

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 &
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



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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 = $\frac{I_P \text{ of soil}}{2.4 \text{ of } \mu m \text{ Soil Fraction}}$
 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
 τ_f PEAK SHEAR STRENGTH
 τ_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)

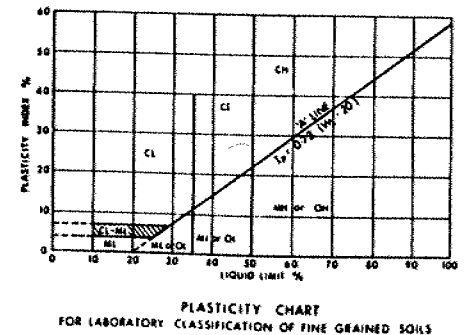
EXTENDED CASAGRANDE SOIL CLASSIFICATION SYSTEM													
FIELD IDENTIFICATION PROCEDURES (EXCLUDING PARTICLES LARGER THAN 75mm (3 INCHES) AND BASING FRACTIONS ON ESTIMATED MASS)										GRP. SYMP.	TYPICAL NAMES	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED 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 75 µm (NO. 200 SIEVE)) COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS: LESS THAN 5% GW, GP, SM, SP 5% TO 12% GM, GC, MH, SL MORE THAN 12% BORDLINE CASES REQ. USE OF DUAL SYMBOLS	C _u = $\frac{D_{60}}{D_{10}}$ GREATER THAN 4 C _c = $\frac{(D_{30})^2}{D_{10} \cdot D_{60}}$ BETWEEN ONE AND 3 NOT MEETING ALL GRADATION REQUIREMENTS FOR GW ATTERBERG LIMITS BELOW A-LINE, OR I _p LESS THAN 4 ABOVE A-LINE WITH I _p BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS C _u = $\frac{D_{60}}{D_{10}}$ GREATER THAN 4 C _c = $\frac{(D_{30})^2}{D_{10} \cdot D_{60}}$ BETWEEN ONE AND 3 NOT MEETING ALL GRADATION REQUIREMENTS FOR SM ATTERBERG LIMITS BELOW A-LINE OR I _p LESS THAN 4 ABOVE A-LINE WITH I _p BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING 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						
			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						
			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) 175µm IS ABOUT THE SMALLEST PARTICLE VISIBLE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 35%	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)			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 INFORMATION & SYMBOL IN PARENTHESIS. FOR UNDISTURBED SOILS ADD INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTENCY IN UNDISTURBED & REMOULDED STATES, MOISTURE & DRAINAGE CONDITIONS.					
			NONE	QUICK	NONE	ML	INORGANIC SILTS & SANDY SILTS OF SLIGHT PLASTICITY, ROCK FLOUR						
			MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM	CL	CLAYEY SILTS (INORGANIC), GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS						
			SLIGHT TO MEDIUM	SLOW	SLIGHT	OL	ORGANIC SILT OF LOW PLASTICITY, ORGANIC SANDY SILTS						
		LIQUID LIMIT BETWEEN 35% AND 50%	NONE TO SLIGHT	SLOW TO QUICK	SLIGHT	MI	INORGANIC COMPRESSIBLE SILTS OR SILTY FINE SANDS WITH SOME CLAY OF MEDIUM PLASTICITY (BELOW A-LINE)						
			HIGH	NONE	MEDIUM TO HIGH	CI	SILTY CLAYS (INORGANIC) OF MEDIUM PLASTICITY						
			SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OI	ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY						
			SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	MH	INORGANIC SILTS, HIGHLY COMPRESSIBLE MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS						
		LIQUID LIMIT GREATER THAN 50%	HIGH TO VERY HIGH	NONE	HIGH	CH	CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS						
			MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM	OH	ORGANIC CLAYS OF HIGH PLASTICITY						
			HIGHLY ORGANIC SOILS							READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL & FREQUENTLY BY FIBROUS TEXTURE	PI	PEAT & OTHER HIGHLY ORGANIC SOILS	

USE GRAIN SIZE CURVE IN IDENTIFYING THE FRACTIONS AS GIVEN UNDER FIELD IDENTIFICATION

PLASTICITY CHART
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

BOUNDARY CLASSIFICATIONS: SOILS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE DESIGNATED BY BOTH 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

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

OFFICE REPORT ON SOIL EXPLORATION

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 \diamond 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		UNIT WEIGHT γ	REMARKS			
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80			100	WATER CONTENT — w w_p ——— w ——— w_L WATER CONTENT %	
							SHEAR STRENGTH PSF								
							○ UNCONFINED + FIELD VANE								
							● QUICK TRIAXIAL × LAB VANE								
1000 2000 10 20 30															
585.7	Ground Level					ELEV	1000	2000		10	20	30	GR SA SI CL		
0.0	Sand Pockets of Silt and Gravel very Loose to compact		1	SS	2	▼							Org 9.6%	0 88 (12)	
			2	SS	7	580									0 76 (24) 2 30 39 2
577.7			3	SS	26										
8.0			4	SS	26										
			5	SS	25										
			6	SS	12										
			7	SS	10	570									
			8	SS	12										
			9	SS	10										
			10	SS	8	560									
			11	SS	7										
			12	SS	6										
529.7			Silty Clay Trace of Sand Stiff		13	SS	10								
56.0	14	SS			12										
481.7	Continued														
104.0															

15 $\frac{20}{10}$ 5 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

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RECORD OF BOREHOLE No 2 cont

