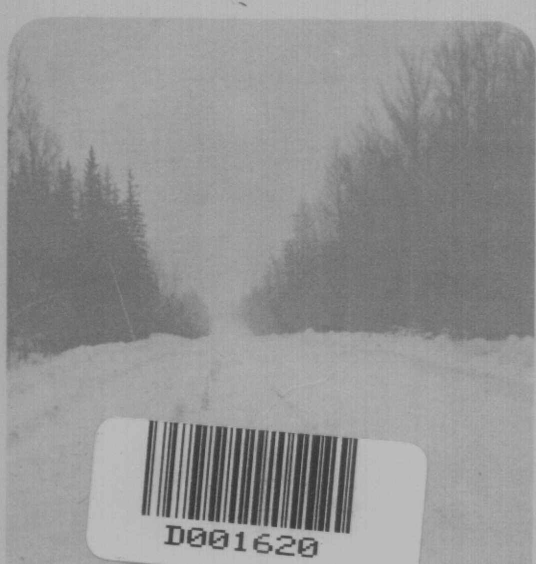
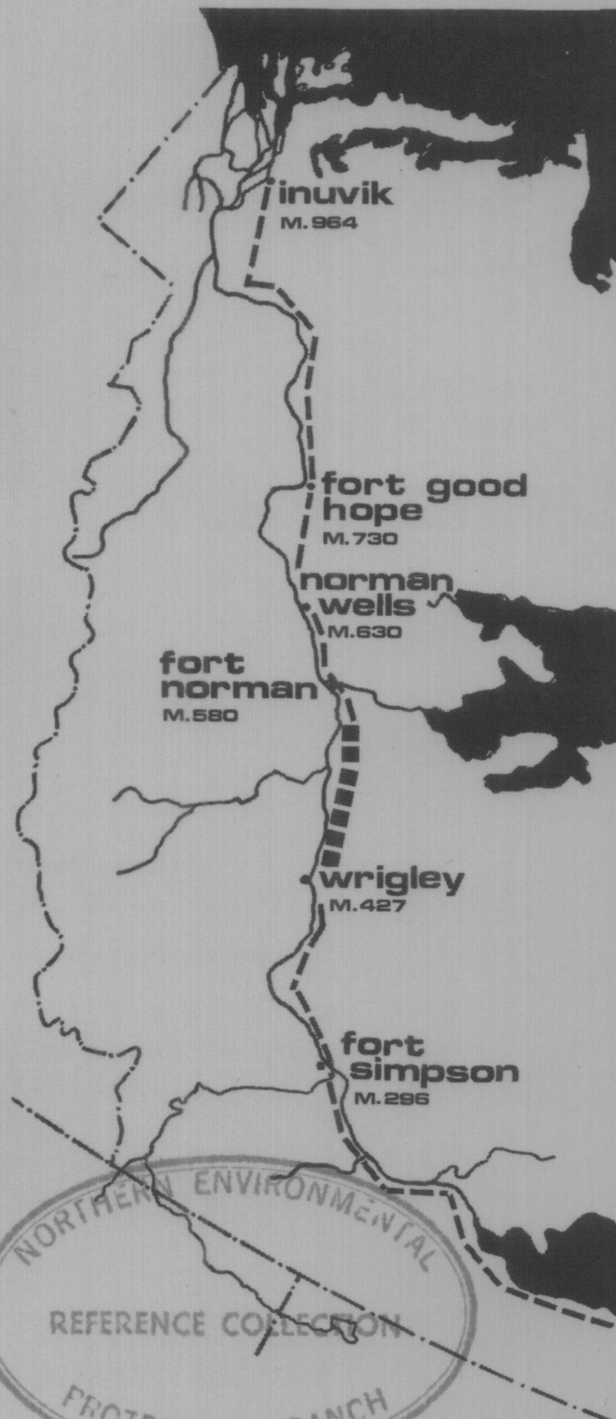




REPORT ON SUBSURFACE SOIL CONDITIONS FOR PROPOSED -

RAINBOW CREEK BRIDGE MILE 471.6

MACKENZIE HIGHWAY

Underwood Mclellan & Associates Ltd.

Underwood McLellan & Associates Limited

2540 KENSINGTON ROAD N.W., CALGARY, ALBERTA T2N 3S3 TELEPHONE 283-4901 TELEX 038 24505

OUR FILE NO 2106-032-45
April 6, 1973

Department of Public Works
P. O. Box 488
Edmonton, Alberta

Attention: Mr. F. E. Kimball,
Project Manager

Dear Sir:

Re: Subsurface Soil Investigation
Rainbow Creek Bridge, Mile 471.6
Mackenzie Highway

Attached please find our report on the subsoil and foundation conditions for the proposed Rainbow Creek Bridge on the Mackenzie Highway in the Northwest Territories.

If you have any questions concerning the contents of this report, we would be pleased to discuss them with you at your convenience.

Yours very truly,

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

Per: D G Pennell
D. G. Pennell, Ph.D, P.Eng.

DGP/al

REPORT ON
SUBSURFACE SOIL CONDITIONS
FOR THE
PROPOSED RAINBOW CREEK BRIDGE
MILE 471.6
MACKENZIE HIGHWAY
NORTHWEST TERRITORIES

Prepared By:

Underwood McLellan and Associates Limited
Consulting Professional Engineers

INDEX

APPENDIX

A. INTRODUCTION

The subsoil investigation undertaken at the Rainbow Creek forms part of the overall geotechnical investigation which was conducted from mile 450 to 550 on the Mackenzie Highway for the Department of Public Works, Government of Canada.

The present report summarizes the results of the geotechnical investigation conducted in connection with the proposed Rainbow River bridge, mile 471.6. This report deals specifically with the design of the bridge abutments and piers and approach fills and cuts.

It was the intention of the present investigation to determine the vertical sequence of the subsoil materials, together with certain physical and structural properties, permafrost conditions and ground water conditions.

The included conclusions and recommendations have been based upon exploration and sample acquisition operations conducted at a total of 13 positions on or near the centreline of the proposed roadway at the bridge site and along the adjacent river banks.

In the formulation of conclusions and recommendations the consistency and composition of the subsoil materials between and proximity to the individual test boring position has been assumed but not verified.

B. FIELD AND LABORATORY INVESTIGATION PROCEDURES

A total of 13 test holes have been drilled within one-half mile of the bridge structure. In addition to the test hole logs located nearest to the bridge site several borrow pit test holes have been included in the Appendix. Test holes along the centreline were drilled to depths ranging from 12 to 50 feet below existing side grades and the borrow pit test holes were generally advanced to the 15 foot level.

Test holes were drilled December 1, 2, 26, 29 and 30, 1972 and January 13 and 14, 1973, by Kenting Big Indian Drilling of Calgary, utilizing a Mayhew 1000 and Heli drill. Air recovery methods were generally employed except where caving was encountered at bridge crossings, water and drilling mud circulation was employed.

The locations of the individual test borings were selected and field located by Underwood McLellan & Associates Limited. The approximate test boring locations are graphically illustrated on the accompanying Mosaic and Test Hole Location Plan.

All variations of soil, permafrost and ground water conditions encountered during the test drilling operations were noted and representative samples of existing subsoils were taken. The majority of samples were disturbed having been obtained by the air recovery method. Samples were also undertaken with 2" and 3" O.D. split spoon sampling tubes.

In the laboratory, samples of materials derived from the drilling operations were subjected to standard laboratory classification procedures including particle size distribution and Atterberg index property determinations. Moisture contents were obtained for all samples returned to the laboratory and whereever a sufficient length of intact sample was retained in the penetrometer tube, both wet and dry densities were obtained. Permafrost samples were classified according to N.R.C. Technical Memorandum

No. 79 "Guide to the Field Description of Permafrost". The excess ice content of permafrost samples was determined by visual inspection and by measured thicknesses of ice lenses. The calculation of excess ice content was performed by division of ice thickness by the total sample thickness.

All soil samples were classified according to the Unified Soil Classification System.

The results of all laboratory and field tests are summarized in the Appendix on the test hole logs.

Test holes have been designated by mileage, type and number. Examples of test holes designations include 471S 138A, 470C 27B, and 470B 222B;

471, 470 - mileage

S, C, B - these letter symbols between mileage and test hole numbers refer to structures, centreline and borrow pit logs, respectively.

138, 27, 222 - indicate test hole numbers.

A, B - these letters occurring after test hole numbers indicate the drilling rig utilized. A - refers to the Mayhew 1000 and B to the Heli drill.

C. SITE AND SUBSOIL CONDITIONS

The Rainbow bridge site is located at mile 471.6 (chainage 1053 + 00) of the Mackenzie Highway in the Northwest Territories. The Rainbow Creek flows into the Mackenzie River from the east having a drainage basin which extends to the Franklin Mountains. The stream has a typical sand-gravel bed which is presently in a state of depositing floodplain sediments at the entrance to the Mackenzie River.

The Rainbow stream bed elevation is approximately 366 (DPW datum) and the recently estimated high water mark near the proposed bridge site as a result of ice jams on the Mackenzie River is at elevation 393.0.

The existing Rainbow stream channel is approximately 325 feet wide and 35 feet deep at the proposed bridge site location.

In general, the overburden material which exists at the location of the bridge site and approach fills is composed of granular sands and gravels which were deposited on the river terraces when the river flowed at higher elevations.

Test holes 33B, 34B, 35B and 140A drilled at the edge of the stream channel were advanced to depths of 40, 35, 23 and 12 feet below existing site grades, respectively.

These test holes in the river channel generally indicated approximately 8 to 10 feet of gravel and sand overburden materials except test hole 140A on the north bank, which disclosed approximately 4 feet of granular material. Below the granular material a 6 foot depth of weathered clayey shale was found. The weathered shale was underlain by a very hard fissile grey shale which constitutes the bedrock at the site. This Cretaceous shale or siltstone bedrock is low plastic, exhibiting a plastic limit of 18% to 22% and a liquid limit from 26% to 31%. The average natural moisture content of 7% is well below the plastic limit and generally confirms the dense nature of the bedrock strata. The boulder nature of the overburden materials would not allow the performance of field, penetration tests and the utilization of drilling mud and water prevented accurate determination of the permafrost condition. But in general it has been concluded that the materials below the stream bed at the site were unfrozen.

The water level was present at approximately 4 feet below the ground surface in test hole 33B. This water level was approximately coincident with the river level at the time of drilling.

Test holes 137A and 50A were drilled on the north river banks above the approaches to the bridge, to depths of 30 and 18 feet, respectively below the existing sites grades. These two test holes indicated that a surface gravel and sand mixture existed to depths of 18 feet which was underlain by approximately 12 feet of very dry sand. Numerous samples obtained from the gravel strata indicated that approximately 60% to 85% of the material was larger than the #4 sieve. In addition, these materials were unfrozen and exhibited moisture contents of approximately 6%.

Test holes 51A, 229B, 32B and 138A were drilled 20 to 50 feet below the surface. These test holes again indicated that the overburden was primarily gravel and sand deposited as a terrace, but in addition, the upper holes exhibited a surface strata of approximately 6 feet of light brown silty clay. The shale bedrock was encountered at 3 of the 4 test holes on the south bank and there was approximately 20 feet of overburden.

