

FOUNDATION INVESTIGATION REPORT

STRUCTURAL CULVERT SITE NO. 30-674/C
TOWNSHIP OF RAMA
HIGHWAY 12 FROM GAMEBRIDGE TO RAMA ROAD 25

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



I.E.
Group

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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-IEG6-30-674/C

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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 extensions 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. 30-674/C, also described in the culvert summary as C15.

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.

This culvert is an equalizing culvert for the wetlands located on both sides of Highway 12. 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 Culvert No. 30-674/C 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 30-674/C is located on Highway 26, approximately 10.7 km north the south limit of this Contract (Station 10+000 at Gamebridge), located at Station 20+674. 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 3.05 m, a height of 0.8 m, a length of 22.0 m (3.00 m span by 1.10 m height by 21.30 m in accordance with ETR Plate No. 205-12/38-0), with an overfill height of approximately 0.90 m. The culvert opening dimensions were obtained from the Culvert Summary provided by Morrison Hershfield and compared with the ETR drawings provided in the RFP.

The culvert site is located between two wetlands severed by Highway 12, and is used as an equalizing culvert for the severed wetlands. The approach embankments were built on both the east and west sides of the culvert, with a maximum height of approximately 1.8 m. The embankment slopes are typically 3H:1V or flatter, with localized steeper zones, and are grass and weed 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 areas adjacent to the ends of the culvert were inundated, with peat or muck present below the mucky water. The water levels were observed at slightly above the obvert of the culvert at an approximate Elevation of 220.06 m on December 2, 2008 and February 17, 2009.

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

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 220.64 m while the ground surface at the base of the embankment and in the wetland a Elevations 218.86 m (east) and 218.82 m (west).

3.0 INVESTIGATION PROCEDURES

3.1 Field Investigation

Between December 2, 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 C15-2 and C15-3) 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 February 17, 2009 adjacent to the original Borehole C15-3 location 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 C15-1 and C15-4 due to inundation of the area, and a series of dynamic cone penetration tests were carried out instead. 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 15, with a Structure Number 30-674/C as presented in the Culvert Summary. The boreholes for this culvert are numbered C15-1 to C15-4 accordingly and the depths of sampling were as follows:

Borehole No.	Depth of Sampling (m)
C15-1 (DCP only)	3.56
C15-2	5.18
C15-3 (with rock coring)	7.01
C15-4 (DCP only)	3.35

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.

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.

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 one-dimensional consolidation test (ASTM D 2435) was conducted on a relatively undisturbed thin-walled (Shelby tube) sample obtained from Borehole C15-3 at a depth of 3.20 m. The consolidation test was carried out by C.T. Soil & Materials Engineering Inc. of Windsor and the results are provided in a Void Ratio vs. Pressure curve plot enclosed in Figure 6 of Appendix B. Microscopic examination was carried out on the same Shelby sample taken within the varved clay, and photographs of part of the Shelby sample and microscopic examination are presented in Appendix "E".

A section of the rock core (at 5.79 m depth from Borehole C15-3) was selected for unconfined 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 7 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 7, 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 embankment fill to 1.22 m depth, placed on peat or buried topsoil and wood (likely tree stump and branches) extending to depths of 2.59 to 3.20 m (Elevations 217.85 to 217.31 m). The fill and buried topsoil/organics were underlain by a firm to stiff, varved clay stratum which was further underlain by limestone bedrock (contacted between Elevations 215.26 and 215.63 m).

4.1.1 Pavement, Fill, Topsoil

Boreholes C15-2 and C15-3, located at the in the shoulder areas encountered 760 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 1.22 m (Elevation 219.22 m) at Borehole C15-2 and to 1.22 m at Borehole C15-3 (Elevation 219.29 m). The fill beneath the shoulder gravel consists of a mixture of silty sand and gravel to sandy silt with clay lumps. The embankment fill was placed on a 1.37 m thick partially decomposed peat layer at Borehole C15-2 and 1.98 m thick peat and wood.

Two (2) grain size distribution analyses of the embankment fill is shown on Figure 1 of Appendix “B”.

Standard penetration tests yielded “N”-values of 6 and 7 blows per 0.3 m. This fill is brown to dark brown in colour and the measured natural moisture contents range from 13 to 25%. Unit weight of the fill was not determined due to the disturbance of the soil samples during sampling and sample retrieval.

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 sand, silt and gravel and in a loose compactness condition.

The partially decomposed peat and wood layer located below the embankment fill are in loose/soft conditions. The high “N”-values are anomaly and were obtained when driving the SPT through wood pieces and a localized sand and gravel pocket.

4.1.2 Varved Clay

A stratum of grey varved clay was contacted below the peat and wood and extended to the limestone bedrock contacted between depths of 2.59 m and 3.20 m below the existing ground surface, at Elevations 217.85 m and 217.31 m, respectively at Boreholes C15-2 and C15-3. The varved clay is generally layered with frequent silt seams and pockets typical of a fluvial deposit. Based on microscopic examination of the Shelby tube sample, the layering within the varved clay has a varve cycle spacing in the order of 7 mm. The sub-millimeter silt seams are composed of white silica (quartz) grains. The clay layers consist of equal thicknesses (2 to 3 mm) of reddish-brown clay (winter deposition) and a dark-grey clay (summer deposition). Microscopic examination also indicate that clay varves contain a significant micaceous content which are aligned and may provide reinforcement to the clay which can breakdown upon disturbance. Photos of the Shelby Tube sample and microscopic examination of the Shelby sample taken between 3.2 m and 3.8 m from Borehole C15-3 are presented in Appendix E.

Two (2) grain size analyses were performed on the clay deposit and the results are presented on Figure 2 of Appendix "B".

Three (3) samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 3 of Appendix "B" and summarized below:

Atterberg Limit	Minimum	Maximum	Average
Liquid Limit (W_L) %	51	57	54.0
Plastic Limit (W_P) %	21	28	24.0
Plasticity Index (I_P) %	29	31	30.0

The results of the Atterberg Limit tests reveal a clay of high plasticity (CH). The natural moisture contents of the varved clay were in the range of 34 to 54%.

