FOUNDATION TECHNICAL MEMORANDUM

For

BAPTISTE CREEK BRIDGE EBL ON HIGHWAY 401
MTO WEST REGION 59 STRUCTURE REHABILITATIONS
SITE 13-188-1, 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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CONSULTING ENGINEERS

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For
Baptiste Creek Bridge, EBL, Highway 401
MTO West Region 59 Structure Rehabilitations
Contract 7, GWP 3084-11-00
Township of Tilbury East
Kent County, Ontario

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1. INTRODUCTION

The Foundation Engineering Service 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 GEOCRES Library of the Baptiste Creek Bridge EBL. 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 rehabilitation of the bridge structure is anticipated and that the rehabilitation will be completed in a single stage construction 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.

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BARRIE, HAMILTON, KITCHENER, TORONTO

2. PROJECT SITE BACKGROUND AND GEOLOGY

The Baptiste Creek EBL Bridge on Highway 401 is located 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 Baptiste Creek runs from a southerly to northwesterly direction. Flat cultivated fields lie in the vicinity of the bridge structure. It is not known whether the Baptiste Creek is a man-made drainage and irrigation channel; however, improvement had been made at some time in the past.

The topography is very flat, and surface drainage is generally poor in the entire Tilbury area. Physiographically, the site is located in the St. Clair Clay Plain, which consists of a flat and relatively deep typically very stiff clayey silt and silty clay till deposits. The shale/limestone bedrock in the area belongs to the Hamilton Group of Middle Devonian period.

3. SOURCE OF INFORMATION

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

1. Report on Soil Site Investigation at Highway 401 – Baptiste Creek Crossing, W.P. 164-58, Tilbury East by E.M. Peto Associates Ltd. for Department of Highways of Ontario, dated February 19, 1959, GEOCRES NO. 40J08-018. (Reference 1)

2. General Arrangement – Tilbury East Township Bridge No. 8 Over Baptiste Creek, The King's Highway no. 401, Co. of Kent, District No. 1, Lot II, Con. V, Township East Tilbury, TWP 104-188-1-A, W.P. 164-58, Department of Highways Ontario, dated May 1959. (Reference 2)

4. SITE RECONNAISSANCE

As part of the current foundation engineering assessment study, a site reconnaissance of the Baptiste Creek Bridge EBL (Photograph 1) was carried out on October 20, 2013. A photographic record of the site visit is attached in Appendix B.

Retaining walls are constructed to confine the adjacent slope soil masses (Photographs 1 and 2). The slope faces were heavily vegetated. No obvious major cracks were observed on abutment walls except some surficial cracks (Photographs 1 to 3). The exposed earth in front of the east and west abutment walls was affected by scouring (Photographs 1 to 3). The weep holes in walls were open.

The creek water was about 0.3 m deep at the time of the site reconnaissance.

5. PREVIOUS FIELD INVESTIGATION AND SUMMARIZED SUBSURFACE CONDITIONS

The site is located on Hwy 401 in the Geographic Township of Tilbury East, Kent County, Ontario. The general subsurface conditions presented in this section are based on the Soil Investigation Report (Reference 1).

The original investigation was carried out for the proposed Highway 401 crossing of the realignment of Baptiste Creek with a single 15.2 m (50 ft.) span rigid frame structure on a 30^{o} skew.

The Soil Investigation Report includes the Borehole location plan (Drawing No.F3534-7), Record of Borehole sheets (1 to 4) and summary of the field and Laboratory tests.

The subsurface investigation was carried out in the period from January 6 to 15, 1959. The investigation comprised four boreholes which were advanced to depth 15.5 to 30.8 m, elevation 147.0 to 162.4.

The field investigation was carried out by means of a skid-mounted diamond drill rig. Samples were recovered ahead of the casing at frequent intervals with either a 50 mm (2 in.) or 75 mm (3 in.) O.D. split barrel sampling tube, Shelby tube or split barrel sampling tube fitted with brass liners and special sharp cutting nose.

Soil conditions encountered at the site location were uniform and are discussed below.

Topsoil (Organic)

A 300 to 455 mm thick surficial organic soil layer was encountered in all boreholes.

Weathered Surface Layer

In borehole 2, a stiff 1.5 m thick clayey silt layer was encountered below the topsoil which extended to elevation 176.3. Silty clay was encountered below the topsoil in boreholes 1, 3 and 4 and below the clayey silt in borehole 2 that extended 15.2 to 16.7 m, elevation 161.0 to 162.7. The upper 1.2 to 1.8 m of the silty clay and clayey silt appeared to be desiccated due to weathering actions on the silty clay beneath. However, the shape of the strength versus elevation and moisture content versus elevation curves (Appendix I in Reference 1) suggested that the desiccation of the silty clay extended with diminishing influence to a depth of approximately 15.2 to 16.8 m (50 to 55 ft.). The clayey silt in this stratum was generally non-plastic and the silty clay in this layer was drier than the plastic limit indicating it was not fully saturated.

N values recorded ranged between 10 and 32. The consistency of the layer was stiff to very hard; however, the general consistency was very stiff. Laboratory shear strengths obtained typically ranged from 210.4 to 49.7 kPa (4395 to 1038 psf). The Atterberg liquid limits ranged from 31.6 to 36.4 and plastic limits ranged between 18 and 19.2 for the desiccated silty clay samples. The plasticity index ranged from 13.6 to 17.2. In addition, the shrinkage limits of two samples from borehole 2 and borehole 4 obtained were 15.6 and 16.5, respectively. Unit weight of the upper silty clay samples varied from 20.1 to 21.3 kN/m^3 (128.3 to 135.8 pcf). Moisture content determinations ranged from 15.2 to 24.4%.

Silty Clay

Below the desiccated silty clay a deposit of stiff to firm silty clay that was probably laid down by two successive glacial lakes was encountered and extended to a depth of approximately 25.0 m below surface. Boreholes 1, 3 and 4 were terminated in this deposit at 15.5 to 18.5 m, elevation 159.5 to 162.4.

The silty clay of this layer was plastic and contained fragments of black shale and Devonian limestone derived from the underlying bedrock in the area. This silty clay layer contained approximately 44 to 46% clay, 40% silt, and 14 to 16% gravel and sand sized particles. The upper half of this stratum tends to be stratified.

The Atterberg limits throughout the silty clay stratum were very consistent. However, the natural moisture contents varied in relation to the limit parameters. The soil was found to be only slightly wetter than the plastic limits near its top boundary but below the 15.4 m depth the natural moisture content assumed a near constant value in between the liquid and plastic limits. It was determined that the silty clay soil was fully saturated by volumetric analyses.

A consolidation test was carried out on an undisturbed 75 mm (3 in) diameter sample from the 7.6 m depth in this stratum, corresponding to the middle of the 15.2 to 16.8 m desiccated zone. A small degree of over-consolidation was indicated. A steep rebound slope was obtained indicating that the soil would tend to swell upon removal of existing overburden stresses. The upper 15.2 m of the silty clay layer was of low compressibility. The corrected compressive index obtained was in the order of 0.104 to 0.130. The soil appeared to be of low to medium compressibility below 15.2 m. Laboratory shear strengths obtained typically ranged from 38.5 to 51.0 kPa (804 to 1065 psf).

N values recorded ranged between 6 and 13 which corresponded to the consistency state of firm to stiff. The Atterberg liquid limits ranged from 33.6 to 38.2 and plastic limits ranged between 18.4 and 20.0 for the lower silty clay samples. The plasticity index ranged from 14.6 to 18.2. Unit weight of the lower silty clay samples varied from 20.1 to 20.2 kN/m^3. Moisture content determinations ranged from 24.2 to 33.3%. The average wet density of the silty clay was determined to be 2.1 Mg/m^3 (132.9 pcf) above 15.2 m and 2.1 Mg/m^3 (128.6 pcf) below 15.2 m. However, only the submerged unit weights are effective below elevation 175.1 (574.5 ft.)

Sandy and Silty Clay, gravel

Below 24.8 or 25.9 m at this site, a soil stratum was encountered that was deposited by an earlier glacial lake, Lake Maumee. The layer was encountered in borehole 2 at 24.8 m, elevation 152.9 and extended to the termination depth of the borehole 30.8 m, elevation 147.0. Geologically, this soil is a clay till. This soil differs from the silty clay above only in that it has more frequent and larger rock fragments and contains some very fine sand. N values recorded ranged between 10 and 13, indicating a stiff consistency. One moisture content obtained was 33.3%.

The deepest borehole (borehole 2) at this site was terminated at 30.8 m, elevation 147.0, and did not completely penetrate the clay till. However, the report suggested that the total thickness of silty clay and clay till is approximately 36.6 m and the soil then becomes a very dense sandy till.

Groundwater

The soil at this site was found to be saturated virtually throughout its full depth, with exception of some 2.4 to 3.0 m of surface. The average ground surface elevation at this site was 177.9, the creek water level was at elevation 175.1, and the level of Lake St. Clair was approximately at elevation 175.3 at the time of investigation. Due to of the impermeability of the clay soil, the water level was not established. Therefore, it was assumed that the true ground water table coincides with either Baptiste Creek water level or the level of Lake St. Clair.

6. FOUNDATION

6.1 Previous Foundation Recommendations

Engineering Considerations

1. At the time of the previous investigation, it was proposed to dig a major diversion of Baptiste Creek to straighten the alignment and widen the channel to a width of approximately 12.2 m (40 ft.). Further, the proposed Highway 401 alignment was to cross the new diversion at a small skew and the final elevation of the highway at the crossing would have been at elevation 178.7 (586 ft.), only 0.9 m (3 ft.) higher than the original grade at the time of investigation.

2. The usual corrections for sample disturbance could not be applied properly to the consolidation test e-log p curve; however, a good approximation of the true field compression curve was obtained. The compressive index was taken as the slope of the virgin branch of the e-log p curve.

3. The shear strength properties of the silty clay, particularly of the upper 'crust', were deemed to provide sufficient soil bearing capacities to support a bridge structure. The additional subsoil pressure due to the highway approach embankments would be very small magnitude, which were to only be about 0.9 m (3 ft.) high and was not considered. A safety factor of 4 was recommended considering the settlement for the following reasons:

   a) The resulting allowable bearing pressure would still be of sufficient magnitude so that very large footing sizes would not be required.
   b) The static yield or creep value of the soil would not be exceeded; thus, minimizing the settlement. It was considered that the primary compression would still occur due to elimination of pore water; however, the secondary compression was precluded due to rearrangement of the soil particles.

   The recommended allowable bearing pressure ($q_{allowable}$) of large rectangular footings under the bridge at this site would be given by the equation $q_{allowable} = 5.7(C/S.F.)(1+0.3(B/L))$, where a value for the ultimate soil shear strength C = 120 kPa (2500 psf) was suggested. With a safety factor (S.F.) of 4, the equation becomes:

   $$q_{allowable} = 3515(1+0.3(B/L)) \text{ p.s.f or } q_{allowable} = 168\ (1+0.3(B/L)) \text{ kPa;}$$

   Where B = Width of rectangular footing; L = Length of footing

   No additional bearing capacity due to surcharge was to be allowed because of the proximity of the footings to the new stream channel.

4. Total settlements could be considerable if the allowable loading given above was to be fully utilized, since the net new load on the soil was considered to be fully equal to the applied footing pressure, and almost all of the soil consolidation would take place along the virgin compression branch.

   For footings at elevation 173.7 (570 ft.), the thickness of the compressible silty clay was approximated to be 22.9 m (75 ft.). The settlement of the sandy and silty clay till at depth was considered negligible.

   The settlement in the silty clay stratum was considered to be a very long-term process due to the drainage boundary conditions. The underlying clay till was considered to be relatively impermeable.

Recommendations and Conclusions

1. The soil report stated that a large multi span reinforced concrete box culvert may be suitable for this site.

2. However, if a bridge structure was to be used, the report recommended it should be a statically determinate type to avoid danger of settlement. Scour was not considered serious in this area; therefore, the report recommended bridge footings might be placed at or slightly lower than the elevation of the new stream channel bed.

   For large rectangular spread footings, safe allowable pressure capacity in the order of 167.6 kPa (3500 psf) was recommended.

3. Although differential settlements between the two ends of the bridge was considered to be small due to the uniformity of the soil stratification, considerable differential settlement between the bridge and the approach embankments was expected.

4. The report indicated that if a culvert was not considered, the new stream channel should be excavated with side slopes of 2:1 and revetment of the slopes for scour protection would not be required.

5. No construction problems were anticipated at this site. It was anticipated that excavation, even below the stream water level, could be maintained in a dry condition because of the impermeable nature of the cohesive soil.

Based on the drawing titled “General Arrangement - Tilbury East Township Bridge No.8 over Baptiste Creek” dated May 1959, the footings of the bridge were to be founded at approximate elevation 173.4 (568.8 ft.). Further, the steel sheet piling was to be driven to approximate elevation of 170.8 (560.25). The original ground slopes adjacent to the realigned creek were shown to be cut back at 1.5H:1V at the bridge site location.

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 (psf)[1]	Previous Equivalent Limit State Design Values		Limit State Design Values Updated to current industry practices[2]	
			Geotechnical Reaction SLS (kPa)	Geotechnical Resistance Factored ULS (kPa)	Geotechnical Reaction SLS (kPa)	Geotechnical Resistance Factored ULS (kPa)
East Abutment on Spread Footing	173.4 (569 ft.)	3500	167.6	250	300	450
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 Baptiste Creek Bridge EBL is not expected provided that the dead load on the bridge does not increase or decrease by more than 10%.

It is understood that rehabilitation of the bridge structure is anticipated and the rehabilitation will be completed in a single stage of construction using median crossovers.

Furthermore, it is suggested that the weep holes in 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 and retaining walls.

