Public Works Canada

Travaux Publics Canada

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Western Region

Region de l'Ouest

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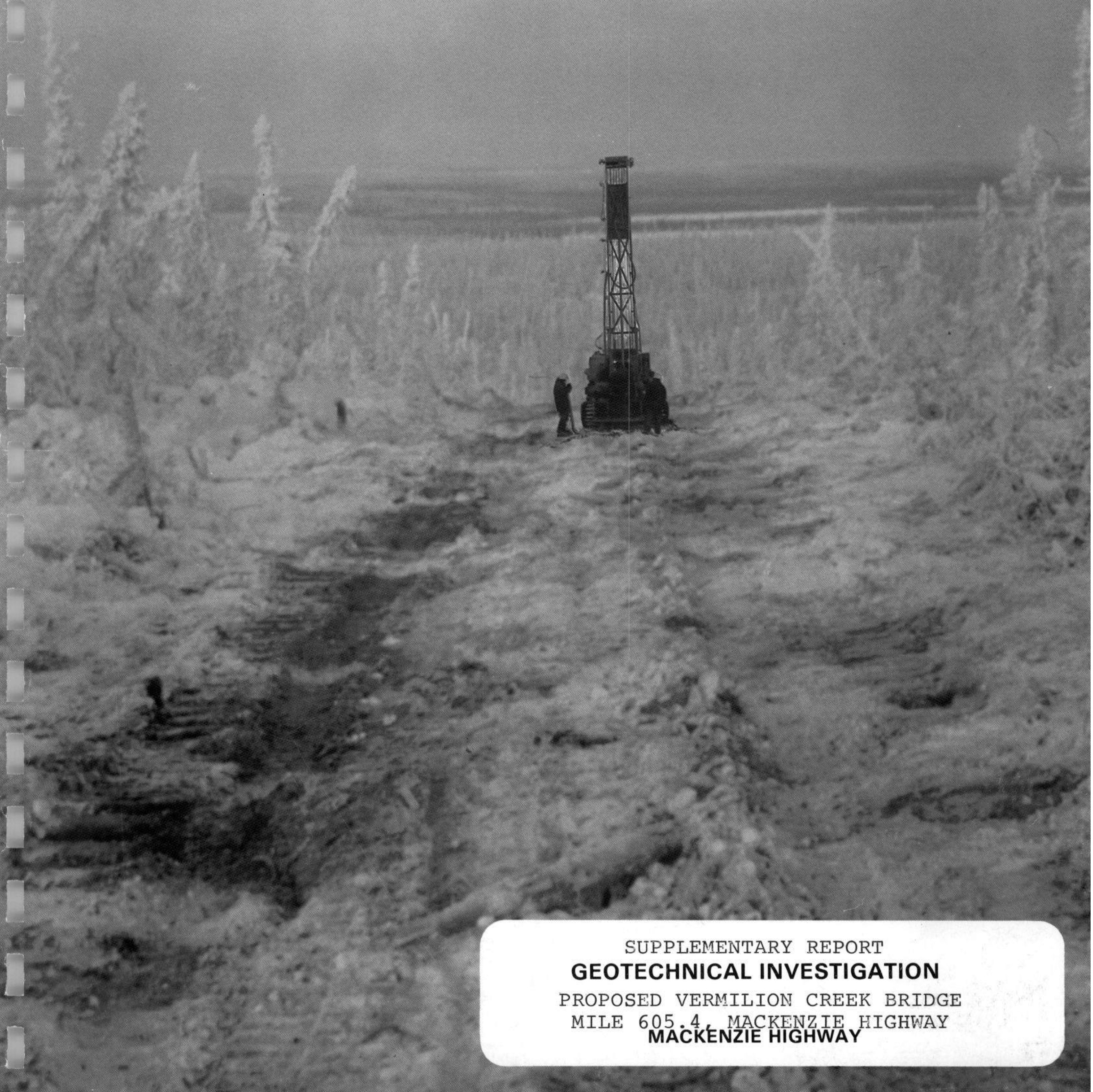

SUPPLEMENTARY REPORT

GEOTECHNICAL INVESTIGATION

PROPOSED VERMILION CREEK BRIDGE

MILE 605.4, MACKENZIE HIGHWAY

MACKENZIE HIGHWAY

PUBLIC WORKS CANADA

WESTERN REGION

SUPPLEMENTARY REPORT

FOUNDATION INVESTIGATION

PROPOSED VERMILION CREEK BRIDGE

MILE 605.4, MACKENZIE HIGHWAY

Submitted by:

