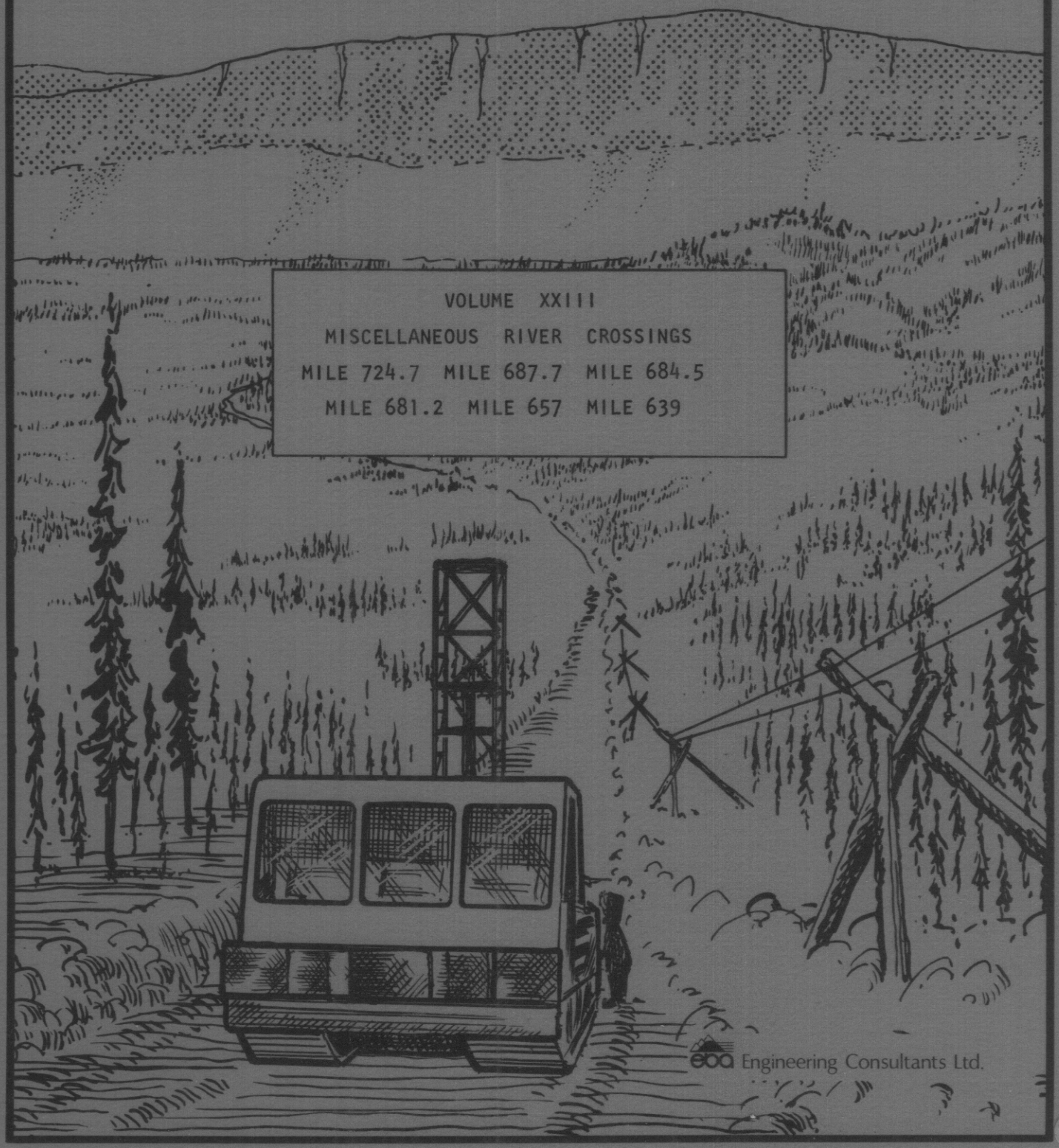
MACKENZIE HIGHWAY
GEOTECHNICAL EVALUATION



VOLUME XXIII

MISCELLANEOUS RIVER CROSSINGS

MILE 724.7 MILE 687.7 MILE 684.5

MILE 681.2 MILE 657 MILE 639

EBA Engineering Consultants Ltd.

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MACKENZIE HIGHWAY
GEOTECHNICAL EVALUATION
VOLUME XXIII
MISCELLANEOUS RIVER CROSSINGS

Mile 724.7 - Rabbit Skin (Hare Indian) River Crossing

Mile 687.7 - Chick Lake Creek Crossing

Mile 684.5 - Little Chick Lake Creek Crossing No. 1

Mile 681.2 - Little Chick Lake Creek Crossing

Mile 657 - Creek Crossing End of Lake

Mile 639 - Lake Narrows Crossing

Submitted To:

GOVERNMENT OF CANADA
DEPARTMENT OF PUBLIC WORKS
CONTRACT NUMBER A10/73
FILE NUMBER 9305-52-307

MARCH, 1974

eba Engineering Consultants Ltd.

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1. INTRODUCTION

In conjunction with a geotechnical engineering study carried out from Mile 725 to Mile 632 of the proposed Mackenzie Highway, a number of major river and stream crossings were investigated. Also boreholes were drilled in the immediate vicinity of several minor streams for preliminary bridge site information. Data collected at such crossings are presented herein.

The lack of comprehensive detailed information at each site does not permit geotechnical evaluation and subsequent site development recommendations. However the available data is assembled herein as a summary from which further geotechnical programs may be developed.

Data has been obtained at and presented herewith for the following crossings:

Mile 724.7 - Rabbit Skin (Hare Indian) River
Mile 687.7 - Chick Lake Creek Crossing
Mile 684.5 - Little Chick Lake Creek Crossing No. 1
Mile 681.2 - Little Chick Lake Creek Crossing
Mile 657 - Creek Crossing End of Lake
Mile 639 - Lake Narrows Crossing

General details of the investigations, site conditions, and geotechnical data are reported herein. Available key plans, site plans, stratigraphic sections, borehole logs, and laboratory data are presented in the attached appendices. Each appendix is referenced by mileage of the appropriate crossing.

This work was carried out for the Government of Canada, Department of Public Works, and was authorized by Contract Number A10/73, File No. 9305-52-307.

II. GEOTECHNICAL DATA AQUISITION

2.1 Field Testing

The evaluation of subsurface conditions has been based on field data obtained from boreholes drilled at the locations shown on the site plans, where available, and/or on the airphoto mosaics, (Volumes II and III, Mackenzie Highway Geotechnical Evaluation). Of the boreholes advanced, some were drilled as center line boreholes, in conjunction with the general route evaluation, and the remainder were located and drilled specifically to define subsurface conditions at the crossings. Detailed boreholes logs are presented in the appendix corresponding to the appropriate crossing.

All boreholes were drilled with either a track mounted Mayhew 500 rotary rig, using a continuous air return circulation system, or a track mounted Texoma Super Economatic power auger, fitted with a 12 inch diameter sub auger. Boreholes advanced with the Mayhew 500 drill rig generally were 4 3/4 inches in diameter. Sampling consisted of representative bag samples, obtained at depths of 2½ and 5 feet, and at depth intervals of about 5 feet, thereafter, to the bottom of each borehole. Undisturbed samples were not obtained at any of the sites discussed herein.

2.2 Laboratory Testing

Laboratory testing was carried out on representative disturbed soil samples to determine the natural water content profile and in some instances, Atterberg limits, grain size distribution, and soluble sulphate concentration of the subsoil. Moisture content tests were undertaken in the field laboratory of EBA Engineering Consultants Ltd., while all other testing was confined to the EBA Edmonton laboratory. In addition to the laboratory testing outlined above, all samples were visually classified in both the EBA field and Edmonton laboratories. Soil classification was based on plasticity according to the extended Unified Classification System [1]* and on textural Classification according to U.S. Engineers Department [2] textural classification triangle.

Frozen ground was classified according to a modification of the NRC system for describing permafrost [3]. The modification was necessary because the disturbed nature of the sample obtained did not permit full usage of the NRC system; especially in describing the form of excess ice. The system used retains the symbols V and N for visible and non-visible ice, respectively, and the modifying symbols B and F for well bonded and poorly bonded non-visible ice, respectively. Excess ice quantities were estimated from visual observations. The results of laboratory tests are presented on the borehole logs, grain size distribution curves and summary of laboratory results tables, where applicable.

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* Superscripted numbers in parentheses refer to the List of References presented at the end of this report.

III. SITE CONDITIONS

3.1 Surface Features

3.1.1 Mile 724.7 Rabbit Skin (Hare Indian) River Crossing

The proposed Mackenzie Highway crosses the Rabbit Skin (Hare Indian) River at Mile 724.7, approximately 6 miles north east of Fort Good Hope, N.W.T. A Key Plan of the Rabbit Skin River area is presented as Drawing No. A-1*, Appendix Mile 724.7, and Drawing No. A-2, Appendix Mile 724.7, presents a detailed Site Plan.

The Rabbit Skin River drains a large area extending north-east of Fort Good Hope, N.W.T. The large water shed of the Rabbit Skin River results in a substantial stream flow throughout the entire year. The clear water and bottom deposits of the Rabbit Skin River may possibly provide good spawning grounds for grayling and other species. (4)

3.1.2 Mile 687.7 - Chick Lake Creek Crossing

The proposed Mackenzie Highway crosses Chick Lake Creek at Mile 687.7, approximately 55 miles north-west of Norman Wells, N.W.T. A Key Plan of the Chick Lake Creek area is presented as Drawing No. A-1, Appendix Mile 687.7, and Drawing No. A-2 Appendix 687.7, presents a detailed Site Plan.

Chick Lake Creek drains a small area extending south-west of Chick Lake. The small watershed of Chick Lake Creek results in a modest stream flow throughout the summer and fall. In the winter there is probably a minimal but continuous flow of water under the ice.

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* All Drawings are presented in the Appendices, which are designated by Mileage.

3.1.3 Mile 684.5 - Little Chick Lake Creek Crossing No. 1

The proposed Mackenzie Highway crosses Little Chick Lake Creek Crossing No. 1 at Mile 684.5, approximately 52 miles north-west of Norman Wells, N.W.T. A Key Plan of the Little Chick Lake Creek Crossing No. 1 area is presented as Drawing No. A-1, Appendix Mile 684.5, and Drawing No. A-2, Appendix 684.5, presents a detailed Site Plan.

Little Chick Lake Creek flows from Little Chick Lake to Chick Lake. The modest watershed of Little Chick Lake results in a moderate stream flow throughout the summer and fall. In the winter there is probably a small but continuous flow of water under the ice.

3.1.4 Mile 681.2 - Little Chick Lake Creek Crossing

The proposed Mackenzie Highway crosses Little Chick Lake Creek Mile 681.2, approximately 49 miles north-west of Norman Wells, N.W.T. A Key Plan of the Little Chick Lake Creek area is presented as Drawing No. A-1, Appendix Mile 681.2, and Drawing No. A-2, Appendix Mile 681.2, presents a detailed Site Plan.

Little Chick Lake Creek flows from Little Chick Lake to Chick Lake. The modest watershed of Little Chick Lake results in a moderate stream flow throughout the summer and fall. In the winter there is probably a small but continuous flow of water under the ice.

3.1.5 Mile 657 - Creek Crossing End of Lake

The proposed Mackenzie Highway crosses an unnamed creek at Mile 657, approximately 27 miles north-west of Norman Wells, N.W.T. A Key Plan of the creek crossing is presented as Drawing No. A-1, Appendix Mile 657, and Drawing No. A-2, Appendix Mile 657, presents a detailed Site Plan.

The creek appears to drain from the nearby lake to another lake near Mile 654. The watershed supplying the upper lake is relatively small, hence only moderate stream flow throughout the summer and fall is expected. In the winter there is probably no flow of water under the ice.

3.1.6 Mile 639 - Lake Narrows Crossing

The proposed Mackenzie Highway crosses the Lake Narrows at Mile 639, approximately 10 miles north-west of Norman Wells, N.W.T. A Key Plan of the Lake Narrows area is presented as Drawing No. A-1, Appendix Mile 639, and Drawing No. A-2, Appendix Mile 639, presents a detailed Site Plan.

The crossing site is a low area between two adjacent lakes. A relatively large drainage basin on the west side of the Norman Range (Discovery Ridge) is the source for water collected in the series of lakes running parallel to Discovery Ridge and the Mackenzie River. The large drainage area results in a modest stream flow of water under the ice.

3.2 Subsurface Features

3.2.1 Mile 724.7 Rabbit Skin (Hare Indian) River Crossing

Two center line boreholes were drilled at the locations indicated on the Site Plan, Drawing A-2, Appendix Mile 724.7. Aerial photographic interpretation of surficial geology is also presented on Drawing A-2, Appendix Mile 724.7, with a terrain legend enclosed as Drawing A-2a, Appendix Mile 724.7. Boreholes 724-C-1 and 724-C-2 were drilled to depths of 39 and 18 feet, respectively, with a Mayhew 500 rotary drilling rig. Both boreholes were drilled on the south side of the Rabbit Skin (Hare Indian) River.

Only Borehole 724-C-1 was located in a position significant to potential bridge crossing development. At this location, frozen sand and gravel were noted over the majority of the depth drilled. In general, the gravel existed at a low moisture content (about 4 to 14 percent) and the ice description varied from NB to NF(3). The sand strata, noted below about 29 feet from existing grade, was observed to contain visible ice, up to about 5 percent by volume. The moisture content was also significantly higher in the sand strata (about 20 to 22 percent). Laboratory test results are plotted on the borehole logs, where applicable.

3.2.2 Mile 687.7 - Chick Lake Creek Crossing

Four center line boreholes were drilled at the locations indicated on the Site Plan, Drawing A-2, Appendix Mile 687.7. The boreholes ranged in depth from 9 to 18 feet. All boreholes were drilled with a Mayhew 500 rotary drilling rig. Aerial photographic interpretation of surficial geology is also presented on Drawing A-2, Appendix Mile 687.7, with a terrain legend enclosed as Drawing A-2a, Appendix Mile 687.7. A center line profile and stratigraphic section is shown on Drawing A-3. Appendix Mile 687.7. Borehole 687-C-2 was drilled within the former channel alignment, which is presently distinguished by high terraces. Thawed gravel was logged at this location below a depth of about 5 feet, with shale bedrock being encountered near 17 feet below grade. Shale bedrock was also noted in Borehole 687-C-3 near a depth of 17 feet below existing grade. The natural moisture content of the thawed gravel and shale in Borehole 687-C-2 was low (about 7 to 9 percent), but all other samples tested indicated high to extreme water contents. Visible ice was common, with up to 50 percent by volume being noted. Laboratory test results are shown on the borehole logs, where applicable, and/or on the grain size distribution sheet and summary of results table enclosed in Appendix Mile 687.7.

3.2.3 Mile 684.5 - Little Chick Lake Creek Crossing No. 1

Two center line boreholes were drilled at the locations indicated on the Site Plan, Drawing A-2, Appendix Mile 684.5. Aerial photographic interpretation of surficial geology is also presented on Drawing A-2, Appendix Mile 684.5, with a terrain legend enclosed as Drawing A-2a, Appendix Mile 684.5. Boreholes 684-C-2 and 684-C-3 were drilled to depths of 18 and 28 feet, respectively, with a Mayhew 500 rotary drilling rig. Both boreholes were drilled on the terrace area (one on each side of Little Chick Lake Creek) adjacent to the creek channel. No borehole information is available within the active creek channel.

Both boreholes indicate similar stratigraphy. Beneath a thin organic covering, frozen to unfrozen silty clay till was noted overlying unfrozen shale bedrock. The depth to shale varied from 7 to 15 feet at the borehole locations. The natural moisture content of the shale is low (11 to 15 percent) in comparison to the liquid and plastic limit (47 and 28 percent, respectively). No visible ice was logged in the near surface frozen soil. Laboratory test results are shown on the borehole logs, where applicable, and/or on the grain size distribution sheet and summary of results table, Appendix Mile 684.5.

3.2.4 Mile 681.2 - Little Chick Lake Creek Crossing

Four center line boreholes and one special borehole were drilled at the locations indicated on the Site Plan, Drawing A-2, Appendix Mile 681.2. Aerial photographic interpretation of surficial geology is also presented on Drawing A-2, Appendix Mile 681.2, with a terrain legend enclosed as Drawing A-2a, Appendix Mile 681.2. A center line profile and stratigraphic section is shown as Drawing A-3, Appendix Mile 681.2. One additional centerline borehole, whose location is not shown on Drawing A-2, Appendix Mile 681.2, was used to develop the stratigraphic section. Borehole depths ranged from 9 to 28 feet. All drilling was accomplished with a Mayhew 500 rotary drill rig.

The boreholes infer a reasonably consistent stratigraphic sequence of organic clay and peat, overlying silt-clay till, which in turn overlies shale bedrock. Frozen soil was noted over the majority of depth logged, although unfrozen soil is present. High (up to 80 percent by volume) ice and moisture contents (up to 230 percent) were noted in the overburden soil, with low moisture contents and no visible ice being noted in the shale bedrock. Laboratory test results are shown on the borehole logs, where applicable, and/or on the grain size distribution sheet and summary of results table, Appendix Mile 681.2.

3.2.5 Mile 657 - Creek Crossing End of Lake

Three center line boreholes and two special boreholes were drilled at the locations indicated on the Site Plan, Drawing A-2, Appendix Mile 657. Aerial photographic interpretation of surficial geology is also presented on Drawing A-2, Appendix Mile 657, with a terrain legend enclosed as Drawing A-2a Appendix Mile 657. A center line profile and stratigraphic section is shown as Drawing A-3, Appendix Mile 657. Borehole depths ranged from 10 to 57 feet. All center line boreholes were drilled with a Texoma Super Economatic power auger, while all special boreholes were drilled with a Mayhew 500 rotary drill rig.

The boreholes indicate uniform stratigraphic conditions across the creek. Organic clay and silt, 0 to 4 feet in thickness, overlies an undetermined thickness of silty clay. High moisture (21 to 120 percent) and ice contents (up to 60 percent by volume) were noted over the majority of depth drilled. Bedrock or thaw stable materials were not encountered within the depth of borehole investigation.

Laboratory test results are shown on the borehole logs, where applicable, and/or on the grain size distribution sheet and summary of results table, Appendix Mile 657.

3.2.6 Mile 639 - Lake Narrows Crossing

Two center line boreholes and two special boreholes were drilled at the locations indicated on the Site Plan, Drawing No. A-2, Appendix Mile 639, Aerial photographic interpretation of surficial geology is also presented on Drawing A-2, Appendix Mile 639, with a terrain legend enclosed on Drawing A-2a, Appendix Mile 639. A center line profile and stratigraphic section is shown as Drawing A-3, Appendix Mile 639. Borehole depths ranged from 9 to 37 feet. All boreholes were drilled with a Mayhew 500 drill rig.

The stratigraphic sequence is relatively uniform across the narrows. In general, lacustrine silt and clay overlies silty clay till in the immediate vicinity of the crossing. The majority of soil at this site is frozen, however, unfrozen zones were logged. In general, the moisture contents (up to 184 percent) and ice contents (up to 35 percent by volume) are very high, in the overlying silt and clay, and modestly high in the underlying till. Bedrock or thaw stable materials were not encountered within the depth of borehole investigation.

Laboratory test results are shown on the borehole logs, where applicable, and/or on the grain size distribution sheet and summary of results table, Appendix Mile 639.

IV. DISCUSSION

4.1 Mile 724.7 - Rabbit Skin (Hare Indian) River Crossing

The necessity for a major bridge structure over the Rabbit Skin (Hare Indian) River, implies that a detailed geotechnical bridge site investigation is required. The information presently available indicates that a significant depth of sand and/or gravel (greater than

37 feet) is to be expected near the channel. The sand and/or gravel was noted to be frozen at a location about 100 feet south and about 100 feet in elevation above the present south river bank on the proposed highway center line, but it would be expected that unfrozen ground is present beneath and immediately adjacent to the active channel. Visible ice was noted within frozen sand, hence thaw settlement must be a consideration. Presently, it would appear that foundation systems could be founded on bedrock at an unknown depth, on thawed cohesionless deposits or on thaw stable cohesionless deposits. It is believed that winter construction is most practical but summer construction may be considered.

4.2 Mile 687.7 - Chick Lake Creek Crossing

The requirement for a bridge structure at the Chick Lake Creek Crossing site is unknown by us at this time. However, if a bridge structure is necessary, it would appear reasonable to expect that pile foundation elements founded in bedrock, noted about 17 feet below grade in the valley bottom, are the only feasible means of structural support. Confirmation of the depth to bedrock and properties there of, is required at bridge abutment locations. Significant thaw settlement, negative skin friction and possibly slope stability problems can be anticipated if the natural subgrade soils are allowed to thaw. Based on the available data, winter construction appears practical at this site.

4.3 Mile 684.5 - Little Chick Lake Creek Crossing No. 1

It is probable that a bridge structure will not be required at this crossing. However, if bridge development is considered, the presence of thawed shale bedrock at a shallow depth will facilitate the design and construction of a practical foundation system. Piers or piles in bedrock may be considered, with the design being contingent upon establishing bedrock properties. Minor construction, thaw settlement, negative skin friction or stability problems are foreseen. It is believed that summer construction would be practical at the site.

4.4 Mile 681.2 - Little Chick Lake Creek Crossing

It is probable that bridge construction will not be required at this crossing. However, if bridge development is considered, it is believed practical to found all structures on shale bedrock, noted about 20 feet below existing grade, utilizing a pile foundation system. The physical properties of the shale bedrock must be obtained prior to undertaking a final pile design. Major thaw settlement, negative skin friction and mobility problems are foreseen, if the near surface soils are allowed to thaw. It is believed that winter construction appears most practical at this site.

4.5 Mile 657 - Creek Crossing End of Lake

It is unlikely that bridge construction will be required at this crossing. However, if bridge development is considered, it is compulsory that further geotechnical field data be obtained. It will be necessary to define the depth to thaw stable material and establish the properties thereof. Major thaw settlement, negative skin friction and mobility problems are foreseen, if the near surface soils are allowed to thaw. It is believed that winter construction appears most practical at this site.

4.6 Mile 439 - Lake Narrows Crossing

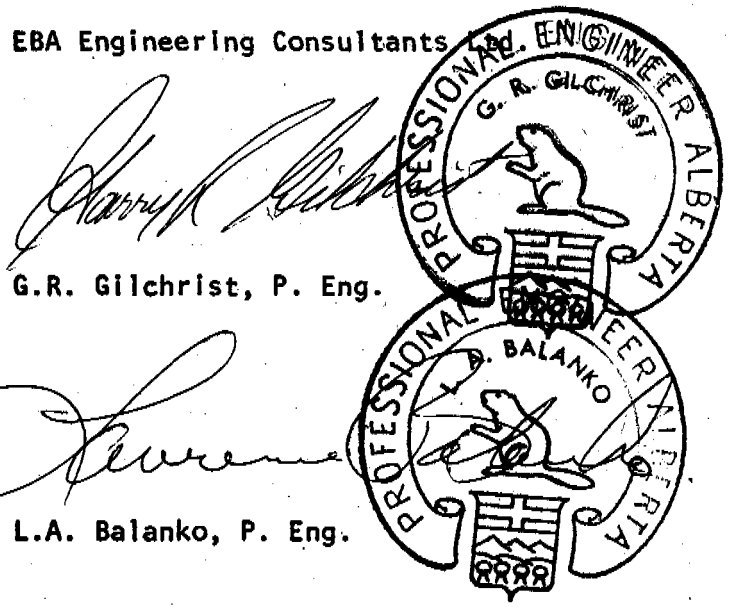
It is unlikely that bridge construction will be required at the Lake Narrows Crossing. However, if bridge development is considered, it is required that further geotechnical field data be obtained. It will be necessary to define the depth to thaw stable material and establish properties thereof. Major thaw settlement, negative skin friction and mobility problems are foreseen, if the near surface soils are allowed to thaw. Winter construction is believed most practical for this site.

V. LIMITATIONS

The enclosed data has been prepared based on our knowledge of existing site conditions at six stream crossings along the proposed Mackenzie Highway. This knowledge has been derived from visual, physical and analytical considerations of existing soil conditions, were obtained from our field investigation. The findings and discussions presented herein, although preliminary, are believed to reflect conditions as they are known to exist. Comprehensive assessment of all of the sites discussed herein would be required prior to preparing final design parameters for structural foundation support systems. Should conditions be encountered, other than described herein, the geotechnical consultant should be contacted so that data may be evaluated in light of new findngs.

Respectively Submitted,

EBA Engineering Consultants Ltd.



G.R. Gilchrist, P. Eng.

L.A. Balanko, P. Eng.

GRG:lmh

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2. Means, R.E. and Parcher, J.V., 1963: Physical Properties of Soils. Charles E. Merrill Books Inc., Columbus, Ohio.

