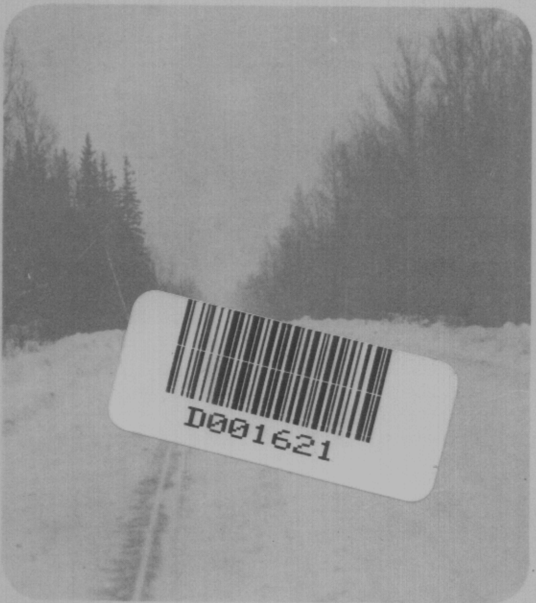
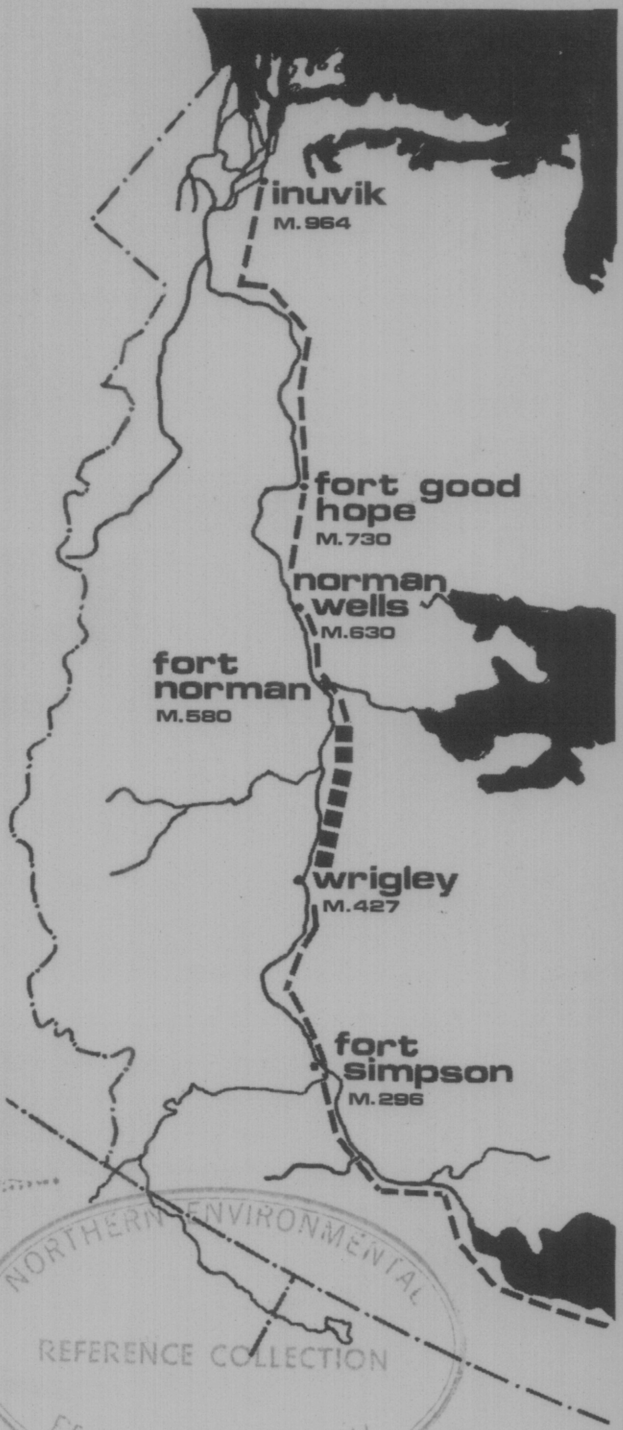




REPORT ON SUBSURFACE SOIL CONDITIONS FOR PROPOSED -

WHITESAND CREEK BRIDGE MILE 459.6

MACKENZIE HIGHWAY

Underwood McLellan & Associates Limited

ISSUE #39

SUBSURFACE
SOIL CONDITIONS
FOR THE
PROPOSED WHITESAND CREEK BRIDGE
MILE 459.6, MACKENZIE HIGHWAY
NORTHWEST TERRITORIES

Prepared by:
Underwood McLellan & Associates Limited
Consulting Engineers

Underwood McLellan & Associates Limited

2540 KENSINGTON ROAD N.W., CALGARY, ALBERTA T2N 3S3 TELEPHONE 283-4061 TELEX 038-24565

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 Whitesand Creek Bridge,
Mile 459.6, Mackenzie Highway

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

INDEX

APPENDIX

A. INTRODUCTION

The present report summarizes the results of sub-soil investigation operations conducted in connection with the proposed Whitesand Creek bridge at mile 459.6 on the Mackenzie Highway.

This bridge site investigation was undertaken as part of the geotechnical investigation from mile 450 to 550 on the Mackenzie Highway for the Department of Public Works, Government of Canada.

It was the intention of the present investigation to determine the vertical sub-soil material sequence, physical and structural properties, permafrost conditions and ground water conditions which would be expected to influence the stability of the valley slopes and the design and construction of the bridge foundation.

The included conclusions and recommendations have been based upon exploratory and sample acquisition operations conducted at a total of 9 positions along the proposed bridge center line in the river channel and slopes of the bridge approaches.

In the formulation of conclusions and recommendations, the consistency and composition of the subsoil material 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 9 test holes have been drilled within one mile of the bridge structure. In addition to the 9 centerline testhole logs, 9 borrow test hole logs in the vicinity of the bridge site have been included in the Appendix. Test holes along the centerline were drilled to depths varying from 11 to 90 feet below the existing site grades. Borrow test holes were generally advanced to the 15 foot level.

Test borings were drilled December 6, 8 and 12, 1972, and January 9 and 12, 1973, by Kenting Big Indian Drilling of Calgary, utilizing a Meyhew 1000 and Heli drill. Air recovery methods were generally employed except where severe caving was encountered at bridge crossings, water and mud drilling methods were utilized. The locations of the individual test borings were selected and 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 groundwater conditions encountered during the test hole boring operations were noted and representative samples of the existing subsoils were taken. The majority of the samples were disturbed having been obtained by air recovery methods. Sampling was also undertaken with 2" and 3" O.D., split spoon sampling tubes and 3" O.D. thin walled Shelby tubes. In the laboratory materials obtained from the drilling operations were subjected to standard laboratory classification procedures including particle size distribution and Atterberg index property determination. 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 NRC technical memorandum No. 79 "Guide to the field description of permafrost." The excess ice content in permafrost samples was determined by visual inspection and by measured thicknesses of ice lenses. The excess ice content was obtained by division of the ice thickness by the total sample thickness.

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

All results of 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 459C 80B, 459S 132A and 459B 159B. The letter symbols and numbers indicate

459 - indicates mileage

B, C, and S - between mileage and test hole number indicates borrow, centerline or structure test holes, respectively.

80, 132 and 159 - indicate test hole numbers.

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

Test holes should be designated by a number followed by A or B.

C. SITE AND SUBSOIL CONDITIONS

The Whitesand bridge site is located at mile 459.6 (chainage 880 + 00) on the Mackenzie Highway in the Northwest Territories. The Whitesand 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 is presently in a state of depositing floodplain sediments at the entrance to the Mackenzie River.

The Whitesand stream bed elevation is 280 (DPW datum) with the estimated high water mark at elevation 306 as a result of ice jams along the Mackenzie River. The main valley of the Whitesand Creek is approximately 400 feet wide, and 50 feet deep. The main stream flow in recent years has been against the north bank in a trench approximately 100 feet wide and 15 feet deep.

Two test holes 124A (879 + 70) and 132A (881 + 70) were drilled at the bottom of the main valley to depths of 40 and 90 feet, respectively. Test hole 124A disclosed alternating layers of sand and gravel to the termination of the hole. These granular materials exhibited very low moisture contents and the water table was indicated at 22 feet below existing grades which was approximately coincident with the stream water level.

Test hole 132A which was drilled to a depth of 90 feet disclosed alternating sand and gravel layers to a depth of approximately 70 feet where a sandstone and shale bedrock was confirmed. The bedrock in the general area of the investigation is believed to consist of sedimentary deposits of interbedded shales siltstones and sandstones which were deposited during the Cretaceous Geologic age.
Test hole 124A did not disclose any permafrost but test hole 132A indicated permafrost to a depth of approximately 30 feet where the water table was encountered. Below the water table, the soil would

be classified as semi-frozen.

Although the mud and water circulation method was utilized, sloughing was extensive and "undisturbed" samples could not be retrieved.

Test holes drilled along the valley walls and near the uplands within approximately ½ mile south and north of the proposed bridge site disclosed granular sand and gravel deposits which were previously deposited by the Whitesand stream when it flowed at higher elevations. It may also be concluded from the test holes drilled that the stream banks and upland consist primarily of permafrost. The majority of the granular materials exhibit very low moisture contents although these materials are frozen.

The gravel samples which were obtained during drilling operations indicated approximately 50% material coarser than the # 10 sieve, but these samples which were subjected to crushing during drilling would exhibit a true gravel size content higher than recorded.

Exception to the dry granular materials was indicated in test hole 123A (885 + 00) which has a surface deposit of 16 feet of high moisture content silt and clay with excess ice contents of approximately 5%. The dry density of the silt clay varied from 88.7 to 92 lb/cu.ft. The materials below the 16 foot level in test hole 123A consisted of dry sand with some boulders and was further underlain by a firm clay till of stiff consistency.

