



FOUNDATION TECHNICAL MEMORANDUM

For

**FRONT STREET AND CNR OVERPASS EBL
MTO WEST REGION 59 STRUCTURE REHABILITATIONS
SITE 14-363-1, CONTRACT 6
GWP 3064-11-00
VILLAGE OF POINT EDWARD
LAMBTON COUNTY, ONTARIO**

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Table 1 – List of Standard Specification

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Appendix A – Previous Foundation Investigation Reports (GEOCRETS No. 40J16-58) and Drawings

- Reference 1. Foundation Investigation Report for Front Street Overpass and CNR Overhead, W.P. 347-65-02/03, Site 14-363, Contract No 81-47, dated July 14, 1977.
- Reference 2. General Layout Revision A - E.B.L, Front street Interchange Overpass and C.N.R Overhead, dated June 1979.
- Reference 3. Front Street Interchange Overpass and C.N.R Overhead, Footings Revision A – E.B.L., dated June 1979.

Appendix B – Site Photographs

FOUNDATION TECHNICAL MEMORANDUM

For

Front Street and CNR Overpass EBL, Highway 402
MTO West Region 59 Structure Rehabilitations
Site 14-363-1, Contract 6, GWP 3064-11-00
Village of Point Edward
Lambton County, Ontario

1. INTRODUCTION

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

This technical memorandum summarizes the factual results of geotechnical data based on the review and compilation of existing subsurface information from relevant reports in the MTO GEOCRES Library for the Front Street and Canadian National Railway (CNR) Overpass EBL (East Bound Lanes) on Highway 402. The Foundation Engineering recommendations from the existing overpass 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".

It is understood from the MMM Group minutes for the review progress meeting with MTO, dated May 1, 2015, that the Front Street Overpass EBL rehabilitation will be implemented in two stages. During each stage of the rehabilitation, the truck traffic will remain on the truck ramp and cross the overpass and the vehicles will be redirected to the W-N/S ramp to Front Street to the N/S-E ramp onto Highway 402 after the overpass crossing.

The purpose of the Technical memo is to summarize the subsurface and groundwater conditions and foundation recommendations based on available reports 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 Front Street and CNR Overpass EBL on Highway 402 is located in the Village of Point Edward, Lambton County, Ontario. The site is located approximately 1.6 km east of the Blue Water Bridge over the St. Clair River. A key plan is shown in Figure 1.

The existing Highway 402 Overpass EBL is a five span post-tensioned concrete deck slab structure that carries two lanes of Highway 402 eastbound traffic and one on-ramp lane used by truck traffic. The CNR track lines have been removed and relocated that used to run parallel to the Front Street at the site location.

Geographically, the residential community along with the health center of Point Edward is located to the north of the site while the commercial and industrial development of Sarnia is situated to the south side of the bridge site. Land use immediately to the east is industrial while to the west there is Ontario Travel Information Centre.

Physiographically, this area is referred to as the Huron Fringe. It consists of sand beach deposits resulting from glacial lakes Algonquin and Nipissing, as well as present Lake Huron. The terrain is flat with the exception of 0.9 to 1.2 m beach ridges in areas not subject to agricultural production. Based on the previous Record of Borehole logs, the bedrock in the site area is at approximate elevation 139.0 to 141.5.

3. SOURCE OF INFORMATION

The following report and drawing were available for review and information for the Front Street and CNR Overpass EBL.

1. Foundation Investigation Report for Front Street Overpass and CNR Overhead, W.P. 347-65-02/03, Site 14-363, Contract No 81-47, Highway 402, District 1, Chatham, Engineering Materials Office, Soil Mechanics Section, Ministry of Transportation and Communication, Ontario, dated July 14, 1977. GEOCREs No. 40J16-58. (Reference 1)



2. General Layout Revision A - E.B.L, Front street Interchange Overpass and C.N.R Overhead, 0.3 miles west of Christina Street, District No. 1, Cont. No. 81-47, W.P. No. 347-65-03. Prepared by Nisbet Letham Limited, dated June 1979. (Reference 2)
3. Front Street Interchange Overpass and C.N.R Overhead, Footings Revision A – E.B.L., Sheet 107, District No. 1, Cont. No. 81-47, W.P. No. 347-65-02. Prepared by Nisbet Letham Limited, dated June 1979. (Reference 3)

4. SITE RECONNAISSANCE

As part of the current foundation engineering assessment study, a site reconnaissance of the Front Street Overpass (Photo 1) was carried out on July 31, 2014. A photographic record of the site visit is attached in Appendix B.

The southwest and southeast slopes were vegetated at the time of the site reconnaissance (Photographs 1 and 8). No erosion effects were observed on the slope toes and faces. The front slopes of the abutments were covered with concrete panels (Photographs 2, and 7). No obvious deterioration or settlement effects were observed on the front concrete panel slopes. The pier columns were observed with surficial concrete cracks with no deterioration or erosion effects around the piers (Photographs 2, 4, 5, 6 and 7).

5. PREVIOUS FOUNDATION INVESTIGATION AND SUBSURFACE CONDITIONS

The general subsurface conditions presented in this section are based on the Foundation Investigation Report, GEOCRE 40J16-058, dated July 14, 1977.

The foundation report includes the borehole location plan (Drawing No. 14-363-A-2), Record of Borehole sheets (1 to 11) and a summary of the Field and Laboratory tests.

The field investigation work was carried out between April 28 and May 11, 1977. The foundation investigation comprised eleven (11) boreholes using a CME75 auger machine mounted on a muskeg vehicle. Hollow stem augers were employed for all boreholes. The boreholes were drilled to 8.5 and



39.4 m (28.0 to 129.3 ft), elevation 139.2 to 169.9 (456.6 to 557.5 ft.). In boreholes 1 and 4 bedrock was proven by recovering BXL size rock core samples by coring within the hollow stem augers from 39.4 and 36.6 m (129.3 and 120.0 ft.) to 41.1 and 39.0 m (135.0 and 127.9 ft.), respectively.

Generally, the subsoil at this site included a 1.8 to 5.2 m (6.0 to 17.0 ft.) thick sand deposit overlying in excess of approximately 30.4 m (100.0 ft.) clayey silt and silty clay which in turn was overlying a second 1.5 to 3.0 m (5.0 to 10.0 ft.) thick sand layer. Beneath the second thin sand layer at approximately 38.1 m (125.30 ft.) black shale bedrock was encountered.

5.1 Sand

A 1.8 to 5.2 m (6.0 to 17.0 ft.) thick surficial deposit of very loose to dense sand was encountered in all boreholes from ground surface elevation 177.9 to 179.3 m (583.8 to 588.1 ft.) which extended to elevation 172.8 m to 177.1 m (566.8 to 581.1 ft.). Pockets of high silt and gravel contents were encountered within the sand deposit. N values recorded for the sand deposit ranged from 2 to 40 but were generally between 5 and 25.

Grain size distribution results of selected sand samples obtained 3 to 65% silt and clay, 35 to 95% sand and 0 to 14% gravel sized particles. Moisture content determinations ranged approximately between 11.0 and 33.0%.

5.2 Clayey Silt, Some sand, Trace of Gravel

A firm to hard clayey silt layer was contacted below the sand deposit in all boreholes and extended to 8.5 to 17.1 m (28.0 to 56.0 ft), elevation 161.5 to 169.9 (529.7 to 557.5 ft.). The N values ranged from 5 to 55 corresponding to consistency of firm to hard but generally the consistency was from stiff to very stiff. Boreholes 3, 5, 6 and 8 to 11 were terminated in clayey silt at 8.5 to 16.2 m (28.0 to 53.0 ft.), elevation 161.9 to 169.9 (531.2 to 557.5 ft.). This clayey silt layer approximately contained 26% to 44% clay, 39% to 46% silt, 14% to 30% sand and up to 6% gravel sized particles. The upper 1.8 to 3.0 m (6.0 to 10.0 ft.) portion indicated desiccation resulting to its very stiff consistency as indicated by N value which ranged up to 30 blows.



The laboratory undrained shear strength obtained for the upper desiccated clayey silt layer ranged approximately between 95.8 to 191.5 kPa (2000.0 to 4000.0 psf). Below the desiccated zone, the shear strength gradually decreases from 95.8 kPa (2000.0 psf) to as low as 38.3 kPa (800.0 psf) and then increases to between 47.9 to 95.8 kPa (1000.0 to 2000.0 psf). Further, this desiccated zone decreases in strength and thickness moving from east to west. The field vane shear test measured shear strengths between 33.5 and 105.3 kPa (700.0 to 2200.0 psf) with sensitivity ranging between 1.3 and 3.3.

The Atterberg liquid limits for the clayey silt samples ranged approximately from 18.0 to 35.0 and the plastic limits approximately from 12.0 to 19.0 for the clayey silt samples. The plasticity index ranged approximately from 5.0 to 18.0. Further, the unit weight of the clayey silt samples varied between 19.4 and 21.0 kN/m³ (123.5 to 134.0 pcf). Moisture content determinations ranged approximately from 10.0 to 25.0%.

5.3 Silty Clay trace of gravel

A 18.3 to 20.7 m (60.0 to 68.0 ft.) thick deep stratum of silty clay was encountered in boreholes 1, 2, 4 and 7 below the clayey silt deposit and extended to 34.7 to 37.5 m (114.0 to 123.0 ft.), elevation 141.1 to 143.3 (462.9 to 470.2 ft.). The N values recorded ranged between 9 and 16, indicating stiff to very stiff consistency.

Laboratory undrained shear strengths obtained for silty clay ranged from 47.9 to 95.7 kPa (1000.0 to 2000.0 psf) and field vane shear tests obtained shear strengths between 38.3 and 100.5 kPa (800 and 2100.0 psf) with sensitivity ranging from 1.3 to 2.0.

The Atterberg liquid limits ranged approximately from 36.0 to 46.0 and the plastic limits approximately from 18.0 to 27.0 for the silty clay samples. The plasticity index approximately ranged from 14.0 to 24.0. Further, a unit weight of the silty clay sample obtained was 18.7 kN/m³ (119.0 pcf) in borehole 4. Moisture content determinations ranged approximately from 25.0 to 35.0%, increasing from the upper portion to the lower boundary.



5.4 Black Sand

A 1.5 to 1.9 m (5.0 to 6.3 ft.) thick deposit of black sand was encountered below the silty clay layer in boreholes 1, 2, 4 and 7 which extended to 36.6 to 39.4 m (120.0 to 129.3 ft.), elevation 139.2 to 141.5 (456.6 to 464.2 ft.). Borehole 7 was terminated at 38.1 m (125.0 ft.), elevation 140.1 (459.5 ft.), where probable bedrock was encountered.

A grain size distribution result on a black sand sample obtained 12% silt and clay, 81% sand and 7% clay sized particles.

5.5 Bedrock

Probable bedrock was encountered below the black sand in boreholes 1, 2, 4 and 7 at 36.6 to 39.4 m (120.0 to 129.3 ft.), elevation 139.2 to 141.5 (456.6 to 464.2 ft.). In borehole 2, auger refusal was met at 38.3 m (125.8 ft.), elevation 140.2 (459.9 ft.) in the probable bedrock. In boreholes 1 and 4, the bedrock was proven by coring the bedrock from 39.4 and 36.6 m (129.3 and 120.0 ft.), elevation 139.2 and 141.5 (456.6 and 464.2 ft.) to 41.1 and 39.0 m (135.0 and 127.9 ft.), elevation 137.4 and 139.1 (450.9 and 456.3 ft.), respectively. The core samples were obtained from boreholes 1 and 4 with 77 and 100% recovery, respectively. The bedrock cores consisted of sound black shale of the Kettle Point formation.

5.6 Groundwater

Groundwater was observed during site investigation in the upper sand layer between 0.9 to 2.1 m (3.0 to 7.0 ft.) below ground level, elevation 176.0 to 178.3 (577.4 to 585.1 ft.). Groundwater was not encountered in borehole 7.



6. FOUNDATION

6.1 Previous Foundation Discussions and Recommendations

It was proposed to construct twin four (4) span structures, each with an overall length of approximately 61.0 m (200 ft.), to carry the Highway 402 over the Front Street and the CNR tracks. The approach fills for the proposed structures were to have an effective height about 9.5 m (31.0 ft.) and a top width in excess of 45.7 m (150.0 ft.). It was anticipated that the construction of such large embankments on a deep deposit of firm to stiff clay would result in significant long-term settlements.

It was considered to place the abutments on short piles and the piers on spread footings. It was estimated that the total settlement of 75 mm (3.0 in.) at the piers and 458 mm (18 in.) at the abutments would take place for the arrangement considered; however, the report noted that based on past experience for a similar project, the estimated settlement values were an overestimation by a factor of 2 and that the actual settlements would be in order of 50 and 230 mm (2.0 and 9.0 in.) for the piers and the abutments, respectively. The differential settlement between the piers and abutments would be about 100 to 125 mm (4.0 to 5.0 in.) if the normal construction procedures were followed. However, if staged construction was used the differential settlement would be reduced to 50 to 75 mm (2 to 3 in.). However, at this site, staged construction was considered expensive and inconvenient as it was necessary to maintain traffic on Highway 402.

