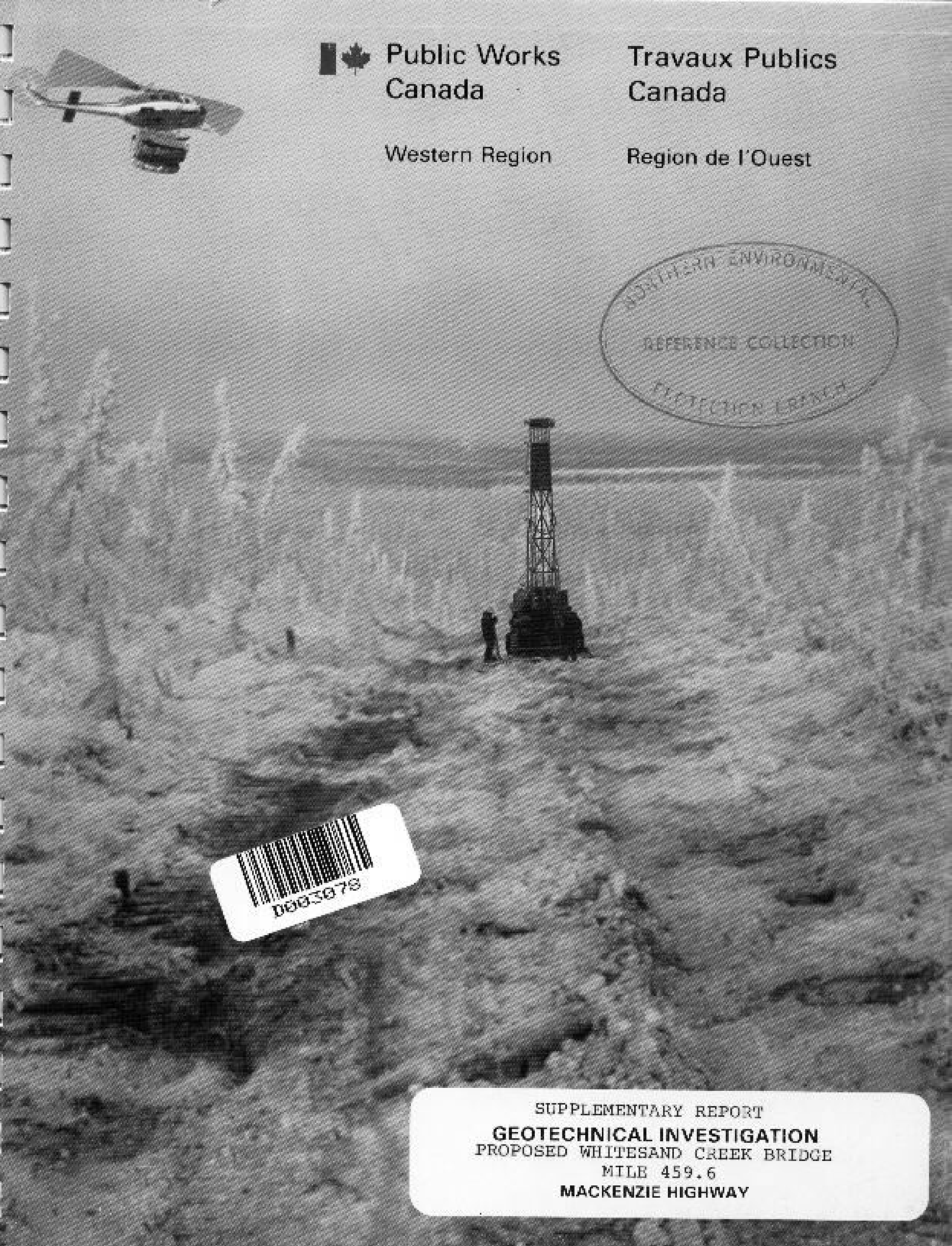
Public Works Canada | Travaux Publics Canada

Western Region | Region de l'Ouest



SUPPLEMENTARY REPORT

GEOTECHNICAL INVESTIGATION
PROPOSED WHITESAND CREEK BRIDGE
MILE 459.6
MACKENZIE HIGHWAY

PUBLIC WORKS CANADA

WESTERN REGION

SUPPLEMENTARY REPORT
FOUNDATION INVESTIGATION
PROPOSED WHITESAND CREEK BRIDGE
MILE 459.6, MACKENZIE HIGHWAY

Submitted By

R. D. Cook
Soils Engineer
Special Services
Western Region

February 2, 1976

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APPENDICES

I Preliminary

The initial foundation investigation at Whitesand Creek was undertaken by Underwood McLellan & Associates Ltd. during the winter of 1973, and summarized in a foundation report dated April, 1973. Pertinent excerpts from that report have been included herein, however this report should be considered as an addendum to the original report by Underwood McLellan and reviewed in conjunction with it.

Five test holes were drilled by Public Works Canada at the proposed crossing site in February, 1975 to augment the initial subsoil data. A profile of the site showing boreholes from both drilling programmes and the inferred subsoil stratigraphy has been included on Drawing No. A-1 in Appendix A, and borehole logs are included in Appendix B. The proposed gradeline, and the locations of piers and abutments as recommended by the bridge consultants (Reid, Crowther & Partners Ltd.) have also been shown on the profile.

