



Golder Associates Ltd.

CONSULTING ENGINEERS

REPORT TO
MINISTRY OF TRANSPORTATION OF ONTARIO

GEOTECHNICAL INVESTIGATION
HWY 407 - HUMBER RIVER BRIDGE
EASTBOUND LANES - W.P. 88-78-32
WESTBOUND LANES - W.P. 88-78-15
SITE 37-973, DISTRICT 6, TORONTO
CONT. 92-40

GEOCRES # 30M13-108

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1.0 INTRODUCTION

The Ministry of Transportation of Ontario has retained Golder Associates Ltd. to carry out a geotechnical investigation for the proposed bridge to carry Highway 407 over the Humber River in Vaughan, Ontario. The purpose of the investigation is to determine the subsurface conditions at the site and, based on our interpretation of the factual information obtained, to provide recommendations on the geotechnical aspects of design of the proposed works.

The investigation was carried out in accordance with the terms of reference as outlined in Golder Associates Ltd. letters dated February 9 and April 20, 1990.

2.0 SITE DESCRIPTION AND GEOLOGY

The site is located within the Humber River floodplain approximately 0.7 km north of Steeles Avenue and 1.4 km south of Highway 7 in the Town of Vaughan. The floodplain at the proposed Hwy 407 crossing extends about 100 m east of the river to the base of the CP Rail embankment which runs approximately north-south. To the west of the river, the Humber River valley connects with the Rainbow Creek valley.

The site is located within the physiographic region known as the Peel Plain. The surficial soils are comprised of recent floodplain deposits consisting of sands and silts which grade with depth to lacustrine clays and clay tills. The lacustrine clays in this area are known to contain zones of reworked till and the clays are thought to be derived from the underlying till deposit. Water well records indicate that the site is located within a deep

depression in the bedrock surface. Shale bedrock of the Dundas Formation has been found in the area at depths of 40 m to 60 m below ground surface.

3.0 SUBSURFACE CONDITIONS

The detailed stratigraphy encountered in the boreholes put down during this investigation is shown on the attached Record of Borehole sheets and summarized on Drawing Numbers 887832-A and 887815-A. It should be noted that the stratigraphic boundaries indicated on the borehole logs and stratigraphic sections represent transitions between soil types and are not intended to define exact planes of geologic change. The subsurface conditions have been identified at the borehole locations only and will vary between and beyond the boreholes.

The locations of the boreholes are shown on Dwg. No.'s 887832-A and 887815-A. The results of laboratory testing carried out on representative samples obtained during the investigation are shown on the Record of Borehole sheets and on Figures 1 to 13. In general, the subsoils at the site consist of surficial loose granular deposits ranging from sandy silt to sand and gravel overlying a deposit of stiff to very stiff clayey silt interlayered with silty clay and silt. The clays and silts are underlain by a complex sequence of interlayered hard clayey silts and very dense silts. A sand and gravel deposit was encountered underlying the hard/very dense strata; the lower granular deposit is under artesian pressure with piezometric head up to about 5 m above ground surface. The following is a summary of the strata encountered at the borehole locations.

3.1 Surficial Sandy Silt to Silty Sand

In all of the boreholes, about 0.7 m to 1.8 m of a deposit which ranges in composition from sandy silt to silty sand was encountered underlying about 0.3 m to 1.6 m of topsoil. The deposit is in a loose to very loose state of packing with Standard Penetration ('N') values ranging from 2 to 11 blows per 0.3 m of penetration. The measured water content of samples of this deposit range from 18 to 27 percent with an average of 23 percent for nine samples.

In Boreholes 1 and 17, the sandy silt deposit is underlain by about 0.5 m to 0.8 m of organic silt. Measured water contents of two samples of the organic silt were 28 percent and 44 percent. The organic content of one sample of organic silt from Borehole 17 was 3 percent.

3.2 Upper Sand to Sand and Gravel

In all of the boreholes, except Boreholes 1 and 11, the surficial sands and silts are underlain by about 0.5 m to 1.7 m of a deposit which varies in composition from sand containing some gravel to sand and gravel (see Figure 1). The deposit is generally in a loose to compact state of packing with 'N' values ranging from 3 to 22 blows per 0.3 m of penetration. Two measured water contents of the sand portions of the deposit were 10 and 18 percent.

3.3 Upper Clayey Silt

The granular deposits are underlain at all borehole locations by about 3.3 m to 9.7 m of a deposit which consists primarily of clayey silt with a trace of sand but which varies in overall composition across the site. The

upper 3.3 m to 6.5 m of the deposit exhibits little stratification and contains a variable proportion of coarse sand sizes with occasional fine gravel. These components give this portion of the deposit a till-like texture. The lower 1.6 m to 5.6 m of the deposit contains silty clay interlayers which differ mainly in plasticity and is stratified with frequent silt partings. The upper and lower portions of the clay stratum in Boreholes 1, 2, 4, 5, 6, 7 and 9, are separated by about 0.7 m to 3 m of a deposit consisting mainly of silt but which contains interlayers of clayey silt and silty sand. The natural water content measured on six samples of the silt ranged from 18 to 28 percent with average of 23 percent.

The results of laboratory testing on the clayey silt deposit are as follows:

Natural Water Content	# of tests	range	average
Massive to till-like layers	29	16 to 31%	23%
Stratified layers	17	20 to 26%	23%
Atterberg Limits			
(see Figures 10 and 11)	# of tests	range	average
Liquid Limit	8	24 to 37%	29%
Plastic Limit	8	19 to 26%	20%
Plast. Index	8	5 to 14%	9%

The above Atterberg Limits test results indicate a silt to clay of low plasticity and clay of low plasticity.

The piezocone penetration tests carried out adjacent to Boreholes 6 and 17 and indicate the extreme variability of stratification within the deposit which is not evident by routine sampling. The stratification consists mainly of silt layers and till-like zones. Although not detected in the samples obtained at all of the borehole locations, it is probable that this layering exists across the site.

The measured consistency of the layered deposit is also variable at the borehole locations. 'N' values range from 4 to 24 blows per 0.3 m of penetration. Undrained shear strength values, measured by in-situ vane tests, range from 42 kPa to 103 kPa (sensitivity ranging from 2 to 4) with higher strength values indicated by refusal to turning of the vane. Interpretation of the piezocone penetration test results also indicate extremely variable undrained shear strength profiles across the site. Over the depth of each clayey silt layer, the undrained shear strength is relatively constant, ranging from about 25 kPa to 135 kPa at the three piezocone penetration test locations. There does not, however, appear to be a consistent correlation with depth across the site.

Two consolidation tests were carried out on samples of this deposit obtained at a depth of about 3.5 m in Borehole 5 and at 7.2 m in Borehole 17. Preconsolidation pressures of 220 kPa and 270 kPa were calculated from the results of tests carried out on samples from Boreholes 5 and 17, respectively (see Figures 12 and 13). These values correspond to over-consolidation ratios of 6 and 5, respectively.

The trend of preconsolidation pressure, interpreted from the piezocone traces, indicate that there two distinct

geologic layers present within this clayey silt deposit. In the upper 1 m to 2 m, the preconsolidation pressure decreases with depth reaching a minimum at the top of a silt stratum which separates the two clayey silt layers. Within the lower portion of the deposit, the preconsolidation pressure commences at a higher value than the minimum of the upper layer, decreases to a minimum at about 8 m to 9 m depth below ground surface and then increases below that depth.

3.4 Middle Silts

In Boreholes 7, 8, 11, 12, 14, 15, 16 and 17, the clayey silt stratum is underlain by about 1.8 m to 5.3 m of a deposit consisting of silt to silty sand (see Figure 3 and 4). Blowing of the fine granular materials occurred within this deposit at most of the borehole locations. Based on observations during drilling, it is considered that the deposit is in a loose to compact state of packing. Measured 'N' values range from 1 to 20 blows per 0.3 m of penetration with an average value of 7. The natural water content measured on 8 samples of this deposit ranged from 14 to 26 percent with an average of 23 percent.

3.5 Lower Till, Clayey Silts and Silts

The clayey silt and silt deposits are underlain at depths of about 11.4 m to 14.6 m by a complex sequence of hard clayey silt to very dense silt strata containing a variable proportion of sand and gravel. Grain size distribution curves carried out on samples of these strata are shown on Figures 5 to 9. The till deposits encountered range in composition from a heterogeneous mixture of silt, sand and gravel to clayey silt containing some sand. The tills are

interlayered and underlain by silt to stratified clayey silt strata.

The surface of the hard/very dense deposit was generally encountered at about Elevation 120.6 m to 123 m in the boreholes located on the east side of the river and at Elevation 123.3 m to Elevation 124.7 m in the boreholes on the west side of the river. 'N' values measured in this deposit were generally greater than 100 blows per 0.3 m of penetration. 'N' values of 25 to 87 blows per 0.3 m of penetration were measured, however, in the upper 5.2 m of the clayey silt and silt strata in Borehole 9 and the upper 2.8 m in Borehole 4 (at the south limits of Pier 1 and the west abutment, respectively). For the total of 47 'N' values obtained within these strata, 12 were less than 100 blows with an average of 60 blows per 0.3 m of penetration.

The following table summarizes the results of laboratory tests carried out on samples of the hard/very dense strata.

Stratum	Test	# of tests	range	average
Clayey Silt	Water Content	15	10 to 17%	14%
	Atterberg Limits (Figures 10 and 11)			
	Liquid Limit	5	23 to 29%	25%
	Plastic Limit	5	16 to 20%	18%
Silt	Water Content	9	14 to 19%	16%
Till	Water Content	9	7 to 11%	9%

3.6 Lower Sand and Gravel

The tills and silts were penetrated in Boreholes 15 and 17 on the east side of the river and were found to be underlain by a sand and gravel deposit which was encountered at about Elevation 115 m and Elevation 116 m (19.5 m and 20.5 m below ground surface) in Boreholes 15 and 17, respectively. The sand and gravel deposit is in a very dense state of packing with 'N' values greater than 79 blows per 0.3 m.

3.7 Groundwater Conditions

During drilling of Boreholes 15 and 17, artesian pressure conditions were encountered as soon as the tills and silts overlying the sand and gravel deposit were penetrated. The head of water was estimated to be about 4.6 m above ground surface at the location of Borehole 17 based on the height to which the water level rose within the hollow stem augers which were installed at ground surface. Because of the high water pressure, these two boreholes had to be packed off with mechanical packers and cement grout was pumped into the hole below the packers until the flow was stopped. Artesian pressure conditions were also noted in Boreholes 9, 11, 12 and 16 which were terminated within the till or the underlying silt strata; in these boreholes, the water level rose to ground surface within a few hours of completion of the drilling. With the relatively low flow of water, it was possible to install a grout plug at the bottom of these boreholes to stop the flow without the use of mechanical packers. All of the above boreholes, where artesian conditions were encountered, are located on the east side of the river.

Piezometers were installed into ten of the boreholes, sealed into the various strata encountered during the drilling. The water level in the piezometer installed in the upper sand and gravel layer in Borehole 12 was at about 1.2 m below ground surface, coincident with the adjacent river water level. All of the remaining piezometers registered artesian pressure conditions.

The head measurements for the piezometer installations which were sealed into the lower hard/dense tills and silts indicate a piezometric level in these strata at about Elevation 136.4 m to Elevation 140.7 m (about 1.4 m to 5.2 m above ground surface) on both sides of the river. Piezometers sealed into the overlying loose silts and stiff clayey silt deposits indicate the piezometric level to be about Elevation 135.8 m to 138.6 m (about 0.5 m to 2.5 m above ground surface) dependant on the elevation of the tip. These results reflect an overall upward gradient through the strata present between the lower sand and gravel deposit and the surficial sands.

Subsequent to measuring the water levels in the piezometers which registered artesian head, the installation were capped using the procedure outlined below. It should be noted that the tubing is only blocked to a depth of about 0.6 m below ground surface; excavations during construction extending below this depth will remove the seal to the piezometers and further blocking will be required.

- o A shallow hole was dug around each installation and the 50 mm diameter PVC piezometer tubing was cut off at about 0.2 m below ground surface; bentonite gravel was then forced down the tube until the tubing was bridged.

- o Powder cement was poured into the tubing and a PVC cap was glued onto the top of the tubing.
- o A concrete cap of Type 10 Portland cement, minimum thickness of 150 mm, was placed in the hole surrounding the installation sealing the PVC cap in place. This concrete is exposed at ground surface.

4.0 DISCUSSION AND RECOMMENDATIONS

The layout of the proposed bridge was provided on Plan E-73-407-17 titled 'Bridge Site Plan, Proposed Crossing at Humber River and King's Highway 407' prepared by the Ministry of Transportation of Ontario dated August 1989. The crossing involves two three span bridges with total length 130 m. The two structures (eastbound and westbound) are separated by a distance of 18.5 m centreline to centreline. The final road grade will be about 8 m above the existing ground surface. Each bridge will carry four lanes of traffic initially although it is understood that the ultimate highway cross-section will require widening of both structures by one lane in the median. It is understood that the westbound (north) bridge will be constructed first to handle both eastbound and westbound traffic. The Humber River will be diverted through an open channel located to the east of the existing alignment at the bridge location.

4.1 Foundations

The soils within several metres of ground surface are extremely variable in composition and consistency at this site; a condition typical of floodplain deposits and probably due in part to the continual upward seepage which occurs. Spread footings are not recommended because of the variability of the upper deposits and because of the disturbance which could occur during excavation in sand deposits near the water table.

It is recommended that the piers and abutments be supported on driven piles founded in the hard clayey silt till and/or very dense silt deposits which were encountered at about

Elevation 120.6 m to Elevation 124.7 m. Consideration could be given to steel H piles or closed ended steel pipe piles. We have a preference for pipe piles at this site due to the requirement to stop the piles as high as possible in the till.

The piles should be terminated as high as possible within the till deposit to minimize the possibility of penetrating the lower sand and gravel deposit which would permit direct access to free water under artesian pressure. The potential for creating a path along the pile for water migration to ground surface has been considered. We consider that as long as the pile does not penetrate permeable layers subject to recharge, which would cause the flow of water to be significant, skin friction can be relied upon. It should be noted, however, that the piezometers installed in the boreholes terminated above the sand and gravel deposit also registered artesian pressure conditions, generally corresponding to a head of 3 m above hydrostatic. There will be some potential for upward flow within the sands and silts at about 8 m to 12 m depth. The total skin friction available above that depth is small and so the effect on the load carrying capacity of the pile will be modest.

A more important effect on the load carrying capacity of piles at this site is the very limited penetration into the hard/dense till and/or silt which is possible without incurring the risk of penetrating the aquifer. Together with the reduced overburden effective stress at the pile toe due to the artesian water pressure, this causes a reduction in the calculated load carrying capacity of piles. The fact that some of the piles will be founded

within silt deposits has to be taken into consideration in the design.

Using an effective stress approach and applying the concept of critical depth, we have calculated that the ultimate capacity of a 324 mm diameter tube pile driven 3 m below the top of the till layer is about 1870 kN. This calculated pile capacity has been checked by reviewing the results of available pile load tests (Ministry of Transportation and Communications Report EM-48) for piles founded in similar materials. Only those results for piles driven into fine silty sands and silts with Standard Penetration Test (N) values in excess of 100 blows per 0.3 m of penetration have been considered. Figure 14 shows the correlation between the equivalent ultimate bearing capacity of the piles as measured in the load tests and the overburden effective stress at the pile toe. The published load test data indicate good correlation between failure load and overburden effective stress at the toe. The calculated ultimate capacity for the Hwy 407/Humber River site is also shown on the figure; this calculated value is towards the upper bound of the measured capacity at the corresponding overburden stress. The grain size distribution envelopes for the founding strata at the Hwy 407/Humber River bridge site are shown on Figure 15.

Using a resistance factor of 0.5, the corresponding calculated factored capacity at ultimate limit states (ULS) for piles driven into the very dense/hard till and silt at this site is 950 kN. If the ultimate capacity of the pile as calculated is established by a static pile load test, however, a factor of 0.6 would be applied and the factored capacity at ULS would then be 1100 kN for design. Pile capacity at serviceability limit states (SLS) will depend

on the pile group action and this can be determined once the group arrangement or the total load on the abutments and piers are known.

We recommend that a pile load test be carried out on each side of the river to establish the design pile load and the driving criteria to be used for all production piles. This procedure avoids the cost of over-conservative design. If the time schedule does not allow such an approach, then the higher factored capacity at ULS value of 1100 kN could be assumed but this would be subject to confirmation by pile load tests at a very early stage of the contract. If this approach is to be adopted, the contract would have to be flexible to allow an adjustment of the design pile capacity; i.e. two alternative designs could be prepared and the load test results used to establish the design to be implemented. It should be stressed that, in view of the variable stratigraphy at this site, the pile capacity should be confirmed by a load test even if the calculated capacity at ULS (950 kN) is used in design.

It is estimated that up to about 90 mm of settlement of the approach fill embankments could occur due to consolidation of the layered silty clay deposit. At the abutment locations, a resultant negative skin friction will develop on the upper section of the pile within the firm to stiff clay. Based on a strain balance approach, we calculate that the design negative skin friction (factored) in the upper clay is 300 kN. This should be considered in combination with dead load for calculating the structural capacity of the piles.

Resistance to lateral loads for piles at this site will be governed by the upper loose sandy silt to sand and gravel

deposits which are present within 3 m of ground surface. For preliminary design, the factored capacity for lateral loading at ULS for a 324 mm diameter tube pile, with 9.5 mm wall thickness and restrained head at ground surface, may be taken as 140 kN. A value of n_h (coefficient of variation of horizontal subgrade reaction) equal to 4 MPa/m has been assumed for the soil reaction in this calculation. The lateral capacity at SLS for a single restrained pile is 224 kN (deflection of 25 mm) although this value reduces to 56 kN for a group with piles spaced at 3 diameters centre to centre and to 90 kN at 4 diameter spacing. The serviceability condition should be examined when the group arrangement has been finalized.

It is recommended that the pile caps be maintained as high as possible to minimize excavations below the groundwater level. Substantial water inflow to excavations should be expected where the excavations are extended into the sand and gravel deposits. Excavation side slopes should be maintained flatter than 2 horizontal to 1 vertical.

Depending on the depth of the excavation with respect to the elevation of the water table, interceptor ditches and pumping from sumps located within the excavations or wells located outside the excavations will be required.

Alternatively, pile cap construction could be carried out within braced sheet pile cofferdams driven to provide a cut-off. Construction of the west pier foundation which extends into the existing river channel will require prior diversion of the river.

4.2 Earth Pressures

The lateral earth loads acting on the abutments will depend on the type and method of placement of the backfill, the

nature of the embankment fills and on the subsequent lateral movement of the structure. The following recommendations are made concerning the design of the abutments.

- o Selected 'free draining' granular fill in accordance with MTO specifications should be used as backfill immediately behind the structures. The granular fill should be placed within the wedge-shaped zone defined by a 60 degree line extending up and back from the bottom of the rear face of the structures' footing or pile cap.
- o All granular fill should be compacted in 200 mm thick lifts to 95 per cent of the materials' Standard Proctor dry density. Heavy compaction equipment should not be used within a lateral distance behind the structure equal to the current height of the fill above the base of the structure.
- o Longitudinal drains should be installed to provide positive drainage of the granular backfill.
- o If the abutment support allows lateral yielding at its top equal to not less than 0.05 per cent of the retained height, 'active' earth pressure conditions apply. If, however, the structure is not permitted to yield by this amount, 'at rest' pressure conditions should be used. The following earth pressure parameters may be used for the calculation of lateral earth pressures:

Granular 'A'			
	unit weight		22 kN/cu.m
	coef. of lateral earth pressure:		
	ULS:	'active'	0.34
		'at rest'	0.50
	SLS:	'active'	0.27
		'at rest'	0.43

Granular 'B'		
unit weight		21 kN/cu.m
coef. of lateral earth pressure:		
ULS:	'active'	0.41
	'at rest'	0.58
SLS:	'active'	0.33
	'at rest'	0.50

4.3 Approach Embankments

Based on the results of the consolidation tests and on our interpretation of the piezocone probes, it is calculated that the stress increase in the silty clay deposits due to the proposed embankment loading will in general not result in stress levels above the preconsolidation pressure of the deposit as measured. The magnitude of settlement of the embankment, therefore, due to consolidation of the clayey silt deposit is dependent on the reloading coefficient of consolidation and it is estimated that about 90 mm of settlement could occur. Discrete layers are evident in CPT 2, however, where the interpreted preconsolidation pressure is lower (100 kPa to 150 kPa) than the applied stress level due to embankment loading. These layers are generally less than 0.5 m thick; consolidation due to embankment loading at this location could result in a total of 110 mm of settlement.

Using the stratigraphic profile with minimum shear strengths measured at the site, the stability of the 8 m high embankment constructed with side slopes at 2 horizontal to 1 vertical is adequate with respect to undrained (total stress) analyses.

Embankment construction should be preceded by stripping of all topsoil and organics from below the fill placement area and by proof rolling of the subgrade to delineate any soft

areas. Such areas should be excavated and backfilled with free-draining granular fill. The embankment fills should consist of clean earth fill, free from organics and rubble and at appropriate water content for compaction. Based on our observations at the site during the investigation, the embankment will be subject to seasonal flood conditions (water level rose to about Elevation 136 m over the floodplain area - March 12, 1990). The embankment side slopes should be topsoiled and seeded and suitable protection be provided to the toe of the embankment.

4.4 Diversion Channel

It is understood that the Humber River will be realigned through a diversion channel located between the proposed piers to the east of the current river channel. Assuming that the new channel will have a depth similar to that of the existing river, excavations for the channel will be about 2 m to 2.5 m deep and will be through loose sandy silt and loose to compact sand to sand and gravel. The excavations will probably be terminated at or near the surface of the underlying clayey silt deposit.

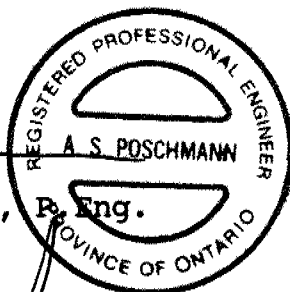
Details of the proposed diversion channel or design flow conditions are not yet known. At this stage, it is considered that the side slopes to the channel should be maintained no steeper than 2.5 horizontal to 1 vertical. Based on the apparent changes in the river course as noted at the site in comparison with that shown on the plan provided, it is evident that there is significant erosion of the east river bank at the bridge crossing. The

proposed channel should be provided with suitable scour protection.

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APPENDIX A
INVESTIGATION PROCEDURES

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INVESTIGATION PROCEDURES

The fieldwork for this investigation was carried out between February 14 and March 26, 1990, at which time a total of sixteen boreholes (numbered Borehole 1, 2 and 4 to 17) and three piezocone penetration tests (numbered CPT 1 to 3) were put down at the site. The boreholes were put down to depths of between 15.5 m and 25.4 m below ground surface with hollow stem augers and wash boring techniques using bombardier mounted drill rigs supplied and operated by Master Soil Investigations Limited.

In each of the boreholes (numbered 1, 2 and 4 to 17), samples of the subsoils were obtained at regular intervals of depth as part of the Standard Penetration Test using conventional 50 mm O.D. split spoon samplers. In-situ field vanes were carried out within the clayey silts to determine the undrained shear strength profile of the deposit. Relatively undisturbed shelby tube samples of the clayey silt deposit were obtained at selected locations for detailed laboratory testing. Piezometers were installed in ten of the boreholes to permit monitoring of the groundwater levels. In order to ensure proper placement and sealing of the piezometers in Boreholes 6 and 16 and the shallow piezometer in Borehole 12, the installations were placed in unsampled boreholes put down to the required depth adjacent to the sampled boreholes.

The piezocone penetration tests (CPT 1 to 3) were advanced to depths of about 10 m to 13 m below ground surface. CPT 1 and CPT 2 were put down adjacent to Boreholes 17 and 6, respectively, (at the abutment locations) to provide additional subsurface data and to provide some

stratigraphic correlation. The third probe (CPT 3) was put down along the west approach. The piezocone penetrometer system consists of a down-the-hole sensing element and ultrasonic transmitter with an on-surface data acquisition system. Measurements of tip resistance and side sleeve friction are made with by a load cell and strain gauges mounted inside a sealed housing. A porous stone ring, located immediately behind the tip, allows porewater pressure to be measured by a pressure transducer. The piezocone was pushed using the hydraulic ram system of the drill rig.

The field work was carried out under the supervision of members of Golder Associates Ltd. staff who cleared the borehole locations for buried services, directed the drilling and sampling operations and logged the boreholes. All of the samples were examined in the field and returned to our laboratory for detailed examination and classification testing.

The completed borehole locations and ground surface elevations were surveyed in the field by Ministry of Transportation of Ontario staff. It is understood that the elevations are referenced to Geodetic datum.

As discussed in Section 3.2.7 of this report, Boreholes 15 and 17 which penetrated into the sand and gravel stratum under artesian head were packed off and grouted to stop the flow. The grout plug is about 9 m thick in Borehole 17, which was sealed off by Groundation Engineering Ltd., and about 6 m thick in Borehole 15, which was sealed by Golder Associates Ltd. Artesian pressure conditions were noted on completion of the drilling of Boreholes 9, 11, 12 and 16

and grout was pumped (without prior placement of packers) into these holes to form a plug about 3 m thick. Subsequent to monitoring of the water levels, the piezometers were sealed off at a depth of about 0.6 m below ground surface.

LIST OF ABBREVIATIONS

The abbreviation commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS auger sample
CS chunk sample
DO drive open
DS Denison type sample
FS foil sample
RC rock core
ST slotted tube
TO thin-walled, open
TP thin-walled, piston
WS wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 0.3 m (12 in.).

Standard Penetration Resistance, *N*:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 0.3 m (12 in.).

WH sampler advanced by static weight—weight, hammer

PH sampler advanced by pressure—pressure, hydraulic

PM sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) <i>Cohesionless Soils</i>	' <i>N</i> ' <u>Blows/0.30m</u> <u>or Blows/ft.</u>
Relative Density	
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

Consistency	<u>kPa</u>	' <i>Cu</i> ' <u>psf.</u>
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	over 200	over 4000

IV. SOIL TESTS

C consolidation test
H hydrometer analysis
M sieve analysis
MH combined analysis, sieve and hydrometer¹
Q undrained triaxial²
R consolidated undrained triaxial²
S drained triaxial
U unconfined compression
V field vane test

NOTES:

¹Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

²Undrained triaxial tests in which pore pressures are measured are shown as \bar{Q} or \bar{R} .

LIST OF SYMBOLS

I. GENERAL

τ	= 3.1416
e	= base of natural logarithms 2.7183
$\log_e a$ or $\ln a$	natural logarithm of a
$\log_{10} a$ or $\log a$	logarithm of a to base 10
t	time
g	acceleration due to gravity
V	volume
W	weight
M	moment
F	factor of safety

II. STRESS AND STRAIN

u	pore pressure
σ	normal stress
σ'	normal effective stress ($\bar{\sigma}$ is also used)
τ	shear stress
ϵ	linear strain
ϵ_{xy}	shear strain
ν	Poisson's ratio (μ is also used)
E	modulus of linear deformation (Young's modulus)
G	modulus of shear deformation
K	modulus of compressibility
η	coefficient of viscosity

III. SOIL PROPERTIES

(a) Unit weight

γ	unit weight of soil (bulk density)
γ_s	unit weight of solid particles
γ_w	unit weight of water
γ_d	unit dry weight of soil (dry density)
γ'	unit weight of submerged soil
G_s	specific gravity of solid particles $G_s = \gamma_s / \gamma_w$
e	void ratio
n	porosity
w	water content
S_r	degree of saturation

(b) Consistency

w_L	liquid limit
w_P	plastic limit
I_P	plasticity index
w_s	shrinkage limit
I_L	liquidity index = $(w - w_P) / I_P$
I_C	consistency index = $(w_L - w) / I_P$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
D_r	relative density = $(e_{max} - e) / (e_{max} - e_{min})$

(c) Permeability

h	hydraulic head or potential
q	rate of discharge
v	velocity of flow
i	hydraulic gradient
k	coefficient of permeability
j	seepage force per unit volume

(d) Consolidation (one-dimensional)

m_v	coefficient of volume change = $-\Delta e / (1+e) \Delta \sigma'$
C_c	compression index = $-\Delta e / \Delta \log_{10} \sigma'$
c_s	coefficient of consolidation
T_v	time factor = $c_s t / d^2$ (d , drainage path)
U	degree of consolidation

(e) Shear strength

τ_f	shear strength
c'	effective cohesion intercept
ϕ'	effective angle of shearing resistance, or friction
c_u	apparent cohesion*
ϕ_u	apparent angle of shearing resistance, or friction
μ	coefficient of friction
S_r	sensitivity

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

RECORD OF BOREHOLE No 1

METRIC

W P 88-78-32; 88-78-15 LOCATION Co-ords. 4,847,389.6N;297,984.7E ORIGINATED BY RF
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ASP
 DATUM Geodetic DATE March 22, 1990 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
135.78	Ground Surface																GR SA SI CL
0.00	Sandy Silt (Topsoil)																
134.18	Very loose Brown		1	SS	2												
1.60	Clayey Silt, trace organics Firm		2	SS	5		134										
133.36																	
132.82	Organic Sandy silt		3	SS	19												
2.90	Clayey Silt, trace sand occasional gravel (Till-like texture)		4	SS	20		132										
	Very stiff Grey		5	SS	26												
			6	SS	25												
							130										
			7	SS	21												
28.78																	
7.00	Silt, trace sand; inter-layered with silt and sand, fine occasional clayey silt seam.		8	SS	13		128										
	Compact Grey																
26.18			9	SS	20												
9.60	End of Borehole																

+3, x⁵: Numbers refer to Sensitivity

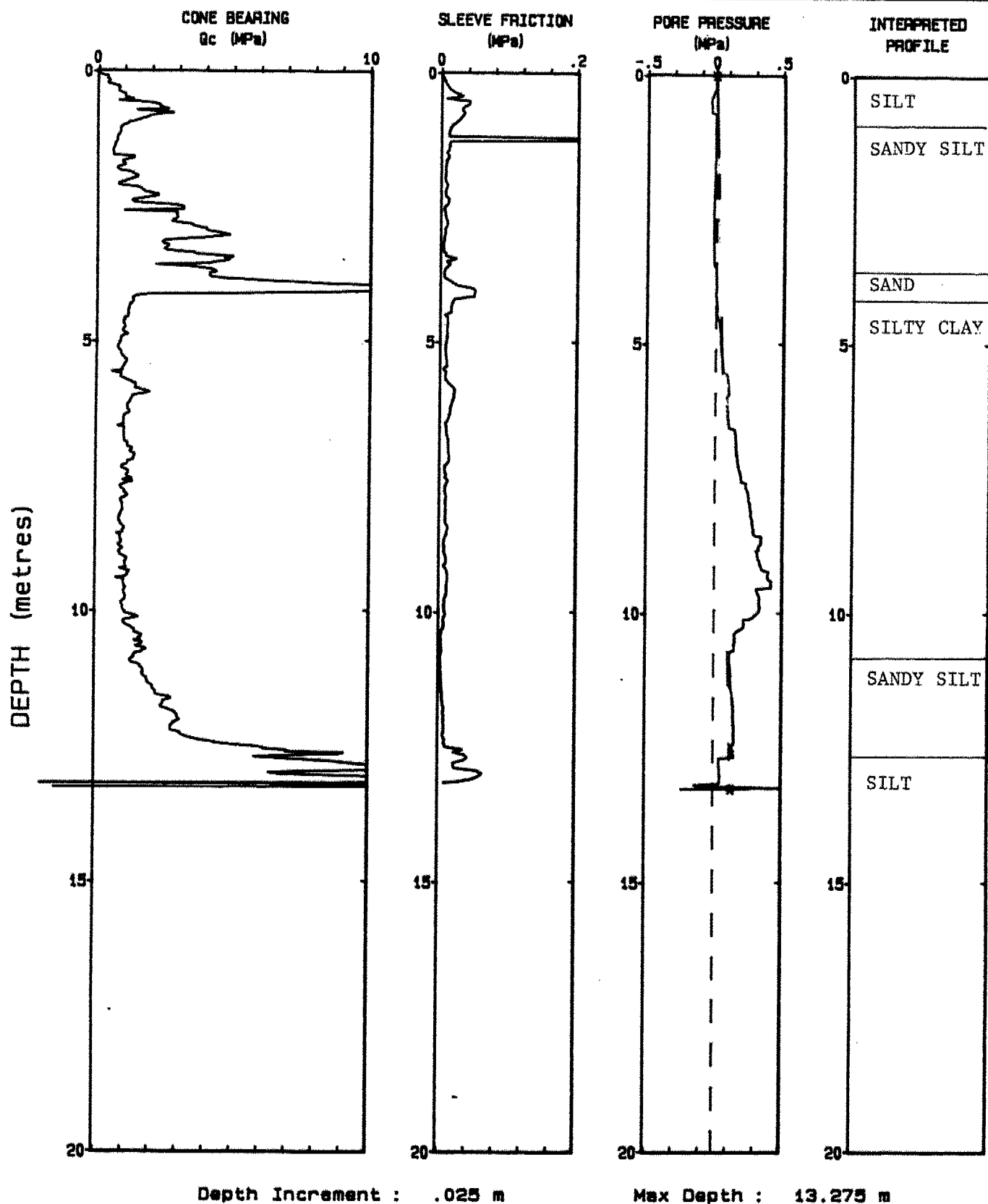
20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF CPT 1

Location: SEE FIGURE 2
Prebore Depth: 0.0m

DATE 90-03-19
Cone: 3015

Page No: 1 / 1
Project No: 901-1314



RECORD OF BOREHOLE No 2

METRIC

W P 88-78-32; 88-78-15 LOCATION Co-ords. 4,847,372.8N;298,011.6E ORIGINATED BY AJW
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ASP
 DATUM Gonderic DATE March 23, 1990 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
135.11	Ground Surface																
0.00	Organic Silt.																
133.81	Firm Brown		1	SS	6		134										
1.30	Sandy Silt, trace clay, some organics.		2	SS	9		Water Level Elev. 133.8 m April 5, 1990.										
133.01	Loose Brown																
2.10	Sand and gravel, trace silt		3	SS	21												
132.21	Compact Grey																
2.90	Stratified Silty Clay and clayey silt, trace sand, frequent silt partings.		4	SS	11												
			5	SS	16												
	Very Stiff Grey		6	SS	15												
			7	SS	14												
127.81																	
7.30	Silt, trace clay interlayered with clayey silt and sandy silt.		8	SS	17												
125.51	Loose to compact Grey		9	SS	8												
9.60	End of Borehole.																