The bedrock and overburden materials are shown on the geologic profile which is included in the Appendix. The permafrost condition was again difficult to establish because of the wet drilling process but there appears to be some frozen areas on the slope and in all cases the moisture contents of the granular materials were below 10%, except for test hole 138A which was drilled at the lower portion of the bank and in which free water was encountered.

The gravel samples which were obtained during drilling operations were subjected to crushing during drilling and would exhibit a true gravel and boulder size content higher than obtained from sieve analyses.

In conclusion, the test holes which were drilled throughout the Rainbow Creek valley generally indicated a granular overburden of 10 to 20 feet which was underlain by a shale bedrock.

D. CONCLUSIONS AND RECOMMENDATIONS

On the basis of the present investigation, we wish to offer the following generalized conclusions and recommendations relative to the design and construction of the proposed Rainbow Creek bridge and approaches.

1. Pier and Abutment Foundation Design

The relatively shallow depth of the granular overburden at this site allows the consideration of a shallow spread footing foundation type or driven piles. Although the depth to bedrock would allow the establishment of pier and abutment footings, variation in bedrock elevation exists and extreme difficulty will be experienced in excavation of overburden materials for footings. Therefore a driven pile foundation is recommended for all structures.

The pile types generally available include timber, pre-cast concrete, steel H-piles and pipe piles. The timber piles are not recommended as a result of their low capacity and possible damage when driving through gravel strata. The pre-cast piles are also not recommended because splicing becomes difficult and expensive, whenever it is not possible to establish the exact ultimate pile length.

Steel H-piles or pipe piles are, therefore, recommended for consideration primarily based on high driving strength, high load capacity and relative splicing ease. The granular strata at this site will provide adequate lateral support such that instability in the form of buckling of the piling will not be a problem.

It is recommended that all piles be driven to "refusal". "Refusal" will depend upon the energy rating of the hammer but is commonly 15,000 ft.-lbs. As an initial guide piles should be driven to blow counts of 180 blows per foot, or 15 blows per inch. Pile capacity is largely a function of the amount of energy expended in installing the pile and not just on the recorded resistances. The pile which is driven to a sustained resistance will perform better than one which is terminated the instant a given resistance is attained. Of course, the pile must not be driven whenever damage may result and whenever resistance increases significantly, the driving should be terminated.

At the Rainbow Creek site, it is anticipated that steel pipe or H-piles will be approximately 15 to 20 feet in length. The exact depths of the steel pipes will depend upon the weathered shale zone depth which varies across the stream channel. It is anticipated that the allowable ultimate capacity of each pile will be in the range of 80 tons, and will depend upon the x-section utilized. The capacity of the piles should be established in the field by several pile driving tests. The ultimate capacity would be calculated on the basis of a dynamic pile-driving formulae such as the Hiley, Danish, or Weisbach. It is recommended that the Engineering News Formula not be utilized as a result of extreme variation in factor of safety.

It is further recommended that static load tests be performed to establish more accurately the bearing capacity of a typical steel pile and the applicability of dynamic pile formulae for capacity prediction. At this site refusal will be attained in the bedrock but some difficulty will be experienced in penetration of boulders in the gravel strata. Vibratory procedures may be utilized to provide advancement of the pile to the bedrock.

The lateral resistance of piles can be established by recently developed methods based on the beam on elastic foundation method but the simple and more conventional approach is based on calculation of the Rankine passive earth pressure against the pile.

Using Rankine theory the ultimate passive resistance force/ft.[2] of pile can be obtained by $P = \frac{1}{2}\gamma_b K_p H^2$. The submerged unit weight of the granular material may be taken as 60 pcf and the passive pressure coefficient K_p as 3.0. In order to establish the allowable lateral load a factor of safety of 2.5 should be applied to the above ultimate load. Generally, in cohesionless soils the lateral load tends to exceed the passive resistance and the above simplified approach is on the conservative side.

Wherever the deep embankments are constructed of compacted granular fill as outlined and recommended in section D3, the abutments may be placed on spread footings in the fill. If inferior material or compaction techniques are utilized in the embankment, the abutments must be carried on piles to refusal in the bedrock. Piles must be designed to carry a negative skin friction load whenever embankment fills may undergo settlement.

2. Lateral Abutment Loads

The magnitude of the pressure applied to the abutment will depend upon the characteristics of the backfill chosen for the approach fill and upon the movements that the wall undergoes during and subsequent to fill compaction. It is recommended that granular backfill from the river terraces or borrow pits be utilized for the abutment approach embankments which will be in the order of 30 feet high.

The most common procedures for analysis of the earth pressures against gravity retaining walls include Rankine and Coulomb methods.

Generally, it is assumed that the wall rotates sufficiently to allow mobilization of the backfill shear strength which reduces the pressure to the active case, the lowest pressure that can be realized. This assumption applies reasonably accurately when the backfill consists of uncompacted granular material but pressures greater than the active occur wherever compaction of the backfill is undertaken. While the total yield at different elevations on the abutment may be adequate for mobilization of the full backfill strength, a gradual build-up of the backfill also results in a gradual yielding of the wall. Therefore, by the time the backfill is complete only a fraction of the total yield of the wall has become effective in decreasing the earth pressure. At the present time it is accepted that the actual earth pressure magnitude will exceed the active case and may approach the earth pressure at rest. Pressures greater than the at-rest case may occur if heavy equipment is utilized near the concrete abutment.

If the Coulomb approach is utilized, the angle of wall friction between concrete and coarse sand and gravel would be 20 degrees. The angle of internal friction for compacted granular material would be 38 degrees and the dry density may be taken as 115 pcf. For a simple vertical retaining wall abutment with horizontal backfill the Coulomb active coefficient would be .24 and the at-rest coefficient based on $K_o = 1 - \sin \phi$ would be .38. The Rankine procedure which disregards the wall friction would also result in an active coefficient of .24. Whenever the wall or backfill are inclined or a surcharge exists, the Coulomb procedure will result in a lower active pressure which will be more exact than the conservative Rankine method. The pressure distribution behind a gravity retaining wall has been shown to be non-triangular, but as a first approximation and for simplicity, the triangular pressure diagram is recommended. It is also recommended that whenever backfill is compacted in lifts by vibratory compactors the at-rest coefficient may be utilized for calculation of the ultimate earth pressure.

A driven pile foundation has been previously recommended for the abutments which will provide significant lateral resistance but it is further recommended that some batter piles be utilized to ensure adequate lateral support against earth pressures.

Positive drainage including horizontal perforated tile and weep holes should be provided to prevent development of hydrostatic pressure against the wall. In addition, free drainage of water will prevent the development of frost heaving pressures against the walls.

3. <u>Bridge Approach Grades and Borrow Material</u>

The proposed centreline grades at the Rainbow Creek valley will not involve cuts but will be entirely fill. The proposed fills will vary from 30 feet in depth at the bridge abutment to approximately 3 - 5 feet above the main stream channel valley. On the north side of the river these relatively shallow fills will directly overlie unfrozen gravel and sand deposits and, therefore, these fill depths are considered adequate and performance should be satisfactory. Near the south approach banks at station 1058 + 00 these fills overlie approximately 6 - 8 feet of silty clay permafrost. It is anticipated that thawing of the subgrade will occur with the 3-foot fills and therefore it is recommended that in these areas on the south bank, the fill depths be increased to at least 6-feet if granular materials are utilized. It is recommended that granular fill be used in all approach fills to the bridge abutments and this material should be compacted to 95% of Standard Proctor density utilizing vibratory compaction. Although construction may be performed during the winter, the dry unfrozen nature of the granular materials will allow satisfactory compaction. Compaction of these deep approach fills is mandatory to ensure stability and in addition, fill slopes are proposed at 2:1 whenever compacted granular materials are utilized.

Common excavation will not be available from the valley slopes as the grade line has been proposed entirely in fill. Satisfactory granular embankment is available throughout the river terraces but its utilization as a construction material may be prohibited by land use regulations. Suitable borrow pits have been located on the north and south upland areas. One gravel borrow pit was located approximately one mile south of the proposed bridge site at station 1104 + 00 and consisted of suitable low moisture content frozen gravel materials.

Another borrow pit on the south side was located at 1056 + 00, 500-feet east of the proposed centreline and consisted of suitable low moisture content gravel. On the north side at station 1025 + 00 a borrow pit approximately 1/2 mile from the bridge site was investigated but consisted of a silty clay which is not recommended for fill at the bridge approaches.

APPENDIX

EXPLANATION OF FIELD & LABORATORY TEST DATA

The field and laboratory test results as shown for a particular test boring by the Test Hole Log Data Sheet are briefly described below:-

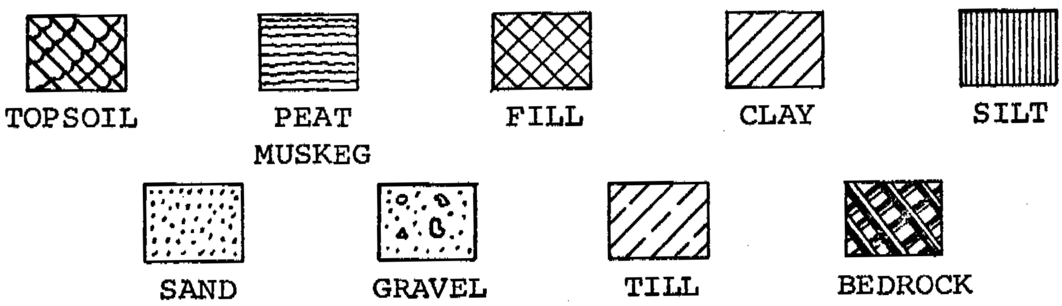
NATURAL MOISTURE CONDITIONS & ATTERBERG LIMITS

The relation between the natural moisture content and depth is significant in determining the subsurface moisture conditions. The Atterberg Limits should be compared to the Natural Moisture Content of the subsurface soil as well as plotted on the Plasticity Chart.

SOIL PROFILE & DESCRIPTION

Each soil strata is classified and described noting any special conditions. The unified classification system is used, and the soil profile refers to the existing ground elevation. When available the ground elevation is shown.

The soil symbols used are briefly shown below but are indicated in more detail in the Soil Classification Chart.



TESTS ON SOIL SAMPLES

Laboratory and field tests are identified by the following symbols:

QU - unconfined compressive strength usually expressed in tons per square foot. This value is used in determining the allowable bearing capacity of the soil.

γ_d - dry unit weight expressed in pounds per cubic foot. This value indicates the density or consistency of the in-situ soil.

C - Consolidation test. These test results are separately enclosed and provide information on the consolidation or settlement properties of the soil strata.

M.A. - grain size analysis. These test results are separately enclosed and indicate the gradation properties of the material tested.