In addition to rehabilitating the bridge, the exposed earth in front of the abutment walls may be protected 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. Nazibur Rahman, P.Eng with the assistance of Mr. Mansoor Khorsand, EIT and was reviewed by Mr. Robert Ng, PhD, P.Eng. 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,

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

NR/RN/BRG:jk

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

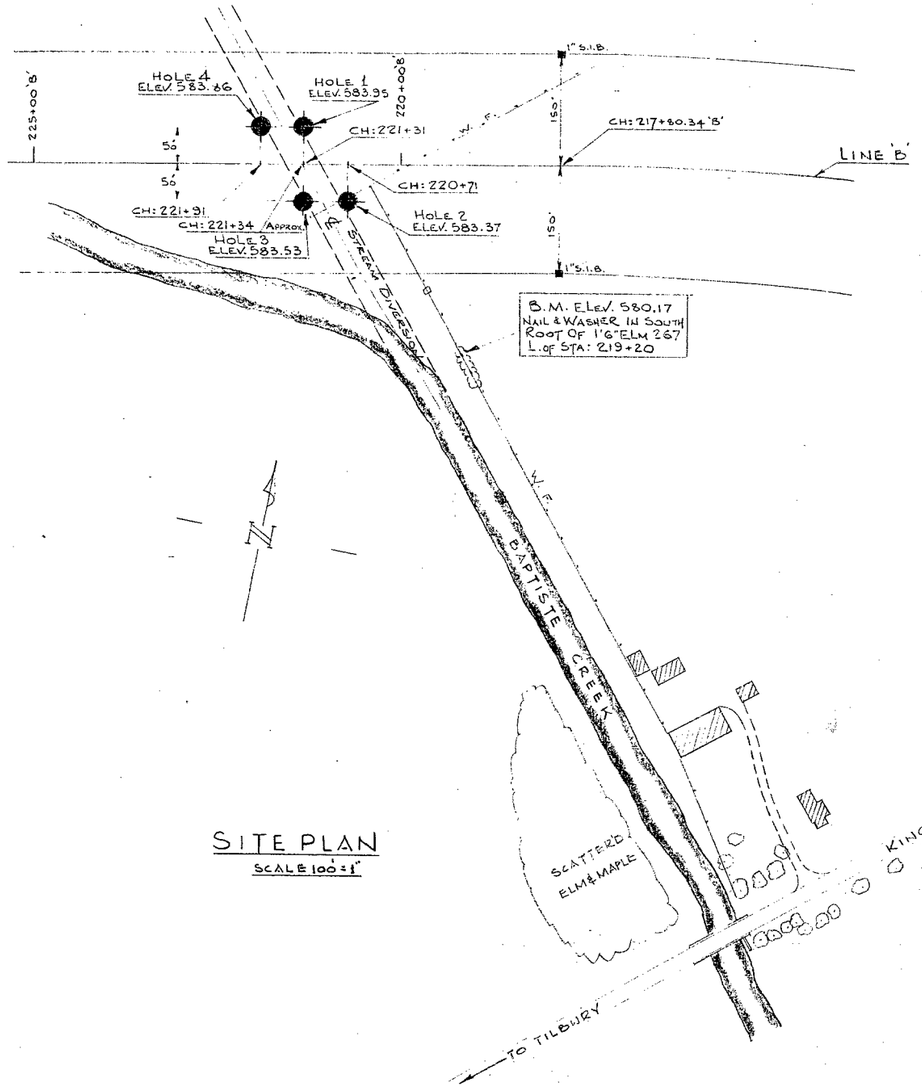
Figure 1 – Key Plan

APPENDIX A

Foundation Report at Baptiste Creek (GEOCRES 40J08-018)

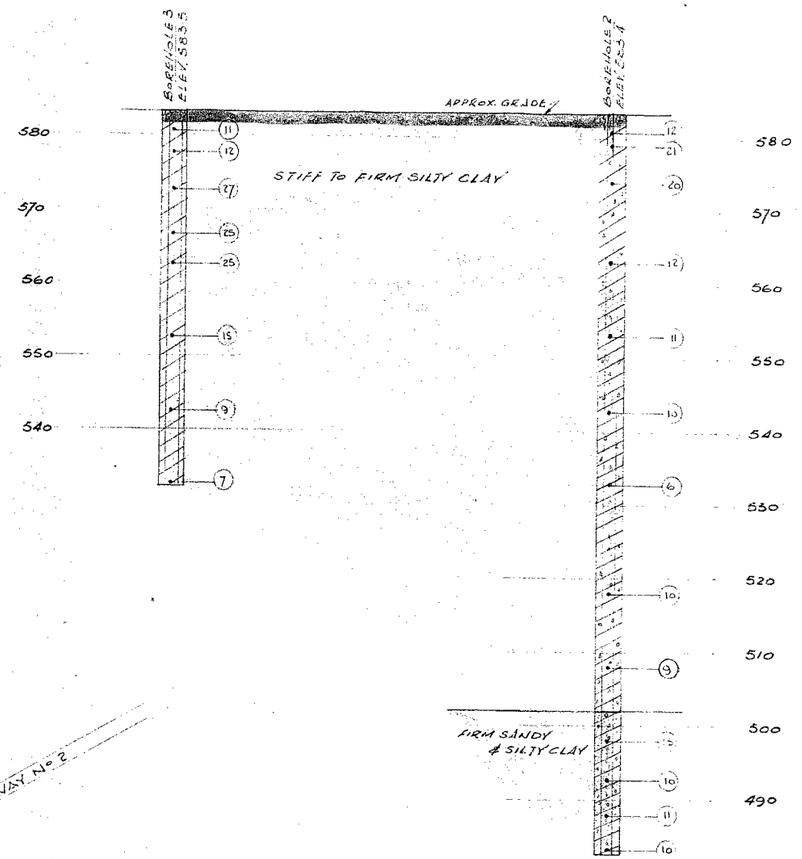
General Arrangement – Tilbury East Township Bridge No. 8 over Baptiste Creek, dated May 1959

#59-F-206C
W.P.#164-58
HWY.#401
BAPTISTE
CREEK
CROSSING
TILBURY EAST



SITE PLAN

SCALE 100 : 1"



SECTION THROUGH HOLES 3 & 2

PROFILE SCALE VERT 10 : 1"
HOR 10 : 1"

LEGEND

BOREHOLE

20 — BLOWS / FOOT

REGISTERED PROFESSIONAL ENGINEER
E. M. PETO
PROVINCE OF ONTARIO

e.m. peto & associates ltd.

SOIL SITE INVESTIGATION
AT
HWY. 401-BAPTISTE CREEK CROSSING
(WORKS PROJECT 164-58)
FOR
DEPT. of HIGHWAYS of ONTARIO

OUR JOB No.- 58100 DATE- 16 FEB 1959
CLIENTS PLAN No.: F3534-7 PER.- C.J.W. & G.T

e. m. peto associates ltd.

850 roselawn avenue,
TORONTO 19, ONTARIO.
RUssell 1-4955.

YOUR REFERENCE:-

OUR REFERENCE:- 58160

March 5th, 1959.

The Department of Highways of Ontario,
Bridge Design Office,
280 Davenport Road,
Toronto, Ontario..

For the attention of Mr. J.C. McAllister.

Re: Soil Investigation
Hwy. 401 - Baptiste Creek Crossing
W.P. 104-58, Tilbury East.

Dear Sir,

As requested by Mr.L. Soderman of the D.H.O. Foundation Section, we have reviewed our report for the above project. In order that our approach be realisti we have fully discussed the design requirements with the Consulting Engineers for this structure, A.D. Margison and Associates Limited,.

The bridge will probably be a single, 50 foot span rigid frame structure, on a 30° skew. Differential settlements of up to 2 or 3 inches could be tolerated. The absolute maximum footing elevation will be elevation 571.0, two feet below stream bed, and the most probable footing position will be elevation 569.0. The footing depth is governed by frost protection requirements, and by recommendations made in the D.H.O. hydrology report. It should be noted that our original report correctly anticipated the footing elevation.

An approximation obtained from the Consultants of the end reaction at each end of the bridge, considering full dead load plus some provision for live load, etc., is 1200 kips. The long dimension of the footings is virtually fixed at 53 feet.

We present below a table of values for footings at elevation 570.0. No additional bearing capacity due to surcharge is considered because of the proximity of the footings to the creek.

Footing Dimension	Actual Soil Pressure at Base of Footing P.S.F.	Actual Safety Factor against Shear Failure if C=2500 P.S.F.	Maximum Theoretical Settlement under Centre of Footing:-INS.
53' x 4'	5000	2.58	0.42"
53' x 6'	3780	3.90	
53' x 7'	3240	4.57	6.35"
53' x 8'	2835	5.26	
53' x 10'	2203	6.74	0.10"

The foregoing table of values points out rather clearly the fact that under the given magnitude of load the settlements will be nearly the same, regardless of the unit soil pressure. We would consider that a permanent factor of safety against shear failure of 2.58 is ample for this site. Therefore any footing dimension within the range given in the table may safely be used.

Differential settlements between the two ends of the bridge should be small, although the fact that the bridge will be built on a skew tends to aggravate this condition.

Some differential movement between the bridge abutments and the highway embankments behind them will probably also develop with time.

We trust that this letter will provide the Consultants with the additional information required for their design.

Yours very truly,

E. M. PETO ASSOCIATES LIMITED.

EMP/fh.

E.M. Peto, P. Eng.

AN INDEPENDENT ORGANIZATION PROVIDING A COMPLETE SOIL ENGINEERING & INVESTIGATION SERVICE

e. m. peto associates ltd.

YOUR REFERENCE:-

OUR REFERENCE:- 58160

850 roselawn avenue,
TORONTO 19, ONTARIO.
RUssell 1-4955.

February 20th, 1959.
59 - F - 206 c

Bridge Office,
Department of Highways of Ontario,
280 Davenport Road,
Toronto, Ontario.

Re: Soil Investigation
Hwy. 401 - Baptiste Creek Crossing
W. P. 164-58, Tilbury East

Attention: Mr. J. C. McAllister

Dear Sirs;

We are pleased to submit herewith four copies of our soils report for the above project. This is not a problem site, and the only matter of concern is the settlements which could potentially arise under a structure founded at or near the surface.

For your convenience we summarize briefly below our findings and recommendations.

1. The site is located on a very flat lacustrine clay plain, and the soils consist of water-laid sediments of extensive thickness.

2. The soil types encountered were:

a) A 4 to 6 foot thick surface layer of weathered silty clay and clayey silt with fine sand content, grits and pebbles. There is also some organic vegetable matter in the upper 12 to 18 inches. The soil is mottled grey-brown in colour, and is drier than the plastic limit. It is not subject to major volume changes accompanying soil moisture variation.

b) Approximately a 76 to 78 foot thick stratum of silty clay with grits, in a stiff to firm condition. The shear strength, C, of this soil is approximately 4000 p.s.f. down to elevation 562, and then drops off until a constant value of approximately 1000 p.s.f. is reached at elevation 524. This soil is of low to medium compressibility, and has been over-consolidated in the past.

c) A layer of sandy and silty clay till with grits, which occurs generally below the 82 foot depth, and probably extends to the 120 foot depth. This soil is grey in colour, firm to stiff in consistency, and probably has a very low compressive index. It may be assumed that very little, if any, consolidation of this stratum will take place.

3. Although the position of the ground water table could not be definitely established by the field crew due to the low permeability of the silty cl it may be assumed that the true ground water table coincides with the water level in Baptiste Creek or Lake St. Clair (approx. elevation 575). The soil is fully saturated below this elevation.

4. A large multi-span box culvert may be suitable at this site, and this alternative warrants consideration.

5. If a bridge is used we recommend that it be a statically determinate structure which could tolerate some differential settlement.

Such a bridge may be supported on large spread footings founded at or slightly below the new stream bed level. Safe allowable loadings in the order of 3500 p.s.f. may be used.

Total settlements under such loading can be considerable, but differential settlements should be small because of the uniform soil conditions.

6. If a culvert is not used, it would be preferable if the new stream channel is excavated with side slopes of 2:1.

7. There should be no undue construction difficulties at this site.

We believe this report to be complete, and to contain all the information you require. However, if we may be of any further assistance please do not hesitate to contact us.

Yours very truly,

E. M. PETO ASSOCIATES LTD.,

E. M. Peto, P. Eng.

THE DEPARTMENT OF HIGHWAYS OF ONTARIO

SOILS REPORT

for

HWY. 401 - BAPTISTE CREEK CROSSING

W.P. 164 - 58, TILBURY EAST

February, 1959

e. m. peto associates ltd.

e. m. peto associates ltd., 850 roselawn avenue, Toronto 19, Ontario

Job No. 58160 Client's Ref. No. Date February 19th, 1959.

Report on

SOIL SITE INVESTIGATION

at

HWY. 401 - BAPTISTE CREEK CROSSING

W.P. 164-58, TILBURY EAST

for

DEPARTMENT OF HIGHWAYS OF ONTARIO

INTRODUCTION:

We were retained, by letter from Mr. J. C. McAllister, dated December 2nd, 1958, to carry out a soils investigation for the proposed Highway 401 crossing of the re-alignment of Baptiste Creek. At the same time we were issued with D. H. O. profile F3534-8 and plan No. F3534-7, on which four suggested soil test holes were shown.

The object of the investigation was to determine:

a) the existing soil conditions at the site.
b) any pertinent ground water information.
c) the most suitable foundation types for the site.
d) any other factors affecting the design or construction of the proposed structure.

PROGRAMME OF WORK:

December 11th, 1959: Reconnaissance of site by Field Engineer. Test holes staked out, levels taken.
January 5th, 1959: Crew #2 moved to site from Little Baptiste Creek crossing.
January 6th, 1959: Field work commenced by crew #2.
January 13th, 1959: Crew #3 moved to site from Tilbury Creek crossing, commenced work at borehole 2.
January 15th, 1959: Field work completed by both crews.
January 16th, 1959: Crews loaded drills and equipment, travelled to Toronto.