A Soil Profile of the bridge valley site is included in the Appendix on Plate 2.

D. CONCLUSIONS AND RECOMMENDATIONS

On the basis of the present investigations we wish to offer the following generalized conclusions and recommendations relative to the design and construction of the proposed Whitesand Creek bridge foundations and approaches.

1. Pier and abutment foundation.

A footing foundation for the abutments and piers will be founded in the gravel and sand deposits which are described in the previous section. These materials which were stream deposited have not been subjected to preconsolidation and significant settlements would result under foundation loadings. In addition, considerable difficulty would be experienced in performing excavations for piers in the saturated granular soil. Consequently, a driven pile foundation system is recommended for all structures.

The pile types generally available would include timber, precast 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.

At the Whitesand Creek site, it is anticipated that steel pipe or H-piles for piers will be approximately 60 feet long based on data summarized on test hole log 132A where bedrock was encountered at elevation 220. The pier foundations will be nearer the stream channel than test hole 132A and the "rotten" nature of the permafrost will likely be more developed. 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 steel section area. "False" refusal may occur whenever extremely large boulders cannot be penetrated during driving. Such boulders were encountered at the 16 foot level in test hole 132A.

Although refusal may be attained while driving, fundamental refusal bearing capacity may not exist below the pile tip. Load tests would be necessary to establish allowable pile 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. Alternatively, large diameter open steel pipe may be utilized to penetrate boulder strata by crushing the boulders with churn-drill methods within the pipe pile.

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.

The south abutment location is proposed in the large fill section at station 881 + 40. Wherever the embankment consists of compacted granular fill as recommended in section D3, the abutment may be placed on a spread footing utilizing 4000 pcf allowable bearing stress. If inferior materials or compaction techniques are utilized in the embankment, the foundation must consist of driven piles into the granular subsoils below. Piles driven through fills subject to settlement must be designed to carry negative skin friction.

At the north abutment, station 883 + 90, a change from fill to cut occurs at the proposed location. The soil strata consists of clayey silt and clay permafrost at this elevation and would not allow satisfactory long-term abutment foundation performance. Piles driven to refusal in the glacial till at elevation 308 should be utilized but steam-jetting of the surface materials will likely be necessary to achieve penetration.

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. Data obtained from load tests on piles driven into deep granular deposits will be of assistance in designing piles throughout the Mackenzie Highway System.

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.

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 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 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 verticle retaining wall abutment with horizontal backfill the Coulomb active coefficient would be .24 and the at-rest coefficient based on $K_o = 1 - \sin \emptyset$ 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 nontriangular, 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. Bridge Approach Grades and Borrow Material

Major cuts are proposed at the north and south banks of the proposed bridge site. The cut on the south bank at station 872 + 00 will be approximately 35 feet in height and will extend approximately 1,000 feet. These cuts will be performed in dry frozen sand and gravel with no excess ice. It is anticipated that the stability of this cut slope will not be a problem and a slope of 2:1 is recommended, although a flatter slope may be employed to increase available fill material.

The cut on the north bank at station 886 + 00 will be undertaken in primarily dry gravel and sandy silt with moisture contents less than 6%. In the lower portion of the cut section at station 885 + 00, the cut of 10 feet will be primarily in silt and silty clays with moisture contents in the order of 25% and excess ice contents of 5%. At this section cut slopes of 2:1 are recommended. Some sloughing of the 10 foot cut can be expected after excavation during thermal readjustment. It is recommended that consideration be given to raising the grade line approximately 12 feet near the north abutment to eliminate cutting in the surface silt permafrost. Some thaw settlement can be expected as the section would be composed of a four foot fill.

Fills of 3 to 5 feet have been proposed north and south of the major cuts which were described in the above paragraph. These fill heights are considered adequate at stations 894 + 00 and 864 + 00 as the subgrade consists of dry granular soil which is not expected to undergo significant thaw settlements, but in the area of test hole 80B at station 855 + 00 approximately 10 feet of fine sandy silt is present which exhibits moisture contents of 40%; dry density near 70 pcf., and contains random ice. It is expected that thaw settlements in the order of 1 to 2 feet will occur.

Therefore, it is recommended that the fill depth in this area be increased to approximately 8 feet if granular materials are utilized.

The approach fills to the bridge will be approximately 30 feet high and it is recommended that because of an adequate granular material supply, these materials be utilized in all fills near the bridge approaches and be compacted to 95% of Standard Proctor utilizing vibratory compaction. Although construction may be performed during the winter, the dry nature of the granular materials will allow adequate compaction. Compaction of these deep approach fills is mandatory to ensure slope stability and all fill slopes should be constructed at slopes of 2:1.

In addition to common excavation which will be obtained from valley cut sections, granular borrow material may be found adjacent to the centreline at station 871 + 00 and 891 + 00. The borrow pit investigated at station 831 + 00 consists of silty clay with moisture contents in the range of 40% and is not considered suitable for roadway embankment fill. Test hole logs for the borrow material are included in the Appendix.

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:-

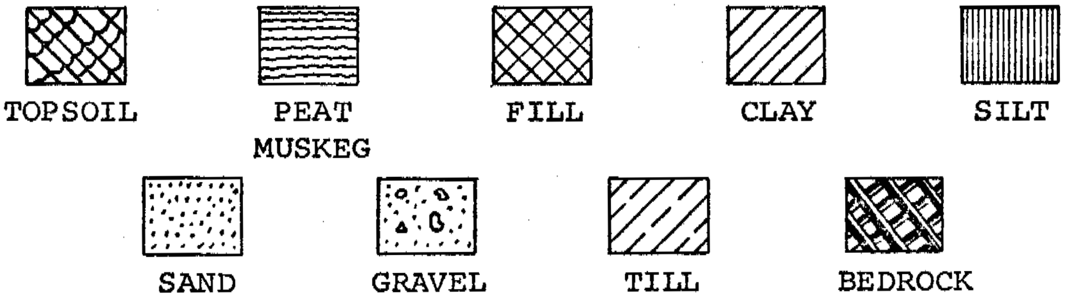
NATURAL MOISTURE CONDITIONS & ATTERBERG LIMITS

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.

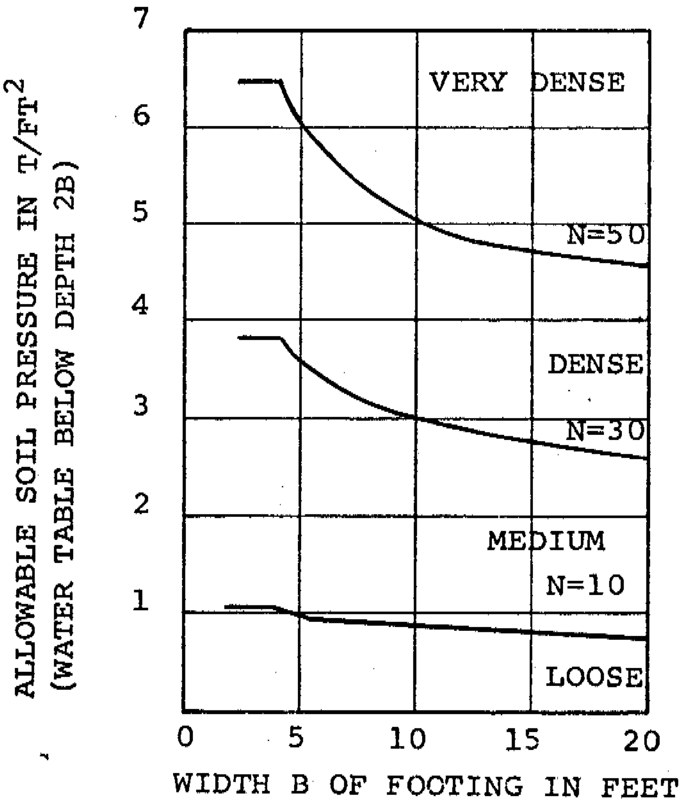
SO_4 - water soluble sulphate content is conducted primarily to determine whether sulphate resistant cement is required for the foundation structure.

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%

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.

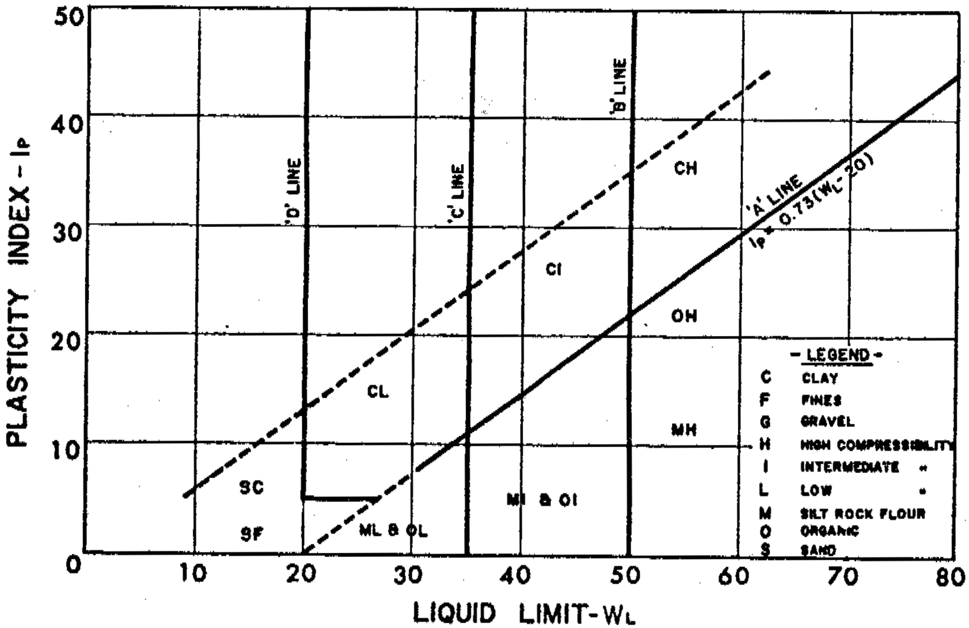
UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS 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

