REPORT

November 2012

PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT

Highway 407 Overpasses
Highway 427 Widening from Albion Road to Highway 7, City of Toronto and Regional Municipality of York
G.W.P 2229-09-00(c)

Submitted to:
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GEOCRES No. 30M13-200

Report Number: 10-1111-0202(c)

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PART A

PRELIMINARY FOUNDATION INVESTIGATION REPORT
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CITY OF TORONTO AND REGIONAL MUNICIPALITY OF YORK
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin, a member of MMM Group (MRC) on behalf of the Ministry of Transportation, Ontario (MTO) to provide preliminary foundation engineering services for the future widening of the Highway 407 overpass structures in the Regional Municipality of York, Ontario. The proposed work is part of the widening of Highway 427 from Albion Road to Highway 7 (approximately 2.3 km) in the City of Toronto and the Regional Municipality of York, Ontario, including the widening of the Highway 427 overpass structures at the 427N – 407E Ramp, Steeles Avenue West, potential modifications to the underpass at Highway 7, culvert extensions, high mast light poles and overhead signs.

This report was primarily developed with information from two previous investigations at the bridge site, as follows:

- **MTO GEOCRES No. 30M13-067:** Report titled "Foundation Investigation Report for Proposed Highway 407 and Highway 427 Interchange; HWY 427 N.B.L Over 407: W.P. 150-87-01, Site 37-1167 and HWY 427 S.B.L Over 407: W.P. 150-87-02, Site 37-1168", prepared for Foundation Design Section by B.P. Walker Associates Limited, dated January 5, 1988.
- **MTO GEOCRES No. 30M13-056:** Report titled "Foundation Investigation Report, Ramp Structure 407E – 427S: W.P. 88-78-25, Site 37-73-1118 and Retaining Wall – Ramp 427N – 407E: W.P. 88-78-25, Site 37, HWY 427/407 Interchange, District 6, Toronto", prepared by Pavement and Foundation Design Section, MTO, dated December 6, 1982.

In addition, because the above two reports were carried out prior to the construction of the Highway 427-Highway 407 interchange, the information from the following report (which was completed after the construction of the interchange) was used to provide information on the construction of the Highway 427 embankment south of the interchange.

- **MTO GEOCRES No. 30M13-116:** Report titled "Foundation Investigation Report for Ramp 427S – 407W over Hwys. 427 and 407: W.P. 368-87-01, Site 37-1335, District 6, Toronto", prepared by Foundation Design Section, MTO, dated November 9, 1990.

The terms of reference and scope of work for the foundation engineering services are outlined in MTO's Request for Proposal (RFP) for Assignment No. 2009-E-0075 dated September 2010, and in Section 5.8 of the *Technical Proposal* for this assignment.

2.0 SITE DESCRIPTION

The existing Highway 407 overpass structures (northbound and southbound) are located in the City of Vaughan in the Regional Municipality of York, Ontario. Both of the existing northbound and southbound overpasses are three span structures and are each 14.2 m wide. The northbound structure is 95.2 m long and the southbound structure is 93.8 m long, with piers supported on spread footings and abutments supported on spread footings on native soils within the embankment.

In general, the terrain in this area is relatively flat and consists of numerous on-ramps and off-ramps at the Highway 427-407 interchange. Prior to the construction of Highway 407, the original ground surface was at

about Elevation 178 m. The current grade of Highway 407 is at about Elevation 173.5 m; therefore Highway 407 was constructed in about a 4.5 m cut below the original grade. The road surface of Highway 427 is at between Elevation 181 m and 181.7 m, therefore approximately 3 m to 4 m high embankments were constructed above the original ground surface. The overall ground surface slopes gradually upwards to the west. The highway embankment side slopes are oriented at approximately 2 horizontal to 1 vertical (2H:1V).

3.0 PREVIOUS INVESTIGATION BY OTHERS

This report was developed with information from previous investigations at the bridge site, as referenced in Section 1.0.

The field work for the Highway 407 subsurface investigation was drilled between October 29 and November 24, 1982; Boreholes 7 and 8 from GEOCRES 30M13-056 investigation was drilled between July 12 to 15, 1982 and Boreholes 6, 7 and 8 from the GEOCRES 30M13-116 investigation was drilled between June 19 to 21, 1990. The locations of the boreholes advanced by B.P. Walker Associates Limited (B.P. Walker) and MTO are shown on Drawing 1 and the borehole records used are presented in Appendix A. Piezometers were installed by B.P. Walker in Boreholes 1, 4, 9, 13 and 16. The results of the grain size distribution laboratory testing carried out by B.P. Walker and MTO are shown on Figures in Appendix A. The results of the water content and Atterberg Limit testing carried out by B.P. Walker and MTO are shown on the boreholes records presented in Appendix A.

The location of the fifteen boreholes advanced as part of the previous investigations at the site, including MTM NAD83 northing and easting coordinates and ground surface elevations referenced to geodetic datum, are summarized below and are shown on Drawing 1.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
GEOCRES 30M13-067				
1	4,845,802.2	294,176.2	177.5	17.8
3	4,845,809.4	294,202.5	177.1	18.4
4	4,845,814.0	294,220.0	177.1	18.4
6	4,845,824.2	294,187.0	178.1	18.4
8	4,845,832.0	294,216.0	177.2	11.1
9	4,845,856.7	294,168.5	178.1	11.0
11	4,845,865.0	294,194.2	178.1	18.7
13	4,845,892.3	294,163.0	178.6	18.4
14	4,845,896.7	294,176.5	178.3	18.5
16	4,845,905.2	294,202.0	177.7	18.5
GEOCRES 30M13-056				
7	4,845,883.2	294,145.0	179.2	8.0
8	4,845,923.5	294,178.7	178.1	7.8

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
GEOCRES 30M13-116				
6	4,845,780.7	294,167.5	178.2	20.0
7	4,845,748.5	294,204.5	179.1	12.6
8	4,845,718.5	294,231.7	181.1	12.6

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The Highway 427 study area lies within the Peel Plain physiographic region, as delineated in *The Physiography of Southern Ontario*[1].

The Peel Plain physiographic region covers the central portions of the Regional Municipalities of York, Peel and Halton. The general topography of this region consists of level to gently rolling terrain, sloping gradually southward toward Lake Ontario. A surficial till sheet, which generally follows the surface topography, is present throughout much of this area. The till is typically comprised of clayey silt to silty clay, with occasional sand to silt zones; it is mapped in this area as the Halton Till. Shallow, localized deposits of loose sand and silt and/or soft clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial meltwater ponds scattered throughout the Peel Plain and concentrated near river valleys. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt and clay. The study area is underlain by Ordovician shales of the Georgian Bay Formation.

4.2 Subsurface Conditions

The subsurface conditions described in the following sections are based on previous geotechnical investigations carried out by B.P. Walker in 1988 (GEOCRES 30M13-067) and MTO in 1982 (GEOCRES 30M13-056) and in 1990 (GEOCRES 30M13-116). Although it is not specified in the referenced report, it is assumed that the split-spoon sampling was carried out using a manual rope hammer as opposed to the automatic hammer which is typically used on current projects. The borehole locations, ground surface elevations and interpreted stratigraphic conditions are shown on Drawings 1, 2 and 3. The detailed subsurface soil and groundwater conditions encountered in the boreholes previously advanced by B.P. Walker and MTO and the results of in situ and geotechnical laboratory testing are given on the borehole records contained in Appendix A. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic section on Drawings 1, 2 and 3 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

It should also be noted that the water levels reported on the borehole records are based on information obtained during the previous investigation and may not reflect the current groundwater levels, which also may have been

[1] Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*, Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.

influenced by the construction of the Highway 407 and Highway 427 interchange and various ramps. In addition, the water levels observed in the open boreholes or measured in the piezometers by B.P. Walker are expected to fluctuate seasonally and should be expected to rise during the spring and other wet periods of the year.

In summary, the subsurface conditions encountered at the site consist of a surficial deposit of clayey silt till (having a thickness of varying from 1.0 m and 3.6 m) which is underlain by a cohesionless deposit consisting of silty sand to sandy silt to silt (which ranged in thickness from 1.1 m to 13.4 m). The cohesionless deposit is underlain by a till deposit that varies in composition from a silty clay to sandy silt. The boreholes penetrated into the till between 0.1 m and 12.4 m and all boreholes terminated in the till. At two borehole locations a deposit of silty clay to clay was encountered between the cohesionless deposit and the till deposit. Two of the borehole records note that possible shale bedrock was encountered underlying the till deposit at Elevations 160 m to 159 m (at a depth of 18 m below ground surface).

Considering that the original ground surface elevation at the existing abutments is about 3 m to 4 m below the grade of Highway 427, it is anticipated that the grade was raised with embankment fill placed and compacted in accordance with MTO standards. Boreholes 6, 7 and 8 from GEOCRES 30M13-116 were advanced through the embankment for Highway 427; although they are between about 70 m and 150 m south of the Highway 427 and Highway 407 interchange, they provide some indication as to the composition of the embankment.

A more detailed description of the soil deposits encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil

Between approximately 250 mm and 500 mm of topsoil was encountered immediately below the existing ground surface in all boreholes advanced during the previous investigations.

4.2.2 Embankment Fill

Based on a previous investigation carried out for 427S – 407W Ramp over Highway 427 and Highway 407 (GEOCRES 30M13-116) the embankment fill for Highway 427, south of the Highway 427 and Highway 407 interchange, consists of clayey silt and sandy silt material. The fill material was encountered at ground surface between Elevation 181.1 m to 178.2 m and extends to depths of between 2.1 m and 5.3 m below the ground surface (between Elevations 176.1 m and 175.8 m) at the Boreholes 6, 7 and 8 (GEOCRES 30M13-116).

The clayey silt portion of the fill material contains some to with sand. The results of grain size distribution tests previously completed by others on two samples of the clayey silt portion of the fill are shown on Figure 1 in Appendix C. Atterberg limits testing was previously completed by others on two samples of the clayey silt fill, and measured plastic limits of 13 per cent and 18 per cent, liquid limits of 28 per cent and 31 per cent, and plasticity indices of 13 per cent and 15 per cent. These test results, which are plotted on a plasticity chart on Figure 2 in Appendix C, confirm that the fill material consists of clayey silt of low plasticity. The water content measured on two samples of the clayey silt fill material was 11 per cent and 19 per cent.

The measured SPT “N” values within the clayey silt portion of the fill material range from 13 to 42 blows per 0.3 m of penetration, suggesting a stiff to hard consistency.

The sandy silt portion of the fill contains trace gravel. The results of grain size distribution tests previously completed by others on one sample of the sandy silt portion of the fill is shown on Figure 1 in Appendix C. The water content measured on one sample of the sandy silt fill material was 12 per cent.

The measured SPT "N" values within the sandy silt portion of the fill material were 3, 5 and 22 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

4.2.3 Clayey Silt Till (Upper Till Deposit)

A deposit of clayey silt till was encountered below the topsoil in all boreholes advanced for the Highway 407 and Highway 427 interchange (GEOCRES 30M13-067) and Ramp 407E – 427S (30M13-056). The surface of the clayey silt till deposit was encountered at between Elevation 178.2 m and 176.5 m. The thickness of the till deposit varies from about 1.0 m to 3.6 m and generally increases in thickness from the south to the north. The till deposit extends to approximately between Elevation 176.5 m to 173.7 m (to depths of between 1.4 m and 4.0 m below ground surface).

Based on field observations during the previous investigation this till deposit consists of clayey silt with trace to some sand and containing trace gravel. Atterberg limits testing was conducted on three selected samples of the clayey silt till, and measured plastic limits between 12 per cent and 16 per cent, liquid limits between 30 per cent and 35 per cent, and plasticity indices between 15 per cent and 21 per cent. These test results, which are plotted on a plasticity chart on Figure 2 in Appendix B, confirm that the till deposit consists of clayey silt of low plasticity. The natural water content measured on samples of the clayey silt till range from 10 per cent to 18 per cent, near the plastic limit of the till soil.

The measured SPT "N" values within the clayey silt till generally range from 8 blows to 69 blows with greater than 100 blows per 0.3 m of penetration measured at a couple of depths, suggesting a stiff to hard consistency.

4.2.4 Silty Sand to Sandy Silt to Silt

A deposit of silty sand to sandy silt to silt was encountered underlying the upper clayey silt till deposit in all boreholes advanced for the Highway 407 and Highway 427 interchange (GEOCRES 30M13-067) and Ramp 407E – 427S (GEOCRES 30M13-056). The surface of the silty sand to sandy silt to silt deposit was encountered at between Elevation 173.7 m to 176.5 m (at depths of between 1.4 m and 4.0 m below ground surface). The deposit extends to depths of between 4.0 m and 16.3 m below ground surface (between Elevations 174.1 m and 161.6 m). Generally, the deposit is thickest at Boreholes 3, 4 and 6, located at the south abutment and south pier and thinnest at Boreholes 11, 13 and 14, located at the north pier and abutment. The deposit has a thickness ranging from 1.1 m to 13.4 m.

The deposit of silty sand to sandy silt to silt contains trace clay. Cobbles and boulders within the sandy silt to silt deposit were noted on the borehole records. The results of grain size distribution tests completed by others on twelve samples of the cohesionless deposit are shown on Figure 1 in Appendix A and Figures 3 and 4 in Appendix B. The natural water content measured on samples of the silty sand to sandy silt to silt range from 8 per cent to 22 per cent.

The measured SPT "N" values within the deposit of silty sand to sandy silt to silt range from 15 blows to greater than 100 blows per 0.3 m of penetration, indicating a compact to very dense relative density. The borehole records note that near the base of the deposit in Boreholes 3, 4 and 6 the SPT "N" values were 18 blows,

17 blows and 15 blows, respectively and that the SPT "N" values are low due to sample disturbance caused by groundwater.

4.2.5 Silty Clay to Clay

Underlying a thin till deposit of silty sand in Borehole 1 and a thin layer of silty sand in Borehole 11 a silty clay to clay deposit was encountered at depths of 7.4 m and 4.0 m, respectively, corresponding to Elevations 170.1 m and 174.1 m, respectively. The base of the deposit extends to a depth of 14.6 m below ground surface (Elevation 162.9 m) in Borehole 1 and to a depth of 11.6 m below ground surface (Elevation 166.5 m) in Borehole 11. In Borehole 1 the deposit is about 7.2 m thick and at Borehole 11 the deposit has a thickness of 7.6 m.

The deposit of silty clay to clay contains trace to some clay and trace gravel. Cobbles within the silty clay deposit were noted on the Record of Borehole 11. The results of grain size distribution tests completed by others on two samples of the silty clay to clay deposit are shown on Figure 2 in Appendix A. Atterberg limits testing was conducted by others on five selected samples of the deposit of silty clay to clay, and measured plastic limits between 13 per cent and 24 per cent, liquid limits between 23 per cent and 45 per cent, and plasticity indices between 7 per cent and 25 per cent. These test results, which when plotted on a plasticity chart, confirm that the deposit consists of silty clay to clay of low to medium plasticity. The natural water content measured on samples of the silty clay to clay range from 9 per cent to 22 per cent, which were generally near the corresponding plastic limit values.

The measured SPT "N" values within the silty clay to clay range from 27 blows to greater than 100 blows per 0.3 m of penetration, suggesting a very stiff to hard consistency.

4.2.6 Clayey Silt Till to Sandy Silt Till (Lower Till Deposit)

A till deposit was encountered below the silty clay to clay deposit in Boreholes 1 and 11 and underlying the silty sand to sandy silt to silt deposit in the remaining boreholes previously advanced at the overpass site. The till deposit primarily consists of clayey silt, however in Boreholes 6 and 16 the till deposit consists of sandy silt. It is noted that on the borehole records the till deposit is described as silty clay; however only two Atterberg limits tests were carried out on samples of the cohesive till and the results indicate that the liquid limit is less than 35 per cent, therefore the material is described as clayey silt in this report as opposed to silty clay on the borehole records.

The surface of the till deposit was encountered at between Elevation 172.6 m to 161.6 m (at depths of between 6.0 m and 16.3 m below ground surface). All of the boreholes advanced for the Highway 427 and Highway 407 interchange terminated within the till deposit at depths of between 17.8 m and 18.4 m below ground surface (between Elevations 160.2 m and 158.7 m), except Boreholes 8 and 9 (GEOCRES 30M13-067) which terminated at a depth of 11.1 m below ground surface (Elevations 166.1 m and 167.1 m, respectively) and Boreholes 7 and 8 (GEOCRES 30M13-056) which terminated at a depth of 8.0 m and 7.8 m below ground surface (Elevations 171.2 m and 170.3 m), respectively. Boreholes 8 and 9 (GEOCRES 30M13-056) and Boreholes 7 and 8 (GEOCRES 30M13-056) penetrated into the till between 0.1 m and 1.5 m; at all the remaining boreholes advanced for GECORES 30M13-056 the boreholes penetrated the till between 2.1 m and 12.4 m. Within the till deposit in Borehole 13, a layer of sand with trace gravel was encountered at a depth of 9.3 m below ground surface (Elevation 169.3 m). This layer of sand is about 0.9 m thick, with its base at approximately Elevation 168.4 m.

