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GEOCRES No. 40I.14-34

DIST 2 REGION Southwestern

W.P. No. 88-69-08/09

CONT. No. 79-20

W. O. No. 73-11020

STR. SITE No. 5-216

HWY. No. _____

LOCATION Proposed Crossing of
St. Thomas Expressway over Kettle
Creek

OVERALL DRAWINGS TO BE INCLUDED WITH THIS REPORT. 4

REMARKS: documents to be unfolded
before microfilming

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: Mr. A. P. Watt, (2)
Regional Structural Planning Eng.,
Southwestern Region,
London, Ontario.

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

ATTENTION:

DATE: September 11, 1973.

OUR FILE REF.

IN REPLY TO

SEP 14 1973

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For
Proposed Crossing of St. Thomas
Expressway Over Kettle Creek
(Revised Alignment - May 1973)
City of St. Thomas, Co. of Elgin
District No. 2 (London)
Site 5-216

W.O. 73-11020 -- W.P. 88-69-08/09

~~401-135~~

4014-34
GEOCRES No.

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
Attch.

c.c. E. J. Orr
B. R. Davis
A. Rutka
A. Wittenberg
L. E. Walker
B. J. Giroux
J. R. Roy
G. A. Wrong
B. A. Singh

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

Foundations Files
Documents

TABLE OF CONTENTS

1. INTRODUCTION.
 2. DESCRIPTION OF SITE AND GEOLOGY.
 3. FIELD AND LABORATORY INVESTIGATION PROCEDURES.
 4. SUBSOIL CONDITIONS.
 - 4.1) General.
 - 4.2) Sandy Silt to Silty Sand.
 - 4.3) Heterogeneous Mixture of Clayey Silt and Sand, Traces of Gravel (Glacial Till).
 5. GROUNDWATER CONDITIONS.
 6. DISCUSSION AND RECOMMENDATIONS.
 - 6.1) General.
 - 6.2) Foundations.
 - a) Spread Footings in Original Ground.
 - b) Steel H-Piles.
 - 6.3) Approach Embankments.
 7. MISCELLANEOUS.
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FOUNDATION INVESTIGATION REPORT
For
Proposed Crossing of St. Thomas
Expressway Over Kettle Creek
(Revised Alignment - May 1973)
City of St. Thomas, Co. of Elgin
District No. 2 (London).
Site 5-216
W.O. 73-11020 -- W.P. 88-69-08/09

1. INTRODUCTION:

A request for an additional subsoil investigation for the crossing of the proposed St. Thomas Expressway over Kettle Creek was received in a memo from Mr. A. P. Watt, Regional Structural Planning Engineer, Southwestern Region, dated March 29, 1973.

A previous investigation of the site was carried out during the period of July 30 to August 3, 1971 (W.O. 71-11072). Subsequently, the structure was moved 95 ft. east and the footings were skewed at an angle of 22° - 30' - 00". It was felt that additional borings would be required because of this shift in the Kettle Creek diversion. The Foundations Office carried out an additional field investigation to determine the subsoil and groundwater conditions existing at the site.

This report contains all the factual data from both investigations, together with recommendations pertaining to the design of the proposed structure foundations and approach embankments.

2. DESCRIPTION OF SITE AND GEOLOGY:

The site is located in the City of St. Thomas.

Topographically the area is generally flat, the average elevation being at the 750 level. However, the eroding effects of numerous creeks in the area has left the region divided with wide and deep valleys. At this particular location the valley is some 1100 ft. wide and approximately 70 ft. deep. The valley

walls are relatively steep in places and are covered with brush and trees. The expressway runs into this valley through a ravine east of this location.

The area in the immediate vicinity is flat and is cultivated land or light brush and grass covered. Kettle Creek at this place meanders about 150 ft. east of the bridge site and the proposed stream diversion.

Physiographically, the site is located in the region referred to as the Mount Elgin Ridges.

3. FIELD AND LABORATORY INVESTIGATION PROCEDURES:

A total of sixteen sampled boreholes and thirteen dynamic cone penetration tests, ten boreholes and nine cone tests being done in July and August of 1971, was carried out during the course of the field investigations. Boring was achieved by means of a continuous flight auger machine (Penn Drill), and a C.M.E. hollow stem auger machine, adapted for soil sampling and diamond drilling purposes. During the field work, disturbed samples were obtained by means of a standard split-spoon sampler; the energy used in driving it, conformed to the requirements of the Standard Penetration Test.

Dynamic cone penetration tests were carried out adjacent to each borehole except Boreholes 4, 14 and 10. Driving energy used to advance the cone was 350 ft.-lbs. per blow.

All boreholes were surveyed in the field by personnel from Southwestern Region Engineering Surveys Office. The location and elevations of the borings are shown on Drawing No. 73-11020A which accompanies this report.

All samples were visually examined and classified at the site as well as in the laboratory. Following this inspection, laboratory tests were carried out on selected samples to determine the following physical properties:

Atterberg Limits

Moisture Content

Grain-Size Distribution

The results of the field and laboratory tests are summarized on the Record of Borehole sheets contained in the Appendix of this

report.

4. SUBSOIL CONDITIONS:

4.1) General:

Generally, uniform subsoil conditions were found to prevail over the area investigated. The subsoil consists of a 4.0 to 9.0 ft. thick sandy silt to silty sand deposit followed by a heterogeneous mixture of clayey silt and sand with traces of gravel.

The boundaries between various soil types are shown on the Record of Borehole sheets. The estimated stratigraphical profile shown on Drawing No. 73-11020A is based upon this information.

A detailed description of soil types and soil properties is given, as follows:

4.2) Sandy Silt to Silty Sand:

This material was found in all boreholes from ground surface downward to depths of 4.0 to 9.0 ft. The material consists of sandy silt to silty sand with small amounts of clay and gravel. In Borehole 2 considerably more gravel was found in one sample. The relative density of the layer varies from very loose to very dense, but in general is loose.

Grain size analyses indicate the following distributions, (except Sample No. 3 in B.H. 2), and are plotted on Figure 1.

Gravel	0 - 2%
Sand	6 - 34%
Silt	30 - 71%
Clay	7 - 15%

4.3) Heterogeneous Mixture of Clayey Silt and Sand, Traces of Gravel (Glacial Till):

This was the predominant soil deposit, and was encountered in all boreholes. All boreholes were terminated in this stratum. The deepest borehole was 44.0.

The material, in general, consists of a heterogeneous

mixture of clayey silt and sand with traces of gravel. These were occasional seams of silt and/or fine sand up to 6 inches in thickness. In general, the percentage of sand and silt content is higher below elevation 660.

The consistency of the material is hard. It was not possible to push Shelby Tubes through the material, indicating that the undrained shear strength was well in excess of 2,000 p.s.f. Below elevation 660 the blows on the split spoon sampler were, in general, more than 100 per ft., and often more than 100 blows for 6 inches penetration.

Grain-size analyses indicate the following distributions, and are plotted on Figure 2.

Gravel	1 - 12%
Sand	14 - 51%
Silt	33 - 56%
Clay	10 - 35%

Physical properties of the material, as determined from laboratory tests are as follows (see Figure 3):

	<u>Min.</u>	<u>Max.</u>	<u>Average</u>
Liquid Limit (%)	13	30	23
Plastic Limit (%)	10	16	13
Natural Moisture Content (%)	7	15	11

5. GROUNDWATER CONDITIONS:

The following water levels were observed in the boreholes at the time of investigation.

<u>July - August 1971</u>		<u>May 1973</u>	
Borehole 1	Elev. 673.7 ft.	Borehole 9	Elev. 674.6 ft.
Borehole 2	Elev. 673.0 ft.	Borehole 10	Elev. 674.1 ft.
Borehole 5	Elev. 673.0 ft.	Borehole 11	Elev. 674.0 ft.
Borehole 6	Elev. 673.4 ft.	Borehole 12	Elev. 673.5 ft.
		Borehole 13	Elev. 673.3 ft.
		Borehole 14	Elev. 671.8 ft.

No water levels were established in Boreholes 3, 4, 7 and 8.

The water level in the creek was 673.0. Thus the general ground water level was the same or slightly higher than the prevailing water level in the creek.

6. DISCUSSION AND RECOMMENDATIONS:

6.1) General:

It is proposed to construct a three-span (92' - 103' - 102') twin structure to carry St. Thomas Expressway over Kettle Creek. The prevailing ground level is at approximate elevation 680, and the proposed grade of the St. Thomas Expressway at this location will be between elevations 720 and 726 ft. This will require fills up to 46 ft. in height. Also it is proposed to construct a creek diversion. This will require a cut approximately 10 ft. deep. Thus the maximum approach heights will be 50 ft. at the east abutment and 56 ft. at the west abutment.

In general, the subsoil at the site consists of a deposit of a hard, heterogeneous mixture of clayey silt and sand with traces of gravel (glacial till), underlying 4.0 to 9.0 ft. of loose sandy silt to silty sand with traces of clay.

6.2) Foundations:

a) Spread Footings in Original Ground:

As described earlier, the shear strength of the subsoil is, in general, greater than 2,000 p.s.f. Therefore, it is recommended that the entire structure be supported on spread footings placed at or below elevation 670.0. A safe net pressure of 3.0 tons/sq. ft. may be assumed for design purposes. The exact depth will be dependent on hydrological requirements.

b) Steel H-Piles:

As an alternative, the entire structure or part of the structure may be supported on steel H-Piles driven to refusal in the glacial till stratum. It is estimated that refusal will be

met at approximate elevation of 650. For design purposes the maximum allowable design load may be assumed for the particular section used.

It is estimated that the following maximum settlements will occur in the subsoil at various locations over a long period of time following the end of construction.

Pier - Spread footings in original ground 1.0 inch
Abutment - Spread footings in original ground 2.0 inches.

Regardless of which of the above methods is adopted, the structure should be built to accommodate the possible 2 inches differential settlements between the abutments and the piers.

All foundations and pile caps should be protected against frost action by at least 4 ft. of earth cover.

6.3) Approach Embankments:

The shear strength of the subsoil is such that it will be able to safely support the 56 ft. high approach embankments constructed with 2:1 side slopes. The fill should consist of well compacted acceptable material. Care should be taken to ensure that no bouldery fill is placed within the approaches through which piles have to be driven, and it is recommended that this portion of the fill contain no larger grain sizes than 3 inches.

