

Foundation Investigation Report

Highway 9 - South Holland Canal Bridge (WBL) Rehabilitation and Protection Systems, Site No. 37-32/2, King, Ontario, Assignment No. 2016-E-0029-06, GWP 2263-16-00

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed superstructure replacement and substructure repair of the existing Highway 9 – South Holland Canal Bridge (MTO Structure Site No. 37-32/2), GWP 2263-16-00, located in Kettleby, Ontario, as shown on the Key Plan on Drawing 1.

This report addresses the foundation investigation carried out to support the rehabilitation of the existing Highway 9 – South Holland Canal Bridge. This report was developed based on information from the current investigation, supplemented with information from 1965 and 1997 foundation investigations completed previously by others at the structure site, as follows:

- **MTO GEOCREs No. 31D-022:** “Foundation Investigation Report for Proposed Holland Marsh Drainage Canal Bridge, Lot 35, Con. VI, Twp of King, Co. of York, Hwy #9, Line ‘K’, District #6 (Toronto). W.J. 65-F-109 - - W.P. 170-65”, prepared by Department of Highway Ontario, Foundation Section – Materials and Testing Division, dated December 9, 1965.
- **MTO GEOCREs No. 31D-364:** “Foundation Investigation Report for Highway 9 – Holland Drainage Canal East Bridge Widening, WP 4-95-01, Site No. 37-32, Highway 9, Central Region, Region of York, Agreement # 9690-4444-9917,” prepared by Thurber Engineering Ltd., dated May 8, 1997.

The Terms of Reference for the foundation engineering services are outlined in MTO's Work Item Order Form dated January 15, 2018 which forms part of the Consultant's Assignment for the Central Region Large Value Retainer under Agreement No. 2016-E-0029-007 for this project.

2.0 SITE DESCRIPTION

The South Holland Canal Bridge is located about 800 m west of Highway 400 along Highway 9, near South Canal Bank Road in Kettleby Ontario. The site is surrounded by marshland to the south and farmland to the north, with the ground generally flat-lying. Highway 9 is at approximately Elevation 222.1 m at the South Holland Canal Bridge, and slopes down to about Elevations 220.9 m to 220.3 m west and east of the bridge, respectively. South Holland Canal is trapezoidal in cross-section with an about 9 m wide base at about Elevation 217 m and the side slopes are inclined at about 2 Horizontal and 1 Vertical (2H:1V). The water level within the canal was measured at Elevation 218.2 m in February 2014.

The South Holland Canal Bridge consists of a three-span concrete box girder structure with span lengths of 11.9 m from the abutment to the piers and 13.4 m from pier to pier. The bridge was constructed on a skew of approximately 45 degrees over South Holland Canal. The abutments and piers are supported on concrete filled 323 mm outer diameter closed end steel tube piles, driven into the very dense sandy till to Elevation 198.7 m.

3.0 INVESTIGATION PROCEDURES

3.1 1965 Investigation

A total of four boreholes (Boreholes 1 to 4) and three cone penetration tests (Boreholes 2, 4 and 5) were advanced as part of the 1965 investigation (GEOCREs No. 31D-022) for the Highway 9 – Holland Drainage Canal Bridge. The boreholes and cone penetration tests are located within or immediately adjacent to the footprint of the existing

abutment foundations of the westbound structure, as shown on Drawing 1. These borehole locations have been developed based on plotting the coordinates and offsets shown on the 1965 drawings, and converting these to MTM NAD83 (Zone 10) coordinates. The borehole records from the 1965 investigation are presented in Appendix A.

The Standard Penetration Test (SPT) “N” values in the 1965 investigation were obtained using a manual hammer.

3.2 1997 Investigation

A total of four boreholes (Boreholes 97-1 to 97-4) were advanced as part of the 1997 investigation (GEOCRE No. 31D-364) for the Highway 9 – Holland Drainage Canal Bridge. Two of these boreholes are located within or immediately adjacent to the footprint of the existing abutments of the eastbound structure, while the other two are located within the approach embankments as shown on Drawing 1. These borehole locations have been developed based on plotting the UTM coordinates shown on the 1997 borehole records and drawings and converting these to MTM NAD 83 (Zone 10) coordinates. The borehole records from the 1997 investigation are presented in Appendix A.

3.3 2018 Investigation

The field work for the current South Holland Canal Bridge investigation was carried out on May 10, 14 and 16, 2018, during which time four boreholes (designated as Boreholes C2-1, C2-2, TP-1 and TP-2) were advanced at the site. Boreholes C2-1 and C2-2 were advanced along the banks of the South Holland Canal, while Boreholes TP1 and TP2 were advanced at Highway 9 grade within the westbound lanes, at approximately the locations shown on Drawing 1.

Boreholes C2-1 and C2-2 was drilled using 152 mm outer diameter hollow-stem augers by a D25 truck-mounted drill rig and Boreholes TP-1 and TP-2 were drilled using 210 mm outer diameter hollow stem augers by a D90 truck-mounted drill rig, both supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm outer diameter split-spoon sampler driven with a manual hammer in Boreholes C2-1 and C2-2, and driven by an automatic hammer in Boreholes TP-1 and TP2 in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)¹.

Boreholes C2-1 and C2-2 were advanced on the northwest and northeast bank of the South Holland Canal adjacent to the Bridge to depths of 11.3 m and 12.8 m below ground surface, respectively. Boreholes TP-1 and TP-2 were advanced from the highway surface to depths of about 12.8 m and 15.8 m, respectively, below existing roadway surface. Traffic protection consisted of a lane closure for boreholes advanced from the roadways platforms, and shoulder and / lane closures to aid in the loading and unloading of the track-mounted drill rig for the borehole advanced off of the roadway, all consistent with Book 7 requirements.

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. A standpipe piezometer was installed in Borehole TP-1 to permit monitoring of the water level. The installed piezometer in Borehole TP-1 consists of a 50 mm diameter PVC pipe, with a 1.5 m slotted screen within a filter sand pack sealed within the clayey silt deposit about 2 m above the bottom of the borehole. The borehole and annulus surrounding the piezometer pipe above the filter sand pack were backfilled to near ground surface with bentonite pellets and the upper 200 mm of the borehole was capped with cold patch asphalt to the roadway surface. Boreholes C2-1, C2-2 and TP-2 were backfilled to ground surface with bentonite and the upper 200 mm of Borehole

¹ ASTM D1586 – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils.

TP-2 was sealed to the roadway surface with cold patch asphalt upon completion, in accordance with Ontario Regulation 903, Wells (as amended).

The field work was monitored on a full-time basis by a member of Golder's technical staff who located the boreholes in the field, directed the sampling and in situ testing operations, logged the boreholes and examined the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further visual review and geotechnical laboratory testing on selected samples, consisting of natural moisture content, Atterberg limits and grain size distribution conducted in accordance with MTO and / or ASTM Standards as applicable.

The borehole locations were marked in the field by Golder personnel relative to the existing guardrails and other site features. The locations given in the Record of Borehole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 (Zone 10) northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, including in geographic (Latitude / Longitude) coordinates, the ground surface elevations and borehole drilled depths are summarized below.

Borehole No.	MTM NAD83		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude)	Easting (m) (Longitude)		
C2-1	4,876,341.1 (44.027018)	296,387.4 (-79.604949)	220.9	11.3
C2-2	4,876,350.1 (44.027099)	296,422.9 (-79.604506)	220.3	12.8
TP-1	4,876,318.8 (44.026817)	296,355.2 (-79.605350)	222.0	12.8
TP-2	4,876,339.5 (44.027004)	296,426.9 (-79.604456)	222.2	15.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 9 is located in the Sand Plains within the Simcoe Lowlands physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)².

The Simcoe Lowlands physiographic region covers the central portion of the County of Simcoe. Following the retreat of the last glacial ice sheet, the lowland was flooded by the now extinct post-glacial Lake Algonquin. This past post-glacial lacustrine environment is marked by deep sand, silt and clay beds overlying glacial ground moraine material. The Holland River valley, which crosses Highway 400 just north of Highway 9 and South Canal Road, is

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

located within the Simcoe Lowlands region. This valley extends to the southwest from Cook Bay at the south end of Lake Simcoe, and was once a shallow extension of the lake. The floor of the valley consists of peat, soft clays and loose sands. It is understood that during initial construction of Highway 400 through this area, a layer of peat about 2 m to 3 m thick was removed to allow construction of the road upon the underlying sand and clay; towards Lake Simcoe the peat deposit is considerably thicker. The Sand Plains is covered by peat / topsoil underlain by sand and clay deposits.

4.2 General Overview of Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes of the current investigation including piezometer installation details and water level readings, and the results of the in situ and laboratory tests are provided on the Record of Borehole Sheets in Appendix B. The results of the in situ field tests (i.e., SPT “N”-values) as presented on the borehole records and in Section 4 are uncorrected. The Standard Penetration Test “N”-values from the 1965 investigation and Boreholes C2-1 and C2-2 from the 2018 investigation are based on use of a manual hammer, while those in the 1997 investigation and Boreholes TP-1 and TP-2 from the 2018 investigation are based on use of an automatic hammer and the values are reported with no adjustment in this report, although it is recognized that SPT “N” values obtained using a manual hammer are frequently higher than those obtained using an automatic hammer (CFEM, 2006)³. The results of the geotechnical laboratory testing on soil samples are presented on the Laboratory test figures in Appendix C.

The stratigraphic boundaries shown on the borehole records and on the stratigraphic profile and cross-section on Drawing 1 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected, however, the factual data presented on the borehole records governs any interpretation of the site conditions.

In general, the native subsurface soils encountered consist of surficial layers of topsoil and asphalt, underlain by fill material and peat / organic silt. The fill and / or organic materials are underlain by interlayered deposits of clayey silt to silty clay and clayey silt to silty clay till, with the till underlain by a silt and sand deposit.

4.2.1 Topsoil

An approximately 0.7 m thick layer of topsoil was encountered immediately below ground surface in Boreholes C2-1 and C2-2. Borehole BH97-1 to BH97-4 encountered an approximately 100 mm to 150 mm thick layer of topsoil immediately below ground surface. Black “muck” was encountered in Boreholes 2 to 4, which were advanced in the then-existing canal or on the banks of the canal. The “muck” material is described as being comprised of silt and clay with decayed organic matter and extended to a depth of up to 1 m.

Standard Penetration Tests (SPT) “N” values-measured within the topsoil are 8 blows and 10 blows per 0.3 m of penetration, suggesting a stiff consistency. The “muck” material was described as having a very soft consistency.

4.2.2 Asphalt

An approximately 220 mm thick layer of asphalt pavement was encountered immediately below ground surface in Boreholes TP-1 and TP-2.

³ Canadian Geotechnical Society, 2006. *Canadian Foundation Engineering Manual*, 4th Edition.

4.2.3 Fill

Fill was encountered underlying the asphalt in Boreholes TP-1 and TP-2 and underlying the topsoil in Boreholes C2-1, C2-2, BH97-1, BH97-3 and BH97-4. The fill layer is between 1.5 m and 5.4 m thick, with its base extends to approximately between Elevations 219.3 m and 215.3 m. The fill is variable in composition and is comprised of an upper layer of gravelly sand to sand and gravel, underlain by a layer of clayey silt to clayey silt with sand in Boreholes TP-1 and TP-2; clayey silt to silty clay fill in Boreholes C2-1, C2-2, BH97-1, and BH97-4; and sandy silt to sand and silt fill in Borehole BH97-3.

SPT “N”-values measured within the non-cohesive portion of the fill range from 19 blows to 76 blows per 0.3 m of penetration with one value of compact of 50 blows per 0.13 m of penetration, indicating a compact to very dense compactness condition. The SPT “N”-values measured within the cohesive portion of the fill range from 4 blows to 30 blows per 0.3 m of penetration and field vane tests measured undrained shear strengths between approximately 39 kPa and over 96 kPa. These results suggest that the cohesive fill has a firm to stiff consistency.

A grain size distribution was carried out on two samples of the non-cohesive silt and sand fill and the results are shown on Figure C1 in Appendix C. Atterberg limits testing was carried out on two samples of the silt and sand fill and measured liquid limits of 14 and 16 per cent, plastic limits of 13 and 14 per cent, and corresponding plasticity indices of 1 and 2 per cent. These results, which are plotted on a plasticity chart on Figure C2 in Appendix C, indicate the presence of low plasticity silt within the silt and sand fill. The natural water content measured on two samples of the gravelly sand to sand and gravel fill is 3 and 7 per cent. The natural water content measured on four samples of the sandy silt to silt and sand fill range between 8 and 17 per cent.

Grain size distribution tests were carried out on four samples of the cohesive clayey silt fill and the results are shown on Figure C3 in Appendix C. Atterberg limits testing was carried out on four samples of the cohesive fill and measured liquid limits ranging between 31 and 33 per cent, plastic limits ranging between 17 and 18 per cent, and plasticity indices ranging between 12 and 16 per cent. These results, which are plotted on a plasticity chart on Figure C4 in Appendix C, indicate the fill consists of clayey silt of low plasticity. The natural water content measured on selected samples of the cohesive fill ranges from about 12 to 34 per cent.

4.2.4 Peat / Organic Silt

A 0.1 m and 0.7 m thick layer of amorphous granular peat was encountered underlying the cohesive fill in Boreholes BH97-1 and BH97-4, respectively. A 0.8 m thick layer of organic silt was encountered underlying the topsoil in Borehole BH97-2, while Borehole BH97-4 terminated within an organic silt layer, penetrating it for 0.3 m.

The SPT “N”-values measured within the peat layer are 8 blows and 10 blows per 0.3 m of penetration and two field vane tests measured undrained shear strengths of about 38 kPa and over 120 kPa, suggesting a firm to very stiff consistency.

The natural water content measured on one sample of the peat is 128 per cent. The natural water content measured on two samples of the organic silt is 23 and 49 per cent.

