

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 40I15-29

DIST. 2 REGION

W.P. No. 479-89-02

CONT. No. 92-06

W. O. No.

STR. SITE No. 19-306

HWY. No. 401

LOCATION Hwy 401 & Putnam Rd E  
CPR

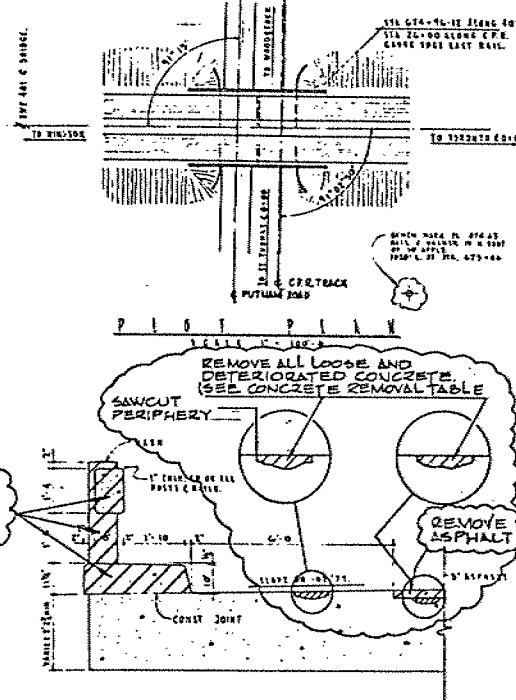
No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

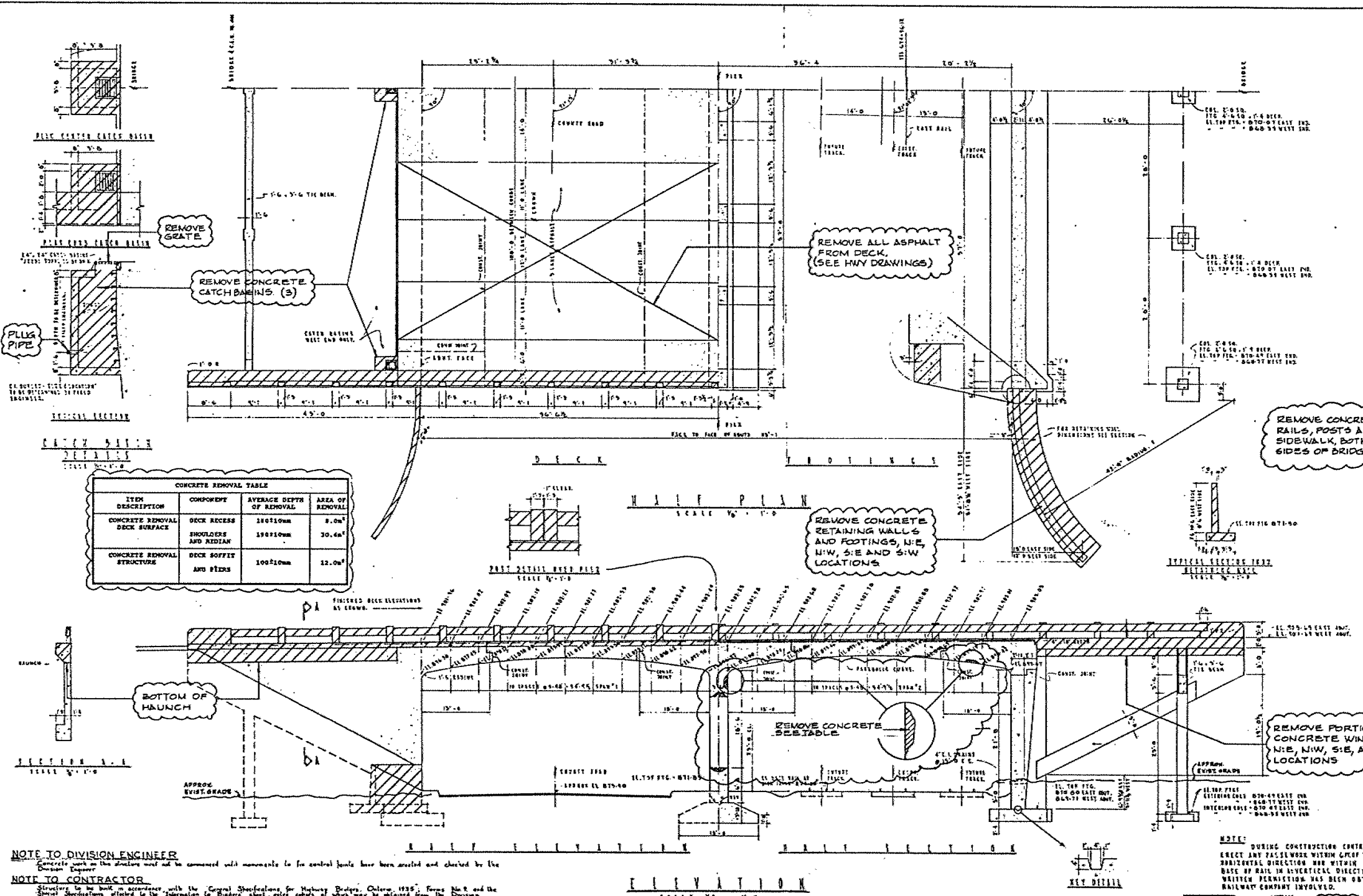




ITEM DESCRIPTION	COMPONENT	AVERAGE DEPTH OF REMOVAL	AREA OF REMOVAL
CONCRETE REMOVAL DECK SURFACE	DECK ACCESS	18011mm	8.0m²
CONCRETE REMOVAL DECK SURFACE	SHOULDER AND MEDIAN	18011mm	30.4m²
CONCRETE REMOVAL STRUCTURE	DECK SOFFIT AND PIERS	10021mm	12.0m²

- REHABILITATION NOTES**
1. TYPICAL AREAS OF REPAIR ARE INDICATED ON DRAWINGS. WHERE REPAIR LIMITS ARE NOT SHOWN, LIMITS SHALL BE IDENTIFIED BY THE ENGINEER.
  2. AREAS OF CONCRETE REMOVAL SHALL BE DELINEATED BY A 25mm DEEP SQUARE EDGE.
  3. WHERE INDICATED ON DRAWING THAT A SAWCUT IS REQUIRED TO DELINEATE AREAS OF CONCRETE REMOVAL, THE SAWCUT SHALL BE 25mm DEEP OR TO FIRST LAYER OF REINFORCING STEEL, WHICHEVER IS LESS.
  4. THE EXISTING STRUCTURE IS WATERPROOFED WITH NASTIC WATERPROOFING.

PROJECT: DORCHESTER TWP. OVERHEAD COVERPASS  
COUNTY ROAD (PUTNAM ROAD) & C.P.R.  
THE HIGHWAY No. 401  
CONTRACT No. 10-1-1-1  
TWP. DORCHESTER LOT 5-4 CON. 1  
GENERAL LAYOUT  
APPROVED: [Signature]  
DATE: 4 DEC 94  
DESIGNER: [Signature]  
DATE: 11 DEC 94  
CHECKED: [Signature]  
DATE: 11 DEC 94  
GENERAL  
35-80  
DWS: 3



**NOTE TO DIVISION ENGINEER**  
Concrete work on this structure must not be commenced until movements to fix control joints have been assessed and checked by the Engineer.

**NOTE TO CONTRACTOR**  
Structures to be built in accordance with the 'General Specifications for Highway Bridges, Ontario, 1995', Form No. 2 and the 'Special Specifications' attached to the 'Information to Bidders' sheet, which may be obtained from the Division Engineer. Only construction joints shown on the drawings will be permitted. Additional construction joints must be approved by the Division Engineer.

**CONCRETE MIX**  
All concrete to be 3000 psi @ 28 days  
Add 30 M. Dowditch "2A" per bag of cement

REFERENCE PLANS - (ISSUED JAN. 94)  
PLAN - P-3527-19 (DM.4956)  
PROFILE - P-3527-11

# METRIC

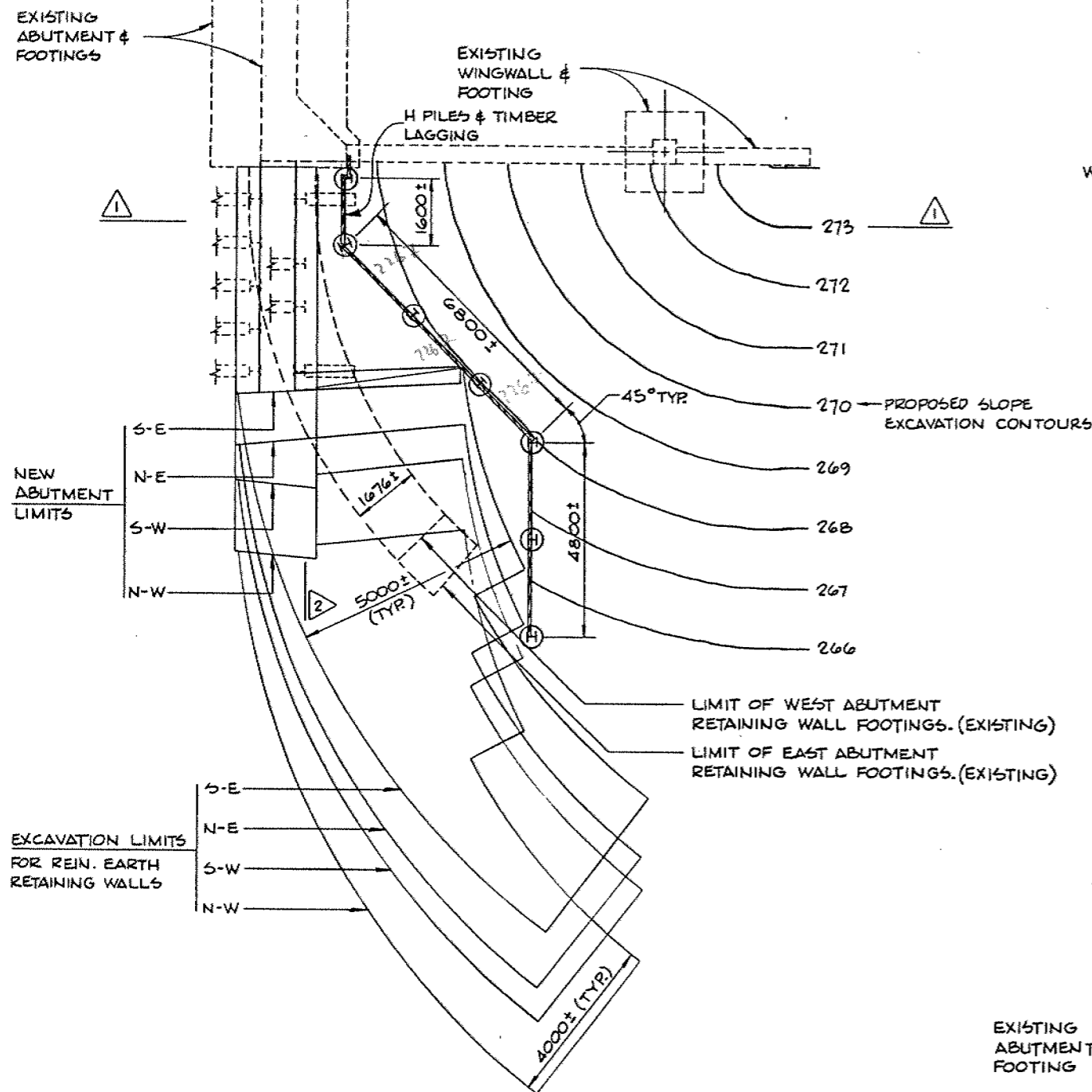
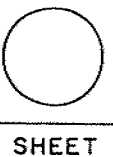
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WP No 479-89-02

