GK-03-031

GEOTECHNICAL INVESTIGATION

PROPOSED BRIDGE SITE

UPPER BLACKSTONE RIVER, MILE 53.8

E-3098

Km 86.6

August 6, 1975

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

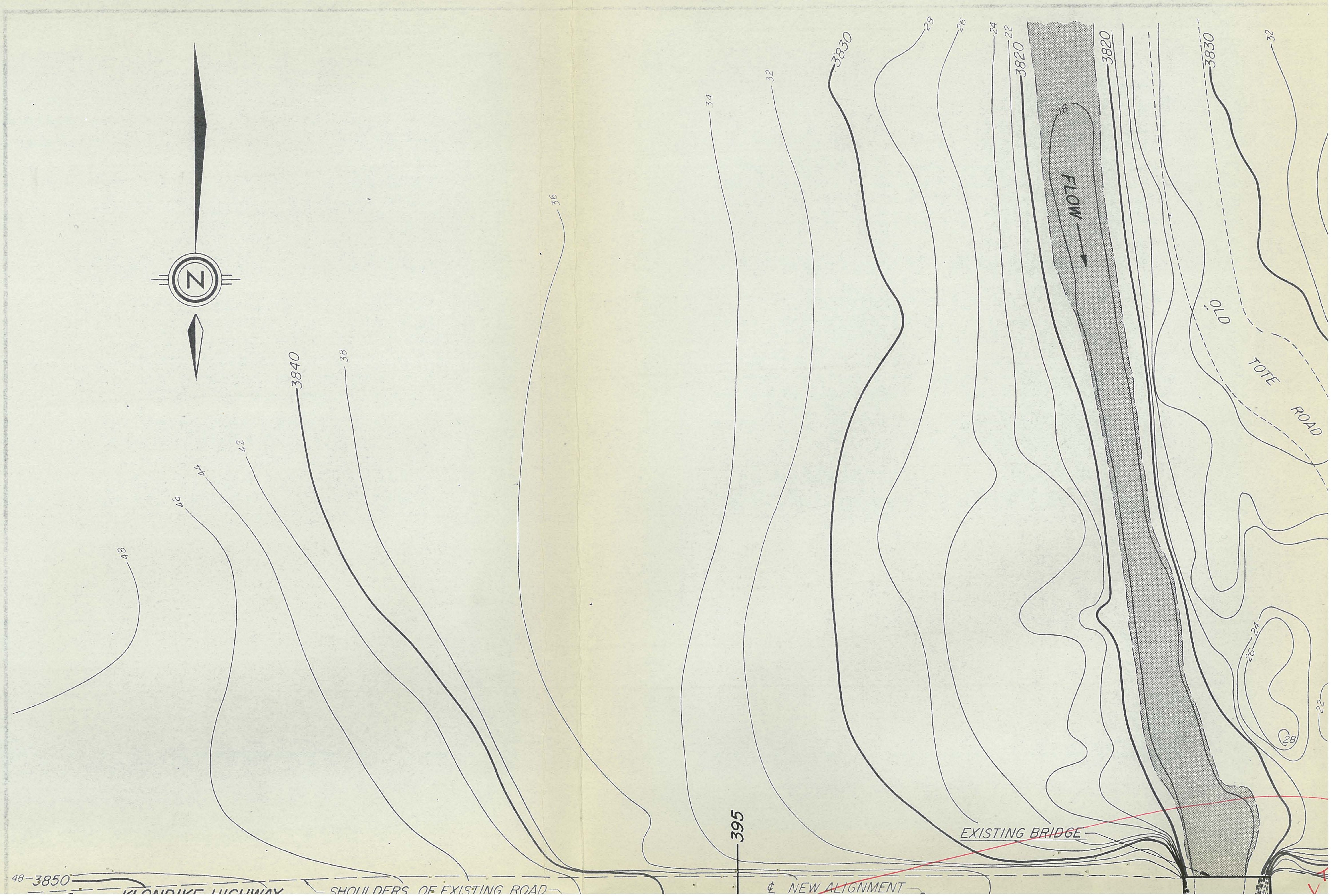
GEOTECHNICAL INVESTIGATION

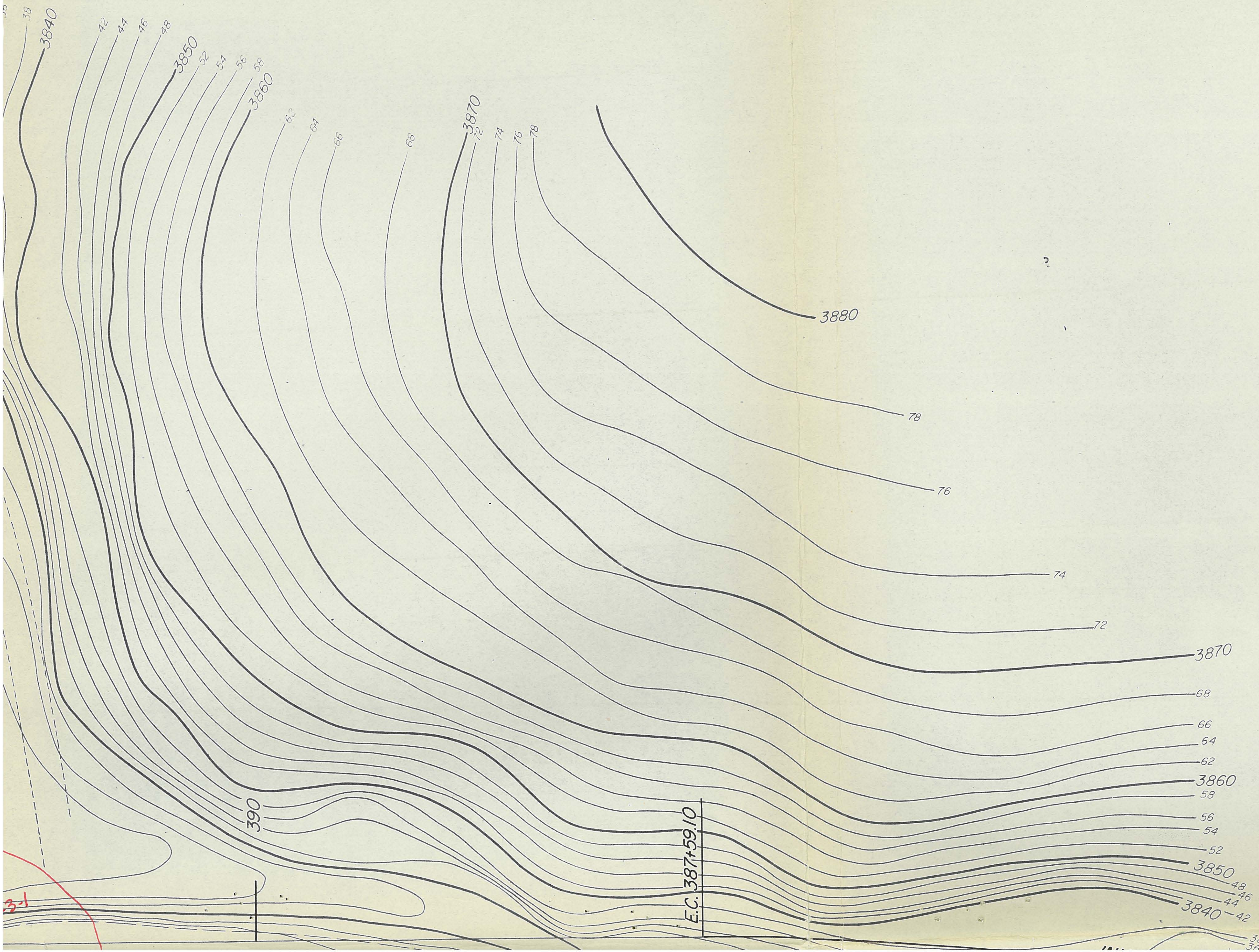
PROPOSED BRIDGE SITE

UPPER BLACKSTONE RIVER, MILE 53.8

E-3098 Km 86.6

August 6, 1975


N
3850
3840
3830
3820
FLOW
OLD TOTE ROAD
EXISTING BRIDGE
395
SHOULDERS OF EXISTING ROAD
¢ NEW ALIGNMENT

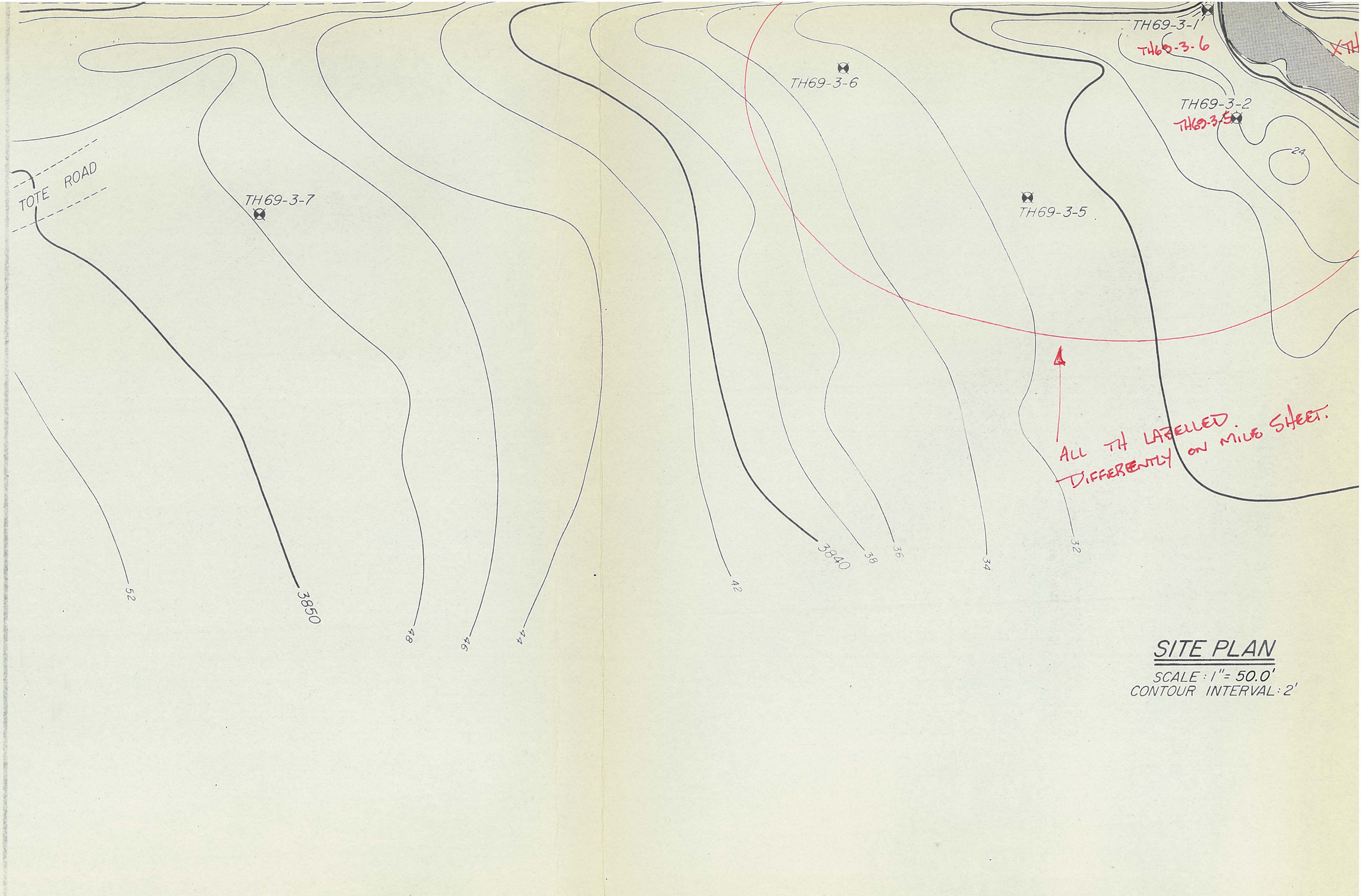


Department of Public Work
Ministère des Travaux publi

WHITEHORSE, YUKO

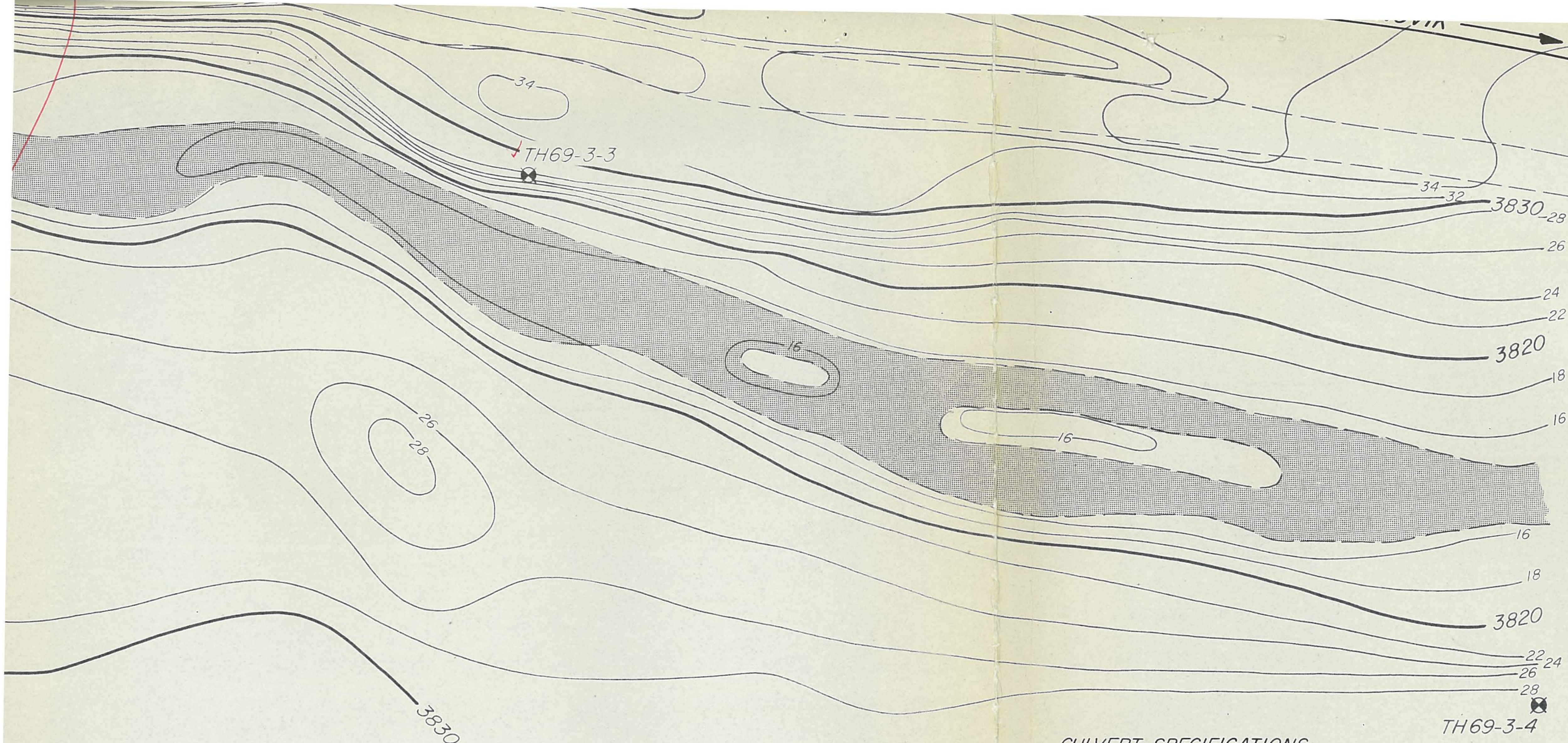
LEGEND

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



SITE PLAN

SCALE: 1" = 50.0'
CONTOUR INTERVAL: 2'