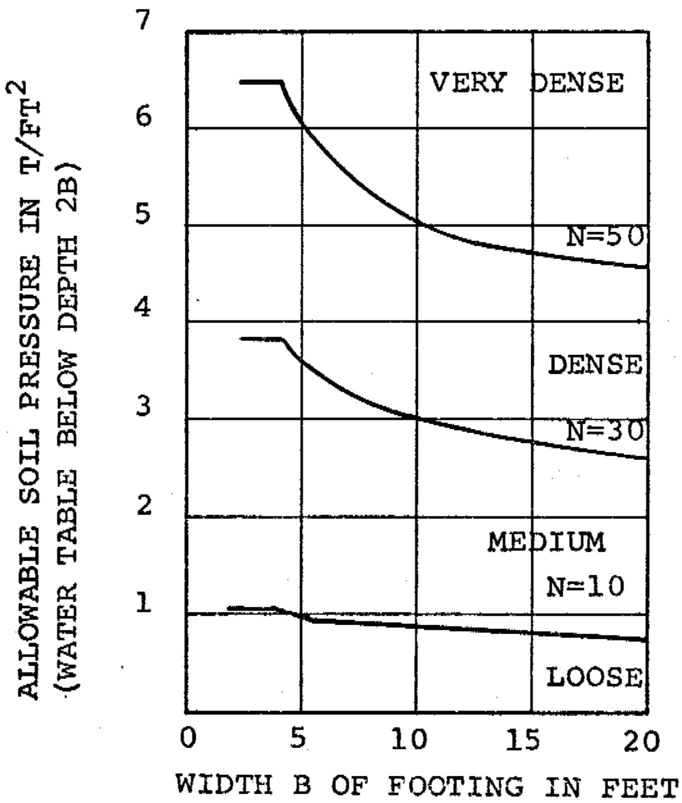
SO_4 - water soluble sulphate content is conducted primarily to determine whether sulphate resistant cement is required for the foundation structure.

N - standard penetration field test. This test is conducted in the field to determine the in-situ consistency of a soil strata. The "N" value recorded is the number of blows from a 140 lb. hammer dropped 30 inches (free fall) which are required to drive a 2" O.D. Raymond type sampler 12 inches into the soil.

The resistance and unconfined compressive strength of a cohesive soil can be related to its consistency as follows:-

N - BLOWS/Ft.	QU - $T/Ft.^2$	CONSISTENCY
2	0.25	very soft
2-4	0.25-0.50	soft
4-8	0.50-1.00	medium or firm
8-15	1.00-2.00	stiff
15-30	2.00-4.00	very stiff
30	4.00	hard

The resistance of a non-cohesive soil (sand) can be related to its consistency as follows:-



SAMPLE CONDITION AND TYPE

The depth and condition of samples are indicated by the following symbols:

$\boxed{P}$		
UNDISTURBED	DISTURBED	LOST SAMPLE

SAMPLE TYPES

T - 3" O.D. Shelby tube sample

P - penetration tube sample

C - rock core sample

PERCENTAGE WATER SOLUBLE SULPHATE CONCENTRATION

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7%

Negligible	Positive	Considerable	Severe
RELATIVE DEGREE OF SULPHATE ATTACK			

Negligible - Normal Portland Cement may be used.

Positive - Normal Portland Cement may be used, provided the strength of the concrete is increased up to 500 psi higher than the compressive strength which would normally be used.

Considerable - Type V cement must be used and the concrete compressive strength should be increased to 500 psi higher than the compressive strength which would normally be used.

Severe - Type V cement must be used and the concrete compressive strength should be increased from 500 to 1000 psi higher than the compressive strength which would normally be used.

GROUND WATER TABLE

The water table is indicated by the level of standing water in a test boring after equilibrium has been reached. This is generally taken 24 hours after the drilling operation. The water table is usually an inclined surface that is dynamic in nature with its highest level late in the winter or early spring gradually falling throughout the summer.

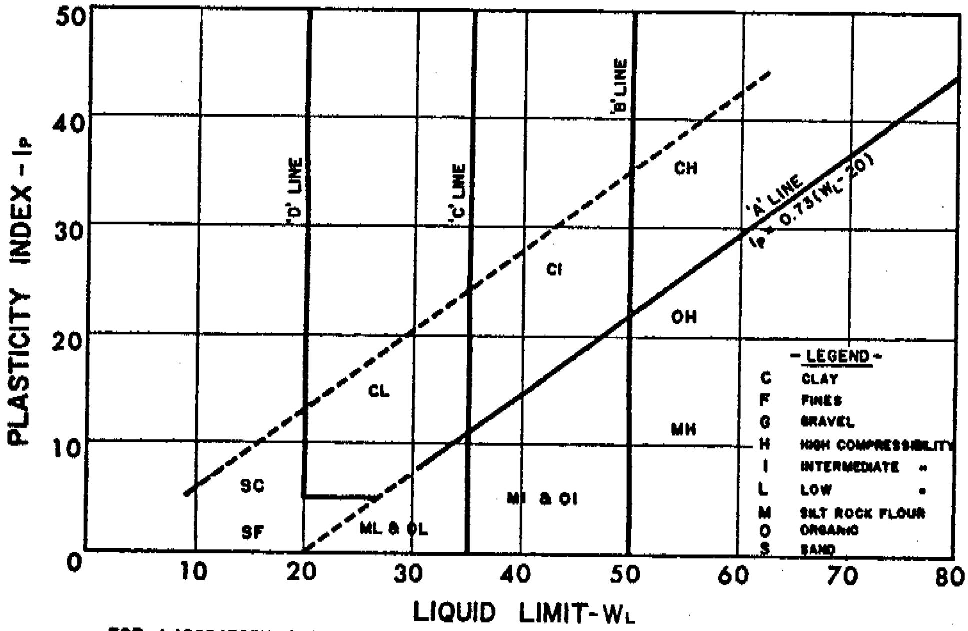
UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
				MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

PLASTICITY CHART



FOR LABORATORY CLASSIFICATION OF FINE-GRAINED SOILS

NATIONAL RESEARCH COUNCIL PERMAFROST
CLASSIFICATION SYSTEM

Permafrost ground ice occurs in three basic conditions including non-visible, visible (less than one inch in thickness) and clear ice.

A. Non-visible - N

N_f - poorly bonded or friable frozen soil

N_{bn} - well bonded soil, no excess ice

N_{be} - well bonded soil, excess ice

B. Visible - V (less than 1" thick)

V_x - individual ice crystals or inclusions

V_c - ice coatings on particles

V_r - random or irregularly oriented ice formations

V_s - stratified or oriented ice formations

C. Visible Ice - (greater than 1" thick)

Ice - ice with soil inclusions

Ice + Soil - ice without soil inclusions.

A more complete description of this system is included in NRC publication TM 79.

Issue	Date	Remarks	No.	Revision	Date	By	Approved

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

CONSULTING ENGINEERS · TOWN PLANNERS

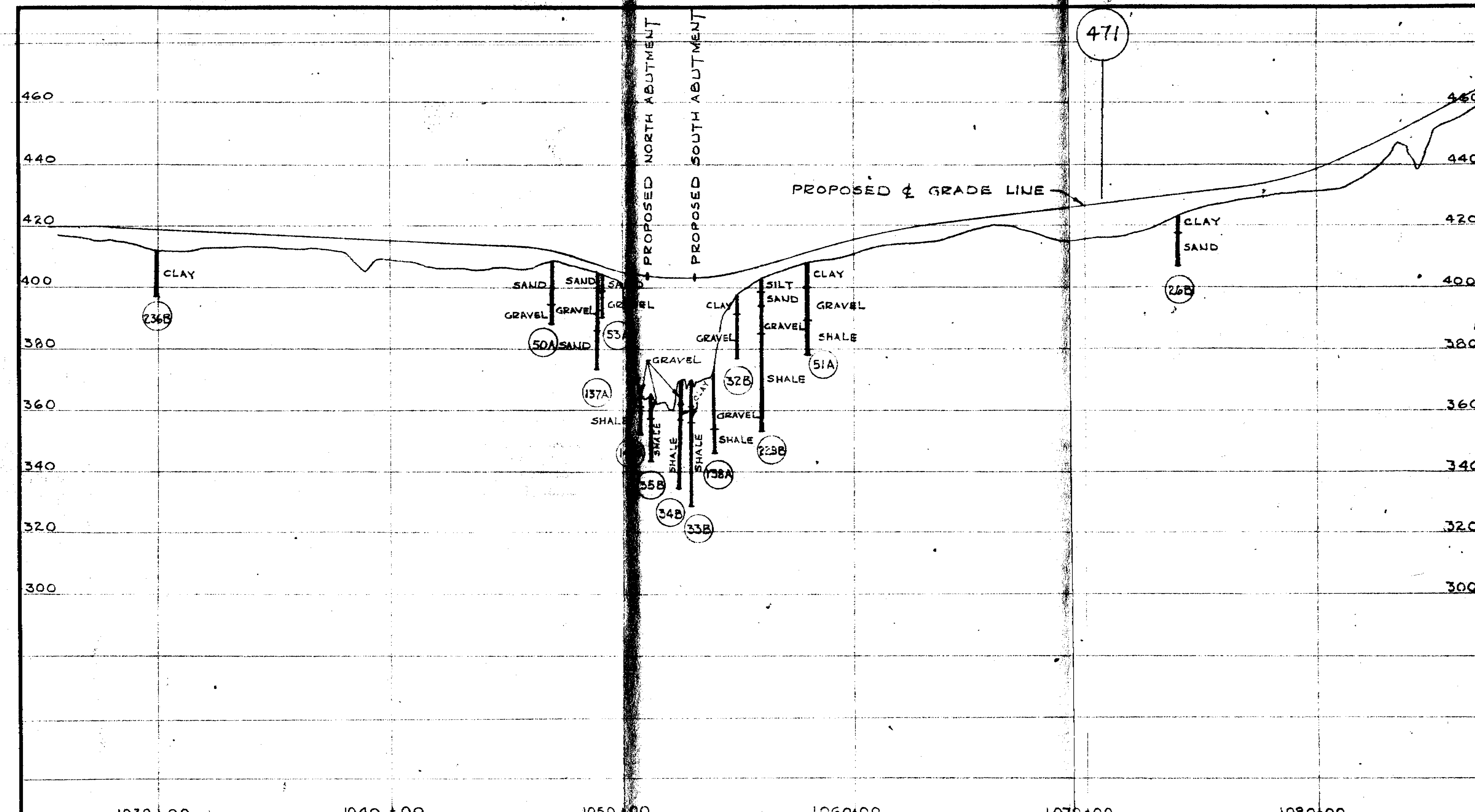
BRITISH COLUMBIA • ALBERTA • SASKATCHEWAN • MANITOBA • ONTARIO

Drawn: H.S.
Checked: D.G.P.
Design:
Traced:
Scale: 1" = 1000'

MACKENZIE HIGHWAY

RAINBOW CREEK MOSAIC AND TEST HOLE LOCATION PLAN

Date:
Job:
Sheet:
Drawing: PLATE - I
Issue:



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Drawn: H.S.
Checked: D.G.P.
Design:
Traced:
Scale:
AS SHOWN

MACKENZIE HIGHWAY

RAINBOW BRIDGE SITE

PROFILE & SOIL CROSS SECTION

Date: MAR 28/73
Job:
Sheet:
Drawing: PLATE-2
Issue:

RAINBOW CREEK
MILE - 471.6

℄

South Bank of Rainbow Crossing
looking South Westerly.