Recommendations

The report recommended to consider either HP 310 x 110 (12HP74) pile sections or 324 mm O.D. by 6 mm (12 ¾ in. X ¼ in.) wall steel tube piles and the choice be governed by economy. In either case, it was recommended that the piles had to be driven to bedrock to achieve a design load of 1177 kN (120 tons). It was recommended that the steel H piles would require tips reinforced by standard flange plates and the steel tube piles would need to be driven closed ended with standard shoe plates. It was noted that to prevent damage to the steel tubes on contact with bedrock, the driving energy for the last 1.5 m (5.0 ft.) was restricted to below 40.7 kJ (30,000 ft-lb) per blow.



Based on the General Layout Drawing (Reference 2), the EBL overpass structure was to have five spans with lengths of 14.3 m (46.96 ft.), 15.2 m (49.97 ft.), 14.4 m (47.17 ft.), 15.2 m (49.98 ft.) and 10.4 m (33.99 ft.) from west abutment to east abutment. The footings were to be founded on 324 mm O.D. by 6 mm (12 ¾ in. X ¼ in.) wall steel tube piles filled with concrete which were to be driven to the bedrock. It was noted in the drawing that the fill material grain sizes below footings should not be greater than 50.8 mm (2 in.).

Based on the Footings Drawing (Reference 3), the following table summarizes the pile data.

Summary of Piles Data for EBL Overpass Structure					
Location	No. Required	Batter	Approximate Pile Length	Pile Cut-off Elevation	Refusal Stratum
West Abutment – Front row	6	4:1	43.9 m (144 ft.)	183.5 m (602.0 ft.)	Black Shale Bedrock
West Abutment – Back row	3	4:1	43.9 m (144 ft.)	183.5 m (602.0 ft.)	
Piers #1E, 2E & 3E	30	4:1	38.1 m (125 ft.)	176.8 (580.0 ft.)	
Piers #4E	10	4:1	40.2 m (132 ft.)	176.6 (586.0 ft.)	
East Abutment – Front row	6	4:1	47.2 m (155 ft.)	183.9 (603.5 ft.)	
East Abutment – Back row	3	4:1	47.2 m (155 ft.)	183.9 (603.5 ft.)	

Approach Fills

No stability problems were anticipated for the approach fills up to 10.6 m (35 ft.) in height if slopes of 2 horizontal to 1 vertical were used. It was recommended that temporary slopes steeper than 2 horizontal to 1 vertical should not be permitted during construction.



Based on the estimated settlement, it was recommended that the construction of the approach slabs and the final paving be delayed at least 6 months after completion of fill construction. Further, to minimize the effect of differential settlement between the approach fills and structures, it was recommended to utilize 10.6 m (35 ft.) approach slabs.

Dewatering

The report recommended a dewatering scheme would be required because the pier footings would be placed below the groundwater level in a highly permeable soil. It was suggested to combine track protection and dewatering, which could be achieved by sheet piling into the clayey silt stratum, where footings were to be placed close the railway tracks.

Frost Protection

It was recommended to cover all footing or pile caps with a minimum 1.2 m (4.0 ft.) frost protection.

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 resistance at SLS and factored geotechnical resistance at ULS are provided.

FOUNDATION DESIGN PARAMETERS

Foundation Foundation Type	Design Load Values	Previous Equivalent Limit State Design Values		Limit State Design Values updated to current industry practice	
	Safe Bearing Resistance	Bearing Resistance		Bearing Resistance	
		SLS	Factored ULS	SLS	Factored ULS
West abutment	120 (tons)	n/a	1600 kN	n/a	1600 kN
East abutment					
Piers					

Notes: Working stress design values. The Ultimate Limit State design values are based on the working stress. No field verifications were made.

Resistance Factor = 0.4 for deep foundation (CFEM 4th edition).

Assumed Factor of safety is 3 (CFEM 4th edition).



The resistance at SLS normally allows for 25 mm of compression of the pile and founding medium. Considering the bedrock to be non-yielding, the design is not expected to be governed by settlement since the required loads causing appreciable deformation of the pile and/or bedrock are much larger than the ULS factored capacity.

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 Front Street and CNR Overpass EBL structure is not expected provided that the total dead load on the overhead structures do not increase or decrease by more than 10%.

It is understood that the Front Street Overpass EBL rehabilitation will be implemented in two stages. During each stage of the rehabilitation, the truck traffic will remain on the truck ramp and cross the overpass and the vehicles will be redirected to the W-N/S ramp to Front Street to the N/S-E ramp onto Highway 402 after the overpass crossing.

If a temporary support system is required during the rehabilitation of the overhead structure then the construction for the temporary support system should conform to OPSS 404 and 539. A performance level of 2 for the protection system, according to OPSS 539, should be adopted to prevent excessive lateral and/or vertical movement of the existing embankment during construction. The contractor is responsible for the selection, detailed design and performance of the roadway protection scheme. The contractor should monitor the movement of the roadway protection system.



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 that 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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NR/RN/BRG:nr-jk-nk

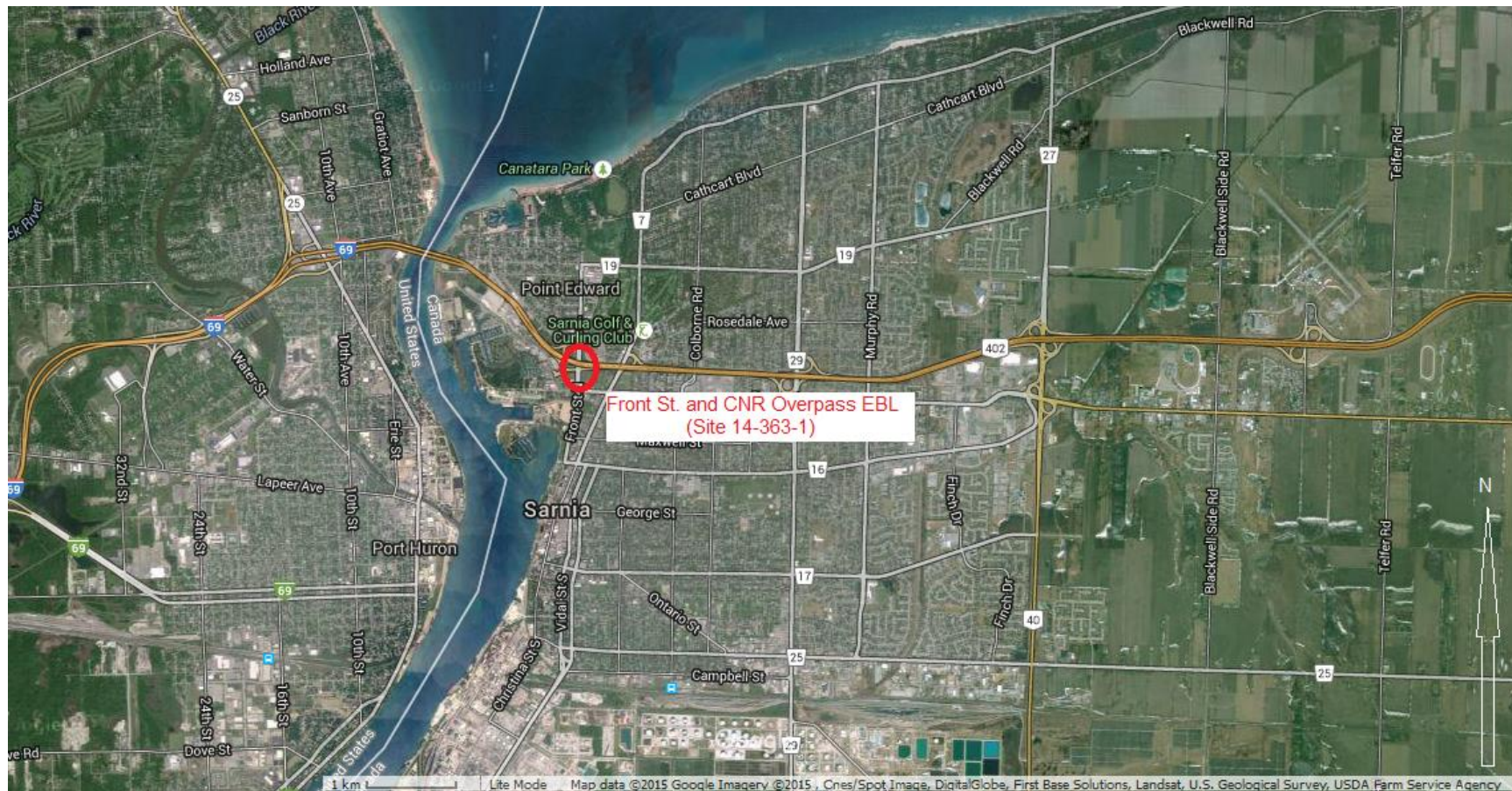


TABLE 1

LIST OF STANDARD SPECIFICATION REFERENCED IN REPORT

DOCUMENT	TITLE
OPSS 404	Construction Specification for Support Systems
OPSS 539	Construction Specification for Temporary Protection Systems
OPSD 3090.101	Foundation Frost Depth for Southern Ontario

Figure 1 – Key Plan





APPENDIX A

Previous Foundation Investigation Reports (GEOCRES No. 40J16-58) and Drawings

- Reference 1. Foundation Investigation Report for Front Street Overpass and CNR Overhead, W.P. 347-65-02/03, Site 14-363, Contract No 81-47, dated July 14, 1977.
- Reference 2. General Layout Revision A - E.B.L, Front street Interchange Overpass and C.N.R Overhead, dated June 1979.
- Reference 3. Front Street Interchange Overpass and C.N.R Overhead, Footings Revision A – E.B.L., dated June 1979.

DOCUMENT MICROFILMING IDENTIFICATION

Reference 1

G.I.-30 SEPT. 1976

GEOCRES No. 40 F 16-58DIST. 1 REGION W.P. No. 347-65-02, 03CONT. No. 81-47W. O. No. STR. SITE No. 14-363HWY. No. 402LOCATION Front St. Overpass of
C.W.R. Overhead at SarniaNo of PAGES - —=====OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 81-47



Ministry of
Transportation and
Communications



INDEX

<u>Page No.</u>	<u>Description</u>
1	Index
2	Abbreviations & Symbols
3	Soil Classification
4- 22	Foundation Investigation Report Front St. Overpass & CNR Overhead W.P. 347-65-02/03.

NOTE: For purposes of the Contract this report supercedes all other foundation reports done by or for the Ministry in connection with the above mentioned projects.

'N' VALUE: AN INDICATOR OF SUBSOIL QUALITY. IT IS OBTAINED FROM THE STANDARD PENETRATION TEST (CSA STD. A119.1). SPT 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 2 INCH O.D. SPLIT-BARREL SAMPLER TO PENETRATE 12 INCHES INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WEIGHING 140 POUNDS, FALLING FREELY A DISTANCE OF 30 INCHES. FOR PENETRATIONS OF LESS THAN 12 INCHES 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. 'N' VALUES CORRECTED FOR OVERBURDEN PRESSURE ARE DENOTED THUS N_c .

DYNAMIC CONE PENETRATION TEST (CSA STD. A119.3): CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 FT-LB IMPACTS ON 1" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 12 INCH ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOIL QUALITY: SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH AS FOLLOWS:

S_u (PSF)	0 - 250	250 - 500	500 - 1000	1000 - 2000	2000 - 4000	> 4000
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSITY: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF SPT 'N' VALUES AS FOLLOWS:

'N' (BLOW/FT)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCK QUALITY: ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH DRILLED IN THAT CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS & SYMBOLS

LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EG. $\bar{C}U$ = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

FIELD SAMPLING

S S SPLIT SPOON
W S WASH SAMPLE
S T SLOTTED TUBE SAMPLE
B S BLOCK SAMPLE
C S CHUNK SAMPLE
T W THINWALL OPEN
T P THINWALL PISTON
O S OSTERBERG SAMPLE
F S FOIL SAMPLE
R C ROCK CORE
P H T.W. ADVANCED HYDRAULICALLY
P M T.W. ADVANCED MANUALLY

EARTH PRESSURE TERMS

μ COEFFICIENT OF FRICTION
 δ ANGLE OF WALL FRICTION
 k_o COEFFICIENT OF EARTH PRESSURE AT REST
 k_A COEFFICIENT OF ACTIVE EARTH PRESSURE
 k_P COEFFICIENT OF PASSIVE EARTH PRESSURE
 i ANGLE OF INCLINATION OF SURCHARGE
 w SLOPE ANGLE-BACKFACE OF WALL
 β ANGLE OF SLOPE
 N, N_q, N_c BEARING CAPACITY FACTORS
 D_f DEPTH OF FOOTING
 B, L FOOTING DIMENSIONS

INDEX PROPERTIES

γ UNIT WEIGHT OF SOIL (BULK DENSITY)
 γ_w UNIT WEIGHT OF WATER
 γ_d UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
 γ' UNIT WEIGHT OF SUBMERGED SOIL
 G_s SPECIFIC GRAVITY OF SOLIDS
 e VOIDS RATIO
 e_o INITIAL VOIDS RATIO
 e_{max} e IN LOOSEST STATE
 e_{min} e IN DENSEST STATE
 D_r RELATIVE DENSITY = $\frac{e_{max} - e}{e_{max} - e_{min}}$
 n POROSITY
 w WATER CONTENT
 w_L LIQUID LIMIT
 w_P PLASTIC LIMIT
 w_S SHRINKAGE LIMIT
 I_P PLASTICITY INDEX = $w_L - w_P$
 I_L LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
 I_c CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
 A_c ACTIVITY = $\frac{I_P \text{ of soil}}{w_L - 2 \text{ } \mu\text{m Soil Fraction}}$
 Om ORGANIC MATTER CONTENT
 S_r DEGREE OF SATURATION
 S SENSITIVITY = $\frac{S_u(\text{undisturbed})}{S_u(\text{remoulded})}$

