



December 3, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

**HIGHWAY 540 KAGAWONG TRIBUTARY CREEK BRIDGE, SITE 49-073
TOWNSHIP OF BILLINGS, MANITOULIN ISLAND, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5057-07-00, WP 5262-10-01**

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REPORT





**FOUNDATION REPORT
HIGHWAY 540 KAGAWONG TRIBUTARY CREEK BRIDGE
SITE 49-073**

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PART A

**FOUNDATION INVESTIGATION REPORT
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of the Kagawong Tributary Creek Bridge (Site 49-073) in the Township of Billings on Manitoulin Island, Ontario. The Key Plan showing the general location of this section of Highway 540 and the location of the investigated area are shown on Drawing 1.

The purpose of this investigation is to establish the subsurface conditions at the location of the bridge by borehole drilling, in situ testing and laboratory testing on selected samples.

2.0 SITE DESCRIPTION

The Kagawong Tributary Creek Bridge is located on Highway 540 in Kagawong, Ontario. The land use in the area is generally rural (i.e., farm land) with a few residences in the vicinity of the site.

In general, the topography in the area of the overall project limits is flat. The banks adjacent to the creek are gently sloping down from the roadway embankment towards the creek and are vegetated with grass. The creek flows from south to north and is approximately 6.5 m wide at the bridge location. A 300 mm diameter steel pipe has been installed along the south side of the bridge, fully spanning the creek. Photographs taken at the site are included following the text of the report.

The existing bridge is 6 m long and 12 m wide and the highway grade at the bridge is at about Elevation 214.1 m. The creek water level was measured by Golder on May 28, 2014 at Elevation 213.0 m.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation was carried out between May 26 and 28, 2014, during which time a total of six boreholes (Boreholes KC-1 to KC-6) were advanced at the locations shown on Drawing 1.

The field investigation was carried out using a truck-mounted CME-55 drill rig supplied and operated by Landcore Drilling of Sudbury, Ontario. The boreholes were advanced through the overburden using 108 mm inside diameter hollow-stem augers. Soil samples were obtained at intervals of depth of about 0.75 m, using a 50 mm outer diameter split-spoon sampler, operated by an automatic hammer on the drill rig, in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08a). Samples of the bedrock were obtained using NW casing and 'NQ' size rock core barrels in each of the boreholes. The groundwater levels in the open boreholes were observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 (as amended).

The fieldwork was supervised throughout by a member of our technical staff who: located the boreholes; arranged for the clearance of underground services; supervised the drilling and sampling 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 our Sudbury Geotechnical Laboratory where the samples underwent further visual examination and laboratory testing. Classification testing (water contents and



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grain size distribution) was carried out on selected soil samples. In addition, uniaxial compressive strength (UCS) testing was carried out on selected specimens of the bedrock core recovered from the boreholes. All of the geotechnical laboratory tests were carried out according to MTO LS standards. The results of the laboratory testing are included on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B.

A sample of the creek water was obtained using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by a member of our technical staff, referenced to stations on the highway. The MTM NAD 83 northing and easting coordinates, ground surface elevations referenced to Geodetic datum and borehole depths at each borehole location are presented on the Record of Borehole sheets in Appendix A and are summarized below.

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (incl. bedrock core) (m)
	Northing	Easting		
KC-1	5084705.4	323531.7	214.3	3.0
KC-2	5084709.5	323550.3	214.1	4.7
KC-3	5084717.4	323548.1	214.1	4.4
KC-4	5084713.5	323557.5	214.1	4.6
KC-5	5084721.3	323556.1	214.1	4.5
KC-6	5084724.1	323573.7	214.1	3.0

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on surficial geology mapping from the Ministry of Natural Resources¹, the site is located within a glaciolacustrine deposit consisting of silt and clay.

Based on bedrock geology mapping from the Ministry of Natural Resources², the bedrock in the area consists of shale and limestone of the Georgian Bay Formation.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced for this investigation, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole and Drillhole sheets in Appendix A. The results of the laboratory testing are provided in Appendix B. The results of the analytical testing on the sample of creek water are summarized in Table B1 in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred

¹ Ministry of Natural Resources, electronic mapping obtained 2014, MRD128, 2007

² Ministry of Natural Resources, electronic mapping obtained 2014, MRD219, 2006



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from non-continuous sampling, observations of drilling progress and the results of SPTs. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy based on the results of the boreholes is shown in profile on Drawing 1 and in cross-sections on Drawing 2.

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

4.2.1 Embankment Fill

A 200 mm to 300 mm thick layer of asphalt was encountered at ground surface in each of the boreholes.

Embankment fill between 1.1 m and 1.3 m thick was encountered below the asphalt in each of the boreholes. The embankment fill generally consisted of brown sand and gravel to gravelly sand with a 0.1 m and 0.2 m thick layer of clayey silt fill encountered at the bottom of Boreholes KC-1 and KC-2, respectively.

Standard Penetration Test (SPT) 'N'-values in the embankment fill range between 10 blows and 28 blows per 0.3 m of penetration indicating a compact relative density.

Grain size distribution tests were carried out on five samples of the embankment fill and the results are shown on Figure B1 in Appendix B.

The natural water content measured on samples of the fill is between 2 per cent and 5 per cent.

4.2.2 Bedrock/Refusal

Bedrock was cored in all of the boreholes and the bedrock surface depths and elevations are presented below.

Borehole No.	Depth to Bedrock (m)	Bedrock Surface Elevation (m)	Notes
KC-1	1.5	212.8	Bedrock Cored for 1.5 m
KC-2	1.4	212.7	Bedrock Cored for 3.3 m
KC-3	1.3	212.8	Bedrock Cored for 3.1 m
KC-4	1.5	212.6	Bedrock Cored for 3.1 m
KC-5	1.4	212.7	Bedrock Cored for 3.1 m
KC-6	1.5	212.6	Bedrock Cored for 1.5 m

The retrieved bedrock core is described as a fine grained, slightly weathered, grey, dolomitic limestone, as presented in the Record of Drillhole sheets in Appendix A. Clay/silt seams/lenses up to about 25 mm thick were encountered in Boreholes KC-4 and KC-5 at the depths noted on the drillhole sheets. Photographs of the retrieved bedrock core samples are shown on Figure B2 in Appendix B.

The Total Core Recovery of the bedrock cored in all boreholes is 100 per cent except at the bottom run in Borehole KC-2 which is 48 per cent, attributed to the loss of the lower portion of bedrock due to the presence of



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a 25 mm clay/silt lens at 4.2 m depth. The Rock Quality Designation measured on the core samples ranges from 29 per cent to 80 per cent, indicating a rock mass of poor to good quality as per Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006)³.

