QUARTERNARY GEOLOGY OF THE NORTH KLONDIKE AND UPPER BLACKSTONE RIVER SYSTEMS, SOUTHERN OGILVIE RANGES, YUKON TERRITORY, CANADA - DEMPSTER HIGHWAY (KM. 0-139).

SUPPLEMENTAL TERRAIN CLASSIFICATION, SENSITIVITY AND ENGINEERING LEGEND
TO ACCOMPANY GEOLOGICAL SURVEY OF CANADA, OPEN FILE 478.

(MAP OF THE ABOVE TITLED AREA)

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Notes:

1. The surficial geology map (Open File 478) is part of a MSc thesis completed at the University of British Columbia, Vancouver, B.C., entitled:

QUATERNARY GEOLOGY IN THE SOUTHERN OGILVIE RANGES, YUKON TERRITORY

And

An Investigation of Morphological, Periglacial, Pedological and Botanical Criteria for Possible Use in the Chronology of Morainal Sequences.

The thesis was writen by Karl Edwin Ricker and is obtainable on inter-library loan from the Main UBC Library under call number: LE3, B7, 1968, A67, R53, C1 or C2. Those copies, and another copy filed at the Department of Geological Sciences Library, are complete with a coloured 1:50,000 scale surficial geology map. The departmental copy is available for perusal only within the confines of the library itself.

2. Other copies of the thesis, with only blackline prints of the 1:50,000 scale surficial geology map, are housed at the following libraries:

Geological Survey of Canada, Vancouver and Ottawa libraries - inter-library loan service is negotiable.
Scott Polar Research Institute, Lensfield Road, Cambridge, Great Britain.
Simon Fraser University, Department of Biology, Burnaby, British Columbia.
Dominion Soil Survey, Canada Department of Agriculture, Vancouver, B.C.
Arctic Institute of North America, Library Tower of the University of Calgary, Calgary, Alberta.

3. At the time the project was undertaken, 1964, the main thrust of the study was directed to the investigation of various ages of Pleistocene moraines in the study area. Field characteristics of each age of moraine were assembled for the purposes of attempting to establish reliable criteria for the assessment of their relative chronology, rather than to collect data for engineering and environmental assessment purposes. As geomorphic and morphostratigraphic criteria were part of the assessment, a surficial geologic mapping program was carried out. This program did not have the benefits of preliminary terrain typing before commencement of the investigation; nor was drill hole data available at this stage of highway construction; and, unfortunately, the borrow pits and highway cuts had lost their fresh "facial" appearances, being several years old at the time of this investigation. Furthermore, the Dempster Highway as of 1964 terminated at km. 125 and only a variety of oil exploration winter tote trails extended to the north of the study area at that time. Nonetheless, a fair amount of data was gathered and much of it, as tabulated in the appendices of the thesis, is pertinent to the terrain sensitivity and engineering performance assessments of this present study. There are no plans to publish any part of the thesis in the forseeable future. This work preceded the era of refined terrain studies as generated during the Environmental-Social Program (Task Force on Northern Oil Development) of the Mackenzie Valley and North Slope programs. Because the focus of pipelining has now shifted to the Yukon, and a possible Dempster Lateral to connect Mackenzie Delta - Beaufort Sea hydrocarbons to proposed main gas trunkline of the Southern Yukon route, a further week of field review of the study-area was commissioned in 1977 in order to update the 1964 work towards the now used standards of terrain evaluation. The mapping covers about 25% of the total Dempster Highway distance between the Klondike and Arctic Red Rivers.

4. Since 1968, the Canada Dept. of Public Works has carried extensive surface and subsurface surveys and investigations of the Dempster route. Within the study area the bridge sites of Benson Creek (km 29.1), Wolf Creek (km 51.0), Grizzly Creek (km 59.4), North Klondike River (km 68.7), "Lil" Creek (km 78.5), East (Upper) Blackstone (km 87.5), "Foxy" Creek (km 92.4), West (Lower) Blackstone (km 117.0) and "Cache" Creek (km 131.1) have all been drilled with several test holes and this program was still underway in 1977. During 1974, a tightly spaced series of 188 test holes were drilled between km 96.5 and km 126.3 in preparation of Dempster highway improvement and relocation work. All drill records of a permanent nature are located in a very efficient library system at their Whitehorse offices. There remains yet a relative dearth of drilling information for the study area south of North Fork Pass (ca. km 80) because the granular nature of the valley floor does not impose the problems of thaw settlement or frost heave that exist to the north. During 1977, the highway was undergoing massive grade improvement between kilometres 1 and 65 and permafrost, where encountered, appeared as surficial lenses in depressional pockets, or on north facing slopes, in areas veneered or blanketed by black organic silt ("muck"). Many of the old borrow pits were enlarged in this program, or if exhausted, contour landscaped, thus rendering them no longer useable for geologic observation. Other new pits were being opened up; therefore, the surficial geologic map is no longer accurate with regard to the delineation of developed aggregate resources. This revised legend draws upon all new sources of information, whether gathered by others in tedious drill records or by direct observation in 1977. All sources of data have been plotted on a common map and the accompanying records and notes are on file with Dr. O.L. Hughes at the Calgary office of the Geological Survey of Canada.

