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Northern Ontario
Engineering Geology Terrain Study 71

THUNDER BAY AREA

(NTS 52A/SW)

District of Thunder Bay

by

D.G. Mollard and J.D. Mollard

1983

Ontario

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THUNDER BAY AREA

(NTS 52A/SW)

District of Thunder Bay

by

D.G. Mollard[1] and J.D. Mollard[2]

1.0 INTRODUCTION:

This report contains an inventory of regional engineering terrain conditions in the Thunder Bay area, District of Thunder Bay. The area, which covers NTS block 52A/SW lies between Latitudes 48°00'N and 48°30'N, and Longitudes 89°00'W and 90°00'W. This report forms part of a series of publications which provide similar terrain data for some 370 000 km^2 of northern Ontario.

The purpose of the mapping is to provide a guide for engineering and resource planning functions at a level of detail consistent with a scale of 1:100 000. The terrain information is contained on the Data Base Map (OGS Map 5047, accompanying this report). The Light Construction

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Manuscript approved for publication by the Chief, Engineering and Terrain Geology Section, August 18, 1981. This report is published with the permission of E.G. Pye, Director, Ontario Geological Survey.

Capability Map (OGS Map 5048, accompanying this report) is a derived map which illustrates the suitability of the terrain in the Thunder Bay area for excavation, and foundation and road construction.

Interpretation of black and white aerial photographs, at a scale of approximately 1:68 000, formed the basis of the terrain mapping process. The interpretation was checked against published and unpublished maps and reports which documented previous field visits and observations. During the fall of 1977, roads in the map area were traversed and observed terrain conditions recorded as further verification of the office studies. Thus, the Data Base Map represents a reconnaissance overview of the engineering conditions of the terrain.

An engineering terrain legend was developd to facilitate the mapping and to provide a common information base for the entire map series. This legend is shown on the accompanying Data Base Map. Further discussion on the mapping techniques, legend format, and possible uses of this engineering geology information is available in the Ontario Engineering Geology Terrain Study Users' Manual (Gartner, Mollard, and Roed 1981), a companion publication to this series of maps and reports.

2.0 PHYSIOGRAPHY AND GEOLOGICAL SETTING:

Maximum local relief in the Thunder Bay area occurs in The Nor'Westers, a mountain range southwest of the City of Thunder Bay, where elevations range from 184 m above sea level (a.s.l.) at Lake Superior to 482 m a.s.l. on Mount McKay. Maximum topographic elevations within the map area occur southeast of Whitefish Lake, where they exceed 580 m.

The northwest portion of the area lies within the Severn Upland physiographic division (Bostock 1967), which is underlain by crystalline Archean rocks having a broad rolling surface. Large areas in the Severn Upland consist of bedrock exposures surrounded by thin and patchy glacial deposits and organic terrain. The remainder of the area lies within the Port Arthur Hills physiographic division (Bostock 1970). The Port Arthur Hills are composed of Proterozoic mafic sills and ancient sediments. Sills have been tilted to the south, forming mesas and cuestas, and long narrow steep sided ridges; some of which extend as promontories into Lake Superior.

A large, relatively flat area of Pleistocene lacustrine deposits extends west of Thunder Bay to Kakabeka Falls along the Kaministikwia River, and southwest toward Whitefish Lake along the Whitefish River.

3.0 ENGINEERING TERRAIN UNITS:

The engineering terrain units mapped are identified in terms of 4 components: surface material, landform, topography, and drainage. Format of the legend used in the terrain mapping is described in detail in the Users' Manual (Gartner, Mollard, and Roed 1981). Landform is a very important component because surface and near-surface materials, topographic expression,and surface and internal drainage conditions, are all related to it. Consequently, the engineering terrain units are grouped, for descriptive purposes, according to the dominant landform.

A particular landform can occur as the only component in a simple terrain unit, or as a dominant or subordinate component in a complex terrain unit. The dominant landform usually occupies more than half of a complex terrain unit. Where only 1 subordinate landform is shown, it usually occupies between 10 and 50 percent of the complex unit. Where 2 subordinate landforms are shown, the first covers the larger area. Landforms that occupy less than 10 percent of the terrain in a complex unit are rarely indicated in the terrain unit letter code. Where 2 or 3 landforms in a complex terrain unit consist of the same material, the landform letter symbols are connected by a dash. Examples of terrain unit letter codes which may occur in this map area, and an explanation of each, are given in the Appendix.

A large number of complex terrain units has been mapped due to the widespread occurrence of irregular topography. Bedrock, which is situated at or near the ground surface throughout much of the map area, controls the topography and therefore the surface drainage conditions. Resource development and engineering planning considerations are complicated by these complex conditions.

Noteworthy occurrences of important landforms are described with respect to location, typical materials, topography, and drainage; their significance in geotechnical investigations, regional engineering planning, and resource development is summarized.

3.1 BEDROCK PLATEAU (RL):

3.1.1 Description:

Areas mapped as bedrock plateau (RL) contain bold mesa-like features that have a capping of resistant rock consisting of eroded remnants of Proterozoic diabase sheets. The surface aspect of mesas and plateaus varies from nearly level to moderately sloping. Cliffs around part or all of these elevated features are strewn with coarse talus debris.

The surface of these landforms tends to be dry. Exceptions are the bottoms of long linear depressions. Usually these narrow trenches are partly filled with standing water or they contain organic deposits. Although bedrock plateau areas generally exhibit elevated planar slopes, they may still have knobby and jagged surfaces locally; these features can markedly affect engineering and construction costs.

The surfaces of many high plateau landforms slope gently to the southwest; their northwestern sides often form cliffs up to 120 m in height. The map user should note that this landform can occur in simple or complex terrain units (e.g. RL(MG/R)).

3.1.2 Occurrence:

Many bedrock plateaus occur in the Port Arthur Hills in the townships of Blake, Scoble, Gillies, Lismore, Crooks, Pardee, Devon, and Hartington, between Thunder Bay and the west and southwest borders of the map area. The upland of Pie Island consists of several rock plateaus. Some of the better known rock plateaus, named on the map, are Mount McKay, Mount McQuaig, Squaretop Mountain, The Palisades, Silver Mountain and Silver Bluff.

3.1.3 Engineering and Planning Significance:

Construction costs are generally high because slopes are steep and the presence of bedrock often necessitates blasting. Because bedrock plateau areas are aesthetically very pleasing, the possibility of developing small acreages, ski slopes, and sight-seeing tours holds considerable promise in some localities. Cliffs may be unstable since they are subject to rock falls. Road construction can be extremely difficult and costly in areas where the bedrock is highly uneven and is situated at or very near the surface. On roadways, horizontal and vertical sight distances are generally low and can create a traffic hazard.

3.2 BEDROCK KNOB (RN):

3.2.1 Description:

Bedrock knob landscape (RN) is characterized by an irregular bedrock surface having complex multiple slopes of varying steepness. The cover of glacial deposits overlying the bedrock knobs is generally thin and discontinuous. Much of the glacial overburden consists of bouldery, sand-rich till that was transported only a short distance by the ice.

3.2.2 Occurrence:

Many areas of bedrock knobs occur along the northern border of the Thunder Bay map area between Navilus and the Matawin River, and in Scoble and Pardee Townships southwest of Thunder Bay.

Rock knobs also occur in the northwestern part of the map sheet, in O'Connor, Marks, and Aldina Townships, as well as on the Welcome Islands and in the Brûlé Bay area of Lake Superior.

Rock knobs occur in complexes with ground moraine, e.g. RN(MG). Several better known rock knobs are Knob Hill and Flat Top Hill (northeast of Oliver Lake) and Drews Mountain (northwest of Hymers in Gillies and O'Connor Townships).

3.2.3 Engineering and Planning Significance:

Two principal engineering considerations are the large volumes of rock that must be excavated during construction and the generally uniform and solid foundation conditions at shallow depths. However, due to difficult topography and the existence of rock fractures, bedrock knob terrain is considered poor for most types of light construction and for waste disposal. Drilling and blasting are required during the construction of almost all types of engineering works.

3.3 BEDROCK PLAIN (RP):

3.3.1 Description:

The bedrock plain unit (RP) has a low-lying, undulating to rolling surface. The bedrock is generally mantled by a thin and variable cover of glacial material, consisting mainly of boulder-rich, sandy till. The rock plains display considerable local variation. They may consist of bare bedrock or may be covered by till or fine-grained water-laid deposits.

3.3.2 Occurrence:

Several small areas of rock plain have been mapped in the Thunder Bay map area. One such area occurs in McIntyre Township (northwest of the City of Thunder Bay), and others occur in Aldina and Strange Townships in the west-central part of the map area.

3.3.3 Engineering and Planning Significance:

Engineering and construction problems relate mainly to the cost of bedrock excavation. Foundation materials are strong, have a low compressibility, and a permeability that is controlled almost entirely by rock fractures. Bedrock plains are poor for construction and waste disposal sites, but are still considered better than areas mapped as bedrock plateau (RL), bedrock knob (RN), or bedrock ridge (RR). Drainage courses tend to follow eroded zones of weakness in the underlying bedrock. Many of these depressions occupy preglacial channels that were enlarged by glacial erosion. A large proportion of the groundwater in this landform is confined to fractures in the upper 45 to 60 m of bedrock. Permeability varies from impervious to highly pervious, depending on the spacing, depth, and width of fissures in the bedrock. Rock materials have high compressive, shearing, and bearing strengths. Position of the water table varies with topography, being closer to the surface beneath depressions. By careful route selection and proper design of vertical alignment, rock cuts on lower class roads can be avoided or at least the volume of rock to be blasted can be minimized. This is possible because of the low relief surfaces associated with many of the bedrock plains.

3.4 BEDROCK RIDGE (RR):

3.4.1 Description:

The bedrock ridge unit (RR) consists of long, narrow, subparallel and intersecting bedrock ridges of varying height. Thickness of drift over the masked bedrock surface varies substantially over short distances. In general, it is relatively thin (1 to 2 m) on ridge tops and thicker on the lower slopes and in the depressions between rock ridges.

3.4.2 Occurrence:

Victoria, Spar, Thompson, and Mink Islands have all been mapped as bedrock ridges. Numerous bedrock ridges also occur in the southern part of the map area near South Fowl Lake, Pigeon River, Lenore Lake, Cloud Bay, Big Trout Bay, and Pigeon Bay. Others are located in the townships of Aldina, Sackville, Adrian, Marks, and Strange, all in the northwestern part of the map area.

3.4.3 Engineering and Planning Significance:

The main construction problem is the large quantities of very hard rock that often must be excavated during construction. Drilling and blasting costs can be very high. Bedrock ridge terrain is considered poor for most types of engineering, construction, and resource development. It also has a low rating for waste disposal due to irregular relief, the presence of rock fractures near the ground surface, and the high cost of earthwork construction.

3.5 END MORAINE (ME):

3.5.1 Description:

End moraine (ME), which forms either prominent or inconspicuous till ridges, was deposited along the margin of the glacier. Although the ridges are usually long and narrow, they can be hummocky in places. End moraine consists largely of ice-deposited till and boulders, with minor inclusions of water-laid silt, sand, and gravel. Segments of end moraine, composed mainly of till, occur with hummocky moraine (MH), kames (GK), and ice-contact deltas (GD) in large moraine complexes which are identified by name in Figure 1. The bedrock surface is nearly always buried in areas of end moraine; there are exceptions, however, and in a few places end moraine ridges have a core of solid rock.

3.5.2 Occurrence:

The Marks Moraine (Zoltai 1963) is a large end moraine located in the northwestern part of the Thunder Bay map area. Elevations along the top of the moraine range from 460 to 490 m. The Marks Moraine indicates the approximate maximum advance of the Superior ice lobe. The Superior ice lobe also formed a less conspicuous end moraine during a temporary halt in its retreat from the area. This end moraine is located in Oliver Township between the communities of Murillo and Intola in the north-central part of the map area. The name Intola Moraine has been proposed for this feature (Burwasser 1977).

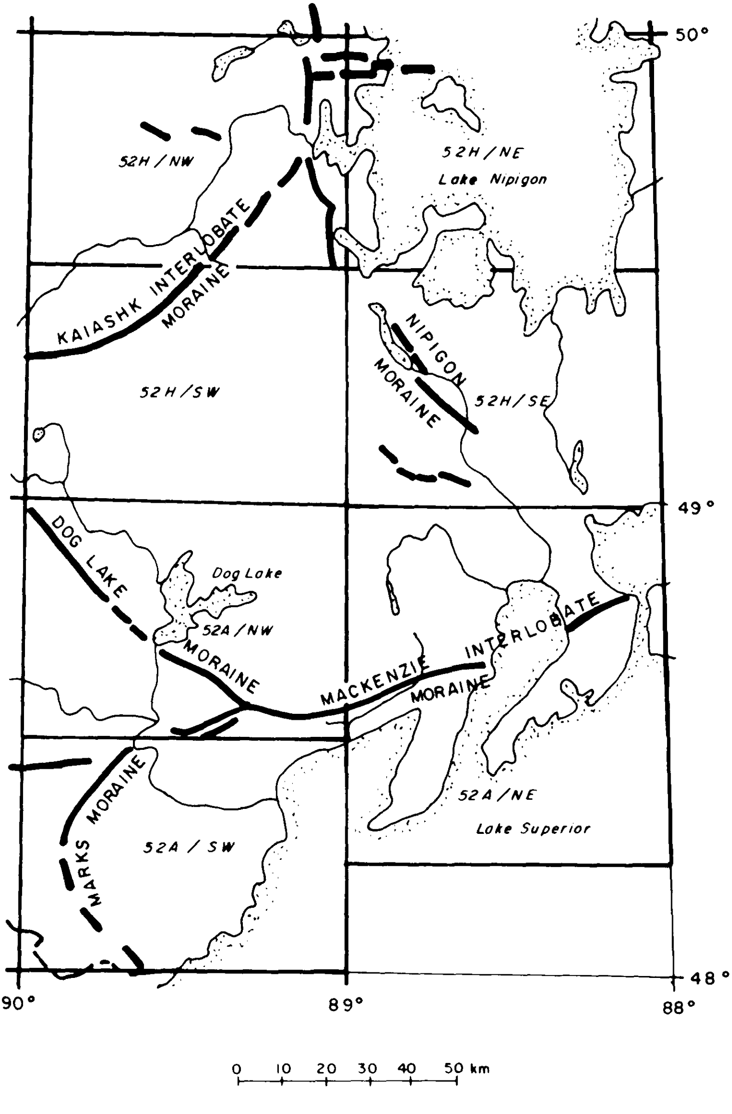
3.5.3 Engineering and Planning Significance:

An important characteristic of end moraines is their variability. Layers of unsorted and unstratified material of varying sizes (i.e. till), can both underlie and overlie sequences of layered silt, sand, and gravel. In general, the boulder content of this landform is high. End moraines in the map area commonly exhibit variable permeability and internal drainage, low compressibility, and high bearing strength. The water table is low in end moraine ridges. Where the unit consists of till that is high in sand- and gravel-sized material, and where sources of stratified sand and gravel are scarce, the coarse till may sometimes be crushed and used as a source of road-surfacing material. End moraines may present excavation difficulties during the building of roads and structures due to the abundance of small and large boulders.

3.6 GROUND MORAINE (MG):

3.6.1 Description:

The term "ground moraine", (MG), refers to an extensive deposit of till forming an undulating to rolling plain. Although till is generally composed of an assortment of particle sizes (including clay, silt, sand, gravel, cobbles, and boulders), till deposits in this map area have a high sand and boulder content. The thickness of till in ground moraine varies from less than 1 m



NOTE: Moraine segments shown in the figure do not necessarily all occur on the Data Base Map accompanying this report.

FIGURE 1 - MAP SHOWING MAJOR MORAINES IN NTS 52A AND 52H (MODIFIED FROM ZOLTAI 1965a)

to many tens of metres. The landform is mapped as MG where the till is thick enough to mask any topographic effect of underlying bedrock. In general, the till layer forms a mantle less than 3 m thick over the bedrock and is mapped as MG/R. Till in ground moraine tends to be thicker in bedrock depressions and thinner over bedrock ridges and knobs.

3.6.2 Occurrence:

Ground moraine occurs extensively in the Thunder Bay map area. The till is mostly silty (tmMG), and is generally shallow over bedrock. In most cases it has been mapped as MG/R or MG(R), the latter being a complex of ground moraine and bedrock exposures. An exception occurs in the northwestern corner of O'Connor Township where the till is clayey (tcMG) and its thickness is up to 6 m. A smaller area of clayey till occurs west of Stanley Hill, south of Harstone in Paipoonge Township.

3.6.3 Engineering and Planning Significance:

The till in ground moraine is coarse and bouldery, and has moderate permeability and internal drainage, low compressibility, and high bearing strength. Water table position varies with relief, being lower beneath knolls and low ridges, and higher beneath depressions. The till in many of the depressions is covered by thin deposits of peat and muck.

The suitability of ground moraine for road and other light foundation construction is fair to good. The fact that the till often forms only a thin mantle over the bedrock (MG/R) has a great deal of significance in road building. Road construction through this type of terrain is difficult owing to the bouldery nature of the till and the probability of encountering bedrock in cuts. The suitability of ground moraine for waste disposal varies from poor to fair.

