

GEOCRES No. 52E-3DIST. 20 REGION W.P. No. CONT. No. EMBANKMENT FAILUREW. O. No. 71-11008STR. SITE No. N/AHWY. No. 17LOCATION EMBANKMENT FAILURE1 1/2 MI. W. OF MANITOBA BORDER (SWAMPS)No of PAGES - —=====OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

52 E - 3
GEOCRES No.

To: Mr. H. W. Hurrell,  
Regional Road Design Supt.,  
Northwestern Region,  
THUNDER BAY, ONT.

FROM: Foundation Section,  
Materials & Testing Office,  
Room 107, Lab. Bldg.

ATTENTION:

DATE: May 11, 1971

OUR FILE REF.

IN REPLY TO MAY 14 1971

SUBJECT:

FOUNDATION INVESTIGATION REPORT

For  
Embankment Failure  
1½ Miles West of Manitoba Border  
On  
Highway #17 - T.C.H.  
District #20 (Kenora)  
W.O. 71-11008 - W.P. (N11)

Enclosed please find our foundation investigation report for the above mentioned embankment failure. We believe you will find the information contained in the report sufficient for your purposes. If additional information should be required, or if the factual information contained in the report requires further interpretation, please contact this Office.

AGS/MdeF  
Attach.

*A. G. Stermac*  
A. G. Stermac  
PRINCIPAL FOUNDATION ENGINEER

cc: Messrs. H. W. Hurrell (2)  
D. W. Farren  
F. G. Allen  
I. C. Campbell  
D. E. Thrasher  
L. P. Shorr  
R. Morgenroth  
B. J. Giroux  
B. A. Singh  
Foundations Files ✓  
Gen. Files

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FOUNDATION INVESTIGATION REPORT  
For  
Embankment Failure  
1½ Miles West of Manitoba Border  
On  
Highway #17 - T.C.H.  
District #20 (Kenora)  
W.O. 71-11008 - W.P. (Nil)

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1. INTRODUCTION:

The Foundation Section was requested to carry out an investigation at the above mentioned site to determine the causes of the failure and make recommendations regarding remedial measures. The request was made verbally by Mr. R. Morgenroth, Regional Materials Engineer, Regional Office, Thunder Bay, on February 1, 1971.

Included in this report are the results of the investigation, together with recommendations regarding remedial measures.

2. DESCRIPTION OF THE SITE:

The site is located some 1-1/2 miles west of the Manitoba border on Hwy. #17. The general topography is rolling and bush-covered with numerous outcrops of bedrock. The highway runs east-west and crosses some 800 feet of swamp by means of an embankment approximately 5.0 ft. high. Bedrock is exposed immediately south of the highway along the 650 feet most easterly portion. Since construction of the highway in 1957, continual settlements of the northerly half of the road have taken place over most of the 800 feet. In May, 1961, an investigation was carried out by the Northwest Region Soils Section, resulting in several alternative recommendations being made to the District by Mr. F. Norman, Regional Materials Engineer, in July, 1961. The results of the investigation and recommendations given are contained in the Appendix of this present report. The District

2. DESCRIPTION OF THE SITE: (cont'd.) ...

adopted the least expensive of the recommendations - i.e., frequent patching with asphalt - and the highway continued to settle.

3. FIELD AND LABORATORY WORK:

A total of 7 boreholes and 5 dynamic cone penetration tests was carried out in the investigation. Four of the boreholes were put down through the shoulder of the road fill - i.e., Nos. 1, 2, 3, 9, and required drilling BX or NX casing to depths of from 6 to 16 feet. The remaining three boreholes were put down in the swamp to the north of the highway - i.e., Nos. 4, 6 and 7. Cone penetration tests were carried out adjacent to the latter three boreholes and also in two other locations - i.e., Nos. 5 and 8.

The equipment used for the operation consisted of a diamond drill adapted for soil sampling purposes.

Samples were recovered at the required depths in a 2" split-spoon sampler which was hammered into the soil in accordance with the requirements of the Standard Penetration Test. Bedrock was cored in 3 boreholes using both AXT and BXT core barrels, and was presumed to have been reached in other boreholes where practical refusal to penetration of the casing, split-spoon or cone was reached.

The locations and elevations of the boreholes are shown on Dwg. 71-11008A, together with the estimated stratigraphical sections.

Surveying was carried out by personnel from Kenora District Office.

