

FOUNDATION INVESTIGATION
AND DESIGN REPORT
PROPOSED RECONSTRUCTION OF
CULVERTS 4, 6, 7, 8, 9, 10, 11, 12, 13 AND 16
G.W.P. 3097-03-00
Agreement # 3005-A-000403

Prepared for:

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1. INTRODUCTION

This report presents the results of a foundation investigation carried out by Infrastructure Engineering Group Inc. on behalf of SNC-Lavalin Engineers & Contractors Inc. The entire scope of the work consists of one (1) culvert on Highway 9 at 4.5 km East of Highway 21 Intersection in Kincardine, and sixteen (16) culverts on Highway 21 from Kingsbridge Northerly to Amberley, Length - 11.8 km. According to the Request for Proposal, Culverts 1 to 3 are to be rehabilitated, while Culverts 4 to 17 are to be reconstructed. Subsequently, the existing condition of Culverts 1 and 2 were assessed structurally and hydraulically by SNC-Lavalin Engineers & Contractors Inc. and recommended for reconstruction. All of the replacement culverts will be lengthened in order to accommodate the future pavement widening to design standards.

This report covers ten (10) culvert sites on Highway 21, which are listed in the following table:

Table 1
Summary of location, structure type, dimensions and overfill height

ID #	Site No.	Structure Name	Structure Type	Station	Dimensions* (W x H x L) (m)	Overfill Height*	Data Reference
4	12-437-C	Culvert - Fitzgerald Drain	NRF - Open Ftg - Extensions w/ Floor - Original Arch Section	21+554	3.0 x 1.2 x 21.3	2.8 m	Appendix 1
6	12-439-C	Culvert	NRF - Open Ftg	23+165	3.7 x 1.5 x 16.41	2.8 m	Appendix 2
7	12-441-C	Culvert	NRF - Open Ftg	25+445	4.6 x 0.91 x 18.42	1.0 m	Appendix 3
8	12-442-C	Culvert - Drennan Drain Works	NRF - Open Ftg	26+390	3.7 x 1.53 x 19.96	2.0 m	Appendix 4
9	12-536-C	Culvert - Drennan Drain Works	NRF - Open Ftg	26+650	3.07 x 1.53 x 22.68	2.6 m	Appendix 5
10	12-443-C	Culvert - MacIntyre Drain	NRF - Open Ftg	27+300	3.7 x 1.22 x 20.92	1.8 m	Appendix 6
11	12-444-C	Culvert - Cowan Drain Works	NRF - Open Ftg	27+650	3.05 x 1.22 x 20.29	1.8 m	Appendix 7
12	12-445-C	Culvert - Colling Drainage Works	NRF - Open Ftg	28+275	3.7 x 1.22 x 20.77	2.2 m	Appendix 8
13	12-446-C	Culvert	NRF - Open Ftg - Floor Has Been Added	28+972	3.7 x 0.91 x 20.0	1.6 m	Appendix 9
16	12-449-C	Culvert	NRF - Open Ftg	31+950	3.05 x 1.45 x 17.47	0.9 m	Appendix 10

The locations of these structures are shown on the key map presented in the respective drawings of Appendices 1 to 10.

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. The existing culverts are to be replaced with new culverts.

The work presented herein was undertaken under MTO G.W.P. # 3097-03-00, Agreement No. 3005-A-000403. Authorization to proceed was given verbally by Mr. Bing Wong of SNC-Lavalin Engineers & Contractors Inc. and confirmed in an email dated May 12, 2004, along with the MTO letter of Conditional Award dated May 12, 2004.

2. SITE DESCRIPTION

2.1 Site Location

These ten (10) culverts are located on Highway 21, approximately 0.7 to 11.1 km south of Amberley. Table 1 summarizes the locations, structure types, dimensions and overfill height of each culvert. Locations of individual culverts are illustrated in the key map presented in the respective drawings of Appendices 1 to 10.

All ten (10) structures are constructed as non-reinforced, open-footing culverts. Culvert 4 (Structure 12-437-C) had extensions with concrete floor slab added. A concrete floor slab was added to Culvert 13 (Structure 12-446-C).

At Culvert 6 (Structure 12-439-C), gabion walls have been installed on both sides of Highway 21, at the ends and on top of the culvert. At Culvert 8 (Structure 12-442-C), gabion walls have been installed as wing walls at the upstream end of the culvert.

Scouring with the footings exposed is common at most culvert sites. A brown silty clay deposit was noted at the streambed.

The embankment slopes are typically 2.5H:1V and are grass covered. No signs of active embankment slope instability were observed at the time of this foundation investigation.

2.2 Physiography and Topography

The site is located within the Physiographic Region known as the "Huron-slope" (Chapman and Putnam, 1984) which occupies the area east of Lake Huron between Sarnia and Tobermory. The area is characterized by a flat topography, heavy textured soil and poor drainage. The surficial deposits consist of brown, calcareous clayey tills which contain very few cobbles and boulders. The tills are known to be underlain by grey stratified clays of lacustrine origin.

3. INVESTIGATION PROCEDURES

3.1 Field Investigation

Between June 14 and July 8, 2004, a CME 55 drill rig was used on site for drilling and Standard Penetration Testing (SPT, following the procedures of ASTM D 1586). Three (3) boreholes at each site were drilled and sampled to obtain data for foundation design of the proposed replacement culvert. The boreholes were drilled to depths of a minimum 6 m depth (or deeper if required) below the culvert inverts to provide sufficient subsurface information for the evaluation of bearing resistances.

The boreholes were advanced using continuous flight solid 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 between 0.75 and 1.5 m to the maximum depth of exploration.

Field pocket penetrometer was used on the retrieved SPT samples to determine the undrained shear strength of the cohesive soil deposits. It is noted that the measured shear strength value would be slightly lower than the actual value due to sampling disturbance.

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 surveyed by AGM London and provided 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 Appendices 1 to 10.

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 C04-2 at a depth of 6.86 m. The

consolidation test was carried out by Trow Associates Inc. of Brampton.

The results of the laboratory testing are presented on the Record of Borehole sheets and in the respective figures presented in Appendices 1 to 10.

4. SUBSURFACE CONDITIONS

Reference is made to the respective appendix of each culvert site for the Record of Borehole sheets and Laboratory Test Results (Appendices 1 to 10) 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 and Soil Data drawings will vary between and beyond the borehole locations.

In general, the subsurface deposits at the ten (10) culverts site consist of loose to compact embankment fill placed on very stiff to hard silty clay till.

4.1 Culvert 4, Structure 12-437-C

Borehole C04-1, which was located at the edge of existing pavement in the shoulder area, encountered 350 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 3.66 m (elevation 203.43 m). The fill typically consists of silty clay with a trace to some organics, mixed with sand and gravel. This fill is generally brown in colour and the measured natural moisture contents range from 11 to 20%. Standard penetration test yielded an "N"-value of 8 to 12 blows per 0.3 m.

Boreholes C04-2 and C04-3 were located at the toe of the embankment (ends of the existing culvert). These two (2) boreholes encountered organic topsoil and mixed fill at the ground surface, with measured thickness of 910 and 610 mm, respectively.

A major stratum of brown to grey silty clay was contacted below the organic topsoil and mixed fill at Boreholes C04-2 and C04-3, and the embankment fill at Borehole C04-1. The silty clay extended to the full depth of the boreholes (i.e., below elevation 196.60 m). Seven (7) grain size analyses were performed and the results are plotted on Figure 4.1 of Appendix 1. Within the silty clay, embedded sand and gravel particles were found.

Standard penetration tests within the silty clay stratum yielded "N"-values from 11 to 42 blows per 0.3 m. Undrained shear strength as determined from field pocket penetrometer ranged from over 225 kPa to 12.5 kPa. The unit weight was measured to be between 20.2 and 22.9 kN/m³.

Eight (8) silty clay samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 4.2 of Appendix 1 and summarized below:

Liquid Limit (W_L)	23 to 26%, average at 24.4%
Plastic Limit (W_P)	12 to 13%, average at 12.6%
Plasticity Index (I_P)	10 to 13%, average at 11.7%

The natural moisture contents were in the range of 11 to 21%. These results are characteristic of clayey soils of low to medium plasticity (CL). The measured natural moisture contents are generally at or slightly above the measured plastic limits and indicate that the deposit is pre-consolidated.

A one-dimensional consolidation test (ASTM D 2435) was conducted on a relatively undisturbed thin-walled (Shelby tube) sample obtained from Borehole C04-2 at a depth of 6.86 m. These results are shown in Figure 4.3 of Appendix 1 and summarized below:

Sample Depth:	6.86 m
Elevation:	197.82 m
Liquid Limit (W_L)	23 %
Plastic Limit (W_P)	13%
Natural Moisture Content (W)	17.9 %
Compression Index (C_C)	0.177
Recompression Index (C_r)	0.014
Preconsolidation Pressure (σ_p)	500 kPa
Effective Overburden Pressure (σ'_{vo})	116 kPa

Based on the above field and laboratory test results and tactile examination, the silty clay deposit has a desiccated, brown, very stiff to hard crust of approximately 3.5m to 5m thick. Below the crust, the stratum becomes grey and decreases in consistency from very stiff to stiff.

The groundwater condition was monitored during and upon completion of sampling. All three (3) boreholes remained dry and open throughout the sampling operations.

4.2 Culvert 6, Structure 12-439-C

Borehole C06-1, which was located at the edge of existing pavement in the shoulder area, encountered 350 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 4.42 m (elevation 200.39 m). The fill typically consists of silty clay with a trace to some organics, mixed with sand and gravel. This fill is generally brown in colour and the measured natural moisture contents range from 11 to 18%. Standard penetration test yielded an "N"-value of 5 to 7 blows per 0.3 m. The unit weight was measured to be 20.8 kN/m³ based on a single test.

Boreholes C06-2 and C06-3 were located at the toe of the embankment (ends of the existing culvert). These two (2) boreholes encountered organic topsoil at the ground surface, with

measured thickness of 560 and 840 mm, respectively. Below the topsoil layer at Boreholes C06-2 and C06-3, a loose to compact, mixed sand, silt and clay fill with topsoil inclusion extended to depths of 2.13 and 1.68 m, respectively. Standard penetration tests yielded "N"-values of 4 to 14 blows per 0.3 m. The natural moisture contents were measured to be 22 and 28%.

Two (2) grain size analyses on the fill materials were performed and the results are plotted on Figure 6.1 of Appendix 2. Two (2) Atterberg Limit tests on the silty clay fill samples reveal that the liquid limits are 22 and 26%; plastic limits are 12 and 15%, with respective plasticity indices of 12 and 11% (Figure 6.3 of Appendix 2).

A major stratum of brown to grey silty clay was contacted below the fill material at all three (3) boreholes and extended to the full depth of the boreholes (i.e., below elevation 193.49 m). Five (5) grain size analyses were performed and the results are plotted on Figure 6.2 of Appendix 2. Within the silty clay, embedded sand and gravel particles were found.

Standard penetration tests within the silty clay stratum yielded "N"-values from 15 to 34 blows per 0.3 m. Undrained shear strength as determined from field pocket penetrometer ranged from over 225 kPa to 37.5 kPa. The unit weight was measured to be between 21.2 and 23.4 kN/m³.

Five (5) silty clay samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 6.4 of Appendix 2 and summarized below:

Liquid Limit (W_L)	23 to 27%, average at 24.4%
Plastic Limit (W_P)	13 to 14%, average at 13.4%
Plasticity Index (I_P)	10 to 13%, average at 11.2%

The natural moisture contents were in the range of 12 to 17%. These results are characteristic of clayey soils of low to medium plasticity (CL). The measured natural moisture contents are generally at or slightly above the measured plastic limits and indicate that the deposit is pre-consolidated.

Based on the above field and laboratory test results and tactile examination, the silty clay deposit has a desiccated, brown, very stiff to hard crust of approximately 3 to 3.5m thick. Below the crust, the stratum becomes grey and decreases in consistency from very stiff to stiff.

The groundwater condition was monitored during and upon completion of sampling. All three (3) boreholes remained dry and open throughout the sampling operations.

4.3 Culvert 7, Structure 12-441-C

Borehole C07-1, which was located at the edge of existing pavement in the shoulder area, encountered 230 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 2.44 m (elevation 199.87 m). The fill typically consists of silty clay with a trace to some organics, mixed with sand and gravel. At 1.5m depth, a concrete

lump was encountered. This fill is generally brown in colour and the measured natural moisture contents range from 9 to 14%. Standard penetration test yielded an "N"-value of 16 and over 100 blows per 0.3 m. The unit weight was measured to be 20.8 kN/m^3 based on a single test.

Boreholes C07-2 and C07-3 were located at the toe of the embankment (ends of the existing culvert). These two (2) boreholes encountered organic topsoil fill at the ground surface, with measured thickness of 1.14 and 1.37 m, respectively. Standard penetration tests yielded "N"-values of 8 to 17 blows per 0.3 m. The natural moisture contents were measured to be between 10 and 15%. One (1) grain size analysis on the fill materials was performed and the results are plotted on Figure 7.1 of Appendix 3. One (1) Atterberg Limit test on the silty clay fill samples reveal that the liquid limit is 30%; plastic limit is 17%, with a plasticity index of 13% (Figure 7.3 of Appendix 3).

A major stratum of brown to grey silty clay was contacted below the fill material at all three (3) boreholes and extended to the full depth of the boreholes (i.e., below elevation 193.53 m). Six (6) grain size analyses were performed and the results are plotted on Figure 7.2 of Appendix 3. Within the silty clay, embedded sand and gravel particles were found.

Standard penetration tests within the silty clay stratum yielded "N"-values from 16 to 55 blows per 0.3 m. Undrained shear strength as determined from field pocket penetrometer ranged from over 225 kPa to 62.5 kPa. The unit weight was measured to be between 22.0 and 23.0 kN/m^3 .

Six (6) silty clay samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 7.4 of Appendix 3 and summarized below:

Liquid Limit (W_L)	23 to 27%, average at 24.7%
Plastic Limit (W_P)	13 to 15%, average at 13.8%
Plasticity Index (I_P)	10 to 13%, average at 10.7%

The natural moisture contents were in the range of 12 to 20%. These results are characteristic of clayey soils of low to medium plasticity (CL). The measured natural moisture contents are generally at or slightly above the measured plastic limits and indicate that the deposit is pre-consolidated.

Based on the above field and laboratory test results and tactile examination, the silty clay deposit has a desiccated, brown, very stiff to hard crust of approximately 4 to 5 m thick. Below the crust, the stratum becomes grey and decreases in consistency to very stiff to stiff.

The groundwater condition was monitored during and upon completion of sampling. All three (3) boreholes remained dry and open throughout the sampling operations.

4.4 Culvert 8, Structure 12-442-C

Borehole C08-1, which was located at the edge of existing pavement in the shoulder area, encountered 300 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 3.96 m (elevation 196.43 m). The fill typically consists of silty clay with a trace to some organics, mixed with sand and gravel. This fill is generally brown in colour and the measured natural moisture contents range from 23 to 37%. Standard penetration test yielded an "N"-value of 7 to 11 blows per 0.3 m.

Boreholes C08-2 and C08-3 were located at the toe of the embankment (ends of the existing culvert). These two (2) boreholes encountered organic topsoil fill at the ground surface, with measured thickness of 1.07 and 0.99 m, respectively. Standard penetration tests yielded "N"-values of 8 to 11 blows per 0.3 m. The natural moisture contents were measured to be between 21 and 31%.

A major stratum of brown to grey silty clay was contacted below the fill material at all three (3) boreholes and extended to the full depth of the boreholes (i.e., below elevation 189.98 m). Six (6) grain size analyses were performed and the results are plotted on Figure 8.1 of Appendix 4. Within the silty clay, embedded sand and gravel particles were found.

Standard penetration tests within the silty clay stratum yielded "N"-values from 13 to 38 blows per 0.3 m. Undrained shear strength as determined from field pocket penetrometer ranged from over 225 kPa to 50 kPa. The unit weight was measured to be between 20.1 and 22.0 kN/m³.

Six (6) silty clay samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 8.2 of Appendix 4 and summarized below:

Liquid Limit (W_L)	23 to 26%, average at 24.6%
Plastic Limit (W_P)	13 to 15%, average at 13.8%
Plasticity Index (I_P)	10 to 13%, average at 10.8%

The natural moisture contents were in the range of 12 to 17%. These results are characteristic of clayey soils of low to medium plasticity (CL). The measured natural moisture contents are generally at or slightly above the measured plastic limits and indicate that the deposit is pre-consolidated.

Based on the above field and laboratory test results and tactile examination, the silty clay deposit has a desiccated, brown, very stiff to hard crust of approximately 2.5 to 3.5 m thick. Below the crust, the stratum becomes grey and decreases in consistency to very stiff to stiff.

The groundwater condition was monitored during and upon completion of sampling. All three (3) boreholes remained dry and open throughout the sampling operations.

4.5 Culvert 9, Structure 12-436-C

Borehole C09-1, which was located at the edge of existing pavement in the shoulder area, encountered 380 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 3.66 m (elevation 196.50 m). The fill typically consists of silty clay with a trace to some organics, mixed with sand and gravel. This fill is generally brown in colour and the measured natural moisture contents range from 25 to 37%. Standard penetration test yielded an "N"-value of 6 to 13 blows per 0.3 m.

Boreholes C09-2 and C09-3 were located at the toe of the embankment (ends of the existing culvert). These two (2) boreholes encountered organic topsoil and/or topsoil fill at the ground surface, with measured thickness of 0.69 and 1.17 m, respectively. Below the topsoil layer at Boreholes C09-2 and C09-3, a loose to compact, mixed sand, gravel and clay fill with topsoil inclusion extended to depths of 1.68 and 1.83 m, respectively. Standard penetration tests yielded "N"-values of 6 to 18 blows per 0.3 m. The natural moisture contents were measured to be 13 and 27%.

A major stratum of brown to grey silty clay was contacted below the fill material at all three (3) boreholes and extended to the full depth of the boreholes (i.e., below elevation 189.28 m). Six (6) grain size analyses were performed and the results are plotted on Figure 9.1 of Appendix 5. Within the silty clay, embedded sand and gravel particles were found.

Standard penetration tests within the silty clay stratum yielded "N"-values from 13 to 49 blows per 0.3 m. Undrained shear strength as determined from field pocket penetrometer ranged from over 225 kPa to 37.5 kPa. The unit weight was measured to be between 20.9 and 23.0 kN/m³.

Six (6) silty clay samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 9.2 of Appendix 5 and summarized below:

Liquid Limit (W _L)	22 to 28%, average at 25.5%
Plastic Limit (W _P)	13 to 15%, average at 13.8%
Plasticity Index (I _p)	9 to 15%, average at 11.7%

The natural moisture contents were in the range of 13 to 18%. These results are characteristic of clayey soils of low to medium plasticity (CL). The measured natural moisture contents are generally at or slightly above the measured plastic limits and indicate that the deposit is pre-consolidated.

Based on the above field and laboratory test results and tactile examination, the silty clay deposit has a desiccated, brown, very stiff to hard crust of approximately 2 to 3 m thick. Below the crust, the stratum becomes grey and decreases in consistency to very stiff to stiff.

The groundwater condition was monitored during and upon completion of sampling. All three (3) boreholes remained dry and open throughout the sampling operations.

4.6 Culvert 10, Structure 12-443-C

Borehole C10-1, which was located at the edge of existing pavement in the shoulder area, encountered 280 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 3.05 m (elevation 195.57 m). The fill typically consists of silty clay with a trace to some organics, mixed with sand and gravel. This fill is generally brown in colour and the measured natural moisture contents range from 26 to 27%. Standard penetration test yielded an "N"-value of 11 to 14 blows per 0.3 m. The unit weight was measured to be 22.8 kN/m^3 based on a single test.

One (1) grain size analysis on the fill material was performed and the results are plotted on Figure 10.1 of Appendix 6. One (1) Atterberg Limit test on the silty clay fill sample reveals that the liquid limit is 32%; plastic limit is 19%, with a plasticity index of 13% (Figure 10.3 of Appendix 6).

Boreholes C10-2 and C10-3 were located at the toe of the embankment (ends of the existing culvert). These two (2) boreholes encountered organic topsoil at the ground surface, with measured thickness of 510 and 560 mm, respectively.

A major stratum of brown to grey silty clay was contacted below the fill material at all three (3) boreholes and extended to the full depth of the boreholes (i.e., below elevation 188.63 m). Seven (7) grain size analyses were performed and the results are plotted on Figure 10.2 of Appendix 6. Within the silty clay, embedded sand and gravel particles were found.

Standard penetration tests within the silty clay stratum yielded "N"-values from 13 to 65 blows per 0.3 m. Undrained shear strength as determined from field pocket penetrometer ranged from over 225 kPa to 50 kPa. The unit weight was measured to be between 19.4 and 23.4 kN/m^3 .

Seven (7) silty clay samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 10.4 of Appendix 6 and summarized below:

Liquid Limit (W_L)	24 to 31%, average at 25.6%
Plastic Limit (W_P)	13 to 13%, average at 14.5%
Plasticity Index (I_P)	10 to 14%, average at 11.7%

The natural moisture contents were in the range of 7 to 17%. These results are characteristic of clayey soils of low to medium plasticity (CL). The measured natural moisture contents are generally at or slightly above the measured plastic limits and indicate that the deposit is pre-consolidated.

Based on the above field and laboratory test results and tactile examination, the silty clay deposit has a desiccated, brown, very stiff to hard crust of approximately 3 to 5.5 m thick. Below the crust, the stratum becomes grey and decreases in consistency to very stiff to stiff.

The groundwater condition was monitored during and upon completion of sampling. Borehole C10-1 had a water level measured at 9.3 m below ground surface. The remaining two (2) boreholes remained dry and open throughout the sampling operations.

The observed water level at Borehole C10-1 originated from the upper wet fill stratum, indicating perched water within the upper fill layer.

4.7 Culvert 11, Structure 12-444-C

Borehole C11-1, which was located at the edge of existing pavement in the shoulder area, encountered 460 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 3.35 m (elevation 195.99 m). The fill typically consists of silty clay with a trace to some organics, mixed with sand and gravel. This fill is generally brown in colour and the measured natural moisture contents range from 7 to 25%. Standard penetration test yielded an "N"-value of 6 and 7 blows per 0.3 m. The unit weight was measured to be 20.4 kN/m³ based on a single test. One (1) grain size analysis on the fill materials was performed and the results are plotted on Figure 11.1 of Appendix 7. One (1) Atterberg Limit test on the silty clay fill samples reveal that the liquid limit is 29%; plastic limit is 15%, with a plasticity index of 14% (Figure 11.3 of Appendix 7).

Boreholes C11-2 and C11-3 were located at the toe of the embankment (ends of the existing culvert). These two (2) boreholes encountered organic topsoil at the ground surface, with measured thickness of 560 and 680 mm, respectively.

A major stratum of brown to grey silty clay was contacted below the fill material at all three (3) boreholes and extended to the full depth of the boreholes (i.e., below elevation 189.18 m). Six (6) grain size analyses were performed and the results are plotted on Figure 11.2 of Appendix 7. Within the silty clay, embedded sand and gravel particles were found.

Standard penetration tests within the silty clay stratum yielded "N"-values from 14 to 49 blows per 0.3 m. Undrained shear strength as determined from field pocket penetrometer ranged from over 225 kPa to 50 kPa. The unit weight was measured to be between 21.5 and 22.6 kN/m³.

Six (6) silty clay samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 11.4 of Appendix 7 and summarized below:

Liquid Limit (W_L)	24 to 27%, average at 25.6%
Plastic Limit (W_P)	13 to 15%, average at 14.0%
Plasticity Index (I_P)	10 to 12%, average at 11.2%

The natural moisture contents were in the range of 11 to 18%. These results are characteristic of clayey soils of low to medium plasticity (CL). The measured natural moisture contents are generally at or slightly above the measured plastic limits and indicate that the deposit is pre-consolidated.

Based on the above field and laboratory test results and tactile examination, the silty clay deposit has a desiccated, brown, very stiff to hard crust of approximately 2.5 to 5 m thick. Below the crust, the stratum becomes grey and decreases in consistency to very stiff to stiff.

The groundwater condition was monitored during and upon completion of sampling. Borehole C11-1 had a water level measured at 3.2 m below ground surface. The remaining two (2) boreholes remained dry and open throughout the sampling operations.

4.8 Culvert 12, Structure 12-445-C

Borehole C12-1, which was located at the edge of existing pavement in the shoulder area, encountered 610 mm of shoulder gravel and granular fill. Underlying the shoulder gravel and granular fill is the embankment fill material that extended to a depth of 3.05 m (elevation 197.08 m). The fill typically consists of silty clay with a trace to some organics, mixed with sand and gravel. This fill is generally brown in colour and the measured natural moisture contents range from 15 to 20%. Standard penetration test yielded an "N"-value of 8 and 11 blows per 0.3 m. The unit weight was measured to be 21.7 kN/m³ based on a single test. One (1) grain size analysis on the fill materials was performed and the results are plotted on Figure 12.1 of Appendix 8. One (1) Atterberg Limit test on the silty clay fill samples reveal that the liquid limit is 29%; plastic limit is 15%, with a plasticity index of 14% (Figure 12.3 of Appendix 8).

Boreholes C12-2 and C12-3 were located at the toe of the embankment (ends of the existing culvert). These two (2) boreholes encountered organic topsoil and clay fill at the ground surface, with measured thickness of 1.05 and 0.68 m, respectively.

A major stratum of brown to grey silty clay was contacted below the fill material at all three (3) boreholes and extended to the full depth of the boreholes (i.e., below elevation 189.61 m). Eight (8) grain size analyses were performed and the results are plotted on Figure 12.2 of Appendix 8. Within the silty clay, embedded sand and gravel particles were found.

Standard penetration tests within the silty clay stratum yielded "N"-values from 18 to 39 blows per 0.3 m. Undrained shear strength as determined from field pocket penetrometer ranged from over 225 kPa to 75 kPa. The unit weight was measured to be between 21.2 and 22.3 kN/m³.

Eight (8) silty clay samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 12.4 of Appendix 8 and summarized below:

Liquid Limit (W_L)	23 to 30%, average at 24.5%
Plastic Limit (W_P)	12 to 16%, average at 13.5%
Plasticity Index (I_P)	10 to 14%, average at 10.8%

The natural moisture contents were in the range of 11 to 17%. These results are characteristic of clayey soils of low to medium plasticity (CL). The measured natural moisture contents are

generally at or slightly above the measured plastic limits and indicate that the deposit is pre-consolidated.

Based on the above field and laboratory test results and tactile examination, the silty clay deposit has a desiccated, brown, very stiff to hard crust of approximately 3 to 4.5 m thick. Below the crust, the stratum becomes grey and decreases in consistency to very stiff to stiff.

The groundwater condition was monitored during and upon completion of sampling. All three (3) boreholes remained dry and open throughout the sampling operations.

4.9 Culvert 13, Structure 12-446-C

Borehole C13-1, which was located at the edge of existing pavement in the shoulder area, encountered 280 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 2.44 m (elevation 199.44 m). The fill typically consists of silty clay with a trace to some organics, mixed with sand and gravel. This fill is generally brown in colour and the measured natural moisture contents range from 12 to 25%. Standard penetration test yielded an "N"-value of 7 and 15 blows per 0.3 m.

Boreholes C13-2 and C13-3 were located at the toe of the embankment (ends of the existing culvert). These two (2) boreholes encountered organic topsoil and mixed fill materials at the ground surface, with measured thickness of 0.99 and 1.14 m, respectively.

A major stratum of brown to grey silty clay was contacted below the fill material at all three (3) boreholes and extended to the full depth of the boreholes (i.e., below elevation 192.36 m). Seven (7) grain size analyses were performed and the results are plotted on Figure 13.1 of Appendix 9. Within the silty clay, embedded sand and gravel particles were found.

Standard penetration tests within the silty clay stratum yielded "N"-values from 17 to 45 blows per 0.3 m. Undrained shear strength as determined from field pocket penetrometer ranged from over 225 kPa to 50 kPa. The unit weight was measured to be between 21.1 and 22.4 kN/m³.

Seven (7) silty clay samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 13.2 of Appendix 9 and summarized below:

Liquid Limit (W_L)	23 to 27%, average at 25.1%
Plastic Limit (W_P)	13 to 15%, average at 13.9%
Plasticity Index (I_P)	10 to 13%, average at 11.3%

The natural moisture contents were in the range of 12 to 17%. These results are characteristic of clayey soils of low to medium plasticity (CL). The measured natural moisture contents are generally at or slightly above the measured plastic limits and indicate that the deposit is pre-consolidated.

Based on the above field and laboratory test results and tactile examination, the silty clay deposit has a desiccated, brown, very stiff to hard crust of approximately 3 to 4 m thick. Below the crust, the stratum becomes grey and decreases in consistency to very stiff to stiff.

The groundwater condition was monitored during and upon completion of sampling. Borehole C13-2 had a water level measured at 7.8 m below ground surface. The remaining two (2) boreholes remained dry and open throughout the sampling operations.

The observed water level at Borehole C13-2 originated from the upper wet granular fill stratum, indicating perched water within the upper fill layer.

4.10 Culvert 16, Structure 12-449-C

Borehole C16-1, which was located at the edge of existing pavement in the shoulder area, encountered 300 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 2.13 m (elevation 201.24 m). The fill typically consists of silty clay with a trace to some organics, mixed with sand and gravel. This fill is generally brown in colour and the measured natural moisture contents range from 22 to 23%. Standard penetration test yielded an "N"-value of 8 and 10 blows per 0.3 m.

Boreholes C16-2 and C16-3 were located at the toe of the embankment (ends of the existing culvert). These two (2) boreholes encountered organic topsoil at the ground surface, with measured thickness of 460 and 530 mm, respectively.

A major stratum of brown to grey silty clay was contacted below the fill material at all three (3) boreholes and extended to the full depth of the boreholes (i.e., below elevation 194.07 m). Six (6) grain size analyses were performed and the results are plotted on Figure 16.1 of Appendix 10. Within the silty clay, embedded sand and gravel particles were found.

Standard penetration tests within the silty clay stratum yielded "N"-values from 14 to 47 blows per 0.3 m. Undrained shear strength as determined from field pocket penetrometer ranged from over 225 kPa to 62.5 kPa. The unit weight was measured to be between 21.7 and 23.2 kN/m³.

Six (6) silty clay samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 16.2 of Appendix 10 and summarized below:

Liquid Limit (W_L)	22 to 25%, average at 23.5%
Plastic Limit (W_P)	12 to 14%, average at 13.3%
Plasticity Index (I_P)	9 to 11%, average at 10.2%

The natural moisture contents were in the range of 9 to 21%. These results are characteristic of clayey soils of low to medium plasticity (CL). The measured natural moisture contents are generally at or slightly above the measured plastic limits and indicate that the deposit is pre-consolidated.

Based on the above field and laboratory test results and tactile examination, the silty clay deposit has a desiccated, brown, very stiff to hard crust of approximately 4.5 to 5.5 m thick. Below the crust, the stratum becomes grey and decreases in consistency to very stiff to stiff.

The groundwater condition was monitored during and upon completion of sampling. All three (3) boreholes remained dry and open throughout the sampling operations.

5. DISCUSSION AND RECOMMENDATIONS

5.1 General

This section of the report provides our recommendations on the geotechnical aspects of foundation design of the proposed reconstruction of Culvert 4, 6, 7, 8, 9, 10, 11, 12, 13 and 16 on Highway 21, based on our interpretation of the factual information obtained during this investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

This following table summarizes the location, structure type, dimensions and overfill height of these ten (10) culverts.

ID #	Site No.	Structure Name	Structure Type	Station	Dimensions* (W x H x L) (m)	Overfill Height*	Data Reference
4	12-437-C	Culvert - Fitzgerald Drain	NRF - Open Ftg - Extensions w/ Floor - Original Arch Section	21+554	3.0 x 1.2 x 21.3	2.8 m	Appendix 1
6	12-439-C	Culvert	NRF - Open Ftg	23+165	3.7 x 1.5 x 16.41	2.8 m	Appendix 2
7	12-441-C	Culvert	NRF - Open Ftg	25+445	4.6 x 0.91 x 18.42	1.0 m	Appendix 3
8	12-442-C	Culvert - Drennan Drain Works	NRF - Open Ftg	26+390	3.7 x 1.53 x 19.96	2.0 m	Appendix 4
9	12-536-C	Culvert - Drennan Drain Works	NRF - Open Ftg	26+650	3.07 x 1.53 x 22.68	2.6 m	Appendix 5
10	12-443-C	Culvert - MacIntyre Drain	NRF - Open Ftg	27+300	3.7 x 1.22 x 20.92	1.8 m	Appendix 6
11	12-444-C	Culvert - Cowan Drain Works	NRF - Open Ftg	27+650	3.05 x 1.22 x 20.29	1.8 m	Appendix 7
12	12-445-C	Culvert - Colling Drainage Works	NRF - Open Ftg	28+275	3.7 x 1.22 x 20.77	2.2 m	Appendix 8
13	12-446-C	Culvert	NRF - Open Ftg - Floor Has Been Added	28+972	3.7 x 0.91 x 20.0	1.6 m	Appendix 9
16	12-449-C	Culvert	NRF - Open Ftg	31+950	3.05 x 1.45 x 17.47	0.9 m	Appendix 10

The preferred replacement culverts are to be new closed box culverts, which are to be constructed of cast-in-place or precast concrete. Alternatively, the replacement culverts could be constructed as rigid frame, open-footing culverts. The open-footing culverts may be over-built

to encompass the existing culverts. This alternative will allow working in the dry and removal of the existing culverts after completion of the new culverts.

It is understood that the replacement culverts will be of similar dimensions as recommended in the Drainage and Hydrological Study Report, but lengthened in order to accommodate the future pavement widening and geometric improvements. The new structures will end at a minimum distance of 4.5m from the R.O.W.

5.2 Closed Box Culvert

The soils encountered at the subject site are considered suitable for the support of a box culvert foundation. Results of all boreholes put down along the proposed culvert alignment indicate that the founding subgrade consists of very stiff to hard silty clay till.

The culvert should be designed to CAN/CSA-S6-00 and to withstand the appropriate weight of overfill, traffic loadings (CL-625-ONT), temporary construction loads and critical loading effects during construction. If the base slab does not have adequate frost cover/protection, it should be designed for frost pressures.