Field vane tests carried out at a depth of 3.81 m (Elevation 216.63 m) in Borehole C15-2 yielded an undrained shear strength of 58 kPa with a sensitivity of 4.7. Field vane tests carried out at a depth of 4.57 m (Elevation 215.94 m) in Borehole C15-3 yielded an undrained shear strength of 35 kPa with a sensitivity of 2.0. The field vane results indicate that the varved clay is classified as medium sensitivity to sensitive. Based on visual examination and the soil structure observed under the microscope, the varved clay could easily be disturbed upon excavation. Undrained shear strength of the varved clay as determined from field pocket penetrometer ranged from 25 to 94 kPa. Standard penetration tests yielded "N"-values from 3 to 5 blows per 0.3 m.

Based on the above field and laboratory test results, together with visual and tactile examination, the varved clay deposit generally exhibited firm to stiff consistency.

The unit weight of the varved clay was measured on three (3) samples to be between 16.4 and 22.3 kN/m³.

A one-dimensional consolidation test (ASTM D 2435) was conducted on a relatively undisturbed thin-walled (Shelby tube) sample obtained from Borehole C15-3 at a depth of 3.20 m. These results are shown in Figure 6 of Appendix B and summarized below:

Sample Depth:	3.50 m
Elevation:	217.01 m
Liquid Limit (W_L)	57 %
Plastic Limit (W_P)	28%
Natural Moisture Content (W)	49%
Compression Index (C_C)	0.742
Recompression Index (C_r)	0.106
Pre-consolidation Pressure (σ_p)	250 kPa
Effective Overburden Pressure (σ_{vo})	40 kPa

The consolidation test was carried out by the Windsor laboratory of C.T. Soil & Materials Testing Inc.

4.1.3 Sandy Silty Clay Pocket

At Borehole C15-2, a localized sandy pocket was penetrated at a depth of 4.57 m within the varved clay stratum. One (1) grain size analysis was performed and the results are presented on Figure 4 of Appendix “B”.

One (1) sample was tested and exhibited the following Atterberg Limits. These results are shown in Figure 4 of Appendix “B” and summarized below:

Liquid Limit (W_L)	23%
Plastic Limit (W_P)	11%
Plasticity Index (I_p)	12%
Natural Moisture Content (W)	34%

Standard penetration tests yielded an “N”-value of 3 blows per 0.3 m. Based on the above field and laboratory test results, together with visual and tactile examination, the sandy silty clay pocket exhibited a soft consistency.

4.1.4 Limestone Bedrock

The varved 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 varies from 100 % to 83%. Rock Quality Designation (RQD) varies from 83 % to 87%, and 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 70 MPa and is considered to be “strong”. The uniaxial compressive strength test report is enclosed in Appendix B as Figure 7.

4.2 Groundwater Conditions

The groundwater condition was monitored during and upon completion of sampling. On completion of drilling, free groundwater was not observed in the sampled boreholes.

The water levels in the wetlands were observed at slightly above the obvert of the culvert at an approximate Elevation of 220.06 m on December 2, 2008 and February 17, 2009 and these likely reflected a high water level condition.

On completion of drilling, water levels were recorded at a depth of 0.9m in both Boreholes C15-2 and 3. The water levels measured in the boreholes may not have stabilized for the short duration that the boreholes were kept opened. It is reasonable to assume that the groundwater level to be consistent with the water levels of the severed wetlands at the time of the investigation.

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 and on top of the organic deposits. It is reasonable to assume that groundwater could be similar to the water level in the wetland during wet seasons, and may be well above the obvert of the culvert.

5.0 STATEMENT OF LIMITATION

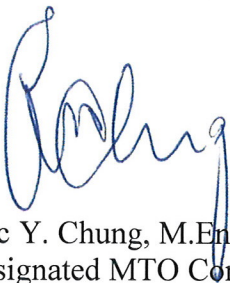
We recommend that once the details of the proposed structure are finalized, our recommendations should be reviewed for their specific applicability.

The Limitations of Report, as Quoted in Appendix "C", is an integral part of this report.

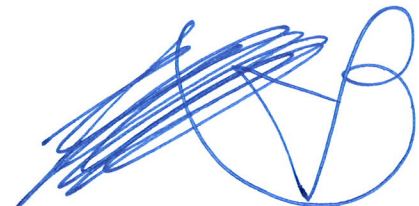
We trust that we have completed the assignment within the Terms of Reference for this project. If there are any questions concerning this report, please do not hesitate to contact our office.

