. The mean annual temperature is -3.5°C (-2.9°C at Fort Chipewyan) and the mean annual precipitation is 340 mm (331 mm at Fort Chipewyan). The mean May to September precipitation ranges from about 200 m on the Flett Lake Plain to 300 mm in the Birch Mountains. Mean maximum and minimum temperatures are colder at Fort Chipewyan than in the Birch Mountains throughout the year except for higher minima in some summer months. Data from the Birch Mountains lookout tower, however, show that maxima are cooler and minima are warmer than at Fort McMurray throughout the year. In other words, the temperature range is greater in Fort McMurray than in the Birch Mountains. The data indicate that although the Fort Chipewyan area has a climate typical of that described for the Northern Boreal ecoregion, the mean annual temperature in the Birch Mountains is probably only marginally lower than that of the Boreal Mixedwood ecoregion as typified by the Fort McMurray climate. However, other factors such as deeper snow cover and longer winters (Longley and Janz 1978; Strong and Leggat 1980) may contribute to the Northern Boreal type of climate in this area.

The characteristic vegetation in the Northern Boreal ecoregion is mixed aspen-white spruce forest. This is similar to the Boreal Mixedwood ecoregion except that white spruce is a more common dominant (Strong and Leggat 1980; Alberta Ecoregions Working Group 1980). Although this is the vegetation typical for the ecoregion in general, aspen-white spruce communities were found to be uncommon in the Birch Mountains and the Flett Lake Plain. Mixed coniferous stands of black spruce-pine mixtures were most commonly found on the well- to moderately well-drained sites. Almost everywhere, these stands are young, reflecting a recent and complex fire history. It is possible that the pines in this area are jack pine-lodgepole pine hybrids (Van Waas 1974). On the Organic and Cryosolic soils, black spruce stands are generally sparse and often less than 2 m in height. Again, this probably results from a complex fire history. The extensive occurrence of Cryoslic soils and stunted black spruce stands, plus the presence of species such as *Ledum decumbens* suggest similarities to the Boreal Subarctic ecoregion. On the Flett Lake Plain, jack pine occurs on rapidly drained and nutritionally poor Brunisols developed on glaciofluvial sands.

5.2 ECODISTRICTS

Ecodistricts are defined as areas of land characterized by a distinctive pattern of relief, geology, geomorphology, and associated regional vegetation. An ecodistrict was considered in this project to be approximately equivalent to a physiographic district as presented in the physiographic map of Alberta (Pettapiece 1981; in prep.) and as discussed in Section 2.5. Where major differences occur in surficial deposits and in extent of peatlands, further subdivisions were made. The ecoregions and ecodistricts which occur in the AOSERP study area are shown on a separate map which accompanies this report. The legend of this map also indicates the physiographic section within which each ecodistrict lies.

5.2.1 Ecodistricts of the Boreal Mixedwood Ecoregion

5.2.1.1 Garson Plain. This ecodistrict is an undulating to hummocky plain in which surficial material is predominantly glacial till of the Kinosis and Gipsy types (Bayrock and Reimchen 1974). Large areas also consist of shallow, sandy to loamy glaciolacustrine deposits overlying the till. Both ground moraine and hummocky moraine of low to moderate relief occur. The elevation range is about 450 to 500 m. Sandstone, siltstones, and shales of the

Grand Rapids Formation underlie the glacial materials at considerable depth, although outcrops occur in the relatively deep valleys of the Clearwater and Christina rivers. Soils of well-drained sites are predominantly Luvisolic. White spruce-aspen forest community types constitute the predominant upland vegetation while various types of wetland communities occupy the low-lying sites with Organic soils. Organic soils occur over 40 to 60% of the area.

5.2.1.2 Hangingstone Plain. This ecodistrict is a level to undulating glaciolacustrine plain with shallow to deep clayey deposits. The elevation range is about 300 to 450 m. Bedrock of the Grand Rapids and Clearwater formations occur below 20 to 40 m of stratified sands, silts, and clays as indicated by groundwater observation wells south of Fort McMurray (Hackbarth 1978). Organic deposits cover about 50 to 70% of the area, but these are mainly shallow. Luvisols and peaty Gleysols are the predominant mineral soils. Small amounts of Solonetzic soils occur in some areas. White spruce-aspen forest community types are most common on upland sites. Organic soils are mainly thin and support black spruce forest with small amounts of other wetland communities.

5.2.1.3 Brule Plain. The Brule Plain consists of undulating sandy eolian deposits with about 60 to 80% organic cover. The sands possibly originated as deltaic deposits in the glacial lake which formed the Hangingstone and Dover plains. Relief is generally low with only a few sand dunes of up to 20 m height having been formed. Undulating veneers and blankets and U-shaped dunes are the dominant landforms. Bedrock materials of the Grand Rapids Formation underlie the area and are exposed in the Athabasca River channel. The elevation range is about 300 to 500 m. Mineral soils are predominantly Brunisols which support jack pine communities. Various wetland vegetation communities occur with fen types being somewhat more common than in most other ecodistricts.

5.2.1.4 McMurray Lowland. The valleys of the Clearwater and Athabasca rivers are considered as a distinct ecodistrict due to the nature of the surficial materials and the physiographic setting. The deep valleys and presence of the rivers may also have various microclimatic influences. The total area represented by these valleys is also significant. The Clearwater River and the Athabasca River north of Fort McMurray occupy wide U-shaped preglacial valleys. West of Fort McMurray, the Athabasca River is incised about 50 m below the surface of the surrounding plains. The bottom deposits of the U-shaped valleys are loamy fluvial (alluvial) deposits which overlie shales and argillaceous limestones of the Clearwater Formation. Colluvial materials of glacial and bedrock origin mantle the steep valley sides in which shales and tar sands of the McMurray and Clearwater formations may also be exposed. West and south of Fort McMurray, the river valley has very little fluvial sediments, the terrain consisting of steep, rough broken slopes and the river itself. Elevations at the valley bottom range from about 200 m near Fort MacKay to over 400 m at the south end of the study area. Much of this elevation change occurs west of Fort McMurray where numerous rapids characterize the Athabasca River. Landforms are a complex of undulating, gently inclined, and terraced valley bottoms and steep, inclined sides. Bottomland and riparian forest or deciduous shrub on Regosolic and Gleysolic soils occur in the valley bottoms. Valley sides support white spruce-aspen forest community types, but are non-vegetated on the steeper slopes.

5.2.1.5 Clearwater Plain. This is an undulating glaciofluvial and glaciolacustrine plain adjacent to the Clearwater and Athabasca rivers. The surficial materials consist of very thin to thick, sandy and loamy, glaciofluvial veneers and blankets overlying glaciolacustrine and morainal deposits. Clayey glaciolacustrine materials occur to a small extent. Meltwater channel landforms account for significant proportions of the area in this ecodistrict and some of the sandy materials have been reworked by wind. Relief is quite low with elevation ranging from about 300 to 400 m. Shallow organic deposits cover 20 to 40% of the area. The bedrock is mainly shale of the Clearwater Formation which underlies less than 5 m to about 35 m of glacial till and stratified sands and gravels. The glacial deposits directly overlie the McMurray Formation or the Devonian Waterways Formation near the Athabasca River. Soils are varied with Luvisols, Gleysols, and Brunisols occurring throughout the area. Upland plant communities are similarly varied and include white spruce-aspen, mixed coniferous and jack pine types. Organic soils are mainly shallow and support black spruce forest.

5.2.1.6 Steepbank Plain. This ecodistrict consists predominantly of organic deposits, some of which are several meters thick. These overlie glaciolacustrine and morainal materials. The landform surface expression is level to undulating. From about 400 m elevation, the plain ascends northward and eastward toward the Muskeg Mountain Upland to an elevation of about 550 m. Local relief is provided only by some abandoned beach ridges and morainal outcrops. The organic cover is estimated to be about 80% of this ecodistrict. Glacial till and stratified sediments underlie the area with thicknesses ranging from about 10 to 50 m. Ice-contact deposits of thicknesses between 5 and 35 m which occur near Kearl Lake are included in this ecodistrict. The underlying bedrock materials are mainly shales, siltstones, and sandstones of the Clearwater and Grand Rapids formations.

Mineral soils of this ecodistrict consist of Luvisols, Brunisols, and Gleysols. White spruce-aspen and jack pine communities occur on relatively well-drained sites while Organic and Gleysolic soils support various wetland community types. Lightly forested tamarack and open muskeg is relatively common in this ecodistrict.

5.2.1.7 Hartley Plain. This ecodistrict consists mainly of wetlands on a level to undulating plain which gently rises eastward and southeastward toward the Muskeg Mountain Upland. Peat deposits occupy 60 to 80% of the area. The elevation ranges from about 300 to 450 m. The underlying materials are mainly outwash deposits of 10 to 20 m thickness overlying glacial till of up to 10 m thickness. Finer glaciolacustrine materials occur to a small extent as well. Relief is generally subdued although the landscape is broken by numerous creeks which flow from the uplands into Hartley Creek and Muskeg River. The underlying bedrock consists of McMurray Formation sandstones and shales in the north and Clearwater Formation shales in the southern part. Soils in this ecodistrict are mainly Luvisols and Gleysols, with inclusions of Brunisols. Upland plant community types are varied while wetland communities consist mainly of black spruce forest on shallow Organic soils.

5.2.1.8 Dover Plain. This ecodistrict is an undulating and gently inclined plain which rises westward from the Athabasca River toward the Birch Mountains and Thickwood Hills uplands. Surficial deposits typically consist of less than 1 m to 5 m of glaciolacustrine clays and silts which overlie about 5 to 20 m of glacial till. About 25 m of clayey materials occur at groundwater observation well 14 in Township 92, Range 12 (Hackbarth 1978). These overlie shales of the Clearwater Formation over most of the area. The glacial deposits are thicker where the Dover Plain abuts higher lands to the west. The glaciolacustrine deposits are thinner at the eastern side of the plain where they directly overlie the tar sands of the McMurray Formation. Relief is very low and the elevation ranges from about 300 m at the eastern margin to 500 m at the west side. Peat deposits occupy about 20 to 40% of this area.

Solonetzic soils with saline subsurfaces are common on the Dover Plain. The origin of the salt is uncertain but may be related to a regional groundwater discharge situation. There have been indications that substantial subsurface flow to the Athabasca River occurs on the east slopes of the Birch Mountains (Neill and Evans 1979). Saline waters may surface in some areas or may flow sufficiently close to the surface to influence soil development. It is also possible, however, that the glacial materials were saline when deposited.

The Solonetzic soils occur in association with Luvisols throughout the Dover Plain. White spruce-aspen communities are the predominant vegetation on these soils, while peaty Gleysols and shallow Organic soils support mainly black spruce forest.

5.2.1.9 MacKay Plain. The MacKay Plain is basically the western extremity of the Dover Plain but has been differentiated on the basis of the predominance of peatlands which occupy over 90% of the area. Large areas of the peat deposits are more than 5 m deep. The landscape is level with several peatland forms such as horizontal bogs, patterned fens, and peat plateaus occurring. The elevation ranges from about 450 to 475 m. The underlying mineral materials are probably glaciolacustrine veneers and blankets over morainal deposits, similar to those of the Dover Plain. The bedrock materials are shales of the Clearwater and Grand Rapids formations. At groundwater observation well 15, located near the MacKay River within this ecodistrict, about 90 m of stratified sediments, mainly sands and gravels, overlie siltstone of the Grand Rapids Formation (Hackbarth 1978). The Organic soils support mainly the 'open' wetland vegetation types such as fen, semi-open black spruce forest, and lightly forested tamarack and open muskeg.

5.2.1.10 Fort Hills Upland. The Fort Hills Upland is an outlier of the Methy Portage Plain physiographic section. This ecodistrict consists of hummocky and rolling, highly dissected kame and kame moraine deposits. Elevation is 200 to 250 m with local relief up to 30 m. The dominantly sandy sediments are believed to have been deposited as a kame delta or fan complex (McPherson and Kathol 1977). Other features of the area include sinkholes and eolian deposits. Peat deposits cover less than 20% of the area. Lenses and layers of till, clay, coarse sand and gravel, and reworked bitumen also occur. The kame deposits are generally about 35 to 90 m in thickness and these overlie 10 to 35 m of glacial till and stratified sediments. Sandstones and associated materials of the McMurray Formation underlie the upland.

A smaller area of kame moraine west of the Athabasca River is included in the Fort Hills Upland ecodistrict. The materials are similar to the Fort Hills deposits but appear to contain coarser-grained sand and a higher percentage of till. This kame area may have originally been connected to the Fort Hills but has since been dissected into two separate segments by the Athabasca River.

Soils are predominantly Brunisolic with inclusions of Luvisols, Gleysols, and Organics. Vegetation consists predominantly of jack pine communities although mixed forest and aspen forest areas are also extensive in this ecodistrict.

5.2.1.11 Johnson Lake Plain. A small part of the Johnson Lake Plain occurs within the study area. Surficial materials consist of kame moraine deposits and morainal materials of the Kinosis till type. The glacial till gradually becomes sandier from the west to the eastern margins where it has been called Gipsy till by Bayrock and Reimchen (1974). The elevation range is about 300 to 450 m. Relief is generally low except in the kettled and eroded kame moraine areas where local relief is up to about 50 m. The landform generally is undulating to rolling with some fluted (ridged) moraine areas occurring near Audet Lake. Information on thickness and character of surficial materials is relatively sparse except for potential mining areas as described by McPherson and Kathol (1977). Thickness of the kame deposits and underlying tills may be over 100 m, as in the Fort Hills, but materials in the area in general may be somewhat thinner. Surface organic cover is quite high, ranging from 40 to 60%.

The kame moraine portion of the Johnson Lake Plain ecodistrict south of the Firebag River might possibly be separated as a distinct ecodistrict due to the type of surficial material and landform. However, insufficient investigation was carried out in the portion of the Johnson Lake Plain lying outside the study area to determine whether kame deposits recurred through the area or if the kame area along the Firebag River is in fact unique.

Mineral soils consist of Brunisols, Luvisols, and Gleysols. Vegetation is varied with mixed forest, mixed coniferous, and jack pine communities occuring on relatively well-drained soils. All types of bog and fen communities occupy the Gleysolic and Organic soils of wetlands.

5.2.1.12 Muskeg Mountain Upland. The Muskeg Mountain Upland is the only ecodistrict within the Firebag Hills Upland physiographic section which occurs in the study area. Surficial materials of this upland consist mainly of glacial till of the Kinosis type. The surface expression is undulating and hummocky. Inclusions of glaciofluvial outwash and ice-contact deposits occur, and peat deposits occupy 40 to 60% of the area. The glacial till is loamy on the eastern portion of the upland but gradually changes eastward to the sandier composition of Gipsy till. The surficial morainal materials overlie other till strata and stratified sediments with thickness ranging from 30 to about 200 m. The uppermost till layer is about 50 m thick in the Muskeg Mountain lookout tower area (Hackbarth 1978). The Cretaceous Clearwater and Grand Rapids formations underlie the glacial materials. The elevation range of the Muskeg Mountain Upland is 400 to 650 m.

Mineral soils are predominantly Luvisols which support mixed coniferous forest. Various types of Organic soils occur (shallow bogs, deep bogs, and fens) and vegetation likewise consists of various bog and fen community types.

5.2.1.13 Wabasca Plain. Only two small sections of the Wabasca Plain ecodistrict occur in the study area. One part lies adjacent to the Stony Mountain Upland and another occurs west of the Athabasca River in the southwest corner of the study area. The ecodistrict is generally an undulating morainal plain with 50 to 70% of the area covered by thin peat deposits. The surficial material is low relief ground moraine which, in the Hangingstone River area, resembles the shaly colluviated ground moraine which occurs along the flanks of the Stony Mountain Upland. West of the Athabasca River, thin loamy glaciolacustrine deposits overlie glacial till of the Horse River type (Bayrock and Reimchen 1974). Data for thickness of glacial deposits are not readily available, but the shaly nature of some tills suggests that they are commonly thin and shales of the Cretaceous Labiche Formation may be quite close to the surface. The elevation range of the plain is about 550 to 600 m and rises gently southward and westward.

The major mineral soils are Luvisols and Gleysols. White spruce-aspen and mixed coniferous communities occur on Luvisolic soils, while black spruce forest predominates on the Gleysolic and Organic soils.

5.2.1.14 Algar Plain. The Algar Plain is a level to undulating glaciolacustrine basin extensively overlain by peat deposits. The glaciolacustrine materials are generally very shallow and overlie glacial till of the Horse River type (Bayrock and Reimchen 1974). Both shallow and deep peat deposits occupy 60 to 80% of the area. Relief is very subdued with elevation ranging from 500 to 550 m. Shales of the Cretaceous Joli Fou and Labiche formations underlie the glacial deposits of this plain. Depth to bedrock is unknown, but may be shallow in places as evidenced by the presence of a very shaly till at Grande lookout tower near Algar Lake.

The mineral soils in this ecodistrict are Luvisols and Gleysols. Vegetation consists of white spruce-aspen forest on Luvisols, black spruce forest on Gleysols, and various bog and fen community types on Organic soils.

5.2.1.15 Dunkirk Plain. The Dunkirk Plain is similar to the Algar Plain but is separated from it by the Athabasca River and the Brule Plain ecodistrict. It is mainly an undulating plain in which the predominant surficial material is a calcareous till of the Horse River type. Shallow loamy to clayey glaciolacustrine deposits occur commonly. Both thick and shallow peat deposits overlie 60 to 80% of the area. The elevation ranges from 475 m at the boundary with the Dover Plain to 550 m at the base of the Birch Mountains. The underlying bedrock materials are mainly shales of the Grand Rapids and Labiche formations. Data on the depth to the bedrock are not available. The vegetation and soil types in this ecodistrict are similar to those of the Algar Plain.

5.2.1.16 Thickwood Hills Upland. The Thickwood Hills Upland is an eastern extremity of the Wabasca-Athabasca Lowlands physiographic section. It is similar to the Dunkirk Plain except that the surficial deposits consist almost entirely of hummocky and ground moraine of calcareous Horse River till composition. The elevation range is about 450 to 500 m and local relief is mainly low. Organic deposits overlie 40 to 60% of the till upland. Inclusions of glaciofluvial sands and gravels occur as well. The underlying glacial deposits are mainly stratified sands and gravels with some till. Their depth at groundwater observation well 13 near Thickwood Hills lookout tower is about 90 m. Shales of the Grand Rapids Formation underlie the glacial drift (Hackbarth 1978). Luvisols with white spruce-aspen vegetation predominate on relatively well-drained sites. Vegetation of the peatlands consist of various bog and fen community types.

5.2.1.17 Cheecham Hills Escarpment. The highly dissected, north-facing escarpment south of Gregoire Lake is the most prominent feature of this ecodistrict. This area extends around the eastern and western flanks of the Stony Mountain upland, but the elevation range and proportion of rough broken lands is not as high as at the north end. The surficial materials are colluviated ground moraine and colluvium of variable thickness. Shales of the Labiche and Joli Fou formations are exposed in the deeper valleys and the surficial material is itself quite shaly. The elevation ranges from 550 to 750 m within a distance of 4 to 5 km in some places. Due to the rapid surface drainage, organic deposits occupy a very small proportion, less than 10% of the area.

Soils of this ecodistrict are mainly Luvisols and Regosols. These support predominantly white spruce-aspen and coniferous forests.

5.2.1.18 House Plain. This ecodistrict is an undulating to hummocky plain in which Kinosis till is the predominant surficial material. The till is loamy to clayey and shaly on the west side of the plain within the study area, and becomes sandier toward the east side. A dark, shaly basal till was found at most soil inspection sites. The till overlies other till units and stratified drift, the total thickness being about 190 m at a groundwater observation well a few kilometres west of the Stony Mountain lookout tower (Hackbarth 1978). Organic materials occur over 40 to 60% of the plain. Relief in hummocky areas may be up to 30 m but is generally somewhat lower than this. The elevation range is about 650 to 750 m.

Luvisols are the predominant mineral soil type. Vegetation on these consists of white spruce-aspen and coniferous forest community types. Wetland types are varied and vegetation in these likewise varies from fen to various bog community types.

5.2.1.19 Richardson Hills Upland. This ecodistrict is an upland of hummocky and rolling, highly dissected kame and kame moraine deposits. The deposits consist mainly of medium sands with stones and boulders. Glacial till inclusions of finer texture are uncommon. Information on depth of glacial deposits to bedrock is not available but Bayrock (1969) has suggested they could be up to about 250 m thick. The elevation range is 300 to 450 m with local relief being more than 50 m in places. A unique feature of this upland is the presence of numerous water bodies of various sizes. The deposits overlie Middle Devonian limestones on the west and Precambrian granitic plutonic rocks on the east side of the upland. Brunisolic soils which support jack pine forest are predominant in this upland.

5.2.1.20 Muskeg River Plain. This area has been included in the Great Slave Plain physiographic section mainly because it lies below 300 m elevation. It is a level to undulating basin drained mainly by the Muskeg River, but it lies adjacent to the Athabasca River at its western edge. Surficial deposits are mainly shallow glaciofluvial sands which may overlie till but commonly directly overlie tar sands of the McMurray Formation or limestone of the Devonian Waterways Formation. The glaciofluvial materials may be less than 1 m to almost 15 m thick. Underlying till, if present, is only a few metres thick. The elevation range is 250 to 300 m. Peat deposits which are commonly greater than 5 m thick occupy 60 to 80% of the area. The peatlands and their vegetation consists of various bog and fen types. Mineral soils are predominantly Brunisols and Luvisols which support mainly mixed forest and jack pine communities.

5.2.1.21 Embarras Plain. This ecodistrict is an undulating, glaciofluvial plain consisting of sandy outwash deposits and some meltwater channel deposits along the Athabasca River. Large areas of outwash sands have been reworked by winds forming undulating eolian veneers and blankets as well as dunes. The outwash deposits have been estimated by Bayrock (1969) to range in thickness from less than 1 m to nearly 20 m. These are underlain by bedrock mainly of Devonian origin which has karstic features resulting in formation of sinkholes in some places. In the northern part of the plain, eolian landforms are more extensive. Dunes of parabolic, or U-shape, and longitudinal form, some of several kilometres length, are common in this area. The height of the dunes can be up to 20 m. Many of the dunes have eroded or blown out patches. There are also two large areas of active dunes which are migrating slowly southeastwards. There are a few large peatland areas in this ecodistrict, but they account for less than 10% of the total area. Except for the high dunes, relief is subdued. The elevation range is 250 to 300 m. Soils are mainly Brunisols and the vegetation predominantly jack pine forest.

5.2.1.22 Buckton Plain. This ecodistrict is a level to undulating or slightly inclined plain skirting the Birch Mountains escarpment. The surficial materials are mainly loamy fluvial fan deposits which overlie sandy deposits similar to those of the Embarras Plain on the east side and glacial till deposits closer to the Birch Mountains on the west side. The fluvial materials are thickest near the Birch Mountains and gradually become thinner toward the eastern margins of the plain. The materials originate in the Birch Mountains with a large proportion likely derived from Cretaceous shales exposed in the strongly dissected escarpment. Depth of the fluvial and glacial materials are not known. Bedrock consists of the Cretaceous McMurray, Clearwater, and Grand Rapids formations. Poorly drained Gleysolic soils with very thin peat cover are typical in this ecodistrict. Thicker peat deposits occupy 20 to 40% of the area. Bottomland and riparian forest, deciduous shrub, and various wetland community types are predominant in this ecodistrict.

5.2.1.23 Athabasca Delta Plain. This is a large deltaic plain composed of sandy to clayey sediments deposited from the Athabasca and Peace Rivers. The surface relief is level to depressional and the elevation is approximately 200 m throughout. There are numerous large and small lakes and streams throughout the area. Poorly drained Gleysolic and Regosolic soils are predominant while Organic soils are of very limited extent within the study area. Depth of the fluvial deposits is not known. They likely overlie glacial deposits which in turn overlie Middle Devonian and Precambrian bedrock. Near Lake Athabasca, outcrops of Precambrian rock occur. Soils are predominantly Gleysolic with some occurrences of Regosols. Bottomland and riparian forest, deciduous shrub, and fen communities are predominant vegetation types.

5.2.2 Ecodistricts of the Northern Boreal Ecoregion

5.2.2.1 Birch Mountains Upland. This ecodistrict extends over most of the southern portion of the Birch Mountains physiographic section. The surficial material consists of hummocky and ridged (fluted) moraine with local relief generally about 10 m and up to about 40 m in some places. The elevation at the top of the escarpment on the east side is 750 m but the range is from 550 m at the southern margin to 825 m at some interior high points. Peat deposits mainly with permafrost, occur over 20 to 40% of the area. Luvisolic soils are typical of the upland. The glacial till is commonly dark and shaly, suggesting that bedrock may be close to the surface in some areas. Estimates of glacial drift thickness are not available but great variability can be assumed. The underlying bedrock is shale of the Cretaceous Smoky Group. The glacial till is commonly stony and bouldery but, in many areas, a shallow silty cover occurs which apparently is of eolian origin (van Waas 1974). Eskers and outwash deposits can also be found in the area.

Soils of the Birch Mountains Upland are mainly Luvisols. Brunisols occur to a very limited extent. The predominant vegetation is mixed coniferous forest with minor amounts of white spruce-aspen forest and jack pine forest. Black spruce forest and fen communities are the most common vegetation types of the peatlands.

5.2.2.2 Birch Mountains Escarpment. The Birch Mountains Escarpment is most prominent on the east side of the upland where the elevation ranges from 350 to 750 m over a distance of about 5 to 8 km. The incline becomes gentler toward the south and terminates at Joslyn Creek. The terrain consists of deeply incised valleys and gorges, massive inclined and ridged slump blocks, and more gently inclined colluviated ground moraine. The material is a mixture of glacial till and shales of variable thickness. Shales, siltstones, and sandstones of various Cretaceous formations are exposed in the valleys. Soils are mainly Regosolic and Luvisolic. Peat deposits occupy less than 10% of the area. Mixed forest and coniferous forest are the major vegetation community types in this area.

5.2.2.3 Gardiner Upland. The Gardiner Upland is the same as the Birch Mountains Depression of van Waas (1974). This is an area of generally lower elevation (700 to 750 m) than the Birch Mountains, but of very hummocky terrain of moderate relief which arises from an abundance of kame and esker complexes. The area contains many large and small lakes from Namur Lake in the south to Eaglenest Lake in the northeast. The lakes may have a moderating effect on the climate of the surrounding areas but soils in peat deposits nevertheless contain permanently frozen layers. Brunisolic soils are more common than Luvisols, and Organic and Cryosolic soils account for 20 to 40% of the area. Topographic breaks from the Birch Mountains Upland toward this lower lying ecodistrict are commonly unstable and have slide, soil creep, and seepage areas (van Waas 1974). As in the Birch Mountains Upland, the underlying bedrock consists of Cretaceous shales and associated materials, probably at considerable depth. Vegetation consists of jack pine and mixed forest types in well-drained areas. Vegetation of peatlands is mainly black spruce forest.

5.2.2.4 McIvor Plain. The McIvor Plain occurs over most of the northern part of the Birch Mountains Upland physiographic section. Peat deposits with permafrost are predominant, occupying about 80% of the area. The landscape generally consists of broad basins and plateau-like upland areas with gently sloping, smooth sides, suggesting that they are bedrock highs. Peat deposits occur throughout the basins and thin out and extend almost to the top of the local uplands. Relief is low with the elevation ranging from 650 to 775 m from the basins to the tops of the uplands. The underlying bedrock, which is probably at shallow depths in the plateaus, consists of shales of the Smoky Group. The soils are predominantly Cryosols which support black spruce forest. Small areas of fens occur throughout this ecodistrict.

5.2.2.5 Flett Lake Plain. This ecodistrict consists of undulating sand plains and hummocky to rolling bedrock outcrops. Brunisolic soils occur on the outwash deposits which are generally quite thin. The granitic and gneissic rock surfaces are bare except where sandy and organic deposits in depressions support some vegetation. Peat deposits occupy about 10 to 20% of the area. Local relief is up to about 35 m and elevation ranges from 200 to 300 m. Jack pine predominates on relatively well-drained sites while black spruce forest is the most common wetland vegetation type.

6. DESCRIPTION OF SOILS IN THE AOSERP STUDY AREA

Detailed descriptions of soils which occur in the study area are presented in this section. Descriptions are in terms of soil groups and soil units as defined in Section 4.5. Generalized profile characteristics are presented along with parent genetic material and landform surface expression on which the soils occur. Brief descriptions of the soils, landforms, and vegetation which constitute different ecosystems are presented in a subsection within each soil group description. The ecosystems described are those in which the soil group is dominant, either as a simple soil unit or in combination with units of other soil groups.

