



FOUNDATION TECHNICAL MEMORANDUM

For

**MEDWAY CREEK BRANCH BRIDGE
MTO WEST REGION 59 STRUCTURE REHABILITATIONS
HIGHWAY 4, SITE 19-161, CONTRACT 5
GWP 3062-11-00
GEOGRAPHIC TOWNSHIP OF LONDON
MIDDLESEX COUNTY, ONTARIO**

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FOUNDATION TECHNICAL MEMORANDUM

For

Medway Creek Branch Bridge
MTO West Region 59 Structure Rehabilitations
Highway 4, Site 19-161, Contract 5, GWP 3062-11-00
Geographic Township of London,
Middlesex County, Ontario

1. INTRODUCTION

The Foundation Engineering Services for the present project involve the detail foundation investigation and design for the rehabilitation of 59 structures in MTO West Region along Highways 4, 6, 401, 402 and 403. Ten (10) Group Work Projects (GWP's) are contemplated to be completed between 2014 and 2020.

This technical memorandum summarizes the factual results of geotechnical data based on the review and compilation of existing subsurface information from relevant reports in the MTO GEOCREST Library for the Medway Creek Branch Bridge on Highway 4. The Foundation Engineering recommendations from the initial bridge foundation reports are summarized with reference to the "Canadian Highway Bridge Design Code" (CHBDC) and follow in general the "Guidelines for Professional Engineers providing Geotechnical Engineering Services".

From the Minutes of Meeting Report, dated January 23, 2015, it is understood that rehabilitation of the bridge structure will be completed in two stages with the use of temporary portable signals to maintain one lane of traffic.

The purpose of the Technical Memorandum is to summarize the subsurface and groundwater conditions and foundation recommendations based on available reports at the bridge location for the design project team's reference.

The elevations in this report are expressed in meters, unless otherwise noted.



2. PROJECT SITE BACKGROUND AND GEOLOGY

The Medway Creek Branch Bridge on Highway 4 is located 7.0 km (4.6 miles) south of Highway 7 in the Geographic Township of London, Middlesex County, Ontario. A key plan is shown in Figure 1.

The existing structure is a single span reinforced concrete rigid frame structure that carries two lanes of traffic. The surrounding areas adjacent to the bridge location are generally flat cultivated field lands. The creek flows from west to east at the bridge location.

Physiographically, the site is located in the region known as the Stratford Till Plain. The till in this area is fairly uniform, being a brown calcareous silty clay whether on the ridges or the more level ground moraine. It is a product of the Huron ice lobe. The topography is flat to undulating. The geology of the subsoil is mainly moraine till composed of silty clay and gravel of glacial origin. The Geographic Township of London is underlain by bedrock of the Dundee, a light brown, medium-grained limestone with some chert (Aggregate Resources Inventory of London Township, Middlesex County, Southern Ontario by Ontario Geological Survey, dated 1983).

3. SOURCE OF INFORMATION

The following foundation report and drawing, appended in Appendix A, were available for review and provided information for the bridge structure, subsoil information and original foundation recommendation.

1. Foundation Investigation for Proposed Crossing Highway 4 and Medway Creek, District No. 2. W.J 59-F-10, W.P. 149-59. Materials and Research Division (Foundation Section), Department of Highways Ontario, dated February, 27, 1962. GEOCRES 40P03-004. (Reference 1)
2. General Arrangement Drawing, Medway Creek Bridge, 4.6 miles south of Highway No. 7, Dist. No. 2, Lot 16 and 17, Con. XI, Township London, Middlesex County, W.P 149-59, Site 19-161, TWP. 93-161-1-B, Department of Highways Ontario, Bridge Division, dated March 1962.(Reference 2)



4. SITE RECONNAISSANCE

As part of the current foundation engineering assessment study, site reconnaissance of the Medway Creek Branch Bridge was carried out on July 24, 2014. A photographic record of the site visit is attached in Appendix B.

The north and south abutment walls had no obvious cracks except for minor surface cracks (Photographs 1 and 4). The weep holes in the abutment walls were open and wet, indicating that they are functioning satisfactorily. Rip-rap protection was observed on the east slope adjacent to the north abutment to prevent further erosion of the slope surface (Photograph 2). The west slope face adjacent to the north abutment was vegetated. However, previous construction debris was dumped on the slope face (Photograph 3). The slopes adjacent to the south abutment were generally vegetated with rip-rap protection placed on areas of the slope faces and toes to prevent further erosion and scour of the earth soil material (Photographs 5 and 6).

At the time of the site reconnaissance the depth of water in the creek was about 0.5 m.

5. PREVIOUS FOUNDATION INVESTIGATION AND SUBSURFACE CONDITIONS

The site is located on Highway 4 crossing a branch at the Medway Creek, about 14.5 km north of London, Ontario. The general subsurface conditions presented in this section are based on the Foundation Investigation Report, GEOCRE 40P03-004, dated February 27, 1962 (Reference 1).

