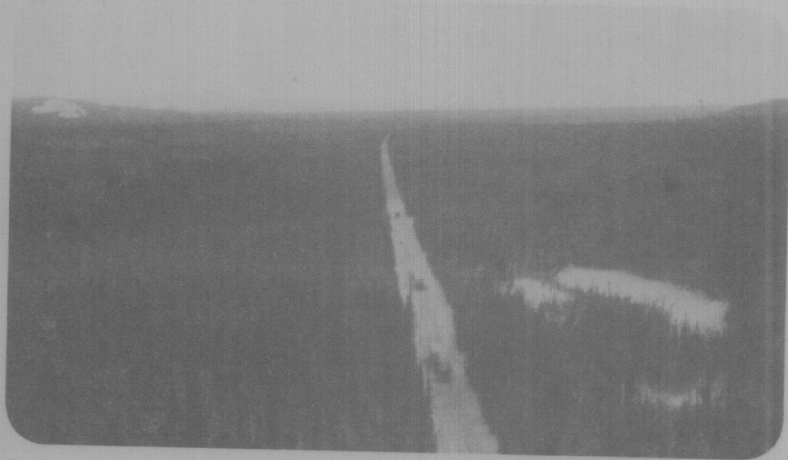
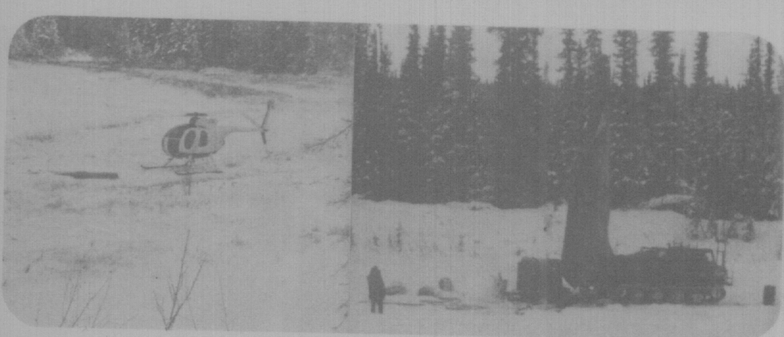
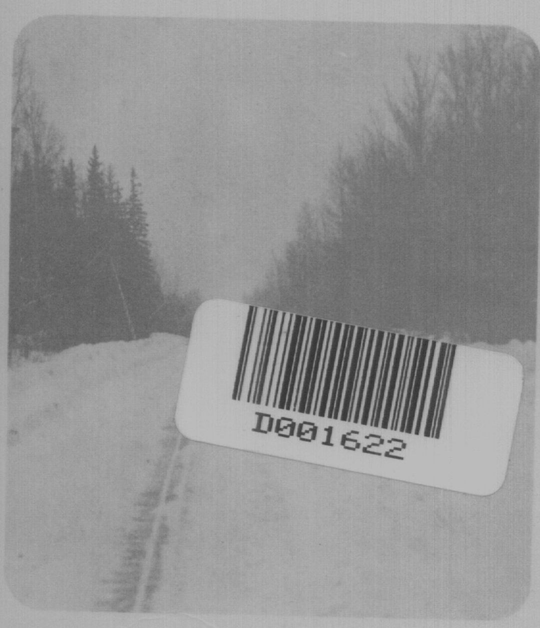
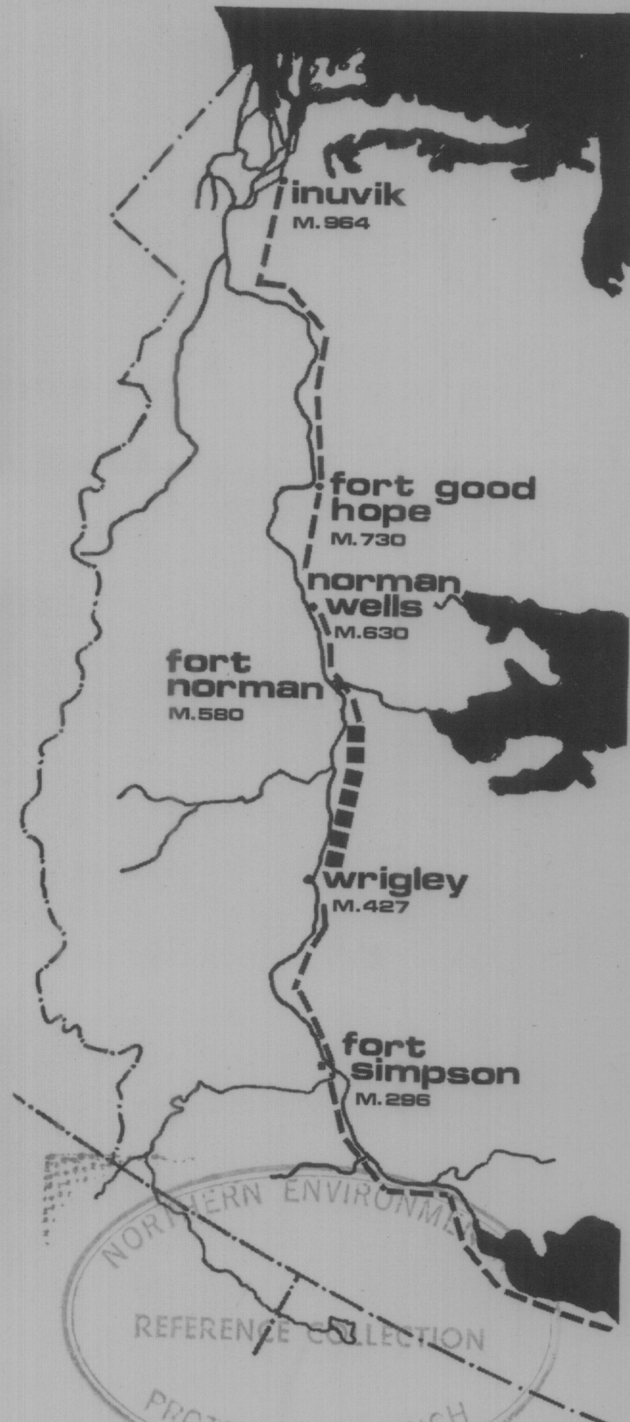








REPORT ON SUBSURFACE SOIL CONDITIONS FOR PROPOSED -

OCHRE RIVER BRIDGE MILE 454.5

MACKENZIE HIGHWAY

Underwood Mclellan & Associates Ltd.

ISSUE #39

REPORT ON

SUBSURFACE SOIL CONDITIONS FOR

PROPOSED OCHRE RIVER BRIDGE

MILE 454.5 MACKENZIE HIGHWAY

NORTHWEST TERRITORIES

Prepared By:

Underwood McLellan and Associates Limited
Consulting Professional Engineers

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
Proposed Ochre Bridge, Mile 454.5
Mackenzie Highway

Attached please find our report on the subsoil and foundation conditions for the proposed Ochre 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

INDEX

APPENDIX

A. INTRODUCTION

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

The present report summarizes the results of subsoil investigation operations conducted in connection with the proposed Ochre River bridge at mile 454.5 of the Mackenzie Highway.

It was the intention of the present investigation to determine the vertical sequence of the subsoil materials, permafrost conditions and groundwater conditions existing which would be expected to influence the stability of the valley slope and the design and construction of the proposed bridge foundations.

The included conclusions and recommendations have been based upon exploration and sample acquisition operations conducted at 15 positions along the proposed bridge centreline in the river channel and slopes of the bridge approaches.

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

B. FIELD AND LABORATORY INVESTIGATION

A total of fifteen test holes have been drilled within one-half mile south and one-half mile north of the bridge structure. In addition to the fifteen centreline test hole logs, borrow hole test logs in the vicinity of the bridge site have been included in the Appendix. Test holes along the centreline were drilled to depths varying from 15 to 80 feet below existing site grades. The borrow pit test holes were generally advanced to the fifteen foot level.

Test borings were drilled December 7 to 11, 1972 and January 10 to 12, 1973 by Kenting Big Indian Drilling of Calgary utilizing a Mayhew 1000 and Heli drill. Air recovery methods were generally employed, except where severe caving was encountered at bridge crossings then water and drilling mud were used.

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 Plot and Test Hole Location Plan.

All variations of soil, permafrost and groundwater conditions encountered during the test boring operations were noted and representative samples of the existing subsoils were taken. The majority of samples were disturbed, having been obtained by the air recovery method. Sampling was also undertaken with two-inch and three-inch O.D. split spoon sampling tubes.

In the laboratory, the 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. Wherever 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 obtained by visual inspection and by measured thicknesses of ice lenses. Excess ice content was determined by the division of the 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 include 454S 102A, 454C 65B and 454B 180B. The letter symbols and numbers indicate:

454 - mileage

B, C, S - between mileage and test hole number indicate borrow, centreline and structure test holes, respectively.

102, 65, 180 - test hole numbers

A, B - after test hole numbers indicate drilling performed by Mayhew 1000 or Heli drill, respectively.

C. SITE AND SUBSOIL CONDITIONS

The Ochre bridge site is located at mile 454.5 (chainage 612 + 00) of the Mackenzie Highway in the Northwest Territories. The Ochre river flows into the Mackenzie River from the east having a drainage basin which extends to the Franklin Mountains. This stream has a typical sand-gravel bed which exhibits relatively stable slopes. The river is presently in a state of depositing flood-plain sediments at the entrance to the Mackenzie River. The floodplain is built up by successive deposits of fine sands and silts during periods of flooding.

The Ochre stream bed elevation is 280 (D.P.W. datum) with the recently recorded high water mark at elevation 289.5 and the high water level of the Mackenzie River during ice jams has been recorded at elevation 311.5.

The existing Ochre stream channel is approximately

250 feet wide and 25 feet deep at the proposed location. The stream channel banks slope up at approximately 5:1 to the gravel terraces on both the south and north sides. Well defined gravel and sand terraces deposited when the river existed at higher elevations are located at chainages 600 + 00, 608 + 00, 617 + 00, 624 + 00 and 629 + 00.

Test holes 93A, 102A and 129A drilled at the stream channel edge were advanced to depths of 15, 74 and 80 feet, respectively. Test hole 93A was attempted without water and mud circulation but caving granular material prevented drilling to a depth greater than 15 feet. Test holes 102A and 129A were subsequently drilled with mud and water but considerable difficulty was again experienced in retrieving suitable samples. These test holes generally indicated unfrozen soil conditions to a depth of 20 feet below the stream bottom but permafrost was encountered from the 20 foot level to a depth of 80 feet

The water table was present at approximately four (4) feet below the ground surface in test hole 102A which coincided with the river level at the time of drilling.

The stratigraphic sequence below the river consisted primarily of coarse sand and fine to coarse gravel with clay layers in the upper portion. Below the granular deposit, a hard dark blue "shale like" clay was encountered at a depth of approximately 70 feet below the surface. It is believed that this preconsolidated clay layer is the bedrock but coring of the strata was not successful due to caving which resulted in loss of a core barrel. The bedrock in the general area of the investigation is believed to consist of Cretaceous sedimentary deposits of interbedded shales, siltstones and sandstones.

Although drilling mud and water circulation methods were utilized, caving was extensive and "undisturbed" penetrometer sampling could not be undertaken.

Drilling difficulty indicated deposits of medium density.

Test holes 94A, 95A, 96A, 100A, 101A, 130A, 131A, 80A, 64B, 65B were drilled on the north and south river terraces.

Test holes 94A and 101A drilled on the terrace at station 609 + 00, elevation 305 on the south side disclosed a coarse sand with gravel layers and was unfrozen. The hard "shale like" clay was encountered at 40 feet in test hole 101A. The moisture content of the sand below elevation 305 was high as a result of submergence. Test hole 96A, elevation 358 at station 604 + 00 disclosed an unfrozen gravel terrace with low moisture contents of 4 to 5 percent. Test holes 95A drilled at elevation 368 on the south, indicated that the gravel deposit is overlain by 10 feet of unfrozen dry sandy to gravelly silt. Test hole 100A drilled at elevation 390 disclosed that the stream deposited gravel had terminated and frozen silty clay and silt was present with a moisture content of 20 percent but test hole 99A at elevation 476 and chainage 575 + 00 indicated unfrozen silty clay of relatively low moisture content of 10%.