+³, x⁵: Numbers refer to
Sensitivity

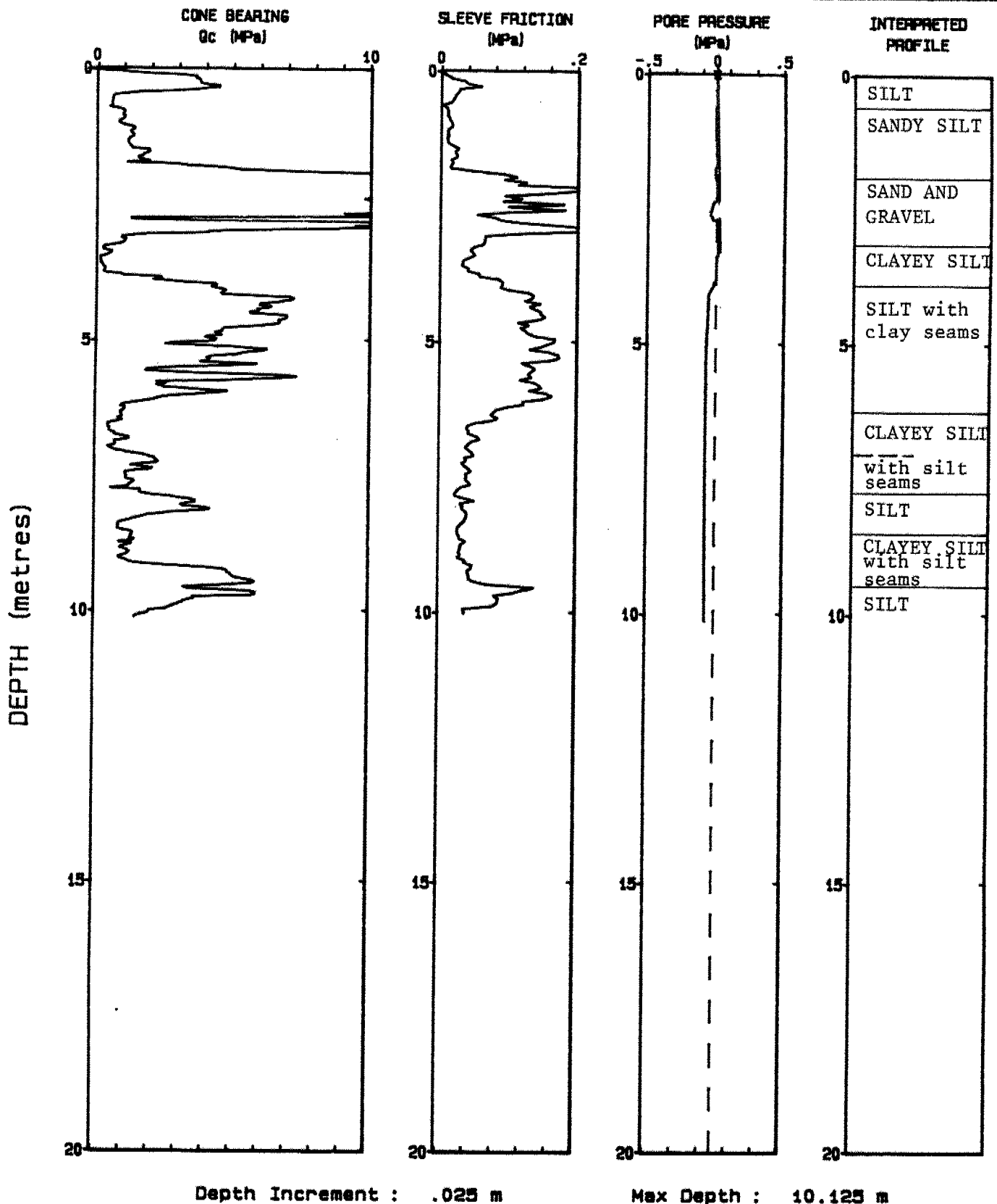
20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF CPT2

Location: SEE FIGURE 2
 Prebore Depth: 0.0m

DATE 90-03-19
 Cone: 3015

Page No: 1 / 1
 Project No: 901-1314

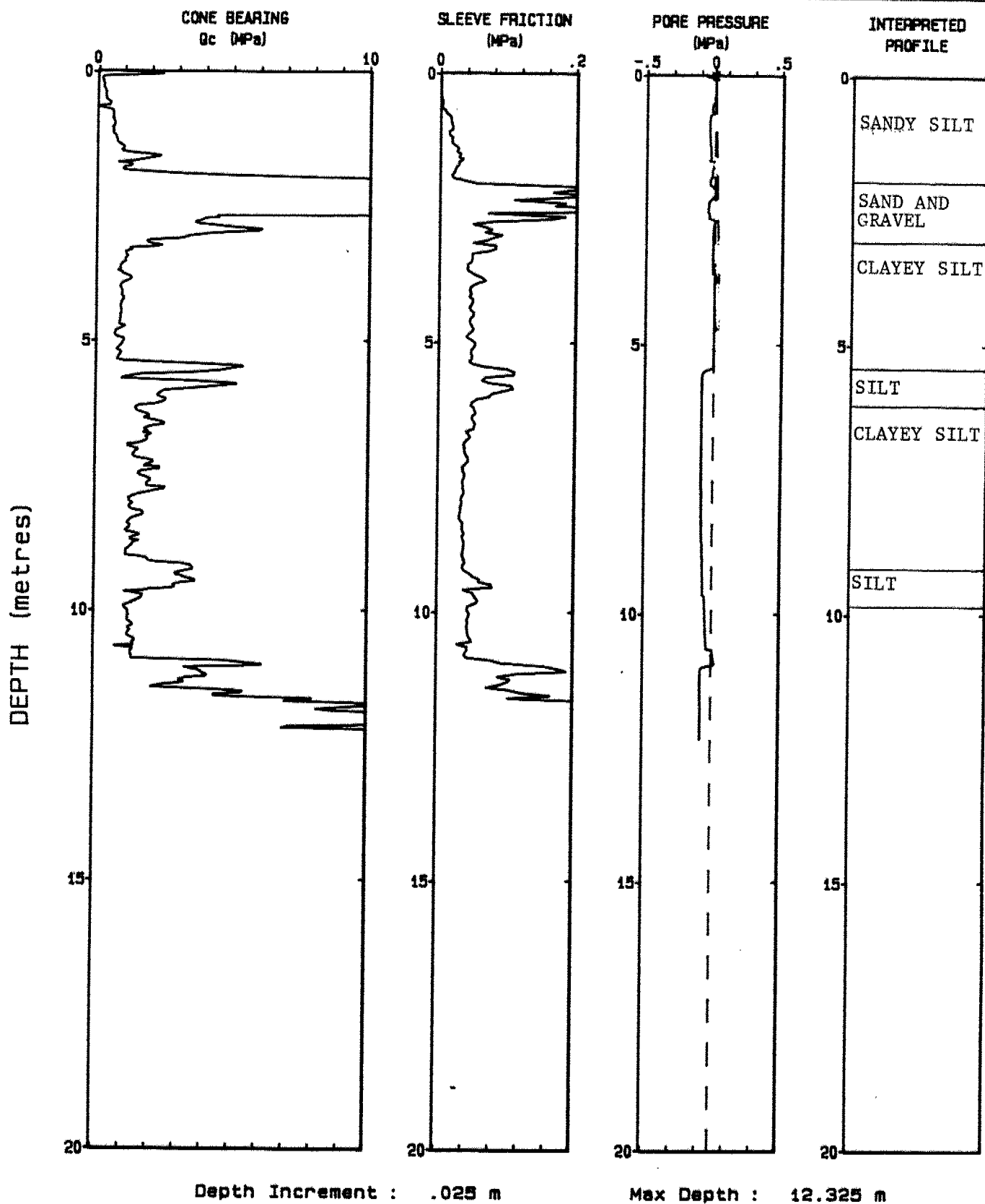


RECORD OF CPT3

Location: SEE FIGURE 2
 Prebore Depth: 0.0m

DATE 90-03-19
 Cone: 3015

Page No: 1 / 1
 Project No: 901-1314



RECORD OF BOREHOLE No 4

METRIC

W P 88-78-32; 88-78-15

LOCATION Co-ords. 4,847,374.1N;298,036.6E

ORIGINATED BY RF

DIST 6 HWY 407

BOREHOLE TYPE Hollow Stem Augers

COMPILED BY ASP

DATUM Geodetic

DATE March 21, 1990

CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
135.08	Ground Surface													
134.43	Topsoil													
0.65	Sand, fine, some silt to sandy silt, trace clay & organics		1	SS	3		134							
133.08	Very loose Brown		2	SS	2									
2.00	Sand and Gravel.		3	SS	3									
132.58	Clayey Silt, trace sand, occasional gravel (Till-like texture)						132		3.5	2				
2.50	Stiff to very stiff Grey		4	SS	5									
			5	SS	14									
129.58	Silt, trace sand, some silty sand interlayers.						130							
5.50	Loose Grey		6	SS	7									
			7	SS	4		128							
126.58	Clayey Silt, trace sand, occasional gravel (Till-like texture). Occasional silt seams.						126							
8.50	Stiff to hard Grey		8	SS	4									
			9	SS	11		124							
			10	SS	74									
121.98	Silt and Sand, trace clay.						122							
13.10	Compact Grey		11	SS	25									1 51 42 6
120.18	Silt, trace sand and clay.						120							
14.90	Very dense Grey		12	SS	159									0 3 90 7
			13	SS	188		118							
117.48	Silty Sand, some grave trace clay (Till)													
17.60	Very dense Grey		14	SS	130									15 56 27 2
116.33	End of Borehole													
18.75														

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5

METRIC

W P 88-78-32;88-78-15

LOCATION Co-ords. 4,847,391.7N;298,034.2E

ORIGINATED BY RF

DIST 6 HWY 407

BOREHOLE TYPE Hollow Stem Augers

COMPILED BY ASP

DATUM Geodetic

DATE March 19 and March 20, 1990

CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
135.20	Ground Surface																
0.00	Topsoil																
134.60	Sandy Silt, trace clay, some organics, occasional shell fragments.		1	SS	4		134										
133.20	Loose Brown		2	SS	7												
2.00	Sand and Gravel. Compact		3	SS	22												
132.60	Clayey Silt, trace sand, occ. gravel (Till-like texture)		4	TW	PH												
2.60	Stiff Grey		5	SS	6												
			6	SS	4												
129.40	Silt, some sand, occ. clayey silt seam. Compact		7	SS	11												
5.80	Stratified Clayey silt and silty clay, trace sand, frequent silt seams.		8	SS	5												
128.50	Stiff to very stiff Grey		9	SS	5												
6.70			10	SS	13												
122.90	Clayey Silt, some sand & gravel (Till). Hard		11	SS	93												
121.80	Clayey Silt, trace sand & interlayered with silt and silty sand. Hard		12	SS	53												
13.40	Silt, trace clay and sand. Very dense		13	SS	134												
120.60	Heterogeneous mixture of silt and gravel, some sand and clay (Till). Very dense		14	SS	100/100 mm												
14.60			15	SS	182												
119.00	Silty Sand, some gravel, trace clay (Till) very dense		16	SS	142												
16.20	End of Borehole																
116.00																	
19.20																	
115.08																	
20.12																	

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6

METRIC

W P 88-78-32; 88-78-15 LOCATION Co-ords. 4,847,427.6N;298,029.1E ORIGINATED BY SB
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ASP
DATUM Geodetic DATE March 9, March 15 and March 16, 1990. 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
135.12	Ground Surface														
134.32	Topsoil														
0.80	Sandy Silt, trace clay.		1	SS	6										
133.31	Loose Brown		2	SS	11										
1.80	Sand and Gravel, some silt.		3	SS	14										
132.22	Compact Brown/Grey		4	SS	6										
2.90	Clayey Silt, trace to some sand, occasional gravel (Till-like texture).		5	SS	12										
	Very Stiff Grey		6	SS	12										
127.92			7	SS	5										
7.20	Silt, trace clay, interlayers of sandy silt and clayey silt.		8	SS	3										
	Very loose to loose Grey		9	SS	8										
125.12			10	SS	19										
10.00	Clayey silt, some silt partings		11	SS	70										
123.52	Very Stiff Grey		12	SS	117										
11.60	Clayey Silt, trace to some sand, trace gravel		13	SS	43										
122.02	Hard Grey		14	SS	176/25 mm										
13.10	Silt to sandy silt, trace clay.		15	SS	92										
	Dense to very dense Grey		16	SS	75										
118.92			17	SS	34										
16.20	Clayey Silt, and gravel some sand (Till).														
117.62	Hard Grey														
17.50	Sandy Silt, some gravel (Till).														
115.92	Very Dense Grey														
19.20	Silty sand, trace gravel.														
114.85	Dense Grey														
20.27	End of Borehole														

+3, x⁵: Numbers refer to Sensitivity
20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7

METRIC

W P 88-78-32; 88-78-15

LOCATION Co-ords. 4,847,447.0N;298,067.7E

ORIGINATED BY JR

DIST 6 HWY 407

BOREHOLE TYPE Hollow Stem Augers

COMPILED BY ASP

DATUM Geodetic

DATE March 20 and March 21, 1990

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
134.96	Ground Surface															
134.66	Topsoil															
0.30	Sandy Silt, trace clay															
133.56	Very loose Brown		1	SS	3		134									
1.40	Sand, some silt & gravel to sand and gravel, trace silt, occ. org. pockets		2	SS	10		Water Level Elev. 136.4 m April 4, 1990. 132									
132.06	Compact Grey		3	SS	13											
2.90	Clayey Silt, trace sand		4	SS	14											
131.26	Very stiff Grey															
3.70	Silt, trace clay.		5	SS	30											
130.56	Dense Grey & Brown		6	SS	19											
4.40	Clayey Silt, trace sand, occ. gravel.															
	Stiff Grey		7	SS	8		130									
127.36																
7.60	Silt, trace sand interlayered with clayey silt.		8	SS	5											
126.16	Loose Grey															
8.80	Silt and Sand, fine.															
	Compact Grey		9	SS	12		126									
124.66																
10.30	Heterogeneous mixture of sand and silt, some gravel, trace clay (Till). Dense		10	SS	39		124									
123.36	Grey															
11.60	Clayey Silt, trace sand (Till-like texture) to stratified clayey silt and silty clay.		11	SS	129											
	Hard Grey		12	SS	125		122									
120.36																
14.60	Silt, trace clay and sand.															
	Very dense Grey		13	SS	103		120									
118.86			14	SS	115											
16.15	End of Borehole															

+3, x5: Numbers refer to Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8

METRIC

W P 88-78-32: 88-78-15 LOCATION Co-ords. 4,847,423.9N;298,059.6E ORIGINATED BY JR
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ASP
 DATUM Geodetic DATE March 20 and March 21, 1990 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
134.74	Ground Surface																
0.00	Topsoil																
134.24																	
0.50	Silty Sand, trace org.																
133.54	Loose Brown		1	SS	5		134										
1.20	Sand and Gravel, trace to some silt.		2	SS	22												
	Compact Grey		3	SS	22												
131.84							132										
2.90	Clayey Silt, some gravel.		4	SS	14												
131.14	Stiff																
3.60	Sand and Gravel.																
130.54	Compact		5	SS	24												
4.20	Clayey Silt, some sand, occasional gravel.		6	SS	22		130										
	Very stiff Grey																
128.54																	
6.20	Stratified Silt, silt and sand, fine, trace clay.		7	SS	10		128										
	Very loose to loose Grey		8	SS	10												
			9	SS	1		126										
			10	SS	1		124										
123.34																	
11.40	Heterogenous mixture of sand and silt, some gravel, trace clay (Till).		11	SS	79		122										
121.64	Very dense Grey																21 34 35 10
13.10	Silt, trace to some clay.		12	SS	122		120										
	Very dense Grey																
119.04			13	SS	156												0 0 88 12
15.70	End of Borehole																

RECORD OF BOREHOLE No 9

METRIC

W P 88-78-32; 88-78-15 LOCATION Co-ords. 4,847,391.3N;298,079.6E ORIGINATED BY JR
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger; BX Core COMPILED BY ASP
DATUM Geodetic DATE March 6 and March 7, 1990 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
135.44	Ground Surface													
0.00	Topsoil													
134.44			1	SS	8									
1.00	Silty Sand, trace clay and organics.		2	SS	6									
133.34	Loose Brown													
2.10	Sand and Gravel, trace silt and organics.		3	SS	13									
132.54	Compact Grey													
2.90	Clayey Silt, trace to some sand, occasional gravel (Till-like texture).		4	SS	15									
			5	SS	19									
	Very stiff Grey		6	SS	21									
			7	SS	19									
128.14														
7.30	Silt, trace clay and sand.		8	SS	13									
	Compact Grey		9	SS	12									
125.44														
10.00	Clayey Silt, trace sand, frequent silt seams.		10	SS	12									
	Very stiff Grey		11	SS	14									
122.94														
12.50	Silty Clay to clayey silt, trace to some sand, trace gravel, occasional silt and sand seams (Till-like texture)		12	SS	36									
	Hard Grey		13	SS	87									
119.24														
16.20	Silt, some fine sand, trace clay.		14	SS	50									
	Very dense Grey													
117.74														
17.70	Clayey Silt, some sand, trace gravel (Till). Boulder at 21.2 m to 22 m depth.		15	SS	225									
			16	SS	171									
			17	RC BX	Ret. 22%									
			18	RF BX	Ret. 53%									
113.19														
22.25	End of Borehole													

+3, x5: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10

METRIC

W P 88-78-32; 88-78-15 LOCATION Co-ords. 4,847,430.8N;298,094.8E
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger
 DATUM Geodetic DATE March 26, 1990
 ORIGINATED BY RF
 COMPILED BY ASP
 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							WATER CONTENT (%)		
								SHEAR STRENGTH kPa							10 20 30		
								○ UNCONFINED	+ FIELD VANE								
								● QUICK TRIAXIAL	x LAB VANE								
								20 40 60 80 100									
135.62	Ground Surface																
135.32	Topsoil																
0.30	Silty Sand grading to sand, some silt, occ. organics.		1	SS	4												
133.52	Loose Brown		2	SS	5												
2.10	Sand and gravel, trace silt.		3	SS	14												
132.72	Compact Grey		4	SS	18												
2.90	Clayey Silt, trace sand, occ. gravel (Till-like texture).		5	SS	20												
	Very Stiff Grey		6	SS	19												
			7	SS	19												
128.32	Stratified Silty Clay and clayey silt, trace sand, frequent silt and sandy silt seams.		8	SS	10												
7.30	Stiff Grey		9	SS	8												
125.41																	
10.21	End of Borehole.																

RECORD OF BOREHOLE No 11

METRIC

W P 88-78-32; 88-78-15 LOCATION Co-ords. 4,847,469.3N; 298,147.6E ORIGINATED BY JR
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger; BW Casing - Wash Boring COMPILED BY ASP
 DATUM Geodetic DATE February 14 to February 20, 1990 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
0.00	Ground Surface.																
134.84	Topsoil																
0.50	Sandy Silt, trace clay		1	SS	8												
133.93	and organics. Loose																
1.40	Silty Sand, silt inter-		2	SS	3												
133.23	layers. Very Loose																
2.10	Silty clay, gravel		3	SS	10												
132.43	seams. Stiff																
2.90	Clayey Silt, trace to		4	SS	15												
	some sand, occasional		5	SS	14												
	to trace gravel (Till- like texture).		6	SS	15												
	Very Stiff Grey																
128.73			7	SS	12												
6.60	Silty Clay, stratified		8	TW	PH												
	with silt partings.																
126.83	Very Stiff Grey		9	SS	13												
8.50	Clayey Silt, some sand,																
	trace gravel (Till).		10	SS	13												
125.33	Very Stiff Grey																
10.00	Silt and sand, fine,		11	SS	9												
	trace clay. Occasional																
	interlayer of clayey		12	SS	WR												
	silt.																
	Loose Grey																
121.93																	
13.40	Silty Clay and clayey		13	SS	110												
	silt, stratified with																
	silt partings.		14	SS	115												
	Hard Grey																
118.87			15	SS	184												
16.46	End of Borehole.																

RECORD OF BOREHOLE No 12

METRIC

W P 88-78-32; 88-78-15 LOCATION Co-ords. 4,847,433.8N; 298,157.4E ORIGINATED BY JR
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger; Wash Boring COMPILED BY ASP
 DATUM Geodetic DATE February 23 to February 27, 1990. 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
135.0	Ground Surface													
0.00	Topsoil													
0.50	Sandy Silt, trace clay and gravel.													
134.10	Loose		1	SS	7									
1.40	Sand and Gravel, trace silt.		2	SS	6									
132.60	Loose to Compact Grey		3	SS	14									
2.90	Clayey Silt, trace to some sand, occasional to trace gravel (Till- like texture).		4	SS	23									
	Very Stiff Grey		5	SS	24									
			6	SS	19									
			7	SS	14									
			8	SS	16									
126.10			9	SS	17									
9.40	Silty Clay, stratified with silt partings.													
	Very Stiff Grey		10	SS	14									
123.90														
11.60	Silt and Sand, fine, trace clay.													
	Very Loose Grey		11	SS	2									
122.10														
13.40	Clayey Silt to silty clay, trace to some sand (Till-like texture).													
	Hard Grey		12	SS	48									
			13	SS	140									
			14	SS	142									
			15	SS	146									
118.10														
17.40	Clayey Silt													
117.67	Hard		16	SS	134									
17.83	End of Borehole.													

RECORD OF BOREHOLE No 13

METRIC

W P 88-78-32; 88-78-15 LOCATION Co-ords. 4,847,398.4N; 298,105.4E ORIGINATED BY SB
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ASP
 DATUM Geodetic DATE March 23, 1990 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
135.45	Ground Surface																
0.00																	
134.92	Topsoil																
0.53	Sandy Silt grading to silty sand, trace gravel, occ. organics.		1	SS	3												
133.35	Very Loose Brown		2	SS	2												
2.10	Sand, some gravel, trace silt and clay.		3	SS	10												
132.10	Compact Grey		4	SS	13												
3.35	Clayey Silt, trace sand, occ. gravel (Till-like texture). Occasional silty clay interlayer.		5	SS	9												
	Very Stiff Grey		6	SS	11												
			7	SS	16												
127.25			8	SS	15												
8.20	Silt, trace clay, stratified.																
125.85	Compact Grey		9	SS	15												
9.60	End of Borehole.																

+3, x5: Numbers refer to
Sensitivity

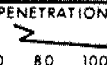
20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 14

METRIC

W P 88-78-32: 88-78-15 LOCATION Co-ords. 4,847,406.1N; 298,129.0E ORIGINATED BY JR
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Augers; Wash Boring COMPILED BY ASP
 DATUM Geodetic DATE March 2, 1990 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa										
								20 40 60 80 100										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
								20 40 60 80 100										
								PLASTIC LIMIT Wp NATURAL MOISTURE CONTENT W LIQUID LIMIT Wl										
								WATER CONTENT (%)										
								10 20 30										
135.17	Ground Surface																	
0.00	Topsoil																	
134.77																		
0.40	Sandy Silt, trace clay & organics.		1	SS	8		134											
	Loose Brown		2	SS	4													
133.37																		
2.10	Sand, some gravel, trace silt, occasional clayey silt seam. Loose to Compact		3	SS	6													
131.72			4	SS	16		132											
3.45	Clayey Silt, trace sand, occ. gravel (Till-like texture). Occ. silty clay inter-layer. Very Stiff Grey		5	SS	21													
			6	SS	17		130											
			7	SS	17													
							128											
127.17			8	SS	15													
8.00	Stratified Silty Clay, clayey silt and silt. Stiff Grey		9	TW	PH													
125.87							126											
9.30	Silt, some sand, trace clay. Very Loose Grey		10	SS	12													
			11	SS	1		124							0 15 80 5				
123.17																		
12.00	Sand, trace silt. Grey		12	WS	-		122											
120.57																		
14.60	Clayey Silt, trace sand (Till-like texture). Hard Grey		13	SS	146		120											
118.97																		
16.20	Clayey Silt, trace sand; sandy silt seams. Hard Grey																	
117.95			14	SS	118		118											
17.22	End of Borehole.																	

RECORD OF BOREHOLE No 15

METRIC

W P 88-78-32; 88-78-15 LOCATION CO-ords. 4,847,433.8N; 298,118.1E
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Augers
 DATUM Geodetic DATE March 8 to March 10, 1990
 ORIGINATED BY JR
 COMPILED BY ASP
 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										
								SHEAR STRENGTH kPo					WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
135.41	Ground Surface							20	40	60	80	100	10	20	30			
0.00	Topsoil																	
134.81																		
0.60	Sand, some silt.		1	SS	7													
134.01	Loose Brown																	
1.40	Sand, some gravel to sand and gravel, trace silt.		2	SS	8													
132.51	Loose to Compact Brown		3	SS	17													
2.90	Clayey Silt, trace sand (Till-like structure).		4	SS	23													
	Very Stiff Grey		5	SS	21													
			6	SS	18													
			7	SS	23													
128.41																		
7.00	Stratified Silty Clay and clayey silt, frequent silt and sandy silt seams.		8	SS	20													
	Stiff Grey		9	SS	13													
125.01																		
10.40	Silt and Sand, fine, trace clay, occasional clayey silt seam.		10	SS	14													
	Loose to Compact Grey		11	SS	5													
122.01																		
13.40	Clayey Silt, some sand, trace gravel (Till).		12	SS	131													
121.01	Hard Grey																	
14.40	Stratified Clayey Silt and silty clay, trace sand.		13	SS	157													
	Hard Grey		14	SS	168													
117.11																		
18.30	Silt, trace clay.		15	SS	70													
	Very Dense Grey																	
115.91																		
19.50	Sand and Gravel.		16	SS	178													
115.29	Very Dense																	
20.12	End of Borehole.																	

RECORD OF BOREHOLE No 16

METRIC

W P 88-78-32; 88-78-15

LOCATION Co-ords. 4,847,461.9N; 298,112.3E

ORIGINATED BY JR

DIST 6 HWY 407

BOREHOLE TYPE Hollow Stem Augers; Wash Boring

COMPILED BY ASP

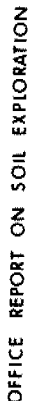
DATUM Geodetic

DATE March 5 and March 6, 1990

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
135.65	Ground Surface																
0.00	Topsoil		1	SS	17												
135.05	0.60 Sandy Silt, trace clay & organics.		2	SS	6												
134.25	Loose Brown																
1.40	Silty Sand, fine, grading to sand, fine to med., trace silt, some org.		3	SS	4												
132.75	Loose Brown		4	SS	5												
2.90	Clayey Silt, trace sand occ. gravel (Till-like texture). Gravel layer (0.2 m thick) at 4.0 m depth.		5	SS	17												
			6	SS	35												
			7	SS	29												
	Grey																
			8	SS	24												
128.65	7.00 Stratified Clayey Silt and silty clay with silt seams.		9	SS	22												
127.15	Very Stiff Grey																
8.50	Silt and Sand, fine to sandy silt, trace clay.		10	SS	7												
	Loose Grey																
			11	SS	7												
124.05	11.60 Silty Sand, trace clay.																
	Compact Grey		12	SS	18												
122.25	13.40 Clayey Silt, some sand, trace gravel (Till).		13	SS	131												
	Hard Grey																
120.45	15.20 Stratified Silty Clay, clayey silt and silt.		14	SS	138												
119.04	Hard Grey		15	SS	120												
16.61	End of Borehole.																



METRIC

W P 88-78-32; 88-78-15 LOCATION Co-ords. 4,847,490.3N; 298,144.9E ORIGINATED BY RF
DIST 6 HWY 407 BOREHOLE TYPE Hollos Stem Auger; BW Casing - Wash Boring COMPILED BY ASP
DATUM Geodetic DATE February 14 to February 20, 1990 CHECKED BY _____

[illegible]

+3, x5; Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 17

METRIC

W P 88-78-32; 88-78-15

LOCATION Co-ords. 4,847,490.3N; 298,144.9E

ORIGINATED BY JR

DIST 6 HWY 407

BOREHOLE TYPE Hollow Stem Auger; BW Casing - Wash Boring

COMPILED BY ASP

DATUM Geodetic

DATE February 14 to February 20, 1990

CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

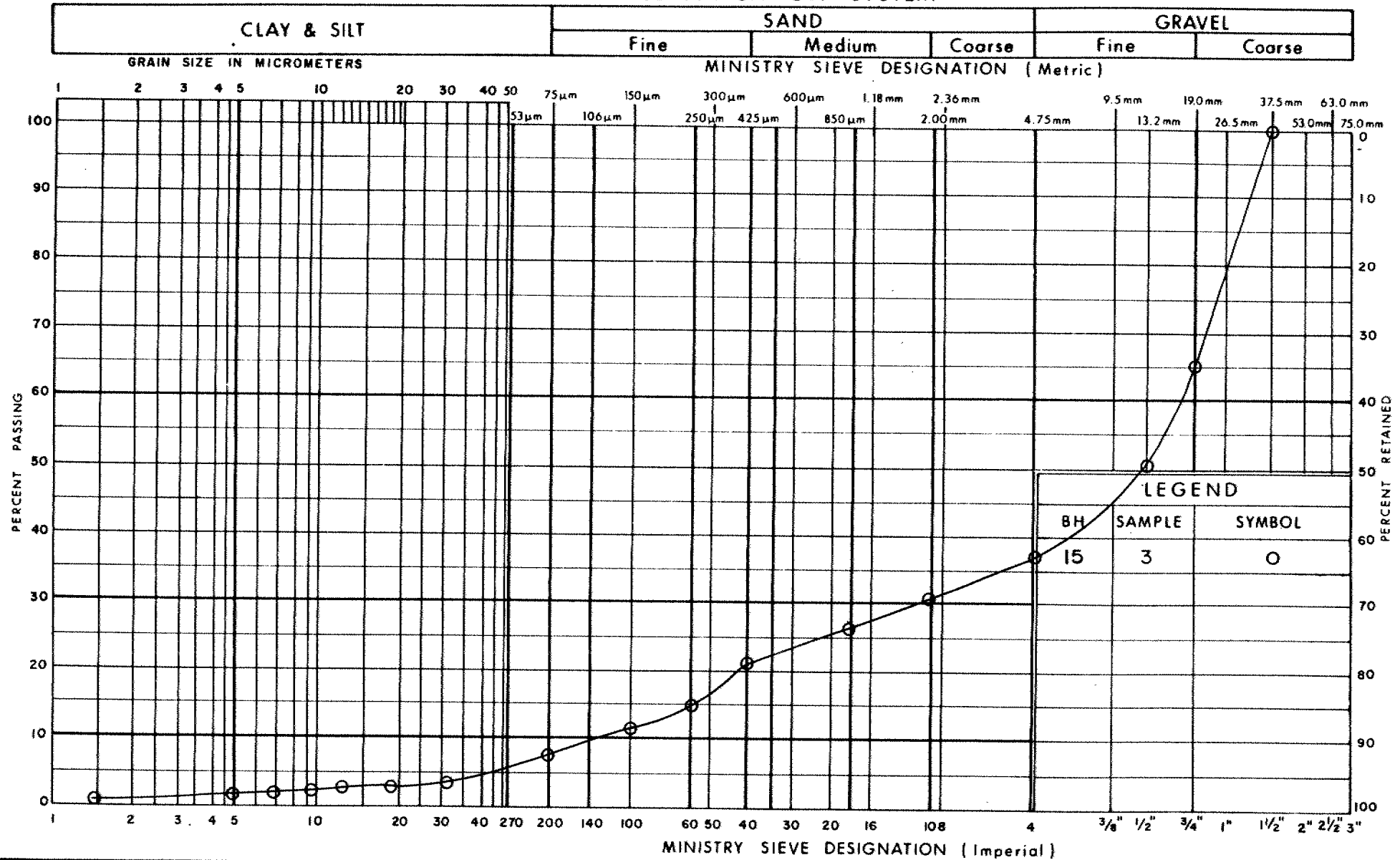
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
135.48	Ground Surface																
0.00	Topsoil																
134.88																	
0.60	Sandy Silt, trace clay and organics. Compact		1	SS	11	Artesian Head at Elev. 140 m on completion of drilling											
134.08																	
1.40	Silty Sand, trace organics. Loose		2	SS	6												
133.38																	
2.10	Organic Silt with peat seams. Soft		3	SS	2												
133.58																	
2.90	Silty Sand and gravel, occ. organics.		4	SS	15												
131.08	Compact Grey		5	SS	10		132										
4.40	Silty Clay and clayey silt, trace sand.		6	SS	11												
	Interlayered with frequent silt partings and seams.		7	SS	7		130										
	Occasional interlayer of sandy silt, trace of clay.		8	TW	PH		128										
			9	SS	7												
	Stiff to very stiff.		10	SS	9		126										
124.81	Grey		11	TW	PH												
10.67	Silt, some sand, trace clay.		12	SS	9		124										
123.88	Loose Grey																
11.60	Sandy Silt, trace gravel and clay.		13	SS	20												
122.68	Compact Grey																
12.80	Clayey Silt to silty clay, trace to some sand, trace gravel. (Till-like texture)		14	SS	172		122										
	Hard Grey		15	SS	130		120										
118.68																	
16.80	Silt, trace clay and sand.						118										
	Very dense Grey		16	SS	115		116										
114.78																	
20.70	Sand and Gravel, trace silt.		17	SS	79		114										
112.98	Very dense Grey																

22.00 Borehole Continued

+3, x5: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION SAND AND GRAVEL

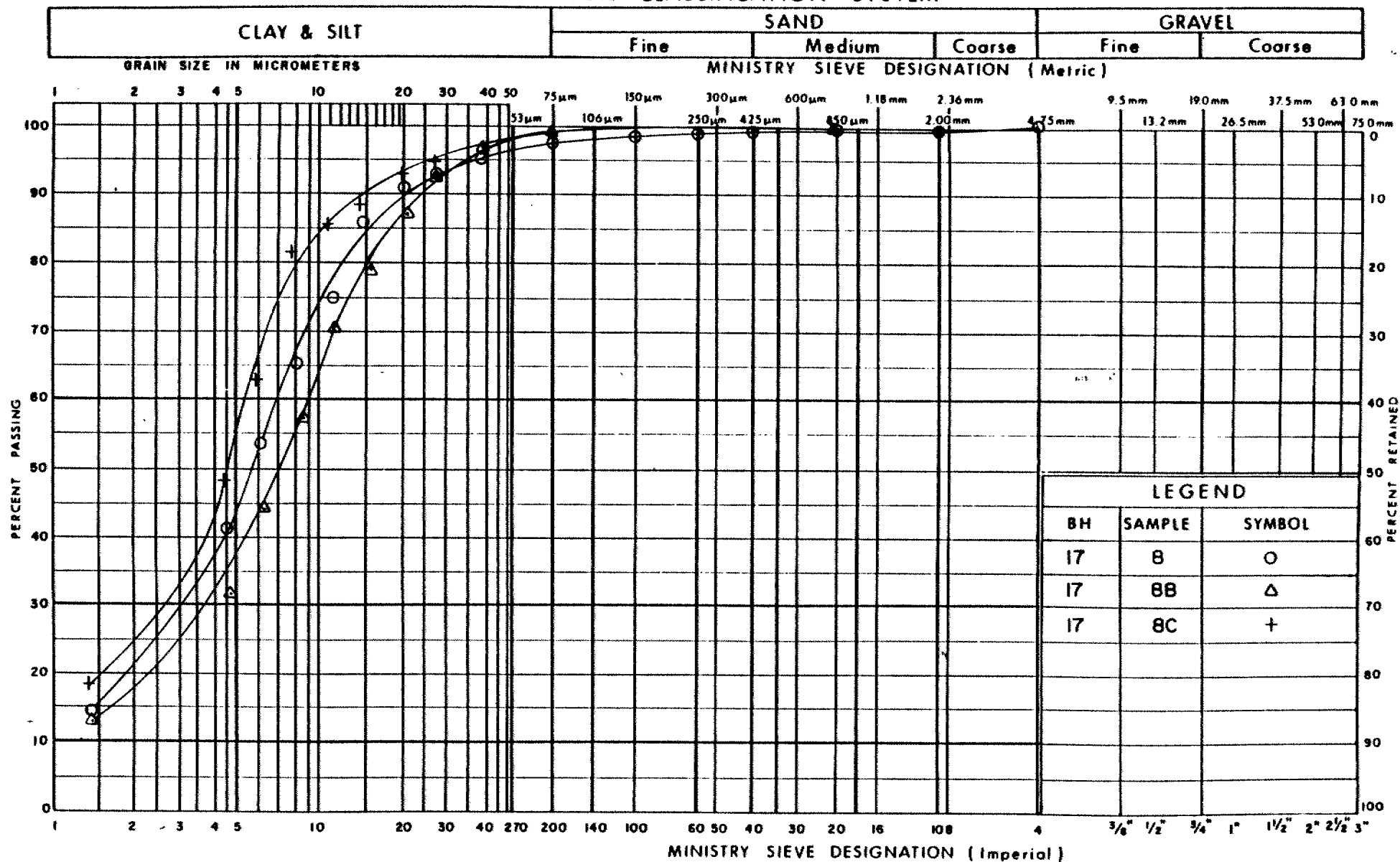
FIG No

1.