Based on the borehole results, the box culverts should be designed to bear on the native, undisturbed very stiff to hard silty clay till at the elevation and bearing resistances shown below:

Culvert Number	Highest Elevation (m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Reaction at SLS (kPa)
4	203.2	900	300
6	199.8	750	250
7	199.7	900	300
8	196.2	900	300
9	195.5	750	250
10	195.4	900	300
11	195.9	900	300
12	196.7	900	300
13	199.2	900	300
16	201.0	900	300

The SLS value given above is based on a maximum settlement of 25 mm under the 3 to 4.6m wide box culverts. This can be achieved provided the founding subgrade is not disturbed during construction.

As there was no hydrostatic pressure observed during borehole sampling (within the silty clay till), piping is not considered likely to occur at the founding subgrade of the culvert.

As per CAN/CSA-S6-00, Clause 1.10.5.6, and OPSD 803.010, cut-off walls of sufficient depth and strength shall be provided at the ends of the culvert to prevent undermining.

A 300 mm thick OPSS Granular "A" bedding and a 75mm thick levelling granular course, or bedding as specified by the precast manufacturer should be placed on the prepared subgrade to achieve a uniform support for precast concrete culvert. The Granular "A" layer should be compacted to 98% of the material's standard Proctor maximum dry density (SPMDD). The levelling granular course for precast concrete culvert should consist of 19.0 mm clear stone meeting the requirements of OPSS 1004.05.07 or as specified by the precast manufacturer.

5.3 Open Footing Culvert (Spread Footing Foundations)

Based on the borehole results, spread footings may be used for the abutments and designed to bear on the undisturbed very stiff to hard native silty clay till at the elevation and bearing resistances shown below:

Culvert Number	Highest Elevation (m)	Factored Geotechnical Resistance at ULS (kPa)	Geotechnical Reaction at SLS (kPa)
4	203.2	900	300
6	199.8	750	250
7	199.7	900	300
8	196.2	900	300
9	195.5	750	250
10	195.4	900	300
11	195.9	900	300
12	196.7	900	300
13	199.2	900	300
16	201.0	900	300

The SLS value given above is based on a maximum settlement of 25 mm for strip footings up to 3 m wide. This can be achieved provided that the founding subgrade is undisturbed during the construction.

Under inclined loading conditions, the bearing resistance at ULS should be reduced in accordance with Clause 6.7.4 of CAN/CSA-S6-00.

As there was no hydrostatic pressure observed during borehole sampling (within the silty clay till), piping is not considered likely to occur at the founding subgrade of the culvert.

Immediately upon excavation, the exposed subgrade should be inspected and approved by the geotechnical engineer.

The sliding resistance of the footings should be checked. The factored horizontal resistance (Clause 6.7.5, CAN/CSA-S6-00) against sliding between concrete and undisturbed, competent silty clay founding soil can be calculated using an adhesion of 50 kPa.

5.4 Lateral Earth Pressures

The lateral earth pressures acting on the abutment walls and culvert walls will depend on the type and method of placement of the backfill materials and on the subsequent lateral movement of the structure whether it is restrained or unrestrained. The lateral earth pressures to be used in the design should be computed in accordance with Section 6.9 of the CAN/CSA-S6-00.

Granular backfill should be placed behind the abutment walls and wing walls to conform to the minimum requirements illustrated in OPSD 3501.00. The granular backfill should conform to OPSS Form 1010 for either Granular "A" or "B" Type III. To maintain free draining characteristics in granular fill materials, the maximum percentage passing the No. 200 sieve (75 μ m) should be limited to 5%.

The backfill should be placed in accordance with OPSS 501. A perforated subdrain should be installed behind the walls with a positive outlet to maintain the granular fill drained above the stream water level. Alternatively, the culvert walls could be designed to resist hydrostatic pressure.

The lateral earth pressure, P_h , may be computed using the equivalent fluid pressures presented in Clause 6.9.2.3 of the CAN/CSA-S6-00, or employing the following equation based on unfactored earth pressure distributions:

$$P_h = K (\gamma h + q)$$

Where:

K = earth pressure coefficient, use value from table below

γ = unit weight of soil, = 21.2 kN/m³ for Granular "B"
= 22.8 kN/m³ for Granular "A"

h = depth below top of wall, m

q = surcharge pressure, of 0.8 m of fill as per Clause 6.9.5, CAN/CSA-S6-00

Wall Type	Earth Pressure Coefficient (K)	
	Granular "A" $\phi = 35^\circ$	Granular "B" $\phi = 30^\circ$
Restrained Wall (K_o)	0.43	0.50
Unrestrained Wall (K_a)	0.27	0.33

The submerged unit weight of the backfill should be used for any submerged portion of the granular backfill when calculating the lateral earth pressure.

The above parameters are based on a horizontal back slope (not exceeding 5 degrees) behind the abutment walls. If concrete approach slabs are not provided, an additional load equivalent to 800 mm of fill should be superimposed on the wall loading to account for traffic surcharge loading. A compaction surcharge equal to 12 kPa should be included in the lateral earth pressures for the structural design of the abutment and retaining walls in accordance with Clause 6.9.3 of the CAN/CSA-S6-00.

Vibratory equipment for use behind abutments and retaining walls should be restricted in size as per current MTO practices.

5.5 Embankment Widening

The existing approach embankments are up to 4.5 m high adjacent to the proposed culvert. For the widening of the embankment, the surficial topsoil and any deleterious materials should be stripped or excavated prior to placing fill materials. The embankment widening should then be constructed as per OPSD 202.010, 202.030 and 208.010. The fill to be used for embankment construction can either be imported silty clay or granular materials. Backfill adjacent to the structure should be carried out in conformance with OPSD 3501.00, and the fill should be placed in accordance with OPSS 501.

Based on the findings of the field investigation, no foundation stability or settlement problems due to widening the approach embankments on the inorganic native soils are anticipated for embankment slope of 2H:1V and up to 4.5 m high. The fill placement should begin at the toe of the embankment, in leveled lifts and each lift compacted to at least 98% SPMDD. Benching into the existing embankment slope at 1 m high steps is recommended.

After stripping, the exposed subgrade should be inspected and approved by the geotechnical engineer. The approved subgrade should then be proof-rolled using a heavy compactor, as directed by the engineer. Unless the excavation is carried out in wet weather conditions, no unusual dewatering is anticipated during stripping and preparation of the subgrade to receive the embankment fills. Where necessary, gravity drainage and pumping from open filtered sumps should suffice.

Measures should be incorporated into the design and staging to ensure that the slope surfaces are protected from surface erosion. Proper erosion control measures should be implemented both during construction of the embankment fills and permanently. Erosion control during construction should be carried out by installing silt fences. Properly designed erosion control blankets could also be placed on any new embankments and adjacent disturbed embankments after completion of fill placement. A vegetative cover should be established as soon as practical upon completion of fill placement to minimize the chances of surface erosion.

Revetments such as rip-rap blanket should be provided at the toe of the slope and the ends of the culvert to prevent erosion/scour by stream action. The design of the rip-rap blanket should be carried out cognizant of the stream hydraulics.

5.6 Excavation, Groundwater Control and Temporary Support

Excavations for this project will involve the construction of the box culvert or footings for the abutment walls. Depending on the design that is finally selected, the anticipated maximum depth of excavation below existing grade of Highway 21 is between 4 and 6 m.

Excavations to depths of 6 m should not present any special difficulties using heavy excavation equipment. However, the buried utilities along the west side of the embankment will likely be in conflict with the excavation. Excavation and protection procedures should be reviewed with the utility companies or authorities prior to construction.

The water in the stream can be controlled by temporary diversion or dam and pump method. Some groundwater control will be required to handle surface runoff and minor seepage, but should be readily handled by conventional sump pumping techniques.

It should be pointed out that if the founding soil is disturbed, excessive settlements could occur after structural loads are applied. The founding level will be located below the streambed and, therefore, a minimum 50 mm thick lean concrete working mat should be placed immediately after excavation and subgrade preparation for footings to protect the integrity of the bearing surface and to facilitate placement of reinforcing steel. All foundation excavations, bearing surfaces, and placement of lean concrete mat should be inspected and approved by the geotechnical engineer.

All excavation must be carried out in compliance with the requirements of the Occupational Health and Safety Act (OHSA). For this purpose, the unsaturated upper fill and sandy silt soils are classified as Type 3 soils and the underlying very stiff to hard silty clay are classified as Type 2 soils. Saturated cohesionless soil could also be present and should be classified as Type 4 soils.

For the Type 2 soils, the excavation can be cut to near vertical in the bottom 1.2 m and then trimmed back to 1H:1V. Within the Type 3 soils and above the water table, the excavation should be cut to no steeper than 1H : 1V throughout. Side slopes of 3H:1V or flatter should be used for excavation within Type 4 soils.

Temporary support within the overfill of the existing culvert may be required to facilitate culvert construction and to maintain access for construction and local traffic, and emergency vehicles. The staging of different phases of this work should be examined to determine if roadway protection is required.

5.7 Frost Protection

This project is located in the Owen Sound Operations District (previously known as District No. 5). The design frost penetration depth for this project is between 1.2 and 1.4m in accordance with OPSD 3400.011. All foundations and spread footings should be provided with at least 1.3 m of soil cover for adequate frost protection.

5.8 Scour Depth

The footings should be founded below the anticipated local and general scour depths established from stream hydraulics. The permissible velocity of the silty clay that is exposed at the streambed is 1.5 m/s (based on American Society of Civil Engineers publication, 1926, reprinted as Design Chart 2.17, MTO Drainage Management Manual 1997).

6. 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 11, is an integral part of this report.

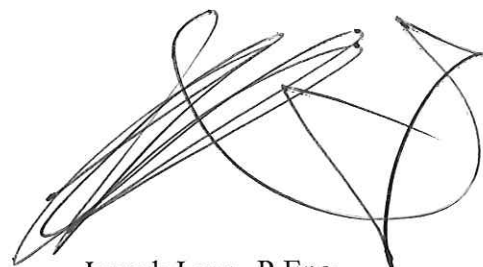
We trust that we have completed the assignment within the Terms of Reference for this project. If there are any questions concerning this report, please do not hesitate to contact our office.

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



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 31mm 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 (31mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON "A" 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 (RQD), 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	50 mm	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'_{v0}	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
ξ	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		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						

Appendix 1

Data for Culvert 4, Structure 12-437-C

Borehole Locations and Soil Data

Drawing C4.1

Record of Borehole Sheets

Boreholes C04-1 to C04-3

Laboratory Test Results

Grain Size Distribution

Figure 4.1

Plasticity Chart

Figure 4.2

Void Ratio – Pressure Curve

Figure 4.3

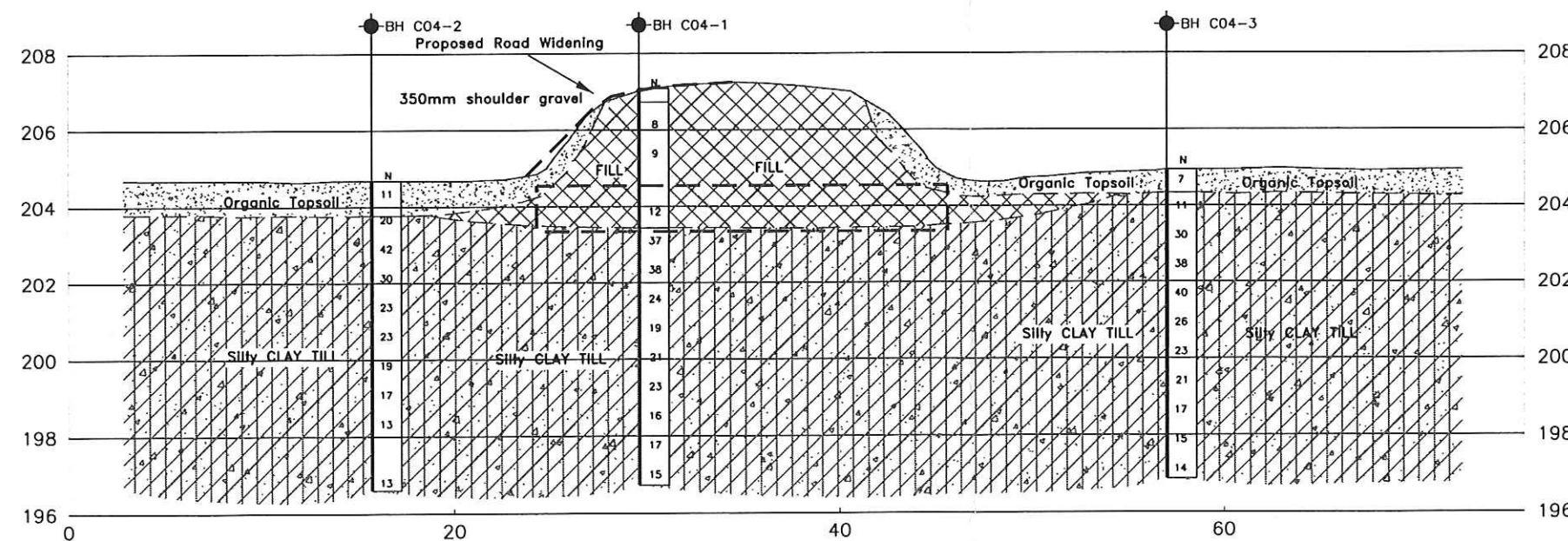
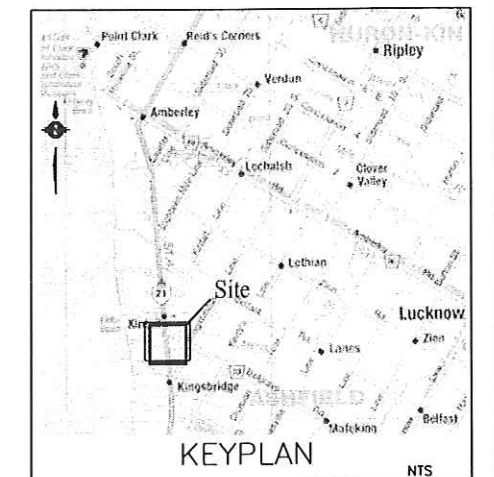
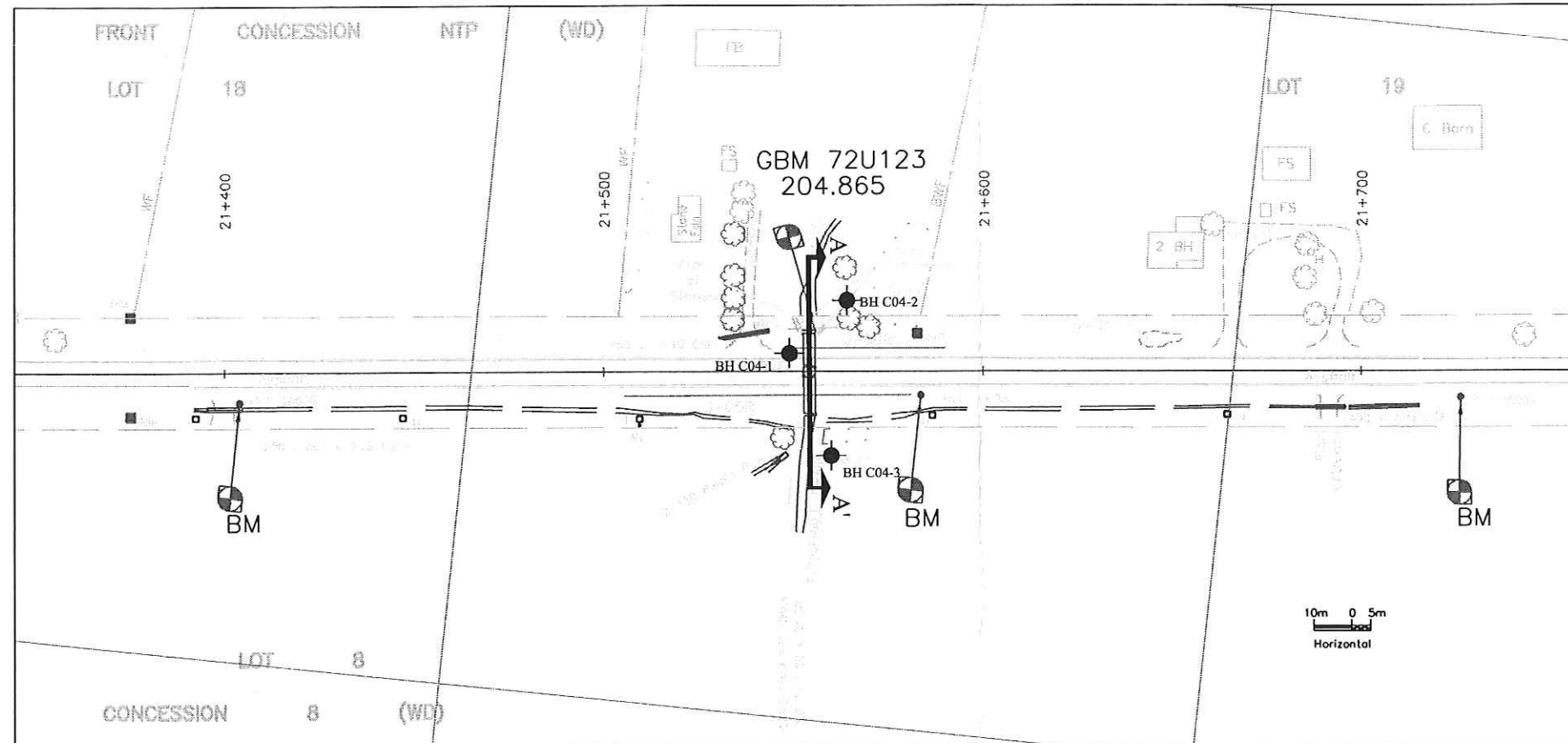
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No xxxx-xxxx
WP No 3097-03-00



Culvert #4-Fitzgerald Drain
Highway 21
BORE HOLE LOCATIONS & SOIL STRATA
I.E. Infrastructure Engineering Group Inc.
Pavement & Construction Materials Consulting Engineers
GTA • Kitchener • London • Windsor

SHEET
1



BH C04-1 is brought into the view of section A-A'

SECTION A-A'



NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC2.01 of OPS Gen. Cond.

LEGEND

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

No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
C04-1	207.09	4867482.814	368903.238
C04-2	204.68	4867496.395	368887.723
C04-3	204.95	4867496.576	368929.239

NOTE
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS		DATE		BY		DISCUSSION	
08/12/04		AL		Drafter			
Geocres : 41A-179		HWY No.		HWY 21		DIST	
SUBM'D		AL		CHECKED J.L.		DATE August 19, 2004	
DRAWN		AL		CHECKED J.L.		APPROVED E.C.	
						SITE 12-437-C	
						DWG C4.1	

RECORD OF BOREHOLE No C04-1

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 21+548.9, OFFSET -4.8 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.17.04 - 6.17.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100							
								20 40 60 80 100							
							UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _P W W _L				
							WATER CONTENT (%)								
207.09	Ground Surface														
0.00	350mm shoulder gravel						207								
206.74															
0.35															
	Brown, moist, loose, FILL, consisting of silty clay, trace to some organics		1	SS	8		206								
			2	SS	9		205								
	trace to some organics						204								
			3	SS	12										
203.43															
3.66			4	SS	37		203								
	Brown	Hard													
			5	SS	38		202								
			6	SS	24		201								
			7	SS	19		200								
	Moist, Silty CLAY with embedded sand and gravel (TILL)		8	SS	21										
	Grey	V. Stiff	9	SS	23		199								
			10	SS	16		198								
			11	SS	17		197								
196.73			12	SS	15										
10.36	End of Borehole. Borehole dry and open at completion.														

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, X³: Numbers refer to
Sensitivity

O 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C04-2

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 21+564.1, OFFSET -18.9 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 7.6.04 - 7.6.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
204.68 0.00	Ground Surface						20	40	60	80	100					
	Wet, Organic Topsoil FILL, becomes sandy with depth		1	SS	11											
203.77 0.91			2	SS	20											
	Brown	V. Stiff														
			3	SS	42											
		Hard														
			4	SS	30											
			5	SS	23											
			6	SS	23											
	Moist, Silty CLAY with embedded sand and gravel (TILL)	V. Stiff														
	Grey		7	SS	19											
			8	SS	17											
			9	SS	13											
		Stiff														
			10	TW												
196.60 8.08	End of Borehole. Borehole dry and open at completion.		11	SS	13											

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, X³: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C04-3

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 21+559.9, OFFSET 22.4 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 7.6.04 - 7.6.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	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 (%)		
204.95	Ground Surface					20	40	60	80	100	10	20	30	GR SA SI CL				
0.00	Organic Topsoil FILL		1	SS	7													
204.34																		
0.61																		
		Stiff	2	SS	11						225+							
	Brown		3	SS	30						225+							
		Hard	4	SS	38						225+							
			5	SS	40						225+							
			6	SS	26						112.5							
	Wet to moist, Silty CLAY with embedded sand and gravel (TILL)		7	SS	23						100							
	Grey		8	SS	21			62.5						1 11 55 32 (88)				
		V. Stiff	9	SS	17													
			10	SS	15			37.5										
		Stiff	11	SS	14			37.5										
196.87	End of Borehole. Borehole dry and open at completion.																	
8.08																		

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO.MOT.GDT 12/2/04

+³, X³: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
		Fine		Medium	Coarse	Fine	Coarse

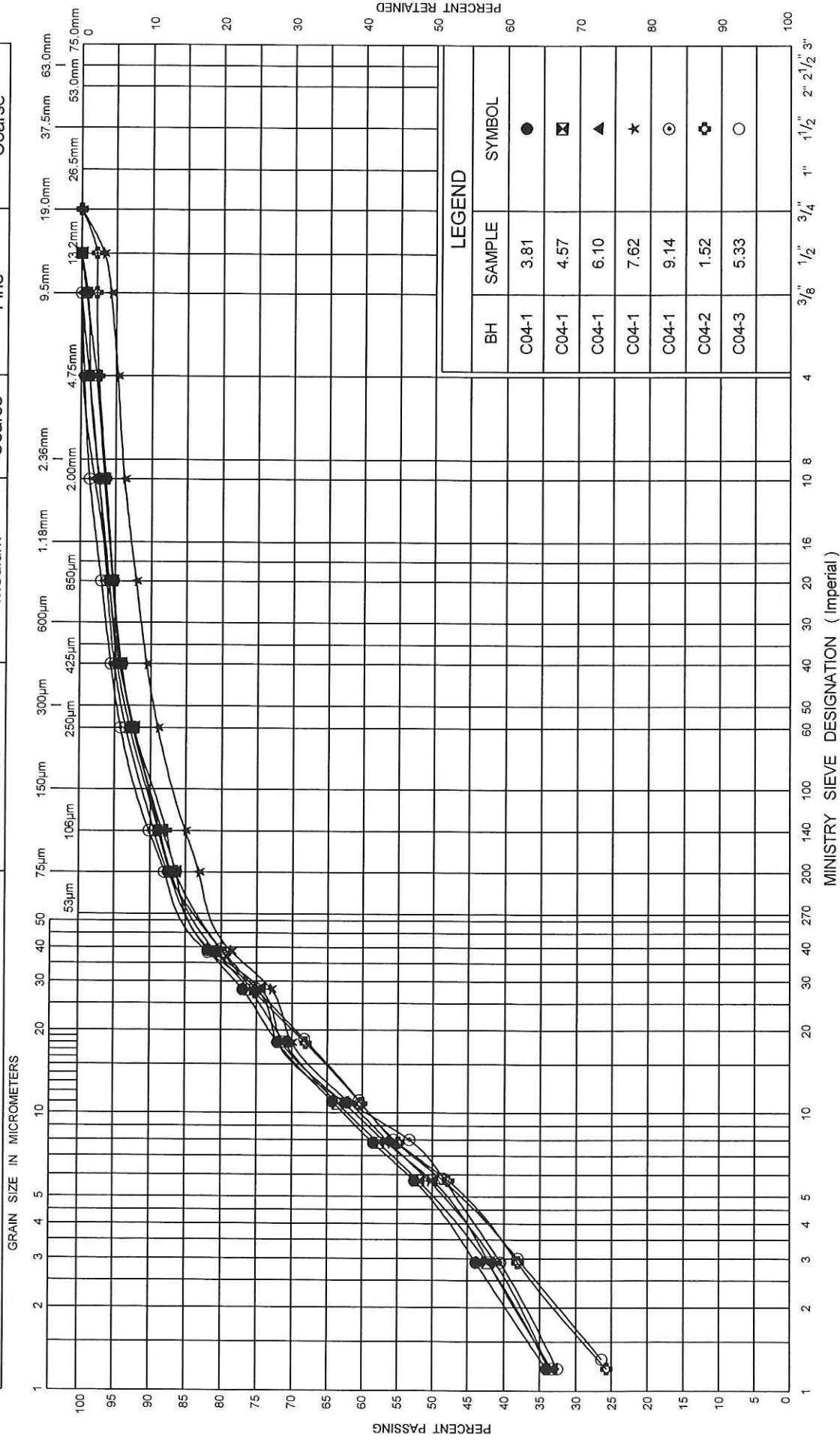
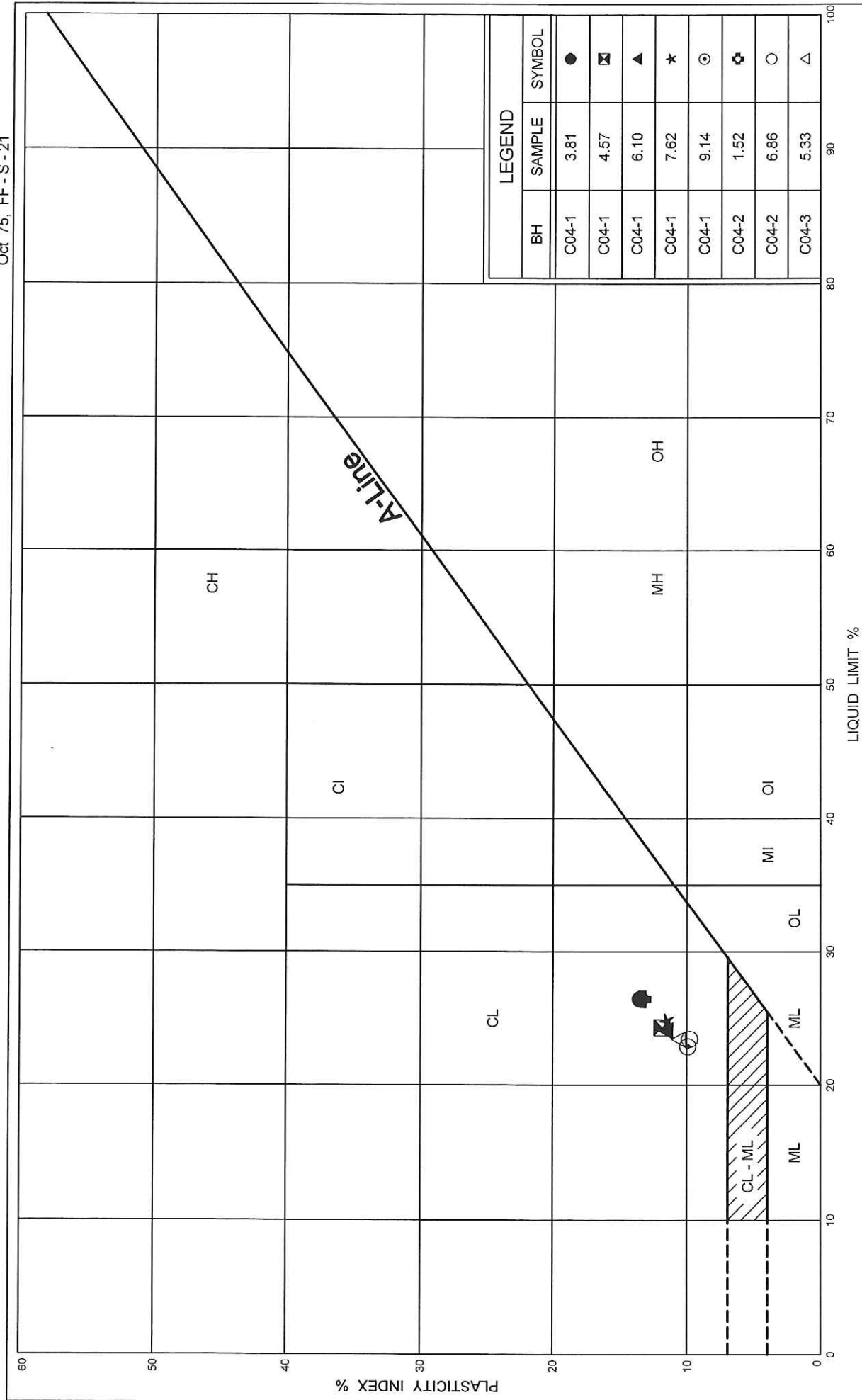


FIG No 4.1

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

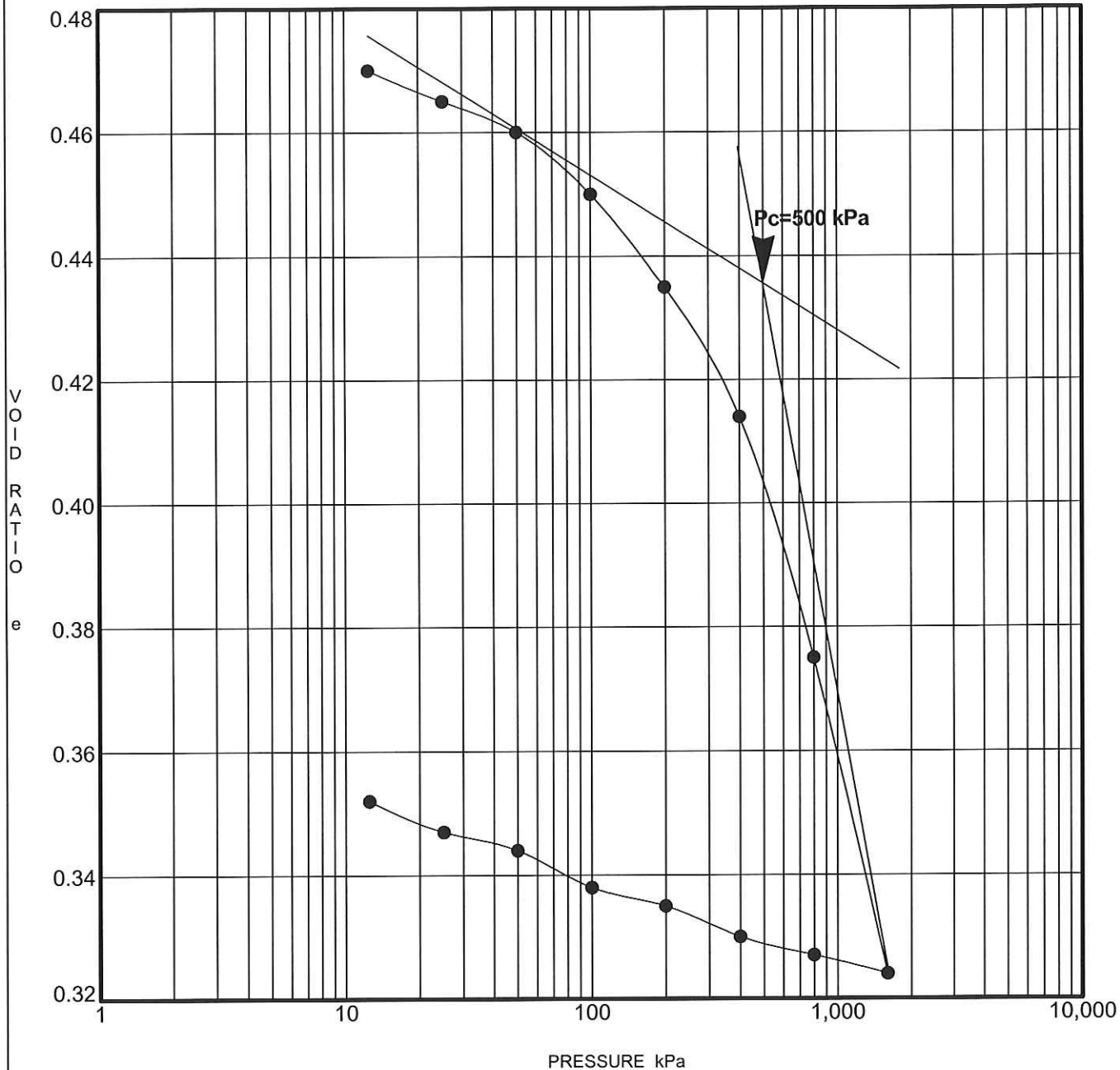


PLASTICITY CHART

FIG No 4.2

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations



JOE CONSOLIDATION PLOT 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/4/04

B H	DEPTH	ELEV.	W_L	W_P	W	C_C	C_R	σ'_{vo}	γ_d	Classification
● C04-2	6.86	197.82	23	13	17.9	0.177	0.014	116	17.9	CL



Ministry of
Transportation

VOID RATIO - PRESSURE CURVE

FIG No 4.3

W P G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

Appendix 2

Data for Culvert 6, Structure 12-439-C

Borehole Locations and Soil Data	Drawing C6.1
Record of Borehole Sheets	Boreholes C06-1 to C06-3
Laboratory Test Results	
Grain Size Distribution	Figures 6.1 to 6.2
Plasticity Chart	Figures 6.3 to 6.4

