GEOTECHNICAL INVESTIGATION

PROPOSED BRIDGE SITE

NORTH KLONDIKE RIVER, MILE 42.7

DEMPSTER HIGHWAY

Km 68.7

GR-05-038

E-3098 August 6, 1975

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

GEOTECHNICAL INVESTIGATION

PROPOSED BRIDGE SITE

NORTH KLONDIKE RIVER, MILE 42.7

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Km 68.7

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August 6, 1975

120 LT. STA. 2195+00

120 RT. STA. 2205+25

150 RT. STA. 2215+00

V.P.I. ELEV. 3288.5+75

B.V.C.

L.V.C. 600'

+4.70%

E.V.C.

B.V.C. +25

L.V.C. 1500'

PLACE 30"X 50' C.M.P.

W.L. AUG. 75 ELEV. 3221.0

PLACE 30"X 66' C.M.P.

V.P.I. ELEV. 3238.0

E.C.

B.C.

E.C.

Δ 75°53'05" D6°00'00"

Δ 63°11'30" D6°00'00"

2200

2210

2215

90

80

70

60

3250

40

30

20

10

3200

90

N Ironbike

150' LT. STA. 2174+50

100' LT. STA. 2185+20

120' LT. STA. 2195+00

V.P.I. ELEV. 3221.0 +50

B.V.C.

L.V.C. 300'

E.V.C.

B.V.C.

L.V.C. 600'

+0.40%

-0.60%

+1.14%

WL. AUG.
ELEV. 3

E.V.C. +25

B.V.C. +75

L.V.C. 350'

E.V.C. +25

V.P.I. ELEV. 3218.0 +50

V.P.I. ELEV. 3238.0

PLACE
36" X 50'
C.M.P.

PLACE
36" X 62'
C.M.P.

PLACE
30" X 66'
C.M.P.

E.C.

B.C.

E.C.

B.C.

18° 53' 30" D 4° 00' 00"

Δ 75° 53' 05" D 6° 00' 00"

2180

2190

2200

PLATE 1, PLAN-PROFILE

KEUFFEL & ESSER CO.

PROFILE		BY	DATE
NOTE BOOK	SURVEYED	R. CURIAL & B. McKAMEY	1975
No.	PLOTTED	TECH. SERVICES	1975/76
	GRADES CHECKED	P. KNYSH	1976
	B. M.'s NOTED	TECH. SERVICES	1975/76
	STRUCTURE NOTATIONS CHECKED	P. KNYSH	1976

120' LT. STA. 2166+05

150' LT. STA. 2174+50

100' LT. STA. 2183+20

90
80
70
60
3250
40
30
20
10
3200
90

E.V.C. +50

+3.31%

B.V.C. +75

L.V.C. 350'

E.V.C. +25

V.P.I. ELEV. 3217.0 +50

+0.40%

B.V.C. +75

L.V.C. 350'

E.V.C. +25

V.P.I. ELEV. 3221.0 +50

-0.60%

B.V.C.

L.V.C. 300'

E.V.C.

V.P.I. ELEV. 3218.0 +50

PLACE 36" X 50' C.M.P.

PLACE 36" X 62' C.M.P.

E.C.

B.C.

E.C.

Δ 6°14'30" D 2°00'00"

Δ 18°53'30" D 4°00'00"

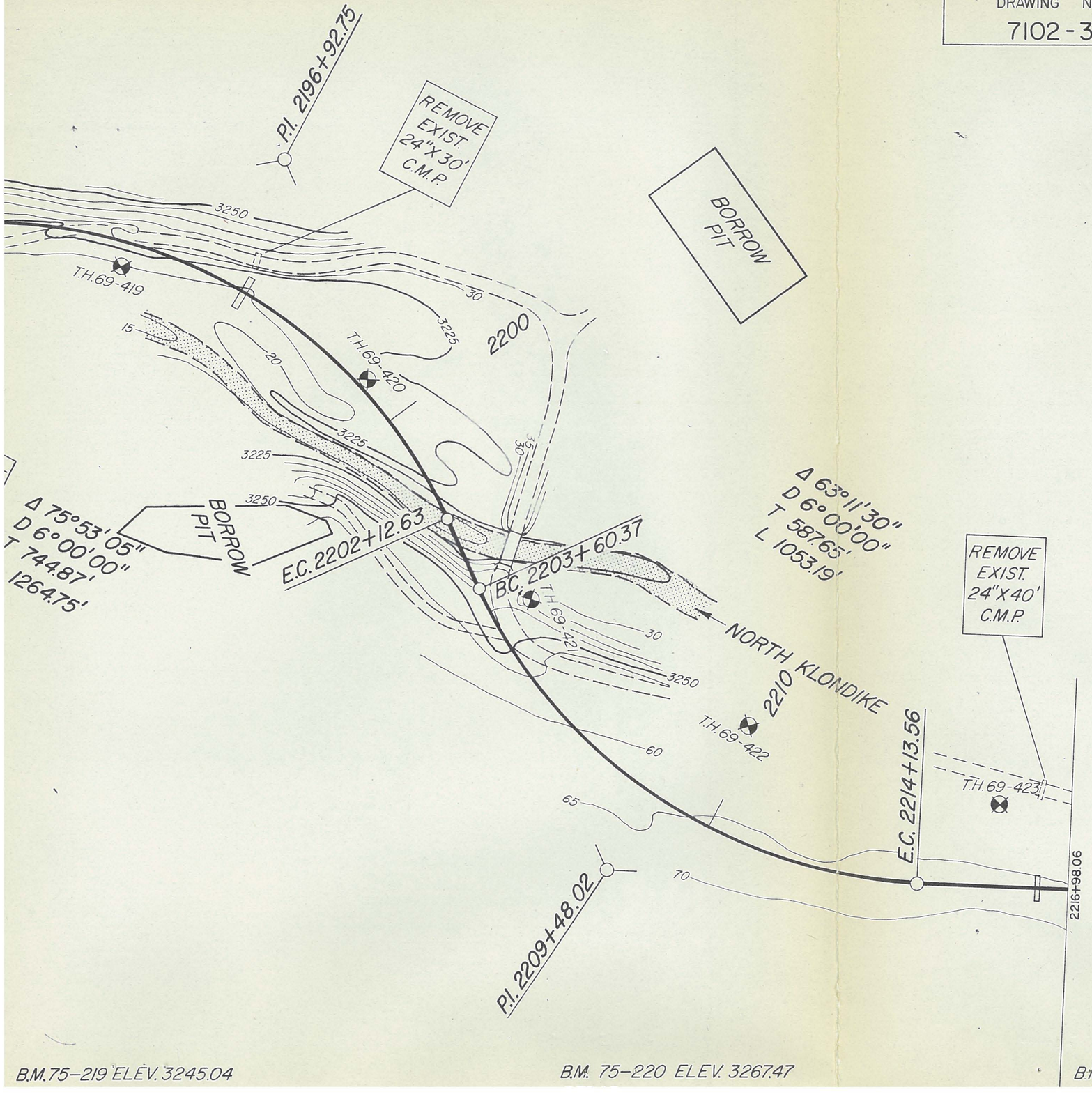
2165

2170

2180

DRAWING NO.	VERT. SCALE	HORIZ. SCALE	SHEET NO.	TOTAL SHEETS
7102-3	1" = 20'	1" = 200'	18	

REC'D
DEC. 24/76



B.M. 75-219 ELEV. 3245.04

B.M. 75-220 ELEV. 3267.47

B.M. 75-221 ELEV. 3274.46

Δ 18° 53' 30"
D 4° 00'00"
T 238.36'
L 472.29'

2170

2180

2190

B.C. 2170+40.81

E.C. 2175+13.10

B.C. 2189+47.88

P.I. 2172+79.17

P.I. 2196+92.75

T.H.69-414

T.H.69-415

T.H.69-416

T.H.69-417

T.H.69-418

T.H.69-419

T.H.69-420

3225

3250

3200

10

15

20

30

45

95

M.P. 42

REMOVE EXIST. 36"X24' C.M.P.

REMOVE EXIST. 36"X36' C.M.P.

REMOVE EXIST. 24"X30' C.M.P.

REMOVE EXIST. 24"X30' C.M.P.

BORROW PIT

Δ 75°53'05"
D 6°00'00"
T 744.87'
L 1264.75'

E.C. 2202+12.63

N

B.M. 75-217 ELEV. 3254.22

B.M. 75-218 ELEV. 3223.94

B.M. 75-219 ELEV. 3245.04

PLAN		BY	DATE
	SURVEYED	B. ANDERSON	1975
	PLOTTED	TECH. SERVICES	1975/76
NOTE BOOK	ALIGNMENT CHECKED	P. KNYSH	1976
	RT. OF WAY CHECKED		
No.			

Δ 18° 53' 30"
D 4° 00'00"
T 238.36'
L 472.29'

2164+18.06

P.I. 2165+04.86

E.C. 2166+60.73

Δ 6°14' 30"
D 2° 00'00"
T 156.21'
L 312.08'

2170

B.C. 2170+40.81

P.I. 2172+79.17

E.C. 2175+13.10

2180

3225

3200

3250

95

90

45

10

T.H. 69-414

T.H. 69-415

T.H. 69-416

T.H. 69-417

REMOVE EXIST. 36"X24' C.M.P.

REMOVE EXIST. 36"X36' C.M.P.

M.P. 42

N

B.M. 75-217 ELEV. 3254.22

B.M. 75-218 ELEV. 3223.94

SITE PLAN

SCALE: 1" = 50' — CONTOUR INTE

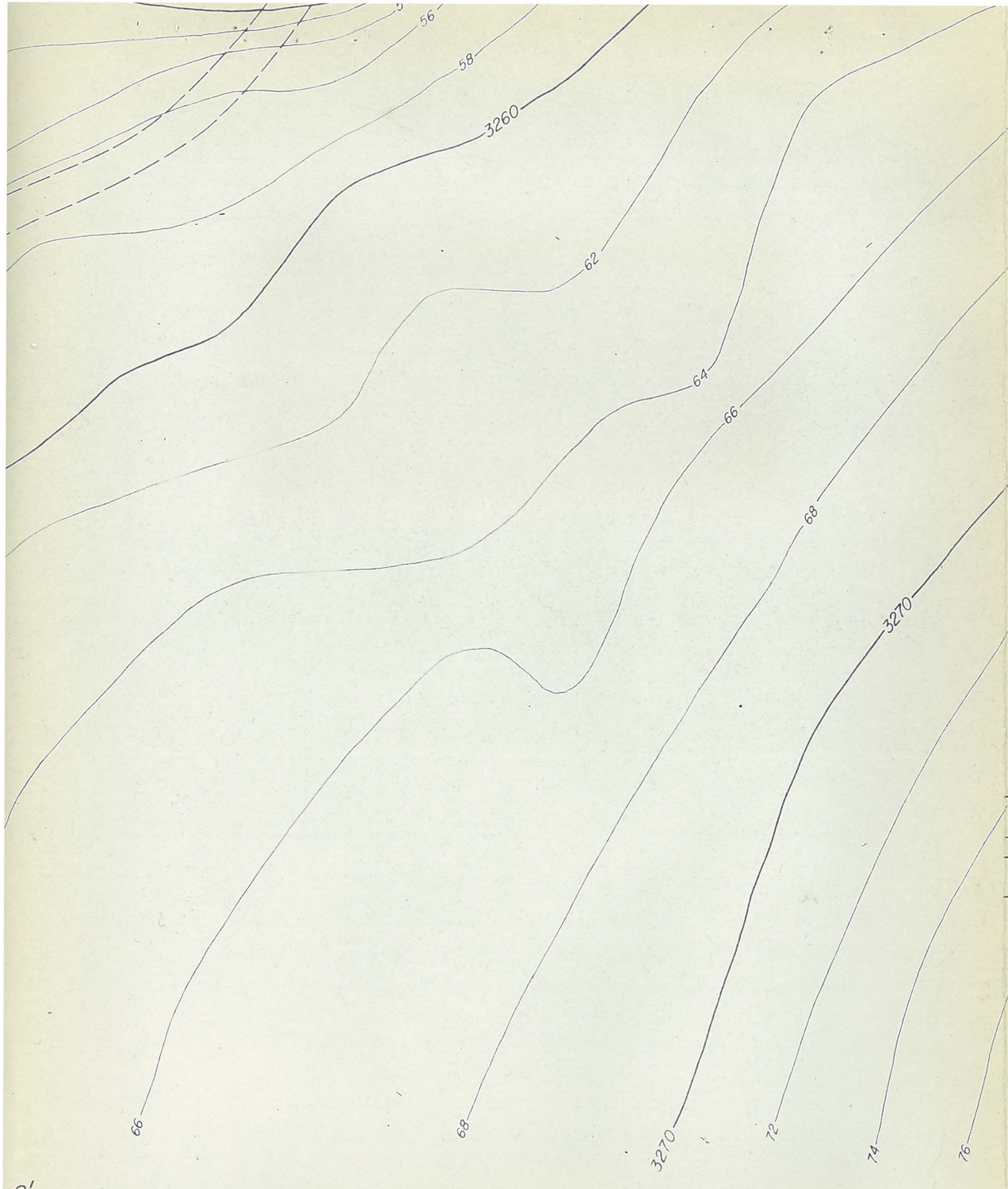
SITE PLAN

SCALE: 1" = 50' — CONTOUR INTERVAL 2'