STRENGTH PARAMETERS

ϕ ANGLE OF SHEARING RESISTANCE
 T_f PEAK SHEAR STRENGTH
 T_R RESIDUAL SHEAR STRENGTH
 c COHESION INTERCEPT
 $\sigma_1, \sigma_2, \sigma_3$ NORMAL PRINCIPAL STRESSES
 u PORE WATER PRESSURE
 u_e EXCESS u
 r_u PORE PRESSURE RATIO
 q_u UNCONFINED COMPRESSIVE STRENGTH
 s_u UNDRAINED SHEAR STRENGTH
 ϵ LINEAR STRAIN
 γ SHEAR STRAIN
 ν POISSON'S RATIO
 E MODULUS OF ELASTICITY
 G MODULUS OF SHEAR DEFORMATION
 k_s MODULUS OF SUBGRADE REACTION
 m, n STABILITY COEFFICIENTS
 A, B PORE PRESSURE COEFFICIENTS
NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:
 ϕ' = EFFECTIVE ANGLE OF SHEARING RESISTANCE;
 σ' = EFFECTIVE NORMAL STRESS

HYDRAULIC TERMS

h HYDRAULIC HEAD OR POTENTIAL
 q RATE OF DISCHARGE
 v VELOCITY OF FLOW
 i HYDRAULIC GRADIENT
 j SEEPAGE FORCE PER UNIT VOLUME
 η COEFFICIENT OF VISCOSITY
 k COEFFICIENT OF HYDRAULIC CONDUCTIVITY
 k_h k IN HORIZONTAL DIRECTION
 k_v k IN VERTICAL DIRECTION
 m_v COEFFICIENT OF VOLUME CHANGE
 c_v COEFFICIENT OF CONSOLIDATION
 C_c COMPRESSION INDEX
 C_r RECOMPRESSION INDEX
 d DRAINAGE PATH DISTANCE
 T_v TIME FACTOR
 U DEGREE OF CONSOLIDATION
 O_c OVERCONSOLIDATION RATIO (OCR)

EXTENDED CASAGRANDE SOIL CLASSIFICATION SYSTEM											
FIELD IDENTIFICATION PROCEDURES (EXCLUDING PARTICLES LARGER THAN 75mm (3 INCHES) AND BASING FRACTIONS ON ESTIMATED MASS)						GRP SYMP	TYPICAL NAMES	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA		
COARSE GRAINED SOILS MORE THAN HALF OF MATERIAL IS LARGER THAN 75µm (NO. 200 SIEVE SIZE TO THE NAKED EYE)	GRAVELS MORE THAN HALF OF COARSE FRACTION IS LARGER THAN 5mm (NO. 4 SIEVE)	CLEAN GRAVELS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZE		GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.	GIVE TYPE, NAME, IF NECESSARY, INDICATE APPROX. % OF SAND & GRAVEL, MAX. SIZE, ANGULARITY, SURFACE CONDITION, & HARDNESS OF THE COARSE GRAINS; LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION; & SYMBOL IN PARENTHESIS. FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITIONS & DRAINAGE CHARACTERISTICS.	DETERMINE PERCENTAGES OF GRAVEL & SAND FROM GRAIN SIZE CURVE, DEPENDING ON PERCENTAGE OF FINES (FRACTION SMALLER THAN 75µm (NO. 200 SIEVE)) COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS: LESS THAN 5% MORE THAN 12% 5% TO 12% BORDERLINE CASES REQ. USE OF DUAL SYMBOLS			
			PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING		GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES; LITTLE OR NO FINES					
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)		GM	SILTY GRAVELS, POORLY GRADED GRAVEL- SAND-SILT MIXTURES					
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)		GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL- SAND-CLAY MIXTURES.					
	SANDS MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN 5mm (NO. 4 SIEVE)	CLEAN SANDS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZES & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES		SW	WELL GRADED SANDS, GRAVELLY SANDS; LITTLE OR NO FINES					
			PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING		SP	POORLY GRADED SANDS, GRAVELLY SANDS; LITTLE OR NO FINES					
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)		SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES					
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)		SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES					
			IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN 425µm (NO. 40 SIEVE SIZE)								
			FINE GRAINED SOILS MORE THAN HALF OF MATERIAL IS SMALLER THAN 75µm (NO. 200 SIEVE SIZE 75µm IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE)	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50%	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CON- SISTENCY NEAR PLASTIC LIMIT)	ML	INORGANIC SILTS & SANDY SILTS OF SLIGHT PLASTICITY, ROCK FLOUR	GIVE TYPE, NAME, IF NECESSARY, INDICATE DEGREE & CHARACTER OF PLASTICITY, AMOUNT & MAXIMUM SIZE OF COARSE GRAINS. COLOUR IN WET CONDITION, ODOUR, IF ANY, LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFOR- MATION & SYMBOL IN PARENTHESIS. FOR UNDISTURBED SOILS ADD INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTENCY IN UNDISTURBED & REMOULDED STATES, MOISTURE & DRAINAGE CONDITIONS.
NONE	QUICK	NONE				CL	CLAYEY SILTS (INORGANIC), GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS				
MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM				OL	ORGANIC SILT OF LOW PLASTICITY, ORGANIC SANDY SILTS				
SLIGHT TO MEDIUM	SLOW	SLIGHT				MI	INORGANIC COMPRESSIBLE SILTS OR SILTY FINE SANDS WITH SOME CLAY OF MEDIUM PLASTICITY (BELOW A-LINE)				
NONE TO SLIGHT	SLOW TO QUICK	SLIGHT				CI	SILTY CLAYS (INORGANIC) OF MEDIUM PLASTICITY				
HIGH	NONE	MEDIUM TO HIGH				OI	ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY				
LIQUID LIMIT BETWEEN 50% AND 50%	SLIGHT TO MEDIUM	VERY SLOW			SLIGHT	MH	INORGANIC SILTS, HIGHLY COMPRESSIBLE MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS				
	SLIGHT TO MEDIUM	SLOW TO NONE			MEDIUM	CH	CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS				
	HIGH TO VERY HIGH	NONE			HIGH	OH	ORGANIC CLAYS OF HIGH PLASTICITY				
	MEDIUM TO HIGH	NONE TO VERY SLOW			SLIGHT TO MEDIUM						
	HIGHLY ORGANIC SOILS					PE	PEAT & OTHER HIGHLY ORGANIC SOILS				
	READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL & FREQUENTLY BY FIBROUS TEXTURE										

BOUNDARY CLASSIFICATIONS: SOILS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE DESIGNATED BY COMBINATIONS OF THEIR SYMBOLS

BOUNDARY CLASSIFICATIONS: SOILS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE DESIGNATED BY COMBINATIONS OF GROUP SYMBOLS. FOR EXAMPLE GW-GC, WELL GRADED GRAVEL-SAND MIXTURE WITH CLAY BINDER

FOUNDATION INVESTIGATION REPORT

For

Front Street Overpass and CNR Overhead
W.P. 347-65-02/03, Site 14-363
Hwy. 402, District 1, Chatham

INTRODUCTION

This report contains the results of a foundation investigation carried out for the above project. Fieldwork consisted of 11 boreholes advanced during the period of April 28 to May 11, 1977, utilizing a CME75 auger machine mounted on a muskeg vehicle. Hollow stem augers were employed for all boreholes, in two of which bedrock was proven by recovering BXL size rock core samples by coring within the hollow stem augers.

SITE DESCRIPTION

The site is located on existing Highway 402 approximately 1 mile east of the Blue Water Bridge over the St. Clair River.

The residential community of Point Edward is located to the north of the site while the commercial heart of Sarnia is situated just a short distance to the south. Land use immediately to the east is industrial while to the west there is informal parkland.

Physiographically, this area is referred to as the Huron Fringe. It consists of sand beach deposits resulting from glacial lakes Algonquin and Nipissing, as well as present Lake Huron. The terrain is flat with the exception of 3 to 4 foot beach ridges in areas not subject to agricultural production.

Highway 402 in this area consists of 4 traffic lanes, as well as short exit and entrance lanes in the area of Front Street. It has gravel shoulders and a grass median with a guide rail running down the centre of the median. A Canadian National Railway spur line runs parallel to Front Street and crosses Highway 402 at a level crossing.

SUBSURFACE CONDITIONS

General

The overburden consists of a shallow deposit (6 to 15 feet) of sand overlying in excess of 100 feet of clayey silt and silty clay which in turn is underlain by a second thin layer (5 to 10 feet) of sand. Under this approximate 125 feet of overburden black shale bedrock was encountered.

Deposit boundaries are shown in the Record of Borehole Sheets which are contained in the Appendix of this report. The locations and elevations of the borings, as well as an inferred subsoil stratigraphy are shown in Drawings Nos. 14-363A-2 and 14-363B-2 of the Contract Drawings.

Sand

Lake Huron and its glacial ancestors have produced extensive beach deposits at Lake Huron's southern tip. At the structure site this sand deposit ranges in depth from 6 to 10 feet. Incorporated within the sand deposit are pockets of material with high silt or gravel contents. Standard Penetration 'N' values ranged from 2 to 40 but are generally between 5 and 25 indicating a loose to dense deposit.

Clayey Silt, Some Sand, Trace of Gravel

This layer, extending over the entire site, varies from 40 to 50 feet in thickness. Its upper 6 to 10 feet shows desiccation and has a very stiff consistency as indicated by Standard Penetration 'N' values which range up to 30 blows per foot. The undrained shear strength is estimated as being between 2000 and 4000 pounds per square foot. It is noted that this desiccated zone decreases in strength and thickness moving from east to west. Below the desiccated zone the undrained shear strength gradually decreases from 2000 to as low as 800 and then increases to between 1000 and 2000 in the lower part of the deposit. Isolated areas of higher strength are found in association with thin sand seams scattered throughout the deposit. Moisture content increases from a low to 12 percent in the desiccated zone to as high as 25 percent at the lower boundary.

Silty Clay, Trace of Gravel

This deposit located below the clayey silt is 50 to 60 feet in thickness. It contains a trace of sand in some areas. Undrained shear strength varies between 1000 and 2000 psf indicating a stiff consistency. Moisture content increases from 25 percent in the upper portion to 35 percent at the lower boundary.

Black Sand

A layer of from 5 to 10 feet of black sand overlies the bedrock. It is primarily composed of shale fragments and is derived from the bedrock in the area.

Bedrock

Bedrock was located beneath in excess of 120 feet of overburden and varies in elevation from 464 under the west abutment to 456 at the east abutment. It consists of sound black shale of the Kettle Point formation.

Groundwater

Groundwater was encountered in the upper sand layer at depths ranging from 3 to 7 feet.

K.G. Selby

K.G. Selby, P. Eng.
Senior Foundations Engineer

APPENDIX

RECORD OF BOREHOLE NO 1

WP 347-65-02/03 LOCATION Co-ords N 15 619 207 E 1 025 870 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE April 28 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT				LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	VALUES		20	40	60	80	100	w_p	w	w_L	
585.9	Ground Level														
0.0	Sand Pockets of Silt and Gravel Very Loose		1	SS	2	580									9.77 (14)
579.9			2	SS	22										
6.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		3	SS	32										0 24 46 30
			4	SS	16										
			5	SS	10	570									
			6	SS	11										
			7	SS	10	560									
			8	SS	9										
			9	SS	9	550									
			10	SS	31										
						540									
			11	SS	21										0 14 42 44
530.9						530									
55.0	Silty Clay Trace of Sand		12	SS	12										
						520									
			13	SS	9										
						510									
			14	SS	12	500									
						490									
481.9	Continued		15	SS	15										
104.0															

20
15 ϕ 5 % STRAIN AT FAILURE
10

RECORD OF BOREHOLE NO 1 cont

WP 347-65-02/03 LOCATION Co-ords N 15 619 207 E 1 025 870 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE April 28, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
481.9	Continued															
104.0	Silty Clay Trace of Sand Stiff					480										
			16	SS	16	470										
462.9																
123.0	Black Sand					460										
456.6																
129.3	Black Shale Bedrock															
450.9			17	RC	Rec											
135.0	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

20
15 ϕ 5 % STRAIN AT FAILURE
10

RECORD OF BOREHOLE NO 2

WP 347-65-02/03 LOCATION Co-ords N 15 619 230 E 1 025 803 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 5, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Augers CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT				LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	20	40	60	80	100	w_p	w	w_L	
585.7	Ground Level													
0.0	Sand Pockets of Silt and Gravel very Loose to compact		1	SS	2									Org 0 88 (12)
			2	SS	7									
577.7			3	SS	26									0 76 (24)
			4	SS	26									2 30 39 2
8.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		5	SS	25									
			6	SS	12									
			7	SS	10									
			8	SS	12									
			9	SS	10									
			10	SS	8									
			11	SS	7									
			12	SS	6									
			13	SS	10									
529.7														
56.0	Silty Clay Trace of Sand Stiff		14	SS	12									
481.7	Continued													
104.0														

OFFICE REPORT ON SOIL EXPLORATION

20
15 ϕ 5 % STRAIN AT FAILURE
10

WP 347-65-02/03 LOCATION Co-ords N 15 619 230 E 1 025 803 ORIGINATED BY PJS
DIST 1 HWY 402 BORING DATE May 5, 1977 COMPILED BY PJS
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

