BC
Ministry of Environment

TERRAIN INFORMATION

A User's Guide to Terrain Maps in British Columbia

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Terrain Information

The geological materials that underlie the surface of the land are one of our most important resources. Surficial materials (unconsolidated deposits such as sand, gravel and glacial till: the engineer's "soil") that range in thickness from a few centimetres to several hundreds of metres overlie solid rock (bedrock) in most places. They form the parent material of the soil (in an agricultural sense) from which we harvest crops and timber. They provide the natural footing upon which bridges, highways, pipelines and transmission lines are constructed, as well as foundations for our own dwellings and most urban structures. Groundwater may be stored within certain types of surficial materials.

Characteristics of surficial materials and landforms vary greatly from place to place. Land that is susceptible to subsidence or landslides may be adjacent to stable terrain that provides good sites for construction. Steep slopes underlain by a particular type of surficial material may be prone to surface erosion should deforestation occur, but similarly steep slopes elsewhere, underlain by different material, may be much more resistant to erosion. Some areas are affected by hazardous geological processes (natural hazards), such as avalanches, mudflows, and floods, that may threaten property, structures, communication lines and even human safety.

Terrain maps provide information about the distribution and characteristics of surficial materials, landforms, and geological processes. The physical properties and conditions of the land surface can be assessed from these data.

All of British Columbia except the highest mountain peaks was covered by glaciers several times during the past two or three million years. Most surficial materials were deposited either during the most recent glaciation which lasted from about 29000 to 10000 years ago, or since then during postglacial time. Within the four billion years of earth history, these materials are very young indeed.

When terrain information is considered as part of the planning process, sites threatened by natural hazards such as debris flows can be avoided.

An examination of the characteristics and properties of terrain is an essential step in any planning process. Appropriate use, in a physical sense, can then be made of land surface materials and optimal land management practices can be determined; natural hazards can be avoided.

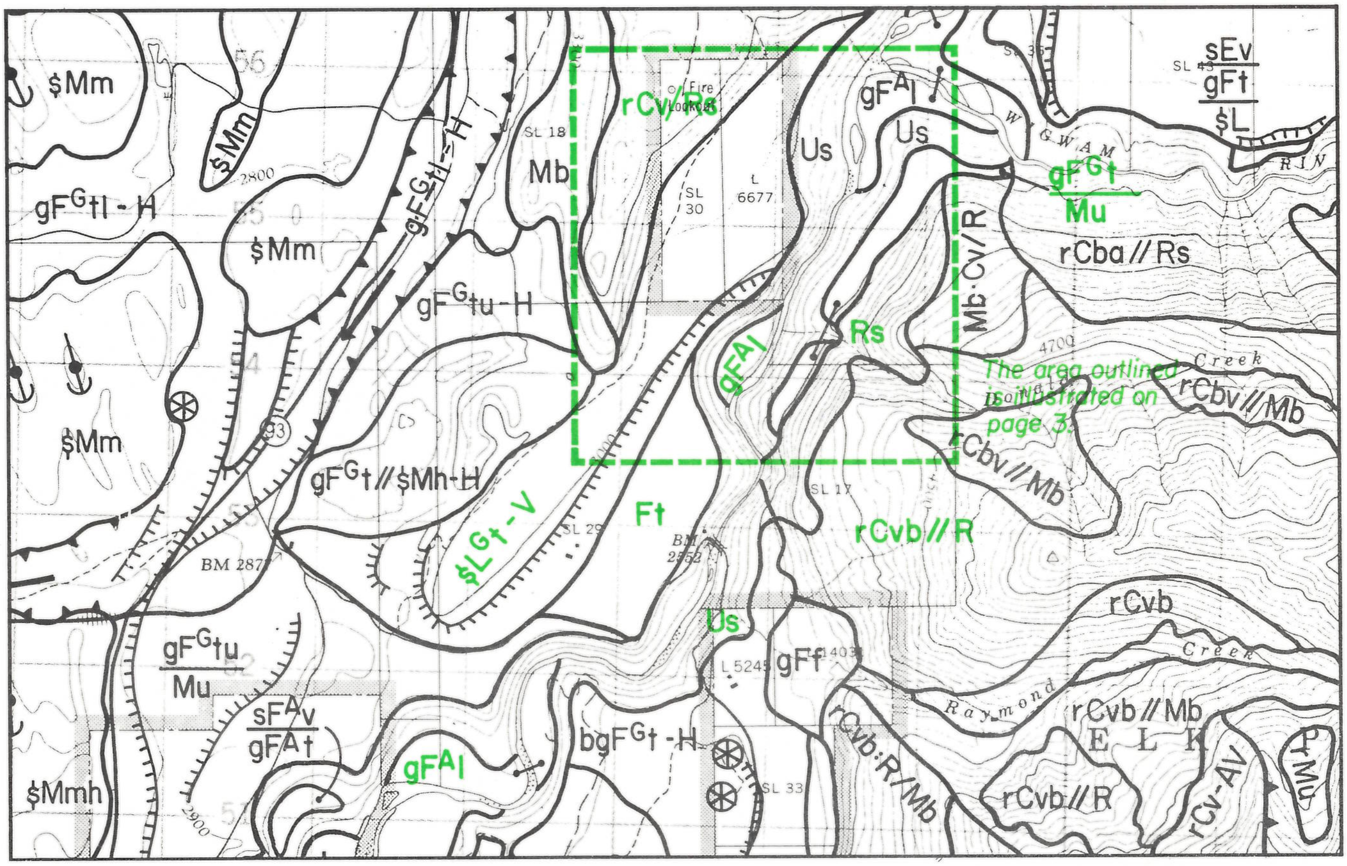
This booklet has been written in order to enable land managers, planners, foresters, biologists, engineers and other non-geologists to make use of terrain map information. Its use is particularly recommended with terrain maps that are not accompanied by a regional terrain or soils report and is intended to supplement, rather than duplicate, information provided in terrain map legends. Persons reading it should keep a terrain map and legend handy for reference purposes.

Terrain and soil-landform maps and reports are available from Maps B.C., Planning and Resource Management Division, Ministry of Environment, Victoria, British Columbia, V8V 1X5. The Division Catalogue (updated periodically) lists all published maps and reports (terrain and others).

Information about bedrock geology is available from the Geological Survey of Canada, 100 West Pender Street, Vancouver, British Columbia, V6B 1R8 and the Ministry of Energy, Mines and Petroleum Resources, Victoria, British Columbia, V8V 1X4.

Terrain Map Symbols

Information is shown on terrain maps by the use of letters and on-site symbols. Each group of letters constitutes a "terrain unit symbol", for example "$L^Gt-V". The letters within the group are arranged so that each letter position represents a particular characteristic of the terrain. The arrangement of letters and groups of letters is explained below by means of examples. Definitions of all individual letter symbols used on each terrain map are given in the map legend. The most commonly used letter symbols are defined in this booklet. On-site symbols are used to provide additional information about surficial materials or landforms that cover areas that are too small to show as terrain units. On-site symbols used on each terrain map are defined in the map legend.