GENERAL INFORMATION:

a) Our standard soil sampling procedures, described in Appendix II, were followed throughout the course of the investigation.

b) All samples obtained at the site were carefully examined, and tested as necessary, in our laboratory. Detailed individual borehole logs and a summary of the test results are appended, together with pertinent graphical data. A site plan showing the borehole locations is also attached.

c) The clay soil encountered is relatively impermeable, and it was not possible, during the limited duration of our work at this site to clearly establish the position of the ground water table. However, this is discussed in more detail in the section of the report sub-titled "Water Conditions".

d) All elevations in this report were obtained by using the D. H. O. bench mark near the site. This is a nail and washer in the South robt of a 1'6" elm tree 267 feet left of station 219 + 20. The elevation of this bench mark was taken to be 580.17 (Geodetic datum).

SITE AND GEOLOGY:

The site investigated lies on a cultivated, flat field adjacentto a bend in the Baptiste Creek, The topography is very flat, and surface drainage is generally poor in the entire Tilbury area. Although it is not known if Baptiste Creek is a man-made drainage and irrigation channel, it is obvious that some improvements have been made to its channel at some time in the past, and 3 to 8 foot high levees of excavated material flank the stream at some points along its course. It is unlikely that serious flooding of this stream could occur.

The site lies in the physiographic region known as the St. Clair Clay Plain, an area with extensive beds of water-laid sediments overlying a till plain.

SOIL CONDITIONS:

Soil conditions at this site are uniform, and are fairly consistent withresults obtained at the nearby Little Baptiste Creek crossing site. For this reason we have been able to reduce somewhat the amount of laboratory testing. The soil strata encountered were:

a) Weathered Surface Layer

This soil type, resulting from weathering action on the silty clay beneath, extends only to a depth of 4 to 6 feet. However, the shape of the strength versus elevation and moisture content versus elevation curves in Appendix I suggests that dessication of the silty clay, with accompanying overconsolidation as the effective intergranular stresses were increased, extended with diminishing influence to a depth of approximately 50 to 55 feet.

SOIL CONDITIONS:

a) Weathered Surface Layer (Cont'd)

The surface layer consists generally of a mottled grey-brown silty clay and clayey silt with fine sand content, and grits and pebbles. Organic vegetable matter is present in the upper 12 inches to 18 inches, which have been cultivated. The clayey silt in this layer is generally non-plastic, and the siltyclay drier than the plastic limit indicating that it is not fully saturated. The shrinkage limits of this soil and of the silty clay immediately beneath it were determined to be 16.5 to 16.6%, and therefore although some soil volume changes would accompany soil moisture variations, these would not be of a serious nature.

The unit weight of this soil for design purposes may be taken to be 125 p.c.f.

b) Silty Clay

Directly underlying the weathered surface layer, and extending to a depth of approximately 82 feet below surface, is a stratum of silty clay which was probably laid down by two successive glacial lakes.

This soil is a stiff to firm, plastic silty clay containing fragments of black shale and Devonian limestone derived from the underlying bedrock in the area. Typical gradings of this material are as follows: 44-46% clay, 40% silt, 14-16% grits and sand. The upper half of this stratum tends to be stratified.

The Atterberg limits throughout the silty clay stratum are very consistent, but it is the natural moisture content in relation to these parameters which varies. This soil is only slightly wetter than the plastic limit near its top boundary, but below the 50 foot depth the natural moisture content assumes a near constant value slightly less than half way between the liquid and plastic limits. By volumetric analyses it has been determined that the silty clay soil is fully saturated.

The soil shear strength, C, in the upper crust is approximately 4000 p.s.f. down to elevation 562, and the shear strength then reduces markedly until a constant value of approximately 1000 p.s.f. is reached below elevation 524. The soil has low sensitivity throughout.

A consolidation test was carried out on an undisturbed 3" diameter sample from the 25 foot depth in this stratum, corresponding to the middle of the 50 or 55 foot dessicated zone. Although the true pre-consolidation stress history of the soil was obscured (a peculiarity of the soil in this area, partly attributable to the content of grits and silt), a small degree of over-consolidation was indicated. A steep rebound slope was obtained, showing that the soil would tend to swell upon removal of existing overburden stresses. The upper 50 feet of the silty clay stratum is of low compressibility, with a corrected compressive index of the order of .104 to .130. The soil appears to be of low to medium compressibility below the 50 foot depth.

SOIL CONDITIONS:

b) Silty Clay (Cont'd)

The average wet density of the silty clay was determined to be 132.9 p.c.f. above the 50 foot depth, and 128.6 p.c.f. below the 50 foot depth, but because of the position of the ground water table only the submerged unit weights are effectivebelow elevation 574.5.

c) Sandy and Silty Clay, Grits

Beneath the 81'6" or 85 ft. depth at this site is a soil stratum deposited by an earlier glacial lake, Lake Maumee. Geologically speaking this soil is a clay till, and it differs from the silty clay above only in that it has more frequent and larger rock fragments, and contains some very fine sand. The clay till is firm to stiff in consistancy, and grey in colour. It probably has a low compressive index.

The deepest borehole at this site was terminated at the 101 foot depth, and did not completely penetrate the clay till. However, from comparison with results at two nearby bridge sites, we believe that the total thickness of silty clay and clay till is approximately 120 feet, and the soil then becomes a very dense, sandy till.

WATER CONDITIONS:

The soil at this site was found to be saturated virtually throughout its full depth, with the exception of some 8 to 10 feet at surface. The average ground surface elevation at the site is 583.7, and the stream water level was 574.5 at the time of our investigation. The level of Lake St. Clair is approximately 575 to the same datum.

Because of the impermeability of the clay soil no reliable ground water information was obtained during the short duration of our investigation on site. However, we must assume that the true ground water table coincides with either Baptiste Creek water level or the level of Lake St. Clair.

At the time our crews left the area, the four uncased holes at this site had remained fairly well open, and the final observed water levels ranged from 30 feet to 43 feet below ground surface.

ENGINEERING CONSIDERATIONS:

1. We understand that it is presently proposed to dig a major diverson of Baptiste Creek to straighten the alignment, and that the new channel is to be some 40 feet wide. Highway 401 will cross the new diverson on a small skew, and the proposed final highway elevation at the crossing is approximately 586, only 3 feet higher than existing grade.

ENGINEERING CONSIDERATIONS: (Cont'd)

2. The usual corrections for sample disturbance could not be applied properly to the consolidation test e-log p curve, but a good approximation of the true field compression curve was obtained, and the compressive index was taken as the slope of the virgin branch of this curve.

3. The shear strength properties of the silty clay, particularly of the upper "crust", are such as to provide ample soil bearing capacities to support a bridge structure. The additional subsoil pressure due to the highway approach embankments, which are only about 3 feet high, would be very small, and need not be considered. However, settlement is an important consideration, and it is our opinion that a safety factor of 4 should be used for the following reasons:

   a) the resulting allowable bearing pressure will still be of sufficient magnitude that very large footing sizes would not be required.

   b) the static yield or creep value of the soil would not be exceeded, thus minimizing the settlement. Primary compression due to elimination of pore water from the soil could still occur, but the possibility of secondary compression due to rearrangement of the soil particles would be precluded.

   The recommended allowable bearing pressure of large rectangular footings under either end of a bridge at this site would be given by:

$$q_{allowable} = \frac{5.70 \quad C}{S.F.} \left(1 + 0.3 \frac{B}{L}\right)$$

   From considerations of the shear strength profile, a value of C = 2500 p.s.f. may be used.

   Because of the proximity of the footings to the new stream channel, no additional bearing capacity due to surcharge is allowed.

$$q_{allowable} = 3515 \left(1 + 0.3 \frac{B}{L}\right) \text{ p.s.f.}$$

   Where B = width of rectangular footing
   L = length of footing.

4. Total settlements can be considerable if the allowable loading given above is fully utilized, since the net new load on the soil in this case will fully equal the applied footing pressure, and almost all of the soil consolidation will take place along the virgin compression branch.

ENGINEERING CONSIDERATIONS:

4. (Cont'd)

For footings at elevation 570, the underlying thickness of compressible silty clay would be approximately 75 feet. Settlement of the sandy and silty clay till at depth is considered negligible.

Settlement will be a very long-term process in the silty clay stratum, because of the boundary drainage conditions. The underlying clay till is relatively impermeable.

RECOMMENDATIONS AND CONCLUSIONS:

1. A large multi-span, reinforced concrete box culvert may be suitable for this site, and this possibility should be considered.

2. If a bridge structure is to be used, we recommend that it be a statically determinate type, because of the danger of settlement.

   Scour is not considered serious in this area and in a clay soil of this type, and therefore the bridge footings may be placed at or slightly lower than the elevation of the new stream channel bed.

   For large rectangular spread footings safe allowable loadings in the order of 3500 p.s.f. may be used.

3. Although differential settlements between the two ends of the bridge should be small due to the uniformity of the soil stratification, considerable differential settlement between the bridge and the approach embankments can be expected.

4. If a culvert is not used, the new stream channel should be excavated with side slopes of 2:1, although steeper slopes would be stable, and revetment of the slopes for scour protection would not be required.

5. We foresee no undue construction problems connected with this site. Excavations, even below the stream water level, can be maintained in a dry condition because of the impermeability of the soil.

E. M. PETO ASSOCIATES LTD.,

E. M. Peto, P. Eng.

MM:sb

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE – TORONTO, ONTARIO

BOREHOLE LOG

Job Name: Highway 401 - Baptiste Creek Crossing. Job No.: 58160 Borehole No.: 1.

Client: Dep't. of Highways of Ontario. Casing: BX (2½" Dia.) Boring Date: Jan. 6th.-12th. 1959.

Datum: Geodetic. Compiled By: M. Mindess. Checked By: E.M. Peto.

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- Q_u UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL

SOIL DESCRIPTION	COLOUR	CONSISTENCY	Depth (Feet)	Elev.			Natural Moisture Content %	WATER LEVELS, SOIL MOISTURE & REMARKS
			0' 0"					
			589.55					
SILTY CLAY, GRITS AND PEBBLES, SOME FINE SAND.	MOTTLED GREY-BROWN.	STIFF			1	S.S.	14	NAT. M.C.=17.5%. DRIER THAN PLASTIC LIMIT.
			5' 0"					
CLAYEY AND SANDY SILT, GRITS AND PEBBLES.	MOTTLED GREY-BROWN	COMPACT			2	S.S.	20	MOIST, NON-PLASTIC. NATURAL M.C.=16.9%.
			10' 0"					
SILTY CLAY, GRITS AND PEBBLES.	GREY-BROWN.	STIFF			3	S.S.	25	NAT. M.C.=18.9% AT PLASTIC LIMIT.
			15' 0"					
STRATIFIED SILTY CLAY, GRITS AND PEBBLES, THIN FINE SAND SEAM.	BROWNISH-GREY.	VERY STIFF			4	S.S.	32	NAT. M.C.=20.0%. DRIER THAN PLASTIC LIMIT.
			20' 0"					
STRATIFIED SILTY CLAY, GRITS AND PEBBLES.	DARK GREY.	STIFF			5	S.S.	27	NAT. M.C.=16.6%. AT PLASTIC LIMIT.
			25' 0"					
STRATIFIED SILTY CLAY, BLACK GRITS.	GREY	STIFF			6	S.S.	22	NAT. M.C.=15.2%. WETTER THAN PLASTIC LIMIT.
			30' 0"					
					7	2" S.L.	TAPPED	
AS ABOVE, NUMEROUS GRITS.	GREY	STIFF			8	S.S.	23	WETTER THAN PLASTIC LIMIT.
			35' 0"					
SILTY CLAY, GRITS.	GREY	FIRM			9	S.S.	14	NAT. M.C.=21.0%. MUCH WETTER THAN PLASTIC LIMIT.
			40' 0"					
					10A, B, C	2" S.L.	PUSHED	
STRATIFIED SILTY CLAY, GRITS.	GREY	FIRM			11		14	MUCH WETTER THAN PLASTIC LIMIT.
			45' 0"					
					12	2" S.L.	PUSHED	
			50' 0"					
					13	2" S.L.	PUSHED	
SILTY CLAY, GRITS.	GREY	FIRM.			14	S.S.	10	MUCH WETTER THAN PLASTIC LIMIT.
			55' 0"					
					15	2" S.L.	PUSHED	
			60' 0"					
AS ABOVE.	"	"	60' 8" 529.9		16	S.S.	7	AS ABOVE. SPECIFIC GRAVITY=2.76

HOLE TERMINATED. NO STIFFENING OR REFUSAL.

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE — TORONTO, ONTARIO

BOREHOLE LOG

Job Name: Highway 401 - Baptiste Creek Crossing. Job No. 58100 Hole No. 2.

Client: Dep't. of Highways of Ontario. Casing: BX (2½" Dia.) Date: Jan. 12th. - 15th. 1959.

Datum: Geodetic. Logged by: M. Mindess. Hole by: E.M. Peto.