CULVERT SPECIFICATIONS

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

- COMPILED FROM UPPER BLACKSTONE SURVEY BOOK (1975)
- SURVEYOR B. McKAMEY
- BM 24 APPROX. 348' RT. STA. 384+50 ELEV. 3834.36 (I.P. ROD ON GRAVEL BANK)

REC'D DEC. 24/76

project title — titre du projet

RECONSTRUCTION
DEMPSTER HIGHWAY
MILE 53-75

drawing title — titre du dessin

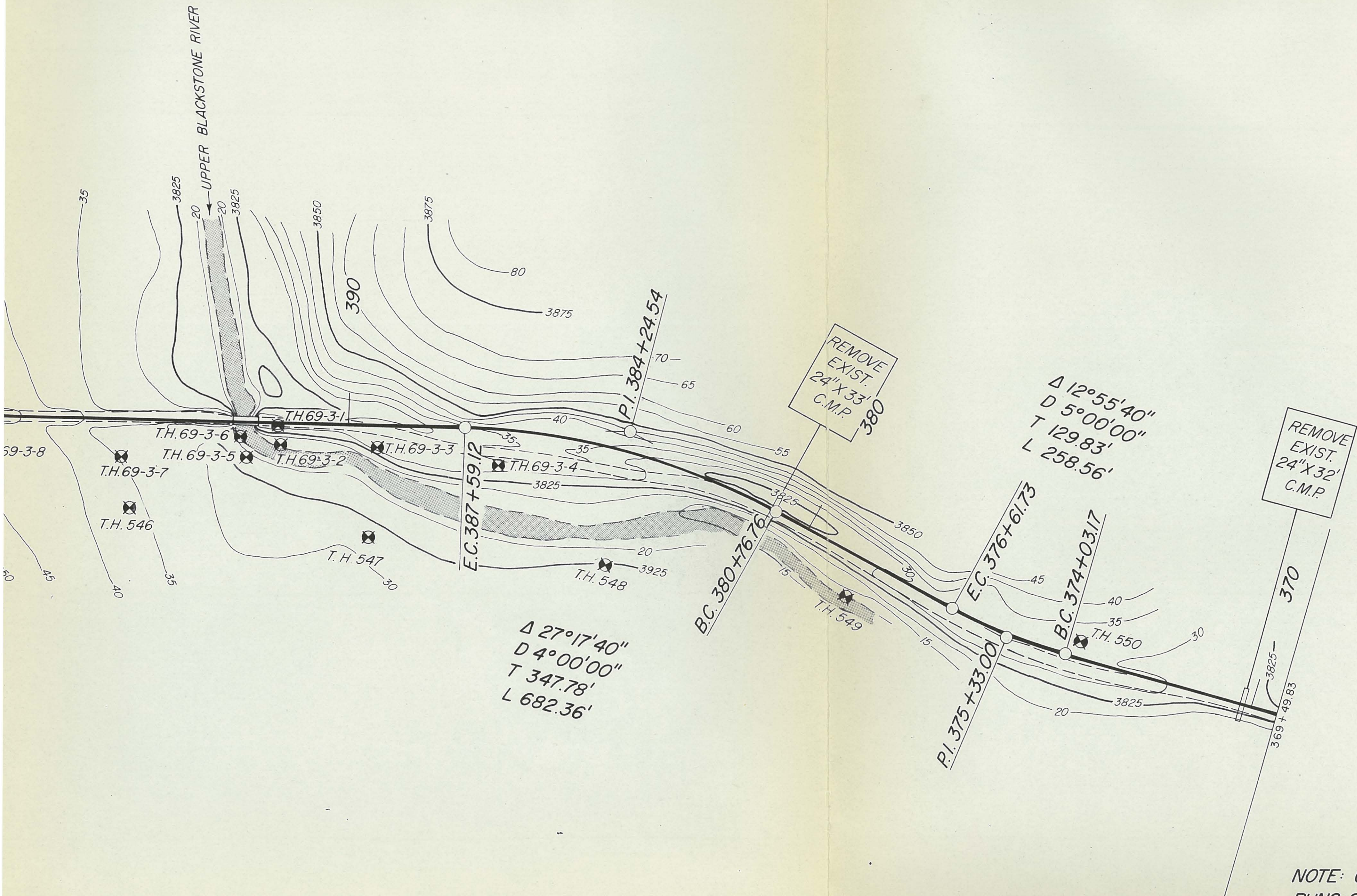
SITE PLAN
UPPER BLACKSTONE
MILE 53.8

designed by J. QUONG	conçu par
date NOV., '76	
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 NOV. '76	
Tender	Soumission
D.P.W. Project Manager	Administrateur de projets M.T.P.
project number	no du projet
drawing no	dessin no

UPPER BLACKSTONE

DRAWING NO.	VERT. SCALE	HORIZ. SCALE	SHEET NO.	TOTAL SHEETS
	1" = 20'	1" = 200'		