W P

88 - 78 - 32
88 - 78 - 15

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

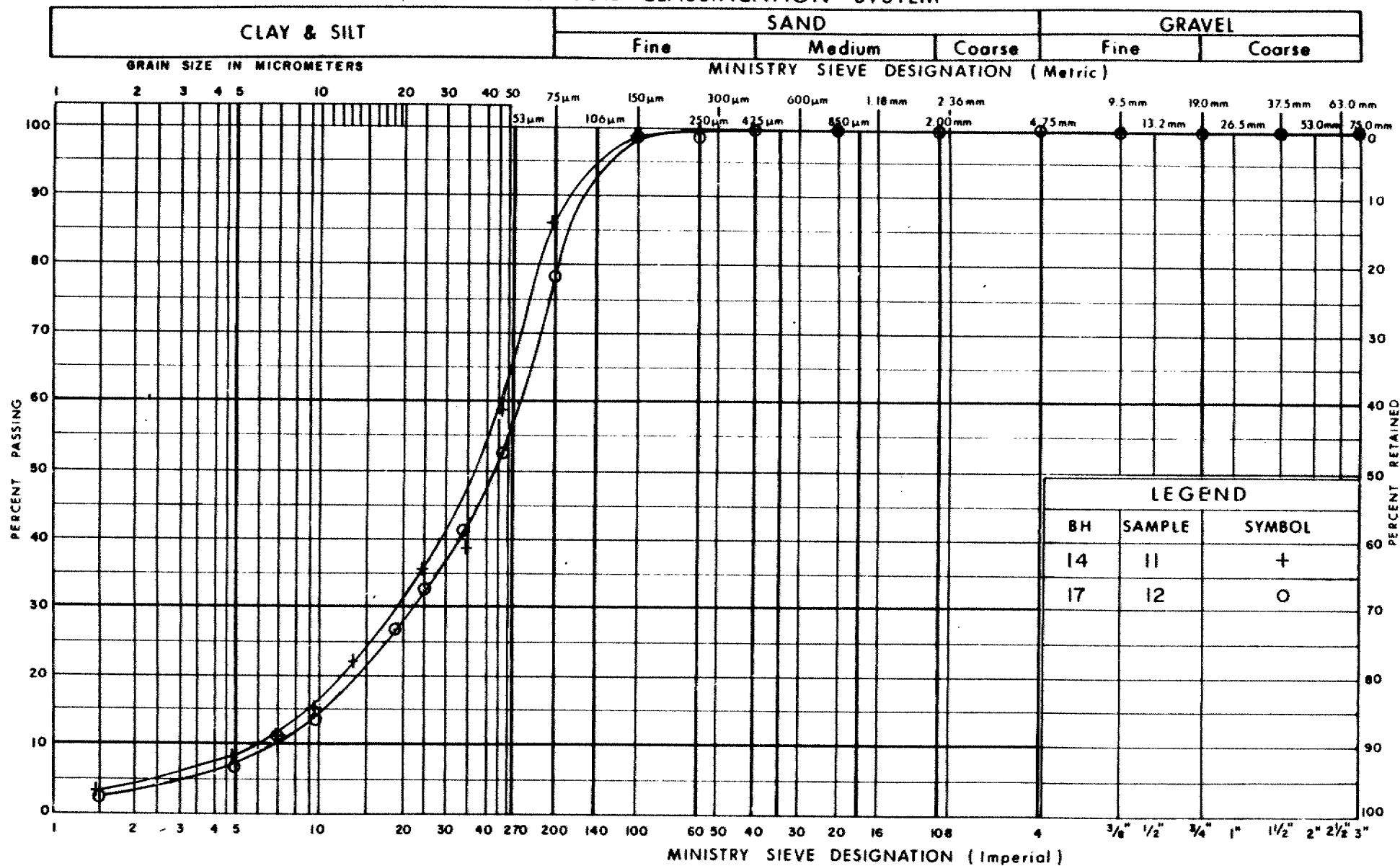
GRAIN SIZE DISTRIBUTION

CLAYEY SILT TO SILTY CLAY

FIG No 2

W P 88 - 78 - 32
88 - 78 - 15

UNIFIED SOIL CLASSIFICATION SYSTEM



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Transportation

Ontario

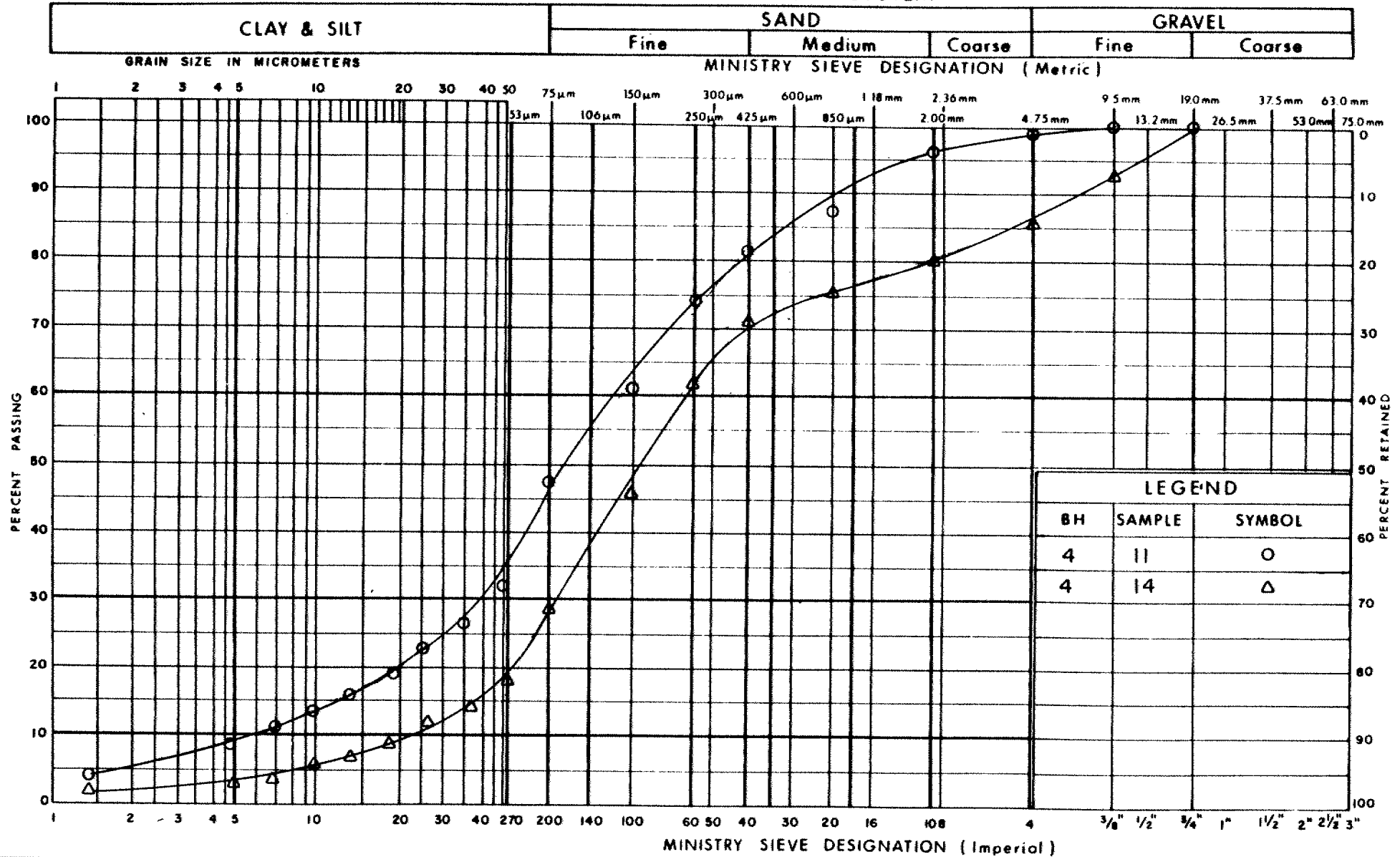
GRAIN SIZE DISTRIBUTION

SILT

FIG No 3.

W P 88 - 78 - 32
88 - 78 - 15

UNIFIED SOIL CLASSIFICATION SYSTEM

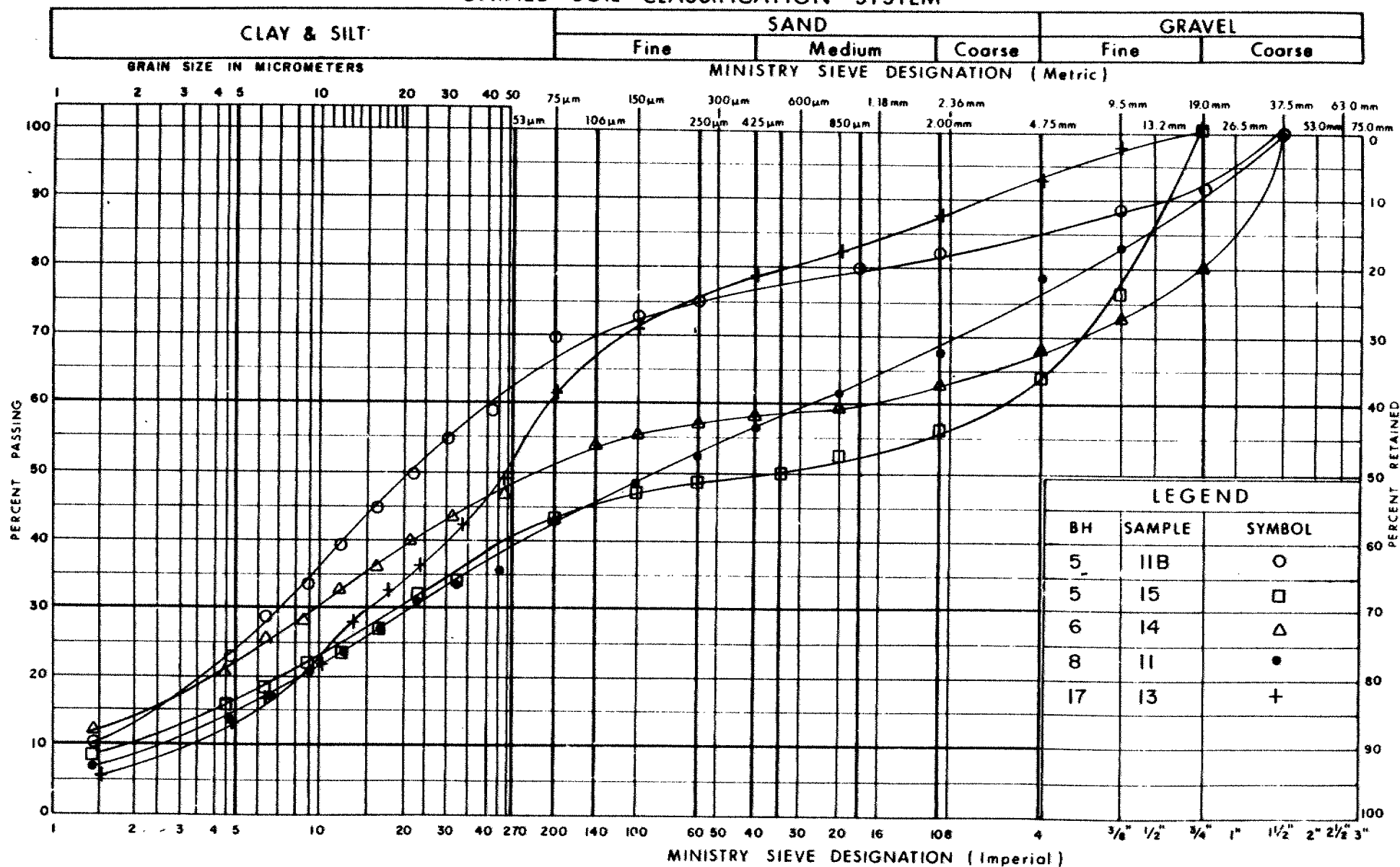


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILT AND SAND TO SILTY SAND

FIG No 4
W P 88 - 78 - 32
88 - 78 - 15

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

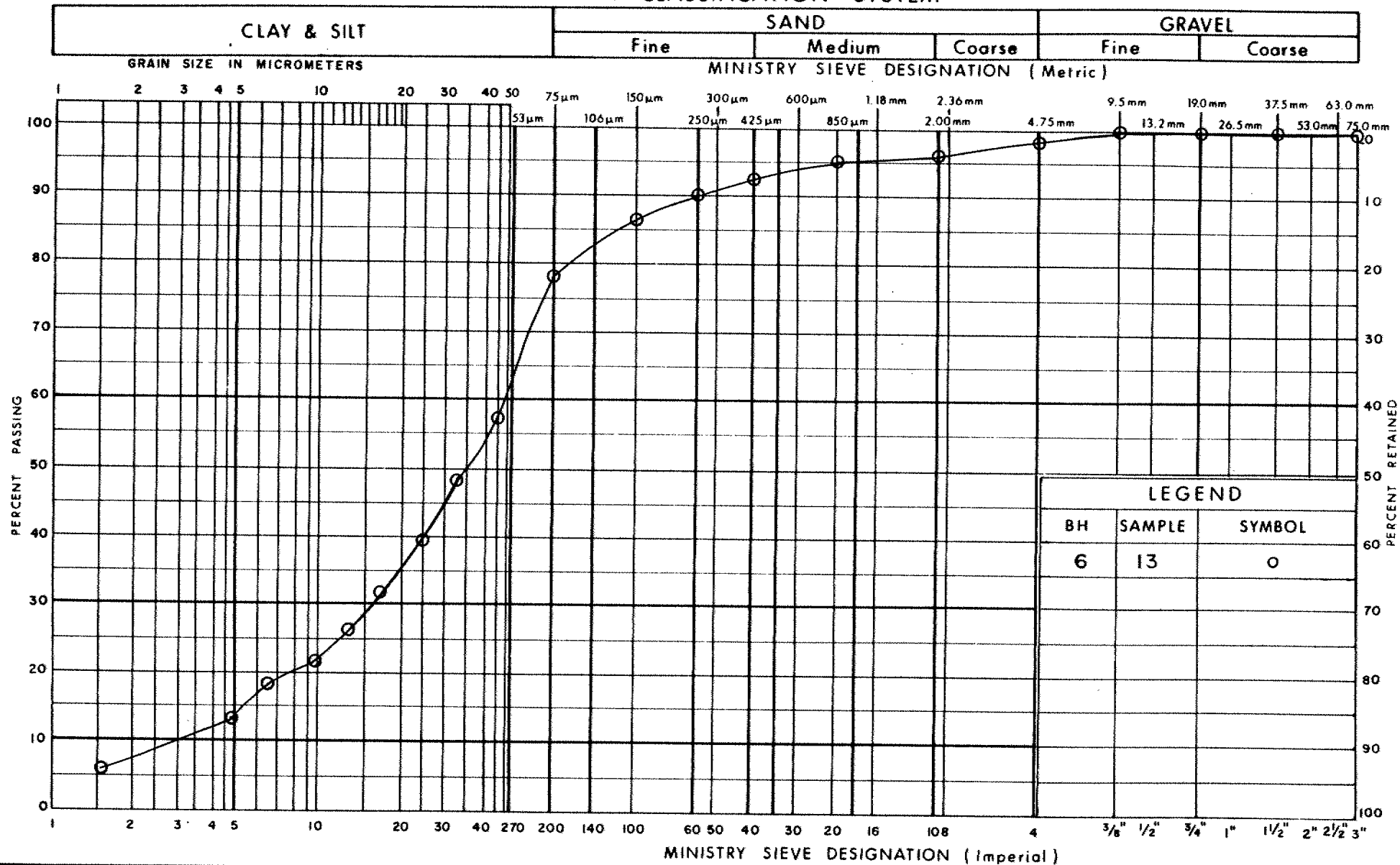
GRAIN SIZE DISTRIBUTION

SILT TILL

FIG No 5

W P 88 - 78 - 32
88 - 78 - 15

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

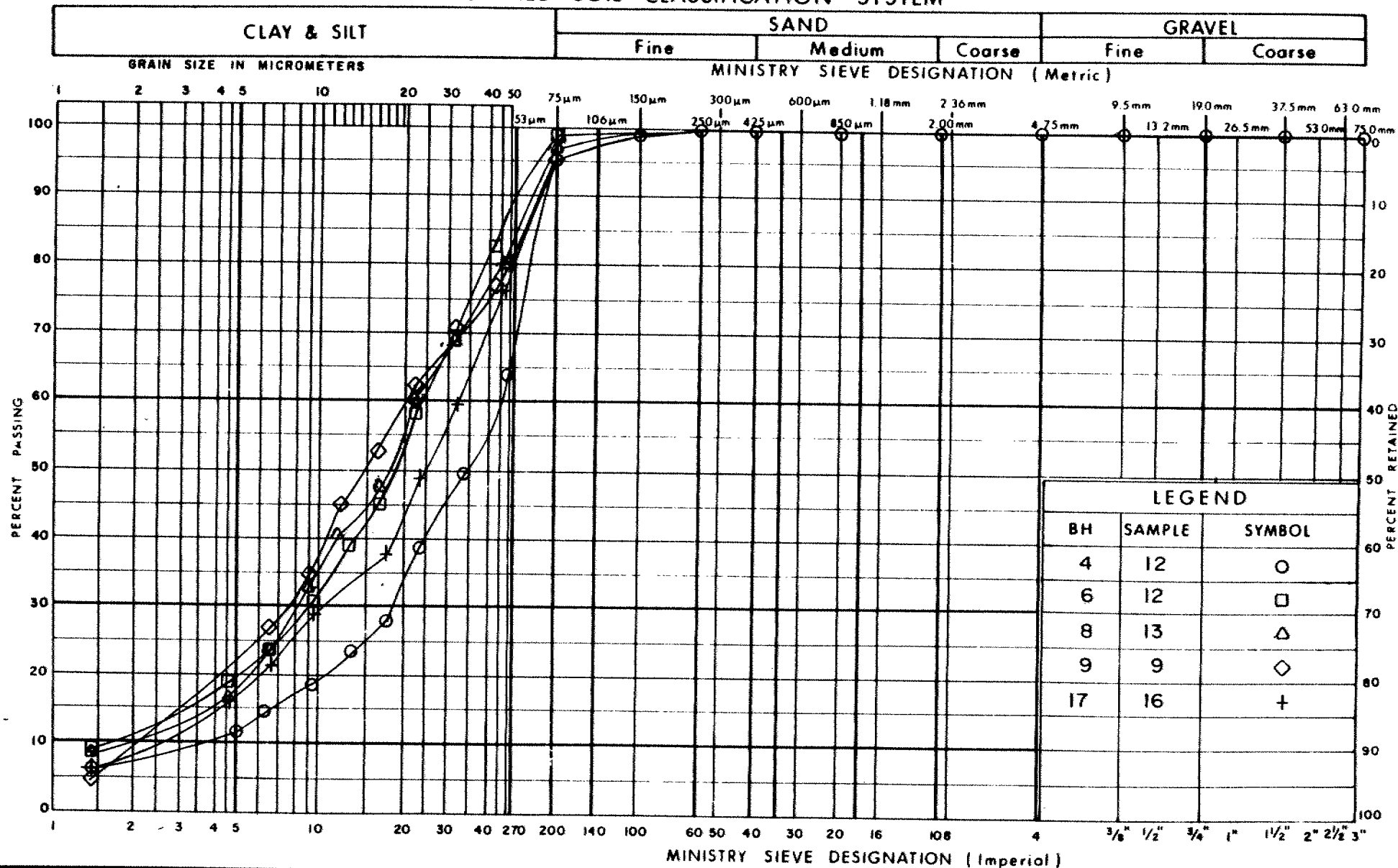
GRAIN SIZE DISTRIBUTION

SANDY SILT

FIG No 6.

W P 88 - 78 - 32
88 - 78 - 15

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

SILT

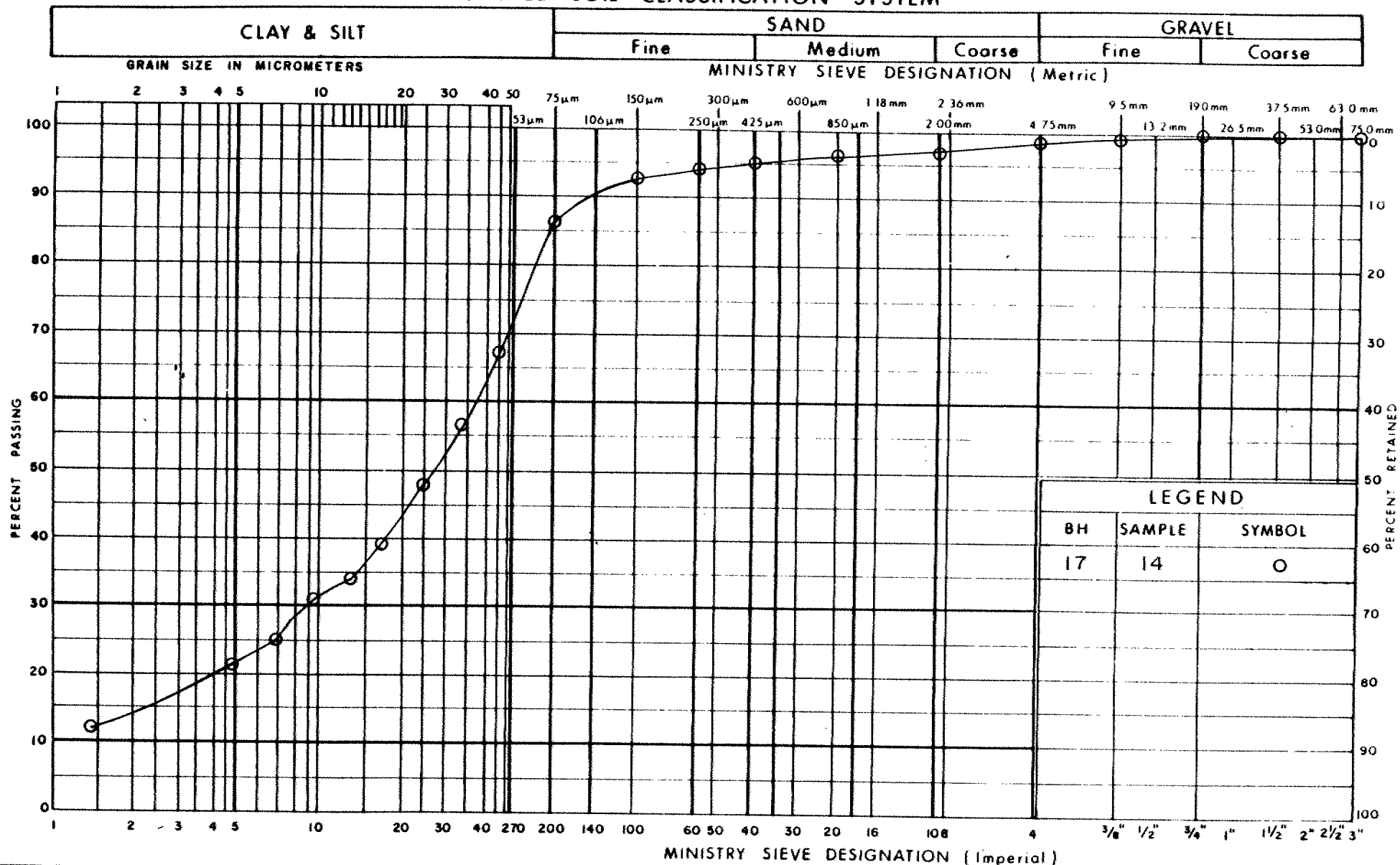
FIG No 7.

W P 88 - 78 - 32
88 - 78 - 15



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Transportation

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation

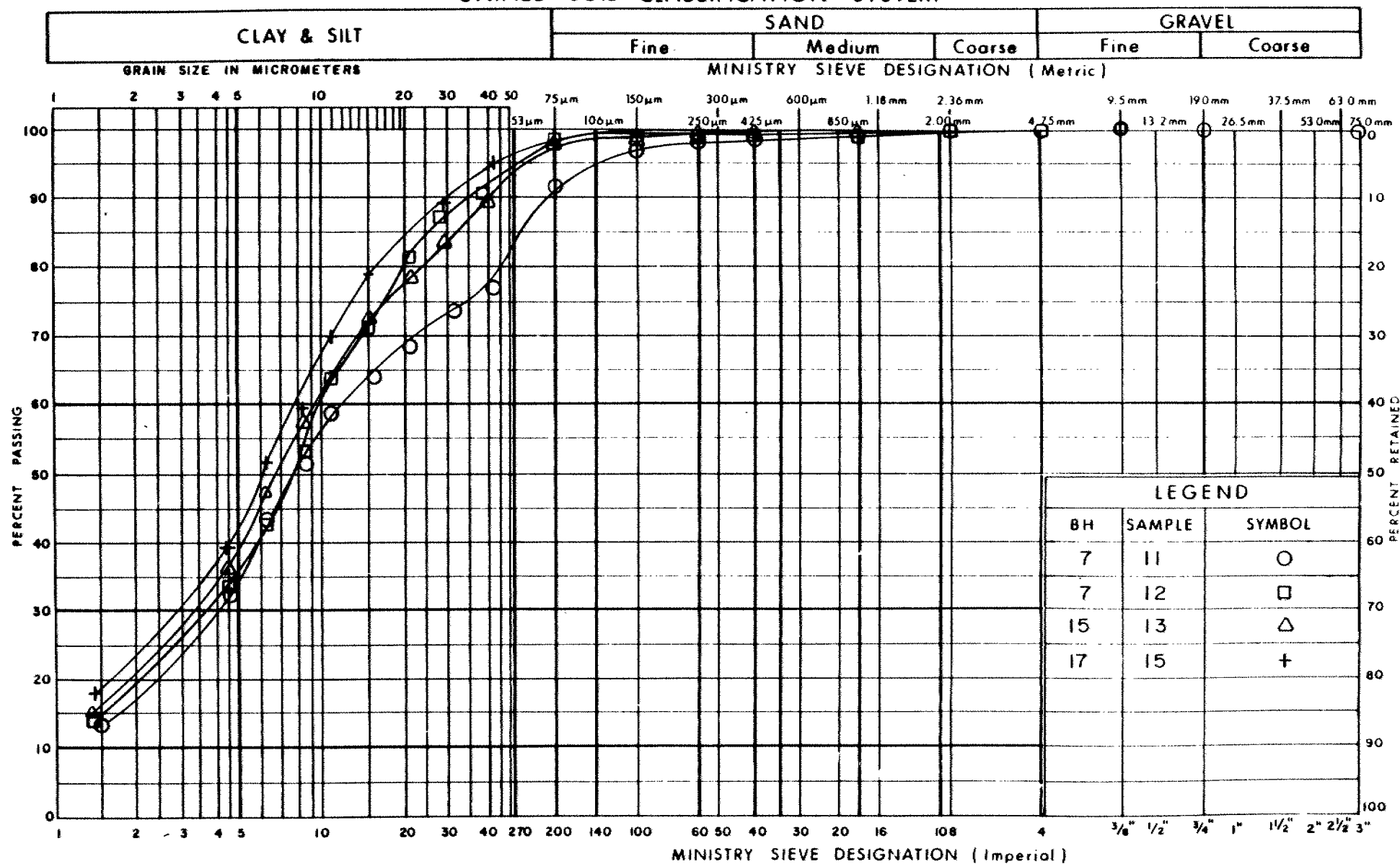
GRAIN SIZE DISTRIBUTION

CLAYEY SILT

FIG No 8.

W P 88 - 78 - 32
88 - 78 - 15

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

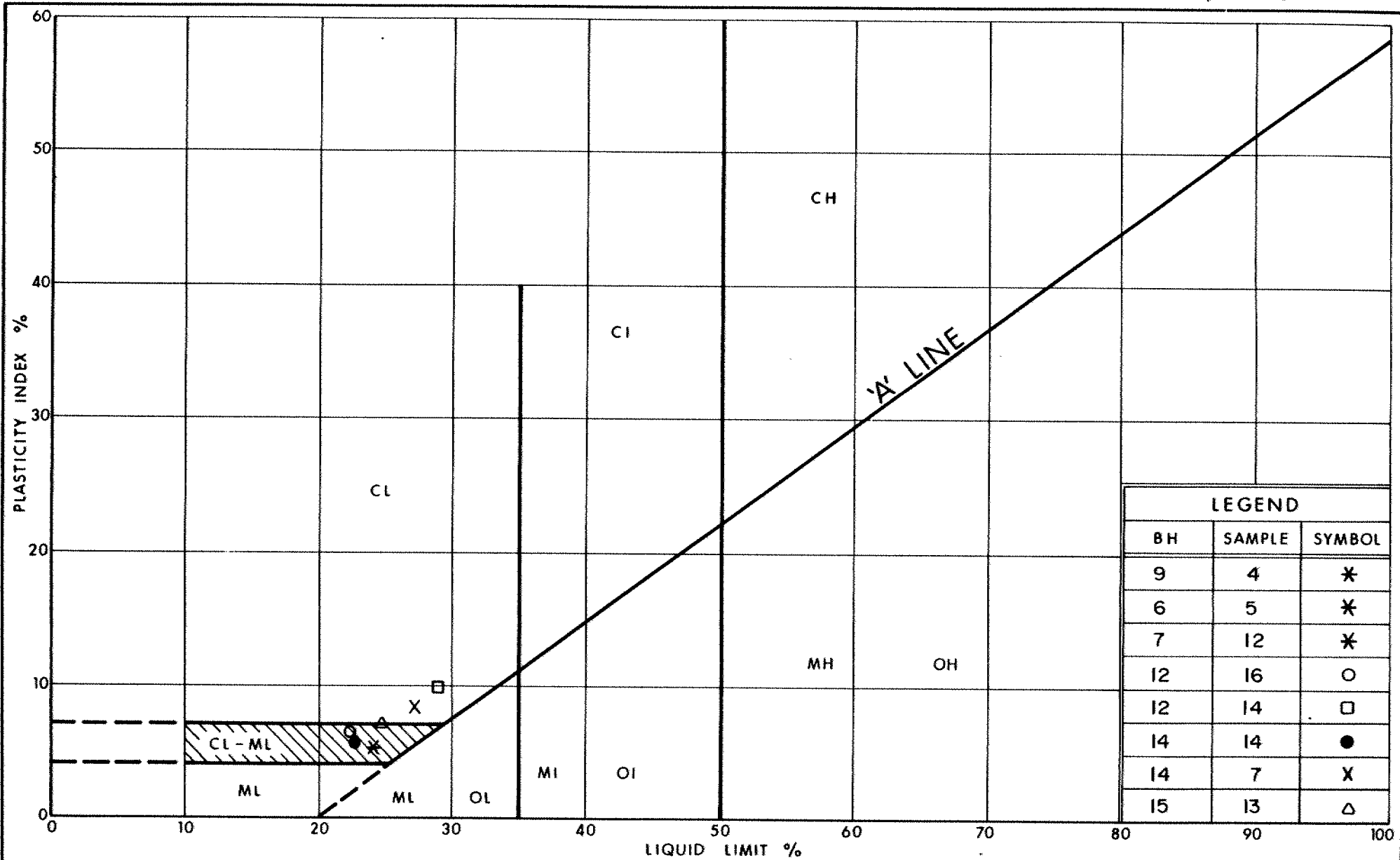
CLAYEY SILT TO SILTY CLAY

FIG No 9.

 W P 88 - 78 - 32
 88 - 78 - 15

 Ministry of
 Transportation

Ontario



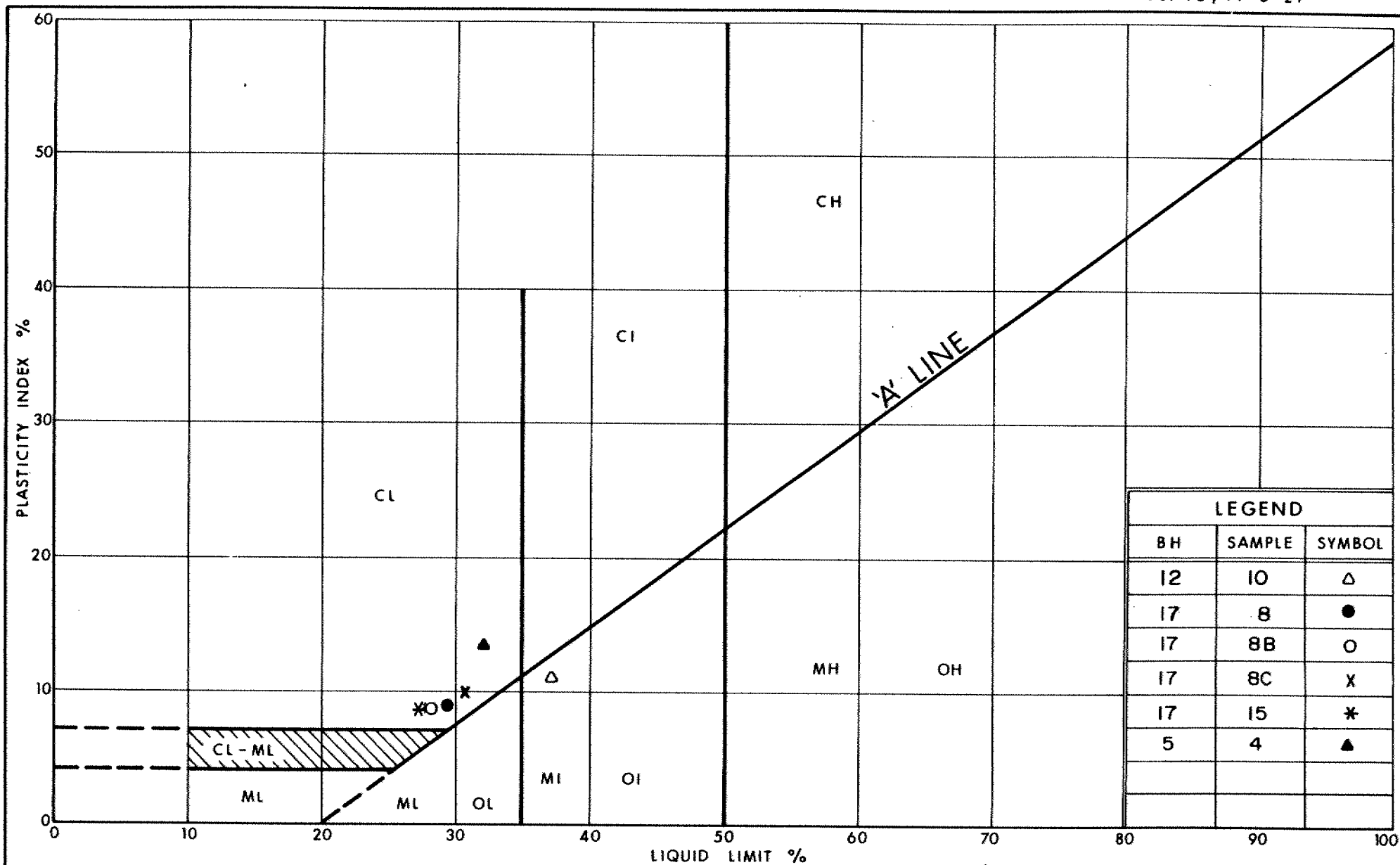
Ministry of
Transportation

PLASTICITY CHART

FIG No 10.

W P 88 - 78 - 32

88 - 78 - 15



Ontario

Ministry of
Transportation

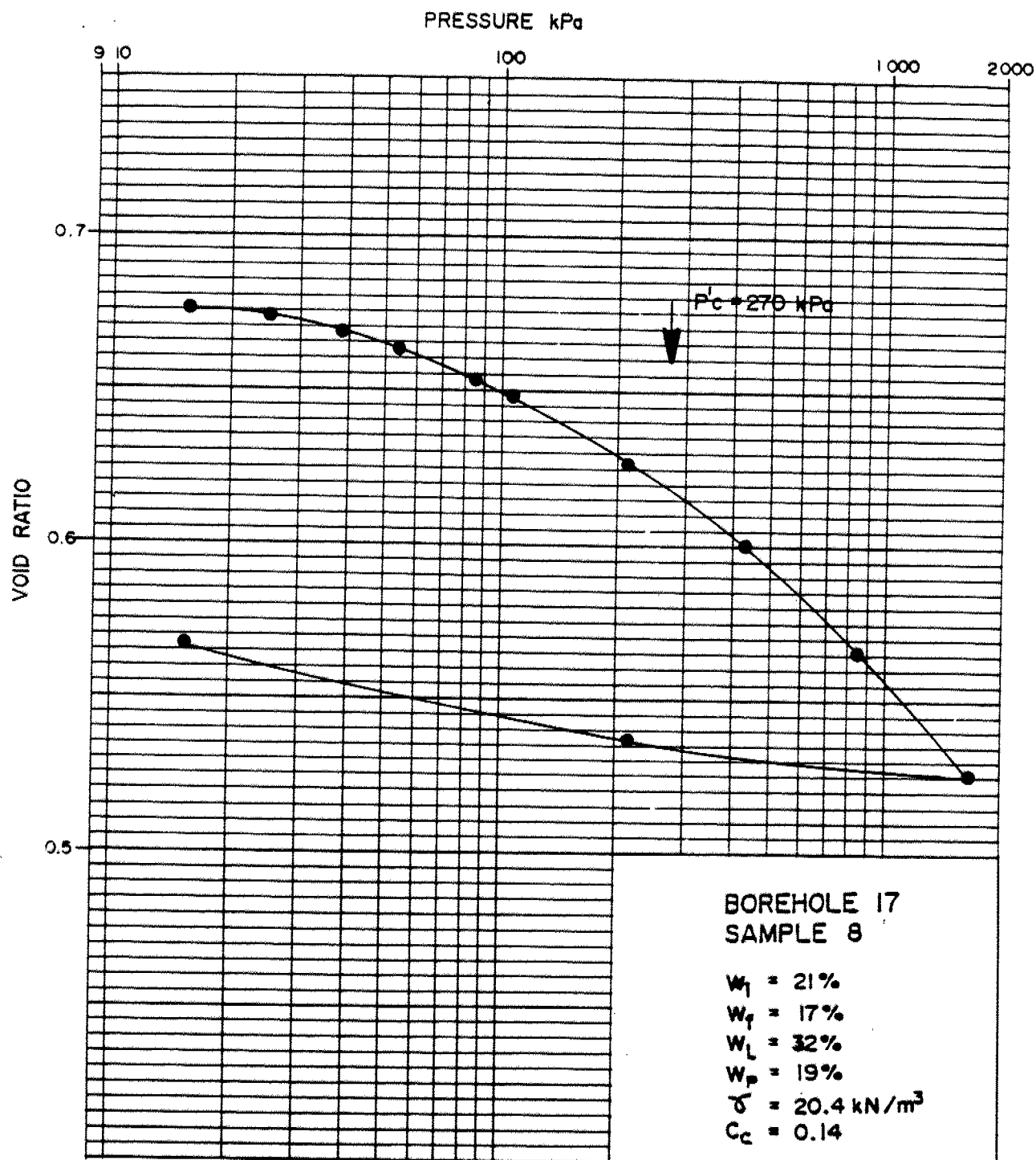
PLASTICITY CHART

FIG No II.

W P 88 - 78 - 32
88 - 78 - 15

VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

FIGURE 12.



