



**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT
for
CATTLE CROSSING CULVERT AT STATION 11+272
HIGHWAY 69 FOUR-LANING 19.7 KM FROM 1.7 KM NORTH OF
HIGHWAY 529 (NORTH JUNCTION) TO 3.9 KM
NORTH OF HIGHWAY 522
TOWNSHIP OF HENVEY, ONTARIO
AGREEMENT NO.: 5013-E-0036
WORK ORDER # 12**

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PML Ref.: 14TF034E
Index No.: 038FIR and 039FDR
GEOCRES No.: 41H-169
June 19, 2017



**PART A – PRELIMINARY FOUNDATION INVESTIGATION REPORT
for
CATTLE CROSSING CULVERT AT STATION 11+272
HIGHWAY 69 FOUR-LANING 19.7 KM FROM 1.7 KM NORTH OF
HIGHWAY 529 (NORTH JUNCTION) TO 3.9 KM
NORTH OF HIGHWAY 522
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PART A
PRELIMINARY FOUNDATION INVESTIGATION REPORT

for
Cattle Crossing Culvert at
Station 11+272, Highway 69
Township of Henvey, Ontario
Agreement No.: 5013-E-0036, Work Order # 12

1. INTRODUCTION

The Ministry of Transportation of Ontario (MTO) has retained Parsons, as the Prime Consultant to carry out Owner's Engineer services for the four-laning of Highway 69. Parsons has retained Peto MacCallum Ltd. (PML) on behalf of the MTO to provide preliminary foundation engineering services for the proposed Cattle Crossing culvert located at Station 11+272, Township of Henvey, Parry Sound District, Ontario. PML conducted the geotechnical investigation under the Agreement No. 5013-E-0036, Work Order # 12. This foundation investigation work is part of an assignment to prepare the Design-Build ready preliminary investigation report for the foundation design and construction of the Cattle Crossing culvert.

This report presents the factual findings obtained from the geotechnical investigation carried out for the proposed culvert to be located on re-aligned Highway 69, 1.2 km east of the existing Highway 69 and Highway 529 (Britt) interchange.

The purpose of the investigation was to explore the subsurface conditions expected to influence the design of the culvert and to aid the designer in selecting the suitable type of structure.

2. SOURCES OF INFORMATION

The following foundation reports were available and reviewed by PML to provide factual information for the adjacent site, subsoil information and site general condition.

1. Foundation Design Report – Culverts – Contract 2, Highway 69 Four – Laning 1.7 Km North of Highway 529 Northerly to 3.9 Km North of Highway 522, Ministry of Transportation, Ontario, GWP 5404-05-00, WP 5404-05-01. Dated September 22, 2015.
2. Foundation Investigation and Design Report – Swamp Crossing and Highfill Areas – Contract 2, Highway 69 Four-Laning, From 1.7 Km North of Highway 529 Northerly to 3.9 Km North of Highway 522, Ministry of Transportation, Ontario, GWP 5404-05-00, WP 5404-05-01. Dated July, 2012. Geocres 41H-115.



3. SITE DESCRIPTION

In general, the proposed site within the overall project limits is located on the north slope of a deep ravine, which slopes from north to south. The surface of the slope is covered with bushes and trees, however, a rock outcrop is visible on the north side of the proposed culvert site. Representative site photographs are appended in Appendix A.

A general arrangement (GA) drawing was not available at the time of preparing this report. Based on the Work Order Item #12 – Detailed Scope of Work, the proposed structure will be approximately 76 m long, 5.0 m span and 5.0 m rise concrete box culvert. The profile drawing of the re-aligned Highway 69 indicates that there will be about 1.5 m high fill above the culvert to set the road grade at El. 188.5 m.

The ground surface along the alignment of Cattle Crossing culvert varies between about El. 189.0 m and El. 196.0 m, referenced to Geodetic datum, and generally slopes toward south.

4. FIELD INVESTIGATION PROCEDURES

The PML staff inspected the site on October 28, 2016, to check the access to the proposed culvert site. PML was informed that the access to the culvert site was through a private property and required permission from the owner to access the site. MTO could not negotiate with the property owner and guarantee permission to gain access to the site with the drilling equipment. As a result, the field investigation was performed by the use of a tripod, which had to be carried on foot over rock outcrop, and rock coring could not be done to confirm the presence of bedrock. Probable bedrock elevations provided in the borehole logs are based on the visual inspections and information obtained by probing with a steel rod.

The fieldwork included thirteen (13) boreholes and was carried out on November 9 and 10, 2016. The location of boreholes in the field was established by PML staff using a portable GPS device. Subsequently, D.S. Dorland Limited of Sudbury, Ontario under contract to PML carried out the survey of the borehole locations and elevations, and provided the co-ordinates for locations in MTM NAD 83 northing and easting. PML used the survey data provided by D.S. Dorland Limited for preparation of this report. All elevations reported in this report are referred to Geodetic datum and expressed in meters.



The drilling equipment used for the investigation was owned and operated by Landcore Drilling of Chelmsford, Ontario, a specialist drilling contractor. The fieldwork was carried out under the full-time supervision of a PML field supervisor. The investigation included probing with a steel rod at eight (8) locations and advancing five (5) boreholes numbered Nos. 1, 2, 5, 7, and No. 9 to a maximum depth of 1.4 m (El. 184.4). These boreholes were advanced by continuous sampling with a manual hammer installed on a tripod. Representative soil samples were recovered from these five boreholes using a conventional 51 mm O.D split spoon sampler in accordance with the Standard Penetration Test (SPT) procedure. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata.

The recovered soil samples were returned to our laboratory for detailed visual examination, and index tests.

5. LABORATORY TEST PROCEDURES

Laboratory tests on representative SPT samples recovered during the fieldwork were carried out by the certified PML laboratory in Toronto. The laboratory testing program included the following:

- Organic Content test (3)
- Grain size distribution analyses (1)
- Atterberg limits (1)

The laboratory tests to determine the index properties were performed in accordance with the MTO test procedures, which follow American Society for Testing Materials (ASTM) test procedures, with the exception of hydrometer test (LS-702). The results of the grain size distribution analyses are presented on Figures GS-CC-1. Results of the Atterberg limit test are provided on Figure PC-CC-1. The test results including organic contents are summarized in the attached Record of Borehole sheets.

6. SITE GEOLOGY AND SUBSURFACE CONDITIONS

6.1 Site Geology

Ontario Geological Survey map available in Google Earth indicate that the project site lies within physiographic region known as the Georgian Bay Fringe, which extends along the east side of



Georgian Bay through the Parry Sound and Muskoka areas, then eastward from Muskoka in patches into the area north of the Kawartha Lakes.

A broad belt bordering Georgian Bay, characterized by very shallow soil and bare rock knobs and ridges, and has been separated from the Algonquin Highlands. It occupies much of Parry Sound and Muskoka, and extends eastward from Muskoka in patches into the area north of the Kawartha Lakes.

This part of the Georgian Bay Fringe physiographic region was never submerged during periods of glacial recession. As a result, the surficial soils in this area consist of shallow deposits of sand, silt and clay underlain by metamorphic bedrock. Numerous bare knobs and ridges of bedrock are present throughout the area. Localized low-lying swampy areas, containing peat and/or organic soils, underlain by soft/loose native soils, are present in valleys between the bedrock knobs and ridges.

The bedrock in the area consists typically of crystalline gneisses of the Britt Domain of the Central Gneiss Belt, a subdivision of the Grenville Structural Province, as described in Geology of Ontario, OGS Special Volume 4. Deposition of Paleozoic strata initially covered the bedrock and later erosion during glaciation exposed these Precambrian rocks.

6.2 Subsurface Conditions

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole Sheets attached to the report. The borehole locations plan and stratigraphic profile sections are shown on the attached Drawings CC-1, 2 and 3. The boundaries between soil strata have been established at the borehole locations only. The boundaries of soil strata between and beyond the boreholes are assumed and may vary from location to location.

The majority of the thirteen boreholes advanced during this investigation (Nos. 3, 4, 6, 8, 10 to 13) were located on rock out-crop or probable bedrock. In the area where four boreholes were advanced (Nos. 1, 2, 5, and 9), the subsoil conditions consist of 100 mm to 200 mm of topsoil immediately below the existing surface and is followed by 200 mm to 400 mm silty sand, which is underlain by probable bedrock. In Borehole No. 2, the silty sand deposit is followed by 0.8 m thick clayey silt layer, which is underlain by probable bedrock at a depth of 1.4 m (El. 184.4). The following table provides the summary of subsoils encountered in boreholes 1 to 13:



SUMMARY OF FIELD INVESTIGATION LOG

| BH NO. | TOPSOIL | SILTY SAND | SILTY CLAY | PROBABLY BEDROCK |
|--------|---|---|---|-----------------------------|
| 1 | Thickness: 100 mm El. 187.1 to El. 187.0 | Thickness: 300 mm El. 187.0 to El. 186.7 | - | Depth (m): 0.4 El. 186.7 |
| 2 | Thickness: 200 mm El. 185.8 to El. 185.6 | Thickness: 400 mm El. 185.6 to El. 185.2 | Thickness: 800 mm El. 185.2 to El. 184.4 | Depth (m): 1.4 El. 184.4 |
| 3 | - | - | - | Depth (m): 0 El. 189.7 |
| 4 | Thickness: 200 mm El. 188.4 to El. 188.2 | - | - | Depth (m): 0.2 El. 188.2 |
| 5 | Thickness: 100 mm El. 186.8 to El. 186.7 | Thickness: 200 mm El. 186.7 to El. 186.5 | - | Depth (m): 0.3 El. 186.5 |
| 6 | - | - | - | Depth (m): 0 El. 190.8 |
| 7 | Thickness: 200 mm El. 188.8 to El. 188.6 | Thickness: 300 mm El. 188.6 to El. 188.3 | | Depth (m): 0.5 El. 188.3 |
| 8 | - | - | - | Depth (m): 0 El. 188.8 |
| 9 | Thickness: 200 mm El. 187.2 to El. 187.0 | Thickness: 300 mm El. 187.0 to El. 186.7 | | Depth (m): 0.5 El. 186.7 |
| 10 | - | - | - | Depth (m): 0 El. 196.0 |
| 11 | - | - | - | Depth (m): 0 El. 194.5 |
| 12 | - | - | - | Depth (m): 0 El. 196.0 |
| 13 | - | - | - | Depth (m): 0 El. 195.5 |



Access was not available to mobilise motorized drilling equipment to the borehole locations. As a result, no rock coring was done to confirm the quality or type of bedrock at the proposed culvert location. Borehole logs from the geotechnical investigation carried out by Golder Associates (dated July 2012, Geocres No. 41H-115), adjacent to this site on the south side, are provided in Appendix B. Comparison of the rock samples collected by pick axe during the fieldwork (Photograph 5) reveal that the type of bedrock presence at the culvert location is similar to that was encountered at the adjacent site.