TEXTURE (one to three lower case letters) describes the size, roundness and sorting of particles in mineral sediments and the fibre content of organic materials (see page 9).
(e.g. $ = silt)

QUALIFIER (one upper case letter as a superscript) is used where appropriate to provide additional information about surficial material and geological processes (see pages 5 to 8 and 11 to 12).
(e.g. G = glacial)

$L^Gt - V

SURFICIAL MATERIAL (GENETIC MATERIAL)
(one upper case letter) is classified according to its original mode of deposition because this indicates many inherent properties of the material (see pages 5 to 8).
(e.g. L = lacustrine, L^G = glaciolacustrine)

SURFACE EXPRESSION
(one to three lower case letters) describes the form (shape) of the land surface or the thickness of the surficial material (see page 10).
(e.g. t = terrace)

GEOLOGICAL PROCESS (MODIFYING PROCESSES) (one to three upper case letters) describes the on-going processes that are modifying either surficial materials or landforms (see pages 11 and 12). (e.g. V = surface erosion that results in gullies)

COMPOSITE TERRAIN UNIT SYMBOLS are used where two or three different kinds of terrain occur within a map unit. The symbol consists of two or three terrain unit symbols that are separated by slashes or dots:

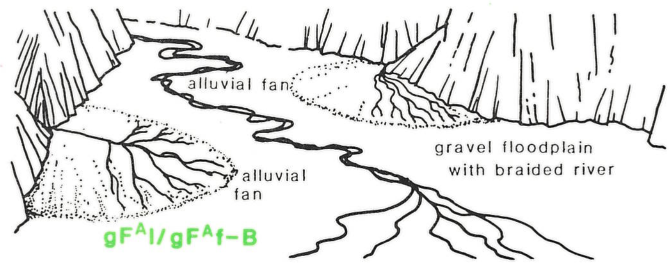
- • (or) = components on either side of this symbol are of approximately equal extent (1:1).
- / the component in front of the slash is more extensive than the one that follows (approximately 2:1).
- // the component in front of the double slash is considerably more extensive than the one that follows (ranges from 3:1 to 9:1)

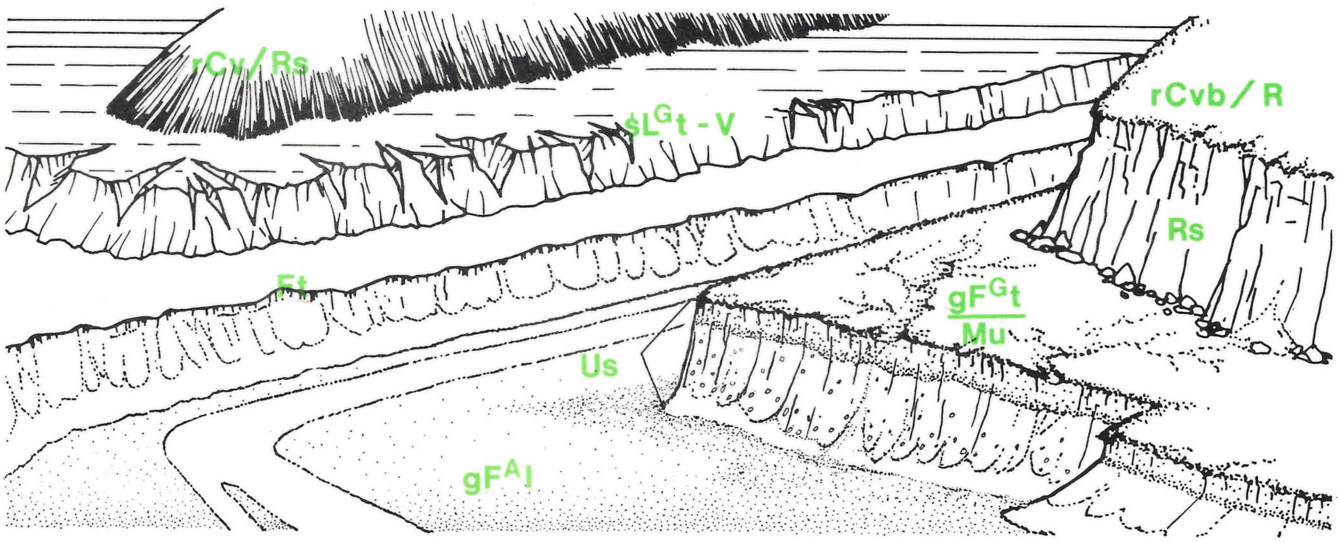
Examples:

rCv/Rs a veneer (v) of rubbly (r) colluvium (C) is more extensive than steep (s) bedrock (R) slopes.

Mb·Cv/R a blanket (b) of moraine (M) and colluvial veneer (Cv) of equal extent, and both are more extensive than bedrock (R).

Note: a geological process affecting any part of a composite unit is always written at the right hand side of the composite terrain unit symbol; see example in illustration.





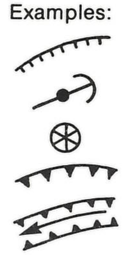
STRATIGRAPHIC SYMBOLS are used where information is available about unconsolidated material that underlies the surface layer of material.

Examples:

gF^G t / Mu	glaciofluvial (F^G) gravels (g) in the form of a terrace (t) that overlies undulating (u) till (M)
sEv / gFt / $L	a veneer (v) of eolian (E) sand (s) overlies a terrace of fluvial gravels (gFt) which in turn rest upon lacustrine (L) silt ($)
sF^A v / gF^A l	a veneer of fluvial sand overlies a gravel floodplain; the area is subject to periodic flooding (F^A).

ON-SITE SYMBOLS are used to show the specific location of some landforms and other features that cannot be accommodated by terrain unit symbols.

Examples:



scarp (steep slope)

drumlin (ice flow direction indicator)

kettle (depression)

cirque (head of glacial trough)

glacial meltwater channel

Map Scale and Reliability

MAP SCALE is the ratio between the length of an object on a map and the true length of that object on the ground. Terrain maps are commonly produced at 1:50000 (1 cm to 500 m) scale, although the system of mapping described in this booklet has been used for scales ranging from 1:10000 to 1:250000. Maps upon which ground features appear relatively large (e.g. 1:10000 scale) are known as large scale maps. The same features appear relatively small upon small scale maps (e.g. 1:500000).

The real features of the land surface are always more complex and variable than can be shown on even the largest-scale terrain map. Consequently, the process of mapping must involve arbitrary means of differentiating between features which are to be shown and those which are to be omitted. For example, if a certain kind of terrain constitutes less than 10% of the area of a terrain unit, it is usually ignored. Most criteria for selection are based upon map scale, as illustrated by the listing of areas of smallest terrain units in the table below. Thus, two aspects of the resulting map — scale and amount of information (or detail) shown — are inseparable. Consequently, terrain maps should be used only at the scale at which they are published. Enlargement (to a larger scale) will result in a highly generalized map upon which boundary line positions and symbols will be inadequately shown. Reduction will result in an excessively detailed map upon which an intricate mass of information masks the broad patterns which should be visible at the smaller scale.