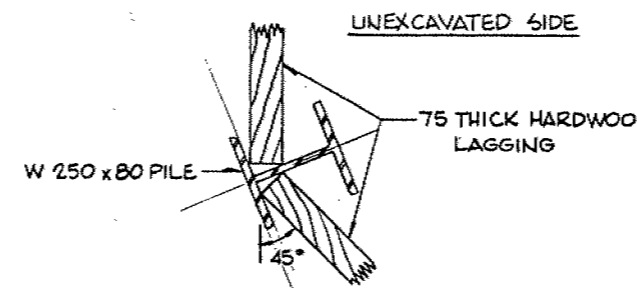
PUTNAM ROAD/C.P. RAIL O'HEAD

SHORING LAYOUT

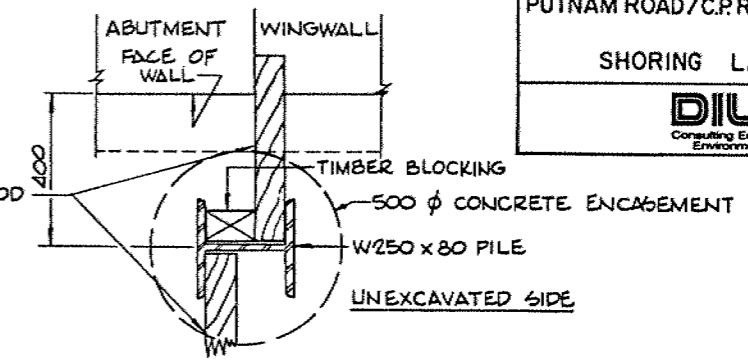
**DILLON**  
Consulting Engineers - Planners  
Environmental Scientists



**PART PLAN**  
S-E CORNER SHOWN - TYP. FOUR CORNERS  
1:75



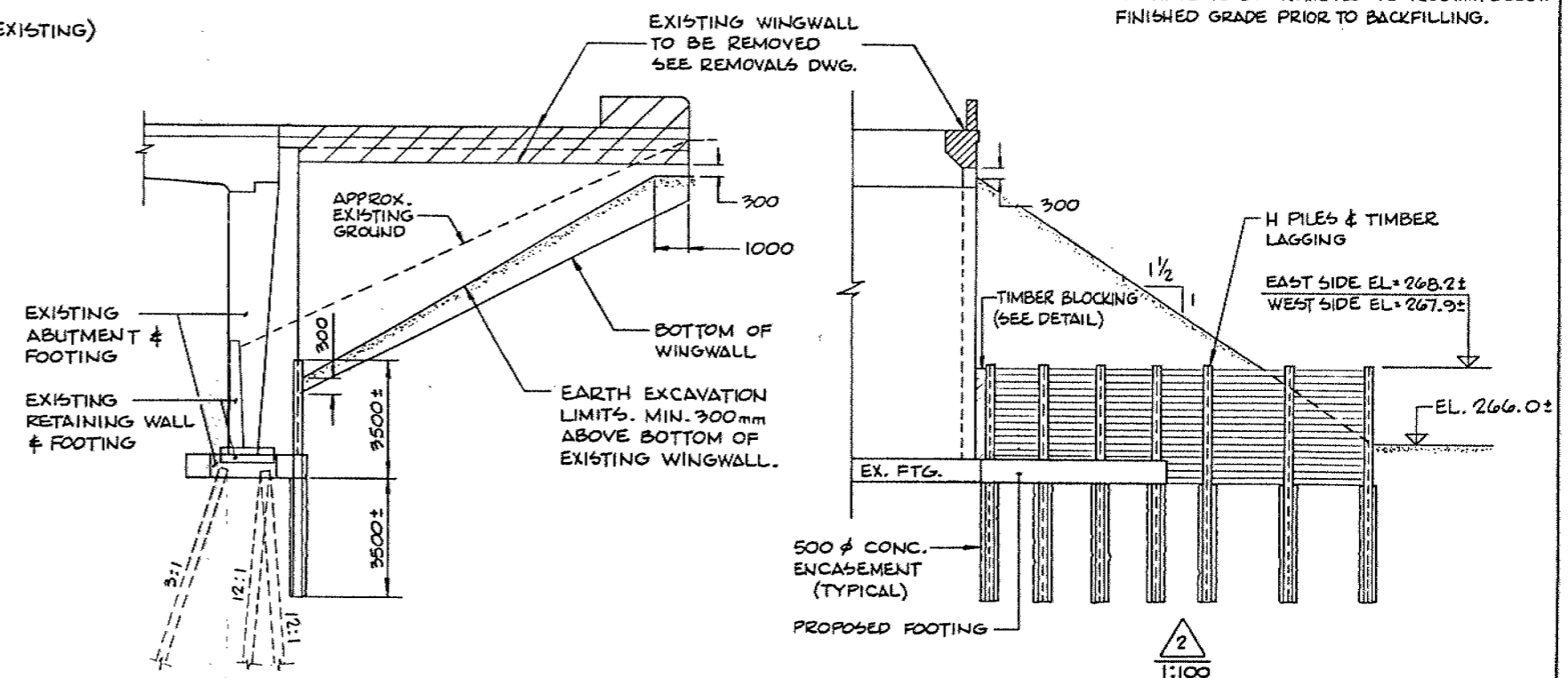
**TYPICAL CORNER PILE**  
1:10



**TIMBER BLOCKING DETAIL**  
1:10

## NOTES:

- ALTERNATIVE SHORING DESIGN MAY BE CONSIDERED BY THE ENGINEER. ALTERNATIVE DESIGNS SHALL CONFORM TO THE FOLLOWING CRITERIA:  
HWY. LIVE LOAD SURCHARGE - 600 mm FILL
- THE CONTRACTOR SHALL SUBMIT CALCULATIONS AND SHOP DRAWINGS SHOWING FULL DETAILS OF PROPOSED SHORING SYSTEM TO THE ENGINEER FOR REVIEW PRIOR TO COMMENCING WORK. ALL CALCULATIONS AND SHOP DRAWINGS SHALL BE STAMPED AND SIGNED BY A QUALIFIED PROFESSIONAL ENGINEER LICENSED IN ONTARIO.
- CLASS OF CONCRETE FOR SOLDIER PILE EMBEDMENT SHALL BE 20 MPa
- SHORING TO BE REMOVED TO 1200 mm BELOW FINISHED GRADE PRIOR TO BACKFILLING.



**2**  
1:100

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN: J.W. CHK: G.K. CODE: OHBOC LOAD: A-83 DATE: 91-07-22  
DRAWN: OPR CHK: EA SITE: 19-306 STRUCT: SCHEME: DWG: 4

# METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WP No 479-89-02

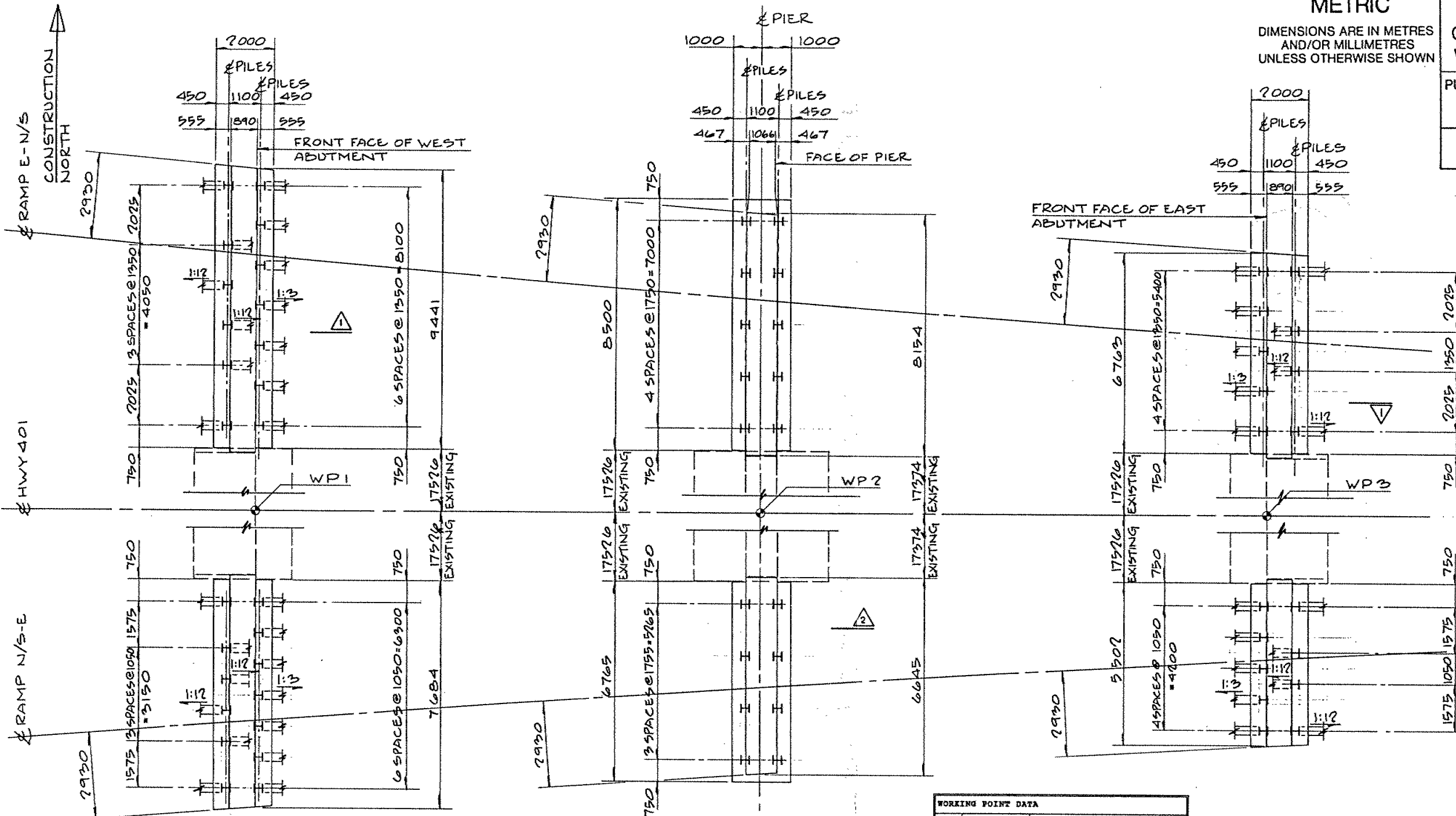
PUTNAM ROAD/C.P. RAIL O'HEAD

FOOTING LAYOUT

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Environmental Scientists



SHEET



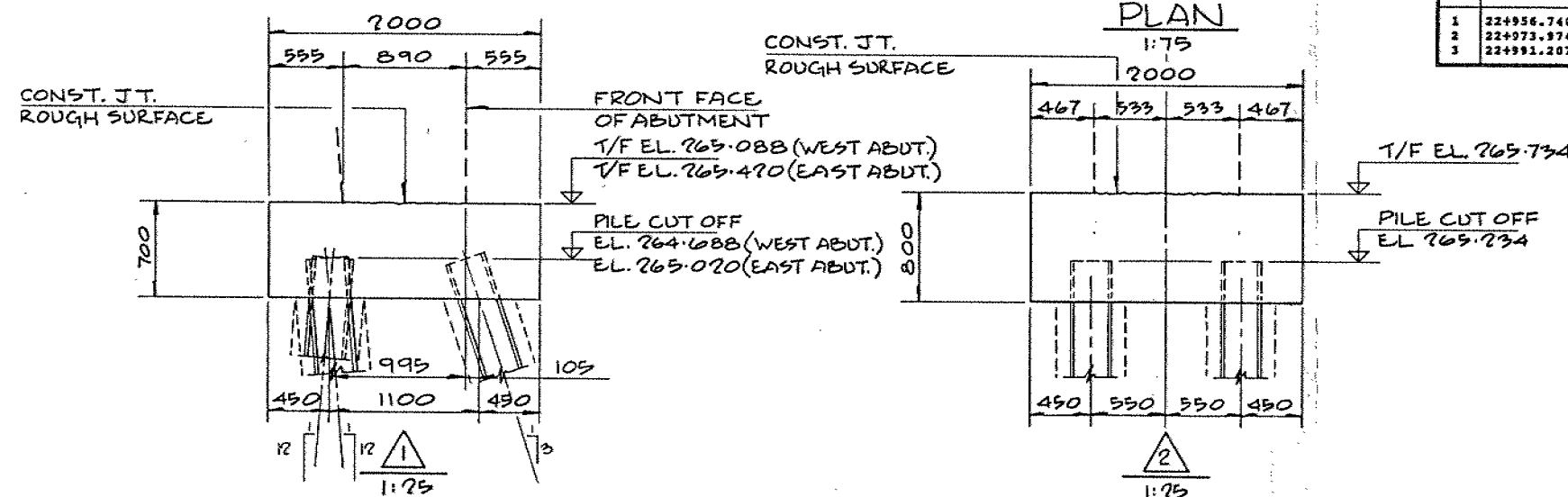
PILE DATA				
LOCATION	BATTER	NUMBER REQUIRED	LENGTH (M)	
			NORTH	SOUTH
WEST ABUTMENT	1:13	14	14.5	10.5
	1:12	12	14.0	10.0
PIER	VERTICAL	18	13.5	12.5
EAST ABUTMENT	1:13	10	12.5	10.0
	1:12	8	12.0	10.0

WORKING POINT DATA			
W.P. No.	STATION CENTRE LINE HWY 401	PROVINCIAL COORDINATES	
		NORTH	EAST
1	22+956.740	4,760,363.782	186,465.024
2	22+973.974	4,760,367.370	186,484.130
3	22+991.207	4,760,370.550	186,501.068

NOTES:  
ALL PILES TO BE HP310 x 110 STEEL PILES.  
PILE SPACING IS MEASURED AT UNDERSIDE OF FOOTING.  
PILES TO BE DRIVEN IN ACCORDANCE WITH STANDARD SS-103-11 USING AN ULTIMATE CAPACITY OF 2700 KN. PER PILE.  
PILE DRIVING HAMMER TO HAVE A MINIMUM ENERGY OF 50,000 JOULES PER BLOW.  
PILE LENGTHS SHOWN IN TABLE ARE THEORETICAL LENGTHS BELOW CUT OFF ELEVATION.  
PILE DESIGN LOADS:  
CAPACITY AT SLS TYPE II - 900 KN.  
FACTORED CAPACITY AT ULS - 1250 KN.  
PILE TO BE FITTED WITH DRIVING SHOES IN ACCORDANCE WITH STANDARD DD-3301.  
ALL PILES ARE TO BE DRIVEN FROM WITHIN A 4 METRE DEEP ( BELOW FOOTING BASE ) PRE-DRILLED LINED HOLE.

## APPLICABLE STANDARD DRAWINGS.

DD-3301 SPlice AND DRIVING SHOE DETAILS FOR STEEL H PILES.

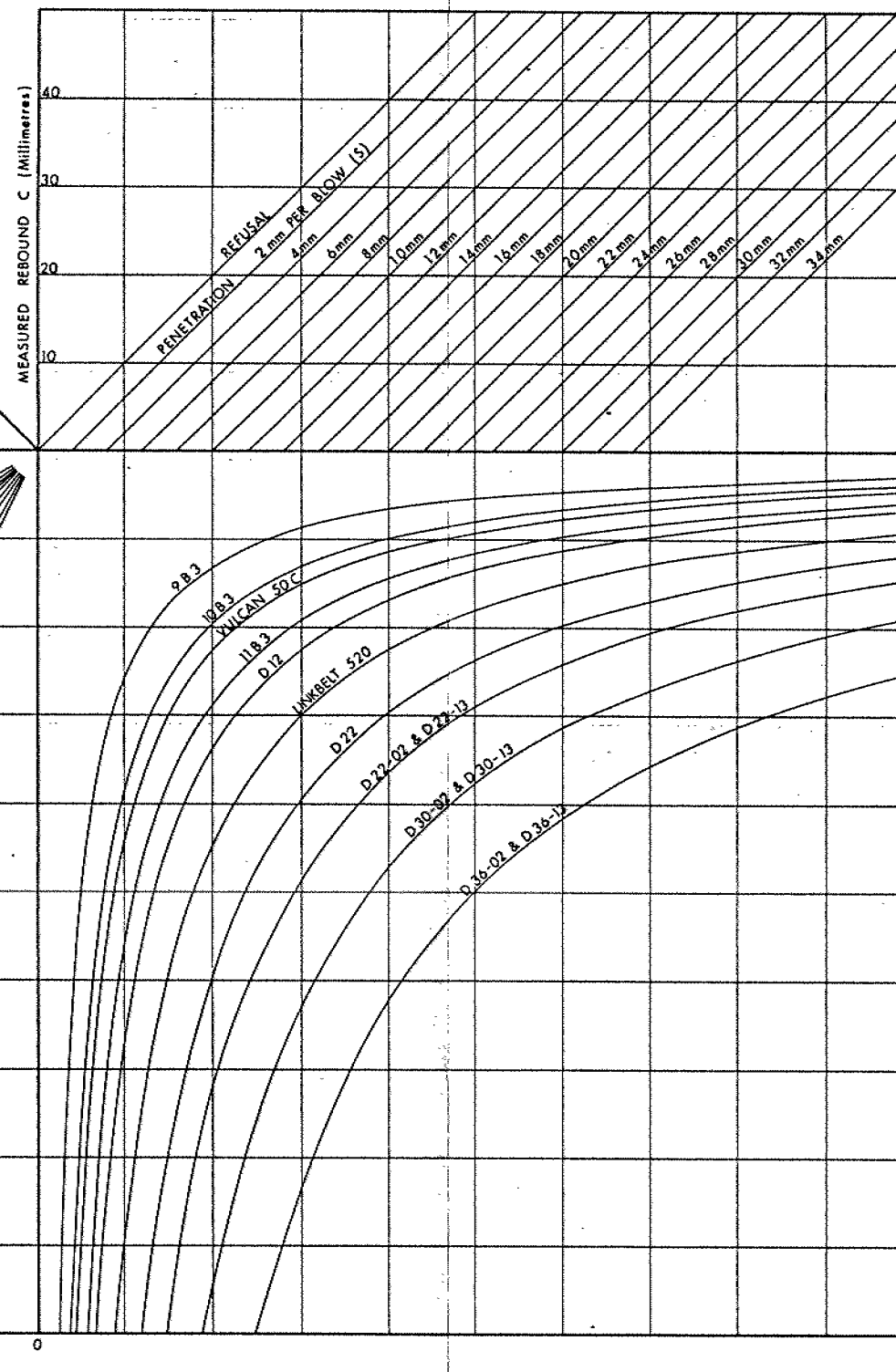
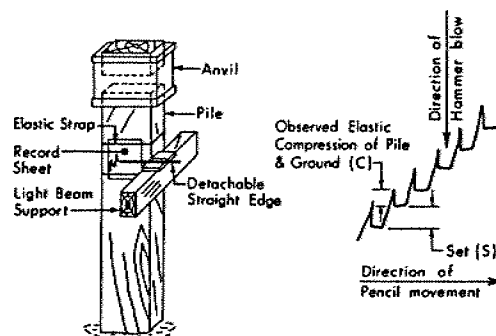


DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS		DATE		BY		DESCRIPTION	
DESIGN	Q.J.W	CHK	G.K.	CODE	Q.H.B.C.	LOAD	A-83
DRAWN	M.A.S	CHK	E.A.	SITE	19-306	STRUCT	SCHEME
							DWG 5