3.7 ICE-CONTACT DELTA (GD):

3.7.1 Description:

Esker deltas, delta-kames, and delta-moraines are all varieties of the ice-contact delta. Some are quite large in area and important in terms of the volume of recoverable sand and gravel which they contain. Individual beds, consisting mainly of sand or gravel, are usually better sorted, cleaner, and less variable than stratified deposits in esker (GE) and kame (GK) landforms. The beds in this unit are also typically less folded and faulted and are more continuous. It is worth noting that materials in many ice-contact deltas are coarse (i.e. gravelly) on the north and northeast sides and finer (i.e. sandy) on the south and southwest sides. These conditions indicate the parts of the delta which were, respectively, closest to and farthest from the glacial front against which the delta was built.

3.7.2 Occurrence:

Several large ice-contact deltas occur in the Thunder Bay map area. They are located in the southwestern corner of Conmee Township (northwest of Kakabeka Falls), in Sackville Township, Fraleigh Township, north and east of North Fowl Lake (in the southwestern part of the map area), in Hartington Township, and on the northern outskirts of the City of Thunder Bay. A small one was mapped on the southern shore of Loch Lomond.

3.7.3 Engineering and Planning Significance:

Ice-contact deltas are good potential sources of concrete and blacktop aggregate. They are also favourable sites for the construction of airstrips, roads, and other types of engineering works. Because the subsoils are highly permeable, deltaic (GD) landforms are relatively poor areas for waste disposal. Larger deposits, however, are generally good groundwater prospects, especially where sand and gravel horizons are thick and extend below the water table. Ice-contact deltas possess high bearing strength and good workability in wet weather. Slopes are stable and subsoils are well drained. Away from the steeply sloping margins of this landform, earth-work volumes and excavation costs are normally low. Reservoirs and sewage lagoons in ice-contact deltas must be lined to prevent excessive leakage.

3.8 ESKER (GE):

3.8.1 Description:

The ridged landform represented by the esker symbol (GE, >>>) also includes crevasse fillings. Both occur as long, narrow, sand and gravel ridges that can be winding or straight and may widen in places. Some of these elongate ice-contact stratified drift ridges include braided, branching, beaded, and kettled segments. Most of the ridges trend roughly parallel to the last direction of glacial flow. The cores of many eskers and crevasse fillings contain complexly layered units, consisting of sandy gravel and gravelly sand, that exhibit collapse structures (i.e. folds, faults, and pinch-outs of strata). Pockets and layers of waterlaid silt and fine sand, boulders, and till may occur within the central parts of eskers and crevasse fillings, as well as along their flanks.

3.8.2 Occurrence:

Most eskers in the Thunder Bay map area ar too small to be shown at the map scale of 1:100 000. One of the larger eskers which is shown on the map is located in Devon Township in the southwestern corner of the map area. Another extends into the northwestern corner of the map area in Sackville Township, east of the Matawin River.

3.8.3 Engineering and Planning Significance:

Eskers and crevasse fillings are generally inferior to ice-contact delta and glacial outwash deposits as sources of good quality granular construction materials. Typically, the unit possesses high permeability and good internal drainage, low compressibility, high bearing strength, low frost susceptibility, and low shrink-and-swell potential. Where esker ridges are steep-sided, narrow, and winding, they may be unsuitable for use as transportation routes. They may trend in the wrong direction for route location purposes, but in regions that are dominated by large expanses of swamp and bedrock, large eskers are frequently considered as good route location possibilities. Where the sand and gravel in large eskers extends many metres below the water table, the unit represents a potential source of groundwater for domestic and, possibly, municipal and industrial use.

3.9 KAME (GK):

3.9.1 Description:

Kames occur either as steep-sided single knobs or as clusters of several knobs in kame fields and kame moraine. The larger, steep-sided kames usually have an irregular surface; in a few places, they contain deep kettle hole depressions. Most are composed of complexly interbedded sand and gravel strata which regularly exhibit fold, fault, and pinch-out structures. Kames also contain variable but usually minor amounts of silt, till, and boulders. Large kame deltas are discussed in Section 3.7; kame terraces are rare.

3.9.2 Occurrence:

Most of the kames in the Thunder Bay map area occur as kame fields rather than as individual kames. Major kame fields occur in the townships of Sackville, Adrian, Aldina, and Marks (all in the northwestern corner of the map area). These kames occur mostly as complexes along with outwash (GO) and deltaic deposits (GD). Smaller areas of kames are located in Lybster Township west of The Palisades; along the township boundary between Hartington and Devon Townships; south of Jackpine; south and west of Intola; and near the southwestern corner of Loch Lomond in Blake Township.

3.9.3 Engineering and Planning Significance:

In general, kames have high permeability and good internal drainage, low compressibility, high shear strength, and good bearing capacity. Position of the water table varies with relief, being nearer the surface beneath kettle depressions and deeper beneath ridges and knobs. Although the granular materials in kames provide good foundations for buildings and small engineering works, the quantities of material that must be excavated during construction can be moderately high. Waste disposal sites require special design procedures and costly construction in order to function properly. Kames should be avoided as waste disposal sites. They vary from poor to good as sources of sand and gravel aggregate, depending upon their size and compositional variability.

3.10 OUTWASH PLAIN (GO):

3.10.1 Description:

Outwash deposits include plains, fans, deltas, and valley trains of varying areal extent, all consisting mainly of sand and gravel. Most outwash sediments were derived from debris within the glacial ice which was subsequently deposited by meltwater flowing from the margin of the glacier. Although most outwash deposits formed in proglacial positions, some accumulated over masses of stagnant glacier ice, resulting in pitted or kettled surfaces. Outwash landscapes that show abandoned channel scars, braid bars, or deep kettle holes are commonly coarse in texture (i.e. gravelly and cobbly rather than sandy).

3.10.2 Occurrence:

Large areas of outwash are located in the northwestern corner of the map area in Sackville, Aldina, Strange, and Marks Townships. Most of the outwash in these areas occurs in a complex with kames (GK), as a veneer overlying bedrock (GO/R), or with a peat veneer (OT/GO). Smaller areas are found along the northeastern shore of Cloud Lake in the south-central part of the map area, and at Kivikoski in McIntyre Township, along the northern boundary of the map sheet.

3.10.3 Engineering and Planning Significance:

Outwash landforms almost always have high permeability and good internal drainage, low to very low compressibility, low shrink-and-swell tendencies, and high shear strength and bearing capacity, particularly where these granular deposits are confined. Granular materials in outwash landforms form stable slopes and are seldom susceptible to frost heave. Being level and well drained, the sediments in outwash plains are not easily eroded by running water. The boulder content is generally low. A high water table can be expected beneath kettle depressions. Extensive outwash plains provide excellent sites for the construction of roads and airstrips, and are often good sources of concrete and bituminous aggregate. They are good potential sites for groundwater development, particularly where the granular deposits are deep and are recharged by water from nearby lakes and rivers.

3.11 RAISED BEACH RIDGES (LB):

3.11.1 Description:

Raised beaches are generally thin and consist of bouldery, gravelly, and sandy wave- and current-transported materials deposited along the shores of glacial lakes. The term "raised beach" denotes a landform marking the position of a former rather than present-day lake margin. Generally, the wave-washed materials were eroded from coarse till and glaciofluvial deposits consisting of sand, gravel, and cobbles.

3.11.2 Occurrence:

Raised beaches occur inland from the shore of Lake Superior between the City of Thunder Bay and the International Boundary; on Pie Island, west of the City of Thunder Bay; and in Devon Township, east of Jackpine.

3.11.3 Engineering and Planning Significance:

The raised beach in this area is generally too thin and narrow to constitute a major source of granular construction material. Because it is nearly level, well drained, and slightly elevated above the surrounding terrain, it is a good feature to follow in route location if it happens to trend in the desired direction. The water table is generally high in this landform. Raised beaches have a high permeability, good internal drainage qualities, and low compressibility (i.e. small amounts of total and differential settlement of structures bulilt upon them). They usually have high shear strength and bearing capacity. They make poor waste disposal sites because of their limited area and the possibility of leakage which can lead to contamination of nearby surface water or groundwater.

3.12 GLACIOLACUSTRINE DELTA (LD):

3.12.1 Description:

Materials in glaciolacustrine deltas range in texture from sandy gravel and coarse sand (gsLD, sLD) near the apex of the delta, where the glacial stream entered the lake, to fine sand and silty sand (smLD) in the distal portion of the delta. The finer materials at the distal end of the delta usually interfinger with, and grade into, finer glaciolacustrine lake bottom sediments (see Section 3.13). The grain size of material in glaciolacustrine deltas is dependent on the composition of the source material and on the size and gradient of the stream transporting the material. The good bedding characteristic of delta sediments is related to variations in streamflow and former lake levels. Individual beds are usually well sorted, uniform, and continuous. Because of these characteristics, glaciolacustrine deltas are generally good sources of granular material for construction purposes.

3.12.2 Occurrence:

Glaciolacustrine deltas occur below Kakabeka Falls, at Navilus; along Highway 61 in Blake Township; in the southwestern corner of Devon Township; northeast of the Town of Cloud Bay in Crooks Township; and in the south-central part of Marks Township, north of Nolalu.

3.12.3 Engineering and Planning Significance:

Glaciolacustrine deltas are good potential sources of concrete and blacktop aggregate. They are also favourable sites for the construction of airstrips, roads, and other types of engineering works. Because the subsoils are highly permeable, this landform is a relatively poor area for waste disposal. Larger deposits, however, are generally good groundwater prospects, especially where the sand and gravel horizons are thick and extend below the water table. Glaciolacustrine deltas possess high strength and good workability in wet weather and, if large enough, are favoured sites for many types of resource development. Slopes are stable and subsoils are well drained. Reservoirs and sewage lagoons in glaciolacustrine deltas should be lined to prevent excessive leakage.

3.13 GLACIOLACUSTRINE PLAIN (LP):

3.13.1 Description:

Sediments in glaciolacustrine plains consist of varved and massive, fine-grained materials deposited in glacial lake basins of varying size and depth. The proportions of clay, silt, and sand deposited at any particular location in these basins varies with depth of water in the former lake, distance from former shorelines, and the size of particles washed into the lake. Most clay, silt, and sand lacustrine deposits contain minor inclusions of till and scattered dropstones which were rafted into the lake within pieces of glacial ice. In places, wave and current action in former glacial lakes eroded the surface of till deposits, producing thin patches of washed sand, gravel, and boulders that rest on till or bedrock. In other areas, bedrock knobs and ridges are surrounded by pockets of glaciolacustrine sediment. Glacial lake deposits usually consist of clay and silt (cLP, cmLP, mcLP) which accumulated in deep offshore waters at a depth where the bottom was no longer affected by wave action (generally below 10 m). Closer to shore, and at points where rivers discharged sandy materials into the lake, the deposits usually consist of fine and medium sand with minor silt (sLP, smLP). Most of these sandy lacustrine deposits accumulated in deltaic environments.

3.13.2 Occurrence:

Glacial lakes inundated large parts of the Thunder Bay map area. In the Arrow River basin, southwestern corner of the map sheet, clayey lacustrine deposits occur at elevations of up to 418 m above sea level (a.s.l.). In the area drained by the Kaministikwia River, silty and sandy lacustrine deposits occur up to 259 m a.s.l. In addition to these areas, clayey lacustrine sediments are found in the Whitefish Lake and Whitefish River basins, in Sackville Township, along the Pine, Pigeon and Cloud Rivers, on Pie and Flatland Islands, and in a broad band along the shore of Lake Superior.

3.13.3 Engineering and Planning Significance:

Glaciolacustrine clay deposits (cLP) have high water retention capacity, low permeability, and poor internal drainage. These characteristics are largely controlled by a network of closely spaced joints. Generally, these landforms possess low density, low bearing strength, and moderate to high compressibility, unless the fine-grained sediments have been consolidated by the weight of overriding glacier ice or by the effects of desiccation. The clay sediments usually provide poor foundation conditions and can be difficult to work with heavy construction equipment during wet weather. Most clay plains in the map-area are level to gently sloping. The sides of river valleys which have been deeply incised into these fine deposits are frequently highly dissected and are susceptible to rill-and-gully erosion on freshly cut ditch slopes and highway back slopes. Higher and steeper natural and man-made slopes are subject to the development of small failures. Where these lacustrine materials carry a high proportion of silt or very fine sand, they are susceptible to frost heave and the formation of frost boils. Subsoil permeability ranges from low to nearly impervious; as noted above, this is largely dependent on the presence of a system of closely spaced joints. In locations where glaciolacustrine clay sediments are highly plastic, they have a tendency to shrink or swell with changes in moisture content. Bearing capacity, shear strength, and compressibility vary greatly with differences in previous loading history and, therefore, the natural moisture content. Bearing capacities can be low in wet areas, particularly where plastic clay soils are normally consolidated or only slightly consolidated.

Low-lying clay plains have a high water table and are subject to local flooding during spring runoff and heavy cloudbursts. During wet weather, the glaciolacustrine clay sediments have poor workability characteristics for building roads and structures. This landform usually provides good sites for waste disposal because of its low permeability.

Lacustrine sand plains (sLP) contain mostly fine and medium sand with minor silt. Coarse sand, gravel, cobbles, boulders, and till are rare in these deposits. Sand plains are gently sloping to undulating and are well drained. A high water table may occur at sites located some distance from the groundwater lowering effects of deep valleys and ravines. Sandy lacustrine materials are typically nonplastic and have high permeability, low compressibility, moderate to high bearing capacity, and high shear strength. They are generally not frost susceptible unless they contain significant amounts of silt and very fine sand. They represent fair to good terrain for most construction, especially that of roads and airstrips. They are poor for waste disposal due to the possibility of effluent seepage and groundwater contamination.

3.14 ALLUVIAL PLAIN (AP):

3.14.1 Description:

Many alluvial deposits (AP) in this map-area consist of fine and medium sand at depth; these materials are commonly overlain by a silty upper stratum of variable thickness. Oxbows and abandoned channel segments occur where meandering streams cross landforms composed largely of loose silt and fine sand. Sediments beneath alluvial plains are finer textured where the material being carried by the stream was eroded from clay and silty clay glaciolacustrine deposits. The landform includes flood plains that have been eroded in till and are strewn with boulders, as well as segments of stream valleys where alluvial sediments range in texture from coarse sand to coarse gravel and cobbles. Long and complex alluvial plain systems sometimes include three constituent landforms: low alluvial terraces, alluvial flood plains, and stream channels.

3.14.2 Occurrence:

Alluvial plains occur along the Serpent River in Sackville Township; along the Whitefish River in the townships of Lybster, Gillies, and O'Connor; along the Arrow River in Devon Township; along the Pine River in Pearson and Pardee Townships; and along the Kaministikwia River for its entire length within the map area.

3.14.3 Engineering and Planning Significance:

Alluvial plains are subject to flooding. The water table is usually situated at or near the surface for much of the year; organic-filled depressions are common. Although some alluvial terraces, flood plains, and channel bottoms represent potential sources of sand and gravel for construction purposes, the high water table may cause problems during excavation of such materials. This landform is generally unsuitable for transportation routes, general construction, or waste disposal sites because of the high water table and risk of flooding.

3.15 TALUS SLOPE (CT):

3.15.1 Description:

Pieces of broken rock that have fallen from cliffs and accumulated in piles along the base of near-vertical rock faces are mapped as talus slopes (CT). Topples (rotated or tilted pieces of rock that have not fallen) and rock falls are common phenomena in this environment and can be hazardous. Angular pieces of rock vary from several centimetres to more than a metre in size. The talus debris is usually composed of only one type of rock (i.e. the lithology that forms the cliff above the talus slope). In this map-area, that lithology is commonly diabase.

The material that comprises the talus slope has been called rubble and is denoted by the letter "r". Downslope from the base of talus piles, scattered pieces of rock have come to rest on sandy to gravelly slopewash deposits that are usually sandy, poorly sorted, and "dirty looking". In many places, blocks of talus are enclosed in slopewash material.

3.15.2 Occurrence:

Many talus piles (CT, ▲▲▲) were mapped along the steep sides of the Port Arthur Hills, southwest of Thunder Bay in the townships of Blake, Crooks, Devon, Pearson, Pardee, and Hartington, and on Pie Island. Most talus slopes have formed in the areas where bedrock of Proterozoic age outcrops.

3.15.3 Engineering and Planning Significance:

Heavy construction work on loose, angular blocks of talus can be hazardous because of (1) the possibility of intermittent rock falls and (2) the slope instability associated with the removal of blocks that support overlying pieces of talus. Most talus deposits possess an open structure with large voids and are thus highly pervious. The rock in talus piles represents a possible source of crushed aggregate for railway ballast and riprap. Permanent engineering structures should not be constructed on thick piles of talus because of the hazards mentioned above and the possibility of talus creep.

3.16 SLOPEWASH SHEET (CW):

3.16.1 Description:

Slopewash sheets are almost always poorly expressed in airphotos. The presence of these sheets must therefore be inferred from depositional environments that are recognizable on the photos. They usually contain poorly sorted, poorly stratified, loosely deposited sediments that have been washed down the surfaces of moderately steep slopes by unconcentrated overland sheet flow or transported down steep slopes by frost action and soil creep processes. Most of these materials were probably transported and deposited in a periglacial climate. Slopewash deposits commonly merge upslope with piles of talus debris and downslope with till and fine-grained lacustrine sediments.

