



## **FOUNDATION TECHNICAL MEMORANDUM**

**For**

**GOVERNMENT DRAIN BRIDGE NO. 1 EBL ON HIGHWAY 401  
MTO WEST REGION 59 STRUCTURE REHABILITATIONS  
SITE 13-055-1, CONTRACT 7  
GWP 3084-11-00  
GEOGRAPHICAL TOWNSHIP OF TILBURY EAST  
KENT COUNTY, ONTARIO**

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June 17, 2015



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**FOUNDATION TECHNICAL MEMORANDUM**

**For**

Government Drain Bridge No. 1 EBL, Highway 401  
MTO West Region 59 Structure Rehabilitations  
Contract 7, GWP 3084-11-00  
Geographical Township of Tilbury East  
Kent County, Ontario

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**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 Highway 401 Government Drain Bridge No. 1 EBL (Eastbound Lanes). The Foundation Engineering recommendations from the existing 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 July 24, 2014, it is understood that the bridge will be rehabilitated in a single stage using median crossovers.

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 Government Drain Bridge No. 1 EBL on Highway 401 is located about 15 km (9 miles) southwest of Chatham in the Geographic Township of Tilbury East, Kent 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 Highway 401 Eastbound traffic. The surrounding areas around the site location are generally flat farming lands on both sides of Highway 401.

Physiographically, the site is located on the Essex Clay Plain of the St. Clair Clay Plains which were inundated by Glacial Lakes Whittlesey and Warren. These plains are covered by relatively deep deposit of typically very stiff clayey silt and silty clay till. The underlying shale or limestone bedrock at the site area belongs to Hamilton Group of Middle Devonian period. The bedrock surface lies at about 38 to 45 m (125 to 150 ft.) below ground surface in the Geographical Township of Tilbury East area (Quaternary Geology of the Chatham-Wheatley Area, Southern Ontario, 1995).

## **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 recommendations.

1. Foundation Report on Highway No. 401, Line "C" and Drainage Canal & Realigned County Road Crossing, Con. V & VI – Lots 1 & 3, Township of Raleigh & Tilbury East, Approx. 9 Miles S.W. of Chatham, W.P.s 10-59 & 69-59, W.J. F-59-13, Department of Highways Ontario, dated May 8, 1959, GEOCRE No. 40J08-07. (Reference 1)
2. Tilbury East Township Bridge No. 2 - General Plan & Elevation, The King's Highway No. 401, Co. Kent, District No. 1, Lot 1. Con. VI, Township-Tilbury East, T.W.P.# 104-55-1-A. W.P. 10-59, Department of Highways Ontario, dated August 1959. (Reference 2)



#### **4. SITE RECONNAISSANCE**

As part of the current foundation engineering assessment study, a site reconnaissance of the Government Drain Bridge No. 1 EBL was carried out on October 20, 2013. A photographic record of the site visit is attached in Appendix B.

The adjacent slopes of the abutments were observed to be vegetated and were visually stable (Photograph 1). No erosion of the slope faces was observed. Further, scouring of the adjacent slope toes was also not observed at this bridge structure location. The front earth slopes at the east and west abutment walls (Photographs 2 and 3), were exposed. The exposed earth was observed to be affected by scouring, most likely due to a repeated cycle of fluctuations of the creek water level throughout the season. Surficial cracks were observed on the abutment walls. The weep holes in the abutment walls were open and wet (Photographs 2 and 3).

At the time of the site reconnaissance, the water level of the drain was about 0.5 m deep and the direction of the water flow was towards the north.

#### **5. PREVIOUS FIELD INVESTIGATION AND SUMMARIZED SUBSURFACE CONDITIONS**

The site is located on Highway 401 in the Geographical Township of Tilbury East, Kent County, Ontario. The general subsurface conditions presented in this section are based on the Foundation Report, GEOCRE 40J08-07, dated May 8, 1959.

The original investigation (Reference 1) was carried out at a structure location where proposed Highway 401 Line 'C' crossed the Drainage Canal (Government Drain No.1) and the Realigned County Road in Lots 1 & 3, Con V & VI, Townships of Raleigh and Tilbury East.

The foundation investigation comprised five boreholes which were drilled between February 9 and 13, 1959. The boreholes were drilled to depths of 6.7 to 12.8 m, elevation 164.6 to 170.7. The investigation was carried out by a trailer-mounted continuous flight auger adapted for soil sampling. Conventional auger boring procedures were followed and samples were recovered at depths



required. Samples were obtained using 50.8 mm (2 in.) I.D. thin walled Shelby tube samplers or 50.8 mm (2 in.) O.D. split barrelled spoon samplers.

The foundation report includes the borehole location plan (Drawing No. F59-13A), Record of Borehole sheets (1, 2, 4, 5 and 6) and summary of the Field and Laboratory test results.

Boreholes 1 and 4 were investigated at the east and the west abutments of the Government Drain Bridge No.1 EBL structure.

#### Desiccated Silty Clay

A deep deposit of very stiff, silty clay, brown to gray, stratum was encountered in boreholes 1 and 4 from surface elevation 178.7 and 178.1 and extended to depth of 9.3 and 7.6 m, elevation 169.4 and 170.5, respectively. It should be noted that the upper 1.5 m silty clay in borehole 4 was stiff in consistency. The upper 1.8 and 2.1 m silty clay stratum had been oxidized giving its brownish color, below which the color was predominately grey. Some interbedded sand seams, 50 to 100 mm thick, were encountered in borehole 1 between elevations 169.4 and 170.8 (556.0 and 560.5 ft.) and in borehole 4 between elevations 170.4 and 171.6 (559 and 563 ft.). N values recorded ranged between 29 and 56 with one high N value of 23 for 150 mm penetration in borehole 4.

Grain size distribution results of silty clay samples contained approximately 51% clay, 25% silt, 18% sand and 6% fine to medium gravel sized particles. Laboratory shear strengths obtained typically ranged from 110.6 to 301.6 kPa (2310 to 6300 psf) with one shear strength value of 73.1 kPa (1526 psf) for the 1.5 m upper silty clay sample in borehole 4. The Atterberg liquid limits ranged from 26.8 to 30.5 and plastic limits ranged from 15.1 to 17.7 for the stiff clay samples. The plasticity index ranged from 11.7 to 12.8. Further, unit weights of the very stiff silty clay samples varied from 19.3 to 22.3 kN/m<sup>3</sup>. Moisture content determinations ranged from 13.6 to 23.8%.

Consolidation characteristics of a silty clay sample obtained during laboratory testing were  $7.3 \times 10^{-5} \text{ kPa}^{-1}$  (0.007 sq.ft./ton) for coefficient of volume compressibility ( $m_v$ ) and  $1.3 \times 10^{-2} \text{ m}^2/\text{day}$  (0.14 sq.ft./day) for coefficient of consolidation ( $c_v$ ).



### Stiff to Firm Silty Clay

Below the very stiff silty clay layer in borehole 4, a stratum of stiff to firm silty clay was encountered at 7.6 m, elevation 170.5, and extended to the borehole termination depth of 12.8 m, elevation 165.3.

Grain size distribution results for stiff to firm silty clay samples contained approximately 58% clay, 24% silt, 12% sand and 6% fine to medium gravel sized particles. Laboratory shear strengths obtained ranged from 36.7 to 99.3 kPa (767 to 2074 psf). Two Atterberg liquid limits obtained for stiff to firm silty clay samples were 24.0 and 29.6, and the corresponding plastic limits obtained were 17.5 and 18.1. The plasticity indices were 6.5 and 11.5. Further, unit weights of the stiff to firm silty clay samples varied from 19.9 to 20.1 kN/m<sup>3</sup>. Moisture content determinations ranged from 19.9 to 23.8%.

For the stiff to firm silty clay samples, the compression index obtained was 0.18 and the coefficient of consolidation ( $c_v$ ) obtained was  $8.1 \times 10^{-3}$  m<sup>2</sup>/day (0.0875 sq.ft./day).

### Groundwater

Groundwater observed in boreholes 1 and 4 during the investigation was between elevations 177.2 and 177.7 (581.4 and 583.0 ft), about 1.5 and 0.4 m (5 and 1.4 ft.) below the ground surface, respectively, which corresponded to the high water level of the drainage canal at the time of the investigation. It was inferred that the high water table condition at the site was due to thawing and raining activities prior to the investigation.

## **6. FOUNDATION**

### **6.1 Previous Foundation Recommendations**

The report stated that the upper very stiff silty clay stratum was competent to provide adequate foundation support for the structure. It was recommended that the spread footings for the bridge structure be founded at elevation 173.7 (570 ft.) or below. A bearing capacity of 240 kPa (2.5 tsf), incorporating a safety factor of 3, was recommended at elevation 173.7 (570 ft.) or below for footings of 2.1 to 3.0 m (7 to 10 ft.) width for foundation design. However, in order to avoid possible undermining of the footing through erosion and scour actions, it was recommended that the footings



be founded at approximate elevation 171.9 (564 ft.), approximately 2.4 m (8 ft.) below the stream bed, assuming stream bed elevation 174.3 (572 ft.). In view of the water-bearing sand seams present in the silty clay stratum between elevations 169.5 and 171.6 (556 and 563 ft.), the report anticipated possible shoring and pumping operations would be required during footing excavations. If the footings were to be placed above elevation 171.6 (563 ft.), the seepage would be local and of minor quantities.

It was stated that the subsoil had sufficient strength to safely support the proposed embankment loading. The following table (reproduced from Reference 1) summarizes the estimated settlements anticipated under the footings as a result of the application of 240 kPa (2.5 tsf) bearing pressure:

<b>Footing Elevation</b>	<b>Footing Size</b>	<b>Loading Intensity</b>	<b>Maximum Theoretical Settlement – Corrected for Rigidity and Depth Factors</b>
172.2 m (565 ft.)	30.5 m by 2.1 m (100 ft by 7 ft.)	240 kPa (2.5 tsf)	68.6 mm (2.7 in.)
172.2 m (565 ft.)	30.5 m by 3.0 m (100 ft by 10 ft)	240 kPa (2.5 tsf)	86.4 mm (3.4 in.)

It was anticipated that the ultimate settlement upon application of 240 kPa (2.5 tsf) bearing pressure would be in the order of 76.2 mm (3 in.). Further, in view of the uniform soil conditions at the site location, the report stated that little differential settlement would be anticipated for a single span structure since each abutment would virtually settle the same amount.

