

FOUNDATION INVESTIGATION REPORT

STRUCTURAL CULVERT SITE NO. 30-675/C
TOWNSHIP OF RAMA
HIGHWAY 12 FROM GAMEBRIDGE TO RAMA ROAD 25

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



I.E.
Group



Infrastructure Engineering Group Inc.

Pavement & Construction Materials Consulting Engineers

GTA • Kitchener • London • Windsor

Corporate Office
39-69 Bessemer Road
London, Ontario
N6E 2V6
tel: (519) 680-9991
fax: (519) 680-9993
email: info@lawengineering.com

FOUNDATION INVESTIGATION REPORT

STRUCTURAL CULVERT SITE NO. 30-675/C
TOWNSHIP OF RAMA
HIGHWAY 12 FROM GAMEBRIDGE TO RAMA ROAD 25

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

Prepared for:
Morrison Hershfield Limited
Suite 600
255 Yorkland Blvd.
Toronto, Ontario M2J 1T1

Mr. Stanley Ma, Project Manager

Prepared by:

Infrastructure Engineering Group Inc.
39-69 Bessemer Road
London, Ontario
N6E 2V6

October 6, 2009

08-1-IEG6-30-675/C

Distribution:

5	Copies -	Morrison Hershfield Limited
	Digital Copies -	Morrison Hershfield Limited
3	Copies -	Infrastructure Engineering Group Inc.

Geocres No.: 31D-487

TABLE OF CONTENTS

PART A – FOUNDATION INVESTIGATION	1
1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	2
2.1 Site Location.....	2
2.2 Physiography and Topography	2
3.0 INVESTIGATION PROCEDURES.....	4
3.1 Field Investigation	4
3.2 Laboratory Analysis	5
4.0 SUBSURFACE CONDITIONS	5
4.1 General Subsurface Conditions	5
4.1.1 Pavement, Fill	6
4.1.2 Silty Sand Till	6
4.1.3 Limestone Bedrock	7
4.2 Groundwater Conditions.....	7
5.0 STATEMENT OF LIMITATION	8

Drawings & Appendices

Drawing 1	Borehole Locations and Soil Strata
Appendix “A”	Explanation of Terms Used in Report
	Record of Borehole Sheets Boreholes C25-1 to C25-4
Appendix “B”	Laboratory Test Results
	Grain Size Distribution Figures 1 and 3
	Plasticity Chart Figures 2 and 4
	Rock Core Compressive Strength Figure 5
Appendix “C”	Limitations of Report
Appendix “D”	Site Photographs

PART A – FOUNDATION INVESTIGATION

1.0 INTRODUCTION

This report presents the results of a foundation investigation carried out in 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 rehabilitation/replacement of non-structural Culvert C03, and rehabilitation of structural Culverts C25 and C28, and no work to be done on structural Culverts 14 and 15.

This report covers the site of Structural Culvert No. 30-675/C, also described as C25 in this report, and in the culvert summary as Culv 25.

The purpose of the investigation was 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.

Based on the information presented in the Culvert Summary provided by Morrison Hershfield, and verbal discussion with the project team, it is understood that no further work will be carried out on Structural Culvert No. 30-675/C for this culvert for this contract. The geotechnical investigation report is completed for the records and future use, if required.

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.

Structure 30-675/C is located on Highway 12, approximately 15.2 km north of the south limit of this Contract at Gamebridge (Station 10+000), located at Station 25+212. Photographs of this culvert site are presented in Appendix "D". The existing structure is a reinforced concrete, rigid frame open footing culvert with a span of 3.66 m, a height of 2.4 m, a length of 23.00 m (3.66 m span by 2.44 m height in accordance with ETR Plate No. 205-12/51-0), with an overfill height of approximately 2.3 m. The culvert opening dimensions were obtained from the Culvert Summary provided by Morrison Hershfield and verified with the ETR drawings provided in the RFP.

This culvert is located within a drainage valley in which the stream flows easterly (northerly). The approach embankments were built on both the north-east and south-west sides of the culvert, with a maximum height of approximately 4.7 m. The embankment slopes are typically 2.5 to 3H:1V and are grass covered. No signs of embankment slope instability were observed at the time of this foundation investigation.

There are no headwalls for this culvert and the ends of the culvert protrude beyond the road embankment. The water levels were observed at slightly above the bottom of the creek, at an approximate elevation of 224.5 m on December 3 and 16, 2008.

Photographs taken on March 1, 2002, as shown in Appendix B of the Highway Assessment Study Report indicate that water level was slightly higher than those observed during the field work. Photos taken by Morrison Hershfield on September 3, 2008 indicate that the water level was slightly lower than the water level taken during the field work for this project.

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.

The asphalt pavement surface over the existing culvert is near elevation 229 m while the ground surface at the base of the embankment is at approximate elevation of 224.3 m.

3.0 INVESTIGATION PROCEDURES

3.1 Field Investigation

Between December 3, 2008 and February 17, 2009, a CME 55 truck mounted drill rig was supplied by London Soil Test Ltd. and used on site for drilling and Standard Penetration Testing (SPT, following the procedures of ASTM D 1586). Two (2) boreholes (Boreholes C25-2 and C25-3) were drilled and sampled to obtain data for foundation design of the proposed rehabilitation work and potential culvert replacement. Rock coring was carried out on December 16, 2008 in Borehole C25-2 to provide geotechnical data as per the requirements of our proposal for this work. Hand-drilled boreholes cannot be completed at the location of Borehole C25-1 and C25-4 due to inaccessibility. A series of dynamic cone penetration tests were carried out at the location C25-1 instead. Dynamic cone penetration tests were also not completed at the location of C25-4 due to slippery site conditions and unsafe for access. The locations of the boreholes are shown on Drawing 1.