All samples were subjected to a careful visual examination in the field and laboratory. Tests were carried out to determine the following physical properties:

Moisture Content

Grain-size Analysis

The results of these tests are plotted on the individual borelog sheets.

4. SUBSOIL CONDITIONS:

4.1) General:

The swamp over which the highway crosses extends from approximately Sta. 247+50 to Sta. 255+50. As mentioned earlier in the report, bedrock is exposed alongside the highway to the south from Sta. 247+50 to approximately Sta. 253+38; beyond this lies the swamp on the south side.

The four boreholes put down through the fill indicated the depth of fill material to vary between 18 to 36 feet, and consisted of a mixture of sand and gravel with occasional boulders; the density of the material varied from loose to very dense. In two of the boreholes - i.e., #1 and #2, the fill was underlain by a shallow layer (5" - 15") of peat which, in turn, overlaid bedrock while, in the remaining two, this shallow peat layer was absent, the fill directly overlying the bedrock.

The boreholes undertaken in the swamp indicated from 15 to over 40 feet of very soft peat overlying silty sand or bedrock.

Boreholes #6 and #7 in the swamp north of the highway, were terminated at points where the casing had almost reached practical refusal. Deformation of the casing and the fact that in Borehole #7 the cone went down much farther than the actual hole, indicates boulders probably pushed out from the highway fill.

4.2) Fill Material:

This material, found in Boreholes #1, 2, 3 and 9, consists of a sand and gravel mixture with occasional boulders. The gradation of the material varied from sand with traces of gravel to gravel with traces of sand. The presence of boulders required drilling NX or BX casing to depths ranging from 6 to 16 feet even though the density of the fill, as indicated by the Standard Penetration Test, dropped off after the first 5 to 6 feet. Apart from the top 5 to 6 feet where the 'N' values were

4. SUBSOIL CONDITIONS: (cont'd.) ...

4.2) Fill Material: (cont'd.) ...

in the realm of 100 blows/3". The 'N' values varied from 3 to 67 blows/ft., indicating the material to be very loose to very dense.

Moisture contents varied from 4.3% to 14.2%.

4.3) Peat:

This material was found in all boreholes not undertaken through the fill from ground level down, and in Boreholes #1 and #2 through the fill in shallow layers of 15" and 5", respectively, overlying the bedrock.

The material consisted of black, saturated peat with wood and decomposed wood. The 'N' values as obtained from the Standard Penetration Test, varied from 0 to 9 blows/ft.; the latter was probably due to the presence of wood though, and the material can be taken generally, to be very soft. Moisture contents ranged from 160 - 577% apart from the shallow layer underlying the fill where the moisture content was only 50%.

4.4) Silty Sand:

This material was found, in this investigation, at Sta. 255+00 only underlying 16 - 20 ft. peat and overlying the bedrock. It has a thickness of some 8 - 24 ft., and 'N' values ranged from 2 to 9 blows/ft., indicating the sand to be very loose to loose.

Laboratory tests gave the following results:

Moisture Content % 20

Grain-size Distribution % -

Gravel 5, Sand 79, Silt and Clay 16.

4.5) Bedrock:

Bedrock was proved in three boreholes only - i.e., Nos. 2, 3 and 9, using both AXT and BX core barrels, and was found to be fine to medium grained igneous.

5. GROUNDWATER CONDITIONS:

Groundwater levels, as observed in the boreholes at the end of operations, were found to be as follows:

<u>Borehole No.</u>		<u>Elevation</u>
1	:	1,175.3 ft.
2	:	1,175.5 ft.
3	:	1,175.5 ft.
4	:	1,175.6 ft.
6	:	1,175.0 ft.
7	:	1,176.0 ft.
9	:	1,175.0 ft.

6. DISCUSSION AND RECOMMENDATIONS:

Continual settlement of the northern half of this portion of Hwy. #17 has taken place since its construction in 1957, requiring frequent maintenance by the District in the form of asphalt patching.

Subsoil at the site consists of very soft peat overlying silty sand and/or bedrock.

It was found that, although the majority of the peat deposit has been displaced, portions of it remain trapped beneath the fill leading to the continual settlement as mentioned above.

The steep crossfall of the bedrock found to underlie the highway from Sta. 249+50 to Sta. 253+38, indicates that surcharging the existing fill in this area would probably not achieve a stable situation, and that settlements would continue. It is felt, therefore, that the highway should be realigned as far south as possible into the bedrock.