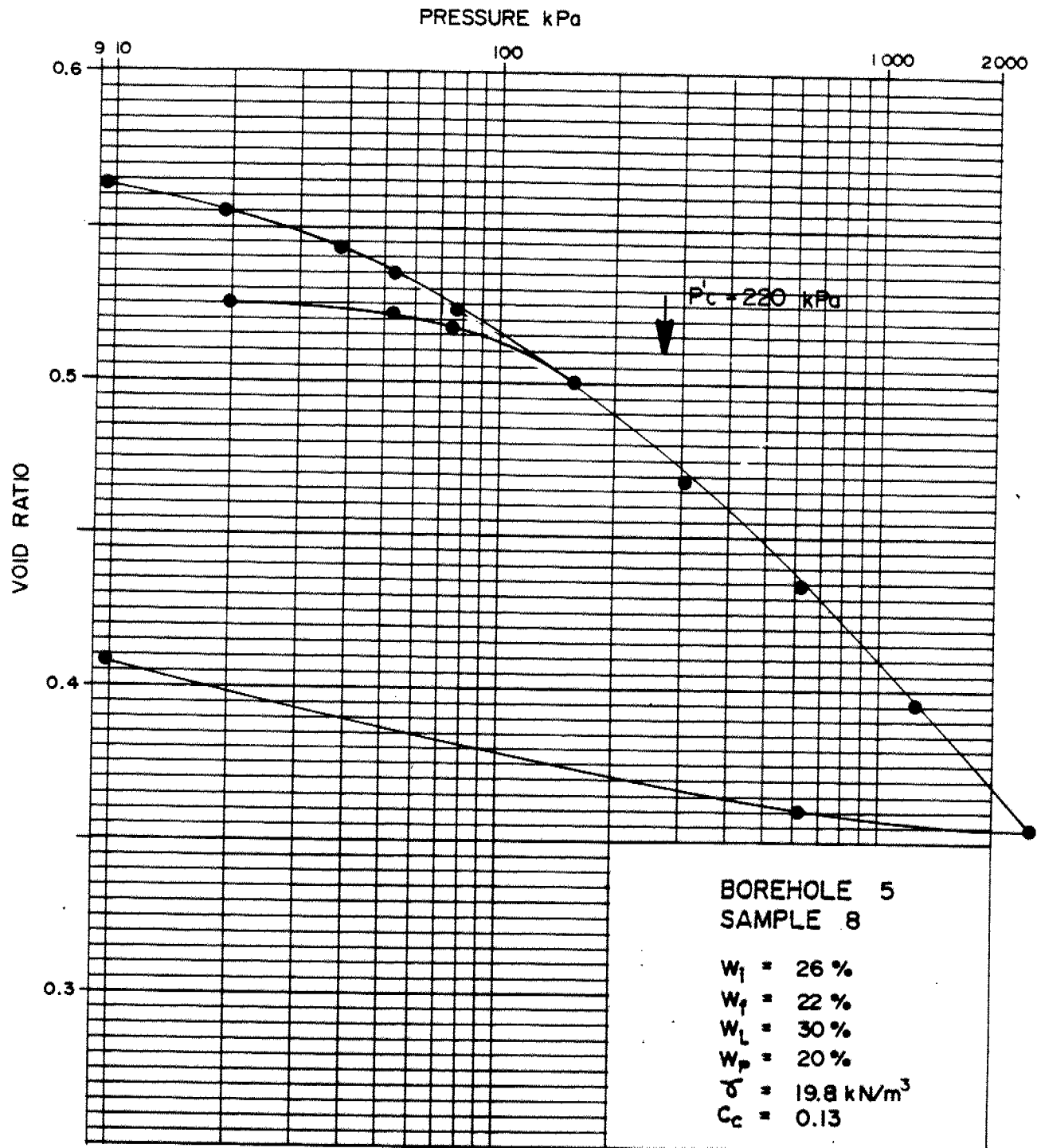
Date APRIL 26, 1990
Project 901-1314

Golder Associates

Drawn R.B.C.
Chkd. _____

VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

FIGURE 13.



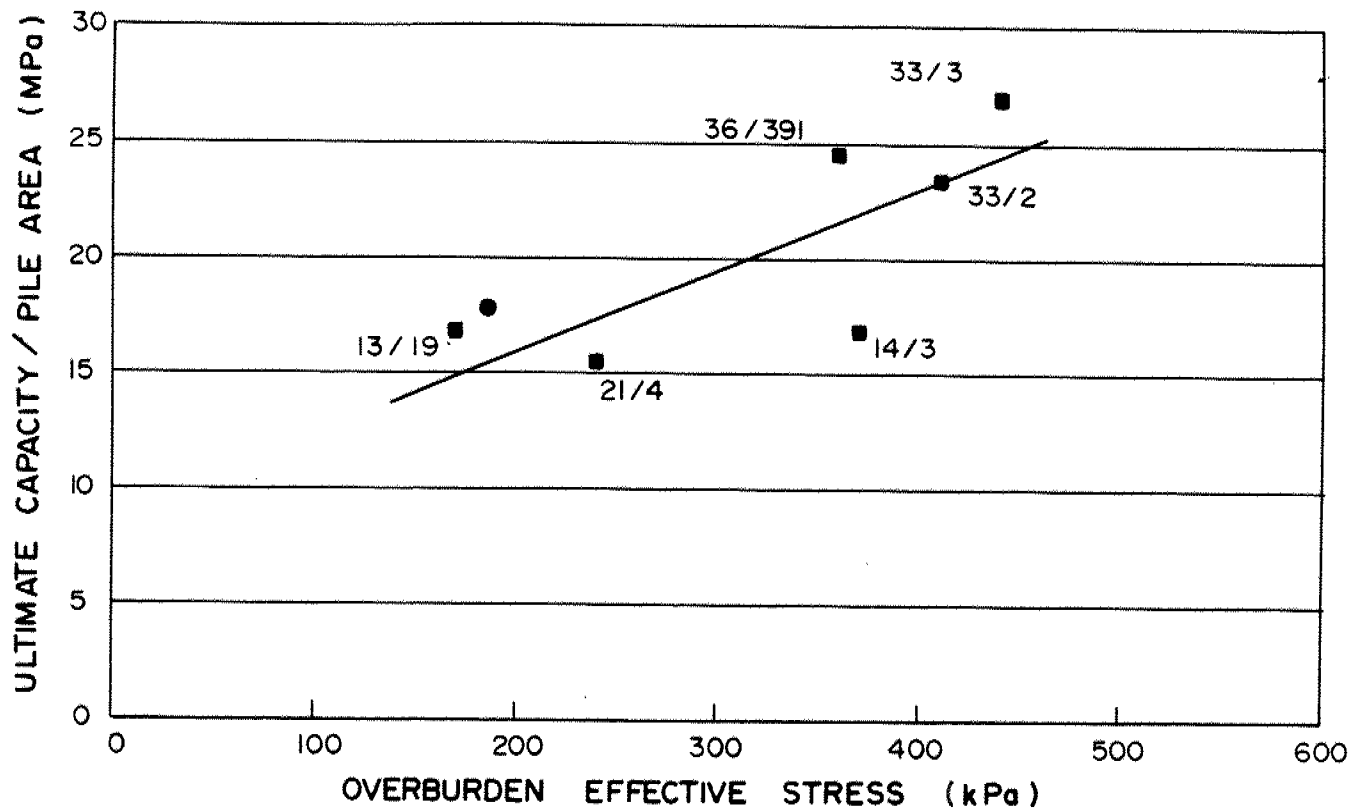
Date APRIL 26, 1990
Project 901-1314

Golder Associates

Drawn R.B.C.
Chkd. _____

ULTIMATE CAPACITY FOR PILES FOUNDED IN VERY DENSE SANDS AND SILTS

FIGURE 14.

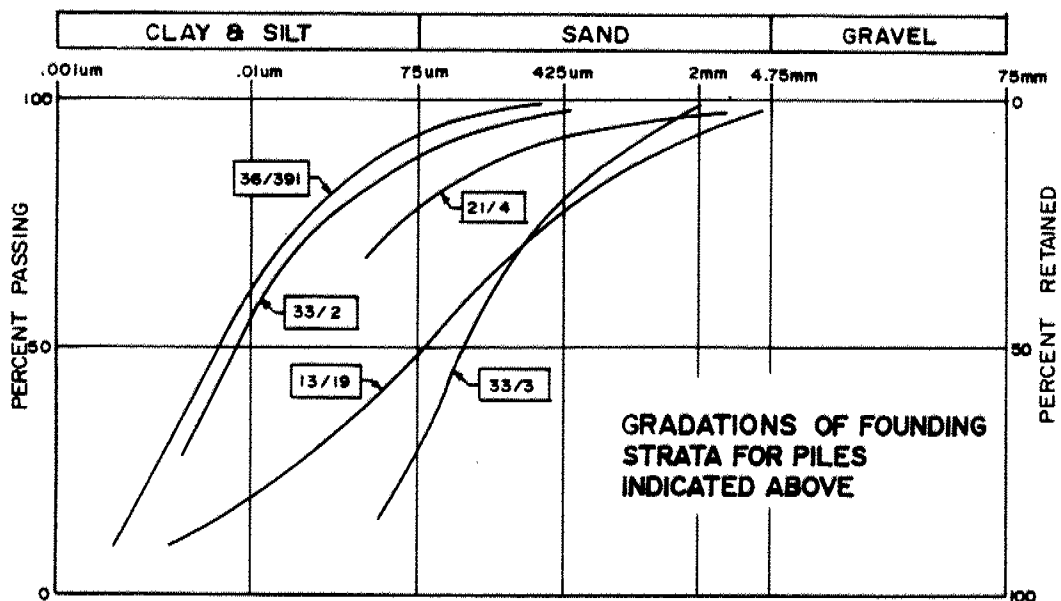


REFERENCE

MTC REPORT EM-48, JUNE 1981.

LEGEND

- SITE NUMBER
- 21/4 PILE NUMBER
- — CALCULATED CAPACITY FOR HWY. 407 / HUMBER RIVER BRIDGE

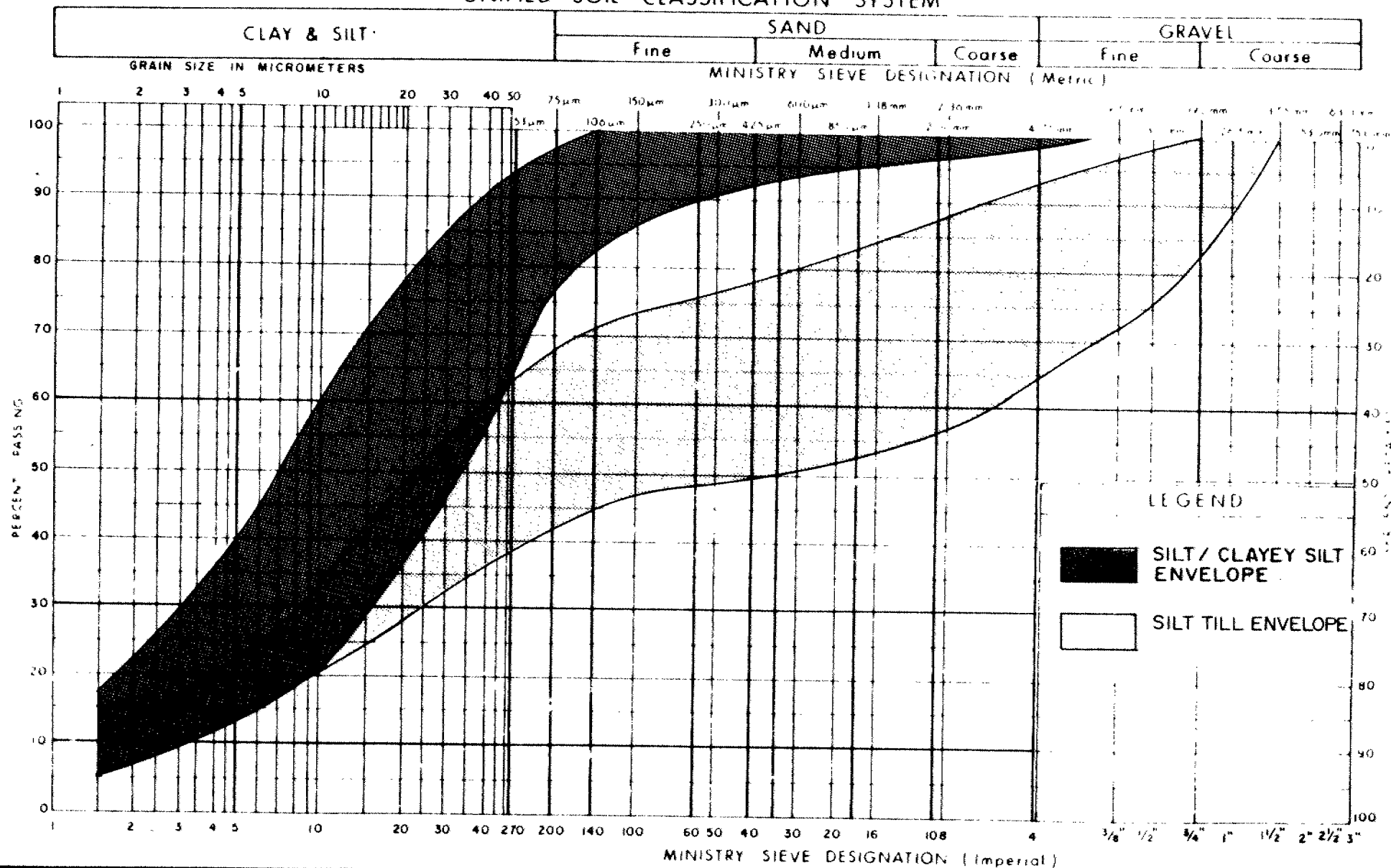


Date APRIL 26, 1990.
Project 901-1314

Golder Associates

Drawn R.B.C.
Chkd.

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
FOUNDING STRATA - HWY 407 / HUMBER RIVER

FIG No 15.

W P 88 - 78 - 32
88 - 78 - 15

OVERSIZE DRAWING



Ontario

Ministry
of
Transportation

FAXGRAM

PLEASE TYPE

DATE 1992 07 30

PAGE 1 OF 1

TO: Russ Middleton
Construction
District 6

FROM: M. Devata
Chief Foundation Engineer
Foundation Design Section

SUBJECT: Pile Driving, East Pier, E.B.L. Hwy. #407 & Humber River

Based on the Hammer information obtained from Balu Iyer, and the details of the vertical piles driven to El. 120.5 provided to us, it appears that the piles are acceptable.

The batter piles also should be driven to El. 120.5. This recommendation is applicable to this footing only and for other footings, the Foundation Design Section should be consulted.

NOTE: Please disregard the previous faxgram sent on July 30, 1992

memorandum



To: K.G. Bassi
Head, Structural Office
7th Floor, Atrium Tower

Attn: G. Al-Bazi

From: Foundation Design Section
Room 315, Central Bldg.

Re: Review of Final Drawings
Highway 407 - Humber River Bridge
✓ W.P. 88-78-15 WBL
W.P. 88-78-32 EBL
District 6, Toronto

Date: 1991 04 02

We have completed the review of the final drawings for the above project and find them to be in general agreement with the recommendations given by this office. We have the following comments on the pile foundations and the filling of the Humber River.

1. In our memo reviewing the general arrangement drawing, it was recommended that piles should be terminated at tip elevations of 120.6 m (at the east abutment) to 124.7 m (at the west abutment).

Changes should be made on Dwg. 1 regarding the above. Pile lengths should be modified accordingly.

2. The recommended pile capacities were 1200 kN (factored ULS) and 1000 kN (factored SLS).

As per note 3 on Dwg. 4, the design values used by the consultant appear to be somewhat higher.

3. Note 4 on Dwg. 4 should be reworded as follows:

Piles are to be driven to the design tip elevations shown on Dwg. 1. Pile driving should be checked using the Hiley formula to develop an ultimate capacity of 3000 kN. If sufficient pile capacity is not obtained at the proposed tip elevations, this matter should be brought to the attention of the Engineer. Under no circumstances shall the piles be driven to lower tip elevations without the approval of the Engineer.

4. The method of filling of Humber River has not been specified on the drawings reviewed.

We have not other comments. Please contact this office if you require further clarification on any aspect of this memo.

A handwritten signature in dark ink, appearing to read 'B. Iyer', with a horizontal line underneath.

Dr. B. Iyer, P. Eng.
Sr. Foundation Engineer

for

M. Devata, P. Eng.
Chief Foundation Engineer

MD/BI/jb

memorandum



To: G. Al-Bazi
Design Engineer
Structural Office
7th Floor, Atrium Tower

Date: 1990 11 05

From: Foundation Design Section
Room 315, Central Building

Re: Design Pile Capacities
Humber River Bridge - Hwy. 407
W.P. 88-78-15/32
District 6, Toronto

Further to your request, we have reviewed the pile capacities to be used in the design of the subject structure.

It is understood that at the structure locations, some fill (to about 4.5 m height) would be placed in advance of the installation of the piles. The settlement due to such advance fill would be realized in about 3 months. If the construction of the structure is carried out after the settlement is complete, then factored ULS and SLS capacities of 1300 kN and 1050 kN respectively shall be used for 310 X 110 steel H-piles. The corresponding values would be 1600 kN and 1250 kN for 310 X 132 steel H-piles.

As mentioned in an earlier memo, the pile tip elevations should be controlled, such that the piles do not penetrate into the lower aquifer possessing artesian water pressure conditions. We would be pleased to provide more detailed and specific recommendations in this regard during our review of the foundation design drawings.

Even with the above option, it is recommended that a granular blanket should be installed below the pile cap to prevent loss of fines from the subsoil strata, if some "bleeding" of artesian water pressures were to occur along the pile surface.

We trust that the information given in this memo is sufficient for your present needs. Please contact this office if you need further elaboration or clarification on any item.

A handwritten signature in dark ink, appearing to read "B. Iyer", with a horizontal line drawn underneath it.

Dr. Balu Iyer, P. Eng.
Sr. Foundation Engineer

BI/jb

cc: V. Boehnke/R. Jeffries



September 26, 1990

Mr. George Al-Bazi
Design Engineer
Structural Office
Ministry of Transportation of Ontario
Seventh Floor
Atrium Tower
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8



Dear George:

Re: Highway #407 — Humber River Bridge
Eastbound Lane — W.P. 88-78-32
Westbound Lane — W.P. 88-78-15
Site 37-973
District 6, Toronto
Foundation Cost Analysis
Based on Allowable Bearing Capacity of Pile

We refer to your telephone conversation with our Mr. A. T. Chan on this subject, and wish to report the findings of our analysis, as follows:

The current foundations of the bridge have been designed, based on an ultimate bearing capacity of 1,200 kN per HP 310 x 110 pile. The preparation of the foundation drawings is nearly complete. The total number of piles required for the entire project is 328.

If the ultimate bearing capacity per pile is increased to 1,600 kN, the total number of piles required is reduced to 252 (i.e., a reduction of 76 piles).

The total construction cost of the project will be reduced by \$190,000, if the ultimate bearing capacity of 1,600 kN, rather than 1,200 kN, is adopted. This is based on an average depth of pile of fifteen metres, a unit price of \$150 per metre, a contingency factor of 1.05 x 1.10, and a nominal increase in reinforcement for the pile caps as a result of greater pile spacing.

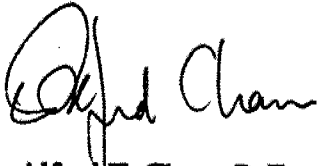
If the ultimate pile bearing capacity of 1,600 kN is adopted, our additional fee to redesign and revise the foundation drawings, and to prepare the pile tests in the contract, will be \$6,000.00, including disbursements.

We trust that the above information is satisfactory to you.

Yours very truly,



Edward K. Y. Li
Project Engineer



Alfred T. Chan, P. Eng.
Project Manager

EKYL/kslb

10-324.00

cc: Mr. R. Jeffries - MTO, Central Region

1000

MEMORANDUM

To: V.F. Boehnke
Head, Structural Section

Attn: R. Jefferies

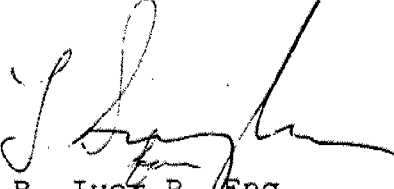
From: Foundation Design Section
Room 315, Central Building

Subject: Humber Bridge - Hwy 407.
Approach Fills
W.P. 88-78-15/32

90 07 17

This in reply to your memo dated May 15, 1990.

1. The total height of fill at this site would be about 8 m. The estimated settlement for this fill would be about 90 mm. if the first lift is limited to 4 m, the estimated settlement would be about 70 mm. Placement by the remainder of the fill would then result in settlement of less than 25 mm.
2. As discussed earlier, special slope erosion protection should be provided upto the expected flood water level. The typical details are shown on the attached sketch.


B. Iyer P. Eng
Sr. Foundation Engineer

BI/lh

MEMORANDUM

To: K.G. Bassi
Head, Structural Office

Attn: G. Al-Bazi

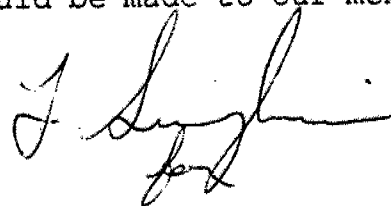
From: Foundation Design Section
Room 315, Central Building

Subject: Review of General Arrangement
Drawing
W.P. 88-78-15
W.P. 88-78-32
Hwy 407 - Humber River Bridge

90 07 13

We have reviewed the above general arrangement drawing and find that the data shown are generally in agreement with our recommendations. However, we have the following general comments:

1. The pile tip elevations should be maintained at or above elevation 120.6 m to 124.7 m , in order to avoid penetrating the lower artesian zone.
2. For piles capacity, reference should be made to our memo dated 90 04 26. (see attached)



B. Iyer, P. Eng
Sr. Foundation Engineer

For

M. Devata, P. Eng
Chief Foundation Engineer

BI/lh

MINISTRY OF TRANSPORTATION

M E M O R A N D U M

To: Dr. Balu Iyer
Senior Foundation Engineer
Rm 315, Central Building

Date: May 15, 1990

From: Structural Section
Central Region



Re: Hwy 407 - Humber River Bridges

As discussed at our meeting of 90/05/08, advanced fill placement is required to minimize the consolidation settlement at the abutments. I requested a minimum fill elevation, which would produce an acceptable settlement range.

We also discussed load testing of piles and the affect of flooding on the abutment fills, both during construction and as a permanent situation.

Please provide recommendations on any requirements for load testing and the concern of flooding.

A response by 90/05/25 would be appreciated.

A handwritten signature in black ink, appearing to read "R. Jeffries".

R. Jeffries
Structural Technician
for:
V. F. Boehnke
Head, Structural Section

RJ/ks

memorandum



To: V. Boehnke
Head, Structural Section
4th Floor, Atrium Tower

Date: 1990 04 26

Atten: R. Jeffries

From: Foundation Design Section
Room 315, Central Building

RE: Preliminary Design Recommendations
Hwy. 407 - Humber River Bridge
W.P. 88-78-15 & 32
Site 37-973, District 6, Toronto

This memo accompanies preliminary design recommendations received on the above project from Golder Associates Limited, our geotechnical consultant for this project.

They have recommended that the proposed structures should be supported on deep foundation, such as Steel 'H' piles or 324 mm diameter steel tube piles, driven to elevation 118 to 123 m. They have preferred the latter pile type for this site. Recommendations are also given in the attached letter for factored ULS (axial-vertical) capacities and factored ULS and SLS lateral capacities.

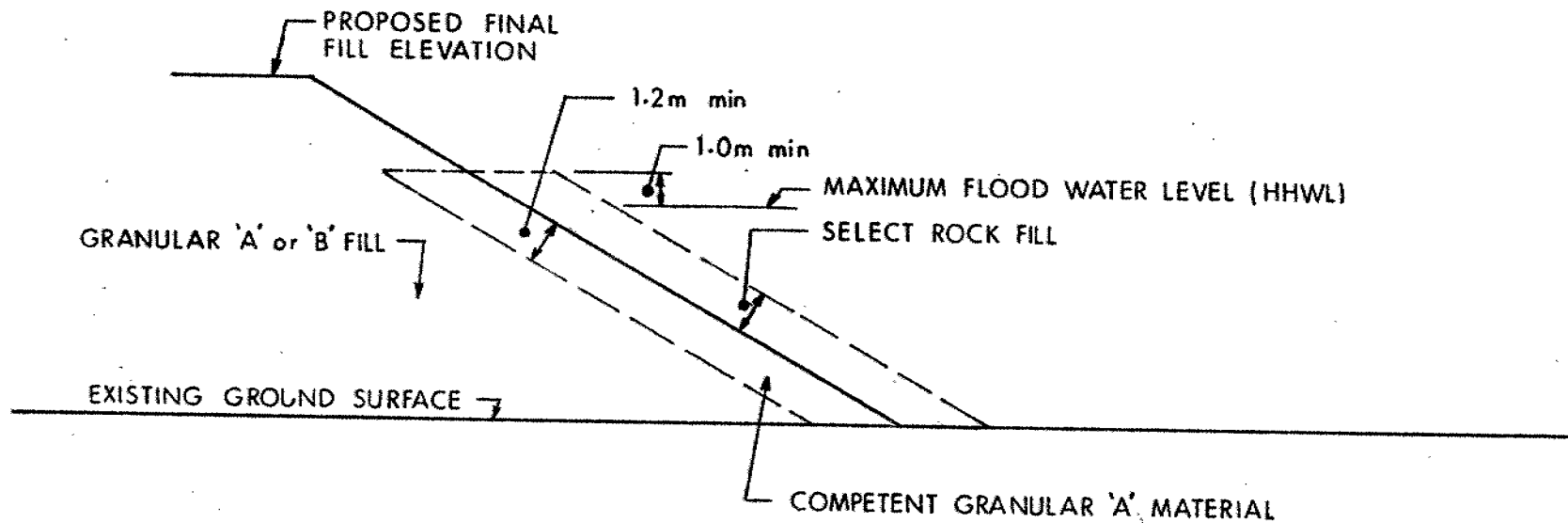
Based on several discussions with the geotechnical consultant and a review of the data given in the attached letter and our past experience with similar conditions elsewhere, we would recommend the following for the foundation design. Steel H piles 310 x 110 mm, driven to elevation 118 to 123 would have a factored U.L.S. and S.L.S. capacities of 1200 kN and 1000 kN respectively. Lateral loads should be carried by batter piles. The consolidation settlement of the foundation soils would be complete in a short time, say about 3 months following the completion of the fill placement. If the piles are installed after this time, then downdrag forces on the piles would be negligible and can therefore be ignored.

If you require further elaboration on any aspect of the attached letter or this memo, please contact this office. Due to difficulties (artesian water pressure conditions) encountered at the site, the fieldwork took more time than anticipated. This resulted in the delay in providing design recommendations for this project. We regret any inconvenience caused because of this.

A handwritten signature in dark ink, appearing to read "B. Iyer", written over a horizontal line.

Dr. Balu Iyer, P.Eng.
Sr. Foundation Engineer
for

M. Devata, P. Eng.
Chief Foundation Engineer



TYPICAL SLOPE EROSION PROTECTION
407 - HUMBER APPROACH FILLS



Golder Associates Ltd.
CONSULTING ENGINEERS

March 27, 1990

Our ref.: 901-1314

Ministry of Transportation of Ontario
1201 Wilson Avenue
Central Building, Room 315
Foundation Design Section
Downsview, Ontario
M3M 1J8

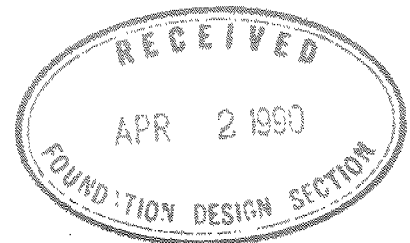
ATTENTION: Dr. B. Iyer, P.Eng.

RE: GEOTECHNICAL INVESTIGATION
HWY 407 - HUMBER RIVER BRIDGE
EASTBOUND LANES - W.P. 88-78-32
WESTBOUND LANES - W.P. 88-78-15
SITE 37-973, DISTRICT 6, TORONTO

Dear Sirs:

This letter presents the preliminary results of the geotechnical investigation carried out at the above site. The drilling program for this investigation is completed, however, the laboratory testing and field measurements are not yet finished. This letter addresses the results as currently available.

It is understood that the project involves the design and construction of two three span bridges to carry the proposed Highway 407 over the Humber River. The two structures (eastbound and westbound) have total length of 130 m and are separated by a distance of 18.5 m centreline to centreline. It is understood that the east and west approach embankments will be about 8 m high.



Investigation Procedures and Subsurface Conditions

Three boreholes have been put down to depths of about 15.5 m to 25.4 m below ground surface along the alignment for each of the proposed piers and abutments. Two boreholes and one piezocone test have been put down to a depth of about 9 m below ground surface along the west approach to the bridge. Two boreholes were drilled in the vicinity of the proposed diversion channel. A further two piezocones were put down to a depth of about 9 m adjacent to the northern borehole at each of the abutment locations to provide additional subsurface data and to provide some stratigraphic correlation.

In general, the subsoils encountered at the borehole locations consist of a surficial layer of topsoil and sandy silt underlain at depths ranging from 1.2 m to 2.9 m by about 0.8 m to 2 m of a waterbearing sand and gravel deposit.

The granular materials are underlain by about 5.5 m to 10 m of a deposit consisting of interlayered to stratified clayey silt and silt. The piezocone traces indicate that the frequency of silt interlayering within this deposit is extremely variable across the site. The measured consistency of the layered deposit is also variable at the borehole locations. Standard Penetration ('N') values ranged from 3 to 24 blows per 0.3 m of penetration. Undrained shear strength values, measured by in-situ vane tests, ranged from about 42 kPa to greater than 96 kPa. Preliminary interpretation of the piezocone test results indicate undrained shear strengths which range from about 50 kPa to 165 kPa at the piezocone probe locations. The results of a consolidation test carried out on a sample of clayey silt, obtained at a depth of 7.2 m below ground surface from the borehole located at the north limit of the east abutment, indicate that the preconsolidation pressure of the sample is about 220 kPa reflecting an overconsolidation ratio of about 3.5.

The layered silts and clayey silts are underlain at depths of about 8.5 m to 12 m by a deposit which ranges in composition from silt to sand and silt. Blowing of the fine granular materials occurred within this deposit at most of the borehole locations. Based on observations during drilling, it is considered that the deposit is in a loose to compact state of packing.

The sand and silt deposit is underlain at depths of about 13 m to 15 m by a hard/very dense till deposit which ranges in composition from clayey silt to sandy silt and contains a variable proportion of gravel. The surface of the deposit was generally encountered at about Elevation 122 m in the boreholes located on the east side of the river and at Elevation 120.5 m to Elevation 123 m in the boreholes on the west side of the river. 'N' values measured in this deposit were generally greater than 100 blows per 0.3 m of penetration. The silt content of this stratum increases with depth and the deposit grades to a silt containing trace sand and clay.

Where the till and silt strata were penetrated (in two of the boreholes on the east side of the river), they were found to be underlain by a sand and gravel deposit which was encountered at Elevation 115 m to Elevation 116 m (about 19.5 m to 20.5 m below ground surface).

During drilling of the two boreholes which penetrated the lower sand and gravel deposit on the east side of the river, artesian water pressure conditions were encountered as soon as this strata was penetrated. The head of water was estimated to be about 4.6 m above ground surface based on the height to which the water level rose within the hollow stem augers which were installed at ground surface. These two holes were packed off and cement grout was pumped into the borehole to stop the flow. Artesian pressure conditions were also encountered in the boreholes on the east side of the river which were

terminated within the till or the underlying silt strata; in these boreholes, the water level rose to ground surface within a few hours of completion of the drilling.

Piezometers were sealed into the various strata encountered during drilling of the boreholes. Although head measurements have not been obtained yet on all of the piezometer installations which were sealed into the till and overlying sand and silt strata, the measurements taken to date indicate a piezometric level in these strata at about Elevation 136 m to Elevation 140.5 m (about 1.4 m to 5.2 m above ground surface) on both sides of the river. Piezometers sealed into the layered silt and clayey silt deposit indicate the piezometric level to be about 0.3 m below ground surface to 0.3 m above ground surface dependant on the elevation of the tip. The water level in a piezometer installed in the upper sand and gravel was at about 1.2 m below ground surface, coincident with the adjacent river water level. These results reflect an upward gradient through the strata present between the lower sand and gravel deposit and the surficial sands.

Discussion

The soils within several metres of ground surface are extremely variable at this site, as is typical of floodplain deposits, and probably due in part to the continual upward seepage which occurs. Spread footings are not recommended because of the variability and because of the disturbance which could occur during excavation in sand deposits above the water table.

It is recommended that the piers and abutments be supported on driven piles founded on the hard/very dense till deposit encountered at about Elevation 120.5 m to Elevation 124 m. Piles should be terminated as high as possible within the till deposit to minimize the possibility of penetrating the lower sand and gravel deposit which would permit

direct access to the artesian water conditions. It should be noted, however, that the piezometers installed in the boreholes terminated above the sand and gravel deposit also registered artesian pressure conditions. The potential for creating a path along the pile for water migration to ground surface exists and provision should be made to account for loss of skin friction during the design life of the piles.

Consideration could be given to steel H piles or closed ended steel pipe piles. We have a preference for pipe piles at this site due to the requirement to stop the piles as high as possible in the till.

It is estimated that about 90 mm of settlement of the approach fill embankments due to consolidation of the layered silty clay deposit. At the abutment locations, a resultant negative skin friction will develop on the upper section of the pile within the firm to stiff clay. The negative skin friction in the upper clay will be approximately balanced by positive skin friction developed in the till. The net effect of this will be for the end bearing resistance of the pile to provide the total available pile capacity.

For preliminary design, a factored capacity at ultimate limit states of 400 kN and a capacity at serviceability limit states of 320 kN may be assumed for 0.3 m diameter pipe piles or HP 310 x 110 piles driven 1.5 m into the till.

For resistance to lateral loads, the horizontal reaction to the piles can be calculated from the expression:

$$k_h = n_h z/B$$

where:

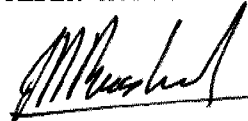
k_h is the horizontal reaction pressure per unit deflection
 n_h is the constant of horizontal subgrade reaction
 z is the depth below the adjacent ground surface (in meters)
 B is the pile or caisson diameter (in metres)


For piles with their upper section in the surficial sands and the layered clayey silt deposit, the value of the product n_h times z should be taken as a constant equal to 4 MPa.

We trust that this letter is sufficient for your immediate requirements. Please do not hesitate to contact us if any of this information require further clarification.

Yours truly,

GOLDER ASSOCIATES LTD.


A.S. Poschmann, P.Eng.


J.R. Busbridge, P.Eng.

ASP/JRB/kvb

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30MB-127 & 128

DIST. 6 REGION

W.P. No. 527-91-01 A/B

CONT. No. 93-72

W. O. No.

STR. SITE No. 37-73-1400

HWY. No. 400

LOCATION Concrete Culvert

Hwy 7 to N of Langstaff Rd.

No of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

G.I.-30 SEPT. 1976

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 93-72



Ministry of
Transportation

INDEX

<u>Page No:</u>	<u>DESCRIPTION</u>
1	Index
2	Abbreviations & Symbols
3-57	Foundation Investigation Report for

Triple Cell Culvert - Sta. 14+260
W.P. 527-91-01(A), Site
Hwy. 400, District 6 Toronto

Concrete Culvert - Sta. 14+938
W.P. 527-91-01(B), Site -
Hwy. 400, District 6 Toronto

High Mast Lighting Hwy. 7 to
North of Langstaff Road
W.P. 528-91-01, Site -
Hwy. 400, District 6 Toronto

Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above mentioned project.

EXPLANATION OF TERMS USED IN REPORT

2

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_a	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
ϕ_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_f	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
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 ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT
For
A Proposed Triple Cell Culvert
Highway 400 - Station 14+260
W.P. 527-91-01(A)
District 6, Toronto

INTRODUCTION

This report summarizes the foundation investigation for the proposed culvert structure shown on Drawing No. 5279101(A)-A.*

SITE DESCRIPTION AND GEOLOGY

The site is located along Highway 400, approximately 110 m north of Langstaff Road, in the Town of Vaughan, Regional Municipality of York. The topography of the area is generally flat with a slight increase in elevation towards the north. Drainage is generally towards the southeast.

Physiographically, the site is located in the Peel Plain which consists of a level-to-undulating tract of clayey soils covering parts of York, Peel and Halton counties. In this area, the soil is known to consist of glacial till. However, in much of the Peel Plain, the till has been modified by a veneer of clay which, when deep enough, is clearly seen to be varved. It is thought that the clay veneer was deposited in a temporary lake impounded between higher land to the north and an ice lobe in the Ontario basin (Reference: Chapman and Putnam, "The Physiography of Southern Ontario"; 3rd Edition, 1984).

PROCEDURES

The fieldwork was carried out during the period covering January 6 to 9, 1992, and consisted of three (3) sampled boreholes, which were advanced to depths of 9.6 to 11.1 m, at the locations shown on Drawing No. 5279101(A).* Two of the boreholes were advanced using continuous flight, solid stem augers driven by a bombardier-mounted drilling rig equipped with standard soil sampling equipment. One of the boreholes (Borehole 7), was drilled along the centreline of the highway using similar equipment on a truck-mounted drilling rig.

Groundwater levels were measured in the open boreholes immediately upon completion of sampling. One of the boreholes (Borehole 7) was immediately backfilled and piezometers were installed in the two remaining boreholes, in order to measure the longer term groundwater conditions.

* DWG NO 2 OF THE CONTRACT DWG'S

The locations of two of the boreholes were staked out in the field, and their elevations determined by the Central Region Surveys and Plans Office. The location and elevation of Borehole 7 was determined by our field representative.

The soil samples, which were obtained in the field, were examined in the laboratory by visual and tactile methods. Moisture Content, Atterberg Limits and Grain Size Distribution tests were carried out on selected samples.