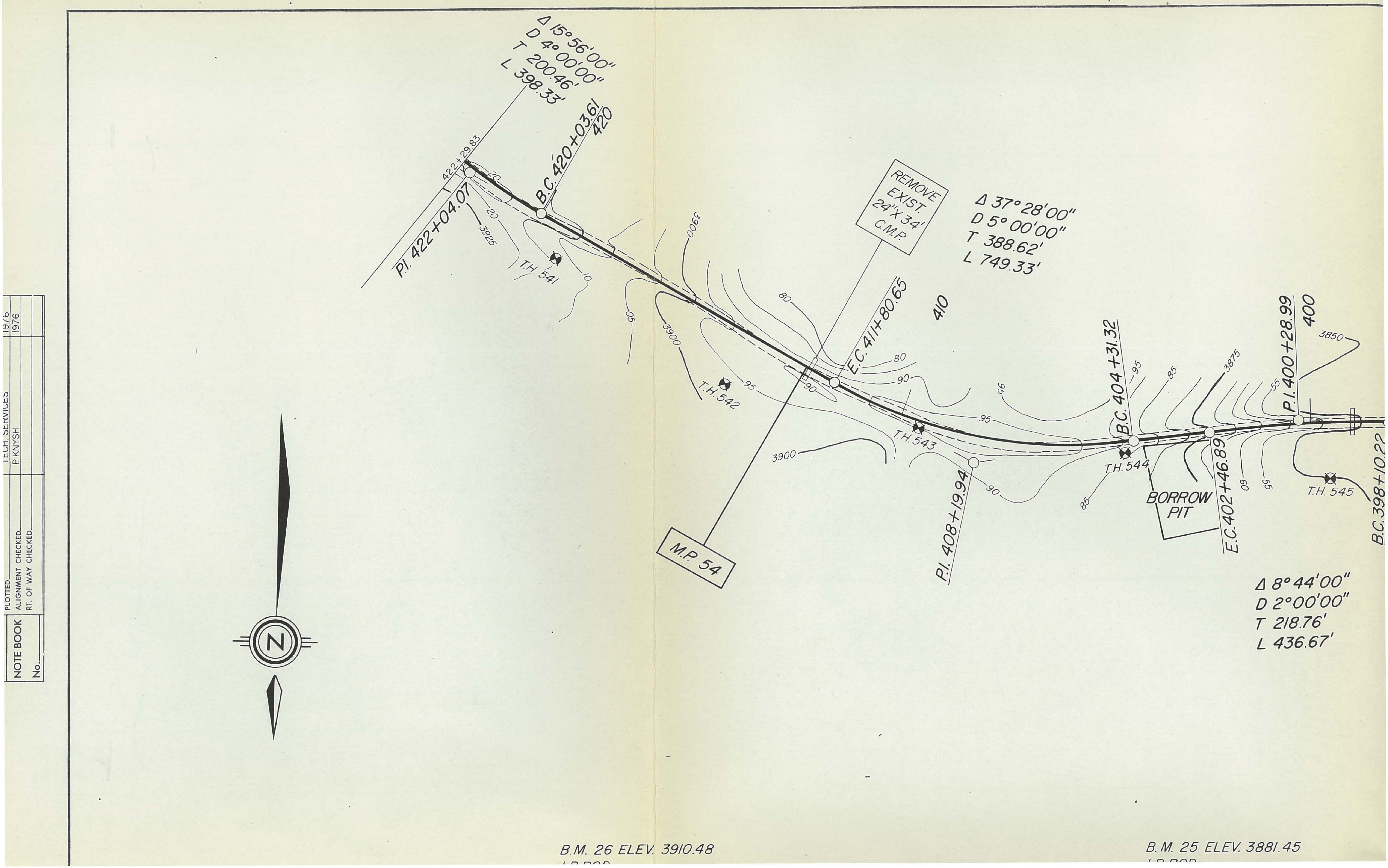
Rec'd Dec. 24/76

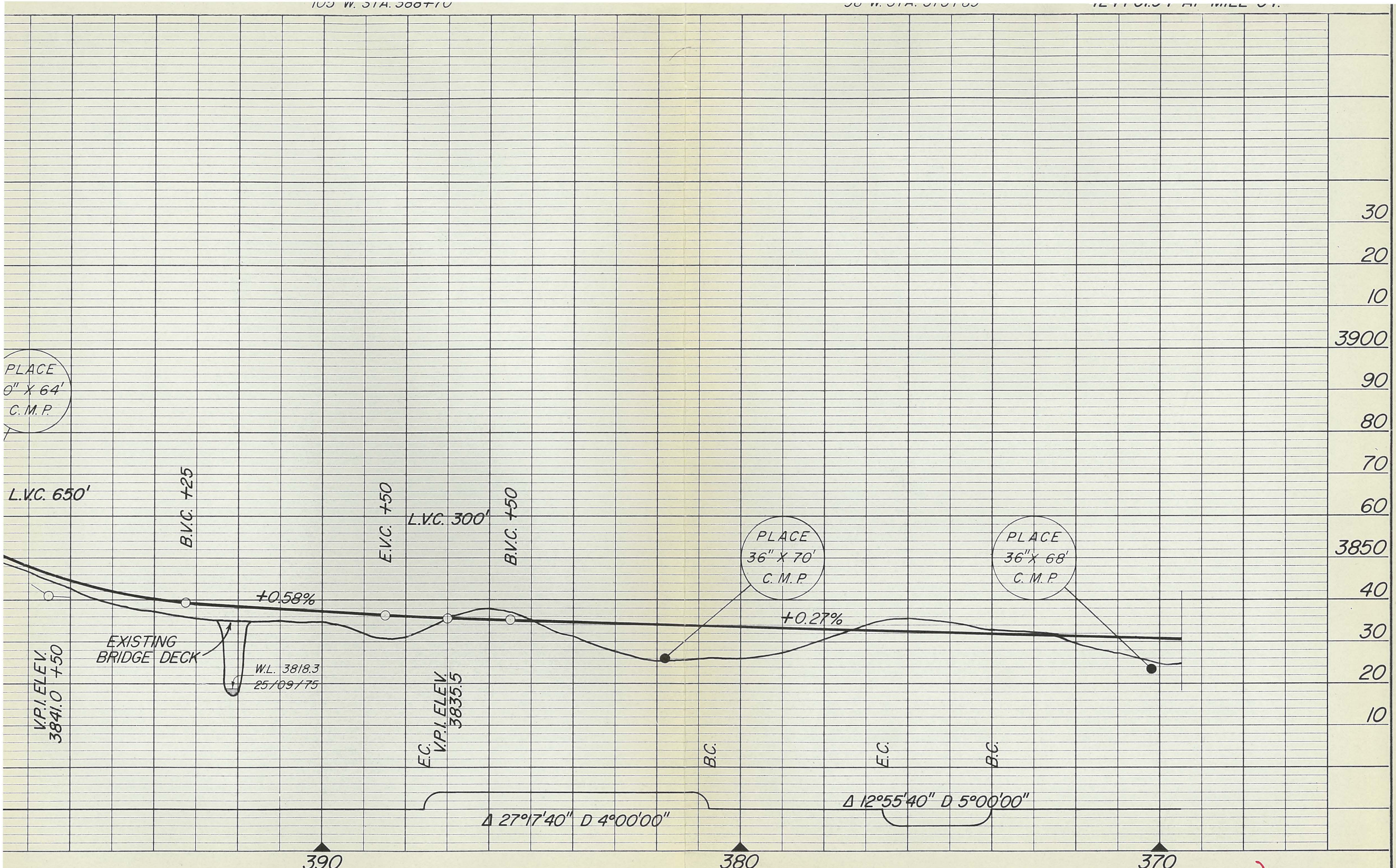


B.M. 24 ELEV. 3834.36

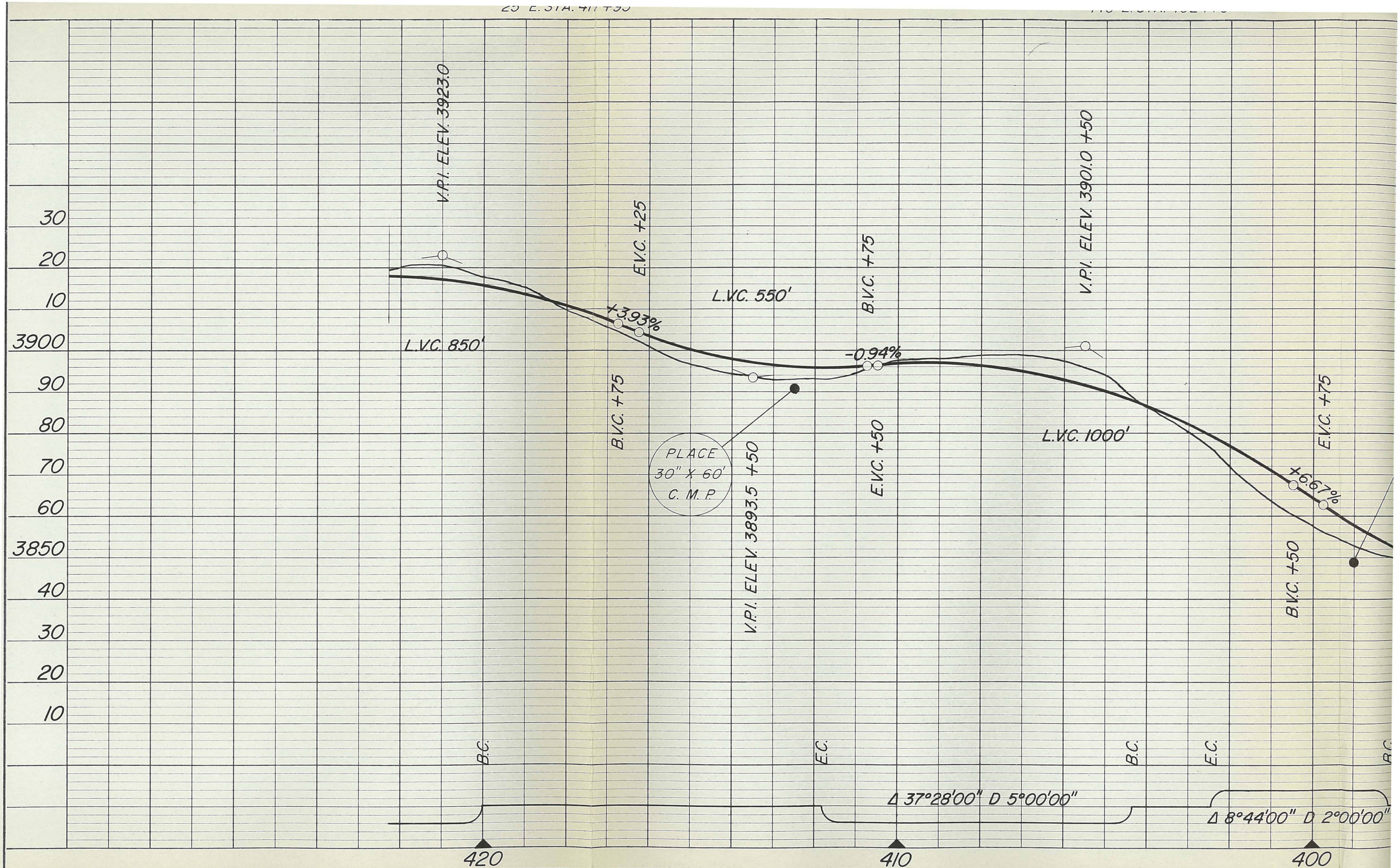
B.M. 23 ELEV. 3844.72

NOTE: CHAINAGE FROM MILE 54-6(RUNS SOUTH, STARTING WITH 100+(AT MILE 60 AND ENDING WITH E.(


Δ 15°56'00"
D 4°00'00"
T 200.46'
L 398.33'
422+29.83
P.I. 422+04.07
B.C. 420+03.61
420
3925
T.H. 541
3900
REMOVE EXIST. 24"X 34' C.M.P.
Δ 37°28'00"
D 5°00'00"
T 388.62'
L 749.33'
E.C. 411+80.65
410
T.H. 542
T.H. 543
M.P. 54
P.I. 408+19.94
B.C. 404+31.32
T.H. 544
3875
BORROW PIT
E.C. 402+46.89
P.I. 400+28.99
400
3850
T.H. 545
B.C. 398+10.22
Δ 8°44'00"
D 2°00'00"
T 218.76'
L 436.67'
B.M. 26 ELEV. 3910.48
B.M. 25 ELEV. 3881.45
NOTE BOOK
No.
PLOTTED
ALIGNMENT CHECKED
RT. OF WAY CHECKED
TECH. SERVICES
P. KNYSH
1976
1976



