



December 15, 2015

FOUNDATION INVESTIGATION REPORT

**KEY RIVER NBL BRIDGE, SITE NO.44-462/1
HIGHWAY 69 FOUR-LANING FROM 1.7 KM NORTH OF HIGHWAY 529
NORTHERLY TO 3.9 KM NORTH OF HIGHWAY 522
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5005-10-00; WP 5147-08-01**

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REPORT





Table of Contents

PART A – FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	1
3.0 INVESTIGATION PROCEDURES	2
3.1 Foundation Investigation.....	2
3.2 Optical Borehole Logging	4
3.3 Evaluation of Photographic Records and Bedrock Mapping.....	5
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS	5
4.1 Regional Geology	5
4.2 Subsurface Conditions.....	6
4.3 South Abutment/Approach.....	6
4.3.1 Topsoil	6
4.3.2 Silty Sand.....	6
4.3.3 Bedrock.....	7
4.3.4 Groundwater Conditions	8
4.4 South Pier (Pier 1)	8
4.4.1 Water	8
4.4.2 Organic Silt and Clayey Silt.....	8
4.4.3 Sand to Gravelly Sand	9
4.4.4 Boulders.....	9
4.4.5 Bedrock.....	9
4.5 North Pier (Pier 2).....	10
4.5.1 Water	11
4.5.2 Organic Silt and Clayey Silt.....	11
4.5.3 Gravelly Sandy Silt to Sand	11
4.5.4 Bedrock.....	12
4.6 North Abutment/Approach	13
4.6.1 Peat	13
4.6.2 Cobble/Sand and Gravel.....	13



FOUNDATION REPORT – KEY RIVER NBL BRIDGE – HIGHWAY 69

GWP 5005-10-00; WP 5147-08-01

4.6.3	Bedrock.....	13
4.6.4	Groundwater Conditions	14
5.0	CLOSURE	14

DRAWINGS

Drawing 1	Index Plan
Drawing 2	Borehole Locations and Soil Strata
Drawing 3	Soil Strata
Drawing 4	Soil Strata

FIGURES

Figure 1	Photograph of South Shore Rock Outcrop
Figure 2	Photograph of North Shore Rock Outcrop

APPENDICES

Appendix A Record of Boreholes and Drillholes

Lists of Symbols and Abbreviations	
Lithological and Geotechnical Rock Description Terminology	
Record of Boreholes	B504-01 to B504-20
Record of Drillholes	B504-01, B504-02, B504-06, B504-09 to B504-14 and B504-17

Appendix B Laboratory Test Results and Bedrock Core Photographs

Table B1	Point Load Test Results on Rock Samples
Table B2-1	Summary of Uniaxial Compressive Strength Test Results
Table B2-2	Unconfined Compression Test (UC) – Borehole B504-02, Run No. 2
Table B2-3	Unconfined Compression Test (UC) – Borehole B504-06, Run No. 7
Table B2-4	Unconfined Compression Test (UC) – Borehole B504-09, Run No. 3
Table B2-5	Unconfined Compression Test (UC) – Borehole B504-09, Run No. 5
Table B2-6	Unconfined Compression Test (UC) – Borehole B504-17, Run No. 2
Table B2-7	Unconfined Compression Test (UC) – Borehole B504-17, Run No. 7
Figure B1A	Plasticity Chart – Organic Silt
Figure B1B	Plasticity Chart – Clayey Silt
Figure B2A	Grain Size Distribution – Organic Silt
Figure B2B	Grain Size Distribution – Clayey Silt
Figure B3A	Grain Size Distribution – Sand to Gravelly Sand
Figure B3B	Grain Size Distribution – Gravelly Sandy Silt to Silt and Sand
Figure B4	Bedrock Core Photographs – B504-01 and B504-02
Figure B5	Bedrock Core Photographs – B504-06
Figure B6	Bedrock Core Photographs – B504-09
Figure B7	Bedrock Core Photographs – B504-10 and B504-11
Figure B8	Bedrock Core Photographs – B504-12
Figure B9	Bedrock Core Photographs – B504-13 and B504-14
Figure B10	Bedrock Core Photographs – B504-17

Appendix C Drilling Photographs and Underwater Locates

Figure C1	Drill Setup Photographs
Figure C2	Drill Setup Photographs
Figure C3	Underwater Cable Locates

Appendix D Geophysical Logs, Bedrock Outcrop Photographs and Structural Analysis

Record of Boreholes	B504-06 and B504-17
Figure D1 to D3	Joints and Features – North Abutments
Figure D4 to D8	Joints and Features – South Abutments



PART A

FOUNDATION INVESTIGATION REPORT

KEY RIVER NBL BRIDGE, SITE NO. 44-462/1

HIGHWAY 69 FOUR-LANING FROM 1.7 KM NORTH OF HIGHWAY 529

NORTHERLY TO 3.9 KM NORTH OF HIGHWAY 522

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5005-10-00; WP 5147-08-01



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation investigation services for the proposed Highway 69 northbound lane (NBL) structure over Key River (Site No. 44-462/1), which is within the Contract 5 limits of the new Highway 69 alignment. The proposed work in Contract 5 is part of the four-laning of Highway 69 from 1.7 km north of Highway 529 northerly to 3.9 km north of Highway 522, for a total distance of 19.7 km, which includes: high fill embankments and embankments over swamps; the Canadian National Railway (CNR) re-alignment; the Bekanon Road and Highway 522 interchanges and structures; the Still River, Straight Lake and Key River structures; the Canadian Pacific Railway (CPR) and Canadian National Railway (CNR) overpass structures; as well as culvert crossings. The Key River NBL structure is to be located approximately 550 m east of the existing Highway 69. The general location of this proposed bridge along the new Highway 69 four-laning alignment is shown on the Index Plan on Drawing 1.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated December, 2008. Golder's proposal for foundation engineering services associated with the Contract 5 Key River NBL structure is contained in Section 6.8 of URS's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Quality Control Plan for foundation engineering services for this project, dated April 19, 2010.

This report addresses the investigation carried out for the Key River NBL structure only. Separate reports address the foundation investigations for the related swamp crossings and high fill areas, culverts and other bridge structures for the project.

The purpose of this investigation is to establish the subsurface conditions at the proposed bridge location, by borehole drilling, rock coring, in situ testing and laboratory testing on selected soil and rock core samples. The foundation units/limits for this investigation were located in the field by Callon Dietz Inc. (Callon Dietz), a professional surveying company retained by URS. The investigation area is shown in plan on Drawing 2. The general arrangement of the proposed structure presented on Drawing 2 was provided to us by URS on November 4, 2013.

Preliminary subsurface information for this project is available and was supplied by the MTO, specifically:

- Preliminary Foundation Investigation and Design Report for Structural Areas (Foundation Investigation 2), Highway 69 Four Laning, From 3.5 km North of Highway 559 to 3.8 km North of Highway 522, GWP 5377-02-00, GEOCRE No. 41H-57, dated July 2006, by Amec Earth and Environmental.

2.0 SITE DESCRIPTION

The proposed Highway 69 alignment is oriented generally in a south-north direction spanning the Township of Wallbridge to the south, the Township of Henvey and the Henvey Inlet First Nation Reserve No. 2 and the Township of Mowat to the north. The Contract 5 section of the new four-lane Highway 69 alignment is also oriented generally in a south-north direction within the overall project limits, for a total distance of 1.6 km in Henvey Inlet First Nation Reserve No. 2. The proposed Key River NBL structure is located approximately 0.5 km east of the existing Highway 69 alignment within the Contract 5 highway alignment and is located approximately 0.2 km from the northern limit of Contract 5, corresponding to approximately 10.3 km north of the junction between existing Highway 69 and Highway 526.

In general, the topography of this section of the overall project limits consists of rolling terrain, including sparsely or densely populated tree covered areas and numerous bedrock outcrops separated by valleys and swamps



containing areas of standing water, and various types of vegetation and organic soils. In the immediate area of the NBL bridge site, the topography consists of rolling terrain with densely treed areas and high bedrock outcrops, covered in places with low scrub-brush adjacent to the river. The bedrock outcrops generally slope upward steeply from the river to the north and south shores near the proposed north and south abutments. At the south abutment and along the approach embankment, the bedrock outcrops rise from the river surface (at about Elevation 176 m) and extend as high as about Elevation 198 m, resulting in outcrop heights up to about 22 m above the river level. At the north abutment and approach embankment, the bedrock outcrops rise from the river surface to greater than Elevation 204 m, resulting in outcrop heights greater than about 28 m above the river level.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

Golder's fieldwork for the proposed Highway 69 NBL structure over Key River was carried out between November 7 and 16, 2012 as well as between July 16 and August 7, 2014, during which time a total of eighteen (18) boreholes were advanced at or adjacent to the locations of the footprint of each proposed foundation element footprints and the approaches. These boreholes were supplemented with two (2) boreholes advanced along the centreline between the NBL and SBL structures. A summary of the respective boreholes and their respective locations relative to each foundation element and approach area is presented below.

Foundation Element/ Approach Area	Borehole No.
South Approach Embankment	B504-03
South Abutment	B504-04
	B504-05
	B504-06
	B504-07
	B504-08
	B504-01
South Pier (Pier 1)	B504-09
	B504-10*
	B504-11
	B504-02
North Pier (Pier 2)	B504-12
	B504-13
	B504-14*
	B504-15
North Abutment	B504-16
	B504-17
	B504-18
	B504-19
	B504-20
North Approach Embankment	B504-20

Note: *Boreholes advanced near centreline between NBL and SBL structures.



The Record of Borehole/Drillhole sheets and the results of the laboratory testing are presented in Appendix A and Appendix B, respectively. The locations of the boreholes are shown in plan on Drawing 2.

The boreholes at the approaches/abutments on the bedrock outcrops were advanced using portable drilling equipment supplied and operated by Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario. The bedrock surface was exposed and confirmed at these boreholes under a thin layer of overburden encountered at several locations. Boreholes B504-06 and B504-17 were advanced at the centre of the proposed south and north abutments by coring to depths of 8.1 m and 10.0 m, respectively, below ground surface. Photographs of the bedrock outcrops on the south and north shores of the river in the immediate vicinity of the proposed abutments are presented on Figures 1 and 2 respectively.

The boreholes in Key River were advanced from a barge using a D-55 or D-120 drill rig supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The boreholes in the river were advanced to depths of up to about 34.2 m below the water surface, to between about 14.9 m and 28.7 m below river bottom, through a water column between about 2.4 m and 7.4 m deep.

Photographs of the set-up of the drilling operations on the bedrock outcrops at the abutments and on the barge in the river are shown on Figures C1 and C2 in Appendix C. In addition, it is noted that an underwater hydro cable (owned by Hydro One Inc.) exists within Key River in the vicinity of the proposed south pier footprints of the SBL and NBL bridge structures. This cable had to be located prior to start of the in-water field investigations using an underwater diving supplied by ASI Group. Photographs showing the set-up of the dive crew are shown on Figure C3 in Appendix C. The approximate location of the underwater cable in the vicinity of the south piers is shown on Drawing 2.

The boreholes were advanced through the overburden using HW casing with wash boring techniques. In general, soil samples were obtained at intervals of depth between about 0.75 m and 3.0 m, using a 50 mm outer diameter split-spoon sampler operated by automatic hammers on the drill rig, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Bedrock coring was carried out using an 'HQ' and/or 'NQ' core barrel. Photographs of the recovered rock core samples are provided in Appendix B. It is noted that no split-spoon sampling was carried out in boreholes B504-10, B504-11, B504-13 and B504-14, however bedrock was confirmed by coring in each of these boreholes. The overburden in these boreholes was inferred from observations during the drilling and from information in the adjacent boreholes.

The groundwater conditions were observed during the drilling operations and all boreholes were backfilled upon completion in accordance with Ontario Regulation 903, Wells (as amended).

The field work was observed by members of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil and rock samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, organic content, grain size distribution and Atterberg limits) was carried out on selected samples. Strength testing, consisting of uniaxial (unconfined) compression and point load index, was carried out on selected specimens of the rock core. The results of the laboratory testing are included in Appendix B.

At the abutments, approaches and piers, the boreholes were located in the field and the ground/water surface elevations were surveyed by Callon Dietz prior to drilling. The locations given on the Record of



Borehole/Drillhole sheets and shown on Drawing 2 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are summarized below.

Borehole No.	Location (MTM NAD 83)		Water/Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
B504-01	5084111.4	222585.9	175.5*	17.3
B504-02	5084194.9	222551.6	175.5*	29.5
B504-03	5084050.1	222611.8	195.6	0.6 (Bedrock Outcrop)
B504-04	5084066.7	222597.1	191.1	Bedrock Outcrop
B504-05	5084072.5	222594.7	189.7	Bedrock Outcrop
B504-06	5084069.8	222603.7	190.8	8.1 (Bedrock Outcrop)
B504-07	5084067.3	222613.1	192.4	Bedrock Outcrop
B504-08	5084073.2	222610.7	190.1	Bedrock Outcrop
B504-09	5084121.2	222583.1	176.3*	29.3
B504-10	5084119.3	222562.6	176.3*	24.8
B504-11	5084118.3	222594.6	176.3*	29.3
B504-12	5084188.2	222554.7	176.3*	34.2
B504-13	5084192.0	222564.3	176.3*	32.4
B504-14	5084190.2	222532.4	176.3*	29.1
B504-15	5084236.5	222526.5	196.6	Bedrock Outcrop
B504-16	5084242.4	222524.0	199.6	Bedrock Outcrop
B504-17	5084239.6	222532.9	197.1	10.0 (Bedrock Outcrop)
B504-18	5084237.1	222542.4	193.6	Bedrock Outcrop
B504-19	5084243.1	222540.0	195.4	Bedrock Outcrop
B504-20	5084259.3	222524.8	204.4	Bedrock Outcrop

*Water surface; Borehole Depth includes water column.

3.2 Optical Borehole Logging

Geophysical borehole surveys (optical borehole logging) were carried out by Golder personnel on August 7 and 8, 2014. The surveys were conducted in the boreholes located at the mid-point at each abutment location (Boreholes B504-06 and B504-17) to collect detailed, oriented optical images of the borehole walls, and the images were interpreted for the type and orientation of the discontinuities intersected by the boreholes. The survey depths are summarized below.

Borehole No.	Borehole Location	Optical Televiwer Depth Range (m)	Caliper Depth Range (m)
B504-06	South Abutment	1.6 to 7.95	1.35 – 7.7
B504-17	North Abutment	1.6 to 8.8	1.35 – 9.65

The optical televiwer and caliper surveys were carried out using an ALT Optical Borehole Imager (ALT-OB140) and a Caliper Probe (2PCA-1000), respectively. The optical televiwer generates a high resolution digital image



of the borehole wall and is capable of resolving fractures as narrow as 0.1 mm at a radial resolution of 1 degree. The data is recorded together with data from an internal magnetometer and a tiltmeter allowing the determination of the orientation (dip and dip direction) of the structural features recorded. The caliper probe measures the borehole diameter with three linked arms operating a single resistive sensor in the probe. The data is used to determine the average borehole diameter and indicate borehole anomalies such as rough borehole walls or washouts.

The survey data was processed using WellCAD software (Advanced Logic Technology Ltd.) and oriented to magnetic north prior to image interpretation. The downhole logs from the optical borehole survey are shown on the Geophysical Record of Borehole sheets presented in Appendix D.

The data were oriented to geographic (true) north prior to interpretation using a magnetic declination of 10.318 degrees.

3.3 Evaluation of Photographic Records and Bedrock Mapping

The bedrock conditions in the area of the abutment locations were assessed using the data from the optical borehole logging as well as photographic records of the rock faces (see Figures D1 to D8 in Appendix D) and the results were used to identify potential failure modes which might require pre-support, stabilization or remedial measures during or following excavation.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario*¹, this section of the new Highway 69 lies within the physiographic region known as the Georgian Bay Fringe, which extends along the east side of Georgian Bay through the Parry Sound and Muskoka areas, then eastward from Muskoka in patches into the area north of the Kawartha Lakes.

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

The bedrock in the area consists typically of crystalline gneisses of the Britt Domain of the Central Gneiss Belt, a subdivision of the Grenville Structural Province, as described in *Geology of Ontario*, OGS Special Volume 4². Deposition of Paleozoic strata initially covered the bedrock and later erosion during glaciation exposed these Precambrian rocks.

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

² *Geology of Ontario*, 1991. Ontario Geological Society Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.



4.2 Subsurface Conditions

The detailed subsurface soil, bedrock and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil and bedrock core samples, are presented on the Record of Borehole and Drillhole sheets and on the laboratory test figures provided in Appendix A and Appendix B, respectively. The stratigraphic boundaries shown on the Record of Borehole sheets and on the stratigraphic profile and cross-sections are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs and in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. The bedrock surface has been inferred from observations made during drilling and coring and generally represents a transition from overburden to the bedrock surface and should not be inferred to represent the exact surface elevation of the bedrock. Furthermore, subsurface conditions will vary between and beyond the borehole locations. It should be noted that the interpreted stratigraphy shown on Drawings 2 to 4 is a simplification of the subsurface conditions.

The subsurface conditions at the site of the NBL structure are characterized essentially by: granitic gneiss bedrock outcrops, in places covered by thin layers of topsoil and granular soils, at the south and north abutments/approaches; and by a sequence of organic silt, clayey silt and gravelly sandy silt to sand to gravelly sand deposits, underlain by granitic gneiss bedrock at the south and north pier below the river water level.

The results of the strength tests on the rock core samples are presented in Tables B1 and B2 and the results of the laboratory testing on the soil samples are presented on Figures B1 to B3, in Appendix B. Photographs of the bedrock core samples are presented on Figures B4 to B10, inclusive, in Appendix B.

A detailed description of the subsurface conditions encountered in the boreholes at the approaches/abutments and at the piers is provided in the following sections.

Because the boreholes were advanced on bedrock outcrops or in the water, and water was introduced into the boreholes during the drilling process, the water level noted in the boreholes is not considered representative of groundwater conditions. Further, the groundwater and river water levels are subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

4.3 South Abutment/Approach

A total of six boreholes (B504-03 to B504-8) were advanced in the vicinity of the proposed south abutment/approach. Bedrock coring was carried out in Borehole B504-06. The interpreted stratigraphy at the south abutment is shown in profile on Drawing 2 and in cross-section on Drawing 3.

4.3.1 Topsoil

A 0.1 m thick deposit of topsoil was encountered at ground surface in Borehole B504-03 at Elevation 195.6 m.

4.3.2 Silty Sand

A 0.5 m thick deposit of brown silty sand with traces of rootlets was encountered below the topsoil layer in Borehole B504-03.

The natural water content measured on the sample of the silty sand is about 26 per cent.



4.3.3 Bedrock

Exposed bedrock outcrops were observed at ground surface at each of the borehole locations and bedrock core samples were recovered from Borehole B504-06. The depth to bedrock below ground surface in the south abutment/approach area and the corresponding bedrock surface elevation are summarized below.

Foundation Element	Borehole	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Comments
South Abutment/Approach	B504-03	0.6	195.0	Refusal/Inferred Bedrock
	B504-04	0.0	191.1	Bedrock Exposed
	B504-05	0.0	189.7	Bedrock Exposed
	B504-06	0.0	190.8	Bedrock Exposed-Cored
	B504-07	0.0	192.4	Bedrock Exposed
	B504-08	0.0	190.1	Bedrock Exposed

In general, the bedrock surface along the south approach and in the area of the proposed south abutment of the NBL structure slopes downward from south to north and east to west, with the bedrock surface elevation changing by as much as about 2.7 m at the abutment borehole locations and up to 5.3 m relative to the approach borehole about 21 m south of the abutment.

Discontinuities in the rock mass noted in the walls of Borehole B504-06 recorded by the optical televiewer were predominantly minor open joints (opening width less than 10 mm) or healed joints. In general, no major anomalies were identified along the borehole walls.

Based on a review of the bedrock core samples recovered from Borehole B504-06, the bedrock consists of granitic gneiss. In general the bedrock samples are described as fresh to slightly weathered, foliated, coarse grained, slightly porous, medium strong to strong, grey and pink, as presented in the Record of Drillhole sheet in Appendix A, and shown on the photograph of the recovered core samples on Figure B5 in Appendix B. The degree of weathering of the bedrock samples (e.g. slightly weathered –W2) is based on field identification, and the strength classification of the intact rock mass is based on laboratory identification (i.e., medium strong to strong – R3 to R4) is described in accordance with the International Society for Rock Mechanics (ISRM)³ standard classification system.

The Rock Quality Designation (RQD) measured on the core samples ranges from about 50 per cent to 98 per cent, indicating a rock mass of fair to excellent quality as per Table 3.10 of CFEM (2006)⁴. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 91 per cent and 100 per cent and between 14 per cent and 97 per cent, respectively.

Point load strength index tests (ASTM D5731 – Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classification) were carried out on selected samples of the bedrock core. The axial and diametral point load strength index values are shown on the Record of Drillhole

³ International Society for Rock Mechanics Commission on Test Methods, 1985. Int. J. Rock Mech.Min. Sci. & Geomech. Abstr. Vol 22, No. 2, pp. 51-60.

⁴ Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd., British Columbia.



sheets and are presented in Table B1 in Appendix B. The axial tests carried out on two samples of the granitic gneiss bedrock core measured Is_{50} values of about 6.2 MPa and 8.3 MPa and the diametral tests carried out on two samples of the granitic gneiss bedrock core measured Is_{50} values of about 7.4 MPa and 7.7 MPa.

One Unconfined Compression (UC) test (ASTM D7012 – Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens) carried out on a selected sample of the granitic gneiss bedrock obtained in Borehole B504-06 measured a compressive strength of about 97 MPa as summarized in Table B2-1 and detailed in Table B2-3 in Appendix B.

Table B1 also presents estimated Uniaxial Compressive Strengths (UCS) correlated to the Point Load Test (PLT) strengths based on the relationship between Is_{50} and UCS. The relationship between Is_{50} and UCS values, given by correlation factor (K), varies depending on the size of the core sample and the strength of the rock. For the NBL (as well as for SBL) bridges using the consolidated rock strength data from both sites, an average correlation factor (K) was calculated by matching UCS test values and PLT values at similar depths from the same boreholes. The average correlation factor (K) of 14 was estimated.

Based on the UCS and PLT test results at the south abutment, in accordance with Table 3.5 in CFEM (2006), the granitic gneiss bedrock is classified as strong to very strong (R4 to R5, 50 MPa < UCS < 250 MPa).

4.3.4 Groundwater Conditions

The water level in Borehole B504-06 was not recorded upon completion of coring operations.

4.4 South Pier (Pier 1)

A total of four boreholes (B504-01 and B504-09 to B504-11) were advanced in the vicinity of the proposed south pier: soil sampling and bedrock coring was carried out in Boreholes B504-01 and B504-09; while Boreholes B504-10 and B504-11 were advanced to the bedrock surface without soil sampling but were cored to obtain additional bedrock information. The soil strata shown on the Record of Boreholes B504-10 and B504-11 are inferred based on the soil information from the adjacent Boreholes B504-01 and B504-09; the inferred soil strata from Boreholes B504-10 and B504-11 are not included in Sections 4.4.2 and 4.4.3. The interpreted stratigraphy at the south pier is shown in profile on Drawing 2 and in cross-section on Drawing 3.

4.4.1 Water

The water surface measured in Key River at the time of drilling Boreholes B504-01 and B504-09 to B504-11 in November 2012 and August 2014 was at Elevations 175.5 m and 176.3 m, respectively, and the depth of water at the boreholes was between 2.4 m and 3.8 m.

4.4.2 Organic Silt and Clayey Silt

A 5.8 m and 6.5 m thick deposit of brown to grey organic silt was encountered from the riverbed in Boreholes B504-01 and B504-09 at Elevations 173.1 m and 172.5 m, respectively, underlain by a 5 m and 3.4 m thick deposit of grey clayey silt and encountered at Elevations 167.3 m and 166.0 m, respectively. In Borehole



B504-01, sandy silt to silty sand seams were encountered within the clayey silt deposit, which extended to the top of bedrock.