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

February 11, 1976

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APPENDICES

I PRELIMINARY

The initial foundation investigation at Vermilion Creek was undertaken by R.M. Hardy and Associates in the winter of 1973, and summarized in a foundation report dated October 16, 1973. Subsequent to this field work by R.M. Hardy, a minor route revision was introduced in the area of Nota and Vermilion Creeks which resulted in a shift of the Vermilion Creek crossing some 2000 feet downstream. Test borings at the revised crossing site were carried out by Public Works Canada during the winter of 1975.

A profile of the revised crossing site showing the two boreholes drilled and the inferred subsoil stratigraphy has been included on Drawing No. A-1 in Appendix A. Borehole logs are included in Appendix B. The proposed gradeline, and the locations of piers and abutments as recommended by the bridge consultants (M.H.L. & Associates Ltd.) have also been shown on the profile.

II SUBSOIL CONDITIONS

Shale underlies the crossing site at a depth in the order of 12 feet. Overburden near the stream consists of partially sorted fluvial deposits varying from silts, to sands, to sandy gravels. Permafrost is present in the south bank, although free water was encountered near the shale surface in both holes (moisture contents of the shale, especially in hole #2, are incorrect due to contamination of samples by water). It is considered likely that there is a thaw zone below the stream channel extending well into the underlying shale. The shale was described as 'hard' by the drilling crew.

The stream channel was frozen to the stream-bed (4.5' of ice) in March 1975, and any flow occurring was subsurface in the permeable sands and gravels.

III FOUNDATION RECOMMENDATIONS - R.M. HARDY & ASSOCIATES

Subsoil conditions at the crossing drilled by R.M. Hardy are essentially similar to those on the revision, and foundation recommendations made for the upstream site are applicable to the present site.

R.M. Hardy have recommended steel H-piles driven to refusal in the shale bedrock and this is concurred with. A depth of embedment of 10 feet into bedrock has been recommended which will require very hard driving, hence a heavy pile section - at least 10BP57 - will be required. Recommendations regarding pile hammers by R.M.H. should be followed except that a minimum energy of 20,000 ft. lbs. is recommended. Piles driven to refusal in bedrock under a driving energy of at least 20,000 ft. lbs. per blow should be capable of developing the full structural strength of the steel section.

As an alternate to steel piling, massive concrete abutments bearing directly upon the shale surface could be employed. There is a probable source of concrete aggregate at roughly Mile 616 (Francis Creek) or approximately 10 miles distant, hence concrete abutments may be a viable alternative providing road construction precedes bridge construction.

Construction of abutments directly on the shale would require that water seepage be largely sealed off and the bearing area continuously pumped during preparation and concrete placement. Any soft or badly weathered shale should be removed and the abutments placed directly upon firm rock. Design bearing pressures of 12,000 psf. may be assumed.

The following 12 pages are the text of the foundation report by R.M. Hardy & Associates for Vermilion Creek.

R D Cook

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

R.M.HARDY & ASSOCIATES LTD.

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GEOTECHNICAL INVESTIGATION

PROPOSED BRIDGE SITE

VERMILION CREEK, MILE 605.6

MACKENZIE HIGHWAY

E-2510

OCTOBER 16, 1973

INTRODUCTION

At the request of Mr. F. E. Kimball, P.Eng., Manager of Northern Roads Programme, Department of Public Works of Canada, Western Region, R. M. Hardy & Associates Ltd. undertook a geotechnical investigation along part of the proposed location of the Mackenzie Highway. This report deals only with that part of the investigation appertaining to the proposed bridge at Vermilion Creek.

The original location of this bridge site is shown on mosaic sheet No. 47 of a set of mosaics prepared by Department of Public Works for the Mackenzie Highway project. The site is covered by aerial photographs Nos. A22783-211, 212 and 213 (scale 1" = 1000'). This original crossing was located where the Canadian National Telecommunications right-of-way crosses the creek. Subsequent to drilling operations being completed in the field, the location of the bridge site was moved downstream a distance of approximately 2000 feet.