The purpose of the previous investigation was to replace an existing structure with a new bridge. The centreline of the existing bridge was proposed to be realigned about 1.5 m (5 ft.) to the west for the new replacement bridge at the site location.

The Foundation Report includes the borehole location plan (Drawing No. F59-10A), Record of Borehole sheets (1 and 2), and Summary of the Field and Laboratory test.



The field investigation was carried out between February 28 and March 3, 1959. Boreholes 1 and 2 were advanced to depth of 7.9 and 8.1 m, elevation 273.3 (896.5 ft.), respectively. The field investigation for the Medway Creek Branch Bridge included two sampled boreholes (1 and 2) and a total of two dynamic cone penetration tests (DCPTs) that were conducted directly adjacent to the location of the two boreholes. The DCPTs were driven adjacent to boreholes 1 and 2 to practical refusal to depths of 7.9 and 8.1 m, elevation 273.3 (896.5 ft.), respectively.

The holes were driven by drilling BX casing and the soil samples were recovered at 1.5 m intervals. Sampling was done by a 50 mm (2 in.) O.D split-barrelled spoon sampler. The dimensions of the sampler and the energy used in driving it conform to the requirements of the Standard Penetration Test at the time of the investigation.

Generally, the subsoil encountered at the site was gravelly, sandy, clayey silt of glacial origin.

Sandy clay

A 0.9 m surficial compact sandy clay layer was encountered in borehole 2 and extended to elevation 280.4 (920 ft.). One N value of 21 was recorded for this surficial layer.

Silty clay

A 1.6 m surficial hard silty clay layer was encountered in borehole 1 and extended to elevation 279.5 (917 ft.). One N value of 34 was recorded for this surficial layer.

Gravelly Clayey Silt Till

A deposit of hard (sandy to silty) clayey silt till was encountered below the surficial silty clay and sandy clay at 1.6 and 0.9 m, elevation 279.5 and 280.4 (917 and 920 ft.), in boreholes 1 and 2, respectively, and extended to borehole termination depths 7.9 and 8.1 m, elevation 273.3 (896.5 ft.). The upper 1.5 m (5 ft.) was oxidized and brown in colour. The rest was grey. N values ranged from 32 to 89.



Two laboratory shear strengths obtained for clayey silt till were 194.4 and 263.3 kPa (4060 and 5500 psf). Two Atterberg liquid limits obtained were 17.6 and 26.2. Four Atterberg plastic limits obtained were between 11.0 and 14.3 for the till samples. Further, two unit weights of the till samples obtained were 22.6 and 23.5 kN/m³ (144.0 and 149.3 pcf). Moisture content determinations ranged from 6.9 to 15.9%.

Groundwater

Groundwater was observed during the site investigation at 0.3 m below the ground surface at elevation 280.9 and 280.7 (921.5 and 921.0 ft.) in boreholes 1 and 2, respectively. The creek water level was at 280.9 (921.5 ft.) at the time of investigation; it was assumed that the ground water level was the same as the creek water level.

6. FOUNDATION

6.1 Previous Foundation Discussions and Recommendations

The foundation report recommended that the dense glacial till subsoil was suitable for supporting the proposed structure on spread footings. It was understood that hydrogeological requirement would be satisfied if the footings were placed at elevation 278.3 (913 ft.) or below. A safe bearing pressure of 287.3 kPa (3 tsf) was proposed. It was anticipated, due to relative impermeability of the subsoil, that dewatering of the excavations would present no special considerations.

Further, no to little differential settlement was anticipated at the site location and hence, use of rigid frame type structure was suggested.

It was anticipated that no stability problem would occur at the proposed approach fill embankments.



Based on the General Arrangement Drawing (Reference 2), the proposed bridge was to be constructed as a single span rigid frame structure. The abutments were to be founded on spread footings at elevation 278.3 (913 ft.). It seems the approach embankments were to be raised about 3.8 to 4.1 m (12.6 to 13.6 ft.) from the original ground surface level. On the slope faces, 0.3 to 0.6 m (1 to 2 ft.) thick handlaid random rip-rap was to be placed to protect against erosion. The slopes were to be cut back at 1.5H:1V.

6.2 Assessment of Foundation Parameters

Based on the previous investigation and subsurface conditions encountered, the following table summarizes the foundation design parameters that were recommended in the previous report and the updated geotechnical reaction at SLS and factored geotechnical resistance at ULS are provided.