Size of Map Units at Various Map Scales

Scale	Area of Smallest Unit	Area of Average Unit
1:10000	1 ha (2.5 ac.)	2-5 ha (5-13 ac.)
1:20000	4 ha (10 ac.)	8-20 ha (20-50 ac.)
1:50000	25 ha (65 ac.)	50-200 ha (130-500 ac.)
1:100000	100 ha (260 ac.)	200-800 ha (500-2000 ac.)
1:250000	625 ha (1563 ac.)	1400-6250 ha (3500-16000 ac.)

THE ACCURACY of terrain maps is difficult to assess in a general manner since it consists of several partially interrelated components, and the process of terrain mapping involves many variables.

The chief components of a terrain map that can be assessed for accuracy include the terrain unit symbol and the position of terrain unit boundary lines. The overall reliability with which these are portrayed depends primarily upon the quality of air photo interpretation, the length of time that was spent in the field, and the ability and experience of the mapper.

Terrain maps are usually most accurate in areas where a road network allows access to much of the map area, where road and railroad cuts and natural cutbanks permit extensive examination of surficial materials, and where there are clearly defined landforms that are indicative of certain materials. Terrain maps are less reliable in areas of no ground access where dense tree cover and lack of distinctive landforms hinder air photo interpretations. Forested valley-sides with intermixed till, colluvium and near-surface bedrock are most difficult to map. Where landforms are distinctive, such as floodplain and fans along a valley floor, or not masked by tree vegetation, such as in alpine areas or dry country, terrain can be mapped with a fair degree of accuracy from air photo interpretation alone.

Character of Surficial Materials

The chief criterion used for subdividing the land surface into terrain units is surficial material characteristics. Surficial materials are classified according to their mode of origin (genesis) because there is a close relationship between the process whereby they were formed and their most important physical properties.

MORAINAL MATERIALS (TILL) (M) were deposited either beneath (basal till), upon (ablation till), or at the snout (end moraines:Mr) of a glacier.

Basal till is widespread in British Columbia. It occurs as a mantle overlying bedrock (Mb, Mv), and as till plains (Mp, Ml), drumlins (Mr, ↑) and fluted moraine (Mm, /). It typically consists of rock fragments of many sizes and shape in a matrix of sand, silt and clay. The proportions of these constituents and related till properties vary in accordance with the geology of the source area. Granitic rocks give rise to sandy, bouldery tills; limestone, many volcanic rocks and shales produce tills with a silty or clayey silt matrix. In many valleys, river sands and gravels and lacustrine silts were reworked by glaciers to form a till that consists of rounded stones in a sandy silt matrix.

Basal till is typically the most cohesive and most highly consolidated of all surficial materials. It has low permeability and may be effectively impermeable if clay content is high. Depressions, lower valleysides and level areas on basal till may be poorly drained, and the water table may be close to the ground surface during rainfall or snowmelt. The bearing strength and shear strength of basal till are relatively high, and consequently this material is good for foundations and road beds, provided that sites are well drained. Basal till is also suitable for fill, although unvegetated embankment slopes are prone to erosion or to failure when saturated. Difficulties may arise when excavating till with earth moving equipment due to its hardness or the presence of large boulders.

Fluvial sand and gravel

Ablation till is comparatively loose, non-compact, and low in silt and clay. Its properties are more similar to those of glaciofluvial gravel than to those of basal till.

Basal till

Till-mantled hill (Mb)

FLUVIAL SEDIMENTS (ALLUVIUM) (F) result from deposition by streams and rivers. They comprise floodplains and alluvial plains ($F^{A}l$, Fl), river terraces (Ft), alluvial fans (Ff, $F^{A}f$), and deltas (Ff, $F^{A}f$, Fl, $F^{A}l$, Fp). They consist of rounded gravel, sand, and silt.

Fluvial deposits are non-cohesive and have low shear strength. Gravels and sands are highly porous and permeable, and permit rapid drainage and groundwater flow. Their bearing strength is generally high. Fluvial sediments are easily excavated by earth moving equipment, although vertical cuts in sand and gravel are modified by dry ravel until a slope of about 35° is attained. Locally, coarse gravels (bF, bgF) may pose problems for excavation.

River terraces generally provide dry, stable sites for construction. Appropriate set-backs should be made at the top of terrace scarps that are being undercut by a river.

Floodplains and "active" fluvial fans are affected by floods and shifting channels. These areas also tend to be poorly drained since the water table lies close to the ground surface. Detailed studies of flood hazard and site conditions must be carried out prior to development on this kind of terrain. Detailed floodplain maps for some major rivers in British Columbia are available from the Water Management Branch, Ministry of Environment, Victoria, British Columbia, V8V 1X5.

GLACIOFLUVIAL SEDIMENTS (F^G) were deposited by meltwater streams in close proximity to glaciers. Their composition, properties and land use potential are similar to those of fluvial materials. Irregular topography (F^Gh, F^Gr, F^Gm) may limit development or require much excavation for site preparation. Glaciofluvial terraces and outwash plains (F^Gt, F^Gl, F^Gp) resemble river terraces and fluvial plains, but they include depressions which may be poorly drained or contain lakes. Groundwater may be present at depth in these gravels and sands.

COLLUVIUM (C) results from accumulation of material that moves downslope due to gravity. There are three groups of colluvial deposits.

Rockslide near Hope (arCh)

The first group consists of talus slopes (Ca, Cc), colluvial mantles (Cv, Cb, Cw), snow avalanche deposits (e.g. Cf-A), and rockslide debris (e.g. aCh). These typically consist of angular rock fragments with interstitial sand and silt. The material is loosely packed, non-cohesive, highly porous and permeable, and well-drained; bearing strength is moderate to high. Some forms of construction, such as roads, are feasible. Development on these types of terrain, however, is severely limited by steep slopes and potential hazards which include rockfalls, rockslides and snow avalanches. Site specific investigations are necessary before development.

The second group of colluvial deposits consists of debris flow or mudflow fans (Cf, dCf, rsCf). These are steeper (8° to 14°) than most alluvial (fluvial) fans, but less steep than talus slopes and avalanche cones. They generally consist of interlayered debris flow deposits and thinner fluvial gravels; the former are relatively cohesive and their bearing strength is relatively high. Colluvial fans are well drained. They provide substrate suitable for development, but this may be offset by the threat of further debris flows. An examination of conditions in basins above fans is necessary in order to assess this hazard.

Earthflows and slumps constitute the third group of colluvial deposits (e.g. Ch, Cm, Cr). The texture and physical properties of these materials depend upon the geology of their source areas. They commonly consist of weathered bedrock and/or till with a high clay content. Many earthflows and slumps are undergoing slow movement at the present time (e.g. dCmr-F). Special investigations are needed before development occurs on this type of colluvium.