The SPT 'N'-values measured within the organic silt deposit are 0 blows (i.e., weight of hammer), whereas the SPT 'N'-values in the clayey silt deposit range between 0 blows (i.e., weight of hammer) and 4 blows per 0.3 m of penetration. In situ field vane tests carried out within these deposits measured undrained shear strengths ranging between 9 kPa and 25 kPa in the organic silt deposit and between 19 and 46 kPa in the clayey silt deposit. The sensitivity is calculated at 2 to 3 in the organic silt deposit and range between 2 and 5 in the clayey silt. The field vane test results indicate that the organic silt and clayey silt deposits have a very soft to soft and soft to firm consistency, respectively.

The natural water content measured on four samples of the organic silt range from 53 per cent and 108 per cent and on three samples of the clayey silt deposit and from about 29 per cent to 43 per cent. The organic content measured on two samples of the organic silt deposit is 4.6 per cent and 11.4 per cent.

Atterberg limits tests were carried out on six samples of the deposits and measured liquid limits ranging from about 25 per cent to 54 per cent, plastic limits ranging from about 13 per cent to 33 per cent and plasticity indices ranging from about 12 per cent to 21 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figures B1A and B1B in Appendix B and, together with the organic contents, indicate that the materials are classified as an organic silt of intermediate to high plasticity and clayey silt of low plasticity, respectively.

The results of the grain size distribution tests completed on two samples of the organic silt and one sample of the clayey silt deposit are shown on Figure B2A and B2B in Appendix B, respectively.

4.4.3 Sand to Gravelly Sand

In Borehole B504-09, a 9.6 m thick deposit of grey sand to gravelly sand was encountered below the clayey silt deposit at Elevation 162.6 m. Cobbles were encountered below a depth of 22.9 m (Elevation 153.4 m) within the deposit immediately overlying the bedrock surface.

The natural water content measured on samples of this deposit range from 13 per cent and 25 per cent

The results of the grain size distribution tests completed on three samples of this deposit are shown on Figure B3A in Appendix B.

4.4.4 Boulders

In Borehole B504-10 a 0.6 m thick layer of boulders was inferred from the resistance to casing advancement at Elevation 155.6 m overlying the bedrock.

4.4.5 Bedrock

Bedrock was encountered and core samples were recovered from Boreholes B504-01 and B504-09 to B504-11. The depths to bedrock below ground surface and the corresponding bedrock surface elevations are summarized below.



Foundation Element	Borehole	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Comments
Pier 1 (South Pier)	B504-01	13.2	162.3	Bedrock Cored
	B504-09	23.3	153.0	Bedrock Cored
	B504-10	21.3	155.0	Bedrock Cored
	B504-11	24.1	152.2	Bedrock Cored

In general, the bedrock surface in the area of the proposed Pier 1 (South) NBL structure slopes downward from south to north and west to east, with the bedrock surface elevation changing by as much as about 10.1 m at the borehole locations.

Based on a review of the bedrock core samples recovered from the boreholes, the bedrock consists of granitic gneiss. In general the bedrock samples are described as fresh to slightly weathered, foliated or massive, fine to coarse grained, slightly porous, medium strong to very strong, grey and black to dark grey, as presented in the Record of Drillhole sheets in Appendix A, and shown on the photograph of the recovered core samples on Figures B4, B6 and B7 in Appendix B.

The Rock Quality Designation (RQD) measured on the core samples generally ranges from about 57 per cent to 100 per cent, indicating a rock mass of fair to excellent quality as per Table 3.10 of CFEM (2006). However, the upper 0.3 m of core recovered from Borehole B504-09 is highly fractured with an RQD value of 0 per cent, indicating that the upper portion of the rock mass is of very poor quality. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 90 per cent and 100 per cent and between 0 per cent and 97 per cent, respectively.

Point load strength index tests (ASTM D5731) were carried out on selected samples of the bedrock core. The axial and diametral point load strength index values are shown on the Record of Drillhole sheets and are presented in Table B1 in Appendix B. The axial tests carried out on two samples of the granitic gneiss bedrock core measured Is_{50} values of about 7.1 MPa and 14.4 MPa and the diametral tests carried out on five samples of the granitic gneiss bedrock core measured Is_{50} values ranging from about 7.1 MPa to 23.9 MPa.

Two Unconfined Compression (UC) tests (ASTM D7012) carried out on selected samples of the granitic gneiss bedrock obtained in Borehole B504-09 measured compressive strengths of about 109 MPa and 178 MPa as summarized in Table B2-1 and detailed in Tables B2-4 and B2-5 in Appendix B.

Table B1 also presents estimated Uniaxial Compressive Strengths (UCS) correlated to the PLT strengths based on the relationship between Is_{50} and UCS and applying an average correlation factor (K) of 14 as discussed in Section 4.3.3.

Based on the UCS and PLT test results at the south abutment, in accordance with Table 3.5 in CFEM (2006), the granitic gneiss bedrock is classified as strong to very strong (R4 to R5, 50 MPa < UCS < 250 MPa).

4.5 North Pier (Pier 2)

A total of four boreholes (B504-2 and B504-12 to B504-14) were advanced in the vicinity of the proposed north pier: soil sampling and bedrock coring was carried out in Boreholes B504-2 and B504-12; while



Boreholes 504-13 and B504-14 were advanced to the bedrock surface without soil sampling but cored to obtain additional bedrock information. The soil strata shown on the Record of Boreholes B504-13 and B504-14 are inferred based on the soil information from the adjacent Boreholes B504-02 and B504-12; the inferred soil strata from Boreholes B504-13 and B504-14 are not included in Sections 4.5.2 and 4.5.3. The interpreted stratigraphy at the north pier is shown in profile on Drawing 2 and in cross-section on Drawing 4.

4.5.1 Water

The water surface measured in Key River at the time of drilling Boreholes B504-02 and B504-12 to B504-14 in November 2012 and August 2014 was at Elevations 175.5 m and 176.3 m, respectively, and the depth of water in the boreholes was between 4.1 m and 7.4 m.

4.5.2 Organic Silt and Clayey Silt

A 6.6 m and 7.3 m thick deposit of brown to grey organic silt was encountered from the riverbed in Boreholes B504-02 and B504-12 at Elevations 171.1 m and 170.8 m, respectively. In Boreholes B504-02 and B504-12, the organic deposit is underlain by a 2 m and 1.5 m thick stratum of clayey silt based on examination of the soil samples and the higher undrained shear strengths recorded by the field vanes.

The SPT 'N'-values measured within the organic silt deposit as well as in the clayey silt stratum are 0 blows (i.e., weight of hammer) per 0.3 m of penetration. In situ field vane tests carried out within the organic silt deposit measured undrained shear strengths ranging between 12 kPa and 25 kPa, while those measured on the clayey silt stratum range between about 30 kPa and 34 kPa, and the sensitivity is calculated to range between 1 and 6 and is 3 for the respective strata. The field vane test results indicate that the organic silt deposit has a very soft to soft consistency while that of the clayey silt stratum is a firm consistency.

The natural water content measured on five samples of the organic silt deposit ranges from about 62 per cent to 166 per cent and that of the clayey silt stratum is about 90 per cent on one sample tested. The organic content measured on one sample of the organic silt deposit is 12.2 per cent.

Atterberg limits tests were carried out on four samples of the organic deposit and measured liquid limits ranging from about 41 per cent to 90 per cent, plastic limits ranging from about 28 per cent to 71 per cent and plasticity indices ranging from about 13 per cent to 29 per cent. The results of the Atterberg limits tests are shown on the plasticity chart Figure B1A in Appendix B and together with the organic content indicate the material is classified as an organic silt of intermediate to high plasticity.

The result of a grain size distribution test completed on one sample of the organic silt deposit is shown on Figure B2A in Appendix B.

4.5.3 Gravelly Sandy Silt to Sand

An 11.5 m and 14.3 m deposit of brown to grey gravelly sandy silt to silt and sand to sand was encountered below the clayey silt stratum in Boreholes B504-02 and B504-12 at Elevations 162.5 m and 162.0 m, respectively. In Borehole B504-12, silt pockets were encountered at Elevation 154.7 m, clay lenses were encountered at Elevation 151.6 m and an approximately 1 m thick boulder was encountered at Elevation 150.2 m.



The SPT 'N'-values measured within this deposit range from 4 blows to 59 blows per 0.3 m of penetration indicating a loose to very dense relative density.

The natural water content measured on seven samples of this deposit range from 17 per cent to 24 per cent.

The result of the grain size distribution tests completed on six samples of this deposit are shown on Figure B3A and B3B.

4.5.4 Bedrock

Bedrock was encountered and core samples were recovered from Boreholes B504-02 and B504-12 to B504-14. The depths to bedrock below ground surface and the corresponding bedrock surface elevations are summarized below.

Foundation Element	Borehole	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Comments
Pier 2 (North Pier)	B504-02	24.5	151.0	Bedrock Cored
	B504-12	28.6	147.7	Bedrock Cored
	B504-13	29.2	147.1	Bedrock Cored
	B504-14	25.5	150.8	Bedrock Cored

In general, the bedrock surface in the area of the proposed Pier 2 (North) NBL structure slopes downward from north to south and from west to east, with the bedrock surface elevation changing by as much as about 3.9 m at the borehole locations.

Based on a review of the bedrock core samples recovered from the boreholes, the bedrock consists of granitic gneiss. In general the bedrock samples are described as fresh to slightly weathered, foliated, medium to coarse grained, slightly porous, medium strong to strong, pink, grey and black, as presented in the Record of Drillhole sheets in Appendix B, and shown on the photograph of the recovered core samples on Figures B4, B8 and B9 in Appendix B.

The Rock Quality Designation (RQD) measured on the core samples generally ranges from about 28 per cent to 100 per cent, indicating a rock mass of poor to excellent quality as per Table 3.10 of CFEM (2006). The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 96 per cent and 100 per cent and between 28 per cent and 100 per cent, respectively.

Point load strength index tests (ASTM D5731) were carried out on selected samples of the bedrock core. The axial and diametral point load strength index values are shown on the Record of Drillhole sheets and are presented in Table B1 in Appendix B. The axial tests carried out on six samples of the granitic gneiss bedrock core measured Is_{50} values ranging from about 7.1 MPa to 11.8 MPa and the diametral tests carried out on six samples of the granitic gneiss bedrock core measured Is_{50} values ranging from about 5.5 MPa to 8.7 MPa.

One Unconfined Compression (UC) tests (ASTM D7012) carried out on a selected sample of the granitic gneiss bedrock obtained in Borehole B504-02 measured a compressive strength of about 94 MPa as summarized in Table B2-1 and detailed in Table B2-2 in Appendix B.



Table B1 also presents estimated Uniaxial Compressive Strengths (UCS) correlated to the PLT strengths based on the relationship between Is_{50} and UCS applying an average correlation factor (K) of 14 as discussed in Section 4.3.3.

Based on the UCS and PLT results at the north pier, in accordance with Table 3.5 in CFEM (2006), the granitic gneiss bedrock is classified as strong to very strong (R4 to R5, 50 MPa < UCS < 250 MPa).

4.6 North Abutment/Approach

A total of six boreholes (B504-15 to B504-20) were advanced in the vicinity of the proposed north abutment/approach. Bedrock coring was carried out in Borehole B504-17. The interpreted stratigraphy at the south pier is shown in profile on Drawing 2 and in cross-section on Drawing 4.

4.6.1 Peat

A 0.1 m thick layer of peat was encountered at ground surface in Borehole B504-17 at Elevation 197.1 m.

4.6.2 Cobble/Sand and Gravel

Below the peat in Borehole B504-17, a 0.1 m thick cobble and 0.1 m thick layer of brown sand and gravel was encountered. The sand and gravel contained silt, trace rootlets and organics.

The natural water content measured on the sample of the sand and gravel is 8 per cent.

4.6.3 Bedrock

The north abutment and approach are located on a bedrock outcrop as observed at the borehole locations and core samples were recovered from Borehole B504-17. The depths to bedrock below ground surface and the corresponding bedrock surface elevations are summarized below.

Foundation Element	Borehole	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Comments
North Abutment/Approach	B504-15	0	196.6	Bedrock Exposed
	B504-16	0	199.6	Bedrock Exposed
	B504-17	0.3	196.8	Bedrock Exposed-Cored
	B504-18	0	193.6	Bedrock Exposed
	B504-19	0	195.4	Bedrock Exposed
	B504-20	0	204.4	Bedrock Exposed

In general, the bedrock surface in the area of the proposed north abutment and along the north approach of the NBL structure slopes downward from north to south and west to east, with the bedrock surface elevation varying



by as much as about 6.0 m at the abutment borehole locations and up to 10.8 m relative to the approach borehole about 22 m north of the abutment.

Discontinuities in the rock mass noted in Borehole B504-17 walls recorded by the optical televiewer were predominantly minor open joints (opening width less than 10 mm) or healed joints. In general, no major anomalies were identified along the borehole walls.

Based on a review of the bedrock core samples recovered from Borehole B504-17, the bedrock consists of granitic gneiss. In general the bedrock samples are described as slightly weathered, foliated, coarse grained, slightly porous, medium strong, light grey to grey and pink, as presented in the Record of Drillhole sheet in Appendix B, and shown on the photograph of the recovered core samples on Figure B10 in Appendix B.

The Rock Quality Designation (RQD) measured on the core samples ranges from about 61 per cent to 100 per cent, indicating a rock mass of fair to excellent quality as per Table 3.10 of CFEM (2006). The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are 100 per cent and between 35 per cent and 100 per cent, respectively.

Point load strength index tests (ASTM D5731) were carried out on selected samples of the bedrock core. The axial and diametral point load strength index values are shown on the Record of Drillhole sheets and are presented in Table B1 in Appendix B. The axial tests carried out on two samples of the granitic gneiss bedrock core measured Is_{50} values of about 9.0 MPa and 9.2 MPa and the diametral tests carried out on two samples of the granitic gneiss bedrock core measured Is_{50} values of about 2.5 MPa and 6.3 MPa.

Two Unconfined Compression (UC) tests (ASTM D7012) carried out on selected samples of the granitic gneiss bedrock obtained in Borehole B504-17 measured compressive strengths of about 88 MPa and 102 MPa as summarized in Table B2-1 and detailed in Tables B2-6 and B2-7 in Appendix B.

Table B1 also presents estimated Uniaxial Compressive Strengths (UCS) correlated to the PLT Strengths based on the relationship between Is_{50} and UCS applying an average correlation factor (K) of 14 as discussed in Section 4.3.3.

Based on the UCS and PLT test results at the south abutment, in accordance with Table 3.5 in CFEM (2006), the granitic gneiss bedrock is classified as medium strong to very strong ($R3$ to $R5$, $25 \text{ MPa} < \text{UCS} < 250 \text{ MPa}$).

4.6.4 Groundwater Conditions

The water level in open Borehole B504-17 measured the morning after the day of coring was at a depth of 7.3 m below ground surface, Elevation 189.8, likely representing residual drill water introduced during the coring operation.

5.0 CLOSURE

The drilling program was directed by Lubomir Kosci and Trevor Moxam. This report was prepared by Mr. Matt Thibeault, EIT., and reviewed by Mr. André Bom, P.Eng., a senior geotechnical engineer and Associate with Golder. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project and Principal with Golder, conducted an independent quality control review of the report.

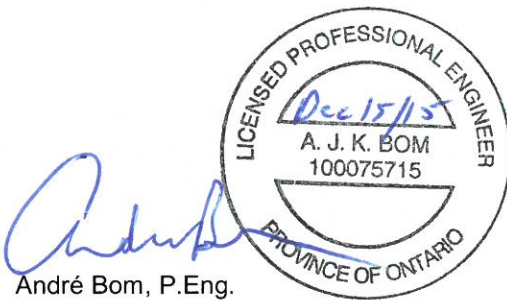


Report Signature Page

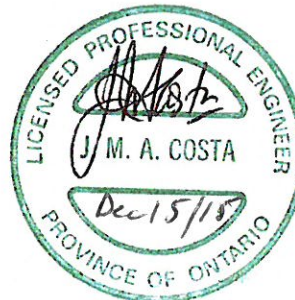
GOLDER ASSOCIATES LTD.

Matt Thibeault

Matt Thibeault, EIT
Geotechnical Engineering Intern



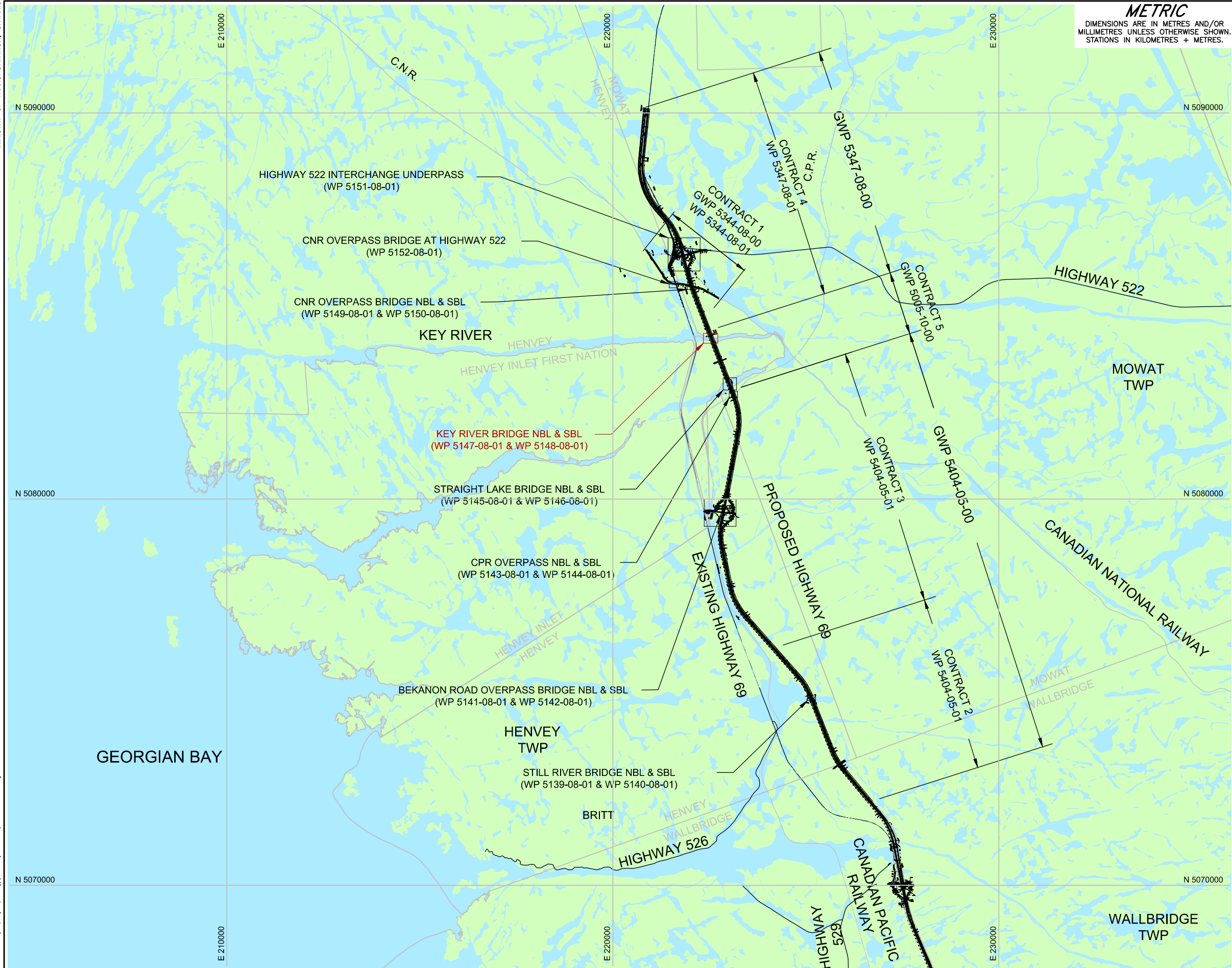
André Bom, P.Eng.
Senior Geotechnical Engineer



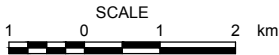
Jorge M. A. Costa., P.Eng.
Designated MTO Contact, Principal

MT/AB/JPD/JMAC/kp

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PLAN

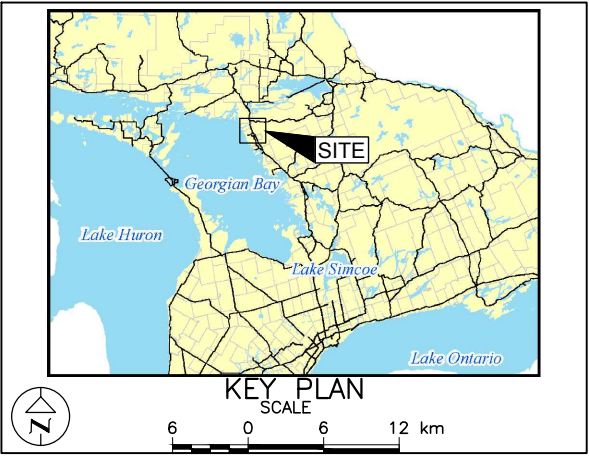


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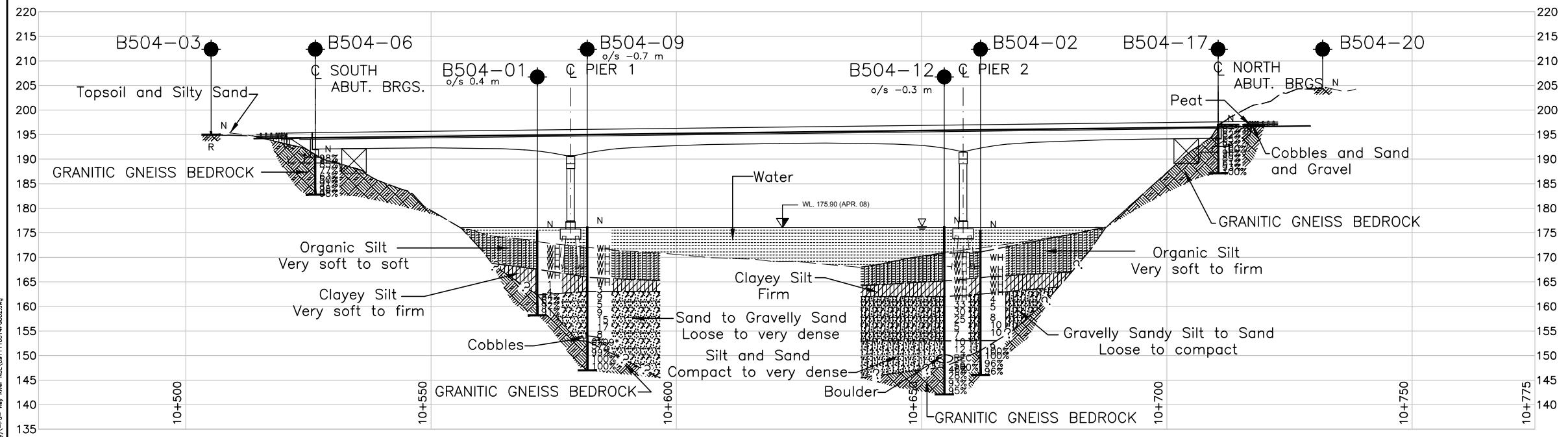
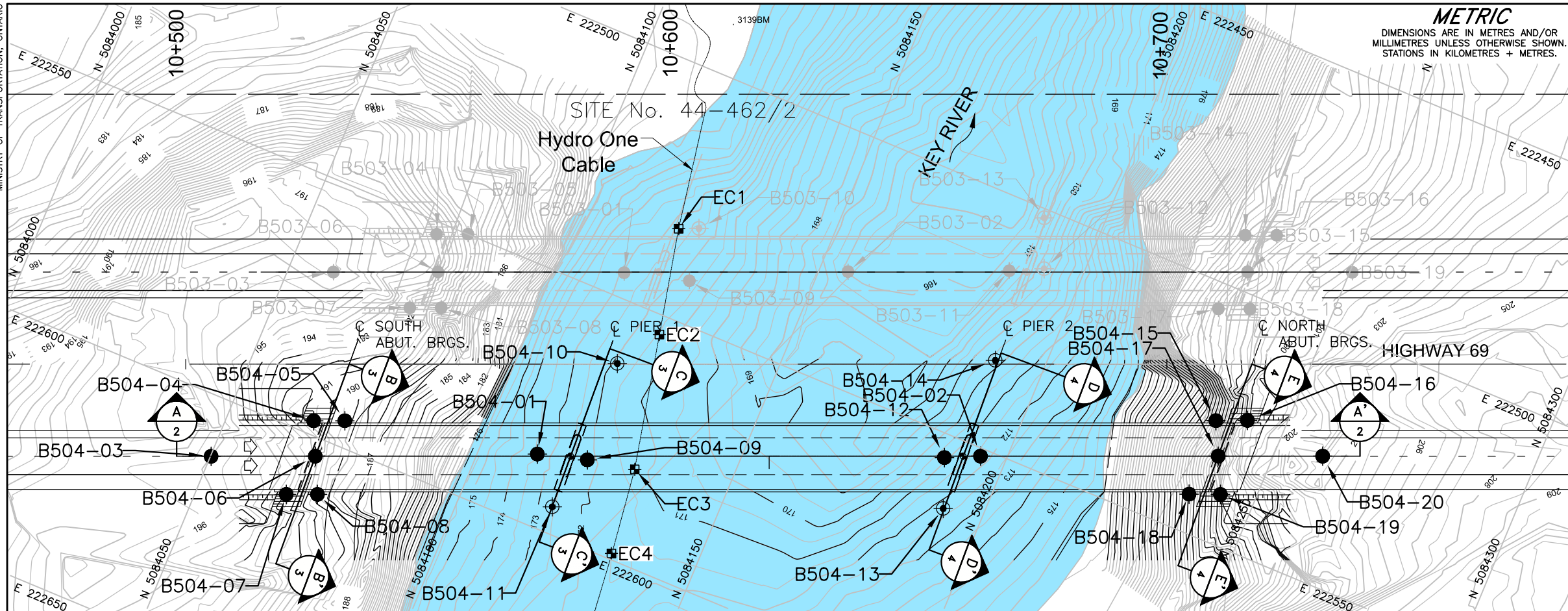
CONT No.
WP No. 5147-08-01

HIGHWAY 69
KEY RIVER NBL BRIDGE
INDEX PLAN

SHEET



REFERENCE				
Base Data – MNR NRVIS, obtained 2004, CANMAP v2008 Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, ©Queens Printer 2008 Datum : NAD 83 Projection : MTM Zone 10				
NO.	DATE	BY	REVISION	
Geocres No. 41H-153				
HWY. 69		PROJECT NO. 09-1111-6014		DIST. .
SUBM'D. MCK	CHKD. MCK	DATE: Dec. 2015	SITE: 44-462/1	
DRAWN: JFC	CHKD. AB	APPD. JPD/JMAC	DWG. 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.