It is estimated that maximum settlements of not more than 2 inches will occur beneath the abutment locations. The topsoil and the soft organic material should be removed in accordance with the pertinent standards within the construction area.

No major dewatering problems are foreseen for the creek diversion or for the footing excavations.

7. MISCELLANEOUS:

The field investigation was carried out during the period of July 30 to August 3, 1971, under the supervision of Mr. A. Prakash, Project Foundations Engineer, and May 24 - 29, 1973, under the supervision of Mr. A. Prakash, Senior Foundations Engineer,

who was in charge of the entire project and Mr. P. Korgemagi, Project Foundations Engineer, who prepared this report.

Equipment was owned and operated by P.V.K. and Sons Limited.

This report was reviewed by Mr. K. G. Selby, Supervising Foundations Engineer.

P. Korgemagi

P. Korgemagi, P. Eng.



K. G. Selby

K. G. Selby, P. Eng.

PK/ao

Sept. 7, 1973.

APPENDIX I

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 1

JOB 73-11000

LOCATION Co. Ont., 1° 52' 59" N; 1° 35' 03" E.

ORIGINATED BY AP

W.P. 88-69-38/00

BORING DATE July 30, 1971

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Bombardier Flight Auger & Cone

CHECKED BY

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 % 10 20 30	BULK DENSITY γ P.C.F. GR SA. S. CL	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE					
679.7	Ground Level								
0.0	Sandy silt to silty sand, some clay.		1	SS	6				0 35 52 13
671.7	Loose to Very Loose		2	SS	3				673.7
8.0	Het. mix. of clayey silt and sand, traces of gravel.		3	SS	71				3 25 49 23
	Glacial Till		4	SS	108				4 18 49 29
	Hard	SS144	5	SS	102.8"				12 41 33 14
			6	SS	128.11"				
			7	SS	195				
638.2			10	SS	72				3 32 62 23
41.5	End of Borehole								

RECORD OF BOREHOLE No 2

108 73-11020

LOCATION Co-ords. 15,549,582 N; 1,350,772 E.

ORIGINATED BY AF

W.P. 88-69-08/09

BORING DATE August 2, 1971

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Follow Stem Auger and Cone

CHECKED BY

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100	LIQUID LIMIT ———— w _L PLASTIC LIMIT ———— w _p WATER CONTENT ———— w	BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT.	NUMBER	TYPE	BLOWS/FOOT	SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	w _p ————— w _L WATER CONTENT %	P.C.P.	GR. SA. SI. CL.
679.2	Ground Level						10 20 30		
0.0	Silty sand to sand & gravel, traces of clay.	.	1	SS	16				2 61 30 7
		.	2	SS	16				∇ 673.0
670.2	Compact to Dense	.	3	SS	32				43 42 (15)
9.0	Het. mix. of clayey silt and sand, traces of gravel.	/	4	SS	48				3 21 48 26
	Glacial Till	/	5	SS	71				1 16 53 30
	Hard	/	6	SS	38				
		/	7	SS	100 1 1/2"				3 40 42 15
		/	8	SS	100 1 1/2"				
648.4		/	9	SS	100 1 1/2"				
30.8	End of Borehole								

20
15 ϕ 5 % STRAIN AT FAILURE
10

OFFICE REPORT • SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 3

JOB 73-11020

LOCATION Co-ords. 15,540 493 N; 1,350,808 E.

ORIGINATED BY AP

W.P. 88-69-08/09

BORING DATE August 2, 1971

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Bombardier Flight Auger and Cone

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 γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE		20	40	60	80	100	W _p	W	W _L		
679.0	Ground Level														
0.0	Sandy silt to silty sand.		1	SS	5										
671.0	Loose to Very Dense		2	SS	53										
8.0			3	SS	54										
	Het. mix. of clayey silt and sand, traces of gravel.		4	SS	55										1 22 50 27
			5	SS	62										3 26 45 21
	Glacial Till		6	SS	96 7/8"										
			7	SS	101 1/2"										2 27 48 23
	Hard		8	SS	133 9"										
			9	SS	100 1/2"										2 27 52 19
638.6			10	SS	101 1/2"										W.L. not established
40.4	End of Borehole														

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 4

JOB 73-11020

LOCATION Co-ords. 15,549,470 N; 1,350,905 E.

ORIGINATED BY AP

W.P. 88-69-08/09

BORING DATE August 3, 1971

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY MS

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT			LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			BULK DENSITY γ P.C.F.	REMARKS		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F.			W_P W W_L						
							\circ UNCONFINED \bullet QUICK TRIAXIAL	$+$ FIELD VANE \times LAB VANE								
679.1	Ground Level															
0.0	Sandy silt to silty sand, traces of clay.		1	SS	8	670								0 30 62 8		
672.1	Loose		2	SS	5											
7.0	Het. mix. of clayey silt and sand, traces of gravel.		3	SS	58	670								2 18 54 26		
			4	SS	46											
			5	SS	49	660									3 14 48 35	
			6	SS	34											
			7	SS	65											
			8	SS	100	5"	650									8 44 37 11
			9	SS	100	5"										
	Glacial Till		10	SS	100	4"	640								4 32 46 18	
	Hard															
638.2			11	SS	100	5"									W.L. not established	
40.9	End of Borehole															

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 5

JOB 73-11020

LOCATION Co-ords. 15,549,654 N; 1,350,737 E.

ORIGINATED BY AP

W.P. 88-69-08/09

BORING DATE July 30, 1971

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger and Cone

CHECKED BY F.S.

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			PLASTIC LIMIT — w_p					
							20	40	60	80	100	WATER CONTENT — w			
SHEAR STRENGTH P.S.F.							UNCONFINED			FIELD VANE			WATER CONTENT %		
							● QUICK TRIAXIAL			× LAB VANE			w_p — w — w_L		
													10 20 30		
679.5	Ground Level														
0.0	Sandy silt to silty sand, traces of clay		1	SS	10									0 19 71 10	
672.5	Loose		2	SS	5									673.	
7.0	Very Stiff		3	SS	24	670								2 19 51 28	
			4	SS	38									1 17 55 27	
	Het. mix. of clayey silt and sand, traces of gravel.		5	SS	40									7 21 49 23	
			6	SS	50										
			7	SS	130.6"	660									
	Glacial Till		8	SS	100.4"									4 51 35 10	
			9	SS	115.6"	650									
	Hard		10	SS	100.0"										
			11	SS	100.6"	640								1 33 46 20	
635.5			12	SS	58									3 26 49 22	
44.0	End of Borehole														

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 6

JOB 73-11020

LOCATION Co-Ords. 15,549,640 N; 1,350,833 E.

ORIGINATED BY AP

W.P. 88-69-08/09

BORING DATE August 2, 1971

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Bombardier Flight Auger and Cone

CHECKED BY J-15

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE	LIQUID LIMIT W_L	BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. LOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT 20 40 60 80 100	PLASTIC LIMIT W_p		
679.9	Ground Level						SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT % W_p W W_L	γ	GR. SA. SI. CL.
0.0	Sandy silt to silty sand, traces of clay		1	SS	9					0 22 63 15 673.4
671.9	Loose		2	SS	7					5 21 49 25
8.0	Het. mix. of clayey silt and sand, traces of gravel.		3	SS	91	670				11 30 41 18
	Glacial Till		4	SS	117					7 31 44 18
	Hard		5	SS	162					
649.4	End of Borehole		6	SS	100.5"	660				
30.5			7	SS	100.5"					
			8	SS	100.6"	650				
						640				

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 7

JOB 73-11020

LOCATION Co-ords. 15,549,564 N; 1,350,866 E.

ORIGINATED BY AP

W.P. 88-69-08/09

BORING DATE August 2, 1971

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger and Cone

CHECKED BY MS

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — W _L PLASTIC LIMIT — W _P WATER CONTENT — W			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS/FOOT		20	40	60	80	100	W _P	W	W _L		
679.3	Ground Level															
0.0	Sandy silt to silty sand, traces of clay		1	SS	8											
672.3	Loose to Compact		2	SS	21											1 22 67 10
7.0			3	SS	100.5"											
	Het. mix. of clayey silt and sand, traces of gravel.		4	SS	46	670										3 16 56 25
			5	SS	46											8 20 46 26
			6	SS	92											
			7	SS	100.4"	660										7 36 45 12
	Glacial Till		8	SS	-											
			9	SS	100.5"	650										
	Hard															
643.4			10	SS	100.5"											4 30 46 20
35.9	End of Borehole					640										W.L. not established

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 8

JOB 73-11020

LOCATION Co-ords. 15,549,537 N; 1,350,963 E.

ORIGINATED BY AP

W.P. 88-69-08/09

BORING DATE August 3, 1971

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Bombardier Flight Auger and Cone

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 γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		20	40	60	80	100	W_p	W	W_L		
679.8	Ground Level															
0.0	Sandy silt to silty sand, traces of clay.		1	SS	6											0 23 69 8
672.3	Loose to Compact		2	SS	29											
7.5	Het. mix. of clayey silt and sand, traces of gravel.		3	SS	85	670										2 21 52 25
			4	SS	67											
			5	SS	57											5 17 48 30
	Glacial Till		6	SS	164	660										
			7	SS	100.5"											
	Hard		8	SS	100.5"	650										7 26 46 21
			9	SS	100.5"											
639.3			10	SS	100.5"	640										9 25 42 24
40.5	End of Borehole															W.L. not established

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 9

JOB 73-11020

LOCATION Co-ords. 15,549,495 N; 1,350,866 E.

W.P. 89-69-08/09

BORING DATE May 23, 1973

ORIGINATED BY LJH

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Auger & Cone

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 γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS/FOOT		20	40	60	80	100	w_p	w	w_L		
677.6	Ground Level															
0.6	Bandy silt to silty sand, traces of clay & org. Loose. Brown		1	SS	6	670										▽ 674.6
5.0	Het. mix. of clayey silt and sand, traces of gravel		2	SS	95											1 22 48 29
	Glacial Till		3	SS	57											
	Hard		4	SS	100.2"	660										7 35 39 19
			5	SS	100.12"											
			6	SS	100.5"	650										
644.3			7	SS	100.3"											
33.3	End of Borehole					640										

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 10

JOB 73-11020

LOCATION Co-ords. 15,549,403 N; 1,350,945 E.

ORIGINATED BY FK

W.P. 89-69-08/09

BORING DATE May 24, 1973

COMPILED BY L.J.H.