[illegible]

15 ϕ 5 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE NO 3

WP 347-65-02/03

LOCATION Co-ords N 15 619 246 E 1 025 726

ORIGINATED BY PJS

DIST 1 HWY 402

BORING DATE May 6, 1977

COMPILED BY PJS

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	W VALUES		20	40	60	80	100	w_p	w	w_L		
584.2	Ground Level															
0.0																
576.2	Sand Pockets of Silt and Sand Loose to Compact		1	SS	21	580										
8.0			2	SS	12											
			3	SS	27											
	Clayey Silt Some Sand		4	SS	16											
	Trace of Gravel		5	SS	13											
	Occasional Sand Seams		6	SS	8	570										
	Very stiff to firm		7	SS	9											
			8	SS	9											
			9	SS	9	560										
			10	SS	10											
			11	SS	5	550										
			12	SS	11											
			13	SS	14	540										
			14	SS	12											
531.2																
53.0	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

20
15 ϕ 5 % STRAIN AT FAILURE
10

WP 347-65-02103

LOCATION Co-ords N 15 619 288 E 1 025 623

ORIGINATED BY PJS

DIST 1 HWY 402

BORING DATE May 2, 1977

COMPILED BY PJS

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LQUID LIMIT ———— w_L PLASTIC LIMIT ———— w_p WATER CONTENT ———— w	UNIT WEIGHT γ PCF	REMARKS			
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		'N' VALUES	SHEAR STRENGTH PSF ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE			WATER CONTENT % w_p — w — w_L		
584.2 0.0	Ground Level											
574.2 10.0	Sand Pockets of Silt and Gravel Loose Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		1	SS	7							
			2	SS	6							
			3	SS	11							
			4	SS	10							
			5	TW	PH							
			6	TW	PH							
			7	SS	7							
			8	TW	PH							
			9	TW	PH							
			10	TW	PH							
			11	TW	PM							
			12	TW	PH							
			13	TW	PH							
			530.2	54.0 Silty Clay Trace of Sand Stiff		14	TW	PH				
			520									
			510			15	TW	PH				
500												
490.0	Continued											

OFFICE REPORT ON SOIL EXPLORATION

20
15 ϕ 5 % STRAIN AT FAILURE
10

WP 347-65-02103 LOCATION Co-ords N 15 619 288 E 1 025 623 ORIGINATED BY PJS
DIST 1 HWY 402 BORING DATE May 2, 1977 COMPILED BY PJS
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT				LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w		UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N° VALUES		20 40 60 80 100				w_p w w_L			
							SHEAR STRENGTH				WATER CONTENT %			
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
481.7	Continued													% GR SA SI CL
104.0	Silty Clay Trace of Sand Stiff		17	SS	14	480								
471.7														
114.0	Black Sand					470								
464.2			18	SS			Sample Disturbed							7 81 (12)
120.0	Black Shale Bedrock													
456.3				BXL	100%	460								
127.9	End of Borehole		19	RC	Rec									

20
15 ϕ -5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE NO 5

WP 347-65-02/03 LOCATION Co-ords N 15 619 266 E 1 025 338 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 11, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT				LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L	
583.8 0.0	Ground Level														
	Sand, Pockets of Silt and Gravel Loose to Dense		1	SS	8										
			2	SS	21										
			3	SS	12										
			4	SS	30										
			5	SS	40										
566.8 17.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Stiff to Firm		6	SS	28										
			7	SS	6										
			8	SS	7										
			9	SS	7										
			10	SS	9										
540.8 43.0	End of Borehole		11	SS	12										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE NO 6

WP 347-65-02103 LOCATION Co-ords N 15 619 172 E 1 025 637 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 10, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ pcf	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	w_p	w	w_L		
584.4	Ground Level															
0.0	Sand, Pockets of Silt and Gravel Loose to Compact		1	SS	6	580										0 35 60 5
			2	SS	8											
575.4			3	SS	18											
9.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		4	SS	16											131 134 132 130
			5	SS	13											
			6	TW	PH											
			7	TW	PH											
			8	TW	PH											
553.4			9	TW	PH											
31.0	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

20
 15 ϕ 5 % STRAIN AT FAILURE
 10

RECORD OF BOREHOLE No 7

WP 347-65-02/03 LOCATION Co-ords N 15 619 156 E 1 025 689 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 10, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT				LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS	
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w			w_L
584.5	Ground Level															
0.0	Sand, Pockets of Silt and Gravel Compact		1	SS	14	580										
			2	SS	10											
576.5			3	SS	23											
8.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		4	SS	15											
			5	SS	16											
			6	SS	11	570										
			7	SS	9											
			8	SS	9											
			9	SS	19	560										
			10	SS	55											
			11	SS	12	550										
			12	SS	8											
			13	SS	7	540										
530.5																
54.0	Silty Clay Trace of Sand Stiff		14	SS	15	530										
						520										
						510										
						500										
						490										
530.5	Continued															

OFFICE REPORT ON SOIL EXPLORATION

20
15
10
% STRAIN AT FAILURE

RECORD OF BOREHOLE No 7 cont

WP 347-65-02/03 LOCATION Co-ords N 15 619 156 E 1 025 689 ORIGINATED BY EJS
 DIST 1 HWY 402 BORING DATE May 10, 1977 COMPILED BY EJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	w_p	w	w_L		
480.5	Continued					480										GR SA SI CL
104.0	Silty Clay Trace of Gravel Stiff					470										
464.5 120.0	Black Sand					460										
459.5																
125.0	End of Borehole Probable Bedrock															
	NOTE Water Level not established															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE NO 8

WP 347-65-02/03 LOCATION Co-ords N 15 619 135 E 1 025 792 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 9, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	w_p	w	w_L		
585.8	Ground Level					ELEV	1000	2000				10	20	30	pcf	GR SA SI CL
0.0	Sand, Pockets of Silt and Gravel Loose		1	SS	6	580										1 38 56 5
579.8			2	SS	19											
6.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		3	SS	26											6 27 41 26
			4	SS	27											
			5	SS	18											
			6	SS	12	570										
			7	TW	PH										131	
			8	TW	PH										131	
			9	TW	PH	560									129	
			10	TW	PH											
552.8	End of Borehole															
33.0																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE NO 9

WP 347-65-02/03

LOCATION Co-ords N 15 619 135 E 1 025 864

ORIGINATED BY PJS

DIST 1 HWY 402

BORING DATE May 9, 1977

COMPILED BY PJS

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ pcf	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
586.5	Ground Level															
0.0	Sand, Pockets of Silt and Gravel Compact		1	SS	12	580										
579.5			2	SS	28											
7.0	Clayey Silt, Some Sand Trace of Gravel Occasional Sand Seams Very Stiff To Firm		3	SS	30											
			4	SS	16											
			5	TW	PH	570										
			6	TW	PH											
			7	SS	10											
			8	TW	PH	560										
			9	SS	10											
			10	SS	10	550										
			11	TW	PH											
543.5																
43.0	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 10

WP 347-65-02/03 LOCATION Co-ords N 15 619 106 E 1 026 084 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 11, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	w_p	w	w_L		
588.1	Ground Level															
0.0	Sand, Pockets of Silt and Gravel Compact Clayey Silt, Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		1	SS	17											
581.0			2	SS	24											
7.0			3	SS	21											
			4	SS	36											
			5	SS	37											
			6	SS	21											
			7	SS	14											
			8	SS	11											
			9	SS	9											
			10	SS	6											
535.1			11	SS	8											
53.0	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

22

RECORD OF BOREHOLE No 11

WP 347-65-02/03 LOCATION Co-ords N 15 619 257 E 1 025 649 ORIGINATED BY EJS
 DIST 1 HWY 402 BORING DATE May 11, 1977 COMPILED BY EJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N VALUES		20	40	60	80	100	w_p	w	w_L		
585.5	Ground Level															
0.0	Sand, Pockets of Silt and Gravel Loose to Compact		1	SS	5	580										
576.5			2	SS	13	570										
9.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		3	SS	13											
			4	SS	11											
			5	SS	9											
			6	SS	9											
			7	SS	8											
			8	SS	8											
557.5						560										
28.0	End of Borehole															

20
15 ϕ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

DIST. No. 1
CONT No
WP No 347-65-03

FRONT ST. INTERCH. OPASS.
E. CNR. CHAD.
0.3 MI. WEST OF CHRISTINA ST.
GENERAL LAYOUT - W.B.L.

N NISBET LETHAM LIMITED
Consulting Engineers
P.O. Box 97, Sarnia
ONT. M2H 1H6

NOTES:
CLASS OF CONCRETE
FOOTINGS - 3000 P.S.I.
DECK SLABS - 5000 P.S.I.
REMAINDER - 4000 P.S.I.
REINFORCING STEEL
ALL STEEL GRADE : 400
REINFORCING BARS WITH THE DESIGNATION 'C'
AT THE END OF BAR MARKS SHALL BE COATED BARS.
CLEAR COVER TO REINFORCING STEEL
FOOTINGS, PIER COL'S & ABUTMENTS - 3"
DECK - 2" TOP, 1 1/2" BOTTOM,
OR AS NOTED ON DRAWINGS
CONSTRUCTION NOTES
THE CONTRACTOR IS RESPONSIBLE FOR
FINISHING THE BEARING SEATS DEAD LEVEL
TO THE SPECIFIED ELEVATIONS WITH A
TOLERANCE OF 1/8".
NO CONCRETE SHALL BE PLACED ABOVE THE
ABUTMENT BEARING SEATS UNTIL CONCRETE
IN THE DECK HAS BEEN PLACED, STRESSED
AND GROUTED.

CONCRETE QUANTITIES :

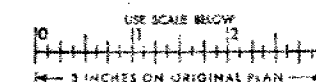
CONCRETE QUANTITIES ARE LISTED BELOW
FOR THE APPROPRIATE CONCRETE
LUMP SUM TENDER ITEM :
CONCRETE IN PIERS, ABUTMENTS
AND WINGWALLS 477 CU.YD.
CONCRETE IN DECK 1186 CU.YD.
CONCRETE IN BARRIER WALLS 26 CU.YD.
CONCRETE IN APPROACH SLABS 71 CU.YD.
CONCRETE IN SLOPE PAVING 45 CU.YD.

LIST OF DRAWINGS :

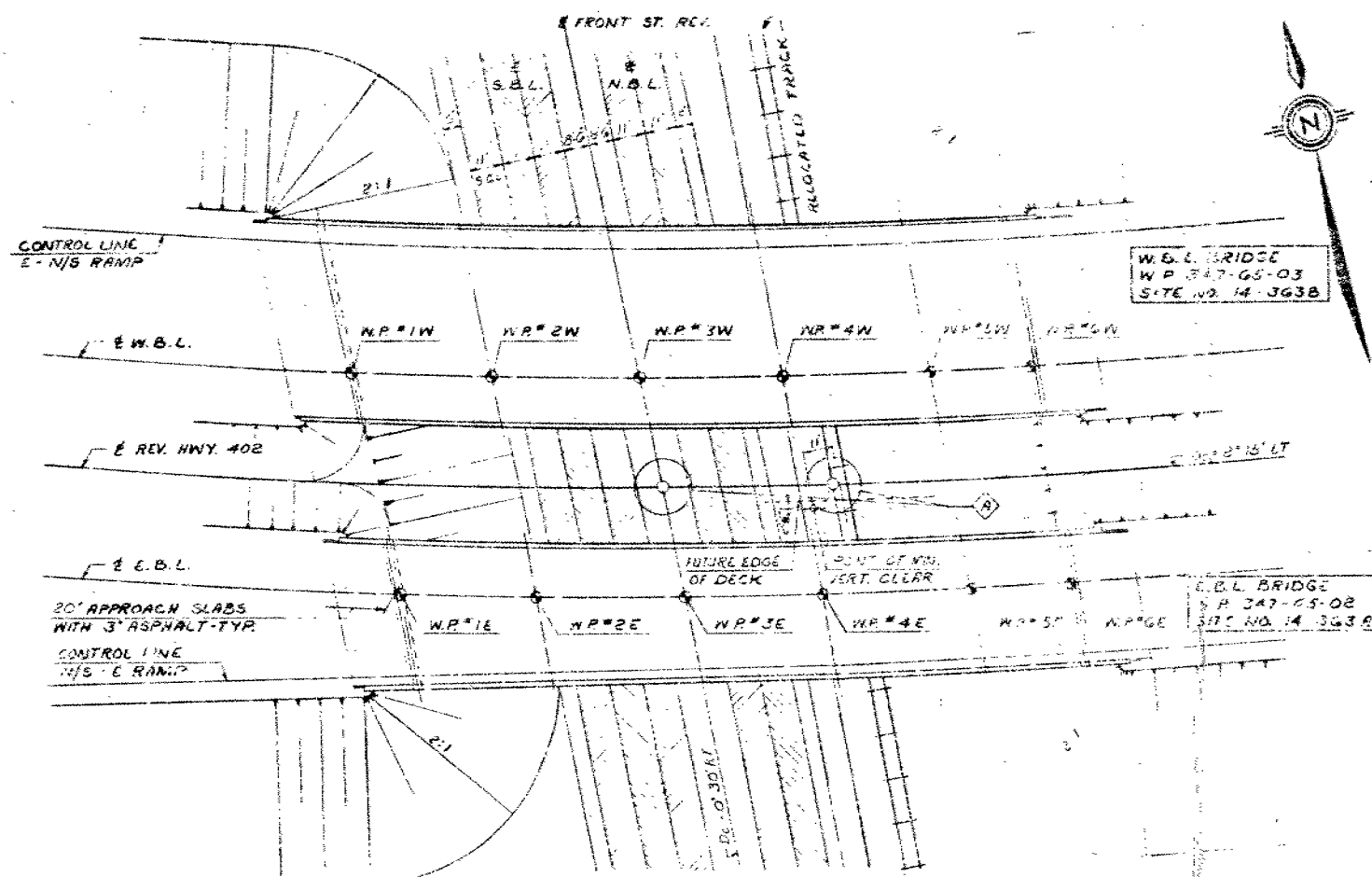
- 1 GENERAL LAYOUT
- 2 BORE HOLE LOCATIONS (SOIL STRATA)
- 3 SITE LAYOUT PLAN
- 4 FOOTINGS
- 5 ABUTMENTS
- 6 PIER #1E
- 7 PIER #2E
- 8 PIER #3E
- 9 PIER #4E
- 10 DECK LAYOUT & SLOPED ELEVATIONS
- 11 DECK LONGITUDINAL CHAIR DETAILS
- 12 DECK TRANSVERSE CHAIR DETAILS
- 13 DECK REINFORCING
- 14 BARRIER WALL
- 15 STEEL RAILING
- 16 APPROACH SLAB
- 17 DETAILS OF CONC. SLOPE PAVING
- 18 STANDARD DETAILS 1
- 19 STANDARD DETAILS 2
- 20 AS CONSTRUCTED ELEVATIONS & DIMS.