WP 347-65-02/03 LOCATION Co-ords N 15 619 230 E 1 925 803 ORIGINATED BY PJS
 DIST 1 HWY 402 BORING DATE May 5, 1977 COMPILED BY PJS
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

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	WATER CONTENT % w_p w w_L			
481.7	Continued														
104.0	Silty Clay Trace of Sand Stiff					480									
						470									
465.7															
120.0	Black Sand														
460.7	Probable Bedrock					460									
125.0	End of Borehole														
125.8															

OFFICE REPORT ON SOIL EXPLORATION

20
15 \diamond 5 % STRAIN AT FAILURE
10

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 _____

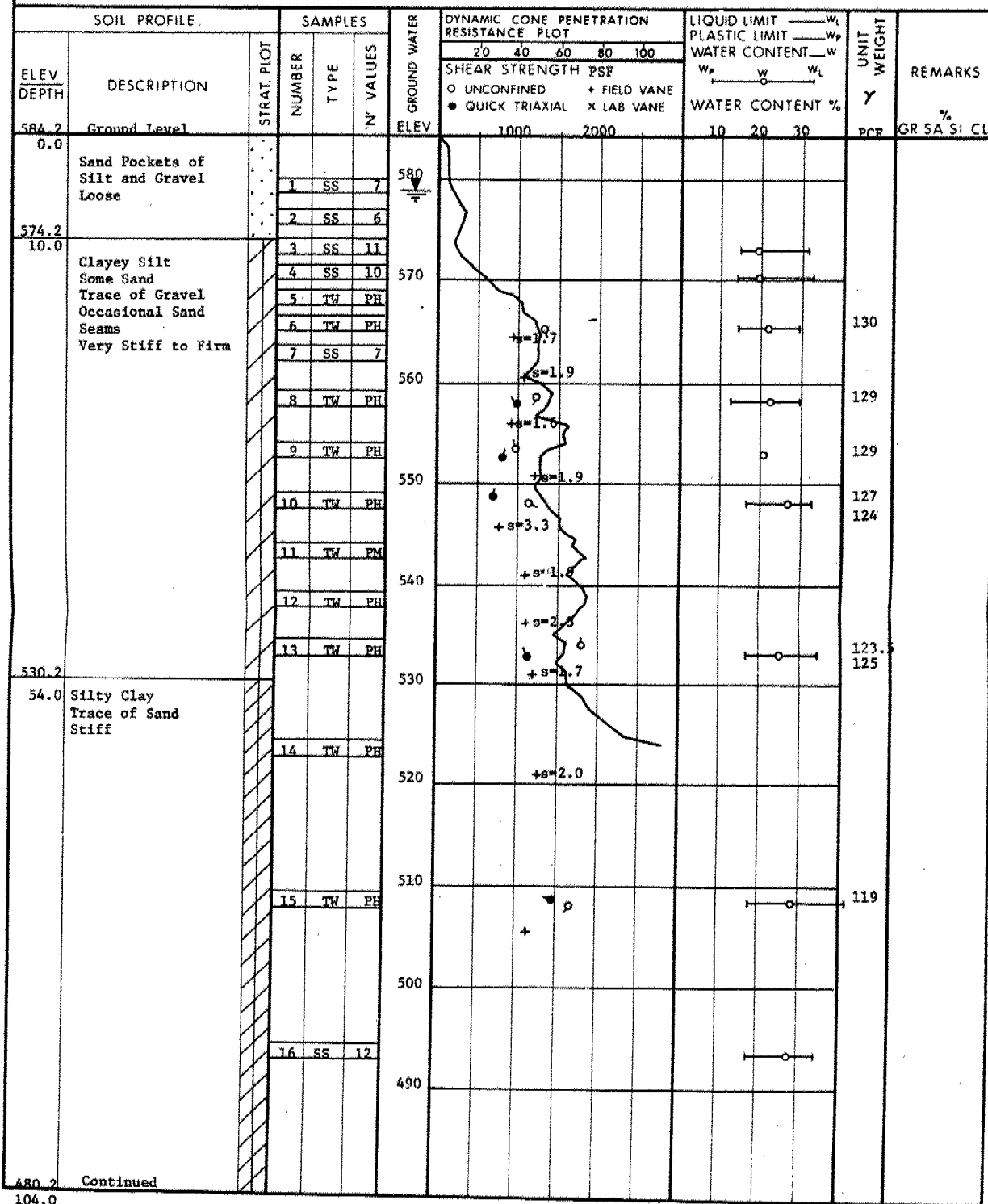
SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	W VALUES		20	40	60	80	100	w_p	w	w_L		
584.2	Ground Level															
0.0																
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

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 _____

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				WATER CONTENT %					
							SHEAR STRENGTH						WATER CONTENT %								
							○ UNCONFINED			+ FIELD VANE											
							● QUICK TRIAXIAL			x LAB VANE											
481.7	Continued					ELEV									% 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											7 81 (12)						
120.0	Black Shale Bedrock																				
456.3				BXL	100%	460															
127.9	End of Borehole		19	RC	Rec																

15 ϕ -5, % STRAIN AT FAILURE

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	570										131 134 132 130
			5	SS	13											
			6	TW	PH											
			7	TW	PH											
			8	TW	PH	560										
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		UNIT WEIGHT γ	REMARKS		
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	WATER CONTENT w w_P — w — w_L			WATER CONTENT %	
584.5	Ground Level															
0.0	Sand, Pockets of Silt and Gravel Compact		1	SS	14	580										1 56 39 4
			2	SS	10											6 19 42 33
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 ϕ 5 % STRAIN AT FAILURE
 10

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 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	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. 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									131	
			6	TW	PH										132	
			7	SS	10											
			8	TW	PH	560									131	
			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		1	SS	17											
581.0			2	SS	24											
7.0	Clayey Silt, Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		3	SS	21											
			4	SS	36											
			5	SS	37											
			6	SS	21											
			7	SS	14											
			8	SS	11											
			9	SS	9											
			10	SS	6											
			11	SS	8											
535.1																
53.0	End of Borehole															

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

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											
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																
28.0	End of Borehole															

20
15 ϕ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

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".