Based on the drawing, titled 'Tilbury East Township Bridge No.2 - General Plan & Elevation', dated August 1959, the footings were to be founded at about elevation 173.7 (570 ft.). Further, it was indicated that steel sheet piles (Type AP3) were to be driven to approximate elevation 171.0± (561± ft.). However, during the site reconnaissance, the presence of sheet piles could not be verified visually. At the abutment locations, the original ground elevation was to be increased by about 2.1 m (7 ft.), to achieve an approximate elevation of 179.6 (589.3 ft.). It was also shown that 20 cm (8") diameter perforated CIP were to be placed behind the abutments, which could not be verified visually during the site reconnaissance. In addition, it was shown that the adjacent slopes were to be graded at 2H:1V slopes.





## 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) <sup>1</sup>	Previous Equivalent Limit State Design Values		Limit State Design Values Updated to current industry practices <sup>2</sup>	
			SLS Geotechnical Reaction (kPa)	ULS Factored Geotechnical Resistance (kPa)	SLS Geotechnical Reaction (kPa)	ULS Factored Geotechnical Resistance (kPa)
East Abutment on Spread Footing	173.7 (570 ft.)	2.5	240	360	350	525
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 4<sup>th</sup> edition)  
Assumed Factor of Safety is 3 (CFEM 4<sup>th</sup> 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 Government Drain Bridge No. 1 EBL 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 the bridge will be rehabilitated in a single stage using median crossovers.

Further, it is suggested that the weep holes in the abutment walls should be maintained and cleaned on 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 from building up behind the abutment walls.

In addition to rehabilitating the bridge, the earth on the adjacent slopes may be protected from erosion and the edge of the slope toes from scouring effects with rock protection, rip-rap or equivalent materials. The aggregate materials should conform to OPSS.PROV 1004 and the construction of the rock protection, rip-rap or equivalent should conform to OPSS 511.



## 8. CLOSURE

This Technical Memorandum was prepared by Mr. N. Rahman, P.Eng with the assistance of Mr. M. Khorsand, EIT and was reviewed by Mr. R. Ng, PhD, P.Eng. Mr. B. 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,

Peto MacCallum Ltd.



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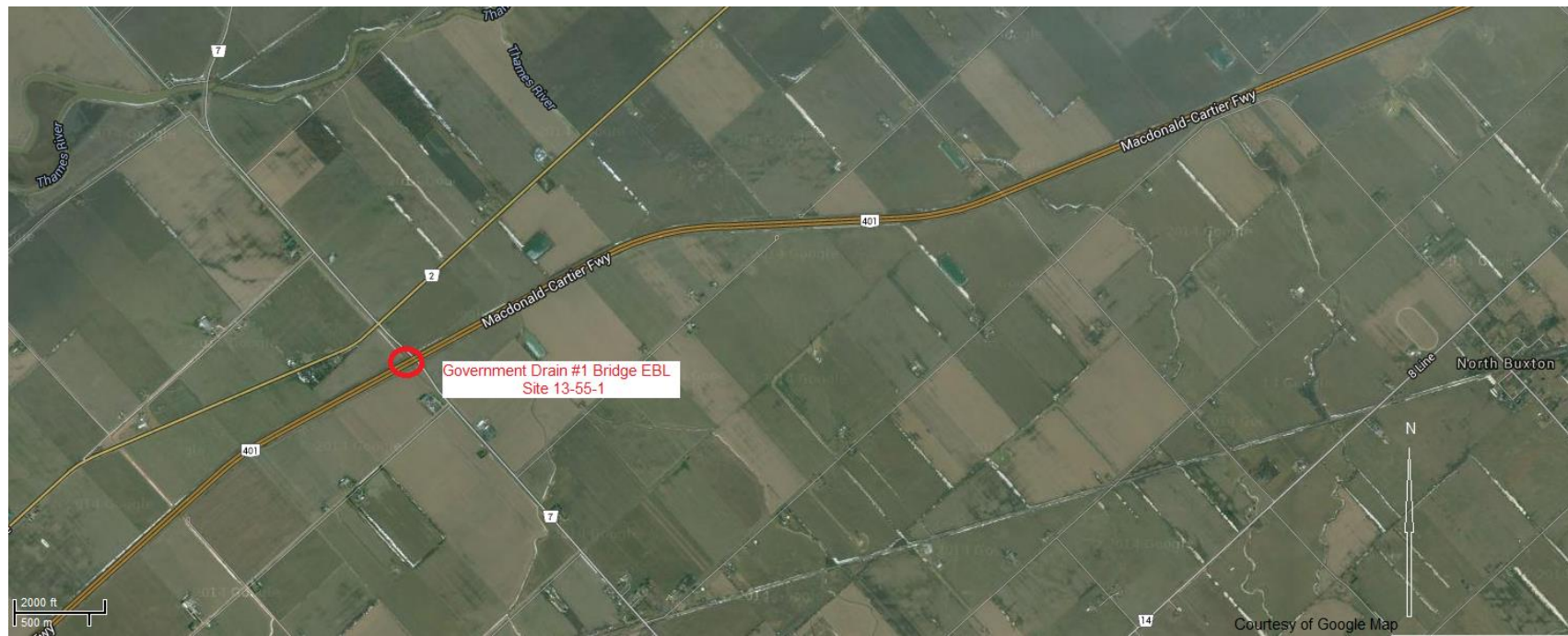


TABLE 1

LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSS 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting
OPSS.PROV 1004	Material Specification for Aggregates - Miscellaneous
OPSD 3090.101	Foundation Frost Depth for Southern Ontario

**Figure 1 – Key Plan**





## **APPENDIX A**

Foundation Report at Government Drain Bridge No. 1 (GEOCRES 40J08-007)

General Plan & Elevation - Tilbury East Township Bridge No. 2, dated August 1959

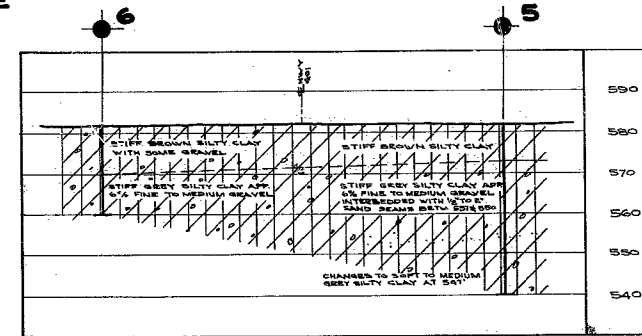
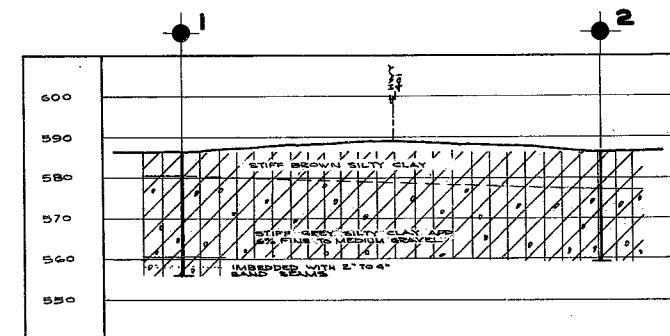
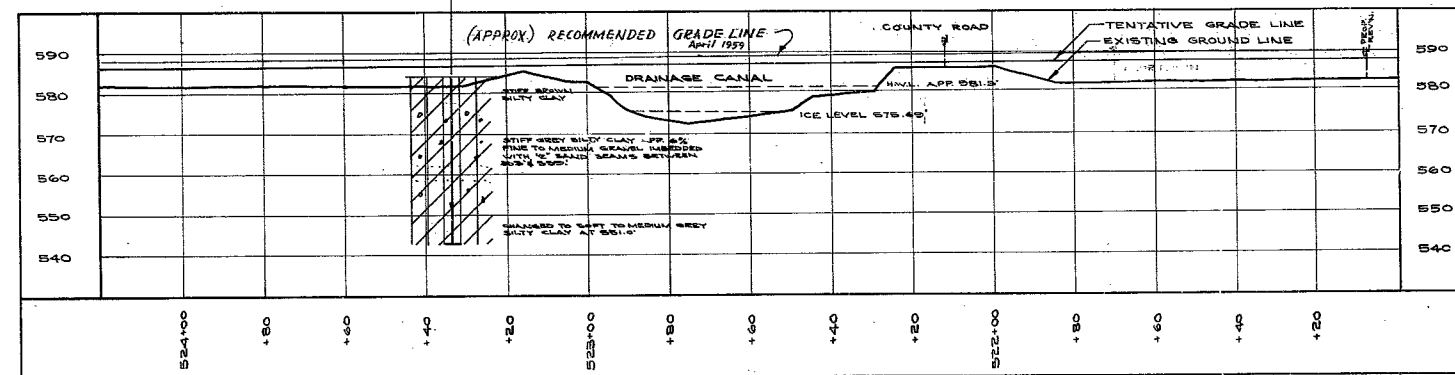
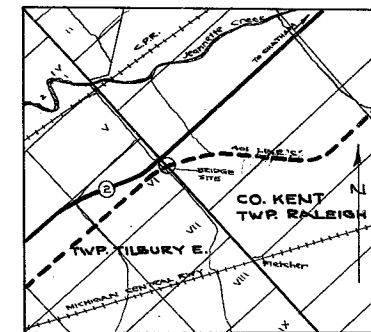
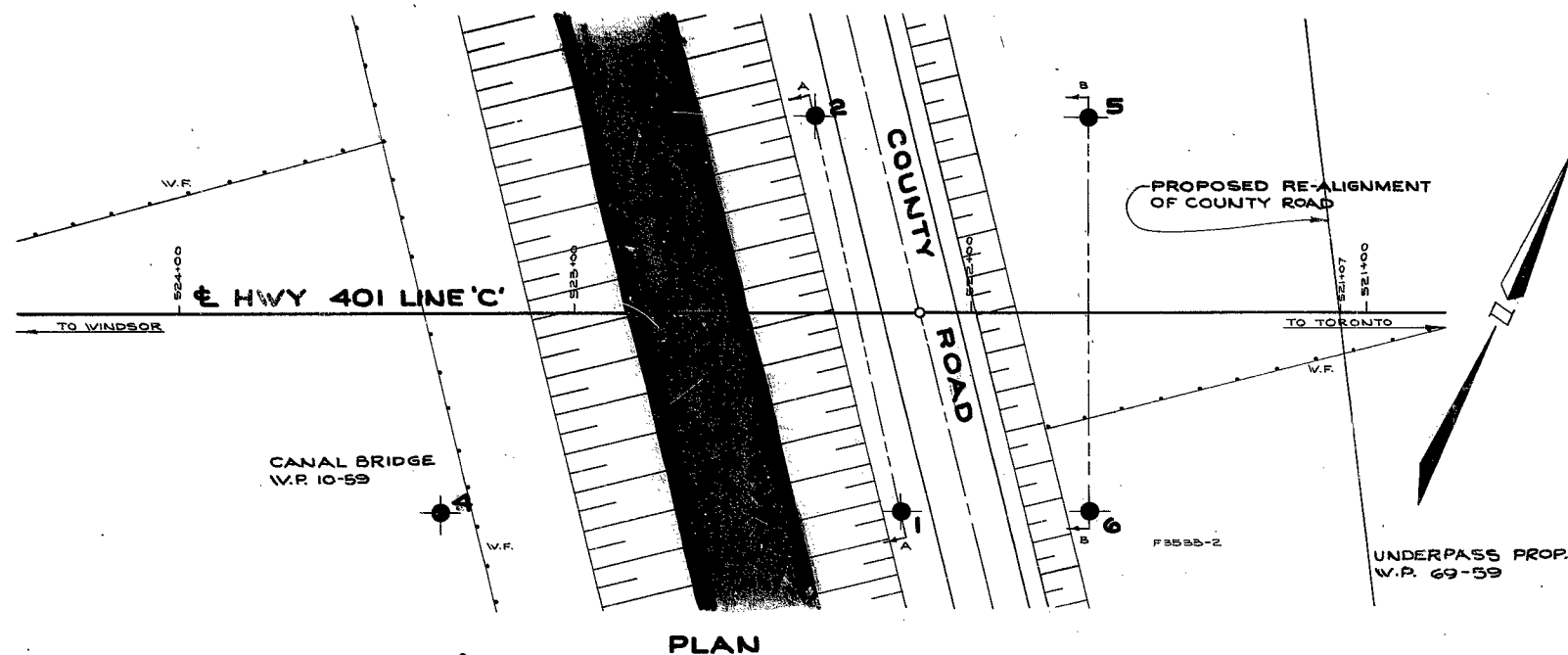
S9. F - 13