Beyond Sta. 253+38, where the bedrock no longer outcrops, the realigned highway must still cross over the swamp, and it is recommended that soundings be undertaken to establish the extent of the swamp along the new alignment. As regards construction,



6. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

the most preferable method would be to completely excavate any peat deposits; if this is not possible due to excessive depth, the remaining peat should be displaced by means of a rolling surcharge. This would consist of suitable fill material - in this case, the rock from the excavation being placed directly on the surface of the swamp and surcharged to such an extent that settlement and displacement will occur until a stable situation is reached. The mud waves formed in front of the fill and at the sides should be excavated as the operation proceeds, so as to ensure no trapping of peat beneath the fill material.

7. MISCELLANEOUS:

The field work, performed during the period of February 9 - March 3, and March 15 - 20, 1971, was supervised by Mr. G. Allen, Project Foundation Engineer, who also prepared this report.

Equipment used was owned and operated by Dominion Soil Investigation Ltd., Toronto.

The report was reviewed by Mr. K. G. Selby, Supervising Foundation Engineer.

May, 1971

APPENDIX I

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DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

JOB 71-11008LOCATION Sta. 255 + 00 o/s 15' Rt.ORIGINATED BY GA

W.P. \_\_\_\_\_

BORING DATE February 9-11 & 16-19, 1971COMPILED BY GADATUM GeodeticBOREHOLE TYPE Washboring, BX Casing, Drill BX CasingCHECKED BY HL

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT ——— $w_L$			BULK DENSITY $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT				PLASTIC LIMIT ——— $w_p$				
							SHEAR STRENGTH P.S.F.				WATER CONTENT ——— $w$				
1181.8	Fill Level														
0.0	Fill material mixture of sand & gravel with occasional boulders		1	SS	100/3"	1180									
			2	SS	100/4"										
			3	SS	16										
			4	SS	27										
			5	SS	4	1170									
			6	SS	6										
	Very Loose to Very Dense														
1160.5			7	SS	60										
1159.2	Peat		8	SS	82/1"	1160									
22.6	Split spoon bouncing Possibly Bedrock End of Borehole														

▼ 1175.3

FOUNDATION SECTION

ORIGINATED BY GA

COMPILED BY GA

CHECKED BY




[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 3

FOUNDATION SECTION

JOB 71-11008 LOCATION Sta. 252 + 00 o/s 17' Rt. ORIGINATED BY GA  
 W.P.                      BORING DATE Feb. 23 - 25 and March 15-18, 1971 COMPILED BY GA  
 DATUM Geodetic BOREHOLE TYPE Washboring & Drill NX Casing, BX Casing, AXT Core CHECKED BY HR

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT ——— $w_L$ PLASTIC LIMIT ——— $w_p$ WATER CONTENT ——— $w$			BULK DENSITY $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE					$w_p$ ——— $w$ ——— $w_L$ WATER CONTENT % 10 20 30				
1180.5	Top of Fill															
0.0	Fill material  Mixture of sand and gravel  occasional boulders  Loose to Very Dense		1	SS	75/3"	1180										 1175.5
			2	SS	70	1170										
			3	SS	8											
			4	SS	22	1160										
			5	SS	11											
			6	SS	18	1150										
			7	SS	30											
1143.4	37.1 Bedrock. Fine - med. grained igneous		8	SS	150/4"											
1140.4			9	RC	100%											
40.1	End of Borehole					1140										

▼ 1175.5

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 4

FOUNDATION SECTION

JOB 71-11008 LOCATION Sta. 255 + 00 o/s 59' Rt. ORIGINATED BY GA  
 W.P.                      BORING DATE Feb. 26, 1971 COMPILED BY GA  
 DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY JK

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT ——— $w_L$ PLASTIC LIMIT ——— $w_p$ WATER CONTENT ——— $w$			BULK DENSITY $\gamma$ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE					WATER CONTENT % $w_p$ ——— $w$ ——— $w_L$ 10 20 30
1179.1	Ground Level																
0.0	Peat		1	SS	9	1170											
	Very Soft		2	SS	2												
1160.1			3	SS	1												
19.0	Grey silty sand		4	SS	9	1160											
	Very Loose to Loose		5	SS	2												
1151.4	Casing bouncing Possibly bedrock					1150											
27.7	End of Borehole																

1175.6  
5 79 (16)  
100

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 5

FOUNDATION SECTION

JOB 71-11008 LOCATION Sta. 253 + 50 o/s 55' Rt. ORIGINATED BY GA  
 W.P.                      BORING DATE February 26, 1971 COMPILED BY GA  
 DATUM Geodetic BOREHOLE TYPE Cone Test CHECKED BY                     