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

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 γ	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				
678.9	0.6' Topsoil Ground Level													
0.0	Sandy silt to silty sand, traces gravel & clay & org. Brown		1	SS	74									1 34 55 10 674.1
673.9	Compact													
5.0			2	SS	80	670								
	Het. mix. of clayey silt and sand, traces of gravel.		3	SS	98									2 20 49 29
			4	SS	100.6"	660								
	Hard		5	SS	100.6"									
	Greyish-Brown		6	SS	100.2"	650								
645.4			7	SS	100.3"									
33.5	End of Borehole					640								

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO. 1

JOB 73-11020

LOCATION Co-ords. 15,549,477 N; 1,351,057 E.

ORIGINATED BY LJH

W.P. 89-69-08/09

BORING DATE May 25, 1973

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Auger & Cone

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 γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		20	40	60	80	100	w_p	w	w_L	
675.2	Ground Level														
	Topsoil														
1.0	traces of org.		1	SS	26	670									
	Black to Grey		2	SS	77										
	Het. mix. of clayey silt & sand, traces of gravel		3	SS	100	660									
	(Glacial Till)		4	SS	100	650									
	Greyish-Brown		5	SS	100										
			6	SS	100										
641.8			7	SS	100										
33.4	End of Borehole					640									

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 12

JOB 73-11020

LOCATION Co-ords. 15,549,356 N; 1,351,001 E.

ORIGINATED BY L.H.

W.P. 89-69-08/09

BORING DATE May 28, 1973

COMPILED BY

DATUM Geodetic

BOREHOLE TYPE Auger & Cone

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 γ P.C.F.	REMARKS		
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS/FOOT		20	40	60	80			100	w_p
							SHEAR STRENGTH P.S.F.							
							O UNCONFINED + FIELD VANE							
							● QUICK TRIAXIAL x LAB VANE							
							WATER CONTENT %		10		20		30	
679.1	Ground Level													
673.1	Silty sand to sandy silt, traces of clay & organics. Loose Brown		1	SS	6									
670.0			2	SS	36									
666.0			3	SS	67									
662.0			4	SS	100.5"									
658.0			5	SS	102.5"									
654.0			6	SS	104.2"									
650.0			7	SS	106.0"									
646.3														
32.8	End of Borehole													

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 13

JOB 73-11020

LOCATION Co-ords. 15,509,807 N; 1,351,116 E.

ORIGINATED BY L.H.

W.P. 84-69-08/09

BORING DATE May 28, 1973

COMPILED BY L.H.

DATUM Geodetic

BOREHOLE TYPE Auger and Cone

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/100T 20 40 60 80 100	SHEAR STRENGTH P.S.F. O UNCONFINED * FIELD VANE • QUICK TRIAXIAL * LAB VANE	LIQUID LIMIT PLASTIC LIMIT WATER CONTENT % W _L — W _P — W _U	WATER CONTENT % 10 20 30	BULK DENSITY Y P.C.F.	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS/FOOT							
678.0	Ground Level											
0.6	Silty sand to sandy silty clay & organics		1	SS	11							673.3
674.0			2	SS	11							
670.0			3	SS	100							
	Het. mix. of clayey silt and sand, traces of gravel (Glacial Till)		4	SS	17							638 h1 1
			5	SS	100							
669.8	Hard											
28.2	End of Borehole											

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 14

73-11020

LOCATION Co-ords. 15,549,320 N; 1,351,074 E.

89-69-08/09

BORING DATE May 29, 1973

ORIGINATED BY L.J.H.

COMPILED BY L.J.H.

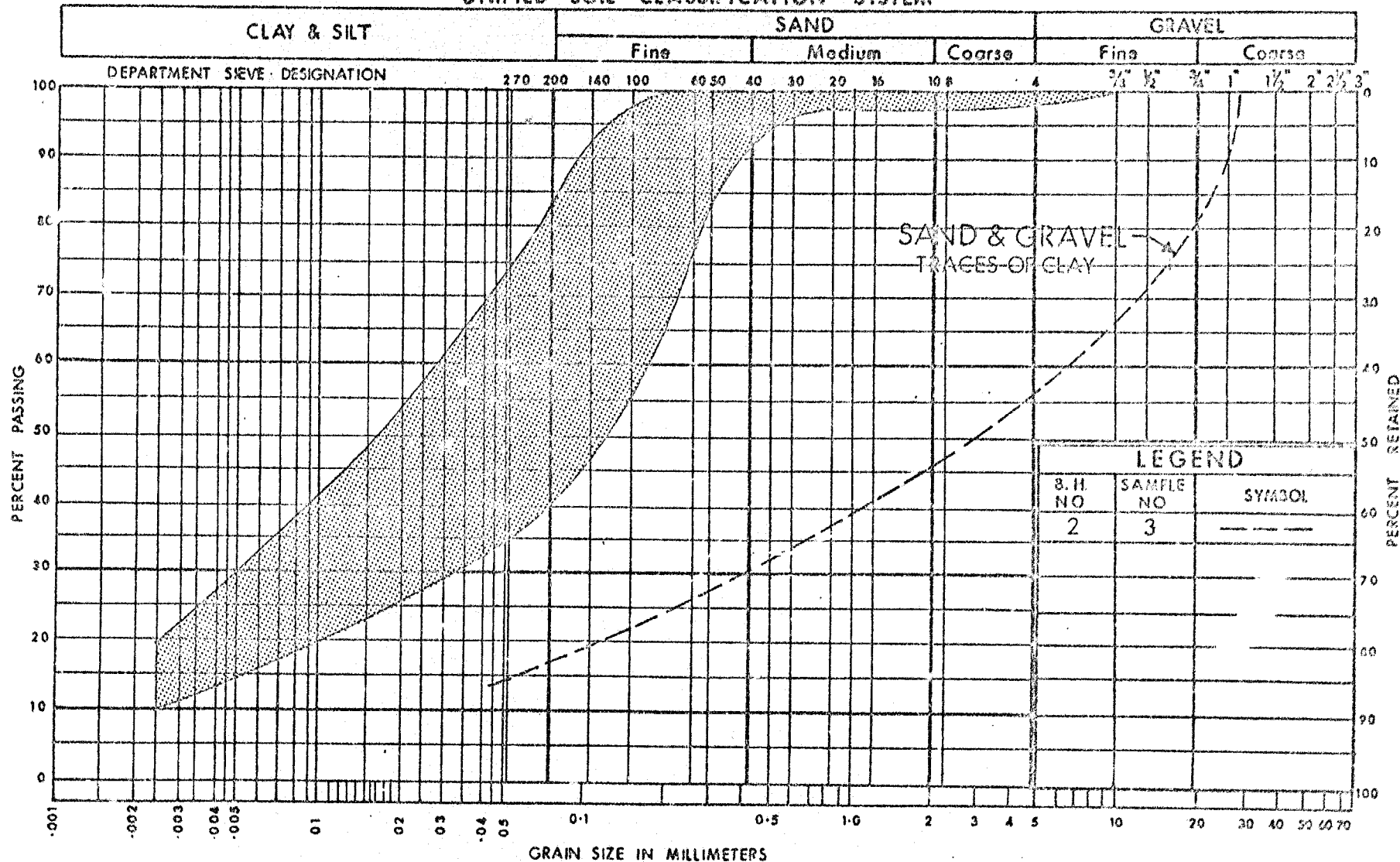
ATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY L.J.H.

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F.		W_P	W	W_L		
676.6	Ground Level						O UNCONFINED + FIELD VANE X QUICK TRIAXIAL X LAB VANE						
0.6	Silty sand to sandy silt, traces clay.		1	SS	8								
676.8	Loose												
5.0	Ret. mix. of clayey silt and sand, traces of gravel (Glacial Till)		2	SS	52	670							
	Hard		3	SS	81								
			4	SS	100	660							
			5	SS	100	650							
			6	SS	100	640							
640.9			7	SS	100	630							
32.9	End of Borehole					640							

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT
OF
TRANSPORTATION AND COMMUNICATIONS