HWY. 401

S. W. OF

CHATHAM

40J8-7



LEGEND			
BORE HOLE			
PENETRATION HOLE			
BORE & PENETRATION HOLE			
NO. NO.	ELEVATION	STATION	DISTANCE FROM E
1	556.4'	522+18	50' LT.
2	556.5'	522+39	50' RT.
4	554.4'	523+34	50' LT.
5	552.0'	521+75	50' RT.
6	552.0'	521+70	50' 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 AND MAY BE SUBJECT TO CONSIDERABLE ERROR.

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH SECTION

**COUNTY ROAD & CANAL  
PROPOSED CROSSING**

SHOWING POSITIONS & ELEVATIONS OF HOLES

HWY. 401 DISTRICT 10 COUNTY KENT  
TOWNSHIP TILBURY E. & RALEIGH LOT 1 & 2 CON. 30 & 31  
LOCATION A.D. 3 M. S.W. & E. CHATHAM

DRAWN BY: T. MELLORS CHECKED BY: J. H. W.P. 10-59 & 69-59  
DATE MAY 1/59 APPROVED BY: J. H. F59-13A  
SCALE 1" = 20'

4038-7  
C.C.R. No.



23-60-35

Mr. A. M. Toye,  
Bridge Engineer.  
Materials & Research Section.

May 8, 1959.

Re: FOUNDATION INVESTIGATION -  
Hwy. 401 and Drain & Gravel Rd.  
Hwy. 10-59 & 60-59 - District

Attention: Mr. S. McCulloch.

Enclosed herewith is our Foundation Report showing the subsoil conditions existing at the above noted site. Reference to the contents of this report shows that the site is underlain by stiff silty clay followed by deep deposits of soft to medium silty clay.

Recommendations pertinent to the foundation design are summarized as follows:-

1. Bridge at Drainage Canal:

A. Subsoil conditions are such that, at Elev. 573' or below, for footings typically of 7' to 10' in width, a safe footing pressure of 2 1/2 t.s.f. can be used for spread footing design. Footings founded at Elev. 50' (approximately 8 ft. below stream bed) are believed to have sufficient protection from stream erosion and scour.

B. Long-term settlements consequent upon application of 2 1/2 t.s.f. bearing pressure have been estimated as of the order of 3 inches. For a single-span structure the resultant differential settlements are considered to be tolerable.

C. No excessive seepage problems during footing excavations are anticipated if footings are founded above Elev. 563'.

D. The proposed grade line does not present any approach fill stability problems.

cont'd. /2 ...

2. Underpass Structure at Reassigned County Road:

A. Subsoil conditions are such that at Elev. 577' or below, for footings typically of 7' to 10' in width, a safe footing pressure of 3 t.s.f. can be used for spread footing design.

B. Long-term settlements resulting from abutment and embankment loadings have been estimated as of the order of 5 inches. If a single-span structure is used, the resultant settlements are considered tolerable. If a multi-span structure is used, long-term differential settlement between the abutments and piers would result. It appears that if a multi-span structure is contemplated, a rigid-frame design is only favourable if the estimated amount of differential settlement of the order of 1" to 1 1/2" can be tolerated.

C. No seepage problems with respect to footing excavations are anticipated if footings are founded above Elev. 557'.

D. Under the proposed grade line the maximum height of fill is approximately 20 feet. The subsoil has sufficient strength to safely support this embankment loading.

If any queries arise with respect to the contents of this report, please contact our office.

L. G. Soderman,  
PRINCIPAL SOIL & FOUNDATION ENGR.  
per:

AL/MEF  
Encl.

cc: Messrs. A. Toye  
H. Tregaskes  
D. G. Lansay  
C. U. Howell  
J. Roy  
Dr. P. Farrow

Foundations Office ✓  
File

*Abraham Loh*  
(A. Loh,  
FOUNDATION ENGR.)

# FOUNDATION REPORT

on

Highway No. 401, Line 'C' and -  
Drainage Canal & Realigned  
County Road Crossing -  
Con. V & VI - Lots 1 & 3,  
Twp. of Raleigh & Tilbury East,  
Approx. 9 Miles S.W. of Chatham.

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Plan No: F-3533-2

Profile No: F-3533-5

## Distribution:

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Department of Mines. (1)

Foundations Office. (1)

File. (1)

W.P.s 10-59 & 62-59

W.J. F-59-13.

## INTRODUCTION:

Presented in this report are the results of an investigation carried out at a structure location approx. 9 miles S.W. of Chatham, where proposed Hwy. 401 Line 'C' crosses the Drainage Canal and the Realigned County Road in Lots 1 & 3, Con. V & VI, Townships of Raleigh and Wilbury West (Sta. 522+70 & Sta. 521+07, Profile No. F-3533-5).

The field work commenced on February 9, 1959 and was completed on February 13, 1959.

## DESCRIPTION OF THE SITE AND GEOLOGY:

The site and its surrounding areas are generally flat farmlands; the areas on both sides of the existing County road and the drainage canal being presently under cultivation. At the time of the investigation the area was covered by ice and snow.

Physiographically, the site under consideration, is located on the Essex Clay Plain of the St. Clair Clay Plains inundated by Glacial Lakes Whittlesey and Warren. According to available geological information, these extensive plains covering a large area of South-Western Ontario, are covered by deep deposits of clay underlain by limestone or shale bedrock. At this site, the upper zone of the clay stratum was found to be desiccated and exists in a stiff condition for a depth of approximately 35 feet.

## DESCRIPTION OF FIELD & LABORATORY WORK:

Field work consisted of 5 sampled boreholes, carried out by a trailer-mounted continuous flight auger adapted for soil sampling. Conventional auger boring procedures were followed and samples were recovered at depths required. Samples were obtained

cont'd. /2 ...

DESCRIPTION OF FIELD & LABORATORY WORK: (cont'd.) ...

by means of a 2" I.D. thin walled Shelby tube sampler or a 2" O.D. split spoon sampler. The dimensions of this split spoon sampler and the energy used in driving it, conform to the requirements of the Standard Penetration Test.

Upon receipt in the laboratory, samples were visually examined and identified. Routine index tests were performed on selected representative samples. Laboratory test results have been presented in the borehole logs and detailed in tabular form.

The location plan and subsoil profile are presented in Drawing No. F-59-13A.

SUBSOIL CONDITIONS:

The site is underlain by a stiff crust of silty clay followed by the thick stratum of medium stiff to soft silty clay.

In each of the sampled boreholes, the frozen topsoil was found to be underlain by a 35 ft. stiff crust of silty clay extending from Elevation 586.0' to 551.0'. Underneath the stiff crust the stratum of soft to medium silty clay was encountered. This stratum was explored to a depth of 42 ft. below the ground surface (i.e., at approximately Elev. 540.0'). According to available geological information, this stratum of soft to medium clay extends to a considerable depth over bedrock. In general, the soil types encountered are as follows:-

cont'd. /3 ...

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

1. Stiff Silty Clay -

This stiff condition of the upper zone of clay is believed to be the result of desiccation and has been subjected to oxidation resulting in its present brownish colour. Below the oxidized zone the colour is predominantly gray. The material contains approximately 25% silt, 12% sand and 6% fine to medium gravel. The average unit weight and moisture content were found to be 131 p.c.f. and 17%, respectively. Liquid and plastic limits averaged 27% and 16%. Laboratory shear strength tests show an average of 2500 p.s.f. to be representative for the 35 ft. layer. Water-bearing sand seams ranging from 1/2" to 2" in thickness were encountered between elevations 560.5' and 556.0' in Bore Hole Nos. 1 and 2, between elevations 563.0' and 559.0' in Bore Hole No. 4, and between elevations 557.0' and 550.0' in Bore Hole No. 5.

Judging from its moisture content and Atterberg limits the stiff silty clay appears to be saturated and preconsolidated. This is borne out by the Consolidation test results.

2. Soft to Medium Silty Clay -

Underneath the stiff clay crust the thick stratum of soft to medium silty clay was encountered. The colour is predominantly gray. It contains approximately 24% silt, 12% sand and 6% fine to medium gravel. The average unit weight was found to be 125 p.c.f. Its consistency is defined by moisture content of 21%, liquid and plastic limits of 24% and 17%, respectively. Laboratory tests show that the shear strength of the silty clay decreases with depth.

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

2. Soft to Medium Silty Clay - (cont'd.) ...

and reaches a constant value of 800 p.s.f. below approximately Elev. 545. A plot of shear strength versus depth has been presented and is included under Appendix I. The soft to medium clay is fully saturated and consolidation test results show that it is normally consolidated.

Laboratory and field test results have been summarized in Table No. 1 and are included in this report under Appendix I.