Test holes 65B and 130A on the north bank at elevation 305 indicated permafrost consisting of silty clay to a depth of 12 feet which was underlain by dry gravel and coarse sand with moisture contents below 10%. The silty clay surface deposit exhibits very high moisture contents although the ice would be described as non-visible.

Test holes 64B, 131A and 80A at stations 626 + 00, 629 + 00 and 635 + 00 respectively, on the north terrace disclosed a gravel and sand terrace. The material was unfrozen and exhibited moisture contents of approximately 4%.

Consequently, the test holes indicate primarily granular deposits from the stream elevation 300 to elevation 360 at station 590 + 00 on the south side and silty clay permafrost from elevation 360 to the uplands at mile 453, station 535 + 00, elevation 630. This silty clay exhibited very thin ice lenses and the moisture content is near the plastic limit. On the north side, the deposits consisted of granular materials from the stream channel to approximately one (1) mile on the uplands. The granular materials vary from sand to coarse gravel. Crushed samples which were obtained during drilling operations in test hole 130A and 131A and subjected to sieve analysis indicated approximately 50% material coarser than the #10 sieve. These samples subjected to crushing during drilling would exhibit a true gravel size content higher than recorded.

A soil profile of the bridge valley site is included in the Appendix, Plate 2.

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 Ochre River bridge foundation and approaches.

1. Pier and Abutment Foundation Design

The gravel and sand deposits which were described in the previous section will form the bearing strata for the proposed bridge piers and abutments. These deposits which are saturated would prove costly to excavate for a spread footing and unconsolidated surface silt strata would undergo settlement. Consequently, a driven pile foundation is recommended for all structures.

The pile types generally available would 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 concrete piles are also not recommended primarily due to the difficulty in establishing ultimate pile lengths and unless the lengths can be pre-determined considerable difficulty in splicing results.

Steel H-piles or pipe piles are, therefore, recommended for consideration primarily based on high driving strength, high load capacity and relative ease in splicing. 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. lb. As an initial guide, piles should be driven to blow counts of 180 blows/ft. or 15 blows/inch. The pile capacity is largely a function of the amount of energy expended in installing the pile and not just of 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 until damage occurs and whenever resistance increases greatly, the driving should be terminated.

Extreme difficulty exists in establishing the insitu density and therefore, predicting the "refusal" depth in gravel strata. Steel piles driven to refusal" can be expected to attain allowable load capacities in the range of 80 tons depending upon the cross-sectional area. False "refusal" may occur whenever extremely large boulders cannot be penetrated during driving. Although "refusal" may be attained while driving in boulders, adequate bearing capacity may not exist below the pile tip. Load tests would be necessary to establish allowable loads if this situation is recognized. In order to attain penetration of the steel piles around large boulders, it may be necessary to utilize vibration techniques or large diameter open pipe piles may be employed with churn-drill crushing of large boulders inside the bottom of the pipe.

Permafrost which was encountered 20 feet below the Ochre stream channel will determine the ultimate pile length. The temperature near $32^{\circ}F$ of the upper permafrost below the river will allow some penetration of the gravel permafrost. Penetration of the permafrost is necessary to prevent the future thaw level from reaching the pile tip.

Whenever conventional driving techniques are employed, the capacity of a pile 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 its 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.

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 load. Generally, in cohesionless soils the lateral load tends to exceed the passive resistance, consequently, the above simplified approach is on the conservative side.

The relatively deep approach fills would be expected to produce settlement of the insitu materials and subject the piles to negative skin friction but the cohesionless nature of the subsoil materials will not produce significant displacements and those which occur will be rapid.

Whenever 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 materials or compaction techniques are utilized in the embankment, the abutment must be carried on piles into the insitu granular subsoils below the creek channel. Piles must be designed to carry a negative skin friction load whenever embankment settlement is anticipated.

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 35 feet high.

The most common procedures for analysis of the earth pressures against gravity retaining walls include the 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 whenever 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 compaction the at-rest coefficient should 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 pressures against the wall. In addition, drainage will prevent development of frost heaving forces against the abutments.

3. Bridge Approach Grades and Borrow Material

Cut heights of approximately 15 feet are proposed at stations 603 + 00 on the south bank and 20 feet at 630 + 00 on the north bank. Both these cuts will be performed in dry unfrozen coarse sand and gravel. It is anticipated that stability of the cut slopes will not be a problem and a backslope of 2:1 is recommended in the granular material although a flatter slope may be employed to increase the available fill material.

Near the north abutment at station 617 + 00, the proposed grade line will result in a fill depth of 12 feet. The insitu material to a depth of 15 feet consists of silty clay permafrost with moisture contents in the 20% to 40% range. Utilization of granular fill will likely not result in thawing of the existing subgrade.

The approach fills to the bridge will be approximately 35 feet high and it is recommended that the granular material be compacted to 95% of Standard Proctor utilization vibrator 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 reduce settlements at the approaches. In addition, fill slopes are proposed at 2:1.

In addition to common excavation which will be obtained from valley cut sections, granular borrow material may be found at station 591 + 00, 1,000 ft. west and east of centreline and station 630 + 00, 800 ft. west of centreline. Test hole logs for borrow materials are included in the Appendix.

At station 578 + 00, approximately ½ mile from the bridge site on the south bank above the highest gravel terrace, a cut of 15 feet is proposed in silty clay and gravel permafrost. Thawing subsequent to excavation and establishment of the final grade line will result in some settlement. In addition, the driving characteristics of the roadway will be of poor quality for many years and significant maintenance will be necessary until thermo-equilibrium is established. The cut back-slopes of 2:1 can be expected to undergo aggradation as a new active layer is established.

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:-

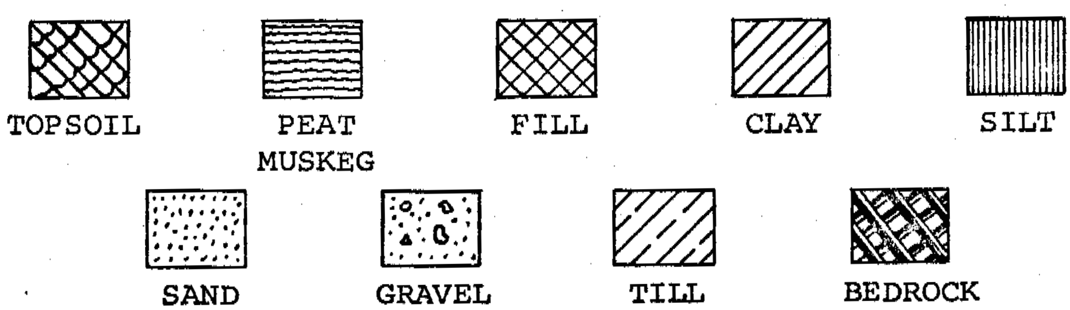
NATURAL MOISTURE CONDITIONS & ATTERBERG LIMITS

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.

γd - 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.

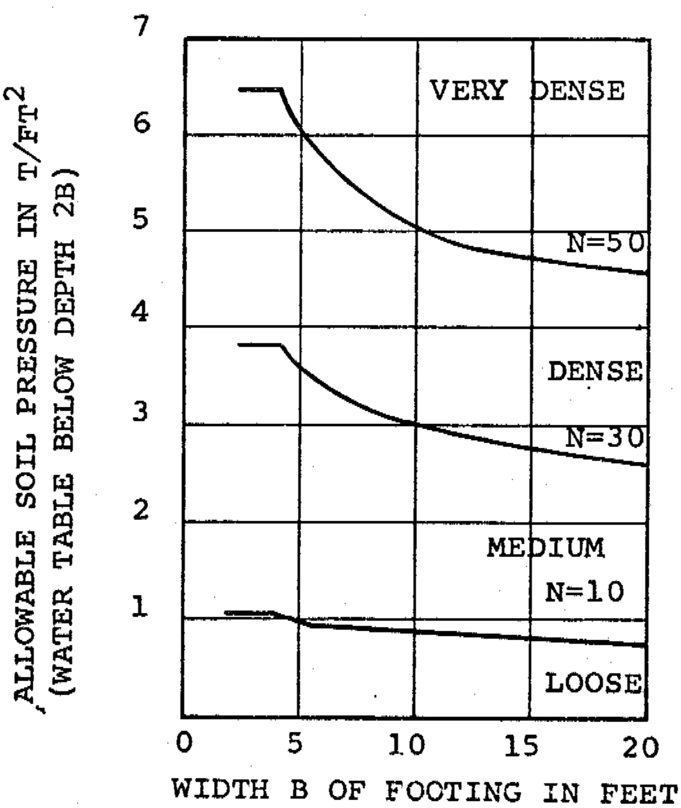
SO_4 - water soluble sulphate content is conducted primarily to determine whether sulphate resistant cement is required for the foundation structure.

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%

Negli-gible	Posi-tive	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.

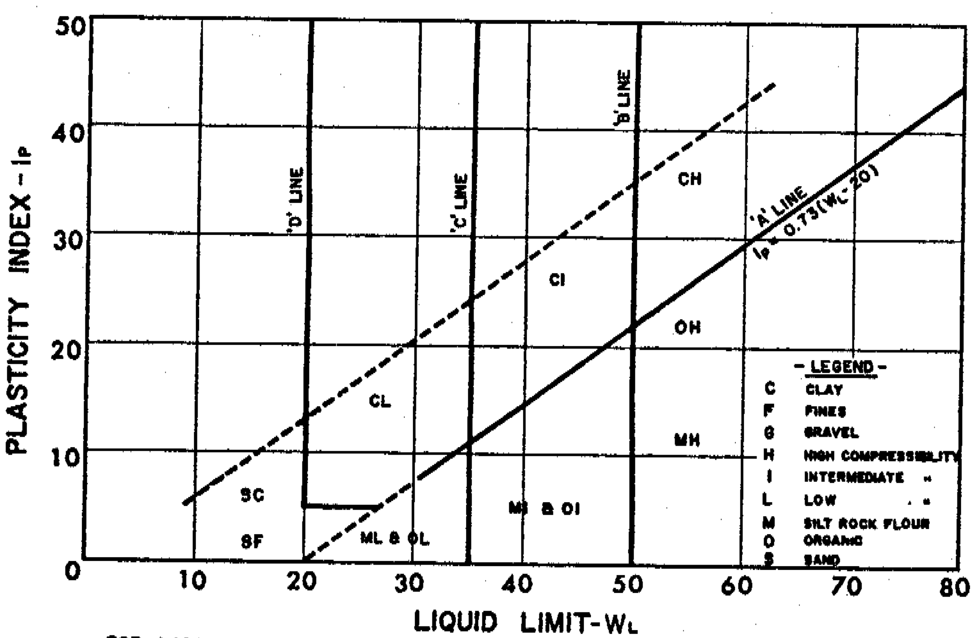
UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	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
		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 MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	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
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				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