4.2.5 Upper Clayey Silt to Silty Clay Deposit

A upper deposit of cohesive material comprised of an upper layer of clayey silt to silty clay and lower layer of silty clay was encountered underlying the fill in Boreholes C2-1, C2-2, TP-1, TP-2, and BH97-3 and is described as laminated in BH97-3; underlying the peat / organic silt in Boreholes BH97-1 and BH97-2; underlying the “muck” in Boreholes 2 to 4; and beneath the water in Borehole 1. Boreholes C2-1, C2-2, TP-1, TP-2 and BH97-1 terminated within this deposit, penetrating into it for approximately 1.0 m to 9.1 m, corresponding to bottom of borehole

Elevations 206.4 m to 218.2 m. The deposit is between approximately 11.6 m and 19.4 m thick in Boreholes BH97-2, BH97-3 and 1 to 4. The surface of the deposit was encountered between Elevations 219.2 m and 215.3 m.

The SPT “N”-values measured within the clayey silt to silty portion of the deposit range from 2 blows to 45 blows per 0.3 m of penetration and field vane tests measured undrained shear strengths ranging between approximately 58 kPa and over 120 kPa and within the silty clay portion of the deposit the undrained shear strength range between about 23 kPa and 76 kPa. These results indicate that the upper clayey silt to silty clay deposit has a stiff to very stiff consistency and the silty clay portion of the deposit has a soft to stiff consistency. Unconfined shear strength tests in Shelby tube samples of the upper clayey silt to silty clay deposit from Boreholes 1 to 4 measures shear strengths between of 20 kPa and 125 kPa. The bulk density measured within the upper clayey silt to silty clay deposit was 18 to 21 kN/m³.

Grain size distribution carried out on six samples of the upper clayey silt to silty clay deposit from the current investigation and the results are shown on Figure C5 in Appendix C. Atterberg limits testing was carried out on twenty three selected samples of the upper clayey silt to silty clay deposit (including seven samples from the current investigation) and measured liquid limits ranging between 22 and 60 per cent, plastic limits ranging between 15 and 24 per cent, and plasticity indices ranging between 5 and 36 per cent. These results, which are plotted on the borehole records for the previous (1965 and 1997) investigations, and six of which are plotted on a plasticity chart on Figure C6 in Appendix C, indicate that the deposit consists of clayey silt of low plasticity to silty clay of high plasticity. The natural water content measured on selected samples of the upper clayey silt to silty clay deposit ranges from about 13 to 33 per cent.

4.2.6 Upper Sandy Clayey Silt Till

A 1.5 m and 2.5 m thick upper till deposit comprised of sandy clayey silt (described as silty clay on Boreholes BH97-2 and BH97-3) containing trace to some gravel was encountered underlying a 1.1 m to 1.2 m thick wet sand seam separating the till from the upper clayey silt to silty clay deposit at Elevations 206.5 m and 206.4 m in Boreholes BH97-2 and BH97-3, respectively. The upper till deposit may contain cobbles as per the notes on the boreholes records.

The SPT “N”-values measured within the upper till deposit are 9 and 10 blows per 0.3 m of penetration, suggesting a stiff consistency. Atterberg limits testing was carried out on one sample of the upper till deposit and measured a liquid limit of 22 per cent, a plastic limit of 12 per cent, and a corresponding plasticity index of 10 per cent. These results indicate that the upper till deposit consists of a clayey silt of low plasticity. The natural water content measured on two samples of the upper till deposit are about 14 and 15 per cent.

4.2.7 Lower Silty Clay

A 4.4 m and 3.5 m thick lower silty clay deposit was encountered underlying the upper till deposit at Elevations 205.0 m and 203.9 m in Boreholes BH97-2 and BH97-3, respectively.

The SPT “N”-values measured within the lower silty clay deposit in these two boreholes range between 21 and 26 blows per 0.3 m of penetration, suggesting a very stiff consistency. Atterberg limits testing was carried out on one sample of the lower silty clay deposit and measured a liquid limit of 48 per cent, a plastic limit of 21 per cent, and a corresponding plasticity index of 27 per cent, indicating that the deposit consists of a silty clay of intermediate plasticity. The natural water content measured on selected samples of the lower silty clay deposit range between 25 and 35 per cent.

4.2.8 Lower Clayey Silt to Silty Clay Till

A lower cohesive till deposit comprised of clayey silt to silty clay was encountered underlying the lower silty clay deposit at Elevations 200.6 m and 200.4 m in Boreholes BH97-2 and BH97-3, respectively. A till deposit described as sandy till comprising of a mixture of sand, gravel, silt and clay was encountered underlying the upper clayey silt to silty clay deposit between Elevations 200.0 m and 199.5 m in Boreholes 1 to 4. Boreholes 1 to 4 terminated within the sandy till deposit, penetrating it for a thickness of between 0.2 m and 0.6 m. The lower cohesive till deposit is 2.2 m and 3.9 m thick in Boreholes BH97-2 and BH97-3, respectively, including an interlayer of sandy silt to silt layer, which is 0.2 m and 1.5 m thick, respectively in these boreholes.

The SPT “N”-values measured within the lower cohesive till deposit, including across the interface with the sandy silt / silt interlayers range between 30 blows and 98 blows per 0.3 m of penetration and 81 blows per 0.24 m of penetration, suggesting a hard consistency. The natural water content measured on selected samples of the lower till deposit range between 14 and 19 per cent.

4.2.9 Silt and Sand

A silt and sand deposit was encountered underlying the lower cohesive till at Elevations 198.4 m and 196.5 m in Boreholes BH97-2 and BH97-3, respectively. The boreholes terminated within this deposit, penetrating it for a thickness of 2.6 m and 3.5 m in Boreholes BH97-2 and BH97-3, respectively.

The SPT “N”-values measured within the silt and sand deposit range from 26 blows to 64 blows per 0.3 m of penetration with N-values of zero weight of hammer and 97 blows per 0.28 m of penetration. The “N”-values with the silt and sand deposit indicate a compact to very dense compactness condition, however artesian groundwater conditions and boiling sand conditions were noted within the deposit and boiling sand conditions were encountered in Borehole BH97-2 at approximately Elevation 197.0 m, which caused the augers to drop about 0.8 m. The natural water content measured on selected samples of the silt and sand deposit range between 18 and 26 per cent.

4.3 Groundwater Conditions

The groundwater levels in the open boreholes were measured upon completion of drilling operations. A standpipe piezometer was installed in Boreholes TP-1 and BH97-4 to permit monitoring of the groundwater level at this site. The groundwater level recorded in the open boreholes and piezometers are shown on the borehole records in Appendices A and B and are summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
C2-1	220.9	5.4	215.5	May 10, 2018	Open borehole (borehole caved to 9.1m)
C2-2	220.3	4.5	215.8	May 10, 2018	Open borehole
TP-1	222.0	1.9	220.1	June 22, 2018	Piezometer
TP-2	222.2	5.9	216.3	May 14, 2018	Open borehole
BH97-1	220.9	Dry	-	January 27, 1997	Open borehole

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
BH97-2	219.9	1.2 above ground surface	221.1	February 1, 1997	Inside Augers in Open borehole
BH97-3	220.9	0.3 above ground surface	221.2	January 24, 1997	Inside Augers in Open borehole
BH97-4	221.1	Dry	-	January 23, 1997	Piezometer
		1.6	219.5	January 31, 1997	
		1.8	219.3	February 10, 1997	
		1.4	219.7	February 26, 1997	

The groundwater level measured in the piezometer sealed within the upper clayey silt deposit during the current (2018) investigation was at Elevation 220.1 m, below the existing ground surface. The groundwater level measured in the shallow piezometer installed within the peat deposit / clayey silt till during the 1997 investigation was at Elevation 219.7 m. These readings suggest that the groundwater level is at about Elevation 220 m. The GEOCRE information further notes that during the 1997 investigation, Boreholes BH97-2 and BH97-3, encountered artesian water conditions, with a flow rate on the order of 0.5 litres per minute once they penetrated the silt and sand deposit below Elevations 198.4 m to 196.5 m, respectively. Reportedly, the upward flow ceased in the backfilled boreholes after about 25 days in Borehole BH97-2 and 1 day in Borehole BH97-3. Further, during the 1965 investigation artesian conditions were encountered at about Elevation 199.6 m, with a head of approximately 0.7 m, and ground surface corresponding to approximately Elevation 219.8 m.

The groundwater level observations at this site will be subject to seasonal fluctuations and precipitation events; the water levels should be expected to be higher during the spring season or during and following periods of heavy precipitation.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Graham Gilles and reviewed by Ms. Nikol Kochmanová, P.Eng. Mr. Jorge M.A. Costa, P.Eng., a Senior Consultant and MTO Foundations Designated Contact of Golder, conducted an independent technical and quality control review of this report.

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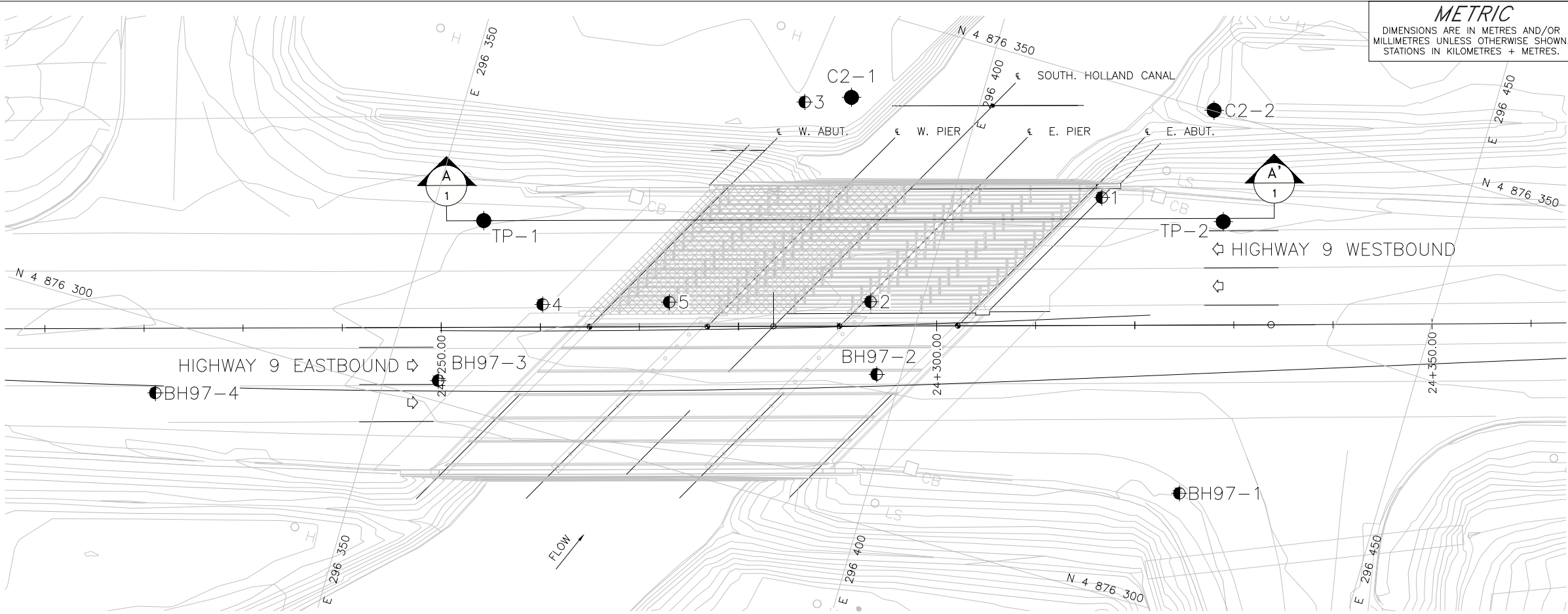
Chapman, L.J. and Putnam, D. F. 1984. The Physiography of Southern Ontario, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.

ASTM International

ASTM D1586 Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

Ontario Water Resources Act

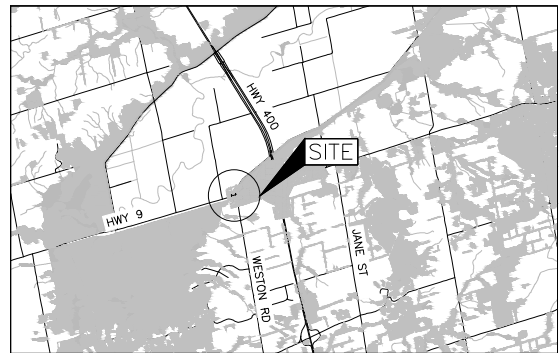
Ontario Regulation 903/90 Wells: O. Reg. 468/10 Amendment to Ontario Regulation 903



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

CONT No. .
GWP No. 2263-16-00

SOUTH HOLLAND CANAL
HIGHWAY 9 WBL
BOREHOLE LOCATIONS
AND SOIL STRATA



KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND

- Borehole - Current Investigation
- ⊕ Borehole - Previous Investigation (GEOCRE 31D-022 and 31D-364)

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
1	218.9	4876338.5	296414.5
2	219.7	4876321.9	296395.0
3	218.9	4876339.4	296383.0
4	219.7	4876312.4	296363.3
5	219.8	4876316.2	296375.5
BH97-1	220.9	4876312.0	296430.3
BH97-2	219.9	4876315.0	296397.6
BH97-3	220.9	4876302.0	296355.3
BH97-4	221.1	4876292.9	296328.2
C2-1	220.9	4876341.1	296387.4
C2-2	220.3	4876350.1	296422.9
TP-1	222.0	4876318.8	296355.2
TP-2	222.2	4876339.5	296426.9