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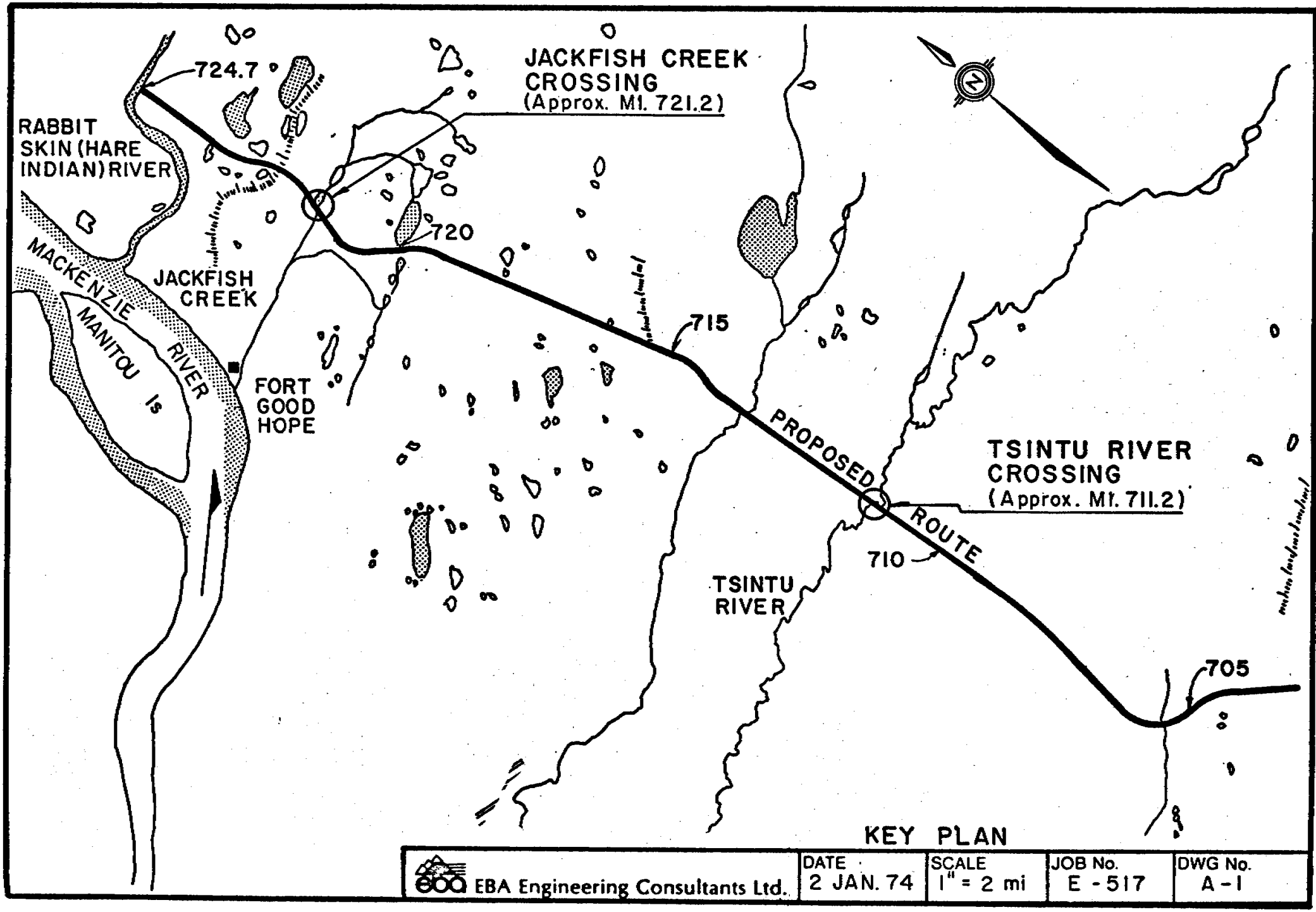
4. Canada, 1972: Land Use Information Series Maps - Norman Wells Sheet. Department of Indian Affairs and Northern Development.



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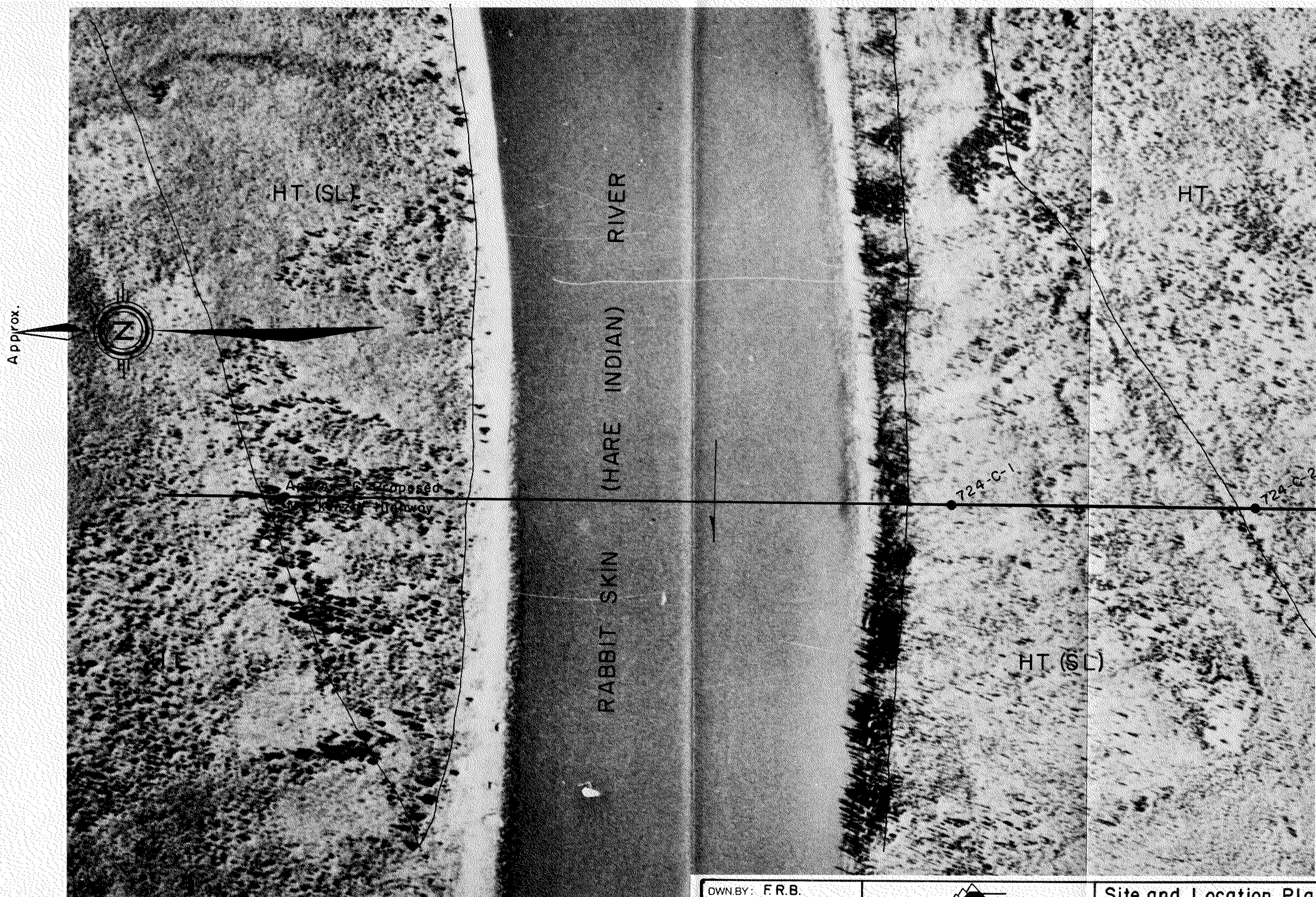

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DATE DWN.:	12 May, 73
SCALE:	1" = 200'
JOB No.:	E-517

eba
E.W. BROOKER & ASSOCIATES LTD.
civil engineers

Site and Location Plan for Boreholes at RABBIT SKIN (HARE INDIAN) RIVER CROSSING

DWG.: A-2

SHT. No.:

TERRAIN LEGEND

SYMBOL	TERRAIN TYPE	PHYSIOGRAPHIC FEATURES	MATERIALS DESCRIPTION
HT	High Terraces	Tabular bodies along the sides of and above present or abandoned river channels	Silt covered stratified sand and/or gravel of fluvial or outwash origin
GLB-1	Glacial Lake Basin (Better drained type)	Lowland occasionally swampy areas	Ice-rich to medium plastic silty clay, occasionally with a trace of sand
GM	Ground Moraine (undifferentiated)	Flat to broad gentle slopes	Silt till to clay till usually some sand and gravel
LB	Lacustrine Basin	Postglacial ponded deposits in larger lowlying areas	Organic and inorganic clay, silt and fine sand
BR	Bedrock	Outcrop to continuous ridge	Exposed rock to rock with generally less than 5 feet of cover
AMP	Alluvial Meander Plain (Mackenzie River Meander Plain)	Flat plain often with sand dunes on it	Sands and silty sands stratified or channel deposits
RKM	Ridge-and-knoll Moraine	Drumlinized till plain rolling large linear features	Molded basal till low plastic silty-clay till
FFP	Fossil Flood Plain	Flat plain may be dissected to rolling topography	Silty topstratum over sand and/or gravel of a flood plain of an inactive stream

Topstratum Phases (Associated with Terrain Types)

SL	Slopewash or solifluction features. Topstratum of ice-rich poorly sorted silty clay and silty sand to gravel
PT	Mixed bog and fen peats in post glacial ponded depression
DF	Thin (0 - 10 feet) of drift over bedrock surfaces

Complexes are shown as combinations of two terrain types with or without phases that pertain to the parent type.

Terrain Symbols are modified from Canadian Gas Arctic Study Limited Terrain Study for this area.

Drawing No. A-2a

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: LAB | DATE DRILLED: 12/8/72 | AIRPHOTO NO: A22858-54 | CHAINAGE: 0 + 05 | OFFSET

CKD: GRG | TECH: TJ | RIG: Mayhew 500 | SURFACE DRAINAGE: Good N To River | VEGETATION: Dwarf Spruce 8' Sparse | ELEV: 199.3'

TEST HOLE C7

MILE	B,C,S	NUMBER
724	C	1

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				CI	CLAY - Med. Brown, Sandy, Gravelly, Silty, Med. Plasticity	U	Unfrozen
4	2				GW	GRAVEL, COBBLES & BOULDERS - Some Sand & Some Silt	F	NB
10	3							
12								NF
14	4				GW	GRAVEL - Wet, Silty, Some Sand, Probably Med. To High Ice Content, Melting In Hole, Sampling Very Difficult		
20	5					- Med. Brown, Sandy Gravel, Some Silt		
24						(Continued)		

O = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT

20 40 60 80 100 100+

DEPTH (FEET)	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						
22						
24						

REMARKS

100 ' S. of River Bank

3½"- 29' Drilled With Tricone Rock Bit

Melting In Hole Sampling Very Difficult

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

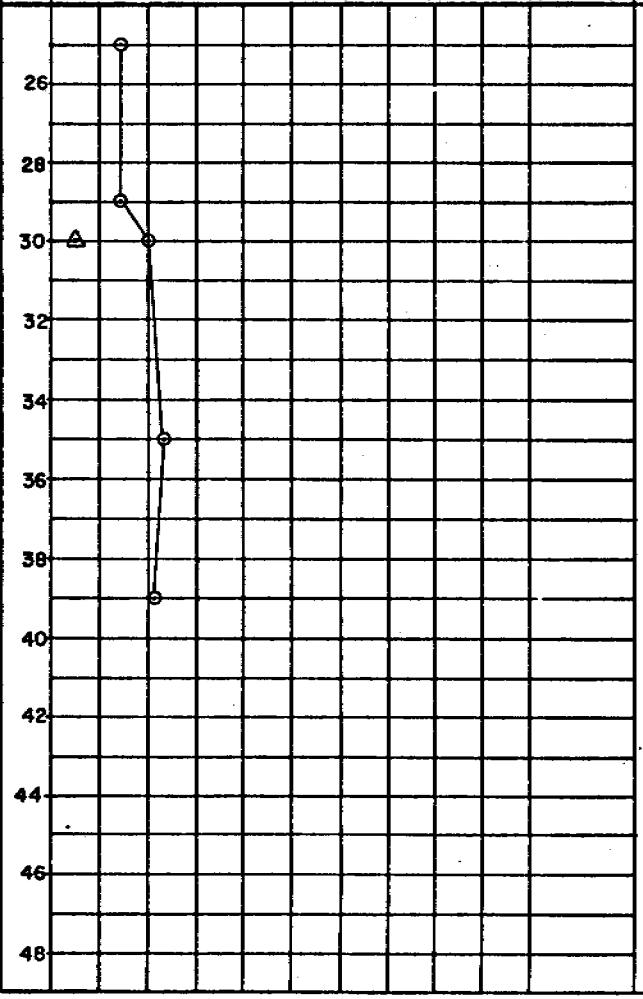
DWN: ALB | FIELD ENG: LAB | DATE DRILLED 12/8/72 | AIRPHOTO NO: A22858-54 | CHAINAGE: 0 + 05 | OFFSET

CKD: GRG | TECH: TJ | RIG: Mayhew 500 | SURFACE DRAINAGE: Good N To River | VEGETATION: Dwarf Spruce 8' Sparse | ELEV: 199.3'

TEST HOLE C7

MILE	B,C,S	NUMBER
724	C	1

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
26	6					- Same as Above		
28	7							
30	8				SW	SAND - Lt. Brown, Fine to Med. Grained, Silty, Some Gravel		V 5%.
32								
34	9							
36								
38	10							
40						END OF HOLE 39'		
42								
44								
46								
48								



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

REMARKS

Page 2 of 2.

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E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

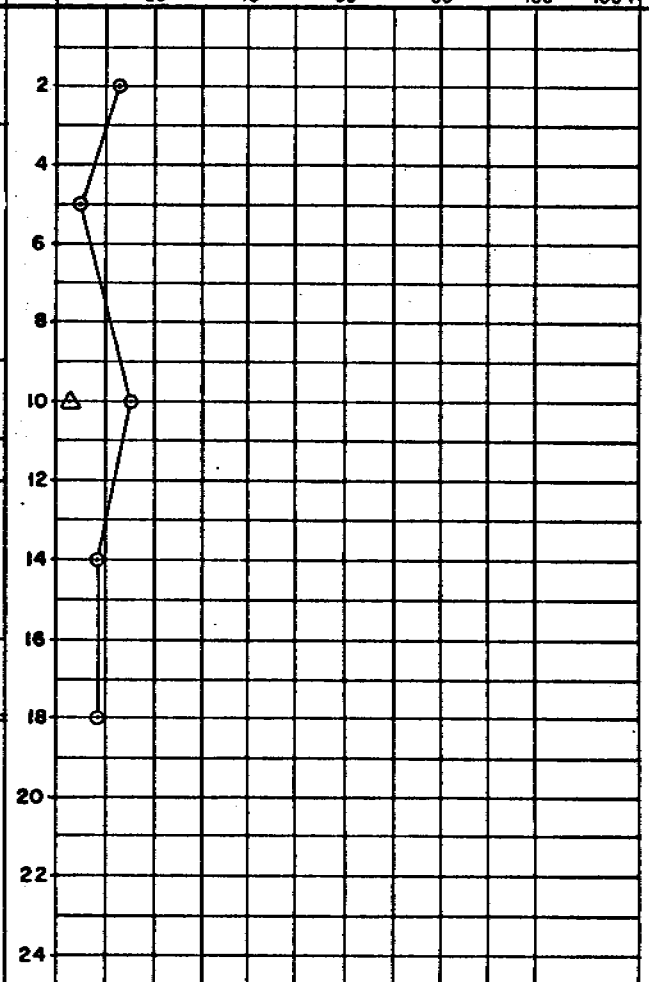
DWN: ALB | FIELD ENG: LAB | DATE DRILLED: 12/8/72 | AIRPHOTO NO: A22858-54 | CHAINAGE: 7 + 44 | OFFSET
CKD: GRG | TECH: TJ | RIG: Mayhew 500 | SURFACE DRAINAGE: V. Good N to River | VEGETATION: Spruce-Willow-Tamarack | ELEV: 262.2'

TEST HOLE C8

MILE	B,C,S	NUMBER
724	C	2

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				CL	CLAY – Med. Brown, Silty Some Sand, Low Plasticity	F	NB
4	2				GW	GRAVEL – Med. Brown, Silty Sandy, Well Graded Subangular – Angular Particles		NB
10	3				SW	SAND – Lt. Brown, Gravelly Coarse		V 2–3% (Est.)
12						BOUNDLER		
14	4				GC	GRAVEL – TILL – LIKE – Med. Brown, Silty, Some Clay	U	Unfrozen
18	5				CL	CLAY (TILL) – Grey-Brown, Silty Clay	F	NB Trace
						END OF HOLE 18'		

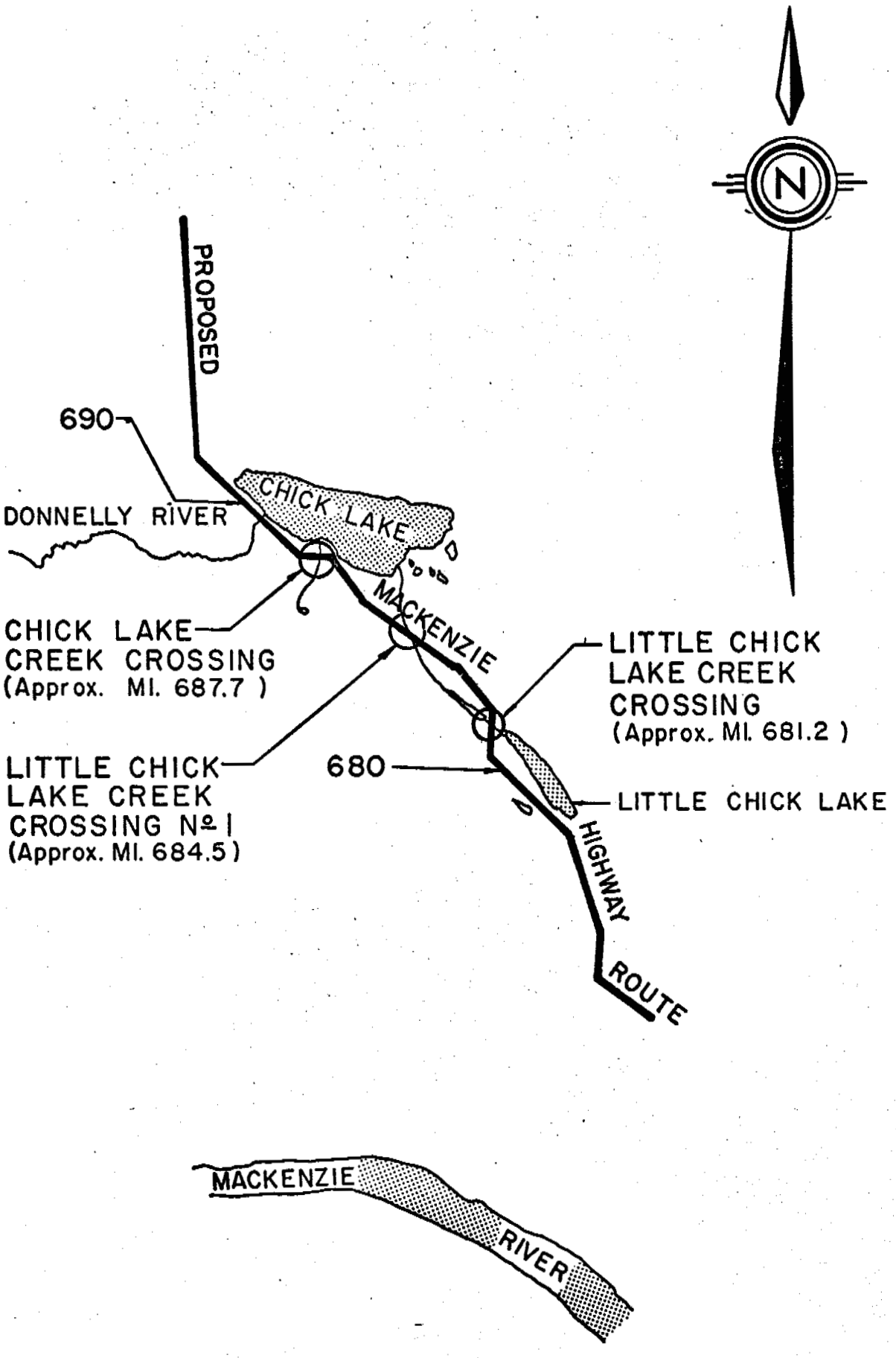
○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)
PLASTIC LIMIT — LIQUID LIMIT
20 40 60 80 100 100+



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

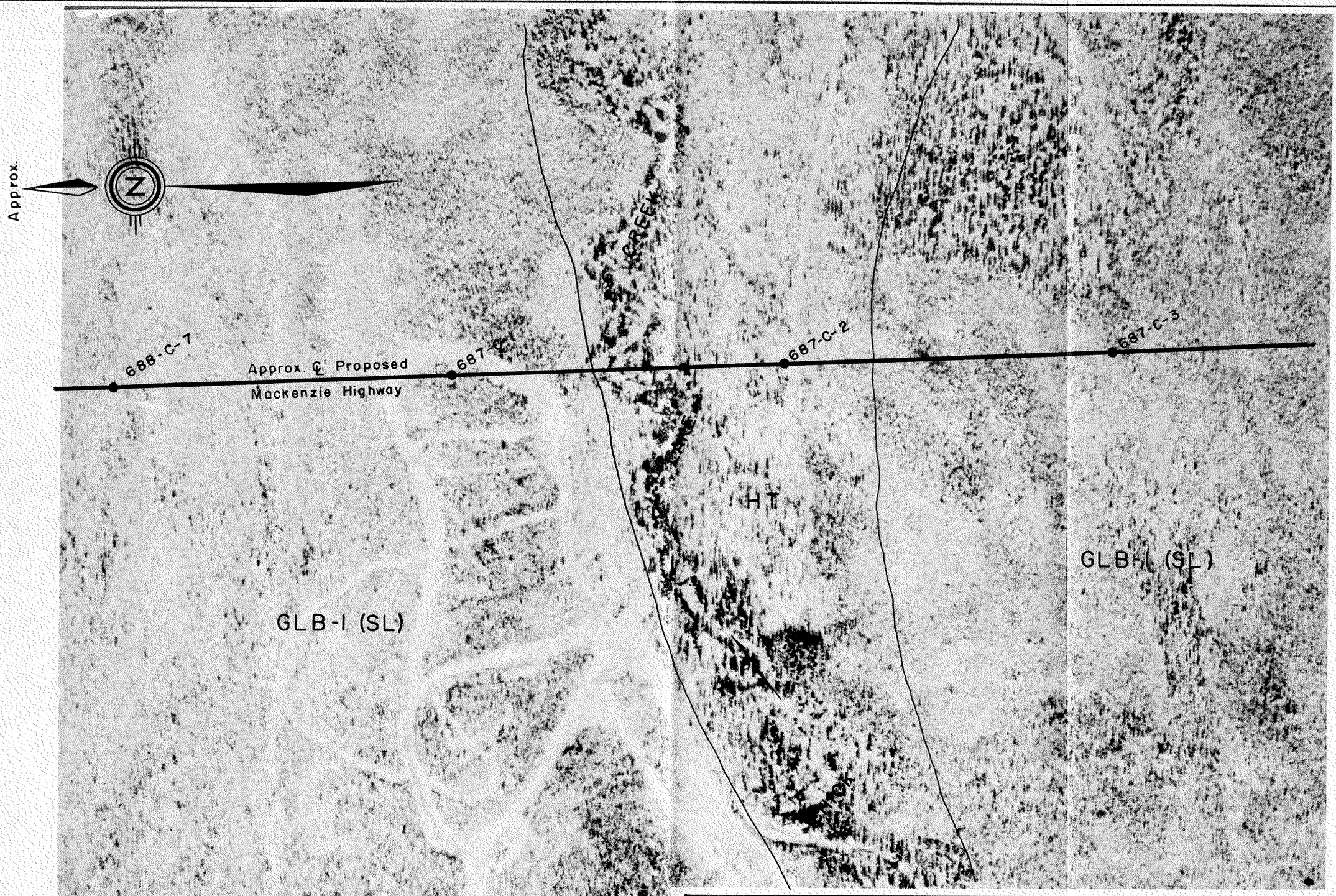
REMARKS

App. 1000' S. of Rabbit Skin River (Hare Indian R.)