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

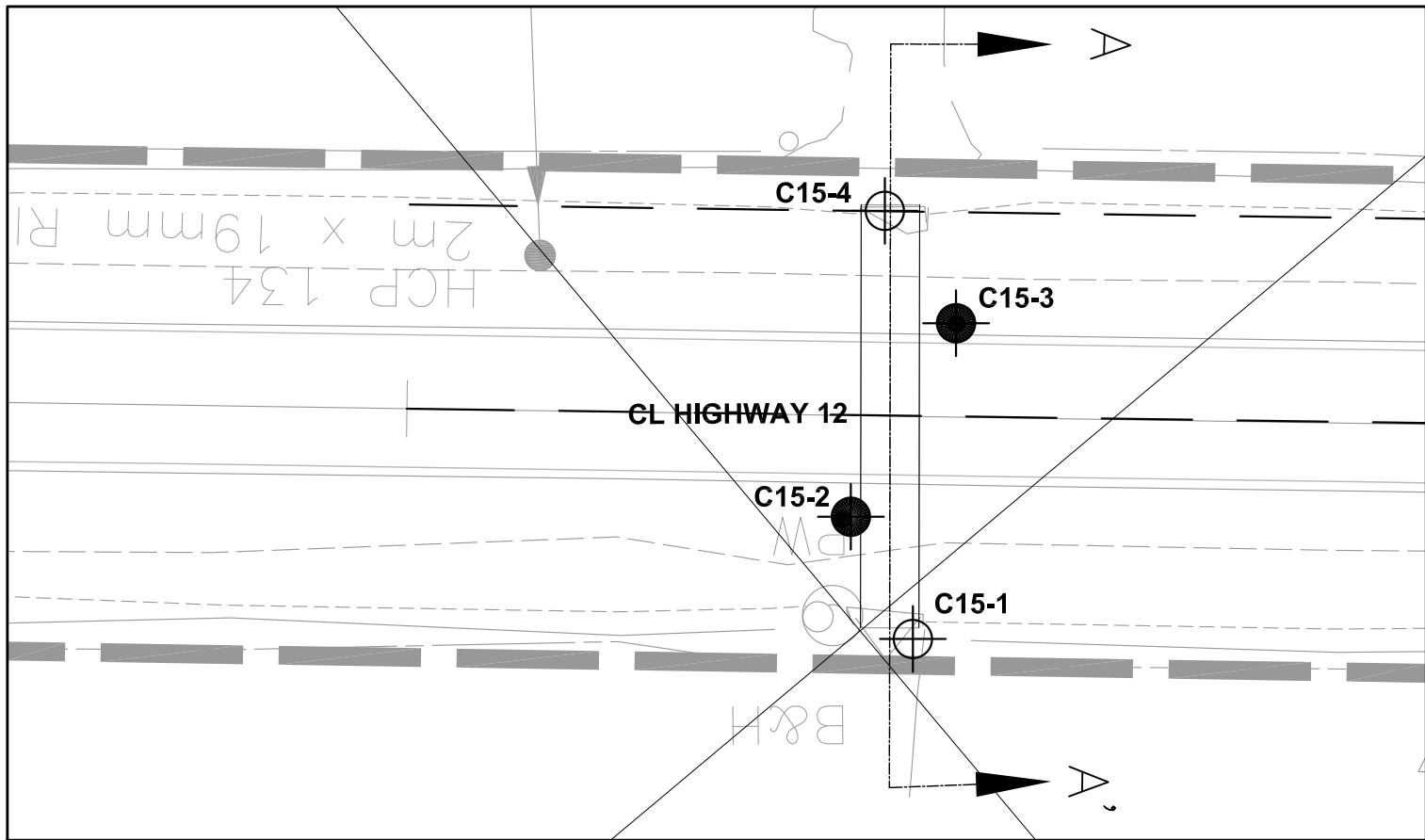


Ministry of Transportation/Morrison Hershfield Limited
W.P. 365-98-00
Rehabilitation of Highway 12 from Rama Road to Gamebridge
Agreement # 2004-E-0070

08-1-IEG6-30-674/C
Final Report
Drawing 1
October 6, 2009

Drawing 1
Borehole Locations
And
Soil Strata

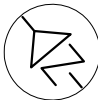
MINISTRY OF TRANSPORTATION, ONTARIO



BOREHOLE LOCATION PLAN

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

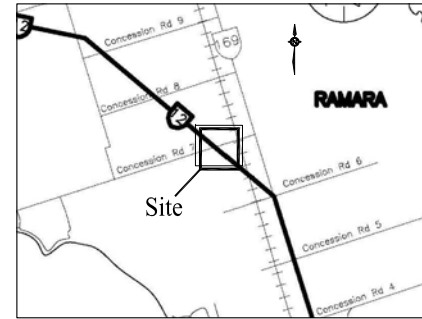
CONT No xxxx-xxxx
WP No GWP 365-98-00
Structural Culvert 30-674/C
Highway 12
BOREHOLE LOCATION PLAN & PROFILE



SHEET
1

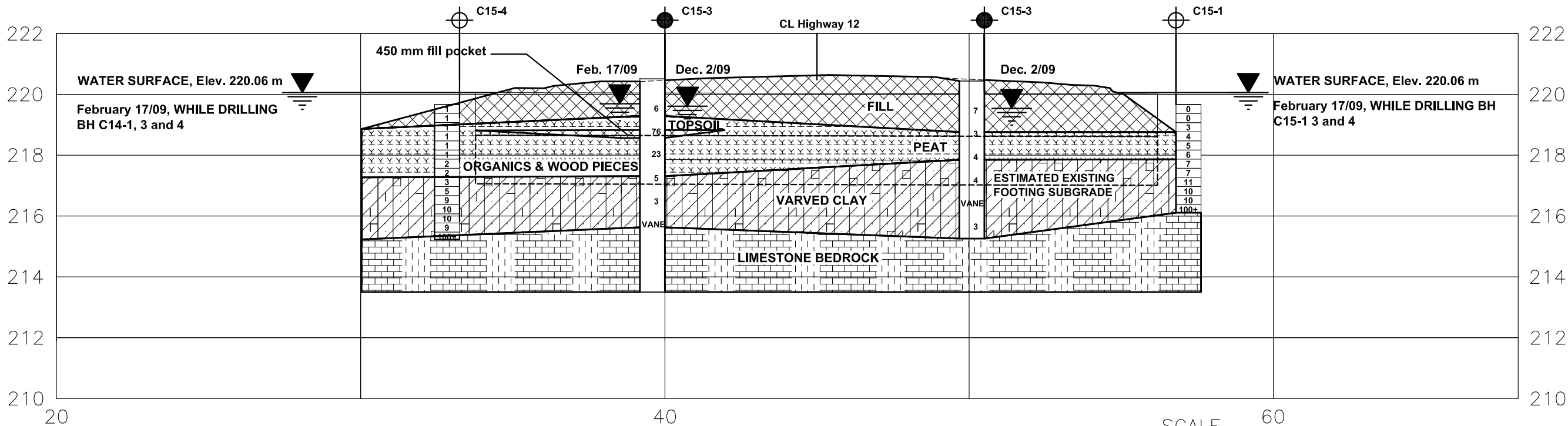
I.E. Infrastructure Engineering Group Inc.
Pavement & Construction Materials Consulting Engineers
GTA • Kitchener • London • Windsor

KEYPLAN NTS

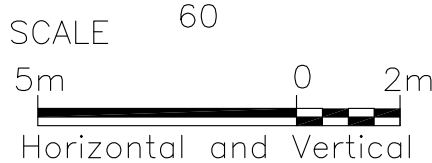


LEGEND

- 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
C15-1	219.67	4937698	328502
C15-2	220.44	4937705	328503
C15-3	220.51	4937709	328514
C15-4	219.67	4937716	328515

REVISIONS			
	06/09/09	J.L.	Final
	18/05/09	J.L.	Draft
	DATE	BY	DISCRPTION
Geocres : 31D-486			
HWY No.		HWY 12	
DIST		CENTRAL	
SUBM'D	J.L.	CHECKED E.C.	DATE 25/03/09
SITE		30-674/C	
DRAWN	J.L.	CHECKED J.L.	APPROVED E.C.
DWG		1	

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Appendix A

Explanation of Terms Used in Report

Record of Borehole Sheet

Boreholes C15A-1 TO C15A-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_c	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_c}$

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 C15-1

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northing - 4937698, Easting - 328502 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 ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE					
							20 40 60 80 100						
219.67 0.00	Ground												31.75 Kg (70lbs.) hammer used for driving dynamic cone. Nc values corrected for standard 63 kg (140 lbs.) hammer.
219													
218													
217													
216.11 3.56	End of Borehole.												Dynamic cone refusal @ 3.56 m on presumed bedrock.