5. The abbreviated 1977 field season represents the first opportunity to "ground truth" or field check the surficial geologic map compiled between 1964 and 1967 (Open File 478). Basically few disagreements were found, though the evolution of surficial geologic mapping since that time would lead to many revisions should it become necessary in the demands of design engineering requirements. A few errors or revelations that warrant comment are as follows:

Unit 7d (flood plain deposits) - in the case of the Blackstone and North Klondike valleys, the unit also includes flights of lowly elevated terraces (Unit 7i) above the levels of climax flooding, that are not recognizable on aerial photos because of vegetated canopy interferences. Thus, Unit 7d should read 7d + 7i in many cases.

Unit 6c (rock glaciers) - those adjacent to the highway (on the west side of the Blackstone River valley) on the north edge of the map area are more likely to be protalus flatirons (Unit 7e) though gradations between the two forms are to be recognized throughout the Northern Cordillera. The rock glacier on the opposing east valley wall is only partially active, and elsewhere this distinction between "active" and "dormant" must be likewise recognized as possibly meaning only "partially active".

Unit 4e (fans - Early Post-glacial) as opposed to Unit 7a (modern fans) - the presence of a frontal scarp is usually diagnostic of the former. In the case of the one 0.5 km north of Ying Yang Creek (North Klondike Valley) the Unit 7a should be re-typed as Unit 4e. The same error exists with the fan located 3.5 km NE of Grizzly Creek bridge (North Klondike Valley). The fan (7a) immediately N of Grizzly Creek is of mixed origin and thus a cross hatch pattern should have been used on the map.

Unit 4a (terraces - Early Post-glacial) - the distinction between this type of terrace and outwash terraces associated with deglaciation (Unit 3e) is often arbitrary but for those of the North Klondike Valley at the "Linta Creek" tributary the very silty nature of the gravel suggests that designated Unit 4a be revised to read Unit 3e.

Unit 8 (mixed facies) - the square hatch pattern indicates a thin veneer of transported material and invariably denotes the presence of permafrost on flat surfaced landforms. Where the Unit 8 is shown instead of the hatch pattern, the deposit is actually a till in many cases, covered by a masking veneer of organic silt - especially on flat landforms (e.g. between Scout Car and Grizzly Creeks).

6. The thickness of permafrost in the study area is not known. In the Blackstone River Valley the drilling programs did not penetrate the entire zone at a bottom hole depth as great as 32 metres and consultants to DPW believe that the total thickness may easily exceed this figure by three fold. Taliks, if present in the Blackstone Valley, are probably thick and of little consequence in engineering or environmental concerns for most of the region. The exception to this state of affairs is the stratigraphic successions of a frozen peat and silt overlying well drained gravelly stratum (the latter may be in Pf as well, at great depth). Two drill holes near km 100 suggest that thick seasonal taliks will develop but the drilling program on the whole indicates that the active layer, in mid September, reaches a maximum thickness averaging 120 cm. though some tussock covered areas had only a 15 cm. thick zone. In early August of 1977 the active layer averaged about 50 cm. in development for the Blackstone Valley area.

For the North Klondike valley the limited drilling data and civil structures suggest that, for granular areas at least, the depth to permafrost is at least 10-11 metres, if present at all, and the zone of permafrost exceeds 18m. of depth in the hole near the North Klondike bridge. Downvalley, lenses of permafrost (or pereletoks) of 120 cm. thickness overlie till, which in some areas is itself ice-free, in the upper zones exposed by construction operations. Thus, it would appear that much of the Klondike valley lies in a thick talik zone or is permafrost-free altogether. Therefore, in view of this ground temperature regime, the already occurring problems of icings, and the granulometry, a gas pipeline should operate in the warm mode of flow for the region south of North Fork Pass.

7. The process of icings is very prevalent throughout the study area. The greatest thickness (4 - 5m.) of aufeis (naleds), in 1964, were noted at the "Lil" Creek and Upper (East) Blackstone River crossings, and great expanses of ice of 1 - 2m. thickness perennially develop at the junction of "Lil" Creek to the North Klondike River, as well as on the Blackstone River adjacent to Chapman Lake. Upon exit into the North Klondike Valley, the change of gradient of many tributaries enhances much aufeis development each winter; problems are encountered by the highway maintenance crew almost routinely at Pea Soup, Scout Car, Grizzly and especially Wolf Creek. Apparently, many road cuts along the entire length of the North Klondike Valley initially provided icing problems, but corrective measures in drainage and other methods, over the years, have stymied such activity.