Further, the borehole information provided in the report of Golder Associates indicates that the thickness of overburden above the bedrock increases towards south of the culvert location.

6.3 Groundwater

The groundwater was not observed in any of the boreholes drilled within the proposed culvert footprint. The borehole logs presented in the report of Golder Associates (Geocres 41H-115) indicate that the groundwater level was observed at about El. 185.8 m, during the site investigation in the borehole located adjacent to the culvert site.

Also, site investigation report prepared by Golder Associates (Geocres 41H-119) reveal that artesian condition was observed in the boreholes located 50 m to 70 m south of the proposed culvert location. Artesian water level in those boreholes were observed at about 0.5 m to 1.5 m above the existing ground surface (El. 184.1 to 183.1). Further investigation may be required to confirm the existence of groundwater within the bedrock.

Groundwater levels may fluctuate due to the influence of precipitation and seasonal change.

6.4 Additional Field Investigation

It should be noted that PML could not gain access to the proposed culvert location with motorized drilling equipment to obtain rock cores to confirm the presence and quality of the local bedrock. The contractor shall be advised to carry out additional field investigation to confirm the elevation and quality of bedrock, and thickness of overburden.



7. CLOSURE

Mr. S. Aziz carried out the field investigations under the supervision of Mr. M. Khorsand B.Sc. Eng., EIT, Project Supervisor and Mr. C. M. P. Nascimento, P.Eng., Project Manager. LandCore Drilling Ltd. of Chelmsford, Ontario supplied the drilling equipment for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

This report was prepared by Mr. Mansoor Khorsand, B.Sc. Eng., EIT, Project Supervisor, and reviewed by Mr. Mark Vasavithasan, M.Sc. Eng., P.Eng., Senior Engineer, Geotechnical Services. Mr. Carlos Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

A blue ink signature of Mansoor Khorsand, written over a circular professional seal. The signature is cursive and includes the name 'Mansoor' and the date 'Jun 19, 2017'.

Mansoor Khorsand, BSc, EIT
Project Supervisor, Geotechnical Services

A circular professional seal for Mark Vasavithasan, a Licensed Professional Engineer in the Province of Ontario. The seal contains the text 'LICENSED PROFESSIONAL ENGINEER', 'M. VASAVITHASAN', and 'Jun 19, 2017'. A blue ink signature is written over the seal.

Mark Vasavithasan, M.Sc. Eng., P.Eng.
Senior Engineer, Geotechnical Services

A circular professional seal for Carlos M.P. Nascimento, a Registered Professional Engineer in the Province of Ontario. The seal contains the text 'REGISTERED PROFESSIONAL ENGINEER', 'C M P Nascimento', and 'Jun 19, 2017'. A blue ink signature is written over the seal.

Carlos M.P. Nascimento, P.Eng
Project Manager and
MTO Designated Principal Contact



APPENDIX A

Site Photographs



Photograph 1: Looking West, approximate location of Cattle Crossing Culvert footprint (November 9, 2016).



Photograph 2: Looking East, approximate location of Cattle Crossing Culvert footprint (November 9, 2016).



Photograph 3: Setting up of tripod at Borehole No. 2 located on the southeast side of Cattle Crossing Culvert site (November 10, 2016).



Photograph 4: Location of Borehole No. 8, view of the borehole located at the center of proposed Cattle Crossing Culvert (November 10, 2016).




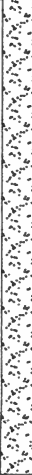
Photograph 5: Rock Samples, chipped by pick axe from the rock out crop found within the proposed culvert footprint.



APPENDIX B

Borehole Logs from Golder Report GEOCREs No. 41H-115

| | | | | | | | |
|----------------------|--|---|--|------------------|--|---------------|--|
| PROJECT 09-1111-6014 | | RECORD OF BOREHOLE No S202-06 | | SHEET 2 OF 2 | | METRIC | |
| W.P. 5404-05-01 | | LOCATION N 5074265.1; E 225378.4 | | ORIGINATED BY MR | | | |
| DIST HWY 69 | | BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring | | COMPILED BY AM | | | |
| DATUM Geodetic | | DATE February 1 and March 9, 2011 | | CHECKED BY TVA | | | |

| 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 | | | 20 40 60 80 100 | SHEAR STRENGTH kPa | | | | | | | WATER CONTENT (%) 20 40 60 | | | |
| | | | | | | | | ○ UNCONFINED | + FIELD VANE | | | | | | | | | | |
| | | | | | | | | ● QUICK TRIAXIAL | × REMOULDED | | | | | | | | | | |
| --- CONTINUED FROM PREVIOUS PAGE --- | | | | | | | | | | | | | | | | | | | |
| 166.6 | SILTY CLAY, trace sand Soft to stiff Brown and grey Moist |  | | | | | 168 | | | | | | | | | | | | |
| 16.5 | SAND, some silt, trace gravel and clay Loose to compact Grey Wet |  | 12 | SS | 12 | | 167 | | | | | | | | | | | | |
| | | | | | | | 166 | | | | | | | | | | | | |
| | | | | | | | 165 | | | | | | | | 2 84 12 2 | | | | |
| | | | | | | | 164 | | | | | | | | | | | | |
| | | | | | | | 163 | | | | | | | | | | | | |
| 161.8 | | | 13 | SS | 7 | | 162 | | | | | | | | | | | | |
| 21.3 | END OF BOREHOLE | | | | | | | | | | | | | | | | | | |
| | NOTES: * Water flowing from top of casing when advanced to a depth of 17.7 m below ground surface (Elev. 165.4 m); height of casing at about 0.8 m above ground surface. 1. Water level (not-stabilized) in casing at 0.8 m above ground surface (Elev. 183.9 m) during drilling - Artesian Condition. 2. Open borehole filled with drilling mud in order to continue borehole advancement; Water level measured in open casing prior to grouting at a depth of 2.8 m below ground surface (Elev. 180.3 m) | | | | | | | | | | | | | | | | | | |

| | | | | | | | |
|-----------------------------|--|---|--|------------------|--|---------------|--|
| PROJECT 09-1111-6014 | | RECORD OF BOREHOLE No S202-07 | | SHEET 1 OF 1 | | METRIC | |
| W.P. 5404-05-01 | | LOCATION N 5074270.5, E 225358.0 | | ORIGINATED BY MR | | | |
| DIST HWY 69 | | BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring | | COMPILED BY AM | | | |
| DATUM Geodetic | | DATE March 14, 2011 | | CHECKED BY TVA | | | |

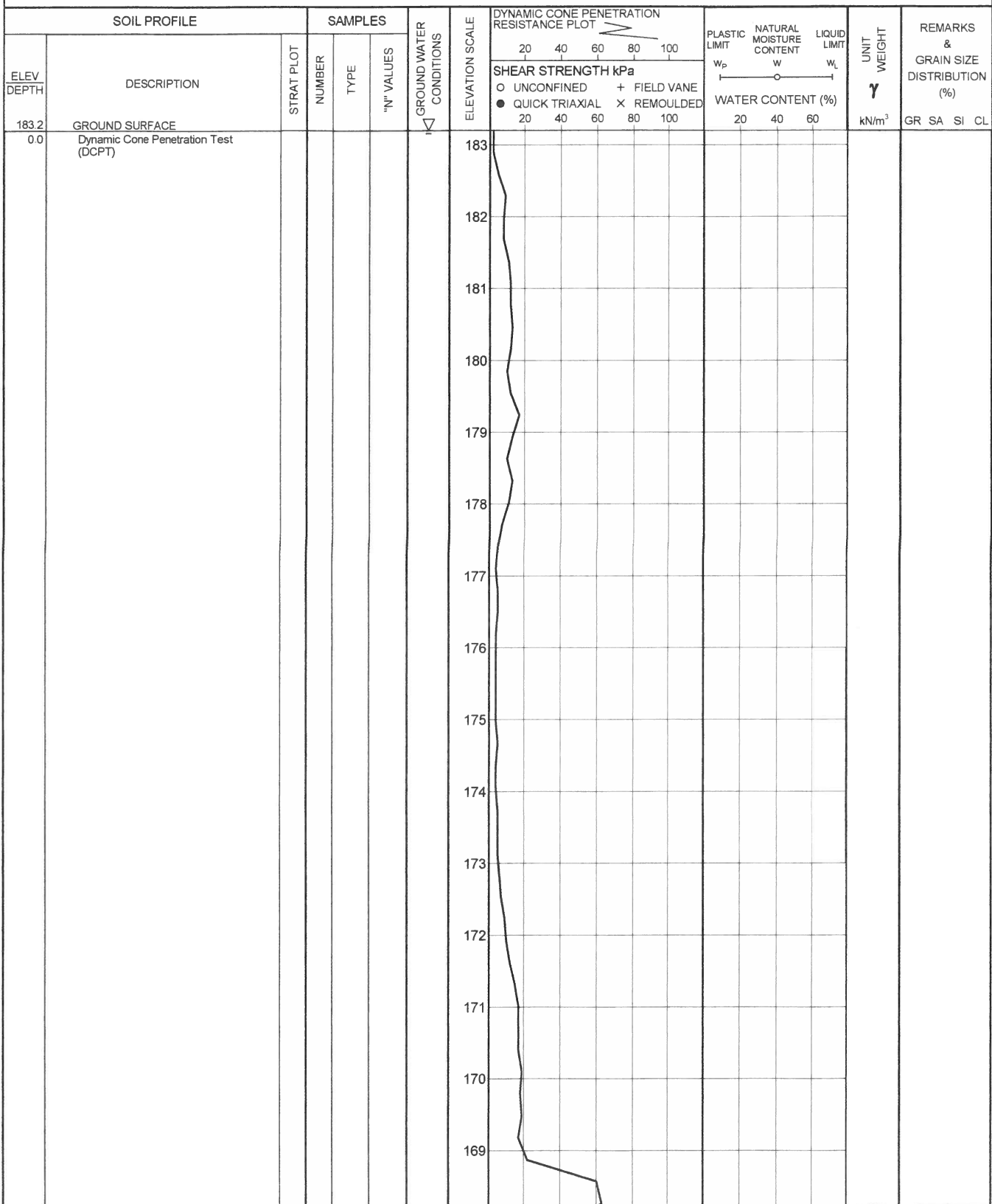
| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x REMOULDED | | | | | | |
| 183.5 | GROUND SURFACE | | | | | | | | | | | | | |
| 0.0 | TOPSOIL | | 1A | | | | | | | | | | | |
| 0.2 | Silty SAND, trace clay | | 1B | SS | 4 | | | | | | | | | |
| 182.8 | Loose Brownish grey | | | | | | | | | | | | | |
| 0.7 | Wet SILTY CLAY, trace sand | | 2 | SS | 8 | | | | | | | | | |
| | Soft Brown and grey | | | | | | | | | | | | | |
| | Moist to wet | | | | | | | | | | | | | |
| | Becoming grey below a depth of 2.4 m | | 3 | SS | 2 | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 4 | SS | WH | | | | | | | | | |
| 179.4 | | | | | | | | | | | | | | |
| 4.1 | SILT, trace clay, trace to some sand Compact Grey Wet | | 5 | SS | 14 | | | | | | | | | 0 6 79 15 |
| 178.3 | | | | | | | | | | | | | | |
| 5.2 | CLAY, some silt, trace sand Firm Brown to grey Moist | | | | | | | | | | | | | |
| | | | 6 | SS | 1 | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 7 | TO | PM | | | | | | | | 15.3 | |
| 175.0 | | | | | | | | | | | | | | |
| 8.5 | SILTY CLAY, trace sand Firm Brown to grey Moist | | | | | | | | | | | | | |
| | | | 8 | SS | 1 | | | | | | | | | 0 2 45 53 |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 9 | SS | WH | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | 10 | SS | WH | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| 170.4 | END OF BOREHOLE SPOON AND CASING REFUSAL | | 11 | SS | 50/0.0 | | | | | | | | | |
| 13.1 | NOTE: 1. Water level in open borehole at a depth of 4.1 m below ground surface (Elev. 179.4 m) upon completion of drilling. | | | | | | | | | | | | | |

