



October 2013

## REPORT ON

### **Preliminary Foundation Investigation and Design Union Road Culvert Replacement Site No. 28-034c 0.4 km North of Union Road Highway 62, Prince Edward County, Ontario W.P. 4153-10-01**

**Submitted to:**

McCormick Rankin | A Member of MMM Group  
1145 Hunt Club Road, Suite 300  
Ottawa, Ontario  
K1V 0Y3

REPORT



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**PRELIMINARY FOUNDATION REPORT  
UNION ROAD CULVERT REPLACEMENT - HIGHWAY 62**

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# **PART A**

**PRELIMINARY FOUNDATION INVESTIGATION REPORT**

**UNION ROAD CULVERT REPLACEMENT**

**SITE 28-034C**

**0.4 KM NORTH OF UNION ROAD**

**HIGHWAY 62**

**W.P. 4153-10-01**





## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin, a member of MMM Group Limited (MRC) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with the Design-Build of seven culvert replacements and two bridge replacements at various locations in the Eastern Region of Ontario as part of the 22 Structures MEGA 2 project. This report presents the results of the foundation investigation conducted for the replacement of the Union Road culvert, Site No. 28-034c (WP 4153-10-01) located on Highway 62 about 0.4 km north of Union Road in Prince Edward County, Ontario.

The purpose of the foundation investigation was to assess the subsurface conditions for the proposed culvert replacement by drilling four boreholes and carrying out in-situ testing and laboratory testing on selected samples. The terms of reference for the original scope of work are outlined in the MTO's Request for Proposal (RFP) dated April 2012. The work was carried out in accordance with Golder's Quality Control Plan dated August 2012.





## **2.0 SITE DESCRIPTION**

The Union Road culvert is located on Highway 62 about 0.4 km north of Union Road in Prince Edward County, Ontario. The existing culvert (Site No. 28-034c) is located at about Station 12+258.

The existing culvert is a 3.05 m wide by 1.5 m high, single-span reinforced concrete non-rigid frame structure, cast-in-place, which is about 23.2 m in length. The date of construction of the culvert is unknown. Extensions have been added to both ends of the culvert and it is in generally poor condition. The existing culvert inverts are at about Elevations 74.3 and 74.2 m at the west and east ends, respectively, with the flow in the culvert from west to east. The depth of water within the culvert was about 1.2 m at the time of the field investigation. The width of the water course is about 4 m at the inlet and about 5 m at the outlet.

The existing pavement grade at the culvert location is at about Elevation 77.3 m. In this area, Highway 62 is one lane wide in each direction (i.e., a two-lane highway). The existing embankment slopes at the culvert locations are about 2 to 3 m in height, with the existing side slopes oriented at about 1.5H:1V. Based on visual observations at the time of Golder's field investigation, the existing embankment and side slopes are in good condition, with no evidence of settlement or instability.





### **3.0 INVESTIGATION PROCEDURES**

The subsurface investigation was carried out for the culvert replacement between October 3 and November 22, 2012, at which time four boreholes (numbered 12-131 to 12-134, inclusive) were advanced at the locations shown on Drawing 1. The boreholes were advanced as follows:

- Boreholes 12-132 and 12-133 were advanced with 108 mm inside diameter continuous-flight hollow-stem augers using a truck-mounted drill rig, supplied and operated by Marathon Drilling Ltd. of Ottawa, Ontario. The boreholes were advanced to auger refusal at depths of about 6.3 and 6.5 m, respectively, below the existing ground surface in the overburden. Borehole 12-132 was then cored for about 3.1 m into the bedrock using NQ-size coring equipment.
- Boreholes 12-131 and 12-134 were advanced using portable drilling equipment supplied and operated by OGS Inc. of Almonte, Ontario. The boreholes were advanced to sampler refusal at depths of about 4.5 and 4.8 m below the existing ground surface in the overburden. Borehole 12-134 was then cored for about 3.5 m into the bedrock using NQ-size coring equipment.

Soil samples in the boreholes were obtained at vertical intervals of about 0.60 m to 0.76 m, using a 50 mm outer diameter split-spoon sampler in accordance with Standard Penetration Test procedures. In-situ vane testing, using an MTO "N"-size vane, was carried out to measure the undrained shear strength of the cohesive soils encountered at the site.

A standpipe piezometer was installed in Borehole 12-134 to monitor the groundwater level at the site. The standpipe consists of a 32 mm diameter rigid PVC pipe with a 1.5 m long slotted screen section, installed within silica sand backfill and sealed by a section of bentonite pellet backfill. The water level in the standpipe piezometer was measured on November 30, 2012 and July 2, 2013.

The boreholes were backfilled with bentonite pellets through the bedrock, and bentonite pellets mixed with native soils in the overburden. The site conditions were restored following completion of work.

The field work was supervised by a member of Golder's technical staff, who located the boreholes, supervised the drilling, sampling and in-situ testing operations, logged the boreholes, and examined and cared for the soil and bedrock samples. The samples were identified in the field, placed in appropriate containers, labelled, and transported to Golder's laboratories in Ottawa and Mississauga for further examination. Index and classification tests consisting of grain size distribution, organic content, Atterberg limit and water content testing were carried out on selected soil samples at the Ottawa laboratory. Axial point load tests and unconfined compressive strength tests were carried out on selected rock core samples in the Mississauga laboratory. All of the laboratory tests were carried out to MTO and/or ASTM standards as appropriate.

The borehole locations and ground surface elevations were surveyed by MRC. The borehole locations, including MTM NAD83 northing and easting coordinates and ground surface elevations referenced to Geodetic datum, are summarized in the following table and are shown on Drawing 1.





## PRELIMINARY FOUNDATION REPORT UNION ROAD CULVERT REPLACEMENT - HIGHWAY 62

| Borehole Number | Borehole Location        | MTM NAD83 Northing (m) | MTM NAD83 Easting (m) | Ground Surface Elevation (m) |
|-----------------|--------------------------|------------------------|-----------------------|------------------------------|
| 12-131          | East end of the culvert  | 4882507.5              | 234693.5              | 75.9                         |
| 12-132          | East side of the culvert | 4882512.2              | 234684.5              | 77.0                         |
| 12-133          | West side of the culvert | 4882495.6              | 234683.1              | 77.4                         |
| 12-134          | West end of the culvert  | 4882500.9              | 234670.9              | 75.2                         |





## **4.0 SITE GEOLOGY AND STRATIGRAPHY**

### **4.1 Regional Geological Conditions**

The site is located in the northern portion of the physiographic region known as the Prince Edward Peninsula, and just south of the Napanee Plain, as delineated in The Physiography of Southern Ontario<sup>1</sup>.

The Prince Edward Peninsula is generally flat-lying and is characterized by relatively shallow soil deposits overlying bedrock. The bedrock within the Prince Edward Peninsula consists of grey limestone of the Lindsay Formation with one hill of Precambrian granite.

The overburden soils within the Prince Edward Peninsula generally consist of silty clay and/or sand and glacial till overlying bedrock. However, in many areas, bedrock outcrops exist at ground surface, while deeper clay deposits (up to 20 m) are present in the southwestern portion of the Peninsula.

### **4.2 Site Stratigraphy**

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole and Drillhole sheets contained in Appendix A. The results of geotechnical laboratory testing are also presented on Figures B1 to B8 contained in Appendix B.

A soil stratigraphy section projected along the centreline of the existing culvert area is shown on Drawing 1. The stratigraphic boundaries shown on the Record of Borehole sheets and on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In general, the subsurface conditions at the locations of the proposed culvert replacement consist of the embankment fill overlying a layered deposit of sand, silt and clay, underlain by glacial till overlying limestone bedrock.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

#### **4.2.1 Pavement Structure and Embankment Fill**

The pavement structure of the shoulder of the highway was penetrated within the northbound lane at Borehole 12-132 and the southbound lane at Borehole 12-133. At the borehole locations, the pavement structure consists of about 0.4 m to 0.5 m of crushed stone to sand and gravel base. The granular base is underlain by about 1.9 m of subbase/embankment fill. The subbase/embankment fill generally consists of varying compositions of sand and gravel containing some silt. However, the bottom 0.8 m of embankment fill at Borehole 12-132 consists of clayey silt, with some sand.

The embankment fill was fully penetrated to depths of about 2.3 and 2.4 m below the ground surface (Elevations 74.7 and 75.0 m) at Boreholes 12-132 and 12-133, respectively.

Standard Penetration Test (SPT) N values for the embankment fill range from 5 to 30 blows per 0.3 m of penetration, indicating a loose to dense state of packing.

<sup>1</sup> Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*. Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.





The results of grain size distribution testing carried out on one sample of the sand embankment fill are provided on Figure B1 in Appendix B. The measured water contents of two samples of the sand and gravel embankment fill were approximately 6 and 15 percent.

The results of Atterberg limit testing on one sample of the clayey silt embankment fill indicate a plasticity index value of 17 percent and a liquid limit value of 34 percent, as shown on Figure B2, indicating a material of low plasticity.

#### **4.2.2 Silty Sand, Silt and Sandy Silt**

A deposit consisting of interlayered silty sand, silt and sandy silt was encountered beneath the embankment fill at Boreholes 12-132 and 12-133 as well as beneath a surficial 0.2 m thick layer of clayey silt (containing organic matter) at Borehole 12-131 and at ground surface at Borehole 12-134. Organic matter was also encountered within the deposit at most locations. The deposit ranges in thickness from about 0.4 to 0.8 m and extends to elevations ranging from 74.0 to 75.3 m.

SPT N values measured for this material range from about 2 to 10 blows per 0.3 m of penetration, indicating a very loose to compact state of packing.

The results of grain size distribution testing carried out on one sample of the silt are provided on Figure B3 in Appendix B. The measured natural water content of one sample of the silt in Borehole 12-132 was about 70 percent. The measured natural water content and organic content of the sandy silt in Borehole 12-133 were about 113 and 21 percent, respectively.

#### **4.2.3 Layered Clay and Silt**

The sandy deposit is underlain by a layered deposit of clayey silt, silty clay, clay and silt with a thickness of between about 2.2 and 3.1 m. The layered deposit was fully penetrated to elevations ranging from 71.5 to 72.2 m. Gravel, sand and organic matter in varying amounts were also encountered in this deposit.

The measured SPT N values within the layered deposit range from 3 to 29 blows per 0.3 m of penetration. The results of in-situ vane testing carried out within the deposit in Boreholes 12-132 and 12-133 indicate undrained shear strengths that range from 52 kPa to greater than 96 kPa. The results of the in-situ testing indicate a stiff to very stiff consistency of the layered clay and silt deposit.

The results of grain size distribution testing carried out on three samples of the deposit are provided on Figure B4. The results of Atterberg limit testing carried out on samples of the clay and silt indicate plasticity index values that range from about 4 to 33 percent and liquid limit values that range from about 21 to 56 percent, as shown on Figure B5, indicating that the deposit varies from a low plasticity silt to clayey silt, to a high plasticity silty clay. The measured natural water content of the deposit ranges from 15 to 34 percent.

#### **4.2.4 Sand and Silt Till**

The layered clay and silt deposit is underlain by a deposit of sand and silt till. The till was fully penetrated to elevations between about 70.5 and 71.4 m with thicknesses between about 0.8 and 1.2 m.

The till is a heterogeneous mixture of gravel and cobbles in a matrix of sand and silt containing a trace to some clay.





## PRELIMINARY FOUNDATION REPORT UNION ROAD CULVERT REPLACEMENT - HIGHWAY 62

SPT N values measured for this material ranged from about 3 to 61 blows per 0.3 m of penetration, indicating a very loose to very dense state of packing.

The results of grain size distribution testing carried out on samples of the glacial till are provided in Figure B6. The results do not reflect the cobble or full gravel contents of the till deposit, because the samples were retrieved using a 50 mm outside diameter sampler. The measured natural water content of the till ranges from about 11 to 13 percent.

### 4.2.5 Refusal and Bedrock

Bedrock was encountered beneath the till and cored for 3.2 and 3.5 m depth, in Boreholes 12-132 and 12-134, respectively. Sampler refusal was encountered at Elevation 71.4 m at Borehole 12-131, and auger refusal was encountered at Elevation 71.0 m at Borehole 12-133. These instances of refusal likely indicate the bedrock surface but could also represent cobbles or boulders in the till.

The following table summarizes the bedrock surface depths and elevations as encountered or inferred at the four borehole locations.

| Borehole Number | Existing Ground Surface Elevation (m) | Depth to Bedrock (m) | Bedrock Surface Elevation (m) |
|-----------------|---------------------------------------|----------------------|-------------------------------|
| 12-131          | 75.9                                  | *4.5                 | *71.4                         |
| 12-132          | 77.0                                  | 6.3                  | 70.7                          |
| 12-133          | 77.4                                  | *6.5                 | *71.0                         |
| 12-134          | 75.2                                  | 4.8                  | 70.5                          |

**Note:** \* Depth and elevation to bedrock inferred from refusal.

The bedrock encountered in the boreholes typically consists of grey to grey-brown limestone bedrock. The bedrock is slightly weathered to fresh and typically medium strong to strong.

The Rock Quality Designation (RQD) values measured on the recovered bedrock core samples ranged from about 80 to 98 percent, indicating good to excellent quality rock. The discontinuities observed in the rock core were associated with the joints and bedding of the bedrock.

Laboratory axial point load index testing as well as unconfined compressive strength testing was carried out on selected specimens of the bedrock core. The results of the testing are summarized on Figures B7 and B8 in Appendix B. The correlated compressive strengths from the point load index testing range from about 18 to 104 MPa. The results of the unconfined compressive strength testing on two sample of the bedrock indicate values of 49 and 70 MPa.

### 4.2.6 Groundwater Conditions

The groundwater conditions observed upon completion of drilling at Boreholes 12-131 and 12-133 were at about Elevations 75.9 and 75.0 m. The groundwater level was not established at Boreholes 12-132.