SUBSURFACE CONDITIONS

The subsurface conditions, at the boreholes, generally consist of a surficial layer of topsoil and/or fill from 0.1 to 2.1 m thick, which is underlain by a layer (up to 2.9 m thick) of silty clay. The clay is, in turn, underlain by a heterogeneous mixture of clayey silt, some sand and a trace of gravel (glacial till). Silt to silty sand deposits occur in random zones within the till, although major ones appear to be confined to certain elevations. The groundwater table was found to be at or close to the original ground surface (ie. prior to construction of Highway 400) or an elevation of 205.4 m.

Details of the subsurface information obtained from this investigation are included on the borehole logs, at the back of this report. Brief descriptions of the individual strata and the groundwater conditions encountered at the boreholes are given below.

Topsoil

Boreholes 6 and 8, which were drilled in the ditches or flatter areas adjacent to the Highway 400 embankment, contacted a surficial layer of dark brown to black, soft to firm, topsoil from 0.1 to 0.5 m thick.

A distinct topsoil layer, about 0.3 m thick was also found beneath the granular and other embankment fills at Borehole 7.

Pavement Structure

At Borehole 7, a thin layer (230 mm thick) of asphalt underlain by 1.1 m of sand to sand and gravel (Fill) was contacted at the ground surface. A penetration resistance or 'N-value' of 7 blows/0.3 m, indicates that the granular fill encountered is in a loose condition.

Silty Clay (Fill)

At Borehole 7, the granular fill was found to be underlain by a 0.7 m thick layer of silty clay fill containing topsoil enclosures. This material represents the lower portion of the embankment fills. An 'N'-value of 2 blows/0.3 m indicates that this silty clay fill is of soft to firm consistency.

Silty Clay

Beneath the topsoil or fill materials described above, all of the boreholes contacted a brown to grey, silty clay layer from 1.6 to 2.9 m thick, at depths of 0.1 to 2.1 m (or elevations of 205.2 m to 205.3 m).

The moisture contents of samples, from this deposit, ranged from 20 to 29 percent (average of 24 percent).

'N'-values measured in this silty clay layer ranged from 3 to 15 blows/0.3 m indicating soils of soft to stiff consistency.

Heterogeneous Mixture of Clayey Silt, some Sand, trace Gravel (Glacial Till)

A deposit of a heterogenous mixture of brown to grey, clayey silt with some sand, a trace of gravel and occasional cobbles and boulders from 5.9 to 7.7 m thick was encountered in all of the boreholes at depths of 3.4 to 3.7 m (or elevations of 201.7 to 203.6 m). This deposit extended to the maximum depth explored in the boreholes.

Atterberg Limits tests, carried out on five samples of the till had liquid limits of 16 to 27 (average of 21) percent and plasticity indices of 5 to 12 (average of 8) percent. These results, which have been plotted on Figure 1, indicate that this soil can be classified as CL-ML to CL or Clayey Silt to Silt.

A grain size distribution test, carried out on a sample of soil obtained from this deposit, and shown on Figure 2, indicates a relatively well-graded material consisting of 50 percent silt, 29 percent sand, 20 percent clay and 1 percent gravel-sized particles. These results, coupled with a visual examination of the texture of the soil, indicate that this material is likely to be of glacial origin and, therefore, may be referred to as glacial till.

Moisture contents of samples, from this deposit, ranged from 8 to 14 (average of 10) percent.

'N'-values measured, during Standard Penetration Testing, ranged from 12 to 50 blows/0.08 m, indicating soils of stiff to hard consistency, although in general, they can be considered to be very stiff.

Silt to Fine Sand

Cohesionless layers and zones of sandy silt to fine sand were encountered within the clayey silt till, at various depths within the boreholes. Occasional partings, seams or zones of silt to fine sand with occasional clayey silt interbeds were generally found between elevations of 201 to 203 m at the boreholes.

A major deposit of silty sand to sand, about 2.0 m thick, was encountered at Borehole 8 at an elevation of 203.3 m. A moisture content of 13 percent was measured in a sample, from this deposit and 'N'-values from 14 to 18 blows/0.3 m indicate generally compact conditions in this zone.

Groundwater Conditions

The groundwater levels, when measured in the open boreholes, immediately upon completion of sampling, were found to be from 2.5 to 3.0 m beneath the existing ground surface. However, water levels, measured in the two piezometers installed at the site, at least 48 hours after their installation, ranged from the ground surface to depths of 0.4 m.

It appears that the groundwater table is at or slightly below the original ground surface (ie. prior to the construction of the Highway 400 embankment) and gently slopes to the east from an elevation of about 205.4 m at Borehole 6 to 205.0 m at Borehole 8.

MISCELLANEOUS

The field investigation was supervised by Mr. J. Blair using equipment owned and operated by Malone's Soil Samples Inc.

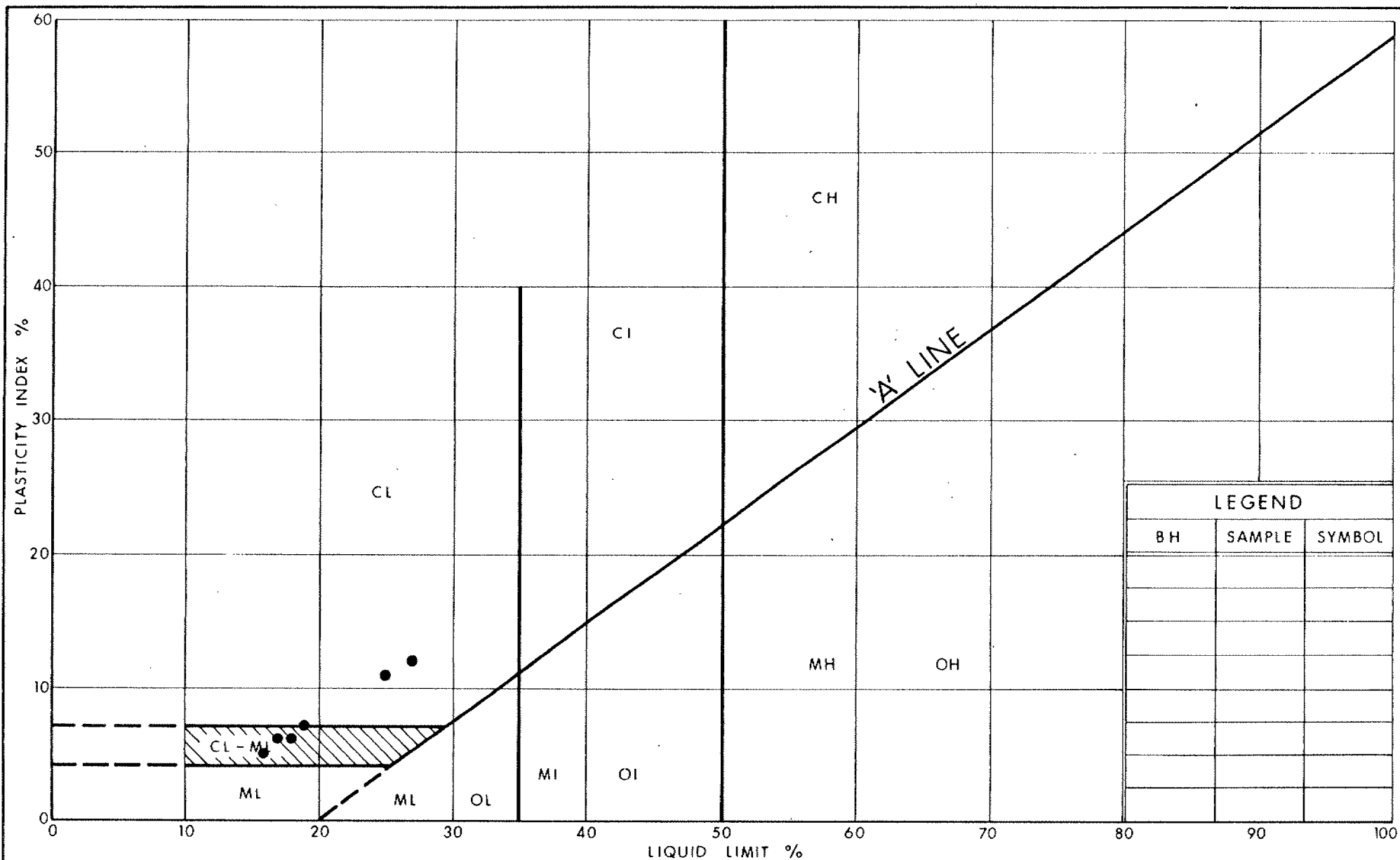
This report was written by Mr. J. Blair, Project Foundation Engineer, reviewed by Mr. D. Dundas, Senior Foundation Engineer and approved by Mr. M. Devata, Chief Foundation Engineer.



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APPENDIX



Ministry of
Transportation

Ontario

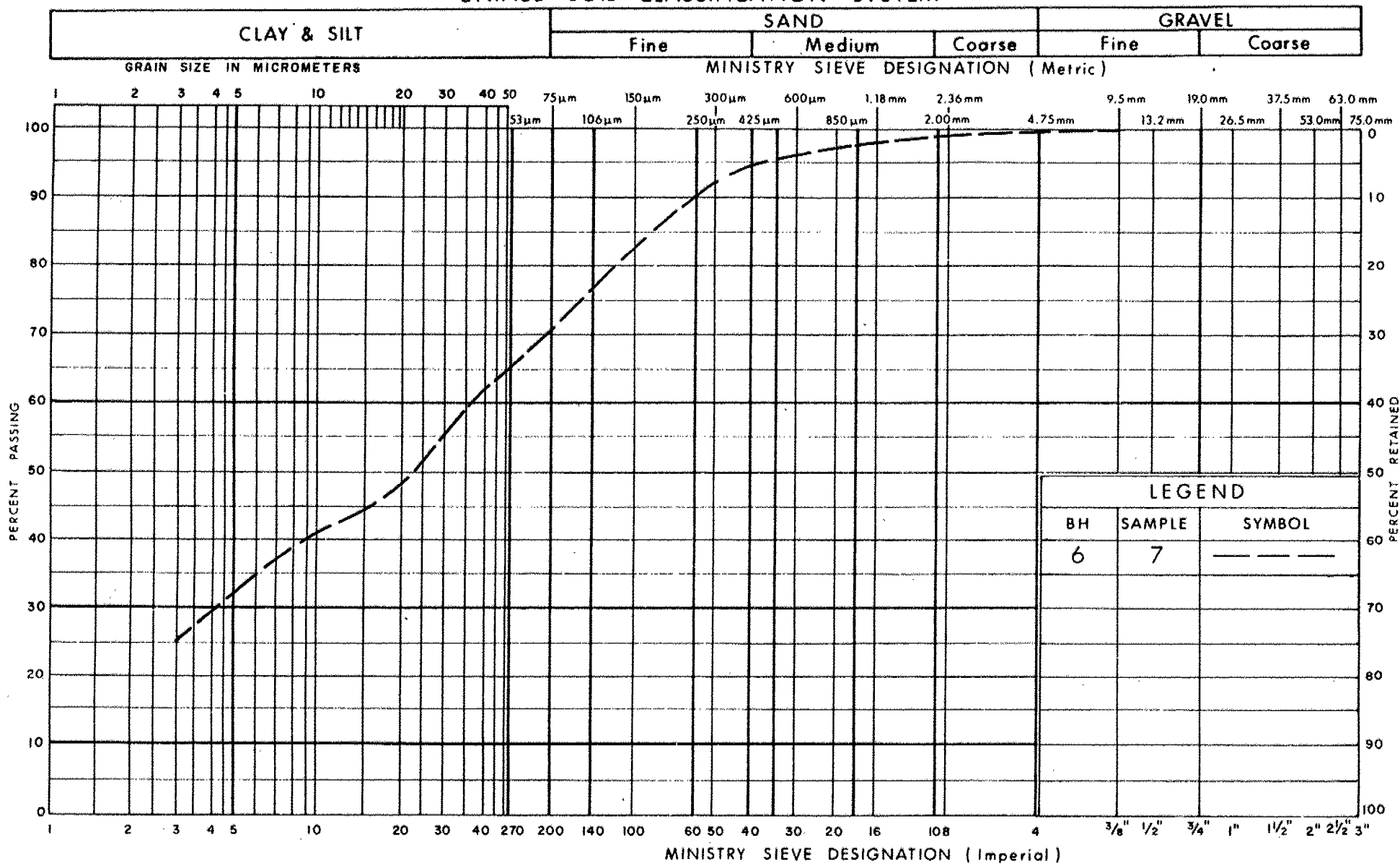
PLASTICITY CHART
 HETEROGENEOUS MIXTURE OF
 CLAYEY SILT, SOME SAND, TRACE GRAVEL (Glacial Till)

FIG No 1

W P 527-91-01(A)

∞

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
 HETEROGENEOUS MIXTURE OF
 CLAYEY SILT, SOME SAND, TRACE GRAVEL (Glacial Till)

FIG No 2

W P 527-91-01 (A)

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 527-91-01(A)(prev. 6:2-89-00) LOCATION Co-ords: N 4 852 049.1; E 301 208.7 ORIGINATED BY JB
DIST 5 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
DATUM Geodetic DATE 92 01 09 CHECKED BY DD

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					
205.7														
0.0	Topsail													
205.2	Dark Brown to Black Soft		1	SS	2									
0.5														
	Silty Clay to Clayey Silt Some Sand, Trace Gravel	Root Fibres	2	SS	5									
			3	SS	11									
	Firm to Very Stiff		4	SS	7									
202.3														
	Silty Sand Layer Brown		5	SS	34									
3.4	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel	Grey	6	SS	45									
		Sandy	7	SS	39									
	Occasional Cobbles and Boulders		8	SS	25									
	Very Stiff to Hard (Glacial Till)		9	SS	28									
			10	SS	33									
	Occasional Silty Clay Zones		11	SS	76									
		Sandy												
194.6			12	SS	38									
11.1	End of Borehole													
	92 01 13													
	• GROUND WATER CONDITIONS													
	PIEZO. NO.	GROUND WATER ELEVATION (Metres)												
	1	205.4												
	> Greater Than													

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 527-91-01(A)(Prev. 612-89-00) LOCATION Co-ords: N 4 852 057; E 301 248.5 ORIGINATED BY JB

DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB

DATUM Geodetic DATE 92 01 06 CHECKED BY DD

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	20 40 60 80 100					
207.3	Ground Surface													
0.0	230 mm Asphalt 130 mm Granular 'A'						207							
	Sand													
	Brown, Loose, (Fill)		1	SS	7									
	Silty Clay													
	Containing Topsoil													
205.8	Grey to Black, Firm, (Fill)		2	SS	7		206						17.6	
205.2	Topsoil, Black, Firm													
2.1	Silty Clay		3	SS	3		205						19.0	
	Traces of Organics													
	Brownish Grey to Grey													
203.6	Soft to Stiff		4	SS	9		204						22.1	
3.7	Brown to Brownish Grey		5	SS	12		203							
	Grey		6	SS	23									
	Sandy		7	SS	49		202							
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		8	SS	50		201						22.8	
	Occasional Cobbles and Boulders						200							
	Hard		9	SS	35		199							
	(Glacial Till)						198							
197.7	End of Borehole		10	SS	39									
9.6	W.L. not stabilized													

RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 527-91-01(A)(Prev. 612-89-00) LOCATION Co-ords: N 4 852 064.0; E 301 285.5 ORIGINATED BY JB

DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB

DATUM Geodetic DATE 92 01 07 CHECKED BY DD

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	20 40 60 80 100					
205.4	Ground Surface													
0.0	130 mm Topsoil													
	Silty Clay Some Sand		1	SS	9									
	Stiff to Very Stiff		2	SS	15									
203.3	Sandy													
2.1	Sandy Silt to Silty Sand Occ. Clayey Silt Layers		3	SS	14									
	Brown to Brownish Grey		4	SS	18									
201.7	Compact													
3.7			5	SS	30	/8cm								
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		6	SS	48									
	Occasional Cobbles and Boulders		7	SS	38									
	Very Stiff to Hard		8	SS	21									
	(Glacial Till)		9	SS	21									
			10	SS	44									
			11	SS	60	/13cm								
	Sandy													
194.5			12	SS	50	/8cm								
10.9	End of Borehole													
	92 01 13 * GROUND WATER CONDITIONS													
	PIEZO. NO.													
	GROUND WATER ELEVATION (Metres)													
	1													
	205													

FOUNDATION INVESTIGATION REPORT
For
Proposed Culvert Extensions
Highway 400 / Langstaff Road to Rutherford Road
W.P. 527-91-01(B)
Central Region
District 6, Toronto

INTRODUCTION

At the request of the Central Region, Structural Section, this report summarizes a foundation investigation, carried out at the above-captioned site, for proposed extensions of two existing culverts located along both sides of Highway 400 between Langstaff Road and Rutherford Road.

SITE DESCRIPTION AND GEOLOGY

The site is located along Highway 400 between Langstaff Road and Rutherford Road, in the Town of Vaughan, Regional Municipality of York. The topography of the area is generally flat with a slight increase in elevation towards the north. Drainage is generally towards the southeast.

Physiographically, the site is located in the Peel Plain which consists of a level-to-undulating tract of clayey soils covering parts of York, Peel and Halton counties. In this area, the soil is known to consist of glacial till. However, in much of the Peel Plain, the till has been modified by a veneer of clay which, when deep enough, is clearly seen to be varved. It is thought that the clay veneer was deposited in a temporary lake impounded between higher land to the north and an ice lobe in the Ontario basin (Reference: Chapman and Putnam, "The Physiography of Southern Ontario"; 3rd Edition, 1984).

PROCEDURES

The fieldwork was carried out by this office on January 8 and 9, 1992, and consisted of 4 sampled boreholes which were advanced to depths of from 9.6 to 11.1 m using continuous flight, solid stem augers driven by a bombardier-mounted drilling rig equipped with standard soil sampling equipment.

Groundwater levels were measured in the open boreholes immediately upon completion of sampling and two were left open for subsequent measurements. Piezometers were installed in the two remaining boreholes, in order to measure the longer term groundwater conditions.

NOTE - CULVERT AT STA. 15+349 NOT PART OF THIS CONTRACT

The locations of the boreholes were staked in the field, and their elevations determined by the Central Region Surveys and Plans Office.

The soil samples, which were obtained in the field, were examined in the laboratory by visual and tactile methods. Moisture content and Atterberg Limits tests were carried out on selected samples.

SUBSURFACE CONDITIONS

The subsurface conditions, at the borehole locations shown on Drawing No. 5279101(B)-A, generally consist of a surficial layer of topsoil and/or fill up to 1.1 m thick, which, at most locations, is underlain by a layer (up to 2.7 m thick) of silty clay. The clay is, in turn, underlain by a heterogeneous mixture of clayey silt, some sand and a trace of gravel (glacial till). Silt to silty sand deposits occur in random zones within the till, although major ones appear to be confined to certain elevations. The groundwater table was found to be at or close to the original ground surface (ie. prior to construction of Highway 400) or at elevations of 207.3 to 207.5 m at Station 14+938 and 209.8 m at Station 15+349.

Details of the subsurface information obtained, from this investigation, are included on the log sheets for Boreholes 10 to 13, given at the back of this report. Brief descriptions of the individual strata and the groundwater conditions encountered at the boreholes are given below.

Topsoil

A surficial layer of dark brown to black, soft to firm, topsoil, up to 0.5 m thick, was encountered at the boreholes.

Silty Clay (Fill)

At Boreholes 10, 12 and 13, the surficial layer of topsoil was found to be underlain by a 0.1 to 1.0 m thick layer of silty clay containing topsoil enclosures. This material has also been referred to as 'fill', since it appears that these soils have been disturbed by past farming activity, which has resulted in traces of topsoil becoming entrained into it.

'N'-values of 1 to 5 blows/0.3 m indicate that the silty clay fill soils are of soft to firm consistency.

NOTE - CULVERT AT STA. 15+349 NOT PART OF THIS CONTRACT

Silty Clay

Beneath the fill materials described above, Boreholes 10, 11 and 13, contacted a brown to grey, silty clay layer from 1.3 to 2.6 m thick at depths of 0.1 to 1.1 m (or elevations of 206.9 to 208.7 m).

An Atterberg Limits test, carried out on a sample of soil from this deposit, had a liquid limit of 38 percent and a plasticity index of 21 percent. These results, indicate that the soil can be classified as CI or Silty Clay. The moisture contents of samples from this deposit ranged from 20 to 26 (average of 23) percent.

'N'-values, measured in this silty clay layer, ranged from 8 to 15 blows/0.3 m indicating soils of generally stiff consistency.

Heterogeneous Mixture of Clayey Silt, some Sand, trace Gravel (Glacial Till)

A heterogenous mixture of brown to grey, clayey silt with some sand and a trace of gravel and containing occasional cobbles and boulders, at least 7.4 to 8.9 m thick, was encountered in all of the boreholes at depths of 0.7 to 3.7 m (or elevations of 205.6 to 209.1 m). This deposit extended to the maximum depth explored in all of the boreholes.

An Atterberg Limits test, carried out on a sample of soil from this deposit, had a liquid limit of 17 percent and a plasticity index of 6 percent. These results, indicate that this soil can be classified as CL-ML or clayey silt to silt. However, Atterberg limits testing, carried out on other samples from the immediate area, indicates that generally the soil can be considered to be a CL or clayey silt.

Visual examination of the texture of the soil indicates that this material is likely to be of glacial origin and, therefore, may be referred to as glacial till.

Moisture content tests carried out on samples of soil obtained from this deposit, ranged from 8 to 20 (average of 14) percent.

'N'-values measured during Standard Penetration Testing ranged from 11 to 45 blows/0.3 m indicating soils of stiff to hard consistency.

Silt to Fine Sand

Cohesionless layers and zones of sandy silt to fine sand were encountered within the clayey silt till at various depths. Although they were often found to be thin (ie. less than 0.5 m thick) and discontinuous, major cohesionless zones were found in Boreholes 10 and 11. Seams or zones of silt to fine sand with occasional clayey silt interbeds were generally found between elevations of 204 to 206 m at Boreholes 10 and 11 and below elevation 199 at Borehole 10 and between elevations 199 and 202 at Borehole 11.

'N'-values ranged from 11 to 23 blows/0.3 m indicating generally compact conditions in these cohesionless zones.

Groundwater Conditions

The groundwater levels, when measured in the open boreholes, immediately upon completion of sampling, were found to be from 0.2 to 1.3 m beneath the existing ground surface. However, water levels, measured in the two piezometers installed at the site, at least 48 hours after their installation, ranged from the ground surface to depths of 0.1 m.

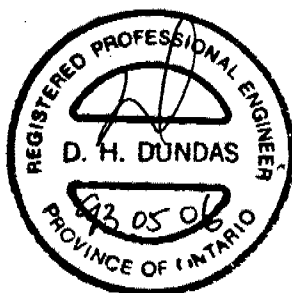
It appears that the groundwater table is at or slightly below the original ground surface (ie. prior to the construction of the Highway 400 embankment) or at elevations of 207.3 to 207.5 m at Station 14+938 and 209.8 m at Station 15+349.

MISCELLANEOUS

The field investigation was supervised by Mr. J. Blair using equipment owned and operated by Malone's Soil Samples Inc.

This report was written by Mr. J. Blair, Project Foundation Engineer, reviewed by Mr. D. Dundas, Senior Foundation Engineer and approved by Mr. M. Devata, Chief Foundation Engineer.

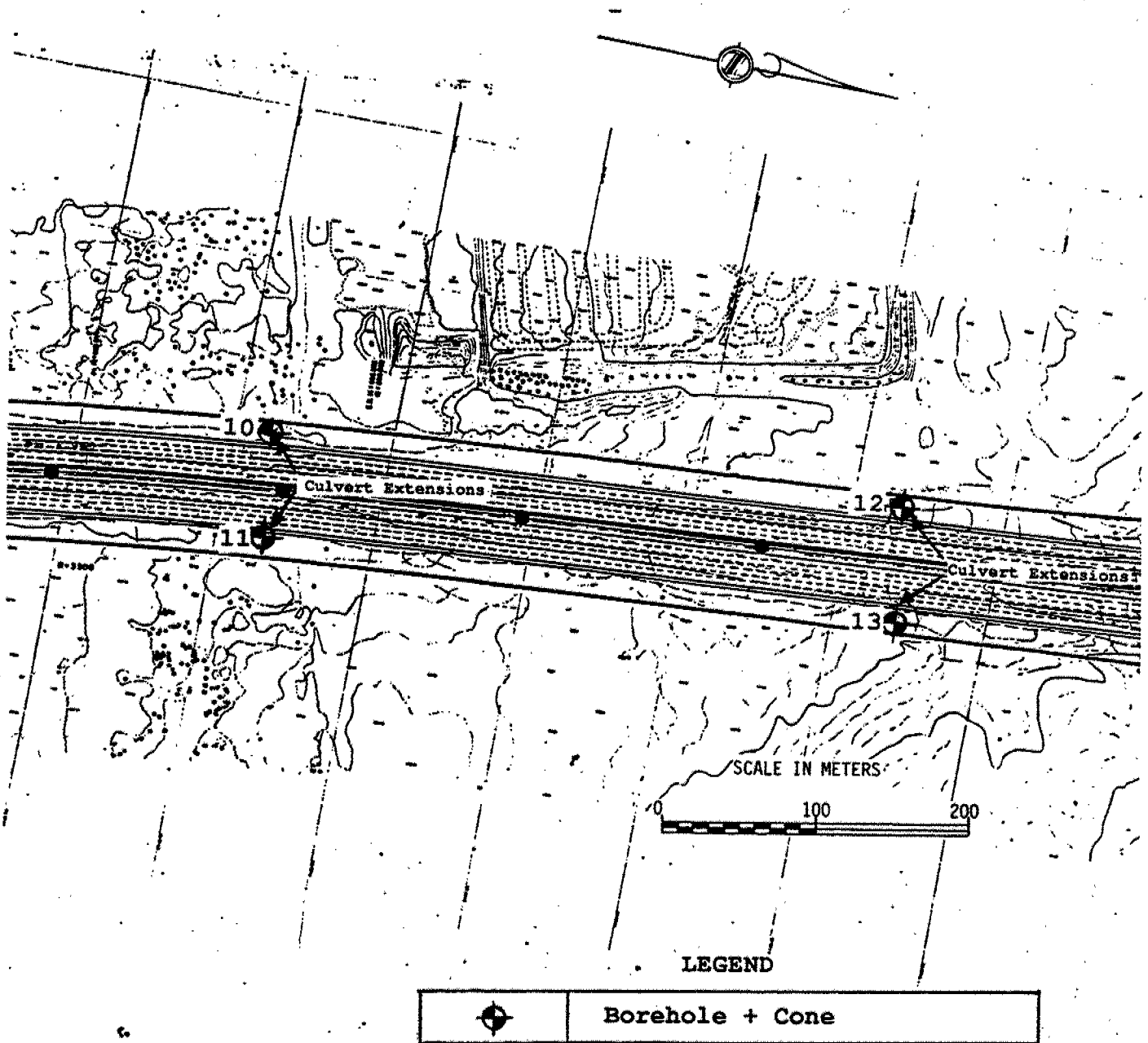
NOTE- CULVERT AT STA 15+349 NOT PART OF THIS CONTRACT



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Chief Foundation Engineer

W P No. 527-91-01(B)



NOTE-CULVERT AT STA. 15+349 NOT PART OF THIS CONTRACT

Dwg: 52791018-A

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

W.P. 527-91-01(B)(Prev. 612-89-00) LOCATION Co-ords: N 4 852 722.7; E 301 111.5 ORIGINATED BY JB
DIST 5 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
DATUM Geodetic DATE 92 01 09 CHECKED BY DD

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					
207.4	Ground Surface													
0.0	Topsoil/Silty Clay (Fill)		1	SS	2									
206.9	Black to Brownish Grey, Soft													
0.5	Root Fibres													
	Silty Clay, Trace Sand		2	SS	8									
	Brown													
205.6	Firm to Stiff													
	Occasional Sandy Silt Layers		3	SS	13									
1.8	Brown Grey Silty Clay Layer		4	SS	18									
	Heterogeneous Mixture of Clayey Silt, Some Gravel, Trace Clay		5	SS	25									
	Silty Clay Layer		6	SS	19									
			7	SS	17									
	Occasional Cobbles, Boulders and Silty Clay Layers		8	SS	14									
	Very Stiff (Glacial Till)		9	SS	18									
			10	SS	21									
198.8	Sandy Silt to Silty Fine Sand		11	SS	23									
8.6	Compact													
196.3			12	SS	13									
11.1	End of Borehole													
	92 01 13													
	* GROUND WATER CONDITIONS													
	PIEZO. NO.	GROUND WATER ELEVATION (Metres)												
	1	207.3												
	> Greater Than													

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 527-91-01(B)(Prev. 612-89-00) LOCATION Co-ords: N 4 852 729.9; E 301 179.6 ORIGINATED BY JB

DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB

DATUM Geodetic DATE 92 01 08 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
207.5	Ground Surface													
0.0	100 mm Topsoil													
	Silty Clay, Some Sand Traces of Root Fibres		1	SS	8									
206.1	Brown, Firm to Stiff													
1.4			2	SS	45									
	Brown to Brownish Grey Grey		3	SS	33									
	Occasional Silty Sand to Sandy Silt Layers		4	SS	29									
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		5	SS	24									
	Occasional Cobbles and Boulders		6	SS	26									
	Very Stiff to Hard (Glacial Till)		7	SS	33									
201.6			8	SS	13									
5.9	Sandy Silt to Sand and Silt		9	SS	13									
	Compact													
198.9														
8.6	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		10	SS	45									
197.9	Hard (Glacial Till)													
9.6	End of Borehole													
	* W.L. on 92 01 13													

RECORD OF BOREHOLE No 12

1 OF 1

METRIC

W.P. 527-91-01(B)(Prev. 612-89-00) LOCATION Co-ords: N 4 853 132.4; E 301 084.8 ORIGINATED BY JB

DIST 5 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB

DATUM Geodetic DATE 92 01 08 CHECKED BY DD

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 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80
209.8	Ground Surface															
0.0	Topsoil, Black, Soft		1	SS	1											
209.1	Silty Clay, Brown, Soft. (Fill)															
0.7			2	SS	10											
	Sandy		3	SS	11											
	Brown		4	SS	27											
	Grey		5	SS	21											
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel.		6	SS	29											
	Occasional Cobbles and Boulders		7	SS	20											
	Stiff to Very Stiff (Glacial Till)		8	SS	12											
			9	SS	25											
			10	SS	24											
	Silty Clay Layer		11	SS	19											
200.2																
9.6	End of Borehole															
	92 01 13 * GROUND WATER CONDITIONS															
	PIEZO. NO.	GROUND WATER ELEVATION (Metres)														
	1	209.8														

RECORD OF BOREHOLE No 13

1 OF 1

METRIC

W.P. 527-91-01(B)(Prev. 612-89-00) LOCATION Co-ords: N 4 853 140.9; E 301 158.9 ORIGINATED BY JB
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
 DATUM Geodetic DATE 92 01 08 CHECKED BY DD

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					
209.8	Ground Surface													
0.0	130 mm Topsoil													
208.7	Silty Clay, Trace Sand Contains Topsoil Soft to Firm		1	SS	5									
1.1	Greyish Brown to Black (Fill)													
	Silty Clay, Trace Sand		2	SS	8									
	Greyish Brown to Grey		3	SS	15									
	Stiff to Very Stiff		4	SS	12									
206.1														
3.7			5	SS	11									
	Sandy Silt Layer		6	SS	23									
			7	SS	25									
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		8	SS	26									
	Occasional Cobbles and Boulders													
	Stiff to Hard		9	SS	33									
	(Glacial Till)		10	SS	41									
198.7			11	SS	30									
11.1	End of Borehole													
	• W.L. measured immediately upon completion of sampling > Greater Than													

FOUNDATION INVESTIGATION REPORT
For
Proposed High Mast Lighting
Highway 400/Highway 7 to North of Langstaff Road
W.P. 528-91-01
Central Region
District 6, Toronto

INTRODUCTION

At the request of the Central Region, Structural Section, a foundation investigation was carried out at the above-captioned site between January 6 and 13, 1992 for 22 proposed high mast light poles (P2 through P23) to be located along Highway 400 between Highway 7 and Rutherford Road and shown on Drawing No. 5289101-A (Sheets 1 to 4).

SITE DESCRIPTION AND GEOLOGY

The site is located along Highway 400 between approximately 200 m north of Highway 7 to about 700 m north of Langstaff Road, in the Town of Vaughan, Regional Municipality of York. The topography of the area is generally flat with a slight increase in elevation towards the north. Drainage is generally towards the southeast.

Physiographically, the site is located in the Peel Plain which, consists of a level-to-undulating tract of clayey soils which covers parts of York, Peel and Halton counties. In this area, the soil is known to consist of glacial till. However, in much of the Peel Plain, the till has been modified by a veneer of clay which, when deep enough, is clearly seen to be varved. It is thought that the clay veneer was deposited in a temporary lake impounded between higher land to the north and the ice lobe in the Ontario basin (Reference: Chapman and Putnam, "The Physiography of Southern Ontario"; 3rd Edition, 1984).

PROCEDURES

The fieldwork was carried out between January 6 and 13, 1992 and consisted of a total of twelve (12) sampled boreholes (including 5 under Ref. No.'s W.P. 527-91-01(A) and W.P. 527-91-01(B)) which were advanced to depths of from 7.6 to 11.1 m. Most of the boreholes were advanced using continuous flight, solid stem augers driven by a bombardier-mounted drilling rig equipped with standard soil sampling equipment. However, one of the boreholes (BH7), was drilled along the centreline of the highway using a truck-mounted drilling rig.

Groundwater levels were measured in several of the open boreholes immediately upon completion of sampling and most were left open for subsequent measurements. Piezometers were installed in three of the boreholes, in order to measure the long term groundwater conditions.

Generally, the locations of the boreholes were staked in the field, and their elevations determined by the Central Region Surveys and Plans Office. However, since Borehole 7 was located close to the centreline of Highway 400, its location and elevation was determined by our field representative.

The soil samples, which were obtained in the field, were examined in the laboratory by visual and tactile methods. Moisture content and Atterberg Limits tests were carried out on selected soil samples.

SUBSURFACE CONDITIONS

The subsurface conditions, at the boreholes, generally consist of a surficial layer of topsoil and/or fill from 0.1 to 2.1 m thick, which, at most locations, is underlain by a layer (up to 3 m thick) of silty clay. The silty clay is, in turn, underlain by a heterogeneous mixture of clayey silt, some sand with a trace of gravel (glacial till). Silt to silty sand deposits occur in random zones within the till, although major ones appear to be confined to certain elevations. The groundwater table was found to be at or close to the original ground surface (ie. prior to construction of Highway 400) or elevations respectively ranging from 208.1 to 203.5 m at the north and south ends of the area of investigation.

Details of the subsurface information obtained from this investigation are included on the borehole logs at the back of this report. Selected borehole logs from two previous investigations (W.P. 164-79-04/05 and W.O. 89-11001) are included in the Appendix.

Brief descriptions of the individual soil strata and the groundwater conditions encountered in the boreholes are given below.

Topsoil

In the ditches or flatter areas adjacent to the Highway 400 embankment (ie. Boreholes 4, 6, 8, 10 and 11), a surficial layer of dark brown to black, soft to firm, topsoil, up to 0.5 m thick was encountered in the boreholes.

Distinct topsoil or organic silty clay layers, 0.8 and 0.3 m thick, were also found beneath the granular and other embankment fills at Boreholes 5 and 7, respectively.

Pavement Structure

A thin layer (230 mm thick) of asphalt was contacted at the ground surface at Borehole 7.

Sand to sand and gravel (Fill), from 0.2 to 0.9 m thick, was found beneath the asphalt at Borehole 7 and contacted at the ground surface at Boreholes 1 to 3, 5, 7, and 9. Penetration resistances or 'N-values' in this fill ranged from 5 to 11 blows/0.3 m, indicating generally loose, (although occasionally compact) conditions.

Silty Clay (Fill)

At several locations (Boreholes 1, 2, 3, 5, 7, 9, and 14) the granular fill was found to be underlain by a silty clay deposit containing topsoil enclosures from 0.4 to 1.7 m thick (ie. to depths of 0.5 to 1.9 m). This material represents the lower portion of the embankment fills.

At Borehole 4, the surficial layer of topsoil noted above was found to be underlain by a thin (0.1 to 0.2 m thick) layer of a similar silty clay material containing topsoil enclosures. This material has also been referred to as fill, since it appears that these soils have been disturbed by past farming activity which has resulted in topsoil enclosures becoming entrained into it.

'N'-values of 2 to 10 blows/0.3 m indicate that the silty clay fills vary from soft to stiff consistency, although they can generally be considered firm.

Silty Clay

Beneath the fill materials described above, Boreholes 1 and 5 to 11 contacted a brown to grey, silty clay layer from 0.2 to 2.9 m thick. This layer extended to depths 1.4 to 3.7 m (or elevations of 202.3 to 206.2 m).

'N'-values measured in this silty clay layer ranged from 5 to 15 blows/0.3 m indicating soils of generally firm to stiff consistency.

Heterogeneous Mixture of Clayey Silt, some Sand, trace Gravel
(Glacial Till)

A heterogenous mixture of brown to grey, clayey silt with some sand and a trace of gravel with occasional cobbles and boulders, from 5.0 m up to at least 8.2 m thick, was encountered in all of the boreholes, at depths of 0.6 to 3.7 m (or elevations of 201.7 to 207.4 m).