℄

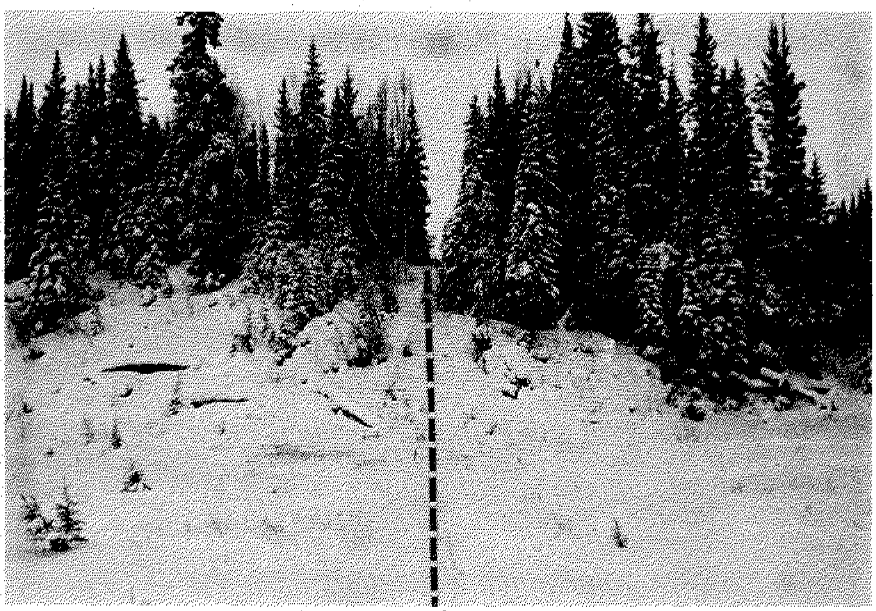
North Bank of Rainbow Crossing
Viewing along ℄ of Crossing.

Plate 3.

RAINBOW CREEK
MILE - 471.6

℄

South Bank of Rainbow Crossing
looking South Westerly.



℄

North Bank of Rainbow Crossing
Viewing along ℄ of Crossing.

Plate 3.

South Bank of Rainbow Crossing
Viewing in a Southerly Direction.

South Bank of
Rainbow
Crossing
Viewing along
℄ of Crossing.

Plate 3.

UNDERWOOD McLELLAN & ASSOCIATES LIMITED | DRILL HOLE REPORT | DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

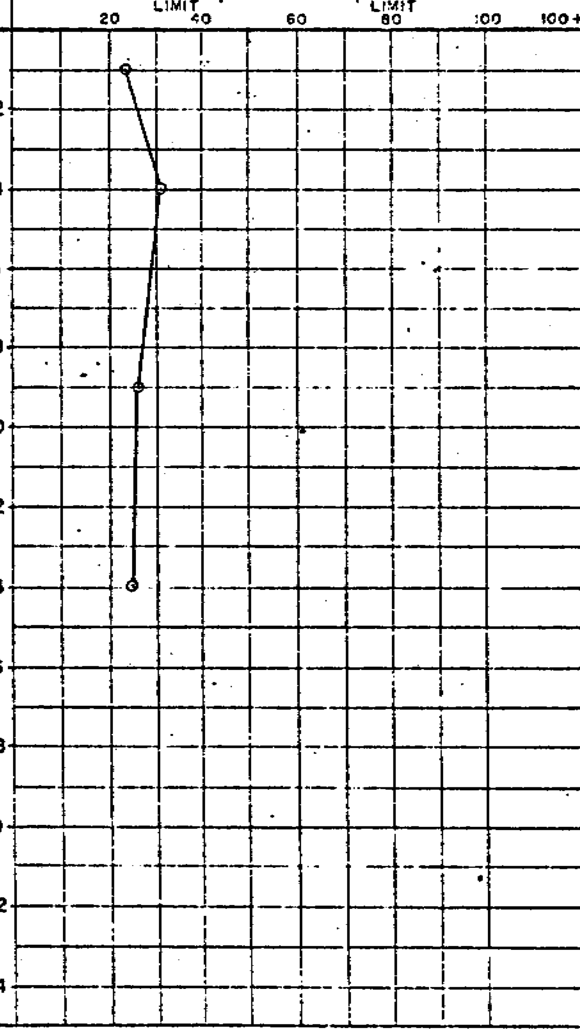
CAN A.E.W	FIELD ENG B M	DATE DRILLED 14/1/73	AIRPHOTO NO:	CHAINAGE: 1030+00	OFFSET ℄
CKD D.G.P	TECH D M	RIG: AIR	SURFACE DRAINAGE: POOR	VEGETATION: SPRUCE & BIRCH TO 20'	ELEV.

TEST HOLE

MILE	B,C,S	NUMBER
471	C	236 B

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	DEPTH (FEET)
0						PEAT ORGANIC	F		
0–15					CL	CLAY DARK, SANDY LIGHT, SANDY SOME GRAVEL		Vr (2 ft) Vr (14 ft)	
15						END OF HOLE			

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)
PLASTIC LIMIT ⊢——⊣ LIQUID LIMIT



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

REMARKS

PLATE 4

UNDERWOOD McLELLAN & ASSOCIATES LIMITED | DRILL HOLE REPORT | DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

DWN: A.E.W	FIELD ENG: T.S	DATE DRILLED: 26/11/72	AIRPHOTO NO:	CHAINAGE: 1047+00	OFFSET: ℄
CKD: DGP	TECH: D.M	RIG: AIR	SURFACE DRAINAGE: FLAT	VEGETATION: CON., POPLAR, BIRCH	ELEV: 404 38

TEST HOLE		
MILE	B,C,S	NUMBER
471	C	50A

DEPTH (FEET)	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)	REMARKS
0 – 13	SW	SAND FINE, SOME GRAVEL	UF								
2					27		73				
9					11		39	50			
13 – 19	GW	GRAVEL SANDY SOME ROCKS COARSE SAND									
19					14		52	34			
19		END OF HOLE									

O = WATER CONTENT (% OF DRY WEIGHT)

△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT ——— LIQUID LIMIT

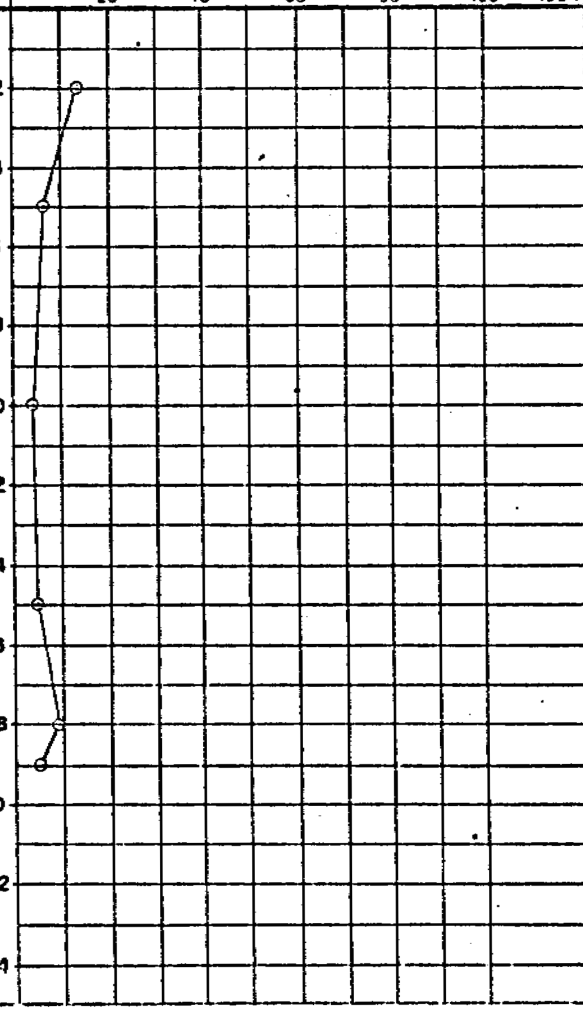


PLATE 5

UNDERWOOD McLELLAN & ASSOCIATES LIMITED | **DRILL HOLE REPORT** | **DEPARTMENT OF PUBLIC WORKS, CANADA — MACKENZIE HIGHWAY**

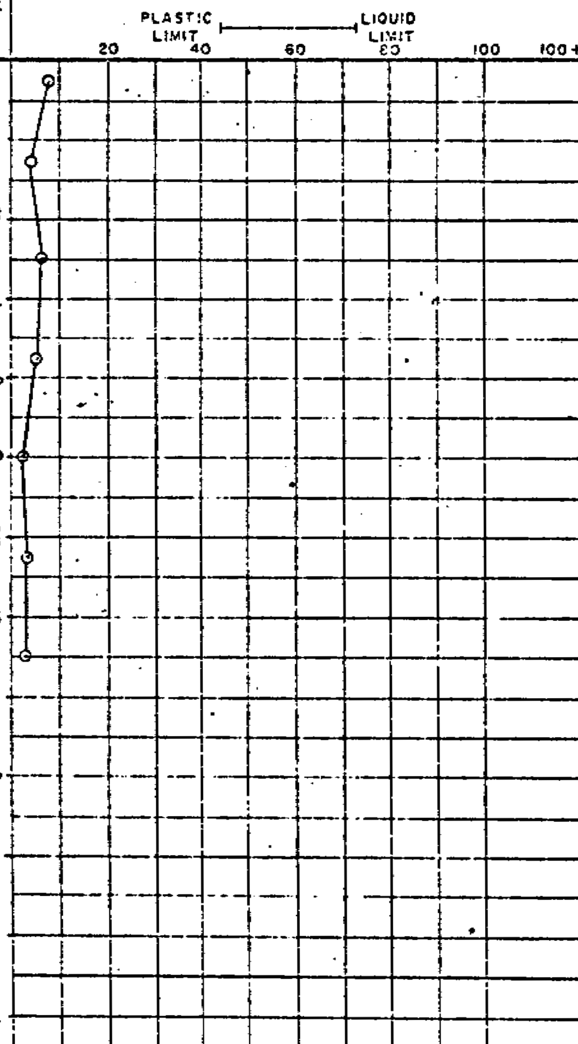
DWN A.E.W. | FIELD ENG. T.S. | DATE DRILLED 14/1/73 | AIRPHOTO NO: | CHAINAGE: 1049+00 | OFFSET

CKD DGP | TECH DM | RIG AIR | SURFACE DRAINAGE: GOOD | VEGETATION: POPLARS & CONIFER TO 30' | ELEV. 406.00

TEST HOLE

MILE	S.C.S	NUMBER
471	S	137A

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



DEPTH (FEET)	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)	REMARKS
0–1	GP	GRAVEL 1' ORGANIC	F								SO_4 - 0.11%
4		MED. FINE, SILTY SANDY	UF								
6					6		40	54			
10					5		35	60			
12		COARSE SAND, BOULDERS DRY & DUSTY									HARD DRILLING
15					3		15	82			
18		SAND									
20					24		76				
22		BROWN, LOOSE VERY DRY, SILTY									
25	SM				14		82	4			NO RETURN, HOLE SLOUGHING
30					23		69	8			
30		END OF HOLE									

UNDERWOOD McLELLAN & ASSOCIATES LIMITED	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