II Subsoil Conditions and Foundation Recommendations - Underwood, McLellan & Associates

The following 10 pages are taken from the foundation report by Underwood McLellan and refer only to the subsoil conditions as inferred from boreholes by their crews, and the foundation recommendations for the bridge structure based upon that information.

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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.

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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

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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

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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.

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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

... 8

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

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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

... 10

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

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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.

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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.

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III Evaluation of Additional Borehole Data

With reference to Drawing No. A-1 in Appendix A, the 1975 boreholes confirm in general the subsoil stratigraphy as inferred from the 1973 boreholes. However there is some discrepancy in the extent of permafrost below the site.

Hole #132A was drilled by UMA immediately adjacent to the stream channel on the south and indicated permafrost to a depth of 90 feet with the exception of a thin (2') thaw zone at a depth of 30' where free water was encountered. This hole generally encountered sands and gravels to a depth of 60' with clay-shale below.

Hole #124A was also drilled by UMA some 225' south of the stream channel and reported no permafrost under 6 feet of peat with the water table near 22'.

Past experience in permafrost terrain would suggest that, if continuously frozen ground were to be encountered in either of these two holes, it would be expected in the hole farthest from the stream channel and under the insulating blanket of peat - that is hole #124A. Both holes by UMA utilized drilling mud which would make absolute confirmation of permafrost very difficult.

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Three holes were drilled by D.P.W. on the south side of the channel, and although the holes were relatively shallow - 15 feet - they indicated only surface frost and no permafrost. The upper subsoil adjacent to the stream on the south consists of very dry, cohesionless deposits and it is very difficult to detect the presence or absence of permafrost from drill cuttings as there is no visible ice. However the presence of free water at depth in both holes by UMA would suggest unfrozen subsoil on the south side of the channel. In addition, Whitesand Creek was not frozen over in mid-February 1975, which would indicate the water is relatively warm and would provide a year-round source of heat to promote thawing below the channel. It is therefore considered likely that there is a substantial, if not complete, thaw zone below the stream channel.

Unfortunately there were no boreholes advanced immediately adjacent to the Creek on the north as access would have required considerable dozer work to prepare a crossing over the open stream, and,because the D.P.W. rig was not equipped for drilling with 'mud', the probability of advancing a deep hole was remote.

Boreholes by both UMA and DPW confirm the presence of a basal till in the lower valley wall on the north, however the nearest borehole is roughly 100 feet from the stream channel. It is

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assumed there is a relatively steep till - sand, gravel, interface at approximately the location of the north bridge abutment as shown on Drawing No. A-1, however the exact location of this interface is unknown.

IV Foundation Recommendations

Underwood, McLellan & Associates have basically recommended steel piling for the foundation elements and this is concurred with. Steel H-piles are considered the most practical for the soil conditions, and, as there is no indication of subsoil density, it should be assumed the piles can be driven to refusal on the bedrock below elevation 220. It is quite possible that practical refusal could be attained in the gravel above elevation 220, thus an excess of H-piling may result on the job, however it undoubtedly will be suitable for use on other bridge structures on the Mackenzie Highway.

A heavy section - 10BP57 - should be used, as some hard driving may be expected at least in the upper 15-20' where cobbles and boulders are present. The hammer used should have a ram at least as heavy as the piling in order to impart relatively high energy - low velocity blows to the piling - an energy of roughly 20,000 ft. lbs. per blow is recommended.

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It will be necessary to drill at least one additional test hole on the north side of the creek before construction to confirm the subsoil and permafrost conditions below the north pier and abutment, and to ensure that sufficient piling equipment is brought to the site to adequately install the piles. It is considered likely that permafrost will be largely absent below the crossing site, however if permafrost does occur it will probably be present in the clay till on the north side rather than in the permeable sands and gravels below the channel and on the south. Any permafrost that is present should be near a temperature of 0°C, and it may be possible to gain penetration through the frozen till to bedrock with H-piles and a heavy hammer for safe bearing, although available experience in driving piles into frozen soils has generally been negative. It would likely be impossible to gain sufficient penetration for safe bearing into frozen sands and gravels even near a temperature of 0°C. Thus additional test drilling would ensure that adequate equipment for pile installation could be brought to the construction site. If the subsoil on the north side of the creek is glacial till and permafrost is present it will be necessary to pre-bore pile holes through the permafrost zone, or to the bedrock surface, and drive the piles to refusal below the base of the lead hole. If the subsoil is frozen sand and gravels either pre-boring or pre-steaming could be utilized to ensure adequate penetration.