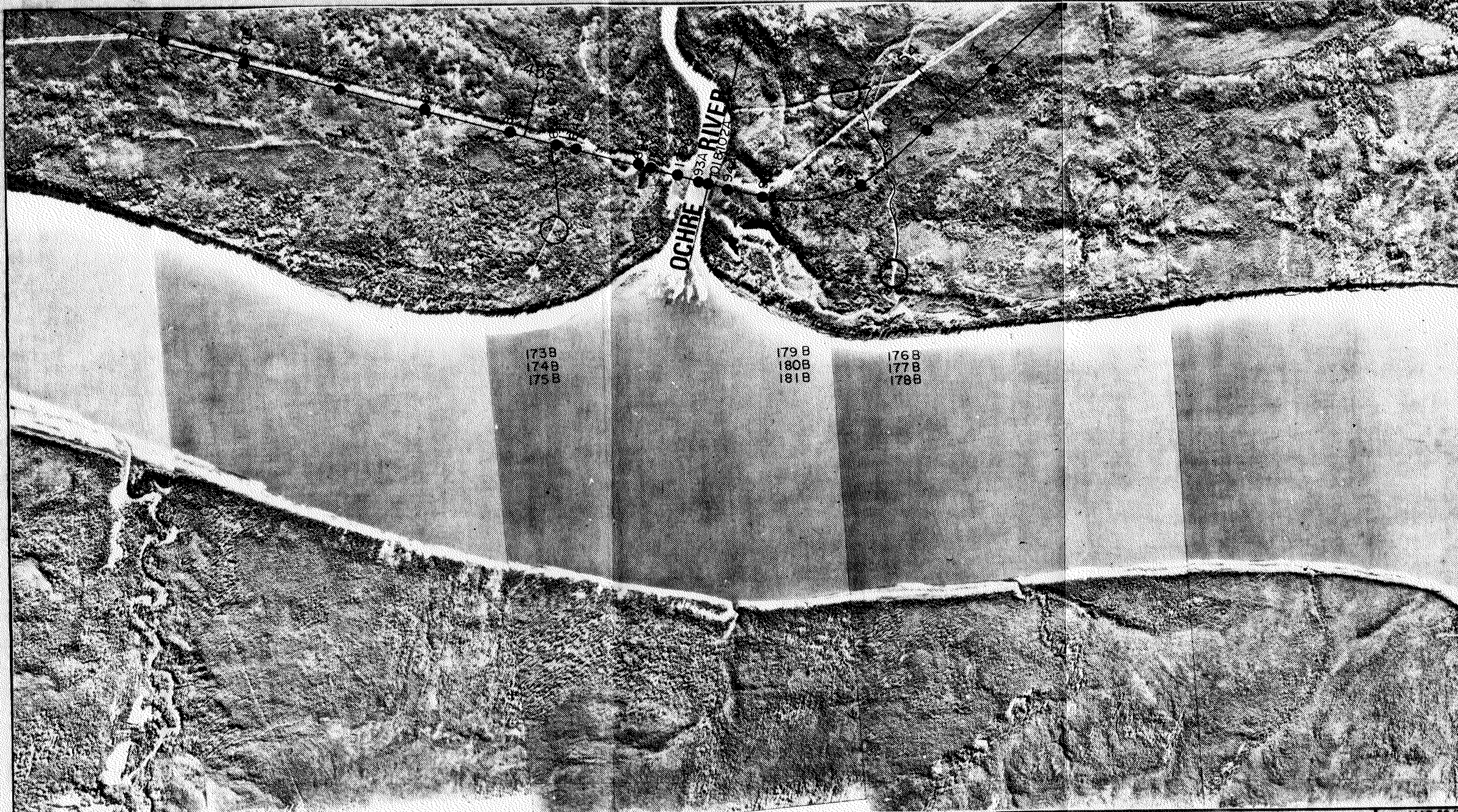
V_s - stratified or oriented ice formations

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

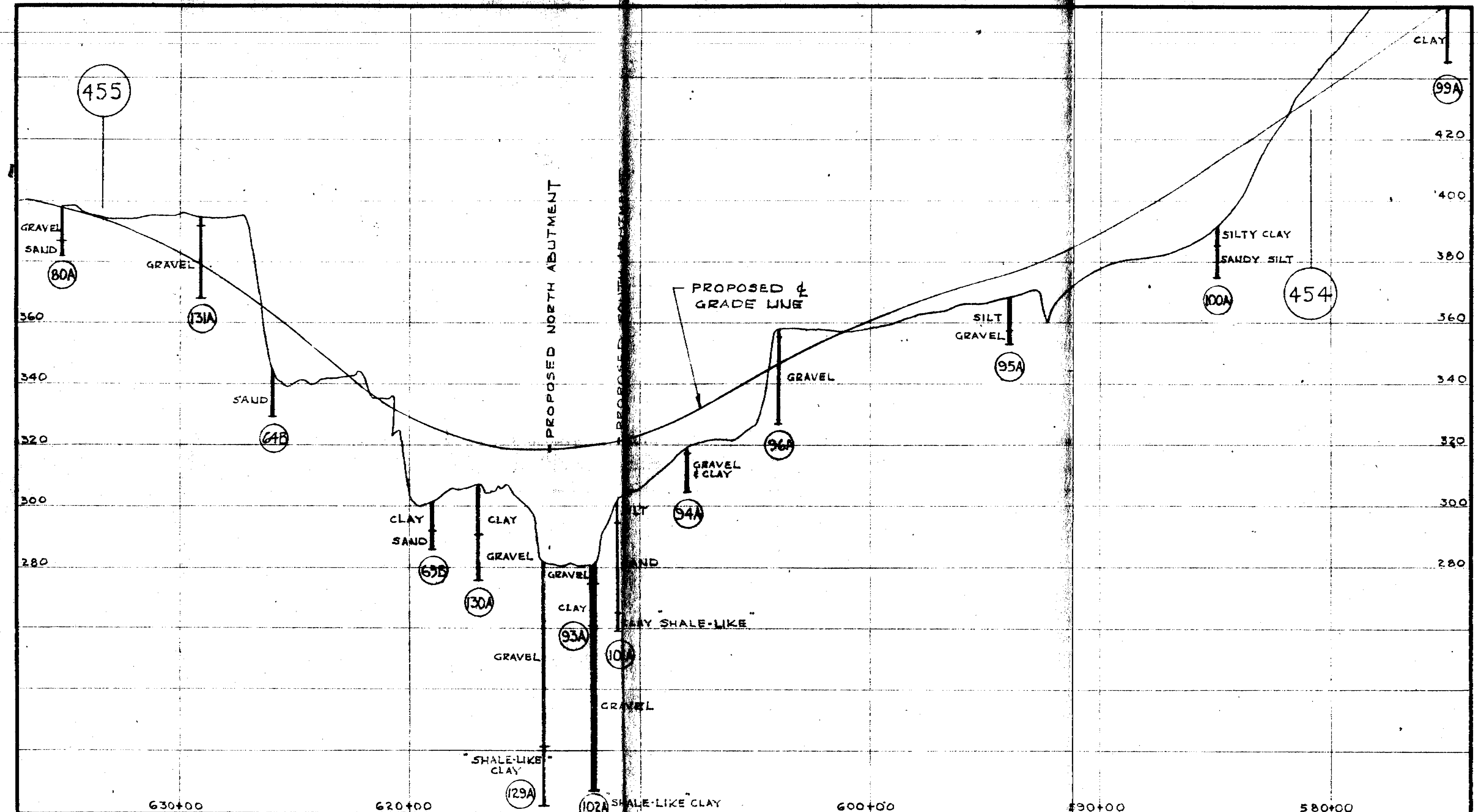
BRITISH COLUMBIA • ALBERTA • SASKATCHEWAN • MANITOBA • ONTARIO

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

MACKENZIE HIGHWAY

OCHRE RIVER MOSAIC AND TEST HOLE LOCATION PLAN

Date: MAR 28/73
Job:
Sheet:
Drawing: PLATE-1
Issue:



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: AS SHOWN

MACKENZIE HIGHWAY

OCHRE BRIDGE SITE

PROFILE & SOIL CROSS SECTION

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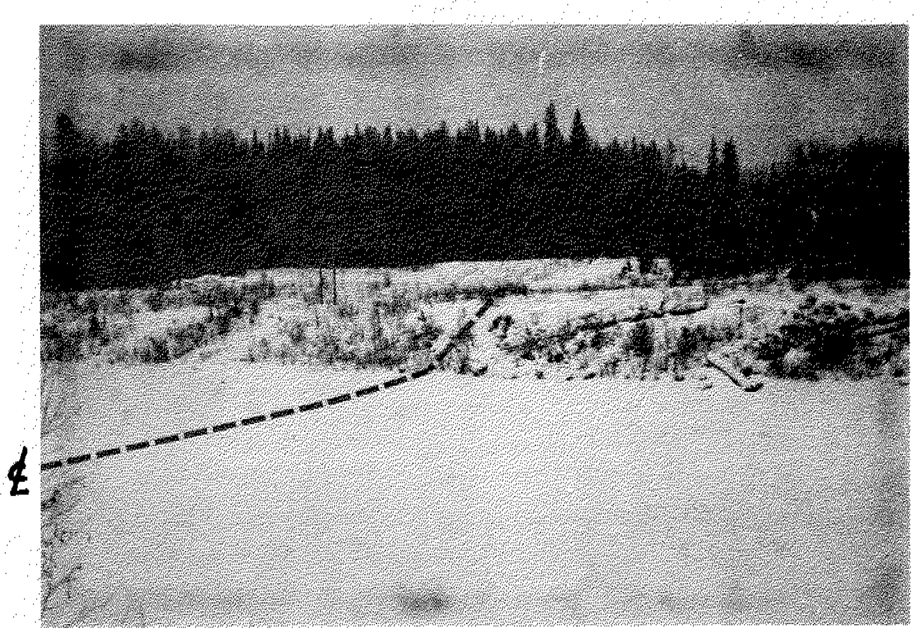
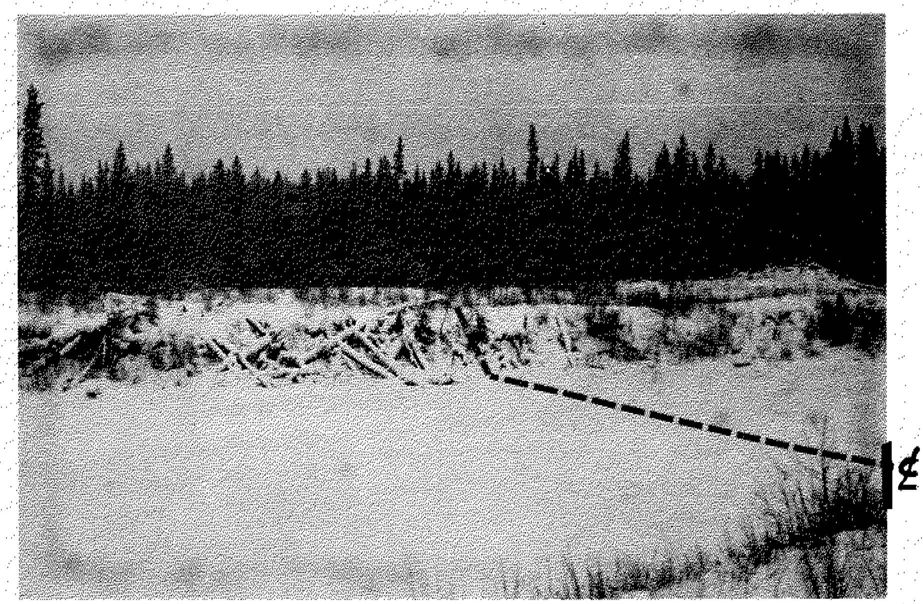
Sheet:
Drawing: PLATE-2
Issue:

OCHRE RIVER CROSSING
MILE 455.0



South Bank of River Crossing Viewed
in a South Easterly Direction.



North Bank of River Crossing
Viewed in a North Easterly Direction.

Plate 3.

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN A.E.W	FIELD ENG RS	DATE DRILLED 7/12/72	AIRPHOTO NO:	CHAINAGE: 635+00
CKD D.G.P	TECH D.M	RIG AIR	SURFACE DRAINAGE: EAST TO WEST	VEGETATION: SPRUCE & POPLAR TO 50'

OFFSET: ℄

ELEV.

