

GEOCRES No. 30M4-72

DIST. 4 REGION

W.P. No. 846-71-00

CONT. No.

W. O. No.

STR. SITE No. N/A

HWY. No. 54

LOCATION HWY 54 FROM EAST LIMITS OF

TOWN OF CALEDONIA TO VILLAGE OF YORK

No of PAGES - 1

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 846-71-00 DIST 4
HWY 54 STR SITE N/A

Gabion Retaining Wall
Station 19+585 to 19+800
Hwy 54 at Sims Locks Drive

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FOUNDATION INVESTIGATION REPORT

FOR

Gabion Retaining Wall

Station 19 +585 to 19 +800

Hwy. 54 at Sims Locks Drive

W.P. 846-71-00, Site N/A

District 4, Burlington

INTRODUCTION

This report summarizes the results of a foundation investigation conducted in conjunction with a proposed gabion retaining wall along Hwy.54 just south of Caledonia. The retaining wall is a component of the planned widening of the west side of Hwy. 54 and resurfacing the highway between the towns of Caledonia and York. A gabion wall approximately 2.5 m in height has been proposed.

SITE DESCRIPTION AND GEOLOGY

The site is located along Hwy. 54 spanning a distance of approximately 200 metres north of Abbey Road. The site is situated in the Town of Haldimand located between the Towns of Caledonia and York within the Regional Municipality of Haldimand-Norfolk.

The topography at the site is sloping westwardly with Hwy. 54 "benched" within the slope.

Hwy. 54 is situated on embankment fill approximately 3 to 4 metres in height and a drainage ditch exists at the toe of the embankment fill slope. The drainage ditch was dry at the time of the investigation and the slopes were generally at 2H:1V. The slopes and drainage ditch is covered with tall grass and short shrubs. Concrete culverts are also present within the proposed retaining wall area as part of the drainage system in the general area. The two lane asphaltic highway shows no signs of instability or settlement. The area adjacent to the site is primarily residential and agricultural farmland.

Physiographically, the site is located within the geological domain known as the Haldimand Clay Plain lying between the Niagara Escarpment and Lake Erie. The Haldimand Clay Plain is the product of glacial Lake Warren that existed subsequent to the Wisconsin glacier that covered the area approximately 12,000 years ago. The overburden, which is generally less than seven(7) metres at the site location consists primarily of silty clays underlain by deposits consisting of unsorted, unstratified mixtures of silt, sand and gravels of glacial till origin. The overburden is underlain by shale bedrock with interbedded dolostone of the Salina Formation.

The Haldimand Clay Plain also contains many wet sloughs which is an indication of poor drainage. In general, drainage is controlled by modest ridges formed by moraines deposited under water. Drainage occurs in an eastward direction in several parallel streams including Twenty Mile Creek, Forty Mile Creek and the Welland River.

INVESTIGATION PROCEDURES

General

Soil and rock data and inherent properties were obtained by conducting both an in situ field investigation and laboratory analyses. Details of the field investigation and laboratory testing program are discussed below.

Field Investigation

The fieldwork for this project was conducted on 93 08 05 and 93 08 06 and consisted of a total of five(5) sampled boreholes. The boreholes were advanced to depths ranging from 5.0 to 9.6 m using a conventional track mounted Central Mining Equipment (CME) 55 drilling unit. Solid stem auguring techniques were used to penetrate the overburden at the site.

Disturbed subsoil samples were retrieved in the overburden using a 50 mm diameter split spoon sampler driven in accordance with the Standard Penetration test (SPT - ASTM D1586). The samples were generally retrieved at 0.76 m intervals.

In situ vane tests were also conducted in the cohesive soil in accordance with ASTM D2573. The test was carried out using a Standard MTO 'N' vane.

All subsoil samples were identified in the field and then properly sealed in plastic

containers to preserve natural moisture contents in the soil. The samples were then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests were conducted as described in the next section below.

Bedrock underlying the overburden was cored for depths ranging from 1.8 to 2.2 m at two boreholes using conventional rock coring techniques. A NXL core barrel within NW casing was used in the coring process. Bedrock was also augured and sampled using a split spoon sampler at BH 3.

Rock core samples were identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and rock core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory.

Groundwater levels were determined by monitoring the water levels in the open boreholes throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevation of the individual boreholes was provided by Central Region Surveys and Plans.

Laboratory Analysis

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil Classification Manual. The behaviour, gradation, natural moisture contents and unit weights were determined by conducting the appropriate laboratory tests on representative samples. Sample preparation and testing were conducted in accordance with the MTO Laboratory Testing Manual.

Detailed rock core logging was conducted in the laboratory by an in-house resident geologist. The core logging included descriptions of colour, grain size, bedding, jointing and strength.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions" and are illustrated on the corresponding boreholes and figures included in the Appendix to this report.

SUBSURFACE CONDITIONS

General

The subsurface conditions at the site are generally uniform and consists of some fill material comprised of an irregular mixture of silty clay, sand and gravel of thickness ranging from 2.3 m to 3.4 m underlain by a native silty clay material of thickness ranging from 0.8 m to 3.3 m. The native silty clay material is in turn underlain by a cohesionless

heterogeneous mixture of gravel, sand and silt of glacial till origin. The thickness of this deposit ranges from 0.8 m to 2.0 m. The overburden at the site is underlain by bedrock comprised of shale with interbedded dolostone.

A plan of the site illustrating the locations and elevations of the boreholes and the proposed retaining wall structure location is shown on Dwg. No. 8467100-A in the Appendix. A stratigraphical section along the proposed retaining wall is also shown. The boundaries between the various soil types, in situ and laboratory test result as well as groundwater levels established at the time of investigation are shown on the stratigraphical section and also on the individual Record of Borehole sheets in the Appendix. A detailed description of the subsurface conditions are given below.

SOIL/ ROCK DESCRIPTIONS

Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material)

An irregular mixture of silty clay, sand and gravel comprises the fill material used in the construction of Hwy. 54 at the site. The thickness of the fill material ranges from 2.3 m to 3.4 m. The fill material is generally brown in colour for the surficial 1.5 metres or so and grey in colour beneath this depth. Traces of organics are also present within the fill material.

Figure 1 in the Appendix illustrates a grain size distribution envelope of the fill material

produced by mechanical sieve and hydrometer analysis. As the envelope exhibits, traces of gravel and some sand is mixed with clay and silt fractions. The clay and silt fractions comprise greater than 70% of the material, and in accordance with the MTO soil classification system, is categorized according to its behaviour because the fine grained percentages exceed 50%. To determine the behaviour of the material Atterberg Limit tests were carried out on material less than $425\ \mu\text{m}$ and the results are plotted on Figure 2. As Figure 2 illustrates, liquid limits ($w_L\%$) range between 35% and 50% and the plasticity index ranges from 17% to 24%. These results are summarized in Table 1 below.