KEY PLAN

EBA Engineering Consultants Ltd.	DATE	SCALE	JOB No.	DWG No.
	7 Jan 74	1" = 4 mi	E-517	A-1



DWN.BY: F.R.B.	eba E.W. BROOKER & ASSOCIATES LTD. civil engineers	Site and Location Plan for Boreholes at CHICK LAKE CREEK CROSSING	DWG.: A-2
DATE DWN.: 12 May, 73			
SCALE: 1" = 200'			SHT. No.:
JOB No.: E-517			

TERRAIN LEGEND

SYMBOL	TERRAIN TYPE	PHYSIOGRAPHIC FEATURES	MATERIALS DESCRIPTION
HT	High Terraces	Tabular bodies along the sides of and above present or abandoned river channels	Silt covered stratified sand and/or gravel of fluvial or outwash origin
GLB-1	Glacial Lake Basin (Better drained type)	Lowland occasionally swampy areas	Ice-rich to medium plastic silty clay, occasionally with a trace of sand
GM	Ground Moraine (undifferentiated)	Flat to broad gentle slopes	Silt till to clay till usually some sand and gravel
LB	Lacustrine Basin	Postglacial ponded deposits in larger lowlying areas	Organic and inorganic clay, silt and fine sand
BR	Bedrock	Outcrop to continuous ridge	Exposed rock to rock with generally less than 5 feet of cover
AMP	Alluvial Meander Plain (Mackenzie River Meander Plain)	Flat plain often with sand dunes on it	Sands and silty sands stratified or channel deposits
RKM	Ridge-and-knoll Moraine	Drumlinized till plain rolling large linear features	Molded basal till low plastic silty-clay till
FFP	Fossil Flood Plain	Flat plain may be dissected to rolling topography	Silty topstratum over sand and/or gravel of a flood plain of an inactive stream

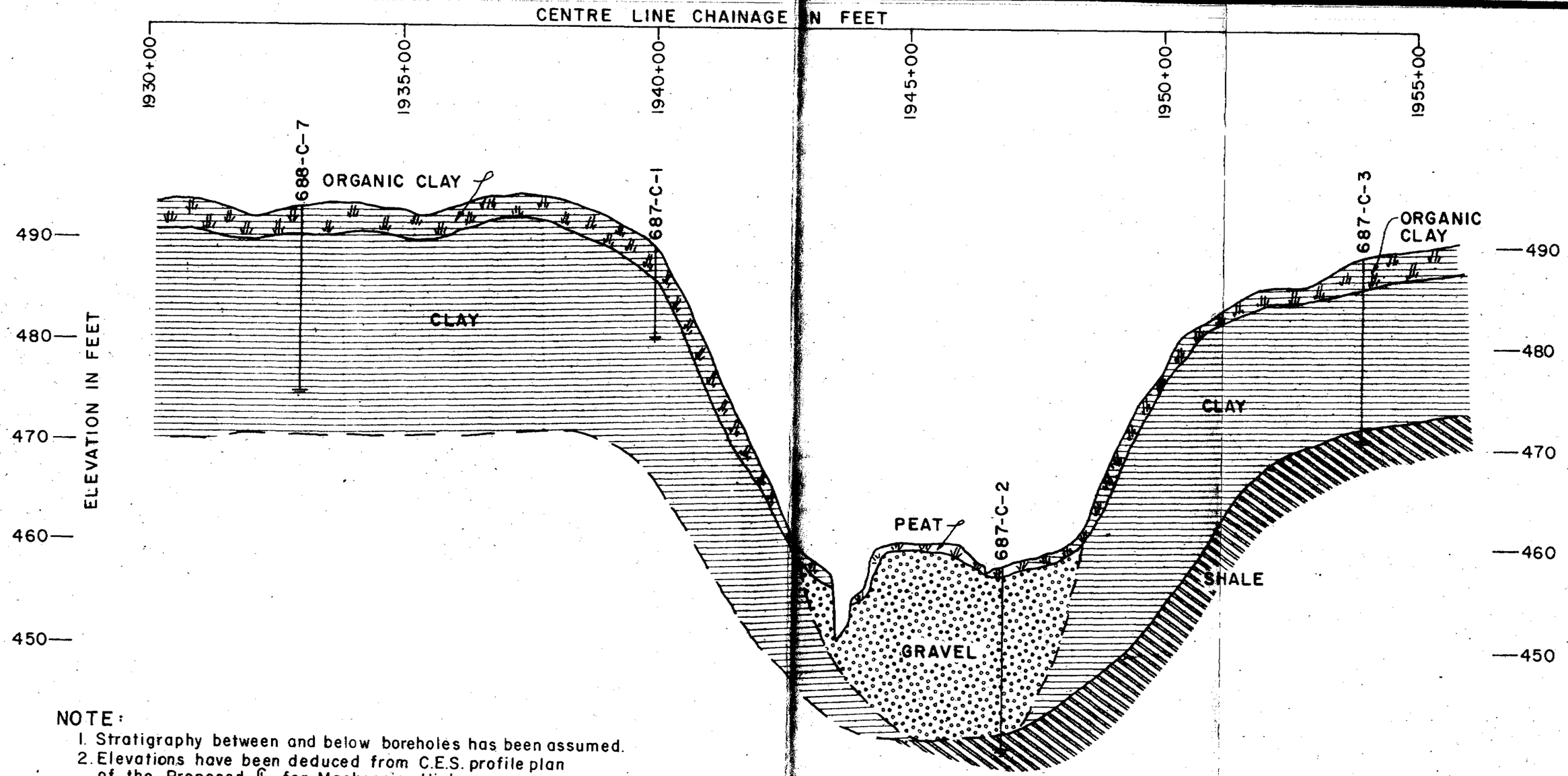
Topstratum Phases (Associated with Terrain Types)

SL	Slopewash or solifluction features. Topstratum of ice-rich poorly sorted silty clay and silty sand to gravel
PT	Mixed bog and fen peats in post glacial ponded depression
DF	Thin (0 - 10 feet) of drift over bedrock surfaces

Complexes are shown as combinations of two terrain types with or without phases that pertain to the parent type.

Terrain Symbols are modified from Canadian Gas Arctic Study Limited Terrain Study for this area.

Drawing No. A-2a



NOTE:

1. Stratigraphy between and below boreholes has been assumed.
2. Elevations have been deduced from C.E.S. profile plan of the Proposed ℄ for Mackenzie Highway
3. Scales: Vert. 1" = 10'
   Horiz. 1" = 200'

DWN BY:	F.R.B.
DATE DWN.:	
SCALE:	As Noted
JOB No.:	E-517

Engineering Consultants Ltd.

CHICK LAKE CREEK CROSSING
℄ PROFILE & STRATIGRAPHY

DWG.: A-3

SHT. No.:

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: GRG | DATE DRILLED: 7/2/73 | AIRPHOTO NO: A22861 - 135 | CHAINAGE: 1933 + 00 | OFFSET

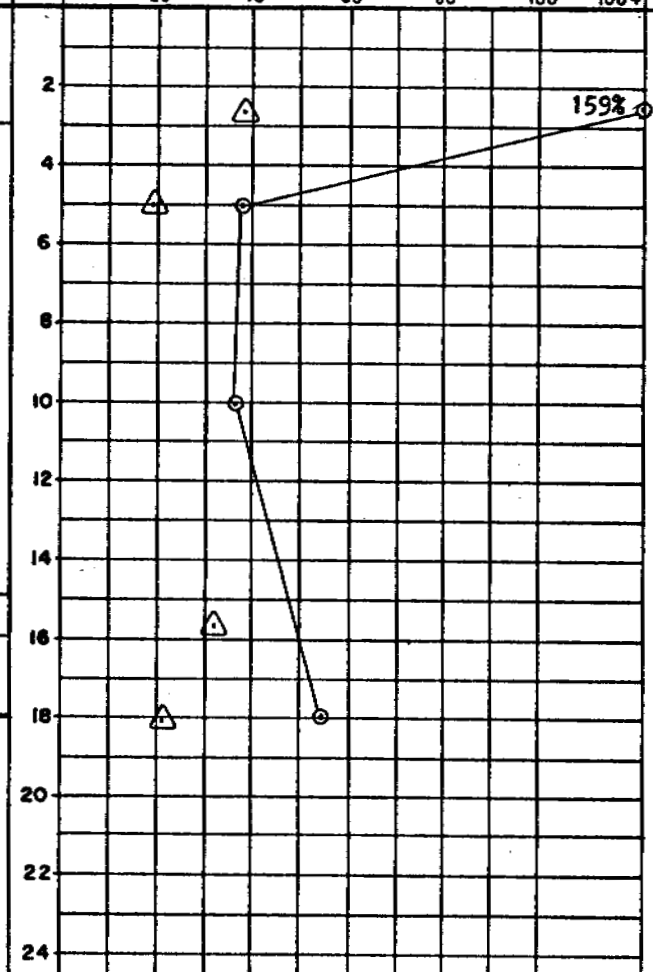
CKD: NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 492.4'

TEST HOLE

MILE	B,C,S	NUMBER
688	C	7

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				OH	CLAY - Black - Organic	F	V 35-40%
4						- Med. Brown - Silty		
6	2				CL	- Low Plasticity		V 15-20%
8								
10	3					- Grey		
12					CI	- Silty - Med. Plasticity		
14								
16								V 30-35%
18	4							V 20-25%
20						END OF HOLE 18'		
22								
24								



DEPTH (FEET)	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						
22						
24						

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: GRG | DATE DRILLED: 7/2/73 | AIRPHOTO NO: A22861 - 137 | CHAINAGE: 1940 + 00 | OFFSET

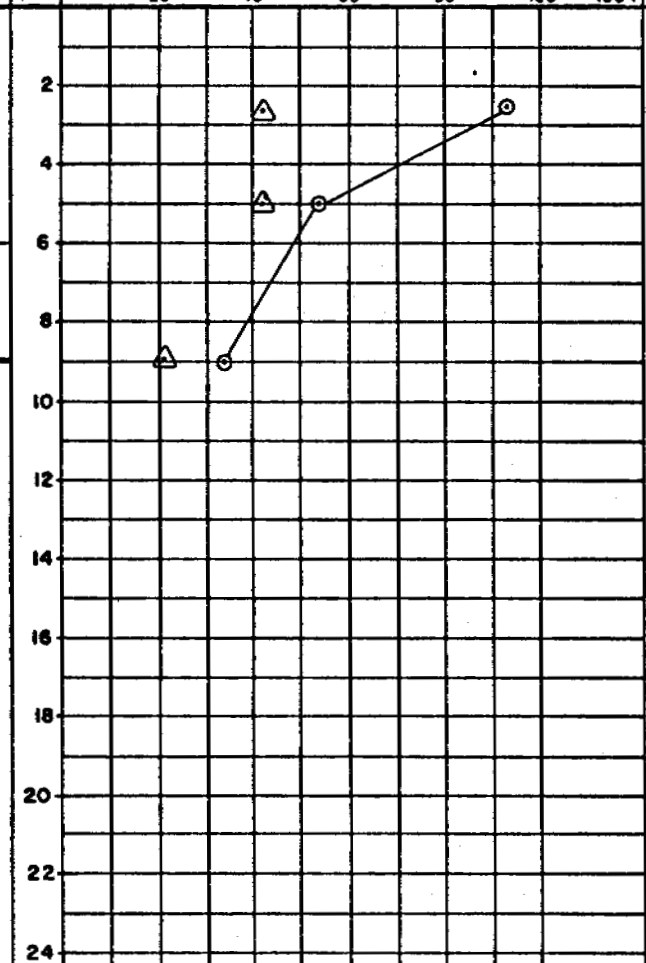
CKD: NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 488.8'

TEST HOLE

MILE	B,C,S	NUMBER
687	C	1

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				CL	CLAY - Dark Brown - Organic - Low Plasticity	F	V 40-45%
4						- Med. Brown - Silty		
6	2				CI	- Med. Plasticity		V 20-25%
8	3							
10						END OF HOLE 9'		
12								
14								
16								
18								
20								
22								
24								



GRAIN-SIZE ANALYSIS

CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)

E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

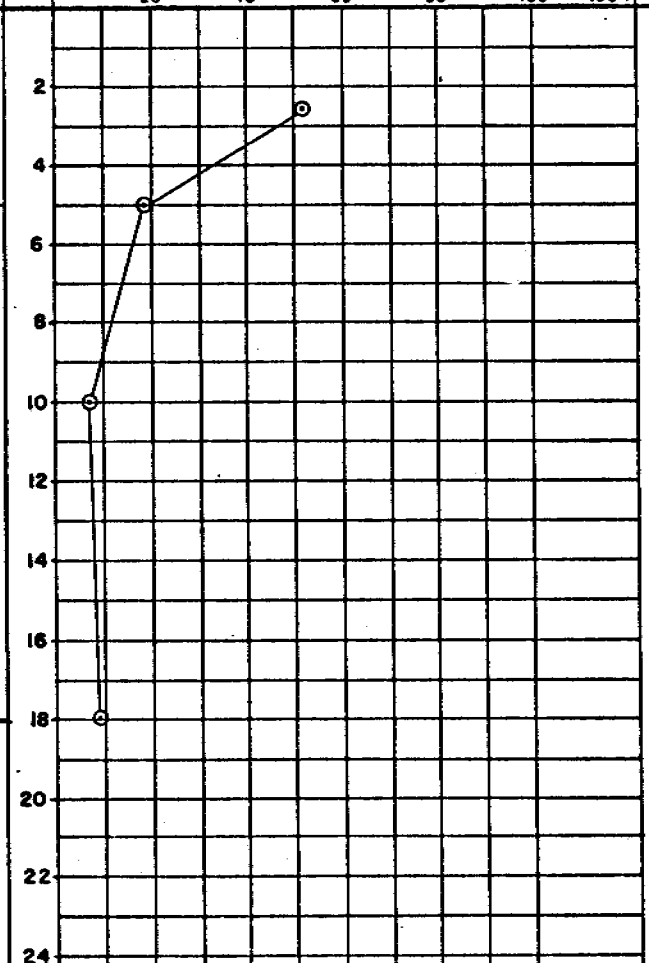
DWN: ALB	FIELD ENG: GRG	DATE DRILLED: 7/2/73	AIRPHOTO NO: A22861 - 137	CHAINAGE: 1947 + 00	OFFSET
CKD: NRM	TECH: DY	RIG: Mayhew 500	SURFACE DRAINAGE: Well Drained	VEGETATION: Black Spruce	ELEV: 457.7'

TEST HOLE

MILE	B,C,S	NUMBER
687	C	2

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0					Pt	PEAT - Med. Brown, Fibrous		
2	1				GC	GRAVEL - Med. Brown - Silty, Clayey - Low Plasticity - Cobbles	F	NB
4								
6	2				to		U	Unfrozen
8					GW			
10	3					- Med. Brown - Cobbles - Some Clay and silt - Some sand		
12								
14								
16								
18	4				CL	SHALE - Grey		
						END OF HOLE 18'		
20								
22								
24								



GRAIN-SIZE ANALYSIS

DEPTH (FEET)	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
10	11	17	72			

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: GRG | DATE DRILLED: 7/2/73 | AIRPHOTO NO: A22861 - 137 | CHAINAGE: 1954 + 00 | OFFSET

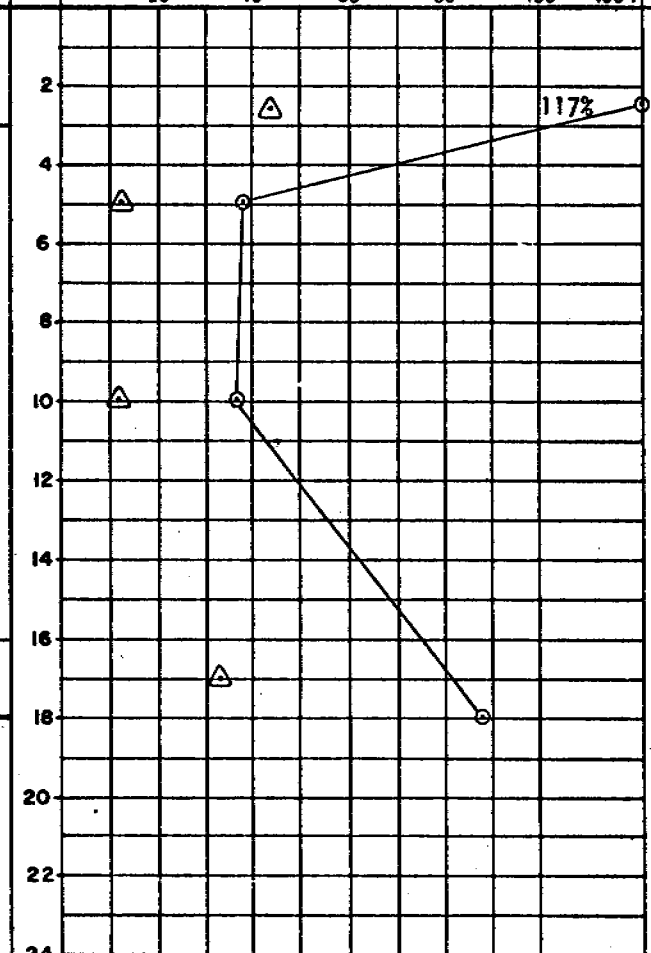
CKD: NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 489.1'

TEST HOLE

MILE	B,C,S	NUMBER
687	C	3

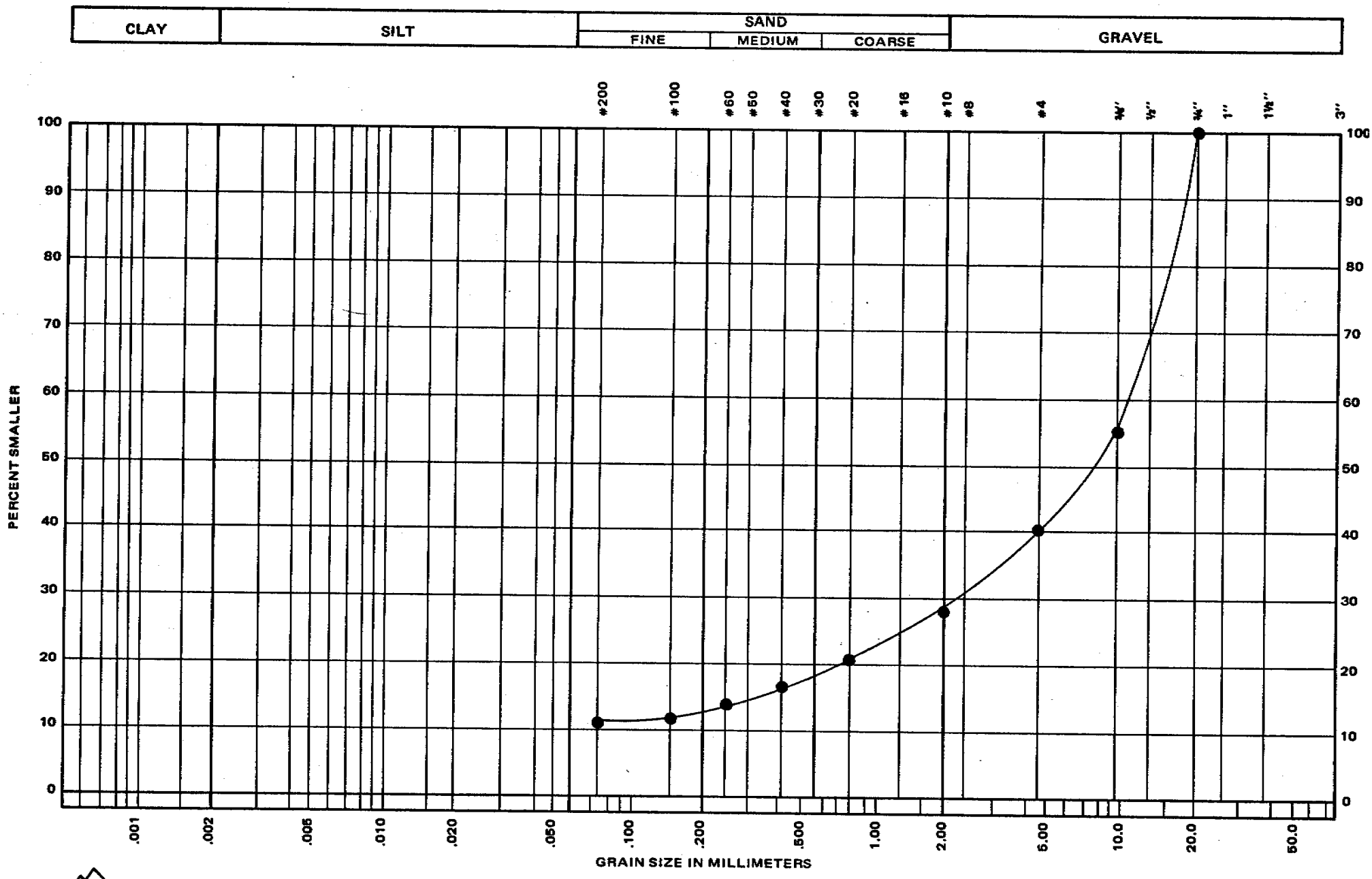
REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				OH	CLAY - Dark Brown - Organic - Med. Plasticity		V 45-50%
4	2				CI	- Med. Brown - Silty - Med. Plasticity		V 10-15%
8							F	
10	3					- Grey, Silty - Low Plasticity - Trace of Gravel		
16								V 30-35%
18	4				CL	SHALE - Grey, Low Plasticity		
						END OF HOLE 18'		



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

GRAIN SIZE DISTRIBUTION



FIGURE

E. W. Brooker & Associates Ltd.

SAMPLE DESCRIPTION Gravel, Some Sand, Some Silt & Clay

PROJECT Mackenzie Highway

JOB No. E-517 DATE April 11/73

SAMPLE No. 687-C-2

DEPTH 10'

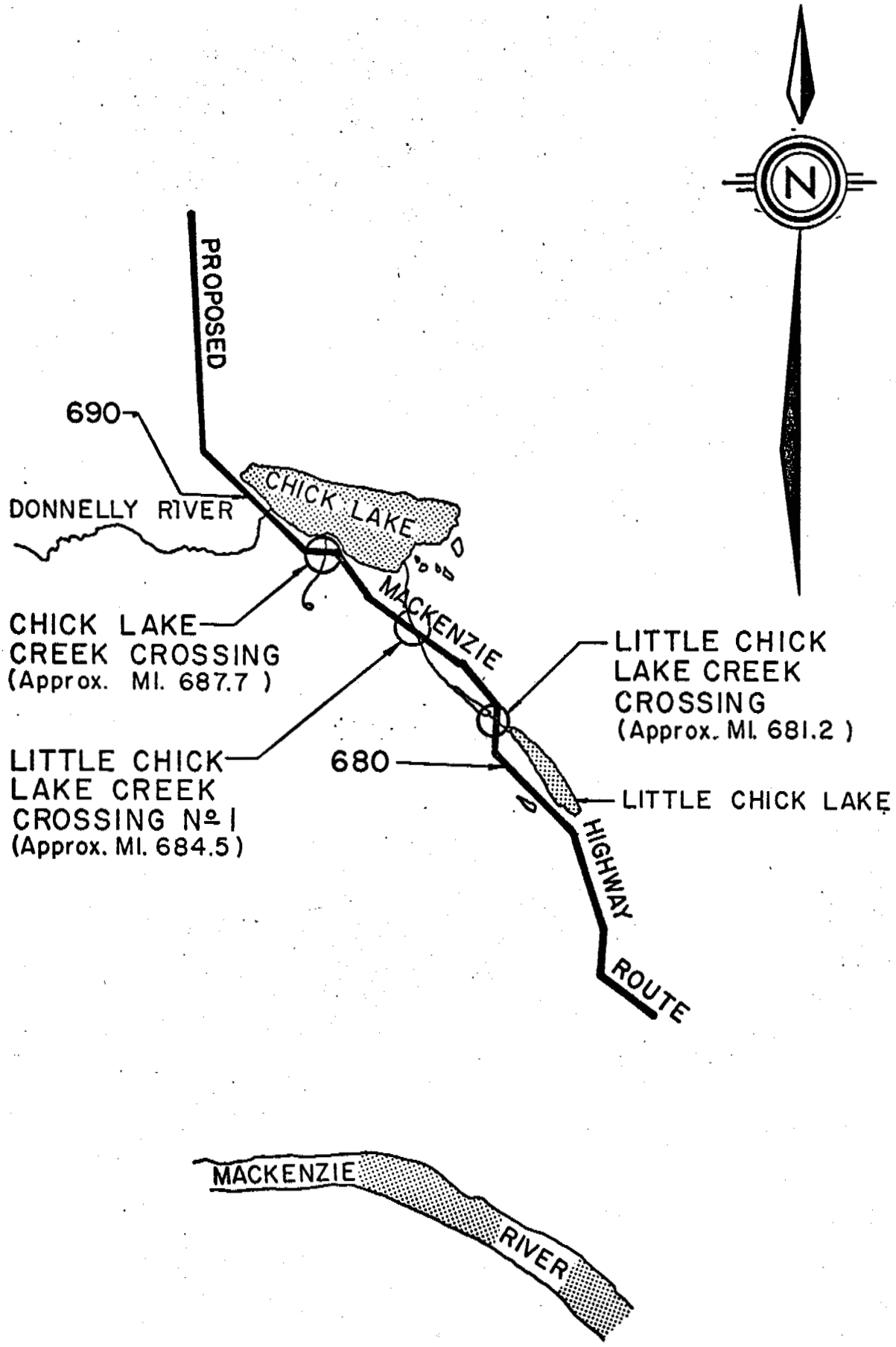
SUMMARY OF TEST RESULTS JOB No. E 517

CHICK LAKE CREEK CROSSING - MILE 687.7

BORE HOLE	DEPTH	NATURAL WATER CONTENT	Atterberg Limits			MECHANICAL ANALYSIS (M.I.T. CLASSIFICATION)				SOIL CLASSIFICATION (UNIFIED)	REMARKS
			W_L	W_P	PI						
	feet	%	%	%	%	% CLAY	% SILT	% SAND	% GRAVEL		
687-C-2	10					11		17	72	GW-GC	