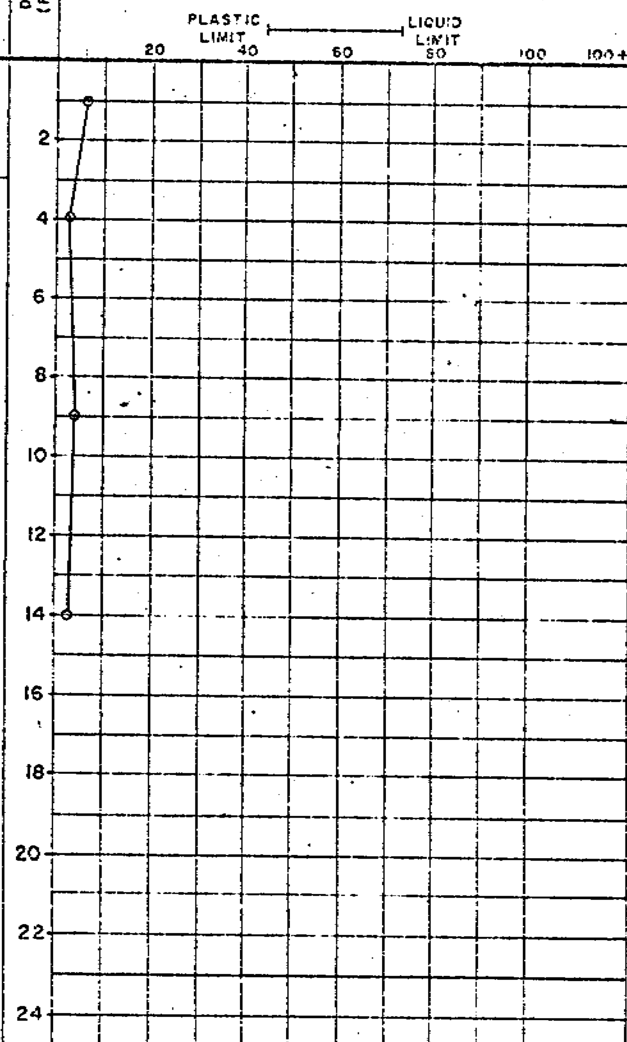
TEST HOLE

MILE	E,C,S	NUMBER
455	C	8CA

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
0–3					Pt	PEAT – 2" ORGANIC	F								
					GP	GRAVEL DRY, TRACE OF SILT ROCKS, SANDY	UF								
10					GP	DRY, WITH SILT			1		40	59			
12–15					SP	SAND DRY, MED. COARSE TRACE OF GRAVEL									
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

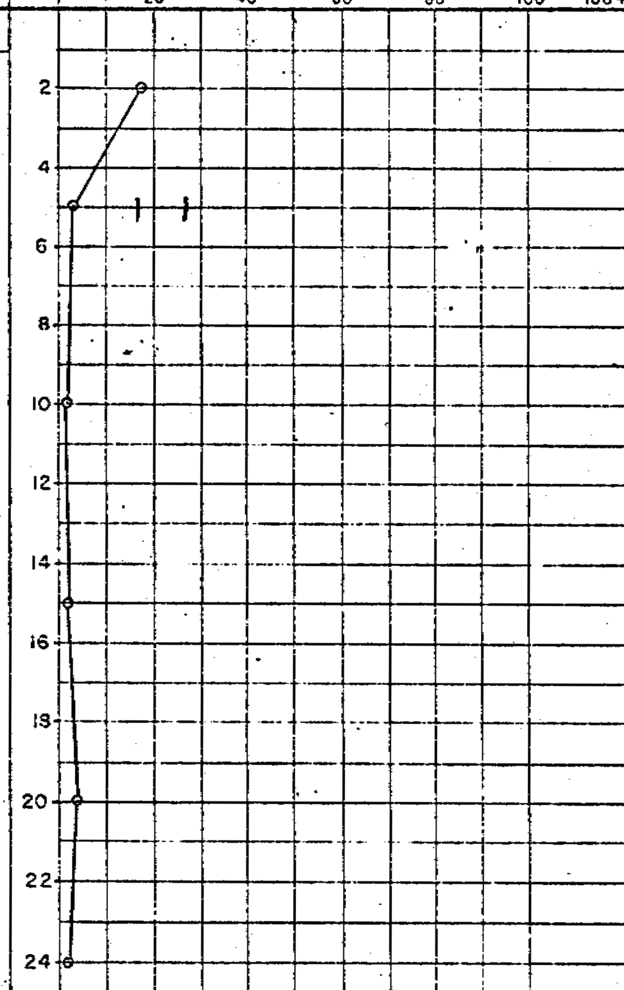
DRN A.E.W	FIELD ENG T.S.	DATE DRILLED 12/1/73	AIRPHOTO NO:	CHAINAGE: 629+00
CKD D G P	TECH: D M	RIG: AIR	SURFACE DRAINAGE:	VEGETATION: CONIFER & POPLAR TO 30'
OFFSET: ℄	ELEV:			

TEST HOLE

MILE	B,C,S	NUMBER
454	S	131A

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

DEPTH (FEET)	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)	REMARKS
0–2		TILL SILTY	F / UF	SEASONAL							
3	GM	GRAVEL									
5		COARSE, DRY			5		50	45			SO_4 = 0.07%
10	GP				9		54	46			
12		FINE GRADED, DRY									
16		MED COARSE			9		36	54			
19	GW										
20					6		78	22			
23	SW	MED. COARSE SAND									
24		END OF HOLE			6		65	35			



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

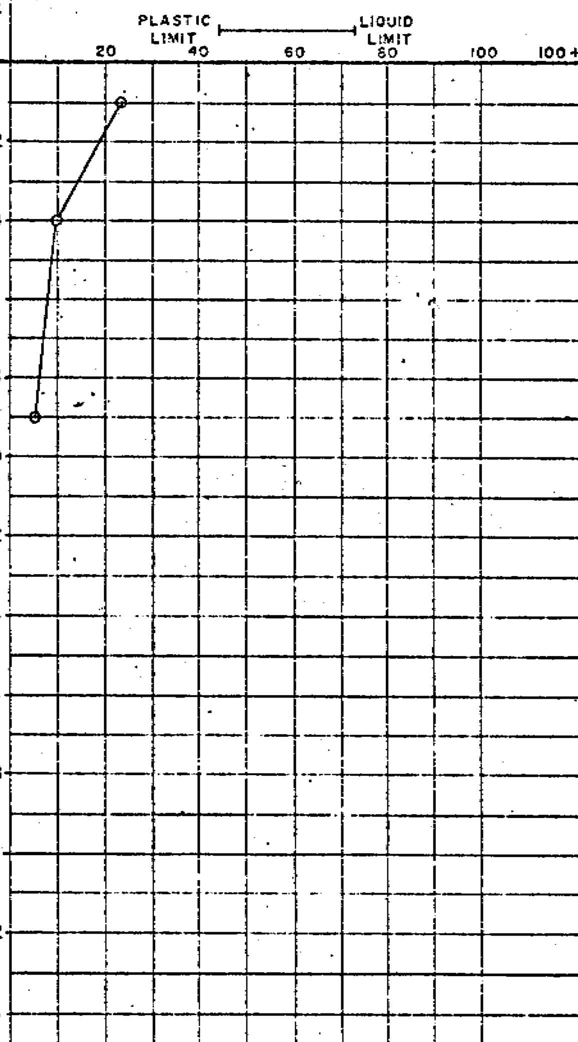
DWN A.E.W	FIELD ENG. B.M	DATE DRILLED 7/12/72	AIRPHOTO NO:	CHAINAGE: 626 700	OFFSET: ℄	
CKD DGP	TECH D.M.	RIG AIR	SURFACE DRAINAGE: GOOD	VEGETATION: SPRUCE & POPLAR TO 40'	ELEV.	

TEST HOLE

MILE	B,C,S	NUMBER
454	C	64B

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 ORGANIC	F								
1–10					SM	SAND SOME CLAY & GRAVEL	UF		31		47	22			
					SP	MORE GRAVELLY									
11						END OF HOLE									

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



UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

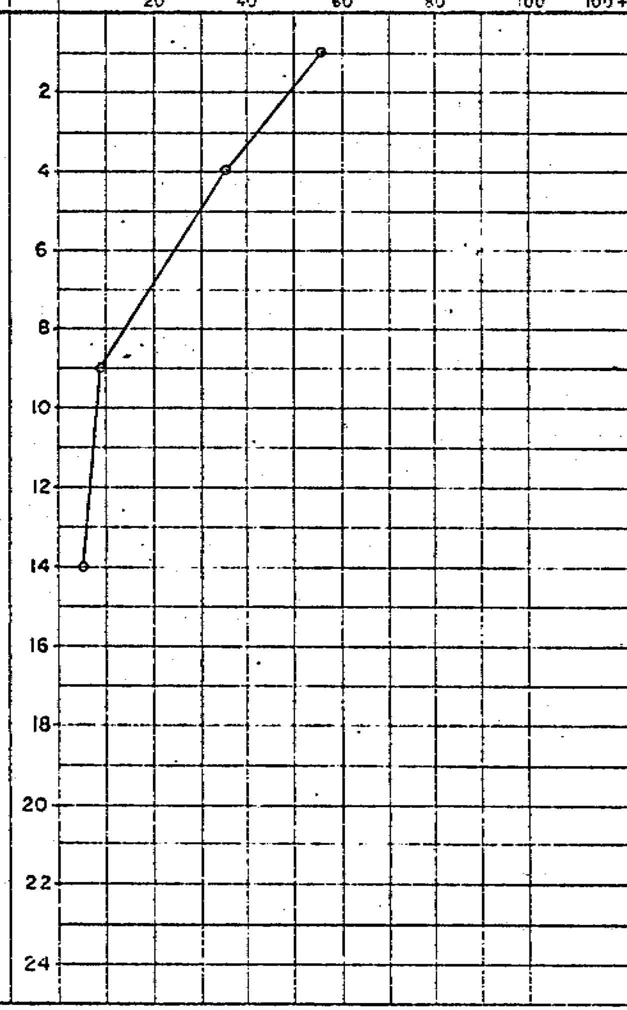
DAT A.E.W	FIELD ENG B M	DATE DRILLED 7/12/72	AIRPHOTO NO:	CHAINAGE: 619+00	OFFSET: ℄
CKD D.G.P.	TECH D M	RIG AIR	SURFACE DRAINAGE: GOOD	VEGETATION: SPRUCE, POPLAR, WILLOW	ELEV:

TEST HOLE

MILE	B,C,S	NUMBER
454	C	658

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT ORGANIC	F	
2–8					CL	CLAY SILTY, ICE CRYSTALS STICKY, SOFT		
10–14					SM	SAND SOME CLAY AND GRAVEL SAND & ROCK CUTTINGS		
16						END OF HOLE		

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



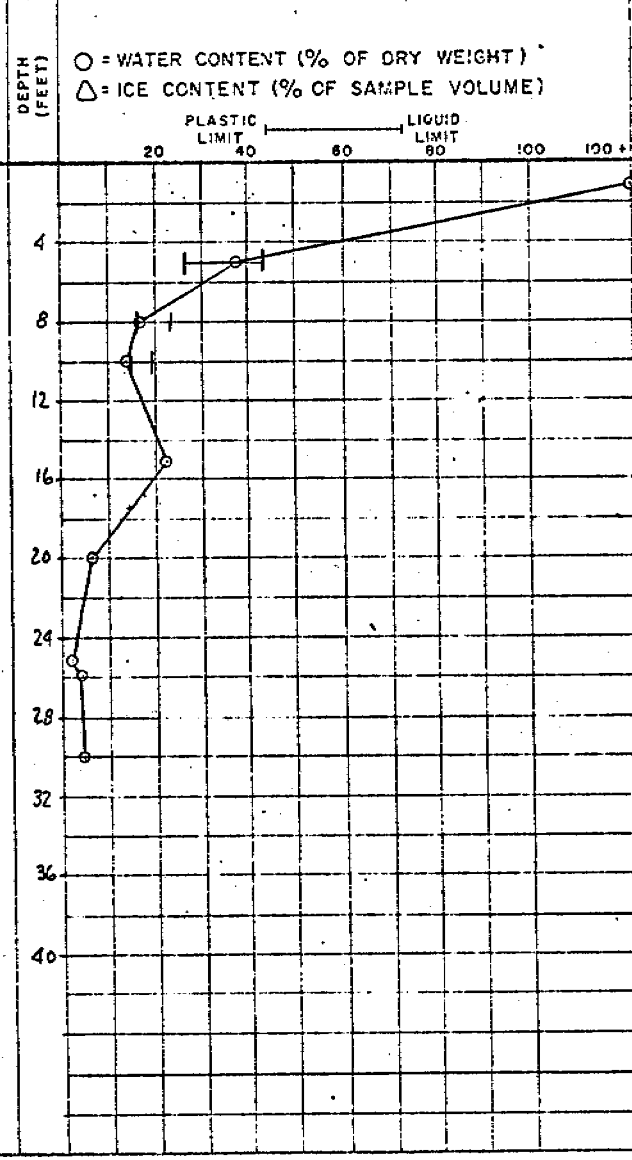
GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)	REMARKS