The culvert borehole numbering system was established from the Culvert Summary spreadsheet provided by Morrison Hershfield. The subject Culvert was identified as Culvert 25, with a Structure Number 30-675/C as presented in the Culvert Summary. The boreholes for this culvert are numbered C25-1 to C25-4 accordingly.

The boreholes were numbered C25-1 to 25-4 for the subject culvert and the depths of sampling were as follows:

Borehole No.	Depth of Sampling (m)
C25-1 (DCP only)	1.58
C25-2 (with rock coring)	7.47
C25-3	5.99
C25-4 (DCP only)	To be completed

The sampled boreholes were drilled 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.

Rock cores were retrieved using NQ core assembly (47.6 mm ID). The rock core samples were identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and rock core recovery. All rock cores were placed in wooden core boxes and transported to our laboratory for further examination, to confirm the field logging, and laboratory testing.

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., supervised the fieldwork and worked under the direction of the project engineer, Mr. Eric Chung, P. Eng. 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 IEG's London laboratory for further examination and laboratory testing.

The chainages and offsets at the borehole locations were provided to Morrison Hershfield and the ground surface elevations and UTM co-ordinates (northing and easting) 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 "A".

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 section of the rock core (at 6.25 m depth from Borehole C25-2) was selected for uniaxial compressive strength testing in accordance with ASTM 2938. The testing was performed by Trow Associates Inc. of Brampton and the results are presented as Figure 5 in Appendix B.

The results of the laboratory testing are presented on the Record of Borehole sheets (Appendix "A"), and Laboratory Test Results (Figures 1 to 5, Appendix "B").

4.0 SUBSURFACE CONDITIONS

4.1 General Subsurface Conditions

Reference is made to the Record of Borehole sheets (Appendix "A") and Laboratory Test Results (Appendix "B") 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 Drawing 1 will vary between and beyond the borehole locations.

In general, the subsurface deposits at the site consist of loose to compact embankment fill, placed on a 0.61 to 1.72m thick layer of silty sand till which is in turn underlain by limestone bedrock.

4.1.1 Pavement, Fill

Boreholes C25-2 and C25-3, located at the edge of existing pavement in the shoulder areas, encountered 610 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 4.27 m (elevation 224.49 m) at Borehole C25-3. The fill beneath the shoulder gravel consists of a mixture of silty sand and gravel to sandy silt with clay lumps. The embankment fill is placed on a 910 mm thick layer of partially decomposed peat.

Borehole C25-3, located at the north-east edge of existing pavement in the shoulder area, encountered 100 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 1.52 m (Elevation 219.19 m). The fill beneath the shoulder gravel consists of a mixture of silty sand and gravel to sandy silt with silty clay lumps and traces of organics.

Four (4) grain size distribution analyses of the embankment fill are shown on Figure 1 of Appendix "B". The results of an Atterberg Limit test are provided in Figure 2.

Standard penetration tests yielded "N"-values from 5 to 28 blows per 0.3 m. This fill is brown to dark brown in colour and the measured natural moisture contents range from 14 to 46%. The higher moisture contents reflect the presence of organic matters and clay lumps. Based on two samples, the unit weight of the fill ranged from 20.3 to 22.8 kN/m³.

Based on the above field and laboratory test results, together with visual and tactile examination, the fill beneath the shoulder gravel consists of a mixture of silty sand and gravel to sandy silt with clay lumps and has a loose to compact compactness condition.

4.1.2 Silty Sand Till

A 0.61 to 1.72m thick layer of silty sand till was penetrated below the embankment fill and was further underlain by limestone bedrock. Two (2) grain size analyses were performed on the silty sand till deposit and the results are presented on Figure 3 of Appendix "B".

Two (2) samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 4 of Appendix "B" and summarized below:

ML, Sample at 4.57 m from Borehole C25-2

Liquid Limit (W_L)	23%
Plastic Limit (W_P)	20%
Plasticity Index (I_p)	3%
Natural Moisture Content (W)	9%

CL, Sample at 5.33 m from Borehole C25-3

Liquid Limit (W_L)	24%
Plastic Limit (W_P)	15%
Plasticity Index (I_p)	9%
Natural Moisture Content (W)	21%

The natural moisture contents of the silty sand till were in the range of 9 to 21%. The results of the grain size and Atterberg Limit tests indicate that the silty sand till deposit contains some clay particles.

Standard penetration tests yielded “N”-values 20 and 89 blows per 0.3 m. Based on the above field and laboratory test results, together with visual and tactile examination, the silty sand till deposit exhibited a compact to very dense compactness condition.

4.1.3 Limestone Bedrock

The sandy silty clay is underlain by a stratum of grey to tan limestone bedrock. The appearance of the rock core sample is fossiliferous with sections that are coralliferous, with close to wide bedding planes.