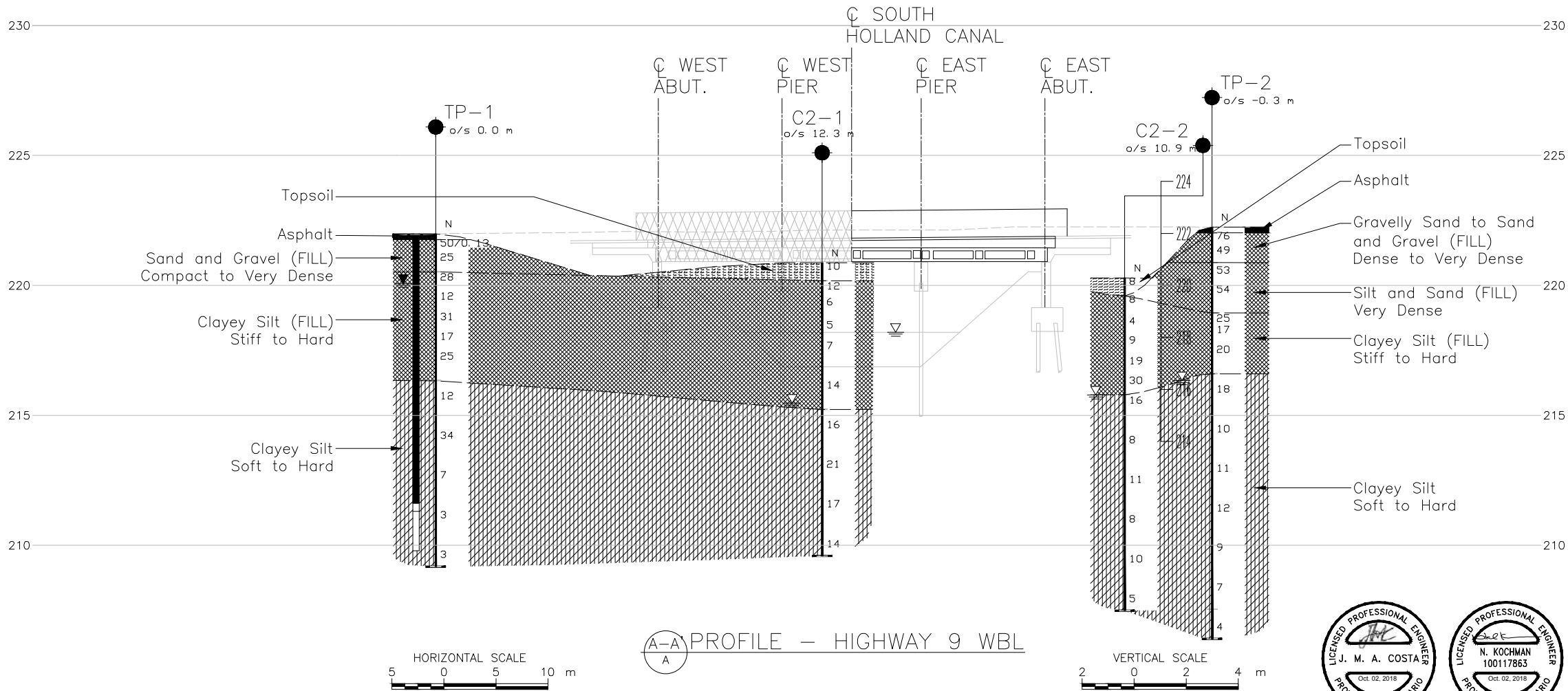
NOTES

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 design configuration as shown elsewhere in the Contracts Documents.

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

REFERENCE

Base plans and general arrangement provided in digital format by Aecom, drawing file nos. 60570685-Holland Canal Bridge_37-32_REHAB.DWG, X-60570685-ALIGN.dwg and DTM.dwg, received June 06, 2017, X-60570685-BASE-B-74-9-81503.DWG, X-60570685-BASE-B-74-9-81504.DWG and X-60570685-BASE-B-74-400-90529.DWG, received June 07, 2018.



A-A PROFILE - HIGHWAY 9 WBL



NO.	DATE	BY	REVISION
1	10/02/2018	JMAC	ISSUED FOR CONSTRUCTION

Geocres No. 31D-711

HWY. 9	PROJECT NO. 1671430	DIST. .
SUBM'D. NK	CHKD. NK	DATE: 10/02/2018
DRAWN: DD	CHKD. NK	APPD. JMAC
		SITE: 37-32/2
		DWG. 1

APPENDIX A

**Borehole Records and Laboratory Test
Results from Previous Investigations
(GEOCRES No. 31D-022 and 31D-364)**

FOUNDATION SECTION

CHECKED BY HK

Gr	0%
Sa	1%
Si	73%
Cl	26%

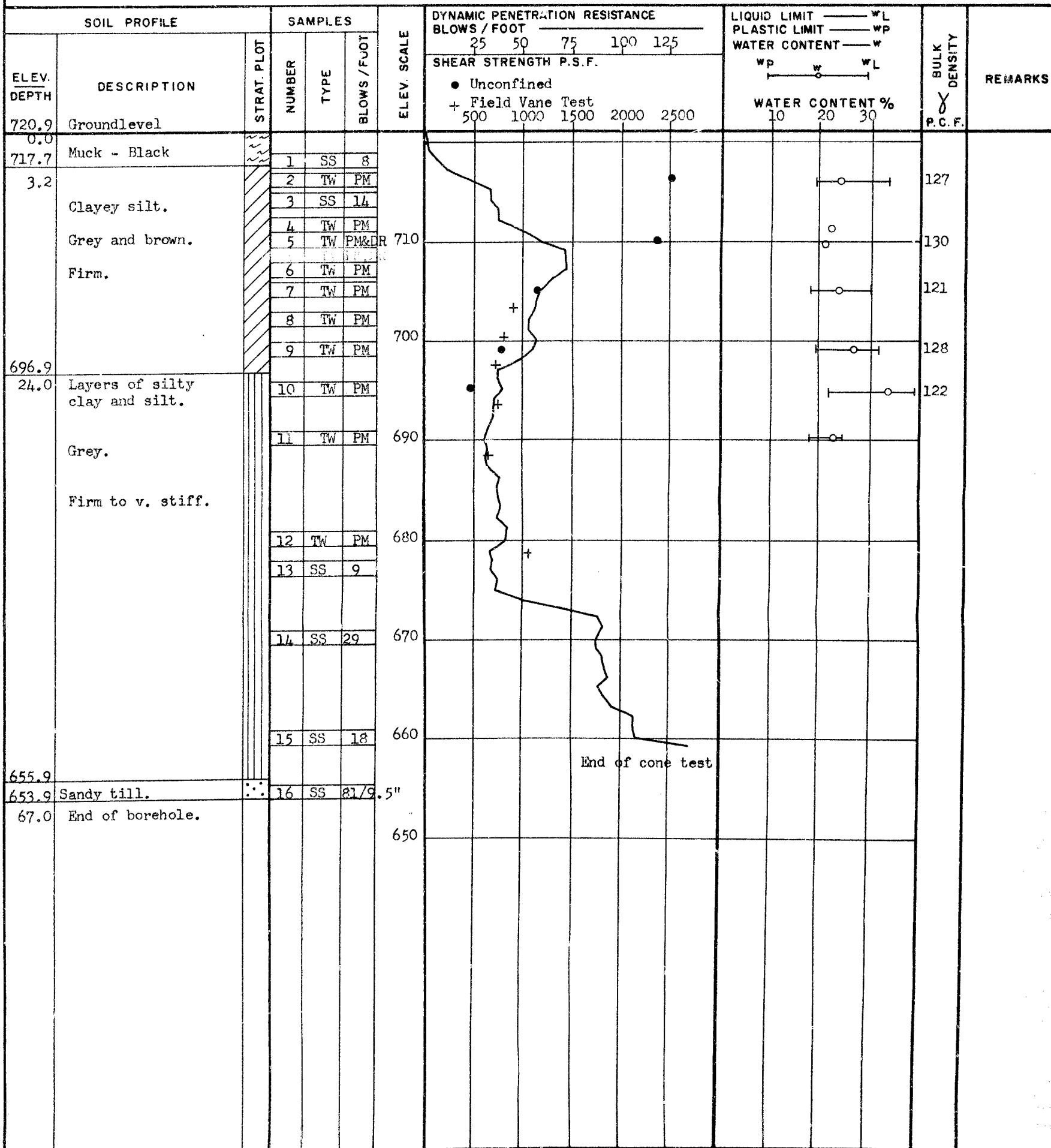
DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 2

FOUNDATION SECTION

JOB E-109 LOCATION East Pier - South Corner ORIGINATED BY P.P.
W.P. 170-65 BORING DATE Oct. 12, 13 & 14, 1965. COMPILED BY P.P.
DATUM Geodetic BOREHOLE TYPE Washbore - NX Casing. CHECKED BY ll



FOUNDATION SECTION

CHECKED BY AK

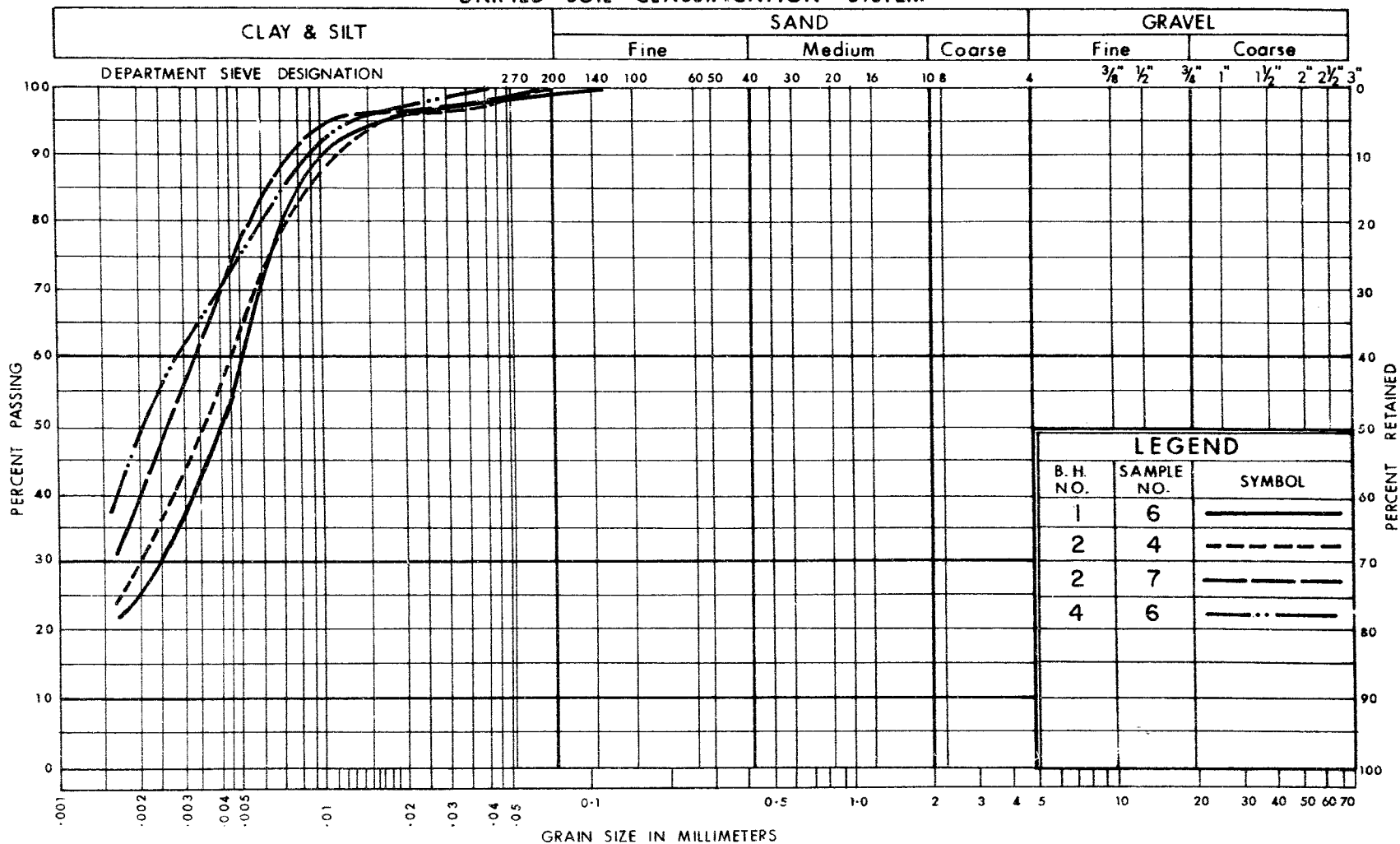
SOIL PROFILE			SAMPLING			ELEV. SCALE		DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F.		WATER CONTENT %					
720.7	Groundlevel							25 50 75 100 125						
								• Unconfined + Field Vane Test						
								500 1000 1500 2000 2500						
0.0	Muck - Black		1	SS	5									
2.3	Clayey silt with traces of sand. Firm to stiff. Brown and grey.		2	TW	PM							133		
			3	SS	19									
			4	SS	20									
			5	SS	16	710								
			6	TW	PM								128	Gr 0% Sa 0% Si 51% Cl 49%
			7	TW	PM									
			8	TW	PM	700								
			9	TW	PM								129	
			10	TW	PM	690							126	Gr 0% Sa 2% Si 78% Cl 20%
			11	TW	PM	680								
678.1	Layers of silty clay and silt. Grey. V. stiff.		12	SS	23	670								
42.6			13	SS	27	660								
			14	SS	55/9"	650								
655.0	Sandy till.													
654.2														
66.5	End of borehole.													

FOUNDATION SECTION

CHECKED BY HK

[illegible]

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION

W.P. No. 170 - 65

JOB No. 65-F-109

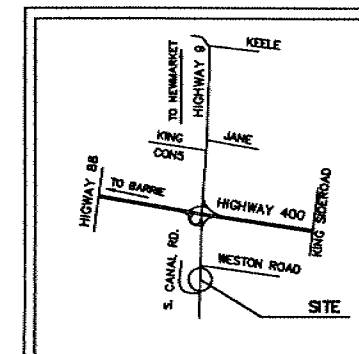
METRIC

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

SHEET







BORE HOLE LOCATIONS & SOIL STRATA

THURBER ENGINEERING LTD.