6.1 ALGAR SOIL GROUP (ALG)

Soils of the Algar soil group are predominantly peaty Gleysols developed on clayey and silty glaciolacustrine and mixed glaciolacustrine deposits. Subgroups which can be identified include peaty phases of Orthic Luvic Gleysols, Orthic Gleysols, and Rego Gleysols. Closely associated and included in this soil group are Gleyed Gray Luvisols, Gleyed Solonetzic Gray Luvisols, and Gleyed Gray Solodized Solonetz subgroups developed on clayey materials.

The Algar parent materials consist of those deposits described by Bayrock (1971) as thick or thin glaciolacustrine materials composed of bedded clay and silt containing pebbles and till-like layers. The glaciolacustrine material is generally thin such that soil development has occurred throughout its depth and commonly has extended into the underlying glacial till. Due to waterlogging, both the solum and parent material are dull dark gray in colour, massive and very sticky. Bands of pinkish materials, as described for the Dover soil group (Section 6.6), may be apparent even under saturated conditions.

Algar soils occur in depressional areas and on level to undulating topography with very gentle slopes (less than 5%). They are associated with the Dover and Joslyn soil groups and occur on the Dover, Hangingstone, Hartley, Clearwater, Algar, and Dunkirk plains.

Relatively well-drained members of the Algar soil group were sampled for analysis (Appendix, Section 9.4). These soils generally exhibit stronger profile development and brighter colours than those soils saturated to the surface. The peaty surface layer may be up to 40 cm thick and is moderately decomposed. Only a thin LFH horizon was present at many sites; the presence of charcoal fragments in this layer and young vegetation at these sites suggested that the surface peaty layer had been burnt off in relatively recent forest fires.

In peaty Orthic Luvic Gleysols, Aeg horizons may be 5 to 20 cm thick with moderately platy structure, gray colours, and silt loam to silty clay loam textures. A Btg horizon is usually 20 to 50 cm thick, yellowish brown to dark brown, clay in texture, and has moderately developed subangular blocky structure. Strong mottling is usually apparent. A transitional BCg horizon is commonly present and the total thickness of the profile above the C horizon (i.e., the solum) can range from 80 to 100 cm.

Soil Unit: One Algar soil unit was established in the study area.

ALG1 - Dominantly poorly drained peaty Gleysols in association with significant amounts of Gleyed Gray Luvisols. Subgroups such as Orthic Gray Luvisols, Gleyed Gray Solodized Solonetz, and Gleyed Gray Luvisol may occur as minor inclusions. Gleyed Gray Luvisols may not be significant in all areas but different combinations of these and the minor subgroups may constitute a significant proportion in different areas. Undifferentiated Organic soils may also occur as inclusions.

Ecosystems: The most common ecosystem with predominantly Algar soils consists of the Algar soil unit on level to undulating landforms. The main vegetation community types are black spruce bog forest, and bottomland and riparian deciduous shrub. These grade into upland types on the relatively well-drained sites. Undifferentiated community types consisting of small aspen, black spruce, and balsam poplar with some shrubs such as willow occur extensively as a result of relatively recent forest fires.

Most ecosystems with predominantly Algar soils occur in combination with Kenzie soils. These occur on level to undulating landforms in which organic materials occupy the depressional areas. Vegetation communities are the same as those described above except that a larger proportion of the area is occupied by black spruce bog forest, semi-open black spruce bog, or lightly forested tamarack and open muskeg.

6.2 BITUMOUNT SOIL GROUP (BMT)

The Bitumount soil group consists of poorly drained peaty Gleysols developed on sandy glaciofluvial and eolian deposits. Subgroups which occur most commonly are Orthic Luvic Gleysols, Orthic Gleysols, and Rego Gleysols. Gleyed Eluviated Eutric Brunisols and Gleyed Eluviated Dystric Brunisols on imperfectly drained sites are associated with the Gleysols. Well-drained Eluviated Dystric Brunisols and Organic soils in poorly drained depressional areas are also usually present. Bitumount soils are mainly found on the Clearwater, Muskeg River, Brule, Johnson Lake, and Embarras plains, and in the Richardson Hills Upland.

The parent material of Bitumount soils is the same as the sandy materials of the Mildred, Firebag, and Heart soil groups. Due to saturated and reduced conditions, the material is dull gray in colour. Where the water table fluctuates below the solum, the parent material may be a brighter yellowish brown colour; yellow brown, and rust coloured mottles and bands may also be present. The textural range is sand to loamy sand, and the reaction is near neutral. In many areas, the sandy deposits are veneers or blankets which overlie less permeable morainal or glaciolacustrine materials. A thin peat layer overlies the sands in most areas.

The peaty surface of Bitumount soils is usually a moderately decomposed forest peat, a material derived from needles, leaves, and other tree and shrub components in combination with feathermosses and various other moss species. There is little horizon development apparent where the soils are continuously waterlogged to the surface. A thin gray or grayish brown Aeg horizon overlying a yellowish brown Bmg of about 30 to 50 cm thickness is found at sites having some restricted internal drainage. A BCg horizon is usually present, and the total solum thickness is about 60 cm but this can be quite variable.

Bitumount soils occupy level to depressional landscape positions within areas of Mildred, Heart, and Firebag soils and are commonly found interspersed with Organic soils. Their surface drainage is slow and internal drainage is impeded due to high water tables. The general landform surface expression is level to undulating with slopes less than 5%.

As noted above, a number of Gleysol subgroups can be distinguished in the field, but proportions and distributions of these were not determined. Thus, soils with differing morphologies are not distinguished on the soils maps. The one characteristic common to these poorly drained soils is their development on sandy parent materials. Descriptions of a peaty Orthic Gleysol and a Rego Gleysol are given in the Appendix (Section 9.4).

Soil Unit: One Bitumount soil unit was established in the study area.

BMT1 - Dominantly poorly drained peaty Gleysolic soils in association with significant amounts of Gleyed Eluviated Eutric Brunisols developed on glaciofluvial or eolian sands. Eluviated Eutric Brunisols and Organic soils may occur in minor amounts. Eluviated Dystric Brunisols and Gleyed Eluviated Dystric Brunisols may occur to a small extent.

Ecosystems: Ecosystems in which the Bitumount soil group is dominant occur to a very limited extent in the study area. In simple ecosystems, the Bitumount soils occur on level to undulating landforms. The most common vegetation community type is black spruce forest which usually has a ground cover of feathermosses rather than sphagnum mosses. Bottomland riparian deciduous shrub and upland coniferous community types, as well as intergrades of these, may also occur. Jack pine and aspen may occur on associated well- to rapidly drained sites.

Other ecosystems consist of Bitumount soils in combination with Kenzie (KNZ1 and KNZ2) and with Eaglesham soils. These also occur on level to undulating terrain. Vegetation consists of black spruce forest in combination with various other wetland community types.

6.3 BUCKTON SOIL GROUP (BKN)

The Buckton soil group is a complex of well-drained Orthic Gray Luvisols and Orthic Regosols developed on loamy to clayey, colluviated morainal deposits and shales of various Cretaceous formations. They occur mainly in the Birch Mountains and Cheecham Hills escarpments.

The nature of the parent material of Buckton soils is variable, but two main types can be identified. One is morainal material of the type described for the Legend soil group. The other material is shale which, in the Birch Mountains Escarpment, belongs to the Smoky Group and to the Dunvegan, Shaftesbury, Grand Rapids, and Clearwater formations. Shales and associated materials in the Cheecham Hills Escarpment are of the Labiche and Joli Fou formations. The shaly material is loamy, silty or clayey, dark gray, and strongly to extremely acidic. Few coarse fragments are found in the shales while moderate amounts, about 10% by volume, may be found in the glacial till. Colluvial activity also results in some mixing of the two types of materials resulting in uniform mixtures or in lenses of contrasting materials occurring in the soils.

The parent material mixture is a consequence of colluvial processes such as slumping. Slump blocks are partially rotated such that former till surfaces face up and back toward a scarp face while the underlying, shaly materials are exposed and face the downslope side. Slump blocks then move downslope and mix to various extents. Massive landslides also occur on some slopes. The overall landscape surface is inclined while the slump blocks result in a ridged surface expression superimposed across the inclines. Slopes of the ridges vary within the 6 to 30% range. Gullies and valleys with steep slopes occur commonly within the slump areas. Those which are large enough to be delineated on the soils maps are called Rough Broken lands. Small lakes and ponds occur between some slump ridges, but these sites are most commonly occupied by poorly drained Gleysolic and Organic soils. Slump activity is a type of landform modifying process called failing; although most areas of Buckton soils are apparently stable, the process status of failing in some places is considered to be active as evidenced by the presence of drunken forest type of vegetation along slump blocks, particularly in upper parts of the escarpments.

Orthic Gray Luvisols of the Buckton soil group are similar to those of the Legend soil group. Due to erosional processes, there is more variability in thickness and degree of development of horizons as compared to Legend soils. In sites examined, the LFH horizon was 5 to 10 cm thick, overlying a strongly developed, pale brown to gray Ae horizon. A brown Bt horizon is relatively thick (about 50 cm), and has moderately developed subangular blocky structure. Variable contents of shale particles and coarse fragments can be found throughout the profile. Orthic Regosols consist of a thin litter layer overlying relatively unaltered shaly materials. In some areas, there are weakly developed soils which have very thin (<2 cm) Ae horizons overlying very weakly developed textural (Bt) horizons.

Soil Unit: One soil unit was used to map the Buckton soil group.

BKN1 - A combination of well-drained Orthic Gray Luvisols and Orthic Regosols. Peaty Gleysols, Organic soils, and exposed bedrock shales occur as minor inclusions and in some areas may together account for a significant portion of the area.

Ecosystems: Ecosystems in which Buckton soils are predominant consist mainly of the uncombined soil group on inclined landforms or on inclined lands with ridges. The inclined landforms may have undulating microtopography, or they may be quite choppy in which case a combination of inclined and hummocky forms is indicated in map symbols. Various upland vegetation community types such as white spruce-aspen forest, coniferous forest, and mixed coniferous types occur on Buckton soils. Deciduous shrub may be associated with upland undifferentiated community types or with black spruce forest on the imperfectly to poorly drained sites.

Less commonly, the Buckton soil unit is mapped in combination with the KNZ2 unit in areas where shallow Organic soils have developed between slump ridges. These ecosystems occur on combined inclined and ridged topography. Vegetation is as described above except that black spruce forest and other wetland communities may occur in larger proportions.

6.4 CHIPEWYAN SOIL GROUP (CPN)

Soils of the Chipewyan soil group are mainly imperfectly drained Gleyed Cumulic Regosols developed on loamy, weakly to moderately calcareous, fluvial delta deposits. They occur only on the Athabasca Delta Plain.

The Chipewyan parent material is generally loamy or silty but is quite variable, both laterally and vertically, between sandy and loamy compositions. Remnant levees and point bars are mainly fine sandy while finer sediments occur in interlevee and levee backslope areas. The material is mainly dark gray to dark grayish brown and is weakly to moderately calcareous. However, on sandy sites, strongly acidic materials can be encountered even at depths greater than 1 m. The deposits generally have a laminated structure in which bands of mineral material alternate with numerous buried former surface layers consisting of leaf litter or dark bands of relatively humified organic matter mixed with mineral soil. The structure is generally amorphous or fine granular and is rather friable. Data are not available, but the deposits appear to be quite deep over most of the area.

Typical Chipewyan landforms are ridged, consisting of recurring patterns of former levees and interlevee depressions. The ridge slopes are very gentle (less than 5%) and micro-topography is mounded in places. These soils can also be found on imperfectly drained level to undulating floodplains. Relief is very low throughout the delta area and any variations are due almost entirely to the levee ridges.

The surface of a Chipewyan soil is usually a dark brown to black layer consisting of slightly to moderately decomposed leaves and needles. Accumulations of litter materials may attain thicknesses of about 20 cm, but usually are about 10 cm. In some places, organic matter has been incorporated into the surface of the mineral material resulting in an AC horizon or a weakly developed Ah horizon. The underlying layers are composed essentially of the dark gray parent material with buried organic materials as described above. The materials are usually gleyed in all or in lower portions of the profile.

Gleyed Regosols and Rego Gleysols are commonly associated in significant proportions with the Gleyed Cumulic Regosols. Peaty Gleysols and Organic soils may occupy minor portions of the landscape.

Soil Unit: There was one Chipewyan soil unit established in the study area.

CPN1 - Dominantly imperfectly drained Gleyed Cumulic Regosols associated with significant amounts of Gleyed Regosols and

Rego Gleysols. Peaty Gleysols and Organic soils may occur as minor inclusions.

Ecosystems: Ecosystems with predominantly Chipewyan soils are mapped on either ridged or undulating landforms as described above. The bottomland and riparian forest community type is typical of these ecosystems. Mature stands of white spruce and balsam poplar are common on the better drained levees. Balsam poplar is found in slightly lower positions than the white spruce and forms the transition to bottomland and riparian deciduous shrub of wetter sites. Paper birch may be co-dominant with balsam poplar in some places. The vegetation and the landscape relationships in the Peace - Athabasca Delta are described in detail by Dirschl et al. (1974).

6.5 DISTURBED LAND TYPE (DL)

Disturbed lands are areas of anthropogenic materials, or man-made and man-modified materials, including those associated with mineral exploitation and waste disposal. In the study area, lands have been disturbed by open pit mining and related construction and land clearing activities, all of which are associated with the oil sands extraction industry. This land type has mainly been mapped in the Ruth Lake and Mildred Lake areas where two oil sands extraction plants are situated.

6.6 DOVER SOIL GROUP (DOV)

Dover soils are mainly Orthic Gray Luvisols developed on clayey, slightly stony, stratified glaciolacustrine and mixed Hangingstone, and Hartley plains, and to a small extent on the Clearwater and Algar plains.

The Dover parent materials are the same as the clayey glaciolacustrine and mixed glaciolacustrine deposits on which the Algar soils have developed. As with the Algar soils, the glacio-lacustrine material is generally thin and soil development has extended into the underlying till in some places. A characteristic feature of the glaciolacustrine material is the present of grayish pink bands of silty clay loam or silty clay texture. The pink colours may be evident in Ae and Bt horizons of some soils as well. The underlying glacial till is commonly brown, massive, firm, slightly stony, weakly to moderately calcareous, and clay loam or loam in texture.

Dover soils occur mainly on undulating topography with almost level to very gentle slopes. On the plains in which these soils occur, the regional slope is toward the Athabasca River. Elevations increase stepwise from the Athabasca River westward toward the Birch Mountain Upland and the Dunkirk Plain, eastward toward the Muskeg Mountain Upland, and southward to the Stony Mountain Upland.

The surface of a Dover Orthic Gray Luvisol is an LFH layer of 5 to 10 cm thickness. The L horizon is very thin consisting of slightly decomposed leaves, needles and twigs. An F horizon predominates in this layer and consists of a brown to dark brown, spongy mat of moderately decomposed leaves, needles, and feathermosses permeated with fungal mycelia. A black, highly decomposed H horizon is usually very thin or non-existent. In areas where relatively recent forest fires have destroyed the vegetation, the LFH layer may also be burnt and a newly developing duff layer is very thin. In these situations charcoal fragments are commonly found at the LFH-mineral soil boundary.

The Ae horizon is usually 5 to 15 cm thick, light gray to grayish brown, silt loam in texture, and very friable. A more strongly bleached upper Ae can often be distinguished from a lower light brownish layer.

The Bt horizon varies from 20 to 45 cm in thickness and is often separable into two types based on colour and structures. The Bt1 horizon generally is a brown, very firm, clay to heavy clay and has a strongly developed subangular blocky structure. The Bt2 horizon is usually slightly darker in colour and weaker in structural development than the Bt1. A transitional BC horizon is usually present and may be developed in the glaciolacustrine material, the underlying till, or in both. The BC horizon is usually 20 to 25 cm thick. The total solum depth is usually 60 to 80 cm.

The upper C horizon is neutral in reaction or may be weakly calcareous. As noted above, a C horizon in the glaciolacustrine parent material may be present, but a IIC in the underlying till is more common. The properties of the lower C are as described above for the parent material.

Homogeneous areas of Dover Orthic Gray Luvisols have not been mapped. These soils are almost everywhere associated with significant proportions of imperfectly drained Gleyed Gray Luvisols and poorly drained peaty Gleysols of the Algar soil group. Gleysols occupy depressional areas in the landscape and almost always are overlain by a thin deposit of mesic peat. These may grade to Organic soils in some places. Gleyed Gray Luvisols occupy lower slope positions where Orthic Gray Luvisols grade into Gleysols.

Also associated with Dover Orthic Gray Luvisols are Solonetzic Gray Luvisols which are transitional to Gray Solodized Solonetz in the Joslyn soil group. Solonetzic Gray Luvisols show some development of Solonetzic features such as columnar or prismatic structure and organic staining, but they contain insufficient amounts of exchangeable sodium in the B horizon to qualify as a Bn horizon as defined in the Canadian System of Soil Classification.

Soil Unit: One Dover soil unit was established in the study area.

DOV1 - Dominantly Orthic Gray Luvisols in association with significant amounts of Gleyed Gray Luvisols and peaty Gleysols. Organic soils and Solonetzic Gray Luvisols may individually occur as minor inclusions.

Ecosystems: Dover ecosystems occur on undulating landforms and are characterized by white spruce - aspen forest vegetation. Three community types within this category - aspen forest, mixed forest, and coniferous forest - occur with stand age generally increasing in this order (Thompson et al. 1979). On moister sites with Gleyed Gray Luvisols, the mixed coniferous forest community type may occur. On more hydric sites downslope, coniferous forest grades into deciduous shrub. On peaty Gleysols, deciduous shrub and black spruce forest occur. Commonly, the wetland vegetation is an undifferentiated type.

Dover soils commonly occur in association with Kenzie soils (KNZ1 and KNZ2). The landform is level to undulating in these ecosystems and vegetation is as described for the individual soil units. Generally, DOV1 - KNZ2 combinations have a significant amount of black spruce forest while DOV1 - KNZ1 combinations may also have semi-open black spruce forest and lightly forested tamarack and open muskeg.

6.7 EAGLESHAM SOIL GROUP (EGL)

The Eaglesham soil group is a complex of Organic soils developed on mesic fen peat that is usually more than 2 m thick. These soils are found in poorly to very poorly drained areas that receive minerotrophic groundwater and are only partially dependent upon precipitation for water and nutrients. Eaglesham soils are found in all ecodistricts in the study area. They are particularly common in the Algar, Brule, MacKay, Muskeg River, and Steepbank plains and in the Muskeg Mountain Upland. There are numerous smaller string fens in the inter-ridge positions of the fluted till plains in the Birch Mountains Upland.

The parent material of Eaglesham soils consists of the decomposing remains of sedges, grasses, and reeds with inclusions of leaves and twigs of shrubs or other plants which thrive in a fen environment. Fens are eutrophic (minerotrophic) due to the close association of the material with mineral rich waters.

Layers of fen peat with admixtures of other material such as sphagnum mosses, brown mosses, and feathermosses mixed with needles and leaves (forest peat) may also be found in fen deposits. The material is generally mesic, usually containing less than 25% fibres. Decomposition often is greater at lower depths. Surface horizons are usually fibric and some profiles may be fibric throughout. Humic layers are uncommon in fennic materials in the study area; a thin humic layer may be found just above the mineral contact or the muck layer in some Eaglesham soils.

The reaction of fennic materials is euic (higher than pH 4.5), and is commonly in the range of pH 5.5 to 7.5. This is a result of the higher mineral or nutrient status in fens as compared to bogs. Some materials sampled in fens were highly acidic (dysic) in reaction. These materials usually contained brown moss remains. The brown moss type of fen appears to be a peatland type transitional between minerotrophic and ombrotrophic peatland types. They are likely influenced by flowing groundwater derived from the immediate catchment area of the peatland resulting in a relatively low supply of mineral soil water and in peat accumulation with components of both bog and fen (Moore and Bellamy 1974).

The mineral material underlying fens in the study area is highly variable. Generally, it can be assumed that the nature of the underlying mineral material of Eaglesham soils within a particular ecodistrict is similar to that of the parent material of the most common mineral soil group in that ecodistrict.

Horizontal fen and patterned fen are two main types of landforms of the Eaglesham soil group. Horizontal fens occupy flat, low-lying areas, show insignificant differences in the level of the peat surface and have a homogeneous cover of sedges and grasses with shrubs in some areas. Patterned fen includes string fen and net-like patterned fen types (Tarnocai 1970). String fens usually occupy long strips of peatland with a very gentle slope. They consist of ridges, separated by water saturated hollows, which are oriented across the slope at right angles to water movement. Net-like patterned fen is the same as string fen except that ridges have coalesced in places and formed a net-like pattern.

Fen types which occur in the study area, but are too small or too limited in extent to show on soil maps, are sloping fens, floating fens, and spring fens. Sloping fens occupy appreciably sloping areas and are fed by seepage waters. Such fens may occur in the Clearwater River valley, although none were examined on site. A floating fen is a mat of vegetation and remains encroaching on a water surface. Many lakes and ponds in the study area are rimmed by a floating fen. Spring fens appear similar to patterned fens, but may be convex or sloping and are formed directly over springs. Fens in the Hangingstone Plain in Section 19, Township 87, Range 8, west of Fourth Meridian, are probably spring fens.

Collapse scars are another fen type common in peat plateaus in areas such as the Birch Mountains Upland and the Dunkirk Plain. These are small, circular fens that have developed as a result of melting of permafrost. They have high water tables and their collapsing edges form a steep bank with leaning and dead trees being typical.

Distinguishing horizons in fens is based on changes in fibre content, material type, and colour. Horizon sequence is variable and a typical profile cannot be defined as with mineral soils. Because Eaglesham soils are usually saturated to the soil surface, soil observations were made on augered samples. Horizonation was thus difficult to observe and materials were mostly characterized on the basis of samples collected in 20 cm increments.

Subgroups most commonly encountered in the Eaglesham soil group are Typic Mesisol, Fibric Mesisol, Typic Fibrisol, and Terric Mesisol. Other subgroups may occur, and sphagnic Organic soils and peaty Gleysols may occur as minor inclusions.

Typic Mesisols are characterized by predominantly mesic material throughout the control section of 160 cm. A thin fibric surface layer, with abundant roots and crowns of sedges and grasses, is usually present. The mesic material is usually brown and fibre size is fine to medium. Fibric Mesisols have a layer of fibric material thicker than 25 cm, usually in the upper part of the middle tier. Typic Fibrisols consist predominantly of fibric material throughout the control section. Terric Mesisols have a mineral contact within 160 cm of the surface but are otherwise similar to Typic Mesisols.

Most fen soils were examined to mineral contact or to 200 cm. However, total depths of the peat deposits were commonly found to be greater than 4 m.

Soil Unit: The variability in Eaglesham soils is too high to permit segregation of different types at small mapping scale. Vertical and horizontal variability can be high, even over a small area. Thus, only one map unit was established and only the most common profile types are identified in this report.

EGL1 - Dominantly Typic Mesisols in association with significant amounts of Fibric Mesisols, Typic Fibrisols, and Terric Mesisols, either individually or in combination with one another. Non-fen soils such as sphagnic Organics and peaty Gleysols may occur as minor inclusions. In many areas, Fibric Mesisol is the dominant subgroup.

Ecosystems: Eaglesham soils on horizontal or patterned landforms, or on landforms displaying a combination of these two forms, are a common ecosystem type in the study area. Typical vegetation of Eaglesham soils is classified as wetland fen communities (Thompson et al. 1978). A fen community type with ridges is typical of patterned fens. Some large fens in the study area have a wetland lightly forested tamarack and aspen muskeg community type in which the tamarack cover is somewhat denser than normal for the area.

There are numerous compound Eaglesham ecosystems because this soil group occurs in association with almost every other soil group mapped in the area. The most common map combinations are with the other Organic soils, Kenzie and Mikkwa. Ecosystems consisting of these combinations occur on various complexes of level, patterned, and peat plateau landforms. Vegetation is as described for the individual soil groups with intergrades of the community type occurring commonly. Soils and vegetation of Eaglesham - Kenzie ecosystems are especially complex. One distinctive type consists of horizontal fen with 'tear drop islands', either large or small in size and somewhat like a bog plateau (Tarnocai 1970). Eaglesham - Mikkwa map combinations occur as complex horizontal fen and peat plateau landforms.

Complexes of Eaglesham with soil groups on morainal materials are not commonly found. Although these do occur, the mineral soil is usually dominant. Landforms in such ecosystems are combinations of level or patterned fens with undulating, hummocky, or ridged morainal surface expressions. The map combinations are Eaglesham with Kinosis, Legend, Horse River, Surmont, and Steepbank.

Ecosystems of Eaglesham soils combined with soil groups on glaciolacustrine and glaciofluvial materials rarely occur. Eaglesham - Heart complexes are common in areas of eolian deposits. The Eaglesham soils occupy sites between dunes or between the 'horns' of U-shaped dunes. Landforms are complexes of horizontal or patterned fens with undulating, hummocky, or ridged (duned) eolian forms. Vegetation on the fen component is as described above. A narrow band of black spruce and deciduous shrub is usually present at the fen edges while jack pine inhabits the rapidly drained sandy sites.

Fens have developed over fluvial sediments in some areas. Eaglesham - McMurray ecosystems occur along many waterways and Eaglesham - Namur combinations occur on the Buckton Plain. Combinations with the Chipewyan and Mamawi soil groups have not been mapped. Fens occur to a very limited extent in the rockland of the Flett Lake Plain.

6.8 FIREBAG SOIL GROUP (FIR)

The firebag soil group consists of Eluviated Dystric Brunisols and associated soils developed on sandy, moderately to exceedingly stony, glaciofluvial ice contact deposits. The main occurrences of these soils are in areas of large kame moraines. The Fort Hills Upland, Richardson Hills Upland, and Johnson Lake Plain consist mainly of these types of deposits. Some large areas of ice contact deposits (kames, eskers) occur in the Gardiner Plain, and isolated kames and kame areas can also be found as inclusions in most morainal areas such as the House Plain, and the Muskeg Mountain, Birch Mountains, and Thickwood Hills uplands.

Bayrock (1971) has described ice-contact deposits occurring in these areas as consisting of sand and gravel with numerous very large boulders. Grain size can be quite variable over short distances. Lenses and layers of clay, till and coarse sand and gravel may be present in minor amounts. The sands in the Fort Hills Upland contain a relatively high percentage of reworked bitumen (McPherson and Kathol 1977).

Kame moraine is a general term used for a series of kames which were formed along the margins of a glacier. The deposits consist of deltas and fans built along an ice front which later melted and collapsed, isolating the mass of sand and rock to form an irregular mound. Topography of kame moraines is generally hummocky to rolling. In the Richardson Hills Upland, individual hills reach heights of several hundred feet. Slopes may be steeper, up to about 30%, than in till moraine areas. This results in extensive channeling and erosion. Deep, steep-sided kettle holes are another common feature of kame moraines.

Individual kames or small kame areas were likely formed by deposition of sediment in crevasses or other openings in or on the surface of stagnant or near stagnant ice. The ice later melted away, leaving the accumulated sediment in the form of isolated or semi-isolated mounds. Eskers may occur as part of kame complexes or as isolated landforms in morainal areas.

The sandy parent material of the Firebag soil group is usually light brownish yellow to brown in colour. Its reaction is strongly to slightly acidic, although, in some areas, it may be in the neutral range. The content of gravel, cobbles, and boulders is highly variable. There is generally a low content of silt and clay but this also can be quite variable.

Firebag soil profiles generally have about a 2 cm thick LFH layer consisting of slightly to moderately decomposed needles and lichens. Under aspen vegetation, this layer is somewhat thicker. The Ae horizon is about 5 to 20 cm thick. Deeper Ae horizons can be subdivided into a dark grayish brown Ahe and an underlying gray to light brownish gray Ae. The material is a very friable or loose sand. Only a few profiles have a transitional AB horizon of about 10 cm thickness.

The Bm horizon ranges from about 20 to 60 cm in thickness. It may be uniformly sandy and light yellowish brown to light brownish yellow in colour, or may be separated into a Bm1 and a Bm2. Some profiles have weakly developed Bfj horizons, indicated by stronger coloration due to sesquioxide accumulation, or weak Btj horizons, indicated by a small increase in content of clay. There is almost always a BC horizon of variable thickness. Because colour changes downward very gradually in the BC horizon, it is difficult to determine at what depth the material may be considered parent material. Properties of the C horizon are as described above for the parent material.

Eluviated Dystric Brunisols of the Firebag soil group are associated with Eluviated Eutric Brunisols. The subgroup a Brunisolic soil falls into is determined by whether the pH in the Bm is greater than or less than 5.5. The two subgroups above can be considered to be very similar since the pH range of Bm horizons in the study area is commonly between 5 and 6.