Recovery of the rock core sample was at 100% and the Rock Quality Designation (RQD) at 83%. Therefore, the limestone bedrock is considered to be of good to excellent quality.

A single uniaxial compressive strength determination carried out on a section of rock core samples yielded a result of 63.4 MPa and is considered to be “strong”. The uniaxial compressive strength test report is enclosed in Appendix B as Figure 5.

4.2 Groundwater Conditions

The groundwater condition was monitored during and upon completion of sampling. On completion of drilling, groundwater was observed in Borehole C25-2 and C25-3 at depths of 4.6 and 4.3 m, respective elevations of 223.55 and 224.46 m.

The water levels were observed at slightly above the bottom of the creek, at an approximate elevation of 224.5 m on December 3 and 16, 2008.

It should be noted that the groundwater level will fluctuate seasonally and in response to weather events. Under adverse conditions, water could be perched within the embankment fill. It is reasonable to assume that groundwater could be similar to the water level in the creek during high flow conditions.

5.0 STATEMENT OF LIMITATION

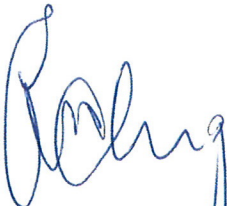
We recommend that once the details of the proposed structure are finalized, our recommendations should be reviewed for their specific applicability.

The Limitations of Report, as Quoted in Appendix "C", 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

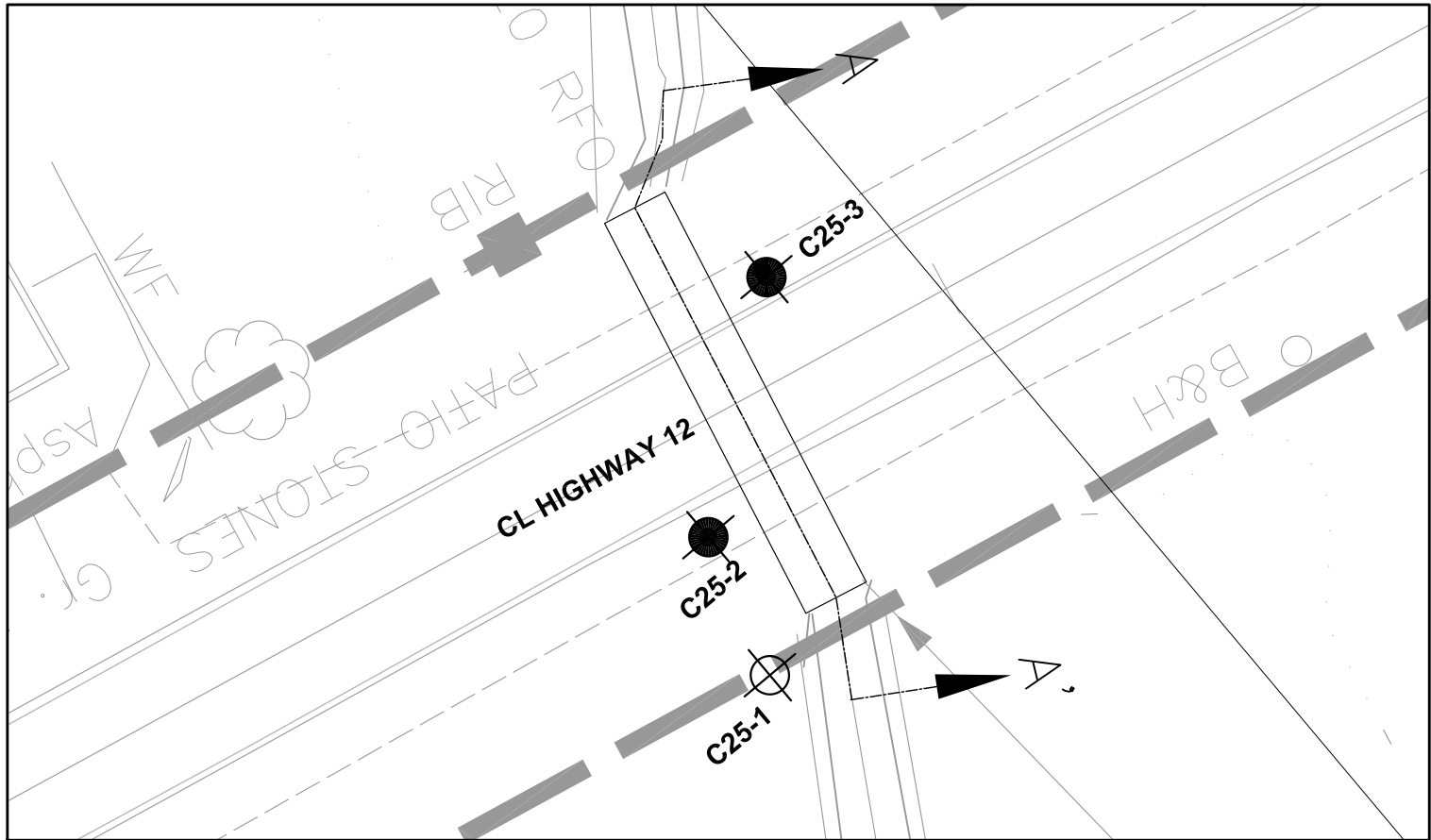


Ministry of Transportation/Morrison Hershfield Limited
W.P. 365-98-00
Rehabilitation of Highway 12 from Rama Road to Gamebridge
Agreement # 2004-E-0070