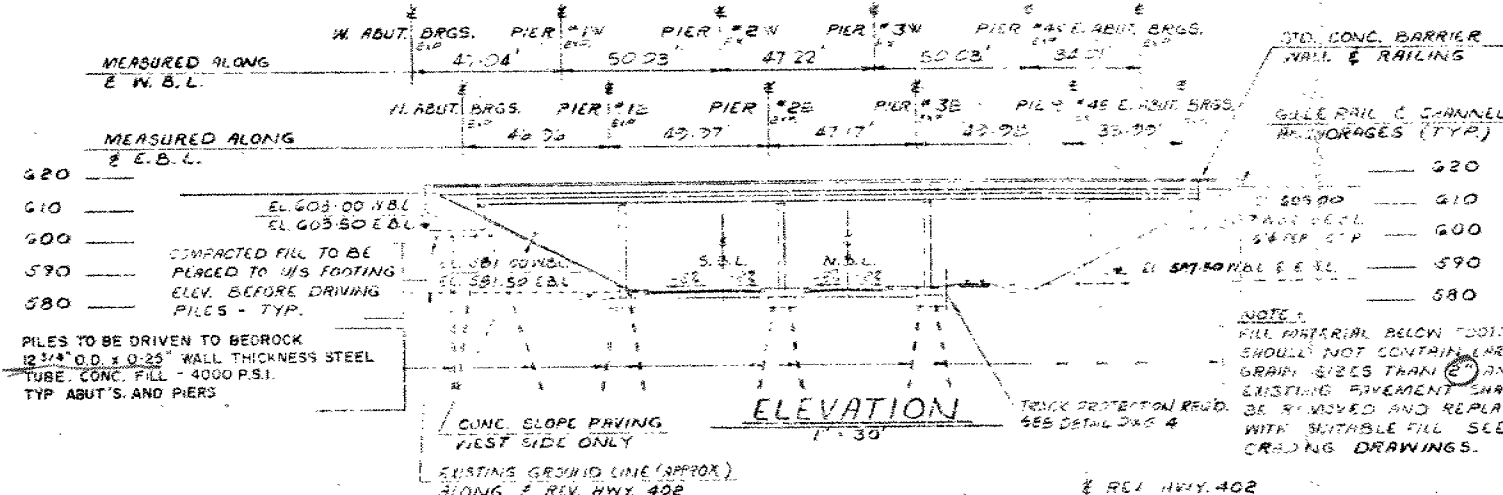
FOR REDUCED PLAN



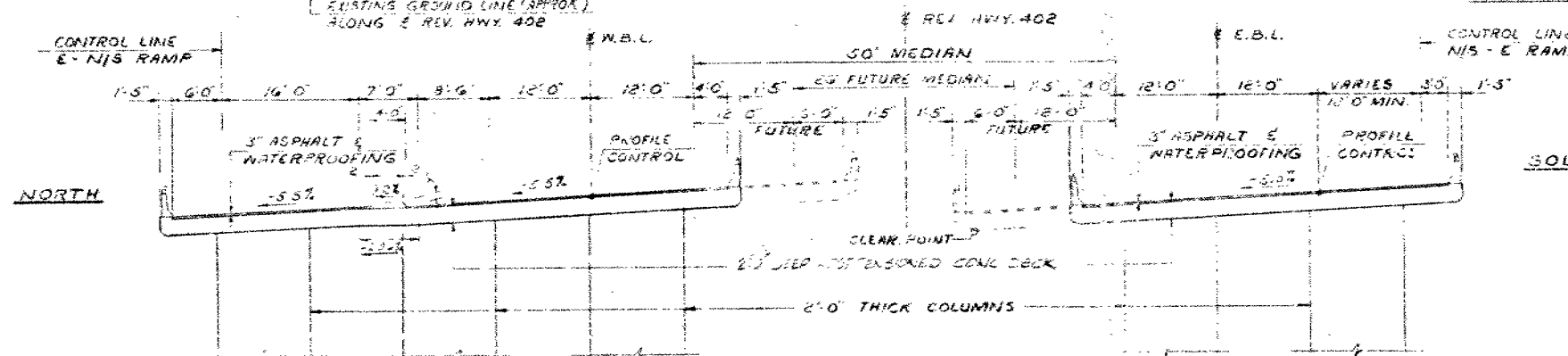
REVISIONS	DATE	BY	DESCRIPTION
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			



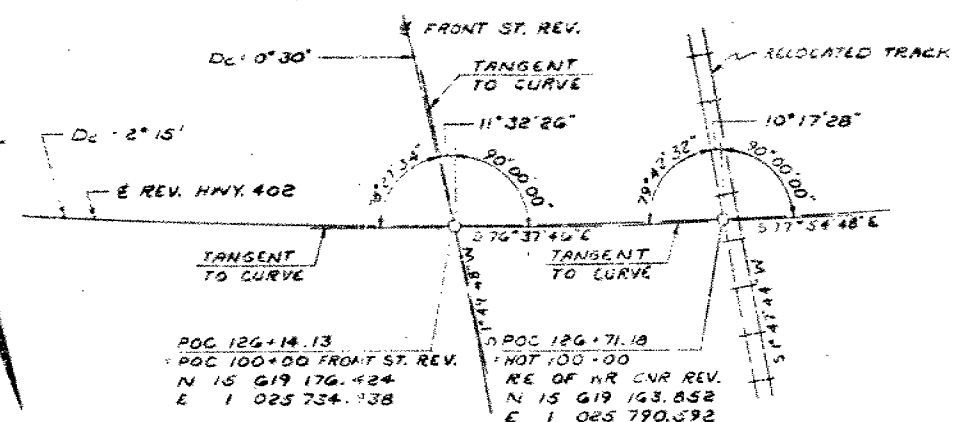
PLAN
1" = 30'



ELEVATION
1" = 30'

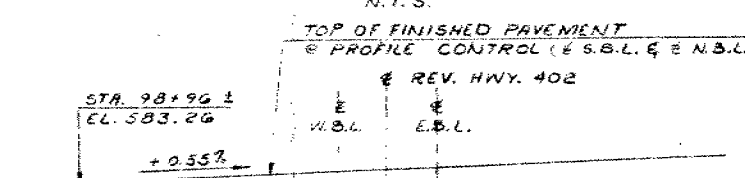


TYPICAL DECK CROSS SECTION
1" = 10'



PROFILE OF REV. HWY. 402
N.T.S.

PROFILE OF FRONT ST. REV.
N.T.S.



CLEARANCE DIAGRAM
1" = 10'

DIST. No. 1
CONT No
WP No 347-65-03

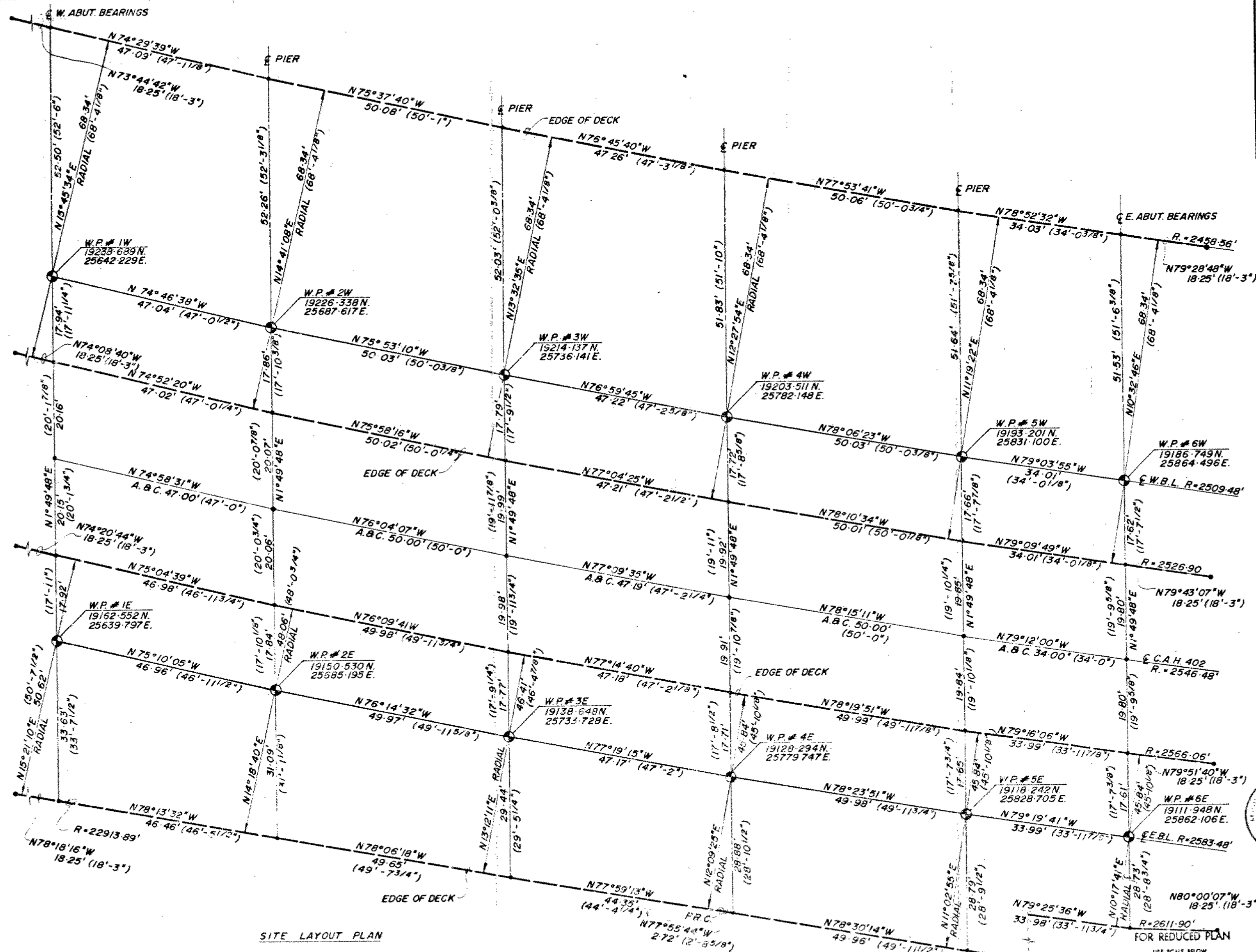


FRONT ST. O'PASS & C.N.R.
O'HEAD
SITE LAYOUT PLAN

SHEET



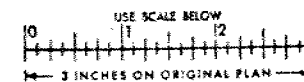
NISBET LETHAM LIMITED
Consulting Engineers
P.O. Box 67, Sarma
N7T 7H5



SITE LAYOUT PLAN

SCALE 1" = 10'-0"