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

S.S. 2" O.D. SPLIT SPOON SAMPLE
S.T. SHELBY TUBE SAMPLE
T.P. TEST PIT SAMPLE
W.S. WASH SAMPLE
R.C. ROCK CORE

ABBREVIATIONS

W.L. WATER LEVEL
N.W.L. NO WATER LEVEL RECORDED
W.W.L. WATER WITHDRAWN

SOIL DESCRIPTION	COLOUR	CONSISTENCY	DEPTH / ELEV.	SAMPLE	TYPE	BLOWS	REMARKS
ORGANIC SANDY AND CLAYEY SILT	GREY-BLACK		0' 0" 583.4				
CLAYEY SILT, MANY GRITS, MOTTLED MINOR ORGANIC CONTENT	GREY-BROWN	FIRM		1	S.S.	12	NAT. M.C.=16.0% DRIER THAN PLASTIC LIMIT
AS ABOVE	AS ABOVE	STIFF	5' 0"	2	S.S.	21	NAT. M.C.=16.1% DRIER THAN PLASTIC LIMIT
STRATIFIED SILTY CLAY, GRITS, OCCASIONAL THIN 1/32" SAND SEAMS.	BROWNISH-GREY	STIFF	10' 0"	3	S.S.	20	NAT. M.C.=16.9% DRIER THAN PLASTIC LIMIT
			15' 0"	4	2" S.L.	TAPPED	
STRATIFIED SILTY CLAY, MANY BLACK GRITS.	GREY	FIRM	20' 0"	5	S.S.	12	NAT. M.C.=20.3% WETTER THAN PLASTIC LIMIT
			25' 0"	6	2" S.L.	PUSHED	
SILTY CLAY, GRITS, INDISTINCTLY STRATIFIED.	GREY	FIRM	30' 0"	7	S.S.	11	NAT. M.C.=20.0% WETTER THAN PLASTIC LIMIT
			35' 0"	8	2" S.L.	PUSHED	
			40' 0"				SPECIFIC GRAVITY=2.75
SILTY CLAY, GRITS.	GREY	FIRM		9	S.S.	10	NAT. M.C.=22.7% MUCH WETTER THAN PLASTIC LIMIT.
			45' 0"	10	2" S.L.	PUSHED	
AS ABOVE	GREY	SOFT	50' 0"	11	S.S.	6	NAT. M.C.=27.7% MUCH WETTER THAN PLASTIC LIMIT.
			55' 0"	12	2" S.L.	PUSHED	
				13	2" S.L.	PUSHED	
			60' 0"	14	2" S.L.	PUSHED	
AS ABOVE	GREY	FIRM	65' 0"	15	S.S.	10	NAT. M.C.=24.2% MUCH WETTER THAN PLASTIC LIMIT.
			70' 0"	16	2" S.L.	PUSHED	SMALL NATURAL GAS POCKET ENCOUNTERED WHEN HOLE FIRST REACHED 71'6". ALL THE PRESSURE HAD DISSIPATED BY THE NEXT MORNING.
SILTY CLAY, GRITS.	GREY	FIRM	75' 0"	17	S.S.	9	NAT. M.C.=24.5%
			80' 0"	18	2" S.L.	PUSHED	
SILTY CLAY, BLACK SHALE FRAGMENTS UP TO 2" SIZE.	GREY		81' 6" 501.9	19	2" S.L.	TAPPED	MUCH WETTER THAN PLASTIC LIMIT.
			85' 0"				
SANDY AND SILTY CLAY	GREY TO GREY-BLACK	FIRM		20	S.S. W.S.	13	
			90' 0"				
SILTY CLAY, GRITS.	GREY	FIRM		21	S.S.	10	
			95' 0"				
SILTY CLAY, BLACK SHALE FRAGMENTS TO 1" SIZE.	GREY	FIRM		22	S.S.	11	MUCH WETTER THAN PLASTIC LIMIT.
SILTY CLAY, GRITS.	GREY, SOME POCKETS BROWNISH-RED.	FIRM	101' 0" 482.4	23	S.S.	10	MUCH WETTER THAN PLASTIC LIMIT. NAT. M.C.=33.3%

HOLE TERMINATED. NO STIFFENING OR REFUSAL.

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE – TORONTO, ONTARIO

BOREHOLE LOG

Job Name: Highway 401 – Baptiste Creek Crossing. Job No.: 58160 Borehole No.: 3.

Client: Dep't. of Highways of Ontario. Casing: 4" Pipe Boring Date: Jan. 13th. – 14th. 1959.

Datum: Geodetic. Compiled By: P.M. Aylett Checked By: M. Mindess

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- Q/u UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL

SOIL DESCRIPTION	COLOUR	Density or Consistency	Depth / Elevation	Legend	Sample No. and Condition	Sample Type	No. of Blows per ft.	WATER LEVEL, SOIL MOISTURE & REMARKS
DEPTH OF FROST = 2'0"			0'0"					
SILTY CLAY, CONSIDERABLE ORGANIC CONTENT, FEW GRITS.	DARK GREY – BROWN		583.5'		1	SAMPLE FROM CASING		MOIST.
SILTY CLAY, GRITS.	MOTTLED GREY-BROWN	FIRM	5'0"		2	S.S.	11	NAT. M.C. = 21.1% AT PLASTIC LIMIT.
AS ABOVE	AS ABOVE	FIRM.	10'0"		3	S.S.	12	NAT. M.C. = 20.0% WETTER THAN PLASTIC LIMIT.
AS ABOVE, MANY GRITS.	BROWNISH GREY.	STIFF	15'0"		4	S.S.	27	NAT. M.C. = 17.4% AT PLASTIC LIMIT.
SILTY CLAY, GRITS	GREY.	STIFF	20'0"		5	3" S.T.	(50)	
					6	S.S.	25	NAT. M.C. 18.3% AT PLASTIC LIMIT.
AS ABOVE, WITH BLACK SHALE FRAGS.	GREY	STIFF	25'0"		7	S.S.	25	NAT. M.C. = 17.5% WETTER THAN PLASTIC LIMIT
SILTY CLAY, GRITS STRATIFIED.	GREY.		30'0"		8	3" S.T.	(38)	
AS ABOVE	GREY	STIFF	35'0"		9	S.S.	15	NAT. M.C. = 19.7% WETTER THAN PLASTIC LIMIT.
AS ABOVE	GREY.		40'0"		10	3" S.T.	(20) (20)	
AS ABOVE	GREY	FIRM.	45'0"		11	SS	9	NAT. M.C. = 22.3% MUCH WETTER THAN PLASTIC LIMIT
AS ABOVE	GREY		50'0"		12	3" S.T.	(15) (25)	
AS ABOVE	GREY	FIRM.	51'0"		13	SS.	7.	NAT. M.C. = 24.4% MUCH WETTER THAN PLASTIC LIMIT.
			532.5'					

HOLE TERMINATED – NO REFUSAL.

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE – TORONTO, ONTARIO

BOREHOLE LOG

Job Name: Highway 401 – Baptiste Creek Crossing. Job No. 58160 Borehole No. 4.

Client: Dep't. of Highways of Ontario. Casing: BX (2½" dia.) Boring Date: Jan. 12th. – 13th. 1950.

Datum: Geodetic. Compiled By: P.M. Aylett. Checked By: M. Mindess.

SAMPLE CONDITION

- UNDISTURBED
- FAIR
- DISTURBED
- LOST

SAMPLE TYPE

- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- Q/u UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL

SOIL DESCRIPTION	COLOUR	Density or Consistency	Depth Elevation	Legend	Sample No. and Condition	Sample Type	No. of Blows per Ft.	WATER LEVELS, SOIL MOISTURE & REMARKS
DEPTH OF FROST 3'0"			0' 0"					
			583.9'					
SILTY CLAY, MINOR SAND POCKETS, GRITS	MOTTLED GREY-BROWN	FIRM			1	SS	14	NAT. M.C. = 16.4%. DRIER THAN PLASTIC LIMIT.
			5' 0"					
AS ABOVE, WITH SHALE FRAGMENTS	AS ABOVE	STIFF			2	SS	27	NAT. M.C. = 15.2%. DRIER THAN PLASTIC LIMIT.
			10' 0"					
SILTY CLAY, MANY GRITS, SMALL SAND POCKETS	GREYISH-BROWN	VERY STIFF			3	SS	32	NAT. M.C. = 19.3%. AT PLASTIC LIMIT.
			15' 0"					
SILTY CLAY, GRITS STRATIFIED	GREY	STIFF			4	SS	20	NAT. M.C. = 15.9%. WETTER THAN PLASTIC LIMIT.
			20' 0"					
AS ABOVE	GREY	STIFF			5A	SS	15	
					5B	AUGER	–	WETTER THAN PLASTIC LIMIT.
			25' 0"					
AS ABOVE	GREY				6	2" S.L.	TAPPED	
			30' 0"					
AS ABOVE	GREY	STIFF			7	S.S.	15	NAT. M.C. = 17.0% WETTER THAN PLASTIC LIMIT.
			35' 0"					
AS ABOVE	GREY				8A/B	2" S.L.	TAPPED	
			40' 0"					
AS ABOVE	GREY	FIRM			9	S.S.	12	NAT. M.C. = 22.3%. MUCH WETTER THAN PLASTIC LIMIT.
			45' 0"					
AS ABOVE	GREY				10	2" S.L.	PUSHED	
			50' 0"					
AS ABOVE	GREY	FIRM	51' 0"		11	S.S.	10	MUCH WETTER THAN PLASTIC LIMIT.
			532.9'					
HOLE TERMINATED – NO REFUSAL								

APPENDIX I

LABORATORY TEST RESULTS

SHRINKAGE LIMITS

Job No. 58189

Borehole Number	2	4
Sample Number	3	2
Depth	9' - 10'	5' - 6'
Wt. of dish & wet soil - gms	51.37	52.49
Wt of dish & dry soil - gms	40.95	42.27
Wt. of dish gms	17.35	17.67
Wt. of water gms	10.42	10.22
Wt. of dry soil - gms (Wo)	23.60	24.60
Moisture Content % (W)	44.4	41.60
Volume of dish c.c. (V)	19.20	19.35
Volume of dry soil c.c. (Vo)	12.65	13.18
Shrinkage Volume c.c. (V-Vo)	6.55	6.17
Shrinkage Limit = (Ws) $W - \frac{(V-Vo \times 100\%}{Wo}$	16.6	16.5
Shrinkage Ratio (R) = $\frac{Wo}{Vo}$	1.870	1.870
S. G. = $\frac{1}{1/R - Ws/100}$	2.71	2.70

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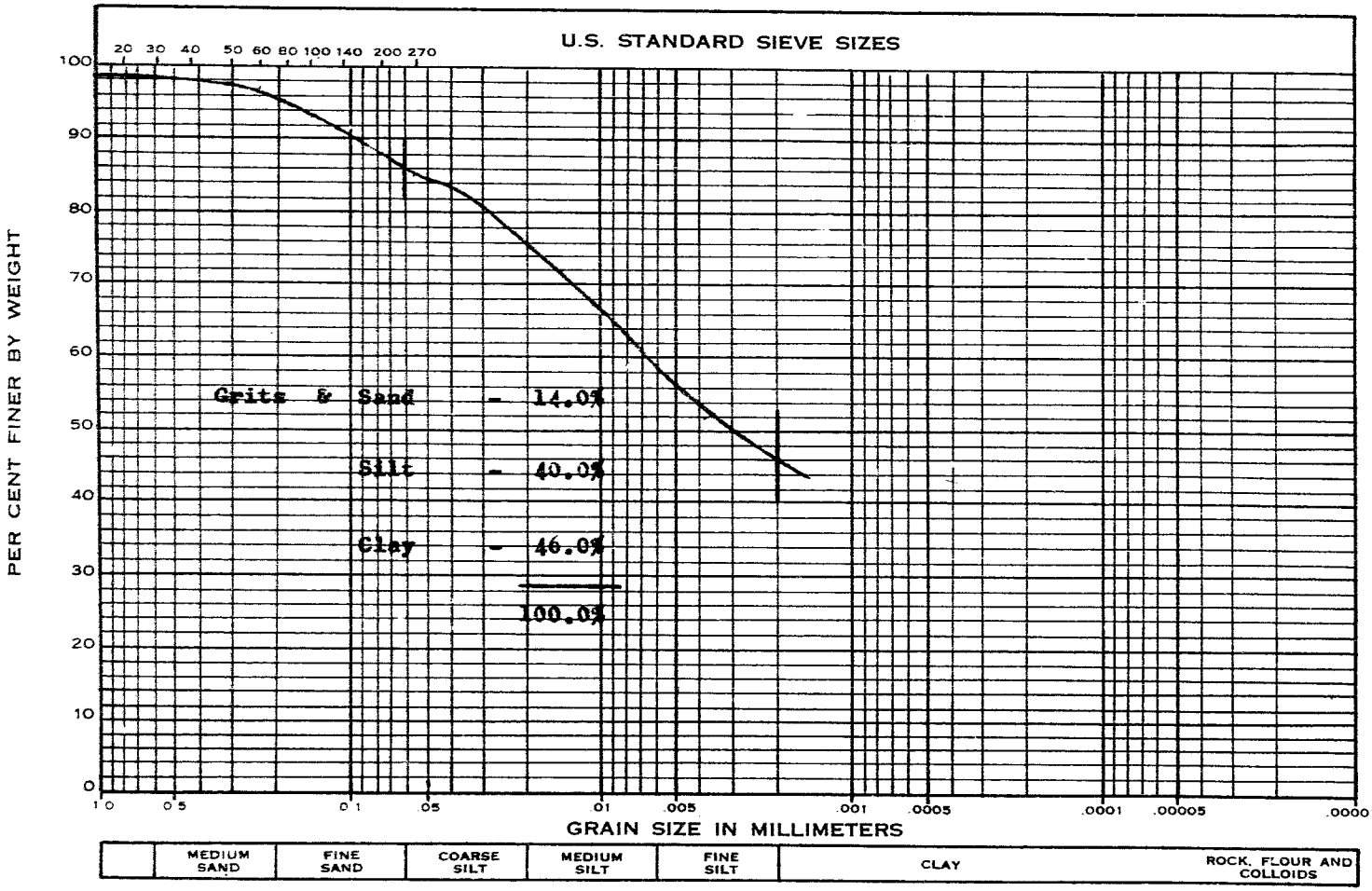
HYDROMETER GRAIN SIZE DISTRIBUTION DIAGRAM