08-1-IEG6-30-675/C
Final Report
Drawing 1
October 6, 2009

Drawing 1
Borehole Locations
And
Soil Strata

MINISTRY OF TRANSPORTATION, ONTARIO



BOREHOLE LOCATION PLAN

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

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

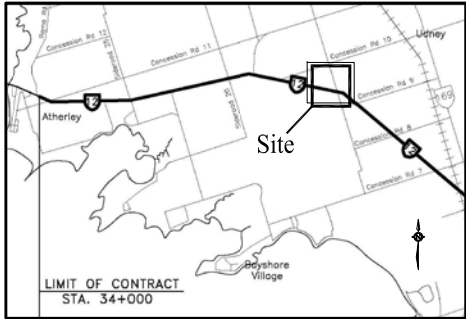


Structural Culvert 30-675/C
Highway 12
BOREHOLE LOCATION PLAN & PROFILE

SHEET
1

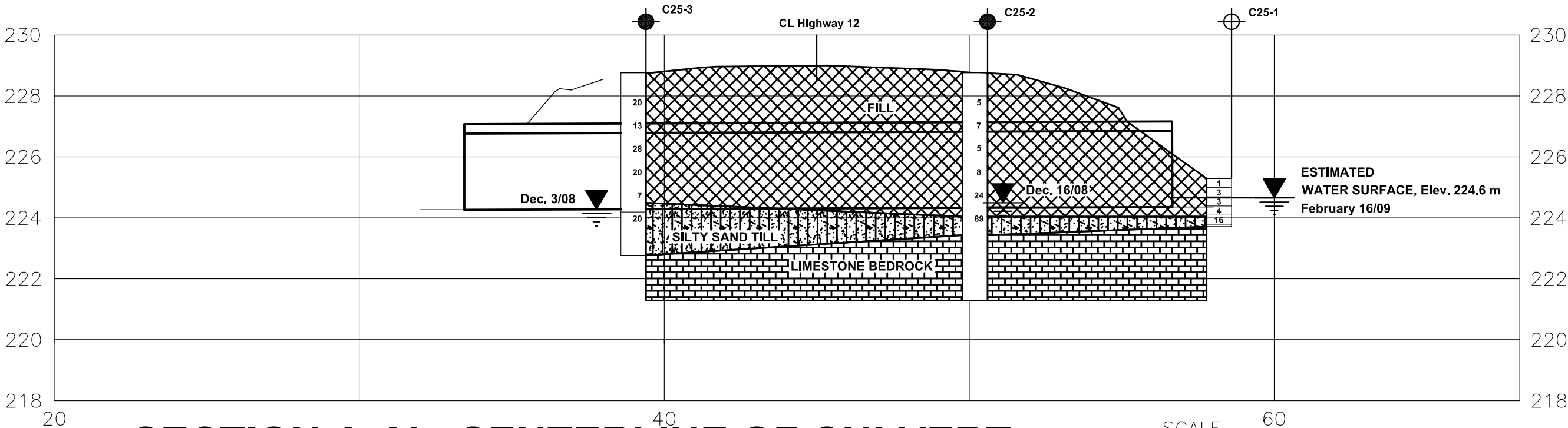
I.E. Infrastructure Engineering Group Inc.
Pavement & Construction Materials Consulting Engineers
GTA • Kitchener • London • Windsor

KEYPLAN NTS

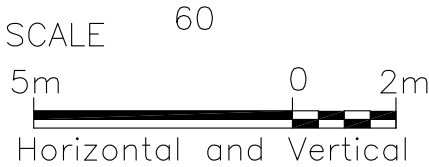


LEGEND

- 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



SECTION A-A' - CENTERLINE OF CULVERT



- NOTES
- 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.
 - THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES AND BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE.
 - SUBGRADE ELEVATION OF THE EXISTING FOOTING NOT KNOWN AND IS ESTIMATED TO BE AT 1.6m BELOW THE CREEK BED.
 - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.

BOREHOLE NO.	ELEVATION	UTM CO-ORDINATES	
		NORTH	EAST
C25-1	225.29	4940306	324880
C25-2	228.76	4940314	324882
C25-3	228.76	4940323	324893
C25-4	???.??	???????	???????

REVISIONS			
	06/09/09	J.L.	Final
	18/05/09	J.L.	Draft
	DATE	BY	DISCRIPTION
Geocres : 31D-487			
HWY No.		HWY 12	DIST CENTRAL
SUBM'D J.L.	CHECKED E.C.	DATE 25/03/09	SITE 30-675/C
DRAWN J.L.	CHECKED J.L.	APPROVED E.C.	DWG 1

Appendix A

Explanation of Terms Used in Report

Record of Borehole Sheet

Boreholes C25-1 TO C25-4

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
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
C_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_r	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1. %	VOID RATIO	e_{min}	1. %	VOID RATIO IN DENSEST STATE
γ_s	kn/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1. %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1. %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kn/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kn/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kn/m ³	UNIT WEIGHT OF DRY SOIL	i_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{i_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kn/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{i_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1. %	VOID RATIO IN LOOSEST STATE	j	kn/m ³	SEEPAGE FORCE
γ'	kn/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No C25-1

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northing - 4940306, Easting - 324880 ORIGINATED BY RB
 DIST Central Region HWY Highway 12 BOREHOLE TYPE Dynamic Cone COMPILED BY JL
 DATUM Geodetic DATE 02.17.09 - 02.17.09 CHECKED BY EC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		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					
						○ UNCONFINED	+ FIELD VANE						
						● QUICK TRIAXIAL	× LAB VANE						
						20 40 60 80 100	20 40 60 80 100						
225.29 0.00	Ground												31.75 Kg (70lbs.) hammer used for driving dynamic cone. Nc values corrected for standard 63 kg (140 lbs.) hammer.
223.71 1.58	End of Borehole.												Dynamic cone refusal @ 1.58 m on presumed bedrock.