Based on field observations during the previous investigation the clayey silt portion of the till deposit contains some sand and trace gravel and the sandy silt portion of the till deposit contains trace gravel with gravelly and sandy lenses. Cobbles and boulders were noted within the clayey silt till deposit in Boreholes 13 and 14. The borehole records also indicate that shale fragments were encountered in the till deposit in Boreholes 1, 13 and 16 at Elevation 159.7 m, 161.4m and at Elevation 163.0 m, respectively. Atterberg limits testing was conducted by others on two selected samples of the clayey silt till deposit, and measured plastic limits of 16 per cent and 17 per cent, liquid limits of 29 per cent and 32 per cent, and plasticity indices between 13 per cent and 15 per cent. These test results, which when plotted on a plasticity chart, confirm that the till deposit consists of clayey silt of low plasticity. The natural water content measured on samples of the clayey silt till range from 6 per cent to 20 per cent.

The measured SPT "N" values within the clayey silt till deposit range from 49 blows to greater than 100 blows per 0.3 m of penetration, suggesting a hard consistency.

4.2.7 Shale Bedrock (Possible)

In addition to the borehole records indicating that shale fragments were encountered in the till deposit (see discussion in Section 4.2.6), the borehole records also note that possible shale bedrock was encountered at the end of the borehole in Boreholes 1 and 4 at Elevation 159.7 m and 158.7 m, respectively. It is also noted that from the investigation carried out for the Ramp 427S – 407W over Highway 427 and Highway 407 the deepest borehole (Borehole 6) extended to about Elevation 158.2 m and terminated in the clayey silt till deposit and did not encounter shale bedrock at that elevation.

4.3 Groundwater Conditions

Details of the water levels observed in the open boreholes at the time of drilling are summarized on the borehole records contained in Appendix A. In general, the borehole records indicate that below about Elevation 173 m the silty sand to sand silt to silt deposit was observed to be water-bearing during the drilling operations. The silty clay and till deposits were noted as damp to moist during the drilling operations. As discussed in Section 4.2.4, the SPT "N" values measured at between Elevations 165 m and 163 m were low probably due to groundwater disturbance; which may indicate that the deposit is under some hydrostatic pressure.

Five standpipe piezometers were installed during the previous investigation in Boreholes 1, 4, 9, 13 and 16 (GEOCRES 30M13-067) to monitor the groundwater levels at the site. There is no reference to the date on which the water levels in the piezometers were read in the report or on the boreholes records. The water levels measured within the open boreholes upon completion of drilling are summarized in the table below:

Borehole Number	Ground Surface Elevation (m)	Depth to Water Level On Completion of Drilling (m)	Water Elevation on Completion of Drilling (m)
3	177.1	4.5	172.6
6	178.1	5.1	173.0
8	177.2	5.2	172.0
11	178.1	3.1	175.0
14	178.3	7.4	170.9

The water levels measured in the piezometers are summarized in the table below:

Borehole Number	Ground Surface Elevation (m)	Stratum Sealed Into	Piezometer Tip Elevation (m)	Depth to Water Level (m)	Water Elevation (m)
1	177.5	Sandy Silt/ Silty Sand Till	170.0	4.5	173.0
4	177.1	Sandy Silt	169.0	4.4	172.7
9	178.1	Sandy Silt	172.3	4.7	173.4
13	178.6	Silty Sand	172.5	4.1	174.5
16	177.7	Sandy Silt Till	165.0	4.7	173.0

Since the date when the water level as measured in the piezometer was not recorded during the previous investigations it is uncertain whether the water elevations reflect near stabilized conditions. At this preliminary stage, based on these measurements it is estimated that the stabilized groundwater level may vary from about Elevation 172.7 m to 174.5 m.

It should also be noted that the water levels reported on the borehole records are based on information obtained during the previous investigation and may not reflect the current groundwater levels, which may have been influenced by the construction of the Highway 407 and Highway 427 interchange and various ramps.

The groundwater levels are expected to fluctuate seasonally and are expected to rise during wet periods of the year.

5.0 CLOSURE

This Preliminary Foundation Investigation Report was prepared by Ms. Sandra McGaghran, P.Eng. a senior geotechnical engineer with Golder. Mr. Fintan Heffernan, P.Eng., the Designated MTO Foundations Contact for Golder, conducted an independent review of this report.

GOLDER ASSOCIATES LTD.

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PART B

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HIGHWAY 407 OVERPASSES
HIGHWAY 427 WIDENING FROM ALBION ROAD TO HIGHWAY 7
CITY OF TORONTO AND REGIONAL MUNICIPALITY OF YORK
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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides preliminary foundation design recommendations for the proposed widening of the existing Highway 407 overpass structures as part of the widening of the Highway 427 northbound and southbound lanes. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during previous subsurface investigations completed by others. These boreholes were advanced prior to the construction of the Highway 407 overpasses and activity associated with the construction of the overpass may have altered the ground conditions from what is presented in the borehole logs. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the preliminary design of the structure foundations; the previous investigation data and the preliminary foundations assessments and recommendations are not sufficient for detail design. Further investigation and analysis will be required during detail design, once the configuration of the proposed overpass is finalized, to confirm and expand on the preliminary foundation recommendations provided in this report.

Where comments are made on construction, they are provided to highlight those aspects that could affect the future detail design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Foundation Options

Based on the planning study completed to date for the widening of Highway 427 from Albion Road to Highway 7, it is understood that the future widening could consist of two additional lanes in both the northbound and southbound directions on Highway 427 and that this will be achieved by filling in the median and widening the east side of the NBL and the west side of the SBL of Highway 427.

The existing Highway 407 overpasses (NBL and SBL) are three-span structures, with the existing abutments and piers supported on spread footings. The following design drawings are available for the overpass structures:

- WP No. 150-87-01/02, Sheets 245, 246 and 247: “Hwy 427 N.B. & S.B. Overpasses at Hwy 407, prepared by Fenco Engineers Inc., dated January, 1988.

The distance from the south abutment to the south pier is about 20.4 m and the distance between the north and south pier and the north pier to the north abutment varies from about 36.7 m to 38 m. Both the NBL and SBL structures are about 14.2 m wide. The current grade of Highway 407 in vicinity of the overpass structures is at about Elevation 173.4 m and the grade of Highway 427 varies from Elevation 181.6 m to 181.2 m, some 8 m higher. Prior to construction of Highway 407 overpass structures, the ground surface was at about Elevation 178 m; therefore Highway 407 was constructed in a 4.6 m cut and the original ground surface was raised with embankments having a thickness of between 3 m and 4 m in order to construct Highway 427 over Highway 407.

Based on the drawings referenced above for the structure, the north and south abutments are founded at about Elevation 174.7 m and 175.5 m, respectively on either hard clayey silt till (upper deposit) or dense to very dense silty sand. The piers consist of three columns supported on a footing (10 m long by 4 m wide, except at the north pier for the NBL where the footing is 10 m long and 6.5 m wide) which is founded at Elevation 171.5 m on either very dense sandy silt to silt or hard silty clay to clayey silt. In front of each the north and south abutments of the NBL and SBL structures there is a concrete slope paving down to the pavement of Highway 407 and between the structures the ground surface is grassed from behind the jersey barrier to the ditch between the NBL and SBL structures and is at a gradient of about 2 horizontal to 1 vertical.

Based on the subsurface conditions from the previous investigations, both shallow and deep foundation options have been considered for the widening of the existing Highway 407 overpass structures. A summary of the advantages and disadvantages associated with each option is provided below, and a comparison of the alternative foundation options based on advantages, disadvantages and risks is provided in Table 1 following the text of this report.

- **Strip or spread footings founded on the hard clayey silt till (upper till deposit) / very dense silty sand to silt:** Shallow footings are feasible for support of the abutment and pier widenings at this site due to the generally hard/very dense nature of the overburden soils. It is recommended that the new strip/spread footings be founded at about the same elevation as the existing footings for the abutment and piers in order to minimize disturbance to the existing foundation units. Therefore, excavations for the piers will be required to Elevation 171.5 m (a depth of about 2 m depth below the grade of Highway 407) and Elevation 174.7 m and 175.5 m at the north and south abutment (to about 2 m depth below the foreslope for the widened abutments). It is anticipated that the excavations would extend through clayey silt till (upper till deposit) to found on either clayey silt till (upper till deposit) or the very dense silty sand to silt. The groundwater level measured at the time of the 1987 investigation was between about Elevation 174.5 m and 173 m, which is approximately at the foundation level for the north abutment and about 2.5 m below the south abutment foundation level; at the piers it is anticipated that excavations will extend about 1.5 m below the groundwater level. There is a potential for up to approximately 10 mm to 15 mm of differential settlement between the existing structures and the new widened portions. Temporary roadway protection would likely be required along the east side of the southbound lanes of Highway 427 and along the west side of the northbound lanes of Highway 427 and adjacent to the existing abutments and adjacent to Highway 407. Further foundation investigation and design should be conducted at the detail design along the alignment of the temporary shoring. This founding option is preferred at this site.
- **Driven steel H-piles founded in the hard clayey silt till (lower till deposit) / very dense sandy silt till:** Driven steel H-piles are feasible and suitable for support of the abutment and pier widenings. Differential settlement between the existing structures (which are founded on spread footings) and the widenings would be negligible. The elevation of the surface of “100-blow” soil is variable across the site, and is relatively shallow particularly at the pier locations. Pre-augering is recommended in order for the piles to reach their minimum embedment of 3.5 m.

- **Driven steel pipe (tube) piles founded in the hard clayey silt till (lower till deposit) / very dense sandy silt till:** Steel tube (pipe) piles could also be considered as a deep foundation option for support of the abutment and pier widenings at this site, although pipe piles would not be acceptable for use with integral abutments due to their rigidity. However, pipe piles are considered to have a slightly higher risk than H-piles for "hanging up" or being deflected away from their vertical or battered orientation due to the potential presence of cobbles and/or boulders within the glacially-derived soils at this site. Since the elevation of the surface of "100-blow" soil is variable across the site and is relatively shallow particularly at the pier locations, similar to installation of steel H-piles, pre-augering is recommended for the installation of pipe piles.

- **Caissons:** Caissons founded within the "100-blow" clayey silt till (lower deposit) to sandy silt till are feasible for support of the abutment and pier widening, although caissons would not be acceptable for use with integral abutments due to their rigidity. However, this option is considered to have potential difficulties associated with potential running/flowing soils and ground loss in the water-bearing sandy silt to silt. Provisions would be required to prevent disturbance of the sides and bases of the caissons and consideration could be given to using liners or drilling mud and tremie concreting techniques. These details would have to be considered at detail design if caissons are considered as an option.

Based on the above considerations, the preferred option from a geotechnical/foundations perspective is to support the abutments and piers for the widening of the Highway 407 overpasses on spread footings founded on the very dense sandy silt till or hard clayey silt till (upper till deposit). Steel H-pile and steel pipe pile foundations are also feasible and are considered to be an acceptable alternative; however pre-augering would be required to reach the minimum required length of pile. However the options of caissons and steel pipe piles precludes the use of integral abutments due to their rigidity.

6.3 Shallow Foundations

For support of widened abutments and new piers, strip or spread footings should be founded below the fill and any loose or soft to stiff surficial soils, on either the very dense sandy silt deposit or the hard clayey silt till (upper till deposit). The following table provides the maximum (highest) founding elevations recommended for preliminary design of footings; these elevations coincide with the existing footing elevations. Therefore, excavations for the piers will be required to Elevation 171.5 m (a depth of about 2 m depth below the grade of Highway 407) and to Elevation 174.7 m and 175.5 m at the north and south abutments (to about 2 m below the foreslope for the widened abutments). The groundwater level measured at the time of the 1987 investigation was between about Elevation 174.5 m and 173 m, which is approximately at the foundation level at the north abutment and about 2.5 m below the south abutment foundation level; at the piers it is anticipated that the excavation will extend about 1.5 m below the groundwater level. It is not recommended to found the footings below these elevations as such excavations have the potential to disturb the existing footings. Strip or spread footings should be founded at a minimum depth of 1.4 m below the lowest surrounding grade to provide adequate protection against frost penetration (per OPSD 3090.101 – *Foundation Frost Depths for South Ontario*).

Foundation Element	Borehole	Founding Stratum	Strip/Spread Footing Maximum Founding Elevation
North Abutment	13, 14 and 16	Hard Clayey Silt Till / Dense to Very Dense Silty Sand to Silt	174.7 m
North Pier	9 and 11	Very Dense Sandy Silt (SBL) Hard Silty Clay to Clayey Silt (NBL)	171.5 m
South Pier	6 and 8	Very Dense Silt	171.5 m
South Abutment	1, 3 and 4	Very Dense Silty Sand / Hard Clayey Silt Till	175.5 m

The founding soils will be susceptible to disturbance from construction traffic and surficial run-off and should be protected with a concrete working slab (100 mm thick concrete slab with a compressive strength of 20 MPa) if the concrete for the footing is not placed within four hours of the inspection and approval of the subgrade.

6.3.1 Geotechnical Resistance

Strip or spread footings placed on the properly prepared, very dense sandy silt / hard clayey silt till (upper till deposit) at or below the design elevations given in the preceding section, should be designed based on the factored geotechnical resistances at Ultimate Limit States (ULS) and geotechnical reaction at Serviceability Limit States (SLS) of the order of the values given below.

Foundation Element	Footing Width	Factored Geotechnical Resistance at ULS	Geotechnical Reaction at SLS*
North and South Abutment	3 m	600 kPa	450 kPa
	4 m	650 kPa	450 kPa
	5 m	750 kPa	400 kPa
North and South Pier	3 m	600 kPa	450 kPa
	4 m	650 kPa	400 kPa
	5 m	750 kPa	350 kPa

* for 10 mm to 15 mm of settlement

There is a potential for up to approximately 10 mm to 15 mm of differential settlement between the existing structure and the new widened portions, which should be considered in the design of the connection/ reinforcement.

These preliminary geotechnical resistances are provided for loads applied perpendicular to the surface of the footings; where applicable, inclination of the load should be taken into account in accordance with Section 6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC 2006)* and its *Commentary*.

The preliminary geotechnical resistance values provided above will have to be re-evaluated and modified as necessary during detail design, based on future additional subsurface investigation at the proposed abutment and pier widening locations.

6.4 Driven Steel H-Pile or Steel Pipe (Tube) Pile Foundations

6.4.1 Founding Elevations

Driven steel H-pile or pipe pile foundations are feasible for support of the widened abutments and piers at this site. The use of deep foundations is considered advantageous from a geotechnical perspective as this option would minimize the depth of excavation and therefore minimize temporary excavation support requirements.

However, the use of deep foundations does present constructability challenges since the depth to "100-blow" soil is quite variable at each of the foundation units and generally ranges from Elevation 174 m to 162 m, some 12 m difference in elevation. If pile foundations are adopted, pre-augering would be required at some locations to allow the piles to reach their target depths (a minimum embedment of 3.5 m below pile cap level) and then driven to achieve the required geotechnical resistances. Where the pre-augering extends below the water table in the sandy silt to silt and sandy silt till deposit, the saturated fine-grained soils will be subject to disturbance due to unbalanced hydrostatic head; therefore, it is recommended that a temporary liner be used to support the soils during pre-augering and pile installation.

To achieve the required geotechnical resistances, it is recommended that an allowance be made for variable pile lengths; it is anticipated that the length of the piles may range from 7.5 m to 14.5 m.

It is noted that at some of the pier widening locations, the boreholes from the previous investigations do not extend deep enough to confirm the end bearing stratum for the piles; additional boreholes will be required within or near the footprints of these pier widening locations at detail design, extended at least 3 m into "100-blow" soil.

The pile caps should be constructed at a minimum depth of 1.4 m for frost protection purposes, per OPSD 3090.101 *(Foundation Frost Penetration Depths for Southern Ontario).*

For the installation of steel H-piles, consideration must be given to the potential presence of cobbles and boulders within the soil deposits. The piles should be reinforced at the tip with driving shoes or flange plates to reduce the potential for damage to the piles during driving. In hard and/or bouldery soils, as may be encountered at this site, driving shoes (such as Titus Standard "H" Bearing Pile Points) are preferred over flange plates. For the installation of steel pipe piles consideration must be given to the potential presence of cobbles and boulders within the soil deposits. In this regard, steel H-piles are preferred over steel pipe piles as pipe piles are considered to pose a higher risk of "hanging up" or being deflected away from their vertical or battered orientation during installation, due to their larger end area. Also pipe piles would not be appropriate for use with integral abutments due to their rigidity.