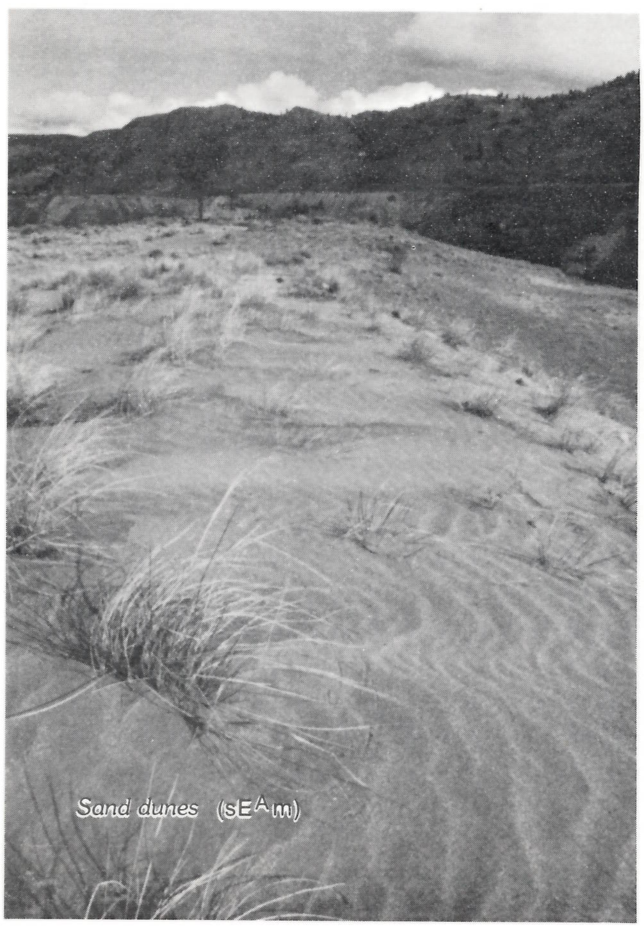
LACUSTRINE AND GLACIOLACUSTRINE SEDIMENTS (L, L^G) accumulated as a result of settling of fine particles from suspension in lakes, chiefly ice-dammed lakes during deglaciation. The sediments consist of thinly interlayered fine sand, silt and clay. They are weakly consolidated with relatively low bearing strength. Silts and clays are cohesive and of low permeability so that level areas and depressions are often wet and poorly drained.

Gullied terrace of glaciolacustrine silt (sL^{G}t - V)

Slopes and terraces underlain by lacustrine sediments are readily affected by surface erosion which results in the formation of deep gullies (Lt-V). Steep slopes such as terrace scarps are also subject to slides and slumps, particularly where groundwater seepage occurs near the foot of the scarp. Piping (underground erosion resulting in surface collapse) takes place within lacustrine terraces (Lt-P). Local dust hazard may exist where vegetation is sparse.

Lacustrine materials are generally unsuited for those kinds of development that aggravate their natural tendency for instability and erosion. Addition of load to slopes and additions to groundwater from irrigation, storm sewers and septic tanks should be carefully planned.

EOLIAN DEPOSITS (E) consist of coarse silt and sand transported and deposited by wind. They commonly occur as mantles on river terraces and inactive fans (e.g. sEv) where they constitute parent material for loamy, stone-free soils. Sand dunes (e.g. sEm) are found in windy locations where there is (or was) a suitable source of sediment.



Sand dunes (sE^{A}m)

Eolian sands are non-cohesive and subject to surface sliding, although cementation by calcium carbonate may stabilize low cut-banks in some areas. Eolian sediments in general are non-consolidated and subject to compaction when loaded. They are normally so thin, however, that foundations rest in the underlying material. Where vegetation is sparse or absent, dust may be a problem.

Recent lava flow near Aiyansh

VOLCANIC MATERIALS (V) consist of unconsolidated pyroclastic deposits (ash and cinders), and recent lava flows with a surface cover of loose, blocky debris.

ANTHROPOGENIC MATERIALS (A) consist of natural materials that have been so disturbed, modified or relocated that their physical properties have been significantly changed. This category includes spoil heaps, settling ponds, open pit mines, and areas of landfill. It does not include urban areas where buildings are constructed upon the natural substrate.

MARINE AND GLACIOMARINE SEDIMENTS (W, W^G) result from settling of sediment from suspension and from the melting of floating ice during deglaciation, and wave action. The former processes result in deposition of silts and clays and stony silts and clays. These have properties that are similar to those of lacustrine sediments, including a susceptibility to erosion, instability, and a tendency to subside when loaded. They are relatively impermeable and poorly drained.

Wave action has formed beaches, bars, and spits of gravel and sand along both the present shoreline (e.g. gW^Am) and older, slightly higher shorelines (e.g. gWm) where they constitute relatively dry and well drained terrain.

BEDROCK (R) is mapped where rock outcrops at the ground surface or is covered by less than 10 cm of surficial material. Rock characteristics such as hardness, strength, drainage and rippability vary in accord with rock type. Bedrock geology maps should be consulted where rock outcrops are extensive.

WEATHERED BEDROCK (D) is mapped where mechanically and chemically weathered debris is derived *in situ* from underlying bedrock. Generally applied to flat or gently sloping terrain because weathered bedrock that has moved downslope is classified as colluvium.

ORGANIC MATERIALS (O) result from the decay and accumulation of vegetation in closed basins or on gentle slopes. Such areas tend to be poorly drained, or even inundated for parts of the year. Bearing strength of organic sediments is very low, and much compaction occurs when they are loaded. When organic sediments are artificially drained or dried, shrinkage and subsidence occur.

Organic terrain does not provide suitable sites for any kind of development unless considerable modification (such as drainage and compaction) is carried out before construction.

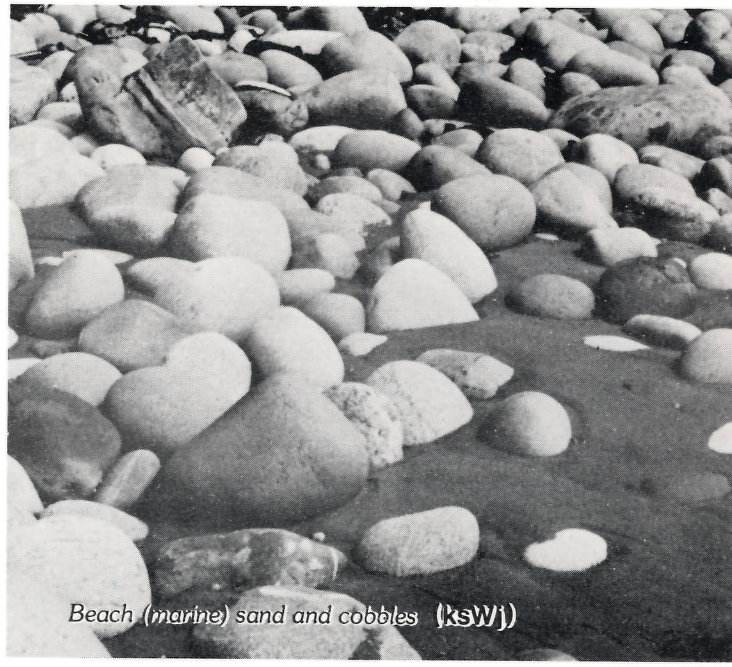
ICE (I) is indicated on terrain maps where glaciers and snowfields occur.