3.16.2 Occurrence:

Slopewash sheets occur in areas having low slopes in the Port Arthur Hills, southwest of Thunder Bay in the townships of Blake, Scoble, Pardee, Pearson, Fraleigh, Devon, and Hartington, and on Pie Island.

3.16.3 Engineering and Planning Significance:

Pits in this landform contain poorly sorted, poorly graded, dirty (silty) sand and angular rock particles of varying sizes. The material is usually too dirty to use as concrete or blacktop aggregate without being washed. Nevertheless, where these deposits are sufficiently thick and dry, the material can be crushed to produce a satisfactory road surfacing material. In general, slopewash deposits are thin and loose, and may possess a loose openwork (i.e. porous) structure. Subsoils are often wet, even though the slopes may appear steep enough to be well drained. Seepages and springs are common occurrences. Engineering problems caused by slopewash terrain include poor geometrics in road design and relatively high cuts and fills during construction.

3.17 SAND DUNES (ED):

3.17.1 Description:

Dunes are composed of fine and medium sand that has been blown into ridges by wind action. Dune ridges range in height from 1 or 2 m to more than 5 m, and may be long, narrow, and either straight, arrowhead, or arcuate in plan view. Dunes usually overlie or occur downwind from sandy outwash plains and sandy glaciolacustrine plains.

The location of sand dune areas may also be indicated on the map by the graphic symbol >.

3.17.2 Occurrence:

An area of sand dunes is located on the southern side of the Kaministikwia River, west of the City of Thunder Bay in central Paipoonge Township. In this area silty sand overlies sandy gravel.

3.17.3 Engineering and Planning Significance:

Sand dunes possess special characteristics of engineering significance. When denuded of vegetation, the fine and medium sand in dune ridges is susceptible to wind erosion and drifting. A moderate to low water table can be expected beneath higher dune ridges. Dunes are well drained, and the sand of which they are composed has a low shear strength when it is not confined. These deposits usually have low compressibility unless sand of a relatively uniform grain size has been deposited in a very loose state. Where dune sand is loose, generally beneath the slip face, it may possess a moderate to low relative density. The bearing strength of dune material is also low where the sand is unconfined, but can increase with the degree of confinement. Caving of wet and dry sand in vertical ditch walls is a potential problem which can increase costs on major construction jobs. Dune sand is nonplastic and is generally not susceptible to frost action or shrinking and swelling.

3.18 ORGANIC TERRAIN (OT):

3.18.1 Description:

Organic terrain includes varying depths of peat and muck in marshes, swamps, fens, and bogs. No attempt was made to separate these organic landscape types during the mapping. Although peat and muck deposits usually occur as relatively thin surficial layers, in places these organic materials can be several metres thick. Moreover, the thickness of the deposits can change drastically over very short distances.

3.18.2 Occurrence:

Thin organic terrain overlies lacustrine deposits (OT/LP) in Hartington and Devon Townships; and along the shore of Lake Superior from the International Boundary to Jarvis Bay and from Mission Flats to Thunder Bay Harbour. In Sackville, Adrian, and Conmee Townships, organic terrain occurs as a veneer or in complex association with lacustrine plains (LP) and outwash (GO) landforms. A relatively large area of organic terrain overlying a lacustrine plain (OT/LP) occurs along Highway 11 and 17, northwest of the City of Thunder Bay, in Oliver Township. In addition to these larger areas there are many small areas of organic terrain located in poorly drained depressions scattered throughout the map area.

3.18.3 Engineering and Planning Significance:

Although organic deposits are commonly thin, they are nonetheless very poor foundation and construction materials. The water table is at or near ground surface for most of the year. The locations of deeper pockets of organic material are difficult to predict reliably without extensive testdrilling. The topography of organic terrain is level or slightly depressional. Peat and muck deposits have low shear and bearing strengths and generally low permeability. They are nearly always poorly drained, highly compressible, and are subject to seasonal flooding. Consequently, they are unsuitable for nearly all types of engineering works and for waste disposal.

4.0 EXAMPLE OF A DERIVED MAP: LIGHT CONSTRUCTION CAPABILITY

4.1 GENERAL COMMENTS:

The Light Construction Capability Map (OGS Map 5048) included in this report has been derived from the Data Base Map (OGS Map 5047, accompanying this report). The purpose of a derived map is to illustrate how basic terrain data can be used to prepare a map depicting the suitability of the terrain units for construction of shallow foundation structures and deep excavations.

Reference should be made to the "Ontario Engineering Geology Terrain Study Users' Manual" (Gartner, Mollard, and Roed 1981) for further information on the preparation and use of the various types of derived maps.

4.2 CAPABILITY RATING CRITERIA:

Criteria for rating the suitability of a terrain unit for the construction of shallow foundation structures and deep excavations are related to landform type, engineering properties of constituent materials, topography, drainage, and groundwater conditions. The principal landforms and surficial materials have been arranged in groups of terrain units, each comprising terrain units having similar properties and capabilities with respect to light construction. Tables 1 and 2 describe the terrain unit groups and indicate the relative suitability of these terrain groups for light construction.

TABLE 1: SUITABILITY OF TERRAIN GROUPS FOR EMBANKMENT, EXCAVATION, AND FOUNDATION CONSTRUCTION

MAJOR TERRAIN GROUPS, TOPOGRAPHY AND MATERIALS IN MAP 5047					SUITABILITY FOR EMBANKMENT, EXCAVATION, AND FOUNDATION CONSTRUCTION	
Group Number (see map)	Letter Symbols	Land-form	Topography	Surficial Material	Construction Properties	Suitability
1	pOT	Organic plain	Level, depressional	Peat and muck; variable thickness over mineral soils	Very weak, highly compressible surficial materials. High water table. Poor drainage. High shrinkage and swelling characteristics. The peat usually must be either drained and consolidated or removed (excavated)	Generally unsuitable
2	rCT, CW, rLB	Colluvial slopes and rubble beaches	Steep slopes, cliffs; sloping beaches	Talus rubble, silty sand and gravel, often a veneer over till; shingle (rubble) beaches along Lake Superior	Potentially unstable slopes (rockfall, rockslides, and creep) where construction occurs in talus areas. Potentially difficult topography and costly excavation. Talus piles and rubble beaches are good sources of riprap and crushed rock borrow. Local erosion hazard in CW and CT terrain and flooding hazard in rLB terrain	Generally unsuitable owing to steepness, natural hazards in special terrain situations (e.g. talus areas) and coarseness of rubble beaches

3	msAP, mAP, sgAP	Alluvial plain	Gently sloping	Sand, silt; minor clay, gravel, cobbles, and boulders; variable texture	Wide range of loose or compressible soil materials. Variable strength and permeability. Periodic flooding likely. Excavations are subject to water problems such as seepage and caving walls. Potential frost heave and bank erosion. Nearly level landscape and low earthwork quantities. Pockets of borrow available	Generally unfavourable owing to highly variable soil materials, high water table, periodic flooding, and local stream erosion hazards
4	sLB	Sand ridge	Low ridges	Fine to medium sand; minor silt (dune, some abandoned beaches)	Generaly small (narrow) area. Sands are commonly quite loose (low relative density). Subject to wind erosion when denuded of vegetation. Good internal drainage and all-weather workability. Medium to high shear strength and bearing capacity if sand is confined. Potential sand borrow.	Generally suitable for shallow foundation structures, and poor for structures requiring deep excavations extending below the water table.
5	sGO, sLD, sLP, smLP	Sand plain	Level to gently sloping	Sand; minor silt, fine gravel (lacustrine, deltaic, outwash)	Medium to high bearing capacities if confined. Low compressibility. High permeability. Good internal driainage and all-weather workability. Good (i.e. level) topography. Potential source of water for construction camps and aggregate processing. Possible caving of steep vertical cuts, especially where the water table is high. Sands may be drained adjacent to deep valleys and ravines. Generally low susceptibility to frost heave, shrinkage, and swelling. Potential source of fill borrow and fine aggregate for concrete.	Favourable terrain for most construction projects

6	msLP	Silt plain	Level to gently sloping; locally gullied	Silt, fine sand; minor clay (lacustrine)	Silts may be underlain at depth by sands or clays. Low to medium bearing capacity. High susceptibility to gully erosion and to frost heave. Where thick and saturated, the silt will likely be unstable in deep excavations. Commonly difficult soils to work in wet weather. Close moisture control is required in compaction. Generally poor subgrade, internal drainage, and workability characteristics when wet	Low to moderate suitability. Suitability depends on type of construction project, time of year, and construction above or below the water table
7	cLP, cmLP	Clay plain	Level, depressional, gently sloping; gullied along valley walls	Clay, mostly highly plastic; minor silt and fine sand (lacustrine)	Practically impervious. Subject to excessive gully erosion on steep slopes. Poor drainage and compaction characteristics. Unworkable in wet weather, but easily worked in dry condition. Moderate frost heave potential. Subject to high shrinkage and swelling with change in moisture content. Generally poor foundation for roads, airfields, and heavy buildings. Improved in-situ engineering soil characteristics where the clay has been overridden by glacier ice. Subject to small slope failures on steep high cuts. Nearly level landscape away from deeper drainage features. Source of impervious (clay) lining material. Excessive expansion and shrinkage may cause cracking of foundation	Low suitability for many construction purposes

8	sgGO, sgLD, sgLP, gsGO	Sand and gravel plain	Level to gently sloping; locally kettled or terraced	Sand, gravel; minor silt, cobbles, boulders (outwash, valley train)	Good to excellent foundation material. High strength and low compressibility when confined. Good internal drainage and workability in dry or wet weather. Low earthwork quantities. Commonly highly pervious. Low frost susceptibility and erosion potential	Generally excellent terrain for construction of most structures. Water retaining structures (e.g. sewage lagoons and water-supply reservoirs) must be lined due to the relatively high permeability of the surficial materials
9	sg and gs GD, GK, LB	Sand and gravel ridges and mounds	Flat-topped, rounded, and A-shaped ridges and mounds	Sand, gravel; minor silt, surface boulders, or till. Often complex bedding	Good to excellent foundation material. Mostly high strength and low compressibility soil materials where confined. Good drainage and workability in all weather conditions. Commonly contains highly pervious strata. Generally low water table. Typically very bouldery surface. Subsurface materials can vary from pure sand to coarse gravel over short distances. Potential source of granular construction material. High earthwork quantities in route construction. Steep road grades. Low erosion and frost susceptibility	Generally favouable terrain. Main limiting factors in construction of transportation systems include high earthwork quantities and locally dense concentrations of surface boulders.

10	tMH, tME	Till mounds and ridges	Irregular topography; commonly conspicuously hummocky or ridgy	Very bouldery till; silt, sand, gravel inclusions locally	Generally coarse, well drained, moderately to highly permeable tills having a high boulder content. Irregular hummocky to ridgy relief, necessitating heavy earthwork quantities. Steep grades. Mostly high bearing capacity, low compressibility materials. Good all-weather workability	Often difficult construction because of relief and excessive boulder conditions. Fairly favourable if relief is not excessive
11	tMG	Till plain	Undulating to rolling; locally drumlinized	Bouldery, silty to sandy till	Generally high bearing strength, low compressibility (settlement of structures), moderately permeable till. Generally well drained on slopes. Closed basins (hollows) are often wet and contain organic material. Easily excavated except for larger boulders. Suitable fill borrow. Slopes generally stable. Good all-weather workability. Commonly high boulder content. Good compaction with close control of moisture	Generally suitable terrain for light construction. Excavation capability may be limited due to the relatively shallow depth to bedrock and the occurrence of large boulders

12	tMG/R	Discontinuous till veneer over bedrock	Irregular topography; frequent bedrock knobs; commonly drumlinized	Thin and patchy bouldery till over bedrock; frequent rock outcrops	Good bearing strength and low compressibility. Generally good foundation materials. Typically poor (irregular) topography and many rock outcrops (frequent blasting). Steep grades. Usually very bouldery surface. Depth to bedrock commonly less than 1 to 2 m. Excavation quantities and costs may be high. Characteristic drained highs and wet organic hollows	Generally unfavourable terrain. Relatively strong foundation materials at shallow depths. Earthwork costs are usually high (blasting) when constructing most types of transportation systems
13	RN, RR, RP, RL	Bedrock knobs, ridges, plateaus, plains	Mostly moderate to high irregular relief; locally with cliffs, scarplets, crevices	Harder rocks usually occur as knobs and ridges; softer rocks usually occur beneath hollows and flat areas	Mostly irregular relief, including cliffs, scarps, crevices, and jagged surface locally. Difficult and costly excavation (high quantities, extensive blasting, seepage). Costly transportation route (pipeline, road, railway, airfield, waterway) construction	Generally unfavourable terrain. Good foundations for heavy structures. Poor construction qualities for high class transportation systems because costly blasting required with earthwork

TABLE 2: RATING OF TERRAIN GROUPS FOR LIGHT CONSTRUCTION CAPABILITY

PRINCIPAL LANDFORMS AND SURFACE MATERIALS	SIGNIFICANT PHYSICAL PROPERTIES OF TERRAIN GROUPS	Engineering and Construction Use Suitability (Good, Fair, Poor)*														Land Use Planning Hazards or Constraints (Low, Moderate, High)*				
		Vertical and horizontal route alignment	Overland accessibility and trafficability	Suitability for earth dams and dikes	Potential source of high quality aggregate	Potential source of low quality aggregate	Construction workability in wet weather	Foundation quality for heavy structures	Foundation quality for light structures	Excavatability of earth materials	Drainage ditch and canal construction	Underground pipeline and cable construction	Likelihood of small earthwork quantities	Septic system waste disposal	Surface water storage (unlined reservoirs)	Contamination of surface and groundwater	Flooding hazard from surface runoff	Possibility of high water table position	Slope stability hazard (slides, flows, falls)	Soil erosion potential on fresh man-made cuts
Group 1: Organic plain: peat and muck (pOT)	Level to depressional, high water table, low bearing strength, low to very low permeability, high compressibility, subject to flooding	G	P	P	P	P	P	P	P	P	P	P	P	P	P	H	H	H	L	L
Group 2: Colluvial slopes and rubbly beaches: (rCT, CW, rLB)	Steep slopes and sloping beaches, active soil creep except on rLB, low frost susceptibility, low shrinkage, low plasticity, moderate to high permeability, variable compressibility	P	P	P	F/G	P	G	P/G	P/G	F/P	P	P/F	P	G	P	H/M	L	L/M	M/H	L/H

Group 3: Alluvial plain: sand, silt, minor clay, gravel, cobbles and boulders; variable texture (msAP, mAP, sgAP)	High water table, high permeability, high strength, variable relative density, low compressibility, high to medium frost susceptibility	G	F	P/F	P	F/P	P/F	P	P/F	G	P	P/F	G/F	G/F	P	H	H	H	L	L
Group 4: Sand ridge: fine to medium sand, minor silt in dunes and abandoned beaches (sLB)	Low unconfined strength, low to medium relative density, non-plastic, non swelling, generally not frost susceptible	G	G	P	P	G	G	G	G	G	P	G/F	G	G	P	H	L	M	L	L
Group 5: Sand plain: sand, minor silt, fine gravel (sGO, sLD, sLP, smLP)	Well drained, nonplastic, high shear strength and permeability, low compressibility, moderate to high bearing capacity, low frost susceptibility	G	G	P	P	G	G	G/F	G	G	P	G/F	G	G	P	H	L/M	M/H	L	M
Group 6: Silt plain: silt, fine sand (msLP)	High frost susceptibility, moderate to low permeability and compressibility, low shrink and swell potential, moderate to high shear strength, nonplastic to low plasticity	G	G	F	P	P	P	F	F	G	F	G	G	F/P	P	L/M	M	M	L/M	M/H

Group 7: Clay plain: clay, mostly highly plastic; minor silt, cobbles, boulders (cLP, cmLP)	Highly plastic, high shrink and swell potential, poor internal drainage, low bearing strength when wet, low permeability	G	G	G	P	P	P	P	P	G	G	G	G	P	G	L	L/H	L	L	L/H
Group 8: Sand and gravel plain: sand, gravel, minor silt, cobbles, boulders, (sgGO, sgLD, sgLP, gsGO)	Low compressibility, high permeability, good internal drainage, high shear and bearing strengths, stable in slopes	G	G	P	G	G	G	G	G	F/G	P	F/G	G	G	P	H	L	L/M	L	L
Group 9: Sand and gravel ridges and mounds: sand, gravel, minor silt, surface boulders or till (sg and gs GD, GK, LB)	Low compressibility, high permeability, good internal drainage, high shear and bearing strengths, stable in slopes	P/F	G/F	P	G/F	G	G	G	G	F/G	P	F/G	P	G	P	H	L	L/M	L	L
Group 10: Till mounds and ridges: very bouldery till; silt, sand, gravel inclusions locally (ts and tm MH, ME)	Moderate permeability, low to moderate internal drainage, low compressibility, high shear and bearing strengths, moderate frost susceptibility, low shrink and swell potential	P/F	F	P	P	F/G	F/G	G	G	P/F	P	P/F	P	F	P	H	L	L	L	L

Group 11: Till plain: bouldery silty to sandy till (ts and tm MG)	Low permeability and compressibility, low plasticity and shrink and swell potential, good internal drainage on rises, high bearing strength	G	G	F/G	P	P	G/F	G	G	G	F	G	G	P/F	F	L/M	L	L	L	L
Group 12: Discontinuous till veneer over bedrock: thin and patchy bouldery till over bedrock; frequent rock outcrops (tsMG)	Variable permeability and water table position, low shrink and swell potential, high shear and bearing capacity	P/F	P/F	F	P	P	P/G	G	G	P/F	P	P	P	P	P/F	L/M	L	L/M	L	L
Group 13: Bedrock knobs, ridges, plateaus and plains (RN, RR, RL, RP)	Variable water table position, high compressive strength, variable permeability dependent on fractures in rock	P	P	P	G/P	P	G	G	G	P	P	P	P/G	P	P	L	L	L	L	L

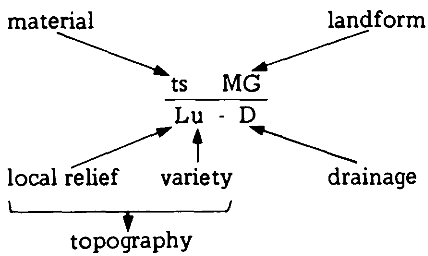
*Rating combinations such as F/G and L/M read fair to good and low to moderate, respectively.

