OFFICE AIRPHOTO STUDY

DEMPSTER HIGHWAY, NORTHWEST TERRITORIES

MILE 278 AT THE YUKON/NWT BOUNDARY

TO

MILE 322 ON THE PEEL RIVER, NORTHWEST TERRITORIE

J D MOLLARD AND ASSOCIATES LIMITED
CONSULTING CIVIL ENGINEERS AND ENGINEERING GEOLOGISTS

A

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Prepared for:

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April 14, 1972

AIRPHOTO MAPPING OF MATERIALS ALONG

DEMPSTER HIGHWAY MILE 278 TO MILE 322

PURPOSE

Purpose of study is defined by terms of reference given in letter from Mr. N. A. Huculak, Regional Engineer, Northern Roads, dated March 15, 1972:

"1) To interpret the surficial bedrock geology within a general two-mile corridor centred on the proposed highway location as shown on the topographic plan, mosaics, and airphotos. The product of interpretation will be the designation of rock by relative hardness (i.e., related to rippability vs. a "drill-and-shoot" quality) for possible use as embankment material.

2) To interpret the surficial soil features related to: potential sources of surfacing materials; potential sources of low-moisture-content, fine-grained material for embankment construction.

3) Identification of surficial features which may indicate potential problems during both the construction and post-construction periods (i.e., indicators of solifluction, icings, massive ground ice, slide or slump areas, etc.) as related to the route now selected. It should be noted that minor relocations may be possible during the summer of 1972, and you should indicate such relocations where potential problem areas are traversed by the present location."

AIRPHOTOS AND PLANS SUPPLIED BY DEPARTMENT OF PUBLIC WORKS

The following airphotos, mosaics, plans and maps were sent to us by your Department:

Plan: scale 1.25 inch = 1 mile between Mile 277.25 and 330.14
Profile: Mile 277.25 to Mile 330.14
Mosaic: scale 1 inch = 2 miles
Mosaic: scale 1 inch = 1000 feet
Airphotos: scale 1 inch = 5000 feet, approximately
Airphotos: scale 1 inch= 1000 feet, approximately
N T S 1:50,000 topographic maps
N T S 1:250,000 route-map showing the flight lines

TERRAIN CONDITIONS SHOWN ON THE MAPPED MOSAICS

The following points concern use of the airphoto mosaics we prepared and terrain data outlined or comments lettered on them.

1) The mosaics are uncontrolled. The proposed highway route crosses back and forth from one mosaiced flight line to the next and, owing to differences in scale, it is not possible to put the strips together side by side and match the terrain detail. The problem of matching flight lines occurs mainly because of the high-relief topography and resulting distortion of the terrain. However, the flight lines are matched reasonably well in the vicinity of the proposed highway location, particularly where the route passes from one sheet to the next.

2) Outlines of terrain map-units have been marked on the airphotos using a red stabilo crayon (see Fig 1). Xerox reproduction of these outlines is faint in some areas. We are sending the original annotated mosaiced flight lines in the event you wish to have your draftsman go over some of the fainter map-unit boundaries, using the original terrain-typed photomosaics as a guide. This would only take a short time, and I think it would be a good idea to do this before the red crayon markings happen to be rubbed off the original mosaics.

3) We noticed that the milepost markers shown on the high-level aerial photos -- having scales of approximately 1 inch = 3300 feet and 1 inch = 5280 feet, respectively -- are not located in precisely the same locations as mileposts shown on the low-level airphotos having a scale of 1 inch = 1000 feet. You are likely already aware of this; and the fact it occurs did not seriously hamper our airphoto work.

4) On Figure 1, sheets 1 and 2, I have shown the approximate boundaries of the different bedrock formations that occur along your proposed route location. These formations are plotted as closely as possible from Geological Survey of Canada Map 30, prepared in 1963. Our draftsman did not get a chance to colour the boundaries between bedrock formations before I sent the mosaics to you last evening. I feel such colouring would be a good idea; and you may also wish to have this done in your office at Edmonton.