JOE MTO 08-1-IEG6 CULVERTS.GPJ ONTARIO MOT.GDT 05/11/09

RECORD OF BOREHOLE No C15-2

1 OF 1

METRIC

W.P. WP 365-98-00 LOCATION Northring - 4937705, Easting - 328503 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 _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	WATER CONTENT (%)
220.44	Ground						20	40	60	80	100	10	20	30	kN/m ³	GR SA SI CL	
0.00	50 mm SHOULDER GRAVEL. FILL Brown, moist, consisting of silty sand and gravel.		1	GRAB		▽	220						○			7 63 22 8 (31)	
219.68							219							○			Water level measured @ 0.9m @ completion of drilling.
0.76	FILL Dark brown, moist, loose, consisting of mixed sand, silt and clay.		2	SPT	7		218							○			
219.22																	
1.22	PEAT Black, moist, partially decomposed.		3	SPT	3		218										
217.85			4	SPT	4		217										
2.59	Varved CLAY, CH Grey, wet, firm to stiff, layered, with frequent silt seams and pockets, trace sand to sandy pockets, occasional gravel pieces.		5	SPT	4		217										0 1 39 61 (99)
			6	VANE		216											
			7	SPT	3											2 37 37 24 (61)	
215.26																	
5.18	End of Borehole.															Auger refusal @ 5.18 m on presumed bedrock.	

+ 3, X 3: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

METRIC

[illegible]

1 OF 1

METRIC

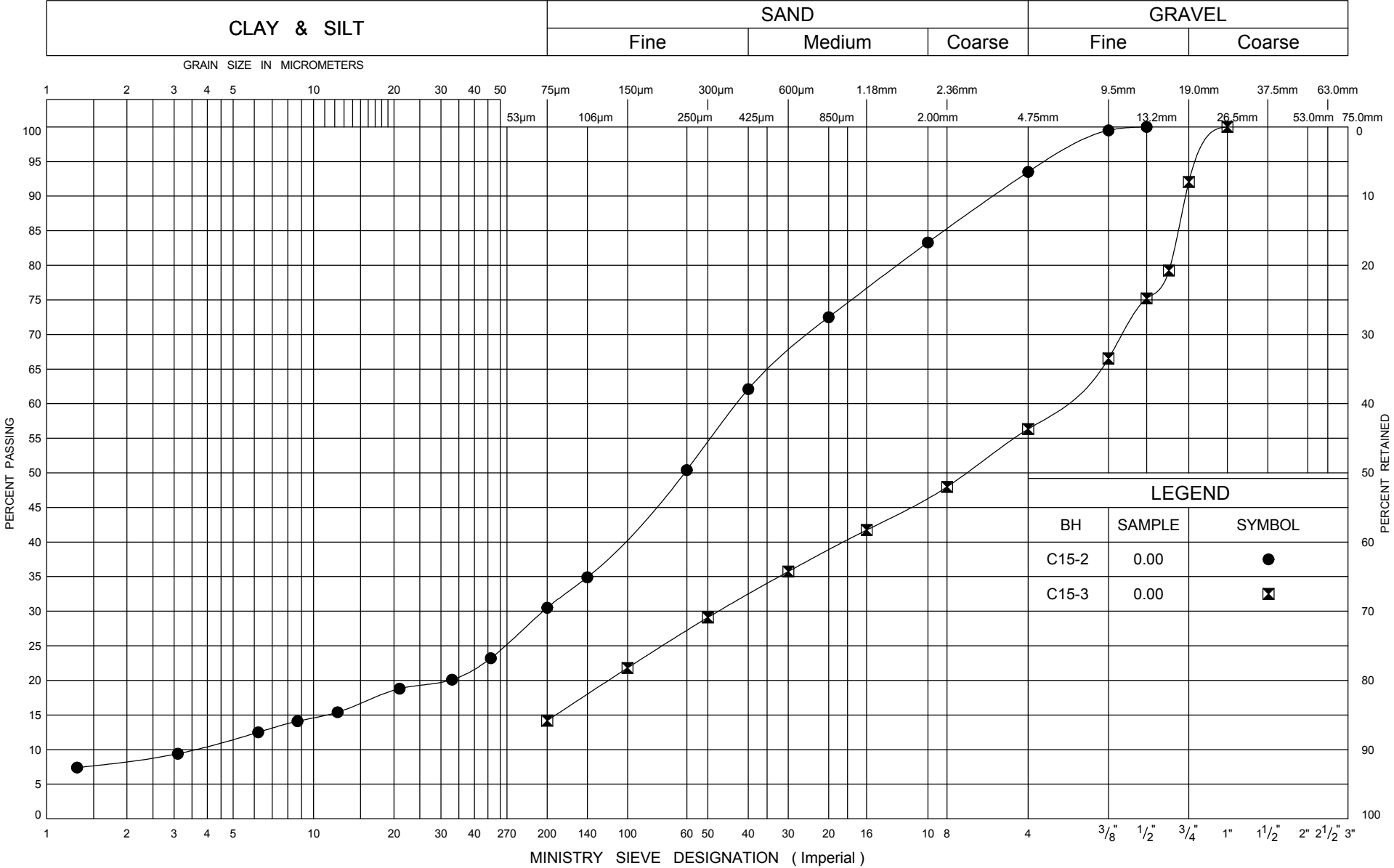
SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE
219.67 0.00	Ground				
216.32 3.35	End of borehole.				