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

DRN A.E.W.	FIELD ENG. D.M.	DATE DRILLED 11/1/73	AIRPHOTO NO:	CHAINAGE: 617+00	OFFSET	TEST HOLE
CKD D.G.P.	TECH	RIG: AIR	SURFACE DRAINAGE: GOOD	VEGETATION: POPLAR & CONIFER TO 40'	ELEV:	

MILE	S,C,S	NUMBER
454	5	130 A

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
0–5					OL	SILT GRANULAR, SOME ORGANIC	F						105.2	76.0	$SO_4 = 0.07\%$
5–14		P, P			CL	CLAY SILTY, NO VISIBLE ICE LENSES, SANDY DRY		Nbn							
14–32		P			GC	GRAVEL SILTY CLAY, COARSE, COBBLES			21		57	32			HARD DRILLING
									16		49	35			
									22		34	44			
									12		22	66			
									17		28	55			
32–35					GW	LOOSE, COARSE									
35						END OF HOLE									



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

DRN: A.E.W	FIELD ENG: D.M	DATE DRILLED: 10/1/73	AIRPHOTO NO:	CHAINAGE: 614+25	OFFSET: ℄
CKD: D.G.P	TECH:	RIG:	SURFACE DRAINAGE: WEST TO EAST	VEGETATION: POPLAR & CONIFER TO 40'	ELEV: 283.3

TEST HOLE		
MILE	B,C,S	NUMBER
454	S	129 A

○ = 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

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
						SAND	UF	
8					GW	GRAVEL BOULDERS, FINE		
16						SANDY CLAY LENSE		
24						COARSE, SOME COBBLES	F	Nf
32						GREY BROWN CLAY LENSE		
40						COARSE WITH SAND STONE LENSES		
48								
56								Nbn
64					CH	CLAY BROWN, MED-HIGH PLASTIC, TRACE OF SAND		
72						VERY HARD BLUISH GREY SOME SAND HIGH PLASTIC		
80								Nbn
						END OF HOLE		

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

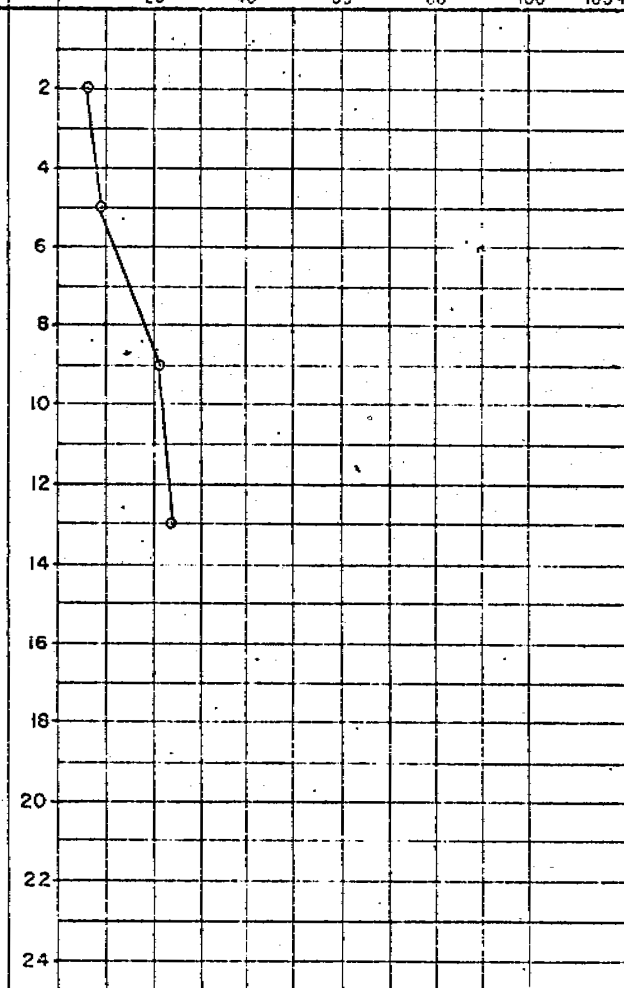
DWN A.E.W	FIELD ENG. R S	DATE DRILLED 8/12/72	AIRPHOTO NO:	CHAINAGE: 612+00	OFFSET: ℄
CKD DG P	TECH: D M	RIG: AIR	SURFACE DRAINAGE: SOUTH TO NORTH	VEGETATION: SHRUBS	ELEV. 3282.00

TEST HOLE

MILE	B,C,S	NUMBER
454	S	93 A

DEPTH (FEET)	SAMPLE TYPE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–2			GRAVEL	UF	
2	☒	GM	VERY WET, CLAYEY		
5–6	☒		COARSE SAND		
8–10	☒		CLAYEY, COARSE SAND IN WATER (DIRTY)		
12–14	☒	GC	CLAY MIXTURE IN WATER		
15			END OF HOLE		

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



GRAIN-SIZE ANALYSIS

DEPTH	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)	REMARKS
~9.5	13		38	49			

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

DRN A E W	FIELD ENG. T. S	DATE DRILLED 11/12/72	AIRPHOTO NO:	CHAINAGE: 611 + 90	OFFSET: ℄	TEST HOLE
CKD D G P	TECH D M	RIG AIR	SURFACE DRAINAGE:	VEGETATION:	ELEV 282.9	

MILE	S,C,S	NUMBER
454	5	102 A

○ = 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	DEPTH (FEET)	WATER / ICE CONTENT (20, 40, 60, 80, 100, 100+)	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)	REMARKS
					Pt	PEAT BLACK TOPSOIL	UF										
8					GP	GRAVEL COARSE WATER TABLE @ 4'			8								
16					CL	CLAY GREYISH BROWN			16								
24						GRAVEL	F	Nbn	24								
32					GP			Nf	32								
40						MAINLY COARSE WITH THIN SEAMS OF FINE GRAVEL			40								
48									48								
56									56								
64					GW				64								
72					CL	CLAY - SANDY, DARK BLUE		Nf	72								
80						END OF HOLE			80								
88									88								
96									96								

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

DWN AEW	FIELD ENG RS	DATE DRILLED 11/12/72	AIRPHOTO NO:	CHAINAGE: 611+00	OFFSET ℄
CKD DGP	TECH DM.	RIG AIR	SURFACE DRAINAGE: NORTH	VEGETATION: NONE	ELEV 302.82

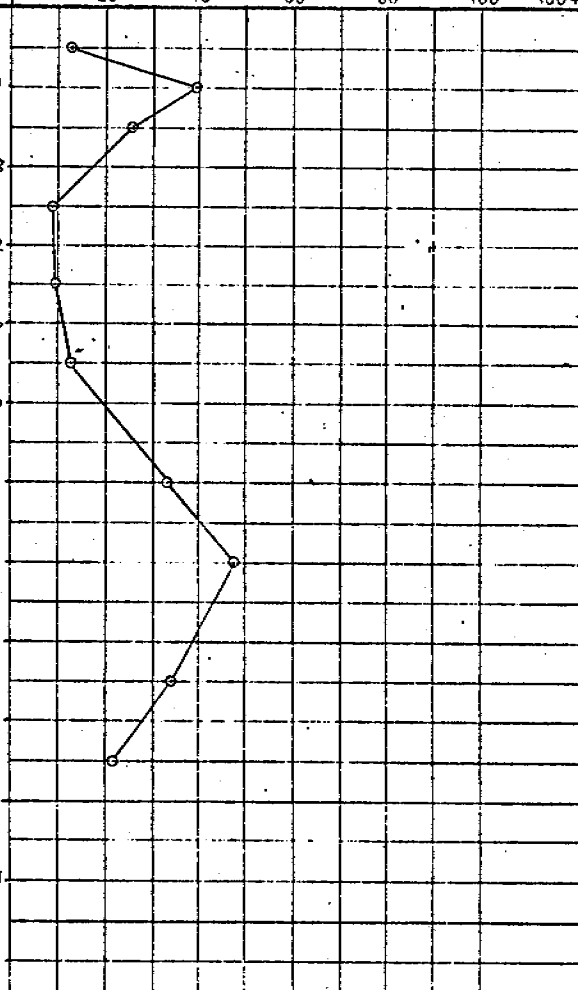
TEST HOLE

MILE	B,C,S	NUMBER
454	5	101A

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
					Pt	PEAT GRANULAR MUSKEG	UF								
		P			ML To CL	SILT CLAYEY, TRACES OF ORGANIC, SANDY									
					SP	SAND COARSE, SOME SILT SOME GRAVEL WATER TABLE @ 15'			8		10	82			
					SM	FINE – MEDIUM, SILTY TRACES OF GRAVEL VERY WET									
						CLAY HARD, SHALE LIKE									
						END OF HOLE									

DEPTH (FEET): 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48

○ = 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

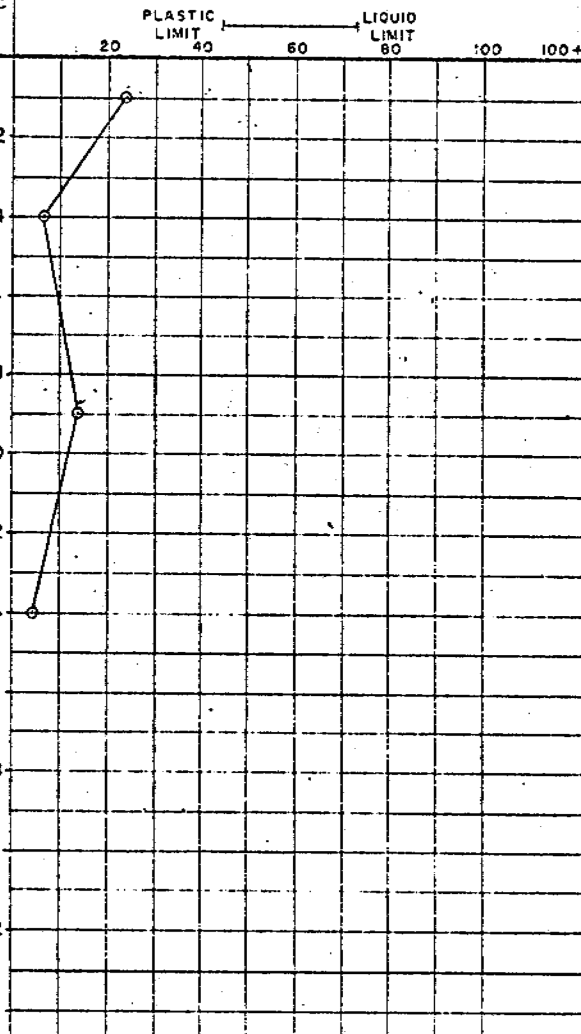
DR: A.E.W	FIELD ENG: R S	DATE DRILLED 8/12/72	AIRPHOTO NO:	CHAINAGE: 608+00	OFFSET: ℄
CKD D.G.P	TECH: DM	RIG: AIR	SURFACE DRAINAGE: SOUTH TO NORTH	VEGETATION:	ELEV:

TEST HOLE

MILE	B,C,S	NUMBER
454	C	94A

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0					Pt	PEAT - 2"	UF	
2					SM	SAND FINE, SILTY TO MEDIUM WITH CLAY		
4–6					SC			
6–8						COARSE WITH GRAVEL AND CLAY		
10					SW			
14						SILTY		
15						END OF HOLE		

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



DEPTH (FEET)	GRAIN-SIZE ANALYSIS: CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)	REMARKS
14–15	8		51	41			