FOUNDATION DESIGN PARAMETERS

Foundation and Type	Elevation of Footings (m)	Previous Safe Bearing Resistance (tsf) ¹	Previous Equivalent Limit State Design Values		Limit State Design Values Updated to current industry practices ²	
			SLS Geotechnical Reaction (kPa)	Factored ULS Geotechnical Resistance (kPa)	SLS Geotechnical Reaction (kPa)	Factored ULS Geotechnical Resistance (kPa)
East Abutment on Spread Footing	278.3 (913 ft.)	3.0	287	430	400	600
West Abutment on Spread Footing						

- Notes:**
1. Working stress design values. The Ultimate Limit State design values are based on the working stress. No field verifications were made.
 2. Resistance Factor = 0.5 for shallow foundation (CFEM 4th edition)
Assumed Factor of Safety is 3 (CFEM 4th edition)



The seismic site coefficient for the conditions at this site is 1.0 (soil profile Type 1, Canadian Highway Bridge Design Code (CHBDC) 2006 Edition, clause 4.4.6). The bearing resistance for inclined loads should be reduced in accordance with the requirements of clause 6.7.4 of the CHBDC. The foundation frost penetration depth at the site is 1.2 m according to OPSD 3090.101.

7. DISCUSSION

From a geotechnical point of view, at the present time, foundation work for the Medway Creek Branch Bridge structure is not expected provided that the total dead load on the bridge does not increase or decrease by more than 10%.

It is understood that rehabilitation of the Medway Creek Branch Bridge structure is anticipated and that rehabilitation will be completed in two stages with the use of temporary signals to maintain one lane of traffic.

Further, it is suggested that the weep holes out of the abutment walls should be maintained and cleaned at a regular basis to prevent any clogging of the holes. Regular maintenance of the weep holes will keep the water flowing from behind the abutment walls and will mitigate hydrostatic pressure to build-up behind the abutment walls.



8. CLOSURE

This technical memorandum was prepared by Mr. Nazibur Rahman, P.Eng with the assistance of Mr. Mansoor Khorsand, EIT and was reviewed by Mr. Robert Ng, PhD, P.Eng., Senior Project Engineer. Mr. Brian R. Gray, MEng, P.Eng., MTO Designated Principal Contact conducted an independent review of the report.

We trust this memo is sufficient for your immediate needs. Please, do not hesitate to contact us if you have any inquiries and/or comments. Yours very truly,

Yours truly,

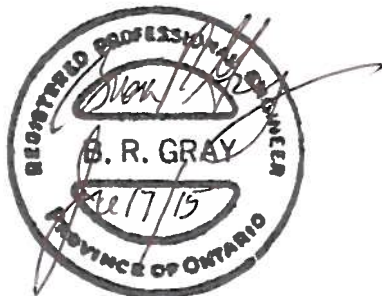
Peto MacCallum Ltd.