UPPER BLACKSTONE



V.P.I. ELEV. 3923.0
E.V.C. +25
L.V.C. 550'
B.V.C. +75
V.P.I. ELEV. 3901.0 +50
+3.93%
L.V.C. 850'
-0.94%
B.V.C. +75
PLACE 30" X 60' C. M. P.
V.P.I. ELEV. 3893.5 +50
E.V.C. +50
L.V.C. 1000'
E.V.C. +75
+6.67%
B.V.C. +50
30
20
10
3900
90
80
70
60
3850
40
30
20
10
B.C.
E.C.
B.C.
E.C.
Δ 37°28'00" D 5°00'00"
Δ 8°44'00" D 2°00'00"
420
410
400

INTRODUCTION

At the request of Mr. J. Quong, P.Eng., Manager o 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 Upper Blackstone River.

The location of the bridge is shown on Plan-Profile Sheet No. 54, Drawing 7102.1 dated 1969. This drawing is to a scale of 1" = 200 feet. The site is covered by aerial Photographs A18137-41 and -42. The crossing is located approximately ? 1700 feet downstream from the location of the existing Bailey Bridge on the existing highway.

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 total of ten test holes have been drilled at or near the bridge site with one test hole being drilled on September 13, 1968 using a Mobile B-40 drill rig. There is no indication on the test hole logs as to the type of drilling employed but it is probable that a continuous flight auger was used.

A further eight test holes were drilled during the summer of 1969 using a rotary drill rig and wet drilling. These test holes are numbered 69-3-1 through 69-3-8. The closest drill hole, of this series, to the crossing is Test Hole 69-3-4 which is located approximately 750 feet upstream ? of the proposed crossing.

The last test hole was drilled during October of 1974 using a Mobile B-40L drill rig modified for rotary drilling and using water and mud as the drilling fluid. Samples were obtained by straining the drilling fluid and by taking standard penetration samples at intervals of 5 to 10 feet.

Testing of samples was carried out in the Department's laboratory in Whitehorse. Logs of the test holes and laboratory data sheets are included in Appendix A.

TOPOGRAPHY

The site lies in the Taiga Valley at an elevation of 3820. The southerly approach is down a gradient of approximately 4 percent with the last 900 feet being level. The northerly approach to the bridge requires a cut of approximately 5 feet to maintain the level gradient for a distance of approximately 600 feet after which the gradient of the road drops slightly more than 1 percent in a northerly direction.

At the time this report was prepared, no details on the width of the water course or the depth of water were available. The existing bridge is a 50 foot long Bailey Bridge and the proposed bridge is to be of the same length using wide flange steel beams as the girders.

SOIL PROFILE

The soil profile in the vicinity of the crossing consists of an organic (peat) cover ranging from 1.0 to 2.5 feet in thickness. Beneath this there is a deposit of gravel which is generally silty and sandy but with clay also being reported. Cobbles and small boulders were commonly reported in the test holes.

The test hole drilled in 1968 using a continuous flight auger penetrated to a depth of 21.5 feet. Permafrost was encountered continuously in this test hole with blow counts being in excess of 100 blows for 6 inches. The test hole drilled in October of 1974, using wet drilling, also had blow counts in excess of 100 blows for 6 inches.

An examination of the available test hole information, the aerial photographs, geological reports, climatic information and theoretical calculations lead us to conclude that permafrost is, for all practical purposes, continuous in the area. Ground polygons, which usually indicate severe permafrost conditions, can be observed on the aerial photographs within one mile of the site.

As discussed in Volume II of our report mentioned above, the effect of heat in a water body will be to create a thaw bulb beneath a river. The depth and extent of this thaw bulb is a function of many factors including: water temperature, the ground's thermal regime, the geothermal gradient and the ground surface temperature. In addition, where the soil is relatively permeable, as in the case of coarse granular material, there will be a tendency for the water to migrate through the soil and thaw the permafrost for a distance on either side of the water course in excess of the theoretical thaw bulb. It will therefore be appreciated that delineating the permafrost profile at a site such as this one would require drilling a large number of test holes.

DISCUSSION AND RECOMMENDATIONS

It is our opinion that the soils at this site are thaw-stable and that conventional piers and abutments could be constructed using strip or spread footings. Because of the relatively severe climate, we believe that any disturbance of the ground thermal regime by an embankment and bridge construction would be relatively small so that degradation of the permafrost would be of only minor extent. However, it should be pointed out that there is little practical experience in this area so that a design utilizing spread of strip footings should also incorporate some provision for adjusting the height of the bridge girders should some settlement be experienced.

Another difficulty in using conventional spread or strip footings is that it may be impossible to accurately estimate the probable depth of scour during periods of spring thaw or heavy rain. Furthermore, such a design would require a high labour content with consequent difficulties of logistics.

An alternative type of foundation would be to use steel piles of H section driven into steam thawed holes. WHY? NO SIGN OF PERMAFROST IN TH It would be necessary to pre-thaw holes for steel piles by using a steam jet. This method has been used in Inuvik for placing timber piles. One of the difficulties experienced is that there is a tendency for the operator of the steaming equipment to "over steam" the holes with the result that an excessively large thawed hole is formed. The time taken for freeze back of the piles is therefore prolonged, sometimes for several months, which often results in frost heaving and "jacking" of the piles. In such cases, it is often considered to be advisable to place the piles for a period of several months before construction of the superstructure is commenced.

Another difficulty in installing driven piles at this site is the presence of boulders in the soil which may cause deflections of piles during driving. However, because of the difficulties in designing and installing spread or strip footings, as mentioned above, we believe that the use of driven steel H piles would probably be preferable at this site.

Steel piles placed in pre-thawed holes should be designed on the basis of an allowable skin friction of

1000 psf on the gross perimeter of the pile. (That is, a 9 inch by 9 inch H pile would have a gross perimeter of 36 inches.) Piles driven on land should have a minimum of 30 feet of embedment and the top 10 feet of pile should be assumed to carry no load. In the case of piles placed within the water course, the length of embedment should be at least 20 feet below the estimated depth of scour. Appendix C "Recommended Construction Procedures" contains some comments on the installation procedures for driven steel piles.

Strip or spread footings placed in the water course should be founded at least 5 feet below the depth of scour. Such footings can be designed on the basis of an allowable soil bearing pressure of 5 ksf. Spread or strip footings placed on land should have a minimum soil cover of 7 feet and can be designed on the basis of an allowable soil bearing pressure of 10 ksf.

The lateral unit pressure behind abutments should be assumed to be equivalent to the pressure exerted by a fluid having 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.

In driving steel H piles the weight of the pile driving hammer should be at least twice the weight of the pile. 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.

The portion of a steel pile above grade may be designed for the full structural strength of the pile acting as a column. The design load will depend on the allowable stresses in the pile, the column length and the arrangement of lateral bracing. 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 higher 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 creek upstream of the bridge should be checked and, should it be observed that there is possibility of large trees being washed downstream, such a fact should be considered by the bridge designer. Embankments constructed below the highest expected flood level should be protected with rip rap.

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

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING - YUKON

Mobile Drill B-40

DRILLING RECORD

PROJECT: Dempster Hwy. Mile 53.8 Upper Blackstone River

HOLE NO. 1 DATE 13-9-68

LOCATION See Plan

ELEVATION ______ DEPTH 21½'

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	DEPTH TO	SOIL DESCRIPTION	DEPTH FROM	DEPTH TO	NO.	TYPE	% RECOV.	N VALUE
0	1½'	Overburden (Partially frozen) Silt, sand and clay mixture Some stones ¼-3"						
1½'	6½'	Silty sand (Frozen) Black, fine Ice lenses	1½'	6½'	1	Bag		
6½'	8'	Silty shale (Frozen)	6½'	8'	1	SPT		286
8'	17'	Sandy clay silt, frozen coarse sand	13	14½'	2	SPT	65	226 for 6"
17'	21'	Till (Frozen)	18'	19½'	3	SPT	30	102 for 5"
21	21½'	Till (Frozen) Refusal	21'	21½'		SPT	0	

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING - YUKON

Diamond Drill NX Rod

DRILLING RECORD

Dempster HWY. Mile 53.8

PROJECT Upper Blackstone River

HOLE NO. 69-3-1 DATE July 7-19 /6

LOCATION See Plan

ELEVATION DEPTH 50'

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	TO	SOIL DESCRIPTION	DEPTH FROM	TO	NO.	TYPE	% RECOV.	N VALUE
0'	1½'	Organic material. Sandy silty clay (Frozen)						
1½'	5'	Fine - coarse sand & gravel						
5'	20'	Fine - coarse sand & gravel 3"-6" Cobbles						
20'	30'	Coarse gravel, some sand (Fine, black dark grey) Cobbles 3-8"						
30'	50'	Fine - coarse gravel. Some sand (Medium, black, dark grey) Cobbles 4-8" Boulders up to 3'						

DRILLING RECORD

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING - YUKON

Diamond Drill NX Rod

Dempster HWY. Mile 53.8

PROJECT Upper Blackstone River

HOLE NO. 69-3-2 DATE July 7-19 /69

LOCATION See Plan

ELEVATION DEPTH 50'

DRILLING NOTES			SAMPLE RECORD						
DEPTH FROM	DEPTH TO	SOIL DESCRIPTION	DEPTH FROM	DEPTH TO	NO.	TYPE	% RECOV.	N VALUE
0'	1'	Organic Material (Frozen)						
1'	3'	Sandy, silty clay (Frozen)						
3'	50'	Fine - medium gravel & sand (Black, dark grey) Some Cobbles 3"-6" Boulders up to 2'						

