This report is incomplete.

The original, printed version had missing pages. We apologize for the inconvenience.

SOIL SURVEY OF LUND'S POINT AREA
On Southern Shore of Cold Lake, Alberta
and
INTERPRETATION FOR RECREATIONAL USE

by
G. M. Greenlee, P. Ag.,
Soils Division
ALBERTA RESEARCH COUNCIL

1976

Alberta Institute of Pedology
Number M-76-3

CONTENTS

LIST OF TABLES

PREFACE

This report is one of a series describing detailed and semi-detailed soil surveys, which were conducted in the following Alberta Provincial Parks during the summer of 1975: Gooseberry Lake, Big Knife, Rochon Sands, Vermilion, Pembina River, and Garner Lake. Also included were areas in the vicinities of Upper and Lower Kananaskis Lakes, Cold Lake (Lund's Point), Calling Lake, and the Notikewin River. The total area mapped was approximately 28,080 acres.

A separate report is written for each area; however a standard explanatory section which is pertinent to all areas is presented at the beginning of each. Specific results and interpretations for a particular area are presented in the second section of the report, entitled "Soil Report". A few additional references and an additional glossary of terms specific to a particular area are also included in this section.

Also, in 1975, soil samples were collected from an archaeological site excavated by the Parks Planning Branch in the Cypress Hills. A detailed field soil profile description was made, and a report will be written after the samples have been analyzed in the laboratory.

INTRODUCTION

The growth in population and per capita income has and will continue to exert an unprecedented demand on the natural resources of Alberta. The nature of today's city living and working makes apparent the recreational value of Provincial Parks. Men and women often work in large factories and plants or in crowded offices, far removed from nature or a natural environment. The work week of forty hours or less, however, provides people with a relatively large amount of leisure time and prompts a constant search for off-time recreation to refresh the spirit. It is this trend in our civilization today that places high priority on comprehensive planning that will bring together the special interests in land use, watershed protection, wildlife, forestry, and parks and recreation based on carefully determined requirements.

Soil being one of the basic resources which man manipulates in his land use activities, requires prudent use, protection and proper management in order to realize its inherent potential on a sustained yield basis (Montgomery and Edminster, 1966). Recognition of natural phenomena and physical limitations is no less important in campground construction or septic tank location than it is in crop production. The kind of soil dictates to a large degree the type and location of recreational facilities. Some soils are not desirable sites for campgrounds, play areas, picnic grounds, cabin sites or nature study areas; other soils are very desirable sites for recreational uses. Knowledge of the soils of an area provides fundamental information needed in recreation planning. The soil information contained in the reports covering Provincial Parks and proposed park areas within Alberta is designed to be of assistance in planning future development.

ACKNOWLEDGMENTS

The Alberta Research Council provided the staff and sixty percent of the funds needed to cover the total costs of the 1975-76 Provincial Parks soil survey program; including field, laboratory and drafting work; as well as equipment and supplies. The Parks Planning Branch of Alberta Recreation, Parks and Wildlife contributed forty percent of the funds. The Alberta Research Council published the report and compiled the soil map. The University of Alberta provided office and laboratory space.

Mrs. Pal Foster typed and assisted in compiling and proof reading the report. Mr. Z. Widtman drafted the soil and landform maps, while Mr. J. Beres and Mr. C. Veauvy determined the physical properties of the soils. The soil chemical analyses were determined by the Alberta Soil and Feed Testing Laboratory.

Able field assistance was given by Mr. M. Hennie.

Special acknowledgment is given to the Park Wardens, as well as other Park employees, who co-operated by allowing soil investigations to be conducted throughout the parks, and also invariably offered assistance.

SUMMARY

The mapped area is situated only a half mile east of the town of Cold Lake bordering a portion of the southern shore of the lake proper, and the total area studied was about 1300 acres. The study area lies within the Eastern Alberta Plains of the Third Prairie Steppe, and the predominant parent material is till. Part of the area has a veneer of moderately fine textured lacustrine overlying till, and three small stretches of very coarse textured lacustrine overlying till occur along the lakeshore. A few small organic deposits are also found. The climate is continental with warm summers and cold winters. The study area lies within the Mixedwood Section of the Boreal Forest Region, where the native forest cover is aspen and white spruce, with lesser amounts of white birch and balsam poplar.

Five Map Units were recognized in the study area. The key profile types consist of Orthic Gray Luvisols, Dark Gray Luvisols, Orthic Regosols, Rego Gleysols - peaty phase, and Mesisols. These are distributed over the landscape in relation to parent material, landform, and drainage. Map Units consist of single soil series or groupings of series; and their distribution is shown on the Soils Map.

Soil interpretations are made for each Map Unit for camp areas, picnic areas, intensive play areas, paths and trails, lawns and landscaping, permanent buildings, septic tank absorption fields, sanitary landfills - trench type, reservoir sites, road location and sources of roadfill, sources of topsoil, and sources of sand or gravel.

In general, soils of Map Units 1 and 2 when found on suitable topography (classes c and d) are well suited to recreational development, and have moderate limitations for construction purposes due to a high clay content of the subsoil, slow permeability, susceptibility to frost heave, and moderate shrink-swell potential. These soil areas can be located by careful study of the Soils Map and Table 18 (interpretations table).

A soil survey properly interpreted is a useful guide for general recreation planning and in site selection. However, all soil differences which occur in the field cannot be shown on a soils map. Thus for design and construction of specific recreational facilities, an on-site investigation is often needed.

METHODS

Field Techniques

The areas surveyed were traversed by motor vehicle along all roads and negotiable trails, and on foot along cut lines and trails not suitable for vehicles. An outboard motor boat was utilized along lake shores and rivers in some areas of otherwise limited access, and foot traverses were made as necessary across areas lacking trails.

Soil pits were dug at frequent intervals to depths of 2 to 5 feet, to examine and describe soil horizons and to classify the soils. The usual procedure was to excavate the upper 2 feet of a soil pit with a shovel, and to examine the lower depths by sampling with a soil auger.

Soil areas were delineated on ozalid copies of photomosaics at a scale of 1:8000 (8 inches = 1 mile). Panchromatic black and white areal photographs of scales varying from 1:31,680 (2 inches = 1 mile) to 1:12,000 (5.25 inches = 1 mile) were also used with the aid of a pocket stereoscope, to facilitate the field mapping.

Representative surface and shallow subsurface soil samples were collected for chemical analyses, and subsurface samples were collected at depths of 3 to 6 feet for physical analyses.

Chemical and Physical Analyses

Chemical analyses were carried out by the Alberta Soil and Feed Testing Laboratory (O.S. Longman Building, Edmonton). These involved the following determinations:

1) Available nutrients; Available nitrogen (N) and available potassium (K) (Jackson 1962), available phosphorus (P) (Dickman and Bray 1940), and available sulphur (S) (Carson et al 1972).
2) Soil Reaction; pH was determined with a glass and calomel electrode, using a 2:1 water to soil ratio (Jackson 1962).
3) Electrical Conductivity was measured by a dip electrode procedure. The electrodes were placed in the supernatant liquid on the surface of a 2:1 water to soil mixture.

4) Soluble Sulphates (SO_4) were determined on soil samples having electrical conductivities of 1 or more. A saturated soil paste was prepared according to the procedure outlined in U.S.D.A. Handbook 60 (1954). A saturation extract was obtained by suction, and sulphates were precipitated with $BaCl_2$ crystals by the turbidimetric method and estimated by a visual inspection.

5) Exchangeable Sodium (Na) was determined by flame photometry (Jackson 1962).

6) Organic Matter was estimated by a visual inspection of the soil sample.

7) Free Lime was determined by a visual estimation of the degree of effervescence when a ten percent solution of dilute HCl was added to a soil sample.

8) Available Aluminum (Al) and Manganese (Mn) were determined on soil samples having a pH of 5.5 or less. These nutrients were determined by atomic adsorption spectrophotometry (Hoyt and Nyborg 1971).

Physical analyses were carried out in the Alberta Institute of Pedology laboratories (ASTM 1970). These involved the following determinations: field moisture content, liquid limit, plastic limit, sieve analysis, and particle size analysis (hydrometer method). Values for optimum moisture content and maximum dry density were obtained from charts prepared by the Alberta Transportation Laboratory of Alberta Transportation (1955).

GENERAL DISCUSSION OF SOIL MAP

The soils were classified according to the System of Soil Classification for Canada (C.D.A. 1974). The areal extent of each different kind of soil is indicated on the soil map. An explanation of the map symbol follows:

Example: $\frac{4}{e\ 2}$ — map unit (Soil Report)
topographic class (Table 1) — surface stoniness rating (Table 2)

The Map Units indicate single soil series, groupings of series, or soil associations. A soil series consists of soils that are essentially alike in all major profile characteristics except the texture of the surface (CDA 1972). Where a Map Unit consists of a grouping

of series, they occur together in a characteristic pattern within the landscape and it is not feasible to outline each separately because of the scale of the soil map. A soil association simply consists of a sequence of soils of about the same age, derived from similar parent materials, and occurring under similar climatic conditions, but having unlike characteristics because of variations in relief and in drainage (CDA, 1972).

Where a Map Unit consists of a single series, other soil series may be found in close proximity. However, the dominant series constitutes roughly 70 to 90% of the Map Unit; the other series are present in such minor amounts that their presence is not considered significant enough to affect the use of a particular Map Unit for recreation.

Where a Map Unit consists of a grouping of series, the different series generally possess very similar properties. The approximate percentage of each series is indicated in the soil report. Minor insignificant inclusions of other series may be present but are not mentioned in the definition of the Map Unit.

Where a Map Unit consists of a soil association, the approximate percentages of only the dominant members (which may also be series) are indicated. Minor insignificant amounts of other members often occur, but are not mentioned. Soil interpretations are for the most dominant member of an association, since interpretations for the less dominant members may be very different.

Other miscellaneous symbols appearing on the soil map are defined or explained in the soil report.

The topographic classes and surface stoniness ratings are defined in Tables 1 and 2 respectively.

Table 1. Topographic Classes and Symbols (CDA, 1974)

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

Table 2. Surface Stoniness Ratings[1] (Greenlee, 1971)

Stony 0 -	(stone-free land)	too few stones to be of any hindrance to recreation
Stony 1 -	(slightly stony land)	some stones, only slight to no hindrance to recreation
Stony 2 -	(moderately stony land)	enough stones to cause some interference with recreation
Stony 3 -	(very stony land)	enough stones to constitute a serious handicap to recreation - some clearing is required
Stony 4 -	(exceedingly stony land)	enough stones to prevent recreational use unless considerable clearing is done
Stony 5 -	(excessively stony land)	too stony to permit any recreational use (boulder or stone pavement)

GENERAL DISCUSSION OF LANDFORM MAP

The landform map is included simply to provide additional information about the mapped area. The landforms don't have any direct bearing on the soil interpretations which appear later in the report.

The symbols, which appear on the landform map, refer to local landforms. A local landform is considered to be comprised of a unique assemblage of slopes which are constantly repeated in nature, and which generally owe their unique form to the composition and mode of origin of a surficial deposit (Acton, 1975). This repetitive landform pattern may be associated with different major geologic structures, the result being similar local landforms or repetitive landform patterns occurring in different regional landform units. An outwash fan of a valley glacier as contrasted to a similar local form associated with continental glaciation would serve as an example of one repetitive landform pattern in regionally different landform units.

The landform classification system is outlined in Table 3. For a more complete description of the landform classification system, see "A Landform Mapping System for Canadian Soil Surveys" (Acton, 1975).

[1] See also definitions in The System of Soil Classification for Canada (CDA, 1974).

Table 3. OUTLINE OF THE LANDFORM CLASSIFICATION SYSTEM (ACTON, 1975).

SURFACE EXPRESSION CATEGORIES	COMPOSITIONAL CATEGORIES						
	MORAINAL	LACUSTRINE	FLUVIAL	COLLUVIAL	EOLIAN	UNDIFFERENTIATED	ROCK
Level (slopes usually < 2 - 3%)	Ml - level morainal	Ll - level lacustrine $L^{G}l$ - level glaciolacustrine	Al - level alluvial $F^{G}l$ - level glaciofluvial		El - level eolian $E^{F}l$ - level fluvioeolian		Rl - level rock
Undulating (slopes usually < 0.5 mile long, dominant grad ent 2 - 5%)	Mu - undulating morainal	Lu - undulating lacustrine $L^{G}u$ - undulating glacio-lacustrine	Au - undulating alluvial $F^{G}u$ - undulating glacio-fluvial		Eu - undulating eolian $E^{F}u$ - undulating fluvioeolian		Ru - undulating rock
Inclined (slopes 3 - 30%)	Mi - inclined morainal			Ci - inclined colluvial			Ri - inclined rock
Steep sloping (slopes usually > 30 %)	Ms - steep sloping morainal			Cs - steep sloping colluvial		Us - steep sloping undifferentiated	Rs - steep sloping rock
Hummocky (irregular expression)	Mh - hummocky morainal	$L^{G}h$ - hummocky glacio-lacustrine	$F^{G}h$ - hummocky glacio-fluvial	Ch - hummocky colluvial	Eh - hummocky eolian $E^{F}h$ - hummocky fluvioeolian		Rh - hummocky rock
Rolling (slope length often 1 mile or more, grad ents > 5%)	Mm - rolling morainal	$L^{G}m$ - rolling glaciolacustrine	$F^{G}m$ - rolling glacio-fluvial		Em - rolling eolian $E^{F}m$ - rolling fluvioeolian		Rm - rolling rock
Ridged (steep sides)	Mr - ridged morainal	$L^{G}r$ - ridged glaciolacustrine	$F^{G}r$ - ridged glaciofluvial	Cr - ridged colluvial	Er - ridged eolian $E^{F}r$ - ridged fluvioeolian		Rr - ridged rock
Pitted (flat area, prominent depressions)	Mp - pitted morainal	$L^{G}p$ - pitted glacio-lacustrine	$F^{G}p$ - pitted glaciofluvial		Ep - pitted eolian		Rp - pitted rock
Terraced (level to gently inclined, bounded by steep slopes)		Lt - terraced lacustrine $L^{G}t$ - terraced glacio-lacustrine	At - terraced alluvial $F^{G}t$ - terraced glacio-fluvial				Rt - terraced rock
Fan (gently sloping, fan shape)			Af - alluvial fan $F^{G}f$ - glaciofluvial fan	Cf - colluvial fan			
Apron (extensive deposit, base of mountain)			Aa - alluvial apron	Ca - colluvial apron			
Veneer (surface form strongly influenced by sub-surface deposits)	Mv - morainal veneer	Lv - lacustrine veneer $L^{G}v$ - glaciolacustrine veneer	Av - alluvial veneer $F^{G}v$ - glaciofluvial veneer	Cv - colluvial veneer	Ev - eolian veneer		
Blanket (surface form shows some influence of sub-surface deposits)	Mb - morainal blanket	Lb - lacustrine blanket $L^{G}b$ - glaciolacustrine blanket	Ab - alluvial blanket $F^{G}b$ - glaciofluvial blanket	Cb - colluvial blanket	Eb - eolian blanket		

Table 3 (cont.)