In areas with numerous depressions, imperfectly drained Gleyed Eluviated Eutric Brunisols and poorly drained peaty Gleysols may occur. In areas of high relief and steep slopes, water and wind erosion has resulted in extensive dissection of the terrain. Unvegetated spots and areas of minimal profile development result from the erosion. Orthic Regosols are associated with the Brunisols in these areas.

Soil Units: Three soil units were distinguished on the basis of proportions of poorly drained soils or of Regosols associated with the predominantly Brunisolic Firebag soil group.

FIR1 - Dominantly rapidly drained Eluviated Dystric Brunisols with significant Eluviated Eutric Brunisols. Inclusions of Gleyed Eluviated Eutric Brunisols and peaty Gleysols may occur.

FIR2 - Dominantly rapidly drained Eluviated Dystric Brunisols associated with significant amounts of Eluviated Eutric Brunisols and of a combination of imperfectly drained Gleyed Eluviated Eutric Brunisols and poorly drained peaty Gleysols. Organic soils are of minor occurrence.

FIR3 - Dominantly very rapidly drained Eluviated Dystric Brunisols associated with significant amounts of Eluviated Eutric Brunisols and Orthic Regosols. Peaty Gleysols and Organics in depressions occur in minor amounts.

Ecosystems: Simple ecosystems with FIR1 or FIR2 soil units occur on undulating or hummocky terrain, or a combination of the two. Upland jack pine forest is the typical community type on Firebag soils. On slightly moister sites of north facing slopes, upland aspen forest may be found. Upland aspen forest and mixedwood forest can also be found over large areas of the Fort Hills Upland

and the Johnson Lake Plain. These stands occur in sites where moisture supply is higher than normal for these soils due to inclusions such as glacial till or tar sand layers which impede internal soil drainage. In ecosystems with the FIR2 soil unit, black spruce forest and deciduous shrub occur in depressional areas.

The hummocky landscapes of ecosystems with the FIR3 soil unit are more rugged than those of the other Firebag units. Jack pine forest is dominant but is usually sparse on the eroded hilltops and steeper slopes.

Firebag soils also occur in combination with the Kenzie, Eaglesham, Mikkwa, and Heart soil groups. Landforms of these ecosystems are various combinations of mineral forms (hummocky, undulating, ridged) and peatland forms (level, patterned, plateau). Because of the rapid internal drainage of Firebag soils, combinations with the Organic soil groups are not common. Firebag - Heart combinations are common in the Richardson Hills Upland where large areas of ice-contact deposits have apparently been reworked into eolian sheets and dunes. Characteristics of soils and vegetation are very similar in these two soil groups.

6.9 HEART SOIL GROUP (HRT)

The Heart soil group is a complex of Brunisolic soils developed on sandy, eolian deposits. They occur extensively on the Embarras and Brule plains. Some Heart soils occur in the Muskeg River and Clearwater plains, and Richardson Hills Upland. Minor areas are found in the Garson and Johnson Lake plains and in the Muskeg Mountain Upland.

The eolian parent material of Heart soils is loose, light olive brown to yellowish brown, and dominantly fine to medium sand texture. The reaction is mainly strongly to slightly acidic. In the Muskeg River Plain where eolian deposits directly overlie limestone bedrock and calcareous glacial deposits, the reaction of the parent material may be slightly acidic to neutral. Although the material is generally stone-free, stones and boulders may occur in deflation hollows in glaciofluvial outwash or ice-contact deposits that have been extensively reworked by wind.

The landforms on which Heart soils have developed are characterized by U-shaped dunes in the Brule Plain and by northwest-southeast oriented longitudinal or U-shaped dunes on the Embarras Plain. Classic examples of seif, barchan, and parabolic dunes occur throughout the area (Thompson 1979). These landforms are classified as ridged surface expression in this survey. Extensive areas of undulating to hummocky landforms, and combinations of these with ridged forms, also occur. On the Brule Plain, eolian deposits are deep near the Athabasca River, but shallow veneers and blankets overlying morainal and glaciolacustrine deposits occur eastward toward the Hangingstone and Dover plains. On the Embarras Plain, the landform in the area of the Firebag River is mainly a complex of glaciofluvial outwash and eolian blankets. On the Muskeg River Plain, veneers and blankets of eolian sand overlie limestone bedrock (Waterways Formation) as well as outwash materials. Other sandy deposits such as fluvial materials along creeks and rivers, and beach ridge deposits, have also been affected by eolian activity.

Eluviated Dystric Brunisol is the predominant subgroup in the Heart soil group. This is associated with Eluviated Eutric Brunisols and peaty Gleysols (of the Bitumount soil group) and with Orthic Regosols.

The surface of an Eluviated Dystric Brunisol consists of 1 to 5 cm of slightly to moderately decomposed pine needles and lichens. A light brownish gray Ae horizon is usually 5 to 15 cm thick. There may be some incorporation of organic materials in the upper Ae, producing a 'salt and pepper' effect. The yellowish brown to dark yellowish brown Bm horizon may be between 15 to 60 cm thick, the thicker ones usually being divisible into two types. A yellowish brown BC horizon of 10 to 25 cm thickness is usually present. Total depth of the solum varies from 50 to 100 cm. Soil reaction is very strongly acid to medium acidic throughout.

Gleyed Eluviated Eutric Brunisols and peaty Gleysols occupy depressional areas. Where the water table is high, possibly supported by an underlying deposit of relatively impermeable material, fens and bogs may occur. Higher and steeper dunes are subject to erosion and small areas of bare soil occur commonly, particularly in the Embarras Plain. Two areas of open, non-vegetated dune sand, each several square kilometres in size, occur in Township 107, Range 8 and Township 106, Range 6. These dunes are apparently migrating eastward and are being revegetated along their western margins.

Soil Units: Three Heart soil units have been recognized within the Heart soil group. These are designated HRT4, HRT5, and HRT6, the units HRT1 to HRT3 having been previously defined in soil surveys of the Wapiti map area (Twardy and Corns 1980) and the Iosegun map area (Knapik, in prep.). Generally, Heart has been used in previous soil surveys as a complex of soils developed on eolian sands in the boreal forest. The Heart soil units in the Wapiti and Iosegun areas differ from those in the study area by having Podzols and Luvisols as associated soils.

HRT4 - Dominantly rapidly drained Eluviated Dystric Brunisols in association with significant amounts of Eluviated Eutric Brunisols. Imperfectly and poorly drained Gleyed Eluviated Eutric Brunisols and peaty Gleysols are minor inclusions.

HRT5 - Dominantly rapidly drained Eluviated Dystric Brunisols in association with significant amounts of Eluviated Eutric Brunisols and significant amounts of a combination of imperfectly drained Gleyed Eluviated Eutric Brunisols and peaty Gleysols. Organic soils may be minor inclusions.

HRT6 - Dominantly very rapidly drained Eluviated Dystric Brunisols in association with significant amounts of a combination of Eluviated Eutric Brunisols and Orthic Regosols.

Ecosystems: Ecosystems with HRT4 and HRT5 units are generally found on gently to moderately sloping (2 to 15%) undulating, hummocky, or ridged surface expressions, or on any combinations of these. The HRT6 soil unit occurs mainly on more steeply sloping (6 to 30%) ridged and hummocky topography. Upland jack pine forest is the characteristic community type on these soils. On imperfectly drained Gleyed Eluviated Eutric Brunisols, black spruce occurs with jack pine. As wetter sites are encountered downslope, vegetation changes over very short distances through a deciduous shrub type to wetland fen or bog communities in depressional areas.

The most common compound ecosystems are combinations of any of the Heart soil units with Kenzie and Eaglesham soil units. Various combinations of eolian and organic landforms occur in these ecosystems. Heart in combination with the KNZ2 soil unit has predominantly jack pine communities with significant proportions of black spruce forest. Where KNZ1 is the combined unit, semi-open black spruce forest, lightly forested tamarack and open muskeg may also occur. Where HRT5 is in combination with Kenzie units, areas of Gleysolic soils surrounding the bogs support black spruce forest with feathermoss as well as sphagnum moss ground cover. Deciduous shrub is also common in these sites.

In Heart - Eaglesham combinations, either horizontal or patterned fen and fen vegetation communities occupy depressional areas. String fens are common between longitudinal dunes and between the points on U-shaped dunes.

In many areas, Heart soils in combination with Firebag and Mildred soils are mapped. Landforms are mainly undulating veneers and blankets of eolian material overlying unmodified glaciolfuvial sediments. In some areas, dunes may also occur. Soil properties of these groups are very similar and jack pine forest is typical of each.

Small areas of Devonian rock outcrops occur in the Muskeg River Plain among Heart and Kenzie soils. The occurrence of rock is indicated on the soil maps by appending the symbol 'R' to the Heart - Kenzie and Kenzie - Heart combinations. Although the Rock unit occurs in minor amounts in these ecosystems, it is a highly contrasting land type and, therefore, is considered important to include on the maps.

6.10 HORSE RIVER SOIL GROUP (HRR)

Horse River soils are well- to moderately well-drained Orthic Gray Luvisols developed on fine-loamy, slightly to moderately calcareous morainal deposits. They are found mainly in the Thickwood Hills Upland and the Dunkirk Plain. A morainal outcrop with Horse River soils occurs on the Buckton Plain, east of the Birch Mountains Escarpment. Horse River soils also occur as non-mappable inclusions on the Dover and Hangingstone plains; a small area of these soils has, however, been mapped in the area of Kiskatinaw Lake.

Horse River soils were named after the Horse River till unit described and mapped by Bayrock and Reimchen (1974). It is described as generally thin and clayey containing fewer stones than Kinosis till. It is present on the western flanks of the Stony Mountain Upland and extends north of the Athabasca River to the Birch Mountains Upland, and underlies glaciolacustrine deposits over most of the area. In this project, the Horse River soil group applies only to those soils which are calcareous within a meter or so from the surface. The soils on the western flanks of the Stony Mountain Upland were found to be developed mainly on acidic parent materials and were included in the Surmont soil group.

The parent material is loam to clay loam in texture, dark grayish brown, and massive with a firm to friable consistency.

Its reaction is mildly to moderately alkaline and carbonate content is low. The content of coarse fragments is generally less than 10% by volume.

The topography of Horse River soils consists of gentle to moderate slopes (2 to 15%) on undulating to hummocky landform surface expressions. The deposit is generally a ground moraine. Some hummocky moraine occurs in the Thickwood Hills Upland and in the morainal area on the Buckton Plain. In Township 88, Range 16, a 'till doughnut' type of landform occurs. The till doughnut landform is also apparent in Township 86, Range 16, although it is partially masked by an eolian veneer.

The soil profile of an Orthic Gray Luvisol in the Horse River soil group contains a 5 to 10 cm thick LFH layer at the surface. It is predominantly a moderately decomposed layer of leaves and needles permeated with fungal hyphae. The Ae horizon is about 10 to 20 cm thick, light brownish gray or light gray, and silt loam in texture; its platy structure is moderately to strongly developed and is friable. An Ae2 with darker brown colouring can often be distinguished from an Ae1. An AB horizon of 5 to 15 cm thickness is usually present.

The Bt horizon is 30 to 60 cm thick and is divisible into Bt1 and Bt2 horizons on the basis of slight differences in colour and structure. Colours are generally brown to dark brown. The structure is strongly developed subangular blocky with firm consistency. A BC horizon is usually present and is about 15 to 40 cm thick, shows weakly developed subangular blocky structure, and is commonly weakly calcareous. Total solum depth is 75 to 100 cm. However, shallow profiles of 30 to 50 cm thickness occur in areas where the parent material is more strongly calcareous. Such soils occur as inclusions in Ruth Lake ecosystems on the Clearwater Plain.

Due to the presence of numerous depressional areas in morainal landforms, Horse River Orthic Gray Luvisols are almost everywhere associated with imperfectly drained Gleyed Gray

Luvisols and poorly drained peaty Gleysols. Organic soils are commonly significant components of ecosystems with predominantly Horse River soils.

Soil Unit: One Horse River soil unit has been described.

HRR1 - Dominantly well-drained Orthic Gray Luvisols in association with a significant amount of a combination of imperfectly drained Gleyed Gray Luvisols and peaty Gleysols. There may be minor inclusions of Organic soils.

Ecosystems: Ecosystems with Horse River soils occur mainly on undulating landforms, to a lesser extent on hummocky landforms, or on a combination of the two. Upland white spruce - aspen forest, aspen forest, mixed forest, and coniferous forest community types occur on Horse River soils. Balsam fir is commonly found in these communities. Transitional bottomland and riparian deciduous shrub and undifferentiated wetland communities occupy imperfectly drained sites. Black spruce forest is the most common community type on Gleysolic and Organic soils. Feathermosses usually form the ground cover on peaty Gleysols.

Ecosystems of Horse River soils in combination with Organic soils are more common than the simple or uncombined Horse River ecosystems. Horse River - Kenzie ecosystems are of greatest extent while combinations with Eaglesham and Mikkwa units are less common. Both landforms and vegetation of these various ecosystems are complexes of types as described elsewhere for the individual soil groups. Generally, these ecosystems consist of the Horse River soils on undulating or hummocky topography. In lower slope positions, transitional coniferous forest and deciduous shrub communities occur on imperfectly drained soils. These grade into black spruce forest and other wetland communities of bogs and fens.

6.11 JOSLYN SOIL GROUP (JSN)

The Joslyn soil group consists predominantly of moderately well-drained Gray Solodized Solonetz soils developed on clayey, stratified glaciolacustrine and mixed glaciolacustrine deposits. These soils occur extensively on the Dover Plain and may be found in minor amounts on the Hangingstone and Dunkirk plains.

The parent materials of Joslyn soils are thick or thin deposits of bedded glaciolacustrine clays and silts, or mixed glaciolacustrine materials composed of bedded silts and clays containing pebbles and till-like layers. The material is essentially the same as that described for the Dover soil group. Pinkish colours in these materials can usually be observed throughout the profile. These materials may be saline within 1 m of the surface with calcium sulphate, sodium sulphate, and other salts being present. Electrical conductivities of water extracts from these materials are generally less than 4 mS/cm, but measurements of up to 6 mS/cm have been obtained.

The landform surface expression is generally undulating with almost level to very gentle (less than 5%) slopes. The deposits are deepest at the eastern edge of the Dover Plain; over most of the plain, the parent materials occur as relatively thin blankets and veneers overlying morainal deposits of the Horse River type. The glaciolacustrine deposits have low perviousness and, consequently, level or depressional areas are generally poorly drained.

Typical Joslyn Gray Solodized Solonetz profiles have a 5 to 10 cm LFH horizon consisting mainly of moderately decomposed leaves and needles, and abundant fungal hyphae. The Ae horizon is about 5 to 15 cm thick, light gray, and has a silt loam texture. The platy structure is strongly developed and is friable when moist, but rather hard when dry. A second Ae2 horizon is uncommon. An AB horizon of 5 to 10 cm thickness may be present. The B horizon usually consists of Bnt1 and Bnt2 horizons which have a total thickness of 35 to 60 cm, are mainly brown in colour, and are clay to heavy clay in texture. The structure of the Bnt1 is columnar with round tops, breaking to strongly developed subangular blocky structure. The columnar structure is more weakly developed in the Bnt2 horizon, but the subangular blocky substructure is strongly developed. Consistency of the Bnt horizons is very firm when moist and hard when dry. There is only weak organic staining along Bnt horizon structure surfaces. Most roots are located in voids rather than in the soil matrix. A BC horizon of 20 to 40 cm thickness is usually present and may or may not be calcareous and saline. There is some subangular blocky structural development in the BC horizons. The C horizon is parent material which is usually a dark gray, slightly calcareous clay. Gypsum crystals may occur in the C horizon.

The upper solum (the Ae and AB horizons) commonly display weak yellowish mottling indicating that reducing conditions due to waterlogging have occurred intermittently. This probably results from water being held above the very slowly pervious Bnt horizon during and for a time after periods of precipitation, or during spring thaw.

Gray Solodized Solonetz soils are dominant in the Joslyn soil group. However, they probably do not account for much more than about 50% in most areas and are associated with other Solonetzic and Luvisolic subgroups. Minor inclusions of Organic soils occur in depressions.

Soil Units: Only one soil unit was used to describe the Joslyn soils.

JSN1 - Dominantly moderately well-drained Gray Solodized Solonetz with a significant to co-dominant proportion of a combination of Solonetzic Gray Luvisols and Orthic Gray Luvisols, and a significant combination of Gleyed Gray Luvisols and peaty Gleysols. Gray Solods and Organic soils occur in minor amounts.

Ecosystems: Joslyn ecosystems on level to undulating landforms are characterized by upland aspen forest, white spruce - aspen forest and mixed forest vegetation community types. The mixed coniferous community type occupies imperfectly drained sites and changes through deciduous shrub and undifferentiated wetland types to black spruce forest on poorly drained Gleysolic and Organic soils. The upland forest types are characterized by variability in stand height and density in areas of Solonetzic soils. This appears as a patchy pattern on aerial photographs, especially in areas with predominantly aspen cover. Small areas of only a few hundred square metres size with very stunted trees or only a vegetative cover of grasses and shrubs may occur in Solonetzic soil areas. Stunted plant growth at these sites results from high bulk density and salinity of the Solonetzic soils.

Combinations of the Joslyn soil group with Kenzie soil units, especially KNZ2, occur on level to undulating landforms. Vegetation is similar to that described above except that black spruce forest communities on Organic soils occupy a larger proportion of the landscape.

6.12 KEARL SOIL GROUP (KEL)

The Kearl soil group consists of rapidly drained Eluviated Dystric Brunisols developed on sandy and gravelly, abandoned beach ridge deposits. Although beach ridge deposits account for a very small proportion of land in the study area, they are considered numerous enough to justify descriptions of these as unique soil units and ecosystems.

The parent material of Kearl soils consists mainly of brown to grayish brown sands with small amounts of silt and clay and with significant gravel content. Stones may be present in small amounts. The reaction is strongly to slightly acidic.

The landform associated with Kearl soils is usually a group of parallel curvilinear ridges with very gentle to moderate slopes (2 to 9%). The deposits may be thick or may overlie fine glaciolacustrine materials within a metre of the surface. The materials are highly pervious and rapidly drained. Inter-ridge areas, however, are usually poorly drained.

The top of a Kearl Eluviated Dystric Brunisol is a LF horizon of about 2.5 cm thickness consisting of moderately decomposed leaves, needles, and lichens. The light gray Ae horizon is about 20 cm thick. An upper Ae1 horizon may have stronger brown and gray colouring due to mixing of organic materials from the litter layer. The B horizon can be quite variable. It is 20 to 30 cm thick but can usually be subdivided into two types. A sandy brown Bm horizon is usually present. This may be overlain by a brown, weakly developed Bt horizon of sandy loam to loam texture, or by a reddish brown, sandy, weakly to moderately developed Bf horizon. A BC horizon is usually present and is underlain by the sandy parent material at 75 to 100 cm, or by a contrasting fine-textured, firm, and relatively impermeable glaciolacustrine material.

As with other sandy soils in the study area, Eluviated Eutric Brunisols are associated with Eluviated Dystric Brunisols and peaty Gleysols while Organic soils occupy the imperfectly to poorly drained depressions between ridges.

Soil Unit: One soil unit was established to map the Kearl soil group.

KEL1 - Dominantly rapidly drained Eluviated Dystric Brunisols associated with significant amounts of Eluviated Eutric Brunisols, imperfectly drained Gleyed Eluviated Eutric Brunisols, and poorly drained peaty Gleysols. Organic soils are associated in minor amounts.

Ecosystems: Ecosystems with only Kearl soils or with combinations such as Kearl - Kenzie have very limited extent in the study area. The Kearl soil unit is most common in ecosystems where Kenzie soils are areally dominant among beach ridges. This is a consequence of the area between ridges (on which Organic soils have developed) being larger than the area occupied by the ridges themselves.

In Kearl and Kearl - Kenzie ecosystems, jack pine forest, mixed forest and aspen forest community types occur on the ridge tops. Although ridge tops are xeric, moisture content of the subsoil may be quite high due to clayey subsoil which impedes moisture movement. Species such as white spruce, aspen, jack pine, white birch, and willow may co-exist on such sites. Deciduous shrub commonly occurs on the imperfectly drained sites at the base of ridges, while black spruce forest occupies the poorly drained sites with peaty Gleysols or Organic soils between ridges.

6.13 KENZIE SOIL GROUP (KNZ)

The Kenzie soil group comprises a number of Organic soil subgroups developed on very poorly drained, extremely acidic (dysic), mesic and fibric bog peats. Soils of the Kenzie group are the most common of all soils in the study area. Ecodistricts in which Kenzie soils predominate are the MacKay, Steepbank, and Muskeg river plains. They occur very commonly in all other land districts except the Embarras and Athabasca Delta plains, and on the Birch Mountain, Gardiner, and McIvor uplands. On these latter uplands organic soils also occur very commonly but are characterized by the presence of permafrost and are, therefore, classified as Cryosolic soils; these are referred to as the Mikkwa soil group (Section 6.19).

Parent materials of the Kenzie soil group are bog peats which are sphagnum or forest peat materials formed in an ombrotrophic environment. Accumulation of these materials results in a slightly raised surface which dissociates a bog from nutrient-rich groundwaters or surrounding mineral soils. The deposits are variable in depth, ranging from 40 cm to greater than 400 cm. The microtopography of bogs is usually strongly mounded. Bogs occur in association with fens and large areas of organic deposits are transitional between these two. The surface expression is generally level but bowl bogs and slightly raised bogs also occur. Portions of bogs commonly have permafrost development with peat plateau surface expressions. Landform surface expression in areas of shallow peat deposits is level to undulating.

In previous soil surveys, the name Kenzie referred to a complex of Mesisols and Fibrisols developed on bog peats. Soil subgroups were not specified on soil maps in which Kenzie soils were identified. In the AOSERP study area, Kenzie also refers to a complex of Organic soils, but some subgroups were found to be more common than others. Fibric Mesisols are most common in the group of soils developed on more than 160 cm of peat. On deposits less than 160 cm, and commonly less than 100 cm, the Terric Mesisol subgroup is dominant.

As discussed previously, Organic soil profiles are divided into three tiers for purposes of description and classification (Section 4.2.1). In a Fibric Mesisol, an undecomposed to slightly decomposed, spongy, pale brown, sphagnic (fibric) Of layer extends through most of the 40 cm surface tier and at least 25 cm into the middle tier. The remainder of the profile consists of brown to dark brown, somewhat layered and compacted, moderately decomposed peat which can be designated as one or more Om horizons. Thin layers which are either weakly or strongly decomposed may be found within this zone. Charcoal may also occur in thin, black bands. A dark brown or black, well-decomposed Oh horizon may occur just above the mineral contact. The underlying mineral soil may be derived from any of the types of mineral parent materials described in the study area. The characteristics can be assumed to be similar to that of the parent material of the predominant mineral soil groups within an eco-district. Generally, the mineral materials in bogs are gray or bluish-gray in colour as a result of reduced, continuously waterlogged conditions.

The characteristics of Terric Mesisols are similar to those of Fibric Mesisols except that the Of horizon is thinner and there is a mineral contact within 160 cm of the surface. Several other Organic subgroups occur as listed in the soil units below. These profile types differ in thickness and degree of decomposition of materials as described in Section 4.2.1. Fibric Organic Cryosols are also associated with these subgroups in some areas.

Soil Units: Two Kenzie soil units distinguished by predominance of one of the main subgroups described above were established in the study area.

KNZ1 - Dominantly very poorly drained Fibric Mesisols in association with significant to co-dominant amounts of combinations of any or all of Typic Mesisols, Mesic Fibrisols, Typic Fibrisols, and Fibric Organic Cryosols. Terric Mesisols, fennic Organic subgroups, and other subgroups may occur in minor proportions.

KNZ2 - Dominantly Terric Mesisols in association with significant to co-dominant amounts of combinations of any or all of Terric Fibric Mesisols, Terric Fibrisols, and Fibric Mesisols. Peaty Gleysols, fennic Organic subgroups, and other subgroups may occur as minor inclusions.

Ecosystems: Ecosystems of KNZ1 with level surface expression and KNZ2 with level or undulating surface expression occur extensively through most of the study area. Complex level and plateau landforms occur where Cryosols are associated with the Organic soils of this group. Black spruce forest is the characteristic community type on Kenzie soils. Ecosystems in which the KNZ1 soil unit is predominant may have other wetland communities such as semi-open black spruce forest and lightly forested tamarack and open muskeg. Fen communities may be associated in minor amounts. Soils of the KNZ2 unit predominantly support black spruce forest. Rather than sphagnum mosses, feathermosses form the dominant ground cover in many KNZ2 ecosystems.

The Kenzie soil group occurs in combination with almost every other soil group in the study area. Only the Chipewyan, Mamawi, and Mikkwa soil groups were not mapped in combination with the Kenzie units. Kenzie soils also occur as minor inclusions in most mineral soil groups. Landforms of the combined ecosystems are complexes of level or undulating forms with any of the various forms on which the mineral soil groups occur. Likewise, vegetation is a combination of wetland bog community types and upland types as described for the individual soil groups.

6.14 KINOSIS SOIL GROUP (KNS)

Soils of the Kinosis group are mainly well- to moderately well-drained Orthic Gray Luvisols developed on loamy, acidic to neutral, morainal deposits. These soils occur on undulating and hummocky terrain with gentle to moderate slopes. Kinosis soils are found in the Muskeg Mountain Upland and on the Steepbank, Garson, and House plains.

The parent genetic material of Kinosis soils is morainal material which has been called Kinosis till by Bayrock and Reimchen (1974). The till is brown to grayish brown, fine sandy loam to clay loam in texture, and contains numerous pebbles, stones, and boulders. Generally, this material is a medium-textured till of the type found at the Muskeg Mountain lookout tower (Tp 94, R 6, W 4; Appendix, Section 9.2). West of this area, the till is finer in texture and may be overlain by very thin mixed glaciolacustrine sediments. Eastward, the till grades into a sandier type of deposit referred to as Gipsy till by Bayrock and Reimchen (1974). On the Stony Mountain Upland, the till is commonly darker and more clayey than elsewhere, possibly as a result of relatively greater incorporation of underlying bedrock shales.

The BC and C horizons of Kinosis soils are commonly strongly acidic in reaction. The parent material is very strongly to extremely acidic where incorporation of shaly materials has apparently occurred. In most areas, however, reaction is weakly acidic or near neutral. Soils developed in tills of similar textures but which are calcareous within 1 m of the surface are included in the Horse River soil group.

The LFH horizon of a Kinosis soil consists of slightly to moderately decomposed needles, leaves and lichens, and is usually 5 to 10 cm thick. An Ae horizon with moderately developed platy structure ranges from about 10 to 25 cm in thickness and usually can be separated into a light gray Ae1 overlying a pale brown Ae2. The texture is usually fine sandy loam. A transitional AB horizon is commonly present. A brown Bt horizon displays weak to moderate subangular blocky structure and ranges from fine sandy loam to clay loam in texture. It can often be subdivided into Bt1 and Bt2 horizons based on small differences in colour and structure. Its total thickness range is about 25 to 55 cm. A BC horizon occurs in almost all of these soils. The lower limit of the solum is usually about 60 to 80 cm, but it often extends to about 120 cm. The properties of the C horizon are as described above for the parent material.

The Kinosis Orthic Gray Luvisols are almost everywhere associated with Gleyed Gray Luvisols and peaty Gleysols of the Steepbank soil group which occupy depressional areas in the morainal terrain. Depressional sites in most areas contain peat deposits, however. Brunisolic Gray Luvisols, which are similar to Orthic Gray Luvisols in properties, and in associated landforms and vegetation may also occur in the Kinosis group.

Soil Unit: There is one soil unit within the Kinosis soil group.

KNS1 - Dominantly well-drained Orthic Gray Luvisols in association with significant amounts of a combination of imperfectly drained Gleyed Gray Luvisols and poorly drained peaty Gleysols. Organic soils may occur in minor amounts. Brunisolic Gray Luvisols and other inclusions such as Eluviated Dystric Brunisols on kame deposits may also occur.

Ecosystems: Ecosystems with the uncombined Kinosis soil unit have undulating or hummocky landforms, or a combination of both. Upland mixed coniferous and jack pine forests are predominant community types on Kinosis soils. Other upland types such as aspen forest, mixed forest, and undifferentiated communities also occur. The distribution of different upland communities does not appear to be wholly related to soil and landform factors, and as in other parts of the study area, fire history is probably one determinant of community type. Deciduous shrub and black spruce occupy imperfectly drained sites and wetland community types, mainly black spruce forest, occur on poorly drained Gleysolic and Organic soils.

Map combinations of Kinosis soils with the KNZ2 soil unit comprise the most common compound ecosystems. Landforms may be undulating, hummocky, or a combination of both. Vegetation is as described above except that black spruce forest occupies a larger proportion of the landscape. Some combinations of Kinosis with the KNZ1 unit and with Eaglesham have been mapped. These occur on undulating topography and have various wetland bog and fen communities associated with upland types as described above. Kinosis soils may also occur in association with Mildred and Livock soils. Such ecosystems occur mainly on undulating landforms and support a variety of upland community types.

