

## FOUNDATION INVESTIGATION REPORT

### PROPOSED RECONSTRUCTION/REHABILITATION OF EIGHT (8) NON-STRUCTURAL CULVERT REPLACEMENT C02, C03, C10, C11, C19, C23, C27 & C44 HIGHWAY 12 - TOWNSHIP OF RAMA FROM GAMEBRIDGE TO RAMA ROAD 25

W.P. 365-98-00  
Agreement # 2004-E-0070



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Group*



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C02, C03, C10, C11, C19, C23, C27 & C44  
HIGHWAY 12 - TOWNSHIP OF RAMA  
FROM GAMEBRIDGE TO RAMA ROAD 25

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Agreement # 2004-E-0070

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## **PART A – FOUNDATION INVESTIGATION**

### **1.0 INTRODUCTION**

This report presents the results of a foundation investigation carried out between December 2008 and February 2009 by Infrastructure Engineering Group Inc. (IEG) on behalf of Morrison Hershfield Limited (Morrison Hershfield).

This assignment involves the rehabilitation of approximately 24 km of Highway 12, from Rama Road to Gamebridge. The original scope of the rehabilitation is based on addressing the immediate and short term deficiencies identified in the Ministry's Highway Assessment Report for W.O. #03-20019 (February 2005). The scope of work was increased to include extension or replacement of seven (7) non-structural culverts and four (4) structural culverts.

Foundation investigation and recommendations are required for the design and construction of culvert replacements and/or extension as part of the improvement of Highway 12. Seven (7) non-structural culverts and four (4) structural culverts are to be investigated. The scope of work was subsequently changed to include replacement of non-structural culvert C03, and rehabilitation of non-structural culvert C23, and structural culverts C25 and C28. No work will be done on structural culverts C14 and C15. This report covers the site of non-structural Culverts C02, C03, C10, C11, C19, C23, C27 and C44. The locations of these culverts are shown in Appendix A, Borehole Location Plan, Drawings 1 and 2.

Eight (8) non-structural culverts are listed in the following table for replacements or rehabilitation as per the information supplied by Morrison Hershfield.

**Table 1**  
**Summary of Location, Existing and Proposed Structure Types & Dimensions**

<b>Culvert No.</b>	<b>Chainage (m)</b>	<b>Existing Culvert Type and Size, W X H</b>	<b>Existing Overfill Height (m)</b>	<b>Recommended Replacement Culvert Type and Size</b>	<b>Length (m)</b>
C02	11+678	Conc. RFO 1.20m X 1.00m	0.66	Precast Concrete Box Culvert, 1.2 m X 0.9 m	18.7
C03	12+352	Conc. RFO with SPPA extensions 1.8m X 0.9m RFO 1800 SPPA	0.94	Precast Concrete Box Culvert, 1.8 m X 0.9 m	Approx. 24.0
C10	16+979	Conc. RFO with RFO & CSP Extensions 1.22m RFO, 1.40m CSP X 0.9m E inlet and 1.2m W outlet	0.47	Precast Concrete Box Culvert , 2.4 m X 1.2 m	26.8
C11	18+137	Conc. RFO 1.82m X 1.3m	0.61	Precast Concrete Box Culvert with Similar Size	21.4

<b>Culvert No.</b>	<b>Chainage (m)</b>	<b>Existing Culvert Type and Size, W X H</b>	<b>Existing Overfill Height (m)</b>	<b>Recommended Replacement Culvert Type and Size</b>	<b>Length (m)</b>
C19	22+853	Conc. RFO 2.4m X 1.5m	0.65	Precast Concrete Box Culvert with Similar Size	22.1
C23	24+713	Conc. RFO 1.82m X 1.6m	0.67	Rehabilitation Only	24.1
C27	26+154	CSP 0.61m	1.43	Precast Concrete Box Culvert, 1.8 m X 0.9 m	19.2
C44	33+790	Conc. RFO 1.22m X 1.28m E Inlet and 0.94m W Outlet	0.32	Precast Concrete Box Culvert, 2.40 X 1.5 m	23.7

The above recommended culvert replacement/rehabilitation was provided in the preliminary design Drawings 1 to 8, dated August 18, 2009 and provided by Morrison Hershfield. Culverts C2, C3, C10, C11, C19, C27 and C44 will be replaced with precast concrete culverts, and Culvert 23 will be rehabilitated. The non-structural culverts will be replaced with precast concrete box culverts. Concrete repairs and struts will be constructed for rehabilitation of Culvert C23.

The purpose of the investigation has been to obtain information about the subsurface conditions at the site by means of boreholes and, based on the findings, to provide geotechnical recommendations for the foundation elements.

The work presented herein was undertaken under MTO W.P. 365-98-00, Agreement No. 2004-E-0070. Authorization to complete this assignment was given by Mr. Stanley Ma, P. Eng., of Morrison Hershfield, the TPM Consultant who is completing this assignment for MTO under Agreement # 2004-E-0070.

## **2.0 SITE DESCRIPTION**

### **2.1 Site Location**

The project alignment starts in Gamebridge, at Station 10+000 and extends northerly to approximately Station 19+200 just south of County Road 169, then extends north-westerly to approximately Station 24+800 just before Side Road 15, then extends westerly to Station 34+000 just east of Rama Road 25. For the purpose of description, standard MTO conventional description will be used, i.e. a site north pointing in the direction of increasing chainage. When facing the direction of increasing chainage, the right hand side is referred to as east, and the left hand side is referred to as west. Any directions with clarifications in brackets (e.g. north-west) are given with reference to the true north direction.

The eight (8) non-structural culverts are located on Highway 12, approximately between 1.7 km (Station 11+678 for Culvert C02) and 23.8 km (Station 33+790 for Culvert 44) north (north to

north-west) of the south limit of the Contract at Gamebridge (STA 010+000). Table 1 summarizes the locations, existing structure types and sizes, overfill height, replacement culvert types and sizes. Locations of the individual non-structural culverts are illustrated in the Borehole Location Plan, Drawings 1 and 2 presented in Appendix A.

These non-structural culvert sites are generally located within drainage valleys, surface water flow paths, or located within wetlands severed by Highway 12. The overfill heights are approximately between 0.34 m and 1.00 m.

The embankment slopes are typically 2.5H:1V to greater than 3H:1V, with localized steeper zones, and are generally grass or weed covered. With the exception of Culvert C27, no signs of embankment erosion above the culvert were observed at the time of this foundation investigation.

Site photographs taken during a site visits are provided in Appendix C. Site Photographs for Culvert C03 are provided by Morrison Hershfield as the Client Supplied Materials for the added scope of work. The photographs indicate that some embankment erosion has taken place immediately above the culvert at the location of C27.

## **2.2 Physiography and Topography**

The project alignment except for the extreme western portion is located within the Simcoe Lowlands physiographic region (Chapman and Putnam, 1984). This area was previously flooded by glacial Lake Algonquin. The portion of the alignment located east of the Atherley Narrows (narrows between Lakes Couchiching and Simcoe) is comprised of an elevated, drumlinized till plain comprised primarily of undifferentiated sand to sandy silt (Chapman and Putnam, 1984). The character of local topography and soils proximity to the highway corridor elsewhere are predominantly comprised of clay plain with interspersed elongated drumlins which comprised of calcareous till (kame moraine) (Chapman and Putnam, 1984). There is a large patch of peat/muck located on the east shore of Lake Simcoe associated with several of the wetland features located along the lakeshore. There is also a section of Carden limestone plain located north of the Talbot River at the south end of the study area. This area is characterized as limestone overlaid with a very shallow overburden (Chapman and Putnam, 1984).

The topography of the study area is primarily flat with scattered drumlin features. The area slopes gently down towards Lake Simcoe. There are numerous headwater areas of small size that traverse the ROW of Highway 12. Movement of shallow ground water is confined by the tight till and clay soils and would follow surficial topography towards Lake Simcoe.

There are six provincially significant wetlands (PSW) located in part within the project alignment. From west to east, they include the Orillia Filtration Swamp, Victoria Point Wetland, Atherley Wetlands, Mud Lake Wetland, Barnstable Bay Wetland, and the Lagoon City Wetland.

### **3.0 INVESTIGATION PROCEDURES**

#### **3.1 Field Investigation**

Between December 1, 2008 and February 19, 2009, a Bombardier-mounted Diedrich drill rig and a truck-mounted CME 55 drill rig, supplied and operated by London Soil Test Ltd. of London, was used on site for drilling and Standard Penetration Testing (SPT, following the procedures of ASTM D 1586). Hand drilling or dynamic cone penetration tests were carried out where the area is not accessible to the drill rig due to inundation or soft wetland conditions. Four (4) boreholes at each site were drilled and sampled to obtain data for foundation and bedding design of the proposed replacement culverts. The boreholes were drilled to a minimum depth of 3.0 m (or deeper if required) below the culvert inverts or refusal at higher depths to provide sufficient subsurface information for the evaluation of bearing resistances and support of bedding material for the proposed culverts. A hand-drilled borehole cannot be completed at most of the non-structural culvert sites due to inundation of the area or very soft ground surface, and a series of dynamic cone penetration tests were carried out instead.

The boreholes were advanced using continuous flight solid stem or hollow stem augers. Soil samples were retrieved at selected intervals throughout the depths of the boreholes in conjunction with Standard Penetration Tests (SPT). Samples were generally taken at intervals of depth of 0.75 m to the maximum depth of exploration.

The culvert locations are described in the Culvert Summary provided by Morrison Hershfield as Culv 02, 03, 10, 11, 19, 23, 27 and 44. The culvert borehole numbering system was adopted with slight modification with a preceding "C" followed by the culvert number, e.g., C02, Culv 02 and Culvert 2 refers to Culv 2 as presented in the Culvert Summary.

For the purpose of proper management of the Borehole Logs within gINT, the borehole logging software, a preceding 0 was added to the culverts numbered 1 to 9, and the last number being the borehole number at the culvert site, i.e., "C02-1" refers to Borehole 1 at the location of Culvert C02, etc.

Field work was not carried out for Culvert C03 since this culvert was added to the scope of work at the time of preparing this report.

The undrained shear strength was obtained by shear vane test, with the sensitivity measured. Field pocket penetrometer was used on the retrieved SPT samples, where applicable, to determine the undrained shear strength of the cohesive soil deposits. These undrained shear strengths are used to supplement the properties of the cohesive soils. It is noted that the measured shear strength value on the retrieved SPT samples would be slightly lower than the actual value due to sampling disturbance. Thin-walled Shelby tube samples were obtained for laboratory consolidation test.

Seepage and water levels were noted in each borehole during and at the completion of drilling and sampling. All boreholes were grouted with a bentonite/cement mix at completion of sampling in accordance with Ontario Regulation 903.

Our field engineer, Mr. Ralph Billings, P. Eng., working under the direction of the project engineer, Mr. Eric Chung, P. Eng., supervised the fieldwork. Our field staff cleared the location of buried utilities and logged the boreholes. The soil samples obtained were placed in labeled containers and transported to our London Office for further examination and laboratory testing.

The stations, offsets and ground surface elevations at the as drilled borehole locations were provided to Morrison Hershfield and the borehole locations (northings and eastings), and ground surface elevations were provided by Morrison Hershfield to Infrastructure Engineering Group Inc. for the purpose of this report.

The results of the drilling, sampling, in-situ testing and groundwater observations are summarized on the Record of Borehole sheets and enclosed in Appendix B.

### **3.2 Laboratory Analysis**

Geotechnical laboratory testing consisted of natural moisture content determinations and visual classifications of all retrieved soil samples. In addition, grain size analyses, Atterberg Limit tests and unit weight tests were performed on selected samples.

A one-dimensional consolidation test (ASTM D 2435) was conducted on a relatively undisturbed thin-walled (Shelby tube) sample obtained from Borehole C10-3 at a depth of 2.44 m. The consolidation test was carried out by Trow Associates Inc. of Brampton and the results are provided in a Void Ratio versus Pressure curve plot enclosed in Appendix B as Figure C-10.10.

The results of the laboratory testing are presented on the Record of Borehole sheets and in the respective figures presented in Appendix B.

## **4.0 SUBSURFACE CONDITIONS**

Reference is made to Appendix B which contains the Record of Borehole sheets and Laboratory Test Results of each culvert site for detailed subsurface soil and groundwater conditions encountered in the boreholes. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and, consequently, represent transitions between soil types rather than exact planes of geological change. The soil profiles depicting the subsurface conditions on the respective Borehole Locations will vary between and beyond the borehole locations.

In general, the subsurface deposits encountered in the boreholes put down at the seven (7) non-structural culvert sites consist of loose to compact embankment fill placed on firm to very stiff



silty clay to silty clay till and soft to stiff clayey silt, with occasional layers of silt, sand and gravel of variable composition.

Limestone bedrock was inferred by refusal to augering and dynamic cone penetration tests at approximate depths of 1.5 to 6.5 m below the present ground surface, corresponding to Elevations 226.6 m at Culvert C02, to Elevation 214.1 m at Culvert C44, dipping in a north to north-westerly direction.

#### **4.1 Pavement, Fill, Buried Topsoil/Peat**

The boreholes were generally located within the road platform and at the shoulders, and encountered a 0.30 and 0.91 m thick layer of granular fill (shoulder gravel). The shoulder gravel is underlain by mixed sand, gravel, silt and silty clay fill materials with localized zones of organic inclusions, and extends to or slightly below the bottom of the culverts, to depths of 1.2 to 2.9 m below road surface.

At Culvert C10, the asphalt was measured to be 200 and 275 mm thick.

At Culverts C10 and C11, the embankment fill was placed on a buried topsoil layer, respectively 300 mm and 460 mm thick. At Culvert C23, a 1.37 m thick peat deposit was penetrated below the upper embankment fill and extended to depths of 2.59 m, Elevation 222.39 m at Borehole C23-2 and Elevation 222.50 m at Borehole C23.3.

At Culvert C44, a concrete layer (760 mm thick) was encountered at 1.68 m depth at Borehole C44-2.

Standard penetration tests taken in the mixed fill yielded “N”-values from 1 to 16 blows per 0.3 m, indicative of typically loose to compact compactness condition with localized very loose layers. The measured natural moisture contents of the mixed fill ranged from 5 to 30%. The higher moisture contents reflect the presence of topsoil and organic mattes, as well as wet silty clay.

Grain size distributions of these fill materials are shown on the first figure of the corresponding culvert site in Appendix B, e.g., Figure C-02.1 refers to the first figure of Culvert C02, etc.

#### **Summary of Figures of Laboratory Test Results**

<b>Culvert Number</b>	<b>Grain Size Figure</b>	<b>Atterberg Limit Figure</b>
C02	C-02.1	C-02.2
C10	C-10.1	C-10.2
C11	C-11.1	N/A
C19	C-19.1	C-19.2
C23	C-23.1	C-23.2

<b>Culvert Number</b>	<b>Grain Size Figure</b>	<b>Atterberg Limit Figure</b>
C27	C-27.1	C-27.2
C44	C-44.1	C-44.2

Unit weight of the fill was measured to be between 21.2 and 24.7 kN/m<sup>3</sup>, based on five samples.

#### **4.2 Sandy Silty Clay Till to Silty Clay (CL to CH)**

At Culverts C02, C10 (Borehole C10-3), C11, C23 and C44, the upper embankment fill and the buried organic layers were underlain by cohesive deposits of variable plasticity, from sandy silty clay till (CL) to silty clay (CL to CH). This stratum extended to the full depths of the boreholes (inferred bedrock elevation) at Culverts C02, C11 and C23 (Borehole C23-3). At the other locations, the silty clay was underlain by saturated sands, silts, and gravels.

Grain size analyses and Atterberg Limit determinations were performed and the results are plotted on the following figures of Appendix B.

**Table of Figures of Laboratory Test Results**

<b>Culvert Number</b>	<b>Grain Size Figure</b>	<b>Atterberg Limit Figure</b>
C02	C-02.3	C-02.4
C10	C-10.5	C-10.6
C11	C-11.3	C-11.4
C23	C-23.3	C-23.4
C44	C-44.3	C-44.4

Thirteen (13) Atterberg Limit determinations on the sandy silty clay till to silty clay (CL to CI) yielded the following results:

<b>Atterberg Limit</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Average</b>
<b>Liquid Limit (W<sub>L</sub>) %</b>	20.0	68.0	42.8
<b>Plastic Limit (W<sub>P</sub>) %</b>	12.0	29.0	19.4
<b>Plasticity Index (I<sub>p</sub>) %</b>	8.0	39.0	23.4

Standard penetration tests taken within the cohesive units yielded “N”-values between 1 and 23 blows per 0.3 m. The natural moisture contents were between 11 and 60%.

It is noted that the sandy silty clay till encountered at Culvert C02 and the silty clay at Culvert C44 is stronger than those in the other three culvert sites. The undrained shear strength as determined from field pocket penetrometer and field shear vane was generally between 60 and

120 kPa. The silty clay at Culverts C10, C11 and C23 is weaker, with undrained shear strength measured generally between 20 and 90 kPa.

The unit weight of the sandy silty clay till to silty clay was measured on ten (10) samples to be between 20.4 and 24.7 kN/m<sup>3</sup>.

Based on the above field and laboratory test results, together with visual and tactile examination, the sandy silty clay till to silty clay deposit generally exhibited soft to very stiff consistency.

The silty clay layer in Borehole C10-3 is layered, with frequent silt seams and pockets, and exhibits a varve-like structure.

A one-dimensional consolidation test (ASTM D 2435) was conducted on a relatively undisturbed thin-walled (Shelby tube) sample obtained from Borehole C10-3 at a depth of 2.44 m. The results are shown in Figure C-10.10 of Appendix B and summarized below:

Sample Depth:	2.44 m
Elevation:	226.57 m
Liquid Limit ( $W_L$ )	31 %
Plastic Limit ( $W_P$ )	14 %
Natural Moisture Content ( $W$ )	39 %
Compression Index ( $C_C$ )	0.476
Recompression Index ( $C_r$ )	0.083
Pre-consolidation Pressure ( $\sigma_p$ )	250 kPa
Effective Overburden Pressure ( $\sigma'_{vo}$ )	46 kPa

#### **4.3 Clayey Silt (CL-ML)**

Beneath the embankment fill at Culvert C10 (Borehole C10-2) and the silty clay at Culvert C44, a layer of clayey silt was encountered. The clayey silt was further underlain by saturated sands and silts.

Grain size analyses and Atterberg Limit determinations were performed and the results are plotted on the following figures of Appendix B.

**Table of Figures of Laboratory Test Results**

<b>Culvert Number</b>	<b>Grain Size Figure</b>	<b>Atterberg Limit Figure</b>
C10	C-10.3	C-10.4
C44	C-44.5	C-44.6

Two (2) Atterberg Limit determinations carried out on the clayey silt (CL-ML) yielded the following results:

<b>Atterberg Limit</b>	<b>%</b>
<b>Liquid Limit (<math>W_L</math>)</b>	19.0 to 21.0
<b>Plastic Limit (<math>W_P</math>)</b>	13.0 to 16.0
<b>Plasticity Index (<math>I_p</math>)</b>	5.0 to 6.0

Standard penetration tests taken within the cohesive units yielded “N”-values between 2 and 9 blows per 0.3 m. The natural moisture contents were between 30 and 32%. Undrained shear strength of the clayey silt as determined from field pocket penetrometer ranged from 12.5 to 80 kPa. Based on the above field and laboratory test results, together with visual and tactile examination, the clayey silt deposit generally exhibited soft to stiff consistency.

#### **4.4 Silt, Sand and Gravel (ML, SM, SP, SW)**

The above-noted embankment fill, silty clay and clayey silt strata at C10, C19, C23, C27 and C44 were underlain by cohesionless deposits of silt, sand and gravel of variable composition. These soil units exist above the underlying limestone bedrock.

Grain size analyses and Atterberg Limit determinations were performed and the results are plotted on the following figures of Appendix B.

**Table of Figures of Laboratory Test Results**

<b>Culvert Number</b>	<b>Grain Size Figure</b>	<b>Atterberg Limit Figure</b>
C10	C-10.7 C-10.9	C-10.8
C19	C-19.3	C-19.4
C23	C-23.5	C-23.6
C27	C-27.3 C-27.5	C-27.4
C44	C-44.7	C-44.8

Seven (7) Atterberg Limit determinations on the silt (ML) yielded the following results:

<b>Atterberg Limit</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Average</b>
<b>Liquid Limit (<math>W_L</math>) %</b>	11.0	18.0	14.0
<b>Plastic Limit (<math>W_P</math>) %</b>	10.0	14.0	11.1
<b>Plasticity Index (<math>I_p</math>) %</b>	1.0	6.0	2.9

Standard penetration tests taken within these cohesionless deposits yielded “N”-values of typically between 4 and 16 blows per 0.3 m, indicative of loose to compact compactness condition with localized very loose and dense layers. The measured natural moisture contents ranged from 5 to 21%, revealing damp to saturated moisture condition.

#### 4.5 Bedrock

Limestone bedrock was inferred by refusal to augering and dynamic cone penetration tests at depths of 1.5 to 6.5 m below road surface, corresponding to Elevations 226.6 m at Culvert C02, to Elevation 214.1 m at Culvert C44, dipping in a north to north-westerly direction. Sounding of the bedrock carried out at the structural culvert sites C14, 15, 25 and 28 confirmed that the bedrock consists mainly of limestone of mostly good to excellent quality.

#### 4.6 Groundwater

The groundwater condition was monitored during and upon completion of sampling. On completion of drilling, groundwater levels noted in the boreholes are summarized in the following table.

**Table 2 - Groundwater Levels**

Culvert Number	Groundwater Levels - Depth/Elevation (m)			
	Borehole 1	Borehole 2	Borehole 3	Borehole 4
C02	N/A	1.80/228.31	3.50/226.55	N/A
C10	N/A	1.40/227.64	1.50/227.51	N/A
C11	N/A	1.80/219.20	2.10/219.00	N/A
C19	BD&O	BD&O	BD&O	0.30/225.36
C23	0.15/222.83	3.00/221.98	3.05/222.04	0/223.16
C27	N/A	2.40/222.68	1.80/222.87	N/A
C44	N/A	0.90/220.381	1.80/219.73	N/A

**Note:** BD&O means borehole dry and open at completion

In general, groundwater was encountered within the upper fill materials and within the wet to saturated silt, sand and gravel and silty clay deposits at the time of the investigation and likely reflects the water levels at the creek or water levels within the wetlands, at the time of the investigation.

The groundwater table might not have been stabilized at the time of the field work for the short durations that the boreholes were kept open at the time of the field work.

The groundwater condition will fluctuate seasonally and in response to weather events, and likely be similar to those of the creek or wetland water levels.

## 5.0 STATEMENT OF LIMITATION

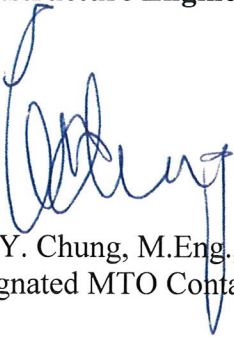
We recommend that once the details of the proposed structure are finalized, our recommendations should be reviewed for their specific applicability.

The Limitations of Report, as quoted in Appendix D, is an integral part of this report.

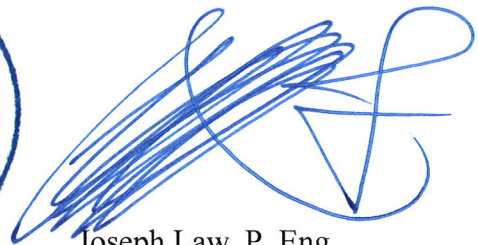
We trust that we have completed the assignment within the Terms of Reference for this project. If there are any questions concerning this report, please do not hesitate to contact our office.

Yours truly,

**Infrastructure Engineering Group Inc.**



Eric Y. Chung, M.Eng., P.Eng.  
Designated MTO Contact



Joseph Law, P. Eng.  
Project Manager



Tom O'Dwyer, P. Eng.  
Quality Review Engineer



Ministry of Transportation/Stantec Consulting Ltd.  
G.W.P. 57-00-00  
Rehabilitation of Highway 12 from Rama Road to Gamebridge  
Agreement # 2004-E-0070

08-1-IEG6-NSCR  
Final Report  
Appendix A  
November 6, 2009

## Appendix A

### Drawings 1 and 2

#### Borehole Location Plans

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

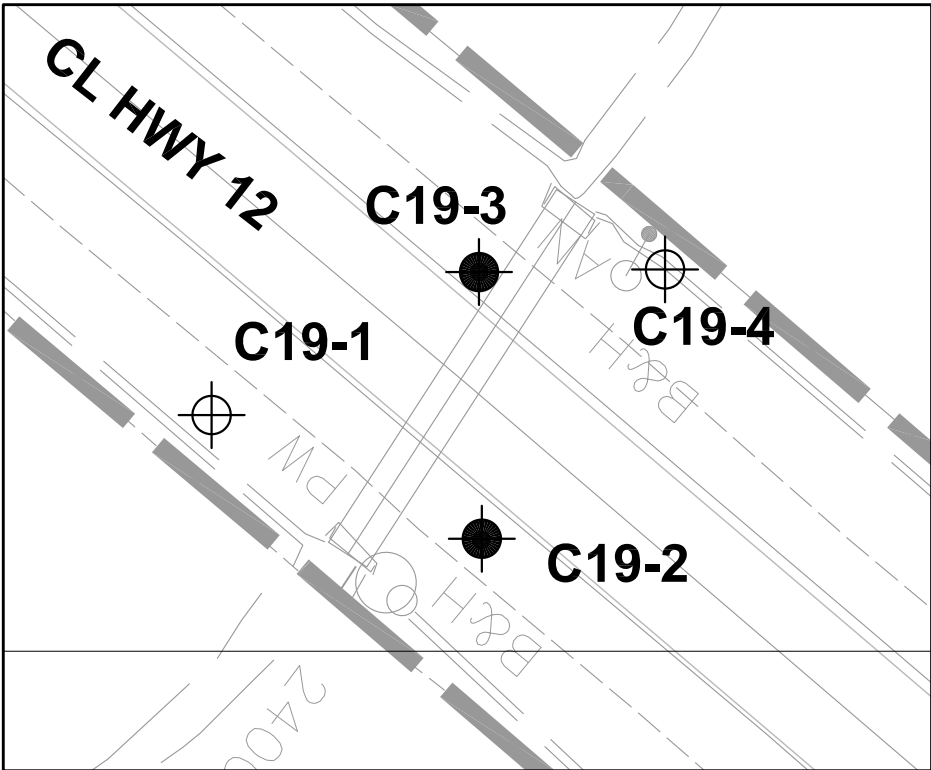
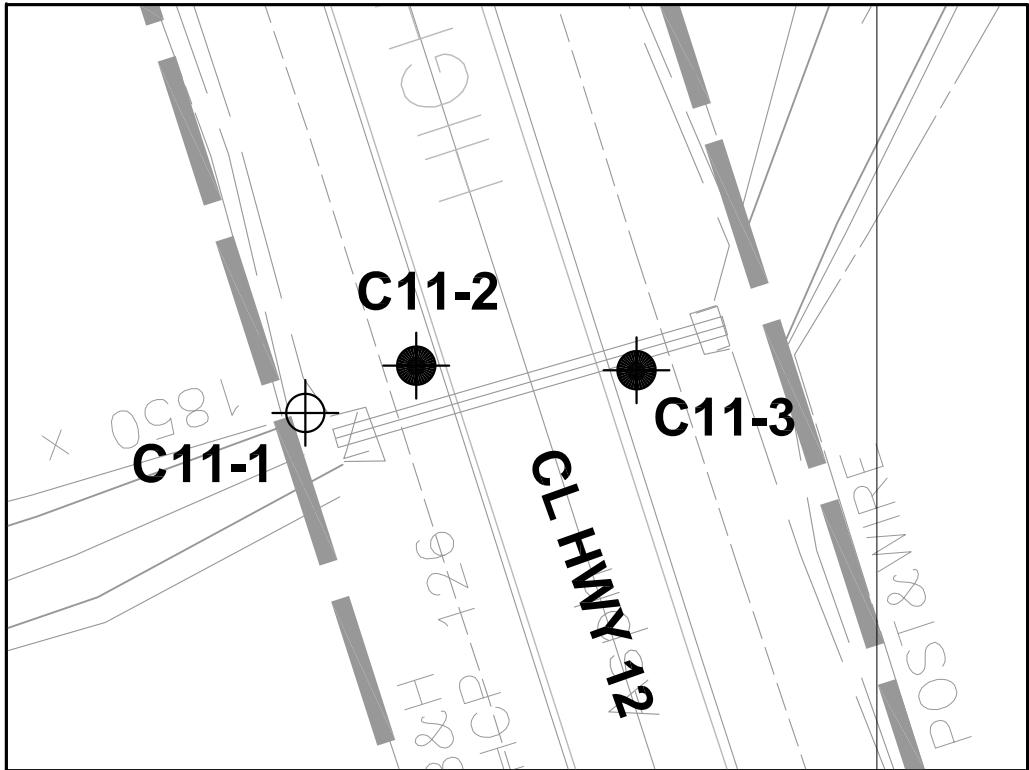
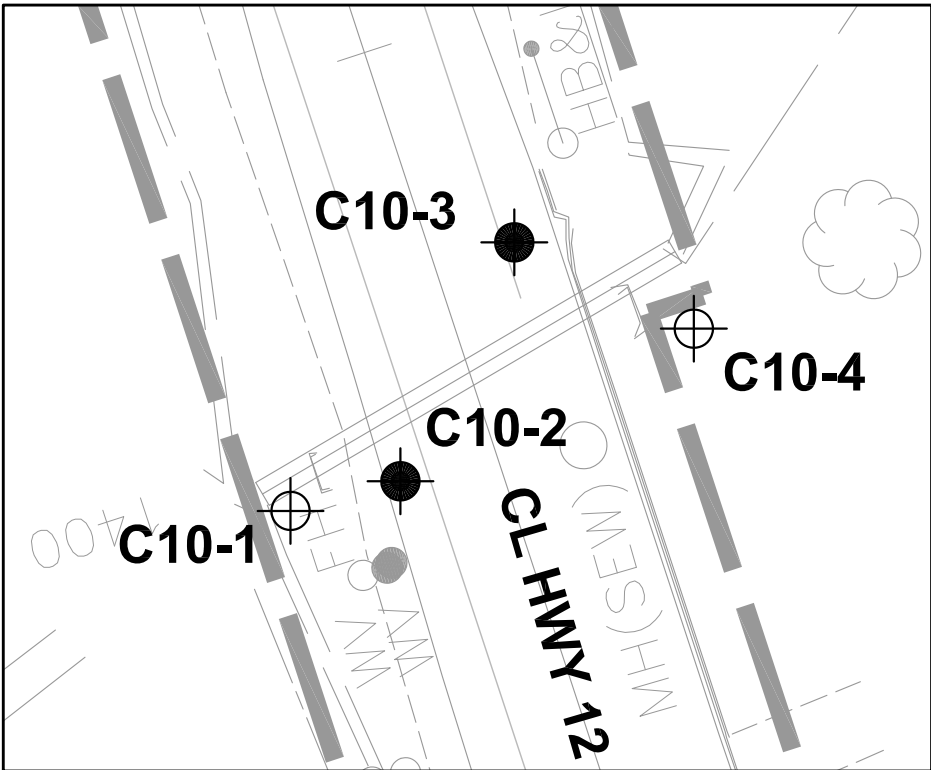
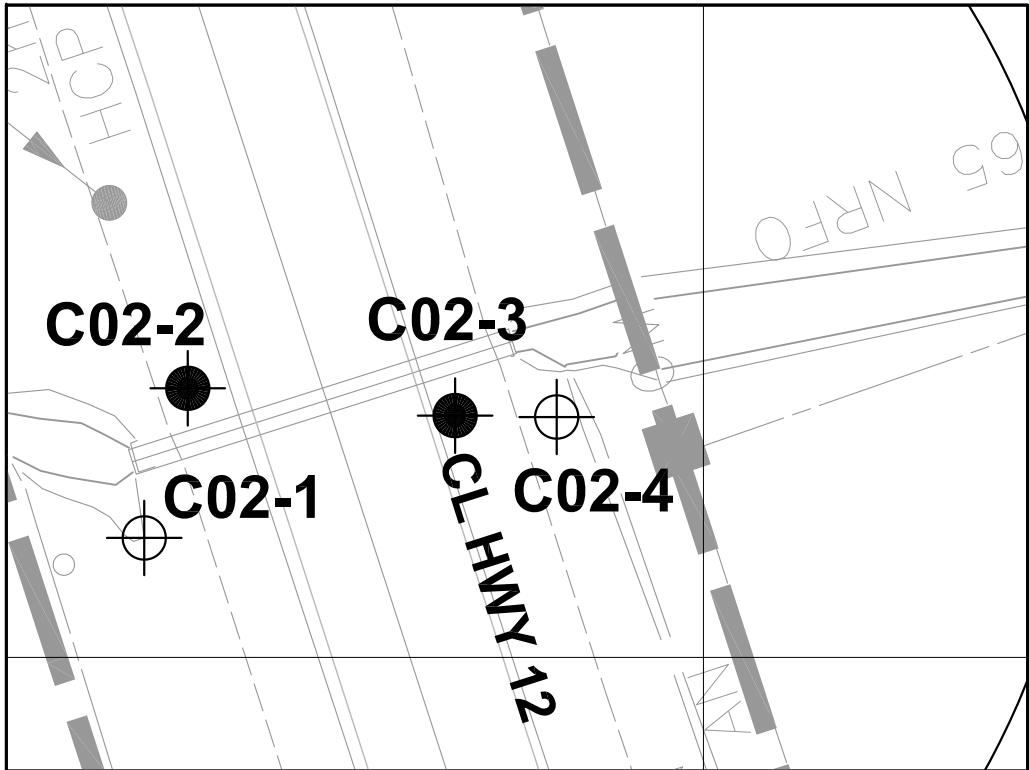
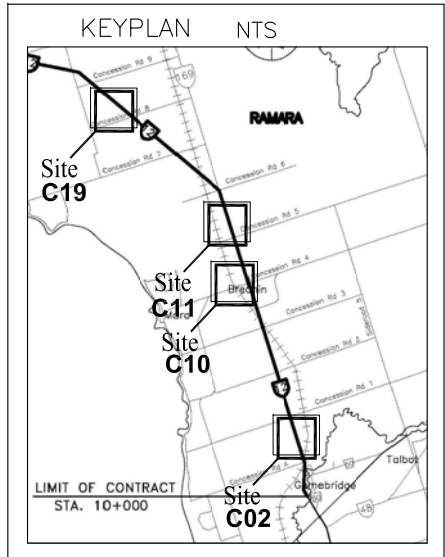
CONT No xxxx-xxxx  
WP No 365-98-00