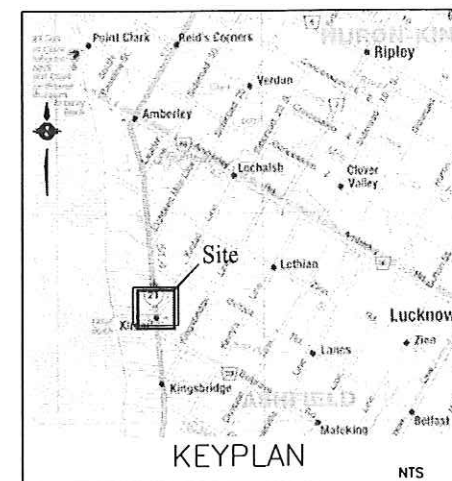
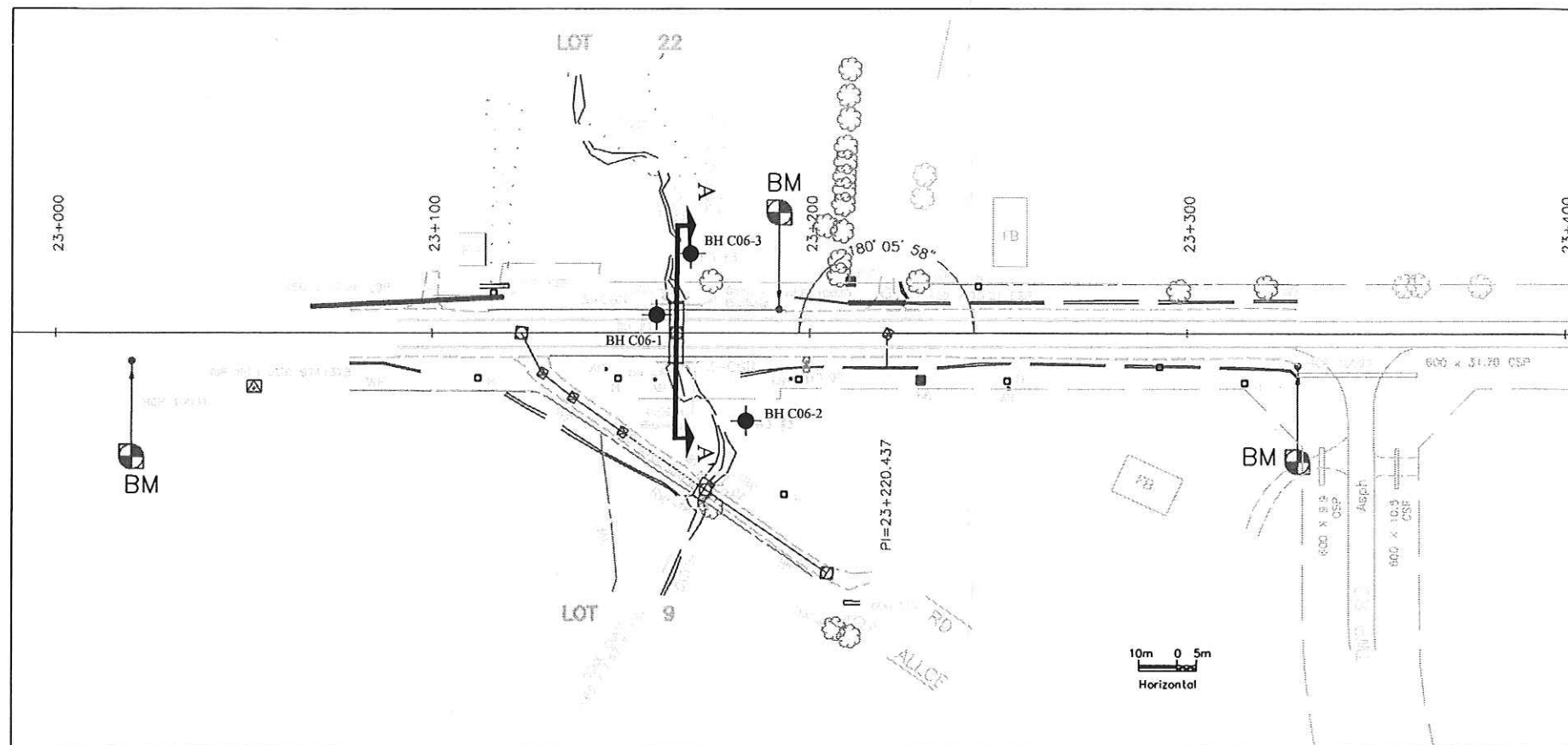
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DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No XXXX-XXXX
WP No 3097-03-00



Culvert #6
Highway 21
BORE HOLE LOCATIONS & SOIL STRATA
I.E. Infrastructure Engineering Group Inc.
Pavement & Construction Materials Consulting Engineers
GTA • Kitchener • London • Windsor

SHEET
1

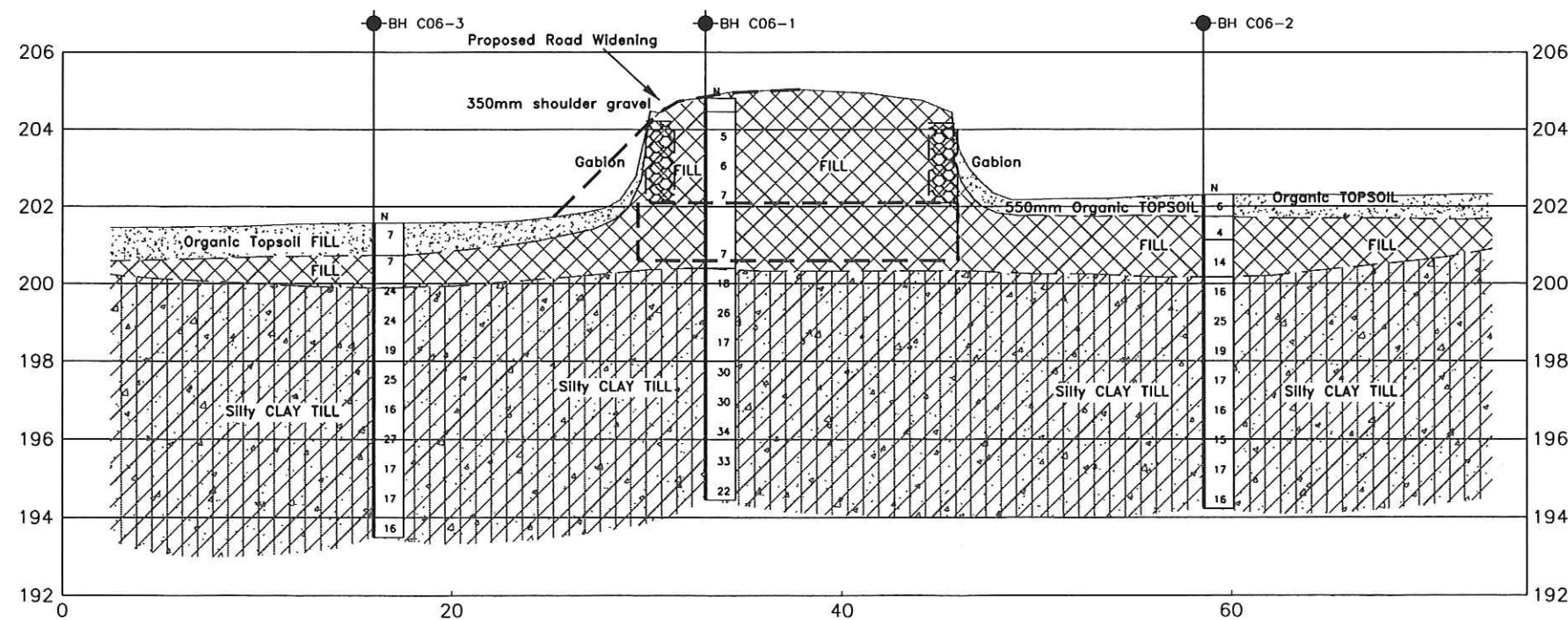


LEGEND

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

No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
C06-1	204.81	4869084.406	368735.059
C06-2	202.30	4869110.983	368760.580
C06-3	201.57	4869091.674	368717.996

NOTE:
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.



Note:

- BH C06-1 is brought into the view of section A-A'
- Base of existing gabion wall not known.

SECTION A-A'



NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC2.01 of OPS Gen. Cond.

REVISIONS		DATE		BY		DISCUSSION	
08/12/04		AL		Draft			
HWY No.		HWY 21		DIST		Owen Sound	
SUBM'D AL		CHECKED J.L.		DATE August 19, 2004		SITE 12-439-C	
DRAWN AL		CHECKED J.L.		APPROVED E.C.		DWG C6.1	

RECORD OF BOREHOLE No C06-1

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 23+159.5, OFFSET -4.8 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.17.04 - 6.17.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
204.81 0.00	Ground Surface																
204.46 0.35	350mm shoulder gravel																
	Brown, moist, loose, FILL, consisting of silty clay, trace to some organics		1	SS	5		204										
			2	SS	6		203										
			3	SS	7		202										
	trace to some organics		4	SS	7		201										
200.39 4.42	Brown		5	SS	18		200										
			6	SS	26		199										
	Moist, Silty CLAY with embedded sand and gravel (TILL)	V. Stiff	7	SS	17		198										
			8	SS	30		197										
			9	SS	30		196										
			10	SS	34		195										
	Grey	Hard	11	SS	33												
			12	SS	22												
194.45 10.36	End of Borehole. Borehole dry and open at completion.																

JOE MTO FINAL 04-5-JEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, ×³: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C06-2

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 23+183.3, OFFSET 23.4 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 7.6.04 - 7.6.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ 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						
202.30	Ground Surface							20 40 60 80 100	10 20 30						
0.00	560mm Organic TOPSOIL		1	SS	6		202								
201.74	Brown, wet, Mixed FILL consisting of sand, gravel, silt and clay		2	SS	4		201								
0.56															
201.13	Brown, wet, Mixed FILL consisting of sand and silt, with clay lumps, occ. gravel		3	SS	14		200								
1.17															
200.17	Grey, moist, very stiff, Silty CLAY with embedded sand and gravel (TILL)		4	SS	16		199	112.5						3 11 55 32 (87)	
2.13			5	SS	25		198	100							
			6	SS	19		197	87.5							
			7	SS	17		196	112.5							
			8	SS	16		195	75							
			9	SS	15			62.5							
			10	SS	17			62.5							
			11	SS	16			37.5							
194.22	End of Borehole. Borehole dry and open at completion.														
8.08															

DE MTO FINAL 04-3-IEG3.GPJ ONTARIO MDT.GDI 11/2/04

JOE MTO FINAL 04-5-JEG3.CPJ ONTARIO MOT.GDT 12/2/04

+³, X³: Numbers refer to Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C06-3

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 23+168.5, OFFSET -21.0 ORIGINATED BY RB
DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
DATUM Geodetic DATE 7.6.04 - 7.6.04 CHECKED BY EC

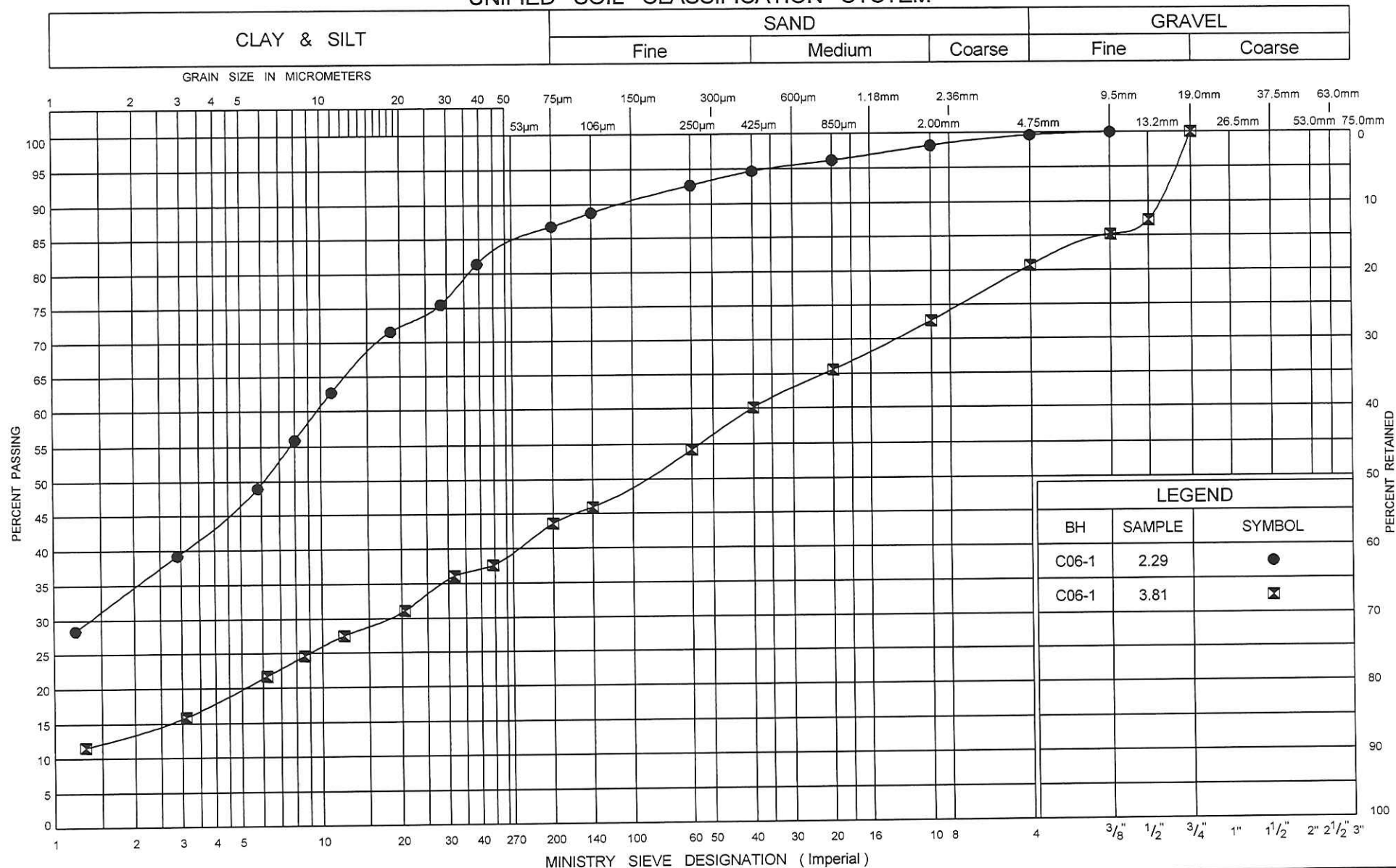
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL							× LAB VANE
201.57 0.00	Ground Surface		1	SS	7												
200.73 0.84	Black, moist to wet, Organic Topsoil FILL		2	SS	7												
199.89 1.68	Brown, moist to wet, FILL consisting of silt, some sand, trace clay		3	SS	24												
	Brown with grey mottling		4	SS	24												
			5	SS	19												
			6	SS	25												
	Moist, very stiff, Silty CLAY with embedded sand and gravel (TILL)		7	SS	16												
	Grey		8	SS	27												
			9	SS	17												
			10	SS	17												
			11	SS	16												
193.49 8.08	End of Borehole. Borehole dry and open at completion.																

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+ 3, X 3: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

FIG No 6.1

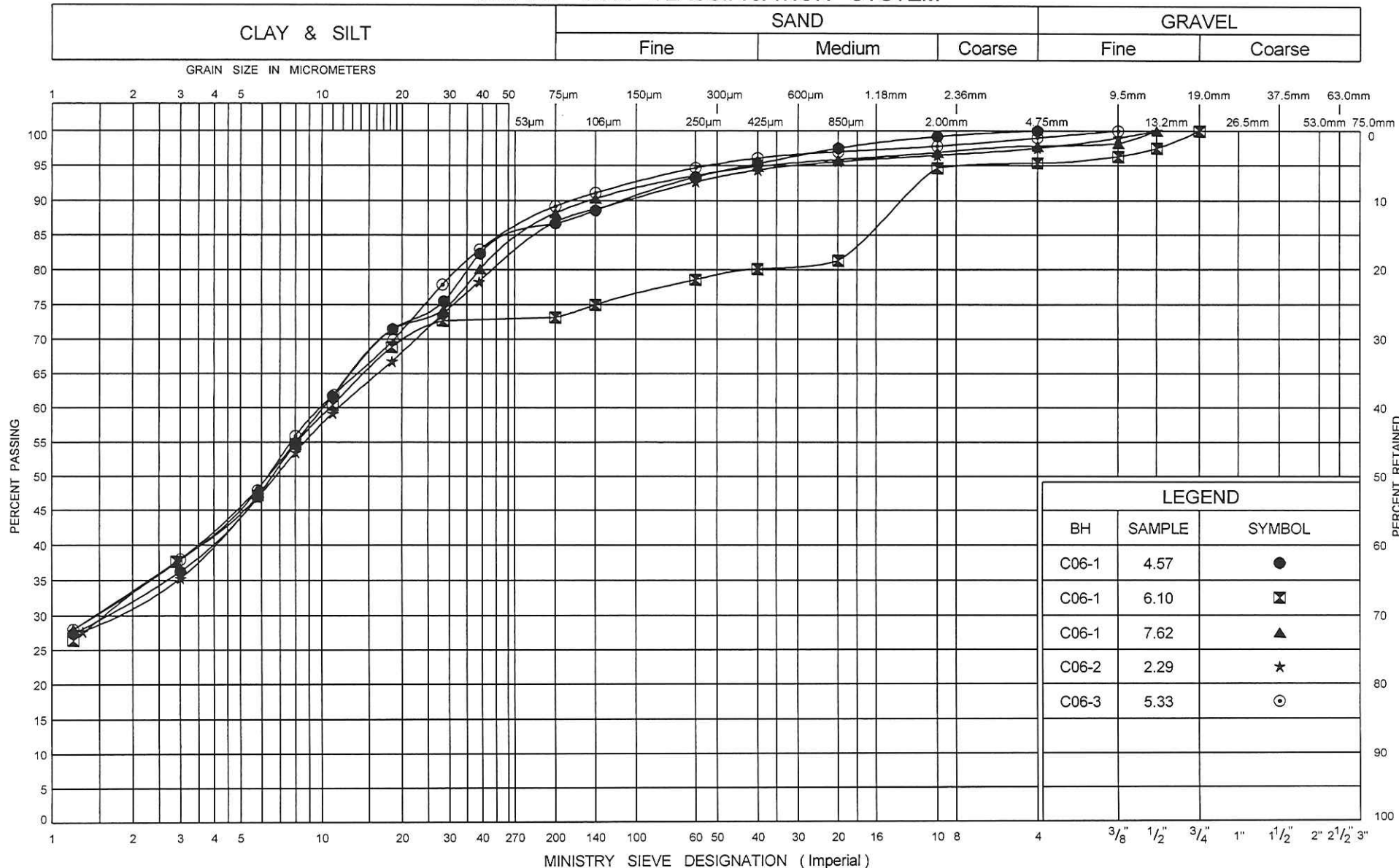
G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations



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Ontario

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

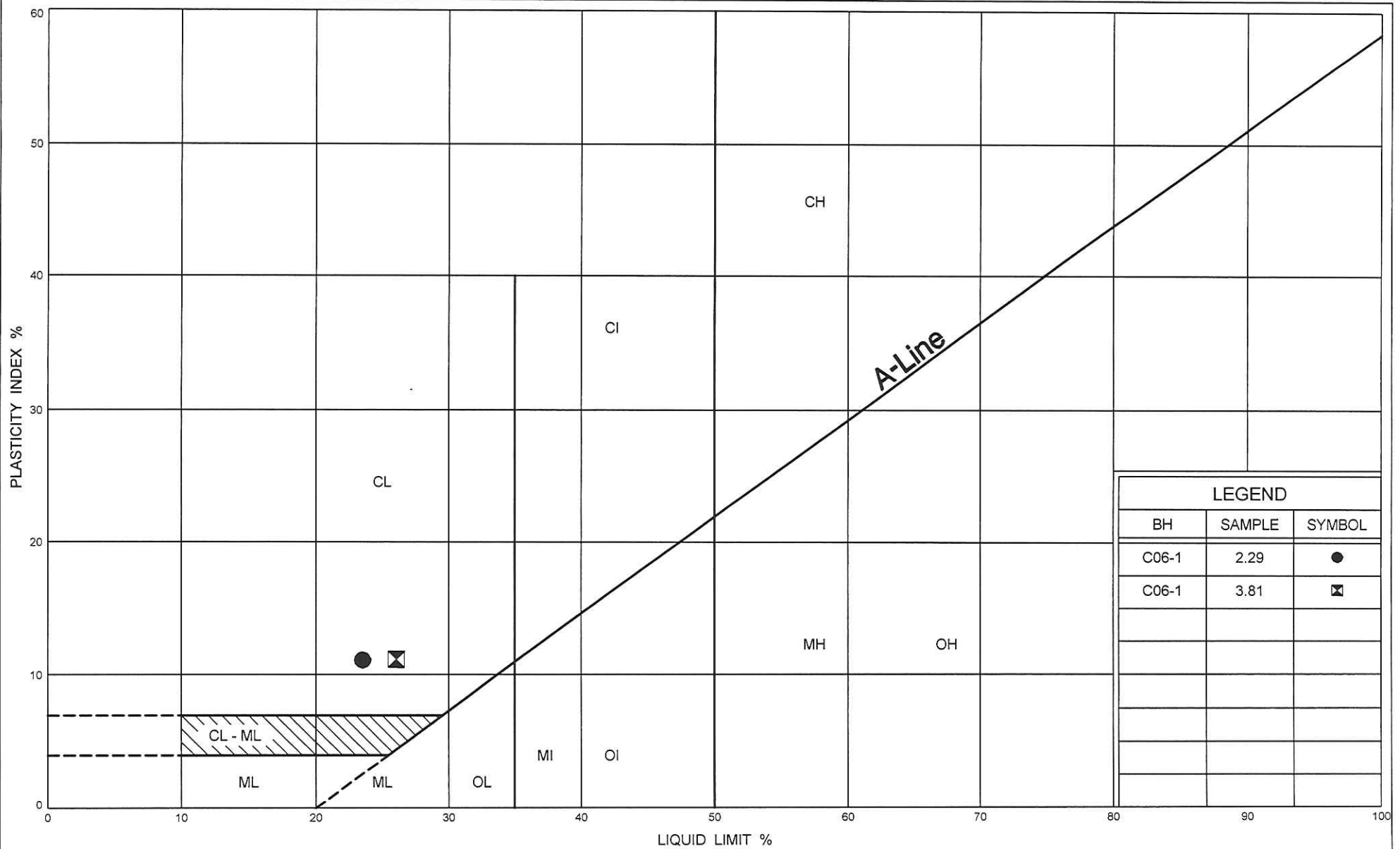
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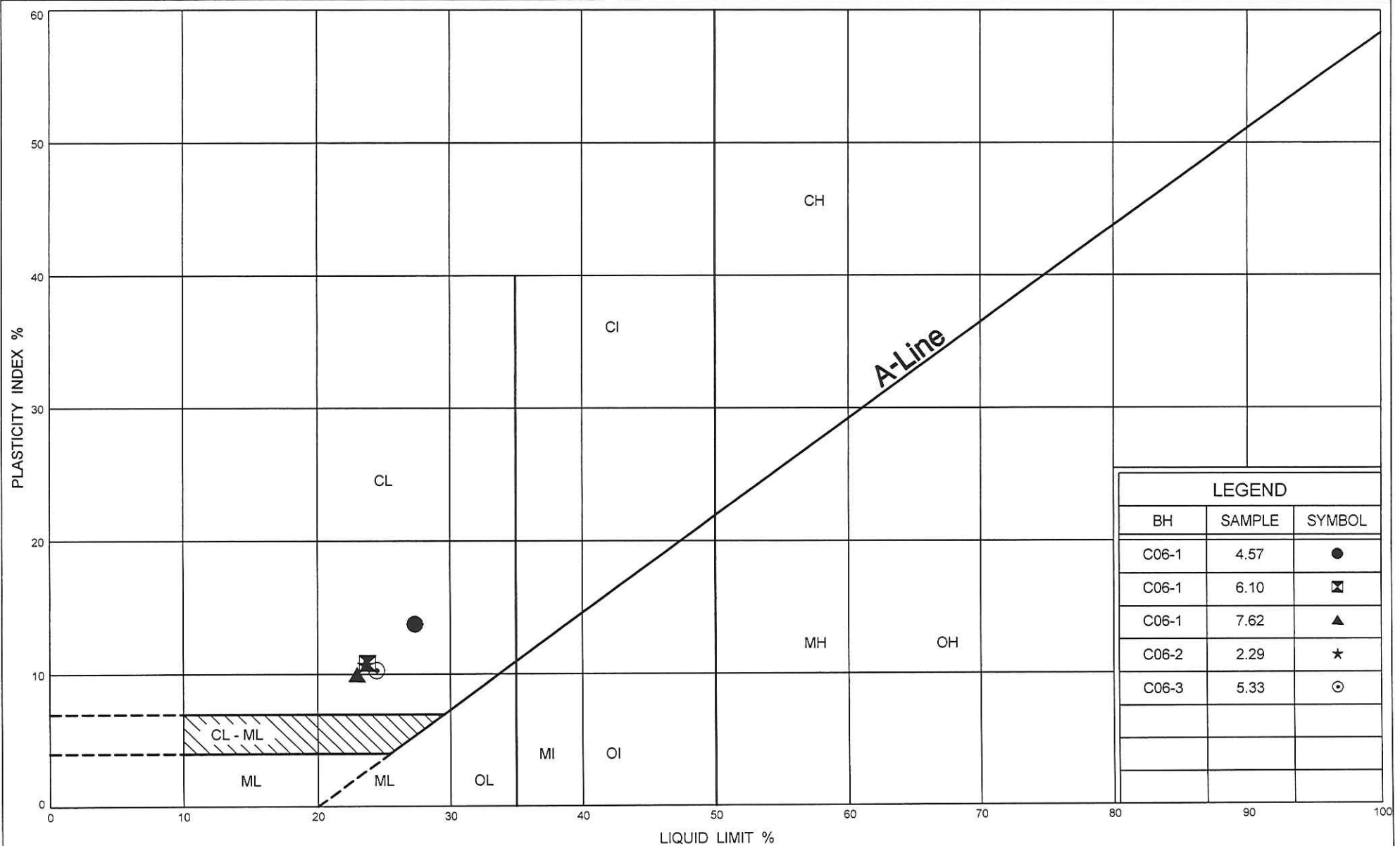
G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations



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PLASTICITY CHART

FIG No 6.4

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

Appendix 3

Data for Culvert 7, Structure 12-441-C

Borehole Locations and Soil Data	Drawing C7.1
Record of Borehole Sheets	Boreholes C07-1 to C07-3
Laboratory Test Results	
Grain Size Distribution	Figures 7.1 to 7.2
Plasticity Chart	Figures 7.3 to 7.4

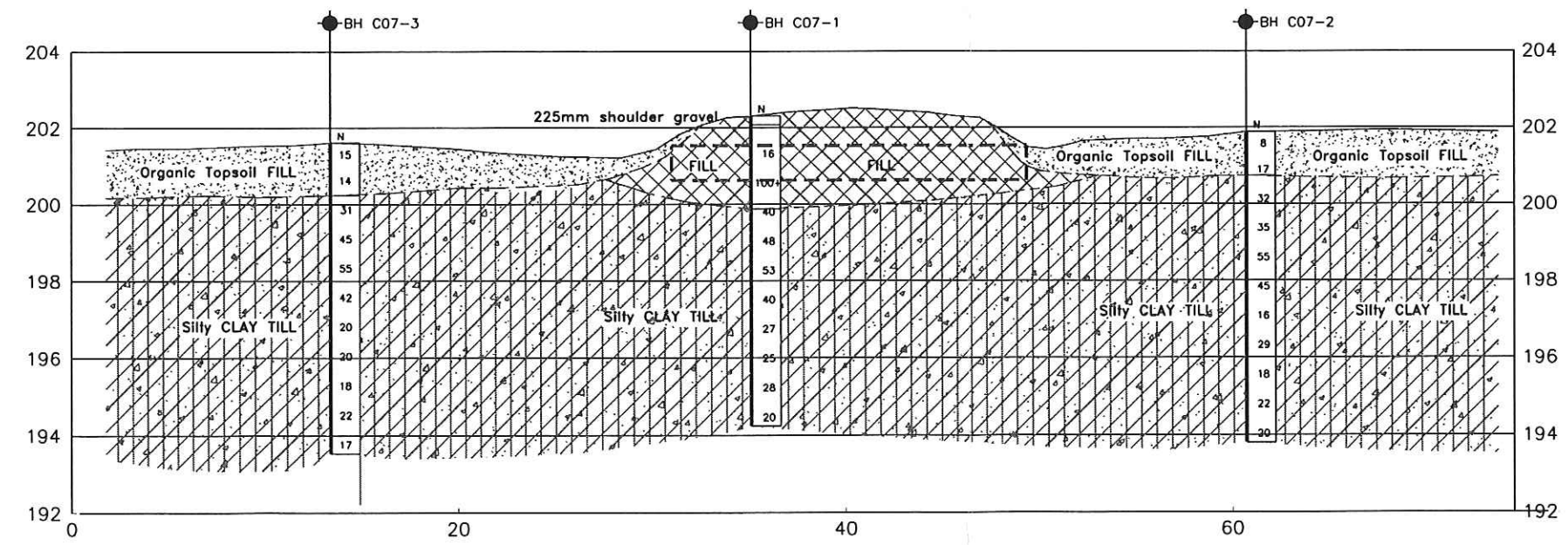
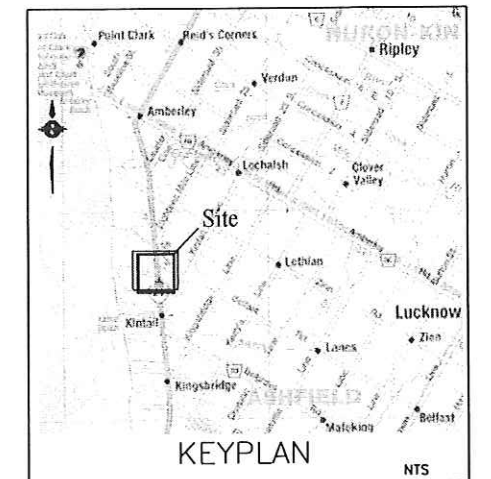
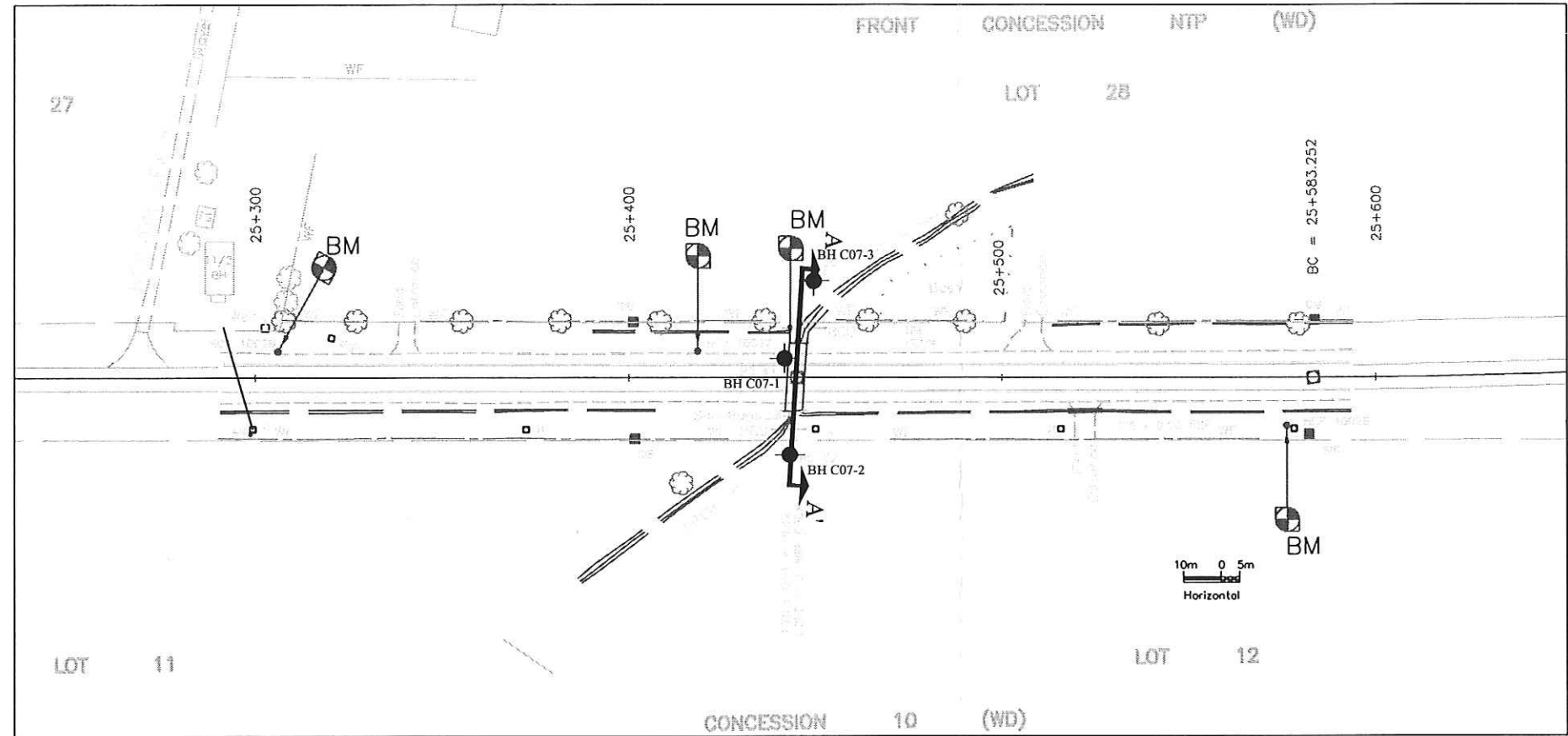
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DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No XXXX-XXXX
WP No 3097-03-00



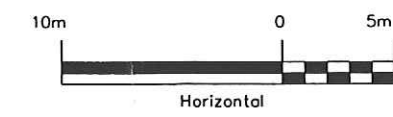
Culvert #7
Highway 21
BORE HOLE LOCATIONS & SOIL STRATA
I.E. Infrastructure Engineering Group Inc.
Pavement & Construction Materials Consulting Engineers
GTA • Kitchener • London • Windsor

SHEET
1



BH C07-1 is brought into the view of section A-A'

SECTION A-A'



NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section CC2.01 of OPS Gen. Cond.