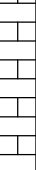
JOE MTO 08-1-IEG6 CULVERTS.GPJ ONTARIO MOT.GDT 05/17/09

RECORD OF BOREHOLE No C25-2

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northring - 4940314, Easting - 324882 ORIGINATED BY RB
 DIST Central Region HWY Highway 12 BOREHOLE TYPE H/S Augering 110 mm Inside Dia. COMPILED BY JL
 DATUM Geodetic DATE 12.16.08 - 12.16.08 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	PENETR. RESISTANCE STANDARD ● DYN. CONE		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
								● QUICK TRIAXIAL	× LAB VANE						
228.76 0.00	Ground						20 40 60 80 100								
228.15 0.61	610 mm SHOULDER GRAVEL.		1	GRAB						○				27 55 12 6 (18)	
			2	SPT	5			228				○			
			3	SPT	7			227				○			Water level measured @ 2.1 m @ completion of coring.
			4	SPT	5			226				○			10 44 32 14 (46)
			5	SPT	8			225				○			
			6	SPT	24			224					○		Water level measured @ 4.6 m @ completion of drilling.
224.04 4.72	Silty SAND TILL, SM Grey, damp, very dense,with embedded gravel.		7	SPT	89					○		H	18 53 22 7 (29)		
223.43 5.33	LIMESTONE BEDROCK Tan to grey, fossiliferous, strong, good quality, close to moderately close bedding plane.												Rock core with NQ wireline.		
			8	CORE	NQWL								Recovery - 100%, RQD - 83% Uniaxial Compressive Strength = 63.4 MPa		
221.29 7.47	End of Borehole														

+ 3, X 3: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C25-3

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northring - 4940323, Easting - 324893 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 _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
228.76 0.00	Ground							20 40 60 80 100		10 20 30					
228.15 0.61	610 mm SHOULDER GRAVEL.		1	GRAB										24 62 11 4 (15)	
			2	SPT	20										
			3	SPT	13										18 41 28 13 (40)
	FILL Dark brown, moist, loose to compact, consisting of mixed sand, gravel, silty clay and trace organics .		4	SPT	28								46	20.3	
			5	SPT	20										
			6	SPT	7										
224.49 4.27	Silty SAND TILL, SM Grey, damp, very dense,with embedded gravel, some clay.		7	SPT	20									W.L. @ 4.3m @ completion of drilling.	
			8	GRAB										14 47 27 13 (40)	
222.77 5.99	End of Borehole													Auger refusal @ 6.00 on presumed bedrock.	

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

1 OF 1

METRIC

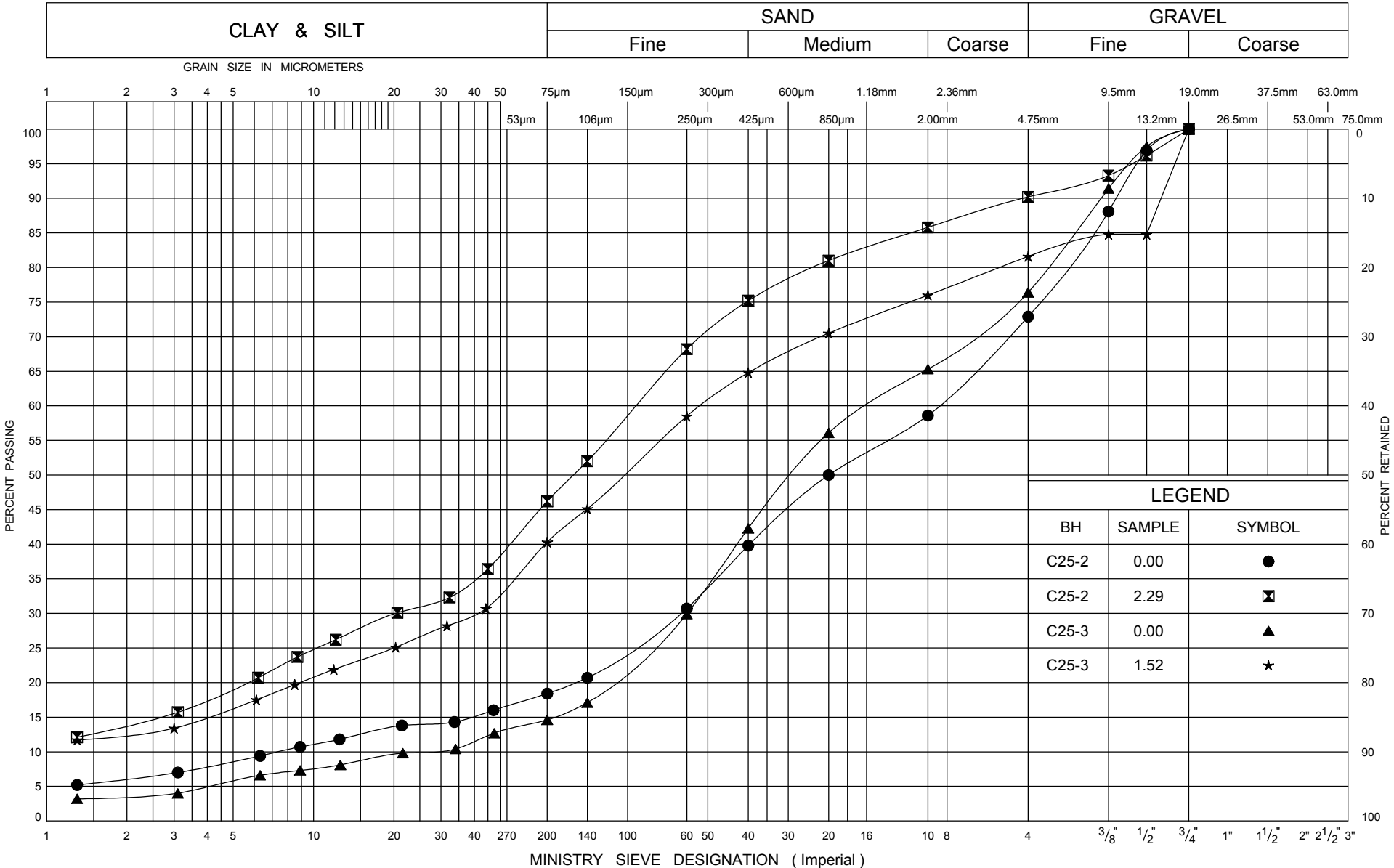
○ ¹⁵⁰ UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