5.0 APPENDIX: EXAMPLES OF TERRAIN UNIT LETTER CODES:

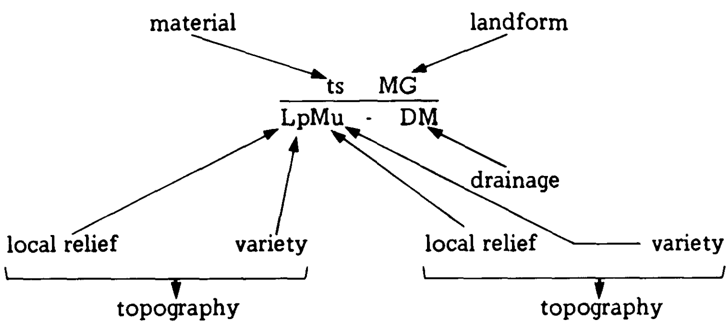
The engineering terrain unit letter codes consist of four components: surface materials, landform, topography, and drainage. The format of the letter codes used in describing the terrain units is discussed in detail in the Users' Manual (Gartner, Mollard, and Roed 1981). Some additional examples of the letter codes are as follows:

5.1 SIMPLE TERRAIN UNIT:

Example 1:



Example 2:

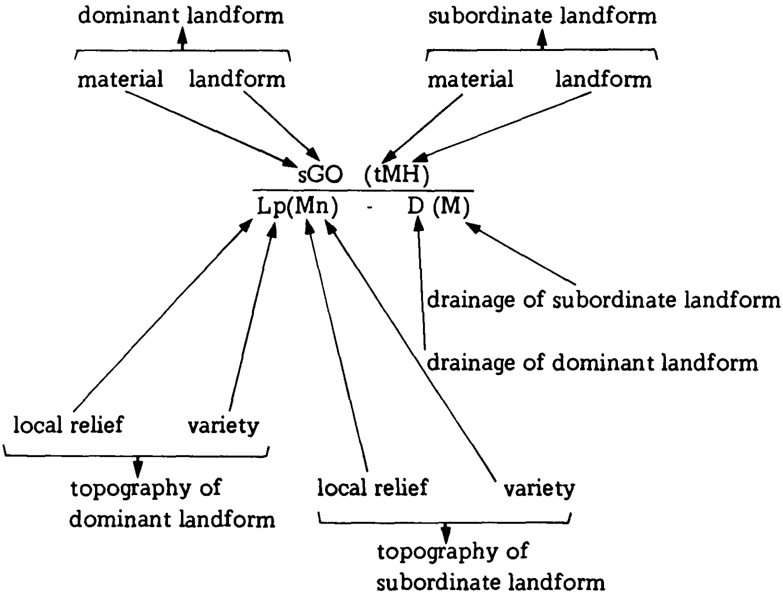


Note: The above type of letter code is used where there are two distinctly different types of topography and/or drainage in a simple terrain unit.

5.2 COMPLEX TERRAIN UNIT:

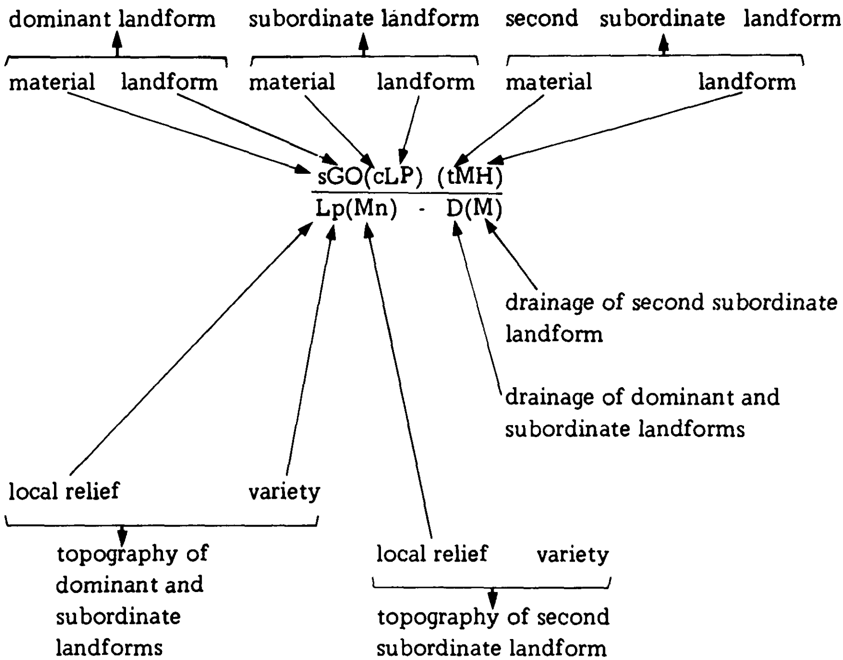
In complex areas, the dominant landform is shown first and the subordinate landform(s) appear in parentheses.

Example 1:



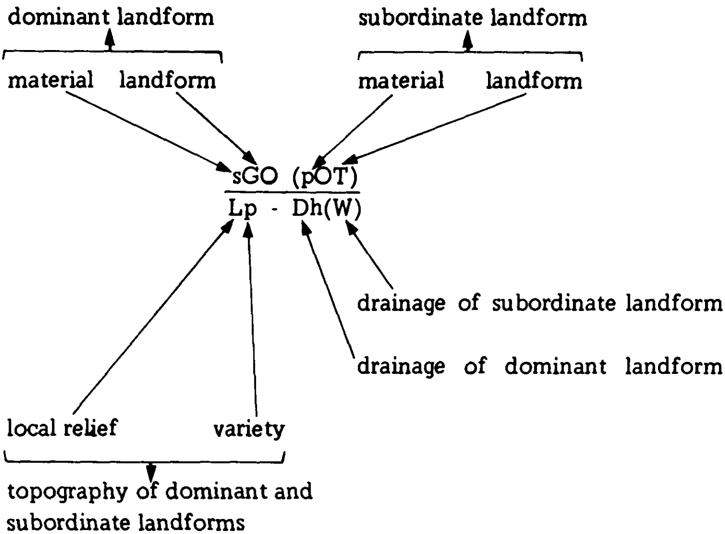
Note: The topography and drainage in parentheses refer to the landform shown in parentheses.

Example 2:



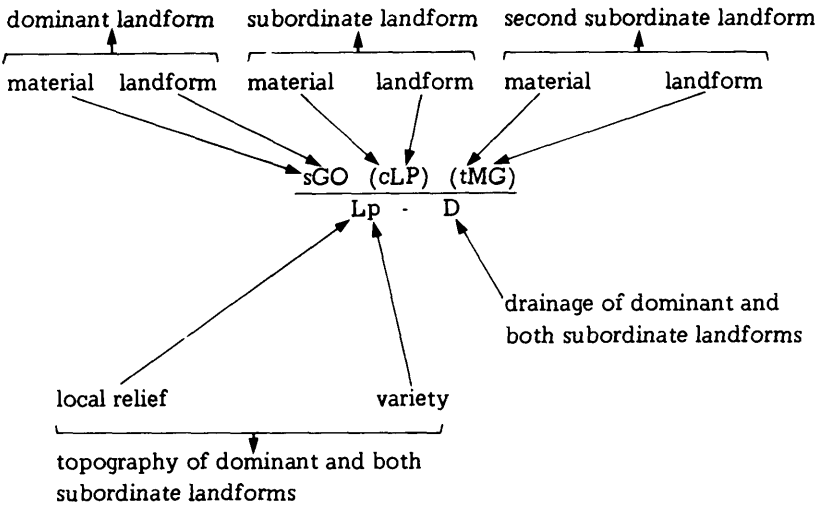
Note: The topography and/or drainage in parentheses refer to the second subordinate landform (in parentheses).

Example 3:



Note: If topography or drainage is similar in the dominant and subordinate landforms, then no topography or drainage symbol is shown in parentheses and the symbol shown applies to both landforms. If topography or drainage conditions are different in one of the landforms, a topography or drainage symbol is shown in parentheses to indicate this difference.

Example 4:



Note: Where topography and drainage conditions are similar in all of the landforms shown, no topography or drainage symbols are placed in parentheses.

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Ontario Geological Survey

Northern Ontario
Engineering Geology Terrain Study 71

THUNDER BAY AREA

(NTS 52A/SW)

District of Thunder Bay

by

D.G. Mollard and J.D. Mollard

1983

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THUNDER BAY AREA

(NTS 52A/SW)

District of Thunder Bay

by

D.G. Mollard[1] and J.D. Mollard[2]

1.0 INTRODUCTION:

This report contains an inventory of regional engineering terrain conditions in the Thunder Bay area, District of Thunder Bay. The area, which covers NTS block 52A/SW lies between Latitudes 48°00'N and 48°30'N, and Longitudes 89°00'W and 90°00'W. This report forms part of a series of publications which provide similar terrain data for some 370 000 km^2 of northern Ontario.

The purpose of the mapping is to provide a guide for engineering and resource planning functions at a level of detail consistent with a scale of 1:100 000. The terrain information is contained on the Data Base Map (OGS Map 5047, accompanying this report). The Light Construction

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Manuscript approved for publication by the Chief, Engineering and Terrain Geology Section, August 18, 1981. This report is published with the permission of E.G. Pye, Director, Ontario Geological Survey.

Capability Map (OGS Map 5048, accompanying this report) is a derived map which illustrates the suitability of the terrain in the Thunder Bay area for excavation, and foundation and road construction.

Interpretation of black and white aerial photographs, at a scale of approximately 1:68 000, formed the basis of the terrain mapping process. The interpretation was checked against published and unpublished maps and reports which documented previous field visits and observations. During the fall of 1977, roads in the map area were traversed and observed terrain conditions recorded as further verification of the office studies. Thus, the Data Base Map represents a reconnaissance overview of the engineering conditions of the terrain.

An engineering terrain legend was developd to facilitate the mapping and to provide a common information base for the entire map series. This legend is shown on the accompanying Data Base Map. Further discussion on the mapping techniques, legend format, and possible uses of this engineering geology information is available in the Ontario Engineering Geology Terrain Study Users' Manual (Gartner, Mollard, and Roed 1981), a companion publication to this series of maps and reports.

2.0 PHYSIOGRAPHY AND GEOLOGICAL SETTING:

Maximum local relief in the Thunder Bay area occurs in The Nor'Westers, a mountain range southwest of the City of Thunder Bay, where elevations range from 184 m above sea level (a.s.l.) at Lake Superior to 482 m a.s.l. on Mount McKay. Maximum topographic elevations within the map area occur southeast of Whitefish Lake, where they exceed 580 m.

The northwest portion of the area lies within the Severn Upland physiographic division (Bostock 1967), which is underlain by crystalline Archean rocks having a broad rolling surface. Large areas in the Severn Upland consist of bedrock exposures surrounded by thin and patchy glacial deposits and organic terrain. The remainder of the area lies within the Port Arthur Hills physiographic division (Bostock 1970). The Port Arthur Hills are composed of Proterozoic mafic sills and ancient sediments. Sills have been tilted to the south, forming mesas and cuestas, and long narrow steep sided ridges; some of which extend as promontories into Lake Superior.

A large, relatively flat area of Pleistocene lacustrine deposits extends west of Thunder Bay to Kakabeka Falls along the Kaministikwia River, and southwest toward Whitefish Lake along the Whitefish River.

3.0 ENGINEERING TERRAIN UNITS:

The engineering terrain units mapped are identified in terms of 4 components: surface material, landform, topography, and drainage. Format of the legend used in the terrain mapping is described in detail in the Users' Manual (Gartner, Mollard, and Roed 1981). Landform is a very important component because surface and near-surface materials, topographic expression,and surface and internal drainage conditions, are all related to it. Consequently, the engineering terrain units are grouped, for descriptive purposes, according to the dominant landform.

A particular landform can occur as the only component in a simple terrain unit, or as a dominant or subordinate component in a complex terrain unit. The dominant landform usually occupies more than half of a complex terrain unit. Where only 1 subordinate landform is shown, it usually occupies between 10 and 50 percent of the complex unit. Where 2 subordinate landforms are shown, the first covers the larger area. Landforms that occupy less than 10 percent of the terrain in a complex unit are rarely indicated in the terrain unit letter code. Where 2 or 3 landforms in a complex terrain unit consist of the same material, the landform letter symbols are connected by a dash. Examples of terrain unit letter codes which may occur in this map area, and an explanation of each, are given in the Appendix.

A large number of complex terrain units has been mapped due to the widespread occurrence of irregular topography. Bedrock, which is situated at or near the ground surface throughout much of the map area, controls the topography and therefore the surface drainage conditions. Resource development and engineering planning considerations are complicated by these complex conditions.

Noteworthy occurrences of important landforms are described with respect to location, typical materials, topography, and drainage; their significance in geotechnical investigations, regional engineering planning, and resource development is summarized.

3.1 BEDROCK PLATEAU (RL):

3.1.1 Description:

Areas mapped as bedrock plateau (RL) contain bold mesa-like features that have a capping of resistant rock consisting of eroded remnants of Proterozoic diabase sheets. The surface aspect of mesas and plateaus varies from nearly level to moderately sloping. Cliffs around part or all of these elevated features are strewn with coarse talus debris.

The surface of these landforms tends to be dry. Exceptions are the bottoms of long linear depressions. Usually these narrow trenches are partly filled with standing water or they contain organic deposits. Although bedrock plateau areas generally exhibit elevated planar slopes, they may still have knobby and jagged surfaces locally; these features can markedly affect engineering and construction costs.

The surfaces of many high plateau landforms slope gently to the southwest; their northwestern sides often form cliffs up to 120 m in height. The map user should note that this landform can occur in simple or complex terrain units (e.g. RL(MG/R)).

3.1.2 Occurrence:

Many bedrock plateaus occur in the Port Arthur Hills in the townships of Blake, Scoble, Gillies, Lismore, Crooks, Pardee, Devon, and Hartington, between Thunder Bay and the west and southwest borders of the map area. The upland of Pie Island consists of several rock plateaus. Some of the better known rock plateaus, named on the map, are Mount McKay, Mount McQuaig, Squaretop Mountain, The Palisades, Silver Mountain and Silver Bluff.

3.1.3 Engineering and Planning Significance:

Construction costs are generally high because slopes are steep and the presence of bedrock often necessitates blasting. Because bedrock plateau areas are aesthetically very pleasing, the possibility of developing small acreages, ski slopes, and sight-seeing tours holds considerable promise in some localities. Cliffs may be unstable since they are subject to rock falls. Road construction can be extremely difficult and costly in areas where the bedrock is highly uneven and is situated at or very near the surface. On roadways, horizontal and vertical sight distances are generally low and can create a traffic hazard.

3.2 BEDROCK KNOB (RN):

3.2.1 Description:

Bedrock knob landscape (RN) is characterized by an irregular bedrock surface having complex multiple slopes of varying steepness. The cover of glacial deposits overlying the bedrock knobs is generally thin and discontinuous. Much of the glacial overburden consists of bouldery, sand-rich till that was transported only a short distance by the ice.

3.2.2 Occurrence:

Many areas of bedrock knobs occur along the northern border of the Thunder Bay map area between Navilus and the Matawin River, and in Scoble and Pardee Townships southwest of Thunder Bay.

Rock knobs also occur in the northwestern part of the map sheet, in O'Connor, Marks, and Aldina Townships, as well as on the Welcome Islands and in the Brûlé Bay area of Lake Superior.

Rock knobs occur in complexes with ground moraine, e.g. RN(MG). Several better known rock knobs are Knob Hill and Flat Top Hill (northeast of Oliver Lake) and Drews Mountain (northwest of Hymers in Gillies and O'Connor Townships).

3.2.3 Engineering and Planning Significance:

Two principal engineering considerations are the large volumes of rock that must be excavated during construction and the generally uniform and solid foundation conditions at shallow depths. However, due to difficult topography and the existence of rock fractures, bedrock knob terrain is considered poor for most types of light construction and for waste disposal. Drilling and blasting are required during the construction of almost all types of engineering works.