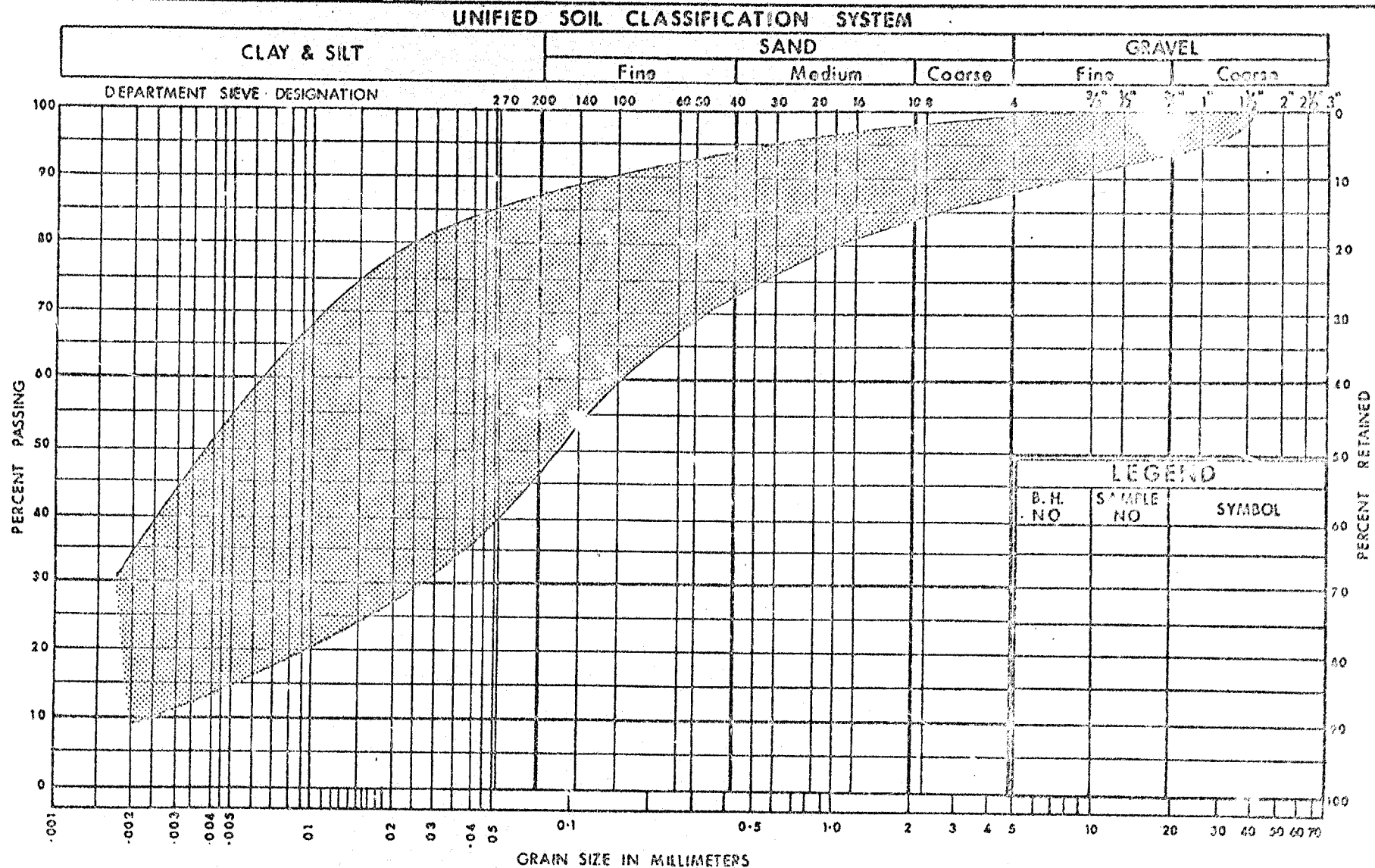
DESIGN SERVICES
BRANCH

GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND
TRACES OF CLAY

W.P. No. 88-69-08 & 09

JOB No. 73-11020

FIG. 1



DESIGN SERVICES
BRANCH

GRAIN SIZE DISTRIBUTION

HET. MIXTURE OF CLAYEY SILT & SAND
TRACES OF GRAVEL (GLACIAL TILL)

W.P. No. 88-69-08 & 09

JOB No. 73-11020

FIG. 2

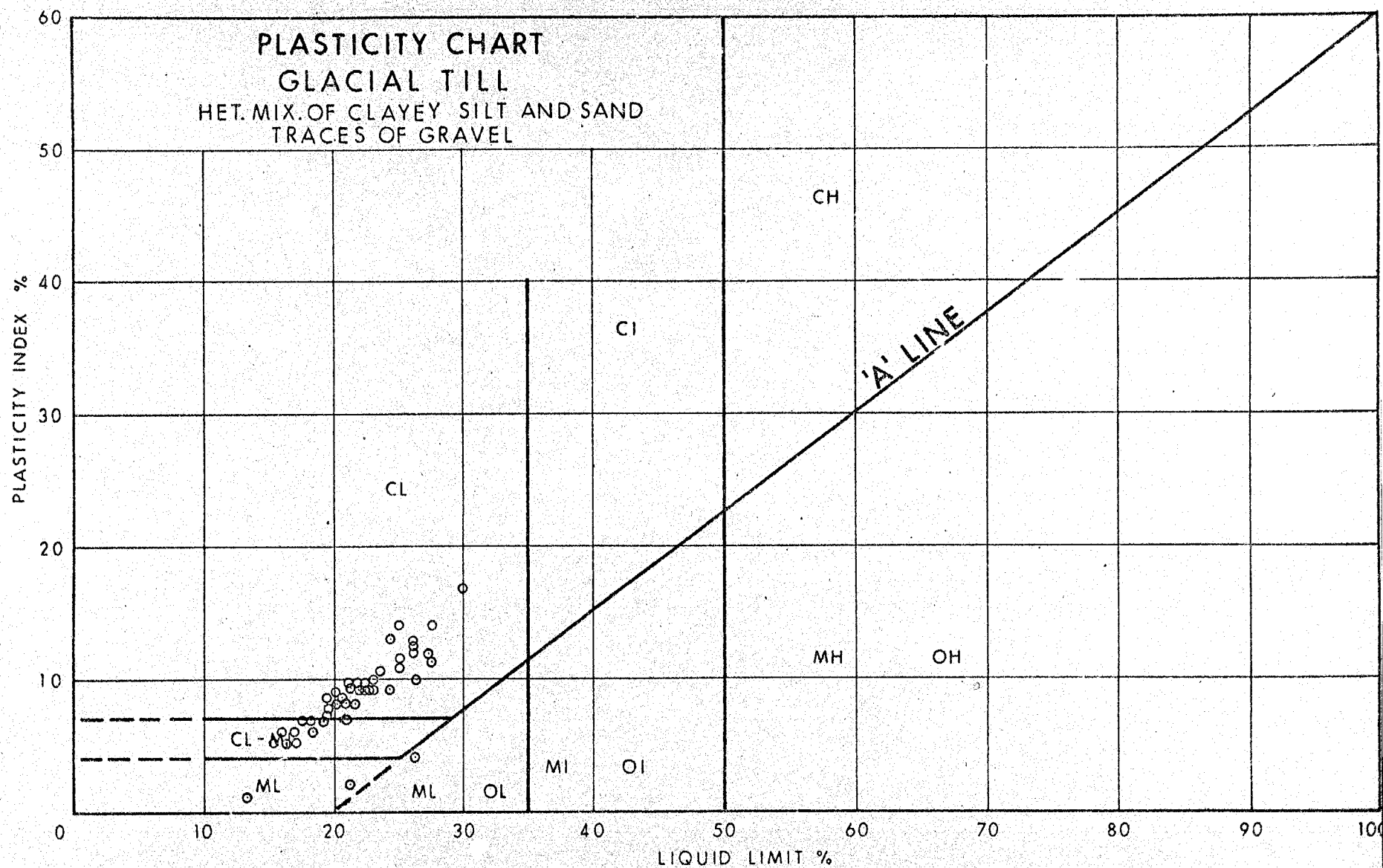


FIG. 3.

FD-9 (Rev. Jan. 73)

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N'=STANDARD PENETRATION RESISTANCE : - 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>c LB./SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CU	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS 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
w_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
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
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
σ'	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

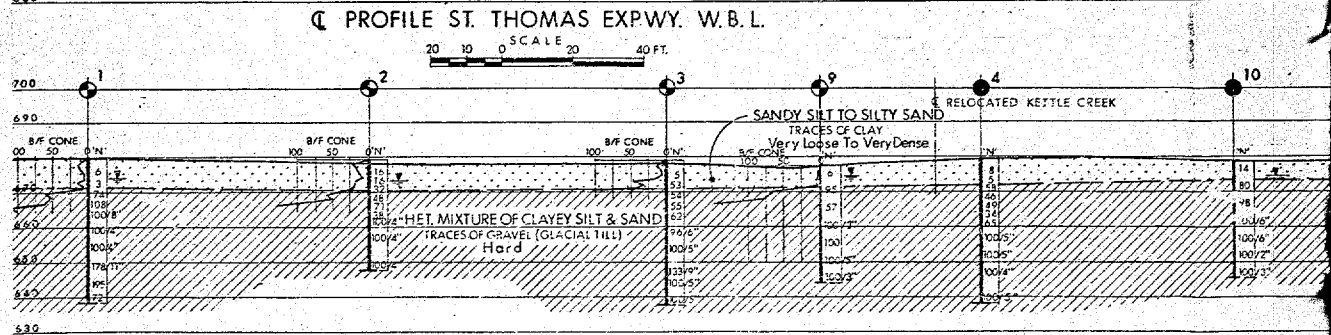
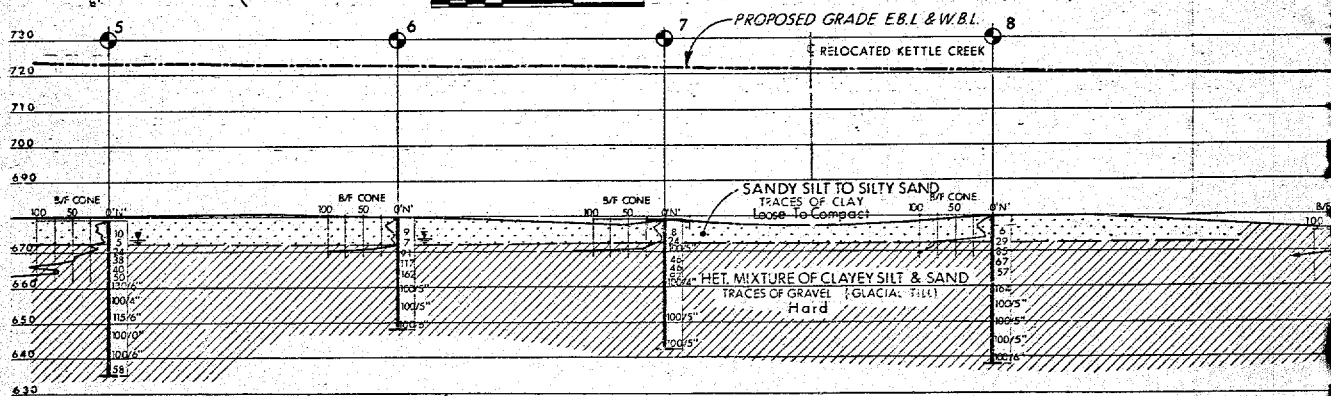
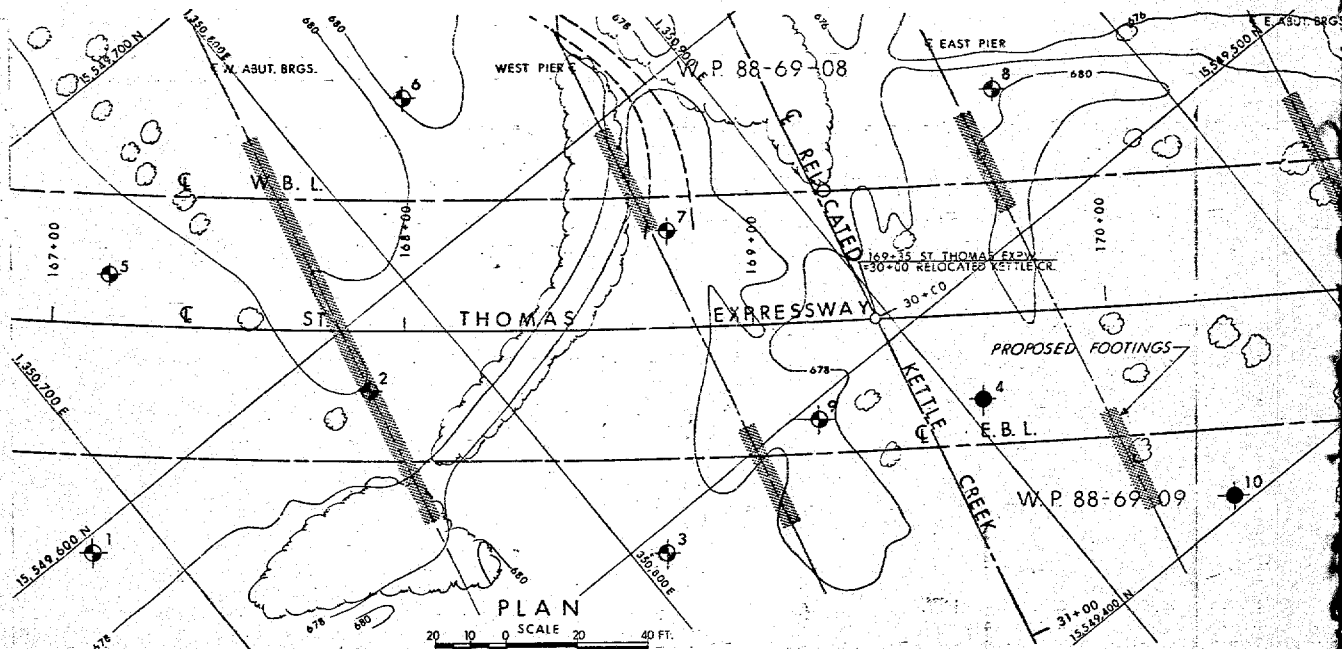
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