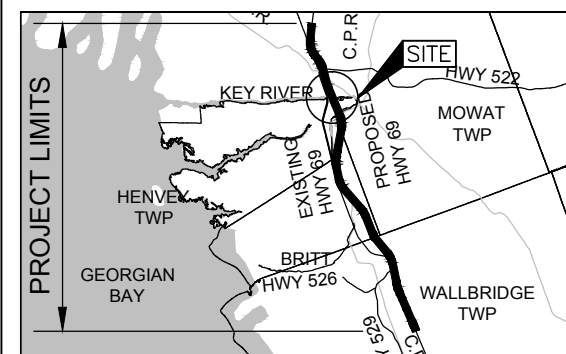
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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.



CONT No. 5147-08-01
WP No. 5147-08-01

HIGHWAY 69
KEY RIVER NBL BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

**KEY PLAN**

SCALE

6 0 6 12 km

LEGEND

- Borehole - Current Investigation
- ⊕ Probeshole
- Hydro One Cable
- 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
- R Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
B504-01	175.5	5084111.4	222585.9
B504-02	175.5	5084194.9	222551.6
B504-03	195.6	5084050.1	222611.8
B504-04	191.1	5084066.7	222597.1
B504-05	189.7	5084072.5	222594.7
B504-06	190.8	5084069.8	222603.7
B504-07	192.4	5084067.3	222613.1
B504-08	190.1	5084073.2	222610.7
B504-09	176.3	5084121.2	222583.1
B504-10	176.3	5084119.3	222562.6
B504-11	176.3	5084118.3	222594.6
B504-12	176.3	5084188.2	222554.7
B504-13	176.3	5084192.0	222564.3
B504-14	176.3	5084190.2	222532.4
B504-15	196.6	5084236.5	222526.5
B504-16	199.6	5084242.4	222524.0
B504-17	197.1	5084239.6	222532.9
B504-18	193.6	5084237.1	222542.4
B504-19	195.4	5084243.1	222540.0
B504-20	204.4	5084259.3	222524.8

REFERENCE

Base plans provided in digital format by URS, drawing file nos. Contours from Hwy69_Contour-Plan_CS.dwg, received August 31, 2012, KEY RIVER CROSSING OPTION B_Northbound_GA.dwg and KEY RIVER CROSSING OPTION B_Southbound_GA.dwg, received November 4, 2013.

NO.	DATE	BY	REVISION
Geocres No. 41H-153			
HWY. 69	PROJECT NO. 09-1111-6014		
SUBM'D. MCK	CHKD. MCK	DATE: Dec. 2015	SITE: 44-462/1
DRAWN: JFC	CHKD. AB	APPD. JPD/JMAC	DWG. 2

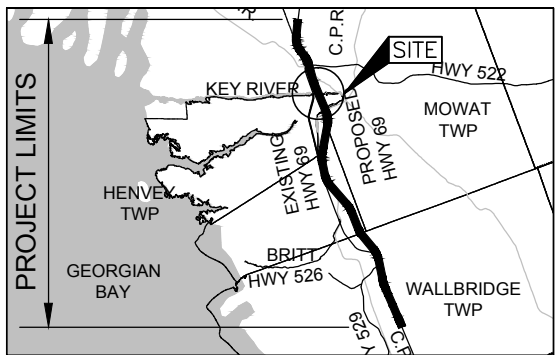
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CONT No.
WP No.5147-08-01

HIGHWAY 69
KEY RIVER NBL BRIDGE

SOIL STRATA

SHEET



KEY PLAN
SCALE
0 6 12 km

LEGEND

- Borehole - Current Investigation
- ⊕ Probehole
- 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

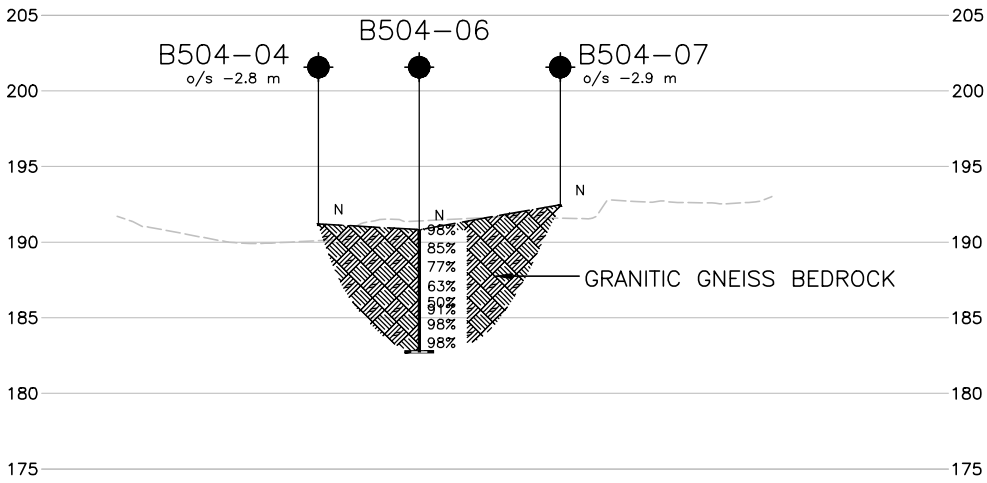
BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
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B504-06	190.8	5084069.8	222603.7
B504-07	192.4	5084067.3	222613.1
B504-09	176.3	5084121.2	222583.1
B504-10	176.3	5084119.3	222562.6
B504-11	176.3	5084118.3	222594.6

NOTES

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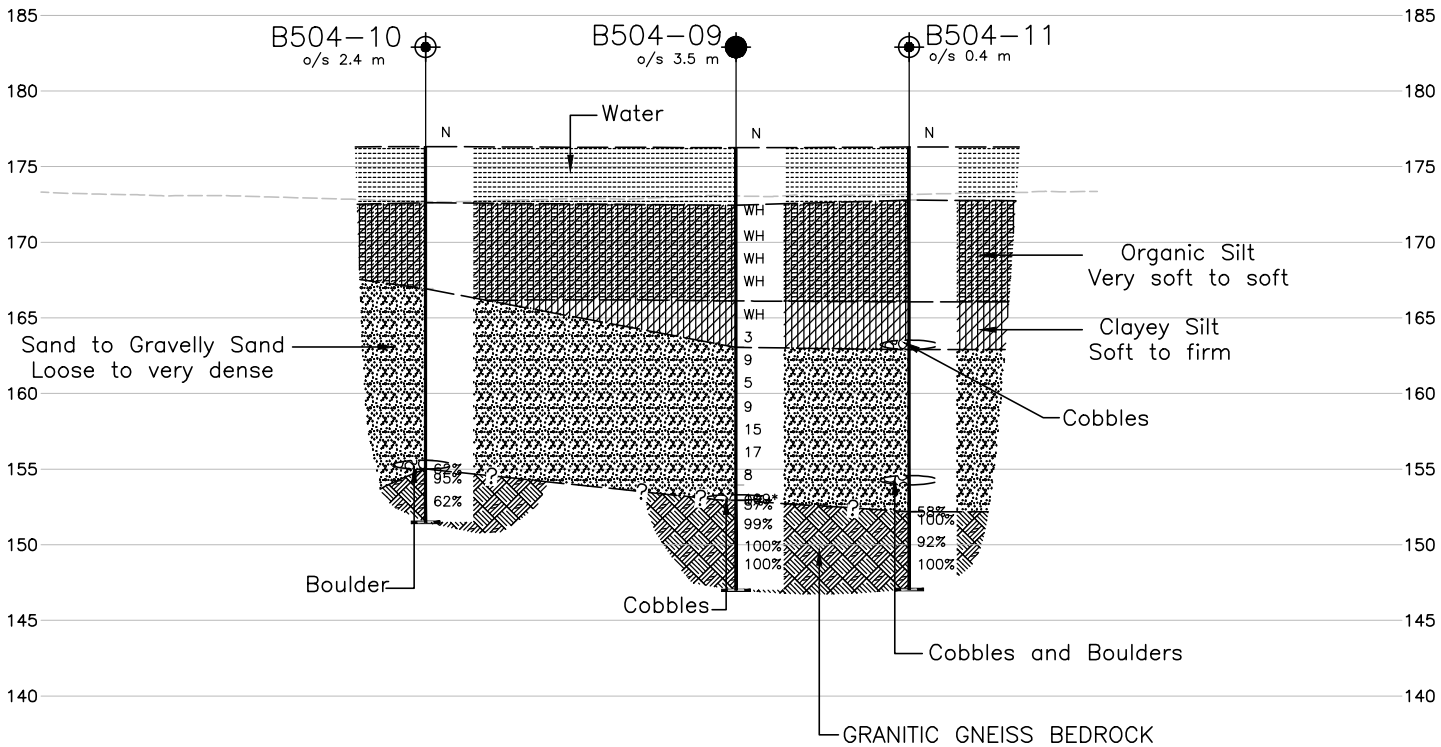
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B-B'
1 NBL SOUTH ABUTMENT CROSS-SECTION B-B'

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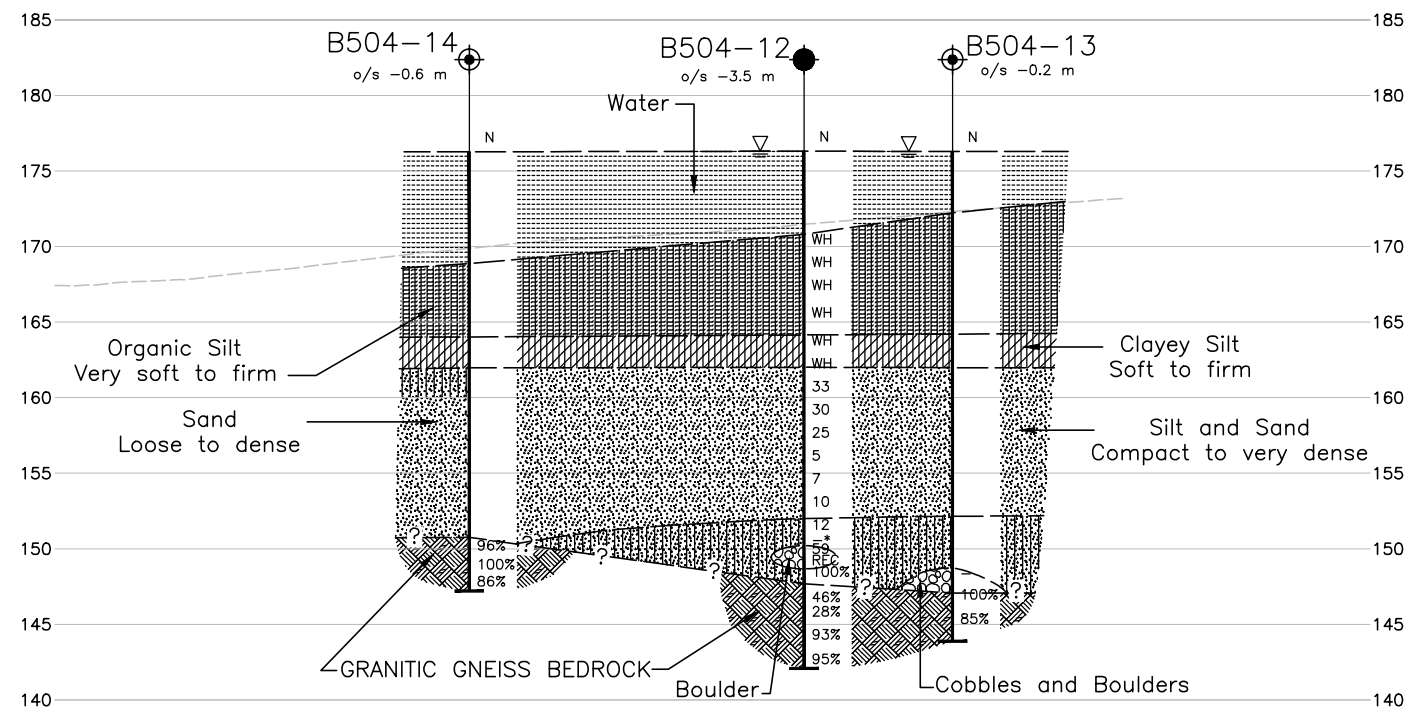


C-C'
1 NBL SOUTH PIER CROSS-SECTION C-C'

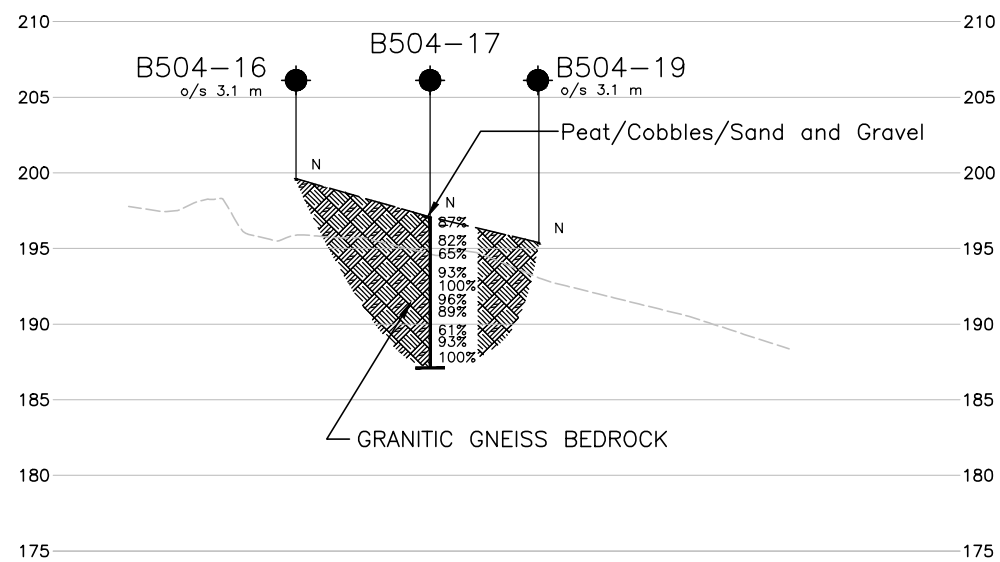
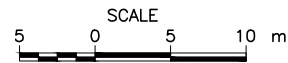
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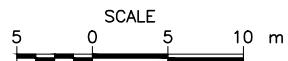
NO.	DATE	BY	REVISION
Geocres No. 41H-153			
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SUBM'D. MCK	CHKD. MCK	DATE: Dec. 2015	SITE: 44-462/1
DRAWN: JFC	CHKD. AB	APPD. JPD/JMAC	DWG. 3



NBL NORTH PIER CROSS-SECTION D-D'





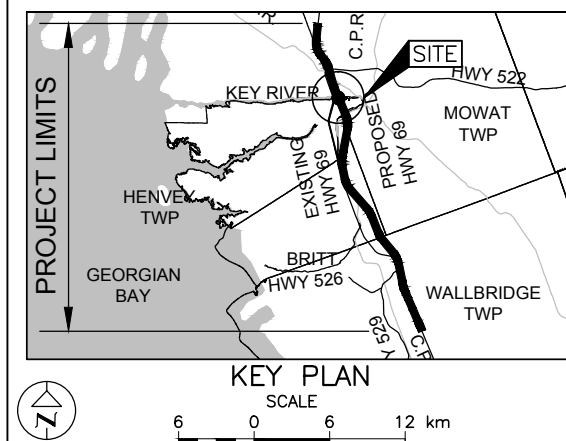



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CONT No.,
WP No.5147-08-01

HIGHWAY 69
KEY RIVER NBL BRIDGE
SOIL STRATA

SHEET



LEGEND

- | | |
|---|--|
|  | Borehole – Current Investigation |
|  | Probehole |
| 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
B504—12	176.3	5084188.2	222554.7
B504—13	176.3	5084192.0	222564.3
B504—14	176.3	5084190.2	222532.4
B504—16	199.6	5084242.4	222524.0
B504—17	197.1	5084239.6	222532.9
B504—19	195.4	5084243.1	222540.0

NOTES

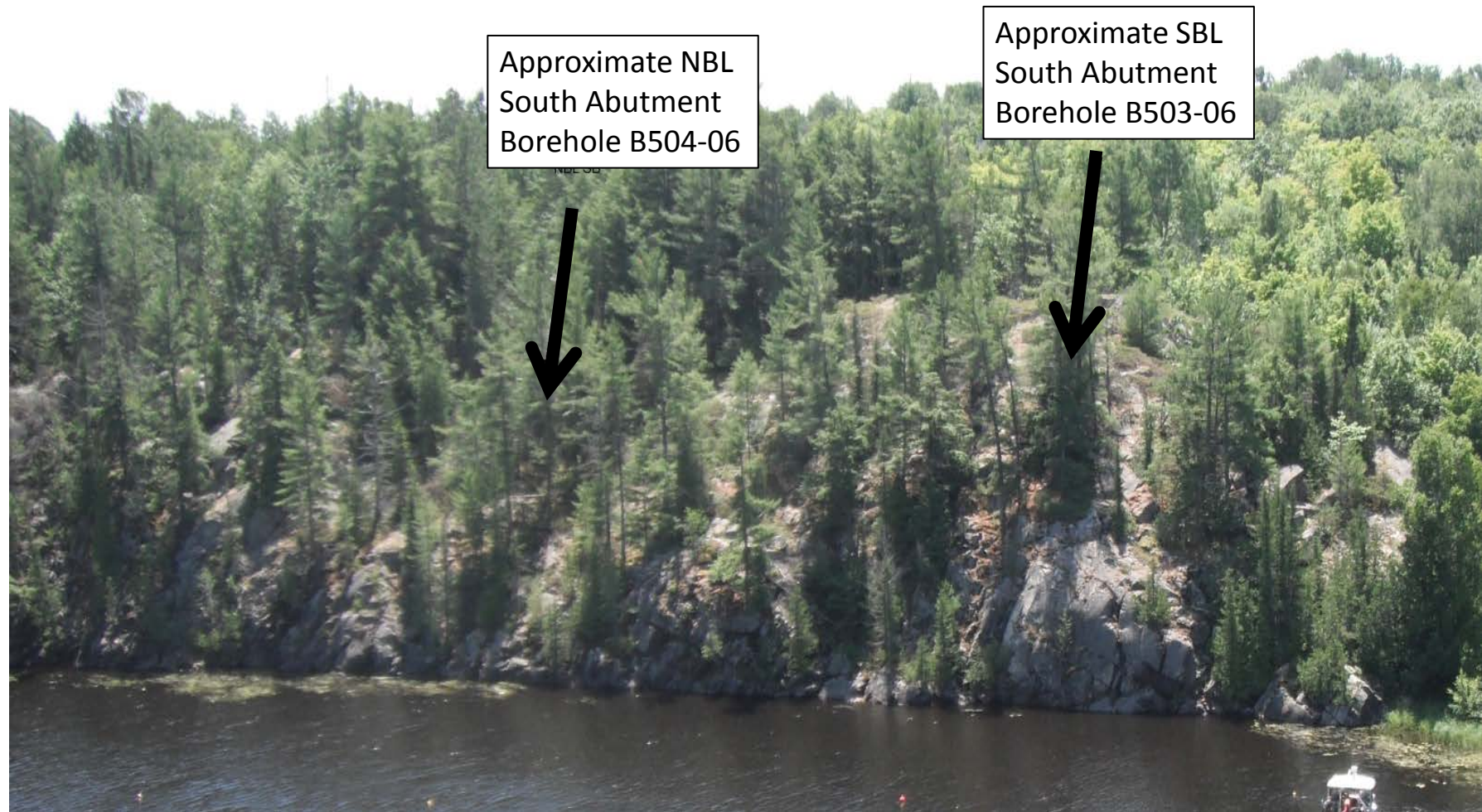
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.