Non-Structural Culverts  
Highway 12  
BOREHOLE LOCATION PLAN

SHEET  
1

**I.E. Group** Infrastructure Engineering Group Inc.  
Pavement & Construction Materials Consulting Engineers  
GTA • Kitchener • London • Windsor



LEGEND	
	Bore Hole
	Dynamic Cone Penetration Test (Cone)
	Bore Hole & Cone
	Blows/0.3m (Std Pen Test, 475 J/blow)
	Blows/0.3m (60° Cone, 475 J/blow)
	W L at time of investigation
	Standpipe

NOTES  
1. 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 ARE SPECIFICALLY EXCLUDED IN ACCORDANCE WITH THE CONDITIONS OF SECTION GC2.01 of OPS GEN. COND.

BOREHOLE NO.	ELEVATION	UTM CO-ORDINATES		BOREHOLE NO.	ELEVATION	UTM CO-ORDINATES		BOREHOLE NO.	ELEVATION	UTM CO-ORDINATES		BOREHOLE NO.	ELEVATION	UTM CO-ORDINATES	
		NORTH	EAST			NORTH	EAST			NORTH	EAST			NORTH	EAST
C02-1	228.40	4929606	331974	C10-1	227.93	4934648	330331	C11-1	219.52	4935751	329970	C19-1	226.08	4939112	326832
C02-2	230.11	4929613	331976	C10-2	229.04	4934650	330337	C11-2	221.00	4935754	329976	C19-2	226.90	4939106	326846
C02-3	230.05	4929611	331988	C10-3	229.01	4934662	330343	C11-3	221.10	4935753	329987	C19-3	226.96	4939120	326846
C02-4	229.23	4929611	331993	C10-4	228.45	4934658	330353					C19-4	225.66	4939120	326856

REVISIONS			
	DATE	BY	DISCUSSION
	06/09/09	J.L.	Final
	18/05/09	J.L.	Draft
Geocres : 31D-484			
HWY No.	HWY 12		DIST CENTRAL
SUBM'D	J.L.	CHECKED E.C.	DATE 25/03/09
DRAWN	J.L.	CHECKED J.L.	APPROVED E.C.
			SITE C02, 10, 11, 19
			DWG 1



MINISTRY OF TRANSPORTATION, ONTARIO

METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No xxxx-xxxx  
WP No 365-98-00

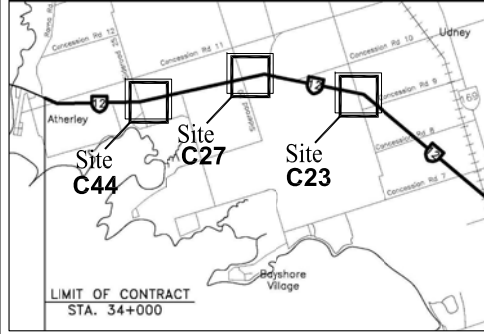


Non-Structural Culverts  
Highway 12  
BOREHOLE LOCATION PLAN

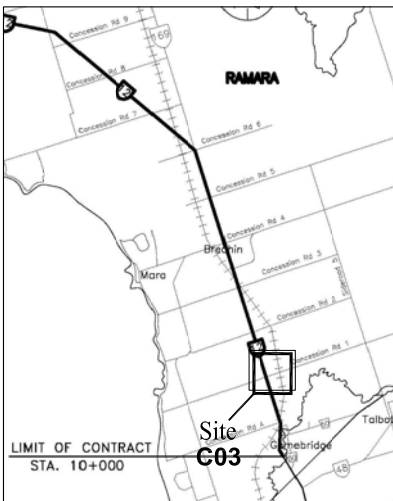
SHEET  
2

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KEYPLAN NTS



KEYPLAN NTS

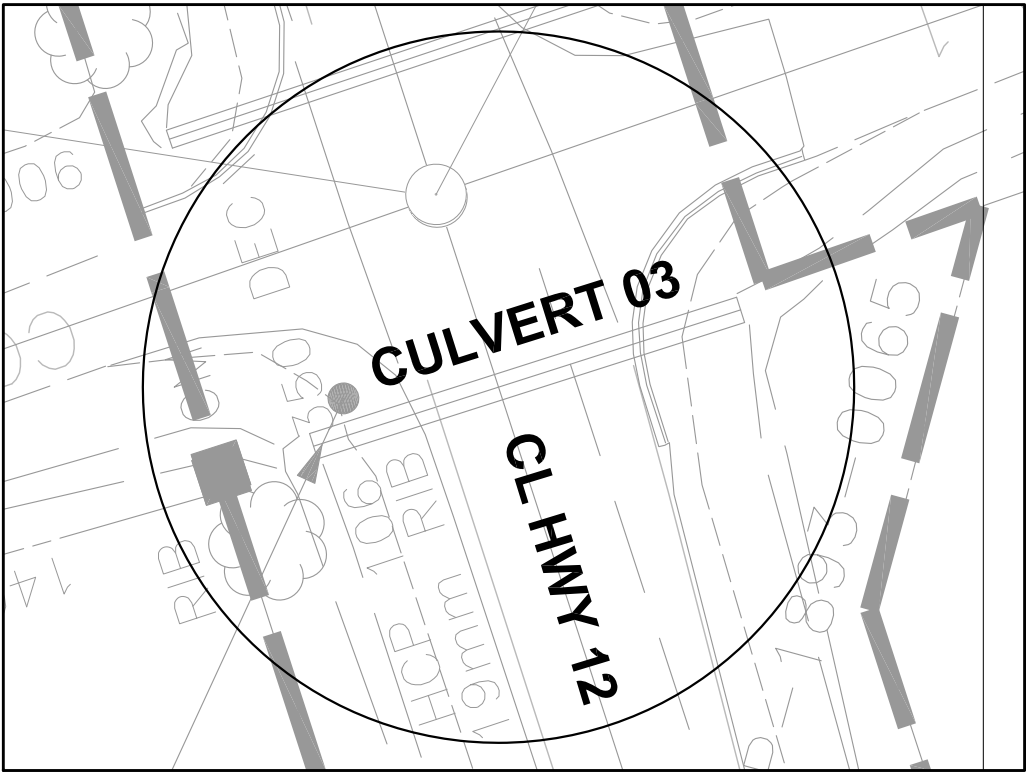
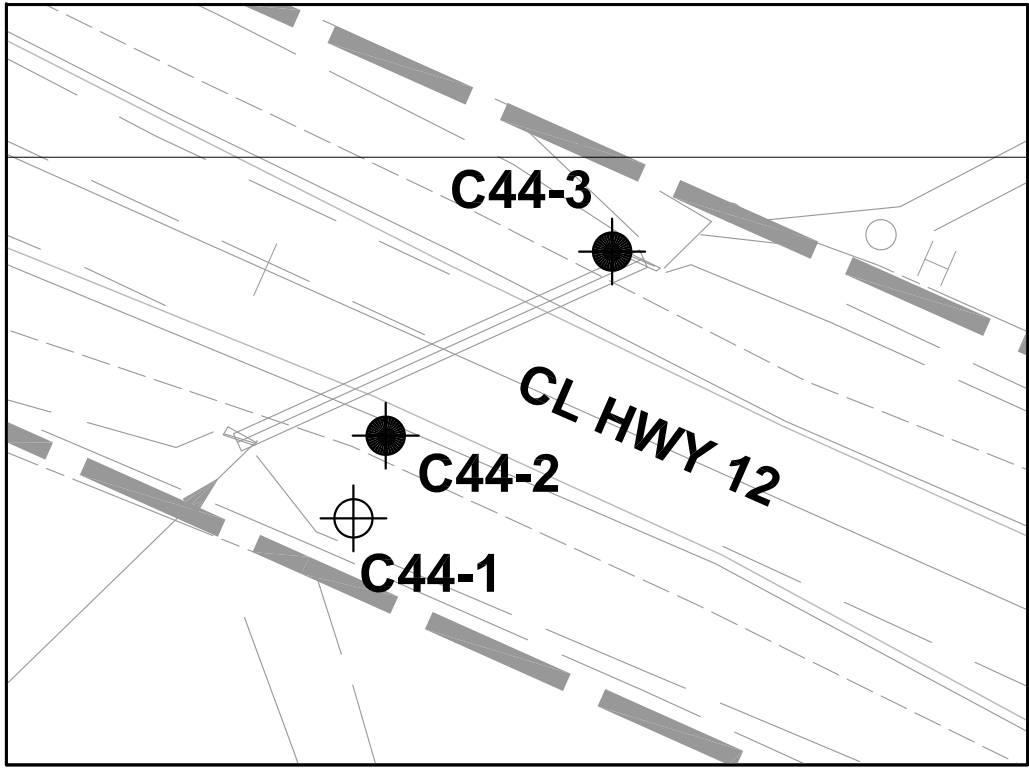
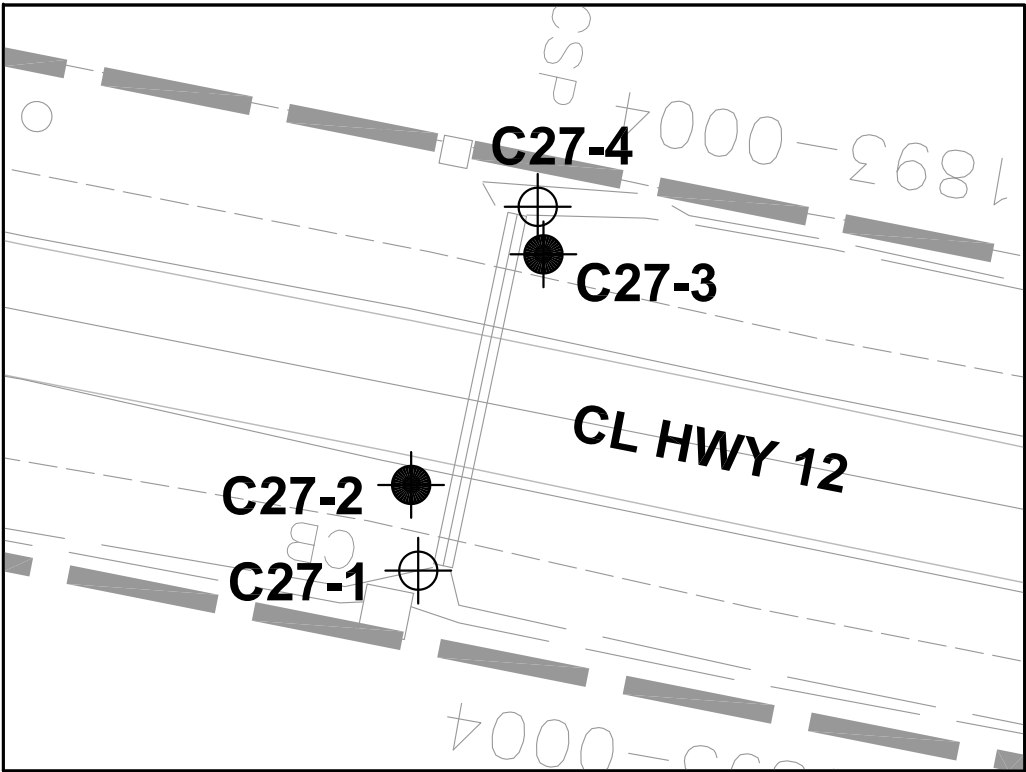
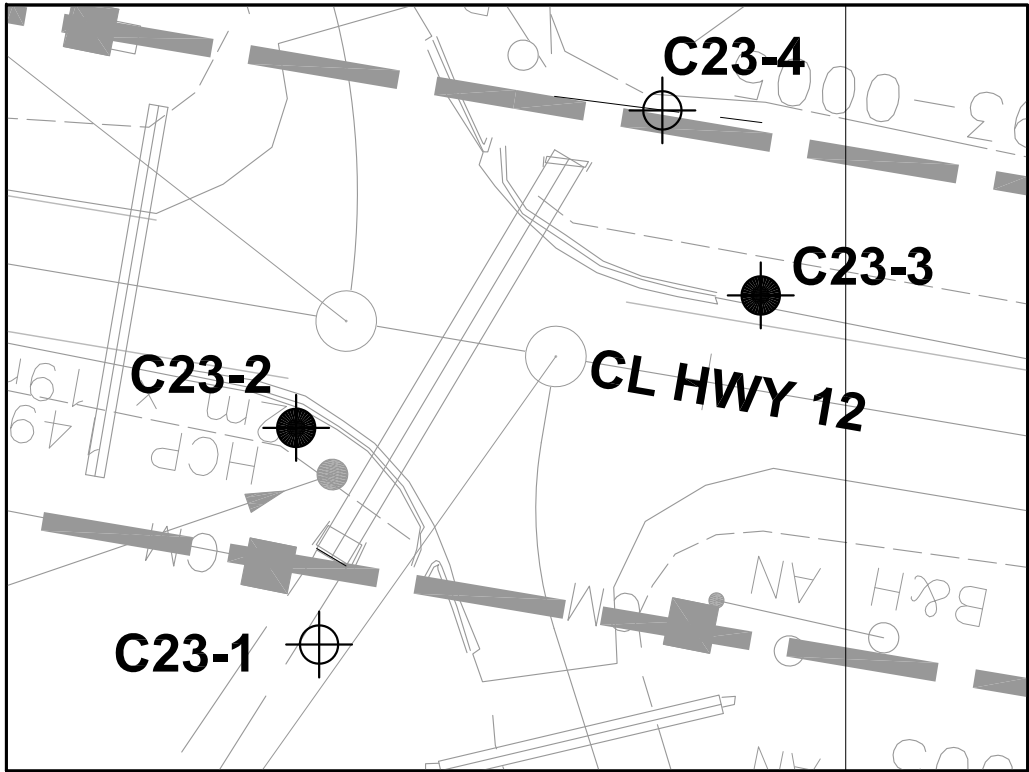


LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- Blows/0.3m (Std Pen Test, 475 J/blow)
- Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation
- Standpipe

REVISIONS			
	DATE	BY	DISCRIPTION

Geocres : 31D-484			
HWY No.	HWY 12		DIST CENTRAL
SUBM'D J.L.	CHECKED E.C.	DATE 25/03/09	SITE C03, 23, 27 & 44
DRAWN J.L.	CHECKED J.L.	APPROVED E.C.	DWG 2



- NOTES
1. 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 ARE SPECIFICALLY EXCLUDED IN ACCORDANCE WITH THE CONDITIONS OF SECTION GC2.01 of OPS GEN. COND.
  2. C03 WAS RECENTLY ADDED TO THE REPLACEMENT/REHABILITATION LIST AND BOREHOLES ARE NOT COMPLETED FOR THIS NON-STRUCTURAL CULVERT SITE.

BOREHOLE NO.	ELEVATION	UTM CO-ORDINATES		BOREHOLE NO.	ELEVATION	UTM CO-ORDINATES		BOREHOLE NO.	ELEVATION	UTM CO-ORDINATES	
		NORTH	EAST			NORTH	EAST			NORTH	EAST
C23-1	222.98	4940216	325372	C27-1	223.45	4940511	323966	C44-1	220.58	4939981	316445
C23-2	224.98	4940227	325371	C27-2	225.08	4940515	323965	C44-2	221.28	4939985	316447
C23-3	225.09	4940234	325395	C27-3	224.67	4940528	323972	C44-3	220.53	4939995	316459
C23-4	223.16	4940244	325390	C27-4	223.67	4940530	323972	C44-4	???.??	???????	???????

SCALE

20m



0

10m

Appendix B

Explanation of Terms Used in Report  
Record of Borehole Sheet  
Laboratory Test Results

<b>Culvert Site</b>	<b>Borehole Logs</b>	<b>Grain Size</b>	<b>Atterberg Limits</b>
C02	C02-1 to 4	Figures C-02.1 and 3	Figure C02.2 and 4
C10	C10-1 to 4	Figures C-10.1, 3, 5, 7, and 9	Figures C-10.2, 4, 6 and 8
C11	C11-1 to 4	Figures C-11.1 and 2	Figures C-11.3
C19	C19-1 to 4	Figures C-19.1 and 3	Figures C-19.2 and 4
C23	C23-1 to 4	Figures C-23.1, 3 and 5	Figures C-23.2, 4 and 6
C27	C27-1 to 4	Figures C-27.1, 3 and 5	Figures C-27.2, and 4
C44	C44-1 to 4	Figures C-44.1, 3, 5, 6 and 8	Figures C-44.2, 4, 7 and 9

Figure C10.10 Consolidation, Void Ratio vs. Pressure Plot

## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 1" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

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

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T.W. ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T.W. ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$C_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_r$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_c$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1. %	VOID RATIO	$e_{min}$	1. %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kn/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1. %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w	1. %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	kn/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kn/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	m <sup>3</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kn/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$i_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{i_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kn/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{i_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1. %	VOID RATIO IN LOOSEST STATE	j	kn/m <sup>3</sup>	SEEPAGE FORCE
$\gamma'$	kn/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

## METRIC




SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	STANDARD			DYN. CONE	WATER CONTENT (%)							
228.40 0.00	Ground							228	20	40	60	80	100	10	20	30	GR SA SI C
226.60 1.80	End of Borehole.							227									Dynamic cone refusal @ 1.8 m on presumed bedrock.

# RECORD OF BOREHOLE No C02-2

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northing - 4929613, Easting - 331976 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
 DATUM Geodetic DATE 12.01.08 - 12.01.08 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE								
230.11 0.00	Ground																
229.65 0.46	460 mm SHOULDER GRAVEL.		1	GRAB			230								24 62 11 4 (15)		
			2	SPT	11												
			3	SPT	4												
227.98 2.13	Sandy Silty CLAY TILL, CL Brown, moist to wet, very stiff to hard, with embedded gravel.		4	SPT	23											21.8	4 30 45 21 (66)
5			SPT	100+													
226.45 3.66	End of Borehole.														Auger refusal @ 3.66 m on presumed bedrock. Water level measured @ 1.8m @ completion of drilling.		

+ 3, X 3: Numbers refer to  
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

# RECORD OF BOREHOLE No C02-3

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northing - 4929611, Easting - 331988 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
 DATUM Geodetic DATE 12.01.08 - 12.01.08 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
230.05 0.00	Ground							20 40 60 80 100		10 20 30					
229.59 0.46	460 mm SHOULDER GRAVEL.  FILL Dark brown, moist, loose to compact, consisting of mixed Sand and Gravel, Silty Clay and Organic Topsoil.		1	GRAB							○			24 56 12 7 (20)	
228.83 1.22	FILL Brown, moist, Silty Clay, some sand.			2	SPT	5							○		10 38 31 21 (52)
228.53 1.52			3	SPT	8				95				42	20.8	
				4	SPT	7				110		○			4 42 30 23 (53)
	Sandy Silty CLAY TILL, CL Brown, moist to wet, firm to hard, with embedded gravel.											○			
				5	SPT	68						○			
226.24 3.81	End of Borehole.														Auger and sampler refusal on presumed bedrock @ 3.81 m. Water level measured @ 3.5m @ completion of drilling.

+ 3, X 3: Numbers refer to  
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

# RECORD OF BOREHOLE No C02-4

1 OF 1

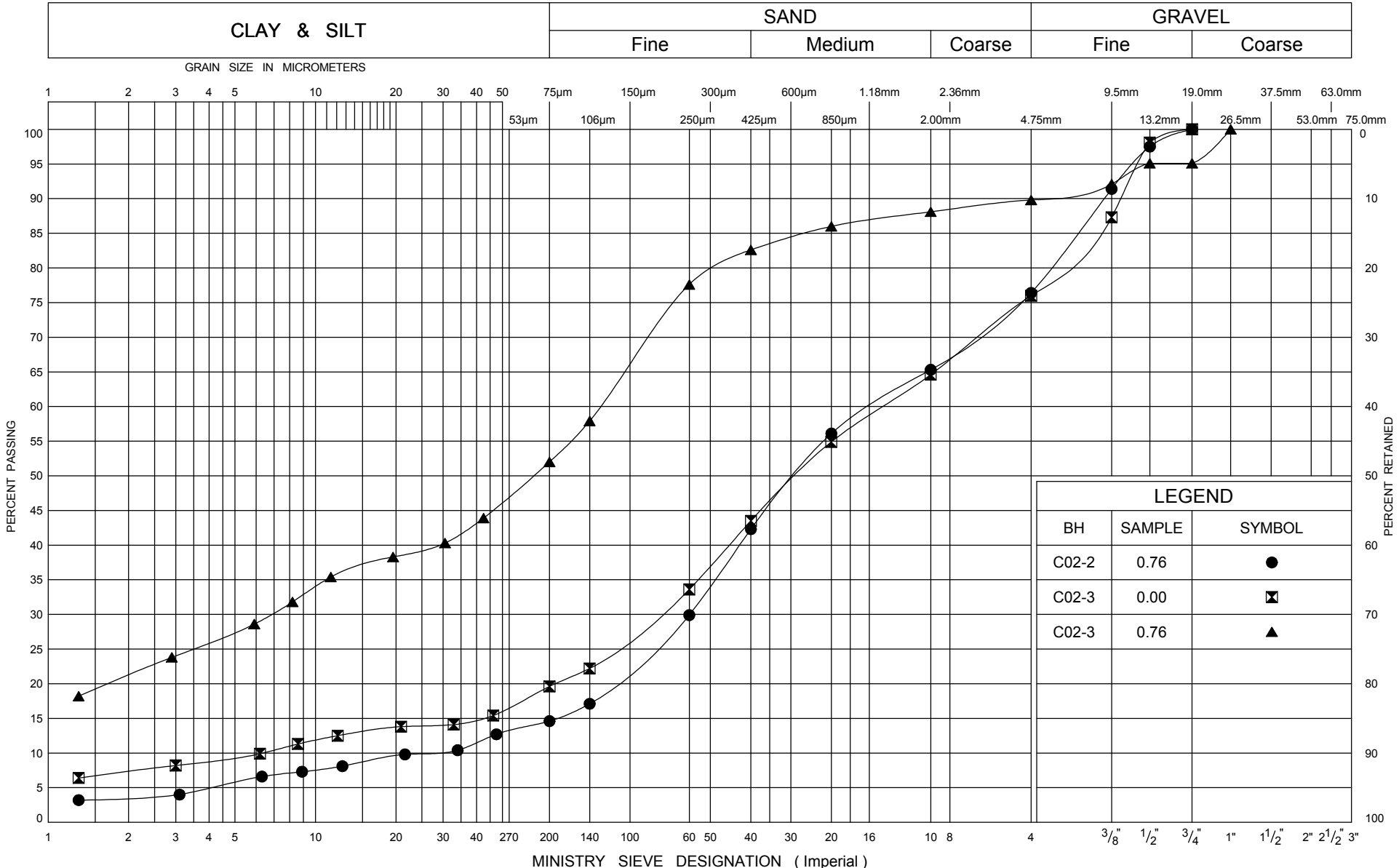
**METRIC**

W.P. WP 365-98-00 LOCATION Northing - 4929611, Easting - 331993 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE Dynamic Cone COMPILED BY JL  
 DATUM Geodetic DATE 12.04.08 - 12.04.08 CHECKED BY EC

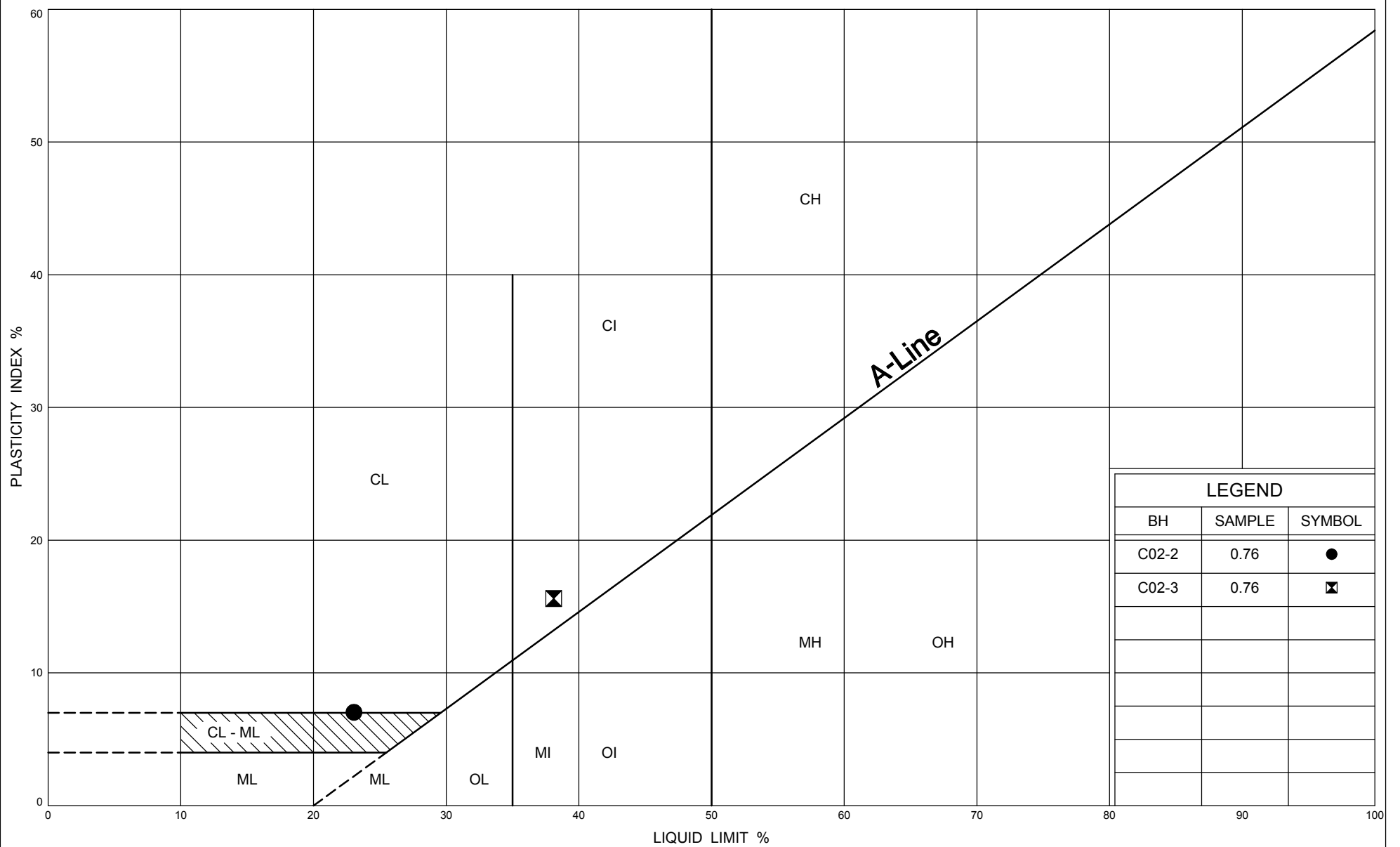
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
229.23 0.00	Ground																31.75 Kg (70lbs.) hammer used for driving dynamic cone. Nc values corrected for standard 63 kg (140 lbs.) hammer.
227.25 1.98	End of Borehole.																Dynamic cone refusal @ 1.98 m on presumed bedrock.