6.4.2 Axial Geotechnical Resistance

For steel HP 310x110 piles, the factored axial resistance at ULS and the axial geotechnical reaction at SLS (for 10 mm to 15 mm of settlement) of the order of the values given below may be used for preliminary design:

Foundation Element	End-Bearing Stratum	Factored Geotechnical Resistance at ULS	Geotechnical Reaction at SLS *
North Abutment	Hard Clayey Silt Till / Very Dense Sandy Silt Till	1,600 kN	1,250 kN
North Pier	Hard Clayey Silt Till	1,600 kN	1,250 kN

Foundation Element	End-Bearing Stratum	Factored Geotechnical Resistance at ULS	Geotechnical Reaction at SLS *
South Pier	Very Dense Sandy Silt Till	1,600 kN	1,250 kN
South Abutment	Hard Clayey Silt Till	1,600 kN	1,250 kN

* for 10 mm to 15 mm of settlement

Similar axial resistances may be used in the design of closed-end, concrete-filled, 324 mm (12 ¾ in.) diameter steel pipe piles having a minimum wall thickness of 9.5 mm (3/8 in.).

Pile installation should be in accordance with provincial standards. The pile termination or set criteria will be dependent on the pile driving hammer type, helmet, selected pile and length of pile; the criteria must therefore be established at the time of construction after the piling equipment is known. The pile capacity should then be verified in the field by the use of the Hiley formula (MTO Standard Structural Drawing SS-103-11) during the final stages of driving below the pre-augered hole to achieve the appropriate ultimate capacity. It is recommended that for pile installation driving shoes be required.

The preliminary geotechnical resistances provided above will have to be re-evaluated and modified as necessary during detail design in consideration of the additional subsurface investigation that will be carried out at the widened foundation elements.

6.5 Caissons

Caisson foundations are feasible for support of abutments and piers for the widening of the Highway 407 overpasses.

Running or flowing of water-bearing sandy silt to silt soils could occur during or after drilling of the caissons due to the unbalanced hydrostatic heads, and basal heave could occur where water-bearing cohesionless soils are present at/near the caisson base. Provisions are required to prevent disturbance of the sides and bases of the caissons and this would be up to the contractor, but consideration could be given to using liners or drilling mud and tremie concreting techniques. These details would have to be considered at detail design, if caissons are considered as an option.

Construction experience in similar soil conditions has demonstrated that temporary liners can be difficult to withdraw, owing to the length of the liners and the very dense nature of the “100-blow” material. Such difficulties can result in “necking” of the caisson, although this can be controlled by tremie-pumping the concrete into the caisson and ensuring that the base of the liner always remains below the surface of the pumped concrete during withdrawal. Alternatively, permanent liners could be considered for the construction of the caissons in these soil conditions.

6.5.1 Founding Elevations

The widened abutments and piers could be supported on caissons founded within the hard / very dense soils (with SPT “N” values of greater than “100 blows” per 0.3 m of penetration). The caissons should extend a minimum of 1.5 m below the elevation of soils having SPT “N” values of greater than “100 blows” per 0.3 m of

penetration. For preliminary design, the following caisson base elevations may be assumed based on the borehole results:

Foundation Element	End-Bearing Stratum	Estimated Design Caisson Elevation
North Abutment	Hard Clayey Silt Till / Very Dense Sandy Silt Till	165 m
North Pier	Hard Clayey Silt Till	164 m
South Pier	Very Dense Sandy Silt Till	160 m
South Abutment	Hard Clayey Silt Till	161 m

6.5.2 Axial Geotechnical Resistance

The caissons will derive the majority of their capacity from base resistance, although some shaft friction has also been taken into account based on "socketing" approximately 1.5 m into the "100-blow" soil. Using the preliminary design elevations given above, the factored axial geotechnical resistance at ULS and the axial reaction at SLS (for 10 mm to 15 mm of settlement) of the order of the values given below may be used for preliminary design purposes:

Foundation Element	Caisson Diameter	Factored Geotechnical Resistance at ULS	Geotechnical Reaction at SLS*
Widened Abutments and Piers	1.2 m	4,500 kN	3,500 kN
	1.5 m	6,500 kN	5,500 kN

* for 10 mm to 15 mm of settlement

The preliminary geotechnical resistances provided above will have to be re-evaluated and modified as necessary during detail design in consideration of the additional subsurface investigation that will be carried out at the widened foundation elements.

6.6 Approach Embankments

Based on the planning study completed to date for the widening of Highway 427 from Albion Road to Highway 7, it is understood that the future widening could consist of two additional lanes in both the northbound and southbound directions on Highway 427 and that this will be achieved by filling in the median and widening of the east side of the NBL and the west side of the SBL.

Between the north and south abutments for the Highway 427 overpass structures (NBL and SBL) the ground surface from the abutment (which is at about Elevation 178 m at the south abutment and Elevation 177 m at the north abutment) slopes up at a gradient of about 2 horizontal to 1 vertical to the median level between the NBL and SBL structures. The pavement level of Highway 427 is at Elevation 181.6 m at the south abutment and at Elevation 181.2 at the north abutment; therefore depending on the foundation option adopted the grade behind the proposed abutment will be raised by about 3.6 m at the south abutment for the new widening and about 4.2 m at the proposed north abutment for the new widening. Based on the previous boreholes advanced in the

area of the site, the existing embankment is likely founded on the very stiff to hard till and as such no instability problems are anticipated.

East of the existing NBL structure and west of SBL structures for the proposed widened Highway 427 overpasses at Highway 407 a 6.4 m and 5.3 m wide abutment, respectively, is also required to accommodate the widening. The widened roadway will result in a fill thickness of between 2.7 m and 3.2 over the existing embankment slope face. Based on the previous boreholes advanced at the site, the existing embankment is likely founded on the very stiff to hard till and as such no instability problems are anticipated.

6.6.1 Subgrade Preparation and Embankment Construction

It is recommended that all organic material and any softened/loosened native soils be stripped from the footprint of the proposed widened Highway 427 approach embankments. The depth and extent of stripping should be assessed during detail design when additional subsurface information will be available for the widened approach embankment areas. It is anticipated that the general depth of subexcavation required will be less than 0.3m, but this would have to be verified during detail design. The requirement for localized subexcavation could be determined by proof rolling and replacement of identified soft areas with acceptable fill.

The embankment fill for the Highway 427 widening should be placed and compacted in accordance with MTO's special provision. Benching of the existing Highway 427 embankment side slopes should be carried out to "key in" the new fill materials for the widening, in accordance with provincial standards. During the widening and benching of slopes outside of the structure it is anticipated that there will a requirement for lane closures of at least the outside lane to facilitate this construction.

Additional fill for construction of the embankment widening could consist of clean earth fill or granular fill. From a geotechnical/foundations perspective, both earth and granular fill will provide good compatibility with the existing Highway 427 embankment fill materials – both those fill materials remaining in-place in the existing embankment side slope, and any existing embankment fill that is re-used for the widening after being cut from the benches.

6.6.2 Settlement

The median widening will require placement of approximately 3.6 m and 4.2 m of fill/pavement structure on top of the existing swale in the median area at the south and north abutment, respectively, and in addition, a fill thickness of between 2.7 m and 3.2 m along the existing embankment slope face. None of the boreholes used to prepare this report were advanced through the existing embankment north and south of Highway 407; however the majority of the settlement will be elastic in nature and should occur in a short period after placement of the fill. At detail design stage it is recommended that boreholes be advanced between the existing abutments in the median in order to estimate the elastic deformation modulus and the estimated settlement.

6.7 Construction Considerations

The following subsections identify future construction issues that should be considered at this stage as they may impact the planning and preliminary design. Where applicable, Non-Standard Special Provisions (NSSP) should be developed during detail design for incorporation in the Contract Documents.

6.7.1 Excavation and Temporary Protection Systems

The foundation excavations for spread footings are expected to extend to a depth of about 2 m below the slope between the northbound and southbound abutments and about 2 m below the existing ground surface at the proposed pier locations. The excavations will extend through possibly shallow fill associated with the construction of the existing abutments, and into the hard clayey silt till and/or dense to very dense silty sand to silt at the north and south abutment; very dense sandy silt and/or hard silty clay to clayey silt at the north pier and very dense silt at the south pier.

Where space permits, open-cut excavations into these materials should be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act (OHSA) for Construction Activities. The existing fill would be classified as Type 3 soil and the dense to very dense and hard native soils would be classified as Type 2 soil, according to the OHSA. Temporary excavations (i.e. those that are open for a relatively short time period) should be made with side slopes no steeper than 1H:1V.

At this preliminary stage, it is anticipated that temporary roadway protection would likely be required in the median along the east side of the southbound lanes of Highway 427 and along the west side of the northbound lanes of Highway 427 and to support the embankment outside of the NBL and SBL existing abutment structures. The excavation behind the new abutment in the Highway 427 median could be made as an open cut excavation; however it must still conform to the requirements under OHSA. In addition, temporary roadway protection would also be required adjacent to Highway 407 to support the existing road. The temporary excavation support system should be designed and constructed in accordance with OPSS 539 *(Construction Specification for Temporary Protection Systems)*. The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS 539, provided that the existing adjacent Highway 427 structures, as well as any adjacent utilities, can tolerate this magnitude of deformation. The median area had been filled, above the competent clayey silt till, to the roadway grade. Soldier pile and lagging could be readily installed with the soldier piles driven or drilled into the compact to very dense sand to silt or the clayey silt till for toe support. Lateral resistance could be provided in the form of temporary soil anchors.

6.7.2 Groundwater Control

Based on the water levels measured in the piezometers installed during the 1987 investigation for the existing overpass structures and depending on what the current groundwater levels are, it is anticipated that the excavations for spread footings / pile caps at the north abutment will be about coincident with the groundwater level. At the piers it is anticipated that excavations for spread footings / pile caps will extend about 2 m below the groundwater level. At the south abutment it is anticipated that the excavations for spread footings / pile caps will be about 2.5 m above the groundwater level.

Seepage is anticipated from the fill and from the native cohesionless soil. For the potential depth of excavation at the abutments associated with spread footings or pile caps at the abutments, the seepage volume is expected to be relatively small, such that the water inflow can be handled by pumping from filtered sumps placed at the base of the excavations. However at the piers groundwater control can best be effected by interlocking steel sheeting which could also provide the temporary shoring at the piers.

Based on these small seepage volumes, a Permit to Take Water (PTTW) may not be required for the groundwater control system at this site but should be reviewed at detail design.

As discussed in Section 6.5, running or flowing of water-bearing cohesionless soil strata could occur during or after drilling of the caissons/pre-augering for driven piles, and basal heave could occur where water-bearing cohesionless soils are present at/near the caisson base. If caisson foundations are adopted, temporary or permanent caisson liners would be required to support the soils during construction. If driven piles through pre-augered holes are adopted temporary or permanent liners would be required to support the soils prior to driving the pile.

6.7.3 Subgrade Protection

The silty sand to silt and clayey silt till soils that will be exposed at the foundation subgrade level will be susceptible to disturbance from construction traffic and/or ponded water. To limit this degradation, it is recommended that a concrete working slab be placed on the subgrade within four hours after preparation, inspection and approval of the footing subgrade.

6.7.4 Obstructions

The soils at this site are glacially derived and as such should be expected to contain cobbles and boulders, which could affect the installation of deep foundations or protection systems. Further observation is recommended in the next stage of investigation in support of the detail design.

6.7.5 Vibration Monitoring During Pile or Caisson Installation

If deep foundations are adopted, pre-augering would be required to reach the embedment depth and then driven in order to achieve the design geotechnical resistances. A maximum peak particle velocity (PPV) of 100 mm/s is generally considered applicable for bridge structures in good condition. Based on vibration monitoring experience, it is considered unlikely that vibrations induced by conventional construction activities (such as pile driving) will reach this threshold level. However, if the Highway 427 NBL and SBL overpass structures are determined to be sensitive to vibrations, the requirement for vibration monitoring should be assessed at detail design.

6.8 Recommendations for Further Work in Detail Design

Additional boreholes will be required within each of the abutment and pier widening areas, at the north and south pier and the approach embankment widening areas during the future detail design stage of investigation, to further assess and/or confirm the subsurface conditions and the preliminary recommendations provided in this report, as follows:

- Abutments and Piers:
  - Assessment of the variability and depth of any existing fill and surficial soils to confirm the founding elevation for spread footings within each widened abutment and pier area, and;
  - Observation of the possible presence of cobbles and/or boulders within the soil deposits, to assess the need for an NSSP to warn the contractor of the presence of such obstructions as they may affect excavations and the installation of driven steel H-pile, steel pipe (tube) piles or caisson foundations;.

- Approach embankments:
  - Assessment of the depth and extent of stripping of organics within the footprint of the widened approach embankments;
  - The filling in the median was carried out subsequent to the previous 1982 foundation investigation and no boreholes are available to determine its competence. It has been assumed that proper material, placement and compaction was carried out and that minimal stripping (less than 1 m) would be required. Further investigation, as recommend in the first bullet, for approach embankments help to confirm this at detail design, and;
  - Further assessment of the thickness and consolidation/elastic compression properties of any surficial soils within the footprint of the widened approach embankments, to confirm the settlement estimates.

7.0 CLOSURE

This Preliminary Foundation Design Report was prepared by Ms. Sandra McGaghran, P.Eng. a senior geotechnical engineer with Golder with technical input from Ms. Lisa Coyne, P.Eng., a senior geotechnical engineer and Principal with Golder, and Mr. M.S. Devata, P.Eng. a specialist foundations consultant to Golder. Mr. Fin Heffernan, P.Eng., the Designated MTO Foundations Contact for Golder, conducted an independent review of this report.

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Ontario Provincial Standard Specifications (OPSS)

OPSS 539 Construction Specification for Temporary Protection Systems

Ontario Provincial Standard Drawings (OPSD)

OPSD 3090.101 Foundation Frost Penetration Depths for Southern Ontario

TABLE 1 – COMPARISON OF FOUNDATION ALTERNATIVES

Foundation Option	Feasibility	Advantages	Disadvantages	Constructability
Spread/strip footings on native soils Preferred Option	• Feasible for support of abutments and piers	• Existing structure supported on shallow foundations, and has performed well • Relatively minor groundwater seepage anticipated at the abutments • Allows for semi-integral abutments	• Although excavations would be shallow (to a depth of up to 2 m below grade) they would require temporary excavation support due to the proximity of Highway 407 to the proposed abutments and piers so as not to undermine the existing footings • Groundwater control required at the pier excavations • Precludes use of integral abutments; potentially greater maintenance required at abutments • Lower geotechnical resistances as compared with deep foundations	• Conventional excavation and construction techniques
Steel H-piles pre-augered and driven to found within “100-blow” sandy silt till / clayey silt till (Lower Till Deposit)	• Feasible but not preferred for support of abutments and piers	• Limited groundwater control required • Allows for integral abutment construction if existing structure can be modified to accommodate, or if replacement is adopted • Would minimize differential settlement between existing structure and widened portions of structure	• Pre-augering required due to the variability of elevation of “100-blow” soil. • Temporary/permanent liners required to minimize disturbance to water-bearing silty sand to sandy silt deposit.	• Conventional construction methods for H-pile foundations

Foundation Option	Feasibility	Advantages	Disadvantages	Constructability
Steel pipe (tube) piles, driven to found within very dense sandy silt till / hard clayey silt till (Lower Till Deposit)	• Feasible for support of widened abutments and piers	• Limited groundwater control required • Allows for semi-integral abutment configuration • Would minimize differential settlement between existing structure and widened portions of structure	• Slightly greater risk than for steel H-pile foundations if obstructions (cobbles and/or boulders) are encountered during driving; this could result in piles "hanging up" and lower geotechnical resistances	• Conventional construction methods
Caissons founded within "100-blow" sandy silt till / clayey silt till (Lower Till Deposit)	• Feasible but not preferred for support of abutments and piers	• Higher capacity than for steel H-piles, so reduced number of deep foundation elements compared to steel H-piles • Would minimize differential settlement between existing structure and widened portions of structure	• Water-bearing sandy silt till deposits could contribute to loss of ground or base disturbance • Temporary or permanent liners would be required • Mud drilling may be required below the water level • Tremie methods necessary to place concrete	• Risk of loosening soils at base of caissons

