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FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT 94-22

WP 127-87-01 DIST 9

HWY 416 STR SITE 3-542

Richmond Road Underpass
Structure #8

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FOUNDATION INVESTIGATION REPORT

For

Richmond Road Underpass

Structure #8

W.P. 127-87-01, Site No. 3-542

Hwy. 416, District 9, Ottawa

INTRODUCTION

This report summarizes the results obtained from a foundation investigation conducted at the aforementioned site. A three span structure is proposed to carry Richmond Road over the proposed Hwy. 416 SB lanes, Hwy. 416 NB lanes and Hwy. 416 S to 417 E ramp lanes. Excavation cuts in the order of magnitude of 6-8 metres will be required in the soil and rock at the site to facilitate advancement of the highway.

Discussion and recommendations pertaining to the subsurface conditions, structure foundations, approach cuts and related earthworks are provided in this report.

SITE DESCRIPTION

The site is located along the existing four lane Richmond Road in the City of Nepean, Ottawa-Carleton Municipality, stretching westwardly from the existing Acres Road to an existing steel plate culvert that underlies Richmond Road at the proposed west abutment location. A small creek flows through the culvert perpendicular to Richmond Road at this location. The site is further bounded by agricultural farmland north of Richmond Road and grassland, shrubs and a meandering creek south of Richmond Road. In addition, a hospital is located approximately 2-3 km southeast of the site and a Silver Springs Farm that supplies public drinking water is located approximately 1 km west of the site.

The terrain surrounding the site is generally flat to gently rolling with roadway ditches existing on either side of Richmond Road.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the lowlands of the St. Lawrence. The native subsoil consists

of clay plains interrupted by ridges of rock or sand. Bedrock at the site is of the March/Nepean and consists of sandstone. Fault scarps are also evident within the area, an illustration of the numerous normal faults that dominate the region.

The overburden was deposited during and immediately following the Wisconsin glacialiation at which time the area was depressed from the effect of the glacialiation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

FIELD INVESTIGATION

The fieldwork for the investigation was carried out between 89 07 31 and 89 08 02 and consisted of 8 sampled boreholes advanced to depths ranging from 5.2 m to 9.3 m below ground surface accompanied by 8 dynamic cone penetration tests advanced to depths ranging from 4.0 m to 7.6 m. Additional sampled boreholes (BH's 8-1, 89-3 to 89-9 incl.) advanced in conjunction with a previous preliminary investigation (W.P. 127-87-00) at the site conducted between 89 04 05 and 89 04 06 have also been included in this report.

Hollow stem auger equipment was used to advance the boreholes in the overburden. Subsoil samples were retrieved at 0.7 m intervals by a split spoon sampler in both cohesionless and cohesive soils encountered in accordance with the Standard Penetration Test (ASTM D1586) and by a Shelby tube sampler at 1.5 m intervals in cohesive soils (ASTM D1587). In situ vane tests were carried out in the surficial cohesive silty clay to clayey silt deposit, in order to determine the undrained shear strength of the cohesive material at both the undisturbed and remoulded state at 0.7 m to 1.5 m intervals. The test was conducted in accordance with ASTM D2573 using the standard MTO 'N' vane. Bedrock was cored at 8 boreholes at the structure foundation locations using conventional rock coring methods in BXL size. All samples were identified in the field and then returned to the laboratory for applicable testing.

Groundwater levels were obtained in the open boreholes and also in sealed piezometers installed at BH's 8-2 and 8-7. Groundwater levels were monitored throughout the duration of the investigation. All open boreholes were backfilled at the completion of the fieldwork. Survey information related to the location and elevation of boreholes was provided by Eastern Region Surveys and Plans.

SUBSURFACE CONDITIONS

Subsoil conditions are generally uniform across the site. The surficial native deposit consists of a cohesive silty clay to clayey silt that extends to a maximum thickness of 6.1 metres (BH 8-6), but is generally of the order of magnitude of 2.5 - 4.5 metres across the site. Underlying the silty clay to clayey silt deposit exists a cohesionless deposit consisting of a heterogeneous mixture of silt, sand and gravel. The glacial till deposit overlies sandstone bedrock and varies in thickness ranging from 0.4 to 2.7 metres.

Fill material consisting of clayey silt with some sand was encountered at isolated locations (BH's 8-1, 8-4) overlying the native clayey silt to silty clay deposit. The thickness of the fill material is approximately 1.4 metres and 2.5 metres at BH's 8-1 and 8-4 respectively. It appears the fill material may have been placed in conjunction with the installation of underground utilities at the site.

The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation, are shown on the attached Record of Borehole sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are provided on Dwg. 1278701-A.

A detailed description of the subsurface conditions encountered is given below.

Fill Material

The fill material encountered at BH's 8-1 and 8-4 consists of a grey clayey silt, some sand and appears to have been placed in conjunction with underground

utility installations. The thickness of the fill is approximately 1.4 m at BH 8-1 and 2.5 m at BH 8-4. Based on the stiff consistency of the cohesive clayey silt, the material appears to have been compacted to acceptable target densities.

Silty Clay to Clayey Silt

The native surficial deposit at the site consists of a silty clay to clayey silt that has been oxidized (brown) for the upper 1-1.5 metres and unoxidized (grey) for its lower thickness. The maximum thickness of the deposit encountered during this investigation is 6.1 metres, but is generally of the order of 2.5-4.5 metres across the site.

This deposit is generally cohesive in behaviour and contains some sand and occasional random sand seams. A grain size distribution envelope for this deposit as determined by mechanical analyses is given in Figure 1.

Atterberg Limits were obtained to evaluate the plasticity of the soil and the results are plotted in Figure 2. A summary of the indices is provided in Table 1. Unit weights are also included.

Table 1 - Silty Clay to Clayey Silt

	<u>Range</u>	<u># of Tests</u>
Natural Moisture Content (w%)	29-35	6
Liquid Limit (w_L %)	32-50	6
Plastic Limit (w_p %)	12-18	6
Unit Weight (kN/m^3)	17.2-19.3	3
Undrained Shear Strength (C_u) (kPa)		
- Field Vane	40->120	25
Sensitivity	3-14	25

The test results reveal that the deposit varies randomly in plasticity ranging from low (clayey silt) to intermediate (silty clay).

Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till)

Underlying the surficial clayey silt to silty clay deposit and extending to bedrock a heterogeneous mixture of silt, sand and gravel (glacial till) exists. The thickness of this deposit ranges from 0.4 m to 2.7 m. Although not encountered during the investigation, boulders are characteristic components of deposits of this origin and hence may exist. A grain size distribution envelope for this deposit is provided in Figure 3 in the Appendix.

Standard Penetration tests carried out in this deposit revealed 'N' values ranging from 2 blows/0.3 m to 61 blows/.18 m indicating that the deposit ranges in denseness from loose to very dense. In general, the deposit can be categorized as compact.

Bedrock

The glacial till deposit is directly underlain by sandstone bedrock of the March/Nepean Formation. The bedrock was cored in BXL size up to 1.7 metres in length at the proposed structure foundation locations.

The sandstone bedrock is light grey in colour and contains close to moderately close spaced horizontal and near vertical fractures. The fractures are generally rough and clean. Some minor interbeds of dolostone are also present in the sandstone. Detailed descriptions of the bedrock are attached in the Appendix entitled "Description of Rock Core".

Core recoveries and Rock Quality Designations (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Rock recoveries varied between 93 and 100% while RQD's varied between 37 and 100%, but generally between 90 and 100%. In general, the rock can be classified as strong and durable.

Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water level in the open boreholes and monitoring the water level in piezometers installed in the bedrock and within the native overburden. Measurements obtained at the time of investigation revealed levels at an elevation ranging from 72.5 m to 76 m which corresponds to depths ranging from 0.9 to 3.6 m below the existing ground surface. Groundwater levels, however, are subject to seasonal fluctuations and hence can vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a 3 span structure (44.2 m - 32.3 m - 44.6 m) with an approximate width of 25 metres to carry Richmond Road over the proposed Hwy. 416. The proposed grade for the highway is approximately at elevation 69 metres whilst the proposed grade for Richmond Road is approximately at elevation 77 metres. Along the north end of the structure and at the east abutment, the bedrock surface elevation is at approximate elevation of 69± metres. Consequently, up to 8 metres of forward earth slopes will be required at the east abutment approach. These forward earth slopes will consist of approximately 2.5 metres of fill material overlying the excavated existing soil and rock. At the proposed west abutment location, the bedrock surface elevation rises in elevation in the southward direction from 69 metres to 73 metres. Consequently, forward earth slopes ranging in magnitude from 4 to 8 metres will be required at the west abutment. The excavation cut at the east approach will be approximately 6 to 6.5 metres in the native overburden and less than 1 metre in the bedrock. At the west approach on the other hand, excavation cuts will vary from approximately 6 m in the overburden and less than 1 metre in the bedrock at the north end of the west abutment to approximately 4 m in the overburden and 4 m in the bedrock at the south end of the west abutment.

Recommendations pertaining to the following geotechnical considerations are provided in the scope of this report.

Structure Foundations

Slope Stability

- Richmond Road Approach
- Hwy. 416 Excavation Cut

Lateral Earth Pressures on Structure

Construction Considerations

Structure Foundations

It is recommended that the structure foundations be founded on one or a combination of the following three (3) alternatives:

- 1) spread footings on bedrock
- 2) open type abutments on steel H piles
- 3) open type abutments on concrete caissons

The alternative or combination that proves to be the most economical and technically feasible should be selected for design.