Visual examination of this soil indicates that it is likely to be of glacial origin and therefore, may be considered to be a glacial till.

'N'-values measured during Standard Penetration Testing ranged from 11 to 50 blows/0.08 m indicating soils of stiff to hard consistency.

Silt to Fine Sand

Cohesionless layers and zones of silt to fine sand were encountered within the clayey silt till at various depths. Although they were often found to be thin (ie. less than 0.5 m thick) and discontinuous, major ones appeared in several boreholes.

Major seams or zones of silt to fine sand with occasional clayey silt interbeds were generally found below elevations of 197 to 199 m south of Borehole 3, between elevations of 201 and 203 m at Boreholes 5 to 9, between elevations of 204 to 206 m at Boreholes 9 to 11 and below elevations of 199 to 202 m at Boreholes 10 and 11.

At Borehole 4, a major cohesionless zone (at least 6.0 m thick) was found below an elevation of 203 m and, with the exception of a small intrusion of clayey silt till, extended to the maximum depth explored in that borehole. Cohesionless zones, which were encountered at Boreholes 1, 3 and 10, at depths of 8.6 to 9.6 m, also extended to the maximum depth explored in those boreholes (ie. indicating thicknesses of greater than 1.5 to 2.5 m).

'N'-values ranged from to 11 to 53 blows/0.3 m indicating compact to very dense conditions in these cohesionless zones.

Groundwater Conditions

The groundwater levels, when measured in the open boreholes, immediately upon completion of sampling, were found to be from the ground surface to depths of 7.4 m. However, water levels, measured in the open boreholes at least 24 hours after completion of sampling ranged from the ground surface to depths of 2.2 m (or elevations of 203.5 to 208.1 m).

Groundwater levels, measured in the three piezometers installed at the site ranged from depths of about 0.1 to 0.4 m (or elevations of 205 to 207.3 m)

It appears that the groundwater table is at or slightly below the original ground surface (ie. prior to the construction of the Highway 400 embankment) and generally slopes with the ground surface towards the south from elevations of 208.1 at Borehole 9 to 203.5 m at Borehole 2, respectively.

MISCELLANEOUS.

The field investigation was supervised by Mr. J. Blair using equipment owned and operated by Malone's Soil Samples Inc.

This report was written by Mr. J. Blair, Project Foundation Engineer, reviewed by Mr. D. Dundas, Senior Foundation Engineer and approved by Mr. M. Devata, Chief Foundation Engineer.



D. Dundas
D. Dundas, P. Eng.
Sr. Foundation Engineer

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

Table I

High Mast Light Pole Locations
Highway 400 and Langstaff Road

<u>Pole #</u>	<u>Northing</u>	<u>Easting</u>	Ground Surface Existing <u>(m)</u>	Elevations Proposed <u>(m)</u>
P2	4 850 270.2	301 556.9	201.0	200.9
P3	4 850 388.5	301 536.7	202.2	202.1
P4	4 850 516.6	301 514.7	203.5	203.5
P5	4 850 647.7	301 492.3	204.5	204.5
P6	4 850 785.7	301 468.7	205.1	205.1
P7	4 850 923.7	301 445.0	205.6	205.5
P8	4 851 060.7	301 421.5	206.1	206.0
P9	4 851 196.8	301 398.2	206.5	206.5
P10	4 851 331.8	301 375.1	207.1	207.0
P11	4 851 467.3	301 351.9	207.6	207.6
P12	4 851 604.3	301 328.4	207.9	207.9
P13	4 851 723.1	301 308.1	207.1	207.3
P14	4 851 860.1	301 284.7	206.9	206.9
P15	4 851 876.5	301 149.4	209.7	211.2
P16	4 851 807.4	301 379.9	205.1	205.1
P17	4 851 922.2	301 377.5	205.0	205.5
P18	4 851 970.9	301 170.3	205.8	205.8
P19	4 852 002.5	301 260.3	207.3	207.1
P20	4 852 145.0	301 235.9	207.6	207.6
P21	4 852 292.8	301 210.6	208.1	208.1
P22	4 852 439.7	301 185.4	208.8	208.8
P23	4 852 588.1	301 163.5	209.3	209.3

TABLE II
Design Parameters for
High Mast Light Poles
Highway 400 and Langstaff Road
W.P. 528-91-01

Pole #	Approximate Ground Surface Elev.		Soil Boundary Elevation		Cohesive/ Non-Cohesive	Assumed Water Level	Closest Boreholes
	Existing (m)	Ultimate (m)	Upper (m)	Lower (m)			
P2	201.0	200.9	201.0 199.5 197.0 <192.0	199.5 197.0 192.0	Non-Cohesive Cohesive Cohesive Non-Cohesive	199.5	C8, C10 (WP 164-79-04/05)
P3	202.2	202.1	202.2 200 198.5 <192.5	200 198.5 192.5	Non-Cohesive Cohesive Cohesive Non-Cohesive	200.0	C10, C11 (WP 164-79-04/05)
P4	203.5	203.5	203.5 202.3 201.0 <198.5	202.3 201.0 198.5	Non-Cohesive Cohesive Cohesive Cohesive	201.0	C11 (WP 164-79-04/05) 1
P5	204.5	204.5	204.5 203.5 202.0 198.5 <194.7	203.5 202.0 198.5 194.7	Non-Cohesive Cohesive Cohesive Cohesive Non-Cohesive	202.5	C11 (WP 164-79-04/05) 1
P6	205.1	205.1	205.1 204.0 203.0 199 <195	204.0 203.0 199.0 195.0	Non-Cohesive Cohesive Cohesive Cohesive Non-Cohesive	202.2	1, 2

TABLE II
Design Parameters for
High Mast Light Poles
Highway 400 and Langstaff Road
W.P. 528-91-01

Pole #	Approximate Ground Surface Elev.		Soil Boundary Elevation		Cohesive/ Non-Cohesive	Assumed Water level	Closest Boreholes
	Existing (m)	Ultimate (m)	Upper (m)	Lower (m)			
P7	205.6	205.5	205.5	204.5	Non-Cohesive	203.0	2, 1
			204.5	203.5	Cohesive		
			203.5	201.0	Cohesive		
			201.0	196.0	Cohesive		
			<196		Non-Cohesive		
P8	206.1	206.0	206.1	204.8	Non-Cohesive	204.0	2, 3
			204.8	203.8	Cohesive		
			203.8	201.5	Cohesive		
			201.5	196.5	Cohesive		
			<196.5		Non-Cohesive		
P9	206.5	206.5	205.5	205.0	Non-Cohesive	204.5	3, 2
			205.0	202	Cohesive		
			202	197.5	Cohesive		
			<197.5		Non-Cohesive		
P10	207.1	207.0	207.1	205.5	Non-Cohesive	205.0	3, 4
			205.5	202.5	Cohesive		
			202.5	199.0	Cohesive		
			<199.0		Non-Cohesive		
P11	207.6	207.6	207.6	206.4	Non-Cohesive	205.5	4, 3
			206.4	205.5	Cohesive		
			205.5	203.5	Cohesive		
			203.5	201.5	Cohesive		
			<201.5		Non-Cohesive		

TABLE II
Design Parameters for
High Mast Light Poles
Highway 400 and Langstaff Road
W.P. 528-91-01

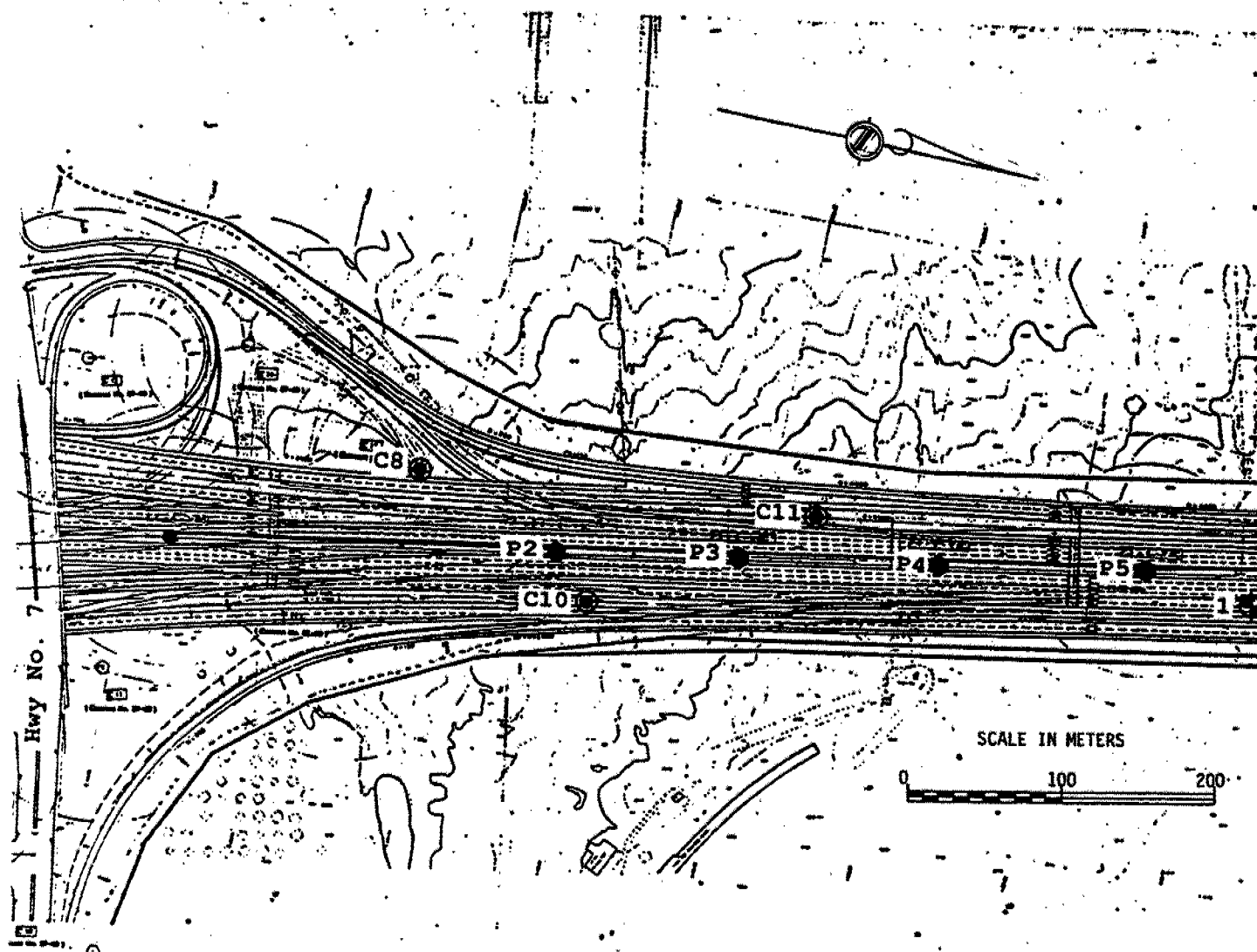
Pole #	Approximate Ground Surface Elev.		Soil Boundary Elevation		Cohesive/ Non-Cohesive	Assumed Water level	Closest Boreholes
	Existing (m)	Ultimate (m)	Upper (m)	Lower (m)			
P12	207.9	207.9	207.9	206.5	Non-Cohesive	205.5	4, 5
			206.5	205.0	Cohesive		
			205.0	203.0	Cohesive		
			203.0	200.5	Non-Cohesive		
			200.5	199.5	Cohesive		
			<199.5		Non-Cohesive		
P13	207.1	207.3	207.1	206.1	Non-Cohesive	205.5	5, 4
			206.1	205	Cohesive		
			205	204	Cohesive		
			204	202	Cohesive		
			202	199	Cohesive		
			<199		Non-Cohesive		
P14	206.9	206.9	206.9	206.5	Non-Cohesive	205.5	5, 7
			206.5	205	Cohesive		
			205.0	204	Cohesive		
			204	201.5	Cohesive		
			201.5	198.5	Cohesive		
			<198.5		Non-Cohesive		
P15	209.7	211.2	209.7	208.5	Non-Cohesive	205.0	1, 2 (W.O. 89-11001)
			208.5	206.5	Cohesive		
			206.5	203.5	Cohesive		
			203.5	201.5	Non-Cohesive		
			<201.5		Cohesive		

TABLE II
Design Parameters for
High Mast Light Poles
Highway 400 and Langstaff Road
W.P. 528-91-01

Pole #	Approximate Ground Surface Elev.		Soil Boundary Elevation		Cohesive/ Non-Cohesive	Assumed Water level	Closest Boreholes
	Existing (m)	Ultimate (m)	Upper (m)	Lower (m)			
P16	205.1	205.1	205.1 203.9 <199	203.9 199.0	Cohesive Cohesive Non-Cohesive	204.5	5 (W.O. 89-11001) 5
P17	205.0	205.5	205.0 203.5 <201.5	203.5 201.5	Cohesive Non-Cohesive Non-Cohesive	203.5	5 (W.O. 89-11001) 5
P18	205.8	205.8	205.8 203.5 <201.3	203.5 201.3	Cohesive Non-Cohesive Cohesive	205.5	2 (W.O. 89-11001) 5
P19	207.3	207.1	207.3 206.0 204.5 203.5 <201.5	206.0 204.5 203.5	Non-Cohesive Cohesive Cohesive Non-Cohesive Cohesive	205.0	4 (W.O. 89-1001) 7
P20	207.6	207.6	207.6 206.5 205.0 204.0 202.5 <201.5	206.5 205.0 204.0 202.5	Non-Cohesive Cohesive Cohesive Cohesive Non-Cohesive Cohesive	205.5	7, 9

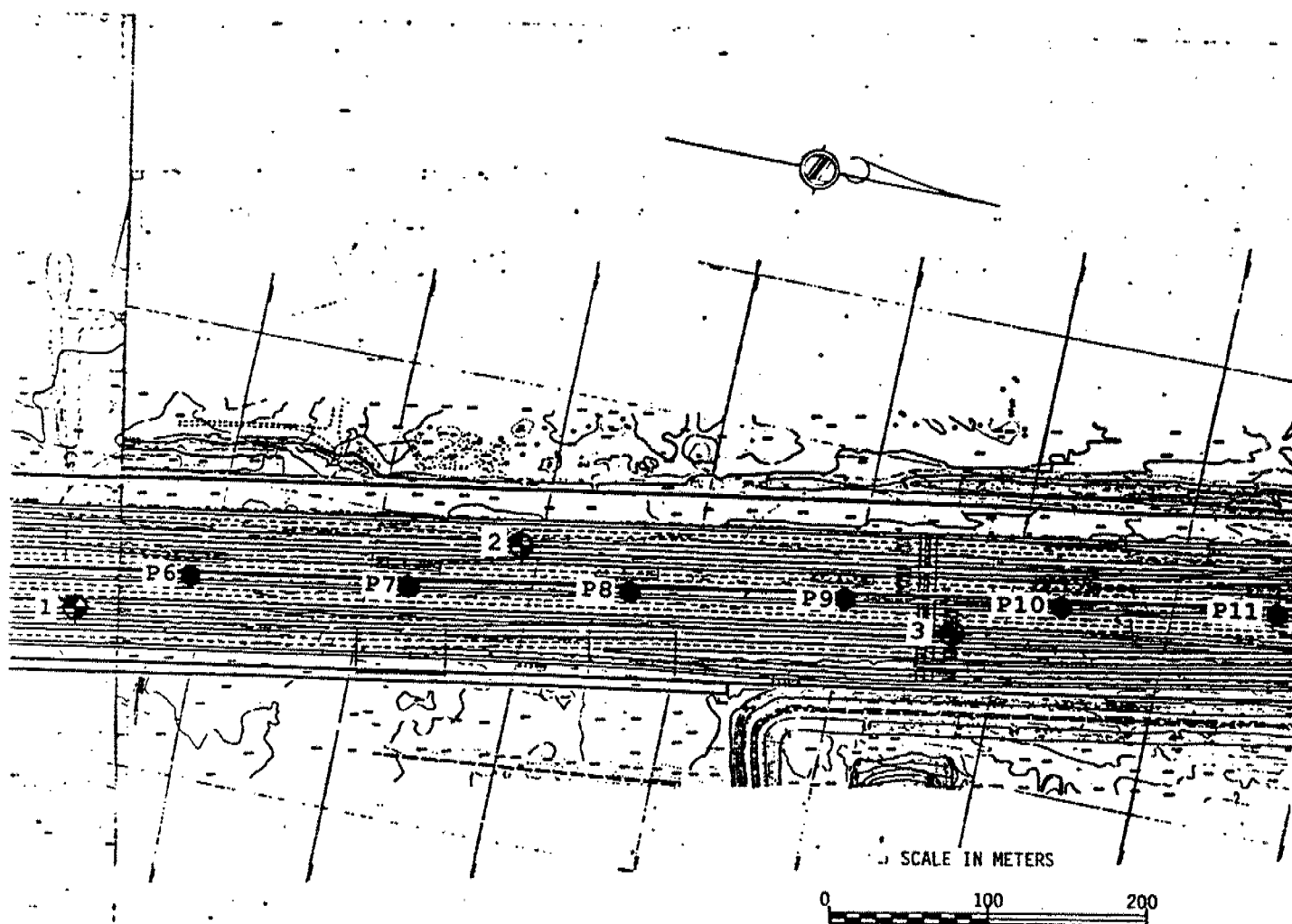
TABLE II
Design Parameters for
High Mast Light Poles
Highway 400 and Langstaff Road
W.P. 528-91-01

Pole #	Approximate Ground Surface Elev.		Soil Boundary Elevation		Cohesive/ Non-Cohesive	Assumed Water level	Closest Boreholes
	Existing (m)	Ultimate (m)	Upper (m)	Lower (m)			
P21	208.1	208.1	208.1	207	Non-Cohesive	207.0	9, 7
			207.0	206	Cohesive		
			206	203	Cohesive		
			203	201	Non-Cohesive		
			<201		Cohesive		
P22	208.8	208.8	208.8	207.8	Non-Cohesive	207.0	9, 14
			207.8	207.0	Cohesive		
			207.0	206.5	Cohesive		
			206.5	201.5	Cohesive		
			<201.5		Cohesive		
P23	209.3	209.3	209.3	207.5	Non-Cohesive	207.5	14, 9
			207.5	206.5	Cohesive		
			206.5	203.0	Cohesive		
			<203.0		Cohesive		



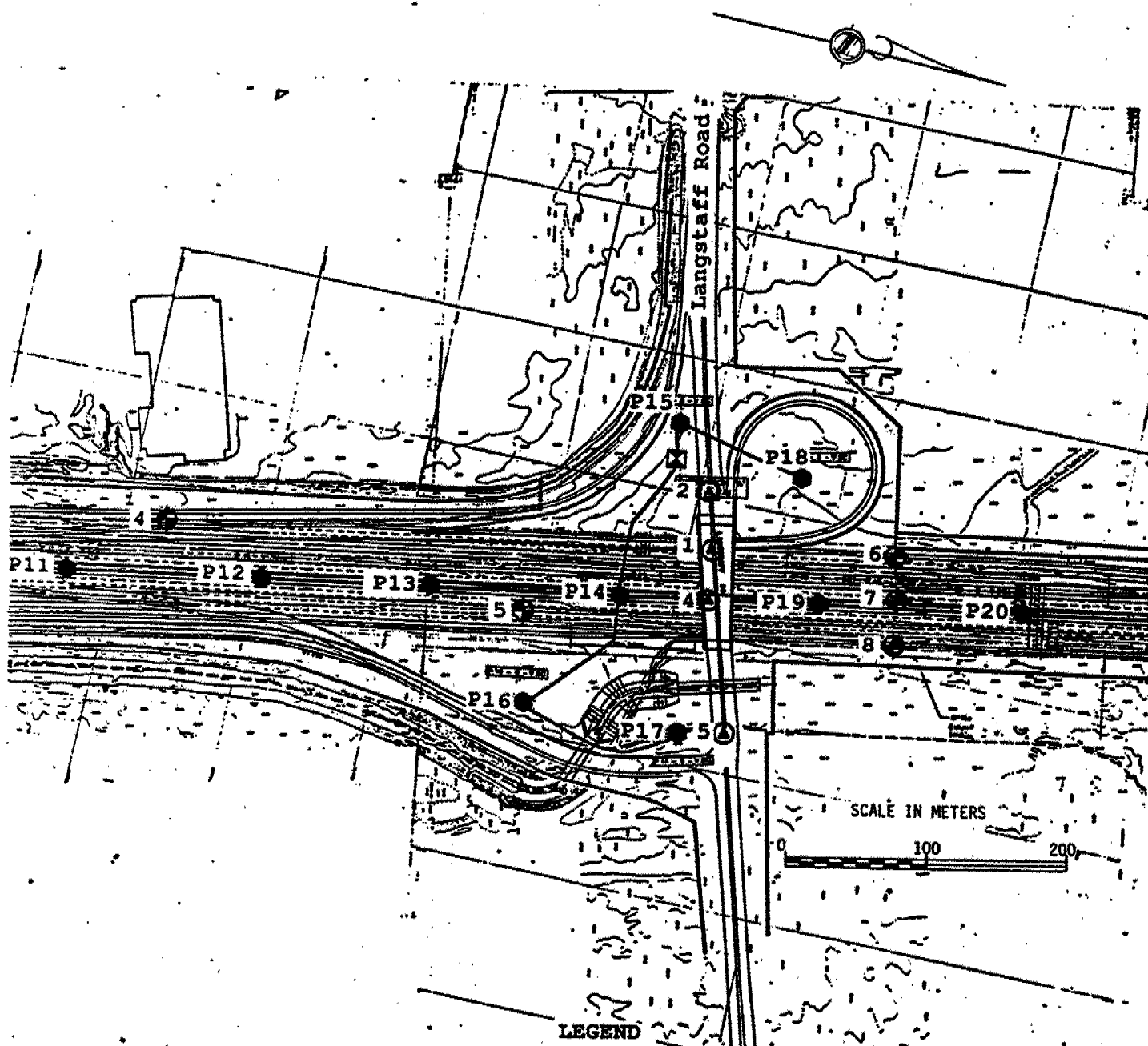
LEGEND

●	Borehole (This Investigation)
⊕	Borehole + Cone (This Investigation)
⊕	Borehole + Cone (W P 527-91-01)
⊙	Borehole (W P 164-79-04/05)
Ⓐ	Borehole (W O 89-11001)
●	Proposed High Mast Light Poles

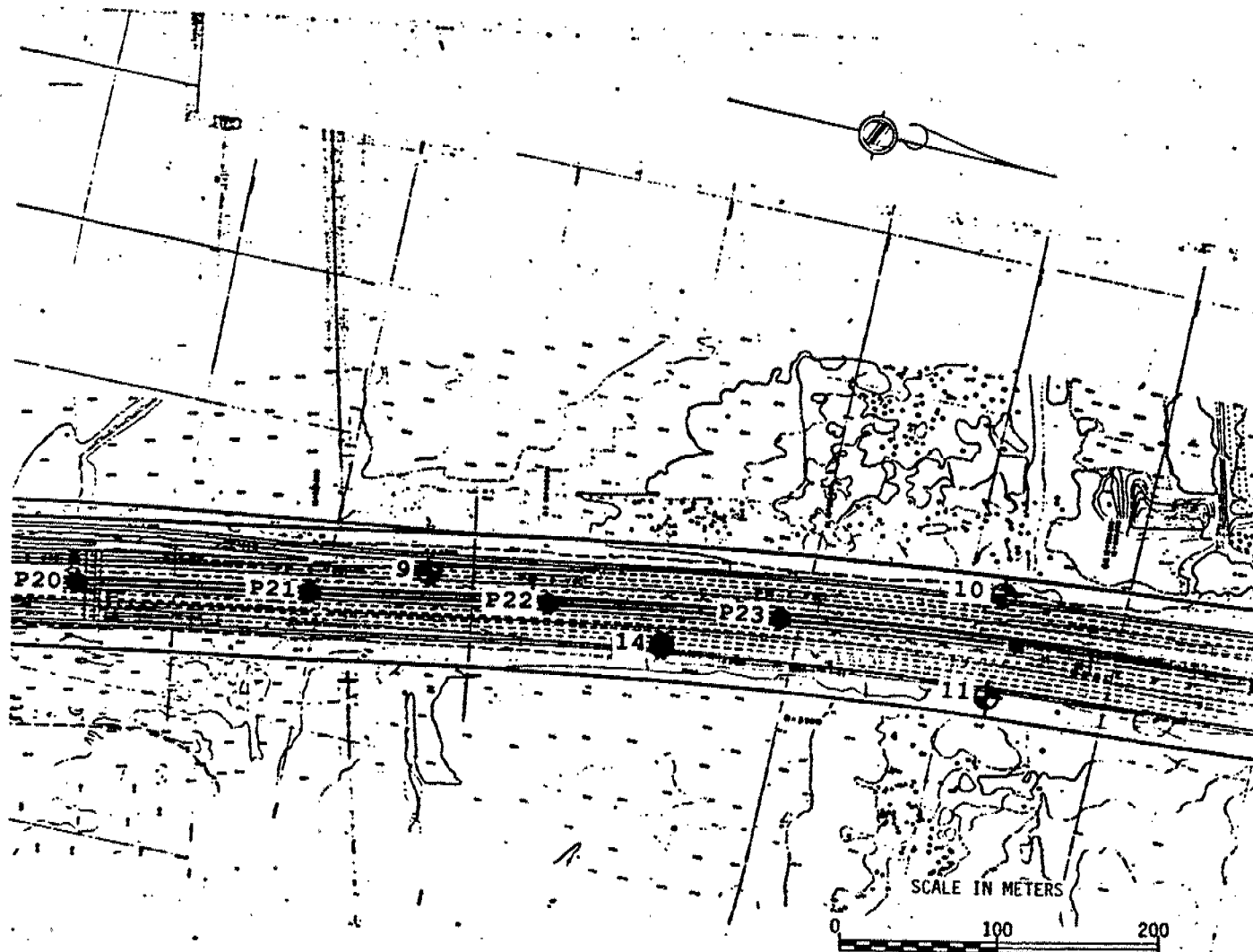


LEGEND

●	Borehole (This Investigation)
⊕	Borehole + Cone (This Investigation)
⊕	Borehole + Cone (W P 527-91-01)
●	Borehole (W P 164-79-04/05)
⊕	Borehole (W O 89-11001)
●	Proposed High Mast Light Poles



●	Borehole (This Investigation)
⊕	Borehole + Cone (This Investigation)
⊕	Borehole + Cone (W P 527-91-01)
⊙	Borehole (W P 164-79-04/05)
⊙	Borehole (W O 89-11001)
●	Proposed High Mast Light Poles



LEGEND

●	Borehole (This Investigation)
⊕	Borehole + Cone (This Investigation)
⊕	Borehole + Cone (W P 527-91-01)
⊙	Borehole (W P 164-79-04/05)
⊙	Borehole (W O 89-11001)
●	Proposed High Mast Light Poles

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 528-91-01(Formerly 612-89-00) LOCATION Co-ords: N 4 850 724.9; E 301 501.2 ORIGINATED BY JB
DIST 5 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
DATUM Geodetic DATE 92 01 13 CHECKED BY DD

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 7 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					
204.3	Ground Surface																
0.0	Gravelly Sand Loose, Dark Grey (Fill)		1	SS	5		204										
203.4	Silty Clay - Organic, Dark Grey, Stiff, (Fill)		2	SS	15		203										
0.9	Silty Clay Trace Sand Brown																
202.6	V. Stiff		3	SS	19		202										
1.7	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel Occasional Cobbles and Boulders		4	SS	18		201										
			5	SS	20		200										
			6	SS	36		199										
			7	SS	16		198										
			8	SS	35		197										
			9	SS	44		196										
			10	SS	40		195										
194.7	Sandy Silt to Silty Sand						194										
9.6	Occ. Clayey Silt Layers Very Dense		11	SS	53												
193.2	End of Borehole • W.L. Not Stabilized																

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 528-91-01 (Formerly 612-89-00) LOCATION Co-ords: N 4 850 990.0; E 301 414 ORIGINATED BY JB
DIST 5 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
DATUM Geodetic DATE 92 01 10 CHECKED BY DD

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	20 40 60 80 100	W _p	W	W _L	10 20 30				
205.7	Ground Surface																
0.0	Gravelly Sand (Fill)		1	SS	8												
203.9	Silty Clay Contains Topsoil Brown to Dark Brown (Fill)		2	SS	10												
1.8	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel Occasional Cobbles and Boulders		3	SS	14												
			4	SS	17												
	Sandy Brown, Stiff to Very Stiff Grey, Hard		5	SS	26												
			6	SS	66	/27cm											
	(Glacial Till)		7	SS	55												
			8	SS	50												
	Silty Sand Layer																
	Random Silty Sand Layers		9	SS	58	/15cm											
196.4			10	SS	70	/13cm											
9.3	End of Borehole • W.L. on 92 01 13																

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 528-91-01 (Formerly 612-89-00) LOCATION Co-ords: N 4 851 269.3; E 301 406.2 ORIGINATED BY JB
DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
DATUM Geodetic DATE 92 01 13 CHECKED BY DD

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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
206.6	Ground Surface																
0.0	Sand, Some Gravel Brown, Loose to Compact (Fill)		1	SS	11												
205.2	Silty Clay - Organic Dark Brown, Firm, (Fill)		2	SS	7												
1.4	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		3	SS	16												
	Occasional Cobbles and Boulders		4	SS	17												
			5	SS	21												
			6	SS	22												
			7	SS	36												
			8	SS	29												
			9	SS	52												
198.0																	
8.6	Silt Trace of Clay Dense to Very Dense		10	SS	57												
195.5			11	SS	36												
11.1	End of Borehole • W.L. Not Stabilized																

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 528-91-01(Formerly 612-89-00) LOCATION Co-ords: N 4 851 528.5; E 301 300.6

ORIGINATED BY JB

DIST 5 HWY 400 BOREHOLE TYPE Solid Stem

COMPILED BY JB

DATUM Geodetic DATE 92 01 10

CHECKED BY DD

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					
206.1	Ground Surface													
0.0	0.5 m Topsoil Silty Clay Occasional Root Fibres (Fill)		1	SS	6									
205.5														
0.5	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel (Glacial Till)		2	SS	16									
	Very Stiff		3	SS	17									
	Hard													
	Brown		4	SS	80									
	Grey													
202.6	Occasional Cobbles and Boulders		5	SS	43									
3.5	Sandy Silt to Silty Fine Sand													
	Compact to Dense		6	SS	31									
			7	SS	18									
200.2														
5.9	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel Occasional Cobbles and Boulders Hard (Glacial Till)		8	SS	71	/17cm								
199.1														
7.0	Sand and Silt to Silty Fine Sand		9	SS	26									
	Compact													
196.5			10	SS	14									
9.6	End of Borehole													
	• W.L. on 92 01 13													

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 528-91-01(Formerly 612-89-00) LOCATION Co-ords: N 4 851 794.8; E 301 313.6 ORIGINATED BY JB
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
 DATUM Geodetic DATE 92 01 06 CHECKED BY DD

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 7 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					
206.9	Ground Surface																
0.0	Gravelly Sand Brown, Loose, (Fill)																
205.8	Silty Clay Containing Traces of Topsoil Dark Brown, Stiff, (Fill)		1	SS	10		206										
1.1	Topsoil																
205.0	Brownish Grey to Dark Brown Greenish Grey to Brown		2	SS	8		205										
1.9	Silty Clay, Trace Sand Stiff		3	SS	8		204										
203.9			4	SS	13		203										
3.0	Sand Layer		5	SS	24		202										
	Brown Grey		6	SS	15		201										
	Occasional Sandy Silt Layers		7	SS	15		200										
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel Occasional Cobbles and Boulders Very Stiff to Hard (Glacial Till)		8	SS	20		199										
198.9			9	SS	37		198										
8.0	Silty Sand to Sandy Silt																
197.3	Compact to Dense		10	SS	17												
9.6	End of Borehole																
	• W.L. on 92 01 07																
	> Greater Than																

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 527-91-01(A)(prev. 612-89-00) LOCATION Co-ords: N 4 852 049.1; E 301 208.7 ORIGINATED BY JB
DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
DATUM Geodetic DATE 92 01 09 CHECKED BY DD

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 × 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 SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
205.7											
0.0	Topsoil		1	SS	2						
205.2	Dark Brown to Black Soft										
0.5			2	SS	5						
	Silty Clay to Clayey Silt Some Sand, Trace Gravel Firm to Very Stiff	Root Fibres	3	SS	11						
			4	SS	7						
202.3			5	SS	34						
3.4	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel Sandy Occasional Cobbles and Boulders Very Stiff to Hard (Glacial Till) Occasional Silty Clay Zones Sandy	Silty Sand Layer Brown Grey	6	SS	45						
			7	SS	39						
			8	SS	25						
			9	SS	28						
			10	SS	33						
			11	SS	76						
194.6			12	SS	38						
11.1	End of Borehole										
	92 01 13 * GROUND WATER CONDITIONS										
	PIEZO. NO.	GROUND WATER ELEVATION (Metres)									
	1	205.4									
	> Greater Than										

RECORD OF BOREHOLE No 7

1 OF 1 METRIC

W.P. 527-91-01(A)(Prev. 612-89-00) LOCATION Co-ords: N 4 852 057; E 301 248.5 ORIGINATED BY JB
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
 DATUM Geodetic DATE 92 01 06 CHECKED BY DD

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 7 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					
207.3	Ground Surface													
0.0	230 mm Asphalt 130 mm Granular 'A'						207							
	Sand													
	Brown, Loose, (Fill)		1	SS	7		206						17.6	
	Silty Clay													
	Containing Topsoil													
	Grey to Black, Firm, (Fill)		2	SS	7		205						19.0	
205.2	Topsoil, Black, Firm													
2.1	Silty Clay		3	SS	3		204						22.1	
	Traces of Organics													
	Brownish Grey to Grey		4	SS	9		203							
203.6	Soft to Stiff													
3.7	Brown to Brownish Grey		5	SS	12		202							
	Grey		6	SS	23		201						22.8	
	Sandy		7	SS	49		200							
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		8	SS	50		199							
	Occasional Cobbles and Boulders													
	Hard		9	SS	35		198							
	(Glacial Till)													
187.7			10	SS	38									
9.6														
	* W.L. not stabilized													

RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 527-91-01(A)(Prev. 612-89-00) LOCATION Co-ords: N 4 852 064.0; E 301 285.5 ORIGINATED BY JB
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
 DATUM Geodetic DATE 92 01 07 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _P W W _L	WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
205.4	Ground Surface											
0.0	130 mm Topsoil											
	Silty Clay Some Sand		1	SS	9							
	Stiff to Very Stiff		2	SS	15							
203.3	Sandy											
2.1	Sandy Silt to Silty Sand Occ. Clayey Silt Layers		3	SS	14							
	Brown to Brownish Grey Grey		4	SS	18							
201.7	Compact											
3.7	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		5	SS	30							
	Occasional Cobbles and Boulders		6	SS	48							
	Very Stiff to Hard		7	SS	38							
	(Glacial Till)		8	SS	21							
			9	SS	21							
			10	SS	44							
	Sandy		11	SS	60							
194.5			12	SS	50							
10.9	End of Borehole											
	92 01 13 * GROUND WATER CONDITIONS											
	PIEZO. NO.	GROUND WATER ELEVATION (Metres)										
	1	205										

RECORD OF BOREHOLE No 9

1 OF 1

METRIC

W.P. 528-91-01(Formerly 612-89-00) LOCATION Co-ords: N 4 852 363.7; E 301 181.9

ORIGINATED BY JB

DIST 5 HWY 400 BOREHOLE TYPE Solid Stem

COMPILED BY JB

DATUM Geodetic DATE 92 01 06

CHECKED BY DD

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			SHEAR STRENGTH kPa							WATER CONTENT (%) 10 20 30
								○ UNCONFINED • QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
208.4	Ground Surface							20 40 60 80 100							
0.0	Gravelly Sand Brown, Loose (Fill)														
	Silty Clay Containing Topsoil Dark Brown to Black, Stiff (Fill)		1	SS	10										
			2	SS	10										
206.2	Silty Clay, Trace Sand, Brown, Stiff														
2.2	Silty Fine Sand Brown Compact		3	SS	19										
205.4															
3.0	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel Occasional Cobbles and Boulders Brown		4	SS	18										
	Occasional Sandy Silt Layers		5	SS	21										
	Very Stiff (Glacial Till)		6	SS	22										
203.2															
5.2	Silty Fine Sand to Sand, Some Silt Compact		7	SS	11										
			8	SS	15										
201.1															
7.3	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel Occasional Cobbles and Boulders Very Stiff to Hard (Glacial Till)		9	SS	23										
			10	SS	79										
198.8															
9.6	End of Borehole														
	* W.L. immediately upon completion of sampling														

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

W.P. 527-91-01(B)(Prev. 612-89-00) LOCATION Co-ords: N 4 852 722.7; E 301 111.5 ORIGINATED BY JB
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
 DATUM Geodetic DATE 92 01 09 CHECKED BY DD