MINISTRY OF TRANSPORTATION, ONTARIO

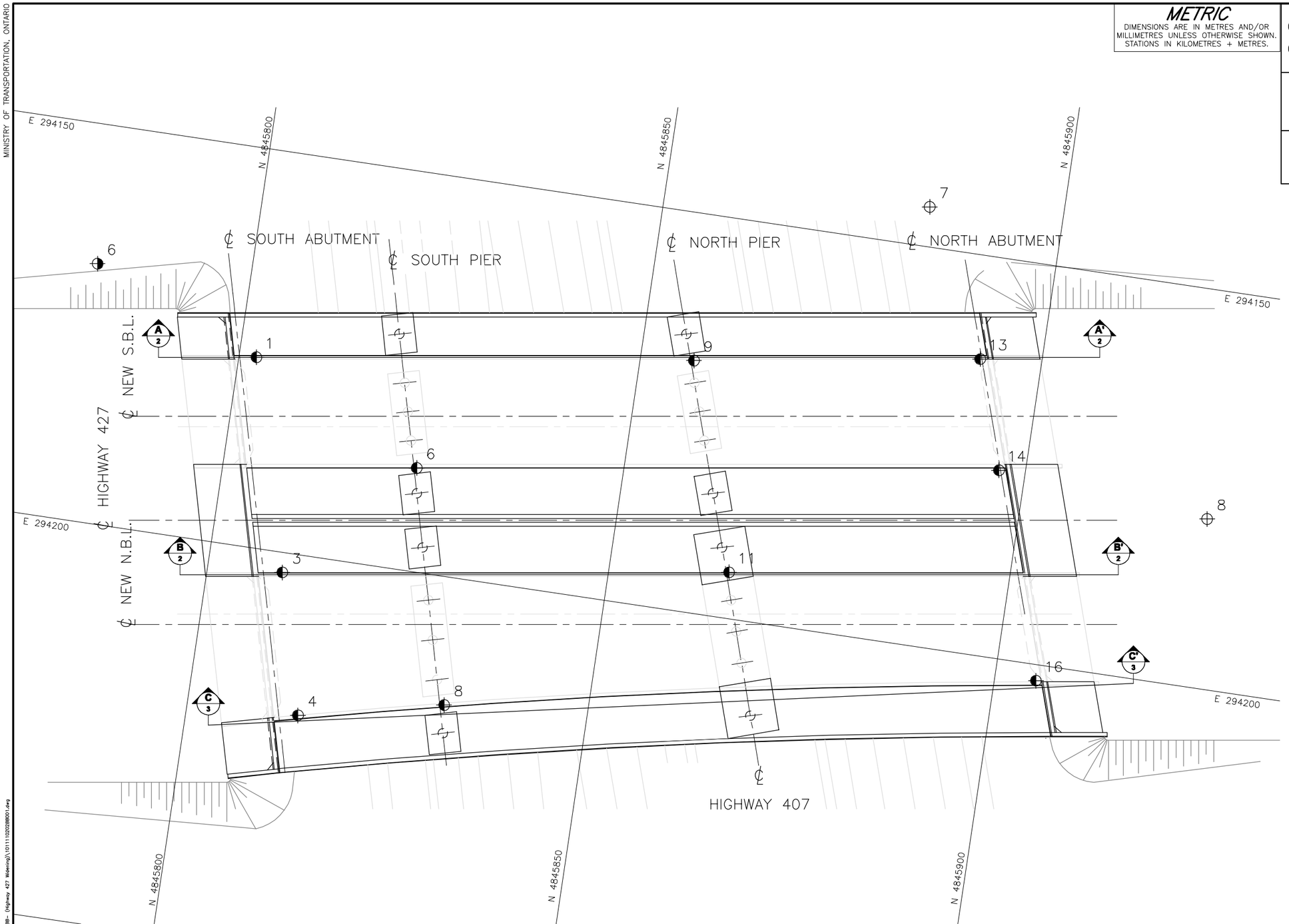
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.2229-09-00(C)

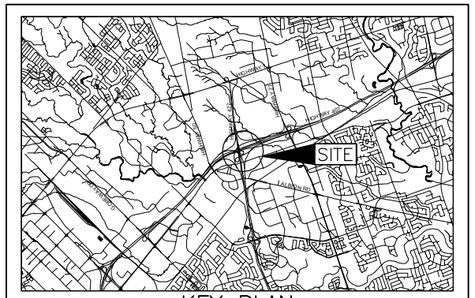
SHEET

HIGHWAY 407 OVERPASSES
HIGHWAY 427 WIDENING
BOREHOLE LOCATIONS

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN
5 0 5 10 m



KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND

- Borehole – Previous Investigation, B.P. Walker Associates, Geocres 30M13-067
- Borehole – Previous Investigation MTO Foundation Design Section, Geocres 30M13-116
- Borehole – Previous Investigation, MTO Foundation Design Section, Geocres 30M13-056

BOREHOLE CO-ORDINATES (30M13-067)

No.	ELEVATION	NORTHING	EASTING
1	177.5	4845802.2	294176.2
3	177.1	4845809.4	294202.5
4	177.1	4845814.0	294220.0
6	178.1	4845824.2	294187.0
8	177.2	4845832.0	294216.0
9	178.1	4845856.7	294168.5
11	178.1	4845865.0	294194.2
13	178.6	4845892.3	294163.0
14	178.3	4845896.7	294176.5
16	177.7	4845905.2	294202.0

BOREHOLE CO-ORDINATES (30M13-056)

No.	ELEVATION	NORTHING	EASTING
7	179.2	4845883.2	294145.0
8	178.1	4845923.5	294178.7

BOREHOLE CO-ORDINATES (30M13-116)

No.	ELEVATION	NORTHING	EASTING
6	178.2	4845780.7	294167.5

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final donfiguration as shown elsewhere in the Preliminary Design Report.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Preliminary Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

General Arrangement provided in digital format by MRC, drawing file no. S3211001-300-001GA.dwg, received May 5, 2012.

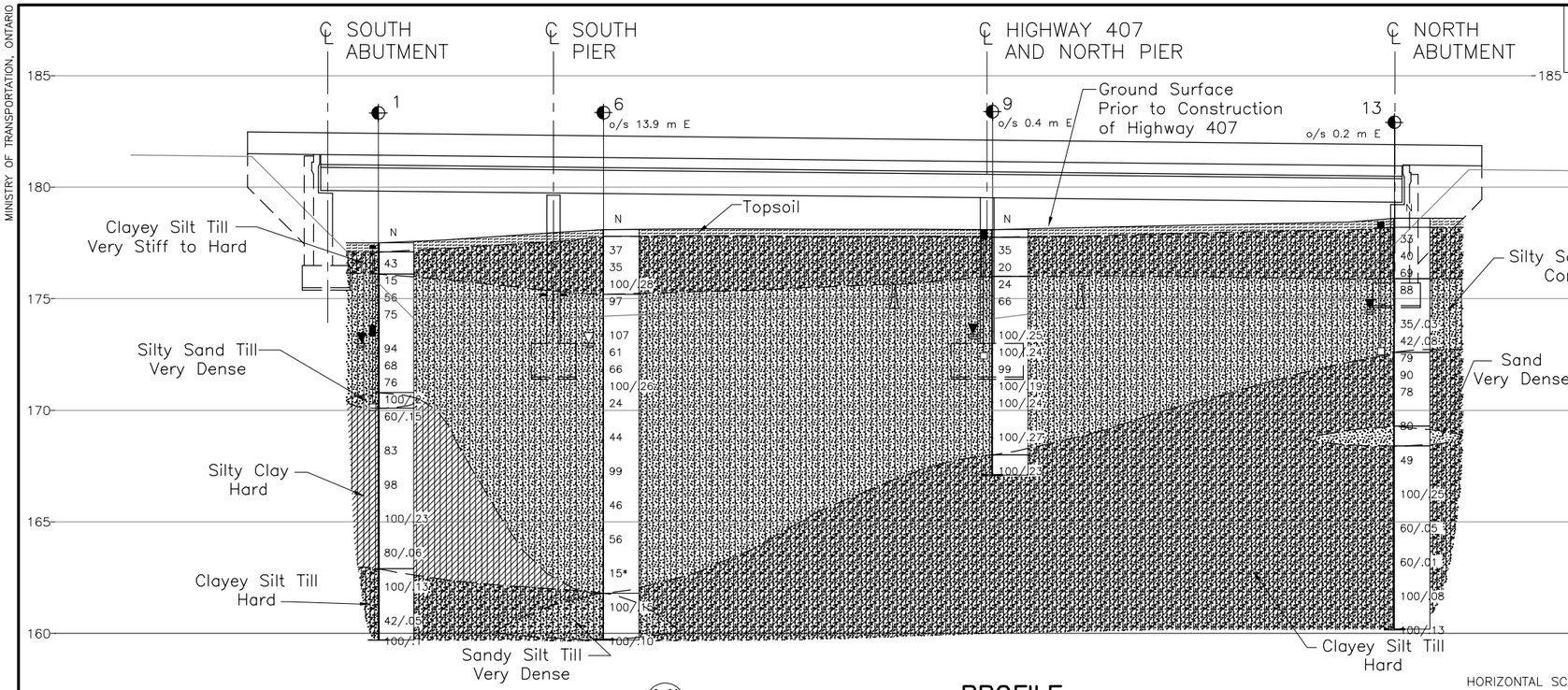
NO.	DATE	BY	REVISION

Geocres No. 30M13-200

HWY. 427	PROJECT NO. 10-1111-0202		DIST.
SUBM'D. SMM	CHKD. LCC	DATE: 11/22/2012	SITE:
DRAWN: LL/JFC	CHKD. SMM	APPD. FJH/SMM	DWG. 1

PLOT DATE: November 23, 2012
PLOTTED: T:\Projects\2011\10-1111-0202 (MRC, Toronto)\-GIS- (Highway 427 Widening)\101111020228501.dwg

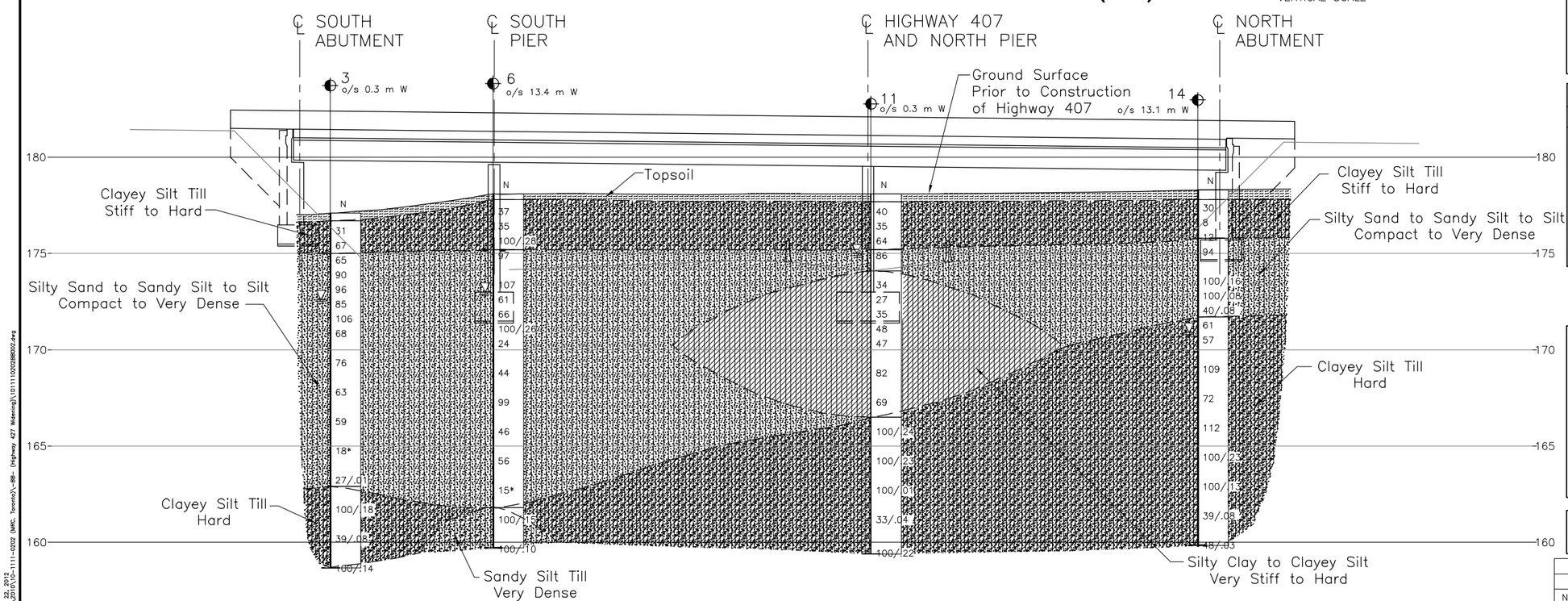
MINISTRY OF TRANSPORTATION, ONTARIO



A-A'
1

PROFILE
WIDENING OF WEST SIDE OF HIGHWAY 427 (SBL)

HORIZONTAL SCALE
5 0 5 10 m
2.5 0 2.5 5 m
VERTICAL SCALE



B-B'
1

PROFILE
MEDIAN WIDENING OF HIGHWAY 427

HORIZONTAL SCALE
5 0 5 10 m
2.5 0 2.5 5 m
VERTICAL SCALE

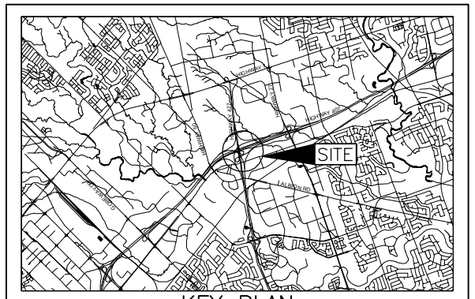
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.2229-09-00(C)

HIGHWAY 407 OVERPASSES
HIGHWAY 427 WIDENING
SOIL STRATA

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



LEGEND

- Borehole – Previous Investigation, B.P. Walker Associates, Geocres 30M13-067
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer (no date recorded)
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (30M13-116)

No.	ELEVATION	NORTHING	EASTING
1	177.5	4845802.2	294176.2
3	177.1	4845809.4	294202.5
6	178.1	4845824.2	294187.0
9	178.1	4845856.7	294168.5
11	178.1	4845865.0	294194.2
13	178.6	4845892.3	294163.0
14	178.3	4845896.7	294176.5

NOTES

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REFERENCE

General Arrangement provided in digital format by MRC, drawing file no. S3211001-300-001GA.dwg, received May 5, 2012.