Laboratory Uniaxial Compressive Strength (UCS) testing was carried out on four core samples of the bedrock and the laboratory test sheet are presented in Appendix B. The UCS values are presented on the Record of Drillhole sheets and are summarized below and the test results indicate that the bedrock is strong to very strong as per Table 3.5 of the CFEM (2006).

Borehole	Depth/Elevation (m)	UCS (MPa)
KC-2	1.7/212.4	135
KC-3	1.8/212.3	122
KC-4	2.1/212.0	86
KC-5	2.0/212.1	73

4.2.3 Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The water level in the creek was at Elevation 213.0 m measured on May 28, 2014.

Borehole No.	Depth to Groundwater Level Below Ground Surface (m)	Groundwater Elevation (m)
KC-1	1.3	213.0
KC-2	1.1	213.0
KC-3	1.1	213.0
KC-4	1.2	212.9
KC-5	1.1	213.0
KC-6	1.3	212.8

Groundwater levels in the area are subject to seasonal fluctuations and to fluctuations after precipitation events and snowmelt.

5.0 CLOSURE

The field drilling program was supervised by Mr. Mathew Riopelle and this report was prepared by Mr. André Bom, P.Eng. Mr. Jorge Costa, P.Eng., Golder's Designated MTO Contact for this project, carried out a quality control review and reviewed the technical aspects of the report.

³ Canadian Geological Society, 2003. Canadian Foundation Engineering Manual, 4th Edition.



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Report Signature Page

GOLDER ASSOCIATES LTD.



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Geotechnical Engineer



Jorge M.A. Costa, P.Eng.
Designated MTO Contact, Principal

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**FOUNDATION REPORT
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PART B

FOUNDATION DESIGN REPORT

HIGHWAY 540, KAGAWONG TRIBUTARY CREEK BRIDGE, SITE 49-073

TOWNSHIP OF BILLINGS, MANITOULIN ISLAND, ONTARIO

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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides an interpretation of the factual geotechnical data obtained during the investigation and conclusions and recommendations on the foundation aspects of design of the proposed works. The recommendations provided are intended for the guidance of the design engineer. Where comments are made on construction, they are provided to highlight aspects of construction that could affect the design of the project. Those requiring information on aspects of construction must make their own interpretation of the subsurface information provided as such interpretation may affect their proposed construction methods, costs, equipment selection, scheduling and the like.

6.1 General

The existing Kagawong Tributary Creek Bridge is a 6 m long single span and 12 m wide structure and will be replaced with a 6.8 m long and 10.8 m wide single span bridge. Concrete wing walls will be constructed at each of the four corners of the structure extending parallel to Highway 540 to a distance of 3.3 m from the ends of the structure. The grade of the highway will essentially remain the same (Elevation 241.1 m) with only a minor grade raise as required for pavement reconstruction.

6.2 Geotechnical Resistance

A factored geotechnical axial resistance at Ultimate Limit States (ULS) of 1,000 kPa may be used for design of the ship/spread footings founded directly on bedrock. The geotechnical reaction at Serviceability Limit States for footings founded on the bedrock will be equal to or greater than the factored geotechnical resistance at ULS and, therefore, the ULS values will govern for design.

The geotechnical resistances are given for loads applied perpendicular to the surface of the base of the footings. Where loads are not applied perpendicular to the base of the footings, inclination of the loads should be taken into account in accordance with Section 6.7.4 and Section C6.7.4 of the Canadian Highway Bridge Code (CHBDC) and its Commentary.

6.2.1 Resistance to Lateral Loads/Sliding Resistance

Resistance to lateral forces/sliding resistance between the base of footings and the bedrock surface should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For a cast-in-place concrete footing, the coefficient of friction is $\tan \phi = 0.7$.

This value is unfactored, in accordance with CHBDC; a factor of 0.8 is to be applied in calculating the horizontal resistances.



6.2.2 Frost Protection

The estimated frost penetration depth at this site is 1.6 m, as per OPSD 3090.101 (Foundation, Frost Penetration Depths for Southern Ontario). As the footings for bridge structure will be founded directly on bedrock, frost susceptibility is not an issue.

6.3 Stability and Settlement

The following sections summarize the results of stability and settlement analyses for the bridge foundations and reconstructed embankment in the immediate vicinity of the structure.

6.3.1 Stability

Based on the existing/proposed embankment geometry and the subsurface conditions at this site, granular fill embankments at this site will be stable at side slopes no steeper than 2 Horizontal to 1 Vertical (2H:1V).

6.3.2 Settlement

As the proposed bridge footings will be founded directly on the bedrock surface, settlement of the footings will not occur.

It is recommended that OPSS.PROV1010 (Aggregates) Granular 'A' or 'B' Type I or II be used for embankment reconstruction at the bridge location. Where granular fill will be placed below the groundwater level, Granular 'B' Type II should be used. The material placed above the water level should be compacted in accordance with OPSS 501 (Compacting). Compression settlement of the fill placed below water and from properly compacted embankment fill above water is expected to occur during construction.

6.4 Lateral Earth Pressures

The lateral earth pressures acting on the abutment walls and wing walls of the bridge will depend on the type and method of placement of backfill materials, the nature of soils/embankment fill behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls.

The following recommendations are made concerning the design of the bridge abutment walls and wing walls. It should be noted that these design recommendations and parameters are applicable to level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select, free draining granular fill meeting the requirements of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II but with less than 5 per cent passing the 200 sieve (0.075 mm) should be used as backfill behind the abutment walls and wing walls. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the granular backfill requirements with



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respect to sub drains and frost taper should be in accordance with OPSD 3101.150 (Wall, Abutment, Backfill) and OPSD 3121.150 (Walls Retaining, Backfill).

- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with CHBDC Section 6.9.3 and Figure 6.6. Compaction equipment should be used in accordance with OPSS 501 (Compacting). Other surcharge loadings should be accounted for in the design as required.
- Granular fill may be placed either in a zone with the width equal to at least 1.6 m behind the back of the walls for a restrained wall (see Figure C6.20(a) of the Commentary to the CHBDC), or within the wedge shaped zone defined by a line drawn at 1.5 H:1V extending up and back from the rear face of the base of the walls for an unrestrained wall (see Figure C6.20(b) of the Commentary to the CHBDC). The pressures are based on the proposed embankment fill material and the following parameters (unfactored) may be used:

Fill Type	Unit Weight	Coefficients of Static Lateral Earth Pressure	
		At-Rest, K_o	Active, K_a
Granular 'A'	22 kN/m ³	0.43	0.27
Granular 'B' Type II	21 kN/m ³	0.43	0.27

If the abutment/wing walls allow for lateral yielding, active earth pressures may be used in the geotechnical design of the structure. If the walls do not allow lateral yielding, at-rest earth pressures should be assumed for geotechnical design. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure, may be taken as presented in Table C6.6 of the Commentary to the CHBDC.