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— $w_L$ PLASTIC LIMIT ——— $w_p$ WATER CONTENT ——— $w$			BULK DENSITY $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	WATER CONTENT % $w_p$ ——— $w$ ——— $w_L$				
1176.6	Ground Level															
0.0	Probably Peat															
						1170										
						1160										
						1150										
						1140										
						1130										
						1120										
						1110										
1101.6																
75.0	End of Cone Test					1100										

FOUNDATION SECTION

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION BLOWS / FOOT	RESISTANCE	LIQUID LIMIT ——— $w_L$	BULK DENSITY $\gamma$ P.C.F.	REMARKS				
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60			80	100	PLASTIC LIMIT ——— $w_p$	WATER CONTENT ——— $w$
							SHEAR STRENGTH P.S.F.					$w_p$ ——— $w$ ——— $w_L$			WATER CONTENT % 10    20    30
						○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    x LAB. VANE									
1176.0	Ground Level														
0.0	Peat  Very Soft		1	SS	0	1170							57%	GR. SA. SI. CL. 1,175.0	
			2	SS	0										
			3	SS	0	1160									159%
			4	SS	0										
			5	SS	0	1150									440%
			6	SS	0										
1143.0	Probably boulders and sand pushed out from fill		7	SS	29	1140									
33.0															
1136.0	End of Borehole														
40.0															
1132.0															
44.0	End of Cone Test														



FOUNDATION SECTION

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 8

FOUNDATION SECTION

JOB 71-11008 LOCATION Sta. 255 + 00 o/s 52' Lt. ORIGINATED BY GA  
 W.P.                      BORING DATE March 2, 1971 COMPILED BY GA  
 DATUM Geodetic BOREHOLE TYPE Cone Test CHECKED BY SR

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION	RESISTANCE	LIQUID LIMIT — $w_L$	BULK DENSITY	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	20 40 60 80 100	PLASTIC LIMIT — $w_p$			WATER CONTENT — $w$
1076.7	Ground Level											
0.0												
	Probably Peat											
1059.7												
17.0												
	Probably Sand											
1036.5												
40.2	End of Cone Test											
	Probably Bedrock											

SHEAR STRENGTH P.S.F.  
 ○ UNCONFINED + FIELD VANE  
 ● QUICK TRIAXIAL × LAB. VANE

WATER CONTENT %  
 $w_p$  —  $w$  —  $w_L$

125/2"

FOUNDATION SECTION

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT ——— $w_L$ PLASTIC LIMIT ——— $w_p$ WATER CONTENT ——— $w$			BULK DENSITY $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE		WATER CONTENT % 10 20 30				
1180.0	Fill Level												
0.0	Fill Material												
	Mixture of sand and gravel with occasional boulders.		1	SS	100/5"	1170							
	Compact to Very Dense		2	SS	15								
			3	SS	13								
1161.5			4	SS	67								
18.5	Bedrock		5	RC	50%	1160							
1157.5	Fine medium grained igneous		6	RC	0%								
22.5	End of Borehole					1150							

## ABBREVIATIONS USED IN THIS REPORT

### PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

### DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS:-

<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

### TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

### SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY

# ABBREVIATIONS USED IN THIS REPORT

## SOIL PROPERTIES

$\gamma$	UNIT WEIGHT OF SOIL (BULK DENSITY)
$\gamma_s$	UNIT WEIGHT OF SOLID PARTICLES
$\gamma_w$	UNIT WEIGHT OF WATER
$\gamma_d$	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
$\gamma'$	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
$S_r$	DEGREE OF SATURATION
$w_L$	LIQUID LIMIT
$w_p$	PLASTIC LIMIT
$I_p$	PLASTICITY INDEX
s	SHRINKAGE LIMIT
$I_L$	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
$I_c$	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
$e_{max}$	VOID RATIO IN LOOSEST STATE
$e_{min}$	VOID RATIO IN DENSEST STATE
$I_D$	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY $D_r$ IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
$m_v$	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
$c_v$	COEFFICIENT OF CONSOLIDATION
$C_c$	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
$T_v$	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
$\tau_f$	SHEAR STRENGTH
$c'$	EFFECTIVE COHESION
$\phi'$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
$c_u$	APPARENT COHESION
$\phi_u$	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
$\mu$	COEFFICIENT OF FRICTION
$S_t$	SENSITIVITY