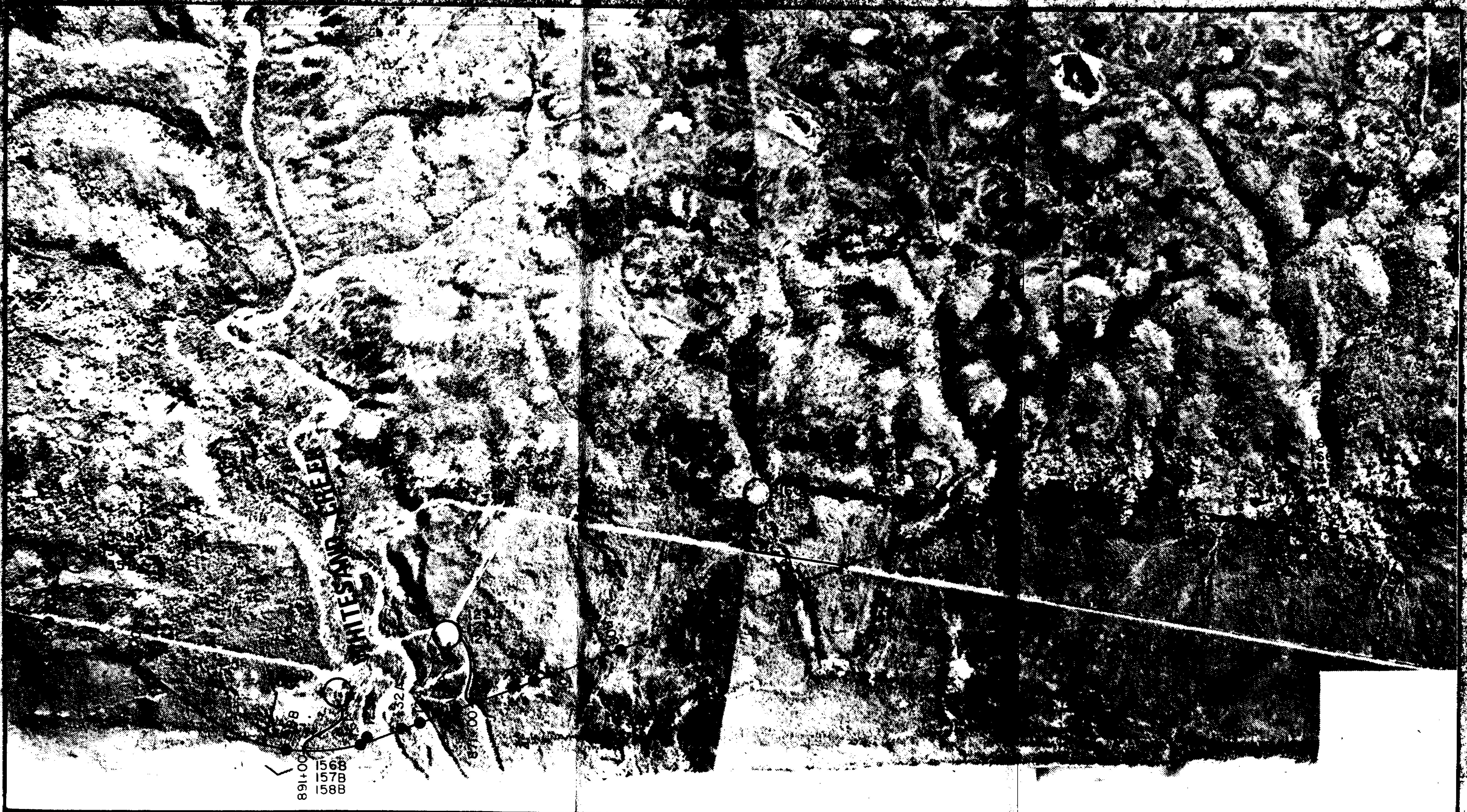
V_s - stratified or oriented ice formations

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

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Checked: D.[illegible].P.
Design:
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Scale:
1" = 1000'

MACKENZIE HIGHWAY

WHITESAND CREEK MOSAIC AND TEST HOLE LOCATION PLAN

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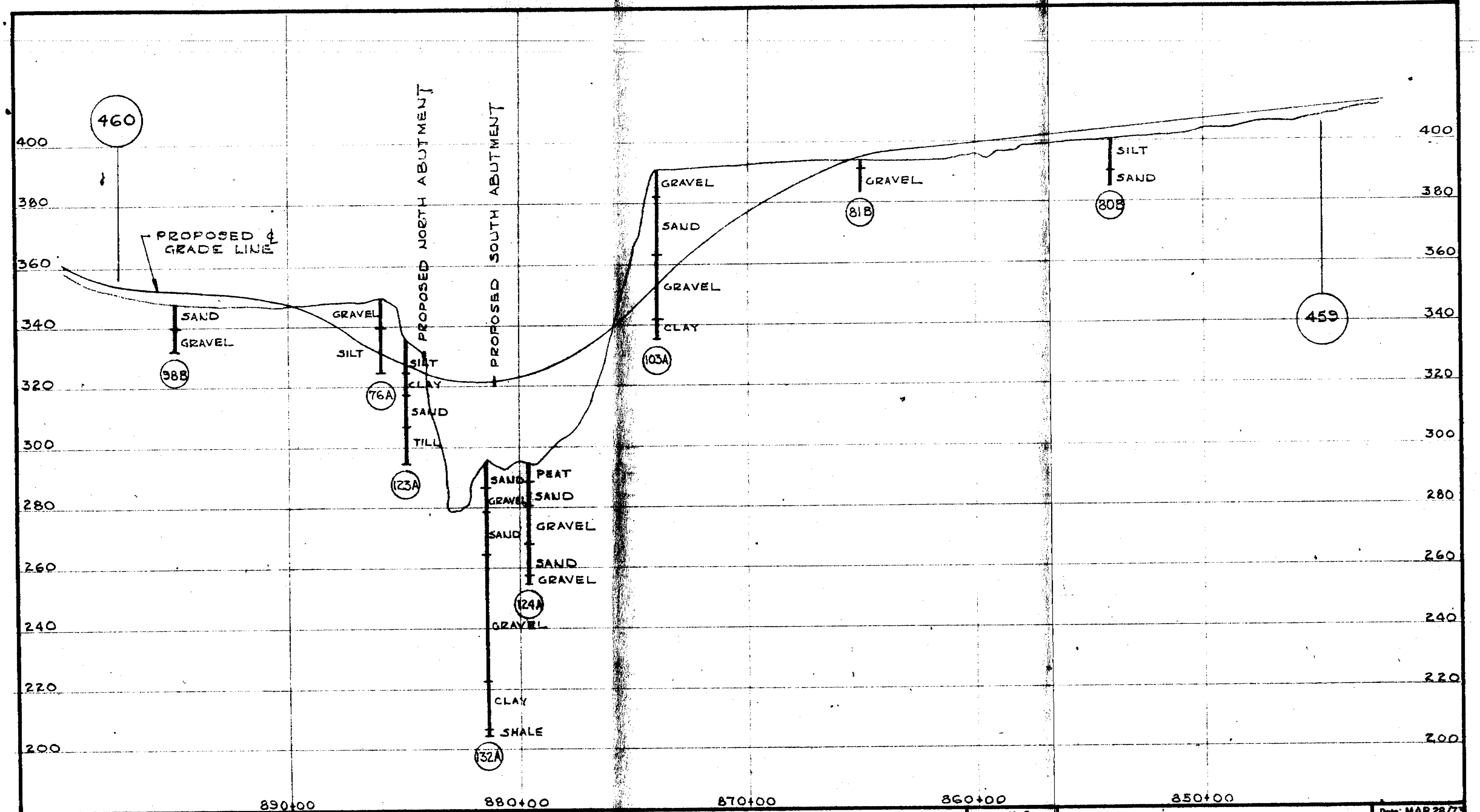
PLATE-1
Issue:



Issue	Date	Remarks	No.	Revision	Date	By	Approved

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CONSULTING ENGINEERS - TOWN PLANNERS
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Scale: AS SHOWN

MACKENZIE HIGHWAY

WHITESAND BRIDGE SITE
PROFILE & SOIL CROSS SECTION

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

WHITESAND CREEK MILE 460.0

Viewing Hill at Sta. 874+00 from
Station 880+00 looking South
Proposed 30 foot Cut Area.

Viewing ℄ of Crossing from Station
880+00 Looking North

Plate 3.

Viewing Proposed Crossing from Station 884+20
Top of North Bank & Looking at Station 874+00
South of Crossing

View down slope of North Bank from
Station 884+20 looking South.

Plate 3.