Table 1 - Atterberg Limit Test Results Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material)		
	<u>Range</u>	<u># of Tests</u>
Natural Moisture Content ($w\%$)	21-26	3
Liquid Limit ($w_L\%$)	35-50	3
Plastic Limit ($w_p\%$)	18-26	3
Plasticity Index ($I_p\%$)	17-24	3
Unit Weight (γ)(kN/m^3)	18.5-20	3

The test results reveal that the fine grained material has an intermediate plasticity and hence can be categorized as silty clay (CI). Natural moisture contents are generally

similar to the plastic limit of the soil. The unit weight of the fill material as tabulated in Table 1 ranges from 18.5 to 20 kN/m³.

The consistency of the soil was determined by interpretation of the 'N' values derived from the Standard Penetration Test and by the results of conducting in situ vane tests. Based on 'N' values ranging from 5 blows/0.3 m to 11 blow/0.3 m and the fact that vanes could not be torqued suggest a consistency ranging from firm to very stiff, but generally the soil is of stiff to very stiff consistency.

Silty Clay

The surficial native soil underlying the fill material at the site consists of a cohesive, brown silty clay of thickness ranging from 0.8 m to 3.3 m. The elevation of the surface of this stratum varies from 184.1 m to 185.4 m. Figure 3 in the Appendix illustrates the grain size distribution curves of this material as determined by mechanical sieve and hydrometer analysis. As is shown on the figure, the deposit is predominantly fine grained with most of the material finer than 75 micrometers. Clay fractions range from 48% to 58%. In accordance with the MTO Soil Classification system, materials with fine grained percentages exceeding 50% are categorized according to its behaviour as mentioned earlier and hence Atterberg Limit tests were conducted on representative samples. Atterberg Limit tests were carried out on material less than 425 μ m and the results are plotted on Figure 4 and summarized in Table 2 below. Natural moisture contents and unit weights have also been included in Table 2.

Table 2 - Atterberg Limit Test Results (Silty Clay)		
	<u>Range</u>	<u># of Tests</u>
Natural Moisture Content (w%)	29-32	4
Liquid Limit (w_L %)	42-42	2
Plastic Limit (w_p %)	21	2
Plasticity Index (I_p %)	21-22	2
Unit Weight (γ) (kN/m^3)	21.2-21.6	2

The test results clearly reveal that the soil has an intermediate plasticity and hence can be categorized as silty clay (CI). Natural moisture contents are generally between the plastic and liquid limits of the soil.

The consistency of the soil was determined by interpretation of the 'N' values derived from the Standard Penetration test and by the results of conducting in situ vane tests. Based on 'N' values ranging from 5 blows/ 0.3 m to 24 blows/ 0.3 m and the fact vanes could not be torqued suggesting an undrained shear strength in excess of 120 kPa, the soil can be described as having a stiff to very stiff consistency.

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

The native silty clay deposit is underlain by a glacial till deposit consisting of a heterogeneous mixture of gravel, sand and silt. The deposit is of relatively shallow thickness ranging from 0.8 m to 2.0 m in thickness. As characteristics of glacial till deposits, the deposit is unsorted, unstratified and non-uniform. Figure 5 illustrates the grain size distribution of samples retrieved in the deposit. As is shown in the figure, particle size distributions vary throughout the deposit and the deposit is broadly graded. Boulders and cobbles which are also characteristic components of glacial till deposits, although not encountered during the investigation, can also exist within the deposit.

The 'N' values as determined by the Standard Penetration test range from 16 blows/ 0.3 m to 100 blows/ 0.3 m indicating that the deposit has a denseness ranging from compact to very dense.

Bedrock

The heterogeneous mixture of gravel, sand and silt is underlain by bedrock founded at an elevation ranging from 182.6 m to 180.8 m or depths of 5.0 to 7.0 below the roadway surface. The bedrock consists of a light grey to dark grey shale with interbedded dolostone of the Salina Formation. The rock is moderately weathered and contains extremely close to very close spaced fractures and very thin horizontal beds. The shale is fine grained and very weak whereas the dolostone is fine to medium grained and is

medium strong. Detailed rock core descriptions are included in the Appendix to the report.

An assessment of the quality and strength of the rock was carried out by measuring core recovery and Rock Quality Designations (RQD's) in the field and conducting physical index property tests. RQD's were 0% indicating a very poor quality rock. This poor quality is indicative of the extent of the weathering of this inherent friable, low slaking durability rock.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water levels in the open boreholes. Groundwater levels ranged from 4.2 m to 5.3 m below the ground surface (Elevation 183.4 m to 183.1 m).

Groundwater levels in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

In conjunction with the future Hwy. 54 widening, a conventional gabion type retaining wall has been proposed between Stations 19+585 and 19+800 on the west side of the highway. A gabion wall approximately 2.5 to 3 metres high offset a distance of 6.5 m to 10.5 m from the centreline is planned. The widening will facilitate an additional lane and a shoulder.

The elevation grade of the existing highway will remain unchanged at approximate Elevation 187.9 to 187.7. The widened portion will therefore be of similar elevation. A slope is proposed beyond the retaining wall to the creek level which is at an elevation of approximately 185 m.

Foundation and geotechnical parameters to facilitate the design and construction of the proposed retaining wall are contained within the purview of this report.

DESIGN CONSIDERATIONS

General

The proposed design includes a gabion wall located within the slope. Although this scheme is viable from a geotechnical point of view and recommendations have been given specific to this proposal, relocating the gabion wall to the toe of the slope and backfilling is considered a more feasible alternative from both a geotechnical and construction perspective. Consequently, consideration should be given to relocating the

wall to the toe of the slope. Consideration should also be given to using slopes without a gabion wall if geometrics permit.

The retaining wall must be designed to satisfy ultimate and serviceability limit states as described in Section 6-9 of the O.H.B.D.C. The following geotechnical related criteria must be considered.

- 1) Foundation Bearing Capacity Failure
- 2) Foundation Sliding Failure
- 3) Overturning Failure
- 4) Overall Stability

The retaining wall design must safeguard against the above mentioned failures.

1) Foundations Bearing Capacity

Structure foundations can be founded on conventional spread footings at or below elevation 184.5 m within the native silty clay stratum. Bearing capacities of the material at the given elevations are provided in Table 3 below.

<u>Table 3 - Spread Footings on Native Silty Clay</u>	
Factored Capacity at U.L.S. (kPa)	300
Bearing Capacity at S.L.S. Type II (kPa)	200

The bearing capacities tabulated in Table 3 account for foundations positioned on the face of the slope with a minimum 0.5 m embedment of the lowest gabion course within the native slope. The bearing capacities are based on a 2H:1V slope or flatter.

At the serviceability limit states, settlements induced as a result of the applied pressures are expected to be within 25 mm magnitude. These deformations will be the result of the recompression of the native soil and hence should occur immediately during construction.

In view of the fact that horizontal pressures will be exerted against the retaining wall in addition to vertical pressures, the resultant pressure will be inclined. Bearing capacity reduction to account for inclination of loads acting on shallow foundations shall be carried out in accordance with Section 6-7.3.3.5 of the O.H.B.D.C. Bearing Capacities tabulated in Table 3 must therefore be modified accordingly.