Nazibur Rahman, P.Eng.
Project Engineer, Geotechnical Services



Robert Ng, MBA, PhD, P.Eng.
Senior Project Engineer



Brian R. Gray, MEng, P.Eng.
MTO Designated Principal Contact

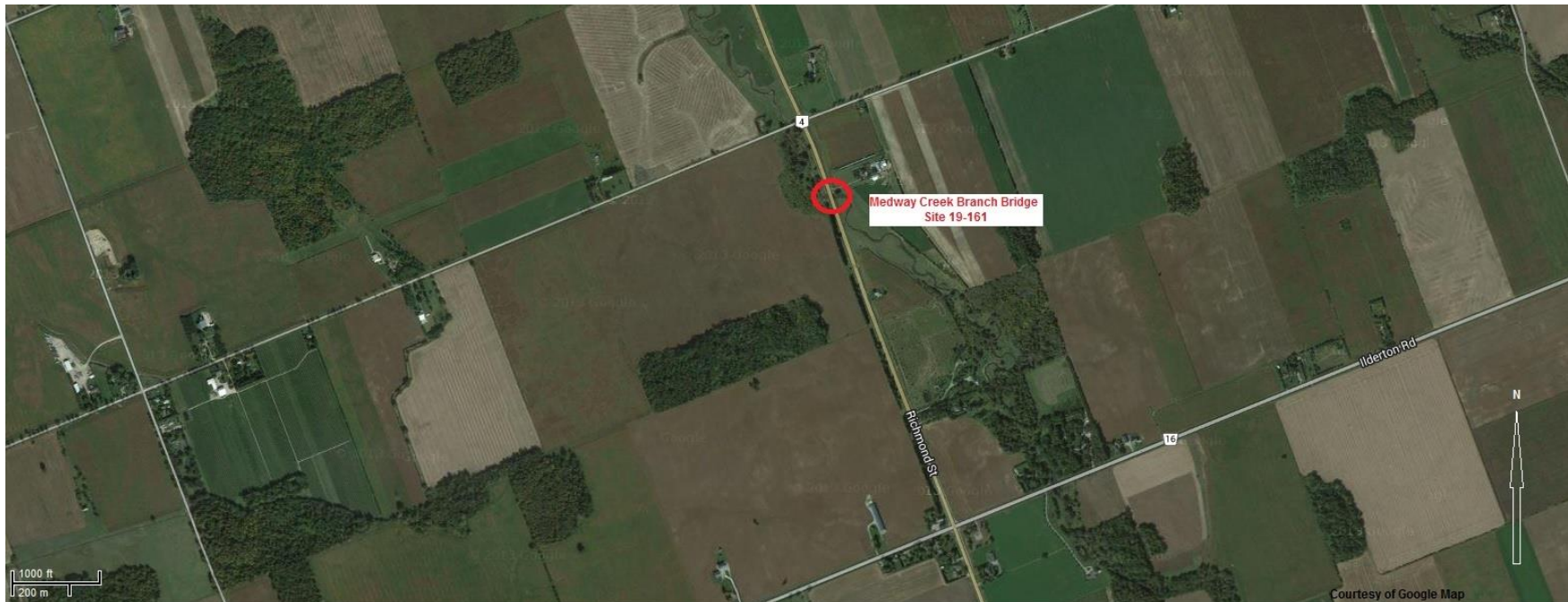


TABLE 1

LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSD 3090.101	Foundation Frost Depth for Southern Ontario

Figure 1 – Key Plan

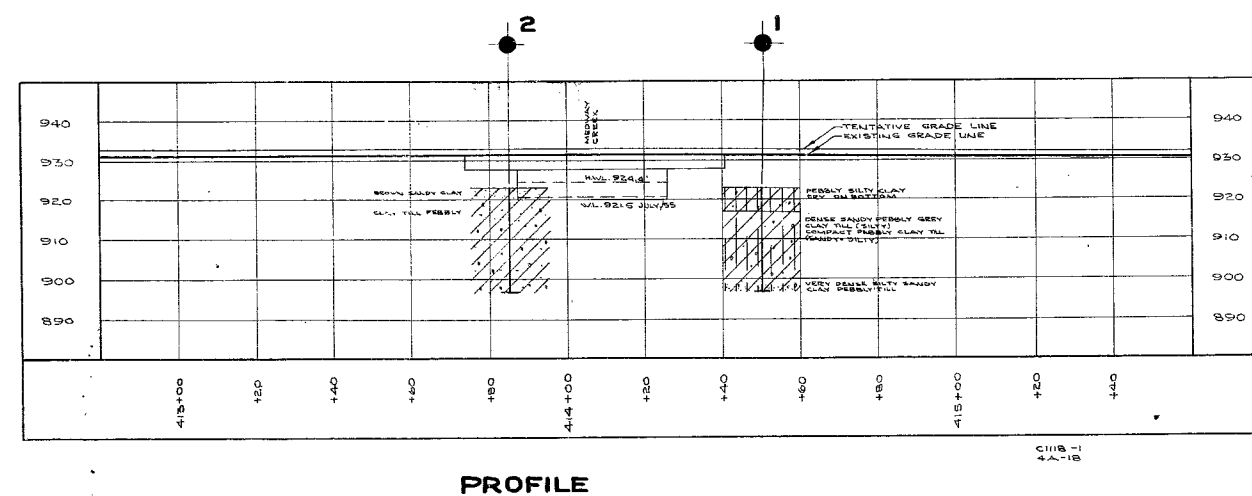
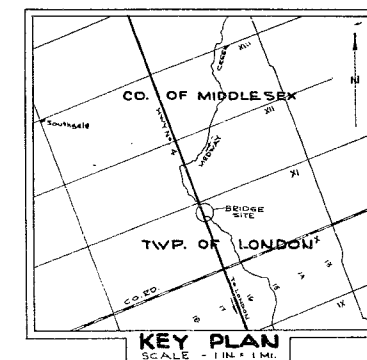
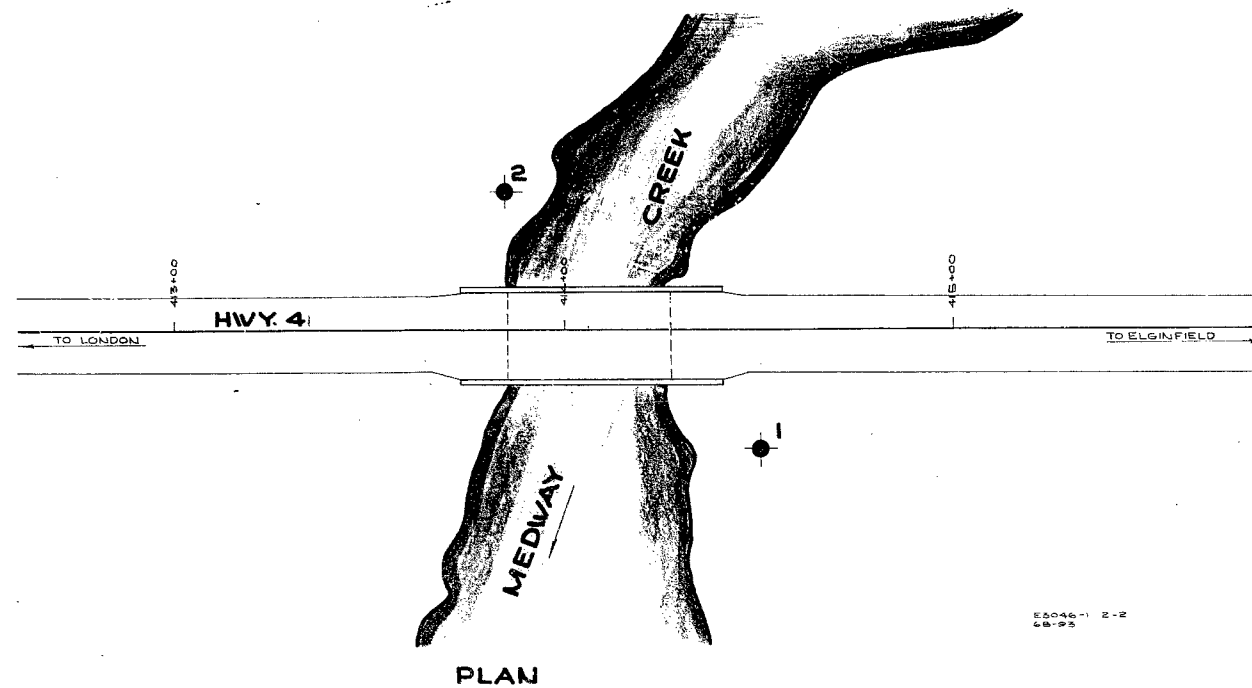