CULVE

CULVE
LENGT
DIAME
GAUGE
& LOC
SKEW
INVER
IN
OU
SLOPE

- COMPIL
SURVE
- SURVE
- BM # 7
APPRO
- BM # 7
APPRO



CULVERT SPECIFICATIONS

CULVERT		
LENGTH		
DIAMETER		
GAUGE		
℄ LOCATION		
SKEW ANGLE		
INVERT ELEV.		
INLET		
OUTLET		
SLOPE		

- COMPILED FROM NORTH KLONDIKE RIVER SURVEY BOOK (1975)
- SURVEYOR - R. CURIAL
- BM # 75-219, ELEV. 3245.04 APPROX. 120' LT. STA. 2195+00
- BM # 75-220, ELEV. 3267.47 APPROX. 120' RT. STA. 2205+25

REC'D DEC. 24/76

project title / titre du projet

RECONSTRUCTION DEMPSTER HIGHWAY MILE 25-53

drawing title / titre du dessin

SITE PLAN NORTH KLONDIKE RIVER MILE 42.7

designed by / conçu par

date

drawn by E. LESLIE / dessiné par

date NOV., '76

reviewed by W. BROWN / examiné par

date NOV., '76

approved by J. QUONG / approuvé par

date

Tender / Soumission

D.P.W. Project Manager / Administrateur de projets M.T.P.

project number / no. du projet

drawing no. / dessin no.

7004-4

N KLONDIKE

N

BORROW PIT

TOTE ROAD

EXIST. HIGHWAY

3280
3270
3260
3250
3240
3230
2200

TH 69-2-1
TH 69-2-2
TH-4
TH-3
TH-2
TH-5

TOTE ROAD

EXIST. HIGHWAY

FLOW

TH 69-2-3

TH 69-2-1

TH 69-2-2

TH-4

TH-3

TH-2

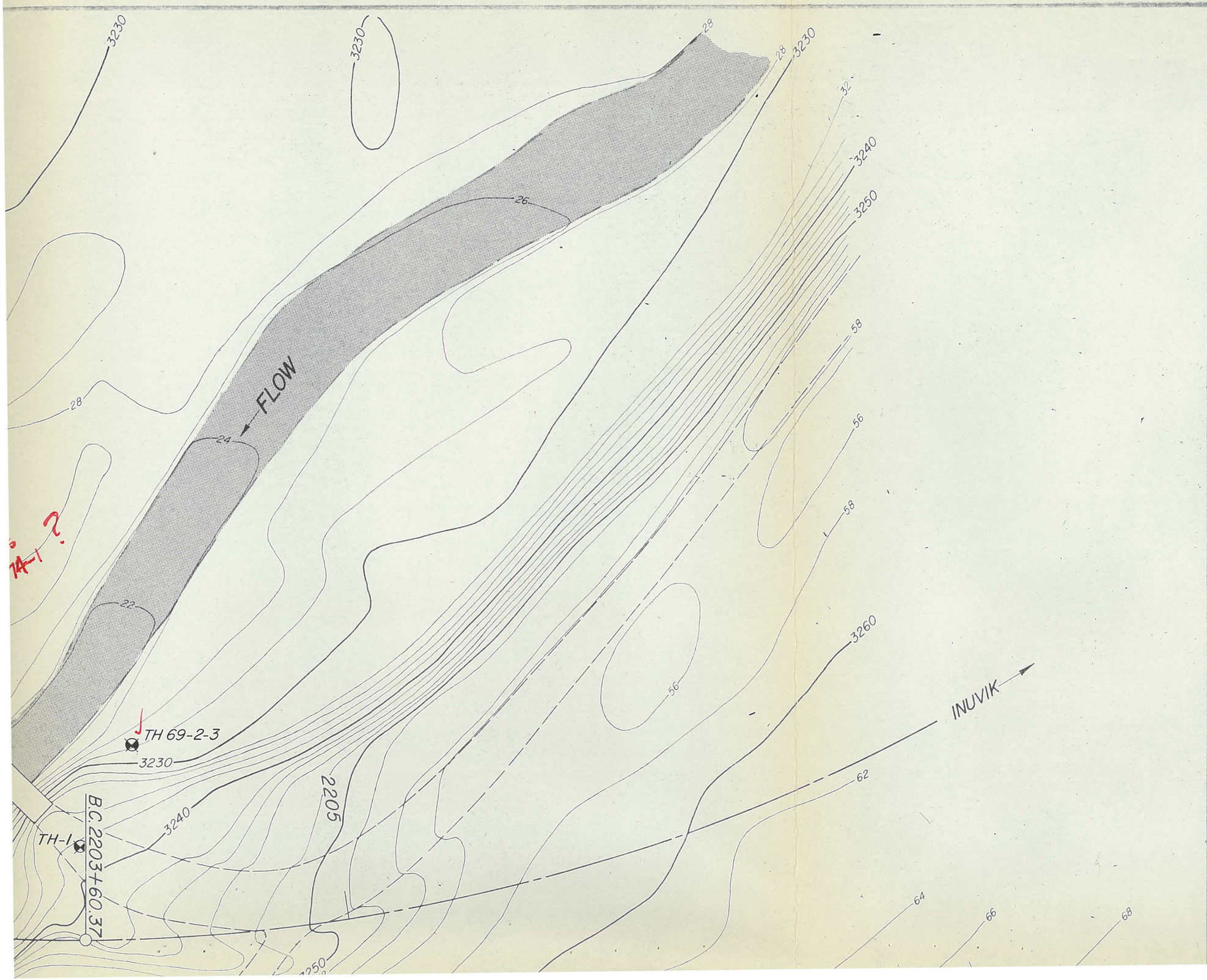
TH-5

TH-1

B.C. 2203+60.37

2205

WHERE IS TH 74-1 ?



Department of Public Works
Ministere des Travaux publics

WHITEHORSE, YUKON

LEGEND

T.D. ..... TOP OF DYKE
..... EDGE OF WATER
..... RANDOM RIP-RAP
..... TEST HOLES

A detail no. detail no.

B location drawing no. sur dessin no.

C drawing no. dessin no.

revisions date

INTRODUCTION

At the request of Mr. J. Y. C. Quong, P.Eng., Manager of Technical Services, Department of Public Works of Canada, Whitehorse, Yukon Territory, R. M. Hardy & Associates Ltd. undertook a geotechnical investigation along part of the existing Dempster highway between Mile 0 and Mile 78. This report deals only with the site of the proposed bridge over the North Klondike River.

The location of the bridge is shown on Plan-Profile Sheet No. 7004-3 "Bridge Site, Plan and Profile, North Klondike River, Mile 12.7, Dempster Highway" dated May, 1969. The site is covered by aerial Photographs No. A18137-31, -32, -33, and -34.

There is an existing steel beam bridge at the site which is shown on Photographs 9 and 10, Appendix A, Volume I of the report mentioned below.

A report entitled "Geotechnical Investigation, Dempster Highway, Mile 0-78" has been previously submitted to the department. The geotechnical conditions are discussed in Volume I while Volume II contains information on permafrost in the area of a more general nature. We recommend that these volumes be read in conjunction with the text of this report.

DRILLING AND TESTING

A number of test holes have been drilled at or near the bridge site. The test holes which are of principal interest

to this study are numbered 69-2-1, 69-2-2, 69-2-3 and Test Hole 74-1. The locations of all these test holes are shown on Drawing 7074-3 with the exception of the location of Test Hole 74-1. This test hole was drilled at the westerly end of the existing bridge on the south side. In Appendix A, Volume I, there is a photograph showing the Mobile B40L drill rig at this site.

The test holes drilled in 1969 used a diamond rotary drill rig while the test hole drilled in 1974 used a Mobile B40L auger with a 20 foot stroke which was modified for rotary drilling using water and mud as the drilling fluid. Samples were obtained using a split spoon penetrometer and also by straining the drilling fluid.

All samples were shipped to the Department's laboratory in Whitehorse for laboratory testing. Logs of the test holes and laboratory data sheets are included in Appendix A of this report.

TOPOGRAPHY

The proposed bridge is to cross the North Klondike River at a place where the valley is constricted by steeply rising ground on either side. Views of the bridge site are shown in Appendix A, Volume I, in Photographs 1, 2, 9 and 10. The existing road alignment makes a 90 degree turn on both sides of the crossing. The proposed realignment will eliminate these sharp curves and the new bridge will be placed

approximately 50 feet downstream from the existing structure. The width of the river, measured at the water line, was 43 feet at the time the survey was carried out on September 20, 1969. The vertical height from the bridge deck to the bottom of the stream will range from 10 to approximately 12 feet. No information is available on the width or depth of the water course during the height of spring runoff or during heavy rain.

SOIL PROFILE

The soils within the river valley of the North Klondike River show evidence of having been deposited and sorted by running water over a considerable period of time. Size sorting in a vertical direction can be seen in the test hole logs.

The soil material ranges from fine sand to boulders although the number of boulders reported in the test hole logs is quite small. The dense state of the soil is evidenced by the blow counts in the standard penetration test which were very high. Moisture contents in Test Hole 1 ranged from 10 to 23 percent with most of the samples in the upper 40 feet of the profile being less than 15 percent.

Permafrost was reported from Test Hole 74-1 at a depth of 38 feet to termination of the hole at 61.5 feet. The upper surface of the permafrost would therefore be approximately 32 feet below the elevation of the creek bottom.

Because of the highly permeable nature of the soil in this river valley we are of the opinion that a thaw bulb

has been formed by natural action beneath the bed of the river so that we would not expect to encounter permafrost within the top 40 feet of the soil profile during pile driving except where piles are placed more than 15 feet from the shoreline. HIGH OR LOW WATER?

DISCUSSION AND RECOMMENDATION

As mentioned above, the natural heat from running water has formed a thaw bulb beneath the bed of the river. Due to the permeability of the soil, the extent of this thaw bulb on either side of the river may be considerable although the actual cross section profile of the permafrost table would vary according to the permeability of the soil. The depth from the bottom of the stream bed to the permafrost table is almost certainly much greater than the probable length of any piles which will be driven at this site.

Visible ice was reported in Test Hole 74-1 from depths of 40 to 60 feet. It will be noted that the water contents in this depth interval ranged from 16 to 27 percent. We believe that the soil material at this site can be classed as being thaw-stable and that any settlements due to thawing of the permafrost will be very small. Furthermore, the effects of embankment construction in altering the thermal regime of the ground surface will be relatively small at this site. Also, it would take many years for the effects of surface changes to be felt at a depth of 40 or more feet.

WHAT ABOUT MORE THAN 15' FROM SHORELINE ?

We are therefore of the opinion that piers and abutments placed on conventional spread footings could be used at this site although driven steel piles would probably be more economical.

One of the more serious problems to be met in the design of piers and abutments at this site will be the determination of the depth of scour. If it is believed that the depth of scour can be determined with reasonable accuracy, we would suggest considering the use of abutments and piers supported on conventional spread footings with the design based on an allowable soil bearing pressure of 8 ksf.