GTA-MTO001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD

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

| PROJECT | | RECORD OF BOREHOLE | | No S202-09 | | SHEET 1 OF 1 | | METRIC | | | | | | | | |
|--------------|--|--------------------|---------|--------------------------|------------|---|-----------------|--|----|----|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|----|
| W.P. | | LOCATION | | N 5074293.7 ; E 225348.8 | | ORIGINATED BY | | MR | | | | | | | | |
| DIST | | HWY | | BOREHOLE TYPE | | 127 mm O.D. Continuous Flight Solid Stem Augers | | COMPILED BY | | | | | | | | |
| AM | | DATE | | March 14, 2011 | | CHECKED BY | | TVA | | | | | | | | |
| DATUM | | Geodetic | | | | | | | | | | | | | | |
| 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 | | | 20 | 40 | 60 | | | | | | 80 |
| 186.2 | GROUND SURFACE | | | | | | | | | | | | | | | |
| 0.0 | TOPSOIL | | 1A | SS | 2 | | | | | | | | | | | |
| 0.2 | Silty SAND, containing rootlets | | 1B | SS | 2 | | | | | | | | | | | |
| 185.5 | Very loose | | | | | | | | | | | | | | | |
| 0.7 | Brown | | | | | | | | | | | | | | | |
| | Wet | | | | | | | | | | | | | | | |
| 184.8 | SILTY CLAY, trace sand | | 2 | SS | 9 | | | | | | | | | | | |
| | Stiff | | | | | | | | | | | | | | | |
| | Brown and grey | | | | | | | | | | | | | | | |
| | Moist | | | | | | | | | | | | | | | |
| 1.7 | Silty SAND and GRAVEL, trace clay | | 3 | SS | 50/05 | | | | | | | | | | | |
| | Very dense | | | | | | | | | | | | | | | |
| | Brown | | | | | | | | | | | | | | | |
| | Moist to wet | | | | | | | | | | | | | | | |
| | END OF BOREHOLE | | | | | | | | | | | | | | | |
| | SPOON AND AUGER REFUSAL | | | | | | | | | | | | | | | |
| | END OF DCPT | | | | | | | | | | | | | | | |
| | Refusal to Further Penetration | | | | | | | | | | | | | | | |
| | (Hammer Bouncing) | | | | | | | | | | | | | | | |
| | NOTES: | | | | | | | | | | | | | | | |
| | 1. Water level in open borehole at a depth of 0.3 m below ground surface (Elev. 185.9 m) upon completion of drilling. | | | | | | | | | | | | | | | |
| | 2. Auger grinding at a depth of 1.6 m below ground surface (Elev. 184.6 m). | | | | | | | | | | | | | | | |
| | 3. A Dynamic Cone Penetration Test was advanced 1.0 m north of Borehole S202-09 to confirm depth to refusal; refusal encountered at a depth of 1.7 m below ground surface (Elev. 184.5 m). | | | | | | | | | | | | | | | |

| | | | | | | | |
|----------------------|--|---|--|------------------|--|---------------|--|
| PROJECT 09-1111-6014 | | RECORD OF DCPT No S202-DC03 | | SHEET 1 OF 2 | | METRIC | |
| W.P. 5404-05-01 | | LOCATION N 5074271.7, E 225333.8 | | ORIGINATED BY MR | | | |
| DIST HWY 69 | | BOREHOLE TYPE Dynamic Cone Penetration Test | | COMPILED BY MAS | | | |
| DATUM Geodetic | | DATE March 10, 2011 | | CHECKED BY TVA | | | |



GTA-MTO 001 09-1111-6014.GPJ GAL-MISS GDT 7/25/12 SAC/DD

Continued Next Page



+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

| | | | | | | | |
|------------------------------------|--|--|--|-------------------------|--|---------------|--|
| PROJECT <u>09-1111-6014</u> | | RECORD OF DCPT No S202-DC03 | | SHEET 2 OF 2 | | METRIC | |
| W.P. <u>5404-05-01</u> | | LOCATION <u>N 5074271.7, E 225333.8</u> | | ORIGINATED BY <u>MR</u> | | | |
| DIST <u> </u> HWY <u>69</u> | | BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u> | | COMPILED BY <u>MAS</u> | | | |
| DATUM <u>Geodetic</u> | | DATE <u>March 10, 2011</u> | | CHECKED BY <u>TVA</u> | | | |

| SOIL PROFILE | | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT <div><div><div></div><div></div><div></div></div><div>20406080100</div></div> | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT <div><div><div></div><div></div><div></div></div><div>W_pWw_L</div></div> | 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 x REMOULDED <div><div><div></div><div></div><div></div></div><div>20406080100</div></div> | | | | | | |
| | --- CONTINUED FROM PREVIOUS PAGE --- | | | | | | | | | | | |
| | Dynamic Cone Penetration Test (DCPT) | | | | | | | 168 | | | | |
| | | | | | | | | 167 | | | | |
| | | | | | | | | 166 | | | | |
| | | | | | | | | 165 | | | | |
| | | | | | | | | 164 | | | | |
| 163.5 | | | | | | | | | | | | |
| 19.7 | END OF DCPT Refusal to Further Penetration (100 Blows / 0.18 m) NOTE: 1. Water flowing out of the DCPT hole at ground surface upon completion of penetration test. | | | | | | | | | | | |

GTA-MTO 001 09-1111-6014.GPJ GAL-MASS.GDT 7/25/12 SAC/DD

| | | | | | | | |
|------------------------------------|--|--|--|-------------------------|--|---------------|--|
| PROJECT <u>09-1111-6014</u> | | RECORD OF DCPT No S202-DC04 | | SHEET 1 OF 1 | | METRIC | |
| W.P. <u>5404-05-01</u> | | LOCATION <u>N 5074288.4, E 225369.2</u> | | ORIGINATED BY <u>MR</u> | | | |
| DIST <u> </u> HWY <u>69</u> | | BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u> | | COMPILED BY <u>MAS</u> | | | |
| DATUM <u>Geodetic</u> | | DATE <u>March 14, 2011</u> | | CHECKED BY <u>TVA</u> | | | |

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT  20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 | PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---------------|---|------------|---------|------|------------|----------------------------|---|--|---|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| 185.6 | GROUND SURFACE | | | | | | | | | | |
| 0.0 | Dynamic Cone Penetration Test (DCPT) | | | | | |  | | | | |
| 181.0 | END OF DCPT Refusal to Further Penetration (Hammer Bouncing) | | | | | | 181 | | | | |
| 4.6 | NOTE: 1. Bedrock outcrop observed in the vicinity of the DCPT. | | | | | | | | | | |

GTA-MTO 001 09-1111-6014.GPJ GAL-MISS.GDT 7/25/12 SAC/DD



APPENDIX C

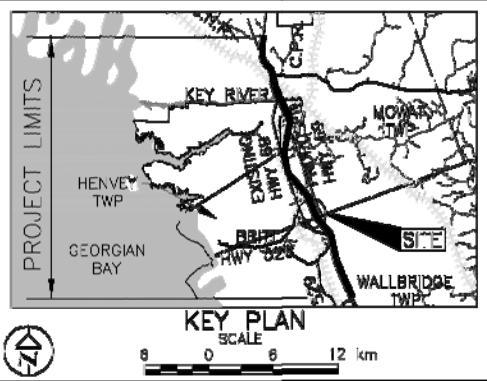
Borehole Locations Plan and Soil Strata at Structure Cattle Crossing Culvert