WATER CONDITIONS:

Observations and measurements carried out during boring and sampling operations indicate that the ground water table at the time of the investigation was at approximately Elev. 531.5, which corresponds to the high water level of the drainage canal. This high water table condition at the site was due to the fact that thawing and raining occurred immediately before the investigation.

In view of the presence of water-bearing sand seams in the stiff clay crust between elevations 563 and 550' (approximately between 20' to 32' depth below existing ground surface), shoring and pumping operations appear to be necessary during footing excavations if footings are placed below these elevations. If footings are placed above Elev. 532.0' no excessive seepage problems are anticipated since the clay is of low permeability. If seepage does occur, the seepage inflow will be local and of minor quantities.

cont'd. /5 ...

FOUNDATION CONSIDERATIONS:

1. Bridge at Drainage Canal -

The stiff upper clay crust is competent to provide adequate foundation support for this proposed structure. Laboratory and field test results are such that spread footing support can be obtained in the stiff upper clay crust at elevation 570' or below. At this elevation or below, for footings of 7' to 10' in width, a bearing capacity of 2 1/2 t.s.f. incorporating a safety factor of 3 can be provided. Considerations should be given to founding the footings below the stream bed elevation in order that they are protected from stream erosion and scour. Footings founded at Elevation 564' (approximately 8 ft. below stream bed, assuming stream bed elevation at 572'), are believed to have sufficient protection from erosion and scour.

In view of the presence of water-bearing sand seams in the stiff clay crust between Elevations 563' and 556', shoring and pumping operations appear to be necessary during footing excavations. If footings are placed above Elevation 563' seepage inflow during footing excavations will be local and of minor quantities.

The subsoil has sufficient strength to safely support the proposed embankment loading.

Settlements under the footings, as a result of the application of 2 1/2 t.s.f. bearing pressure, based on footing sizes of 100 ft. long and 7' to 10' wide, have been estimated and are tabulated as follows:-

cont'd. /6 ...



FOUNDATION CONSIDERATIONS: (cont'd.) ...

1. Bridge at Drainage Canal - (cont'd.) ...

<u>Footings Elevation</u>	<u>Footings Size</u>	<u>Loading Intensity</u>	<u>Max. Theoretical Settlement Corrected for Rigidity and Depth Factors</u>
565	100' x 7'	2 1/2 t.s.f.	2.7"
565	100' x 10'	2 1/2 t.s.f.	3.4"

Reference to the above figures shows that ultimate settlements upon application of 2 1/2 t.s.f. bearing pressure will be of the order of 3 inches. In view of the relatively uniform soil conditions at the site, little differential settlement of any consequence should be anticipated of a single-span structure since each abutment will sensibly settle the same amount.

2. Underpass Structure at Realigned County Road -

Adequate foundation support for this underpass structure can be derived from the stiff upper clay crust. Subsoil conditions are such that spread footing support can be obtained at elevation 577' or below. At this elevation or below, for footings of 7' to 10' in width, a bearing capacity of 3 t.s.f. incorporating a safety factor of 3 can be provided. Footings founded at Elev. 577' are believed to have sufficient protection from frost action.

No excessive seepage problems are anticipated with respect to shallow footing excavations if footings are founded above Elev. 557'. In view of the presence of water-bearing sand seams in the stiff clay crust between Elevations 557' and 550', shoring and

FUNDATION CONSIDERATIONS: (cont'd.) ...

2. Underpass Structure at Realigned County Road - (cont'd.) ...

pumping operations appear to be necessary if excavations are carried to these elevations.

Under the proposed grade line of the realigned County road the maximum height of fill is approximately 20 feet. The subsoil has sufficient strength to safely support this embankment loading.

Settlements under the footings, as a result of the application of 3 tons/sq.ft. abutment bearing pressure and embankment load, have been estimated and found to be of the order of 5 inches. This magnitude of settlement is mainly due to the fact that the stresses caused by the applied loads will influence the thick stratum of soft clay for a considerable depth. In view of the slow rate of consolidation expected of clay, settlement will continue over several decades. It is suggested that a total settlement of the order of 3 inches may be anticipated over a period of 50 years. For a single-span structure, little differential settlement should be anticipated since each abutment will sensibly settle the same amount. If centre piers are incorporated in the design, long term differential movement between the abutments and piers would result since the consolidation under the footings of the piers would be unaffected by the fills adjacent to the abutments.

In order to avoid endangering the stability of the canal, the toe of slope of the realigned County road should not be closer than 17 feet from the top of the canal banks. This distance is greatly exceeded at the proposed relocated centre line shown on the enclosed Plan No. F 59-13A.

CONCLUSIONS & RECOMMENDATIONS:

(1) The site is underlain by stiff silty clay, followed by a deep deposit of soft to medium silty clay.

(2) Bridge at Drainage Canal:

A. At elevation 570' or below, in the upper stiff clay crust, for footings of 7' to 10' in width, a bearing pressure of 2 1/2 t.s.f. can be used for spread footing design. Footings founded at Elev. 564' (approximately 6 ft. below stream bed) are believed to have sufficient protection from erosion and scour.

B. Long term settlement consequent upon application of 2 1/2 t.s.f. bearing pressure will be of the order of 3 inches. Little differential settlement should be anticipated of a single-span structure since each abutment will sensibly settle the same amount.

C. The presence of water-bearing sand seams in the stiff clay crust between elevations 563' and 556' will necessitate shoring and pumping operations during footing excavations if footings are placed below these elevations. If footings are founded above Elev. 563' no excessive seepage problems with respect to footing excavations are anticipated.

D. The proposed grade line does not present any approach fill stability problem.

cont'd. /p ...

CONCLUSIONS & RECOMMENDATIONS: (cont'd.) ...

(3) Underpass Structure at I aligned County Road:

- A. Spread footing support can be obtained in the stiff upper clay crust at Elev. 577' or below. At this elevation or below, for footings of 7' to 10' in width, a bearing pressure of 3 t.s.f. can be used for spread footing design.
- B. Long term settlement consequent upon application of 3 t.s.f. abutment bearing pressure and embankment load will be of the order of 5 inches. A total settlement of the order of 3 inches that may be anticipated for the lifetime that the structure is designed for, has been suggested. Differential settlement can be taken as of the order of 1" to 1 1/2". Little differential settlement need be anticipated for a single-span structure since each abutment will sensibly settle the same amount. If centre piers are incorporated in the design, long term differential settlement between the abutments and piers would result. It appears that if a multi-span structure is contemplated, a rigid-frame design is only favourable if the above mentioned amount of differential settlement can be tolerated.
- C. No excessive seepage problems with respect to footing excavations are anticipated if footings are founded above Elev. 577'.

cont'd. /10 ...

CONCLUSIONS & RECOMMENDATIONS: (cont'd.) ...

(3) Underrpass Structure at Realigned County Road: (cont'd.) ...

D. Under the proposed grade line the maximum height of fill is approximately 20 feet. The subsoil has sufficient strength to safely support this embankment loading.

*Abraham Loh*  
A. Loh,  
FOUNDATION ENGR.

APPENDIX 1.

DEFECTS IN NEGATIVE DUE TO  
CONDITION OF ORIGINAL DOCUMENT

**DEPARTMENT OF HIGHWAYS - ONTARIO**  
**MATERIALS AND RESEARCH SECTION**

W.P. 10-59. BORE HOLE NO. 1.  
JOB F-59-13 STATION 522+18 (50' Lt.)  
DATUM Geodetic COMPILED BY B.K.  
BORING DATE Feb. 12/59. CHECKED BY A.L.

**LEGEND**

BSS 1/2 UNCONFINED COMPRESSION (QU) — 0  
BTW VANE TEST (C) AND SENSITIVITY (S) — 1  
NATURAL MOISTURE AND LIQUIDITY INDEX — 1  
LIQUID LIMIT — 1  
PLASTIC LIMIT — 1

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE			
				2000	4000	6000	8000
	Ground Level.	556.4		50	100	150	200
	Stiff brown silty clay.	W.L. 551.4					
		550.4					
	Stiff grey silty clay - Approx. 6% fine to med. gravel.		10				
			20				
	Interbedded with 2" to 4" sand seams.	550.4					
		556.0	30				
	End of Borehole.		40				

CONSISTENCY			SAMPLE	NATURAL UNIT WT. P.C.F.
MOIST. CONTENT - % DRY WT.	10	20		
			1	123.0
			2	127.0
			3	132.0
			4	129.0
			5	
			6	

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS AND RESEARCH SECTION

W.P. 10-59

BORE HOLE NO. 2.

JOE F-59-13

STATION 522+39 (50' Rt.)

**DATUM** Geodetic

COMPILED BY B.K.

BOHRING DATE Feb. 12/59. CHECKED BY A.L.

CHECKED BY A.L.

### LEGEND

SS	1/2 UNCONFINED COMPRESSION (Qu)	0
TW	VANE TEST (C) AND SENSITIVITY (S)	1
	NATURAL MOISTURE AND	
	LIQUIDITY INDEX	
	LIQUID LIMIT	
	PLASTIC LIMIT	

[illegible]



## MATERIALS AND RESEARCH SECTION

- CHECKED BY A.L.

### LEGEND

SS	UNCONFINED COMPRESSION (QU)	
TW	WANE TEST (G) AND SENSITIVITY (S)	
	NATURAL MOISTURE AND	
	LIQUIDITY INDEX	
	LIQUID LIMIT	
	PLASTIC LIMIT	

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE			
				2000	4000	6000	8000
	Ground Level.	584.4		50	100	150	200
1/4 Frost	W.L.	583.9					
	Stiff brown silty clay.	677.4					
	Stiff grey silty clay - Approx. 6% fine to medium gravel interbedded with 1/2" sand seams between Elev. 563' and 559.		10				
	Changed to soft to medium grey silty clay at Elev. 551.0'		20				
			30				
			40				
	End of Borehole.	541.4					

CONSISTENCY		SAMPLE	WATER UNIT WT. P.C.P.
MOIST. CONTENT - % DRY WT.			
10	20	30	
		TW 1	126.7
		TW 2	135.0
		TW 3	132.6
		TW 4	133.6
		TW 5	130.8
		SS 6	142.2
		TW 7	128.0
		TW 8	126.5
		TW 9	128.0

**DEPARTMENT OF HIGHWAYS - ONTARIO**  
**MATERIALS AND RESEARCH SECTION**

W.P. 10-59

BORE HOLE NO. 5.

JOB F-59-13

STATION 521+70 (50' Rt.)

DATUM Geodetic

COMPILED BY B.K.

BORING DATE Feb. 9/59. CHECKED BY A.L.