Spread Footings

In consideration of the proposed excavation cut sections at the site, the structure abutments and piers can be founded on conventional spread footings on the sandstone bedrock. The footings can be founded at or below the bedrock surface identified in Table 3 below provided that the footing be located at a minimum edge distance of 3 metres from any excavated rock slope. In addition, the footing base should be scaled of any loose surficial overburden or any loosen/fractured rock. For purposes of the O.H.B.D.C., the following design values are recommended:

Table 3 - Spread Footings on Bedrock

<u>Structure</u>	<u>Factured Capacity at U.L.S. (kPa)</u>	<u>Bearing Capacity at S.L.S. (kPa)</u>	<u>Bedrock Surface El. (m)</u>
West Abutment	3000	N/A	69.5-73
West Pier	3000	N/A	69-70.5
East Pier	3000	N/A	69-70
East Abutment	3000	N/A	68.5

The bedrock is considered to be an unyielding foundation base and hence the bearing capacity at S.L.S. Type II will not govern.

Sliding resistance between the concrete footing and unweathered sandstone bedrock should be calculated in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. assuming an unfactored angle of friction of 24° between the concrete and the rock. If additional sliding resistance is required, consideration can be given to employing dowels or rock anchors provided the bedrock is not

severely fractured. Please contact this office for pertinent design parameters should any of these options be considered.

To prevent potential footing uplift caused by pressures exerted by heaving created by freezing of water beneath the footing, it is recommended that the footings be protected against frost penetration. The frost penetration depth in the site area is 1.8 metres. In addition, ascertaining a clean and tight contact between the concrete and the rock will also assist in the prevention of ice accretion.

No major dewatering problems are anticipated during footing excavation and construction. Some groundwater inflow into the excavation can be expected predominantly through the glacial till and bedrock. Such inflow, however, can be controlled by conventional sump pumping techniques and applying a granular blanket on the slope (slope protection is discussed in subsequent sections of this report).

A concrete working slab should be provided immediately following excavation to protect the bearing surface of the bedrock at the footing location from the effects of weathering and other disturbances.

Perched Abutments on Steel H Piles

Alternatively, the abutments can be designed as an open-type abutment founded on end-bearing steel H piles driven to the bedrock surface. To facilitate pile penetration through the basal glacial till deposit, it is recommended that the steel H piles be equipped with reinforced tips. The following design parameters are recommended for vertical steel H piles.

<u>Structure</u>	<u>Pile Type</u>	<u>Factured Capacity at U.L.S. (kPa)</u>	<u>Bearing Capacity at S.L.S. (kPa)</u>	<u>Bedrock Surface El. (m)</u>
West Abutment	310x79	890	1150	69.5-73
	310x110	1150	1600	
East Abutment	310x79	890	1150	68.5±
	310x110	1150	1600	

Reductions of axial capacities for inclined loadings shall conform to factors provided in Section 6-8.3.4.3. of the O.H.B.D.C.

No dewatering problems are anticipated for the construction of pile caps within the surficial silty clay to clayey silt material. Conventional sump pumping techniques will suffice in discharging any localized seepage. Pile caps shall be protected against frost penetration by providing a minimum 1.8 metres earth cover.

The lateral resistance for both vertical and battered piles shall be computed in accordance with Section 6.8.3.8 of the O.H.B.D.C.

Alternative 3 - Perched Abutments on Concrete Caissons

Open-type abutments may be supported on reinforced concrete caissons founded on or socketed into the bedrock. For purposes of the O.H.B.D.C., the following design values are recommended.

<u>Structure</u>	<u>Caisson Diameter (m)</u>	<u>Pile Tip Elev. (m)</u>	Capacity at	Factored Capacity
			S.L.S. Type II	at U.L.S.
			<u>(kN)</u>	<u>(kN)</u>
West Abutment	0.76	<69.5-73	1500	2250
East Abutment	0.76	<68.5±	1500	2250

Resistance to lateral load shall be computed in accordance with Section 6.8.3.8 of the O.H.B.D.C.

In view of the elevation of the groundwater table and the fact that the cohesionless till deposit is submerged, the shaft of the preaugered holes must be protected against caving during the installation of the concrete caissons. One method of achieving this is by installing a steel liner and constructing the caisson within the steel liner. After the liner has been cleaned out and the required reinforcing installed, the concrete should be placed in the dry. Alternatively mud drilling and tremie techniques may be employed. The proposed method of installation shall be based in accordance with OPSS 903.07.03 and subject to review by this office.

No dewatering problems are anticipated for the construction of pile caps within the surficial silty clay to clayey silt material. Conventional sump pumping techniques will suffice in discharging any localized seepage. Pile caps shall be protected against frost penetration by providing a minimum 1.8 metres earth cover.

Slope Stability

General

The critical condition examined in the evaluation of excavation cuts such as that proposed at the site location is the long term (drained) condition and consequently an effective stress analysis was implemented. In all cases, stability computations were carried out using Bishop's method on an in-house mainframe program incorporating a factor of safety of 1.3. The properties of the fill material and subsoil and the geometries selected for the Richmond Road approach and the Hwy. 416 cut approach are shown in Figures 4 and 5 respectively in the Appendix. Details of the analysis are described under the appropriate subheadings below. In all cases earth slopes are to be "benched" a distance of 3.0 m from any rock slope as per OPSD 201.01 and 201.02.

Drained stability analyses of the slopes are very sensitive to groundwater levels and pore pressures that can develop in the slope. Therefore slope protection and drainage measures will be required to ensure their long-term surficial stability. By employing a 1.2 m thick granular blanket consisting of

free draining material such as Granular 'A' material, softening of material due to freeze-thaw cycles and development of excess pore water pressures can be prevented. Inabilities to control these parameters usually result in surficial slope failures.

The granular blankets should be designed in conjunction with a permanent drainage system that will discharge drained water both from the slope and the bedrock. It is recommended that toe drains be constructed consisting of a perforated pipe encased with a suitable geotextile filter fabric and in turn surrounded by a suitable granular soil filter material. The toe drains should then be connected to an appropriate integrated drainage system. At the site, the toe drains can be constructed in conjunction with the highway perimeter drainage system (see Figure 4).

Normal slope vegetation should be established as soon as possible after completion of the cut in order to control surficial erosion.

Richmond Road Approach

Approaches at Richmond Road will require the placement of up to 2 m of fill material at the surface of the Hwy. 416 excavation cut slope. The maximum overburden thickness at the abutment location is 6 m.

The results of the analysis for the stability of the forward earth slopes are illustrated in Figure 6 in the Appendix. The "Equivalent Depth of Cut" that identifies the ordinate scale of the graph represents the total depth that includes the approach fill thickness of 2 metres. Based on the results, it can be concluded that for an equivalent depth of 5 metres, the forward slopes can be constructed at 2H:1V. For an equivalent depth exceeding 5 metres, mid-depth benches are recommended. A bench design configuration is illustrated in Figure 4a. For an equivalent depth of 8 metres, which is the maximum depth at the site, a bench width of 6 metres will be required.

Transverse slopes for the approach fills can be constructed at 2H:1V. Any local softened and/or surficial organic soil should be removed within the plan limits

of the fill prior to its placement. The fills should be placed and compacted according to MTO specifications and standards (OPSS 501). Settlements induced by the fill placement are expected to be negligible.

Hwy. 416 Approach Cut

Excavation cuts ranging in magnitude from 4 to 8 metres, generally 4-7 m in soil and 1-4 metres in bedrock, will be required in the advancement of Hwy. 416 at the structure foundation location and immediate approaches. The deepest rock excavation will be required in the area of BH 8-7, where the bedrock surface elevation is at El. 73.0 m.

The results of stability analysis indicate that excavated overburden slopes with the applied slope surface treatment, can be safely constructed at 2H:1V for depths less than or equal to 5 metres. As Figure 7 illustrates, mid-depth benches will be required for depths exceeding 5 metres. For instance, a 7 m cut required just north of the structure will require a mid-depth bench 5 metres in width.

No stability problems are anticipated for bedrock slopes, provided that the bedrock is not severely fractured and permanent cut slopes are 1H:4V or flatter.

Lateral Earth Pressures on Structure

Free draining material such as Granular 'A' or Granular 'B' is recommended as appropriate backfill to the abutments to prevent hydrostatic pressure build-up. Design parameters of the soil are given below:

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m ³)	22.8	21.2
Coefficient of Active Earth Pressure (K_a)	0.27	0.33
Coefficient of Earth Pressure at Rest (K_0)	0.43	0.5

The earth pressure coefficient at rest is to be used in design if the abutment walls are rigid and unyielding. Weep holes in the abutment walls should be designed to drain any accumulation of water in the backfill.

Construction Considerations

Earth and rock excavation shall be carried out in accordance with OPSS 206.07.03 and 206.07.04 respectively. Rock Grading shall be carried out in accordance with OPSD 201.02. In order to prevent excess fracturing of the bedrock foundations and slopes, rock excavation should be carefully monitored.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, J. White and A. Lako, Student Engineers, utilizing equipment owned and operated by Marathon Drilling and Johnston Drilling. The description of bedrock core samples was carried out by S. Senior, Geologist.

The project was carried out by T. Sangiuliano under the general supervision of Dr. B. Iyer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by Dr. B. Iyer and approved by Mr. M.S. Devata, Chief Foundation Engineer.



A handwritten signature in black ink, appearing to read 'T. Sangiuliano'.