HAMMERS		
TYPE	MASS OF RAM W Kilograms	MAXIMUM ENERGY Joules/blow
9B3	726	12 419
10B3	1361	16 948
50C	2 268	20 337
11B3	2 268	26 005
D12	1 250	30 506
B225	1 360	39 300
LB520	2 300	40 675
B300	1 700	46 100
D22	2 200	53 826
B400	2 268	62 400
D22-02	2 200	67 000
D22-13	2 200	67 000
D30-02	3 000	91 000
D30-13	3 000	91 000
B500	3 129	107 100
D36-02	3 600	115 000
D36-13	3 600	115 000

NOTE:  
Ram may also be referred to as Piston



METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN

CONT No  
WP No 479-89-02

PUTNAM ROAD/C.P. RAIL O'HEAD SHEET  
PILE DRIVING-STEAM & DIESEL HAMMERS

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Consulting Engineers - Planners  
Environmental Scientists

## METHOD OF APPLYING THE HILEY FORMULA

$$R = \frac{nWgh}{S + \frac{C}{2}} \quad (\text{Hiley Formula}) \quad g = 9.80665 \text{ m/s}^2$$

Where R = Ultimate pile capacity in kilonewtons  
S = Measured penetration of pile per hammer blow in millimetres  
C = Measured rebound of pile per hammer blow in millimetres  
Wgh = Energy of hammer blow in joules  
n = Efficiency of blow =  $\frac{W + Pe}{W + P}$

where e = 0.32 for steel (These values of e have been  
= 0.25 for timber determined by experiment)

P = Mass of pile + anvil in kilograms

W = Mass of ram (piston) in kilograms

The P/W curves form the required reduction of total energy of the hammer blow according to the value of P/W

L = R/Q kilonewtons

Where L = Design capacity of pile

Q = Factor of safety

Use Q=3 unless otherwise authorized by the Engineer

## EXAMPLE 1:

Steel tube pile, O D=323.90mm linear density=49.73 kg/m,  
20m long plus anvil of mass 600 kg, giving P=994.6+600=1594.6 kg

Delmag D12 hammer W=1250 kg P/W=  $\frac{1594.6}{1250} = 1.28$

Observed measured rebound C=10mm

Observed measured penetration S=5mm

USING CHART: With C=10 proceed horizontally to right  
to cut line S=5 then vertically down to cut curve D12 then  
horizontally to left to cut P/W=1.28 then vertically down to  
read ultimate capacity R=1512 kN L=  $\frac{1512}{3} = 504$  kN

## EXAMPLE 2:

HP 310x110, 50m long plus anvil of mass 600 kg giving  
P=5500+600=6100 kg. The hammer is a Delmag D22-13

W=2200 kg, n=  $\frac{W + Pe}{W + P} = \frac{2200 + (6100 \times 0.32 \times 0.32)}{2200 + 6100} = \frac{2824}{8300} = 0.34$

Energy of hammer (Wgh)=67 000 J/blow

Observed measured rebound C=10mm

Observed measured penetration S=5mm

## USING HILEY FORMULA

Ultimate capacity R=  $\frac{nWgh}{S + \frac{C}{2}} \text{ kN} = \frac{0.34 \times 67000}{10} = 2278$  kN

Design capacity L=  $\frac{2278}{3} = 759$  kN

## NOTE 1:

These charts are designed to cover most cases which will be encountered on normal construction projects. Occasionally it will be found that R cannot be obtained from the charts, for instance when C=5mm and S=2mm using a Delmag D22 hammer. In such cases it will be necessary to calculate R using the original equation R=  $\frac{nWgh}{S + \frac{C}{2}}$

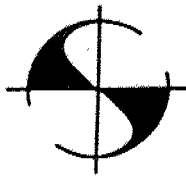
In cases where the energy of the hammer being used is slightly different from the hammer energy for which curves are drawn the curves may still be used but the result should be reduced or increased according to the energy ratios. Example use Linkbelt 520 curve (Energy 40 675 J) for Berminghammer 225 (Energy 39 300 J) but reduce result by multiplying by  $\frac{39300}{40675}$

## NOTE 2:

For projects designed to the OHBDC, the ultimate capacity (R) is shown on the contract drawings and L and Q are not required

STANDARD DRAWING JULY 1981 SS 103-11

REVISIONS	DATE	BY	DESCRIPTION
DESIGN K S	CHECK GK	LOADING A-83	DATE 91-07
DRAWING CP	CHECK MAS	SITE No 19-306	DWG 17



**STRATA ENGINEERING CORP.**

RESEARCH . ENGINEERING . SCIENCE

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Don Mills, Ontario, Canada M3C 2G3

**FOUNDATION INVESTIGATION REPORT**

**W.P. 479-89-02 Bridge Site No: 19-306**

Proposed Structure Extension

**Hwy. 401 -Putnam Road and CPR Overpass**

District 2, London

Ministry of Transportation, Ontario

*CONT 92-06*

Report Issue Date: 1991 01 07

Strata File: W-90-003

*GEOCRES # 40I 15-29*

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## APPENDIX

## **FOUNDATION INVESTIGATION REPORT**

**W.P. 479-89-02, Bridge Site No: 19-306**

**Proposed Structure Extension**

**Hwy. 401 - Putnam Road and CPR Overpass**

**District 2, London**

**Ministry of Transportation, Ontario**

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### **1.0 INTRODUCTION**

Strata Engineering Corp. has been retained by the Foundation Design Section of the Ministry of Transportation, Ontario, under Consultant Agreement No: 4240-9190-090, to conduct a foundation investigation for a proposed extension to an existing overpass structure which carries Highway 401 across Putnam Road and a CPR siding track. The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests, and to provide a full geotechnical report in advance of the issuance of E-Plans for the site.

This report is submitted in compliance with these terms of reference and contains recommendations for the design and construction of: the foundations for the proposed structure extension, new ramp fills, and widening of the existing approach fills.

### **2.0 SITE AND GEOLOGY**

The site is located on Highway 401 at Interchange No. 208, in North Oxford Township, County of Middlesex, about 21km east of London.

The terrain in this area is flat to gently undulating.

This site lies in an area where two physiographic regions of southern Ontario intersect, namely the Mount Elgin Ridges and the Oxford Till Plain.

The dominant geomorphological feature of the site is a north-south tending spillway breached into the east-west tending Ingersoll Moraine. Outwash flow occurred from south to north through the breached channel.

The major soil types in this area are therefore ice-contact stratified drift related to the Ingersoll and Westminster Moraines, and the outwash materials through the spillway.

Drift thickness and bedrock topography maps indicate a depth to bedrock in this area of some 30m below ground surface. The bedrock has been mapped as dolomites and limestones of the Detroit River Group of Middle Devonian Age.

### **3.0 FIELD AND LABORATORY WORK**

At the time of assignment of the project, an ETR plan was supplied showing the proposed structure extensions on the north and south sides of Highway 401. After clearing all underground utilities, boreholes were laid out to coincide with the ends of the proposed extensions. Borehole locations are shown on Drawing 4798902-A.

The field investigation was conducted from 1990 07 25 to 1990 07 27, using a bombardier mounted CME 55 hollow stem auger drilling machine. At certain depths in some boreholes, washboring techniques were employed, along with tri-cone drilling, to advance the boreholes through very dense or hard strata.

A total of four sampled boreholes were drilled (Boreholes 1, 2, 3 and 6). Near Borehole 6, a dynamic cone penetration resistance test was conducted. Two additional cone tests were performed at locations shown as Boreholes 4 and 5 to supplement the soils data from the sampled boreholes.

Bedrock was not reached in any of the boreholes.

Samples of the overburden were obtained in the split-barrel sampler, the N values being noted for the Standard Penetration Test in blows/0.3m.

In the laboratory, all soil samples were examined visually. Index property tests, such as moisture contents, Atterberg limits and grain size distributions were conducted on selected specimens. The laboratory test results are shown in Figures 1 to 5, and on the Borehole Log Sheets in the Appendix.

Groundwater levels were monitored on a daily basis and a week after completion of drilling. The last recorded levels are shown on the Borehole Log Sheets.

Sealed perforated standpipes were installed to measure artesian head conditions in Boreholes 1 and 3, where artesian groundwater conditions were suspected to be the cause of blockage and seizure of the hollow stem augers.

## **4.0 SUBSURFACE CONDITIONS**

### **4.1 General**

Below road fill materials adjacent to Putnam Road and the CPR tracks, the predominant soil deposit is a silty sand to sandy silt which is underlain by very dense coarse sand. The details follow.

### **4.2 Fill Material**

Fill material, comprising sand and gravel with some concrete debris, and ranging in thickness between 0.9m and 1.5m, was encountered from surface downwards in all sampled boreholes. It is inferred to be also present at the cone test locations. The moisture content of the fill material ranged between 4 and 8 per cent. N values varied between 13 and 53 blows/0.3m indicating a relative density of compact to very dense.

Typical grain size distribution curves of the fill material are given in Figure 1.

### **4.3 Sandy Silt to Silty Sand**

The major soil deposit at this site is a sandy silt to silty sand stratum, which occurs at between elevations 259.4m and 265.0m across the site. The thickness of this deposit ranges at the sampled borehole locations between about 6 and 8 metres.

The moisture content of the soil was found to be quite variable, depending on position above or below the water table, silt content, and the presence of clayey silt lenses. Values obtained ranged between 4 and 30 per cent. The moisture content tends to increase with depth in Boreholes 2 and 3.

Grain size distribution curves for this deposit are given in envelope form in Figure 2.

The deposit has randomly occurring lenses or seams of slightly cohesive silt and clayey silt. The clayey silt was encountered only in Borehole 1 at a depth below ground surface of about 6m. It had a total thickness of about 1m. Atterberg Limits for the silt and clayey silt are given respectively in Figures 3 and 4.

Standard Penetration Resistance N values in this stratum generally decreased with depth, ranging between 53 and 11 blows/0.3m. On the basis of these N values the deposit is considered to be compact to very dense, being generally compact. The clayey silt layer in Borehole 1 is considered to be of stiff consistency, based on tactile examination of the recovered sample.

#### 4.4 Coarse Sand

The sandy silt to silty sand stratum is underlain by a coarse sand deposit whose thickness was found to be 6m at Borehole 3 and over 7m at Borehole 1. The layer was not fully penetrated at all borehole locations, and therefore its thickness could not be established conclusively.

The moisture content of the stratum averages about 15 per cent. A grain size distribution envelope for the soil is given in Figure 5, and shows the presence of gravel in varying proportions in some samples.

The N values in this deposit increased with depth, ranging from 33 blows/0.3m near the upper horizon to over 100 blows/0.3m at depth. These observations indicate a compact to very dense deposit.