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## PRELIMINARY FOUNDATION REPORT UNION ROAD CULVERT REPLACEMENT - HIGHWAY 62

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The groundwater level in the piezometer in Borehole 12-134 was measured on November 30, 2012 and July 2, 2013. A summary of the groundwater levels in this piezometer is given in the table below.

| Borehole | Ground Surface Elevation (m) | Water Level Depth (m) | Water Level Elevation (m) | Date              |
|----------|------------------------------|-----------------------|---------------------------|-------------------|
| 12-134   | 75.2                         | 0.00                  | 75.20                     | November 30, 2012 |
|          |                              | 0.05                  | 75.15                     | July 2, 2013      |

Based on the measurements summarized above, the stabilized groundwater level in the area is typically at or near the ground surface.

It should be noted that groundwater levels in the area are subject to fluctuations both seasonally and with precipitation events.





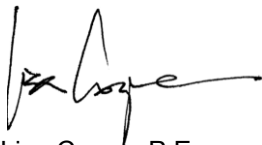
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### 5.0 CLOSURE

This Preliminary Foundation Investigation Report was prepared by Ms. Susan Trickey, P.Eng. and reviewed by Ms. Lisa Coyne, P.Eng., a Principal and geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., Golder's Designated MTO Foundations Contact for this project, conducted an independent quality review of the report.

#### GOLDER ASSOCIATES LTD.

  
Susan Trickey, P.Eng.  
Geotechnical Engineer

  
Lisa Coyne, P.Eng.  
Senior Geotechnical Engineer, Principal



  
Fintan Heffernan, P.Eng.  
Designated MTO Contact



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**PRELIMINARY FOUNDATION REPORT  
UNION ROAD CULVERT REPLACEMENT - HIGHWAY 62**

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# **PART B**

**PRELIMINARY FOUNDATION DESIGN REPORT**

**UNION ROAD CULVERT REPLACEMENT**

**SITE 28-034C**

**0.4 KM NORTH OF UNION ROAD**

**HIGHWAY 62**

**W.P. 4153-10-01**





## **6.0 DISCUSSION AND PRELIMINARY ENGINEERING RECOMMENDATIONS**

### **6.1 General**

This section of the report provides preliminary foundation design recommendations for the proposed replacement of the existing Union Road culvert on Highway 62. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during this preliminary subsurface investigation. The discussion and preliminary recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the preliminary design of the foundations for the replacement structure. Further investigation and analysis will be required during detail design.

Where comments are made on construction, they are provided to highlight those aspects that could affect the preliminary design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

The replacement of the culvert will be along the existing highway and culvert alignment as shown on Drawing 1. The proposed invert level will be at the average of the existing invert levels, at about Elevation 74.4 m, but the existing grades of Highway 62 will be maintained. A temporary embankment widening, approximately 1.6 m wide and 2.5 m high, is required on the west side of the highway in the southbound direction to accommodate the construction staging, however, the existing pavement grades will be maintained. This widening will result in placement of an approximately 0.8 m thickness of fill on top of the existing embankment side slope.

### **6.2 Foundation Options**

The existing Union Road culvert is a 3.05 m wide by 1.5 m high, single-span reinforced concrete non-rigid frame structure, cast-in-place, which is about 23.2 m in length. The date of construction of the culvert is unknown. Extensions have also been added to both ends of the culvert and it is in generally poor condition. The existing culvert inverts are at about Elevations 74.3 and 74.2 m, at the west and east ends, respectively, and the flow in the culvert is from west to east. The depth of water within the culvert was about 1.2 m at the time of the field investigation. The width of the water course is about 4 m at the inlet and about 5 m at the outlet.

The existing pavement grade at the culvert location is at about Elevation 77.3 m. In this area Highway 62 is one lane wide in each direction (i.e., a two-lane highway). The existing embankment slopes at the culvert locations are about 2 to 3 m in height with the side slopes oriented at about 1.5H:1V.

Based on the subsurface conditions, only shallow foundation options have been considered in sufficient detail for preliminary design for the replacement of the existing Union Road culvert. It is not considered to be a practical or economical option to support the culvert on deep foundations because the shallow subsoils will provide adequate bearing resistance and settlement performance given that the Highway 62 grade will not be raised and only a minor widening will be required.





A summary of the advantages and disadvantages associated with each shallow foundation option is provided below, and a comparison of the alternative foundation options based on advantages, disadvantages, constructability and relative costs is provided in Table 1 following the text of this report.

- **Concrete box culvert founded on the native clay and silt:** A box culvert could be considered for the culvert replacement provided it is founded on or within the native layered clay and silt. Relatively low geotechnical resistances will apply for the compressible native soils, with potential for some settlement of the culvert. However, the foundation loads would be distributed over a larger area, resulting in lower foundation stress levels, and therefore reduced settlement magnitudes. It is noted that the depth of the existing foundations is unknown and may be below the proposed founding level of the box culvert replacement. If this is the case, the existing foundations should be removed to below the proposed bedding level, to about Elevation 73.3 m, and the subgrade inspected at that time to verify the foundation conditions (i.e., whether or not any remaining portion of the existing foundations can remain in place or should be removed and replaced with granular fill). Consideration could also be given to shifting the alignment of the culvert to avoid removal of the existing culvert; however, further foundation investigation would likely be required for this option. It is expected that temporary protection systems and/or cofferdams would be required during excavation and construction. A precast culvert would be preferred over a cast-in-place culvert for this option because it would likely take less time to install, shortening the period for dewatering and traffic staging.
- **Rigid frame open footing culvert founded on the native clay and silt:** A rigid frame open footing culvert could also be considered for the culvert replacement, provided it is founded on the native layered clay and silt. The settlements for this type of culvert would be somewhat larger than those for a closed box culvert due to the higher concentration of foundation stresses below the footings. As above, the depth of the existing foundations is unknown but it is expected that the foundations for the open footing culvert would extend either to or below that of the existing culvert which would be removed. Excavations for this option would be up to about 4.5 m below the pavement grade in the sensitive clay and silt soils. A temporary protection system and/or cofferdams would be required during excavation and construction. A precast culvert would be preferred over a cast-in-place culvert for this option because it would likely be easier and quicker to install, and require less construction time and disruption to traffic. Alternatively, a precast culvert founded on cast-in-place footings could also be considered.

Based on the above considerations, the preferred option from a geotechnical/foundations perspective is to replace the culvert with a precast concrete box culvert founded on the native clay and silt.

## **6.3 Culvert Foundation Options**

### **6.3.1 Concrete Box Culvert**

#### **6.3.1.1 *Founding Level and Bedding***

It is not necessary to found the box culvert at the standard depth for frost protection purposes as box structures are tolerant of small magnitude movements related to freeze-thaw cycles should these occur. The box culvert should, however, be founded below any existing fill and surficial soils containing organic matter.





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The bedding and/or leveling pad requirements for a box culvert replacement should be in accordance with Ontario Provincial Standard Specification (OPSS) 422 (*Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut*) for concrete box culverts. It is recommended that the box culvert segments be placed on a minimum thickness of 300 mm of granular bedding material (which includes the 75 mm leveling pad thickness) meeting OPSS 1010 Granular A or Granular B Type II.

The table below summarizes the recommended preliminary founding level for the culvert, assuming a substrate thickness of 450 mm, a culvert base slab thickness of 300 mm and bedding thickness as described above. Based on these elevations, the box culvert replacement will be typically founded on the layered clay and silt.

| Invert Location | Proposed Invert Elevation (m) | Box Culvert Founding Elevation (m) | Subgrade Level (m) |
|-----------------|-------------------------------|------------------------------------|--------------------|
| East End        | 74.21                         | 73.46                              | 73.16              |
| West End        | 74.24                         | 73.49                              | 73.19              |

It is understood that the depth of the existing foundations is not known. If the existing foundations extend beneath the proposed subgrade levels as provided above, the existing footings should be removed to a minimum depth of Elevation 73 m and the subgrade should be inspected to determine whether or not the existing foundations can remain in place.

Where the subgrade consists of sensitive layered clay and silt, the subgrade will be susceptible to disturbance and degradation on exposure to water and construction traffic. As an alternative to the placement of a minimum 300 mm thick layer of Granular A, a 100 mm thick concrete working slab could be placed on the subgrade within the culvert footprint, to protect the subgrade from such degradation. In this case, a 75 mm thick layer of OPSS 1010 Granular A or concrete fine aggregate meeting the gradation requirements set out in OPSS 1002 (*Material Specification for Aggregates - Concrete*) should be placed on top of the concrete mat to provide a "levelling pad" for the box culvert replacement. The working slab should be placed within four hours after inspection and approval of the subgrade.

The footing subgrade should be inspected in accordance with OPSS 902 (*Construction Specification for Excavating and Backfilling – Structures*). Further discussion regarding subgrade preparation and protection is provided in Section 6.7.3.

### 6.3.1.2 Geotechnical Resistances

For a box culvert founded at the elevations provided in Section 6.3.1.1 a factored geotechnical resistance at Ultimate Limit States (ULS) of 150 kPa and a geotechnical resistance at Serviceability Limit States (SLS) for 25 mm of settlement of 100 kPa may be used for preliminary design purposes.

These preliminary geotechnical resistances are provided for loads applied perpendicular to the surface of the footings; where applicable, inclination of the load should be taken into account in accordance with Section 6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC 2006)* and its *Commentary*.

The preliminary geotechnical resistance values provided above will have to be re-evaluated and modified as necessary during detail design.





## **6.3.2 Rigid Frame Open Footing Culvert**

### **6.3.2.1 Founding Level and Frost Protection Requirements**

Strip footings for an open footing culvert replacement, and for any associated concrete wing walls/retaining walls should be founded on the layered silt and clay.

As per Ontario Provincial Standard Drawing (OPSD) 3090.101 (*Foundation Frost Depths for Southern Ontario*), the frost penetration depth in the area is 1.4 m. Therefore, the footings should be provided with a minimum of 1.4 m of earth cover below the lowest surrounding grade to provide adequate protection against frost penetration. The table below summarizes the recommended preliminary founding levels for the culvert.

| <b>Invert Location</b> | <b>Proposed Invert Elevation (m)</b> | <b>Open Footing Culvert Founding Elevation (m)</b> |
|------------------------|--------------------------------------|--|
| East End               | 74.21                                | 72.81  |
| West End               | 74.24                                | 72.84  |

As discussed in Section 6.3.1.1, the depth of the existing culvert foundations is not known. If the existing foundations extend beneath the proposed subgrade levels provided above, the existing foundations and subgrade should be inspected as described in Section 6.3.1.1. In addition, there is potential for the foundation excavations to intersect the water-bearing silt layer that was encountered below the layered clay deposit; in this case, additional subexcavation may be required if groundwater pumping from filtered sumps cannot maintain the silt layer in “dry” conditions for foundation construction. Where the subgrade for the culvert and/or associated wall footings consists of native clay and silt, it will be susceptible to disturbance and degradation on exposure to water and construction traffic. It is recommended that a 100 mm thick concrete working slab be placed within four hours following inspection and approval of the subgrade, to protect the subgrade from softening.

The footing subgrade should be inspected in accordance with OPSS 902 (*Construction Specification for Excavating and Backfilling – Structures*). Further discussion regarding subgrade preparation and protection is provided in Section 6.7.3.

### **6.3.2.2 Geotechnical Resistance**

Strip footings placed on the properly prepared subgrade, at the founding elevations identified above, should be designed based on the following preliminary factored geotechnical resistances at ULS and geotechnical resistances at SLS.

| <b>Footing Width</b> | <b>Factored Geotechnical Resistance at ULS</b> | <b>Geotechnical Resistance at SLS*</b> |
|----------------------|--|--|
| Up 1.5 m             | 125 kPa  | 100 kPa                                |

**Note:** \* For 25 mm of total settlement for the given footing width.





The structural engineer must verify that the selected footing width is sufficient to resist overturning. The ULS resistance and settlement are dependent on the footing size, configuration and applied loads; the preliminary geotechnical resistances should, therefore, be reviewed if the selected footing width or founding elevation differs significantly from those given above.

These preliminary geotechnical resistances are provided for loads applied perpendicular to the surface of the footings; where applicable, inclination of the load should be taken into account in accordance with Section 6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC 2006)* and its *Commentary*.

The preliminary geotechnical resistance values provided above will have to be re-evaluated and modified as necessary during detail design. If higher resistances are required due to grade raises or more significant embankment widening, consideration could be given to carry out consolidation testing as part of the detailed design to better characterize the compressibility of the layered clay and silt deposit.

### 6.4 Settlement

It is understood that an approximately 1.6 m wide, temporary widening of the 2.5 m high embankment will be required along the west side of Highway 62 to accommodate the construction staging, with the existing pavement grades will be maintained. This will require placement of an approximately 0.8 m thickness of new fill on top of the existing side slope on the west side of the embankment. Provided the SLS geotechnical resistance for the culvert are limited to the values provided in Section 6.3, then the total and differential culvert settlements should be minimal (i.e., less than about 25 and 15 mm, respectively). Most of this settlement will consist of the recompression of the layered clay and silt and will occur during construction.

### 6.5 Culvert Backfill and Erosion Protection

Backfill, cover and construction of the frost taper (backfill transition) for concrete culverts should be completed in accordance with OPSS 422 (*Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut*) or OPSS 902 (*Construction Specification for Excavating and Backfilling - Structures*) as well as OPSD 803.010 (*Backfill and Cover for Concrete Culverts*) or OPSD 803.031 (*Frost Treatment – Pipe Culverts Frost Penetration Line Between Top of Pipe and Bedding Grade*), as appropriate.