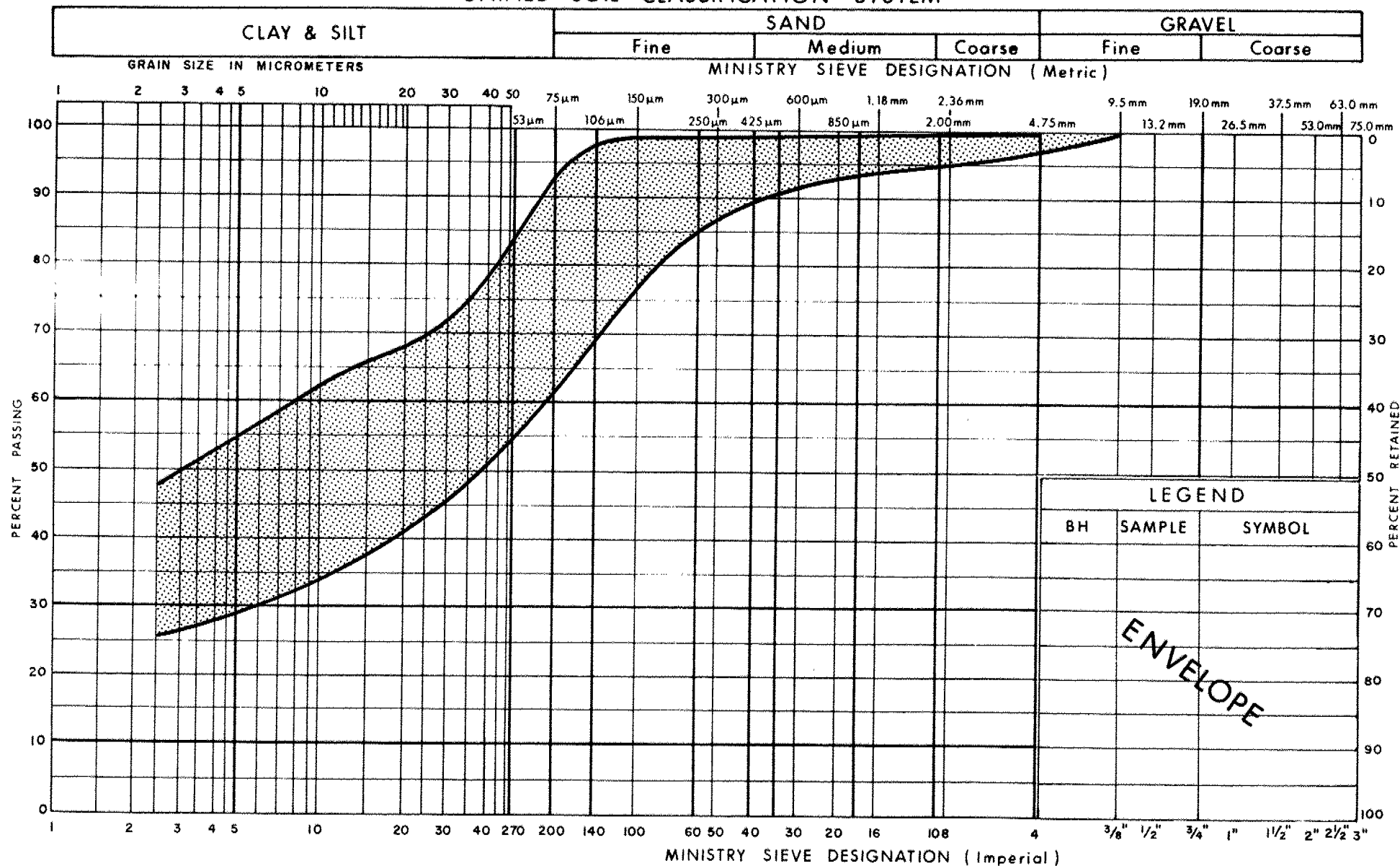
T. Sangiuliano, P.Eng.
Foundation Engineer

A handwritten signature in black ink, appearing to read 'M.S. Devata'.

M.S. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

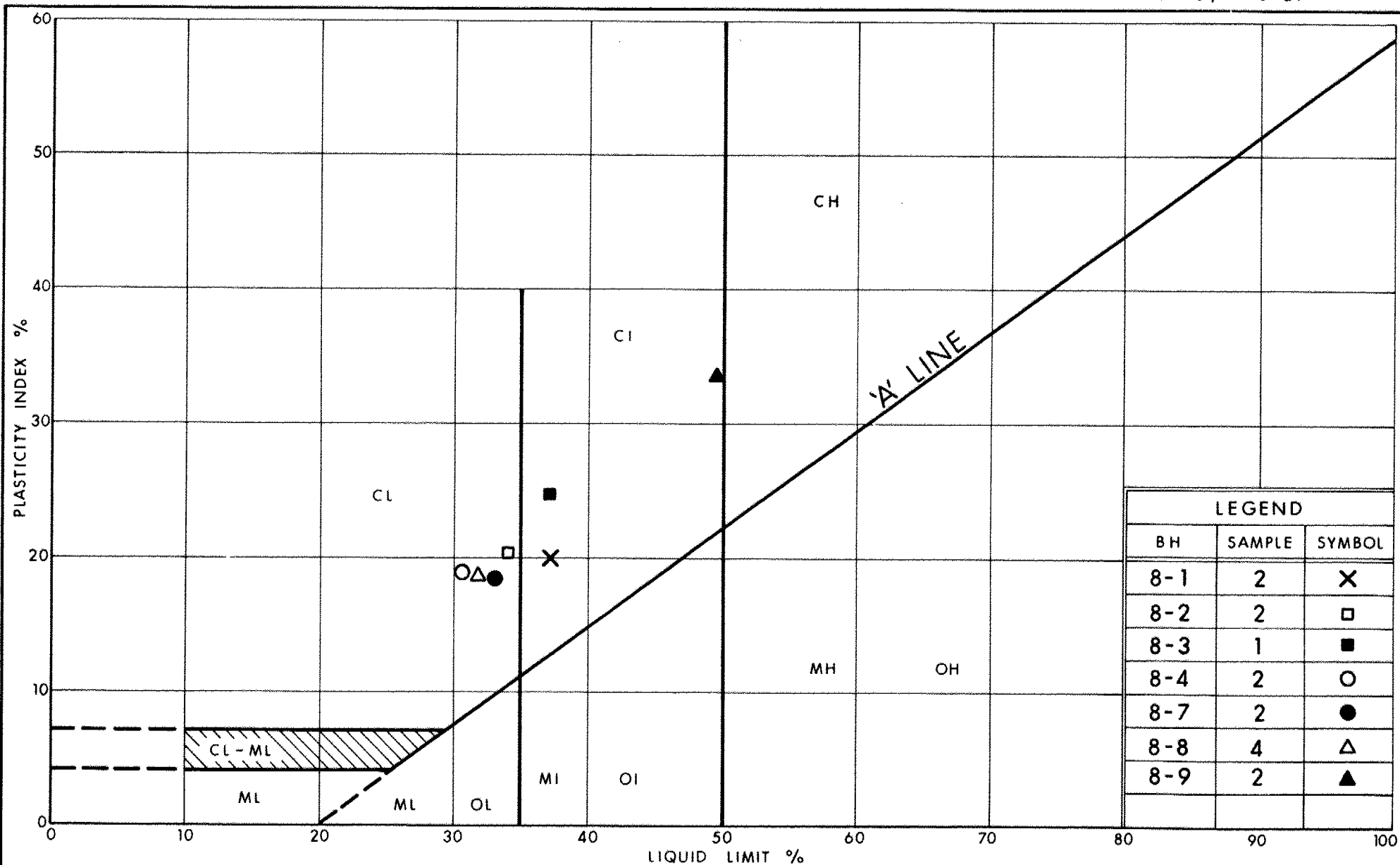


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GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAYEY SILT, SOME SAND

FIG No 1

W P 127-87-01



Ontario

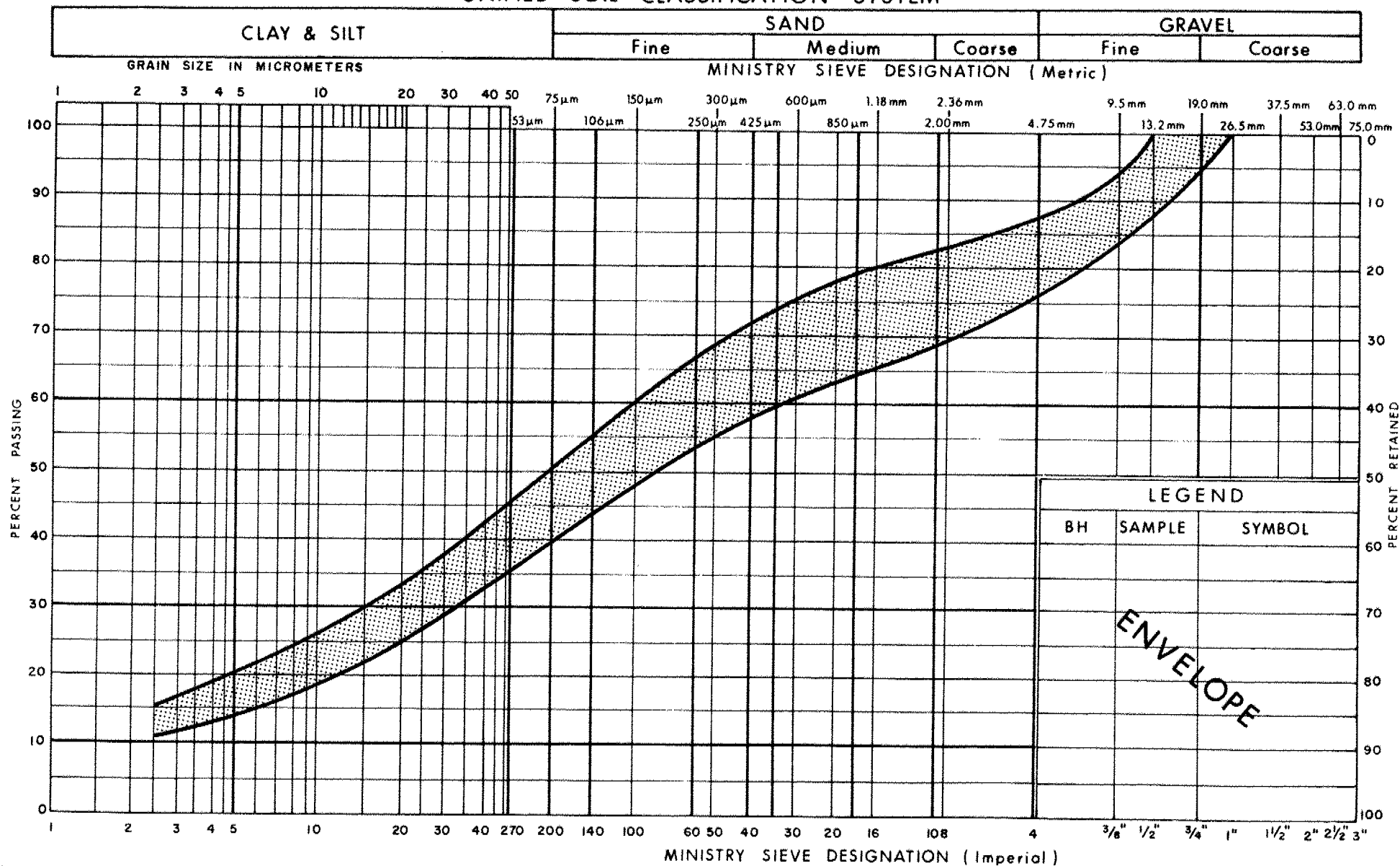
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Transportation