R. M. Hardy & Associates Ltd. have been provided with a sketch plan and profile showing the revised crossing. This drawing is entitled "Proposed Drainage Structure at Vermilion Creek" and is not dated. It was used as the basis for Plate 1, Appendix A.

A report entitled "Geotechnical Investigations, Mackenzie Highway, Mile 544 to Mile 635", has been previously submitted to the Department. The geotechnical conditions are discussed in Volume 1 while Volume II contains information on permafrost of a more general nature. We recommend that these volumes be read in conjunction with this report.

TOPOGRAPHY

The general direction of the drainage in the area is southwesterly towards the Mackenzie River. The valley sides of Vermilion Creek are relatively steep and rise at an average gradient of 8 percent on the northerly side and 5 percent on the southerly side. The vertical distance from high water level to the surrounding terrain is approximately 68 feet. The width of the creek at the water line is approximately 50 feet.

SOIL PROFILE

The soil profile in the area of the approaches consists mainly of glacial lake basin deposits overlying clay till. The valley walls of Vermilion Creek are covered with slopewash of shallow depth. The floor of the valley has been classed as alluvial meander flood plain. At the original crossing site, shale was encountered at shallow depths on the south side of the valley but was not encountered on the northerly side. We believe that, in the floor of the valley at the present site, shale will be encountered within 20 feet of the ground surface.

The glacial lake basin deposits of this area usually contain high water contents and considerable quantities of excess ice. The slopewash deposits are also generally of fine grained material with high ice contents. The underlying till and shale have low water contents with little or no visible ice being present.

Permafrost can be expected to considerable depth on either sides of the creek but is not expected to be present actually beneath the creek within the depths normally penetrated by piles.

DISCUSSION AND RECOMMENDATIONS

The effect of a stream on the permafrost profile is shown on Plate 2, Appendix A. This chart shows that the thaw bulb beneath a small creek can penetrate to considerable depth so that, for bridge building purposes, the presence of permafrost beneath the stream bed can be ignored. However, it should be noted that the permafrost profile beneath the sides of the stream bed plunges at an extremely steep angle.

As is well known, the flow of water in northern streams varies tremondously throughout the year. Very large flows can be experienced during the spring runoff. The bed of the stream is composed of a mixture of gravel silt and clay overlying clay till and shale. The depth of scour should therefore be limited. The amount of scour that should be expected will depend on the flow of water during the height of the spring runoff and the constriction imposed on the stream by the bridge structure.

Because of the nature of the soil in the approach area and the valley sides we do not believe it would be advisable to use concrete abutments or piers. Also, because of difficulties due to logistics, it will be highly desirable that onsite work be kept to a minimum. We therefore recommend the bridge abutments and any piers be supported on driven steel H piles. It is extremely unlikely that timber piles could be driven to the required depths at this site without damaging the timbers. Precast concrete piles should not be used due to difficulties of transportation and also because the length of precast pile would have to be determined in advance. Steel pipe piles are an alternative possibility. However, it is probable that they would not be able to withstand the driving stresses and preboring of holes would be necessary.

Steel H piles which are to be placed on the banks where they will not be affected by scour should be driven a minimum of 30 feet below existing grade and designed on the basis of an allowable skin friction of 400 psf (on the gross perimeter) with the top 10 feet of pile being assumed to carry no load.

Steel H piles driven in the stream bed should be driven a minimum distance of 20 feet below the bottom of anticipated scour and should be designed on the basis of the "Table of Penetration Resistance" following. Design parameters are summarized on Plate 3, Appendix A. If bedrock is encountered within the depths specified, the piles should be driven 10 feet into it.

Driving steel H piles will require considerable energy. The weight of the pile driving hammer should be at least twice the weight of the pile being driven. If a diesel hammer is used the weight of the hammer should be at least equal to the weight of the pile. To prevent damage to the points of the pile they should be reinforced with flange plates for a distance equal to 1.5 times the size of the pile. Alternatively, the point can be reinforced with the driving shoe. Piles should be driven to practical refusal or refusal according to the following table of penetration resistances assuming that the hammer delivers an energy of 15,000 ft. pounds per blow.

TABLE OF PENETRATION RESISTANCE

Description	Inches Per Blow
refusal	.00-.05
practical refusal	.05-.25
high resistance	.25-.50
medium resistance	.50-1.25

In order to ensure that refusal has been reached, driving should be continued for at least 100 blows after refusal is first recorded.