FOR REDUCED PLAN



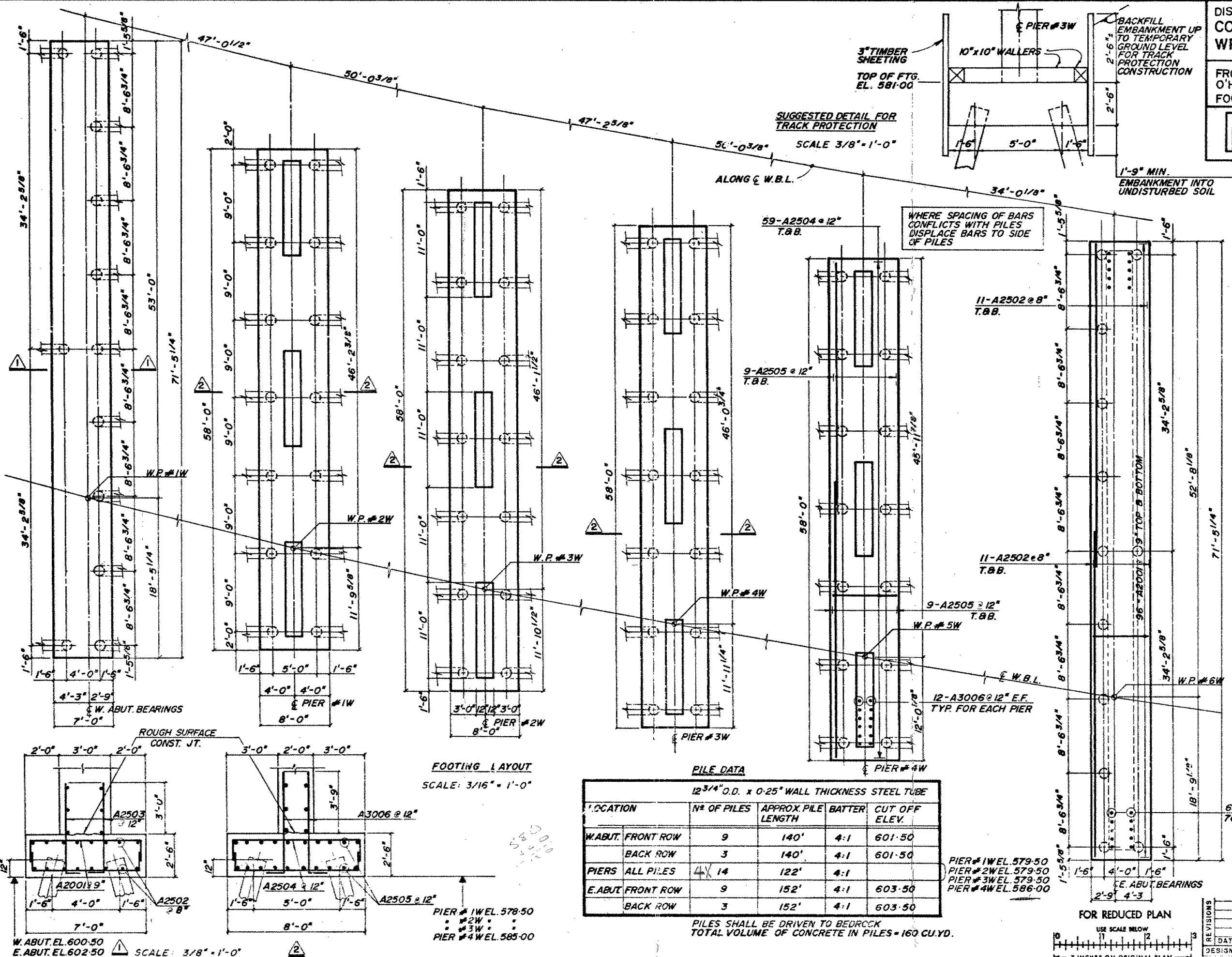
REVISIONS	DATE	BY	DESCRIPTION

DIST. No. 1
CONT No
WP No 347-65-03

FRONT ST. O'PASS & C.N.R.
 O'HEAD
 FOOTINGS

SHEET

NISBET LETHAM LIMITED
 Consulting Engineers
 P.O. Box 67, Sarnia
 N7T 7H4

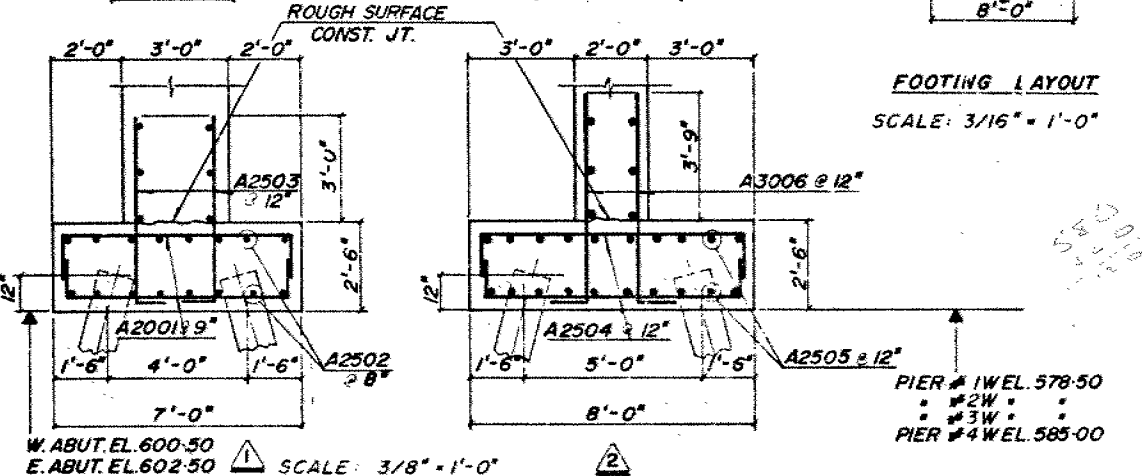


PILE DATA

12 3/4" O.D. x 0.25" WALL THICKNESS STEEL TUBE

LOCATION	Nº OF PILES	APPROX. PILE LENGTH	BATTER	CUT OFF ELEV.
W.ABUT. FRONT ROW	9	140'	4:1	601.50
BACK ROW	3	140'	4:1	601.50
PIERS ALL PILES	14	122'	4:1	
E.ABUT. FRONT ROW	9	152'	4:1	603.50
BACK ROW	3	152'	4:1	603.50

PILES SHALL BE DRIVEN TO BEDROCK
 TOTAL VOLUME OF CONCRETE IN PILES = 160 CU. YD.



FOR REDUCED PLAN

USE SCALE BELOW

0 1 2 3

1 INCHES ON ORIGINAL PLAN

REVISIONS	DATE	BY	DESCRIPTION

DESIGN: [] CHECK: [] LOADING: [] DATE: []
 DRAWING: [] CHECK: [] SITE: [] DWG: []



Ministry of
Transportation and
Communications

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
SOIL MECHANICS SECTION

WP 347-65-02/03

DIST 1

HWY 402

STR SITE 14-363

Front Street Overpass
and CNR Overhead

DISTRIBUTION

A.P. Watt (2)
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R.S. Pillar

R. Hore

A. Crowley)
J. Anderson) cover only
G. Sloan)

Files ✓

SAMPLE DISPOSITION NOTICE		
TYPE	DISCARD AFTER	RECOMM. BY
JARS	77-07-15	14g
TUBES	77-07-15	14g
ROCK CORES	77-07-15	14g

FOUNDATION INVESTIGATION REPORT

For

Front Street Overpass and CNR Overhead
W.P. 347-65-02/03, Site 14-363
Hwy. 402, District 1, Chatham

INTRODUCTION

This report contains the results of a foundation investigation carried out for the above project. Fieldwork consisted of 11 boreholes advanced during the period of April 28 to May 11, 1977, utilizing a CME75 auger machine mounted on a muskeg vehicle. Hollow stem augers were employed for all boreholes, in two of which bedrock was proven by recovering BXL size rock core samples by coring within the hollow stem augers.

SITE DESCRIPTION

The site is located on existing Highway 402 approximately 1 mile east of the Blue Water Bridge over the St. Clair River.

The residential community of Point Edward is located to the north of the site while the commercial heart of Sarnia is situated just a short distance to the south. Land use immediately to the east is industrial while to the west there is informal parkland.

Physiographically, this area is referred to as the Huron Fringe. It consists of sand beach deposits resulting from glacial lakes Algonquin and Nipissing, as well as present Lake Huron. The terrain is flat with the exception of 3 to 4 foot beach ridges in areas not subject to agricultural production.

Highway 402 in this area consists of 4 traffic lanes, as well as short exit and entrance lanes in the area of Front Street. It has gravel shoulders and a grass median with a guide rail running down the centre of the median. A Canadian National Railway spur line runs parallel to Front Street and crosses Highway 402 at a level crossing.

SUBSURFACE CONDITIONS

General

The overburden consists of a shallow deposit (6 to 15 feet) of sand overlying in excess of 100 feet of clayey silt and silty clay which in turn is underlain by a second thin layer (5 to 10 feet) of sand. Under this approximate 125 feet of overburden black shale bedrock was encountered.

Deposit boundaries are shown in the Record of Borehole Sheets which are contained in the Appendix of this report. The locations and elevations of the borings, as well as an inferred subsoil stratigraphy are shown in Drawing No. 3476502 and 03-A.

Sand

Lake Huron and its glacial ancestors have produced extensive beach deposits at Lake Huron's southern tip. At the structure site this sand deposit ranges in depth from 6 to 10 feet. Further to the west under the approach fill the depth of sand increases to about 15 feet. Incorporated within the sand deposit are pockets of material with high silt or gravel contents. Standard Penetration 'N' values ranged from 2 to 40 but are generally between 5 and 25 indicating a loose to dense deposit.

Clayey Silt, Some Sand, Trace of Gravel

This layer, extending over the entire site, varies from 40 to 50 feet in thickness. Its upper 6 to 10 feet shows dessication and has a very stiff consistency as indicated by Standard Penetration 'N' values which range up to 30 blows per foot. The undrained shear strength is estimated as being between 2000 and 4000 pounds per square foot. It is noted that this dessicated zone decreases in strength and thickness moving from east to west. Below the dessicated zone the undrained shear strength gradually decreases from 2000 to as low as 800 and then increases to between 1000 and 2000 in the lower part of the deposit. Isolated areas of higher strength are found in association with thin sand seams scattered throughout the deposit. Moisture content increases from a low to 12 percent in the dessicated zone to as high as 25 percent at the lower boundary.

Silty Clay, Trace of Gravel

This deposit located below the clayey silt is 50 to 60 feet in thickness. It contains a trace of sand in some areas. Undrained shear strength varies between 1000 and 2000 psf indicating a stiff consistency. Moisture content increases from 25 percent in the upper portion to 35 percent at the lower boundary.

Black Sand

A layer of from 5 to 10 feet of black sand overlies the bedrock. It is primarily composed of shale fragments and is derived from the bedrock in the area.

Bedrock

Bedrock was located beneath in excess of 120 feet of overburden and varies in elevation from 464 under the west abutment to 456 at the east abutment. It consists of sound black shale of the Kettle Point formation.

Groundwater

Groundwater was encountered in the upper sand layer at depths ranging from 3 to 7 feet.

DISCUSSION AND RECOMMENDATIONS

Discussion

The Structural Section, Southwestern Region, has proposed a scheme, shown on Drawing 3476502/03-A, consisting of twin 4 span structures, each with an overall length of approximately 200 feet, to carry Hwy. 402 over Front Street and the Canadian National Railway tracks. The approach fills to the twin structures will have an effective height of approximately 31 feet and will have a top width in excess of 150 feet. The construction of such large embankments on a deep deposit of firm to stiff clay such as exists at this site will result in significant long-term settlements.

The possibility of placing the abutments on short piles and the piers on spread footings was considered. For this arrangement total settlements of 3 inches at the piers and 18 inches at the abutments were calculated. Past experience, including a similar railway crossing by Highway 402, some 2 miles east of this site, suggests that these calculated values are an overestimation by a factor of 2 and that the actual settlements will be in the order of 2 inches and 9 inches respectively. Nevertheless, differential settlement between the abutments and piers would be significant and might approach 4 to 5 inches if normal construction procedures were followed. Using stage construction might reduce this value to 2 or 3 inches. However, at this particular site (where it is necessary to maintain traffic on Hwy. 402) stage construction would be inconvenient and expensive. In any event differential settlement of 2 or 3 inches would necessitate a simply supported structure.

Recommendations

Based on previous experience in similar deposits we would recommend that 12HP74 sections and 12 3/4" x 1/4" wall steel tubes be considered and the choice be governed by economy. In either case a design load of 120 tons per pile should be achieved provided the piles are driven to bedrock. Steel H piles should have tips reinforced by standard flange plates. Steel tube piles should be driven closed ended with standard shoe plates. In order to prevent damage to the steel tubes on contact with bedrock the driving energy for the last 5 feet should not be greater than 30,000 ft-lb. per blow.

Approach Fills

No stability problems are anticipated with approach fills up to 35 feet in height if slopes of 2 horizontal to 1 vertical are used. Temporary slopes steeper than this should not be permitted during construction.

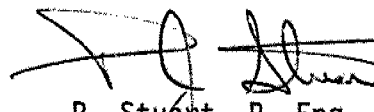
Due to the anticipated settlement of the subsoil under the approach fills it is recommended that the construction of the approach slabs and the final paving be delayed until at least 6 months after the completion of the fill construction. As a further measure to minimize the effect of differential settlement between the approach fills and structures it is recommended that 35 foot approach slabs be used.

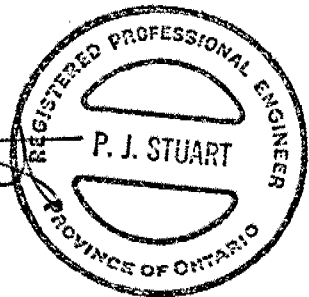
Dewatering

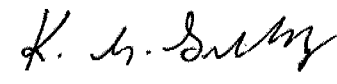
Pier footings will be placed below the groundwater level in a highly permeable soil. A dewatering scheme will, therefore, be required. Where footings are placed close to the railway tracks it may be desirable to combine track protection and dewatering. This could be achieved by keying sheet piling into the clayey silt stratum.

Frost Protection

A minimum of 4 feet of cover will be required at all footings or pile caps for frost protection.