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

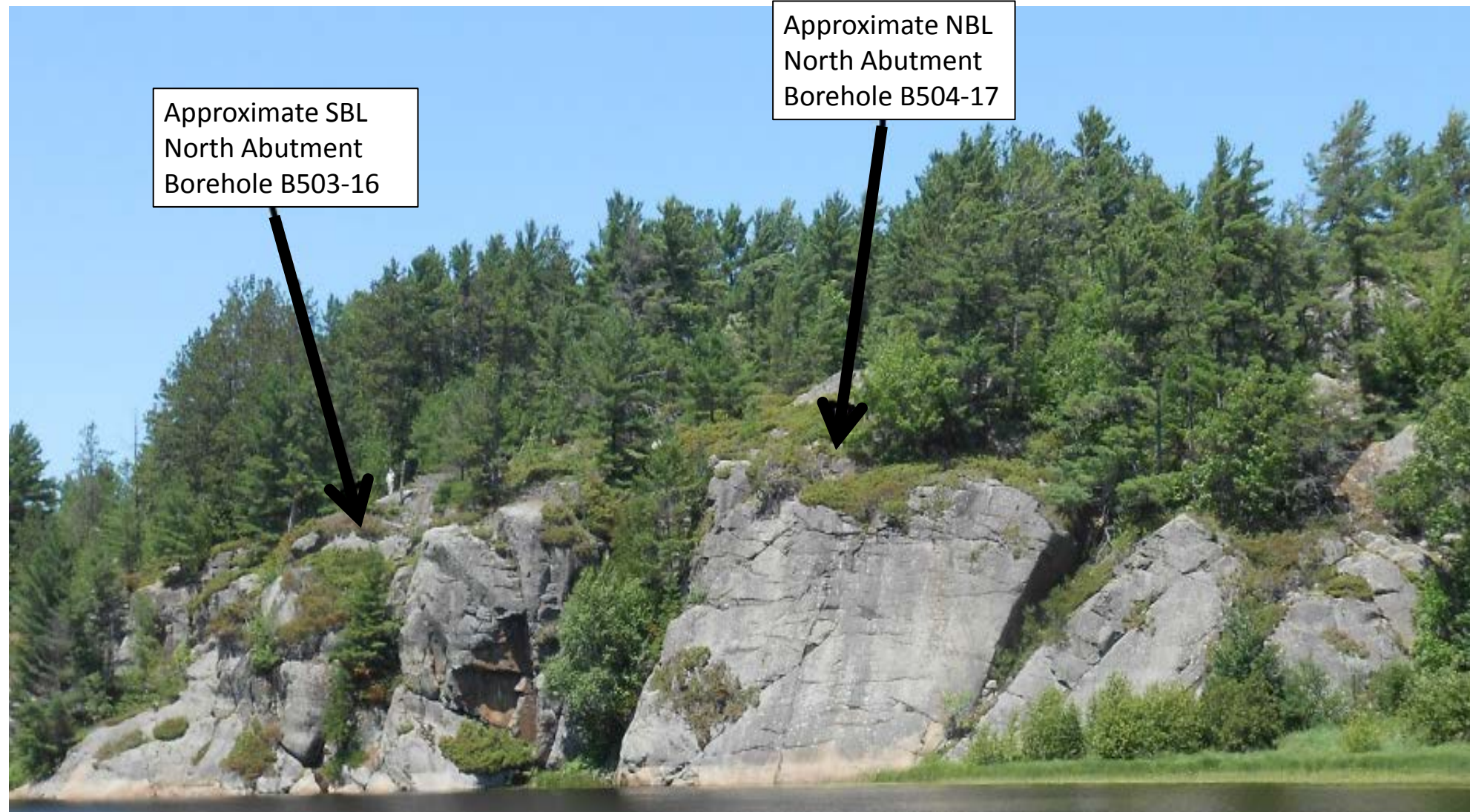
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

NO.	DATE	BY	REVISION		
Geocres No. 41H-153					
HWY. 69		PROJECT NO. 09-1111-6014		DIST. .	
SUBM'D. MCK		CHKD. MCK		DATE: Dec. 2015	
DRAWN: JFC		CHKD. AB		APPD. JPD/JMAC	
				DWG. 4	





PROJECT				
Highway 69 - Key River NBL and SBL				
TITLE				
KEY RIVER NBL AND SBL PHOTOGRAPH OF SOUTH SHORE ROCK OUTCROP				
	PROJECT No. 09-1111-6014			FILE No. ----
	DESIGN	ARB	April 2015	SCALE AS SHOWN
	CADD	--		REV.
	CHECK	AB	April 2015	FIGURE 1
	REVIEW			



Approximate SBL
North Abutment
Borehole B503-16

Approximate NBL
North Abutment
Borehole B504-17

PROJECT

Highway 69 - Key River NBL and SBL

TITLE

**KEY RIVER NBL AND SBL
PHOTOGRAPH OF NORTH SHORE ROCK
OUTCROP**



PROJECT No. 09-1111-6014			FILE No. ----	
DESIGN	ARB	April 2015	SCALE	AS SHOWN
CADD	--		REV.	
CHECK	AB	April 2015	FIGURE 2	
REVIEW				



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 <u>09-1111-6014</u>		RECORD OF BOREHOLE No B504-01		SHEET 1 OF 2		METRIC	
W.P. <u>5147-08-01</u>		LOCATION <u>N 5084111.4 ; E 222585.9</u>		ORIGINATED BY <u>LK</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>100 mm I.D. HW Casing, Wash Boring</u>		COMPILED BY <u>JFC</u>			
DATUM <u>Geodetic</u>		DATE <u>November 14 and 16, 2012</u>		CHECKED BY <u>MCK/AB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT 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 (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	20 40 60 80 100	20 40 60	W _p W W _L						
175.5 0.0	WATER SURFACE WATER																
173.1 2.4	ORGANIC SILT, trace sand Very soft to soft Brown Wet																
			1	SS	WH									OC = 4.6%			
							3 +										
			2	SS	WH												
							2 +										
			3	SS	WH												
			4	SS	WH												
							2 +							OC = 11.4%			
167.3 8.2	CLAYEY SILT, trace sand Very soft to firm Grey Wet Sandy silt to silty sand seams below a depth of 8.2 m (Elev. 167.3 m)		5	TO	WH												
			6	SS	1		2 +										
			7	SS	4												
162.3 13.2	Granite Gneiss (BEDROCK) Bedrock cored from depths 13.2 m to 17.3 m. For bedrock coring details refer to Record of Drillhole B504-1.		1	RC	REC 90%										RQD = 84%		
			2	RC	REC 96%										RQD = 62%		
			3	RC													

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B504-01				SHEET 2 OF 2		METRIC										
W.P. 5147-08-01		LOCATION N 5084111.4 ; E 222585.9				ORIGINATED BY LK												
DIST _____ HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring				COMPILED BY JFC												
DATUM Geodetic		DATE November 14 and 16, 2012				CHECKED BY MCK/AB												
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)					
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p W W _L 20 40 60						
158.2	Granite Gneiss (BEDROCK) Bedrock cored from depths 13.2 m to 17.3 m. For bedrock coring details refer to Record of Drillhole B504-1.		3	RC	REC 100%	160												RQD = 92%
17.3			4	RC	REC 97%	159												RQD = 91%
17.3	END OF BOREHOLE																	

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B504-01

SHEET 1 OF 1

LOCATION: N 5084111.4 ; E 222585.9

DRILLING DATE: November 15 to 16, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Diedrich D55

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	RECOVERY	R.Q.D. %	FRACT. INDEX PER 0.25	B Angle	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q AVG.	NOTES
		Continued from Record of Borehole B504-1		162.34															
	NW Casing	Fresh, foliated, medium grained, slightly porous, very strong, grey and black GRANITIC GNEISS		13.16	1							JN,PL,RO	1.5	1					14.68 MPa (Axial)
14					2							JN,CU,RO JN,PL,VR JN,PL,RO	3	1	3				
15					3							JN,PL JN,PL,SM JN,PL,SM	1	2	1				
16	NORC November 15 to 16, 2012				4							JN,UN,RO JN,PL,RO JN,PL,RO	3	1	3				23.88 MPa
17												JN,PL,RO	1.5	1					7.20 MPa (Axial)
		END OF DRILLHOLE		158.19								JN,PL,RO	1.5	1					
18				17.31															
19																			
20																			
21																			
22																			
23																			

DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15

PROJECT		RECORD OF BOREHOLE		No B504-02		SHEET 2 OF 2		METRIC									
W.P. 09-1111-6014		LOCATION		N 5084194.9 ; E 222551.6		ORIGINATED BY		LK									
DIST		HWY 69		BOREHOLE TYPE		100 mm I.D. HW Casing, Wash Boring		COMPILED BY									
JFC		DATE		November 7 to 9, 2012		CHECKED BY		MCK/AB									
DATUM		Geodetic															
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---																
157.2	Gravelly Sandy SILT, trace clay Loose Grey Wet		7	SS	5		160										
159																	
158			8	SS	8												
157	SAND, trace to some silt, trace gravel and clay Loose to compact Grey Wet		9	SS	10												
156																	
155			10	SS	10												0 93 6 1
154																	
153																	
152			11	SS	9												
151	Granitic Gneiss (BEDROCK)		1	RC	REC 100%												RQD = 100%
150	Bedrock cored from depths of 24.5 m to 29.5 m. For bedrock coring details refer to Record of Drillhole B504-02.		2	RC	REC 100%												RQD = 94%
149																	
148			3	RC	REC 96%												RQD = 96%
147			4	RC	REC 96%												RQD = 96%
146.0	END OF BOREHOLE																
29.5																	

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B504-02

SHEET 1 OF 1

LOCATION: N 5084194.9 ; E 222551.6

DRILLING DATE: November 8 to 9, 2012

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Diedrich D55

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	FLUSH	COLOUR % RETURN	RECOVERY				R.Q.D. %	FRACT. INDEX PER 0.25	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY K, cm/sec				Diametral Point Load Index (MPa)	RMC -Q AVG.	NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
					DEPTH (m)	TOTAL CORE %				SOLID CORE %	B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION			Jr	Ja	Jn	10 ⁶	10 ⁵	10 ⁴	10 ³	10 ²	10 ¹																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
		Continued from Record of Borehole B504-2		151.03																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									

DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15

PROJECT		RECORD OF BOREHOLE		No B504-03		SHEET 1 OF 1		METRIC									
W.P. 09-1111-6014		LOCATION		N 5084050.1 ; E 222611.8		ORIGINATED BY		TM									
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment		COMPILED BY									
JFC		DATE		August 6, 2014		CHECKED BY		MCK/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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
195.6	GROUND SURFACE																
0.0	TOPSOIL																
0.1	SILTY SAND, trace rootlets		1	AS	-												
195.0	Brown																
0.6	Moist																
	END OF BOREHOLE AUGER REFUSAL																
NOTE: 1. Borehole dry upon completion of drilling.																	




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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15



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

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B504-06		SHEET 1 OF 1		METRIC											
W.P. 5147-08-01		LOCATION N 5084069.8 ; E 222603.7		ORIGINATED BY TM/SP													
DIST _____ HWY 69		BOREHOLE TYPE Portable Equipment		COMPILED BY JFC													
DATUM Geodetic		DATE August 6, 2014		CHECKED BY MCK/AB													
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)				
190.8 0.0	GROUND SURFACE Granitic Gneiss (BEDROCK) Bedrock cored from depths of 0.0 m to 8.1 m. For bedrock coring details refer to Record of Drillhole B504-06.		1	RC	REC 100%	190											RQD = 98%
			2	RC	REC 98%	189											RQD = 85%
			3	RC	REC 100%	188											RQD = 77%
			4	RC	REC 91%	187											RQD = 63%
			5	RC	REC 100%	186											RQD = 50%
			6	RC	REC 98%	185											RQD = 91%
			7	RC	REC 100%	184											RQD = 98%
182.7 8.1	END OF BOREHOLE NOTE: 1. Water level not recorded upon completion of drilling.			8	RC	REC 98%	183										RQD = 98%

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B504-06

SHEET 1 OF 1

LOCATION: N 5084069.8 ; E 222603.7

DRILLING DATE: August 6, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: OGS Inc

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	RECOVERY TOTAL CORE %	R.Q.D. % SOLID CORE %	FRACT. INDEX PER 0.25 m	B Angle °	DIP w.r.t. CORE AXIS °	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Ur	Ja	Jn	K, cm/sec °	°	°	°	Diametral Point Load Index (MPa)	RMC -Q AVG.	NOTES
0		Continued from Record of Borehole B504-06		190.82																		
1		Slightly weathered, foliated, grey and pink, coarse grained, faintly porous, strong to very strong GRANITIC GNEISS		0.00	1							JN,PL,RO SO	1.5	1								
2					2							JN,CU,RO BC LC JN,PL,RO	3	1								7.67 MPa
3					3							JN,PL,RO SO BC	1.5	1								
4	HORC August 6, 2014				4							JN,PL,RO SA JN,PL,RO SO JN,UN,RO BC LC	1.5	2	1							
5					5							JN,UN,RO BC JN,PL,RO BC	3	1								
6					6																	
7					7							FO,PL,RO SO FO,PL,RO SO JN,PL,RO SA JN,PL,RO	1.5	1								8.34 MPa (Axial)
8					8																	UC = 96.6 MPa
9																						6.19 MPa (Axial)
10		END OF DRILLHOLE		182.74								JN,PL,RO	1.5	1								7.35 MPa
				8.08																		

DEPTH SCALE

1 : 50



LOGGED: TM/SP

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/26/15



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



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

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No B504-09		SHEET 1 OF 2		METRIC	
W.P. <u>5147-08-01</u>		LOCATION <u>N 5084121.2 ; E 222583.1</u>		ORIGINATED BY <u>LK</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>100 mm I.D. HW Casing, Wash Boring</u>		COMPILED BY <u>JFC</u>			
DATUM <u>Geodetic</u>		DATE <u>August 5 to 7, 2014</u>		CHECKED BY <u>MCK/AB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p	W	W _L			WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED						
176.3 0.0	WATER SURFACE WATER						176								
							175								
							174								
							173								
172.5 3.8	ORGANIC SILT Very soft to soft Grey Wet		1	SS	WH		172								
							171								
			2	SS	WH		170								
							169								
							168								
			4	SS	WH		167								
							166								
166.0 10.3	CLAYEY SILT, trace to some sand, trace gravel Soft to firm Grey Wet		5	SS	WH		165								
							164								
			6A 6B	SS	3		163								
162.6 13.7	SAND, trace so some silt, trace clay, trace gravel Loose to compact Grey Wet		7	SS	9		162								

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B504-09		SHEET 2 OF 2		METRIC						
W.P. 5147-08-01		LOCATION N 5084121.2 ; E 222583.1		ORIGINATED BY LK								
DIST _____ HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring		COMPILED BY JFC								
DATUM Geodetic		DATE August 5 to 7, 2014		CHECKED BY MCK/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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES					
	--- CONTINUED FROM PREVIOUS PAGE ---						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					
			8	SS	5	161						1 83 15 1
						160						
			9	SS	9	159						
						158						1 86 12 1
			10	SS	15	157						
						156						
			11	SS	17	155						
						154						
154.0	22.3											
	Gravelly SAND, some silt, trace clay, trace gravel Loose to compact Grey Wet											
153.0	23.3		13	SS	109*	153						26 56 16 2
	Containing cobbles below a depth of 22.9 m (Elev. 153.4 m)		1	RC	REC 100%							RQD = 0%
	Granitic Gneiss (BEDROCK)		2	RC	REC 100%	152						RQD = 57%
	Bedrock cored from depths of 23.3 m to 29.3 m.		3	RC	REC 100%	151						RQD = 99%
	For bedrock coring details refer to Record of Drillhole B504-09.		4	RC	REC 100%	150						RQD = 100%
	NOTE: * Split-Spoon Sampler bouncing.		5	RC	REC 100%	148						RQD = 100%
147.0	29.3					147						
	END OF BOREHOLE											

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: WALKER DRILLING

LOGGED: LK
CHECKED: MCK/AB

Continued Next Page

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

PROJECT		RECORD OF BOREHOLE		No B504-10		SHEET 2 OF 2		METRIC									
W.P. 09-1111-6014		LOCATION		N 5084119.3 ; E 222562.6		ORIGINATED BY		LK									
DIST 5147-08-01 HWY 69		BOREHOLE TYPE		100 mm I.D. HW Casing, Wash Boring		COMPILED BY		JFC									
DATUM Geodetic		DATE		August 7, 2014		CHECKED BY		MCK/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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
	Inferred SAND to GRAVELLY SAND No sample taken between depths of 3.7 m and 21.3 m.																
155.6																	
20.7	Inferred BOULDERS																
155.0																	
21.3	Granitic Gneiss (BEDROCK) Bedrock cored from depths of 21.3 m to 24.8 m. For bedrock coring details refer to Record of Drillhole B504-10.		1	RC	REC 100%											RQD = 62%	
			2	RC	REC 100%											RQD = 95%	
			3	RC	REC 100%											RQD = 62%	
151.5																	
24.8	END OF BOREHOLE NOTE: 1. Soil stratigraphy inferred from field observations during drilling and from information in adjacent boreholes.																

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: WALKER DRILLING

LOGGED: LK
CHECKED: MCK/AB

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B504-11		SHEET 1 OF 3		METRIC												
W.P. 5147-08-01		LOCATION N 5084118.3 ; E 222594.6		ORIGINATED BY LK														
DIST _____ HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring		COMPILED BY JFC														
DATUM Geodetic		DATE July 31 to August 1, 2014		CHECKED BY MCK/AB														
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 (%)					
								20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	20 40 60	γ	GR	SA	SI	CL
176.3 0.0	WATER SURFACE WATER						176											
							175											
							174											
							173											
172.8 3.5	Inferred ORGANIC SILT No sample taken between depths of 3.5 m and 24.1 m.						172											
							171											
							170											
							169											
							168											
							167											
166.0 10.3	Inferred CLAYEY SILT						166											
							165											
							164											
	Cobbles encountered at a depth of 12.8 m (Elev. 163.5 m)						163											
162.9 13.4							162											

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15



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

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B504-11				SHEET 3 OF 3		METRIC													
W.P. 5147-08-01		LOCATION N 5084118.3 ; E 222594.6				ORIGINATED BY LK															
DIST HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring				COMPILED BY JFC															
DATUM Geodetic		DATE July 31 to August 1, 2014				CHECKED BY MCK/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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa													
--- CONTINUED FROM PREVIOUS PAGE ---							<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>					<div style="display: flex; justify-content: space-between;"> 20 40 60 20 40 60 </div>									
NOTE: 1. Soil stratigraphy inferred from field observations during drilling and from information in adjacent boreholes.																					

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B504-11

SHEET 1 OF 1

LOCATION: N 5084118.3 ; E 222594.6

DRILLING DATE: August 1, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Diedrich D120

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	JN - Joint FLT - Fault SH - 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 VR - Very Rough				MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.				NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
								RECOVERY		R.Q.D. %	FRACT INDEX PER 0.25	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec				Diametral Point Load Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
								TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 10 10 10	10 10 10 10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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		Continued from Record of Borehole B504-11		152.19																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							

8.11 MPa

DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No B504-12		SHEET 1 OF 3		METRIC	
W.P. <u>5147-08-01</u>		LOCATION <u>N 5084188.2 ; E 222554.7</u>		ORIGINATED BY <u>LK</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>100 mm I.D. HW Casing, Wash Boring</u>		COMPILED BY <u>JFC</u>			
DATUM <u>Geodetic</u>		DATE <u>July 16 to 18, 2014</u>		CHECKED BY <u>MCK/AB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							W _p	W	W _L	
								○ UNCONFINED + FIELD VANE							WATER CONTENT (%)			
						● QUICK TRIAXIAL × REMOULDED												
						20 40 60 80 100						20 40 60						
176.3 0.0	WATER SURFACE WATER						176											
							175											
							174											
							173											
							172											
170.8 5.5	ORGANIC SILT Very soft to soft Brown to grey Wet		1	SS	WH		171											
							170	6 + 2 +										
			2	SS	WH		169	2 + 1 +										
			3	SS	WH		168							152.9				
							167	2 + 2 +										
			4	SS	WH		166											
							165	2 + 2 +										
163.5 12.8	CLAYEY SILT, trace sand Firm Grey Wet		5	SS	WH		164							150.8				
							163	3 + 3 +										
162.0 14.3			6	SS	WH		162											

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15


PROJECT 09-1111-6014		RECORD OF BOREHOLE No B504-12		SHEET 2 OF 3		METRIC	
W.P. 5147-08-01		LOCATION N 5084188.2 ; E 222554.7		ORIGINATED BY LK			
DIST _____ HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring		COMPILED BY JFC			
DATUM Geodetic		DATE July 16 to 18, 2014		CHECKED BY MCK/AB			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	20	40	60	80	100	w _p	w		w _L							
	--- CONTINUED FROM PREVIOUS PAGE ---																							
152.5 23.8	SAND, trace to some silt, trace to some gravel Loose to dense Brown to grey Moist to wet Silt pockets encountered at a depth of 21.6 m (Elev. 154.7 m).		7	SS	33																			
			8	SS	30										○					5	87	8	0	
			9	SS	25																			
			10	SS	5											○					16	75	9	0
			11	SS	7																			
147.7 28.6	SILT and SAND, trace to some gravel, trace clay Compact to very dense Grey Wet Clay lenses encountered at a depth of 24.7 m (Elev. 151.6 m). Boulder encountered at a depth of 26.1 m (Elev. 150.2 m).		13	SS	12									○					12	43	45	0		
			14	SS	-*																			
			15	RC	REC 100%																			
147.7 28.6	Granitic Gneiss (BEDROCK) Bedrock cored from depths of 28.6 m to 34.2 m. For bedrock coring details refer to Record of Drillhole B504-12.																							
			16	SS	59										○					0	59	38	3	
			1	RC	REC 100%																	RQD = 46%		
			2	RC	REC 100%																			

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

PROJECT		RECORD OF BOREHOLE No B504-12				SHEET 3 OF 3		METRIC									
W.P. 09-1111-6014		LOCATION N 5084188.2 ; E 222554.7				ORIGINATED BY LK											
DIST HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring				COMPILED BY JFC											
DATUM Geodetic		DATE July 16 to 18, 2014				CHECKED BY MCK/AB											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)				
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p W W _L 20 40 60					
142.1	Granitic Gneiss (BEDROCK)		2	RC	REC 100%	146											RQD = 28%
	Bedrock cored from depths of 28.6 m to 34.2 m.		3	RC	REC 100%	145											RQD = 93%
	For bedrock coring details refer to Record of Drillhole B504-12.		4	RC	REC 100%	144											RQD = 95%
34.2	END OF BOREHOLE																
	NOTE: * Split-spoon sampler bouncing.																

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B504-12

SHEET 1 OF 1

LOCATION: N 5084188.2 ;E 222554.7

DRILLING DATE: July 17 to 18, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Diedrich D120

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	COLOUR % RETURN	FLUSH	JN - Joint FLT - Fault SH - 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 VR - Very Rough	MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES																	
				DEPTH																										
				(m)																										
RECOVERY													DISCONTINUITY DATA																	
TOTAL CORE %		SOLID CORE %		R.Q.D. %		FRACT. INDEX PER 0.25		B Angle		DIP w.r.t. CORE AXIS		TYPE AND SURFACE DESCRIPTION		Jr		Ja		Jn		HYDRAULIC CONDUCTIVITY K, cm/sec		Diametral Point Load Index (MPa)		RMC -Q' AVG.						
10	20	30	40	50	60	70	80	90	100	0	30	60	90	120	150	180	210	240	270	300	10	20	30	40	50	60	70	80	90	100
		Continued from Record of Borehole B504-12		147.69																										
29	HW Casing	Slightly weathered to fresh, foliated, grey and pink, medium grained, faintly porous GRANITIC GNEISS		28.62	1																									

DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: MCK/AB


GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15

Continued Next Page

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



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

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B504-13				SHEET 3 OF 3		METRIC										
W.P. 5147-08-01		LOCATION N 5084192.0 ; E 222564.3				ORIGINATED BY LK												
DIST _____ HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring				COMPILED BY JFC												
DATUM Geodetic		DATE July 18 to 19, 2014				CHECKED BY MCK/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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)	
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					20 40 60						
	Granitic Gneiss (BEDROCK)		2	RC	REC 100%		146											RQD = 100%
	Bedrock cored from depths of 29.2 m to 32.4 m. For bedrock coring details refer to Record of Drillhole B504-13.		3	RC	REC 98%		145											RQD = 85%
143.9 32.4	END OF BOREHOLE						144											
	NOTE: 1. Soil stratigraphy inferred from field observations during drilling and from information in adjacent boreholes.																	

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B504-13

SHEET 1 OF 1

LOCATION: N 5084192.0 ; E 222564.3

DRILLING DATE: July 19, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Diedrich D120

DRILLING CONTRACTOR: WALKER DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	COLOUR % RETURN	FLUSH	JN - Joint FLT - Fault SH - 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 VR - Very Rough	MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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															RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.25	B Angle 0 to 90 20 to 70	DIP w.r.t. CORE AXIS 0 to 90 0 to 90	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec				Diametral Point Load Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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	HW Casing	Slightly weathered, foliated, grey and pink, medium grained, faintly porous, strong to very strong GRANITIC GNEISS		29.20	1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														

DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15

Continued Next Page

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

PROJECT <u>09-1111-6014</u>		RECORD OF BOREHOLE No B504-14		SHEET 2 OF 3		METRIC	
W.P. <u>5147-08-01</u>		LOCATION <u>N 5084190.2 ; E 222532.4</u>		ORIGINATED BY <u>LK</u>			
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>100 mm I.D. HW Casing, Wash Boring</u>		COMPILED BY <u>JFC</u>			
DATUM <u>Geodetic</u>		DATE <u>July 25 to 26, 2014</u>		CHECKED BY <u>MCK/AB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED												
	--- CONTINUED FROM PREVIOUS PAGE ---																				
	Inferred SAND No sample taken between depths of 7.4 m and 25.5 m.																				