Backfill to culvert walls should consist of granular fill meeting the requirements of OPSS 1010 Granular A or Granular B Type II, but with less than 5 per cent passing the No. 200 sieve. The backfill should be placed and compacted in accordance with MTO's Special Provision SP105S21 (Amendment to OPSS 501). The fill depth during placement should be maintained equal on both sides of the culvert walls, with one side not exceeding the other by more than 500 mm. The culvert should be designed for the full overburden pressure and live load assuming that the embankment fill has a unit weight of 22 kN/m<sup>3</sup> for Granular A and 21 kN/m<sup>3</sup> for Granular B Type II or select earth fill above and/or surrounding the culvert.

To prevent surface water from flowing either beneath the culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a clay seal or concrete cut-off wall should be provided at the upstream and downstream ends of the culvert replacement.





If the flow velocities are sufficiently high, provision should be made for scour and erosion protection (suitable non-woven geotextiles and/or rip-rap) at the culvert inlet and outlet. The requirements for and design of erosion protection measures for the culvert inlet should be assessed by the hydraulic design engineer. As a minimum, rip-rap treatment for the culvert outlet should be consistent with the standard Treatment Type A presented in OPSP 810.010 (*Rip-Rap Treatment for Sewer and Culvert Outlets*), with the rip-rap placed up to the toe of slope level, in combination with the cut-off measures noted above.

## **6.6 Embankment Construction and Stability**

It is understood that an approximately 1.6 m wide temporary embankment widening is required on the west side of the culvert to accommodate the construction staging of the existing Highway 62 embankment. The widening of the embankment will be about 2.5 m in height relative to the original ground, requiring placement of a 0.8 m thickness of fill on top of the existing embankment side slopes, sloped at 2H:1V. It is also understood that this widening will only remain in place during the first stage of culvert replacement which is expected to take about one month to complete and will be removed as part of the culvert replacement in Stage 2.

The subsurface conditions on the west side of the culvert in the area of the widening consist of sandy silt with organic matter, layered clay and silt and till underlain by limestone bedrock. In preparation for the widening, any topsoil, organic matter or softened/loosened soils should be stripped from below the embankment area.

The embankment fill for the widening areas of the culvert should be placed and compacted in accordance with MTO's Special Provisions 206S03 and 105S10. Benching of the existing embankment side slopes should be carried out to "key in" the new fill materials for the widening, in accordance with OPSP 208.010. Commonly in embankment widening construction, the fill material cut from the existing embankment side slope for creation of these benches is re-used for the embankment widening below/adjacent to each bench area. Additional fill for construction of the embankment widening above the level of the original ground surface (i.e., above the groundwater level) could consist of clean earth fill or granular fill.

Following removal of the fill for the temporary widening in Stage 1, replacement of topsoil and seeding or pegged sod is recommended to reduce surface water erosion on the west embankment side slopes.

For the soil conditions at the culvert and the embankment height, the embankment will have an adequate factor of safety against both static and seismic slope instability (i.e., at or greater than 1.3 and 1.1 under static and seismic conditions, respectively).

Settlement of the Highway 62 embankment will occur as a result of compression of the new embankment fill placed in the immediate vicinity of the culvert replacement. Provided that the embankment material consists of Select Subgrade Material or clean earth fill, the settlement of the embankment fill itself is expected to be less than 25 mm. The use of granular fill for the new embankment construction would reduce this magnitude of post-construction settlement (likely to less than half that value) since the majority of settlement of these fills will occur during construction.

## **6.7 Construction Considerations**

The following sections identify future construction issues that should be considered during the functional design as they may impact the planning and preliminary design.





### **6.7.1 Groundwater and Surface Water Control**

Control of the surface water and groundwater will be necessary for the construction of the replacement culvert, to allow excavation and foundation construction to be carried out in dry conditions.

Some groundwater inflow into the excavations should be expected. It should be possible to handle the groundwater inflow by pumping from well filtered sumps established in the floor of the excavations. As noted in Section 6.3, if the foundation excavations for the culvert replacement intersect the water-bearing silt layer that was encountered below the layered clay deposit, additional subexcavation may be required if pumping cannot maintain the silt in “dry” conditions for foundation construction.

Depending on the flow at the time of construction, the surface water flow could be passed through the culvert area by means of a temporary pipe, or diverted by pumping from behind a temporary cofferdam.

Surface water should be directed away from the excavation area, to prevent ponding of water that could result in disturbance and weakening of the sensitive clay and silt subgrade soils; further discussion on this aspect is provided in Section 6.7.3.

### **6.7.2 Excavation and Temporary Protection Systems**

Temporary excavations for the culvert, up to a depth of about 4.5 m, will be made through the existing fill, silty sand, silt, sandy silt and layered clay and silt. Excavation works must be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. The existing fill above the water table and the layered clay and silt would be classified as Type 3 soil based on the OHSA. According to OHSA, excavations that extend to, or into, Type 3 soils should be made with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V). The silty sand, silt and sandy silt below the water table would be classified as Type 4 soil based on OSHA, and excavations in these materials should be sloped no steeper than 3H:1V.

If the above open cut excavation side slopes cannot be accommodated, then a temporary protection system (i.e., temporary excavation shoring) will be required. Where shoring is required, the support system should be designed and constructed in accordance with OPSS 539 (*Temporary Protection Systems*). The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS 539, provided that any utilities that may be present in the area can tolerate this magnitude of deformation.

It is considered that either a driven, interlocking sheetpile system or a soldier pile and timber lagging system would be suitable for the temporary excavation support at this site, based on the subsurface soil and groundwater conditions. An interlocking sheetpile system would contribute to both ground and groundwater control. For a soldier pile and lagging system, it would be necessary to control seepage or include measures to mitigate loss of soil particles through the lagging boards. The soldier piling and lagging or interlocking steel sheet piling would be supported against lateral movement using walers, tie backs (into the underlying bedrock) and/or internal struts/braces or socketing into the bedrock.

### **6.7.3 Existing Foundations and Subgrade Protection**

All embankment fill, topsoil, organics, and soft or loose soils should be removed from below the proposed founding elevations and wasted or reused as landscaping fill, as required. Subgrade preparation should be performed and monitored in accordance with OPSS 902 (*Construction Specification for Excavating and Backfilling – Structures*). The cleaned excavation base should be inspected prior to pouring the footings for the





rigid frame open footing culvert or placing granular bedding for the box culvert. As discussed in Sections 6.2 and 6.3, the depth of the existing culvert foundations is unknown and they may extend below the proposed founding level for a box culvert replacement; in this case, the existing foundations should be removed to below the proposed bedding level, to about Elevation 73.3 m, and the subgrade inspected at that time to verify the foundation conditions (i.e., whether or not any remaining portion of the existing foundations can remain in place or should be removed and replaced with granular fill).

The sensitive layered clay and silt subgrade will be susceptible to disturbance and degradation on exposure to water and construction traffic. It is recommended that a minimum 300 mm thick layer of Ontario Provincial Standard Specification 1010 (*Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material*) Granular A be placed below the base slab on the subgrade to form a bedding layer for the box culvert segments, and to limit the degradation of the sensitive clay and silt subgrade. The bedding should be placed within four hours after inspection and approval of the subgrade to limit such degradation.

As an alternative to the placement of a minimum 300 mm thick layer of Granular A for a box culvert, a 100 mm thick concrete working slab could be placed on the subgrade within the culvert footprint, to protect the subgrade from such degradation. In this case, a 75 mm thick layer of OPSS 1010 Granular A or concrete fine aggregate meeting the gradation requirements set out in OPSS 1002 (*Material Specification for Aggregates – Concrete*) should be placed on top of the concrete mat to provide a “levelling pad” for the box culvert replacement. The working slab should be placed within four hours after inspection and approval of the subgrade.

The layered clay and silt subgrade for a rigid frame open footing culvert option, together with any associated wall footings, will also be susceptible to disturbance and degradation on exposure to water and construction traffic. It is recommended that a 100 mm thick concrete working slab be placed within four hours following inspection and approval of the subgrade, to protect the subgrade from softening.

## 6.8 Recommendations for Further Work in Detail Design

The design-build proponent will be responsible for the detail design and assessing additional requirements for investigations to suit the final design and mitigating any identified construction risks. However, at this functional design stage, it is anticipated that additional boreholes will be required during the design-build stage of investigation, to further assess and/or confirm the subsurface conditions and the preliminary recommendations provided in this report, as follows:

- Assessment of the variability of any existing fill and surficial soils to confirm the founding elevations within the culvert area.
- Assessment of the consolidation characteristics of the layered clay and silt deposit, if higher resistances are required due to grade raises or more significant embankment widening.
- Confirmation of the foundation depths of the existing culvert at the time of construction.





## PRELIMINARY FOUNDATION REPORT UNION ROAD CULVERT REPLACEMENT - HIGHWAY 62

### 7.0 CLOSURE

This Preliminary Foundation Design Report was prepared by Ms. Susan Trickey, P.Eng. and reviewed by Ms. Lisa Coyne, P.Eng., a Principal and geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., Golder's Designated MTO Foundations Contact for this project, conducted an independent quality review of the report.

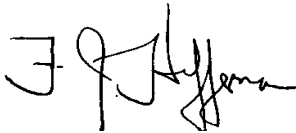
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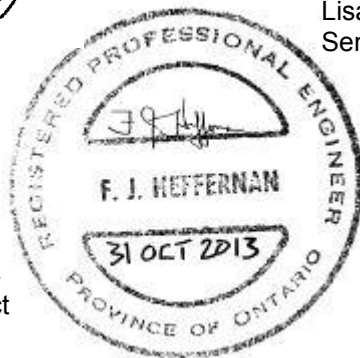
Susan Trickey, P.Eng.  
Geotechnical Engineer



Lisa Coyne, P.Eng.  
Senior Geotechnical Engineer, Principal



Fintan Heffernan, P.Eng.  
Designated MTO Contact



WAM/SAT/LCC/FJH/bg

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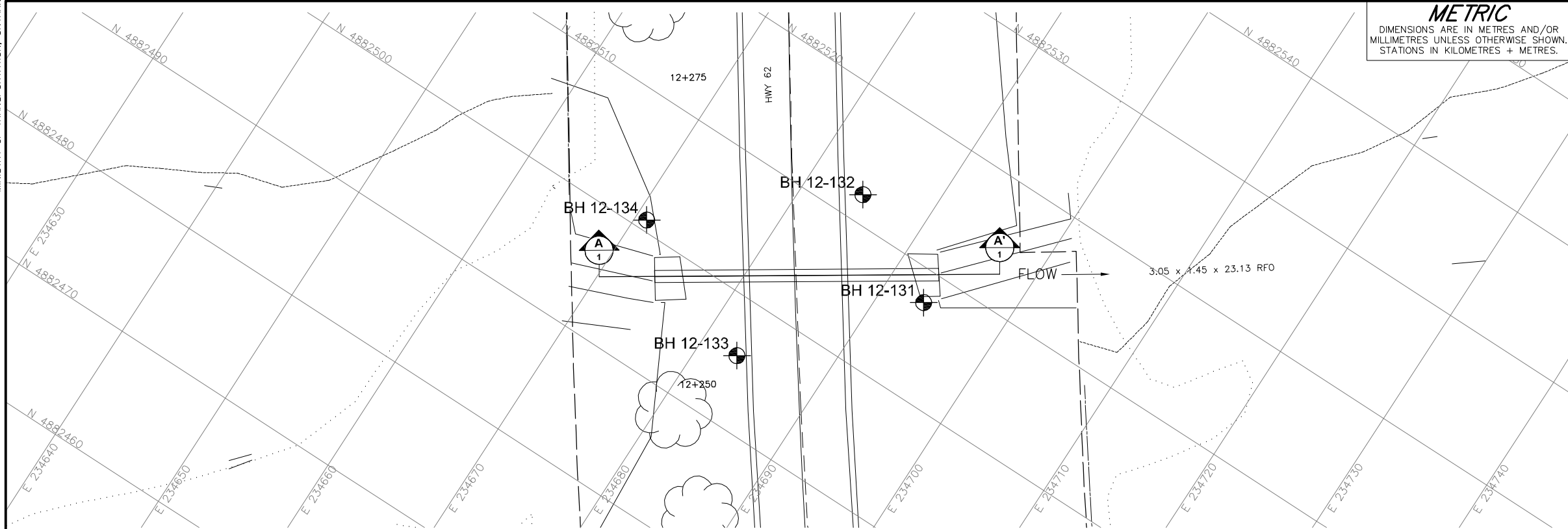