APPENDIX A

Foundation Investigation Report (GEOCRES 40P03-004)
General Arrangement, Medway Creek Bridge (Dated March, 1962)

59-F-10
W.P.# 149-59
Hwy. # 4
PROP. CROSSING
MEDWAY CREEK
4.6 MILES S. OF
Hwy. # 7



LEGEND			
BORE HOLE			
PENETRATION HOLE			
BORE & PENETRATION HOLE			
HOLE NO.	ELEVATION	STATION	DISTANCE FROM E.
1	922.5'	414+50	30 FT.
2	923.0'	413+85	35 FT.

NOTE -
THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BORE HOLE LOCATIONS. BETWEEN BORE HOLES THE BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE AND MAY BE SUBJECT TO CONSIDERABLE ERROR.

DEPARTMENT OF HIGHWAYS - ONTARIO			
MATERIALS & RESEARCH SECTION			
MEDWAY CREEK PROPOSED CROSSING			
SHOWING POSITIONS & ELEVATIONS OF HOLES			
HWY 4	DISTRICT 2	COUNTY MIDDLESEX	
TOWNSHIP LONDON	LOT 16	CON. XI	
LOCATION APP. 9 MI. N. OF LONDON			
DRAWN BY: T. MELLOR'S	CHECKED BY:	W.P. 149-59	
DATE: 1 JUNE 59	APPROVED BY:	DRAWING NO.	
SCALE: 1 IN. = 20 FT.		F59-10A	

Mr. A. M. Toye,
Bridge Engineer.
Materials & Research Division,
(Foundation Section).

December 29, 1961.

D.H.O. PRELIMINARY FOUNDATION
INVESTIGATION REPORT -
W.J. 59-F-10 -- W.P. 149-59.

Attention: Mr. S. McCombie.

Re: Proposed Crossing -
Hwy. #4 and Medway Creek,
District #2.

It is proposed to construct a new bridge at the location indicated above, to replace an existing structure. This involves a shift in Centre Line some 5 ft. to the west.

A field investigation was carried out in 1959 by this Section, to determine the subsoil conditions existing at the site.

The results of this investigation and subsequent laboratory tests, together with recommendations pertaining to the foundations for the proposed structure, are summarized as follows:-

SUBSOIL:

Subsoil at the site consists of a very dense heterogeneous mixture of clay silt sand and gravel of glacial origin. For de-watering considerations, this material may be assumed to be relatively impermeable. Ground water level may be assumed to be at creek level.

cont'd. /2 ...

FOOTINGS:

The depth of the footings is governed by hydrological requirements. It is understood that elev. 913.00 is the minimum depth necessary to fulfill these. At this elevation, a design load of 3 tons per sq. ft. may be used. Dewatering of excavations should present no major problems. If sheeting is used for scour protection, it may be incorporated in a dewatering scheme.

Little or no differential settlement is anticipated; hence, the new bridge may be any type of rigid frame structure.

APPROACHES:

No problems are anticipated with regard to the stability of the proposed approach embankments.

A complete report will follow
at a later date.

A. G. Stermac,
PRINCIPAL FOUNDATION ENGR.
Per:

K. G. Selby

(K. G. Selby,
SR. PROJECT FOUNDATION ENGR.)