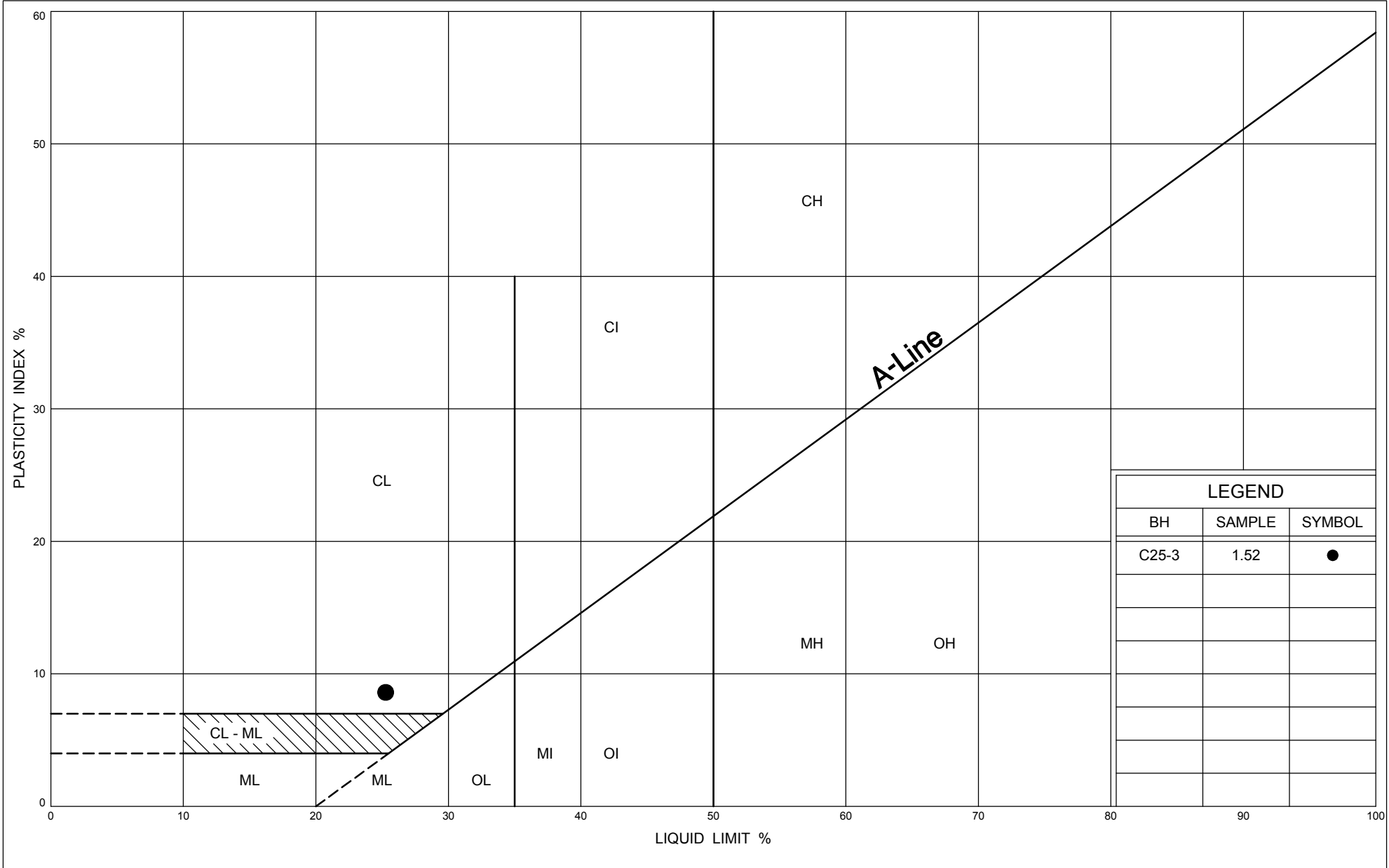
Appendix B

Laboratory Test Results

Grain Size Distribution	Figures 1 and 3
Plasticity Chart	Figures 2 and 4
Rock Core Report	Figure 5