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

PROJECT 09-1111-6014		RECORD OF BOREHOLE No B504-14				SHEET 3 OF 3		METRIC														
W.P. 5147-08-01		LOCATION N 5084190.2 ; E 222532.4				ORIGINATED BY LK																
DIST HWY 69		BOREHOLE TYPE 100 mm I.D. HW Casing, Wash Boring				COMPILED BY JFC																
DATUM Geodetic		DATE July 25 to 26, 2014				CHECKED BY MCK/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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa														
--- CONTINUED FROM PREVIOUS PAGE ---							<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>															
NOTE: 1. Soil stratigraphy inferred from field observations during drilling and from information in adjacent boreholes.																						

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: WALKER DRILLING

[illegible]

CHECKED: MCK/AB

GTARCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15



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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15



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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15

PROJECT		RECORD OF BOREHOLE		No B504-17		SHEET 1 OF 1		METRIC					
W.P.		LOCATION		ORIGINATED BY		TM							
DIST		BOREHOLE TYPE		COMPILED BY		JFC							
DATUM		DATE		CHECKED BY		MCK/AB							
09-1111-6014		N 5084239.6 ; E 222532.9											
5147-08-01		Portable Equipment											
HWY 69		July 24 to 26, 2014											
Geodetic													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	GR SA SI CL
197.1	GROUND SURFACE												
0.0	PEAT (Fibrous)		1	GRAB	-		197						
0.3	COBBLE												
	SAND and GRAVEL, trace silt, trace rootlets and organics		1	RC	REC 100%								RQD = 87%
	Dark brown Moist												
	Granitic Gneiss (BEDROCK)		2	RC	REC 100%		196						RQD = 82%
	Bedrock cored from depths of 0.3 m to 10.0 m.												
	For bedrock coring details refer to Record of Drillhole B504-17.		3	RC	REC 100%		195						RQD = 65%
			4	RC	REC 100%		194						RQD = 93%
			5	RC	REC 100%		193						RQD = 100%
			6	RC	REC 100%		192						RQD = 96%
			7	RC	REC 100%		191						RQD = 89%
			8	RC	REC 100%		190						RQD = 61%
			9	RC	REC 100%		189						RQD = 93%
			10	RC	REC 100%		188						RQD = 100%
187.1	END OF BOREHOLE												
10.0	NOTE: 1. Water level in open corehole at a depth of 7.3 m below ground surface (Elev. 189.8 m) on the morning of July 27, 2014.												

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: OGS Inc

[illegible]

CHECKED: MCK/AB

GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 11/24/15



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



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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15



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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 11/24/15



APPENDIX B

Laboratory Test Results and Bedrock Core Photographs

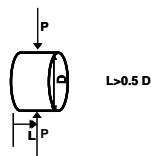
TABLE B1
POINT LOAD TEST RESULTS ON ROCK SAMPLES

Foundation Element	Borehole Number	Run Number	Sample Depth (m)	Sample Elevation (m)	Bedrock Description	Test Type	Core Length (mm)	Core Diameter (mm)	Is (50mm) (MPa)	Approx. UCS Value ⁽¹⁾ (MPa)
South Abutment	B504-06	2	1.6	189.2	Granitic Gneiss	Diametral	84.00	63.00	7.67	107
	B504-06	7	6.3	184.5	Granitic Gneiss	Axial	47.00	63.00	8.34	117
	B504-06	8	7.5	183.3	Granitic Gneiss	Axial	66.00	63.00	6.19	87
	B504-06	8	8.0	182.8	Granitic Gneiss	Diametral	84.00	63.00	7.35	103
South Pier	B504-01	1	13.5	162.0	Granitic Gneiss	Axial	22.97	47.27	14.68	206
	B504-01	3	15.5	160.0	Granitic Gneiss	Diametral	84.70	39.03	23.88	334
	B504-01	4	16.8	158.7	Granitic Gneiss	Axial	22.73	46.79	7.20	101
	B504-09	3	25.1	151.2	Granitic Gneiss	Diametral	120.00	63.00	7.13	100
	B504-09	5	28.8	147.5	Granitic Gneiss	Diametral	105.00	63.00	7.89	110
	B504-10	2	23.3	153.0	Granitic Gneiss	Diametral	69.00	63.00	8.58	120
	B504-11	3	26.1	150.2	Granitic Gneiss	Diametral	90.00	63.00	8.11	114
North Pier	B504-02	2	24.8	150.7	Granitic Gneiss	Axial	23.63	47.52	11.77	165
	B504-02	3	26.7	148.8	Granitic Gneiss	Diametral	60.99	40.19	8.69	122
	B504-02	4	28.4	147.1	Granitic Gneiss	Axial	22.02	47.39	8.94	125
	B504-13	2	29.3	147.0	Granitic Gneiss	Diametral	115.00	63.00	5.48	77
	B504-13	2	29.3	147.0	Granitic Gneiss	Axial	61.00	63.00	7.12	100
	B504-13	2	29.6	146.7	Granitic Gneiss	Diametral	102.00	63.00	5.68	80
	B504-13	2	29.6	146.7	Granitic Gneiss	Axial	63.00	63.00	7.70	108
	B504-13	3	31.7	144.6	Granitic Gneiss	Axial	60.00	63.00	8.27	116
	B504-13	3	31.7	144.6	Granitic Gneiss	Diametral	120.00	63.00	7.60	106
	B504-14	1	25.8	150.5	Granitic Gneiss	Diametral	115.00	63.00	7.89	110
	B504-14	2	27.7	148.6	Granitic Gneiss	Diametral	96.00	63.00	5.94	83
	B504-14	2	27.7	148.6	Granitic Gneiss	Axial	52.00	63.00	8.31	116
North Abutment	B504-17	1	1.2	195.9	Granitic Gneiss	Diametral	100.00	56.00	2.47	35
	B504-17	1	1.4	195.7	Granitic Gneiss	Axial	41.00	56.00	9.01	126
	B504-17	3	2.8	194.3	Granitic Gneiss	Axial	40.00	56.00	9.23	129
	B504-17	5	5.1	192.0	Granitic Gneiss	Diametral	107.00	56.00	6.26	88

⁽¹⁾ $Is_{90} \times K$, from ASTM Designation: D 5731 "Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications". A value of $K = 14$ has been determined based on UCS tests for both SBL and NBL bridges.

DIAMETRAL SPECIMEN SHAPE REQUIREMENTS

note: Diametral tests are perpendicular to core axis (planes of weakness)



AXIAL SPECIMEN SHAPE REQUIREMENTS

note: Axial tests are parallel to core axis (planes of weakness)

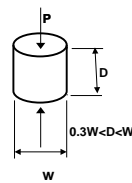


TABLE B2-1
SUMMARY OF UNIAXIAL COMPRESSIVE STRENGTH TEST RESULTS
KEY RIVER NBL BRIDGE
HIGHWAY 69 GWP 5404-05-00; WP 5147-08-01

Borehole Number (Core Run)	Sample Depth (m)	Sample Elevation (m)	Rock Type	Core Diameter (mm)	Uniaxial Compressive Strength (MPa)
B504-02	25.6	149.9	Granitic Gneiss	47.2	94.1
B504-06	6.9	183.9	Granitic Gneiss	63.1	96.6
B504-09	25.5	150.8	Granitic Gneiss	63.1	109.4
B504-09	28.7	147.6	Granitic Gneiss	63.1	177.7
B504-17	1.6	195.5	Granitic Gneiss	56.4	88.1
B504-17	6.4	190.7	Granitic Gneiss	56.4	101.6

Compiled By: ABReviewed By: JMAC

TABLE B2-2
UNCONFINED COMPRESSION TEST (UC)
ASTM D 7012-07

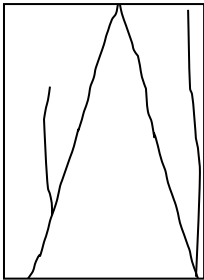
SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	2
BOREHOLE NUMBER	B504-02	SAMPLE DEPTH, m	25.52-25.69
TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.33
SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	11.02	WATER CONTENT, (specimen) %	0.24
SAMPLE DIAMETER, cm	4.72	UNIT WEIGHT, kN/m ³	26.16
SAMPLE AREA, cm ²	17.50	DRY UNIT WT., kN/m ³	26.09
SAMPLE VOLUME, cm ³	192.82	SPECIFIC GRAVITY	-
WET WEIGHT, g	514.46	VOID RATIO	-
DRY WEIGHT, g	513.23		
VISUAL INSPECTION		FAILURE SKETCH	
			
TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	94.1
REMARKS:		DATE: 12/13/2012	
PREPARED BY: AB		REVIEWED BY: JPD/JMAC	

TABLE B2-3
UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

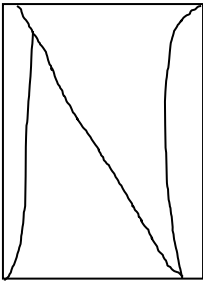
SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	7
BOREHOLE NUMBER	B504-06	SAMPLE DEPTH, m	6.88-7.10
TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.29
SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	14.44	WATER CONTENT, (specimen) %	0.11
SAMPLE DIAMETER, cm	6.31	UNIT WEIGHT, kN/m ³	26.30
SAMPLE AREA, cm ²	31.30	DRY UNIT WT., kN/m ³	26.27
SAMPLE VOLUME, cm ³	451.83	SPECIFIC GRAVITY	-
WET WEIGHT, g	1212.10	VOID RATIO	-
DRY WEIGHT, g	1210.77		
VISUAL INSPECTION	FAILURE SKETCH		
			
TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRENGTH, MPa	96.6
REMARKS:	DATE:		04/22/15
PREPARED BY:	AB	REVIEWED BY:	JMAC

TABLE B2-4
UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

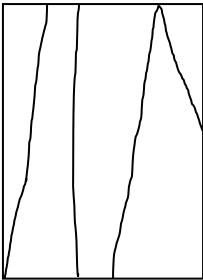
SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	3
BOREHOLE NUMBER	B504-09	SAMPLE DEPTH, m	25.40-25.65
TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.25
SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	14.23	WATER CONTENT, (specimen) %	0.20
SAMPLE DIAMETER, cm	6.31	UNIT WEIGHT, kN/m ³	29.17
SAMPLE AREA, cm ²	31.30	DRY UNIT WT., kN/m ³	29.11
SAMPLE VOLUME, cm ³	445.48	SPECIFIC GRAVITY	-
WET WEIGHT, g	1325.50	VOID RATIO	-
DRY WEIGHT, g	1322.85		
VISUAL INSPECTION	FAILURE SKETCH		
			
TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRENGTH, MPa	109.4
REMARKS:	DATE:		04/23/15
PREPARED BY:	AB	REVIEWED BY:	JMAC

TABLE B2-5
UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1111-6014	RUN NUMBER	5
BOREHOLE NUMBER	B504-09	SAMPLE DEPTH, m	28.57-28.78

TEST CONDITIONS

MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.30

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	14.52	WATER CONTENT, (specimen) %	0.15
SAMPLE DIAMETER, cm	6.31	UNIT WEIGHT, kN/m ³	29.21
SAMPLE AREA, cm ²	31.29	DRY UNIT WT., kN/m ³	29.17
SAMPLE VOLUME, cm ³	454.19	SPECIFIC GRAVITY	-
WET WEIGHT, g	1353.30	VOID RATIO	-
DRY WEIGHT, g	1351.27		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRENGTH, MPa	177.7
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REMARKS:	DATE:	04/22/15
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PREPARED BY:	AB	REVIEWED BY: JMAC
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TABLE B2-6
UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

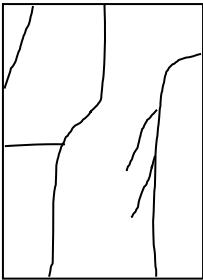
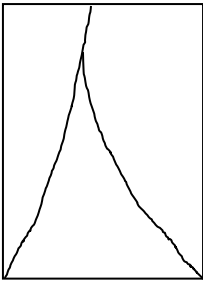
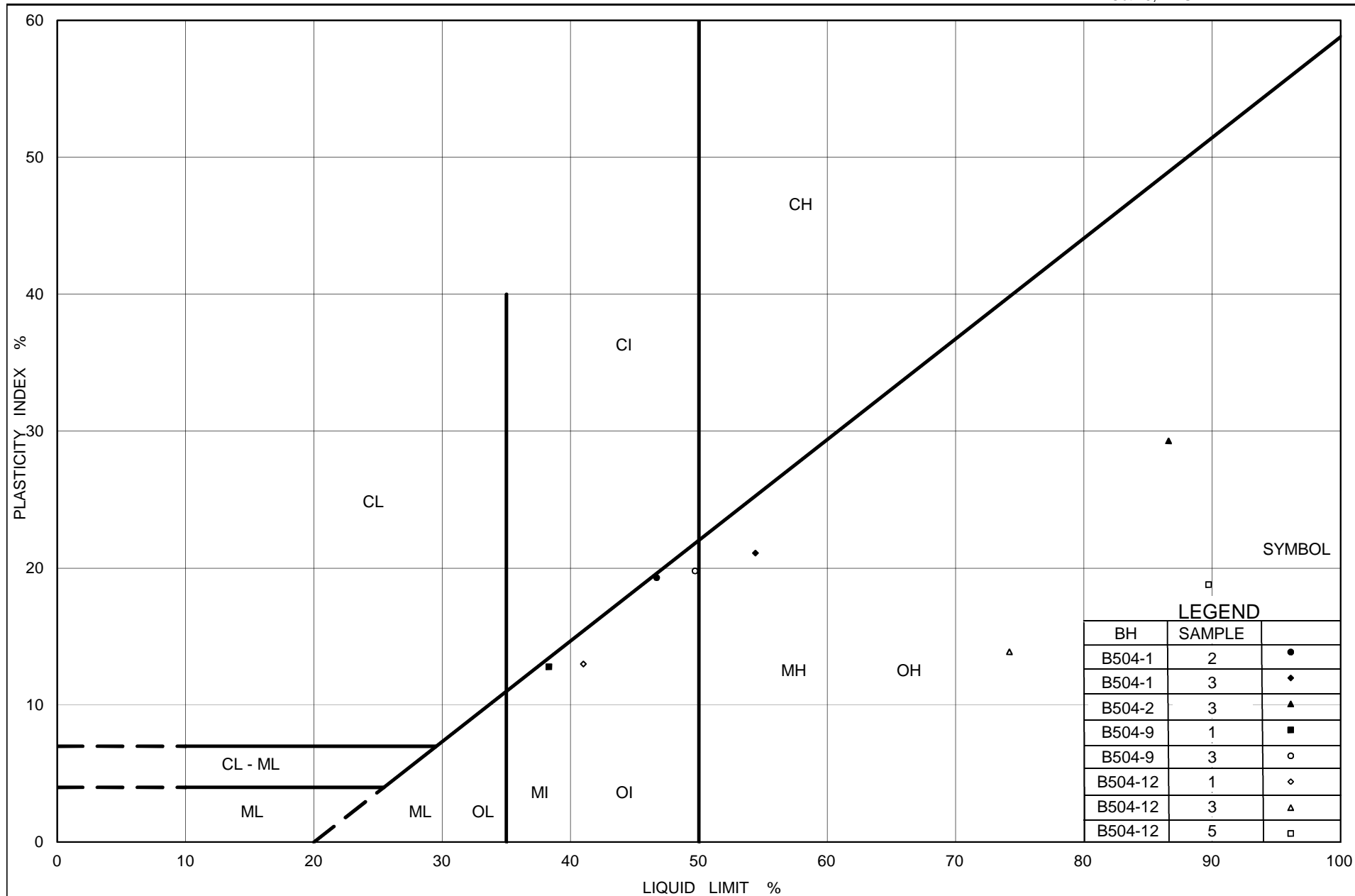
SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	2
BOREHOLE NUMBER	B504-17	SAMPLE DEPTH, m	1.54-1.75
TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.21
SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	12.49	WATER CONTENT, (specimen) %	0.06
SAMPLE DIAMETER, cm	5.64	UNIT WEIGHT, kN/m ³	26.67
SAMPLE AREA, cm ²	25.00	DRY UNIT WT., kN/m ³	26.66
SAMPLE VOLUME, cm ³	312.34	SPECIFIC GRAVITY	-
WET WEIGHT, g	849.80	VOID RATIO	-
DRY WEIGHT, g	849.29		
VISUAL INSPECTION	FAILURE SKETCH		
			
TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRENGTH, MPa	88.1
REMARKS:	DATE:		04/22/15
PREPARED BY:	AB	REVIEWED BY:	JMAC

TABLE B2-7
UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	7
BOREHOLE NUMBER	B504-17	SAMPLE DEPTH, m	6.32-6.50
TEST CONDITIONS			
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.25
SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	12.67	WATER CONTENT, (specimen) %	0.09
SAMPLE DIAMETER, cm	5.64	UNIT WEIGHT, kN/m ³	27.15
SAMPLE AREA, cm ²	24.95	DRY UNIT WT., kN/m ³	27.12
SAMPLE VOLUME, cm ³	316.09	SPECIFIC GRAVITY	-
WET WEIGHT, g	875.40	VOID RATIO	-
DRY WEIGHT, g	874.61		
VISUAL INSPECTION	FAILURE SKETCH		
			
TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRENGTH, MPa	101.6
REMARKS:	DATE:		04/22/15
PREPARED BY:	AB	REVIEWED BY:	JMAC



Ministry of Transportation

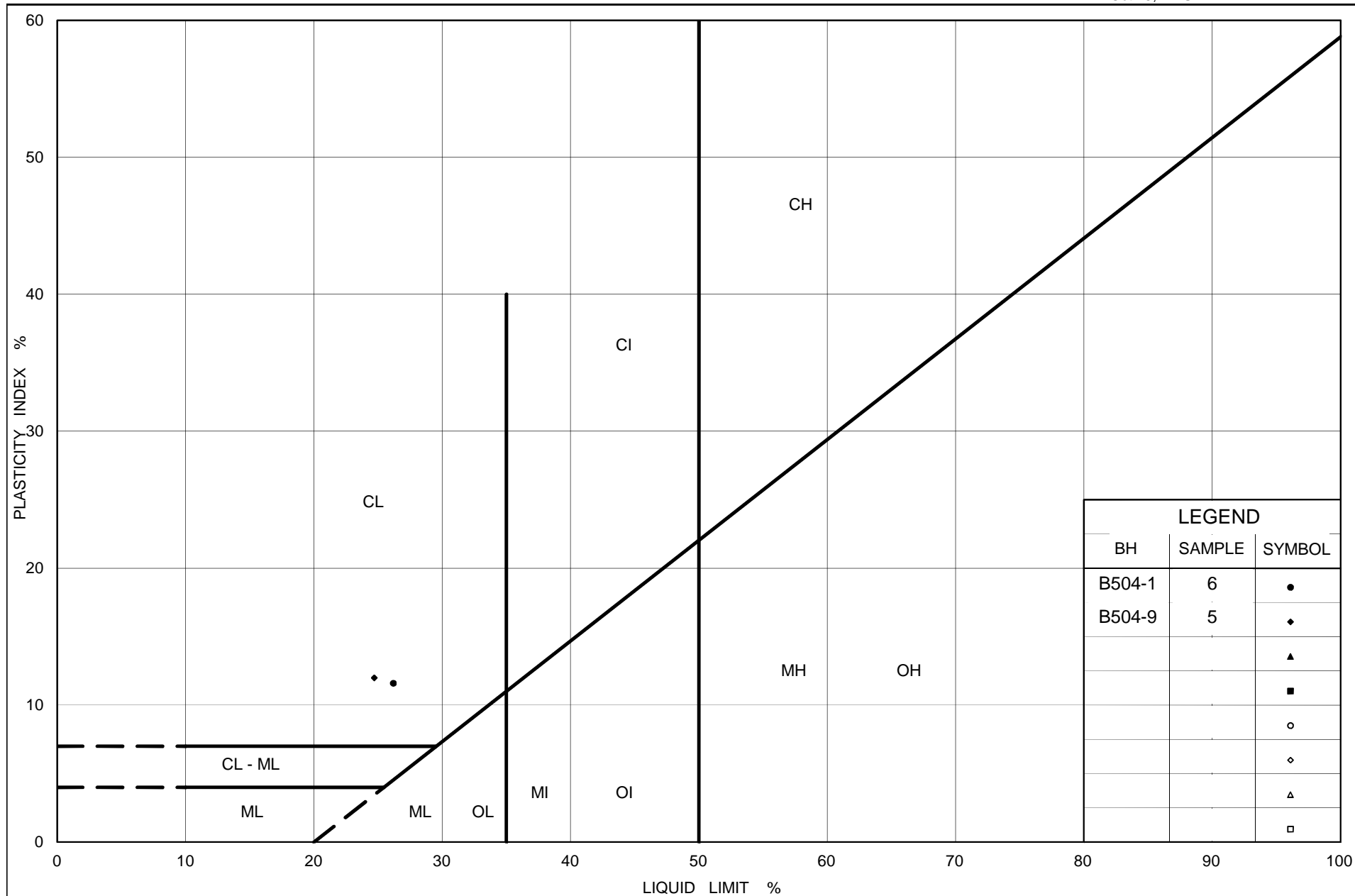
Ontario

PLASTICITY CHART Organic Silt

Figure No. B1A

Project No. 09-1111-6014

Checked By: AB



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt

Figure No. B1B

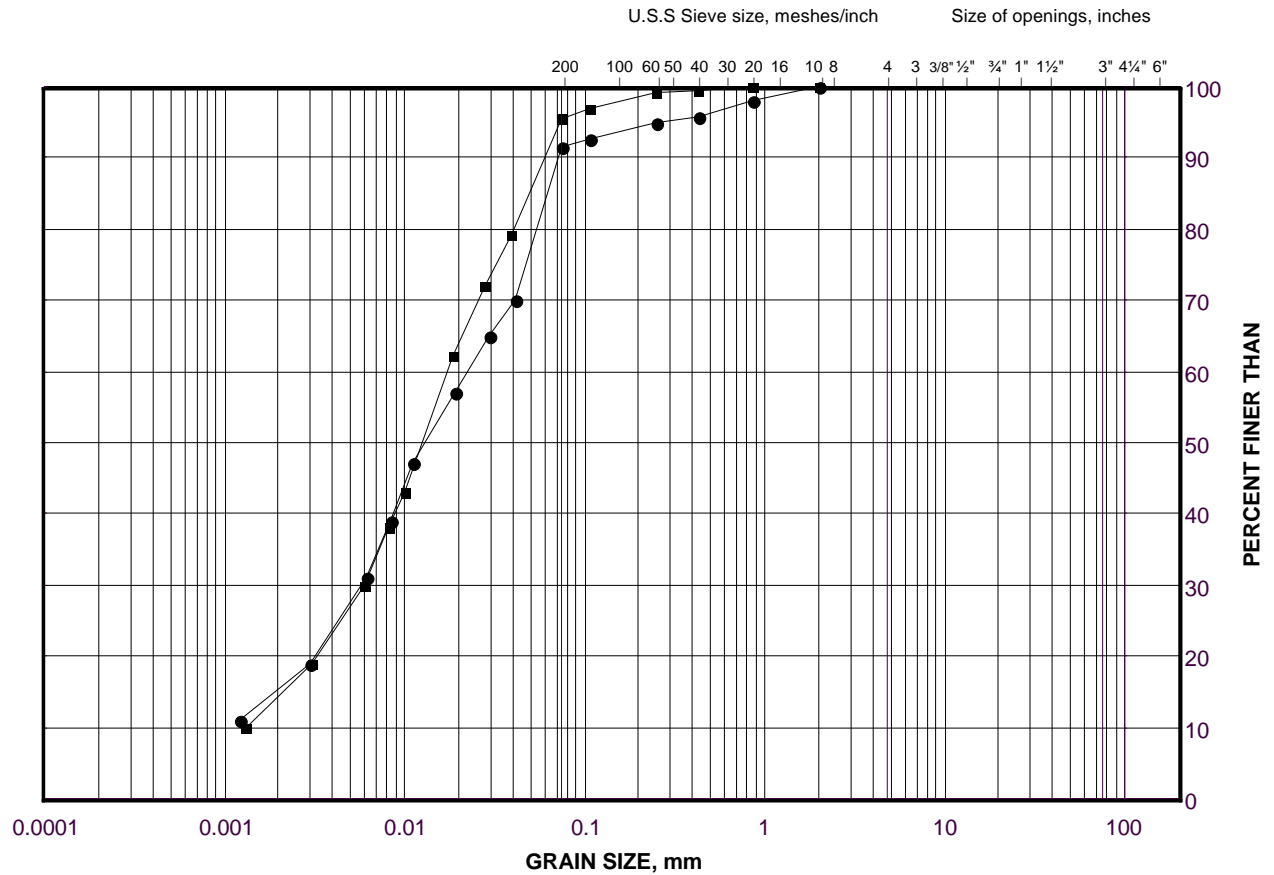
Project No. 09-1111-6014

Checked By: AB

GRAIN SIZE DISTRIBUTION

Organic Silt

FIGURE B2A



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B504-02	3	166.4
■	B504-01	3	169.7