6.15 LEGEND SOIL GROUP (LGD)

Soils of the Legend group are well- to moderately well-drained Orthic Gray Luvisols developed on loamy to clayey, strongly to extremely acidic morainal deposits. These soils occur mainly on hummocky and fluted, or ridged, landforms. Areas of these soils on undulating landforms are of limited extent. Stoniness and rockiness of Legend soils is moderate to extreme, but the flutings are generally exceedingly stony. Pockets of gravelly and stony ice-contact deposits are associated with the morainal materials.

The Legend soils occur entirely in the Birch Mountains, Gardiner uplands, and the McIvor Plain.

The glacial till in which Legend soils have formed is brown to very dark grayish brown, loamy to clayey, firm, and strongly to extremely acidic. The content of coarse fragments is about 10% by volume. Depth of the morainal material is variable and is probably deepest in hummocky highs on the McIvor Plain. Where the surface deposit is thin, an abrupt boundary divides the till in which soils have developed from an underlying very dark grayish brown, basal till. Much of the fine earth fraction is likely derived locally from shales of the underlying Cretaceous formations.

The LFH layer of Legend soils is normally less than 5 cm and occasionally up to 10 to 12 cm in thickness. This litter layer consists of moderately decomposed needles, leaves, lichens, and mosses. The Ae horizon is generally thin (5 to 10 cm), silt loam in texture, and strongly platy. A 5 to 20 cm AB horizon is usually present. There generally is a Bt1 and a Bt2 horizon which together are about 30 to 55 cm thick. The Bt is dark yellowish brown, clay loam in texture, firm in consistency, and has strong subangular blocky structure. The Bt2 commonly has weaker structural development and more friable consistency as compared to the Bt2 and to upper Bt horizons of Luvisols in other parts of the study area. A BC horizon of 15 to 30 cm thickness contributes to a total solum depth of 60 to 90 cm.

Soils of the Legend group have developed in a slightly cooler and wetter environment than Luvisols in other parts of the study area. From observations made in the field, these soils appear to be relatively wet through most of the growing season. Frost is encountered in mineral soils even in early July. After periods of several millimetres precipitation, it was observed that a saturated zone formed above the relatively impermeable Bt horizon and above the basal till at some sites. Weak mottling occurs in these soils, suggesting that they are subjected to reducing conditions for appreciable periods of time. These are classified as Gleyed Gray Luvisols and can be found on apparently well-drained sites as well as in lower slope positions. Peaty Gleysols are associated with the better-drained soils in all areas.

Thin LFH horizons as described above are another characteristic feature of Legend soils. It is probable that the litter layer is burnt off by forest fires. This observation as well as the generally young age of forest stands suggest that fires occur frequently in the Birch Mountains.

Soil Units: One soil unit was used to map the Legend soil group.

LGD1 - Dominantly well- to moderately well-drained Orthic Gray Luvisols in association with significant, and in some areas, co-dominant amounts of a combination of imperfectly drained Gleyed Gray Luvisols and poorly drained peaty Gleysols. Organic soils and other subgroups such as Eluviated Dystric Brunisols on sandy ice-contact deposits may occur as minor inclusions.

Ecosystems: Areas of land consisting only of the Legend soil unit on hummocky, ridged or undulating landforms, or on combinations of these, constitute ecosystems which have limited extent in the study area. Map combinations of Legend and Mikkwa soils are of greatest extent. Upland mixed coniferous forest is common on Legend soils while mixed forest, aspen forest, and jack pine forest occur less extensively. The mixed coniferous community type is dominated by jack pine in upper slope positions and by black spruce in mid and lower slope positions. As indicated in Section 5.1.2, the pines may include jack pine - lodgepole pine hybrids. Black spruce and deciduous shrub occupy imperfectly drained sites and grade into black spruce forest as more poorly drained Gleysolic and Organic soils are encountered downslope.

In Legend - Mikkwa ecosystems, landforms are the same as described above except that depressions are filled with peat.

Soils on the peat deposits are Organic Cryosols which support mainly black spruce forest communities. Complex peat plateau and mineral landforms are indicated on the soil maps where these ecosystems occur. Both units of the Mikkwa soil group are mapped in combination with Legend soils. The Legend soil group also occurs in association with Eaglesham soils, especially in fluted morainal terrain where string fens occupy the elongated depressions between ridges. Numerous examples of these ecosystems can be found south of the Buckton lookout tower in Tp 102, R 13, W 4.

6.16 LIVOCK SOIL GROUP (LVK)

The Livock group of soils is composed dominantly of well-drained Orthic Gray Luvisols developed on loamy, glaciolacustrine or glaciofluvial veneers and blankets overlying finer textured deposits. They occur most commonly on the Dunkirk, Algar, and Clearwater plains.

Particle size composition of Livock soils ranges from coarse-loamy to silty and fine-loamy in glaciofluvial deposits. Some of the materials are possibly eolian in origin. The deposits are mainly veneers and blankets, which overlie finer morainal or glaciolacustrine sediments; others, however, overlie sandy glaciofluvial materials. A loam to clay loam texture in the Bt horizon is the main criterion which distinguishes Livock soils from the fine-textured Dover soils and the coarser-textured Mildred soils. Relatively unaltered parent materials of Livock soils are rarely found because the solum is developed throughout the primary parent material and often extends into the underlying secondary parent material. This secondary material, if morainal, is the calcareous Horse River type of till; if glaciolacustrine, the material is similar to that of Dover soils.

The surface of a Livock Orthic Gray Luvisols is a 5 to 10 cm thick LF horizon which consists of slightly to moderately decomposed leaves and needles, and abundant fungal hyphae. A gray silty and platy Ae horizon is 10 to 20 cm thick. A strongly bleached upper Ae1 horizon can usually be distinguished from a slightly darker Ae2 horizon. There may be a thin AB horizon. The Bt horizon is 25 to 45 cm thick and usually has two subhorizons. It is brown, loam to clay loam in texture, and has strongly developed subangular blocky structure. Part of the Bt horizon and the BC horizon are developed in the secondary parent material in many areas. The total depth of the solum varies between about 60 and 100 cm. Soil reaction ranges from extremely to medium acidic from the top to the bottom of the solum.

The landform surface expression of Livock soils is generally undulating with gentle slopes (2 to 9%). As almost all Livock soils are developed on veneers and blankets, the surface expression reflects the landform of the underlying material. Soils similar to the Livock group occur along meltwater channels but are often stony and rocky and are, therefore, included in the Ruth Lake soil group.

Other soils associated with Orthic Gray Luvisols are imperfectly drained Gleyed Gray Luvisols and poorly drained peaty Gleysols. Organic soils occur in minor amounts. Some soils in the Livock group have a relatively brightly coloured (yellowish brown to strong brown) Bm horizon overlying the Bt horizon. Such soils are classified in the Brunisolic Gray Luvisol subgroup. They are similar to Orthic Gray Luvisols in their properties, drainage conditions, and the type of vegetation they support.

Soil Unit: One unit within the Livock soil group was described.

LVK1 - Dominantly well-drained Orthic Gray Luvisols in association with significant amounts of imperfectly drained Gleyed Gray Luvisols and poorly drained peaty Gleysols. Organic soils and Brunisolic Gray Luvisols occur as minor inclusions.

Ecosystems: Livock ecosystems occur on undulating landforms as described above. Vegetation is quite variable, with mixed forest probably being most common, but white spruce-aspen, aspen, and coniferous forest community types also occur. Jack pine forest occurs on coarser textured members of this soil group. Bottomland and riparian forest occurs on imperfectly drained sites in Livock ecosystems in the southwest corner of the map area, west of the Athabasca River. The soils of large, imperfectly to poorly drained areas in this region are placed in the Steepbank soil group. In other areas, deciduous shrub and mixed coniferous forest occupy imperfectly drained sites with Gleyed Gray Luvisols. Mixed coniferous forest with predominantly black spruce and feathermoss ground cover, or black spruce forest, occur on poorly drained peaty Gleysols in depressional areas.

Combinations of Livock soils with Kenzie, Eaglesham, Mildred, and Mikkwa soil groups have been mapped. All occur on level to undulating landforms or on complex landforms including patterned surface expressions for the Eaglesham soil group, and peat plateaus for the Mikkwa group. Bog and fen vegetation communities occupy a significant proportion of ecosystems with Kenzie, Eaglesham, and Mikkwa soils. Livock - Mildred soil complexes have a larger proportion of jack pine forest than the simple Livock ecosystems.

6.17 MAMAWI SOIL GROUP (MMW)

Mamawi soils are predominantly poorly drained Rego Gleysols developed on fluvial delta deposits. They are of limited extent, occurring only in the Athabasca Delta Plain in association with the Chipewyan soil group.

Parent materials are weakly calcareous or neutral in reaction, non-stony, and loamy to clayey in particle size composition. They are dark grayish brown, massive, and very sticky. There is horizontal and vertical variability in composition, but not as great as in Chipewyan soils. The deposits are laminated with bands of mineral materials alternating with thin layers of organic matter in various stages of decomposition. Organic matter content of the mineral material can be fairly high to the extent that some layers have a mucky composition.

The landform of Mamawi soils is level to depressional. It consists of relatively large inter-levee areas, back swamps, lake margins, and floodplains of the delta area. Mamawi soils which occur in narrow inter-levee areas are significant components of the Chipewyan soil group.

The surface of a Mamawi Rego Gleysol is usually a very thin peaty layer of slightly to moderately decomposed reeds and sedges. Parent material with essentially no profile development directly underlies this layer.

Other soils associated with Mamawi Rego Gleysols include Gleyed Cumulic Regosols and Gleyed Regosols of the Chipewyan soil group. Peaty Gleysols and Organic subgroups occur in minor amounts. Rock outcrops occur in areas of Mamawi soils north of Lake Athabasca.

Soil Units: Two soil units in the Mamawi group were distinguished on the basis of proportions of better-drained soils associated with the poorly drained Gleysols.

MMW1 - Dominantly poorly drained Rego Gleysols in association with significant amounts of imperfectly drained Gleyed Cumulic Regosols and Gleyed Regosols. Gleysols overlain by thin peat and Organic soils occur in minor amounts.

MMW2 - Dominantly poorly drained Rego Gleysols. Peaty Gleysols may occur as minor inclusions.

Ecosystems: Ecosystems consist of the MMW1 soil unit on level to undulating surfaces and of MMW2 on level landforms. In areas which are flooded for relatively long periods in the spring, the vegetation on these soils is similar to that of fen communities except that various species of rushes and reeds are more common. Where spring flooding occurs only for brief periods, willow species invade areas of fen communities. Mature willow - sedge communities occupy large areas farther away from lake edges and may form transition zones to bottomland and riparian forest communities on better drained soils. Reference should be made to the report of Dirschl et al. (1974) for more complete descriptions of landform - vegetation relationships in the delta.

6.18 McMURRAY SOIL GROUP (MMY)

McMurray soils are imperfectly to poorly drained Regosolic and Gleysolic soils developed on postglacial fluvial deposits on floodplains of creeks and rivers. These soils are found throughout the study area. The largest areas are the floodplains of the Clearwater and Athabasca river valleys.

Across the map area, particle size composition of McMurray parent materials varies greatly due to the meandering nature of the streams and the variable lithology of the sediments. Textures are also dependent on the nature of the glacial deposits regionally; the fluvial sediments are generally sandy in eolian and glaciofluvial plains, but are loamy and clayey in morainal and glaciolacustrine areas. Loamy composition is probably most common, but with a profile the textures can range from sandy loam to clay among strata of various thicknesses. The materials are generally dark gray, dark brown, or very dark grayish brown in colour, and very friable in consistence. Reaction is slightly acidic, neutral, or mildly alkaline where carbonates are present. Stones are absent except near valley banks where some colluvial materials may have accumulated.

McMurray soils occur on floodplains of aggrading rivers and streams. The landform surface expression is generally level to undulating. Terraces are common and many of the floodplains are slightly inclined. Meander scars are common features on floodplains of streams with low gradient. Ecosystems with McMurray soils usually include the inclined to steep, rough broken valley banks above the floodplains.

The Cumulic Regosol subgroup is prevalent in the McMurray soil group. These soils consist of banded deposits in which many of the layers are buried organo-mineral (Ah) horizons which represent former surfaces. Horizon development is otherwise lacking. Relatively undecomposed organic material may be preserved in some of the buried horizons. Associated with these soils are Orthic Regosols which have little or no evidence of buried horizons, and Gleyed Regosols and Gleyed Cumulic Regosols, which display mottling within 50 cm of the soil surface. Peaty Gleysols are commonly associated with the Regosols. Soils on upper terraces or on upper slopes of inclined floodplains may show juvenile soil development as indicated by the presence of thin Ae horizons.

Soil Units: Based on proportions of poorly drained soils, the McMurray group is divided into two soil units.

MMY1 - Dominantly a combination of moderately well- to imperfectly drained Cumulic Regosols and Orthic Regosols in association with significant amounts of a combination of imperfectly drained Gleyed Cumulic Regosols and poorly drained peaty Gleysols. Gleyed Regosols may also occur, and Organic soils may be present in minor amounts.

MMY2 - Dominantly a combination of imperfectly to poorly drained Gleyed Cumulic Regosols and peaty Gleysols associated with significant amounts of moderately well to imperfectly drained Cumulic Regosols and Orthic Regosols. Minor inclusions of Organic soils may occur.

Ecosystems: Ecosystems with the MMY1 soil unit occur on level, undulating, inclined or terraced surfaces, while the MMY2 soil unit is found mainly on level surfaces. Bottomland and riparian forest is the predominant community type on Regosolic soils.

The wetter Gleyed Cumulic Regosols and the peaty Gleysols support deciduous shrub communities. Fen or bog communities associated with Organic soils occur on the wettest sites.

McMurray soils commonly occur in combination with the Rough Broken land unit of valley sides. If the valley banks with Rough Broken lands account for a minor proportion (less than 15%) of a valley ecosystem, a McMurray soil unit is shown on the map in uncombined form. When these account for a significant areal proportion, compound units are mapped. Vegetation on the McMurray component of these ecosystems is as described above. Rough Broken lands may be non-vegetated but commonly support communities such as mixed forest or coniferous forest dominated by white spruce.

Combinations of McMurray with Kenzie and Eaglesham are uncommon. Fen vegetation occupies shallow channels along many of the small watercourses in the study area. Soils along these streams are thought to be peaty Gleysols, but many may have sufficient depths of peat accumulation for classification as Organic soils. Such land units were not inspected thoroughly and most are mapped as the MMY2 soil unit on level topography. Where peat accumulation was apparent from aerial photographs, McMurray - Eaglesham combinations were mapped.

6.19 MIKKWA SOIL GROUP (MKW)

The Mikkwa soil group is a complex of Organic Cryosolic subgroups that have developed on very poorly drained, extremely acidic (dysic), fibric and mesic bog peats. Mikkwa soils have developed on the same types of materials as the Kenzie group, but due primarily to climatic factors, a permanently frozen layer has developed within the organic deposits. These soils are extensive in the Birch Mountains and Gardiner uplands, and the McIvor Plain. They also occur commonly on the Dunkirk and Algar plains, but are rarely mapped in other parts of the area. The Mikkwa soils, however, occur as inclusions in the Kenzie soil group in all parts of the study area with the possible exception of the Athabasca Delta Plain and the McMurray Lowland.

The parent material of Mikkwa soils is much the same as that described for the Kenzie soil group. Occurrence of fibric peat is probably more widespread than mesic peat. The ice contact is between 40 and 80 cm, and thickness of the frozen layer varies from less than 1 m to about 4 m. The frozen layer is mostly confined within the peat deposit, but in some locations it extends into the underlying mineral material. Most of the soils are classified as Fibric Organic Cryosols due to the dominance of fibric peat in the control section (100 cm), but material below 100 cm is commonly mesic. A thin layer of well-humified peat may be present at the contact with mineral soil. Forest and fen peats, as well as sphagnum peat, occur at various depths in these soils.

The peat plateau landform type is characteristic of Mikkwa soils. Development of peat plateaus has been described by Zoltai (1972). The development of permafrost layers is generally dependent on the climatic factors of temperature and precipitation. Various interrelated factors include depth of frost penetration, depth of snow cover, amount of solar radiation, tree density, and others. The plateau landform is caused by doming, or elevation by volume increase due to freezing and by buoyancy of the frozen peat. The doming also produces an insulating effect due to drying of the surface layers of peat upon being raised.

The peat plateaus go through young, mature, and overmature developmental stages (Zoltai 1972). Examples of each of these can be found in the study area. Young peat plateaus are in an aggrading stage while overmature areas are in a degrading stage. The overmature stage is characterized by thermokarst features and collapsing edges. Circular collapse scars are the most common thermokarst features in the study area, and these also appear to be in different stages of development as some have only fen vegetation and others have small peat plateaus reforming in them.

'Drunken Forest' vegetation and a ring of shallow water is typical of the edges of collapse scars.

The height of peat plateaus is generally 1 to 3 m in the Birch Mountains Upland and less than 1 m in other areas. Within plateaus, the surface is strongly mounded or 'micro-hummocky'. Small drainage channels with fen vegetation separate individual peat plateaus. In the Birch Mountains, peat plateaus occur on slopes as great as 9%. Elsewhere in the study area, they occur only in level peatlands.

The Fibric Organic Cryosol subgroup is predominant in Mikkwa soils. It usually consists of pale brown, sphagnic, fibric peat in the top metre, but is frozen below 40 to 80 cm. Ice lenses of a few centimetres thickness can be found in this layer. Thin bands of dark mesic material which often contain charcoal occur in most profiles. The Mesic Organic Cryosol subgroup can be found in association with Fibric Organic Cryosols. These have a fibric and sphagnic surface layer, but below 15 to 40 cm, the material is moderately decomposed and dark brown to black in colour. Below 1 m, the material is commonly mesic and of varied origin in both subgroups. Typic Fibrisols and other Organic subgroups may also be associated with the Cryosols. Terric Mesic Organic Cryosols have less than 1 m of peat above a mineral contact. These occur in association with Mesic Organic Cryosols and Terric Mesisols.

Soil Units: Two soil units were established within the Mikkwa soil group.

MKW1 - Dominantly Fibric Organic Cryosols in association with significant amounts of Mesic Organic Cryosols and Typic Fibrisols. Fennic Organic soils in collapse scars are minor inclusions. (The Typic Fibrisols occur in smaller amounts in the Birch Mountains Upland than in other parts of the study area.)

MKW2 - Dominantly Terric Mesic Organic Cryosols in association with significant to co-dominant amounts of Mesic Organic Cryosols and Terric Mesisols. Fennic Organics in collapse scars are minor inclusions.

Ecosystems: Both simple and compound ecosystems with predominantly Mikkwa soils are extensive in the Birch Mountains and Gardiner uplands, and occur over almost all of the McIvor Upland. Ecosystems with the Mikkwa soil units occur on plateau landforms or on combined plateau and inclined surfaces. The typical vegetation is black spruce forest. Sphagnum mosses form the ground cover in most areas, but feathermosses also occur. The small hummocks or mounds typical of peat plateaus are quite dry and usually have a lichen cover. Extensive areas of treeless peat plateaus occur in the Birch Mountain Upland, particularly in the McIvor Upland. Fires have occurred in some of the areas very recently. (For example, see Figure 5, p. 9, in Thompson (1979). In other locations, regenerating black spruce are sparse and 1 to 2 m in height. Lichens, ericaceous shrub, and some mosses comprise the dominant cover species in these areas.

The most common compound ecosystems consist of Mikkwa and Eaglesham soils on a combination of plateau, horizontal, and patterned landforms, and with the associated bog and fen vegetation. Many Mikkwa - Legend combinations have also been mapped. These have landforms which are complexes of peat plateau and mineral hummocky, ridged, or undulating forms. Combinations of Mikkwa with Firebag, Livock, and Algar soil groups are found rarely. In these combinations, the associated landforms and vegetation are complexes of those described individually for each soil group.

6.20 MILDRED SOIL GROUP (MIL)

The Mildred soil group consists of rapidly drained Eluviated Dystric Brunisols and Eluviated Eutric Brunisols developed on sandy, glaciofluvial outwash deposits. They are found extensively in the Embarras Plain and to a limited extent in the Muskeg River, Clearwater, and Flett Lake plains. Their extent is very limited in the Johnson Lake Plain and occurrences in other areas are rare.

The parent material of Mildred soils is brownish yellow to brown, and strongly to slightly acidic. The sands are well sorted with very little, if any, silt and clay. There may be some gravel and a few rounded stones. The deposits of the Embarras Plain are generally deep. Those of the Muskeg River and Clearwater plains are mainly veneers and blankets overlying morainal and glaciolacustrine deposits, and in some locations they directly overlie tar sands or limestone. Lenses or slabs of tar sand incorporated in these sediments may also occur in some areas.

The surfaces of the glaciofluvial deposits have been reworked by eolian activity in many areas. Where the entire soil profile is in eolian sand and where dunes have formed, soils were mapped in the Heart group. Composition and properties of Mildred and Heart soils are similar and they commonly occur together.

The landform surface expression of the Mildred soil group is undulating with nearly level to gentle slopes. Some areas are hummocky or rolling, but they have not been separated from the predominantly undulating areas on the soils maps.

The Eluviated Dystric Brunisol subgroup is predominant in the Mildred soil group. This subgroup is characterized by a pH of less than 5.5 throughout the solum as compared to Eluviated Dystric Brunisols which have a pH greater than 5.5 in part of the solum. Morphologically, soils of these two subgroups are very similar. The surfaces are 1 to 5 cm thick LFH layers consisting of dark brown to black, slightly to moderately decomposed leaves, needles and lichens. The Ae horizons are 5 to 10 cm thick, but are thinner in some places. At some sites, a dark brown Ahe can be separated from the gray to brown Ae. A yellowish brown to dark yellowish brown AB horizon is usually present. The Bm horizon is 20 to 50 cm thick and is typically yellowish brown in colour. In some areas, however, a very weakly developed textural (Btj) horizon occurs. The Bm horizon changes very gradually with depth and boundaries are often arbitrarily established in soil descriptions. A BC horizon of 20 to 30 cm thickness is commonly present. Depth of the solum varies from about 50 to 100 cm. The soil material is highly pervious and drainage is rapid to very rapid in all Mildred soils.

Soil profiles on the Flett Lake Plain in the Precambrian Shield area have somewhat brighter B horizons than those occurring elsewhere. Their appearance is similar to that of Podzols, but their iron and aluminum content is not as high as that of Podzols.

Eluviated Eutric Brunisols, as noted above, are similar to Eluviated Dystric Brunisols. Some of those occurring in the Muskeg River and Clearwater plains, however, overlie calcareous glacial till and limestone bedrock. These soils have higher pH and probably higher base status than members of this group elsewhere. Those Mildred soils developed in veneers usually overlie relatively impermeable materials and have relatively higher moisture status which is reflected in vegetation type. Gleyed Eluviated Eutric Brunisols and peaty Gleysols may occupy depressional sites in areas of Mildred soils. Gleyed Eluviated Dystric Brunisols are uncommon as the subsurface water is usually sufficiently high in cations to maintain pH in the solum above 5.5.

Soil Units: Two soil units within the Mildred soil group are differentiated on the basis of proportions of poorly drained soils.

MIL1 - Dominantly rapidly drained Eluviated Dystric Brunisols associated with significant amounts of rapidly drained Eluviated Eutric Brunisols. Gleyed Eluviated Eutric Brunisols and peaty Gleysols are minor inclusions.

MIL2 - Dominantly rapidly drained Eluviated Dystric Brunisols associated with significant amounts of rapidly drained Eluviated Eutric Brunisols, imperfectly drained Gleyed

Eluviated Eutric Brunisols, and poorly drained peaty Gleysols. Organic soils may occur in minor amounts.

Ecosystems: Ecosystems of Mildred soils on undulating topography are extensive in the northeastern part of the study area. Jack pine forest is the typical vegetation type of these ecosystems. Upland mixed forest may occur in some moister sites. In moving through imperfectly drained to poorly drained sites, vegetation is transitional from mixed forest or mixed coniferous forest types, through deciduous shrub, to black spruce forest. Jack pine stands vary considerably in height, density, and age due to numerous forest fires.

Combinations of Mildred with Heart, Kenzie, Eaglesham, and Rock units have also been mapped. These ecosystems occur on predominantly undulating surfaces, or on combined undulating and hummocky surfaces in the case of combinations with the Rock land type. Vegetation is as described above. In ecosystems with Kenzie and Eaglesham soils, bog and fen vegetation types occupy a relatively larger portion of the landscape.

6.21 NAMUR SOIL GROUP (NAM)

Namur soils are a group of moderately well- to imperfectly drained Regosols and poorly drained Gleysols developed on loamy to clayey, fluvial fan, and apron deposits. The Buckton Plain consists predominantly of Namur soils. They also occur in the Garson and Hangingstone plains at the base of the Cheecham Hills Escarpment.

On the Buckton Plain, the parent materials of Namur soils are derived from the surficial glacial deposits and the underlying Cretaceous shales of the Birch Mountains Upland. Erosion is very active in the Birch Mountain Escarpment. Eroded material is removed via numerous creeks and rivers flowing eastward from the Birch Mountains and is deposited in fans and aprons on the plains below. A similar process occurs on the Cheecham Escarpment on the north and east flanks of the Stony Mountain Upland. The fluvial material is gray to dark grayish brown, extremely to strongly acidic, non-stony, and varies from fine sandy loam to clay in texture. The thickness of these deposits is variable, generally decreasing eastward away from the Birch Mountain Escarpment. On the eastern edges of the Buckton Plain, glaciofluvial and eolian sands underlie the fluvial materials.

Fans and aprons with nearly level to very gentle slopes are the main landform surface expressions of Namur soils. Many areas, particularly those more distant from the uplands, are level. Some small channelled areas which are devoid of vegetation indicate that the fluvial process status is active.

Orthic Regosols, Gleyed Regosols, and Cumulic Regosols are common subgroups on moderately well to imperfectly drained sites. The surface on these is a 5 to 15 cm thick LFH horizon consisting of slightly to moderately well-decomposed leaves. The mineral material underlying the LFH is the parent material as described above. Different C horizons can be distinguished on the basis of small differences in colour, texture, and structure. The structure of the C horizon material is mainly granular to fine subangular blocky.

Cumulic Regosols differ from Orthic Regosols in having buried Ah and LFH horizons in the profile. Gleyed Regosols, including Gleyed Cumulic Regosols, show evidence of gleying, usually mottling, within 50 cm of the surface.

Peaty Gleysols, mostly of the Rego Gleysol subgroup, are found in poorly drained areas. The surface consists of a thick LFH layer or up to 60 cm of fibric peat of either sphagnic or fennic origin. The underlying mineral material is as described for the parent materials except that it is strongly gleyed to the surface and is water saturated either permanently or for very long periods during the year.

Soil Units: Two Namur soil units were established on the basis of difference in proportions of relatively well-drained and poorly drained soils.

NAM1 - Dominantly a combination of moderately well-drained Orthic Regosols and Cumulic Regosols, in association with significant to co-dominant proportions of a combination of imperfectly drained Gleyed Regosols (and Gleyed Cumulic Regosols) and peaty Gleysols. Organic soils may be minor inclusions.

NAM2 - Dominantly a combination of imperfectly drained Gleyed Regosols (and Gleyed Cumulic Regosols) and poorly drained peaty Gleysols in association with significant amounts of a combination of Orthic Regosols and Cumulic Regosols. Organic soils may be minor inclusions.

The subgroup in brackets above is not indicated in the legend accompanying the soil maps. Gleyed Cumulic Regosols are present, but are often difficult to distinguish from Gleyed Regosols.

Ecosystems: In ecosystems having predominantly Namur soils, the NAM1 unit occurs on fan or apron surfaces, and the NAM2 unit on apron or level surfaces. The main vegetation types on the mesic, relatively well-drained sites of Namur soils are bottomland and riparian forest, coniferous forest, and mixed coniferous forest. Mixed forest and aspen forest may occur on well-drained sites. On imperfectly drained soils, bottomland and riparian deciduous shrub is most common, although fen communities and black spruce forest also occur. Deciduous shrub on Namur soils had a high proportion of dwarf birch at sites examined. Numerous white birch stands are also characteristic of these soils.

Large areas of Namur soils are associated with Kenzie and Eaglesham soils. These ecosystems occur on apron or depressional to level surfaces. Except for larger proportions of bog and fen communities, vegetation is as described for the simple ecosystems.

6.22 ROCK LAND TYPE (R)

Although Rock is included in the legend under the heading of 'Soil Group', it is considered to be non-soil. This unit is distinguished by material rather than soil and is, therefore, more appropriately termed a Land Type.