**LEGEND**

BSS 1/2 UNCONFINED COMPRESSION (QU)  
 ETW VANE TEST (C) AND SENSITIVITY (S)  
 NATURAL MOISTURE AND LIQUIDITY INDEX  
 LIQUID LIMIT  
 PLASTIC LIMIT

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE			
				2000	4000	6000	8000
	Ground Level	582.0		50	100	150	200
	Stiff brown silty clay.	573.0					
	Stiff grey silty clay - Approx. 6% fine to med. gravel interbedded with 1/2" to 2" sand seams between Elev. 557' and 550'.	547.0	10				
	Changed to soft to medium grey silty clay at Elev. 547'.	540.0	20				
			30				
			40				
	End of Borehole.						

CONSISTENCY			SAMPLE	NATURAL UNIT P.C.
MOIST. CONTENT - % DRY WT				
10	20	30		
			TW 1	126.0
			TW 2	132.0
			TW 3	133.0
			TW 4	132.0
			TW 5	
			SS 6	131.0
			SS 7	
			TW 8	122.0

# DEPARTMENT OF HIGHWAYS - ONTARIO

## MATERIALS AND RESEARCH SECTION

W.P. 10-59

BORE HOLE NO. 6.

JOB F-59-13.

STATION 521+70 (50' Lt.)

DATUM Geodetic

COMPILED BY B.K.

BORING DATE Feb. 12/59

CHECKED BY A.L.

### LEGEND

BSS 1/2 UNCONFINED COMPRESSION ( $Q_u$ )  
 BTW VANE TEST (C) AND SENSITIVITY (S)  
 NATURAL MOISTURE AND LIQUIDITY INDEX  
 LIQUID LIMIT  
 PLASTIC LIMIT

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE			
				2000	4000	6000	8000
	Ground Level	582.0		50	100	150	200
	W.L.	581.0					
	Stiff brown silty clay with some gravel.		10				
		570.0					
	Stiff grey silty clay - Approx. 6% fine to medium gravel.		20				
		560.0					
	End of Borehole.		30				
			40				

CONSISTENCY			SAMPLE	NATURAL UNIT WT. P.C.P.
MOIST. CONTENT	FLUIDITY	W.T.		
10	20	30		
			TW 1	128.0
			TW 2	127.4
			TW 3	124.5
			TW 4	128.5
			TW 5	132.0

## SUMMARY OF FIELD &amp; LABORATORY TESTS

JOB 59-13

W.P. 10-59

SAMP. NO.	SAMPLE DEPTH (FEET)	MATERIAL DESCRIPTION	PENET'N RESIST. BLOWS/FT.	MOIST CONT. %	PLASTIC LIMIT %	LIQUID LIMIT %	SHEAR STRENGTH psf.	UNIT WEIGHT p.c.f.	REMARKS
T1	7'-9'	Stiff brown silty clay.	-	21.1	-	-	2310	123.0	Approximately 6% fine to medium gravel throughout
T2	10'-12'	Stiff grey silty clay.	-	16.8	-	-	5240	127.0	
T3	15'-17'	" " " "	-	16.6	-	-	3980	132.0	
T4	20'-22'	" " " "	-	17.7	-	-	3180	129.0	
S5	27'-28'6"	Stiff grey silty clay interbedded with 2" to 4" sand seams.	48	13.6	-	-	-	-	
S6	29'-30'6"		35	14.0	-	-	-	-	Approximately 6% fine to medium gravel throughout
T1	5'-7'	Stiff brown silty clay.	-	25.6	-	-	4100	117.0	
T2	10'-12'	Stiff grey silty clay.	37	16.7	17.7	32.0	6780	130.0	
T3	15'-17'	" " " "	20	17.8	-	-	3510	128.0	
T4	20'-22'	" " " "	-	18.3	16.1	27.2	-	127.0	
T5	25'-27'	Stiff grey silty clay interbedded with 2" sand seams at 26'.	35	16.0	-	-	-	130.0	
T1	3'-5'	Stiff brown silty clay.	-	19.5	-	-	1526	120.7	Approximately 6% fine to medium gravel throughout
T2	6'-8'	Stiff grey silty clay.	56	17.2	17.7	30.5	6300	135.0	
T3	10'-12'	" " " "	31	15.8	-	-	3800	132.6	
T4	15'-17'	" " " "	-	16.0	15.1	26.8	3120	133.3	
T5	20'-22'	Stiff grey silty clay interbedded with 1/2" sand seams	23 for 6"	16.4	-	-	3320	130.8	
S6	22'-23'6"	between 21'6" and 25'6".	29	18.4	15.1	26.8	-	142.2	

cont'd. /2 ...

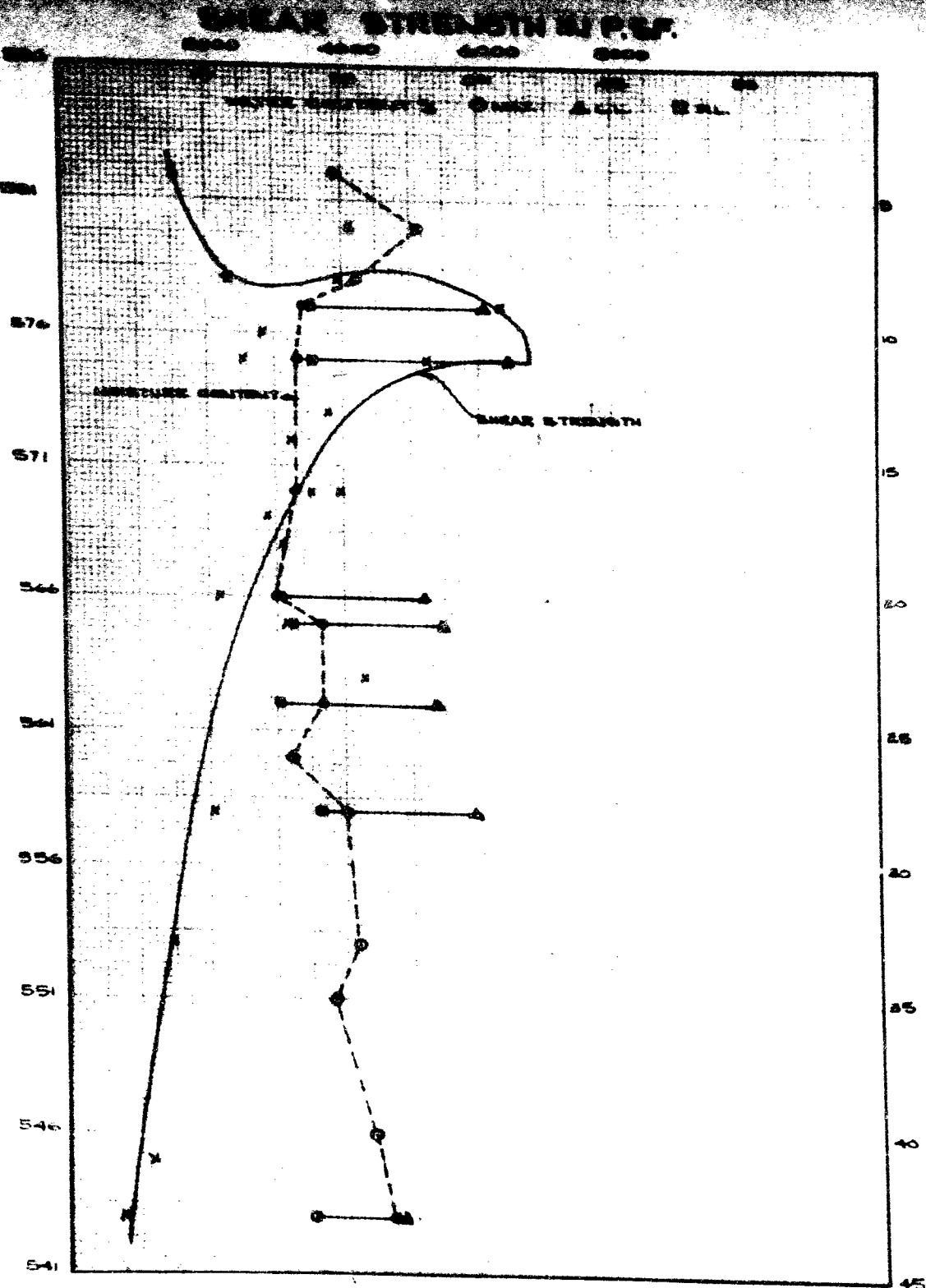
## SUMMARY OF FIELD &amp; LABORATORY TESTS

JOB 59-13

W.P. 10-59

SAMP NO.	SAMPLE DEPTH FEET	MATERIAL DESCRIPTION	PENET'N RESIST. BLOWS/FT.	MOIST. CONT. %	PLASTIC LIMIT %	LIQUID LIMIT %	SHEAR STRENGTH p.s.f.	UNIT WEIGHT p.c.f.	REMARKS
E7	25'-27'	Stiff grey silty clay.	-	19.9	18.1	29.6	2074	128.0	Approximately 6% fine medium gravel throughout
E8	30'-32'	Medium stiff grey silty clay.	-	20.9	-	-	1448	126.5	
E9	40'-42'	Soft to medium grey silty clay.	-	23.8	17.5	24.0	767	128.0	
E11	5'-7'	Stiff brown silty clay.	-	12.5	-	-	2820	126.0	
E12	12'-14'	Stiff grey silty clay.	23	16.8	-	-	2880	132.0	
E13	15'-17'	" " " "	-	15.8	15.8	25.8	7000	133.0	
E14	20'-22'	" " " "	-	17.4	-	-	-	132.0	
E15	25'-27'	Stiff grey silty clay inter- )	-	15.8	-	-	-	-	Approximately 6% fine medium gravel throughout
E16	30'-31'6"	bedded with 1/2" to 2" sand ) seams between 25'-0" to 32'-0"	17	19.4	-	-	-	131.6	
E17	35'-36'0"	Medium stiff grey silty clay.	20	22.2	-	-	-	-	
E18	40'-42'	Soft to med. grey silty clay.	-	21.4	-	-	1250	122.2	
E21	3'-5'	Stiff brown silty clay.	-	18.8	-	-	3950	128.0	
E22	6'-8'	" " " "	-	19.4	-	-	2540	127.4	
E23	9'-11'	" " " "	45	21.2	-	-	3240	124.5	
E24	15'-17'	Stiff grey silty clay.	-	18.1	-	-	2150	128.2	
E25	20'-22'	" " " "	-	17.2	15.0	27.6	-	132.0	
		T1 - denotes thin walled Shelby sample. S1 - denotes split spoon sample.							
		Consolidation Characteristics:-							
		Depth: 0'-35' - Coefficient of volume compressibility .....							0.007 sq. ft./ton.
		Coefficient of consolidation .....							0.14 sq. ft./day.
		Depth: 35' and below - Compression Index .....							0.18
		Coefficient of consolidation .....							0.0875 sq.ft./day.
		Preconsolidation pressure .....							Submerged unit weight x depth (normally consolidated)

ELEVATION IN FEET



DEFECTS IN NEGATIVE DUE TO  
CONDITION OF ORIGINAL DOCUMENT

Mr. S. McCobbie

June 17, 1960

Bridge Planning Engineer

Foundation Section

Amleigh Twp. Bridge #15, Hwy. 401,  
Dist. 1. Review of Preliminary  
Plan W.F. 69-5.