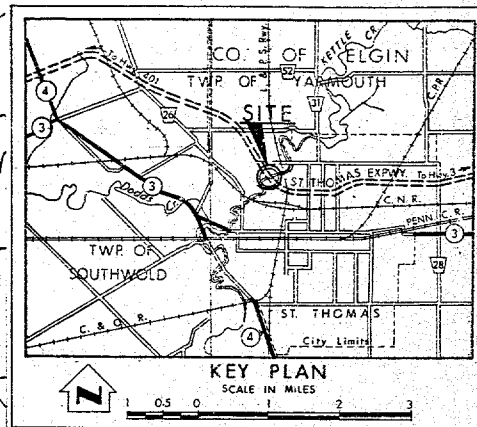
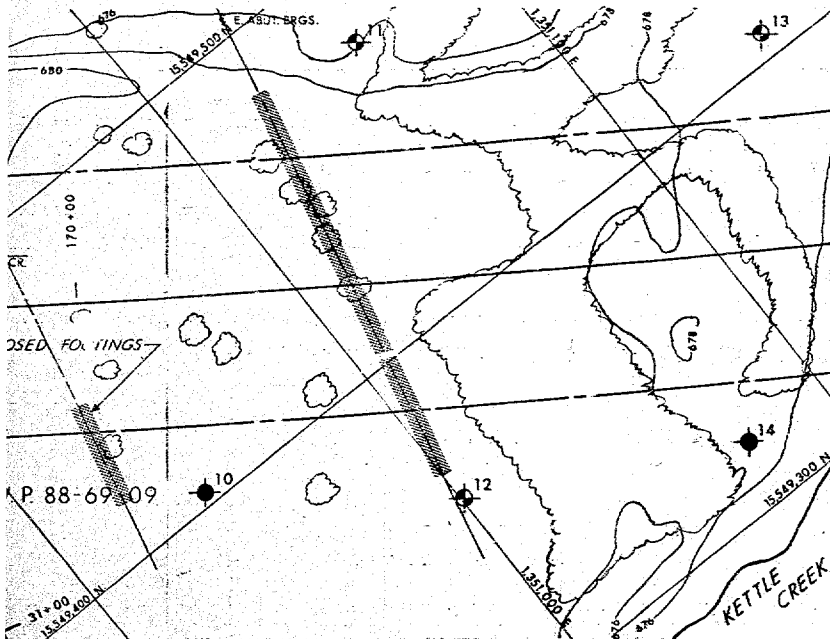
FOUNDATIONS

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.		
	Bore Holes No 1, 2, 5 & 6: AUG. 1971		
	Bore Holes No 9, 10, 11, 12, 13 & 14: MAY 1973		
	Bore Holes No 3, 4, 7 & 8: W.L. not observed		
NO.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	679.7	15,549,376	1,350,683
2	679.2	15,549,582	1,350,772
3	679.0	15,549,493	1,350,808
4	679.1	15,549,470	1,350,905
5	679.5	15,549,634	1,350,737
6	679.9	15,549,640	1,350,833
7	679.3	15,549,564	1,350,866
8	679.8	15,549,537	1,350,963
9	677.6	15,549,495	1,350,866
10	678.9	15,549,403	1,350,945
11	675.2	15,549,477	1,351,037
12	679.1	15,549,336	1,351,001
13	678.0	15,549,407	1,351,148
14	676.8	15,549,920	1,351,074

— NOTE —

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

CONTRACT DOCUMENT NOTE

The complete soil investigation report for this structure may be examined at the Structural and the Foundations Office, Downsview, and at the London District Office.

REV	DATE	BY	DESCRIPTION

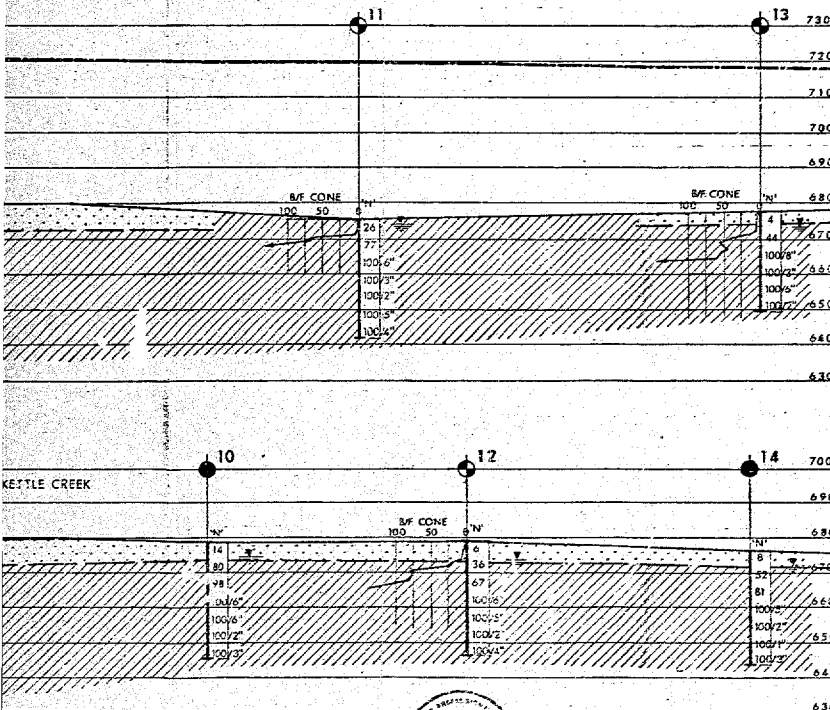
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH—FOUNDATIONS OFFICE

KETTLE CREEK
(REVISED ALIGNMENT)

HIGHWAY NO. ST. THOMAS EXPWY DIST. NO. 2
CO. ELGIN CITY OF ST. THOMAS
TWP. YARMOUTH LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBWD A.P. CHECKED	W.P. NO. 68-69-08-639	DRAWING NO.
DRAWN M.S. CHECKED	A.C. NO. 73-11020	73-11020 A
DATE AUG. 20, 1973	SITE NO.	BRIDGE DRAWING NO.
APPROVED	CONT. NO.	



REF. NO. FENCO 3802-7T-1

Ontario
Department of Transportation and Communications

~~XXXXXXXXXXXXXXXXXXXX~~

MEMORANDUM

40I-62

TO: Mr. A. P. Watt, (2)
Regional Bridge Planning Engineer,
Southwestern Region,
London, Ontario.

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

ATTENTION: DATE: September 28, 1971.

OUR FILE REF. IN REPLY TO

OCT 4 1971

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For

Proposed Crossing At
Kettle Creek & St. Thomas Expressway
Twp. of Yarmouth, Co. of Elgin
District No. 2 (London)
W.O. 71-11072 -- W.P. 88-69-08 & 09

40I4-62

GEOCREC No.

Attached, we are forwarding to you our detailed
foundation investigation report on the subsoil conditions
existing at the above structure 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: Messrs. B. R. Davis

A. Rutka
D. W. Farren
W. A. Zonnenberg
L. E. Walker
B. J. Giroux
J. R. Roy
J. Harris
G. A. Wrong
B. A. Singh

Foundations files
Documents

A. G. Stermac
A. G. Stermac,
PRINCIPAL FOUNDATION ENGINEER.

TABLE OF CONTENTS

1. INTRODUCTION.
 2. DESCRIPTION OF THE SITE.
 3. FIELD AND LABORATORY INVESTIGATION PROCEDURES.
 4. SUBSOIL CONDITIONS.
 - 4.1) General.
 - 4.2) Sandy Silt to Silty Sand.
 - 4.3) Heterogeneous Mixture of Clayey Silt and Sand,
Traces of Gravel (Glacial Till).
 5. GROUNDWATER CONDITIONS.
 6. DISCUSSION AND RECOMMENDATIONS.
 - 6.1) General.
 - 6.2) Foundations.
 - a) Spread Footings in Original Ground.
 - b) Steel H-Piles.
 - 6.3) Approach Embankments.
 7. MISCELLANEOUS.
-

FOUNDATION INVESTIGATION REPORT
For
Proposed Crossing At
Kettle Creek & St. Thomas Expressway
Twp. of Yarmouth, Co. of Elgin
District No. 2 (London)
W.O. 71-11072 -- W.P. 88-69-08 & 09

1. INTRODUCTION:

A request for a foundation investigation at the crossing of Kettle Creek and St. Thomas Expressway, was received from Mr. T. P. Hodgson, Bridge Location Engineer, in a memo, dated July 21, 1971.

A field investigation was subsequently carried out by the Foundation Section to determine the subsoil conditions existing at the site. This report contains the results of this investigation and our recommendations pertaining to the design of the proposed structure foundations and approach embankments.

2. DESCRIPTION OF THE SITE:

The site of the proposed crossing is located near the north-west boundary of the City of St. Thomas. The proposed structure is located in a valley about 1000 ft. wide and 85 ft. deep. The expressway runs through a ravine east of this location.