6.5 Construction Considerations

6.5.1 Excavations, Subgrade Preparation and Backfill

Since the proposed structure footings will be founded on the bedrock surface, temporary support systems such as sheet piling will not be feasible at this site. Soldier piles and lagging (with the piles socketted into bedrock or supported by tie backs or rakers) may be used for support of the excavation along the structure, as well as along the roadway for traffic protection. Temporary excavation support systems should be designed and constructed in accordance with OPSS 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadways. Alternatively, the bridge footings could be installed using open-cut excavations with a maximum temporary side slope of 1.5H:1V or flatter within the existing fill (short-term excavations). The existing fill at this site may be classified as Type 3 soil. All excavations must be carried out in accordance with Ontario Regulation 213 Ontario Occupational Health and Safety Act for Construction Projects (as amended). In addition, provisions for traffic control measures should be included in the Contract Documents to maintain the safe operation of the existing Highway 540.



FOUNDATION REPORT HIGHWAY 540 KAGAWONG TRIBUTARY CREEK BRIDGE SITE 49-073

Prior to placing any fill for new construction, all fill, organics and native soils should be excavated to expose the bedrock surface within the plan limits of the proposed footings.

Groundwater control will be required as further discussed in Section 6.5.3 to construct the footings in-the-dry.

The thickness of fill placed during backfilling should be maintained equal on both sides of the structure with one side not exceeding the other by more than 500 mm.

New granular fill should be keyed into the existing embankment side or cut slopes as per the requirements of OPSP 208.010 (Benching of Earth Slopes) to minimize differential settlement between the existing embankment and the newly placed embankment fill.

The structure should be designed for the full overburden stress and appropriate live loads, assuming a fill unit weight of 22 kN/m^3 for Granular 'A' and 21 kN/m^3 for Granular 'B' Type II backfill above and surrounding the structure. Inspection and field density testing should be carried out by qualified personnel during fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

6.5.2 Erosion Protection

Provision should be made for scour and erosion protection at the structure foundations (footings on bedrock). The requirements for and design of erosion protection measures for the upstream and downstream sides of the structure and side slope of the adjacent approach embankment should be assessed by the hydraulics design engineer. The abutment front slopes and side slopes adjacent to the creek should be protected with erosion protection in accordance with OPSS 511 (Rip Rap), placed on the slopes to at least 0.5 m above the design high water level. .

6.5.3 Control of Groundwater and Surface Water

The existing creek will likely have to be diverted/piped during construction of the bridge foundations. Surficial water seepage into the excavation should be expected and will be heavier during periods of sustained precipitation. Seepage from the granular fills and from along the fill bedrock contact should be expected, particularly after precipitation events. It is anticipated that this surficial seepage can be controlled by using properly filtered sumps within the excavation.

Unwatering will be required for construction of the concrete footings in-the-dry. The excavations will be advanced through water-bearing granular fill to the fill/bedrock contact and appropriate unwatering of the granular fill and the fractured dolomitic limestone bedrock will be required to maintain the water level below the founding level of the footings during excavation and construction. It is recommended that an NSSP be included in the Contract to address unwatering for the culvert site; a sample NSSP is included in Appendix C.



6.5.4 Analytical Testing for Construction Materials

The analytical test results on a sample of creek water taken adjacent to the existing structure are presented in Table B1. The suite of parameters tested is intended to allow the structural engineer to assess the requirements for the appropriate type of cement to be used in construction and the need for corrosion protection.

7.0 CLOSURE

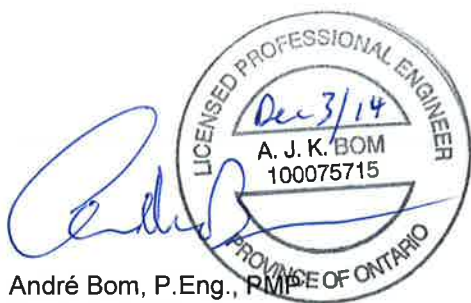
This report was prepared by Mr. André Bom, P.Eng. Mr. Jorge Costa, P.Eng., Golder's Designated MTO Contact, carried out a quality control review and reviewed the technical aspects of the report.



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REFERENCES

Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.

Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA-S6-06. 2006. CSA Special Publication, S6.1-06. Canadian Standard Association.

Ministry of Natural Resources, electronic mapping obtained 2014, MRD128, 2007.

Ministry of Natural Resources, electronic mapping obtained 2014, MRD219, 2006.

STANDARDS

ASTM International:

ASTM D1586-08a	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
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Ontario *Occupational Health and Safety Act*

Ontario Regulation 213	Construction Projects (as amended)
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Ontario Provincial Standard Drawing