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
207.4	Ground Surface															
0.0	Topsoil/Silty Clay (Fill)		1	SS	2											
206.9	Black to Brownish Gray, Soft															
0.5	Root Fibres															
	Silty Clay, Trace Sand		2	SS	8											
	Brown															
205.6	Firm to Stiff															
1.8	Occasional Sandy Silt Layers		3	SS	13											
	Brown															
	Grey		4	SS	18											
	Silty Clay Layer															
	Heterogeneous Mixture of Clayey Silt, Some Gravel, Trace Clay		5	SS	25											
			6	SS	19											
	Silty Clay Layer		7	SS	17											
			8	SS	14											
	Occasional Cobbles, Boulders and Silty Clay Layers		9	SS	18											
	Very Stiff															
	(Glacial Till)		10	SS	21											
198.8																
8.6	Sandy Silt to Silty Fine Sand		11	SS	23											
	Compact															
196.3			12	SS	13											
11.1	End of Borehole															
	92 01 13															
	* GROUND WATER CONDITIONS															
	PIEZO. NO.															
	GROUND WATER ELEVATION (Metres)															
	1															
	207.3															
	> Greater Than															

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 527-91-01(B)(Prev. 612-89-00) LOCATION Co-ords: N 4 852 729.9; E 301 179.6 ORIGINATED BY JB
DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
DATUM Geodetic DATE 92 01 08 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
207.5	Ground Surface													
0.0	100 mm Topsoil													
	Silty Clay, Some Sand Traces of Root Fibres		1	SS	8									
206.1	Brown, Firm to Stiff													
1.4			2	SS	45									
	Brown to Brownish Grey Occasional Silty Sand to Sandy Silt Layers		3	SS	33									
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		4	SS	29									
	Occasional Cobbles and Boulders		5	SS	24									
	Very Stiff to Hard (Glacial Till)		6	SS	26									
201.6			7	SS	33									
5.9			8	SS	13									
	Sandy Silt to Sand and Silt													
	Compact		9	SS	13									
198.9														
8.6	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel													
197.9	Hard (Glacial Till)		10	SS	45									
9.6	End of Borehole													
	• W.L. on 92 01 13													

RECORD OF BOREHOLE No 14

1 OF 1

METRIC

W.P. 528-91-01(Formerly 612-89-00) LOCATION Co-ords: N 4 852 517.0; E 301 190.7 ORIGINATED BY JB
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
 DATUM Geodetic DATE 92 01 07 CHECKED BY DD

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100		WATER CONTENT (%) 10 20 30				
208.8														
0.0	Gravelly Sand, Brown, Compact, (Fill)					*								
	Silty Clay, Traces of Topsoil Soft to Firm, (Fill)						208							
207.4	Dark Brown													
1.4	Brown													
	Traces of Organics		1	SS	11		207							
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		2	SS	23		206							
	Brown						205							
	Grey													
	Occasional Cobbles and Boulders		3	SS	16		204							
	Stiff to Hard						203							
	(Glacial Till)		4	SS	38		202							
201.2			5	CS										
7.6	End of Borehole													
	* W.L. not established													

RECORD OF BOREHOLE No C 8

METRIC

W P 164-79-04/05 LOCATION Co-ords. N 4 850 173; E 301 521
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem Augers, Cone Test
 DATUM Geodetic DATE 85 06 10
 ORIGINATED BY FS
 COMPILED BY FS
 CHECKED BY *JP*

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	W VALUES			20 40 60 80 100						
198.1	Ground Surface													
0.0	Silty Clay trace to with Sand trace Gravel Very Stiff						198							
			1	SS	17		197							
			2	SS	25		196							
			3	SS	30		195							
	Hard		4	SS	34		194							
			5	SS	72		193							
			6	SS	189 / 15		192							
	Silty Sand to Sandy Silt Very Dense		7	SS	120		191							
							190							
189.1							189							
9.0	Sand some Silt trace Clay, Gravel Very Dense		8	SS	185									
9.6	End of Borehole *groundwater level not established													

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No C 10

METRIC


W P 164-79-04/05 LOCATION Co-ords. N 4 850 297; E 301 587 ORIGINATED BY FS
DIST 6 HWY 400 BOREHOLE TYPE Solid Stem Auger, Cone Test COMPILED BY FS
DATUM Geodetic DATE 85 06 14 CHECKED BY [Signature]

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	W VALUES			20 40 60 80 100	SHEAR STRENGTH					
								○ UNCONFINED ○ QUICK TRIAXIAL	• FIELD VANE • LAB VANE					
								WATER CONTENT (%)						
								10	20	30				
200.0	Ground Surface													
0.0	Silty Clay trace to with Sand trace Gravel Firm		1	SS	7		199							
			2	TV	PH		198							3 29 41 25
	Hard		3	SS	37		197							
			4	SS	69		196							4 17 54 25
			5	SS	126		195							
			6	SS	105		194							1 19 55 25
							193							
192.2	Silty Sand to Sandy Silt Very Dense		7	SS	80	15cm								
7.8	End of Borehole													
	*groundwater level not established													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No C 11

METRIC

W P 164-79-04/05 LOCATION Co-ords N 4 850 432; E 301 498
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem Augers, Cone Test
 DATUM Geodetic DATE 85 06 10
 ORIGINATED BY FS
 COMPILED BY FS
 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	W' VALUES			20	40					
199.9	Ground Surface													
0.0	Silty Clay trace to with Sand trace Gravel													
	Very Stiff		1	SS	17									
	Hard		2	SS	60									
			3	SS	90									
			4	SS	100									
			5	SS	88									
			6	SS	100	15cm								
192.4														
7.5	Refusal due to probable boulder End of Borehole													

*3, *5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE 1

SHEET 1

LOCATION SEE FIGURE 2

BORING DATE JAN 19, 1989

DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, CM/SEC		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (M)	NUMBER	TYPE	SHEAR STRENGTH CU, KPa	WATER CONTENT, PERCENT				
0	CHES POWER AUGER BORING 200mm DIA. HOLLOW STEM AUGER	GROUND SURFACE	206.16								
			0.00	1	DO						
		Soft to firm, mottled grey-brown SILTY CLAY, trace sand, occ. organics.		2	DO						
			203.68								
		Firm to stiff, grey inter-layered SILTY CLAY, trace sand (TILL) and SILTY CLAY; some seams of silt, sandy silt and silty sand.	1.60	3	DO						
			202.25	4	DO						
		Compact, grey SANDY SILT, trace clay and gravel. TILL. Boulder at 2.9m depth	2.90	5	DO						
			201.45								
			3.70	6	DO						
				7	DO						
6				8	DO						
				9	DO						
				10	DO						
				11	DO						
				12	DO						
				13	DO						
				14	DO						
				15	DO						
				16	DO						
				17	DO						
10		Stiff, grey CLAYEY SILT, trace sand with interlayers of SANDY SILT, trace clay and gravel.	8.80	18	DO						
			104.76								
		Compact grey SANDY SILT, trace sand and gravel. TILL. Seam of silty clay.	10.40	19	DO						
			103.65								
		Dense, grey SILTY SAND, trace gravel with interlayers of CLAYEY SILT, some sand.	11.60	20	DO						
			102.05								
			13.10								
15		Hard, grey stratified SILTY CLAY, CLAYEY SILT and SILT, fine sand partings throughout.									
			188.95								
			16.20								
		Very loose, grey SILT, trace clay and sand.									
			187.45								
		Compact, to dense grey SAND, trace silt to SILTY SAND. (Sands blowing: 1.5m to 3m up augers at each sample depth prior to washing.)	17.70								
20			185.16								
			20.00								
		CONTINUED ON NEXT PAGE									

RECORD OF BOREHOLE 1

SHEET 2

LOCATION SEE FIGURE 2

BORING DATE JAN 19, 1989

DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, CM/SEC		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (M)	NUMBER	TYPE	36 72 108 144	36 72 108 144	36 72 108 144	36 72 108 144		
20	CHESSE POWER AUGER BORING 200mm DIA. HOLLOW STEM AUGER	CONTINUED FROM PREVIOUS PAGE	185.15								
			20.00								
		Compact to dense grey SAND, trace silt to SILTY SAND. (Sands blowing: 1.5m to 3m up augers at each sample depth prior to washing.)		18	50 DO	43					
				19	50 DO	28					
			180.85								
25		Very stiff to hard, grey SILTY CLAY, trace fine sand partings.	24.30	20	50 DO	62					
				21	50 DO	27					
			178.05								
		Hard, grey SILTY CLAY, trace sand, occ. fine gravel.	27.10	22	50 DO	62					
				23	50 DO	48					
30	END OF HOLE		174.64								
			30.61								
35	NOTE: Borehole continued below elevation 178.8m. at location of Borehole 1A: 7.6m. west of initial borehole: ground surface elevation 205.32m. Noted increase in auger resistance at about elevation 179.8 m.										
40											

Caved

10

MH

Water level in
piezometer at
elevation 204m.
on Jan. 28, 1989.

0
10
15 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1: 100

Golder Associates

LOGGED RF

CHECKED ASP

RECORD OF BOREHOLE 2

SHEET 1

LOCATION SEE FIGURE 2

BORING DATE JAN 20, 1989

DATUM GEODETIC

SAMPLER HAMMER, 83.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 83.5kg, DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, CM/SEC		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (M)	NUMBER	TYPE	BLOWS/0.3M	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT				
0	CMSS POWER AUGER BORING 200mm DIA. HOLLOW STEM AUGER	GROUND SURFACE	205.77									
5		Stiff, mottled gray-brown SILTY CLAY, trace sand, occ. gravel, trace organics.	0.00	1	DO	18					Bentonite Seal Backfill	
				2	DO	11						
				3	DO	10						
		Loose to compact, brown to gray SANDY SILT, trace clay and gravel. TILL.	2.10	4	DO	9						
				5	DO	18						
		Hard, interlayered CLAYEY SILT and SANDY SILT, numerous silt partings.	202.07	6	DO	30						
			201.37	7	DO	58						
10		Hard, gray CLAYEY SILT, some sand, trace gravel. TILL.	4.40	8	DO	33						
				9	DO	33						
			197.27	10	DO	20						
		Very stiff, gray stratified SILTY CLAY and CLAYEY SILT.	8.50	11	DO	21						
			12	DO	77							
15		Dense to very dense, gray SANDY SILT, trace clay and gravel. TILL.		13	DO	73						
	190.87		14	DO	32							
			190.07									
	Hard, stratified SILTY CLAY, trace sand, occ. gravel.	14.90										
	END OF HOLE	15.70										

10 0 10 PERCENT AXIAL STRAIN AT FAILURE

Water level in
piezometer at
elev. 204 m. on
Jan. 28, 1989

 0
 10 PERCENT AXIAL STRAIN AT FAILURE
 10

DEPTH SCALE

1: 100

Golder Associates

LOGGED RF

CHECKED ASP

RECORD OF BOREHOLE 4

SHEET 1



LOCATION SEE FIGURE 2

BORING DATE JAN.23,1989

DATUM GEODETIC

SAMPLER HAMMER, 83.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, CM/SEC		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (M)	NUMBER	TYPE	BLOWS/0.3M	SHEAR STRENGTH Cu, kPa nat.V.- + Q.- ● rem.V.- ● U.- ○	WATER CONTENT, PERCENT w _p — w _L — w _U			
0	CMES POWER AUGER BORING 200mm DIA. HOLLOW STEM AUGER	GROUND SURFACE	206.97								
		ASPHALT	206.70								
		Sand and gravel, FILL.	206.22	1	50	15					
			0.53	2	50	10					
		Loose to compact, brown sand, trace silt and gravel, FILL.		3	50	5					
			204.97	4	50	3					
		Soft, mottled brown silty clay, some organics, FILL.	2.00	5	50	4					
			204.27	6	50						
		Stiff, gray-brown SILTY CLAY, trace sand, occ. organics.	2.70	7	50	14					
			203.27	8	50	11					
		Compact to dense, gray SANDY SILT, trace clay and gravel. TILL.	3.70	9	50	31					
			201.47	10	50						
		Dense, gray SILT, some sand, trace clay.	6.50	11	50	32					
			199.87	12	50						
		Very stiff, gray CLAYEY SILT, some sand, trace gravel, TILL. Interlayers of stratified silt and clayey silt below 9.4m depth.	7.30	13	50	25					
5			14	50	20						
10			15	50	3						
			16	50							
			17	50	22						
			18	50							
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			180	50							

RECORD OF BOREHOLE 4

SHEET 2

LOCATION SEE FIGURE 2

BORING DATE JAN 23, 1989

DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, CM/SEC		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (M)	NUMBER	TYPE	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT				
20	CME65 POWER AUGER BORING 200mm DIA. HOLLOW STEM AUGER	CONTINUED FROM PREVIOUS PAGE	185.97 20.00								
25		Very loose to compact, grey SILTY SAND to SAND, trace silt.	182.87	16	50 DO	98					
		Hard, grey CLAYEY SILT to SILTY CLAY, some sand, trace gravel, TILL	24.10	16	50 DO	85					
		END OF HOLE	180.45 20.62	16	50 DO						
30		NOTE: Soil description between elevation 194m and 183m based on recovery from augers									
35											
40											

Water level in open hole at elevation 204.8m on completion of drilling.

LOGGED RF
CHECKED ASP

1: 100

Golder Associates

RECORD OF BOREHOLE 5

SHEET 1

LOCATION SEE FIGURE 2

BORING DATE JAN.25,1989

DATUM GEODETTIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k. CM/SEC		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (M)	NUMBER	TYPE	BLOWS/0.3M	SHEAR STRENGTH		WATER CONTENT, PERCENT			
							Cu, kPa	nat.V.- rem.V.-	+ Q.- U.-			Wp
0	CM665 POWER AUGER BORING 200mm DIA. HOLLOW STEM AUGER	GROUND SURFACE	205.88									
		Clayey TOPSOIL	205.22	1	50 DO	10						Backfill
		Firm to very stiff, mottled grey-brown SILTY CLAY, trace sand.	0.48	2	50 DO	8						MH
			203.38									
		Compact, grey SANDY SILT, trace clay and gravel. TILL.	2.30	3	50 DO	13						Bentonite seal Backfill
		Compact, grey stratified SILTY SAND and SANDY SILT.	202.08	4	50 DO	13						
			3.80	5	50 DO	19						
6		Compact, grey SANDY SILT, trace clay and gravel (clay content increasing with depth) TILL.	201.28	6	50 DO	16						Granular Filter
			4.40									
		END OF HOLE	189.13	7	50 DO	28						Water level in piezometer at elevation 203.1m on Jan.28,1989.
			6.55									

10 PERCENT AXIAL STRAIN AT FAILURE

DEPTH SCALE

1: 100

Golder Associates

LOGGED RF

CHECKED ASP

MEMORANDUM

FILE COPY

(416) 235-3731

Date: 1992 04 30

To: Mr. V. F. Boehnke
Head, Structural Section
4th Floor, Atrium Tower
Central Region

Att: Mr. Dennis Wong

From: Foundation Design Section
Room 315, Central Building
Downsview, Ontario

Re: Foundation Design Report
Concrete Culvert (Sta. 14+938, Hwy 400), Lt. Extension
Concrete Culvert (Sta. 14+938, Hwy 400), Rt. Extension
Concrete Culvert (Sta. 15+349, Hwy 400), Lt. Extension
Concrete Culvert (Sta. 15+349, Hwy 400), Rt. Extension
Highway 400/Langstaff Road to Rutherford Road
W.P. 527-91-01(B)
Central Region
District 6, Toronto .CONT 93-72

The attached report provides recommendations for the proposed culvert extensions to be constructed at the above-captioned site.

We believe that this report will be adequate for your purposes. However, should you have any questions regarding the report, please do not hesitate to contact this office.

John A. Blair
J. A. Blair, P.Eng.
Project Foundation Engineer

For

D. H. Dundas, P.Eng.
Sr. Foundation Engineer

Distribution

V. F. Boehnke (2)
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FOUNDATION INVESTIGATION REPORT
For
Proposed Culvert Extensions
Highway 400 / Langstaff Road to Rutherford Road
W.P. 527-91-01(B)
Central Region
District 6, Toronto

INTRODUCTION

At the request of the Central Region, Structural Section, this report summarizes a foundation investigation, carried out at the above-captioned site, for proposed extensions of two existing culverts located along both sides of Highway 400 between Langstaff Road and Rutherford Road.

SITE DESCRIPTION AND GEOLOGY

The site is located along Highway 400 between Langstaff Road and Rutherford Road, in the Town of Vaughan, Regional Municipality of York. The topography of the area is generally flat with a slight increase in elevation towards the north. Drainage is generally towards the southeast.

Physiographically, the site is located in the Peel Plain which consists of a level-to-undulating tract of clayey soils covering parts of York, Peel and Halton counties. In this area, the soil is known to consist of glacial till. However, in much of the Peel Plain, the till has been modified by a veneer of clay which, when deep enough, is clearly seen to be varved. It is thought that the clay veneer was deposited in a temporary lake impounded between higher land to the north and an ice lobe in the Ontario basin (Reference: Chapman and Putnam, "The Physiography of Southern Ontario"; 3rd Edition, 1984).

PROCEDURES

The fieldwork was carried out by this office on January 8 and 9, 1992, and consisted of 4 sampled boreholes which were advanced to depths of from 9.6 to 11.1 m using continuous flight, solid stem augers driven by a bombardier-mounted drilling rig equipped with standard soil sampling equipment.

Groundwater levels were measured in the open boreholes immediately upon completion of sampling and two were left open for subsequent measurements. Piezometers were installed in the two remaining boreholes, in order to measure the longer term groundwater conditions.

The locations of the boreholes were staked in the field, and their elevations determined by the Central Region Surveys and Plans Office.

The soil samples, which were obtained in the field, were examined in the laboratory by visual and tactile methods. Moisture content and Atterberg Limits tests were carried out on selected samples.

SUBSURFACE CONDITIONS

The subsurface conditions, at the borehole locations shown on Drawing No. 5279101(B)-A, generally consist of a surficial layer of topsoil and/or fill up to 1.1 m thick, which, at most locations, is underlain by a layer (up to 2.7 m thick) of silty clay. The clay is, in turn, underlain by a heterogeneous mixture of clayey silt, some sand and a trace of gravel (glacial till). Silt to silty sand deposits occur in random zones within the till, although major ones appear to be confined to certain elevations. The groundwater table was found to be at or close to the original ground surface (ie. prior to construction of Highway 400) or at elevations of 207.3 to 207.5 m at Station 14+938 and 209.8 m at Station 15+349.

Details of the subsurface information obtained, from this investigation, are included on the log sheets for Boreholes 10 to 13, given at the back of this report. Brief descriptions of the individual strata and the groundwater conditions encountered at the boreholes are given below.

Topsoil

A surficial layer of dark brown to black, soft to firm, topsoil, up to 0.5 m thick, was encountered at the boreholes.

Silty Clay (Fill)

At Boreholes 10, 12 and 13, the surficial layer of topsoil was found to be underlain by a 0.1 to 1.0 m thick layer of silty clay containing topsoil enclosures. This material has also been referred to as 'fill', since it appears that these soils have been disturbed by past farming activity, which has resulted in traces of topsoil becoming entrained into it.

'N'-values of 1 to 5 blows/0.3 m indicate that the silty clay fill soils are of soft to firm consistency.

Silty Clay

Beneath the fill materials described above, Boreholes 10, 11 and 13, contacted a brown to grey, silty clay layer from 1.3 to 2.6 m thick at depths of 0.1 to 1.1 m (or elevations of 206.9 to 208.7 m).

An Atterberg Limits test, carried out on a sample of soil from this deposit, had a liquid limit of 38 percent and a plasticity index of 21 percent. These results, indicate that the soil can be classified as CI or Silty Clay. The moisture contents of samples from this deposit ranged from 20 to 26 (average of 23) percent.

'N'-values, measured in this silty clay layer, ranged from 8 to 15 blows/0.3 m indicating soils of generally stiff consistency.

Heterogeneous Mixture of Clayey Silt, some Sand, trace Gravel (Glacial Till)

A heterogenous mixture of brown to grey, clayey silt with some sand and a trace of gravel and containing occasional cobbles and boulders, at least 7.4 to 8.9 m thick, was encountered in all of the boreholes at depths of 0.7 to 3.7 m (or elevations of 205.6 to 209.1 m). This deposit extended to the maximum depth explored in all of the boreholes.

An Atterberg Limits test, carried out on a sample of soil from this deposit, had a liquid limit of 17 percent and a plasticity index of 6 percent. These results, indicate that this soil can be classified as CL-ML or clayey silt to silt. However, Atterberg limits testing, carried out on other samples from the immediate area, indicates that generally the soil can be considered to be a CL or clayey silt.

Visual examination of the texture of the soil indicates that this material is likely to be of glacial origin and, therefore, may be referred to as glacial till.

Moisture content tests carried out on samples of soil obtained from this deposit, ranged from 8 to 20 (average of 14) percent.

'N'-values measured during Standard Penetration Testing ranged from 11 to 45 blows/0.3 m indicating soils of stiff to hard consistency.

Silt to Fine Sand

Cohesionless layers and zones of sandy silt to fine sand were encountered within the clayey silt till at various depths. Although they were often found to be thin (ie. less than 0.5 m thick) and discontinuous, major cohesionless zones were found in Boreholes 10 and 11. Seams or zones of silt to fine sand with occasional clayey silt interbeds were generally found between elevations of 204 to 206 m at Boreholes 10 and 11 and below elevation 199 at Borehole 10 and between elevations 199 and 202 at Borehole 11.

'N'-values ranged from 11 to 23 blows/0.3 m indicating generally compact conditions in these cohesionless zones.

Groundwater Conditions

The groundwater levels, when measured in the open boreholes, immediately upon completion of sampling, were found to be from 0.2 to 1.3 m beneath the existing ground surface. However, water levels, measured in the two piezometers installed at the site, at least 48 hours after their installation, ranged from the ground surface to depths of 0.1 m.

It appears that the groundwater table is at or slightly below the original ground surface (ie. prior to the construction of the Highway 400 embankment) or at elevations of 207.3 to 207.5 m at Station 14+938 and 209.8 m at Station 15+349.

DISCUSSIONS AND RECOMMENDATIONS

General Considerations

In order to widen Highway 400 between Langstaff Road and Rutherford Road from three lanes in each direction to a complete core/collector system, it will also be necessary to lengthen the two existing 1.2 X 0.9 m, open footing concrete culverts, located at Stations 14+938+/- and 15+349+/- on both ends by about 14 m. The flow through both of these extended culverts is from west to east.

At the time of the investigation, it was assumed that the extensions would be constructed as open footing culverts. However, box culverts with matching invert levels are also being considered.

At Station 14+938, the invert elevations on the west and east ends of the proposed culvert will be 207.40 m and 207.15 m, respectively. Boreholes 10 and 11, were drilled to determine the stratigraphy beneath the proposed extensions of this culvert. In this area, the top of the existing embankment is at an elevation of approximately 210.1 m.

At Station 15+349, the west and east invert elevations for the proposed culvert will be 209.48 and 209.29 m, respectively with Boreholes 12 and 13 representing the stratigraphy at these locations. In this area, the top of the existing embankment is at an elevation of approximately 211.9 m.

Design

Structure Foundations

Open Footing Culvert Extensions

If the culvert extensions are being constructed as open footing culverts, it is recommended that the foundations for the culvert extensions be taken below the topsoil, organic-fill or otherwise unsuitable soil to bear on undisturbed silty clay at or about the elevation of the footings for the existing culverts. A design value of 300 kPa may be used for the factored bearing capacity at U.L.S. and 150 kPa for the bearing capacity at S.L.S. Type II at or below the following elevations:

<u>Culvert at Station</u>	<u>Inlet (ie. west) Extension</u>	<u>Outlet (ie. east) Extension</u>
14+938	206.3	206.3
15+349	208.7	208.0

It must be assumed that the existing footings will remain undisturbed, at all times. If it appears that the elevations of the new footings will be different than the existing ones, then transitional footings should be provided which slope down or up at an angle no steeper than 1H:1V.

It should be noted, that the boreholes drilled for the culvert at Station 14+938, encountered thin layers and zones of cohesionless soils in the upper part of the underlying clayey silt till, below an elevation of about 205.5 m. To avoid such zones, which will be extremely susceptible to disturbance, it is recommended that the foundations be kept as high as possible and at least above elevation 206.0 m.

Box Culvert Extensions

If the extensions are being constructed as box culverts, then it is recommended that all topsoil, organic fill and soft silty clay be subexcavated throughout the full width of the proposed culvert extension. At Station 14+938, the soil should be subexcavated to an elevation of about 206.3 m.

It is required that, at all times, the existing footings remain undisturbed. Where subexcavations must take place adjacent to existing footings, the excavation should be sloped downwards and outwards from the bottom outer edge of the existing footing at no steeper than 10 horizontal to 7 vertical.

The grade should then be raised to the underside of the proposed extensions using Granular 'A', placed and compacted according to MTO standards and practice. For bedding requirements, a minimum of 0.6 m of Granular 'A' should be used.

For culverts placed on Granular 'A', design bearing capacities of 400 and 200 kPa may be used for the factored bearing capacity at U.L.S. and the bearing capacity at S.L.S., Type II, respectively.

Frost Protection

A minimum of 1.2 m of earth cover is required for frost protection. This requirement applies to open footing culverts. It is our understanding that box culverts are structurally designed to withstand frost pressures. If this is not the case, frost cover recommendations apply.

Backfilling/Lateral Pressure

Backfilling, below the groundwater level, should consist of Granular 'A' or 'B'. The granular fill should be placed and compacted in accordance with MTO standards and practice and OPSD 803.02. For open footing culverts, the remainder of the backfill should also consist of granular fill. However, for box culverts, the remaining fill may consist of either granular material or suitable earth fill as per MTO procedures.

The backfill operations should be carried out simultaneously on both sides of all culvert extensions as per MTO specifications. The following properties are recommended for the calculation of lateral pressure if any cut-off or retaining walls are required:

Granular 'A' $\gamma = 22.8 \text{ kN/m}^3$, $\phi = 35^\circ$, $K_o = 0.43$ $K_a = 0.27$
Granular 'B' $\gamma = 21.2 \text{ kN/m}^3$, $\phi = 30^\circ$, $K_o = 0.50$ $K_a = 0.33$

For structural elements, such as headwalls, rigidly connected to the culverts, the at rest condition (K_o) should be used to calculate lateral pressure.

Stability and Settlement

Deep seated slope failure is not of concern at this site. The slopes of the highway embankments should be constructed at 2H:1V.

Construction Considerations

Temporary Diversion

To facilitate the construction of the proposed culvert extensions, a temporary diversion of the water courses may be considered.

Dewatering

It is expected that most groundwater infiltration can be controlled by gravity drainage and properly-filtered sumps.

However, the Contractor should be cautioned that the clayey silt till contains zones and layers of sandy silt to fine sand below the groundwater table and that these zones are susceptible to disturbance under conditions of unbalanced hydrostatic head.

Excavation

In general, temporary excavations through the silty clay and underlying clayey silt till are expected to be stable at 1H:1V both above and below the groundwater table. However, where cohesionless zones of sandy silt to fine sand are encountered, slopes of 1.5H:1V or flatter are likely to be required.

In any case, all excavations should be carried out in accordance with the provincial safety regulations.

Bedding

Bedding consisting of a minimum 0.6 m thick layer of Granular 'A' should be provided beneath all box culverts.

Cambering

Due to competent soil conditions, no significant settlements are anticipated and cambering is not required.

Construction Joints

Construction joints will be required at connections between the old and new culverts to accommodate any differential movement that may occur. Such joints should be able to accommodate differential settlement of up to 12 mm and still provide proper seal.

Erosion Protection

Erosion protection will be required at the inlet and outlet ends of all culvert extensions.

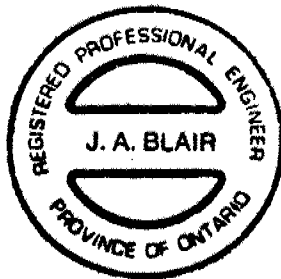
A seal (see OPSS 1205) of cohesive material (CI-CH clay) with a minimum thickness of 0.6 m should be constructed at the inlets of both extended culverts. The seal should extend a minimum of 2 m on each side of the culvert inlet, and from the high water level down the embankment to the creek bed and 2 m along the creek bed.

Rock protection (with a minimum thickness of 0.6 m), should be placed in order to protect the embankment at both the inlet and outlet areas. This material should extend from the high water level to the toe of the slope and 2 m along the creek bed. In the transverse direction, such erosion protection should extend a minimum of 5 m on each side of the culvert. Rock protection is not required beneath the headwalls. At the outlet, the rock protection should be underlain by a 0.6 m thick layer of Granular 'A'.

MISCELLANEOUS

The field investigation was supervised by Mr. J. Blair using equipment owned and operated by Malone's Soil Samples Inc.

This report was written by Mr. J. Blair, Project Foundation Engineer, reviewed by Mr. D. Dundas, Senior Foundation Engineer and approved by Mr. M. Devata, Chief Foundation Engineer.

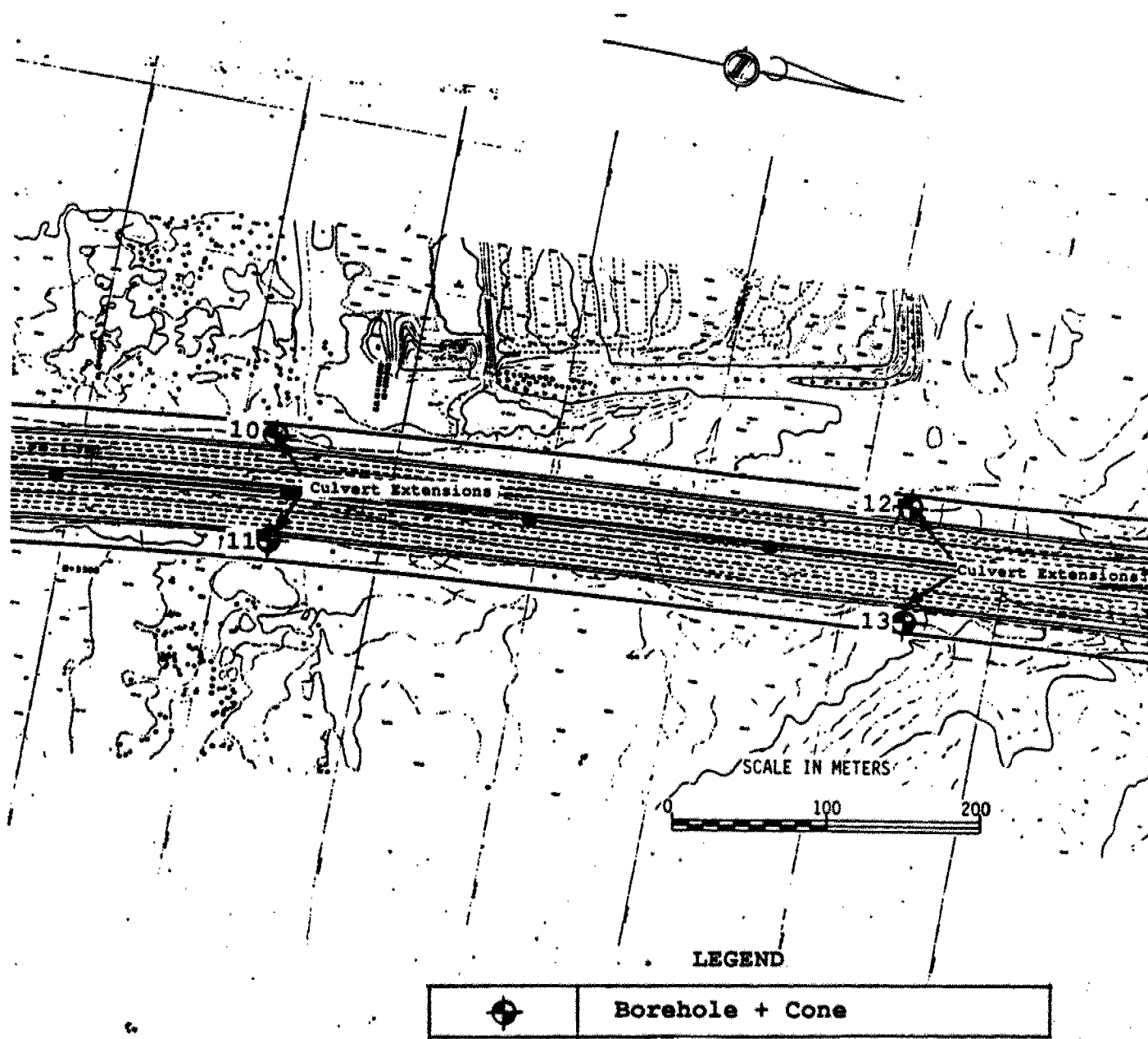


John A. Blair

John A. Blair, P.Eng.
Project Foundation Engineer

M. Devata

Murty Devata, P.Eng.
Chief Foundation Engineer



RECORD OF BOREHOLE No 10

1 OF 1 METRIC

W.P. 527-91-01(8)(Prev. 612-89-00) LOCATION Co-ords: N 4 852 722.7; E 301 111.5 ORIGINATED BY JB
 DIST 5 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
 DATUM Geodetic DATE 92 01 09 CHECKED BY DD

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 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa						
207.4	Ground Surface							20 40 60 80 100						
0.0	Topsoil/Silty Clay (Fill)		1	SS	2									
206.9	Black to Brownish Grey, Soft													
0.5	Root Fibres													
	Silty Clay, Trace Sand Brown		2	SS	8									
205.6	Firm to Stiff													
			3	SS	13									
1.8	Occasional Sandy Silt Layers													
	Brown Grey Silty Clay Layer		4	SS	18									
	Heterogeneous Mixture of Clayey Silt, Some Gravel, Trace Clay		5	SS	25									
			6	SS	19									
	Silty Clay Layer		7	SS	17									
			8	SS	14									
	Occasional Cobbles, Boulders and Silty Clay Layers		9	SS	18									
	Very Stiff (Glacial Till)		10	SS	21									
198.8														
8.6	Sandy Silt to Silty Fine Sand		11	SS	23									
	Compact													
196.3			12	SS	13									
11.1	End of Borehole													
	92 01 13													
	* GROUND WATER CONDITIONS													
	PIEZO. NO.													
	GROUND WATER ELEVATION (Metres)													
	1													
	207.3													
	> Greater Than													

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 527-91-01(B)(Prev. 612-89-00) LOCATION Co-ords: N 4 852 729.9; E 301 179.6 ORIGINATED BY JB
DIST 5 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
DATUM Geodetic DATE 92 01 08 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIMIT 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	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)		
207.5	Ground Surface												
0.0	100 mm Topsoil												
	Silty Clay, Some Sand Traces of Root Fibres		1	SS	8		207						
206.1	Brown, Firm to Stiff												
1.4			2	SS	45		206						
	Brown to Brownish Grey Grey		3	SS	33		205						
	Occasional Silty Sand to Sandy Silt Layers		4	SS	29		204						
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		5	SS	24		203						
	Occasional Cobbles and Boulders		6	SS	26		202						
	Very Stiff to Hard (Glacial Till)		7	SS	33		201						
201.6			8	SS	13		200						
5.9	Sandy Silt to Sand and Silt												
	Compact		9	SS	13		199						
198.9													
8.6	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel												
197.9	Hard (Glacial Till)		10	SS	45		198						
9.6	End of Borehole												
	* W.L. on 92 01 13												

RECORD OF BOREHOLE No 12

1 OF 1

METRIC

W.P. 527-91-01(B)(Prev. 812-89-00) LOCATION Co-ords: N 4 853 132.4; E 301 084.8 ORIGINATED BY JB
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
 DATUM Geodetic DATE 92 01 08 CHECKED BY DD

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
209.8	Ground Surface																		
0.0	Topsoil, Black, Soft		1	SS	1														
209.1	Silty Clay, Brown, Soft, (Fill)																		
0.7			2	SS	10														
	Sandy		3	SS	11														
	Brown Grey		4	SS	27														
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		5	SS	21														
			6	SS	29														
	Occasional Cobbles and Boulders		7	SS	20														
			8	SS	12														
	Stiff to Very Stiff (Glacial Till)		9	SS	25														
	Silty Clay Layer		10	SS	24														
200.2			11	SS	19														
9.6	End of Borehole																		
92 01 13 = GROUND WATER CONDITIONS <table border="1"> <tr> <th>PIEZO. NO.</th> <th>GROUND WATER ELEVATION (Metres)</th> </tr> <tr> <td>1</td> <td>209.8</td> </tr> </table>			PIEZO. NO.	GROUND WATER ELEVATION (Metres)	1	209.8													
PIEZO. NO.	GROUND WATER ELEVATION (Metres)																		
1	209.8																		

RECORD OF BOREHOLE No 13

1 OF 1

METRIC

W.P. 527-91-01(B)(Prev. 612-89-00) LOCATION Co-ords: N 4 853 140.9; E 301 158.9 ORIGINATED BY JB
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
 DATUM Ceodetic DATE 92 01 08 CHECKED BY DD

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					
209.8	Ground Surface																
0.0	130 mm Topsoil																
208.7	Silty Clay, Trace Sand Contains Topsoil Soft to Firm		1	SS	5												
1.1	Greyish Brown to Black (Fill)																
	Silty Clay, Trace Sand		2	SS	8												
	Greyish Brown to Brown																
	Grey		3	SS	15												
	Stiff to Very Stiff																
206.1			4	SS	12												
3.7																	
	Sandy Silt Layer		5	SS	11												
			6	SS	23												
			7	SS	25												
	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		8	SS	26												
	Occasional Cobbles and Boulders																
	Stiff to Hard		9	SS	33												
	(Glacial Till)																
			10	SS	41												
198.7			11	SS	30												
11.1	End of Borehole																
	* W.L. measured immediately upon completion of sampling > Greater Than																

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



Ministry
of
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FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
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CONT. 93-72

WP 527-91-01 (A)

DIST 6

HWY 400

STR SITE

A Proposed Triple Cell Culvert

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FOUNDATION INVESTIGATION REPORT
For
A Proposed Triple Cell Culvert
Highway 400 - Station 14+260
W.P. 527-91-01(A)
District 6, Toronto

INTRODUCTION

This report summarizes the foundation investigation for the proposed culvert structure shown on Drawing No. 5279101(A)-A.