Project Number: 09-1111-6014

Checked By: AB

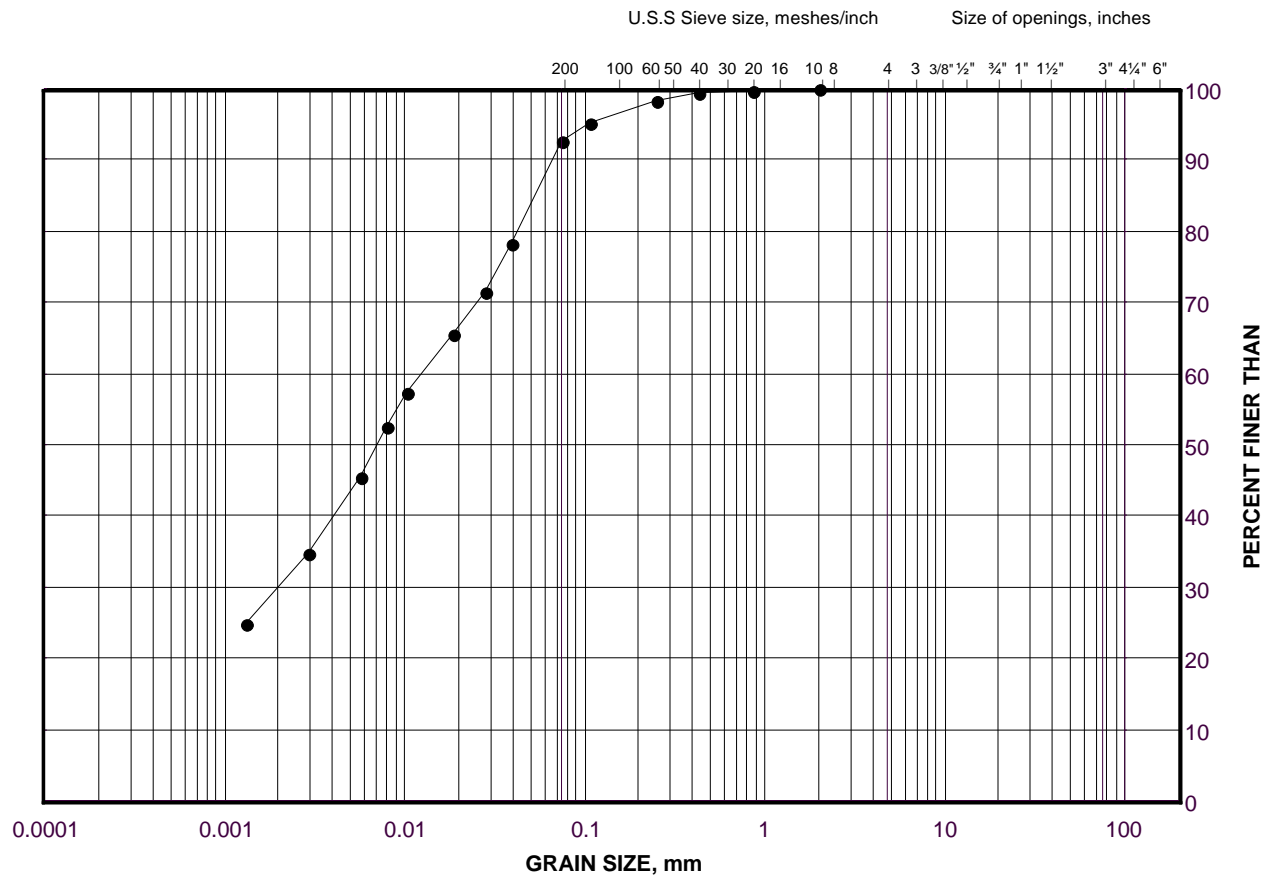
Golder Associates

Date: 30-Apr-15

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B2B



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	B504-01	6	164.8

Project Number: 09-1111-6014

Checked By: AB

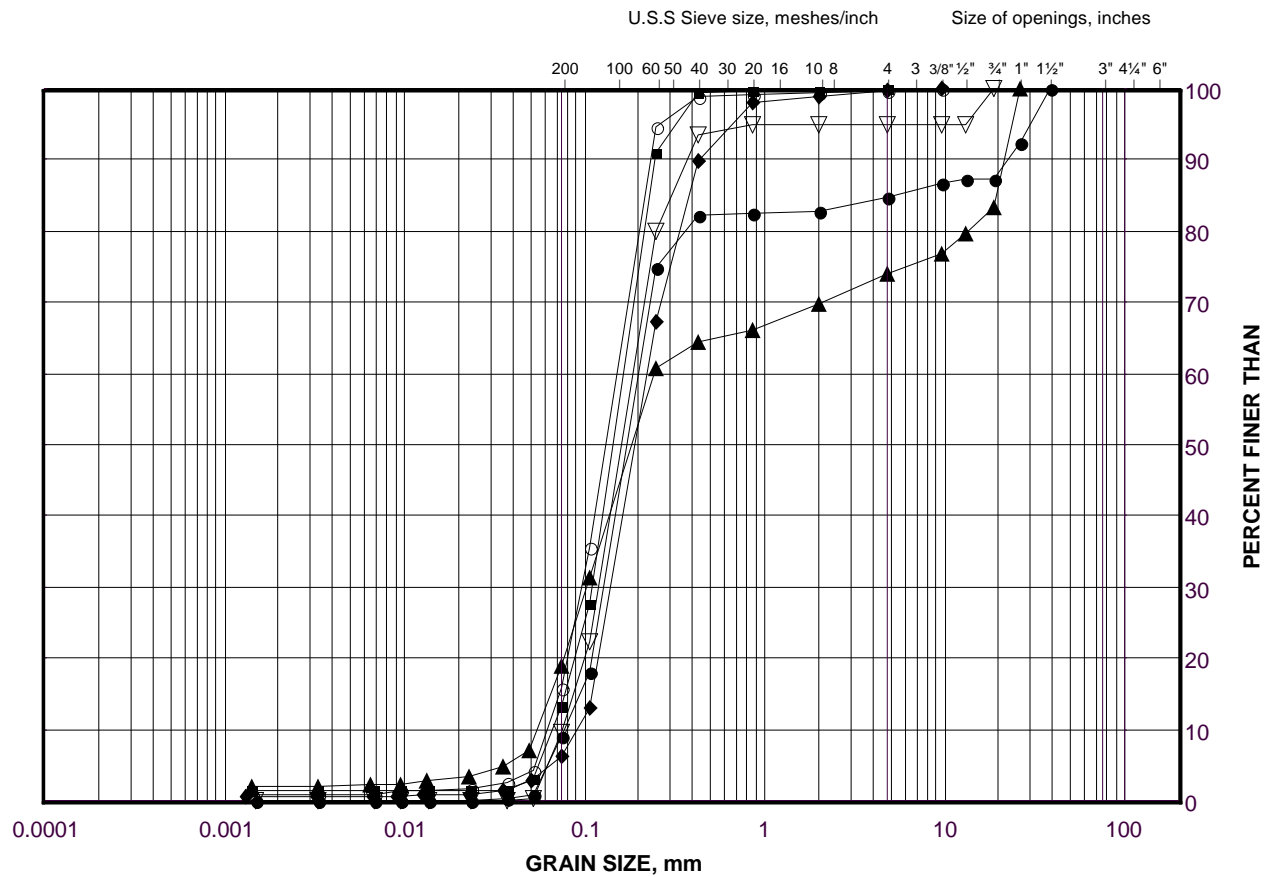
Golder Associates

Date: 30-Apr-15

GRAIN SIZE DISTRIBUTION

Sand to Gravelly Sand

FIGURE B3A



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B504-12	10	156.2
■	B504-09	10	157.8
◆	B504-02	10	155.1
▲	B504-09	13	153.2
▽	B504-12	8	159.3
○	B504-09	8	160.8

Project Number: 09-1111-6014

Checked By: AB

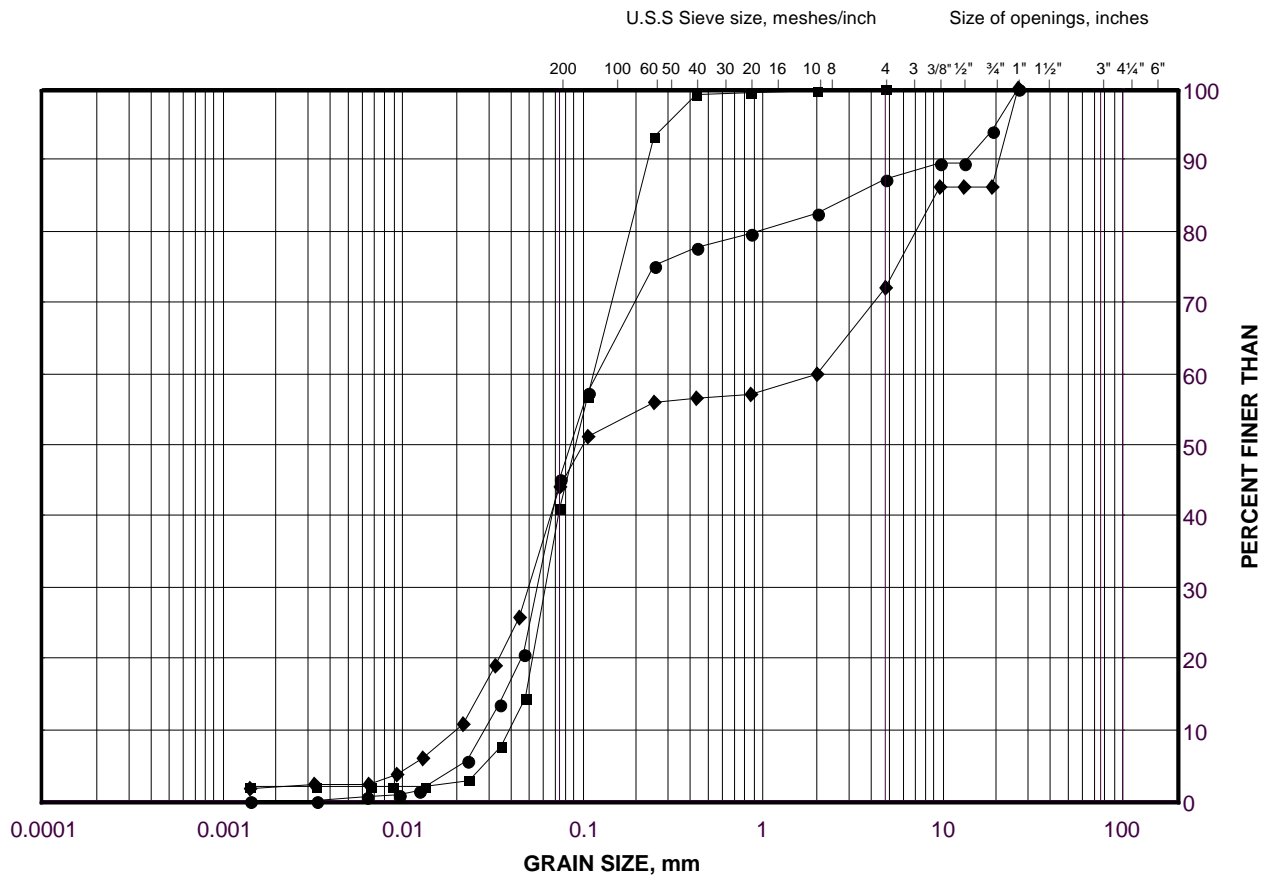
Golder Associates

Date: 30-Apr-15

GRAIN SIZE DISTRIBUTION

Gravelly Sandy Silt to Silt and Sand

FIGURE B3B



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B504-12	13	151.7
■	B504-12	16	148.2
◆	B504-02	6	161.8

Borehole B504-01



Box 1: 13.16 m – 17.31 m

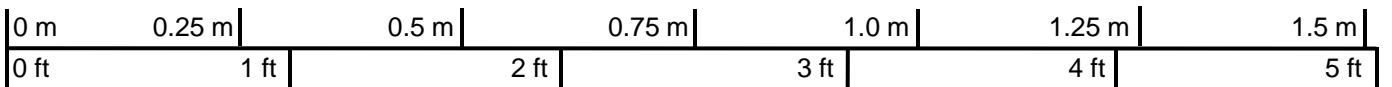
Borehole B504-02




Box 1: 24.47 m – 27.89 m



Box 2: 27.89 m – 29.47 m



Scale

PROJECT		KEY RIVER (NBL) Highway 69 GWP 5404-05-00; WP 5147-08-01		
TITLE		Bedrock Core Photograph – Borehole B504–01 & Borehole B504–02		
		PROJECT No. 09-1111-6014		FILE No. ----
		DESIGN	MCK	MAR 15
		CADD	-- --	
		CHECK	AB	APR 15
		REVIEW	JMAC	APR 15
		SCALE NTS REV.		
		FIGURE B4		

Borehole B504-06



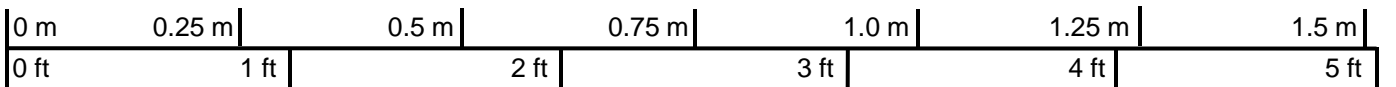
Box 1: 0.00 m – 2.45m




Box 2: 2.45 m – 5.26 m



Box 3: 5.26 m – 8.08 m



Scale

PROJECT			KEY RIVER (NBL) Highway 69 GWP 5404-05-00; WP 5147-08-01		
TITLE			Bedrock Core Photograph – Borehole B504-06		
			PROJECT No. 09-1111-6014		FILE No. ----
			DESIGN	MCK	MAR 15
			CADD	-- --	
			CHECK	AB	APR 15
			REVIEW	JMAC	APR 15
			SCALE NTS REV.		
			FIGURE B5		

Borehole B504-09



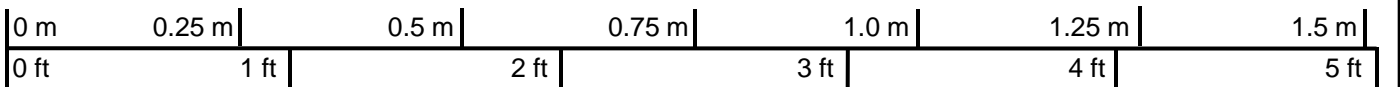
Box 1: 23.32 m – 25.60 m




Box 2: 25.60 m – 27.51 m



Box 3: 27.51 m – 29.26 m



Scale

PROJECT		KEY RIVER (NBL) Highway 69 GWP 5404-05-00; WP 5147-08-01			
TITLE		Bedrock Core Photograph – Borehole B504-09			
		PROJECT No. 09-1111-6014		FILE No. ----	
		DESIGN	MCK	MAR 15	SCALE NTS REV.
		CADD	--		
		CHECK	AB	APR 15	FIGURE B6
		REVIEW	JMAC	APR 15	

Borehole B504-10



Box 1: 21.31 m – 23.57 m



Box 2: 23.57 m – 24.84 m

Borehole B504-11




Box 1: 24.11 m – 26.70 m



Box 2: 26.70 m – 29.26 m

0 m	0.25 m	0.5 m	0.75 m	1.0 m	1.25 m	1.5 m
0 ft	1 ft	2 ft	3 ft	4 ft	5 ft	

Scale

PROJECT		KEY RIVER (NBL) Highway 69 GWP 5404-05-00; WP 5147-08-01		
TITLE		Bedrock Core Photograph – Borehole B504–10 & Borehole B504–11		
		PROJECT No. 09-1111-6014		FILE No. ----
		DESIGN	MCK	MAR 15
		CADD	--	
		CHECK	AB	APR 15
		REVIEW	JMAC	APR 15
		SCALE NTS REV.		
		FIGURE B7		

Borehole B504-12



Box 1: 26.12 m – 28.78 m

(Boulder: 26.12 to 27.19 m, Silt and Sand: 27.19 m to 28.62 m, Top of Bedrock at 28.62 m)



Box 2: 28.78 m – 31.09 m




Box 3: 31.09 m – 33.04 m



Box 4: 33.04 m – 34.23 m

0 m	0.25 m	0.5 m	0.75 m	1.0 m	1.25 m	1.5 m
0 ft	1 ft	2 ft	3 ft	4 ft	5 ft	

Scale

PROJECT		KEY RIVER (NBL) Highway 69 GWP 5404-05-00; WP 5147-08-01		
TITLE		Bedrock Core Photograph – Borehole B504-12		
		PROJECT No. 09-1111-6014		FILE No. ----
		DESIGN	MCK	MAR 15
		CADD	--	
		CHECK	AB	APR 15
		REVIEW	JMAC	APR 15
		SCALE NTS REV.		
		FIGURE B8		

Borehole B504-13

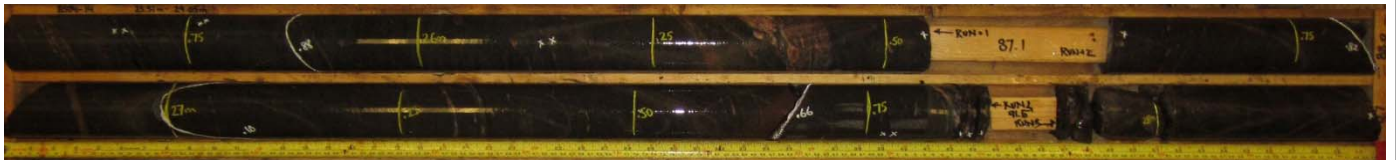


Box 1: 27.60 m – 30.04 m
(Cobbles and Boulders: 27.60, Top of Bedrock: 29.20 m)



Box 2: 30.04 m – 32.40 m

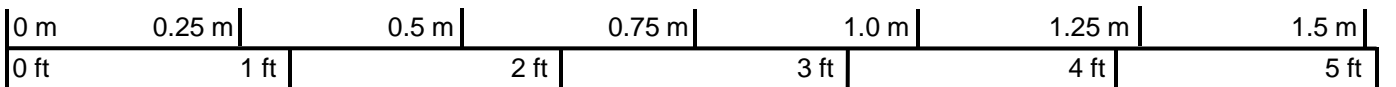
Borehole B504-14




Box 1: 25.51 m – 28.22 m



Box 2: 28.22 m – 29.05 m



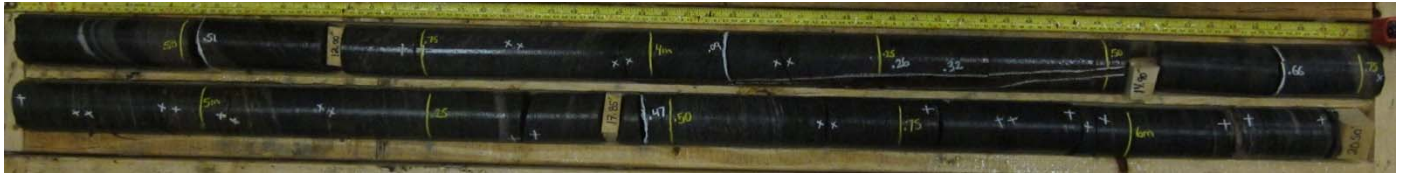
Scale

PROJECT			KEY RIVER (NBL) Highway 69 GWP 5404-05-00; WP 5147-08-01		
TITLE			Bedrock Core Photograph – Borehole B504–13 & Borehole B504–14		
			PROJECT No. 09-1111-6014		FILE No. ----
			DESIGN	MCK	MAR 15
			CADD	--	
			CHECK	AB	APR 15
			REVIEW	JMAC	APR 15
			SCALE NTS REV.		
			FIGURE B9		

Borehole B504-17



Box 1: 0.34 m – 3.29 m



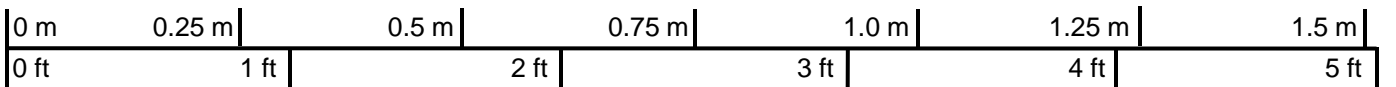
Box 2: 3.29 m – 6.25 m




Box 3: 6.25 m – 9.22 m



Box 4: 9.22 m – 9.98 m



Scale

PROJECT		KEY RIVER (NBL) Highway 69 GWP 5404-05-00; WP 5147-08-01		
TITLE		Bedrock Core Photograph – Borehole B504-17		
		PROJECT No. 09-1111-6014		FILE No. ----
		DESIGN	MCK	MAR 15
		CADD	-- --	
		CHECK	AB	APR 15
		REVIEW	JMAC	APR 15
		SCALE NTS REV.		
		FIGURE B10		



APPENDIX C

Drilling Photographs and Underwater Locates



Photograph 1: Drilling with portable equipment at SBL north abutment



Photograph 2: Drilling with portable equipment at SBL south abutment

PROJECT					
HIGHWAY 69 - KEY RIVER NBL AND SBL					
TITLE					
Drill Setup Photographs					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	MCK	MAR 15	SCALE	NTS	REV.
CADD	-- --		FIGURE C1		
CHECK	AB	APR 15			
REVIEW	JMAC	APR 15			



20140728 - Key River - Drilling
over BH 503-10 SBL.



Photograph 1: Drilling from barge at SBL south pier

20140824 - Key River - steel posts
welded and rope installed around
the barge.



Photograph 2: Drilling from barge at SBL north pier

PROJECT

HIGHWAY 69 - KEY RIVER NBL AND SBL

TITLE

Drill Setup Photographs



**Golder
Associates**

PROJECT No. 09-1111-6014

FILE No. ----

DESIGN

MCK

MAR 15

SCALE

NTS

REV.