JOE MTO 08-1-IEG6 CULVERTS.GPJ ONTARIO MOT.GDT 05/17/09

UNIFIED SOIL CLASSIFICATION SYSTEM







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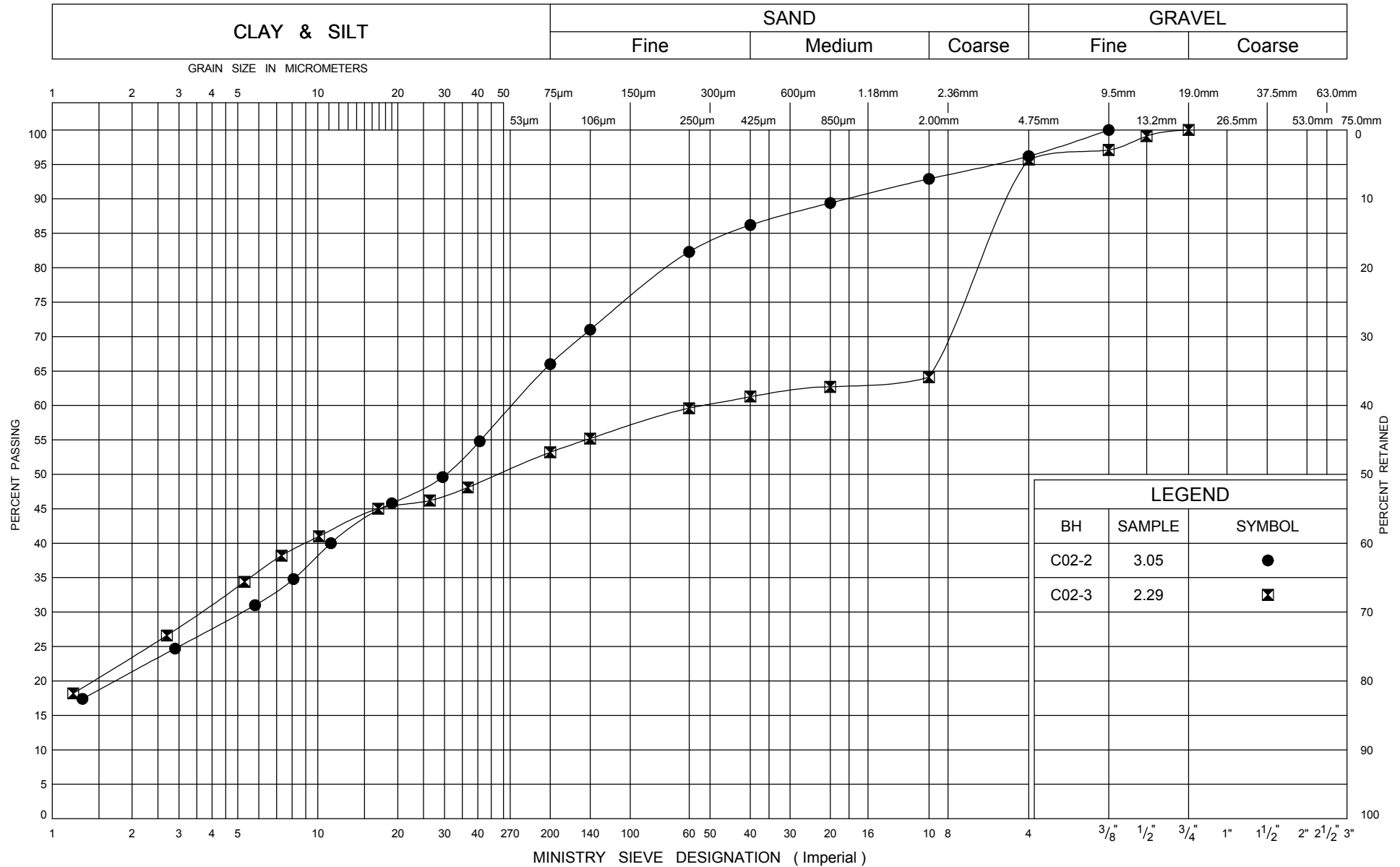
## PLASTICITY CHART FILL

FIG No C- 02.2

GWP 365-98-00

Highway 12, Rama Road to Gamebridge

## UNIFIED SOIL CLASSIFICATION SYSTEM



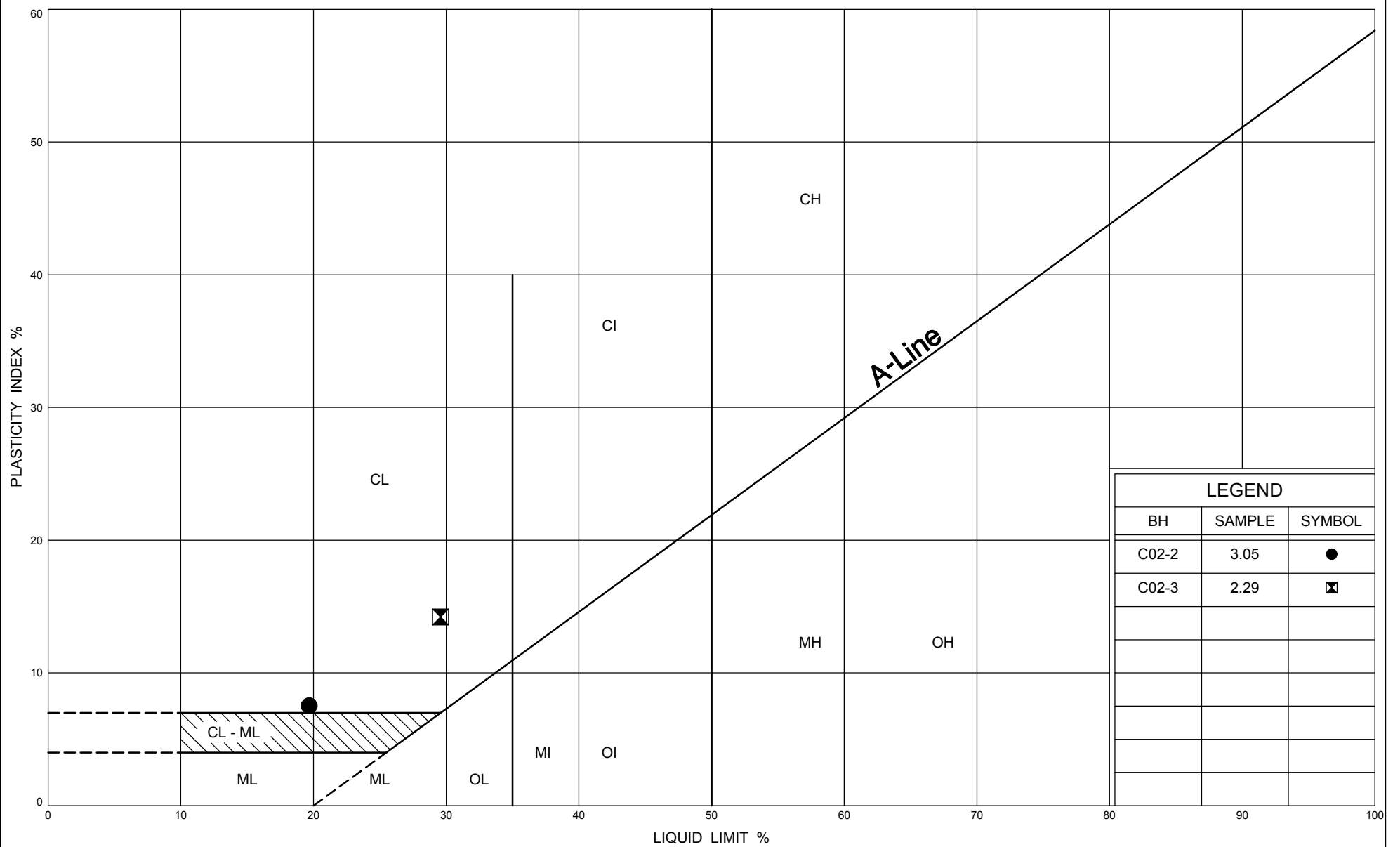
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GRAIN SIZE DISTRIBUTION  
SANDY SILTY CLAY TILL, CL

FIG No C- 02.3

GWP 365-98-00

Highway 12, Rama Road to Gamebridge



Ministry of  
Transportation

# PLASTICITY CHART SANDY SILTY CLAY TILL, CL

FIG No C- 02.4

GWP 365-98-00

Highway 12, Rama Road to Gamebridge

# RECORD OF BOREHOLE No C10-1

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northring - 4934648, Easting - 330331 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE Dynamic Cone COMPILED BY JL  
 DATUM Geodetic DATE 12.04.08 - 12.04.08 CHECKED BY EC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
							20 40 60 80 100						
227.93 0.00	Ground												GR SA SI CL
													31.75 Kg (70lbs.) hammer used for driving dynamic cone. Nc values corrected for standard 63 kg (140 lbs.) hammer.
224.63 3.30	End of Borehole.												Dynamic cone refusal @ 3.30 m on presumed bedrock.

JOE MTO 08-1-IEG6 CULVERTS.GPJ ONTARIO MOT.GDT 05/17/09

# RECORD OF BOREHOLE No C10-2

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northing - 4934650, Easting - 330337 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
 DATUM Geodetic DATE 12.02.08 - 12.02.08 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE							
								● QUICK TRIAXIAL	× LAB VANE							
229.04 0.00	Ground						20	40	60	80	100	10	20	30		GR SA SI CL
	200mm ASPHALT		1	GRAB												32 42 20 7 (27)
	FILL Dark brown, moist, loose to compact, consisting mainly of silty sand, some gravel, trace organics, occasional silty clay lumps, .		2	SPT	10											18 54 21 6 (28)
227.21 1.83			3	SPT	8											Water Level measured @ 1.4m @ completion of drilling.
	Sandy Clayey SILT, CL-ML Grey, wet, soft, with embedded gravel.		4	SPT	2											3 26 53 17 (71)
225.84 3.20			5	SPT	13											attempted vane test, cannot penetrate. Retry with SPT, top 150 mm of sample disturbed by vane.
	SILT, ML Grey, wet, compact, trace fine sand.															
225.03 4.01			6	SPT	100+											Sampler refusal @ 4.01 m on presumed bedrock.
	End of Borehole.															

+ 3, X 3: Numbers refer to  
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

## METRIC

[illegible]

# RECORD OF BOREHOLE No C10-4

1 OF 1

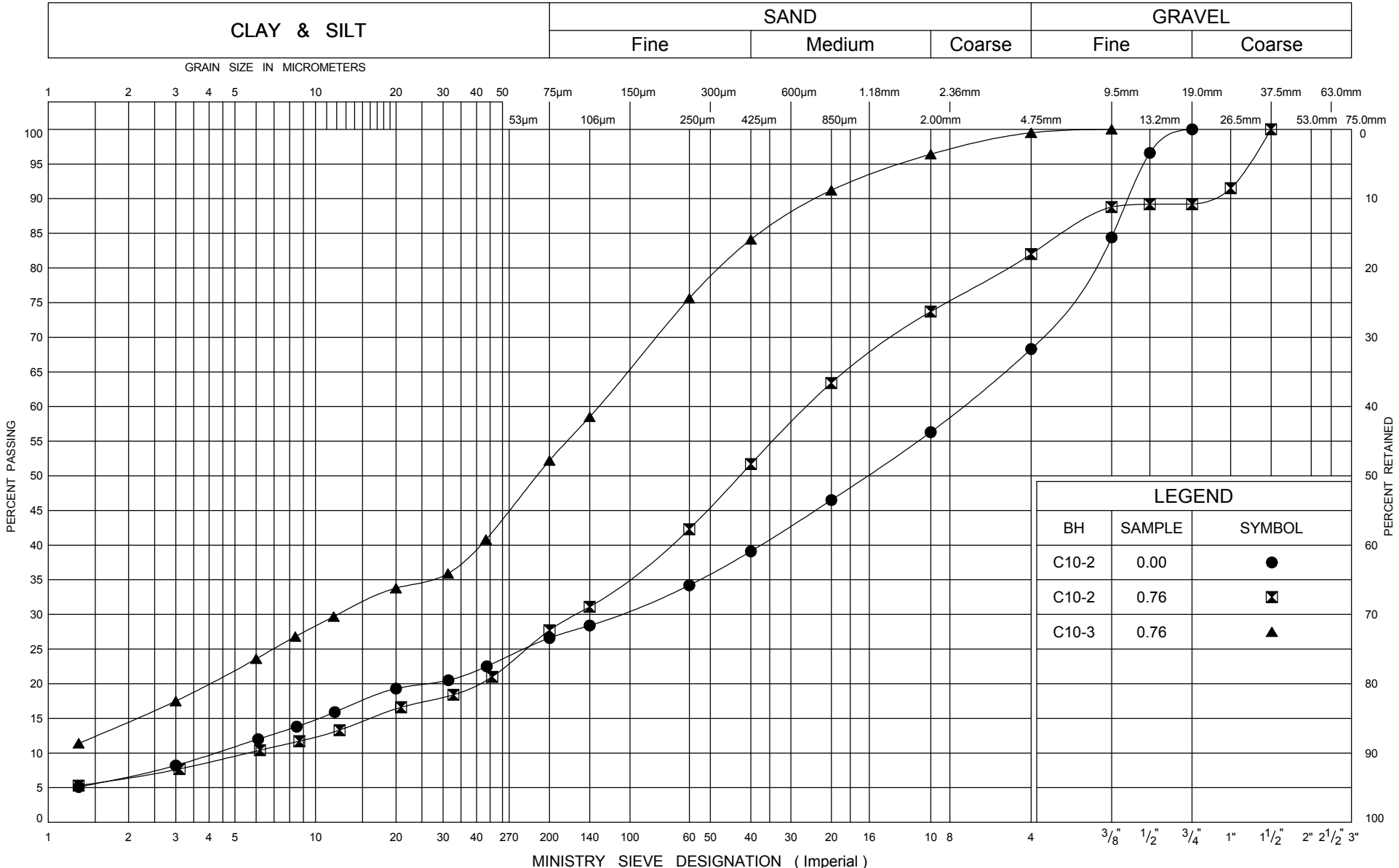
**METRIC**

W.P. WP 365-98-00 LOCATION Northing - 4934658, Easting - 330353 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE Dynamic Cone COMPILED BY JL  
 DATUM Geodetic DATE 12.04.08 - 12.04.08 CHECKED BY EC

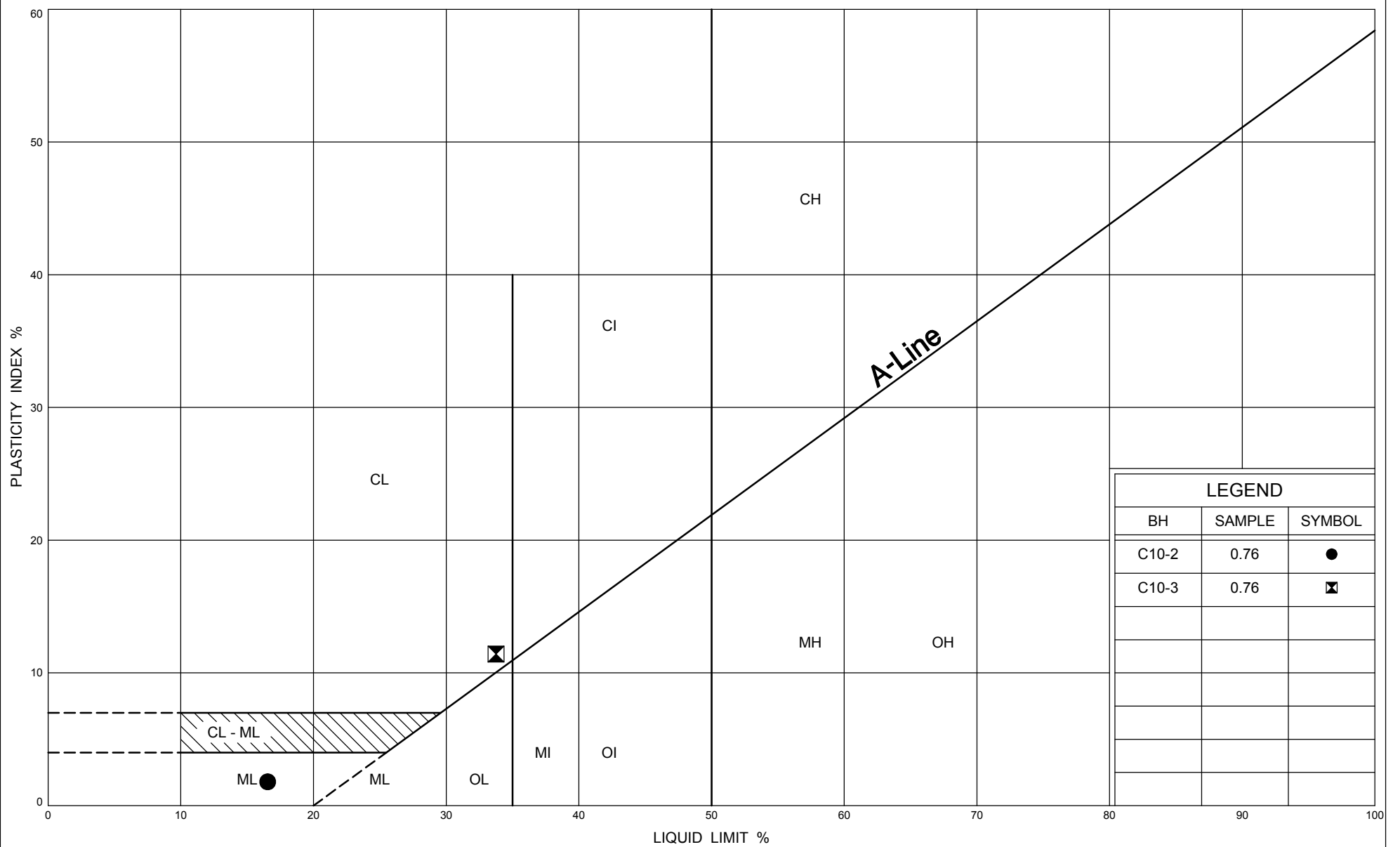
SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa												
						○ UNCONFINED			+	FIELD VANE								
						● QUICK TRIAXIAL			×	LAB VANE								
							WATER CONTENT (%)											
228.45 0.00	Ground																	

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## PLASTICITY CHART FILL

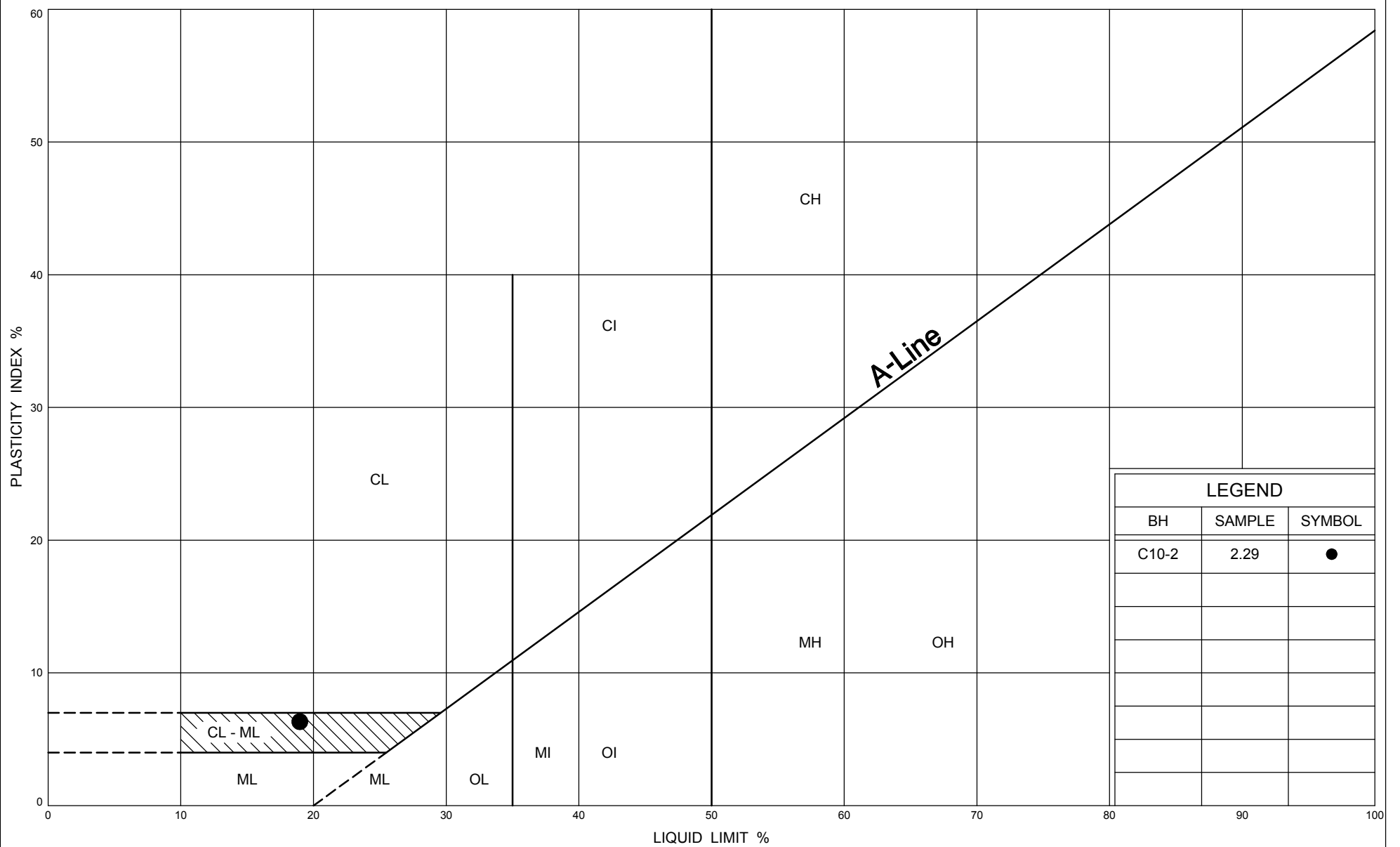
FIG No C- 10.2

GWP 365-98-00

Highway 12, Rama Road to Gamebridge



Highway 12, Rama Road to Gamebridge



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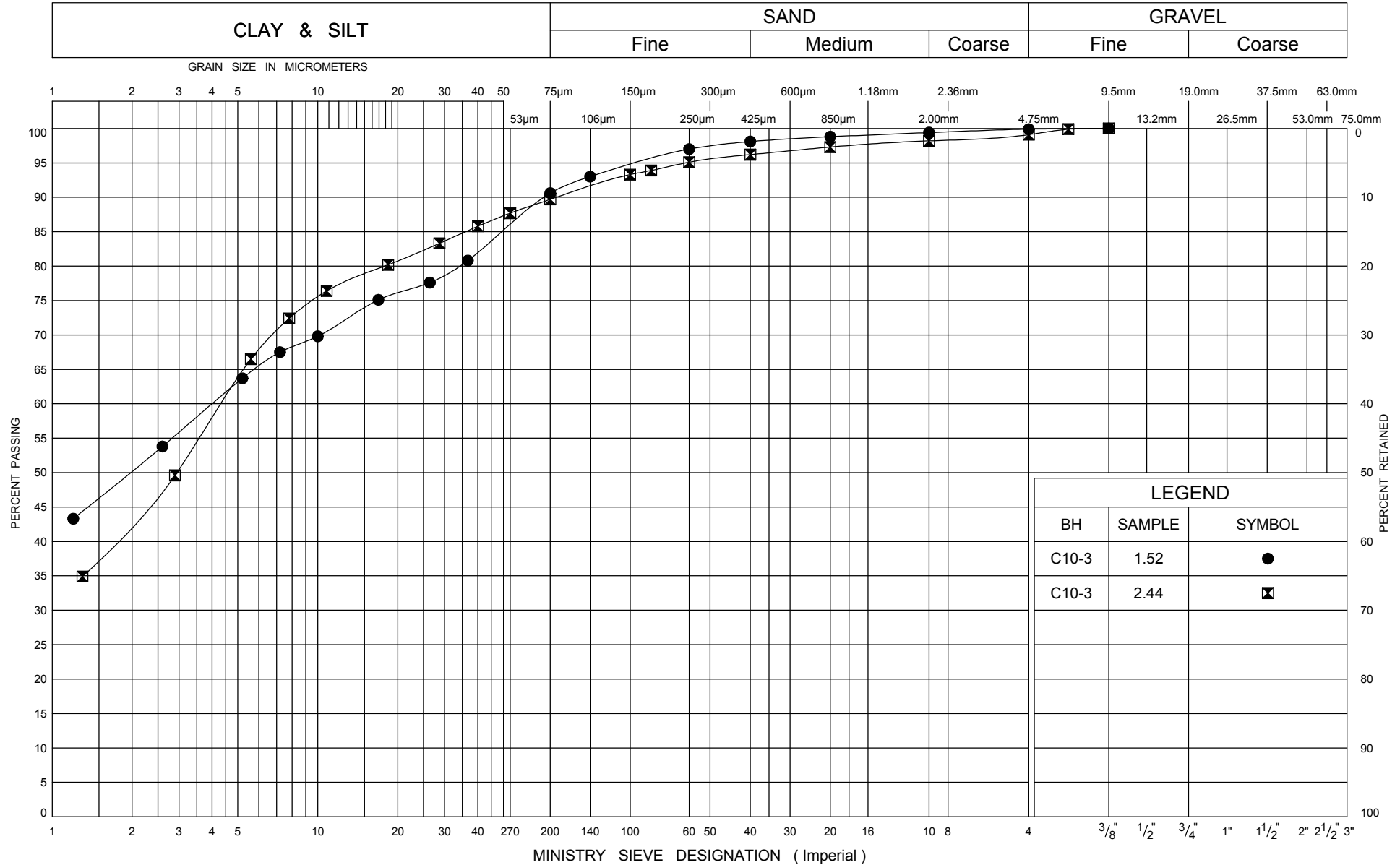
# PLASTICITY CHART SANDY CLAYEY SILT, CL-ML