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

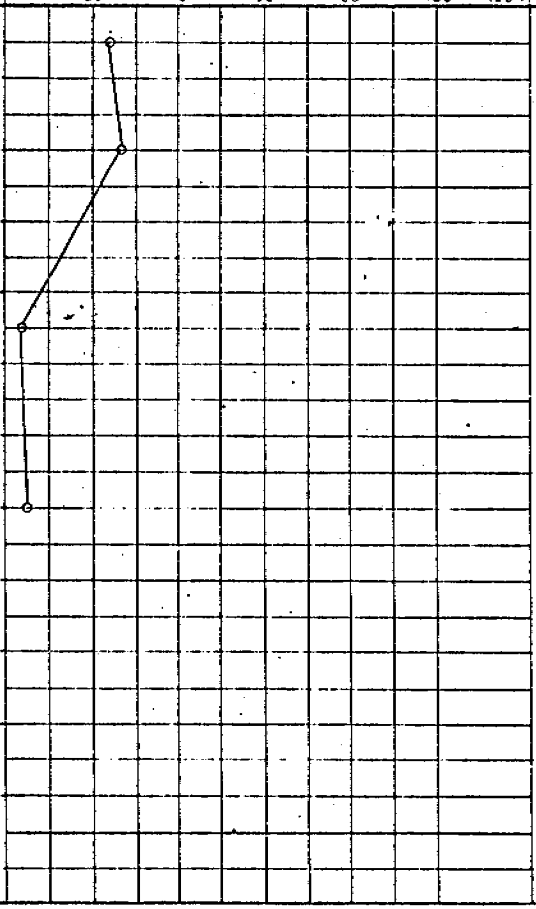
DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DR. A.A.W. | FIELD ENG. S.M. | DATE DRILLED 12/12/72 | AIRPHOTO NO: | CHAINAGE 905+00 | OFFSET 2
CKD AGP | TECH D.M. | RIG: AIR | SURFACE DRAINAGE: GOOD | VEGETATION: SPRUCE TO 25' | ELEV

TEST HOLE

MILE	E,C,S	NUMBER
460	C	99B

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0					Pt	PEAT COARSE, FIBROUS, GRANULAR	F	
1					SM	SAND BROWN, SOME SILT FEW PEBBLES GRAVELLY BROWN, SILTY		Nbn
9					GM	GRAVEL BROWN, SANDY		Nf Nbn
15						END OF HOLE		



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

PLATE 4

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRN A.E.H | FIELD ENG. B.M | DATE DRILLED 12/12/72 | AIRPHOTO NO: | CHAINAGE: 895+00 | OFFSET ℄

CKD D.G.P | TECH D.M | RIG AIR | SURFACE DRAINAGE: FAIR | VEGETATION: SPRUCE TO 25' | ELEV

TEST HOLE

MILE	B,C,S	NUMBER
459	C	98 B

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 COARSE, GRANULAR MUSKEG, MOSS, ROOTS	F								
1–7		◩			SM	SAND REDDISH, GRAVEL, SILT BROWN, GRAVEL WHITE, GRAVELLY		Nf		5	61	34			
7–15		◩			GP	GRAVEL SOME LARGE SIZES COBBLES, SILTY		Nf							
15						END OF HOLE									

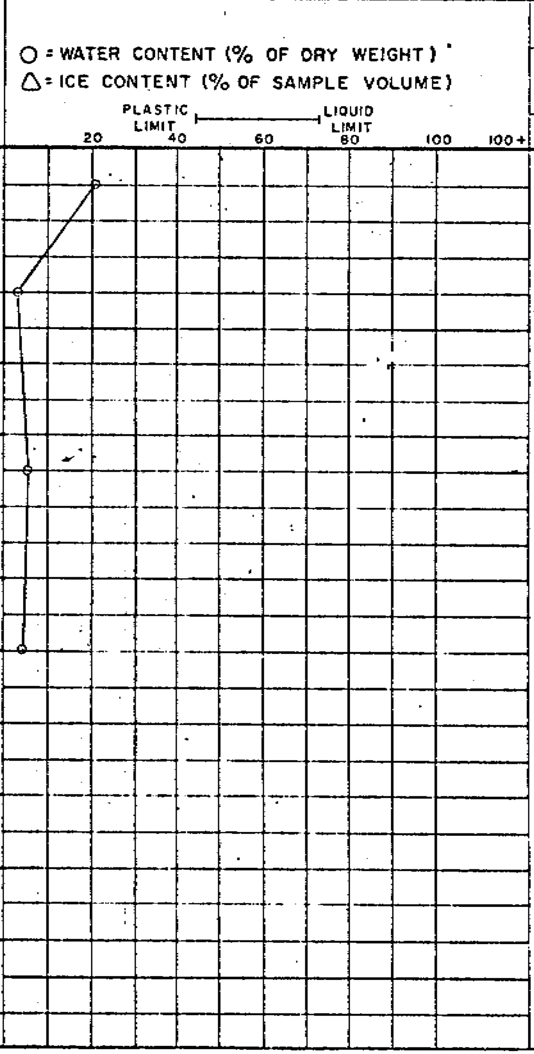


PLATE 5

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

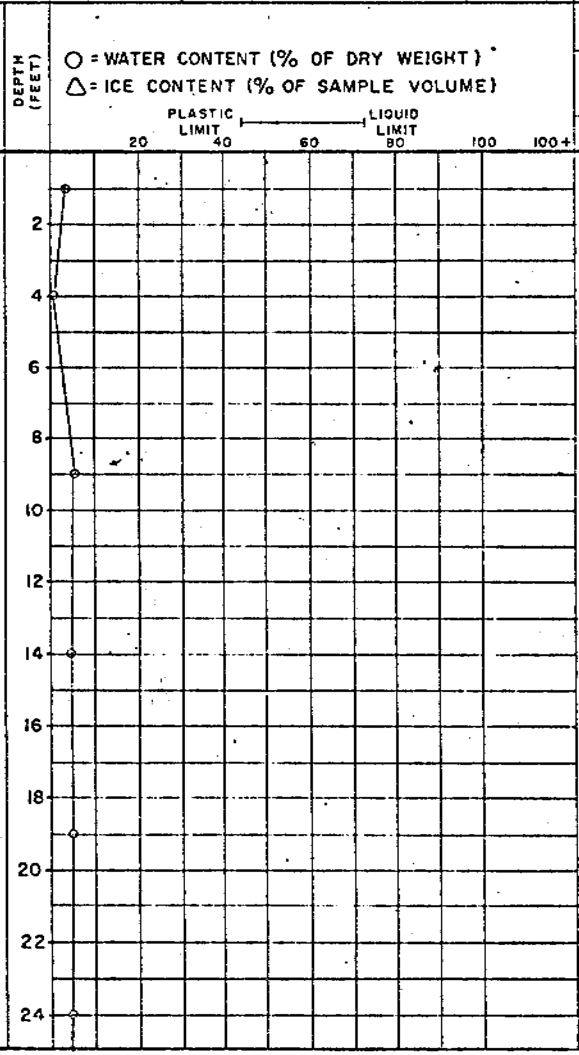
DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN A F M
FIELD ENG R S
DATE DRILLED 6/12/72
AIRPHOTO NO:
CHAINAGE: 885+00
OFFSET ℄
CKD D G P
TECH D.M
RIG AIR
SURFACE DRAINAGE: NORTH – SOUTH
VEGETATION: SPRUCE TO 25'
ELEV 3458.69

TEST HOLE

MILE	E,C,S	NUMBER
459	C	76A

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–10					GP	GRAVEL COARSE, BOULDERS SANDY, POORLY GRADED	UF	
10–24					GC	SILT SANDY WITH BOULDERS END OF HOLE @ 35'		



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

PLATE 6

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN A E W
FIELD ENG R S
DATE DRILLED 9/1/73
AIRPHOTO NO:
CHAINAGE: 885+00
OFFSET 50' E of ℄
CKD D G P.
TECH D.M.
RIG: AIR
SURFACE DRAINAGE: SOUTH
VEGETATION: CONIFER TO 50'
ELEV 3334.50

TEST HOLE

MILE	B,C,S	NUMBER
459	5	123A

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
0–2					Pt	PEAT ORGANIC	F								
4–8		P			OL	SILT FINE SAND, LITTE CLAY VERY SOFT WHEN THAWED SANDY, HARD		Nbe					113.3	88.7	
12–16		P P			CL	CLAY HARD WITH SILT AND SAND SEAMS		Vr					114.2 117.5	90.1 92.4	
20–28					SM	SAND COARSE, SANDY WITH SOME CLAY BOULDERS		Vr							
28–40					GC	TILL FIRM, CLAYEY LESS CLAY, SOFTER SILTY, DRY, COARSE SAND									
						END OF HOLE									

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

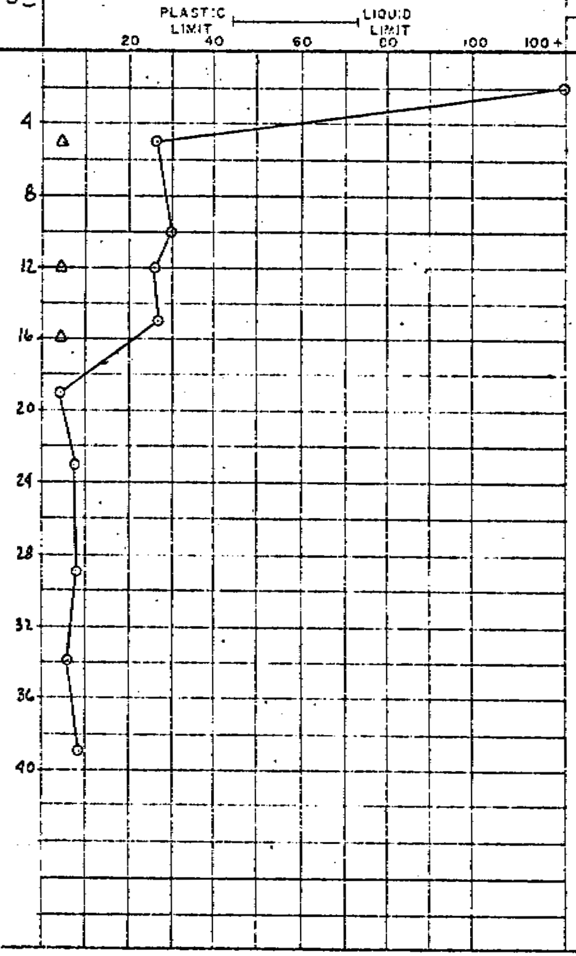


PLATE 7

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: 881+70	OFFSET
CKD DGP	TECH D.M.	RIG AIR	SURFACE DRAINAGE:	VEGETATION: CONIFER TO 30'	ELEV 293.13