Because of the remoteness of the site, and consequent difficulties due to logistics, it would probably be more economical to use driven steel H piles. We do not believe it would be possible to drive timber piles at this site due to the high driving resistance which would be encountered and a consequent risk of damage to the timbers. Steel pipe piles are not recommended and it is unlikely that they will be able to withstand the driving stresses. Precast concrete piles should not be used due to the difficulties of transportation and also because the length of pile could not be determined in advance. As some permafrost may be encountered during driving, it would probably be a wise precaution to require the piling contractor to have steam jetting equipment on the site in case it should be needed.

Steel H piles which are to be placed outside the confines of the water course, so that they will not be affected by scour, should be driven a minimum of 30 feet below existing grade and designed on the basis of the "Table of Penetration Resistance" following. For preliminary design purposes, an allowable skin friction of 800 psf (on the gross perimeter of the pile) can be assumed with top 10 feet of pile being assumed to carry no load. Piles driven in the stream bed should have a minimum length of embedment of 20 feet measured below the expected depth of scour. These piles can also be designed according to the following table.

TABLE 1

TABLE OF PENETRATION RESISTANCE

Description	Inches per Blow
Refusal	0.00-0.05
Practical Refusal	0.05-0.25
High Resistance	0.25-0.50
Medium Resistance	0.50-1.25
Low Resistance	1.25-1.75

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 piles we suggest that they 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 a driving shoe. Piles should be driven to at least practical refusal, according to the above table of penetration resistance, assuming that the hammer delivers an energy of at least 15,000 foot lbs. per blow. 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 to refusal may be designed for the full structural strength of the pile section acting as a column for that portion of the pile above final ground surface. The design load will depend on the allowable stresses of 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 acting 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 foot pounds per blow unless calculations show that the pile can safely take high impact stresses.

One of the problems faced by bridges is the possibility of log jams occurring which can cause partial or

complete failure of the bridge. 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 the river upstream of the bridge should be checked and, should it be observed that there is a possiblity of large trees being washed downstream, such a fact should be considered by the bridge designer.

If piles are used to support a vertical face of embankment fill, the lateral force against the piles 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, and 75 pounds per cubic foot where the backfill is compacted.

Embankments constructed below the highest expected flood level should be protected with riprap.

Respectfully submitted,

R. M. HARDY & ASSOCIATES LTD.

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA
PERMIT NUMBER P226
R. M. HARDY & ASSOCIATES LTD.

Per:

PROFESSIONAL ENGINEER ALBERTA G. McCORMICK

G. McCormick, P. Eng.

GM:cmg

APPENDIX A

Test Hole Logs

Laboratory Test Data Sheets

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING - YUKON

DRILLING RECORD

Dempster Hwy. Mile 42.7

PROJECT North Klondike River

HOLE NO. 69-2-1 DATE June 9/69

LOCATION See Plan

ELEVATION _____ DEPTH 20'

Diamond Drill Casing

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	DEPTH TO	SOIL DESCRIPTION	DEPTH FROM	DEPTH TO	NO.	TYPE	% RECOV.	N VALUE
0	6'	Fine grey sand with some gravel. Some organic material present 0-3' Cobbles 3-8" Some boulders up to 2' REFUSAL—— (sampler on rock)	5'	5½'	1	SPT		89 for 6"
6'	20'	Fine to coarse sand and gravel Sand-black, angular Cobbles 3-8"	9½'	10'	2	C		
		Temporary water loss at 14'	14'	15'	3	C		
			15'	16'	4	C		

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING – YUKON

Diamond Drill Tri-Cone with mud

DRILLING RECORD

Dempster Hwy. Mile 42.7

PROJECT North Klondike River

HOLE NO. 69-2-2 DATE June 12/ 69

LOCATION See Plan

ELEVATION _____ DEPTH 39

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	DEPTH TO	SOIL DESCRIPTION	DEPTH FROM	DEPTH TO	NO.	TYPE	% RECOV.	N VALUE
0	7'	Fine grey sand with fine to coarse gravel. Cobbles 3-4" Some organic material present 0-3' Sand-angular and flat						
7'	15'	Fine to coarse gravel with coarse black sand. Cobbles 3-8"						
15'	30'	Medium to coarse gravel, some sand present. Cobbles 4-10" Sand-angular and black						
30'	39'	Mediun to coarse gravel, fine to coarse black sand. Cobbles 6-12" Sand-hard packed, angular	35'	39'		W		

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING – YUKON

DRILLING RECORD

DEMPSTER HWY. MILE 42.7
PROJECT . NORTH KLONDIKE RIVER

HOLE NO. 69-2-3 DATE 21-06-69

LOCATION SEE PLAN

ELEVATION _____ DEPTH 51

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	DEPTH TO	SOIL DESCRIPTION	DEPTH FROM	DEPTH TO	NO.	TYPE	% RECOV.	N VALUE
0	5'	Fine gray sand with fine to coarse gravel. Cobbles 4-6" Some organic material present 0-½"						
5	15'	Medium to coarse gravel with sand Cobbles 4-6". Very hard drilling.						
15	30'	Medium to coarse gravel and sand. Cobbles 4-8". Sand angular and black.						
30	40'	Medium to coarse gravel and fine to coarse sand. Some cobbles 6-10" Sand hard packed.						
40	51'	Fine to coarse sand with medium gravel. Sand-angular and black.						

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING – YUKON

DRILLING RECORD

DEMPSTER HWY. MILE 42.7

PROJECT NORTH KLONDIKE RIVER

HOLE NO. 60-2-4 DATE 26-06-69

LOCATION SEE PLAN

ELEVATION _____ DEPTH 53

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	DEPTH TO	SOIL DESCRIPTION	DEPTH FROM	DEPTH TO	NO.	TYPE	% RECOV.	N VALUE
0	6'	Fine gray sand and fine to coarse gravel. Cobbles 4-6".						
6	15'	Medium to coarse gravel, with some fine to coarse sand present. Sand angular and black. Cobbles 4-6".						
15	26'	Medium to coarse gravel and sand. Sand-hard packed, angular. Cobbles 4-6".						
26	53'	Very fine to coarse sand some medium gravel. Sand-black with angular grain, fairly hard.						

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING – YUKON

DRILLING RECORD

PROJECT DEMPSTER HWY. MILE 42.7 NORTH KLONDIKE RIVER

HOLE NO. 69-2-5 DATE 2-7-69

LOCATION SEE PLAN

ELEVATION _____ DEPTH 52

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	DEPTH TO	SOIL DESCRIPTION	DEPTH FROM	DEPTH TO	NO.	TYPE	% RECOV.	N VALUE
0	7'	Fine gray sand with fine to coarse gravel. Some cobbles 4-6".						
7	28'	Medium to coarse gravel with fine to coarse sard. Sand-black and angular.						
28'	52'	Very fine to coarse sand with some medium gravel. Sand-fairly hard angular grain, extremely fine to coarse. Fairly easy drilling.						

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING – YUKON

DRILLING RECORD

PROJECT DEMPSTER HWY. MILE 42.7 NORTH KLONDIKE RIVER

HOLE NO. 69-2-6 DATE 5-07-69

LOCATION SEE PLAN

ELEVATION _____ DEPTH 50

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	TO	SOIL DESCRIPTION	DEPTH FROM	TO	NO.	TYPE	% RECOV.	N VALUE
0	15'	Fine to coarse sand with medium to coarse gravel. Cobbles 4-6". Some organic material 0-2'.						
15'	30'	Medium to coarse gravel and fine to coarse sand. Sand-black and angular. Cobbles 4-6".						
30'	45'	Medium to coarse gravel and fine to coarse sand. Sand-black and angular, extremely fine to coarse. Some cobbles 4-8".						
45	50'	Extremelyfine to coarse sand. Some medium gravel.						

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING – YUKON

PROJECT DEMPSTER HWY. N. KLONDIKE RIVER MILE 42.7

HOLE NO. 1 DATE Aug. 1968

LOCATION SEE PLAN

ELEVATION _____ DEPTH 15'

DRILLING NOTES			LABORATORY TESTING				
DEPTH FROM	TO	SOIL DESCRIPTION	DEPTH FROM	TO	% W.	L.L.	P.L.	P.I.
0	6'	"Fill" Broken Rock						
6	10'	Very hard drilling - coarse sandy gravel. Boulders 10" to 18".						
10	11'	Boulder						
11½	13'	Brown silt						
13	15'	Boulder						
		Refusal at 15½'.						

DRWG. NO. 60-148 T.S. 73-107

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING – YUKON

RECORD OF SUBSURFACE EXPLORATION PROGRAM
DRILLING AND LABORATORY TESTING
WHITEHORSE QUALITY CONTROL CENTER, WHITEHORSE, Y.T.

HOLE NO 1 DATE Oct. 12-15/74
LOCATION North Klondike River - Mi 42.7
ELEVATION _____ SHEET 1 OF 2

DRILLING NOTES
HOLE DEPTH 61½'
TYPE OF DRILL Rotary (Mud)
WATER LEVEL _____

LABORATORY TESTING

DEPTH (FT)	SOIL DESCRIPTION	SAMPLE ID: SAMPLE DEPTH (FT) FROM	TO	SAMPLE NUMBER (FIELD)	SAMPLE TYPE	LABORATORY NUMBER	NATURAL MOISTURE CONTENT %	DEGREE OF SATURATION %	VOID RATIO	POROSITY	DRY DENSITY LBS/CU FT	SPECIFIC GRAVITY	STANDARD PENETRATION RESISTANCE BLOWS/FT	UNCONFINED COMPRESSIVE STRENGTH LBS/SQ FT	CONSISTENCY LIMITS: LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	UNIFIED CLASSIFICATION	MECHANICAL ANALYSIS: MAXIMUM SIZE	% PASSING: .005 mm	#200	#40	#10	#4
5'	Silty Sandy Gravel – cobbles & few boulders																							
	Sandy Gravel																							
	5-6½ – 2" recovery saturated, low fines, gravel angular	5	6½	1	S/P	9160	-						91					GP	1½"	-	-	-	0.2	0.8
10	Silty Sandy Gravel – trace clay, some cobbles																							
	10-11½ – moist, few sand pockets, clean, dark red, med. grain, slight plasticity	10	11½	2	S/P	9161	10						99					GW-GM	1½"	-	10.7	18.2	30.3	42.0
	15-16½ – moist, grey to black silt in pockets, gravel angular to round.	15	16½	3	S/P	9162	15						112					GW-GM	1½"	-	9.6	15.4	28.9	44.6
20	Silty Gravel-Sand Mix																							
	20-21½ – moist to wet, black, rounded particles	20	21½	4	S/P	9163	11						79/8½"					SM	1"	-	14.5	24.2	43.7	57.9
25	Sandy Gravel-Silt Mix – some cobbles																							
	25-26½ – moist to wet grey to black, some pockets of red to yellow clean sand, rounded pebbles	25	26½	5	S/P	9164	10						118/8"					GM	1½"	-	15.6	25.2	37.0	48.4
30	Gravelly Silty Sand – no cobbles																							
	30-32 wet, black sand some fine gravel	30	32	6	S/P	9165	14						26					SM	1½"	-	10.7	34.4	63.9	79.4

FIELD — DRILLED: BY PA, RH DATE Oct 74 | LOGGED: BY P.A. DATE Oct 74
LABORATORY — TESTED: BY Soils DATE JAN 75 | RECORDED: BY BF DATE 28-2-75
DRAFTING — PLOTTED: DRWG NO _____ BY _____ DATE _____ | PROJECT NO TS

DRWG NO 60-151 TS 73-107

BL WO , DA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING – YUKON

RECORD OF SUBSURFACE EXPLORATION PROGRAM

DRILLING AND LABORATORY TESTING

WHITEHORSE QUALITY CONTROL CENTER, WHITEHORSE, Y.T.