The area in the immediate vicinity is flat and is cultivated land or light brush and grass covered. The Kettle Creek at this place meanders about 150 ft. east of the bridge site.

Physiographically, the site is located in the region referred to as the Mount Elgin Moraines.

3. FIELD AND LABORATORY INVESTIGATION PROCEDURES:

A total of ten sampled boreholes and nine dynamic cone penetration tests was carried out during the course of the field work. Boring was achieved by means of a continuous flight auger machine (Penn Drill), and a C.M.E. hollow stem auger machine, adapted for soil sampling and diamond drilling purposes.

3. FIELD AND LABORATORY INVESTIGATION PROCEDURES: (cont'd) ... During the field work, disturbed samples were obtained by means of a standard split-spoon sampler; the energy used in driving it, conformed to the requirements of the Standard Penetration Test.

Dynamic cone penetration tests were carried out adjacent to each borehole except Borehole 4. Driving energy used to advance the cone was 350 ft.-lbs. per blow.

All boreholes were surveyed in the field by personnel from London Region Engineering Survey Section. The location and elevations of the borings are shown on Drawing No. 71-11072A, which accompanies this report.

All samples were visually examined and classified at the site as well as in the laboratory. Following this inspection, laboratory tests were carried out on selected samples to determine the following physical properties.

Atterberg Limits

Moisture Content

Grain-Size Distribution

The results of the field and laboratory tests are summarized on the Record of Borehole sheets contained in the Appendix of this report.

4. SUBSOIL CONDITIONS:

4.1) General:

Generally, uniform subsoil conditions were found to prevail over the area investigated. The subsoil consists of a 7 to 9 ft. thick sandy silt to silty sand deposit followed by a heterogeneous mixture of clayey silt and sand with traces of gravel.

The boundaries between various soil types are shown on the Record of Borehole sheets. The estimated stratigraphical profile shown on Drawing No. 71-11072A is based upon this information.

A detailed description of soil types and soil properties is given, as follows:

4.2) Sandy Silt to Silty Sand:

This material was found in all boreholes from ground surface downward to depths of 7.0 to 9.0 ft.

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

4.2) Sandy Silt to Silty Sand:

The material consists of sandy silt to silty sand with small amounts of clay and gravel. In Borehole 2 considerably more gravel was found in one sample. The relative density of the layer varies from very loose to very dense, but in general is loose.

Grain size analyses indicate the following distributions, (except Sample No. 3 in B.H. 2), and are plotted on Figure 1.

Gravel	0 - 2 %
Sand	19 - 6 %
Silt	30 - 71 %
Clay	7 - 15 %

4.3) Heterogeneous Mixture of Clayey Silt and Sand, Traces of Gravel (Glacial Till):

This was the predominant soil deposit, and was encountered in all boreholes. All boreholes were terminated in this stratum. The deepest borehole was 44.0.

The material, in general, consists of a heterogeneous mixture of clayey silt and sand with traces of gravel. These were occasional seams of silt and/or fine sand up to 6 inches in thickness. In general, the percentage of sand and silt content is higher below elevation 660.

The consistency of the material is hard. It was not possible to push Shelby Tube through the material, indicating that the undrained shear strength was well in excess of 2,000 p.s.f. Below elevation 660 the blows on the split spoon sampler were, in general, more than 100 per ft., and often more than 100 blows for 6 inches penetration.

Grain size analyses indicate the following distributions, and are plotted on Figure 2.

Gravel	1 - 12 %
Sand	14 - 51 %
Silt	33 - 56 %
Clay	10 - 35 %

Physical properties of the material, as determined from laboratory tests are as follows (See Figure 3):

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

4.3) Heterogeneous Mixture of Clayey Silt and Sand,
Traces of Gravel (Glacial Till): (cont'd) ...

		<u>Min.</u>	<u>Max.</u>	<u>Average</u>
Liquid Limit	(%)	13	30	23
Plastic Limit	(%)	10	15	13
Natural Moisture Content	(%)	7	15	11

5. GROUNDWATER CONDITIONS:

The following water levels were observed in the boreholes at the time of investigation.

Borehole 1 Elev. 673.7 ft.
Borehole 2 Elev. 673.0 ft.
Borehole 5 Elev. 673.0 ft.
Borehole 6 Elev. 673.4 ft.

No water levels were established in Boreholes 3, 4, 7 and 8.

The water level in the creek was 673.0. Thus the general ground water level was the same or slightly higher than the prevailing water level in the creek.

6. DISCUSSION AND RECOMMENDATIONS:

6.1) General:

It is proposed to construct a three-span (76'-85'-81') twin structure to carry St. Thomas Expressway over Kettle Creek. The prevailing ground level is at approximate elevation 680, and the proposed grade of the St. Thomas Expressway at this location will be between elevations 720 and 726 ft. This will require fills up to 46 ft. in height. Also it is proposed to construct a creek diversion. This will require a cut approximately 10 ft. deep. Thus the maximum approach heights will be 50 ft. at the east abutment and 56 ft. at the west abutment.

In general, the subsoil at the site consists of a deposit of a hard, heterogeneous mixture of clayey silt and sand with traces of gravel (glacial till), underlying 7 to 9 ft. of loose sandy silt to silty sand with traces of clay.

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

6.2) Foundations:

a) Spread Footings in Original Ground:

As described earlier, the shear strength of the subsoil is, in general, greater than 2,000 p.s.f. Therefore, it is recommended that the entire structure be supported on spread footings placed at or below elevation 670.0. A safe net pressure of 3.0 tons/sq. ft. may be assumed for design purposes. The exact depth will be dependent on hydrological requirements.

b) Steel H-Piles:

As an alternative, the entire structure or part of the structure may be supported on steel H-Piles driven to refusal in the glacial till stratum. It is estimated that refusal will be met at approximate elevation of 650. For design purposes the maximum allowable design load may be assumed for the particular section used.

It is estimated that the following maximum settlements will occur in the subsoil at various locations over a long period of time following the end of construction.

Pier	-	Spread footings in original ground	1.0 inch
Abutment	-	Spread footings in original ground	2.0 inches

Regardless of which of the above methods is adopted, the structure should be built to accommodate the possible 2 inches differential settlements between the abutments and the piers.

All foundations and pile caps should be protected against frost action by at least 4 ft. of earth cover.

6.3) Approach Embankments:

The shear strength of the subsoil is such that it will be able to safely support the 56 ft. high approach embankments constructed with 2:1 side slopes. The fill should consist of well compacted acceptable material. Care should be taken to ensure that no bouldery fill is placed within the approaches through which piles have to be driven, and it is recommended that this portion of the fill contain no larger grain sizes than 3 inches.

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

6.3) Approach Embankments: (cont'd) ...

It is estimated that maximum settlements of not more than 2 inches will occur beneath the abutment locations. The topsoil and the soft organic material should be removed in accordance with the pertinent Standards within the construction area.

No major dewatering problems are foreseen for the creek diversion or for the footing excavations.

7. MISCELLANEOUS:

The field investigation was carried out during the period of July 30 to August 3, 1971, under the supervision of Mr. A. Prakash, Project Foundation Engineer, who also prepared this report.

Equipment was owned and operated by P.V.K. and Sons Ltd.

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

September, 1971.

APPENDIX I

FOUNDATION SECTION

ORIGINATED BY AP

COMPILED BY AP

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 71-11072

LOCATION 549,582 N; 350,772 E.

ORIGINATED BY AP

W.P. 88-69-08 & 09

BORING DATE August 2, 1971

COMPILED BY AP

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger and Cone

CHECKED BY *AK*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w w_p — w — w_L WATER CONTENT % 10 20 30	BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT 20 40 60 80 100	SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE			
679.2	Ground Level										
0.0	Silty sand to sand & gravel, traces of clay.		1	SS	16						2 61 30 7
			2	SS	16						673.
670.2	Compact to Dense		3	SS	32						43 42 (15)
9.0	Het. mix. of clayey silt and sand, traces of gravel.		4	SS	48	670					3 21 48 28
			5	SS	71						
			6	SS	38						1 16 53 30
	Glacial Till		7	SS	100 1/4"	660					
	Hard		8	SS	100 1/4"						3 40 42 19
648.4			9	SS	100 1/4"	650					
30.8	End of Borehole					640					

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 3

FOUNDATION SECTION

JOB 71-11072 LOCATION 549,493 N; 350,808 E. ORIGINATED BY AP
 W.P. 88-69-08 & 09 BORING DATE August 2, 1971 COMPILED BY AP
 DATUM Geodetic BOREHOLE TYPE Bombardier Flight Auger and Cone CHECKED BY AP

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS						
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100			w_p	w	w_L			
							SHEAR STRENGTH P.S.F.							WATER CONTENT % 10 20 30					
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE													
679.0	Ground Level																		
671.0	Sandy silt to silty sand.		1	SS	5	670													
	2		SS	53															
8.0	Het. mix. of clayey silt and sand, traces of gravel. Glacial Till Hard		3	SS	54	660										1 22 50 27			
			4	SS	55														
			5	SS	62													8 26 45 21	
			6	SS	96 76"														
			7	SS	100 75"		650												2 27 48 23
			8	SS	133 79"														
			9	SS	100 75"														2 27 52 19
			10	SS	100 75"			640											
			638.6																
40.4	End of Borehole																		

FOUNDATION SECTION

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 5

FOUNDATION SECTION

JOB 71-11072 LOCATION 549,654 N; 350,737 E.