Rock refers to consolidated material consisting of tightly packed, indurated materials of bedrock origin. In this survey, this unit refers to outcrops of undifferentiated rock materials. However, different rock classes do occur in the study area and their distribution can be indicated in relation to the ecodistricts they occur in.

Rocks of the Precambrian shield differentiate the Flett Lake Plain, at the north end of the study area, from other ecodistricts. They are mainly composed of granite, gneiss, and metasedimentary rocks (Green 1972). The surface expression of these outcrops is hummocky. They are associated with Brunisolic soils on small glaciofluvial sand plains and with coarse glacial sediments deposited mainly on their lee sides.

On the Muskeg River Plain, rocks of the Devonian Waterways Formation and of the Cretaceous Clearwater and McMurray formations are exposed, but their extent is very limited. The Waterways Formation consists of argillaceous limestone and gray shale, the Clearwater Formation of dark gray silty shale and siltstone, and the McMurray Formation of quartzose sandstone and siltstone impregnated with oil (Green 1972). Ironstone concretions can be found in the material from the Clearwater Formation near Fort MacKay. Fossils are common in the Waterways limestones. All outcrops of these materials occur on or near river and creek banks. These materials commonly underlie Mildred and other soil groups on the Muskeg River Plain (Hardy Associates Ltd. 1980).

Materials of various Cretaceous formations are also exposed in many river and creek valleys, and in slump areas in the Birch Mountains and Cheecham Hills escarpments. These are described as inclusions in the Buckton soil group or the Rough

Broken land type. Shaly bedrock may also occur near the surface on topographical highs of the McIvor Upland in the Birch Mountains and may be exposed in creeks and gullies through much of the study area.

Map Unit: There is one Rock unit used in mapping the study area.

R - Dominantly undifferentiated rock outcrops (non-soil). Lithic Brunisols and Organic soils may occur in minor amounts.

Ecosystems: Rock ecosystems are mapped predominantly in the Flett Lake Plain. Small rock outcrops also occur in the Athabasca Delta Plain in the Fort Chipewyan area. The surface form is predominantly hummocky. Lithic Eluviated Dystric Brunisols occur where sediments have collected and Organic soils may be found in depressional areas. The landscape is sparsely vegetated. Jack pine and some other species grow out of rock cracks, crevasses, and other suitable microsites as well as on the small areas of lithic Brunisols. Black spruce forest occurs in the poorly drained sites with Organic soils.

Ecosystems consisting of the Rock land unit in combination with Mildred, Kenzie, and Eaglesham soils were also mapped in the Flett Lake Plain. Landforms are combinations of hummocky with undulating or level surface forms. Areas with Mildred soils mainly support jack pine forest while areas with Kenzie and Eaglesham soils have mainly black spruce forest and fen communities.

The Rock land unit on the Muskeg River Plain occurs in association with Mildred, Heart, Ruth, Kenzie and Eaglesham soils. The outcrops occur only in minor amounts, but, because they are very different from soils and may affect land use interpretations, they are indicated in map symbols as second or third components in soil combinations.

6.23 ROUGH BROKEN LAND TYPE (RB)

Rough Broken is another kind of land unit more appropriately called a Land Type because it is distinguished more by landform than by soils. Rough Broken lands consist of strongly eroded, steep banks along creek and river valleys. The materials are highly variable and designated as undifferentiated on the map legend. They consist of exposed glacial deposits and bedrock, and of thin colluvium on valley slopes. A minor proportion (less than 15%) of alluvial materials along streams is included in this land type. Surface expression ranges from inclined and steep to canyon-like forms, and slopes are generally strong to very steep. Within an inclined or steep bank, the surface may be strongly dissected. Like fluvial channel deposits, Rough Broken lands occur throughout the study area within all physiographic areas.

Soils in Rough Broken areas are mainly shallow, lithic Regosols. Rock, or non-soil, may be significant or dominant at some sites. Except for spots where springs and seepages occur, soil and rock surfaces are very rapidly drained. Chemical and physical properties of the soils vary considerably.

Soil Unit: There is one Rough Broken map unit.

RB - Predominantly undifferentiated soils. Bedrock outcrops may occur in some areas.

Ecosystems: The Rough Broken land type on inclined or steep landforms is mapped along most of the major creeks and rivers in the study area. The largest areas are along the Athabasca River south of Fort McMurray, along the Clearwater River, and in the Birch Mountains Escarpment. Vegetation of Rough Broken lands is variable. Bottomland and riparian communities occur at the boundaries of alluvial and colluvial deposits, but various upland types occur on the slopes. The steepest sites are devoid of vegetation but in some locations excellent stands of white spruce occur, possibly because of higher fertility and moisture status of the sites. At the same time, protection from fire has enabled the stands to reach maturity in many locations in the Rough Broken areas.

Combinations of Rough Broken lands and McMurray soils were mapped where the alluvial McMurray soils occupy more than 15% of a valley area. The surface expressions of these ecosystems are combinations of level and terraced forms of the fluvial deposits with inclined and steep forms of the Rough Broken lands. The McMurray component of such ecosystems is characterized by bottomland and riparian forest and shrub communities.

6.24 RUTH LAKE SOIL GROUP (RUT)

Ruth Lake soils are a group of rapidly drained Eluviated Eutric Brunisols and Eluviated Dystric Brunisols, and well- to moderately well-drained Orthic Gray Luvisols developed on sandy, gravelly and loamy glaciofluvial meltwater channel deposits. These soils are found to a limited extent in the Clearwater and Muskeg River plains, and to a very limited extent in the Embarras Plain.

The meltwater channel sediments are found along the Athabasca, Clearwater, and Christina rivers. They include meltwater channel complexes, spillways, eroded till plains, and early postglacial terraces of these rivers. Deposits consist of 3 to 6 m of sand over about 1 to 3 m of gravel and boulders in many places (Bayrock 1971). The eroded till plains along meltwater channels are usually very gravelly and stony. The coarser parent materials are yellowish brown to dark yellowish brown, very strongly acidic to neutral, slightly to excessively stony, and sand to sandy loam in texture. The eroded till is dark yellowish brown, slightly acidic to calcareous, slightly to excessively stony, and loam to clay loam in texture. The parent materials may also consist of veneers of coarse sediments overlying glacial till. Landforms are undulating or ridged with gentle slopes. Eroded till plains slope very gently toward channels.

Both Brunisols and Luvisols have developed in the variably textured meltwater channel sediments. Variability in reaction of the coarser parent materials has resulted in development of both Eluviated Eutric Brunisols and Eluviated Dystric Brunisols. Soil profiles of both these subgroups are similar and consist of a 5 to 10 cm thick LFH horizon over 10 to 20 cm of a light gray, Ae horizon. A dark yellowish brown Bm horizon is 20 to 50 cm thick. A BC horizon is usually present and total solum depth is about 50 to 75 cm.

The Orthic Gray Luvisols have 5 to 10 cm of LFH horizon over light brownish gray Ae horizons of 5 to 15 cm thickness. Dark yellowish brown Bt horizons are about 40 cm thick. Solum thickness is generally about 50 to 60 cm.

Drainage of the Brunisolic soils is rapid. The Orthic Gray Luvisols have medium perviousness and are well- to imperfectly drained. Gleyed Eluviated Eutric Brunisols, Gleyed Gray Luvisols, and peaty Gleysols are common associates of the better-drained soils.

Soil Unit: One soil unit was established for the Ruth Lake group.

RUT1 - Dominantly a combination of rapidly drained Eluviated Eutric and Dystric Brunisols, and of well- to moderately -well drained Orthic Gray Luvisols. Gleyed Eluviated Eutric Brunisols, Gleyed Gray Luvisols, and peaty Gleysols are associated in significant amounts. Organic soils may be present in minor amounts.

Ecosystems: Ecosystems with predominantly Ruth Lake soils on undulating or ridged landforms support mixed forest and jack pine forest community types. Deciduous shrub and mixed coniferous forest community types occur in the imperfectly to poorly drained sites while black spruce forest is predominant on Gleysolic and Organic soils.

Ruth Lake soils also occur in combination with Kenzie soils. Land surfaces of these are also level to undulating. Vegetation is the same as described above except that black spruce forest is more widespread.

6.25 STEEPBANK SOIL GROUP (STP)

The Steepbank soil group consists predominantly of poorly drained peaty Gleysols developed on loamy morainal and glaciolacustrine deposits. They have developed in the same parent materials as the Kinosis, Surmont, Horse River, Livock, and Ruth Lake soil groups. The glaciolacustrine deposits are mainly veneers and blankets overlying glacial till. Although developed in materials of various origins, the common characteristics are the predominantly loamy nature of the parent materials and the poor drainage. They differ from other Gleysolic soil groups in that Algar soils are clayey, Bitumount soils are sandy, and soils of the McMurray, Namur, and Mamawi groups are developed on postglacial fluvial deposits in which the sedimentation processes are active. Steepbank soils have been mapped mainly in the Muskeg Mountain Upland and the Steepbank, Hartley, Johnson Lake, Hangingstone, House, Algar, and Dunkirk plains.

The parent materials are predominantly gray to dark gray in colour and have massive structure with very sticky consistence. They are non- to moderately stony. In morainal areas, the surface may be non-stony due to very thin overlays of glaciolacustrine or lacustrine materials. The surface expression of Steepbank soils is depressional, level, or undulating with less than 5% slopes.

A predominant subgroup in the Steepbank soil group has not been identified, but those that most commonly occur are peaty phases of Orthic Gleysols, Rego Gleysols, and Orthic Luvic Gleysols. The surfaces of these soils consist of up to 60 cm of fibric peat or up to 40 cm of mesic and humic peat. The forest peat type is most common, but fennic and sphagnic peats may also comprise the surface layer. In Orthic Gleysols and Orthic Luvic Gleysols, there may be a thin Ah or Ahe horizon, but well-developed Ae horizons are uncommon. A Bmg horizon is present in Orthic Gleysols while a Btg horizon occurs in Orthic Luvic Gleysols. All mineral horizons display evidence of gleying such as prominent mottling or dull gray to dark bluish gray colours indicative of water saturation either permanently or for very long periods of the year.

Imperfectly drained Gleyed Gray Luvisols and Orthic Gray Luvisols are commonly associated with the peaty Gleysols of this soil group. The characteristics of these soils are as described for the Kinosis, Surmont, Horse River, Livock, and Ruth Lake soil groups. Luvisols within areas mapped as Steepbank can be assumed to be similar to the predominant Luvisolic soil groups mapped within the same ecodistrict.

Soil Unit: One Steepbank soil unit was defined in the study area.

STP1 - Dominantly poorly drained peaty Gleysols in association with significant amounts of Gleyed Gray Luvisols and Orthic Gray Luvisols. Organic soils may be minor inclusions.

Ecosystems: Ecosystems with Steepbank soils have surface forms indicated as undulating on the soil maps. Generally, these areas include a large proportion of depressional and level surfaces. Typical vegetation consists of bottomland and riparian forest and deciduous shrub, and black spruce forest community types. Fen communities may also occur sporadically in this ecosystem.

Map combinations of Steepbank with Kenzie and Eaglesham constitute ecosystems that are very similar to the simple Steepbank ecosystems except that other wetland communities such as semi-open black spruce forest and lightly forested tamarack and open muskeg may occur. Fen communities are more common in complexes of Steepbank with Eaglesham soils.

6.26 SURMONT SOIL GROUP (SRT)

Surmont soils are mainly Orthic Gray Luvisols developed on loamy, colluviated morainal materials. These deposits have been described by Bayrock (1971) as till composed of sand, silt, and clay which mantles colluviated steep slopes, is partly bedded near the surface, is generally thin, and has stable slopes. They are found on the lower slopes of the Birch Mountains and Cheecham Hills escarpments, and on the Wabasca Plain. Surmont soils differ from the Buckton soil group in that they do not have Regosolic soils and exposed glacial sediments and shales associated with them. Moreover, Surmont landscapes are stable, colluviation having occurred during deglaciation or soon after, while colluviation in Buckton landscapes is active.

Surmont soils have very dark grayish brown and very dark gray parent materials that are slightly stony and very strongly acid to neutral in reaction. Bayrock (1971) noted that carbonates were present in this till on the east side of the Birch Mountains. The till in parts of the Cheecham Hills Escarpment, however, is strongly acidic apparently because of a high shale content. In most areas, the material is clay loam in texture, and is massive and firm. The amount of coarse fragments is low. In parts of the Cheecham Hills Escarpment the material is very sandy.

The surface forms of Surmont soils are inclined, undulating, hummocky, or combinations of these. Slopes range from 2 to 15%.

The Orthic Gray Luvisols of the Surmont soil group have LFH horizons of 5 to 10 cm thickness which consist of slightly to moderately decomposed leaves and needles. A gray, platy Ae horizon is up to 25 cm thick and overlies a Bt horizon having strong, subangular blocky structure, and thickness up to 50 cm. There is usually an AB horizon but no BC horizon. The total solum depth is commonly about 75 cm. Other subgroups associated with the Orthic Gray Luvisols are imperfectly drained Gleyed Gray Luvisols and poorly drained peaty Gleysols which occur in depressional sites.

Soil Unit: There is one Surmont soil unit mapped in the study area.

SRT1 - Dominantly well-drained Orthic Gray Luvisols in association with significant amounts of imperfectly drained Gleyed

Gray Luvisols and poorly drained peaty Gleysols. There may be minor inclusions of Organic soils.

Ecosystems: Surmont ecosystems mainly have inclined surface forms and occur on undulating or hummocky forms to a smaller extent. Vegetation consists predominantly of upland white spruce-aspen forest and coniferous forest community types. Aspen and mixed forest also occur, while mixed coniferous forest and deciduous shrub occupy imperfectly drained sites. Black spruce forest occupies the poorly drained depressional sites.

Ecosystems of Surmont in association with Kenzie soils occur but are not common because the predominantly inclined landforms of Surmont soils promote rapid surface drainage. Vegetation of these ecosystems has a relatively high proportion of black spruce forest and other wetland communities but is otherwise similar to simple Surmont ecosystems.

7. SOIL SURVEY INTERPRETATIONS

Upon obtaining information on soil properties, interpretations can be made with regard to potential for various land uses and to limitations and potential hazards for certain uses of soils. Interpretations are based on soil properties observed in the field, laboratory data, and on available published information. When used with the soils maps, the interpretations can be geographically related to a particular planning area. Planners can use interpretations to help predict the type and degree of potential problems, and plan the kind and amount of on-site investigations needed. The number of investigations, however, can be considerably reduced by use of a map and accompanying interpretations. (Greenlee 1980).

The following sections present information and general interpretative comments on forestry, engineering, agriculture, and other land uses, and on sensitivity to acidification of soils in the study area. Because of the reconnaissance nature of the survey, it must be emphasized that information presented is a general guide only and does not preclude the necessity for on-site investigations.

7.1 SOIL INTERPRETATIONS FOR FOREST MANAGEMENT

Information on land capability classification for forestry in northeastern Alberta is available in a series of Alberta Land Inventory (ALI) maps produced by Resource Evaluation, Alberta Energy and Natural Resources, and published by Alberta Environment. Capability is categorized in seven classes with Class 1 lands being the best areas for commercial tree growth and Class 7 lands yielding no commercial timber. Because of climatic limitations, the highest capability within the AOSERP study area is Class 3, which refers to land having moderate limitations to the growth of commercial forests. In the northern part of the study area, the highest capability is Class 4 (having moderately severe limitations). Areas of Class 3 lands are rare and occur only on moderately well- to imperfectly drained soils developed in fluvial and some morainal deposits.

For soils developed on morainal and glaciolacustrine deposits, capabilities decrease due to limitations of wetness or dryness. Soils are rated Class 5, 6, or 7 as degree of wetness increases. Classes 5 and 6, having severe limitations to growth of commercial forests, are the most common capabilities of mineral soils in the study area. Sandy soils have fair to low capabilities for forest production, the limitations being soil moisture and nutrient deficiencies. Most of these are also rated Class 5 or 6. Organic soils are rated Class 6 or 7 due to very poor drainage.

No attempt was made to categorize soil groups discussed in this report according to capability for forestry. Reference should be made to the ALI maps for capability information. However, some soil interpretations for timber production can be made by rating specific soil characteristics that affect growth and management of trees. The ratings are somewhat subjective but may be useful in planning soil management programs related to forestry operations. The ratings are presented in Table 9. The ratings relate to soil properties only, while other land characteristics such as slope and aspect are not considered except in the case of soil erosion potential. The interpretations are based on chemical and physical properties characteristic of the different soil groups. The purpose of the ratings presented in Table 9 is to provide information which can be used in combination with the soils maps, ALI maps, and other sources of information in making soil interpretations in forest management and other programs.

In Table 9, drainage class refers to the predominant drainage regime within a soil unit. There usually are minor inclusions or significant areas of either more well-drained or more poorly drained soils within each unit. The drainage classes are explained in the Appendix (Section 9.3). The permeability rating provides an indication of the ease with which water can pass through the soil and is dependent on soil porosity or perviousness. The least permeable horizon or layer in a soil usually determines its

Table 9. Some soil interpretations for forest management.

Soil Group	Soil Unit	Slope (%)	Drainage Class	Permeability	Moisture Status	Thickness of Organic Layer	Potential Erosion Hazard	Potential Windthrow Hazard
Algar	ALG1	<5	poorly	low	poor (wet)	thick	moderate[a]	high
Bitumont	BMT1	<5	poorly	high	poor (wet)	thick	low	high
Buckton	BKN1	6-30	well	medium	moderate	variable	high	moderate
Chipewyan	CPN1	<5	imperfectly	medium	good	medium	low	moderate
Dover	DOV1	<5	well	low	moderate	medium	moderate[a]	moderate
Eaglesham	EGL1	<2	very poorly	high	poor (wet)	thick	moderate	high
Firebag	FIR1	2-15	rapidly	high	poor (dry)	thin	low[b]	moderate
	FIR2	2-15	rapidly	high	poor (dry)	thin	low[b]	moderate
	FIR3	6-30	very rapidly	high	poor (dry)	thin	high	moderate
Heart	HRT1	2-15	rapidly	high	poor (dry)	thin	low[b]	moderate
	HRT2	2-15	rapidly	high	poor (dry)	thin	low[b]	moderate
	HRT3	6-30	very rapidly	high	poor (dry)	thin	high	moderate
Horse River	HRR1	2-15	well	medium	moderate	medium	moderate	moderate
Joslyn	JSN1	<5	well to imperfectly	low	moderate	thin to medium	moderate[a]	high
Kearl	KEL1	2-9	well to rapidly	high	poor (dry)	thin	moderate	moderate
Kenzie	KNZ1	<2	very poorly	high	poor (wet)	thick	moderate	high
	KNZ2	<5	poorly	high	poor (wet)	thick	moderate	high
Kinosis	KNS1	2-15	well	medium to high	moderate	thin	low to moderate	moderate
Legend	LGD1	6-15	well to imperfectly	medium	good	thin to medium	moderate	moderate
Livock	LVK1	<5	well	medium to high	moderate	medium	low[a]	moderate
Mamawi	MMW1	<2	poorly	medium	poor (wet) to moderate	medium	low	high
	MMW2	<0.5	poorly	medium	poor (wet)	medium	low	high
McMurray	MMY1	<5	imperfectly	medium	good	thick	high	moderate
	MMY2	<2	poorly	medium	good to poor (wet)	thick	moderate	high
Mikkwa	MKW1	<9	very poorly	high	poor (wet)	thick	moderate	high
	MKW2	<9	poorly	high	poor (wet)	thick	moderate	high
Mildred	MIL1	2-9	rapidly	high	poor (dry)	thin	low[b]	moderate
	MIL2	2-9	rapidly	high	poor (dry)	thin	low[b]	moderate
Namur	NAM1	<5	imperfectly	medium	good	medium	high	moderate
	NAM2	<2	poorly to imperfectly	medium	poor (wet) to moderate	thick	moderate	high
Ruth Lake	RUT1	2-9	moderately to rapidly	medium to high	poor (dry) to moderate	thin	low to moderate[b]	low to moderate
Steepbank	STP1	<5	poorly	medium	poor (wet)	thick	low	high
Surmont	SRT1	2-15	well	medium	moderate	medium	moderate[a]	moderate

[a]Depending on nature of slope. Given a more severe rating on long slopes.

[b]Subject to wind erosion in some areas.

overall ratings. In Luvisolic soils, this is usually the textural (Bt) horizon.

Moisture status refers to the amount of moisture available for tree growth during the growing season. The rating is based on moisture holding capacity of soil inferred from its texture (particle size distribution) as well as on internal and external drainage conditions. Soils are rated as good, moderate, or poor, with wet or dry conditions being given as the reason for poor ratings.

Soil erosion hazard is the expected rapidity and amount of soil loss due to wind or water or both that may be expected following removal of the protective vegetative cover in areas where proper erosion control measures are not implemented (Dumanski et al 1972). Extensive areas of sandy soils in the study area are vulnerable to wind erosion. Two large active sand dune areas and numerous small blowouts suggest that wind erosion should be a major concern if the vegetative cover is disturbed or destroyed. Water erosion depends on factors such as the amount, intensity, and seasonal distribution of rainfall; the steepness and length of slopes; the absence or presence of channels of concentration; the type of vegetative cover; and the properties of the soil (Twardy and Corns 1980). The two most important soil factors are infiltration capacity and structural stability. In the study area, lands with the highest potential for erosion are the Birch Mountains and Cheecham Hills escarpments. As these areas are already highly dissected or eroded, the concern is that of accelerated erosion upon loss of forest cover. Heart and Firebag soils on steep slopes may be subject to water erosion. The clayey Dover and Joslyn soils may have a high erosion potential where they occur on long gentle slopes. The presence of mud flats on the Buckton Plain suggests that Namur soils may be easily rilled and channelled by water running out of the adjacent Birch Mountains Escarpment. Erosion potential in Table 9 is rated as low, moderate, or high.

Potential windthrow hazard refers to the risk of trees being toppled by normal winds as a result of soil characteristics which affect development of tree roots. Some factors which cause shallow rooting are high water tables, impermeable B horizons, and shallow depths to lithic layers. Organic, peaty Gleysolic, and Solonetzic soils have high windthrow potentials. Soils in which trees root relatively deeply are described as having moderate or low windthrow potentials in Table 9. The ratings are inferred from soil properties and are also based on observations of windthrow in the field.

7.2 AGRICULTURAL INTERPRETATIONS

The AOSERP study area lies within the agro-climatic areas of 3H and 5H (Bowser 1967). Areas with climate 5H have adequate precipitation but the average frost-free period is so short (generally less than 60 days) that it is not practical to grow cereal crops. Only hay crops can be grown in such areas. Ecodistricts within area 5H are generally those of highest elevation and include those of the Birch Mountains Upland, the Muskeg Mountain Upland, the Cheecham Hills Escarpment, and the House, Steepbank, and Johnson Lake plains. Most of the Richardson Hills Upland can also be regarded as having 5H climate.

The remainder of the study area is in agro-climatic area 3H. This area has adequate rainfall but it is not considered practical to grow cereal crops because of the frequency of damaging frosts. The Flett Lake Plain is within an area designated 3H(A) which refers to lack of rainfall in addition to length of frost-free period as being limiting to crop growth.

No soil capability maps for agriculture have been produced for northeastern Alberta. Almost all soils within agro-climatic zone 3H would fall into soil capability Class 5 or 6 which refers to lands having very severe limitations that restrict their capability to production of perennial forage crops or to native pasture. Improvement practices such as clearing, introducing tame hay species, or fertilization may be feasible in some areas. The main soil limitations in the study area are: adverse topography and stoniness of soils on morainal materials; undesirable soil structure and low permeability of many of the soils on glaciolacustrine materials; a significant amount (15 to 40%) of excessively wet areas (Gleysols and Organics) in almost all of the soils; and low fertility status and moisture holding capacity in sandy soils. Organic soils are not placed in agricultural capability classes.

Capability classes for agriculture in agro-climatic areas 5H and 3H(A) are probably similar to those of the Birch Mountains Upland where van Waas (1974) considered the highest class to be 6 due to percentages of Organic soils and to presence of surface boulders. Capability Class 7 (having no potential for arable culture or permanent pasture) would apply to areas with adverse topography, with certain patterns of mineral and organic soils, or with sandy soils.

7.3 ENGINEERING INTERPRETATIONS

Soil chemical and physical properties are important factors in the design, construction, and maintenance of roads, pipelines, powerlines, airfields, buildings, and various other facilities. In this regard, the soil properties of most importance to the engineer are grain size distribution, plasticity, compaction, shrink-swell characteristics, strength, permeability to water, drainage, and salinity. Topography and depth to water and to bedrock may be important site factors. Some of these properties were evaluated by analyzing samples representative of the various soil groups according to procedures outlined in the ASTM Book of Standards, Part 19 (American Society for Testing and Materials, 1979). The data are presented in Table 10.

Samples for the engineering tests were taken by hand auger from the Bt, BC, or C horizons, mainly at 1 to 1.5 m depth. Results of tests for Atterberg limits and particle size composition were used to classify the soil materials according to the American

Table 10. Engineering test data for soils in the AOSERP study area.

Soil Group	Location	Site	Horizon	Depth (cm)	Percentage Passing Sieve							Percentage smaller than[a]		Liquid Limit	Plasticity Index	Classification		
					1"	3/4"	5/8"	#4	#10	#40	#200	0.05 mm	0.002 mm			USDA	Unified	AASHO
ALGAR	SW26-88-9-4	M76-10	Cg	80-120	100	100	100	100	100	97	90	92	57	44	23	C	CL	A-7-6(14)
	NW7-91-10-4	M78-9	Cgj	46-67	100	100	100	100	100	98	79	82	54	44	25	C	CL	A-7-6(15)
	NW7-91-10-4	M78-9	IICKgj	67-95	100	100	100	100	100	93	65	65	37	34	14	CL	CL	A-6(8)
	SW19-82-12-4	M79-1	Csg	100-135	100	100	100	100	100	98	94	94	36	38	19	SiCL	CL	A-6(12)
BUCKTON	SE13-100-12-4	M77-20	C	75+	100	100	100	100	100	95	50	59	35	33	10	CL	CL	A-4(3)
CHIPEWYAN	NE8-109-9-4	M78-25	Ckg	50-100	100	100	100	100	100	100	85	99	32	58	25	SiCL	MH	A-7-5(18)
	NE15-109-7-4	M78-29	Ckg	39-100	100	100	100	100	100	100	68	61	15	31	10	L	CL	A-4(7)
DOVER	NE11-87-10-4	M77-17	Ck	60-85	100	100	100	100	100	100	88	74	36	46	21	CL	CL	A-7-6(13)
	NE11-87-10-4	M77-17	IICk	85-150	100	100	100	100	100	99	79	77	36	44	21	CL	CL	A-7-6(13)
	SE25-92-17-4	M78-35	BC	55-80	100	100	100	100	99	91	60	62	33	31	12	CL	CL	A-6(6)
	NE2-87-9-4	M78-56	BCk	48-66	100	100	100	100	99	97	68	74	36	31	15	CL	CL	A-6(9)
	NE2-87-9-4	M78-56	IICk	66-85	100	100	100	100	100	97	68	62	27	31	15	CL	CL	A-6(9)
FIREBAG	SE10-98-4-4	M77-24	C	68-115	100	100	100	100	99	81	1	4	4	NP	NP	S	SW	A-3
	SW9-100-12-4	M77-29	C	50-80	100	100	98	94	90	63	5	9	1	NP	NP	S	SW	A-3
HORSE RIVER	NW29-96-12-4	M77-8	BCK	48-80	87	87	87	84	83	74	44	53	14	25	8	L	SC	A-4(2)
	NE8-90-12-4	M77-18	BC	60-100	100	100	98	98	97	93	63	64	26	30	12	L	CL	A-6(6)
	SW11-97-10-4	M77-27	Ck	85-110	-	-	-	-	-	-	-	64	29	32	14	CL	CL	A-6(8)
	NW12-87-7-4	M78-5	Ck2	80-120	100	100	99	99	98	95	68	-	-	31	15	CL	CL	A-6(9)
	NW18-95-15-4	M78-33	Ck	72+	100	100	100	100	100	97	79	77	33	39	18	CL	CL	A-6(11)
	NE3-91-18-4	M78-36	Ck	54-110	100	100	100	100	100	96	66	63	22	27	13	L	CL	A-6(7)
	SW2-88-16-4	M78-39	Ck	82-110	100	100	100	100	99	95	56	53	19	28	13	L	CL	A-6(5)
	NE3-88-18-4	M78-40	Ck	34-70	100	100	100	100	100	98	80	87	61	58	29	HC	CH-MH	A-7-6(19)
JOSLYN	NW10-92-11-4	M77-4	Ck4	130-150	-	-	-	-	-	-	-	83	48	44	24	C	CL	A-7-6(14)
	SE28-92-12-4	M77-5	BCK	49-90	100	100	98	97	97	96	82	89	54	43	20	C	CL	A-7-6(13)
	SE28-92-12-4	M77-5	Ck	90-135	-	-	-	-	-	-	-	91	55	40	20	C	CL	A-7-6(12)
	SW17-94-11-4	M77-6	IICk	70-120	100	100	100	99	99	96	76	82	36	38	16	CL	CL	A-6(10)
	NW17-97-12-4	M77-99	Csk2	120-150	100	100	100	98	98	93	57	59	28	37	19	CL	CL	A-6(8)
	NW8-94-13-4	M78-32	Ck	90-110	100	100	100	100	100	97	81	79	49	44	21	C	CL	A-7-6(13)
KINOSIS	NW10-93-6-4	M77-12	C	68-93	-	-	-	-	-	-	-	42	16	18	5	FL	SC	A-4(2)
	SE9-94-6-4	M77-13	BC	90-120	-	-	-	-	-	-	-	42	17	19	6	FL	SC	A-4(2)
	NW25-96-6-4	M77-14	BC	54-100	100	100	98	98	96	87	57	46	19	24	10	FL	CL	A-4(4)

continued...