SURFACE EXPRESSION CATEGORIES	COMPOSITIONAL CATEGORIES			
	BOG	FEN	MARSH	UNDIFFERENTIATED
Blanket	Bb – blanket bog			
Domed	Bd – domed bog	Nd – domed fen		
Plateau	Bp – bog plateau			
Flat	Bl – flat bog			
Bowl	Bo – bowl bog			
Horizontal		Nh – horizontal fen	Hh – horizontal marsh	
Patterned		Np – patterned fen		
Sloping		Ns – sloping fen		
Floating		Nf – floating fen		
Collapse		Nc – collapse fen		
Spring		Ng – spring fen		
				Ou – undifferentiated organic

Ten compisitional classes have been established; six unconsolidated mineral deposits (one being undifferentiated), three organic classes and one class for all types of bedrock. Deposits of fluvial and lacustrine origin are further subdivided depending upon their glacial or non-glacial origin. The definition of each class follows:

Group I - Unconsolidated Mineral Deposits

Colluvial: accumulations of any loose, heterogeneous, and incoherent mass of material or rock fragments (variable mixture of boulder to clay) deposited chiefly by mass-wasting, usually at the base of a steep slope or cliff.

Eolian: accumulations of deposits (sand and silt) whose constituents were transported (blown) and laid down by atmospheric currents, or of deposits produced or eroded by the wind.

Fluvioeolian: pertaining to deposits formed by the combined action of streams and wind.

Fluvial: accumulations of sediment (sand, gravel, silt, and minor coarser material) produced by the action of a stream or river.

Glaciofluvial: pertaining to the deposits and landforms produced by meltwater streams flowing from wasting glacier ice.

Alluvial: accumulations of material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semisorted sediment in the bed of the stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope.

Fluvial-eolian; pertaining to modification of fluvial sediments by wind action.

Fluvial-lacustrine: pertaining to sedimentation partly in lake water and partly in streams, or to sediments deposited under alternating or overlapping lacustrine and fluvial conditions. (Glaciofluvial - glaciolacustrine would infer glacial streams and lakes).

Lacustrine: accumulations of stratified sediment (silt, clay, sand and minor coarser material) deposited in the bottom of a lake or produced by a lake.

Glaciolacustrine: deposits composed of suspended material brought by meltwater streams flowing into lakes bordering the glacier, as delta kames and varved sediments.

Morainal: accumulations of unsorted, unstratified glacial drift, predominantly till (variable mixture of boulders, gravel, sand, silt and clay) deposited chiefly by direct action of glacier ice in a variety of topographic landforms that are independent of control by the surface on which the drift lies.

Undifferentiated: accumulations of unconsolidated deposits where differentiation into one of the six classes above is impractical or impossible.

Group II - Organic Deposits

Bog: a peat-covered or peat-filled area, generally with a high ombrotrophic and acid water table. The peat is derived from mosses and the groundwater is usually acidic and low in nutrients.

Fen: a peat-covered or peat-filled area with a high water table. The peat is derived from sedges, grass and reeds and waters are generally minerotrophic.

Marsh: a deposit comprised of mineral or organic material with a high mineral content, but with little peat accumulation. It is associated with a grassy, wet area, periodically inundated up to a depth of 6.5 feet or less with standing or slowly moving water.

Group III - Bedrock

Rock: any consolidated or coherent and relatively hard, naturally formed mass of mineral matter.

Four mutually exclusive groups have been established within the pattern category; one for unconsolidated and bedrock deposits and one for each of the three organic deposits. The definition of each class follows:

Group I - Patterns Associated with Unconsolidated and Bedrock Classes

Level, planar: a relatively flat area having few or no prominent surface irregularities; slopes generally less than 2 - 3%.

Inclined: areas with a pronounced slope, usually continuous from top to bottom throughout the entire area. Slopes from 3 to 30%.

Steep: areas with a very pronounced slope; usually greater than 30%.

Undulating: a regular, smooth, wave-like pattern with slopes generally less than 0.5 mile long and dominant gradient of slopes from 2 to 5%.

Rolling: a regular, smooth, wave-like pattern with slope length often one mile or greater and gradients greater than 5%.

Hummocky: abounding in irregular, rounded or conical knolls, mounds, or other small elevations, generally equidimensional in shape and not ridge-like.

Pitted: a relatively flat area having prominent depressions or pits.

Ridged: a long, narrow elevation of the surface, usually sharp crested with steep sides, occurring either as an independent hill or as part of a larger hill.

Terraced: a long, narrow, relatively level or gently inclined surface bounded along one edge by a steeper descending slope and along the other by a steeper ascending slope; a large bench or step-like ledge breaking the continuity of a slope.

Fan: a gently sloping, fan shaped mass forming a section of a very low cone commonly at a place where there is a noticeable decrease in gradient.

Apron: an extensive, continuous, outspread, blanket-like deposit of alluvial or colluvial material deposited at the base of a mountain.

Blanketed: surface form in areas of thin surficial deposits; shows some influence of subsurface deposits.

Veneered: surface form in areas of very thin surficial deposits which is strongly influenced by subsurface deposits.

Group II - Patterns Associated with Bogs

Blanket: a bog covering slopes and depressions alike, up to a considerable degree of slope.

Bowl: a bog with a concave shaped surface associated with organic-filled depressions.

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

Flat: a bog with an insignificant difference in the level of the peat surface.

Plateau: a bog with an elevated, flat, central area only slightly higher than the margin.

Group III - Patterns Associated with Fens

Collapse scar: circular fen areas with steep banks developed as a result of permafrost melting.

Domed: a fen with a convex central area slightly higher than the margins. It is elevated due to ice lens formation.

Floating: a fen floating on an open water surface.

Horizontal: a fen with insignificant differences in the surface of the peat.

Patterned: a fen with a pattern of ridges and hollows, which occurs on gently sloping surfaces.

Sloping: a fen occupying sloping areas and fed by seepage.

Spring: convex or sloping fen areas situated directly over springs or in areas where springs abound.

Group IV - Patterns Associated with Marshes

Horizontal: a flat, unidirectional surface not broken by marked elevations and depressions.

SOIL CHARACTERISTICS AND INTERPRETATIONS FOR RECREATIONAL USE

Soil surveys provide for classifying, defining and delineating each kind of soil and making predictions of soil behaviour under specific management (Montgomery and Edminster 1966). The soils within an area are mapped and classified without regard for existing or expected land ownership boundaries, or types of use. Each delineated soil is defined so that the information is available for planning different kinds of land use.

Each kind of soil has its own peculiar set of characteristics and qualities which are described in terms that can be observed (Montgomery and Edminster 1966). These include soil texture; colour; structure; consistence; depth (to rock, hardpan, water table, etc.); kind and amount of coarse fragments; kind, thickness and sequence of soil layers; organic matter content; reaction; and slope. When accurately defined a specific soil can be distinguished from all other kinds of soil.

Most soils can be used for recreational activities of some kind. Some have no limitations for specific kinds of recreational uses; others have moderate to severe limitations for certain uses. Many soil properties affect the use limitations of soils for recreation, and the effects of a given soil property often vary with different uses (Brocke, 1970).

The soil properties affecting most recreational uses include susceptibility to flooding, wetness, slope, and surface stoniness (Brocke, 1970). Other soil properties also having an effect include: depth to sand and gravel, an impeding horizon and surface soil texture, as they affect permeability and erodibility; texture and plasticity, as they affect shrink-swell potential, and susceptibility to frost heaving; soluble sulphate content, as it affects concrete corrosion hazard; and salinity of the topsoil.

Soils that are subject to flooding during the season of use are considered to have severe limitations for recreation facilities such as camping areas, building sites, and roads. Such areas require permanent design considerations. These soils should not be developed for campsites or building sites unless they are protected by dikes, levees or other flood prevention structures, which may be uneconomical. These soils may be better suited for hiking or nature study areas, or for greenbelt open space, if the flooding is not too frequent. Montgomery and Edminster (1966) suggest one or two floodings during the season of use constitutes only a moderate limitation for picnic areas, playground areas and hiking trails. These are the less permanent facilities that can be moved with relative ease. Thus, the soils can be managed to a high level without maintenance costs rising beyond the financial capacity of the administration.

Soils that are wet all year, even if not flooded, have severe limitations for campsites, roads, hiking trails, playgrounds and picnic areas. The economic feasibility of installing subsurface drainage in these soils is questionable. Soils that are wet only part of the year or those with a water table that fluctuates without actually reaching the surface are not easily detected. These soils are considered to have moderate to severe limitations for most recreational uses, and if possible should be avoided for the more permanent facilities such as camping areas and building sites. With careful

planning, design, and management, however, these soils can be used for most recreational facilities. Soils that dry out slowly after rains also present problems where intensive use is contemplated. The soils that are dry during the season of use and have a water table greater than 3 feet from the surface are considered to have slight to no limitations for most recreational uses.

Droughty or very rapidly drained soils also have limitations for many recreational uses. On such sites grass cover needed for playing fields is difficult to establish and maintain. Access roads may be excessively dusty. Vehicles are easily mired down in sandy soils and soil blowing is common. Knowledge of these soil problems enables planners to use corrective conservation practices, such as irrigation, or to choose alternative locations.

The ability of a soil to support a load is important in many kinds of recreational activities. Some soils when wet fail to support structures such as access roads, trails and buildings.

Slope affects the use of soils for recreation. Generally, slopes of less than 2% offer no limitations for use as playgrounds, campsites, sites for recreation buildings, roads and trails. Slopes greater than 9% constitute a severe limitation for playground areas, since levelling costs would become prohibitive. Slopes of more than 15% constitute a severe limitation for camping areas, picnic areas and some building sites for the same reason. The smaller areas required for these facilities as compared to playground areas, account for the greater tolerance. On the other hand, steeply sloping soils are essential for ski runs and are desirable for hiking areas and scenic values. Hiking trails are not limited unless slopes are greater than 30%. Of course, steep, gently sloping and moderately sloping soils can be levelled for campsites, playgrounds and building costs, where the cost is justified. Where this is done it is especially urgent that effective soil conservation practices be applied and maintained, based on the specific conditions at hand.

Permeability is an important property affecting the recreational use of soils. Since no permeability measurements were made, it has been estimated from a consideration

of texture, structure and depth to an impeding horizon in the profile (O'Neal, 1952). Soils with very rapid to moderately rapid permeability have no limitations, and soils with slow and very slow permeability have severe limitations. The same classes apply to suitability for road subgrade material but are reversed when considering suitability for reservoir sites. Soils are rated for this purpose on their capacity to hold water without allowing seepage. It should be noted that the degree of limitation due to permeability will vary with climate. In high rainfall areas permeability is much more important than in low rainfall areas.

Surface stoniness limits the use of some soils for recreational facilities. Generally the non-stony (class 0) to slightly stony (class 1) land offers no limitation for recreational facilities. Very stony (class 3) to excessively stony (class 5) land offers severe limitations for camping areas, playground areas and building sites. The expense of removing the stone hazard is considered prohibitive. The very stony (class 3) land is considered to constitute only a moderate limitation for picnic areas and hiking trails because of the lesser areal intensity of use associated with these facilities. In some instances, it is feasible to remove the stones, thus eliminating the hazard. Rounded gravels and stones present hazards on steeply sloping soils used for foot trails.

Surface texture is an important soil property to consider. High clay or sand content in the surface horizon constitutes a severe limitation for playgrounds, campsites or other uses that involve heavy foot traffic by people or horses. Soils high in clay become sticky and slippery when wet and dry out slowly after rains. On the other hand, loose sandy soils are undesirable as they are unstable when dry, making it difficult to establish sod grasses capable of withstanding concentrated foot traffic. Generally, sandy loam and loam surface soil textures are the most desirable for recreational uses involving heavy use by people.

Soil depth affects many uses. Soils underlain by bedrock or sand and gravel at shallow depths cannot be levelled for playgrounds except at high cost. Roads, trails, basements and reservoirs are very difficult to construct on soils with shallow bedrock, and soils with shallow sand and gravel are undesirable sites for reservoirs.

It is difficult to establish vegetation on shallow soils overlying impervious soil layers, rock or sand and gravel, thus making them poor locations for playing fields and other intensive use areas.

Sewage disposal is also an important consideration in designing recreation areas. Some soils absorb septic effluent rapidly and other soils absorb it very slowly. Soils that are slowly or rapidly permeable, poorly drained, subject to flooding, shallow to rock, or steeply sloping all have severe limitations for septic tank filter fields. These include soils of high clay content, sandy soils and Gleysolic soils. The most desirable soils for sewage disposal have a moderate permeability, are well drained and are situated in nearly level areas. The most desirable soils for sewage disposal are also the most desirable soils for sanitary land fills. In some cases where soils cannot handle the volume of waste involved, sewage lagoons can be used. These also are feasible only in soils that meet the special requirements for sewage lagoons.

Shrink-swell potential is inferred from Atterberg limits. Soils with low to medium shrink-swell potential are considered to have no to slight limitations for recreational facilities. Soils with a very high shrink-swell potential are considered to constitute severe limitations for building sites and road subgrade materials, as these soils tend to be unstable with changing moisture conditions. Soils with a high shrink-swell potential offer moderate limitations for use and thus should be avoided if possible.

The suitability of the underlying soil material for road subgrade depends upon the additional property of susceptibility to frost action. Generally soils high in silt content are highly susceptible to frost action. Other factors, such as the availability of water, also affect this parameter. The availability of water is dependent upon climatic conditions and depth to water table. Thus, soils high in silt content may not necessarily undergo appreciable frost heaving unless they are imperfectly or poorly drained, or sugject to high rainfall shortly before freezing. Frost heaving is not generally considered to be a serious problem for roads in Alberta except in poorly drained locations where the water table is near the soil surface.[1] A frost design soil classification is shown in Table 4.

1. Personal Communication, Mr. H. H. Rix, Highways Division, Alberta Research Council.

Table 4. Frost Design Soil Classification[1]

Frost Group	Kind of Soil	% Finer than 0.02 mm by weight	Typical Soil Types Under Unified Soil Classification System
F1	Gravelly soils	3 to 10	GW, GP, GW-GM, GP-GM
F2	(a) Gravelly soils	10 to 20	GM, GW-GM, GP-GM
	(b) Sands	3 to 15	SW, SP, SM, SW-SM, SP-SM
F3	(a) Gravelly soils	over 20	GM, GC
	(b) Sands, except very fine silty sands	over 15	SM, SC
	(c) Clays, PI > 12	-	CL, CH
F4	(a) All silts	-	ML, MH
	(b) Very fine silty sands	over 15	SM
	(c) Clays, PI < 12	-	CL, CL-ML
	(d) Varved clays and other fine-grained, banded sediments	-	CL and ML; CL, ML, and SM; CL, CH, and ML; CL, CH, ML, and SM

[1] From United States Army Corps of Engineers, 1962.