CADD

-- --

CHECK

AB

APR 15

REVIEW

JMAC

APR 15


FIGURE C2



Photograph 1: Key River ASI Group Diver Locates first buoy on west side of river



Photograph 2: Key River ASI Group - Diver out of Water

PROJECT								
HIGHWAY 69 - KEY RIVER NBL AND SBL								
TITLE								
Underwater Locates Photographs								
			PROJECT No. 09-1111-6014		FILE No. ----			
			DESIGN	MCK	MAR 15	SCALE	NTS	REV.
			CADD	-- --		FIGURE C3		
			CHECK	AB	APR 15			
			REVIEW	JMAC	APR 15			





APPENDIX D

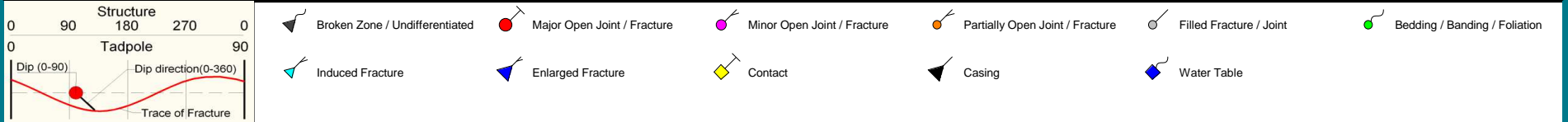
Geophysical Logs, Bedrock Outcrop Photographs and Structural Analysis



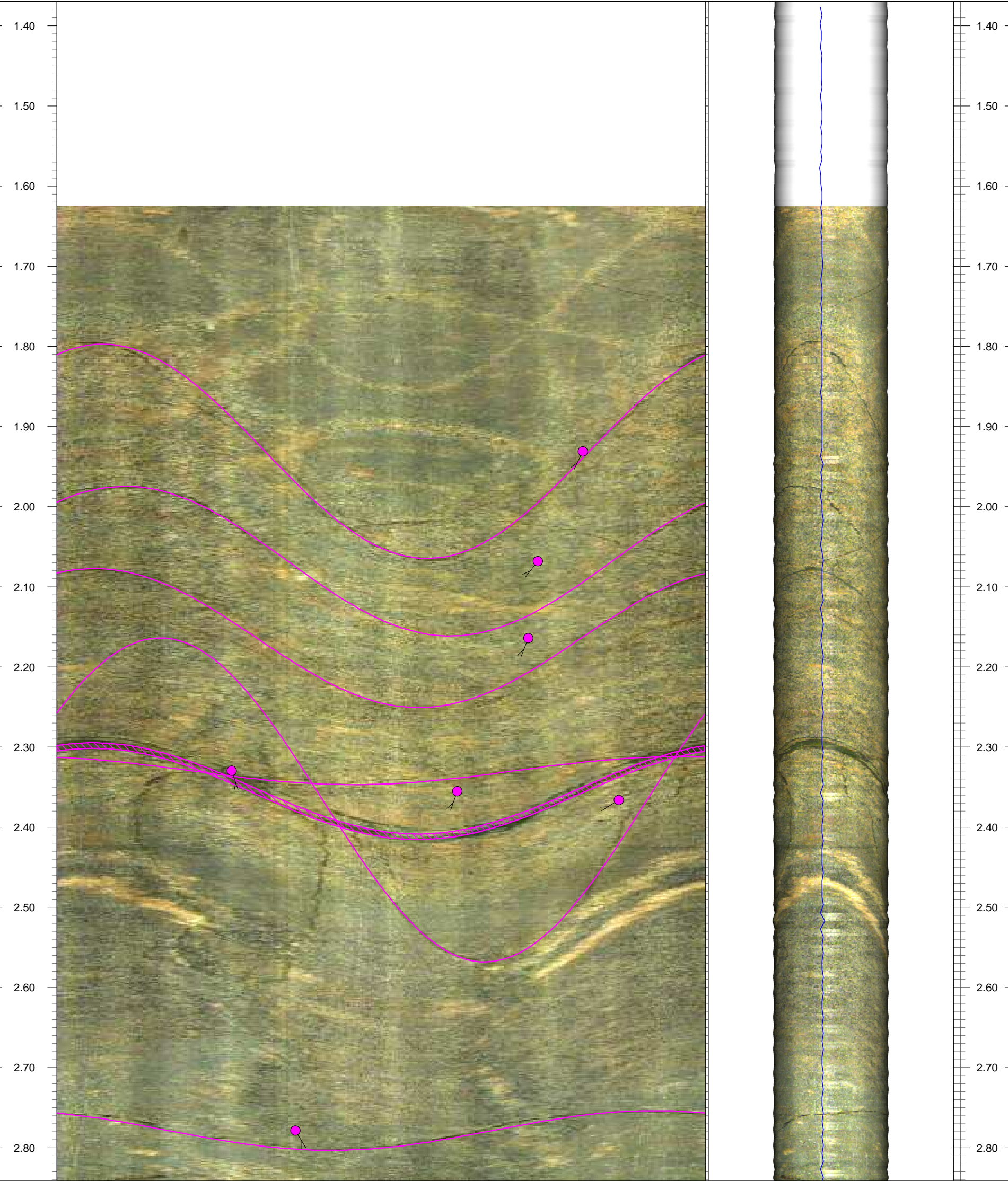
GEOPHYSICAL RECORD OF BOREHOLE: B504-06

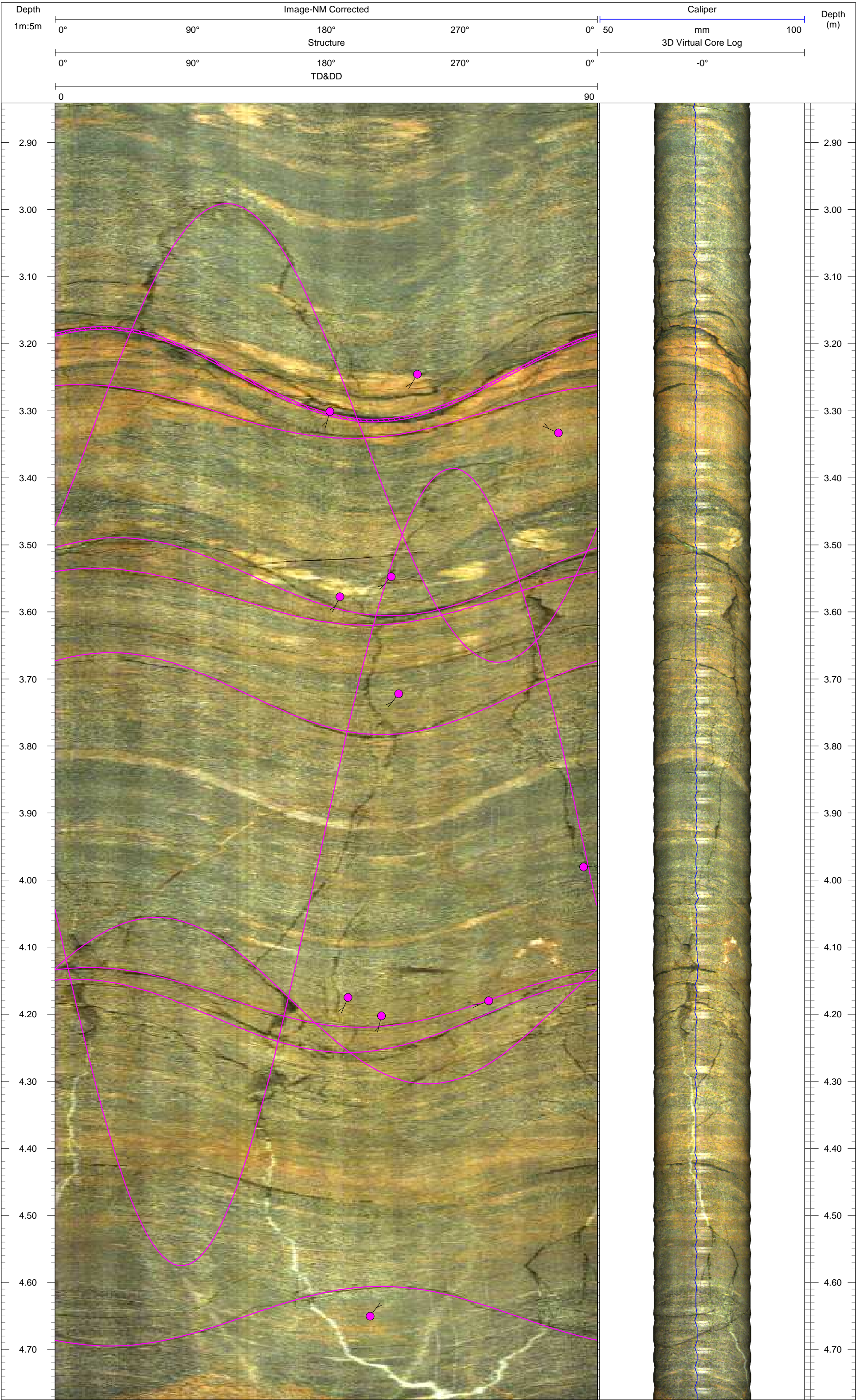
Project Number: 09-1111-6014
Client: MTO
Date: August 2014

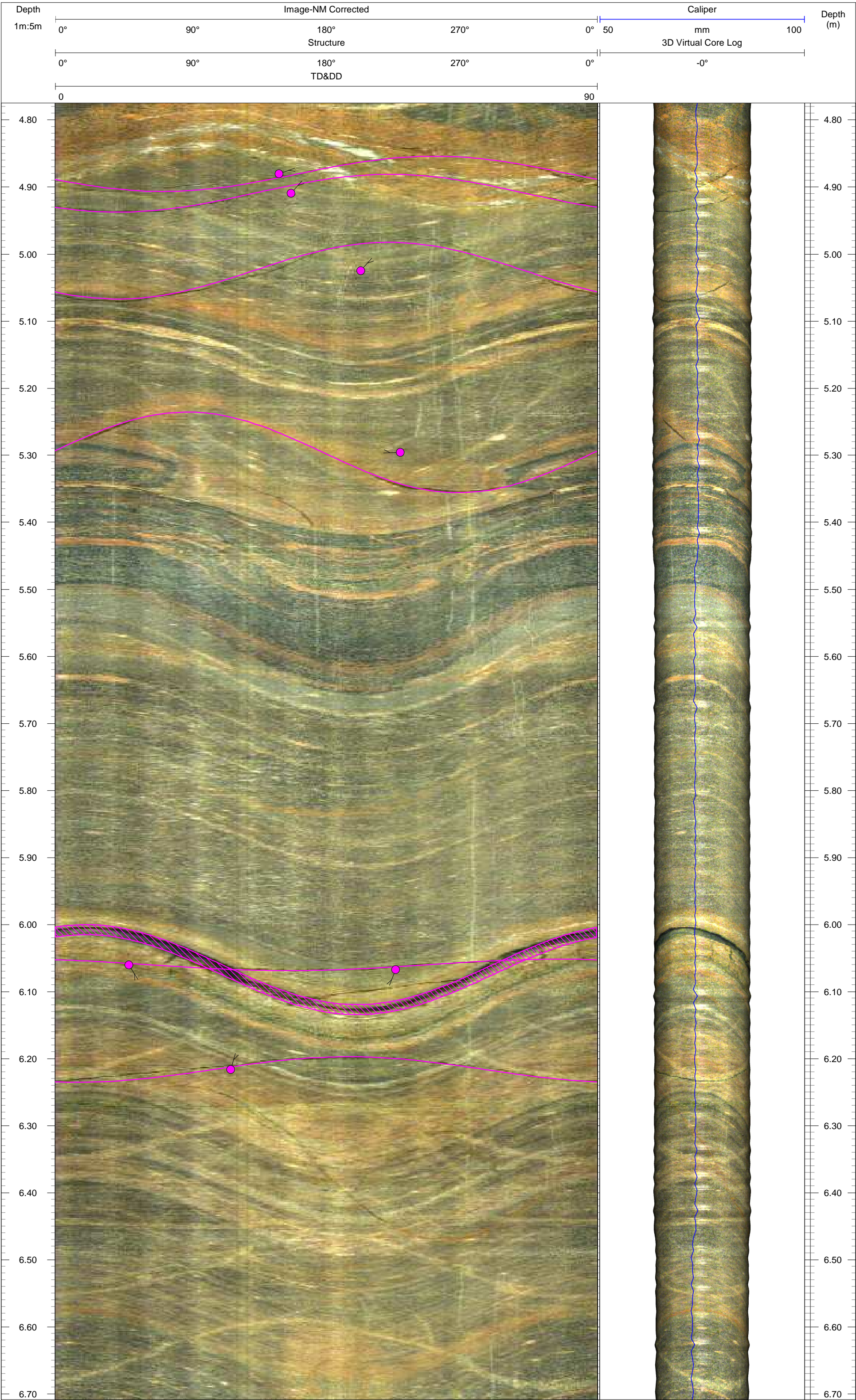
Datum:	WGS84, UTM Zone 17N	Elevation:	190.822 m asl	Borehole Diameter:	73 mm	Water Level:	N/A	Location:	South Abuttment, NBL
Easting:	222,603.680 m	Depth Reference:	"0" at Ground	Casing Diameter:	N/A	Borehole Inclination:	Vertical	Log Date:	7-Aug-14
Northing:	5,084,069.756 m	Drilled Depth:	7.97 m bgs	Casing Depth:	N/A	Borehole Azimuth:	N/A	Logged By:	AR

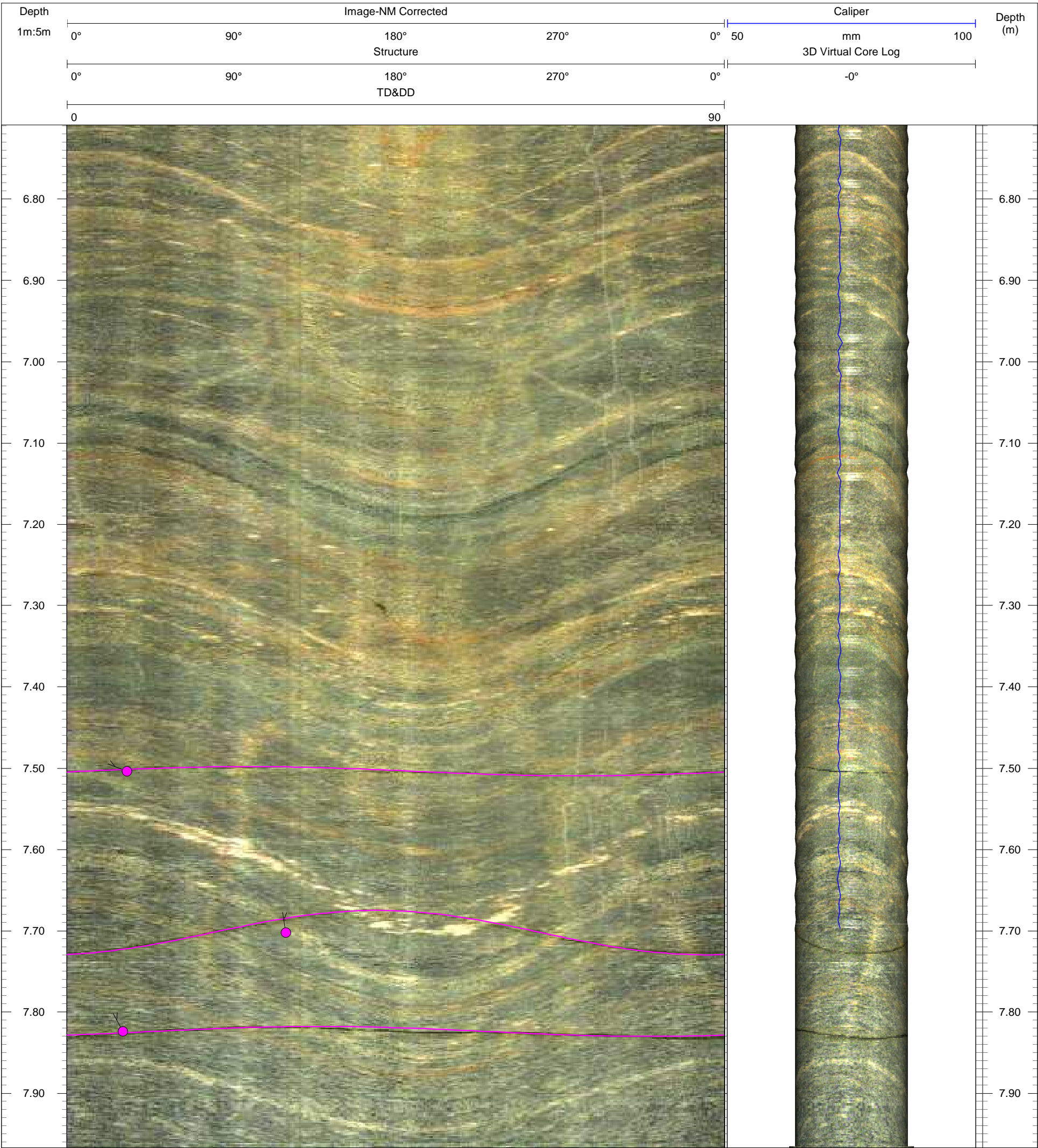


Notes:











GEOPHYSICAL RECORD OF BOREHOLE: B504-17

Project Number: 09-1111-6014
Client: MTO
Date: August 2014

Datum:	WGS84, UTM Zone 17N	Elevation:	197.085 m asl	Borehole Diameter:	67 mm	Water Level:	N/A	Location:	North Abuttment, NBL
Easting:	222,532.942 m	Depth Reference:	"0" at Ground	Casing Diameter:	N/A	Borehole Inclination:	Vertical	Log Date:	8-Aug-14
Northing:	5,084,239.648 m	Drilled Depth:	8.80 m bgs	Casing Depth:	N/A	Borehole Azimuth:	N/A	Logged By:	AR

0901802700

090

Dip (0-90)

Dip direction(0-360)