3.3 BEDROCK PLAIN (RP):

3.3.1 Description:

The bedrock plain unit (RP) has a low-lying, undulating to rolling surface. The bedrock is generally mantled by a thin and variable cover of glacial material, consisting mainly of boulder-rich, sandy till. The rock plains display considerable local variation. They may consist of bare bedrock or may be covered by till or fine-grained water-laid deposits.

3.3.2 Occurrence:

Several small areas of rock plain have been mapped in the Thunder Bay map area. One such area occurs in McIntyre Township (northwest of the City of Thunder Bay), and others occur in Aldina and Strange Townships in the west-central part of the map area.

3.3.3 Engineering and Planning Significance:

Engineering and construction problems relate mainly to the cost of bedrock excavation. Foundation materials are strong, have a low compressibility, and a permeability that is controlled almost entirely by rock fractures. Bedrock plains are poor for construction and waste disposal sites, but are still considered better than areas mapped as bedrock plateau (RL), bedrock knob (RN), or bedrock ridge (RR). Drainage courses tend to follow eroded zones of weakness in the underlying bedrock. Many of these depressions occupy preglacial channels that were enlarged by glacial erosion. A large proportion of the groundwater in this landform is confined to fractures in the upper 45 to 60 m of bedrock. Permeability varies from impervious to highly pervious, depending on the spacing, depth, and width of fissures in the bedrock. Rock materials have high compressive, shearing, and bearing strengths. Position of the water table varies with topography, being closer to the surface beneath depressions. By careful route selection and proper design of vertical alignment, rock cuts on lower class roads can be avoided or at least the volume of rock to be blasted can be minimized. This is possible because of the low relief surfaces associated with many of the bedrock plains.

3.4 BEDROCK RIDGE (RR):

3.4.1 Description:

The bedrock ridge unit (RR) consists of long, narrow, subparallel and intersecting bedrock ridges of varying height. Thickness of drift over the masked bedrock surface varies substantially over short distances. In general, it is relatively thin (1 to 2 m) on ridge tops and thicker on the lower slopes and in the depressions between rock ridges.

3.4.2 Occurrence:

Victoria, Spar, Thompson, and Mink Islands have all been mapped as bedrock ridges. Numerous bedrock ridges also occur in the southern part of the map area near South Fowl Lake, Pigeon River, Lenore Lake, Cloud Bay, Big Trout Bay, and Pigeon Bay. Others are located in the townships of Aldina, Sackville, Adrian, Marks, and Strange, all in the northwestern part of the map area.

3.4.3 Engineering and Planning Significance:

The main construction problem is the large quantities of very hard rock that often must be excavated during construction. Drilling and blasting costs can be very high. Bedrock ridge terrain is considered poor for most types of engineering, construction, and resource development. It also has a low rating for waste disposal due to irregular relief, the presence of rock fractures near the ground surface, and the high cost of earthwork construction.

3.5 END MORAINE (ME):

3.5.1 Description:

End moraine (ME), which forms either prominent or inconspicuous till ridges, was deposited along the margin of the glacier. Although the ridges are usually long and narrow, they can be hummocky in places. End moraine consists largely of ice-deposited till and boulders, with minor inclusions of water-laid silt, sand, and gravel. Segments of end moraine, composed mainly of till, occur with hummocky moraine (MH), kames (GK), and ice-contact deltas (GD) in large moraine complexes which are identified by name in Figure 1. The bedrock surface is nearly always buried in areas of end moraine; there are exceptions, however, and in a few places end moraine ridges have a core of solid rock.

3.5.2 Occurrence:

The Marks Moraine (Zoltai 1963) is a large end moraine located in the northwestern part of the Thunder Bay map area. Elevations along the top of the moraine range from 460 to 490 m. The Marks Moraine indicates the approximate maximum advance of the Superior ice lobe. The Superior ice lobe also formed a less conspicuous end moraine during a temporary halt in its retreat from the area. This end moraine is located in Oliver Township between the communities of Murillo and Intola in the north-central part of the map area. The name Intola Moraine has been proposed for this feature (Burwasser 1977).

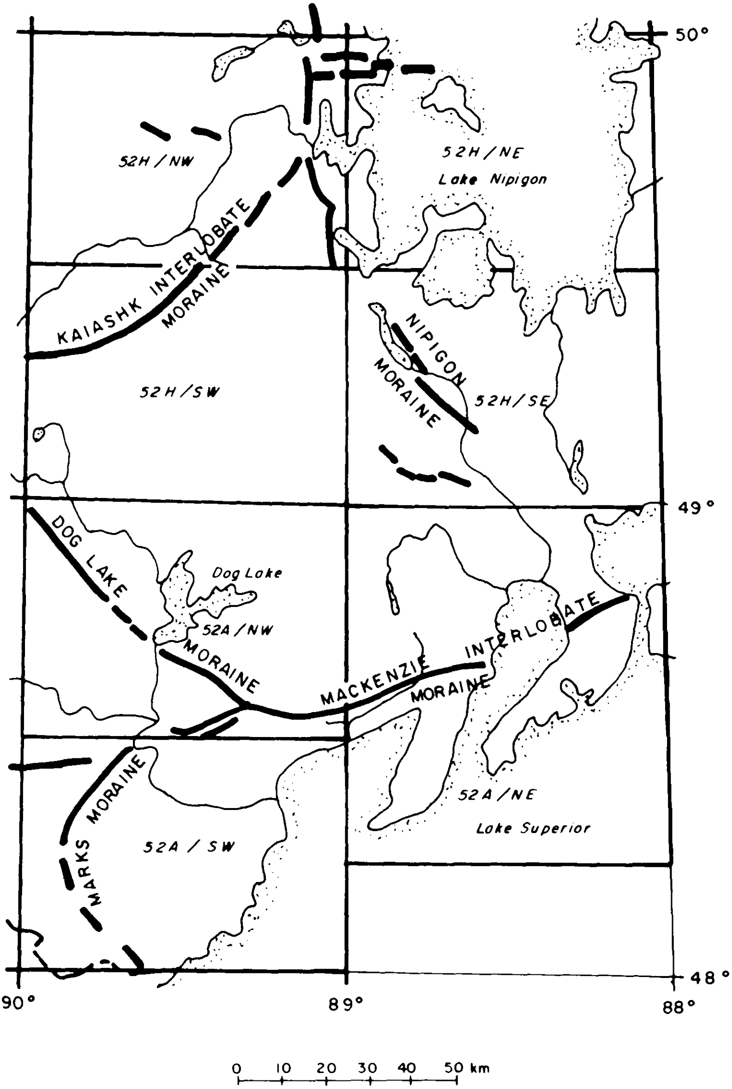
3.5.3 Engineering and Planning Significance:

An important characteristic of end moraines is their variability. Layers of unsorted and unstratified material of varying sizes (i.e. till), can both underlie and overlie sequences of layered silt, sand, and gravel. In general, the boulder content of this landform is high. End moraines in the map area commonly exhibit variable permeability and internal drainage, low compressibility, and high bearing strength. The water table is low in end moraine ridges. Where the unit consists of till that is high in sand- and gravel-sized material, and where sources of stratified sand and gravel are scarce, the coarse till may sometimes be crushed and used as a source of road-surfacing material. End moraines may present excavation difficulties during the building of roads and structures due to the abundance of small and large boulders.

3.6 GROUND MORAINE (MG):

3.6.1 Description:

The term "ground moraine", (MG), refers to an extensive deposit of till forming an undulating to rolling plain. Although till is generally composed of an assortment of particle sizes (including clay, silt, sand, gravel, cobbles, and boulders), till deposits in this map area have a high sand and boulder content. The thickness of till in ground moraine varies from less than 1 m



NOTE: Moraine segments shown in the figure do not necessarily all occur on the Data Base Map accompanying this report.

FIGURE 1 - MAP SHOWING MAJOR MORAINES IN NTS 52A AND 52H (MODIFIED FROM ZOLTAI 1965a)

to many tens of metres. The landform is mapped as MG where the till is thick enough to mask any topographic effect of underlying bedrock. In general, the till layer forms a mantle less than 3 m thick over the bedrock and is mapped as MG/R. Till in ground moraine tends to be thicker in bedrock depressions and thinner over bedrock ridges and knobs.

3.6.2 Occurrence:

Ground moraine occurs extensively in the Thunder Bay map area. The till is mostly silty (tmMG), and is generally shallow over bedrock. In most cases it has been mapped as MG/R or MG(R), the latter being a complex of ground moraine and bedrock exposures. An exception occurs in the northwestern corner of O'Connor Township where the till is clayey (tcMG) and its thickness is up to 6 m. A smaller area of clayey till occurs west of Stanley Hill, south of Harstone in Paipoonge Township.

3.6.3 Engineering and Planning Significance:

The till in ground moraine is coarse and bouldery, and has moderate permeability and internal drainage, low compressibility, and high bearing strength. Water table position varies with relief, being lower beneath knolls and low ridges, and higher beneath depressions. The till in many of the depressions is covered by thin deposits of peat and muck.

The suitability of ground moraine for road and other light foundation construction is fair to good. The fact that the till often forms only a thin mantle over the bedrock (MG/R) has a great deal of significance in road building. Road construction through this type of terrain is difficult owing to the bouldery nature of the till and the probability of encountering bedrock in cuts. The suitability of ground moraine for waste disposal varies from poor to fair.

3.7 ICE-CONTACT DELTA (GD):

3.7.1 Description:

Esker deltas, delta-kames, and delta-moraines are all varieties of the ice-contact delta. Some are quite large in area and important in terms of the volume of recoverable sand and gravel which they contain. Individual beds, consisting mainly of sand or gravel, are usually better sorted, cleaner, and less variable than stratified deposits in esker (GE) and kame (GK) landforms. The beds in this unit are also typically less folded and faulted and are more continuous. It is worth noting that materials in many ice-contact deltas are coarse (i.e. gravelly) on the north and northeast sides and finer (i.e. sandy) on the south and southwest sides. These conditions indicate the parts of the delta which were, respectively, closest to and farthest from the glacial front against which the delta was built.

3.7.2 Occurrence:

Several large ice-contact deltas occur in the Thunder Bay map area. They are located in the southwestern corner of Conmee Township (northwest of Kakabeka Falls), in Sackville Township, Fraleigh Township, north and east of North Fowl Lake (in the southwestern part of the map area), in Hartington Township, and on the northern outskirts of the City of Thunder Bay. A small one was mapped on the southern shore of Loch Lomond.

3.7.3 Engineering and Planning Significance:

Ice-contact deltas are good potential sources of concrete and blacktop aggregate. They are also favourable sites for the construction of airstrips, roads, and other types of engineering works. Because the subsoils are highly permeable, deltaic (GD) landforms are relatively poor areas for waste disposal. Larger deposits, however, are generally good groundwater prospects, especially where sand and gravel horizons are thick and extend below the water table. Ice-contact deltas possess high bearing strength and good workability in wet weather. Slopes are stable and subsoils are well drained. Away from the steeply sloping margins of this landform, earthwork volumes and excavation costs are normally low. Reservoirs and sewage lagoons in ice-contact deltas must be lined to prevent excessive leakage.

3.8 ESKER (GE):

3.8.1 Description:

The ridged landform represented by the esker symbol (GE, >>>) also includes crevasse fillings. Both occur as long, narrow, sand and gravel ridges that can be winding or straight and may widen in places. Some of these elongate ice-contact stratified drift ridges include braided, branching, beaded, and kettled segments. Most of the ridges trend roughly parallel to the last direction of glacial flow. The cores of many eskers and crevasse fillings contain complexly layered units, consisting of sandy gravel and gravelly sand, that exhibit collapse structures (i.e. folds, faults, and pinch-outs of strata). Pockets and layers of waterlaid silt and fine sand, boulders, and till may occur within the central parts of eskers and crevasse fillings, as well as along their flanks.

3.8.2 Occurrence:

Most eskers in the Thunder Bay map area ar too small to be shown at the map scale of 1:100 000. One of the larger eskers which is shown on the map is located in Devon Township in the southwestern corner of the map area. Another extends into the northwestern corner of the map area in Sackville Township, east of the Matawin River.

3.8.3 Engineering and Planning Significance:

Eskers and crevasse fillings are generally inferior to ice-contact delta and glacial outwash deposits as sources of good quality granular construction materials. Typically, the unit possesses high permeability and good internal drainage, low compressibility, high bearing strength, low frost susceptibility, and low shrink-and-swell potential. Where esker ridges are steep-sided, narrow, and winding, they may be unsuitable for use as transportation routes. They may trend in the wrong direction for route location purposes, but in regions that are dominated by large expanses of swamp and bedrock, large eskers are frequently considered as good route location possibilities. Where the sand and gravel in large eskers extends many metres below the water table, the unit represents a potential source of groundwater for domestic and, possibly, municipal and industrial use.

3.9 KAME (GK):

3.9.1 Description:

Kames occur either as steep-sided single knobs or as clusters of several knobs in kame fields and kame moraine. The larger, steep-sided kames usually have an irregular surface; in a few places, they contain deep kettle hole depressions. Most are composed of complexly interbedded sand and gravel strata which regularly exhibit fold, fault, and pinch-out structures. Kames also contain variable but usually minor amounts of silt, till, and boulders. Large kame deltas are discussed in Section 3.7; kame terraces are rare.

3.9.2 Occurrence:

Most of the kames in the Thunder Bay map area occur as kame fields rather than as individual kames. Major kame fields occur in the townships of Sackville, Adrian, Aldina, and Marks (all in the northwestern corner of the map area). These kames occur mostly as complexes along with outwash (GO) and deltaic deposits (GD). Smaller areas of kames are located in Lybster Township west of The Palisades; along the township boundary between Hartington and Devon Townships; south of Jackpine; south and west of Intola; and near the southwestern corner of Loch Lomond in Blake Township.

3.9.3 Engineering and Planning Significance:

In general, kames have high permeability and good internal drainage, low compressibility, high shear strength, and good bearing capacity. Position of the water table varies with relief, being nearer the surface beneath kettle depressions and deeper beneath ridges and knobs. Although the granular materials in kames provide good foundations for buildings and small engineering works, the quantities of material that must be excavated during construction can be moderately high. Waste disposal sites require special design procedures and costly construction in order to function properly. Kames should be avoided as waste disposal sites. They vary from poor to good as sources of sand and gravel aggregate, depending upon their size and compositional variability.

3.10 OUTWASH PLAIN (GO):

3.10.1 Description:

Outwash deposits include plains, fans, deltas, and valley trains of varying areal extent, all consisting mainly of sand and gravel. Most outwash sediments were derived from debris within the glacial ice which was subsequently deposited by meltwater flowing from the margin of the glacier. Although most outwash deposits formed in proglacial positions, some accumulated over masses of stagnant glacier ice, resulting in pitted or kettled surfaces. Outwash landscapes that show abandoned channel scars, braid bars, or deep kettle holes are commonly coarse in texture (i.e. gravelly and cobbly rather than sandy).

3.10.2 Occurrence:

Large areas of outwash are located in the northwestern corner of the map area in Sackville, Aldina, Strange, and Marks Townships. Most of the outwash in these areas occurs in a complex with kames (GK), as a veneer overlying bedrock (GO/R), or with a peat veneer (OT/GO). Smaller areas are found along the northeastern shore of Cloud Lake in the south-central part of the map area, and at Kivikoski in McIntyre Township, along the northern boundary of the map sheet.

3.10.3 Engineering and Planning Significance:

Outwash landforms almost always have high permeability and good internal drainage, low to very low compressibility, low shrink-and-swell tendencies, and high shear strength and bearing capacity, particularly where these granular deposits are confined. Granular materials in outwash landforms form stable slopes and are seldom susceptible to frost heave. Being level and well drained, the sediments in outwash plains are not easily eroded by running water. The boulder content is generally low. A high water table can be expected beneath kettle depressions. Extensive outwash plains provide excellent sites for the construction of roads and airstrips, and are often good sources of concrete and bituminous aggregate. They are good potential sites for groundwater development, particularly where the granular deposits are deep and are recharged by water from nearby lakes and rivers.

3.11 RAISED BEACH RIDGES (LB):

3.11.1 Description:

Raised beaches are generally thin and consist of bouldery, gravelly, and sandy wave- and current-transported materials deposited along the shores of glacial lakes. The term "raised beach" denotes a landform marking the position of a former rather than present-day lake margin. Generally, the wave-washed materials were eroded from coarse till and glaciofluvial deposits consisting of sand, gravel, and cobbles.

3.11.2 Occurrence:

Raised beaches occur inland from the shore of Lake Superior between the City of Thunder Bay and the International Boundary; on Pie Island, west of the City of Thunder Bay; and in Devon Township, east of Jackpine.

3.11.3 Engineering and Planning Significance:

The raised beach in this area is generally too thin and narrow to constitute a major source of granular construction material. Because it is nearly level, well drained, and slightly elevated above the surrounding terrain, it is a good feature to follow in route location if it happens to trend in the desired direction. The water table is generally high in this landform. Raised beaches have a high permeability, good internal drainage qualities, and low compressibility (i.e. small amounts of total and differential settlement of structures bulilt upon them). They usually have high shear strength and bearing capacity. They make poor waste disposal sites because of their limited area and the possibility of leakage which can lead to contamination of nearby surface water or groundwater.