TERRAIN MAP-UNITS CORRESPONDING TO ITEMS IN OUR TERMS OF REFERENCE

Following are the five items mentioned in our terms of reference, and the terrain map-units (soil and rock types and conditions) that are most important in their assessment (see the accompanying legend). We would emphasize that these are shown only as a guide to field exploration because we believe that permafrost is generally only a few inches below the surface and that all terrain types, even bedrock, may contain ice lenses and ice wedges.

1) Rippable and "drill-and-shoot" bedrock: BR,MB,EB,TD,TS

2) Potential sources of surfacing materials: AP,IF,PB,BR,MB,EB, AT,TD,TS

3) Potential sources of fine-grained embankment material: AF,some IF,AT, some GM

4) "Hazards" in road construction: AS,IP,OS,ST,TS

5) Map-units most likely to contain the highest and largest inclusions of ice: CF,HM,IP,ST,PG,OM,AF,MD,SC,TD,PT.

We have attempted to place the map-units in order of desirability under items 1, 2 and 3 and in order of undesirability in items 4 and 5.

BEDROCK MAPPING

The mosaic (Figure 1 -- sheets 1 and 2) that we put together from high-level aerial photographs shows the study-area, which I have divided in to six (6) main bedrock divisions. These divisions are as follows:

1) Mile 277 to Mile 278	Jurassic shale, sandstone, and conglomerate (partly Lower Cretaceous)
2) Mile 278 to Mile 291	Upper Devonian sandstone, siltstone, and shale
3) Mile 291 to Mile 292	Jurassic shale, sandstone, and conglomerate (partly Lower Cretaceous)
4) Mile 292 to Mile 295	Carboniferous (mainly Pennsylvanian) and Permian sandstone and conglomerate
5) Mile 295 to Mile 317	Lower Cretaceous shale, sandstone, and conglomerate
6) Mile 317 to Mile 322	Upper Devonian sandstone, siltstone, and shale

These divisions in the bedrock and their boundaries were transferred to the airphoto mosaic from Geological Survey of Canada Map 30-1963 showing the Yukon and Northwest Territories. Scale of this G S C map is 1 inch = 47 miles. It was therefore difficult to make the transfer to 1 inch = 1 mile mosaics with a high degree of precision. This bedrock map was the most up-to-date one available for the study-area.

Even though G S C Map 30-1963 shows six (6) boundaries delineating bedrock of varying geologic ages crossing the 45 miles of proposed highway route location, each of these six bedrock divisions are composed of much the same types of rocks, but of varying hardness. These rock types are mainly shale, siltstone, sandstone, and conglomerate. Generally as a general guide, one can assume that the harder bedrock types are going to be ridge-formers and knob-formers in foothill areas. The softer bedrock types are going to underlie depressions. Shales tend to be black on airphotos and to produce finer slopewash (colluvium). When looking for rippable bedrock we think you should check all small exposures where the tundra has been removed, especially those on knobs, ridges and undercut valley slopes and hillsides.

GEOPHYSICAL FIELD WORK

If time and budget permit, some geophysical work might be done between Mile 277 and Mile 300. Barringer Research in Toronto claim success with their resistivity surveys. Seismic velocities in thousands of feet per second give a yardstick of the rippability of bedrock. By measuring seismic velocities at selected points along and adjacent to your proposed highway route you may get enough data to establish fair correlations between bedrock type, depth to bedrock and, possibly, its rippability.