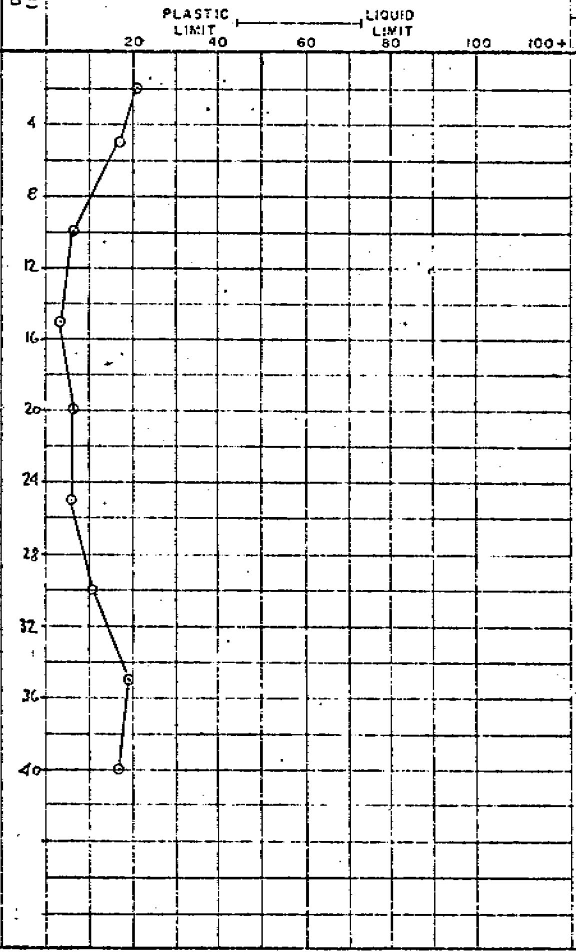
TEST HOLE

MILE	E,C,S	NUMBER
459	S	132 A

DEPTH (FEET)	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND
		PEAT - MUSKEG	F
		SILT SANDY	
4	SM	SAND DRY, SILTY	
8		HARD ROCK	
12	GM	GRAVEL SILTY, SANDY	
20			UF
28		CLAY GREY, FINE SAND	
32	GM	GRAVEL CLAYEY, COARSE	
40		END OF HOLE	

ICE DESCRIPTION

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



GRAIN-SIZE ANALYSIS

CLAY %	SILT %	SAND %	GRAVEL %
48		51	1
28		41	31
11		44	45
21		35	44
14		46	40
35		62	3
9		44	47
9		37	54

WET DENSITY (PCF)

DRY DENSITY (PCF)

REMARKS

SO_4 = 0.07%

SAND MAY BE WASHED AWAY. LOST MOST ON RISING STEM. HOLE REDRILLED TO 30' (SEE NEXT PAGE)

PLATE 8

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN A E W FIELD ENG DM
DATE DRILLED 12/1/73
AIRPHOTO NO:
CHAINAGE 661+70
OFFSET
CKD L G P TECH
RIG AIR
SURFACE DRAINAGE GOOD
VEGETATION: POPLAR & CONIFER TO 45' ELEV

TEST HOLE

MILE	E,C,S	NUMBER
459	S	132 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)

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	DEPTH (FEET)	REMARKS
					Pt	PEAT FIBROUS MUSKEG	F			
					SP	SAND FINE				
8					GP	GRAVEL SOME BOULDERS		Nbn	8	
16									16	
24					SP	SAND LITTLE CLAY			24	
32					GW	GRAVEL COARSE SAND	UF	FREE WATER	32	
40							F		40	
48						CLAY MIXED WITH SAND LENSES			48	
56									56	
64					GP	FINE, SAND LENSES SANDSTONE LAYER @ 62'		Nbn	64	
72					CH	CLAY BLUISH GREY, MED PLASTIC, SANDSTONE OR SHALE LAYERS			72	
80									80	ROCKS IN SAMPLE ARE FROM WALLS AS CLAY COMING UP.
88						SHALE VERY HARD, SAND STONE		Nbn	88	
96						END OF HOLE			96	

PLATE 8A

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN. A.E.W. FIELD ENG. R.S. DATE DRILLED 9/1/73 AIRPHOTO NO: CHAINAGE 879+70 OFFSET 50' E OF ℄

CKD D.G.P TECH: RIG: AIR SURFACE DRAINAGE: VEGETATION: CONIFER TO 40' ELEV. 295.4

TEST HOLE

MILE	E,C,S	NUMBER
459	S	124A

REMARKS

○ = 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 (PCF)	DRY DENSITY (PCF)
4					Pt	PEAT ORGANIC, GRANULAR	F UF						138.4	113.3
8 12		T P			SP	SAND FINE, MOIST			25		71	4		
16 20 24					GC	GRAVEL MED. COARSE SAND SILTY, BOULDERS CLAYEY ▽			18 32 33		45 14 25	27 54 42		
28 32 36					SC	SAND CLAYEY								
40					GC	GRAVEL CLAYEY								
44						END OF HOLE								

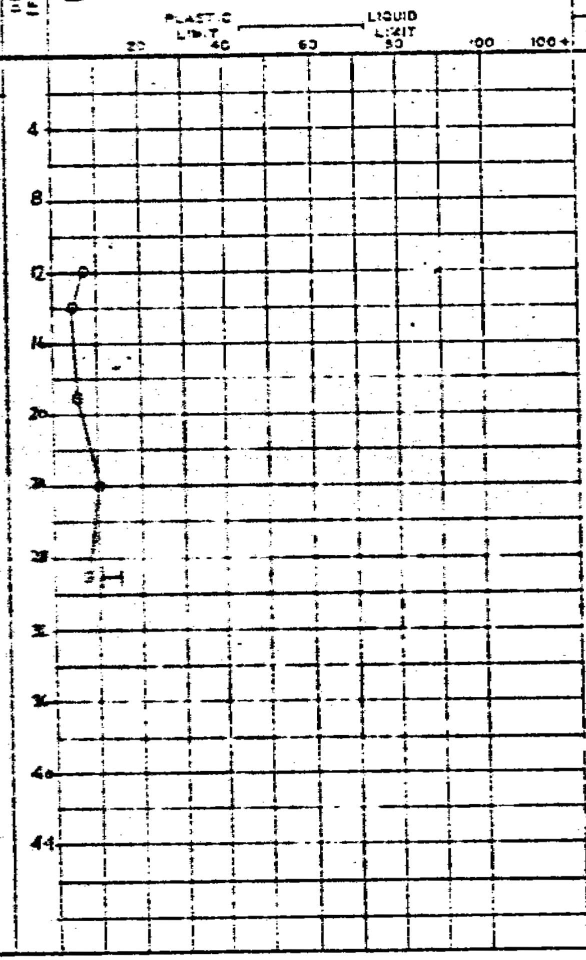


PLATE 9

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN A E W	FIELD ENG T. S.	DATE DRILLED 12/12/72	AIRPHOTO NO:	CHAINAGE 674 +00	OFFSET L
CKD GSP	TECH DM	RIG AIR	SURFACE DRAINAGE EAST TO WEST	VEGETATION: SPRUCE TO 40'	ELEV.

TEST HOLE

MILE	E,C,S	NUMBER
459	C	103A

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
					ML	SILT LIGHT BROWN, SANDY	F								
5					GM	GRAVEL LIGHT BROWN, SANDY SILTY		Nf							
10 15 20 25					SP	SAND BROWN, MED COARSE SOME GRAVEL, DRY SANDY		Nf	3		60	37			
30 35 40					GC	GRAVEL BROWN, COARSE, SOME CLAY									
45					GP	FINE, BROWN		Nf							
50 55					GC	CLAY BROWN, SANDY, GRAVEL COARSER WITH DEPTH		Nf							
60						END OF HOLE									