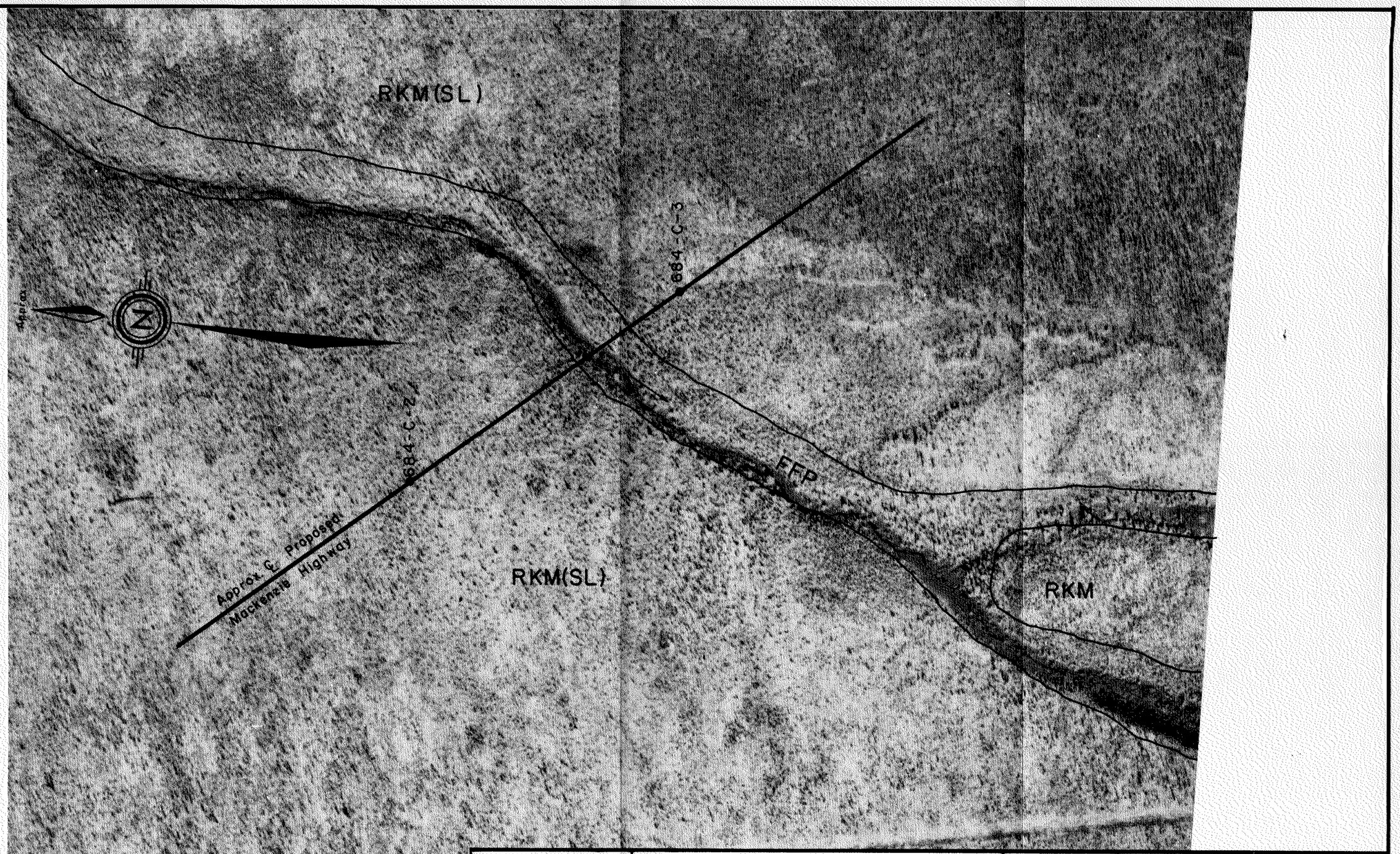
DWG. No.

EBA ENGINEERING CONSULTANTS LTD.



KEY PLAN

EBA Engineering Consultants Ltd.	DATE	SCALE	JOB No.	DWG No.
	7 Jan 74	1" = 4 mi	E-517	A-1



DWN BY F.R.B DATE DWN MAR 74 SCALE 1"= 200' JOB No. E-517	EBA Engineering Consultants Ltd.	Site and Location Plan for Boreholes at LITTLE CHICK LAKE CREEK CROSSING No 1	DWG A-2 SHT No.

TERRAIN LEGEND

SYMBOL	TERRAIN TYPE	PHYSIOGRAPHIC FEATURES	MATERIALS DESCRIPTION
HT	High Terraces	Tabular bodies along the sides of and above present or abandoned river channels	Silt covered stratified sand and/or gravel of fluvial or outwash origin
GLB-1	Glacial Lake Basin (Better drained type)	Lowland occasionally swampy areas	Ice-rich to medium plastic silty clay, occasionally with a trace of sand
GM	Ground Moraine (undifferentiated)	Flat to broad gentle slopes	Silt till to clay till usually some sand and gravel
LB	Lacustrine Basin	Postglacial ponded deposits in larger lowlying areas	Organic and inorganic clay, silt and fine sand
BR	Bedrock	Outcrop to continuous ridge	Exposed rock to rock with generally less than 5 feet of cover
AMP	Alluvial Meander Plain (Mackenzie River Meander Plain)	Flat plain often with sand dunes on it	Sands and silty sands stratified or channel deposits
RKM	Ridge-and-knoll Moraine	Drumlinized till plain rolling large linear features	Molded basal till low plastic silty-clay till
FFP	Fossil Flood Plain	Flat plain may be dissected to rolling topography	Silty topstratum over sand and/or gravel of a flood plain of an inactive stream

Topstratum Phases (Associated with Terrain Types)

SL — Slopewash or solifluction features. Topstratum of ice-rich poorly sorted silty clay and silty sand to gravel

PT — Mixed bog and fen peats in post glacial ponded depression

DF — Thin (0 - 10 feet) of drift over bedrock surfaces

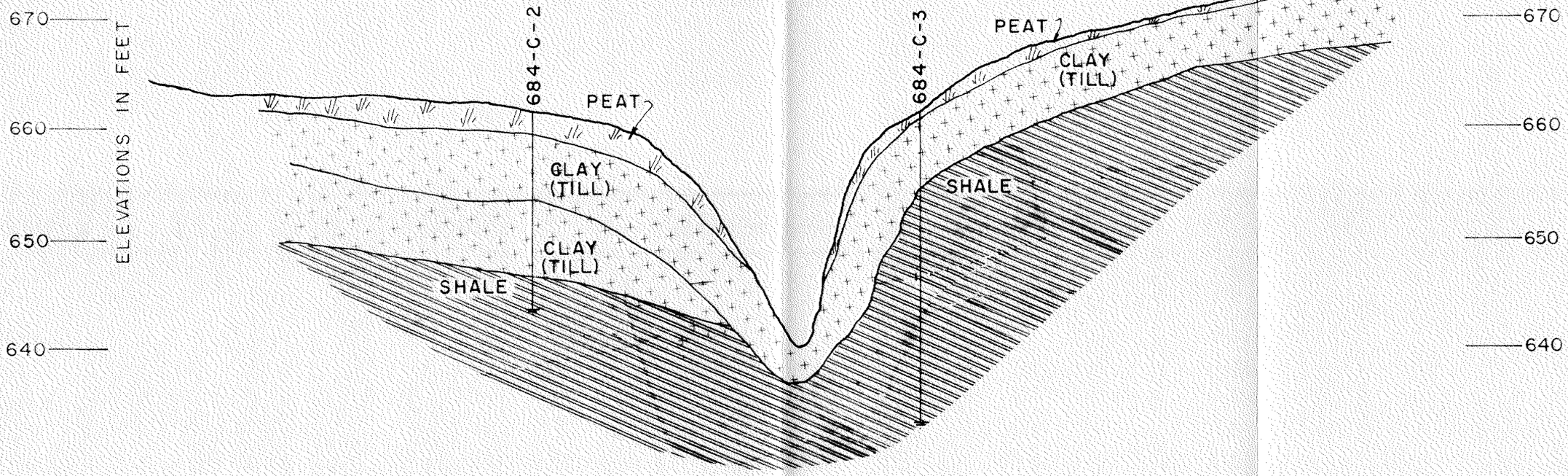
Complexes are shown as combinations of two terrain types with or without phases that pertain to the parent type.

Terrain Symbols are modified from Canadian Gas Arctic Study Limited Terrain Study for this area.

Drawing No. A-2a

CENTRE LINE CHAINAGE IN FEET

2104+00 — 2106+00 — 2108+00 — 2110+00 — 2112+00 — 2114+00 — 2116+00 — 2118+00 — 2120+00 — 2122+00



NOTE:

1. Stratigraphy between and below boreholes has been assumed.
2. Elevations deduced from C.E.S. ℄ Profile plan of proposed Mackenzie Highway.
3. Scales: Horiz. 1" = 200'
   Vert. 1" = 10'

DWN BY:	F R B
DATE DWN:	MAR. 74
SCALE:	AS NOTED
JOB No:	E - 517

eba Engineering Consultants Ltd.

LITTLE CHICK LAKE
CREEK CROSSING Nº 1
℄ PROFILE &
STRATIGRAPHY

DWG: A - 3 - 1

SHT No:

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: GRG | DATE DRILLED 8/2/73 | AIRPHOTO NO: A22861 - 141 | CHAINAGE: 2108 + 00 | OFFSET

CKD: NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 661.6'

TEST HOLE

MILE	B,C,S	NUMBER
684	C	2

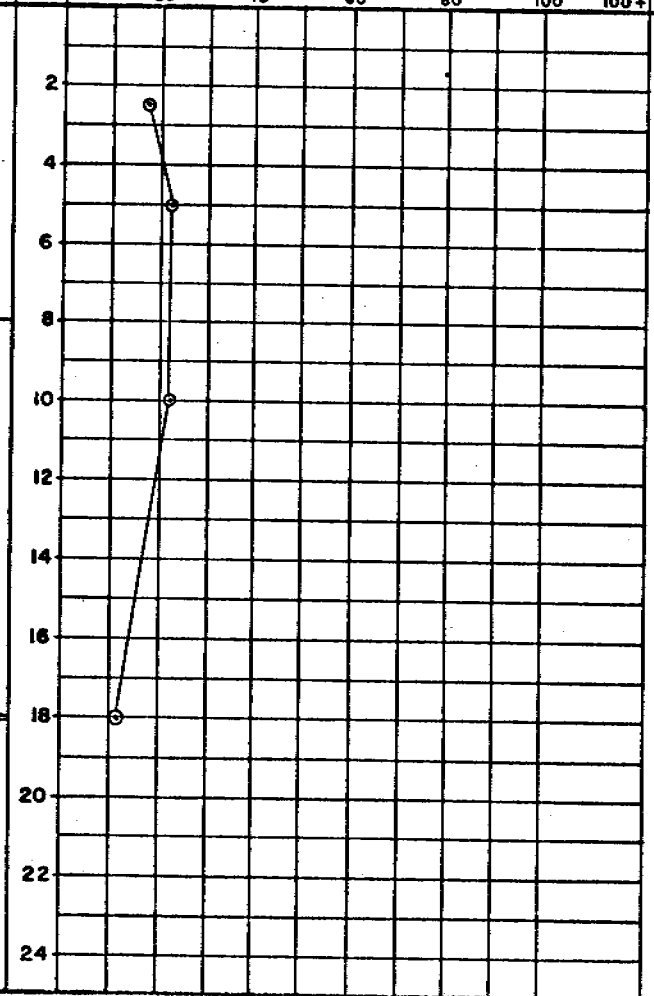
REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0					Pt	PEAT - Dark Brown - Fibrous	F	NB
2	1				CL	CLAY (TILL) - Med. Brown - Silty - Low Plasticity - Some Gravel		
4	2							
6								
8					CI	CLAY (TILL) - Grey, Silty - Med. Plasticity - Trace of Gravel	U	Unfrozen
10	3							
12								
14								
16					ML	SHALE - Grey - Weathered		
18	4					END OF HOLE 18'		
20								
22								
24								

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT

20 40 60 80 100 100+



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

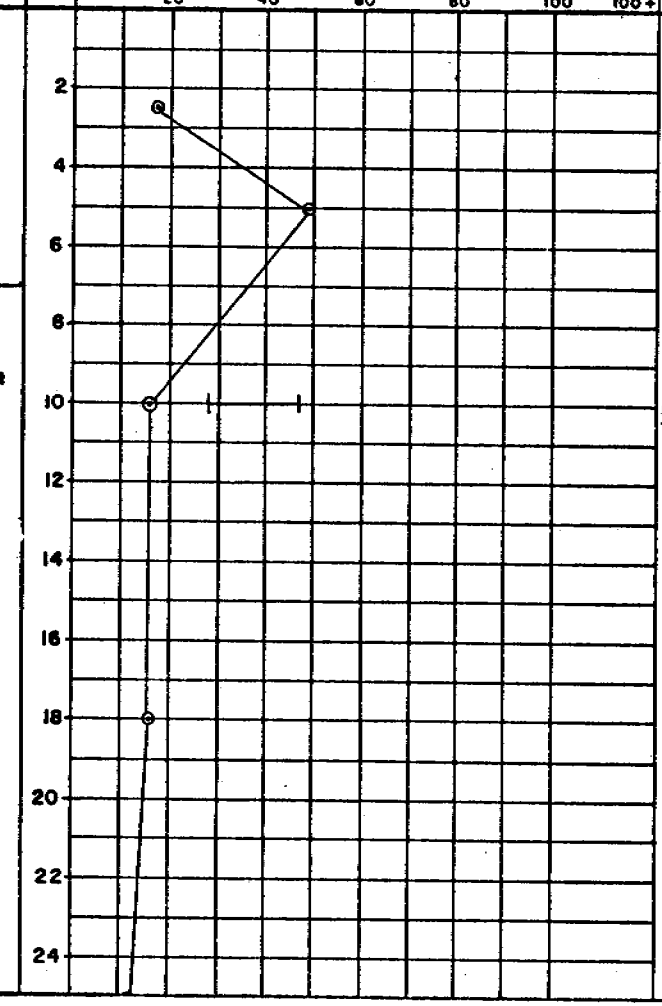
DWN: ALB | FIELD ENG: GRG | DATE DRILLED: 8/2/73 | AIRPHOTO NO: A22861 - 141 | CHAINAGE: 2115 + 00 | OFFSET

CKD: NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 661.4'

TEST HOLE

MILE	B,C,S	NUMBER
684	C	3

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT - Dk. Brown, Fibrous		
2	1				CL	CLAY - Dark Brown (TILL) - Silty - Low Plasticity - Trace of Gravel	F	NB
4	2							
6								
8					Cl	SHALE - Grey - Badly Weathered - Clay-silt - Trace of Sand	U	Unfrozen
10	3							
12								
14								
16								
18	4							
20								
22								
24								



GRAIN-SIZE ANALYSIS

DEPTH (FEET)	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
10	51	47	2	-		

REMARKS

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: GRG | DATE DRILLED 8/2/73 | AIRPHOTO NO: A22861 - 141 | CHAINAGE: 2115 + 00 | OFFSET

CKD: NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 661.4'

TEST HOLE

MILE	B,C,S	NUMBER
684	C	3

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
26					CI	SHALE - Grey - Badly Weathered - Silty	U	Unfrozen
28	5					END OF HOLE 28'		
30								
32								
34								
36								
38								
40								
42								
44								
46								
48								

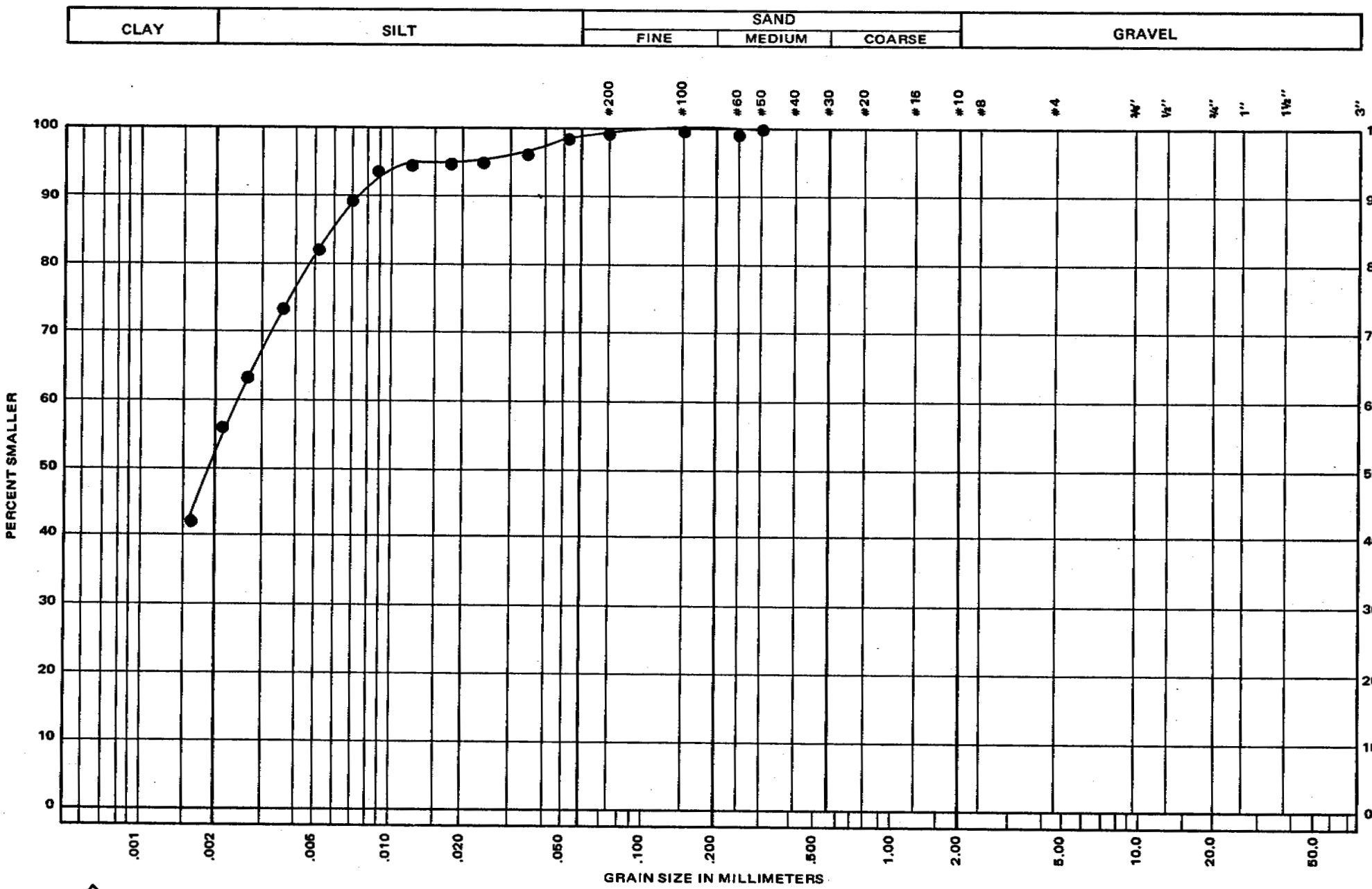
O = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT ⟷ LIQUID LIMIT

20 40 60 80 100 100+

GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

GRAIN SIZE DISTRIBUTION



FIGURE

eba
Engineering Consultants Ltd.

SAMPLE DESCRIPTION Silty Clay, (Shale)
Trace of Sand

PROJECT Mackenzie Highway
JOB No. E-517 DATE April 9/74
SAMPLE No. 684-C-3
DEPTH 10'

SUMMARY OF TEST RESULTS

JOB No.:

LITTLE CHICK LAKE CREEK CROSSING NO. 1 - MILE 684.5

BORE HOLE	DEPTH	NATURAL WATER CONTENT	Atterberg Limits			MECHANICAL ANALYSIS (M.I.T. CLASSIFICATION)				SOIL CLASSIFICATION (UNIFIED)	REMARKS
			W_L	W_P	PI						
	feet	%	%	%	%	% CLAY	% SILT	% SAND	% GRAVEL		
684-C-3	10	16.5	46.7	27.8	18.9	51	47	2	0	C1	

DWG. No.

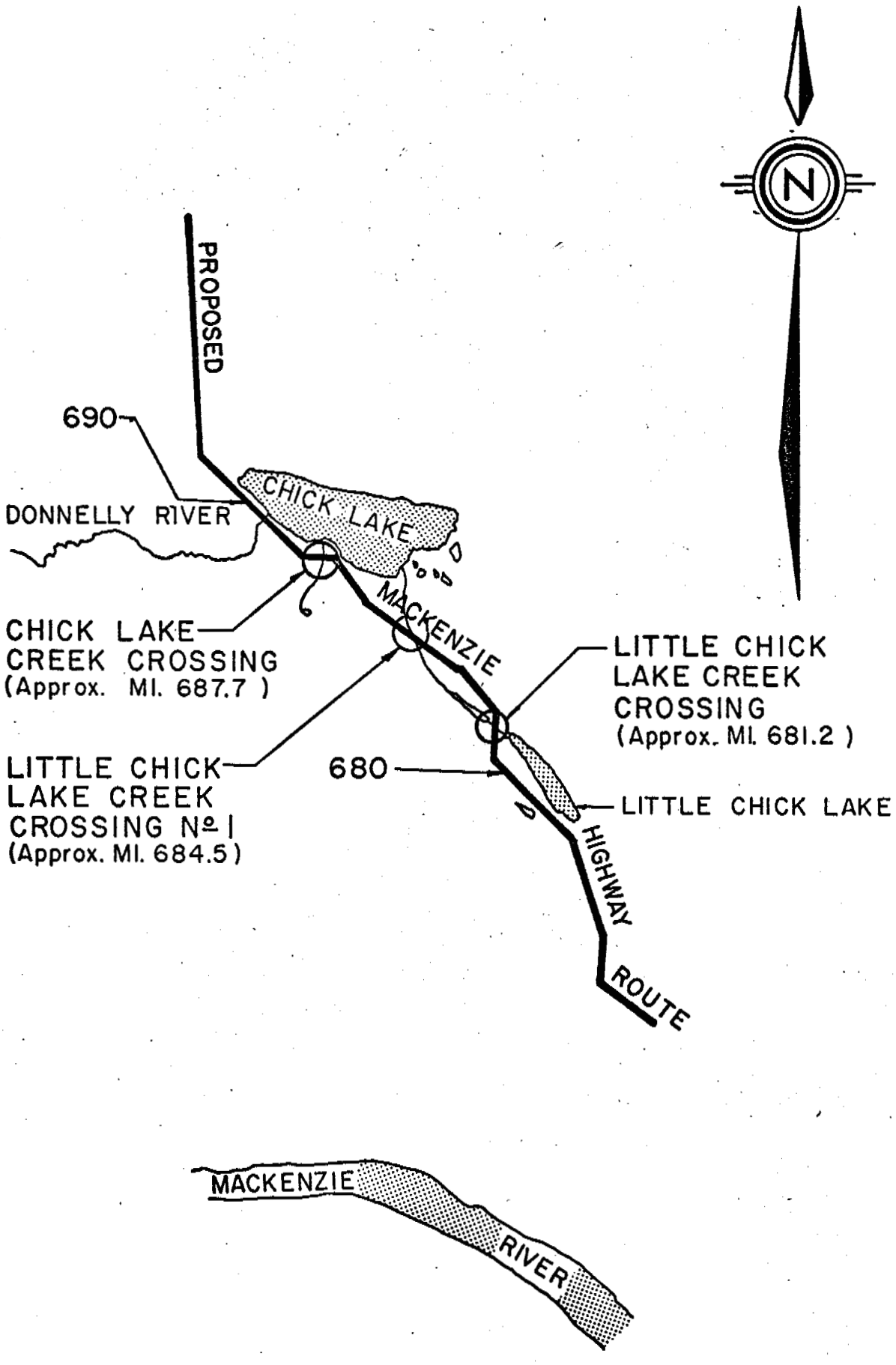
EBA ENGINEERING CONSULTANTS LTD.