HOLE NO 1 DATE Oct. 12-15/74

LOCATION North Klondike River Mi 42.7

ELEVATION _____ SHEET 2 OF 2

DRILLING NOTES

HOLE DEPTH 61½'

TYPE OF DRILL Rotary (Mud)

WATER LEVEL _____

LABORATORY TESTING

DEPTH (FT)	SOIL DESCRIPTION	SAMPLE IDENTIFICATION DATA: SAMPLE DEPTH (FT) FROM	TO	SAMPLE NUMBER (FIELD)	SAMPLE TYPE	LABORATORY NUMBER	NATURAL MOISTURE CONTENT %	DEGREE OF SATURATION %	VOID RATIO	POROSITY	DRY DENSITY LBS/CU FT	SPECIFIC GRAVITY	STANDARD PENETRATION RESISTANCE BLOWS/FT	UNCONFINED COMPRESSIVE STRENGTH LBS/SQ FT	CONSISTENCY LIMITS: LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	UNIFIED CLASSIFICATION	MECHANICAL ANALYSIS: MAXIMUM SIZE	% PASSING: .005 mm	# 200	# 40	# 10	# 4
35	Silty Sand																							
	35 – 37½ – wet, black sand	35	37½	7	S/P	9166	17						18				N.P.	SM	¾"	–	12.2	38.9	70.4	86.5
40	Gravelly Silty Sand																							
	Permafrost From 38½'																							
	40 – 41½ – Nbn, odd very small ice crystal	40	41½	8	S/P	9167	16						91				N.P.	SM	½"	–	10.3	36.6	68.8	88.3
	45 – 47½ – Nbn, odd visible ice crystal – black silt, med. grain sand.	45	47½	9	S/P	9168	23						82					SM	1"	–	15.6	53.5	74.3	87.7
	50 – 51½ – Nbn – first 1' has numerous pebbles – last 6" high % silt	50	51½	10	S/P	9169	27						68					SM	¾"	–	17.9	80.6	92.5	96.9
	55 – 56½ – Nbn – odd visible ice crystal	55	56½	11	S/P	9170	21						100				N.P.	SM	⅜"	–	14.4	45.9	84.6	97.0
	60 – 61½ – Nbn – odd visible ice crystal	60	61½	12	S/P	9171	23						102				N.P.	SM	⅜"	–	10.3	47.1	87.7	98.2
61½	Bottom of Hole																							

FIELD: DRILLED BY PA, RH DATE Oct 74 | LOGGED BY PA. DATE Oct 74

LABORATORY: TESTED BY Soils DATE Jan 75 | RECORDED BY BF DATE 28-2-75

DRAFTING: PLOTTED DRWG NO. _____ BY _____ DATE _____ | PROJECT NO. T.S

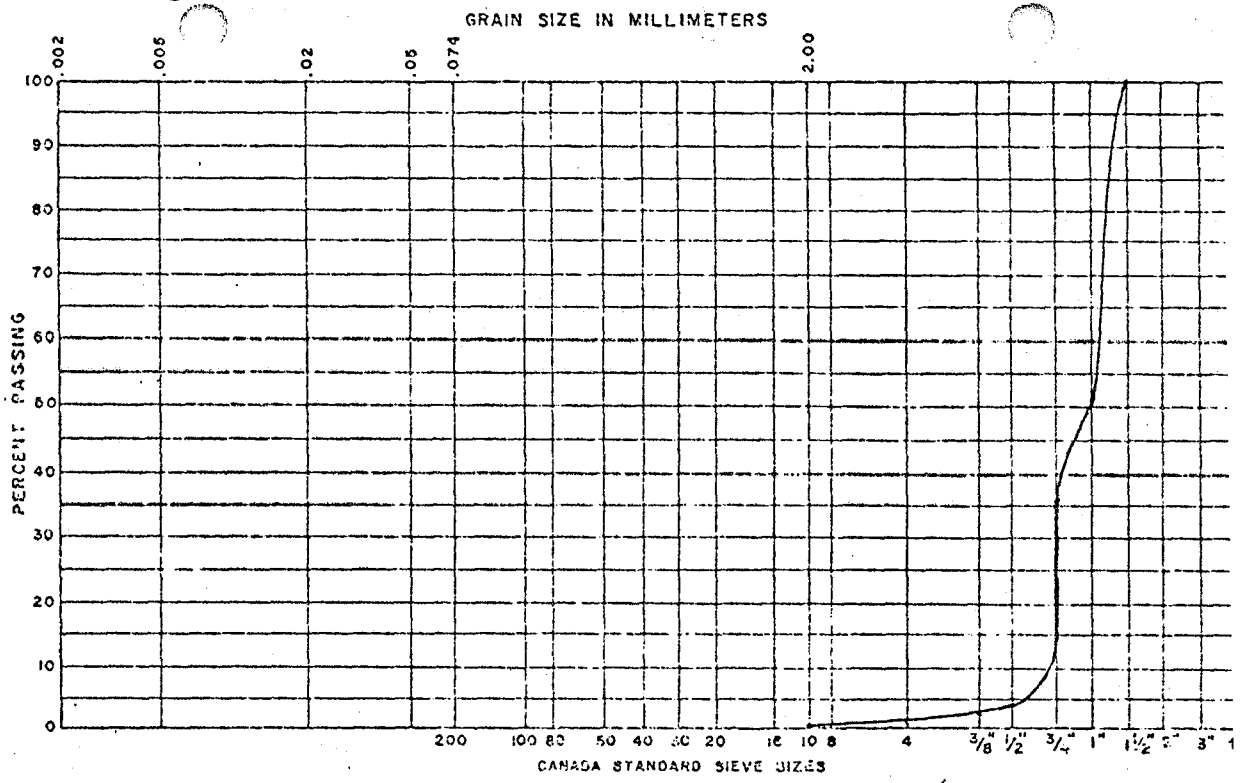
DRWG NO 60-151 T.S 73-107

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
1 1/2"	100.0	#40	-					
1	50.7	100	-					
3/4	35.5	200	-					
1/2	4.2							
3/8	3.5							
#4	0.8							
10	0.2							
20	-							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	GP				-	
	POORLY GRADED GRAVEL					

CRUSH COUNT %



PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
BASALT	
LIMESTONE	
GRANITIC	
SANDSTONE	
SHALE	
SCHIST	
QUARTZITE	
OTHERS	

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	

PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION NORTH KLONDIKE RIVER MILE 42.7

HOLE NO. 1

DEPTH 5'-6 1/2' FIELD NO. 1

SAMPLE TYPE S/P

LAB. NO. 9160

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING.

DATE SAMPLED 13-10-74

DATE RECEIVED - -10-74

DATE RECORDED 30-12-74

TESTED BY RK JE DH KJ SE

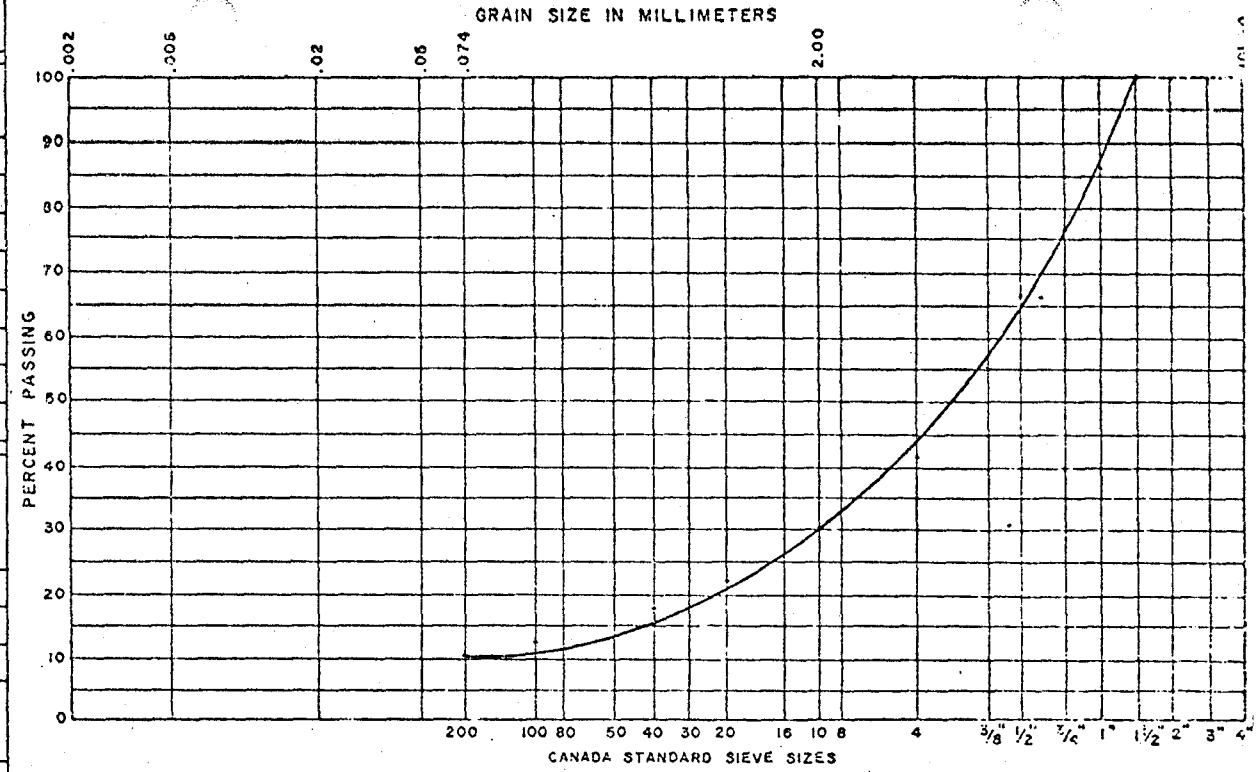
GRAIN SIZE ANALYSIS

VE E	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
2"	100.0	#40	18.2					
	26.0	80	12.6					
4	76.8	200	10.7					
2	67.0							
3	55.2							
4	42.0							
0	30.3							
2	22.5							

PLE O.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SILT-SAND				10	
	SILTY SANDY GRAVEL					

CRUSH COUNT %

GRAIN SIZE IN MILLIMETERS



CLAY	SILT	SAND	GRAVEL

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
SALT	
IESTONE	
ANITIC	
DSTONE	
ALE	
IIST	
ARTZITE	
HERS	

PARTICLE SHAPE ANALYSIS

UND	
-ROUND	
GULAR	
-ANGULAR	
ATS	
DLES	

PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION NORTH KLONDIKE RIVER MILE 42.7

HOLE NO. 1

DEPTH 10'-11½' FIELD NO. 2

SAMPLE TYPE S/P

LAB. NO. 9161

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING

DATE SAMPLED 13-10-74

DATE RECEIVED - -10-74

DATE RECORDED 30-12-74

TESTED BY RK JE JH BJ SE

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
12"	100.0	#40	15.4					
	92.9	100	11.3					
14	85.7	200	9.6					
2	71.3							
8	62.3							
4	44.6							
0	28.9							
0	19.6							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	GW-GM				15	
	SILTY-SANDY GRAVEL					

CRUSH COUNT %

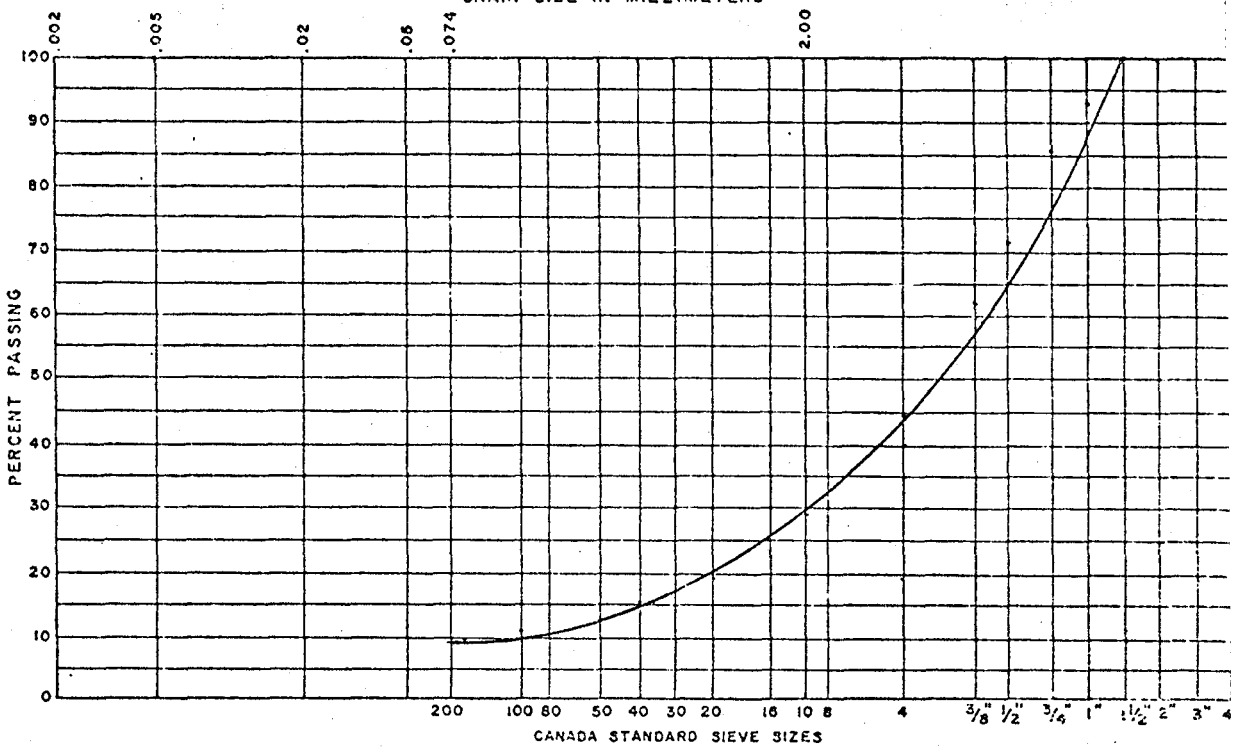
PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
ASALT	
IMESTONE	
RANITIC	
ANDSTONE	
HALE	
CHIST	
UARTZITE	
THERS	

PARTICLE SHAPE ANALYSIS

OUND	
UB-ROUND	
NGULAR	
UB-ANGULAR	
LATS	
EEDLES	

GRAIN SIZE IN MILLIMETERS



CLAY	SILT	SAND	GRAVEL

PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION NORTH KLONDIKE RIVER MILE 42.7

HOLE NO. 1

DEPTH 15'-16½' FIELD NO. 3

SAMPLE TYPE S/P

LAB. NO. 9162

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING.