NO.	DATE	BY	REVISION

Geocres No. 30M13-200

HWY. 427		PROJECT NO. 10-1111-0202	DIST.
SUBM'D. SMM	CHKD. LCC	DATE: 11/22/2012	SITE:
DRAWN: LL/JFC	CHKD. SMM	APPD. FJH/SMM	DWG. 2

PLOT DATE: November 22, 2012
PLOTTED: C:\Projects\2010\10-1111-0202 (MRC, Toronto)\-BB- (Highway 427 Widening)\10111102028B002.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

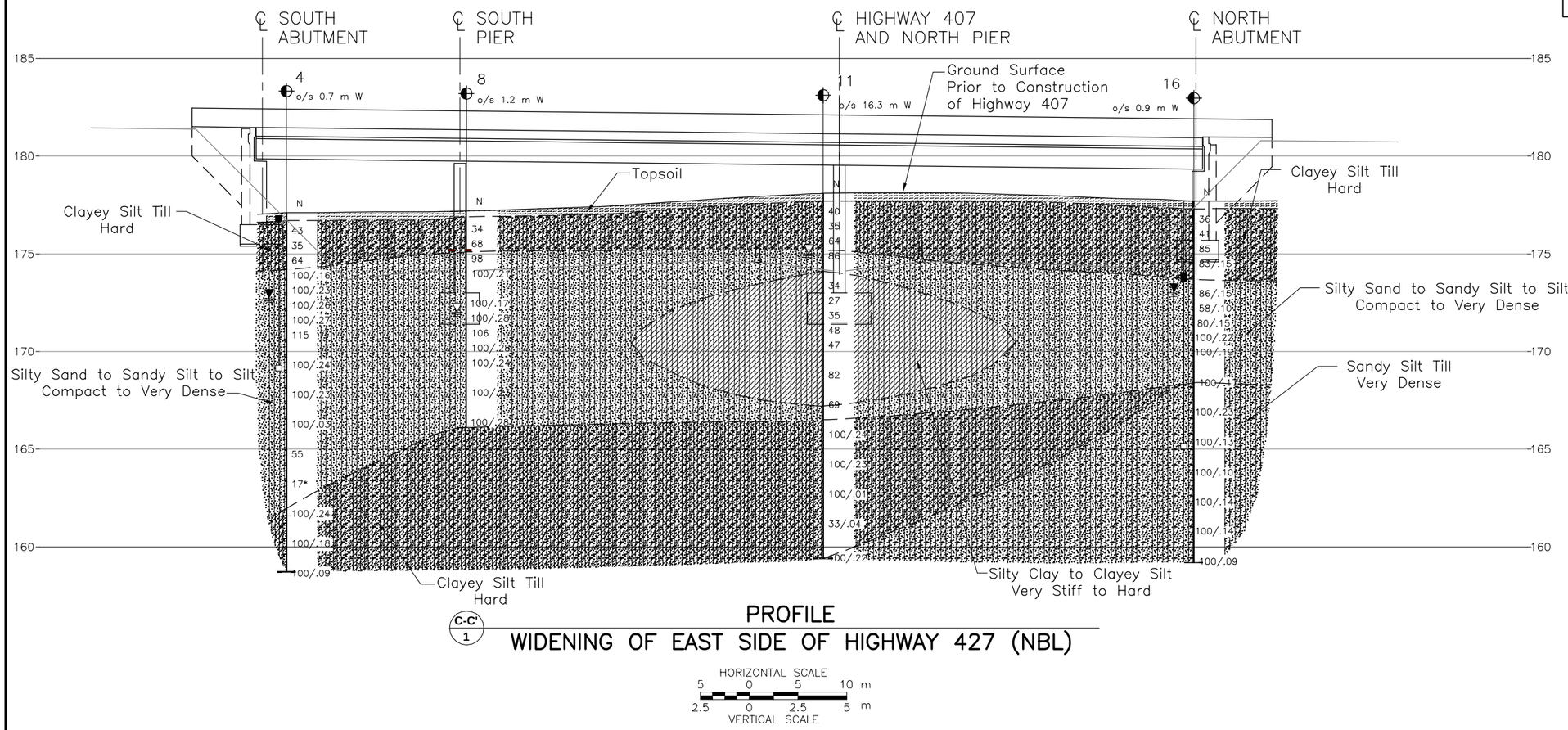
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.2229-09-00(C)

HIGHWAY 407 OVERPASSES
HIGHWAY 427 WIDENING
SOIL STRATA

SHEET

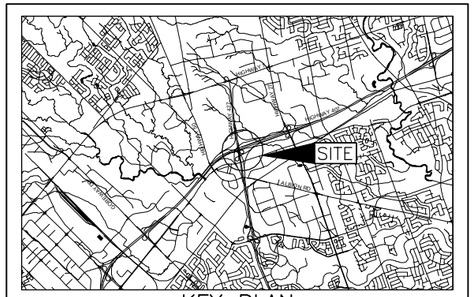
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



C-C'
1

PROFILE
WIDENING OF EAST SIDE OF HIGHWAY 427 (NBL)

HORIZONTAL SCALE
5 0 5 10 m
2.5 0 2.5 5 m
VERTICAL SCALE



LEGEND

- Borehole – Previous Investigation, B.P. Walker Associates, Geocres 30M13-067
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer (no date recorded)
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (30M13-116)

No.	ELEVATION	NORTHING	EASTING
4	177.1	4845814.0	294220.0
8	177.2	4845832.0	294216.0
11	178.1	4845865.0	294194.2
16	177.7	4845905.2	294202.0

NOTES

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The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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REFERENCE

General Arrangement provided in digital format by MRC, drawing file no. S3211001-300-001GA.dwg, received May 5, 2012.

NO.	DATE	BY	REVISION

Geocres No. 30M13-200

HWY. 427	PROJECT NO. 10-1111-0202		DIST.
SUBM'D. SMM	CHK'D. LCC	DATE: 11/22/2012	SITE:
DRAWN: LL/JFC	CHK'D. SMM	APP'D. FJH/SMM	DWG. 3

PLOT DATE: November 22, 2012
FILENAME: I:\Projects\2010\10-1111-0202 (MRC, Toronto)_BB\ (Highway 427 Widening)\101111020288003.dwg

APPENDIX A

Borehole Records, Laboratory Test Results and Drawing 1 GEOCRES 30M13-067

Ministry of Transportation and Communications
Ontario

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 1 — METRIC

W P 150-87-01 / 150-87-02 — LOCATION N 4 845 802.2; E 294 176.2 — ORIGINATED BY LSR
DIST 6 — HWY 407/427 — BOREHOLE TYPE 100mm dia. Solid Stem Augering — COMPILED BY LSR
DATUM Geodetic — DATE 1987 - 10 - 29 — CHECKED BY UR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
177.5	Ground Level										
0.0	0.38m Topsoil					Seal	177				
176.1	Silty Clay, Some Sand, Trace Gravel, Hard, Glacial Till, Damp		1	SS	43						
1.4	Sandy Silt, trace Gravel with compact / very dense Fine Sand Layers		2	SS	15						
			3	SS	56		175				
			4	SS	75	Seal					
	Damp to moist / Saturated						173				
			5	SS	94						0 44 53 3
	Brown / Grey cobbles		6	SS	68						
170.8			7	SS	76		171			23.2	1 5 85 9
6.7	Silty Sand, Some Gravel, V. Dense, Glacial Till, Moist		8	SS	100/ 0.12m	Piezometer				23.5	
170.1			9	SS	60/ 0.15m						
7.4	Clay, with Silt Laminations and Layers						169				
			10	SS	83						3 10 34 53
							167				
	Hard Grey Damp		11	SS	98						
			12	SS	100/ 0.23 m		165				
			13	SS	80/ 0.06 m						
162.9							163				
14.6	Silty Clay, Some Sand, Trace Gravel, Glacial Till Hard Grey Damp		14	SS	100/ 0.13 m						
			15	SS	42/ 0.05 m		161				
159.7	Shale Fragments, Possibly Bedrock		16	SS	100/ 0.10m						
17.8	End of Borehole						159				

+3, ×5 : Numbers refer to Sensitivity

15 20 5 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical , Inspection, and Testing Engineers
Project NO. 2121.1

RECORD OF BOREHOLE No 3

METRIC

W P 150-87-01
150-87-02
LOCATION N 4 845 809.4; E 294 202.5
ORIGINATED BY LSR
DIST 6 HWY 407/427
BOREHOLE TYPE 100mm dia. Solid Stem Augering
COMPILED BY LSR
DATUM Geodetic
DATE 1987 - 11 - 03 & 04
CHECKED BY ue

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
177.1	Ground Level										
0.0	0.38m Topsoil Silty Clay, some Sand, trace Gravel, Glacial Till		1	SS	31		177				
175.0	Hard Brown Damp		2	SS	67						
2.1	Sandy Silt, with Fine Sand and Silt layers very dense Moist Saturated		3	SS	65		175				0 28 64 8
			4	SS	90						
			5	SS	96	▼	173				0 80 15 5
	Brown / Grey		6	SS	85						
			7	SS	106						2 80 13 5
			8	SS	68		171				
			9	SS	76		169				0 15 80 5
			10	SS	63						
							167				
			11	SS	59						
							165				
			12	SS	18						SS 12: Low N probably due to sample disturbance caused by groundwater
162.9	Boulders		13	SS	270/	01m	163				
14.2	Silty Clay, some Sand, trace Gravel, Occasional Sandy lenses		14	SS	100/	0.18m					
	hard						161				
	Grey Damp		15	SS	397	0.08m					
158.7			16	SS	100/	0.14m	159				
18.4	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

15 (20 / 10) 5 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 4 METRIC

W P 150-87-01, 150-87-02 LOCATION N 4 845 814.0; E 294 220.0 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 11 - 02 & 03 CHECKED BY UR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
177.1	Ground Level										
0.0	0.4m Topsoil Silty Clay, some Sand trace Gravel, occasional Silt lenses Glacial Till		1	SS	43		177				
			2	SS	35						
174.2	Hard Brown Damp		3	SS	64		175				
2.9	Sandy Silt with Fine Sand and Silt layers		4	SS	100/0.16m						
	very dense		5	SS	100/0.23m		173				
	Moist to Wet Saturated		6	SS	100/0.26m						
			7	SS	100/0.27m		171				
	Brown Grey		8	SS	115						
			9	SS	100/0.24m	Piezometer	169				
			10	SS	100/0.23m						
	cobbles		11	SS	100/0.03m		167				
			12	SS	55		165				
			13	SS	17		163				SS13: low N probably due to sample disturbance caused by groundwater
161.6			14	SS	100/0.24m						
15.5	Silty Clay, some Sand, trace Gravel, with Sand lenses Glacial Till						161				
	Moist to Wet		15	SS	100/0.18m						
158.7	Hard Grey		16	SS	100/0.09m		159				
18.4	End of Borehole Possibly Shale Bedrock										

+3, ×5 : Numbers refer to Sensitivity

15 20 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation and Communications
Ontario

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 6

METRIC

W P 150-87-01, 150-87-02 | LOCATION N 4 845 824.2; E 294 187.0 | ORIGINATED BY LSR
DIST 6 HWY 407/427 | BOREHOLE TYPE 100mm dia. Solid Stem Augering | COMPILED BY LSR
DATUM Geodetic | DATE 1987 - 11 - 04 | CHECKED BY UR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.1	Ground Level										
0.0	0.25m Topsoil Silty Clay, some Sand, trace Gravel Glacial Till		1	SS	37		177				
			2	SS	35						
175.2	Hard Brown Damp		3	SS	100/0.28m		175				
2.9	Silt, with Fine Sand layers Moist Saturated		4	SS	97						2 9 82 7
			5	SS	107	▼	173				
			6	SS	61			DYNAMIC CONE PEN. TEST			
			7	SS	66						
	Brown Grey		8	SS	100/0.26m		171	164			
			9	SS	24			295 392 372 405			0 13 74 13
	very dense		10	SS	44		169				
			11	SS	99		167				
			12	SS	46						
			13	SS	56		165				
161.8			14	SS	15		163				SS14: low W probably due to sample disturbance caused by groundwater
16.3	Sandy Silt, trace Gravel, Glacial Till		15	SS	100/0.15m		161				
159.7	very dense Grey Damp to moist		16	SS	100/0.10m						
18.4	End of Borehole						159				

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 8 METRIC

W P 150-87-01
150-87-02
LOCATION N 4 845 832.0; E 294 216.0
ORIGINATED BY LSR
DIST 6 HWY 407/427
BOREHOLE TYPE 100mm dia. Solid Stem Augering
COMPILED BY LSR
DATUM Geodetic
DATE 1987 - 11 - 24
CHECKED BY UR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
177.2	Ground Level										
0.0	0.30m Topsoil						177				
	Silty Clay, trace Sand and Gravel		1	SS	34						
	Glacial Till										
175.1	Hard Brown Damp		2	SS	68		175				
2.1	Silt, some Fine Sand, trace Gravel, with occasional Fine Sand layers		3	SS	98				○		
			4	SS	100/0.21m				○		
	Moist / Saturated						173				
			5	SS	100/0.17m	▽			○		7 13 77 3
			6	SS	100/0.28m						
	very dense Brown / Grey		7	SS	106		171		○		
			8	SS	100/0.28m						
			9	SS	100/0.24m		169				
			10	SS	100/0.23m						
166.2	Silty Clay, Hard, Glacial Till						167				
			11	SS	100/0.28m						
11.1	End of Borehole						165				

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation and Communications, Ontario

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 9 METRIC

W P 150-87-01 / 150-87-02 LOCATION N 4 845 856.7; E 294 168.5 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 11 - 24 CHECKED BY CSR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.1	Ground Level										
0.0	0.34m Topsoil										
	Silty Clay, some Sand, trace Gravel Glacial Till		1	SS	35		177				
176.0	Hard to very stiff Brown Damp		2	SS	20						
2.1	Sandy Silt, with Fine Sand and Silt lenses or layers compact v. dense moist saturated		3	SS	24						
			4	SS	66		175				0 11 85 4
			5	SS	100/0.25m	▼	173				
			6	SS	100/0.24m	Piezometer					
	Brown / Grey		7	SS	99						
			8	SS	100/0.19m		171				
			9	SS	100/0.24m						
168.0			10	SS	100/0.27m		169				
10.1	Silty Clay, some Sand, trace Gravel, with Silt lenses Hard Grey Moist		11	SS	100/0.23m						
167.1											
11.0	End of Borehole						167				

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 11 METRIC

W P 150-87-01 / 150-87-02 LOCATION N 4 845 865.0; E 294 194.2 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 11 - 04 & 05 CHECKED BY USR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.1	Ground Level							
0.0	0.4m Topsoil Silty Clay, some Sand trace Gravel, Glacial Till		1	SS	40		177	
			2	SS	35			
175.2	Hard Brown Damp		3	SS	64			
2.9	Silty Fine Sand, very		4	SS	86	▽	175	
174.1	dense Brown Damp							
4.0	Clay, with Silt laminations and layers, occasional Sand lenses		5	SS	34		173	
			6	SS	27			0 7 53 40
	hard Brown / Grey Damp		7	SS	35			
			8	SS	48		171	
			9	SS	47			
			10	SS	82		169	
166.5	cobbles		11	SS	69		167	
11.6	Silty Clay, some Sand trace Gravel		12	SS	100/0.24m			
	Glacial Till						165	
	hard Brown / Grey Damp		13	SS	100/0.23m			
			14	SS	100/0.01m		163	
			15	SS	33/0.04m		161	
159.4			16	SS	100/0.22m			
18.7	End of Borehole						159	

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE
PLASTIC LIMIT Wp — NATURAL MOISTURE CONTENT W — LIQUID LIMIT Wl
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ

+3, x5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications, Ontario

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 13 METRIC

W P 150-87-01 / 150-87-02 LOCATION N 4 845 892.3; E 294 163.0 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 10-30 CHECKED BY UM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.6	**Ground Level**										
0.0	0.40m Topsoil Silty Clay, some Sand trace Gravel Glacial Till		1	SS	33	seal					
			2	SS	40		177				
175.9	Hard brown Damp to Moist		3	SS	69						
2.7	Silty Sand, occasional coarse Sand lenses, trace Gravel Damp Moist		4	SS	88		175				
	very dense		5	SS	35/	0.03m					
172.6	Brown Grey		6	SS	42/	0.08m	173				
6.0	Silty Clay, some Sand trace Gravel, with Silt and Sand lenses, Glacial Till		7	SS	79	Piezometer					
			8	SS	90						
			9	SS	78		171				
169.3	Hard Grey Moist										
9.3	Sand, trace Gravel, Very Dense Grey Wet		10	SS	80		169				
168.4											
10.2	Silty Clay, some Sand trace Gravel		11	SS	49						
	Glacial Till						167				
	Damp to		12	SS	100/	0.25m					
	Hard Grey Moist		13	SS	60/	0.05m	165				
	Water Seepage at 15m		14	SS	60/	0.00m					
	Boulders						163				
	occasional shale fragments		15	SS	100/	0.08m					
160.2							161				
18.4	End of Borehole		16	SS	100/	0.13m					
							159				

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Tesing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 14 METRIC

W P 150-87-01 150-87-02 LOCATION N 4 845 896.7; E 294 176.5 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Solid Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 11 - 05 CHECKED BY CAR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.3	**Ground Level**										
0.0	0.5m Topsoil Silty Clay, some Sand ~~Hard~~ trace Gravel **Stiff** Glacial Moist Till Brown		1	SS	30		177				
175.8			2	SS	8						
2.5	Silt, with Sand layers or lenses, trace Gravel Very Dense Brown Damp		3	SS	12		175				
			4	SS	94						
			5	SS	100/0.16m						
			6	SS	100/0.08m		173				
171.7	Boulders		7	SS	40/0.08m						
6.6	Silty Clay, some Sand trace Gravel, occasional more Sandy zones Glacial Till Gravel Lenses Hard ~~Grey~~ cobbles **Brown**		8	SS	61	▼	171				
			9	SS	57						
			10	SS	109		169				
	Damp to Moist		11	SS	72		167				
			12	SS	112						
	~~grey~~		13	SS	100/0.23m		165				
	frequent gravel lenses		14	SS	100/0.13m		163				
			15	SS	39/0.08m		161				
159.8			16	SS	48/0.03m						
18.5	End of Borehole										

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation and Communications
Ontario