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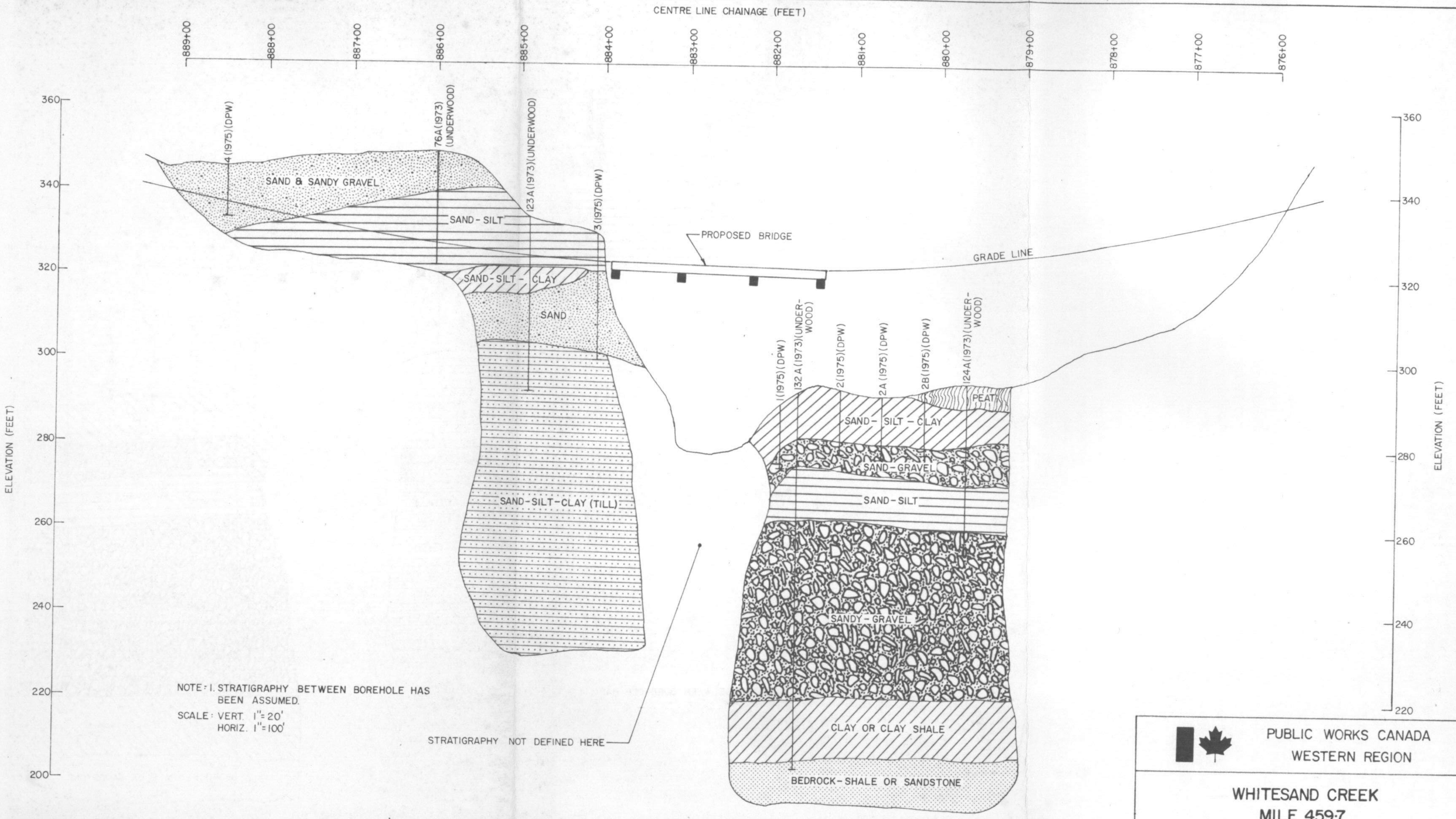
Piles driven to refusal as defined by U.M.A. may be designed for the full structural strength of the pile section acting as a column. Underwood, McLellan have recommended a pile load test, however this is considered unnecessary and impractical at this site because of the small number of piles required and the variable subsoil and permafrost conditions. It is recommended the bridge piers and abutments be designed assuming the bearing elements will be H-piles driven to refusal - subsequent test borings will determine exactly how the piles will be installed to ensure long term 'refusal'.

Additional borings will require a rotary rig outfitted for drilling with "drilling mud" to maintain an open hole in the granular soils, or a rig that advances a cased hole, such as the Becker rig. A dozer will be required to prepare access to the north side of the creek.

RDCook.
R. D. Cook, P. Eng.
Soils Engineer
Special Services
Western Region



NOTE: 1. STRATIGRAPHY BETWEEN BOREHOLE HAS BEEN ASSUMED.

SCALE: VERT. 1" = 20'
HORIZ. 1" = 100'