The soluble sulphate content of the underlying soil material is an important factor for buildings with concrete foundations, as well as for underground conduits. The U.S. Bureau of Reclamation (1966) has established classes for sulphate attack on concrete. Soils with 0 to 0.1% soluble sulphate content are considered to have no limitations for standard concrete foundations, and soils with 0.1 to 0.2% are considered to have slight limitations. Soils with 0.2 to 0.5% soluble sulphate content are considered to have moderate limitations, and foundations may require sulphate resistant concrete. Soils with greater than 0.5% soluble sulphate are considered to have severe limitations and should be avoided.

Salinity and depth of topsoil affect soil suitabilities for lawns and landscaping, and sources of topsoil. An electrical conductivity of less than 1 (mmhos/cm) and a depth of topsoil of more than 6 inches offer no limitations. An electrical conductivity of more than 3 (mmhos/cm) and a depth of topsoil of less than 3 inches render severe limitations.

Productive capacity of soils for vegetation of different kinds is closely related to the feasibility of many recreational enterprises. The ability of soils to grow sods than can take concentrated human traffic has already been noted as a factor in such areas as playgrounds and campsites. The development of such vegetative conservation practices as shade tree plantings, living fences, plant screens and barriers to trespass is guided by soil conditions. The capacity of an area to produce economically harvestable crops of game is dependent in part upon the productive ability of its soils.

Thus we find that basic soil qualities and characteristics are closely associated with the various types of outdoor recreational activities. By knowing the characteristics and qualities of the different kinds of soils and their behaviours, and with the aid of a soil map, soil scientists and other specialists can develop soil interpretations for recreational uses. Interpretations for recreation can best be made locally by those familiar with the soils and conditions in the area.

EXPLANATION OF SOIL INTERPRETATIONS

Soil limitation or suitability ratings are for evaluating each soil for a particular use (Olsen, et al, 1971). Interpretations are based on evaluation of the soil to a depth of about 40 inches; however, some interpretations can be made below the 5 foot depth. These interpretations are made largely from soil descriptions and field observations made during the soil mapping program. Only surface and shallow subsurface soil samples were collected for routine chemical analyses, while only limited numbers of deeper subsurface samples were collected for engineering tests. Engineering properties of some map units sampled were extrapolated to other map units not sampled, where soils of the different map units were developed on like or very similar parent materials.

It is important that the proper perspective be placed on the use of soil interpretations in recreation planning (Montgomery and Edminster, 1966). The interpretations are for soils in the natural state only and not for disturbed areas. Nor do they include other factors, such as location, aesthetic values, and nearness to population centres. A soil survey properly interpreted is a useful guide for general recreation planning and in site selection; however, all soil differences which occur in the field cannot be shown on the soils map. Thus for design and construction of specific recreational facilities, an "on-site" investigation is often needed.

The soils are grouped into three categories according to their limitations or suitabilities for specific uses. They are evaluated by considering the interaction of the various properties to give an overall degree of limitation or suitability to each soil area. The three categories of limitations are as follows:

(1) S - None to slight limitations - Soils relatively free of limitations that affect the intended use, or the limitations are easy to overcome.

(2) M - Moderate limitations - Soils having limitations that need to be recognized but can be overcome with correct planning, careful design and good management.

(3) V - Severe limitations - Soils with limitations severe enough to make the proposed use questionable. It does not mean the soil cannot be used for

a specific use, but it does mean that careful planning and design, and very good management are needed. This often includes major soil reclamation work. In many cases the limitations will not be economically feasible to correct.

The soils are simply rated as good (G), fair (F), poor (P) or unsuitable (U) as sources of topsoil, or sand and gravel.

Interpretations are not included for wildlife use. However, it is recognized that all soils are suited for some form of wildlife and that this is an important use which is compatible with certain other uses.

DEFINITION OF SELECTED USES AND GUIDES FOR DEVELOPING SOIL INTERPRETATIONS

The guides set forth in Tables 5 through 16 are suggested for use in developing soil interpretations for camp areas, picnic areas, intensive play areas, paths and trails, lawns and landscaping, permanent buildings, septic tank absorption fields, sanitary landfills - trench type, reservoir sites, road location and sources of roadfill, sources of topsoil, and sources of sand or gravel, respectively. The information in these tables presents the nature and degree of limitations or suitabilities for selected park uses.

These guides are useful in evaluating each kind of soil to be grouped into limitation and suitability classes for different recreational and other uses. It is recognized that interactions among some soil and other properties listed in these guides may be great enough to change the limitation or suitability rating by one class. If a moderate or severe limitation occurs in a given map unit, lesser limitations are usually not specified. Limitations due to slope are not subdivided once the limitation becomes severe for the specified use. It follows, however, that the steeper the slope, the more severe the limitation, and this fact should be considered in using the soil interpretation tables.

It is not anticipated that all of these interpretations will be needed in all areas; however, they should all be useful in some areas.

Table 5. Guides for Developing Soil Interpretations for Camp Areas.

This guide applies to soils to be used intensively for tents and small camp trailers, and the accompanying activities of outdoor living (Olsen, et al, 1971.)

It is assumed that little site preparation will be done other than shaping and levelling for tent areas and gravelling for parking areas. The soil should be suitable for heavy foot traffic by humans, and for limited vehicular traffic (see Table 14, ratings for road location and sources of roadfill). Soil suitability for growing and maintaining vegetation is not a part of this guide, but is an important item to consider in the final evaluation of a site (see Table 9, ratings for lawns and landscaping).

Table 5.

Properties Affecting Use	Degree of Limitation		
	None to Slight	Moderate	Severe
Flooding	None	None during season of use.	Subject to flooding during season of use
Wetness[1] (soil drainage)	Very rapidly, rapidly, well and moderately well drained soils with no ponding. Water table below 30 inches during season of use	Moderately well and imperfectly drained soils with no ponding. Water table below 20 inches during season of use	Imperfectly drained soils with occasional ponding of short duration, poorly and very poorly drained soils. Water table above 20 inches during season of use
Slope	0 to 9% (aA - dD)	9+ to 15% (eE)	Greater than 15% (fF - hH)
Permeability[2]	Moderate to very rapid (more than 0.6 inches/hour)	Moderately slow (0.2 to 0.6 inches/hour)	Slow and very slow (less than 0.2 inches/hour)
Surface stoniness[3]	0 to 1	2	3, 4 and 5
Rockiness[4]	No rock exposures	Rock exposures greater than 30 feet (10 m) apart and cover less than 25% of the surface	Rock exposures less than 30 feet (10 m) apart and cover greater than 25% of the surface
Surface soil texture[5]	SL, FSL, VFSL, L and LS with textural B horizon. Not subject to soil blowing	CL, SCL, SiCL, SiL, LS and sand other than loose sand	SC, SiC, C, loose sand and soils subject to severe blowing. Organic soils.

1. See definitions of soil drainage classes in Glossary.

2. In low rainfall areas, soils may be rated one class better. See definitions of soil permeability classes in Glossary.

3. See definitions of surface stoniness in section entitled "General Discussion of Soil Map".

4. Very shallow soils are rated as having a severe limitation for rockiness. See definitions of rockiness in The System of Soil Classification for Canada (CDA, 1974).

5. See definitions of soil textural classes in Glossary.

Table 6. Guides for Developing Soil Interpretations for Picnic Areas.

This guide applies to soils considered for intensive use as park type picnic areas, and are subject to heavy foot traffic by humans (Olsen et al, 1971). It is assumed that most vehicular traffic will be confined to access roads and parking areas (see Table 14, ratings for road location and sources of roadfill). Soil suitability for growing and maintaining vegetation is not a part of this guide, but is an important item to consider in the evaluation of a site (see Table 9, ratings for lawns and landscaping).

Table 6.

Properties Affecting Use	Degree of Limitation		
	None to Slight	Moderate	Severe
Flooding	None during season of use	May flood 1 or 2 times for short periods during season of use	Floods more than 2 times during season of use
Wetness[1] (soil drainage)	Very rapidly, rapidly, well and moderately well drained soils. Water table below 20 inches during season of use.	Moderately well drained soils subject to occasional ponding. Imperfectly drained soils not subject to ponding. Water table above 20 inches for short periods during season of use.	Poorly and very poorly drained soils. Imperfectly drained soils subject to ponding. Water table above 20 inches and often near the surface for a month or more during season of use
Slope	0 to 9% (aA - dD)	9+ to 15% (eE)	Greater than 15% (fF - hH)
Permeability[2]	Moderately slow to very rapid (more than 0.2 inches/hour)	Slow (0.06 to 0.2 inches/hour)	Very slow (less than 0.06 inches/hour)
Surface stoniness[3]	0 to 2	3	4 and 5
Rockiness[4]	Rock exposures roughly 100 to 300 or more feet (30 - 100 m) apart and cover less than 10% of the surface	Rock exposures 30 to 100 feet (10 - 30 m) apart and cover about 10 to 25% of the surface	Rock exposures less than 30 feet (10 m) apart and cover greater than 25% of the surface
Surface soil texture[5]	SL, FSL, VFSL, L and LS with textural B horizon. Not subject to soil blowing	CL, SCL, SiCL, SiL, LS and sand other than loose sand	SC, SiC, C, sand and soils subject to severe blowing. Organic soils

1. See definitions of soil drainage classes in Glossary.

2. In low rainfall areas, soils may be rated one class better. See definitions of soil permeability classes in Glossary.

3. See definitions of surface stoniness in section entitled "General Discussion of Soil Map".

4. See definitions of rockiness in The System of Soil Classification for Canada (CDA, 1974).

5. See definitions of soil textural classes in Glossary.

Table 7. Guides for Developing Soil Interpretations for Playing Fields.

This guide applies to soils that are to be used intensively for organized games, such as fastball, baseball, football, volleyball, badminton, and others (Olsen et al, 1971). These areas are subject to heavy foot traffic by humans. A level surface, good drainage, and a surface soil texture and consistence that provide a firm surface which is not slippery and sticky when wet are generally required. The most desirable soils are free of rock outcrops and surface stones. Soil suitability for growing and maintaining vegetation is not a part of this guide, but is an important item to consider in the final evaluation of a site (see Table 9, ratings for lawns and landscaping).

(Table 7)

Properties Affecting Use	Degree of Limitation		
	None to Slight	Moderate	Severe
Flooding	None during season of use	May flood once in 3 years during season of use	May flood more than once in 3 years during season of use
Wetness[1] (soil drainage)	Very rapidly, rapidly, well and moderately well drained soils with no ponding or seepage. Water table below 30 inches during season of use	Moderately well drained soils subject to occasional ponding or seepage of short duration. Imperfectly drained soils. Water table below 20 inches during season of use	Imperfectly drained soils subject to ponding, poorly and very poorly drained soils. Water table above 20 inches and too wet for use for 1 to 5 weeks during season of use
Slope	0 to 2% (aA - bB)	2+ to 5% (cC)	Greater than 5% (dD - hH)
Permeability[2]	Moderate to very rapid (more than 0.6 inches/hour)	Moderately slow (0.2 to 0.6 inches/hr)	Slow and very slow (less than 0.2 inches/hour)
Surface stoniness[3]	0 to 1	2	3, 4 and 5
Rockiness[4]	Rock exposures more than 300 feet (100 m) apart and cover less than 2% of the surface	Rock exposures 100 to 300 feet (30 - 100 m) apart and cover about 2 to 10% of the surface	Rock exposures less than 100 feet (30 m) apart and cover more than 10% of the surface
Depth to bedrock	More than 40 inches	20 to 40 inches[5]	Less than 20 inches
Depth to sand or gravel	More than 40 inches	20 to 40 inches[5]	Less than 20 inches
Surface soil[6] texture	SL, FSL, VFSL, L and LS with textural B horizon. Not subject to soil blowing	CL, SCL, SiCL, SiL, LS and sand other than loose sand	SC, SiC, sand and LS subject to soil blowing. Organic soils

1. See definitions of soil drainage classes in Glossary.

2. In arid regions, soils may be rated one class better. See definitions of soil permeability classes in Glossary.

3. See definitions of surface stoniness in section entitled "General Discussion of Soil Map".

4. See definitions of rockiness in The System of Soil Classification for Canada (CDA, 1974).

5. These soils have severe limitations if slopes are greater than 2%.

6. See definitions of soil textural classes in Glossary.

Table 8. Guides for Developing Soil Interpretations for Paths and Trails.

This guide applies to soils to be used for local and cross country footpaths, and trails for bridle paths. It is assumed that these areas will be used as they occur in nature and that little or no soil will be moved (excavated or filled) (Olsen et al, 1971). The steeper the slope upon which a trail is to be built, the more soil that will have to be moved to obtain a level tread, and the more miles of trail needed to cover a given horizontal distance (Coen and Holland, in press). Soil features, such as surface texture and structure, that affect trafficability, dust, and design and maintenance of trafficways, should be given special emphasis.

(Table 8)

Properties Affecting Use	Degree of Limitation		
	None to Slight	Moderate	Severe
Flooding	Not subject to flooding during season of use	May flood 1 or 2 times during season of use	Subject to flooding more than 2 times during season of use
Wetness[1] (soil drainage)	Very rapidly, rapidly, well and moderately well drained soils. Water table below 20 inches during season of use	Moderately well drained soils subject to occasional seepage or ponding, and imperfectly drained soils. Water table may be above 20 inches for short periods during season of use	Poorly and very poorly drained soils. Water table above 20 inches and often near the surface for a month or more during season of use
Slope[2]	0 to 15% (aA - eE)	15+ to 30% (fF)	Greater than 30% (gG - hH)
Surface stoniness[3]	0 to 2	3	4 and 5
Rockiness[4]	Rock exposures roughly 100 feet (30 m) apart and cover less than 10% of the surface	Rock exposures 30 to 100 feet (10 - 30 m) apart and cover 10 to 25% of the surface	Rock exposures less than 30 feet (10 m) apart and cover more than 25% of the surface
Surface soil[5] texture	SL, FSL, VFSL and L	SiL, SiCL, SCL, CL and LS	SC, SiC, C, sand and soils subject to severe blowing. All very gravelly, very cherty, very cobbly and very channery soils. Organic soils

1. See definitions of soil drainage classes in Glossary.

2. Slope in this context refers to the slope of the ground surface, not the slope of the tread of the trail. Soil erodibility is an important item to consider in rating this limitation. Some adjustments in slope range may be needed in different climatic zones.

3. See definitions of surface stoniness in section entitled "General Discussion of Soil Map".

4. See definitions of rockiness in The System of Soil Classification for Canada (CDA, 1974).

5. In regions of arid or subhumid climate, some of the finer textured soils may be rated one class better. See definitions of soil textural classes in Glossary.

Table 9. Guides for Developing Soil Interpretations for Lawns and Landscaping.

This guide applies to soils to be used for lawn turf, shrubs and trees. It is assumed that the addition of topsoil will not be needed for good establishment, and that irrigation will be provided (Olsen et al, 1971).