Appendix B

Laboratory Test Results

Grain Size Distribution	Figures 1, 2 and 4
Plasticity Chart	Figures 3 and 5
Void vs Stress Consolidation Plot	Figure 6
Rock Core Report	Figure 7

UNIFIED SOIL CLASSIFICATION SYSTEM



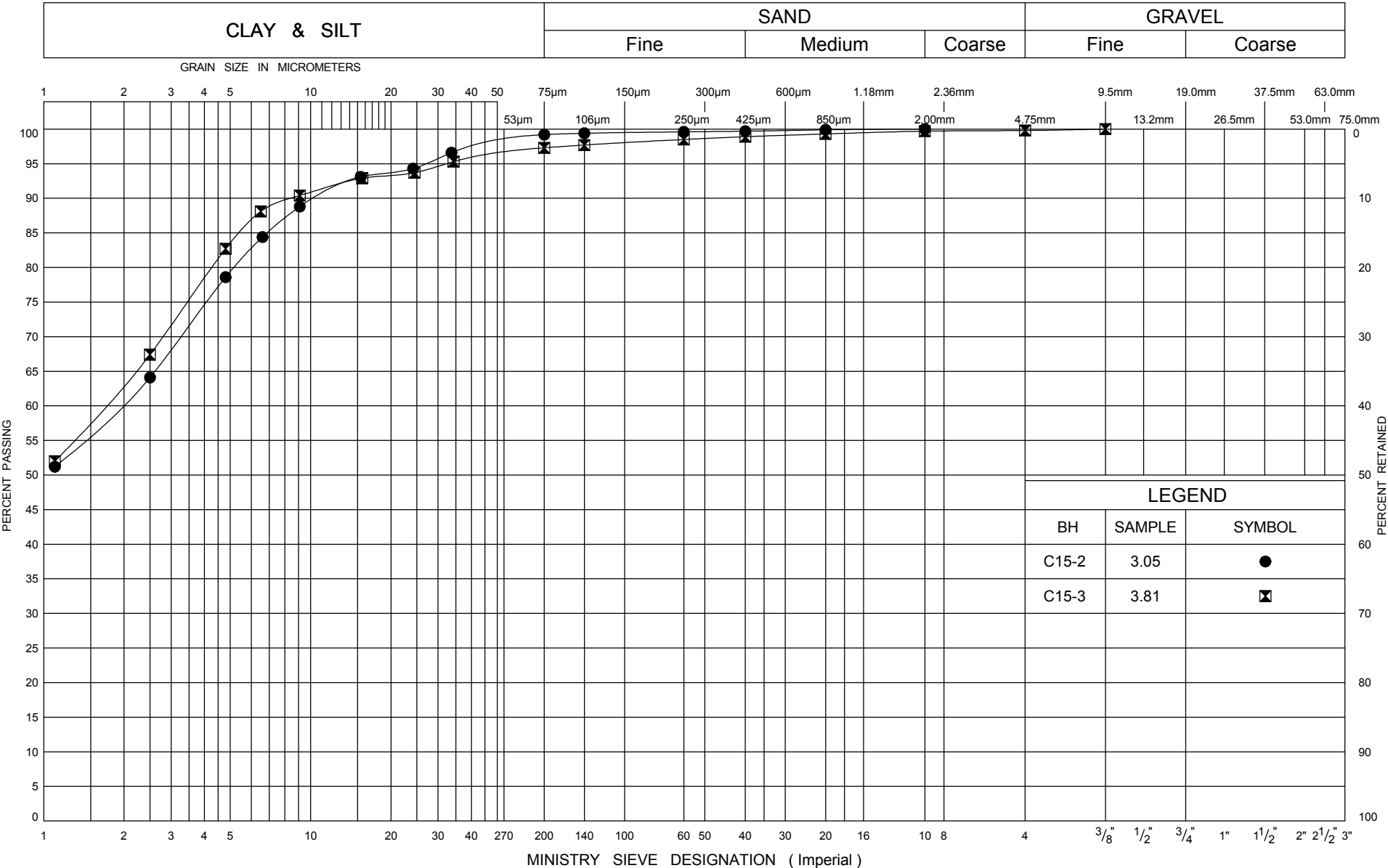
LEGEND		
BH	SAMPLE	SYMBOL
C15-2	0.00	●
C15-3	0.00	⊠