3.12 GLACIOLACUSTRINE DELTA (LD):

3.12.1 Description:

Materials in glaciolacustrine deltas range in texture from sandy gravel and coarse sand (gsLD, sLD) near the apex of the delta, where the glacial stream entered the lake, to fine sand and silty sand (smLD) in the distal portion of the delta. The finer materials at the distal end of the delta usually interfinger with, and grade into, finer glaciolacustrine lake bottom sediments (see Section 3.13). The grain size of material in glaciolacustrine deltas is dependent on the composition of the source material and on the size and gradient of the stream transporting the material. The good bedding characteristic of delta sediments is related to variations in streamflow and former lake levels. Individual beds are usually well sorted, uniform, and continuous. Because of these characteristics, glaciolacustrine deltas are generally good sources of granular material for construction purposes.

3.12.2 Occurrence:

Glaciolacustrine deltas occur below Kakabeka Falls, at Navilus; along Highway 61 in Blake Township; in the southwestern corner of Devon Township; northeast of the Town of Cloud Bay in Crooks Township; and in the south-central part of Marks Township, north of Nolalu.

3.12.3 Engineering and Planning Significance:

Glaciolacustrine deltas are good potential sources of concrete and blacktop aggregate. They are also favourable sites for the construction of airstrips, roads, and other types of engineering works. Because the subsoils are highly permeable, this landform is a relatively poor area for waste disposal. Larger deposits, however, are generally good groundwater prospects, especially where the sand and gravel horizons are thick and extend below the water table. Glaciolacustrine deltas possess high strength and good workability in wet weather and, if large enough, are favoured sites for many types of resource development. Slopes are stable and subsoils are well drained. Reservoirs and sewage lagoons in glaciolacustrine deltas should be lined to prevent excessive leakage.

3.13 GLACIOLACUSTRINE PLAIN (LP):

3.13.1 Description:

Sediments in glaciolacustrine plains consist of varved and massive, fine-grained materials deposited in glacial lake basins of varying size and depth. The proportions of clay, silt, and sand deposited at any particular location in these basins varies with depth of water in the former lake, distance from former shorelines, and the size of particles washed into the lake. Most clay, silt, and sand lacustrine deposits contain minor inclusions of till and scattered dropstones which were rafted into the lake within pieces of glacial ice. In places, wave and current action in former glacial lakes eroded the surface of till deposits, producing thin patches of washed sand, gravel, and boulders that rest on till or bedrock. In other areas, bedrock knobs and ridges are surrounded by pockets of glaciolacustrine sediment. Glacial lake deposits usually consist of clay and silt (cLP, cmLP, mcLP) which accumulated in deep offshore waters at a depth where the bottom was no longer affected by wave action (generally below 10 m). Closer to shore, and at points where rivers discharged sandy materials into the lake, the deposits usually consist of fine and medium sand with minor silt (sLP, smLP). Most of these sandy lacustrine deposits accumulated in deltaic environments.

3.13.2 Occurrence:

Glacial lakes inundated large parts of the Thunder Bay map area. In the Arrow River basin, southwestern corner of the map sheet, clayey lacustrine deposits occur at elevations of up to 418 m above sea level (a.s.l.). In the area drained by the Kaministikwia River, silty and sandy lacustrine deposits occur up to 259 m a.s.l. In addition to these areas, clayey lacustrine sediments are found in the Whitefish Lake and Whitefish River basins, in Sackville Township, along the Pine, Pigeon and Cloud Rivers, on Pie and Flatland Islands, and in a broad band along the shore of Lake Superior.

3.13.3 Engineering and Planning Significance:

Glaciolacustrine clay deposits (cLP) have high water retention capacity, low permeability, and poor internal drainage. These characteristics are largely controlled by a network of closely spaced joints. Generally, these landforms possess low density, low bearing strength, and moderate to high compressibility, unless the fine-grained sediments have been consolidated by the weight of overriding glacier ice or by the effects of desiccation. The clay sediments usually provide poor foundation conditions and can be difficult to work with heavy construction equipment during wet weather. Most clay plains in the map-area are level to gently sloping. The sides of river valleys which have been deeply incised into these fine deposits are frequently highly dissected and are susceptible to rill-and-gully erosion on freshly cut ditch slopes and highway back slopes. Higher and steeper natural and man-made slopes are subject to the development of small failures. Where these lacustrine materials carry a high proportion of silt or very fine sand, they are susceptible to frost heave and the formation of frost boils. Subsoil permeability ranges from low to nearly impervious; as noted above, this is largely dependent on the presence of a system of closely spaced joints. In locations where glaciolacustrine clay sediments are highly plastic, they have a tendency to shrink or swell with changes in moisture content. Bearing capacity, shear strength, and compressibility vary greatly with differences in previous loading history and, therefore, the natural moisture content. Bearing capacities can be low in wet areas, particularly where plastic clay soils are normally consolidated or only slightly consolidated.

Low-lying clay plains have a high water table and are subject to local flooding during spring runoff and heavy cloudbursts. During wet weather, the glaciolacustrine clay sediments have poor workability characteristics for building roads and structures. This landform usually provides good sites for waste disposal because of its low permeability.

Lacustrine sand plains (sLP) contain mostly fine and medium sand with minor silt. Coarse sand, gravel, cobbles, boulders, and till are rare in these deposits. Sand plains are gently sloping to undulating and are well drained. A high water table may occur at sites located some distance from the groundwater lowering effects of deep valleys and ravines. Sandy lacustrine materials are typically nonplastic and have high permeability, low compressibility, moderate to high bearing capacity, and high shear strength. They are generally not frost susceptible unless they contain significant amounts of silt and very fine sand. They represent fair to good terrain for most construction, especially that of roads and airstrips. They are poor for waste disposal due to the possibility of effluent seepage and groundwater contamination.

3.14 ALLUVIAL PLAIN (AP):

3.14.1 Description:

Many alluvial deposits (AP) in this map-area consist of fine and medium sand at depth; these materials are commonly overlain by a silty upper stratum of variable thickness. Oxbows and abandoned channel segments occur where meandering streams cross landforms composed largely of loose silt and fine sand. Sediments beneath alluvial plains are finer textured where the material being carried by the stream was eroded from clay and silty clay glaciolacustrine deposits. The landform includes flood plains that have been eroded in till and are strewn with boulders, as well as segments of stream valleys where alluvial sediments range in texture from coarse sand to coarse gravel and cobbles. Long and complex alluvial plain systems sometimes include three constituent landforms: low alluvial terraces, alluvial flood plains, and stream channels.

3.14.2 Occurrence:

Alluvial plains occur along the Serpent River in Sackville Township; along the Whitefish River in the townships of Lybster, Gillies, and O'Connor; along the Arrow River in Devon Township; along the Pine River in Pearson and Pardee Townships; and along the Kaministikwia River for its entire length within the map area.

3.14.3 Engineering and Planning Significance:

Alluvial plains are subject to flooding. The water table is usually situated at or near the surface for much of the year; organic-filled depressions are common. Although some alluvial terraces, flood plains, and channel bottoms represent potential sources of sand and gravel for construction purposes, the high water table may cause problems during excavation of such materials. This landform is generally unsuitable for transportation routes, general construction, or waste disposal sites because of the high water table and risk of flooding.

3.15 TALUS SLOPE (CT):

3.15.1 Description:

Pieces of broken rock that have fallen from cliffs and accumulated in piles along the base of near-vertical rock faces are mapped as talus slopes (CT). Topples (rotated or tilted pieces of rock that have not fallen) and rock falls are common phenomena in this environment and can be hazardous. Angular pieces of rock vary from several centimetres to more than a metre in size. The talus debris is usually composed of only one type of rock (i.e. the lithology that forms the cliff above the talus slope). In this map-area, that lithology is commonly diabase.

The material that comprises the talus slope has been called rubble and is denoted by the letter "r". Downslope from the base of talus piles, scattered pieces of rock have come to rest on sandy to gravelly slopewash deposits that are usually sandy, poorly sorted, and "dirty looking". In many places, blocks of talus are enclosed in slopewash material.

3.15.2 Occurrence:

Many talus piles (CT, ▲▲▲) were mapped along the steep sides of the Port Arthur Hills, southwest of Thunder Bay in the townships of Blake, Crooks, Devon, Pearson, Pardee, and Hartington, and on Pie Island. Most talus slopes have formed in the areas where bedrock of Proterozoic age outcrops.

3.15.3 Engineering and Planning Significance:

Heavy construction work on loose, angular blocks of talus can be hazardous because of (1) the possibility of intermittent rock falls and (2) the slope instability associated with the removal of blocks that support overlying pieces of talus. Most talus deposits possess an open structure with large voids and are thus highly pervious. The rock in talus piles represents a possible source of crushed aggregate for railway ballast and riprap. Permanent engineering structures should not be constructed on thick piles of talus because of the hazards mentioned above and the possibility of talus creep.

3.16 SLOPEWASH SHEET (CW):

3.16.1 Description:

Slopewash sheets are almost always poorly expressed in airphotos. The presence of these sheets must therefore be inferred from depositional environments that are recognizable on the photos. They usually contain poorly sorted, poorly stratified, loosely deposited sediments that have been washed down the surfaces of moderately steep slopes by unconcentrated overland sheet flow or transported down steep slopes by frost action and soil creep processes. Most of these materials were probably transported and deposited in a periglacial climate. Slopewash deposits commonly merge upslope with piles of talus debris and downslope with till and fine-grained lacustrine sediments.

3.16.2 Occurrence:

Slopewash sheets occur in areas having low slopes in the Port Arthur Hills, southwest of Thunder Bay in the townships of Blake, Scoble, Pardee, Pearson, Fraleigh, Devon, and Hartington, and on Pie Island.

3.16.3 Engineering and Planning Significance:

Pits in this landform contain poorly sorted, poorly graded, dirty (silty) sand and angular rock particles of varying sizes. The material is usually too dirty to use as concrete or blacktop aggregate without being washed. Nevertheless, where these deposits are sufficiently thick and dry, the material can be crushed to produce a satisfactory road surfacing material. In general, slopewash deposits are thin and loose, and may possess a loose openwork (i.e. porous) structure. Subsoils are often wet, even though the slopes may appear steep enough to be well drained. Seepages and springs are common occurrences. Engineering problems caused by slopewash terrain include poor geometrics in road design and relatively high cuts and fills during construction.

3.17 SAND DUNES (ED):

3.17.1 Description:

Dunes are composed of fine and medium sand that has been blown into ridges by wind action. Dune ridges range in height from 1 or 2 m to more than 5 m, and may be long, narrow, and either straight, arrowhead, or arcuate in plan view. Dunes usually overlie or occur downwind from sandy outwash plains and sandy glaciolacustrine plains.

The location of sand dune areas may also be indicated on the map by the graphic symbol ➤.

3.17.2 Occurrence:

An area of sand dunes is located on the southern side of the Kaministikwia River, west of the City of Thunder Bay in central Paipoonge Township. In this area silty sand overlies sandy gravel.

3.17.3 Engineering and Planning Significance:

Sand dunes possess special characteristics of engineering significance. When denuded of vegetation, the fine and medium sand in dune ridges is susceptible to wind erosion and drifting. A moderate to low water table can be expected beneath higher dune ridges. Dunes are well drained, and the sand of which they are composed has a low shear strength when it is not confined. These deposits usually have low compressibility unless sand of a relatively uniform grain size has been deposited in a very loose state. Where dune sand is loose, generally beneath the slip face, it may possess a moderate to low relative density. The bearing strength of dune material is also low where the sand is unconfined, but can increase with the degree of confinement. Caving of wet and dry sand in vertical ditch walls is a potential problem which can increase costs on major construction jobs. Dune sand is nonplastic and is generally not susceptible to frost action or shrinking and swelling.

3.18 ORGANIC TERRAIN (OT):

3.18.1 Description:

Organic terrain includes varying depths of peat and muck in marshes, swamps, fens, and bogs. No attempt was made to separate these organic landscape types during the mapping. Although peat and muck deposits usually occur as relatively thin surficial layers, in places these organic materials can be several metres thick. Moreover, the thickness of the deposits can change drastically over very short distances.

3.18.2 Occurrence:

Thin organic terrain overlies lacustrine deposits (OT/LP) in Hartington and Devon Townships; and along the shore of Lake Superior from the International Boundary to Jarvis Bay and from Mission Flats to Thunder Bay Harbour. In Sackville, Adrian, and Conmee Townships, organic terrain occurs as a veneer or in complex association with lacustrine plains (LP) and outwash (GO) landforms. A relatively large area of organic terrain overlying a lacustrine plain (OT/LP) occurs along Highway 11 and 17, northwest of the City of Thunder Bay, in Oliver Township. In addition to these larger areas there are many small areas of organic terrain located in poorly drained depressions scattered throughout the map area.

3.18.3 Engineering and Planning Significance:

Although organic deposits are commonly thin, they are nonetheless very poor foundation and construction materials. The water table is at or near ground surface for most of the year. The locations of deeper pockets of organic material are difficult to predict reliably without extensive testdrilling. The topography of organic terrain is level or slightly depressional. Peat and muck deposits have low shear and bearing strengths and generally low permeability. They are nearly always poorly drained, highly compressible, and are subject to seasonal flooding. Consequently, they are unsuitable for nearly all types of engineering works and for waste disposal.

4.0 EXAMPLE OF A DERIVED MAP: LIGHT CONSTRUCTION CAPABILITY

4.1 GENERAL COMMENTS:

The Light Construction Capability Map (OGS Map 5048) included in this report has been derived from the Data Base Map (OGS Map 5047, accompanying this report). The purpose of a derived map is to illustrate how basic terrain data can be used to prepare a map depicting the suitability of the terrain units for construction of shallow foundation structures and deep excavations.

Reference should be made to the "Ontario Engineering Geology Terrain Study Users' Manual" (Gartner, Mollard, and Roed 1981) for further information on the preparation and use of the various types of derived maps.

4.2 CAPABILITY RATING CRITERIA:

Criteria for rating the suitability of a terrain unit for the construction of shallow foundation structures and deep excavations are related to landform type, engineering properties of constituent materials, topography, drainage, and groundwater conditions. The principal landforms and surficial materials have been arranged in groups of terrain units, each comprising terrain units having similar properties and capabilities with respect to light construction. Tables 1 and 2 describe the terrain unit groups and indicate the relative suitability of these terrain groups for light construction.

TABLE 1: SUITABILITY OF TERRAIN GROUPS FOR EMBANKMENT, EXCAVATION, AND FOUNDATION CONSTRUCTION

MAJOR TERRAIN GROUPS, TOPOGRAPHY AND MATERIALS IN MAP 5047					SUITABILITY FOR EMBANKMENT, EXCAVATION, AND FOUNDATION CONSTRUCTION	
Group Number (see map)	**Letter Symbols**	**Land-form**	**Topography**	**Surficial Material**	**Construction Properties**	**Suitability**
1	pOT	Organic plain	Level, depressional	Peat and muck; variable thickness over mineral soils	Very weak, highly compressible surficial materials. High water table. Poor drainage. High shrinkage and swelling characteristics. The peat usually must be either drained and consolidated or removed (excavated)	Generally unsuitable
2	rCT, CW, rLB	Colluvial slopes and rubble beaches	Steep slopes, cliffs; sloping beaches	Talus rubble, silty sand and gravel, often a veneer over till; shingle (rubble) beaches along Lake Superior	Potentially unstable slopes (rockfall, rockslides, and creep) where construction occurs in talus areas. Potentially difficult topography and costly excavation. Talus piles and rubble beaches are good sources of riprap and crushed rock borrow. Local erosion hazard in CW and CT terrain and flooding hazard in rLB terrain	Generally unsuitable owing to steepness, natural hazards in special terrain situations (e.g. talus areas) and coarseness of rubble beaches

3	msAP, mAP, sgAP	Alluvial plain	Gently sloping	Sand, silt; minor clay, gravel, cobbles, and boulders; variable texture	Wide range of loose or compressible soil materials. Variable strength and permeability. Periodic flooding likely. Excavations are subject to water problems such as seepage and caving walls. Potential frost heave and bank erosion. Nearly level landscape and low earthwork quantities. Pockets of borrow available	Generally unfavourable owing to highly variable soil materials, high water table, periodic flooding, and local stream erosion hazards
4	sLB	Sand ridge	Low ridges	Fine to medium sand; minor silt (dune, some abandoned beaches)	Generaly small (narrow) area. Sands are commonly quite loose (low relative density). Subject to wind erosion when denuded of vegetation. Good internal drainage and all-weather workability. Medium to high shear strength and bearing capacity if sand is confined. Potential sand borrow.	Generally suitable for shallow foundation structures, and poor for structures requiring deep excavations extending below the water table.
5	sGO, sLD, sLP, smLP	Sand plain	Level to gently sloping	Sand; minor silt, fine gravel (lacustrine, deltaic, outwash)	Medium to high bearing capacities if confined. Low compressibility. High permeability. Good internal driainage and all-weather work-ability. Good (i.e. level) topography. Potential source of water for construction camps and aggregate processing. Possible caving of steep vertical cuts, especially where the water table is high. Sands may be drained adjacent to deep valleys and ravines. Generally low susceptibility to frost heave, shrinkage, and swelling. Potential source of fill borrow and fine aggregate for concrete.	Favourable terrain for most construction projects

6	msLP	Silt plain	Level to gently sloping; locally gullied	Silt, fine sand; minor clay (lacustrine)	Silts may be underlain at depth by sands or clays. Low to medium bearing capacity. High susceptibility to gully erosion and to frost heave. Where thick and saturated, the silt will likely be unstable in deep excavations. Commonly difficult soils to work in wet weather. Close moisture control is required in compaction. Generally poor subgrade, internal drainage, and workability characteristics when wet	Low to moderate suitability. Suitability depends on type of construction project, time of year, and construction above or below the water table
7	cLP, cmLP	Clay plain	Level, depressional, gently sloping; gullied along valley walls	Clay, mostly highly plastic; minor silt and fine sand (lacustrine)	Practically impervious. Subject to excessive gully erosion on steep slopes. Poor drainage and compaction characteristics. Unworkable in wet weather, but easily worked in dry condition. Moderate frost heave potential. Subject to high shrinkage and swelling with change in moisture content. Generally poor foundation for roads, airfields, and heavy buildings. Improved in-situ engineering soil characteristics where the clay has been overridden by glacier ice. Subject to small slope failures on steep high cuts. Nearly level landscape away from deeper drainage features. Source of impervious (clay) lining material. Excessive expansion and shrinkage may cause cracking of foundation	Low suitability for many construction purposes

8	sgGO, sgLD, sgLP, gsGO	Sand and gravel plain	Level to gently sloping; locally kettled or terraced	Sand, gravel; minor silt, cobbles, boulders (outwash, valley train)	Good to excellent foundation material. High strength and low compressibility when confined. Good internal drainage and work-ability in dry or wet weather. Low earthwork quantities. Commonly highly pervious. Low frost susceptibility and erosion potential	Generally excellent terrain for construction of most structures. Water retaining structures (e.g. sewage lagoons and water-supply reservoirs) must be lined due to the relatively high per-meability of the surficial materials
9	sg and gs GD, GK, LB	Sand and gravel ridges and mounds	Flat-topped, rounded, and A-shaped ridges and mounds	Sand, gravel; minor silt, surface boulders, or till. Often complex bedding	Good to excellent foundation material. Mostly high strength and low compressibility soil materials where confined. Good drainage and workability in all weather conditions. Commonly contains highly pervious strata. Generally low water table. Typically very bouldery surface. Subsurface materials can vary from pure sand to coarse gravel over short distances. Potential source of granular construction material. High earthwork quantities in route construction. Steep road grades. Low erosion and frost susceptibility	Generally favouable terrain. Main limiting factors in construction of transportation systems include high earthwork quantities and locally dense concentrations of surface boulders.