LITTLE CHICK LAKE CREEK CROSSING NO. 1 - MILE 684.5

BORE HOLE	DEPTH	NATURAL WATER CONTENT	Atterberg Limits			MECHANICAL ANALYSIS (M.I.T. CLASSIFICATION)				SOIL CLASSIFICATION (UNIFIED)	REMARKS
			W_L	W_P	PI						
	feet	%	%	%	%	% CLAY	% SILT	% SAND	% GRAVEL		
684-C-3	10	16.5	46.7	27.8	18.9	51	47	2	0	C1	

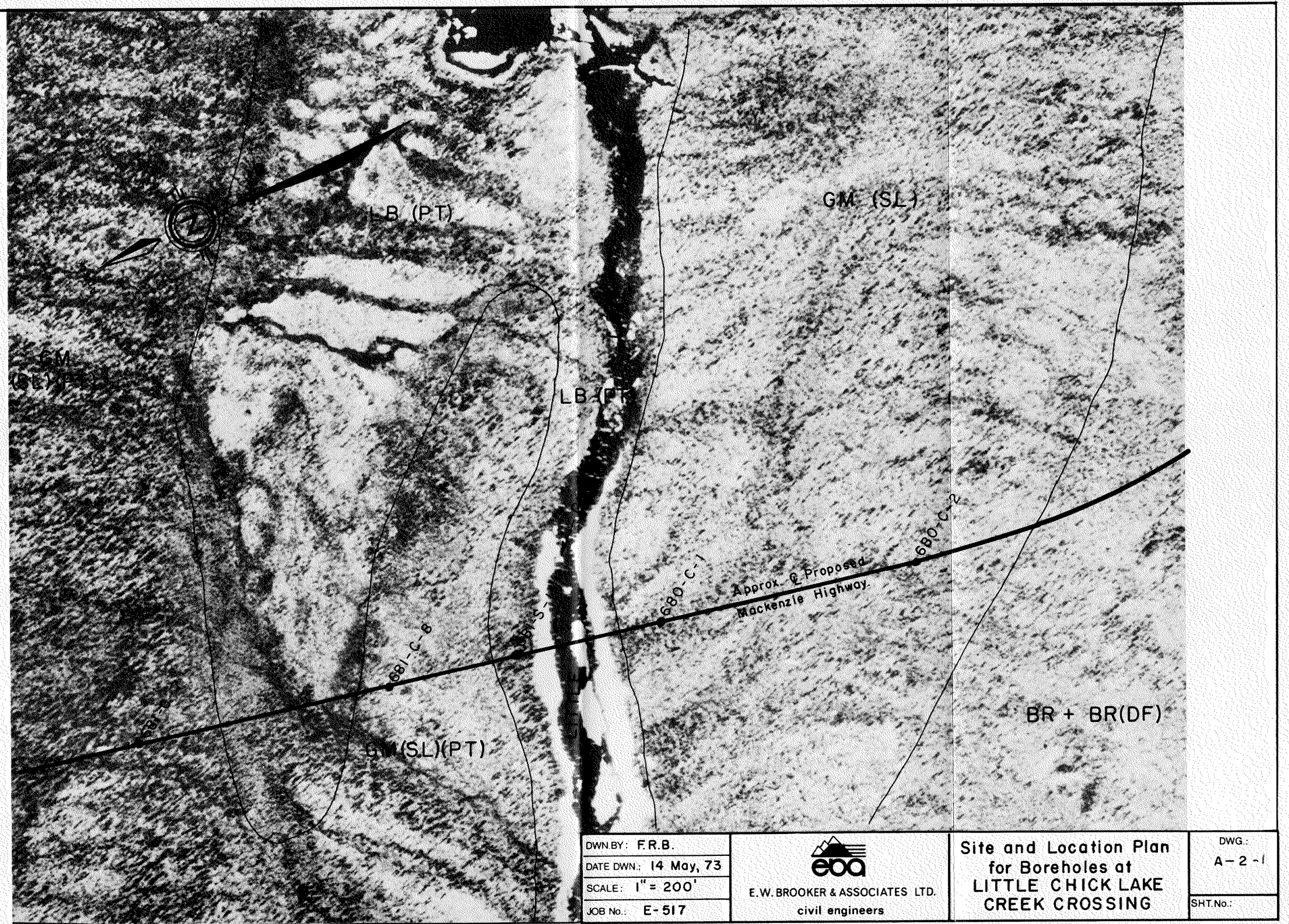
DWG. No._____

EBA ENGINEERING CONSULTANTS LTD.



KEY PLAN

EBA Engineering Consultants Ltd.	DATE	SCALE	JOB No.	DWG No.
	7 Jan 74	1" = 4 mi	E-517	A-1



DWN.BY: F.R.B.	eba E.W. BROOKER & ASSOCIATES LTD. civil engineers	Site and Location Plan for Boreholes at LITTLE CHICK LAKE CREEK CROSSING	DWG.: A-2-1
DATE DWN.: 14 May, 73			SHT.No.:
SCALE: 1" = 200'			
JOB No.: E-517			

TERRAIN LEGEND

SYMBOL	TERRAIN TYPE	PHYSIOGRAPHIC FEATURES	MATERIALS DESCRIPTION
HT	High Terraces	Tabular bodies along the sides of and above present or abandoned river channels	Silt covered stratified sand and/or gravel of fluvial or outwash origin
GLB-1	Glacial Lake Basin (Better drained type)	Lowland occasionally swampy areas	Ice-rich to medium plastic silty clay, occasionally with a trace of sand
GM	Ground Moraine (undifferentiated)	Flat to broad gentle slopes	Silt till to clay till usually some sand and gravel
LB	Lacustrine Basin	Postglacial ponded deposits in larger lowlying areas	Organic and inorganic clay, silt and fine sand
BR	Bedrock	Outcrop to continuous ridge	Exposed rock to rock with generally less than 5 feet of cover
AMP	Alluvial Meander Plain (Mackenzie River Meander Plain)	Flat plain often with sand dunes on it	Sands and silty sands stratified or channel deposits
RKM	Ridge-and-knoll Moraine	Drumlinized till plain rolling large linear features	Molded basal till low plastic silty-clay till
FFP	Fossil Flood Plain	Flat plain may be dissected to rolling topography	Silty topstratum over sand and/or gravel of a flood plain of an inactive stream

Topstratum Phases (Associated with Terrain Types)

SL — Slopewash or solifluction features. Topstratum of ice-rich poorly sorted silty clay and silty sand to gravel

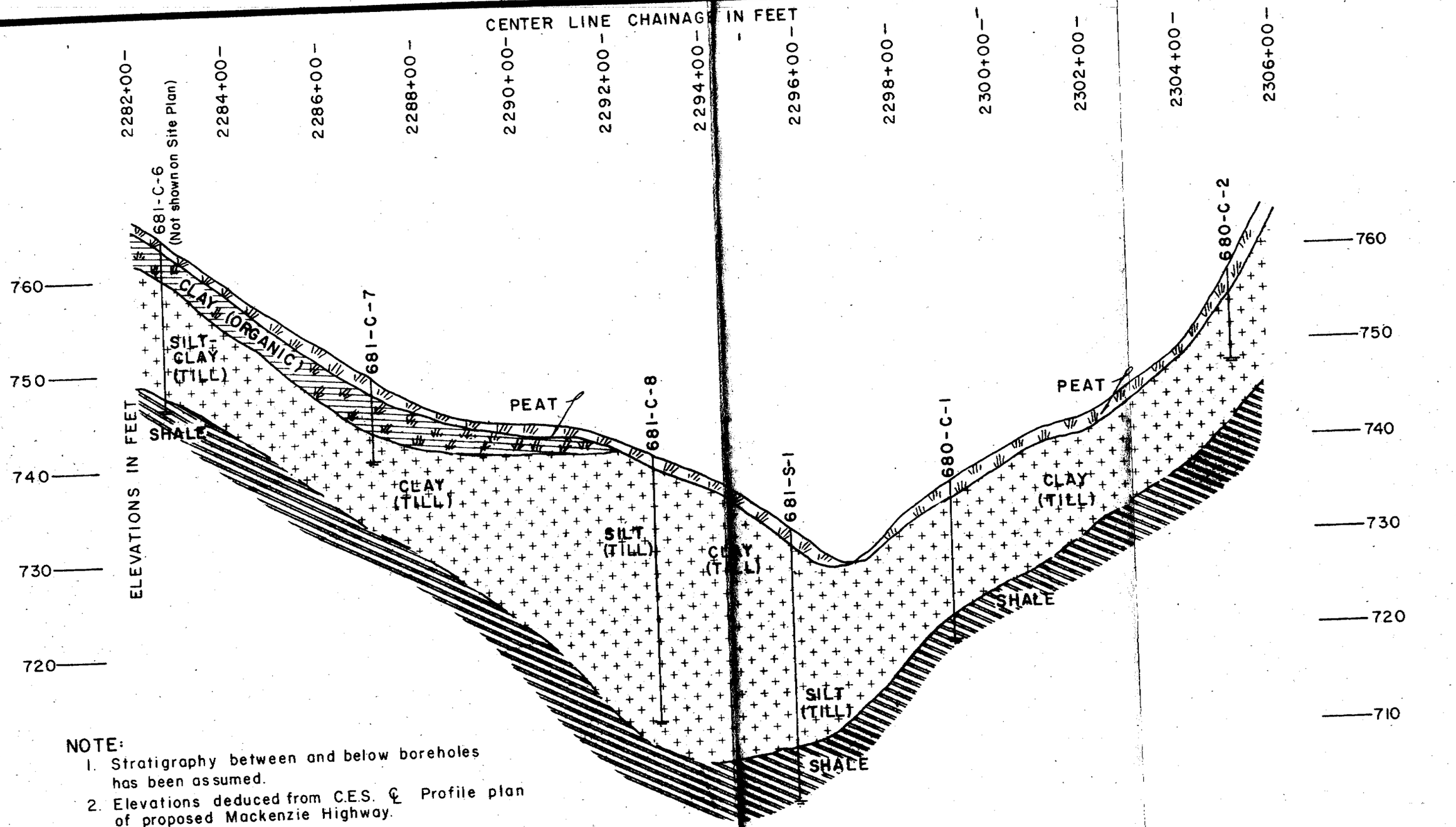
PT — Mixed bog and fen peats in post glacial ponded depression

DF — Thin (0 - 10 feet) of drift over bedrock surfaces

Complexes are shown as combinations of two terrain types with or without phases that pertain to the parent type.

Terrain Symbols are modified from Canadian Gas Arctic Study Limited Terrain Study for this area.

Drawing No. A-2a



NOTE:

1. Stratigraphy between and below boreholes has been assumed.
2. Elevations deduced from C.E.S. ℄ Profile plan of proposed Mackenzie Highway.

DWN.BY: F.R.B.	eba Engineering Consultants Ltd.	LITTLE CHICK LAKE CREEK CROSSING ℄ PROFILE & STRATIGRAPHY	DWG.: A-3-1
DATE DWN.: 11 JAN.74			SHT.No.:
SCALE: Vert. 1"=10' Horiz. 1"=200'			
JOB No.: E-517			

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: GRG | DATE DRILLED: 9/2/73 | AIRPHOTO NO: A22861 - 145 | CHAINAGE: 2282 + 60 | OFFSET

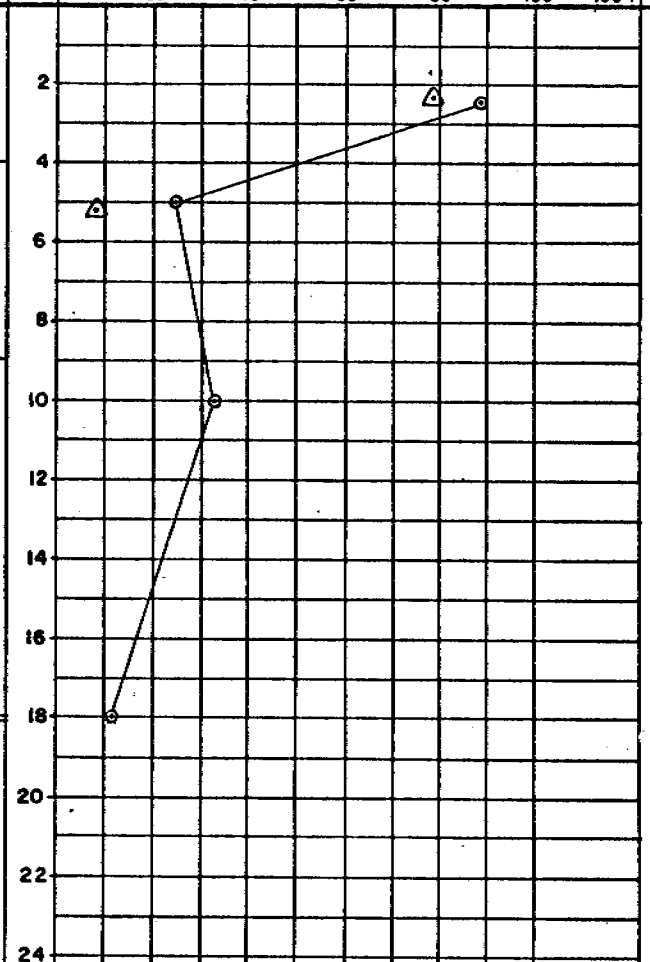
CKD: NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 764.2'

TEST HOLE

MILE	B,C,S	NUMBER
681	C	6

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT - Dark Brown, Fibrous		V
2	1				OH to CL	CLAY - Med. Brown - Silty - Organic		75-80%
4								
6	2				ML	SILT (TILL) - Med. Brown - Clayey - Low Plasticity - Trace of Sand - Some Gravel	F	V 5-10%
8								
10	3				CL	CLAY (TILL) - Grey, Silty - Low Plasticity - Some Shale - Gravelly		NB
12								
14								
16					ML	SHALE - Clayey, Silt - Low Plasticity		
18	4					END OF HOLE 18'		
20								
22								
24								



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: GRG | DATE DRILLED: 9/2/73 | AIRPHOTO NO: A22861 - 145 | CHAINAGE: 2286 + 90 | OFFSET

CKD NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 749.3'

TEST HOLE

MILE	B,C,S	NUMBER
681	C	7

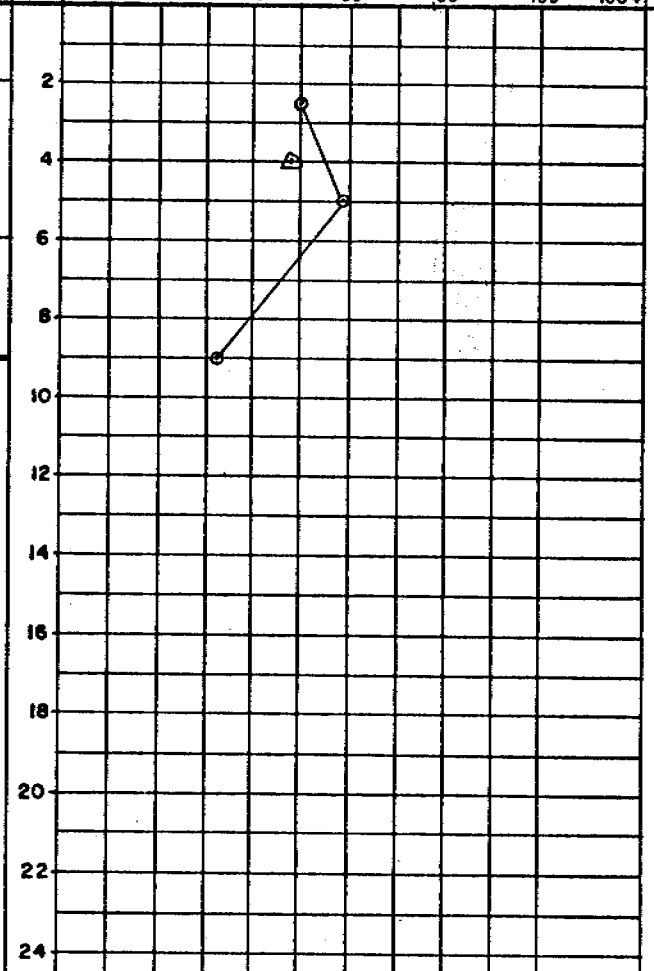
REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2					Pt	PEAT - Dark Brown - Fibrous		NB
4	1				OH to CL	CLAY - Med. Brown - Silty - Low Plasticity - Trace of Gravel - Organic	F	V 45-50%
6	2							
8	3				CI	CLAY (TILL) - Grey, Silty - Med. Plasticity - Trace of Gravel		NB
10						END OF HOLE 9'		

O = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT

20 40 60 80 100 100+



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

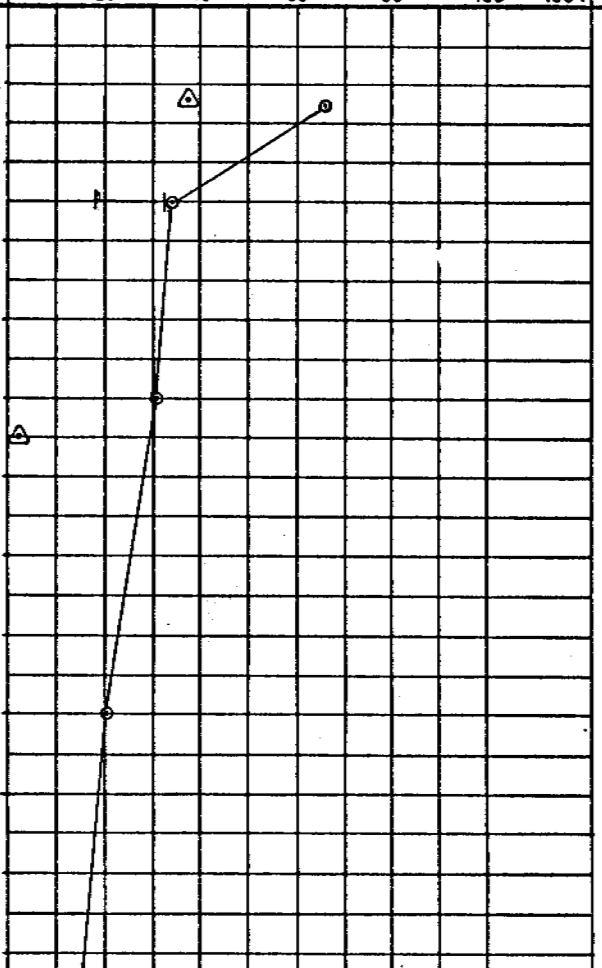
DWN: ALB | FIELD ENG: GRG | DATE DRILLED: 9/2/73 | AIRPHOTO NO: | CHAINAGE: 2292 + 80 | OFFSET
CKD: NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 739.8'

TEST HOLE

MILE	B,C,S	NUMBER
681	C	8

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT - Dk. Brown, Fibrous		
2	1				CL	CLAY - Med. Brown (TILL) - Silty - Low Plasticity - Gravelly	F	V 35-40%
4								
6	2							NB
8					ML	SILT - Med. Brown (TILL) - Sandy		
10	3					- Grey - Sandy - Trace of Clay		V - 1-5%
12								
14								
16								
18	4				CL	CLAY - Grey (TILL) - Silty - Low Plasticity - Trace of Gravel		
20								
22								
24								



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: GRG | DATE DRILLED 9/2/73 | AIRPHOTO NO: | CHAINAGE: 2292 + 80 | OFFSET

CKD: NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 739.8'

TEST HOLE

MILE	B,C,S	NUMBER
681	C	8

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
26					CL	CLAY - Grey (TILL) - Silty - Low Plasticity - Trace of Gravel	F	V 1-5%
28	5					END OF HOLE 28'		

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT
20 40 60 80 100 100+

GRAIN-SIZE ANALYSIS				WET DENSITY (PCF)	DRY DENSITY (PCF)
CLAY %	SILT %	SAND %	GRAVEL %		

E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB	FIELD ENG: GRG	DATE DRILLED 13/2/73	AIRPHOTO NO: A22861 - 146	CHAINAGE: 2295 + 70	OFFSET
CKD: NRM	TECH: DY	RIG: Mayhew 500	SURFACE DRAINAGE: Well Drained	VEGETATION: Black Spruce	ELEV: 731.4'

TEST HOLE MVPL11

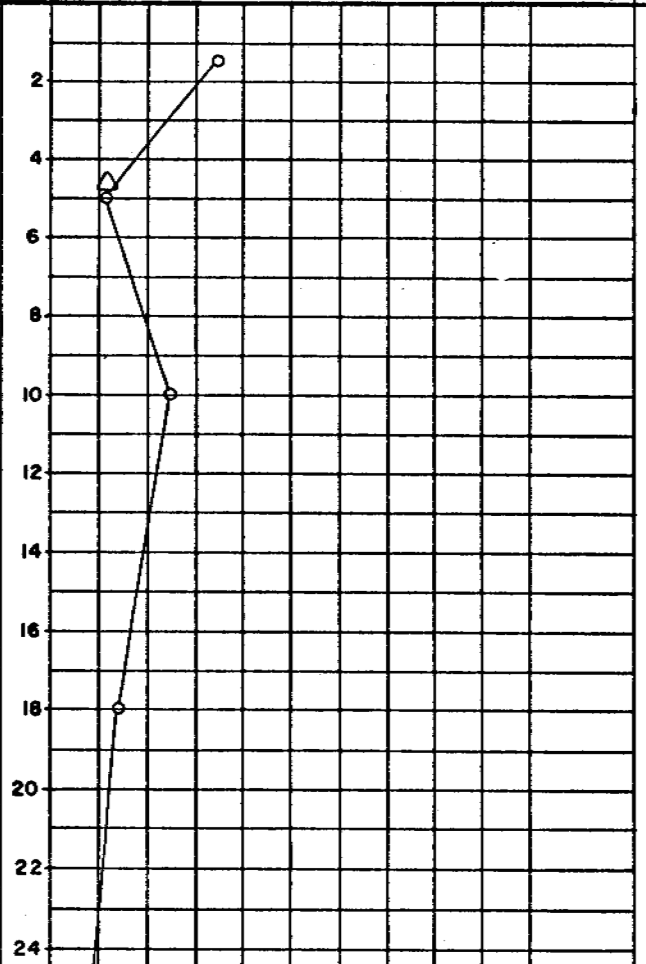
MILE	B,C,S	NUMBE
681	S	1

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0					Pt	PEAT - Dk. Brown, Fibrous		
2	1				CL	CLAY (TILL) - Med. Brown - Silty - Low Plasticity - Trace of Sand	F	V 10-15%
4	2							
6								
8								
10	3				CL to ML	CLAY (SILT) (TILL) - Grey - Low Plasticity	U	Unfrozen
12								
14								
16						- Grey - Low Plasticity - Some Gravel		
18	4							
20								
22					CL	SHALE - Grey - Weathered		
24								

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT
20 40 60 80 100 100+



GRAIN-SIZE ANALYSIS	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)

E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: GRG | DATE DRILLED: 13/2/73 | AIRPHOTO NO: A22861 - 146 | CHAINAGE: 2295 + 70 | OFFSET

CKD: NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 731.4'

TEST HOLE MVPL1

MILE	B,C,S	NUMBER
681	S	1

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
26						- Same as above	U	Unfrozen
28	5					END OF HOLE 28'		

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT
20 40 60 80 100 100+

GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

REMARKS

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: GRG | DATE DRILLED: 9/2/73 | AIRPHOTO NO: A22766-116 | CHAINAGE: 2299 + 10 | OFFSET

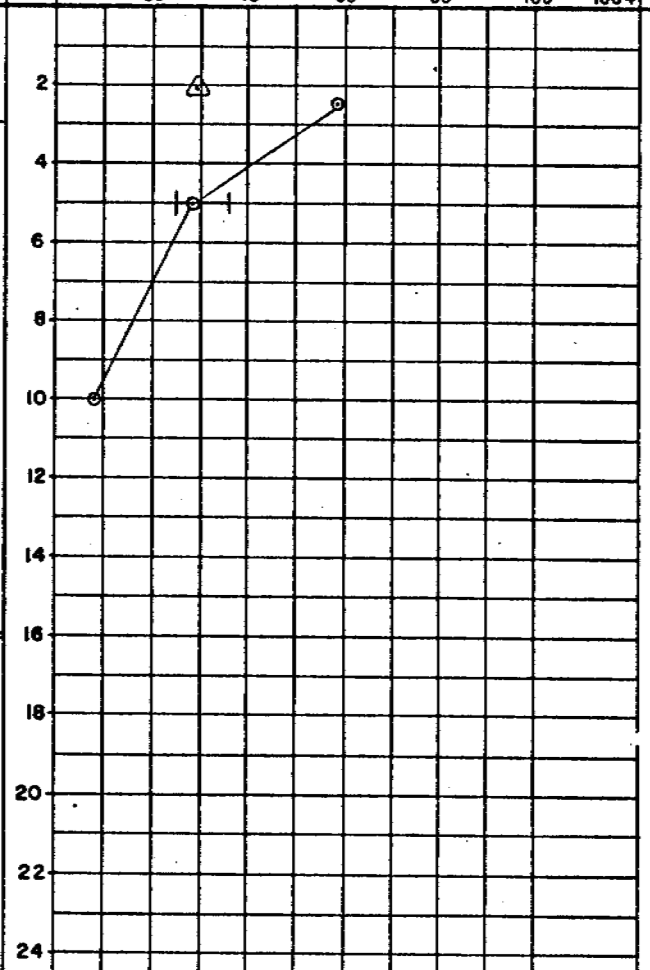
CKD: NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 736.0'