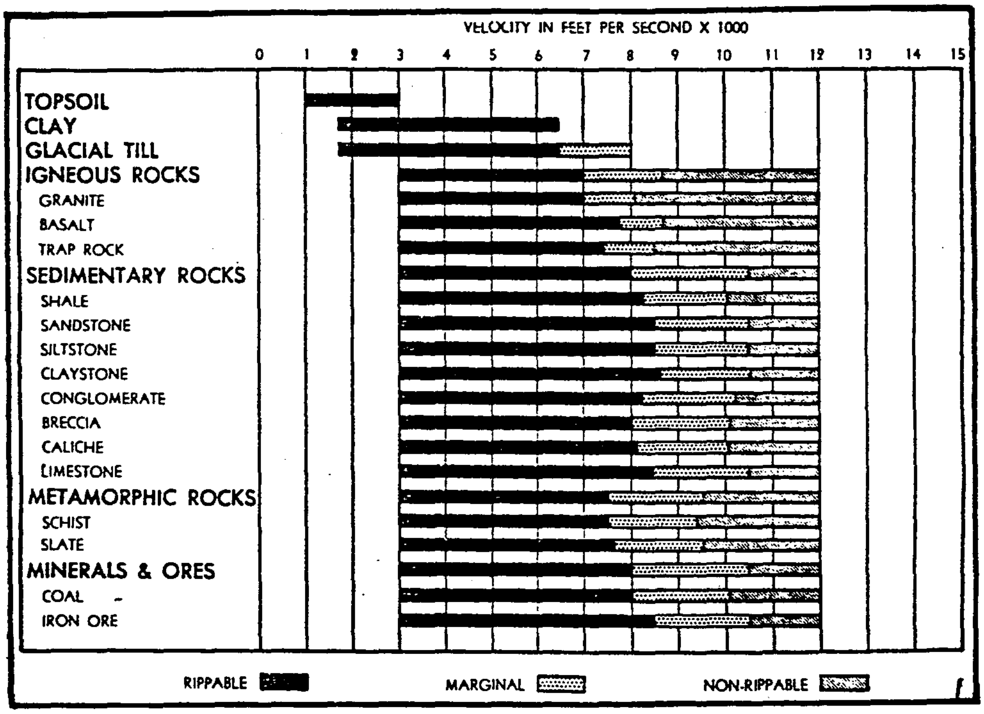
I am including two charts, Figure 3 and Figure 4, that may be helpful in the event you do any such geophysical field work to establish rippability for embankment purposes or bedrock quality for surfacing materials.

The person who discussed Jack's airphoto terrain mapping paper given to the Canadian Northern Pipeline Research Conference in Ottawa was:

Mr. J. D. McNeill
Barringer Research Limited
Rexdale, Toronto.

I am in no position to say whether their work is helpful or not; but these people may be worth talking to on an experimental basis.

Figure 3*



*after: Design Manual, Soils Mechanics Foundations and Earth Structures, Newdocks DM 7. July '66 - Dec. '67.

Figure 4*

Rock Types	Locality and Reference	Seismic Velocity (kilo ft/sec) Frozen	Unfrozen	Estimated Ground Temp., °C
Quaternary sediments				
Silt and organic matter	Fairbanks Area, Alaska[a]	5-10	1.8-4	-1
Alluvial clay	Northway, Alaska[b]	7.8		-2
Silt and gravel	Fairbanks Area, Alaska[c]	7.7-10		-1
Aeolian sand	Tetlin Junction, Alaska[c]	8		-3
Floodplain alluvium	Fairbanks Area, Alaska[c]	8-14	6.1-7	-1
Tundra silts, sands, and peats				
(Gubik Formation, probably saline)	Barrow Area, NPR-4, Alaska [9]	8-8.8		-9
(Gubik Formation, probably saline)	Skull Cliff Area, NPR-4, Alaska [9]	7.4-8.9		-9
(Gubik Formation, less saline)	Topagoruk Area, NPR-4, Alaska [9]	8-12		-9
Gravel	Fairbanks Area, Alaska[a]	13.0-15.2	6-7.5	-1
Outwash gravel	Tanacross, Alaska[c]	7.6-10		-3
Glacier moraine	Delta Junction, Alaska[c]	7.6-13.2		-2
Unclassified sediments	Isachsen, Canada [44]	8.8		-10
Glacier outwash	Thule, Greenland [4]	14.1-15.3		-11
Glacier till	Thule, Greenland [4]	15.4-15.5		-11
Mesozoic sediments				
Mudstone (Ogotoruk Formation)[d]	Ogotoruk Creek, Alaska [45]	14.2	11[d]	-5
Mudstone (Ogotoruk Formation)[d,e]	Ogotoruk Creek, Alaska [45]	13.2		-5
Shale and siltstone (Schrader Bluff Formation)[e]	Fish Creek Test Well 1, NPR-4, Alaska [5]	8.9-9.8	6.6-7.6	-8
Shale and sandstone (Chandler Formation)[e,f]	Umiat Test Well 2, NPR-4, Alaska [6]	12.7		-7
Shale and sandstone (Nanushuk Group)[e,g]	Simpson and Minga Wells, NPR-4, Alaska [7,8]	8.1-8.4	5-7	-9
Sandstone (Colville Group)	Umiat Area, NPR-4, Alaska [9]	10.7		-7
Sandstone and shale (Nanushuk and Colville Group)	Meade-Oumalik Area, NPR-4, Alaska [9]	10-14		-9
Sandstone (Isachsen Formation)	Isachsen, Canada [44]	11.1		-10
Paleozoic and older sediments				
Shale (Dundas Formation)	Thule, Greenland [4]	13.3-14		-11
Sandstone (Narssarssuk Formation)	Thule, Greenland [4]	15.6-17.9		-11
Quartzite (Wohlstenholm Formation)	Thule, Greenland [4]	18.[illegible]		-11
Dolomite (Narssarssuk Formation)	Thule, Greenland [4]	18.9-19.5		-11
Metamorphic rocks				
Schist (Birch Creek Schist)	Fairbanks Area, Alaska[a]	13-16		-1
Gneiss	Thule, Greenland [4]	20		-11