(Table 9)

Properties Affecting Use	Degree of Limitation		
	None to Slight	Moderate	Severe
Flooding	None during growing season	May flood 1 or 2 times for short periods during growing season	Subject to flooding more than 2 times during growing season
Wetness[1] (soil drainage)	Very rapidly, rapidly, well and moderately well drained soils not subject to ponding	Moderately well drained soils subject to occasional ponding of short duration. Imperfectly drained soils	Poorly and very poorly drained soils. Imperfectly drained soils subject to ponding for periods of more than 4 weeks during growing season
Slope	0 to 9% (aA to dD)	9+ to 15% (eE)	Greater than 15% (fF to hH)
Surface stoniness[2]	0 to 1	2	3, 4 and 5
Rockiness[3]	Rock exposures more than 300 feet (100 m) apart and cover less than 2% of the surface	Rock exposures 100 to 300 feet (30 - 100 m) apart and cover about 2 to 10% of the surface	Rock exposures less than 100 feet (30 m) apart and cover more than 10% of the surface
Surface soil texture[4]	SL, FSL, VFSL, L, SiL and LS with textural B horizon. Not subject to soil blowing	CL, SCL, SiCL, LS and sand other than loose sand.	SC, SiC, C, sand and LS subject to soil blowing. Organic soils
Depth of Ah horizon[5]	Greater than 3 inches	0 to 3 inches	Lack of Ah horizon not a severe limitation by itself
Salinity of topsoil	E.C.[6] 0 to 1	E.C. 1+ to 3	E.C. greater than 3
Depth to bedrock	More than 40 inches	20 to 40 inches[7]	Less than 20 inches
Depth to sand or gravel	More than 40 inches	20 to 40 inches[7]	Less than 20 inches
Permeability[8]	Moderately slow to moderately rapid (0.2 to 6.0 inches/hour)	Slow (0.06 to 0.2 inches/hour)	Rapid and very rapid (more than 6.0 inches/hour, and very slow (less than 0.06 inches/hour)

1. See definitions of soil drainage classes in Glossary.
2. See definitions of surface stoniness in section entitled "General Discussion of Soil Map".
3. See definitions of rockiness in The System of Soil Classification for Canada (CDA, 1974).
4. See definitions of soil textural classes in Glossary.
5. See definition of Ah horizon in Glossary.
6. E.C. means "electrical conductivity". See explanation in Appendix.
7. May be rated "none to slight" on 0 to 2% slopes.
8. In low rainfall areas, soils may be rated one class better. See definitions of soil permeability classes in Glossary.

Table 10. Guides for Developing Soil Interpretations for Permanent Buildings

This guide provides ratings for undisturbed soils that are evaluated for single story buildings and other structures with similar foundation requirements. The emphasis in rating soils for buildings is on foundations; but slope, susceptibility to flooding, and seasonal wetness, that have effects beyond those related exclusively to foundations, are also considered (U.S.D.A., 1971). The properties affecting foundation support are those that affect bearing capacity and settlement under load, and those that affect excavation and construction costs. The properties affecting bearing strength and settlement of the natural soil are density, wetness, plasticity, texture, and shrink-swell behaviour. Shrink-swell potential and plasticity (Atterberg limits) are inferred from the Unified Soil Classification. Properties influencing the ease and amount of excavation are wetness, slope, depth to bedrock and sand or gravel, stoniness and rockiness. These properties also affect the ease of installing underground utilities. Excluded are limitations for septic tank absorption fields (see Table 11), and lawns and landscaping (see Table 9).

On-site investigations are needed for specific placement of buildings and utility lines, and for detailed design of foundations. All ratings are based on undisturbed soils to a depth of 4 to 6 feet.

(Table 10)

Properties Affecting Use	Degree of Limitation		
	None to Slight	Moderate	Severe
Flooding	None	None	Subject to flooding
Wetness[1] (soil drainage)	WITH BASEMENTS: Very rapidly, rapidly and well drained soils. Water table below 60 inches WITHOUT BASEMENTS: Very rapidly, rapidly, well and moderately well drained soils. Water table below 30 inches	WITH BASEMENTS: Moderately well drained soils. Water table below 30 inches WITHOUT BASEMENTS: Imperfectly drained soils. Water table below 20 inches	WITH BASEMENTS: Imperfectly, poorly and very poorly drained soils. Water table above 30 inches one month or more during year WITHOUT BASEMENTS: Poorly and very poorly drained soils. Water table above 20 inches one month or more during year.
Slope	0 to 9% (aA to dD)	9+ to 15% (eE)	Greater than 15% (fF to hH)
Shrink-swell potential	Low - Unified Groups GW, GP, SW, SP, GM, GC, SM, SC, and CL with P.I.[2] less than 15	Moderate-Unified[3] Groups ML, and CL with P.I. less than or equal to 15	High - Unified Groups CH, MH, OL, OH and Pt
Potential frost action[4]	Low (F1, F2)	Moderate (F3)[3]	High (F4)
Depth to bedrock[5]	WITH BASEMENTS: More than 60 inches WITHOUT BASEMENTS: More than 40 inches	WITH BASEMENTS: 40 to 60 inches WITHOUT BASEMENTS: 20 to 40 inches	WITH BASEMENTS: Less than 40 inches WITHOUT BASEMENTS: Less than 20 inches
Potential sulphate attack on concrete	0 to 1000 p.p.m.[6]	1000 to 2000 p.p.m.[3]	Greater than 2000 p.p.m.
Surface stoniness[7]	0 to 1	2	3, 4 and 5
Rockiness[8]	Rock exposures more than 300 feet (100 m) apart and cover less than 2% of the surface	Rock exposures 100 to 300 feet apart (30 - 100 m) and cover 2 to 10% of the surface	Rock exposures less than 100 feet (30 m) apart and cover more than 10% of the surface

1. See definitions of soil drainage classes in Glossary.

2. P.I. means Plasticity Index. See definition in Appendix.

3. These factors are limitations only where basements and underground utilities are planned.

4. The "potential frost action" classes are outlined in Table 4.

5. If bedrock is soft enough so that it can be dug out with light power equipment, such as backhoes, the soils can be rated one class better.

6. p.p.m. means parts per million.

7. See definitions of surface stoniness in section entitled "General Discussion of Soil Map".

8. See definitions of rockiness in The System of Soil Classification for Canada (CDA, 1974).

Table 11. Guides for Developing Soil Interpretations for Septic Tank Absorption Fields.

The septic tank absorption field is a subsurface tile system laid out in such a way that effluent from the septic tank is distributed with reasonable uniformity into the natural soil (USDA, 1971). When the effluent is percolated into the ground, the contained impurities are attacked by myriad biological organisms, naturally present in the soil (Plumbing Inspection Branch, 1972).

Absorption fields are influenced by the ease of downward movement of effluent through the soil (Olsen, et al, 1971). This guide provides ratings for undisturbed soils that are evaluated on their ability to absorb and filter the liquid or effluent passed through the tile field. Soils with slow permeability are rated severe. Clean sands and gravels with rapid permeability may constitute a hazard for groundwater contamination.

(Table 11)

Properties Affecting Use	Degree of Limitation		
	None to Slight	Moderate	Severe
Flooding	Not subject to flooding	Not subject to flooding	Subject to flooding
Wetness[1] (soil drainage)	Very rapidly, rapidly, well and moderately well drained soils not subject to ponding or seepage. Water table below 72 inches	Well and moderately well drained soils subject to occasional ponding or seepage. Imperfectly drained soils not subject to ponding. Water table 48 to 72 inches	Imperfectly drained soils subject to ponding. Poorly and very poorly drained soils. Very rapidly and rapidly drained soils if groundwater contamination hazard. Water table less than 48 inches
Slope	0 to 9% (aA - dD)	9+ to 15% (eE)	Greater than 15% (fF to hH)
Permeability[2]	Moderate to very rapid (more than 0.6 inches/hour)	Moderately slow (0.2 to 0.6 inches/hour)	Slow and very slow (less than 0.2 inches/hour). Rapid and very rapid if groundwater contamination hazard (more than 6.0 inches/hour)
Depth to bedrock[3]	More than 72 inches	48 to 72 inches	Less than 48 inches
Depth to[3] sand or gravel	More than 72 inches	If less than 72 inches and a groundwater contamination hazard exists, limitation is severe	Less than 72 inches if groundwater contamination hazard exists

1. Water table depth is based on the assumption that the tile depth is 2 feet in the soil. Also, see definitions of soil drainage classes in Glossary.

2. The limitation ratings should be related to the permeability of soil layers at and below the depth of the tile line. Also, see definitions of soil permeability classes in Glossary.

3. Based on the assumption that the tile depth is 2 feet in the soil.

Table 12. Guides for Developing Soil Interpretations for Sanitary Landfills - Trench Type[1].

The trench type sanitary landfill is a dug trench in which refuse is buried (USDA, 1971). The refuse is covered with at least a 6 inch layer of compacted soil material daily, or more frequently if necessary. Soil material excavated when digging the trench is used for this purpose. A final cover of soil material at least 2 feet thick is placed on the landfill when the trench is full.

This guide provides ratings for evaluating undisturbed soils on their suitability as sites for good sanitary landfills that should be usable all year, and should operate without contaminating water supplies or causing a health hazard (Olsen et al, 1971). Because routine soil investigations are normally confined to depths of about 5 or 6 feet and many landfill operations use trenches as deep as 15 feet or more, there is need for a geological investigation of the area to determine the potential for pollution of groundwater, as well as to obtain the design of the sanitary landfill (USDA, 1971). The presence of hard nonrippable bedrock, creviced bedrock, sandy or gravelly strata within or immediately underlying the proposed trench bottom is undesirable from the standpoint of excavation, and from the standpoint of the potential for pollution of groundwater.

(Table 12)

Properties Affecting Use	Degree of Limitation		
	None to Slight	Moderate	Severe
Flooding	Not subject to flooding	Not subject to flooding	Subject to flooding
Wetness[2] (soil drainage)	Very rapidly, rapidly, well and moderately well drained soils. Water table more than 72 inches	Imperfectly drained soils. Water table more than 72 inches	Poorly and very poorly drained soils. Water table less than 72 inches
Slope	0 to 15% (aA - eE)	15+ to 30% (fF)	Greater than 30% (gG - hH)
Permeability[3]	Moderate to very slow (less than 2.0 inches/ hour)	Moderate to very slow (less than 2.0 inches/ hour)	Moderately rapid to very rapid (more than 2.0 inches/hour)
Soil texture[4] (dominant to a depth of 60 inches)	SL, FSL, VFSL, L, SiL, SCL	SiCL, CL, SC, LS	SiC, C, S, gravel, peat, muck
Depth to bedrock	More than 72 inches	More than 72 inches	Less than 72 inches
Depth to sand or gravel	More than 72 inches	More than 72 inches	Less than 72 inches if groundwater contamination hazard
Surface stoniness[5]	0 to 1	2	3, 4 and 5
Rockiness[6]	Rock exposures more than 300 feet (100 m) apart and cover less than 2% of the area	Rock exposures more than 300 feet (100 m) apart and cover less than 2% of the area	Rock exposures less than 300 feet (100 m) apart and cover more than 2% of the area

1. Based on a soil depth (5 to 6 feet) commonly investigated in making soil surveys. If it is probable that the soil material to a depth of 10 to 15 feet will not alter a rating of slight or moderate, indicate that by an appropriate footnote such as "Probably slight to 12 feet", or "Probably moderate to 12 feet".

2. See definitions of soil drainage classes in Glossary.

3. Reflects ability of soil to retard movement of landfill leachate. May not be a factor in arid and semiarid areas. Also, see definitions of soil permeability classes in Glossary.

4. Reflects the ease of digging and moving soil material (workability) and trafficability in the immediate area of the trench that may not have surfaced roads. Also, see definitions of soil textural classes in Glossary.

5. See definitions of surface stoniness in section entitled "General Discussion of Soil Map".

6. See definitions of rockiness in The System of Soil Classification for Canada (CDA, 1974).

Table 13. Guides for Developing Soil Interpretations for Reservoir Sites.

This guide provides ratings for evaluating those features and qualities of undisturbed soils that affect their suitability for water impoundments (USDA, 1971). Reservoirs must be capable of holding water while allowing only a minimum amount of seepage. Another factor to consider is the suitability of the soil material for dam construction, or earth fill (see Table 14, ratings for road location and sources of roadfill). The material should be free of coarse fragments (over 10 inches in diameter) that interfere with compaction.

(Table 13)

Properties Affecting Use	Degree of Limitation		
	None to Slight	Moderate	Severe
Permeability [1]	Moderately slow to very slow (less than 0.6 inches /hour)	Moderate (0.6 to 2.0 inches/hour)	Moderately rapid to very rapid (more than 2.0 inches/hour)
Slope	0 to 2% (aA - bB)	2+ to 9% (cC - dD)	Greater than 9% (eE - hH)
Unified soil group	GC, SC, CL and CH	GM, ML, SM and MH	GP, GW, SW, SP, OL, OH and Pt
Depth to bedrock	More than 72 inches	60 to 72 inches	Less than 60 inches
Depth to sand or gravel	More than 72 inches	60 to 72 inches	Less than 60 inches
Coarse fragments under 10 inches in diameter by percent volume	Less than 20	20 to 50	More than 50
Depth to [2] water table	More than 72 inches	60 to 72 inches	Less than 60 inches one month or more during year
Flooding	Not subject to flooding	Not subject to flooding	Subject to flooding

1. See definitions of soil permeability classes in Glossary.

2. Depth to water table affects the ease of excavation.

Table 14. Guides for Developing Soil Interpretations for Road Location and Sources of Roadfill.

This guide applies to soils evaluated for construction and maintenance of local roads, streets and parking areas; as well as to the suitability of soils as a source of roadfill. These are improved roads and streets having some kind of all weather surfacing, commonly asphalt or gravel, and are expected to carry automobile traffice all year (USDA, 1971). They consist of: (1) underlying local soil material (either cut or fill) called the subgrade; (2) the base material of gravel, crushed rock or soil cement - stabilized soil called the subbase; and (3) the actual road surface or pavement, either flexible or rigid. They also are graded to shed water, and have ordinary provisions for drainage. With the probable exception of the hardened surface layers, the roads and streets are built mainly from the soil at hand, and cuts and fills are limited, usually less than 6 feet. Excluded from consideration in this guide are highways designed for fast moving, heavy trucks.

Properties that affect design and construction of roads and streets are: (1) those that affect the load supporting capacity and stability of the subgrade, and (2) those that affect the workability and amount of cut and fill (USDA, 1971). The AASHO and Unified Classifications, and the shrink-swell potential give an indication of the traffic supporting capacity. Wetness and flooding affect stability. Slope, depth to bedrock, stoniness, rockiness, and wetness affect the ease of excavation and the amount of cut and fill required to reach an even grade.