DATE SAMPLED 13-10-74

DATE RECEIVED - - 10-74

DATE RECORDED 30-12-74

TESTED BY RK JE DH BJ SE

GRAIN SIZE ANALYSIS

VE ZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
11	100.0	#100	17.1					
14	83.2	200	14.5					
2	74.2							
13	70.1							
4	57.9							
0	43.7							
0	31.3							
0	24.2							

PLE O.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SM				11	
	SILTY GRAVEL-SAND MIXTURE					

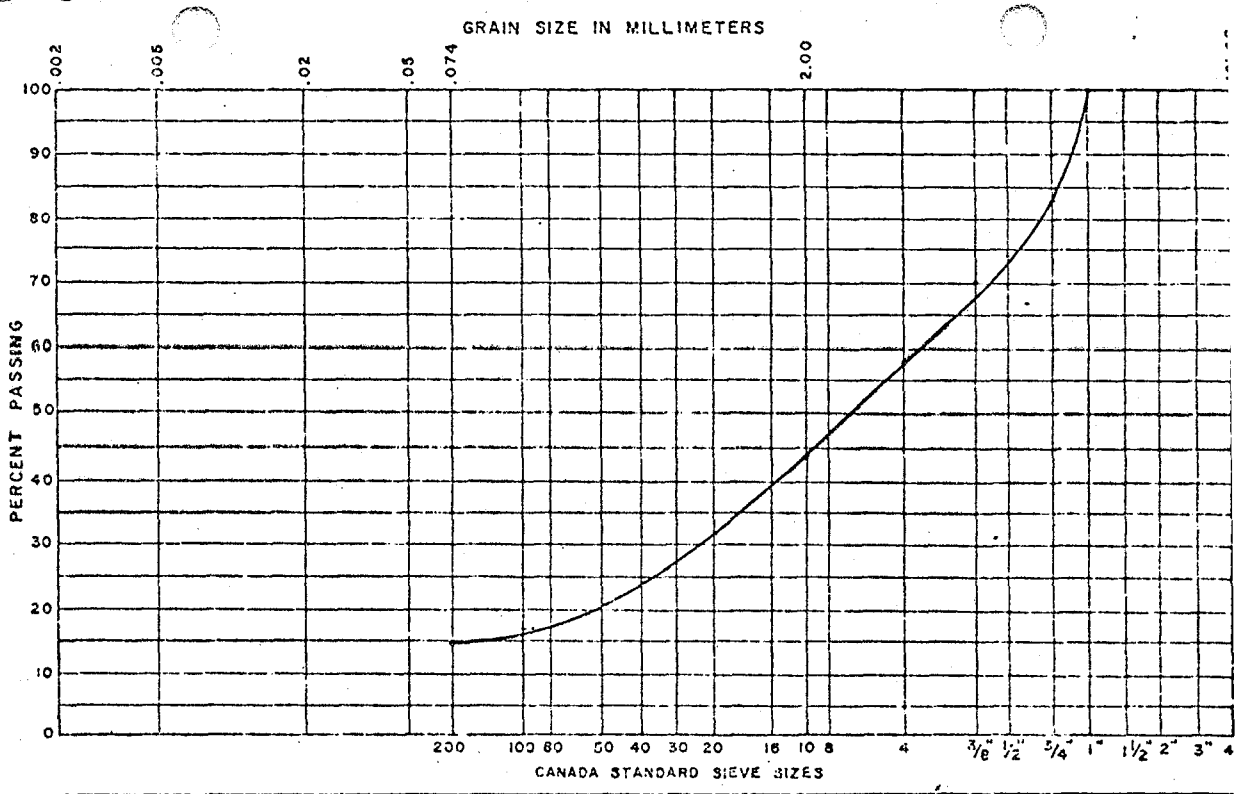
CRUSH COUNT %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
SALT	
MESTONE	
ANITIC	
NDSTONE	
IALE	
HIST	
ARTZITE	
THERS	

PARTICLE SHAPE ANALYSIS

UND	
B-ROUND	
GULAR	
B-ANGULAR	
ATS	
DLES	



PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION NORTH KLONDIKE RIVER MILE 42.7

HOLE NO. 1

DEPTH 20'-21½' FIELD NO. 4

SAMPLE TYPE S/P

LAB. NO. 9163

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING.

DATE SAMPLED 13-10-74

DATE RECEIVED --10-74

DATE RECORDED 30-12-74

TESTED BY RK JE JH BJ SE

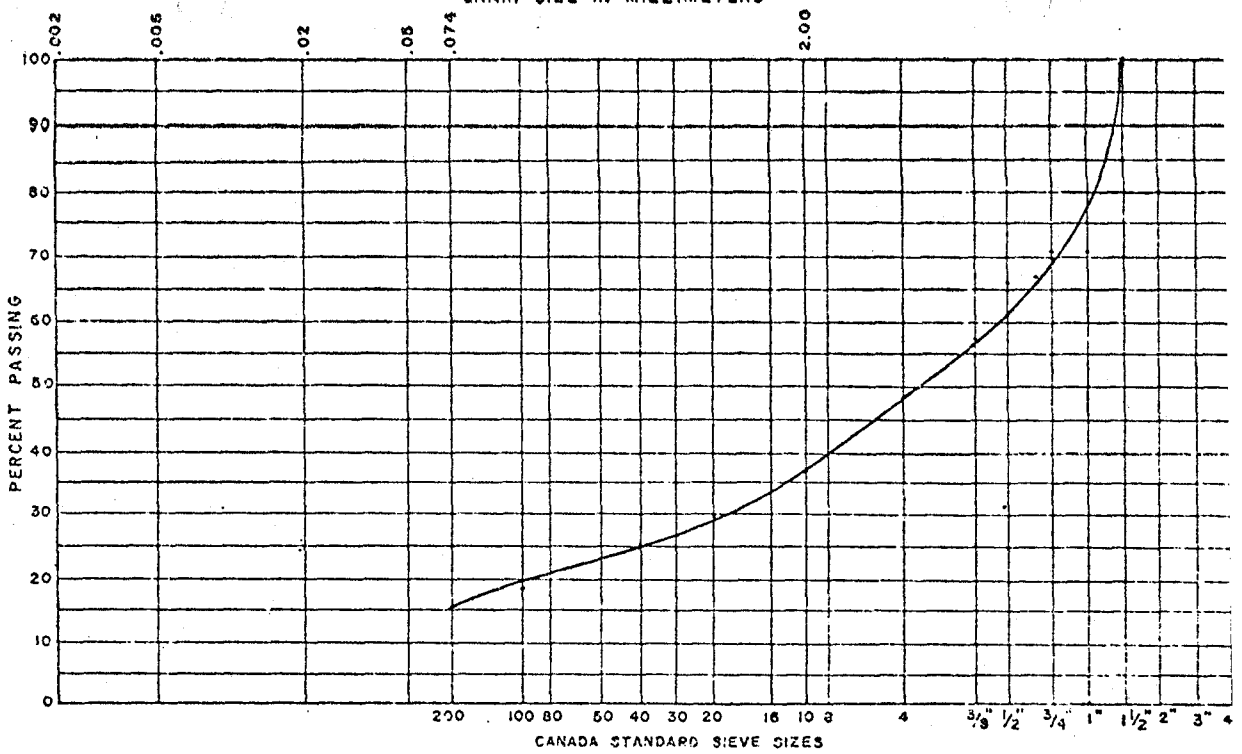
GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
1/2"	100.0	#16	25.2					
1	70.8	40	18.4					
1/4	70.8	200	15.6					
2	65.9							
8	57.3							
4	48.4							
0	37.0							
0	21.9							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	GM				10	
	SILTY SANDY GRAVEL					

CRUSH COUNT %

GRAIN SIZE IN MILLIMETERS



CLAY	SILT	SAND	GRAVEL

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
SALT	
MESTONE	
ANITIC	
NDSTONE	
IALE	
HIST	
IARTZITE	
HERS	

PARTICLE SHAPE ANALYSIS

UND	
B-ROUND	
GULAR	
B-ANGULAR	
ATS	
EDLES	

PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION NORTH KLONDIKE RIVER MILE 42.7

HOLE NO. 1

DEPTH 25'-26½' FIELD NO. 5

SAMPLE TYPE S/P

LAB. NO. 9164

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING

DATE SAMPLED 13-10-74

DATE RECEIVED - - 10-74

DATE RECORDED 30-12-74

TESTED BY RK JE JH GT SE

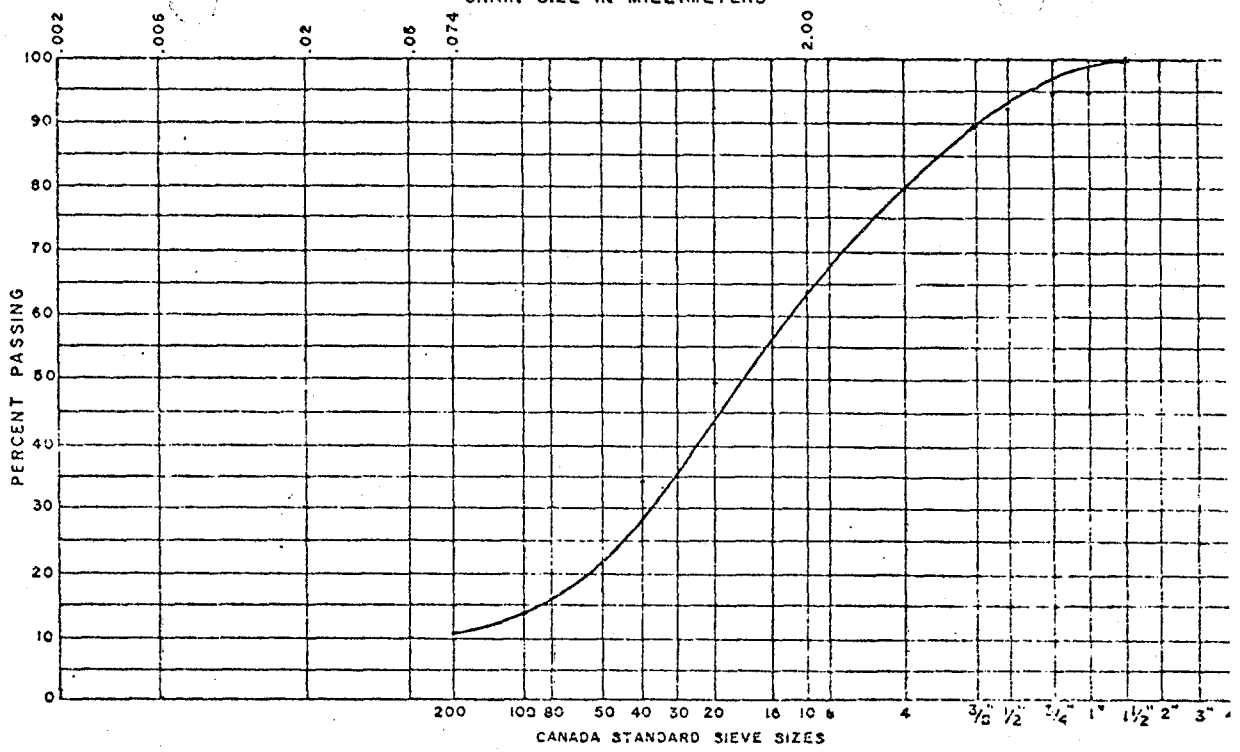
GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
1/2"	100	1#40	34.4					
1	94.9	100	13.7					
3/4	91.9	200	10.7					
1/2	92.5							
3/8	89.7							
4	77.4							
0	63.9							
0	49.3							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SM				14	
	SILTY GRAVELLY SAND					

CRUSH COUNT %

GRAIN SIZE IN MILLIMETERS



CLAY	SILT	SAND	GRAVEL

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
BASALT	
LIMESTONE	
GRANITIC	
SANDSTONE	
SHALE	
SCHIST	
QUARTZITE	
OTHERS	

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	

PROJECT DEMPSTER HWY. RELOCATION MILE 0-78.