SITE DESCRIPTION AND GEOLOGY

The site is located along Highway 400, approximately 110 m north of Langstaff Road, in the Town of Vaughan, Regional Municipality of York. The topography of the area is generally flat with a slight increase in elevation towards the north. Drainage is generally towards the southeast.

Physiographically, the site is located in the Peel Plain which consists of a level-to-undulating tract of clayey soils covering parts of York, Peel and Halton counties. In this area, the soil is known to consist of glacial till. However, in much of the Peel Plain, the till has been modified by a veneer of clay which, when deep enough, is clearly seen to be varved. It is thought that the clay veneer was deposited in a temporary lake impounded between higher land to the north and an ice lobe in the Ontario basin (Reference: Chapman and Putnam, "The Physiography of Southern Ontario"; 3rd Edition, 1984).

PROCEDURES

The fieldwork was carried out during the period covering January 6 to 9, 1992, and consisted of three (3) sampled boreholes, which were advanced to depths of 9.6 to 11.1 m, at the locations shown on Drawing No. 5279101(A). Two of the boreholes were advanced using continuous flight, solid stem augers driven by a bombardier-mounted drilling rig equipped with standard soil sampling equipment. One of the boreholes (Borehole 7), was drilled along the centreline of the highway using similar equipment on a truck-mounted drilling rig.

Groundwater levels were measured in the open boreholes immediately upon completion of sampling. One of the boreholes (Borehole 7) was immediately backfilled and piezometers were installed in the two remaining boreholes, in order to measure the longer term groundwater conditions.

The locations of two of the boreholes were staked out in the field, and their elevations determined by the Central Region Surveys and Plans Office. The location and elevation of Borehole 7 was determined by our field representative.

The soil samples, which were obtained in the field, were examined in the laboratory by visual and tactile methods. Moisture Content, Atterberg Limits and Grain Size Distribution tests were carried out on selected samples.

SUBSURFACE CONDITIONS

The subsurface conditions, at the boreholes, generally consist of a surficial layer of topsoil and/or fill from 0.1 to 2.1 m thick, which is underlain by a layer (up to 2.9 m thick) of silty clay. The clay is, in turn, underlain by a heterogeneous mixture of clayey silt, some sand and a trace of gravel (glacial till). Silt to silty sand deposits occur in random zones within the till, although major ones appear to be confined to certain elevations. The groundwater table was found to be at or close to the original ground surface (ie. prior to construction of Highway 400) or an elevation of 205.4 m.

Details of the subsurface information obtained from this investigation are included on the borehole logs, at the back of this report. Brief descriptions of the individual strata and the groundwater conditions encountered at the boreholes are given below.

Topsoil

Boreholes 6 and 8, which were drilled in the ditches or flatter areas adjacent to the Highway 400 embankment, contacted a surficial layer of dark brown to black, soft to firm, topsoil from 0.1 to 0.5 m thick.

A distinct topsoil layer, about 0.3 m thick was also found beneath the granular and other embankment fills at Borehole 7.

Pavement Structure

At Borehole 7, a thin layer (230 mm thick) of asphalt underlain by 1.1 m of sand to sand and gravel (Fill) was contacted at the ground surface. A penetration resistance or 'N-value' of 7 blows/0.3 m, indicates that the granular fill encountered is in a loose condition.

Silty Clay (Fill)

At Borehole 7, the granular fill was found to be underlain by a 0.7 m thick layer of silty clay fill containing topsoil enclosures. This material represents the lower portion of the embankment fills. An 'N'-value of 2 blows/0.3 m indicates that this silty clay fill is of soft to firm consistency.

Silty Clay

Beneath the topsoil or fill materials described above, all of the boreholes contacted a brown to grey, silty clay layer from 1.6 to 2.9 m thick, at depths of 0.1 to 2.1 m (or elevations of 205.2 m to 205.3 m).

The moisture contents of samples, from this deposit, ranged from 20 to 29 percent (average of 24 percent).

'N'-values measured in this silty clay layer ranged from 3 to 15 blows/0.3 m indicating soils of soft to stiff consistency.

Heterogeneous Mixture of Clayey Silt, some Sand, trace Gravel (Glacial Till)

A deposit of a heterogenous mixture of brown to grey, clayey silt with some sand, a trace of gravel and occasional cobbles and boulders from 5.9 to 7.7 m thick was encountered in all of the boreholes at depths of 3.4 to 3.7 m (or elevations of 201.7 to 203.6 m). This deposit extended to the maximum depth explored in the boreholes.

Atterberg Limits tests, carried out on five samples of the till had liquid limits of 16 to 27 (average of 21) percent and plasticity indices of 5 to 12 (average of 8) percent. These results, which have been plotted on Figure 1, indicate that this soil can be classified as CL-ML to CL or Clayey Silt to Silt.

A grain size distribution test, carried out on a sample of soil obtained from this deposit, and shown on Figure 2, indicates a relatively well-graded material consisting of 50 percent silt, 29 percent sand, 20 percent clay and 1 percent gravel-sized particles. These results, coupled with a visual examination of the texture of the soil, indicate that this material is likely to be of glacial origin and, therefore, may be referred to as glacial till.

Moisture contents of samples, from this deposit, ranged from 8 to 14 (average of 10) percent.

'N'-values measured, during Standard Penetration Testing, ranged from 12 to 50 blows/0.08 m, indicating soils of stiff to hard consistency, although in general, they can be considered to be very stiff.

Silt to Fine Sand

Cohesionless layers and zones of sandy silt to fine sand were encountered within the clayey silt till, at various depths within the boreholes. Occasional partings, seams or zones of silt to fine sand with occasional clayey silt interbeds were generally found between elevations of 201 to 203 m at the boreholes.

A major deposit of silty sand to sand, about 2.0 m thick, was encountered at Borehole 8 at an elevation of 203.3 m. A moisture content of 13 percent was measured in a sample, from this deposit and 'N'-values from 14 to 18 blows/0.3 m indicate generally compact conditions in this zone.

Groundwater Conditions

The groundwater levels, when measured in the open boreholes, immediately upon completion of sampling, were found to be from 2.5 to 3.0 m beneath the existing ground surface. However, water levels, measured in the two piezometers installed at the site, at least 48 hours after their installation, ranged from the ground surface to depths of 0.4 m.

It appears that the groundwater table is at or slightly below the original ground surface (ie. prior to the construction of the Highway 400 embankment) and gently slopes to the east from an elevation of about 205.4 m at Borehole 6 to 205.0 m at Borehole 8.

DISCUSSIONS AND RECOMMENDATIONS

General Considerations

It is proposed to construct a new three-cell ie. "triple cell" (3 X 2.40 m X 2.40 m) concrete box culvert at Station 14+260, in order to direct the flow from Black Creek beneath Highway 400, at a point approximately 110 m north of Langstaff Road. The flow through the culvert will be from west to east with invert elevations of 202.93 and 202.85 m, respectively. The flow from this culvert will then be re-directed south through a drainage channel towards an identical, recently-constructed culvert beneath Langstaff Road and east of Highway 400.

We understand that it is proposed to carry out the excavation for the culvert in two main stages. During stage 1, the traffic flow will be 'squeezed' towards the centreline of the existing Highway 400. Roadway protection will then be installed at approximately 15 m east and west of the centreline of the highway. Excavation will be carried out and the two outside sections of the culvert will then be constructed. The culvert will then be backfilled and the road surface will be completed to form the detour for Stage 2. During stage 2, the traffic will be moved onto the detour and excavation for the middle portion of the culvert will be carried out using the roadway protection installed in Stage 1. The middle portion of the culvert will be constructed, backfilled and the pavement completed to approximately elevation 207.7 m.

Design

Structure Foundations

Boreholes 7 and 8 indicate that the base of the proposed triple-cell concrete box culvert will extend below an upper capping of silty clay and be placed within the clayey silt till, over about two-thirds of its length. It should be noted, however, that the east invert end of the proposed culvert will contact an approximately 2 m thick layer of wet, sandy silt to silty sand, containing occasional clayey silt layers.

It is recommended that the triple-cell culvert be founded below the upper capping of silty clay and any cohesionless zones to bear on undisturbed clayey silt till at or below the following elevations at its east and west ends:

<u>Location</u>	<u>Recommended Founding Elevation</u>	<u>Factored Bearing Capacity at U.L.S.</u>	<u>Bearing Capacity at S.L.S. Type II</u>
East End (35.8 m Rt. of CL med)	201.7 or below	600 kPa	300 kPa
CL med	202.3 or below	600 kPa	300 kPa
West End (44.2 m Lt. of CL - med)	202.3 or below	600 kPa	300 kPa

It should be noted that, where zones of sandy silt to silty sand are encountered, below the base of the culvert, such as those expected at its east end (Borehole 8), it will be necessary to subexcavate and replace this material with Granular 'A', placed and compacted according to MTO standards and practice.

Frost Protection

It is our understanding that box culverts are structurally designed to withstand frost pressures. If this is not the case, please contact this office for recommendations regarding frost protection.

Backfilling/Lateral Pressure

Backfill below the groundwater level, should consist of Granular 'A' or 'B'. The remaining backfill may consist of either granular fill or suitable earth fill. The backfill operations should be carried out, simultaneously, on both sides of the culvert, as per MTO specifications. In any case, all backfill material should be placed and compacted in accordance with MTO standards and practice and OPSD 803.02.

The following properties are recommended for the calculation of lateral pressure for the retaining walls adjacent to the inlet and outlet areas:

Granular 'A' $\gamma = 22.8 \text{ kN/m}$, $\phi = 35$, $K_o = 0.43$ $K_a = 0.27$
Granular 'B' $\gamma = 21.2 \text{ kN/m}$, $\phi = 30$, $K_o = 0.50$ $K_a = 0.33$

For granular fills, fines should be limited in accordance with SP109F03.

For structural elements rigidly connected to the culverts, the at rest condition (K_o) should be used to calculate lateral pressure.

For head and wing walls, consideration can be given to using Reinforced Earth.

Stability and Settlement

Deep seated slope failure is not of concern at this site. The slopes of the highway embankments should be constructed at 2H:1V to a maximum height of 6 m without a berm.

If the foundations are constructed in accordance with the recommendations provided herein, settlements will be within the tolerances of S.L.S. Type II.

Construction Considerations

Temporary Diversion

Since, at present, there is no watercourse at the proposed location for the triple-cell culvert, no temporary diversion of water will be required during construction.

Roadway Protection

Wherever 1H:1V slopes cannot be established adjacent to the existing roadway, roadway protection will be required.

In order to construct the triple-cell culvert in two stages, it is proposed to construct roadway protection at about 15 m east and west of the centreline of the existing Highway 400. Shoring will be required in these areas.

Shoring could consist of either sheet piles driven into the very stiff to hard underlying till or soldier piles and lagging.

For ease of construction, it would be preferable to design the shoring as a cantilevered system. However, if the shoring cannot be designed in this manner then, during Stage 1, soil anchors installed through the existing embankment and into the underlying undisturbed soils, will be necessary. It should be noted, however, that if anchors are used, then, it will be necessary to excavate through them, during Stage 2. Rakers may also be considered as an alternative.

In any case, at Station 14+260, the shoring system, 15 m left and right of the centreline of the existing road should be designed using the unfactored parameters given in the following table:

Elev (m)		ϕ	γ
From	To	Degrees	kN/m ³
207.5	206.5	30	20
206.5	203.5	24	20
203.5	and below	30	20

If sheet piles are used, heavy sections would be needed, in order to sufficiently penetrate the clayey silt till. The minimum depth of penetration of the sheetpile below the base of the excavation should be equal to the depth of the excavation below the prevailing groundwater table, in order to prevent piping in the silt seams of the cohesive deposits. Earth pressure stability would still require analysis using the parameters noted above.

If anchors or rakers are used, please contact this office for details regarding their design. However, for planning purposes, the following unfactored parameters may be used:

Bond Resistance For Anchors
(in Silty Clay or Clayey Silt Till) = 75 kPa

Raker Footing Support
(on Clayey Silt Till)
Bearing Capacity at S.L.S. Type II: = 200 kPa

It should be noted that the value given above for raker footing support refers to a perpendicular load applied to a spread footing placed on undisturbed clayey silt till.

Dewatering

It is expected that most groundwater infiltration can be controlled by gravity drainage and properly-filtered sumps.

However, as has been pointed out previously, the clayey silt till contains zones and layers of sandy silt to fine sand below the groundwater table. One such zone was encountered in Borehole 8, at the east end of the proposed triple-cell culvert.

To control groundwater inflow, in such areas, an oversized excavation may be considered with perimeter drainage ditches and properly-filtered sumps. However, the ditches must be designed in such a way that, a plane dipping outwards and downwards from the bottom outer edge of any footing, passes below (ie. does not daylight) into the ditch excavation.

In any case, it is recommended that a Special Provision, be included in the contract requiring the Contractor to lower the groundwater level below the base of the excavation, prior to excavation. It should also be noted that non-cohesive soil under conditions of unbalanced hydrostatic head is susceptible to disturbance. The Contractor should submit his drawings for review at least 10 working days prior to the beginning of construction.

Excavation

Generally, temporary excavations through the silty clay and underlying clayey silt till are expected to be stable at 1H:1V to depths of 5 m, both above and below the groundwater table.

However, where cohesionless sandy silt to fine sand is encountered, the temporary slopes should be flattened to 2H:1V. It is noted that a cohesionless deposit was encountered at Borehole 8, near the east end of the proposed culvert.

In any case, all excavations should be carried out in accordance with the provincial safety regulations.

Bedding

Bedding consisting of a minimum, 0.6 m thick layer of Granular 'A' should be provided beneath the triple-cell culvert. The bedding should extend laterally a distance of 1.0 m beyond the imprint of the culvert and should be compacted as per MTO standards and practice.

Cambering

Due to competent soil conditions, no significant settlements are anticipated and cambering is not required.

Erosion Protection

Since concrete headwalls are being proposed, erosion protection will not be required at the inlet and outlet of the proposed triple-cell culvert. However, if reinforced earth is being considered, please contact this office for details regarding erosion protection.

In any case, it should be noted that, the base of the proposed drainage channel from the east end of the culvert to the existing triple-cell culvert under Langstaff Road, will extend into a highly erodible deposit of sandy silt to silty sand. In addition, flow through the proposed channel will be forced to rapidly change direction three times ie. immediately west of the inlet, immediately east of the outlet and approximately 100 m northwest of the inlet.

It is recommended that, in these areas, the base and side slopes of the proposed connecting drainage channel should be protected from loss of soil through surface runoff and channel erosion. It is recommended that the Hydrology Section be contacted in order to provide further input for the design of the erosion protection in these areas.

However, for planning purposes, a minimum thickness of 0.6 m of rock protection or gabion baskets should be provided. The erosion protection should extend from the high water level (or in the area to the east of the culvert, above elevation 204- whichever is greater) to the toe of the slope and along the base of the channel for a distance of 35 m to the east of the outlet and a distance of 40 m to the west of the inlet. Similar erosion protection should be placed along the drainage channel between 80 and 120 m north of the inlet. For the remaining section between the existing and the proposed culverts, the erosion protection need only extend up the side of the cut slope above the granular soils (ie. to elevation 204 m).

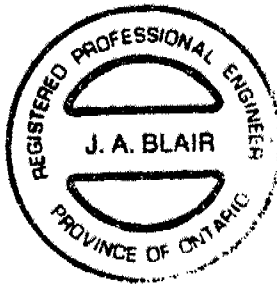
Weeping Holes

In order to relieve excess hydrostatic pressure behind retaining walls, weep-holes should be provided at intervals or 6 m or less centre-to-centre.

MISCELLANEOUS

The field investigation was supervised by Mr. J. Blair using equipment owned and operated by Malone's Soil Samples Inc.

This report was written by Mr. J. Blair, Project Foundation Engineer, reviewed by Mr. D. Dundas, Senior Foundation Engineer and approved by Mr. M. Devata, Chief Foundation Engineer.



John A. Blair

J. A. Blair, P.Eng.
Project Foundation Engineer

M. Devata

M. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

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} .

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

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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

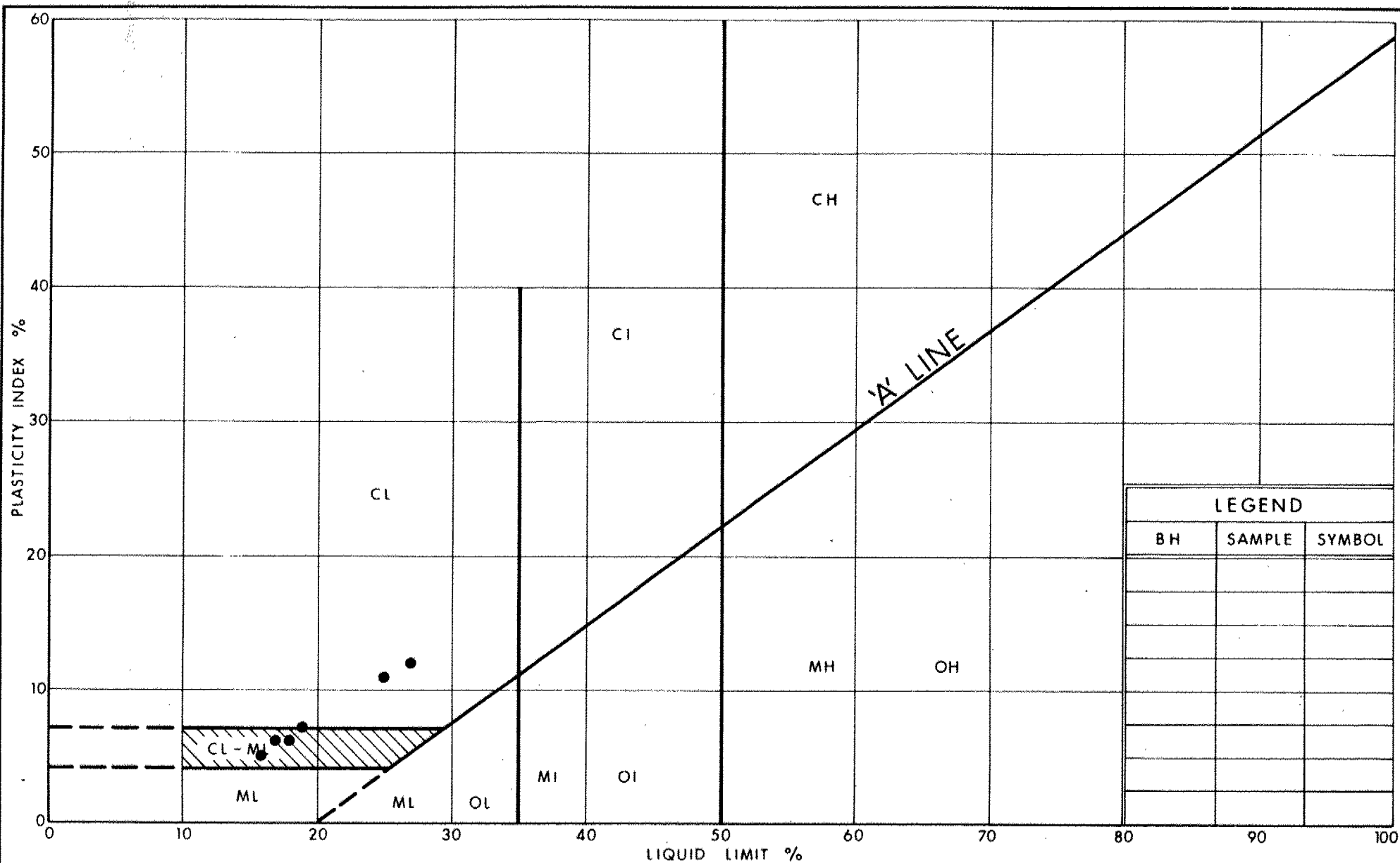
u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	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
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 ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						



Ministry of
Transportation

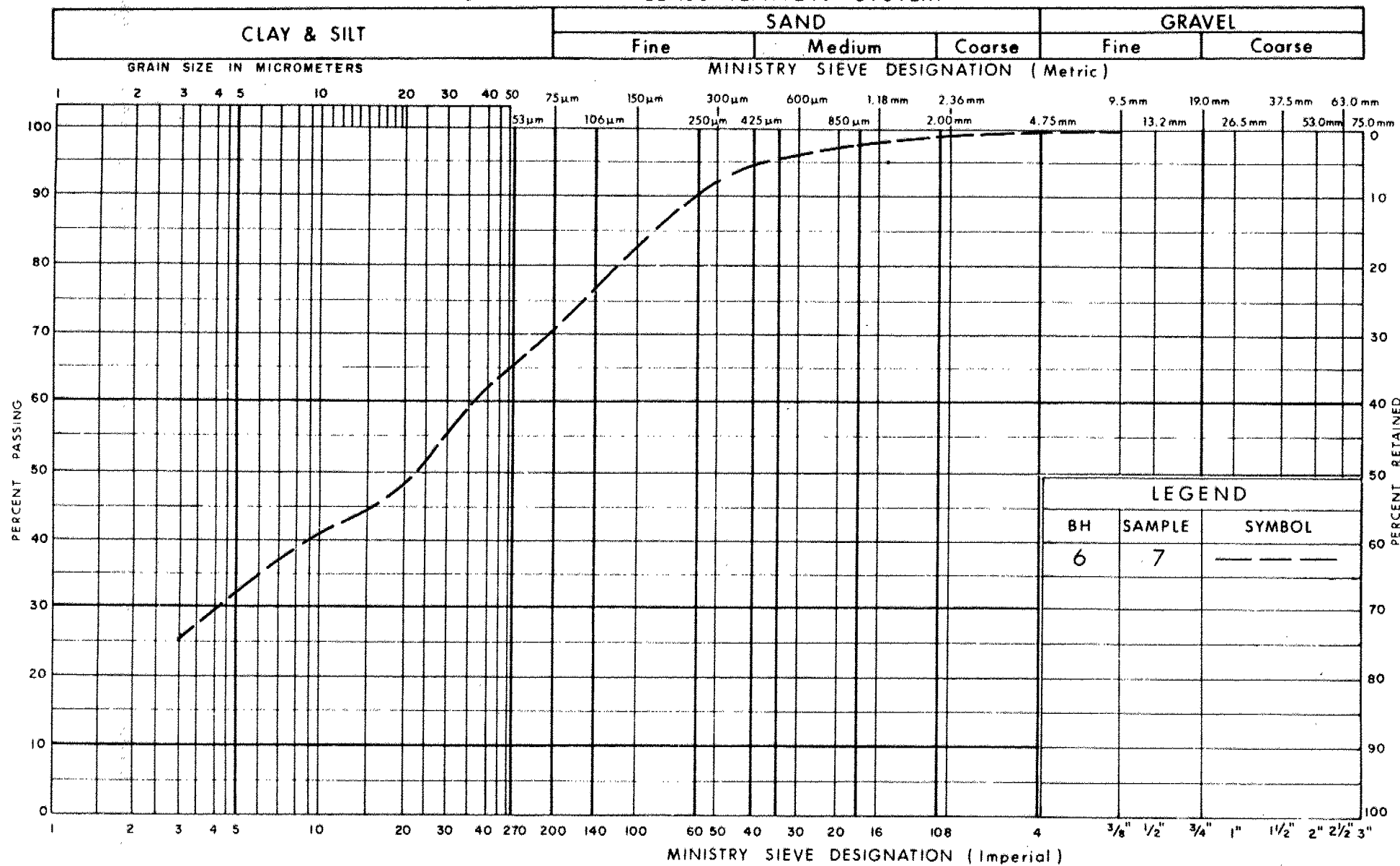
Ontario

PLASTICITY CHART
HETEROGENEOUS MIXTURE OF
CLAYEY SILT, SOME SAND, TRACE GRAVEL (Glacial Till)

FIG No 1

W P 527-91-01 (A)

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
 HETEROGENEOUS MIXTURE OF
 CLAYEY SILT, SOME SAND, TRACE GRAVEL (Glacial Till)

FIG No 2

W P 527-91-01 (A)

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 527-91-01(A)(prev. 612-89-00) LOCATION Co-ords: N 4 852 049.1; E 301 208.7 ORIGINATED BY JB
DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
DATUM Geodetic DATE 92 01 09 CHECKED BY DD

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	20 40 60 80 100					
205.7														
0.0	Topsoil		1	SS	2									
205.2	Dark Brown to Black Soft													
0.5														
	Root Fibres		2	SS	5									
	Silty Clay to Clayey Silt													
	Some Sand, Trace Gravel		3	SS	11									
	Firm to Very Stiff		4	SS	7									
202.3	Silty Sand Layer Brown		5	SS	34									
3.4	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		6	SS	45									
	Sandy		7	SS	39									
	Occasional Cobbles and Boulders		8	SS	25									
	Very Stiff to Hard (Glacial Till)		9	SS	28									
	Occasional Silty Clay Zones		10	SS	33									
	Sandy		11	SS	76									
194.6			12	SS	38									
11.1	End of Borehole													
	92 01 13													
	* GROUND WATER CONDITIONS													
	PIEZO. NO.													
	GROUND WATER ELEVATION (Metres)													
	1													
	205.4													
	> Greater Than													

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 527-91-01(A)(Prev. 612-89-00) LOCATION Co-ords: N 4 852 057; E 301 248.5 ORIGINATED BY JB
 DIST. 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
 DATUM Geodetic DATE 92 01 06 CHECKED BY DD

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 7 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					
207.3	Ground Surface													
0.0	230 mm Asphalt 130 mm Granular 'A'						207							
	Sand													
	Brown, Loose, (Fill)		1	SS	7									
	Silty Clay						206							
205.5	Containing Topsoil												17.6	
205.2	Grey to Black, Firm, (Fill)		2	SS	7									
	Topsoil, Black, Firm													
2.1	Silty Clay						205						19.0	
	Traces of Organics		3	SS	3									
	Brownish Grey to Grey						204						22.1	
203.6	Soft to Stiff		4	SS	9									
3.7							203							
	Brown to Brownish Grey		5	SS	12									
	Grey		6	SS	23									
	Sandy		7	SS	49		202							
			8	SS	50								22.8	
	Heterogeneous Mixture of Cloyey Silt, Some Sand, Trace Gravel						201							
	Occasional Cobbles and Boulders						200							
	Hard		9	SS	35		199							
	(Glacial Till)						198							
197.7			10	SS	39									
9.6	End of Borehole													
	* W.L. not stabilized													

RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 527-91-01(A) (Prev. 612-89-00) LOCATION Co-ords: N 4 852 064.0; E 301 285.5 ORIGINATED BY JB
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem COMPILED BY JB
 DATUM Geodetic DATE 92 01 07 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
205.4	Ground Surface												
0.0	130 mm Topsoil						205						
	Silty Clay Some Sand		1	SS	9		204						
	Stiff to Very Stiff		2	SS	15		203						
203.3	Sandy						202						
2.1	Sandy Silt to Silty Sand Occ. Clayey Silt Layers		3	SS	14		201						
	Brown to Brownish Grey		4	SS	18		200						
201.7	Compact		5	SS	30	/8cm	199						
3.7	Heterogeneous Mixture of Clayey Silt, Some Sand, Trace Gravel		6	SS	48		198						
	Occasional Cobbles and Boulders		7	SS	38		197						
	Very Stiff to Hard		8	SS	21		196						
	(Glacial Till)		9	SS	21		195						
			10	SS	44								
	Sandy		11	SS	60	/13cm							
194.5			12	SS	50	/8cm							
10.9	End of Borehole												
	92 01 13 * GROUND WATER CONDITIONS												
	PIEZO. NO.												
	GROUND WATER ELEVATION (Metres)												
	1												
	205												

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

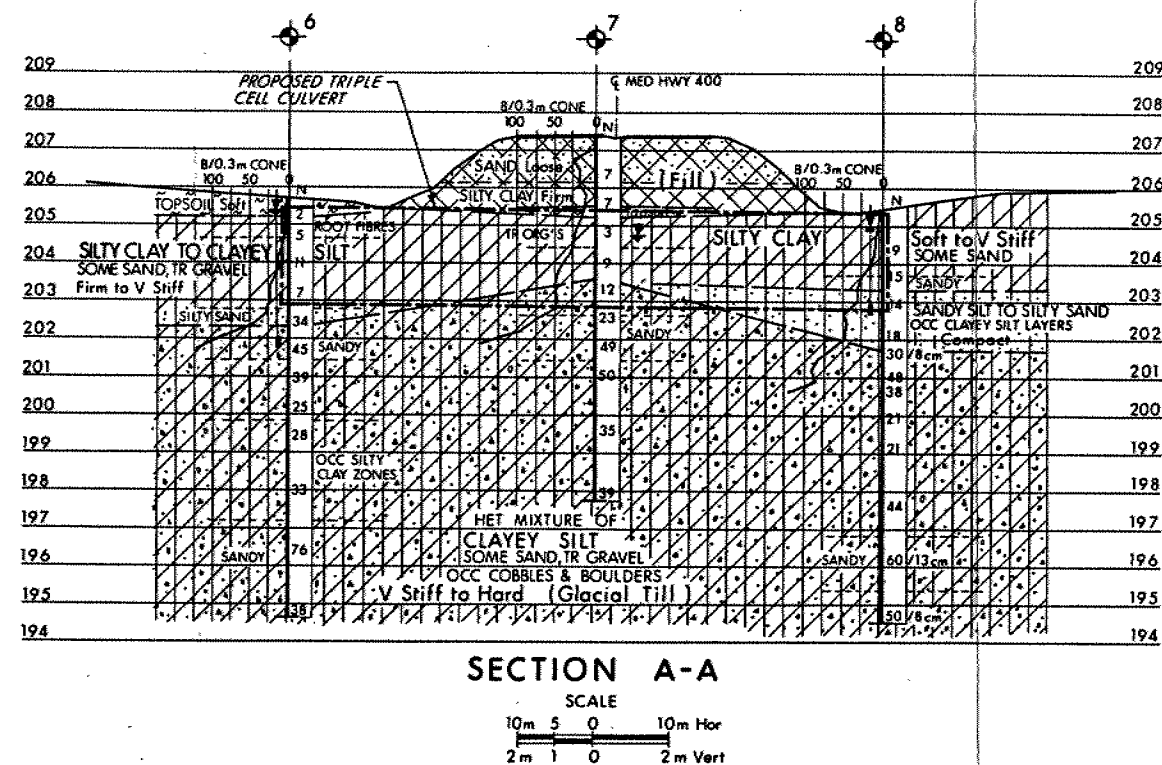
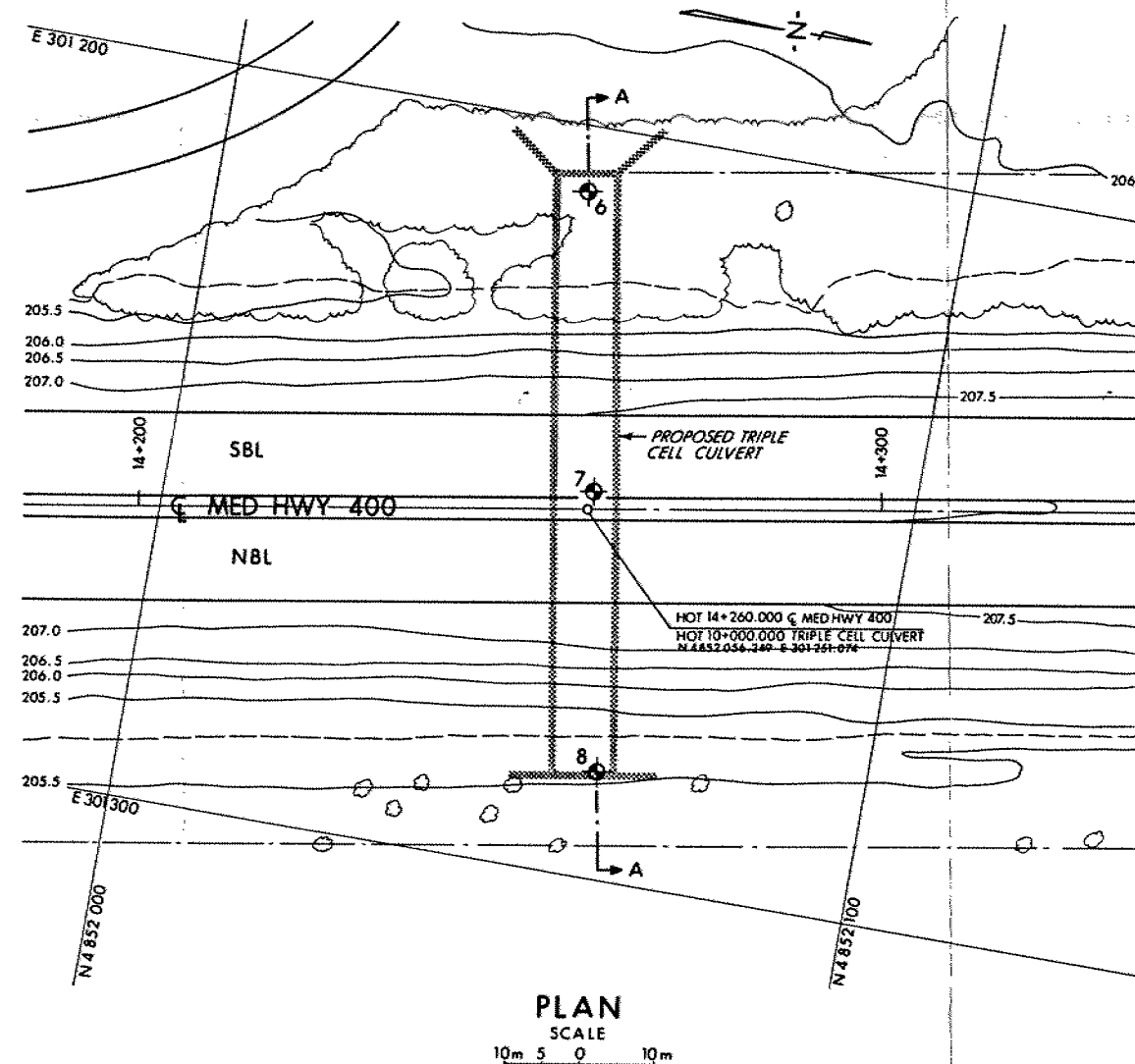
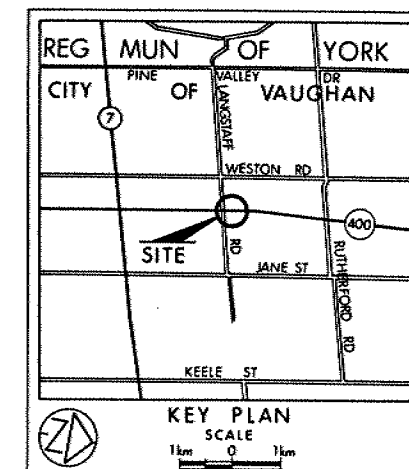
CONT No
WP No 527-91-01(A)

TRIPLE CELL CULVERT

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)
- Wt at time of investigation 9201
- Wt in piezometer

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
6	205.7	4 852 049.1	301 208.7
7	207.3	4 852 057.0	301 248.5
8	205.4	4 852 064.0	301 285.5

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 30M13-128

HWY No 400	DIST 6
SUBWD JB	CHECKED DATE 1992.06.06
DRAWN SO	CHECKED SITE
	DWG 527910(A)-A

OVERSIZE DRAWING

SEND
TOBILL WISMAYER
HEAD INSPECTOR
MTO, CONSTRUCTIONHWY 400 CULVERT
STAGE II
CONT 93-72
W P 527-91-01

FROM

KEN AHMAD

DEPT.

FOUNDATION DESIGN

DATE

SEP 24, 1993

SUBJECT

FOUNDATION INSPECTION, WET SOIL

▶ WE INSPECTED THE ABOVE MENTIONED SITE TODAY. THE EXCAVATION WAS CARRIED OUT TO ELEVATION 201.5m ±. THE PROPOSED CULVERT ELEVATION WAS 202.5m. THE EXCAVATION TOOK PLACE ON THE EAST SIDE OF HWY 400 BESIDE THE SHORING. WATER HAD SEAPED INTO THE EXCAVATION AND BEING PUMPED OUT. WE PROBED THE SOIL WITH A SHOVEL. THE SOIL WAS CLAYEY SILT WITH SAND. BELOW 150mm LOOSE / SOFT MATERIAL THE SOIL WAS VERY STIFF AND COULD NOT BE PENETRATED. THE CONTRACTOR EXPLAINED THAT DUE TO WET SOIL AND WATER GRANULAR A

REPLY

▶ COULDN'T BE USED AND COMPACTED.
▶ WE ADVISED TO REMOVE THE LOOSE / SOFT MATERIAL AND IMMEDIATELY PLACE CLEAR STONE.

KEN AHMAD

REPLY FROM

REPLY DATE