Attention: Mr. G. Scott  
Bridge Locations Engineer

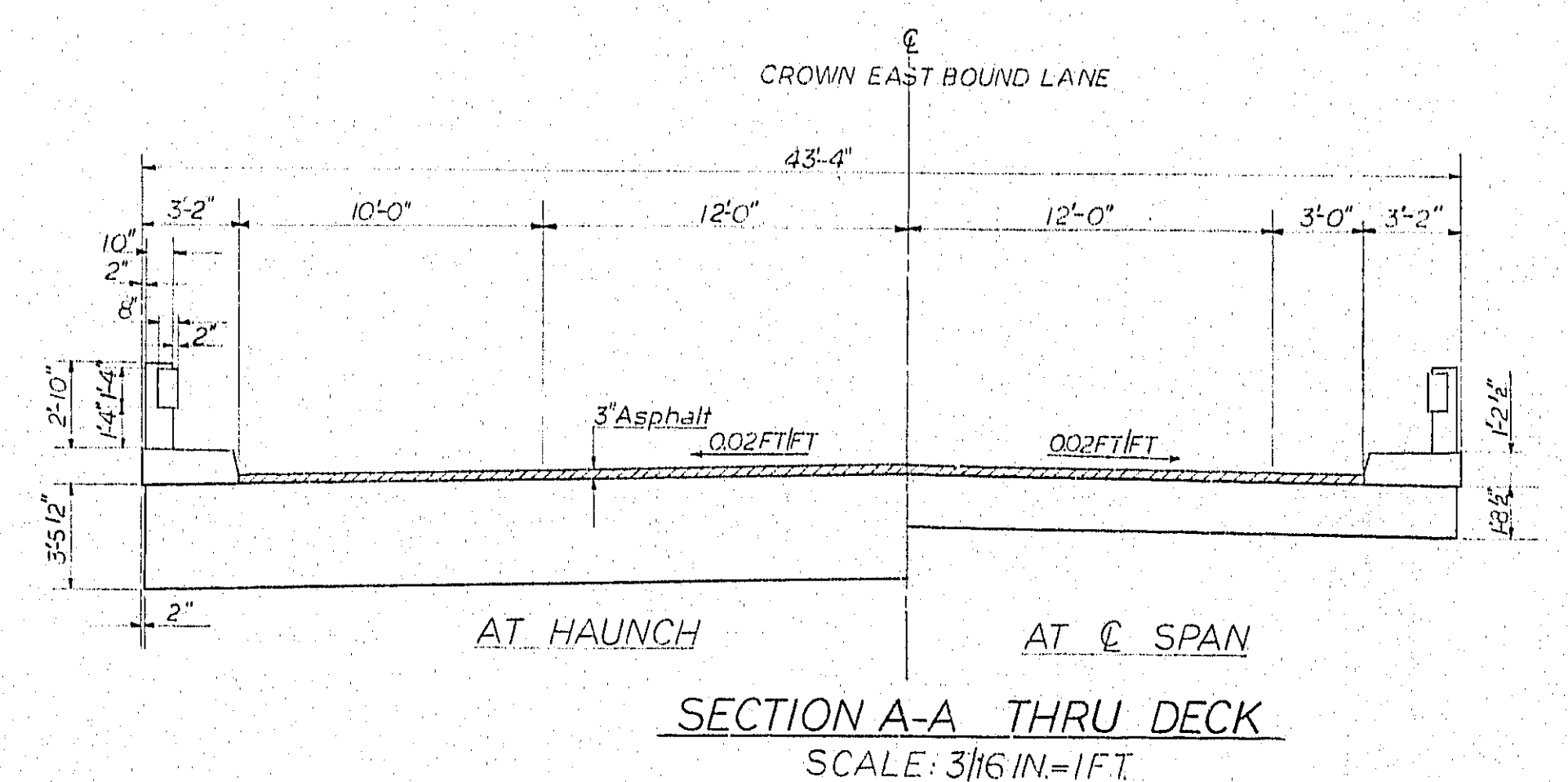
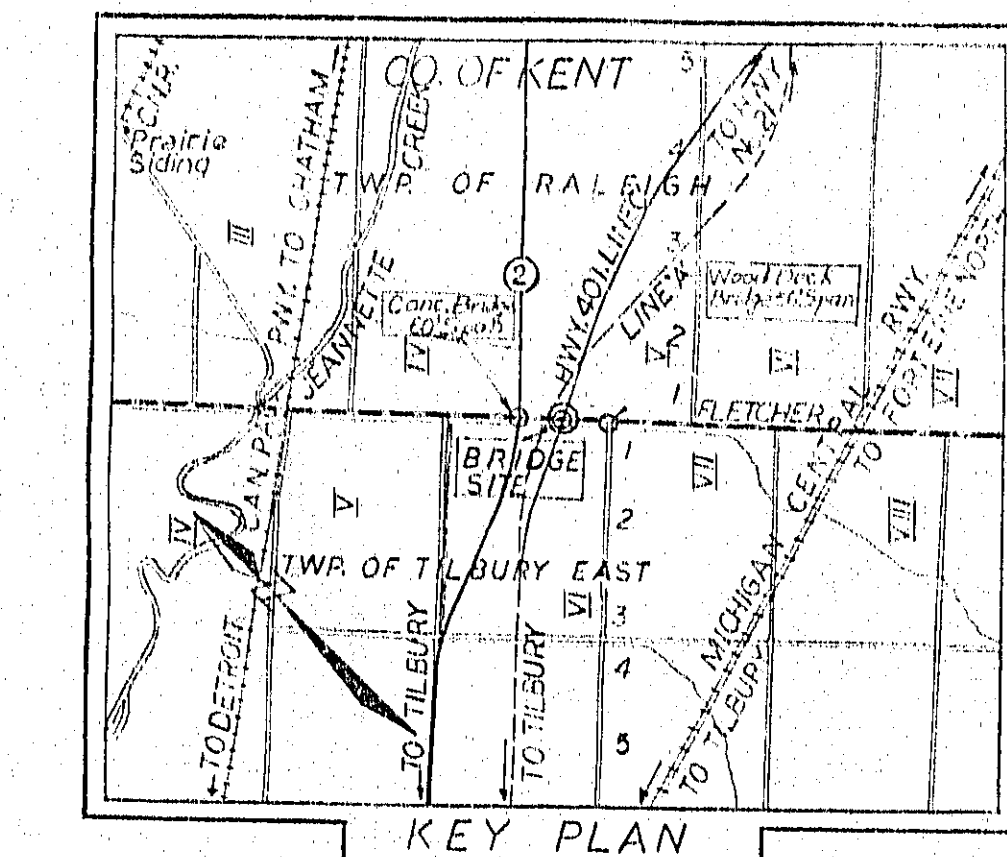
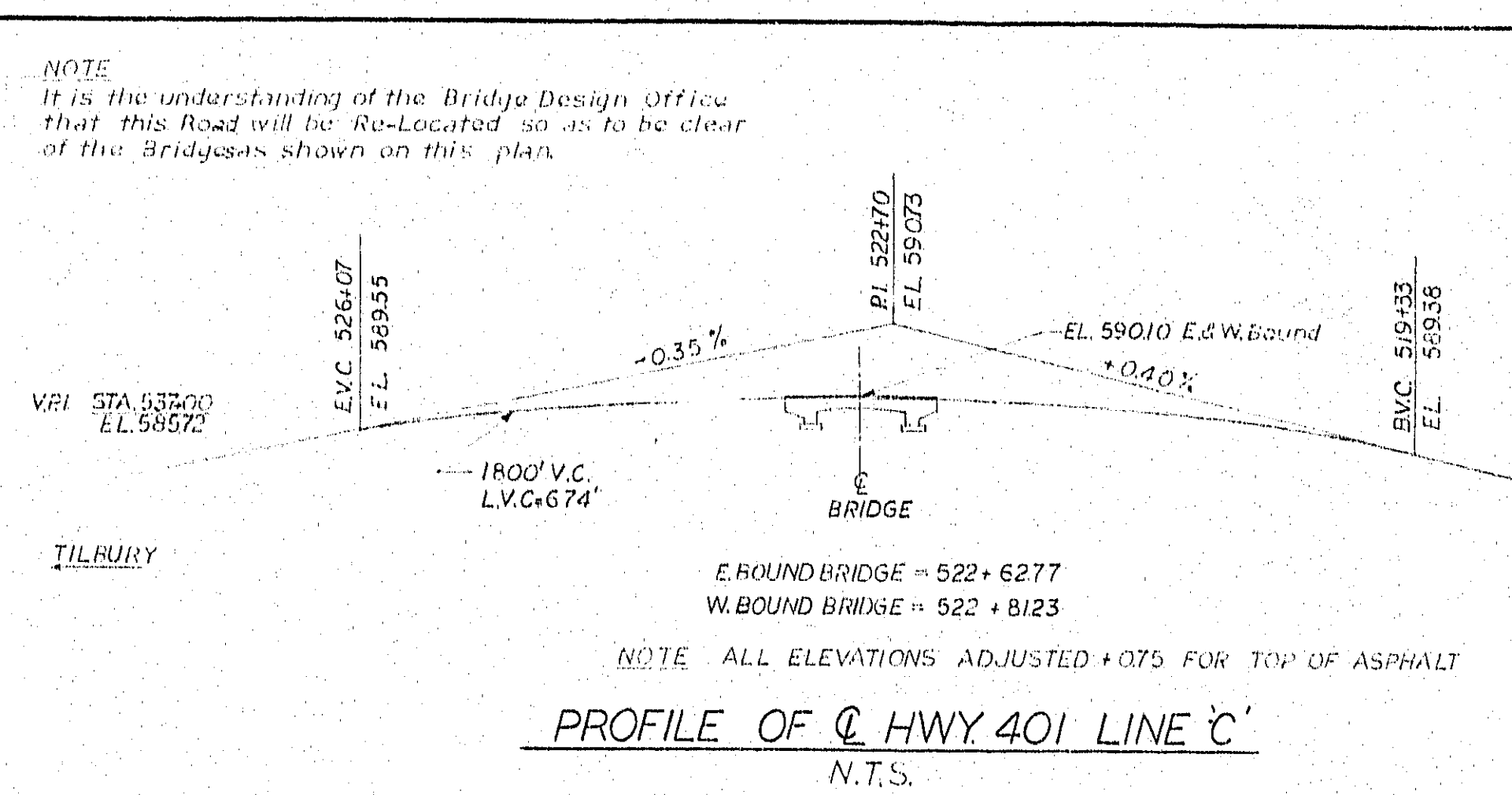
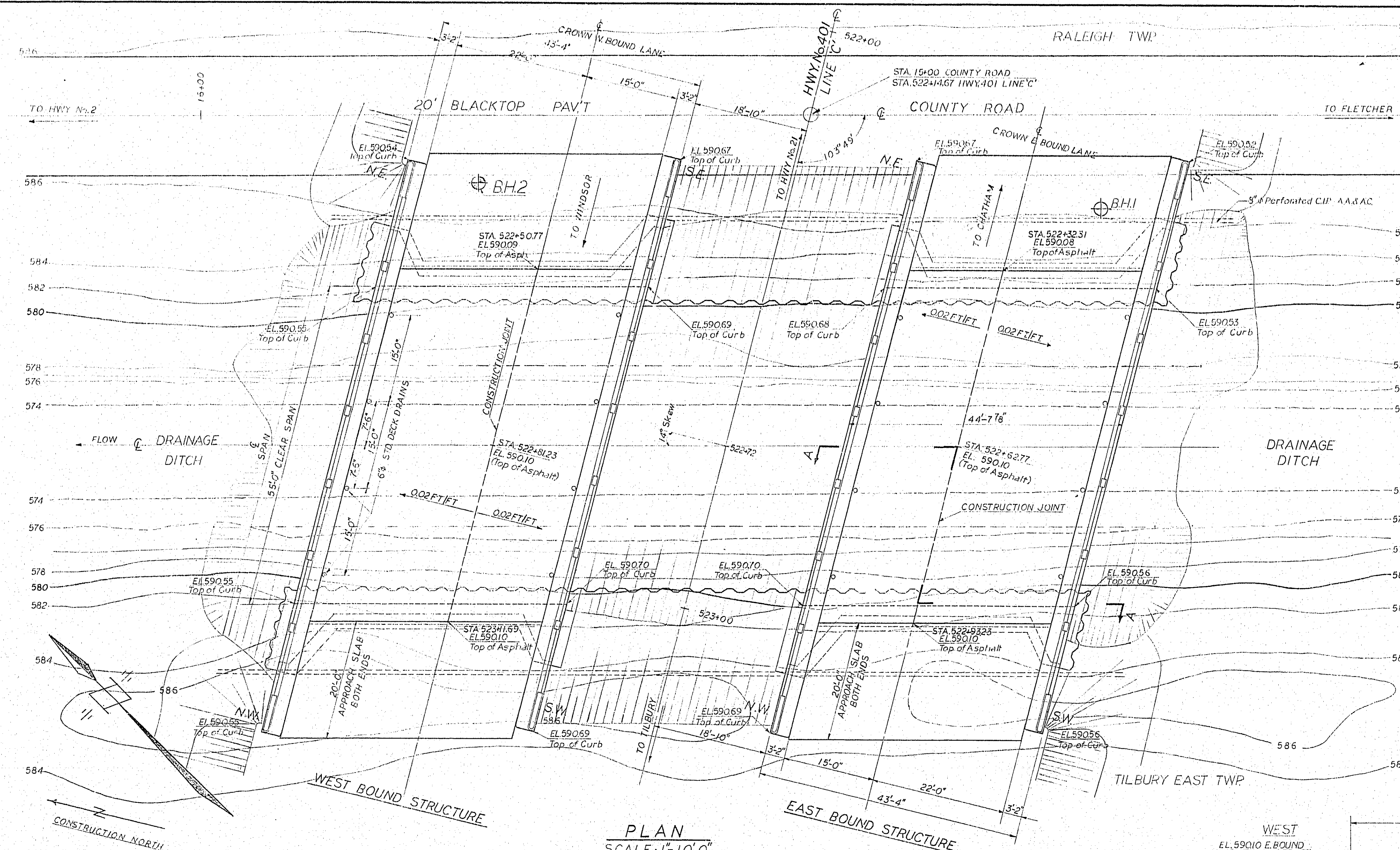
We have reviewed Preliminary Drawing No. D-4647-P showing the proposed general arrangement of the design details at the above noted structure location. The foundation design is in agreement with the recommendations contained in our report P59-13. According to the proposed arrangement the height of fill under the grade line of the gravel road is approx. 25 ft. The subsoil can safely support this embankment loading. Since the recommended footing placement elevation is at 577', only 5 ft. below the existing ground surface, we do not recommend a raise of the footing placement depths.