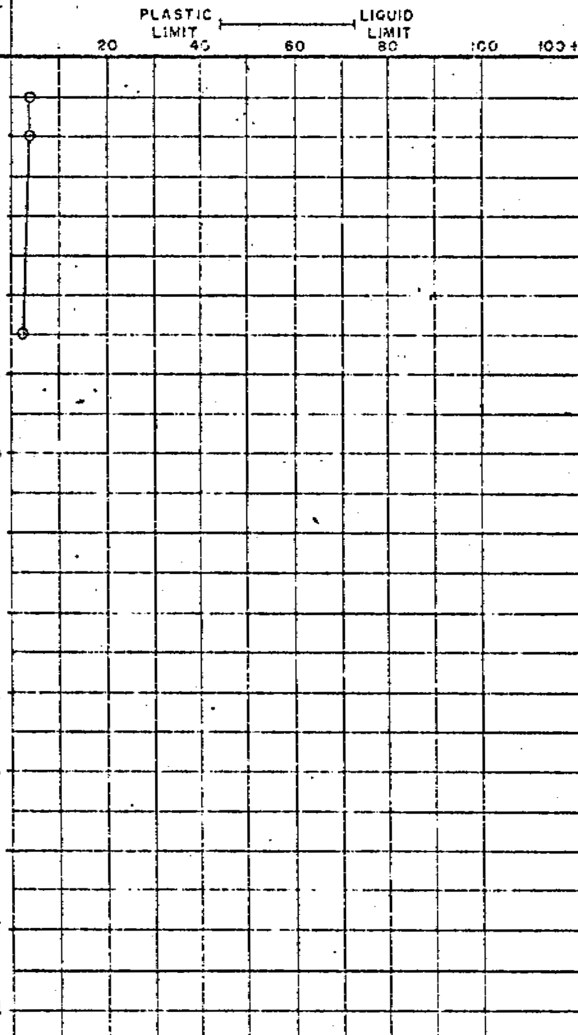
UNDERWOOD McLELLAN & ASSOCIATES LIMITED	DRILL HOLE REPORT	DEPARTMENT OF PUBLIC WORKS, CANADA MACKENZIE HIGHWAY

DAN A E W	FIELD ENG. R S	DATE DRILLED 9/12/72	AIRPHOTO NO:	CHAINAGE: 604+0'0	OFFSET: ℄	TEST HOLE
CKD D G P	TECH D.M	RIG AIR	SURFACE DRAINAGE: NORTH	VEGETATION: SPRUCE & POPLAR	ELEV.	

MILE	S,C,S	NUMBER
454	C	96 A

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					CL	CLAY SANDY	UF	
4						GRAVEL		
8					GP			
12						COARSE SAND BOULDERS		
16								
20					SP			
24								
28					GP	COARSE, BOULDERS		
32						END OF HOLE		
36								
40								
44								
48								

○ = 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

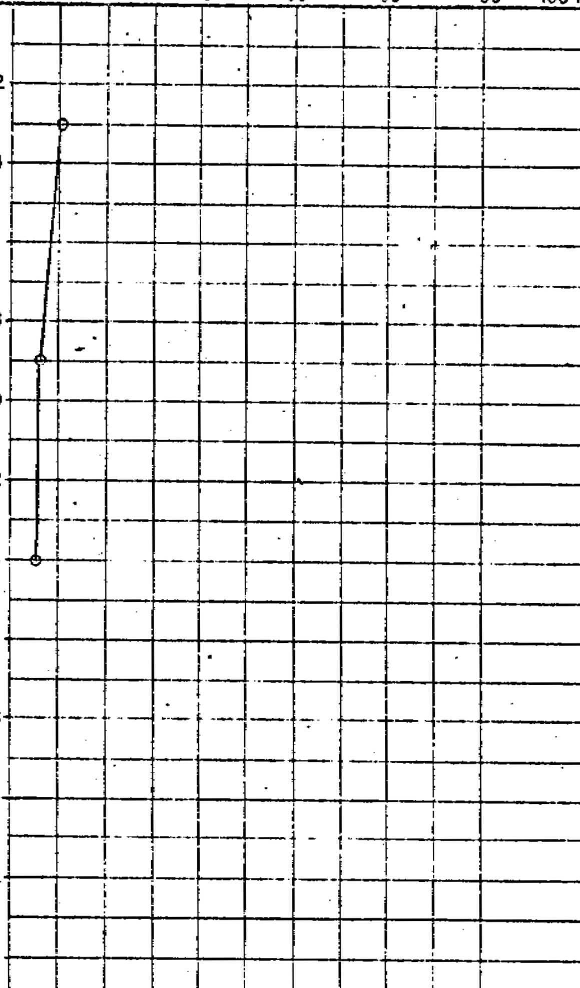
DWN A.E.N	FIELD ENG R.S	DATE DRILLED 9/12/72	AIRPHOTO NO:	CHAINAGE: 594+00	OFFSET: ℄
CKD D.G.D	TECH: D.M	RIG: AIR	SURFACE DRAINAGE: SOUTH TO NORTH	VEGETATION: POPLAR & SPRUCE (SPARSE)	ELEV:

TEST HOLE

MILE	B,C,S	NUMBER
454	C	95A

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–10						SILT SANDY, GRAVELLY	UF	
10–15						GRAVEL SILTY WITH BOULDERS		
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

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

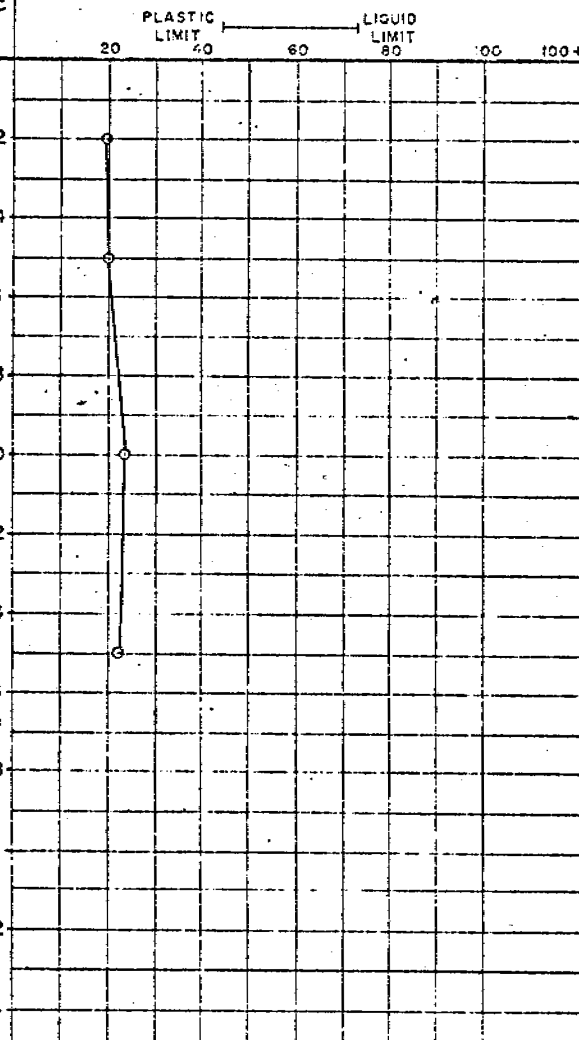
DWN A.E.W.	FIELD ENG T.S.	DATE DRILLED 9/12/72	AIRPHOTO NO:	CHAINAGE: 585+00	OFFSET: ℄		TEST HOLE
CKD D.S.P.	TECH D.M.	RIG AIR	SURFACE DRAINAGE: NORTH	VEGETATION: SPRUCE TO 40'	ELEV:		

MILE	B,C,S	NUMBER
454	C	100A

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–5					SC	CLAY SILTY, TRACE OF SAND	F	Nbn
5–15					ML	SILT SANDY SAND SEAM SANDY		Nf
15						END OF HOLE		

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



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

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

DWN A.E.W	FIELD ENG T.S	DATE DRILLED 9/12/72	AIRPHOTO NO:	CHAINAGE: 575+00	OFFSET: C
CHD DGP	TECH DM	RIG AIR	SURFACE DRAINAGE:	VEGETATION:	ELEV:

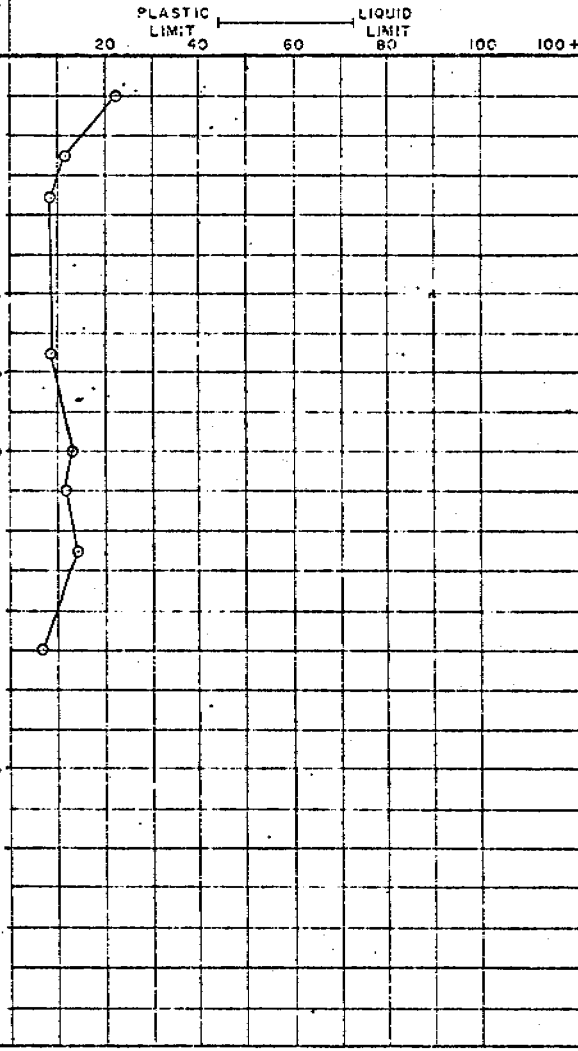
TEST HOLE

MILE	B,C,S	NUMBER
453	C	99A

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT - MOSS	F	
					ML	SILT - BROWN, SANDY, GRAVEL		
4					GM	GRAVEL SILTY, COBBLES		
8						CLAY		
12								
16					CL	BROWN, SILTY SAND & GRAVEL		Vr
20								
24								
28						GREY, SILTY WITH SAND & GRAVEL		
32						END OF HOLE		
36								
40								

DEPTH (FEET)

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



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

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

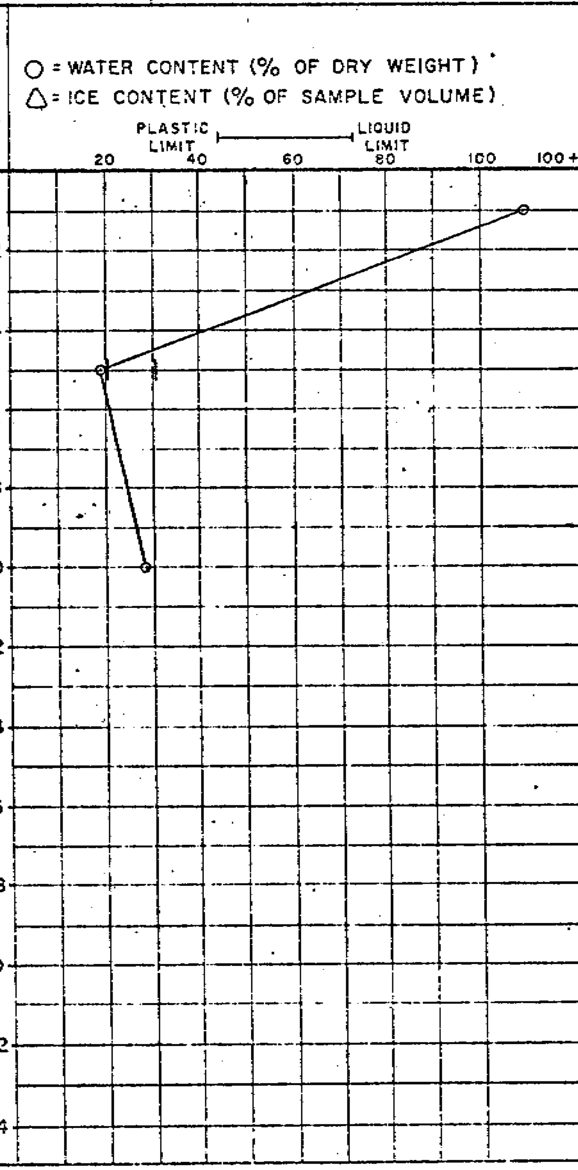
DWN A.E.W	FIELD ENG. T.S	DATE DRILLED 9/12/72	AIRPHOTO NO:	CHAINAGE: 565+00	OFFSET: ℄
CKD D.G.P	TECH: DM	RIG AIR	SURFACE DRAINAGE: FLAT	VEGETATION: SPRUCE TO 40'	ELEV.

