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GEOCRES No. 41K-26

DIST. 18 REGION

W.P. No.

CONT. No. MUNICIPAL

W. O. No. 72-11075

STR. SITE No. 385-287

HWY. No. LOC

LOCATION PROPOSED CULVERT AT KARS

CREEK ON GOULAIS MISSION ROAD

No of PAGES - —

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

41K-26

GEOCRES No.

To: Mr. T. A. Hickey, (2)
District Municipal Engineer,
District #18,
Sault Ste. Marie, Ontario.

FROM: Foundations Office,
Design Services Branch,
West Bldg., Downsview.

ATTENTION:

DATE: October 13, 1972

OUR FILE REF.

IN REPLY TO

OCT 17 1972

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For
Proposed Culvert
At Kars Creek
On the Goulais Mission Road
District 18 (Sault Ste. Marie)
W.O. 72-11075 -- W.P. (Nil)

Attached we are forwarding to you our detailed foundation investigation report on the subsoil conditions existing at the above-mentioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your design requirements. Should additional information be required, please do not hesitate to contact our Office.

AGS/ao
Attach.

cc: A. A. Ward
G. R. Browning
K. L. Kleinsteinber
A. Rutka
B. J. Giroux
P. D. Lester
R. Morgenroth
G. A. Wrong
B. A. Singh

Foundations Files
Documents

A. G. Stermac
A. G. Stermac,
PRINCIPAL FOUNDATIONS ENGINEER.

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FOUNDATION INVESTIGATION REPORT
For
Proposed Culvert
At Kars Creek
On the Goulais Mission Road
District 18 (Sault Ste. Marie)
W.O. 72-11075 -- W.P. (Nil)

1. INTRODUCTION:

A request for a foundation investigation where the Goulais Mission Road crosses Kars Creek was requested by Mr. T.A. Hickey, District Municipal Engineer, in a memorandum dated June 6, 1972.

A field investigation was subsequently carried out by the Foundations Office to determine the subsoil conditions at this site. This report contains the results of this investigation and our recommendations pertaining to the design of the proposed culvert.

2. SITE CONDITIONS:

The site is located on the Goulais Mission Road about 8 miles west of Hwy. 17 north and 18 miles north of Sault Ste. Marie. The surrounding area at this location is flat and there is a rock outcrop about 100 ft. south of the crossing.

Kars Creek is 60 feet wide at this location, narrowing to a 25 foot width at the bridge. The creek is approximately 5 feet deep directly under the bridge.

The existing structure is a 27-foot-span timber bridge founded on wood piles at the centre of the creek and founded on wood cribs at the abutments. The bridge deck fell recently

and was replaced with a new deck. The entire structure has settled excessively and a permanent replacement is required.

3. FIELD AND LABORATORY WORK:

The field work consisted of two sampled boreholes and four dynamic cone penetration tests. The boreholes were advanced using continuous flight augers, washboring, and diamond drilling equipment mounted on a bombardier. Disturbed samples were obtained using a 2-inch O.D. split-spoon sampler driven according to specifications for the Standard Penetration Test. Undisturbed samples were taken using 2-inch I.D. Shelby tubes which were pushed into the soil manually. Field vane tests were carried out 18 inches below split spoon samples wherever possible. A rock core was obtained at the end of one of the boreholes.

Dynamic cone penetration tests were performed adjacent to both boreholes and at two other locations. Driving energy to advance the cone was 350 ft.-lbs. per blow.

The locations and elevations of the boreholes and cone tests are marked on Drawing #72-11075A accompanying this report.

Samples were examined visually in the field and again in the laboratory. Tests were performed on selected samples to determine the following physical properties:

- Grain-Size Distribution
- Atterberg Limits
- Natural Moisture Content
- Bulk Density
- Unconfined Shear Strength
- Consolidation characteristics
- Triaxial Shear Strength

The results of the field and laboratory test are given in the Record of Borehole sheets and in Figure 1, which are contained in the Appendix of this report.

4. SUBSOIL CONDITIONS:

4.1) General:

There are four major soil strata at this site underlain

by probable bedrock. The bedrock appears to dip to the west on about an 8 horizontal to 1 vertical slope. The strata listed from ground level downwards are as follows.