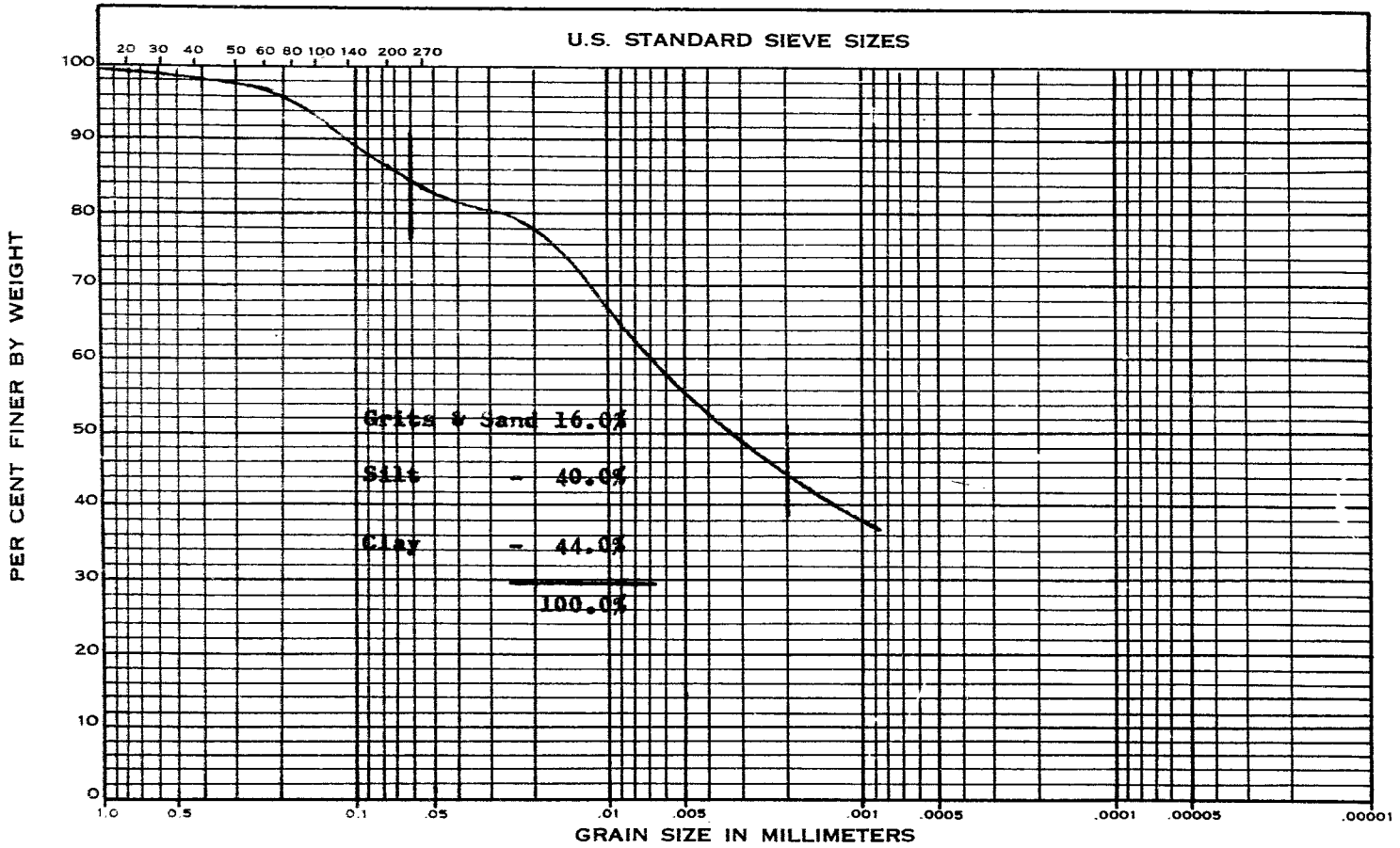
Hwy. 401-Baptiste Creek M.I.T. CLASSIFICATION

JOB NAME Crossing. JOB No. 58160 BOREHOLE No. 2 SAMPLE No. 5

DEPTH 20'-21' ELEVATION 562.9 REMARKS Typical Grading Silty Clay Soil, Tilbury Area

E. M. PETO ASSOCIATES LTD.

HYDROMETER GRAIN SIZE DISTRIBUTION DIAGRAM



	MEDIUM SAND	FINE SAND	COARSE SILT	MEDIUM SILT	FINE SILT	CLAY	ROCK, FLOUR AND COLLOIDS

JOB NAME Hwy. 401 - Baptiste Creek Crossing. M.I.T. CLASSIFICATION

JOB No. 58160 BOREHOLE No. 1 SAMPLE No. 16

DEPTH 59'8"-60'8" ELEVATION 523.8 REMARKS Typical Grading Silty Clay Soil.

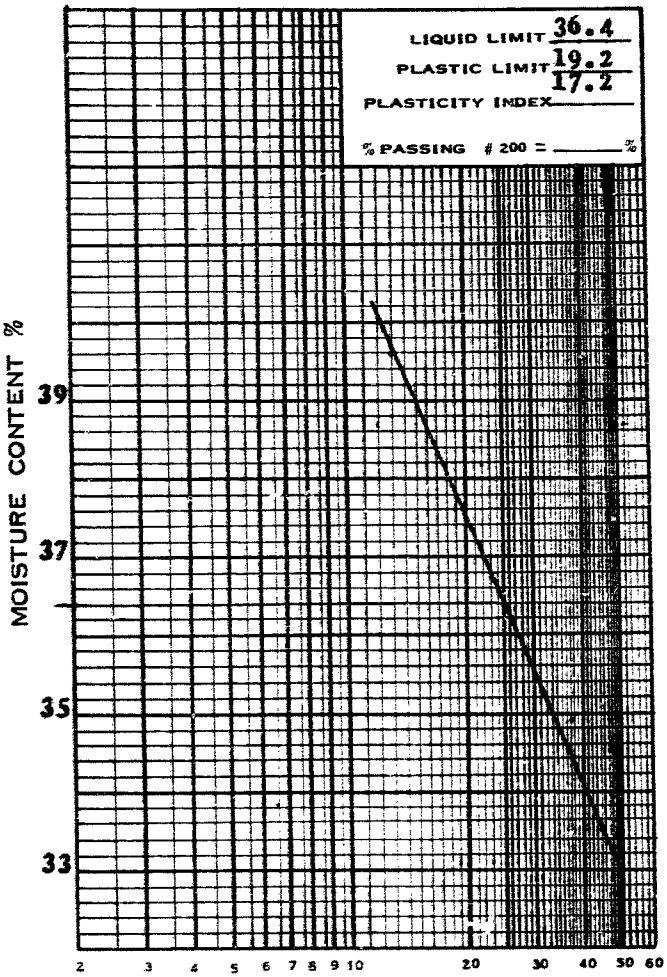
e. m. peto associates ltd.

SOIL TESTING LABORATORY

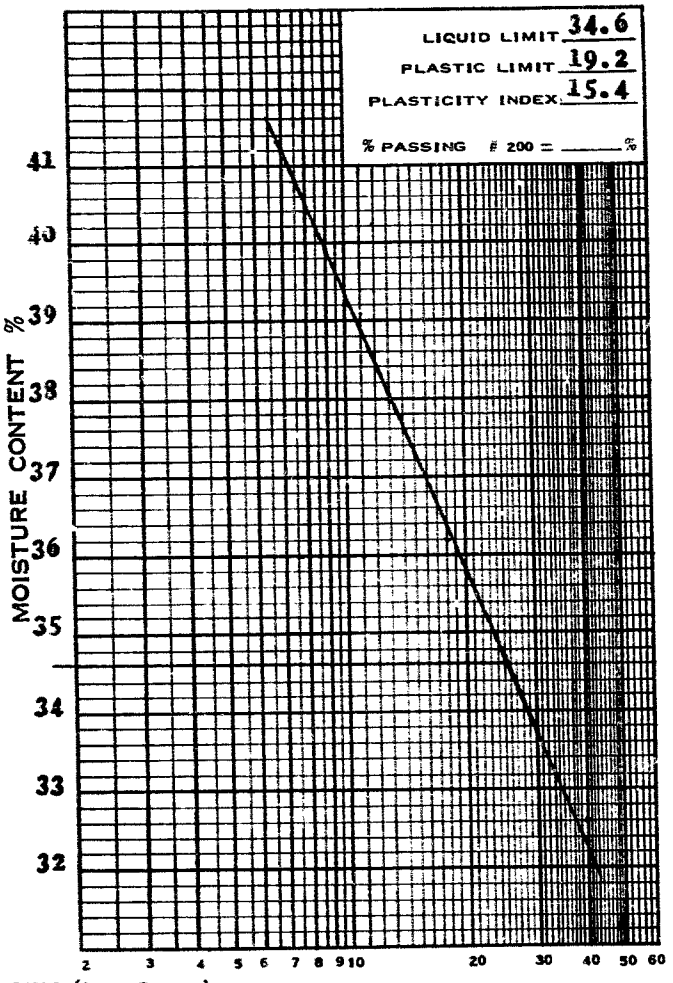
LIQUID LIMIT TEST — FLOW LINE CHARTS

Job No. 58160 Project Hwy. 401 - Baptiste Creek Crossing.

Sample From B.H.4. Sample # 2.
Depth 5' - 6'



Sample From B.H.2. Sample # 3.
Depth 9' - 10'.



NO. OF BLOWS (Log Scale)

e. m. peto associates ltd.

SOIL TESTING LABORATORY

LIQUID LIMIT TEST — FLOW LINE CHARTS

Job No. ~~38160~~ Project ~~Hwy. 401 - Baptiste Creek Crossing.~~

Sample From ~~B.H.4. Sample # 4.~~

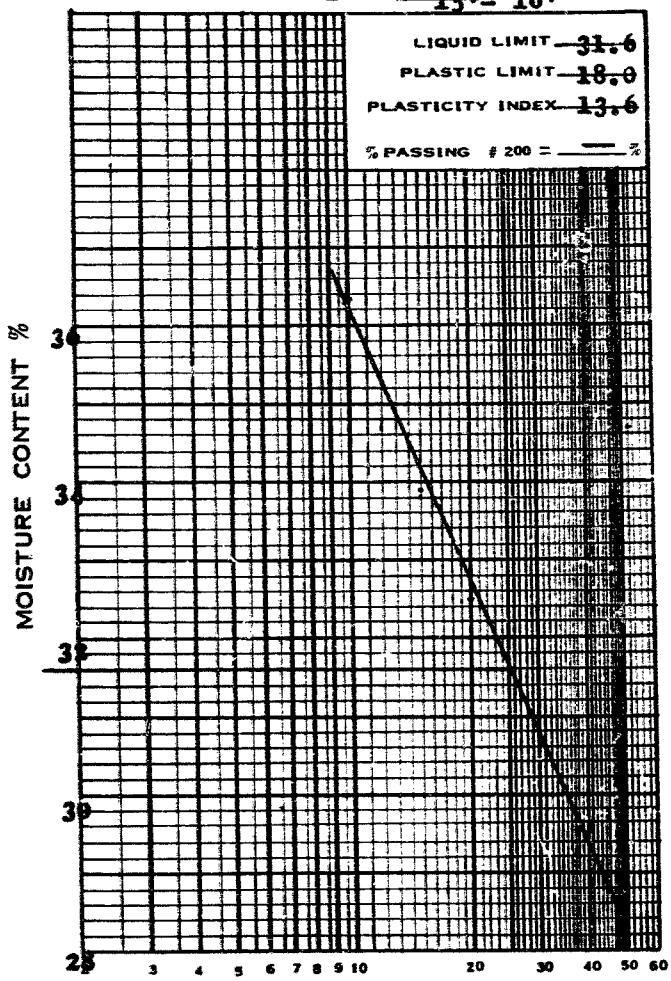
Depth ~~15' - 16'~~

LIQUID LIMIT ~~31.6~~

PLASTIC LIMIT ~~18.0~~

PLASTICITY INDEX ~~13.6~~

% PASSING # 200 = ——— %



Sample From B.H.1. Sample # 5.

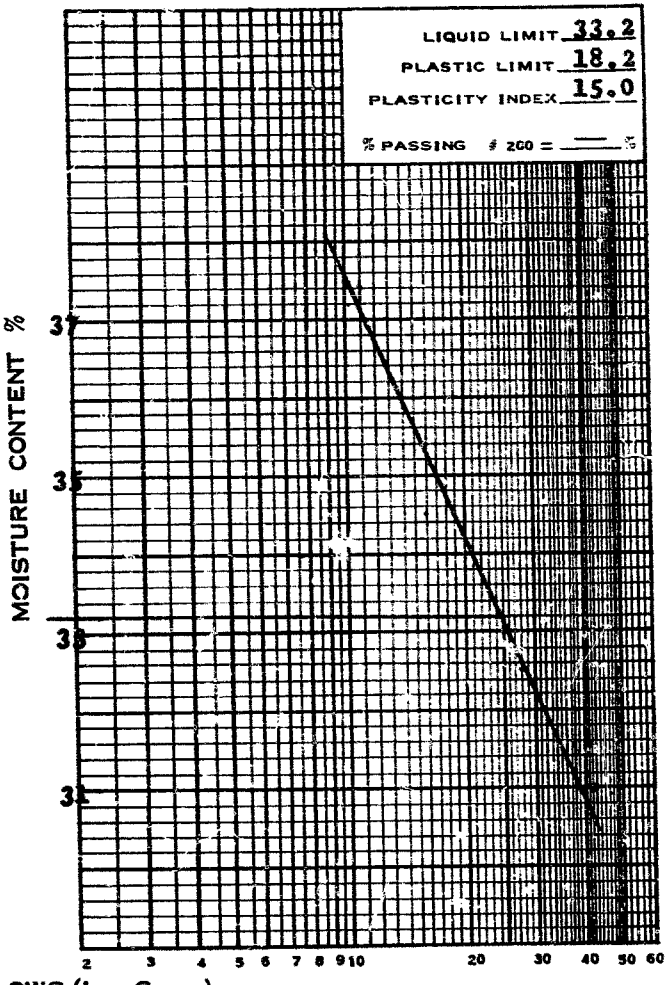
Depth 20' - 21'

LIQUID LIMIT 33.2

PLASTIC LIMIT 18.2

PLASTICITY INDEX 15.0

% PASSING # 200 = ——— %



NO. OF BLOWS (Log Scale)

e. m. peto associates ltd.