Piles driven in the stream bed to refusal, as defined above, may be designed for the full structural strength of the pile section acting as a column. A design load will depend upon the allowable stresses in the pile, the column length and the arrangement of lateral bracing. Piles driven to practical refusal, as defined above, should be designed for two-thirds of the value permitted for the pile as a structural column. Consideration should be given to using battered piles on the outside of the pile bents in order to provide increased lateral resistance.

If a drop hammer is used in driving the piles, care should be taken that the energy delivered to the piles is not greater than 50,000 ft. pounds per blow unless calculations show that the pile can safely take higher impact stresses.

It is probable that bedrock will be encountered by the piles driven in the stream bed. If possible, the depth of embedment in the bedrock should be 10 feet. The bedrock will shatter to some extent under driving with some consequent deterioration of the material. However, we believe that piles driven into the bedrock would be capable of developing the full structural strength of the steel section.

One of the problems facing the bridge is the possibility of log jams occurring which can cause partial or complete failure of the structure. Log jams are only likely to occur where trees travelling down the river have a greater length than the clear span of the bridge. We suggest that the height of trees growing adjacent to Vermilion Creek upstream of the bridge site should be checked, and should it be observed that there is a possibility of large trees being washed downstream, such facts should be borne in mind by the bridge designer.

If piles are used to support a vertical face of embankment fill, the lateral force against the pile can be computed by assuming the backfill to be a fluid with a density of 60 pounds per cubic foot where the backfill is not compacted.

Embankments constructed below the highest expected flood level should be protected with riprap. As suitable rock may not be available, sandbags filled with concrete may have to be used.

Respectfully submitted,

R. M. HARDY & ASSOCIATES LTD.,

Per:

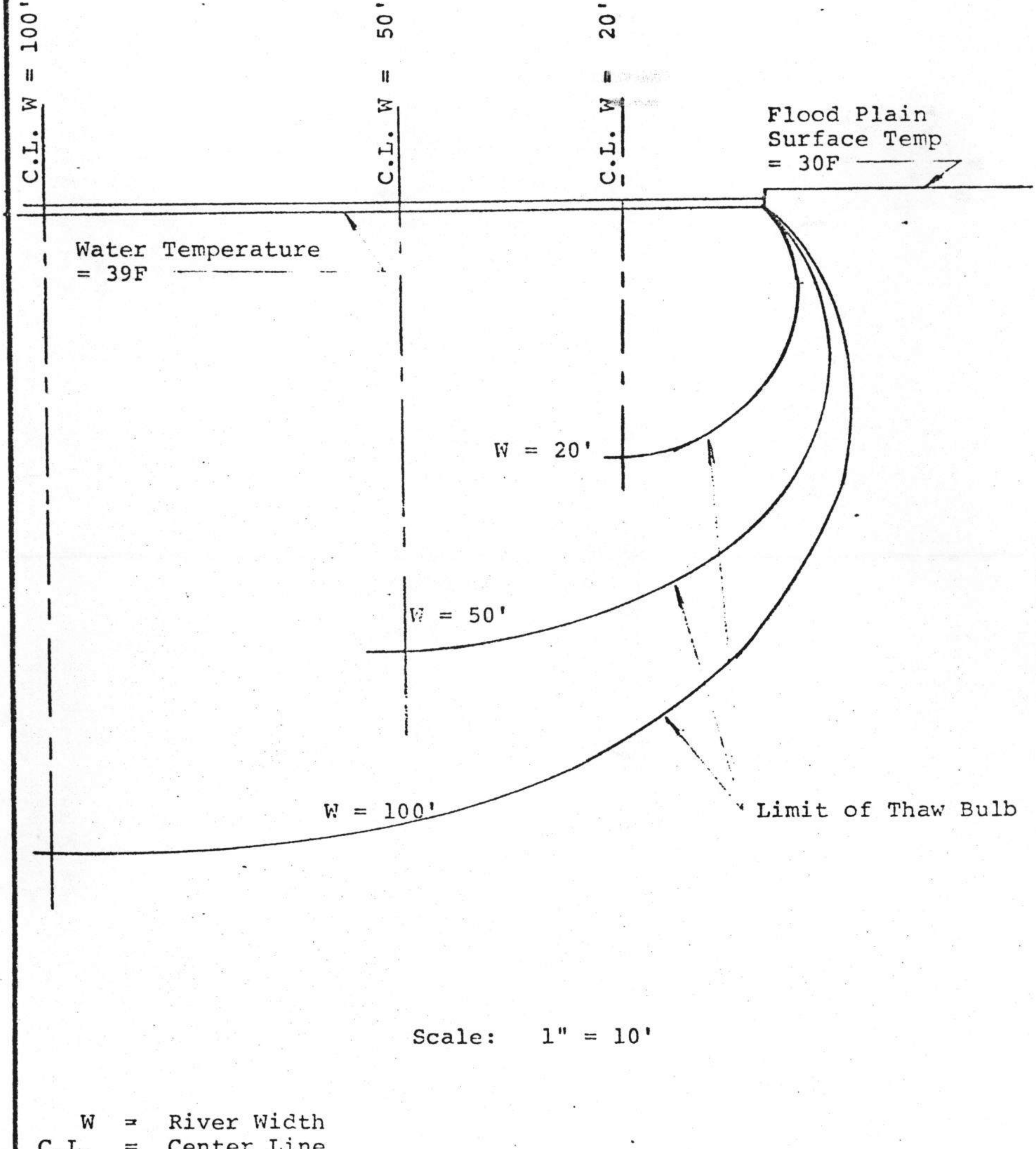
G. McCormick, P.Eng.