PLASTICITY CHART SILTY CLAY TO CLAYEY SILT, SOME SAND

FIG No 2

W P 127-87-01

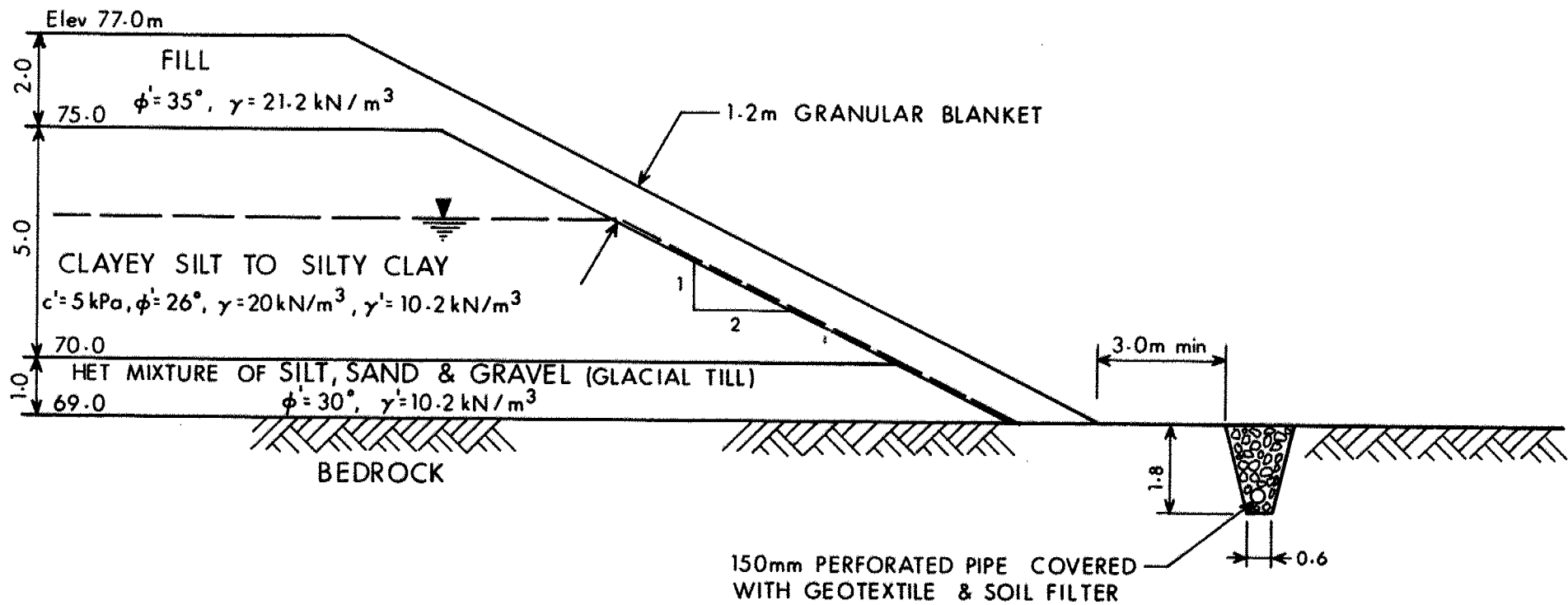
UNIFIED SOIL CLASSIFICATION SYSTEM


 Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
 HET MIXTURE OF
 SILT, SAND & GRAVEL (Glacial Till)