On the Blackstone River system, the reach between the upper bridge crossing and Foxy Creek (km 87.0 to 92.4) generates copious aufeis on an annual basis. Elsewhere, the road maintenance crew cannot recall any particularly troublesome areas.

8. Unusual flood activity is apparently confined to a few locales of the Blackstone system. "Cache" Creek (km 131.1), and neighbouring creek to north (km 133.0), flash flood with little warning during the late spring to early autumn period of the year. "Cache" Creek backs up a substantial temporary lake behind the high road embankment. "Henry" Creek (km 108.6) also develops an unusual peak flow during the spring runoff and backs water upstream from its road culvert(s). During the 1964 climax year of flooding nearly all culverts and bridges on the Dempster were in trouble. After a cold spring which left culverts and bridges filled with aufeis, a sudden warm spell created a deluge of runoff water which overflowed or ripped out the artificial crossings. Decaying aufeis was either breached or bypassed by flood waters and thus modified the previously established channel configurations in some instances. Prior to 1964, the initial alignment of the Dempster (marked as a tote road on the surficial geology map at about km 84.5) was set on, and parallel to, the East Blackstone Floodplain upstream of the present-day bridge (km 87.5) Much of this section of the road was washed out during the first runoff period that followed construction.

9. Finally, during the preparation of the surficial geology map in 1964-1967, the 1:50,000 topographic maps (NTS 116B/9 and 116B/16) were not available. Therefore, contours and summit spot elevations on the north half of the surficial geology map are only approximate. Trig.Stn. 1440 m. ("Geodesy Dome") was misplotted in error, and should really fall onto "Chapman Hills" at a point about 8 km. north of where it is shown, on a bearing of 013°.