TEST HOLE

MILE	B,C,S	NUMBER
680	C	1

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0					Pt	PEAT- Dark Brown, Fibrous		V
2	1				CL to CI	CLAY (TILL) - Grey to Brown - Silty, Low to Med. Plasticity - Some Sand - Trace of Gravel	F	25-30%
4								
6	2				ML			
8								NB
10	3							
12					ML	SILT (TILL) - Greyish Brown - Some Shale - Some Sand		
14								
16					ML	SHALE - Bedrock - Grey		
18						END OF HOLE 16'		
20								
22								
24								



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: GRG | DATE DRILLED: 9/2/73 | AIRPHOTO NO: A22766-116 | CHAINAGE: 2305 + 10 | OFFSET

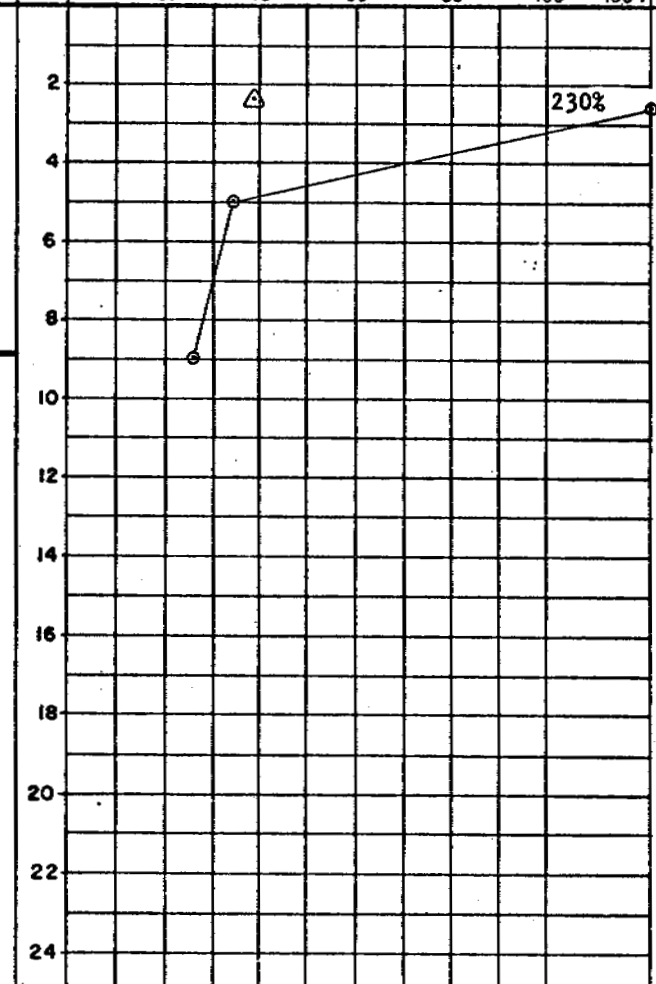
CKD: NRM | TECH: DY | RIG: Mayhew 500 | SURFACE DRAINAGE: Well Drained | VEGETATION: Black Spruce | ELEV: 757.3'

TEST HOLE

MILE	B,C,S	NUMBER
680	C	2

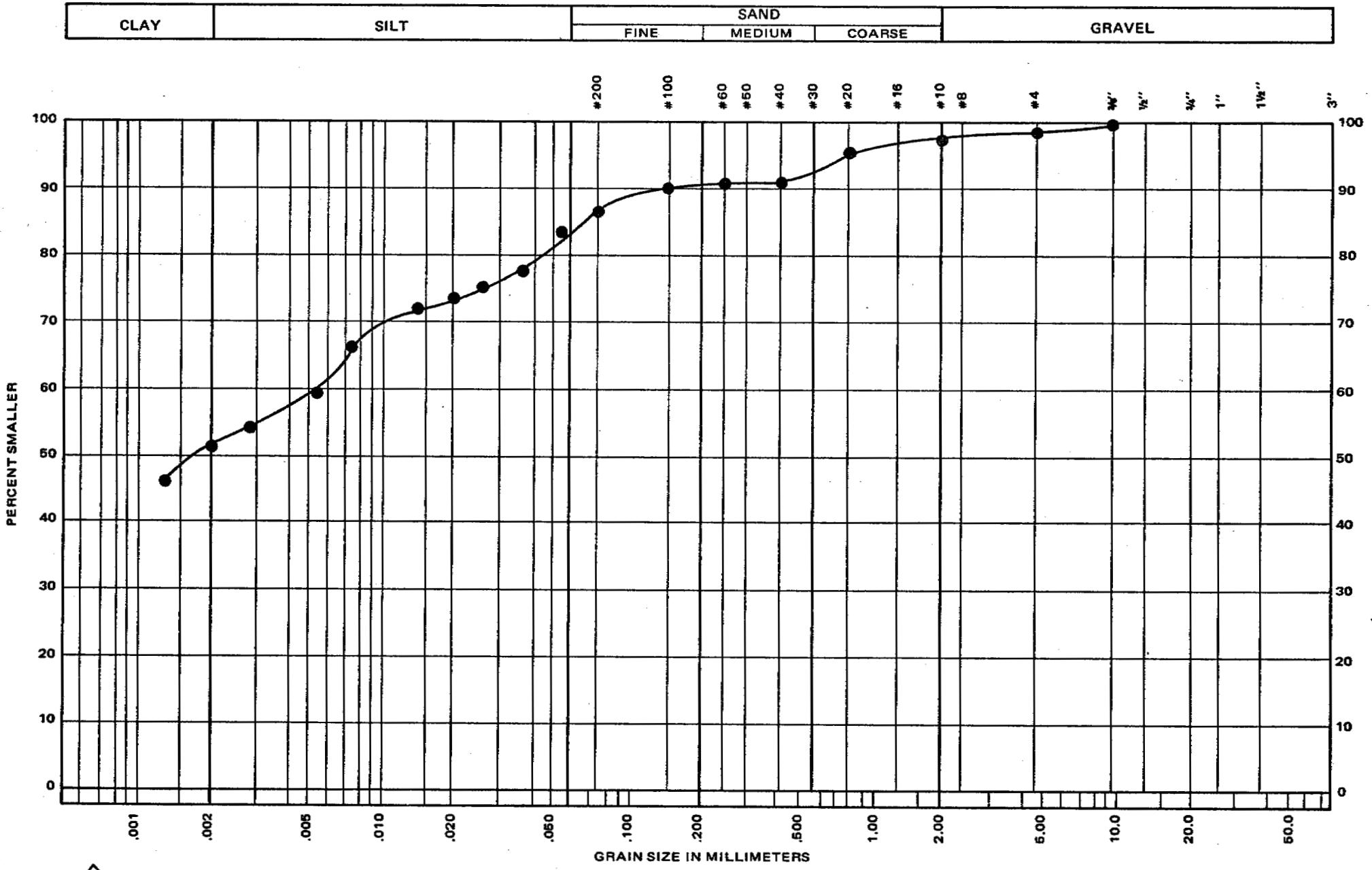
REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0					Pt	PEAT - Dark Brown - Fibrous	F	V 35-40%
2	1				CL	CLAY - Med. Brown - Silty - Low Plasticity - Some Gravel		
4	2							
6								
8	3							
10						END OF HOLE 9'		
12								
14								
16								
18								
20								
22								
24								



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

GRAIN SIZE DISTRIBUTION



FIGURE

eba
Engineering Consultants Ltd.

SAMPLE DESCRIPTION Clay (Till) Silty, Some Sand

PROJECT Mackenzie Highway
JOB No. E-517 DATE April 7/73
SAMPLE No. 680-C-1
DEPTH 5'

SUMMARY OF TEST RESULTS

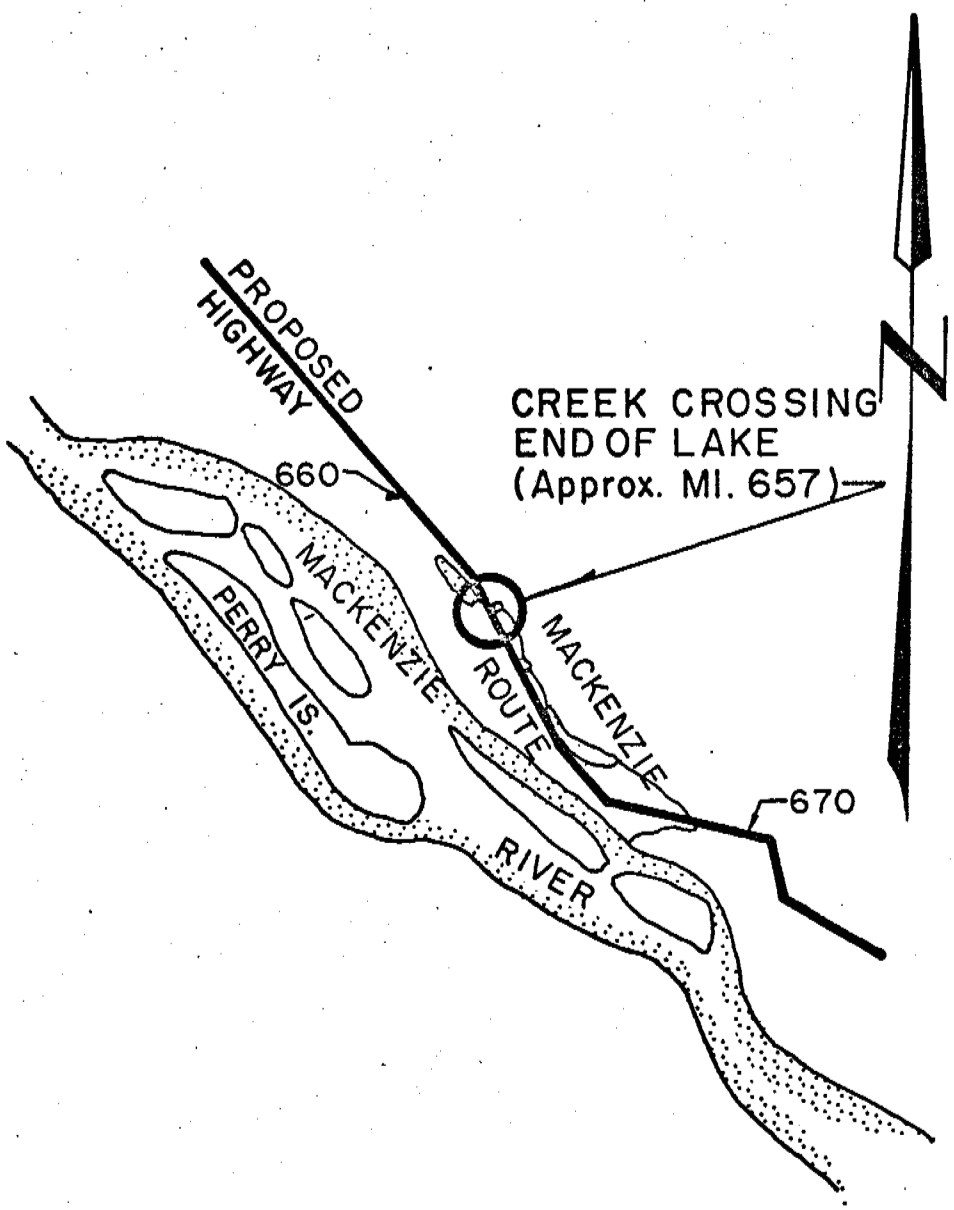
JOB No. E - 517

LITTLE CHICK LAKE CREEK CROSSING-MILE 681.2

BORE HOLE	DEPTH	NATURAL WATER CONTENT	Atterberg Limits			MECHANICAL ANALYSIS (M.I.T. CLASSIFICATION)				SOIL CLASSIFICATION (UNIFIED)	REMARKS
			W_L	W_P	PI						
	feet	%	%	%	%	% CLAY	% SILT	% SAND	% GRAVEL		
681-C-8	5	34.3	32.8	19.3	13.5					CL	SO_4 0.17%
680-C-1	5	28.0	34.9	26.0	8.9	52	31	15	2	ML	

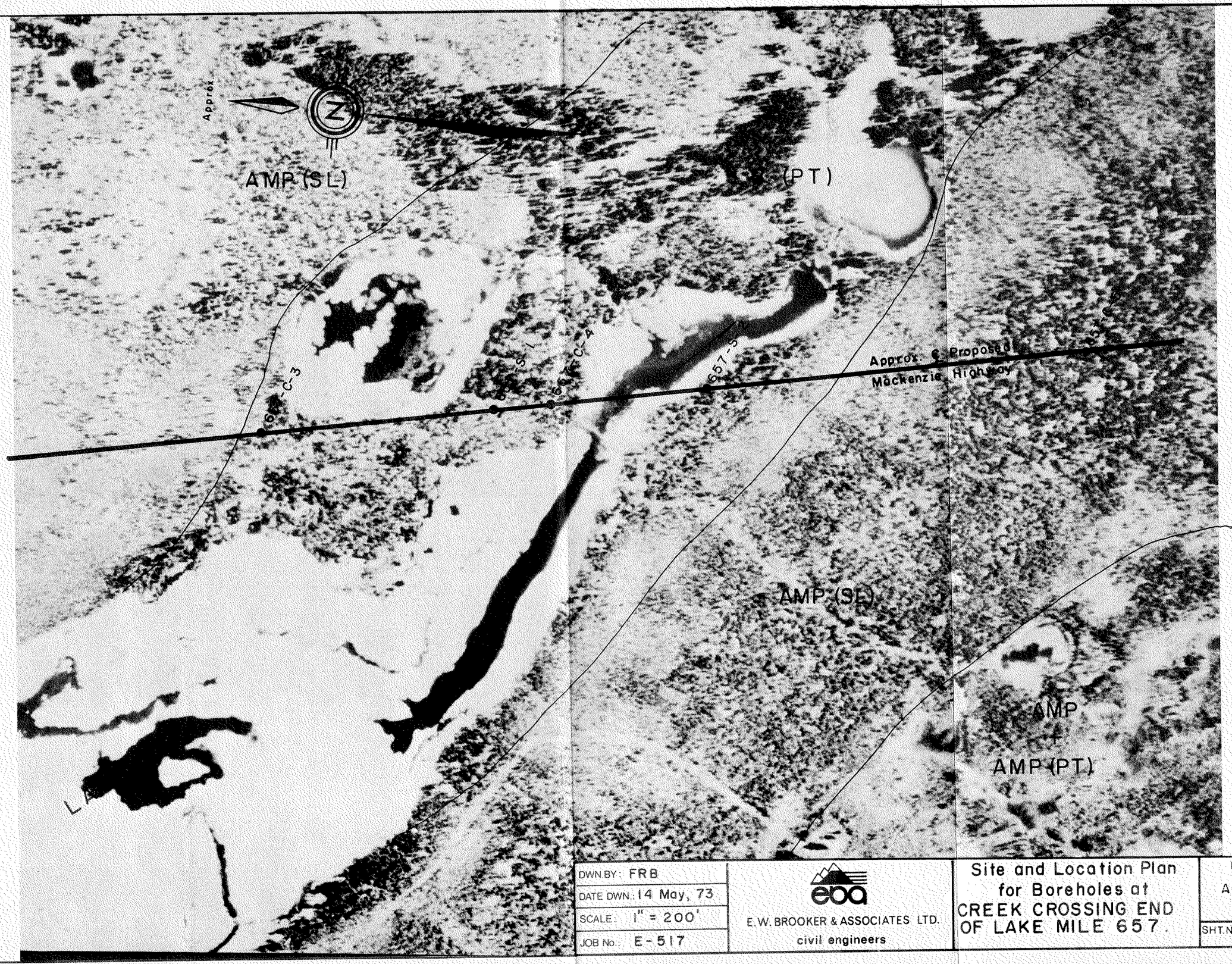
DWG. No.

EBA ENGINEERING CONSULTANTS LTD.



KEY PLAN

EBA Engineering Consultants Ltd.	DATE	SCALE	JOB No.	DWG No.
	15 May 74	1" = 4 mi	E - 517	A - 1



DWN.BY: FRB	eba E.W. BROOKER & ASSOCIATES LTD. civil engineers	Site and Location Plan for Boreholes at CREEK CROSSING END OF LAKE MILE 657.	DWG.: A - 2-2
DATE DWN.: 14 May, 73			SHT.No.:
SCALE: 1" = 200'			
JOB No.: E-517			

TERRAIN LEGEND

SYMBOL	TERRAIN TYPE	PHYSIOGRAPHIC FEATURES	MATERIALS DESCRIPTION
HT	High Terraces	Tabular bodies along the sides of and above present or abandoned river channels	Silt covered stratified sand and/or gravel of fluvial or outwash origin
GLB-1	Glacial Lake Basin (Better drained type)	Lowland occasionally swampy areas	Ice-rich to medium plastic silty clay, occasionally with a trace of sand
GM	Ground Moraine (undifferentiated)	Flat to broad gentle slopes	Silt till to clay till usually some sand and gravel
LB	Lacustrine Basin	Postglacial ponded deposits in larger lowlying areas	Organic and inorganic clay, silt and fine sand
BR	Bedrock	Outcrop to continuous ridge	Exposed rock to rock with generally less than 5 feet of cover
AMP	Alluvial Meander Plain (Mackenzie River Meander Plain)	Flat plain often with sand dunes on it	Sands and silty sands stratified or channel deposits
RKM	Ridge-and-knoll Moraine	Drumlinized till plain rolling large linear features	Molded basal till low plastic silty-clay till
FFP	Fossil Flood Plain	Flat plain may be dissected to rolling topography	Silty topstratum over sand and/or gravel of a flood plain of an inactive stream

Topstratum Phases (Associated with Terrain Types)

SL — Slopewash or solifluction features. Topstratum of ice-rich poorly sorted silty clay and silty sand to gravel

PT — Mixed bog and fen peats in post glacial ponded depression

DF — Thin (0 - 10 feet) of drift over bedrock surfaces

Complexes are shown as combinations of two terrain types with or without phases that pertain to the parent type.

Terrain Symbols are modified from Canadian Gas Arctic Study Limited Terrain Study for this area.

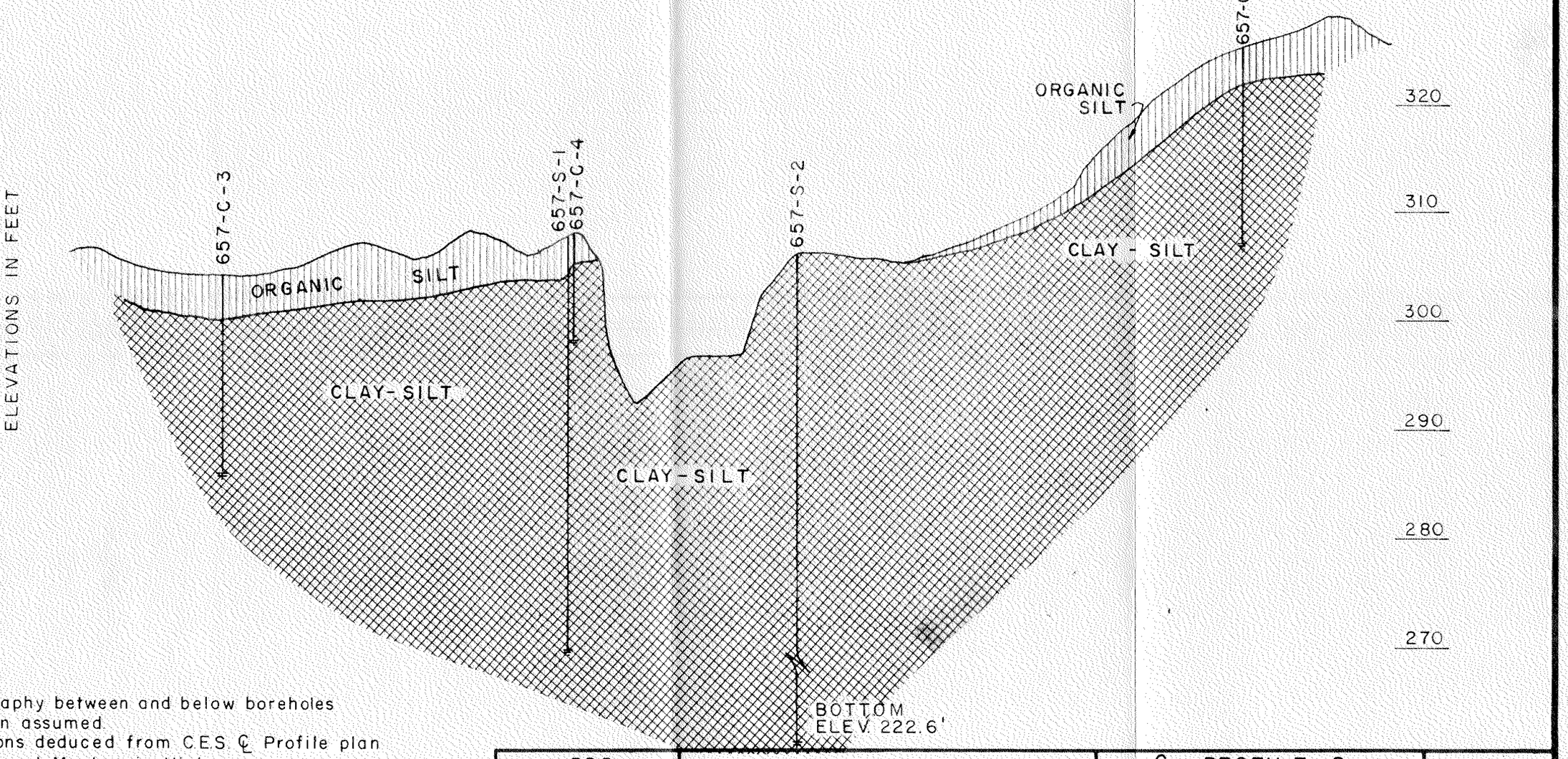
Drawing No. A-2a

CENTRE LINE CHAINAGE IN FEET

3550+00 — 3552+00 — 3554+00 — 3556+00 — 3558+00 — 3560+00 — 3562+00 — 3564+00 — 3566+00 — 3568+00 — 3570+00 — 3580+00

ELEVATIONS IN FEET

320 — 310 — 300 — 290 — 280 — 270



NOTE:

1. Stratigraphy between and below boreholes has been assumed.
2. Elevations deduced from C.E.S. ℄ Profile plan of proposed Mackenzie Highway.
3. Scales: Horiz. 1" = 200'
   Vert. 1" = 10'

DWN BY	F.R.B.
DATE DWN	MAR 74
SCALE	AS NOTED
JOB No.	E-517

eda Engineering Consultants Ltd.

℄ PROFILE & STRATIGRAPHY FOR CREEK CROSSING END OF LAKE (Approx. Mi. 657)

DWG: A-3-1

SHT No.