PUBLIC WORKS CANADA
WESTERN REGION

WHITESAND CREEK
MILE 459·7
MACKENZIE HIGHWAY

DWG NO A-1

SOUTH BANK WHITE SAND CREEK # 1

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

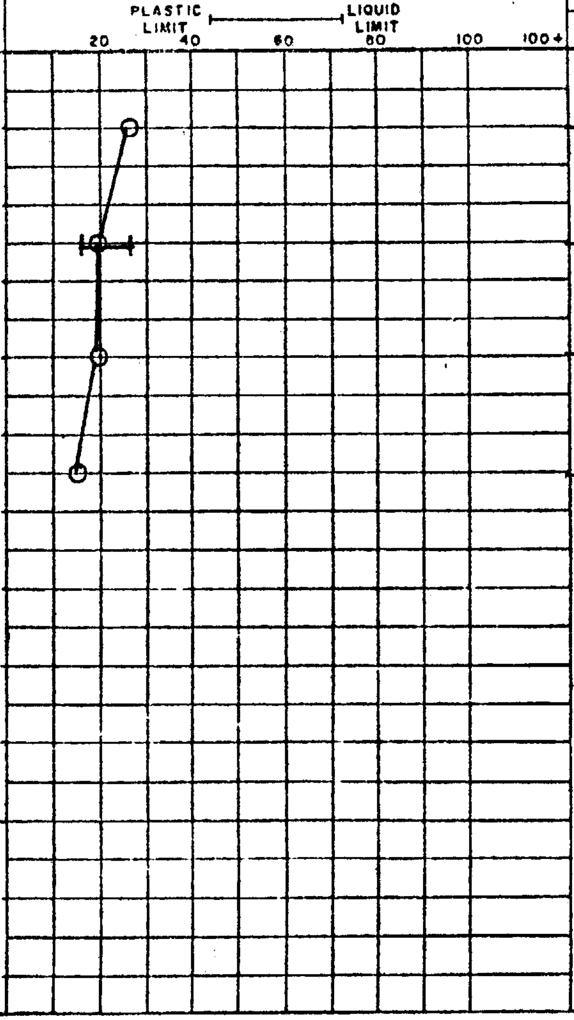
DWN
CKD
FIELD ENG
TECH REYNOLDS
DATE DRILLED 28/2/75
RIG AIR
AIRPHOTO NO:
SURFACE DRAINAGE:
CHAINAGE:
VEGETATION SPRUCE 14"
OFFSET
ELEV

TEST HOLE

MILE	B,C,S	NUMBER

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	DEPTH (FEET)	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)	REMARKS
					Pt	PEAT										
2						CLAY - SILTY SANDY	F	Vx	2	-80-		20	0	DAMP		
4									4							
						LOW PLASTIC				-58-		42	0	DAMP		
6									6							
					CL											
8									8	-70-		30	0	DAMP		
10									10							
										-57-		42	1	DAMP		
12									12							
14									14							
						15										
16						BOTTOM OF HOLE - 15'			16							
18						LOST CIRCULATION @ 15'			18							
20									20							
22									22							
24									24							

R073

WHITE SAND CREEK # 2

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

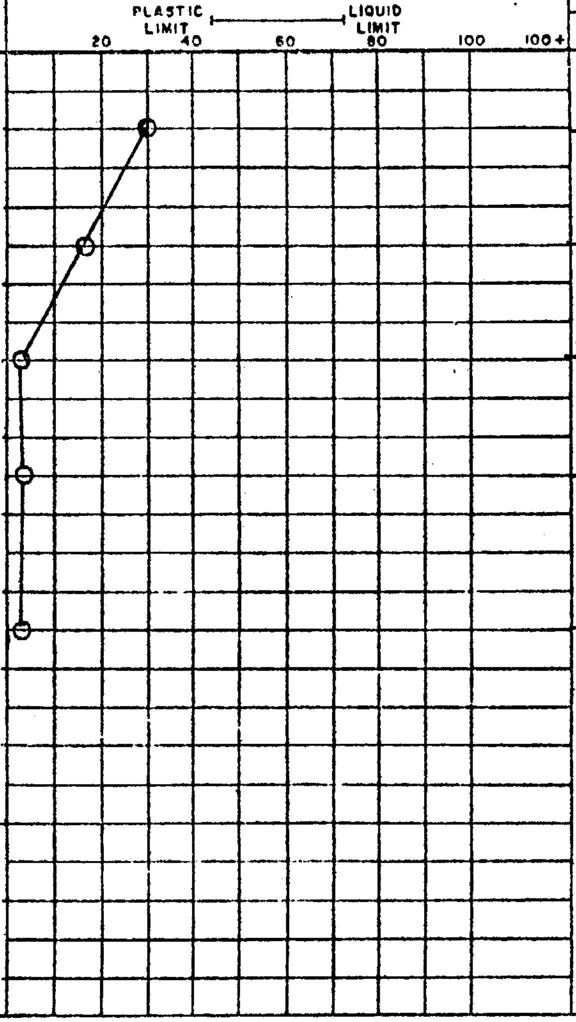
DWN	FIELD ENG.	DATE DRILLED 1/3/75	AIRPHOTO NO:	CHAINAGE:	OFFSET 50' SOUTH OF # 1
CKD	TECH REYNOLDS	RIG: AIR	SURFACE DRAINAGE:	VEGETATION:	ELEV

TEST HOLE

MILE	B,C,S	NUMBER

○ = 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	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (P.C.F.)	DRY DENSITY (P.C.F.)	REMARKS
					Pt	PEAT 1'									
2					CL	CLAY - SILTY SANDY			84-		16	0	WET		
4							F		69-		31	0	DAMP		
6						6' SAND - GRAVELLY									
8					SM				7[illegible]-		66	27	DAMP		
10						SILTY - PEBBLES			12-		84	4	DAMP		
12					GM	GRAVEL - SANDY SILTY 15'									
14									24-		30	46	DAMP		
16						BOTTOM OF HOLE - 15'									
18															
20															
22															
24															