Explanation of Terms Used in Report

Record of Borehole Sheets

Results of Grain Size Distribution Analysis – Figure GS-CC-1

Plasticity Chart – Figure PC-CC-1

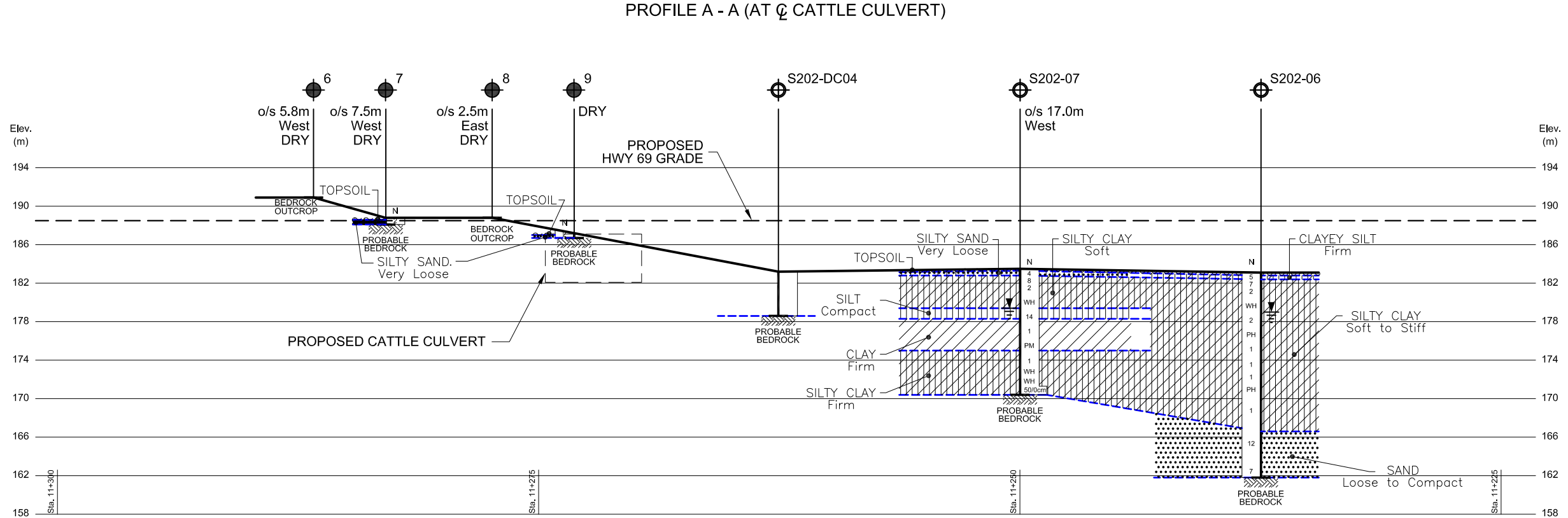
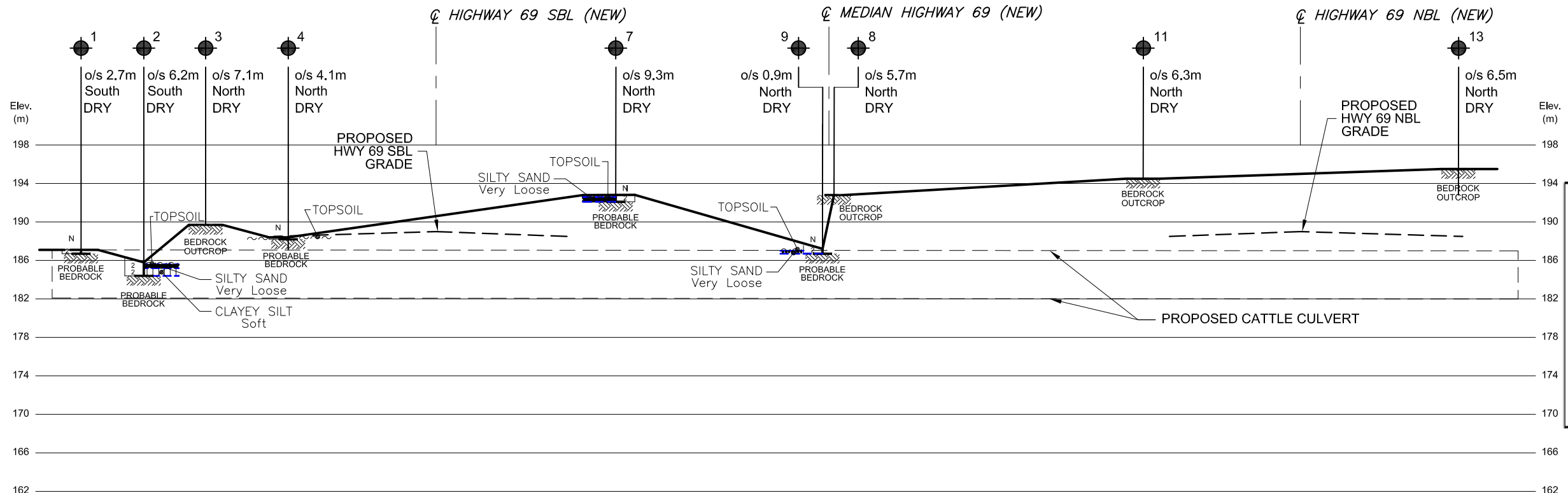


| LEGEND | | | |
|------------------------------------|--|-------------|----------|
| | Borehole | | |
| | Borehole & Cone | | |
| | Geocres Report Borehole (41H-119) | | |
| | Geocres Report Dynamic Cone (41H-119) | | |
| N | Blows/0.3m (Std. Pen Test, 475 J/blow) | | |
| CONE | Blows/0.3m (60 Cone, 475 J/blow) | | |
| | W L at time of investigation Nov. 2016 | | |
| | Head | | |
| | ARTESIAN WATER | | |
| | Encountered | | |
| | PIEZOMETER | | |
| BH No | ELEVATION | COORDINATES | |
| | | NORTHINGS | EASTINGS |
| REFER TO DRAWING CC-1, FOR DETAILS | | | |

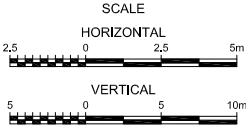
— NOTE —
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|----|-------------|
| | | | |
| | | | |
| | | | |

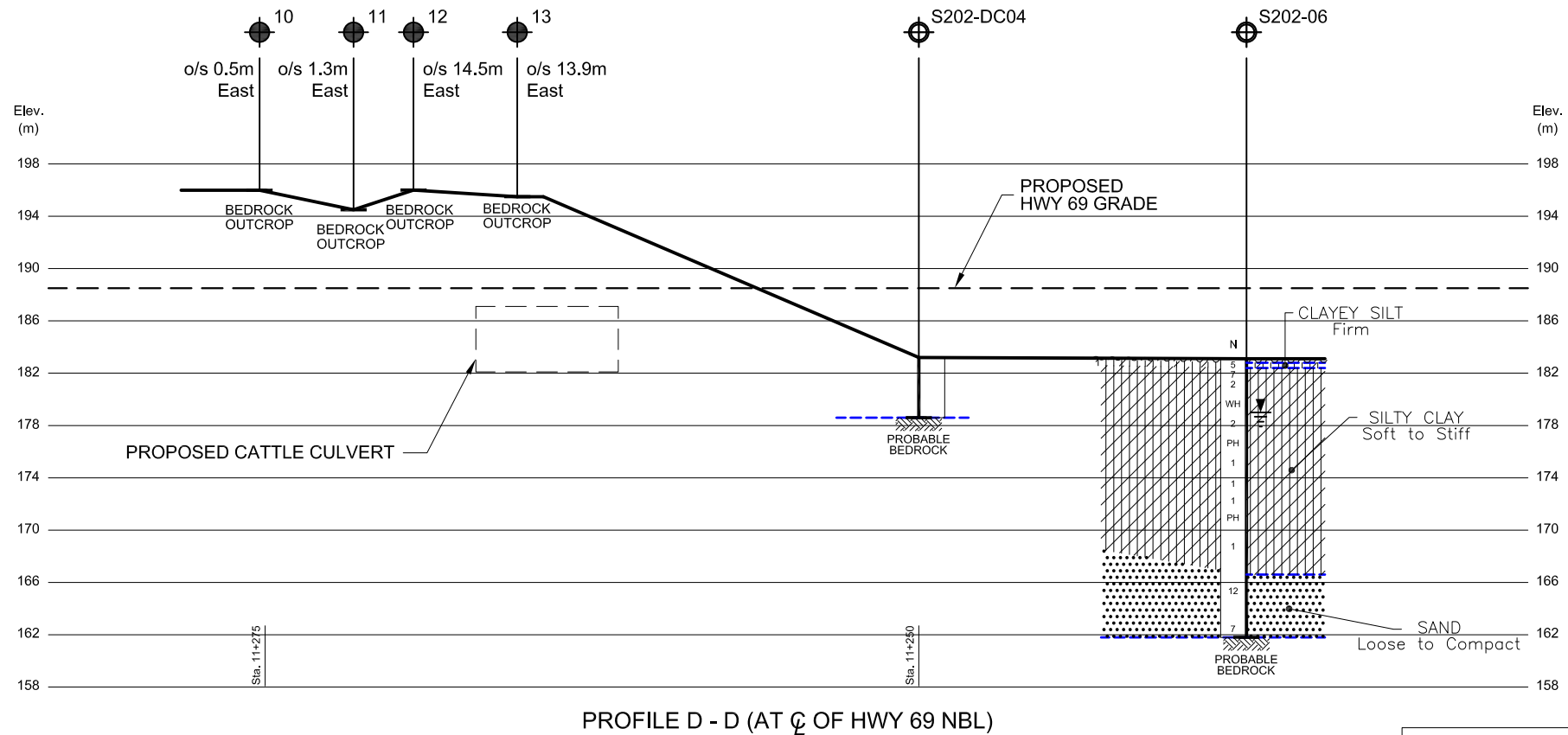
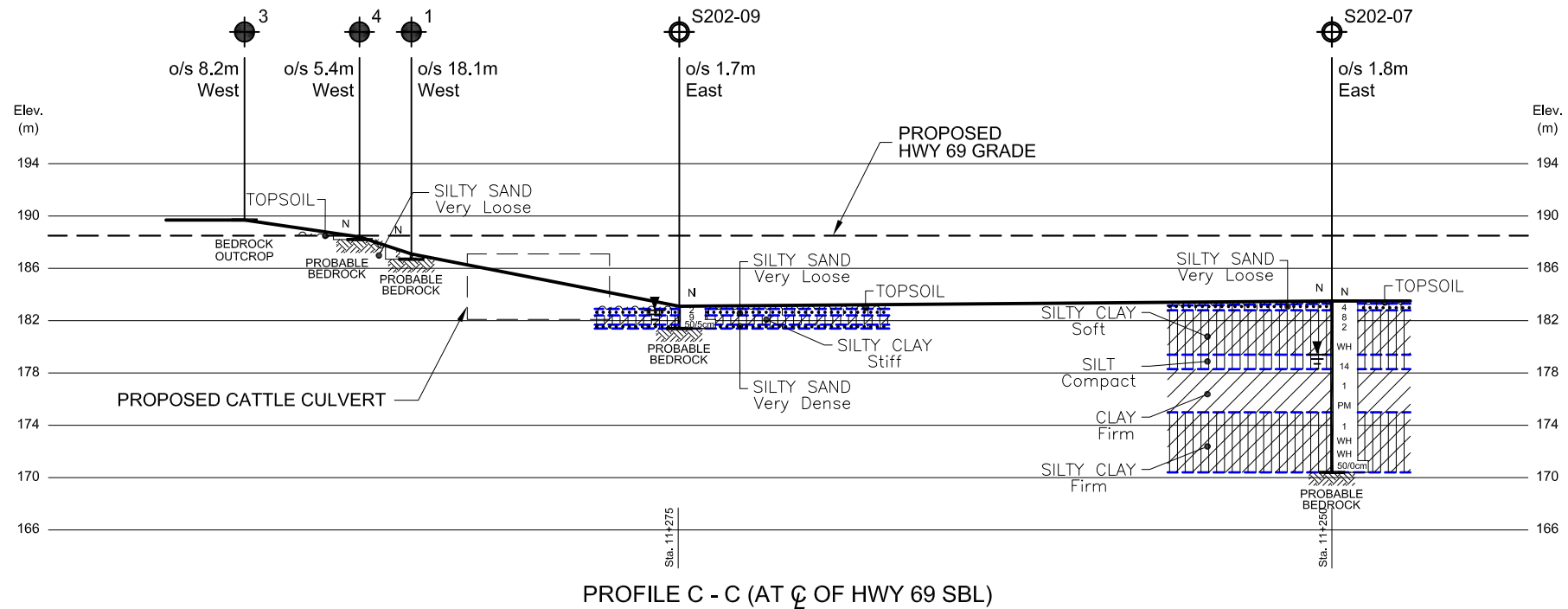
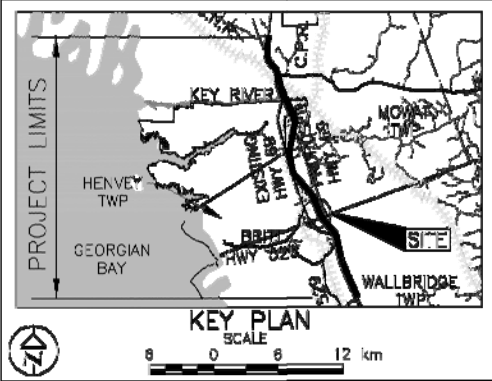
| | | | |
|---------------------|-----|-------------|--------------------|
| Geocres No. 41H-169 | | | |
| HWY No | 69 | DIST | 54 |
| SUBM'D | NA | CHECKED MKH | DATE JUNE 19, 2017 |
| DRAWN | NA | CHECKED MV | APPROVED CN |
| SITE | --- | DWG | CC-2 |