KGS/MdeF

cc: Messrs. A. M. Toye (2) ✓
H. A. Tregaskes
H. D. McMillan
A. Gater
W. L. Fraser
J. Roy
T. J. Kovich
J. E. Gruspier
E. R. Saint
F. Norman
Foundations Office
Gen. Files.



DEPARTMENT OF HIGHWAYS

Bridge Division.

Memo to	Mr. B. Davis,	Date	March 12, 1962.
	Bridge Design Engineer,		
	Administration Building,	Subject	W.P. 149-59
	DOWNSVIEW, Ontario.		Medway Creek Bridge
From	G. Scott		Hwy. #4 4.6 mi. S. of
			Hwy. #7 - District #2

Attached herewith, please find the soil report
BA1326A for the above project.

This project is now under design based on a
Preliminary Soil Report BA1326. It would appear
that the original information is confirmed, however,
we would ask that the designer verify this.

Gavin Scott

GS/ea
cc. S. McCombie
C. Grebski

G. Scott,
Bridge Location Engineer.



ONTARIO
DEPARTMENT OF HIGHWAYS

Memo to Mr. A. M. Toye, **Date** February 27, 1962.
Bridge Engineer. **Subject** D.H.O. FOUNDATION INVESTIGATION
From Materials and Research Division, W.J. 59-F-10 -- W.P. 149-59.
(Foundation Section)
Attention: Mr. S. McCombie.

Re: Proposed Crossing -
Hwy. #4 and Medway Creek,
District #2.

Attached, we are forwarding to you, our detailed report on the subsoil conditions existing at the above structure site. A preliminary foundation report for this project was prepared December 29, 1961.

We believe the factual data and recommendations contained therein, should prove adequate for your future design work. If further assistance is required in connection with this project, please do not hesitate to contact our Office.

AGS/MdeF
Attach.

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

cc: Messrs. A. M. Toye (2) ✓
H. A. Tregaskes
H. D. McMillan
A. Gater
W. L. Fraser
J. Roy
T. J. Kovich
J. E. Gruspier
E. R. Saint
F. Norman
A. Watt
Foundations Office -- Gen. Files.

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-

FOUNDATION INVESTIGATION

For

Proposed Crossing
Hwy. #4 and Medway Creek,
District #2.

W.J. 59-F-10 -- W.P. 149-59

1. INTRODUCTION:

A field investigation was carried out to determine the subsoil conditions at this site. The results of this investigation and laboratory test results, together with recommendations for foundations for the proposed structure, are presented in this report.

A preliminary foundation report for this project was prepared during December 1961.

2. DESCRIPTION OF SITE AND GEOLOGY:

The site is located at Hwy. No. 4 crossing Medway Creek, about 9 miles north of the City of London.

This site is located within the physiographic region referred to as "Stratford Till Plain".

The topography is flat to undulating. The geology of the subsoil is mainly moraine till composed of silty clay and gravel of glacial origin.

3. FIELD AND LABORATORY WORK:

The investigations at the site were carried out by means of a core drill machine adapted for soil sampling.

cont'd. /2 ...

3. FIELD AND LABORATORY WORK: (cont'd.) ...

Due to the difficulty of access to the site, only two boreholes were made; one hole near opposite corners of the existing two abutments.

The holes were driven by drilling BX casing, and at 5-ft. intervals, soil samples were taken.

Sampling was done by a 2" O.D. split-barrelled spoon sampler. The dimensions of this sampler and the energy used in driving it, conform to the requirements of the Standard Penetration Test.

The split spoon samples were visually examined in the field and representative samples were brought to the laboratory for further tests.

The logs of the boreholes and their respective locations are shown on Drawing #59-F-10A, attached under Appendix I.

4. SOIL TYPES ENCOUNTERED:

4.1) General:

The subsoil encountered at the site is mainly, gravelly sandy, clayey silt of glacial origin. The holes were driven down about 30 ft. in the same layer and stopped.

4.2) Dense, Gravelly Clayey Silt:

The 30 ft. of the investigated subsoil is made up of gravelly clayey silt material. The upper 5 ft. is oxidized and brown in colour, the rest is grey.

4. SOIL TYPES ENCOUNTERED: (cont'd.) ...

4.2) Dense, Gravelly Clayey Silt: (cont'd.) ...

The measured average liquid limit (22%) and Plasticity Index (10%) indicate the material is clayey silt of low plasticity.

The matrix is mainly clayey silt, and the range of 'N' values 30 - 80 blows per foot, indicate that the layer is in a dense to very dense state.

5. GROUND WATER:

The ground water level may be assumed to be the same as the creek water level, which was 921.5 ft. at the time of the investigation.

6. DISCUSSION AND RECOMMENDATIONS:

The dense till subsoil is suitable for supporting the proposed structure on spread footings. From information received from the Bridge Office, it is understood that hydrological requirements will be satisfied if the footings are placed at elevation 913 ft. or below. At this elevation, a design load of 3 t.s.f. may be used.