DESCRIPTION OF TERRAIN UNITS

MAP UNIT	GEOLOGIC NAME OF UNIT	TOPOGRAPHIC CHARACTERISTICS	TEXTURE, MOISTURE AND THICKNESS	PERMAFROST, GROUND ICE ACTIVE LAYER, DRAINAGE, and THAW SEASON	HAZARDS	SOURCES OF CONSTRUCTION MATERIAL
1A	Terminal (End) moraine	Arcuate gently rolling ridges arranged in corrugate pattern with mod. to high (30m.$\pm$) relief.	Loose to compact indurated sandy to silty gravelly till, no stratification or size sorting, thickness exceeds 14m. in one borehole at km 87.5. Alpine turf cover in the N.Klondike basin while peat or tussock sedge is much more common in the E. Blackstone system. Plasticity is low at km 88.2 test hole.	Pf is beyond range of normal excavation, if present at all in the N.Klondike basin; and drainage is therefore mod. to well developed as evidenced by the late seasonal dryness of pond basins. Pf is ubiquitous in the E. Blackstone drainage and maximum thickness of active layer appears to be only 45 - 50 cm; drainage is generally very poor.	Variable stability: within thermal bulb on river, 37° slopes are stable; elsewhere in the presence of permafrost, minor retrogressive slumps occur along road cut excavations. Thermokarst activity at some ponds on morainal surface in the Blackstone drainage; as well as along ice wedge patterns.	Moraines in the N. Klondike drainage basin are sources of fill material. In the E. Blackstone drainage, high ice content limits the usefulness.
1B and 2G	Lateral moraine and recessional moraine	Isolated elongate ridges or benches with irregular to tapered low relief.	No test drilling of these units to date. Moderately indurated till which is silty in the Blackstone drainage basin and sandy in the North Klondike basin. Landform expression probably includes "in wash" of exotic sediments. Covered by tussock sedge.	Permafrost appears to be present though local absence in ridgelike exposed portions to be expected (e.g. km 86.9). Springs and aufeis visible between recessionals to SW of East Blackstone bridge.	In the presence of Pf, ground ice slumps, thermokarst at ponds, and flow slides are to be expected on silt-rich tills.	Generally a poor source of aggregate because of high ice content, but local exceptions on exposed ridges offer a bouldery till.
1C and 1D	Ground and drumlinoid moraine	Flat to gently rolling or billowy sheets, or whaleback ridges with or without grooved relief. Relief is moderate (20 m.) to low except on drumlins. Natural slopes are usually less than 10° though local steepening at pond margins is quite common.	Tills are sand rich on the N. Klondike Valley, and silt-rich (low plasticity) of unstable nature in the Blackstone Valley. Drumlins are well indurated areas. The N. Klondike areas are generally covered by a thick moss matt with local "muck" pockets, whereas the Blackstone tills are covered by reworked silts, peat, fen, and tussock sedge to thicknesses of 5 metres or more. Thicknesses of till are generally 1 to a few metres, but many test holes did not penetrate the total thickness of the till unit(s).	South of North Fork Pass (km 81), till sheets are often dry and devoid of Pf if not under a forest canopy. Under a forest cover, Pf presence is guaranteed if a thick moss matt, or if a northerly aspect; in early August, the active layer is less than 45 cm. thick, often in overlying organic muck. Recent degradation of permafrost has been generated by forest fires. North of North Fork Pass tills are in permafrost excepting near river edges. Ice wedge polygons, thin to thick (1.4 m) ground ice lenses, and solifluction features are common. Moisture contents to 139% of dry weight; generally the drainage is very poor with the	South of North Fork Pass, road cuts in Pf undergo minor retrogressive flow slides or slumps. On dry faces 35° slopes are stable though susceptible to gullying or rill wash. In the Blackstone drainage thermokarst activity is common, ground ice slumps and detachment flow slides of the active layer are present, gullying takes place along river escarpments. The largest land slide risk is now developing at km 119.1 on an escarpment overlooking the Blackstone River. Dry river facing slopes of 20 m. height stand at 30 - 35°.	South of North Fork Pass till is scraped and excavated as road fill. High ice content, silty organic cover and permafrost conditions preclude such use to the north of the pass though river escarpments could be utilized as local sources for minor requirements.
1E, 2A, 3E, and 3C	Outwash - proglacial, proximal, distal; terraces kettled.	Fan, apron and prism-like terrace features of flat to slightly convex relief; river edge escarpments up to 10 m.; with or without pitted or channel rilled surfaces. Surface slopes 1 - 5°.	Poorly sorted to well sorted gravels, silty sandy gravels, and gravelly sands; loosely packed; with sporadic presence of boulders, usually with a veneer of loess or reworked silt.	South of North Fork Pass - well drained, relatively dry ground surface, rare Pf island under thick forest canopy and moss matt. North of the pass, permafrost is usually present unless near thermal influence of water. Covered by palsa bog, tussock sedge, reworked loess that are encased in Pf up to 2 m. in thickness. Thickness of active layer is 30 - 60 cm.	River edge escarpments of 10 m. height can be stable on 40 - 45° slopes. Uneven settlements and scarp retreat at km 125.7.	Excellent gravel and sand resource in the North Klondike Valley; frozen organic veneer and excessive cobbles and boulders limit usefulness in the Blackstone drainage though stripping of veneer and consequent drying of the gravels can be employed.