P. J. Stuart, P. Eng.
Project Engineer




K.G. Selby, P. Eng.
Supervising Engineer

KGS/PS/gs
July, 1977

APPENDIX

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 1

WP 347-65-02/03 LOCATION Co-ords N 15 619 207 E 1 025 870 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE April 28 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W_P	W	W_L		
585.9	Ground Level															
0.0	Sand Pockets of Silt and Gravel Very Loose		1	SS	2	580										9 77 (14)
579.9			2	SS	22											
6.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		3	SS	32											0 24 46 30
			4	SS	16											
			5	SS	10											
			6	SS	11											
			7	SS	10											
			8	SS	9											
			9	SS	9											
			10	SS	31											
			11	SS	21											0 14 42 44
530.9																
55.0	Silty Clay Trace of Sand		12	SS	12											
			13	SS	9											
			14	SS	12											
			15	SS	15											
481.9	Continued															
104.0																

20
15 ϕ -5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 1 cont

WP 347-65-02/03 LOCATION Co-ords N 15 619 207 E 1 025 870 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE April 28, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W_P	W	W_L		
481.9	Continued															
104.0	Silty Clay Trace of Sand Stiff															
			16	SS	16	470										
462.9																
123.0	Black Sand					460										
456.6																
129.3	Black Shale Bedrock			BXL	77%											
450.9			17	RC	Rec											
135.0	End of Borehole															

20
15 ϕ 5 % STRAIN AT FAILURE
10

WP 347-65-02/03 LOCATION Co-ords N 15 619 230 E 1 025 803 ORIGINATED BY PJS
DIST 1 HWY 402 BORING DATE May 5, 1977 COMPILED BY PJS
DATUM Geodetic BOREHOLE TYPE Hollow Stem Augers CHECKED BY _____

104.0

20
15 ϕ 5 % STRAIN AT FAILURE
10

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

WP 347-65-02/03 LOCATION Co-ords N 15 619 230 E 1 025 803 ORIGINATED BY PJS
DIST 1 HWY 402 BORING DATE May 5, 1977 COMPILED BY PJS
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

20
15 ϕ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 3

WP 347-65-02/03 LOCATION Co-ords N 15 619 246 E 1 025 726 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 6, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
584.2	Ground Level															
0.0																
576.2	Sand Pockets of Silt and Sand Loose to Compact		1	SS	21	580										
8.0			2	SS	12											
			3	SS	27											
	Clayey Silt Some Sand		4	SS	16											
	Trace of Gravel		5	SS	13											
	Occasional Sand Seams		6	SS	8	570										
	Very stiff to firm		7	SS	9											
			8	SS	9											
			9	SS	9											
			10	SS	10	560										
			11	SS	5											
			12	SS	11											
			13	SS	14	550										
			14	SS	12											
531.2						540										
53.0	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 4

WP 347-65-02/03 LOCATION Co-ords N 15 619 288 E 1 025 623 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 2, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
584.2	Ground Level															
0.0																
574.2	Sand Pockets of Silt and Gravel Loose		1	SS	7	580										
			2	SS	6											
10.0			3	SS	11											
	Clayey Silt		4	SS	10											
	Some Sand		5	TW	PH	570										
	Trace of Gravel		6	TW	PH											
	Occasional Sand Seams		7	SS	7											
	Very Stiff to Firm		8	TW	PH	560										
			9	TW	PH											
			10	TW	PH	550										
			11	TW	PM											
			12	TW	PH	540										
			13	TW	PH											
530.2						530										
54.0	Silty Clay		14	TW	PH											
	Trace of Sand					520										
	Stiff															
			15	TW	PH	510										
						500										
			16	SS	12	490										
480.2	Continued															
104.0																

OFFICE REPORT ON SOIL EXPLORATION

20
15 ϕ 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 4cont

WP 347-65-02/03 LOCATION Co-ords N 15 619 288 E 1 025 623 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 2, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
481.7	Continued															
104.0	Silty Clay Trace of Sand Stiff		17	SS	14	480										
471.7																
114.0	Black Sand					470										
464.2			18	SS												
120.0	Black Shale Bedrock															
456.3				BXL	100X	460										
127.9	End of Borehole		19	RC	Rec											

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 5

WP 347-65-02/03 LOCATION Co-ords N 15 619 266 E 1 025 338 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 11, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
583.8	Ground Level															
0.0																
	Sand, Pockets of Silt and Gravel Loose to Dense		1	SS	8											
			2	SS	21											
			3	SS	12											
			4	SS	30											
			5	SS	40	570										
			6	SS	28											
566.8			7	SS	6											
17.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Stiff to Firm		8	SS	7	560										
			9	SS	7											
			10	SS	9	550										
			11	SS	12											
540.8																
43.0	End of Borehole															

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 6

WP 347-65-02/03 LOCATION Co-ords N 15 619 172 E 1 025 637 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 10, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w			UNIT WEIGHT γ pcf	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
584.4	Ground Level															
0.0	Sand, Pockets of Silt and Gravel Loose to Compact	...	1	SS	6	580										0 35 60 5
			2	SS	8											
575.4			3	SS	18											
9.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		4	SS	16											131 134 132 130
			5	SS	13	570										
			6	TW	PH											
			7	TW	PH											
			8	TW	PH	560										
553.4			9	TW	PH											
31.0	End of Borehole															

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 7

WP 347-65-02/03 LOCATION Co-ords N 15 619 156 E 1 025 689 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 10, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
584.5	Ground Level						1000	2000				10	20	30		
0.0	Sand, Pockets of Silt and Gravel Compact		1	SS	14	580										1 56 39 4
576.5			2	SS	10											6 19 42 33
8.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		3	SS	23											
			4	SS	15											
			5	SS	16											
			6	SS	11	570										
			7	SS	9											
			8	SS	9											
			9	SS	19	560										
			10	SS	55											
			11	SS	12	550										
			12	SS	8											
			13	SS	7	540										
530.5						530										
54.0	Silty Clay Trace of Sand Stiff		14	SS	15											
						520										
						510										
						500										
						490										
530.5	Continued															
54.0																

20
15 ϕ 5 % STRAIN AT FAILURE
10




OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 7 cont

WP 347-65-02/03 LOCATION Co-ords N 15 619 156 E 1 025 689 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 10, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT _____ w_L PLASTIC LIMIT _____ w_p WATER CONTENT _____ w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100					w_p w w_L				
							SHEAR STRENGTH					WATER CONTENT %				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
480.5	Continued															
104.0	Silty Clay Trace of Gravel Stiff					480										
						470										
464.5																
120.0	Black Sand															
459.5						460										
125.0	End of Borehole Probable Bedrock															
	<u>NOTE</u> Water Level not established															

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 8

WP 347-65-02/03 LOCATION Co-ords N 15 619 135 E 1 025 792 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 9, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w			UNIT WEIGHT γ pcf	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
585.8	Ground Level															
0.0	Sand, Pockets of Silt and Gravel Loose		1	SS	6	580										1 38 56 5
579.8			2	SS	19											
6.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		3	SS	26											6 27 41 26
			4	SS	27											
			5	SS	18											
			6	SS	12	570										
			7	TW	PH										131	
			8	TW	PH										131	
			9	TW	PH	560									129	
			10	TW	PH											
552.8																
33.0	End of Borehole															

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 9

WP 347-85-02/03 LOCATION Co-ords N 15 619 135 E 1 025 864 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 9, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w			UNIT WEIGHT γ pcf	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	w_p	w	w_L		
586.5	Ground Level															
0.0	Sand, Pockets of Silt and Gravel Compact		1	SS	12	580										
579.5			2	SS	28											
7.0	Clayey Silt, Some Sand Trace of Gravel Occasional Sand Seams Very Stiff To Firm		3	SS	30											
			4	SS	16											
			5	TW	PH	570										
			6	TW	PH											
			7	SS	10											
			8	TW	PH	560										
			9	SS	10											
			10	SS	10	550										
			11	TW	PH											
543.5	End of Borehole															
43.0																

WP 347-65-02/03 LOCATION Co-ords N 15 619 106 E 1 026 084 ORIGINATED BY PJS
DIST 1 HWY 402 BORING DATE May 11, 1977 COMPILED BY PJS
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

20
15 ϕ 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 11

WP 347-65-02/03 LOCATION Co-ords N 15 619 257 E 1 025 649 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 11, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_p	w	w_L		
585.5	Ground Level															
0.0	Sand, Pockets of Silt and Gravel Loose to Compact	...	1	SS	5	580										6 68 23 3
576.5			2	SS	13											
9.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		3	SS	13											
			4	SS	11											
			5	SS	9	570										
			6	SS	9											
			7	SS	8											
			8	SS	8	560										
557.5	End of Borehole															
28.0																

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N' STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL. THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

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

TERMS TO BE USED IN DESCRIBING SOILS:-

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

TYPE OF SAMPLE

S.S	SPLIT SPOON	T.W	THINWALL OPEN
WS	WASHED SAMPLE	T.P	THINWALL PISTON
S.T	SLOTTED TUBE SAMPLE	OS	OESTERBERG SAMPLE
A.S	AUGER SAMPLE	FS	FOIL SAMPLE
CS	CHUNK SAMPLE	R.C	ROCK CORE

P.H SAMPLE ADVANCED HYDRAULICALLY

P.M SAMPLE ADVANCED MANUALLY

SOIL TESTS

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

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
w_s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX $= \frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX $= \frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	$= 3.1416$
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e \sigma$ OR $\ln \sigma$	NATURAL LOGARITHM OF σ
$\log_{10} \sigma$ OR $\log \sigma$	LOGARITHM OF σ TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
$\bar{\sigma}$	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

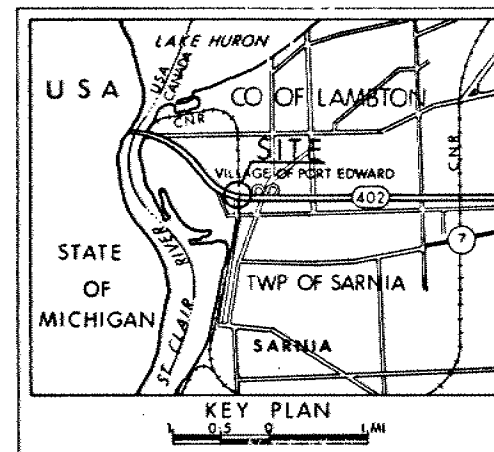
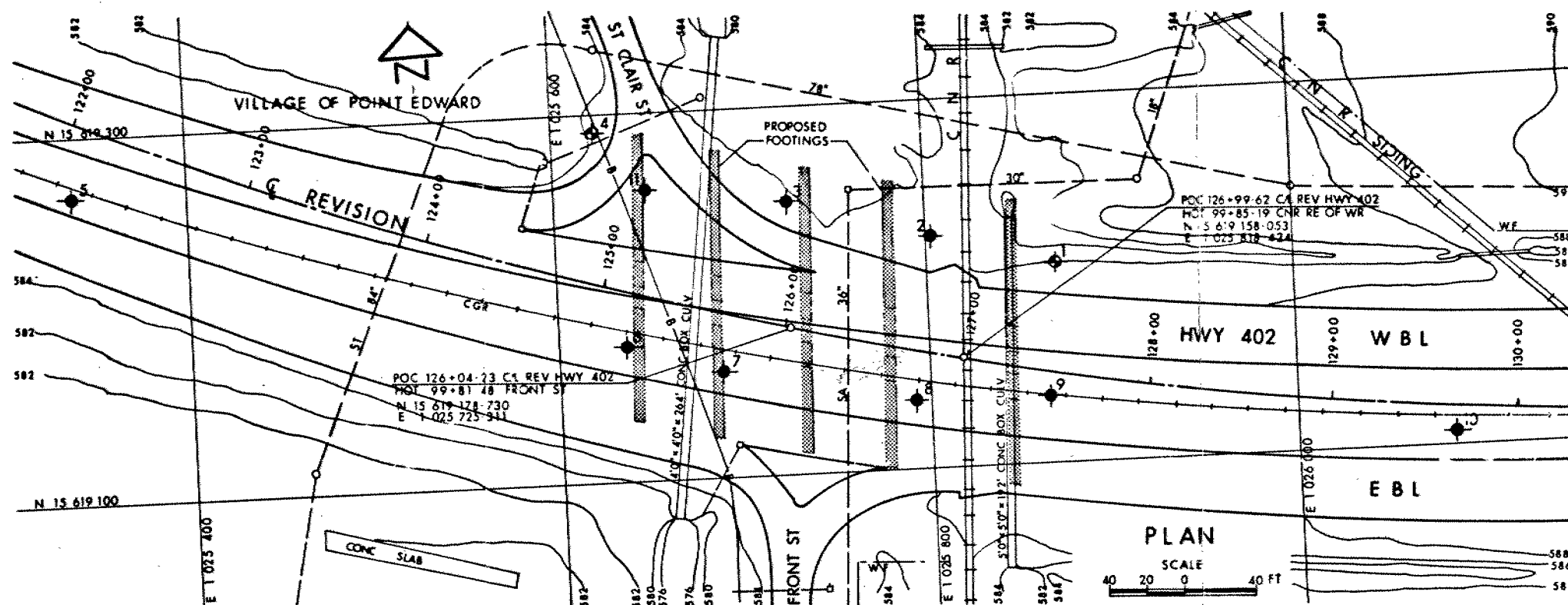
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX, APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