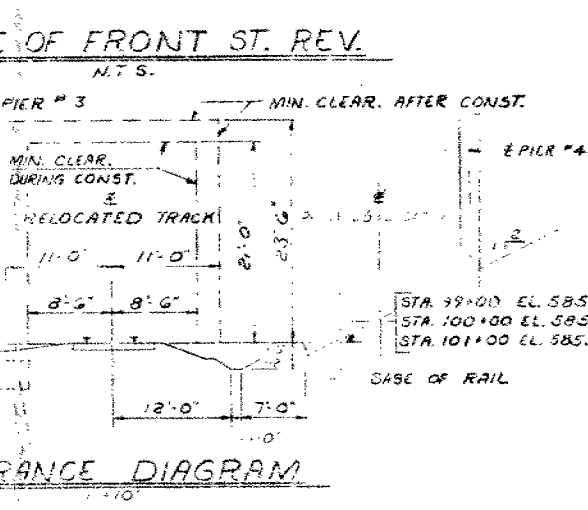
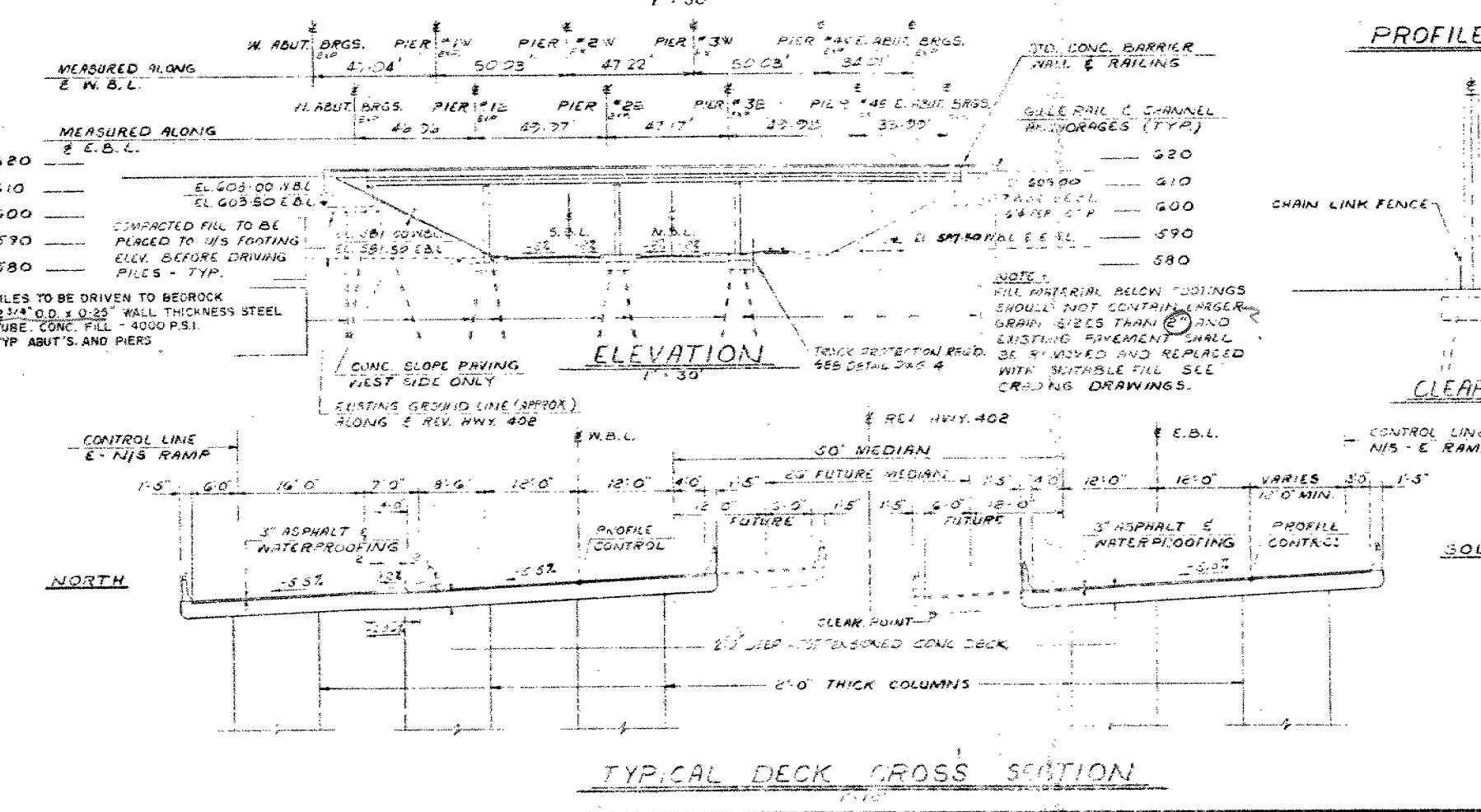
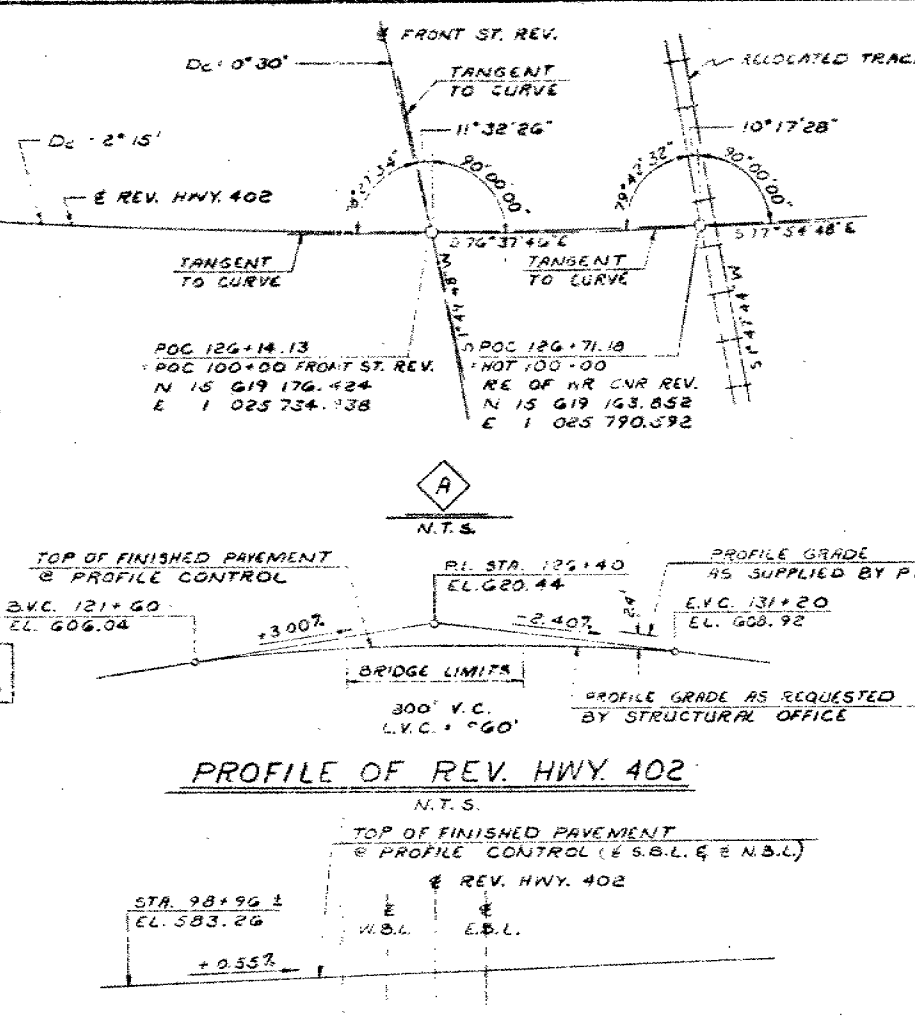
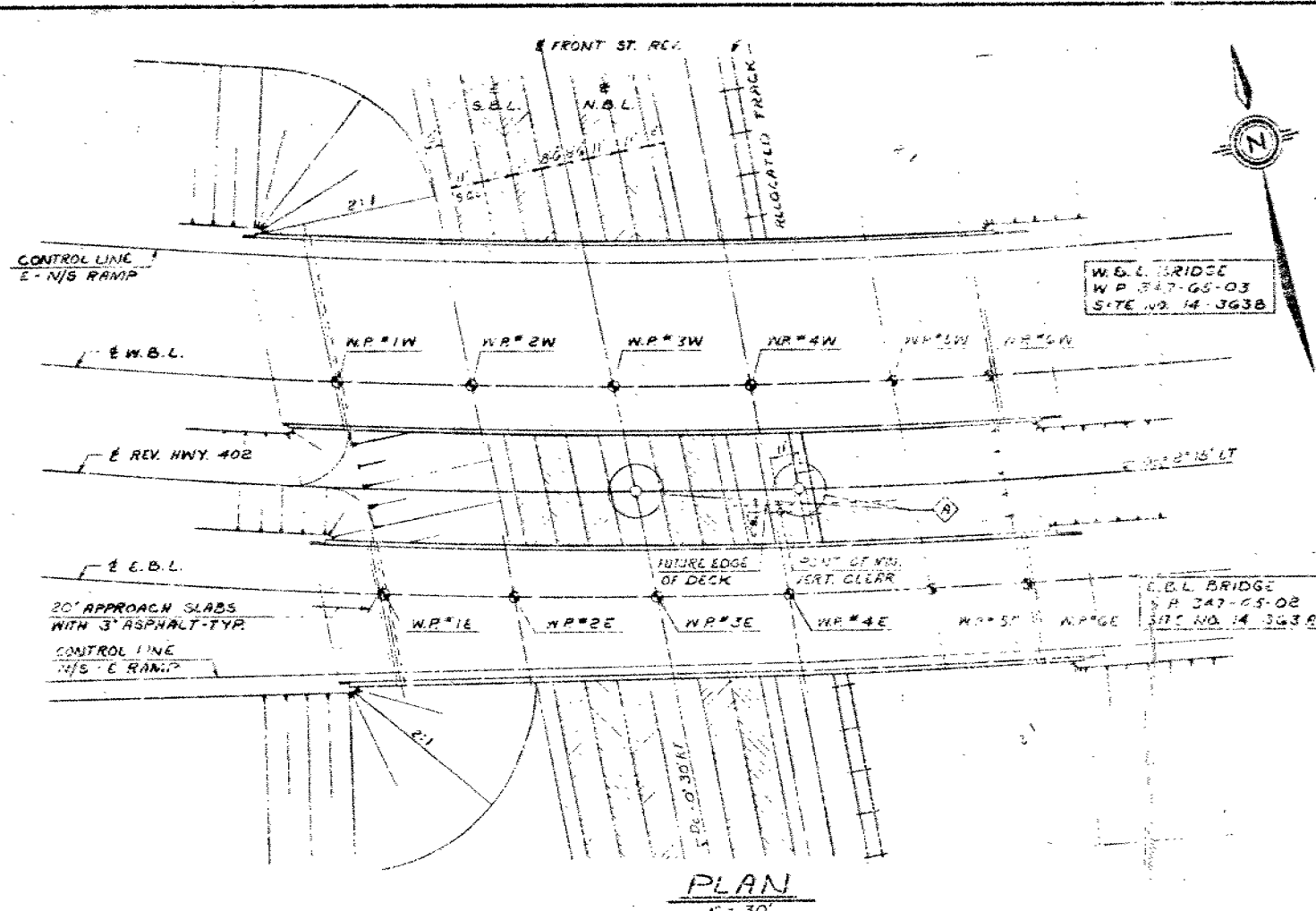
NO CONCRETE SHALL BE PLACED ABOVE THE ABUTMENT BEARING SEATS UNTIL CONCRETE IN THE DECK HAS BEEN PLACED, STRESSED AND GROUTED.