All softened and/or organic material present at the footing founding elevation shall be removed and replaced with a granular material and/or mass concrete. In addition, to preserve the founding soil during construction, it is recommended that a granular or concrete working slab be placed in advance of the wall construction.

2) Sliding

Slope of Cut, Backfill and Drainage

The excavation cut geometry and backfill treatment behind the gabion retaining shall be in accordance with OPSD 3504.00. The 1H:6V slope shall be taken from the heel of the retaining wall.

Granular backfill consisting of Granular 'A' or Granular 'B' shall be used to facilitate drainage and prevent hydrostatic pressure build-up behind the retaining wall. In addition, no filter fabrics are needed because these granular materials are considered as adequate filter soils. The granular material shall be carefully placed and compacted using hand operated compaction equipment in accordance with OPSS 501 series.

Lateral Earth Pressure on Structure

In view of the angle of excavation cut behind the gabion wall, the native silty clay soil will govern the earth pressures behind the retaining wall. Design parameters of the soil are provided in Table 4 below. Earth pressures shall be computed in accordance with Section 6-6.1 of the O.H.B.D.C. The earth pressure calculation shall account for any sloping surface, fill material overlying the native soil, wall batter and surcharge loading. Buoyant unit weights are to be used for any soil submerged below the groundwater table.

<u>Table 4 - Earth Pressure Computation Parameters</u>		
<u>Soil</u>	<u>Angle of Internal Friction (ϕ)°(unfactored)</u>	<u>Unit Weight (γ) (kN/ m³)</u>
Fill Material	30	20
Silty Clay	30	19
Het. Mix. of Gravel, Sand and Silt (Glacial Till)	30	20

For flexible walls, the coefficient of active earth pressure shall be applied. Rankine's theory of earth pressure can be used in the computation of earth pressure coefficients. Soil strength parameters shall be factored in accordance with the O.H.B.D.C.

Angle of Friction Between Base and Soil

In the computation of the sliding resistance of the foundation, an unfactored friction angle of 30° can be used between the gabion footing and the native silty clay soil. Additional sliding resistance, if required can be achieved by supporting the gabion wall on a compacted Granular 'A' pad. An unfactored friction angle of 35° can be used between the gabion footing and a minimum 0.5 m thick Granular 'A' pad. The Granular 'A' pad shall be placed and compacted in accordance with OPSS 501 series.

3) Overturning

Overturning failure involves rotation of the wall about its toe. Earth pressures to be used in the analysis can be computed employing the soil parameters given in Table 4 and the drainage conditions described above. The gabion wall footing width shall be of sufficient width to prevent overturning. Overturning stability can also be improved by tilting the wall slightly inward at an angle of 1 horizontal to 10 vertical (at 6 degrees).

4) Overall Stability

In view of the stiff to very stiff consistency of the irregular mixture of silty clay, sand and gravel (Fill Material) and the silty clay material and the competent underlying glacial till deposit and bedrock, there are no long term deep seated overall stability problems anticipated for the proposed gabion type retaining wall provided that (1) the slope beyond the gabion wall is 2H:1V or flatter, (2) Scour protection is provided for the slope. It is recommended that 300 mm thick rip rap be placed on the slope up to 0.5 metres above the highest water level. (3) Surface runoff from the highway be effectively drained and controlled by a drainage ditch on the east side of Hwy. 54. This will prevent seepage pressures within the embankment.

Hwy. 54 Steeper Slope Alternative

This office has reviewed the proposal to construct steeper 1.5H:1V slopes as a cost effective alternative to the originally proposed retaining wall. Although, there is no deep seated problems anticipated for a steeper 1.5H:1V earth or rock slope at the site, it is recommended that to ensure the surficial stability of the slopes, earth slopes should be constructed at 2H:1V. Rock fill slopes using material defined in OPSS 1004-08-06 can, however, be constructed at 1.5H:1V.

CONSTRUCTION CONSIDERATIONS

1) Construction Sequence Scheme

To avoid an expensive temporary scheme that would be required to maintain traffic on Hwy. 54 during construction, it is recommended that the construction of the gabion wall be coordinated such that the modular gabion baskets are installed in six(6) metre maximum strips. A NSSP shall be included in the contract documents to define this restriction. Transverse temporary slopes to facilitate this installation shall be sufficiently adequate to enable the granular backfill placement behind the wall. Longitudinal temporary slopes shall not be steeper than 1H:1V. All temporary slopes shall be protected against surface water using polyethylene, tarpaulins or equivalent.

Dewatering

No dewatering problems are anticipated during the excavation and construction of the gabion retaining wall in view of the impervious nature of the fill material and the silty clay material. Conventional sump pump techniques will suffice in discharging any surface runoff or localized seepage from the excavation.

MISCELLANEOUS

The fieldwork for this investigation was carried out by N. Mullen, Student Engineer, under the supervision of T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Malone's Soil Samples.

The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by M. Devata, Chief Foundation Engineer.



A handwritten signature in black ink, appearing to read "T. Sangiuliano".

T. Sangiuliano, P.Eng.

Foundation Engineer

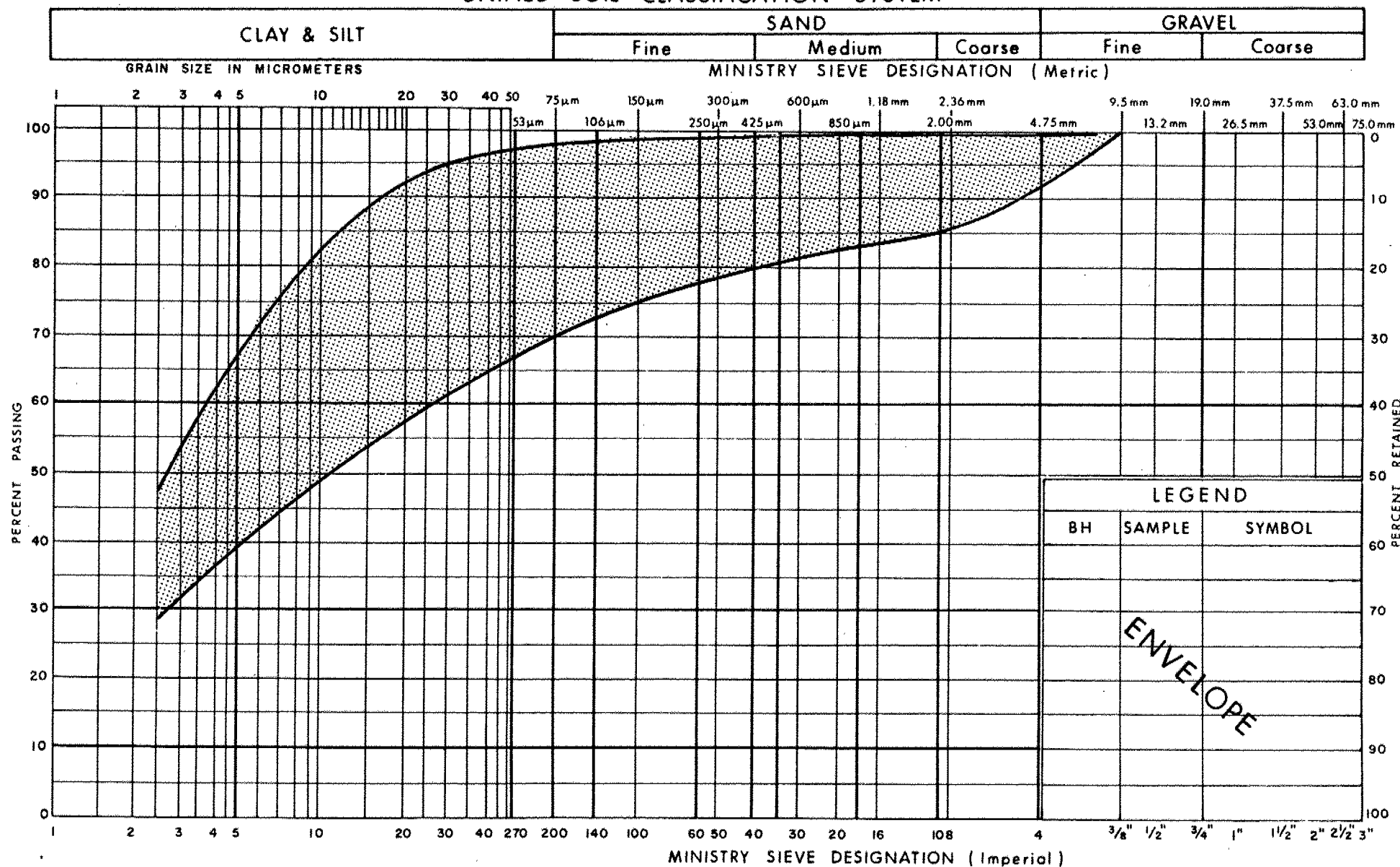
A handwritten signature in black ink, appearing to read "M. Devata".