* after: P. 350, Proceedings Permafrost International Conference, November 1963,, Lafayette, Indiana.

LEGEND

TERRAIN TYPES

AF Alluvial-fan deposits: fan-shaped poorly sorted complexly stratified ice-rich organic silt, sand, and clay

AP Active floodplain: exposed clean and dirty riverbed sand, gravel, and cobbly strata (riverbeds of tributaries may be largely silt for some distance upstream from the point where they meet the Peel River)

AT Alluvial terraces: consists of fluvial terraces composed mainly of stratified ice-rich sandy to pebbly silt with sand and gravel interbeds

AV Alluvium in abandoned meltwater valleys: silty alluvial deposits on the floor of relict meltwater channels

BR Bedrock: periglacially much-modified submontane bedrock hills; includes a cover of residual soil, colluvium (slopewash debris), and solifluction debris as well as exposed and fragmented bedrock

CF Coalescing alluvial fans: poorly sorted heterogeneous mixture of boulders to silt with numerous inclusions of excess ice

GM Ground moraine: mainly discontinuous thin to thick silty slopewash deposits over ground moraine (till), with few to many inclusions of excess ice and boulders

HM Hummocky moraine: mainly widespread cover of thick interbedded windlaid and waterlaid silt and clay overlying hummocky moraine consisting of ablation till, commonly with associated glaciofluvial deposits (kames); contains frequent inclusions of excess ice

IF Inactive floodplain: consists of an ice-rich silty topstratum over clean to dirty sand, gravel, and cobbles

MD Mackenzie River Delta: thick stratified estuarine-deltaic organic silt, silty clay, sand and peat with highly variable excess ice contents and widespread thermokarst features

OM Old moraine: mainly modified (weathered) pre-Wisconsin moraine consisting of till with minor sand and gravel inclusions; the till is overlain by a discontinuous mantle of lacustrine (lakelaid), eolian (windlaid), and colluvial (gravity and sheetwash) organic silt, silty clay, and fine sand; contains numerous inclusions of thick excess ice

PB Point-bar deposits: mainly silt and fine sand

SC Submontane valley colluvium: mainly thin to thick interlayered fine (silty) and coarse colluvial deposits over till and bedrock with frequent boulders and numerous inclusions of thick excess ice

TD Talus debris: mainly poorly sorted heterogeneous boulders to silt in cones and continuous sheets, with large amounts of excess ice

Topographic, hydrographic, and peat phases and features

AS Avalanche-susceptible slopes

EB Exposed bedrock occurs frequently in lower portions of valley walls; commonly highly dissected