FIG No C- 10.4

GWP 365-98-00

Highway 12, Rama Road to Gamebridge

## UNIFIED SOIL CLASSIFICATION SYSTEM



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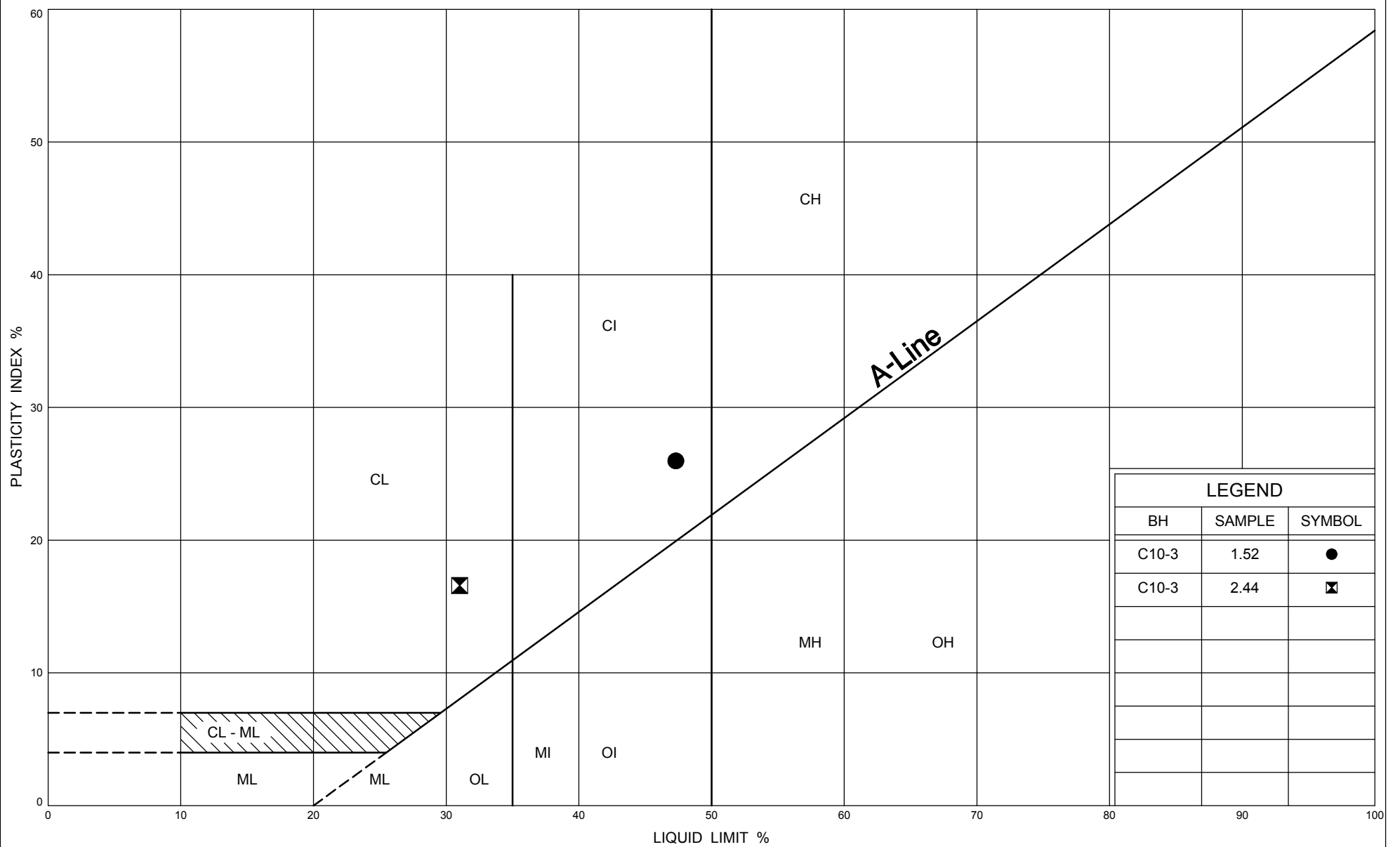
## GRAIN SIZE DISTRIBUTION

SILTY CLAY, CL TO CI  
LAYERED, WITH FREQUENT SILT SEAMS AND POCKETS

FIG No C- 10.5

WP 365-98-00

Highway 12, Rama Road to Gamebridge



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## PLASTICITY CHART

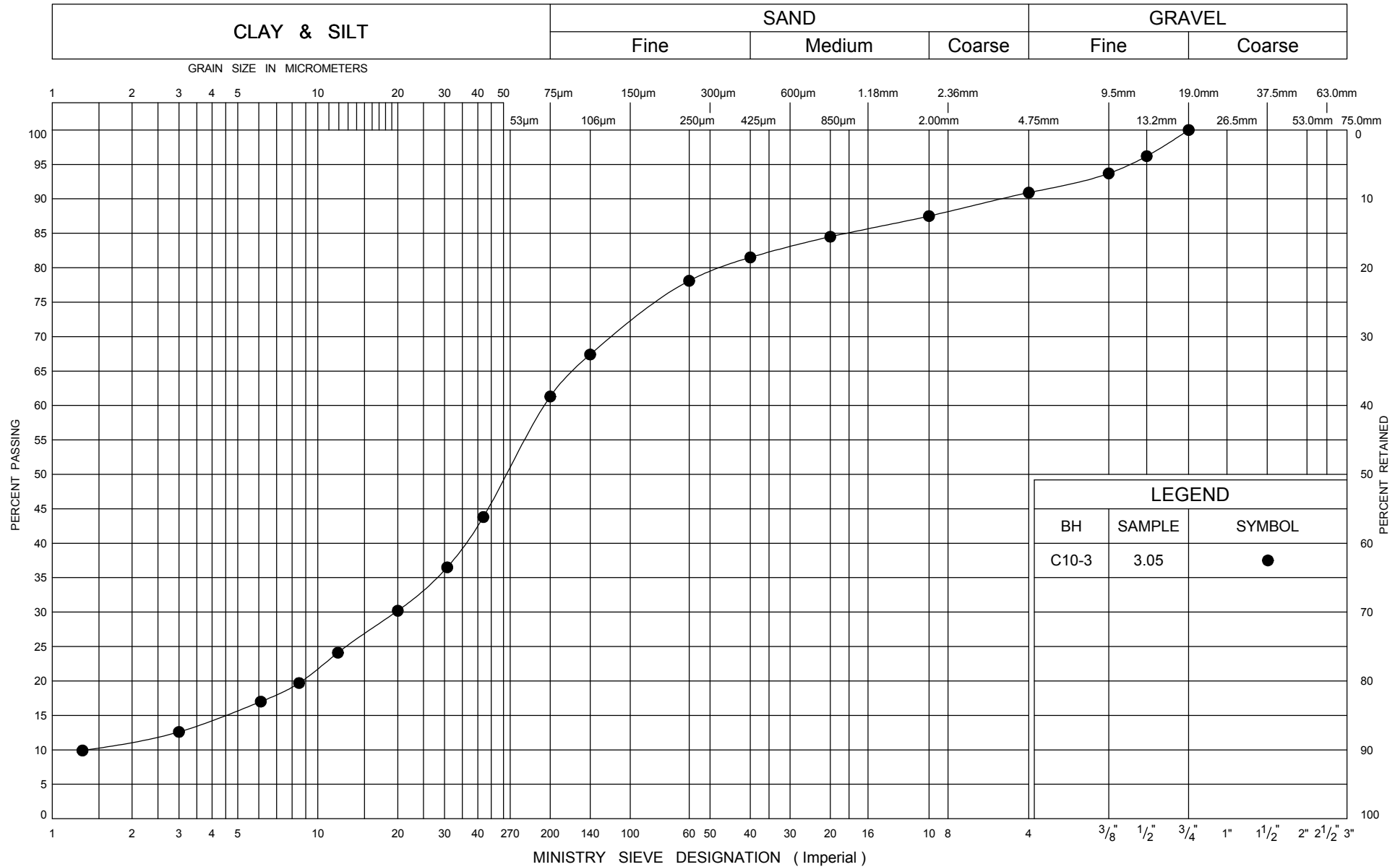
SILTY CLAY, CL TO CI  
LAYERED, WITH FREQUENT SILT SEAMS AND POCKETS

FIG No C- 10.6

WP 365-98-00

Highway 12, Rama Road to Gamebridge

## UNIFIED SOIL CLASSIFICATION SYSTEM



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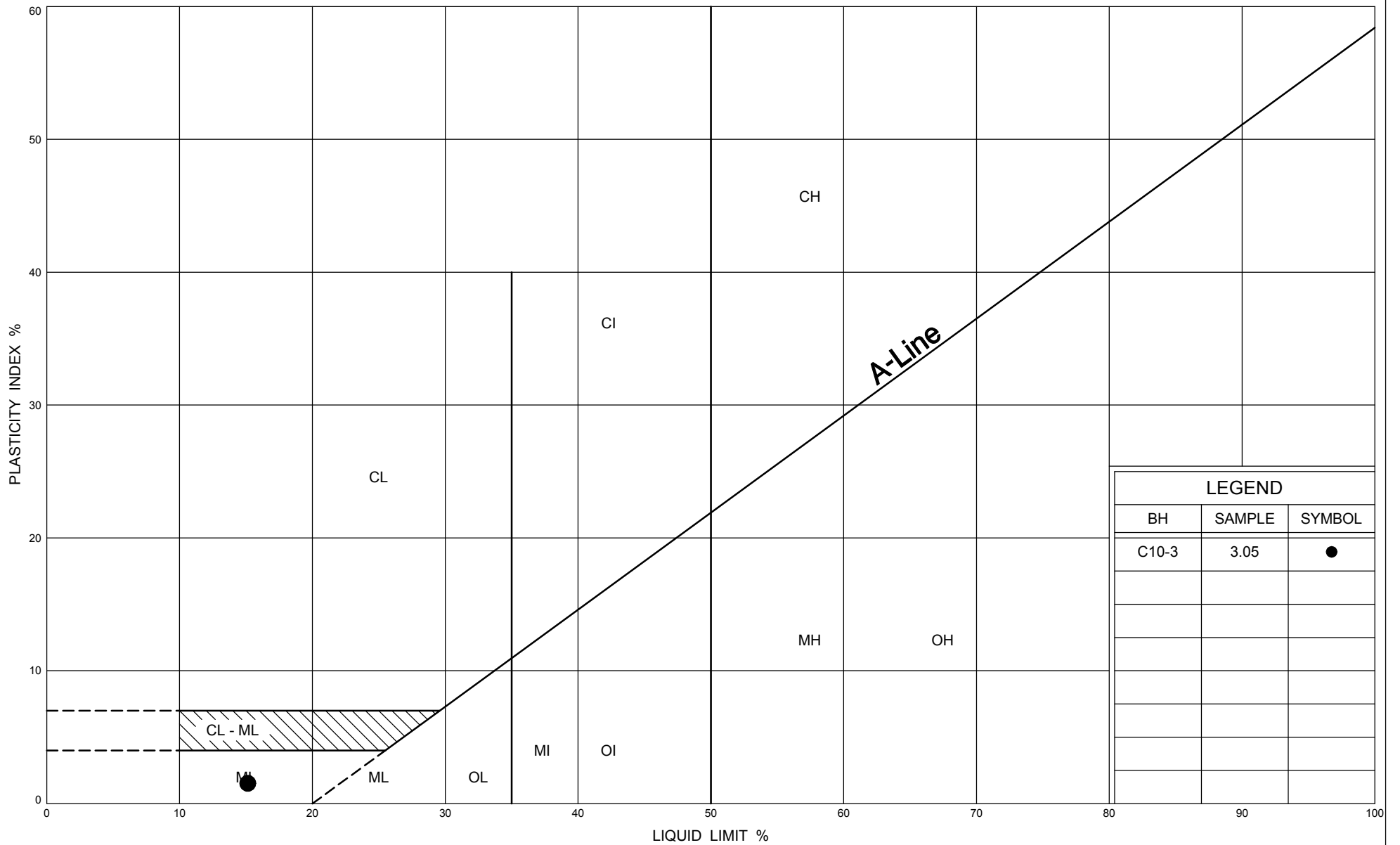
## GRAIN SIZE DISTRIBUTION

### SANDY SILT, ML

FIG No C- 10.7

GWP 365-98-00

Highway 12, Rama Road to Gamebridge



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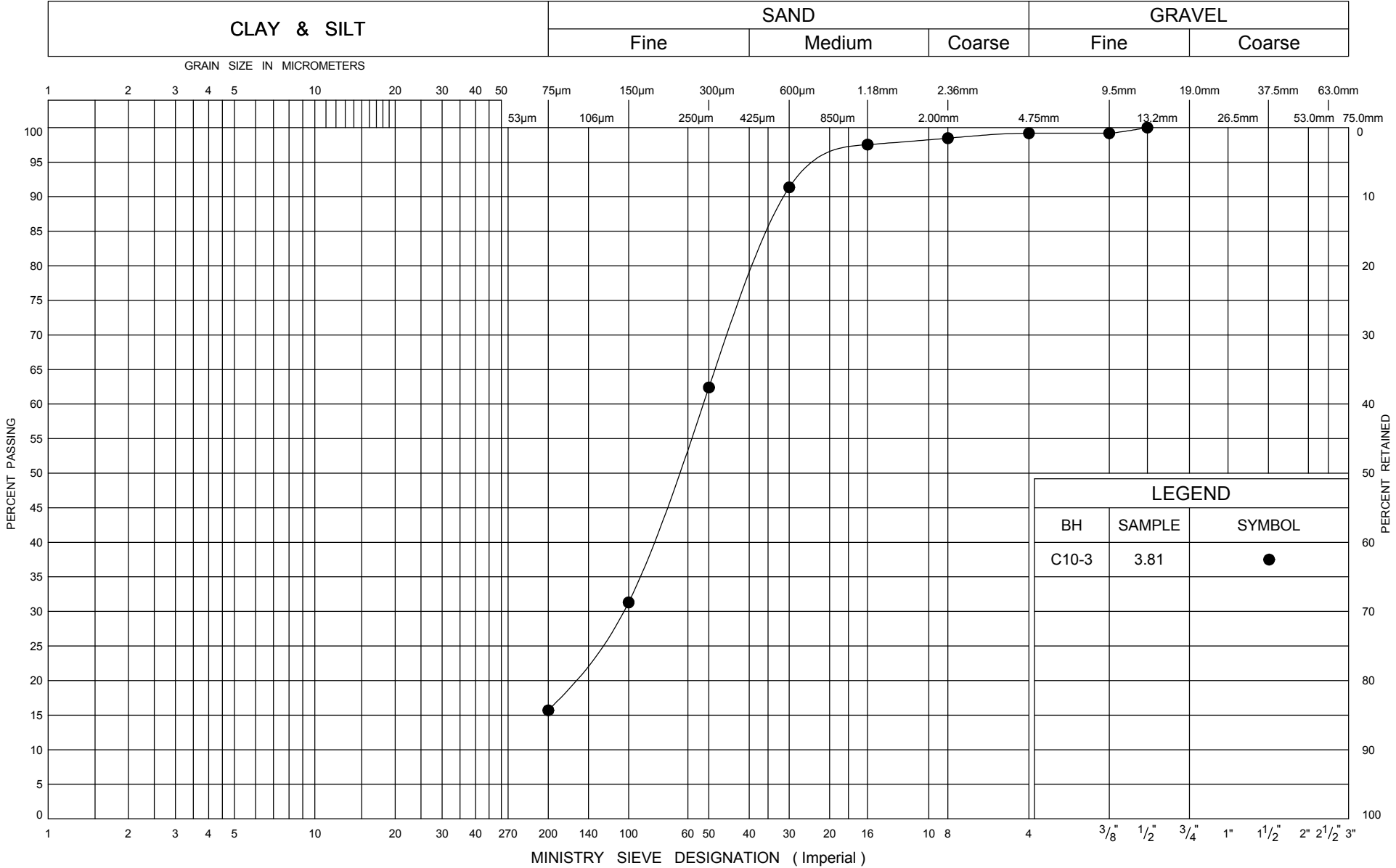
## PLASTICITY CHART SANDY SILT, ML

FIG No C- 10.8

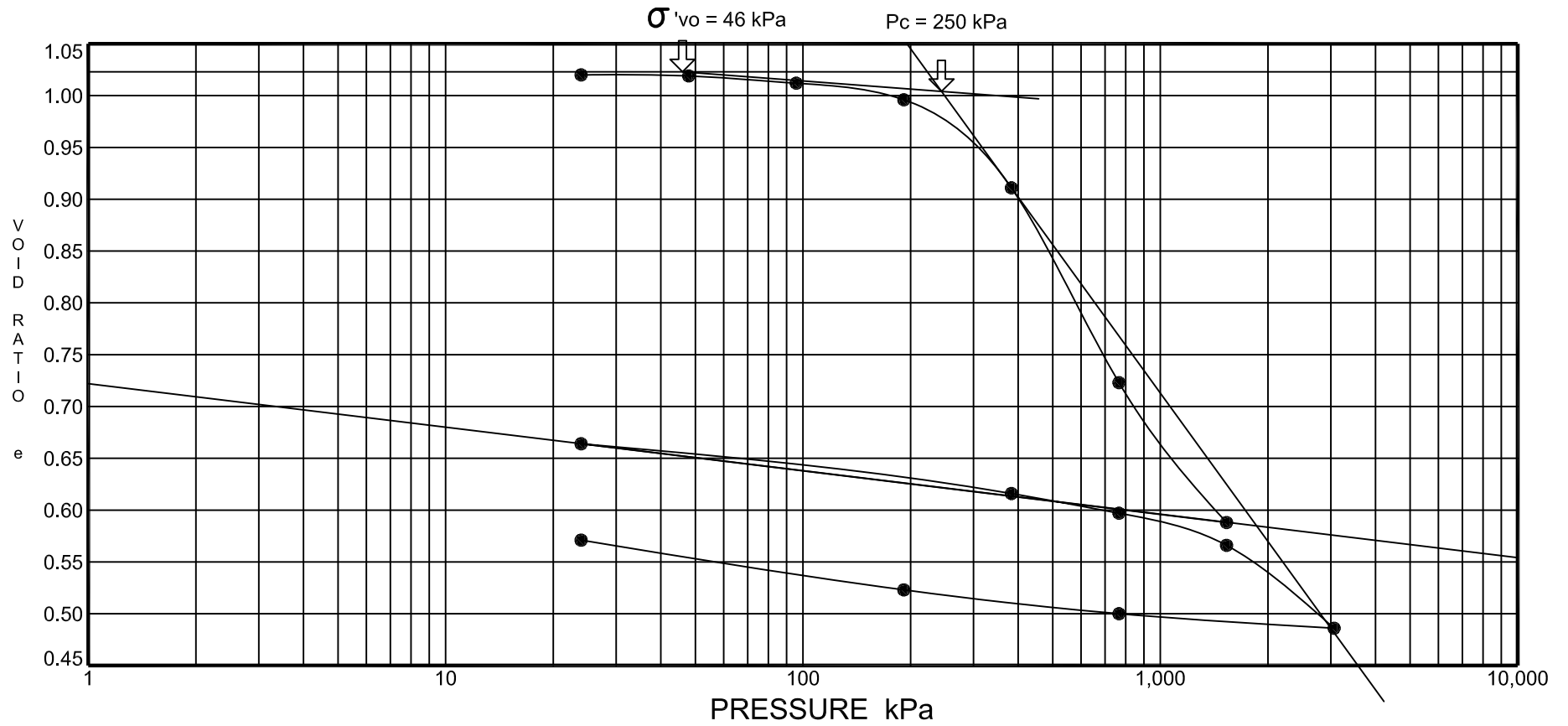
GWP 365-98-00

Highway 12, Rama Road to Gamebridge

UNIFIED SOIL CLASSIFICATION SYSTEM







R	BH	DEPTH	ELEV.	W <sub>L</sub>	W <sub>P</sub>	W	C <sub>C</sub>	C <sub>R</sub>	$\sigma'_{vo}$	$\gamma_d$	Classification
●	C10-3	2.44	226.57	31	14	39	0.476	0.083	46	13.3	LAYERED SILTY CLAY, CL



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VOID RATIO - PRESSURE CURVE

FIG No C-10.10

WP 365-98-00

Highway 12, Rama Road to Gamebridge

# RECORD OF BOREHOLE No C11-1

1 OF 1

**METRIC**

W.P. WP 365-98-00 LOCATION Northing - 4935751, Easting - 329970 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE Dynamic Cone COMPILED BY JL  
 DATUM Geodetic DATE 02.18.09 - 02.18.09 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
219.52	Water																
0.00	PONDED WATER																
219.22	GROUND SURFACE																
0.30																	
							219										
							218										
							217										
							216										
							215										
214.14	End of Borehole.																
5.38																	

31.75 Kg (70lbs.)  
hammer used for  
driving dynamic  
cone. Nc values  
corrected for  
standard 63 kg  
(140 lbs.)  
hammer.

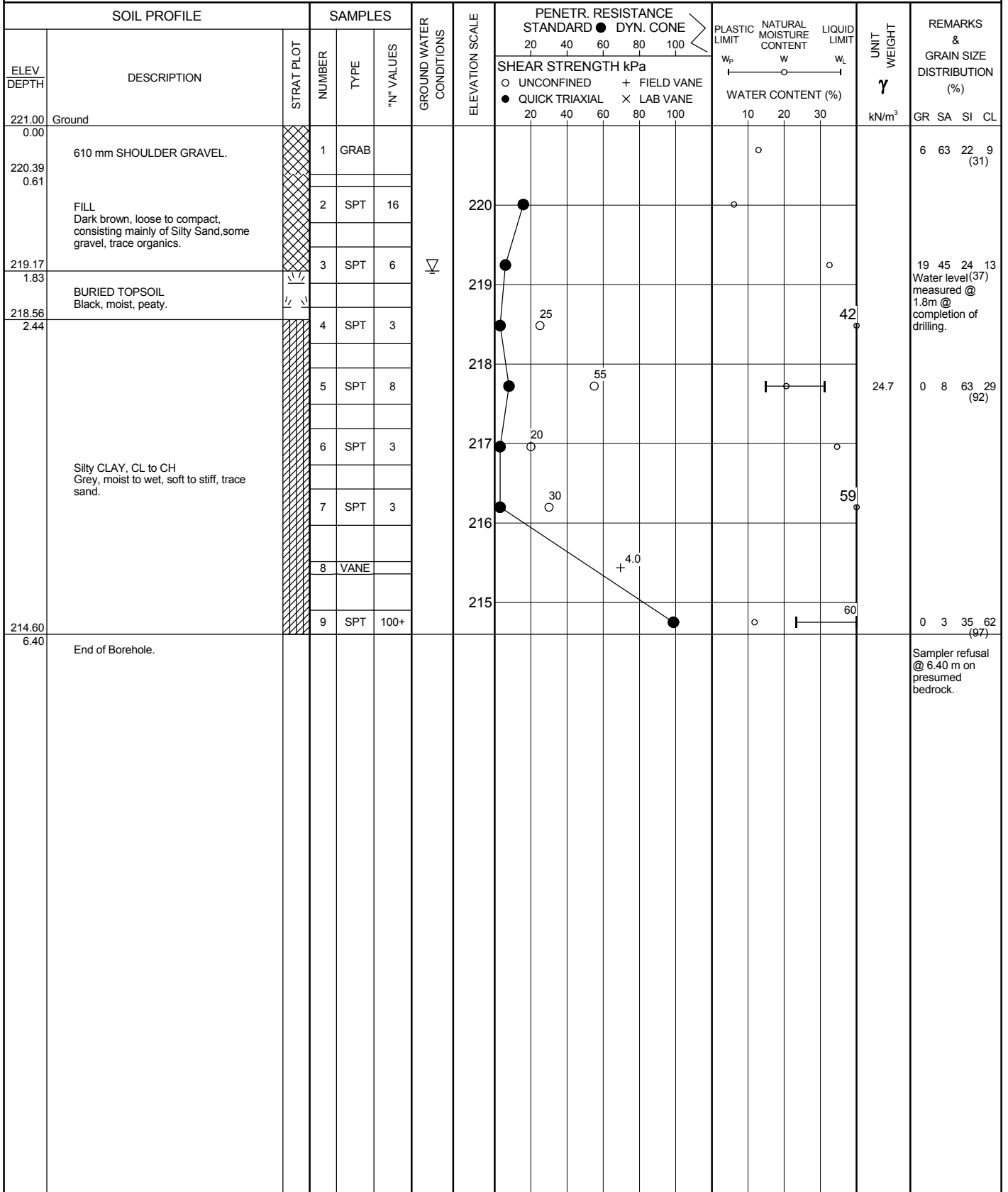
Dynamic cone  
refusal @ 5.38 m  
on presumed  
bedrock.

# RECORD OF BOREHOLE No C11-2

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northing - 4935754, Easting - 329976 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
 DATUM Geodetic DATE 12.01.08 - 12.02.08 CHECKED BY EC



+ 3, X 3: Numbers refer to  
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

# RECORD OF BOREHOLE No C11-3

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northing - 4935753, Easting - 329987 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
 DATUM Geodetic DATE 12.01.08 - 12.01.08 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
221.10 0.00	Ground															
220.49 0.61	610 mm SHOULDER GRAVEL.		1	GRAB		▽	221									
	FILL Dark brown, wet, loose, consisting mainly of inter-mixed clayey silt and topsoil.		2	SPT	9		220								5 18 42 35 (77)	
219.27 1.83	BURIED TOPSOIL Black, moist, peaty.		3	SPT	8		219								Water level measured @ 2.1m @ completion of drilling 55 35 (90)	
218.81 2.29	Silty CLAY, CI Grey, moist to wet, soft to firm, trace gravel and sand.		4	SPT	6		218		56					41	21.5	
			5	SPT	7		217			94						
			6	SPT	5		216			88						
			7	SPT	4		215			60					51	20.4
			8	SPT	2					25					45	1 5 44 50 (94)
			9	SPT	100+					20						
214.70 6.40	End of Borehole.													Sampler refusal @ 6.40 m on presumed bedrock.		