GM/jc

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA
PERMIT NUMBER
P 223
R. M. HARDY AND ASSOCIATES LTD.

APPENDIX A

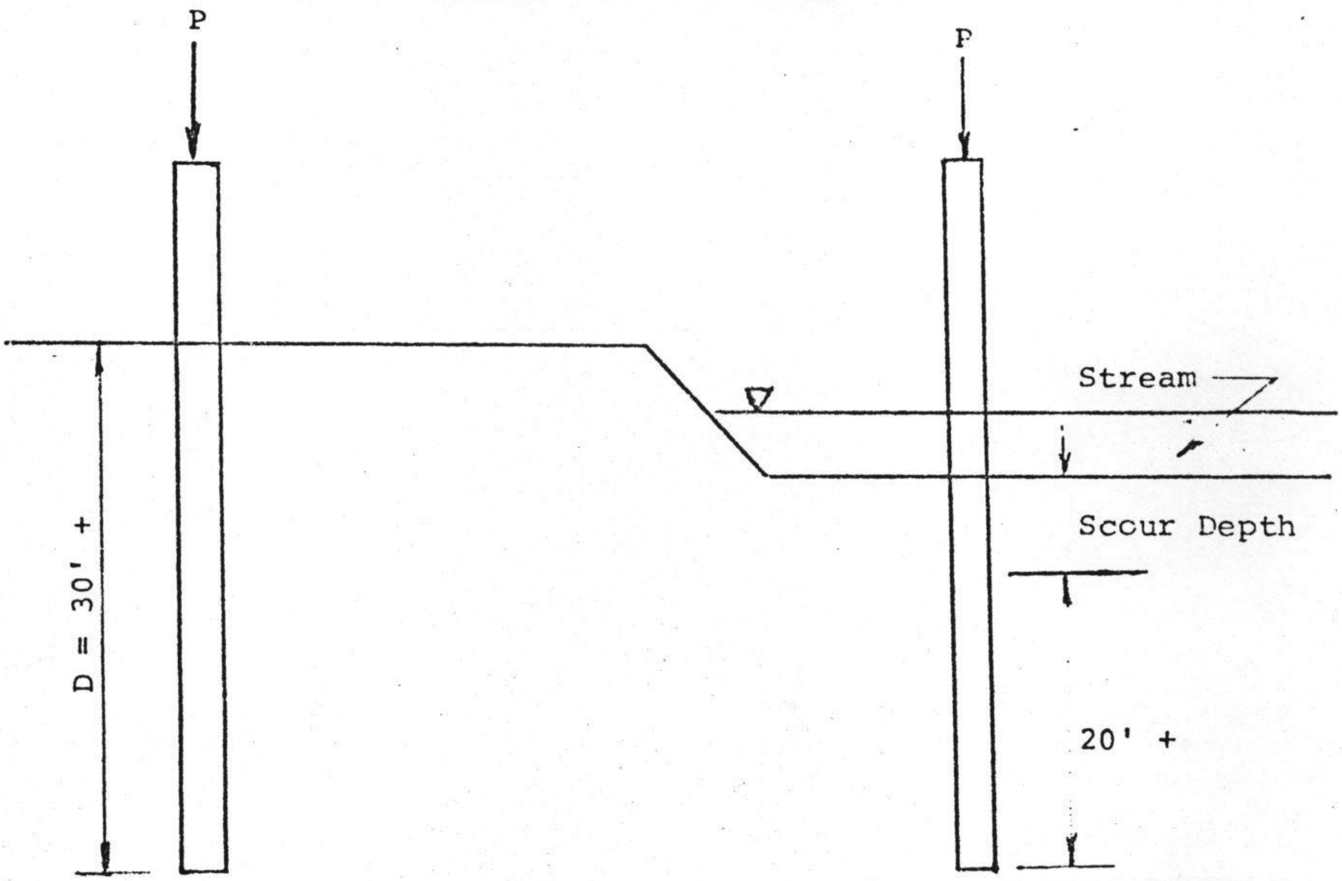
Section
Chart

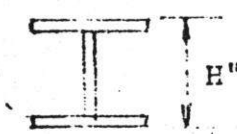


G.Mc September 14/73 E-2510

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