FIG No 3

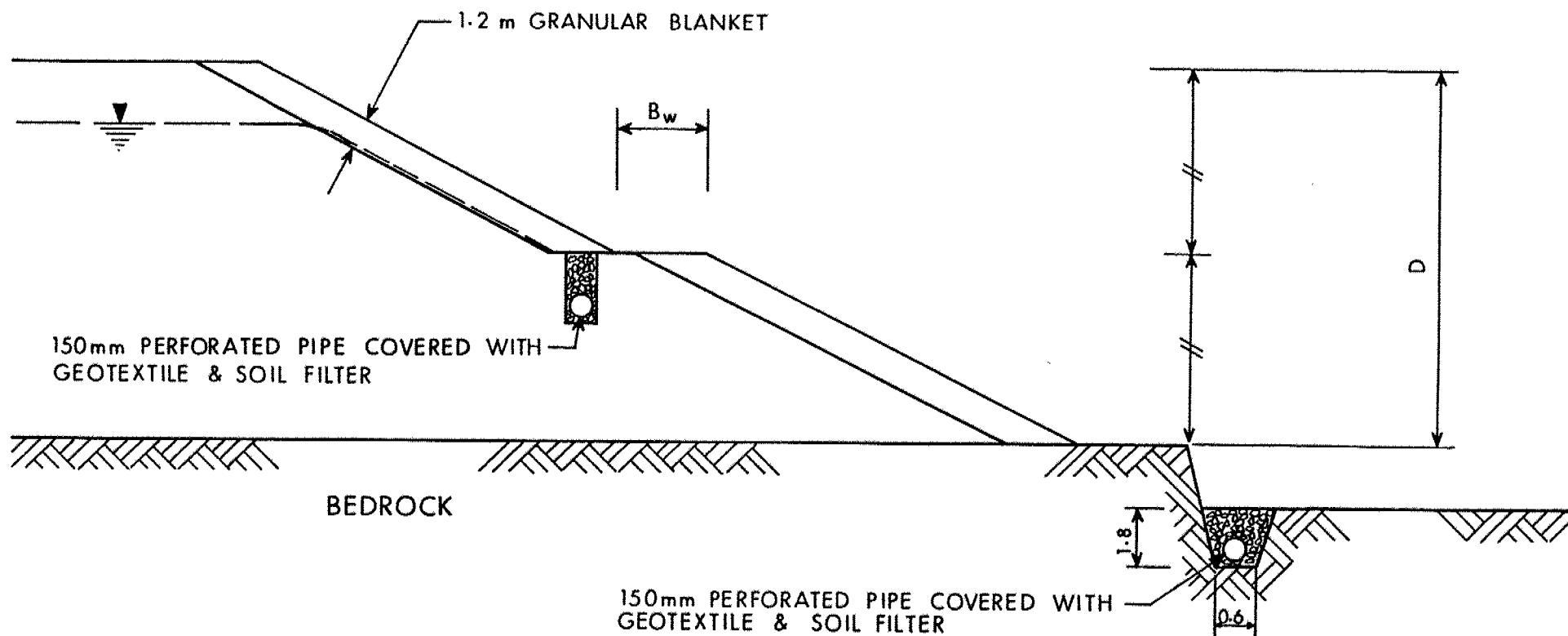
W P 127-87-01



RICHMOND RD APPROACH

FIG 4

WP 127-87-01



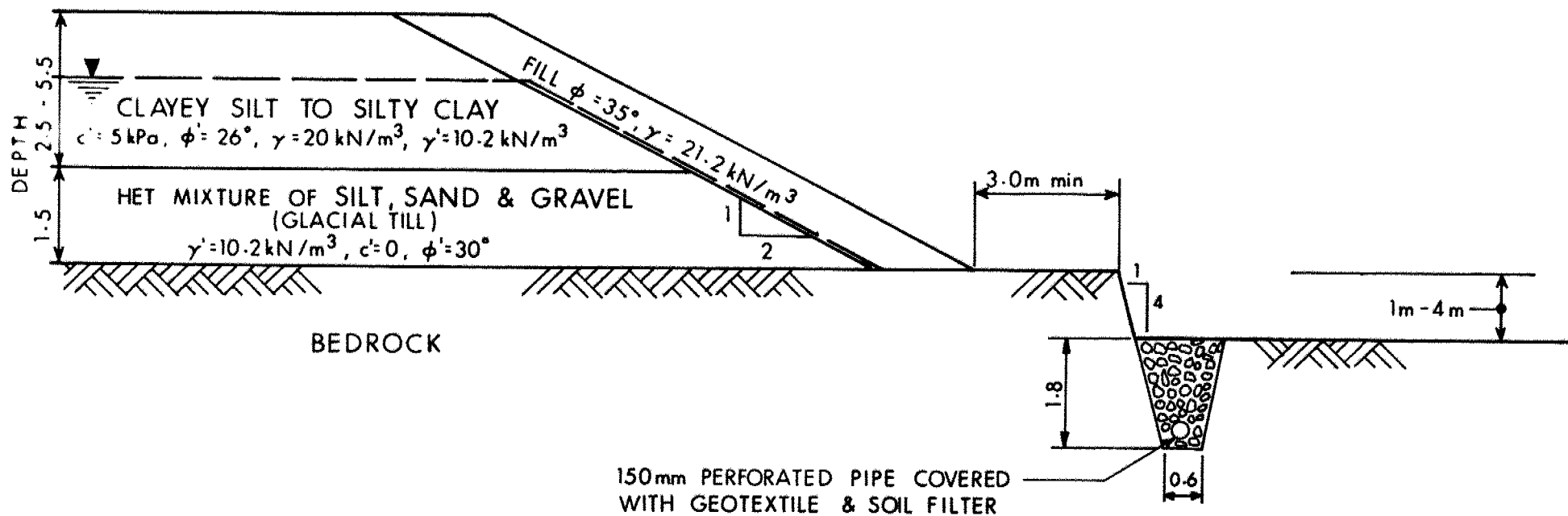
B_w = BENCH WIDTH

D = DEPTH OF CUT IN OVERBURDEN

BENCH DESIGN

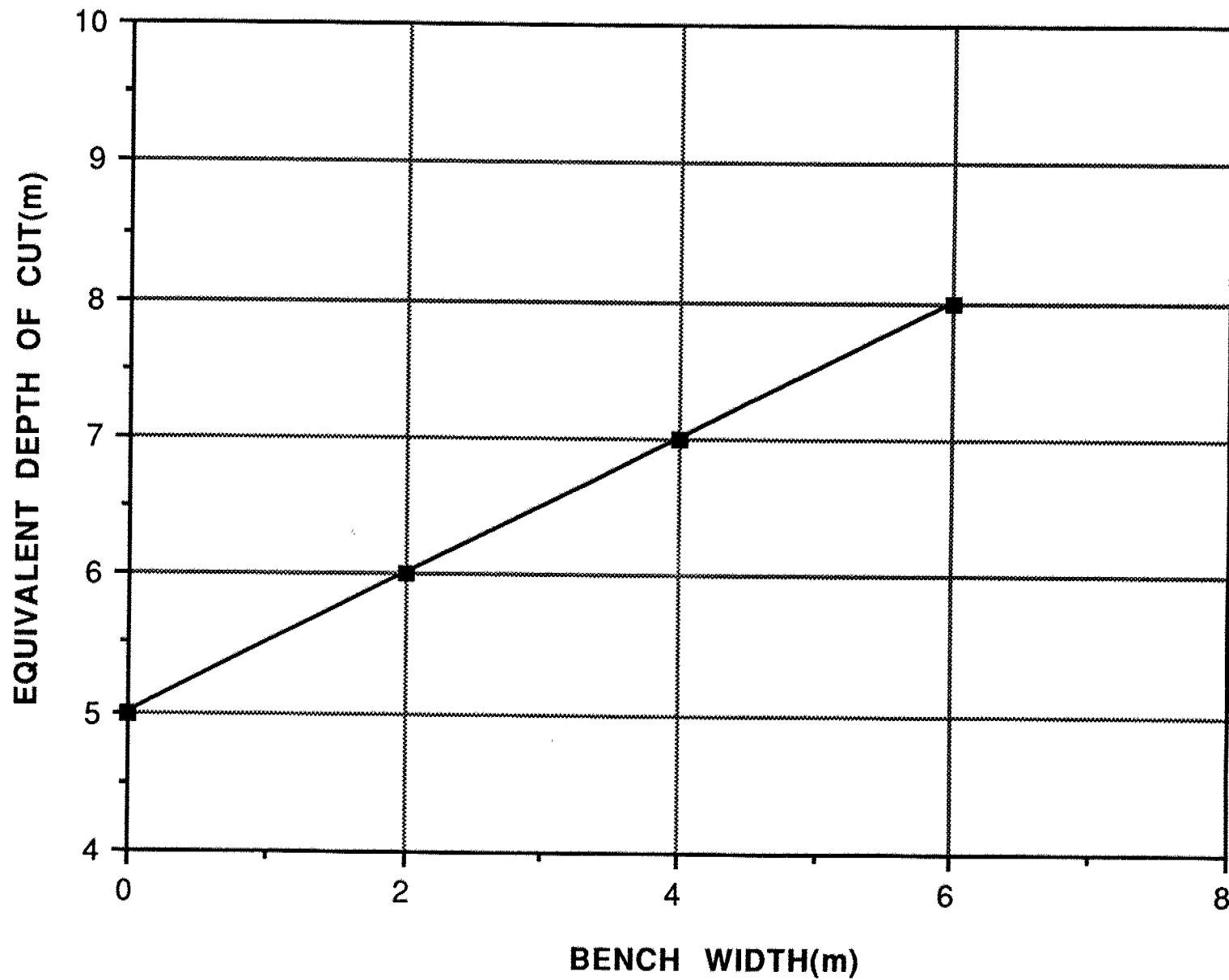
FIG 4A

WP 127-87-01

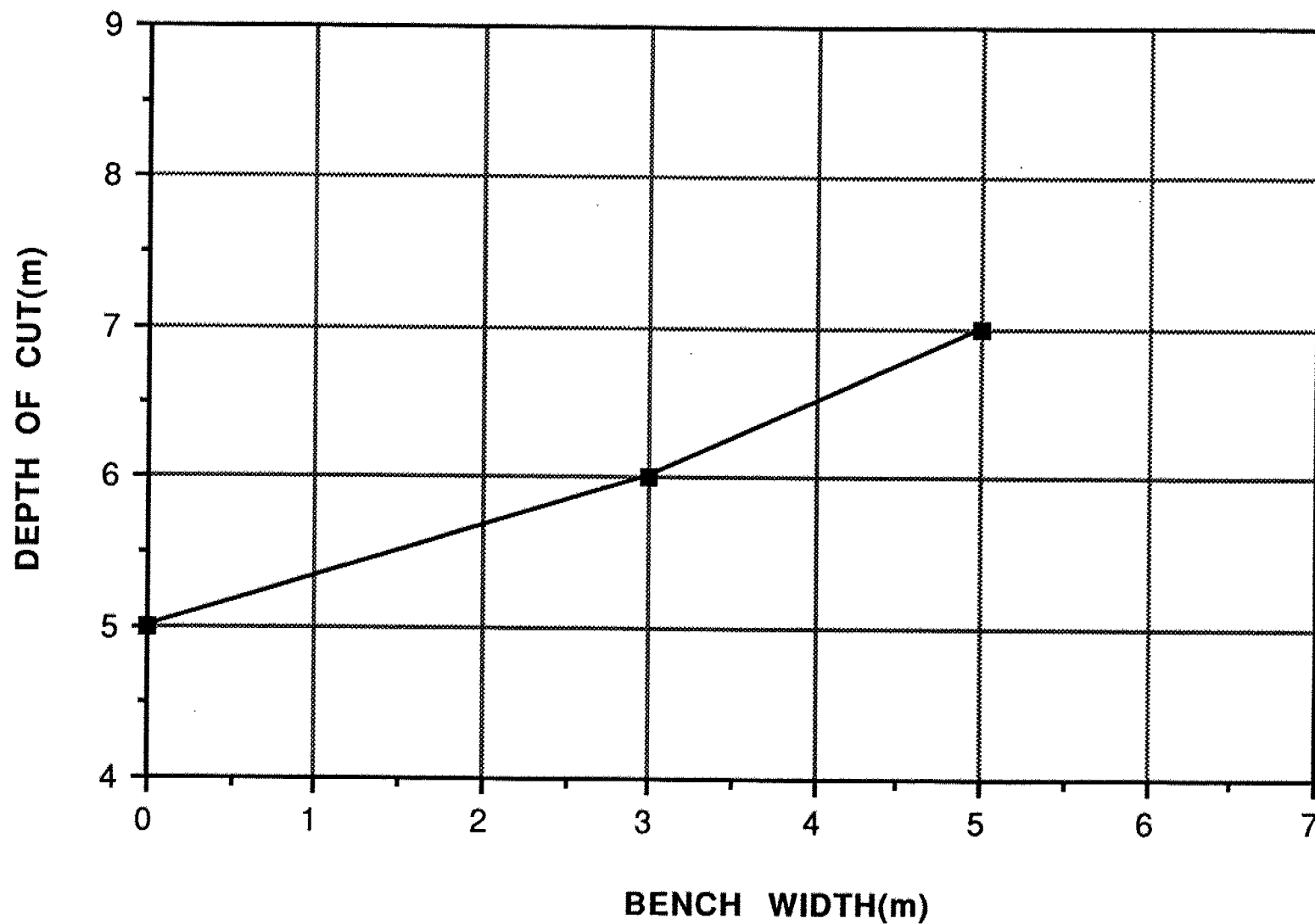


HWY 416 EXCAVATION CUT
 SLOPE TREATMENT

FIG. 6 - RICHMOND RD APPROACH



**FIG.7 - HIGHWAY 416 EXCAVATION CUT
SLOPE TREATMENT**



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 / 0.3 m)	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 (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	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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	KN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	KN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	KN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	KN/m^3	UNIT WEIGHT OF DRY SOIL	i_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	KN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	KN/m^2	SEEPAGE FORCE
γ'	KN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

ROCK CORE DESCRIPTION
WP 127-87-01

1../2

CORE RECOVERY					CORE DESCRIPTION	
BH #	RC #	DEPTH (m)	CR* (%)	RQD* (%)	DEPTH (m)	DESCRIPTION
8-2	6	5.79-7.77	100	89	5.79-7.77	SANDSTONE, light grey with thin, dark grey argillaceous bands, calcareous; medium grained; strong rock; unweathered; close to moderately close spaced fractures: horizontal, rough, clean.
8-3	7	5.18-6.78	100	93	5.18-6.78	SANDSTONE with interbedded DOLOSTONE, light grey to medium grey, fine to medium grained, argillaceous bands; strong rock; unweathered; close to moderately close spaced fractures: horizontal, rough, clean.
8-4	8	7.62-9.35	100	95	7.62-9.35	SANDSTONE with interbedded DOLOSTONE, light grey to medium grey, fine to medium grained, argillaceous bands; strong rock; unweathered; close to moderately close spaced fractures: horizontal, rough, clean.
8-5	5	4.14-5.79	98	37	4.14-5.79	SANDSTONE, light grey with minor argillaceous banding; medium grained; strong rock; unweathered; close spaced fractures: (i) horizontal, rough, clean; (ii) vertical, planar, minor calcite. Very close spaced fractures from 4.29-4.45m.