EV Eroded valleysides: includes finely gullied river banks affected by combined thermal and fluvial erosion, mainly in glacial-drift deposits

IP Ice-wedge polygons: well expressed in low-level aerial photographs

MB Mantled bedrock-controlled relief: mainly drift-covered mesas and buttes below elevation 2000

MC Meltwater channels: includes abandoned ice-marginal channels and glacial spillways

OS Old slides: pear-shaped and horseshoe-shaped flow slides occurring along upper valley side underlain by stratified ice-rich fine-grained overburden materials and weathered clay shale; common in stratified silt and clay in map-unit HM

PG Patterned ground: includes sorted and nonsorted stripes, garlands, polygons and nets; only marked where outstandingly developed as guide to its detection

PT Peat deposits: refers to somewhat deeper and more widespread areas of peat; however peat is seldom over 3 feet in depth and generally below elevation 1000 west of the Peel River

ST Lobate solifluction terraces, lobes, sheets and related features on steep bedrock slopes, often over 5° and ranging up to 40°

SW Deeper silty and sandy slopewash (colluvial) deposits over till and bedrock: surficial deposit may be 4 to 10 feet deep; expect frequent inclusions of thick excess ice

TK Individual thermokarst lakes and large ponds

TS Talus slopes with little or no cover of colluvial debris

POTENTIAL SOURCES OF SURFACING AGGREGATE AND EMBANKMENT MATERIAL

Actively braiding floodplains (AP)

We believe these deposits are the best potential sources of aggregate and embankment material. They will likely be large unfrozen. Problems that may accompany removal of material from floodplain areas are the following:

a) potentially high content of soft shale particles

b) potentially high content of minus 200-mesh sieve fines

c) shallow-water excavation from below the water table

d) effect of extraction of sand and gravel on fish spawning at certain times of the year

e) nearly always steep upgrade haul out of floodplain when the units are heavily loaded.

Despite all these anticipated problems, active floodplains may still be your most economical source of highway construction material.

Inactive ("fossil") floodplains and low river terraces (IF)

These deposits probably contain granular materials in the subsurface, but the following anticipated problems may be serious:

a) a thick ice-rich silt layer overlying the sand and gravel to be recovered

b) the sand and gravel beneath icy silt overburden will likely be frozen

c) some of the problems outlined under active floodplains.

Bedrock sources (BR)

Bedrock quarry sources are locally an attractive possibility and they should be carefully investigated. But there are problems and some of them are the following:

a) often steep slopes that are difficult to negotiate with conventional construction equipment

b) high excess ice contents in colluvium (e.g., talus) over bedrock; thus depth of stripping may vary substantially

c) difficult topography can make quarry-rock workability costly

d) the interbedded and tilted nature of tightly folded, subsequently deeply eroded sedimentary rocks means that quarries in harder sandstone or shale strata may have to be long and narrow as well as being located on steep faces

e) anomalous-looking knobs and ridges in the piedmont and foothills belt have variable depths of overburden; thus helicopter-supported field examination of places where the tundra is removed or torn may be a very worthwhile exercise.

GUIDES TO POTENTIAL BEDROCK QUARRY SITES

1) In looking for masked (buried) bedrock near the surface, check solifluction features (stripes, sheets, lobes, terraces). Solifluction forms are often associated with a thin soil cover over bedrock.

2) Sorted stripes (rings and stripes of angular rock rubble) may give clues to the underlying rock type.

3) Look for anomalous knobs and ridges in piedmont and foothill areas (Mile 295 to 300).

4) The sharper more angular ridges and knobs may contain harder rock below a mantle of drift (MB areas).

5) We have marked specific "points" rather than outlining "areas" on our maps because boundaries between different materials are vague and indefinite and because, once potentially suitable material has been identified, it will be necessary to carry out field subsurface exploration to better define quantities and identify materials-handling problems.

6) We believe that use of a fewer number of real good sources of quarry rock, at the expense of longer haul, is possibly more economic than developing a larger number of poorer quarries having a shorter average haul distance.