## PRELIMINARY FOUNDATION REPORT UNION ROAD CULVERT REPLACEMENT - HIGHWAY 62

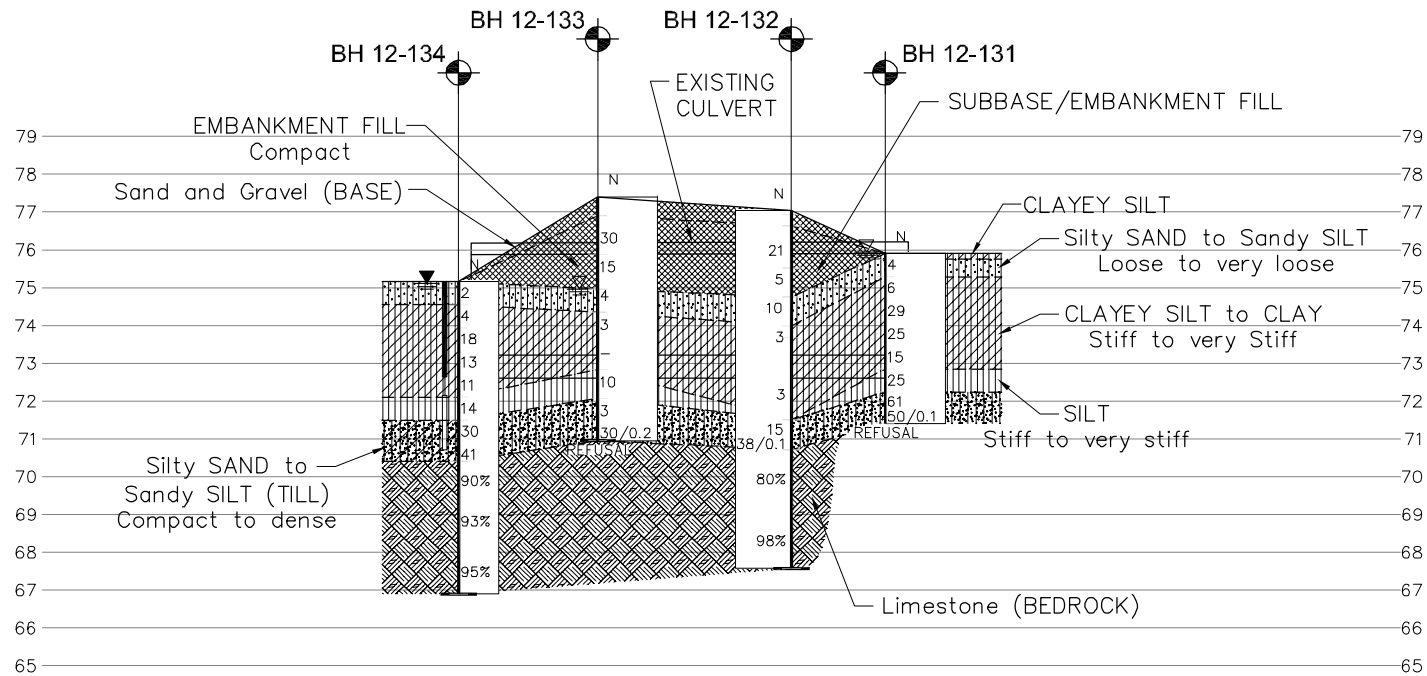
**Table 1 – Comparison of Foundation Alternatives**

| Foundation Option   | Feasibility  | Advantages   | Disadvantages   | Constructability  | Relative Costs  |
|---|--|--|---|---|---|
| Box Culvert founded on the layered clay and silt                      | <ul style="list-style-type: none"> <li>Feasible, preferred option</li> </ul> | <ul style="list-style-type: none"> <li>Potentially shallower excavation depths</li> <li>Foundation loads distributed over a larger area, therefore reducing settlement magnitudes</li> <li>Precast sections would be quicker and easier to install (i.e., less disruption to traffic)</li> </ul> | <ul style="list-style-type: none"> <li>Relatively low geotechnical resistances on the compressible native soils</li> <li>Could require the removal of the existing culvert foundations</li> <li>Groundwater control and a temporary protection system are required</li> </ul> | <ul style="list-style-type: none"> <li>Conventional excavation and construction techniques and temporary protection system</li> </ul> | <ul style="list-style-type: none"> <li>Moderate cost</li> </ul> |
| Rigid Frame Open Footing Culvert founded on the layered clay and silt | <ul style="list-style-type: none"> <li>Feasible</li> </ul>                   | <ul style="list-style-type: none"> <li>Foundations would likely be at or below the existing foundation level</li> <li>Foundation would match that of the existing foundation conditions</li> </ul>   | <ul style="list-style-type: none"> <li>Deeper excavation depth</li> <li>Somewhat larger settlement than those of a box culvert due to the higher concentration of foundation stresses</li> <li>Groundwater control and a temporary protection system are required</li> </ul>  | <ul style="list-style-type: none"> <li>Conventional excavation and construction techniques and temporary protection system</li> </ul> | <ul style="list-style-type: none"> <li>Moderate cost</li> </ul> |





PLAN  
SCALE  
8 0 4 8 m



CULVERT PROFILE

A-A'  
1

HORIZONTAL SCALE  
4 0 4 8 m  
2 0 2 4 m  
VERTICAL SCALE

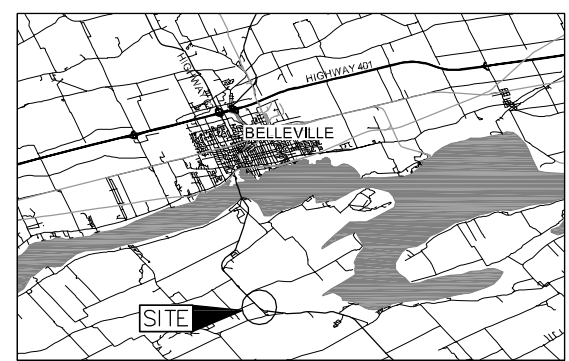
**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
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CONT No.  
GWP No. 4153-10-01

HIGHWAY 62-CULVERT REPLACEMENT  
UNION ROAD  
SITE 28-034C  
BOREHOLE LOCATIONS AND SOIL STRATA



**Golder Associates Ltd.**  
OTTAWA, ONTARIO, CANADA



KEY PLAN

SCALE

5 0 5 10 km

LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation
- WL in piezometer, measured on Nov. 30, 2012
- WL upon completion of or during drilling

BOREHOLE CO-ORDINATES

| No.    | ELEVATION | NORTHING  | EASTING  |
|--------|-----------|-----------|----------|
| 12-131 | 75.9      | 4882507.5 | 234693.5 |
| 12-132 | 77.0      | 4882512.2 | 234684.5 |
| 12-133 | 77.4      | 4882495.6 | 234683.1 |
| 12-134 | 75.2      | 4882500.9 | 234670.9 |

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the design configuration as shown elsewhere in the Preliminary Design Report.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Preliminary Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by MMM Group Limited, drawing file no. BPLAN-28-034.dwg, received November 30, 2012.

| NO.                 | DATE      | BY               | REVISION                 |
|---------------------|-----------|------------------|--------------------------|
| Geocres No. 31C-218 |           |                  |                          |
| HWY. 62             |           |                  | PROJECT NO. 12-1121-0099 |
| SUBM'D. SAT         | CHKD. FJH | DATE: Sept. 2013 | DIST. Eastern            |
| DRAWN: JM           | CHKD. SAT | APPD. FJH        | SITE: 28-034C            |
|                     |           |                  | DWG. 1                   |







# **APPENDIX A**

## **Borehole and Drillhole Records**



## LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures, and in the text of the report are as follows:

| I. SAMPLE TYPE             |   | III. SOIL DESCRIPTION  |   |                |
|----------------------------|---|--|---|----------------|
| AS                         | Auger sample  | (a) Cohesionless Soils   |   |                |
| BS                         | Block sample  | Density Index<br>(Relative Density)  | N   |                |
| CS                         | Chunk sample  |  | Blows/300 mm  |                |
| DO or DP                   | Seamless open-ended, driven or pushed tube samplers |  | Or Blows/ft.  |                |
| DS                         | Denison type sample                                 |  | 0 to 4  |                |
| FS                         | Foil sample   |  | 4 to 10   |                |
| RC                         | Rock core   |  | 10 to 30  |                |
| SC                         | Soil core   |  | 30 to 50  |                |
| SS                         | Split spoon sampler                                 |  | over 50   |                |
| ST                         | Slotted tube  | (b) Cohesive Soils<br>C <sub>u</sub> or S <sub>u</sub>   |   |                |
| TO                         | Thin-walled, open                                   |  |   |                |
| TP                         | Thin-walled, piston                                 |  |   |                |
| WS                         | Wash sample   |  |   |                |
| DT                         | Dual tube sample                                    |  |   |                |
| DD                         | Diamond drilling                                    |  |   |                |
| II. PENETRATION RESISTANCE |   |  | Consistency   |                |
|                            |   |  |   | kPa            |
|                            |   | Very soft  | 0 to 12   | 0 to 250       |
|                            |   | Soft   | 12 to 25  | 250 to 500     |
|                            |   | Firm   | 25 to 50  | 500 to 1,000   |
|                            |   | Stiff  | 50 to 100   | 1,000 to 2,000 |
|                            |   | Very stiff   | 100 to 200  | 2,000 to 4,000 |
|                            |   | Hard   | Over 200  | Over 4,000     |
|                            |   | IV. SOIL TESTS   |   |                |
|                            |   | w  | Water content   |                |
|                            |   | w <sub>p</sub> or PL   | Plastic limited   |                |
|                            |   | w <sub>l</sub> or LL   | Liquid limit  |                |
|                            |   | C  | Consolidaiton (oedometer) test  |                |
|                            |   | CHEM   | Chemical analysis (refer to text)   |                |
|                            |   | CID  | Consolidated isotropically drained triaxial test <sup>1</sup>                                       |                |
|                            |   | CIU  | Consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup> |                |
|                            |   | D <sub>R</sub>   | Relative density  |                |
|                            |   | DS   | Direct shear test   |                |
|                            |   | G <sub>s</sub>   | Specific gravity  |                |
|                            |   | M  | Sieve analysis for particle size  |                |
|                            |   | MH   | Combined sieve and hydrometer (H) analysis  |                |
|                            |   | MPC  | Modified Proctor compaction test  |                |
|                            |   | SPC  | Standard Proctor compaction test  |                |
|                            |   | OC   | Organic content test  |                |
|                            |   | SO <sub>4</sub>  | Concentration of water-soluble sulphates  |                |
|                            |   | UC   | Unconfined compression test   |                |
|                            |   | UU   | Unconsolidated undrained triaxial test  |                |
|                            |   | V  | Field vane test (LV-laboratory vane test)   |                |
|                            |   | γ  | Unit weight   |                |
|                            |   | Note: <sup>1</sup> Tests which are anisotropically consolidated prior shear are shown as CAD, CAU. |   |                |
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## LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

### I. GENERAL

|                           |                             |
|---------------------------|-----------------------------|
| $\pi$                     | 3.1416                      |
| $\ln x$                   | natural logarithm of x      |
| $\log_{10} x$ or $\log x$ | logarithm of x to base 10   |
| $g$                       | acceleration due to gravity |
| $t$                       | time                        |
| FOS                       | factor of safety            |
| V                         | volume                      |
| W                         | weight                      |

### II. STRESS AND STRAIN

|                              |  |
|------------------------------|--|
| $\gamma$                     | shear strain   |
| $\Delta$                     | change in, e.g. in stress: $\Delta \sigma'$                                  |
| $\epsilon$                   | linear strain  |
| $\epsilon_v$                 | volumetric strain  |
| $\eta$                       | coefficient of viscosity   |
| $\nu$                        | Poisson's ratio  |
| $\sigma$                     | total stress   |
| $\sigma'$                    | effective stress ( $\sigma' = \sigma - u$ )                                  |
| $\sigma'_{vo}$               | initial vertical effective overburden stress                                 |
| $\sigma_1 \sigma_2 \sigma_3$ | principal stresses (major, intermediate, minor)                              |
| $\sigma_{oct}$               | mean stress or octahedral stress<br>$= (\sigma_1 + \sigma_2 + \sigma_3) / 3$ |
| $\tau$                       | shear stress   |
| $u$                          | porewater pressure   |
| $E$                          | modulus of deformation   |
| $G$                          | shear modulus of deformation   |
| $K$                          | bulk modulus of compressibility  |

### III. SOIL PROPERTIES

#### (a) Index Properties

|                    |   |
|--------------------|---|
| $\rho(\gamma)$     | bulk density (bulk unit weight)*  |
| $\rho_d(\gamma_d)$ | dry density (dry unit weight)   |
| $\rho_w(\gamma_w)$ | density (unit weight) of water  |
| $\rho_s(\gamma_s)$ | density (unit weight) of solid particles  |
| $\gamma'$          | unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )   |
| $D_R$              | relative density (specific gravity) of<br>solid particles ( $D_R = \rho_s / \rho_w$ ) formerly ( $G_s$ )  |
| $e$                | void ratio  |
| $n$                | porosity  |
| $S$                | degree of saturation  |
| *                  | Density symbol is $\rho$ . Unit weight symbol is $\gamma$<br>where $\gamma = \rho g$ (i.e. mass density multiplied by<br>acceleration due to gravity) |

#### (a) Index Properties (continued)

|               |  |
|---------------|--|
| $w$           | water content  |
| $w_L$ or $LL$ | liquid limit   |
| $w_p$ or $PL$ | plastic limit  |
| $I_p$ or $PI$ | plasticity Index $= (w_L - w_p)$   |
| $w_s$         | shrinkage limit  |
| $I_L$         | liquidity index $= (w - w_p) / I_p$  |
| $I_c$         | consistency index $= (w_L - w) / I_p$  |
| $e_{max}$     | void ratio in loosest state  |
| $e_{min}$     | void ratio in densest state  |
| $I_D$         | density index $= (e_{max} - e) / (e_{max} - e_{min})$<br>(formerly relative density) |

#### (b) Hydraulic Properties

|     |  |
|-----|--|
| $h$ | hydraulic head or potential                          |
| $q$ | rate of flow   |
| $v$ | velocity of flow                                     |
| $i$ | hydraulic gradient                                   |
| $k$ | hydraulic conductivity (coefficient of permeability) |
| $j$ | seepage force per unit volume                        |

#### (c) Consolidation (one-dimensional)

|             |  |
|-------------|--|
| $C_c$       | compression index (normally consolidated range)      |
| $C_r$       | recompression index (overconsolidated range)         |
| $C_s$       | swelling index                                       |
| $C_\alpha$  | coefficient of secondary consolidation               |
| $m_v$       | coefficient of volume change                         |
| $c_v$       | coefficient of consolidation (vertical direction)    |
| $T_v$       | time factor (vertical direction)                     |
| $U$         | degree of consolidation                              |
| $\sigma'_p$ | pre-consolidation stress                             |
| OCR         | overconsolidation ratio $= \sigma'_p / \sigma'_{vo}$ |