Texture of Surficial Materials

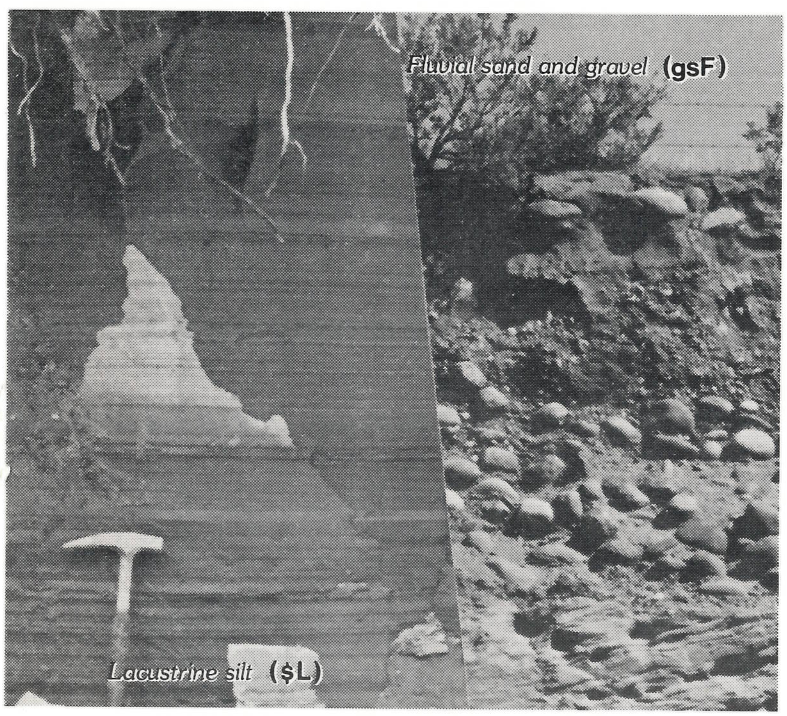
Texture refers to the size and roundness (degree of curvature of corners and edges) of the particles that constitute a surficial material, and to the sorting (uniformity of particle sizes) within the mass of sediment. On some terrain maps, the texture of organic sediments may be identified. Organic texture denotes the relative proportions of fibres (undecomposed remains of vegetation) and humus (decomposed material).

Texture is important because it influences many physical properties of surficial materials. It largely determines their permeability, compressibility, drainage characteristics, and stability and erodibility on steep slopes; it also influences the response of a sediment to freezing and thawing (frost heave susceptibility) and changes in moisture content (shrink-swell potential). For example, coarse textured materials such as gravel tend to be highly permeable, well drained, and non-compressible. Fine textured materials such as silt and clay have low permeability and are subject to frost heave; they may be plastic, highly compressible, and shrink and swell when dried and wetted; they commonly give rise to landslides and mudflows.

Thus texture gives some indication of the physical properties of a surficial material. It should always be considered when assessing the suitability of an area for development or any change in land use.



Beach (marine) sand and cobbles (ksWj)



Fluvial sand and gravel (gsF)

Lacustrine silt ($L)

Description of Commonly Used Textural Terms and Map Symbols

Name	Map Symbol	Size (mm)	Roundness
boulders	b	> 256	rounded
cobbles	k	64-256	rounded
pebbles	p	2-64	rounded
gravel	g	mixture of above	rounded
sand	s	.0625-2	not specified
silt*	$	.004-.625 or .002-.625	not specified
clay*	c	< .004 or < .002	not specified
fines	f	mix of silt and clay	not specified
mud	m	mix of silt and clay	not specified
blocks	a	> 256	angular
rubble	r	2-256	angular
angular fragments	x	> 2	angular
diamicton	d	course particles in matrix of silt and/or clay	angular and/or rounded
shelly	y	shells	—
Organic Terms			
fibric	e	least decomposed organic material, contains large amount of well preserved fibre	
mesic	m	intermediate degree of decomposition	
humic	h	highly decomposed organic material, contains little well preserved fibre.	

refer to map legend for silt/clay boundary used

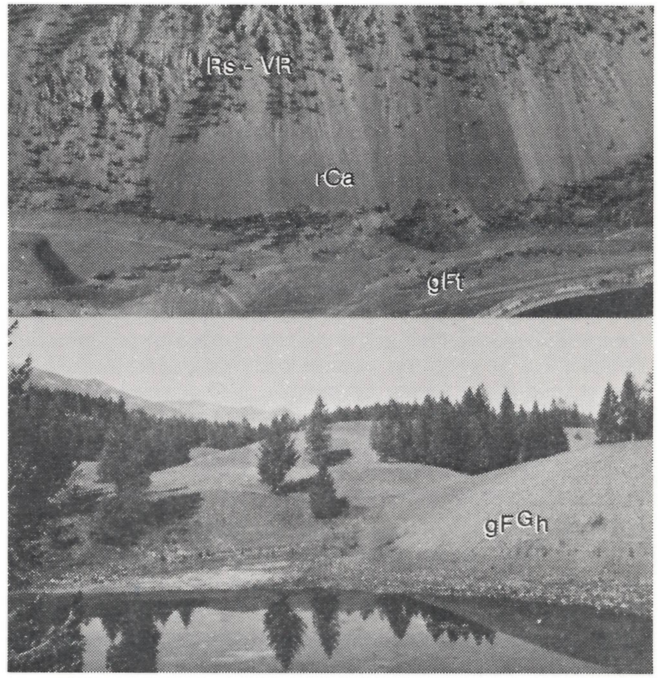
If more than one letter symbol is used to indicate the texture of a surficial material, the right hand letter indicates the dominant texture, and the left hand letter(s) the minor component(s). Thus sgFt is a fluvial terrace composed of sandy gravel; $sgFt indicates a small admixture of silt in the sandy gravel. If texture is omitted from a terrain unit symbol, then the map user should refer to the appropriate surficial material in the map legend for a general description of texture.

Surface Expression (Landforms)

Surface expression describes the configuration (three dimensional shape) of the land surface. It is generally used to indicate small landforms that are not shown by the contours of the topographic base of the terrain map. Some surface expression terms (v, b, w) indicate that the shape of the land surface is related to the configuration of the buried landscape upon which the surficial material lies.

Slope steepness is usually not shown explicitly on terrain maps. However, it is included in the definitions of surface expression terms and it may also be determined from the spacing of contours. On some detailed terrain maps (e.g. 1:20 000 scale), slope steepness is indicated in an expanded terrain unit symbol.