E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

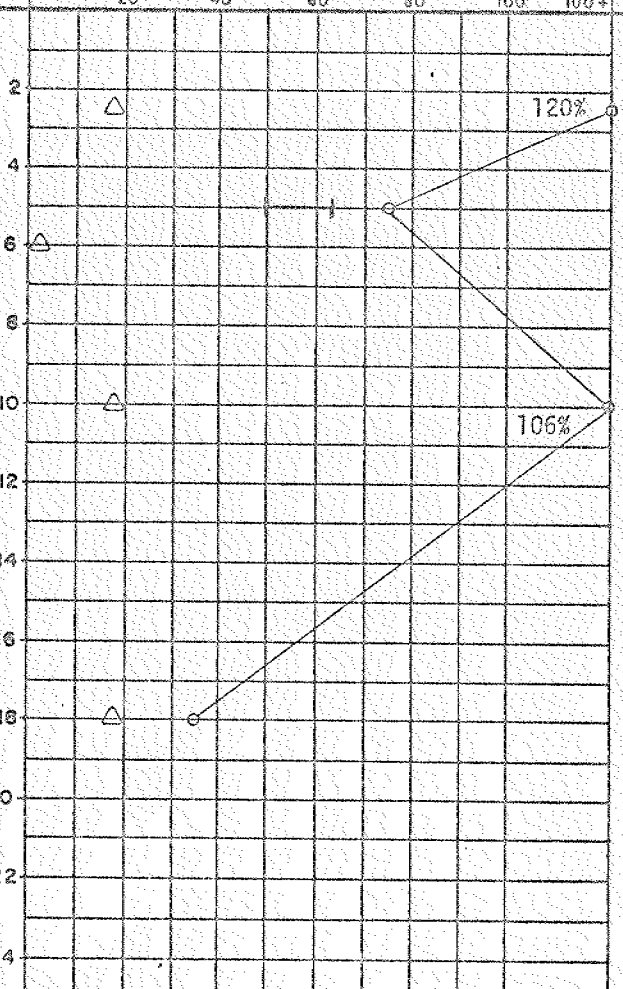
DWN: ALB | FIELD ENG: NRM | DATE DRILLED: 19/2/73 | AIRPHOTO NO: A22763 - 81 | CHAINAGE: 3551 + 40 | OFFSET:
CKD: GRG | TECH: JK | RIG: Texoma | SURFACE DRAINAGE: Poor | VEGETATION: Black Spruce & Birch | ELEV: 304.3'

TEST HOLE

MILE	B,C,S	NUMBER
657	C	3

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				OL to ML	ORGANIC SILT - Dark Brown - Clayey	F	V- 15-20%
4								
6	2				MH CH	CLAY - Dark Brown - High Plasticity - Sandy 9'		V- 0-5%
8								
10	3					- Med. Plasticity		
12					CI			V- 15-20% More ice with depth
14								
16						- Grey, Med. Plastic		
18	4							
20						END OF HOLE 18'		
22								
24								



DEPTH (FEET)	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						
22						
24						

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB	FIELD ENG: NRM	DATE DRILLED 25/2/73	AIRPHOTO NO: A22774 - 53	CHAINAGE: 3557 + 80	OFFSET
CKD: GRG	TECH: JK	RIG: Mayhew 500	SURFACE DRAINAGE: Fair to South	VEGETATION: Black Spruce & Birch	ELEV: 307.6'

TEST HOLE

MILE	B,C,S	NUMBER
657	S	1

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				OL	ORGANIC SILT - Clayey		V 25 - 30
4								
6	2				CL	CLAY - Med. Greyish Brown SILT - Low Plasticity - Trace of Sand	F	V 15 - 20
8								
10	3							
12								
14					CL to CI	CLAY - Grey SILT - Low to Med. Plasticity		
16	4							
18								
20	5							V 30 - 40%
22								
24								

O = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT
20 40 60 80 100 100+

GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

REMARKS

50' North of North Bank

E.W. BROOKER & ASSOCIATES LTD.	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: NRM | DATE DRILLED 25/2/73 | AIRPHOTO NO: A22774 - 53 | CHAINAGE: 3557 + 80 | OFFSET

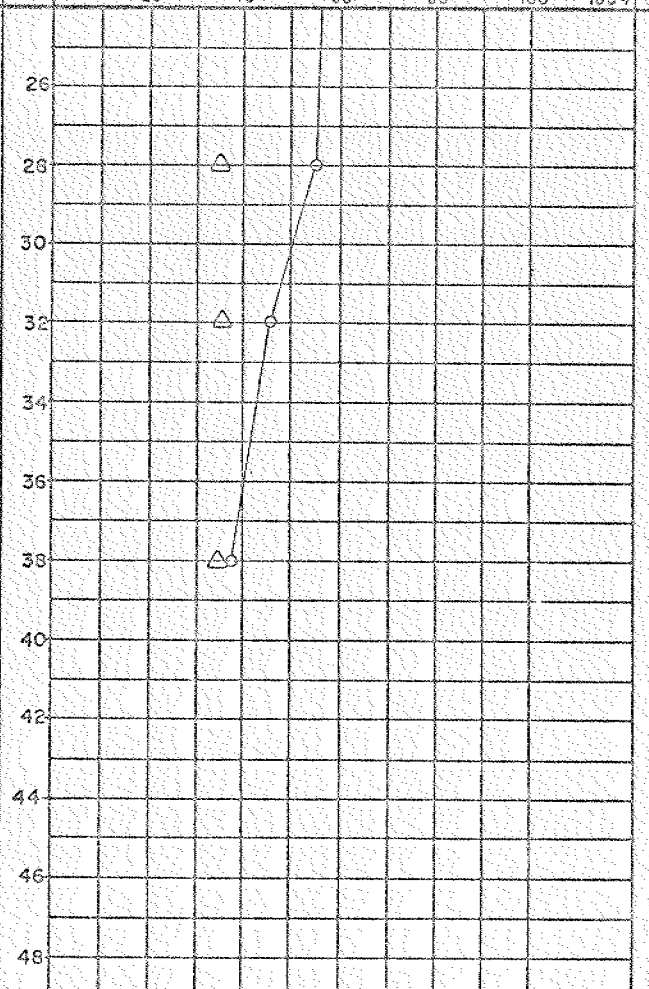
CKD: GRG | TECH: JK | RIG: Mayhew 500 | SURFACE DRAINAGE: Fair to S | VEGETATION: Black Spruce & Birch | ELEV: 307.6'

TEST HOLE

MILE	B,C,S	NUMBER
657	S	1

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
26					CL to CI	CLAY SILT - same	F	V 30 - 40%
28	6							
30								
32	7							
34								
36								
38	8							
40						END OF HOLE 38'		
42								
44								
46								
48								



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: NRM | DATE DRILLED: 9/2/73 | AIRPHOTO NO: A22763 - 81 | CHAINAGE: 3557 + 90 | OFFSET:

CKD: GRG | TECH: JK | RIG: Texoma | SURFACE DRAINAGE: Fair to South | VEGETATION: Black Spruce & Birch | ELEV: 307.9'

TEST HOLE

MILE	B,C,S	NUMBER
657	C	4

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				OL	ORGANIC SILT - Dark Brown - Clayey		V- 0-5%
4								
6	2				CI	CLAY - Dark Brown - Med. Plasticity - Trace of Med. Sand F		V- 15-20% to V- 50-60%
8								
10	3							
						END OF HOLE 10'		

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT

20 40 60 80 100 100+

114%

GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

REMARKS

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: NRM | DATE DRILLED: 25/2/73 | AIRPHOTO NO: A22774 - 53 | CHAINAGE: 3562 + 00 | OFFSET:
CKD: GRG | TECH: JK | RIG: Mayhew 500 | SURFACE DRAINAGE: Good to North | VEGETATION: Black Spruce & Birch | ELEV: 306.1'

TEST HOLE MVPL17

MILE	B,C,S	NUMBER
657	S	2

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				CL to CI	CLAY - Grey, Some Med. SILT Sand - Low to Med. Plasticity	F	V 35 - 40%
4	2							
6								
8								
10	3				OL	- Black		
12								
14	4							
16								
18								
20	5				CI	CLAY - Silty, Grey, Med. Plasticity		V 50 - 60%
22								V 15 - 20%
24								

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)
PLASTIC LIMIT — LIQUID LIMIT
20 40 60 80 100 100+

GRAIN-SIZE ANALYSIS				WET DENSITY (PCF)	DRY DENSITY (PCF)
CLAY %	SILT %	SAND %	GRAVEL %		
23	62	15	-		

REMARKS: South Bank

E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: NRM | DATE DRILLED 25/2/73 | AIRPHOTO NO: A22774 - 53 | CHAINAGE: 3562 + 00 | OFFSET

CKD GRG | TECH: JK | RIG: Mayhew 500 | SURFACE DRAINAGE: Good to North | VEGETATION: Black Spruce & Birch | ELEV: 305.1'

TEST HOLE MVPL17

MILE	B,C,S	NUMBER
657	S	2

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
25	6				CL to CI	CLAY - same		V 15 - 20
30	7						F	V - 5-10%
35	8							
40	9							V - 0-5%
45								

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT
20 40 60 80 100 100+

DEPTH (FEET)	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (pcf)	DRY DENSITY (pcf)
25						
30						
35						
40						
45						

E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: NRM | DATE DRILLED: 25/2/73 | AIRPHOTO NO: A22774 - 53 | CHAINAGE: 3562 + 00 | OFFSET
CKD: GRG | TECH: JK | RIG: Mayhew 500 | SURFACE DRAINAGE: Good to North | VEGETATION: Black Spruce & Birch | ELEV: 306.1'

TEST HOLE

MILE	B,C,S	NUMBER
657	S	2

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
50	11				CL to CI	CLAY - same	F	V-0-5%
52								
54	12							
56								
58						END OF HOLE 57'		
60								
62								
64								
66								
68								
70								
72								

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT
20 40 60 80 100 100+

GRAIN-SIZE ANALYSIS	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)

REMARKS

E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: AJB | FIELD ENG: NRM | DATE DRILLED 20/2/73 | AIRPHOTO NO: A22776 - 81 | CHAINAGE: 3570 + 30 | OFFSET
CKD: GRG | TECH: JK | RIG: Texoma | SURFACE DRAINAGE: Good to North | VEGETATION: Black Spruce & Birch | ELEV: 325.3'

TEST HOLE

MILE	B,C,S	NUMBER
657	C	5

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				OL	ORGANIC SILT - Med. Brown		V - 20-25%
4	2				CL to CI	CLAY - Med. to Dk. Brown SILT - Low to Med Plasticity - Trace of Fine Sand		V - 0-5%
10	3						F	NB
14					CL	- Grey - Low Plasticity		
18	4					END OF HOLE 18'		

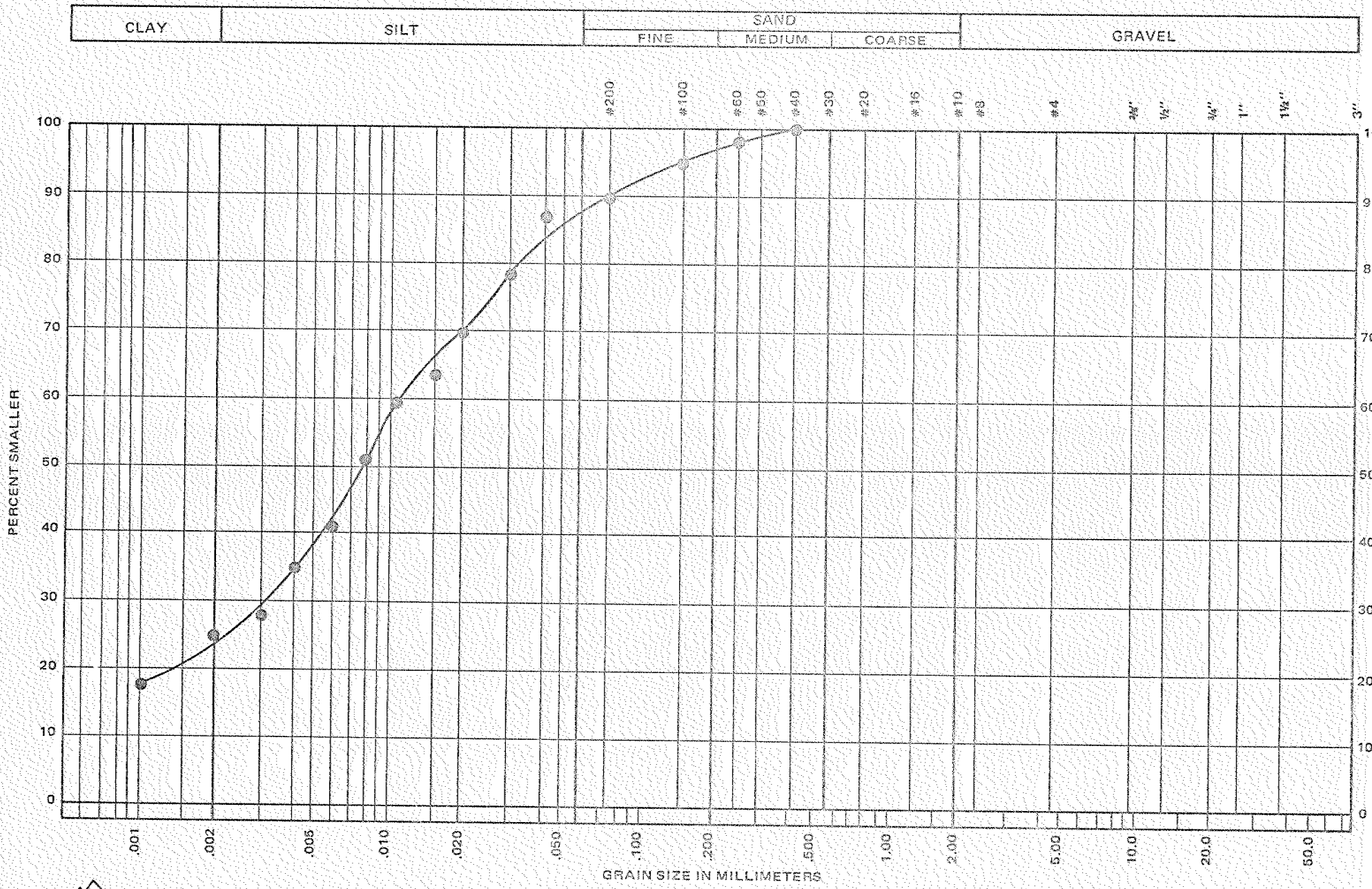
○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT
20 40 60 80 100 100+

GRAIN-SIZE ANALYSIS	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
	29	66	5	-		

REMARKS

GRAIN SIZE DISTRIBUTION



FIGURE

Engineering Consultants Ltd.

SAMPLE DESCRIPTION Silt - Clayey, Some Sand

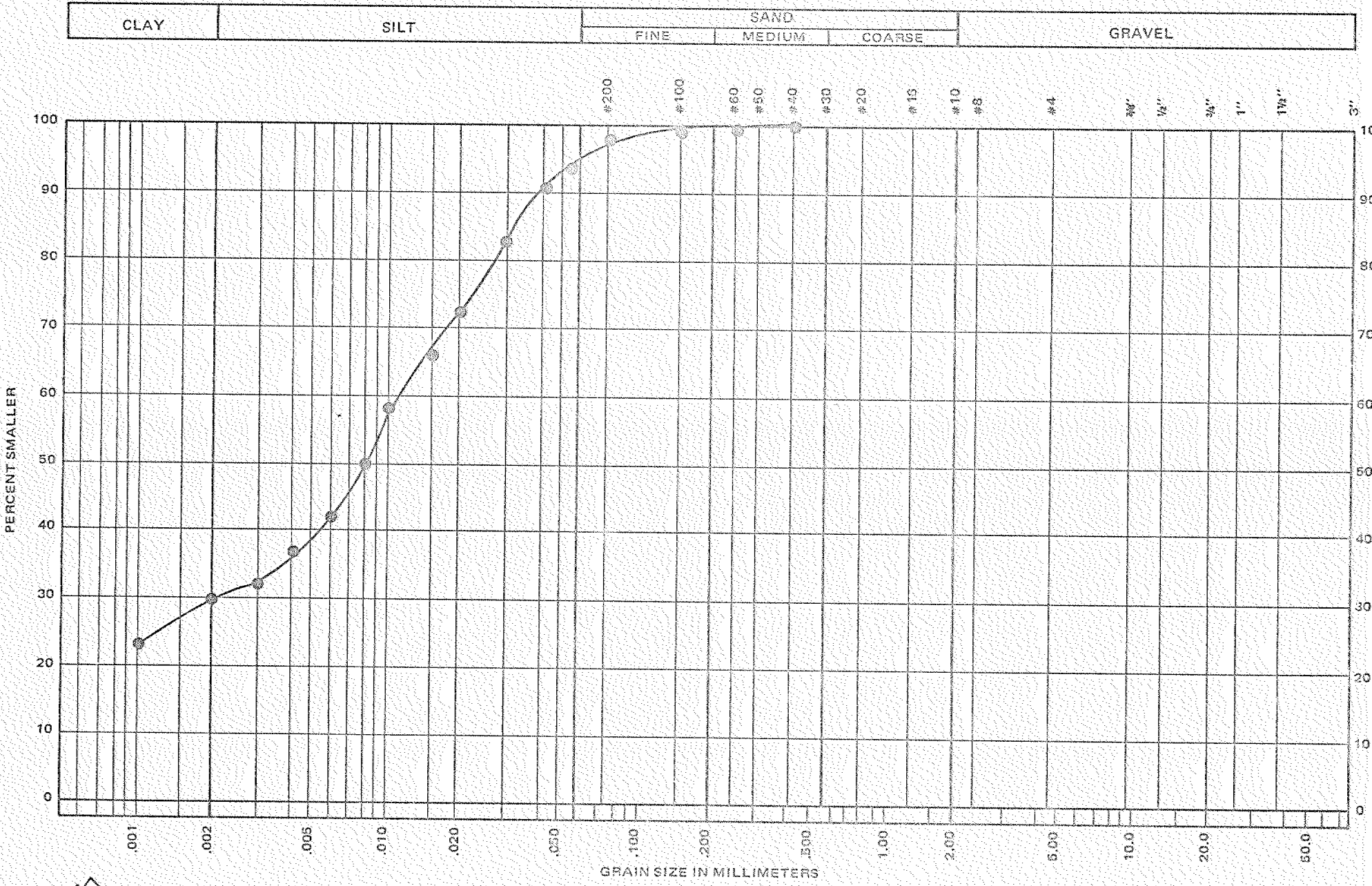
PROJECT Mackenzie Highway

JOB No. E-517 DATE April 4/73

SAMPLE No. 657-S-2

DEPTH 10'

GRAIN SIZE DISTRIBUTION



FIGURE

Engineering Consultants Ltd.

SAMPLE DESCRIPTION Clay-Silt, Trace of Fine Sand

PROJECT Mackenzie Highway

JOB No. E-517 DATE April 8/73

SAMPLE No. 657-C-5

DEPTH 5'

SUMMARY OF TEST RESULTS

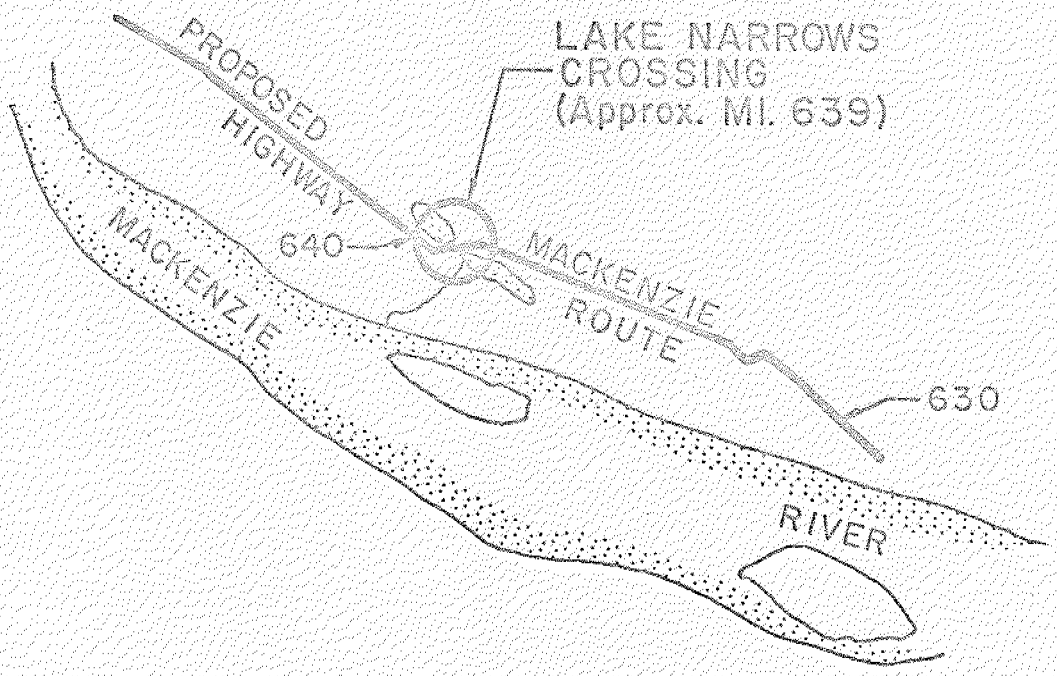
JOB No. E-517

CREEK CROSSING END OF LAKE - MILE 657

BORE HOLE	DEPTH	NATURAL WATER CONTENT	Atterberg Limits			MECHANICAL ANALYSIS (M.I.T. CLASSIFICATION)				SOIL CLASSIFICATION (UNIFIED)	REMARKS
			W_L	W_P	PI						
	feet	%	%	%	%	% CLAY	% SILT	% SAND	% GRAVEL		
657-C-3	5	74.2	62.9	50.0	12.9					OH-MH	
657-S-2	10	66.0	46.5	36.7	9.8	23	62	15	0	OL-ML	SO4 - 0.36%
657-C-5	5	43.0	36.5	19.2	17.3	29	66	5	0	CI	

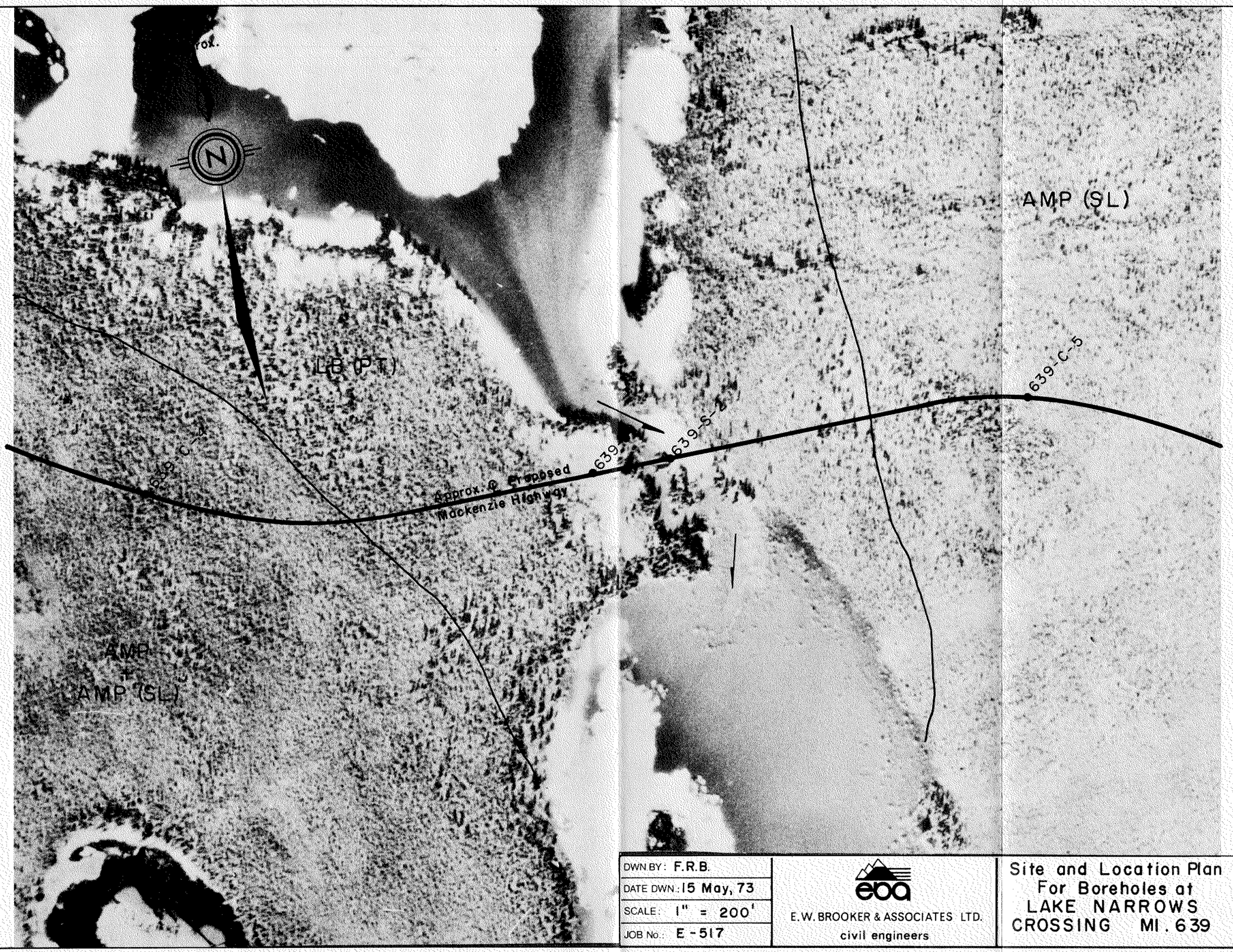
DWG. No.

EBA ENGINEERING CONSULTANTS LTD.