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

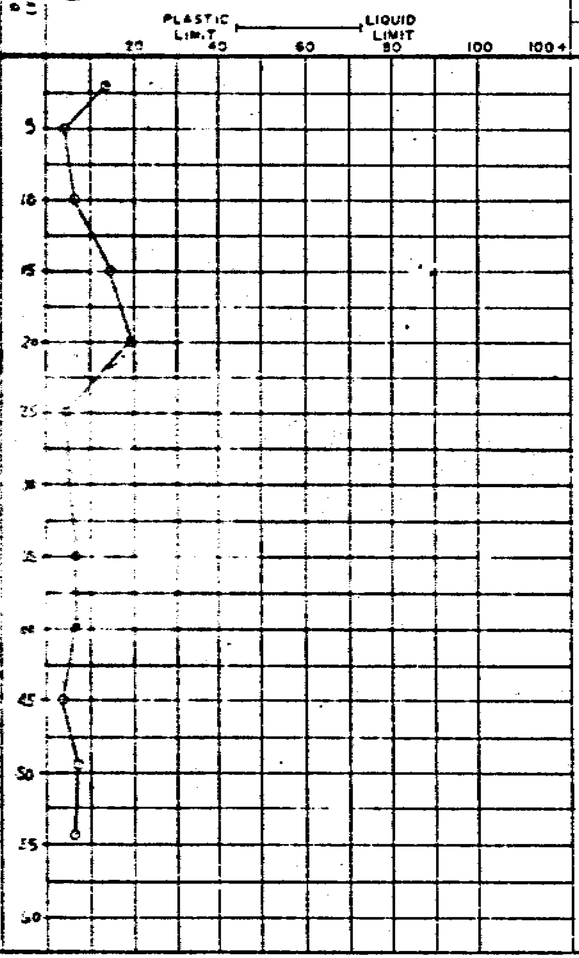


PLATE 10

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

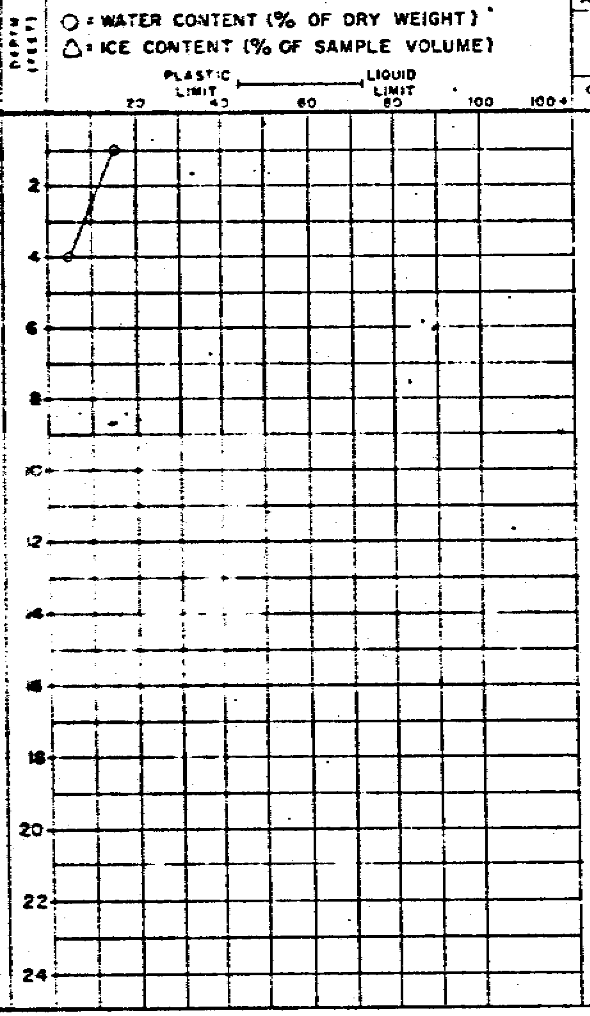
DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DAN: A.E.W. | FIELD ENG: B.M. | DATE DRILLED: 8/12/72 | AIRPHOTO NO.: | CHAINAGE: 865+00 | OFFSET: ℄
CKD: D.G.P. | TECH: D.M. | RIG: AIR | SURFACE DRAINAGE: FAIR | VEGETATION: SPRUCE & ASPEN | ELEV:

TEST HOLE

MILE	S,C,S	NUMBER
459	C	818

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT - COARSE, FIBROUS, MOSS ROOTS	F	
2					SP	SAND - FINE, SOME GRAVEL DRY		Nbe
4 6 8 10					GP	GRAVEL SOME SAND, DRY		Nf
12 14 16 18 20 22 24						END OF HOLE		



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

PLATE 11

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

DWN: ? E.W
FIELD ENG: B.M
DATE DRILLED: 8/12/72
AIRPHOTO NO:
CHAINAGE: 855+00
OFFSET: ℄
CKD: D.G.P
TECH: DM.
RIG: AIR
SURFACE DRAINAGE: Good
VEGETATION: SPRUCE & POPLAR To 25'
ELEV:

TEST HOLE

MILE	S,C,S	NUMBER
159	C	80B

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						SILT	F								
2						FINE SAND		Vr							
4					SM								96.8	69.0	
6						FINE, SANDY							102.2	74.1	
9								Vr	4		17	79			
10					SP	SAND COARSE, GRAVELLY		Nf							
13					SM	SAND SILTY, LITTLE CLAY TRACE OF GRAVEL		Nf							
15						END OF HOLE									

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

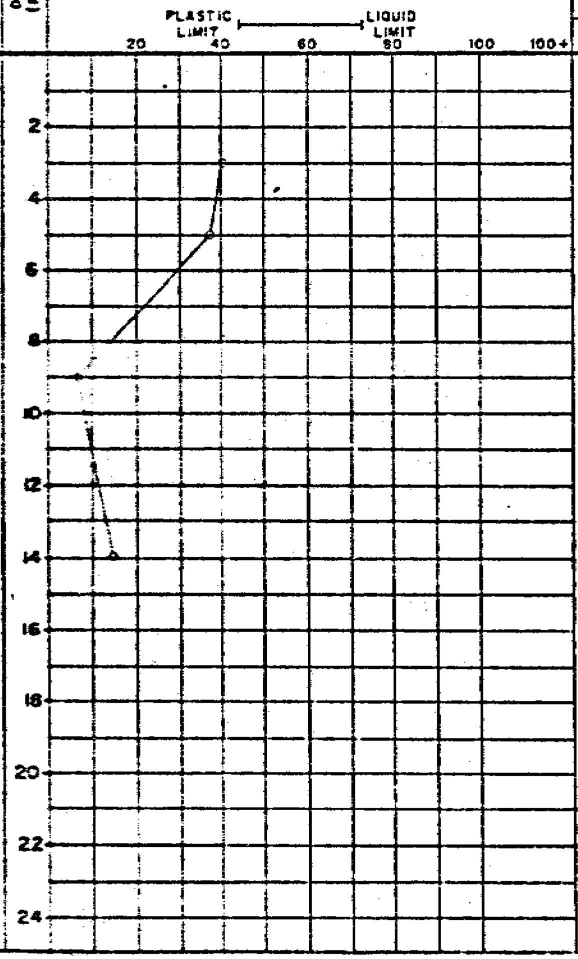


PLATE 12

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

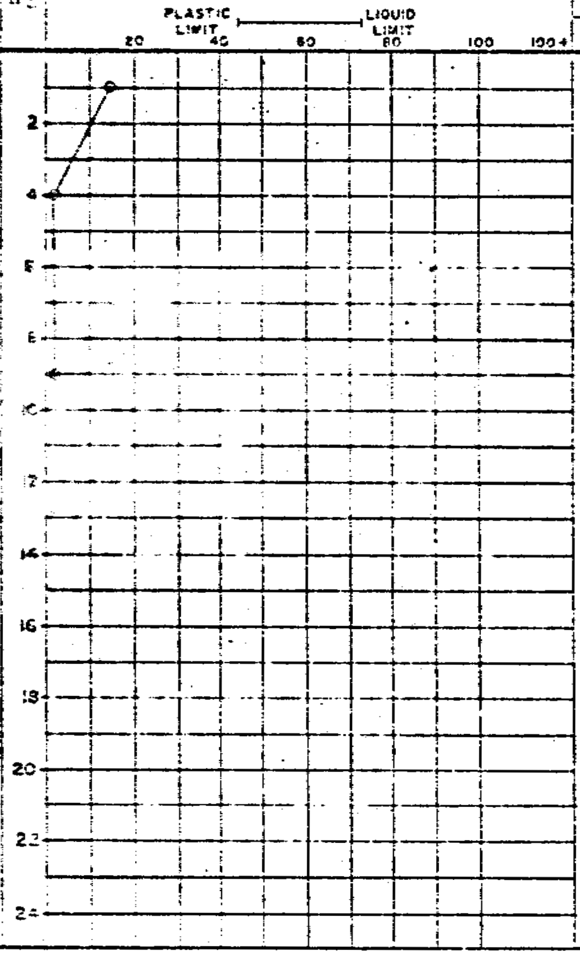
DRN A.E.W
FIELD ENG. B.M
DATE DRILLED 9/11/73
AIRPHOTO NO.
CHAINAGE 391+00
OFFSET ℄
CKD D G P.
TECH D M
RIG AIR
SURFACE DRAINAGE GOOD
VEGETATION: SPRUCE & ASPEN TO 25'
ELEV

TEST HOLE

MILE	E,C,S	NUMBER
453	B	156B

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
						GRAVEL ½" ORGANIC	F	
2					GM		UF	
						SILTY, SANDY		
4								
6								
8						VERY HARD FINE SAND		
					GP			
10								
						END OF HOLE		
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 (PCF)	DRY DENSITY (PCF)	REMARKS

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

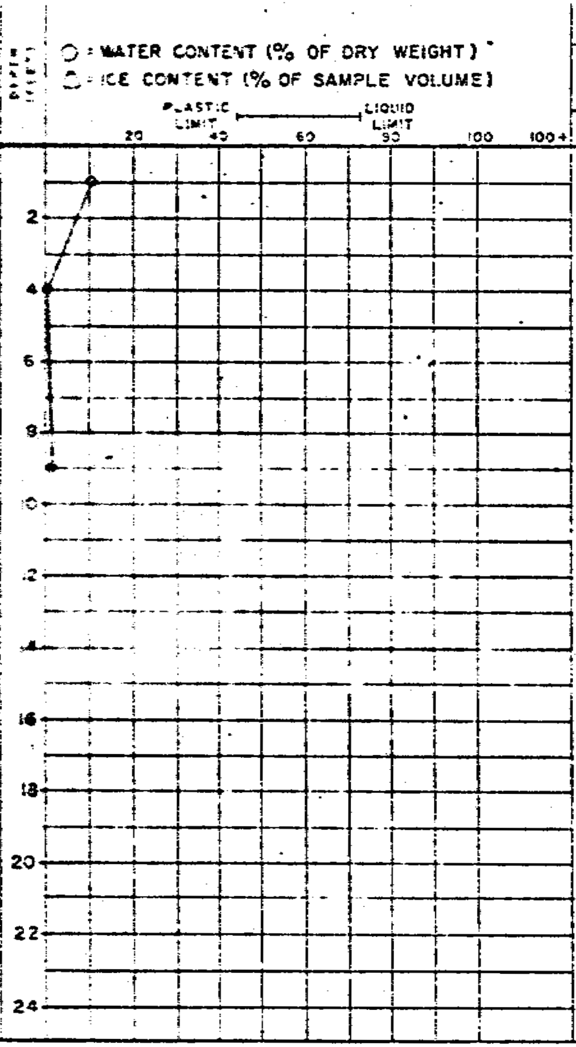
DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN A.E.W FIELD ENG. B M DATE DRILLED 9/1/73 AIRPHOTO NO. CHAINAGE 891+00 OFFSET 2
CKD D6P TECH D.M RIG AIR SURFACE DRAINAGE GOOD VEGETATION: SPRUCE TO 30' ELEV.