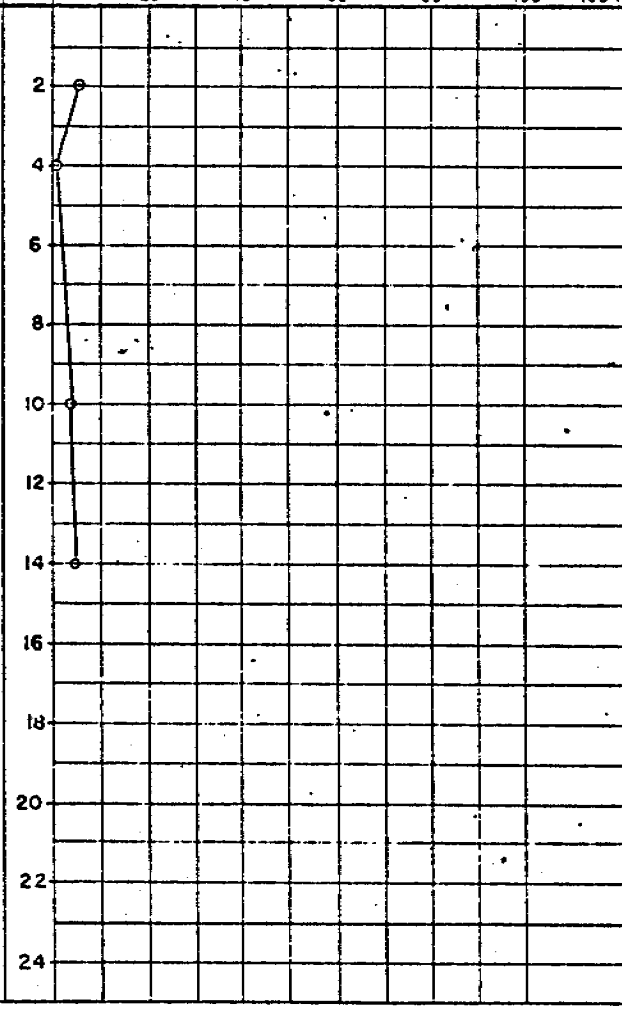
DWN: A E W	FIELD ENG: T. S	DATE DRILLED: 29/11/72	AIRPHOTO NO:	CHAINAGE: 1049+00	OFFSET: ℄
CKD: D G P	TECH: D M	RIG: AIR	SURFACE DRAINAGE: E-W 2%	VEGETATION: BIRCH, BLACK SPRUCE	ELEV: 406.00

TEST HOLE

MILE	B,C,S	NUMBER
471	C	53 A

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–2						GRAVEL DRY, SANDY	UF	
2					GP	NO SEASONAL FROST		
4								
6						, DRY		
8					GP			
10								
12						VERY SANDY		
14						END OF HOLE		

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



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

REMARKS

HOLE ABANDONED DUE TO CAVING AFTER TWO ATTEMPTS

UNDERWOOD McLELLAN & ASSOCIATES LIMITED	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

DWN A.E.W | FIELD ENG D.M | DATE DRILLED 14/1/73 | AIRPHOTO NO: | CHAINAGE: 1050+90 | OFFSET

CKD DGP | TECH | RIG AIR | SURFACE DRAINAGE: GOOD | VEGETATION: CONIFER & POPLAR TO 50' | ELEV.

TEST HOLE

MILE	B,C,S	NUMBER
471	S	140A

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–4					GW	GRAVEL BOULDERS	F UF	
4–12						SHALE		
12						END OF HOLE		

○ = 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

PLATE 8

UNDERWOOD McLELLAN & ASSOCIATES LIMITED — DRILL HOLE REPORT — DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

DWN: A E W	FIELD ENG: B M	DATE DRILLED: 2/12/72	AIRPHOTO NO:	CHAINAGE: 1051+30	OFFSET: ℄
CKD: D G P	TECH: D M.	RIG: WATER	SURFACE DRAINAGE: POOR	VEGETATION: SHRUBS & GRASS	ELEV:

TEST HOLE

MILE	B,C,S	NUMBER
471	S	35 B

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	○ = WATER CONTENT (% OF DRY WEIGHT) △ = ICE CONTENT (% OF SAMPLE VOLUME) PLASTIC LIMIT — LIQUID LIMIT 20 40 60 80 100 100+	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)	REMARKS
0					Pt	PEAT - FINE, FIBROUS										
0–1.5					CL	CLAY - SOME SAND SEASONAL FREEZING	F	Nbn								
1.5–4.5					GP	CLAY COBBLES AND BOULDERS	UF									
4.5–7.5					GC	GRAVEL SOFT, CLAYEY										
7.5–23						SHALE GREY										DIFFICULT TO DETERMINE FROZEN SOIL WITH WATER & DRILLING MUD
23						END OF HOLE										

UNDERWOOD McLELLAN & ASSOCIATES LIMITED	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

DWN: A E W	FIELD ENG: B.M.	DATE DRILLED: 1/12/72	AIRPHOTO NO:	CHAINAGE: 1052+70	OFFSET: ℄	TEST HOLE
CKD: D G P	TECH: D M	RIG: WATER	SURFACE DRAINAGE: POOR	VEGETATION: GRASS & SHRUBS	ELEV:	

MILE	B,C,S	NUMBER
471	S	348

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

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)	REMARKS
0–1					Pt	PEAT ORGANIC	F	Nf							
1–7		2–8			GP	GRAVEL SMALL	UF								
7–12					CH	CLAY SOME GRAVEL									DIFFICULT TO DETERMINE FROZEN SOIL WITH WATER & DRILLING MUD
12–23						SHALE GREY									
						END OF HOLE @ 35'									

UNDERWOOD McLELLAN & ASSOCIATES LIMITED	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

DWN: A E W	FIELD ENG: B.M.	DATE DRILLED: 30/11/72	AIRPHOTO NO:	CHAINAGE: 1053+00	OFFSET:	
CKD: D.G.P.	TECH: D M	RIG: AIR	SURFACE DRAINAGE: POOR	VEGETATION: GRASS & SHRUBS	ELEV: 6068	

TEST HOLE

MILE	B,C,S	NUMBER
471	S	33B

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

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	DEPTH (FEET)	WATER / ICE CONTENT	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)	REMARKS
0					Pt	MUSKEG GRANULAR											
0–3					CL	CLAY SILTY SEASONAL FROST	F	Nbn	2								
3–7					GP	GRAVEL FREE WATER @ 4' ROCKS.	UF		4, 6								DRILLING WITH ROCK BIT, WATER & DRILLING MUD
7–12					CL	CLAY SOFT SHALE LAYERS GREY			8, 10								
12–15					GP	SHALE SOFT, LAYERED FISSILE			12, 14	○ ~22 at 12 ft							
15–30					GP	SHALE GREY-BLUE, HARD LAYERED			16, 18								
30–40					GP	SHALE SOME GRAVEL GRANITE PEBBLES BOULDERS			30, 35, 40								
40						END OF HOLE			40								

UNDERWOOD McLELLAN & ASSOCIATES LIMITED	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

DWN A.E.W	FIELD ENG. T.S.	DATE DRILLED 14/1/73	AIRPHOTO NO:	CHAINAGE: 1054+00
CKD D.G.P	TECH D.M	RIG AIR	SURFACE DRAINAGE:	VEGETATION: ALDERS

OFFSET:

ELEV. 7407

TEST HOLE

MILE	B,C,S	NUMBER
471	S	138A

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

DEPTH (FEET)	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)	REMARKS
0–1	Pt	PEAT GRANULAR MUSKEG	F								
1–17	GM	GRAVEL SILTY, SANDY, DRY	UF		6		30	64			
					8		36	59			
		WET, SILTY, SOME SHALE									SO_4 - 0.11%
17–26		SHALE GREY, LITTLE GRAVEL SILTY			14		29	57			
26		END OF HOLE									

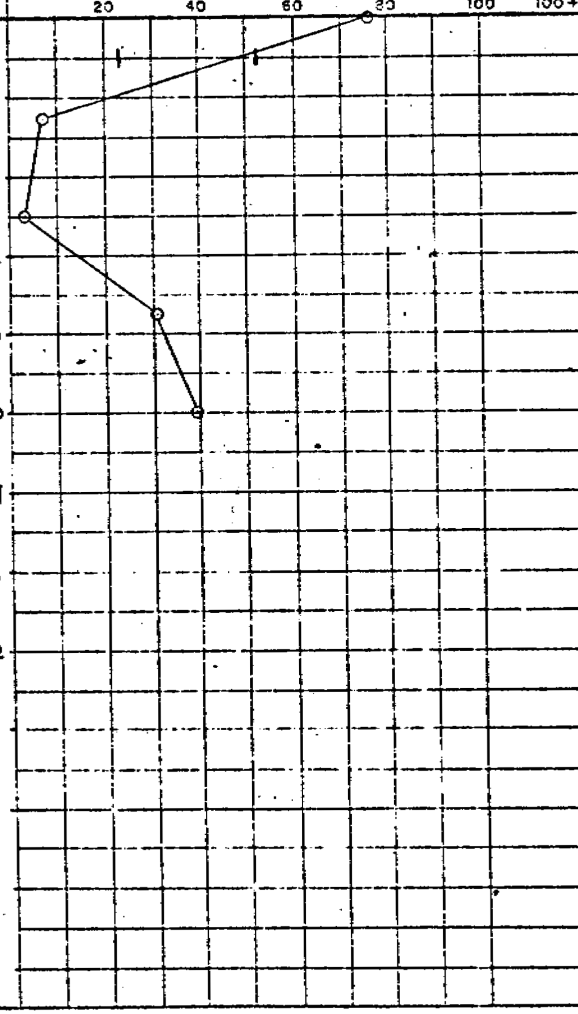


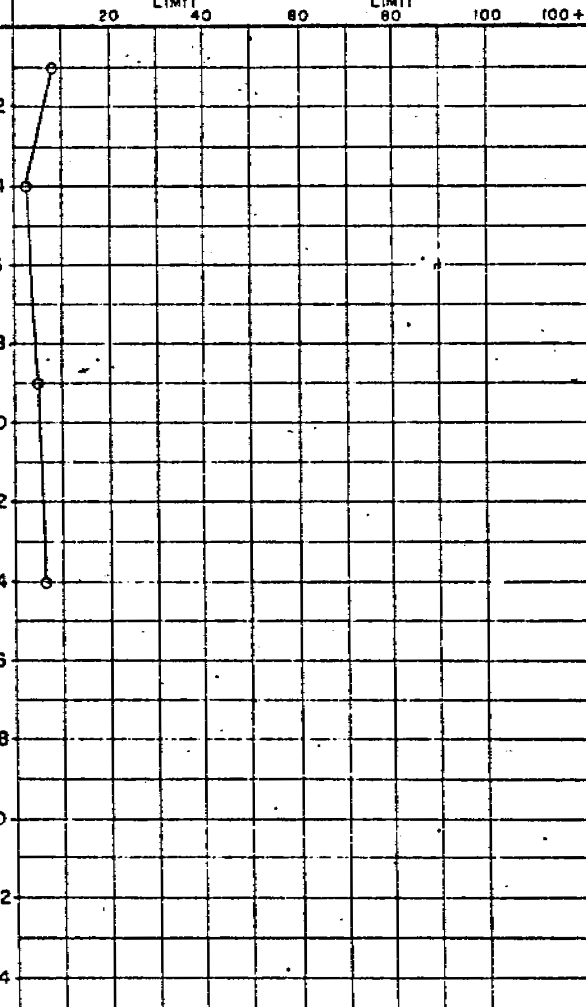
PLATE 12

UNDERWOOD McLELLAN & ASSOCIATES LIMITED	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