FIELD-INSPECTION SITES

Table I contains about 175 locations that we feel may warrant field inspection.Whether they are worth inspection will depend on many factors -- such as proved sources, topography, logistics, etc. You may wish to test drill selected sites in order to learn more about them; many of them will be difficult to get to and drill unless you are using helicopter-mounted drilling equipment. You may have to be satisfied with visual inspection of many of these sites and with digging using a hand spade, likely to a depth of a foot or less in many cases.

The field inspection sites have been selected with a view to enhancing your appreciation of the four or five points listed in the terms of reference (see page 1 of this report).

Inspection sites are numbered 1 to 171, starting with site 1 at the Peel River and progressing westerly along the route. The point of each black arrow, accompanying each number, indicates the site to be inspected in the field.

NOTES ON ANTICIPATED MATERIALS AND FIELD CHECKING

1) Terrain boundaries in the study-area, even though helpful in understanding the general distribution of subsurface materials, may not be as helpful to you as our designated field-inspection locations. Vertical and

horizontal alignment (geometric) standards, rather than materials, tend to control the proposed route location. The main problem is one of finding suitable materials with which to build and surface the grade. Accordingly, we feel that checking of specific spots in the field should provide you with the most useful information. We have therefore devoted much of our study time to the selection of field-inspection sites.

2) The area of scarcest construction material appears to be between Mile 290 and Mile 295. We have not attempted any route relocation in this area because of major controls imposed by vertical and horizontal alignment.

3) We have tried to keep most of the field inspection sites within reasonable distances of your proposed highway route. We assumed there was little value in outlining prospects isolated from the route by deep valleys or high mountain ridges.

4) You might consider the possible use of conveyor-belt systems to elevate large sources of active floodplain (AP) or inactive floodplain (IF) sand and gravel onto the upland from where it might then be truck-hauled or scraper-hauled to the roadbed. Some 200 feet or 300 feet of conveyor-type lift out of such valleys might be an economically feasible proposition.

5) You might also consider use of primary crushers to crush the harder talus rock for surfacing material. Here I am thinking of talus fragments that are less than 30 inches in diameter and deposits that are relatively free of excess ice.

6) Between Mile 277 and Mile 295 I have terrain mapped large areas as an intermingled complex of SC+BR. Colluvium (SC) over bedrock in these areas may vary in thickness from a few inches to several tens of feet. Many exposures of bedrock occur in areas mapped SC+BR. These exposures should be checked for rippability, especially where they occur near the proposed highway route.

TABLE I

Inspection-site number	Comments
1 - 4	On island in the Peel River floodplain. Expect till over bedrock. Try to locate bedrock exposure and check bedrock hardness. Bedrock may be sandstone, conglomerate, or shale
3A	Check the gradation of materials in exposed point bars (PB) slightly above shoreline and at the small gully (newly eroded)
4A	Check the south-facing slope of a small island remnant on Peel River floodplain. May be bedrock-cored
5 - 11	On eroded west bank of Peel River. Check bedrock type and hardness if an exposure can be found. Expect sandstone. Bedrock may be buried under several feet of valleyside slopewash debris
12 - 14	Expect bedrock at or near surface. On scarp face north of Mile 319.5. Check for bedrock exposures and check hardness and rock type, if exposed
15 - 18	Bedrock may (?) be near surface. Test drill if surface indications look promising
19	Looks more promising as possible bedrock-exposure area
20	Trim down and inspect valley wall to get a good look at the subsoil materials. This should be done at several steep, eroded valleyside locations between Mile 295 and Mile 322 in order to get an appreciation of near-surface materials and of the occurrence of boulders in till-like materials expected here
21	Patterned ground. Inspect stripes and nets to see if they are of the nonsorted or sorted variety. Hardness of the surface rocks on these patterned ground areas may reflect the competence of underlying source bedrock in the immediate area
22 - 23	Inspect steep and eroded valleysides to determine cross-section of near-surface materials
24	Appear to be bedrock exposures. Check bedrock type and hardness where an exposure is found
25 - 29	Doubtful bedrock exposures, but check closely
30 - 31	Appear to be bedrock-controlled knobs. Check rock type and hardness. Mile 30 appears to be the best prospect
32	Near-vertical north-facing slope of thermokarst lake. Good opportunity to inspect exposed material. This type of visual inspection is often more revealing and helpful than looking at cuttings from test drilling