#### 4.5 Sandy Silt (Glacial Till)

In Borehole 3 only, the coarse sand stratum was found to be underlain by a sandy silt with some clay (glacial till). This deposit may represent a discontinuous stratum present at random below or within the coarse sand outwash deposit. One N value of 90 blows/0.3m is indicative of the very dense character of this soil.

### 5.0 GROUNDWATER CONDITIONS

Groundwater level observations were made in open boreholes at time of drilling or in piezometers and open standpipes after completion of drilling. These observations show the general phreatic level to be at about elevation  $\pm 264$ m.

In the sealed perforated standpipes, the groundwater level was observed to be at elevation 263.6m.

During advancement of the boreholes, sand and fine gravel entered the hollow stem augers, even with the plug in place during advancement. Attempts to limit entry of sediment into the hollow stems with a positive head of water in the stem shaft did not prevent upward movement of the soil into the augers. From these observations, it is suspected that sub-artesian conditions may be prevalent within the lower coarse sand deposit.

## **6.0 DISCUSSION AND RECOMMENDATIONS**

### **6.1 General**

It is proposed to widen Highway 401 to 6 lanes between London and Woodstock. This will involve a reconstruction of the existing interchange at Putnam Road. In connection with this reconstruction, the existing two span overpass structure will need to be extended on both the north and south sides.

The existing approach fill heights are about 10m, to accommodate the required clearance for the CPR tracks. It is therefore anticipated that the realigned interchange ramp heights will also be about 10m in height above prevailing ground level.

Archival drawings of the existing structure suggest that it is supported on spread footings placed at shallow depth (approximately 1.2 to 1.5m below present grade, as determined by scaling from the old drawings). The central pier has a trapezoidal footing with a base width of about 4m. The wing walls are not cantilevered, but supported at their ends on their own spread footings.

The proposed reconstruction of the S/N-E Ramp loop will involve a southerly extension of the south end of the existing structure, and the proposed reconstruction of the E-S/N Ramp loop will involve a northerly extension of the northern end of the existing structure.

This site investigation shows the presence of road fill materials (sands and gravels) overlying a compact silty sand to sandy silt deposit, above a very dense coarse sand stratum. The groundwater table is situated at a depth of 2 to 3 metres below ground surface.

### **6.2 Structure Foundations**

#### **6.2.1 Spread Footings**

At a depth of between 1.2m and 1.5m, within the natural sandy silt to silty sand stratum, the N values are in the order of 25 blows/0.3m. The extension footings will be about  $\pm 4$ m in width. The prevailing water level is located at a depth of 2.0m to 2.7m which is less than the footing width below the proposed footing base level. Therefore, to limit settlements to tolerable values, the allowable bearing pressure in Serviceability Limit State Type II must be reduced by half.

The factored bearing capacity in ULS will be of the order of 360kPa, and in SLS Type II will be 150 kPa.

At this limiting pressure, settlements of the extension footings are likely to be elastic in nature and not in excess of 20mm with respect to the existing footings. Therefore, construction slip joints would need to be provided to accommodate such potential differential movements.

If these pressures are too low to support the proposed structure loads, or if the differential settlements cannot be tolerated, then a deep foundation alternative may be more feasible and economical.

### 6.2.2 Deep Foundations

The proposed footing extensions may be supported on steel H piles driven into the dense to very dense coarse sand deposit.

For steel H piles (eg. HP 310x110) the factored axial load capacity at ultimate limit states is 1,250kN. The recommended SLS Type II capacity is 900kN.

For this site it is recommended that a pile driving shoe should be used to drive the piles through the coarse sand with gravel stratum.

The likely toe elevations of Steel H Piles at design capacity are shown below:

Location of Footing	Reference Borehole	Likely Pile Toe Elev. @ Design Capacity
North Extension		
East Side	2	253.5
West Side	1	251.0
Central Pier		
North Side	5	252.0
South Side	6	253.0
South Extension		
East Side	3	256.0
West Side	4	255.0

Pile driving should be monitored using the Hiley Formula.

Pile caps should be provided with 1.2m of earth cover for protection against frost action.

Due to potential for soil compaction (and hence added settlements of the existing structure footings) by vibrations resulting from pile driving, it is recommended that the H piles be driven through holes augered at least 4m into the ground.

### 6.3 Earth Pressures

Earth pressures should be computed as per subsection 6-6.1.2.2 of OHBD Code. A yielding foundation condition may be assumed. The Granular "A" or "B" backfill should be backfill should be in accordance with Special Provision No. 109F03 (latest revision). The following parameters are recommended for the granular backfill:

	Gran. "A"	Gran. "B"
Angle of internal friction, $\phi'$	35.0°	30.0°
Unit Weight (kN/m <sup>3</sup> ), $\gamma$	22.8	21.2

Surcharge effects, if any, should be computed as per Clause 6-6.1.2.4 of the OHBD Code.

### 6.4 Approach and Ramp Fills

A review of the existing approach and ramp fills shows no signs of instability.

The subsurface conditions preclude any potential for a deep-seated instability of approach fills and ramps of up to 11m in height above prevailing ground level, provided they are constructed with standard 2:1 side slopes.

Settlement analyses show maximum settlements, of 10m high fills, to be in the order of 30mm to 40mm, which will be elastic in nature, and will occur almost immediately upon application of the load.

### 6.5 Construction Considerations

Excavations taken below prevailing groundwater levels will require dewatering. Dewatering may be accomplished either by the use of interlocking steel sheet piling or tongue and groove timber sheeting driven or installed a minimum depth below excavation base equal to or slightly greater than the height of unbalanced hydrostatic head outside the excavation, or by well pointing. The fine gradation of the upper sandy silt soil

precludes the use of gravity drainage, even if the system is installed well in advance of excavation.

For temporary excavations in the existing fill, which is likely sandy in nature, the cut slopes should be no steeper than 1.5 Hor. to 1.0 Vert. (which is equivalent to about 34°, representing the angle of repose of the sandy material).

## 7.0 CLOSURE

The field work for this investigation was carried out by Ms. Andrea C. Abel, assisted by Mr. Justin Klodner.

The drilling equipment and crew were rented from Atcost Soil Drilling Limited of Concord, Ontario.

Respectfully submitted:  
STRATA ENGINEERING CORP.



A. C. Abel, M. Sc  
Project Engineer



C. Mirza, P. Eng.  
Senior Principal

### Report Distribution:

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Date of Submission: 1991 01 07

Computer File No: W90003.REP

**W.P. 479-89-02**

## **APPENDIX**

**Explanation of Terms Used in Report**

**Office Record of Borehole Logs 1-6**

**Figures 1-5**

**Drawing 4798902-A**

## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

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 OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), 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	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_i$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{\min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{\text{sat}}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{\text{sat}}$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{\max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$\text{kN}/\text{m}^3$	SEEPAGE FORCE
$\gamma'$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						

## METRIC

W P 479-89-02

LOCATION Co-ords. 4 760 392 N; 186 463 E

ORIGINATED BY AA

DIST 2 HWY 401

BOREHOLE TYPE Hollow Stem Auger & Wash Boring & Tricone

COMPILED BY AK

DATUM Geodetic

DATE 1990 07 25

CHECKED BY CM

[illegible]

**+3, x5 : Numbers refer to Sensitivity**

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No2

METRIC

W P 479-89-02 LOCATION Co-ords. 4 760 398 N; 186 498 E ORIGINATED BY JK  
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Wash Boring COMPILED BY AK  
 DATUM Geodetic DATE 1990 07 26 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
266.2	Ground surface																GR SA SI CL
0.0	Sand, Gravel Tr. asphaltic concrete (Road Fill)		1	SS	30		266										
264.9							265										
1.3	Sandy Silt to Silty Sand		2	SS	30												
			3	SS	25		264										0 46 (54)
	Compact to Dense		4	SS	38		263										WL on 1990 07 26
	Brown		5	SS	37		262										
			6	SS	26												
			7	SS	24		261										
			8	SS	24		260										0 59 (41)
259.4																	
6.8	Coarse Sand Tr. gravel		9	SS	38		259										
	Dense to Very Dense						258										2 86 (12)
			10	SS	56		257										
	Grey						256										
	Occ. clayey silt seams throughout		11	SS	73		255										
253.5			12	SS	101		254										
12.7	End of borehole																

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No3

METRIC

W P 479-89-02 LOCATION Co-ords. 4 760 345 N; 186 507 E ORIGINATED BY AA  
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger, Wash Boring and Dynamic Cone COMPILED BY AK  
 DATUM Geodetic DATE 1990 07 27 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
266.4	Ground surface							20 40 60 80 100						GR SA SI CL	
0.0	Sand and Gravel (Road Fill)	X												Concrete ob- struction to 1.1m depth	
	Very Dense Brown		1	SS	53									33 54 (13)	
265.0															
1.4	Sandy Silt to Silty Sand		2	SS	24										
			3	SS	28									WL on 1990 08 10	
	Occ. gravel		4	SS	25									4 85 (11)	
	Compact to Dense Compact		5	SS	49										
			6	SS	30									0 67 (33)	
	Brown		7	SS	12										
			8	SS	12										
259.4															
7.0	Coarse Sand with gravel		9	SS	48									15 79 (6)	
	Dense to Very Dense		10	SS	107										
			11	SS	45/15 cm										
	Grey		12	SS	122									0 89 (11)	
253.5															
12.9	Sandy Silt some clay Occ. gravel (Glacial Till)														
	Very Dense Grey		13	SS	90										
252.2															
14.2	End of borehole														

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 4

METRIC

W P 479-89-02 LOCATION Co-ords. 4 760 338 N; 186 472 E ORIGINATED BY JK  
 DIST 2 HWY 401 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AA  
 DATUM Geodetic DATE 1990 07 26 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa			W <sub>p</sub>	W	W <sub>L</sub>		
266.4	Ground surface							20 40 60 80 100	○ UNCONFINED      + FIELD VANE	WATER CONTENT (%)				GR SA SI CL	
0.0	Probable Road Fill						266								
265.2 1.2							265								
	Probable Sandy Silt to Silty Sand						264								
							263								
							262								
							261								
							260								
259.0 7.4	Probable Coarse Sand						259								
							258								
							257								
255.4							256								
11.0	End of Cone Test														

OFFICE REPORT ON SOIL EXPLORATION

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to Sensitivity  
 20  
 15  
 10  
 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 5