#### (d) Shear Strength

|                      |  |
|----------------------|--|
| $\tau_p$ or $\tau_r$ | peak and residual shear strength                             |
| $\phi'$              | effective angle of internal friction                         |
| $\delta$             | angle of interface friction                                  |
| $\mu$                | coefficient of friction $= \tan \delta$                      |
| $c'$                 | effective cohesion   |
| $c_u$ or $s_u$       | undrained shear strength ( $\phi = 0$ analysis)              |
| $p$                  | mean total stress $(\sigma_1 + \sigma_3) / 2$                |
| $p'$                 | mean effective stress $(\sigma'_1 + \sigma'_3) / 2$          |
| $q$                  | $(\sigma_1 - \sigma_3) / 2$ or $(\sigma'_1 - \sigma'_3) / 2$ |
| $q_u$                | compressive strength $(\sigma_1 - \sigma_3)$                 |
| $S_t$                | sensitivity  |

Notes:

$$^1 \tau = c' + \sigma' \tan \phi'$$

$$^2 \text{ shear strength} = (\text{compressive strength}) / 2$$



# LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

## WEATHERING STATE

**Fresh:** no visible sign of rock material weathering

**Faintly Weathered:** weathering limited to the surface of major discontinuities.

**Slightly weathered:** penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

**Moderately weathered:** weathering extends throughout the rock mass but the rock material is not friable

**Highly weathered:** weathering extends throughout rock mass and the rock material is partly friable.

**Completely weathered:** rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

## BEDDING THICKNESS

| <u>Description</u>  | <u>Bedding Plane Spacing</u> |
|---------------------|------------------------------|
| Very Thickly Bedded | > 2 m                        |
| Thickly Bedded      | 0.6 m to 2m                  |
| Medium Bedded       | 0.2 m to 0.6 m               |
| Thinly Bedded       | 60 mm to 0.2 m               |
| Very Thinly Bedded  | 20 mm to 60 mm               |
| Laminated           | 6 mm to 20 mm                |
| Thinly Laminated    | < 6 mm                       |

## JOINT OR FOLIATION SPACING

| <u>Description</u> | <u>Spacing</u> |
|--------------------|----------------|
| Very Wide          | > 3 m          |
| Wide               | 1 – 3 m        |
| Moderately Close   | 0.3 – 1 m      |
| Close              | 50 – 300 mm    |
| Very Close         | < 50 mm        |

## GRAIN SIZE

| <u>Term</u>         | <u>Size*</u>     |
|---------------------|------------------|
| Very Coarse Grained | > 60 mm          |
| Coarse Grained      | 2 – 60 mm        |
| Medium Grained      | 60 microns – 2mm |
| Fine Grained        | 2 – 60 microns   |
| Very Fine Grained   | < 2 microns      |

Note: \*Grains > 60 microns diameter are visible to the naked eye.

## CORE CONDITION

### Total Core Recovery

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

### Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core 100% for core in solid sticks.

## DISCONTINUITY DATA

### Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including naturally occurring fractures but not including mechanically induced breaks caused by drilling.

### Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

### Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature information concerning the nature of fracture surfaces and infillings are also noted.

### Abbreviations

|       |                       |       |                |
|-------|-----------------------|-------|----------------|
| BD -  | Bedding               | PY -  | Pyrite         |
| FO -  | Foliation/Schistosity | Ca -  | Calcite        |
| CL -  | Clean                 | PO -  | Polished       |
| SH -  | Shear Plane/Zone      | K -   | Slickensided   |
| VN -  | Vein                  | SM -  | Smooth         |
| FLT - | Fault                 | RO -  | Ridged/Rough   |
| CO -  | Contact               | ST -  | Stepped        |
| JN -  | Joint                 | PL -  | Planar         |
| FR -  | Fracture              | IR -  | Irregular      |
| MB -  | Mechanical Break      | UN -  | Undulating     |
| BR -  | Broken Rock           | CU -  | Curved         |
| BL -  | Blast Induced         | TCA - | To Core Axis   |
| Il -  | Parallel To           | STR - | Stress Induced |
| OR -  | Orthogonal            |       |                |



|                                   |  |   |  |                          |  |               |  |
|-----------------------------------|--|---|--|--------------------------|--|---------------|--|
| PROJECT <u>12-1121-0099-1130</u>  |  | <b>RECORD OF BOREHOLE No 12-131</b>               |  | SHEET 1 OF 1             |  | <b>METRIC</b> |  |
| G.W.P. <u>4153-10-01</u>          |  | LOCATION <u>N 4882507.5 ; E 234693.5</u>          |  | ORIGINATED BY <u>DWM</u> |  |               |  |
| DIST <u>Eastern</u> HWY <u>62</u> |  | BOREHOLE TYPE <u>Portable Drill, NW/BW Casing</u> |  | COMPILED BY <u>JM</u>    |  |               |  |
| DATUM <u>Geodetic</u>             |  | DATE <u>November 21, 2012</u>                     |  | CHECKED BY <u>SAT</u>    |  |               |  |

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS        | ELEVATION SCALE         | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  |              | PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT |                   |                | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m³ | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |    |    |    |
|---------------|---|------------|---------|------|------------|-----------------------------------|-------------------------|---|--|--|--|--------------|---|-------------------|----------------|--------------------------------------|---|----|----|----|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                                   |                         | SHEAR STRENGTH kPa                          |  |  |  |              | W <sub>p</sub>  | W                 | W <sub>L</sub> |                                      | GR  | SA | SI | CL |
|               |   |            |         |      |            |                                   |                         | ○ UNCONFINED      + FIELD VANE              |  |  |  |              |   | WATER CONTENT (%) |                |                                      |   |    |    |    |
|               |   |            |         |      |            | ● QUICK TRIAXIAL      × REMOULDED | 20   40   60   80   100 |   |  |  |  | 25   50   75 |   |                   |                |                                      |   |    |    |    |
| 75.9          | GROUND SURFACE  |            |         |      |            | ▽                                 |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
| 0.0           | CLAYEY SILT, containing organic matter  |            |         |      |            |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
| 0.2           | Silty SAND, trace gravel  |            | 1       | SS   | 4          |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
| 75.3          | Loose Grey Wet  |            |         |      |            |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
| 0.6           | CLAYEY SILT to SILTY CLAY, trace to some sand   |            | 2       | SS   | 6          |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
|               | Stiff to very stiff Grey-brown Damp to moist  |            | 3       | SS   | 29         |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
|               |   |            | 4       | SS   | 25         |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
|               |   |            | 5       | SS   | 15         |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
| 72.9          |   |            |         |      |            |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
| 3.1           | SILT, some sand and clay, trace gravel  |            | 6       | SS   | 25         |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
|               | Stiff to very stiff Grey-brown Moist to wet   |            |         |      |            |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
| 72.2          |   |            |         |      |            |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
| 3.7           | Sandy SILT, some clay, trace gravel (TILL)  |            | 7       | SS   | 61         |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
|               | Very dense Grey Wet   |            |         |      |            |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
| 71.4          |   |            | 8       | SS   | 50/0.1     |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
| 4.5           | END OF BOREHOLE SAMPLER REFUSAL   |            |         |      |            |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |
|               | NOTES:<br><br>1. Water level in open borehole at ground surface (Elev. 75.9 m), measured during drilling. |            |         |      |            |                                   |                         |   |  |  |  |              |   |                   |                |                                      |   |    |    |    |



GTA-MTO 001 1211210099.GPJ GAL-GTA.GDT 10/23/13 JM

Continued Next Page

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



| PROJECT <u>12-1121-0099-1130</u>  |   | <b>RECORD OF BOREHOLE No 12-132</b>   |        |      |                            | SHEET 2 OF 3             |  | <b>METRIC</b>      |  |  |  |   |                                     |                                   |   |  |  |  |  |  |
|-----------------------------------|---|---|--------|------|----------------------------|--------------------------|--|--------------------|--|--|--|---|-------------------------------------|-----------------------------------|---|--|--|--|--|--|
| G.W.P. <u>4153-10-01</u>          |   | LOCATION <u>N 4882512.2 ; E 234684.5</u>  |        |      |                            | ORIGINATED BY <u>DWM</u> |  |                    |  |  |  |   |                                     |                                   |   |  |  |  |  |  |
| DIST <u>Eastern</u> HWY <u>62</u> |   | BOREHOLE TYPE <u>Power Auger 200 mm Diam. (Hollow Stem), Rotary Drill NQ Core</u> |        |      |                            | COMPILED BY <u>JM</u>    |  |                    |  |  |  |   |                                     |                                   |   |  |  |  |  |  |
| DATUM <u>Geodetic</u>             |   | DATE <u>November 1, 2012</u>  |        |      |                            | CHECKED BY <u>SAT</u>    |  |                    |  |  |  |   |                                     |                                   |   |  |  |  |  |  |
| SOIL PROFILE                      |   | SAMPLES   |        |      | GROUND WATER<br>CONDITIONS | ELEVATION SCALE          | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT  |                    |  |  |  | PLASTIC<br>LIMIT<br>W <sub>p</sub>  | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub> | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |  |  |  |  |
| ELEV<br>DEPTH                     | DESCRIPTION   | STRAT PLOT  | NUMBER | TYPE |                            |                          | "N" VALUES   | SHEAR STRENGTH kPa |  |  |  |   |                                     |                                   |   |  |  |  |  |  |
|                                   | --- CONTINUED FROM PREVIOUS PAGE ---  |   |        |      |                            |                          | <div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED</span> <span>+ FIELD VANE</span> </div> <div style="display: flex; justify-content: space-between;"> <span>● QUICK TRIAXIAL</span> <span>× REMOULDED</span> </div> |                    |  |  |  | <div style="display: flex; justify-content: space-between;"> <span>25 50 75</span> </div> |                                     |                                   |   |  |  |  |  |  |
|                                   | END OF BOREHOLE<br><br>NOTES:<br><br>1. Water level in open borehole at a depth of 2.1 m below ground surface (Elev. 74.9 m), measured during drilling. |   |        |      |                            |                          |  |                    |  |  |  |   |                                     |                                   |   |  |  |  |  |  |



PROJECT: 12-1121-0099-1130

**RECORD OF DRILLHOLE: 12-132**

SHEET 3 OF 3

LOCATION: N 4882512.2 ; E 234684.5

DRILLING DATE: November 1, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG:

DRILLING CONTRACTOR: Marathon Drilling

| DEPTH SCALE<br>METRES | DRILLING RECORD | DESCRIPTION                              | SYMBOLIC LOG | ELEV.<br>DEPTH<br>(m) | RUN No. | NOTE:<br>For abbreviations, symbols and descriptions refer to<br>LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY |                 |             |                        |                                |                                 |    |    |  |                  |                          |                  | FEATURES | NOTES |    |    |    |    |    |    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |    |
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|                       |                 |  |              |                       |         | RECOVERY  |                 | R.Q.D.<br>% | FRACT.<br>INDEX<br>PER | DISCONTINUITY DATA             |                                 |    |    | HYDRAULIC<br>CONDUCTIVITY<br>K, cm/sec |                  | WEATH-<br>ERING<br>INDEX |                  |          |       |    |    |    |    |    |    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |    |
|                       |                 |  |              |                       |         | TOTAL<br>CORE %   | SOLID<br>CORE % |             |                        | DIP w.r.t<br>CORE<br>AXIS<br>° | TYPE AND SURFACE<br>DESCRIPTION | Jr | Js | 10 <sup>-5</sup>                       | 10 <sup>-4</sup> | 10 <sup>-3</sup>         | 10 <sup>-2</sup> |          |       | W1 | W2 | W3 | W4 | W5 | W6 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |    |
|                       |                 |  |              |                       |         |   |                 |             |                        |                                |                                 |    |    |  |                  |                          |                  |          |       |    |    |    |    |    |    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |    |
|                       |                 |  |              |                       |         |   |                 |             |                        |                                |                                 |    |    |  |                  |                          |                  |          |       |    |    |    |    |    |    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |    |
|                       |                 | Continued from Record of Borehole 12-132 |              | 70.72                 |         |   |                 |             |                        |                                |                                 |    |    |  |                  |                          |                  |          |       |    |    |    |    |    |    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | </ |

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: SAT

GTA-RCK 031 1211210099.GPJ GAL-MISS.GDT 10/23/13 JM



| PROJECT  |   | 12-1121-0099-1130 |         | RECORD OF BOREHOLE No 12-133 |            | SHEET 1 OF 1                           |                 | METRIC                                   |    |    |    |                                 |                               |                                |                  |                                       |                   |
|--|---|-------------------|---------|------------------------------|------------|--|-----------------|--|----|----|----|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|-------------------|
| G.W.P.   |   | 4153-10-01        |         | LOCATION                     |            | N 4882495.6 ; E 234683.1               |                 | ORIGINATED BY                            |    |    |    |                                 |                               |                                |                  |                                       |                   |
| DIST   |   | Eastern HWY 62    |         | BOREHOLE TYPE                |            | Power Auger 200 mm Diam. (Hollow Stem) |                 | COMPILED BY                              |    |    |    |                                 |                               |                                |                  |                                       |                   |
| DATUM  |   | Geodetic          |         | DATE                         |            | October 3, 2012                        |                 | CHECKED BY                               |    |    |    |                                 |                               |                                |                  |                                       |                   |
| SAT  |   |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| SOIL PROFILE   |   |                   | SAMPLES |                              |            | GROUND WATER CONDITIONS                | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT |    |    |    | PLASTIC LIMIT<br>W <sub>p</sub> | NATURAL MOISTURE CONTENT<br>W | LIQUID LIMIT<br>W <sub>L</sub> | UNIT WEIGHT<br>γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |                   |
| ELEV<br>DEPTH  | DESCRIPTION   | STRAT PLOT        | NUMBER  | TYPE                         | "N" VALUES |  |                 | SHEAR STRENGTH kPa                       |    |    |    |                                 |                               |                                |                  |                                       | WATER CONTENT (%) |
| 77.4   | GROUND SURFACE  |                   |         |                              |            |  |                 | 20                                       | 40 | 60 | 80 | 100                             |                               |                                |                  |                                       |                   |
| 0.0  | Sand and gravel, some silt (BASE)<br>Grey-brown to brown  |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 76.9   |   |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 0.5  | Sand and gravel, some silt<br>(SUBBASE/EMBANKMENT FILL)<br>Compact to dense<br>Brown<br>Dry               |                   | 1       | SS                           | 30         |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 75.9   |   |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 1.5  | Gravel, some sand and silt<br>(EMBANKMENT FILL)<br>Compact<br>Brown<br>Wet                                |                   | 2       | SS                           | 15         |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 75.0   |   |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 2.4  | Sandy SILT, containing organic<br>matter and decomposed wood<br>Loose to very loose<br>Black-brown<br>Wet |                   | 3       | SS                           | 4          |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 74.4   |   |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 3.1  | SILTY CLAY, trace sand and<br>gravel<br>Very stiff<br>Grey-brown<br>Wet                                   |                   | 4       | SS                           | 3          |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
|  |   |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
|  |   |                   | 5       | SS                           | -          |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 72.8   |   |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 4.6  | SILT, some sand and clay<br>Stiff to very stiff<br>Brown<br>Wet   |                   | 6       | SS                           | 10         |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 72.1   |   |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 5.3  | Sandy SILT, some gravel and clay<br>(TILL)<br>Very loose to loose<br>Grey<br>Wet                          |                   | 7       | SS                           | 3          |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
|  |   |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
|  |   |                   | 8       | SS                           | 30/0.2     |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 71.0   |   |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| 6.5  | END OF BOREHOLE<br>AUGER REFUSAL  |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |
| NOTES:<br>1. Water level in open borehole at a depth of 2.4 m below ground surface (Elev. 75.0 m), measured during drilling. |   |                   |         |                              |            |  |                 |  |    |    |    |                                 |                               |                                |                  |                                       |                   |



| PROJECT      |       | 12-1121-0099-1130  |            | RECORD OF BOREHOLE No 12-134 |      | SHEET 1 OF 2                             |                         | METRIC          |   |                |   |                |          |                   |                                       |  |           |             |
|--------------|-------|--|------------|------------------------------|------|--|-------------------------|-----------------|---|----------------|---|----------------|----------|-------------------|---------------------------------------|--|-----------|-------------|
| G.W.P.       |       | 4153-10-01   |            | LOCATION                     |      | N 4882500.9 ; E 234670.9                 |                         | ORIGINATED BY   |   |                |   |                |          |                   |                                       |  |           |             |
| DIST         |       | Eastern HWY 62   |            | BOREHOLE TYPE                |      | Portable Drill, NW/BW Casing             |                         | COMPILED BY     |   |                |   |                |          |                   |                                       |  |           |             |
| DATUM        |       | Geodetic   |            | DATE                         |      | November 21-22, 2012                     |                         | CHECKED BY      |   |                |   |                |          |                   |                                       |  |           |             |
|              |       |  |            |                              |      |  |                         | SAT             |   |                |   |                |          |                   |                                       |  |           |             |
| SOIL PROFILE |       |  | SAMPLES    |                              |      | DYNAMIC CONE PENETRATION RESISTANCE PLOT |                         |                 | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |                |   | UNIT WEIGHT    |          |                   | REMARKS & GRAIN SIZE DISTRIBUTION (%) |  |           |             |
| ELEV         | DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER                       | TYPE | "N" VALUES                               | GROUND WATER CONDITIONS | ELEVATION SCALE | SHEAR STRENGTH kPa                                  |                |   |                |          | WATER CONTENT (%) |                                       |  | γ         | GR SA SI CL |
|              |       |  |            |                              |      |  |                         | 20 40 60 80 100 | 20 40 60 80 100                                     | W <sub>p</sub> | W | W <sub>L</sub> | 25 50 75 | kN/m <sup>3</sup> |                                       |  |           |             |
| 75.2         | 0.0   | GROUND SURFACE   |            |                              |      |  |                         |                 |   |                |   |                |          |                   |                                       |  |           |             |
|              |       | Sandy SILT, containing organic matter<br>Brown<br>Wet  |            | 1                            | SS   | 2  |                         | 75              |   |                |   |                |          |                   |                                       |  |           |             |
| 74.6         | 0.6   | CLAY, some sand and silt<br>Brown<br>Moist   |            | 2                            | SS   | 4  |                         | 74              |   |                |   |                |          |                   |                                       |  |           |             |
| 74.0         | 1.2   | CLAYEY SILT, trace sand<br>Very stiff<br>Grey-brown to grey<br>Moist   |            | 3                            | SS   | 18                                       |                         |                 |   |                |   |                |          |                   |                                       |  |           |             |
|              |       |  |            | 4                            | SS   | 13                                       |                         | 73              |   |                |   |                |          |                   |                                       |  |           |             |
|              |       |  |            | 5                            | SS   | 11                                       |                         |                 |   |                |   |                |          |                   |                                       |  |           |             |
| 72.2         | 3.1   | SILT, some sand and clay<br>Stiff to very stiff<br>Grey<br>Wet   |            | 6                            | SS   | 14                                       |                         | 72              |   |                |   |                |          |                   |                                       |  |           |             |
| 71.5         | 3.7   | Layered Silty SAND and Sandy SILT, some clay, trace gravel (TILL)<br>Compact to dense<br>Grey<br>Wet                   |            | 7                            | SS   | 30                                       |                         | 71              |   |                |   |                |          |                   |                                       |  |           |             |
|              |       |  |            | 8                            | SS   | 41                                       |                         |                 |   |                |   |                |          |                   |                                       |  |           |             |
| 70.5         | 4.8   | Limestone (BEDROCK)  |            |                              |      |  |                         | 70              |   |                |   |                |          |                   |                                       |  |           |             |
|              |       | Bedrock cored from depths of 4.8 m to 8.3 m  |            | 1                            | RC   | REC 100%                                 |                         |                 |   |                |   |                |          |                   |                                       |  | RQD = 90% |             |
|              |       | For bedrock coring details refer to Record of Drillhole 12-134   |            | 2                            | RC   | REC 100%                                 |                         | 69              |   |                |   |                |          |                   |                                       |  | RQD = 93% |             |
|              |       |  |            | 3                            | RC   | REC 100%                                 |                         | 68              |   |                |   |                |          |                   |                                       |  | RQD = 95% |             |
| 66.9         | 8.3   | END OF BOREHOLE  |            |                              |      |  |                         | 67              |   |                |   |                |          |                   |                                       |  |           |             |
|              |       | NOTES:<br><br>1. Water level in screen at 0.05 m depth below ground surface (Elev. 75.15 m), measured on July 2, 2013. |            |                              |      |  |                         |                 |   |                |   |                |          |                   |                                       |  |           |             |



PROJECT: 12-1121-0099-1130

**RECORD OF DRILLHOLE: 12-134**

SHEET 2 OF 2

LOCATION: N 4882500.9 ; E 234670.9

DRILLING DATE: November 21-22, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG:

DRILLING CONTRACTOR: OGS

| DEPTH SCALE<br>METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | NOTE:<br>For abbreviations, symbols and descriptions refer to<br>LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY |         |              |                 |                 |             |                        |                            |                    |    |  |                  |                  |                          |    |    | FEATURES | NOTES |    |    |    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |    |
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|                       |                 |             |              | ELEV.<br>DEPTH<br>(m)   | RUN No. | FLUSH RETURN | RECOVERY        |                 | R.Q.D.<br>% | FRACT.<br>INDEX<br>PER | DIP w.r.t.<br>CORE<br>AXIS | DISCONTINUITY DATA |    | HYDRAULIC<br>CONDUCTIVITY<br>K, cm/sec |                  |                  | WEATH-<br>ERING<br>INDEX |    |    |          |       |    |    |    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |    |
|                       |                 |             |              |   |         |              | TOTAL<br>CORE % | SOLID<br>CORE % |             |                        |                            | Jr                 | Js | 10 <sup>-6</sup>                       | 10 <sup>-5</sup> | 10 <sup>-4</sup> | W1                       | W2 | W3 |          |       | W4 | W5 | W6 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |    |
|                       |                 |             |              |   |         |              |                 |                 |             |                        |                            |                    |    |  |                  |                  |                          |    |    |          |       |    |    |    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |    |
|                       |                 |             |              |   |         |              |                 |                 |             |                        |                            |                    |    |  |                  |                  |                          |    |    |          |       |    |    |    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |    |
|                       |                 |             |              |   |         |              |                 |                 |             |                        |                            |                    |    |  |                  |                  |                          |    |    |          |       |    |    |    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | </ |

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: SAT

GTA-RCK 031 1211210099.GPJ GAL-MISS.GDT 10/23/13 JM





# **APPENDIX B**

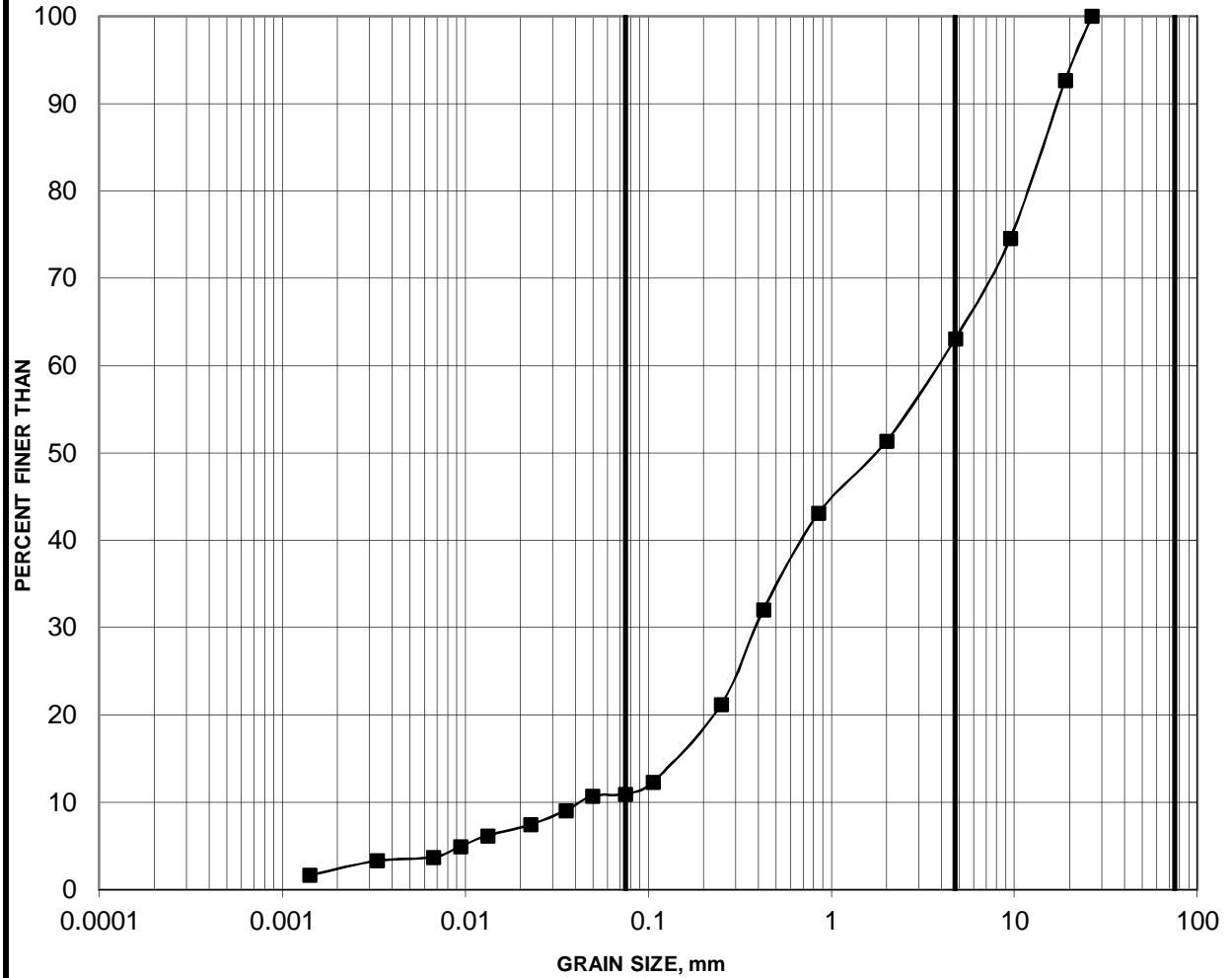
## **Laboratory Test Results**



# GRAIN SIZE DISTRIBUTION

FIGURE B1

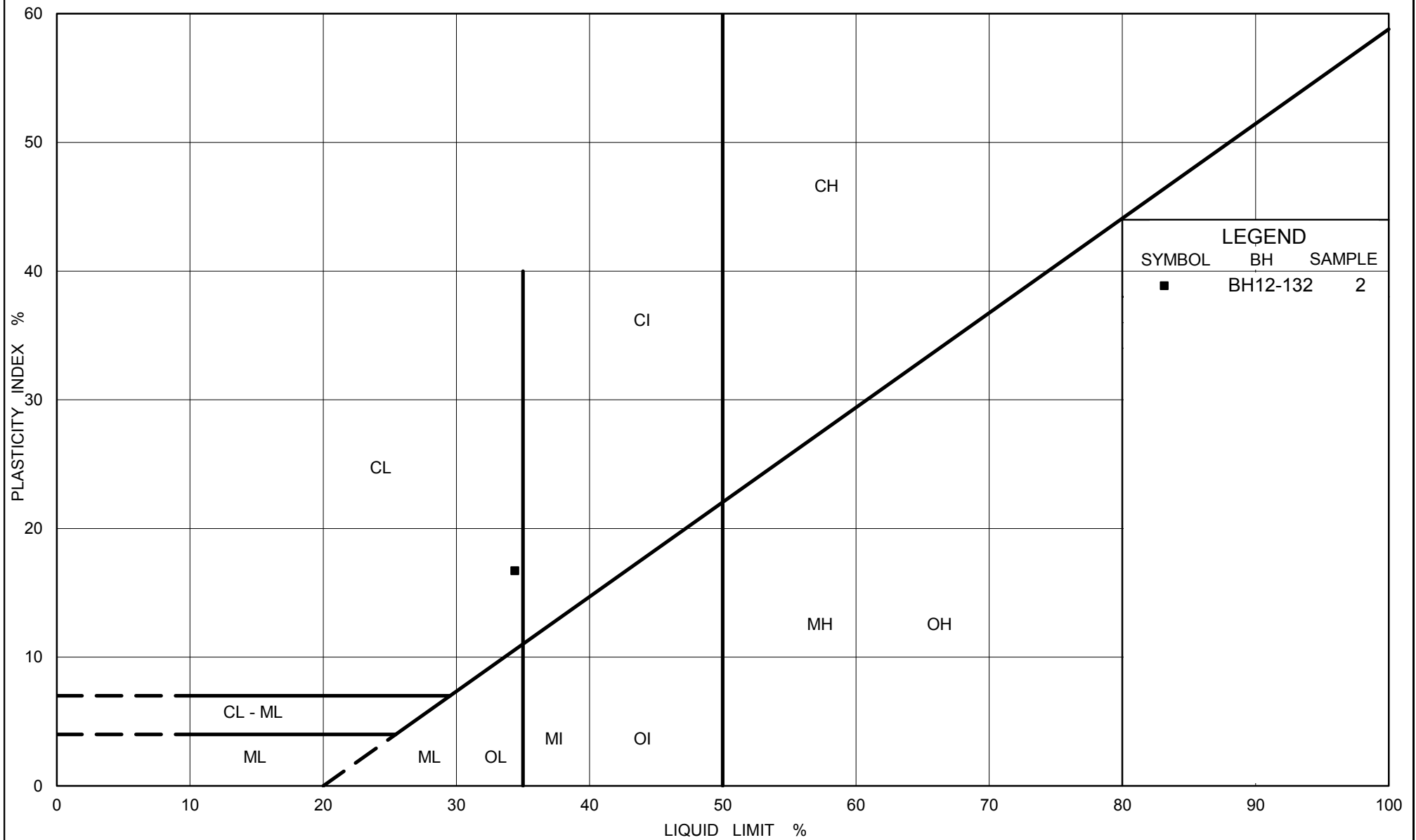
## EMBANKMENT FILL



|               |           |        |        |             |        |                |
|---------------|-----------|--------|--------|-------------|--------|----------------|
| SILT AND CLAY | FINE      | MEDIUM | COARSE | FINE        | COARSE | COBBLE<br>SIZE |
|               | SAND SIZE |        |        | GRAVEL SIZE |        |                |

| Borehole   | Sample | Depth (m) |
|------------|--------|-----------|
| —■— 12-132 | 1      | 0.76-1.37 |





Ontario

Ministry of Transportation

## PLASTICITY CHART EMBANKMENT FILL

FIG No. B2

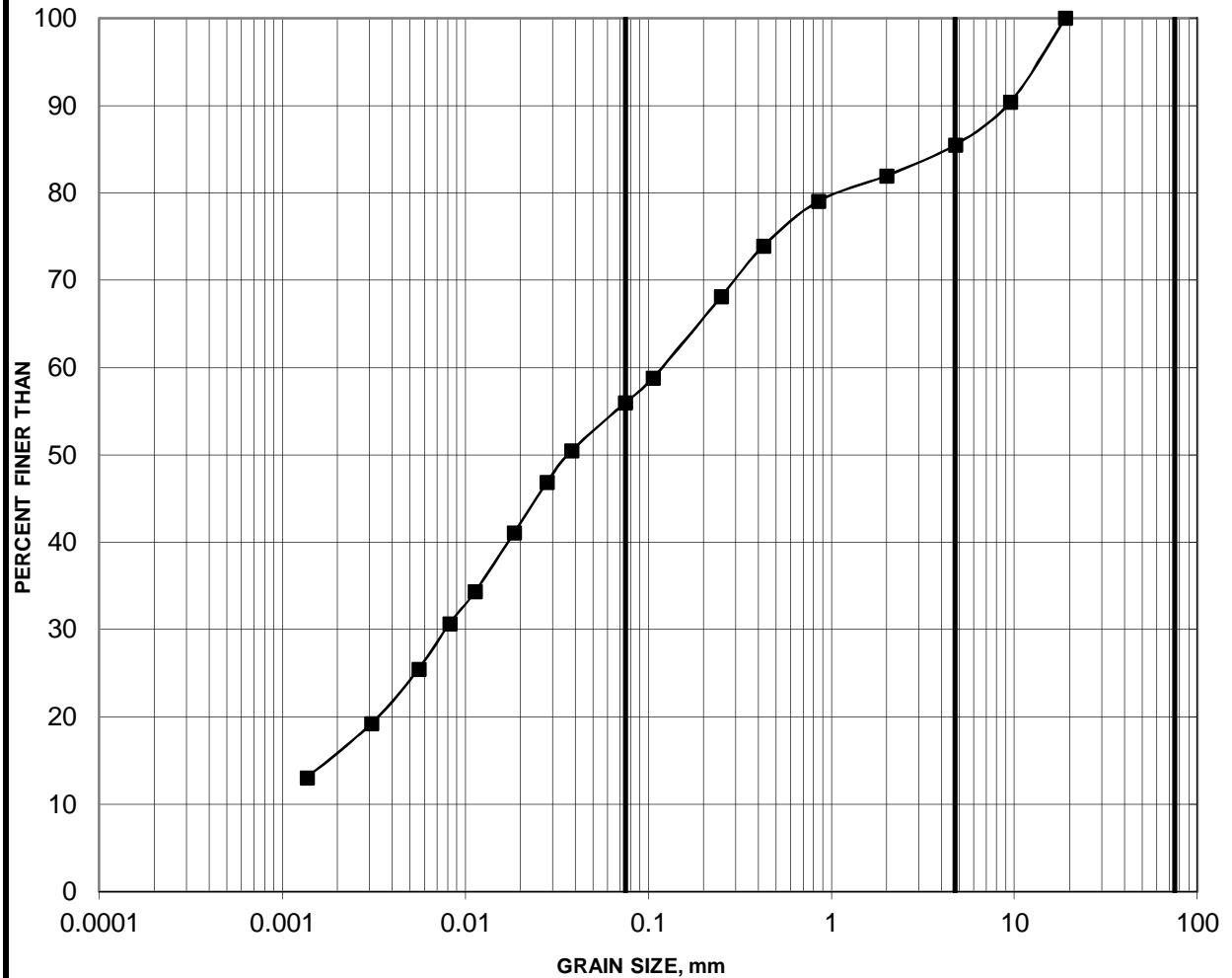
Project No. 12-1121-0099-1130



# GRAIN SIZE DISTRIBUTION

FIGURE B3

SILT, some sand, gravel and clay



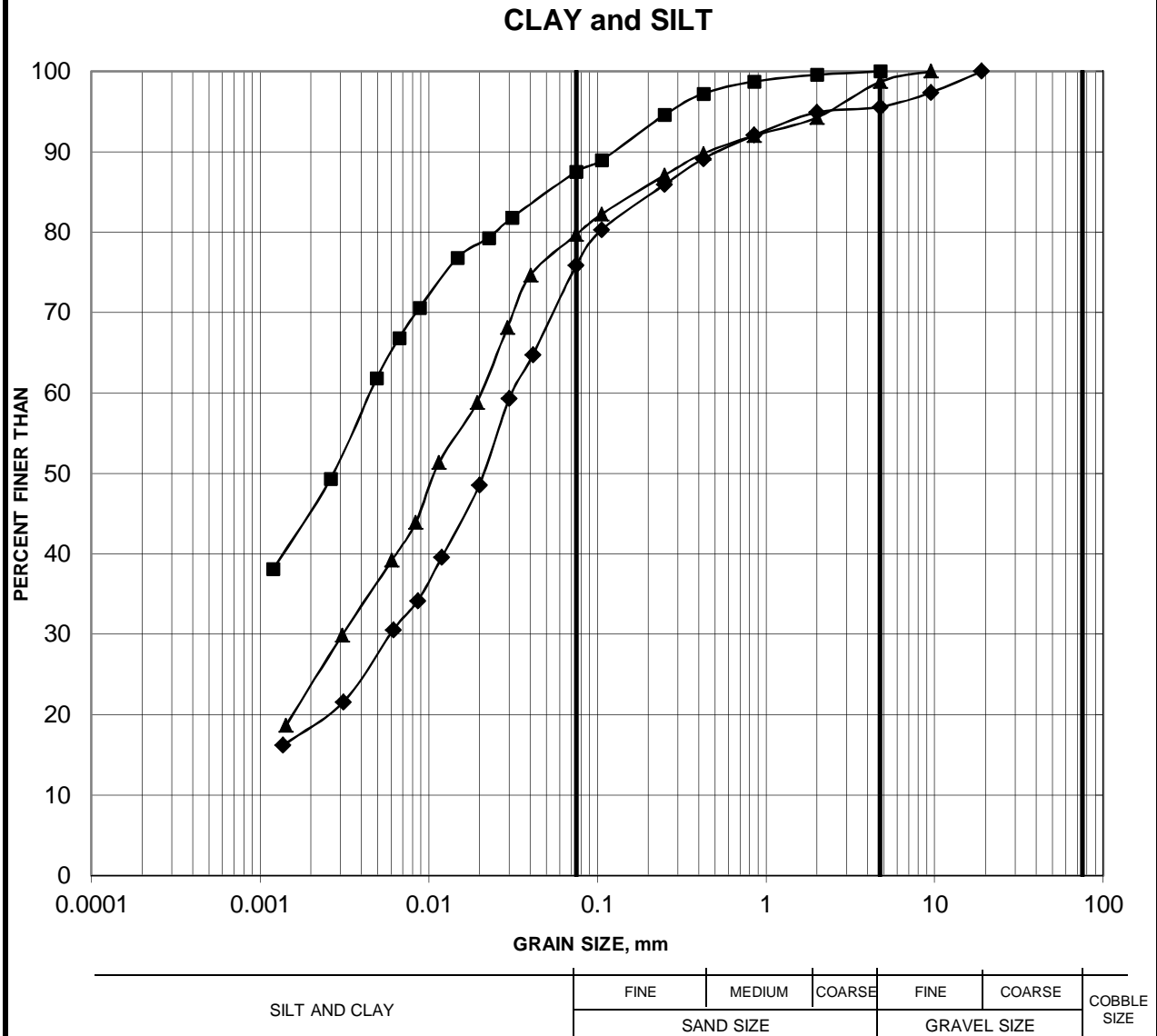
|               |           |        |        |             |        |                |
|---------------|-----------|--------|--------|-------------|--------|----------------|
| SILT AND CLAY | FINE      | MEDIUM | COARSE | FINE        | COARSE | COBBLE<br>SIZE |
|               | SAND SIZE |        |        | GRAVEL SIZE |        |                |

| Borehole | Sample | Depth (m) |
|----------|--------|-----------|
| 12-132   | 3      | 2.29-2.90 |



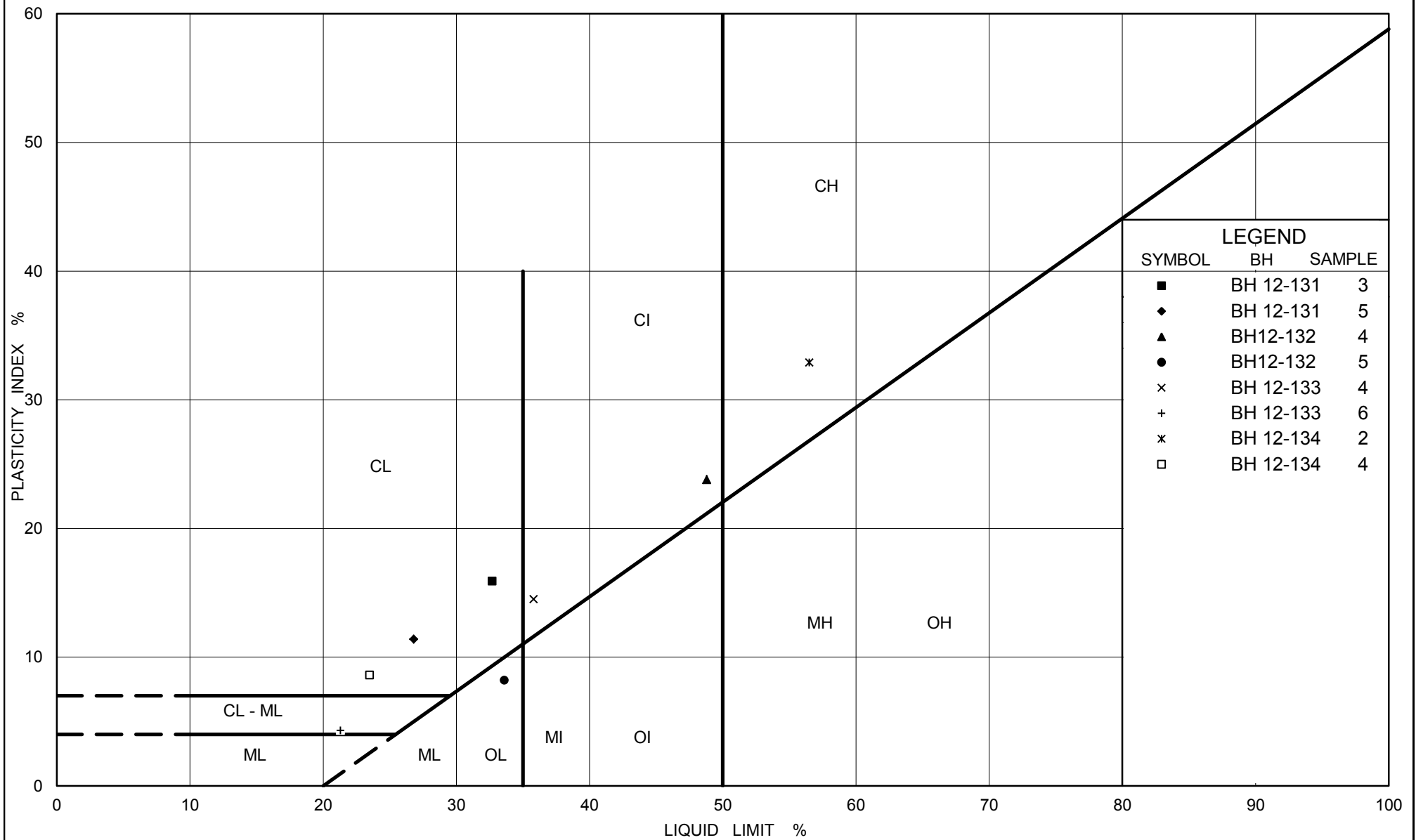
# GRAIN SIZE DISTRIBUTION

FIGURE B4



| Borehole | Sample | Depth (m) |
|----------|--------|-----------|
| 12-131   | 2      | 0.61-1.22 |
| 12-131   | 6      | 3.05-3.66 |
| 12-134   | 6      | 3.05-3.66 |