*CR = CORE RECOVERY (NOTE: Depths are approximated in zones of poor core recovery.)

*RQD = ROCK QUALITY DESIGNATION

Logged by: SAS, Soils and Aggregates Section.

ROCK CORE DESCRIPTION
WP 127-87-01

2../2

CORE RECOVERY					CORE DESCRIPTION	
BH - RC # #	DEPTH (m)	CR* (%)	RQD* (%)	DEPTH (m)	DESCRIPTION	
8-6 6	7.26-8.86	100	100	7.26-8.86	SANDSTONE, light grey with minor argillaceous banding; medium grained; strong rock; unweathered; moderately close spaced fractures: horizontal, rough, clean.	
8-7 6	3.96-5.51	100	96	3.96-5.51	SANDSTONE, light grey with minor argillaceous banding; medium grained; strong rock; unweathered; moderately close to close spaced fractures: horizontal, rough, clean.	
8-8 5	5.49-6.96	100	78	5.49-6.96	SANDSTONE, light grey with minor argillaceous banding; medium grained; strong rock; unweathered; very close to close spaced fractures: horizontal, rough, clean.	

*CR = CORE RECOVERY (NOTE: Depths are approximated in zones of poor core recovery.)

*RQD = ROCK QUALITY DESIGNATION

Logged by: SAS, Soils and Aggregates Section.



RECORD OF BOREHOLE No 8-1

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 789.5; E 358 720.0 ORIGINATED BY TK
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BW Casing, BXL Rock Core & Cone Test COMPILED BY AL
DATUM Geodetic DATE 89 04 05 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Wl	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
74.8	Ground Surface												
0.0	Clayey Silt (Fill)		1	SS	1		74						
73.4	Brown Grey		2	TW	PH		73						
1.4	Silty Clay to Clayey Silt Some Sand Firm		3	SS	5		72						
70.8	Het. Mixture of Silt, Sand & Gravel Compact to Very Dense (Glacial Till)		4	SS	23		71						
4.0			5	SS	9 / 12 cm		70						
68.5	Sandstone Bedrock Sound		6	BXL RC	100% Rec		69						
6.3							68						
66.9							67						
7.9	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 8-2

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 834.9; E 358 702.5 ORIGINATED BY JW
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BW Casing, BXL Rock Core & Cone Test COMPILED BY JW
DATUM Geodetic DATE 89 07 31 to 89 08 01 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100			W _p	W	W _L
								SHEAR STRENGTH kPa							WATER CONTENT (%)		
74.5	Ground Surface																
0.0	Silty Clay to Clayey Silt	Brown Grey	1	SS	10												
	Some Sand, Occ. Sand Seams		2	TW	PH												
	Firm to V. Stiff		3	SS	2												
70.2						Seal											
4.3	Het. Mixture of Silt Sand & Gravel (Glacial Till) Compact to V. Dense		4	SS	27	Piezometer											
						Seal											
68.7			5	SS	86												
5.8	Bedrock																
	Sandstone		6	BXL RC	REC 100%	Seal											
	Sound, Unweathered					Piezometer											
66.7						Seal											
7.8	End of Borehole					Seal											

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 8-3

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 755.1; E 358 704.0 ORIGINATED BY AL
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BW Casing, BXL Rock Core & Cone Test COMPILED BY AL
DATUM Geodetic DATE 89 08 01 CHECKED BY _____

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
75.4	Ground Surface										
0.0	Silty Clay to Clayey Silt Brown Grey Some Sand, Occ. Sand Seams Stiff to Very Stiff		1	SS	6		75			19.3	0 6 50 44
			2	TW	PH		74				
72.5							73				
2.9	Het. Mixture of Silt, Sand & Gravel (Glacial Till) Loose		3	SS	4		72				
			4	SS	7		71				
			5	SS	4		70				
70.2							69				
5.2	Bedrock Sandstone Sound, Unweathered		7	BXL RC	REC 100%			120/23cm			RQD = 93%
68.6											
6.8	End of Borehole										



RECORD OF BOREHOLE No 8-4

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 794.8; E 358 683.0 ORIGINATED BY AL
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BW Casing, BXL Rock Core & Cone Test COMPILED BY AL
DATUM Geodetic DATE 89 07 31 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA S ₁ CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
76.6	Ground Surface										
0.0	Clayey Silt, Some Sand (Fill) Grey, Very Stiff		1	SS	5		76			20.3	
74.1			2	SS	6		75				
2.5	Silty Clay to Clayey Silt Some Sand, Occ. Sand Seams Grey, Stiff to Very Stiff		3	SS	2		74				
71.4			4	TW	PH		73				
5.2	Het. Mixture of Silt, Sand & Gravel (Glacial Till) Compact		5	SS	1		72				
69.0			6	SS	10		71				
7.6	Bedrock Sandstone Sound, Unweathered		7	SS	*		70				
67.3			8	BXL RC	REC 100%		69	102/25cm			RQD = 95%
9.3	End of Borehole * Sampler Bouncing						68				



RECORD OF BOREHOLE No 8-5

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 721.9; E 358 693.6 ORIGINATED BY TS
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BW Casing, BXL Rock Core & Cone Test COMPILED BY TS
DATUM Geodetic DATE 89 08 01 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Wl	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
74.8	Ground Surface												
74.5	Topsoil												
0.3													
	Silty Clay to Clayey Silt		1	SS	8								
	Occ. Sand Seams		2	SS	2								
	Grey, Firm												
71.8													
3.0	Het. Mixture of Silt, Sand & Gravel (Glacial Till)		3	SS	2								12 41 38 9
70.7			4	SS	61/								
4.1	Bedrock Sandstone Sound, Unweathered		5	BXL REC RC 100%		18cm							RQD = 37%
69.0													
5.8	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 8-6

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 770.7; E 358 669.6 ORIGINATED BY JW
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BW Casing, BXL Rock Core & Cone Test COMPILED BY JW
DATUM Geodetic DATE 89 08 01 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
76.3	Ground Surface													
0.0	Silty Clay to Clayey Silt		1	SS	9									
	Brown Grey		2	TW	PH									
	Some Sand, Occ. Sand Seams		3	SS	1									
	Stiff to Very Stiff		4	TW	PH									
70.2	Het. Mixture of Silt, Sand and Gravel		5	SS	43									
6.1	(Glacial Till) Dense													
69.0	Bedrock		6	BXL RC	REC 100%									
7.3	Sandstone Sound, Unweathered													RQD = 100%
67.4	End of Borehole													
8.9														

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 8-7

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 672.0; E 358 682.0 ORIGINATED BY AL
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BW Casing, BXL Rock Core & Cone Test COMPILED BY TS
DATUM Geodetic DATE 89 08 02 CHECKED BY _____

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
77.0 0.0	Ground Surface													
	Silty Clay to Clayey Silt Some Sand Brown Grey		1	SS	11		76						17.2	2 36 38 24
75.0 2.0	Occ. Sand Seams Grey Very Stiff		2	TW	PH		75							
	Het. Mixture of Silt, Sand & Gravel (Glacial Till) Compact to Dense		3	SS	28		74							17 40 33 10
			4	SS	41									
73.0 4.0			5	SS	*		73							
	Bedrock Sandstone Sound, Unweathered		6	BXL RC	REC 100%		72							RQD = 96%
71.5 5.5	End of Borehole *Sampler Bouncing													



RECORD OF BOREHOLE No 8-8

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 728.0; E 358 642.0 ORIGINATED BY JW
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BW Casing, BXL Rock Core & Cone Test COMPILED BY JW
DATUM Geodetic DATE 89 08 01-02 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
75.2	Ground Surface												
74.9	Topsoil						75						
0.3							74						
	Brown Grey		1	SS	6								
	Silty Clay to Clayey Silt		2	TW	PH								
	Some Sand Occ. Sand Seams		3	SS	1								
	Firm to Stiff												
70.5			4	TW	PH								
4.7	Het. Mixture of Silt, Sand & Gravel (Glacial Till)												3 25 40 32
69.7													
5.5	Bedrock Sandstone		5	BXL RC	REC 100%								
	Sound, Unweathered												RQD = 78%
68.2													
7.0	End of Borehole												

RECORD OF BOREHOLE No 8-9

METRIC

W P 127-87-01

LOCATION Co-ords: N 5 021 605.0; E 358 680.0

ORIGINATED BY AL

DIST 9 HWY 416

BOREHOLE TYPE H.S. Auger & Cone Test

COMPILED BY TS

DATUM Geodetic

DATE 89 08 02

CHECKED BY _____

[illegible]