L.G. Soderman  
Principal Foundations Engineer

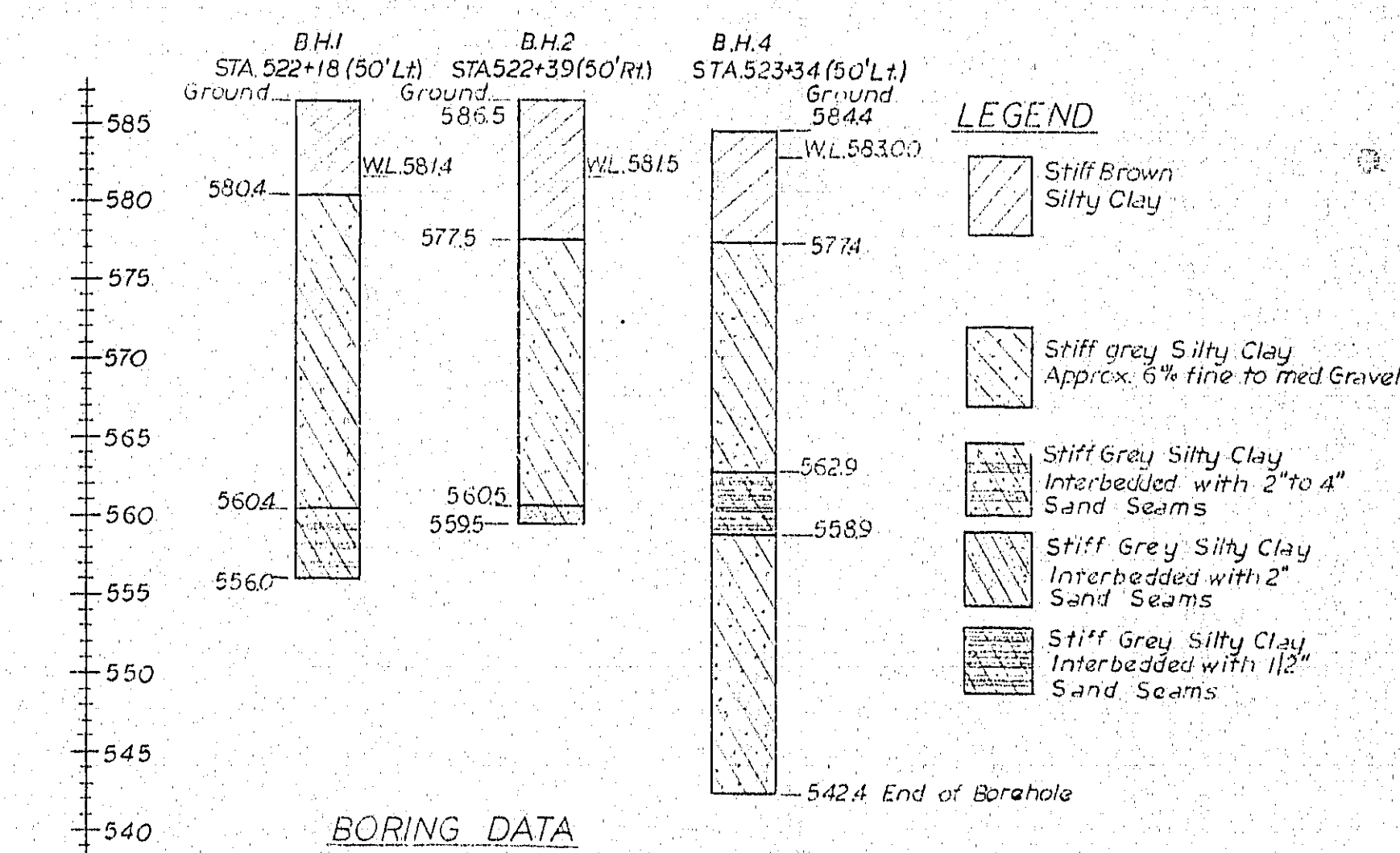
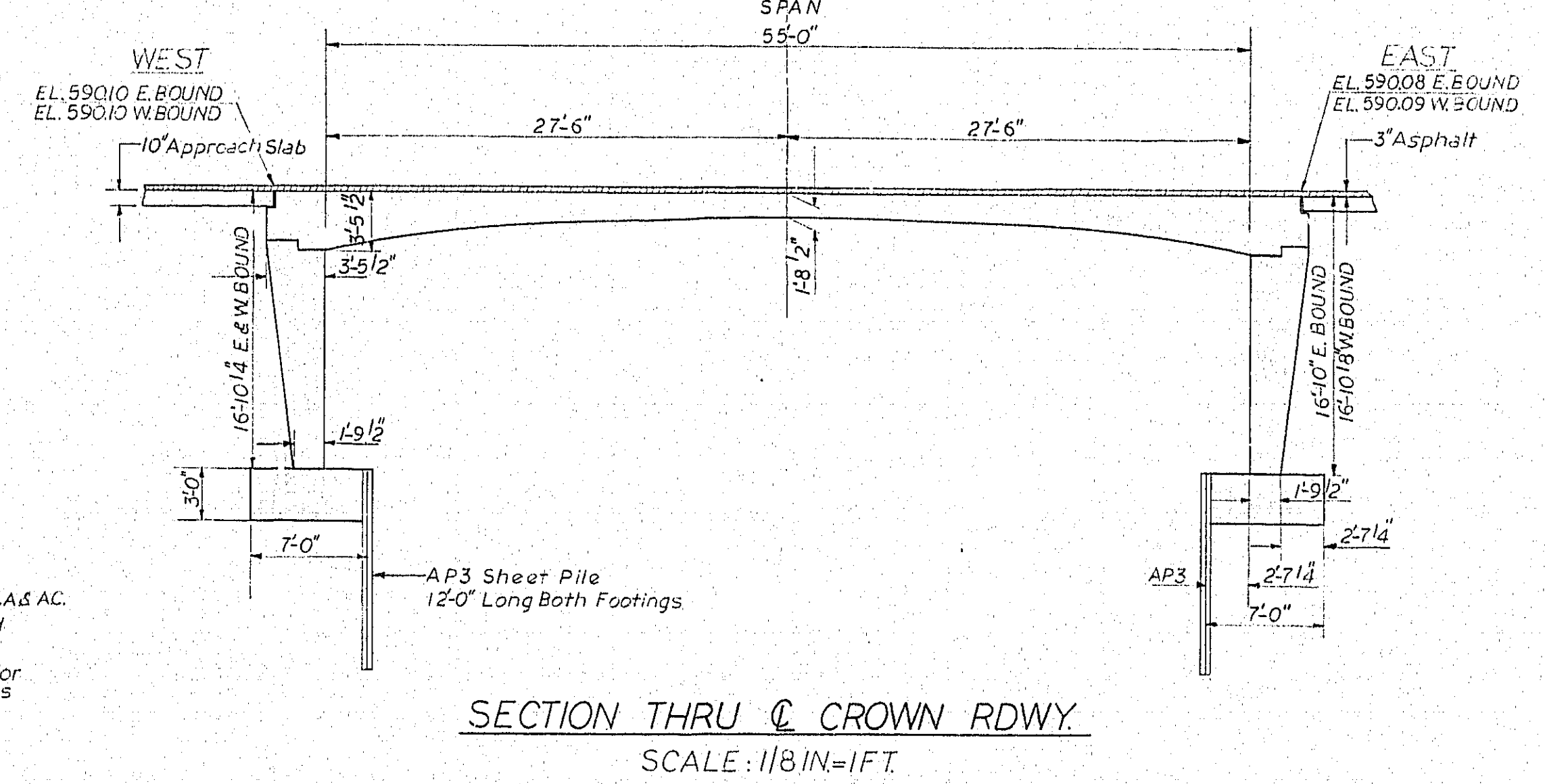
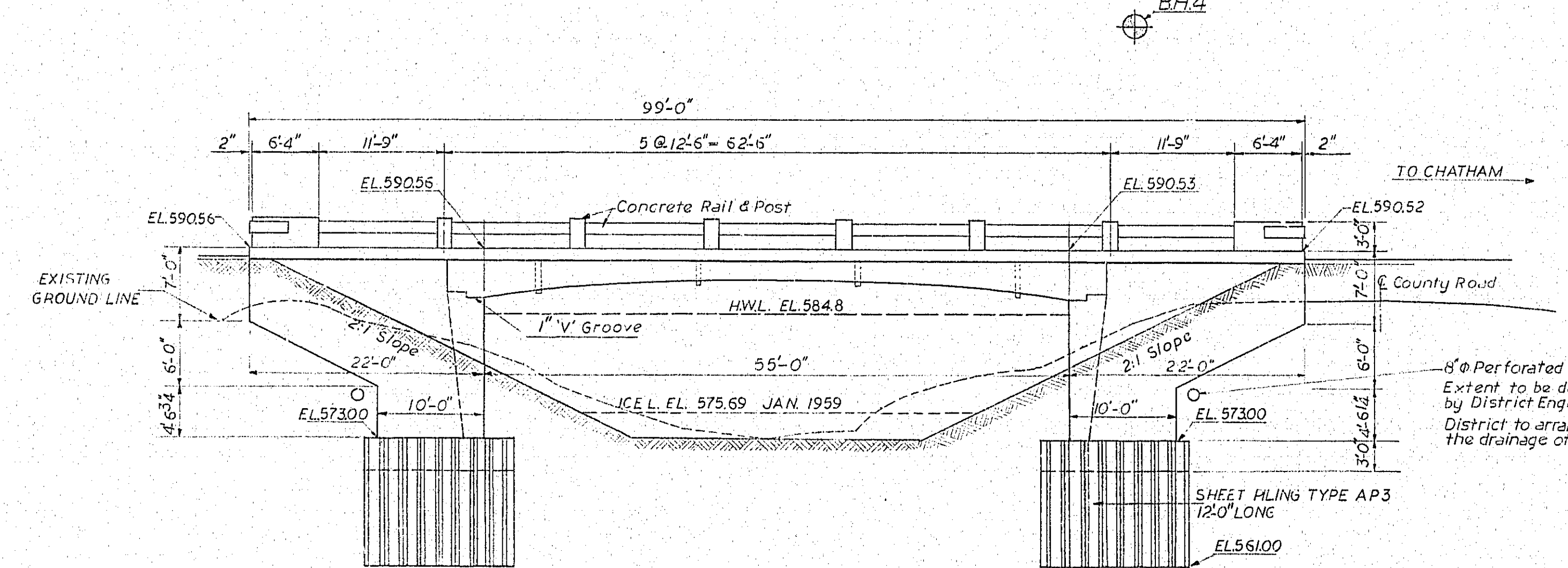
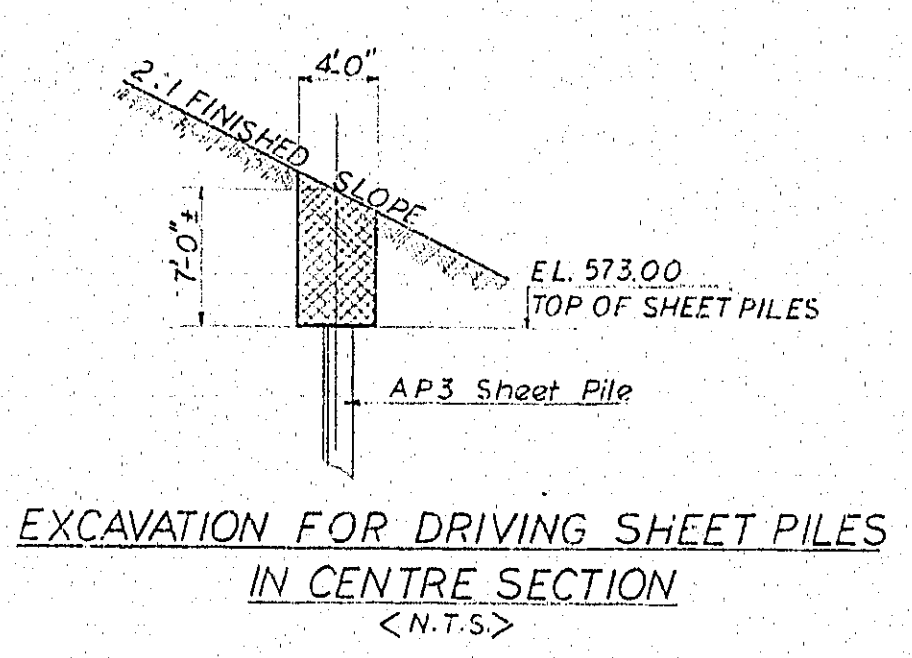
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c.c. to Plan. Section  
Files

*AKCL*  
per: A.K. Loh  
Foundations Engineer





**NOTES**  
**CONSTRUCTION NOTES:**  
 1. All exposed edges to be chamfered 1" unless otherwise stated.  
 2. Footing concrete to be poured against undisturbed soil.  
 3. Falsework supporting the deck must not be removed until backfill behind the abutments has been placed.  
 4. Backfill should be placed simultaneously at both ends if possible.  
 5. Do not remove falsework supporting wingwalls until curbs have been poured & attained 28 day strength.  
 6. Contractor to cut off deck drains 3" below concrete.  
**NOTE TO DISTRICT ENG.:** Concrete work on this structure must not be commenced until monuments to fix control points have been erected & checked by the Dist. Eng.  
**NOTE TO CONTRACTOR:** Structure to be built in accordance with Form No. 9 & the Special Provisions, extra copies of which may be obtained from the District Engineer.  
**REINFORCING STEEL:** (Minimum Cover): 3" to surfaces in contact with earth & water, 2" elsewhere. Deck & guardrail as shown.



- LIST OF DRAWINGS**  
 D-4367-1: GENERAL PLAN & ELEVATION  
 D-4367-2: FOOTINGS, WINGWALLS & ABUTMENTS  
 D-4367-3: FRAME CURB, APPROACH SLAB & HANDRAILS  
 D-4367-4: REINFORCING STEEL SCHEDULE  
 D-4367-5: DO

SKEW= 14° 00' 00"  
 Sin= 0.2419219 Cosec= 4.1335655  