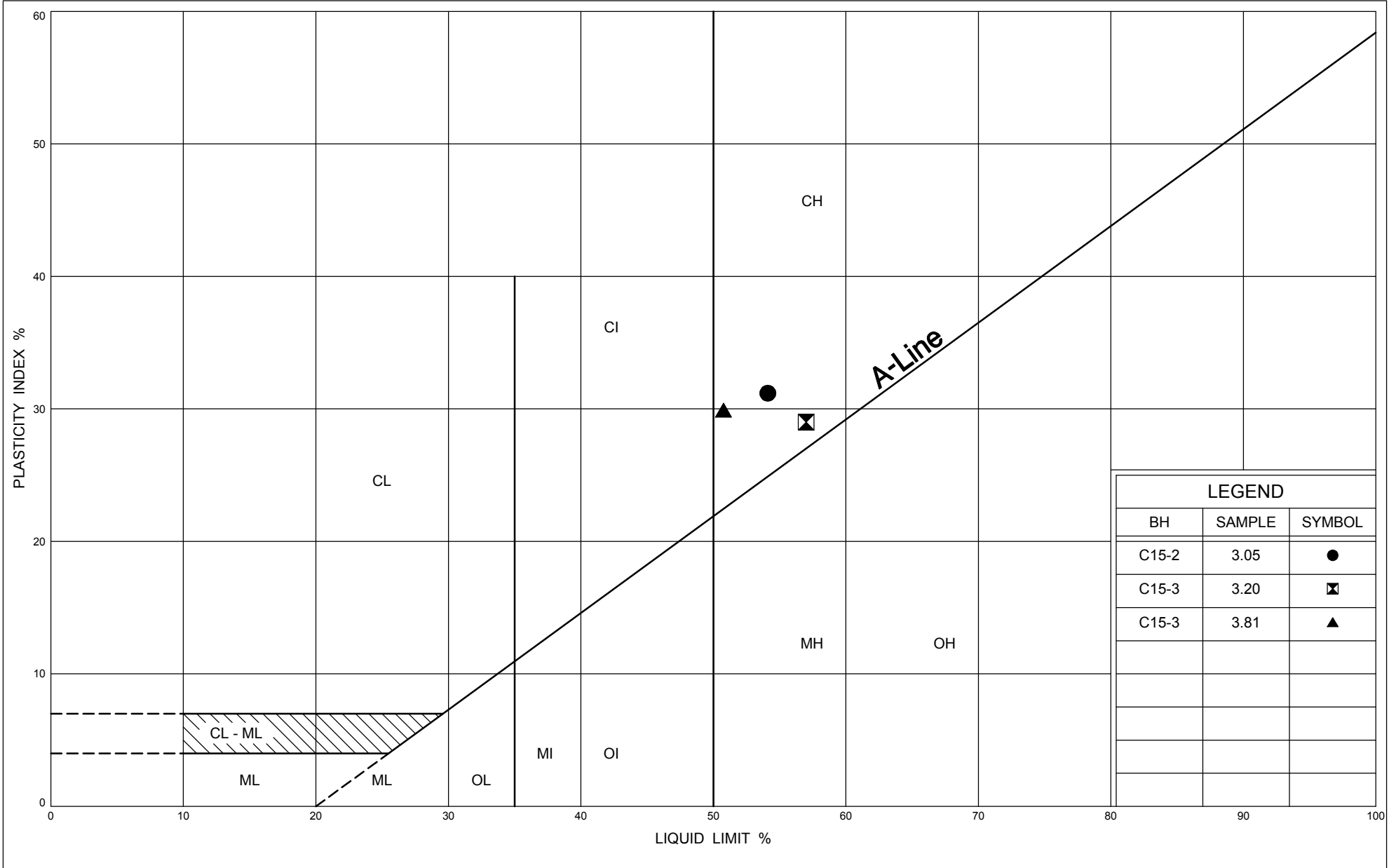


GRAIN SIZE DISTRIBUTION
FILL

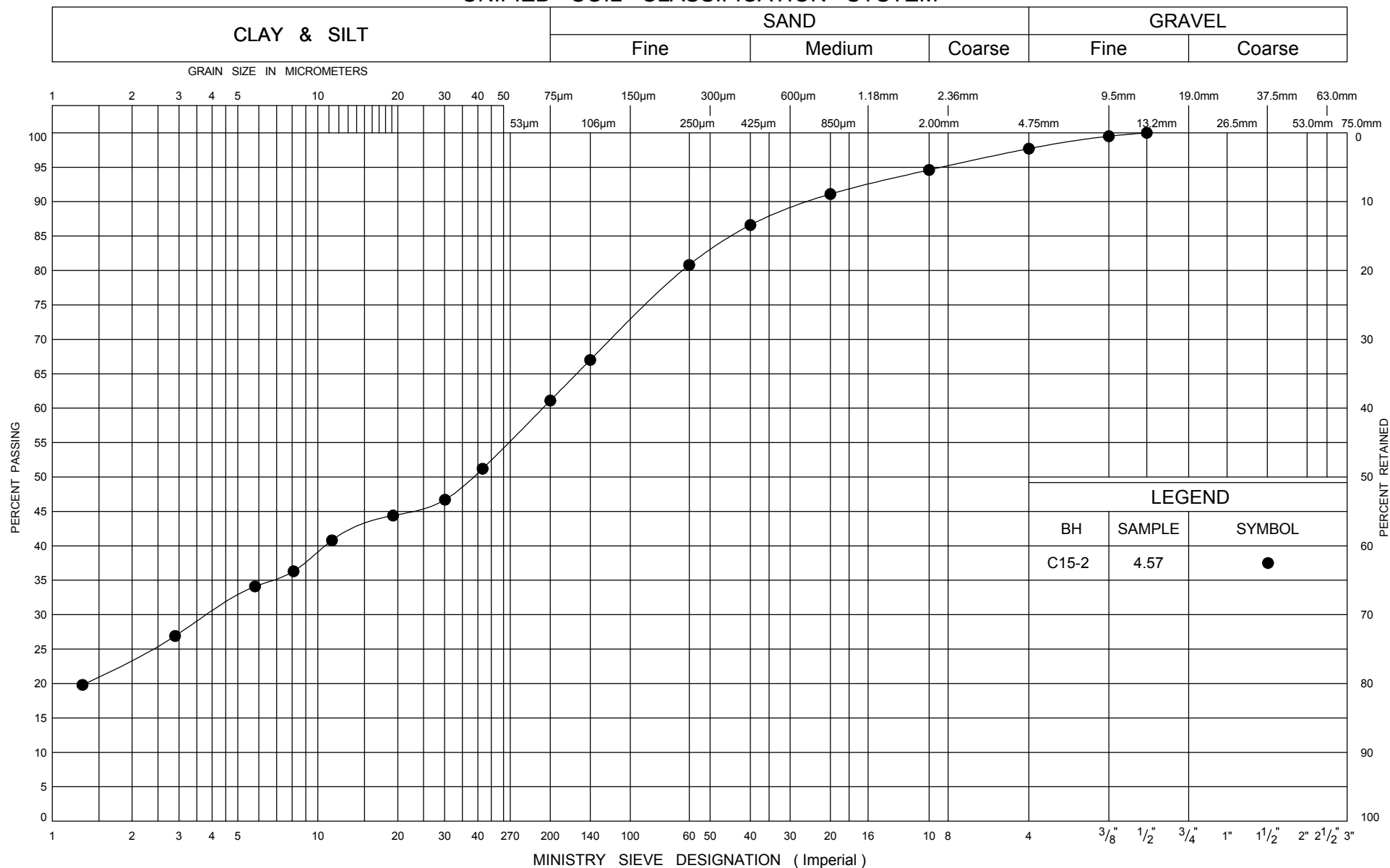
FIG No 1
WP 365-98-00
Highway 12, Rama Road to Gamebridge