+3, x5 : Numbers refer to Sensitivity

15 ϕ 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 89-3

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 646.0; E 358 779.0 ORIGINATED BY SH
 DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger & Cone Test COMPILED BY AL
 DATUM Geodetic DATE 89 04 05 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
77.5	Ground Surface										
0.0											
	Silty Clay to Clayey Silt Soft to Very Stiff	Brown Grey									
75.4	Het. Mixture of Silt, Sand & Gravel		1	SS	18						2 32 43 23
2.1											
74.8	(Glacial Till)		2	SS	62 / 20 cm						6 29 54 11
2.7	End of Borehole										
	Probable Bedrock or Boulders							80 / 18 cm Refusal			

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 89-4

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 690.0; E 358 758.0 ORIGINATED BY SH
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BW Casing, BXL Core & Cone Test COMPILED BY AL
DATUM Geodetic DATE 89 04 05 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
76.8 0.0	Ground Surface										
74.8 2.0	Silty Clay to Brown Clayey Silt Grey Some Sand		1	TW	PH						0 23 38 39
73.2 3.6	Het. Mixture of Silt, Sand and Gravel (Glacial Till) Loose to Compact		2	SS	7						9 40 45 6
71.5 5.3	Sandstone Bedrock Sound		3	SS	23						RQD = 15%
			4	BXL RC	100% Rec						RQD = 79%
			5	BXL RC	93% Rec						
	End of Borehole										



RECORD OF BOREHOLE No 89-5

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 735.5; E 358 738.5 ORIGINATED BY SH
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger & Cone Test COMPILED BY JW
DATUM Geodetic DATE 89 04 06 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
74.0 0.0	Ground Surface										
71.5 2.5	Silty Clay to Clayey Silt with Some Sand Het. Mixture of Silt, Sand and Gravel (Glacial Till)		1	SS	1						2 40 35 23
69.7 4.3	End of Borehole Probable Bedrock or Boulders		2	SS	2						16 31 44 9

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 89-6

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 834.5; E 358 693.5 ORIGINATED BY TK
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BW Casing, BXL Rock Core & Cone Test COMPILED BY AL
DATUM Geodetic DATE 89 04 05 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
74.4 0.0	Ground Surface										
		Brown Grey									
	Silty Clay to Clayey Silt Some Sand Firm		1	SS	6						0 7 49 44 0 15 65 20
			2	SS	4						0 8 48 44
70.1 4.3	Het. Mixture of Silt, Sand and Gravel (Glacial Till)		3	SS	52						22 35 35 8
68.4 6.0	Very Dense Sandstone Bedrock Sound		4	BXL RC	98% Rec						RQD = 75%
67.4 7.0	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 880.0; E 358 675.0 ORIGINATED BY SH
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger & Cone Test COMPILED BY JW
DATUM Geodetic DATE 89 04 06 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					
72.9 0.0	Ground Surface												
	<div><div><div>Brown Grey</div></div><div>Silty Clay to Clayey Silt with Some Sand Soft to Stiff</div></div>	<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div>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+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 89-8

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 786.5; E 358 628.0 ORIGINATED BY TK
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, Bw Casing, BXL Rock Core & Cone Test COMPILED BY JW
DATUM Geodetic DATE 89 04 06 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
76.8	Ground Surface													
0.0														
	Brown Grey		1	SS	6									0 15 46 39
	Silty Clay to Clayey Silt Some Sand Very Soft to Firm		2	SS	0									0 6 55 39
			3	SS	0									1 24 38 37
71.2														
5.6	Het. Mixture of Silt, Sand and Gravel (Glacial Till) Compact		4	SS	18									17 32 41 10
69.9														
6.9	Sandstone Bedrock Sound		5	BXL RC	100% Rec									RQD = 100%
68.9														
7.9	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION



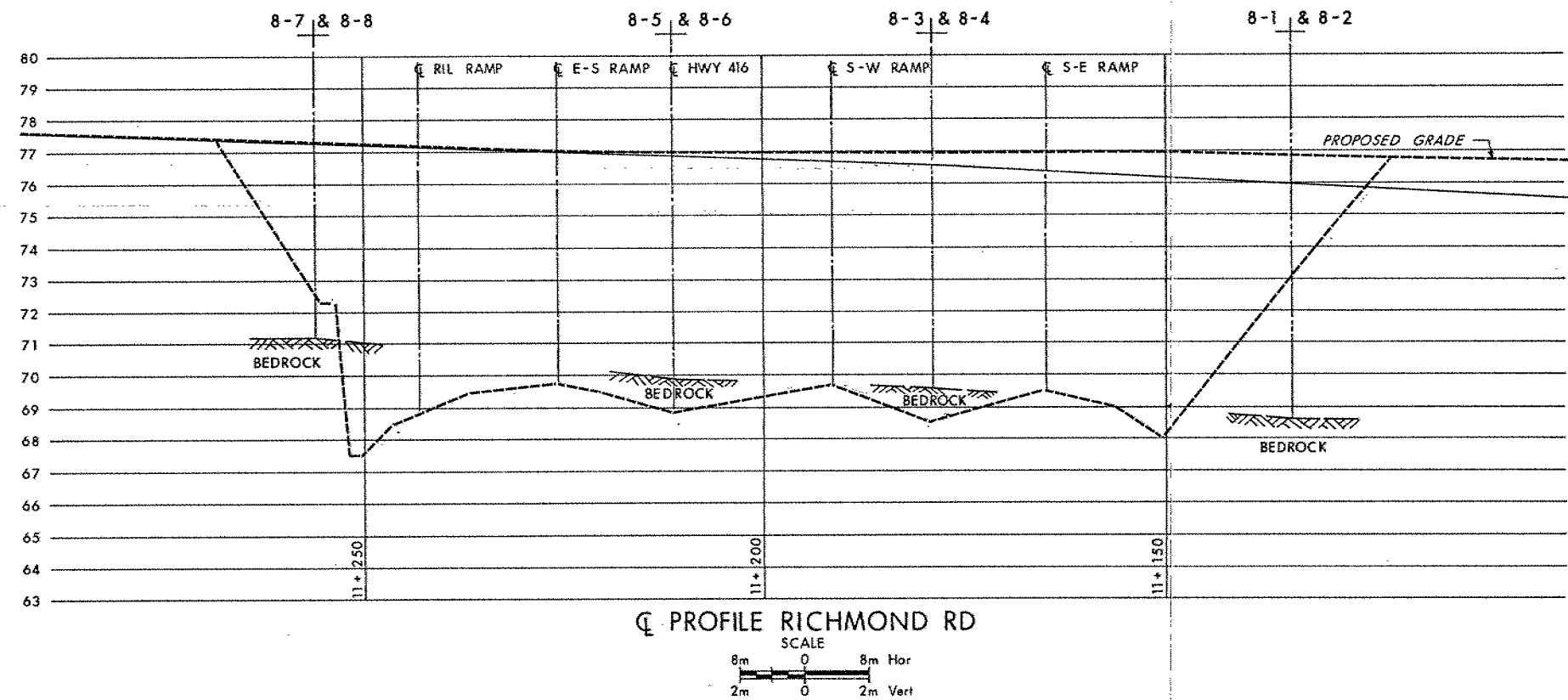
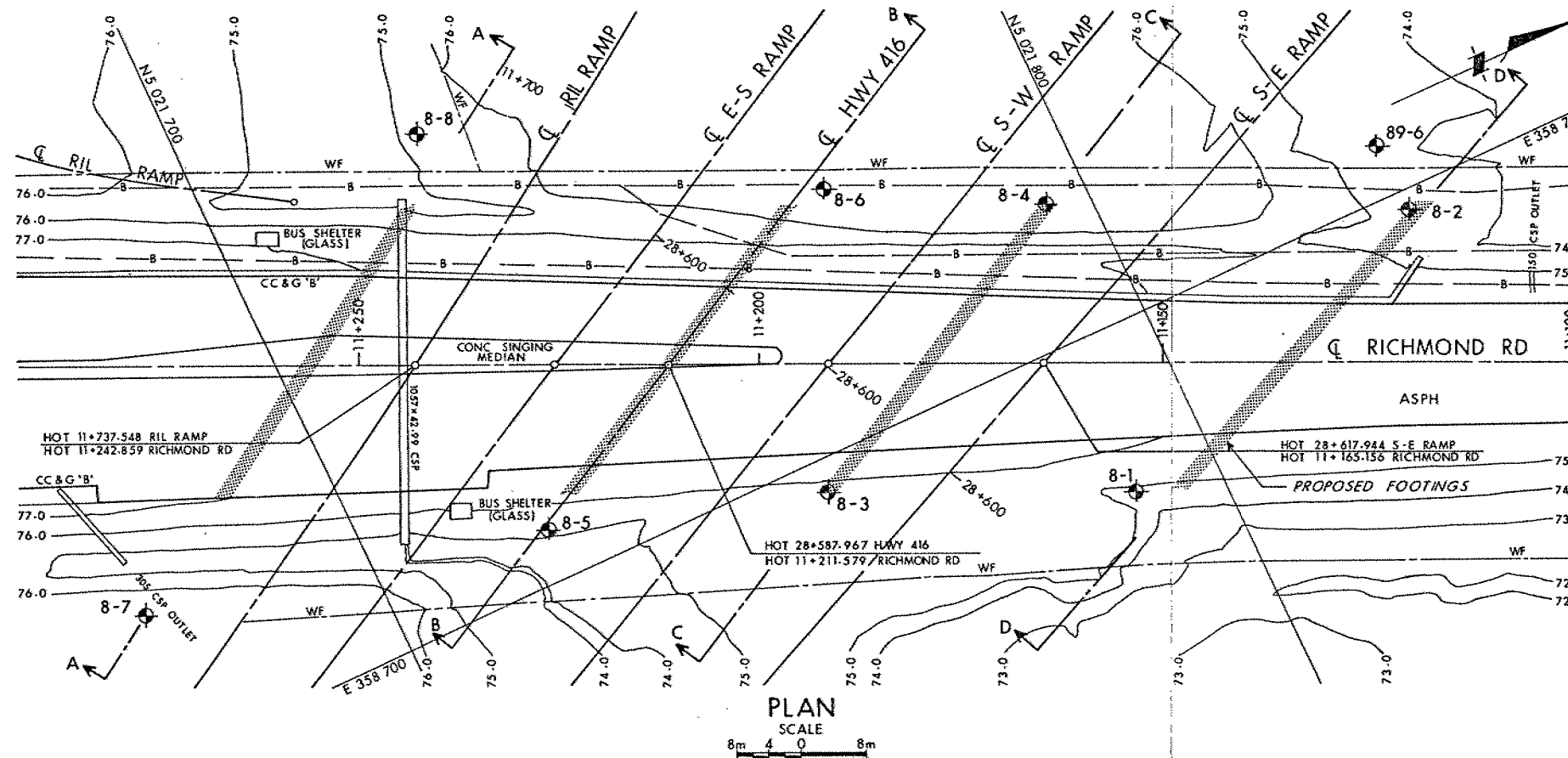
RECORD OF BOREHOLE No 89-9