CONCRETE QUANTITIES :

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

CONCRETE IN PIERS, ABUTMENTS AND WINGWALLS — 47 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 :**
- 4-3638 - 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 ELEV. & DIMS.



REVISIONS	DATE	BY	DESCRIPTION
1	1979	1	DESIGN
2	1979	2	CHECK
3	1979	3	LOADING
4	1979	4	DATE
5	1979	5	DATE
6	1979	6	DATE
7	1979	7	DATE
8	1979	8	DATE
9	1979	9	DATE
10	1979	10	DATE
11	1979	11	DATE
12	1979	12	DATE
13	1979	13	DATE
14	1979	14	DATE
15	1979	15	DATE
16	1979	16	DATE
17	1979	17	DATE
18	1979	18	DATE
19	1979	19	DATE
20	1979	20	DATE

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

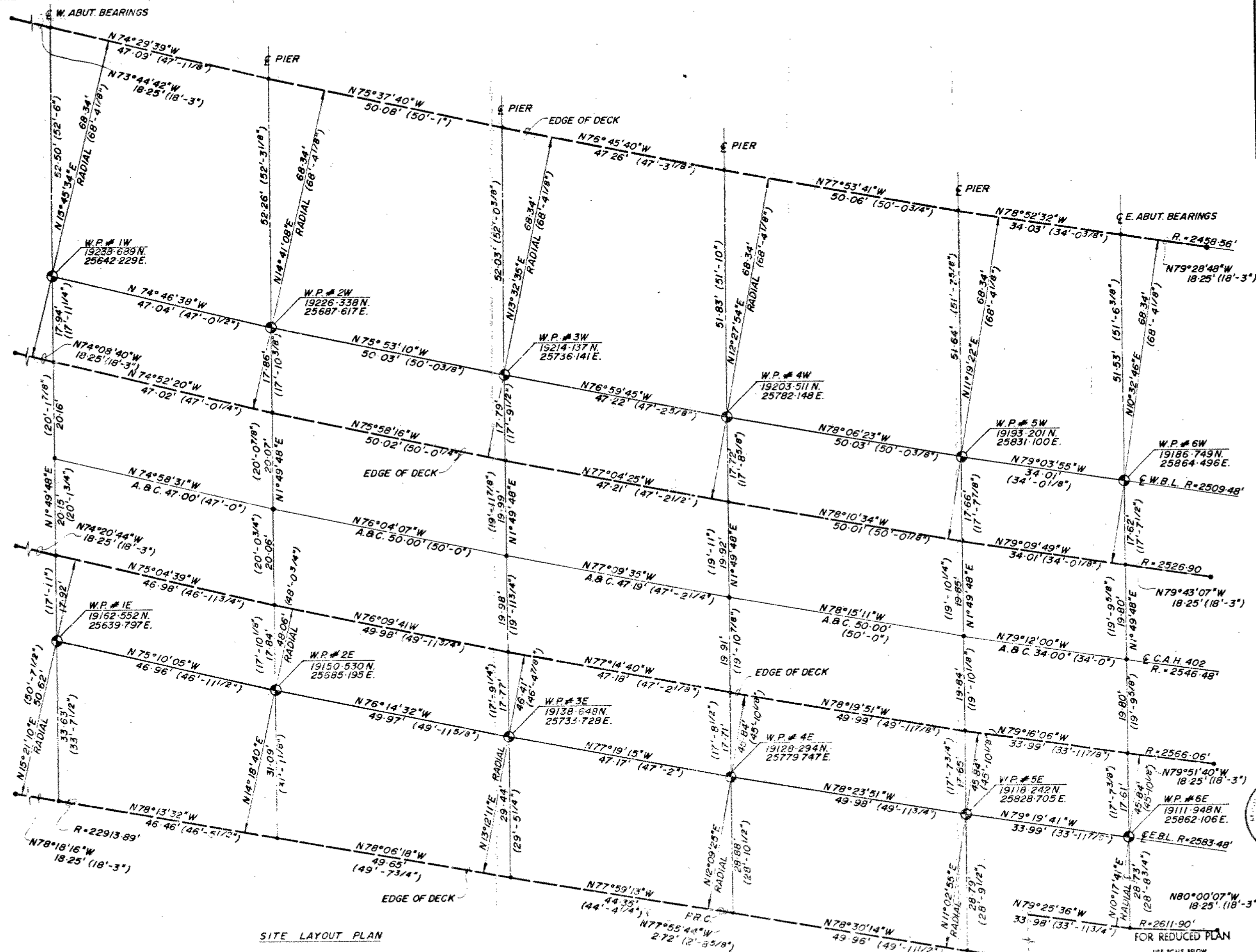


FRONT ST. O'PASS & C.N.R.
O'HEAD
SITE LAYOUT PLAN

SHEET



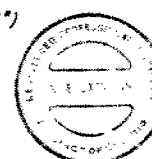
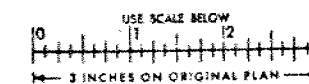