10	tMH, tME	Till mounds and ridges	Irregular topography; commonly conspicuously hummocky or ridgy	Very bouldery till; silt, sand, gravel inclusions locally	Generally coarse, well drained, moderately to highly permeable tills having a high boulder content. Irregular hummocky to ridgy relief, necessitating heavy earthwork quantities. Steep grades. Mostly high bearing capacity, low compressibility materials. Good all-weather workability	Often difficult construction because of relief and excessive boulder conditions. Fairly favourable if relief is not excessive
11	tMG	Till plain	Undulating to rolling; locally drumlinized	Bouldery, silty to sandy till	Generally high bearing strength, low compressibility (settlement of structures), moderately permeable till. Generally well drained on slopes. Closed basins (hollows) are often wet and contain organic material. Easily excavated except for larger boulders. Suitable fill borrow. Slopes generally stable. Good all-weather workability. Commonly high boulder content. Good compaction with close control of moisture	Generally suitable terrain for light construction. Excavation capability may be limited due to the relatively shallow depth to bedrock and the occurrence of large boulders

12	tMG/R	Discontinuous till veneer over bedrock	Irregular topography; frequent bedrock knobs; commonly drumlinized	Thin and patchy bouldery till over bedrock; frequent rock outcrops	Good bearing strength and low compressibility. Generally good foundation materials. Typically poor (irregular) topography and many rock outcrops (frequent blasting). Steep grades. Usually very bouldery surface. Depth to bedrock commonly less than 1 to 2 m. Excavation quantities and costs may be high. Characteristic drained highs and wet organic hollows	Generally unfavourable terrain. Relatively strong foundation materials at shallow depths. Earthwork costs are usually high (blasting) when constructing most types of transportation systems
13	RN, RR, RP, RL	Bedrock knobs, ridges, plateaus, plains	Mostly moderate to high irregular relief; locally with cliffs, scarplets, crevices	Harder rocks usually occur as knobs and ridges; softer rocks usually occur beneath hollows and flat areas	Mostly irregular relief, including cliffs, scarps, crevices, and jagged surface locally. Difficult and costly excavation (high quantities, extensive blasting, seepage). Costly transportation route (pipeline, road, railway, airfield, waterway) construction	Generally unfavourable terrain. Good foundations for heavy structures. Poor construction qualities for high class transportation systems because costly blasting required with earthwork

TABLE 2: RATING OF TERRAIN GROUPS FOR LIGHT CONSTRUCTION CAPABILITY

PRINCIPAL LANDFORMS AND SURFACE MATERIALS	SIGNIFICANT PHYSICAL PROPERTIES OF TERRAIN GROUPS	Engineering and Construction Use Suitability (Good, Fair, Poor)*														Land Use Planning Hazards or Constraints (Low, Moderate, High)*				
		Vertical and horizontal route alignment	Overland accessibility and trafficability	Suitability for earth dams and dikes	Potential source of high quality aggregate	Potential source of low quality aggregate	Construction workability in wet weather	Foundation quality for heavy structures	Foundation quality for light structures	Excavatability of earth materials	Drainage ditch and canal construction	Underground pipeline and cable construction	Likelihood of small earthwork quantities	Septic system waste disposal	Surface water storage (unlined reservoirs)	Contamination of surface and groundwater	Flooding hazard from surface runoff	Possibility of high water table position	Slope stability hazard (slides, flows, falls)	Soil erosion potential on fresh man-made cuts
Group 1: Organic plain: peat and muck (pOT)	Level to depressional, high water table, low bearing strength, low to very low permeability, high compressibility, subject to flooding	G	P	P	P	P	P	P	P	P	P	P	P	P	P	H	H	H	L	L
Group 2: Colluvial slopes and rubbly beaches: (rCT, CW, rLB)	Steep slopes and sloping beaches, active soil creep except on rLB, low frost susceptibility, low shrinkage, low plasticity, moderate to high permeability, variable compressibility	P	P	P	F/G	P	G	P/G	P/G	F/P	P	P/F	P	G	P	H/M	L	L/M	M/H	L/H

Group 3: Alluvial plain: sand, silt, minor clay, gravel, cobbles and boulders; variable texture (msAP, mAP, sgAP)	High water table, high permeability, high strength, variable relative density, low compressibility, high to medium frost susceptibility	G	F	P/F	P	F/P	P/F	P	P/F	G	P	P/F	G/F	G/F	P	H	H	H	L	L
Group 4: Sand ridge: fine to medium sand, minor silt in dunes and abandoned beaches (sLB)	Low unconfined strength, low to medium relative density, non-plastic, non swelling, generally not frost susceptible	G	G	P	P	G	G	G	G	G	P	G/F	G	G	P	H	L	M	L	L
Group 5: Sand plain: sand, minor silt, fine gravel (sGO, sLD, sLP, smLP)	Well drained, nonplastic, high shear strength and permeability, low compressibility, moderate to high bearing capacity, low frost susceptibility	G	G	P	P	G	G	G/F	G	G	P	G/F	G	G	P	H	L/M	M/H	L	M
Group 6: Silt plain: silt, fine sand (msLP)	High frost susceptibility, moderate to low permeability and compressibility, low shrink and swell potential, moderate to high shear strength, nonplastic to low plasticity	G	G	F	P	P	P	F	F	G	F	G	G	F/P	P	L/M	M	M	L/M	M/H

Group 7: Clay plain: clay, mostly highly plastic; minor silt, cobbles, boulders (cLP, cmLP)	Highly plastic, high shrink and swell potential, poor internal drainage, low bearing strength when wet, low permeability	G	G	G	P	P	P	P	P	G	G	G	G	P	G	L	L/H	L	L	L/H
Group 8: Sand and gravel plain: sand, gravel, minor silt, cobbles, boulders, (sgGO, sgLD, sgLP, gsGO)	Low compressibility, high permeability, good internal drainage, high shear and bearing strengths, stable in slopes	G	G	P	G	G	G	G	G	F/G	P	F/G	G	G	P	H	L	L/M	L	L
Group 9: Sand and gravel ridges and mounds: sand, gravel, minor silt, surface boulders or till (sg and gs GD, GK, LB)	Low compressibility, high permeability, good internal drainage, high shear and bearing strengths, stable in slopes	P/F	G/F	P	G/F	G	G	G	G	F/G	P	F/G	P	G	P	H	L	L/M	L	L
Group 10: Till mounds and ridges: very bouldery till; silt, sand, gravel inclusions locally (ts and tm MH, ME)	Moderate permeability, low to moderate internal drainage, low compressibility, high shear and bearing strengths, moderate frost susceptibility, low shrink and swell potential	P/F	F	P	P	F/G	F/G	G	G	P/F	P	P/F	P	F	P	H	L	L	L	L

Group 11: Till plain: bouldery silty to sandy till (ts and tm MG)	Low permeability and compressibility, low plasticity and shrink and swell potential, good internal drainage on rises, high bearing strength	G	G	F/G	P	P	G/F	G	G	G	F	G	G	P/F	F	L/M	L	L	L	L
Group 12: Discontinuous till veneer over bedrock: thin and patchy bouldery till over bedrock; frequent rock outcrops (tsMG)	Variable permeability and water table position, low shrink and swell potential, high shear and bearing capacity	P/F	P/F	F	P	P	P/G	G	G	P/F	P	P	P	P	P/F	L/M	L	L/M	L	L
Group 13: Bedrock knobs, ridges, plateaus and plains (RN, RR, RL, RP)	Variable water table position, high compressive strength, variable permeability dependent on fractures in rock	P	P	P	G/P	P	G	G	G	P	P	P	P/G	P	P	L	L	L	L	L

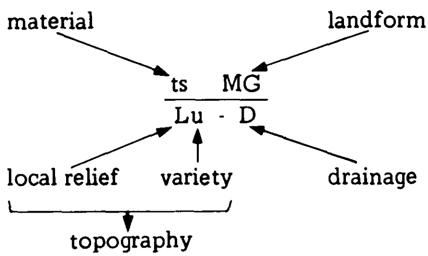
*Rating combinations such as F/G and L/M read fair to good and low to moderate, respectively.

5.0 APPENDIX: EXAMPLES OF TERRAIN UNIT LETTER CODES:

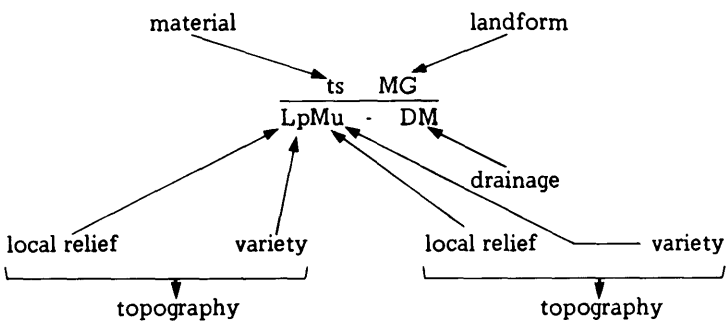
The engineering terrain unit letter codes consist of four components: surface materials, landform, topography, and drainage. The format of the letter codes used in describing the terrain units is discussed in detail in the Users' Manual (Gartner, Mollard, and Roed 1981). Some additional examples of the letter codes are as follows:

5.1 SIMPLE TERRAIN UNIT:

Example 1:



Example 2:

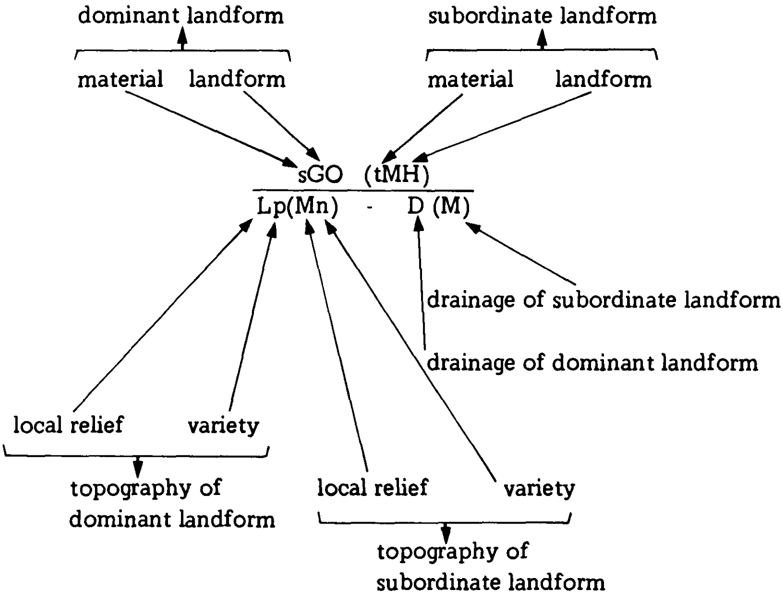


Note: The above type of letter code is used where there are two distinctly different types of topography and/or drainage in a simple terrain unit.

5.2 COMPLEX TERRAIN UNIT:

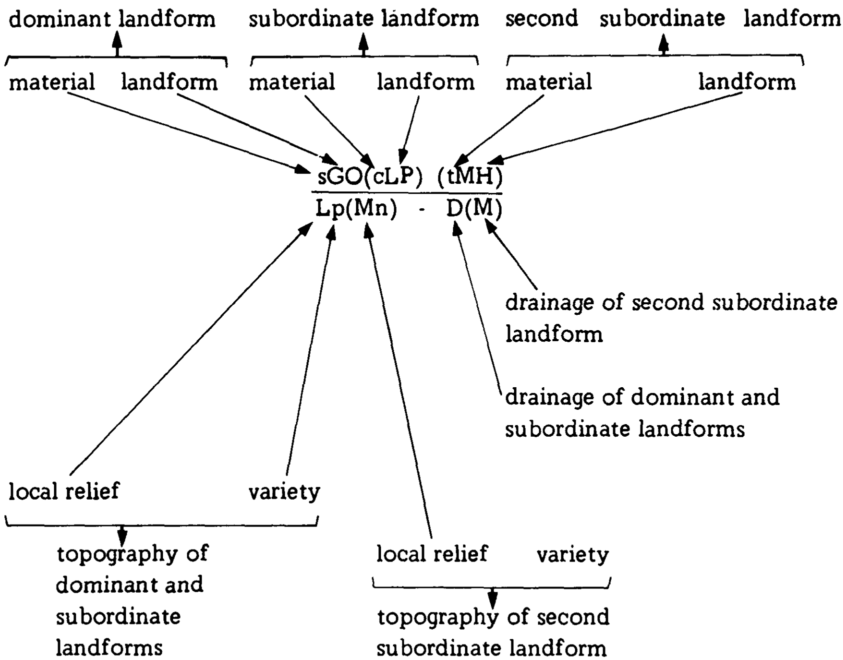
In complex areas, the dominant landform is shown first and the subordinate landform(s) appear in parentheses.

Example 1:



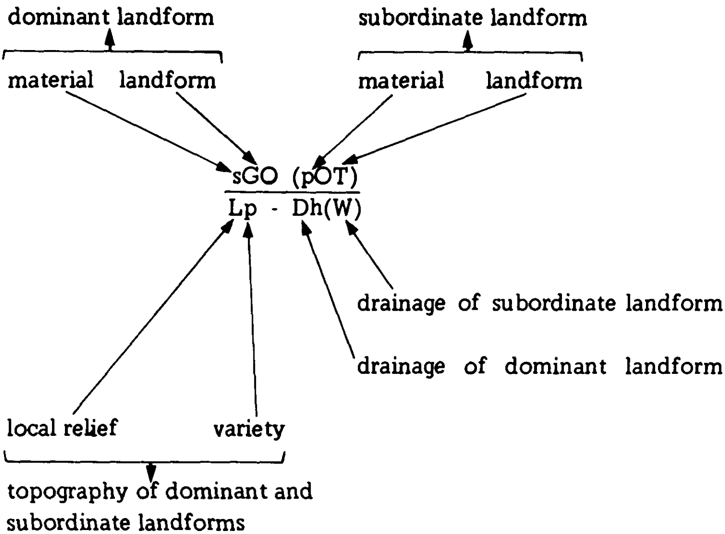
Note: The topography and drainage in parentheses refer to the landform shown in parentheses.