LEGEND

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

No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
C07-1	202.31	4871353.139	368491.741
C07-2	201.88	4871357.283	368517.509
C07-3	201.61	4871358.529	368470.152

NOTE: The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS		DATE		BY		DISCUSSION	
08/12/04		AL		Draft			
Geocres : 41A-179		HWY No.		HWY 21		DIST	
SUBM'D AL		CHECKED J.L.		DATE August 19, 2004		SITE	
DRAWN AL		CHECKED J.L.		APPROVED E.C.		DWG	
						C7.1	

RECORD OF BOREHOLE No C07-1

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 25+441.5, OFFSET -5.2 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.17.04 - 6.17.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
202.31	Ground Surface												
0.00 202.08 0.23	230mm shoulder gravel												
	Brown, moist, loose, FILL, consisting of silty clay, trace to some organics concrete lump		1	SS	16		202						20.8 1 20 52 27 (79)
			2	SS	100+		201						
199.87 2.44	Hard Grey, moist, Silty CLAY with embedded sand and gravel (TILL) V. Stiff		3	SS	40		200			225+			22.2 2 13 52 33 (85)
			4	SS	48		199			225+			1 14 54 31 (85)
			5	SS	53		198			225+			23.0 1 13 54 33 (87)
			6	SS	40		197			225+			
			7	SS	27		196			112.5			22.0 1 31 44 24 (68)
			8	SS	25		195			100			
			9	SS	28					87.5			
			10	SS	20					75			
194.23 8.08	End of Borehole. Borehole dry and open at completion.												

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, X³: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C07-2

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 25+442.9, OFFSET 20.9 ORIGINATED BY RB
DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
DATUM Geodetic DATE 7.7.04 - 7.7.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ 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						
201.88	Ground Surface						20	40	60	80	100						
0.00	Moist, Organic Topsoil FILL, sandy		1	SS	8												
			2	SS	17												
200.74	Brown	Hard	3	SS	32							225+				10 17 46 28 (74)	
1.14				4	SS	35							225+				
				5	SS	55							225+				
				6	SS	45							225+				
				7	SS	16											
				8	SS	29							87.5				
				9	SS	18							100				
				10	SS	22							75				
				11	SS	20							62.5				
193.80	End of Borehole. Borehole dry and open at completion.																
8.08																	

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/5/04

RECORD OF BOREHOLE No C07-3

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 25+449.2, OFFSET -26.1 ORIGINATED BY RB
DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
DATUM Geodetic DATE 7.7.04 - 7.7.04 CHECKED BY EC

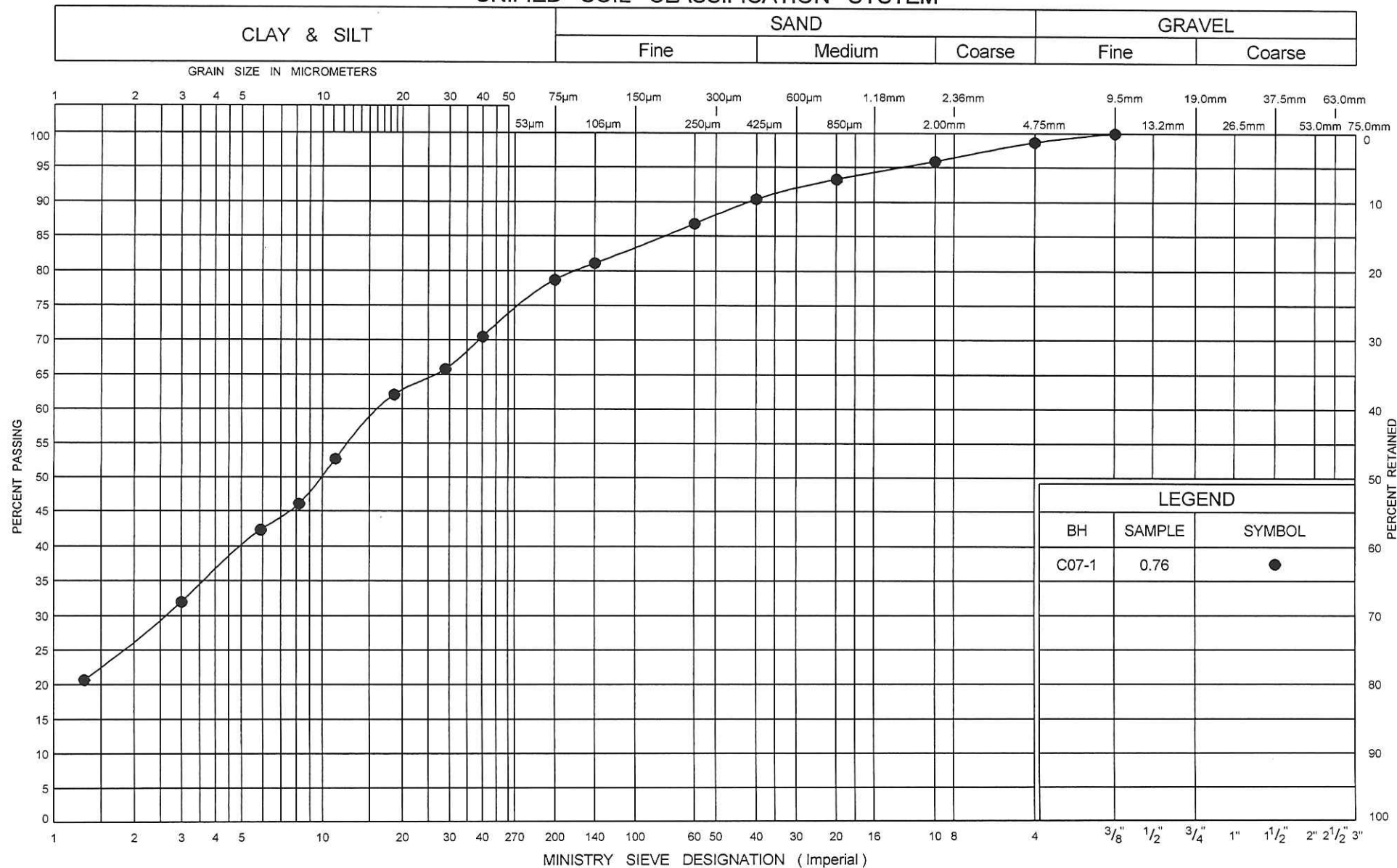
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								20	40	60							80	100
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL							× LAB VANE	
201.61 0.00	Ground Surface																	
	Moist, Organic Topsoil FILL, silty		1	SS	15		201											
			2	SS	14													
200.24 1.37							200											
	Brown		3	SS	31													
			4	SS	45		199											
	Hard		5	SS	55													
			6	SS	42		198											
	Moist, Silty CLAY with embedded sand and gravel (TILL)		7	SS	20		197											
	Grey		8	SS	20		196							1 11 54 34 (89)				
			9	SS	18		195											
	V. Stiff		10	SS	22		194											
			11	SS	17													
193.53 8.08	End of Borehole. Borehole dry and open at completion.																	

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, ×³: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

Ontario

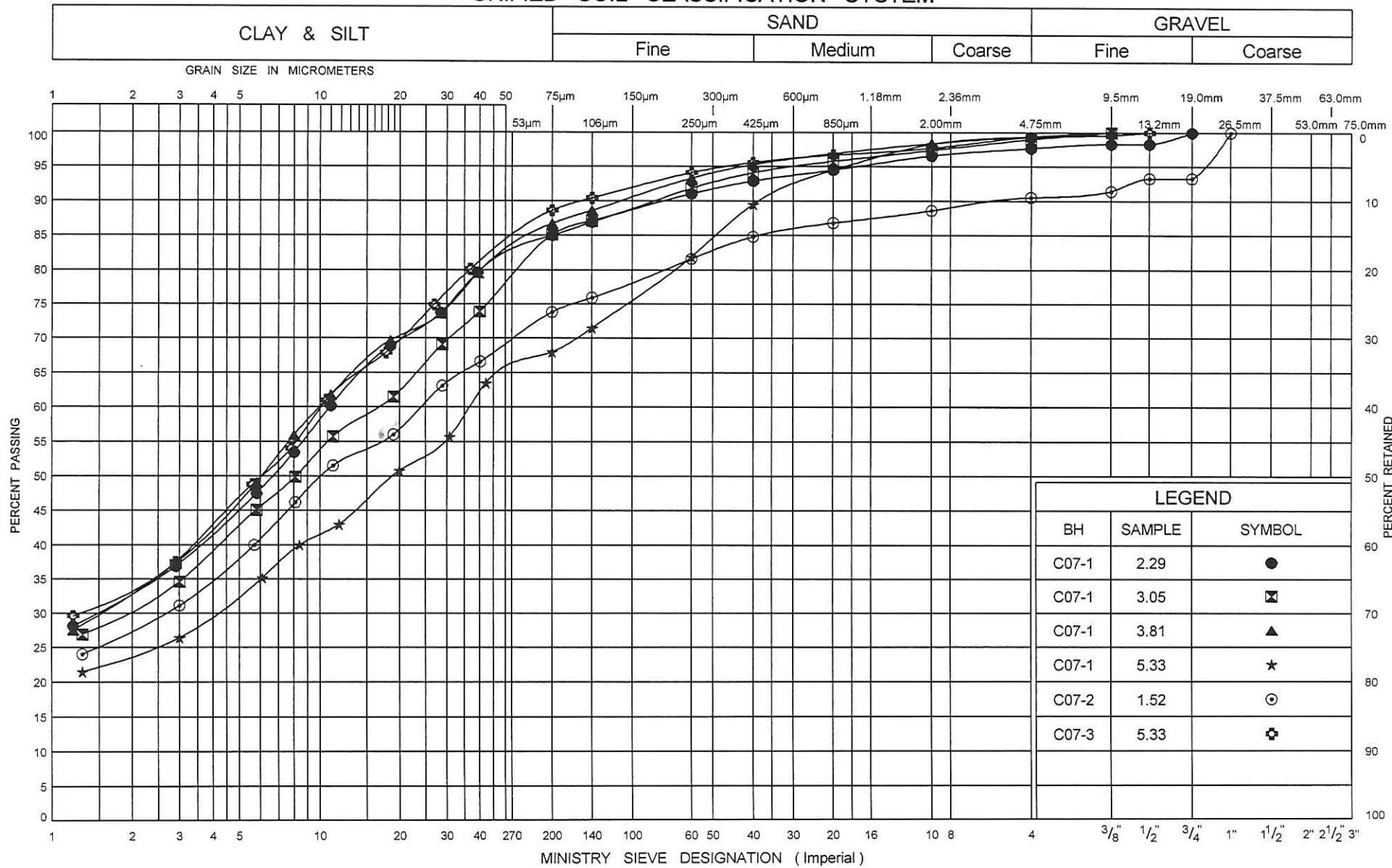
GRAIN SIZE DISTRIBUTION

FIG No 7.1

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

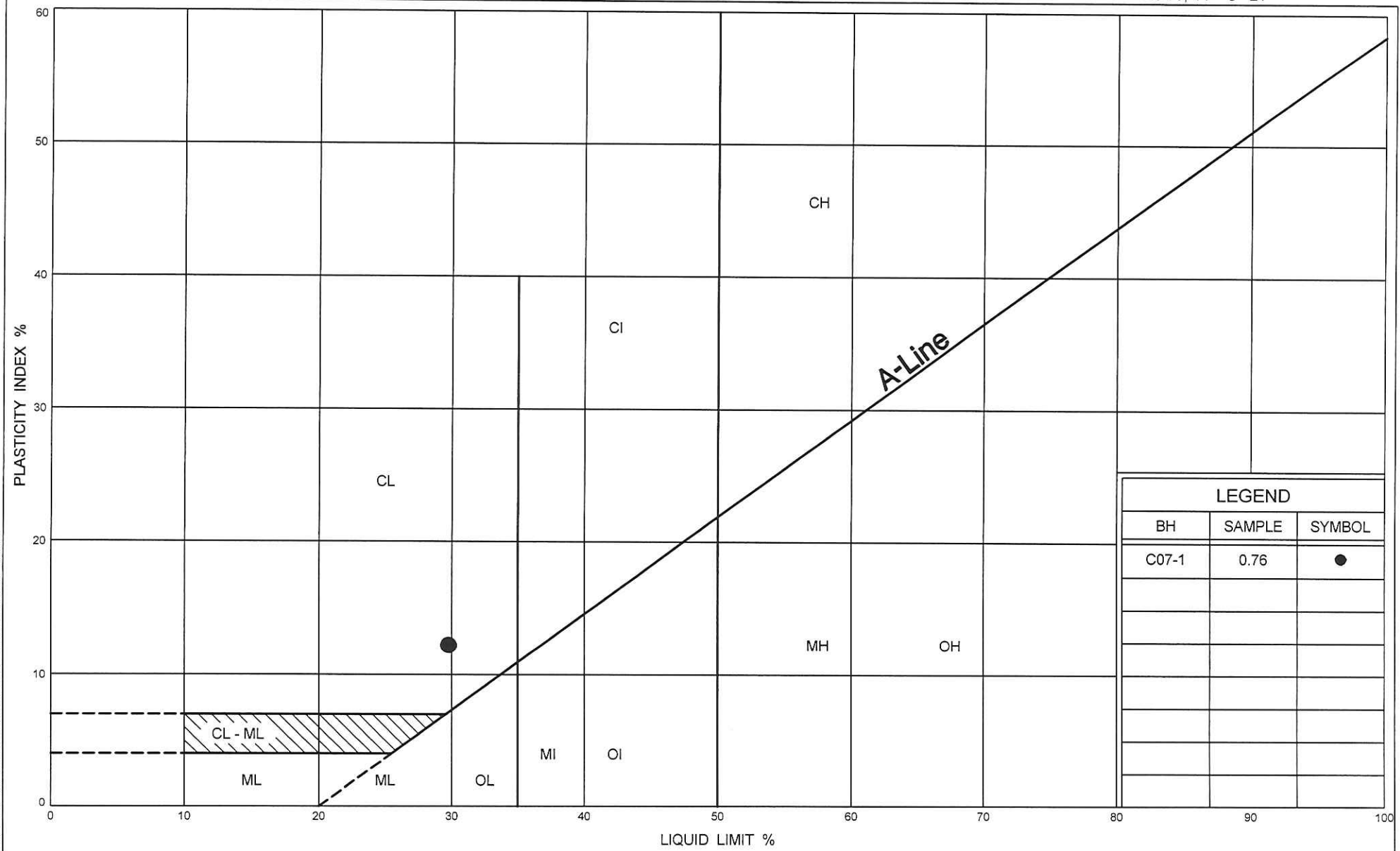
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Transportation

GRAIN SIZE DISTRIBUTION

FIG No 7.2

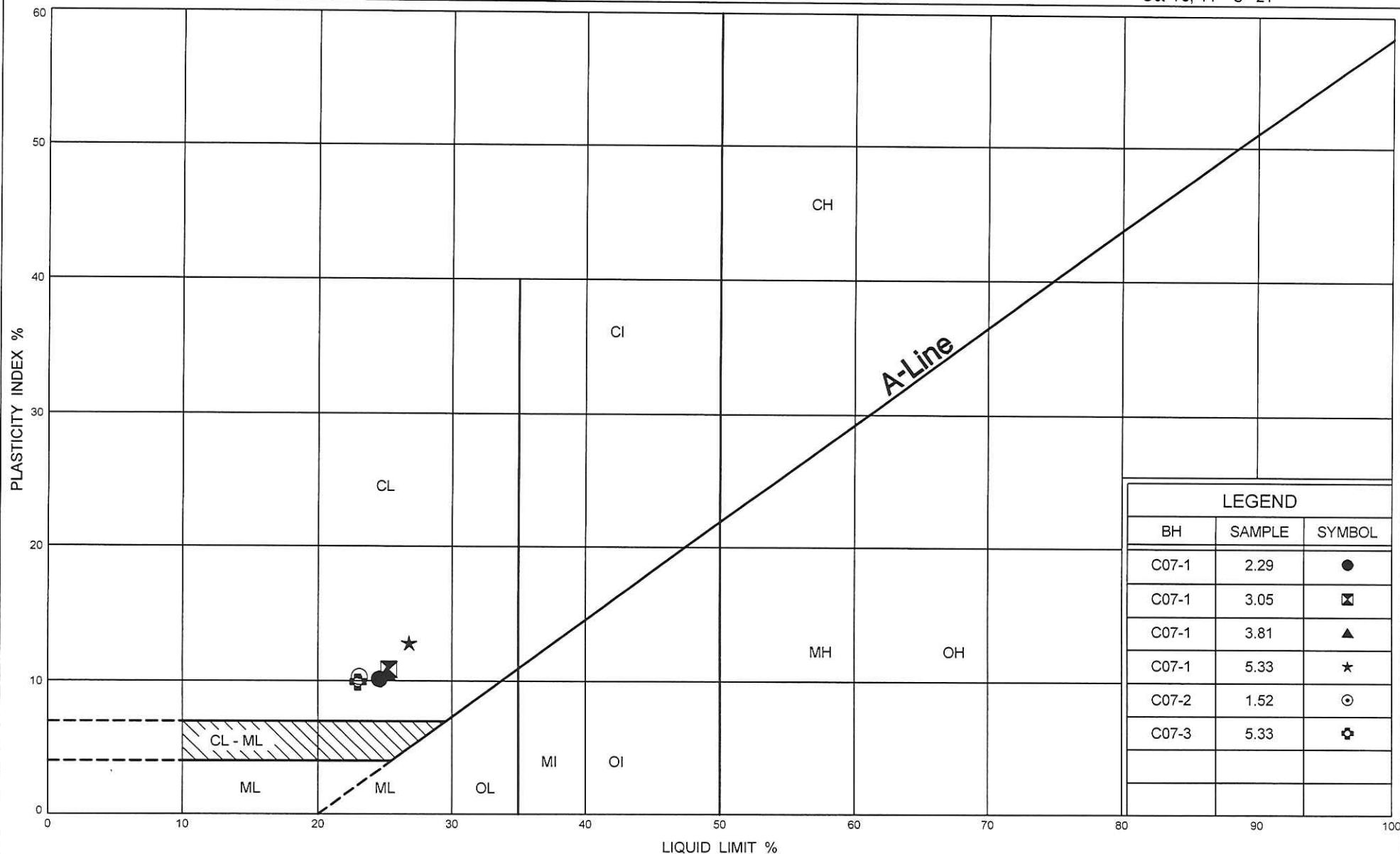
G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations



ONTARIO MOT PLASTICITY CHART 04-S-IEG3.GPJ ONTARIO MOT.GDT 12/4/04

Oct 75, FF - S - 21



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Transportation

PLASTICITY CHART

FIG No 7.4

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

Appendix 4

Data for Culvert 8, Structure 12-442-C

Borehole Locations and Soil Data	Drawing C8.1
Record of Borehole Sheets	Boreholes C08-1 to C08-3
Laboratory Test Results	
Grain Size Distribution	Figure 8.1
Plasticity Chart	Figure 8.2

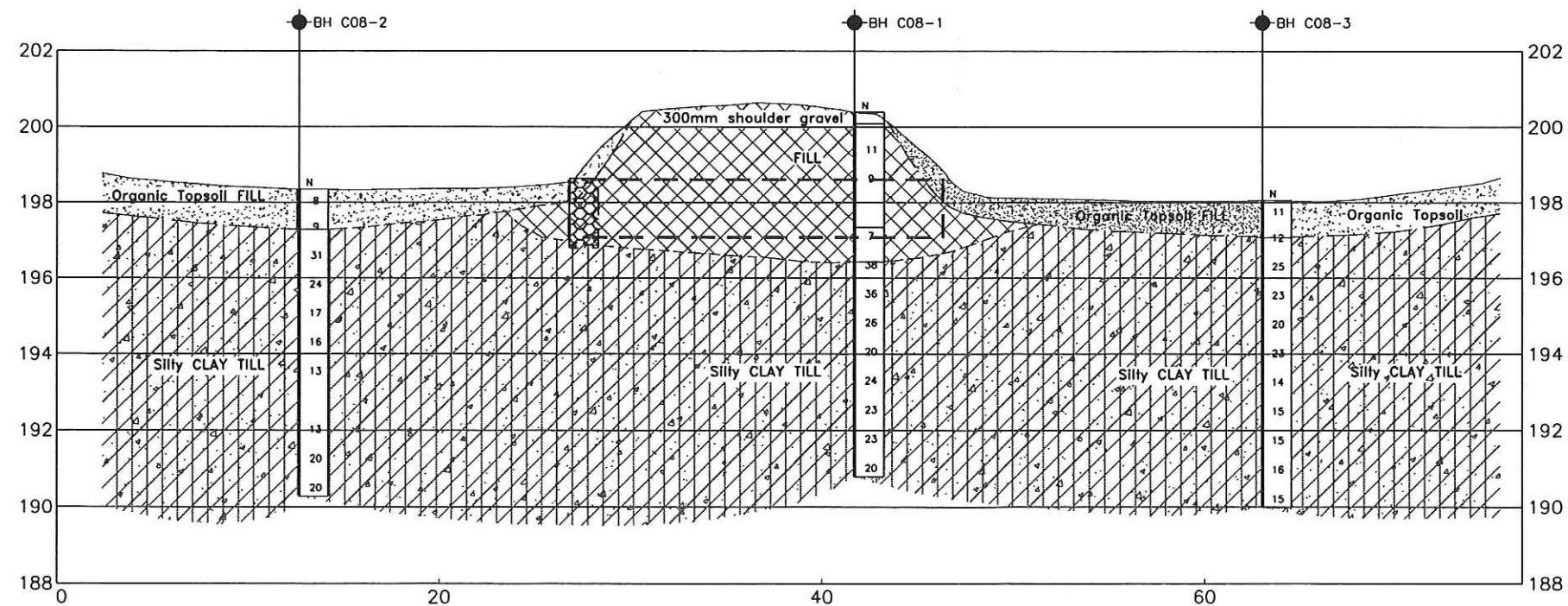
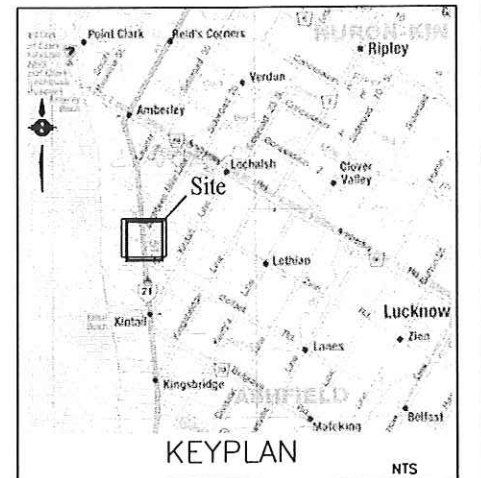
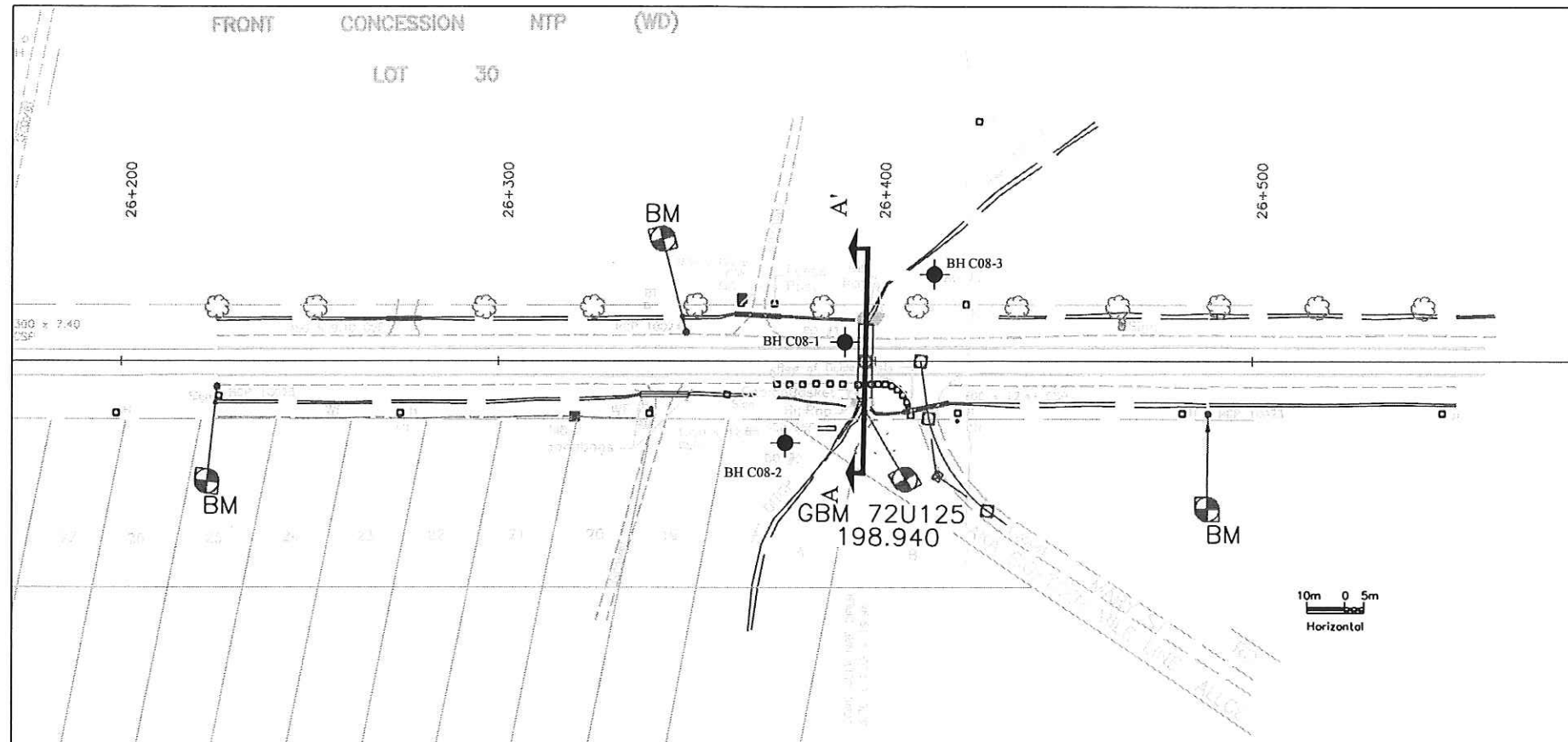
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No XXXX-XXXX
WP No 3097-03-00



Culvert #8 - Drennon Drain Works
Highway 21
BORE HOLE LOCATIONS & SOIL STRATA
I.E. Infrastructure Engineering Group Inc.
Pavement & Construction Materials Consulting Engineers
GTA • Kitchener • London • Windsor

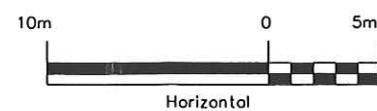
SHEET
1



Note:

- BH C08-3 is brought into the view of section A-A'
- Base of existing gabion wall not known.

SECTION A-A'



NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC2.01 of OPS Gen. Cond.

LEGEND

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

No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
C08-1	200.39	4872293.822	368363.007
C08-2	198.35	4872280.904	368391.545
C08-3	198.06	4872315.438	368342.593

NOTE: The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS			
	08/12/04	AL	Draft
	DATE	BY	DISCUSSION

Geocres : 41A-179

HWY No.		HWY 21		DIST Owen Sound	
SUBM'D AL	CHECKED J.L.	DATE August 19, 2004		SITE 12-442-C	
DRAWN AL	CHECKED J.L.	APPROVED E.C.		DWG C8.1	

1 OF 1

METRIC

W.P.	G.W.P. 3097-03-00	LOCATION	STA 26+391.9, OFFSET -5.2	ORIGINATED BY	RB
DIST	Owen Sound	HWY	9 & 21	BOREHOLE TYPE	100mm SST Auger
DATUM	Geodetic	DATE	6.16.04 - 6.16.04	CHECKED BY	EC

[illegible]

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

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

RECORD OF BOREHOLE No C08-2

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 26+376.0, OFFSET 21.8 ORIGINATED BY RB
DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
DATUM Geodetic DATE 7.7.04 - 7.8.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	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					

198.35 0.00	Ground Surface															
	Organic Topsoil FILL		1	SS	8		198									
197.28 1.07			2	SS	9											
	Brown	Hard	3	SS	31		197					225				1 12 52 34 (87)
			4	SS	24		196					225+				
		V. Stiff	5	SS	17		195					87.5				
			6	SS	16											
	Moist, Silty CLAY with embedded sand and gravel (TILL)		7	SS	13		194									
	Grey	Stiff	8	TW			193									TW sampler damaged by cobbles or boulder
			9	SS	13		192									
			10	SS	20		191									
		V. Stiff														
190.27 8.08	End of Borehole. Borehole dry and open at completion.		11	SS	20											

JOE MTO FINAL 04-5-JEG3.GPJ ONTARIO MOT.GDT 12/2/04

+ 3, X 3: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C08-3

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 26+415.6, OFFSET -23.1 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 7.8.04 - 7.8.04 CHECKED BY EC

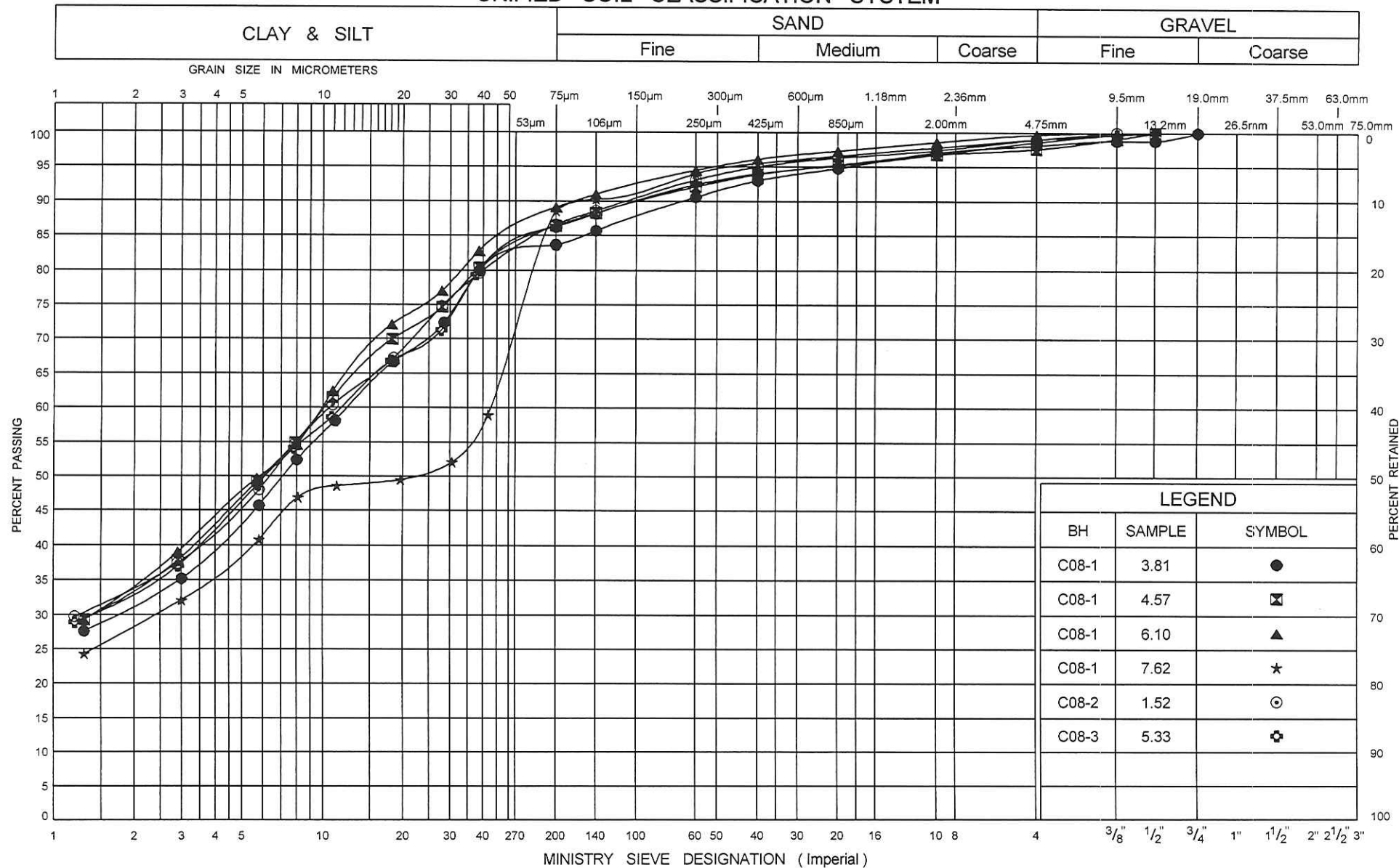
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
198.06 0.00	Ground Surface						198						
	Wet, Organic Topsoil FILL, sandy		1	SS	11								
197.07 0.99			2	SS	12		197						
	Brown		3	SS	25								
			4	SS	23		196						
			5	SS	20		195						
			6	SS	23		194						
	Moist, Silty CLAY with embedded sand and gravel (TILL)		7	SS	14		193						
	Grey		8	SS	15		192						
			9	SS	15		191						
			10	SS	16		190						
			11	SS	15		189						
189.98 8.08	End of Borehole. Borehole dry and open at completion.						189						

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, ×³: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