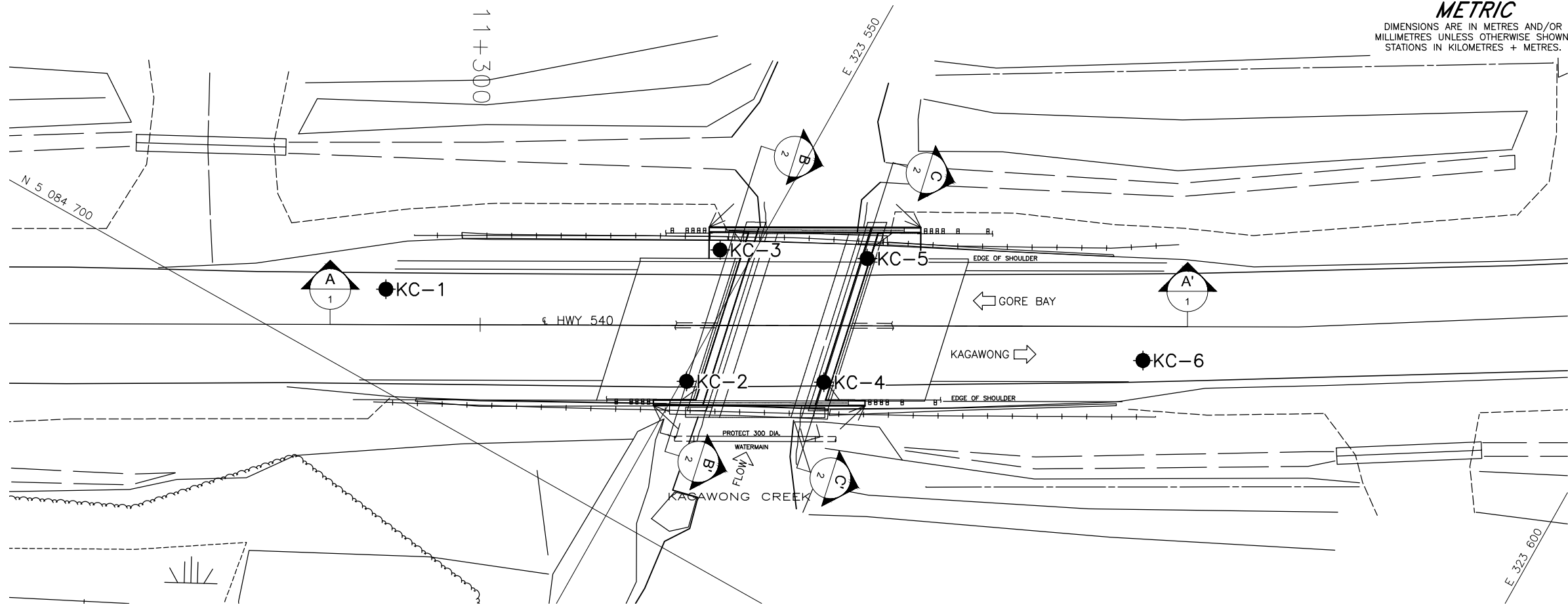
OPSD 208.010	Benching of Earth Slopes
OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario
OPSD 3101.150	Walls, Abutment, Backfill, Minimum Granular Requirement
OPSD 3121.150	Walls, Retaining, Backfill, Minimum Granular Requirement

Ontario Provincial Standard Specification

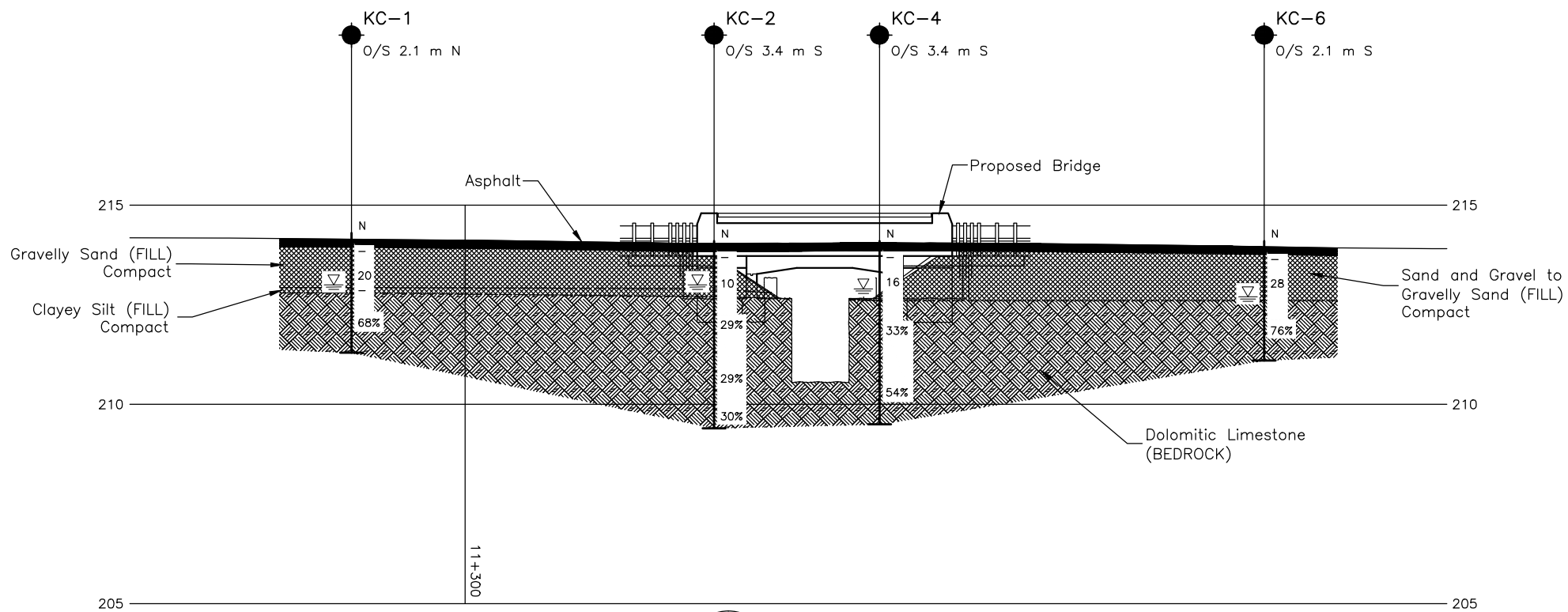
OPSS 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip Rap, Rock Protection and Granular Sheeting
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario *Water Resources Act*

Ontario Regulation 372/97	Amendment to Ontario Regulation 903
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PLAN
SCALE
3 0 3 6 m



A-A'
1

PROFILE

HORIZONTAL SCALE
3 0 3 6 m
1.5 0 1.5 3 m
VERTICAL SCALE

METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.5262-10-01

HIGHWAY 540
KAGAWONG CREEK BRIDGE
BORE-HOLE LOCATIONS AND SOIL STRATA



KEY PLAN

LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
KC-1	214.3	5084705.4	323531.7
KC-2	214.1	5084709.5	323550.3
KC-3	214.1	5084717.4	323548.1
KC-4	214.1	5084713.5	323557.5
KC-5	214.1	5084721.3	323556.1
KC-6	214.1	5084724.1	323573.7

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 final design configuration as shown elsewhere in the Contracts Documents.