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING - YUKON

Diamond Drill NX Rod

DRILLING RECORD

PROJECT: Dempster Hwy. Mile 53.8 Upper Blackstone River

HOLE NO. 69-3-3 DATE July 7-19 /6

LOCATION See Plan

ELEVATION ______ DEPTH 25

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	DEPTH TO	SOIL DESCRIPTION	DEPTH FROM	DEPTH TO	NO.	TYPE	% RECOV.	N VALUE
0'	1'	Organic Material (Frozen)						
1'	4'	Sandy, silty clay. Some cobbles 2"-4"						
4'	25'	Fine gravel, fine-medium sand. Some cobbles 3"-8" Some boulders up to 1½' (21'- 25')						

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING - YUKON

Diamond Drill - NX Rod

DRILLING RECORD

Dempster Hwy. Mile 53.8

PROJECT Upper Blackstone River

HOLE NO. 69-3-4 DATE July 7-19/69

LOCATION See plan

ELEVATION ______ DEPTH 25

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	TO	SOIL DESCRIPTION	DEPTH FROM	TO	NO.	TYPE	% RECOV.	N VALUE
0	2'	Organic material (Frozen)						
2'	5'	Sandy, silty clay. Some cobbles 3-6"						
5'	9'	Fine gravel, fine-coarse sand. Some cobbles 3-6"						
9'	19'	Fine-coarse gravel and sand. Some cobbles 3-8"						
19'	25'	Fine to coarse gravel & sand Some cobbles 3-8" Boulders up to 1½'						

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING - YUKON

Diamond Drill NXRod

DRILLING RECORD

Dempster Hwy. Mile 53.8

PROJECT: Upper Blackstone River

HOLE NO. 69-3-5 DATE July 7-19 /6

LOCATION See Plan

ELEVATION ____ DEPTH 50'

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	DEPTH TO	SOIL DESCRIPTION	DEPTH FROM	DEPTH TO	NO.	TYPE	% RECOV.	N VALUE
0'	2'	Fine silty sand & clay (Frozen) Some organic material						
2'	5'	Fine silty sand & clay. Some medium to coarse gravel. Some cobbles 3-6"						
5'	35'	Sand & gravel. Sand-dark brown Cobbles 3-8" Some boulders up to 1'						
35'	50'	Sand & gravel. Sand-dark brown Cobbles 3-8" Some boulders up to 3'						

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING - YUKON

Diamond DRill NX Rod

DRILLING RECORD

PROJECT Dempster Hwy. Mile 53.8 Upper Blackstone River

HOLE NO. 69-3-6 DATE July 7-19 /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'	2'	Fine sand						
2'	36'	Fine to coarse sand & gravel Sand-dark brown. Cobbles 3-8" Some boulders up to 1½'						
36'	52'	Fine to coarse sand & gravel Sand-dark brown. Cobbles 3-8" Some boulders up to 2½' Fairly hard drilling						

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING - YUKON

DRILLING RECORD

Dempster Hwy. Mile 53.8

PROJECT Upper Blackstone River

HOLE NO. 69-3-7 DATE July 7-19 /69

LOCATION See Plan

ELEVATION ____ DEPTH 25'

Diamond Drill NX Rod

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	DEPTH TO	SOIL DESCRIPTION	DEPTH FROM	DEPTH TO	NO.	TYPE	% RECOV.	N VALUE
0'	6'	Fine silty sand & clay Some medium to coarse gravel Cobbles 3-8" Easy drilling						
6'	25'	Medium to coarse sand & gravel Sand-light to dark brown Cobbles 3-8" Some boulders up to 1'						

PUBLIC WORKS, CANADA

PACIFIC REGION
DESIGN / CONSTRUCTION
CIVIL ENGINEERING – YUKON

Diamond Drilling NX Rod

DRILLING RECORD

PROJECT Dempster Hwy. Mile 53.8 Upper Blackstone River

HOLE NO. 69-3-8 DATE July 7-19 /69

LOCATION See Plan

ELEVATION ______ DEPTH 25'

DRILLING NOTES			SAMPLE RECORD					
DEPTH FROM	DEPTH TO	SOIL DESCRIPTION	DEPTH FROM	DEPTH TO	NO.	TYPE	% RECOV.	N VALUE
0'	4'	Fine silty sand & clay, some fine to coarse gravel Cobbles 3-6"						
4'	25'	Fine to coarse sand & gravel Sand-dark brown Cobbles 3-8" Some boulders up to 1'						

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. 9-11/74
LOCATION Upper Blackstone River - Mi. 54.8
ELEVATION ______ SHEET 1 OF 1

DRILLING NOTES

HOLE DEPTH 51'
TYPE OF DRILL Rotary (Mud)
WATER LEVEL ______

DEPTH (FT)	SOIL DESCRIPTION
	Organic & Organic Silt
2½'	Clayey Silty Sandy Gravel
	10 - 10½ - 4" recovery - slight plasticity - grey to med. brown
	30-30½ - 5" recovery - dry to damp
51'	Bottom of Hole

LABORATORY TESTING

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	Liquid Limit %	Plastic Limit %	Plasticity Index %	Unified Classification	Maximum Size	% Passing .005 mm	No 200	No 40	No 10	No 4
10	10½	1	SPT	9172	4						100/5"					SM	¾"	-	32.2	44.3	60.0	73.2
15	15½	2	SPT	9173	9						108/6"					GM	1½"	-	20.8	30.3	42.6	51.7
20	20½	3	SPT	9174	9						100/4½"					SM	1"	-	37.1	52.3	66.8	76.1
25	25½	4	SPT	9175	13						25/1"					GM	1½"	-	24.5	35.2	45.8	54.0
30	30½	5	SPT	9176	9						150/5"					GM	1"	-	20.7	29.7	38.5	45.9
35	35½	6	SPT	9177	14						150/5"					GP-GM	1½"	-	11.2	19.0	31.1	41.6
40	40½	7	SPT	9178	9						150/3¾"					GP-GM	1"	-	9.0	13.8	22.3	32.8
50	50½	8	SPT	9179	8						150/5"					GP	1½"	-	3.9	8.3	17.4	26.0

FIELD		LABORATORY		DRAFTING	
DRILLED BY P.A., R.H. DATE Oct. 74	LOGGED BY P.A. DATE Oct. 74	TESTED BY Soils DATE Jan. 75	RECORDED BY B.F. DATE 28-2-75	PLOTTED DRWG NO ______ BY ______	PROJECT NO. TS ______ DATE ______

DRWG NO 60-151 TS 73-107

... LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
3/4"	100.0	#200	32.2					
1/2	87.0							
3/8	84.6							
#4	73.2							
10	60.0							
20	50.4							
40	44.3							
100	35.8							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SM				4	
	GRAVEL - SILT - SAND MIXTURE					

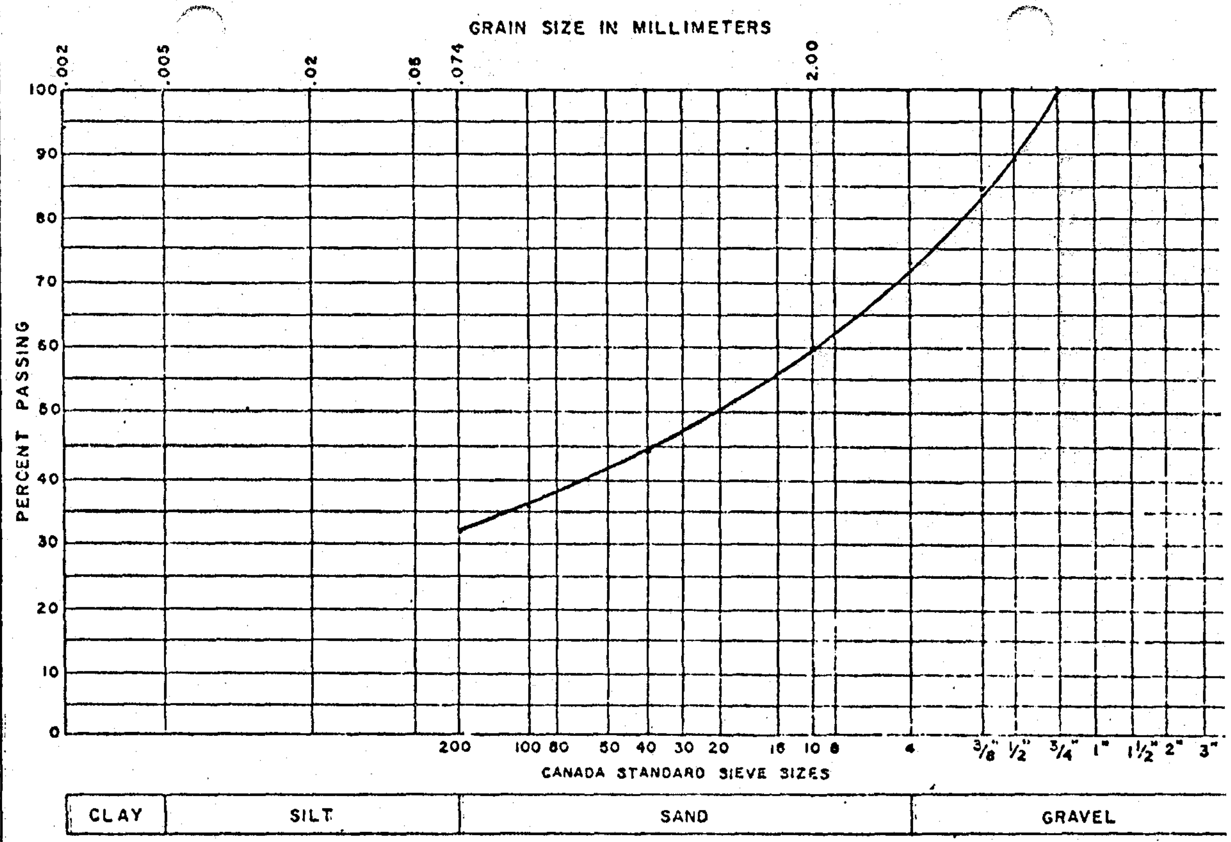
CRUSH COUNT %

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 UPPER BLACKSTONE RIVER MILE 54.8.
HOLE NO. 1
DEPTH 10'-10 1/2' FIELD NO. 1
SAMPLE TYPE S/P

LAB. NO. 9172

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING.