FIG No 8.1

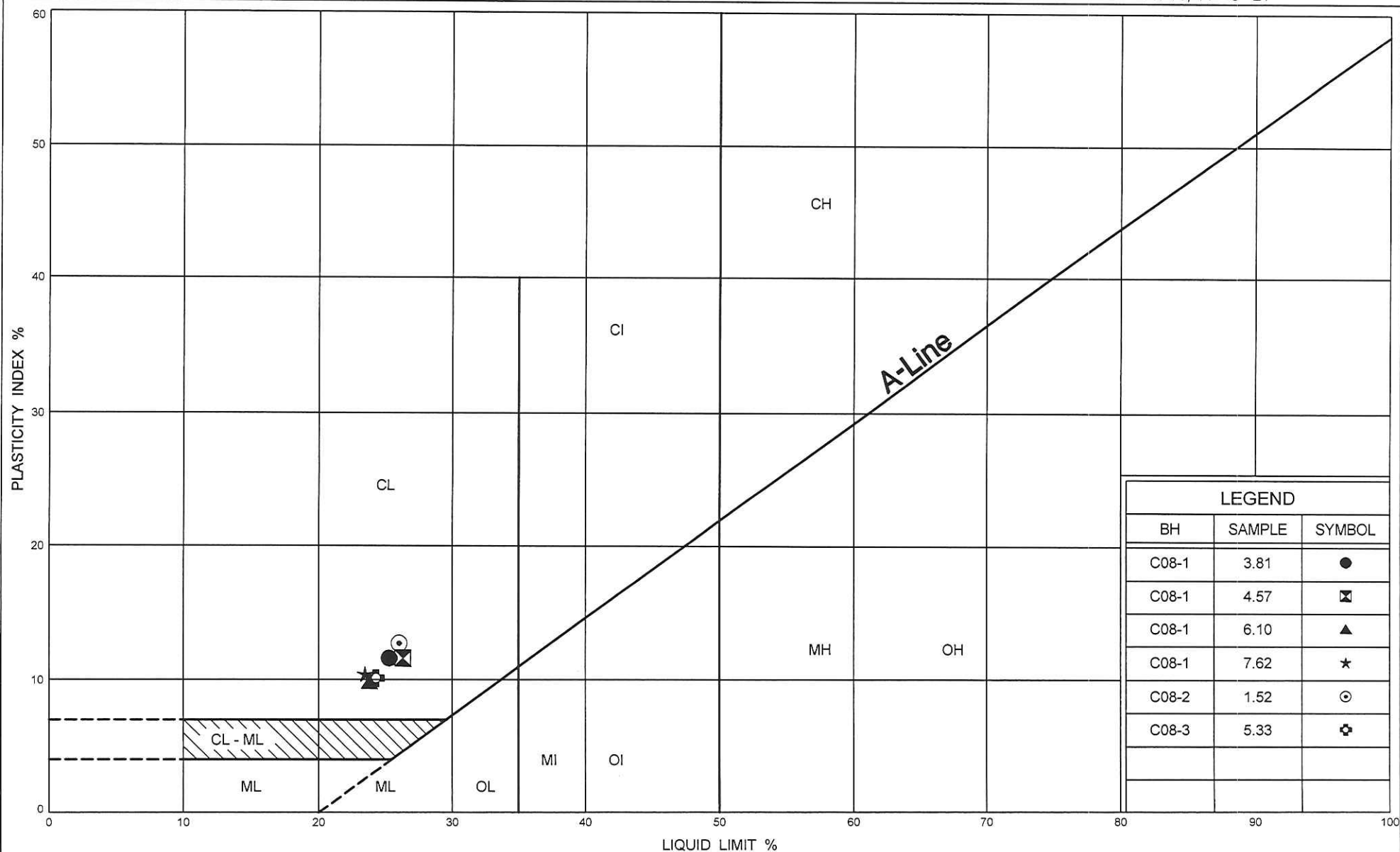
G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations



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PLASTICITY CHART

FIG No 8.2

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

Appendix 5

Data for Culvert 9, Structure 12-436-C

Borehole Locations and Soil Data	Drawing C9.1
Record of Borehole Sheets	Boreholes C09-1 to C09-3
Laboratory Test Results	
Grain Size Distribution	Figure 9.1
Plasticity Chart	Figure 9.2

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

CONT No xxxx-xxxx
WP No 3097-03-00

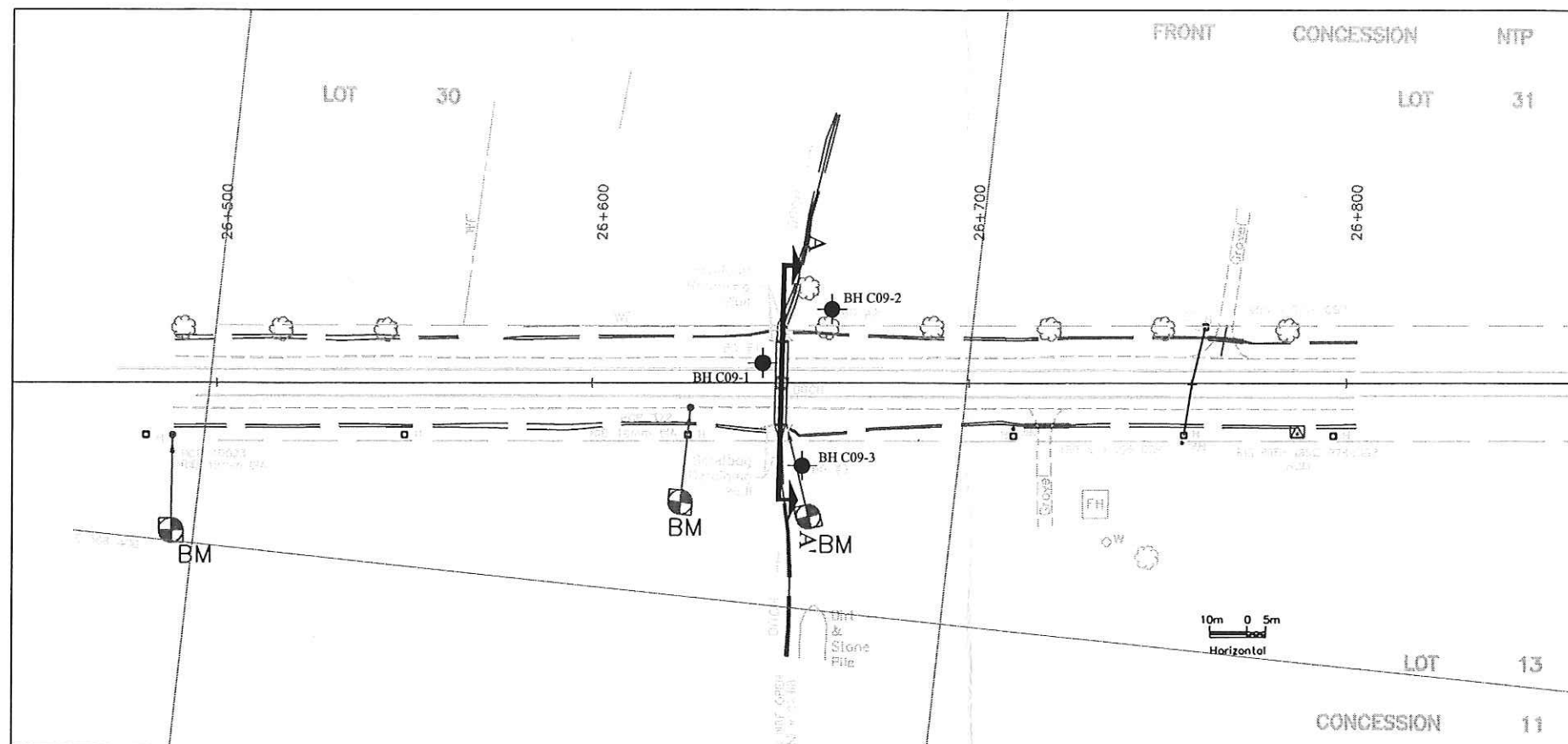


Culvert #9 - Drennan Drain Works
Highway 21

SHEET
1

BORE HOLE LOCATIONS & SOIL STRATA

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

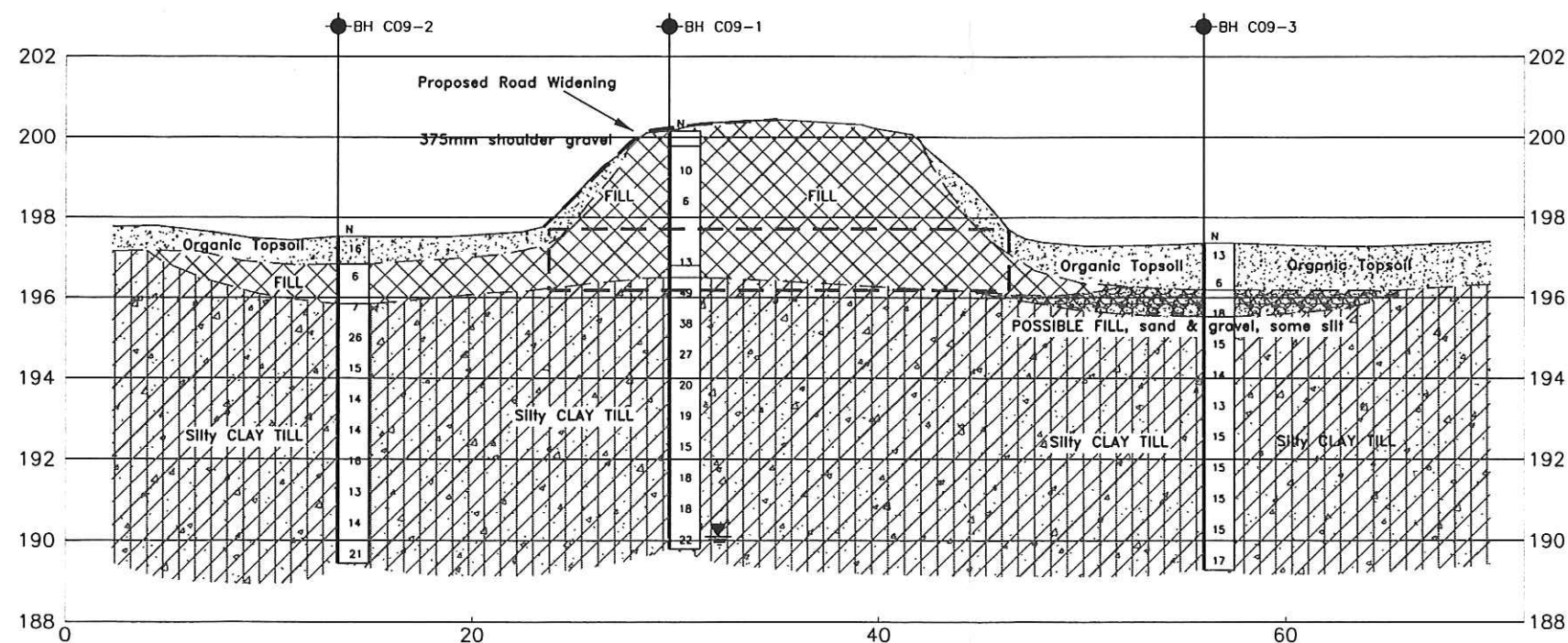


LEGEND

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

No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
C09-1	200.16	4872545.567	368335.487
C09-2	197.52	4872562.412	368319.250
C09-3	197.36	4872559.045	368361.739

NOTE:
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.



NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC2.01 of OPS Gen. Cond.

REVISIONS	DATE	BY	DISCRIPTION
08/12/04	AL	Draft	
Geocres : 41A-179			
HWY No.	HWY 21	DIST	Owen Sound
SUBM'D AL	CHECKED J.L.	DATE August 19, 2004	SITE 12-536-C
DRAWN AL	CHECKED J.L.	APPROVED E.C.	DWG C9.1

RECORD OF BOREHOLE No C09-1

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 26+645.2, OFFSET -5.4 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.16.04 - 6.16.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	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
200.16	Ground Surface						20	40	60	80	100					GR SA SI CL	
0.00																	
199.78	380mm shoulder gravel																
0.38																	
	Brown, wet, loose to compact, FILL, consisting of silty clay, trace to some organics		1	SS	10												
			2	SS	6												
	300mm Organic silt layer		3	SS	13												
196.50																	
3.66																	
	Brown	Hard	4	SS	49						225+			23.0	1 11 55 33 (88)		
			5	SS	38					150							
			6	SS	27					175				21.1	2 11 55 33 (88)		
			7	SS	20						100			21.5	2 11 54 33 (87)		
			8	SS	19												
	Moist, Silty CLAY with embedded sand and gravel (TILL)	V. Stiff	9	SS	15						75						
			10	SS	18					50				20.9	1 11 53 35 (88)		
			11	SS	18					62.5							
	Grey		12	SS	22												
189.80																	
10.36	End of Borehole. Water level measured at 10.1m at completion of drilling.																

JOE MTO FINAL 04-5-IEG3.GPI ONTARIO MOT.GDT 12/2/04

RECORD OF BOREHOLE No C09-2

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 26+663.7, OFFSET -19.7 ORIGINATED BY RB
DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
DATUM Geodetic DATE 7.8.04 - 7.8.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L		
197.52 0.00	Ground Surface													
196.83 0.69	Moist, Organic Topsoil FILL		1	SS	16		197							
195.84 1.68	Dark brown, moist to wet, loose, FILL, consisting of silt, some clay, trace organics		2	SS	6		196							
			3	SS	7		195							
	Brown	Firm	4	SS	26		194							
		V. Stiff	5	SS	15		193							
			6	SS	14		192							
	Moist, Silty CLAY with embedded sand and gravel (TILL)		7	SS	14		191							
	Grey	Stiff to V. Stiff	8	SS	16		190							
			9	SS	13									
			10	SS	14									
			11	SS	21									
189.44 8.08	End of Borehole. Borehole dry and open at completion.													

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, ×³: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C09-3

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 26+655.8, OFFSET 22.2 ORIGINATED BY RB
DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
DATUM Geodetic DATE 7.8.04 - 7.8.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
197.36 0.00	Ground Surface												
	Moist to wet, Organic Topsoil FILL		1	SS	13		197				o		
196.19 1.17			2	SS	6							o	
	Brown, wet, loose, POSSIBLE FILL, consisting sand and gravel, some silt						196						
195.53 1.83			3	SS	18						o		
		V. Stiff	4	SS	15		195				o		
			5	SS	14		194		112.5		o		
			6	SS	13		193		62.5		o		
			7	SS	15		192		75		o		
	Brown changing to grey, moist, Silty CLAY with embedded sand and gravel (TILL)	Stiff to V. Stiff	8	SS	15		191		50		o		1 10 57 33 (90)
			9	SS	15		190		50		o		
			10	SS	15				37.5		o		
			11	SS	17				62.5		o		
189.28 8.08	End of Borehole. Borehole dry and open at completion.												

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, X³: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

Appendix 6

Data for Culvert 10, Structure 12-443-C

Borehole Locations and Soil Data	Drawing C10.1
Record of Borehole Sheets	Boreholes C10-1 to C10-3
Laboratory Test Results	
Grain Size Distribution	Figures 10.1 to 10.2
Plasticity Chart	Figures 10.3 to 10.4

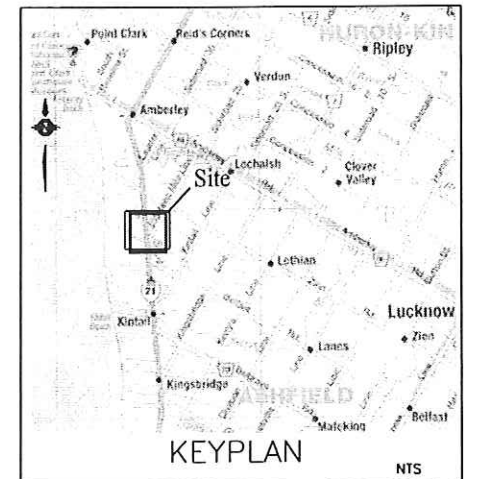
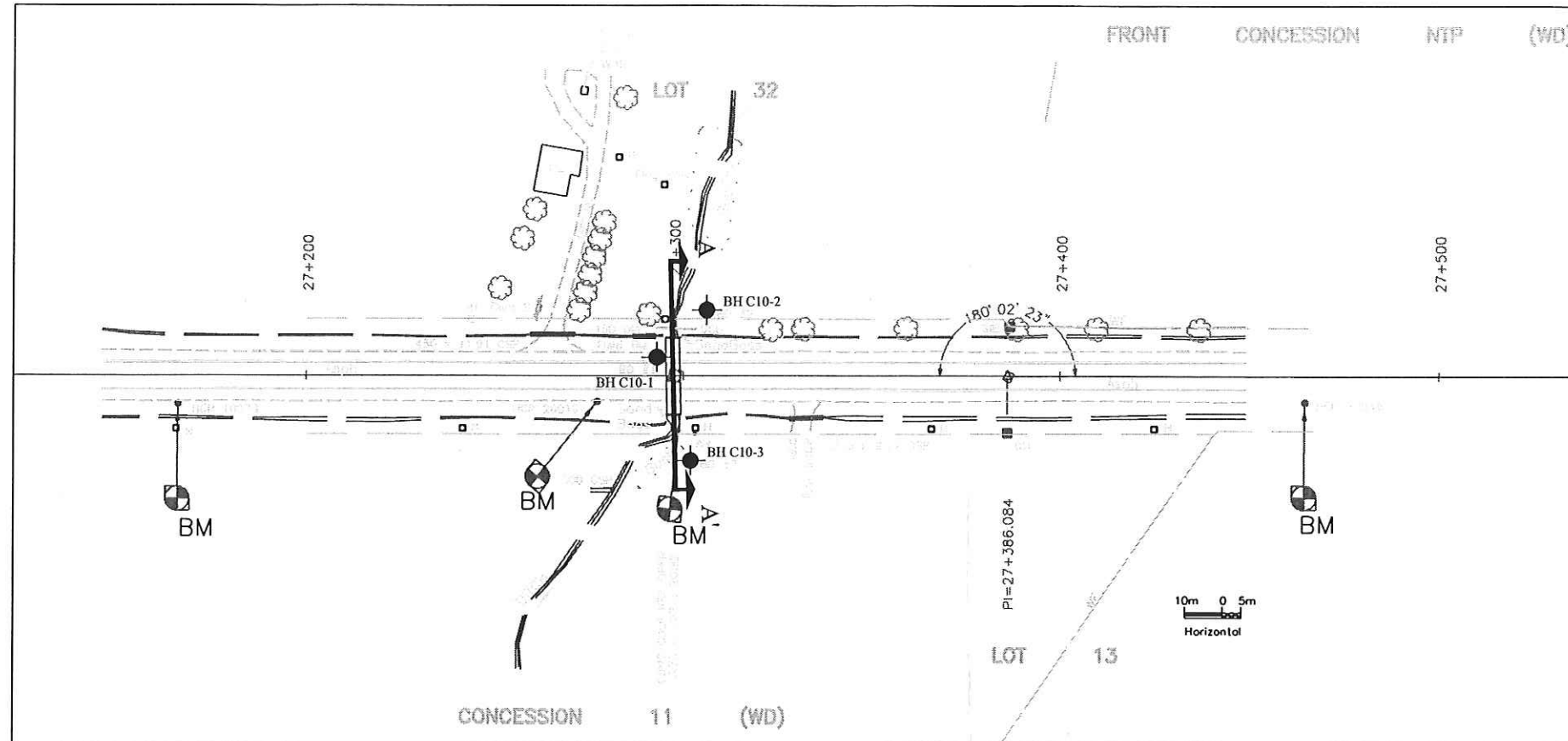
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No xxxx-xxxx
WP No 3097-03-00



Culvert #10 - MacIntyre Drain
Highway 21
BORE HOLE LOCATIONS & SOIL STRATA
I.E. Group Infrastructure Engineering Group Inc.
Pavement & Construction Materials Consulting Engineers
GTA • Kitchener • London • Windsor

SHEET
1

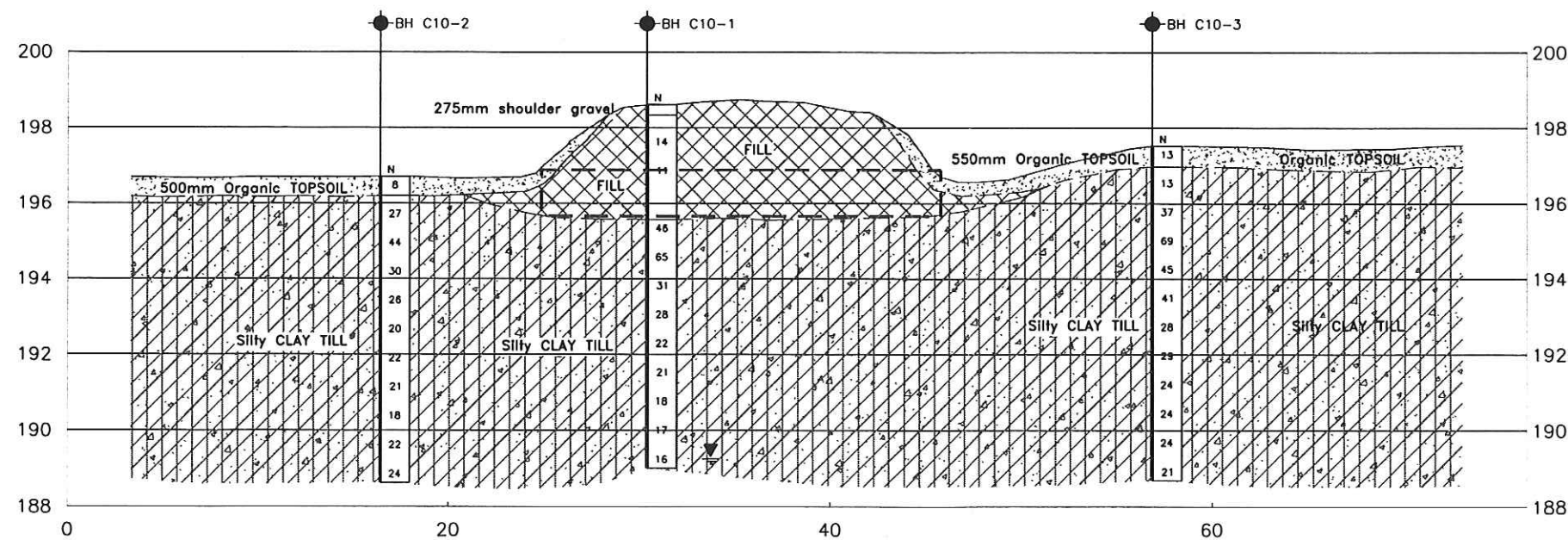


LEGEND

- 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

No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
C10-1	198.62	4873189.634	368265.792
C10-2	196.71	4873201.455	368251.855
C10-3	197.53	4873201.545	368292.286

NOTE
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.



BH C10-1 is brought into the view of section A-A'

SECTION A-A'



NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC2.01 of OPS Gen. Cond.

REVISIONS			
	08/12/04	AL	Draft
	DATE	BY	DISCUPTION
	Geocres : 41A-179		
HWY No.		HWY 21	DIST Owen Sound
SUBM'D AL	CHECKED J.L.	DATE August 19, 2004	SITE 12-443-C
DRAWN AL	CHECKED J.L.	APPROVED E.C.	DWG C10.1

RECORD OF BOREHOLE No C10-1

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 27+292.9, OFFSET -4.9 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.16.04 - 6.16.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ 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 (%)
								20 40 60 80 100							
								20 40 60 80 100							
198.62	Ground Surface														
0.00															
198.34	280mm shoulder gravel														
0.28															
			1	SS	14		198						19.5	2 20 48 30 (78)	
	Brown, wet, compact, FILL, consisting of layers of silty clay with trace to some organics and sandy silt		2	SS	11		197								
							196								
195.57			3	SS	46		195			225+			22.8	1 13 55 31 (86)	
3.05	Brown		4	SS	65		194			225+				1 12 55 33 (87)	
		Hard	5	SS	31		193			212.5			23.4	2 10 55 32 (88)	
			6	SS	28		192			100					
	Moist, Silty CLAY with embedded sand and gravel (TILL)		7	SS	22		191			75			21.6	3 13 43 41 (84)	
			8	SS	21		190			62.5					
	Grey		9	SS	18					62.5			19.4	2 10 58 30 (89)	
		V. Stiff	10	SS	17					50					
			11	SS	16					50					
189.02	End of Borehole. Water level measured at 9.3m at completion of drilling.														
9.60															

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/5/04

+ 3, X 3: Numbers refer to
Sensitivity





○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C10-2

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 27+306.2, OFFSET -17.6 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.29.04 - 6.29.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		w _p	w	w _L		
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL x LAB VANE					
196.71 0.00	Ground Surface							20 40 60 80 100						
196.20 0.51	510mm Organic TOPSOIL		1	SS	8							46.6		
	Brown		2	SS	27					225+				
			3	SS	44					225+				
			4	SS	30					225+				
			5	SS	26					175				
			6	SS	20					112.5				
	Moist, Silty CLAY with embedded sand and gravel (TILL)		7	SS	22					100				
			8	SS	21					75				
			9	SS	18									
			10	SS	22					75				
			11	SS	24					75				
188.63 8.08	End of Borehole. Borehole dry and open at completion.													

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+3, x3: Numbers refer to Sensitivity

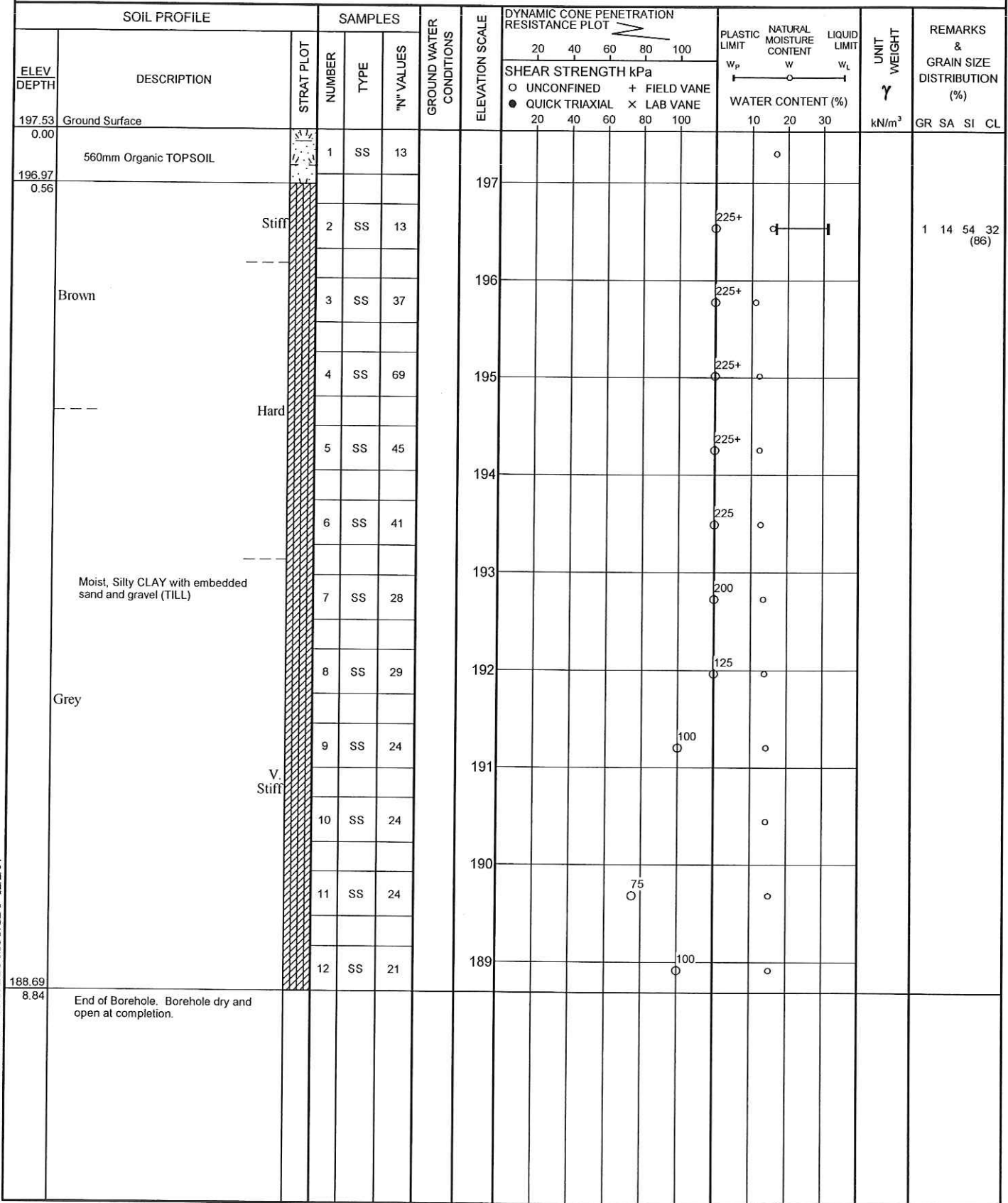
○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C10-3

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 27+301.9, OFFSET 22.6 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.29.04 - 6.29.04 CHECKED BY EC

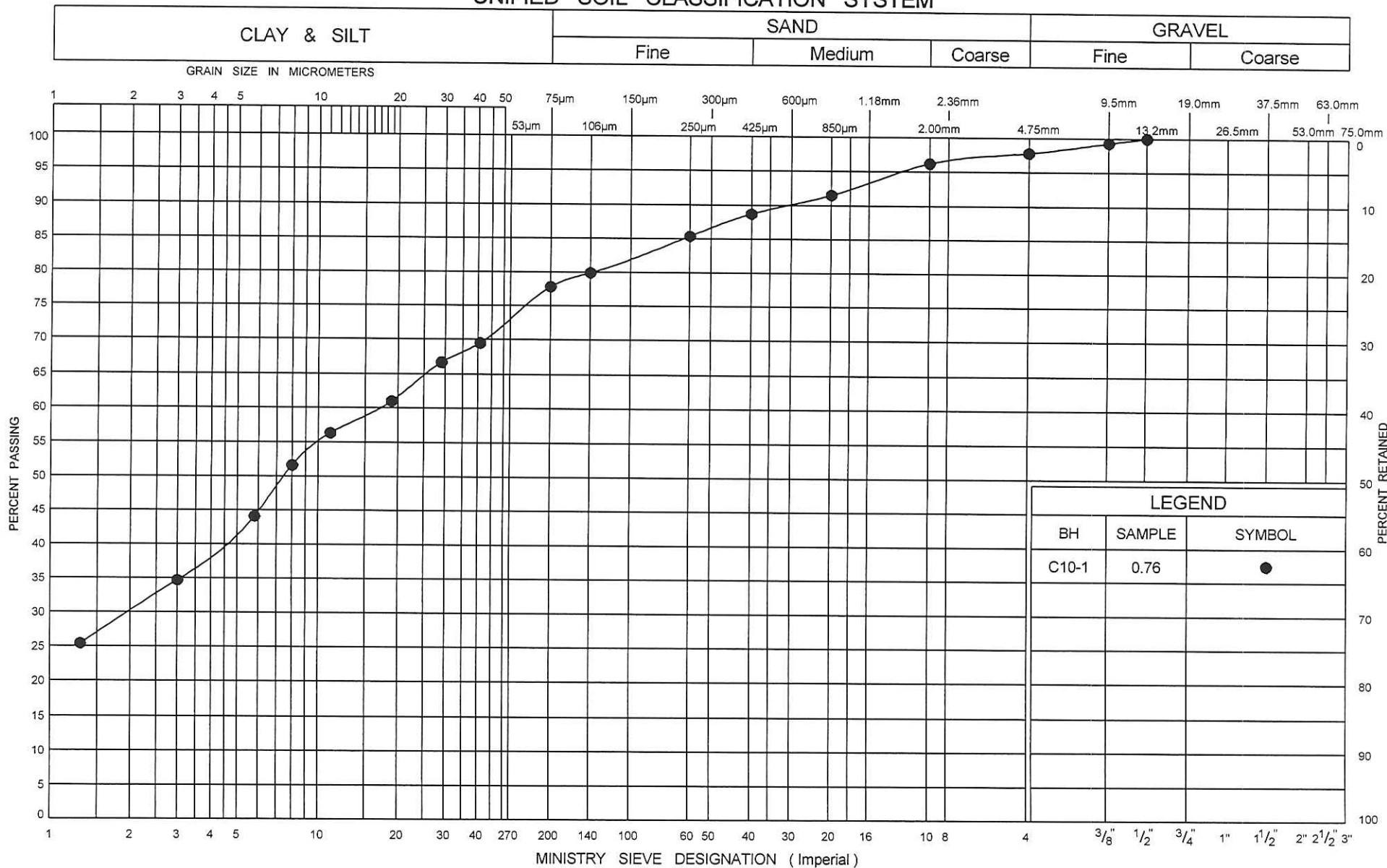


JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT GDT 12/2/04

+ 3, X 3: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

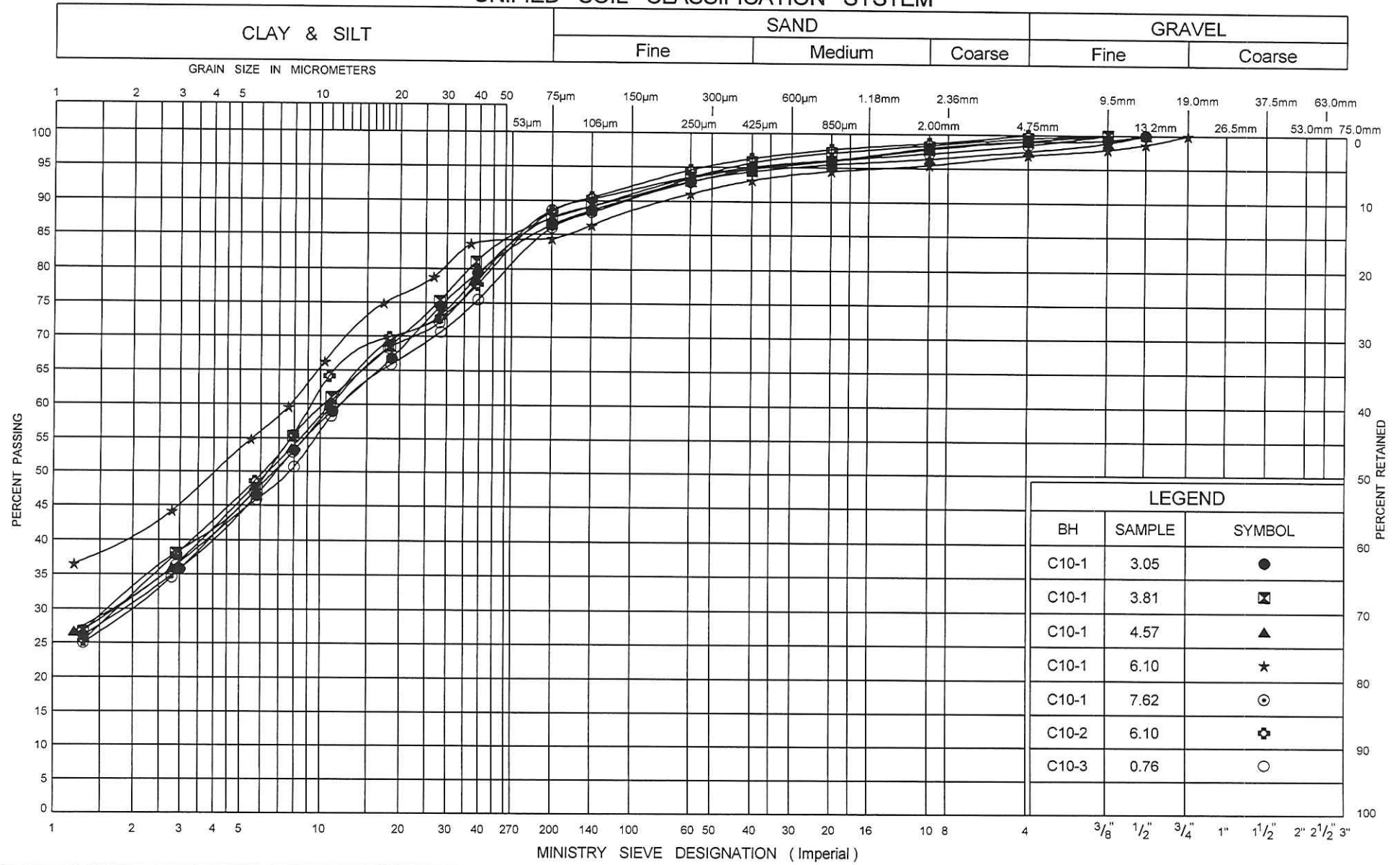
GRAIN SIZE DISTRIBUTION

FIG No 10.1

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

UNIFIED SOIL CLASSIFICATION SYSTEM



ONTARIO MOT GRAIN SIZE 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/4/04