- NOTES:
- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
 - REFER TO DRAWING CC-1 FOR PROFILE LOCATIONS AND TO DRAWING CC-3 FOR PROFILES C-C AND D-D.
 - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
 - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



REF No.: HWY 69 plan.dwg prepared by URS; AND 17637 SKETCH.dwg dated December 16, 2016 and prepared by Dorland Limited, Ontario Land Surveyor



| LEGEND | | | |
|------------------------------------|--|-------------|----------|
| | Borehole | | |
| | Borehole & Cone | | |
| | Geocres Report Borehole (41H-119) | | |
| | Geocres Report Dynamic Cone (41H-119) | | |
| | Blows/0.3m (Std. Pen Test, 475 J/blow) | | |
| | Blows/0.3m (60 Cone, 475 J/blow) | | |
| | W L at time of investigation Nov. 2016 | | |
| | Head | | |
| | ARTESIAN WATER | | |
| | Encountered | | |
| | PIEZOMETER | | |
| BH No | ELEVATION | COORDINATES | |
| | | NORTHINGS | EASTINGS |
| REFER TO DRAWING CC-1, FOR DETAILS | | | |

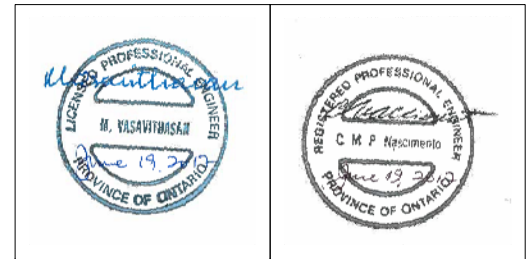
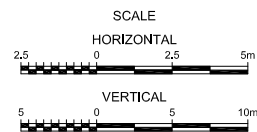
— NOTE —
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|----|-------------|
| | | | |
| | | | |
| | | | |

| | | | | | |
|---------------------|----|---------|-----|----------|---------------|
| Geocres No. 41H-169 | | | | | |
| HWY No | 69 | CHECKED | MKH | DATE | JUNE 19, 2017 |
| SUBM'D | NA | CHECKED | MV | APPROVED | CN |
| DRAWN | NA | CHECKED | MV | APPROVED | CN |
| DIST | 54 | SITE | -- | DWG | CC-3 |

REF No.: HWY 69 plan.dwg prepared by URS; AND 17637 SKETCH.dwg dated December 16, 2016 and prepared by Dorland Limited, Ontario Land Surveyor

- NOTES:
- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
 - REFER TO DRAWING CC-1 FOR PROFILE LOCATIONS AND DRAWING CC-2 FOR PROFILES A-A AND B-B.
 - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
 - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



EXPLANATION OF TERMS USED IN REPORT

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

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON '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.

COMPOSITION: SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

| PERCENT BY MASS | 0 - 10 | 10 - 20 | 20 - 30 | 30 - 40 | > 40 |
|-----------------|--------|---------|---------|-------------------|----------------|
| | TRACE | SOME | WITH | ADJECTIVE (SILTY) | AND (AND SILT) |

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

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

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

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

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

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

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

| R Q D (%) | 0 - 25 | 25 - 50 | 50 - 75 | 75 - 90 | 90 - 100 |
|-----------|-----------|---------|---------|---------|-----------|
| | VERY POOR | POOR | FAIR | GOOD | EXCELLENT |

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

| | | |
|--------------------------------------|-----|-------------------------------|
| u_w | kPa | PORE WATER PRESSURE |
| 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 |
| S_i | 1 | SENSITIVITY = $\frac{c_u}{\tau_r}$ |

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No 1

1 of 1

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 074 296.0 N ; 295 326.6 E ORIGINATED BY S.A.
DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.
DATUM Geodetic HWY 69 DATE November 09, 2016 CHECKED BY M.V.

| 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/m³ | 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 | | -----○----- |
| 187.1 | Ground Surface | | | | | | 20 | 40 | 60 | 80 | 100 | 20 | 40 | 60 | | | | | | |
| 187.0 | Topsoil | | 1 | SS | 2 | | 187 | | | | | | | | | | | | | |
| 186.7 | Silty sand, rootlets | | | | | | | | | | | | | | | | | | | |
| 0.4 | Very loose Dark brown/black | | | | | | | | | | | | | | | | | | | |
| | End of borehole | | | | | | | | | | | | | | | | | | | |
| | Refusal on probable bedrock | | | | | | | | | | | | | | | | | | | |
| | * Borehole dry | | | | | | | | | | | | | | | | | | | |
| | NOTE: Organic content of surficial material was at 14.6% | | | | | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No 2

1 of 1

METRIC

| | | | | | |
|--------|------------|----------|--------------------------------------|---------------|------|
| G.W.P. | 5404-05-00 | LOCATION | Co-ords: 5 074 292.4 N ; 295 329.8 E | ORIGINATED BY | S.A. |
|--------|------------|----------|--------------------------------------|---------------|------|

DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.

DATUM Geodetic HWY 69 DATE November 09, 2016 CHECKED BY M.V.

[illegible]

RECORD OF BOREHOLE No 3

1 of 1

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 074 305.5 N ; 295 333.5 E ORIGINATED BY S.A.
DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.
DATUM Geodetic HWY 69 DATE November 09, 2016 CHECKED BY M.V.


| 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/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL | | | |
|---------------|---------------------|------------|---------|------|------------|---------------------------------|-----------------|--|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|------------------------------|--|--|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | | | WATER CONTENT (%) | | |
| | | | | | | | | <div>○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE</div> | | | | | | | | | | <div>W_p W W_L</div> | | |
| 189.7 | Ground Surface | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | | | |
| 0.0 | Bedrock at surface | | | | | | | | | | | | | | | | | | | |
| | * Borehole dry | | | | | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No 4

1 of 1

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 074 302.4 N ; 295 337.7 E ORIGINATED BY S.A.
DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.
DATUM Geodetic HWY 69 DATE November 09, 2016 CHECKED BY M.V.

| 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 | | | | | | | | | |
| 188.4 | Ground Surface |  | | | | * | | 20 | 40 | 60 | 80 | 100 | | | | | GR SA SI CL |
| 188.2 | Topsoil | | | | | | | | | | | | | | | | |
| 0.2 | End of borehole | | | | | | | | | | | | | | | | |
| | Refusal on probable bedrock | | | | | | | | | | | | | | | | |
| | * Borehole dry | | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No 5

1 of 1

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 074 294.0 N ; 295 337.4 E ORIGINATED BY S.A.
 DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.
 DATUM Geodetic HWY 69 DATE November 09, 2016 CHECKED BY M.V.

| 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 | | | | | | | | | |
| | | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | |
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RECORD OF BOREHOLE No 6

1 of 1

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 074 308.7 N ; 295 355.0 E ORIGINATED BY S.A.

DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.

DATUM Geodetic HWY 69 DATE November 10, 2016 CHECKED BY M.V.

[illegible]

RECORD OF BOREHOLE No 7

1 of 1

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 074 304.6 N ; 295 354.8 E ORIGINATED BY S.A.
DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.
DATUM Geodetic HWY 69 DATE November 10, 2016 CHECKED BY M.V.

| 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 | | | | | | | | | | WATER CONTENT (%) | | |
| | | | | | | | | ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | | | | | | | |
| 188.8 | Ground Surface | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | | | |
| 188.6 | Topsoil | | 1 | SS | 2 | | | | | | | | | | | | | | | |
| 0.2 | Silty sand, organics | | | | | | | | | | | | | | | | | | | |
| 188.3 | Very loose Dark Moist brown | | | | | | | | | | | | | | | | | | | |
| 0.5 | End of borehole | | | | | | | | | | | | | | | | | | | |
| | Refusal on probable bedrock | | | | | | | | | | | | | | | | | | | |
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RECORD OF BOREHOLE No 8

1 of 1

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 074 303.1 N ; 295 366.1 E ORIGINATED BY S.A.
DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.
DATUM Geodetic HWY 69 DATE November 10, 2016 CHECKED BY M.V.

| 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 (%) 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 | | | | | | | |
| 188.8 | Ground Surface | | | | | | | | | | | | | | | | | | | |
| 0.0 | Bedrock at surface | | | | | | | | | | | | | | | | | | | |
| | * Borehole dry | | | | | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No 9

1 of 1

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 074 298.3 N ; 295 365.3 E ORIGINATED BY S.A.
DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.
DATUM Geodetic HWY 69 DATE November 10, 2016 CHECKED BY M.V.

| 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/m³ | 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 | | | | | | | | | |
| 187.2 | Ground Surface | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | | | |
| 187.0 | Topsoil | | 1 | SS | 2 | | 187 | | | | | | | | | | | | | |
| 0.2 | Silty sand, organics | | | | | | | | | | | | | | | | | | | |
| 186.7 | Very loose Dark Moist brown | | | | | | | | | | | | | | | | | | | |
| 0.5 | End of borehole | | | | | | | | | | | | | | | | | | | |
| | Refusal on probable bedrock | | | | | | | | | | | | | | | | | | | |
| | * Borehole dry | | | | | | | | | | | | | | | | | | | |
| | NOTE: Organic content of surficial material was at 17.2% | | | | | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No 10

1 of 1

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 074 307.3 N ; 295 382.4 E ORIGINATED BY S.A.
 DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.
 DATUM Geodetic HWY 69 DATE November 10, 2016 CHECKED BY M.V.

| 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/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL | | | |
|---------------|--------------------|------------|---------|------|------------|---------------------------------|-----------------|--|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|------------------------------|--|-------------------|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | | | WATER CONTENT (%) | | |
| | | | | | | | | <div>○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE</div> | | | | | | | | | | <div>○</div> | | |
| 196.0 | Ground Surface | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | | | |
| 0.0 | Bedrock at surface | | | | | | | | | | | | | | | | | | | |
| | * Borehole dry | | | | | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No 11

1 of 1

METRIC

G.W.P. 5404-05-00 LOCATION Co-ords: 5 074 303.3 N ; 295 382.1 E ORIGINATED BY S.A.
DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.
DATUM Geodetic HWY 69 DATE November 10, 2016 CHECKED BY M.V.

| 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 | | | | | | | | | | WATER CONTENT (%) | | |
| | | | | | | | | ○ UNCONFINED | ● QUICK TRIAXIAL | + | × | FIELD VANE | | | | | | LAB VANE | | |
| 194.5 | Ground Surface | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | GR SA SI CL | | | |
| 0.0 | Bedrock at surface | | | | | | | | | | | | | | | | | | | |
| | * Borehole dry | | | | | | | | | | | | | | | | | | | |

RECORD OF BOREHOLE No 12

1 of 1

METRIC

| | | | | | |
|--------|------------|----------|--------------------------------------|---------------|------|
| G.W.P. | 5404-05-00 | LOCATION | Co-ords: 5 074 306.9 N ; 295 397.6 E | ORIGINATED BY | S.A. |
|--------|------------|----------|--------------------------------------|---------------|------|

DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.

DATUM Geodetic HWY 69 DATE November 10, 2016 CHECKED BY M.V.

[illegible]

RECORD OF BOREHOLE No 13

1 of 1

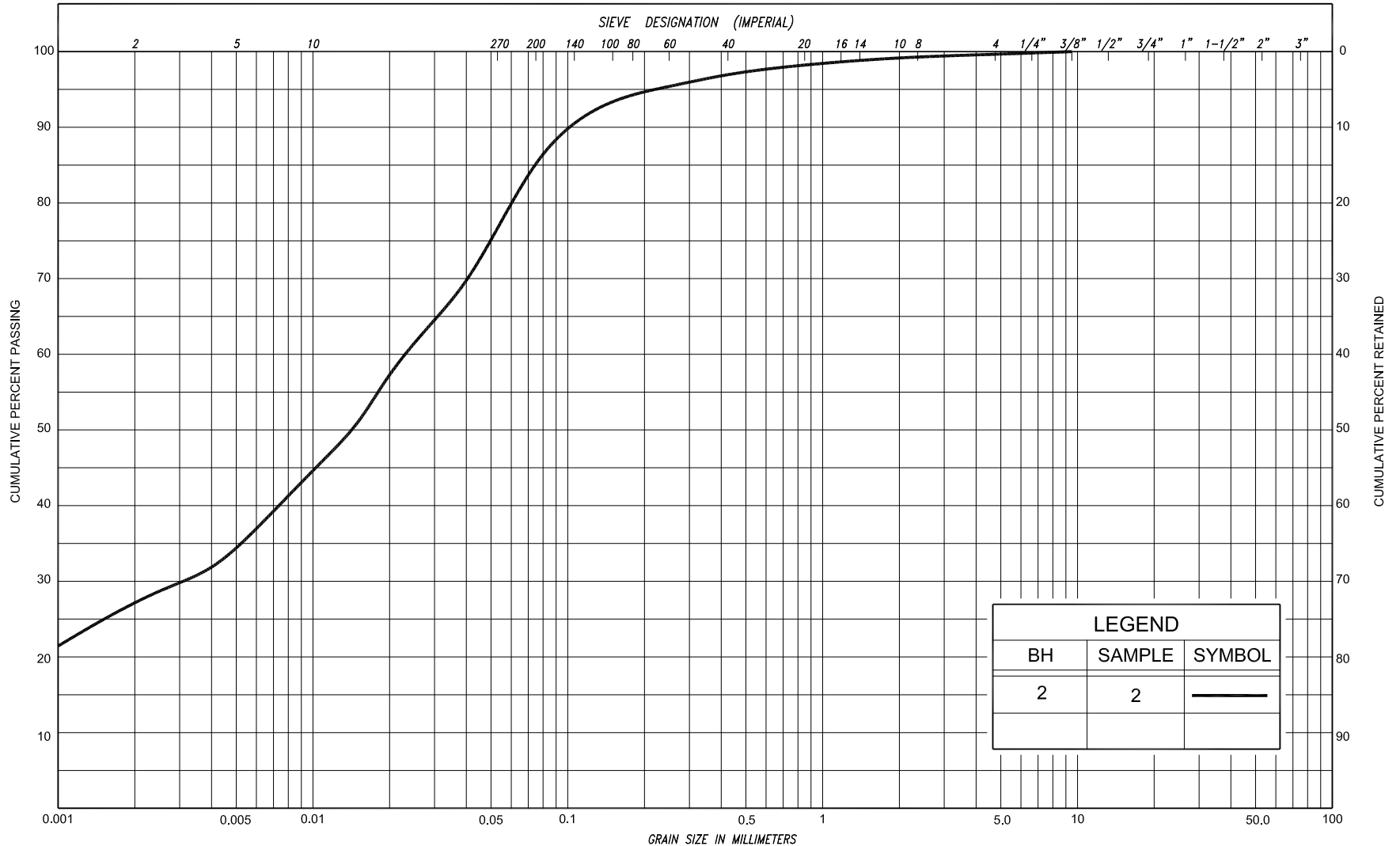
METRIC

| | | | | | |
|--------|------------|----------|--------------------------------------|---------------|------|
| G.W.P. | 5404-05-00 | LOCATION | Co-ords: 5 074 303.0 N ; 295 398.5 E | ORIGINATED BY | S.A. |
|--------|------------|----------|--------------------------------------|---------------|------|

DIST Sudbury BOREHOLE TYPE Tripod - Hand Augers COMPILED BY M.Kh.

DATUM Geodetic HWY 69 DATE November 10, 2016 CHECKED BY M.V.