THAW BULBS BENEATH RIVERS
NORMAN WELLS AREA





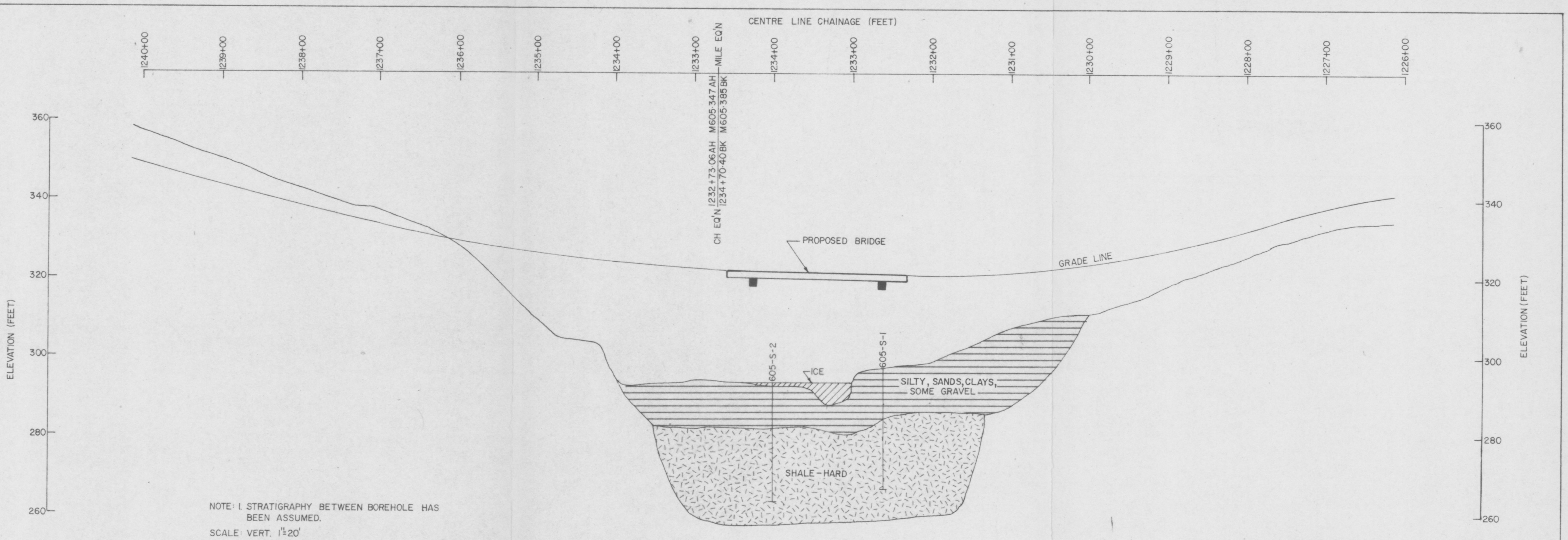
$$\text{Gross Perimeter} = \frac{4H}{12} = \frac{H}{3} \text{ ft.}$$

Piles on dry land to be designed on the basis of an allowable shaft friction over effective length of embedment of D-10 with D minimum = 30 ft.