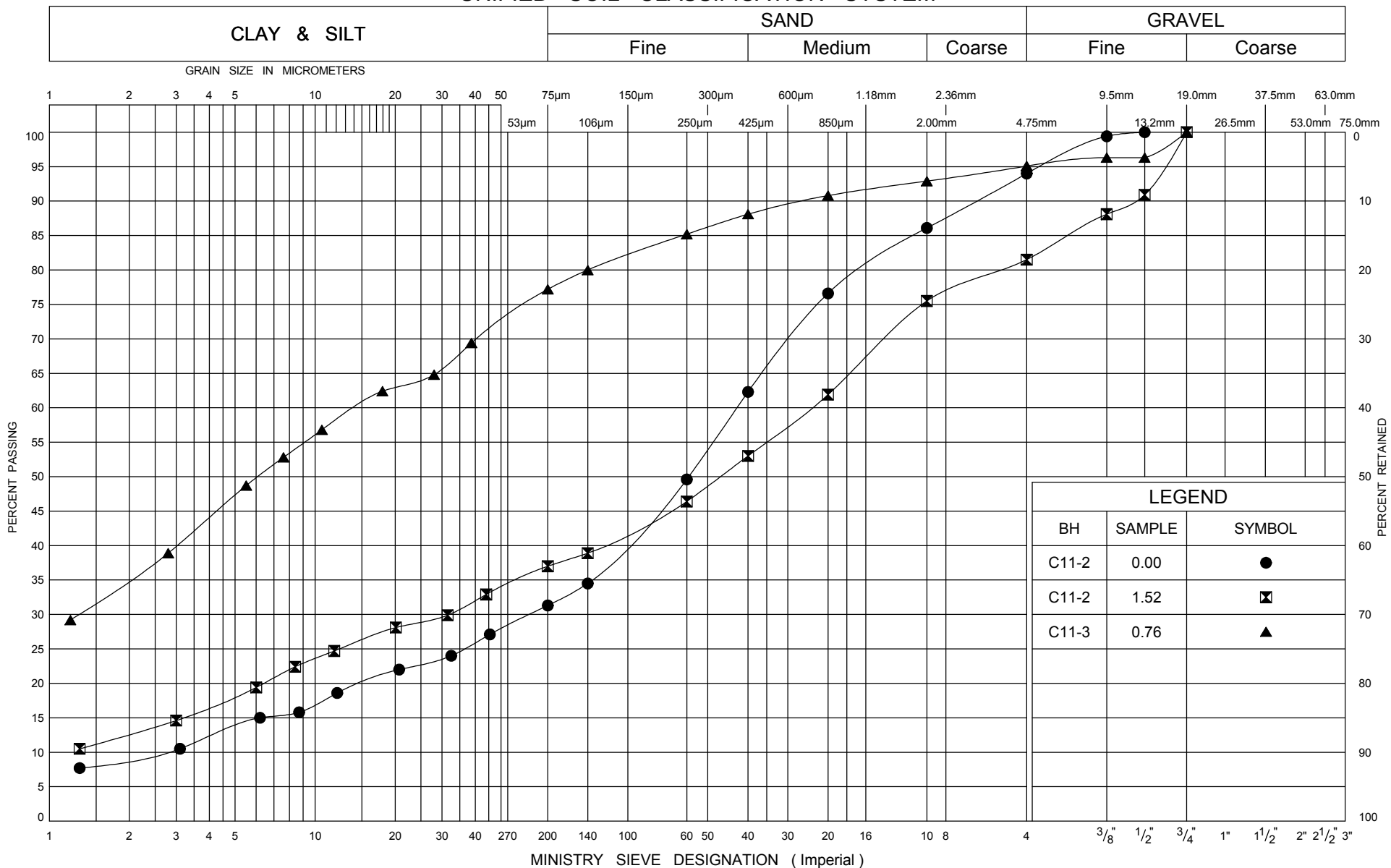
JOE MTO 08-I-IEG6 CULVERTS.GPJ ONTARIO MOT.GDT 05/17/09

1 OF 1

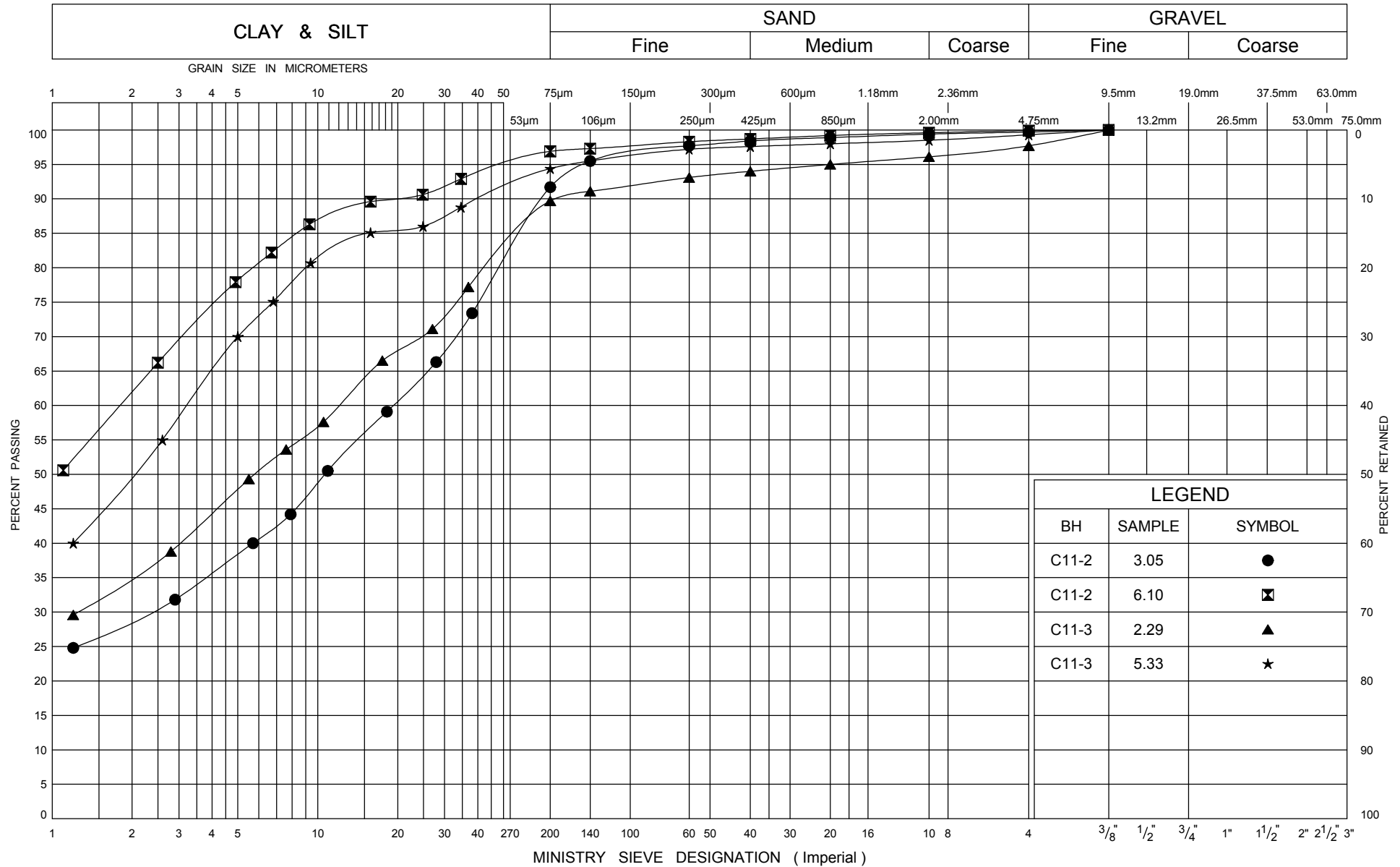
METRIC

○ <sup>150</sup> UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

# UNIFIED SOIL CLASSIFICATION SYSTEM



## UNIFIED SOIL CLASSIFICATION SYSTEM



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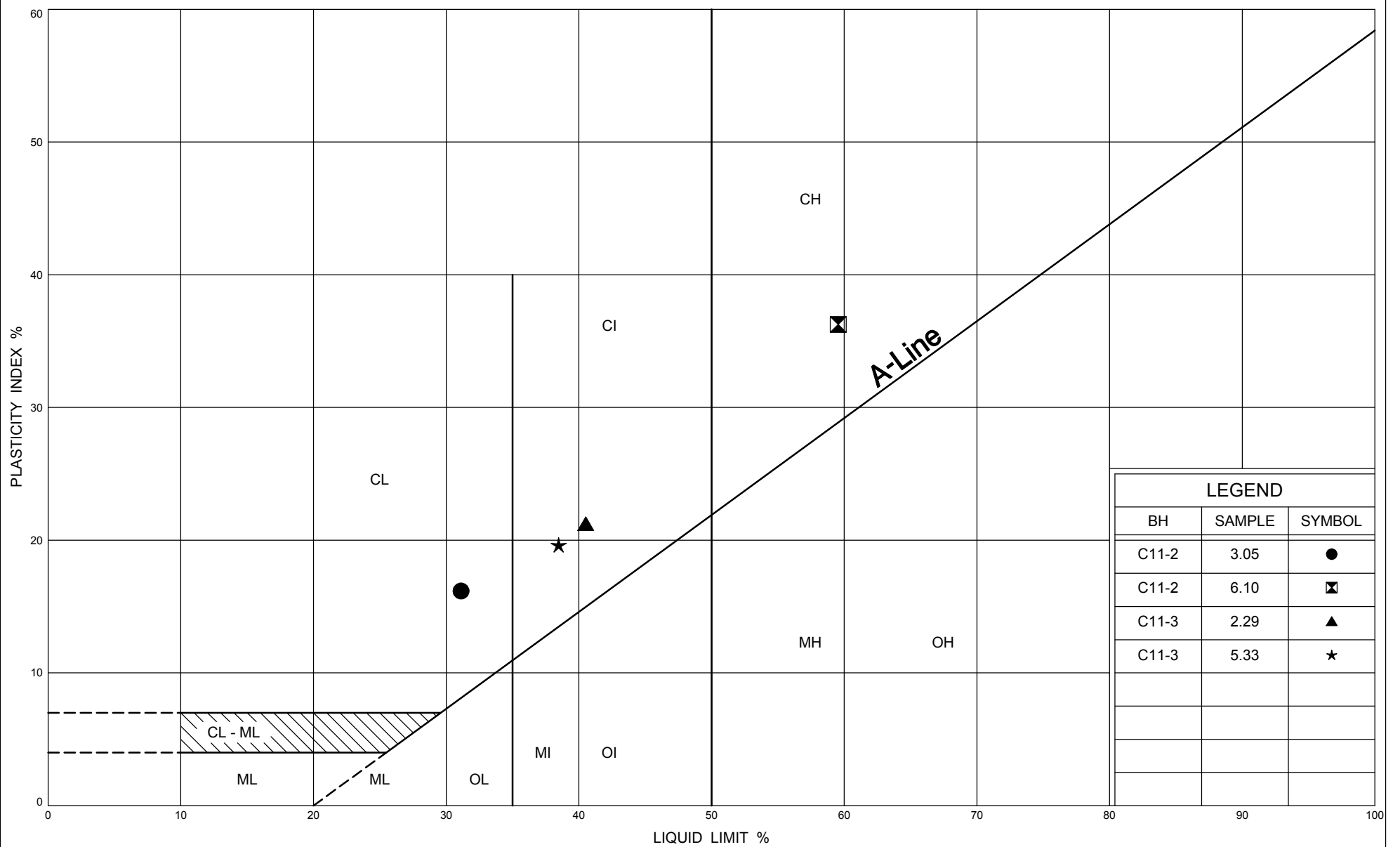
# GRAIN SIZE DISTRIBUTION

## SILTY CLAY, CL TO CH

FIG No C- 11.2

GWP 365-98-00

Highway 12, Rama Road to Gamebridge



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## PLASTICITY CHART SILTY CLAY, CL TO CH

FIG No C- 11.3

GWP 365-98-00

Highway 12, Rama Road to Gamebridge



# RECORD OF BOREHOLE No C19-1

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northing - 4939112, Easting - 326832 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
 DATUM Geodetic DATE 12.03.08 - 12.03.08 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
226.08	Ground						226									
0.00	150 mm TOPSOIL.		1	SPT	1											
	Gravelly Silty SAND, SW Brown to grey, moist, very loose to compact, some silt, trace clay.		2	SPT	7										22 52 19 7 (26)	
224.56			3	SPT	100+										26 49 17 8 (26)	
1.52	End of Borehole.														Sampler refusal @ 1.52 m on presumed bedrock. Borehole dry and open at completion.	

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# RECORD OF BOREHOLE No C19-2

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northring - 4939106, Easting - 326846 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
 DATUM Geodetic DATE 12.02.08 - 12.02.08 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
226.90	Ground							20 40 60 80 100		10 20 30					
0.00	500 mm Shoulder GRAVEL.		1	GRAB	n/a						○			GR SA SI CL	
	FILL Dark brown to grey, moist, loose, consisting of mixed silty clay, sandy silt, some gravel and organics.		2	SPT	11		226				○	—		11 35 33 21 (54)	
			3	SPT	8		225				○	—		17 47 24 13 (37)	
224.61	Gravelly Silty SAND, SW-SM Greyish brown, moist, dense, some clay.		4	SPT	31						○	—		26 44 20 10 (30)	
2.29															
224.00															
2.90	End of borehole.													Auger refusal @ 2.90 m on presumed bedrock. Borehole dry and open at completion.	

+ 3, X 3: Numbers refer to  
Sensitivity



○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

# RECORD OF BOREHOLE No C19-3

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northing - 4939120, Easting - 326846 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
 DATUM Geodetic DATE 12.02.08 - 12.02.08 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED	+ FIELD VANE									
						● QUICK TRIAXIAL	× LAB VANE											
226.96	Ground							20	40	60	80	100						
0.00	500 mm Shoulder GRAVEL.		1	GRAB	0													28 53 12 7 (19)
			2	SPT	8													
			3	SPT	7													
	FILL Dark brown to grey, moist, loose, consisting of mixed silty clay, sandy silt, some gravel and organics.																	4 22 27 47 (74)
224.52																		
2.44	Gravelly Silty SAND, SW-SM Greyish brown, moist, very dense, some clay.		4	SPT	70													
223.81																		
3.15	End of Borehole		5	SPT	100+													Sampler refusal @ 3.15 m on presumed bedrock. Borehole dry and open at completion.

+ 3, × 3: Numbers refer to  
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

# RECORD OF BOREHOLE No C19-4

1 OF 1

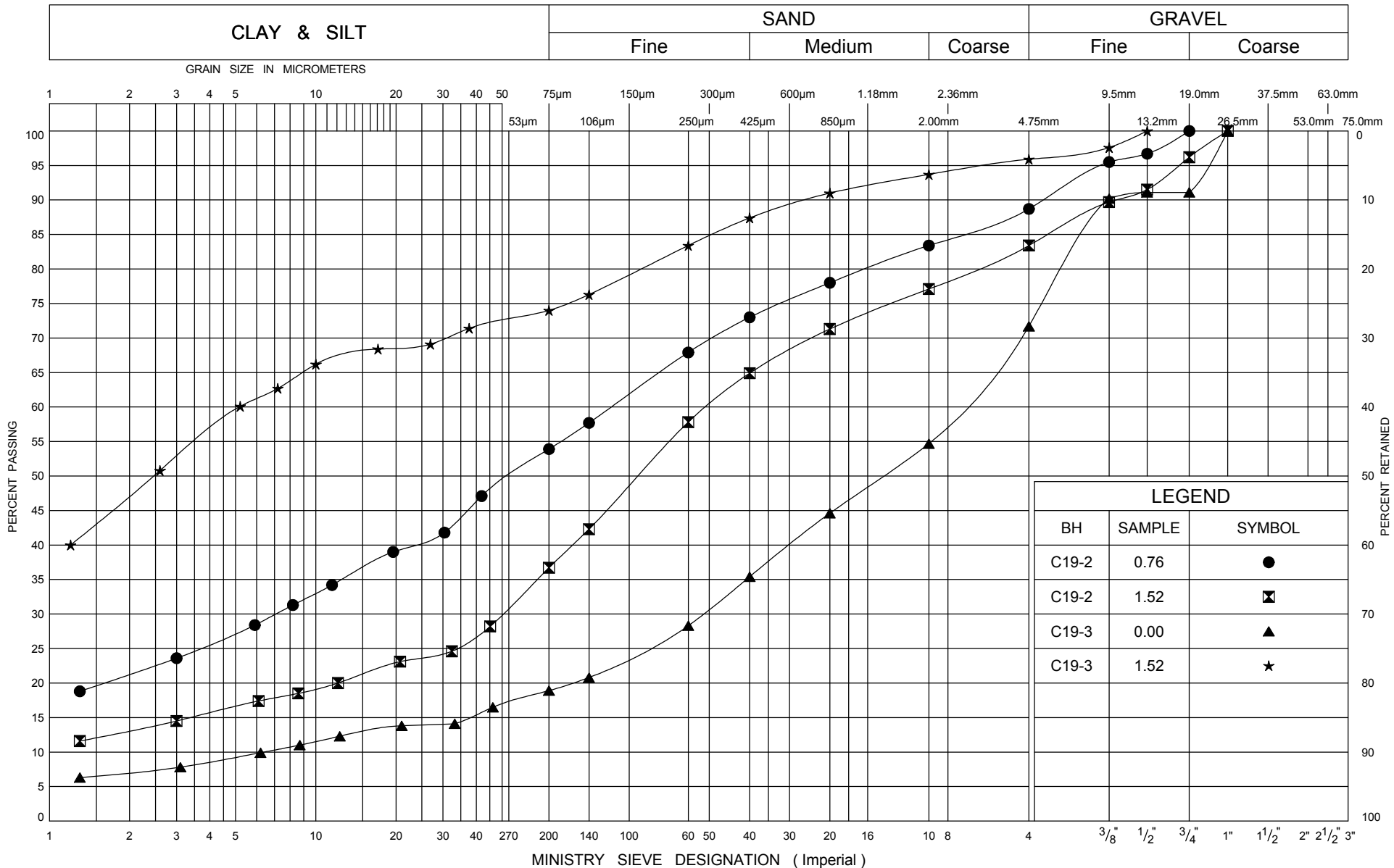
**METRIC**

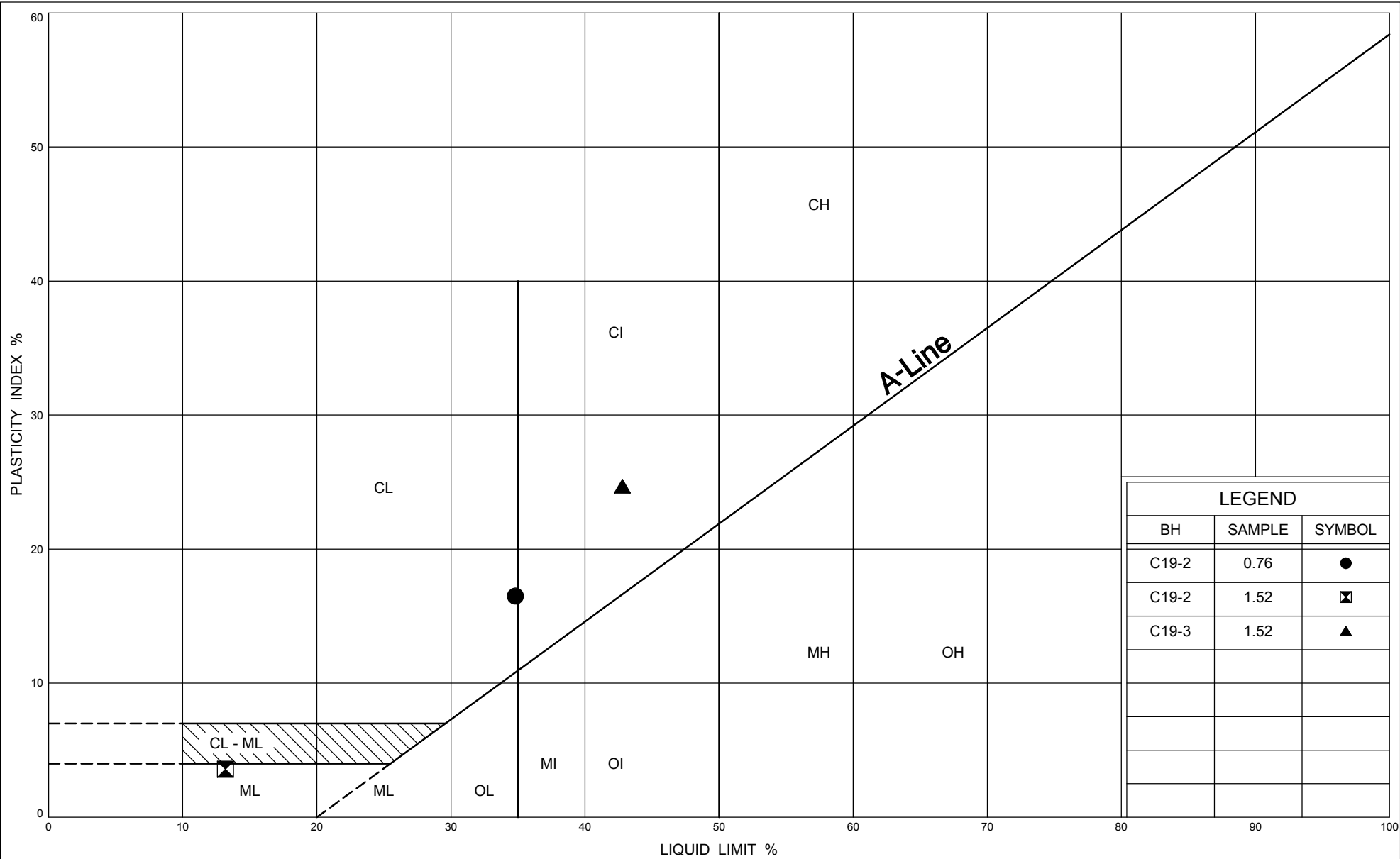
W.P. WP 365-98-00 LOCATION Northing - 4939120, Easting - 326856 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
 DATUM Geodetic DATE 12.03.08 - 12.03.08 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE						
225.66	Ground																
0.00	150 mm TOPSOIL.		1	SPT	1												
	Silty SAND, SM Brown, loose to compact, some gravel, trace clay.		2	SPT	9											18 49 22 11 (33)	
224.49																	
1.17	End of Borehole															Sampler and auger refusal @ 1.17 m on presumed bedrock. Water level measured @ 0.3m @ completion of drilling.	

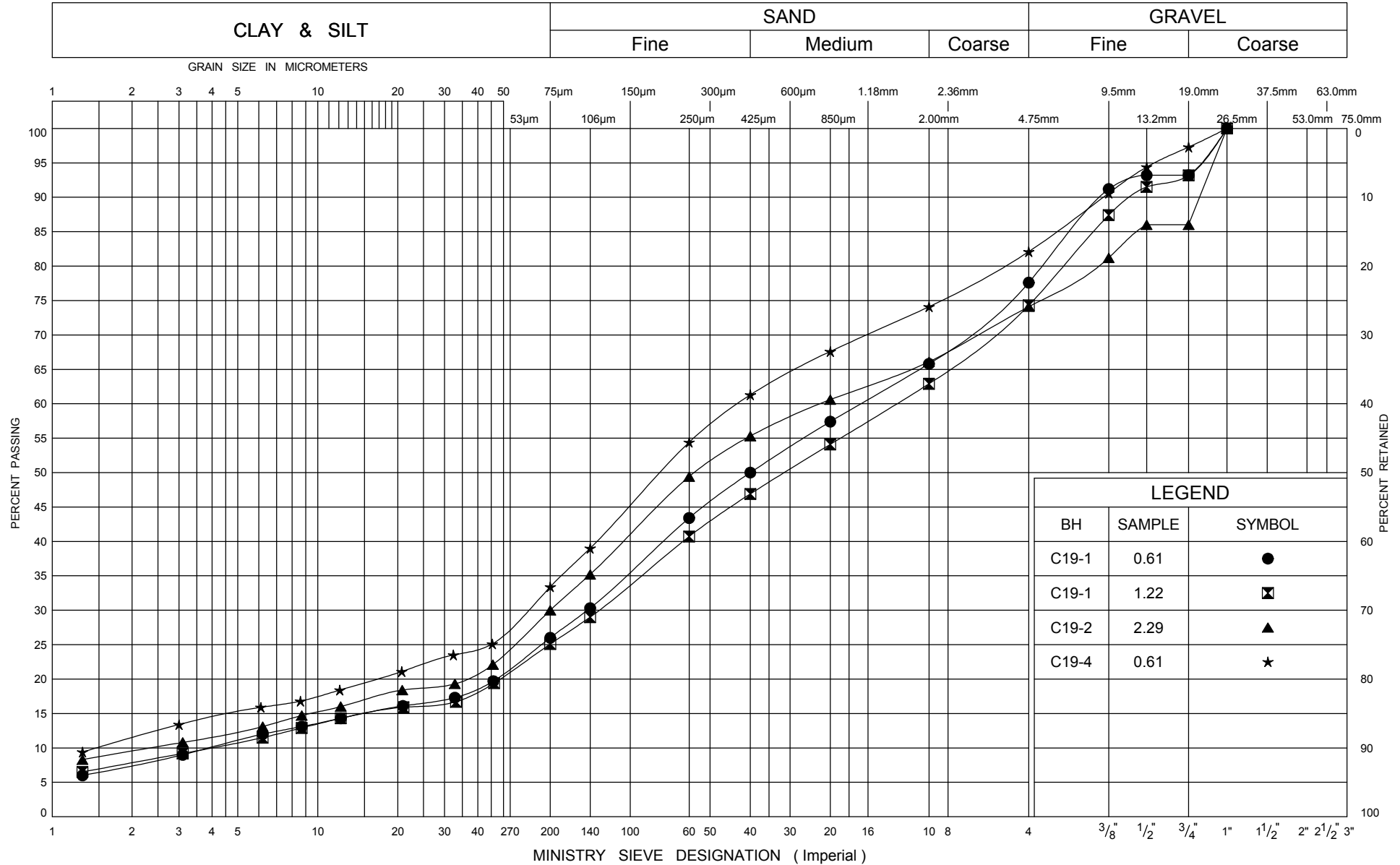
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# UNIFIED SOIL CLASSIFICATION SYSTEM





## UNIFIED SOIL CLASSIFICATION SYSTEM



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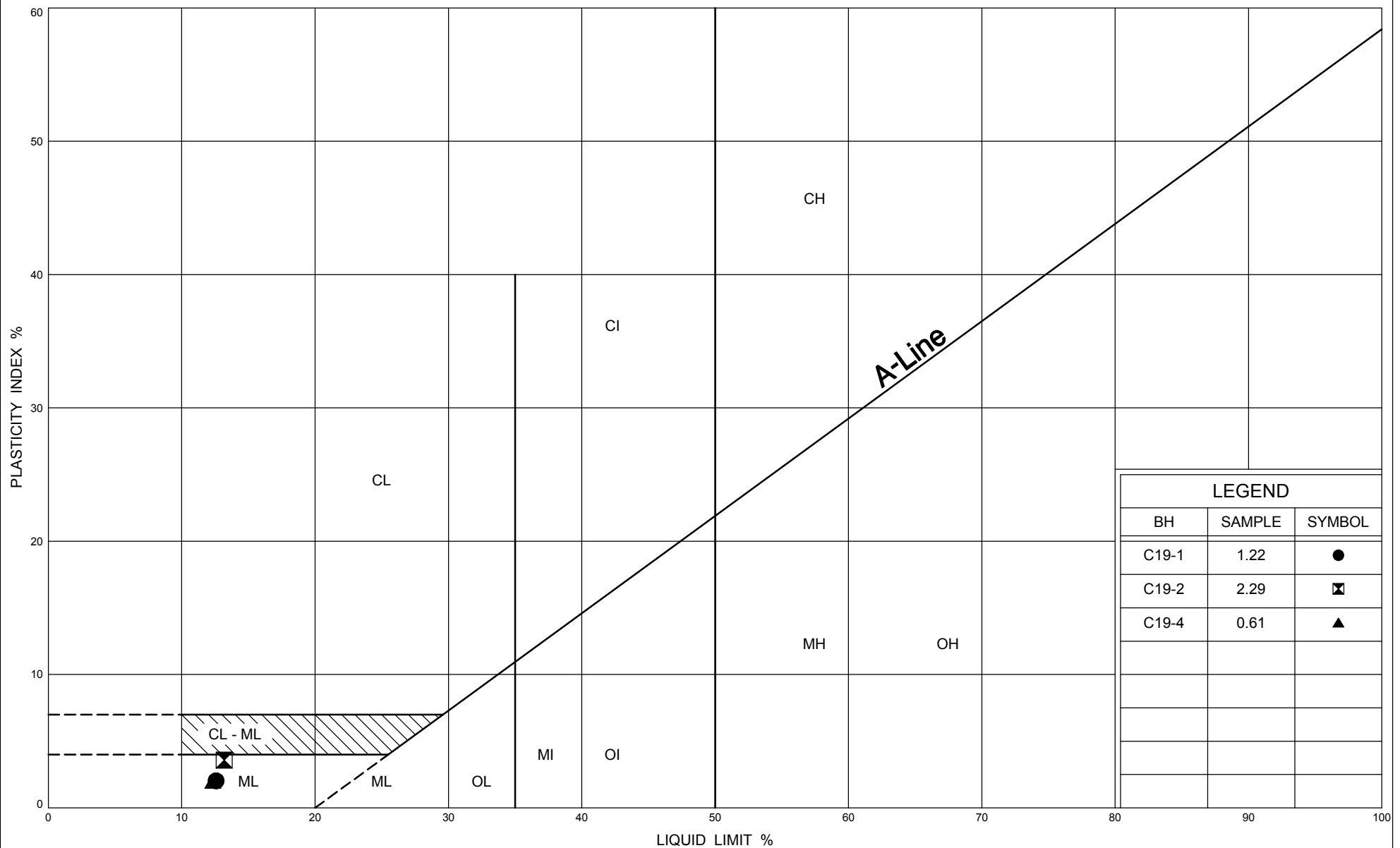
# GRAIN SIZE DISTRIBUTION

## GRAVELLY SILTY SAND TO SILTY SAND, SW-SM

FIG No C- 19.3

WP 365-98-00

Highway 12, Rama Road to Gamebridge



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# PLASTICITY CHART GRAVELLY SILTY SAND TO SILTY SAND, SW-SM

FIG No C- 19.4

WP 365-98-00

Highway 12, Rama Road to Gamebridge



1 OF 1

**METRIC**

+ 3, X 3: Numbers refer to Sensitivity      ○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

## METRIC

[illegible]

○ <sup>150</sup> UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

# RECORD OF BOREHOLE No C23-3

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northring - 4940234, Easting - 325395 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
 DATUM Geodetic DATE 12.02.08 - 12.02.08 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																
								○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE									× LAB VANE					
																			WATER CONTENT (%)					
225.09 0.00	Ground						20	40	60	80	100	10	20	30										
224.18 0.91	FILL Brown, moist, loose, consisting of Gravelly Sand, trace silt.		1	GRAB								○					28 50 15 7 (22)							
223.57 1.52	FILL Dark brown, moist, compact, mixed Silty Gravelly Sand and Topsoil.		2	SPT	10							○	┌───┐			22.4	23 45 23 10 (33)							
222.50 2.59	PEAT Black, moist, partially decomposed.		3	SPT	6									○										
	Silty CLAY, CL-CH Grey, wet, firm, trace to some sand, trace gravel.		4	SPT	5						90			○										
			5	SPT	5						60						48							
			6	VANE									>> 2.5											
			7	SPT	1												55							
220.06 5.03	End of borehole.																	1 16 45 39 (84)						
																		Auger refusal @ 5.03 m on presumed bedrock.						