METRIC

W P 479-89-02 LOCATION Co-ords. 4 760 392 N; 186 480 E ORIGINATED BY AA  
 DIST 2 HWY 401 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AK  
 DATUM Geodetic DATE 1990 07 26 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
266.0	Ground surface													
0.0	Probable Road Fill													
265.1							265							
0.9	Probable Sandy Silt to Silty Sand						264							
							263							
							262							
261.4	End of Cone Test													
4.6														

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 6

METRIC

W P 479-89-02 LOCATION Co-ords. 4 760 343 N; 186 489 E ORIGINATED BY AA  
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger, Wash Boring and Tricone COMPILED BY AK  
 DATUM Geodetic DATE 1990 07 27 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
266.1	Ground surface						20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		GR SA SI CL	
0.0	Sand, Gravel (Road Fill)	⊗															
	Compact	⊗	1	SS	13												
264.6	Brown	⊗															
1.5	Sandy Silt to Silty Sand	⊙	2	SS	29												
	Compact to Dense	⊙	3	SS	23												
	Brown	⊙	4	SS	29												
	-----	⊙															
	Grey	⊙	5	SS	27												
		⊙	6	SS	20												
		⊙	7	SS	11												
		⊙	8	SS	36												
259.4	Coarse Sand	⊙															
6.7	some clay	⊙	9	SS	33												
	Tr. gravel	⊙															
	Dense to Very Dense	⊙															
	Grey	⊙	10	SS	80												
		⊙	11	SS	99												
		⊙															
253.4		⊙	12	SS	103												
12.7	End of Borehole																

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

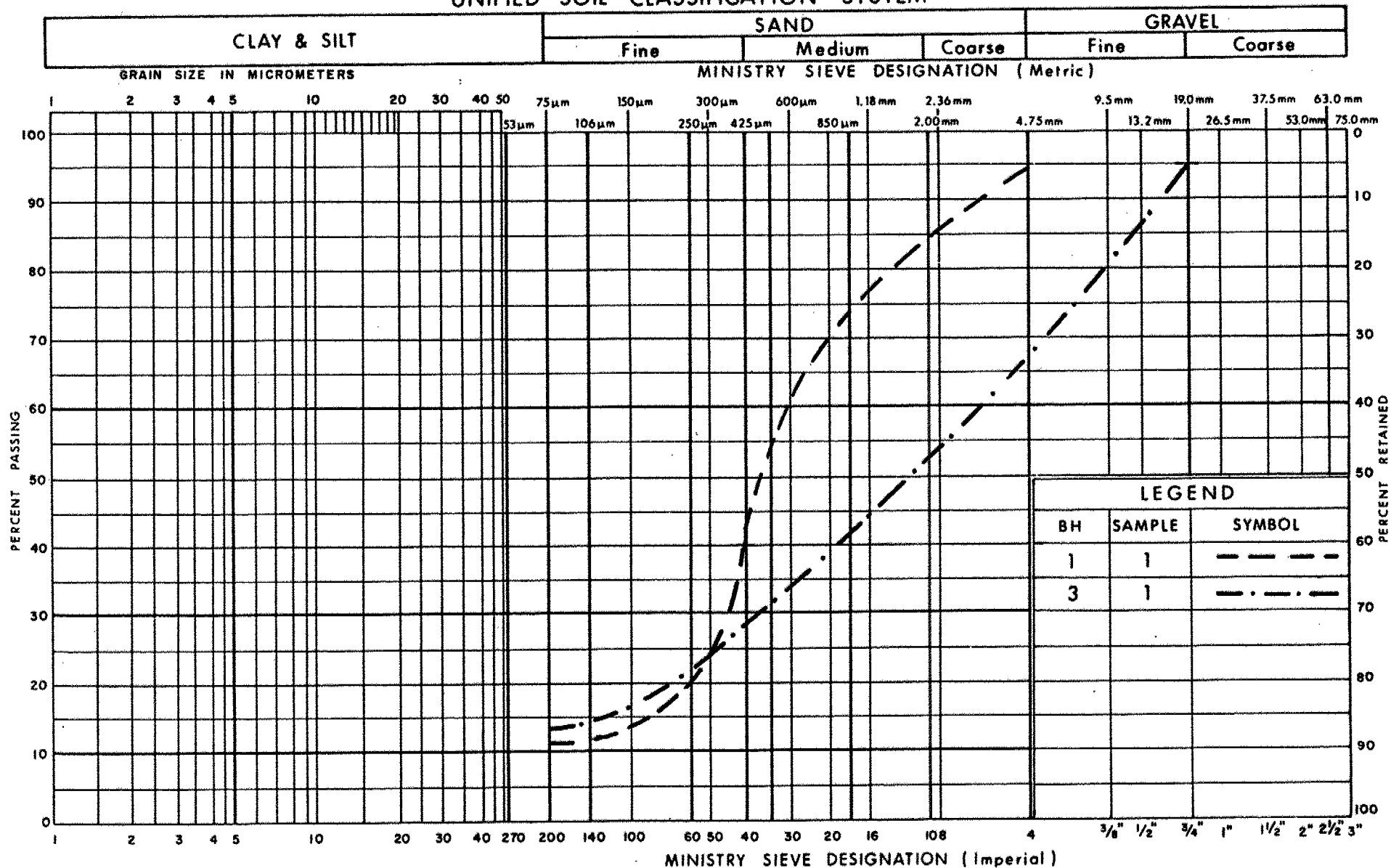
WL on  
1990 07 27

0 62 (38)

5 72 (23)

Wash casing  
installed  
Borehole  
advanced by  
triconing  
1 83 (16)

## UNIFIED SOIL CLASSIFICATION SYSTEM



### GRAIN SIZE DISTRIBUTION

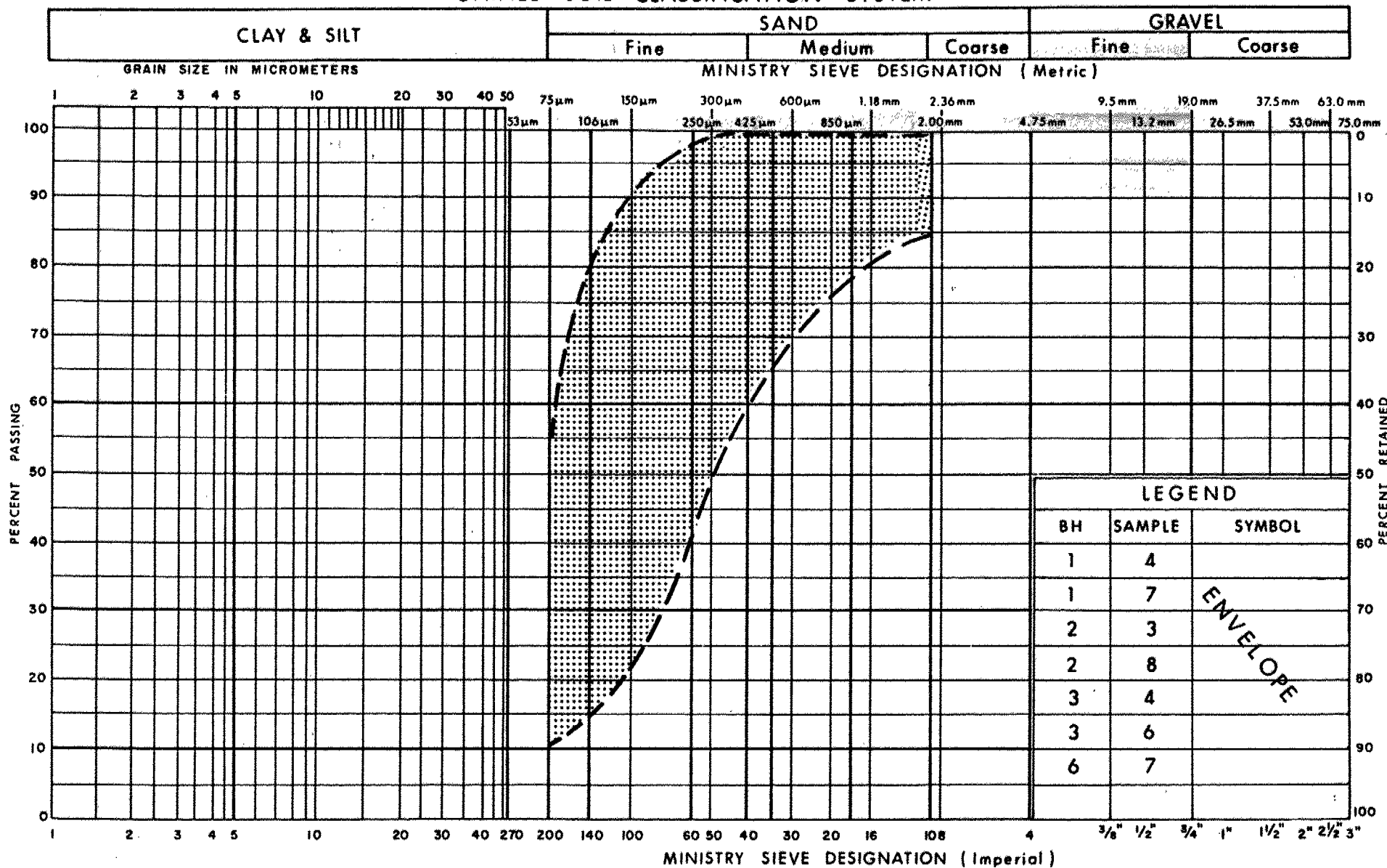
Sand and Gravel (Road Fill)