UNIFIED SOIL CLASSIFICATION SYSTEM





UNIFIED SOIL CLASSIFICATION SYSTEM



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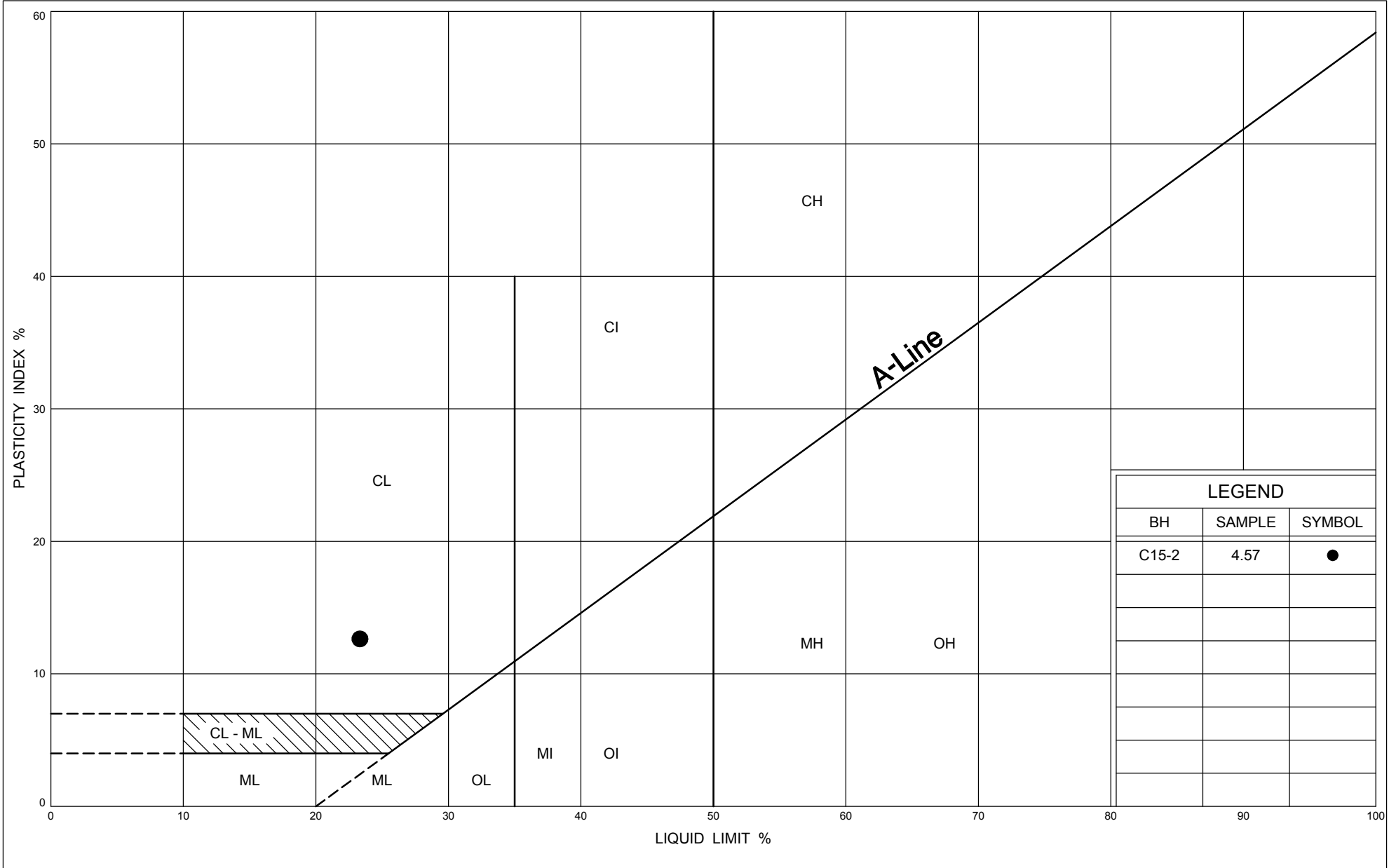
GRAIN SIZE DISTRIBUTION