Example 2:



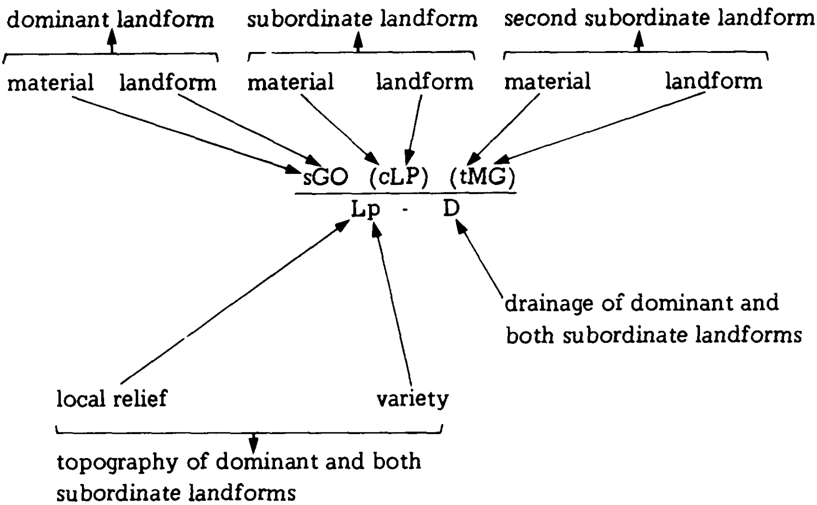
Note: The topography and/or drainage in parentheses refer to the second subordinate landform (in parentheses).

Example 3:



Note: If topography or drainage is similar in the dominant and subordinate landforms, then no topography or drainage symbol is shown in parentheses and the symbol shown applies to both landforms. If topography or drainage conditions are different in one of the landforms, a topography or drainage symbol is shown in parentheses to indicate this difference.

Example 4:



Note: Where topography and drainage conditions are similar in all of the landforms shown, no topography or drainage symbols are placed in parentheses.

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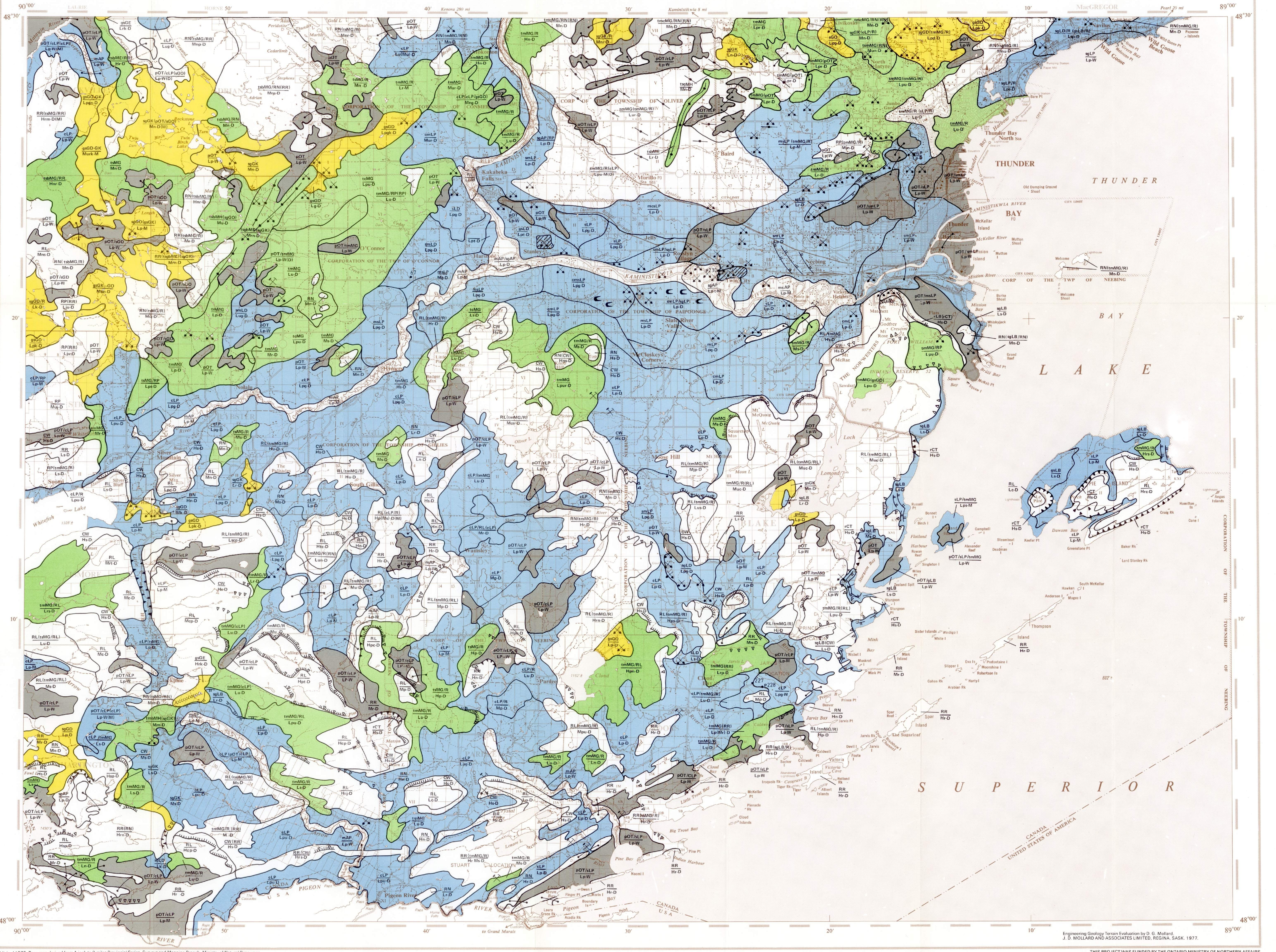


Ministry of Natural Resources
Ontario
Hon. James A. C. Auld
Minister
Dr. J. K. Reynolds
Deputy Minister

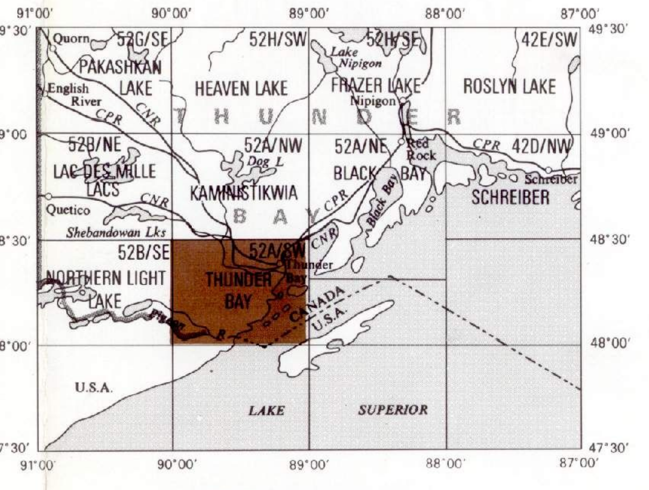
Ontario Geological Survey
Map 5047

Northern Ontario Engineering Geology Terrain Study

Data Base Map

THUNDER BAY

NTS 52A/SW



INDEX TO ADJOINING SHEETS

1:100 000

One centimetre represents one kilometre

ENGINEERING TERRAIN LEGEND

The legend comprises four main components arranged as follows:

MATERIAL	LANDFORM
TOPOGRAPHY	DRAINAGE

Examples:

1. tMG(RN) / Mu(Hj)-D — material; dominant landform; subordinate landform; drainage; relief of subordinate landform; topographic variety of dominant landform; local relief

pOT/sGO / Lp-W — slash indicates a veneer of one landform overlying a second landform

LETTER SYMBOLS

MATERIAL

b boulders, bouldery
c clay, clayey
g gravel, gravelly
p peat, muck
r rubble
s sand, sandy
m silt, silty
t till

LANDFORMS

MORAINAL

ME End moraine
MG Ground moraine
MH Hummocky moraine

GLACIOFLUVIAL

GD Ice contact delta, esker delta, kame delta, delta moraine
GE Esker, esker complex, crevasse filling
GK Kame, kame field, kame terrace, kame moraine
GO Outwash plain, valley train

GLACIOLACUSTRINE

LB Raised (abandoned) beach ridge
LD Glaciolacustrine delta
LP Glaciolacustrine plain

ALLUVIAL

AP Alluvial plain

COLLUVIAL

CS Slope failure
CT Talus pile
CW Slopewash and debris creep sheet; minor talus

EOLIAN

ED Sand dunes

ORGANIC

OT Organic terrain

BEDROCK

RL Bedrock plateau
RN Bedrock knob
RP Bedrock plain
RR Bedrock ridge
/R Bedrock below a drift veneer

TOPOGRAPHY

LOCAL RELIEF

H Mainly high local relief
M Mainly moderate local relief
L Mainly low local relief

VARIETY

c channeled
d dissected
j jagged, rugged, cliffed
j* cliffy volcanic rock signature
k kettled, pitted
n knobby, hummocky
p plain
r ridged
s sloping
t terraced
u undulating to rolling
w washed, reworked
g gullied

DRAINAGE

SURFACE CONDITION

W Wet
D Dry
M Mixed wet and dry
h Suspected high water table

GRAPHIC SYMBOLS

- Major end moraine (symbol located over ridge crest if present)
- Well expressed drumlins and drumlinoid ridges
- All other linear ice-flow features
- Esker ridge (continuous, discontinuous; the symbol does not indicate direction of flow)
- Abandoned shoreline (continuous, discontinuous)
- Local dune area (type and location of individual dunes not indicated)
- Abandoned river channel, spillway, or ice marginal channels
- Escarpment
- Small landslide scar
- Sand or gravel pit
- Quarry or mine workings evident from airphotos or field observation (crossed picks are shown in the area of open excavation)
- Other man-made features (rock dumps, tailings, lagoons, landfills, etc.; type of feature mentioned where identifiable)
- Steep-walled valleys, often bedrock-controlled features (continuous, discontinuous)
- Talus (defined, inferred; base of talus triangle indicates downslope side of escarpment)
- Line joining the same terrain units

NOTE 1:

This map is a landform inventory that provides base data for engineering and resource planning. Accuracy of terrain unit boundaries is consistent with map scale. Detailed investigations are required to obtain site specific geotechnical information. Refer to accompanying report for more detailed terrain descriptions and engineering significance.

NOTE 2:

Colour is used to highlight only glaciolacustrine, glaciofluvial, morainal and organic landforms. In the case of layered or complex terrain units, colour is used only if one of the above noted landforms is dominant from an engineering viewpoint in the terrain unit.

NOTE 3:

Not all letter and graphic symbols shown in the legend necessarily appear on this map sheet.

Reference to this map is recommended as follows:

Mollard, D. G.

1979: Northern Ontario Engineering Geology Terrain Study, Data Base Map, Thunder Bay. Ontario Geological Survey, Map 5047, Scale 1:100 000

Engineering Geology Terrain Evaluation by D. G. Mollard, J. D. Mollard and Associates Limited, Regina, Sask. 1977.

Published 1979. Base map derived from 1 inch to 2 miles Provincial Series, Surveys and Mapping Branch, Ministry of Natural Resources.

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Ministry of Natural Resources
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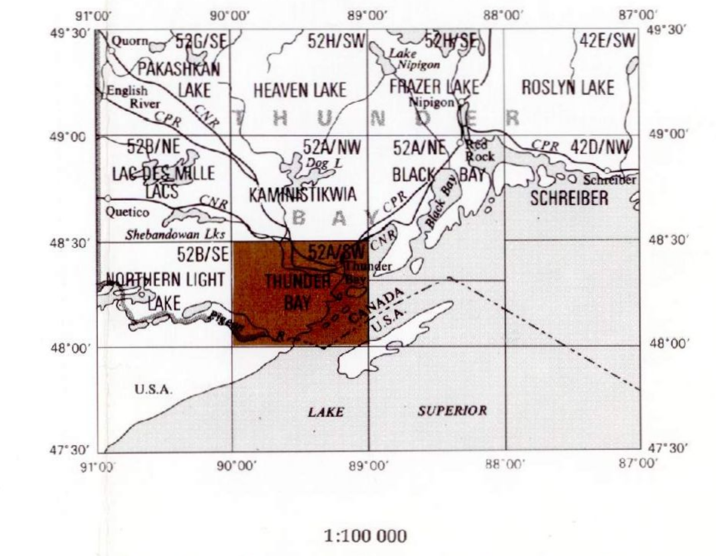
Ontario Geological Survey
Map 5048

Northern Ontario Engineering Geology Terrain Study

Light Construction Capability Map

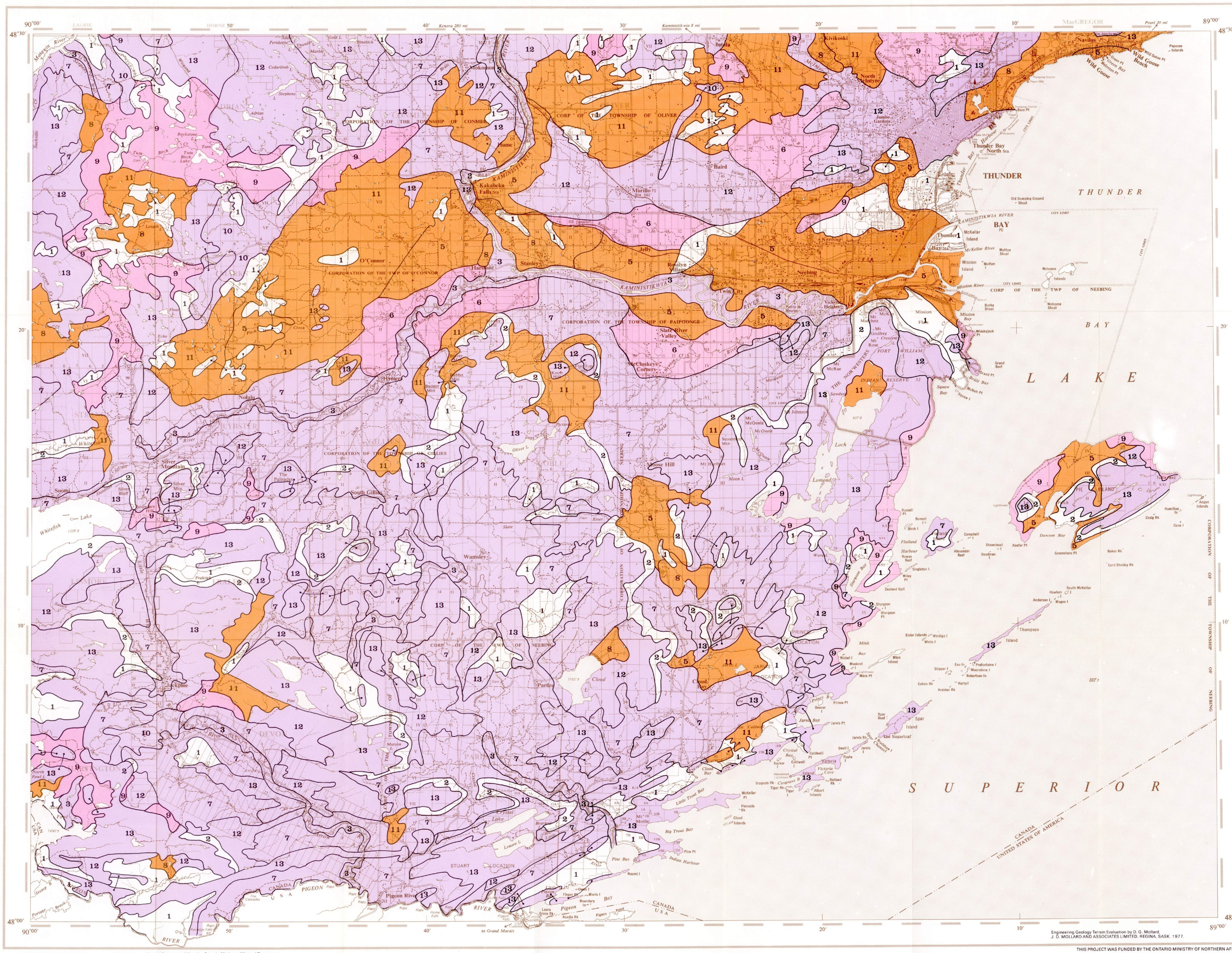
THUNDER BAY

NTS 52A/SW



1:100 000

One centimetre represents one kilometre



LIGHT CONSTRUCTION CAPABILITY MAP LEGEND*

GOOD (includes Terrain Group nos. 4, 5, 8 and 11).** Favorable terrain for all shallow foundation structures and some deep excavations. Main limitations include poor compaction qualities of clean sands on unimproved road subgrades, shallow depth to bedrock in group 11, and the risk of a high water table in depressions.

FAIR (includes Terrain Group nos. 6 and 9).** Generally favorable terrain. Suitability is limited by local concentrations of large boulders and by high water tables in fine grained soils. Excavations required in esker ridges may increase earthwork costs.

POOR (includes Terrain Group nos. 3, 7, 10, 12 and 13).** Generally unfavorable terrain. Suitability is limited by erosion and flooding hazards, high variability of soil materials and excessive earthwork costs due to blasting required in bedrock terrain.

UNSUITABLE (includes Terrain Group nos. 1 and 2).** Unsuitable due to high compressibility of materials in swamps and unstable slopes in talus areas.

*See Tables 1 and 2 in accompanying report for additional detailed information.
**For detailed descriptions of Terrain Group characteristics see Tables 1 and 2 in accompanying report.

Information from this publication may be quoted if appropriate credit is given. Reference to this map is recommended as follows:

Mollard, D. G.

1979: Northern Ontario Engineering Geology Terrain Study, Light Construction Capability Map, Thunder Bay. Ontario Geological Survey, Map 5048, Scale 1:100 000

Engineering Geology Terrain Evaluation by D. G. Mollard,
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