KEY PLAN

LEGEND

-  Bore Hole
-  Dynamic Cone Penetration Test (Cone)
-  Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475J/blow)
- CONE Blows/0.3m (60° Cone, 475J/blow)
-  WL at time of investigation Feb.26,1997
-  Head Artesian Water
-  Piezometer

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
97-1	220.9	4876090.120	296417.335
97-2	219.9	4876093.127	296384.850
97-3	220.9	4876080.186	296342.314
97-4	221.1	4876071.030	296315.254
1	218.9	4876116.6	296401.5
2	219.7	4876100.0	296382.0
3	218.9	4876117.5	296370.0
4	219.7	4876090.5	296350.3
5	219.8	4876094.5	296352.5

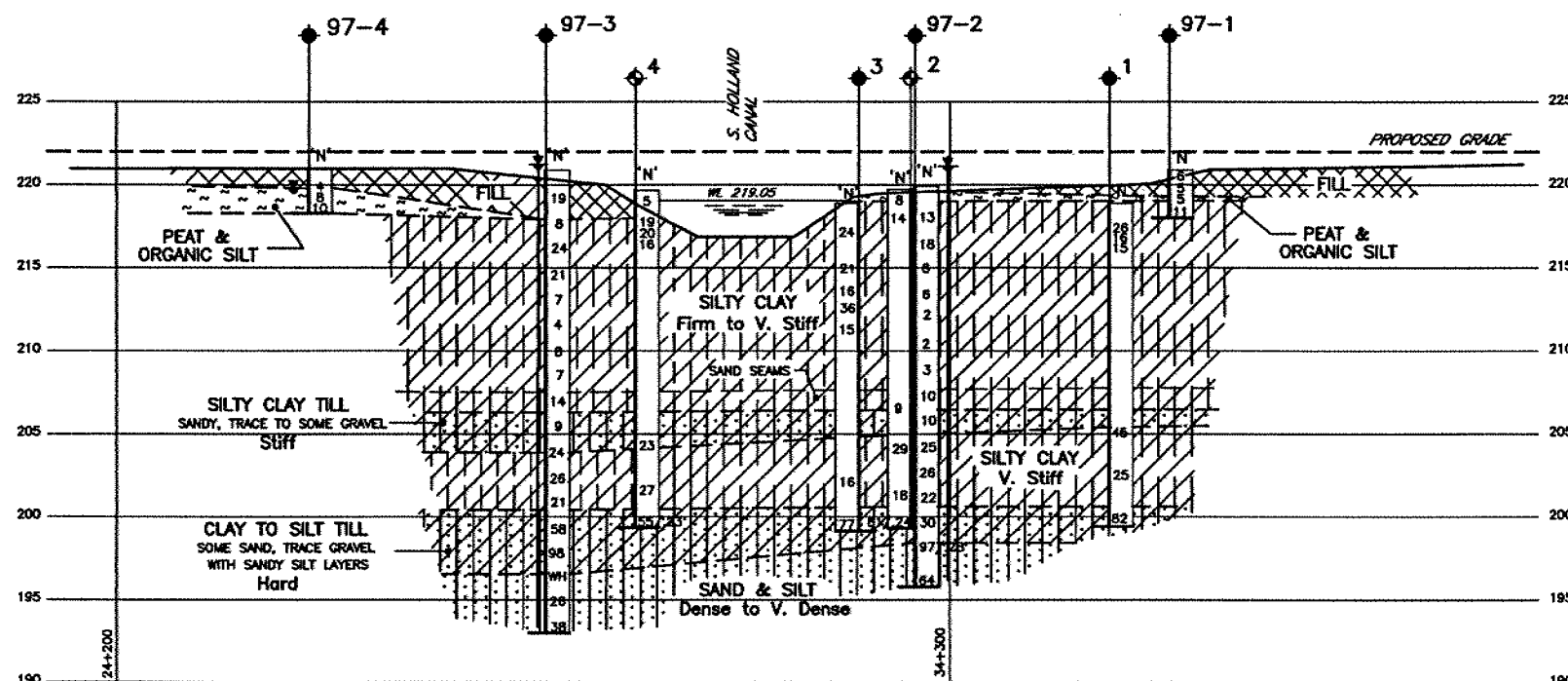
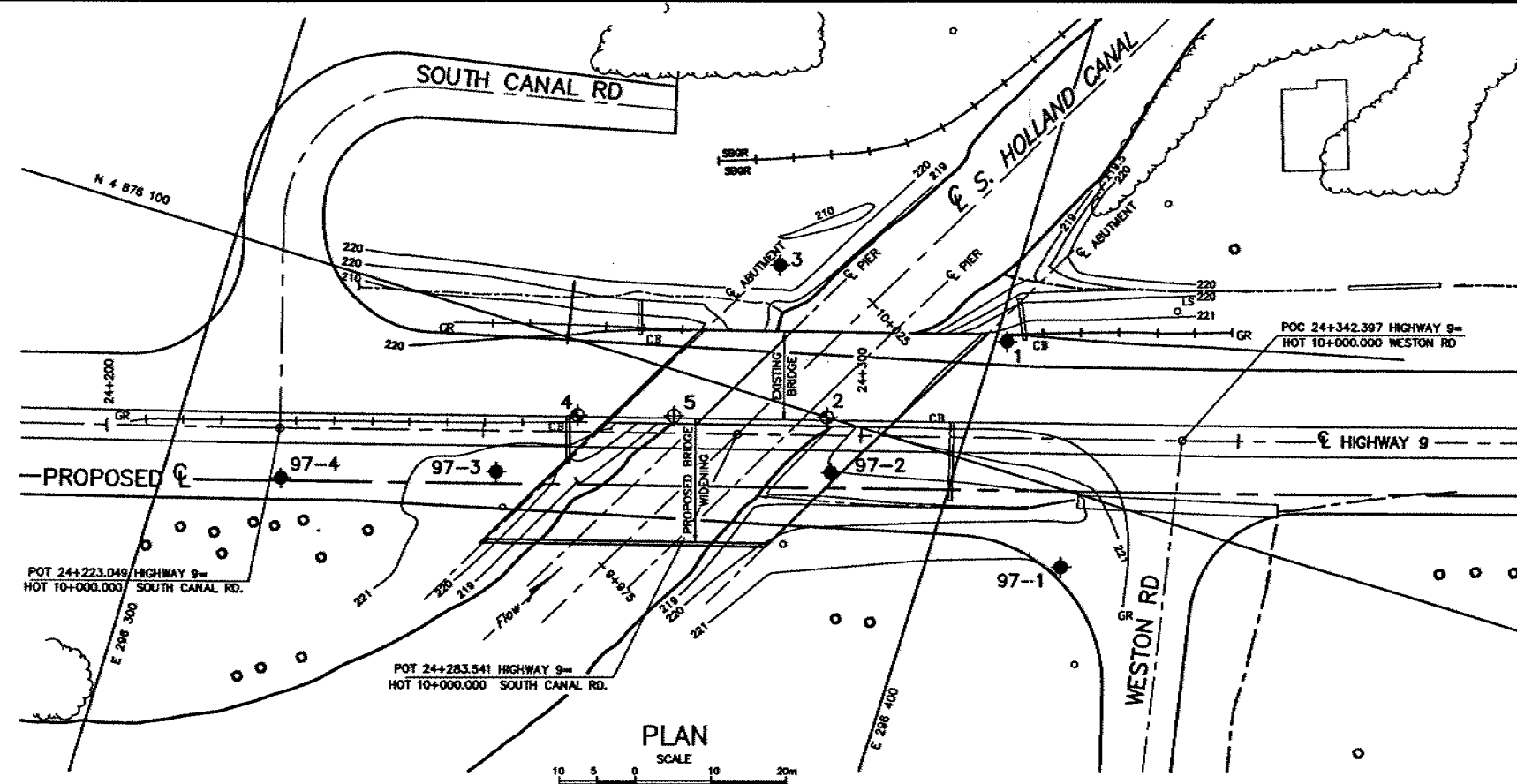
NOTE

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

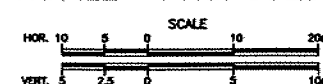
NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2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

REV.	DATE	BY	REVISION
------	------	----	----------

INVT No 9			DISC
SUBM'D	CHECKED DWP	DATE MAR.8,1997	SITE 37-32
CURRANT DWP	RECEIVED B/C	RECEIVED	DATE 15-84-98



PROFILE PROPOSED C



RECORD OF BOREHOLE No BH97-1

1 OF 1

METRIC

W.P. 4-95-01 LOCATION Coords: N4 876 090.120 E296 417.335 ORIGINATED BY EDK
DIST CR HWY 9 BOREHOLE TYPE 110mm SOLID STEM AUGERS COMPILED BY DWP
DATUM Geodetic DATE 97.01.27 - CHECKED BY PKC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
220.9 220.8 0.1	TOPSOIL (125mm), frozen		1	SS	6		220							
	SILTY CLAY FILL, with pockets of dark brown topsoil and organics Brown, Firm to Stiff		2	SS	5									
219.3														
1.7	PEAT, amorphous granular		3	SS	5		219							
218.2	CLAYEY SILT													
1.7	with sand laminations													
218.8	Brown, Firm		4	SS	11									
2.1														
218.2	SILTY CLAY													
2.7	with oxide staining Grey, Very Stiff to Stiff													
	END OF BOREHOLE AT 2.9m Borehole dry upon completion.													

METRIC

+ 3, x 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No BH97-2

2 OF 2

METRIC

W.P. 4-95-01 LOCATION Coords: N4 876 093.127 E296 384.650 ORIGINATED BY EDK
DIST CR HWY 9 BOREHOLE TYPE 210mm HOLLOW STEM AUGERS COMPILED BY DWP
DATUM Geodetic DATE 97.01.30 - 97.02.01 CHECKED BY PKC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
14.9	soil (possible cobble)												
	SILTY CLAY laminated Grey Very Stiff		11	SS	25		204						
			12	SS	26		203						
			13	SS	22		202						
200.6							201						
19.3	SILTY CLAY TILL, some sand, trace gravel						200						
200.0	Grey, Hard		14	SS	30								
199.8	SANDY SILT						199						
20.2	CLAYEY SILT TILL, some sand, trace gravel												
198.4	Grey, Hard		15	SS	97/ 28		198						
21.5	SILT and SAND occasional pockets of silty clay						197						
	Grey Very Dense												
197.1							196						
22.9	augers dropped 0.8m due to boiling sand condition		16	SS	64								
195.8													
24.1	END OF BOREHOLE AT 24.1m UPON COMPLETION: Water level in augers rose to 1.2m above ground surface (el. 221.1m)												

RECORD OF BOREHOLE No BH97-3

1 OF 2

METRIC

W.P. 4-95-01 LOCATION Coords: N4 876 080.188 E296 342.314 ORIGINATED BY EDK
DIST CR HWY 9 BOREHOLE TYPE 110mm SOLID STEM AUGERS COMPILED BY DWP
DATUM Geodetic DATE 97.01.23 - 97.01.24 CHECKED BY PKC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L	
220.9	TOPSOIL (150mm), frozen		1	SS			220					
220.0 0.1	SANDY SILT FILL, some clay, trace gravel some pockets of organics, trace rootlets											
219.4	Grey		2	SS	19		219					
1.5	SAND and SILT FILL, trace gravel Brown, Compact											
218.0	SILTY CLAY with oxide staining Grey to Brown Stiff to Very Stiff		3	SS	8		218					
2.9							217					
			4	SS	24		216					
215.3	SILT CLAY Grey Very Stiff to Stiff						215					
5.6			5	SS	21		214					
							213					
			6	SS	7		212					
							211					
			7	SS	4		210					
							209					
			8	SS	8		208					
							207					
			9	SS	7		206					
207.5	wet sand seams		10	SS	14							
13.4												
206.4	SILTY CLAY TILL, sandy, trace gravel Grey											
14.5												

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH97-3

2 OF 2

METRIC

W.P. 4-95-01 LOCATION Coords: N4 876 080.188 E296 342.314 ORIGINATED BY EDK
DIST CR HWY 9 BOREHOLE TYPE 110mm SOLID STEM AUGERS COMPILED BY DWP
DATUM Geodetic DATE 97.01.23 - 97.01.24 CHECKED BY PKC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
203.9	Stiff tried vane at 15.2m but could not insert into soil (possible cobble)		11	SS	9		205							
17.0			12	SS	24		204							
	SILTY CLAY laminated Grey Very Stiff		13	SS	26		203							
			14	SS	21		202							
200.4			15	SS	58		201							
20.5	SILTY CLAY TILL, trace sand, trace gravel Grey Hard		16	SS	98		200							
199.3			17	SS	WH		199							
21.6	SILT some sand Grey Very Dense		18	SS	26		198							
197.8			19	SS	38		197							
23.1	SILTY CLAY TILL, some sand, trace gravel Grey Hard						196							
196.5							195							
24.4	SAND and SILT Grey Dense N values for samples #17,18,19 are not representative due to disturbance by artesian ground water conditions						194							
193.0							193							
27.9	END OF BOREHOLE AT 27.9m UPON COMPLETION OF DRILLING: Water in augers rose to 0.3m above ground surface (el. 221.2m) Borehole backfilled and sealed with granular bentonite and cement/bentonite grout.													