B. P. WALKER ASSOCIATES LIMITED
Consulting Geotechnical, Inspection and Testing Engineers
Project No. 2121.1

RECORD OF BOREHOLE No 16 METRIC

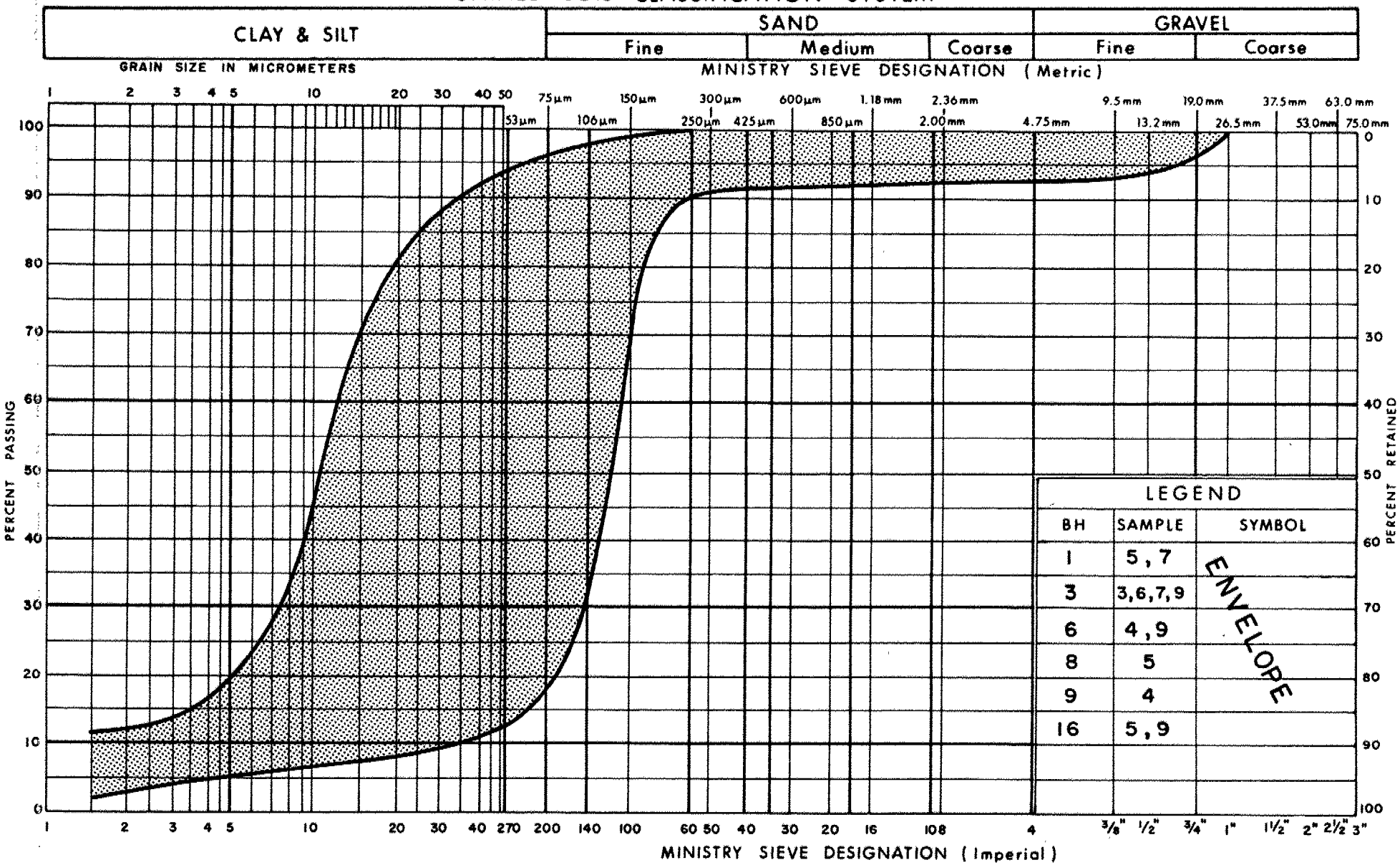
W P 150-87-01 / 150-87-02 LOCATION N 4 845 905.2; E 294 202.0 ORIGINATED BY LSR
DIST 6 HWY 407/427 BOREHOLE TYPE 100mm dia. Soldi Stem Augering COMPILED BY LSR
DATUM Geodetic DATE 1987 - 10 - 30 & 31 and 11 - 02 CHECKED BY UR

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
177.7	Ground Level										
0.0	0.4m Topsoil Silty Clay, some Sand trace Gravel Glacial Till Hard Brown Damp		1	SS	36		177				
			2	SS	41						
			3	SS	85		175				
173.7			4	SS	83/0.15m						
4.0	Silt with Fine Sand lenses moist saturated Very Dense Brown					Seal					
			5	SS	86/0.15m		173				0 18 72 10
			6	SS	58/0.10m						
			7	SS	80/0.15m						
			8	SS	100/0.22m		171				
			9	SS	100/0.19m						2 11 78 9
168.4							169				
9.3	Sandy, Silt, trace Gravel with Gravelly and Sandy lenses Glacial Till Grey Very Dense Moist Traces of Shale Fragments		10	SS	100/0.17m						
			11	SS	100/0.23m		167				
			12	SS	100/0.13m	Piezometer					
			13	SS	100/0.10m		165				
			14	SS	100/0.14m		163				
			15	SS	100/0.14m		161				
159.2			16	SS	100/0.09m						
18.5	End of Borehole						159				

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

UNIFIED SOIL CLASSIFICATION SYSTEM



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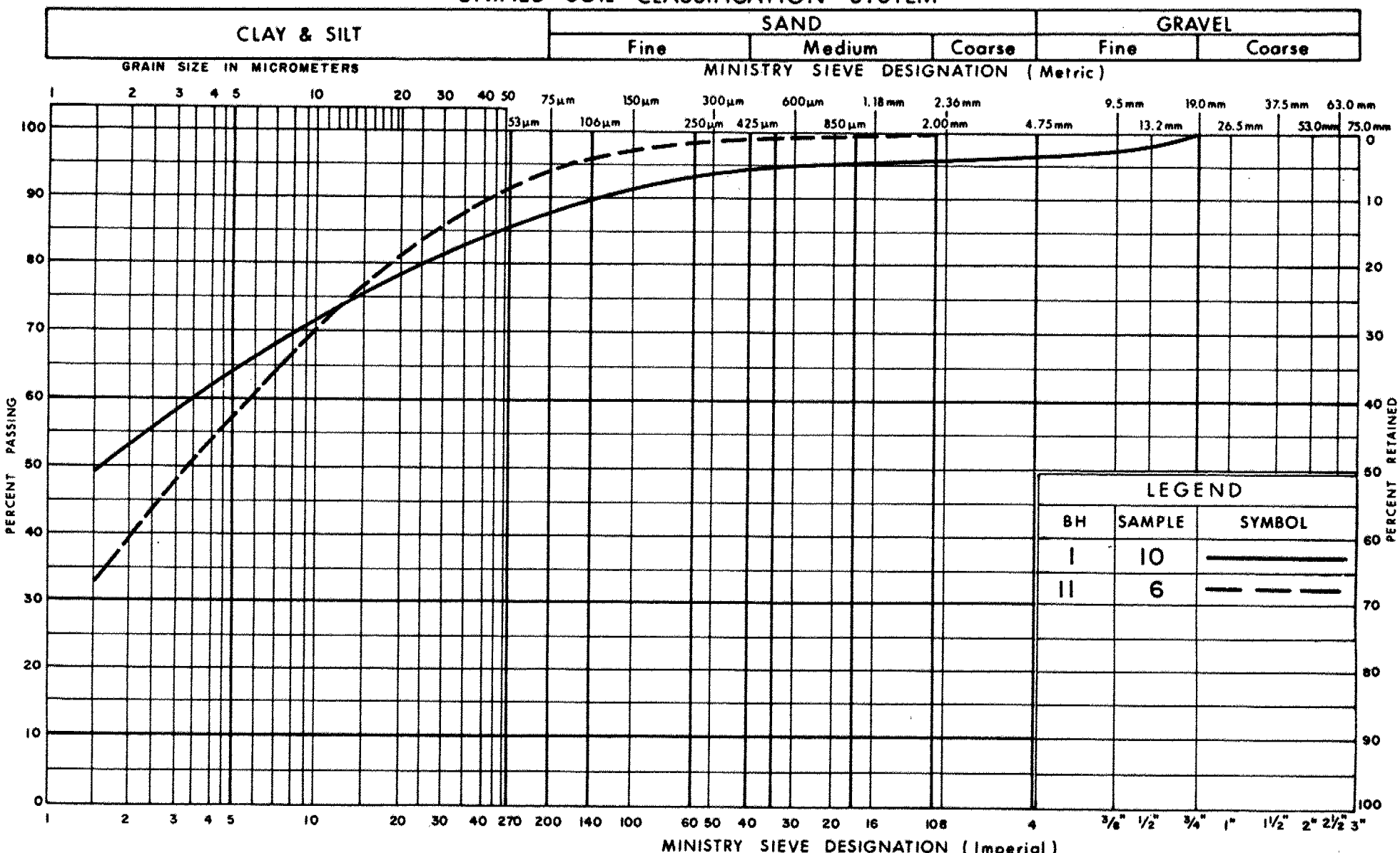
GRAIN SIZE DISTRIBUTION

SILT TO SANDY SILT with fine Sand layers
(layered deposit)

FIG No 1
W P 150-87-01/02

UNIFIED SOIL CLASSIFICATION SYSTEM



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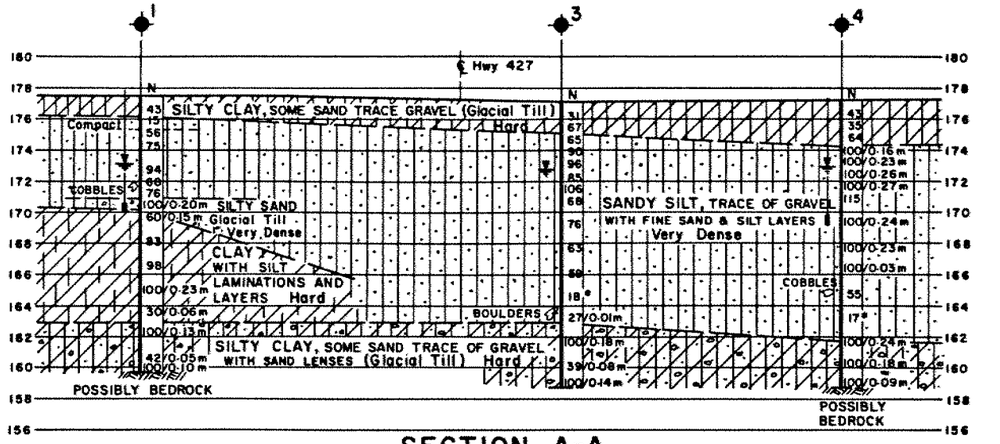
GRAIN SIZE DISTRIBUTION