M. Devata, P.Eng.

Chief Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

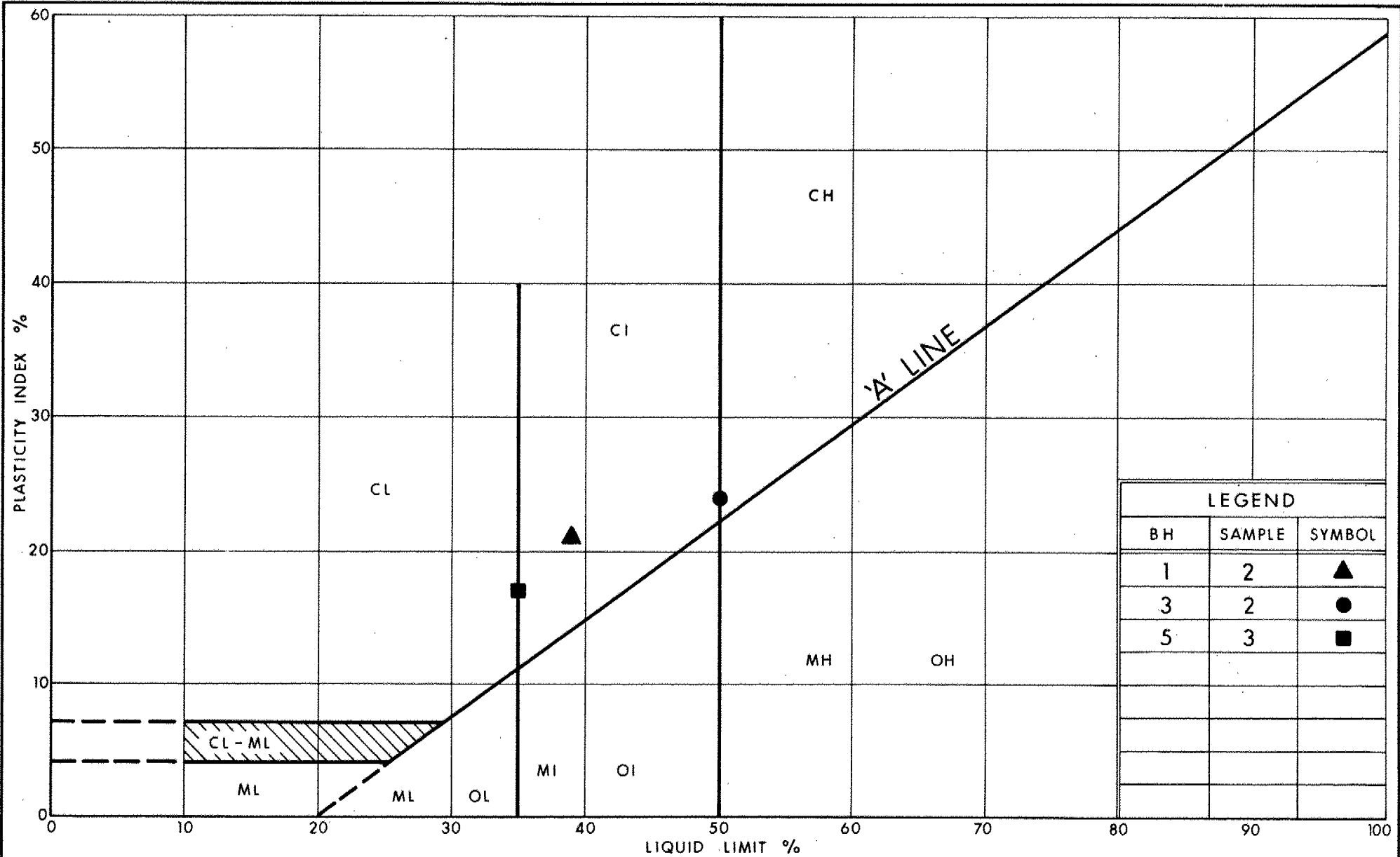


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GRAIN SIZE DISTRIBUTION
IRREGULAR MIXTURE OF
SILTY CLAY, SAND & GRAVEL (FILL MATERIAL)