RECORD OF BOREHOLE No BH97-4

1 OF 1

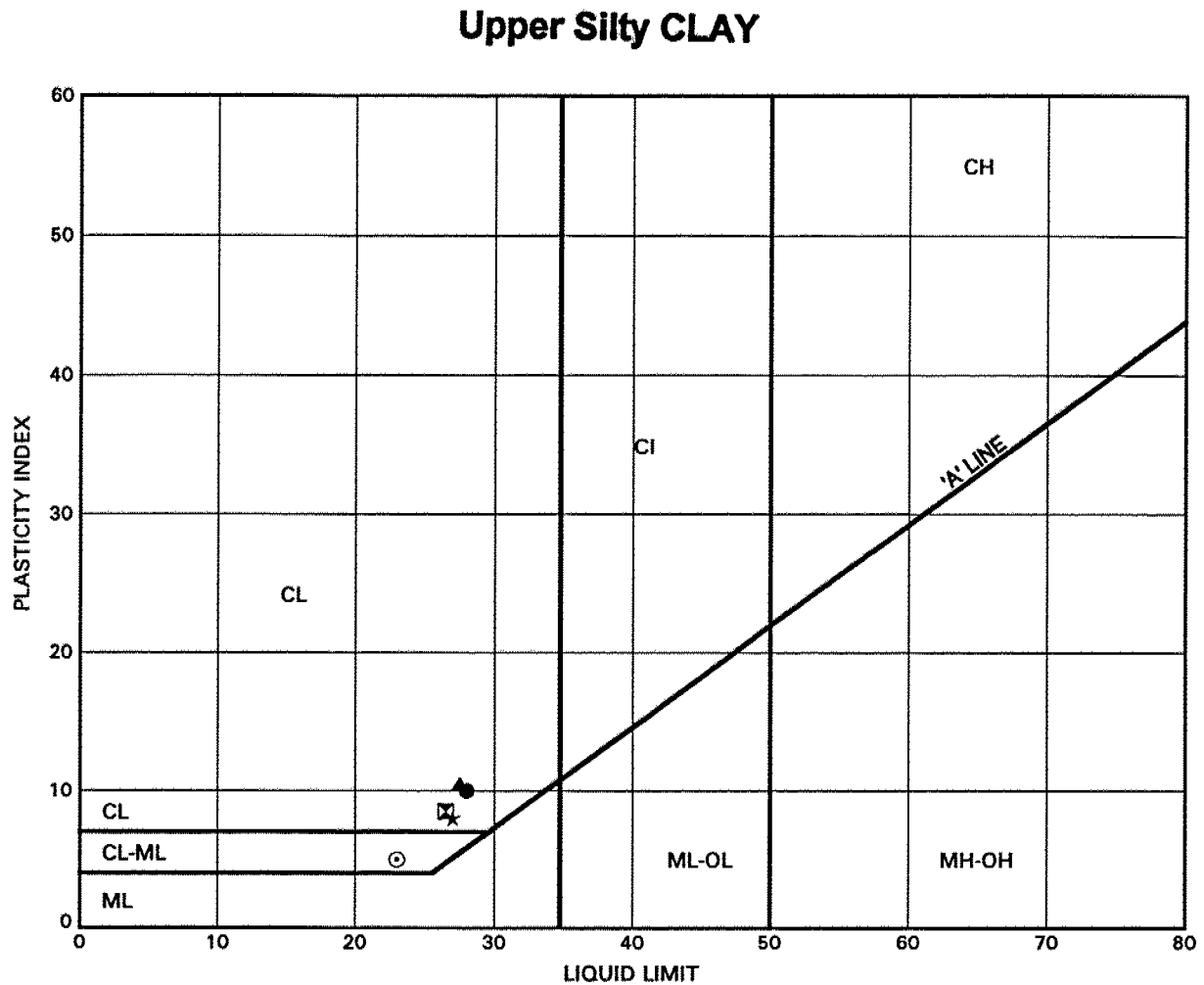
METRIC

W.P. 4-95-01 LOCATION Coords: N4 876 071.030 E296 315.254 ORIGINATED BY EDK
DIST CR HWY 9 BOREHOLE TYPE 110mm SOLID STEM AUGERS COMPILED BY DWP
DATUM Geodetic DATE 97.01.23 - CHECKED BY PKC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
221.1	TOPSOIL (100mm), frozen		1	SS			221							
220.0	CLAYEY SILT FILL, sandy with sand pockets trace gravel and organics Brown to Gray Firm		2	SS	4		220							
219.3			3	SS	8		219							
218.7	PEAT, amorphous granular Dark Brown, Firm to Very Stiff		4	SS	10									
218.4	ORGANIC SILT (MARL) Light Gray, Stiff													
217.7	END OF BOREHOLE AT 2.7m BOREHOLE DRY UPON COMPLETION.													
WATER LEVEL READINGS DATE DEPTH ELEVATION (m) (m) 97/01/23 dry 97/01/31 1.56 219.50 97/02/10 1.77 219.29 97/02/26 1.43 219.67														

W.P. NO. 4-95-01 HIGHWAY 9/HOLLAND DRAINAGE CANAL
ATTERBERG LIMITS TEST RESULTS

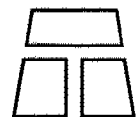
FIGURE B1



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	BH1	1.43	217.47
⊠	BH1	3.69	215.21
▲	BH1	5.28	213.62
★	BH1	7.29	211.61
⊙	BH1	10.40	208.50

Date December 1997

Project 4-95-01



THURBER

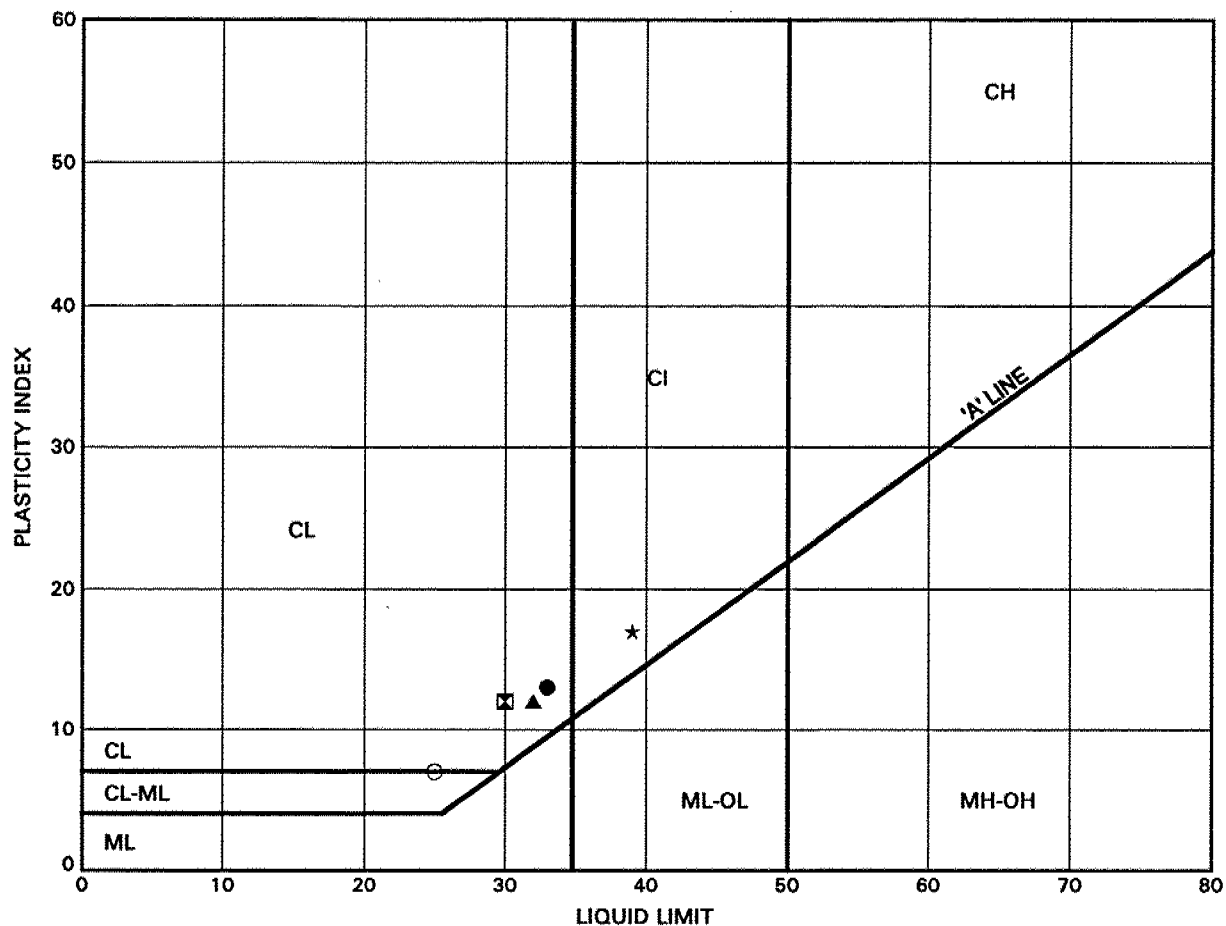
Prep'd

Chkd.

W.P. NO. 4-95-01 HIGHWAY 9/HOLLAND DRAINAGE CANAL
ATTERBERG LIMITS TEST RESULTS

FIGURE B2

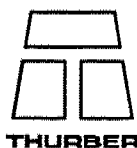
Upper Silty CLAY (Cont'd)



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	BH2	1.49	218.21
⊠	BH2	4.79	214.91
▲	BH2	6.58	213.12
★	BH2	7.95	211.75
⊙	BH2	9.36	210.34

Date December 1997

Project 4-95-01



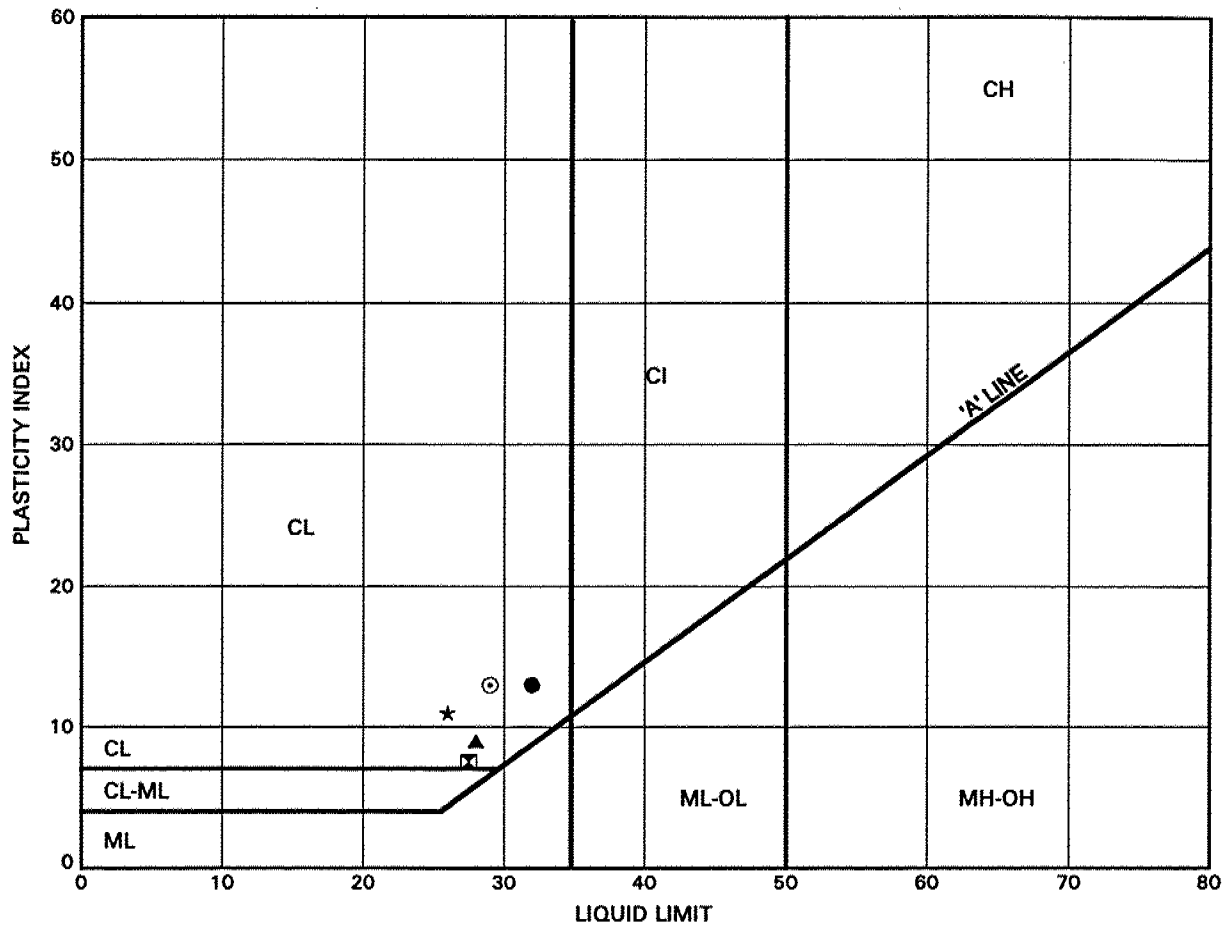
Prep'd

Chkd.