R073

SOUTH BANK WHITE SAND CREEK # 2B

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

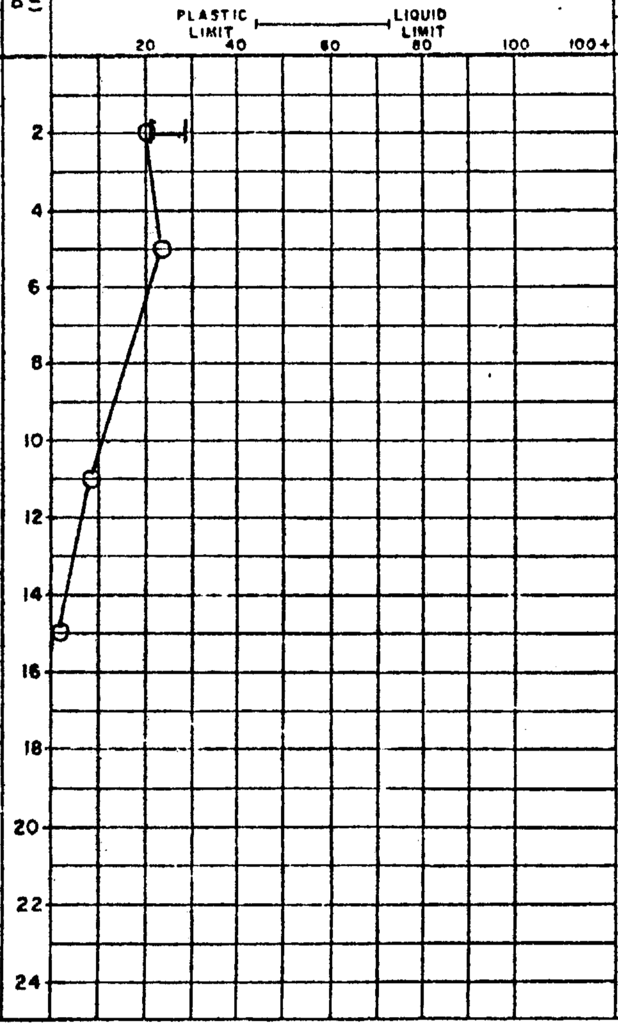
DWN
CKD
FIELD ENG
TECH REYNOLDS
DATE DRILLED 1/3/73
RIG: AIR
AIRPHOTO NO:
SURFACE DRAINAGE:
CHAINAGE:
VEGETATION: SPRUCE 12"
OFFSET
ELEV

TEST HOLE

MILE	B,C,S	NUMBER

O = 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 (P.C.F.)	REMARKS
					Pt	PEAT									
2						2'			97-		3	0	DAMP		
					CL	CLAY - SILTY		?							
4					ML	SILT - CLAYEY									
									90-		10	0	DAMP		
6															
8						8'			51-		39	10	H.I.3		
					ML	SILT - SANDY PEBBLES									
10															
					SM	SAND - SILTY - PEBBLES			28-		65	7	DAMP		
12															
14															
						15'			13-		76	11	H.I.13		
16						BOTTOM OF HOLE - 15'									
18															
20															
22															
24															



R073

WHITE SAND CREEK #3

DRILL HOLE REPORT

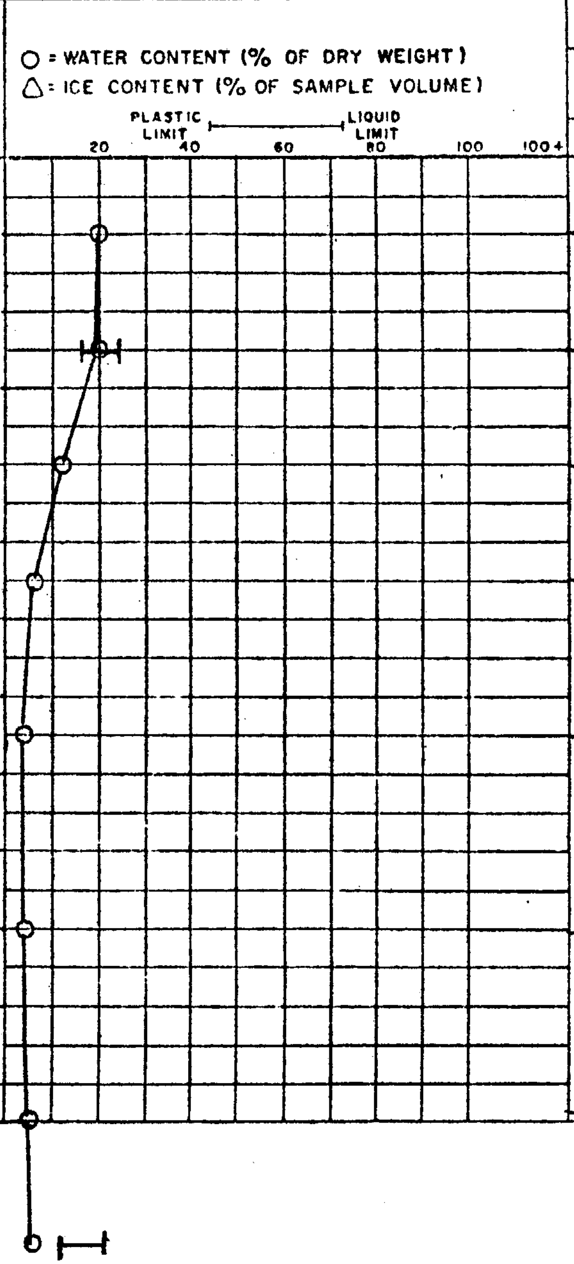
DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN
FIELD ENG
DATE DRILLED 1 3 75
AIRPHOTO NO:
CHAINAGE:
OFFSET
CKD
TECH REYNOLDS
RIG: AIR
SURFACE DRAINAGE:
VEGETATION SPRUCE 10'
ELEV