NISBET LETHAM LIMITED
Consulting Engineers
P.O. Box 67, Sarma
N7T 7H5



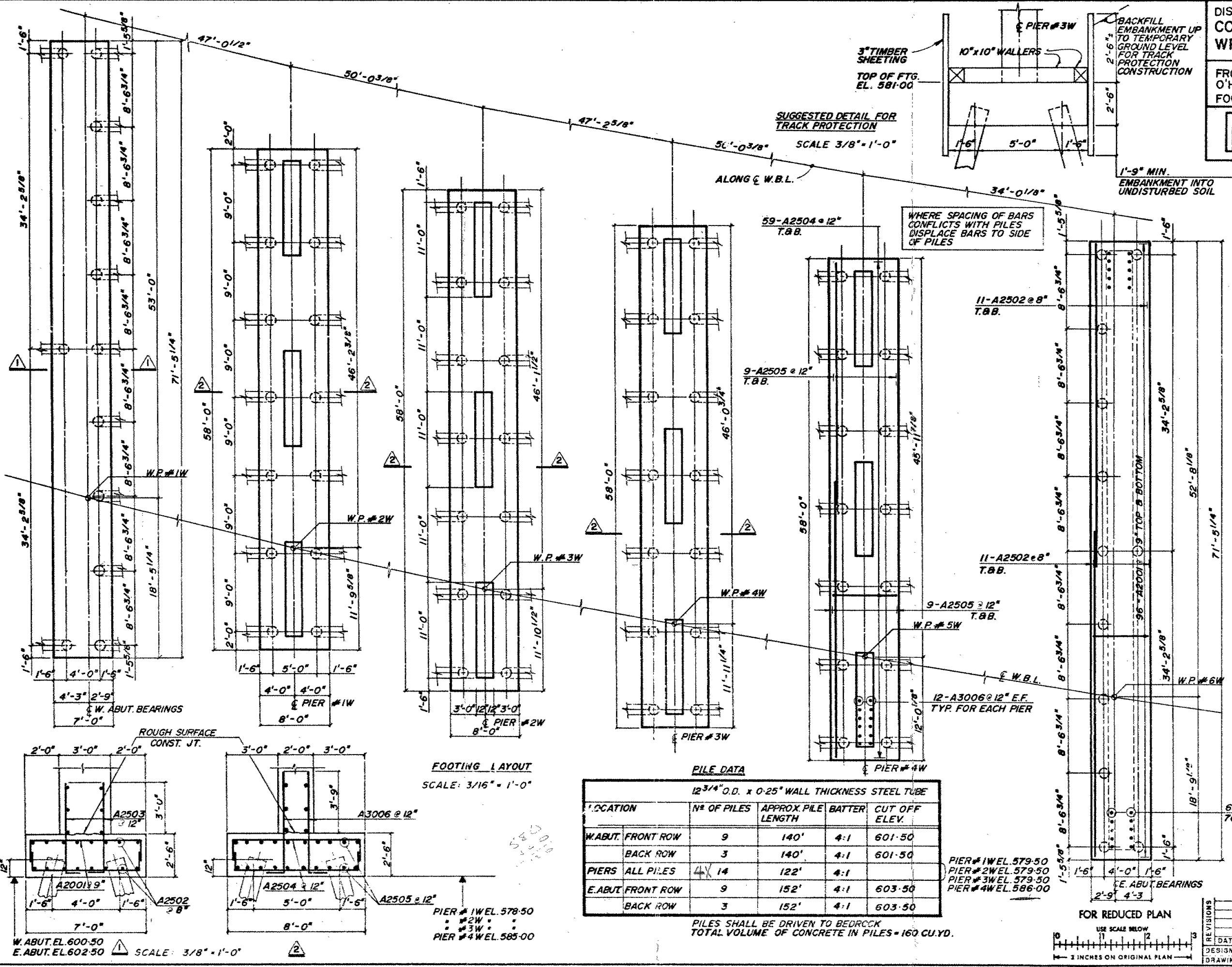
SITE LAYOUT PLAN

SCALE 1" = 10'-0"

FOR REDUCED PLAN



REVISIONS	DATE	BY	DESCRIPTION



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

PIER #1 WEL. 579.50
PIER #2 WEL. 579.50
PIER #3 WEL. 579.50
PIER #4 WEL. 586.00

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

160,000
80



FOR REDUCED PLAN

USE SCALE BELOW

0 1 2 3

3 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

W P 347-65-02/03

DIST 1

HWY 402

STR SITE 14-363

Front Street Overpass
and CNR Overhead

DISTRIBUTION

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R. Hore

A. Crowley)
J. Anderson) cover only
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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.