FIG No 1

W P 846-71-00



LEGEND		
BH	SAMPLE	SYMBOL
1	2	▲
3	2	●
5	3	■



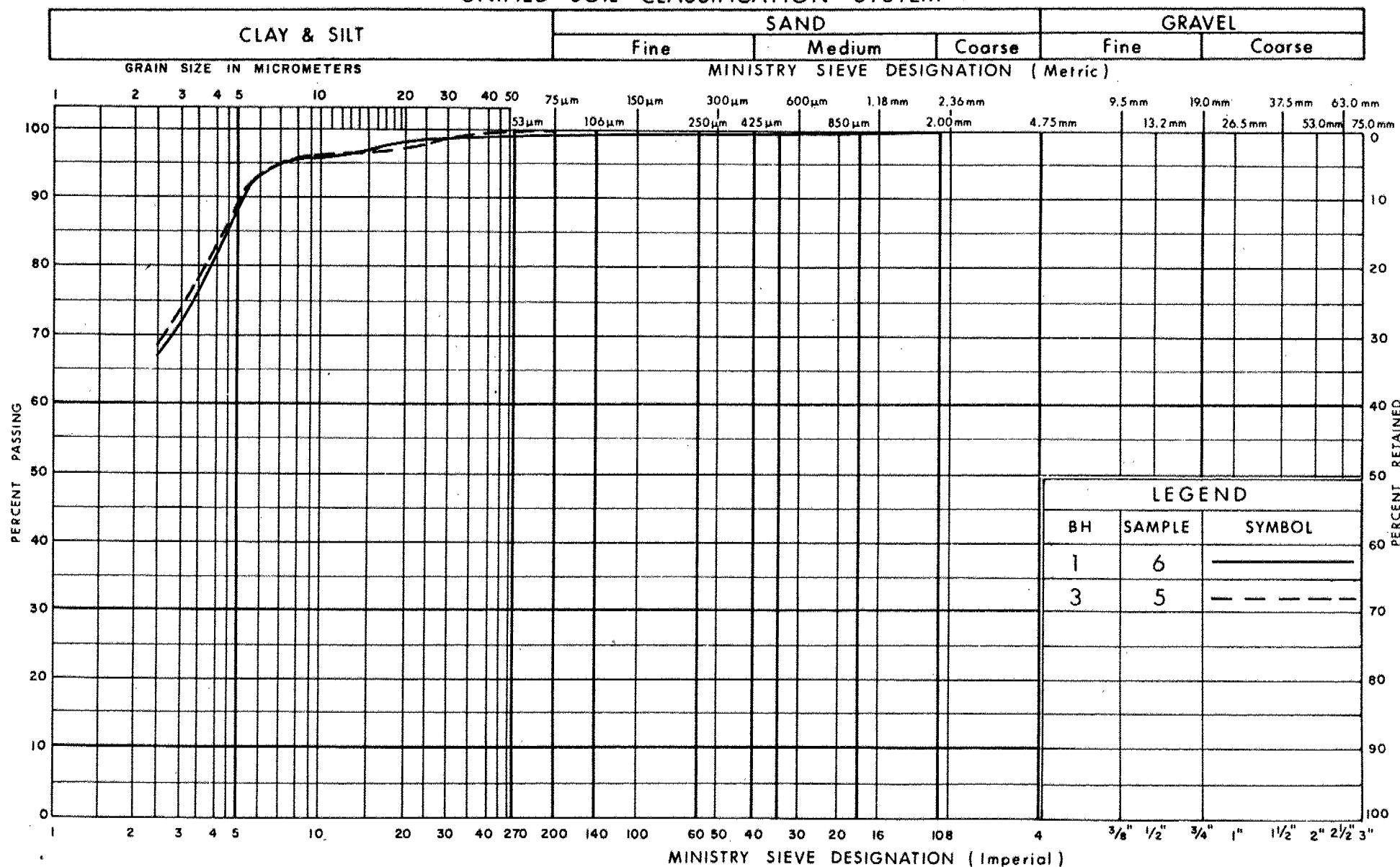
Ministry of
Transportation
Ontario

PLASTICITY CHART IRREGULAR MIXTURE OF SILTY CLAY, SAND & GRAVEL (FILL MATERIAL)

FIG No 2

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UNIFIED SOIL CLASSIFICATION SYSTEM

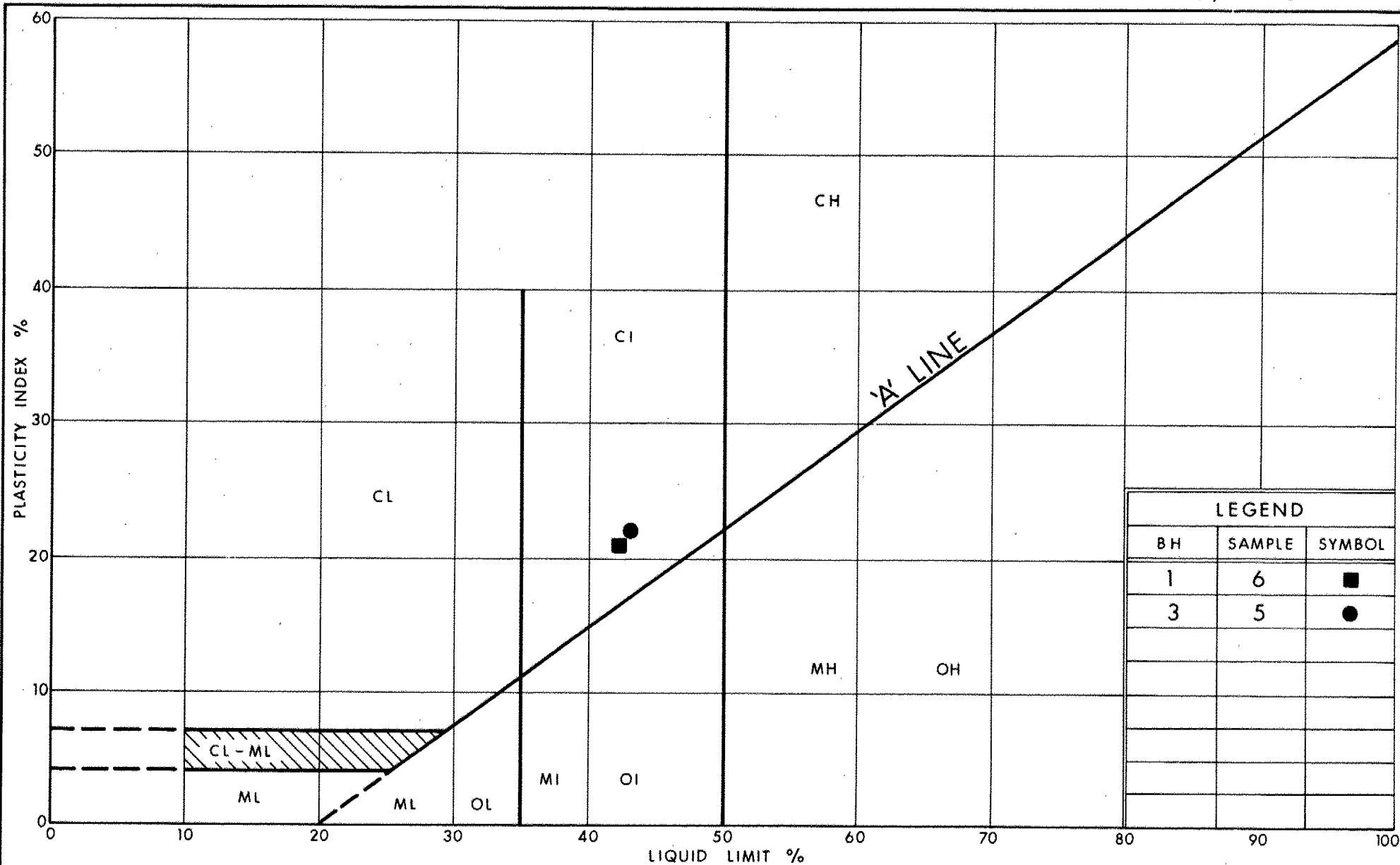


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GRAIN SIZE DISTRIBUTION
SILTY CLAY