(Table 14)

Properties Affecting Use	Degree of Limitation		
	None to Slight	Moderate	Severe
Flooding[1]	None	Once in 5 years	More than once in 5 years
Wetness[2] (soil drainage)	Very rapidly, rapidly, well and moderately well drained	Imperfectly drained	Poorly and very poorly drained
Slope[1]	0 to 9% (aA - dD)	9+ to 15% (eE)	Greater than 15% (fF - hH)
Shrink - swell potential	Low - Unified groups GW,[3] GP, SW,[3] SP, GM GC,[3] SM, SC[3]	Moderate - Unified groups CL with P.I. 15 or less than 15. ML[4]	High - CL with P.I. 15 or more. CH, MH, OH, OL, Pt
AASHO group index	0 to 4	5 to 8	More than 8
Potential frost action[5]	Low (F1, F2)	Moderate (F3)	High (F4)
Depth to bedrock[6]	More than 40 inches	20 to 40 inches	Less than 20 inches
Surface stoniness[7]	0 to 2	3	4 and 5
Rockiness[8]	Rock exposures greater than 300 feet (100 m) apart and cover less than 2% of the surface	Rock exposures 100 to 300 feet (30 - 100 m) apart and cover about 2 to 10% of the surface	Rock exposures less than 100 feet (30 m) apart and cover more than 10% of the surface

1. Applies to road location.
2. See definitions of soil drainage classes in Glossary.
3. Downgrade to moderate if content of fines is greater than about 30 percent.
4. P.I. means Plasticity Index. See definition in Appendix.
5. Frost heave is important where frost penetrates below the paved or hardened surface layer, and moisture transportable by capillary movement is sufficient to form ice lenses at the freezing point. The "potential frost action" classes are outlined in Table 4.
6. If bedrock is soft enough so that it can be dug with light power equipment and is rippable by machinery, reduce moderate and severe limitations by one class.
7. See definitions of surface stoniness in section entitled "General Discussion of Soil Map".
8. See definitions of rockiness in The System of Soil Classification for Canada (CDA, 1974).

Table 15. Guides for Developing Suitability Ratings of Soils as Sources of Topsoil[1].

The purpose of this interpretation is to provide information for use by engineers, landscapers, nurserymen, planners and others who make decisions about selection, stockpiling, and the use of topsoil (USDA, 1971).

Topsoil has several meanings, but in soil survey interpretations it refers essentially to the Ah horizon[2]. It means soil material to spread over barren surfaces, usually made barren by construction, so as to improve soil conditions for re-establishment and maintenance of adapted vegetation; and to improve soil conditions on lawns, gardens, and flower beds where vegetation may already exist. In some cases, soil material from the B and C horizons can be used for top dressing of disturbed lands.

Good topsoil has physical, chemical and biological characteristics favourable for the establishment and growth of adapted plants. It is friable, and easy to handle and spread. While a high content of plant nutrients in good balance is desirable, it is perhaps less important than responsiveness to fertilization; and to liming if pH adjustments are necessary.

A rating of "good" means that the soil provides a good source of topsoil for removal and transfer to another place, or it can be used in place. Also, after topsoil has been stripped off, the remaining soil should be reclaimable. These ratings are based on quality of the topsoil and ease of excavation. In addition to the ratings of "good, fair and poor", a rating of "unsuitable" is used.

(Table 15)

Properties Affecting Use	Degree of Suitability		
	Good	Fair	Poor
Moist consistence[3]	Very friable, friable	Loose, firm	Very firm
Texture[4]	SL, FSL, VFSL, L and SiL	CL, SCL and SiCL	LS, S, SC, SiC and C. Organic soils
Thickness of Ah Horizon	More than 6 inches	3 to 6 inches	Less than 3 inches
Coarse fragments (percent by volume)	Less than 3	3 to 15	More than 15
Salinity of topsoil[5]	E.C. 0 to 1	E.C. 1+ to 3	E.C. more than 3
Surface stoniness[6]	0 to 1	2	3,4 and 5
Slope[7]	0 to 9%(aA-dD)	9+ to 15% (eE)	More than 15% (fF-hH)
Wetness[8] (soil drainage)	Drainage class not determining if better than poorly drained		Poorly and very poorly drained
Flooding	None	May flood occasionally for short periods	frequent flooding, or constantly flooded

1. See definition of topsoil in Glossary.
2. See definition of Ah horizon in Glossary.
3. See Glossary for descriptions of terms used to define soil consistence.
4. See definitions of soil textural classes in Glossary.
5. E.C. means the electrical conductivity of a saturation extract expressed in mmhos/cm. These limits are suggested by the Alberta Soil and Feed Testing Laboratory, as indicators of soluble salt concentrations that adversely affect lawn growth.
6. See definitions of surface stoniness in section entitled "General Discussion of Soil Map".
7. Influences ease of excavation, and susceptibility to soil erosion after topsoil has been removed.
8. Affects accessibility, and ease of excavation. See definitions of soil drainage classes in Glossary.

Table 16. Guides for Developing Suitability Ratings of Soils as Sources of Sand and Gravel.

. The principal purpose of this interpretation is to provide guidance about where to look for sand and gravel.

Ratings are based on the probability that soils contain sizeable quantities of sand or gravel, excluding soft materials such as shale or siltstone. To qualify as either a good or fair probable source, the layer should be at least about 3 feet thick (USDA, 1971). All of this however, need not be in the top 5 or 6 feet. If the approximate lowest 6 inches of this section is sand or gravel, and from observations made in deep cuts and other evidence, including geological, the sand or gravel reached at the bottom of this section is known to extend downward for several feet, the thickness requirement is satisfied.

Only the suitability as a source of sand or gravel is rated. No attempt is made to rate the quality of the sand or gravel for specific uses, such as road base, concrete, etc. The general relative quality for many uses in terms of grain size is indicated in Table 17, by classes in the Unified soil classification system. However, quality determinations should be made at the site of the source, since both grain sizes, and shapes of sand and gravel determine the suitability for specific uses (Olsen et al, 1971).

A particular area outlined on the soil map can be identified as predominantly sand or predominantly gravel, by consulting the soil report for a description of the map unit under consideration. In addition to the ratings of "good, fair and poor", a rating of "unsuitable" is used.

(Table 16)

Properties Affecting Use	Degree of Suitability		
	Good	Fair	Poor
Unified soil group	SW, SP, GW, GP	SW-SM, SP-SM, GW-GM, GP-GM	SM, SW-SC, SP-SC, GM, GW-GC, GP-GC (all other groups unsuitable)
Thickness of overburden	Less than 2 feet	2 to 5 feet	More than 5 feet
Wetness[1] (soil drainage)	Drainage class not determining if better than poorly drained		Poorly and very poorly drained
Flooding	None	May flood occasionally for short periods	Frequent flooding or constantly flooded

1. Affects accessibility, and ease of excavation. See definitions of soil drainage classes in Glossary, page

REFERENCES

Acton, D. F. 1975. A Landform Mapping System for Canadian Soil Surveys. Saskatchewan Inst. of Pedology Publ. M 26. Saskatoon. 19 pp.

American Society for Testing and Materials. 1970. Annual Book of ASTM Standards, Part II. Philadelphia. 982 pp. (ASTM, 1970).

Brocke, L.K. 1970. Soil Survey Interpretations for Recreation Site Planning in two Alberta Provincial Parks. Unpubl. M.Sc. Thesis, Univ. of Alberta, Edmonton.

Canada Department of Agriculture. 1972. Glossary of Terms in Soil Science. Publication 1459, Canada Dept. of Agric., Ottawa. 66 pp.

Canada Department of Agriculture. 1974. The System of Soil Classification for Canada. Queen's Printer, Ottawa. 255 pp. (CDA, 1974).

Committee on Classification of Materials for Subgrades and Granular Type Roads. 1945. Classification of highway subgrade materials. Highway Research Board, Proc. 25th annual meeting, pp. 375-392.

Greenlee, G.M. 1971. Detailed Soil Survey and Interpretation for Recreational Use at Miquelon Lake, Alberta. Alberta Institute of Pedology, Number M-71-4, U of A., Edmonton. 8 pp.

Means, R.E. and J. V. Parcher. 1964. Physical Properties of Soils. Charles E. Merrill, Columbus, Ohio. 464 pp.

Montgomery, P.H. and F.C. Edminster. 1966. The Use of Soil Surveys in Planning and Recreation. In: Soil Surveys and Land Use Planning, Bartelli et al. (ed.) Soil Sci. Soc. Amer. and Amer. Soc. Agron., Madison, Wisconsin. pp.104 - 112.

Olsen, J.A., B. F. Leeson and G. A. Nielson. 1971. Soil Interpretations for Land Use Planning and Development in the Gallatin Canyon Area, Montana. Misc. Rep. No. 10, Montana Agric. Exp. Sta., Montana State U., Bozeman, Montana. 23 pp.

O'Neal, A.M. 1952. A Key for Evaluating Soil Permeability by Means of Certain Field Clues. Soil Sci. Soc. Amer. Proc. 16: 312-315.

Portland Cement Association. 1962. PCA Soil Primer. Portland Cement Ass'n., Chicago. 52 pp. (PCA, 1962).

Soil Science Society of America. 1970. Glossary of Soil Science Terms. Soil Sci. Soc. Amer., Madison, Wisconsin. 27 pp.

Swenson, E.G. 1971. Concrete in Sulphate Environments. CBD 136. Can. Building Digest, NRC, Ottawa. 4 pp.

United States Army Corps of Engineers. 1962. Pavement Design for Frost Conditions. Eng. Manual 1110-1-306, pp. 5 - 8.

United States Army Corps of Engineers. 1961. Procedures for Foundation Design of Buildings and Other Structures (except hydraulic structures). Eng. Manual 1110-345-147. pp. 21-26.

United States Army Corps of Engineers. 1961. Trafficability of Soils, Soil Classification. Tech. Memorandum No. 3-240, 16th supplement. Waterways Exp. Sta., Mississippi. 10 pp.

United States Army Corps of Engineers. 1957. The Unified Soil Classification System. Tech. Memorandum No. 3-357. Appendix B. Waterways Exp. Sta., Mississippi. pp. B2-B6.

United States Salinity Laboratory Staff. 1954. Diagnosis and Improvement of Saline and Alkali Soils. Hdbk. 60, U.S. Dept. Agric., Washington. 160 pp.

U.S.D.I. Bureau of Reclamation. 1966. Concrete Manual. 7th ed. U.S. Gov't. Printing Office, Washington. 642 pp.

GLOSSARY

Atterberg limits - Various moisture contents of a soil at which it changes from one major physical condition to another. The Atterberg limits which are most useful for engineering purposes are liquid limit and plastic limit.

The liquid limit is the moisture content at which a soil passes from a plastic to a liquid state.

The plastic limit is the moisture content at which a soil changes from a semi-solid to a plastic state.

Plasticity index (P.I.) is defined as the numerical difference between liquid limit and plastic limit.

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

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

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

consistence - (a) The resistance of a material to deformation or rupture. (b) The degree of cohesion or adhesion of the soil mass.

droughty soil - Sandy or very rapidly drained soil.

electrical conductivity, soil - Measurement on a saturated soil paste or a water extract of the soil, made to estimate the salt content of the soil.

engineering tests - Laboratory tests made to determine the physical properties of soils that affect their uses for various types of engineering construction.

erodibility - Susceptibility to erosion.

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

fertile soil - A soil with an abundant supply of available elements necessary for plant growth.

fertilizer - Any organic or inorganic material of natural or synthetic origin that is added to a soil to supply certain elements essential to the growth of plants.

field capacity (field moisture capacity) - The percentage of water remaining in a soil 2 or 3 days after having been saturated and after free drainage has practically ceased.

frost heave, in soil - The raising of a surface caused by ice formation in the underlying soil.

Gleysolic soil - soil developed under wet conditions resulting in reduction of iron and other elements and in gray colors and mottles.

grain size - The effective diameter of a particle measured by sedimentation, sieving, or micrometric methods.

groundwater - That portion of the total precipitation which at any particular time is either passing through or standing in the soil and the underlying strata and is free to move under the influence of gravity.

hardpan - A hardened soil layer, in the lower A or in the B horizon, caused by cementation of soil particles with organic matter or with materials such as silica, sesquioxides, or calcium carbonate.

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

irrigation - The artificial application of water to the soil for the benefit of growing crops.

landform - Any physical recognizable form or feature of the earth's surface, having a characteristic shape, and produced by natural causes.

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.

pedogenic - Pertaining to the origin, morphology, genesis, distribution, and classification of soils.

permeability, soil - The ease with which gases, liquids, or plant roots penetrate or pass through a bulk mass of soil or a layer of soil. The classes of soil permeability are rated as follows:

Permeability Class	Rate of Permeability
Very slow	Less than 0.06 inches/hour
Slow	0.06 to 0.2 inches/hour
Moderately slow	0.2 to 0.6 inches/hour
Moderate	0.6 to 2.0 inches/hour
Moderately rapid	2.0 to 6.0 inches/hour
Rapid	6.0 to 20.0 inches/hour
Very rapid	Over 20.0 inches/hour

productive capacity, soil - The capacity of a soil, in its normal environment, for producing a specified plant or sequence of plants under a specified system of management. The "specified" limitations are necessary since no soil can produce all crops with equal success nor can a single system of management produce the same effect on all soils.

regolith - The unconsolidated mantle of weathered rock and soil material overlying solid rock.

seepage, soil - (a) The escape of water downward and laterally through the soil. (b) The emergence of water from the soil along an extensive line of surface in contrast to a spring where the water emerges from a local spot.

shrink-swell potential - Tendency of soils to undergo volume changes with changes in water content.

soil blowing - Soil erosion by wind.

soil conservation - (a) Protection of the soil against physical loss by erosion or against chemical deterioration; that is, excessive loss of fertility by either natural or artificial means. (b) A combination of all management and land use methods which safeguard the soil against depletion or deterioration by natural or by man-induced factors.

soil drainage classes - The soil drainage classes are defined in terms of (a) actual moisture content in excess of field moisture capacity, and (b) the extent of the period during which such excess water is present in the plant-root zone. The soil drainage classes are defined as follows:

1. Rapidly drained - The soil moisture content seldom exceeds field capacity in any horizon except immediately after water additions.

2. Well drained - The soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year.

3. Moderately well drained - The soil moisture in excess of field capacity remains for a small but significant period of the year.

4. Imperfectly drained - The soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year.

5. Poorly drained - The soil moisture in excess of field capacity remains in all horizons for a large part of the year.

6. Very poorly drained - Free water remains at or within 12 inches of the surface most of the year.

soil horizon - 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.

soil organic matter - 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.

soil reaction - 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, < 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 > 9.0.

soil salinity - The amount of soluble salts in a soil, expressed in terms of percentage, parts per million, or other convenient units.

soil structure - The combination or arrangement of primary soil particles into secondary particles, units, or peds. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades.