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

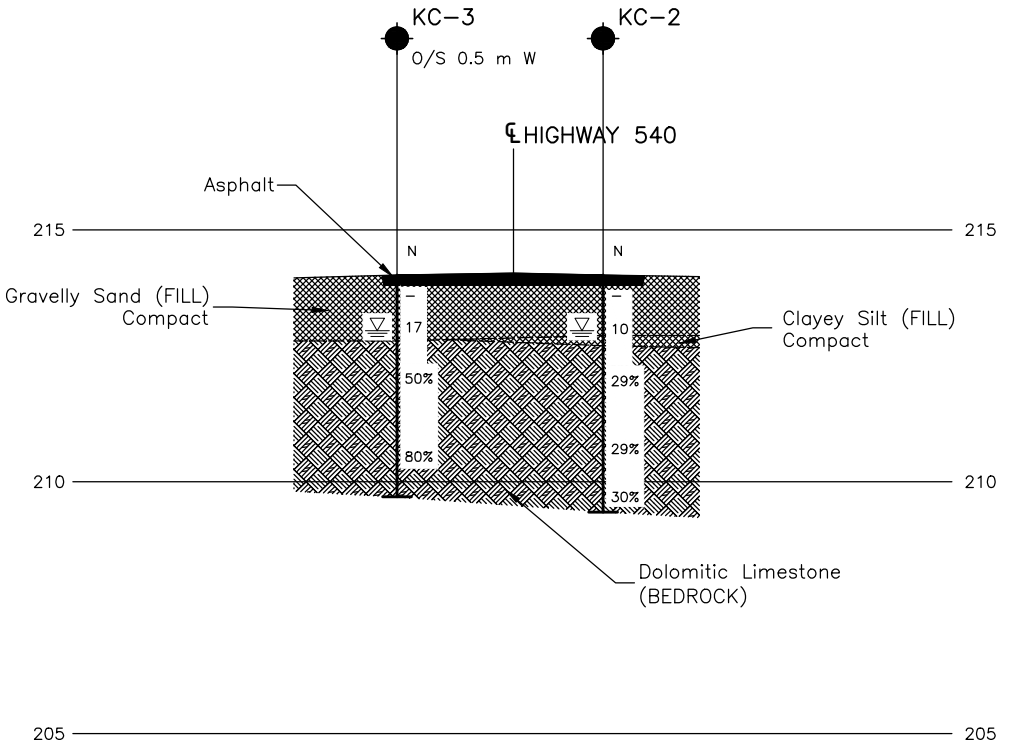
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

REFERENCE

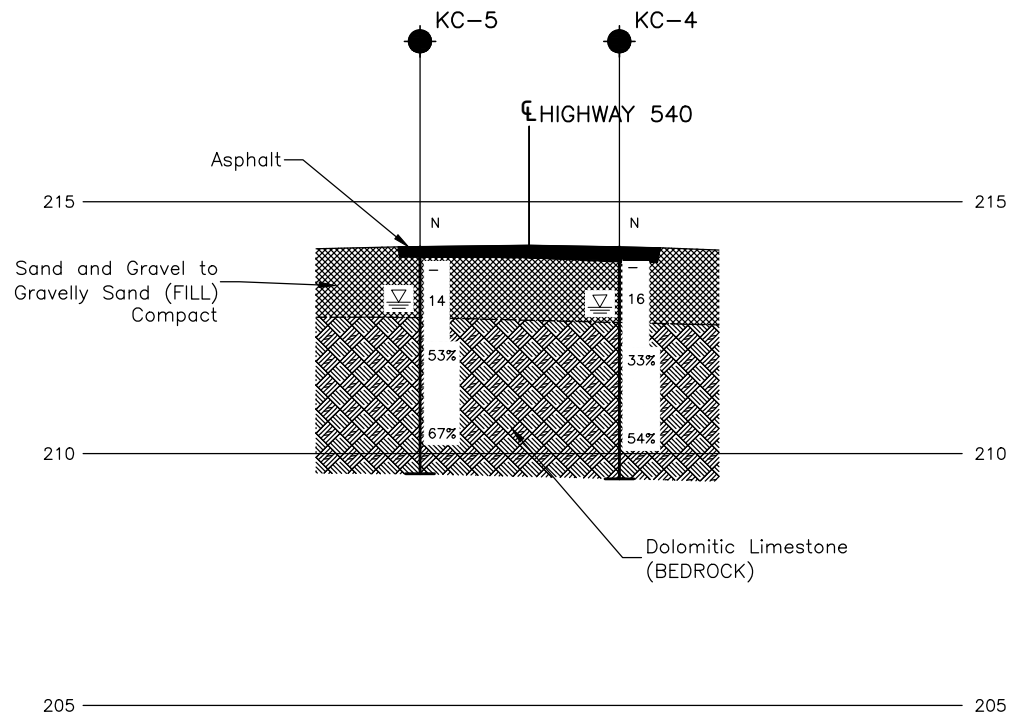
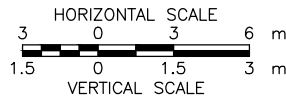
Base plans provided in digital format by AECOM, drawing file nos. GWP 5057-07-00.dwg, received AUG 08, 2014 Kagawong Bridge 49-073.dwg, received NOV 27, 2014.



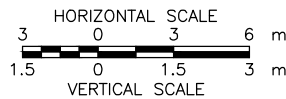
NO.	DATE	BY	REVISION
1	DEC 03, 2014	JMAC	ISSUED FOR PERMIT
2	DEC 03, 2014	JMAC	REVISED FOR COMMENTS
3	DEC 03, 2014	JMAC	REVISED FOR COMMENTS
4	DEC 03, 2014	JMAC	REVISED FOR COMMENTS
5	DEC 03, 2014	JMAC	REVISED FOR COMMENTS
6	DEC 03, 2014	JMAC	REVISED FOR COMMENTS
7	DEC 03, 2014	JMAC	REVISED FOR COMMENTS
8	DEC 03, 2014	JMAC	REVISED FOR COMMENTS
9	DEC 03, 2014	JMAC	REVISED FOR COMMENTS
10	DEC 03, 2014	JMAC	REVISED FOR COMMENTS



B-B' WEST ABUTMENT SECTION
1



C-C' EAST ABUTMENT SECTION
1



METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.5060-07-01

HIGHWAY 540
KAGAWONG CREEK BRIDGE
SOIL STRATA

SHEET



LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
KC-2	214.1	5084709.5	323550.3
KC-3	214.1	5084717.4	323548.1
KC-4	214.1	5084713.5	323557.5
KC-5	214.1	5084721.3	323556.1

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 final design configuration as shown elsewhere in the Contracts Documents.

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

The complete 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 AECOM, drawing file nos. GWP 5057-07-00.dwg, received AUG 08, 2014 and Kagawong Bridge 49-073.dwg, received NOV 27, 2014.