Inspection-site number	Comments
33	Patterned ground. Check character of rock in stripes for clues to the hardness of underlying bedrock
34	Flow slide. Check materials in the steep wall of the slide area
35	Ice-wedge polygons are well-defined here. Check closely because we suspect that many areas of ice-wedge polygons exist along the route, even though only a few areas are discernible in the airphotos. Width and depth of the ice wedges in areas like site 35 may give a clue to the degree of development and frequency of polygons that are expected along much of the proposed route
36 - 38	Knobs appear to be bedrock exposures. Check hardness and rock type if bedrock is present
39	Well-defined ice-wedge polygons. Check ice-wedge width and frequency where possible
40	Bedrock ridge appears to contain harder strata. Check rock type and hardness
41 - 42	Suspect shale in slopes of deeply cut valley
43	Recent-looking flow slide (mudflow) in what appears to be deep stratified silt and clay. Inspect face of slide area. Department of Public Works report gravel at surface at this slide
44	Somewhat older-looking slide adjacent to site 43. Trees have regenerated. Inspect north-facing slope
45 - 46	Inspect what appear to be very small shallow "skin" slides. These appear to be areas where the "active" surface layer (perhaps 1 or 2 feet deep) has become saturated and has moved downslope. Both sites 45 and 46 occur on relatively steep sidehill slopes
47	Inspect head end of gully for possible bedrock exposure. Doubtful prospect
48	Gravel reported on surface by Department of Public Works at Mile 308.2
49	Solifluction stripes. Check rock type and character
50	Inspect valley slopes for exposed shale
50A	Inspect near-vertical south-facing slope of huge old flow slide. Expect either stratified silt and clay or soft weak clay shale

Inspection-site number	Comments
51	Classic ice-wedge polygon area. Inspect closely and try to determine whether ice-wedge pattern extends beyond limits of area shown on the airphotos
52	Gravel reported on surface by Department of Public Works
53	Small flow slides along the crest of valley side. Inspect slide face in order to get appreciation of materials
54	Drift-covered mesa may be bedrock-cored. Check at arrow. May have several feet of drift over bedrock
54A	Area of patterned ground. Check stripes
55,55A,56,57,59	Check eroded head end of small gullies for possible bedrock exposures where these gullies extend into drift-covered mesa
58	Check small knob on slope of mesa
60	Gravel reported by the Department of Public Works
61	Inspect walls of old deeply-eroded seismic trail to determine soil materials and the occurrence of ice. Exposed face in trench may be between 5 feet and 15 feet high
62 - 63	Check crest of mesas for signs of near-surface bedrock
64 - 65	Appears that shale exists below a relatively deep cover of drift. At site 65 drift/shale contact appears to occur about one-quarter distance down the valley wall
66	Check rim of mesa for signs of bedrock exposure. Bedrock will likely be covered by a thin mantle of drift or present near the surface
67	Check small shallow flow slide
68	Old flow slide at edge of a thermokarst lake. Check materials on slide face and the patterned ground immediately adjacent to the top of slide area
69 - 71	Check materials at top of valley walls of old meltwater channel. Check small erosion scars, which allow better visual inspection of subsurface materials
72 - 73	Check old eroded faces and along gullies
74	More definite-looking bedrock exposure. Check rock type and competence
75	Check shale face in tributary branch of Vittrekwa River