TEST HOLE

MILE	B,C,S	NUMBE

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
					Pt	PEAT 1'										
2						SILT-CLAYEY SANDY			2	72	-	28	0	WET		
4							F	Vx	4							
					ML					89	-	11	0	DAMP		
6									6							
8									8	61	-	38	1	DAMP		
						9'										
						SAND-SILTY GRAVELLY										
10									10							
										30	-	54	16	DAMP		
12									12							
14									14							
										18	-	59	23	DAMP		
16					SM				16							
18									18							
								FROZEN?								
20									20	29	-	71	0	HUMID		
							F?									
22									22							
24									24							
										47	-	53	0	HUMID		



R073

CL CLAY-SANDY SILTY
PEBBLES

BOTTOM OF HOLE-30'

-55-40-5 HUMID

WHITE SAND CREEK #4

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

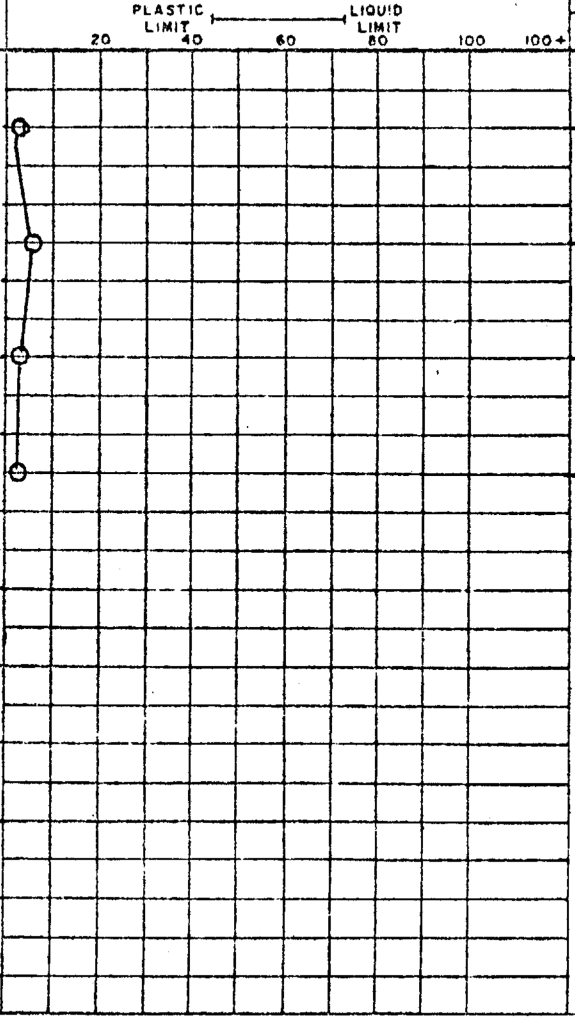
DWN	FIELD ENG	DATE DRILLED 28/2/75	AIRPHOTO NO:	CHAINAGE:	OFFSET
CKD	TECH CURRIE	RIG AUGER	SURFACE DRAINAGE:	VEGETATION: POPLAR	ELEV

TEST HOLE

MILE	B,C,S	NUMBER

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
					Pt	PEAT 1'										
2						GRAVEL - SANDY			2	10	-	43	47	DAMP		
4									4							
										9	-	20	71	DAMP		
6					Gw				6							
8									8	7	-	57	36	Moist		
10									10							
										4	-	38	58	Moist		
12									12							
						13'										
14						BOTTOM OF HOLE - 13'			14							
16						REFUSAL · 13'			16							
18									18							
20									20							
22									22							
24									24							

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



UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

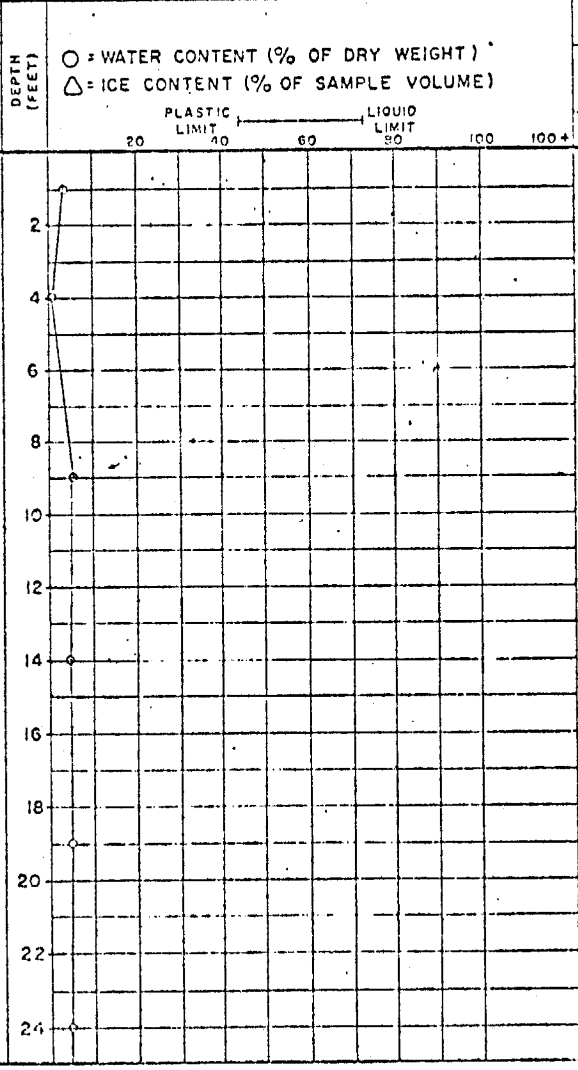
DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN A.F. | FIELD ENG. R.S. | DATE DRILLED 6/12/72 | AIRPHOTO NO: | CHAINAGE: 836+00 | OFFSET ℄
CKD [illegible] | TECH D.M. | RIG AIR | SURFACE DRAINAGE: NORTH – SOUTH | VEGETATION: SPRUCE TO 25' | ELEV 345.69