NO.	DATE	BY	REVISION
1	DEC 03, 2014	JMAC	ISSUED FOR CONSTRUCTION
2	DEC 03, 2014	JMAC	REVISED
3	DEC 03, 2014	JMAC	REVISED
4	DEC 03, 2014	JMAC	REVISED
5	DEC 03, 2014	JMAC	REVISED
6	DEC 03, 2014	JMAC	REVISED
7	DEC 03, 2014	JMAC	REVISED
8	DEC 03, 2014	JMAC	REVISED
9	DEC 03, 2014	JMAC	REVISED
10	DEC 03, 2014	JMAC	REVISED

Geocres No. 41G-18

HWY. 540	PROJECT NO. 13-1191-0005	DIST.
SUBM'D. AC	CHKD.	DATE: DEC 2014
DRAWN: TB	CHKD. AB	APPD. JMAC
		DWG. 2



SITE PHOTOGRAPHS

Photograph 1: Looking West from North Side of Bridge (May 2014)



Photograph 2: Looking West from South Side of Bridge (May 2014)





APPENDIX A

Record of Boreholes and Drillholes



LIST OF SYMBOLS

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

I. GENERAL

π	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

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	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
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(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 = $(e_{max} - e) / (e_{max} - e_{min})$ (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 (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, 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

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$
$$\text{shear strength} = (\text{compressive strength})/2$$



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

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	c_u, s_u	
	kPa	psf
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_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
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 ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of 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 and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
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	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

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 varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to 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 abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

PROJECT 13-1191-0005			RECORD OF BOREHOLE No KC-1			1 OF 2 METRIC											
W.P. 5262-10-01			LOCATION N 5084705.4; E 323531.7			ORIGINATED BY MR											
DIST HWY 540			BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring			COMPILED BY JLL											
DATUM GEODETIC			DATE May 28, 2014			CHECKED BY AB											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
214.3	GROUND SURFACE																
0.0	ASPHALT (300 mm)																
0.3	Gravelly sand, some silt (FILL) Compact Brown Moist		1	AS	-												
			2	SS	20												
212.9	Clayey silt, trace sand, trace gravel (FILL) Grey Wet		3	AS	-												
1.5	DOLOMITIC LIMESTONE (BEDROCK)		1	RC	REC 100%												
211.3	Bedrock cored from 1.5 m depth to 3.0 m depth.																
3.0	For coring details see Record of Drillhole KC-1. END OF BOREHOLE																
Note: 1. Water level at a depth of 1.3 m below ground surface (Elev. 213.0 m) upon completion of drilling.																	

PROJECT: 13-1191-0005

RECORD OF DRILLHOLE: KC-1

SHEET 2 OF 2

LOCATION: N 5084705.4 ;E 323531.7

DRILLING DATE: May 28, 2014

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55 Truck Mount

DRILLING CONTRACTOR: Landcore

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	CORRELATION LOG																	NOTES WATER LEVELS INSTRUMENTATION		
						FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY k, cm/s			Diametral Point Load Index (MPa)	RMC -Q AVG				
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 m	10 m	10 m						
																						JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate		BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular
NOTE: For additional abbreviations refer to list of abbreviations & symbols.																									
		TOP OF BEDROCK		212.8																					
2	CME 55 NQ CORING	Dolomitic Limestone Fine grained Slightly weathered Grey		1.5	1	GREY 100%																			
		Numerous joints between 1.6 m and 1.7 m and vertical joint between 1.7 m and 2.0 m depth. All joints irregular and rough.																							
3		END OF DRILLHOLE		211.3																					
4																									
5																									
6																									
7																									
8																									
9																									
10																									
11																									

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: AB

SUD-RCK 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:

PROJECT		13-1191-0005		RECORD OF BOREHOLE No KC-2		1 OF 2 METRIC										
W.P.		5262-10-01		LOCATION		N 5084709.5; E 323550.3										
DIST		HWY 540		BOREHOLE TYPE		108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring										
DATUM		GEODETIC		DATE		May 27, 2014										
				ORIGINATED BY		MR										
				COMPILED BY		JJL										
				CHECKED BY		AB										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
214.1	GROUND SURFACE															
0.0	ASPHALT (200 mm)															
0.2	Gravelly sand, some silt (FILL) Compact Brown Moist		1	AS	-											
212.9	Clayey silt, trace sand, trace gravel (FILL) Grey		2	SS	10											27 61 (12)
1.4	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 1.4 m depth to 4.7 m depth. For coring details see Record of Drillhole KC-2.		1	RC	REC 100%											RQD = 29%
			2	RC	REC 100%											RQD = 29%
			3	RC	REC 48%											RQD = 30%
209.4	END OF BOREHOLE															
4.7	Note: 1. Water level at a depth of 1.1 m below ground surface (Elev. 213.0 m) upon completion of drilling.															

SUD-MTO 001 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:

SHEET 2 OF 2

DATUM: GEODETIC

DRILL RIG: CME 55 Truck Mount

DRILLING CONTRACTOR: Landcore

[illegible]

1 : 50

CHECKED: AB

PROJECT 13-1191-0005				RECORD OF BOREHOLE No KC-3				1 OF 2 METRIC									
W.P. 5262-10-01				LOCATION N 5084717.4; E 323548.1				ORIGINATED BY MR									
DIST HWY 540				BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring				COMPILED BY JLL									
DATUM GEODETIC				DATE May 26, 2014				CHECKED BY AB									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
214.1	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT (200 mm)						214										
0.2	Gravelly sand, some silt (FILL) Compact Brown Moist		1	AS	-												
212.8			2	SS	17		213										25 64 (11)
1.3	DOLOMITIC LIMESTONE (BEDROCK)																
	Bedrock cored from 1.3 m depth to 4.4 m depth.		1	RC	REC 100%		212										RQD = 50%
	For coring details see Record of Drillhole KC-3.																
			2	RC	REC 100%		211										RQD = 80%
209.7							210										
4.4	END OF BOREHOLE																
	Note: 1. Water level at a depth of 1.1 m below ground surface (Elev. 213.0 m) upon completion of drilling.																

SUD-MTO 001 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:

PROJECT: 13-1191-0005

RECORD OF DRILLHOLE: KC-3

SHEET 2 OF 2

LOCATION: N 5084717.4 ;E 323548.1

DRILLING DATE: May 26, 2014

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55 Truck Mount

DRILLING CONTRACTOR: Landcore

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.																NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
								RECOVERY				R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY k, cm/s		Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
								FLUSH	TOTAL CORE %	SOLID CORE %	TYPE AND SURFACE DESCRIPTION			Jr	Ja	Jn	10 10 10 10	10 10 10 10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: AB

SUD-RCK 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:

PROJECT 13-1191-0005				RECORD OF BOREHOLE No KC-4				1 OF 2 METRIC									
W.P. 5262-10-01				LOCATION N 5084713.5; E 323557.5				ORIGINATED BY MR									
DIST _____ HWY 540				BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring				COMPILED BY JJJ									
DATUM GEODETIC				DATE May 27, 2014				CHECKED BY AB									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
214.1	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT (300 mm)						214										
0.3	Gravelly sand, some silt (FILL) Compact Brown Moist		1	AS	-												
			2	SS	16		213										27 60 (13)
212.6	DOLOMITIC LIMESTONE (BEDROCK)																
1.5	Bedrock cored from 1.5 m depth to 4.6 m depth. For coring details see Record of Drillhole KC-4.		1	RC	REC 100%		212										RQD = 33%
			2	RC	REC 100%		211										
							210										RQD = 54%
209.5	END OF BOREHOLE																
4.6	Note: 1. Water level at a depth of 1.2 m below ground surface (Elev. 212.9 m) upon completion of drilling.																