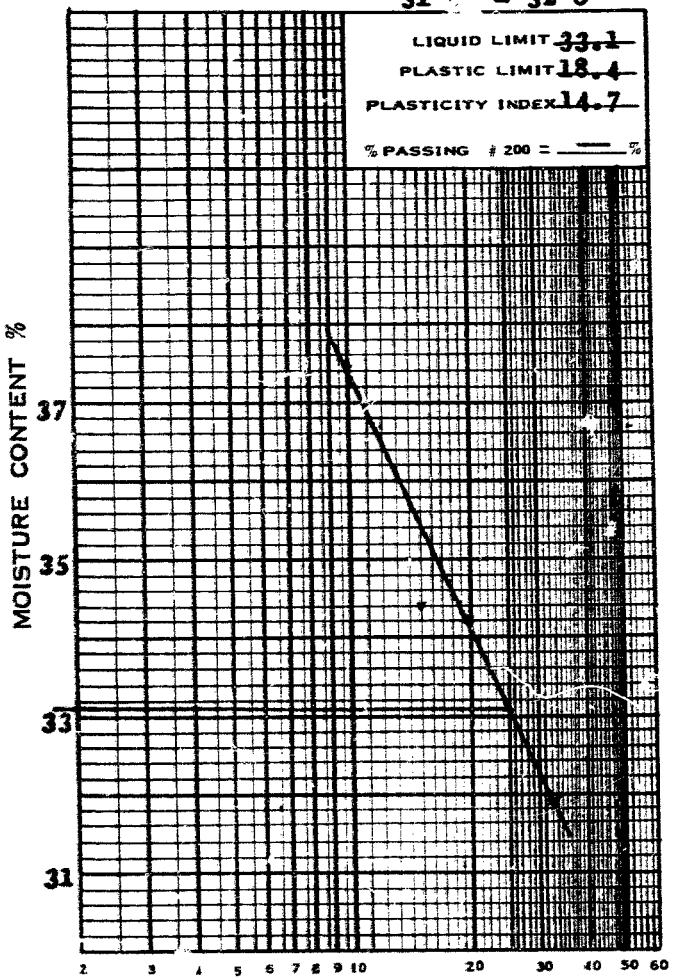
SOIL TESTING LABORATORY

LIQUID LIMIT TEST — FLOW LINE CHARTS

Job No. 58160 Project Hwy. 401 - Baptiste Creek Crossing.

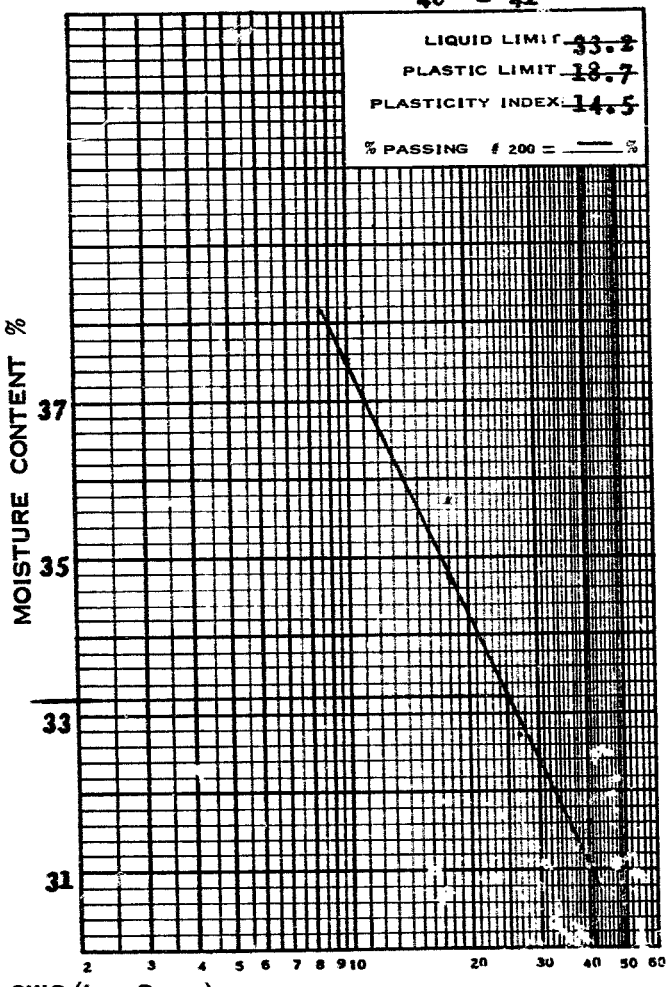
Sample From B.H.# 1. Sample # 8.

Depth 31'6" - 32'8"



Sample From B.H.# 2. Sample # 9.

Depth 40' - 41'



NO. OF BLOWS (Log Scale)

e. m. peto associates ltd.

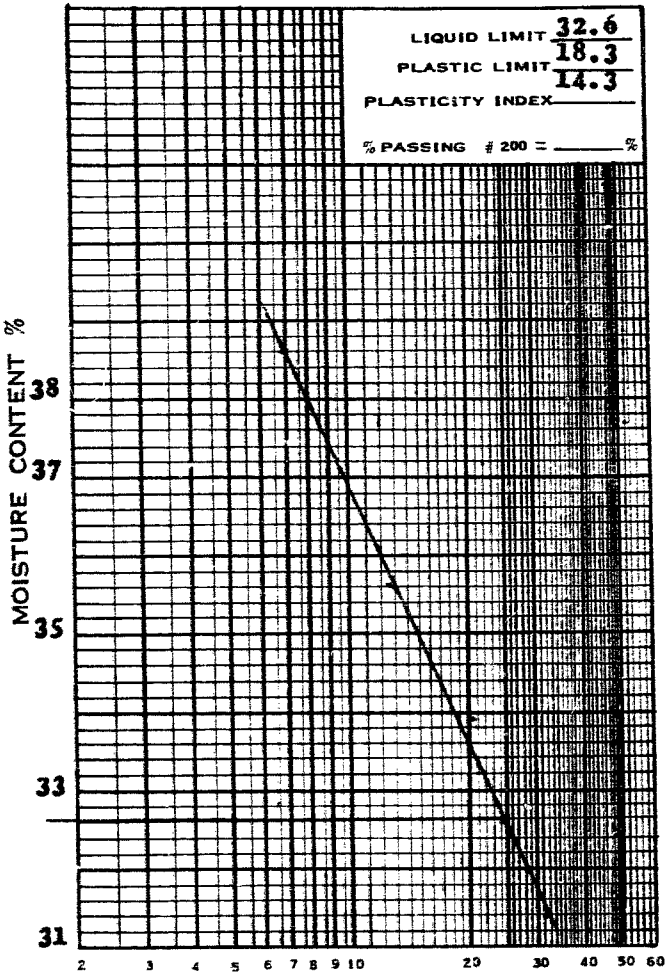
SOIL TESTING LABORATORY

LIQUID LIMIT TEST — FLOW LINE CHARTS

Job No. 58160 Project Hwy. 401 - Baptiste Creek Crossing.

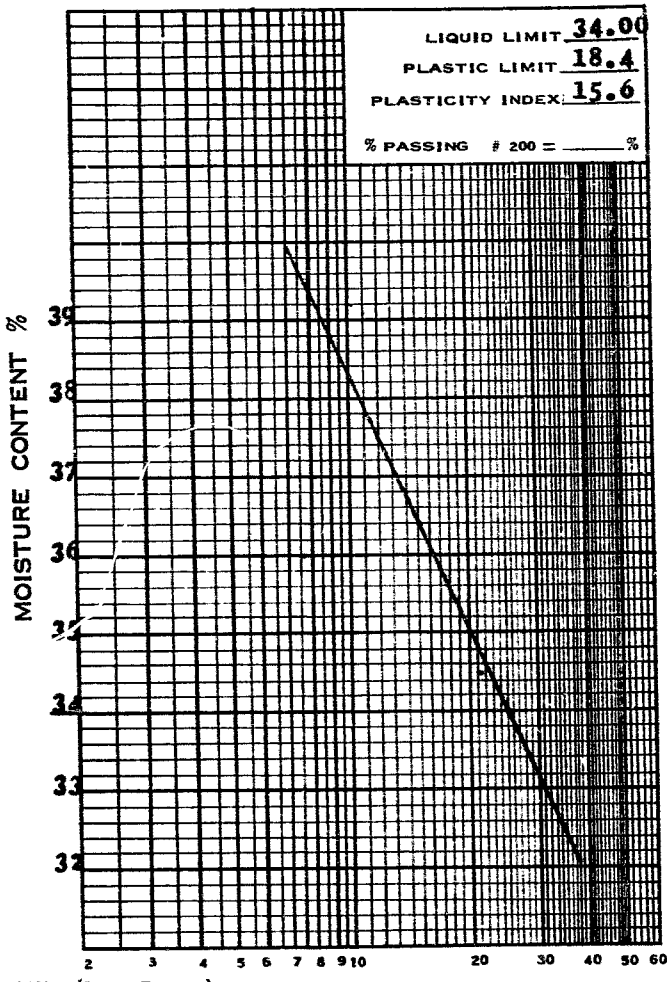
Sample From B.H.3. Sample # 13.

Depth 50' - 51'



Sample From B.H.2. Sample # 15.

Depth 65' - 66'



NO. OF BLOWS (Log Scale)

e. m. peto associates ltd.

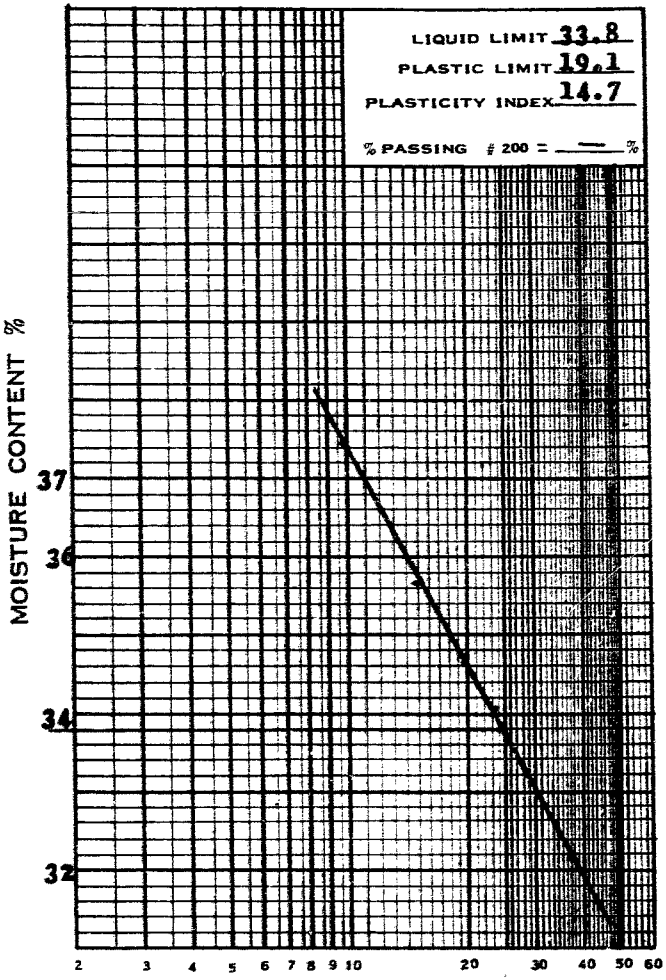
SOIL TESTING LABORATORY

LIQUID LIMIT TEST — FLOW LINE CHARTS

Job No. 58160 Project Hwy. 401 - Baptiste Creek Crossing.

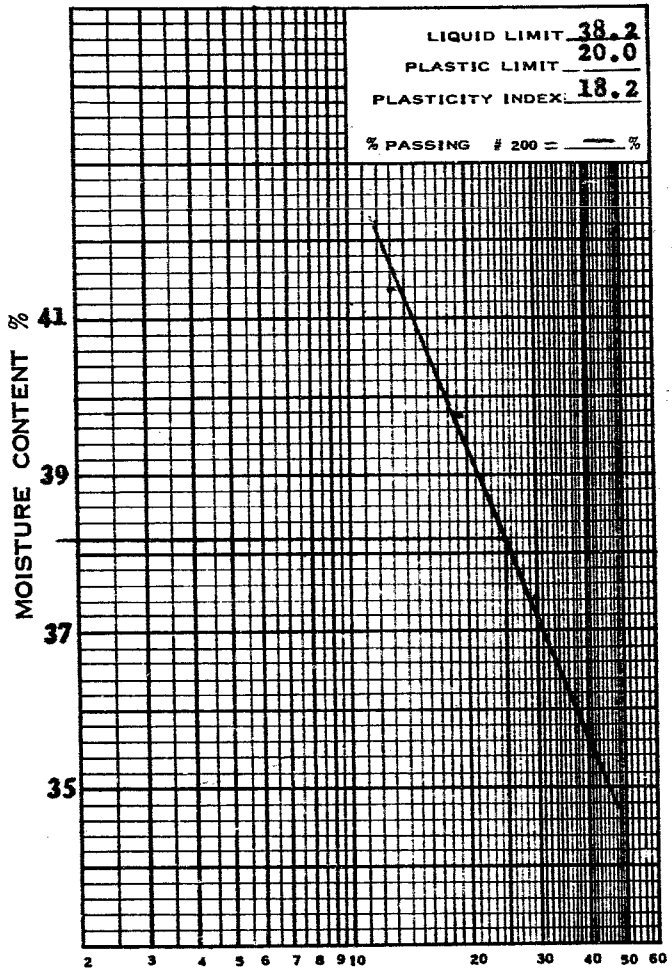
Sample From B.H.# 2. Sample # 17.

Depth 75' - 76'



Sample From B.H.# 2. Sample # 21.

Depth 90' - 91'



NO. OF BLOWS (Log Scale)

e. m. peto associates ltd.