Table 10. Concluded.

Soil Group	Location	Site	Horizon	Depth (cm)	Percentage Passing Sieve 1"	3/4"	5/8"	#4	#10	#40	#200	Percentage smaller than[a] 0.05 mm	0.002 mm	Liquid Limit	Plasticity Index	Classification USDA	Unified	AASHO
	NE18-85-8-4	M77-31	C	67-120	100	100	100	98	96	79	46	50	23	28	9	SCL	SC	A-4(2)
	SE35-84-9-4	M78-6	C	70-110	100	100	100	99	98	88	50	54	25	31	16	L	CL	A-6(5)
KINOSIS	8-82-7-4	M78-7	C	80-120	100	100	100	100	99	91	55	59	24	32	15	L	CL	A-6(6)
	NE31-83-6-4	M78-8	C	70+	100	97	97	97	97	91	59	53	23	28	12	L	CL	A-6(6)
	SW32-92-4-4	M78-10	C	70-110+	100	100	100	98	98	91	52	50	17	23	9	L	CL	A-4(3)
	NW9-100-12-4	M77-30	C	45-65	100	98	94	88	81	60	30	48	21	28	9	L	SC	A-2-4
	SE11-97-15-4	M78-12	C	90-120+	100	100	100	100	99	90	54	54	26	30	14	L	CL	A-6(6)
	SW8-99-14-4	M78-13	C	77+	100	100	99	97	96	83	53	55	26	31	13	L	CL	A-6(5)
	NE13-100-15-4	M78-14	BC	62-80+	100	96	95	92	91	76	49	56	30	33	16	CL	CL	A-6(5)
	SW8-100-15-4	M78-15	C	62-80	100	100	100	100	100	100	70	100	57	66	29	SiC	MH	A-7-5(18)
	NE18-100-16-4	M78-16	C	80-120	100	98	98	98	97	90	60	69	34	37	17	CL	CL	A-6(8)
LEGEND	SW25-104-15-4	M78-19	Cgj	89+	100	97	97	97	97	90	66	73	34	41	17	CL	CL	A-7-6(9)
	NE23-103-18-4	M78-20	C	59+	100	100	100	100	100	97	77	85	42	46	22	SiC	CL	A-7-6(14)
	NE29-97-18-4	M78-21	C	60-100	100	100	100	100	100	99	81	94	49	44	20	SiC	CL	A-7-6(13)
	SW24-98-17-4	M78-22	C	60-100	100	100	100	99	98	91	67	69	36	37	17	CL	CL	A-6(9)
	SW18-100-17-4	M78-23	BC	52+	100	100	100	100	98	85	51	54	27	29	13	SCL	CL	A-6(4)
	SW14-102-17-4	M78-24	Cgj	60-90	100	100	100	100	100	99	92	91	48	48	22	SiC	CL	A-7-6(15)
	NE8-95-18-4	M78-34	IIIC	85-110	100	100	100	97	96	88	57	64	32	31	13	CL	CL	A-6(5)
LIVOCK	SE34-92-8-4	M77-11	IIBt	27-60	-	-	-	-	-	-	-	51	24	23	9	SCL	CL	A-4(4)
	NW2-90-14-4	M78-38	IICk	70-100	100	100	100	100	99	90	55	55	20	26	12	L	CL	A-6(5)
MILDRED	NE12-100-8-4	M77-26	CI	55-90	100	100	100	100	99	95	3	5	2	NP	NP	S	SW	A-3
NAMUR	NE13-99-11-4	M77-19	Cgj4	65-92	100	100	100	100	100	100	98	99	59	66	24	SiC	MH	A-7-5(18)
ROUGH BROKEN	SW1-101-12-4	M77-32	-	500+	-	-	-	-	-	-	-	62	22	89	8	Si	MH	A-7-5(17)
STEEPBANK	NE19-85-15-4	M78-41	IICg	55-110	100	100	100	100	99	96	71	75	29	31	13	CL	CL	A-6(8)
	SE22-94-8-4	M79-3	Cg	26-60	100	95	95	94	93	83	53	60	32	25	12	CL	CL	A-6(4)
	11-83-13-4	M78-2	C	75-120	100	100	100	99	98	86	51	54	24	28	12	L	CL	A-6(4)
SURMONT	NE8-84-11-4	M78-4	C	85-120	100	100	100	99	99	90	57	56	27	31	17	CL	CL	A-5(7)
	SW15-85-10-4	M78-57	C	75-120	100	100	100	99	99	97	74	74	35	39	15	CL	CL	A-6(10)

[a] determined by the pipette method

Association of State Highway Officials (AASHO) and Unified soil classification systems. These are correlated in Table 10 with the United States Department of Agriculture (USDA) system for describing texture used elsewhere in this report. The methodology and classification systems are described in a publication of the Portland Cement Association (1962) and by Greenlee (1981).

Most of the subsoils are CL in the Unified system or A-6(4-11) in the AASHO system. The USDA texture for these is mainly clay loam. Some clay loam and clay soils have relatively high liquid limits and fall into AASHO class A-7-6(11-20) or A-7-5(18). The Unified equivalents for these are CL, MH and CH-MH. Some loams fall into A-4(2-7) or Unified SC and CL. Soils with the highest plasticity indices and clay contents are clayey glaciolacustrine sediments, fluvial materials of the Buckton Plain, and shaly subsoils in some morainal deposits. Sands, gravels, and some coarse till materials are nonplastic and generally fall into SW, SM, and GM categories of the Unified system. AASHO classifications of these are A-4 or lower.

In addition to AASHO and Unified classifications of some of the soil materials, other data relevant to engineering interpretations can be found in soil descriptions in the Appendix (Section 9.4). Salinity of materials in the Joslyn soil group and particle size distribution of other soil groups may be of particular importance.

Using the various data collected, specific interpretations can be made for each soil group. Dwellings, road location, and sewage disposal are examples of numerous uses. This is not attempted in this report because of the reconnaissance nature of this survey and the resulting lack of information for making some of the interpretations. Very general ratings of suitability of soil materials in specific areas for specific uses can be obtained by use of the soil maps and reference to guidelines as presented in Guidebook for Use with Soil Survey Reports of Alberta Provincial Parks and Recreation Areas by Greenlee (1981). Although this guidebook is oriented to interpretations for recreational uses, the guidelines are applicable to other situations as well. Additional information can be found in a guide for engineering interpretations by the United States Department of Agriculture (1972).

7.4 OTHER LAND CAPABILITY CLASSIFICATIONS

Alberta Land Inventory maps are available for northeastern Alberta which present capability ratings for recreational uses, ungulates, and waterfowl. The following is a very brief summary of land capabilities in the study area.

Most of the study area has very low to low ratings for recreational uses. Water based recreation along some rivers and lakes has the highest potential in the area. Potential for waterfowl is also low except for small areas adjacent to some of the lakes. One exception is the Athabasca Delta Plain which has high ratings and very high waterfowl production. The land classification for ungulates is mainly moderate but ranges from very low to very high. Generally, areas with sandy or organic soils have the lowest capabilities for wildlife. Lack of nutrients and excessive or deficient moisture for optimum plant growth are the major adverse soil conditions which contribute to poor capability for supporting wildlife. In the study area, soil groups with these properties are Kenzie, Eaglesham, Mikkwa, Heart, Mildred, and Firebag. Except where lakes with recreational potential occur, areas of these soils also have the lowest recreational potentials.

For detailed information, the reader is referred to the ALI maps mentioned above. Maps indicating capabilities for sport fishing and fur bearing animals are also available for some areas.

7.5 SENSITIVITY OF SOILS TO ACIDIC DEPOSITION

Soil groups in the AOSERP study area were classified into three broad categories of sensitivity to change in response to acidic deposition according to criteria described by Holowaychuk and Lindsay (1980) and Holowaychuk et al. (1981). The following discussion of criteria and sensitivity categories is derived from these two publications.

The term sensitivity refers to the susceptibility of a soil to the degree of change in its pH, base saturation, and mobilization of exchangeable bases (Ca, Mg, K, etc.) in response to a given input of acidity. The buffering capacity (BFC) of a soil is considered to be the most important parameter that determines its sensitivity. Buffering capacity is defined as the amount of acid or base required to change the pH of a given quantity of soil by one pH unit or some other selected increment of pH. Generally, sensitivity is inversely related to BFC. However, BFC changes with changes in pH such that it is greater in the very strongly to strongly acid range than it is at higher pH. However, in a medium acidic to neutral soil, a large drop in pH resulting from addition of a small quantity of acid will be accompanied by a relatively low mobilization of bases. In a more acidic soil, a small drop in pH upon addition of a relatively large quantity of acid will mobilize a relatively large amount of bases. Thus, BFC and pH are the most significant factors in determining sensitivity.

Other soil properties influence the degree of response to acidity inputs. Permeability and moisture holding capacity determine the rate and extent of movement of soil solutions and thus affect factors such as the time dissolved materials and soil particles have to react. Soil drainage is a sensitivity rating factor: where minerotrophic subsurface water contributes to soil water, the effects of acidic depositions are likely diminished. Mineralogy affects sensitivity such that soils with a large pool of easily weatherable minerals have relatively low sensitivity because they can readily replenish some of the materials mobilized by acidification.

The soil groups mapped in the study are classified according to the following three broad categories of sensitivity

(Holowaychuk and Lindsay 1980):

1. Most sensitive soils
2. Soils of intermediate sensitivity
3. Least sensitive soils

Three ranges of buffering capacity characterize the three broad categories of sensitivity. The BFC is based on cation exchange capacity (CEC) of mineral soils as follows:

Low BFC - CEC $\leq$ 6 me/100 g soil

Medium BFC - CEC = 6 to 15 me/100 g soil

High BFC - CEC > 15 me/100 g soil

Organic soils have very high CEC compared to mineral soils. However, their bulk densities are low and CEC per unit volume of soil is also relatively low. Reaction, CEC, and bulk density of an Organic soil is largely dependent on the origin of the peat and on its degree of decomposition. Thus, the relatively more decomposed fen peats in the study area are considered to be less sensitive to acidic inputs than the highly fibric sphagnum and forest peats.

The classification of pH, or active acidity of soils, is given in Table 11. The sensitivity ratings of soils in the AOSERP study area are presented in Tables 12 and 13 along with the main soil criteria upon which ratings are based.

Soils of the study area vary greatly in profiled properties. Some profiles are relatively uniform with depth while others have contrasting horizons and layers. These factors are considered in determining sensitivity, and BDC and pH, therefore, are given for each primary horizon in the various groups in Tables 12 and 13. Information on types and locations of reaction in soils resulting from acidic deposition is scarce. Many reactions possibly occur in the surface litter layer, but considerable research is necessary to determine activity at the surface and throughout the profile. Thus, it must be emphasized that the sensitivity classes are very broad categories and that they are relative. There is insufficient information available to quantitatively predict the response to a given acidic input within any one soil group.

Table 11. Classification of soil acidity.

Class	Abbreviation	pH Values
Extremely acid	EA	<4.5
Very strongly acid	VSA	4.5 to 5.0
Strongly acid	SA	5.1 to 5.5
Moderately acid	MA	5.6 to 6.0
Slightly acid	SlA	6.1 to 6.5
Neutral	N	6.6 to 7.3
Mildly alkaline	MiAl	7.4 to 7.8
Moderately alkaline	MoAl	7.9 to 8.4
Strongly alkaline	SAl	8.5 to 9.0

Table 12. Relative sensitivity of mineral soils to acidic deposition.

Soil Group	Drainage Class	Perviousness	Moisture Holding Capacity	LFH Horizons		A Horizons		B Horizons		C Horizons		Relative Sensitivity
				Reaction	BFC[a]	Reaction	BFC	Reaction	BFC	Reaction	BFC	
Algar	poorly	L	H	SA-VSA[b]	M	EA-N	L	VSA-N	M-H	N-MoAl	M-H	least
Bitumount	poorly	H	L	EA	L	N-MA	L	N	L	N	L	least
Buckton	well	M	M-H	EA	L	EA	M	EA	H	EA	H	least
Chipewyan	imp.	M	M	N	H	-	-	-	-	N-MiAl	H	least
Dover	well	L	H	EA-SA	M	EA-MA	M-H	EA-N	H	N-MiAl	H	least
Firebag	rapidly	H	L	EA	L	EA-VSA	L	VSA-MA	L	VSA-MA	L	most
Heart	rapidly	H	L	EA	L	EA-VSA	L	VSA-MA	L	VSA-MA	L	most
Horse River	well	M	M	SlA-EA	L-M	EA-SA	L-M	EA-N	H-M	N-MiAl	M-H	inter.
Joslyn	well-imp.	L	H	VSA-N	M	SA-EA	M	SA-MiAl	H	MiAl-N	M-H	inter.
Kearl	rapidly	H	L	MA	L	EA	L	VSA	L	VSA	L-M	most
Kinosis	well	M-H	M-L	EA	L	EA	L-M	EA-SA	M-L	EA-MA	M-L	most
Legend	well-imp.	M-L	M-H	EA	L	EA	M	EA-VSA	M-H	EA-SA	H-M	inter.
Livock	well	M-H	M-L	EA-SA	L	EA	M-L	SA-EA	M-H	MiAl	M-H	inter.
Mamawi	poorly	M	M	N	H	-	-	-	-	N	H	least
McMurray	imp.-poorly	M	M	VSA-N	M-H	N	M-H	-	-	N	M-H	least
Mildred	rapidly	H	L	EA-SA	L	SA-EA	L	VSA-MA	L	VSA-SlA	L	most
Namur	imp.-poorly	M	M	MA-VSA	M	-	-	-	-	SA-VSA	M-H	least
Rock	rapidly	-	-	-	-	-	-	-	-	-	-	least
Rough Broken	rapidly	V	V	-	-	-	-	-	-	V	V	least
Ruth Lake	rapidly-well	H-M	L-M	EA	L	EA	L	SA-EA	L-M	SA	L-H	most
Steepbank	poorly	M	M	EA	L	EA-N	L-M	SA-MiAl	M	MA-MiAl	M-H	least
Surmont	well	M	M	EA	L	EA	L-M	VSA-EA	H	VSA-EA	H	inter.

[a]Abbreviations: BFC = buffering capacity; L = low; M = medium; H = high; V = variable; imp. = imperfectly; inter = intermediate; see Table 11 for abbreviations of reaction classes.

[b]The first part of any given range is predominant.

Table 13. Relative sensitivity of Organic soils to acidic deposition.

Soil Group	Drainage Class	Perviousness	Moisture Holding Capacity	Surface Tier		Middle Tier		Bottom Tier		Relative Sensitivity
				Reaction	BFC[a]	Reaction	BFC	Reaction	BFC	
Eaglesham	very poorly	M-H	H	SlA-SA	M-H	SlA-SA	M-H	SlA-SA	M-H	least
Kenzie	very poorly	M-H	H	EA-SA	L-M	EA-SA	L-M	EA-SA	L-M	most
Mikkwa	very poorly	L[b]	H	EA-SA	L-M	EA-SA	L-M	EA-SA	L-M	most

[a]Abbreviations as in Table 12.

[b]Perviousness rated low due to permafrost layer.

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9. APPENDIX

9.1 PHOTOGRAPHS ILLUSTRATING SOIL PROFILES AND LANDSCAPES IN THE AOSERP STUDY AREA

Photographs of a few of the more commonly occurring landforms and soil profiles in the AOSERP study area are presented in this section. The photographs of soil profiles were selected to represent the major soil subgroups and illustrate general features which can be found in more than one soil group. Photographs of common vegetation types in the AOSERP study area can be found in the report of Stringer (1976). Additional landform and vegetation photos are presented by Thompson (1979). Photography was by L. W. Turchenek and G. A. Spiers with the exception of Photographs 10, 11, and 12 which are accredited to M. Fairbarns.

Photograph 1.

Hummocky moraine in the House Plain with areas of Luvisolic and Gleysolic soils of the Kinosis and Steepbank soil groups.

Photograph 2.

Ridged (fluted) moraine in the Birch Mountains Upland near the Birch Mountain Lookout tower. The high land in the left background is hummocky moraine. In the right background, the Birch Mountains Escarpment, with Rough Broken lands and Buckton soils, overlooks the Buckton Plain.

Photograph 3.

Undulating terrain of the predominantly glaciolacustrine Hartley Plain. Soils are mainly those of the Dover, Steepbank, and Kenzie soil groups.

Photograph 4.

Undulating landform of the Dover Plain. Kenzie soils with fen inclusions occupy the depressional areas, and Livock, Dover, and Joslyn soils occur on glaciolacustrine veneers overlying till.




Photograph 5.

Orthic Gray Luvisol, Kinosis soil group, Muskeg Mountain Upland.

Photograph 6.

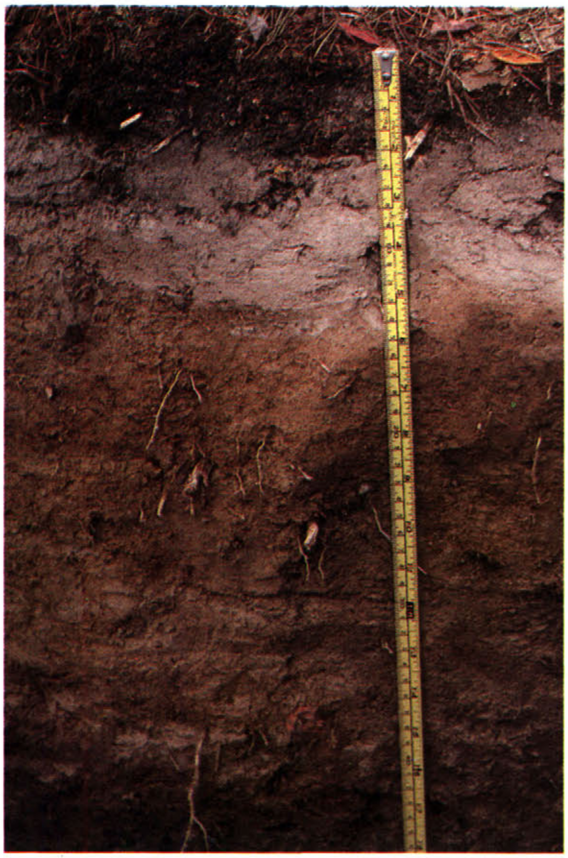
Orthic Gray Luvisol, Legend soil group, Birch Mountains Upland. Orthic Gray Luvisols of the Horse River, Buckton, and Livock soil groups have profiles similar to those in Photographs 5 and 6.

Photograph 7.

Orthic Gray Luvisol, Dover soil group, Dover Plain.

Photograph 8.

Gray Solodized Solonetz, Joslyn soil group, Dover Plain.



Photograph 9.

Undulating, glaciofluvial outwash with thin eolian veneers in the Embarras Plain north of McLelland Lake. Combinations of Mildred and Heart soil groups are mapped in this area.

Photograph 10.

Hummocky, glaciofluvial ice-contact deposits typical of the Fort Hills and Richardson Hills Uplands. Firebag soils, which are commonly eroded where slopes are strong, are mapped in these uplands.

Photograph 11.

Ridged and hummocky, eolian landform of the Brule Plain where bog and fen peats have accumulated in depressions between U-shaped dunes. Heart, Kenzie, and Eaglesham soils are mapped here. Similar landforms occur in parts of the Embarras Plain.

Photograph 12.

An active, hummocky, eolian landform in the Embarras Plain near Barber Lake.




Photograph 13.

Eluviated Dystric Brunisol in glaciofluvial sands. This profile type is common in Mildred and the eolian Heart soils. The morphology of Eluviated Eutric Brunisols is very similar to this profile.

Photograph 14.

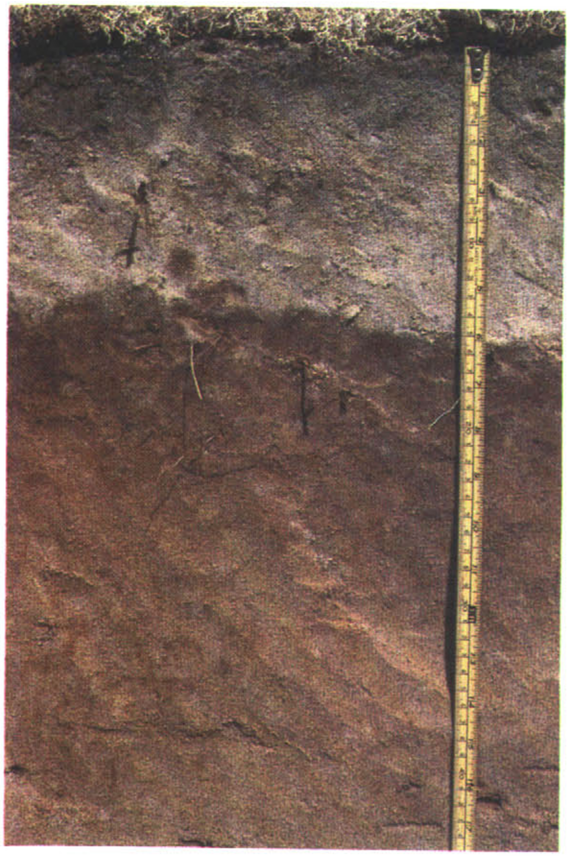
Eluviated Dystric Brunisol in glaciofluvial outwash sands near Lake Athabasca. This profile type is common in some Mildred and many Firebag soils. The strong colours in the upper B horizon indicate larger quantities of Fe and Al oxides and hydroxides than in the profile in Photograph 13.

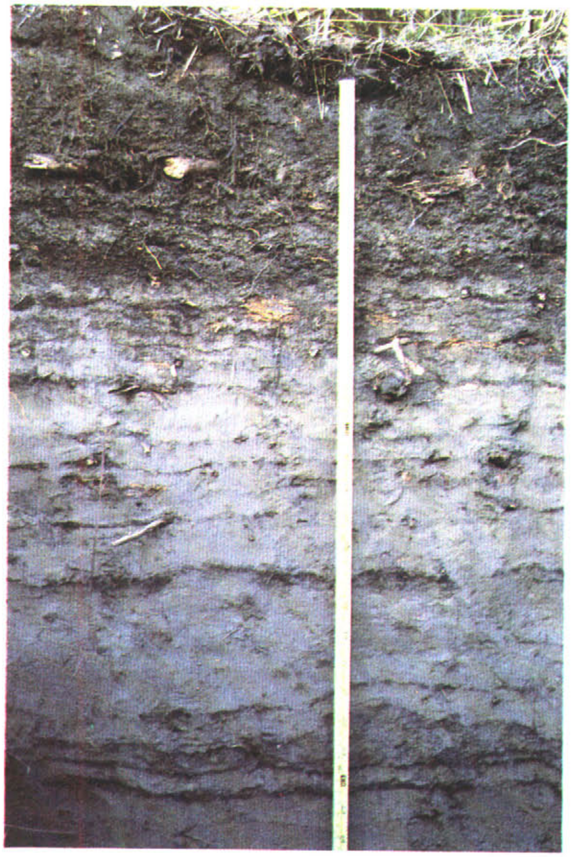
Photograph 15.

Cumulic Regosol in fluvial deposits of the Athabasca Delta Plain. The dark bands are remnants of former organic surfaces. These types of soils are typical of Chipewyan, Mamawi, Namur, and McMurray soil groups.

Photograph 16.

Peaty Rego Gleysol in loamy to sandy fluvial deposits of the Buckton Plain. Strong mottling indicates a fluctuating water table. Similar profiles are common in Namur, Mamawi, McMurray, Steepbank, Bitumount, and Algar soil groups.





Photograph 17.

Meandering stream in a small shallow fluvial channel. Peaty Gleysols of the McMurray soil group occupy the floodplain. These soils and landforms occur throughout the study area.

Photograph 18.

Channeled and sparsely vegetated mud flats on fans and aprons of the Buckton Plain suggest high potential erosion hazard of Namur soils due to the nature of the clayey material and to very long slopes.

Photograph 19.

Fluvial apron landform of the Buckton Plain. Namur and Eaglesham soils are typical of this area.

Photograph 20.

Fluvial delta landform of the Athabasca Delta Plain. Chipewyan soils occur on low ridges and support bottomland and riparian forest. Mamawi soils occupy depressions and support shrub and fen vegetation.

Photograph 21.

Colluvial landforms in the Birch Mountains Escarpment. Rough Broken lands with steep slopes occur in actively slumping areas while Buckton soils occur on the relatively stable, inclined surface in the right centre of the photograph.

Photograph 22.

Very thin lithic Brunisols occur in depressions within outcrops of granitic rock in the Flett Lake Plain and support sparse jack pine - lichen plant communities.

Photograph 23.

A helicopter was used for access throughout the study area. The landform in this photo is a bog plateau in the MacKay Plain.

Photograph 24.

Bog and fen landforms with Kenzie and Eaglesham soils occur throughout the Boreal Mixedwood ecoregion in the study area. This area is in the MacKay Plain, a large peatland in the central west part of the study area.

Photograph 25.

Large patterned fens such as this one near McLelland Lake are a characteristic feature of the Boreal Mixedwood ecoregion within the study area.

Photograph 26.

Bog plateaus with Organic Cryosols of the Mikkwa soil group characterize the Northern Boreal ecoregion. Legend and Eaglesham soils also occur in this area in the McIvor Plain.

Photograph 27.

Some bog plateaus are almost devoid of vegetation as a result of forest fires. Strongly mounded microrelief is the typical surface form of Mikkwa soils.

Photograph 28.

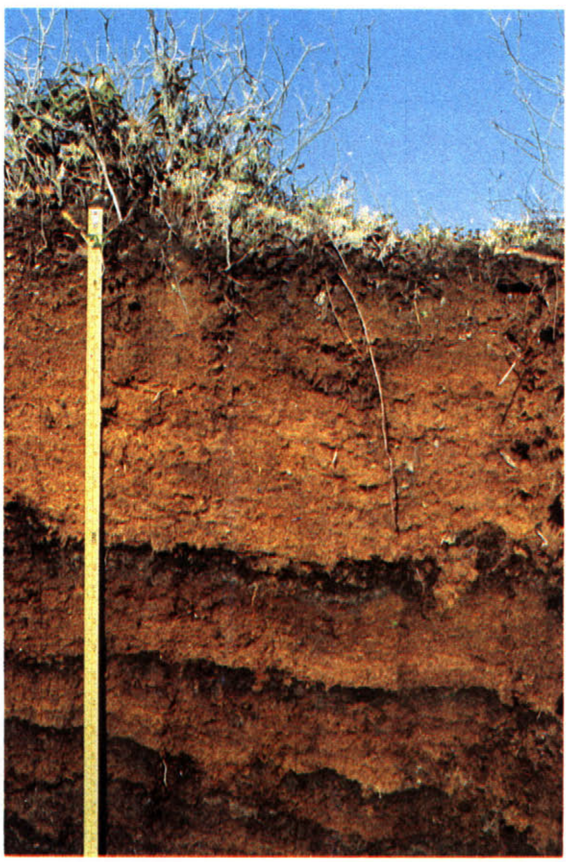
Bog plateau and fen complex in the Birch Mountains Upland with collapse scars and 'drunken forest' along some of the collapsing edges.

Photograph 29.

A Typic Fibrisol developed on peat of predominantly Sphagnum origin. A thin mesic layer, possibly a former burned surface, lies just below the straw coloured sphagnic material at the top of the profile. These profiles are common in the Kenzie soil group.

Photograph 30.

A Typic Fibrisol developed in Sphagnum peat. This profile is common in the Kenzie soil group. Similar profiles with frozen layers in the control section are typical of the Mikkwa soil group.