W.P. NO. 4-95-01 HIGHWAY 9/HOLLAND DRAINAGE CANAL
ATTERBERG LIMITS TEST RESULTS

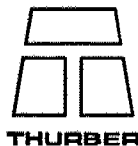
FIGURE B3

Upper Silty CLAY (Cont'd)



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	BH3	2.47	216.43
⊠	BH3	8.93	209.97
▲	BH3	10.52	208.38
★	BH4	1.49	218.21
⊙	BH4	4.42	215.28

Date December 1997
 Project 4-95-01

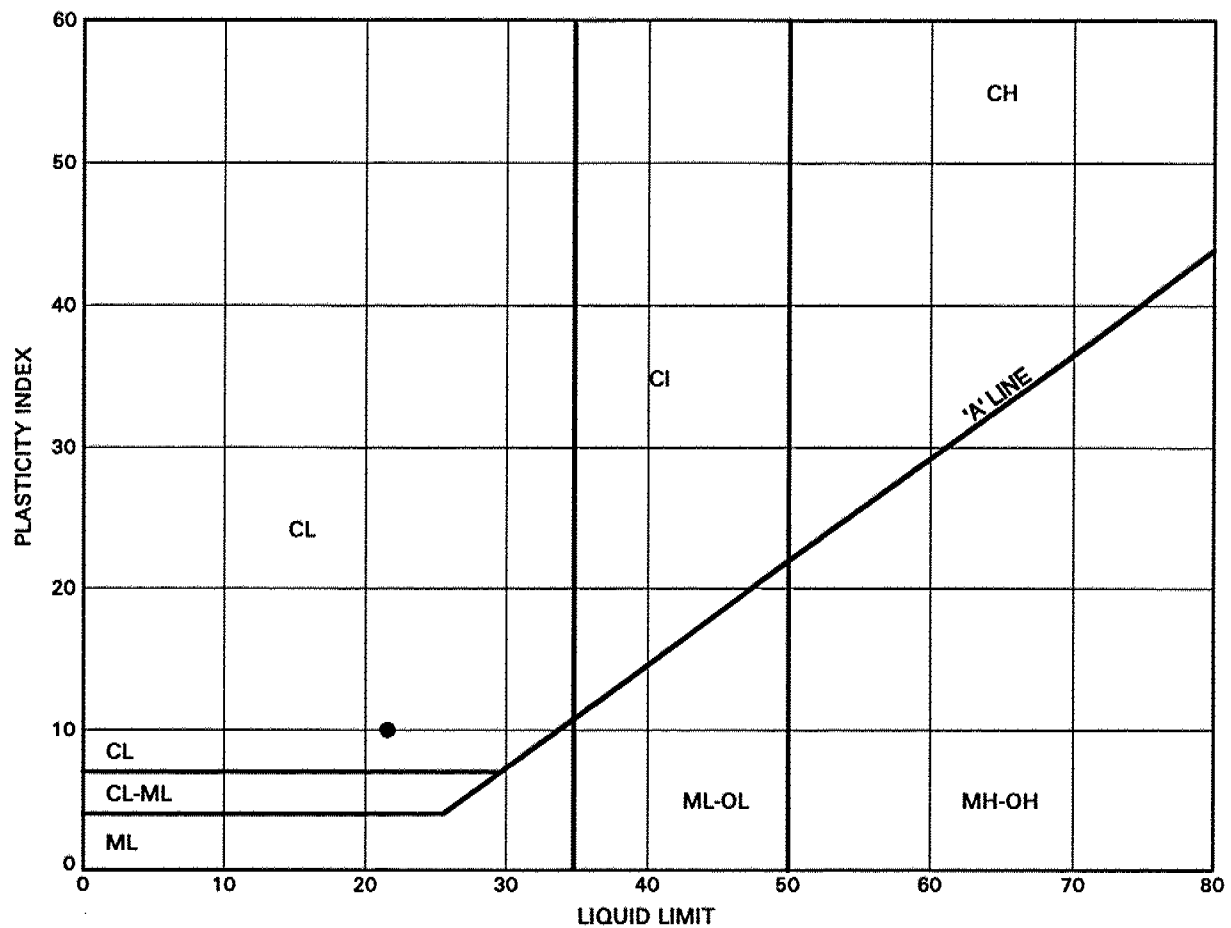


Prep'd
 Chkd.

W.P. NO. 4-95-01 HIGHWAY 9/HOLLAND DRAINAGE CANAL
ATTERBERG LIMITS TEST RESULTS

FIGURE B4

Upper Silty CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	BH97-3	15.47	205.42

Date December 1997
 Project 4-95-01

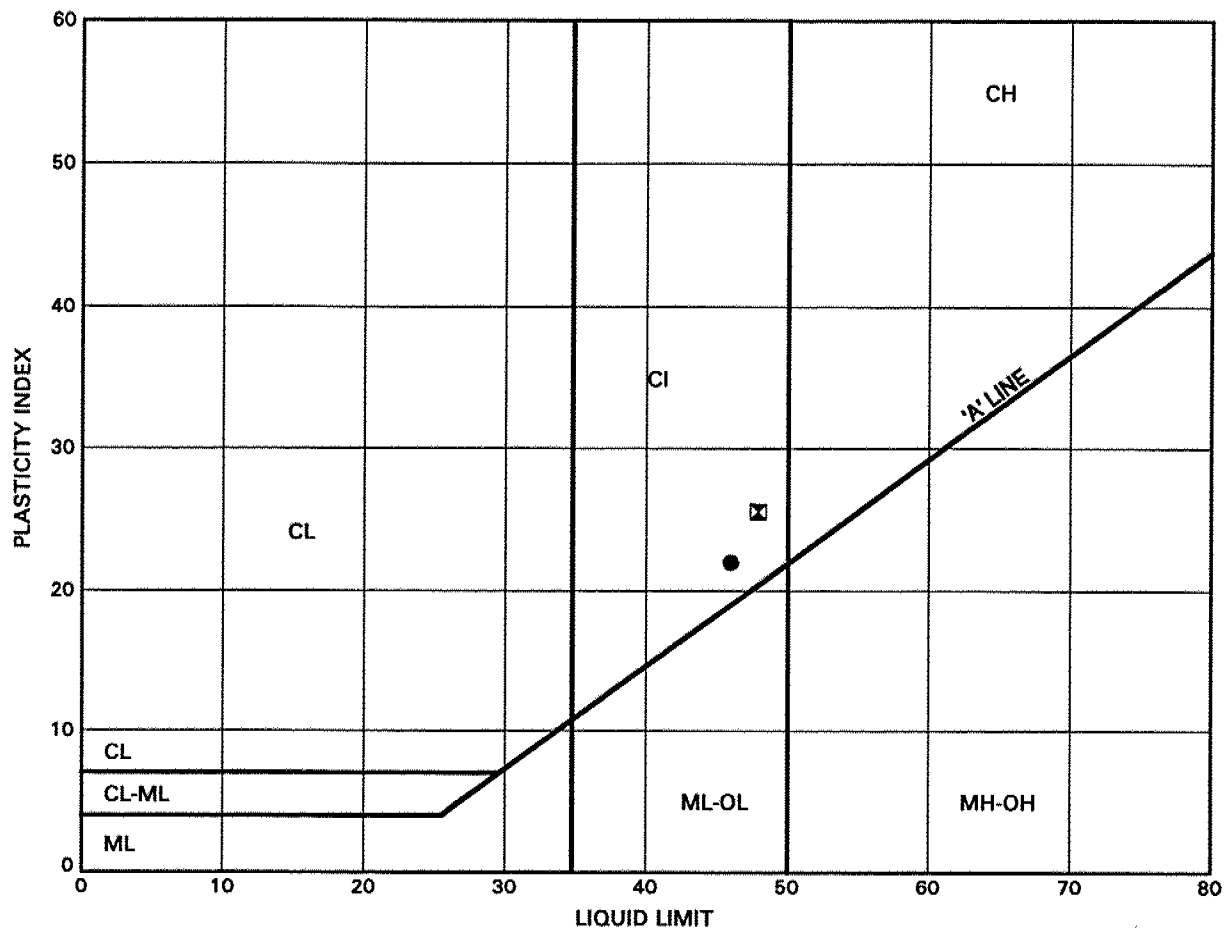


Prep'd WM
 Chkd. DWP

W.P. NO. 4-95-01 HIGHWAY 9/HOLLAND DRAINAGE CANAL
ATTERBERG LIMITS TEST RESULTS

FIGURE B5

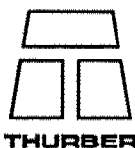
Lower Silty CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	BH3	16.49	202.41
⊠	BH97-2	18.52	201.42

Date December 1997

Project 4-95-01

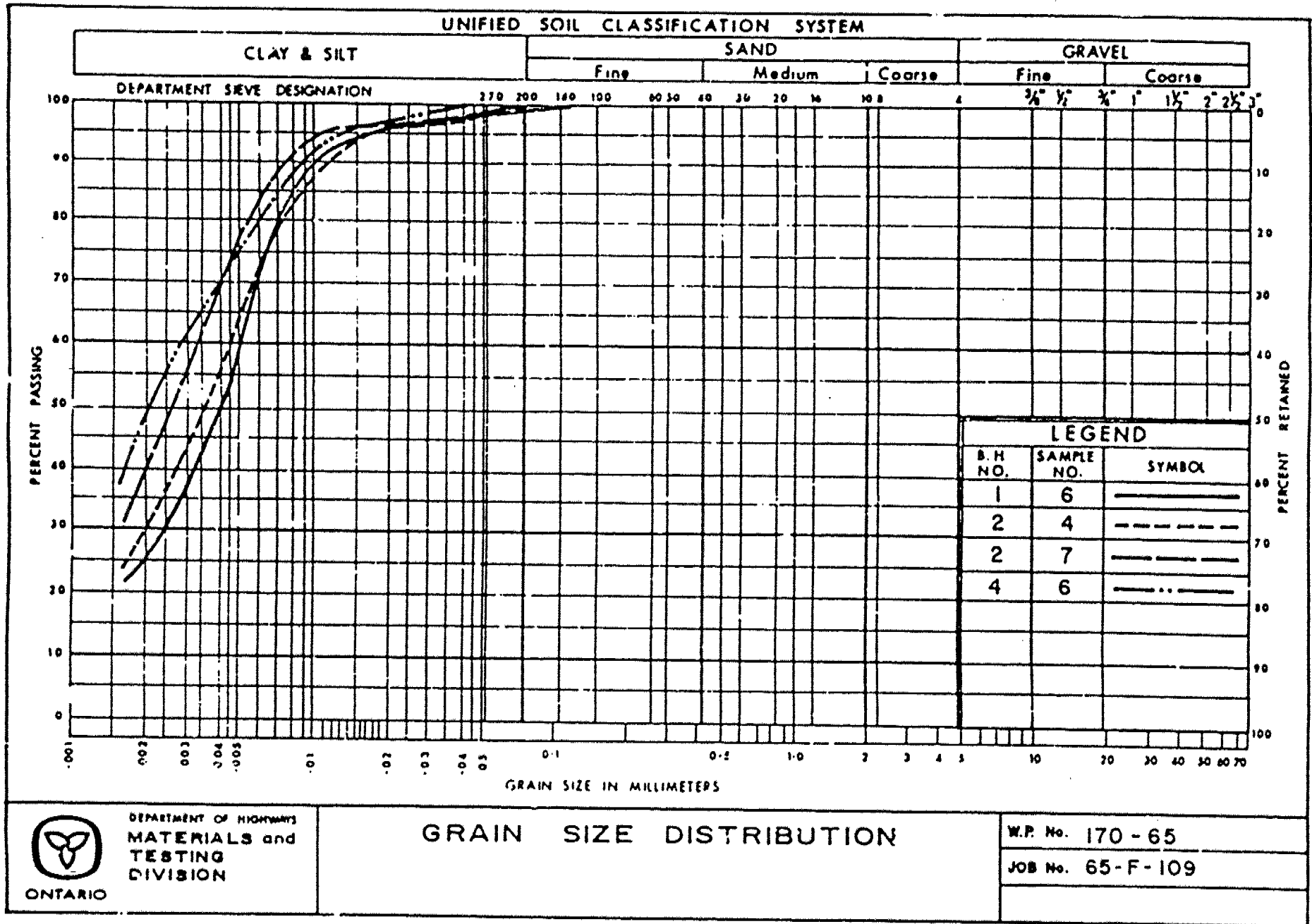


Prep'd

Chkd.

Upper Silty CLAY

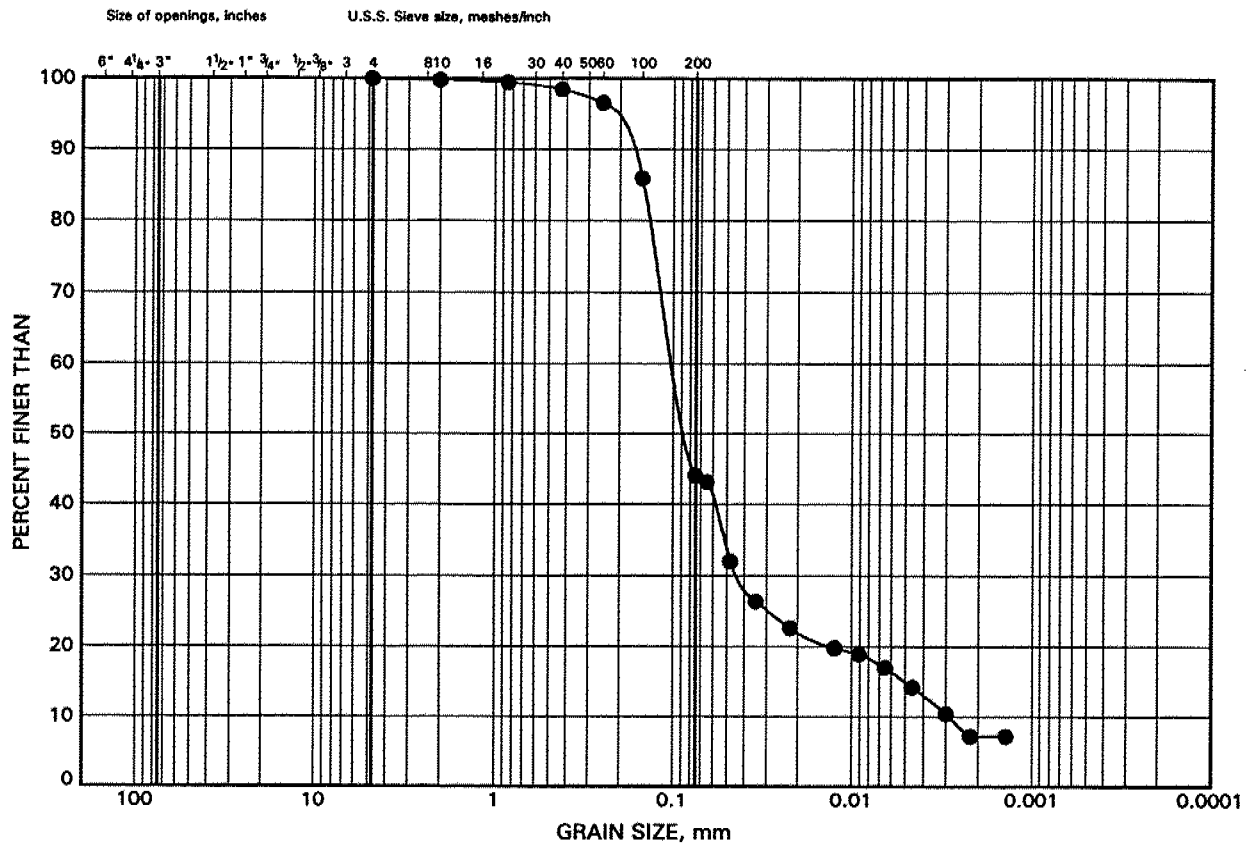
FIGURE B6



W.P. NO. 4-95-01 HIGHWAY 9/HOLLAND DRAINAGE CANAL
GRAIN SIZE DISTRIBUTION

FIGURE B7

SAND and SILT



APPENDIX B

Borehole Records from Current Investigation

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_c	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_{α}	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Compactness	N
Condition	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	C_u, S_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