DATE SAMPLED 9-10-74.
DATE RECEIVED - 10-74
DATE RECORDED 30-12-74.
TESTED BY DK TE NH RT 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 1/2"	100.0	#40	30.3					
1	83.8	100	23.6					
3/4	78.4	200	20.8					
1/2	66.9							
3/8	60.6							
#4	51.7							
10	42.6							
20	34.9							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	GM				9	
	SILTY SANDY GRAVEL					

CRUSH COUNT %

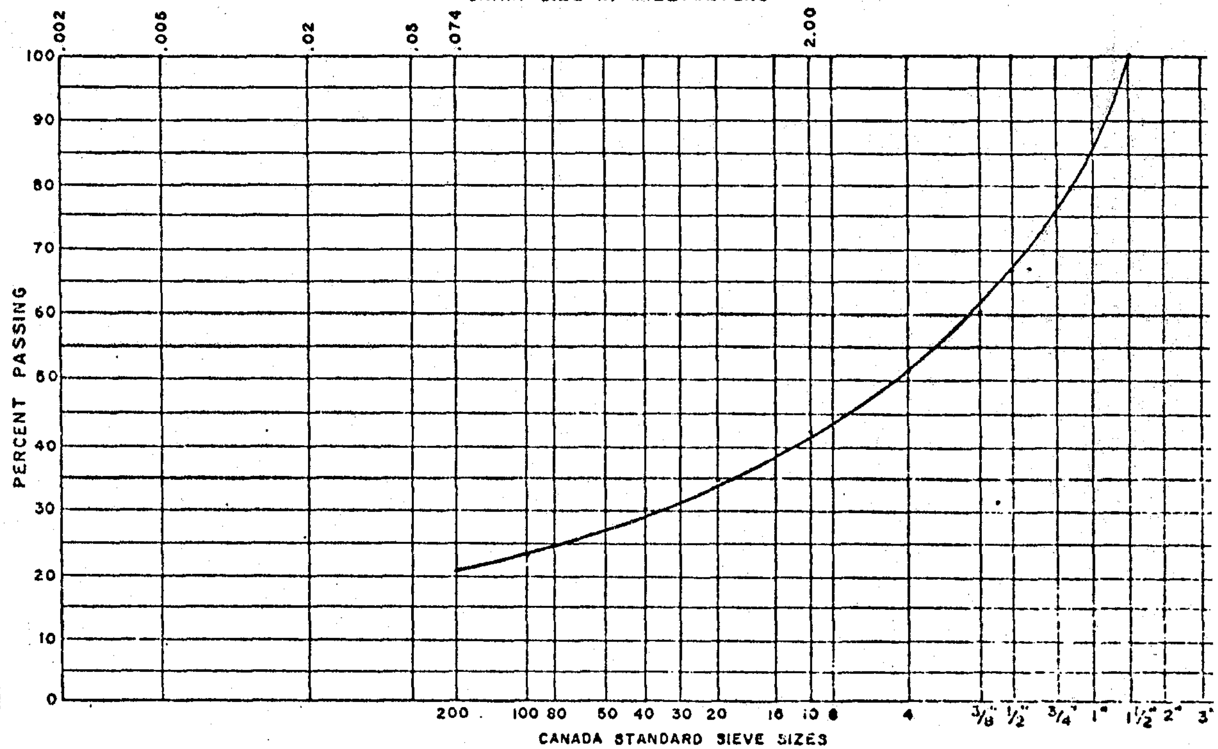
PETROGRAPHIC ANALYSIS

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

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	

GRAIN SIZE IN MILLIMETERS



CLAY	SILT	SAND	GRAVEL

PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION UPPER BLACKSTONE RIVER MILE 54.8

HOLE NO. 1

DEPTH 15'-15½' FIELD NO. 2

SAMPLE TYPE S/P

LAB. NO. 9173

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING

DATE SAMPLED 09-10-74.

DATE RECEIVED - 10-74.

DATE RECORDED 30-12-74.

TESTED BY RK JE JH BJ S

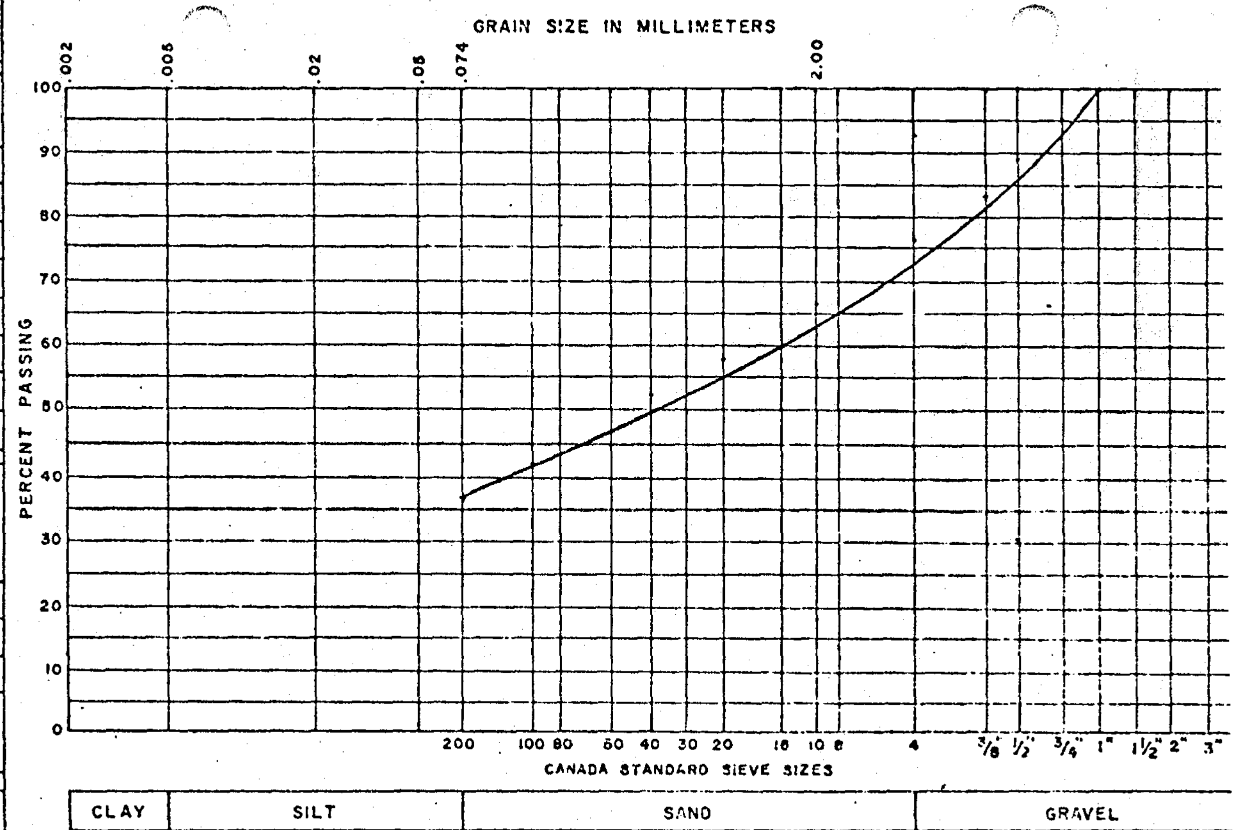
LABORATORY TESTING REPORT

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	42.2					
3/4	95.1	200	37.1					
1/2	87.0							
3/8	83.6							
#4	76.1							
10	66.8							
20	58.2							
40	52.3							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SM				9	
	GRAVELLY SAND-SILT MIXTURE					

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 UPPER BLACKSTONE RIVER MILE 54.8

HOLE NO. 1

DEPTH 20'-20'1/2' FIELD NO. 3

SAMPLE TYPE S/P

LAB. NO. 9174

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING.

DATE SAMPLED 10-10-74

DATE RECEIVED - 10-74

DATE RECORDED 30-12-74

TESTED BY RK JE DH 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
/2"	100.0	#40	35.2					
	89.1	100	28.2					
/4	87.1	200	24.5					
2	75.4							
8	64.7							
4	54.0							
0	45.8							
0	39.4							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	F.M.
	GM				13	
	SILTY-SANDY GRAVEL					

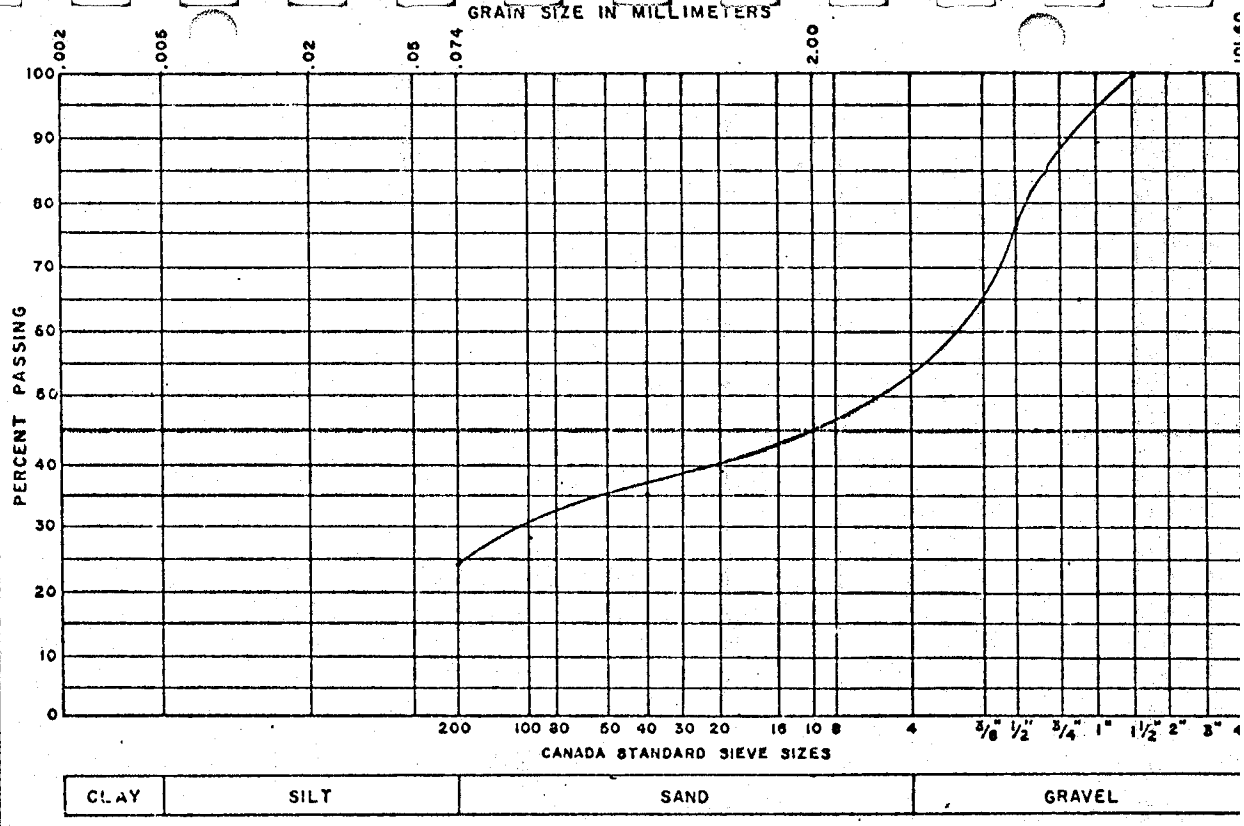
CRUSH COUNT %

PETROGRAPHIC ANALYSIS

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

PARTICLE SHAPE ANALYSIS

UND	
JB-ROUND	
NGULAR	
JB-ANGULAR	
LATS	
EDLES	



PROJECT DEMPSTER HWY. RELOCATION MILE 0-78

LOCATION UPPER BLACKSTONE RIVER MILE 54.8

HOLE NO. 1

DEPTH 25'-25½' FIELD NO. 4

SAMPLE TYPE S/P

LAB. NO. 9175

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING

DATE SAMPLED 10-10-74

DATE RECEIVED - 10-74

DATE RECORDED 30-12-74.