CLAY, with Silt Laminations and Layers

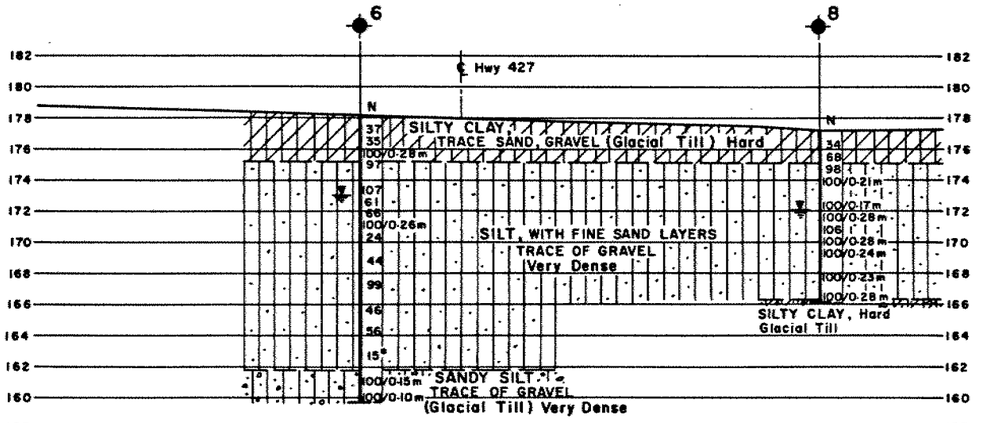
FIG No 2

W P 150-87-01/02



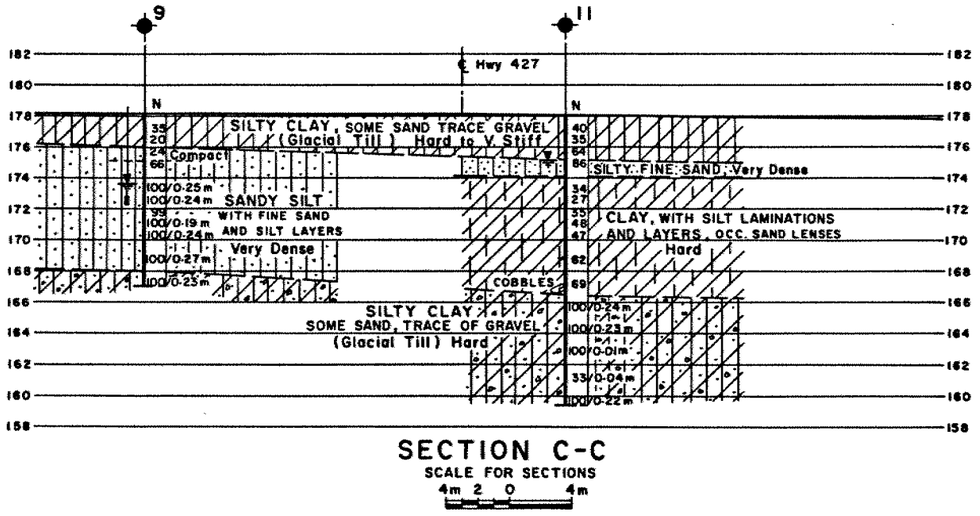
SECTION A-A

* Low N value probably due to sample disturbance caused by groundwater



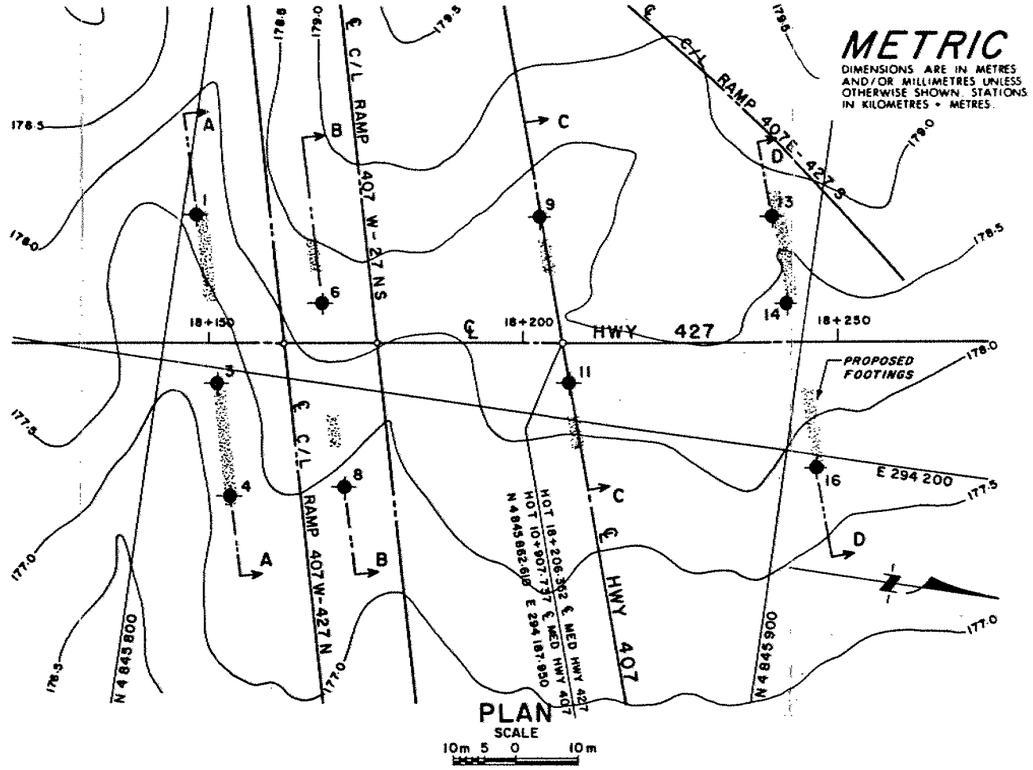
SECTION B-B

* Low N value probably due to sample disturbance caused by groundwater



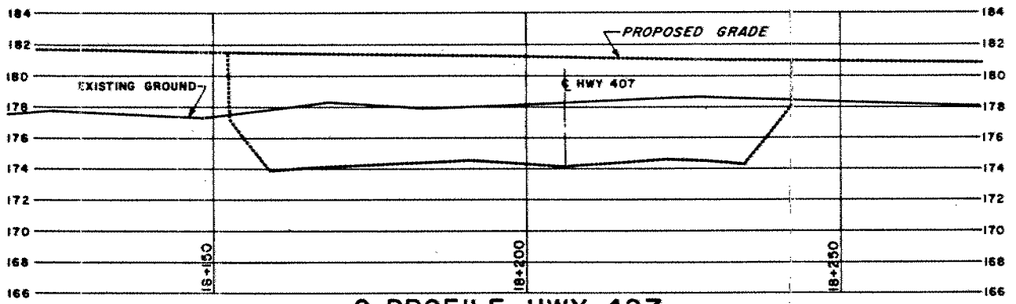
SECTION C-C

SCALE FOR SECTIONS
4m 2 0 4m



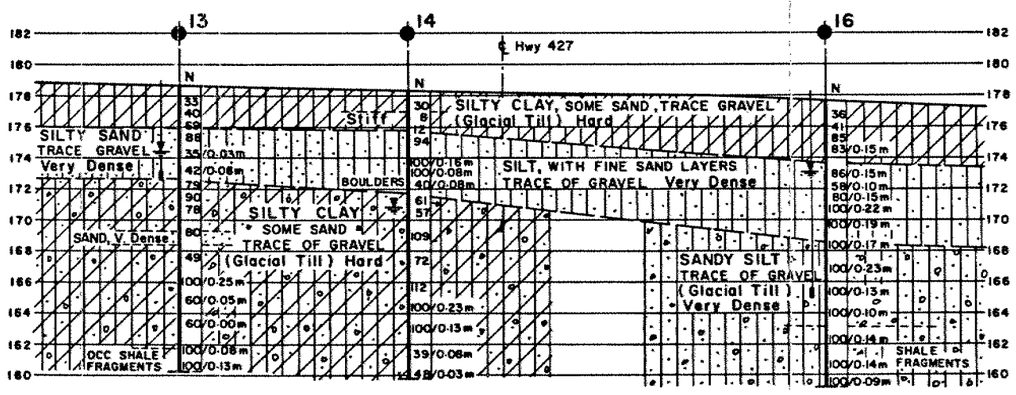
PLAN

SCALE
10m 5 0 10m



℄ PROFILE HWY 427

SCALE
Hor 10m 5 0 10m
Vert 4m 2 0 4m



METRIC

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

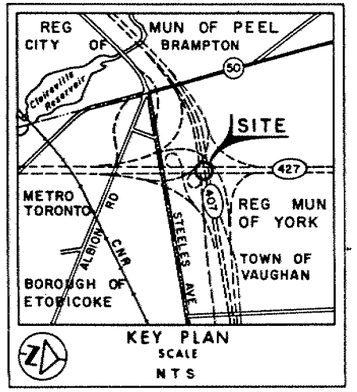
CONT No
WP No 150-87-01/02

HWY 427 OVER HWY 407

BORE HOLE LOCATIONS & SOIL STRATA

SHEET

B. P. Walker Associates Ltd.



KEY PLAN
SCALE
NTS

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0·3m (Std Pen Test, 475 J/blow)
- CONE Blows/0·3m (60° Cone, 475 J/blow)
- W L at time of investigation 87 11
- W L in Piezometer
- Piezometer

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	177·5	4 845 802·2	294 176·2
3	177·1	4 845 809·4	294 202·5
4	177·1	4 845 814·0	294 220·0
6	178·1	4 845 824·2	294 187·0
8	177·2	4 845 832·0	294 216·0
9	178·1	4 845 856·7	294 168·5
11	178·1	4 845 865·0	294 194·2
13	178·6	4 845 892·3	294 163·0
14	178·3	4 845 896·7	294 176·5
16	177·7	4 845 905·2	294 202·0

NOTE

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

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 30M13-67

HWY No 407 / 427 | DIST 6

APPENDIX B

Borehole Records, Laboratory Test Results
GEOCRES 30M13-056

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Ontario

RECORD OF BOREHOLE No 7 METRIC

W P 88-78-25 LOCATION Co-ords. N 4 845 883.2; E 294 145.0 ORIGINATED BY DW
DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger & Cone Test COMPILED BY TJK
DATUM Geodetic DATE 82 07 14 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
179.2	Ground Surface										
0.0	Brown mottled Silty Clay Some Sand Trace Gravel V. Stiff to Hard		1	SS	22	*	178				GR SA SI CL
176.5			2	SS	47						5 19 46 30
			3	SS	100/25 cm			50/15 cm			
2.7	Brown Silt to Silty Sand Trace Clay & Gravel V. Dense		4	SS	100/15 cm		176				2 7 86 5
			5	SS	100/10 cm						
			6	SS	100/13 cm						8 17 73 2
172.7							174				
6.5	Grey (Glacial Till) Silty Clay, Sand, Gravel Hard		7/8	SS	72						
171.2			9	SS	100/19 cm		172				
8.0	End of Borehole										

* Note: Water Level not encountered

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH: o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE
WATER CONTENT (%): 10 20 30

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 8

METRIC

W P 88-78-25 LOCATION Co-ords. N 4 845 923.5; E 294 178.7 ORIGINATED BY DW

DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY TJK

DATUM Geodetic DATE 82 07 15 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
178.1	Ground Surface						178				
0.0	Brown mottled Silty Clay with Sand Trace Gravel		1	SS	25	*					
			2	SS	50		176				
175.2	V. Stiff to Hard		3	SS	89						
2.9	Brown Silty Sand Trace Clay & Gravel		4	SS	100/10 cm						
			5	SS	130/20 cm		174				
	Very Dense		6	SS	100/8 cm						
171.1			7	SS	130/15 cm		172				
7.0	Grey (Glacial Till)										
170.3	Hard		8	SS	125/15 cm						
7.8	End of Borehole										

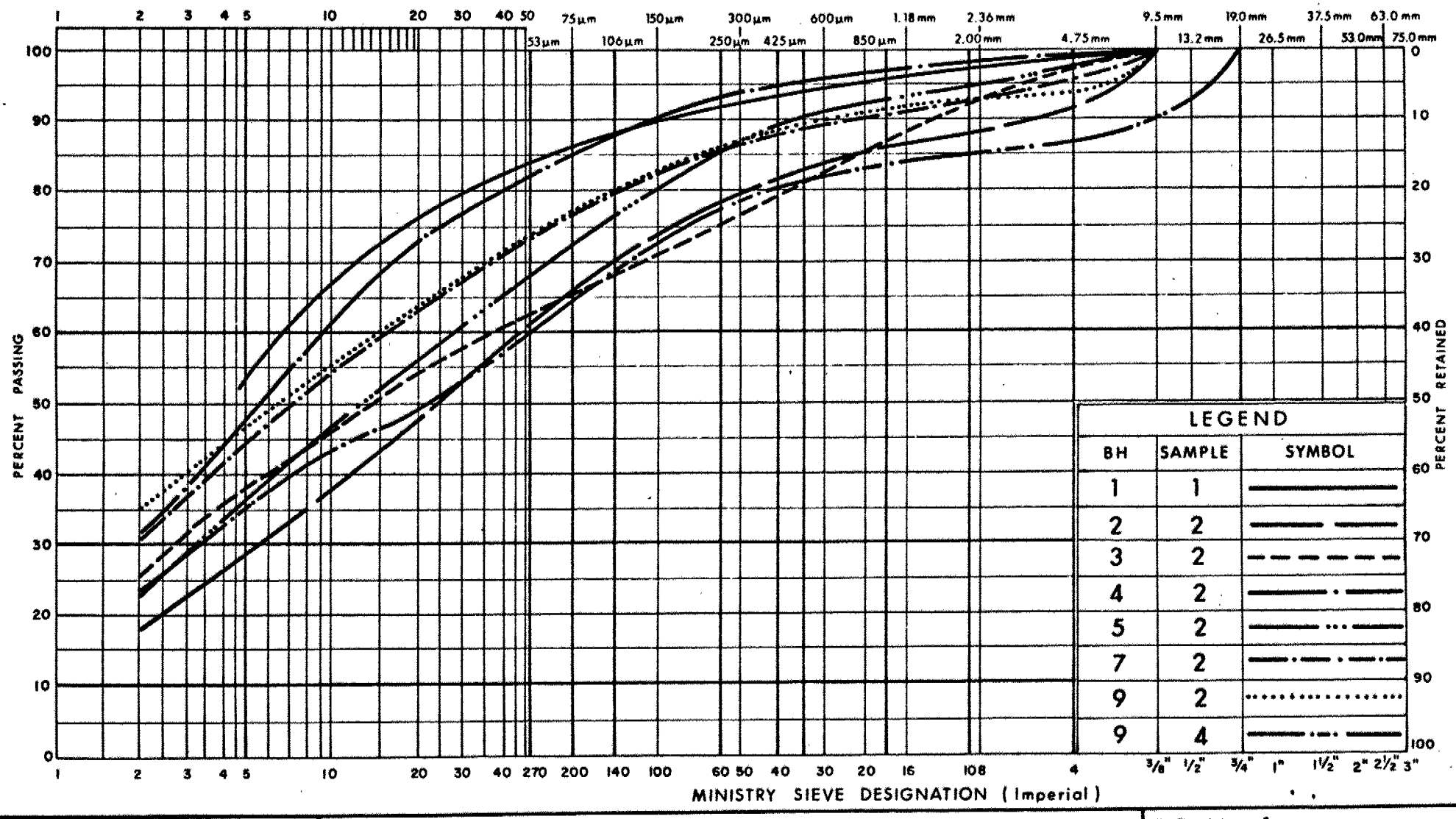
* Note: Water Level not encountered

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



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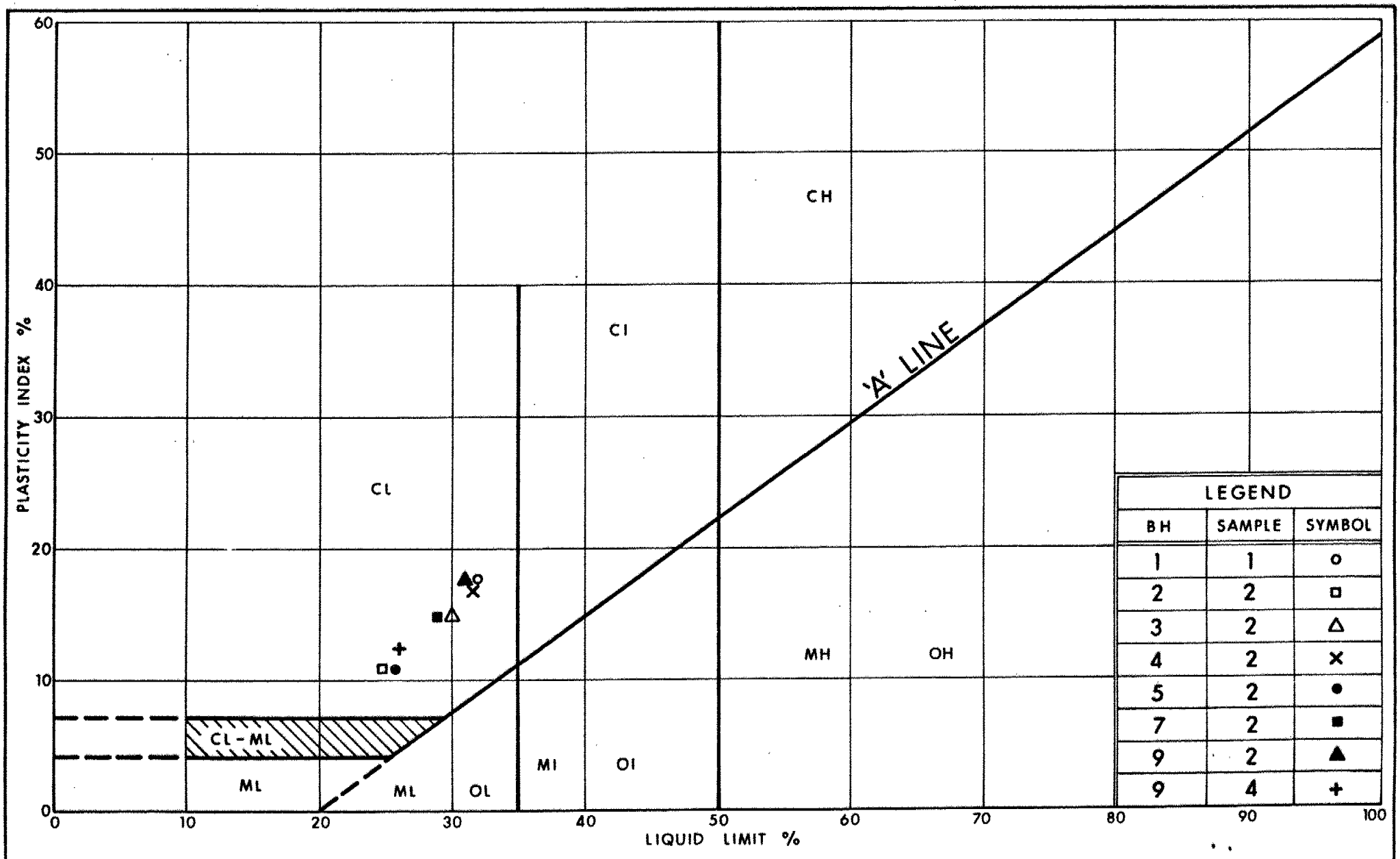
GRAIN SIZE DISTRIBUTION

SILTY CLAY WITH SAND TRACE OF GRAVEL

FIG No 1

W P 88-78-25



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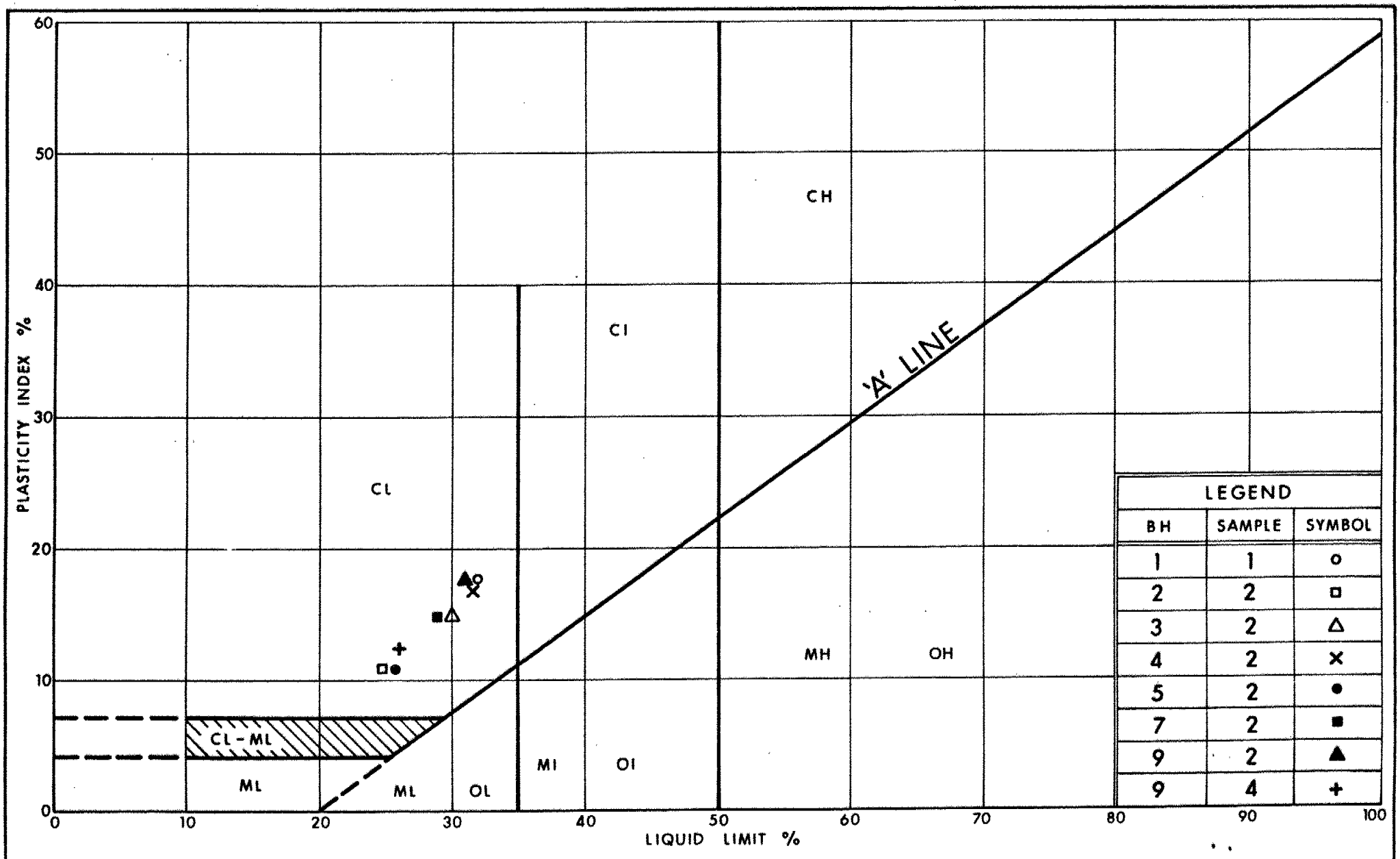
PLASTICITY CHART