Because of the relative impermeability of the subsoil, dewatering of the excavations should present no special problems.

At this site, no differential settlements are anticipated and hence, a rigid frame type structure may be used.

The proposed approach fill embankments will not present any stability problem.

cont'd. /4 ...

7. SUMMARY:

The subsoil consists of very dense sandy, gravelly clayey silt of glacial origin.

The proposed structure of rigid frame type, if desired, can be supported on spread footings with a safe bearing value of 3 t.s.f.

To satisfy the hydrological requirements, the footings should be placed at elevation 913 ft. or below.

Dewatering of the excavations should present no special problems at this location.

Approach fill embankments do not present any stability problem.

8. MISCELLANEOUS:

The field work started on Feb. 28/59 and was completed on March 5/59. The field work was supervised by Mr. V. Korlu of this Section. All laboratory testing was done by the D.H.O. Materials and Research Laboratories.

February 1962

REPORT PREPARED BY:

V. Korlu
.....
V. Korlu,
PROJECT FOUNDATION ENGR.

REPORT APPROVED BY:

K. G. Selby
.....
K. G. Selby,
SR. PROJECT FOUNDATION ENGR.

APPENDIX I.

SUMMARY OF FIELD & LABORATORY TESTS

JOB F-59-10

W.P. 149-59

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

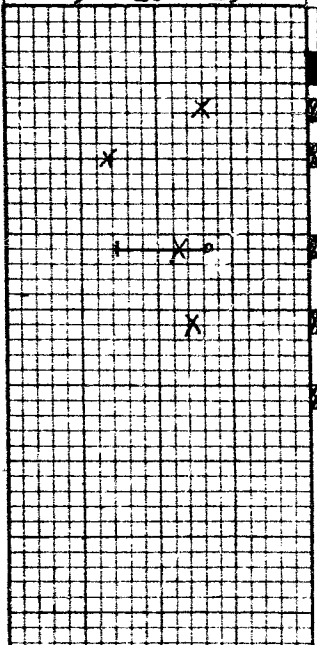
W.P. 149-59 BORE HOLE NO. 1
 JOB F-59-10 STATION 414/50 (30' R.)
 DATUM Geodetic COMPILED BY _____
 BORING DATE Feb. 28/59 CHECKED BY V.K.

2" DIA. SPLIT TUBE _____
 2" SHELBY TUBE _____
 2" SPLIT TUBE _____
 2" DIA. CONE _____
 2" SHELBY _____
 CASING _____

LEGEND

1/2 UNCONFINED COMPRESSION (Q_u) _____ O
 VANE TEST (C) AND SENSITIVITY (S) _____ +
 NATURAL MOISTURE AND LIQUIDITY INDEX _____ LI
 LIQUID LIMIT _____ X
 PLASTIC LIMIT _____

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE	
				P.S.F.	
	Groundlevel	922.5	0	50 100	
	Pebbly silty clay Dry on bottom	921.5	1		
		917.0	5		
	Dense sandy pebbly grey clay till (silty)		10		
	Compact pebbly clay till (sandy-silty)		15		
	Very dense silty sandy clay pebbly till	896.5	25		
	End of borehole		30		