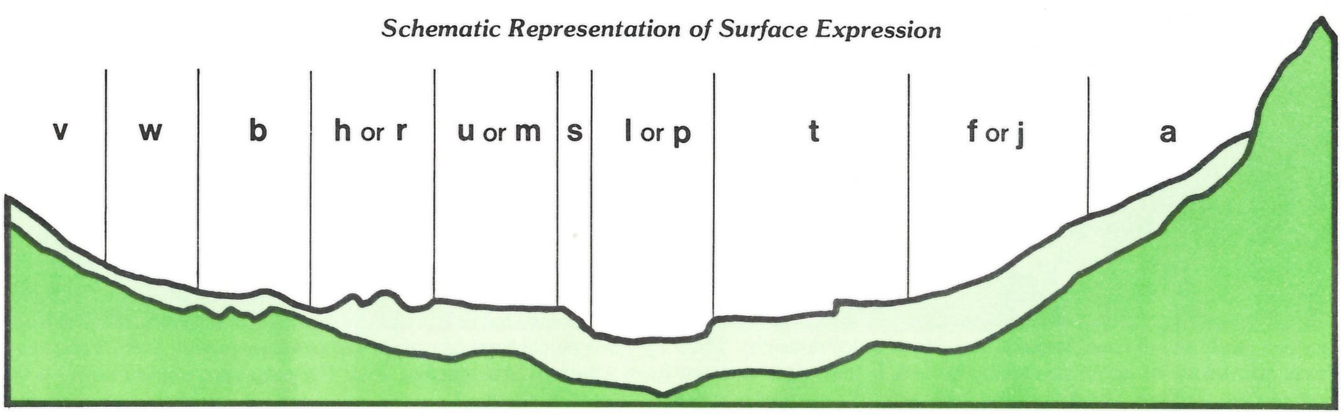
One to three surface expression terms are applied to a surficial material. The use of two or three symbols implies that there is a mixing of discrete forms and not a combination of forms. For example, $gF^{G}hr$ indicates that both ridges and hummocks of glaciofluvial gravel are present within the terrain unit. Where two or three symbols are used together, they are written either in order of importance or in alphabetical order with no order of importance implied (see map legend).



Description of Commonly Used Terms and Map Symbols

moderate slope, apron	a	a slope of 10°-35° with a unidirectional surface.
blanket	b	a mantle of material that reflects the topography of underlying unit and is > 1m thick.
cone	c	a fan-shaped surface with slope > 10°.
fan	f	a fan-shaped surface with slope of 2°-10°.
hummocky	h	steep-sided hillocks that are irregular or rounded in plan; slopes > 10°.
gentle slope	j	a slope between 2° and 10° with unidirectional surface.
rolling	m	elongated rises and depressions that are parallel in plan; slopes < 10°.
plain, level	p, l	level or gently inclined unidirectional surface < 2° for p; < 5° for l.
ridged	r	narrow, elongated hills with slopes > 10°.
steep slope	s	steep slopes > 35°.
terrace	t	step-like topography; consisting of scarps and horizontal surfaces.
undulating	u, m	gently sloping hillocks that are irregular in plan; slopes < 10°.
veneer	v	a layer of material that reflects the topography of the underlying unit and is < 1m thick.
mantle	w	a layer or discontinuous layer of material of variable thickness.

Schematic Representation of Surface Expression



Geological Processes

These terms are applied to terrain units that are being (or have been) modified by geological processes. These processes are often complex, since they are affected by many factors including climate, geological history, topography, and surficial material characteristics. A brief description of the processes that are most commonly indicated on terrain maps and their likely effects on various land use activities is given below. Map users should consult map legends for specific definitions of symbols used on any particular terrain map.

EROSIONAL PROCESSES (FLOWING WATER) involve the erosion of earth materials by flowing water either on or below the land surface. Surface erosion is the loosening and removal of particles by surface runoff and may result in the development of narrow, linear gullies (-V). Subsurface erosion of particulate material (usually silt) — "piping" (-P) — forms tunnels and cavities that may collapse to produce small rounded hollows in the land surface. Chemical erosion of soluble rocks such as limestone and dolomite — "karst processes" (-K) — results in caverns and passageways followed by underground streams, and collapse-depressions on the land surface.

Where erosional process symbols appear on a terrain unit, the land surface is susceptible to erosion or subsidence. These processes constrain development of residential areas, transportation routes, forestry roads, and other land uses. Particular care is required in order to avoid acceleration of erosion by deforestation or agricultural activities, or by any process that involves addition of extra water to natural runoff.


Surface erosion (gullying) of glaciolacustrine silts.


Bank erosion


Inundation

FLUVIAL (RIVER) PROCESS symbols are applied to "active" floodplains (see p. 5) in order to distinguish between rivers with different kinds of behaviour.

Four types of rivers may be shown. Braiding rivers (-B) are a network of shallow channels around islands of sand and gravel. They are characterized by great fluctuations of discharge (water level and velocity) and frequent shifts of channels to new courses. Anastamosing rivers (-J) split around vegetated islands: they behave like braided rivers, but channels shift less frequently and islands are rarely flooded. Meandering (-M) and irregularly sinuous (-I) rivers usually have a single winding channel that shifts gradually in either a regular (-M) or irregular (-I) manner due to bank erosion. On older terrain maps, only one fluvial process symbol — "channelling" (-E^{A}) — was applied to rivers that are likely to change course by channel shifts or bank erosion.

Fluvial process symbols describe the hazards that affect human activities on a floodplain. The significance of each hazard varies with land use. For example, bank erosion may undermine a road or campsite, or destroy agricultural land but occasional flooding of these same sites by standing water (inundation) would cause relatively little damage.

MASS MOVEMENT PROCESSES occur when surficial materials or bedrock fragments move downslope due to gravity. "Rapid mass movement" (-R), such as rockfalls, rockslides and debris flows, tend to occur repeatedly at many sites. Slow mass movement — "failing" (-F) — generally affects large masses of rock or unconsolidated material; ground motion is indicated by tension cracks and tilted trees. Snow "avalanches" (-A) consist of snow, slush or ice mixed with rock and vegetation debris.

Rockfalls, debris flows and avalanches may block or damage transportation routes, and bury or demolish buildings and bridges. Permanent structures built upon slowly moving ground require continual maintenance. A steep slope affected by slow deformation (e.g. Rs-F) may suddenly collapse and generate a catastrophic landslide. An extreme hazard to life and property exists at the present time where residential areas have expanded indiscriminately onto the foot of steep slopes during the interval between infrequent but recurring rapid mass movements, such as debris flows and large rockfalls.

In general , mass movement processes constitute a sufficiently serious threat to human activities that affected areas should be avoided. If this is not possible, a thorough geological engineering investigation of slope (in)stability should be part of any development plan.

Pavilion earthflow

Debris flow at Port Alice

Periglacial processes affect most of the ice-free areas in this landscape.

PERIGLACIAL AND PERMAFROST PROCESSES result from freezing and thawing and from subzero ground temperatures. Terrain above timberline is modified by frost heaving and churning — "cryoturbation" (-C), by slow flow of a saturated surface layer — "solifluction" (-S), and by erosion around snowbanks — "nivation" (-N). These processes may be mapped collectively as "periglacial processes" (-Z).

Unconsolidated materials that are known to contain perennial ice and areas where thawing of ground ice has resulted in erosion or subsidence (thermokarst) are indicated by -X "permafrost processes".

Terrain where periglacial and/or permafrost processes are operating is sensitive to disturbance by man. Precautions are necessary in order to avoid subsidence or surface erosion around construction sites: drainage systems must be specially designed and maintained, and vegetation cover must be preserved. Structures must be designed to withstand the effects of frost heave and solifluction, and to avoid thawing ice-rich frozen ground. Even minor modifications to the landscape such as trails, unsurfaced roads, campsites, and excavations for refuse disposal require careful considerations.