PROJECT		1671430		RECORD OF BOREHOLE No C2-1		SHEET 1 OF 1		METRIC						
G.W.P.		2016-E-0029		LOCATION		N 4876341.1; E 296387.4 MTM NAD 1983 ZONE 10 (LAT. 44.027018; LONG. -79.604949)		ORIGINATED BY						
DIST		CENTRAL HWY 9		BOREHOLE TYPE		152 mm O.D. Hollow Stem Augers, D-25 - Truck-mounted Drill Rig		COMPILED BY						
DATUM		Geodetic		DATE		May 10, 2018		CHECKED BY						
								NK						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
220.9	GROUND SURFACE													
0.0	(TOPSOIL) - Clayey silt, trace to some gravel, some sand, trace organics, rootlets, grass		1	SS	10									
220.2	Brown		2	SS	12									
0.7	Stiff Moist		3	SS	6									
	Clayey silt, trace to some gravel, trace sand, trace organics to 2.2 m (FILL)		4	SS	5									
	Brown		5	SS	7									
	Firm to very stiff													
	Moist to wet below 3.1 m													
215.3	CLAYEY SILT, trace sand													
5.6	Grey		7	SS	16									
	Stiff to very stiff													
	Wet													
			8	SS	21									
			9	SS	17									
			10	SS	14									
209.6	END OF BOREHOLE													
11.3	NOTE:													
	1. Water level measured at a depth of 5.4 m below ground surface (Elev. 215.5 m) upon completion of drilling.													
	2. Borehole caved to a depth of 9.1 upon removal of augers.													

PROJECT		1671430		RECORD OF BOREHOLE No C2-2		SHEET 1 OF 1		METRIC					
G.W.P.		2016-E-0029		LOCATION		N 4876350.1; E 296422.9 MTM NAD 1983 ZONE 10 (LAT. 44.027099; LONG. -79.604506)		ORIGINATED BY					
DIST		CENTRAL HWY 9		BOREHOLE TYPE		152 mm O.D. Hollow Stem Augers, D-25 - Truck-mounted Drill Rig		COMPILED BY					
DATUM		Geodetic		DATE		May 10, 2018		CHECKED BY					
								NK					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p W W _L			
220.3	GROUND SURFACE												
0.0	(TOPSOIL) - Clayey silt, trace organics, rootlets		1	SS	8								
219.6	Brown Stiff Moist		2	SS	8								
0.7	Clayey silt, trace sand, trace organics from 0.7 m to 2.1 m (FILL)		3	SS	4								
	Brown-grey Firm to hard Moist		4	SS	9								
	- Wood fragments from 1.5 m to 2.1 m depths		5	SS	19								
	- Minor seepage at 2.4 m		6	SS	30								
215.8	CLAYEY SILT, trace sand Grey		7	SS	16								
4.5	Firm to very stiff Moist to wet below 6.1 m		8	SS	8								
	- Wood fragments from 3.8 m to 5.2 m depth		9	SS	11								
			10	SS	8								
			11	SS	10								
			12	SS	5								
207.5	END OF BOREHOLE												
12.8	NOTE:												
	1. Water level measured at a depth of 4.5 m below ground surface (Elev. 215.8 m) upon completion of drilling following auger removal.												

PROJECT		1671430		RECORD OF BOREHOLE		No TP-1		SHEET 1 OF 2		METRIC			
G.W.P.		2016-E-0029		LOCATION		N 4876318.8; E 296355.2 MTM NAD 1983 ZONE 10 (LAT. 44.026817; LONG. -79.605350)		ORIGINATED BY		CC			
DIST		CENTRAL HWY 9		BOREHOLE TYPE		210 mm O.D. Hollow Stem Augers, D-90 - Truck-mounted Drill Rig		COMPILED BY		AM			
DATUM		Geodetic		DATE		May 16, 2018		CHECKED BY		NK			
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)		
222.0	GROUND SURFACE												
0.0	ASPHALT (220 mm)												
0.2	Sand and gravel, trace to some silt (FILL) Brown Compact to very dense Moist		1	SS	50/0.13								
			2	SS	25								
220.5													
1.5	Clayey silt, trace to with sand, trace gravel, trace organics (FILL) Grey-brown Stiff to hard Moist		3	SS	28								
			4	SS	12								
	- 0.1 m thick silt and sand interlayer at 3.0 m		5	SS	31								3 44 44 9
			6	SS	17								
			7	SS	25								0 1 56 43
216.4													
5.6	CLAYEY SILT Grey Soft to hard Moist to wet below 9.1 m		8	SS	12								
			9	SS	34								
			10	SS	7								
			11	SS	3								0 0 72 28
			12	SS	3								
209.2													
12.8	END OF BOREHOLE												
NOTES:													
1. Water level measured at a depth of 10.6 m below ground surface (Elev. 211.4 m) upon completion of well installation.													

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+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE


PROJECT 1671430		RECORD OF BOREHOLE No TP-2		SHEET 1 OF 2		METRIC										
G.W.P. 2016-E-0029		LOCATION N 4876339.5; E 296426.9 MTM NAD 1983 ZONE 10 (LAT. 44.027004; LONG. -79.604456)		ORIGINATED BY CC												
DIST CENTRAL HWY 9		BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, D-90 - Truck-mounted Drill Rig		COMPILED BY AM												
DATUM Geodetic		DATE May 14, 2018		CHECKED BY NK												
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
222.2	GROUND SURFACE															
0.0	ASPHALT (220 mm)															
0.2	Gravelly sand to sand and gravel, trace silt (FILL) Brown Dense to very dense Moist		1	SS	76											
			2	SS	49											
220.8																
1.4	Silt and sand, trace to some clay, trace gravel, trace organics, trace rootlets, trace cobbles (FILL) Grey to brown Very dense Moist		3	SS	53											
			4	SS	54											
218.9			5A													
3.3	Clayey silt, trace sand (FILL) Grey-brown Very stiff Moist - Organic matter/wood fragments observed at a depth of 4.0 m		5B	SS	25											
			6	SS	17											
			7	SS	20											
216.6																
5.6	CLAYEY SILT, trace sand to sandy Grey Firm to very stiff Moist to wet below 7.6 m		8	SS	18											
			9	SS	10											
			10	SS	11											
			11	SS	12											
			12	SS	9											
			13	SS	7											
207.5																
14.7																

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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PROJECT <u>1671430</u>		RECORD OF BOREHOLE No TP-2				SHEET 2 OF 2		METRIC	
G.W.P. <u>2016-E-0029</u>		LOCATION <u>N 4876339.5; E 296426.9 MTM NAD 1983 ZONE 10 (LAT. 44.027004; LONG. -79.604456)</u>				ORIGINATED BY <u>CC</u>			
DIST <u>CENTRAL</u> HWY <u>9</u>		BOREHOLE TYPE <u>210 mm O.D. Hollow Stem Augers, D-90 - Truck-mounted Drill Rig</u>				COMPILED BY <u>AM</u>			
DATUM <u>Geodetic</u>		DATE <u>May 14, 2018</u>				CHECKED BY <u>NK</u>			

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _p	W		
206.4	CLAYEY SILT-SILT Grey Soft Wet --- CONTINUED FROM PREVIOUS PAGE ---		14	SS	4	207							14			
15.8	END OF BOREHOLE NOTE: 1. Water level measured at a depth of 5.9 m below ground surface (Elev. 216.3 m) upon completion of drilling.															

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APPENDIX C

Geotechnical Laboratory Test Results

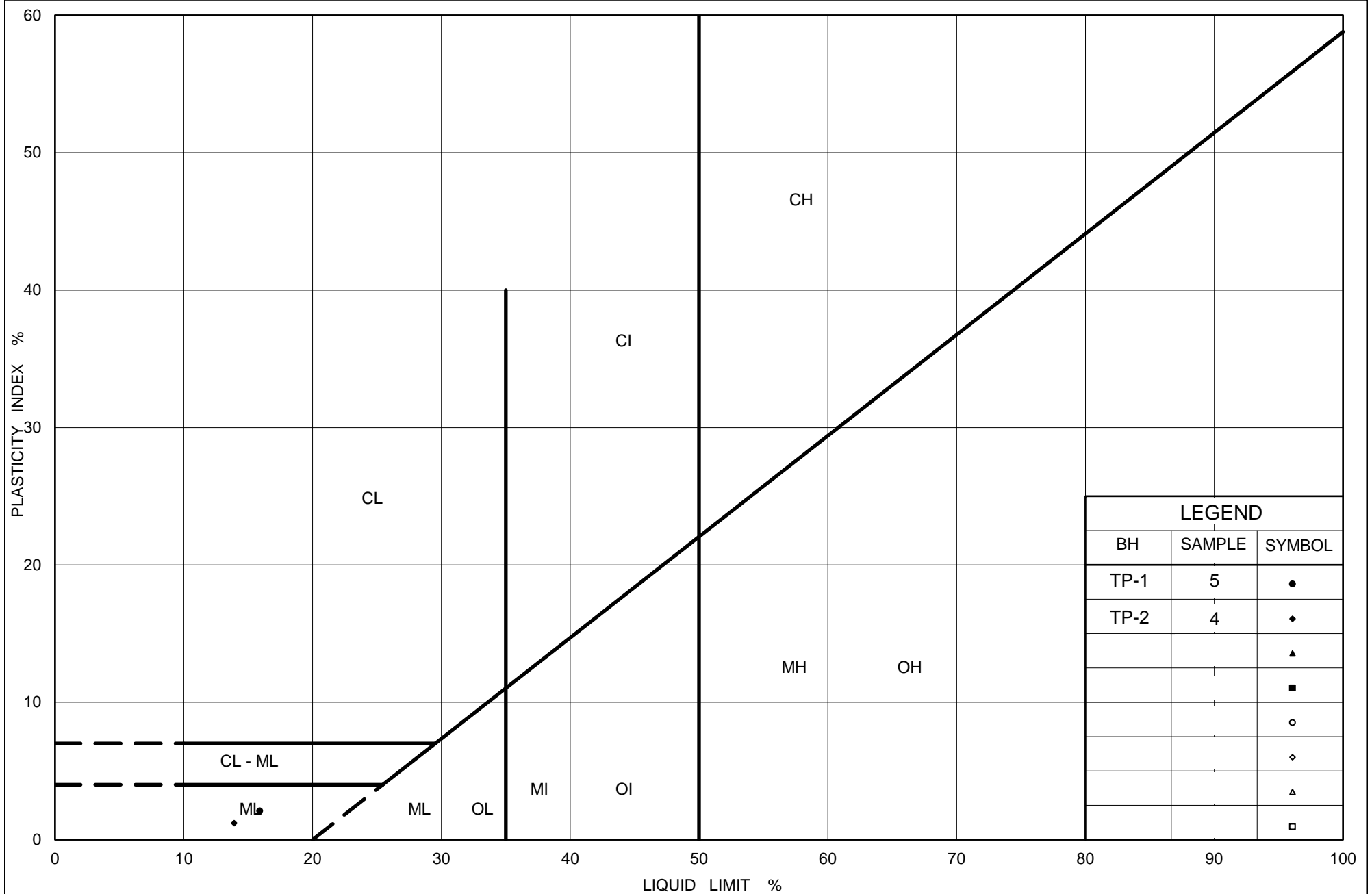
Silt and Sand (Fill)

FIGURE C1



SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	TP-2	4	219.7
■	TP-1	5	218.6

Date: 31-Jul-18



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PLASTICITY CHART

Silt and Sand (Fill)