TESTED BY RK JE DH GJ 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"	100.0	#100	23.1					
3/4	75.9	200	20.7					
1/2	59.8							
3/8	52.1							
#4	45.9							
10	38.5							
20	33.5							
40	27.7							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	GM				9	
	SILTY SANDY GRAVEL					

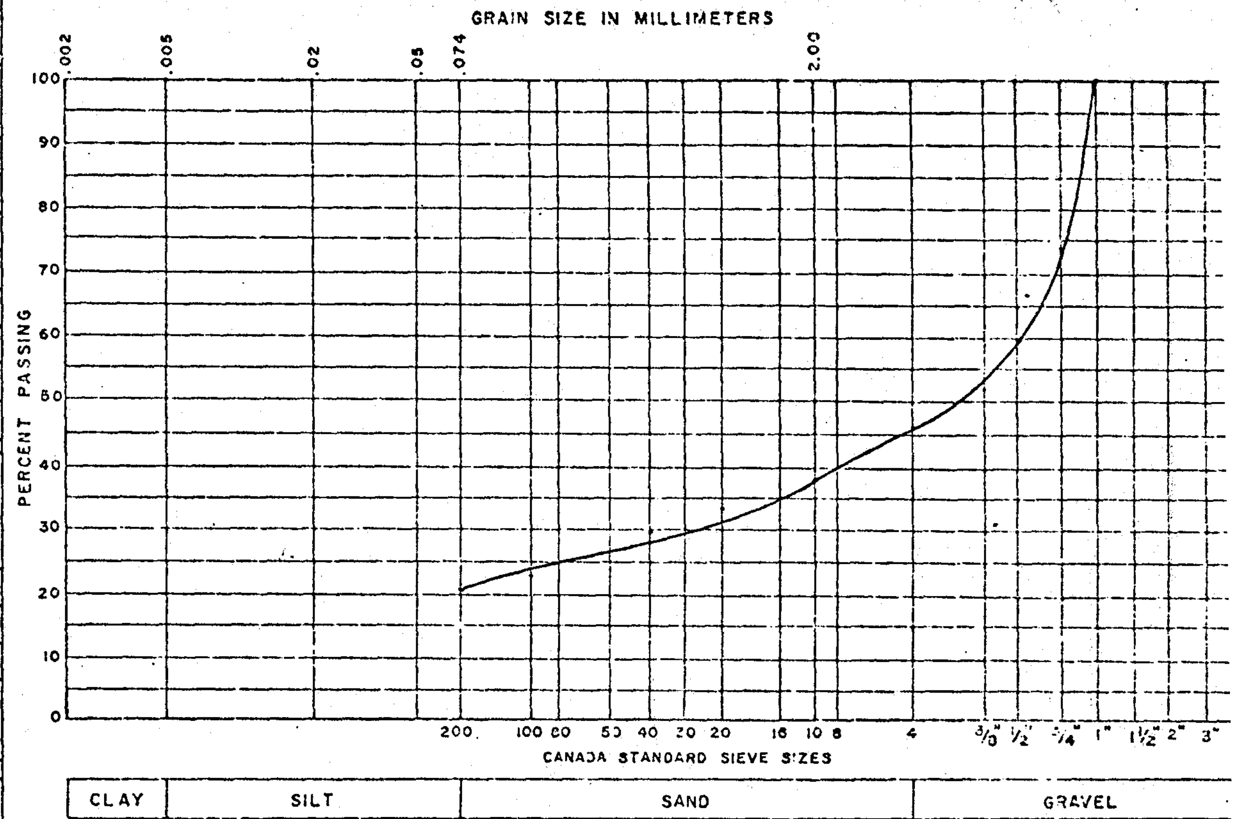
CRUSH COUNT %

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 UPPER BLACKSTONE RIVER MILE 54.8

HOLE NO. 1

DEPTH 30'-30½' FIELD NO. 5

SAMPLE TYPE S/P

LAB. NO. 9176

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING.

DATE SAMPLED 10-10-74

DATE RECEIVED - 10-74

DATE RECORDED 2-1-75

TESTED BY [illegible]

GRAIN SIZE ANALYSIS

EVE ZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
/2"	100.0	#40	19.0					
1	81.3	100	13.6					
/4	77.6	200	11.2					
/2	62.0							
/8	53.1							
4	41.6							
0	31.1							
0	23.4							

PLE O.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	GP-GM				14	
	SILTY GRAVEL					

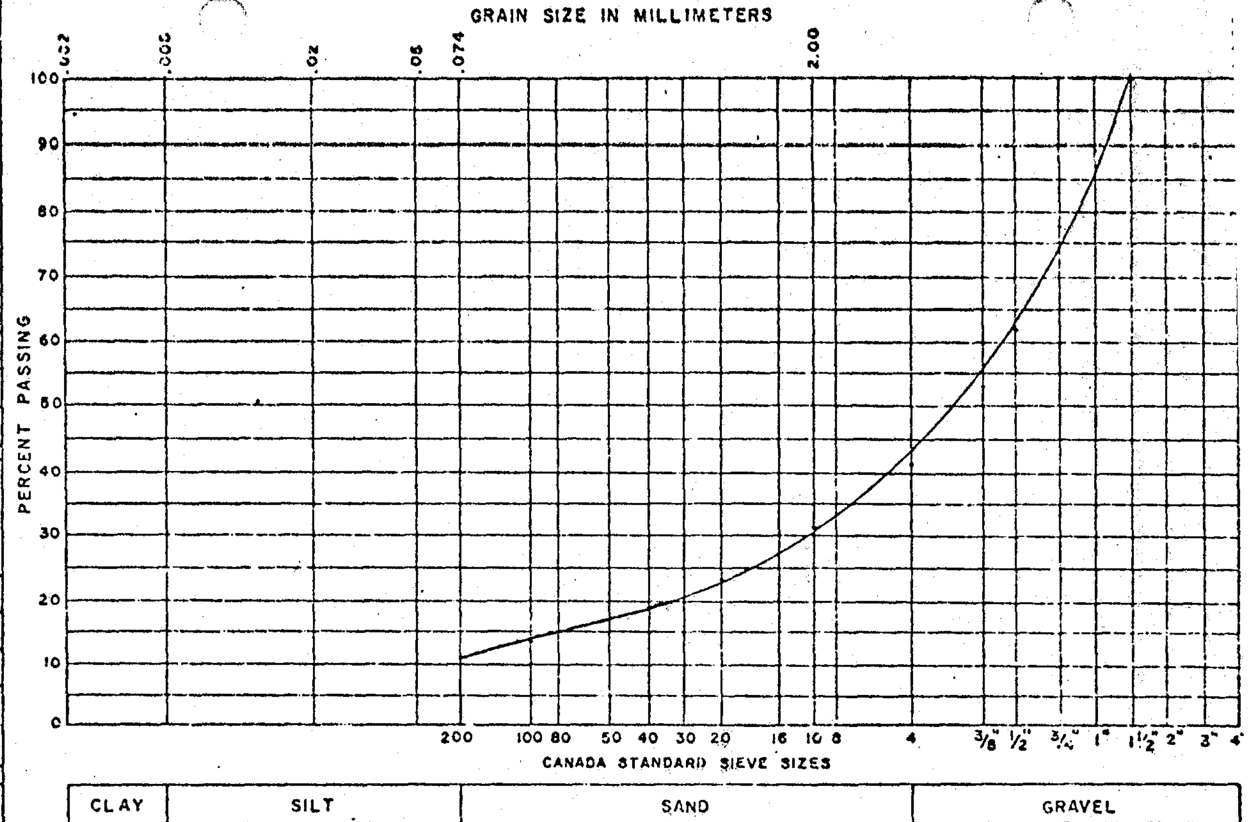
CRUSH COUNT %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE
SALT	
IESTONE	
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 UPPER BLACKSTONE RIVER MILE 54.8

HOLE NO. 1

DEPTH 35'-35½' FIELD NO. 6

SAMPLE TYPE S/P

LAB. NO. 9177

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING

DATE SAMPLED 11-10-74

DATE RECEIVED - 10-74

DATE RECORDED 2-1-75

TESTED BY RK JE JH KT 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	10.1					
3/4	80.0	200	9.0					
1/2	56.7							
3/8	49.0							
4	32.8							
10	22.3							
20	16.9							
40	13.3							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	GP-GM				9	

POORLY GRADED SILTY GRAVEL

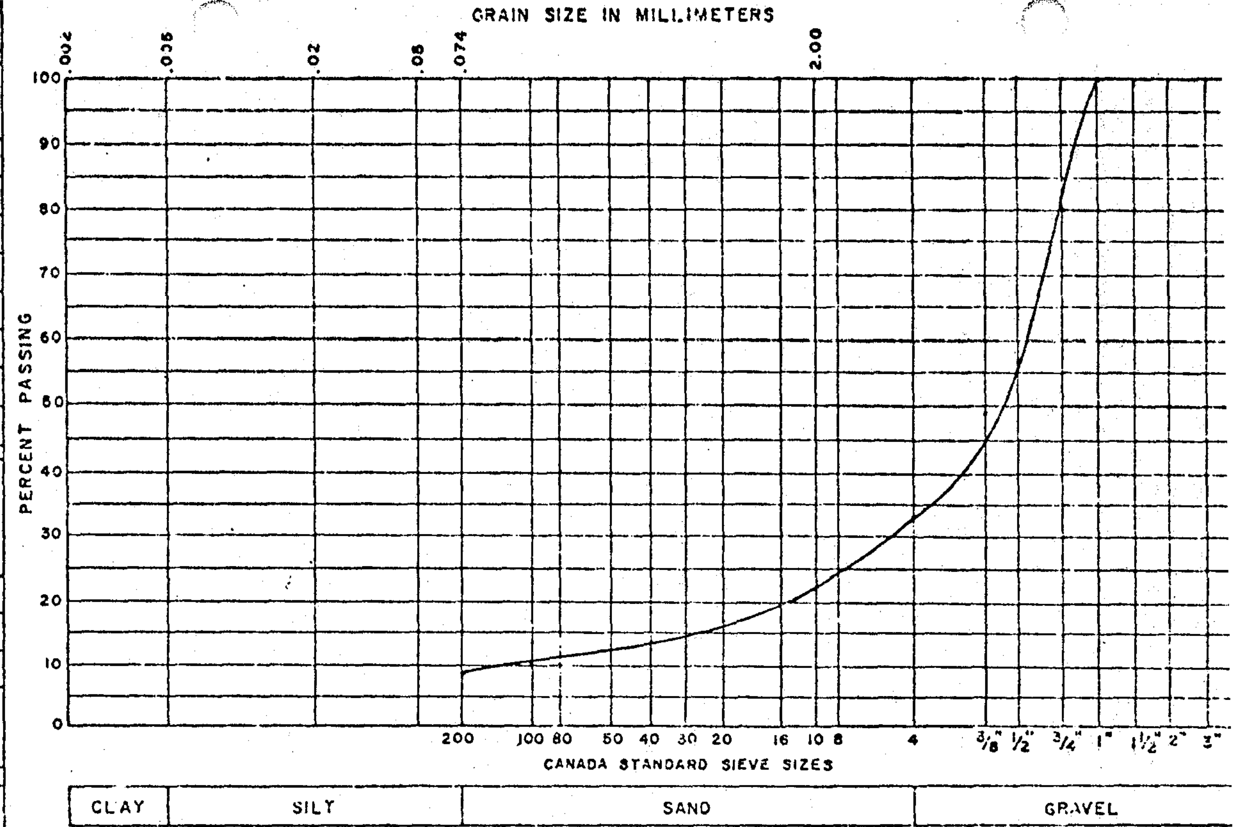
CRUSH COUNT %

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 UPPER BLACKSTONE RIVER MILE 54.8