2B, 2C, 2D, and 3F	Meltwater channels and associated rill deposits.	Straight to sinuoidal or serpentine channels of steep walls of low (1½ - 3°) to moderate axial gradients. Cross valley profile varies from broad U-shape (300 m.) to narrow V-shape (10 - 20m.), with slopes of 30°($\pm$).	Floored by either till with a lag veneer of gravel or thick wedge of poorly sorted gravel; veneered occasionally by ponded or organic silts. Channel walls in till, outwash gravels or bedrock.	Channels may or may not be floored in permafrost - shade is a requirement for Pf development as is the presence of either a thick moss matt or sedge tussock. North facing walls of channel are usually in Pf. North of the pass, drilling reveals excess ice in silty organic veneer lying over gravel in one hole, but absence of Pf to 2½m. depth in another.	Local degradation of Pf may induce minor detachment slides on slopes, but none were noted in the field examination.	Confined working area, and veneer thicknesses of aggregates in them, suggest only minor reserves. One such pit was developed at km. 124.4. Permafrost also inhibits any large scale developments.
2E, 2F, 3A, and 3B.	Kame deposits, hummocky or ablation moraine deposits, eskers and crevasse deposits.	Elongate prisms, irregular hummocky sheets or mounds, irregular ridge crests with anastomosing or reticulate pattern of moderate to high (50m.) relief. Surface pitted to hummocky to smooth. Slopes 0 - 20°.	Poorly sorted coarse gravel and till, loosely packed, except in the case of eskers where clean, cross-bedded sandy gravels may be present (not exposed in field examination). Thicknesses are variable (1 - 50 m.) and veneers of silt are not uncommon.	Features of the North Klondike valley appear to be free of permafrost and are well drained. In the Blackstone basin, Unit 2F is generally free of Pf in the upper few metres but varying thicknesses of onlapped organic bogs and reworked silt can raise Pf to within 3 m. of the ground surface. Underlying till with ice wedges at both the North Fork Pass and Chapman Lake moraines.	Cavernous hollows develop in borrow pits due to melting out of underlying ice wedges. (e.g. pit at Km. 118.6). At river edge, debris avalanches or flow slides on 41° slope where toe support is removed by lateral erosion. 45° slopes in pits are stable as are 36° slopes on natural river bank exposures.	These features provide excellent gravel aggregates but where thin (less than 10 m) the underlying Pf regime is disrupted. Thus small hummocky areas are to be avoided.
3D	Glacio-lacustrine deposits	Flat to gently rolling sheets, with pits or thermokarst pond depressions. Overlain by peat bogs, till sheet(s) or fan(s) at some localities. Unstable escarpments near Chapman Lake. Not ubiquitous in regional occurrence and yet to be recognized on the North Klondike Valley.	Varved well sorted beds of fine sand, silt and clay; semi-indurated; cohesive; unstable; low plasticity; thicknesses variable, but over 30 m. at Chapman Lake area, and thinner horizons of silt of unknown origin found in some drill holes at "Two Moose Lake" area, and as thin as 1½ m. upstream of E. Blackstone Bridge.	Can be in Pf in non-excess ice condition (moisture = 30%) but usually the beds are in a very segregated ice-rich condition, with up to 3.35 m. thick ice lenses at Chapman Lake. Pronounced thermokarst activity accounts for origin of Chapman Lake. Thermal influence of Blackstone River, and southerly exposure, has brought about withdrawal of ice-rich condition on exposed escarpment. However, upper E. Blackstone River exposures reveal ice-rich silt overhanging the flood plain.	Thermokarst slumping on steep (50°$\pm$) slopes. Unfrozen ground is soft and erodible. Undercutting action of river brings about slumping (in 1 - 1½ m. wide elongate blocks) as shown at km. 118.1. Continuance of slumping here will eventually segment road and drain Chapman Lake.	No source of granular material and unsuitable for use as fill.
4A and 7I	River terrace deposits	Elongate prisms, flat surface without pits, appearing as benches above river courses. Unit 7I forms are with low escarpments (2 - 3 m.) and are of modern vintage. Includes organic silt, peat and tussock sedge veneers. Flights of low terraces on broad fluvial plains.	Loosely packed, clean to sandy gravel with minor lenses of silt and occasional boulder to 2 m. in diameter. Older gravels of North Klondike valley are well oxidized and with rotten clasts at two BP localities. Thicknesses of older deposits as much as 6 m. or greater.	Pf is discontinuous with these units in both the Blackstone and North Klondike Valleys - i.e., vegetation canopy, thermal modifier and exposure controlled. Drainage percolation varies from good to poor dependent on presence or absence of surface silt veneer (and associated Pf or seasonal frost). If thick peat cover, even frozen gravels can contain 100% moisture. Water table can be less than 2 m. below surface on lowest terrace forms.	Degradation of Pf in surficial veneer of silt or organics, of local nuisance only. Banks are generally stable subject only to minor ravelling.	Exploration for gravel is excellent though in Pf area, the removal of the surficial veneer could create local siltation problems.
4E and 7A	Fans (and Bajadas)	Fan or apron-like surfaces with slight convex profile, silty-organic or turf veneer; frontal escarpment on Unit 4E forms. Slopes vary from 1 - 10° on lower reaches - steep upslope on valley wall localities.	Slightly bedded, poor to moderately sorted coarse gravel with a recognizable silt content; boulders or angular blocks prevalent; loosely packed. Fans on valley walls are of local lithologic origin whereas those emanating from glaciated valleys are of mixed lithology with higher percentage of rounded clasts.	Fans transected by permanent streams are usually void of Pf to depths greater than 16 m. - thus seasonal taliks are to be expected. Flowing ground water at km. 103.1. Elsewhere Pf is to be expected if the vegetation canopy lies on a thick organic silt veneer capping the landform. Drainage variable. Ice wedge polygons in Unit 4E in Blackstone valley.	Fans developed in local shale sources (e.g. km. 70) are soft; elsewhere the landform in the non-Pf environment is stable on even 45° faces. Where overlying organic veneers are thick, (e.g. "Ptarmigan - Caribou" Creek area) excessive settlements are to be expected.	In non-Pf areas of the N. Klondike valley, many fans with excess of coarse bouldery sizes providing excavation problems. Fans of Blackstone valley are more useable in this regard though Pf is a severe limitation in development. Use for fill purposes, but can be size-screened and washed.