9.2 SOIL SURVEY CORRELATION IN THE OIL SANDS AREA

Two other soil surveys, on portions of the Syncrude and Alsands leases, have been carried out within the oil sands area to date. In the soil survey of a portion of the Syncrude Lease 17 area (Twardy 1978), the soil names used were mainly derived from previous soil surveys of other areas. Thus, different names are used for similar soils in the two reports. Table 14, in which the various soil names are correlated, may be of benefit to users of both reports.

In the soil maps and report of the Alsands area (Hardy Associates Ltd. 1980), soil names were taken from the AOSERP soils inventory project, but new names were also necessary for the more detailed mapping of that area. A correlation of Alsands and AOSERP soil names and map units is provided in the Alsands report.

Use of soil names in future soil surveys within the oil sands area should be consistent with that of previously published maps and reports. In this way, some uniformity of soil mapping in the oil sands area may be attained, thus preventing confusion and aiding users of soil maps in comparing soils across the area. A listing of soil names and descriptions at the soil family level of classification can be obtained from the Provincial Soil Survey Correlator, Alberta Soil Survey, 6th Floor, Terrace Plaza, 4445 Calgary Trail South, Edmonton, Alberta, T6H 5R7 Tel. (403) 438-1555.

Table 14. Correlation of soil group names used in "Soil survey of a portion of the Syncrude Lease 17 area, Alberta" with those used in this report.

Syncrude Name	AOSERP Name
McMurray	Dover
Mildred Lake	Algar
Blackmud	Mildred
Gunderson	Bitumont
Lodge	Mildred or Ruth Lake
Kenzie 1, 2	Kenzie 2
Kenzie 3	Kenzie 1
Eaglesham 1, 2	none
Eaglesham 3	Eaglesham 1

9.3 GLOSSARY

AASHO classification (soil engineering) - The official classification of soil materials and soil aggregate mixtures for highway construction used by the American Association of State Highway Officials.

adsorption complex - The group of substances in the soil capable of adsorbing water and nutrients.

aeration, soil - The process by which air in the soil is replaced by air from the atmosphere. The rate of aeration depends largely on the volume and continuity of pores in the soil.

aggregate, soil - A group of soil particles cohering so as to behave mechanically as a unit.

alkalization - The process whereby the exchangeable sodium content of a soil is increased.

alluvium - A general term for all detrital material deposited or in transit by streams, including gravel, sand, silt, clay, and all variations and mixtures of these.

anion - An ion carrying a negative charge of electricity. The common soil anions are carbonate, sulfate, chloride, and hydroxyl.

ash - The loss on ignition of a peat sample; the percent of original material remaining as residue after heating at 450 degrees Celsius for 16 hours in an electric muffle furnace.

Atterberg limits - Various moisture contents at which a soil changes from one major physical state to another. The Atterberg limits which are most useful for engineering purposes are liquid limit, plastic limit, and plasticity index (q.v.).

available nutrient - That portion of any element or compound in the soil that can readily be absorbed and assimilated by growing plants.

base saturation percentage - The extent to which the adsorption complex of a soil is saturated with exchangeable cations other than hydrogen and aluminum.

bed - A unit layer 1 cm or more thick that is visually or physically more or less distinctly separable from other layers above and below in a stratified sequence.

bedrock - The solid rock underlying soils and the regolith in depths ranging from zero (where exposed to erosion) to several hundred feet.

blowout - A small area from which soil material has been removed by wind.

bog - A peat covered area or peat filled depression with a high water table and a surface carpet of mosses, chiefly *Sphagnum* spp.

bottomland - See floodplain.

boulders - Stones which are larger than 60 cm in diameter.

boundary, horizon - The contact plane between soil horizons which is described by indicating its distinctness and form.

Distinctness

abrupt: less than 2.5 cm wide.
clear: 2.5 to 6 cm wide
gradual: 6 to 13 cm wide
diffuse: more than 13 cm wide

Form

smooth: nearly a plane
wavy: pockets are wider than deep
irregular: pockets are deeper than wide
broken: some parts are unconnected

bulk density, soil - The mass of dry soil per unit bulk volume.

calcareous classes - The calcareous classes, expressed in terms of $CaCO_3$ equivalent are: weakly (<6%), moderately (6-15%), strongly (15-25%), very strongly (26-40%), and extremely (>40%).

calcareous soil - Soil containing sufficient calcium carbonate, often with magnesium carbonate, to effervesce visibly when treated with cold 0.1N hydrochloric acid.

calcium carbonate equivalent - The total inorganic carbon content of soil material expressed in terms of percent calcium carbonate ($CaCO_3$).

cation - An ion carrying a positive charge of electricity. The common soil cations are calcium, magnesium, sodium, potassium, and hydrogen.

cation exchange - The interchange between a cation in solution and another on the surface of any surface-active material in the soil such as clay or organic matter.

cation exchange capacity (total exchange capacity) - The total amount of exchangeable cations that a soil can adsorb. It is expressed in milliequivalents per 100 g of soil.

chroma - The relative purity, strength, or saturation of a colour. It is directly related to the dominance of the determining wavelength of light.

clay - (1) As a particle-size term: a size fraction less than 0.002 mm in equivalent diameter, or some other limit (geologists and engineers). (2) As a rock term: a natural, earthy, fine grained material that develops plasticity with a small amount of water. (3) As a soil term: a textural class. See also texture, soil. (4) As a soil separate: a material usually consisting largely of clay minerals but commonly also of amorphous free oxides and primary minerals.

clay films (skins) - Coatings of oriented clays on the surface of soil peds and mineral grains, with a phyllosilicate structure.

climatic moisture index - An expression of the percentage contribution of precipitation in the growing season to the total amount of water required by a crop if lack of water is not to limit its production.

climax vegetation - Stable, self-perpetuating plant communities that are the end products of plant succession.

coarse fragments - Rock or mineral fragments greater than 2.0 mm in diameter.

cobbly - Containing appreciable quantities of rounded or subrounded coarse rock or mineral fragments 8 to 25 cm in diameter. "Angular cobbly" is used when the fragments are less rounded.

colloid, soil - Organic or inorganic matter having very small particle size and a correspondingly large surface area per unit of mass. Most colloidal particles are too small to be seen with the ordinary compound microscope.

colour - See Munsell colour system.

consistence - (1) The resistance of a material to deformation or rupture. (2) The degree of cohesion or adhesion of the soil mass. Terms used for describing consistence at various soil moisture contents are:

wet soil - nonsticky, slightly sticky, sticky, and very sticky.

moist soil - loose, very friable, friable, firm, and very firm.

dry soil - loose, soft, slightly hard, hard, very hard, and extremely hard.

control section, soil - The vertical section upon which the taxonomic classification of soil is based. The control section usually extends to a depth of 100 cm in mineral materials and to 160 cm in organic materials.

crevasse fillings - Ridges or hummocks formed from glacial sediments that were deposited by water in the cracks and crevasses of the ice.

cryoturbation - Frost action, including frost heaving.

degree days - The difference between the mean daily temperature and a selected standard temperature, accumulated daily over a period of time, such as the growing season.

delta - The accumulation of sediments where a stream empties into a body of quiet water, resulting in the building out of the shoreline.

deposition - The accumulation of material left in a new position by a natural transporting agent such as water, wind, ice, or gravity; or by the activity of man.

drainage - The removal of excess surface water or groundwater from land by natural runoff and percolation, or by means of surface or subsurface drains. Soil drainage classes are defined in terms of available water storage capacity (AWSC) and source of water, as follows:

very rapidly drained - Water is removed from the soil very rapidly in relation to supply. Excess water flows downward very rapidly if underlying material is pervious. There may be very rapid subsurface flow during heavy rainfall provided there is a steep gradient. Soils have very low AWSC (usually <2.5 cm) within the control section and are usually coarse textured, shallow, or both. Water source is precipitation.

rapidly drained - Water is removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep gradients during heavy rainfall. Soils have low AWSC (2.5 to 4 cm) within the control section, and are usually coarse textured, or shallow, or both. Water source is precipitation.

well-drained - Water is removed from the soil readily but not rapidly. Excess water flows downward rapidly into underlying pervious material or laterally as subsurface flow. Soils have intermediate AWSC (4 to 5 cm) within the control section, and are generally intermediate in texture and depth. Water source is precipitation. On slopes subsurface flow may occur for short durations but additions are equalled by losses.

moderately well-drained - Water is removed from the soil somewhat slowly in relation to supply. Excess water is removed somewhat slowly due to low perviousness, shallow water table, lack of gradient, or some combination of these. Soils have intermediate to high AWSC (5 to 6 cm) within the control section and are usually medium to fine textured. Precipitation is the dominant water source in medium to fine textured soils; precipitation and significant additions by subsurface flow are necessary in coarse textured soils.

imperfectly drained - Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Excess water moves slowly downward if precipitation is the major supply. If subsurface water or groundwater, or both, are the main sources, flow rate may vary but the soil remains wet for a significant part of the growing season. Precipitation is the main source if AWSC is high; contributions by subsurface flow or groundwater flow, or both, increases as AWSC decreases. Soils have a wide range in available water supply, texture, and depth, and are gleyed phases of well-drained subgroups.

poorly drained - Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen. Excess water is evident in the soil for a large part of the time. Subsurface flow or groundwater flow, or both, in addition to precipitation are the main water sources; there may also be perched water tables with precipitation exceeding evapotranspiration. Soils have a wide range in AWSC, textures and depths, and are gleyed subgroups, Gleysols, and Organic soils.

very poorly drained - Water is removed from the soil so slowly that the water table remains at or on the surface for the greater part of the time the soil is not frozen. Excess water is present in the soil for the greater part of the time. Groundwater flow and subsurface flow are the major water sources. Precipitation is less important except where there is a perched water table with precipitation exceeding evapotranspiration. Soils have a wide range in AWSC, texture, and depth, and are either Gleysolic or Organic.

drift, glacial - Rock debris transported by glaciers and deposited either directly from the ice or from the meltwater.

dune - A mound or ridge of sand piled up by the wind.

dysic - pH <4.5 in all parts of the control section of an Organic soil.

edaphic - (1) Of or pertaining to the soil. (2) Resulting from or influenced by factors inherent in the soil or other substrate, rather than by climatic factors.

eluvial horizon - A soil horizon that has been formed by the process of eluviation.

eluviation - The transportation of soil material in suspension or in solution within the soil by the downward or lateral movement of water.

ericaceous - Of or relating to the heath family.

erosion - The wearing away of the land surface by running water, wind, ice or other geological agents, including such processes as gravitational creep.

esker - A winding ridge of irregularly stratified sand, gravel and cobbles deposited under the ice by a rapidly flowing glacial stream.

euic - pH >4.5 in all parts of the control section of an Organic soil.

eutrophic - Rich in nutrients.

evapotranspiration - The combined loss of water from a given area and during a specific period of time, by evaporation from the soil surface and by transpiration from plants.

exchangeable cation - A cation that is held by the adsorption complex of the soil and is easily exchanged with other cations of neutral salt solutions.

fen - A peat-covered or peat-filled area with a high water table which is usually at the surface. The peat materials are derived primarily from sedges with inclusions of partially decayed stems of shrubs formed in a eutrophic environment due to the close association of the material with mineral rich waters.

fennic - A general term used to describe soils formed in fen peat material; used in describing Organic soil families.

fertility, soil - The status of a soil in relation to the amount and availability to plants of elements necessary for plant growth.

fiber, rubbed, or unrubbed - The organic material retained on a 100-mesh sieve (0.15 mm) either with or without rubbing, except for wood fragments that cannot be crushed in the hand and are larger than 2 mm in the smallest dimension.

fibric - The least decomposed state of all organic materials. There is a large amount of well-preserved fiber that is readily identifiable as to botanical origin. Fibers retain their character upon rubbing.

floodplain - The land bordering a stream, built up of sediments from overflow of the stream and subject to inundation when the stream is at flood stage.

flutings - Groups of ridge-like and groove-like glacial landforms combining to impart a fluted pattern to the surface.

forb - A herbaceous plant which is not a grass, sedge, or rush.

forest peat - Peat materials derived mainly from black spruce, ericaceous shrubs, and feathermosses.

frost free period - The period or season of the year between the last spring frost and the first autumn frost.

fungi - The allophytic plants that lack chlorophyll and are filamentous in structure; molds.

genesis, soil - The mode of origin of the soil, especially the processes or soil forming factors responsible for development of the solum from unconsolidated parent material.

gravel - Rock or mineral fragments 2 mm to 8 cm in diameter.

gravelly - Containing appreciable quantities of rounded or subrounded coarse rock or mineral fragments 2 mm to 8 cm in diameter. 'Angular gravelly' is used when the fragments are less rounded.

great group - A category in the Canadian system of soil classification. It is a taxonomic grouping of soils having certain morphological features in common and a similar pedogenic environment.

ground moraine - The rock debris deposited or released from glacial ice during ablation, to form an extensive, fairly even thin layer of till, having a gently rolling surface and low relief.

groundwater - Water that is passing through or standing in the soil and the underlying strata in the zone of saturation. It is free to move by gravity.

growing season - Period with soil temperatures over 5° C at a depth of 50 cm.

herb - Any flowering plant except those developing persistent woody bases and stems above ground.

horizon, soil - A layer of soil or soil material approximately parallel to the land surface; it differs from adjacent genetically related layers in properties such as colour, structure, texture, consistence, and chemical, biological, and mineralogical composition. A list of the designations and some of the properties of soil horizons and layers follows. More detailed definitions of some horizons and layers may be found in *The System of Soil Classification for Canada.*

Organic layers contain 17% or more organic carbon. Two groups of these layers are recognized:

O - An organic layer developed mainly from mosses, rushes, and woody materials.
- Of - The least decomposed organic layer, containing large amounts of well-preserved fiber, and called the fibric layer.
- Om - An intermediately decomposed organic layer containing less fiber than an Of layer and called the mesic layer.
- Oh - The most decomposed organic layer, containing only small amounts of raw fiber and called the humic layer.

L-F-H - Organic layers developed primarily from leaves, twigs, and woody materials, with a minor component of mosses.
- L - The original structures of the organic material are easily recognized.
- F - The accumulated organic material is partly decomposed.
- H - The original structures of the organic material are unrecognizable.

Mineral horizons and layers contain less than 17% organic carbon.

A - A mineral horizon formed at or near the surface in the zone of removal of materials in solution and suspension, or maximum in situ accumulation of organic carbon, or both.

B - A mineral horizon characterized by one or more of the following:
- (1) An enrichment in silicate clay, iron, aluminum, or humus.
- (2) A prismatic or columnar structure that exhibits pronounced coatings or stainings associated with significant amounts of exchangeable solution.

(3) An alteration by hydrolysis, reduction, or oxidation to give a change in color or structure from the horizons above or below, or both.

C - A mineral horizon comparatively unaffected by the pedogenic processes operative in A and B, except gleying, and the accumulation of carbonates and more soluble salts.

R - Underlying consolidated bedrock that is too hard to break with the hands or to dig when moist.

Roman numerals are prefixed to horizon designations to indicate unconsolidated lithologic discontinuities in the profile. Roman numeral I is understood for the uppermost material and usually is not written. Subsequent contrasting materials are numbered consecutively in the order in which they are encountered downward, that is, II, III, and so on.

Lowercase Suffixes

b - A buried soil horizon.

ca - A horizon of secondary carbonate enrichment where the concentration of lime exceeeds that in the unenriched parent material.

e - A horizon characterized by removal of clay, iron, aluminum, or organic matter alone or in combination and higher in color value by one or more units when dry than an underlying B horizon. It is used with A(Ae).

f - A horizon enriched with amorphous material, principally Fe and Al combined with organic matter. It usually has a chroma of 3 or more. The criteria for a f horizon except for Bgf are: it contains 0.6% or more pyrophosphate-extractable Fe plus Al in textures finer than sand and 0.4% or more in sands; the ratio of pyrophosphate-extractable Fe plus Al to clay (less than 2 μm) is greater than 0.5; and organic carbon exceeds 0.5%. These horizons are differentiated on the basis of organic carbon content into:
Bf, 0.5% to 5% organic carbon
Bhf, more than 5% organic carbon.

g - A horizon characterized by gray colors, or prominent mottling indicative of permanent or periodic intense reduction, or both; for example, Aeg, Btg, Bg, and Cg.

h - A horizon enriched with organic matter.

Ah - An A horizon of organic matter accumulation. It contains less than 17% organic carbon. It is one Munsell unit of color value darker than the layer immediately below, or it has at least 0.5% more organic carbon than the IC, or both.

Ahe - This horizon has been degraded, as evidenced by streaks and splotches of light and dark gray material and often by platy structure.

j - This is used as a modifier of suffixes e, g, n, and t to denote an expression of, but failure to meet, the specified limits of the suffix it modifies; for example, Aej is an eluvial horizon that is thin, discontinuous, or faintly discernible.
k - Presence of carbonate.
m - A horizon slightly altered by hydrolysis, oxidation, or solution, or all three, to give a change in color, or structure, or both.
n - A horizon in which the ratio of exchangeable Ca to exchangeable Na is 10 or less.
p - A layer disturbed by man's activities, for example, Ap.
s - A horizon containing detectable soluble salts.
sa - A horizon of secondary enrichment of salts more soluble than Ca and Mg carbonates, where the concentration of salts exceeds that present in the unenriched parent material.
t - A horizon enriched with silicate clay, as indicated by a higher clay content (by specified amounts) than the overlying eluvial horizon, a thickness of at least 5 cm, oriented clay in some pores, or on ped surfaces, or both, and usually a higher ratio of fine (less than 0.2 μm) to total clay than in the IC horizon.
x - A horizon of fragipan character.
y - A horizon affected by cryoturbation.
z - A perennially frozen layer.

hue - The aspect of colour that is determined by the wavelengths of light, and changes with the wavelength. Munsell hue notations indicate the visual relationship of a colour to red, yellow, green, blue, or purple, or an intermediate of these hues.

humic - Highly decomposed organic material. Small amounts of fiber are present that can be identified as to their botanical origin. Fibers can be easily destroyed by rubbing.

humification - The processes by which organic matter decomposes to form humus.

hummocky moraine - An area of knob and kettle topography that may have been formed either along a live ice front or around masses of stagnant ice.

humus - (1) The fraction of the soil organic matter that remains after most of the added plant and animal residues have decomposed. It is usually dark coloured. (2) Humus is also used in a broader sense to designate the humus forms referred to as forest humus. (3) All the dead organic matter on and in the soil that undergoes continuous breakdown, change and synthesis.

hydrophyte - A plant that grows in water, or in wet or saturated soils.

hypha, mycelium - Threadlike filaments, branched or composing a network, that constitute the vegetative structure of a fungus.

igneous rock - Rock formed by solidification from a molten or partially molten state.

illuvial horizon - A soil horizon in which material carried from an overlying layer has been precipitated from solution or deposited from suspension as a layer of accumulation.

illuviation - The process of depositing soil material removed from one horizon in the soil to another, usually from an upper to a lower horizon in the soil profile. Illuvial substances include silicate clay, hydrous oxides of iron and aluminum, and organic matter.

impeding horizon - A horizon which hinders the movement of water by gravity through soils.

infiltration - The downward entry of water into the soil.

kame - A conical hill or short irregular ridge of stratified gravel or sand deposited by glacial meltwater in contact with glacier ice.

kettle - A steep-sided, usually basin- or bowl-shaped hole or depression without surface drainage in glacial drift deposits.

lacustro till - A glacial deposit that looks like lacustrine material, has a texture of clay and contains a few stones.

lagg - The depressed margin of a raised bog.

laminations - Layering or bedding less than 1 cm thick in a stratified sequence.

landforms - The various shapes of the land surface resulting from a variety of actions such as deposition or sedimentation (eskers, lacustrine basins), erosion (gullies, canyons), and earth crust movements (mountains). See Section 4.2.3. for definitions of landforms in the study area.

leaching - The downward movement within the soil of materials in solution.

lessivage - The washing in suspension of fine clay and lesser amounts of coarse clay and fine silt down cracks and other voids in a soil body.

lime (in soil) - A soil constituent consisting principally of calcium carbonate; and including magnesium carbonate, and perhaps the oxide and hydroxide of calcium and magnesium.

limestone - A sedimentary rock composed of calcium carbonate.

liquid limit - (1) The water content corresponding to an arbitrary limit between the liquid and plastic states of consistence of a soil. (2) The water content at which a pat of soil, cut by a standard-sized groove, will flow together for a distance of 12 mm under the impact of 25 blows in a standard liquid-limit apparatus.

lithic layer - Bedrock under the control section of a soil. In Organic soils, bedrock occuring within a depth of between 10 cm and 160 cm from the surface.

loess - Material transported and deposited by wind, and consisting of predominantly silt sized particles.

matrix, soil - The main soil constituent or material that encloses other soil features, for example, concretions embedded in a fine grained matrix.

mesic - Organic material in an intermediate stage of decomposition. Intermediate amounts of fiber are present that can be identified as to their botanical origin.

mesophyte - A plant that grows under intermediate moisture conditions.

metamorphic rock - Rock derived from pre-existing rocks but that differs from them in physical, chemical and mineralogical properties as a result of natural geological processes, principally heat and pressure, originating within the earth.

microclimate - (1) The climate of a small area resulting from the modification of the general climate by local differences in elevation or exposure. (2) The sequence of atmospheric changes within a very small region.

microrelief - Small scale, local differences in relief, including mounds, swales, or hollows.

milliequivalent (me) - One one-thousandth of the equivalent weight of a molecule.

millisiemen (mS) - One one-thousandth of a siemen; a unit of electrical conductance, the reciprocal ohm.

mixed lacustrine - Same as lacustro till.

mor - A humus form of well drained to imperfectly drained sites consisting of organic horizons sharply delineated from the mineral soil.

moraine - A mound, ridge, or other distinct accumulation of unsorted, unstratified glacial drift, predominantly till, deposited chiefly by direct action of glacial ice in a variety of topographic landforms.

morphology, soil - The physical constitution, particularly the structural properties, of a soil profile as exhibited by the kinds, thickness and arrangement of the horizons in the profile; and by the texture, structure, consistence, and porosity of each horizon.

mottling - Spotting and blotching of different colour or shades of colour interspersed with the dominant colour.

mounded - A type of microtopography consisting of small basins and knolls categorized as follows: level or micromounded; slightly mounded (mounds 0.3 - 1 m high and >7 m apart); moderately mounded (mounds 0.3 - 1 m high and 3 - 7 m apart); strongly mounded (mounds 0.3 - 1 m high and 1 - 3 m apart); severely mounded (mounds 0.3 - 1 m high and 0.3 - 1 m apart); extremely mounded (mounds >1 m high and >3 m apart); ultramounded (mounds >1 m high and <3 m apart).

muck - Fairly well-decomposed organic soil material relatively high in mineral content, dark in colour, and accumulated under conditions of imperfect drainage.

Munsell colour system - A colour designation system specifying the relative degrees of the three simple variables of colour; hue, value, and chroma (q.v.).

nonsoil - The aggregate of surficial materials that do not meet the definition of soil.

ombrotrophic - Acidic and low in nutrients.

order, soil - A category in the Canadian system of soil classification. All the soils within an order have one or more characteristics in common.

organic carbon, soil - The percent by weight of carbon in organic forms of soil materials, determined by the difference between total carbon (determined by dry combustion) and inorganic carbon (determined by acid dissolution).

organic matter, soil - The organic fraction of the soil; includes plant and animal residues at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. It is estimated by multiplying the soil organic carbon content by 1.724.

orthic - A subgroup referring to the modal or central concept of various great groups in the Brunisolic, Chernozemic, Cryosolic, Gleysolic, Luvisolic, Podzolic, and Regosolic orders of the Canadian system of soil classification.

outcrop - That part of a geologic formation or structure that appears at the surface of the earth.

outwash - Stratified detritus (chiefly sand and gravel) washed out from a glacier by meltwater streams and deposited in front of or beyond the terminal moraine of an active glacier.

parent material - The unconsolidated and more or less chemically weathered mineral or organic matter from which the solum of a soil has developed by pedogenic processes.

particle-size analysis - The determination of the various amounts of the different separates in a soil sample, usually by sedimentation, sieving, micrometry, or combinations of these methods. Has been called grain-size analysis or mechanical analysis.

particle-size classes (for soil families and parent materials) Groupings of particle-size distribution of the whole soil or soil material including the coarse fraction. They are used for generalized descriptions of soils, and differ from texture which refers to the fine earth fraction (<2 mm) only. The classes are diagrammatically presented in Figure 7 and are described as follows:

Fragmental - Stones, cobbles and gravel, with too little fine earth to fill interstices larger than 1 mm.

Sandy-skeletal - Particles coarser than 2 mm occupy 35% or more by volume with enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is that defined for the sandy particle-size class.

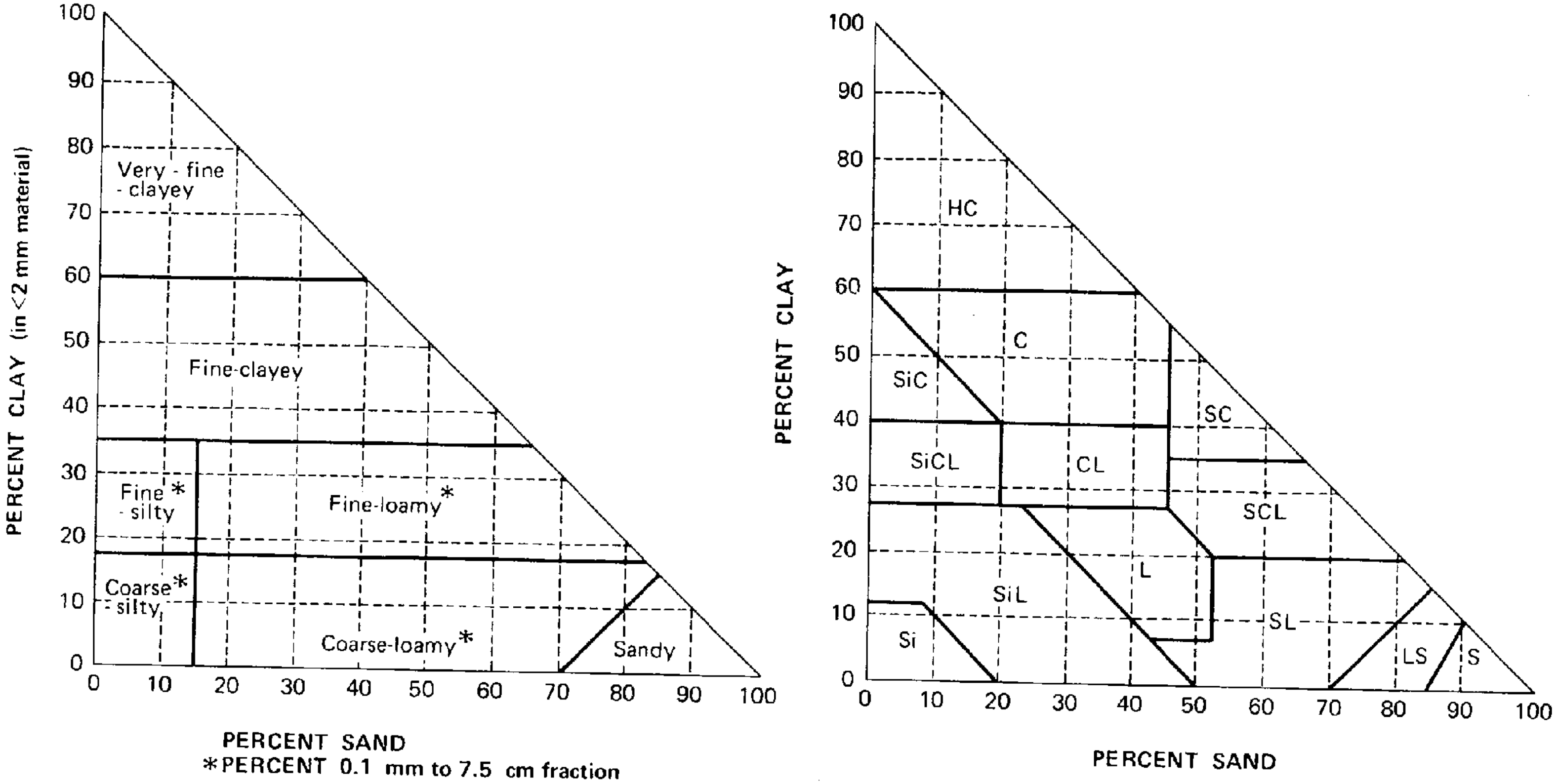


Figure 7. Family partical size classes and texture classes shown in terms of percentages of sand and clay. (The remainder of each class is silt).

Loamy-skeletal - Particles 2 mm-25 cm occupy 35% or more by volume with enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is that defined for the loamy particle-size class.

Clayey-skeletal - Particles 2 mm-25 cm occupy 35% or more by volume with enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is that defined for the clayey particle-size class.

Sandy - The texture of the fine earth includes sands and loamy sands, exclusive of loamy very fine sand and very fine sand textures; particles 2 mm-25 cm occupy less than 35% by volume.