FIG No 3

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Ontario

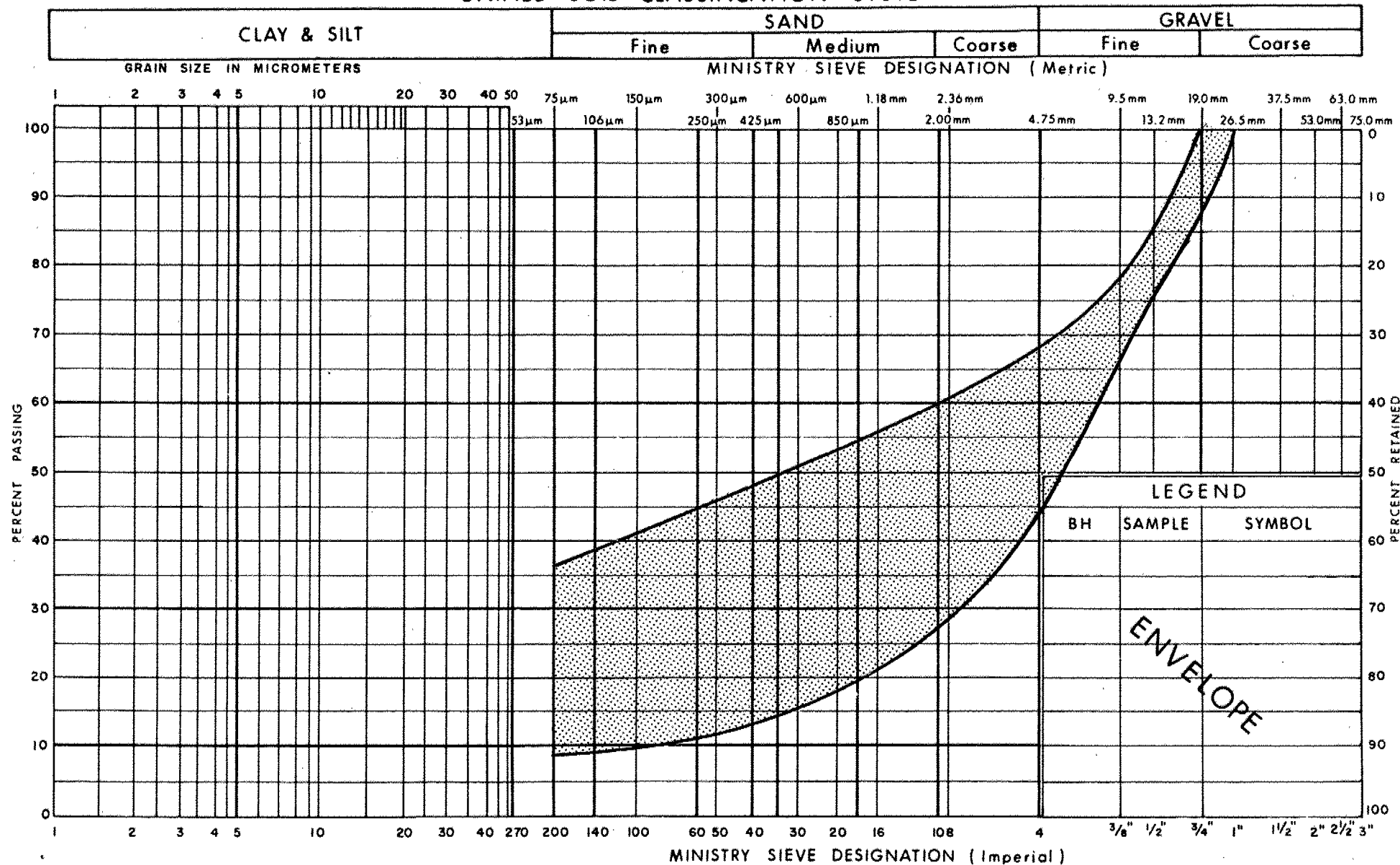
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PLASTICITY CHART SILTY CLAY

FIG No 4

W P 846 - 71 - 00

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF GRAVEL, SAND & SILT (Glacial Till)

FIG No 5

W P 846-71-00

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 (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

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

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

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 = $\frac{c_u}{\tau_r}$

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
P	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^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 846-71-00 LOCATION Sta. 19+593 o/s 4.3m Rt C/L Hwy 54 ORIGINATED BY NM
DIST 4 HWY 54 BOREHOLE TYPE SS Auger COMPILED BY NM
DATUM Geodetic DATE 93 08 05 CHECKED BY TS/PP

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					
188.4	Ground Surface																
0.0	Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material) Brown Grey		1	SS	6		188									20.0	9 18 33 40
	Firm to Very Stiff		2	SS	6												
			3	SS	11		186										
185.4			4	SS	18												
3.0	Silty Clay Brown, Stiff to Very Stiff		5	SS	9												
			6	SS	6		184									21.2	0 1 51 48
			7	SS	5												
182.3			8	SS	16		182										48 38 (14)
6.1	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) traces of Shale Grey, Compact																
181.4			9	SS	68		180										
7.0	Shale Bedrock Moderately Weathered Grey, Very Weak																
179.2			10	SS	100	5cm											
9.2	End of Borehole * 93 08 05																

RECORD OF BOREHOLE No 2

1 OF 1 METRIC

W.P. 846-71-00 LOCATION Sta. 19+643 o/s 4.2m Rt C/L Hwy 54 ORIGINATED BY NM
 DIST 4 HWY 54 BOREHOLE TYPE SS Auger, NW Casing, NXL Core COMPILED BY NM
 DATUM Geodetic DATE 93 08 06 CHECKED BY TS/PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			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		
187.8	Ground Surface																
0.0	Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material)		1	SS	8												
	Brown		2	SS	5												
	trace of Organics		3	SS	6												
	Stiff to Very Stiff																
184.8																	
3.0	Silty Clay		4	SS	12												
	trace of organics		5	SS	12												
	Brown, Very Stiff		6	SS	12												
182.5																	
5.3	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)		7	SS	18												
	Grey, Compact		8	SS	18												
180.8																	
7.0	Shale Bedrock																
	Moderately Weathered																
	Grey, Very Weak		9	RC	REC 100%												RQD = 0%
178.7																	
9.1	End of Borehole																
	* 93 08 06 (CWL not established)																

RECORD OF BOREHOLE No 3

1 OF 1 METRIC

W.P. 846-71-00 LOCATION Sta. 19+693 o/s 4.3m Rt C/L Hwy 54 ORIGINATED BY NM
 DIST 4 HWY 54 BOREHOLE TYPE SS Auger COMPILED BY NM
 DATUM Geodetic DATE 93 08 05 CHECKED BY TS/PP