Piles in stream bed to be driven to 20+ feet below scour depth and designed on the basis of penetration values (see text).

R.M. HARDY & ASSOCIATES LTD. CONSULTING ENGINEERING & TESTING	MACKENZIE HIGHWAY BRIDGE PILES NORMAN WELLS AREA

SCALE	DATE	MADE G.Mc	CHKD.	JOB: E2510	PLATE



NOTE: I. STRATIGRAPHY BETWEEN BOREHOLE HAS BEEN ASSUMED.

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

PUBLIC WORKS CANADA
WESTERN REGION

VERMILLION CREEK
MILE 605·4
MACKENZIE HIGHWAY

DWG NO A-1

DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

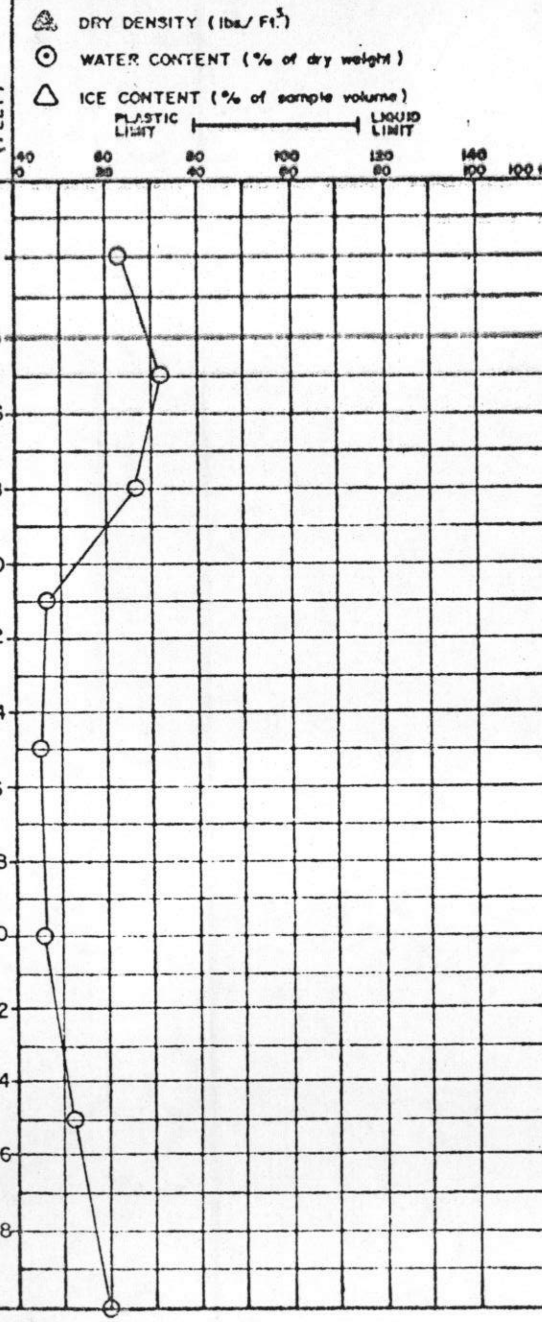
DRILL HOLE REPORT

SITE: VERMILION CREEK - SOUTH SIDE

FIELD ENG.	DATE DRILLED. 29/3/75	AIRPHOTO NO.	CHAINAGE.
TECH. REYNOLDS	RIG. AIR	SURFACE DRAINAGE.	VEGETATION. SPRUCE 12"
OFFSET.	ELEV.	TEST HOLE	#1 (1975)
MILE 605			

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION
0–2'					Pt	Peat		
2'–4'						Sand-Silty	F	$V_r - V_c$
4'–8'					ML	Silt-Sandy Pebbles	F	$V_r - V_c$
8'–12'					SM	Sand-Silty Gravelly	F	$V_r - V_c$
12'–						Shale - Hard - Drilled with Rock Bit		Unable to Determine if Frozen Below 12'

Bottom of Hole 30'