SILTY CLAY OF LOW PLASTICITY

FIG No 2
WP 88-78-25



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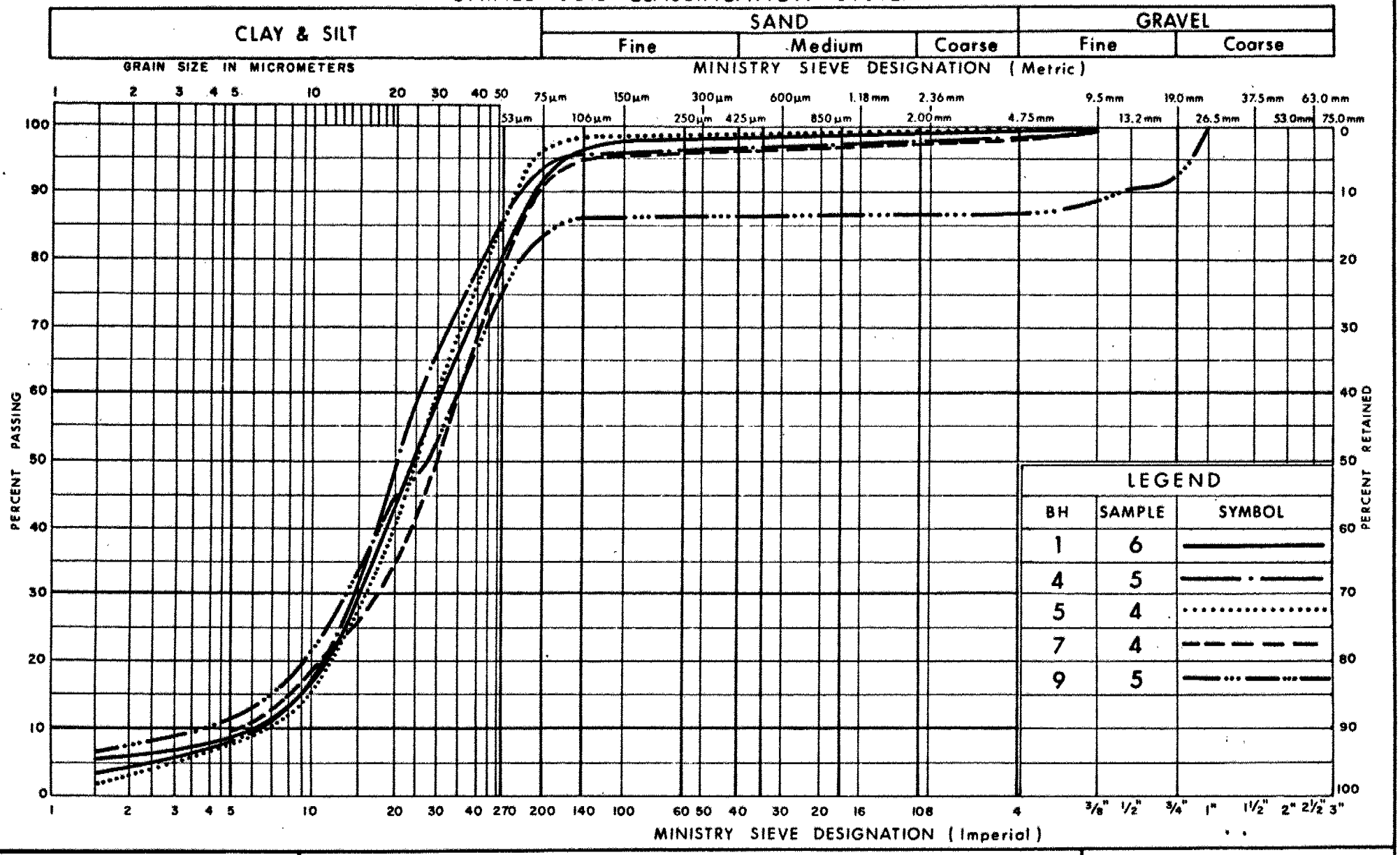
PLASTICITY CHART

SILTY CLAY OF LOW PLASTICITY

FIG No 2
WP 88-78-25

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
INTERBEDDED SILT LAYERS

FIG No 4
W P 88-78-25

APPENDIX C

Borehole Records, Laboratory Test Results
GEOCRES 30M13-116

RECORD OF BOREHOLE No 6 1 OF 2 METRIC

W.P. 388-87-01 LOCATION Co-ords:N4 845 780.7; E294 167.5 ORIGINATED BY MM
DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
DATUM Geodetic DATE 90 06 20 CHECKED BY TS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.2	Ground Surface										
0.0	Irregular mixture of Clayey Silt, sand and gravel (Fill Material) Brown, V.Stiff to Hard		1	SS	19	**	178				
176.1			2	SS	42				o	21.7	0 25 45 30
2.1	Sandy Silt V.Dense Brown		3	SS	56		176				
			4	SS	57				o		0 33 (67)
			5	SS	60		174				
	Grey		6	SS	46						
171.0			7	SS	60		172				
7.2			8	SS	162						
	Silt		9	SS	50		170				
	Heterogeneous mixture of Clayey Silt,sand and gravel (Glacial Till) Hard		10	SS	58		168		o		0 0 60 40
			11	SS	40		166				
			12	SS	46		164		o		1 18 51 30
163.0											

15.2 Continued

Continued

$+^3$, $\times^3$; Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6 2 OF 2 METRIC

W.P. 368-87-01 LOCATION Co-ords:N4 845 780.7; E294 167.5 ORIGINATED BY MM
DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
DATUM Geodetic DATE 90 06 20 CHECKED BY TS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o 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 kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
38.3	Continued									7	
	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Hard		13	SS	66		162				
			14	SS	129				o —		
			15	SS	120	*	160				
158.2			16	SS	120	/15cm					
20.0	End of Borehole										

* Sampler Bouncing –Probable Boulder

** Water level not encountered

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 7 1 OF 1 METRIC

W.P. 368-87-01 LOCATION Co-ords: N 4 845 748.5 ; E 294 204.5 ORIGINATED BY MM
DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
DATUM Geodetic DATE 90 06 19 CHECKED BY TS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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 kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.1	Ground Surface										
0.0	Sandy Silt (Fill Material) Brown, Compact		1	SS	22	DRY	178			7	
177.7											
1.4	Irregular mixture of Clayey Silt, sand and gravel (Fill Material) trace organics Brown, Stiff		2	SS	14						
			3	SS	13						0 16 45 39
176.2							176				
2.9	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Brown, V. Stiff to Hard		4	SS	24						
			5	SS	39						3 26 47 24
174.7											
4.4	Brown Grey		6	SS	100		174				
			7	SS	103						
			8	SS	53						
	Sandy Silt V. Dense		9	SS	136		172				
			10	SS	147		170				
168.9											
10.2	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Hard		11	SS	69		168				
			12	SS	41						
166.5											
12.6	End of Borehole										

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

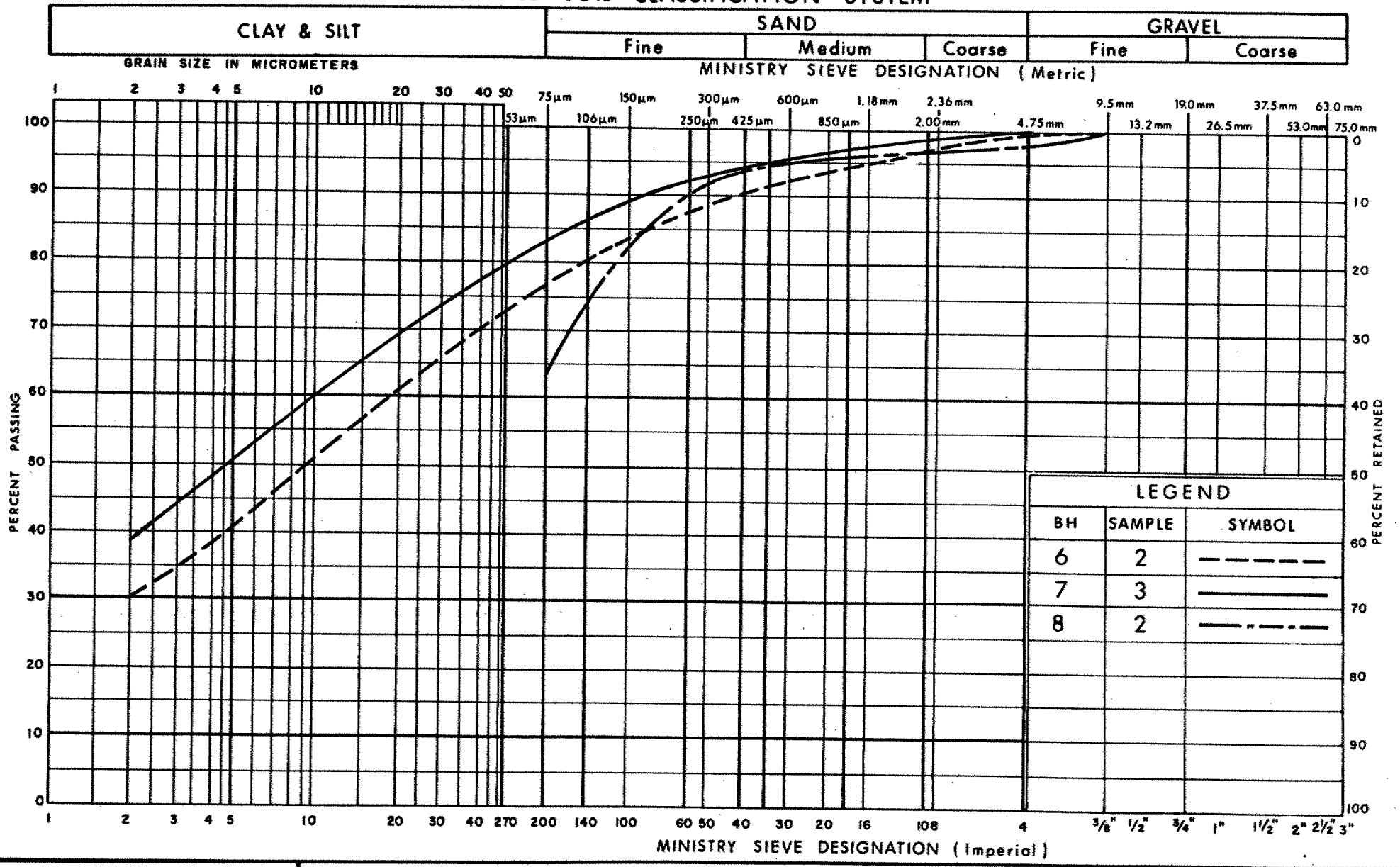
W.P. 368-87-01 LOCATION Co-ords: N 4 845 718.5 ; E 294 231.7 ORIGINATED BY MM
DIST 6 HWY 407 BOREHOLE TYPE HS Auger, Washboring COMPILED BY MI
DATUM Geodetic DATE 90 06 19 CHECKED BY TS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.1	Ground Surface										
0.0	Sandy Silt Brown, V. Loose to Loose (Fill Material)					DRY	180				
			1	SS	3						
							178				
			2	SS	5				o		2 35 (63)
177.0											
4.1	Irregular mixture of Clayey Silt, sand and gravel (Fill Material) Brown, Stiff		3	SS	15		176				
175.8											
5.3	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Brown, Hard		4	SS	32				o⊢—		2 13 50 35
173.9							174				
7.2	Brown Grey Sandy Silt V. Dense		5	SS	101						
							172				
			6	SS	120						
			7	SS	132				o		6 34 (60)
							170				
168.5			8	SS	143						
12.6	End of Borehole										

+³, x⁵ : Numbers refer to Sensitivity

20
15◇5 (%) STRAIN AT FAILURE
10

UNIFIED SOIL CLASSIFICATION SYSTEM



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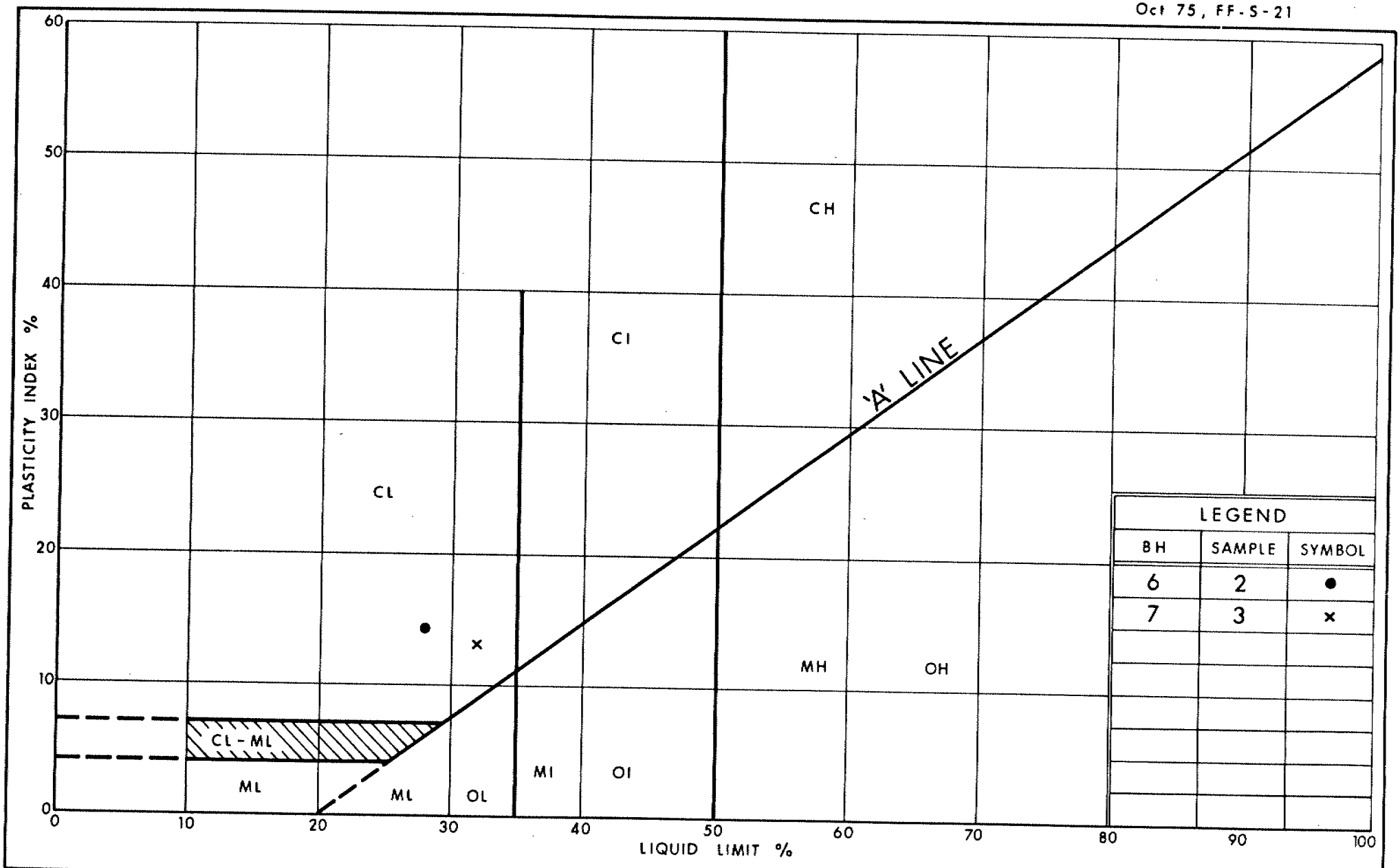
GRAIN SIZE DISTRIBUTION
(FILL MATERIAL)

FIG No 1

W P 368-87-01

13



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Ontario

PLASTICITY CHART
IRREGULAR MIXTURE OF CLAYEY SILT, SAND & GRAVEL (FILL MATERIAL)

FIG No 2
W P 368-87-01

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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