## GENERAL

$\pi$	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e \sigma$ OR $\ln \sigma$	NATURAL LOGARITHM OF $\sigma$
$\log_{10} \sigma$ OR $\log \sigma$	LOGARITHM OF $\sigma$ TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

## STRESS AND STRAIN

u	PORE PRESSURE
$\sigma$	NORMAL STRESS
$\sigma'$	NORMAL EFFECTIVE STRESS ( $\bar{\sigma}$ IS ALSO USED)
$\tau$	SHEAR STRESS
$\epsilon$	LINEAR STRAIN
$\gamma$	SHEAR STRAIN
$\nu$	POISSON'S RATIO ( $\mu$ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
$\eta$	COEFFICIENT OF VISCOSITY

## EARTH PRESSURE

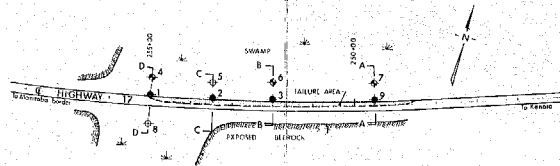
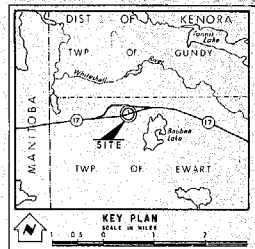
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

## FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
$k_s$	MODULUS OF SUBGRADE REACTION

## SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
$\beta$	ANGLE OF SLOPE TO HORIZONTAL



# LEGEND

- ◆ Bore Hole
- ⊕ Core Penetration Hole
- ⊕ Bore & Core Penetration Hole
- ★ Water Levels established at time of field investigation. FID A 1148 1971

NO.	ELEVATION	STATION	OFFSET
1	1181.5	255+00	15' RT.
2	1181.0	253+50	16' RT.
3	1180.5	252+00	17' RT.
4	1179.1	255+00	5' RT.
5	1176.6	253+50	52' RT.
6	1174.0	253+00	40' RT.
7	1176.4	246+50	55' RT.
8	1176.2	255+00	52' LT.
9	1180.0	249+50	17' RT.

## NOTE

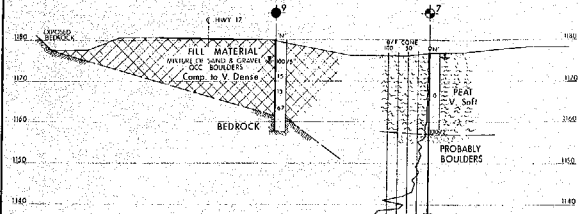
The boundaries between soil strata have been established only of Bore Hole locations. Between Bore Holes the boundaries are assumed from geophysical evidence and may be subject to considerable error.

STATION	DATE	BY	DESCRIPTION

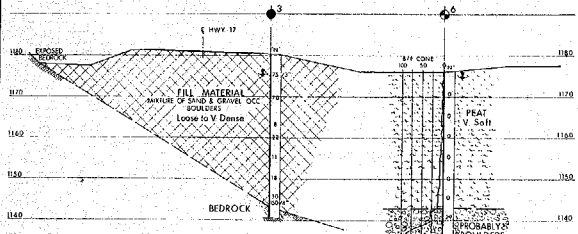
DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS AND TESTING OFFICE - OUBURN SECTION

**EMBANKMENT FAILURE**  
(STA. 248+50 TO STA. 255+00)  
KIN'S HIGHWAY 17 DIST. NO. 20  
KENORA DIST. OF KENORA  
TWP. EWART LOT CORN.  
BORE HOLE LOCATIONS & SOIL STRATA  
SUB'D. C. A. CHILDS V. V. W. P. NO. 71-11008A  
CHILDS V. V. W. P. NO. 71-11008  
DATE: 17. APRIL 1971  
APP'D: [Signature] DATE: [ ]  
DRAWN: [Signature] DATE: [ ]

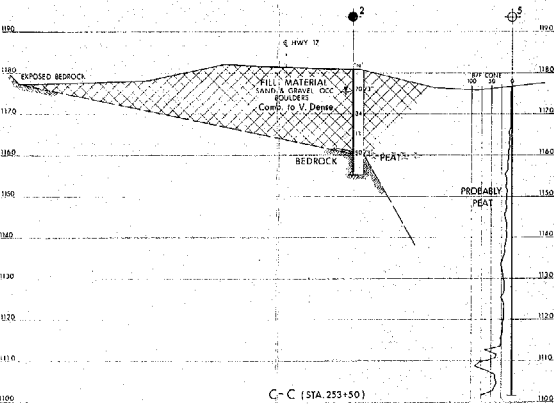
## A-A (STA. 249+50)