DEPTH (FEET)	GRAIN-SIZE ANALYSIS CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT	REMARKS
2	- 37 -		63	0	Damp	
5	- 63 -		35	2	Moist	
8	- 62 -		32	6	Moist	
11	- 20 -		48	32	Damp	
15					Damp	
20	- 13 -		36	51	Wet	
25					Sat.	
30					Freewater	

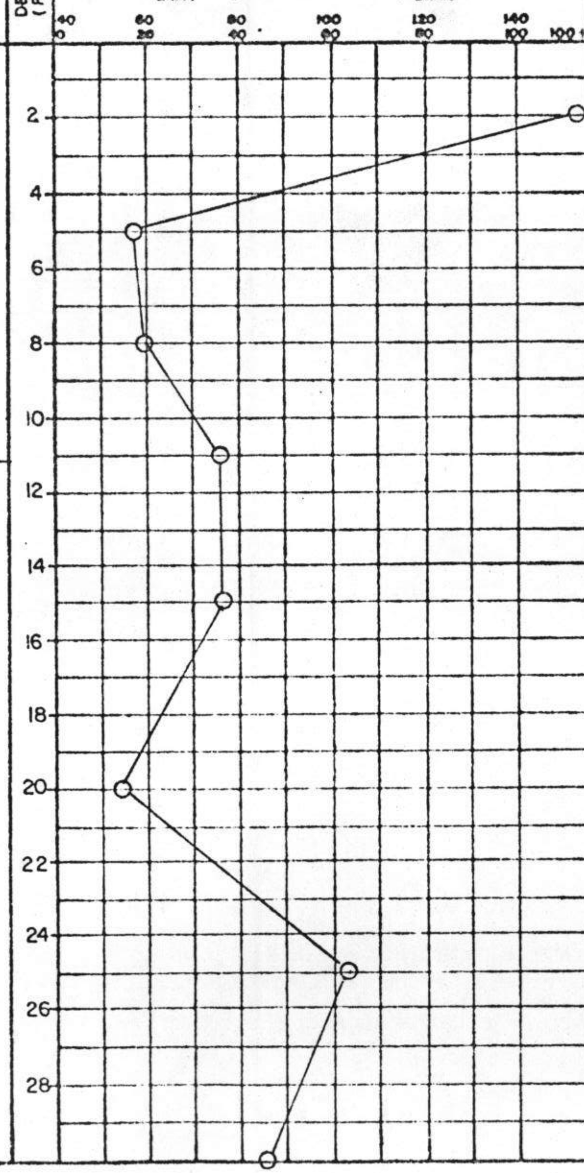
DEPARTMENT OF PUBLIC WORKS, CANADA
MACKENZIE HIGHWAY

DRILL HOLE REPORT

SITE: VERMILION CREEK - NORTH SIDE

FIELD ENG.	DATE DRILLED. 29/3/75	AIRPHOTO NO.	CHAINAGE.	OFFSET.	TEST HOLE #2 (1975)
TECH. REYNOLDS	RIG. AIR	SURFACE DRAINAGE.	VEGETATION.	ELEV.	MILE 605

DRY DENSITY (lbs/Ft.^{3})
WATER CONTENT (% of dry weight)
ICE CONTENT (% of sample volume)
PLASTIC LIMIT — LIQUID LIMIT



DEPTH (FEET)	SAMPLE NUMBER	SAMPLE TYPE	% RECOVERY	PENETRATION RESISTANCE	UNIFIED SOIL SYMBOL	SOIL DESCRIPTION	LIMITS OF FROZEN GROUND	ICE DESCRIPTION	CLAY %	SILT %	SAND %	GRAVEL %	RELATIVE THAWED MOISTURE CONTENT
2					Pt	Peat & Sandy Gravel — 3'			-	20 -	32	48	Freewater
5					Cl	Clay-Silty, Shale Fragments, Medium Plastic	F	V_s	-	40 -	38	22	Moist
8									-	19 -	42	39	Wet
11						Water @ 11' — 11'			-	17 -	36	47	Freewater
15						Shale - Hard - Drilled with Rock Bit			-	9 -	43	48	Freewater
20									-	1 -	47	52	Sat.
25									-	1 -	43	56	Freewater
30									-	6 -	43	51	Freewater

Bottom of Hole 30'

REMARKS

Note:
Moisture Contents in Shale Contaminated by Seepage