LOCATION NORTH KLONDIKE RIVER, MILE 42.7

HOLE NO. 1

DEPTH 30'-32' FIELD NO. 6

SAMPLE TYPE S/P

LAB. NO. 9165

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING.

DATE SAMPLED 13-10-74

DATE RECEIVED - -10-74

DATE RECORDED 30-12-74

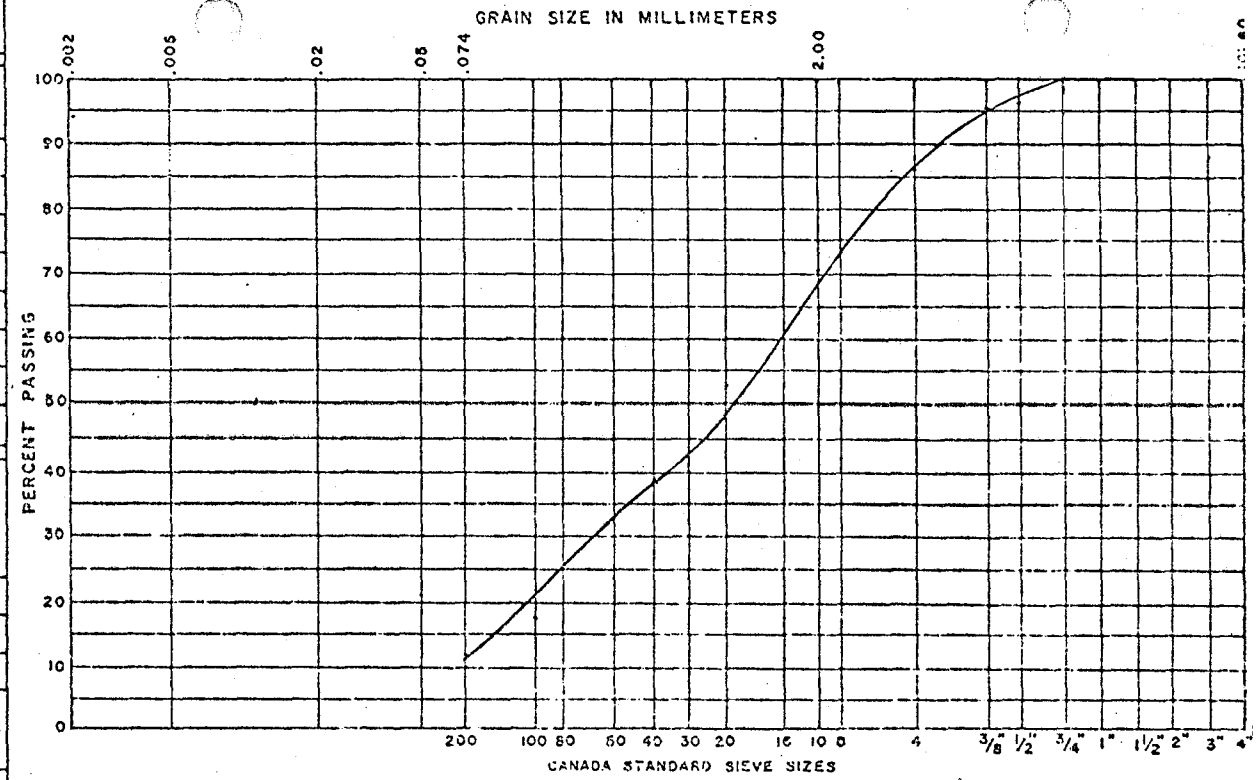
TESTED BY RK JE JH BT SF

GRAIN SIZE ANALYSIS

VE ZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
4"	100.0	#200	12.2					
3	96.6							
2	95.4							
1	84.5							
½	78.4							
¼	52.7							
#10	38.9							
#40	17.8							

PLE O.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SM			N.P.	17	
	SILTY SAND WITH PEBBLES					

CRUSH COUNT %



PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
SALT	
MESTONE	
ANITIC	
NDSTONE	
ALE	
HIST	
ARTZITE	
HERS	

PARTICLE SHAPE ANALYSIS

UND	
B-ROUND	
GULAR	
B-ANGULAR	
ATS	
DLES	

PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION SOUTH KLONDIKE RIVER MILE 42.7

HOLE NO. 1

DEPTH 35'-37½' FIELD NO. 7

SAMPLE TYPE S/P

LAB. NO. 9166

LABORATORY'S REMARKS

DATE SAMPLED 13-10-74

DATE RECEIVED --10-74

DATE RECORDED 30-12-74.

TESTED BY RK JE ~~DH~~ KT SE

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
"	100.0						
	92.5						
	88.3						
	68.6						
	50.1						
	36.6						
	14.2						
	10.3						

LE	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SM			N.P.	16	
	SILTY SAND WITH PEBBLES					

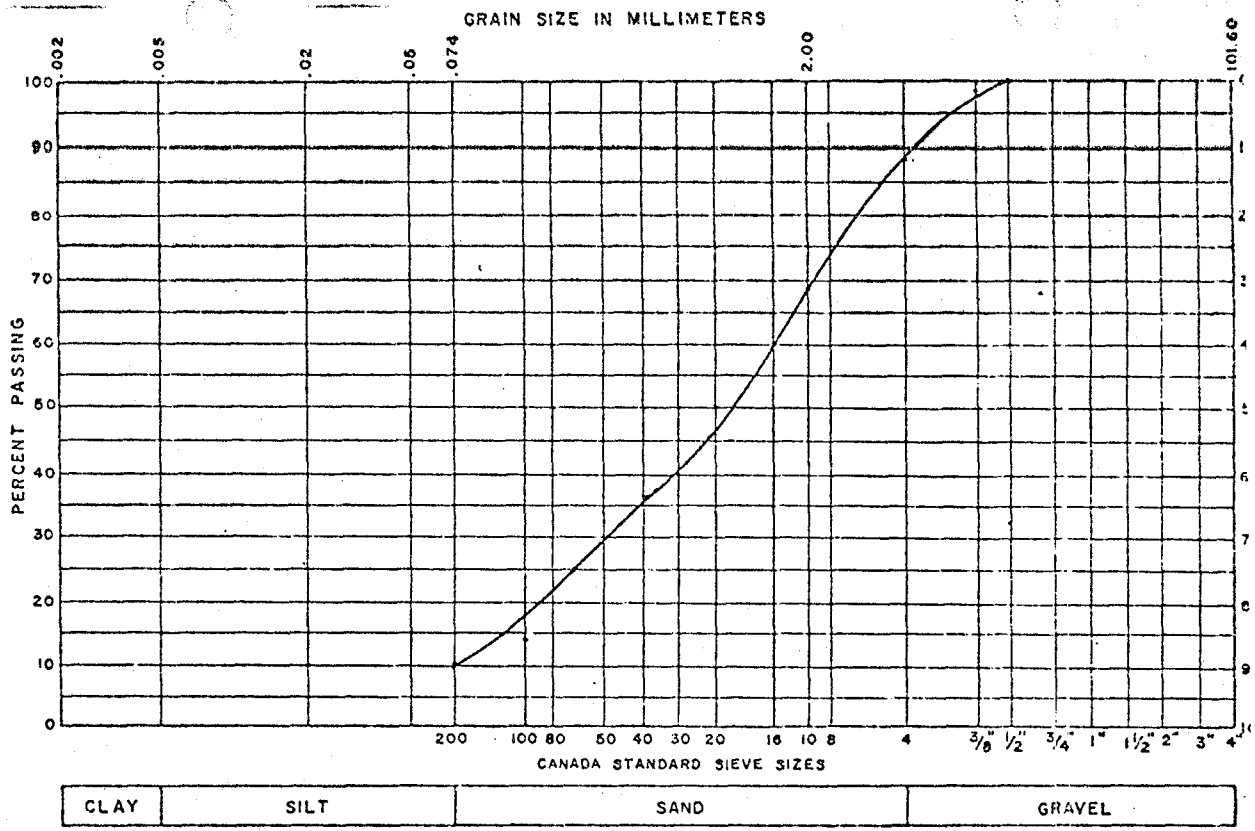
CRUSH COUNT %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
ALT	
ESTONE	
NITIC	
DSTONE	
LE	
IST	
RTZITE	
ERS	

PARTICLE SHAPE ANALYSIS

ND	
-ROUND	
ULAR	
-ANGULAR	
TS	
DLES	



PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION NORTH KLONDIKE RIVER MILE 42.7

HOLE NO. 1

DEPTH 40'-41 1/2' FIELD NO. 8

SAMPLE TYPE

LAB. NO. 9167

LABORATORY'S REMARKS

DATE SAMPLED 15-10-74

DATE RECEIVED - - 10-74

DATE RECORDED 30-12-74

TESTED BY RK JE JH RT SF

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
1"	100.0	#100	22.7					
3/4	76.5	200	15.6					
1/2	75.9							
3/8	94.7							
#4	84.7							
10	74.3							
20	63.1							
40	53.5							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SM				23	
	SILTY SAND WITH PEBBLES					

CRUSH COUNT %

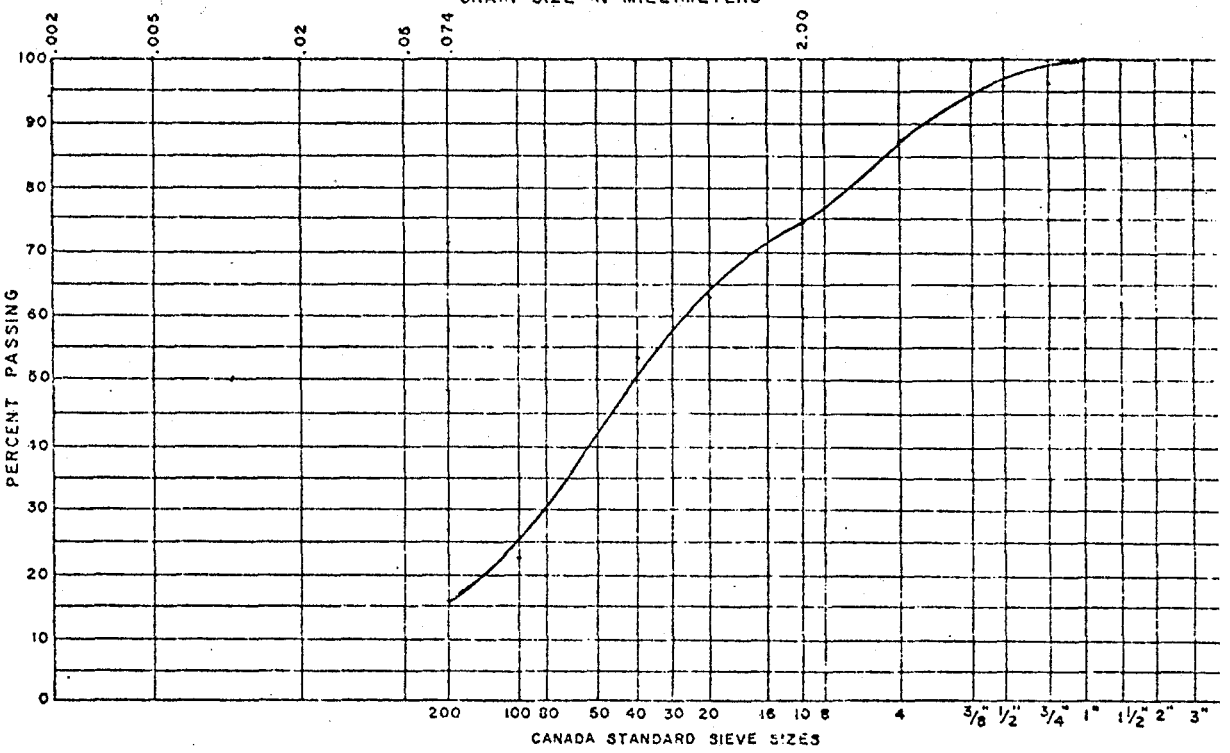
PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
BASALT	
LIMESTONE	
GRANITIC	
SANDSTONE	
SHALE	
SCHIST	
QUARTZITE	
OTHERS	