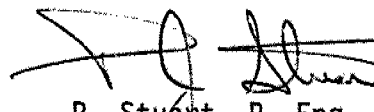
Due to the anticipated settlement of the subsoil under the approach fills it is recommended that the construction of the approach slabs and the final paving be delayed until at least 6 months after the completion of the fill construction. As a further measure to minimize the effect of differential settlement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

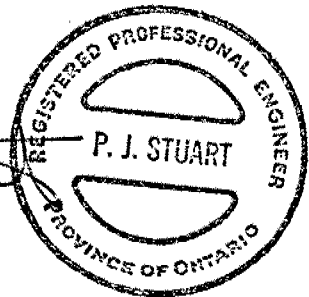
Dewatering

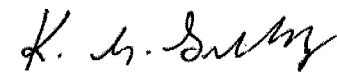
Pier footings will be placed below the groundwater level in a highly permeable soil. A dewatering scheme will, therefore, be required. Where footings are placed close to the railway tracks it may be desirable to combine track protection and dewatering. This could be achieved by keying sheet piling into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

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

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	580									Org	0 88 (12)
			2	SS	7											
577.7			3	SS	26											0 76 (24) 2 30 39 29
8.0	Clayey Silt Some Sand Trace of Gravel Occasional Sand Seams Very Stiff to Firm		4	SS	26											
			5	SS	25											
			6	SS	12	570										
			7	SS	10											
			8	SS	12											
			9	SS	10	560										
			10	SS	8											
			11	SS	7	550										
			12	SS	6											
						540										
			13	SS	10											
529.7	Silty Clay Trace of Sand Stiff					530										
56.0			14	SS	12											
						520										
						510										
						500										
						490										
481.7	Continued															

104.0

20
15 ϕ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

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										
			2	SS	12											
8.0			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

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

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 _____

20
15 ϕ 5 % STRAIN AT FAILURE
10

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 _____

15 ϕ 5 % STRAIN AT FAILURE

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		GR SA SI CL
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			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	PLASTIC LIMIT w_p	WATER CONTENT w	WATER CONTENT %		
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															
	NOTE Water Level not established															

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															
579.8	Loose		1	SS	6	580										1 38 56 5
6.0	Clayey Silt		2	SS	19											
	Some Sand		3	SS	26											
	Trace of Gravel		4	SS	27											
	Occasional		5	SS	18											
	Sand Seams		6	SS	12	570										
	Very Stiff to Firm		7	TW	PH											
			8	TW	PH											
			9	TW	PH	560										
			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																

OFFICE REPORT ON SOIL EXPLORATION

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

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

OFFICE REPORT ON SOIL EXPLORATION

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										
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	O.S	OESTERBERG SAMPLE
A.S	AUGER SAMPLE	F.S	FOIL SAMPLE
C.S	CHUNK SAMPLE	R.C	ROCK CORE

P.H SAMPLE ADVANCED HYDRAULICALLY

P.M SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V	FIELD VANE
CU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
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

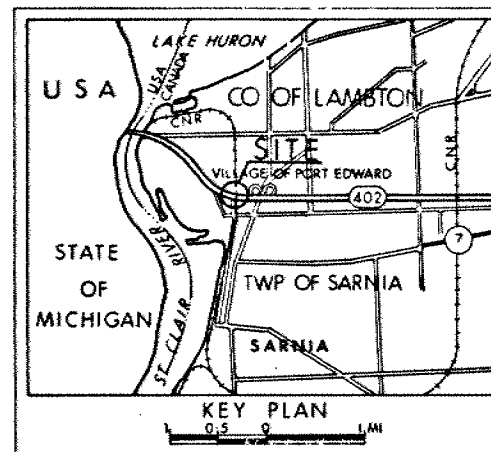
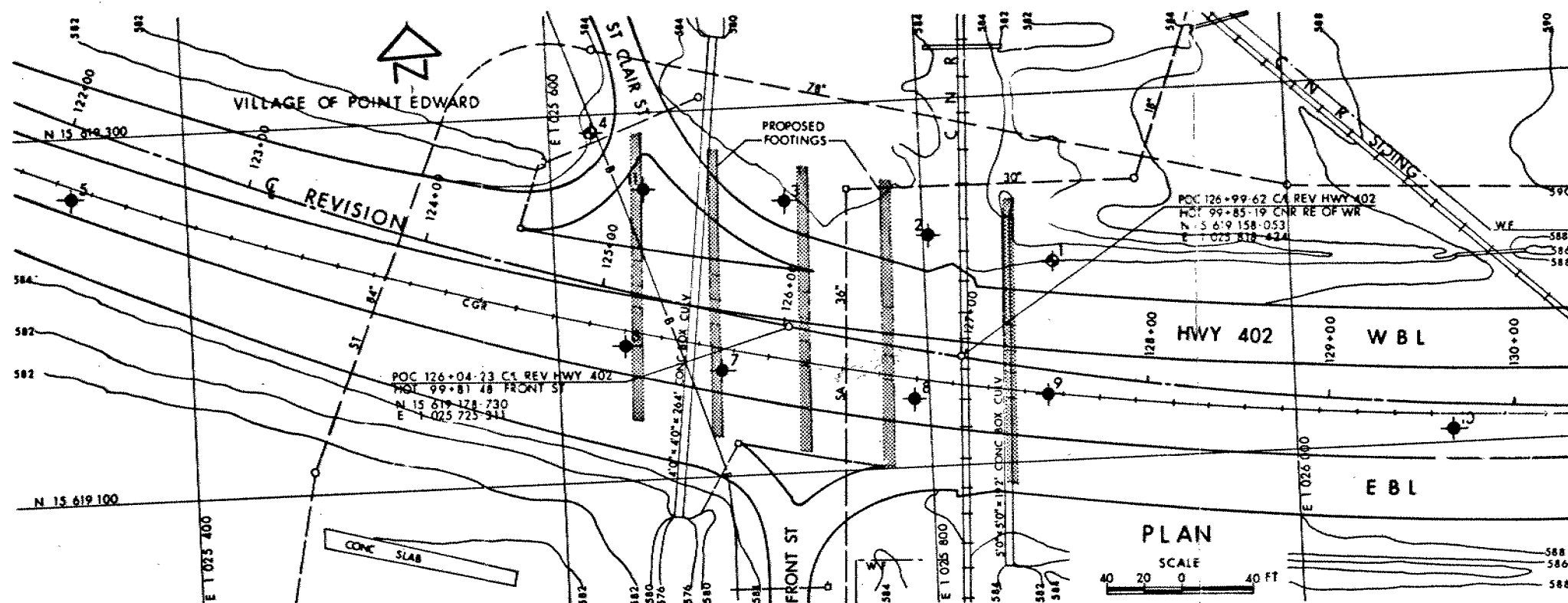
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