TEST HOLE

MILE	S,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
						GRAVEL	UF	
2		⧅				COARSE, BOULDERS		
4		⧅			GP			
6						SANDY, POORLY GRADED		
8								
10		⧅				SILT		
12								
14		⧅						
16					GC	SANDY WITH BOULDERS		
18								
20		⧅						
22								
24		⧅				END OF HOLE @ 35'		



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

PLATE 6

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

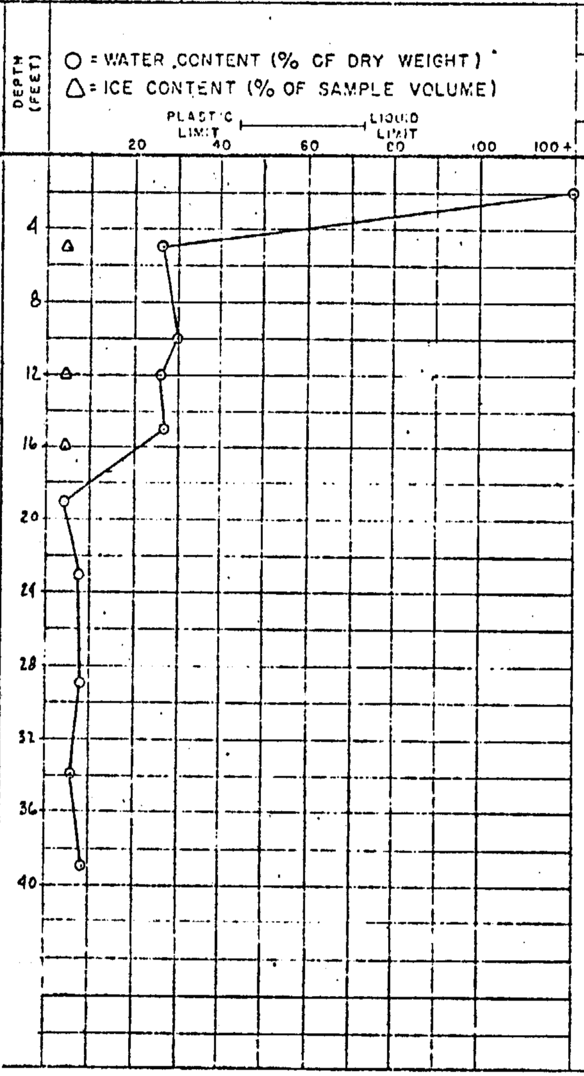
DWN. A.E.W. FIELD ENG. R.S. DATE DRILLED 9/11/73 AIRPHOTO NO: CHAINAGE: 885+00 OFFSET 50' R of ℄

CKD. D.G.D. 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

UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	WET DENSITY (PCF)	DRY DENSITY (PCF)
Pt	PEAT ORGANIC	F			
OL	SILT FINE SAND, LITTE CLAY VERY SOFT WHEN THAWED SANDY, HARD		Nbe	113.3	58.7
CL	CLAY HARD WITH SILT AND SAND SEAMS		Vr	114.2 117.5	90.1 92.4
SM	SAND COARSE, SANDY WITH SOME CLAY BOULDERS		Vr		
GC	TILL FIRM, CLAYEY LESS CLAY, SOFTER SILTY, DRY, COARSE SAND				
	END OF HOLE				



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

REMARKS

PLATE 7

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DWN. A E W FIELD ENG D M | DATE DRILLED 12/1/73 | AIRPHOTO NO: | CHAINAGE EE1+70 | OFFSET
CKD LGP TECH | RIG AIR | SURFACE DRAINAGE: GOOD | VEGETATION: POPLAR & CONIFER TO 45' ELEV

TEST HOLE

MILE	E,C,S	NUMBER
459	5	132A

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

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	DEPTH (FEET)	CLAY %	SILT %	SAND %	GRAVEL %	WET DENSITY (PCF)	DRY DENSITY (PCF)	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						GRAVEL	UF F	FREE WATER	32							
40					GW				40							
48						COARSE SAND CLAY MIXED WITH SAND LENSES			48							
56									56							
64					GP	FINE, SAND LENSES SANDSTONE LAYER @ 62'		Nbn	64							
72						CLAY			72							
80					CH	BLUISH GREY, MED PLASTIC, SANDSTONE OR SHALE LAYERS			80							ROCKS IN SAMPLE ARE FROM WALLS AS CLAY COMING UP.
88						SHALE VERY HARD, SANDSTONE		Nbn	88							
96						END OF HOLE			96							PLATE 8A