SOIL TESTING LABORATORY

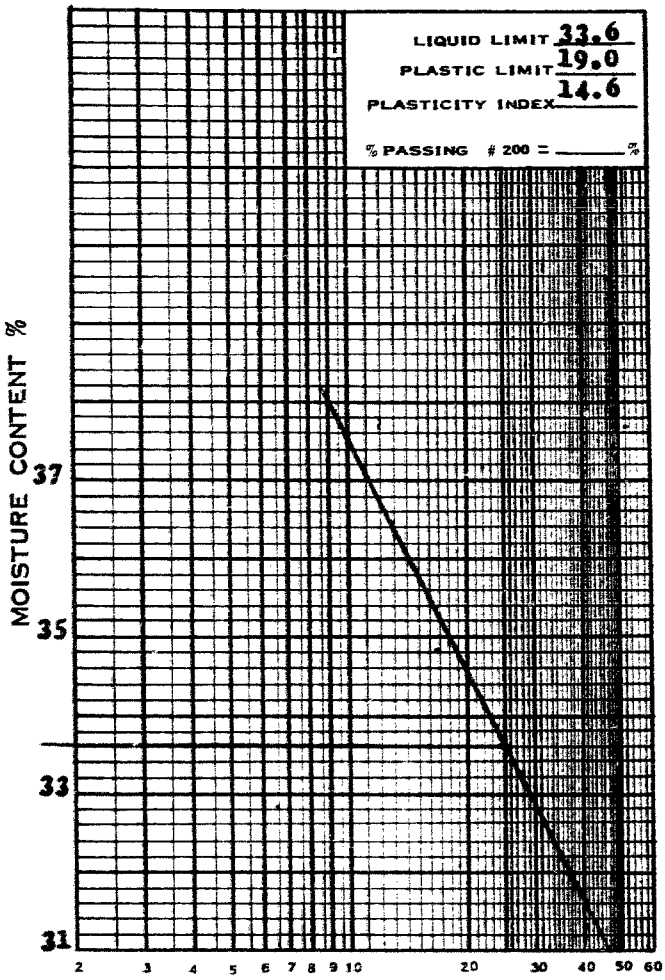
LIQUID LIMIT TEST — FLOW LINE CHARTS

JOB NO. 58160 PROJECT Hwy. 401 - Baptiste Creek Crossing.

SAMPLE FROM B.H.# 2.Sample # 23.

DEPTH 100' - 101'

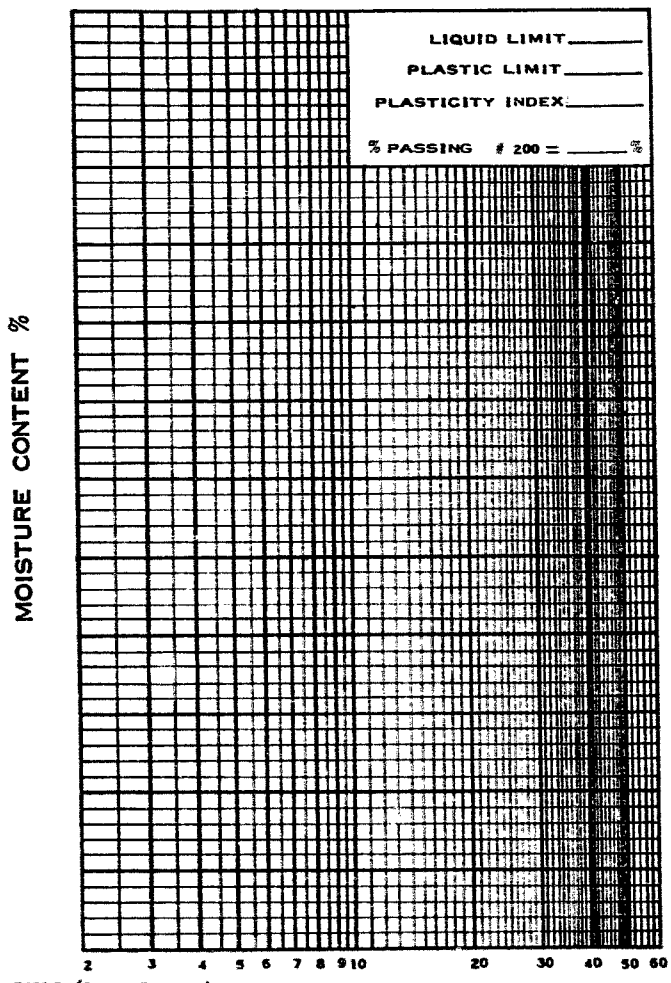
LIQUID LIMIT 33.6
PLASTIC LIMIT 19.0
PLASTICITY INDEX 14.6
% PASSING # 200 = _____ %



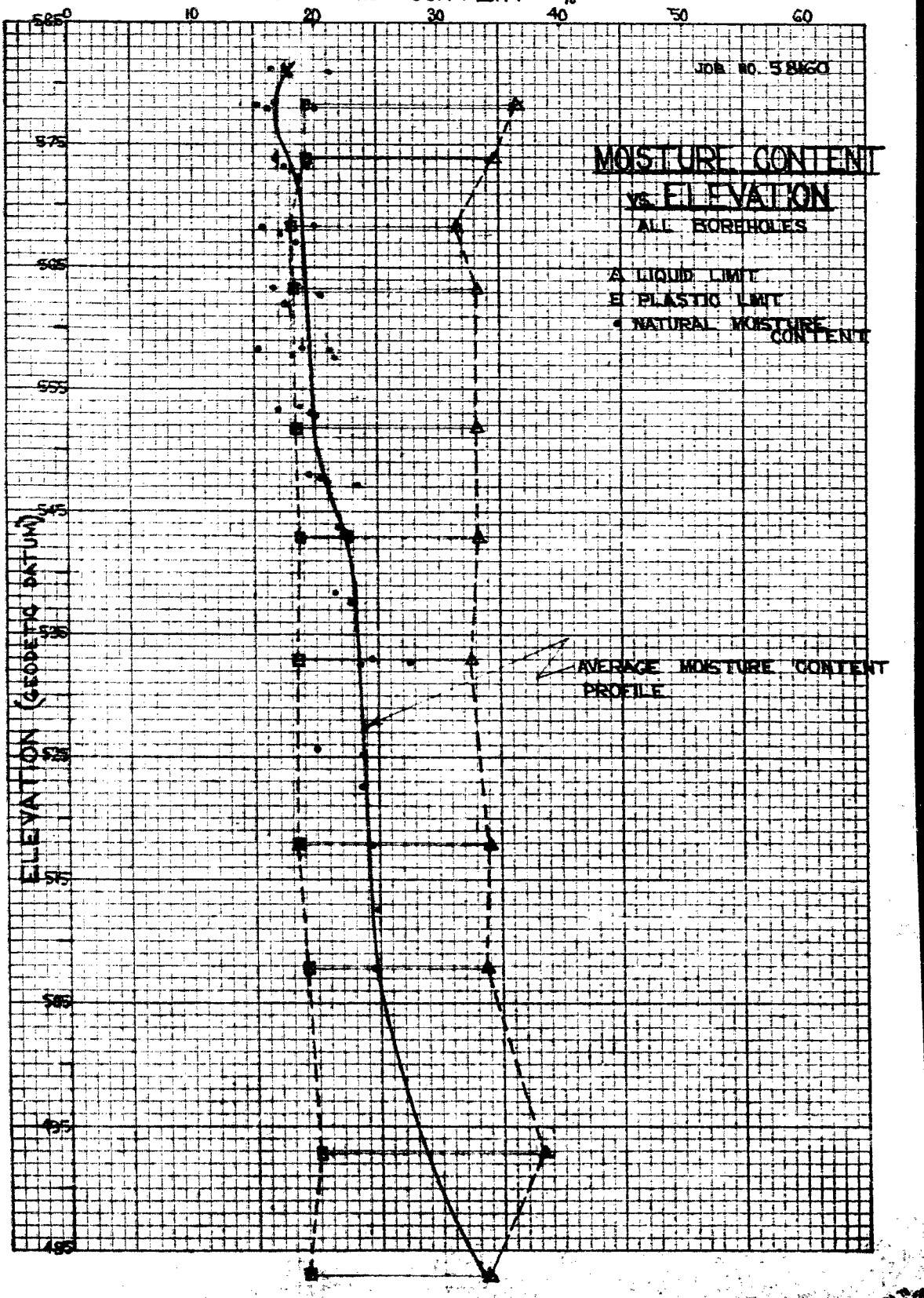
SAMPLE FROM _____

DEPTH _____

LIQUID LIMIT _____
PLASTIC LIMIT _____
PLASTICITY INDEX _____
% PASSING # 200 = _____ %



NO. OF BLOWS (LOG SCALE)



SUMMARY OF SOIL SHEAR STRENGTH TESTS

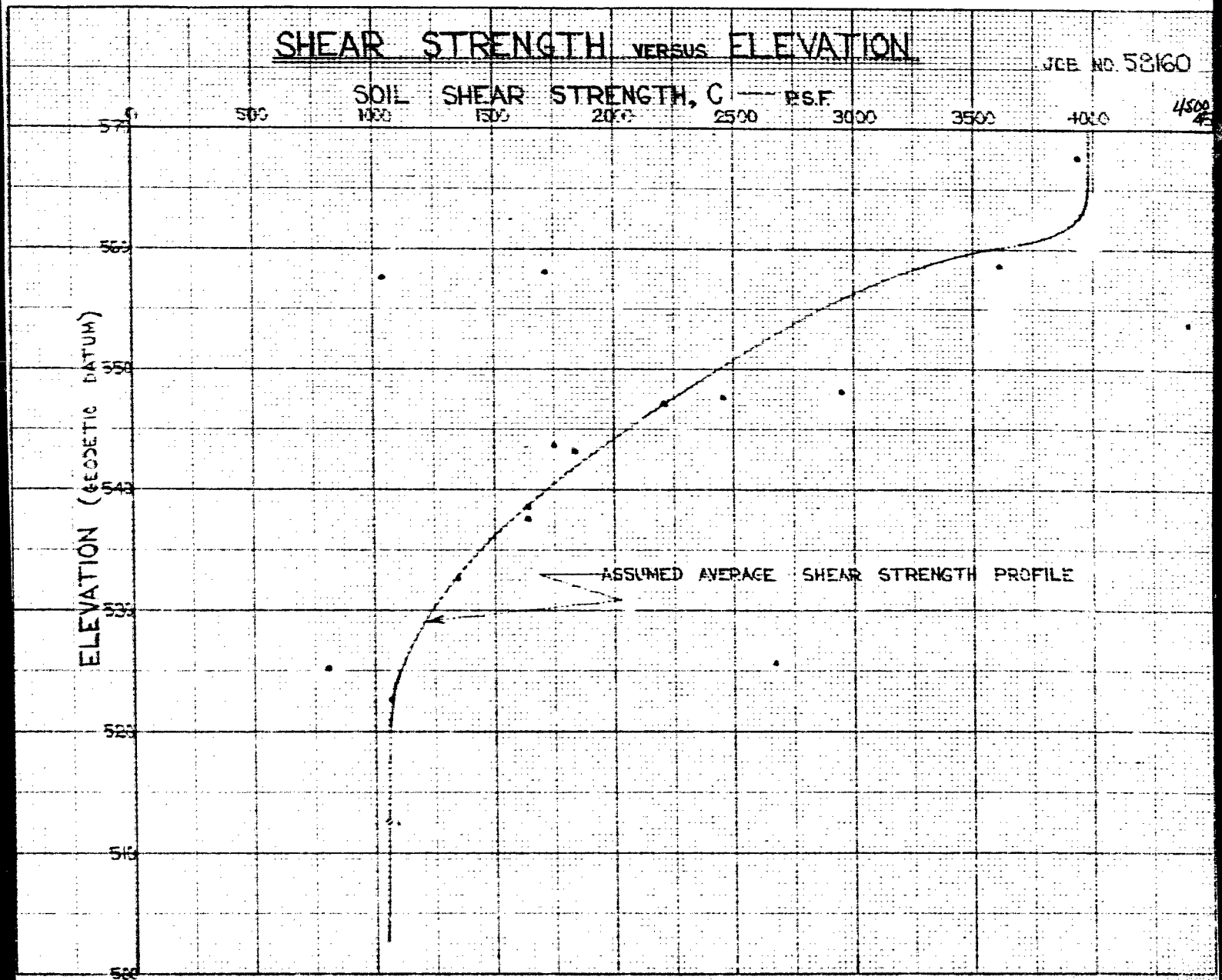
Job No. 58160

Bore-Hole #	Sample No.	Depth	Elevation	Nat. M.C.%	Wet Density p.c.f.	Degree of Saturation %	Void Ratio, e	% Strain at Failure	Soil Shear Strength C, p.s.f.
1	7A	30' - 30'6"	553.7	18.9	134.4	100	.491	20	4395
	10A	40' - 40'6"	543.7	21.8	132.0	100	.570	14.5	1750[X]
	10B	40'6" - 41'	543.2	22.6	132.2	100	.561	20	1838
	13A	51' - 51'6"	532.7	23.4	128.3	100	.621	20	1345
	15A	58' - 58'6"	525.7	20.0	128.0	100	.605	8.5	2672[X]
	15B	58'6" - 59'	525.2	23.5	126.9	100	.621	20	804
2	4B	15'6" - 16'	567.6	17.1	135.0	99.0	.467	20	3935
	6A	25' - 25'6"	558.1	21.1	131.6	100	.553	20	1722
	6B	25'6" - 26'	557.6	21.5	130.1	100	.580	9.5	1038[X]
	8B	35'6" - 36'	547.6	20.4	133.7	100	.521	20	2460
	8C	36' - 36'6"	547.1	23.2	134.0	100	.560	11.5	2210[X]
	10B	45'6" - 46'	537.6	22.8	129.6	100	.604	16.7	1640
	14B	60'6" - 61'	522.6	23.6	128.9	100	.615	20	1065
	16B	70'6" - 71'	512.6	24.9	128.9	100	.632	13.3	1050
4	6A	25' - 25'6"	558.6	19.0	135.8	100	.478	20	3608
	8B	35'6" - 36'	548.1	19.3	135.2	100	.486	20	2950
	10A	45' - 45'6"	538.6	21.6	130.9	100	.588	20	1640

[X]Denotes 1/2 x deviator stress from quick triaxial compression test
Lateral pressure approximately = overburden pressure.