Other processes that may be shown on terrain maps are deflation (-D), washed (-W), kettled (-H), and inundated terrain (-U). For details of their application refer to terrain map legend.

Land Capability

The following table is intended as a *very general guide* to the physical capability of various kinds of terrain for particular land uses. The ratings given in columns 4 to 11 are based upon the physical properties of each type of surficial material. Many additional factors that influence land surface conditions vary considerably within individual terrain units and thus cannot be adequately assessed in a general manner. They include constraints, such as steep slopes and poor drainage, and natural hazards. These are indicated in columns 2 and 3 and should be considered *in addition* to the ratings of columns 4 to 11 for each terrain unit within any area under consideration.

A "desirable" rating should be interpreted as "some land within this terrain unit is capable of supporting light foundations (or unpaved roads, or ...); further investigations are necessary before detailed plans are finalized". A "possible problems" rating should be interpreted as "some land *may* be suitable for ...". An "undesirable" rating indicates that terrain is generally unsuited for the indicated land use, although substantial modification of existing conditions (e.g. drainage, landfill) may overcome natural constraints.

Material	Constraints most likely to be encountered	Hazards most likely to be encountered	Light foundations (low rise dwellings)	Heavy foundations	Excavation	Liquid waste disposal	Solid waste disposal	Highways, railroads, airfields	Water storage above ground	Unpaved roads
M basal till	drainage	—	D	D	P	P	D	D	D	D
gM ablation till	topography	—	D	D	D	P	U	D	U	D
F "inactive" fluvial	—	—	D	D	D	P	U	D	U	D
F^A "active" fluvial	drainage	floods, shifting channels	D	U	D	U	U	D	P	D
F^G glaciofluvial	topography	—	D	D	D	P	U	D	U	D
C colluvium (group 1 — see text)	slope	rockfall, debris flows avalanches	D	U	P	U	U	U	U	D
Cf debris flow fans	—	debris flows	D	D	D	P	U	D	P	D
Cm, Ch earthflows, slumps	drainage topography	slow flow	P	U	D	P	P	U	U	P
L, L^G lacustrine	drainage	erosion, slumping	D	U	D	P	D	P	P	D
W, W^G marine	drainage	erosion, slumping	P	U	D	P	D	P	D	D
E eolian	—	—	D	U	D	P	U	D	U	D
O organic	drainage	—	U	U	U	U	U	U	U	U
R bedrock	—	—	D	D	U	U	U	U	U	U

D — desirable, P — possible problems, U — undesirable

Assessment of Geological Hazards

Geological hazards are naturally occurring processes and conditions that present a risk to life and property. Hazards portrayed on terrain maps result from gravity-induced downslope movement of materials, and processes involving water and wind. They range from catastrophic and dramatic effects, such as avalanches and rockslides, to barely perceptible but persistant processes such as slow earthflows. Geological hazards resulting from earthquake and volcanic activity are not identified.

A geological hazards map can be derived from a terrain map by identifying and coding, usually by colour, areas that may be vulnerable to the various types of hazardous processes. The following table provides a key for the identification of hazard-prone terrain units.

Terrain Units That May be Affected by Geological Hazards

Texture*	Material	Surface* Expression	Processes
**	C	h,r,u,m	potential landslide site
a, r	C	a,f	potential rockfall site
**	C	a,f,h,r	area may be affected by debris flows
**	E^A	**	potential wind erosion and blowing dust
**	F^A	**	"active" fluvial environment
**	F	l,p,f	fluvial processes may affect this area
c,s,f,m	L^G	s,t	scarp (steep) slopes are potential landslide and mudflow sites
s,fs,m	L,L^G	**	slopes are potential sites for surface and subsurface (see -P) erosion
	U	s	potential landslide, debris flow, and surface erosion site
c,s,f,m	W,W^G	s,t	scarp (steep) slopes are potential landslide and mudflow sites
s,f,s,m	W,W^G	**	slopes are potential sites for surface erosion

** any texture may be shown; any surface expression may be shown

* commas are used to separate alternative symbols. e.g. a,r means that either 'a' or 'r' or both may appear in the terrain unit symbol.

Geological (Modifying) process symbols that indicate geological hazards

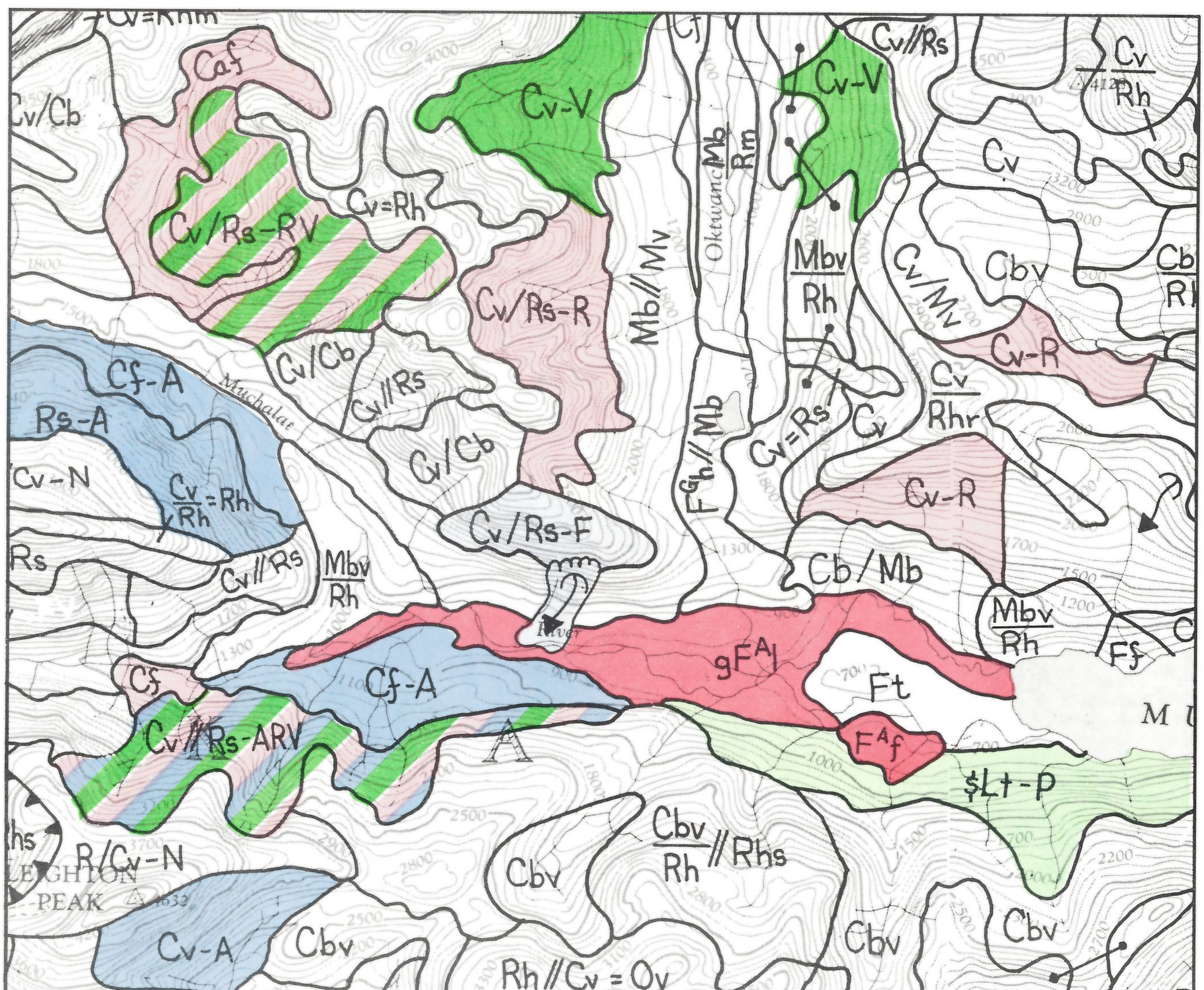
Note: These symbols may appear in any terrain unit symbol. See map legend or pp. 11-12 of this booklet for definition of symbols.