UNDERWOOD McLELLAN & ASSOCIATES LIMITED

DRILL HOLE REPORT

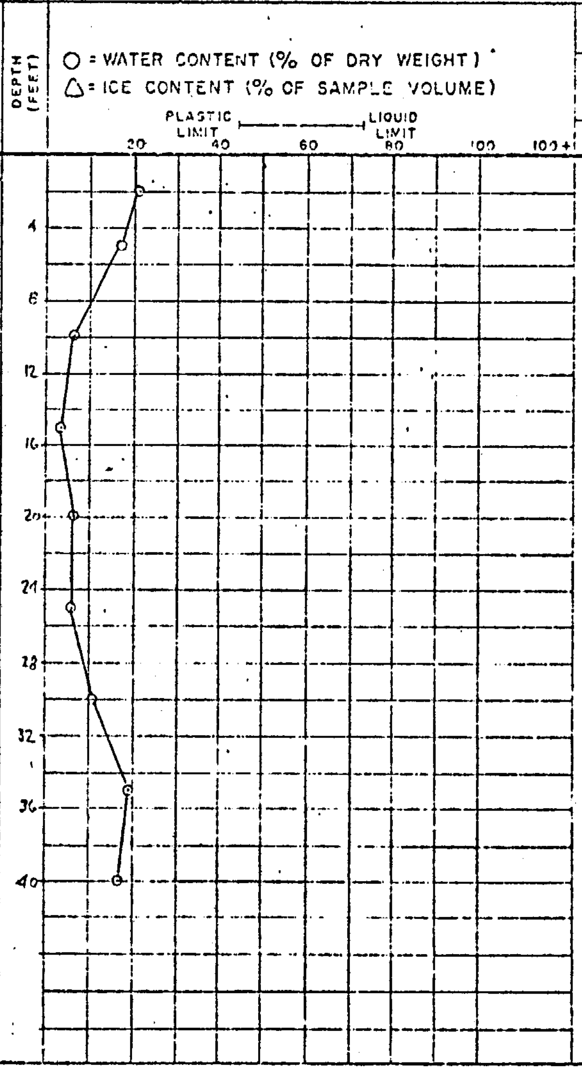
DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

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	L,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		GRAVEL	
16		SILTY, SANDY	
20	GM		UF
24			
28		CLAY GREY, FINE SAND	
32		GRAVEL	
36	GM	CLAYEY, COARSE	
40			
		END OF HOLE	



GRAIN-SIZE ANALYSIS

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

REMARKS

SO_4 = 0.07%

SAND MAY BE WASHED AWAY. TEST HOLE ON MOVING STREAM 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 R S.	DATE DRILLED 9/1/73	AIRPHOTO NO:	CHAINAGE 879+70	OFFSET 50' E OF ℄	TEST HOLE
CKD D.G.P.	TECH:	RIG: AIR	SURFACE DRAINAGE:	VEGETATION: CONIFER TO 40'	ELEV 295.4	

MILE	E,C,S	NUMBER
459	S	124 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
						PEAT	F								
4					Pt	ORGANIC, GRANULAR	UF						135.4	113.3	
8					SP	SAND									
12		P				FINE, MOIST			25		71	4			
16						GRAVEL			18		45	27			
20					GC	MED. COARSE. SAND SILTY, BOULDERS			32		14	54			
24						CLAYEY			33		25	42			
28						SAND									
32					SC	CLAYEY									
36															
40					GC	GRAVEL CLAYEY									
44						END OF HOLE									

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

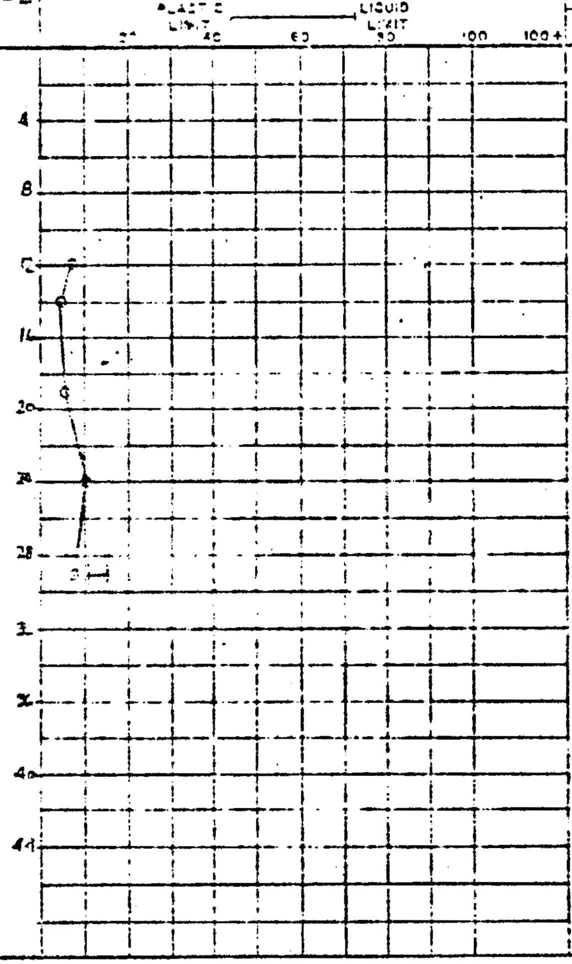


PLATE 9