TEST HOLE

MILE	S,C,S	NUMBER
459	B	1578

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–1						GRAVEL	F	
1–2		⊠					UF	
4		⊠				SANDY, SOME SILT		
9–10		⊠				FINE SAND, VERY HARD FROM 9½		
10						END OF HOLE		



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

PLATE 14

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN A.E.W
FIELD ENG B.M
DATE DRILLED 9/1173
AIRPHOTO NO.
CHAINAGE E91+00
OFFSET ℄
CKD D.G.P.
TECH DM
RIG AIR
SURFACE DRAINAGE GOOD
VEGETATION SPRUCE, POPLAR & BIRCH
ELEV

TEST HOLE

MILE	B,C,S	NUMBER
459	B	158E

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
					GM	GRAVEL	F								
2						SILT, SAND	UF								
4															
6					GW										
8					GP	VERY HARD FINE SAND									
10						END OF HOLE									
12															
14															
16															
18															
20															
22															
24															

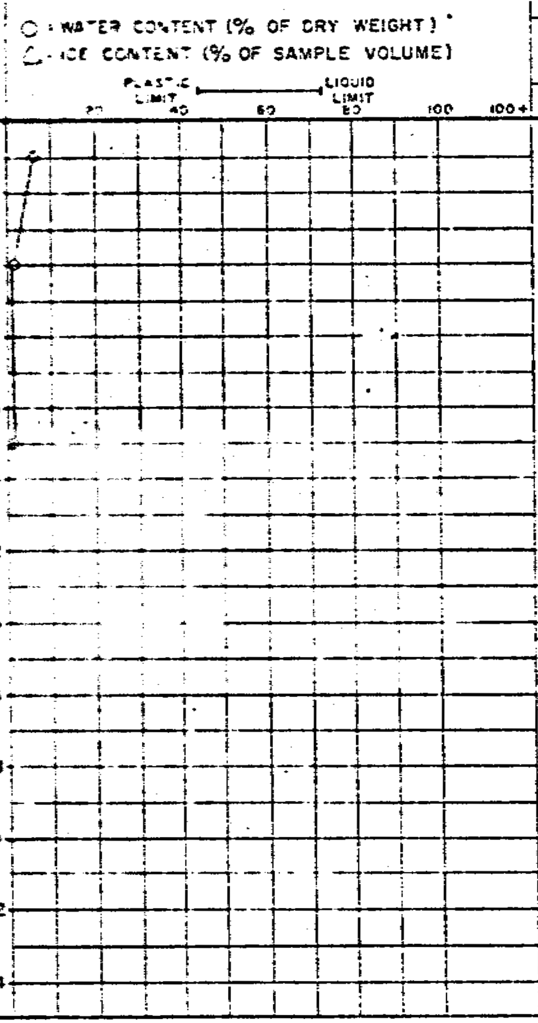


PLATE 15

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

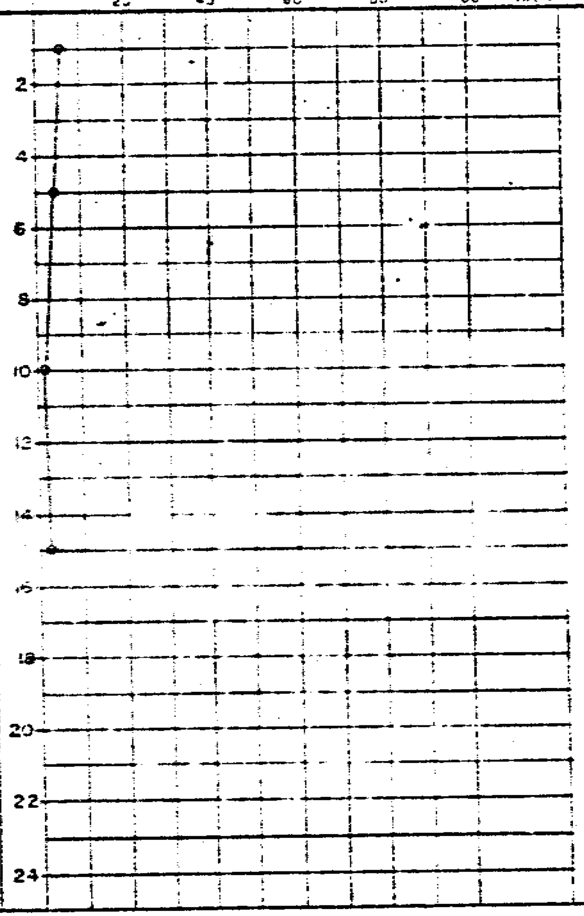
DRN A.E.W
FIELD ENG R S
DATE DRILLED 9/1/73
AIRPHOTO NO:
CHAINAGE: 871+00
OFFSET ℄
CKD D6P
TECH: D.M.
RIG: AIR
SURFACE DRAINAGE:
VEGETATION: CONIFER TO 60'
ELEV

TEST HOLE

MILE	C.C.S	NUMBER
459	B	125 A

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0					Pt	PEAT – MUSKEG	F	
1–2		◪			GM	GRAVEL FINE SILT	UF	
5–6		◪				MED. COARSE SAND WITH BOULDERS		
					To			
10–11		◪				COARSE SAND		
13					GP			
14–15		◪						
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.)	REMARKS

PLATE 16

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

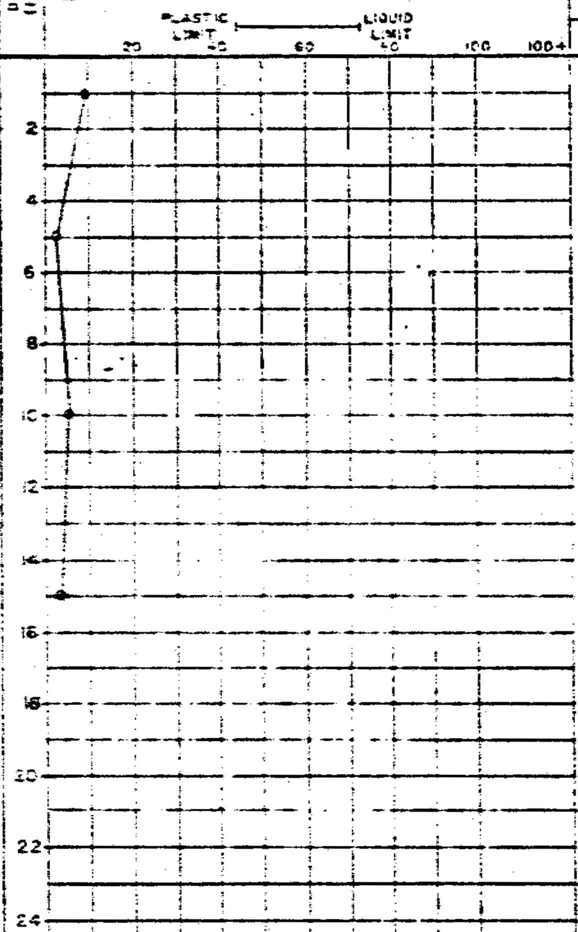
DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN A.E.W	FIELD ENG. R.S	DATE DRILLED 9/1/73	AIRPHOTO NO:	CHAINAGE 871+00	OFFSET ℄
CKD D.G.P	TECH: D.S	RIG: AIR	SURFACE DRAINAGE:	VEGETATION: CONIFER To 60'	ELEV.

TEST HOLE

MILE	B,C,S	NUMBER
459	B	126A

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)
0						PEAT MUSKEG								
1					GM	GRAVEL FINE, DRY	F							
2							UF							
7.5					SP	SAND MED FINE TRACES OF GRAVEL								
10									13		35	52		
15						END OF HOLE								



REMARKS

PLATE 17

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN A.E.W | FIELD ENG. T.S | DATE DRILLED 9/1/73 | AIRPHOTO NO: | CHAINAGE: 871+00 | OFFSET ℄

CKD DGP | TECH: DM | RIG: AIR | SURFACE DRAINAGE | VEGETATION: SPRUCE TO 60' | ELEV

TEST HOLE

MILE	C,C,S	NUMBER
459	B	127A

DEPTH (FEET)	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0	GRAVEL	F	
2	SANDY, SILTY		
4–5		UF	
8	SANDY		
15	LOOSE, SANDY SOME COBBLES		
21	SOME SILT		
23	END OF HOLE		

Columns also printed: SAMPLE NUMBER, SAMPLE TYPE, % RECOVERY, PENETRATION RESISTANCE, UNIFIED SOIL SYMBOL; GRAIN-SIZE ANALYSIS: CLAY %, SILT %, SAND %, GRAVEL %; WET DENSITY (P.C.F.); DRY DENSITY (P.C.F.); REMARKS