5	Loess	Low relief sheets on underlying rolling to flat topographic forms (with reticulate patterns due to the common presence of ice wedge polygons). Smooth topographic appearance on aerial photographs. Commonly covered by peat bogs or tussock tundra sedge.	Well sorted silt and fine sand in the non-disturbed state, but often congeliturbated with organic horizons and underlying strata yielding chaotic structures and bedding patterns. Thicknesses vary from thin non-mappable veneers to blankets greater than 3 m. thickness on the Chapman Lake moraine. Slight plasticity and universally non-stable.	Pf is present below varying thicknesses of the active layer (where disturbed the active layer can be 3 m. thick). Drainage is poor to non-existent. Pf present as either visible or non-visible ice. Ice lenses to 75 cm. thickness recorded in the drilling of the Blackstone valley area.	Excessive downslope movement through solifluction processes; excessive settlements upon ground disturbance, and thermokarst induced retrogressive slumpage are all common to the characteristics of this unit.	Not suitable for construction purposes.
6A	Solifluction lobes	Festoons and sloping sequences of terraces or draped sheets on hillsides; hummocky, scalloped and downslope escarpments with low but distinctive relief (a few metres). Slopes vary from 5 to 30°. Ubiquitous in areal distribution.	Tilloid of silt to angular block mixes, somewhat tightly packed, dry to moist to saturated depending on time of year and portion of the feature being tested (proximal = dry, and distal edges being saturated in most cases).	Permafrost may be present in active forms and is probably present beneath the zone of movement in terrain underlying the active forms. Depth to Pf on inactive form at km. 85.2 is only 40 cm.	Active forms represent unstable sloped environment for any sort of construction; forms creeping over escarpments can cause catastrophic washouts. Inactive forms of high organic and silt content are subject to retrogressive slumping.	Inactive forms in permafrost-free state are usable as fill material.
6B 6E and 6F	Patterned ground, pingos and felsenmeere	With the exception of ice wedge polygons (see description of other map units) the scant lowland distribution of these forms does not warrant further explanation. In the case of construction on stony alpine ridges, felsenmeere is being used as an aggregate source, and upland patterned ground forms are being used as fill material, farther to north in Eagle Plain Basin and adjacent Richardson Mountains.				
6C	Rock glaciers	Tongue shape, spatulate aprons and lobate crenulated benches with convex, hummocky arcuate transverse ridges on distal portions; and longitudinal swell and swale form on the upstream portions. Relief varies from mod to high; overall slope ca. 20°; frontal slope is 37° and planar if active, and 10 - 20° (rounded) if dormant. Distribution is governed by presence and absence of suitable competent lithology, and aspect.	Rough angular blocks of competent rock with porous enclosing matrix of pebbles, grit and silt. Loose on surface but probably frozen at depth in the active forms. Angular blocks of quartzite up to 5 m. dimension on the minimal axis.	Permafrost is present in the dry (i.e. below 0°C.) mode and as intermittent interstitial ice or ice lenses in the wet mode for active forms. Permafrost regime in dormant forms is probably negative, or at least without the presence of interstitial ice.	There are no hazards on the Dempster Highway with rock glaciers; elsewhere construction on same yields creep problems.	Exceptional coarse rock of lower dormant lobes (km. 134.2 and 69.2) is usable as rip rap stock but abundant oversized blocks will require blasting techniques. However, esthetic considerations suggest that rock glaciers should not be utilized for such purposes.
6D	Peat bogs (and strangmoors or fens) and complexes of the two forms.	Flatiron to irregular to rounded basins with a hummocky or reticulate ridge and grater-like relief. Open surface water characterizes the strangmoor despite their presence on low profile slopes. Ubiquitous in the Blackstone Valley and rarely developed (and much smaller) in the N.Klondike valley.	Fibrous, wet (excess moisture) sedge overlain by sphagnum peat material both being highly compressible and of low strength in the unfrozen form. Palsen hummocks on bog are ice cored. Maximum recorded thickness is about 4 m.; overlying or mixed with inorganic silts and/or ice lenses; though characteristically, thicknesses are 1 - 2m.	Both forms are in permafrost though thickness of active layer on open water forms is greater than in the dry peaty forms (45 - 65 cm.) or on the palsen hummocks (10 - 40 cm). Often ice-rich and moisture content (by % dry volume) can exceed 700% (933% at km. 117.0).	Wet sites: material is compressible. "Dry" sites: vegetation disturbance also leads to excessive settlements. "Muck" veneers of North Klondike Valley "trap" all types of construction machinery.	Not suitable and requires thick gravel pad for construction thereon.