LOCATION AND SIZE

The mapped area is situated only a half mile east of the town of Cold Lake, and borders a portion of the southern shore of the Lake proper. It includes sections 17, 19 and 29; as well as N½ of 18 and S½ of 29, in township 63 and range 1, west of the fourth meridian. Variable portions of these sections are covered by lake waters, and the total land area studied was only about 1300 acres.

PHYSIOGRAPHY AND SURFICIAL DEPOSITS

The mapped area lies within the Eastern Alberta Plains of the Third Prairie Steppe (Kocaoglu, 1975). The surface elevations in the study area range between 1700 and 1800 feet above sea level. The area is drained by a number of small channels which outlet into Cold Lake.

The majority of the study area is covered by till, and a thin veneer of moderately fine textured lacustrine is found overlying till in the north half of section 17 and the south half of section 20. Three small stretches of very coarse textured lacustrine overlying till are found along the lake shore, and a few small organic deposits also occur.

CLIMATE

The general climate of the study area is the continental type, characterized by warm summers and cold winters (Kocaoglu, 1975). The following statistics were obtained over the 10 year period of 1964 through 1973 from a weather recording station near Elk Point, about 50 miles southwest of the mapped area at an elevation of 1925 feet (Env. Canada): A mean annual temperature of slightly less than 1° C, mean annual precipitation of 45.3 cm with 71% falling as rain, and an average frost free period of 99 days. The coldest month of the year is January with a mean temperature of -20.9° C, and July is the warmest month with a mean temperature of 16.3° C.

VEGETATION

The mapped area lies within the Mixedwood Section of the Boreal Forest Region (Kocaoglu, 1975). However, the vegetation is not discussed extensively herein, because the Parks Planning Branch of Alberta Recreation, Parks and Wildlife currently conducts biological studies of Provincial Parks and proposed park areas. Some of the more common plant species observed in association with different soils are listed in the Map Unit descriptions. The common and scientific names of these are as follows: aspen (Populus tremuloides), white spruce (Picea glauca), white birch (Betula papyrifera), balsam poplar (Populus balsamifera), black spruce (Picea mariana), tamarack (Larix laricina), lowbush cranberry (Viburnum edule), rose (Rosa spp.), dogwood (Cornus stolonifera), beaked hazelnut (Corylus cornuta), wild red raspberry (Rubus spp.), wild gooseberry (Ribes spp.), saskatoon berry (Amelanchier alnifolia), choke cherry (Prunus virginiana), willow (Salix spp.), Canadian buffalo-berry (Shepherdia canadensis), alder (Alnus spp.), grass (various species), blueberry (Vaccinium myrtilloides), ferns, Labrador tea (Ledum groenlandicum), marsh marigold (Caltha palustris), slough grass (Beckmannia syzigachne), sphagnum moss, and feather moss.

SOILS

Five Map Units were recognized in the study area. The soils of two of these belong to the Luvisolic Order, and the soils of the other three are classified in the Regosolic, Gleysolic and Organic Orders of the Canadian System of Soil Classification (CDA, 1974). The pertinent features of the different Map Units are shown in Table 17.

Delineation of different Map Units is usually justified on the basis of differences which are significant with regard to some recreational or engineering use. The extreme variability commonly found in soils is illustrated by the wide variations in horizon thicknesses, as demonstrated in the following soil descriptions.

The dominant plant species are listed, using common names. These are not intended to be complete or exhaustive species lists.

Table 17. Key to the Soils

Map Unit	Classification	Parent Material	Surface Texture	Slope (class and gradient)	Surface Stoniness	Drainage	Comments and Limitations
1	Orthic Gray Luvisol	moderately fine textured till	L to SL	d, e, f (5+ to 30%)	1 and 2	well drained	slight to severe limitations - excessive slope, surface stoniness, high clay content, of subsoil, slow permeability, susceptibility to frost heave, lack of Ah horizon, moderate shrink-swell potential.
2	Dark Gray Luvisol - 70% Orthic Gray Luvisol - 30%	moderately fine textured lacustrine overlying moderately fine textured till	L, SL, SiL	c,d,e,f, (2+ to 30%)	0 and 1	well drained	thickness of lacustrine veneer variable, till often extends to surface, slight to severe limitations - excessive slope, high clay content of subsoil, slow permeability, susceptibility to frost heave, thin Ah horizo moderate shrink-swell potential.
3	Orthic Regosol	sand overlying moderately fine textured till	S	b (0.5+ to 2%)	0	upper profile rapidly drained, water table at shallow depth	water table occurs at 12 to 20 inches, till occurs at 24 to 48 inches, severe limitations flooding hazard (overflow) seasonally high groundwater table, sandy surface texture, shallow depth to sand, rapid permeability (droughtiness), groundwater contamination hazard, lack of Ah horizon, thin deposit of sand.
4	Rego Gleysol - peaty phase	moderately fine textured till	SCL	a (0 to 0.5%)	0	poorly drained	severe limitations - seasonally high groundwater table or surface ponding, slow permeability, groundwater contamination hazard, susceptibility to frost heave, lack of Ah horizon, organic surface layer more than 6 inches thick, moderate shrink-swell potential.
M	Mesisol	predominantly moderately decomposed	Organic	a (0 to 0.5%)	0	very poorly drained	severe limitations - organic soil, seasonally high groundwater table, groundwater contamination hazard, high shrink-swell potenti lack of Ah horizon.

Map Unit 1

Classification: Orthic Gray Luvisol.

Parent Material: moderately fine textured till.

Landform: hummocky morainal (Mh).

Slope: gently to strongly rolling (5+ to 30%).

Surface Stoniness: slightly to moderately stony (1 and 2).

Drainage: well drained.

Vegetation: various combinations of aspen and white spruce, considerable white birch, some balsam poplar, understory consists of various combinations of lowbush cranberry, rose, dogwood, beaked hazelnut, gooseberry, raspberry, some buffalo-berry, some patches of saskatoon and choke cherry.

Profile Description:

Horizon	Thickness (in.)	Texture	Structure	Consistence
L-H	2 to 3	leaf litter		
Ae	3 to 5	L to SL	platy	very friable, moist
Bt	14 to 18	CL	blocky	firm to very firm, moist; hard, dry
BC	6 to 12	CL	amorphous	firm to very firm, moist; hard, dry
Cca	26 to 32 from surface	CL	amorphous	firm to very firm moist; hard, dry

Comments: none.

Limitations: severe for playing fields; slight on suitable topography for camp and picnic areas, paths and trails, and buildings without basements; moderate on suitable topography for other uses. Specific limitations are excessive slope, surface stoniness, high clay content of subsoil, slow permeability, susceptibility to frost heave, lack of Ah horizon, and moderate shrink-swell potential.

Map Unit 2

Classification: Dark Gray Luvisol - 70%; Orthic Gray Luvisol - 30%.

Parent Material: moderately fine textured lacustrine overlying moderately fine textured till.

Landform: glaciolacustrine veneer overlying undulating morainal ($L^{G}v/Mu$); glaciolacustrine veneer overlying hummocky morainal ($L^{G}v/Mh$).

Slope: undulating to strongly rolling (2+ to 30%).

Surface Stoniness: stone free to slightly stony (0 and 1).

Drainage: well drained.

Vegetation: mostly aspen, some balsam poplar and white birch, patches of white spruce, understory consists of various proportions of beaked hazelnut, lowbush cranberry, dogwood, rose, raspberry, gooseberry, saskatoon.

Profile Description:

Horizon	Thickness (in.)	Texture	Structure	Consistence
L-H	2 to 3 (occasionally 4 to 5)	leaf litter		
Ah	0 to 3 (discontinuous)	L	granular	very friable, moist
Ahe	2 to 4	SL, sometimes L to SiL	granular to platy	very friable, moist
Ae1	2 to 4	L to SL	platy	very friable to friable, moist
Ae2 (usually absent)	2 to 8	S	single grain	loose, moist
Bt	16 to 24	SiCL to SiC	blocky	firm to very firm, moist
IIBC (till)	10	CL	amorphous	firm to very firm, moist
IICca	40 from surface	CL	amorphous	firm to very firm, moist

Comments: thickness of the lacustrine veneer is highly variable. The depth of till is generally 30 to 40 inches, but ranges from the surface to more than 4 feet. Where the till is more than 4 feet from the surface, the texture of the C horizon varies from sandy clay loam and clay loam, to silty clay loam; and occasional sand pockets are found.

Limitations: slight on suitable topography for camp and picnic areas, paths and trails, and buildings without basements; otherwise moderate. Specific limitations are excessive slope, high clay content of subsoil, slow permeability, susceptibility to frost heave, thin Ah horizon, and moderate shrink-swell potential.

Map Unit 3

Classification: Orthic Regosol.

Parent Material: sand overlying moderately fine textured till.

Landform: Lacustrine veneer overlying level morainal (Lv/Ml).

Slope: gently undulating (0.5+ to 2%).

Surface Stoniness: stone free (0).

Drainage: upper profile rapidly drained, shallow water table.

Vegetation: sparse growth of willow and dogwood.

Profile Description:

Horizon	Thickness (in.)	Texture	Structure	Consistence
Ck	24 to 48	S	single grain	loose, dry and moist
IICk (till)	24 to 48 from surface	CL	amorphous	firm to very firm, moist

Comments: a water table is found at 12 to 20 inches from the surface.

Limitations: severe for all uses, other than sandy beaches. Specific limitations are flooding hazard (overflow), seasonally high groundwater table, sandy surface

texture, shallow depth to sand, rapid permeability (droughtiness), groundwater contamination hazard, lack of Ah horizon, thin deposit of sand.

Map Unit 4

Classification: Rego Gleysol - peaty phase.

Parent Material: moderately fine textured till.

Landform: level morainal (Ml).

Slope: nearly level (0 to 0.5%).

Surface Stoniness: stone free (0).

Drainage: poorly drained.

Vegetation: white spruce, a few white birch and willow, understory of feather moss and ferns.

Profile Description:

Horizon	Thickness (in.)	Texture	Structure	Consistence
Om	4	semidecomposed peat		
Oh	12	highly decomposed peat		
Ccag (till)	0+	CL to SCL	amorphous	firm, moist

Comments: none.

Limitations: severe. Specific limitations are seasonally high groundwater table or surface ponding, slow permeability, groundwater contamination hazard, susceptibility to frost heave, lack of Ah horizon, organic surface layer more than 6 inches thick, and moderate shrink-swell potential.

M (Organic Soil)

Classification: Mesisol.

Parent Material: moderately decomposed peat.

Landform: flat bog (Bl).

Slope: nearly level (0 to 0.5%).

Surface Stoniness: stone free (0).

Drainage: very poorly drained.

Vegetation: predominantly black spruce, and some white spruce, tamarack, white birch, alder, willow; understory of predominantly Labrador tea and sphagnum moss as well as some blueberry, slough grass and marsh marigold.

Profile Description:

Horizon	Thickness (in.)	Horizon Description
Of	6	undecomposed peat
Om	48+	semidecomposed peat

Comments: none.

Limitations: severe. Specific limitations are organic soil, seasonally high groundwater table, groundwater contamination hazard, high shrink-swell potential, lack of Ah horizon.

MISCELLANEOUS LAND TYPES

1. D.L. Disturbed Land. This appears to be an area of fill, consisting primarily of clay loam textured till. The topography is gently undulating (0.5+ to 2%), and the area is slightly stony (class 1). Limitations for most uses are moderate to severe due to factors such as high clay content, slippery or sticky when wet, slow permeability, moderate shrink-swell potential, susceptibility to frost heave, lack of Ah horizon, and high lime content (soil nutrient imbalance).

2.  This symbol indicates marshy areas. They are generally inundated and are characterized by the growth of hydrophytic vegetation such as slough grass, marsh marigold, willow and others, as well as some white birch. The limitations are severe for all uses because of the extreme wetness.

3. _ _ _ _ _ This symbol defines the location of drainage courses, which contain intermittent streams.

4. ıılıılıılıı This symbol indicates escarpments. They have severe limitations for all uses because of the extreme slopes.

SOIL INTERPRETATIONS

Soil interpretations are predictions of soil performance under different uses, not recommendations for land use (Greenlee, 1975). They do not eliminate the need for land use planning; rather they are valuable tools that can be used to assist the planner. They indicate limitations and suitabilities of the various kinds of soil for any particular use. The planner can then predict the type and degree of problem likely to be encountered, and plan the kind and amount of on-site investigation needed to determine corrective measures. However the actual number of on-site investigations can be reduced considerably by the use of a soil survey map.

Using the basic soil survey data of an area, it is possible to make soil performance predictions, based on soil morphology and the associated soil physical and chemical properties. Soils in the provincial parks are used mainly for recreational pursuits, and as construction materials.

In general, soils of Map Units 1 and 2 when found on suitable topography (classes c and d) are well suited to recreational development and have moderate limitations for construction purposes due to a high clay content of the subsoil, slow permeability, susceptibility to frost heave, and moderate shrink-swell potential. Soils of Map Units 3 and 4 have severe limitations for all uses. Adverse factors of Map Unit 3 soils are flooding hazard (overflow), sandy surface texture, shallow depth to sand, and rapid permeability. Limiting factors of Map Unit 4 soils are seasonally high groundwater table or surface ponding, and organic surface layer more than 6 inches thick. Other limiting factors of soils in the mapped area include excessive slope, surface stoniness, slippery or sticky when wet, groundwater contamination hazard, high shrink-swell potential, high lime content (soil nutrient imbalance), thin Ah horizon, organic soil, and thin deposit of sand. Severe limitations of soils for recreational development and

construction purposes don't necessarily mean that they cannot be used. However, the importance of the limitations is realized in that higher costs will be incurred in developing these soils than if more suitable soils could be developed. Careful construction and conservation practices are needed.

The soils of Map Unit 2 could provide a source of topsoil, and the soils of Map Unit 3 could provide a source of sand; however, both of these materials are present in very limited quantities. A source of gravel was not found in the mapped area.

The limitations and suitabilities of the various soils for selected uses are shown in Table 18. The ratings were determined on the basis of soil morphological, physical, and chemical properties, as well as steepness of slope. The principal limiting properties are indicated by numerals which correspond to those listed beneath the table. The limiting properties are generally listed in decreasing order of importance in the table.

In Table 18, the soil limitations for various uses have been designated as slight (S), moderate (M), and severe (V). As a source of topsoil or as a source of sand and gravel the soils are simply rated as good (G), fair (F), poor (P), and unsuitable (U).