SHEAR STRENGTH VERSUS ELEVATION

JOB NO. 58160



CONSOLIDATION TEST.

PRESSURE — VOID RATIO CURVE.

JOB No. 58160

BOREHOLE No 3 SAMPLE 8

DEPTH 25'0" - 26'0"

(1) COMPUTED OVERBURDEN PRESSURE = 2300 PSF.

(2) INDICATED PRE-CONSOLIDATION PRESSURE = 2550 PSF.

(3) LABORATORY REBOUND.

(4) LABORATORY VIRGIN COMPRESSION BRANCH.

(5) ESTIMATED TRUE FIELD VIRGIN BRANCH.

COMPRESSIVE INDEX, C_c = ·104.

VOID RATIO, e

·500 ·490 ·480 ·470 ·460 ·450 ·440 ·430 ·420 ·410 ·400 ·390 ·380

0·01 0·1 1·0 10·0 100·0

PRESSURE - KSF

e m peto & associates ltd.

B.M.A. Feb. 1952

APPENDIX II

METHOD OF OPERATION

The field investigation work is carried out by means of a skid-mounted diamond drill rig.

Standard sampling procedures are followed. Casing is driven and cleaned, either by tubes or by wash water.

Samples are recovered ahead of the casing at frequent intervals, with either a 2 inch or 3 inch O.D. split barrel sampling tube, Shelby tube, or split barrel sampling tube fitted with brass liners and special sharp cutting nose.

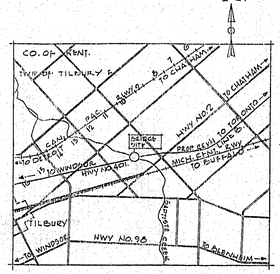
The standard penetration test results are recorded when sampling with the regular 2 inch O.D. split barrel sampler, these being the number of blows of a 140 pound hammer falling 30 inches, required to drive the sampling tube a distance of one foot into undisturbed soil.

The Dutch cone probe test is made by driving the drill rods into the ground with a 2-1/4" - 90° cone tip. The number of 4200 inch pound blows per foot of penetration are recorded, as in the standard penetration test.

Where required, "in situ" shear strength tests are made ahead of the casing, using modified Acker vane test equipment.

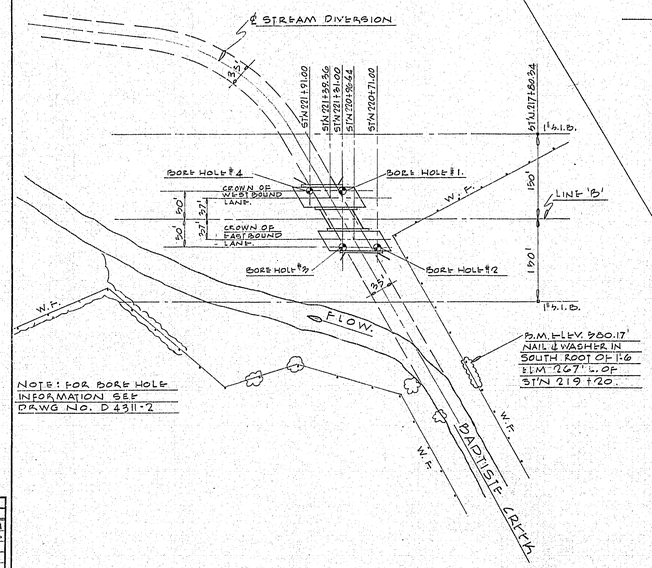
Disturbed samples are visually classified in the field, sealed in sample jars, and are re-examined, and tested as necessary, in the soils laboratory. Undisturbed samples are returned to the laboratory for later examination and testing, as required.

The test holes are bailed at the end of the day and on completion. Subsequent water level readings are taken for the duration of the field work. Water pressure readings are recorded when Artesian water conditions are encountered. Moisture content samples are recovered at frequent intervals to assist in the soil classification and the interpretation of water table results.



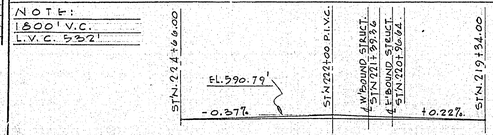
KEY PLAN

1 INCH = 1 MILE



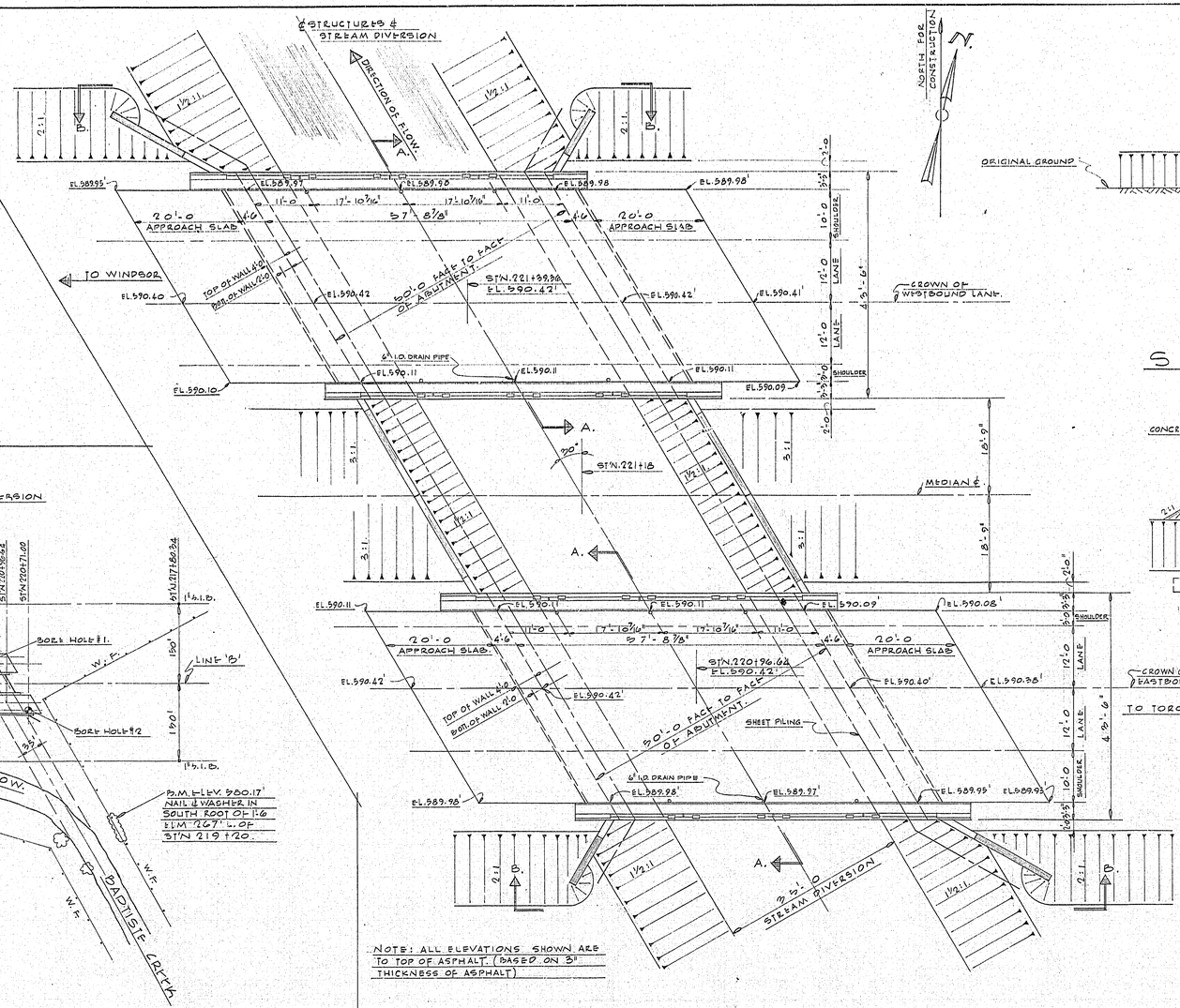
NOTE: FOR BORE HOLE INFORMATION SEE DRWG NO. D 4311-2

SITE PLAN 1" = 100'



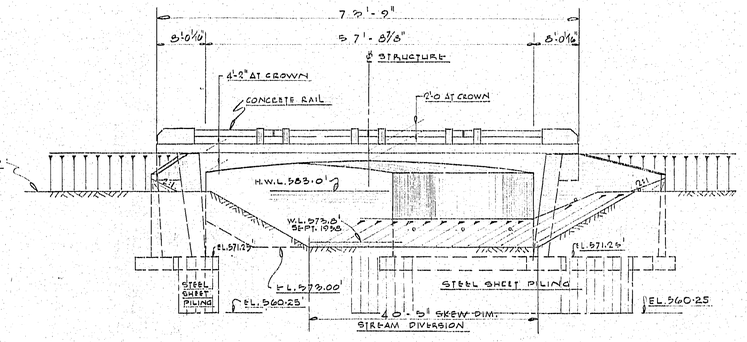
FINISHED ROAD PROFILE AT CROWN OF HWY 401

SCALES 1" = 10' VERTICAL; 1" = 100' HORIZONTAL.

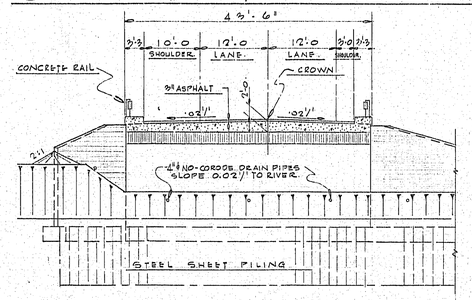


NOTE: ALL ELEVATIONS SHOWN ARE TO TOP OF ASPHALT. (BASED ON 3" THICKNESS OF ASPHALT)

PLAN 1" = 10 FEET



SECTION 'B-B' 1" = 10'



SECT. 'A-A' 1" = 10'

GENERAL NOTES:

1. ALL CONCRETE TO DEVELOP A COMPRESSIVE STRENGTH OF 21000 P.S.I. AT 28 DAYS.
2. AN ADMIXTURE, 19 TO BE ADDED TO THE CONCRETE AS SPECIFIED BY MATERIALS RESEARCH SECTION D.H.O.
3. MAX. CONC. AGGREGATE SIZE TO BE 3/4".
4. CONC. COVER TO REINFORCEMENT:
   - UNDERSIDE DECK SLAB 1"
   - TOP OF DECK SLAB 1 1/2"
   - INTERNAL & EXTERNAL FACES OF ABUTM'TS WINGWALLS & RETAINING WALLS 2"
   - FOOTINGS IN CONTACT WITH SOIL 3".
5. ALL EXPOSED EDGES OF CONC. TO HAVE A 1" CHAMFER, EXCEPT AS NOTED.
6. NO FILL SHALL BE PLACED BEHIND ABUTMENTS UNTIL COMPLETE DECK SLAB HAS BEEN POURED AND HAS SET.
7. FOR PROPERTIES OF SKEW ANGLE SEE DRWG. D 4311-3.

INDEX TO DRAWINGS

NOTE TO DISTRICT ENGINEER: CONCRETE WORK ON THIS STRUCTURE MUST NOT BE COMMENCED UNTIL MONUMENTS TO FIX CONTROL POINTS HAVE BEEN ERECTED AND CHECKED BY THE DISTRICT ENGINEER.

NOTE TO CONTRACTOR: STRUCTURE TO BE BUILT IN ACCORDANCE WITH FORM NO. 9 AND THE SPECIAL PROVISIONS, EXTRA COPIES OF WHICH MAY BE OBTAINED FROM THE DISTRICT ENGINEER.

ALL CONSTRUCTION JOINTS MUST BE APPROVED BY THE BRIDGE ENGINEER.

PRINT RECORD		
NO.	FOR	DATE
30	FILM OVER	31-11-59
10	BLUE PRINTS	28-11-59
30	REVISED	8-3-61
10	BLUE PRINTS	15-3-61

REVISIONS:			REFERENCE PLANS
DATE	BY	DESCRIPTION	
			F 3534-8
			F 3534-7
			F 3517-1

W.P. 164-58

A. D. MARGISON AND ASSOCIATES LIMITED
CONSULTING PROFESSIONAL ENGINEERS
TORONTO CANADA

DEPARTMENT OF HIGHWAYS:-ONTARIO-
BRIDGE OFFICE:-TORONTO

TILBURY EAST TOWNSHIP

BRIDGE Nº 8 OVER BAPTISTE CREEK

THE KING'S HIGHWAY No. 401 DIST. No. 1

CO. OF KENT

TWP. EAST TILBURY LOT 11 CON. V

GENERAL ARRANGEMENT

APPROVED

BRIDGE ENGINEER DESIGN ENGINEER

DESIGN	E.S.	CHECK	G.P.M.	CONTRACT NUMBERS	ANCELLE 59-3044
DRAWING	G.L. HILL	CHECK	E.S.		61-00 59-332
TRACING		CHECK		LOADING	H20-S16
DATE	MAY. 1959			DRAWING NUMBER	D 4311-1

TWP 104-188-1-A 13-188 D4311 1 to 10

APPENDIX B

Site Photographs

Photograph 1: Looking east at the east abutment and retaining walls from the west side of the Baptiste Creek Bridge EBL. Scouring of the exposed earth in front of the abutment wall was observed. The weep holes in the walls were open and wet. (October 20, 2013)

Photograph 2: Looking at east abutment and retaining walls of the structure. The adjacent slopes were heavily vegetated. Scouring of the exposed earth in front of the abutment was observed. (October 20, 2013)

Photograph 3: Looking at west abutment of the structure. Slight scouring of the exposed earth was observed. The weep holes in the wall were open and dry. Water was at about 0.3 m depth at the abutment location.