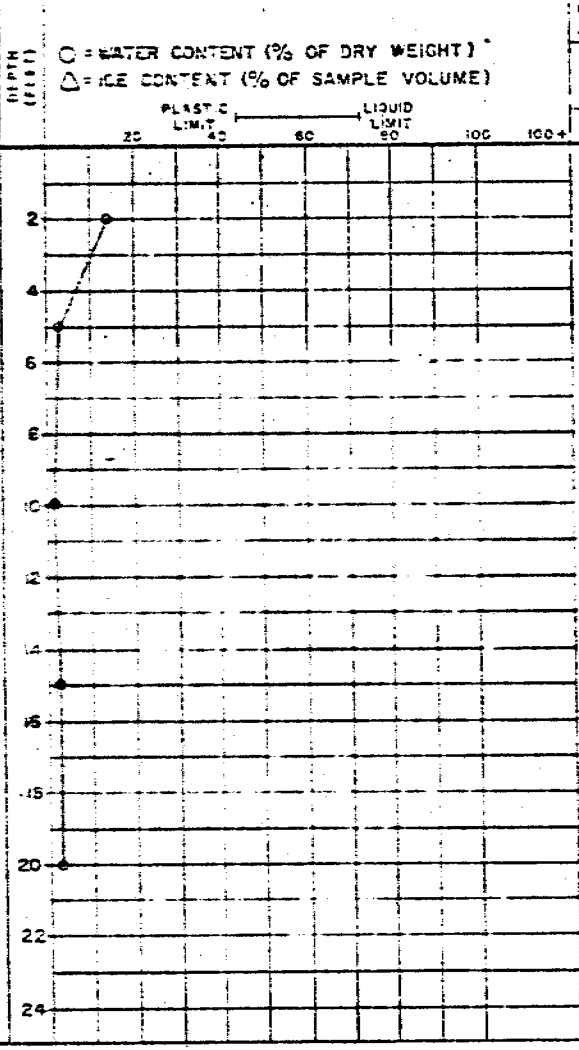


PLATE 18

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN A.E.W. | FIELD ENG BM | DATE DRILLED 9/1/73 | AIRPHOTO NO | CHAINAGE 831+00 | OFFSET 300' E of ℄

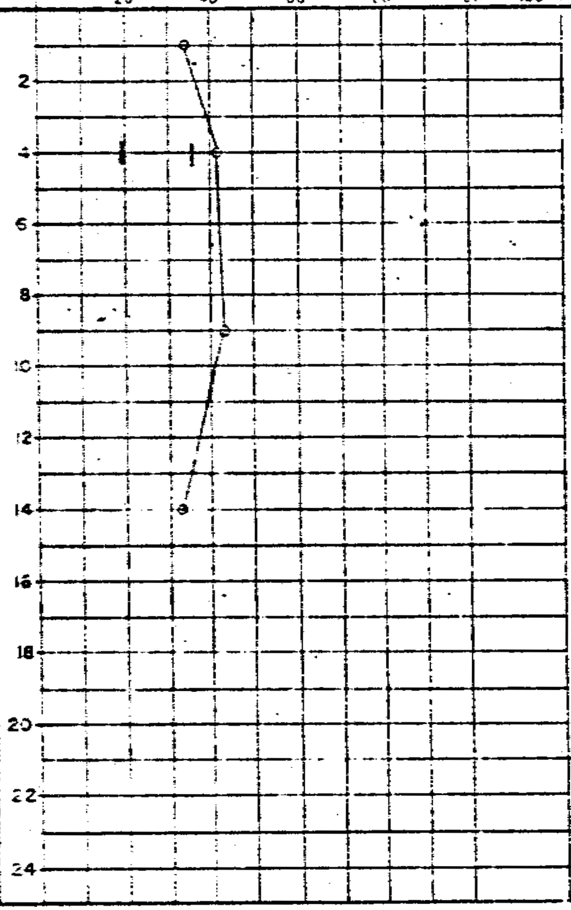
CKD DGP | TECH DM | RIG AIR | SURFACE DRAINAGE FAIR | VEGETATION SPRUCE TO 35' | ELEV

TEST HOLE

MILE	B,C,S	NUMBER
458	B	159 B

REMARKS

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
					Pt	PEAT - FINE FIBROUS, MUSKEG	F	
					CL	CLAY SILTY, ROOTS TO 2' MOIST, GREY, TILL LIKE, SOME EXCESS ICE		Nbe
						END OF HOLE		



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

PLATE 19

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN. A.E.W.	FIELD ENG. B.M.	DATE DRILLED 9/1/73	AIRPHOTO NO.	CHAINAGE 831400	OFFSET 300' E OF ℄
CKD D.G.P.	TECH. DM	RIG AIR	SURFACE DRAINAGE F.F. R	VEGETATION SPRUCE TO 35'	ELEV.

TEST HOLE

MILE	B,C,S	NUMBER
459	B	1606

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
0–1					Pt	PEAT - FINE FIBROUS, MUSKEG	F								
1–8.5		P P			CL	CLAY GREY, SILTY, VERY HARD, FINE SAND, SOME WOOD FIBRE		Vr EXCESS ICE < 5%					99.5	71.0	
8.5–12.5		P			SM	SAND SOME SILTY CLAY		Vr					95.1	62.9	
12.5–15		P			CL	CLAY SILTY		EXCESS ICE < 5% Vr					105.9	76.8	
15						END OF HOLE									

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

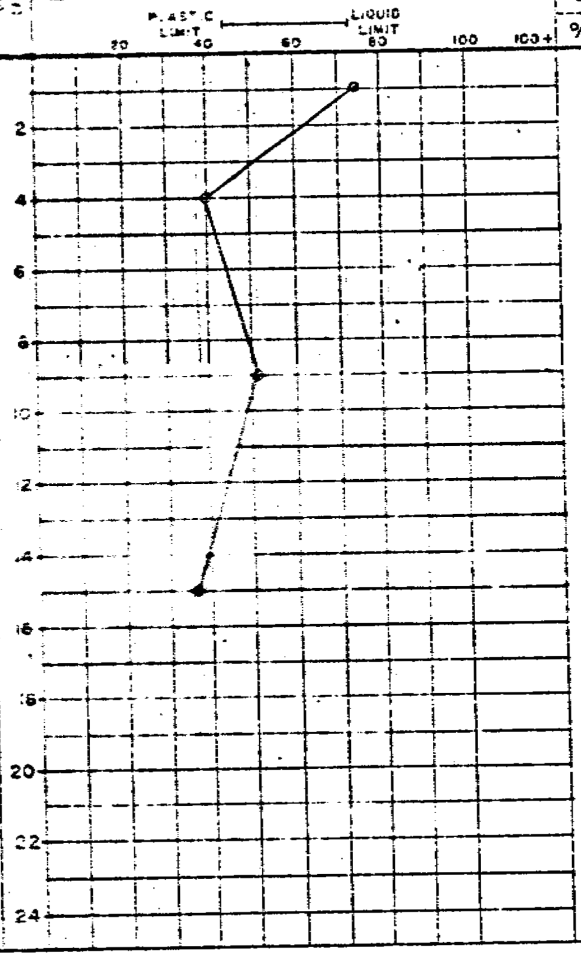


PLATE 20

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

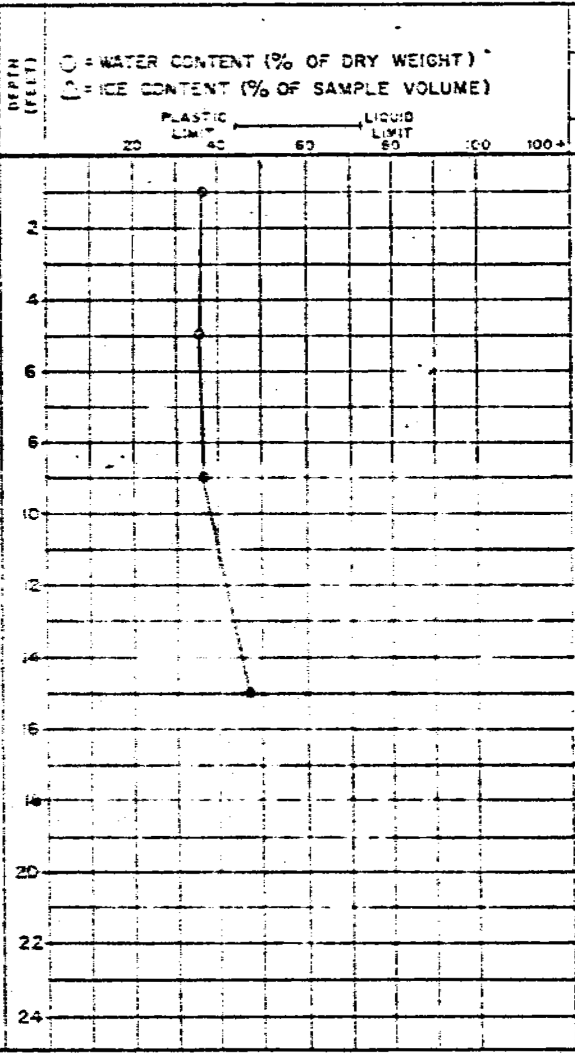
DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

TEST HOLE

MILE	E,C,S	NUMBER
458	B	161 B

DWN: A.E.W
FIELD ENG: B.M
DATE DRILLED: 9/1/73
AIRPHOTO NO:
CHAINAGE: 831+00
OFFSET: 300' E OF ℄
CKD: D.G.P.
TECH: D.M
RIG: AIR
SURFACE DRAINAGE: FAIR
VEGETATION: SPRUCE TO 35'
ELEV:

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)	REMARKS
0–1						PEAT FINE, FIBROUS, MUSKEG	F		107.8	78.8	
1–2		◺				CLAY VERY HARD, SOME SILT,		Vr			
3–5						SILTY, LITTLE SAND		EXCESS ICE <5%			
5		P							[illegible]	[illegible]	
9		P				SOME WOOD FIBRE CHIPS FIRM			[illegible]	[illegible]	
14						SAND LENSE – 9"		EXCESS ICE <5% Vr			
15		P							[illegible]	[illegible]	
16						END OF HOLE					



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

PLATE 21