TEST HOLE

MILE	E,C,S	NUMBER
453	C	98A

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	WET DENSITY (PCF)	DRY DENSITY (PCF)	REMARKS
0–3					Pt	PEAT	F				
3–15		T			CL	CLAY		Vr	110.3	90.5	
						LIGHT BROWN, ICE SILTY					
		P				1/4" LAYER OF ICE		Vr			
15						END OF HOLE					

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



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

CAN A.E.W.	FIELD ENG B.M.	DATE DRILLED 10/1/73	AIRPHOTO NO:	CHAINAGE: 630+00	OFFSET: 800' W OF ℄
CKD D.G.P.	TECH D.M.	RIG AIR	SURFACE DRAINAGE: GOOD	VEGETATION: SPRUCE & POPLAR TO 30'	ELEV:

TEST HOLE

MILE	B,C,S	NUMBER
455	B	173 B

○ = 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	DEPTH (FEET)	WATER/ICE CONTENT (20 40 60 80 100 100+; PLASTIC LIMIT – LIQUID LIMIT)	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)	REMARKS
						GRAVEL	F	SEASONAL									
2					GM	SANDY	UF		2								
4						SILTY, CLAY, SOME SAND			4								
6									6								
8					TO				8								
10						CLAY, SANDY			10								
12						TILL LIKE			12								
14					GC				14								
16						END OF HOLE			16								
18									18								
20									20								
22									22								
24									24								

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

DRN A.E.W	FIELD ENG B.M	DATE DRILLED 10/1/73	AIRPHOTO NO:	CHAINAGE: 630+00	OFFSET 700' W OF ℄
CKD DGP	TECH DM	RIG AIR	SURFACE DRAINAGE: GOOD	VEGETATION: SPRUCE & POPLAR TO 30'	ELEV:

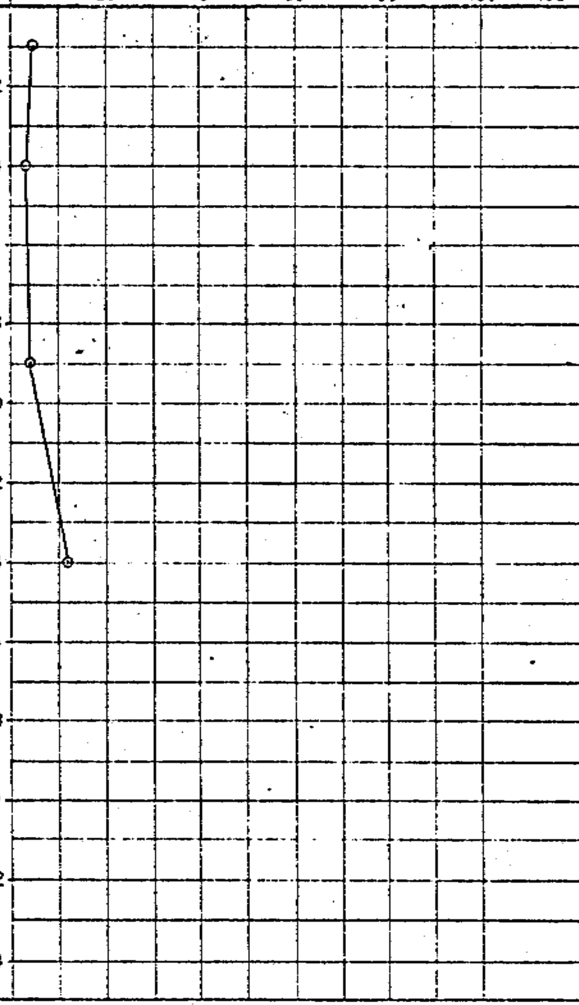
TEST HOLE

MILE	B,C,S	NUMBER
455	B	174 B

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–11					GM	GRAVEL 2" ORGANIC; SANDY, SOME SILT; SANDY	F (to ~1'); UF	SEASONAL
11–15					ML	SILT SANDY	UF	
15						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)



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

DN A.E.W	FIELD ENG. B.M	DATE DRILLED 10/1/73	AIRPHOTO NO:	CHAINAGE: 630+00	OFFSET 600' W OF ℄
CKD D.G.P	TECH DM	RIG: AIR	SURFACE DRAINAGE: GOOD	VEGETATION: SPRUCE & POPLAR TO 30'	ELEV

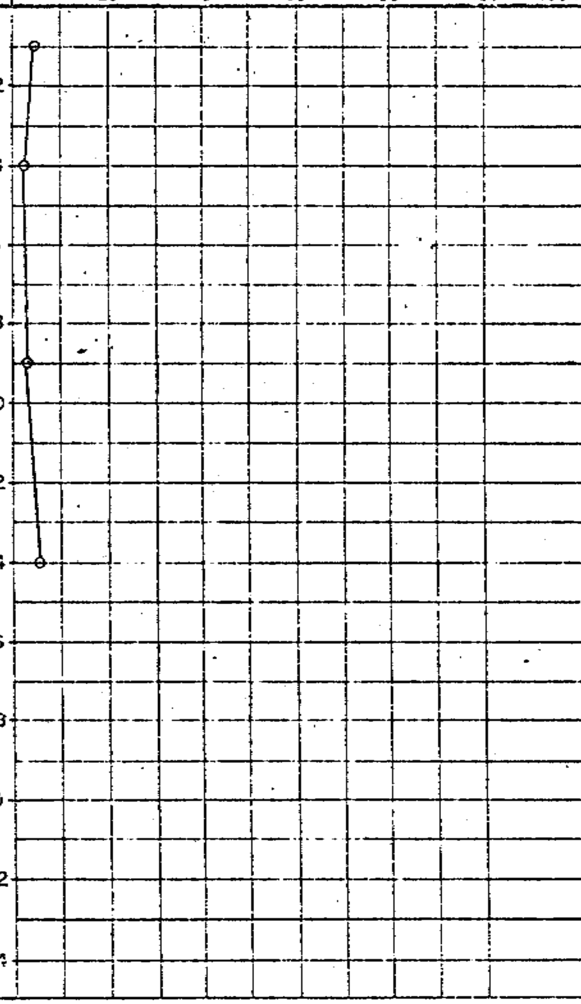
TEST HOLE

MILE	B,C,S	NUMBER
455	B	175B

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–1						GRAVEL 2" ORGANIC	F	
2					GM	SANDY, SILTY	UF	
5–6						SILTY, SANDY VERY HARD GRANITE		
9						SANDSTONE (HARD)		
14					GM	SILTY, SANDY		
16						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.)

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

DWN. A.E.W	FIELD ENG. B.M	DATE DRILLED 11/1/73	AIRPHOTO NO:	CHAINAGE: 591+00 ℄	OFFSET 500' E of ℄
CKD DGP	TECH	RIG AIR	SURFACE DRAINAGE: FAIR	VEGETATION: SPRUCE TO 15'	ELEV

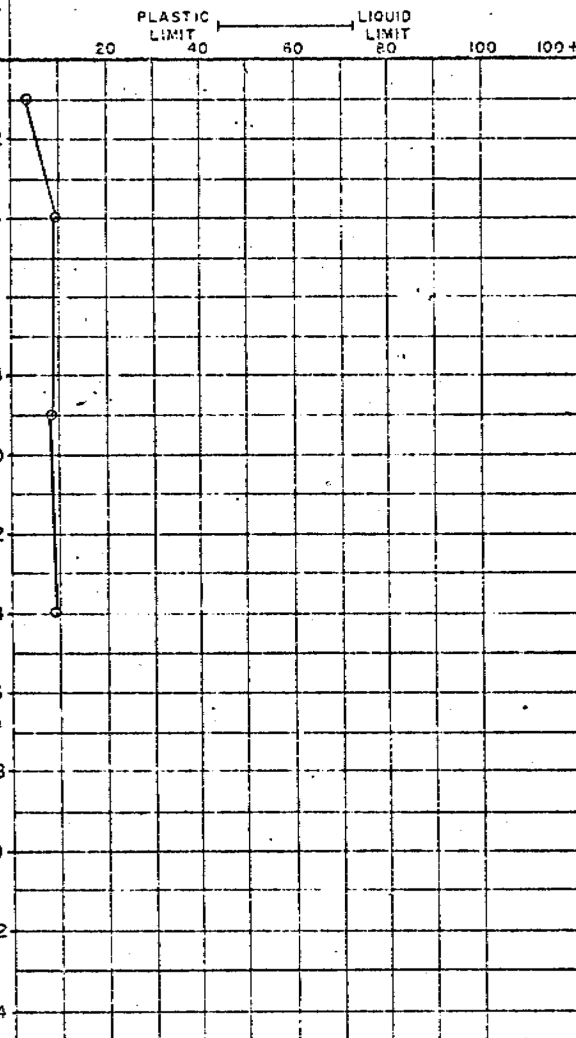
TEST HOLE

MILE	B,C,S	NUMBER
454	B	179B

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0						PEAT ORGANIC MUSKEG	F	SEASONAL
0–2					GM	GRAVEL SANDY	UF	
2–15					ML	SILT SANDY, GRAVELLY		
15						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)



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

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRN AEW	FIELD ENG BM	DATE DRILLED 11/1/73	AIRPHOTO NO:	CHAINAGE: 591+00 ℄	OFFSET 500' E of ℄
CKD DGP	TECH DM	RIG AIR	SURFACE DRAINAGE: FAIR	VEGETATION: SPRUCE TO 15'	ELEV:

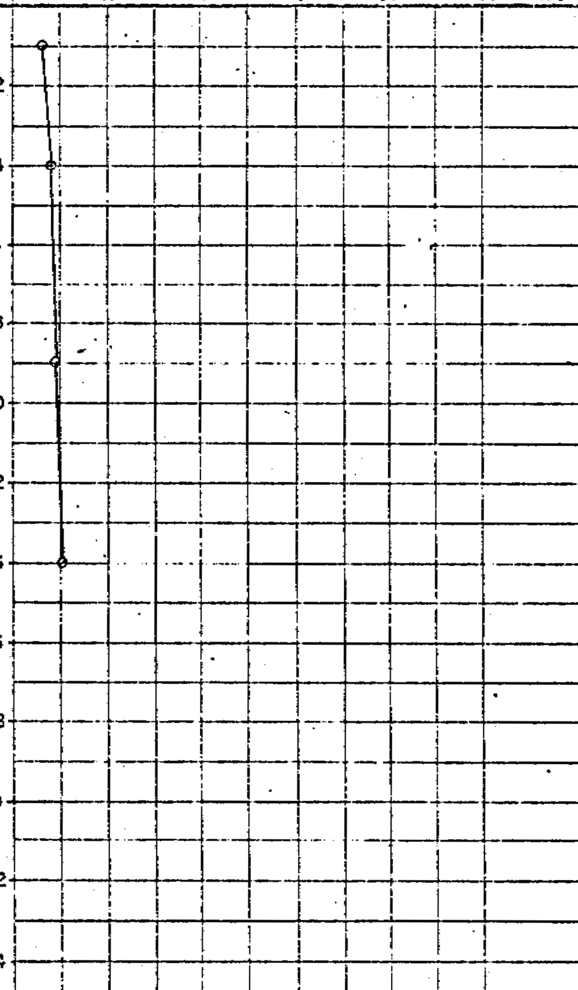
TEST HOLE

MILE	B,C,S	NUMBER
454	B	180B

DEPTH (FEET)	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0	Pt	PEAT GRANULAR MUSKEG	F	
0–4	GM	GRAVEL SOME SAND, SILTY	UF	
4–10	ML	SILT SOME GRAVEL, SAND		
10–15	GM	TILL SANDY & GRAVELLY SILT		
15		END OF HOLE		