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

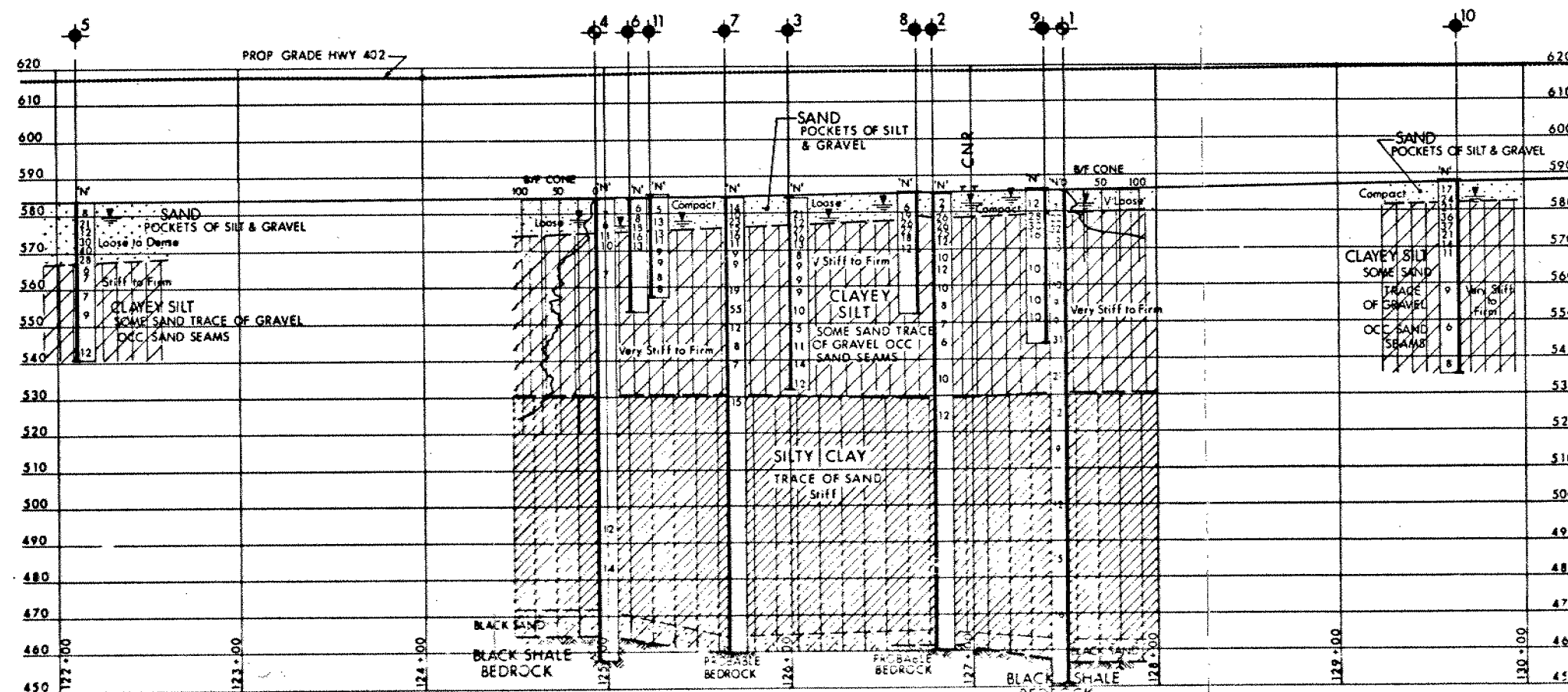
SLOPES

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



No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	585.9	15 619 207	1 025 870
2	585.7	15 619 230	1 025 803
3	584.2	15 619 246	1 025 726
4	584.2	15 619 288	1 025 623
5	583.8	15 619 266	1 025 338
6	584.4	15 619 172	1 025 637
7	584.5	15 619 156	1 025 689
8	585.8	15 619 135	1 025 792
9	586.5	15 619 135	1 025 864
10	588.1	15 619 106	1 026 084
11	585.5	15 619 257	1 025 649

NOTE

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



PROFILE HWY 402 (REV'N)