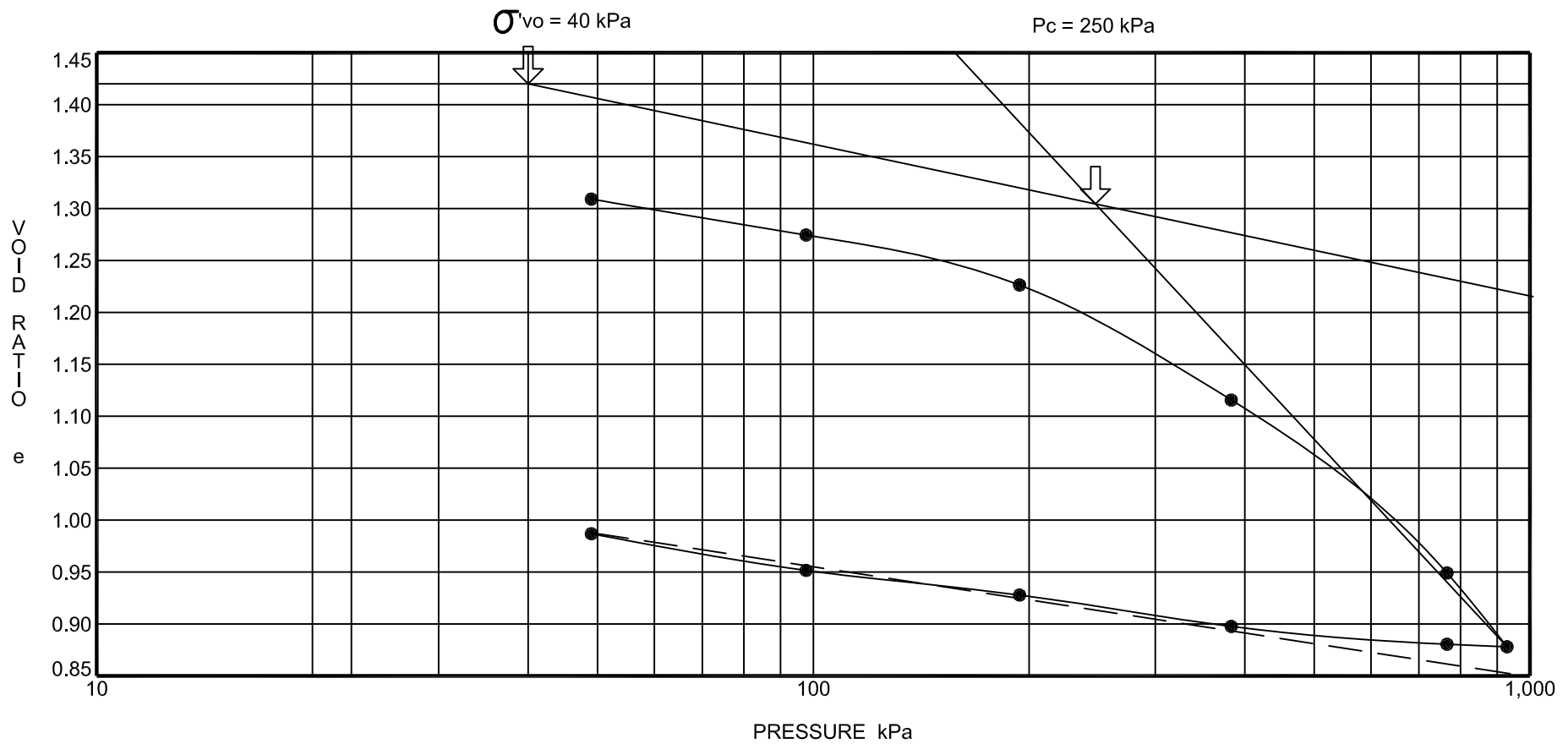
SANDY POCKET WITHIN VARVED CLAY, CL

FIG No 4

WP 365-98-00

Highway 12, Rama Road to Gamebridge





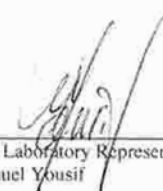
B H	DEPTH	ELEV.	WL	WP	W	CC	CR	σ'_{vo}	γ_d	Classification
● C15-3	3.50	217.01	57	28	49.3	0.742	0.106	40	11.0	VARVED CLAY, CH

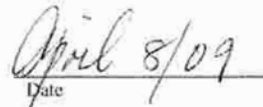
Rock Core Test Report

Project No.: LAGM00289085C

Project Name: Hwy 12 – 03/20019

Core No.	BH C15-3
Location	19'0"-20'4"
Date Cored	
Date Tested	April 7, 2009
Height - (mm)	125.1
Average Diameter - (mm)	46.2
Corrected Compressive Strength - (MPa)	70.0


 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 7

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-IEG6-30-674/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-IEG6-30-674/C
Final Report
Appendix D
October 6, 2009

Appendix D

Site Photographs



C15 - Station 20+674 - Looking North



C15 - Station 20+674 - Looking Downstream (west)



C15 - Station 20+674 - Looking Upstream (east)

SITE PHOTOGRAPHS

SITE NO.:30-674/C



Photo 1 Roadway Above Culvert / South Approach Roadway



Photo 3 Asphalt Deterioration Along Roadway



Photo 2 West Elevation



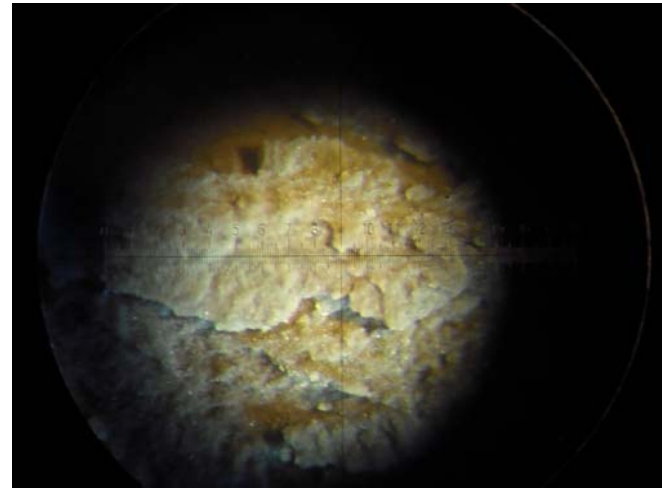
Appendix E

Photographs of Shelby Sample And Microscopic Examination

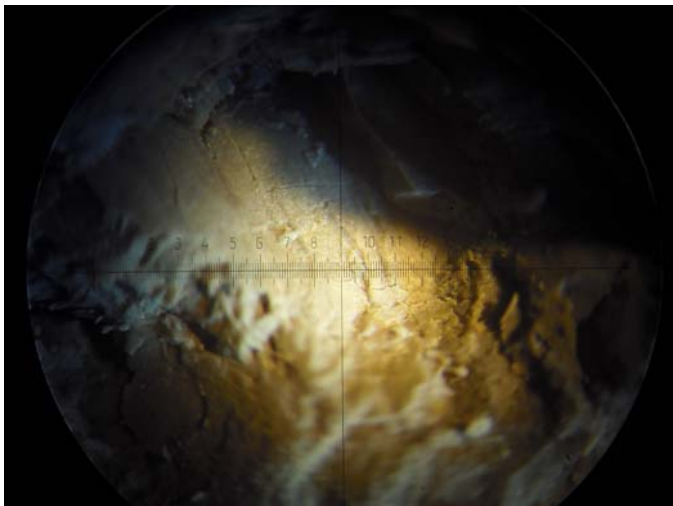
Taken Between Depths of 3.2 m and 3.8 m
Borehole C15-3



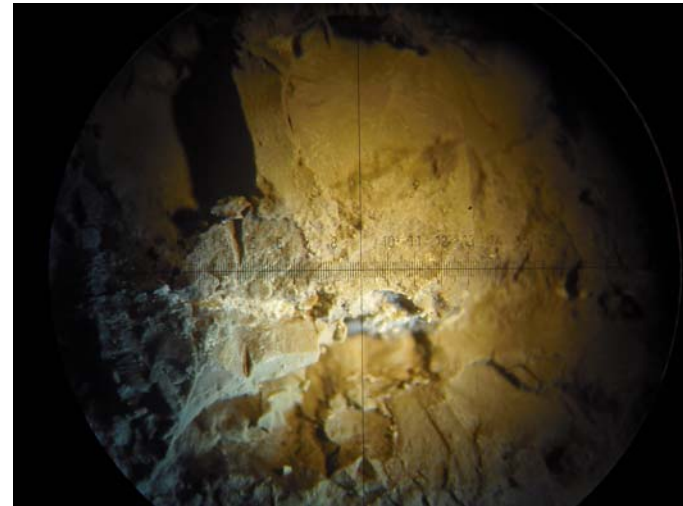
C15-3 Cut Section of Shelby Sample of Varved Clay



C15-3 .Microscopic Photo of Clay Varve, 1 div=11 μ m



C15-3 .Microscopic Photo of Clay Varve, 1div=25 μ m



C15-3 .Microscopic Photo of Silt Varve, 1div=5 μ m