7D and 7B	Flood plain deposits and fan-head trenches.	Ellipsoidal flats connected by anastomosing and meandering ribbon like belts of channels; low gradient, though conspicuously incised in all major drainage systems to depths of 30 m. or less.	On inactive portions of the flood plain (i.e. the zone that is flooded in only climax runoff years), a stratified sequence of fine sand or organic silt (1 m.) overlying coarser sandy gravels, or gravel, is common. Active channels are typically coarse gravel with areas of boulders at gradient changes. Thickness of deposits can exceed 18.75 m. in the Upper North Klondike Valley and 16 m. at Upper E. Blackstone bridge.	With the exception of smaller creeks (e.g. Foxy Creek), Pf is probably absent to great depths beneath the active flood plain. However, inactive flood plains, where veneered in silt and tussock sedge, seasonal frost or pereletoks usually develop. A talik zone appears to exist in many areas - the depth to Pf being 1.5 to 11.6 metres. "Twisted" black spruce canopies suggest large Pf "islands" on the lower N. Klondike floodplain. Pf is much more prevalent in the Blackstone drainage. Icings are common occurrences on most broad active and inactive flood plains. Water table is close to ground surface on inactive portions of most flood plains.	The gravels are normally thaw stable; the overlying veneer of sand, silt and organics are unstable when thawed. Gravel faces are stable at 45° slopes on 2 m. high faces. Icings can encroach onto vegetated portion of inactive flood plain, and travel on aufeis can be dangerous due to the presence of large cavities. Spring runoff in climax years either lifts decadent aufeis and smashes civil structures or swirls laterally around the ice to create new channels. Construction on, or near, the active floodplain is to be discouraged.	Flood plains are by far the dominant sources of aggregate used to date in the construction of the Dempster Highway. Both active and inactive portions of the flood plain are used but use of the former is to be discouraged because of possible influence on channel shifting and consequent acceleration of erosion.
7E and 7C	Talus (or protalus) and cone deposits.	Irregular sloping sheets with or w/o basal elongate mounds, and steep coalescing aprons with convex or irregular hummocky surfaces. Occur on low to high gradient slopes exposed to rockfall from exposed rock faces. Slopes are usually 20 to 30° though toe of deposit can be less than 5°.	Loosely packed angular blocks, flags, and smaller rubble sizes of bedrock. Incompetent bedrock gives rise to talus of finer clast sizes. Coarse blocks exceed 3 m. in minimal axis measurement. Sizes tend to become finer to proximal position but exceptions exist.	As manifest by the presence of ice permafrost appears to be absent except on those protalus forms that are transitional to rock glaciers. Drainage is excellent on coarse zones but diminishes at contact to colluvium (Unit 8).	Rockfalls on coarse talus areas and gullying on finer talus slopes or cones. Avalanches are other possibilities.	Rubble of competent rock sources can serve as granular aggregate or rip rap. Less resistant rock types can be useful as fill.
7F	Lacustrine, and local ponded deposits (see also Unit 8)	Small flat ellipsoidal or irregular areas in areas of open water or where water is seasonally drained.	Humic silt or "muck" of low stability and high moisture content; cohesive; granular to edge of basin. Thicknesses are unkown but probably less than a few metres in all cases.	Permafrost probably present but beyond depth of practical probing except at locales of areal restricted extent. Some material is generated by peripheral thermokarst activity on pond edges. Poorly drained.	Compressible, excessive settlements, slumps, gullying, siltation of water courses, etc.	None.
7H	Landslides	Spoon-shaped depressions with tongue or lobe spatulate downslope toe; with transverse ridges and possible closed depressions; or upslope longitudinal furrows. Moderate to high relief. Rockslides of North Klondike valley with stepped appearance: 20 m. wide risers on 30° slopes, and 100 m. wide treads on about 9° slopes.	Slides in bedrock are of coarse blocks incorporating finer debris that lie on lower slopes. Slides in unconsolidated deposits are of tilloid character, with moderate to well-indurated compaction.	Permafrost may have invaded old rock slides (in the dry mode). Slides in unconsolidated deposits are commonly associated with permafrost or detachment of active layer from permafrost-bound sediments. Drainage of slide debris is variable - the toe of one North Klondike rockslide contains a pond whereas another is of coarse well-drained debris.	Undercutting the toe of old slide debris may promote further local slope failures. Terrain adjacent to old slides should be treated as suspect slide areas. Old slide debris zones may still be creeping and therefore should not be constructed upon until proven otherwise.	Known inactive debris zones of rock slides may provide source of granular aggregate or riprap. Debris zones of slides in unconsolidated deposits generally unsuitable for most purposes being not only small, but also thin and probably in Pf.
8	Mixed Deposits	Extensive irregular sheets of subdued appearance but showing flow lines parallel to the "fall-line" of the slope.	½ to 4 m. of organic silts (loess? and peat?) predominate, and generally overlie tilloid deposits of mixed origins. Silt is cohesive, unstable, and may exceed 100% moisture content.	Pf is usually present; tussock sedge or thick moss matt being typical insulators. Drainage is usually poor. Excess ice to non-visible ice in drill results.	Creep, compressibility, excessive settlement, retrogressive slumps shown on fresh cut exposures.	With selective excavation at non ice-rich locales the material can be used as fill, but generally the deposits are not worth the effort.