Ministry of  
Transportation

FIG No 1  
W P 479-89-02  
SITE No: 19-306

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

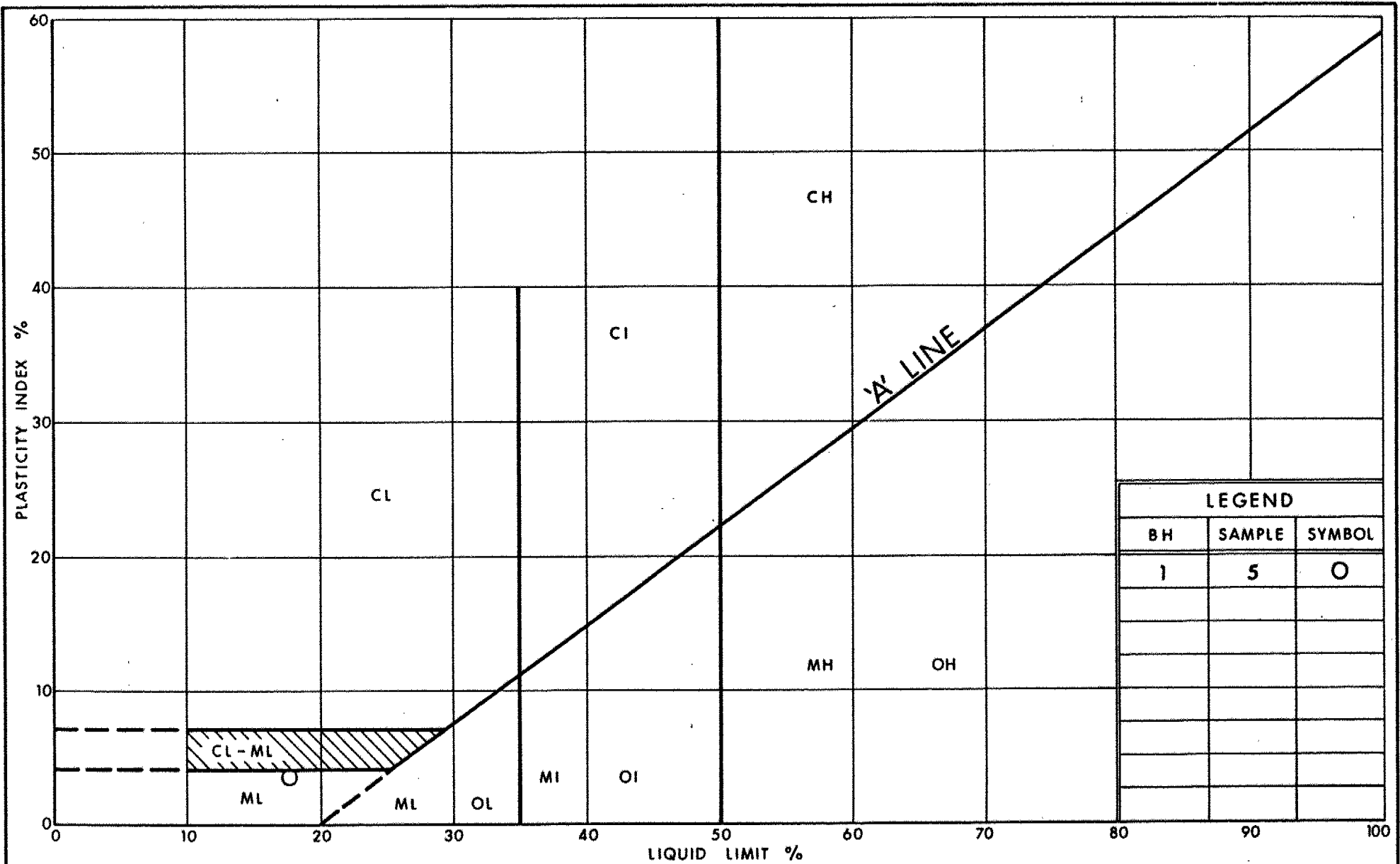
## GRAIN SIZE DISTRIBUTION

Sandy Silt to Silty Sand

FIG No 2

W P 479-89-02

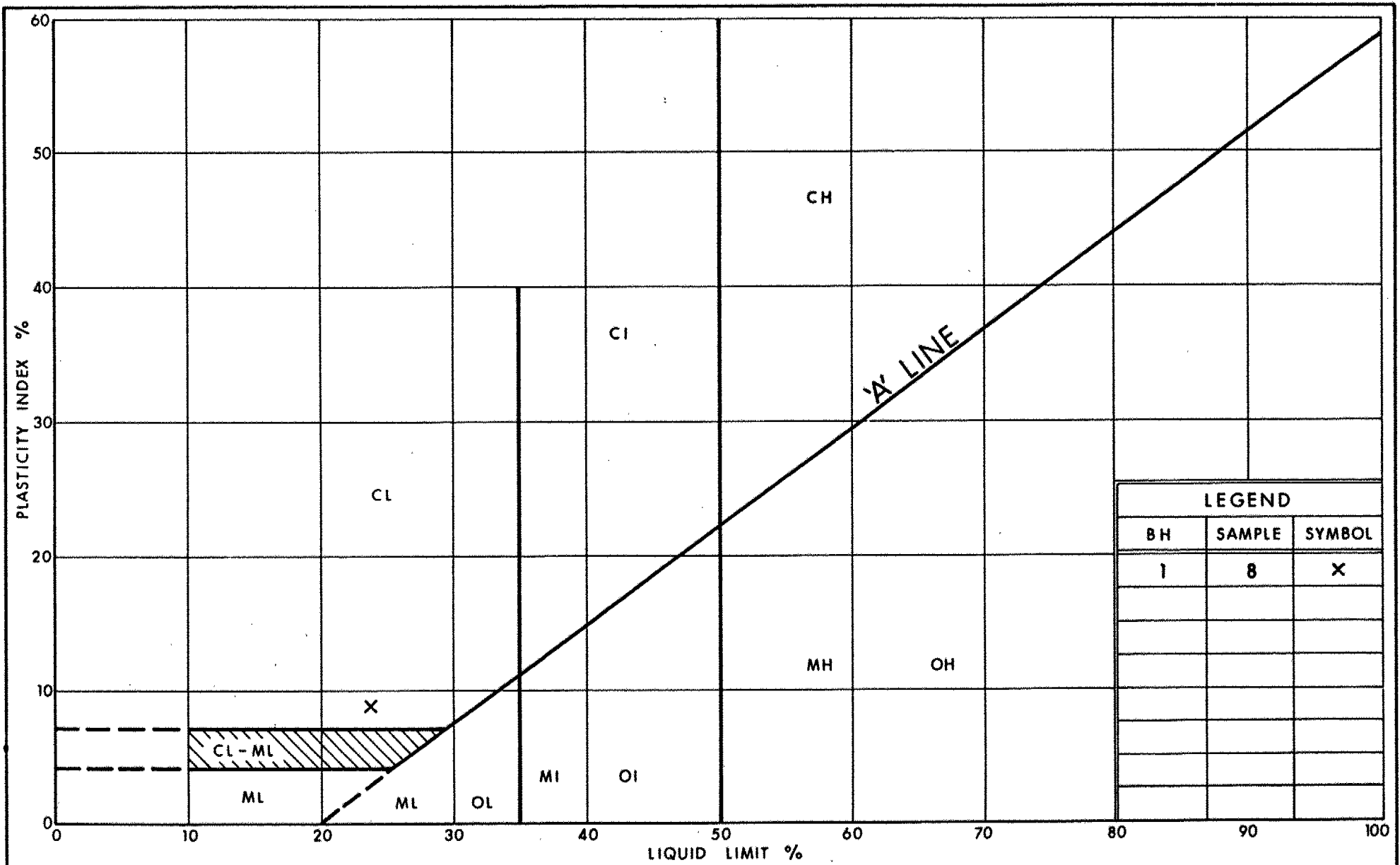
Site No. 19-306



Ministry of  
Transportation  
Ontario

# PLASTICITY CHART Silt

FIG No 3  
W P 479-89-02  
Site No. 19-306



Ministry of  
Transportation

Ontario

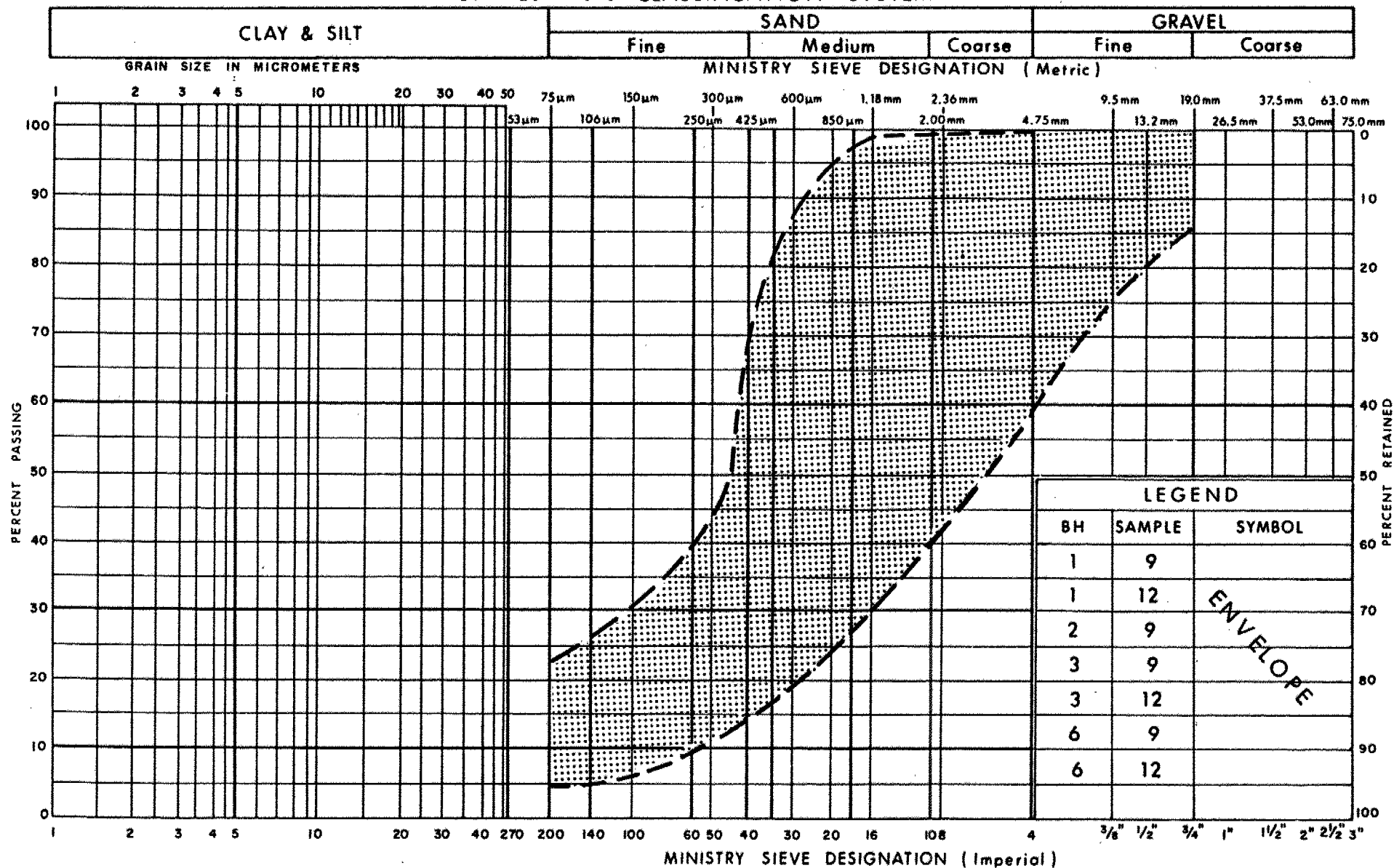
# PLASTICITY CHART Clayey Silt

FIG No 4

W P 479-89-02

SITE No: 19-306

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

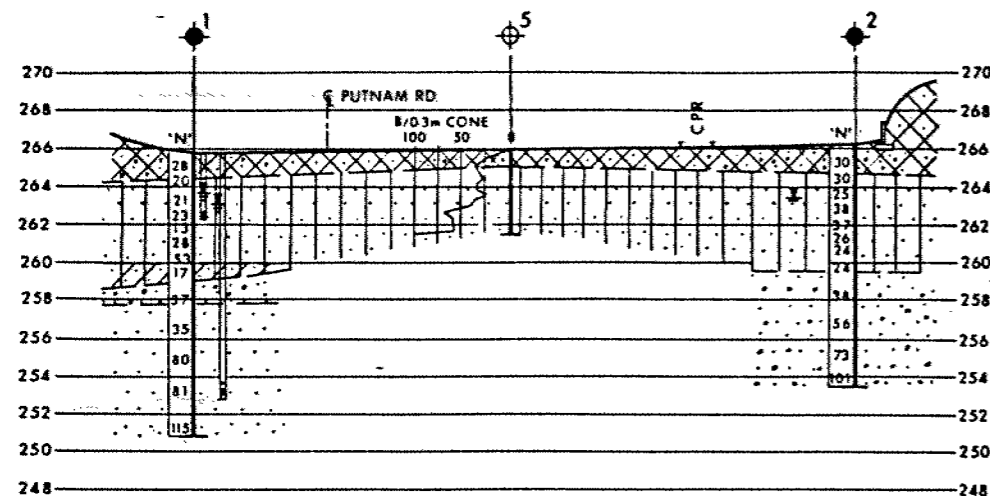
## GRAIN SIZE DISTRIBUTION

Coarse Sand with Gravel

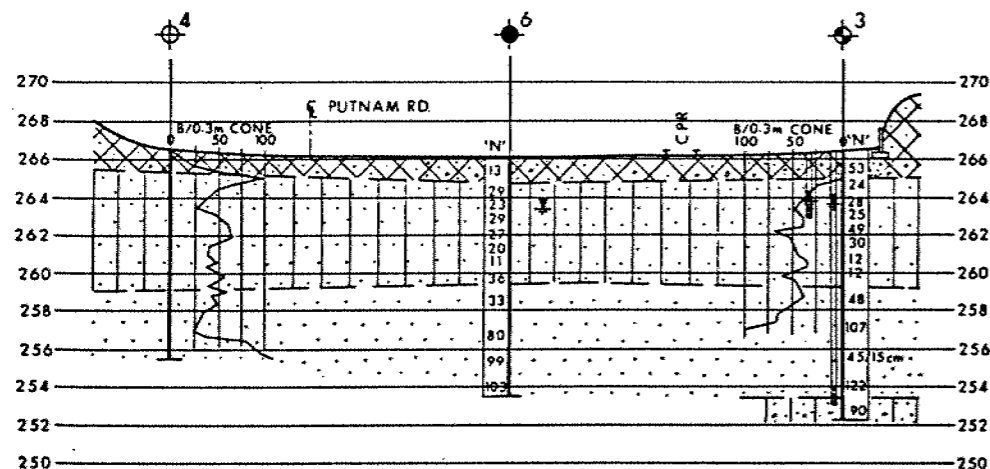
FIG No 5

W P 479-89-02

Site No. 19-306

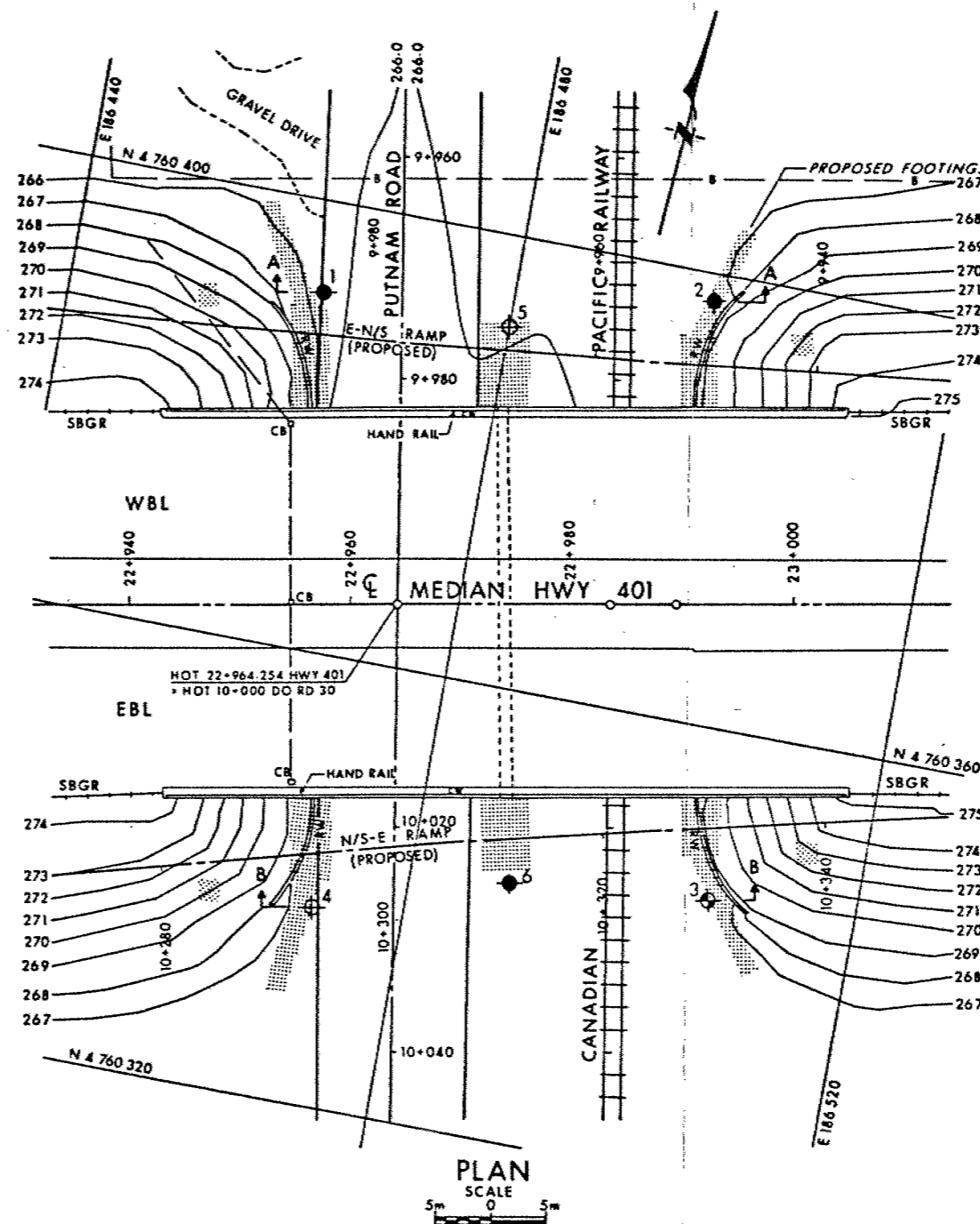


SECTION A-A  
SCALE  
0 5m 5m

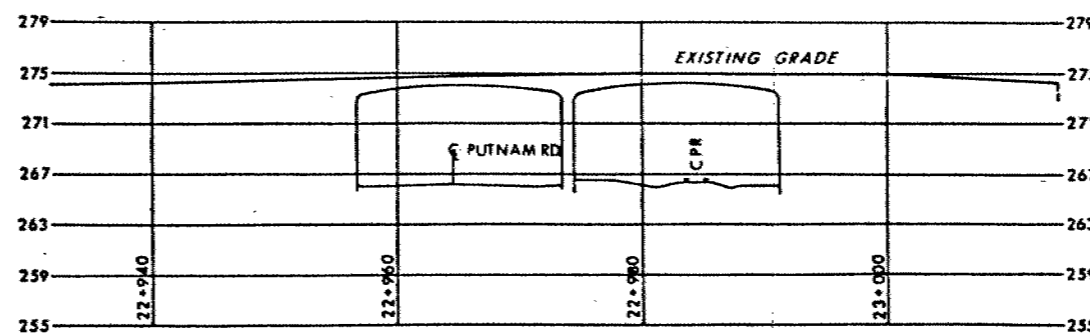


SECTION B-B  
SCALE  
0 5m 5m

SOIL STRATA SYMBOLS			
	SAND & GRAVEL (ROAD FILL) Compact - V.Dense		SANDY SILT to SILTY SAND Compact - Dense