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	

GRAIN SIZE IN MILLIMETERS



CLAY	SILT	SAND	GRAVEL

PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION NORTH KLONDIKE RIVER MILE 42.7

HOLE NO. 1

DEPTH 45'-46½' FIELD NO. 9

SAMPLE TYPE S/P

LAB. NO. 9168

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING

DATE SAMPLED 15-10-74

DATE RECEIVED -- 10-74

DATE RECORDED 30-12-74

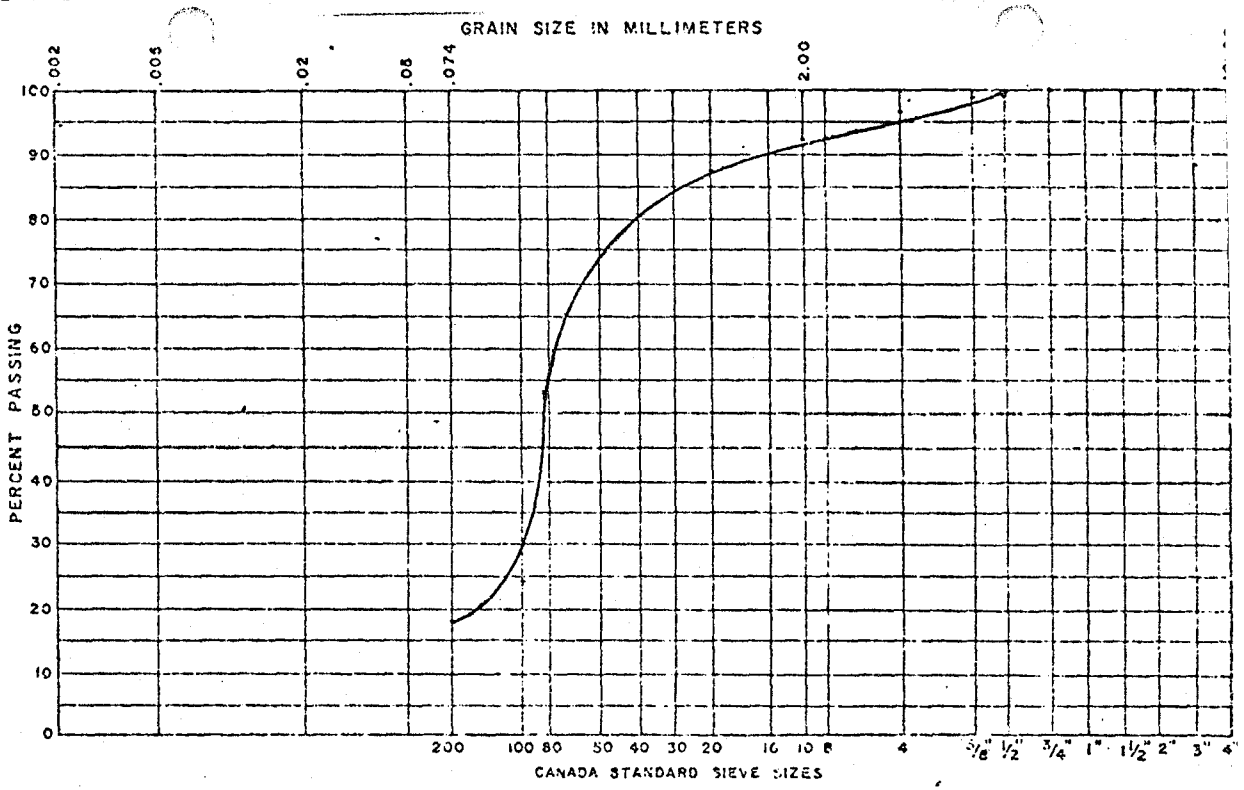
TESTED BY RK JE JH RJ SE

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
4"	100.0	#200	17.9					
2	99.1							
2	99.1							
4	96.9							
0	92.5							
0	87.4							
0	80.6							
0	74.4							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SM				27	
	SILTY SAND					

CRUSH COUNT %



PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
SALT	
IESTONE	
ANITIC	
NDSTONE	
ALE	
HIST	
ARTZITE	
HERS	

PARTICLE SHAPE ANALYSIS

JND	
B-ROUND	
GULAR	
B-ANGULAR	
ATS	
OLES	

PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION NORTH KLONDIKE RIVER MILE 42.7

HOLE NO. 1

DEPTH 50'-51 1/2' FIELD NO. 10

SAMPLE TYPE S/P

LAB. NO. 9169

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING.

DATE SAMPLED 15-10-74

DATE RECEIVED - - 10-74

DATE RECORDED 30-12-74

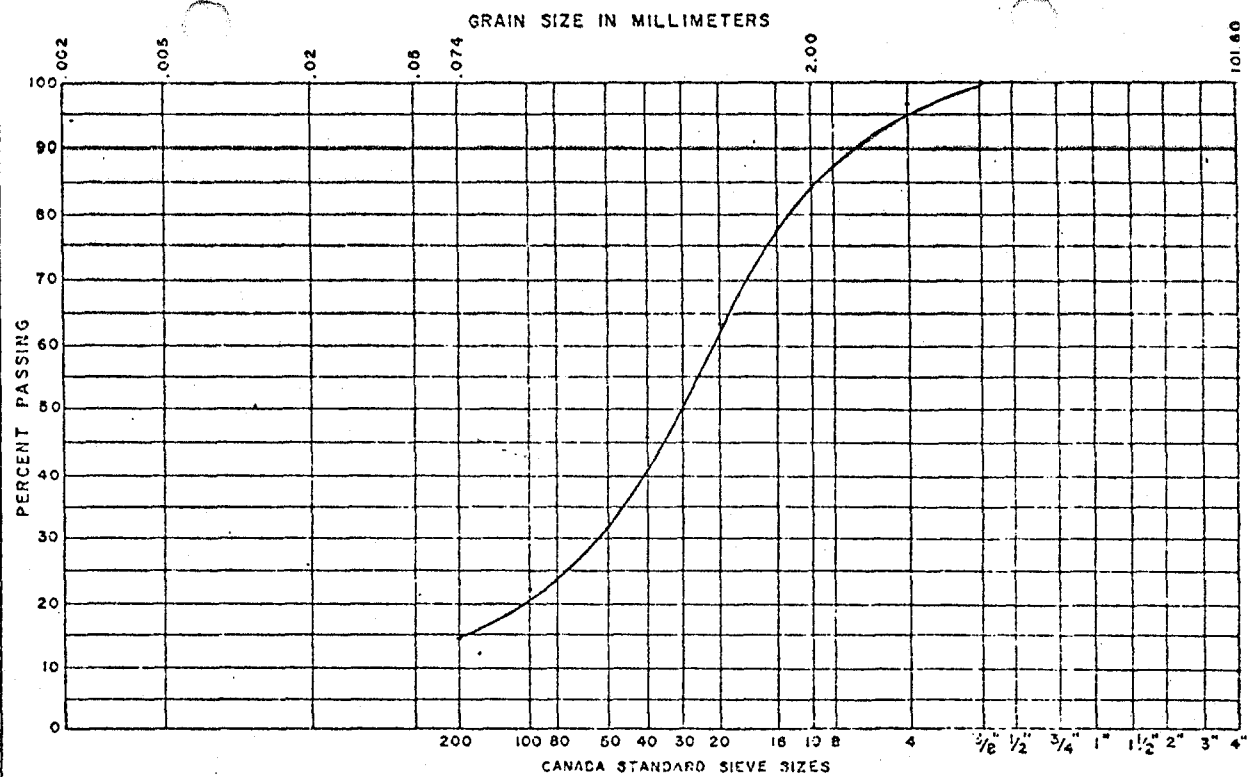
TESTED BY RK JE MR SF

GRAIN SIZE ANALYSIS

VE E	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
18"	100.0							
4	97.0							
0	84.6							
5	63.6							
0	45.9							
2	27.4							
0	14.4							

PLE O.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SM			N.P.	21	
	SILTY SAND.					

CRUSH COUNT %



CLAY	SILT	SAND	GRAVEL

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
SALT	
ESTONE	
ANITIC	
NDSTONE	
ALE	
IIST	
ARTZITE	
HERS	

PARTICLE SHAPE ANALYSIS

UND	
B-ROUND	
GULAR	
B-ANGULAR	
ATS	
FOLES	

PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION NORTH KLONDIKE RIVER MILE 42.7

HOLE NO. 1

DEPTH 55'-56½' FIELD NO. 11

SAMPLE TYPE S/P

LAB. NO. 9170

LABORATORY'S REMARKS

DATE SAMPLED 15-10-74.

DATE RECEIVED -- 10-74.

DATE RECORDED 30-12-74.

TESTED BY RK JE DH KT SE

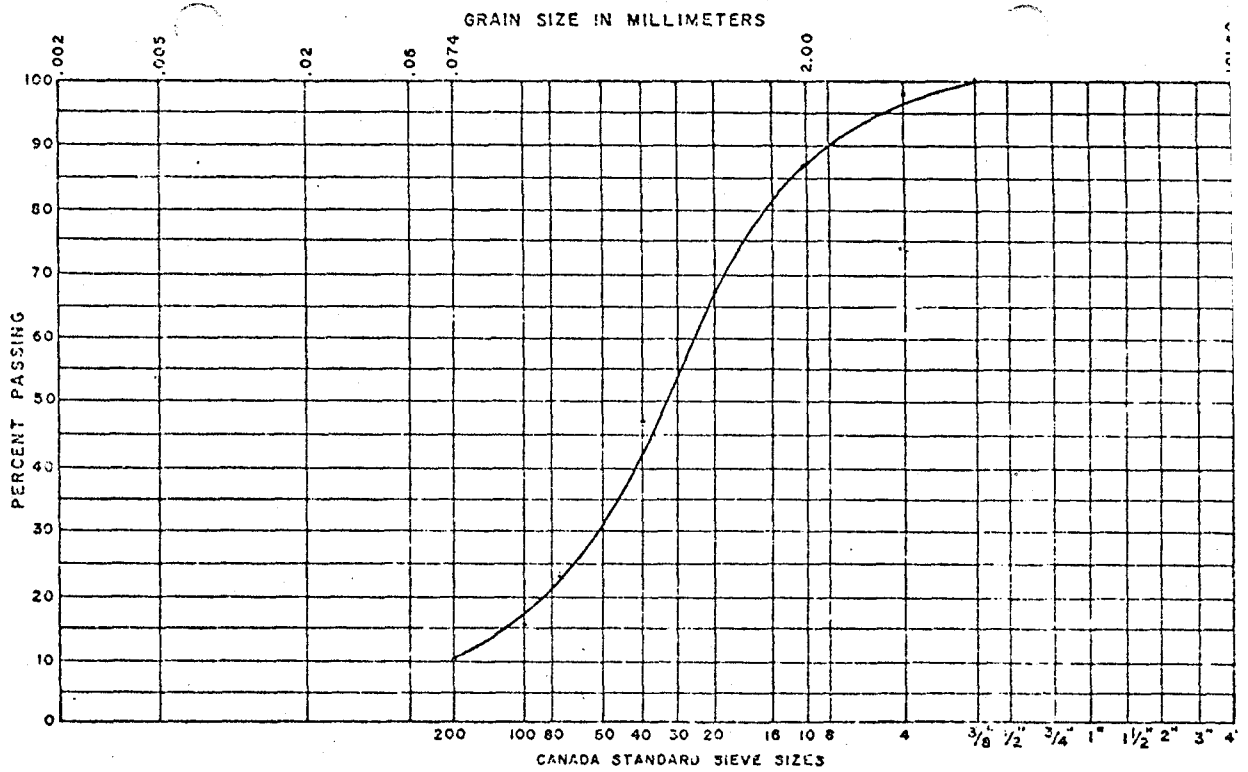
GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
3"	100.0						
4	78.2						
0	67.7						
0	57.2						
0	47.1						
0	15.4						
0	10.3						

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SM			N.P.	23	
	SILTY SAND.					