TABLE 18. LIMITATIONS AND SUITABILITIES FOR SELECTED USES

Map[2] Symbol	Limitations For:											Suitability as a Source of	
	Camp Areas	Picnic Areas	Playing Fields	Paths and Trails	Lawns & Landscaping	Buildings with basement	Buildings without basement	Septic Tank Absorption Fields	Sanitary Landfills-Trench Type	Reservoir Sites	Road Location & Source of Roadfill	Topsoil[1]	Sand or Gravel
1/d1	S	S	V3	S	M18	M22,14	S	M11	M*7	M3	M22,14	P18	U
1/d2	M4	S	V3,4	S	M18,4	M22,14	M4	M11	M*7,4	M3	M22,14	P18,4	U
1/e2	M3,4	M3	V3	S	M18,3	M22,14	M4,3	M11,3	M*7,4	V3	M22,3	P18,4	U
1/f2	V3	V3	V3	M3	V3,18	V3,22	V3,4	V3,11	M*3,7	V3	V3,22	P3,18	U
2/c1	S	S	M3	S	M18	M22,14	S	M11	M*7	M3	M22,14	F18	U
2/d0	S	S	V3	S	M18	M22,14	S	M11	M*7	M3	M22,14	F18	U
2/d1	S	S	V3	S	M18	M22,14	S	M11	M*7	M3	M22,14	F18	U
2/e1	M3	M3	V3	S	M18,3	M22,14	M3	M11,3	M*7	V3	M22,3	F18,3	U
2/f1	V3	V3	V3	M3	V3,18	V3,22	V3	V3,11	M*3,7	V3	V3,22	P3,18	U
3/b0	V5,1	V5	V5,8	V5	V5,18,9	V2,1	V1,2	V1,2,12	V1,2,12	V8,9	V1	U	F24,1
4/o0	V2,20	V2,20	V2,20	V2,20	V2,20,18	V2,20, 22	V2,20	V2,11,12	V2,12	V2	V2,22,14	U	U
M	V19,2	V19,2	V19,2	V19,2	V19,2,18	V19,2, 13	V19,2	V19,2,12	V19,2,12	V19,2	V19,2,13	U	U

Legend: S - none to slight, M - moderate, V - severe, G - good, F - fair, P - poor, U - unsuitable

1 Topsoil being considered here is Ah horizon or its equivalent (see Glossary)

2 Example: Map unit → 6 / topography → d 3 ← surface stoniness

Note: for definitions, see section entitled "General Discussion of Soil Map"

* Probably moderate to 12 feet.

LIMITING SOIL PROPERTIES AND HAZARDS

1. Flooding hazard (overflow)
2. Seasonally High Groundwater Table or Surface Ponding
3. Excessive slope
4. Surface Stoniness
5. Sandy Surface Texture
6. Slippery or Sticky When Wet
7. High Clay Content
8. Shallow Depth to Sand or Gravel
9. Rapid Permeability (Droughtiness)
10. Moderate Permeability
11. Slow Permeability
12. Groundwater Contamination Hazard
13. High Shrink-Swell Potential
14. Susceptibility to Frost Heave
15. Surface Soil Salinity
16. High Lime Content (Soil Nutrient Imbalance)
17. Shallow Depth to Bedrock
18. Thin Ah Horizon
19. Organic Soil
20. Organic Surface Layer More Than 6 Inches Thick
21. Thick Overburden above Gravel or Sand
22. Moderate Shrink-Swell Potential
23. Possible Concrete Corrosion Hazard (Soluble Sulphate)
24. Thin Deposit of Sand or Gravel
25. Erosion Hazard
26. Solonetzic Soil
27. Excessive Coarse Fragments

REFERENCES

Brady, N.C. 1974. The Nature and Properties of Soils. Eighth ed. Macmillan Publ. Co. Ltd., New York. 639 pp.

Environment Canada. Monthly Record Meteorological Observations in Canada, 1964 to 1973. Information Canada, Ottawa. (Env. Canada).

Greenlee, G. M. 1975. Soil Survey of Long Lake Provincial Park and Interpretation for Recreational Use. Alberta Inst. of Pedology Number M-75-5, Alberta Research Council, Edmonton. 53 pp.

Kocaoglu, S.S. 1975. Reconnaissance Soil Survey of the Sand River Area (73L). Univ. of Alberta Bull. SS15, Alberta Inst. of Pedology Rep. S-74-34, Edmonton. 83 pp.

Moss, E. H. 1959. Flora of Alberta. Univ. of Toronto Press. 546 pp.

Terzaghi, K. and R. B. Peck. 1967. Soil Mechanics in Engineering Practice. 2nd ed. John Wiley and Sons Inc., New York. 729 pp.

United States Department of Agriculture, 1957. The Yearbook of Agriculture. U.S.D.A., Washington, D. C., 784 pp. (U.S.D.A., 1957).

Williams, H. E., I. S. Allison, C. R. Stauffer, and G. A. Thiel. 1960. Geology: Principles and Processes, 5th ed. McGraw-Hill, New York, Toronto, London. 491 pp.

APPENDIX

Chemical Analyses of the Soils

The chemical analyses carried out on representative soil samples are presented in Table 19. The samples analyzed are surface and subsoil samples, taken of the Map Units at representative sites. Surface samples are taken from the 0 to 6 inch depth, and the subsoil samples from the 6 to 12 inch depth. Each surface sample consists of five separate samples taken at random locations and bunched together into one composite sample. A brief explanation of the significance of each chemical analysis follows.

TABLE 19. CHEMICAL ANALYSES OF SELECTED MAP UNITS *

Map Unit	Sample Depth (inches)	Pounds per Acre			Sodium**	Sulphur**	Soil Reaction (pH)	Cond. (mmhos/ cm.)	Sulphate **	Organic Matter**	Free Lime ** ($CaCO_3$)	REMARKS
		Nitrogen (N)	Phosphorus (P)	Potassium (K)								
1	0-6	1	99	270	L	M	5.6	0.4	-	L	-	forested - white spruce, aspen, white birch
1	6-12	1	3	265	L	M-	5.5	0.1	-	L	-	
2	0-6	1	57	300	L	M-	5.8	0.2	-	L	-	aspen forest
2	6-12	1	17	220	M	L+	5.6	0.2	-	L	-	

Chemical Analyses done by Alberta Soil and Feed Testing Laboratory.

These tests are rated into four categories: high (H), medium (M), low (L), and none (-). The degree within each category is indicated by a plus or minus sign. The tests for organic matter and free lime are estimates only.

1. Nitrogen.

Plant growth in regions where rainfall is adequate is determined more by soil nitrogen than by any other mineral element supplied by the soil. (USDA, 1957). Nitrogen is of special importance because plants need it in rather large amounts and it is easily lost from the soil.

Soil nitrogen supply can be markedly affected by climatic conditions, native vegetation, and soil texture.

In humid areas, where forests predominate, the higher rainfall causes much leaching and the removal of most soil nitrogen from upper horizons. In contrast, in areas of somewhat limited rainfall where grass predominates, much more nitrogen remains near the soil surface.

A clay or clay loam soil commonly contains two to three times as much nitrogen as does a very sandy soil under the same type of climatic conditions. Poorer aeration and less leaching favour the retention of nitrogen in the finer textured soils.

In general, low soil nitrogen levels will likely occur in virgin soils, in soils low in organic matter, and in soils that are cold or poorly drained.

General soil test ratings for supplies of available nitrogen, expressed in pounds per acre, are: low, zero to 20; medium, 21 to 50; and high 51 or more.[1]

The primary natural source of soil nitrogen is air. Important artificial sources are fertilizers, animal manures, green manures, and various crop residues.

2. Phosphorus.

Phosphorus is present in all living tissue. It is particularly concentrated in the younger parts of the plant, and in the flowers and seed (USDA, 1957). As phosphorus does not move appreciably in the soil, accumulations are found primarily in the first foot of soil.

Most of the total phosphorus supply is tied up chemically in a form that is not usable by plants; it is not available to the growing plant. The available soil phosphorus originates from the breakdown of soil minerals and soil organic matter or from the addition

[1] Alberta Soil and Feed Testing Laboratory.

of phosphate fertilizer. The available soil phosphorus is usually only about 1% of the total soil phosphorus.

Soil tests show that a majority of Alberta soils are low in available phosphorus.[1] Plants respond markedly to phosphate fertilizer on deficient soils.

General soil test ratings for supplies of available phosphorus, expressed in pounds per acre, are: low, zero to 30; medium, 31 to 70; and high, 71 or more.

3. Potassium.

Plants need large amounts of potassium, one of the three major plant nutrients (USDA, 1957). It is supplied to roots by soil minerals, artificial fertilizers, manures and crop residues.

Most Alberta soils contain adequate amounts of potassium.[1] Deficiencies occur most frequently in peat soils or poorly drained soils.

General soil test ratings for supplies of available potassium, expressed in pounds per acre, are: low, zero to 150; medium, 151 to 300; and high 301 or more.

4. Sulphur.

Sulphur is essential to life (USDA, 1957). Many plants use about as much sulphur as they do phosphorus. Plants obtain sulphur from the soil, rain and irrigation water, artificial fertilizers, and the atmosphere.

General soil test ratings for supplies of available sulphur are: low (L), medium (M), high (H), and none (nil). The degree within each category is indicated by a + or - sign.[1]

The soil test determines whether adequate amounts of sulphur are available for normal plant growth. Where the sulphur test is low, a sulphur containing fertilizer should be applied; where it is medium, a field test using sulphur and non-sulphur fertilizers should be conducted. Plant responses to sulphur fertilizer can vary considerably within very small areas.

5. Soil Reaction (pH).

This test measures soil acidity or alkalinity. Acid soils have pH values of less than 6.6; decreasing pH values indicate increasing soil acidity. Neutral soils

have pH values of 6.6 to 7.3; alkaline soils have pH values of more than 7.3. Increasing pH values indicate increasing soil alkalinity.

The best pH range for most crops in Alberta is 5.5 to 7.5.[1]

6. Soil Salinity and Conductivity Test.

Conductivity is a measure of the total soluble salt concentration in a soil. Soluble salts are present in soils at all times; however, when the salt concentration is high, plant growth is reduced and the soil is considered "saline". Sulphates and sodium are determined to identify specific salts commonly causing salinity.

In general, lawn growth is affected on soils having conductivity readings as follows:[1]

0 to 1, negligible salt effects.

1.1 to 3, lawn growth noticeably restricted.

3.1 or more, lawn growth considerably restricted.

The sulphate and sodium tests are rated in four categories: high (H), medium (M), low (L), and none (nil). The degree within each category is indicated by a + or - sign.

A high sodium test may indicate a solonetzic soil which is characterized by poor physical structure and requires special management. A high sulphate test may indicate a hazard of sulphate attack on concrete, indicating a need for sulphate resistant concrete to be used in constructing foundations and underground conduits.

7. Organic Matter and Free Lime.

These tests are estimates of the amounts contained in the soil. Results are rated into four categories: high (H), medium (M), low (L), and none (nil). The degree within each category is indicated by a + or - sign.[1]

Organic matter influences physical and chemical properties of soils far out of proportion to the small quantities contained therein (Brady, 1974). It commonly accounts for at least half the cation exchange capacity of soils and is responsible,

[1] Alberta Soil and Feed Testing Laboratory.

perhaps more than any other single factor, for the stability of soil aggregates. Furthermore it supplies energy and body building constituents for the soil micro-organisms.

Free lime is present in some soils and may reduce nutrient availability to plants in the following ways:

a) Deficiencies of available iron, manganese, copper or zinc may be induced.

b) Phosphate availability may decrease due to the formation of complex and insoluble calcium phosphates.

c) The uptake and utilization of boron may be hindered.

d) The high pH, in itself, may be detrimental.

Free lime cannot be readily removed from the soil. The only practical way to counteract its effect is to increase soil organic matter content.

Engineering Properties of the Soils

Engineering test data determined on a representative soil sample are presented in Table 20. The sample analyzed was taken from the subsoil of Map Unit 1 at a representative site. Depth of sampling was between 4 and 5 feet below the surface. A brief description of the significance of each analytical parameter follows:

1. Field Moisture Percentage.

This is a determination of the natural moisture content of the soil as it occurs in the field.

For any potential borrow material, it is essential to know in advance of construction whether, for the compaction procedure likely to be specified, the moisture content in the field is excessive or deficient with respect to the optimum value for that procedure (Terzaghi and Peck, 1967).

2. Particle Size Analysis.

The particle size distribution within a soil is determined by laboratory tests, usually referred to as the particle size analysis of the soil (PCA, 1962). The amounts

TABLE 20. PHYSICAL ANALYSES OF SELECTED MAP UNITS

Map Unit	Depth (feet)	Field Moisture %	Mechanical Analysis: Percentage Passing Sieve							Mechanical Analysis: Percentage Smaller than				Liquid Limit	Plasticity Index	Optimum Moisture % **	Maximum Dry Density lb/ft^3 **	Classification		
			1 inch	3/4 inch	5/8 inch	#4 (4.7 mm.)	#10 (2.0 mm.)	#40 (0.42 mm.)	#200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.	0.001 mm.					AA SHO	Unified	USDA
1	4-5	10	100	100	100	100	99	95	66	60	35	27	23	28	13	14	117.5	A-6 (7)	CL	CL

Map Units developed on similar parent material: 1, 2 and 4.

These values are obtained from charts worked out by the Highways Testing Laboratory, Alberta Department of Highways.

of the gravel and sand fractions are determined by sieving, while the silt and clay contents are determined by sedimentation techniques. The amount of each soil separate contained in a soil determines its texture.

Where soil texture is known, approximations and estimates can be made of soil properties, such as permeability, water holding capacity, shrink-swell potential, bearing value, susceptibility to frost heave, adaptability to soil cement construction, etc.

3. Plasticity.

In soil mechanics, plasticity is defined as that property of a material which allows it to be deformed rapidly, without rupture, without elastic rebound, and without volume change (Means and Parcher, 1964).

Tests have been devised to determine the moisture content of a soil at which it changes from one major physical condition to another (PCA, 1962). These tests, conducted on the material passing the number 40 sieve (0.42 mm), have been used as key factors in classifying soils for structural purposes.

The tests used for estimating plasticity are plastic limit, liquid limit, and plasticity index. The plastic limit is the moisture content at which the soil passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the soil passes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid and plastic limits. This parameter gives the range in moisture content at which a soil is in a plastic condition. A small plasticity index, such as 5, indicates that a small change in moisture content will change the soil from a semisolid to a liquid condition. A large plasticity index, such as 20, shows that a considerable amount of water can be added before a soil changes to a liquid condition.

4. Moisture - Density Relationships.

The purpose of every laboratory compaction test is to determine a moisture density curve comparable to that for the same material when compacted in the field

by means of the equipment and procedures likely to be used (Terzaghi and Peck, 1967). Most of the current methods are derived from the procedure known as the "Standard Proctor Test". The "optimum moisture content", according to the Standard Proctor Test, is the water content at which the dry density is a maximum ("maximum dry density").

5. Soil Classification.

In order that soils may be evaluated, it is necessary to devise systems or methods for identifying soils with similar properties and then to follow this identification with a grouping or classification of soils that perform in a similar manner when their densities, moisture contents, textures, etc., are similar. (PCA, 1962). A brief description of three widely used soil classification systems follows.

(a) AASHO Classification System.

The American Association of State Highway Officials system is an engineering property classification based on field performance of highways. In the AASHO system, soil material is classified into seven basic groups with each group having about the same general load carrying capacity and service. The groups are designated A-1 to A-7; the best soils for road subgrades are classified as A-1, the next best A-2, etc., with the poorest soils being classified as A-7.