KEY PLAN

EBA Engineering Consultants Ltd.	DATE	SCALE	JOB No.	DWG No.
	16 May 73	1" = 4 mi	E-517	A-1



DWN.BY: F.R.B.	eba E.W. BROOKER & ASSOCIATES LTD. civil engineers	Site and Location Plan For Boreholes at LAKE NARROWS CROSSING MI. 639	DWG.: A-2
DATE DWN.: 15 May, 73			
SCALE: 1" = 200'			SHT.No.:
JOB No.: E-517			

TERRAIN LEGEND

SYMBOL	TERRAIN TYPE	PHYSIOGRAPHIC FEATURES	MATERIALS DESCRIPTION
HT	High Terraces	Tabular bodies along the sides of and above present or abandoned river channels	Silt covered stratified sand and/or gravel of fluvial or outwash origin
GLB-1	Glacial Lake Basin (Better drained type)	Lowland occasionally swampy areas	Ice-rich to medium plastic silty clay, occasionally with a trace of sand
GM	Ground Moraine (undifferentiated)	Flat to broad gentle slopes	Silt till to clay till usually some sand and gravel
LB	Lacustrine Basin	Postglacial ponded deposits in larger lowlying areas	Organic and inorganic clay, silt and fine sand
BR	Bedrock	Outcrop to continuous ridge	Exposed rock to rock with generally less than 5 feet of cover
AMP	Alluvial Meander Plain (Mackenzie River Meander Plain)	Flat plain often with sand dunes on it	Sands and silty sands stratified or channel deposits
RKM	Ridge-and-knoll Moraine	Drumlinized till plain rolling large linear features	Molded basal till low plastic silty-clay till
FFP	Fossil Flood Plain	Flat plain may be dissected to rolling topography	Silty topstratum over sand and/or gravel of a flood plain of an inactive stream

Topstratum Phases (Associated with Terrain Types)

SL — Slopewash or solifluction features. Topstratum of ice-rich poorly sorted silty clay and silty sand to gravel

PT — Mixed bog and fen peats in post glacial ponded depression

DF — Thin (0 - 10 feet) of drift over bedrock surfaces

Complexes are shown as combinations of two terrain types with or without phases that pertain to the parent type.

Terrain Symbols are modified from Canadian Gas Arctic Study Limited Terrain Study for this area.

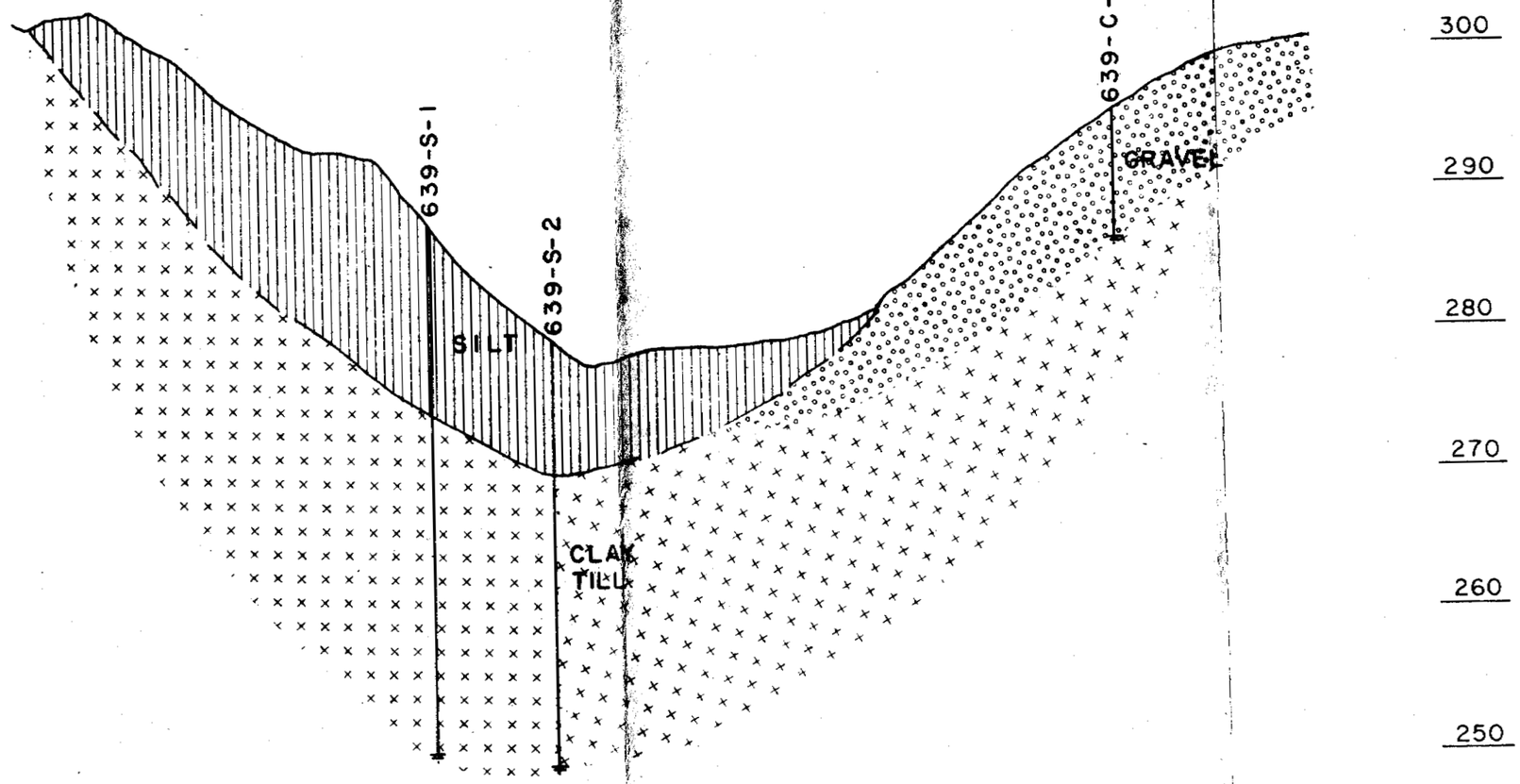
Drawing No. A-2a

CENTRE LINE CHAINAGE IN FEET

4510+00 — 4512+00 — 4514+00 — 4516+00 — 4518+00 — 4520+00 — 4522+00 — 4524+00 — 4526+00 — 4528+00 — 4530+00

ELEVATIONS IN FEET

300 — 290 — 280 — 270 — 260 — 250



NOTE:

1. Stratigraphy between and below boreholes has been assumed.
2. Elevations deduced from C.E.S. ℄ profile plan of proposed Mackenzie Highway
3. Scales: Horiz. 1"= 200'
   Vert. 1"= 10'

DWN BY:	F.R.B.
DATE DWN.:	MAR. 74
SCALE:	AS NOTED
JOB No.:	E-517

eba Engineering Consultants Ltd.

℄ PROFILE & STRATIGRAPHY FOR LAKE NARROWS CROSSING (Approx. Mi. 639)

DWG. A-3

SHT. No.:

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

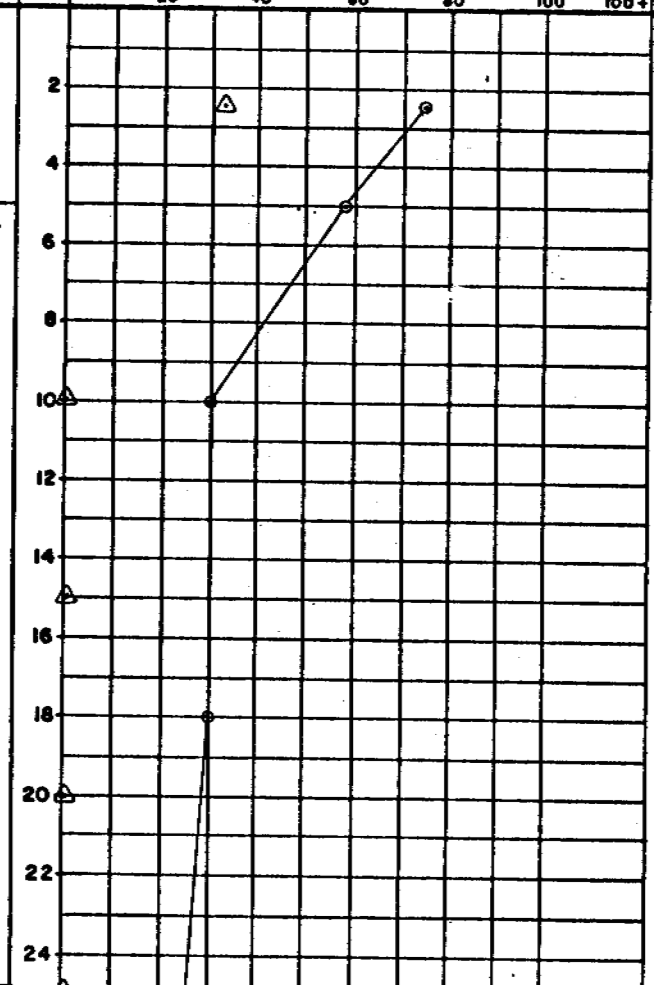
DWN: ALB | FIELD ENG: NRM | DATE DRILLED 6/3/73 | AIRPHOTO NO: A22763 - 159 | CHAINAGE: 4507 + 70 | OFFSET

CKD: BD | TECH: TJ | RIG: Mayhew 500 | SURFACE DRAINAGE: Excellent to East | VEGETATION: Thick Spruce 6 - 12' | ELEV: 306.2'

TEST HOLE

MILE	B,C,S	NUMBER
639	C	4

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				CL to CI	CLAY - Med. Brown - Silty - Low Plasticity	F	V 30 - 35%
4							F	
6	2						U to F	Unfrozen - V- 0 - 3%
8						- Med. Brown - Silty -. Med. Plastic		
10	3							
12								
14								
16								
18	4							
20								
22								
24								
	5							



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

REMARKS

60' N of B.C.

E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

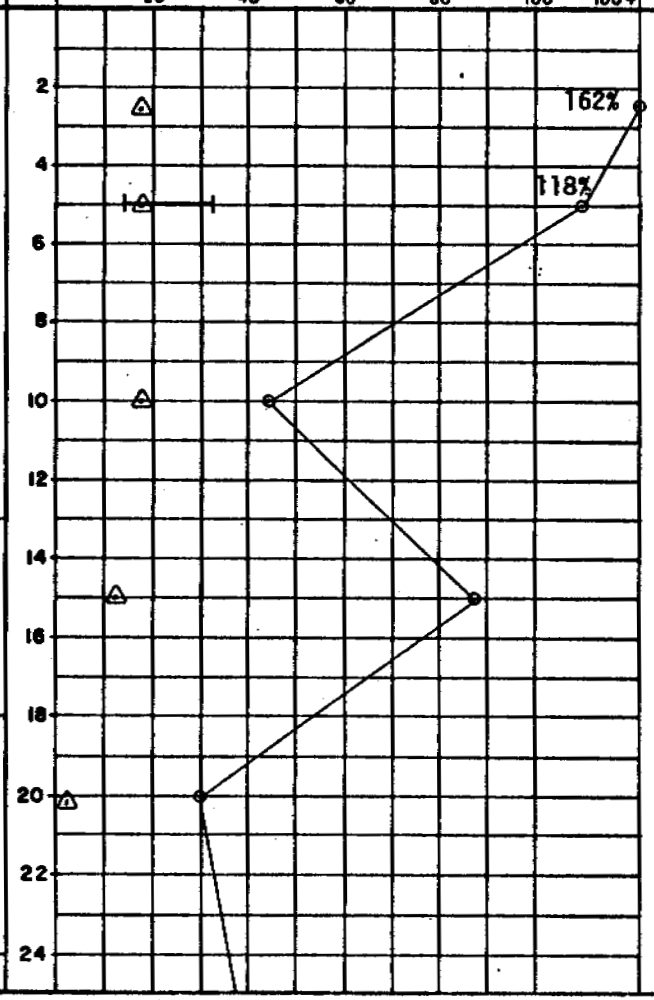
DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: NRM | DATE DRILLED 6/3/73 | AIRPHOTO NO: A22774 - | CHAINAGE: 4517 +80 | OFFSET
CKD: BD | TECH: TJ | RIG: Mayhew 500 | SURFACE DRAINAGE: Good to East | VEGETATION: Thick Spruce 25 - 30' | ELEV: 282.3'

TEST HOLE MVPL25

MILE	B,C,S	NUMBER
639	S	1

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				CL	SILT - Organic - Dark Brown - Low Plasticity	F	NB -V 15 - 20%
4	2							
6								
8								
10	3					- Root @ 10' - Trace of Clay		
12								
14	4				CI	CLAY (TILL) - Grey-Brown - Silty - Med. Plasticity		V 10 - 15%
16								
18								NB - V - 0-5%
20	5							
22								
24								



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

REMARKS

W. Bank Down in Bottom.
40' W. of Creek

E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB	FIELD ENG: NRM	DATE DRILLED: 6/3/73	AIRPHOTO NO: A22774 - 32	CHAINAGE: 4517 + 80	OFFSET
CKD: BD	TECH: TJ	RIG: Mayhew 500	SURFACE DRAINAGE: Good to East	VEGETATION: Thick Spruce 25-30'	ELEV: 282.3'

TEST HOLE MVPL25

MILE	B,C,S	NUMBER
639	S	1

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
26	6					CLAY (TILL) - same as above	F	NB to V-0-5%
28								
30	7							
32								
34								
36	8				CH	- High Plasticity		
38						END OF HOLE 37'		
40								
42								
44								
46								
48								

O = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT
20 40 60 80 100 100+

GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

REMARKS

E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB	FIELD ENG: NRM	DATE DRILLED: 6/3/73	AIRPHOTO NO: A22774 - 32	CHAINAGE: 4517 + 80	OFFSET	TEST HOLE MVPL25
CKD: BD	TECH: TJ	RIG: Mayhew 500	SURFACE DRAINAGE: Good to East	VEGETATION: Thick Spruce 25-30'	ELEV: 282.3'	MILE: 639 / B,C,S: S / NUMBER: 1

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
26	6					CLAY (TILL) - same as above	F	NB to V-0-5%
28								
30	7							
32								
34								
36	8				CH	- High Plasticity		
38						END OF HOLE 37'		
40								
42								
44								
46								
48								

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT
20 40 60 80 100 100+

GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		

REMARKS

E.W. BROOKER & ASSOCIATES LTD. — DRILL HOLE REPORT

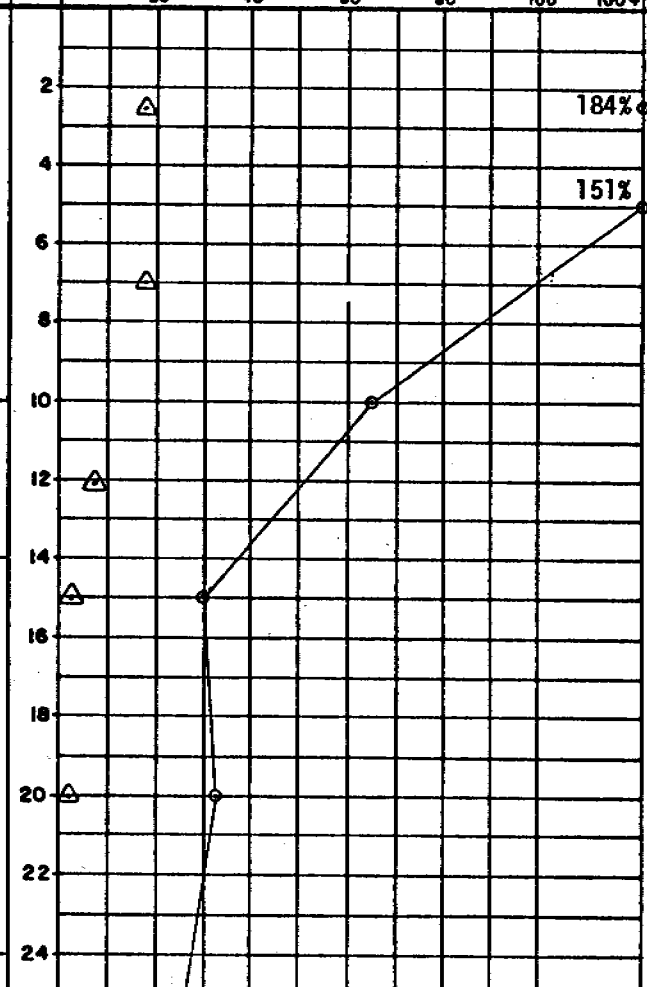
DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: NRM | DATE DRILLED 6/3/73 | AIRPHOTO NO: A22774 - 32 | CHAINAGE: 4519 + 50 | OFFSET
CKD: BD | TECH: TJ | RIG: Mayhew 500 | SURFACE DRAINAGE: Good to West | VEGETATION: Thick Spruce 30-35' | ELEV: 279.6'

TEST HOLE

MILE	B,C,S	NUMBER
639	S	2

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				OL	SILT - Organic - Dk. Brown - Non Plastic	F	NB -V 15-20%
4	2							
6								
8						- Root @ 8'		
10	3				CL	CLAY (TILL) - Grey-Brown - Silty - Low Plasticity		NB -V 5 - 10%
12								
14	4							NBE-V 0 - 5%
16								
18								
20	5							
22								
24								



DEPTH (FEET)	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						
22						
24						

REMARKS

E. Bank
35' E of Creek

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: NRM | DATE DRILLED: 7/3/73 | AIRPHOTO NO: A2274 - 32 | CHAINAGE: 4527 + 50 | OFFSET

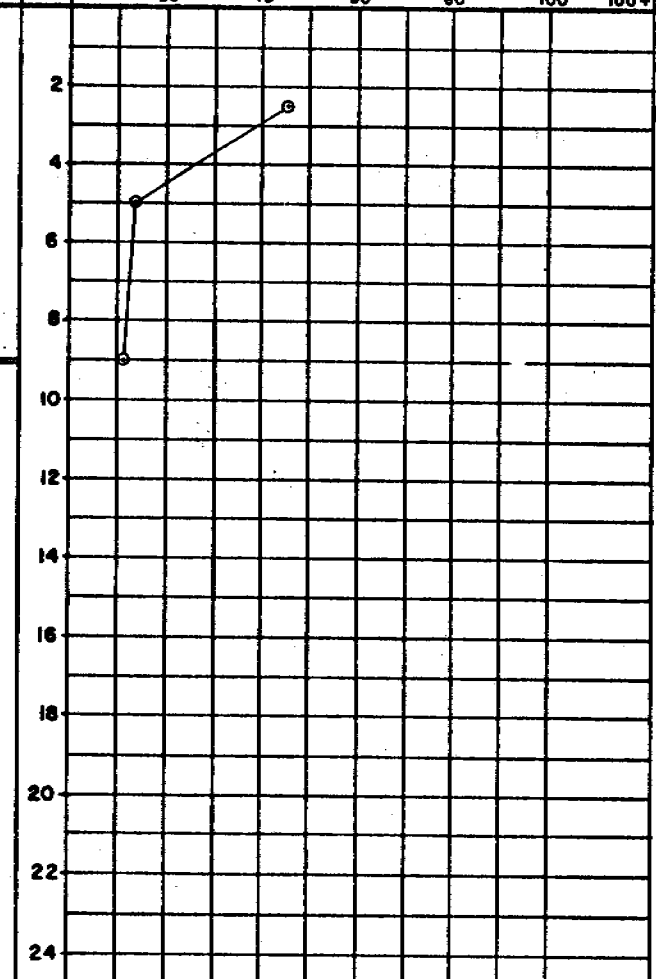
CKD: BD | TECH: TJ | RIG: Mayhew 500 | SURFACE DRAINAGE: Good to Northwest | VEGETATION: Thick Spruce 10 - 15' | ELEV: 295.5'

TEST HOLE

MILE	B,C,S	NUMBER
639	C	5

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
2	1				GW	GRAVEL - Med. Brown - Sandy, some Silt - Non-Plastic		
4	2						F	NF
6								
8	3							
10						END OF HOLE 9'		



GRAIN-SIZE ANALYSIS				WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)
CLAY %	SILT %	SAND %	GRAVEL %		
(11)	40	49	-		

E.W. BROOKER & ASSOCIATES LTD.

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: ALB | FIELD ENG: NRM | DATE DRILLED 6/3/73 | AIRPHOTO NO: A22774 - 32 | CHAINAGE: 4519 + 50 | OFFSET

CKD: BD | TECH: TJ | RIG: Mayhew 500 | SURFACE DRAINAGE: Good to West | VEGETATION: Thick Spruce 30-35' | ELEV: 279.6'

TEST HOLE

MILE	B,C,S	NUMBER
639	S	2

REMARKS

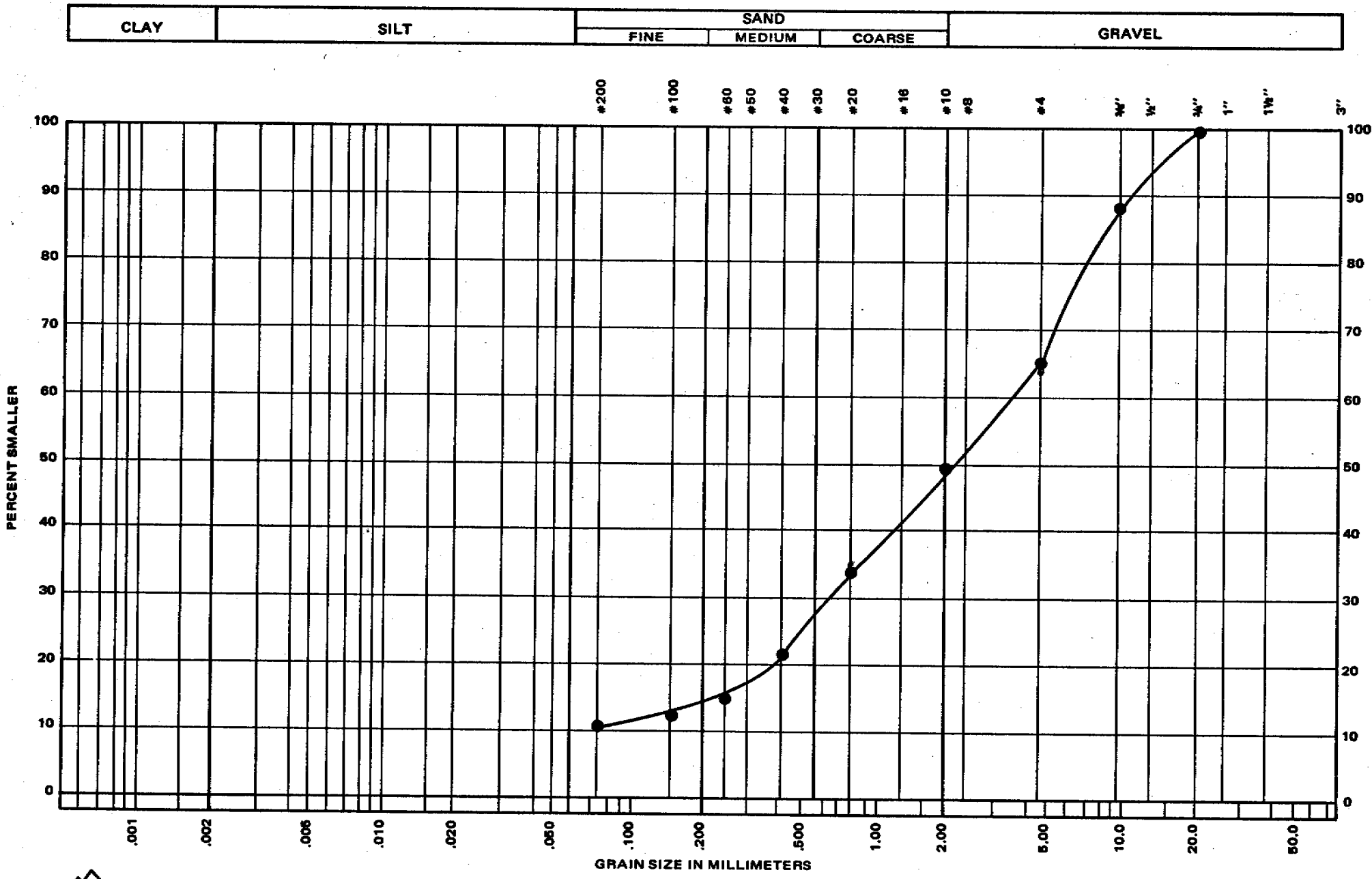
DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
26	6				CL	CLAY (TILL) - Same as above	F	NB - V 0 - 5%
28								
30	7					END OF HOLE 30'		
32								
34								
36								
38								
40								
42								
44								
46								
48								

O = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT — LIQUID LIMIT
20 40 60 80 100 100+

GRAIN-SIZE ANALYSIS				WET DENSITY (PCF)	DRY DENSITY (PCF)
CLAY %	SILT %	SAND %	GRAVEL %		

GRAIN SIZE DISTRIBUTION



FIGURE

Engineering Consultants Ltd.

SAMPLE DESCRIPTION GRAVEL - SANDY, SOME SILT

PROJECT MACKENZIE HIGHWAY

JOB No. E-517 DATE APRIL 11/73

SAMPLE No. 639-C-5

DEPTH 2½'

SUMMARY OF TEST RESULTS JOB No. E-517

LAKE NARROWS CROSSING - MILE 639

BORE HOLE	DEPTH	NATURAL WATER CONTENT	Atterberg Limits			MECHANICAL ANALYSIS (M.I.T. CLASSIFICATION)				SOIL CLASSIFICATION (UNIFIED)	REMARKS
			W_L	W_P	PI						
	feet	%	%	%	%	% CLAY	% SILT	% SAND	% GRAVEL		
639-C-5	2½					11		40	49	GW	
639-S-1	5	118.0	32.1	17.8	14.3					CL	

DWG. No.

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