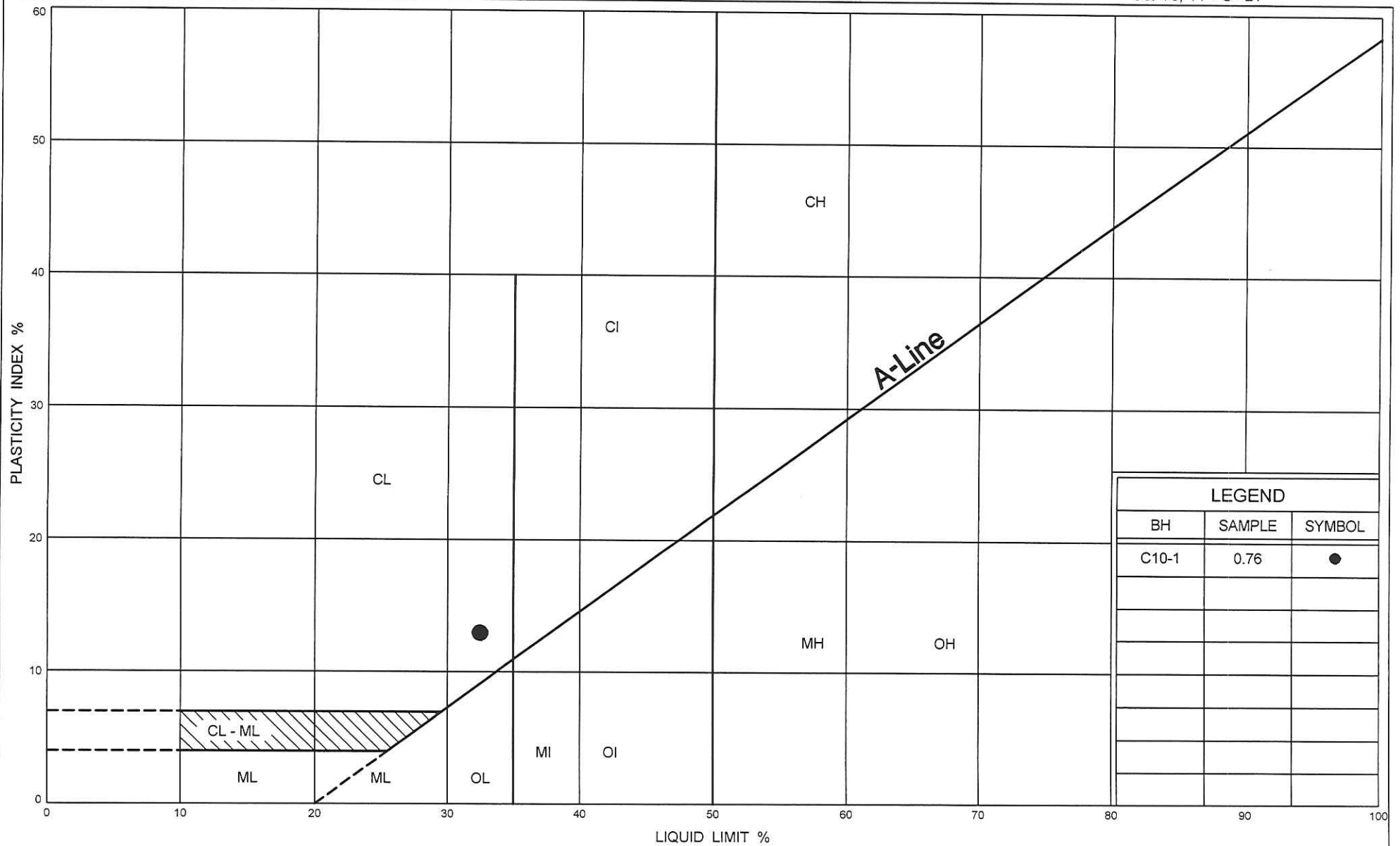


GRAIN SIZE DISTRIBUTION

FIG No 10.2

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations



PLASTICITY CHART

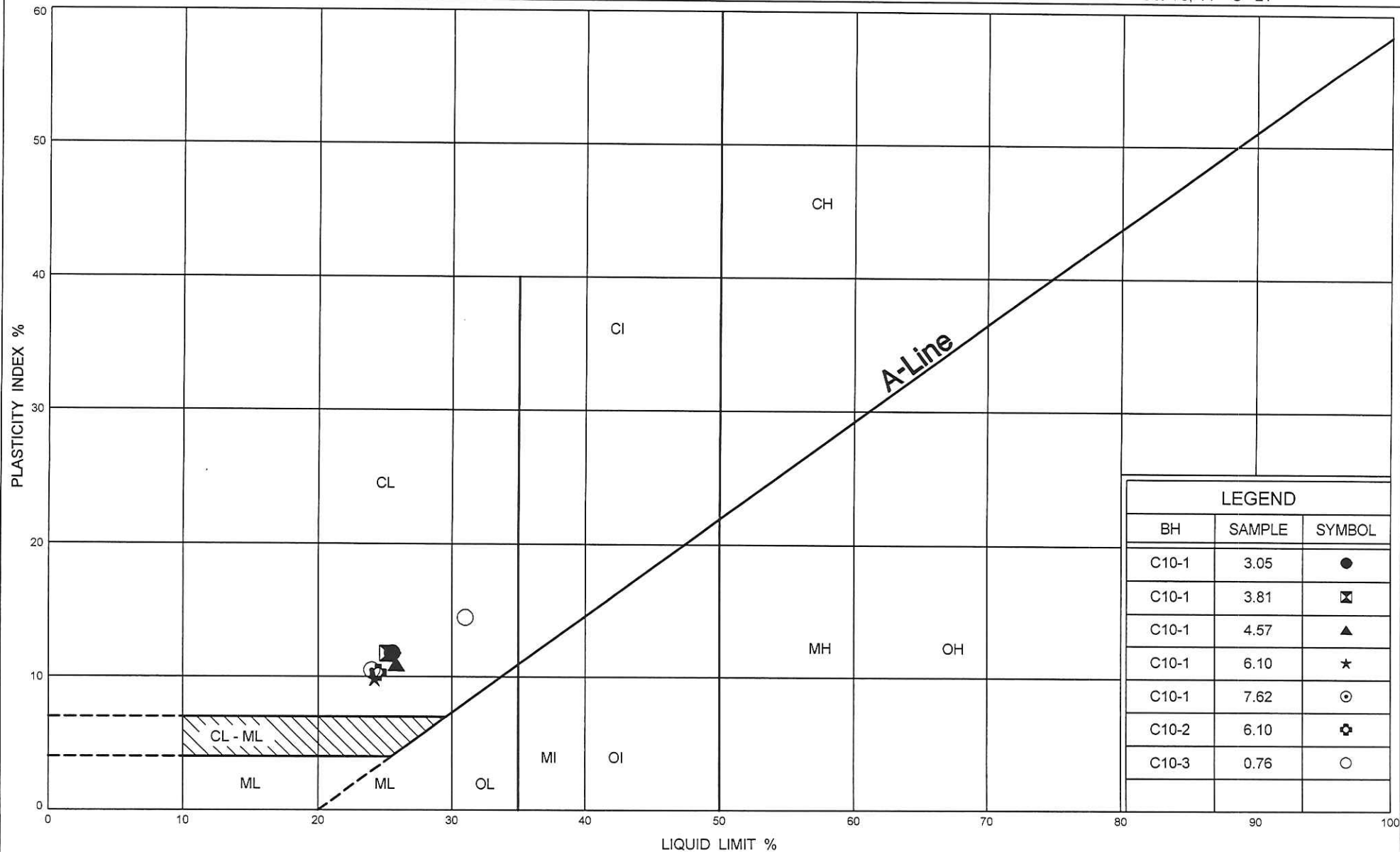
FIG No 10.3

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations



Ministry of
Transportation
Ontario



Ministry of
Transportation

PLASTICITY CHART

FIG No 10.4

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

Appendix 7

Data for Culvert 11, Structure 12-444-C

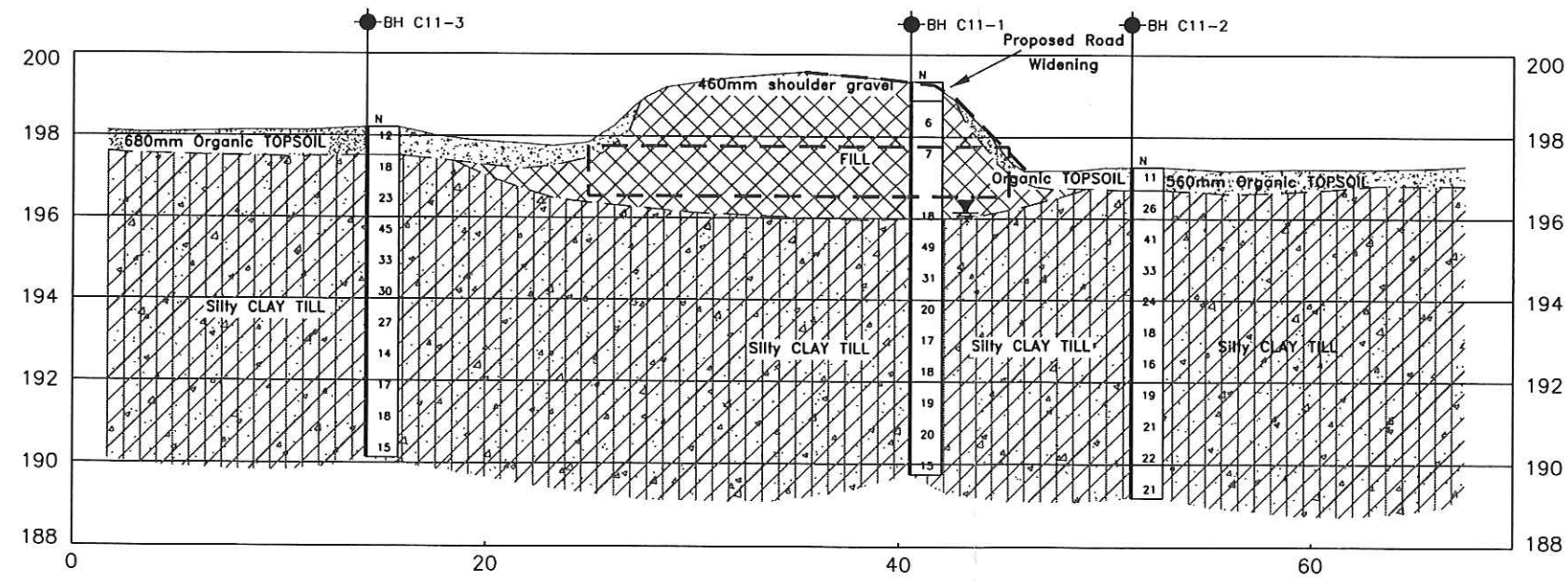
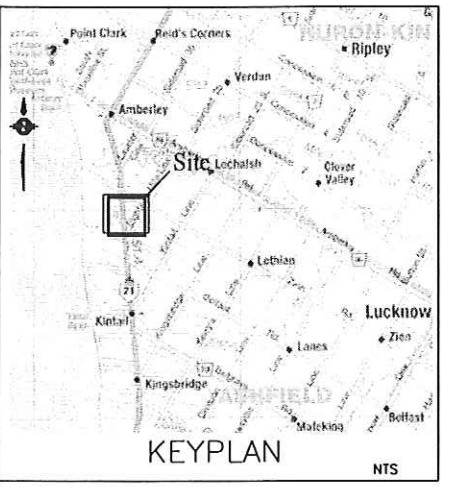
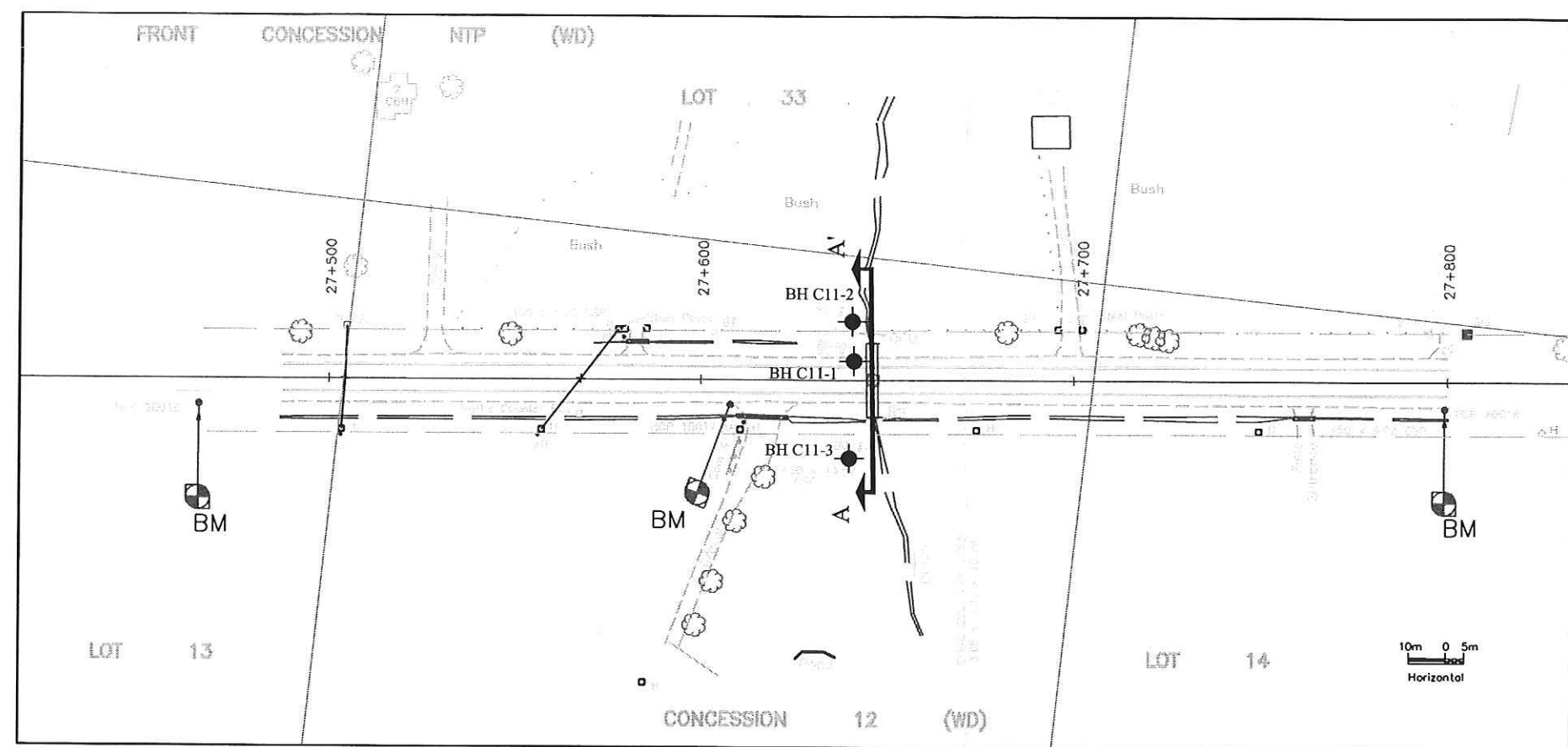
Borehole Locations and Soil Data	Drawing C11.1
Record of Borehole Sheets	Boreholes C11-1 to C11-3
Laboratory Test Results	
Grain Size Distribution	Figures 11.1 to 11.2
Plasticity Chart	Figures 11.3 to 11.4

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

CONT No XXXX-XXXX
WP No 3097-03-00



Culvert #11-Cowan Drain Works
Highway 21
BORE HOLE LOCATIONS & SOIL STRATA
I.E. Infrastructure Engineering Group Inc.
Pavement & Construction Materials Consulting Engineers
GTA • Kitchener • London • Windsor



LEGEND

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

No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
C11-1	199.34	4873535.252	368228.169
C11-2	197.26	4873533.751	368217.516
C11-3	198.21	4873536.901	368254.461

NOTE: The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC2.01 of OPS Gen. Cond.

REVISIONS			
	08/12/04	AL	Draft
	DATE	BY	DISCRIPTION
Geocres : 41A-179			
HWY No.		HWY 21	
DIST		Owen Sound	
SUBM'D	AL	CHECKED J.L.	DATE August 19, 2004
SITE		12-444-C	
DRAWN	AL	CHECKED J.L.	APPROVED E.C.
DWG		C11.1	

RECORD OF BOREHOLE No C11-1

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 27+640.6, OFFSET -5.1 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.15.04 - 6.15.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa														
								UNCONFINED + FIELD VANE														
								QUICK TRIAXIAL x LAB VANE														
							20	40	60	80	100	10	20	30	GR	SA	SI	CL				
199.34 0.00	Ground Surface						199															
198.88 0.46	460mm shoulder gravel						198															
	Brown, dry to wet, loose, FILL, consisting of silty clay, trace to some organics		1	SS	6												20.4	4	14	58	24 (81)	
			2	SS	7																	
							197															
195.99 3.35			3	SS	18		196										22.6	7	13	42	38 (80)	
	Brown	Hard	4	SS	49		195											2	13	53	32 (85)	
			5	SS	31		194											21.5	3	12	44	41 (85)
			6	SS	20		193															
	Moist, Silty CLAY with embedded sand and gravel (TILL)	V. Stiff	7	SS	17		192															
			8	SS	18		191															
			9	SS	19		190															
	Grey		10	SS	20																	
			11	SS	15																	
189.74 9.60	End of Borehole. Water level measured at 3.2m at completion of drilling.																					

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+3, X3: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C11-2

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA27+640.3, OFFSET -15.8 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.28.04 - 6.29.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ 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						
197.26 0.00	Ground Surface						20	40	60	80	100						
196.70 0.56	560mm Organic TOPSOIL		1	SS	11												
		V. Stiff	2	SS	26							225+					
	Brown		3	SS	41							225+					
		Hard	4	SS	33							200					
			5	SS	24							112.5					
			6	SS	18							100					
	Moist, Silty CLAY with embedded sand and gravel (TILL)		7	SS	16							62.5					
		V. Stiff	8	SS	19							62.5					
	Grey		9	SS	21							62.5					
			10	SS	22												
			11	SS	21												
189.18 8.08	End of Borehole. Borehole dry and open at completion.																

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, X³: Numbers refer to
Sensitivity

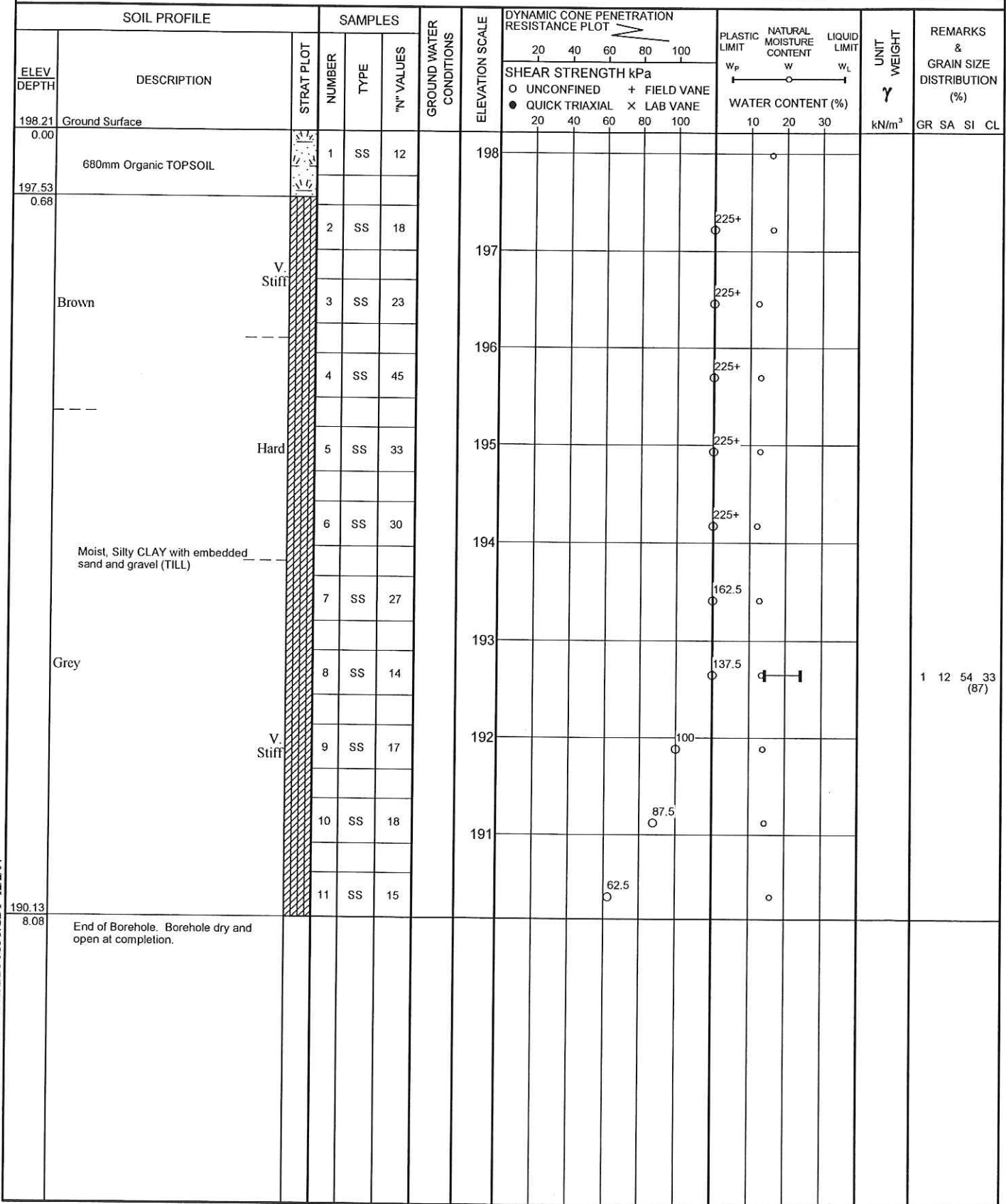
○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C11-3

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 27+639.4, OFFSET 21.3 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.29.04 - 6.29.04 CHECKED BY EC

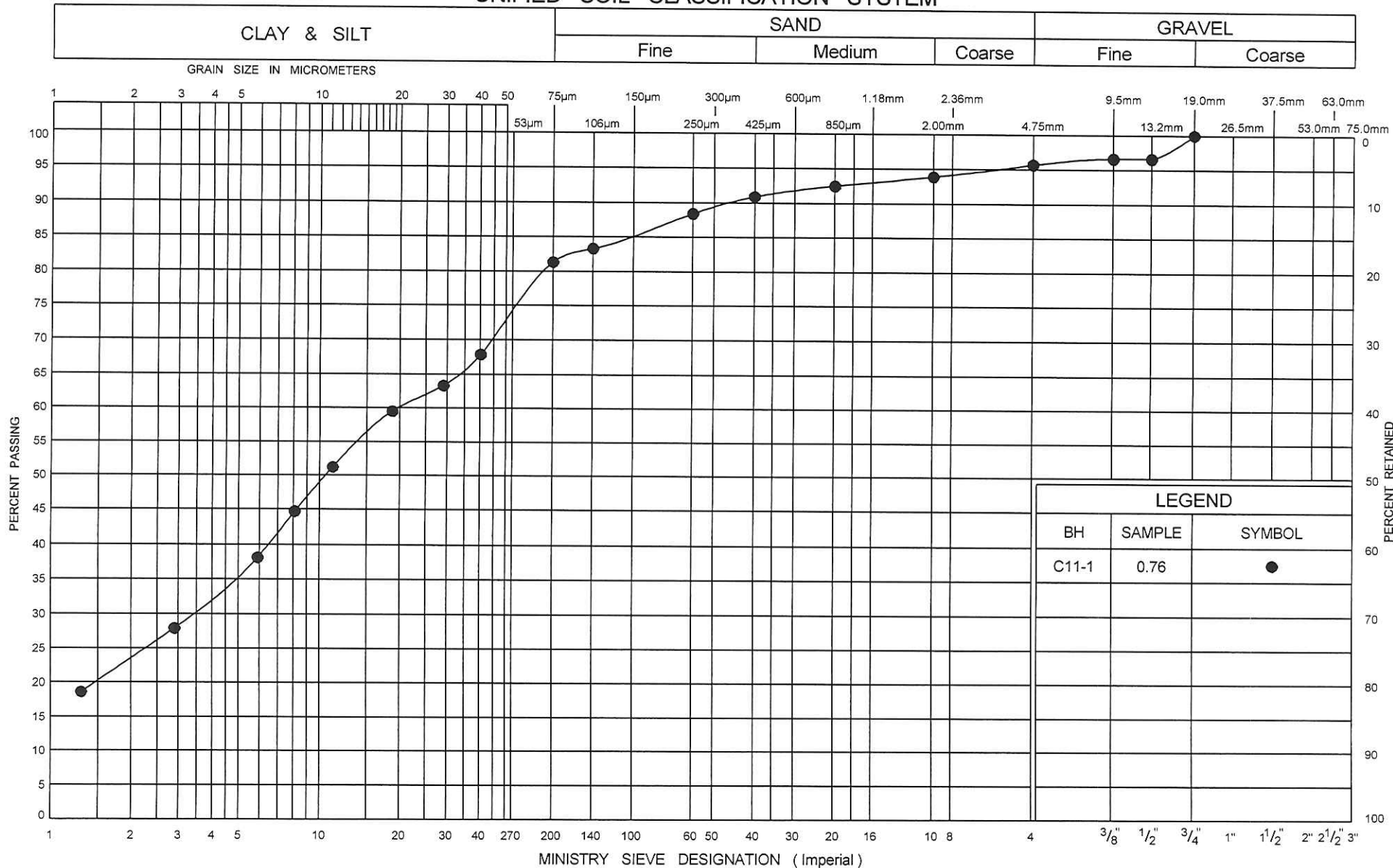


JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, ×³: Numbers refer to Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