# RECORD OF BOREHOLE No C23-4

1 OF 1

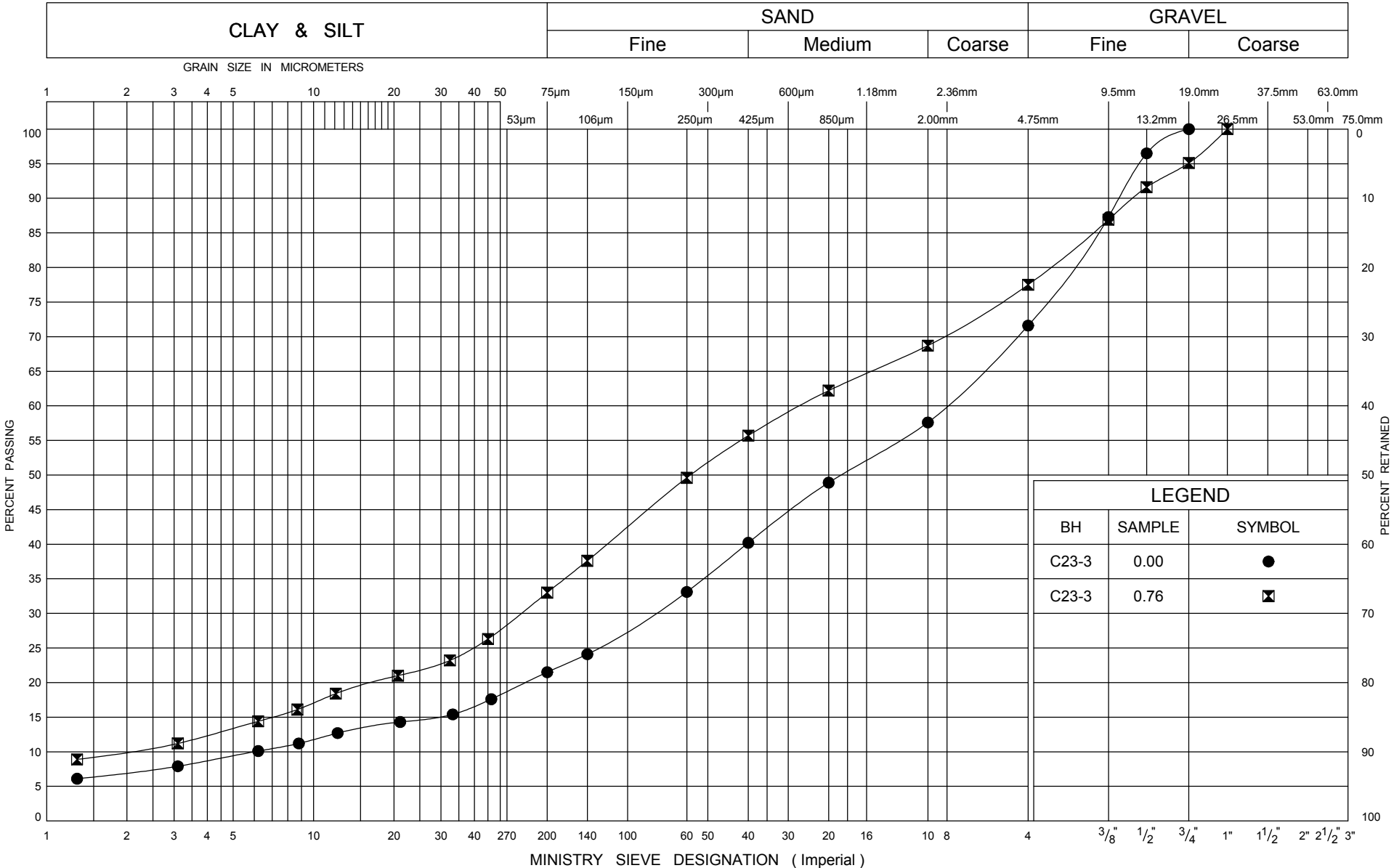
**METRIC**

W.P. WP 365-98-00 LOCATION Northing - 4940244, Easting - 325390 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE Dynamic Cone COMPILED BY JL  
 DATUM Geodetic DATE 12.15.08 - 12.15.08 CHECKED BY EC

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE			PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa			WATER CONTENT (%)									
						○ UNCONFINED			+	FIELD VANE								
						● QUICK TRIAXIAL			×	LAB VANE								
223.16 0.00	Ground						▽	223								Water level @ surface @ completion of dynamic cone. 31.75 Kg (70lbs.) hammer used for driving dynamic cone. Nc values corrected for standard 63 kg (140 lbs.) hammer.		
								222										
								221										
								220										
219.58 3.58	End of Borehole. Refusal on assumed limestone bedrock.															Dynamic cone refusal @ 3.58 m on presumed bedrock.		

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UNIFIED SOIL CLASSIFICATION SYSTEM

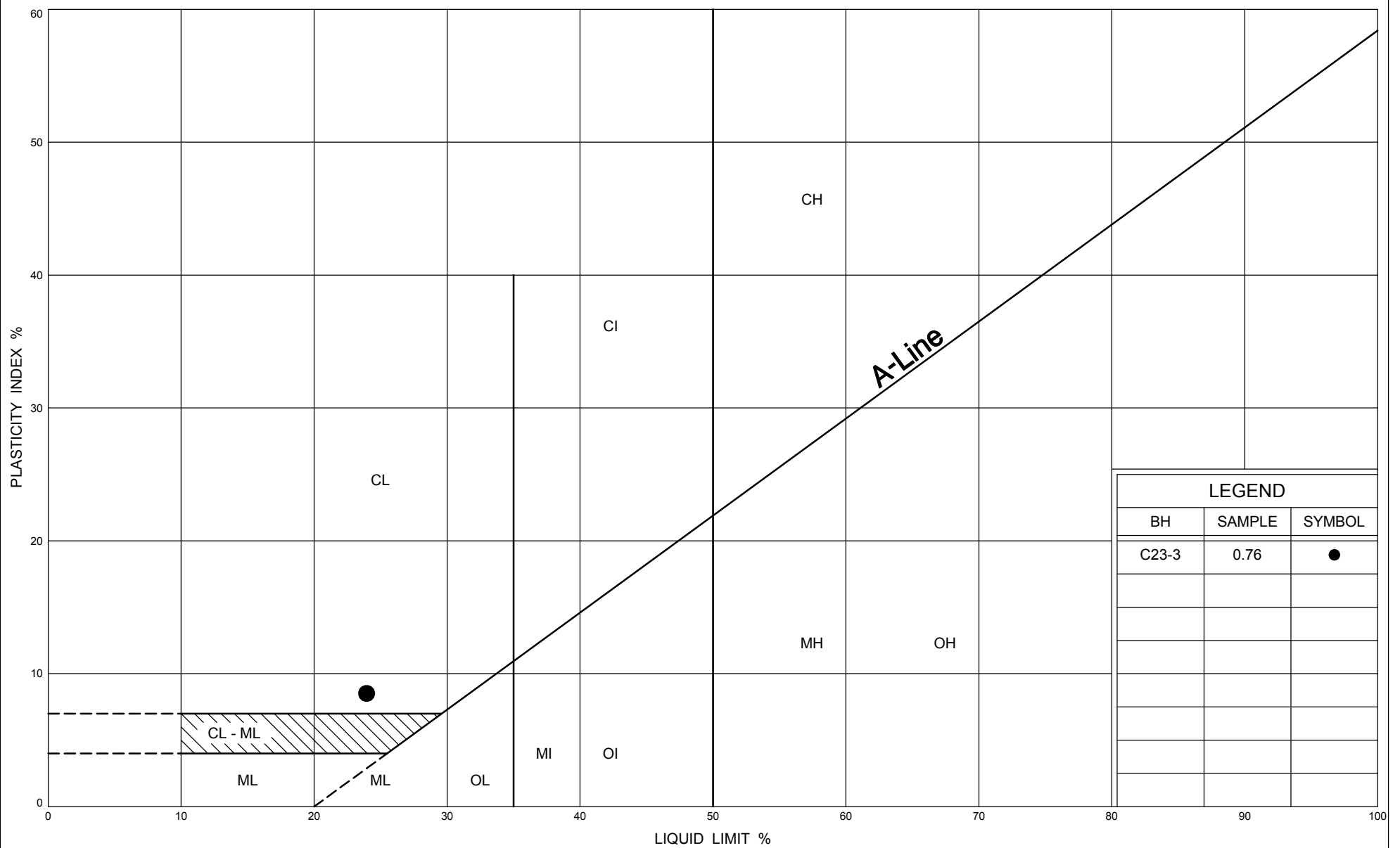


GRAIN SIZE DISTRIBUTION  
FILL

FIG No C- 23.1

GWP 365-98-00

Highway 12, Rama Road to Gamebridge



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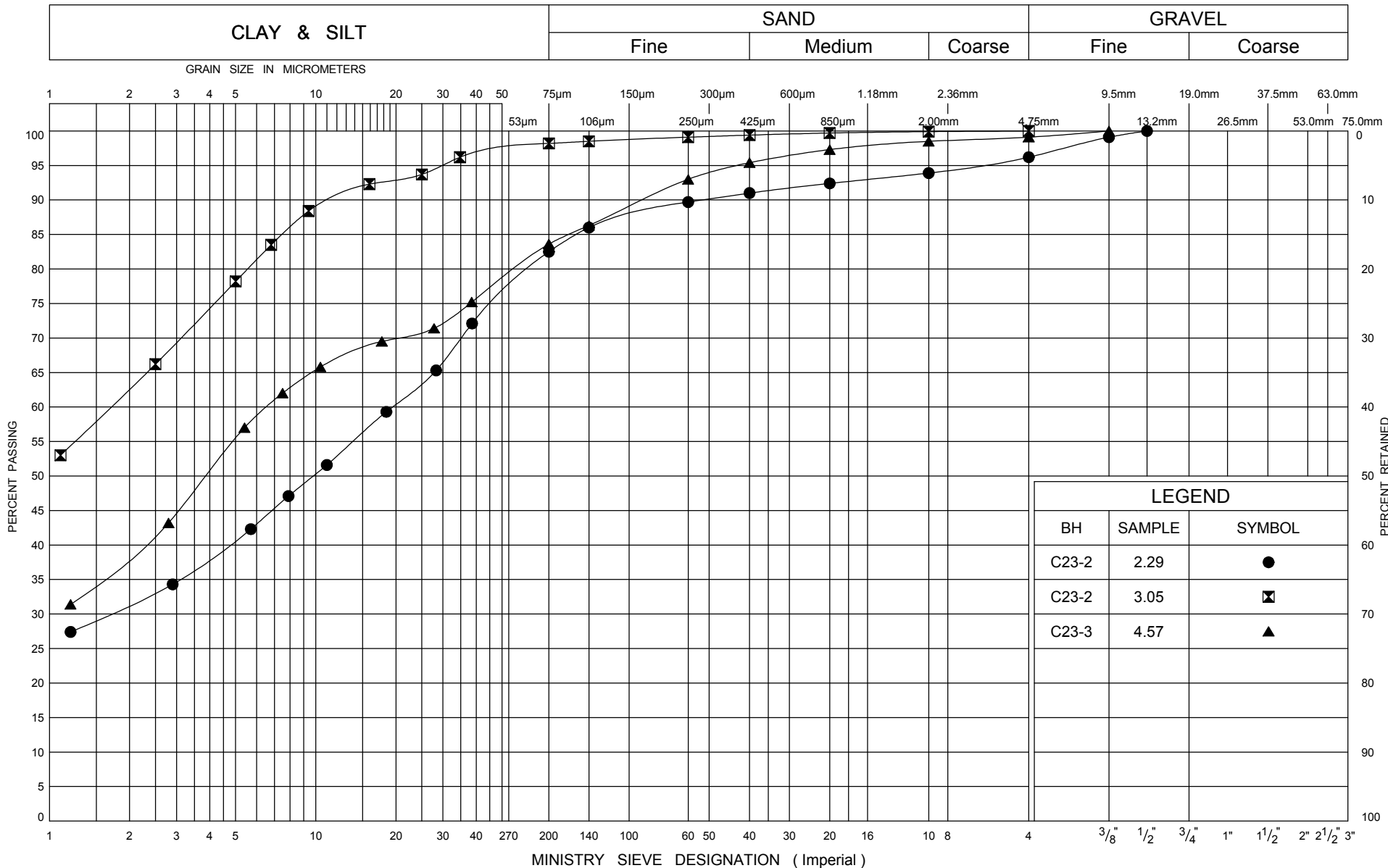
## PLASTICITY CHART FILL

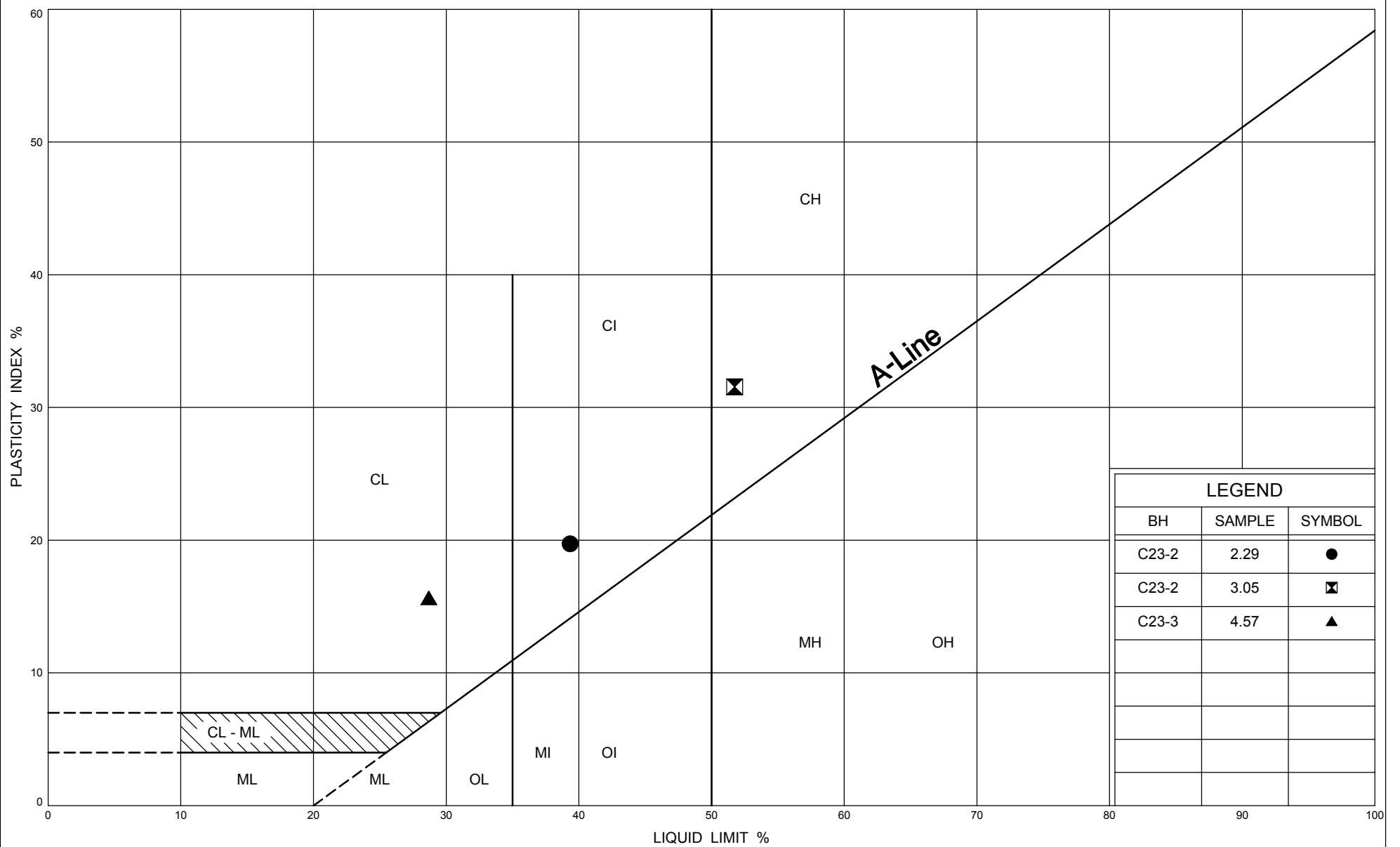
FIG No C- 23.2

GWP 365-98-00

Highway 12, Rama Road to Gamebridge

# UNIFIED SOIL CLASSIFICATION SYSTEM





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## PLASTICITY CHART SILTY CLAY, CI-CH

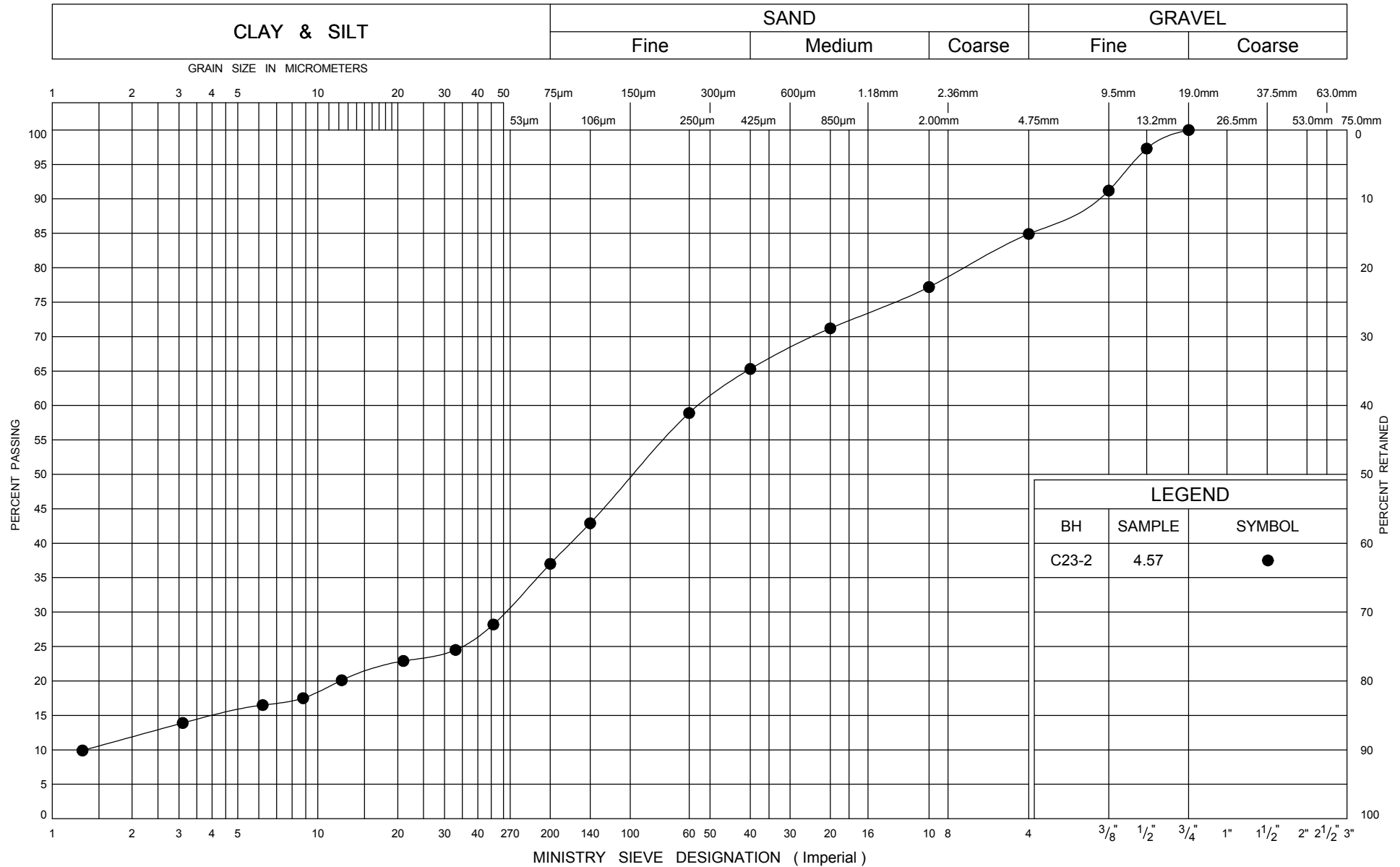
FIG No C- 23.4

GWP 365-98-00

Highway 12, Rama Road to Gamebridge



## UNIFIED SOIL CLASSIFICATION SYSTEM



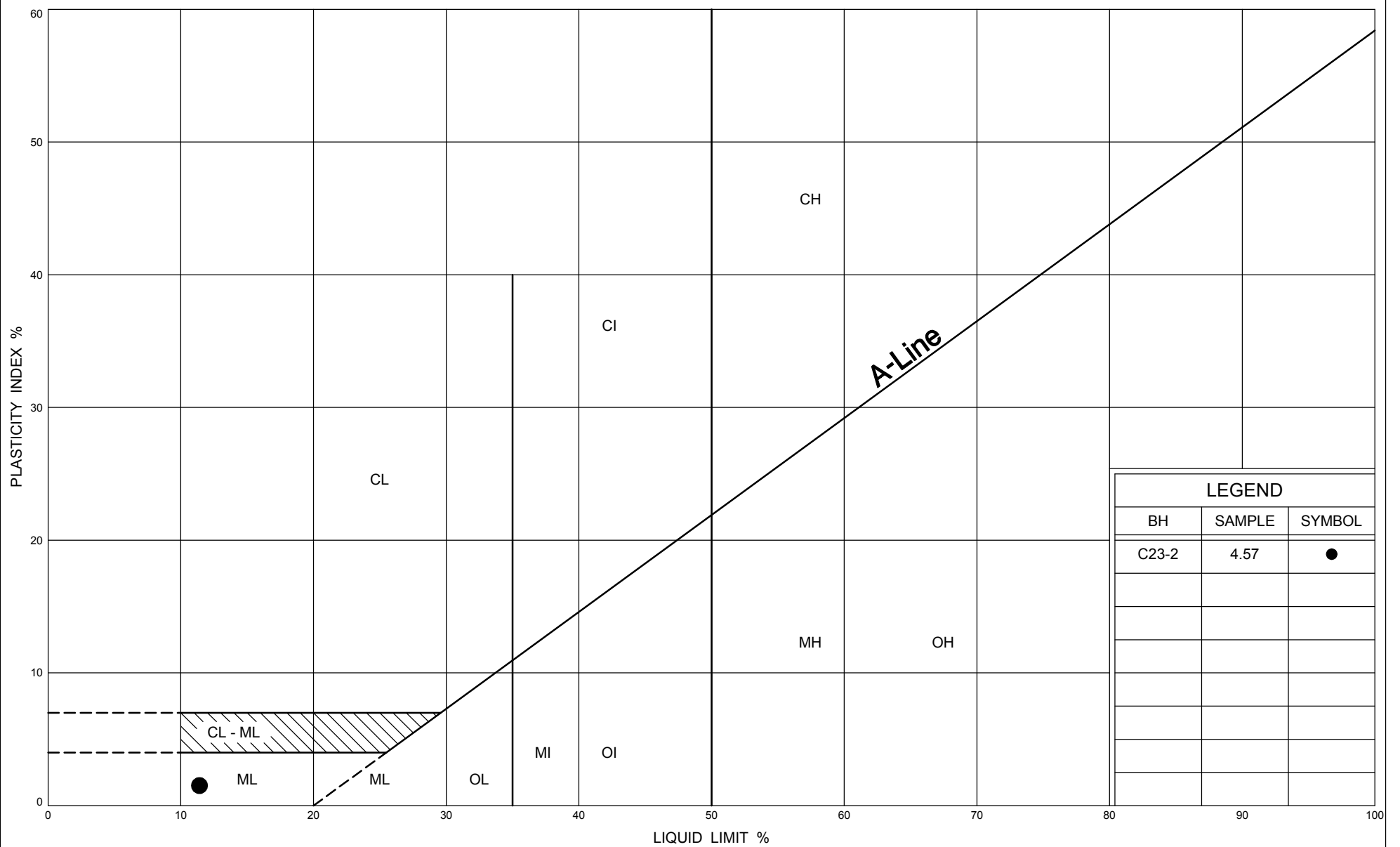
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**GRAIN SIZE DISTRIBUTION**  
**SILTY SAND, SM**

**FIG No C- 23.5**

**GWP 365-98-00**

Highway 12, Rama Road to Gamebridge



LEGEND		
BH	SAMPLE	SYMBOL
C23-2	4.57	●



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## PLASTICITY CHART SILTY SAND, SM

FIG No C- 23.6

GWP 365-98-00

Highway 12, Rama Road to Gamebridge

1 OF 1

METRIC

[illegible]

**METRIC**[illegible]

# RECORD OF BOREHOLE No C27-3

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northing - 4940528, Easting - 323972 ORIGINATED BY RB  
DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
DATUM Geodetic DATE 12.03.08 - 12.03.08 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED	+	FIELD VANE							
						● QUICK TRIAXIAL	×	LAB VANE			WATER CONTENT (%)						
						20	40	60	80	100	10	20	30				
224.67	Ground																
0.00																	
224.37	300 mm SHOULDER GRAVEL.		1	GRAB			224								31 41 19 9 (28)		
0.30																	
			2	SPT	5												
	FILL																
	Dark brown to brown, wet, loose to compact, consisting of silty clay, some sand, occasional wet silty sand pockets, occasional organics in upper 1m.		3	SPT	7		223								0 36 42 22 (63) W.L. @ 1.8m @ completion of drilling.		
			4	SPT	4												
221.77							222										
2.90			5	SPT	2										5 56 35 5 (40)		
	Silty SAND to SAND & SILT, SM-ML Grey, wet, compact to dense, trace to some gravel, occasional clayey silt seams.						221										
			6	SPT	9												
							220								6 66 19 9 (29)		
			7	SPT	16												
219.34																	
5.33	SAND & GRAVEL, SW-GW Grey, saturated, very dense, some silt.		8	SPT	75		219								37 48 (14)		
218.88																	
5.79	End of Borehole																

JOE MTO 08-I-IEG6 CULVERTS.GPJ ONTARIO MOT.GDT 05/17/09

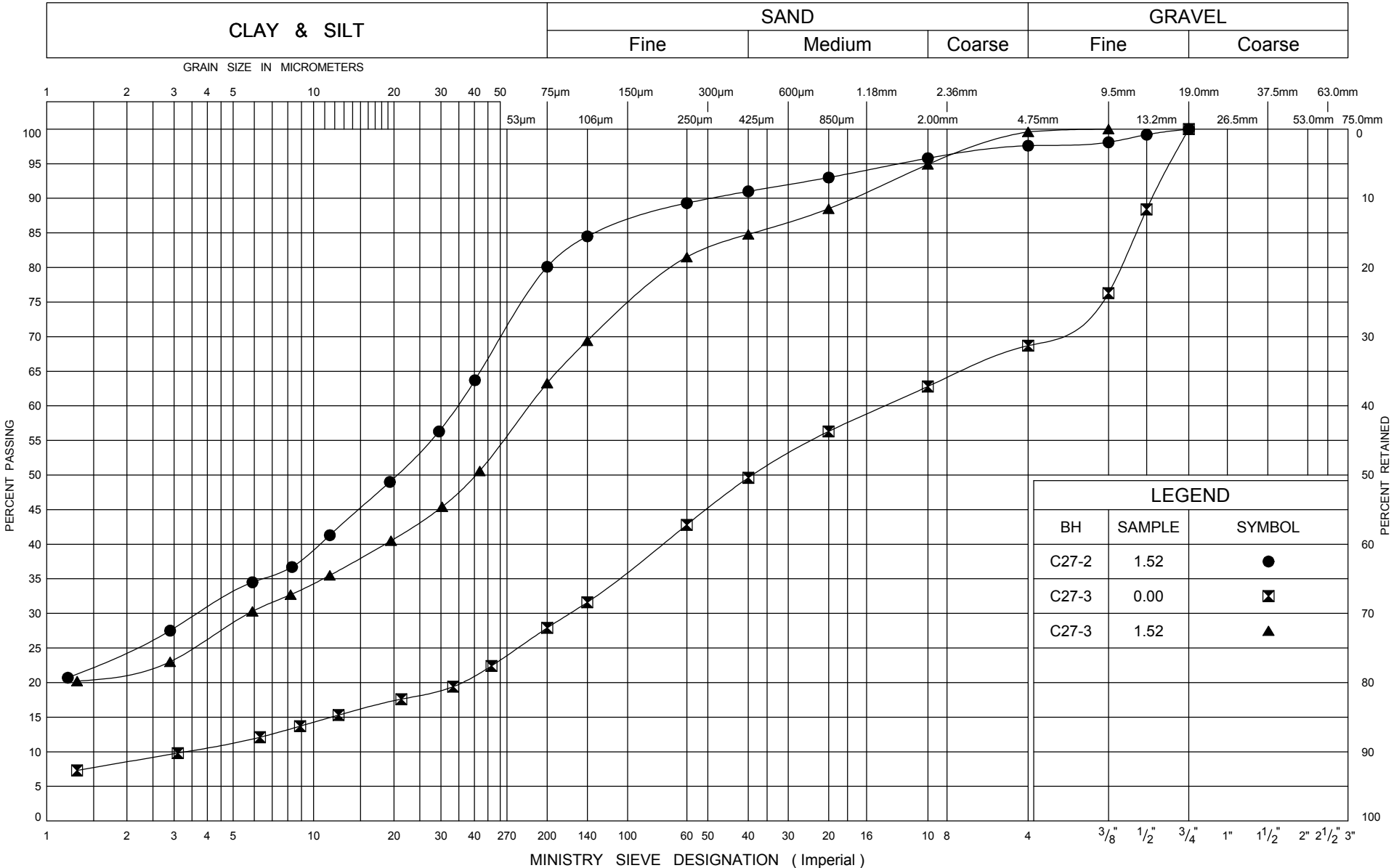
+ 3, X 3: Numbers refer to  
Sensitivity

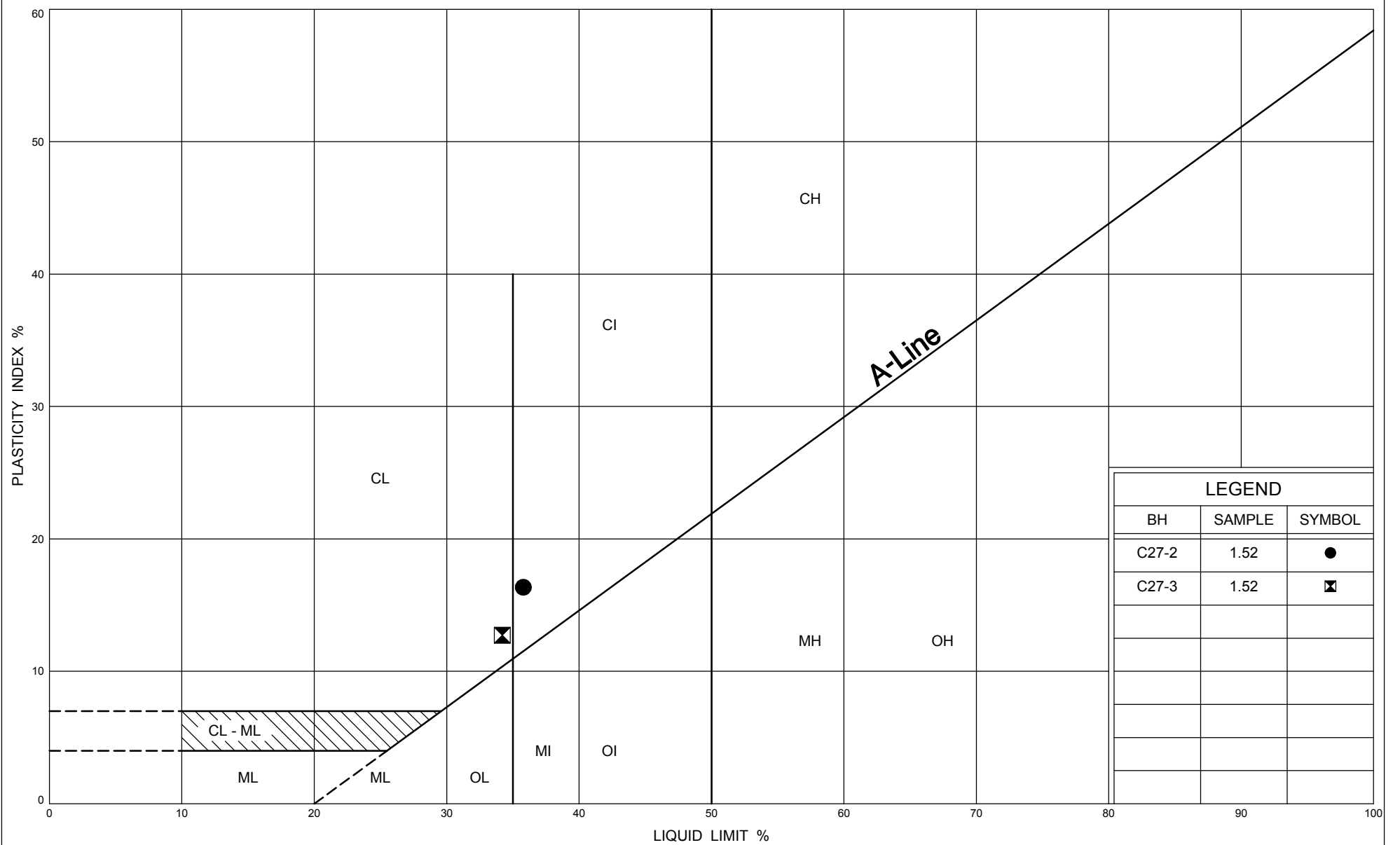
○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

## METRIC

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD DYN. CONE		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W <sub>p</sub> w      W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE			20	40				60
223.67 0.00	Ground													31.75 Kg (70lbs) hammer used for driving dynamic cone. Nc values corrected for standard 63 kg (140 lbs.) hammer.
220.01 3.66	End of Borehole.													