Loamy - The texture of the fine earth includes loamy very fine sand, very fine sand, and finer textures with less than 35% clay; particles 2 mm-25 cm occupy less than 35% by volume.

Coarse-loamy. A loamy particle size that has 15% or more by weight of fine sand (0.25-0.1 mm) or coarser particles, including fragments up to 7.5 cm, and has less than 18% clay in the fine earth fraction.

Fine-loamy. A loamy particle size that has 15% or more by weight of fine sand (0.25-0.1 mm) or coarser particles, including fragments up to 7.5 cm, and has 18-35% clay in the fine earth fraction.

Coarse-silty. A loamy particle size that has less than 15% of fine sand (0.25-0.1 mm) or coarser particles, including fragments up to 7.5 cm, and has less than 18% clay in the fine earth fraction.

Fine-silty. A loamy particle size that has less than 15% of fine sand (0.25-0.1 mm) or coarser particles, including fragments up to 7.5 cm, and has 18-35% clay in the fine earth fraction.

Clayey - The fine earth contains 35% or more clay by weight and particles 2 mm-25 cm occupy less than 35% by volume.

Fine-clayey. A clayey particle size that has 35-60% clay in the fine earth fraction.

Very-fine-clayey. A clayey particle size that has 60% or more clay in the fine earth fraction.

particle-size distribution - The amounts of the various soil separates in a soil sample, usually expressed as weight percentages.

peat - Unconsolidated soil material consisting largely of undecomposed, or only slightly decomposed, organic material.

ped, soil - A unit of soil structure such as a prism, block, or granule, which is formed by natural processes.

pedogenic - Pertaining to the mode of origin of the soil, especially the processes or soil forming factors responsible for the development of the solum.

pedologist - A person who specializes in those aspects of soil science dealing with the origin, morphology, genesis, mapping and taxonomy of soils, and classification in terms of their use.

perched water table - A water table due to the 'perching' of water on a relatively impermeable layer at some depth within the soil. The soil within or below the impermeable layer is not saturated with water.

percolation - The downward movement of water through saturated or nearly saturated soil.

permafrost - (1) Perennially frozen material underlying the solum. (2) A perennially frozen soil horizon.

permafrost table - The upper boundary of permafrost, usually coincident with the lower limit of seasonal thaw.

permeability, soil - The ease with which gases and liquids penetrate or pass through a bulk mass of soil or a layer of soil. Because different soil horizons vary in permeability, the specific horizon should be designated.

perviousness - The potential of a soil to transmit water internally, as inferred from soil characteristics such as structure, texture, porosity, cracks, and shrink-swell properties. It is closely related to measures of permeability, percolation rate, infiltration rate, and others. Perviousness classes are applied to soils, the class being controlled by the water-transmitting potential of the least permeable layer in the soil. The classes are as follows:

rapidly pervious - The capacity to transmit water vertically is so great that the soil would remain wet for no more than a few hours after thorough wetting if there were no obstructions to water movement outside the body classified.

moderately pervious - The capacity to transmit water vertically is great enough that the soil would remain wet for no more than a few days after thorough saturation if there were no obstructions to water transmission outside the body classified.

slowly pervious - The potential to transmit water vertically is so slow that the horizon or the soil would remain wet (saturated) for periods of a week or more after thorough wetting whether or not there were obstructions to water movement outside the body classified.

pH, soil - The negative logarithm of the hydrogen-ion activity of a soil. The degree of acidity or alkalinity of a soil as determined by means of a glass, quinhydrone, or other suitable electrode or indicator at a specified moisture content or soil-water ratio, and expressed in terms of the pH scale.

pH-dependent cation exchange capacity - The difference between the effective cation exchange capacity and the cation exchange capacity of a soil measured at a pH higher than that of its natural value.

plastic limit - (1) The water content corresponding to an arbitrary limit between the plastic and the semisolid states of consistence of a soil. (2) The water content at which a soil will just begin to crumble when rolled into a thread approximately 3 mm in diameter.

plasticity index - The numerical difference between the liquid limit and the plastic limit.

platy - Consisting of soil aggregates that have developed predominantly along the horizontal axes; laminated; flaky.

podzolization - A process of soil formation resulting in the genesis of Podzolic soils.

porosity, soil - The volume percentage of the total bulk not occupied by solid particles.

profile, soil - A vertical section of the soil through all its horizons and extending into the parent material.

pyrophosphate index - An indicator of the degree of decomposition of peat materials measured by extracting samples with sodium pyrophosphate and determining the optical density of the extracts. The greater the optical density, the higher the index and the degree of decomposition or humification.

reaction, soil - The degree of acidity or alkalinity of a soil, usually expressed as a pH value. Descriptive terms commonly associated with certain ranges in pH are: extremely acid, less than 4.5; very strongly acid, 4.5-5.0; strongly acid, 5.1-5.5; moderately acid, 5.6-6.0; slightly acid, 6.1-6.5;

neutral, 6.6-7.3; slightly alkaline, 7.4-7.8; moderately alkaline, 7.9-8.4; strongly alkaline, 8.5-9.0; and very strongly alkaline, greater than 9.0.

reed - A type of tall grass that grows in wet places.

relief - The elevations or inequalities of the land surface when considered collectively.

reworked - Descriptive of material modified after its preliminary deposition, commonly by water or wind.

rock - Any naturally formed, consolidated or unconsolidated material, other than soil, composed of two or more minerals or occasionally of one mineral, and having some degree of chemical and mineralogic constancy.

rush - A grass-like herb growing in marshy ground, and having cylindrical leafless stems.

saline soil - A nonalkali soil that contains enough soluble salts to interfere with the growth of most crop plants.

salinization - The process of salt accumulation in soil.

saturation extract - The extract from a soil sample that has been saturated with water.

sedge - Grass-like herb that grows in marshy places.

sedimentary rock - Rock formed by the lithification of mechanical, chemical or organic sediments.

seepage, soil - The emergence of water from the soil along an extensive line of surface.

separates, soil - Mineral particles, less than 2.0 mm in equivalent diameter, ranging between specified size limits. The names and size limits of separates recognized by soil pedologists in Canada and the United States are: very coarse sand, 2.0 to 1.0 mm; coarse sand, 1.0 to 0.5 mm; medium sand, 0.5 to 0.25 mm; fine sand, 0.25 to 0.10 mm; very fine sand, 0.10 to 0.05 mm; silt, 0.05 to 0.002 mm; clay, less than 0.002 mm; and fine clay, less than 0.0002 mm.

series, soil - A category in the Canadian system of soil classification. This is the basic unit of soil classification, and consists of soils that are essentially alike in all major profile characteristics except the texture of the surface.

sesquioxide - A collective term for various iron and aluminum oxides and hydroxides.

shale - A laminated, detrital sedimentary rock in which the particles are predominantly of clay size.

shrub - A woody perennial plant differing from a tree by its low stature and by generally producing several basal shoots instead of a single trunk.

sieve analysis - A laboratory test to determine the amounts of gravel and sand fractions in a soil.

siltstone - A very fine grained, consolidated, clastic rock composed predominantly of particles of silt grade.

silvic - Pertaining to organic soils developed in forest peat; used in describing organic soil families.

slope classes - The description of an area or region in terms of the steepness of slopes. The slope classes and class limits, and descriptive terminology are:

Slope Class	Percent Slope	Approximate Degrees	Terminology
1	0-0.5	0	level
2	0.5-2.5	0.3-1.5	nearly level
3	2-5	1-3	very gentle slopes
4	6-9	3.5-5	gentle slopes
5	10-15	6-8.5	moderate slopes
6	16-30	9-17	strong slopes
7	31-45	17-24	very strong slopes
8	46-70	25-35	extreme slopes
9	71-100	35-45	steep slopes
10	>100	>45	very steep slopes

slump - A landslide characterized by a shearing and rotary movement of a generally independent mass of rock or earth along a curved slip surface (concave upward) and about an axis parallel to the slope from which it descends, and by backward tilting of the mass with respect to that slope so that the slump surface often exhibits a reversed slope facing uphill.

solum, soil (plural = sola) - The upper horizons of a soil in which the parent material has been modified and in which most plant roots are contained. It usually consists of A and B horizons.

solution, soil - The aqueous liquid phase of the soil and its solutes consisting of ions dissociated from the surfaces of the soil particles and of other soluble materials.

sphagnic - Pertaining to Organic soils developed in peat derived mainly from *Sphagnum* spp.; used in describing organic soil families.

spring - A place where groundwater flows naturally from a rock or the soil onto the land surface or into a body of surface water.

stones - Rock fragments greater than 25 cm in diameter if rounded and greater than 38 cm along the greater axis if flat.

stoniness - The relative proportion of stones in or on the soil. The stoniness classes are:

nonstony - stones cover <0.01% of surface and are more than 30 m apart.

slightly stony - stones cover 0.01-0.1% of surface and are 10-30 m apart.

moderately stony - stones cover 0.1-3% of surface and are 2-10 m apart.

very stony - stones cover 3-15% of surface and are 1-2 m apart.

exceedingly stony - stones cover 15-50% of surface and are 0.1-1 m apart.

excessively stony - stones cover >50% of surface and stones are less than 0.1 m apart.

stratified drift (or sorted drift) - Materials that are distinctly sorted according to size and weight of their component fragments, indicating a medium of transport (water or wind) more fluid than glacier ice.

structure classes, soil - A grouping of soil structural units or peds on the basis of size. These are tabulated under structure types, soil.

structure grades, soil - A grouping or classification of soil structure on the basis of inter- and intra-aggregate adhesion, cohesion, or stability within the profile. Three grades of structure designated from 1 to 3 are:

(1) weak - poorly formed, indistinct peds, barely evident in place.

(2) moderate - well-formed distinct peds, moderately durable and evident, but not distinct, in undisturbed soil.

(3) strong - durable peds that are quite evident in undisturbed soil, adhere weakly to one another, withstand displacement, and become separated when the soil is disturbed.

structure, soil - The combination or arrangement of primary soil particles into secondary particles, units, or peds. These peds may be, but usually are not, arranged in the profile in such a manner as to give a distinctive characteristic pattern. The peds are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades.

structure types, soil - A classification of soil structure based on the shape of the aggregates or peds and their arrangement in the profile. Structure types and classes are described in Table 15 and in Figure 8.

subgroup, soil - A category in the Canadian system of soil classification. These soils are subdivisions of the great groups, and therefore each soil is defined more specifically.

subsoil - The B horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below the plowed soil (or its equivalent of surface soil), in which roots normally grow.

terric layer - An unconsolidated mineral substratum underlying organic soil material.

texture, soil - The relative proportions of the various soil separates in a soil as described by the classes of soil texture. The limits of the various classes and subclasses are given below and are shown in Figure 7.

sand - Soil material that contains 85% or more sand.

loamy sand - Soil material that usually contains 70 to 85% sand but may contain as much as 90% sand depending upon the amount of clay present.

sandy loam - Soil material that usually contains 52 to 70% sand but may contain as much as 85% and as little as 43% sand depending upon the amount of clay present.

loam - Soil material that contains 7 to 27% clay, 28 to 50% silt, and less than 52% sand.

silt loam - Soil material that contains 50% or more silt and 12 to 27% clay, or 50 to 80% silt and less than 12% clay.

silt - Soil material that contains 80% or more silt and less than 12% clay.

sandy clay loam - Soil material that contains 20 to 35% clay, less than 28% silt, and 45% or more sand.

sandy clay - Soil material that contains 35% or more clay and

Table 15. Types, kinds, and classes of soil structure

Type	Kind	Class	Size (mm)
1. Structureless—no observable aggregation or no definite orderly arrangement around natural lines of weakness.	A. Single grain—loose, incoherent mass of individual particles as in sands.		
	B. Amorphous (massive)—a coherent mass showing no evidence of any distinct arrangement of soil particles.		
2. Blocklike—soil particles arranged around a point and bounded by flat or rounded surfaces.	A. Blocky (angular blocky)—faces rectangular and flattened, vertices sharply angular.	Fine blocky Medium blocky Coarse blocky Very coarse blocky	<10 10–20 20–50 >50
	B. Subangular blocky—faces subrectangular, vertices mostly oblique, or subrounded.	Fine subangular blocky Medium subangular blocky Coarse subangular blocky Very coarse subangular blocky	<10 10–20 20–50 >50
	C. Granular-spheroidal—characterized by rounded vertices.	Fine granular Medium granular Coarse granular	<2 2–5 5–10
3. Platelike—soil particles arranged around a horizontal plane and generally bounded by relatively flat horizontal surfaces.	A. Platy—horizontal planes more or less developed.	Fine platy Medium platy Coarse platy	<2 2–5 >5
4. Prismlike—soil particles arranged around a vertical axis and bounded by relatively flat vertical surfaces.	A. Prismatic—vertical faces well defined and edges sharp.	Fine prismatic Medium prismatic Coarse prismatic Very coarse prismatic	<20 20–50 50–100 >100
	B. Columnar—vertical edges near top of columns not sharp. (Columns may be flat-topped, round-topped, or irregular).	Fine columnar Medium columnar Coarse columnar Very coarse columnar	<20 20–50 50–100 >100

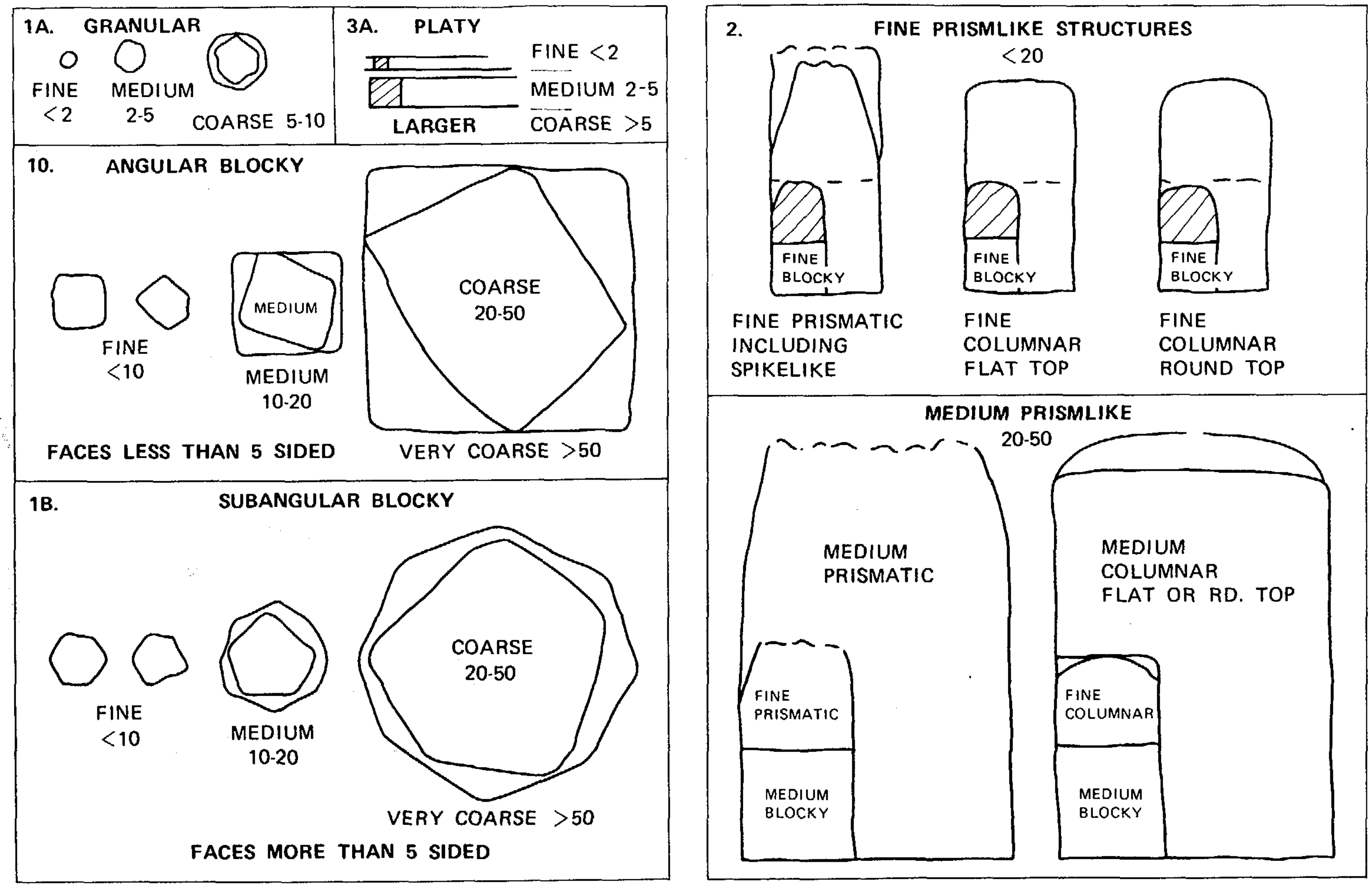


Figure 8. Diagrammatic representation of some of the types, kinds, and classes of soil structure (Source: Canada Soil Survey Committee, 1978a)

45% or more sand.

silty clay - Soil material that contains 40% or more clay and 40% or more silt.

clay - Soil material that contains 40% or more clay, less than 45% sand, and less than 40% silt.

heavy clay - Soil material that contains more than 60% clay.

till - Unstratified glacial drift deposited directly by the ice and consisting of clay, sand, gravel, and boulders intermingled in any proportion.

topography - The physical features of a district or region, such as those represented on a map, taken collectively; especially the relief and contours of the land.

Unified Soil Classification System (engineering) - A classification system based on the identification of soils according to their particle size, gradation, plasticity index, and liquid limit. Procedures and criteria are outlined in the ASTM Book of Standards (American Society for Testing and Materials 1979).

USDA textural classification - Same as soil texture as described in the Canadian System of Soil Classification (Canada Soil Survey Committee 1978). See texture.

void - Space in a soil mass not occupied by solid mineral matter. This space may be occupied by air, water, or other gaseous or liquid material.

volume weight - The bulk density a peat sample assumes after settling in a waterlogged condition. It is mainly determined on horticultural peats, but it is used in this report to crudely estimate the bulk density of undisturbed peat.

water capacity - The percentage of water remaining in organic soil material (peat) after having been saturated and after drainage of free water has practically ceased.

water table - The upper surface of groundwater or that level below which the soil is saturated with water.

waterlogged - Saturated with water.

weathering - The physical and chemical disintegration, alteration, and decomposition of rocks and minerals at or near the earth's surface by atmospheric agents.

xerophyte - A plant capable of surviving periods of prolonged moisture deficiency.

LIST OF AOSERP RESEARCH REPORTS

1. AOSERP first annual report, 1975.

2. Walleye and goldeye fisheries investigations in the Peace-Athabasca Delta--1975.

3. Structure of a traditional baseline data system 1976.

4. A preliminary vegetation survey of the AOSERP study area. 1976.

5. The evaluation of wastewaters from an oil sand extraction plant. 1976.

6. Housing for the north--the stackwall system; construction report--Mildred Lake tank and pump house. 1976.

7. A synopsis of the physical and biological limnology and fishery programs within the Alberta oil sands area. 1977.

8. The impact of saline waters upon freshwater biota (a literature review and bibliography). 1977.

9. A preliminary investigation into the magnitude of fog occurrence and associated problems in the oil sands area. 1977.

10. Development of a research design related to archaeological studies in the Athabasca oil sands area. 1977.

11. Life cycles of some common aquatic insects of the Athabasca River, Alberta. 1977.

12. Very high resolution meteorological satellite study of oil sands weather: "a feasibility study". 1977.

13. Plume dispersion measurements from an oil sands extraction plant, March 1976.

14.

15. A climatology of low-level air trajectories in the Alberta oil sands area. 1977.

16. The feasibility of a weather radar near Fort McMurray, Alberta. 1977.

17. A survey of baseline levels of contaminants in aquatic biota of the AOSERP study area. 1977.

18. Interim compilation of stream gauging data to December 1976 for AOSERP. 1977.

19. Calculations of annual averaged sulphur dioxide concentrations at ground level in the AOSERP study area. 1977.

20. Characterization of organic constituents in waters and wastewaters of the Athabasca oil sands mining area. 1978.

21. AOSERP second annual report, 1976-77.

22. AOSERP interim report covering the period April 1975 to November 1978.

23. Acute lethality of mine depressurization water to trout-perch and rainbow trout: Volume I: 1979.

24. Air system winter field study in the AOSERP study area, February 1977.

25. Review of pollutant transformation processes relevant to the Alberta oil sands area. 1977.

26. Interim report on an intensive study of the fish fauna of the Muskeg RI8ver watershed of northeastern Alberta. 1977.

27. Meteorology and air quality winte field study in the AOSERP study area, March 1976.

28. Interim report on a soils inventory in the Athabasca oil sands area. 1978.

29. An inventory system for atmospheric emissions in the AOSERP study area. 1978.

30. Ambient air quality in the AOSERP study area. 1977.

31. Ecological habitat mapping of the AOSERP study area: Phase I. 1978.

32. AOSERP third annual report, 1977-78.

33. Relationships between habitats, forages, and carrying capacity of moose range in northern Alberta. Part I: moose preferences for habitat strata and forages. 1978.

34. Heavy metals in bottom sediments of the mainstem Athabasca River system in the AOSERP study area. 1978.

35. The effects of sedimentation on the aquatic biota. 1978.

36. Fall fisheries investigations in the Athabasca and Clearwater rivers upstream of Fort McMurray: Volume I. 1978.

37. Community studies: Fort McMurray, Anzac, Fort MacKay. 1978.

38. Techniques for the control of small mammal damage to plants: a review. 1979.

39. The climatology of the AOSERP study area. 1979.

40. Mixing characteristics of the Athabasca River below Fort McMurray--winter conditions. 1979.

41. Acute and chronic toxicity of vanadium to fish. 1978.

42. Analysis of fur production records for registered traplines in the AOSERP study area, 1970-75.

43. A socio-economic evaluation of the recreational use of fish and wildlife resources in Alberta, with particular reference to the AOSERP study area. Vol. I: summary and conclusions. 1979.

44. Interim report on symptomology and threshold levels of air pollutant injury to vegetation, 1975 to 1978.

45. Interim report on physiology and mechanisms of air-borne pollutant injury to vegetation, 1975 to 1978.

46. Interim report on ecological benchmarking and biomonitoring for detection of air-borne pollutant effects on vegetation and soils, 1975 to 1978.

47. A visibility bias model for aerial surveys of moose in the AOSERP study area. 1979.

48. Interim report on a hydrogeological investigation of the Muskeg River basin, Alberta. 1979.

49. The ecology of macrobenthic invertebrate communities in Hartley Creek, northeastern Alberta.

50. Literature review on pollution deposition processes. 1979.

51. Interim compilation of 1976 suspended sediment data for the AOSERP study area. 1979.

52. Plume dispersion measurements from an oil sands extraction plant, June 1977.

53. Baseline states of organic constituents in the Athabasca River system upostream of Fort McMurray. 1979.

54. A preliminary study of chemical and microbial characteristics of the Athabasca River in the Athabasca oil sands area of northeastern Alberta. 1979.

55. Microbial populations in the Athabasca River. 1979.

57. Ecological habitat mapping of the AOSERP study area (supplement): Phase I. 1979.

58. Interim report on ecological studies on the lower trophic levels of Muskeg rivers within the AOSERP study area. 1979.

59. Semi-aquatic mammals: annotated bibliography. 1979.

60. Synthesis of surface water hydrology. 1979.

61. An intensive study of the fish fauna of the Steepbank River watershed of northeastern Alberta. 1979.

62. Amphibians and reptiles in the AOSERP study area. 1979.

63. Analysis of AOSERP plume sigma data. 1979.

64. A review and assessment of the baseline data relevant to the impacts of oil sands developments on large mammals in the AOSERP study area. 1979.

65. A review and assessment of the baseline data relevant to the impacts of oil sands development on black bear in the AOSERP study area. 1979.

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67. Aquatic biological investigations of the Muskeg River watershed. 1979.

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69. Native employment patterns in Alberta's Athabasca oil sands region. 1979.

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71. Lake acidification potential in the AOSERP study area. 1979.

72. The ecology of five major species of small mammals in the AOSERP study area: a review. 1979.

73. Distribution, abundance, and habitat associations of beavers, muskrats, mink, and river otters in the AOSERP study area, northeastern Alberta. 1979.

74. Air quality modelling and user needs. 1979.

75. Interim report on a comparative study of benthic algal primary productivity in the AOSERP study area. 1979.

76. An intensive study of the fish fauna of the Muskeg River watershed of northeastern Alberta. 1979.

77. Overview of local economic development in the Athabasca oil sands region since 1961. 1979.

78. Habitat relationships and management of terrestrial birds in northeastern Alberta. 1979.

79. The multiple toxicity of vanadium, nickel, and phenol to fish. 1979.

80. History of the Athabasca oil sands region, 1890 to 1960's. Volume I: socio-economic developments. Volume II: oral history. 1980.

81. Species distribution and habitat relationships of waterfowl in northeastern Alberta. 1979.

82. Breeding distribution and behaviour of the white pelican in the Athabasca oil sands area. 1979.

83. The distribution, foraging behaviour and allied activities of the white pelican in the Athabasca oil sands area. 1979.

84. Investigagions of the spring spawning fish populations in the Athabasca and Clearwater rivers upstream from Fort McMurray: Volume I. 1979.

85. An intensive surface water quality study of the Muskeg River watershed. Volume I: water chemistry. 1979.

86. An observational study of fog in the AOSERP study area. 1979.

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88. Ecological studies of the aquatic invertebrates of the AOSERP study area of northeastern Alberta. 1980.

89. Fishery resources of the Athabasca River downstream of Fort McMurray, Alberta: Volume I. 1980.

90. A wintertime investigation of the deposition of pollutants around an isolated power plant in northern Alberta. 1980.

91. Characterization of stored peat in the Alberta oil sands area. 1980.

92. Fisheries and habitat investigations of tributary streams in the southern portion of the AOSERP study area. Volume I: summary and conclusions. 1980.

93. Fisheries and aquatic habitat investigations in the MacKay River watershed of northeastern Alberta. 1980.

94. A fisheries and water quality survey of ten lakes in the Richardson Tower area, northeastern Alberta. Volume I: methodology, summary, and discussion. 1980.

95. Evaluation of the effects of convection on plume behaviour in AOSERP study area. 1980.

96. Service delivery in the AThabasca oil sands region since 1961. 1980.

97. Differences in the composition of soils under open and canopy conditions at two sites close-in to the Great Canadian Oil Sands Operation, Fort McMurray, Alberta. 1980.

98. Baseline condition of jack pine biomonitoring plots in the Athabasca oil sands area: 1976-77.

99. Synecology and autecology of boreal forest vegetation in the AOSERP study area. 1980.

100. Baseline inventory of aquatic of aquatic macrophyte species distributions in the AOSERP study area. 1980.

101. Woodland caribou population dynamics in northeastern Alberta. 1980.

102. Wolf population dynamics and prey relationships innortheastern Alberta.

103. Analysis of the leisure delivery system 1972-1979, with projections for future servicing requirements.

104. Review of requirements for air quality simulation models. 1980.

105. Approaches to the design of a biomonitoring program using arthropods as bioindicators for the AOSERP study area. 1980.

106. Meteorological factors affecting ambient SO_2 concentrations near an oil sands extraction plant. 1980.

107. Small mammal populations of northeastern Alberta. Volume I: populations in natural habitats. 1980.

108. Small mammal populations of northeastern Alberta. Volume II: populations in reclamation areas. 1980.

109. Symptomology and threshold levels of air pollutant injury to vegetation, 1979-80.

110. Physiology and mechanisms of airborne pollutant injury to vegetation, 1979-80.

111. Ecological benchmarking and biomonitoring for detection of airborne pollutant effects on vegetation and soils. 1980.

112. A study of human adjustment in Fort McMurray. Volume I: field study and results. 1980.

113. A laboratory study of long-term effects of mine depressurization groundwater on fish and invertebrates. 1980.

114. Aquatic biophysical inventory of major tributaries in the AOSERP study area. Volume I: summary report. 1980.

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116. An assessment of benthic secondary production in the Muskeg River of northeastern Alberta. 1980.

117. Development of a chemically reactive plume model for application in the AOSERP study area. 1980.

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119. Airshed management system for the Alberta oil sands. Volume I: A Gaussian frequency distribution model. 1981.

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123. Circulation of water and sediment in the Athabasca delta area. 1981.

124. Airshed management system for the Alberta oil sands. Volume III. validation and sensitivity studies.

125. The 1981 snowpack survey in the AOSERP study area. 1981.

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127. Alberta Oil Sands Environmental Research Program annual report 1981/82. 1982. in prep.

128. A comparative study of benthic algal primary productivity in the AOSERP study area. 1982. in prep.

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