ORIGINATED BY AP

W.P. 88-69-08 & 09 BORING DATE July 30, 1971

COMPILED BY AP

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger and Cone

CHECKED BY 


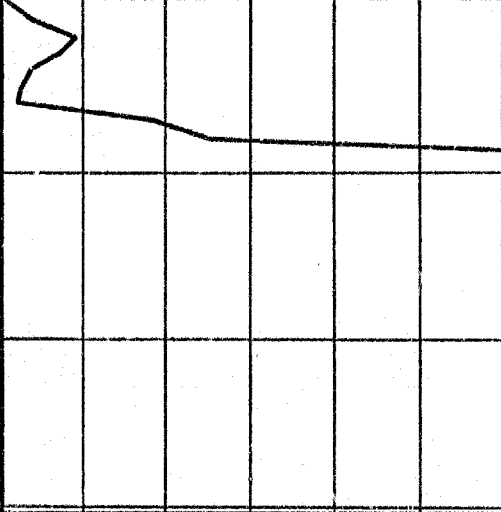
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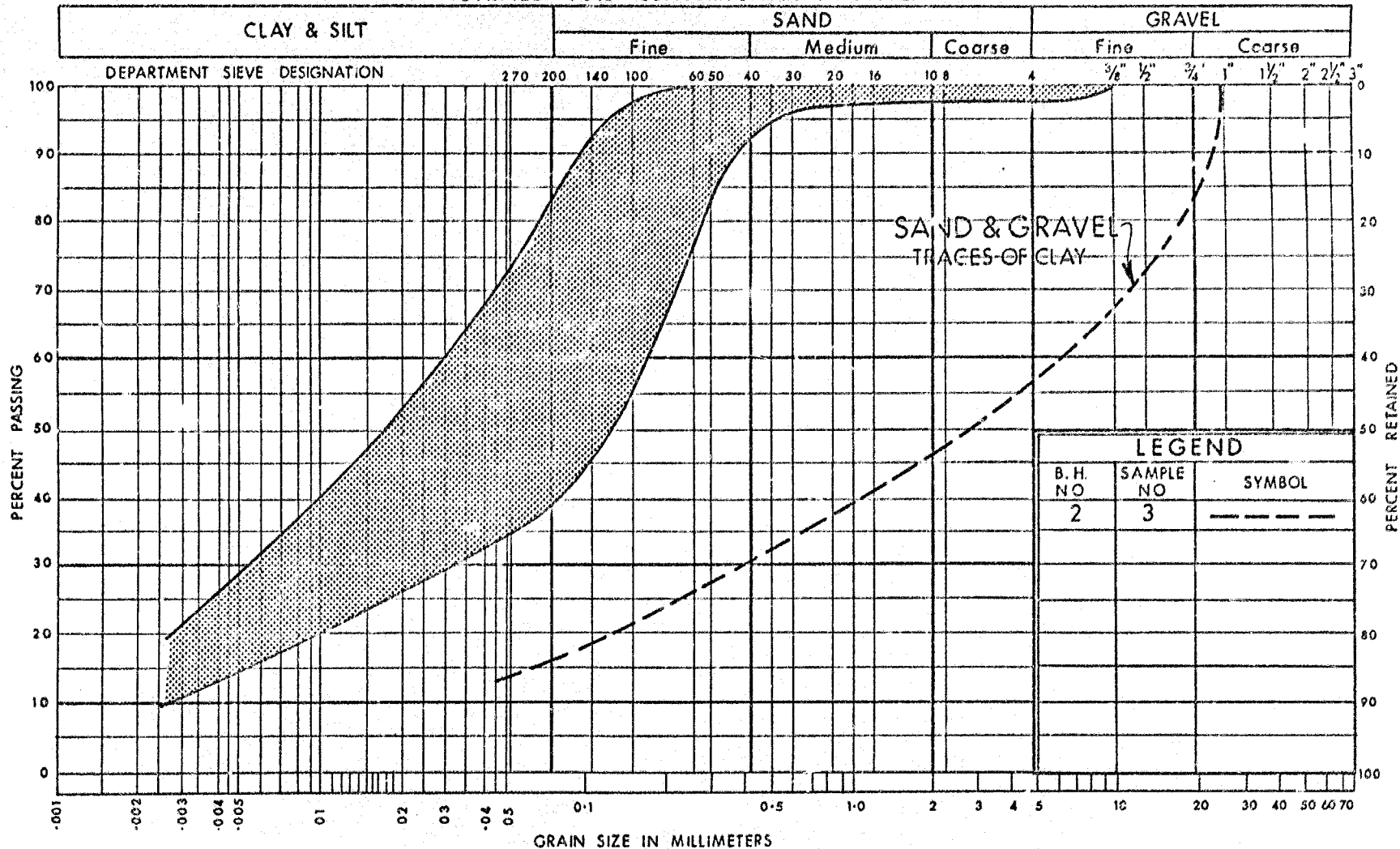
ORIGINATED BY AP

COMPILED BY AP

CHECKED BY *AK*

SOIL PROFILE		STRAT. PLOT	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w		BULK DENSITY γ P.C.F.	REMARKS				
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE		BLOWS / FOOT	20	40	60			80	100	w_p ——— w ——— w_L	
						SHEAR STRENGTH P.S.F.		WATER CONTENT %							
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE									
679.9	Ground level														
0.0	Sandy silt to silty sand, traces of clay.		1	SS	9								0 22 63 15 673.4		
671.9	Loose		2	SS	7										
8.0	Het. mix. of clayey silt and sand, Traces of gravel Glacial Till Hard	3	SS	91	670									5 21 49 25	
		4	SS	117											11 30 41 14
		5	SS	162											
		6	SS	100.5"	660										
		7	SS	100.5"											7 31 44 18
		8	SS	100.6"	650										
649.4															
30.5	End of Borehole														
						640									

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT
OF
TRANSPORTATION AND COMMUNICATIONS



DESIGN SERVICES
BRANCH

GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND
TRACES OF CLAY

W.P. No. 88-69-08 & 09

JOB No. 71-11072

FIG. 1

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

Coarse

Fine

Coarse

DEPARTMENT SIEVE DESIGNATION

270	200	140	100	60	50	40	30	20	16	10	8	4	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3
-----	-----	-----	-----	----	----	----	----	----	----	----	---	---	---------------	---------------	---------------	---	----------------	---	----------------	---

PERCENT PASSING

2000

LEGEND

B. H.
NO

SAMPLE
NO

SYMBOL

GRAIN SIZE IN MILLIMETERS

DEPARTMENT
OF
TRANSPORTATION AND COMMUNICATIONS



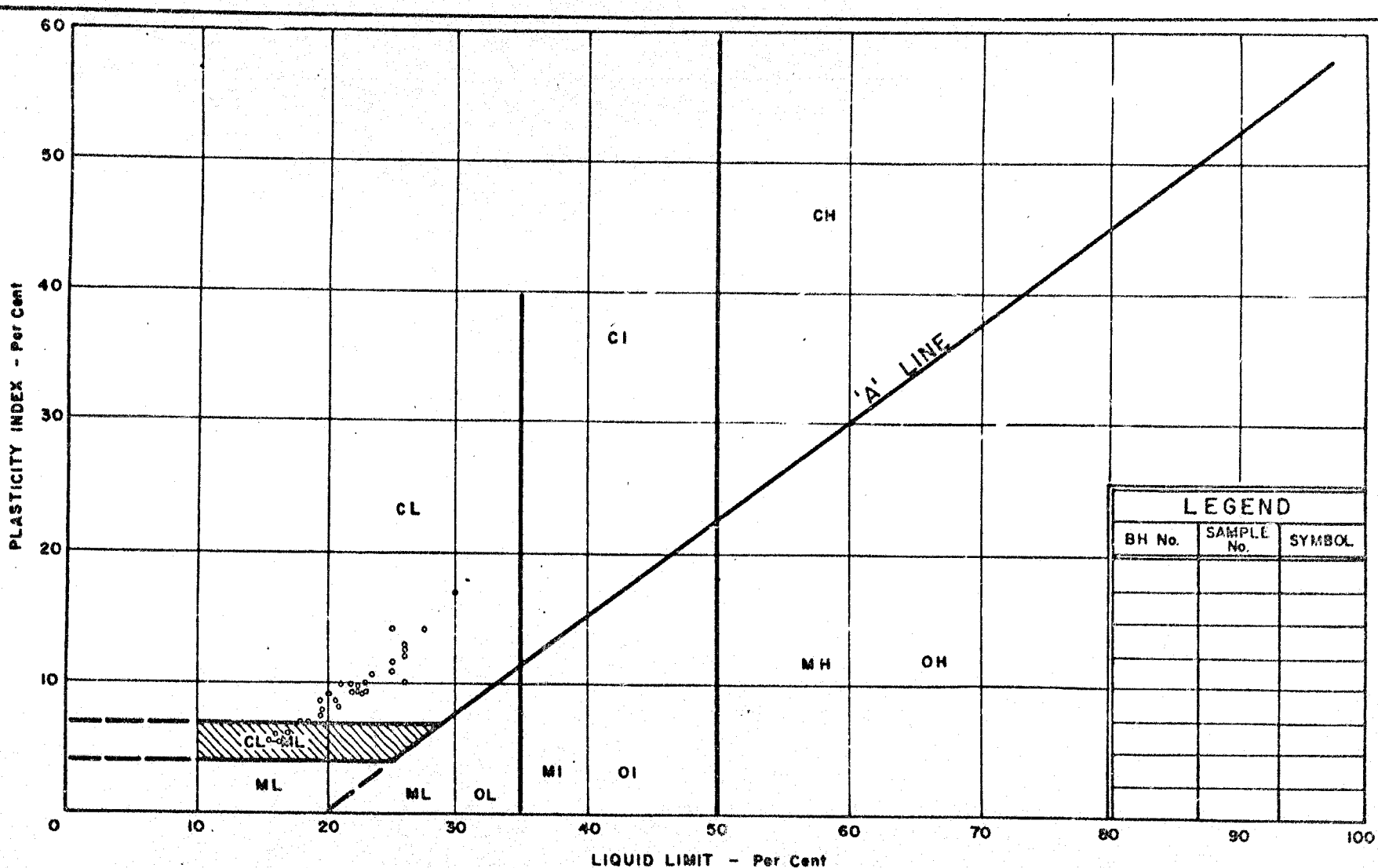
DESIGN SERVICES
BRANCH

GRAIN SIZE DISTRIBUTION
HET. MIXTURE OF CLAYEY SILT & SAND
TRACES OF GRAVEL (GLACIAL TILL)

W.P. No. 88-69-08 & 09

JOB No. 71-11072

FIG. 2



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

PLASTICITY CHART
HET. MIXTURE OF CLAYEY SILT & SAND
- TRACES OF GRAVEL

W.F. No. 38-69-08 & 09

JOB No. 71-11072

FIG. 3

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
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_f	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 VISCOUSITY

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

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.	CESTERBERG 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

Planning
Engineering
Project Management

FENCO

1 Yonge Street
Toronto Canada M5E 1E7
416-361-4722
Cable Foundaneng
Telex 02 2814

September 18, 1973

Mr. A.G. Stermac, P.Eng.
Principal Foundation Engineer
Ministry of Transportation and
Communications
West Building
Downsview, 464 Ontario

Attention Mr. K.G. Selby
Supervising Foundation Engineer

Dear Sirs,

ST. THOMAS EXPRESSWAY
KETTLE CREEK OVERPASS
W.P. 88-69-08/09

This is to confirm to-day's conversation regarding differential settlements for the above structure. There will be no settlement at the abutments since they are supported on H-piles driven to refusal. The piers, on spread footings will settle up to 1 inch (Soil Report).