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					
187.6	Ground Surface																
0.0	Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material) trace of organics Brown Grey		1	SS	4												
	Firm to Stiff		2	SS	9		186								50	20.0	1 2 55 42
185.3																	
2.3	Silty Clay Brown, Very Stiff		3	SS	14												
			4	SS	12		184										
			5	SS	10										43	21.6	0 0 42 58
			6	SS	5												
182.3																	
5.3	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)		7	SS	100	/25cm	182										
181.5	Grey, Very Dense		8	SS	100	/15cm											
6.1																	
	Shale Bedrock Moderately Weathered Grey, Very Weak		9	SS	28		180										
178.0			10	SS	16												
9.6	End of Borehole * 93 08 06																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 846-71-00 LOCATION Sta. 19+743 o/s 4.3m Rt C/L Hwy 54 ORIGINATED BY NM
 DIST 4 HWY 54 BOREHOLE TYPE SS Auger, NW Casing, NXI Core COMPILED BY NM
 DATUM Geodetic DATE 93 08 06 CHECKED BY TS/PP

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					
187.5	Ground Surface																
0.0	Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material)		1	SS	10												
	Brown																
	Grey		2	SS	6		186										
	trace of Organics																
	Firm to Very Stiff		3	SS	9												
184.1			4	SS	14		184										
3.4	Silty Clay																
183.3	Brown, Very Stiff		5	SS	24												
4.2	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)		6	SS	28												
	Grey, Compact to Dense		7	SS	45		182										56 36 (8)
181.3																	
6.2	Dolostone Bedrock, Moderately Weath.		8	RC	REC 100%												RQD = 0%
180.9	Grey, Medium Strong																
6.6	Shale Bedrock		9	RC	REC 64%		180										RQD = 0%
	Moderately Weathered																
	Grey, Very Weak																
179.5																	
8.0	End of Borehole																
	* 93 08 06 (GWL not established)																

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 846-71-00 LOCATION Sta. 19+793 o/s 4.3m Rt C/L Hwy 54 ORIGINATED BY NM
 DIST 4 HWY 54 BOREHOLE TYPE SS Auger COMPILED BY NM
 DATUM Geodetic DATE 93 08 05 CHECKED BY TS/PP

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					
187.6	Ground Surface																
0.0	Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material) trace of Organics Brown Grey Firm to Stiff		1	SS	7		186									18.5	9 21 43 27
184.6			2	SS	5												
3.0	Silty Clay		3	SS	5												
183.8	Brown, Very Stiff		4	SS	13		184										
3.8	Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till) Brown, Very Dense		5	SS	68												31 33 (36)
182.6			6	SS	83												
5.0	End of Borehole Refusal (Probable Bedrock) • 93 08 06																

ROCK CORE DESCRIPTION
WP 846-71-00

Page 1 of 1

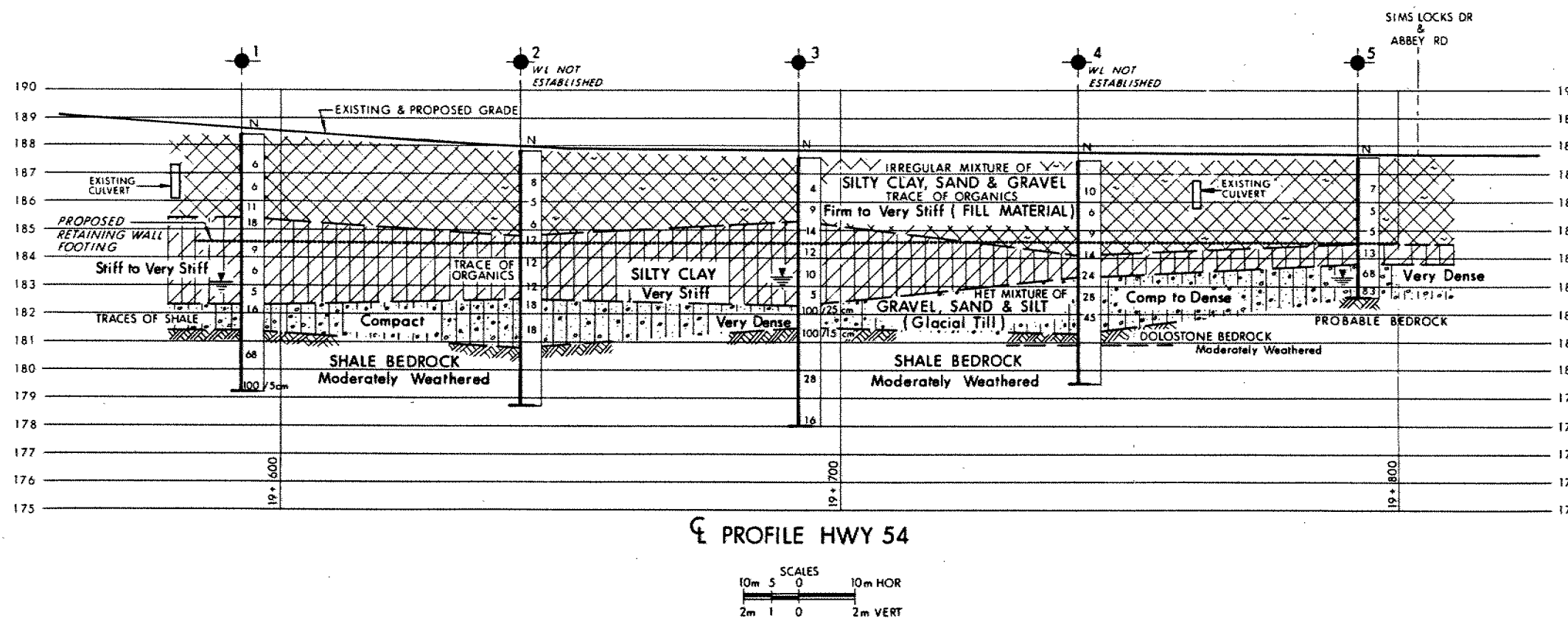
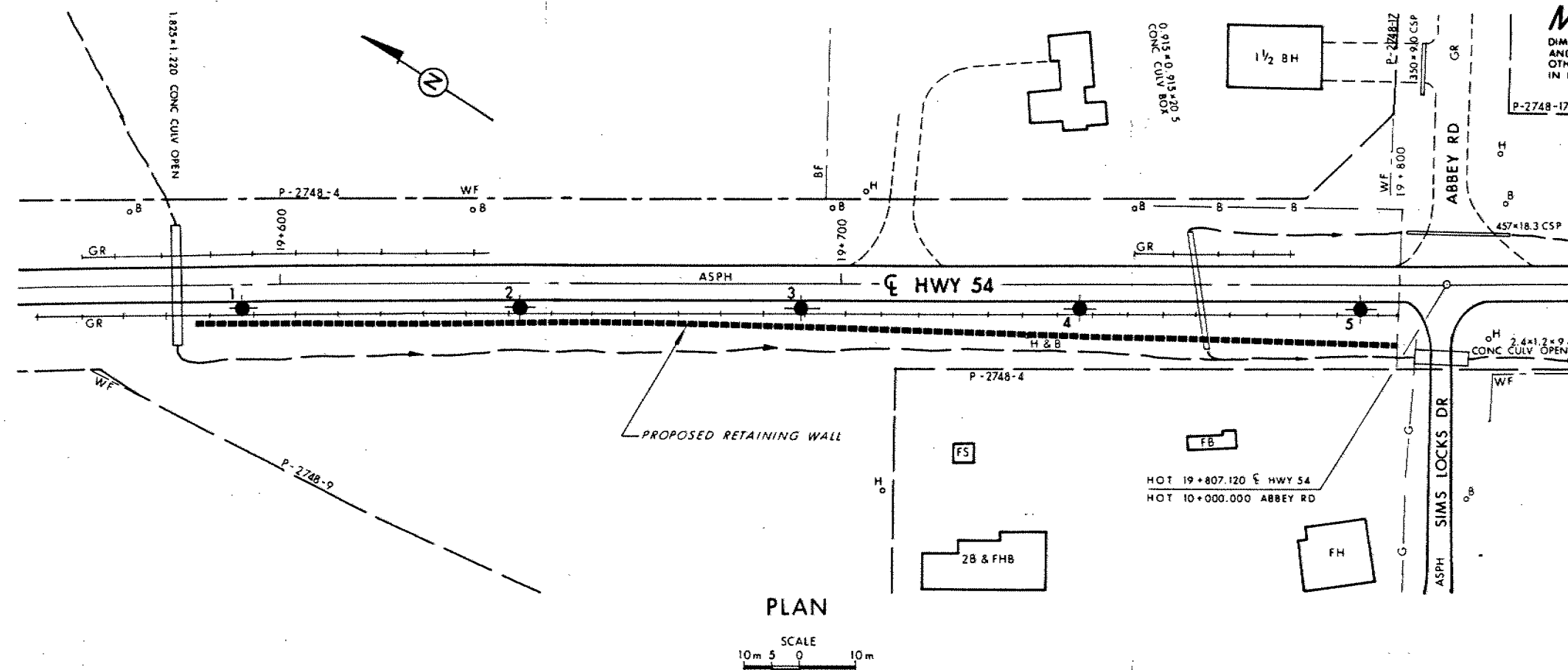
CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
2	9	7.62-9.14	100	0	7.62-9.14	SHALE (dolomitic), dark greenish grey to medium dark grey to light grey; fine grained; very weak; moderately weathered; fractures extremely close to very close spaced, flat to near vertical, planar to undulating, smooth.
4	8	6.10-6.61	100	0	6.10-6.25	OVERBURDEN (till).
	9	6.61-8.03	64	0	6.25-6.61	DOLOSTONE with vugs up to 3 cm in diameter, light grey to medium grey to pale yellowish brown; fine to medium grained; medium strong; moderately weathered; fractures extremely close to very close spaced, flat to near vertical, planar to undulating, smooth to rough.
					6.61-8.03	SHALE (dolomitic), dark greenish grey to medium dark grey to light grey; fine grained; very weak; moderately weathered; fractures extremely close to very close spaced, flat to near vertical, planar to undulating, smooth.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