	COARSE SAND Dense - V.Dense		CLAYEY SILT SOME SAND V.Stiff
	SANDY SILT (GLACIAL TILL) V.Dense		GRAVELLY SAND Dense - V.Dense



PLAN  
SCALE  
0 5m 5m



ME MED PROFILE HIGHWAY 401  
SCALE  
0 5m 5m

**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES.

CONT No  
WP No 479-89-02

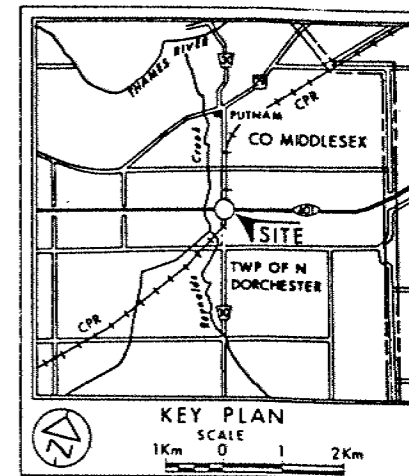
PUTNAM RD/CPR OVERPASS

BORE HOLE LOCATIONS & SOIL STRATA



SHEET

STRATA ENGINEERING CORP.



# LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N: Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation  
July & August 1990
- Strand Pipe

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	265.8	4760 392	186 463
2	266.2	4760 398	186 498
3	266.4	4760 345	186 507
4	266.4	4760 338	186 472
5	266.0	4760 392	186 480
6	266.1	4760 343	186 489

# NOTE

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION
1			

Geocres No 40115-29

MWY No 401	DIST 2
SUBMD A.A. [CHECKED A] DATE Nov 14, 1990	SITE 19-306
DRAWN A.K. [CHECKED A] APPROVED	DWG 4798902-A