METRIC

W P 127-87-01 LOCATION Co-ords: N 5 021 830.0; E 358 602.0 ORIGINATED BY TK
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger & Cone Test COMPILED BY AL
DATUM Geodetic DATE 89 04 06 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
74.3 0.0	Ground Surface										
	<div><div>Brown</div><div>Grey</div></div> <div>Silty Clay to Clayey Silt Some Sand Soft to Firm</div>		1	SS	6		74				0 9 43 48
							73				
							72				
70.6 3.7	Het. Mixture of Silt, Sand & Gravel (Glacial Till)		2	SS	2		71				8 28 35 29 0 30 40 30
70.2 4.1	End of Borehole										
	Probable Bedrock or Boulders							Refusal			

OFFICE REPORT ON SOIL EXPLORATION

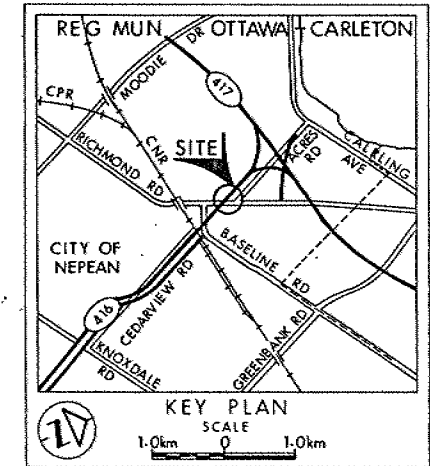


NOTE:
For Sections Refer to Dwg No 1278701-B

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

CONT No
WP No 127-87-01
RICHMOND RD UNDERPASS
(STRUCTURE-8)
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



- 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
89 04, 89 07 and 89 08
 - W.L. in Piezometer
 - Piezometer

No	ELEVATION	CO-ORDINATES NORTH	EAST
8-1	74.8	5 021 789.5	358 720.0
8-2	74.5	5 021 834.9	358 702.5
8-3	75.4	5 021 755.1	358 704.0
8-4	76.6	5 021 794.8	358 683.0
8-5	74.8	5 021 721.9	358 693.6
8-6	76.3	5 021 770.7	358 669.6
8-7	77.0	5 021 672.0	358 682.0
8-8	75.2	5 021 728.0	358 642.0
8-9	77.4	5 021 605.0	358 680.0
89-3	77.5	5 021 646.0	358 779.0
89-4	76.8	5 021 690.0	358 758.0
89-5	74.0	5 021 735.5	358 738.5
89-6	74.4	5 021 834.5	358 693.5
89-7	72.9	5 021 880.0	358 675.0
89-8	76.8	5 021 786.5	358 628.0
89-9	74.3	5 021 830.0	358 602.0

* BH'S ADVANCED IN
CONJUNCTION WITH HWY 416
APPROACH EXCAVATION
(NOT SHOWN ON PLAN)
FOR SUBSOIL INFORMATION
REFER TO RECORD OF
BOREHOLE SHEETS

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

Geocres No 31G5-168

HWY No 416	DIST 9
SUBMD TS CHECKED DATE 89 10 18	SITE 3-542
DRAWN DT CHECKED DT APPROVED	DWG 1278701-A

METRIC

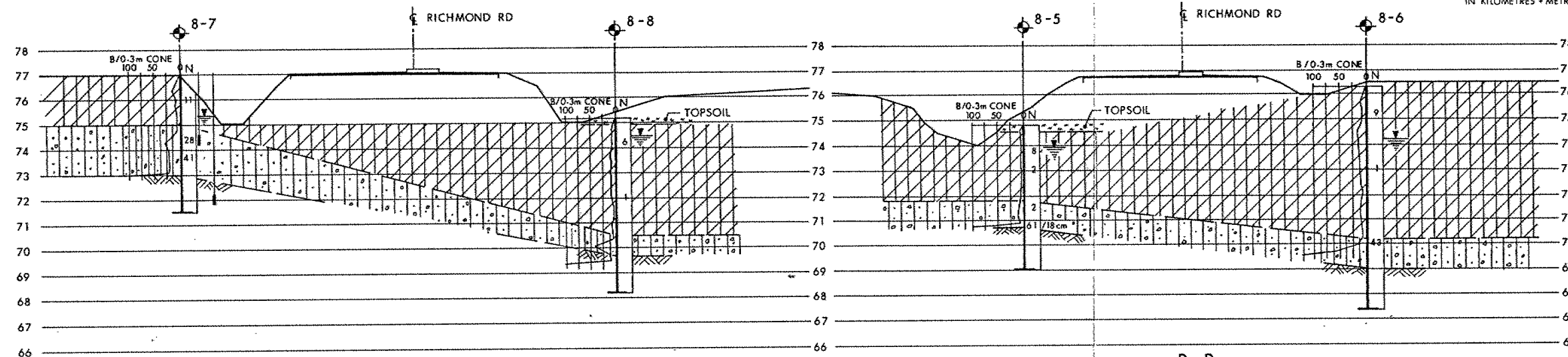
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 127-87-01

RICHMOND RD UNDERPASS
(STRUCTURE -8)

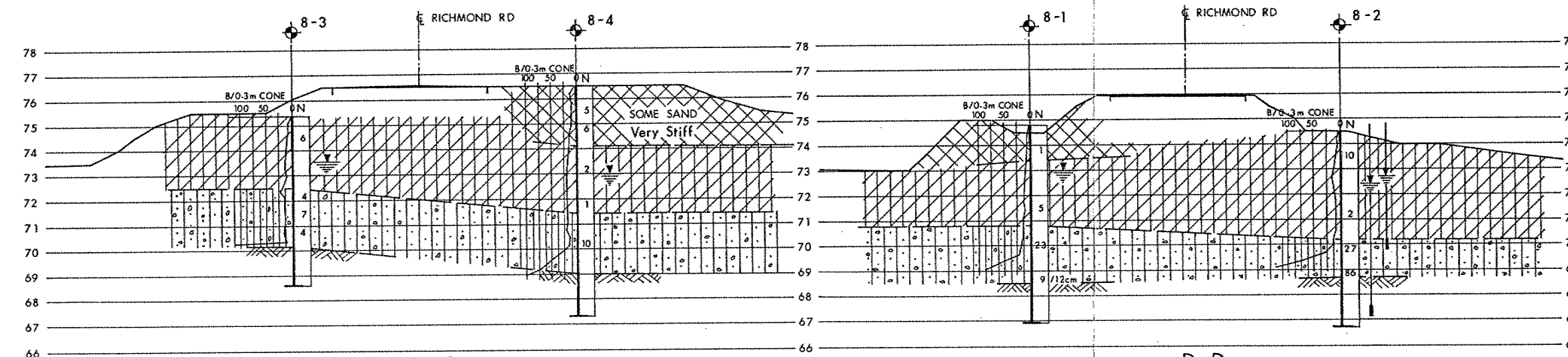
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



A-A

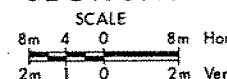
B-B



C-C

D-D

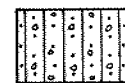
SECTIONS



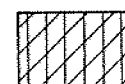
SOIL STRATIGRAPHY LEGEND



CLAYEY SILT
(FILL)



HETEROGENEOUS MIXTURE OF
SILT, SAND & GRAVEL
Loose to Very Dense
(GLACIAL TILL)



SILTY CLAY TO CLAYEY SILT
SOME SAND, OCCASIONAL SAND SEAMS
Firm to Very Stiff



SANDSTONE BEDROCK
Sound, Unweathered

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
89 04, 89 07 and 89 08
- W L in Piezometer
- Piezometer

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8-2	74.5	5 021 834.9	358 702.5
8-3	75.4	5 021 755.1	358 704.0
8-4	76.6	5 021 794.8	358 683.0
8-5	74.8	5 021 721.9	358 693.6
8-6	76.3	5 021 770.7	358 669.6
8-7	77.0	5 021 672.0	358 682.0
8-8	75.2	5 021 728.0	358 642.0

NOTE

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

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NOTE:

For Plan and Profile
Refer to Dwg No 1278701-A

DATE	BY	DESCRIPTION
89 05 16	31G5-168	
HWY No 416	DIST 9	
SUBMD TS	CHECKED	DATE 89 10 19
DRAWN DT	CHECKED	APPROVED
		SITE 3-542
		DWG 1278701-B

[illegible]