4.2) Fill Material:

Both boreholes were placed on the shoulder of the road where the fill material was from 4.5 to 7 feet thick. This material is a loose, brown gravelly sand with some boulders.

4.3) Sandy Silt:

In Borehole 1 only, a 3.5 foot thick sandy silt stratum is present. This stratum is a loose, dark brown silt with some sand and traces of organics.

4.4) Clay:

A 10- to 20-foot-thick stratum of soft to very soft, reddish-brown clay, is found beneath the sandy silt stratum. This stratum increases in thickness towards the west.

In Borehole 1 the clay is soft with irregular, hair-line grey silt seams. A 2-foot-thick layer of loose sand with some gravel occurs in the middle of this stratum. In Borehole 2 the clay is very soft, with occasional tiny pockets of grey silt.

Atterberg limit and natural moisture content tests were carried out on the clay portion. The liquid limits for undisturbed samples averaged about 90% with a plasticity index of about 60%. The moisture contents of the samples were found to be above the liquid limit with liquidity indices ranging from 1.0 to 1.3.

Sensitivity of the clay ranged from $S = 3$ to $S = 8$. This material will behave as a viscous liquid without appreciable shear strength, when remoulded. The undisturbed shear strength of the clay is 200 p.s.f.

4.5) Silty Sand:

Beneath the clay stratum a 3- to 3.5-ft.-thick stratum of silty sand occurs. This stratum is silty sand with traces of

gravel to sand with silt and traces of gravel. It is reddish-brown and dense to very dense.

4.6) Probable Bedrock:

At depths ranging from 24 to 31 feet, probable bedrock is encountered. This stratum dips to the west at about an 8 horizontal to 1 vertical slope. A 2.5-foot-long rock core was obtained from Borehole 1 with 100% recovery. Drilling was suspended at this point due to equipment problems but it is expected that this stratum is bedrock. The surface bedrock near the hole location and the consistency of results from cone tests provide further evidence that this is indeed bedrock.

5. GROUNDWATER CONDITIONS:

The groundwater level appears to be at the same level as the creek due to the high permeability of the embankment material which drains immediately.

6. DISCUSSION AND RECOMMENDATIONS:

6.1) General:

It is proposed to replace the existing timber structure with a pipe or pipe-arch culvert. Subsoils consist of soft to very soft clay extending to a maximum depth of 20 feet.

6.2) Placing of Culvert:

If a culvert is economically feasible then no problems are foreseen with the placing of a culvert at this location. The culvert should be designed to the appropriate Ministry standard. The granular bedding beneath the culvert should have a minimum thickness of 2 feet. The invert elevation and size of culvert should be determined by the hydrology section.

It is recommended that the creek bed at both the upstream and the downstream end be protected by rip-rap. The size of the area to be covered by rip-rap should be determined by the Hydrology

Office. The lack of such protective measures might cause serious washouts of the granular bedding, which in turn would endanger the stability of the embankment.

6.3) Embankment Stability:

The stability of the embankment has been checked assuming that the present grade will not be changed. Stability analyses were carried out by means of an electronic computer assuming that failure occurs along a circular arc immediately after construction. Such computations are based on shear stress parameters in terms of total stresses.

The results of the stability analyses indicate that the embankment will be stable if the present grade is maintained. If the grade is to be raised then further analyses will be necessary to determine the stability of the embankment. An embankment slope of 2 horizontal to 1 vertical is recommended.

6.4) Settlement:

Computation of settlements due to compression of the clay stratum were carried out using laboratory consolidation curves. Stresses induced by the embankment were calculated by the Boussinesq theory. The results of these calculations indicated that a 3" - 4" consolidation of the clay will occur under the centre-line of the embankment.

6.5) Further Considerations:

It is recommended that consideration be given to placing a new timber structure bridge at this location. If a timber structure is economically feasible then it could be founded on wood piles driven to the silty sand stratum. If #14 timber piles were used then a maximum load of 25 tons/pile could be used for design. The piles would be end bearing in the dense to very dense silty sand stratum at elevations of 577+ feet at the west end of the present structure, of 579+ feet at the present stream centre-line, and of 581+ feet at the east end of the present structure. All piles should be 'treated' if not completely below the permanent groundwater level.