UNIFIED SOIL CLASSIFICATION SYSTEM





LEGEND		
BH	SAMPLE	SYMBOL
C27-2	1.52	●
C27-3	1.52	⊠

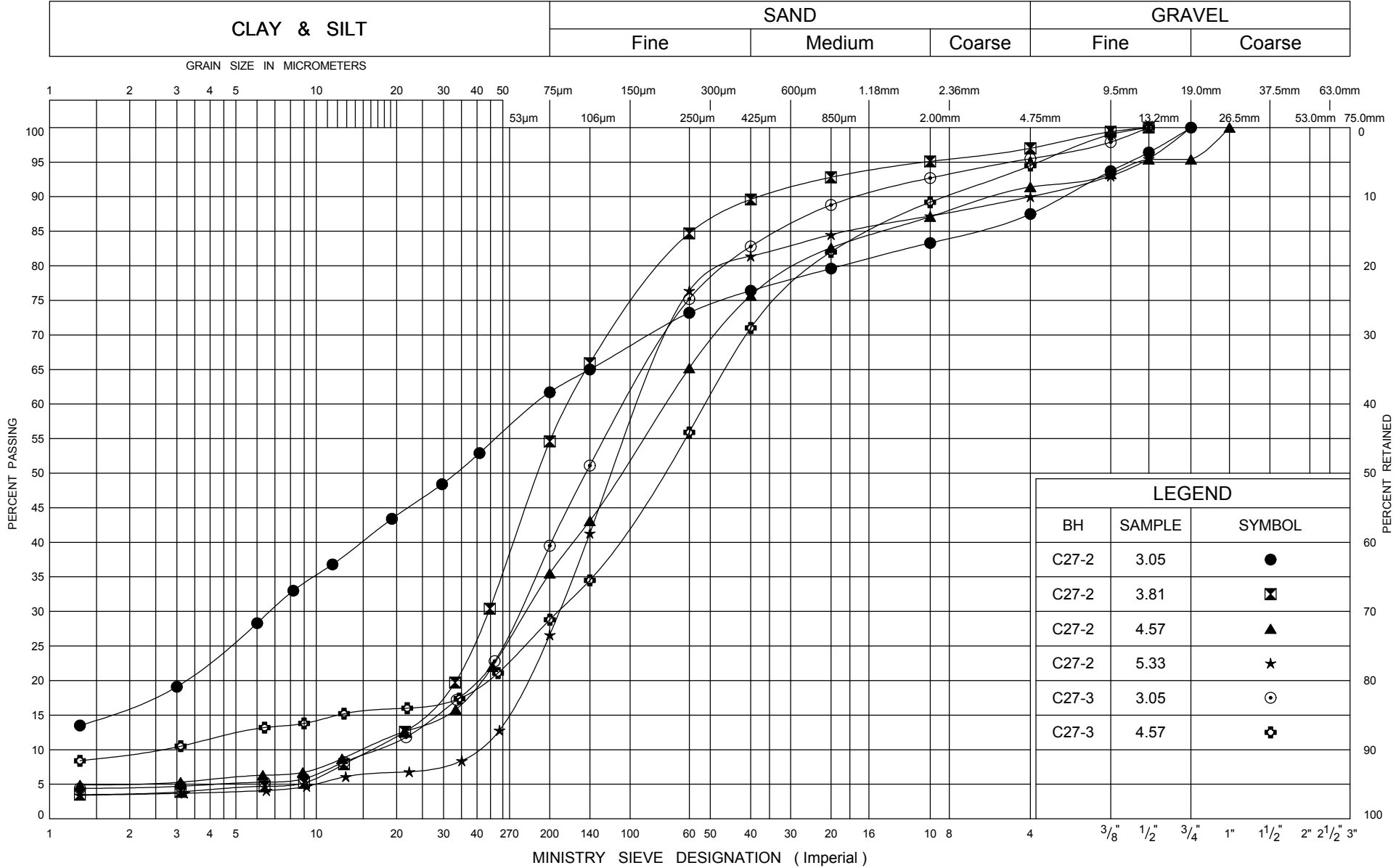
# PLASTICITY CHART FILL

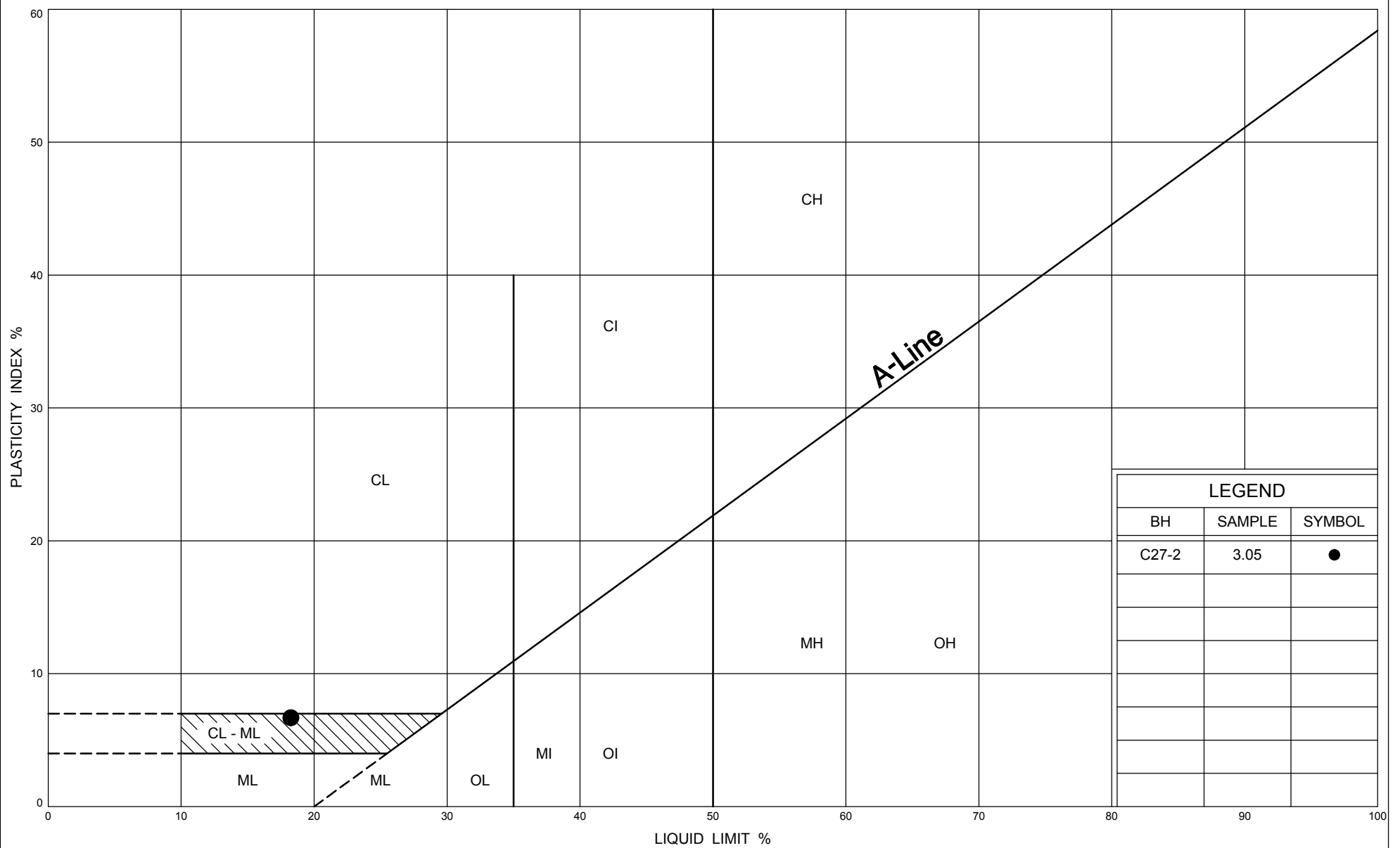
FIG No C- 27.2  
GWP 365-98-00  
Highway 12, Rama Road to Gamebridge





UNIFIED SOIL CLASSIFICATION SYSTEM





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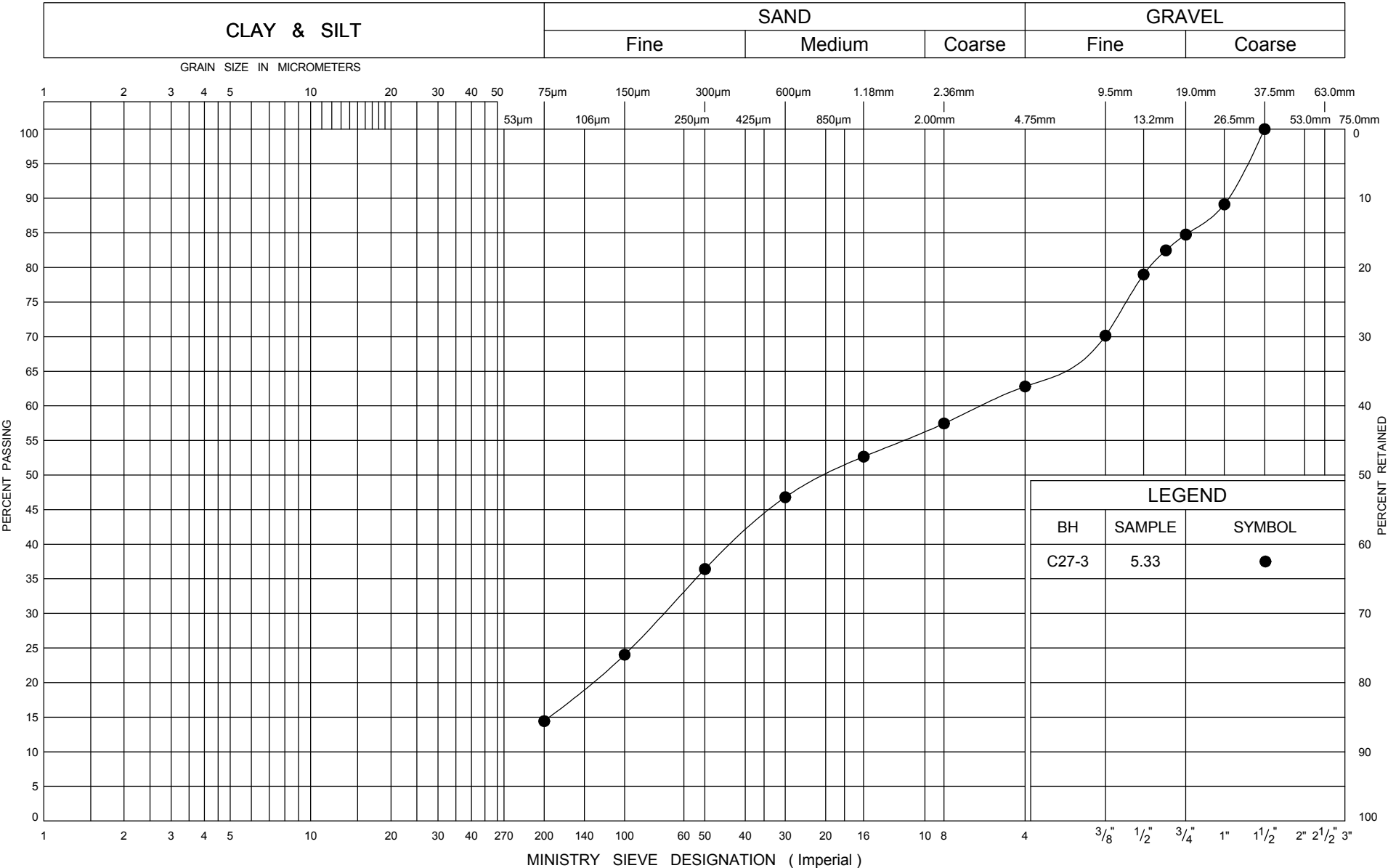
## PLASTICITY CHART SANDS & SILTS, SM-ML

FIG No C- 27.4

GWP 365-98-00

Highway 12, Rama Road to Gamebridge

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION  
SAND AND GRAVEL, SW-GW

FIG No C- 27.5

GWP 365-98-00

Highway 12, Rama Road to Gamebridge

# RECORD OF BOREHOLE No C44-1

1 OF 1

**METRIC**

W.P. WP 365-98-00 LOCATION Northing - 4939981, Easting - 316445 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE Dynamic Cone COMPILED BY JL  
 DATUM Geodetic DATE 12.15.08 - 12.15.08 CHECKED BY EC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
220.58 0.00	Ground																31.75 Kg (70lbs.) hammer used for driving dynamic cone. Nc values corrected for standard 63 kg (140 lbs.) hammer. W.L. @ 0.2m @ completion.
214.89 5.69	End of Borehole.																Dynamic cone refusal @ 5.69 m on presumed bedrock.

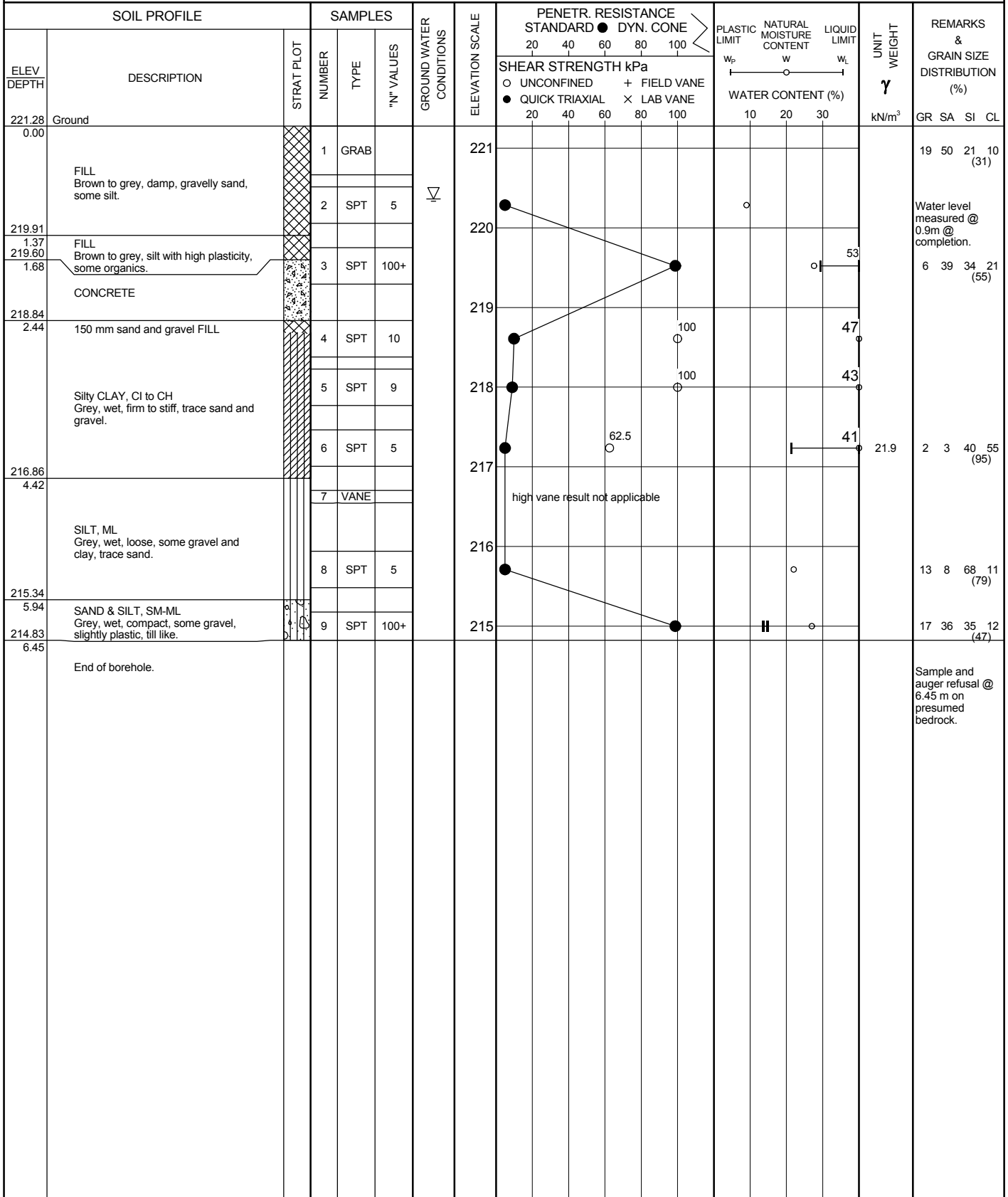
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# RECORD OF BOREHOLE No C44-2

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northing - 4939985, Easting - 316447 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
 DATUM Geodetic DATE 12.03.08 - 12.03.08 CHECKED BY EC



+ 3, X 3: Numbers refer to Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

# RECORD OF BOREHOLE No C44-3

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northring - 4939995, Easting - 316459 ORIGINATED BY RB  
 DIST Central Region HWY Highway 12 BOREHOLE TYPE S/S Augering 110 mm Dia. COMPILED BY JL  
 DATUM Geodetic DATE 12.03.08 - 12.03.08 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
								● QUICK TRIAXIAL	× LAB VANE						
221.53	Ground							20 40 60 80 100							
0.00			1	GRAB			221							32 43 16 9 (25)	
	FILL Brown/Grey, damp, loose, Gravelly Sand, some silt.		2	SPT	8										
220.16							220								
1.37	FILL Brown, moist, very dense, mixed sand, gravel, silty clay, wood with creosote like odour.		3	SPT	100+										
219.70															
1.83			4	SPT	9		219						49	Water level measured @ 1.8 m @ completion.	
	Silty CLAY, CH Grey, wet, firm to stiff, trace sand and gravel.		5	SPT	4								46	2 10 32 57 (89)	
			6	VANE			218	60	2.7					0 8 25 67 (92)	
217.26							217								
4.27	Clayey SILT, CL-ML Grey, wet, firm, some sand, trace gravel, low plasticity.		7	SPT	9									2 11 67 20 (88)	
216.20			8	VANE			216		high vane result not applicable						
5.33	Gravelly Silty SAND, SM-SW Grey, wet, compact, slightly plastic, till like.		9	SPT	100+										
215.05														23 45 23 9 (33)	
6.48	End of Borehole													Sampler and auger refusal @ 6.48 m on presumed bedrock.	

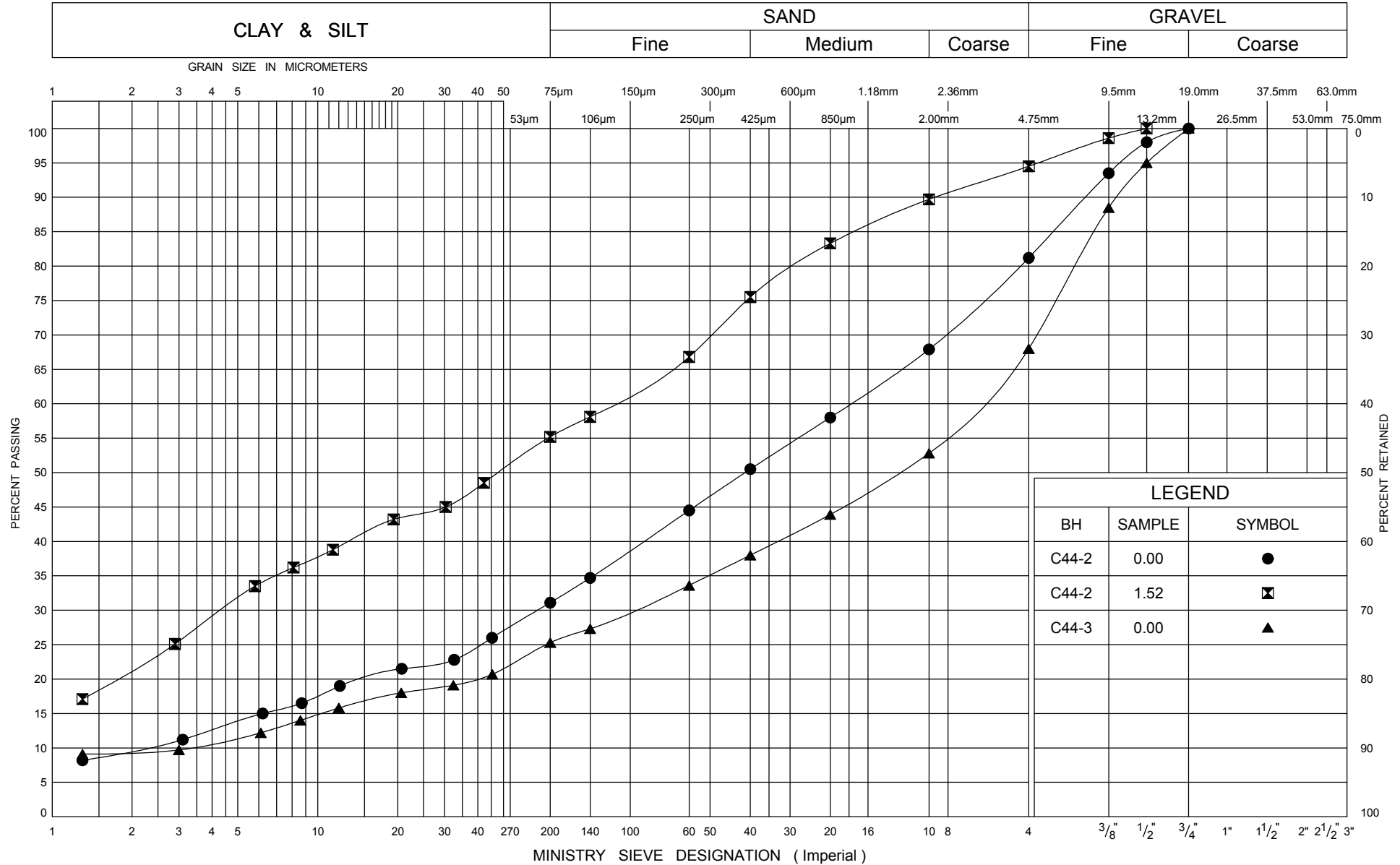
+ 3, × 3: Numbers refer to  
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

## METRIC

○ <sup>150</sup> UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

## UNIFIED SOIL CLASSIFICATION SYSTEM



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# GRAIN SIZE DISTRIBUTION FILL