CRUSH COUNT %

GRAIN SIZE IN MILLIMETERS



CLAY	SILT	SAND	GRAVEL

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
SALT	
MESTONE	
ANITIC	
NDSTONE	
ALE	
HIST	
ARTZITE	
HERS	

PARTICLE SHAPE ANALYSIS

UND	
B-ROUND	
GULAR	
B-ANGULAR	
ATS	
EDLES	

PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION NORTH KLONDIKE RIVER MILE 42.7

HOLE NO. 1

DEPTH 60'-61½' FIELD NO. 12.

SAMPLE TYPE S/P

LAB. NO. 9171

LABORATORY'S REMARKS

DATE SAMPLED 15-10-74.

DATE RECEIVED --10-74

DATE RECORDED 30-12-74

TESTED BY RK JE JH BJ SE

APPENDIX B

Explanation Sheets

EXPLANATION OF TERMS AND SYMBOLS USED ON TEST HOLE LOG SHEETS

Depth

This column refers to the depth below the ground surface in feet.

Sample Number

Tube and core samples were numbered consecutively from the surface. Grab samples were not numbered.

Sample Type

This column indicates the depth interval and condition of each sample attempted. Undisturbed samples in this program were obtained with Shelby tubes of 18 inches length and 3 inches diameter, manufactured from 11 gauge steel, or by core drilling. Cores were of 2.85 inch diameter and up to 36 inches long.

Disturbed samples were obtained from the returned cuttings.

T indicates tube sample

C indicates core sample

 indicates large grab sample

Note: Grab samples taken for water content and visual examination are not indicated in this column.

Percent Recovery

This column shows the length of sample recovered as a percentage of the length attempted. 100% recovery is not indicated and may be assumed where no value is shown.

Penetration Resistence

Unless otherwise noted this column refers to the number of blows (N) of a 140 pound hammer dropping 30 inches required to drive a 2 inch O.D. open end sampler a distance of one foot from 0.5 to 1.5 feet into the soil. This is the standard penetration test referred to in ASTM, D1586.

Unified Soil Symbol

The soil symbols used are explained in full on page 5 of this appendix.

Soil Description.

Soils of different engineering classification are grouped generically for ease of reference. The system used is the Modified Unified Classification System for Soils.

Frozen Ground

The depth intervals over which frozen and unfrozen ground were encountered are indicated by F and UF respectively. No attempt was made to differentiate between seasonal frost and permafrost.

Ice Description

The ice content of permafrost soils has been classified according to the National Research Council System for describing permafrost. A brief review of the NRC System is contained on page 9 of this appendix. Where no entry is made, the type was not recorded in the field.

Water Content

The natural water content of the soil at the time of drilling is plotted against depth on the chart at the right hand side of the log. The water content, which is indicated by a circle, is expressed as a percentage of the dry weight of the soil. It will be observed that water contents in excess of 100% are indicated in the column at the right of the chart by figures.

Volume of Ice

The total volume of ice in undisturbed samples is indicated on the same chart as water contents. The value is indicated by a triangle. This volume is the total volume of ice in an undisturbed sample and includes intersticial ice, as well as excess ice, and is expressed as a percentage of the total volume of the sample.

Grain Size Analysis

The proportions of clay, silt, sand and gravel in a sample are summarized. Grain size curves for each sample so analyzed are on separate sheets.

Wet Density

The wet in situ density of undisturbed samples is the total weight of the sample in pounds (including ice and water) divided by the volume of the sample in cubic feet.

Dry Density

The dry in situ density of undisturbed samples is the weight of dry soil divided by the volume of the sample in cubic feet.

Atterberg Limits

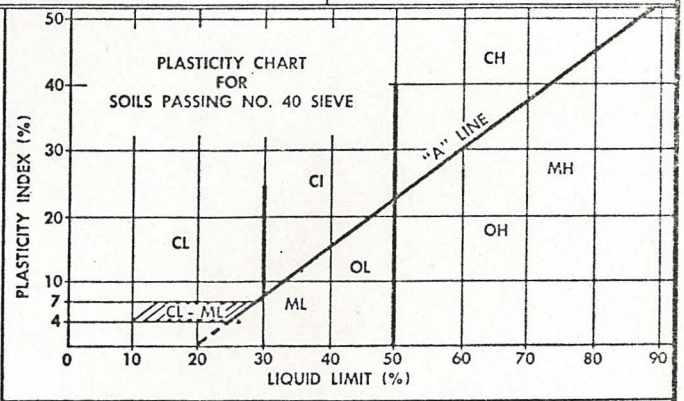
The plastic and liquid limits are shown on the water content chart by a horizontal bar. The Atterberg system is discussed in the following section.

NOTES ON ATTERBERG LIMITS

Soils which possess a significant fraction of clay can exist in liquid, plastic or solid states according to the water content. Where the water content is very high, so that the soil is in the form of a slurry, the soil behaves as a liquid. If the water content is reduced, for example through evaporation, the clay will enter into a plastic state. If the water content is reduced yet further, the clay will become a solid. The transition from one state to another occurs gradually over a range of water content. Atterberg, a Swedish agronomist, developed a method for delineating the boundaries between the three states. If his method is used, the water content which marks the dividing line between the plastic and liquid state is known as the Liquid Limit. These water contents are all expressed as percentages of the dry weight of soil. The range of water content between the plastic

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	COLOR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 200 SIEVE)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		RED	WELL GRADED GRAVELS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 6$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			GP		RED	POORLY GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM		YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE P.I. LESS THAN 4
			GC		YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-(SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
	SANDS MORE THAN HALF FINE GRAINS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	SW		RED	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 4$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			SP		RED	POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM		YELLOW	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE P.I. LESS THAN 4
			SC		YELLOW	CLAYEY SANDS, SAND-(SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES 200 SIEVE)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	ML		GREEN	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (see below)	
		$W_L > 50\%$	MH		BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS		
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART NEGLIGIBLE ORGANIC CONTENT	$W_L < 30\%$	CL		GREEN	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS		
		$30\% < W_L < 50\%$	CI		GREEN-BLUE	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS		
		$W_L > 50\%$	CH		BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW "A" LINE ON CHART	$W_L < 50\%$	OL		GREEN	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	WHENEVER THE NATURE OF THE FINE CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", E.G. SF IS A MIXTURE OF SAND WITH SILT OR CLAY	
		$W_L > 50\%$	OH		BLUE	ORGANIC CLAYS OF HIGH PLASTICITY		
HIGHLY ORGANIC SOILS			Pt		ORANGE	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE	



1. ALL SIEVE SIZES MENTIONED ON THIS CHART ARE U.S. STANDARD, A.S.T.M. E.11.
2. BOUNDARY CLASSIFICATIONS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE GIVEN COMBINED GROUP SYMBOLS, E.G. GW-GC IS A WELL GRADED GRAVEL SAND MIXTURE WITH CLAY BINDER BETWEEN 5% AND 12%.

and liquid limit is known as the plastic range and the numerical difference between the liquid and plastic limits is called the Plasticity Index.

It will be appreciated that where the natural water content is in excess of the liquid limit, the soil mass will be most unstable and will readily flow into excavations or trenches. Such considerations will not apply where the soil mass is kept frozen. However, in cases where the frozen soil is allowed to thaw, the relationship between the natural water content and liquid limit becomes critical.

On page 5 there is a chart showing the relationship between the Plasticity Index, the Liquid Limit and the group symbols of the Unified Classification System. The Atterberg Limit system is extremely useful for identifying and classifying soils.

NOTES ON THE RADFORTH SYSTEM FOR CLASSIFYING PEAT

The Radforth classification system for describing muskeg (organic terrain) is a method for classifying the three elements of vegetation, topography and organic surface cover using letter and figure symbols. Height and type of vegetation is described by using capital letters (A through I). Topography is described by using lower case letters (a through p) Organic cover type if described by using figures (1 through 16).

Table I outlines these figure symbols and the peat structure and type represented by them. A complete description of the Radforth system is contained in "Guide to a Field Description of Muskeg" published by National Research Council, Ottawa, from which has been copied Table I.

TABLE I

SUBSURFACE CONSTITUTION

Predominant Characteristic	Category	Name
	1.	Amorphous-granular peat
	2.	Non-woody, fine-fibrous peat
	3.	Amorphous-granular peat containing woody fine fibres
	4.	Amorphous-granular peat containing woody fine fibres
	5.	Peat, predominantly amorphous-granular, containing non-woody fine fibres, held in a woody, fine fibrous framework.
	6.	Peat, predominantly amorphous-granular containing woody fine fibres, held in a woody, coarse-fibrous framework.
	7.	Alternate layering of non-woody, fine fibrous peat and amorphous-granular peat containing non-woody fine fibres.
	8.	Non-woody, fine-fibrous peat containing a mound of coarse fibres.
	9.	Wood, fine fibrous peat held in a woody, coarse-fibrous framework.
	10.	Woody particles held in a non-woody, fine-fibrous peat.
	11.	Woody and non-woody particles held in fine-fibrous peat.
	12.	Woody, coarse-fibrous peat.
	13.	Coarse fibres criss-crossing fine-fibrous peat.
	14.	Non-woody and woody fine-fibrous peat held in a coarse-fibrous framework.
	15.	Woody mesh of fibres and particles enclosing amorphous-granular peat containing fine fibres.
	16.	Woody, coarse-fibrous peat containing scattered woody chunks.

NOTES ON THE NATIONAL RESEARCH COUNCIL SYSTEM FOR DESCRIBING PERMAFROST

Ground ice occurs in three conditions. Non-visible, visible (but less than one inch in thickness) and clear ice. Non-visible ice is designated N with an added suffix of one or two lower case letters. Visible ice is designated V with an added suffix of one lower case letter. Clear ice is designated ICE with notes on ice type.

TABLE IV

Symbol	Description
Nf	Non-visible ice, frozen soil in friable condition.
Nbn	Non-visible ice, frozen soil well bonded, no excess ice.
Nbe	Non-visible ice, frozen soil well bonded, excess ice revealed on melting sample.
Vx	Visible ice crystals.
Vc	Ice coatings on soil particles.
Vr	Ice formations irregularly orientated.
Vs	Stratified ice lenses.
ICE	Clear ice over one inch in thickness.
ICE + soil	Ice over one inch thick with soil inclusions.

A complete description of this system is contained in "Guide to a Field Description of Permafrost" published by National Research Council, Ottawa.

APPENDIX C

Driving Steel Piles

DRIVEN STEEL PILES

Piles shall be driven by equipment having a striking weight not less than one-third of the driven weight of the piles. The driver should be capable of delivering at least 15,000 ft. lbs. of energy.

The number of blows required to drive the pile each foot should be recorded for every pile as an indication of the satisfactory carrying capacity of the pile and as an indicator of potential tip damage.

After each pile is driven to its required depth an elevation should be taken of the pile top or on a suitable mark on the side of the pile. This elevation should be checked periodically to ensure that it is not heaved by the driving of adjacent piles. Piles that are heaved must be redriven.

For piles which displace a considerable amount of soil during driving, such as closed-end pipe piles, care must be taken that the driving does not cause damaging horizontal displacement of existing structures or foundations.

Where piles are designed to gain support by skin friction in the soil it is essential that the pile have ends and walls free from protrusions which could cause voids or disturbance of the adjacent soil during driving.