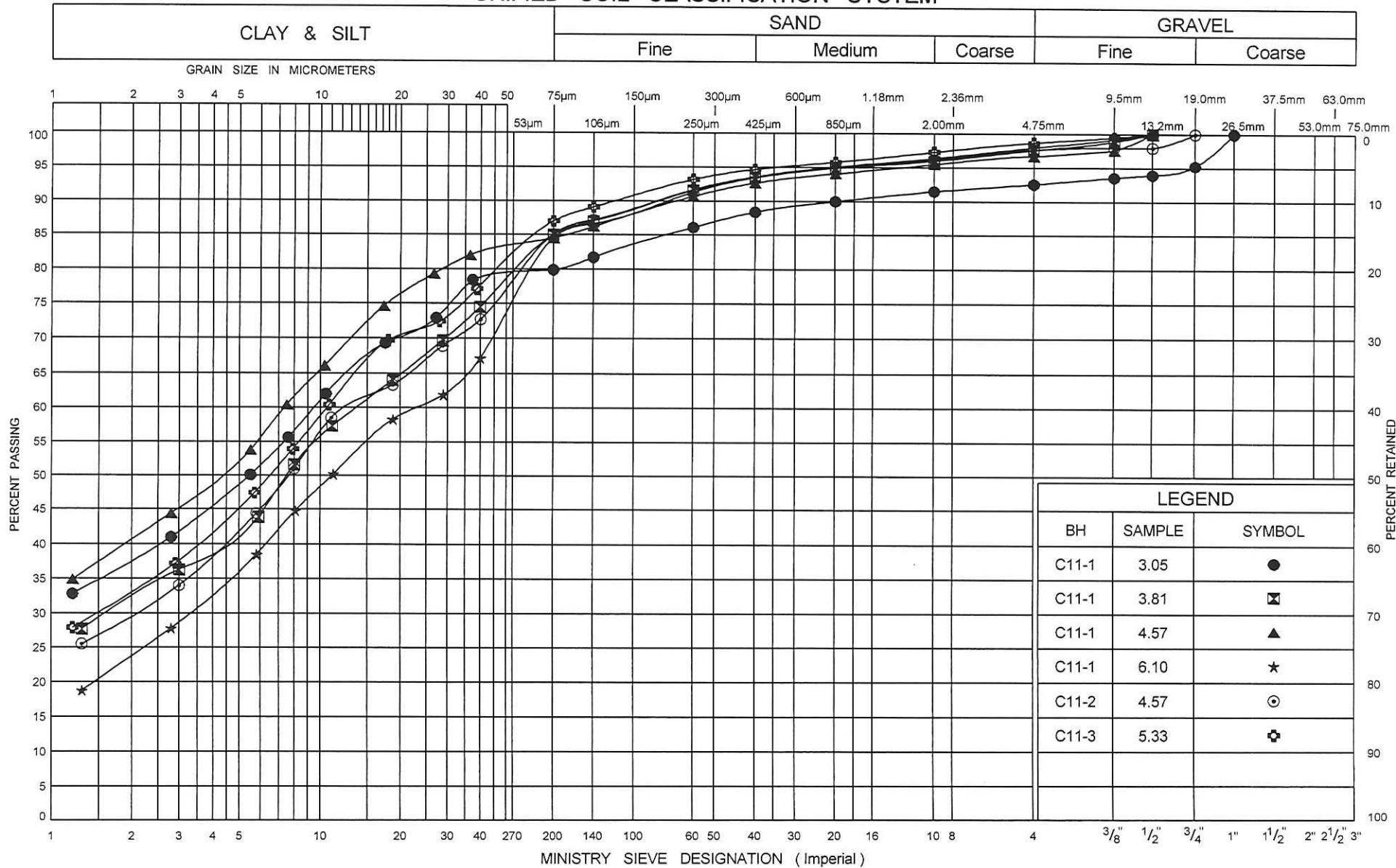
GRAIN SIZE DISTRIBUTION

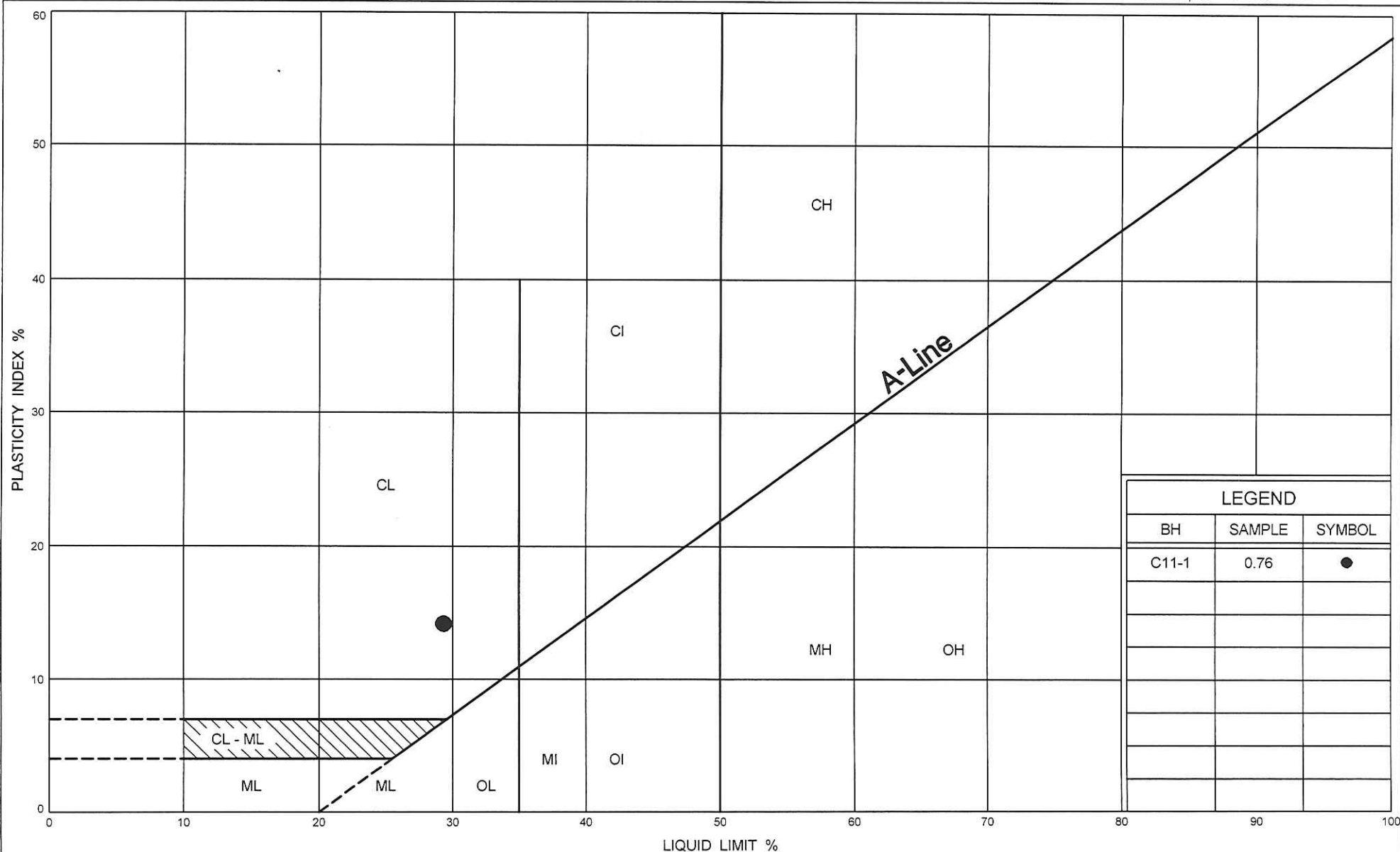
FIG No 11.1

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

UNIFIED SOIL CLASSIFICATION SYSTEM





LEGEND		
BH	SAMPLE	SYMBOL
C11-1	0.76	●



Ministry of
Transportation

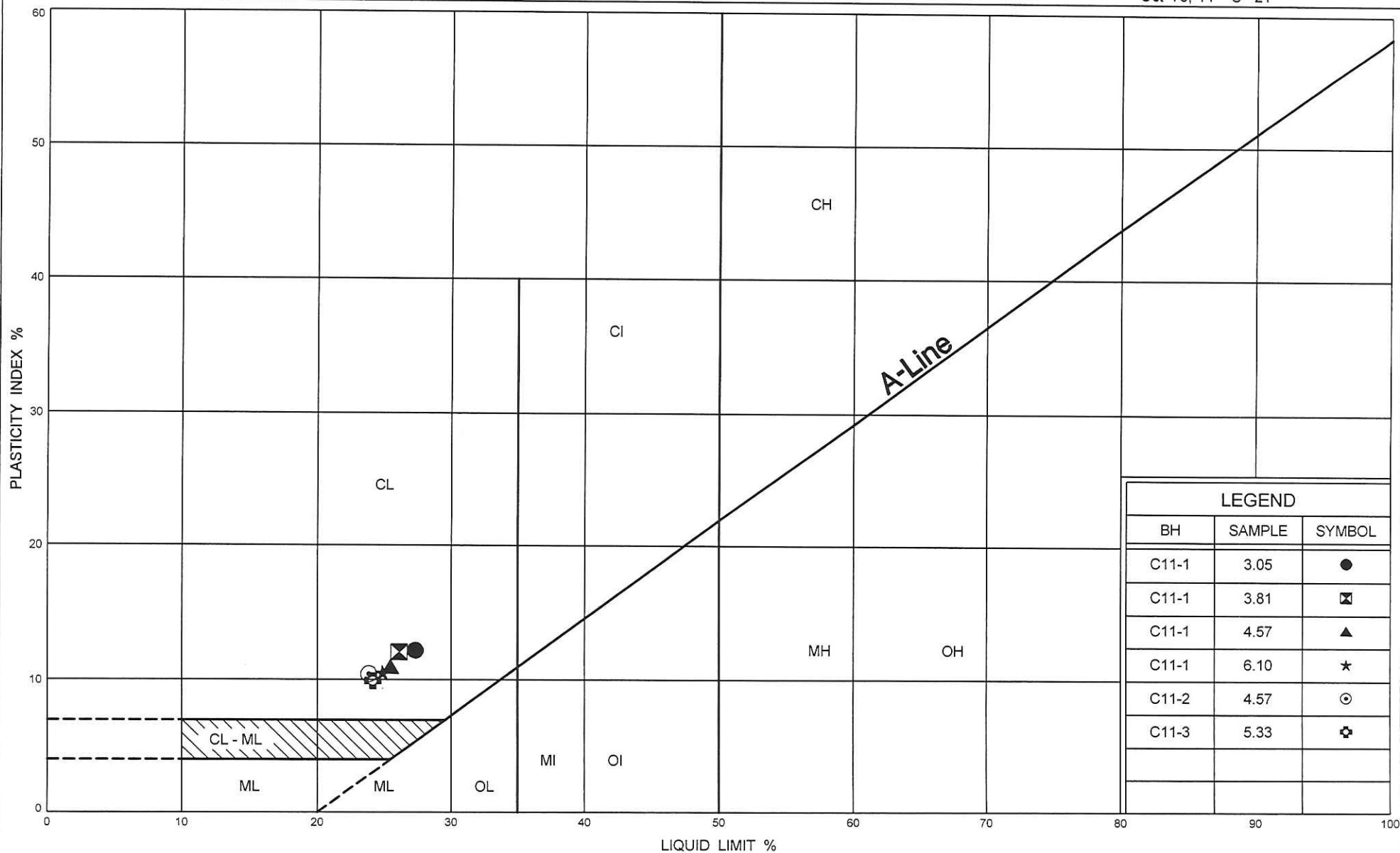
PLASTICITY CHART

FIG No 11.3

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

Oct 75, FF - S - 21



Ministry of
Transportation

PLASTICITY CHART

FIG No 11.4

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

Appendix 8

Data for Culvert 12, Structure 12-445-C

Borehole Locations and Soil Data

Drawing C12.1

Record of Borehole Sheets

Boreholes C12-1 to C12-3

Laboratory Test Results

Grain Size Distribution
Plasticity Chart

Figures 12.1 to 12.2
Figures 12.3 to 12.4

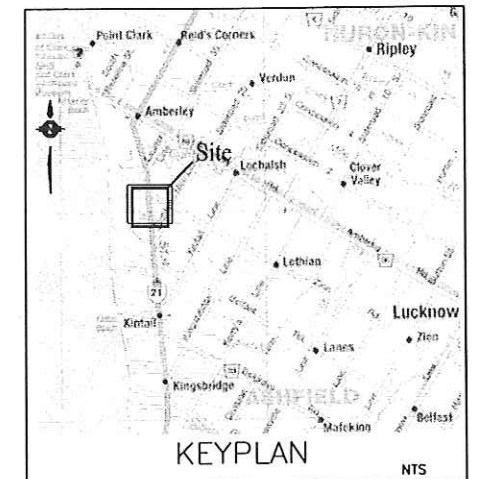
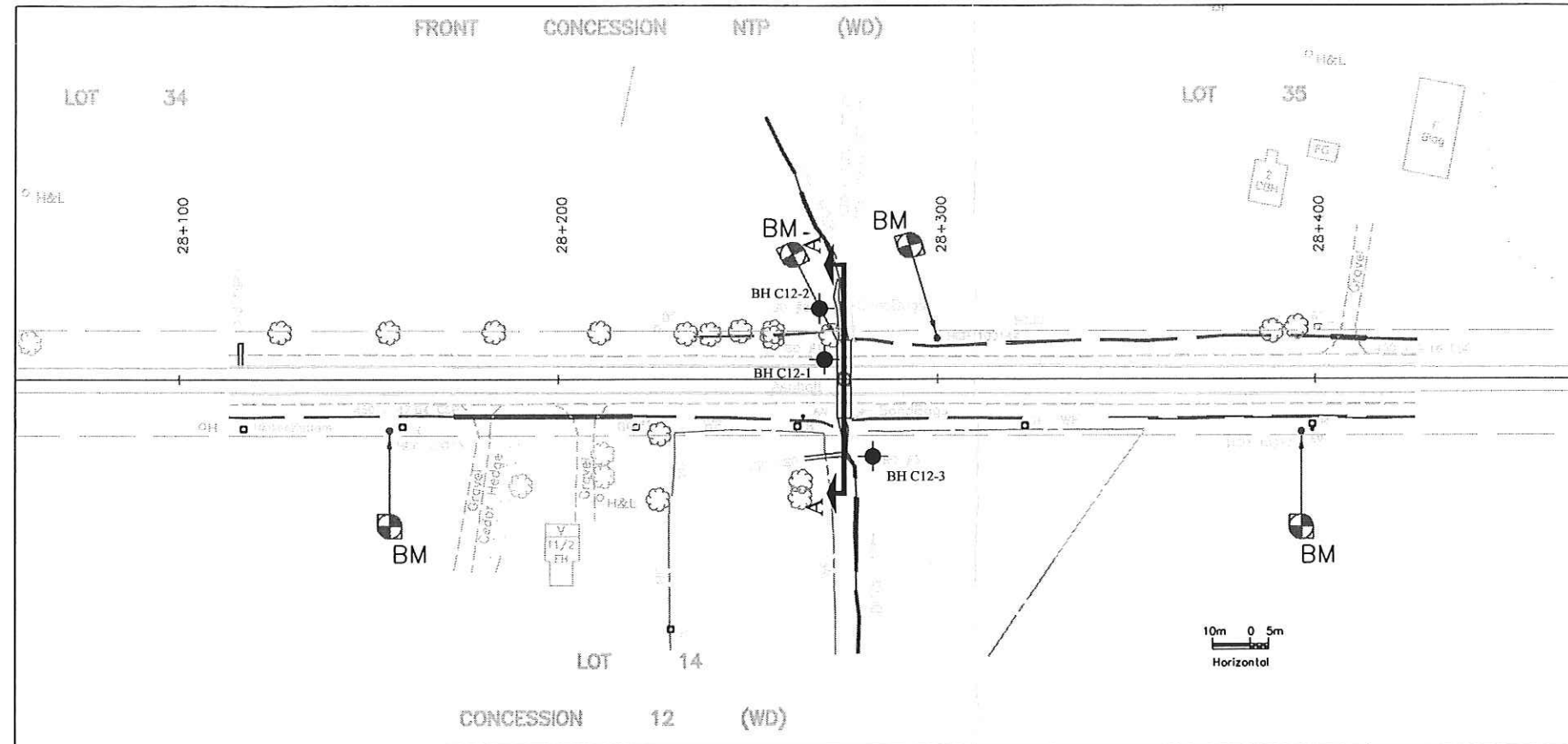
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No xxxx-xxxx
WP No 3097-03-00



Culvert #12-Colling Draine Works
Highway 21
BORE HOLE LOCATIONS & SOIL STRATA
I.E. Infrastructure Engineering Group Inc.
Permeant & Construction Materials Consulting Engineers
Group GTA • Kitchener • London • Windsor

SHEET
1

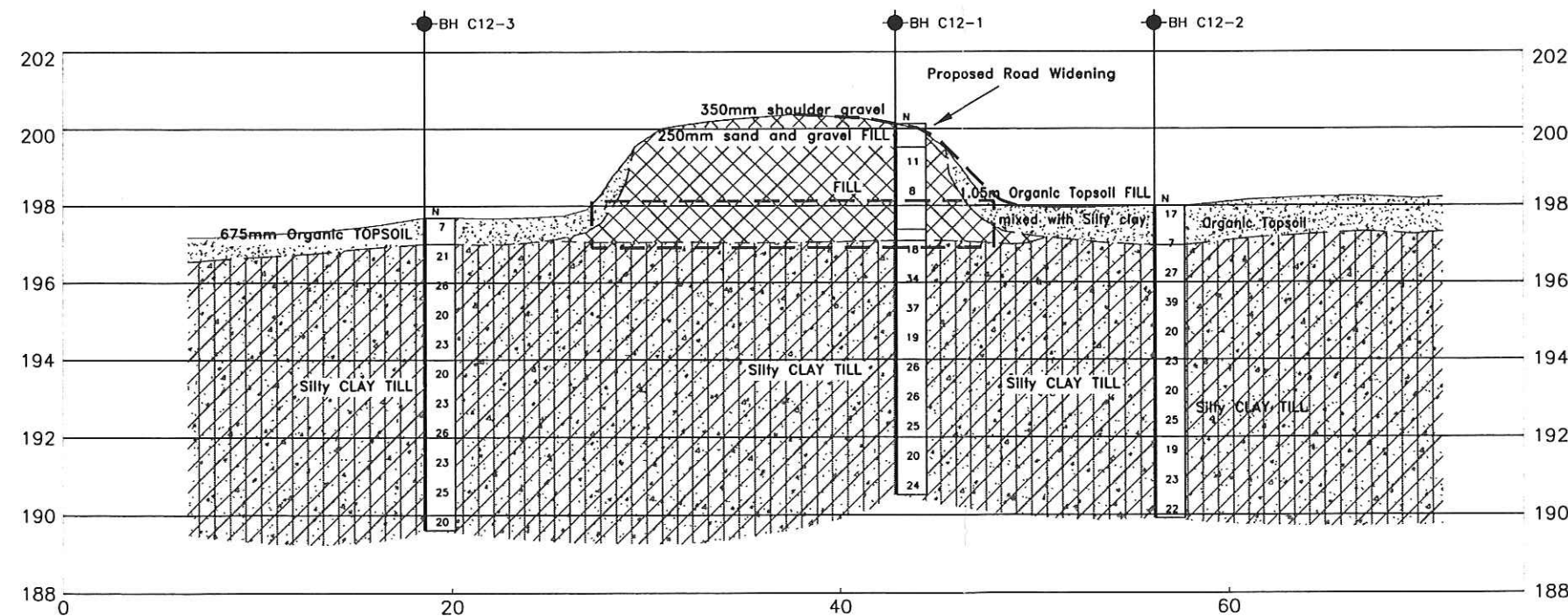


LEGEND

- 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 of time of investigation
- Standpipe

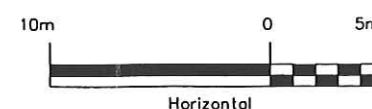
No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
C12-1	200.13	4874161.041	368160.082
C12-2	197.99	4874158.313	368146.762
C12-3	197.69	4874176.492	368184.337

NOTE:
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.



BH C12-3 is brought into the view of section A-A'

SECTION A-A'



NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC2.01 of OPS Gen. Cond.

REVISIONS		DATE		BY		DISCUSSION	
08/12/04		AL		Draft			
Geocres : 41A-179		HWY No.		HWY 21		DIST	
SUBM'D AL		CHECKED J.L.		DATE August 19, 2004		SITE	
DRAWN AL		CHECKED J.L.		APPROVED E.C.		DWG	
						C12.1	

RECORD OF BOREHOLE No C12-1

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 28+270.3, OFFSET -5.2 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.15.04 - 6.15.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED							+ FIELD VANE		
								● QUICK TRIAXIAL							x LAB VANE		WATER CONTENT (%)
200.13	Ground Surface						20	40	60	80	100	10	20	30	GR SA SI CL		
0.00																	
199.52	610mm shoulder gravel & sand and gravel FILL																
0.61																	
			1	SS	11								21.7				
			2	SS	8									0 11 54 34 (88)			

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+3, x3: Numbers refer to Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C12-2

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 28+269.0, OFFSET -18.8 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.28.04 - 6.28.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL			× LAB VANE			
197.99	Ground Surface						20	40	60	80	100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L		
0.00	1.05m, moist, Organic Topsoil FILL mixed with Silty clay		1	SS	17											
196.94			2	SS	7											
1.05	Brown	V. Stiff	3	SS	27							225+				
		Hard	4	SS	39							225+				
	Moist, Silty CLAY with embedded sand and gravel (TILL)		5	SS	20							112.5				
			6	SS	23							137.5				
	Grey		7	SS	20							100				
		V. Stiff	8	SS	25											3 12 53 32 (85)
			9	SS	19											8 12 49 31 (80)
			10	SS	23							87.5				
			11	SS	22											0 14 53 33 (86)
189.91	End of Borehole. Borehole dry and open at completion.															
8.08																

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO.MOT.GDT 12/2/04

+³, ×³: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C12-3

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 28+283.0, OFFSET 20.6 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.28.04 - 6.28.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ 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											
197.69	Ground Surface						20	40	60	80	100								
0.00	680mm Organic TOPSOIL		1	SS	7														
197.01																			
0.68	Brown		2	SS	21														
			3	SS	26														
			4	SS	20														
			5	SS	23														
			6	SS	20														
	Moist, Very Stiff, Silty CLAY with embedded sand and gravel (TILL)																		
	Grey		7	SS	23														
			8	SS	26														
			9	SS	23														
			10	SS	25														
			11	SS	20														
189.61																			
8.08	End of Borehole. Borehole dry and open at completion.															4 13 51 32 (84)			

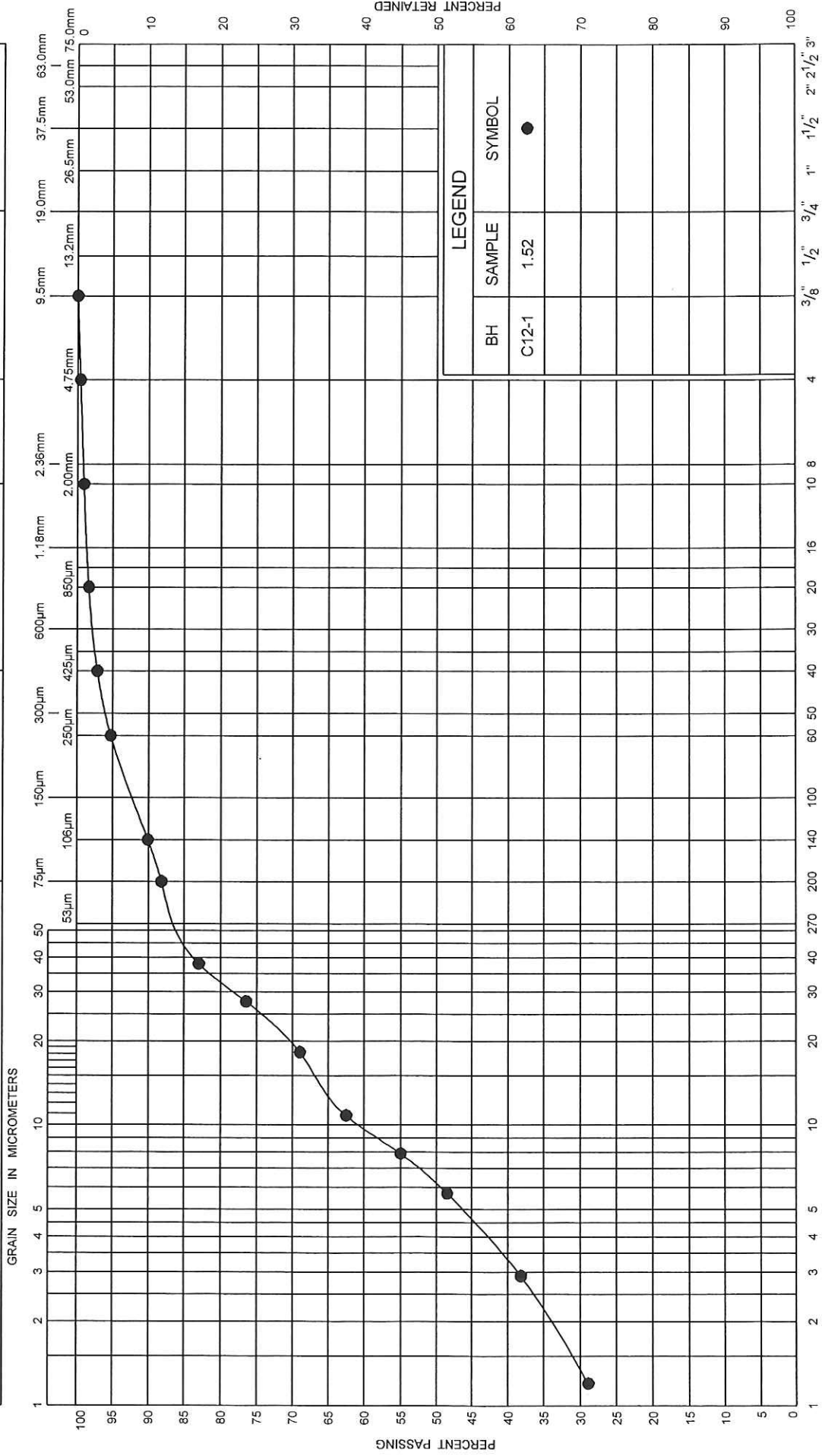
JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, x³: Numbers refer to Sensitivity

○¹⁵⁰ UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	Coarse

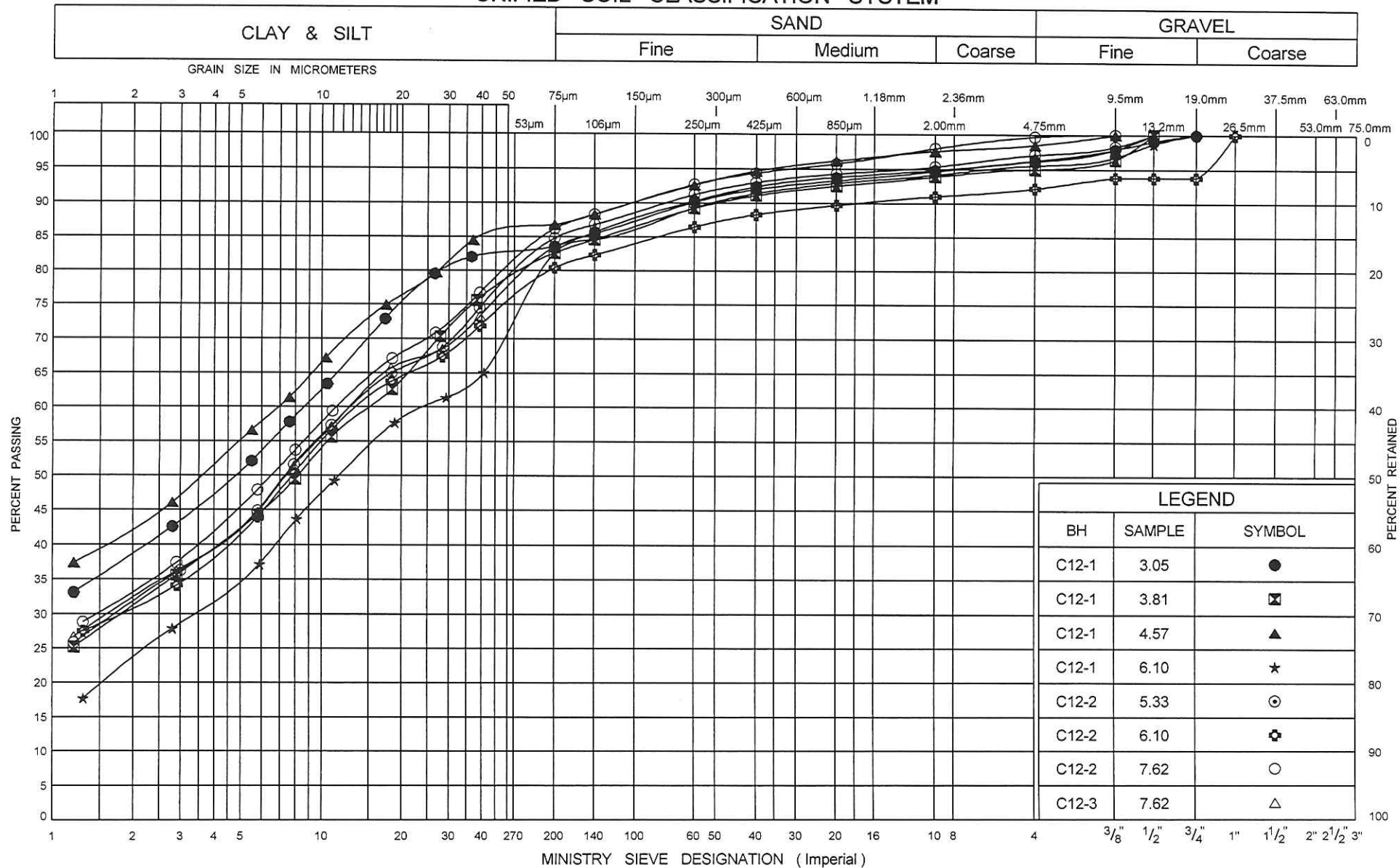


LEGEND

BH	SAMPLE	SYMBOL
C12-1	1.52	●

FIG No 12.1
GRAIN SIZE DISTRIBUTION

UNIFIED SOIL CLASSIFICATION SYSTEM



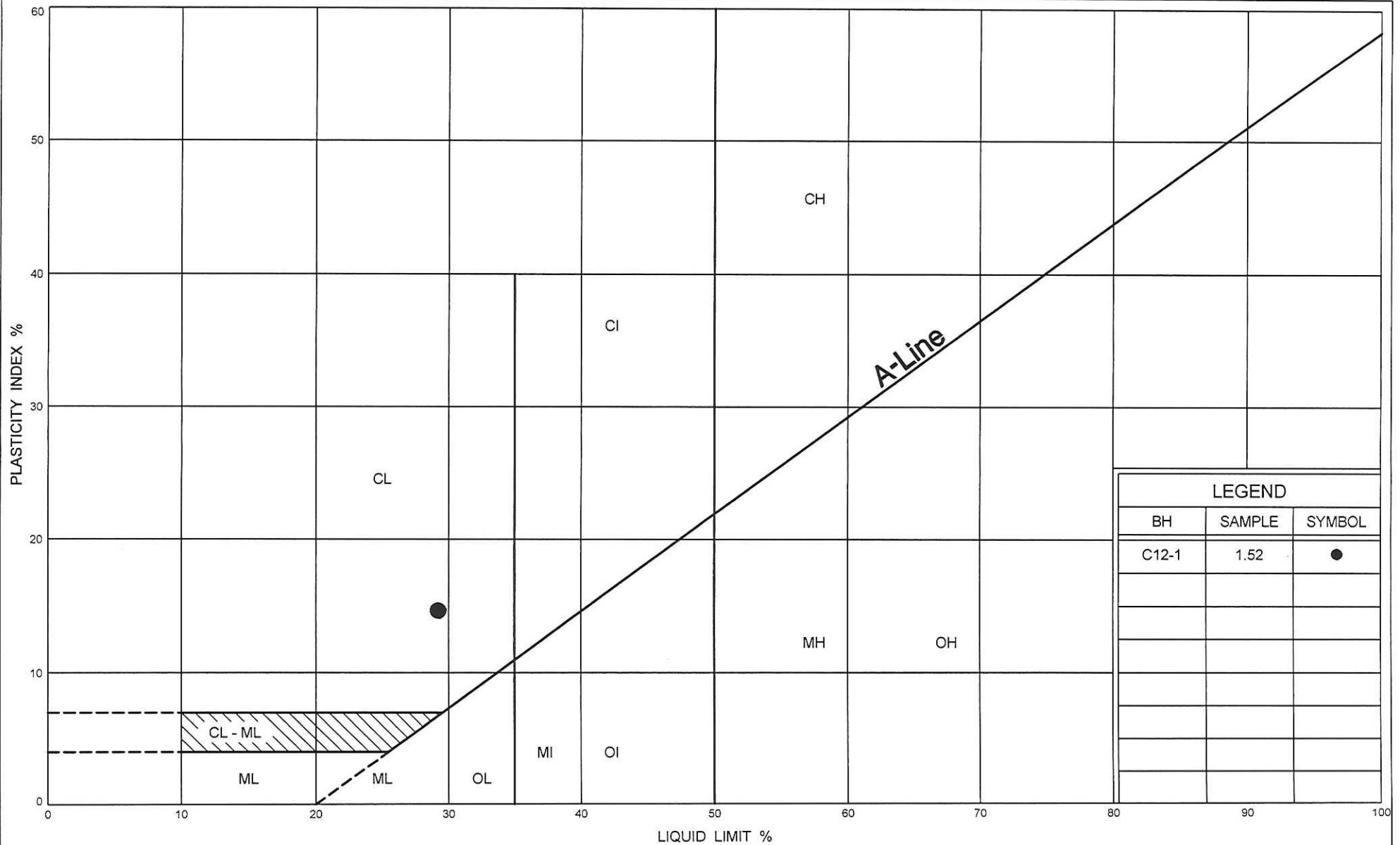
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Ontario

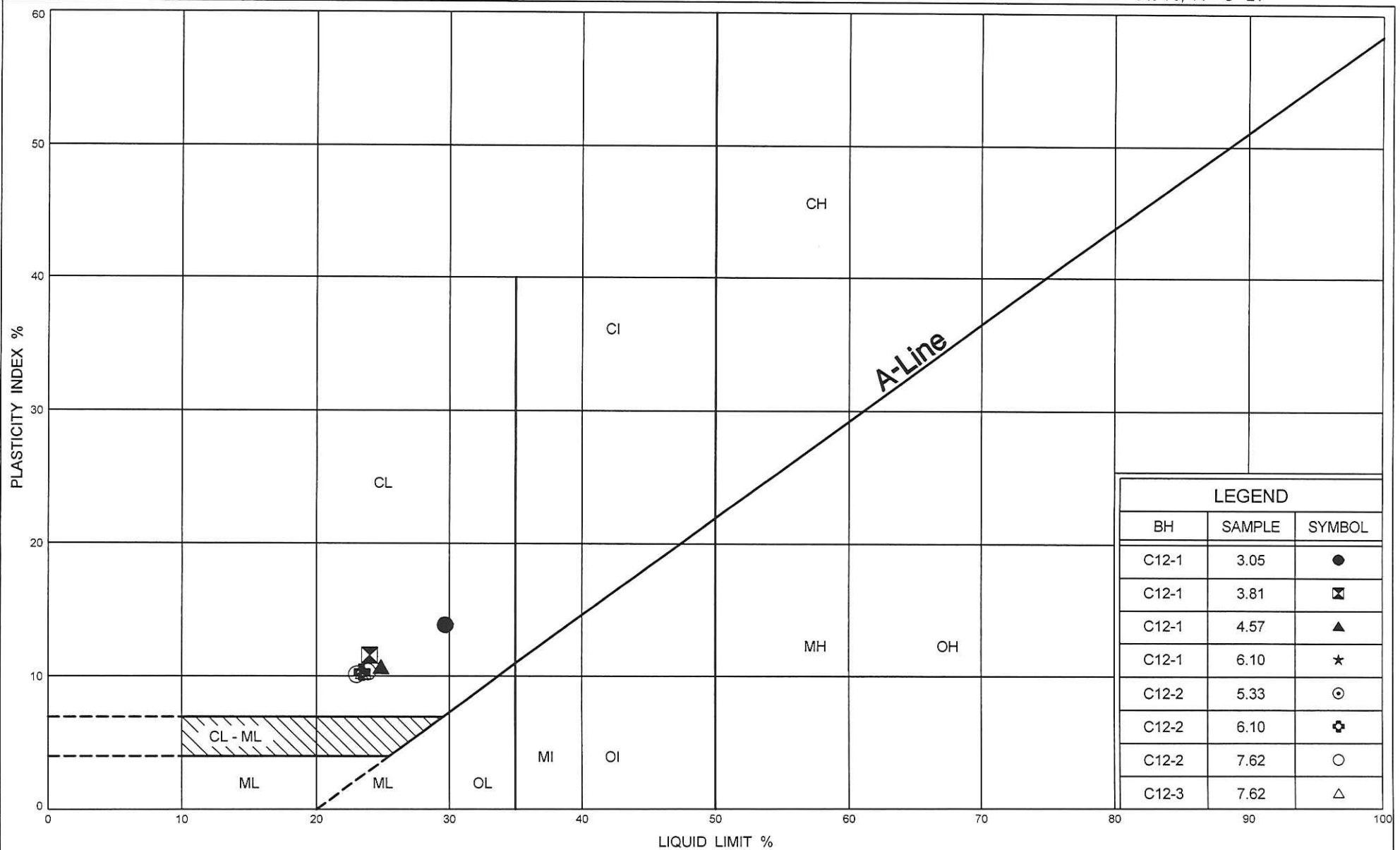
GRAIN SIZE DISTRIBUTION

FIG No 12.2

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations





Ministry of
Transportation
Ontario

PLASTICITY CHART

FIG No 12.4

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

Appendix 9

Data for Culvert 13, Structure 12-446-C

Borehole Locations and Soil Data	Drawing C13.1
Record of Borehole Sheets	Boreholes C13-1 to C13-3
Laboratory Test Results	
Grain Size Distribution	Figure 13.1
Plasticity Chart	Figure 13.2