 Cos= 0.9702997 Sec= 1.0306156  
 Tan= 0.2493280 Cot= 4.0107099

W.P. 10-59  
 DEPARTMENT OF HIGHWAYS-ONTARIO  
 BRIDGE OFFICE-TORONTO  
 TILBURY EAST TOWNSHIP BRIDGE No. 2  
 THE KING'S HIGHWAY No. 401 DIST. No. 1  
 CO. KENT  
 TWP. TILBURY EAST LOT 1 CON. VI  
 GENERAL PLAN & ELEVATION  
 APPROVED  
 BRIDGE ENGINEER  
 DESIGN ENGINEER  
 DESIGN A.W. CHECK F.G. CONTRACT NO. 61-207 13-254 60-25  
 DRAWING A.T. CHECK F.G. LOADING H-20 S-16  
 TRACING CHECK  
 DATE AUGUST, 1959  
 D-4367-1

NO.	FOR	DATE
1	DESIGNED	11-10-58
2	BY	11-10-58
3	CHECKED	11-10-58
4	APPROVED	11-10-58

REVISIONS	DATE	BY	DESCRIPTION
1			
2			
3			





## **APPENDIX B**

### Site Photographs



**Photograph 1:** Looking north at the Government Drain Bridge #1 EBL Structure from the south bank. The north and south slopes adjacent to the structure were densely vegetated. No scouring and erosion were observed. (October 20, 2013)



**Photograph 2:** Looking at east abutment of the structure from the adjacent south slope of the west abutment. Concrete surface deterioration including concrete spalls and cracks were observed. It was noticed that very few vegetation was growing in front of the abutment. Slight scouring effect of the exposed earth was observed at the abutment wall. No rock protection was observed. (October 20, 2013)



**Photograph 3:** Looking at west abutment of the structure from the adjacent north slope of the east abutment. Slight scouring effect was observed at the abutment wall location. No rock protection was observed. Water was at about 0.1 m deep close to the abutment wall. (October 20, 2013)