DWN: A. EW	FIELD ENG: B. M.	DATE DRILLED: 30/11/72	AIRPHOTO NO:	CHAINAGE: 1055+00	OFFSET:
CKD: D.G.P	TECH: D.M.	RIG: AIR	SURFACE DRAINAGE: GOOD	VEGETATION: SPRUCE & BIRCH TO 40'	ELEV: 97.11

TEST HOLE		
MILE	B,C,S	NUMBER
471	S	328

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)
PLASTIC LIMIT — LIQUID LIMIT



DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	GRAIN-SIZE ANALYSIS: CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)	REMARKS
0–2					GP	STONES	F	Nf							
2–5					CL	CLAY BROWN, LARGE GRAVEL VERY DRY		Nbn	7		11	82			
5–8					GP	GRAVEL SOME SAND		Nf							
8–11					GN	GRAVEL SMALL, SANDY, SOME BROWN CLAY		Nbn	17		35	48			47% COARSE FRACTION CRUSHED DURING DRILLING
11–20					GC	GRAVEL CLAYEY		Nf							
20						END OF HOLE									

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN AE.W	FIELD ENG B.M	DATE DRILLED 13/1/73	AIRPHOTO NO:	CHAINAGE: 1056+00	OFFSET ℄
CKD DGP	TECH DM	RIG	SURFACE DRAINAGE: GOOD	VEGETATION SPRUCE TO 30'	ELEV. 403.12

TEST HOLE

MILE	B,C,S	NUMBER
471	S	229B

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)	REMARKS
0–2					ML	SILT 6" ORGANIC	F								
2–5							UF								SO_4 - 0.10%
5–8					GM	SAND BROWN, SOME GRAVEL									
8–18					GW	GRAVEL SANDY, SILTY COARSE; SAND SEAM 18'-19'			23		28	49			
									11		13	76			
18–50						SHALE SOFT, GREY									
50						END OF HOLE @ 50'									

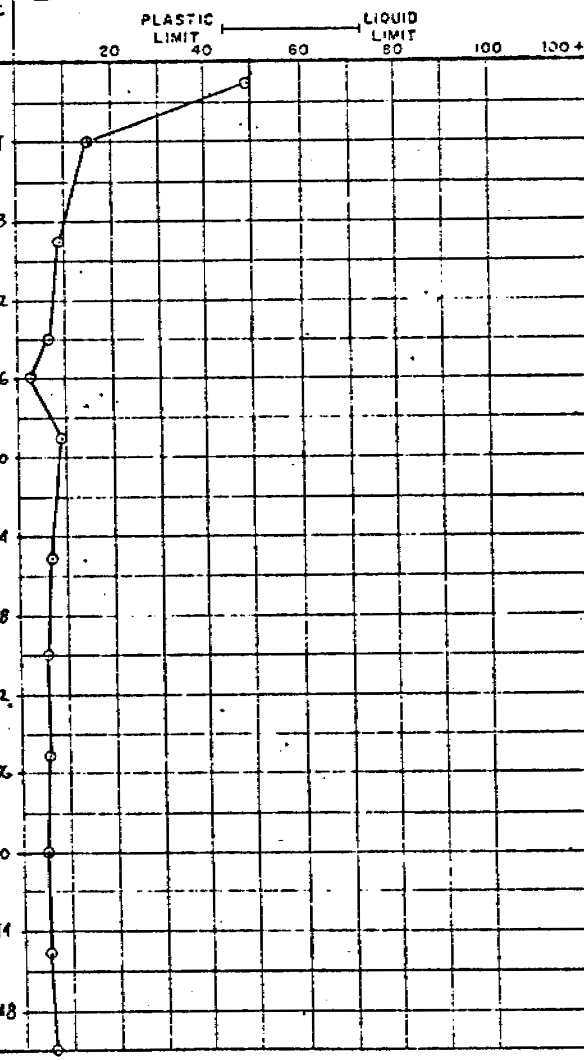


PLATE 14

UNDERWOOD McLELLAN & ASSOCIATES LIMITED	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

DWN: A.E.W	FIELD ENG: T.S.	DATE DRILLED: 26/11/72	AIRPHOTO NO:	CHAINAGE: 1058+00	OFFSET: ℄
CKD: DSP	TECH: D.M	RIG: AIR	SURFACE DRAINAGE: WEST 4%	VEGETATION: CONIFER 20'	ELEV: 407.31

TEST HOLE

MILE	B,C,S	NUMBER
471	C	51A

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)	REMARKS
0–2					Pt	PEAT ORGANIC, GRANULAR	F	Nbn							
2–8					CL	CLAY LIGHT BROWN, SILTY SOME ROCKS & COBBLES, HARD									ROCK CRUSHED BY DRILL BIT
8–19					GC	GRAVEL FINE, SOME ROCKS SOME CLAY			10		22	68			DIFFICULT DRILLING
19–30'						SHALE GREY END OF HOLE @ 30'									

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)
PLASTIC LIMIT ├──┤ LIQUID LIMIT

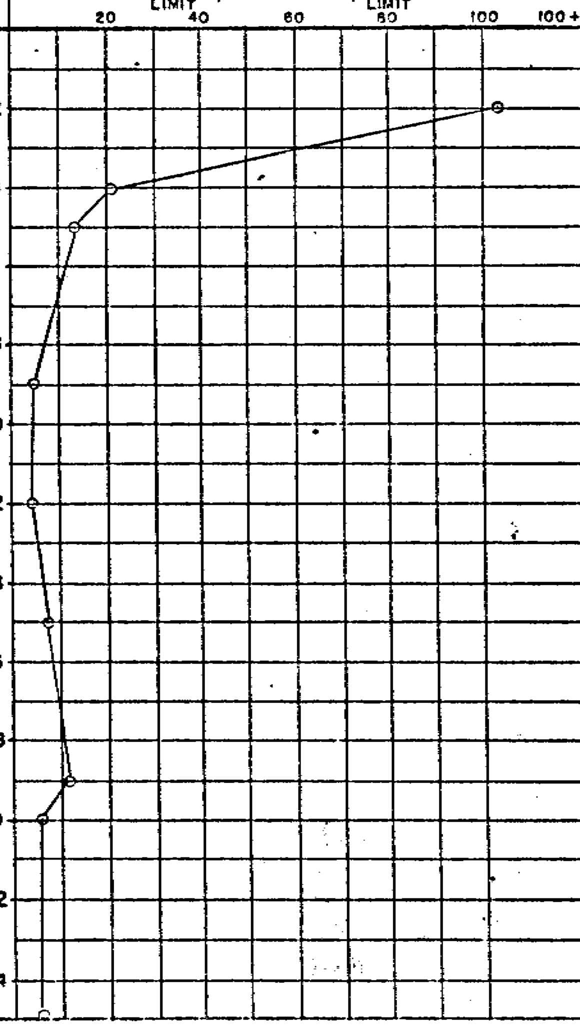


PLATE 15

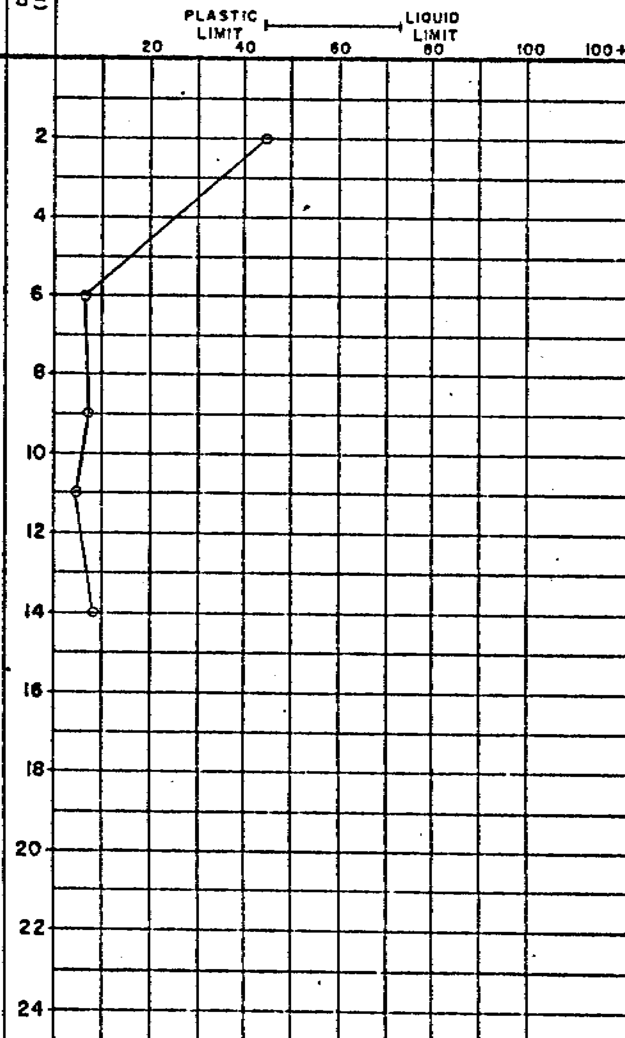
UNDERWOOD McLELLAN & ASSOCIATES LIMITED	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

DRN A.E.W	FIELD ENG: B.M	DATE DRILLED: 26/11/72	AIRPHOTO NO:	CHAINAGE: 1074+00	OFFSET: ℄	TEST HOLE
CKD: D.G.P	TECH: D.M	RIG: AIR	SURFACE DRAINAGE: GOOD	VEGETATION: SPRUCE & ASPEN TO 35'	ELEV:	

MILE	B,C,S	NUMBER
470	C	26B

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

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)	REMARKS
0–1					Pt	PEAT GRANULAR, MUSKEG	F	Nbn							
1–5.5					CL	CLAY BROWN, SOME SILT ROCKS, COBBLES AND BOULDERS									
5.5–15					SC	SAND SOME GRAVEL CLAY FINES	F	Nf	18		58	24			
15						END OF HOLE									



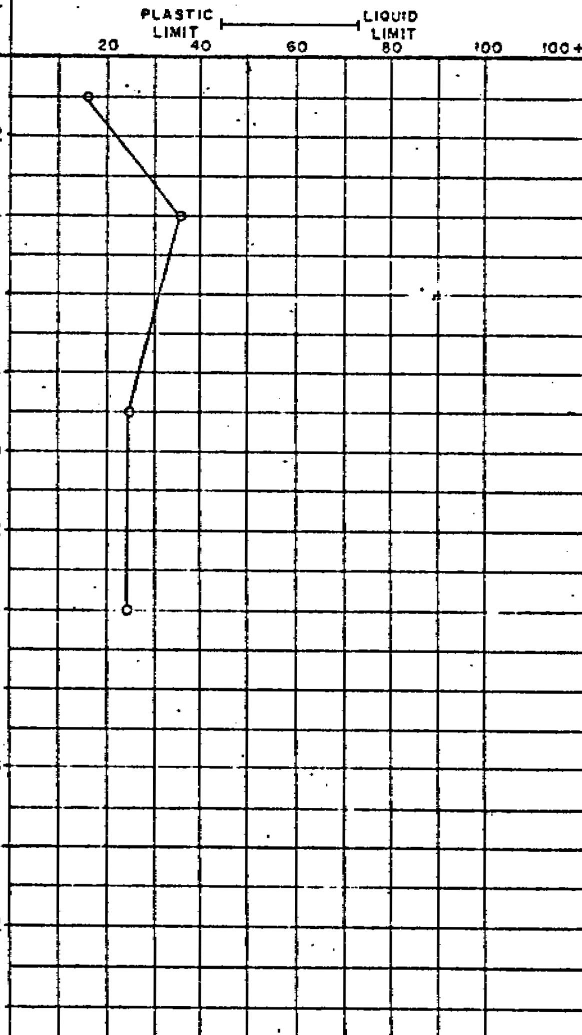
UNDERWOOD McLELLAN & ASSOCIATES LIMITED | **DRILL HOLE REPORT** | **DEPARTMENT OF PUBLIC WORKS, CANADA — MACKENZIE HIGHWAY**