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

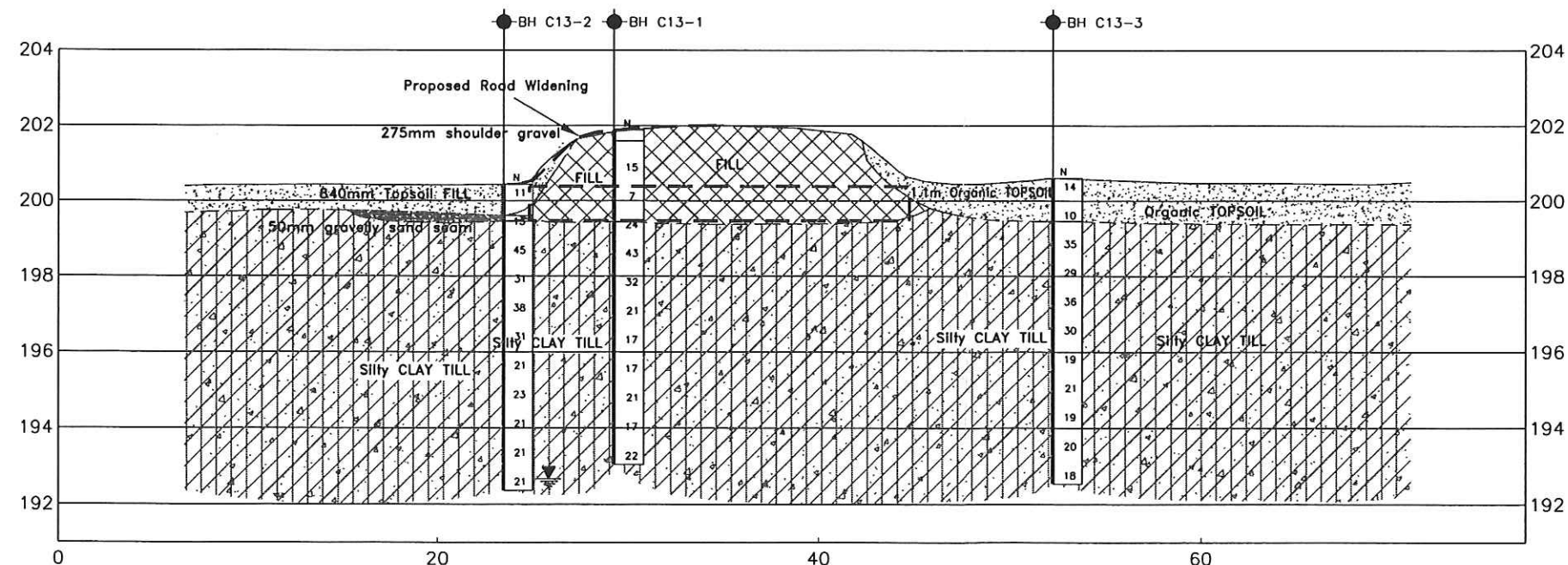
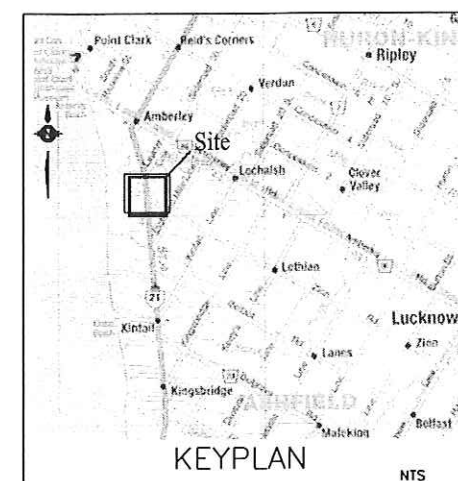
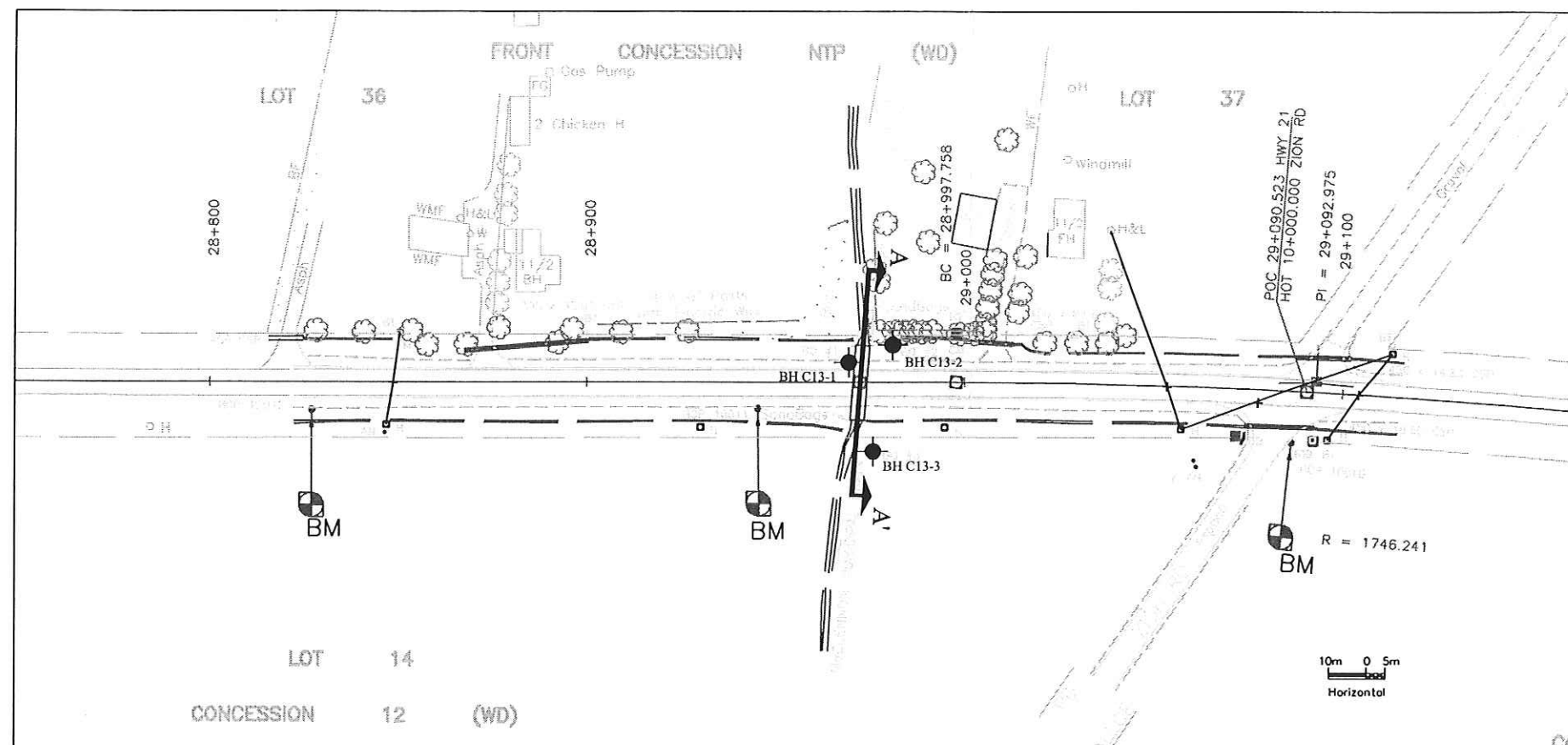
CONT No XXXX-XXXX
WP No 3097-03-00



Culvert #13
Highway 21
BORE HOLE LOCATIONS & SOIL STRATA

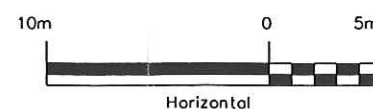
SHEET
1

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BH C13-1 is brought into the view of section A-A'

SECTION A-A'



NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC2.01 of OPS Gen. Cond.

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 of time of investigation
- Standpipe

No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
C13-1	201.88	4874855.929	368084.585
C13-2	200.44	4874867.013	368078.751
C13-3	200.61	4874864.899	368107.584

NOTE:
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS		DATE		BY		DISCUSSION	
08/12/04		AL		Draft			
Geocres : 41A-179		HWY No.		HWY 21		DIST	
SUBM'D AL		CHECKED J.L.		DATE August 19, 2004		SITE	
DRAWN AL		CHECKED J.L.		APPROVED E.C.		DWG	
						C13.1	

RECORD OF BOREHOLE No C13-1

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 28+969.25, OFFSET -5.3 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.14.04 - 6.14.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
201.88	Ground Surface													
0.00														
201.60	280mm shoulder gravel													
0.28														
			1	SS	15		201							
	Brown, moist to wet, compact to loose, FILL, consisting of silty clay		2	SS	7		200							
199.44			3	SS	24		199							
2.44			4	SS	43		198							
	Brown	Hard	5	SS	32		197							
			6	SS	21		196							
			7	SS	17		195							
	Moist, Silty CLAY with embedded sand and gravel (TILL)		8	SS	17		194							
			9	SS	21									
	Grey	V. Stiff	10	SS	17									
			11	SS	22									
193.04														
8.84	End of Borehole. Borehole dry and open at completion.													

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, ×³: Numbers refer to Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C13-2

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 28+980.9, OFFSET -9.9 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.24.04 - 6.24.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L		
200.44 0.00	Ground Surface											
	Black, moist to wet, compact, Topsoil FILL		1	SS	11		200					
199.45 0.99	50mm wet gravelly sand seam		2	SS	13					162.5		
	Brown		3	SS	45		199			225+		
			4	SS	31		198					
	Hard		5	SS	38		197			125		
			6	SS	31							
	Moist, Silty CLAY with embedded sand and gravel (TILL)		7	SS	21		196					
	Grey		8	SS	23		195			75		
			9	SS	21		194			87.5		
	V. Stiff		10	SS	21							
			11	SS	21		193			62.5		
192.36 8.08	End of Borehole. Water level measured at 7.8m at completion of drilling.											0 13 54 33 (87)

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+3, X3: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No C13-3

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 28+975.7, OFFSET 18.5 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.28.04 - 6.28.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									

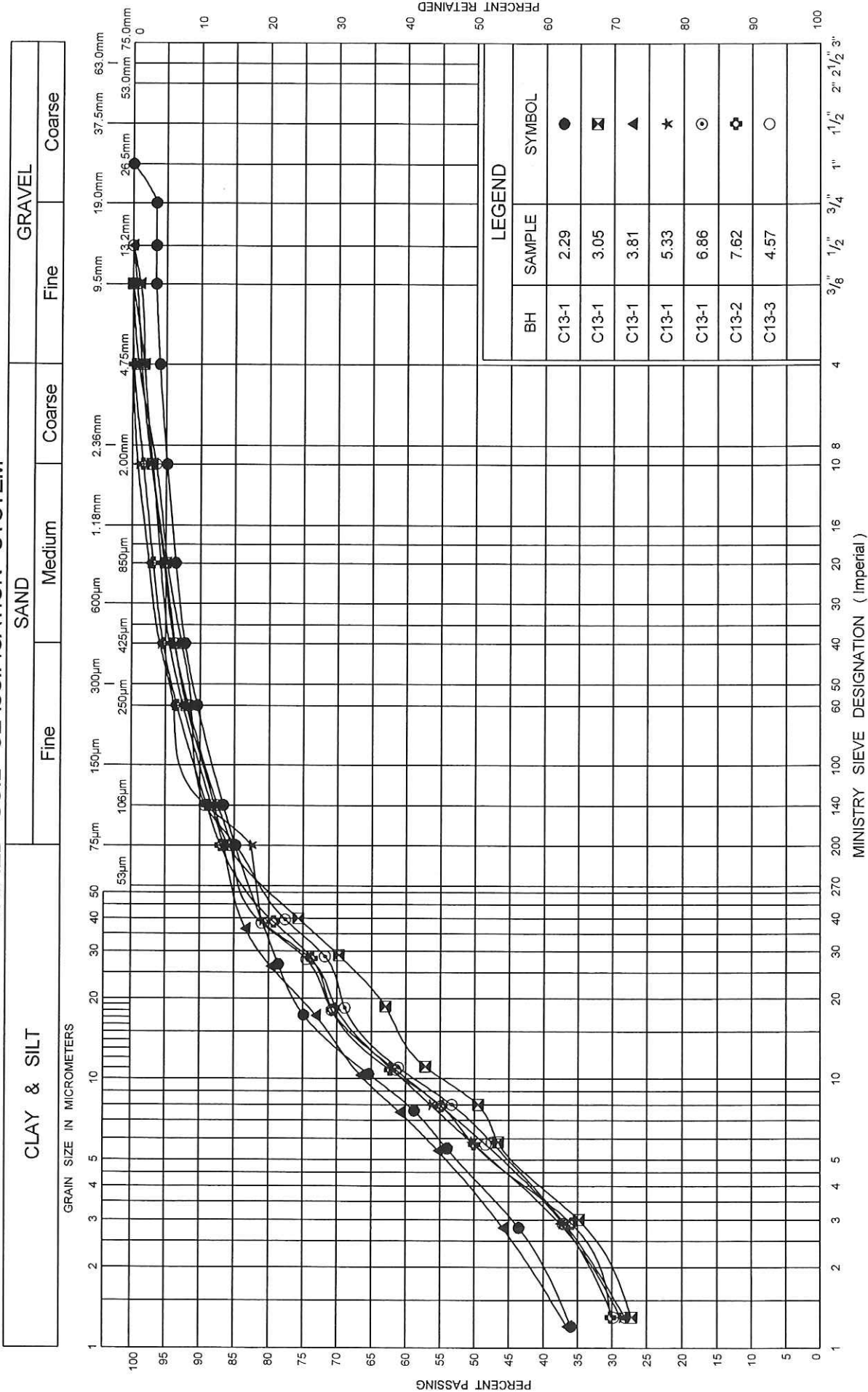
200.61	Ground Surface															
0.00	Black, moist to wet, compact, Organic TOPSOIL FILL		1	SS	14											
199.47			2	SS	10											
1.14	Brown Moist, very stiff to hard, Silty CLAY with embedded sand and gravel (TILL) Grey		3	SS	35						225+					
			4	SS	29						225+					
			5	SS	36						187.5					
			6	SS	30											
			7	SS	19						125					
			8	SS	21						62.5					
			9	SS	19						75					
			10	SS	20											
			11	SS	18											
192.53		End of Borehole. Borehole dry and open at completion.														
8.08																

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, ×³: Numbers refer to
Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

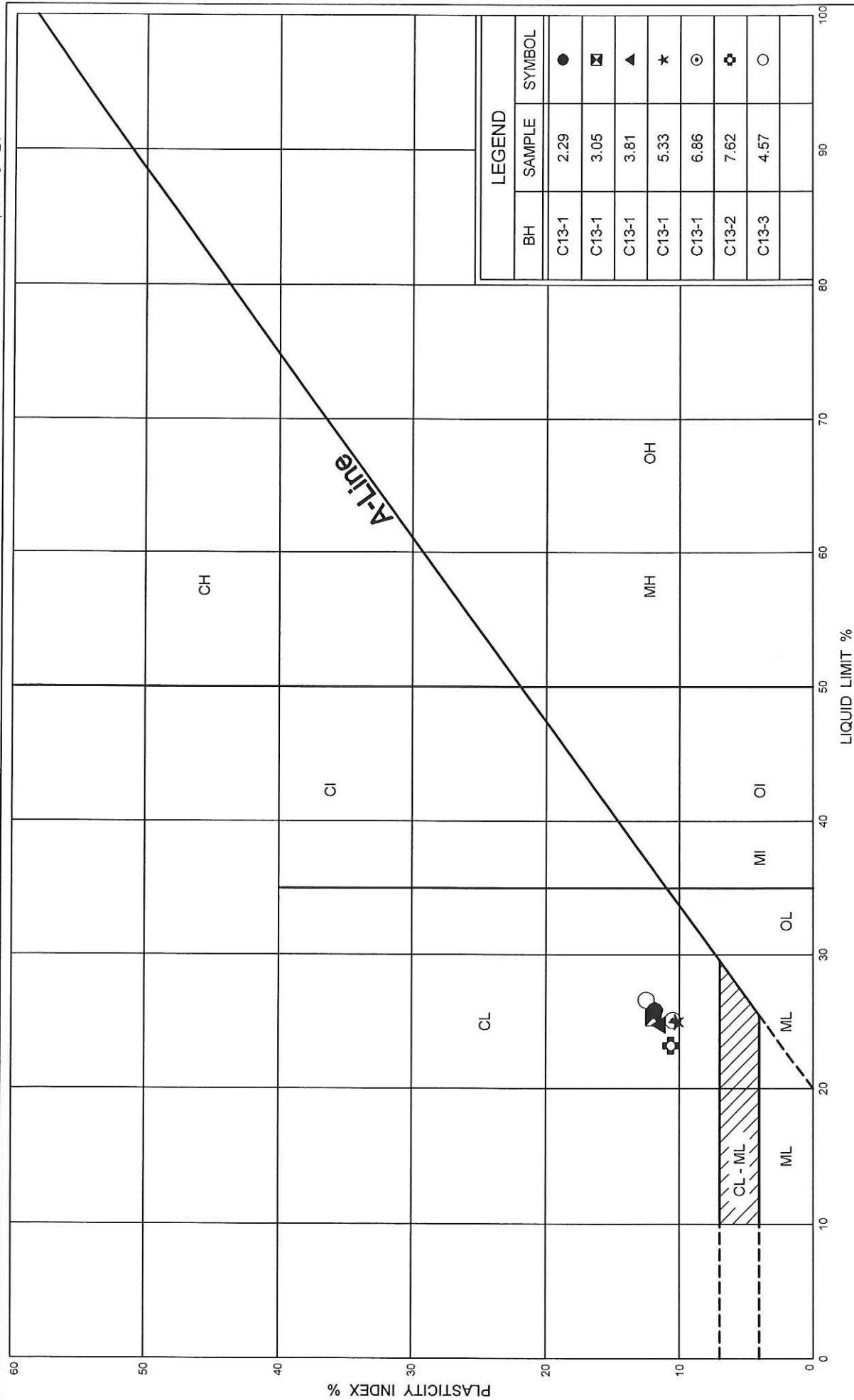
FIG No 13.1

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

Ministry of
Transportation





PLASTICITY CHART

FIG No 13.2

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations

Appendix 10

Data for Culvert 16, Structure 12-449-C

Borehole Locations and Soil Data

Drawing C16.1

Record of Borehole Sheets

Boreholes C16-1 to C16-3

Laboratory Test Results

Grain Size Distribution
Plasticity Chart

Figure 16.1
Figure 16.2

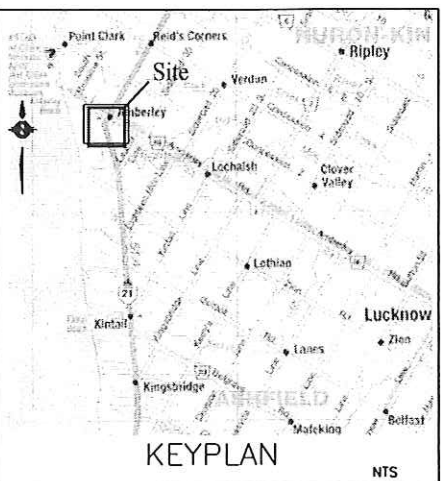
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No xxxx-xxxx
WP No 3097-03-00

SHEET
1

Culvert #16
Highway 21
BORE HOLE LOCATIONS & SOIL STRATA

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LEGEND

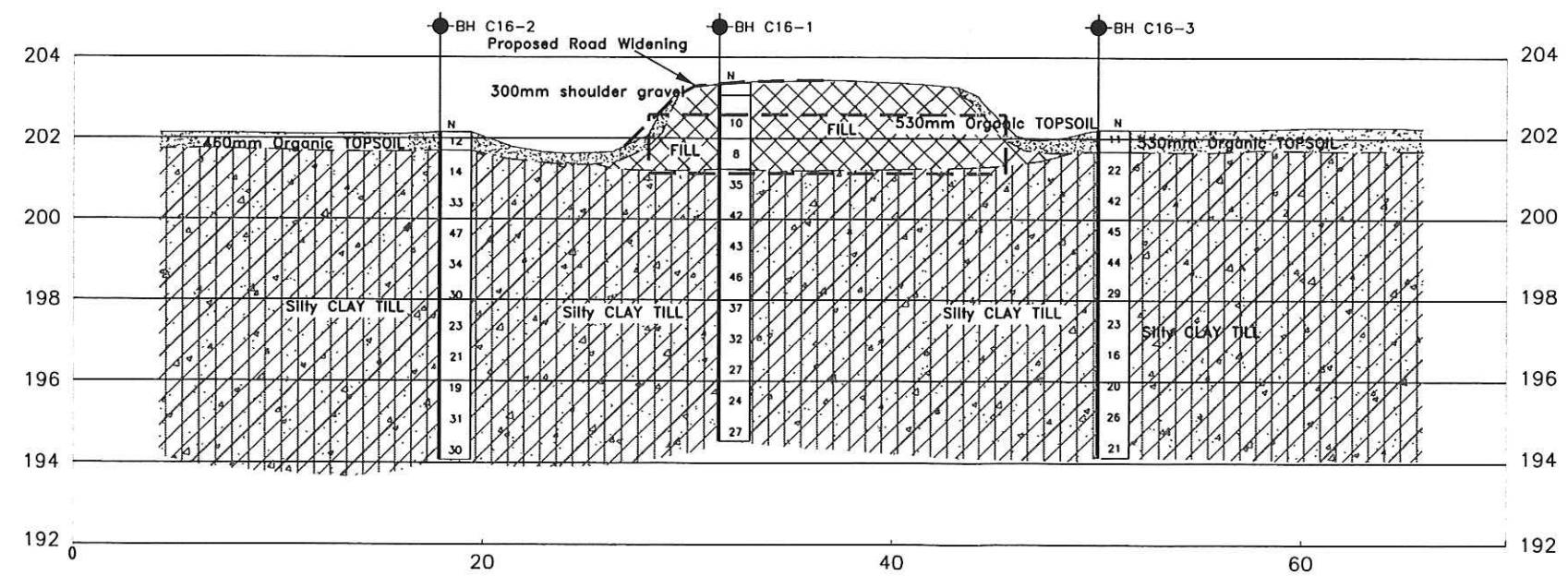
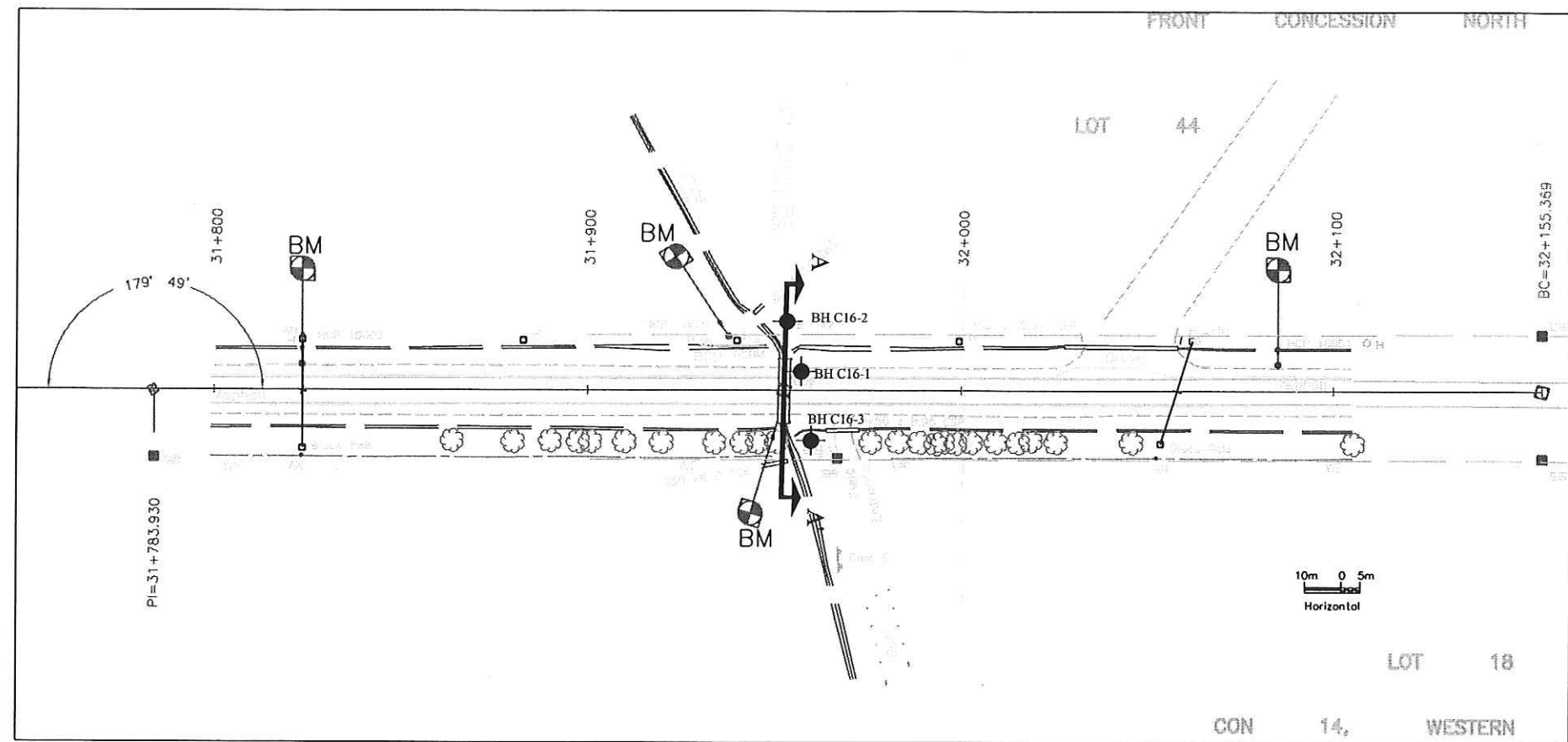
- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation
- Standpipe

No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
C16-1	203.37	4877762.097	367507.361
C16-2	202.15	4877754.712	367495.254
C16-3	202.21	4877769.907	367524.445

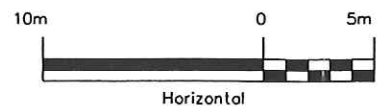
NOTE: The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION
	08/12/04	AL	Draft

Geocres : 41A-179			
HWY No.	HWY 21		DIST Owen Sound
SUBM'D AL	CHECKED J.L.	DATE August 19, 2004	SITE 12-449-C
DRAWN AL	CHECKED J.L.	APPROVED E.C.	DWG C16.1



SECTION A-A'



NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC2.01 of OPS Gen. Cond.

RECORD OF BOREHOLE No C16-1

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 31+956.9, OFFSET -5.1 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.14.04 - 6.14.04 CHECKED BY EC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
								20 40 60 80 100					
203.37	Ground Surface												
0.00	300mm shoulder gravel												
203.07													
0.30													
	Brown, moist to wet, compact to loose, FILL, consisting of layers of sand, silt and clay		1	SS	10								
			2	SS	8								
201.24													
2.13			3	SS	35								
	Brown		4	SS	42								
			5	SS	43								
		Hard	6	SS	46								
			7	SS	37								
			8	SS	32								
			9	SS	27								
			10	SS	24								
		V. Stiff	11	SS	27								
194.53													
8.84	End of Borehole. Borehole dry and open at completion.												

JOE MTO FINAL 04-5-1EG3.GPJ ONTARIO MOT.GDT 12/2/04

RECORD OF BOREHOLE No C16-3

1 OF 1

METRIC

W.P. G.W.P. 3097-03-00 LOCATION STA 31+959.7, OFFSET13.6 ORIGINATED BY RB
 DIST Owen Sound HWY 9 & 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
 DATUM Geodetic DATE 6.22.04 - 6.22.04 CHECKED BY EC

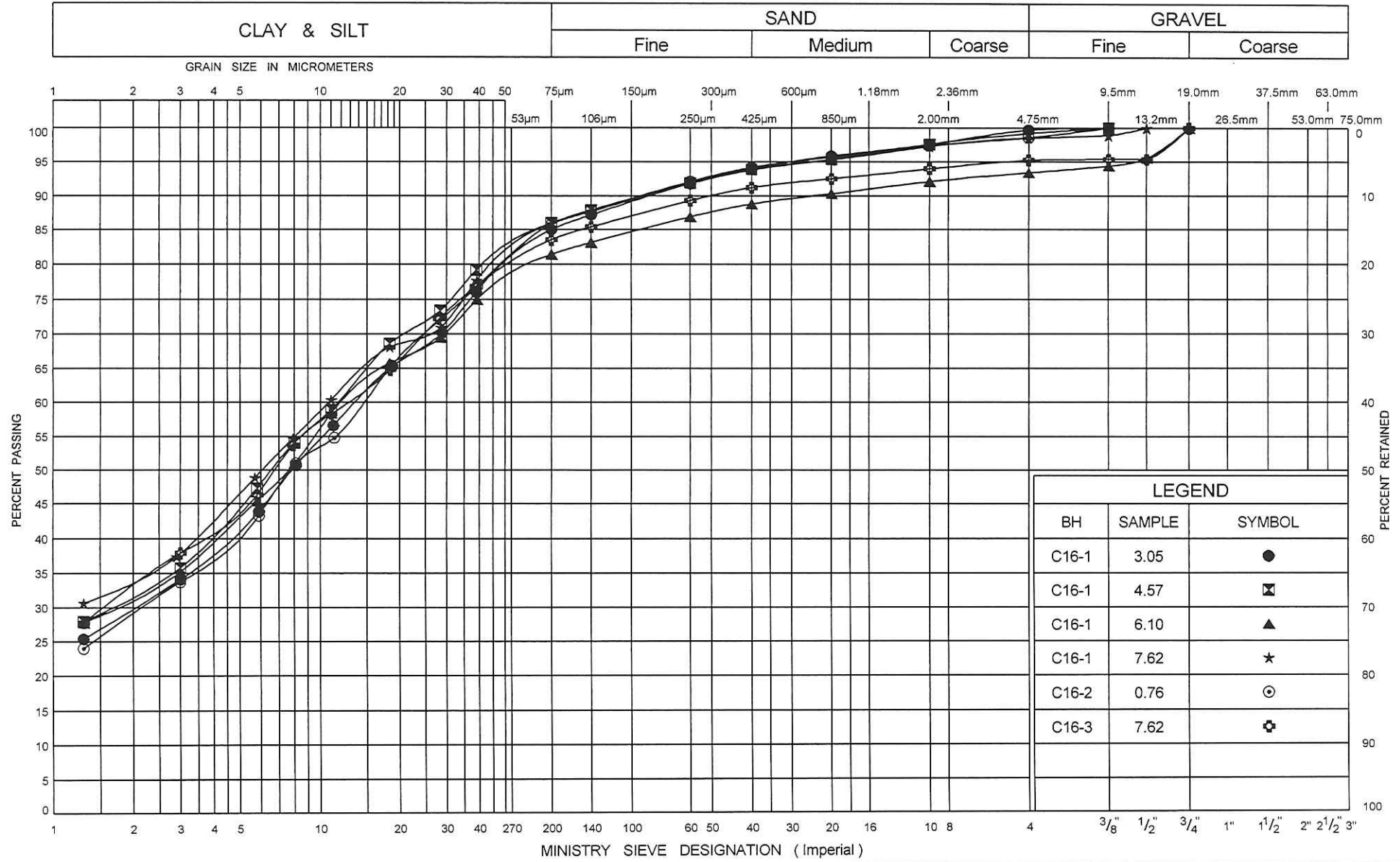
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								WATER CONTENT (%)						
202.21 0.00	Ground Surface		1	SS	11									
201.68 0.53	530mm Organic TOPSOIL													
		V. Stiff	2	SS	22									
	Brown		3	SS	42									
		Hard	4	SS	45									
			5	SS	44									
			6	SS	29									
	Moist, Silty CLAY with embedded sand and gravel (TILL)		7	SS	23									
			8	SS	16									
	Grey	V. Stiff	9	SS	20									
			10	SS	26									
			11	SS	21									
194.13 8.08	End of Borehole. Borehole dry and open at completion.													

JOE MTO FINAL 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/2/04

+³, X³: Numbers refer to Sensitivity

○ 150 UNCONFINED SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

UNIFIED SOIL CLASSIFICATION SYSTEM

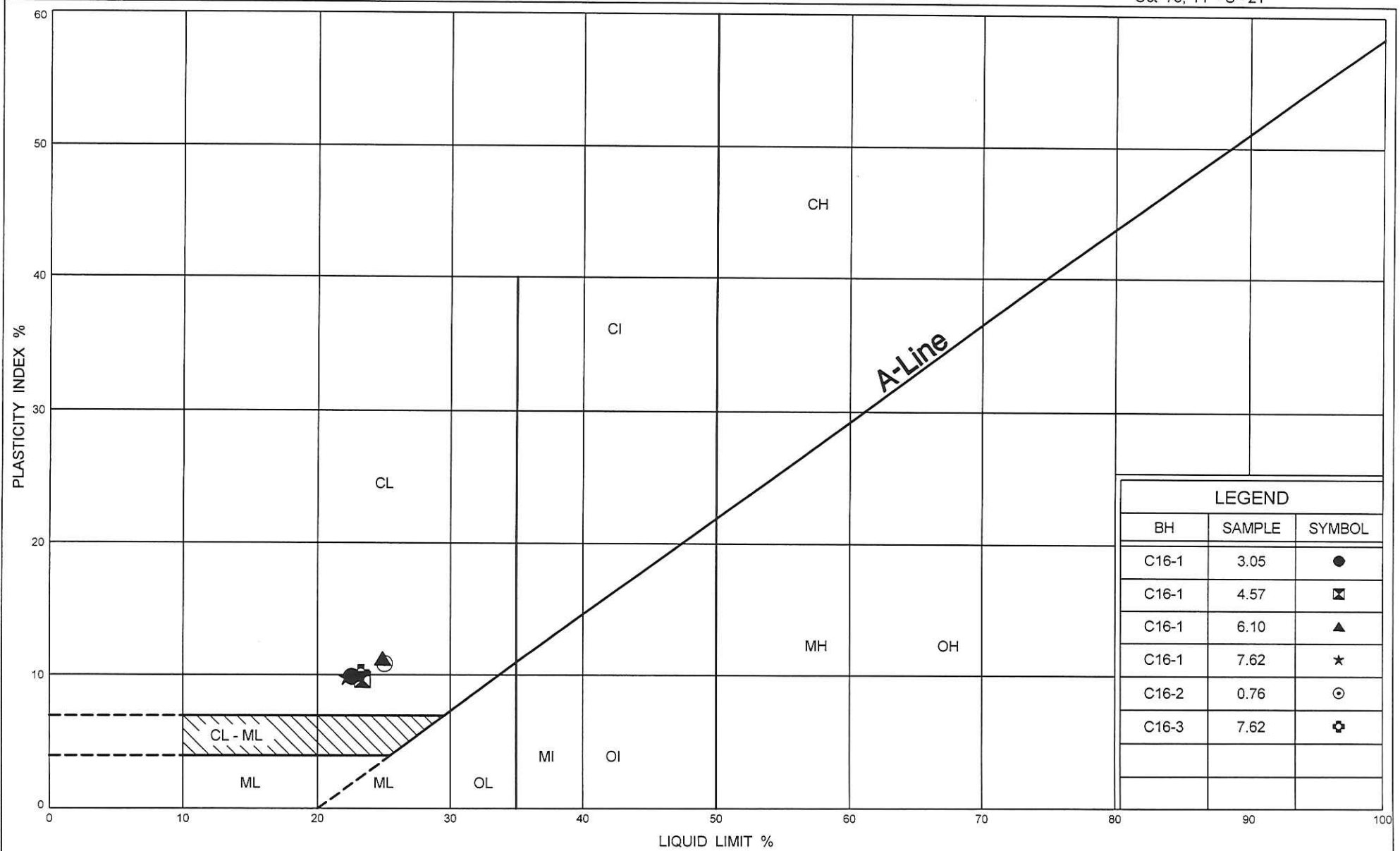


GRAIN SIZE DISTRIBUTION

FIG No 16.1

G.W.P. 3097-03-00

Concrete Culvert Replacements & Rehabilitations



ONTARIO MOT PLASTICITY CHART 04-5-IEG3.GPJ ONTARIO MOT.GDT 12/4/04

Appendix 11

Limitations of Report

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, I.E. Group 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.