7. MISCELLANEOUS:

The field investigation, carried out during the period August 2-10, 1972, was supervised by Mr. E. A. Wood, Project Foundations Engineer. The equipment was owned and operated by Canadian Longyear Ltd.

This report was written by Mr. E. A. Wood and reviewed by Mr. K. G. Selby, Supervising Foundations Engineer.

E. A. Wood

E. A. Wood

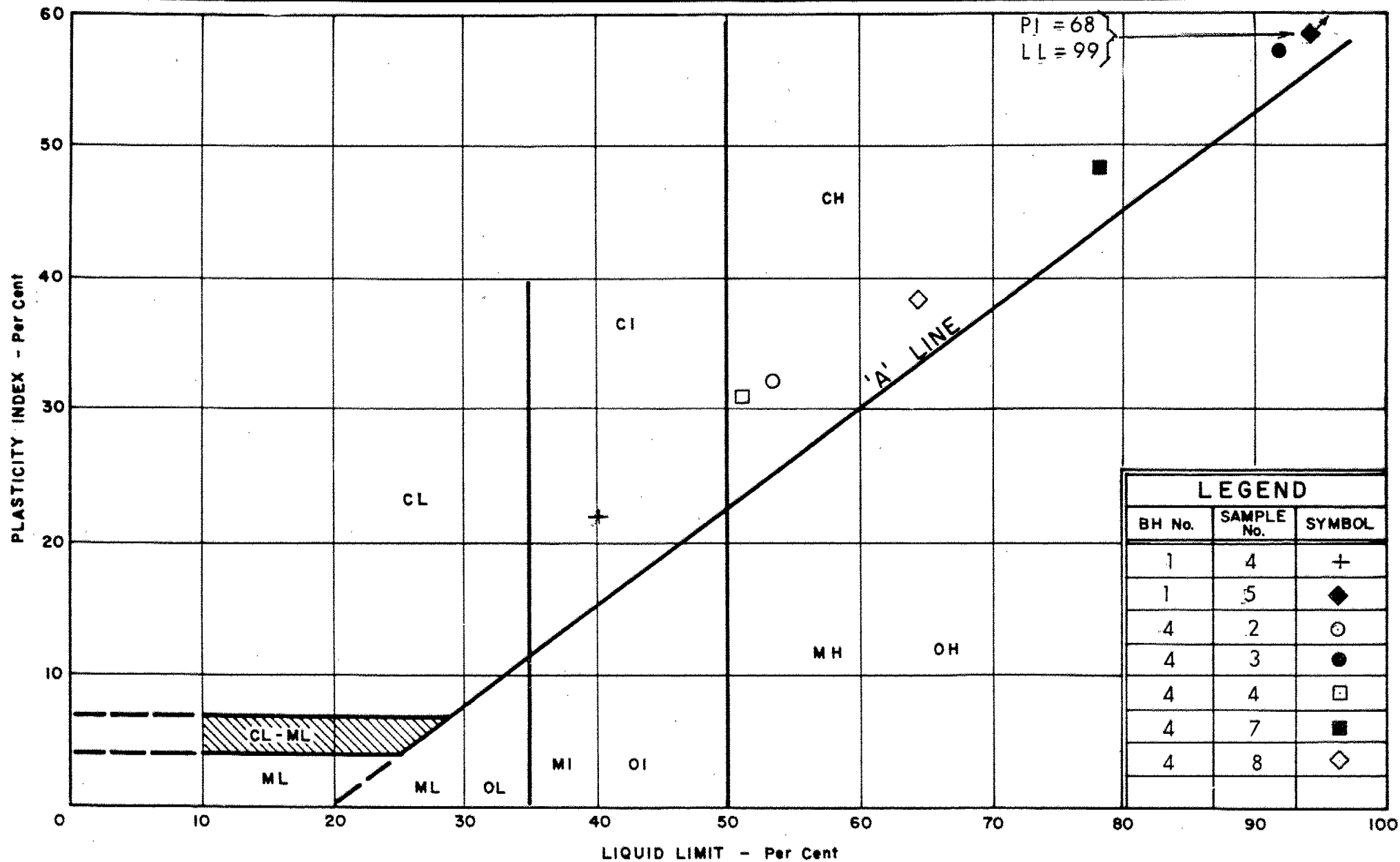
K. G. Selby

K. G. Selby, P. Eng.

EAW/ao

Oct. 11, 1972.