DWN: H.S.	FIELD ENG: B.N.	DATE DRILLED: 14/1/73	AIRPHOTO NO:	CHAINAGE: 1025+00
OFFSET: 500' E ℄	CKD:	TECH: D.M.	RIG: AIR	SURFACE DRAINAGE: good
VEGETATION: Spruce, willow, aspen 20'	ELEV:			

TEST HOLE		
MILE	B,C,S	NUMBER
471	B	230E

DEPTH (FEET)	SAMPLE TYPE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	WET DENSITY (PCF)	DRY DENSITY (PCF)
0–1			GRANULAR MUSKEG	F			
1–4	P	CL	CLAY - brown, silty, dry, well bonded, clumpy, penetration hard.		no visible ice		
4–9	P		well bonded, penetration firm		Vr excess ice barely visible as random crystals	114.4	83.8
9–14	P	CL	CLAY, well bonded, penetration firm		5-10% fair amount of excess ice as random crystals	116.2	93.2
14–15	P	CL	CLAY, some sand, well bonded		Vr ice lenses of 1/4" about 21"		
15			END OF HOLE				

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)
PLASTIC LIMIT — LIQUID LIMIT



GRAIN-SIZE ANALYSIS: CLAY % | SILT % | SAND % | GRAVEL %

REMARKS: This hole may be ab... [illegible]

PLATE 17

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DATA: H.S.	FIELD ENG: B.m.	DATE DRILLED: 14/1/73	AIRPHOTO NO:	CHAINAGE: 1025+00
CKD: D.G.P.	TECH: J.m.	RIG: AIR	SURFACE DRAINAGE: good	VEGETATION: Spruce, [illegible], aspen 20'
OFFSET: 500' E ℄	ELEV:			

TEST HOLE

MILE	B,C,S	NUMBER
471	B	2313

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)	REMARKS
0					P	GRANULAR MUSKEG	F								
2		P				CLAY, brown silty, clumpy, well bonded, penetration hard.		no visible ice							
4		P			CL	CLAY, well bonded, penetration firm		excess ice just barely visible as inclusions							
8								Vr							
10					CL	a few rocks									
14		P			CL	well bonded, penetration firm		Vr a small amount of excess ice as inclusions					109.9	81.3	
16						END OF HOLE									

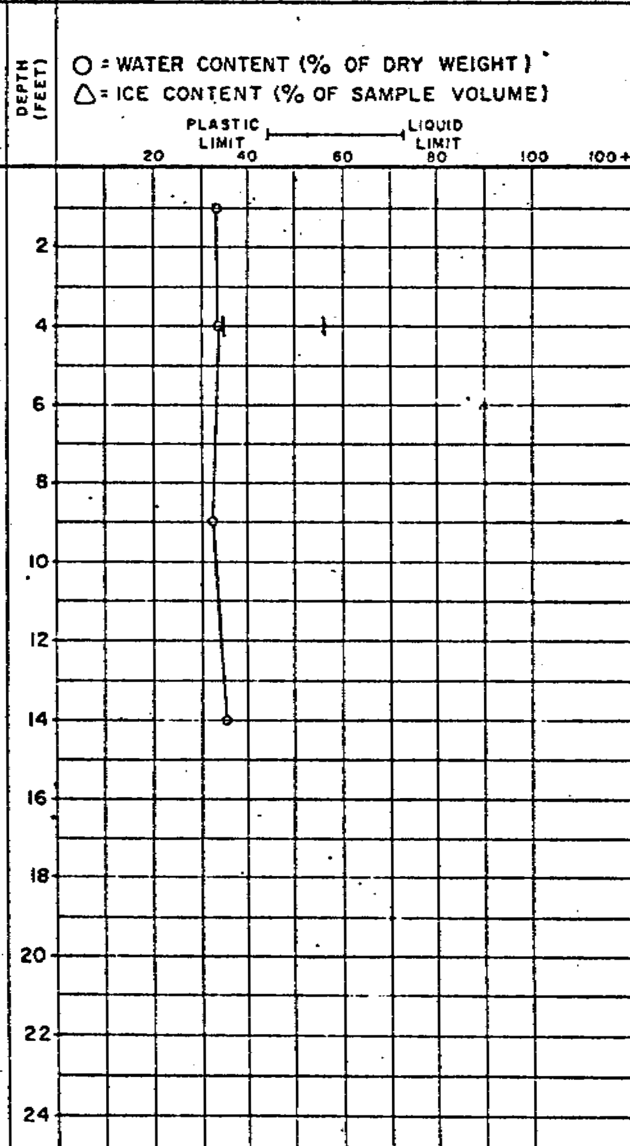


PLATE 18

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

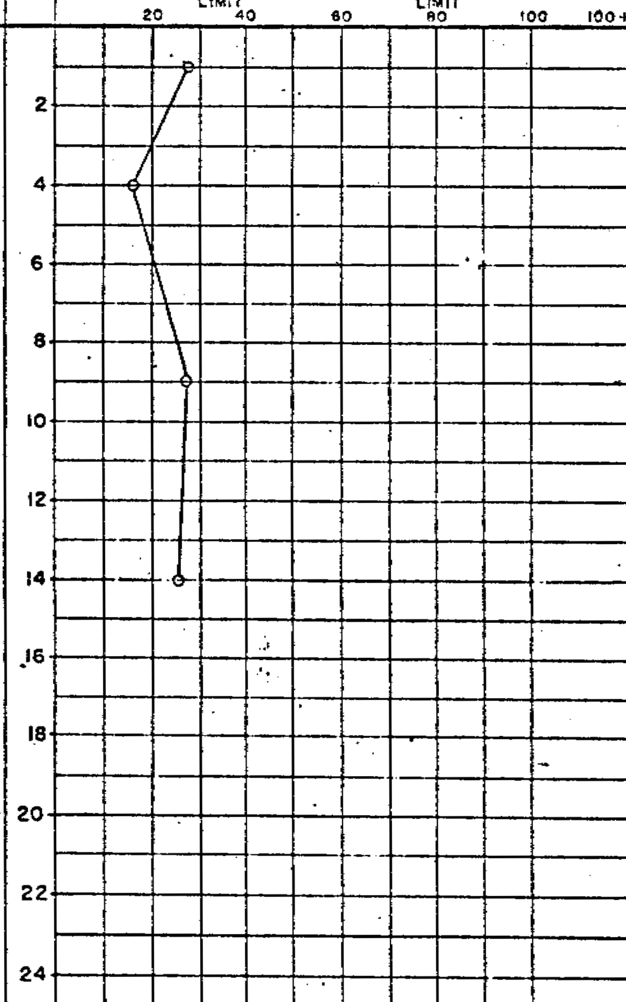
DWN H. S.	FIELD ENG B. m	DATE DRILLED 14/1/73	AIRPHOTO NO:	CHAINAGE: 1025+00	OFFSET: 500' E ¢
CKD	TECH D. m	RIG: AIR.	SURFACE DRAINAGE: good	VEGETATION: spruce, willow, aspen 20	ELEV:

TEST HOLE

MILE	B,C,S	NUMBER
471	B	2332

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	GRAIN-SIZE ANALYSIS: CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)	REMARKS
0					Pt	GRANULAR MUSKEG	F								
1–2		P			CL	CLAY sandy, silty, brown, well bonded, penetration hard.		no visible ice							
4–6		P			CL	CLAY silty, well bonded, brown, clumpy, penetration firm. Vr		no visible ice					97.0	83.6	
9–10		P			CL	well bonded, smooth penetration, firm.		random crystals, just visible.					107.5	83.5	
14–15		P			CL	well bonded, smooth penetration, firm.		random crystals - small amount					108.5	86.4	
15						END OF HOLE									

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)
PLASTIC LIMIT ⊢—⊣ LIQUID LIMIT



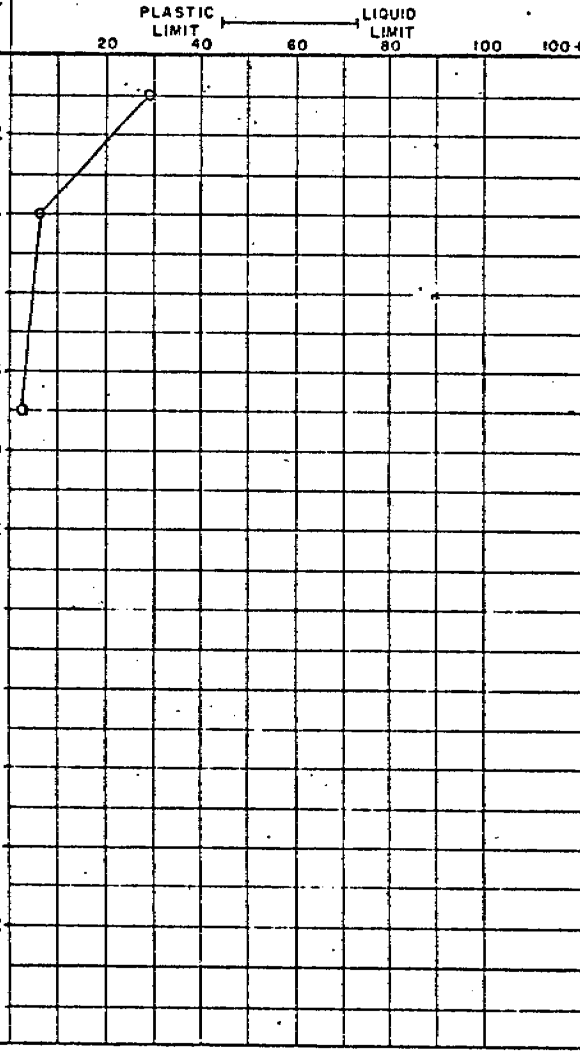
UNDERWOOD McLELLAN & ASSOCIATES LIMITED	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

DAN: H.S.	FIELD ENG: B.M.	DATE DRILLED: 13/1/73	AIRPHOTO NO:	CHAINAGE: 1056+00	OFFSET: 500' E of ℄
CKD: D.G.P.	TECH: D.M.	RIG: AIR	SURFACE DRAINAGE: Good	VEGETATION: cleared	ELEV:

TEST HOLE		
MILE	B,C,S	NUMBER
471	B	226E

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–0.25						ORGANIC 3"		
1–2					SM	SANDY SILT	F	
4–5					GM	SILTY SAND & GRAVEL		
9–10					GW	SAND & GRAVEL		
10						END OF HOLE		

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



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

REMARKS

UNDERWOOD McLELLAN & ASSOCIATES LIMITED	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