FIG No C- 44.1

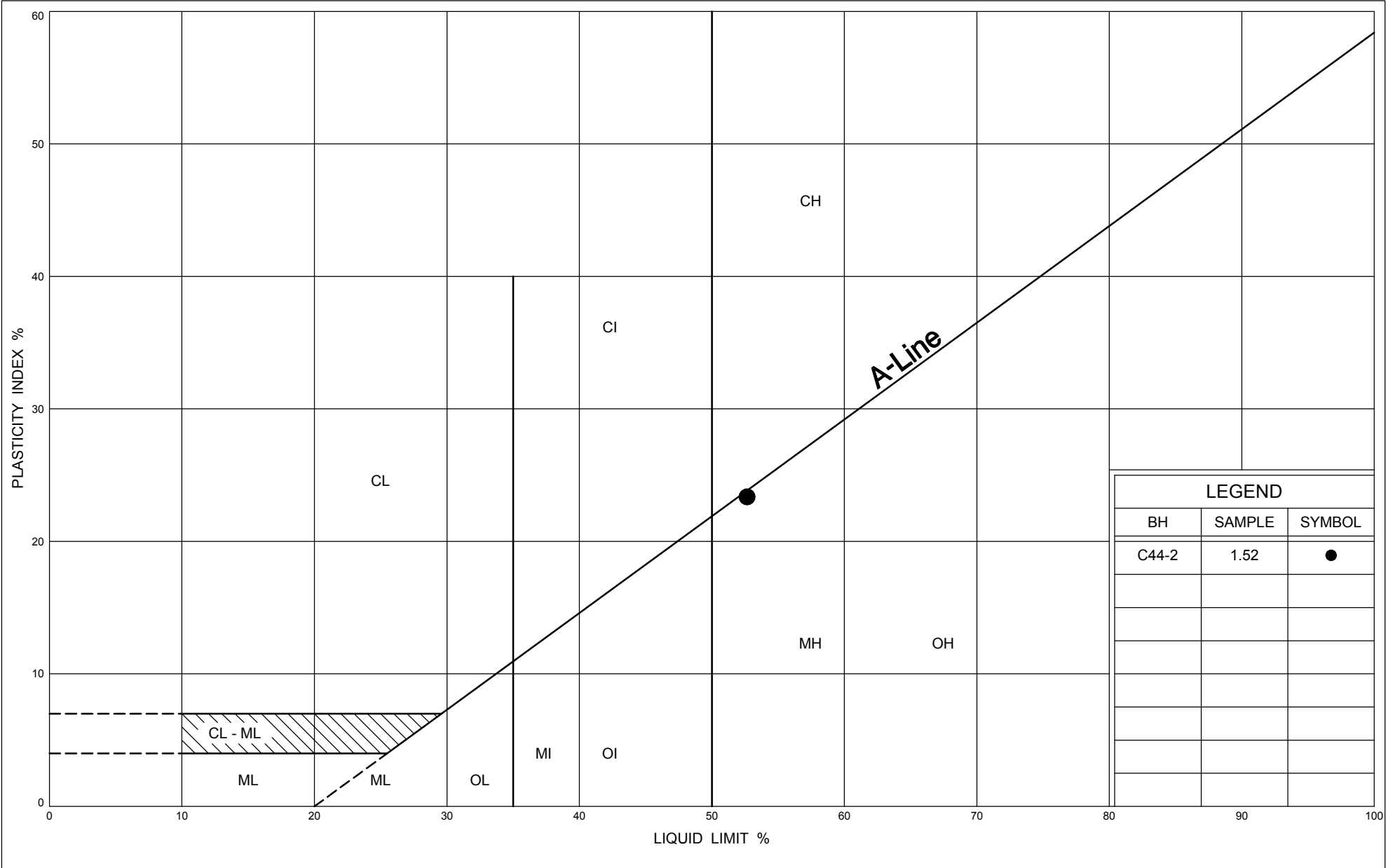
GWP 365-98-00

Highway 12, Rama Road to Gamebridge

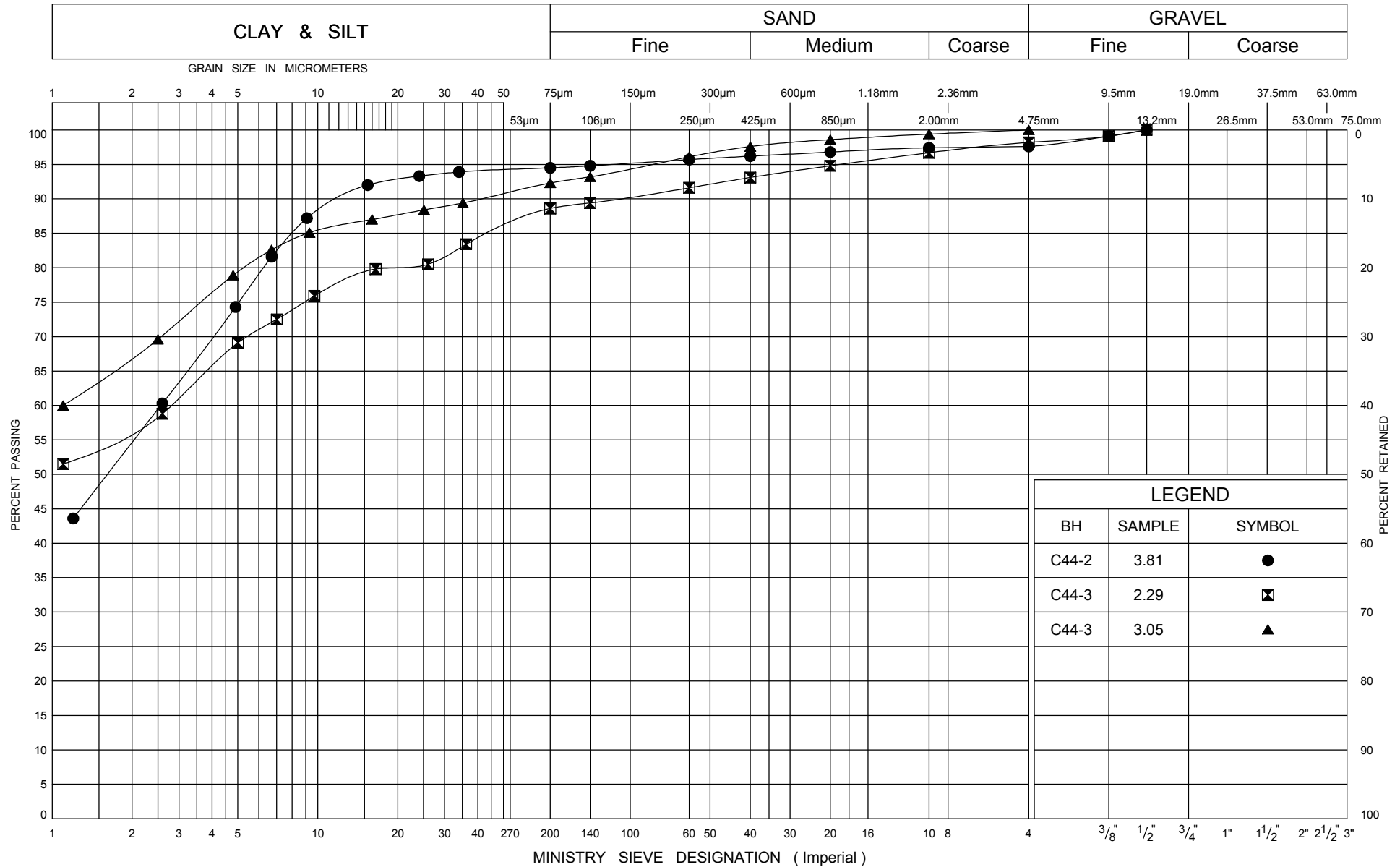


ONTARIO MOT PLASTICITY CHART SMALL CULVE 08-1-IEG6 CULVERTS GPI ONTARIO MOT.GDT 04/08/09

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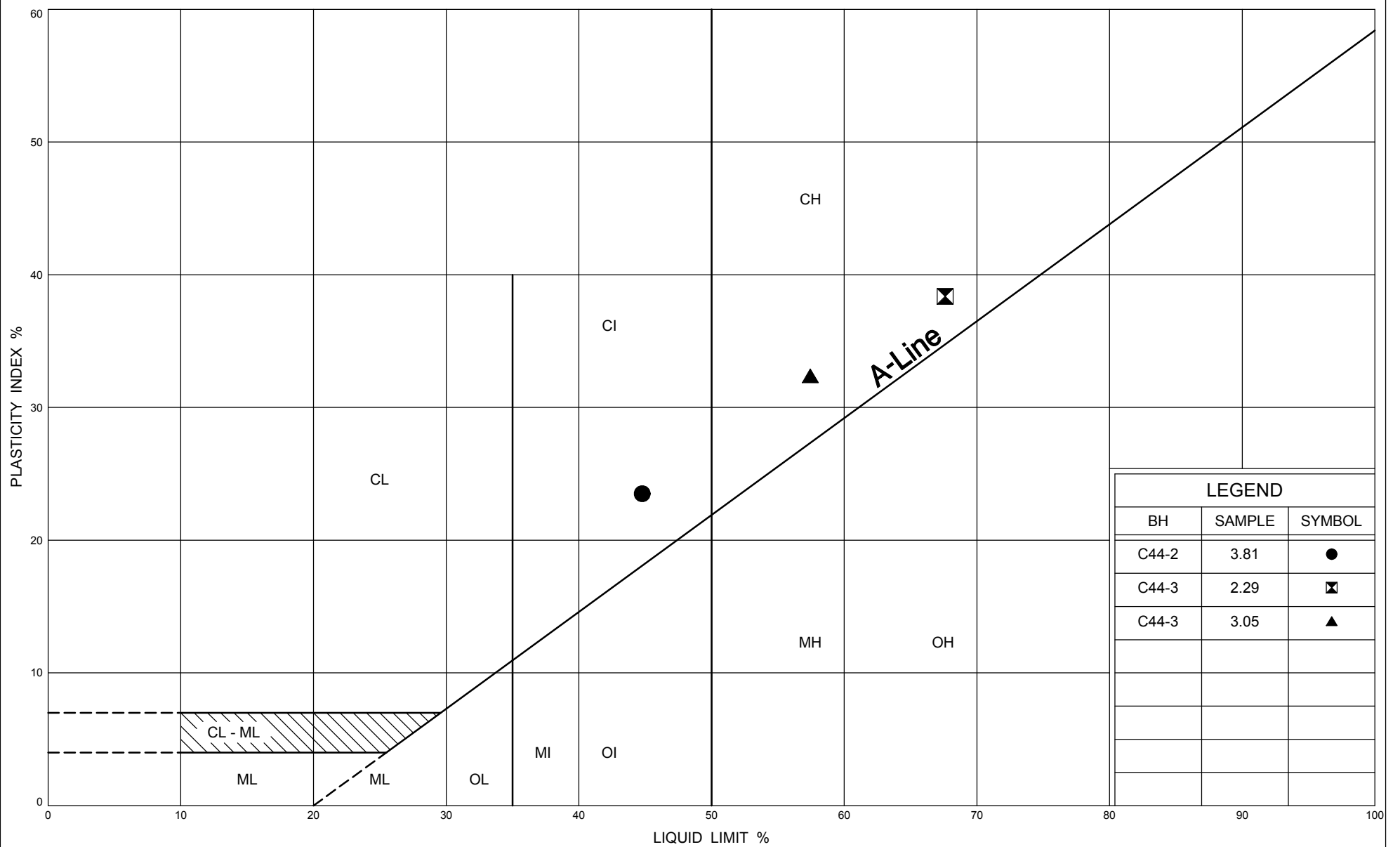
# GRAIN SIZE DISTRIBUTION

## SILTY CLAY, CI TO CH

FIG No C- 44.3

GWP 365-98-00

Highway 12, Rama Road to Gamebridge



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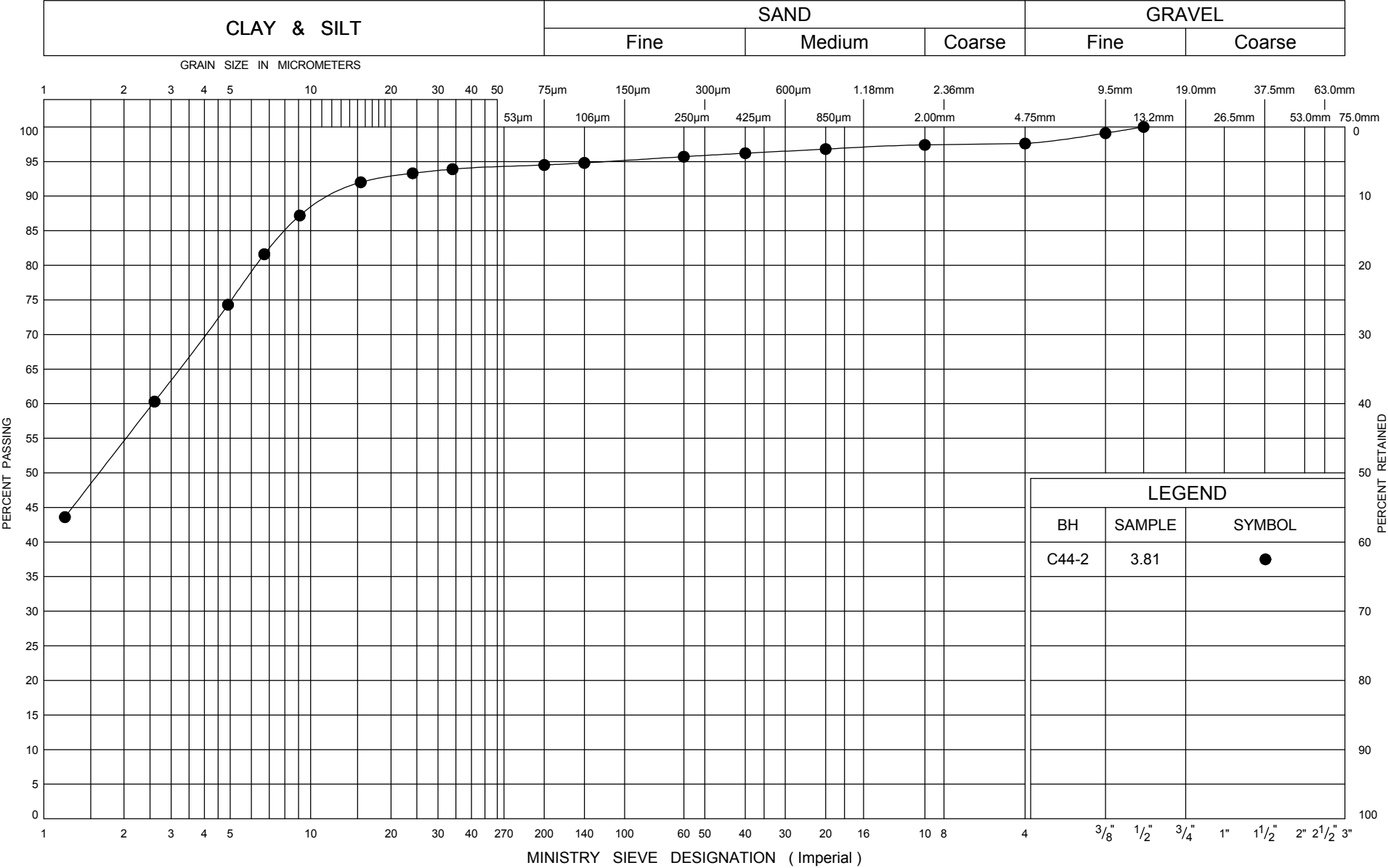
## PLASTICITY CHART SILTY CLAY, CI TO CH

FIG No C- 44.4

GWP 365-98-00

Highway 12, Rama Road to Gamebridge

UNIFIED SOIL CLASSIFICATION SYSTEM



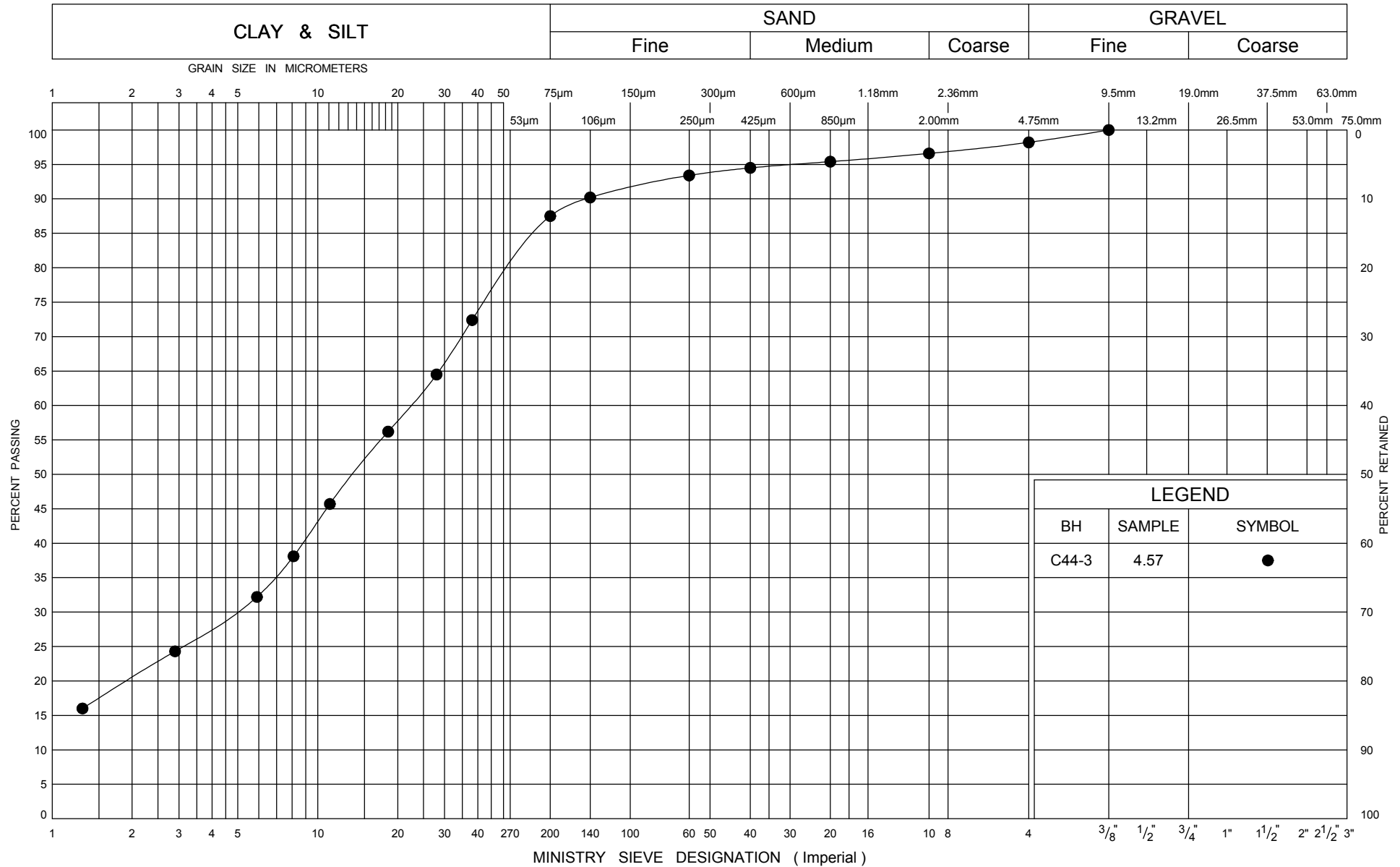
GRAIN SIZE DISTRIBUTION  
SILT, ML

FIG No C- 44.5

WP 365-98-00

Highway 12, Rama Road to Gamebridge

## UNIFIED SOIL CLASSIFICATION SYSTEM



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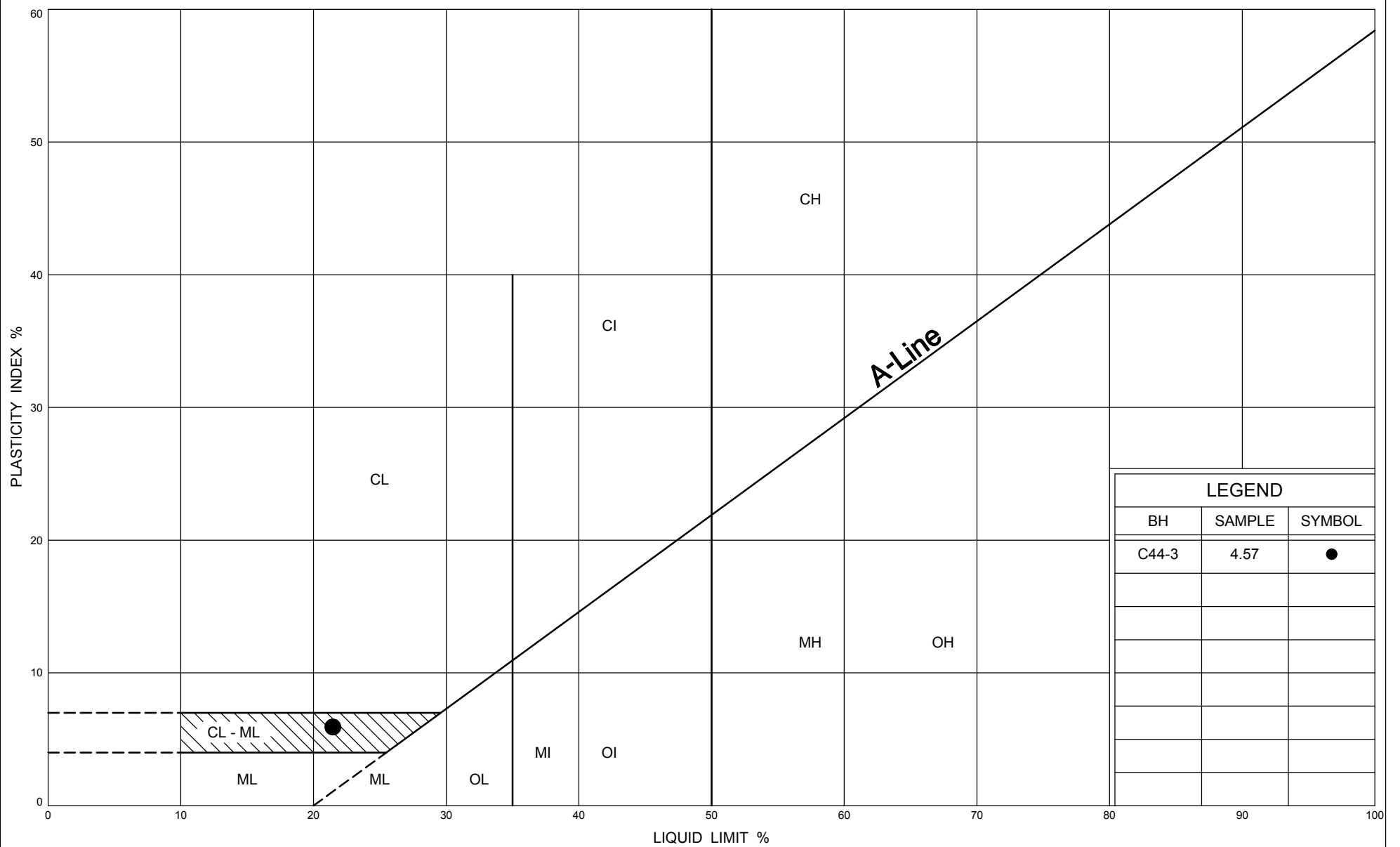
## GRAIN SIZE DISTRIBUTION

### CLAYEY SILT, CL-ML

FIG No C- 44.6

WP 365-98-00

Highway 12, Rama Road to Gamebridge



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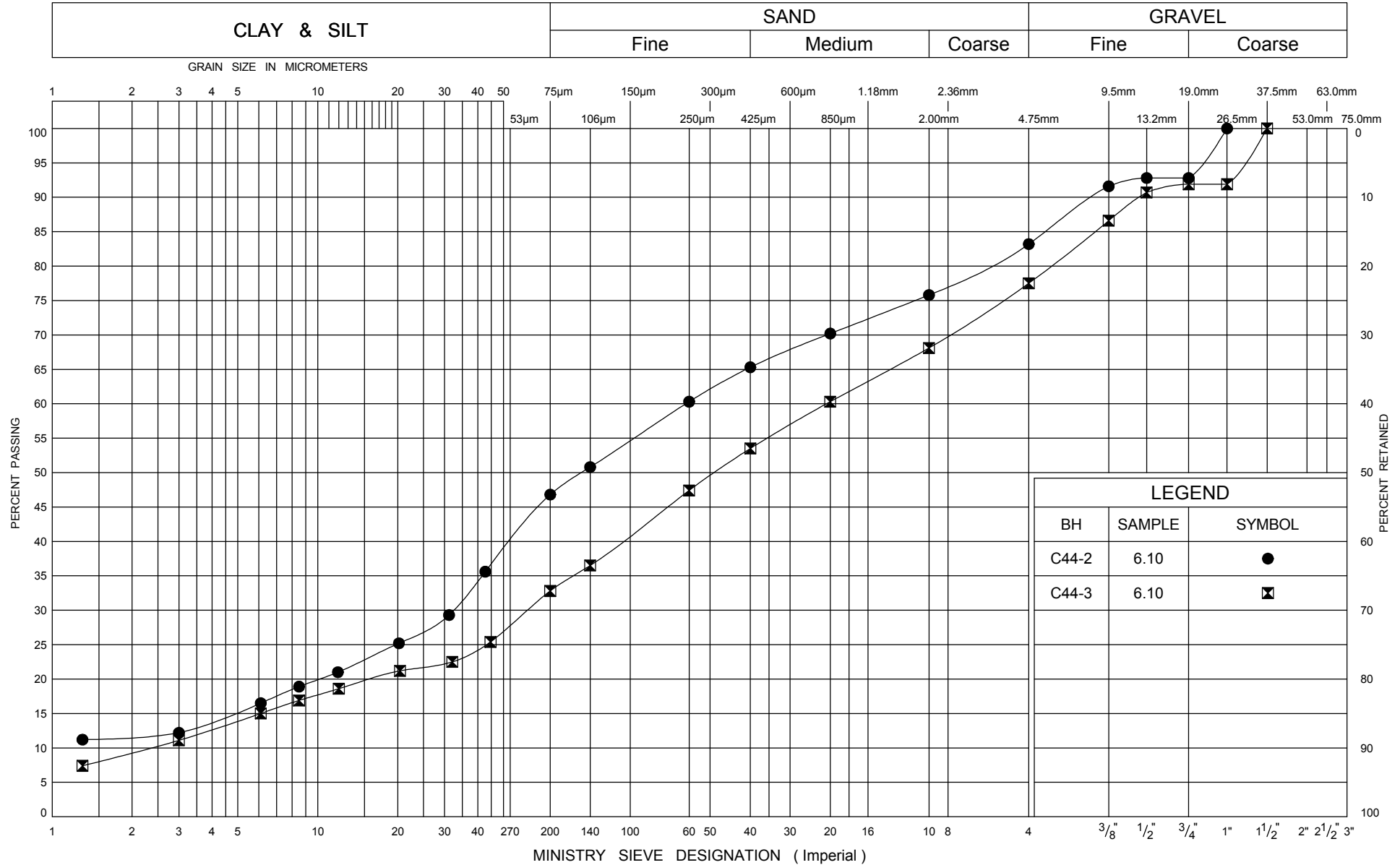
## PLASTICITY CHART CLAYEY SILT, CL-ML

FIG No C- 44.7

WP 365-98-00

Highway 12, Rama Road to Gamebridge

## UNIFIED SOIL CLASSIFICATION SYSTEM



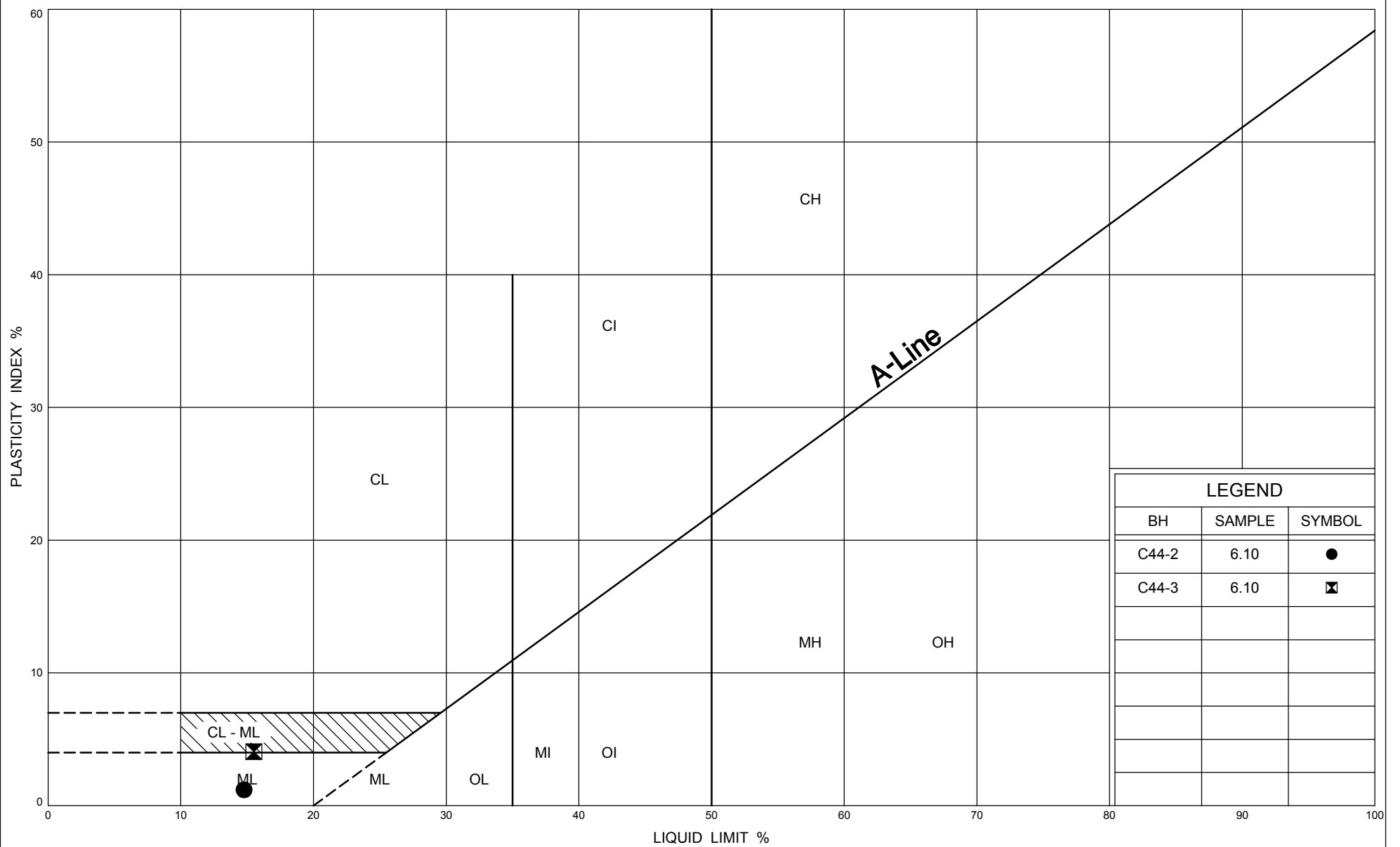
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**GRAIN SIZE DISTRIBUTION**  
**SAND & SILT TO GRAVELLY SILTY SAND. SM-SW-ML**

**FIG No C- 44.8**

**WP 365-98-00**

Highway 12, Rama Road to Gamebridge



LEGEND		
BH	SAMPLE	SYMBOL
C44-2	6.10	●
C44-3	6.10	⊗



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# PLASTICITY CHART SAND & SILT TO GRAVELLY SILTY SAND. SM-SW-ML

FIG No C- 44.9

WP 365-98-00

Highway 12, Rama Road to Gamebridge



Ministry of Transportation/Stantec Consulting Ltd.  
G.W.P. 57-00-00  
Rehabilitation of Highway 12 from Rama Road to Gamebridge  
Agreement # 2004-E-0070

08-1-IEG6-NSCR  
Final Report  
Appendix C  
November 6, 2009

## Appendix C

### Site Photographs



C02 - Station 11+678 - Looking North



C02 - Station 11+678 - Downstream



C02 - Station 11+678 - Upstream



C03 - Station 12+352 - SPPA Culvert Extension



C03 - Station 12+352 - Culvert Extension and  
Original Concrete culvert



C03 - Station 12+352 - Culvert Extension and  
Original Concrete culvert



C10 - Station 16+979 - Looking North



C10 - Station 16+979 - Upstream



C10 - Station 16+979 - Downbstream





C11 - Station 18+137 - Looking North



C11 - Station 18+137 - Upstream



C11 - Station 181+137 - Downstream



C19 - Station 22+853 - Upstream



C19 - Station 22+853 - Downstream



C23 - Station 24+713 - Looking North



C23 - Station 24+713 - Upstream



C23 - Station 24+713 - Downstream





C27 - Station 26+154 - Looking North



C27 - Station 25+154 - Upstream



C27 - Station 25+154 - Downstream





C44 - Station 33+790 - Looking South



C44 - Station 33+790 - Upstream



C44 - Station 33+790 - Downstream

Ministry of Transportation/Stantec Consulting Ltd.  
G.W.P. 57-00-00  
Rehabilitation of Highway 12 from Rama Road to Gamebridge  
Agreement # 2004-E-0070

08-1-IEG6-NSCR  
Final Report  
Appendix D  
November 6, 2009

## Appendix D

### Limitations of Report

## **APPENDIX D**

### **LIMITATIONS OF REPORT**

The conclusions and recommendations given in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Soils Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

The benchmark and elevations mentioned in this report were obtained strictly for use in the geotechnical design of the project and by this office only, and should not be used by any other parties for any other purposes.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Infrastructure Engineering Group Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

This report does not reflect the environmental issues or concerns unless otherwise stated in the report.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, IEG recommends that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.