HOLE NO. 1

DEPTH 40' - 40½' FIELD NO. 7

SAMPLE TYPE S/P

LAB. NO. 9178

LABORATORY'S REMARKS

INSUFFICIENT SAMPLE FOR FURTHER TESTING

DATE SAMPLED 11-10-74

DATE RECEIVED - 10-74

DATE RECORDED 2-1-75

TESTED BY RK JE DH BJ S

MATERIALS LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT
1½"	100.0	#40	8.3					
1	52.2	100	5.0					
3/4	52.2	200	3.9					
1/2	43.6							
3/8	33.0							
4	26.0							
10	17.4							
20	11.4							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	GP				8	
	POORLY GRADED GRAVEL					

CRUSH COUNT %

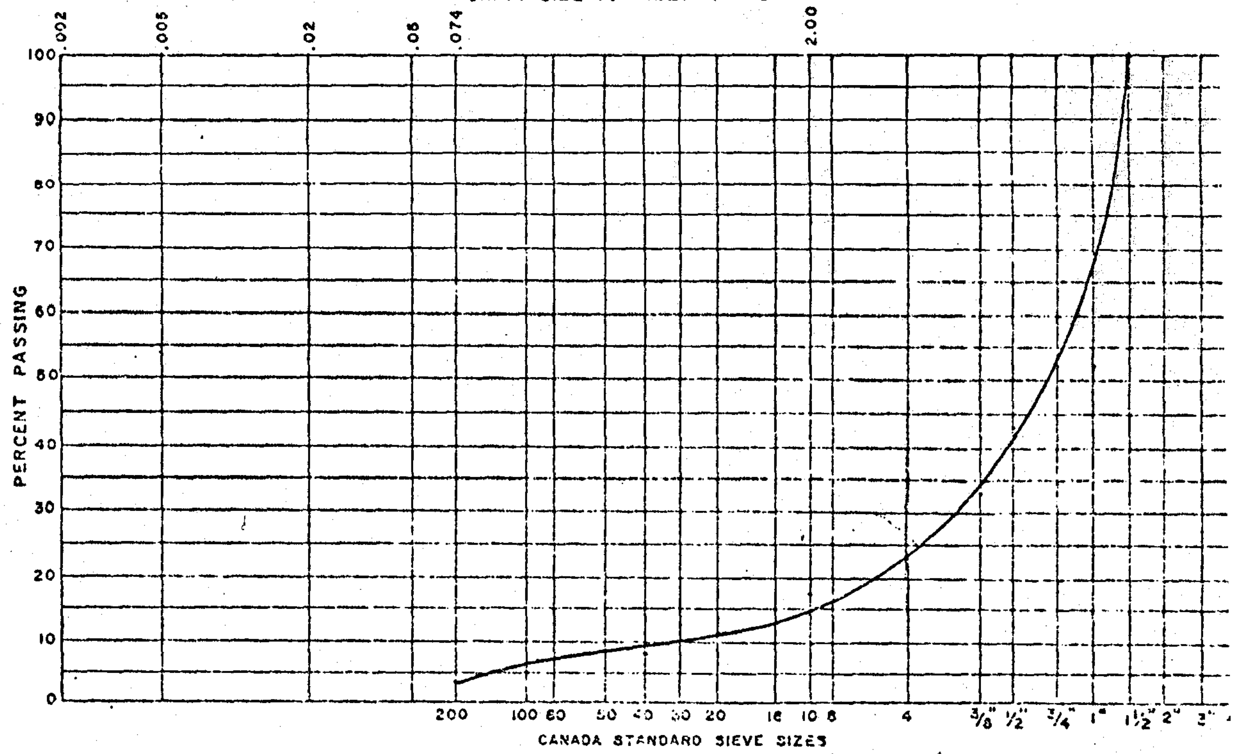
PETROGRAPHIC ANALYSIS

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

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	

GRAIN SIZE IN MILLIMETERS



CLAY	SILT	SAND	GRAVEL

PROJECT DEMPSTER HWY RELOCATION MILE 0-78
LOCATION UPPER BLACKSTONE RIVER MILE 54.8
HOLE NO. 1
DEPTH 50'-50½' FIELD NO. 8
SAMPLE TYPE S/P

LAB. NO. 9179.

LABORATORY'S REMARKS
INSUFFICIENT SAMPLE FOR FURTHER TESTING.

DATE SAMPLED 11-10-74
DATE RECEIVED - 10-74.
DATE RECORDED 2-1-75
TESTED BY ...

LABORATORY TESTING REPORT

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	27.8					
3/4	92.5	200	24.3					
1/2	87.5							
3/8	85.0							
#4	67.4							
10	55.5							
20	44.6							
40	37.6							

SAMPLE NO.	CLASSIFICATION	L.L.	P.L.	P.I.	NAT. %W	S.G.
	SM	19.9		TRACE	13	
SILTY GRAVELLY SAND						

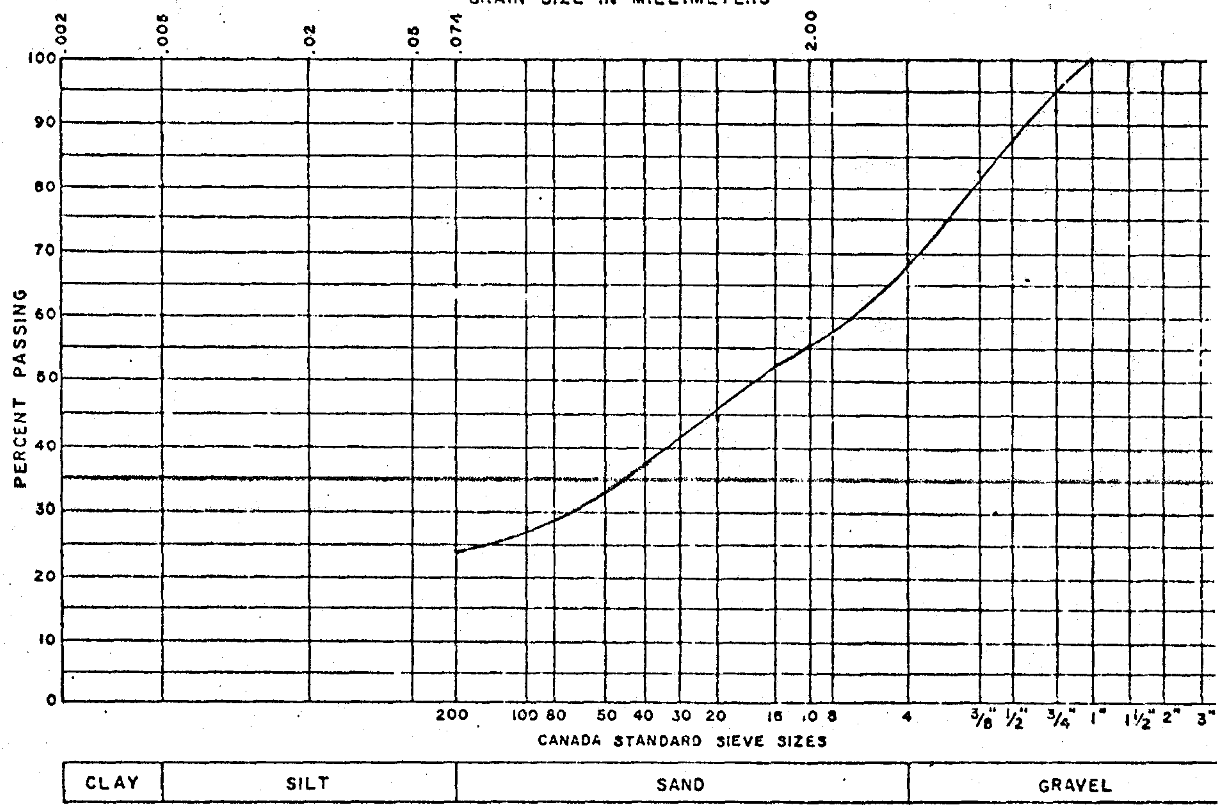
CRUSH COUNT %

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 UPPER BLACKSTONE RIVER MILE 54.8
HOLE NO. 1
DEPTH 15'-21' FIELD NO. -
SAMPLE TYPE AUGER

LAB. NO. 9180

LABORATORY'S REMARKS

DATE SAMPLED 9-10-74
DATE RECEIVED - 10-74
DATE RECORDED 03-1-75
TESTED BY RK JJ DH KJ 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

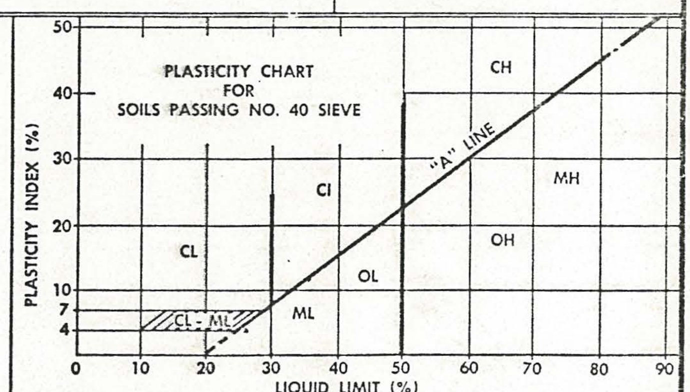
The plastic and liquid limits are shown on the water content chart by a horizontal bar. The Atterberg system is discussed in the following section.

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	$C_U = \frac{D_{60}}{D_{10}} > 6 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			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	$C_U = \frac{D_{60}}{D_{10}} > 4 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			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

Recommended Construction Procedures

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.