[illegible]



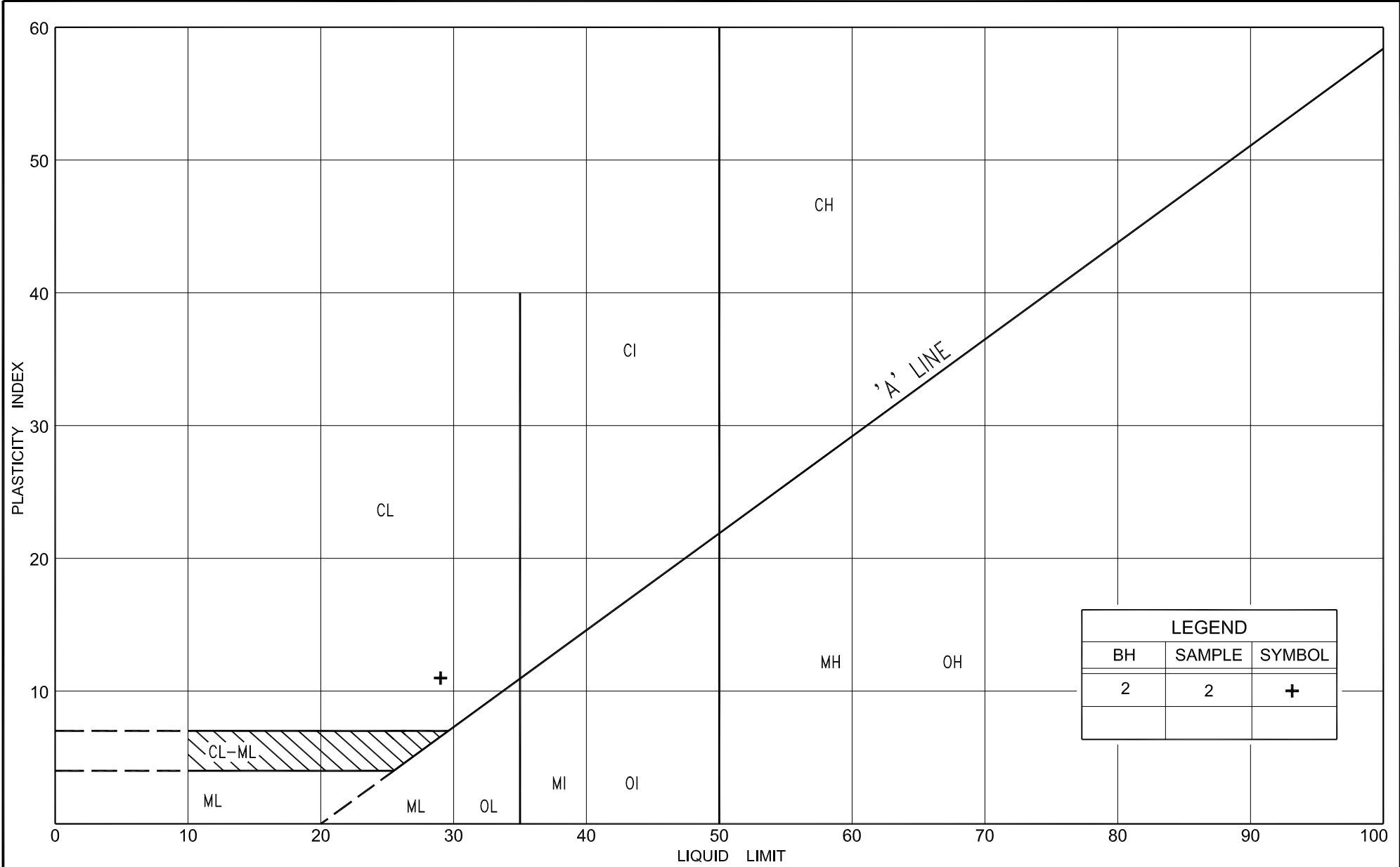
| LEGEND | | |
|--------|--------|--------|
| BH | SAMPLE | SYMBOL |
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| | | | | | | | | | | | | | | | | | |
|-------------|------|------|--------|---------|------|--------|--------|--------|--------|--|--|---------|---------|-------------|--|--|--|
| SILT & CLAY | | | | FINE | | MEDIUM | | COARSE | GRAVEL | | | COBBLES | UNIFIED | | | | |
| | | | | SAND | | | | | | | | | | | | | |
| CLAY | FINE | | MEDIUM | COARSE | FINE | | MEDIUM | COARSE | GRAVEL | | | | COBBLES | M.I.T. | | | |
| | SILT | | | SAND | | | | | | | | | | | | | |
| CLAY | | SILT | | V. FINE | FINE | MED. | COARSE | GRAVEL | | | | | | U.S. BUREAU | | | |
| | | | | SAND | | | | | | | | | | | | | |



GRAIN SIZE DISTRIBUTION CLAYEY SILT, some sand

| | |
|---------|------------|
| FIG No. | GS-CC-1 |
| HWY | 69 |
| G.W.P. | 5054-05-00 |



PLASTICITY CHART

CLAYEY SILT, some sand

FIG No. PC-CC-1

HWY 69

G.W.P. 5054-05-00



**PART B – PRELIMINARY FOUNDATION DESIGN REPORT
for
CATTLE CROSSING CULVERT AT STATION 11+272
HIGHWAY 69 FOUR-LANING 19.7 KM FROM 1.7 KM NORTH OF
HIGHWAY 529 (NORTH JUNCTION) TO 3.9 KM
NORTH OF HIGHWAY 522
TOWNSHIP OF HENVEY, ONTARIO
AGREEMENT NO.: 5013-E-0036
WORK ORDER # 12**

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email: toronto@petomaccallum.com

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1 cc: PML Toronto

PML Ref.: 14TF034E
Index No.: 039FDR
GEOCRES No.: 41H-169
June 19, 2017



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Appendix FDR-A – List of Standard Specifications Relevant to Report

PART B
PRELIMINARY FOUNDATION DESIGN REPORT
for
Cattle Crossing Culvert at
Station 11+272, Highway 69
Township of Henvey, Ontario
Agreement No.: 5013-E-0036, Work Order # 12

8. INTRODUCTION

This foundation investigation and design report with the interpretation and recommendations are intended for the use of Parsons on behalf of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The design-build contractor must make their own interpretation based on the factual data in Part A of the report. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided in Part A of the report, as it may affect equipment selection, proposed construction methods, and scheduling.

9. PROJECT DESCRIPTION

9.1 General

This report provides preliminary foundation design recommendations based on interpretation of the geotechnical data presented in the factual report (Part A). This report is to assist the design team in the selection of a suitable type of foundation for the Cattle Crossing Culvert located on re-aligned Highway 69 at Sta. 11+272, in the Township of Henvey, District of Parry Sound, Ontario.

A preliminary General Arrangement (GA) drawing for the Cattle Crossing Culvert was not available at the time of preparing this report. Based on the RFP document provided by MTO, it is proposed to place a 5 m x 5 m, approximately 76 m long box culvert across re-aligned Highway 69 at Sta. 11+272, to accommodate appropriate access for cattle grazing on both sides of the new highway. The profile of Highway 69 provided by Parsons indicates that the proposed invert of the culvert is expected to vary from approximately El. 181.96 at the east end to El. 182.13 at the west end. The grade of the road at the proposed culvert location will be set at elevation of El. 188.5, which will result in a fill height of 1.5 m above the culvert and up to 6.5 m on the sides of the culvert.



9.2 Structure Foundation

In general, the subsoil conditions on the north side of the proposed culvert footprint consist of an exposed rock outcrop locally covered by a thin layer of topsoil. The overburden on the south side of the culvert location consists of 0.4 m silty sand followed by about 0.8 m clayey silt deposit underlain by bedrock. The bedrock surface slopes down from north to south and the bedrock elevations on the south side are approximately 3.0 m lower than that on the north side. Groundwater was not observed in any of the boreholes during the investigation carried out by PML. However, site investigation report prepared by Golder Associates reveal that artesian condition was observed in the boreholes located 50 m to 70 m south of the proposed culvert location. Artesian water level in those boreholes were observed at about 0.5 m to 1.5 m above the existing ground surface (El. 184.1 to 183.1). Further investigation may be required to confirm the existence of groundwater within the bedrock.

The probable bedrock surface within the footprint of the proposed culvert varies from El. 196.0 to El. 184.4. Since the invert level of the proposed culvert vary from El. 182.0 to 182.10, the culvert subgrade will consist of the local bedrock formation. It is noted that the probable bedrock surface elevations presented on the borehole logs were inferred by probing with a steel rod and the bedrock levels require confirmation by rock coring. To carry out the final design and construction of the proposed culvert, an additional site investigation is recommended to establish the bedrock elevations and to assess the quality and type of bedrock.

The feasibility of the following three options are discussed for construction of culvert at the proposed location:

- Precast concrete box culvert,
- Cast-in-Place concrete box culvert, and
- Cast-in-Place concrete open culvert on strip footing.

In addition, the exposed rock wall with a concrete slab may also be considered as an option for the culvert crossing. However, sufficient data such as fractures and joints of the bedrock should be obtained. Considering the subsurface conditions, the recommendations for the proposed culvert foundations are provided below in the order of preference. A comparison of the technical advantages and disadvantages for the proposed culvert are presented in Table 9-2.



Table 9-2 - Comparison of Alternate Culvert Options

| OPTION 1: CAST-IN-PLACE OPEN CULVERT | OPTION 2: CAST-IN-PLACE CONCRETE BOX CULVERT | OPTION 3: PRECAST CONCRETE BOX CULVERT |
|---|--|---|
| <p>Advantages:</p> <ol style="list-style-type: none"> 1. Generally allows for natural terrain surface of passage to remain 2. Footings may be placed at the surface of bedrock and dowelled into the rock to minimise rock excavation 3. North side wall of the culvert may be cast against the bedrock with a vertical drainage system to reduce the formwork required 4. High geotechnical resistance is available at the founding level to support the culvert on strip footing and provide sliding resistance | <p>Advantages:</p> <ol style="list-style-type: none"> 1. Eliminates uneven path way for cattle 2. Reduces water leakage and deterioration of culvert 3. Longer life span of the structure 4. Larger base surface area results in higher sliding resistance 5. Ability to withstand differential settlement | <p>Advantages:</p> <ol style="list-style-type: none"> 1. High degree of quality and uniformity, design flexibility, superior strength, and durability 2. Eliminates uneven path way for cattle 3. Does not require site formwork and reduces construction operations 4. Construction can performed in wet conditions 5. Construction is not dependent on weather condition |
| <p>Disadvantages:</p> <ol style="list-style-type: none"> 1. Requires formwork to construct the culvert 2. Requires vertical drainage system behind the sidewalls 3. Construction should be performed in dry condition 4. Likely requires dowels to mobilise adequate sliding resistance | <p>Disadvantages:</p> <ol style="list-style-type: none"> 1. Requires deeper rock excavation and formwork to construct the culvert compared to open culvert 2. Natural terrain surface will not remain 3. Requires more costly concrete base slab compared to open culvert 4. Construction should be performed in dry condition | <p>Disadvantages:</p> <ol style="list-style-type: none"> 1. Require substantially larger rock excavation and bedding compared to open culvert 2. Natural terrain surface will not remain 3. Will require backfill and protection of bedding from washouts |
| Recommended | Technically Feasible; Not Preferred | Technically Feasible; Not Recommended |



9.2.1 Option 1: Cast-In-Place Rigid Frame Open Culvert on Footings

Based on the information available, it is assumed that the proposed culvert will be placed at about El. 181.95. The proposed founding elevation of the culvert is expected to result in approximately 7.4 m of rock excavation on the north side and about 4.5 m on the south side

The footings for the open culvert placed on the inferred competent bedrock surface or surfaces exposed by excavation, may be designed assuming a factored geotechnical resistance of 1000 kPa at ULS. Geotechnical resistance or the bearing pressure at SLS will not govern because of the competent bedrock at the founding elevation and the load expected from the proposed structure at the footing level. The load required to produce detrimental settlement of the structure will be much larger than the recommended value for factored geotechnical resistance at ULS.