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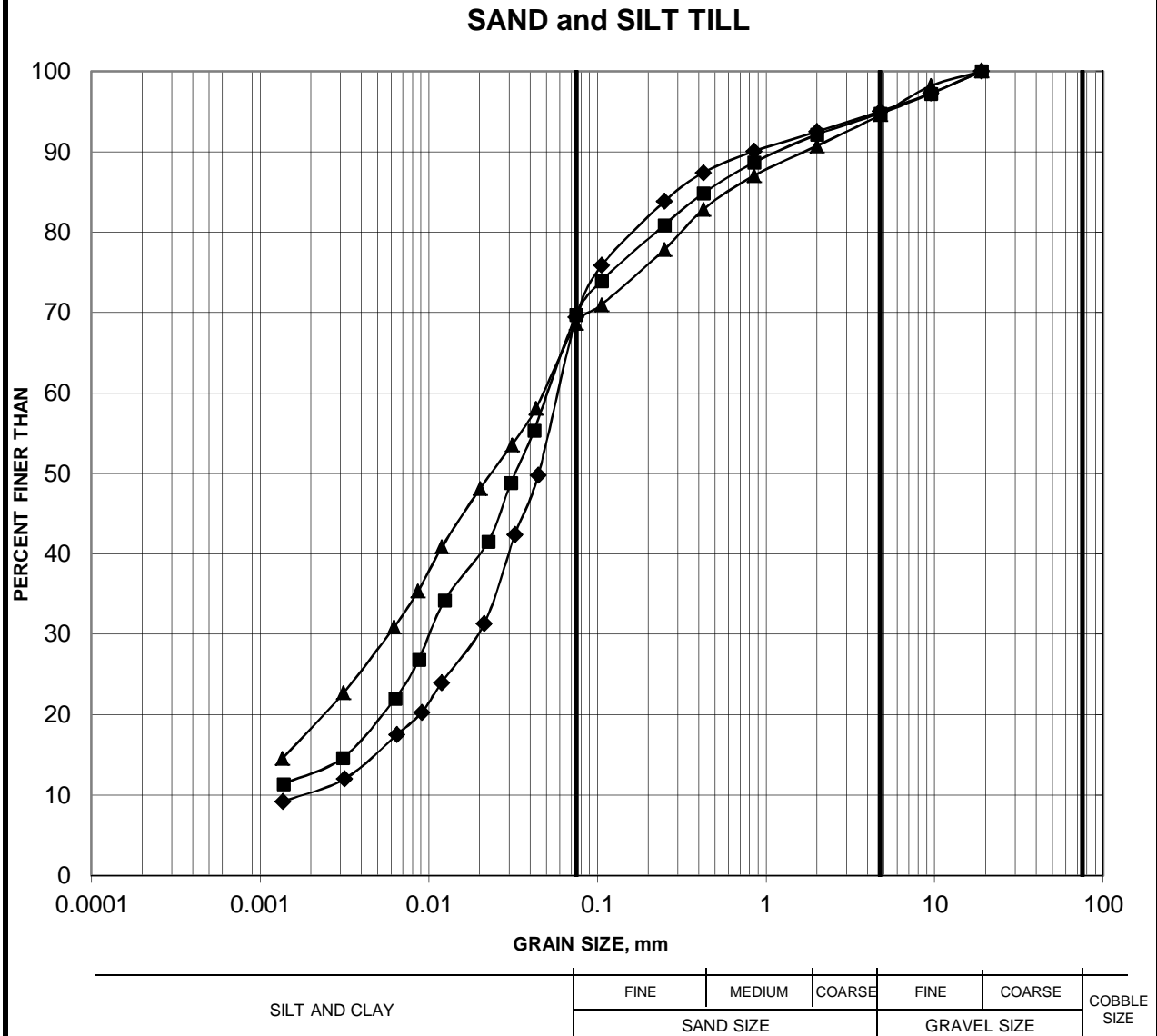
FIG No. B5

Project No. 12-1121-0099-1130



# GRAIN SIZE DISTRIBUTION

FIGURE B6

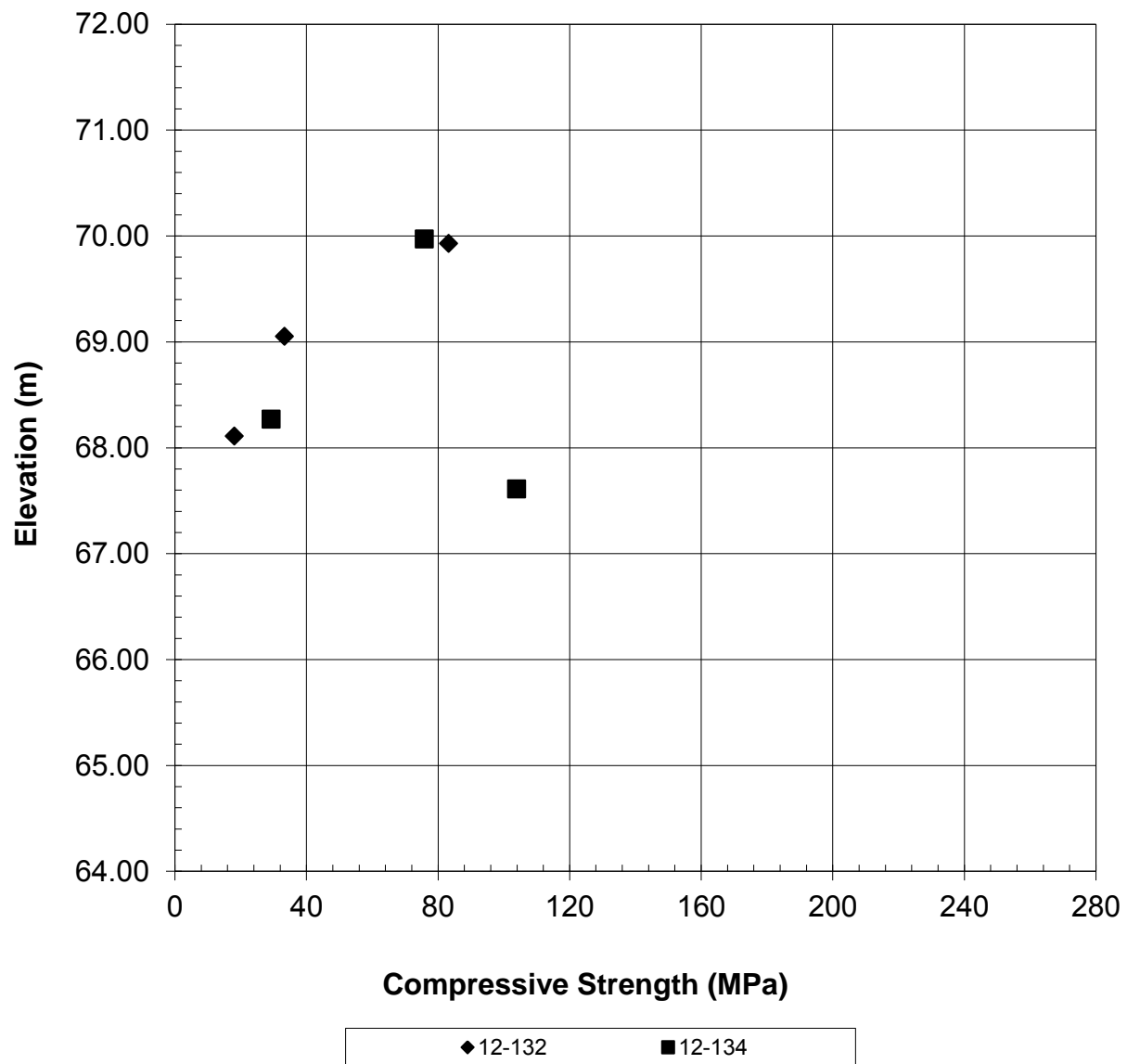


| Borehole   | Sample | Depth (m) |
|------------|--------|-----------|
| —■— 12-131 | 7      | 3.66-4.27 |
| —◆— 12-132 | 6      | 5.49-6.10 |
| —▲— 12-133 | 7      | 5.34-5.95 |



**SUMMARY OF LABORATORY COMPRESSIVE STRENGTH  
POINT LOAD TESTING**

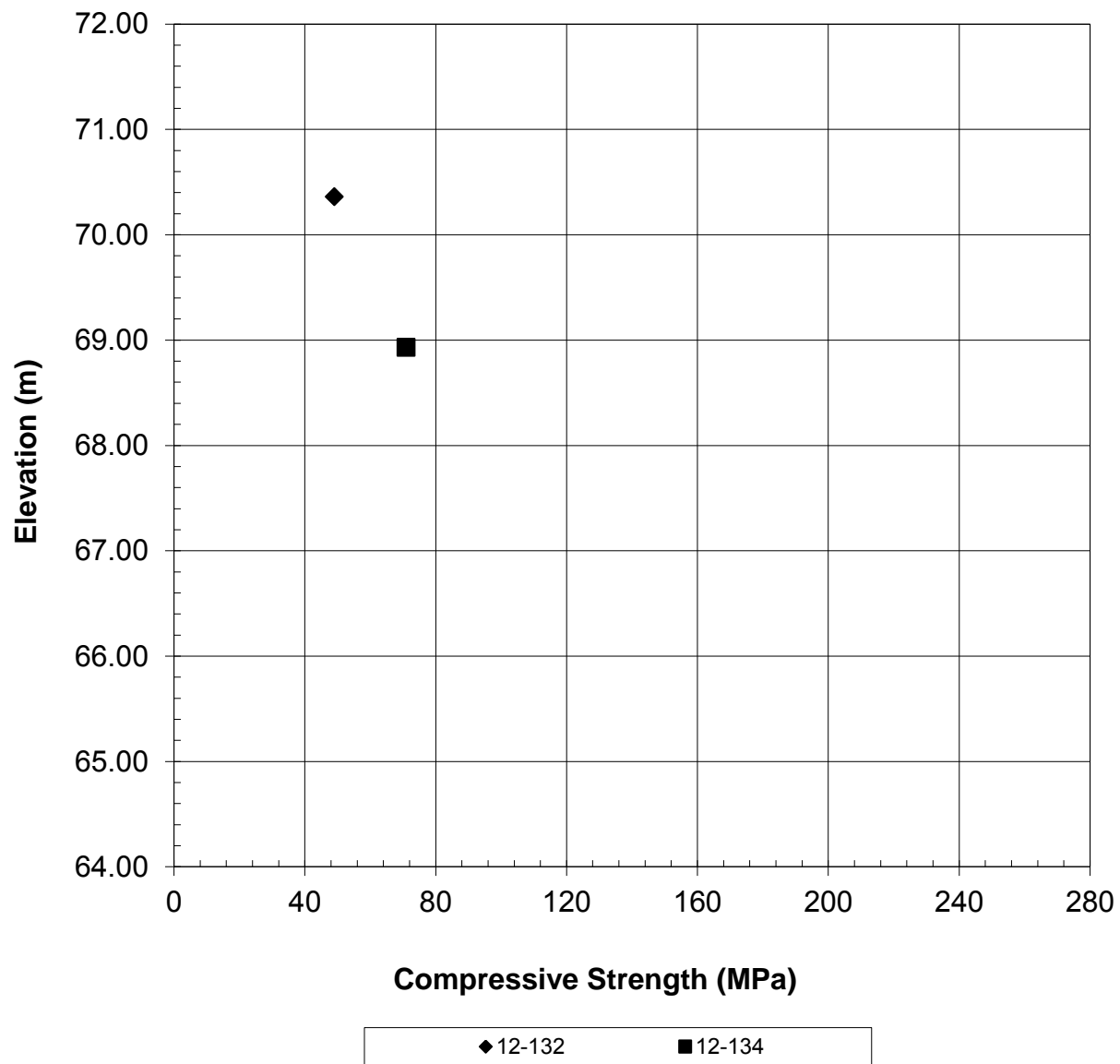
**FIGURE B7**





**SUMMARY OF LABORATORY COMPRESSIVE STRENGTH  
UNCONFINED COMPRESSION TESTS**

**FIGURE B8**





At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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[solutions@golder.com](mailto:solutions@golder.com)  
[www.golder.com](http://www.golder.com)

**Golder Associates Ltd.**  
**32 Steacie Drive**  
**Kanata, Ontario, K2K 2A9**  
**Canada**  
**T: +1 (613) 592 9600**