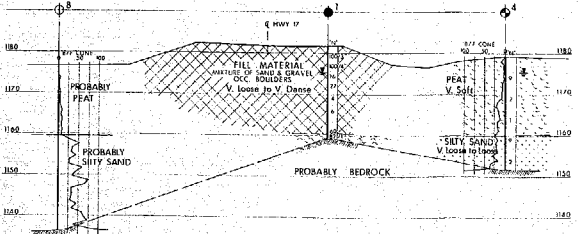
## B-B (STA. 252+00)



## C-C (STA. 253+50)



## D-D (STA. 255+00)



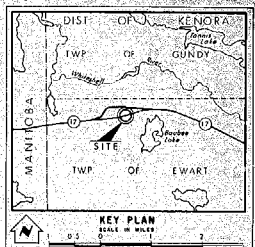
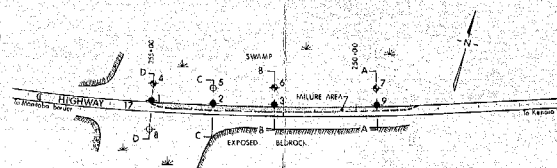
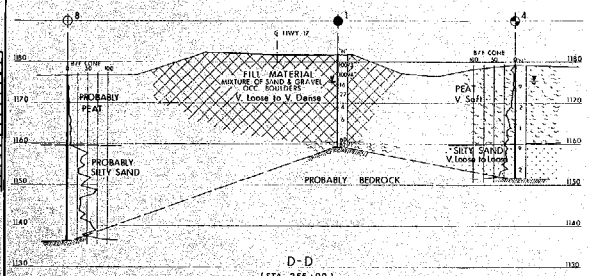
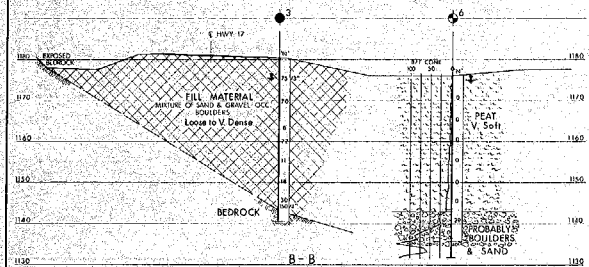
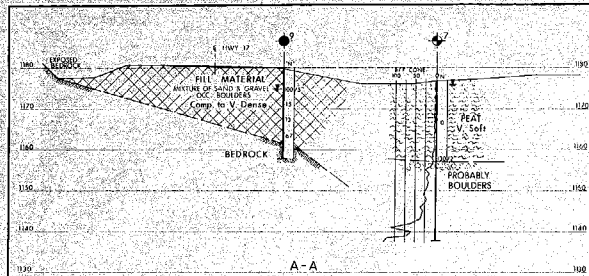
## SECTIONS



REF. PLOT 18340

WENT RECORD

NO.	DATE	BY	DESCRIPTION



**LEGEND**

- Bore Hole
- Core Penetration Hole
- Bore & Core Penetration Hole
- Water Levels established at time of field investigation, Feb 6 & 18, 1971

NO.	ELEVATION	STATION	OFFSET
1	1181.8	253+00	15' RT.
2	1181.0	253+50	16' RT.
3	1180.5	252+00	17' RT.
4	1179.1	255+00	29' RT.
5	1176.6	253+50	35' RT.
6	1176.6	253+50	50' RT.
7	1176.6	249+50	53' RT.
8	1176.7	255+00	32' LT.
9	1180.0	249+50	17' RT.

**NOTE**

The boundaries between soil strata have been established only of Bore Hole locations. Between Bore Holes the boundaries are drawn from geological evidence and may be subject to considerable error.

DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING OFFICE - FORMATION SECTION

**EMBANKMENT FAILURE**

STA. 248+50 TO STA. 255+00

CO. DIST. OF KENORA

KIND OF HIGHWAY NO. 17 DIST. NO. 20

TWP. EWART LOT. COR.

**BORE HOLE LOCATIONS & SOIL STRATA**

BORE HOLE NO. 1

DATE 27 APRIL 1971 SITE NO. 71-11008A

APPROVED BY [Signature] DATE [Date]