Figure No. C2

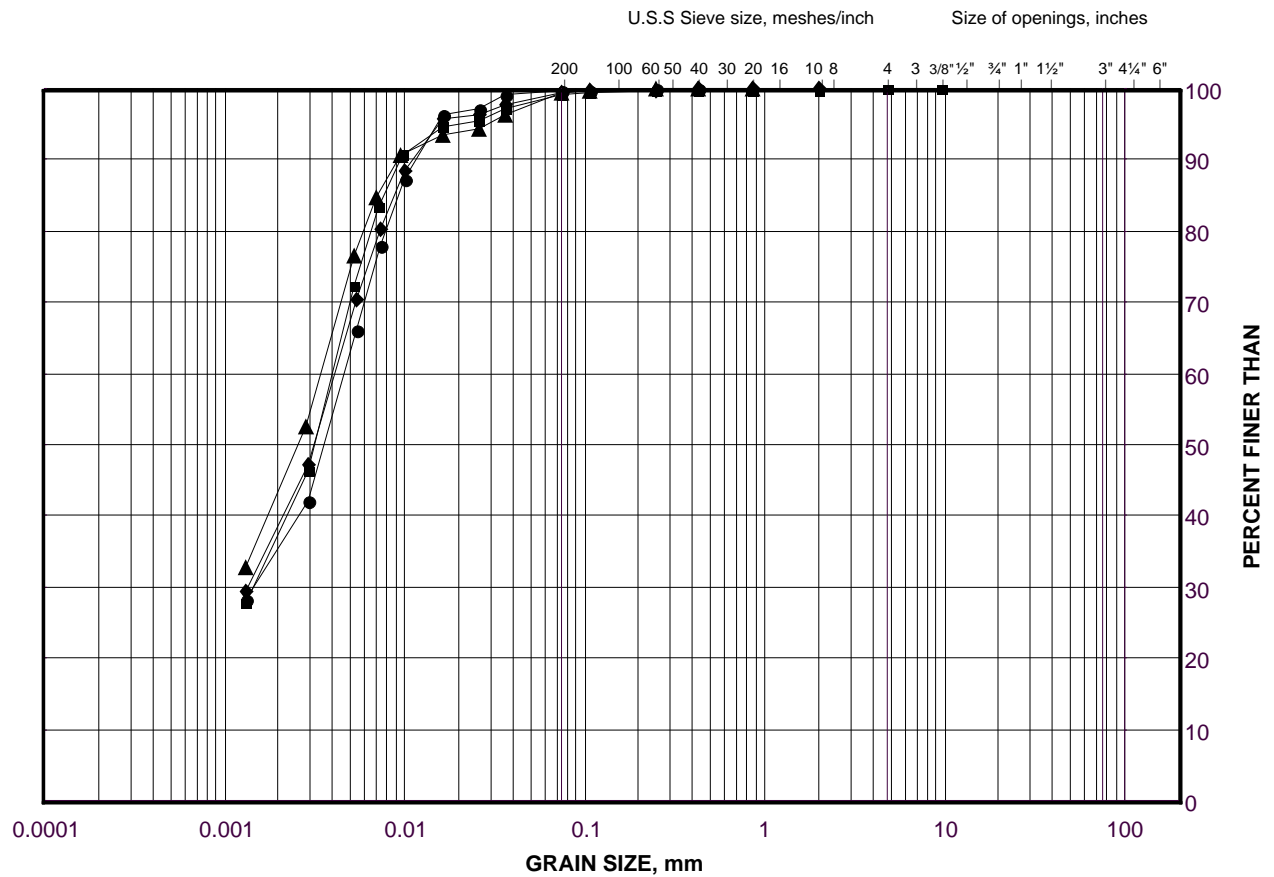
Project No. 1671430

Checked By: NK

GRAIN SIZE DISTRIBUTION

Clayey Silt (Fill)

FIGURE C3



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

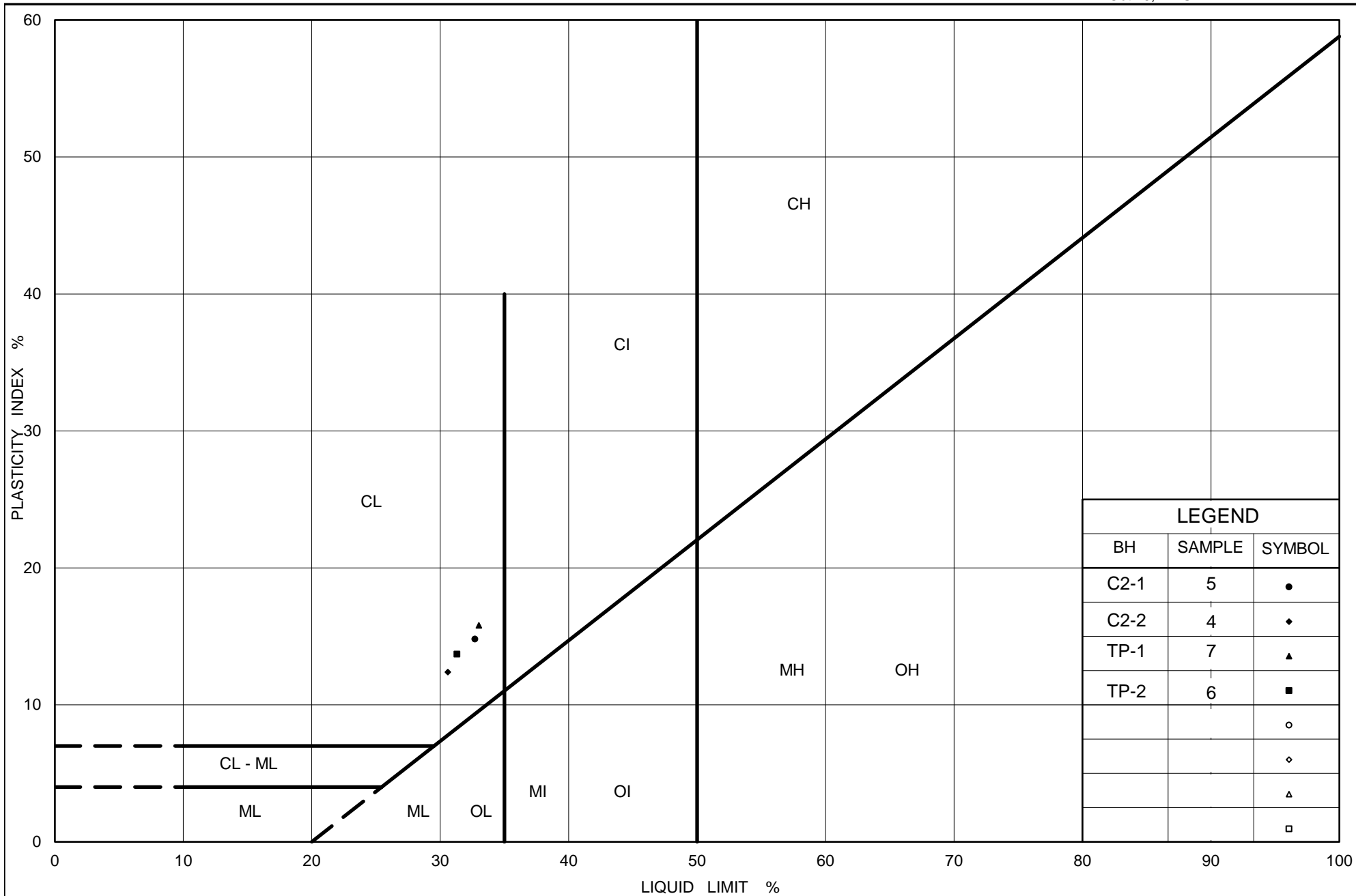
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	C2-2	4	217.7
■	C2-1	5	217.5
◆	TP-2	6	218.1
▲	TP-1	7	217.1

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PLASTICITY CHART

Clayey Silt (Fill)

Figure No. C4

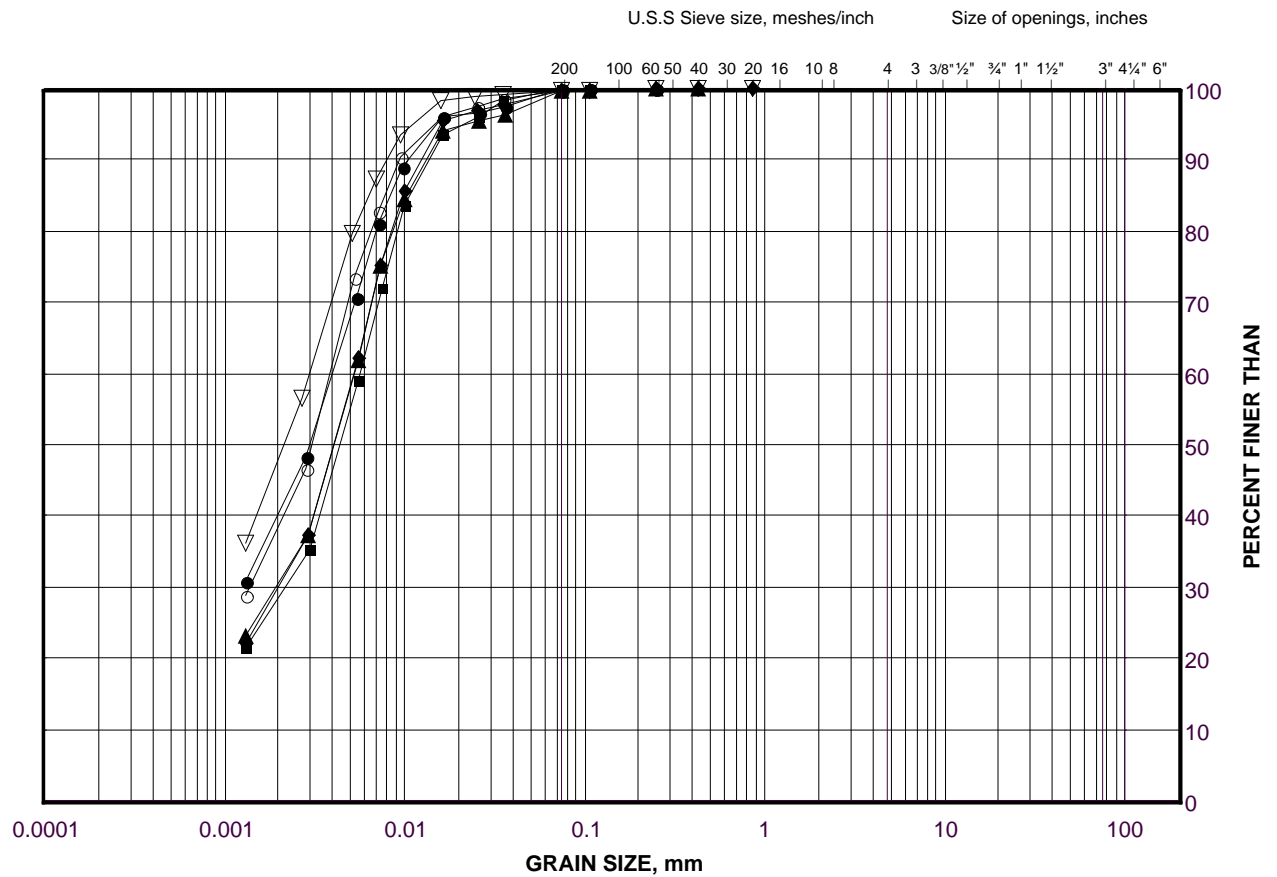
Project No. 1671430

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GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE C5



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

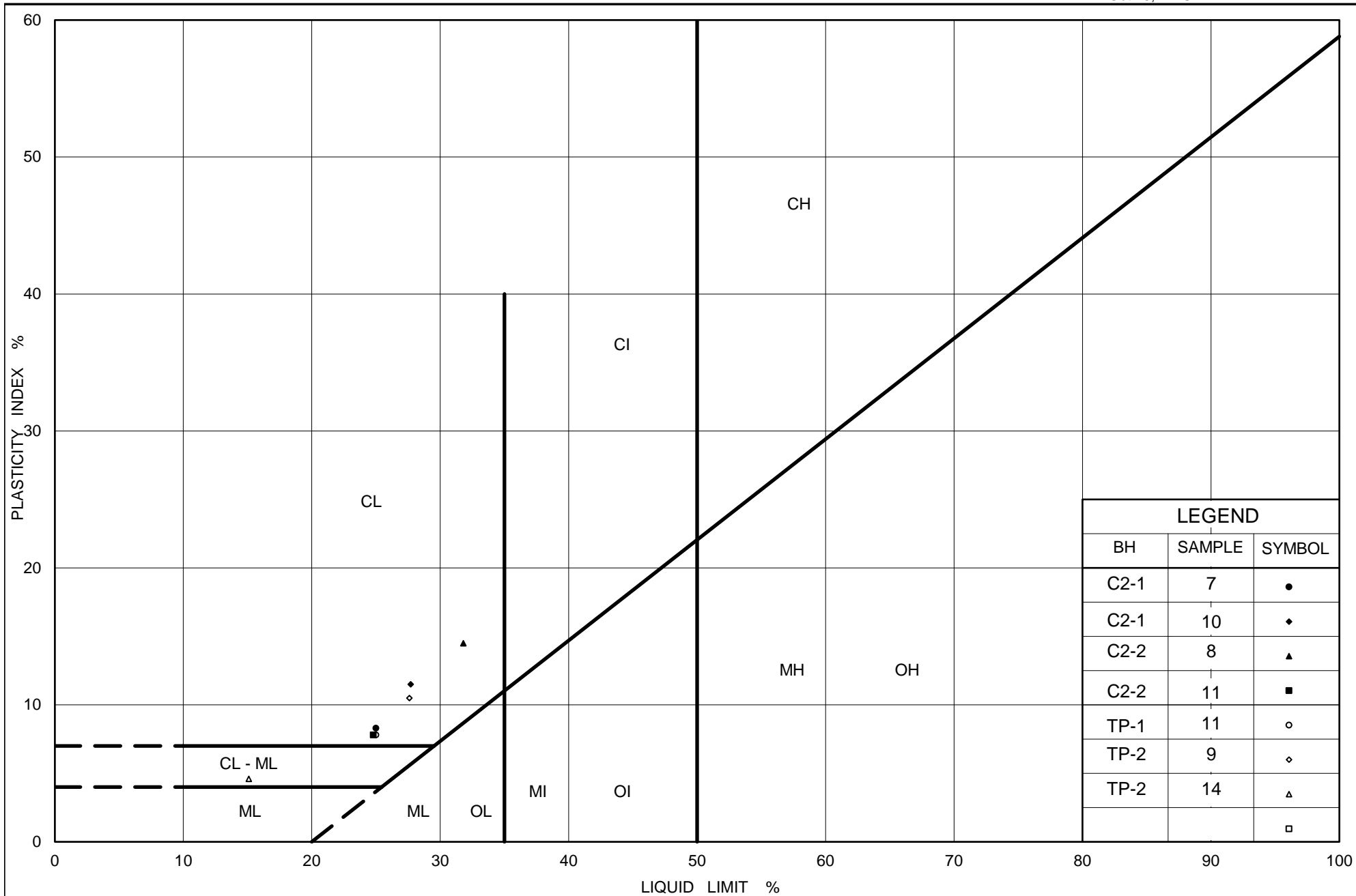
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	C2-1	10	209.9
■	TP-1	11	211.0
◆	C2-2	11	209.3
▲	C2-1	7	214.5
▽	C2-2	8	213.9
○	TP-2	9	214.3

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PLASTICITY CHART Clayey Silt-Silt to Clayey Silt

Figure No. C6

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