Note: Depths are approximated where core recovery is less than 100%

Logged by: DAW, Soils and Aggregates Section



METRIC

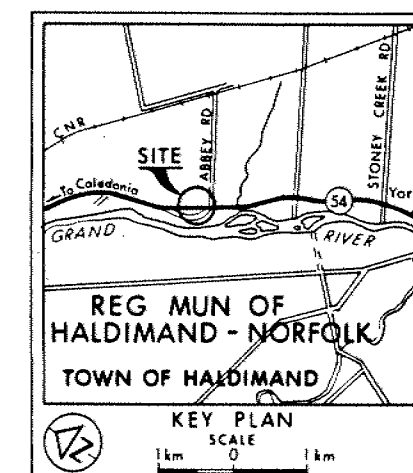
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES • METRES.

CONT No
WP No 846-71-00





PROP GABION RETAINING WALL
(Hwy 54, Sta 19+585 to 19+800
at Sims Locks Dr / Abbey Rd)
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) |
|  | WL at time of investigation 1993/08 |

No	ELEVATION	STATION	OFFSET
1	188.4	19+593	4.3m RT
2	187.8	19+643	4.2m RT
3	187.6	19+693	4.3m RT
4	187.5	19+743	4.3m RT
5	187.6	19+793	4.3m RT

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 GC 2.01 of OPS GenCond

REV					
DATE	BY	DESCRIPTION			

Geocres No 30M4-72

HWY No 54		DIST 4	
SUBMIT TS	CHECKED TS	DATE 1993 12 01	SITE
DRAWN RS	CHECKED RS	APPROVED	DWG 8467100-A



W.P. 846-71-01
Highway 54, Caledonia E. Lts - York W. Lts

Cayuga St. $100+00 = 320+12$ Hwy. 54

9+80 2.0 m Lt &

0 - 130 mm surf treated gr.
130 - 400 br.si.gr.
400 - 1.5 br.si.cl. m.p.

Delaware St $100+00 = 324+30$ Hwy 54

9+80 2.9 m Lt &

0 - 40 mm asph.
40 - 340 cr.stone water ent. 320-340mm
360 - 800 dk.br.si.cl.tps.
800 - 1.5 m br.si.cl. m.p.

River Dr. $100+00 = 376+00$ Hwy. 54

100+20 3.0 m Rt &

0 - 40 mm mulch.
40 - 300 cr.gr.
300 - 1.5 m br.si.cl. m.p.

Sims Locks Dr. $100+00 = 400+00$ Hwy. 54

100+15 2.8 m Rt &

0 - 20 mm mulch.
20 - 200 cr.gr.
200 - 1.5 m br.si.cl. m.p.

Abbey Rd. $100+00 = 421+80$ Hwy. 54

9+80 3.0 m Rt. &

0 - 70 mm cr.gr.
70 - 1.5 m br.si.cl. m.p.

Sims Locks Dr. $100+00 = 421+80$ Hwy. 54

100+15 2.3 m Lt &

0 - 70 mm asph.
70 - 250 cr.gr.
250 - 1.5 m br.si.cl. m.p.

Young Rd. $100+00 = 459+50$ Hwy. 54

9+75 2.0 m Lt &

0 - 150 mm.cr.gr.
150 - 250 br.si.sa.
250 - 1.5 m br.si.cl. m.p.

Stoney Creek Rd $100+00 = 497+25$ Hwy. 54

9+70 3.4 m Rt &

0 - 20 mm mulch.
20 - 180 cr.gr.
180 - 1.5 m br.si.cl. m.p.

Nelles St. Reg. Rd. 16 $100+00 = 516+35$ Hwy. 50

9+70 3.6 m Rt &

0 - 40 mm asph.
40 - 400 br.stny.si.sa.
400 - NFP. stones

Queen St. $100+00 = 519+85$ Hwy. 54

9+85 2.8 m Rt &

0 - 30 mm mulch.
30 - 500 cr.gr.
500 - 1.5 m br.si.cl. m.p.

W.P. 846-71-01

Highway 54, Caledonia E. Lt - York W. Lts

10+000 = 23+178.357

King St 100+00 = 532+36 Hwy. 54

9+75 3.8 m Rt ±

0	-	100 mm asph.
100	-	190 cr.gr.
190	-	1.5 m br.si.cl. m.p.

CONT	No
WP	No

SHEET

THE HONOURABLE ABRAHAM
ON

THE HONOURABLE ABRAHAM NELLES TRACT