These seven basic groups are further divided into subgroups with a group index that was devised to approximate within group evaluations. Group indexes range from 0 for the best subgrades, to 20 for the poorest.

(b) Unified Soil Classification System.

In this system, the soils are identified according to their textures and plasticities, and are grouped according to their performance as engineering construction materials. Soil materials are divided into coarse grained soils, fine grained soils, and highly organic soils. The coarse grained soils are subdivided into eight classes; the fine grained soils into six classes; and there is one class of highly organic soils.

Coarse grained soils are those that have 50% or less of material passing the number 200 sieve; fine grained soils have more than 50% of material passing the number 200 sieve. The letters G, S, C, M, and O stand for gravel, sand, clay, silt, and organic materials respectively. The highly organic soils are designated by the symbol "pt". Additional letters used in the secondary divisions of the fine grained soils are L and H, meaning relatively low liquid limit and relatively high liquid limit, respectively.

The designation CL for example, indicates inorganic clays of low to medium plasticity; SW indicates well graded sands; and SC indicates clayey sands and sand-clay mixtures.

(c) United States Department of Agriculture Soil Classification System.

The system of textural soil classification, used by Canadian soil scientists, is known as the USDA system. It is defined under 'soil texture' in the glossary. There is some variation in the particle size limits between the USDA system and the two engineering systems just described, but the differences are not great. A comparison of the different systems is given in the PCA Soil Primer (1962).

GLOSSARY

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.

amorphous structure - A coherent mass showing no evidence of any distinct arrangement of soil particles.

available nutrient - The portion of any element or compound in the soil that can be readily adsorbed 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.

blocky structure - Soil particles are arranged around a point and bounded by rectangular and flattened surfaces, vertices sharply angular.

Dark Gray Luvisol - A Luvisolic soil with an Ah or Ahe horizon, or both, more than 5 cm (2 in.) thick; and the total thickness of the Ah and Ae horizons is greater than 15 cm (6 in.).

degraded - A leached and weathered state of a soil, usually indicated by morphological features such as an eluviated, light coloured A (Ae) horizon.

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.

escarpment - A steep slope or cliff separating gently sloping areas.

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.

fibric - Composed of organic soil material containing large amounts of weakly decomposed fiber whose botanical origin is readily identifiable.

firm consistence - The consistence at which a moist soil offers distinctly noticeable resistance to crushing, but can be crushed with moderate pressure between the thumb and forefinger.

forb - A broadleaf seed producing plant, other than grass, that does not develop persistent woody tissue, but dies down at the end of a growing season.

friable consistence - Consistence at which a moist soil crushes easily under gentle to moderate pressure between the thumb and forefinger, and coheres when pressed together.

gleyed - Characterized by gray colours, or prominent mottling, or both, indicative of permanent or periodic reducing conditions.

Gleysolic - An Order of soils that are saturated with water and are under reducing conditions continuously or during some period of the year, unless they are artificially drained. They have developed under hydrophytic vegetation and may be expected to support hydrophytic vegetation if left undisturbed.

granular structure - soil particles are arranged around a point in a spherical shape, vertices rounded.

gravel - Rounded and subrounded rock or mineral fragments greater than 2 mm and up to 7.6 cm (3 inches) in diameter.

Gray Luvisol - A Luvisolic soil in which the Ah horizon, if present, is less than 5 cm (2 inches) thick.

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

green manure - Plant material incorporated with the soil, while the plant material is still green. The purpose is to improve the soil.

hard consistence - Consistence at which a dry soil mass is moderately resistant to pressure; it can be broken in the hands without difficulty, but is rarely breakable between the thumb and forefinger.

humic - Composed of highly decomposed organic soil material containing little fibre.

humus - (1) The fraction of the soil organic matter that remains after most of the added plant and animal residues have been 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 material on and in the soil that undergoes a continuous breakdown, change and synthesis.

hydrophytic - Growing in water or in very wet soil.

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.

landform - Any physical, recognizable form or feature of the earth's surface, having a characteristic shape, and produced by natural causes.

leaching - The removal from the soil of materials in solution.

lime (in soil) - A soil constituent consisting principally of calcium carbonate, and including magnesium carbonate and perhaps other materials.

loose consistence - Consistence at which a moist or dry soil is noncoherent.

Luvisolic - An Order of soils that have developed under climatic conditions ranging from mild humid to very cold humid. The soils have developed under deciduous, mixed deciduous-coniferous, or boreal forests, or under mixed forest in the forest-grassland transitional zones. These soils have eluviated light coloured surface (Ae) horizons, brownish illuvial B (Bt) horizons in which silicate clay is the main accumulation product, and parent materials that are generally neutral to alkaline in reaction.

mesic - Composed of organic soil material at a stage of decomposition between that of fibric and humic materials.

Mesisol - A great group of soils in the Organic Order. The diagnostic layer is composed dominantly of mesic material.

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

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

Organic - An order of soils that have developed dominantly from organic deposits that are saturated for most of the year, or are artificially drained, and contain 30% or more organic matter to certain specified depths.

orthic - Refers to the modal or central concept in the definition of a soil Order.

particle size distribution - The amounts of the various soil separates in a soil sample, usually expressed in weight percentages.

peat - Unconsolidated soil material consisting largely of undecomposed, or only slightly decomposed organic matter.

peaty phase (of soil) - Soil having 6 to 16 inches (15 to 40 cm) of mixed peat or 6 to 24 inches (15 to 60 cm) of fibric moss peat on the surface.

platy structure - Soil particles are arranged around a horizontal plane, and bounded by relatively flat horizontal surfaces.

rego - An adjective used to indicate a soil that lacks a B horizon.

Regosolic - An Order of soils having no horizon development, or development of the A and B horizons insufficient to meet the requirements of the other Orders.

single grain structure - Loose, incoherent mass of individual particles as in sands.

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

soil horizon - A layer of soil or soil material approximately parallel to the land surface; it differs from adjacent genetically related layers in physical properties such as colour, structure, texture and consistence; and chemical, biological, and mineralogical composition. Soil horizons are designated by letters according to the following definitions:

1. Organic Layers - These contain more than 30% organic matter. Two groups are recognized:

O - An organic layer developed under poorly drained conditions, or under conditions of being saturated most of the year, or on wet soils that have been artificially drained.

Of - The least decomposed organic layer, containing large amounts of well preserved fibre whose botanical origin is readily identifiable, and called the fibric layer.

Om - An intermediately decomposed organic layer containing less fibre 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 under imperfectly to well drained conditions, often forest litter (commonly abbreviated to L-H). They are defined as follows:

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.

2. Master Mineral Horizons - These are mineral soil layers containing less than 30% organic matter. They are defined as follows:

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 matter, or both.

B - A mineral horizon characterized by one or more of the following:
a) An enrichment in silicate clay, iron, aluminum, or humus.
b) A prismatic or columnar structure that exhibits pronounced coatings or staining associated with significant amounts of exchangeable sodium.
c) An alteration by hydrolysis, reduction, or oxidation to give a change in colour or structure from 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.

3. Lowercase Suffixes - These indicate a secondary or subordinate feature or features, in addition to those characteristic of the defined master horizon. They are defined as follows:

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

e - A horizon characterized by removal of clay, iron, aluminum, or organic matter, alone or in combination, and lighter coloured when dry than an underlying B horizon.

g - A horizon characterized by gray colours, or prominent mottling indicative of permanent or periodic intense reduction, or both, and caused by conditions of imperfect or poor drainage. Examples are Aeg, Btg, Bg and Cg.

h - A horizon enriched with organic matter. Ah - An A horizon of organic matter accumulation. It contains less than 30% organic matter. It is darker than the layer immediately below, or has at least 1% more organic matter than the IC or both. Ahe - This horizon has been degraded, as evidenced by streaks and splotches of light and dark material and often by platy structure.

k - Denotes the presence of carbonates, as indicated by visible effervescence when dilute HCl is added. Most often it is used with B and m (Bmk) or C (Ck), and occasionally with Ah (Ahk).

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 2 inches (5 cm), and usually a higher ratio of fine (less than 0.2 micron) to total clay than the IC horizon.

soil morphology - The colour, structural, and textural characteristics of the soil or any of its parts.

soil ped - A unit of soil structure such as a prism, block, or granule, which is formed by natural processes.

soil profile - A vertical section of the soil through all its horizons and extending into the parent material.

soil separate - Mineral particles, less than 2.0 mm in equivalent diameter, ranging between specified size limits. The names and size limits of separates recognized 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; and clay, less than 0.002 mm.

subgroup, soil - The fourth category in the Canadian soil classification system. These soils are subdivisions of the Great Groups, and therefore each soil is defined more specifically.

till - Unstratified glacial drift deposited directly by the ice and consisting of clay, sand, gravel and boulders intermingled in any proportion.

very firm consistence - Consistence at which moist soil material crushes under strong pressure, and is barely crushable between the thumb and forefinger.

very friable consistence - Consistence at which moist soil material is crushed under very gentle pressure, but coheres when pressed together.

water table - The upper surface of the zone of saturation.

SOILS MAP OF LUND'S POINT AREA

Tp. 63, R.1, W 4

Soil Classification:

MAP UNIT	SOIL ORDER	SOIL SUBGROUP	SOIL PARENT MATERIAL
1	Luvisolic	Orthic Gray Luvisol	moderately fine textured till
2	Luvisolic	Dark Gray Luvisol – 70% Orthic Gray Luvisol – 30%	moderately fine textured lacustrine overlying moderately fine textured till
3	Regosolic	Orthic Regosol	sand overlying moderately fine textured till
4	Gleysolic	Rego Gleysol – peaty phase	moderately fine textured till
M	Organic	Mesisol	moderately decomposed peat

LEGEND:

Map Symbol

1 ← map unit
e 2 ← surface stoniness rating
↘ topographic class

D.L. – Disturbed Land
– marshy area
– drainage course
– escarpment
– soil line
– park boundary
– slope direction

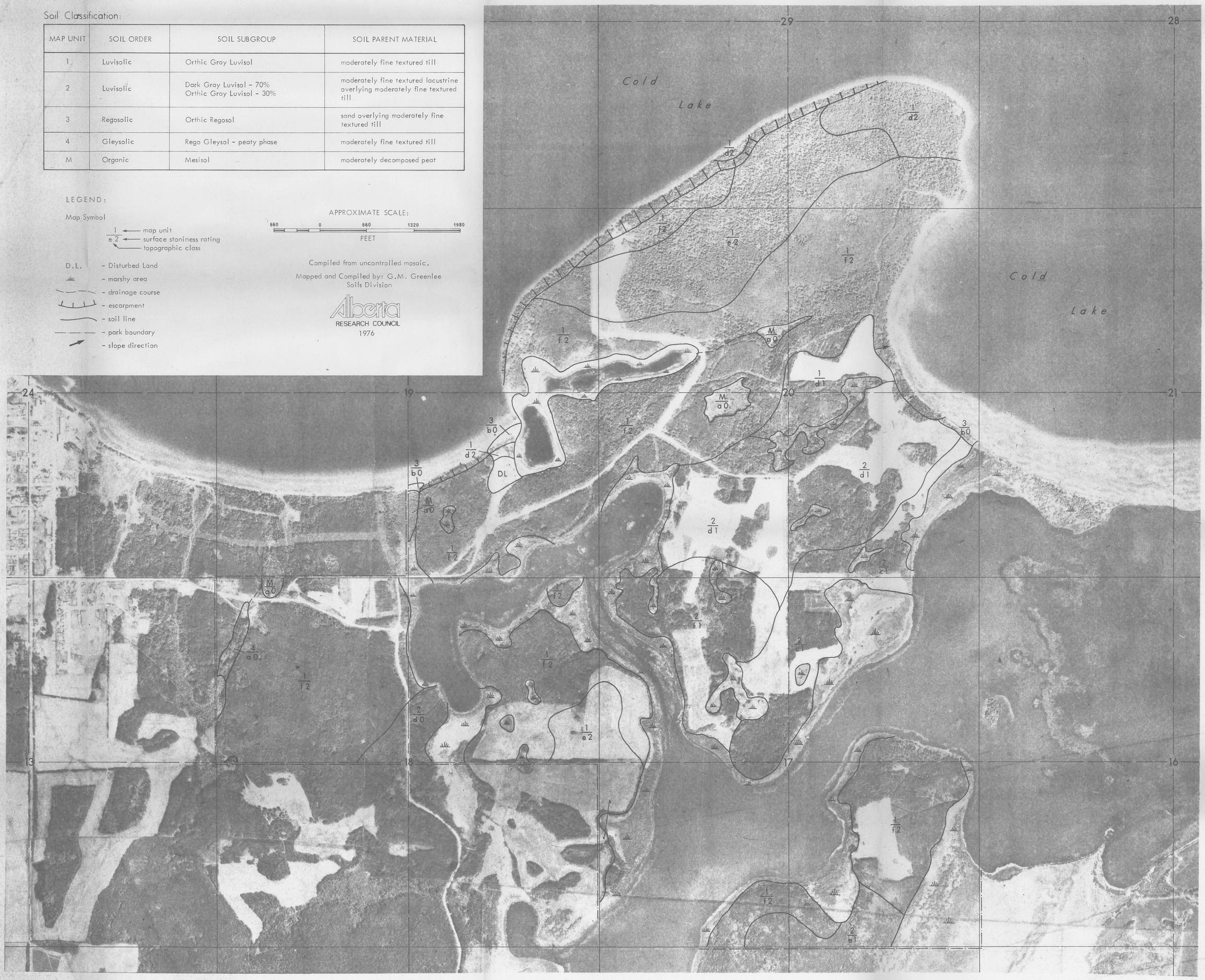
APPROXIMATE SCALE:

660 0 660 1320 1980
FEET

Compiled from uncontrolled mosaic.

Mapped and Compiled by: G.M. Greenlee
Soils Division

Alberta
RESEARCH COUNCIL
1976



map 53 2

OFR 1976-3

LANDFORM MAP OF LUND'S POINT AREA

Tp. 63, R. 1, W 4

LEGEND

M – Morainal
Ml – level morainal
Mh – hummocky morainal

L – Lacustrine
Lv – lacustrine veneer
L^{G}_{v} – glaciolacustrine veneer

B – Bog
Bl – flat bog

H – Marsh
Hh – horizontal marsh

D.L. – Disturbed Land
– drainage course
– escarpment
– landform boundary
– park boundary
– slope direction

APPROXIMATE SCALE:

660 0 660 1320 1980
FEET

Compiled from uncontrolled mosaic.

Mapped and Compiled by: G.M. Greenlee
Soils Division

Alberta
RESEARCH COUNCIL
1976

Cold Lake

Cold Lake

25 30 29 28

24 19 20 21

13 18 17 16

Mh Hh Bl Lv/Ml DL L^{G}_{v}/Mh L^{G}_{v}/Mu

map 2 of 2

OFR 1976-3