RATING TABLE OF OBSERVED-INFERRED TERRAIN SENSITIVITY AND PERFORMANCE

MAP UNIT	PERMAFROST TERRAIN				NON-PERMAFROST TERRAIN		FLOODING HAZARD
	Occurrence	Degradation following disturbance of ground surface: flat ground (< 3° slope)	Degradation following disturbance of ground surface: sloping ground (> 3° slope)	Performance of newly thawed materials	Occurrence	Performance of unfrozen materials	
1A	Blackstone	2K	2-3K, 2S	2 - 3	N. Klondike V. and local slopes at river edge	1 - 2	N (icings?)
1B & 2G	General	2K, 1S	1-2G, 2S, 1K	2	N. Klondike V. and exposed ridges	1 - 2	N (icings?)
1C & 1D	General (1C only)	2-3K, 1S	2G, 2-3S, 1K	2 - 3 - 1	local escarpments and N. Klondike V. (1C & 1D)	2 - 1	2 (icings)
1E, 2A, 3E & 3C	Blackstone Valley	1-2K	1-2S	1 - 2	local escarpments and N. Klondike V.	1	N (icings)
2B, 2C, 2D & 3F	General	2-1K	1-2S, 2G	1 - 2	N. Klondike V.	1 - 3	3 - N
2E, 2F, 3A & 3B	General ($\pm$)	1K	1G, 1S	1 - 2	local slopes, and N. Klondike V.	1 - 2	N
3D	Blackstone Valley	3K	3K, 3S, 2G	3	N	N	N
4A & 7I	General	1K	N	1 - 2	General	1 - 2	N
4E & 7A	General	1-2K	N	1 - 3	General	1 - 2	7A=3-1; 4E-N (icings for both)
5	General	3K, 2S, 1G	(3S, 3G, 3K)	3	local S-facing slopes	3	N - 3
6A	General	N	2-3S, 2-3G	3 - 2	S-facing slopes	2	N (icings)
6B, 6E & 6F	General ($\pm$)	6B (lowland) = 3K, 2S 6E = (3K) 6F = 1	6B (upland) = (1G, 1S) 6E = (2G, 2K, 3S) 6F = N	6B = 3 6E = 3 6F = 1	N	N	6B (lowland) = 3-1 6E = 3-N 6F = N
6C	General (Active forms)	1	1S	1 - oversize clasts	General (inactive forms only)	1 - oversize clasts	N
6D	Peatlands & Strangmoor	3K	(?) 2S, 2G(?)	3	Strangmoor	3	3-N
7D & 7B	General: fine facies coarse facies	 2K 1-K	 (2) (1)	 3 - 2 1 - 2	 General General	 2 - 1 1	 3-1 (icings) 3-1 (icings)
7E & 7C	General	N	1	1 - 2	General	1	N (icings?)
7F	General	N	N	N	General	3	3
7H*	General (for those in unconsolidated deposits)	2	3 - 2	3 - 2	N. Klondike V.	1 - 3	N (icings)
8	General	2 - 3K	2-3S (2-3K) (2-3G)	2 - 3	General	2 - 3	N-3 (icings)
1	2	3	4	5	6	7	8

C O L U M N   N U M B E R

* refers to the debris zones of old landslides; not pertinent to potential slides developing in other terrain units.

KEY TO PERFORMANCE RATING TABLE - EXPLANATORY NOTES

Sensitivity - Performance Scale

Rating Number	General	Columns 3 and 4	Columns 5 and 7	Column 8
1	good sites	low frequency and/or low intensity	least troublesome materials	flooding is remote possibility (>100 year flood cycle)
2	fair sites	moderate frequency and intensity	moderately troublesome materials	flooding under extreme conditions (25 year flood cycle)
3	poor sites	high frequency and/or high intensity	highly troublesome materials	flooding a common occurrence (yearly)
N	not applicable or not represented			no flood hazard

Degradation following disturbance of ground surface (Columns 3 and 4)

Rating applies to changes resulting from man-induced disturbance such as stripping of the surface down to mineral soil, long term ponding of water on surface, or re-routing of flowing water for substantial periods. Degradation of somewhat lesser intensity and/or frequency results from compaction or mechanical disturbance of the surface vegetation mat or peat. Earthflows may develop in sloping sites following fire on units rated as 2 and 3.

K - thermokarst depressions or ground subsidence from melting of ground ice.
S - slope failures such as ground ice slumps, earth flows, landslides, block collapse (minor sloping sites in brackets).
G - Gully erosion (minor sloping sites in brackets).

Sloping ground includes:

- eroded banks in gullies, along rivers and valley walls.
- slumped banks around thermokarst lakes or thermokarst depressions.
- sloping hillsides.
- mountainside and escarpments.

Performance of newly thawed material (Column 5)

The rating is for performance of thawed materials under worst conditions, (i.e. - immediately after melting of constituent ice), when subjected to load in place, when used as fill, or when exposed on a cut slope. Rating also applies to "normal" active layer materials under the same conditions.

Performance of normal unfrozen material (Column 7)

The rating is for performance of materials under typical field moisture conditions when subjected to load in place, when used as fill, or when exposed on a cut slope.

Flooding hazard

The rating applies to the equivalent standard of the climax 1964 year flood. Icings due to groundwater outflow from newly cut exposures are also so noted.