APPENDIX I



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

PLASTICITY CHART CLAY

W.P. No. _____

JOB No. 72-11075

FIGURE 1

DESIGN SERVICES BRANCH

FOUNDATION OFFICE

RECORD OF BOREHOLE NO 1

JOB 72-11075

LOCATION Sta. 3 + 65 1h" Lt. Ø

ORIGINATED BY EW

W.P.

BORING DATE August 10, 1972

COMPILED BY EW

DATUM Geodetic

BOREHOLE TYPE Washboring & Cone Test

CHECKED BY *EW*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100	SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 200 400 600 800 1000	LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w w_p — w — w_L WATER CONTENT % 30 60 90	BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT						
603.7	Ground Level										
0.0	Gravelly sand, loose										
599.2	Fill Material		1	SS	3						
4.5	Sandy silt. Dark		2	SS	6						
595.7	Brown. Loose		3	SS	1						
8.0	Clay with silt seams										
592.7	Soft		4	SS	2						
590.7	Gravelly sand. Loose		5	TW	PM						
13.0	Clay with silt seams		6	SS	45						
584.5	Soft										
19.2	Silty sand. Dense										
581.7											
22.0	Probable Bedrock		7	RC	100%						
579.1											
24.6	End of Borehole										

9 64 (27)

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE NO 2

JOB 72-11075

LOCATION Sta. 3 + 60 8' Rt. Ø

ORIGINATED BY EW

W.P.

BORING DATE August 3, 1972

COMPILED BY EW

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100	LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W W_P — W — W_L WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT					
605.0	Ground Level									
0.0										
580.7										
24.3	End of Cone Test									

DESIGN SERVICES BRANCH

FOUNDATION OFFICE

RECORD OF BOREHOLE NO 3

JOB 72-11075

LOCATION Sta. 4 + 22 8' Rt. 0

ORIGINATED BY EW

W.P.

BORING DATE August 3, 1972

COMPILED BY EW

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	BLOWS / FOOT	20	40	60	80	100	PLASTIC LIMIT — w_p		
604.9	Ground Level														
0.0															
575.4															
29.5	End of Cone Test														

DESIGN SERVICES BRANCH

FOUNDATION OFFICE

RECORD OF BOREHOLE NO 4

JOB 72-11075

LOCATION Sta. 4 + 26 8' Lt. Ø

ORIGINATED BY EW

W.P.

BORING DATE August 9, 1972

COMPILED BY EW

DATUM Geodetic

BOREHOLE TYPE Washboring, drilling, Cone Test

CHECKED BY *AK*

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	20	40	60	80	100	W_P	W	W_L		
604.7	Ground Level														
0.0	Gravelly sand with some boulders.														
597.7	Loose Fill Material														
7.0	Clay, reddish brown, very soft, with occasional tiny silt pockets.		1	TW	PM										
			2	SS	0										
			3	TW	PM										
			4	SS	0										
			5	TW	PM										
			6	SS	0										
	Grey		7	TW	PM										
577.2			8	SS	0										
27.5	Silty sand.														
573.7	Very Dense		9	SS	100	8"									
31.0	End of Borehole Probable Bedrock														

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
Q _{cu}	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Q _d	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	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
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	* 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a 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
σ	NORMAL STRESS
$\bar{\sigma}$	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