Consequently we will assume for design purposes we need only consider the differential settlement of the piers settling 1 inch with respect to the abutments.

Yours very truly,
FOUNDATION OF CANADA ENGINEERING
CORPORATION LIMITED

B.T. Phalp

B.T. Phalp P.Eng.
SUPERVISING ENGINEER

BTP/pm
II-3802-7

cc: Mr. J. Keen
M.T.C. Downsview



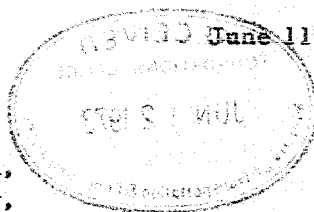
Jan 15/74

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

Copy for the information of Mr. K. Selby, Supervising Foundations Engineer, Downsview.

Mr. D. Baird,
Reg. Right-of-Way Manager,
London Regional Office.

Mr. J. R. Roy,
Manager Engineering Services,
London Regional Office.



Foundation Investigation,
St. Thomas Expressway,
Lots 3 and 4, Con. 9,
Township of Yarmouth,
A. F. Parkins Property

In carrying out the foundation investigation at Kettle Creek access was gained through the A. F. Parkins' property.

Unloading and loading of the boring equipment was carried out adjacent to the Parkins' barn and access to the bridge site was by a farm road from the barn and over a small timber "bridge".

In loading the equipment some damage was done to a grassed area beside the barn. In addition Mrs. Parkins is concerned that the passage of the equipment over the "bridge" may have weakened the "bridge".

Would you please have one of your agents visit Mrs. Parkins Tuesday, June 12th in the afternoon to settle for the damages caused.

If Mrs. Parkins is still concerned about the "bridge" it may be necessary to purchase a few timbers to strengthen it.

J. R. Roy,
Manager Engineering Services,
London Regional Office.

JRR:gp
c.c. K. Selby

Jan 15/74

DOCUMENT NO. _____ DATE OF COLLECTION _____

GEOCRES No. 50714-34

DIST. 2 REGION Southern

W.P. No. 88-69-08/09

CONT. No. 79-20

W. O. No. 73-11020

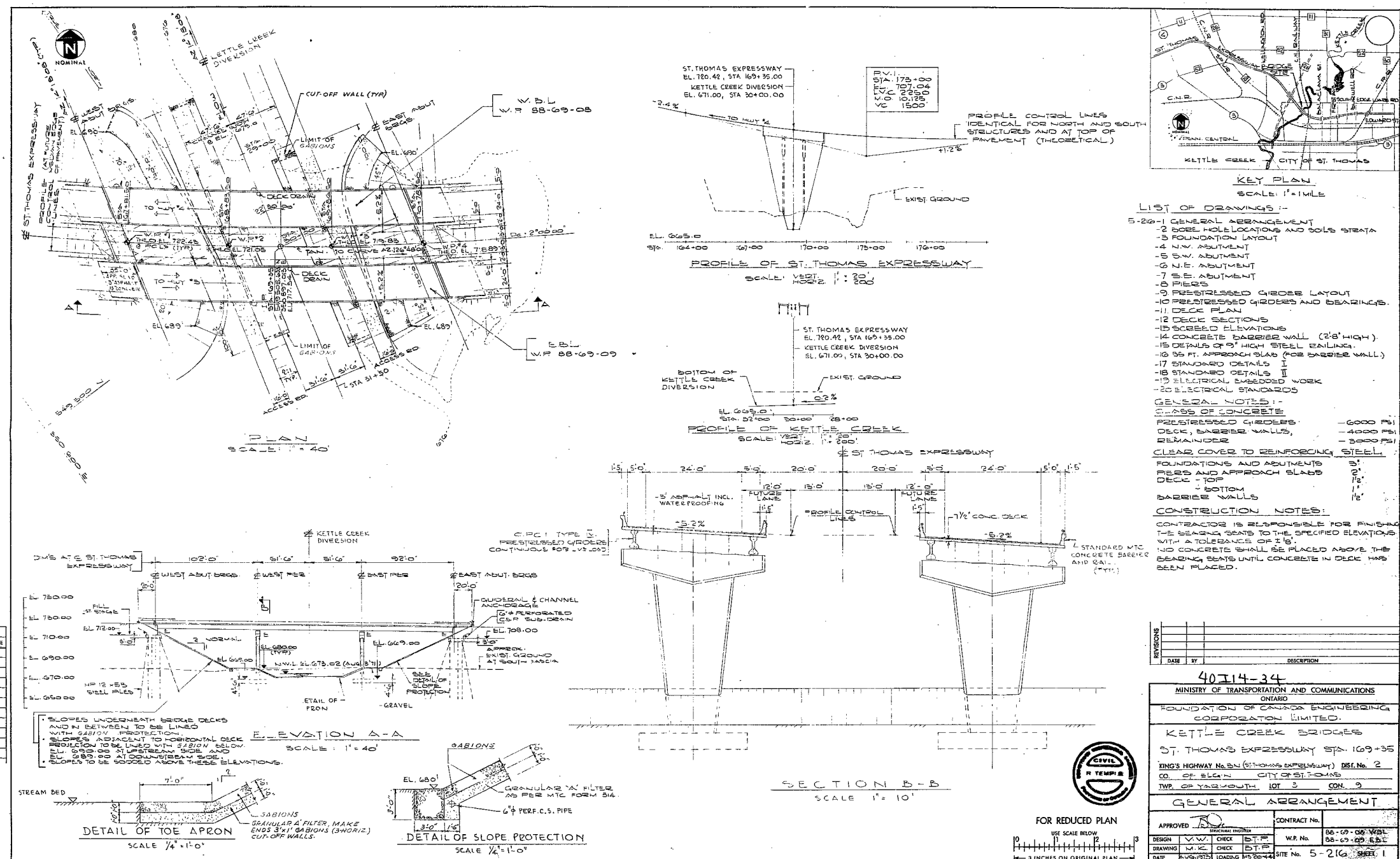
STR. SITE No. 5-216

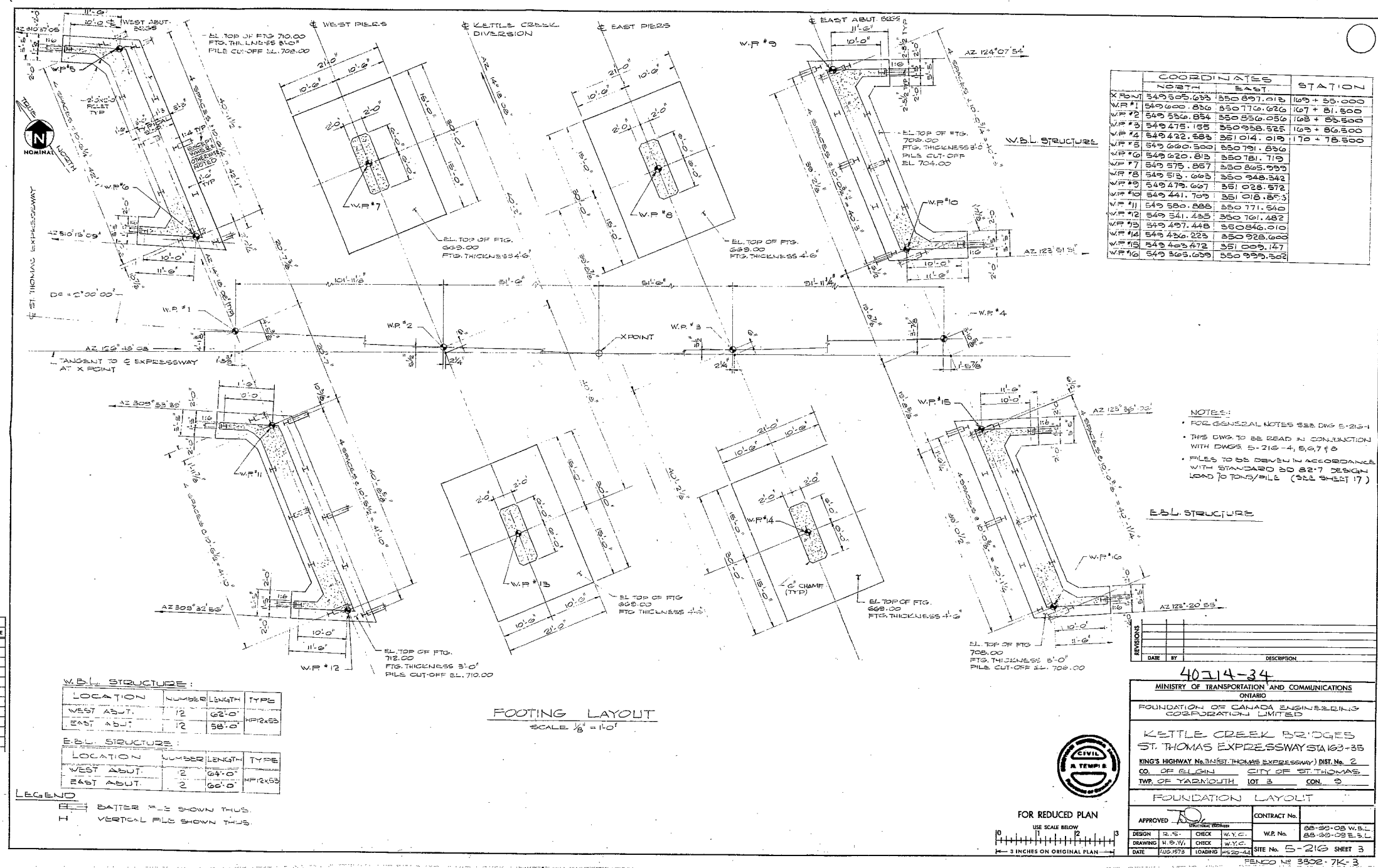
HWY. No. _____

LOCATION Proposed Crossing of
St. Thomas Expressway over
Kettle Creek

OVERSIGHT BOARD NO. _____ POST 4

REMARKS: _____





38-011-REV