Column headings: DEPTH (FEET) · SAMPLE NUMBER · SAMPLE TYPE · % RECOVERY · PENETRATION RESISTANCE · UNIFIED SOIL SYMBOL · SOIL DESCRIPTION · LIMITS OF FROZEN GROUND · ICE DESCRIPTION · DEPTH (FEET) · GRAIN-SIZE ANALYSIS (CLAY %, SILT %, SAND %, GRAVEL %) · WET DENSITY (PCF) · DRY DENSITY (PCF) · REMARKS

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



REMARKS

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

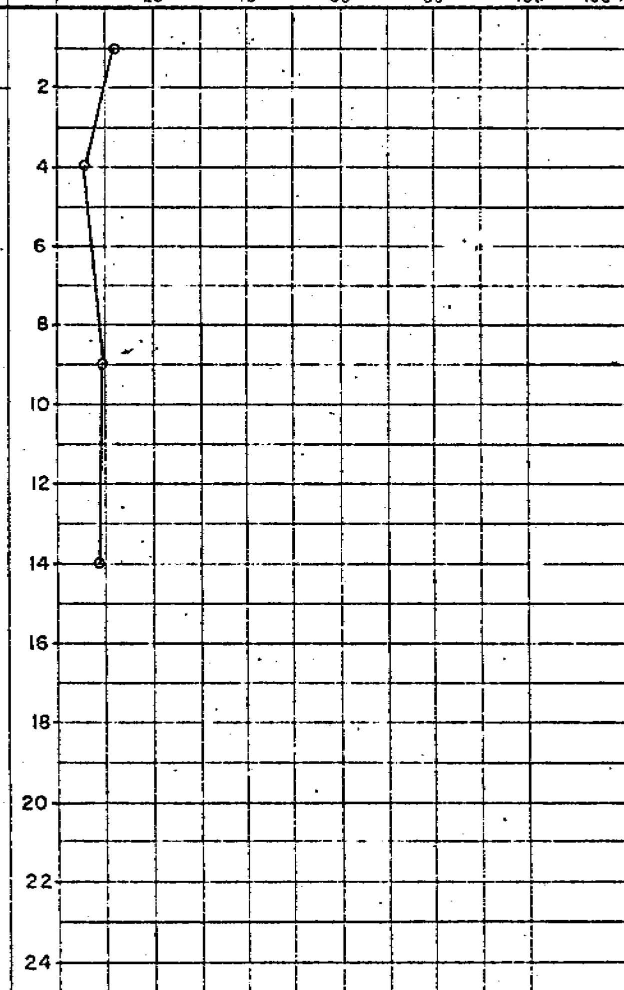
DWN A.E.W	FIELD ENG. B.M	DATE DRILLED 11/1/73	AIRPHOTO NO:	CHAINAGE: 591+00	OFFSET 500' E of ℄
CKD DGP	TECH D.M	RIG: AIR	SURFACE DRAINAGE: FAIR	VEGETATION: SPRUCE TO 15'	ELEV.

TEST HOLE

MILE	S,C,S	NUMBER
454	B	181B

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0					Pt	PEAT GRANULAR MUSKEG		
1–2		⧄			GM	GRAVEL SOME SAND, SILTY	F	
2							UF	
4–5		⧄						
7					GM	SANDY, SILTY, CLAYEY		
9–10		⧄						
12						TILL TEXTURE		
14–15		⧄						
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 (PCF)	DRY DENSITY (PCF)	REMARKS

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

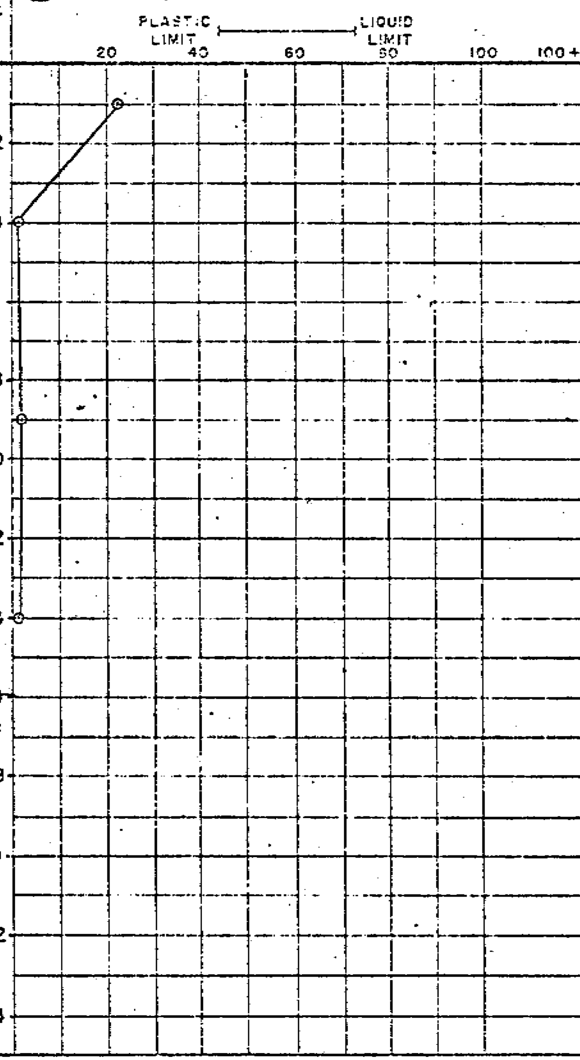
DWN A.E.W.	FIELD ENG B.M.	DATE DRILLED 10/11/73	AIRPHOTO NO:	CHAINAGE: 591+00	OFFSET 1200' W of ℄
CKD D.G.P.	TECH D.M.	RIG AIR	SURFACE DRAINAGE: FAIR	VEGETATION: SPRUCE TO 25'	ELEV

TEST HOLE

MILE	B,C,S	NUMBER
454	B	176 B

DEPTH (FEET)	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	REMARKS
0	PE	PEAT ORGANIC	F		
1–4	GW	GRAVEL COBBLES, DRY	UF		HARD DRILLING
4–14	GP	SOME FINE SAND			
14		END OF HOLE			

Column headings: DEPTH (FEET); SAMPLE NUMBER; SAMPLE TYPE; % RECOVERY; PENETRATION RESISTANCE; UNIFIED SOIL SYMBOL; SOIL DESCRIPTION; LIMITS OF FROZEN GROUND; ICE DESCRIPTION; DEPTH (FEET); 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: AEW	FIELD ENG: BM	DATE DRILLED: 10/1/73	AIRPHOTO NO:	CHAINAGE: 591+00	OFFSET: 1200 W of ℄
CKD: DGP	TECH: DM	RIG: AIR	SURFACE DRAINAGE: FAIR	VEGETATION: SPRUCE 70 25'	ELEV:

TEST HOLE

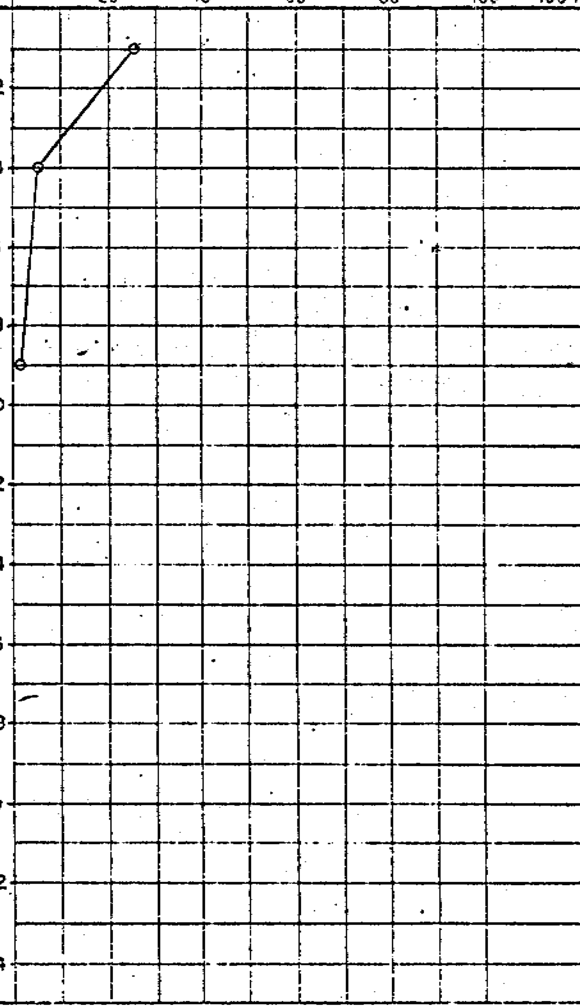
MILE	B,C,S	NUMBER
454	B	177 B

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0					Pt	PEAT GRANULAR MUSKEG	F	SEASONAL
0–2					ML	SILT BROWN, MOIST	UF	
2–6					GC	GRAVEL SAND, SOME SILT CLAY, (TILL LIKE)		
6–12					SP	SAND LITTLE GRAVEL ODD COBBLE		
12						END OF HOLE		

DEPTH (FEET)

○ = 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

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

DAN: A.E.W	FIELD ENG: B.M	DATE DRILLED: 11/1/73	AIRPHOTO NO:	CHAINAGE: 591+00 ℄
CKD: DGP	TECH: DM	RIG: AIR	SURFACE DRAINAGE: FAIR	VEGETATION: SPRUCE TO 25'

OFFSET: 1200' W of ℄

ELEV:

TEST HOLE

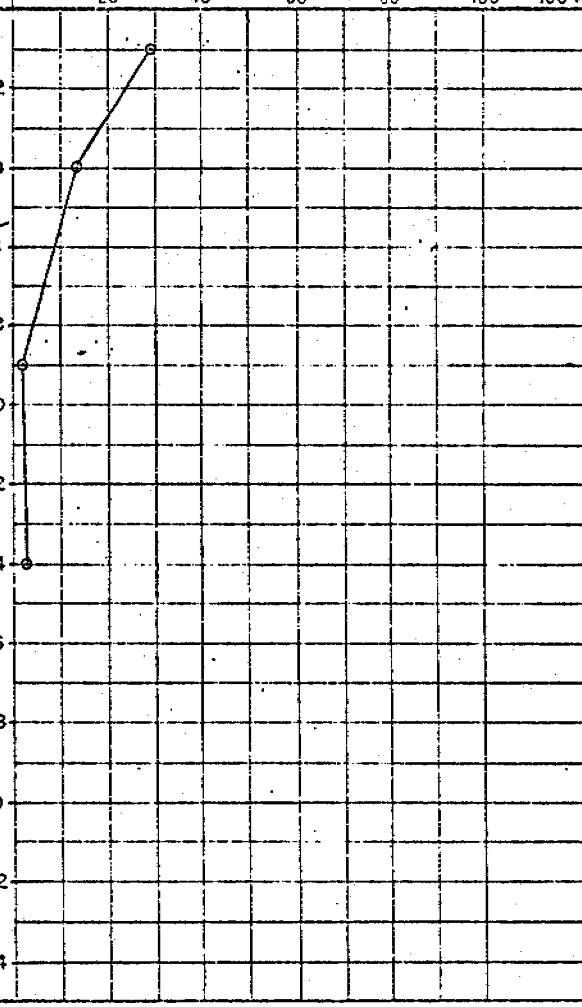
MILE	B,C,S	NUMBER
454	B	178B

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0					Pt	PEAT GRANULAR MUSKEG		
0–4					ML	SILT — BROWN, DRY	F (0–2); UF (below 2)	SEASONAL
4–14					GP	GRAVEL — FINE SAND, COBBLES	UF	
14						END OF HOLE		

○ = WATER CONTENT (% OF DRY WEIGHT)

△ = ICE CONTENT (% OF SAMPLE VOLUME)

PLASTIC LIMIT —— LIQUID LIMIT



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