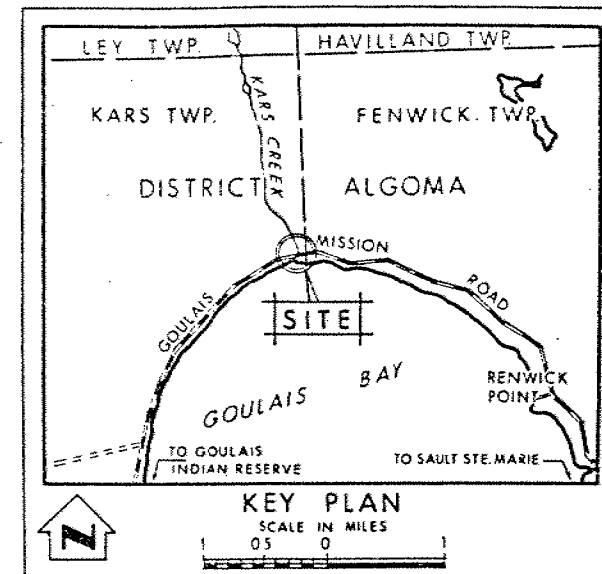
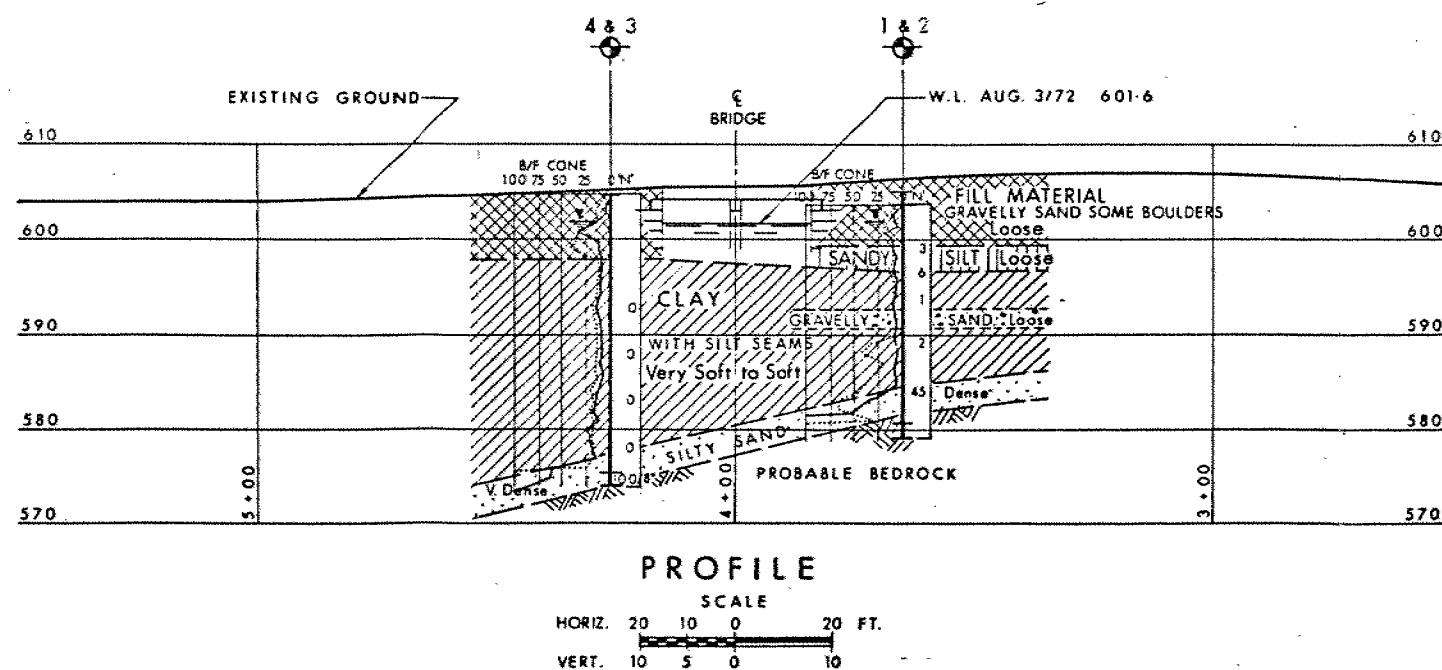
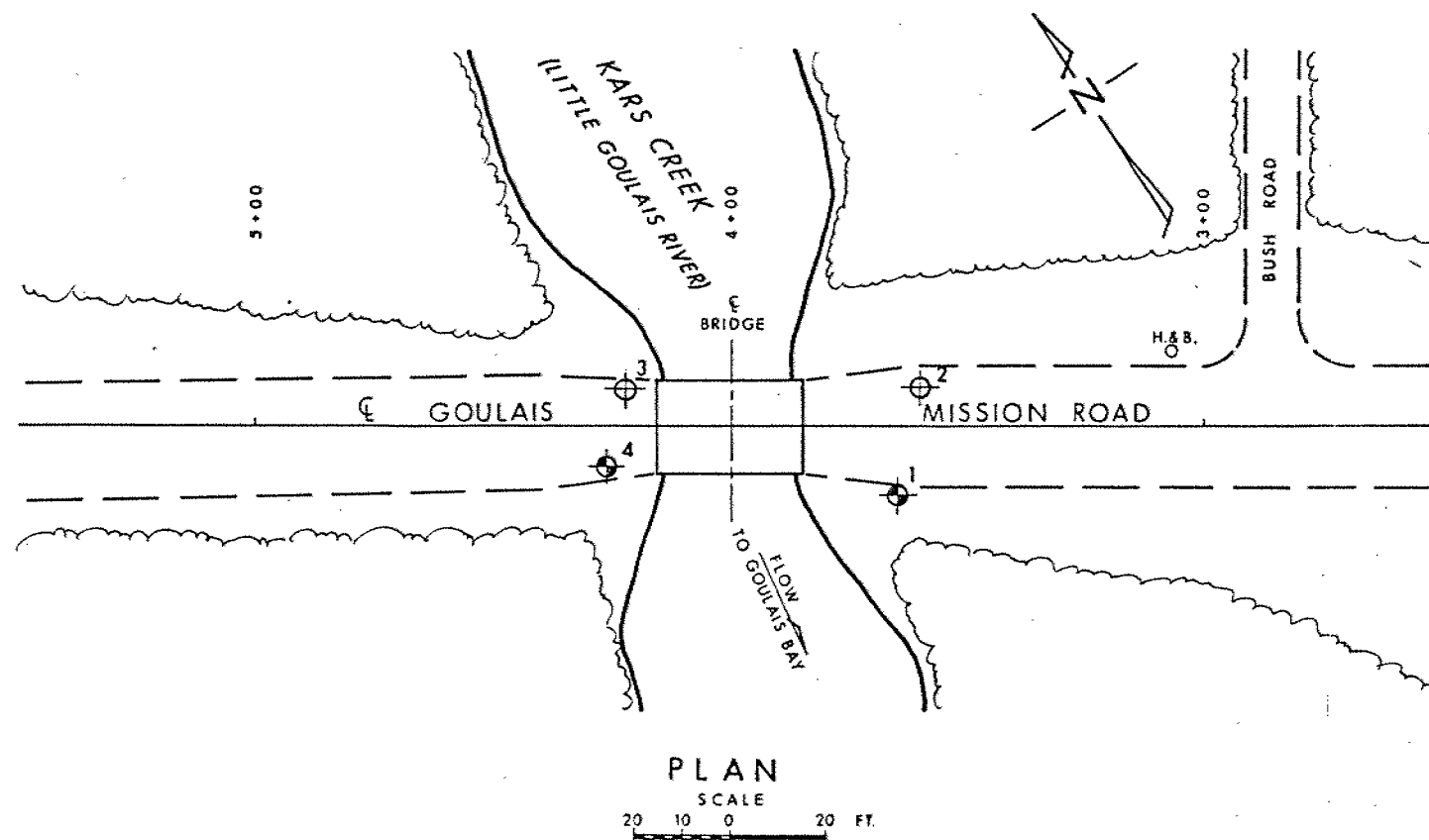
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

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
β	ANGLE OF SLOPE TO HORIZONTAL



LEGEND			
	Bore Hole		
	Cone Penetration Test		
	Bore Hole & Cone Test		
	Water Levels established at time of field investigation, Aug. 1972		
NO.	ELEVATION	STATION	OFFSET
1	603.7	3+65	14' LT.
2	605.0	3+60	8' RT.
3	604.9	4+22	8' RT.
4	604.7	4+26	8' LT.

— NOTE —
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH—FOUNDATIONS OFFICE

KARS CREEK

HIGHWAY NO. GOULAIS MISSION ROAD DIST. NO. 18
DIST. ALGOMA
TWP. KARS LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. T. W. CHECKED <input checked="" type="checkbox"/>	W. P. NO. <u> </u>	DRAWING NO. <u>72-11075 A</u>
DRAWN O. L. J. CHECKED <input checked="" type="checkbox"/>	W. O. NO. <u>72-11075</u>	
DATE <u>20 SEPT. 1972</u>	SITE NO. <u>7</u>	BRIDGE DRAWING NO. <u> </u>
APPROVED <u>W. J. Thomas</u>	CONT. NO. <u> </u>	

PRINCIPAL FOUNDATION ENGINEER