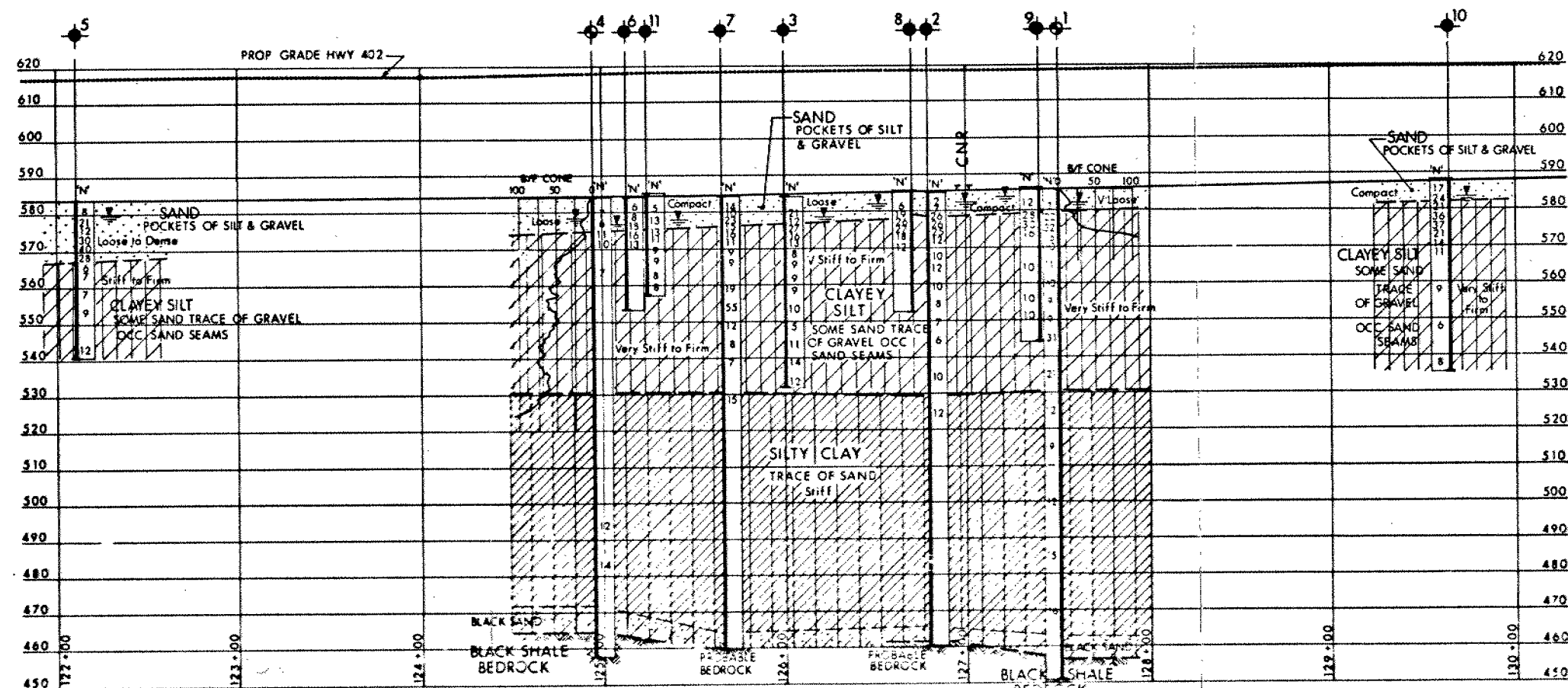
SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

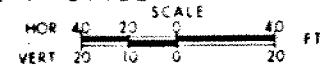


LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- 'N' Blows/ft (Std Pen Test 350ft lbs energy)
- CONE Blows/ft (60° Cone, 350ft lbs energy)
- ↓ WL at time of investigation
APR & MAY 1977
NO WL established BH No 7



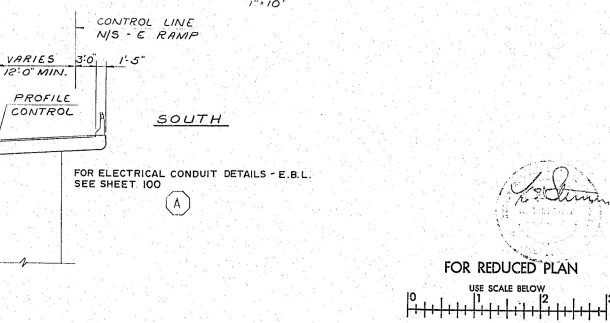
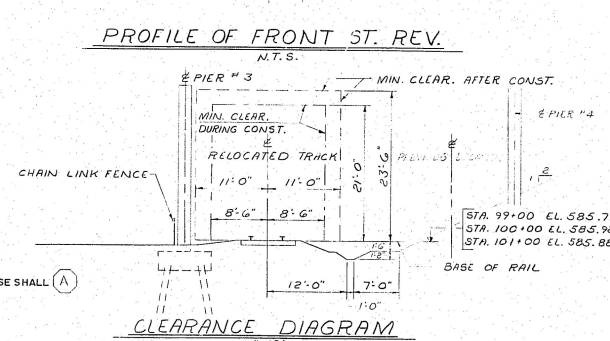
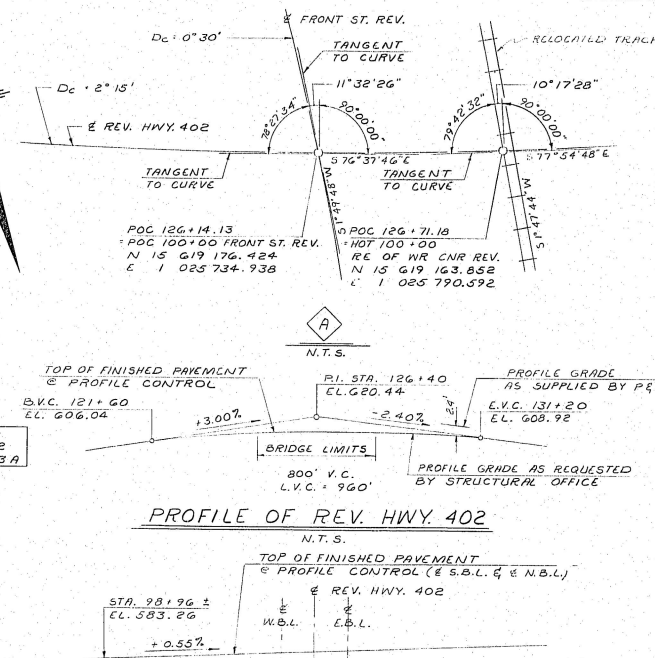
PROFILE HWY 402 (REV'N)



NOTE

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

REVISIONS	DATE	BY	CHKD



NOTES:
CLASS OF CONCRETE
FOOTINGS - 20 MPa
DECK SLABS - 20 MPa
REMAINDER - 30 MPa
REINFORCING STEEL
ALL STEEL GRADE 400
REINFORCING BARS WITH THE DESIGNATION 'C'
AT THE END OF BAR MARKS SHALL BE COATED
BARS.
CLEAR COVER TO REINFORCING STEEL
FOOTINGS, PIER COL'S & ABUTMENTS - 3"
DECK - 2" TOP, 1 1/2" BOTTOM
OR AS NOTED ON DRAWINGS
CONSTRUCTION NOTES
THE CONTRACTOR IS RESPONSIBLE FOR
FINISHING THE BEARING SEATS DEAD LEVEL
TO THE SPECIFIED ELEVATIONS WITH A
TOLERANCE OF $\pm 1/8"$.
NO CONCRETE SHALL BE PLACED ABOVE THE
EXISTENT BEARING SEATS UNTIL CONCRETE
IN THE DECK HAS BEEN PLACED, STRESSED
AND GROUTED.

CONCRETE QUANTITIES :

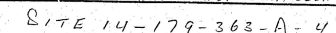
CONCRETE QUANTITIES ARE LISTED BELOW
FOR THE APPROPRIATE CONCRETE
LUMP SUM TENDER ITEM :

CONCRETE IN PIERS, ABUTMENTS AND WINGWALLS _____	297 CU. YD.
CONCRETE IN DECK _____	793 CU. YD.
CONCRETE IN BARRIER WALLS _____	46 CU. YD.
CONCRETE IN APPROACH SLABS _____	67 CU. YD.
CONCRETE IN SLOPE PAVING _____	34 CU. YD.

LIST OF DRAWINGS :

14-363A - 1 GENERAL LAYOUT
2 BORE HOLE LOCATIONS & SOIL STRATA
3 SITE LAYOUT PLAN
4 FOOTINGS
5 ABUTMENTS
6 PIER # 1 E
7 PIER # 2 E
8 PIER # 3 E
9 PIER # 4 E
10 DECK LAYOUT & SCREED ELEVATIONS
11 DECK LONGITUDINAL CABLE DETAILS
12 DECK TRANSVERSE CABLE DETAILS
13 DECK REINFORCING
14 BARRIER WALL
15 STEEL RAILING
16 20' APPROACH SLAB
17 DETAILS OF CONC. SLOPE PAVING
18 STANDARD DETAILS I
19 STANDARD DETAILS 2
20A STANDARD DETAILS 3
20 AS CONSTRUCTED ELEV. & DIMS.
21 ELECTRICAL EMBEDDED WORK
22 ELECTRICAL STANDARD DETAILS I
23 ELECTRICAL STANDARD DETAILS II

REVISIONS				
06/79	KAM	①	CHECKED BY: [Signature] DATE: 06-07-79	
DATE	BY		DESCRIPTION	
DESIGN	KEB	CHECK	LOADING HS 20-44	DATE 7-8-86
DRAWING	KEB	CHECK	SITE No 14-36 3A	DWG 1





APPENDIX B

Site Photographs



Photograph 1: Looking west at the adjacent south slope of the structure. The slope was covered with vegetation. No erosion effect was observed on the slope face and toe (July 31, 2014).



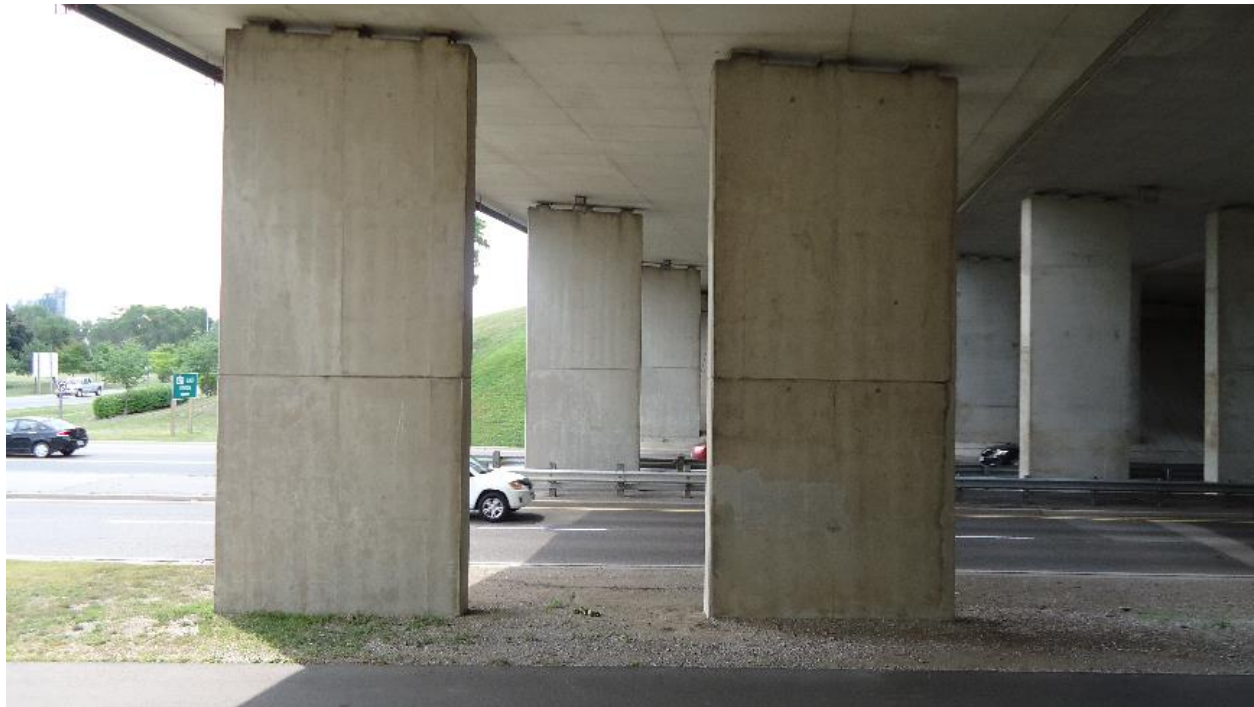
Photograph 2: Looking southeast towards the west front slope which was covered with concrete panels. No obvious major cracks or settlement effects were observed on the concrete paved slope (July 31, 2014).



Photograph 3: Looking at the west abutment. Surficial cracks were observed on the wall (July 31, 2014).



Photograph 4: Looking at the west piers. No obvious major cracks were observed except some surface cracks (July 31, 2014).



Photograph 5: looking west at the centre and east piers. No erosion effects were observed around the piers. Surficial crack were observed on the piers (July 31, 2014).



Photograph 6: Looking east at the center pier. No erosion effects were observed around the piers. Surficial crack were observed on the piers (July 31, 2014).



Photograph 7: Looking to the east pier and abutment. The front slope covered with concrete panels. Some rehabilitation work was completed on the piers (July 31, 2014).



Photograph 8: Looking at the adjacent east south slope. The slope was heavily vegetated. No erosion effects were observed on the slope face and toe (July 31, 2014).