SUD-MTO 001 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:

PROJECT: 13-1191-0005

RECORD OF DRILLHOLE: KC-4

SHEET 2 OF 2

LOCATION: N 5084713.5 ;E 323557.5

DRILLING DATE: May 27, 2014

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55 Truck Mount

DRILLING CONTRACTOR: Landcore

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate										BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage										PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular										PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break										BR - Broken Rock	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
								RECOVERY					R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY					Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
								TOTAL CORE %	SOLID CORE %	FLUSH	JN	FLT			SHR	VN	CJ	BD	FO	CO	OR	CL	PL	CU	UN	ST	IR	PO	K			SM	Ro	MB	k, cm/s																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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PROJECT 13-1191-0005				RECORD OF BOREHOLE No KC-5				1 OF 2 METRIC									
W.P. 5262-10-01				LOCATION N 5084721.3; E 323556.1				ORIGINATED BY MR									
DIST HWY 540				BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring				COMPILED BY JLL									
DATUM GEODETIC				DATE May 26, 2014				CHECKED BY AB									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
214.1	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT (200 mm)						214										
0.2	Sand and gravel to gravelly sand, some silt (FILL) Compact Brown Moist		1	AS	-		213										
212.7			2	SS	14												
1.4	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 1.4 m depth to 4.5 m depth. For coring details see Record of Drillhole KC-5.		1	RC	REC 100%		212										RQD = 53%
			2	RC	REC 100%		211										RQD = 67%
209.6							210										
4.5	END OF BOREHOLE Note: 1. Water level at a depth of 1.1 m below ground surface (Elev. 213.0 m) upon completion of drilling.																

PROJECT: 13-1191-0005

RECORD OF DRILLHOLE: KC-5

SHEET 2 OF 2

LOCATION: N 5084721.3 ;E 323556.1

DRILLING DATE: May 26, 2014

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55 Truck Mount

DRILLING CONTRACTOR: Landcore

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate										BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage										PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular										PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break										BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: AB

SUD-RCK 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:

PROJECT <u>13-1191-0005</u>		RECORD OF BOREHOLE No KC-6		1 OF 2 METRIC	
W.P. <u>5262-10-01</u>		LOCATION <u>N 5084724.1; E 323573.7</u>		ORIGINATED BY <u>MR</u>	
DIST <u> </u> HWY <u>540</u>		BOREHOLE TYPE <u>108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring</u>		COMPILED BY <u>JJL</u>	
DATUM <u>GEODETIC</u>		DATE <u>May 27, 2014</u>		CHECKED BY <u>AB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	w _p	w	w _L		
214.1	GROUND SURFACE																
0.0	ASPHALT (200 mm)																
0.2	Sand and gravel, some silt (FILL) Compact Brown Moist		1	AS	-											42 46 (12)	
			2	SS	28												
212.6																	
1.5	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 1.5 m depth to 3.0 m depth. For coring details see Record of Drillhole KC-6.		1	RC	REC 100%											RQD = 76%	
211.1																	
3.0	END OF BOREHOLE Note: 1. Water level at a depth of 1.3 m below ground surface (Elev. 212.8 m) upon completion of drilling.																

SUD-MTO 001 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:

PROJECT: 13-1191-0005

RECORD OF DRILLHOLE: KC-6

SHEET 2 OF 2

LOCATION: N 5084724.1 ;E 323573.7

DRILLING DATE: May 27, 2014

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55 Truck Mount

DRILLING CONTRACTOR: Landcore

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	UN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.																NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
								FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY k, cm/s			Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: AB

SUD-RCK 13-1191-0005.GPJ GAL-MISS.GDT 11/09/14 DATA INPUT:



**FOUNDATION REPORT
HIGHWAY 540 KAGAWONG TRIBUTARY CREEK BRIDGE
SITE 49-073**

APPENDIX B

Laboratory Test Results



**FOUNDATION REPORT
HIGHWAY 540 KAGAWONG TRIBUTARY CREEK BRIDGE
SITE 49-073**

Table B1 - Summary of Analytical Testing of Creek Water

Parameter	Units	Method Detection Limit	Result
Resistivity	ohm-cm	n/a	2600
Conductivity	µmho/cm	1	390
pH	n/a	n/a	8.30
Sulphate	mg/L	1	Not Detected
Chloride	mg/L	1	2

Notes:

1. Sample obtained May 28, 2014.
2. Analytical testing carried out by Maxxam Analytics Inc.

Prepared by: DAM

Reviewed by: AB

Golder Associates Ltd.
 1010 Lorne Street
 Sudbury, Ontario, Canada P3C 4R9
 Telephone: (705) 524-6861
 Fax: (705) 524-1984



TABLE B2 - SUMMARY OF ROCK CORE TEST DATA

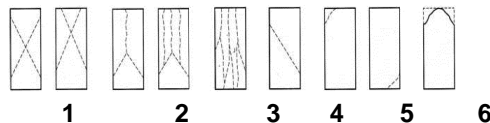
PROJECT NO.: 13-1191-0005
JOB NAME: Kagawong Creek Bridge
TYPE OF UNIT: Bedrock Core