CONSISTENCY		SAMPLE	NATURAL UNIT WT. P.C.F.
MOIST. CONTENT - % DRY WT.			
5	10	15	
			
		TW1	
		SS2	
		SS3	
		SS4	144.0
		SS5	
		SS6	

DEPARTMENT OF HIGHWAYS - ONTARIO

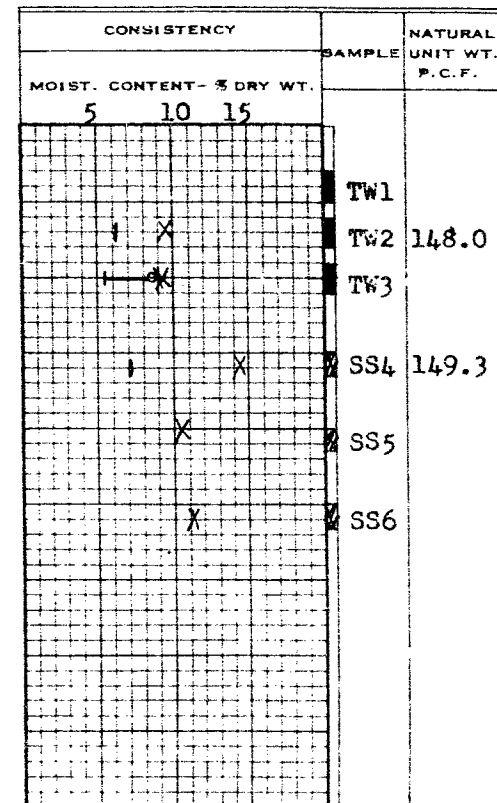
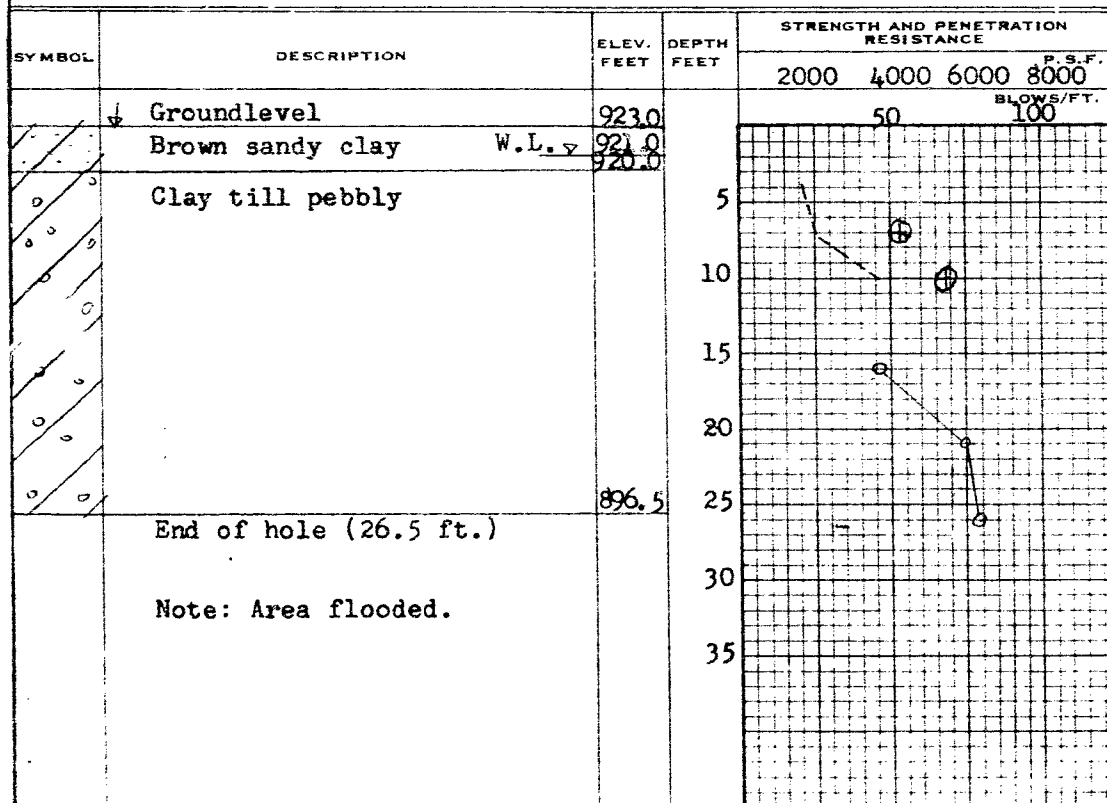
MATERIALS AND RESEARCH SECTION

W.P. 149-59 BORE HOLE NO. 2JOB E-59-10 STATION 413+85 (35' Lt.)DATUM Geodetic COMPILED BY _____BORING DATE Mar. 3/59 CHECKED BY V.K.

2" DIA. SPLIT TUBE _____
 2" SHELBY TUBE _____
 2" SPLIT TUBE _____
 2" DIA. CONE _____
 2" SHELBY _____
 CASING _____

LEGEND

1/2 UNCONFINED COMPRESSION (Q_u) _____
 VANE TEST (G) AND SENSITIVITY (S) _____
 NATURAL MOISTURE AND LIQUIDITY INDEX _____
 LIQUID LIMIT _____
 PLASTIC LIMIT _____





APPENDIX B

Site Photographs



Photograph 1: Looking north at the north abutment. No obvious cracks were observed on abutment wall except some surficial cracks. Weep holes observed in the abutment wall were open and wet. (July 24, 2014)



Photograph 2: Looking north at the east slope adjacent to the north abutment. Rip-rap protection was observed on the slope face to prevent further erosion of the exposed earth. (July 24, 2014)



Photograph 3: Looking north at the west slope adjacent to the north abutment. The slope face was vegetated. However, previous construction debris was observed on the slope face. (July 24, 2014)



Photograph 4: Looking at the south abutment from the northeast corner of the bridge. No obvious cracks were observed on the abutment wall, except some surficial cracks. Weep holes in the abutment wall were open and wet. (July 24, 2014)



Photograph 5: Looking south at the east slope adjacent to the south abutment. The slope face was vegetated. Rip-rap was observed at the toe of the slope. (July 24, 2014)



Photograph 6: Looking south at the west slope adjacent to the south abutment. The slope face observed was vegetated with rip-rap placed on the face and at the toe of the slope to prevent erosion and scour of the exposed earth. (July 24, 2014)