Inspection-site number	Comments
76 - 79	Bedrock exposures are likely shale. Check rock type and competence
80 - 81	Bedrock. Check ridges at 80 and 81 to see if more competent rock exists at these locations
82	There may be some avalanching activity on this slope. Check for definite signs in the field
83 - 84	Check quality of gravel on active flood plain at sites 83 and 84
85 and 87	Bedrock appears to be exposed here and is expected to be near surface along larger ridge in adjacent area mapped as MB. Check rock type and character (hardness)
86, 88, 89	Locations where bedrock are expected to be at or near surface
90	Check east-facing near-vertical face of old glacial meltwater channel for materials
91 - 92	Check small scars
93 - 96	Bedrock at or near surface. Check rock type and hardness at these sites
97 - 98	Drainages seem to originate at base of bedrock cliff. Check to see if these drainages are caused by springs discharging along a fault zone
99 - 100	Check stratigraphy of bedrock along near-vertical face between sites 99 and 100. Check hardness and type of rock
101 - 102	Check type and hardness of bedrock at sites 101 and 102
103 - 104	Check bedrock stratigraphy and hardness at nearly vertical sections
105 - 106	Check what may be old avalanche areas
107 - 108	Check rock faces
108A	Check talus debris for size of rock pieces and occurrence of ice inclusions
109 - 110	Check vertical faces. Appears to be more competent bedrock
111 - 115	Check these sites for hardness of bedrock
116	Talus debris at base of talus slope. Check hardness of broken rock

Inspection-site number	Comments
117	Check talus debris at base of talus slope. Check size and hardness
118 - 120	Possible convenient quarry sites. Check rock quality
120A	Looks like a shale face
121 - 122	Check near-vertical faces of bedrock as possible quarry sites
121A	Check material in the active floodplain. Expect unfrozen sand, gravel, and cobbles
122A	Check quality of bedrock
123	Flat-lying bedrock exposed. Check competence to determine rippability
124 and 126	Talus debris at base of talus slope. Check particle size, quality and for possible massive ice inclusions
125	Appears to be ice-wedge polygon pattern in bedrock. Areas of bedrock showing ice-wedge polygon patterns are expected to be a softer, more rippable type of rock
127	Inspect face of talus slope
128 - 130	Inspect and drill if possible. Old inactive floodplain deposits. Expect shallow silt cover over frozen sand, gravel, and cobbles
130A	Ice-wedge polygons in bedrock. May be rippable shale in this area
131	Check for talus debris along base of cliff. Talus deposit not apparent on photos but may be present. Check in field
131A	Check materials in the active flood plain. Expect unfrozen sand, gravel, and cobbles
132	Appears to be more competent type of bedrock. Check
132A	Check materials in riverbed (active floodplain)
133	Check flatter-lying bedrock for competence (quality)
134	Check exposed bedrock knob for competence (quality)
135 - 136	Check active floodplain materials. Expect granular material to be unfrozen
137 - 138	Inspect inactive ("fossil") floodplain materials. Expect shallow layer of silt over coarser material. Likely frozen

Inspection-site number	Comments
139	Talus debris may be source of aggregate if not too large and if massive excess ice not present
140 - 141	Check bedrock type. Appears to exhibit ice-wedge polygons at site 140
142 - 143	Talus cones occur all along base of this talus cliff. Check for size, competence, and presence of excess ice in talus deposit
144	Inactive flood plain. Check
145 - 146	On more recent active flood plain
147	Check both active and more-elevated "fossil" flood plain in same area
148	Good-looking source of aggregate on active flood plain. Expect unfrozen. Check
149 - 149A	Check base of cliff at more-competent looking bedrock ridges
150 and 152	Looks like high-level alluvial terraces. Likely sand, gravel, and cobbles but expect frozen. Check
151	Inactive flood plain. Expect frozen with silt cover
153	Good-looking source of unfrozen aggregate on active flood plain
154	Potentially a good nearby quarry site. Check bedrock competence (quality, suitability)
155 and 158	Check gravel in riverbed
156	May be solifluction lobes in this area
157	Check talus debris at the base of slope
159	Expect ice-wedge polygons in bedrock. Check quality of rock where polygons occur
160 and 161	Check depth and gradation of riverbed materials over bedrock
162 - 163	Check rock type and competence at points shown
164 - 167	Classic solifluction lobes
168 - 169	Classic talus debris area. Much broken rock on the surface
170 - 171	Check rock type and quality at sites 170 and 171 and compare to type of broken rock occurring at sites 168 and 169