All the shattered and loose rock or any mica deposits from the bedrock surface within the footprint of the footings should be removed prior to placing concrete, to ensure proper bond between the footing and the bedrock.

Provisions should be included in the contract document to address the requirement for a field investigation to establish the bedrock surface, and to inspect and approve the founding surface. Provision shall also be allowed in the design to accommodate at least 75 mm of lean concrete to cover the bedrock surface to prevent any deterioration of founding surface until the dowels or the concrete for footings is poured. This requirement should be addressed with a note on the structural drawing for foundation and/or with a Non Standard Special Provision (NSSP).

9.2.2 Option 2: Cast-In-Place Reinforced Concrete Box Culvert

In the case of cast-in-place concrete box culvert, the proposed founding level of El. 181.95 will involve substantially larger quantity of rock excavation than that of the open culvert on footings, unless the floor of the culvert can be placed at different levels. The design of the cast-in-place box culvert placed on competent bedrock may be designed assuming the factored resistance recommended for Option 1.



9.2.3 Option 3: Precast Concrete Box Culvert

The invert of the precast concrete box culvert will have to be placed at the same elevation across the width of the floor, i.e., at El. 181.95. This will involve substantially larger quantity of rock excavation compared to Option 1. The option of a precast box culvert will require at least 75 mm of leveling course meeting the requirement of OPSS 422.07.08 and bedding material as specified in OPSS 422.05.13. The bedding for the replacement culvert should be placed in accordance with Section 422.07.07 of OPSS 422.

For the design of the precast concrete box culvert placed at El. 181.95 on a competent bedrock, a factored geotechnical resistance of 800 kPa at ULS should be utilized.

In view of the construction difficulties expected, this option is not preferred.

9.2.4 Recommended Option for the Proposed Culvert

Considering the depth of excavation through bedrock and from a construction perspective, cast-in-place rigid frame open culvert placed at about El 181.95 on strip footings or footings with dowels into the bedrock is the preferred option for the proposed culvert.

Options 2 and 3 are technically feasible. As outlined previously, considering the construction difficulties and amount of rock excavation involved, these options are not recommended.

9.2.5 Lateral Earth Pressure

Earth pressure for the concrete structure should be computed as per the Clause 6.12.2 (b) of Canadian Highway Bridge Design Code (CHBDC, 2014). The lateral earth and compaction pressure, p (kPa), may be computed using the equivalent fluid pressures presented in Section 6.12 of the CHBDC 2014 or employing the following equation assuming a triangular pressure distribution.



$$P = K (\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2 + C_p + C_s$$

Where, P = lateral earth pressure (kPa)

K = lateral earth pressure coefficient

γ = unit weight of backfill material above water level (kN/m³)

γ' = unit weight of submerged backfill ($\gamma - \gamma_w$) material below water level (kN/m³)

γ_w = unit weight of water (9.8 kN/m³)

h_1 = depth below final grade (m), above assumed water level

h_2 = depth below assumed water level (m)

q = surcharge load (kPa)

C_p = compaction pressure (refer to clause 6.12.3 of CHBDC 2014)

C_s = earth pressure induced by seismic events, kPa (refer to clause 4.6.5 of CHBDC 2014)

ϕ = angle of internal friction of retained soil (35° for Granular A or 30° for Granular B Type II)

δ = angle of friction between soil and wall (24° for Granular A or B Type II)

The seismic site coefficient for the conditions at this site is provided in Section 10 of this report. Granular 'A' or 'B' should be utilized as backfill material and should be carried out in accordance with the requirements specified in the OPSS 902. The following parameters are recommended for the granular backfill:

Table 9.2.5: Recommended Geotechnical Parameters

| GEOTECHNICAL PARAMETER | GRANULAR A GRANULAR B TYPE II | GRANULAR B TYPE I | ROCK FILL |
|---|-------------------------------------|----------------------|-----------|
| Angle of Internal Friction, Degrees | 35° | 30° | 40° |
| Unit Weight, kN/m ³ | 22.5 | 21.5 | 19.0 |
| Coefficient of Active Earth Pressure (K_a) | 0.27 | 0.33 | 0.21 |
| Coefficient of Earth Pressure at Rest (K_o) | 0.43 | 0.5 | 0.35 |
| Coefficient of Passive Earth Pressure (K_p) | 3.69 | 3 | 4.6 |



The foundation of the culvert placed on bedrock should be considered unyielding and movement of the wall may not be expected to mobilise active earth pressure. In view of this, “at rest” conditions should be assumed for the calculation of earth pressure for all three options.

An unfactored coefficient of friction value of $\tan 35^\circ$ may be assumed for the estimate of the sliding resistance if the spread footings for open culvert is placed directly on competent bedrock. In view of the limited depth of embedment into the bedrock, dowels may be provided at the base of the foundation, if sufficient resistance cannot be mobilized from the weight of the structure.

In case the vertical wall of the culvert is constructed against the rock surface, a minimum of 300 mm thick drainage layer behind the wall with weep holes located near the floor of the culvert may be provided to drain any water accumulated. There may be freezing of water behind the wall and it may be advisable to design the wall to resist lateral pressure.

9.3 Approach Embankments

Based on the profile grade of re-aligned Highway 69 at the culvert location, the height of approach fill on the north side of the culvert within SBL and the median of Highway 69 is expected to be approximately 1.5 m above the existing ground surface and on the south side, it will be about 2.5 m high. The approach embankment fill on the north side is expected to be placed on bedrock surface. However, based on the subsoil information from the report of Golder Associates, the fill on the south side of the culvert is expected to be placed mainly over very loose silt or silty sand.

The design of approach embankments on the south side of the culvert may require stability analyses and estimate of post construction settlements at the design build stage.

Based on the profile grade of NBL, the pavement near the culvert on both side is expected to be constructed directly on the exposed competent rock surface and no settlement or stability problems are anticipated.

9.4 Foundation Frost Depth

In accordance with OPSD 3090.101, a minimum of 2.0 m earth cover is required to protect against the frost penetration in the area where the site is located. However, frost cover may not be required if footings are placed directly on competent bedrock where pooling or ponding of water below footing is not expected.



9.5 Backfill, Bedding and Cover

9.5.1 Backfill and Bedding for Cast-in-Place Concrete Culvert

Granular backfill and bedding materials should be as specified in OPSS 902.05.01 and meet the requirements of OPSS 1010. Any 19.0 mm clear stone that is used for wall drains should be according to OPSS 1004. If native material is used as backfill, it should be in accordance with OPSS 902.05.02 and free from any rock or boulders over 150 mm in dimension.

As required by OPSS 902.07.06.01, the differential in surface elevation of the backfill material on each side of cast-in-place concrete culverts should not be greater than 500 mm during backfilling.

9.5.2 Cover and Backfill for Precast Concrete Box Culvert

Backfill materials shall meet the requirements of Group I, or Group II specified in OPSS 422.05.14, and placed according to the procedures described in Section 422.07.11. It shall be placed in layers not exceeding 200 mm in thickness before compaction and compacted in accordance with OPSS 501. Backfill on each side of the precast box culvert should be completed simultaneously and at the backfill levels on each side of the culvert not exceed 400 mm. Restrictions on compaction near the culvert shall be as specified in OPSS 902.07.06.02.

The cover material shall meet the requirements of OPSS 422.05.15 and placed in accordance with OPSS 422.07.12.

9.6 Excavation

Based on the borehole data, the excavation to construct the proposed culvert is expected to advance through about 4.6 m deep bedrock and overburden soils below the ground surface. The overburden at this site may be categorised as Type 3 Soils according to Occupational Health and Safety Act (OHSA). Excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and MTO regulations.



10. GROUNDWATER CONTROL

The groundwater was not observed during the field investigation, however, it may be expected depending on the time of the construction. In order to carry out construction in the dry, any groundwater or surface run-off encountered during the excavation should be removed. A sump and pump method supplemented with perimeter drains should be adequate to control the water.

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

A drainage layer or blanket may be required behind the wall of the culvert to drain the water and to reduce the buildup of potential hydrostatic pressure on the sides of the culvert. This should be taken into consideration during the detail design of the culvert.

11. SCOPE OF WORK REQUIRED FOR FINAL DESIGN

The recommendations in this report are based on a limited field investigation due to access constraints and is for preliminary design. Detailed foundation engineering services will be required during the Detail Design phase of the project.

It should be noted that the bedrock surface elevations presented on the borehole logs were inferred by probing with a steel rod and the bedrock levels require confirmation by rock coring. To carry out the final design and construction of the proposed culvert, an additional site investigation is recommended to establish the bedrock elevations and to assess the quality and type of bedrock.



12. CLOSURE

This Foundation Investigation and Design Report was prepared by Mr. M. Khorsand, B.Sc. Eng., EIT., Project Supervisor, and reviewed by Mr. M. Vasavithasan, MSc. Eng., P.Eng. Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

A handwritten signature in blue ink, appearing to read "Mansoor", with the date "Jun 19, 2017" written below it.

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APPENDIX FDR-A

List of Standard Specifications Relevant to Report



LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

| DOCUMENT | TITLE |
|---------------|---|
| OPSS 422 | Construction Specification for Precast Reinforced Concrete Box Culverts in Open Cut |
| OPSS 501 | Construction Specification for Compacting |
| OPSS 902 | Construction Specification for Excavating and Backfilling - Structures |
| OPSD 3090.101 | Foundation Frost Depth for Southern Ontario |