-A	snow avalanches
-B	river with shifting channels and great variations in water level
-D	soil erosion by wind, or blowing dust
$-E^A$	river with shifting channels and eroding banks
-F	slow downslope movement and/or potential landslide
-I	river with eroding banks
-J	river with shifting channels
-K	surface collapse over underground cavities in bedrock
-P	surface collapse over cavities in surficial material
-R	rockfall on bedrock terrain or debris (mud) flows on surficial material
-V	gully erosion by water or debris flows; floods or debris flows may emerge from lower end of gullies

Potential users should be aware that a geological hazards map produced by this process has certain limitations. It indicates only those types of geological processes that may be active under present-day conditions. It provides no information about the intensity, frequency, or time of occurrence of any process, nor does it permit areas to be rated with regard to high-medium-low hazard potential. The identification of two or more processes within a unit does not indicate that the area is potentially more hazardous than a unit modified by only one process. The potential hazards implied on the map may not affect the whole unit; the map merely indicates that a certain geological hazard may exist within a designated area.

The hazards map is a derivative map and is no more accurate than the original terrain map. Since most terrain maps are prepared from air photo interpretation supplemented by limited ground checking, both terrain and hazards maps should be used only to indicate the general condition of the land surface over large areas. Detailed ground investigations will be necessary for assessment of small areas and specific sites.

Geological hazards maps should be used for regional planning purposes. They can be applied to the delimitation of potential development areas, selection of corridors for roads, and preliminary identification of town or industrial sites. An example of a colour-coded geological hazards map is shown below. The table on page 14 is the map legend. Areas undergoing modification by two or more processes are identified by a different colour hatching.

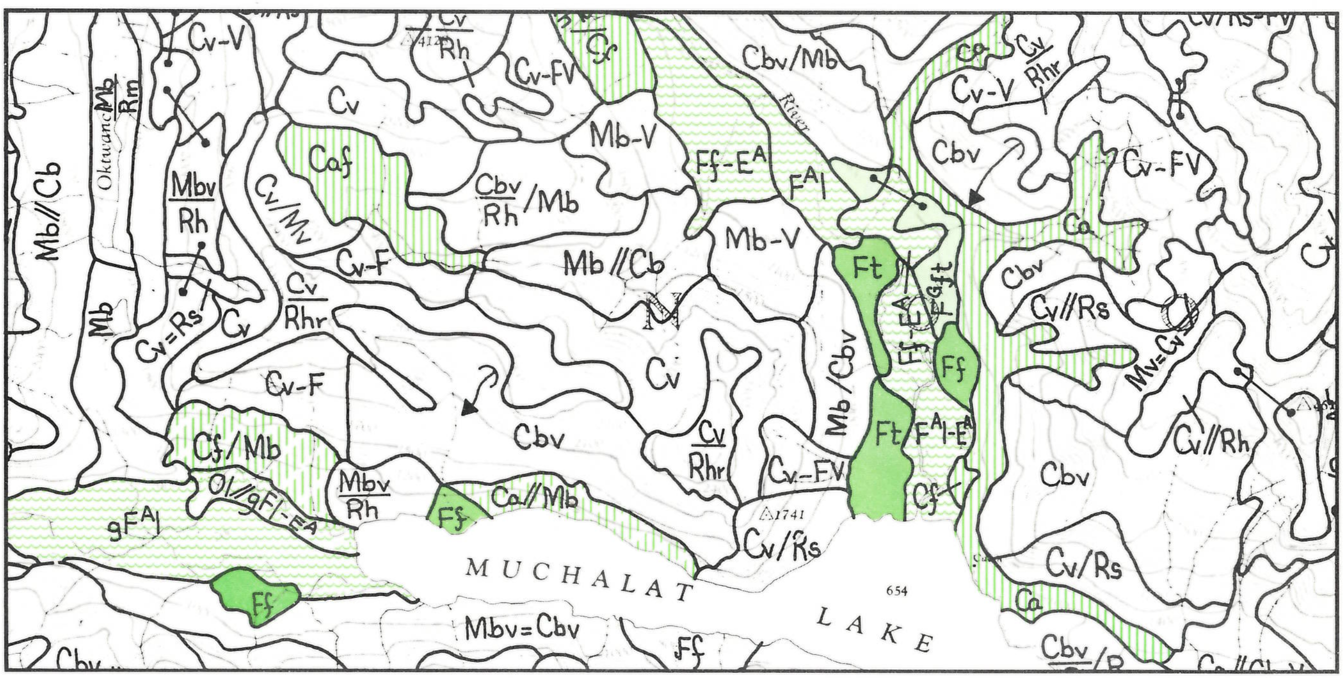


Granular Resources

Terrain maps can be used to identify materials that are potential sources of construction and road aggregate and fill. The following table provides a guide to the identification of appropriate terrain units, such as are shown on the map below. A colour-coded terrain map can then be used as a guide to detailed field investigation of granular resources or for rough planning of road layout. Hatched tones on the map indicate terrain units that are only partially made up of potential granular resources.

CHARACTER OF GRANULAR RESOURCES	TERRAIN UNIT SYMBOL*	LANDFORM
Generally good sources of aggregate	Ft Ff $F^{G}r$ $F^{G}l$, $F^{G}p$	river terrace fan or delta esker outwash plain
Possibly good sources of aggregate, but character of material is variable	$F^{G}h$ $F^{G}t$, $F^{G}t$-H Wt Wm, Wj	kame kame terrace beach terrace beach
Material suitable for aggregate but subject to flooding	$F^{A}l$, $F^{A}p$ $F^{A}f$ $F^{A}t$	floodplain fan, delta low terrace
Possible subgrade material	Cf, Ca, Cc Cf-A, Ca-A Cc-A Cf	talus slopes avalanche cones and fans colluvial fans

*See specific symbols on terrain maps for further information about texture.



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