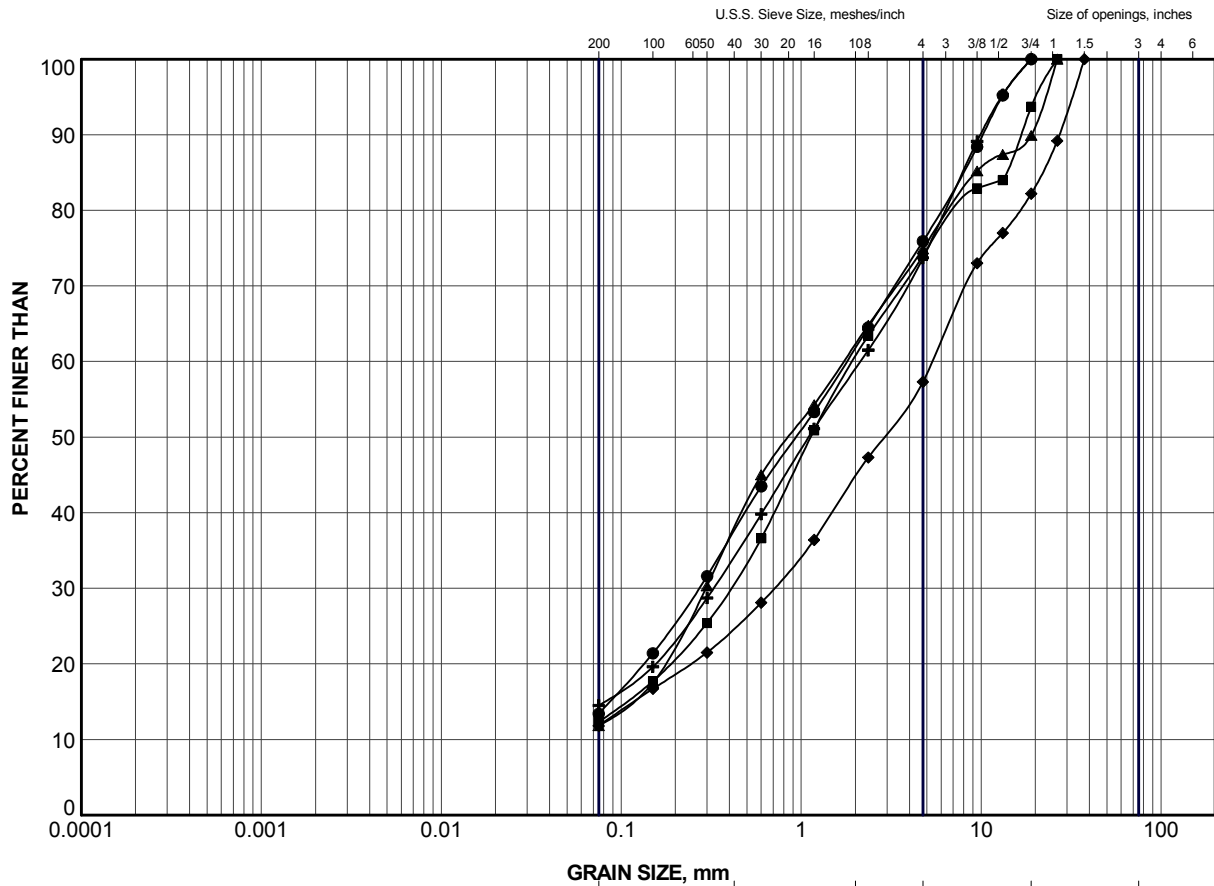
GOLDER LAB NUMBER	GO382	G0383	G0384	G0385
BOREHOLE	KC2	KC3	KC4	KC5
DATE TESTED	June 16, 2014	June 16, 2014	June 16, 2014	June 16, 2014
DEPTH OF TESTED CORE (m)	1.7	1.8	2.1	2.0
LENGTH AS CUT (mm)	97.0	97.0	97.5	98.0
DIAMETER (mm)	47.0	47.0	47.0	47.0
DENSITY (kg/m3)	2832.0	2825	2793	2758
COMPRESSIVE STRENGTH (KN)	233.4	211.7	149.4	127.2
COMPRESSIVE STRENGTH (MPa)	135	122	86	73
TYPE OF FRACTURE	3	3	3	3

Tested by: SA

Type of Fracture

Reviewed by : TG





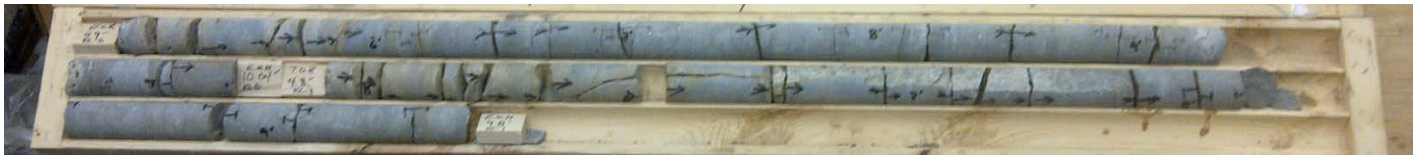
CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	KC-1	2	213.2
■	KC-2	2	213.0
▲	KC-3	2	213.0
+	KC-4	2	213.0
◆	KC-6	2	213.0

PROJECT					
HIGHWAY 540 KAGAWONG CREEK BRIDGE					
TITLE					
GRAIN SIZE DISTRIBUTION GRAVELLY SAND to SAND and GRAVEL (FILL)					
PROJECT No.		13-1191-0005		FILE No. 13-1191-0005.GPJ	
DRAWN	TB	Sep 2014	SCALE	N/A	REV.
CHECK	AB	Sep 2014			
APPR	JMAC	Sep 2014			
			FIGURE B1		





Borehole KC-1 and KC-6
Elevation 212.8 m to 211.3 m and 212.6 m to 211.1 m



Borehole KC-2
Elevation 212.7 m to 209.4 m



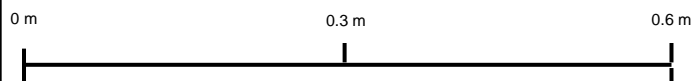
Borehole KC-3
Elevation 212.8 m to 209.7 m




Borehole KC-4
Elevation 212.6 m to 209.5 m



Borehole KC-5
Elevation 212.7 m to 209.6 m



PROJECT		HIGHWAY 11 KAGAWONG CREEK BRIDGE	
TITLE		BEDROCK CORE PHOTOGRAPHS	
	PROJECT No.	13-1191-0005	FILE No. ----
	DESIGN		SCALE AS SHOWN REV.
	CADD	--	
	CHECK	AB	Sept. 2014
	REVIEW		
FIGURE B2			



APPENDIX C

Non-Standard Special Provisions

GROUNDWATER CONTROL - Item No.

Non-Standard Special Provision

Foundations for the new Kagawong Tributary Creek bridge will require excavations to extend below the groundwater level at the site. The non-cohesive fill materials (sand and gravel, gravelly sand) that are present overlying the bedrock extending below the groundwater level will slough, run or cave into the excavation unless appropriate groundwater controls are in place. The Contractor is to design and install an appropriate groundwater control system to enable construction of the footing foundations in dry conditions, and prevent disturbance to the founding stratum.

Basis of Payment

Payment at the lump sum contract price for this Tender Item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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