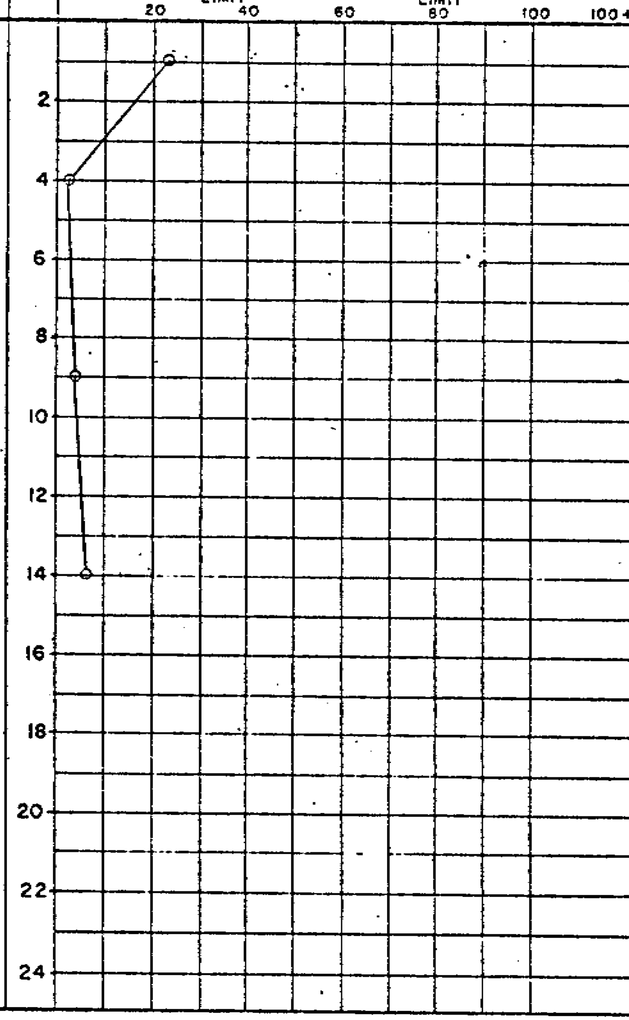
DWN: H S	FIELD ENG: B m	DATE DRILLED: 13/1/73	AIRPHOTO NO:	CHAINAGE: 1056+00	OFFSET: 500' E of ℄
CKD: J. G. H.	TECH: D m	RIG: AIR.	SURFACE DRAINAGE: Good - N W	VEGETATION: Cleared	ELEV:

TEST HOLE

MILE	B,C,S	NUMBER
471	B	2273

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)	REMARKS
0						ORGANIC TO 4"									
2					ML	SILT, light, slightly sandy F									
4						SAND & GRAVEL med. fine									
9						SAND med. fine, some pebbles				1	93	6			
15						END OF HOLE									

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)
PLASTIC LIMIT ├──┤ LIQUID LIMIT



UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN: R.S.	FIELD ENG: E.N.	DATE DRILLED: 13/1/73	AIRPHOTO NO:	CHAINAGE: 1056+00	OFFSET: 500' E of ℄
CKD: [illegible]	TECH: D.m	RIG: AIR	SURFACE DRAINAGE: Good N.W.	VEGETATION: Cleared	ELEV:

TEST HOLE		
MILE	B,C,S	NUMBER
471	B	228B

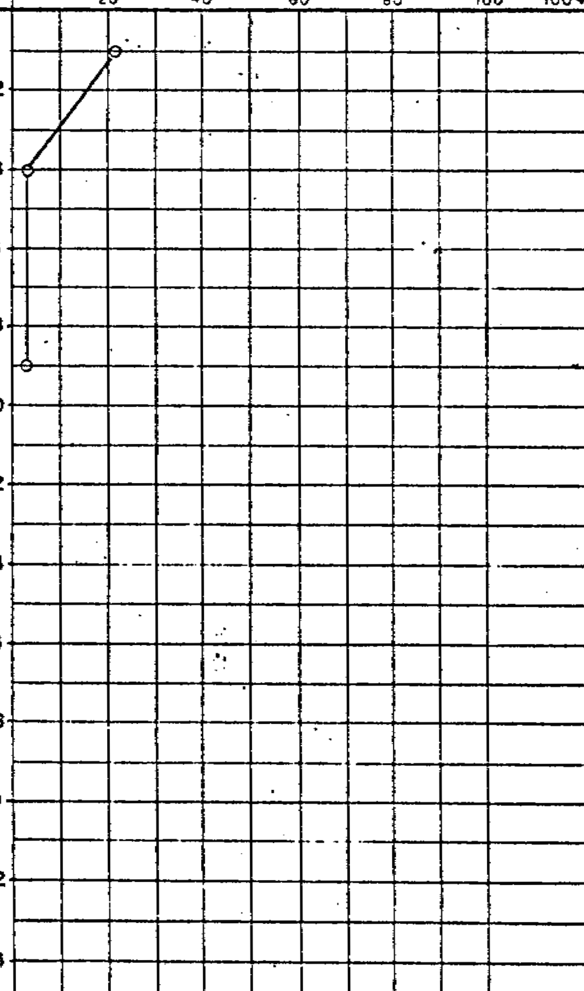
DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–4						ORGANIC TO 4"		
1–2		◸			ML	SILT - sandy	F	
4–5		◸			GM	SAND & GRAVEL, silty		
9–10		◸			SP.	SAND, some pebbles.		
10						END OF HOLE		

DEPTH (FEET) 2 4 6 8 10 12 14 16 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						
CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)	REMARKS

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRN H.S.	FIELD ENG.	DATE DRILLED 13/1/73	AIRPHOTO NO:	CHAINAGE: 1104+00	OFFSET: 700' W of ℄
CKD D.G.P.	TECH:	RIG: AIR	SURFACE DRAINAGE: Good - wet	VEGETATION: Spruce to 30'	ELEV:

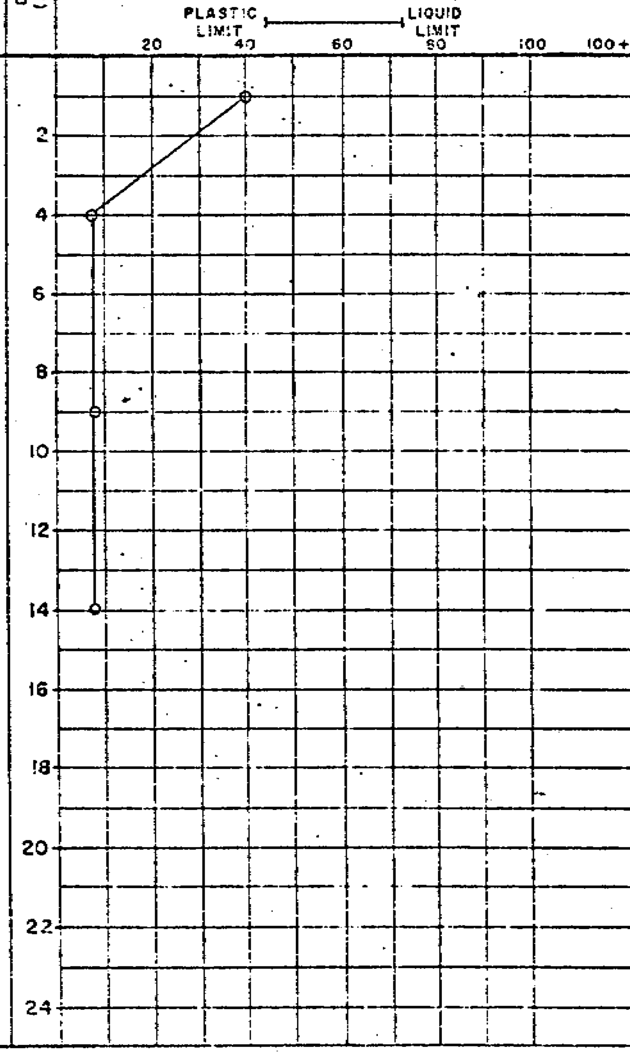
TEST HOLE

MILE	B,C,S	NUMBER
470	B	2225

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0					Pt	ORGANIC 7"		
2					ML	LIGHT SILT & SAND	F	
4					GW	GRAVEL & SAND		
9					GW	GRAVEL & SAND		
14					GW			
15						END OF HOLE		

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



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

UNDERWOOD McLELLAN & ASSOCIATES LIMITED	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

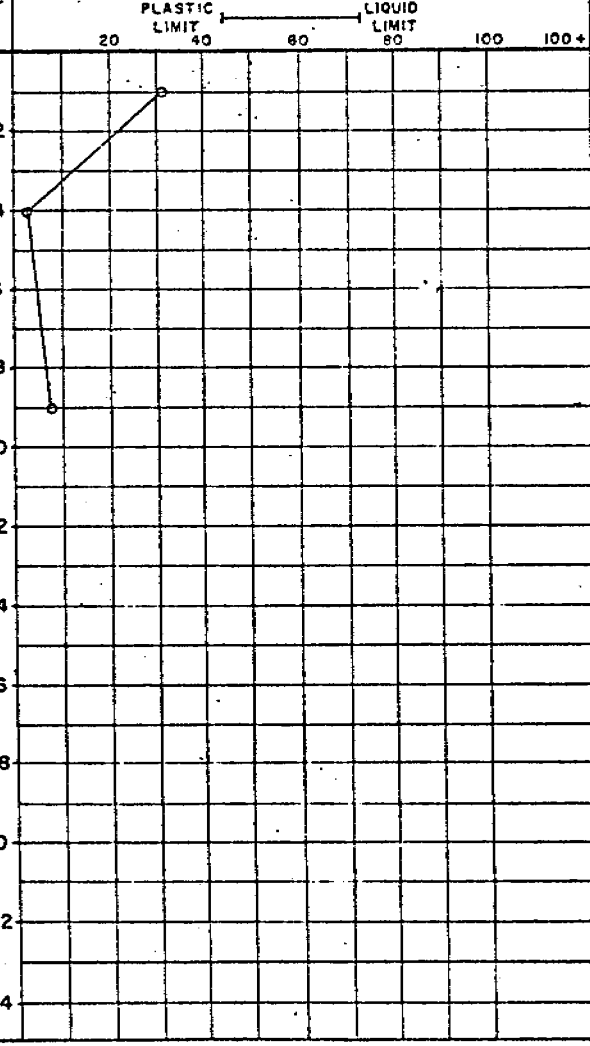
DWN H.S.	FIELD ENG.	DATE DRILLED 13/1/73	AIRPHOTO NO:	CHAINAGE: 1104+00	OFFSET: 700' W of ℄
CKD D.G.	TECH	RIG: AIR	SURFACE DRAINAGE: Good - west	VEGETATION: Spruce to 30'	ELEV:

TEST HOLE

MILE	B,C,S	NUMBER
470	E	223B

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0						ORGANIC 7"		
1–2		⊠			CL	CLAY, silty	F	
4–5		⊠			GP	Gravel & sand		
9–10		⊠			GP	Sand & gravel, silty		
10						END OF HOLE		

○ = WATER CONTENT (% OF DRY WEIGHT)
△ = ICE CONTENT (% OF SAMPLE VOLUME)
PLASTIC LIMIT ├──┤ LIQUID LIMIT



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

REMARKS