UNIFIED SOIL CLASSIFICATION SYSTEM



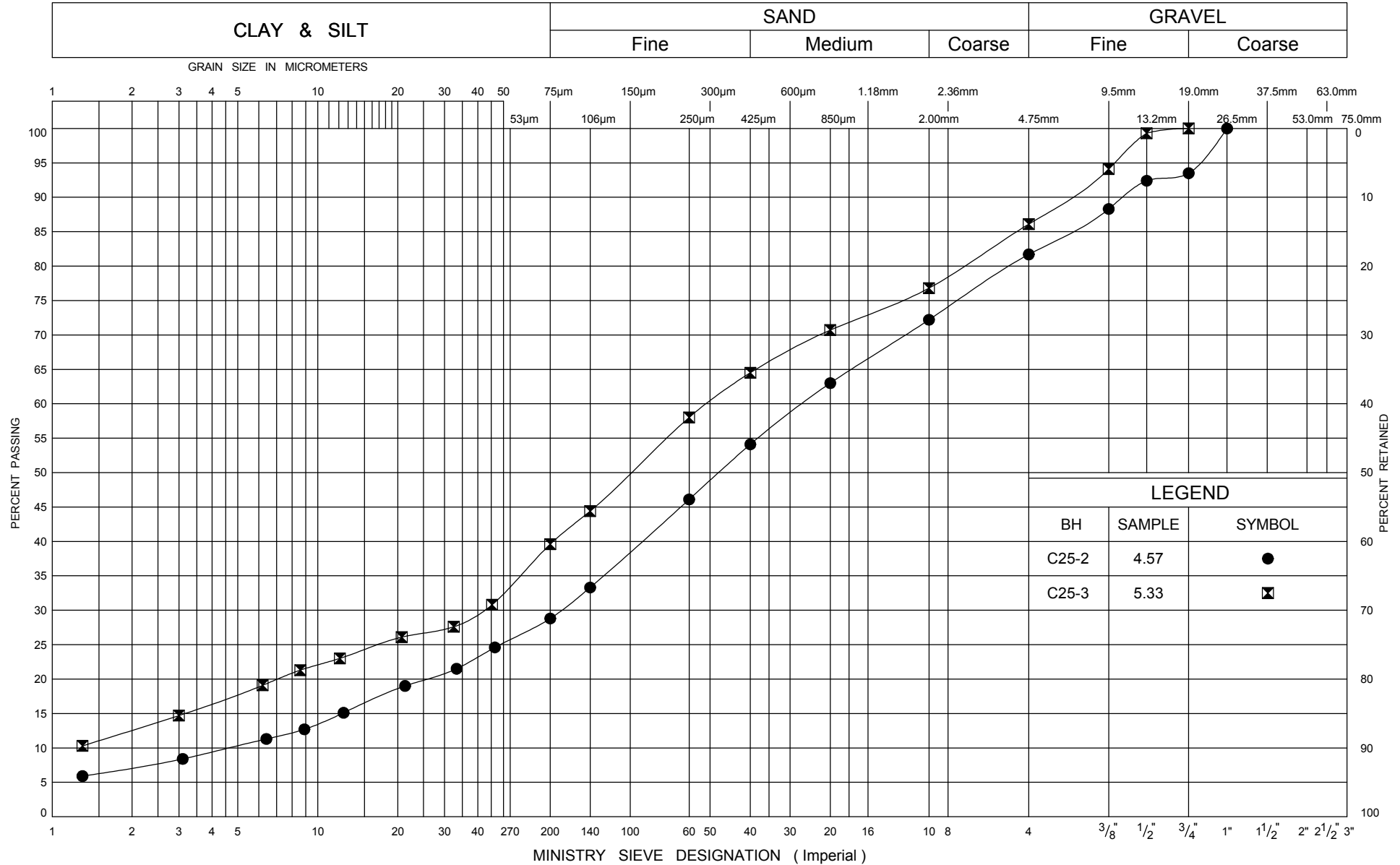


Ministry of
Transportation

PLASTICITY CHART FILL

FIG No 2
GWP 365-98-00
Highway 12, Rama Road to Gamebridge

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

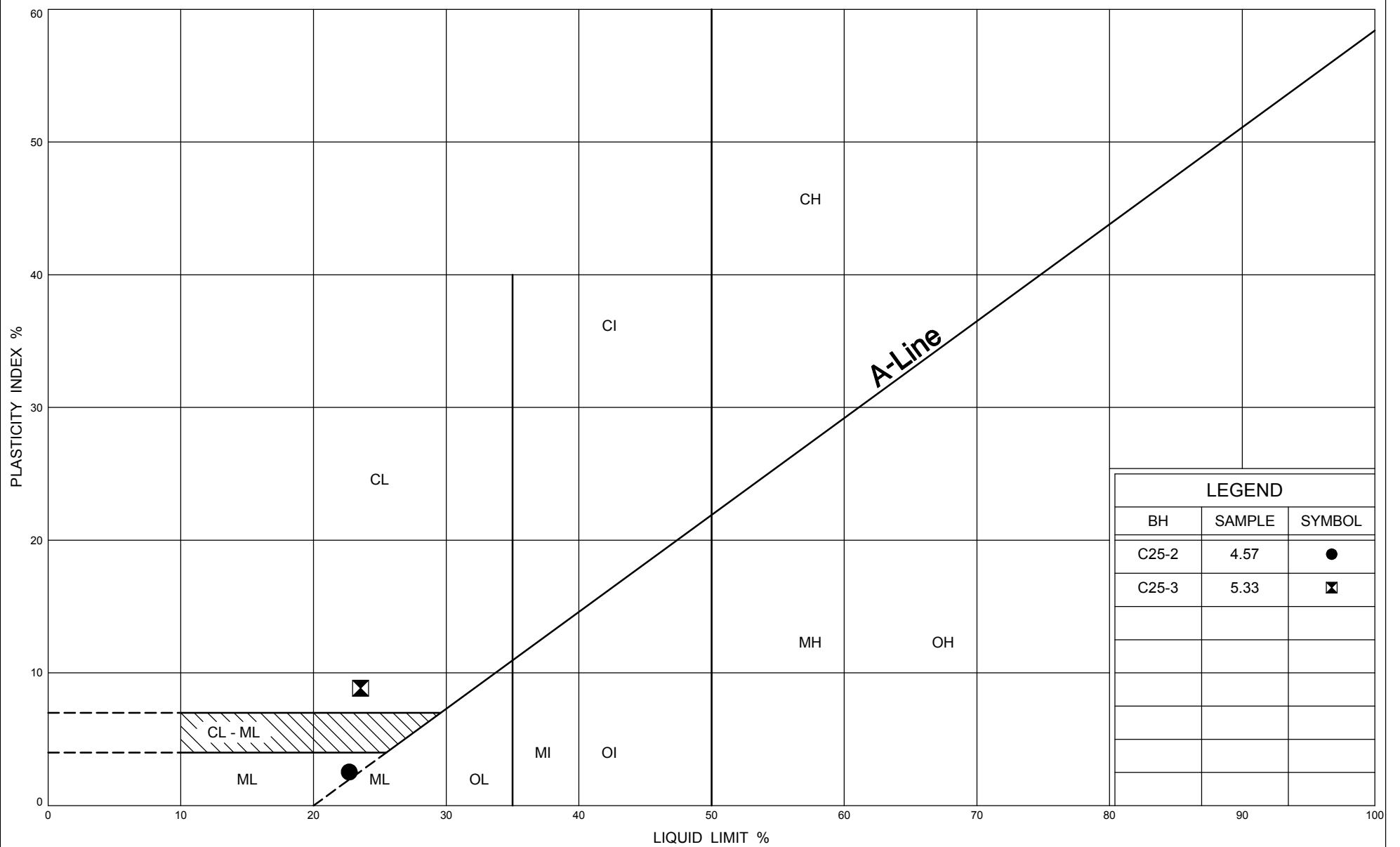
GRAIN SIZE DISTRIBUTION

SILTY SAND TILL, SM

FIG No 3

GWP 365-98-00

Highway 12, Rama Road to Gamebridge



Ministry of
Transportation

PLASTICITY CHART SILTY SAND TILL, SM

FIG No 4

GWP 365-98-00


Highway 12, Rama Road to Gamebridge

Rock Core Test Report

Project No.: LAGM00289085C

Project Name: Hwy 12 – 03/20019

Core No.	BH C25-2
Location	20' 5"-21' 0"
Date Cored	
Date Tested	April 7, 2009
Height - (mm)	126.7
Average Diameter - (mm)	45.8
Corrected Compressive Strength - (MPa)	63.4


 Testing Laboratory Representative Signature
 Ammanuel Yousif


 Date

I:\2003-Brampton\Projects\Geotechnical Engineering\Materials & Quality Management\00200000\00280000\289085c - Hwy 12\Concrete Core Test Report - Apr 8, 2009.rtf



Ministry of
Transportation

ROCK CORE UNIAXIAL COMPRESSIVE STRENGTH REPORT

FIG No 5

WP 365-98-00

Highway 12, Rama Road to Gamebridge

Ministry of Transportation/Morrison Hershfield Limited
W.P. 365-98-00
Rehabilitation of Highway 12 from Rama Road to Gamebridge
Agreement # 2004-E-0070

08-1-IEG6-30-675/C
Final Report
Appendix C
October 6, 2009

Appendix C

Limitations of Report

APPENDIX C

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.

Ministry of Transportation/Morrison Hershfield Limited
W.P. 365-98-00
Rehabilitation of Highway 12 from Rama Road to Gamebridge
Agreement # 2004-E-0070

08-1-IEG6-30-675/C
Final Report
Appendix D
October 6, 2009

Appendix D

Site Photographs



C25 - Station 25+212 - Looking North



C25 - Station 25+212 - Downstream



C25 - Station 25+212 - Upstream