Trace of Fracture

Broken Zone / Undifferentiated

Major Open Joint / Fracture

Minor Open Joint / Fracture

Partially Open Joint / Fracture

Filled Fracture / Joint

Bedding / Banding / Foliation

Induced Fracture

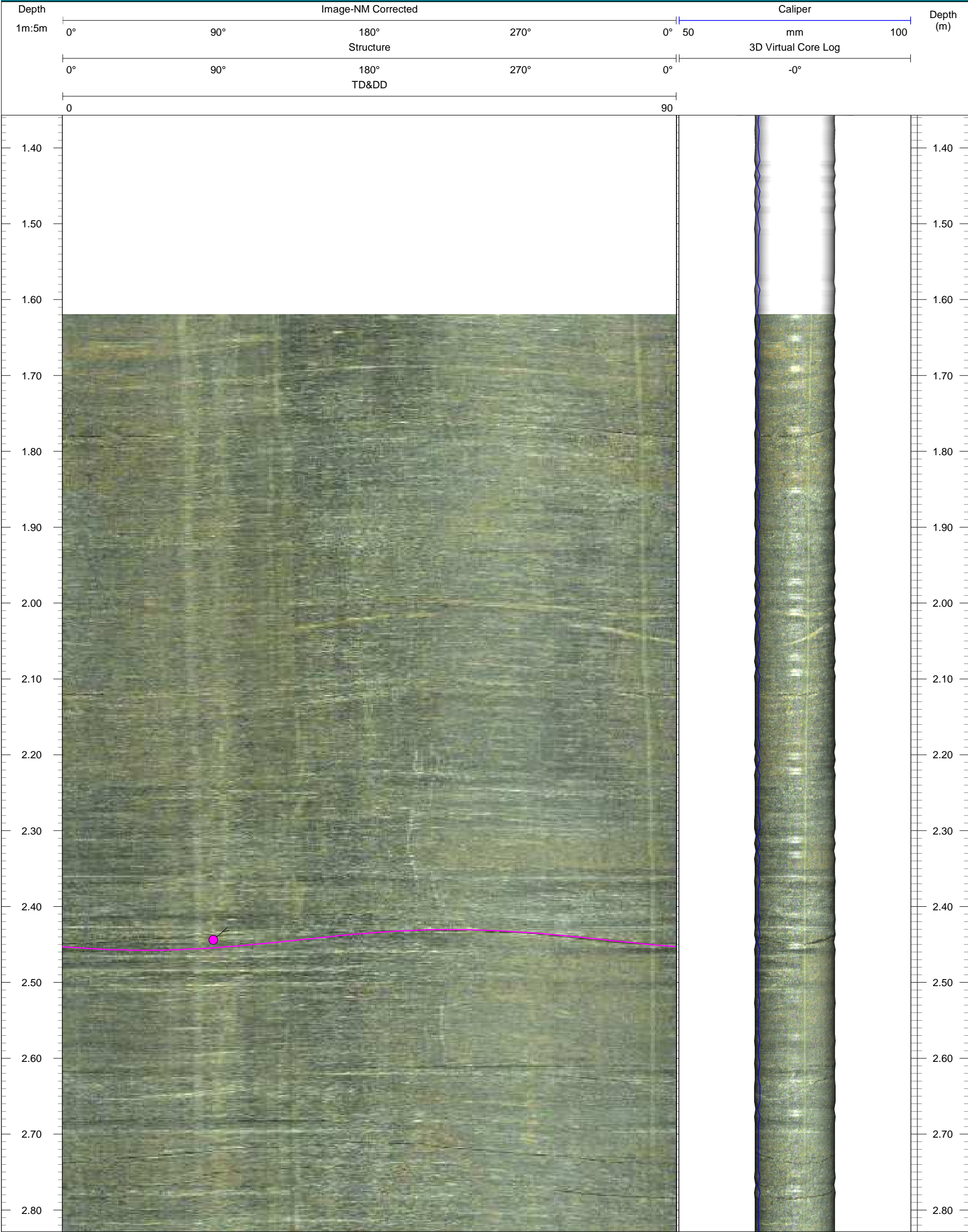
Enlarged Fracture

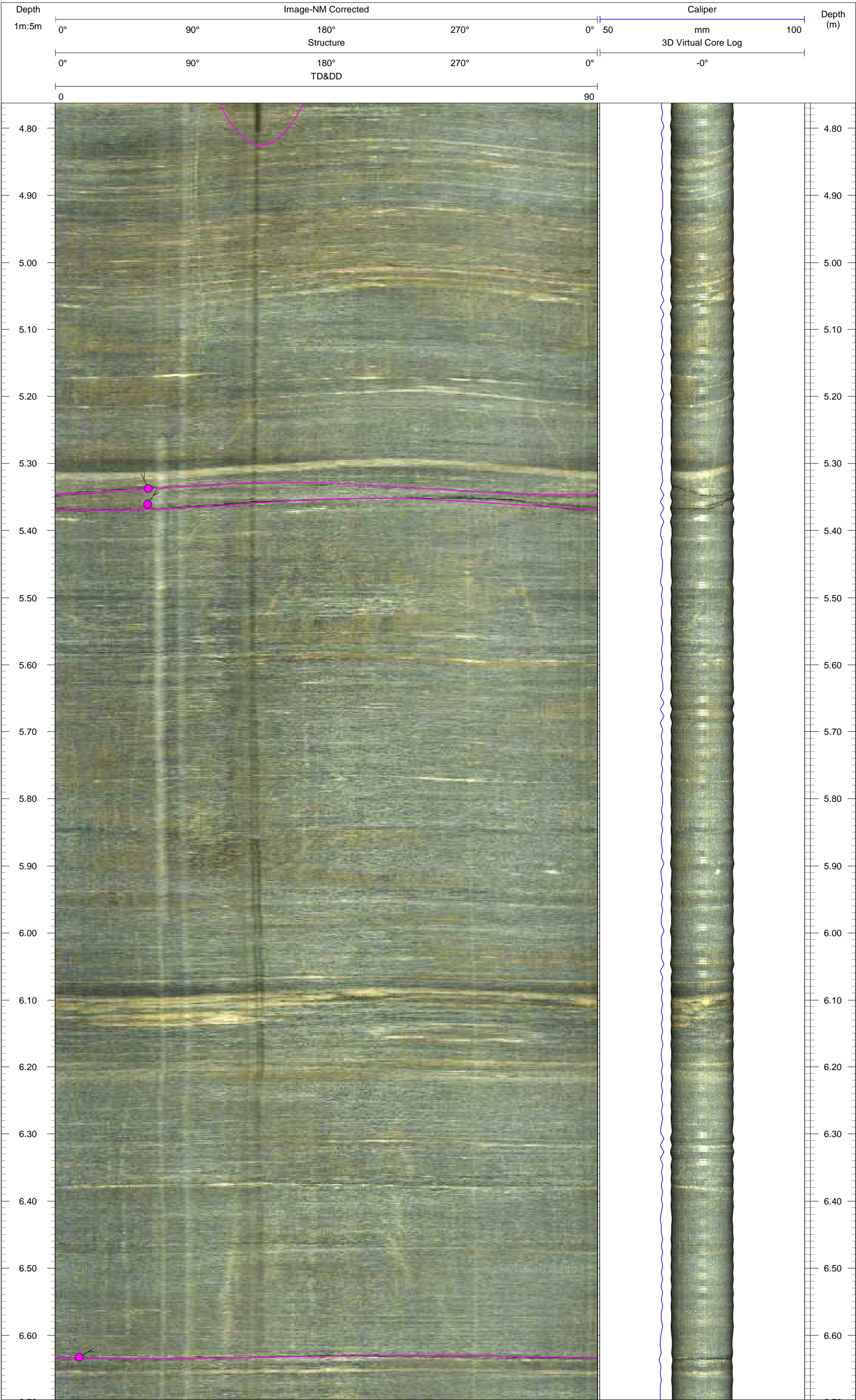
Contact

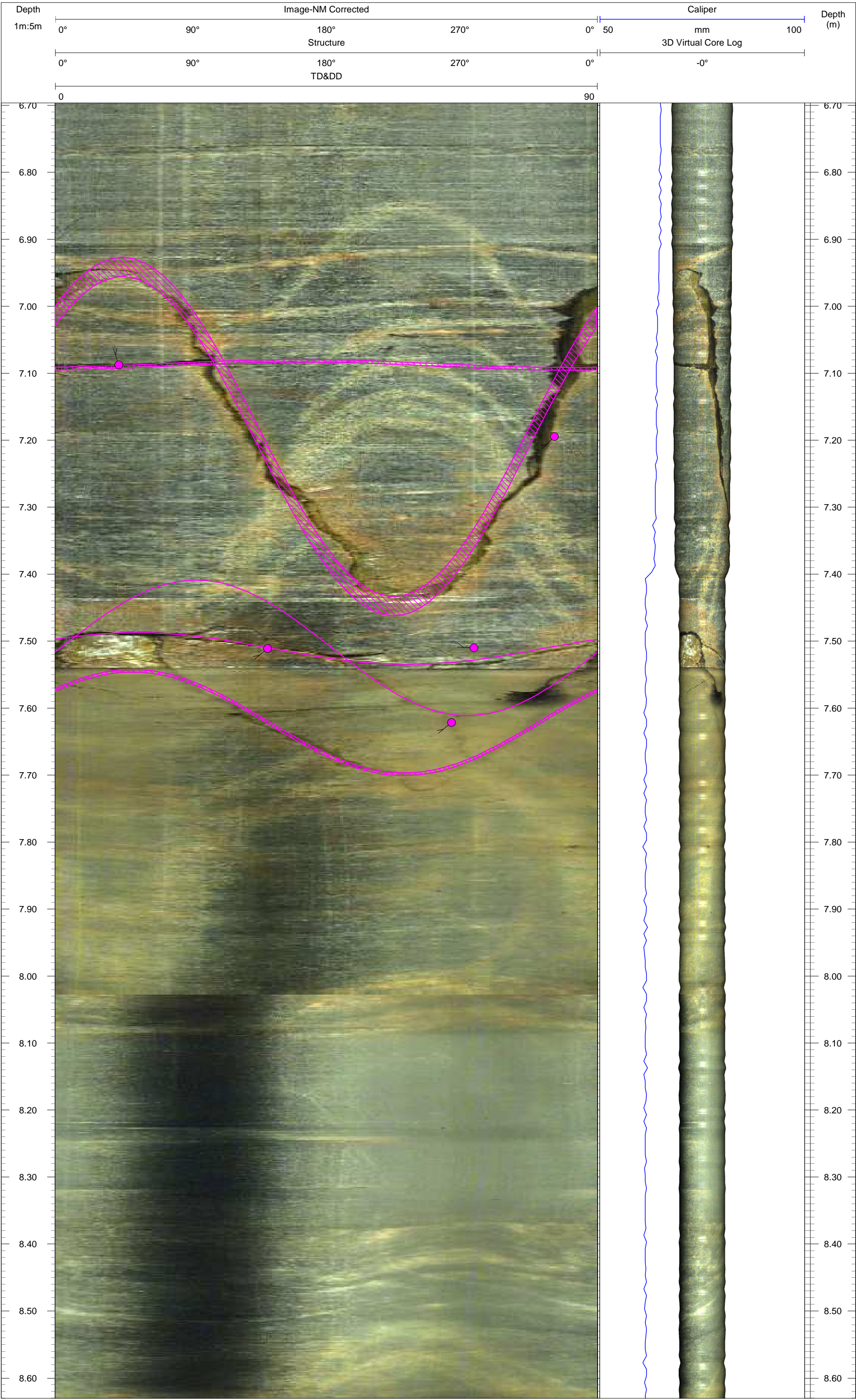
Casing

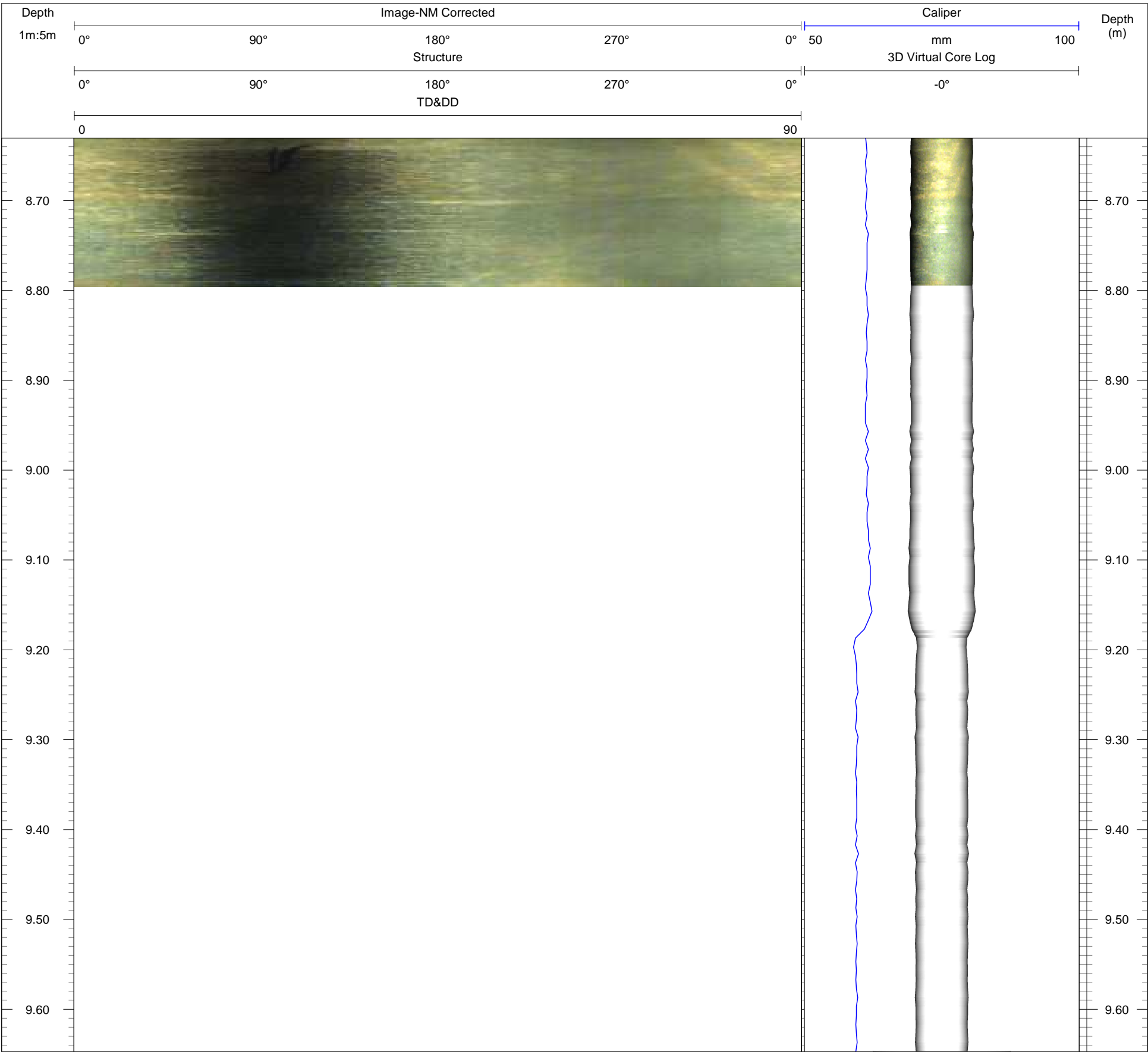
Water Table

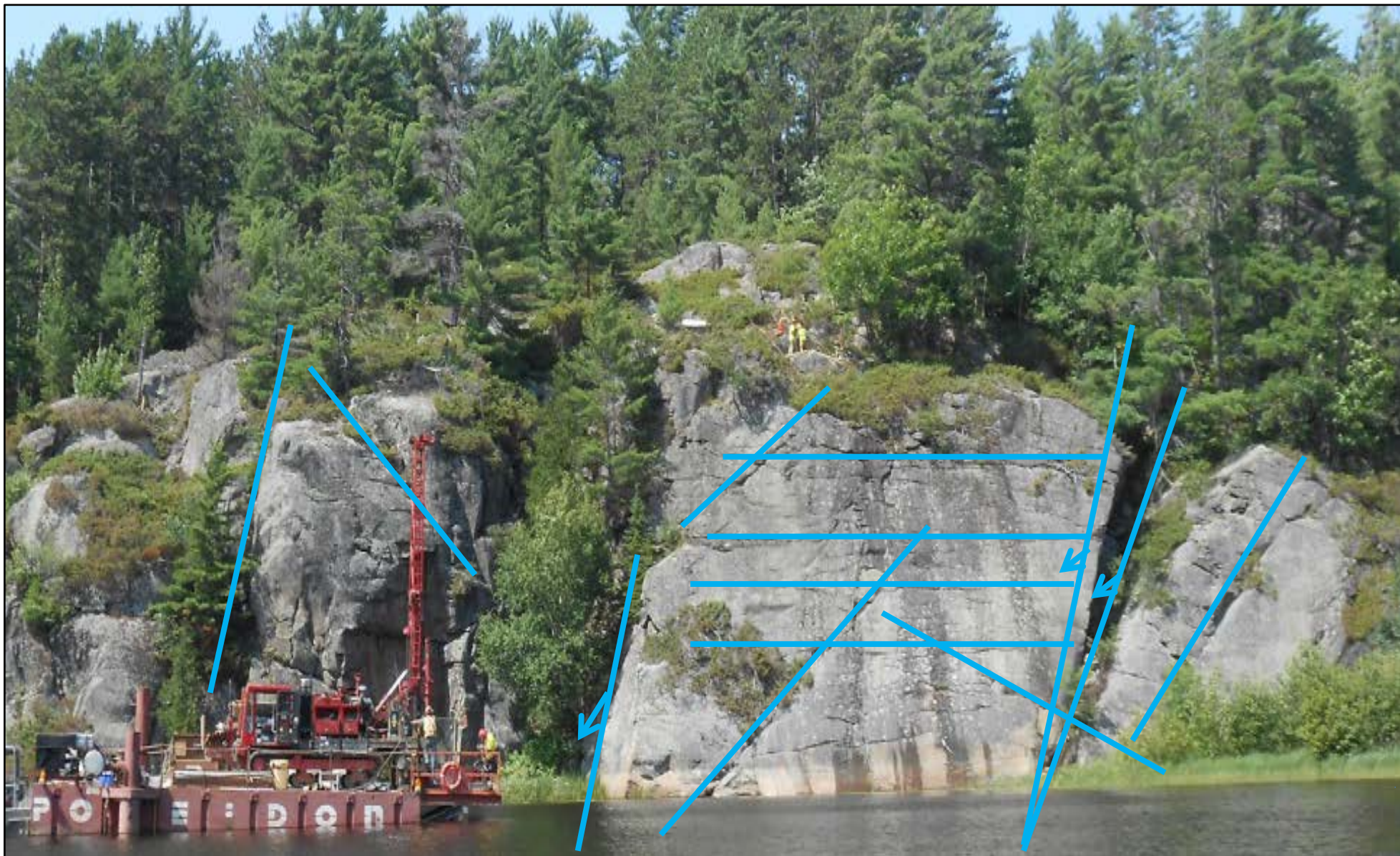
Notes:











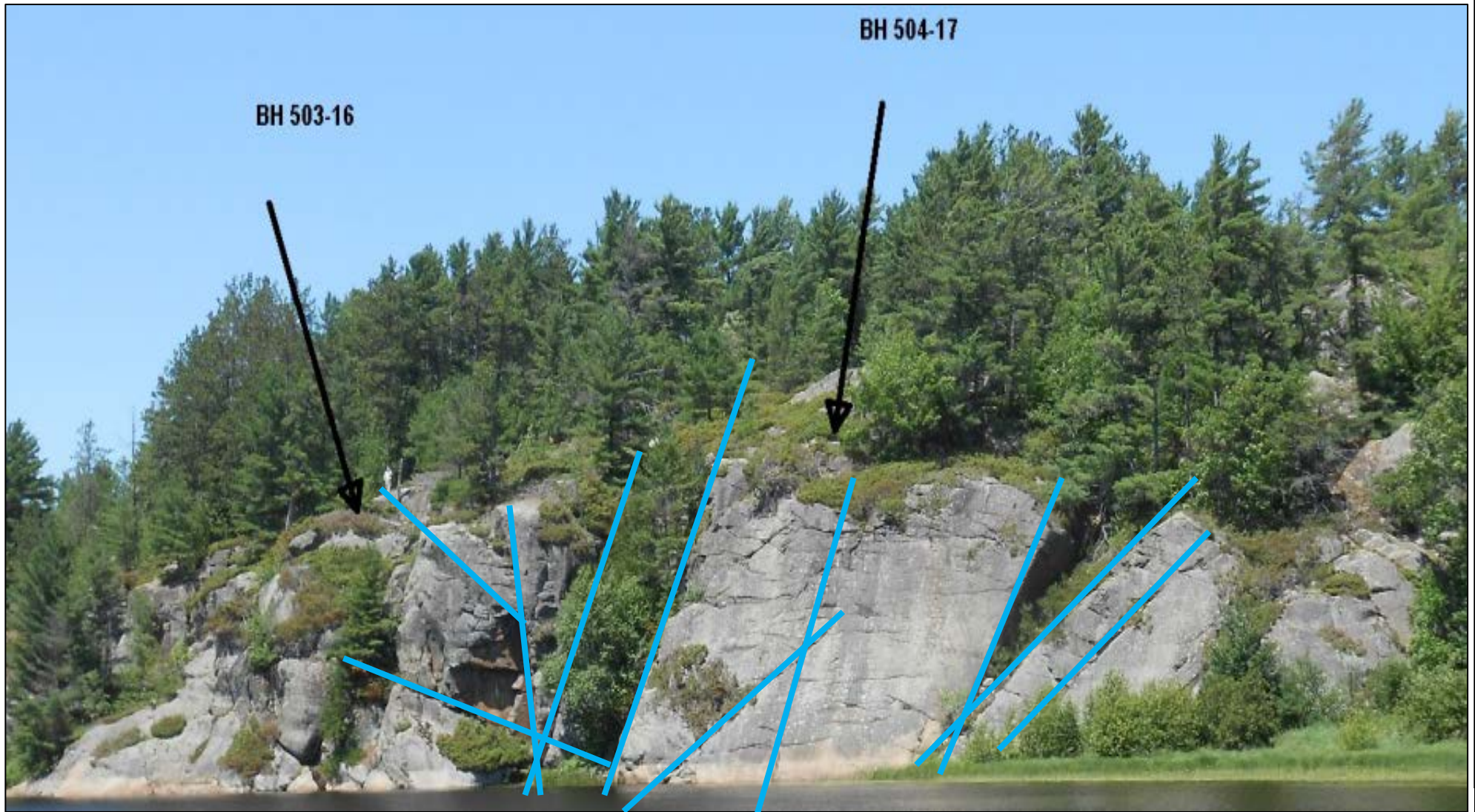
North Wall of Bedrock Outcrop at NBL and SBL Structures

TITLE


**KEY RIVER BRIDGE – ABUTMENT AREAS
JOINTS AND FEATURES
NORTH ABUTMENTS**

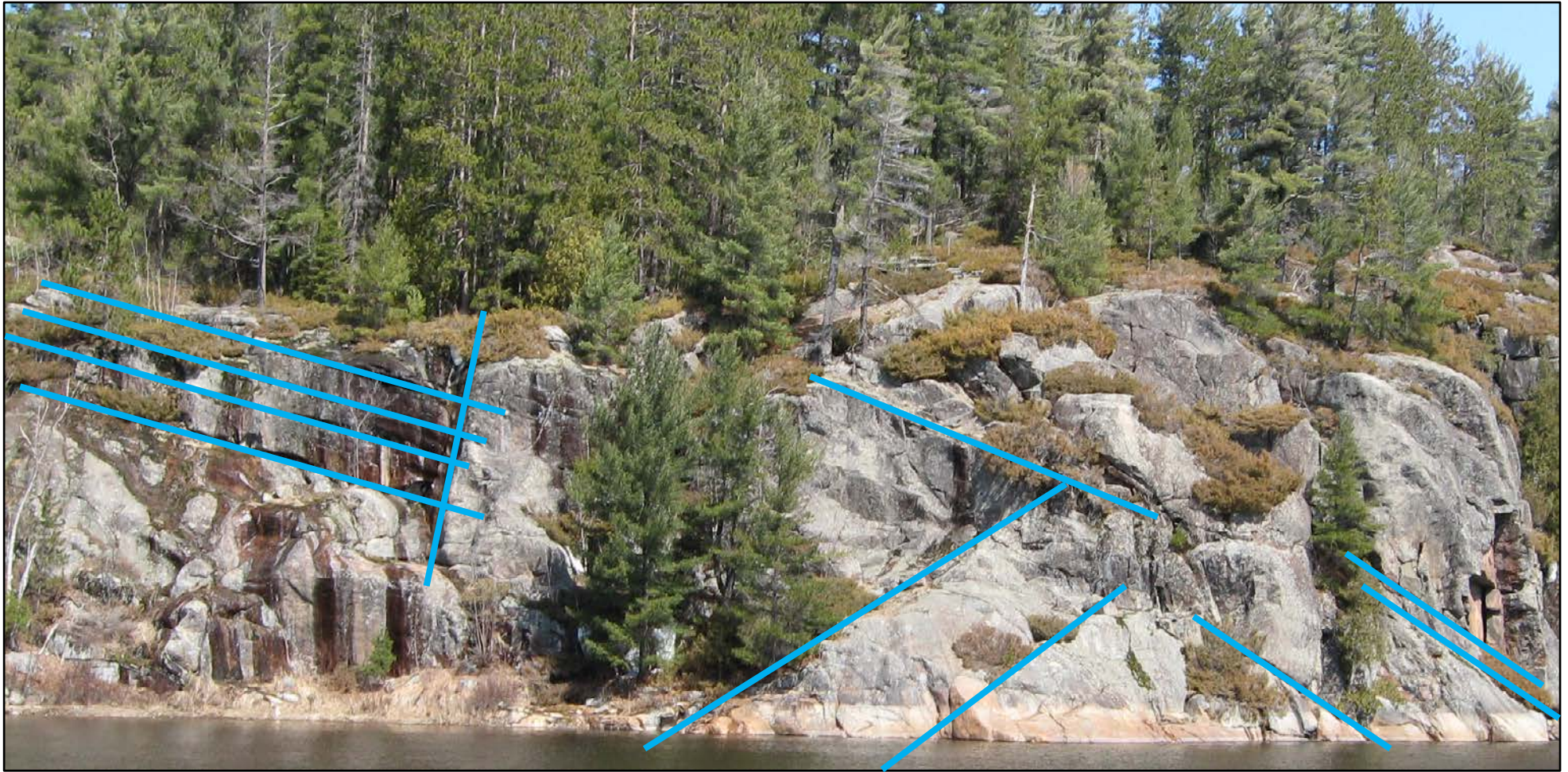


PROJECT No. 09-1111-6014			FILE No. ----	
DESIGN	AB	April 2015	SCALE AS SHOWN	REV.
CADD	--		FIGURE D1	
CHECK	MT/JPD	April 2015		
REVIEW				



North Wall of Bedrock Outcrop at NBL and SBL Structures

TITLE					
KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES NORTH ABUTMENTS					
	PROJECT No. 09-1111-6014			FILE No. ----	
	DESIGN	AB	April 2015	SCALE	AS SHOWN REV.
	CADD	--			
	CHECK	MT/JPD	April 2015	FIGURE D2	
	REVIEW				



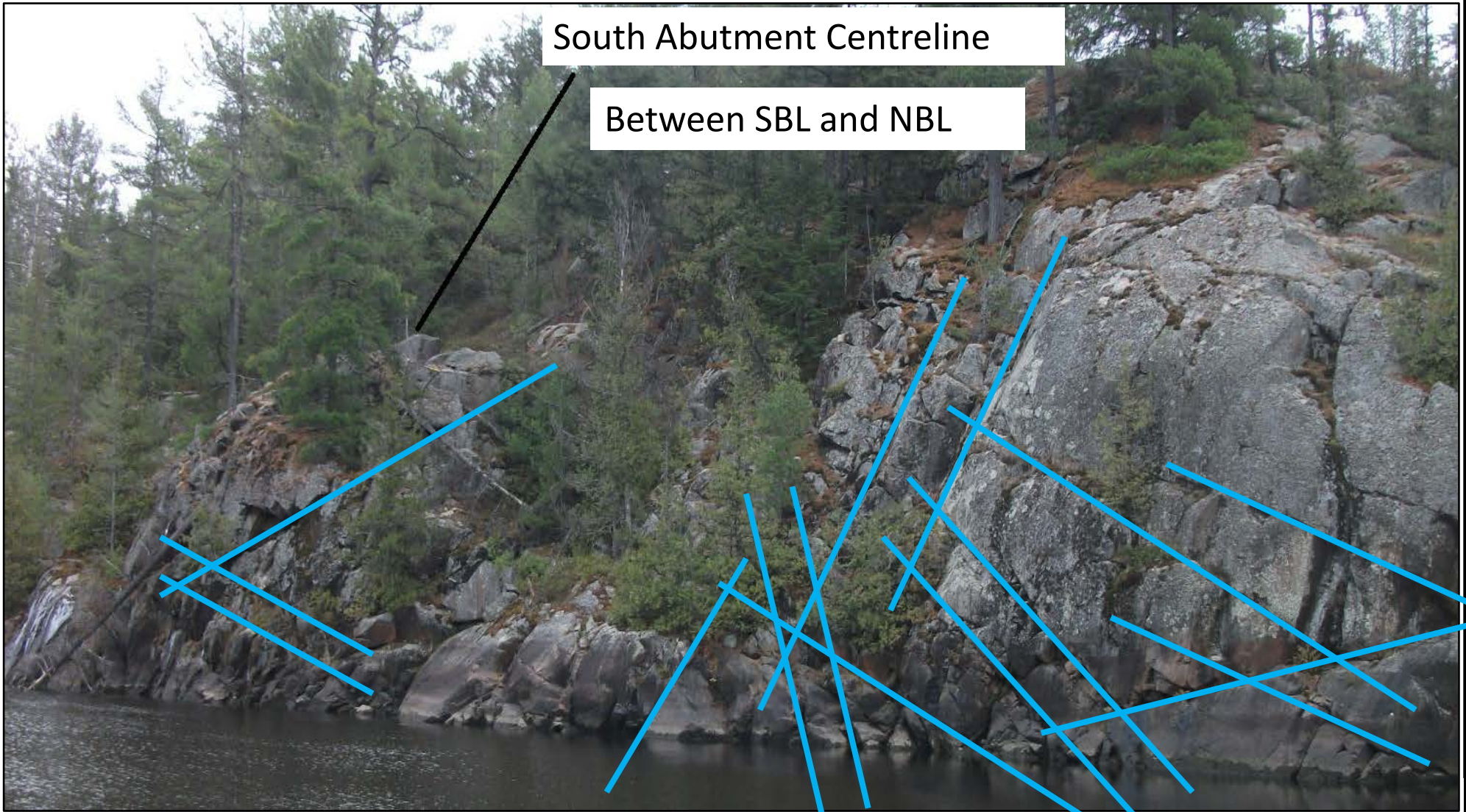
North Wall of Bedrock Outcrop

TITLE					
KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES NORTH ABUTMENTS					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	AB	April 2015	SCALE	AS SHOWN	REV.
CADD	--		FIGURE D3		
CHECK	MT/JPD	April 2015			
REVIEW					



South Abutment Centreline

Between SBL and NBL



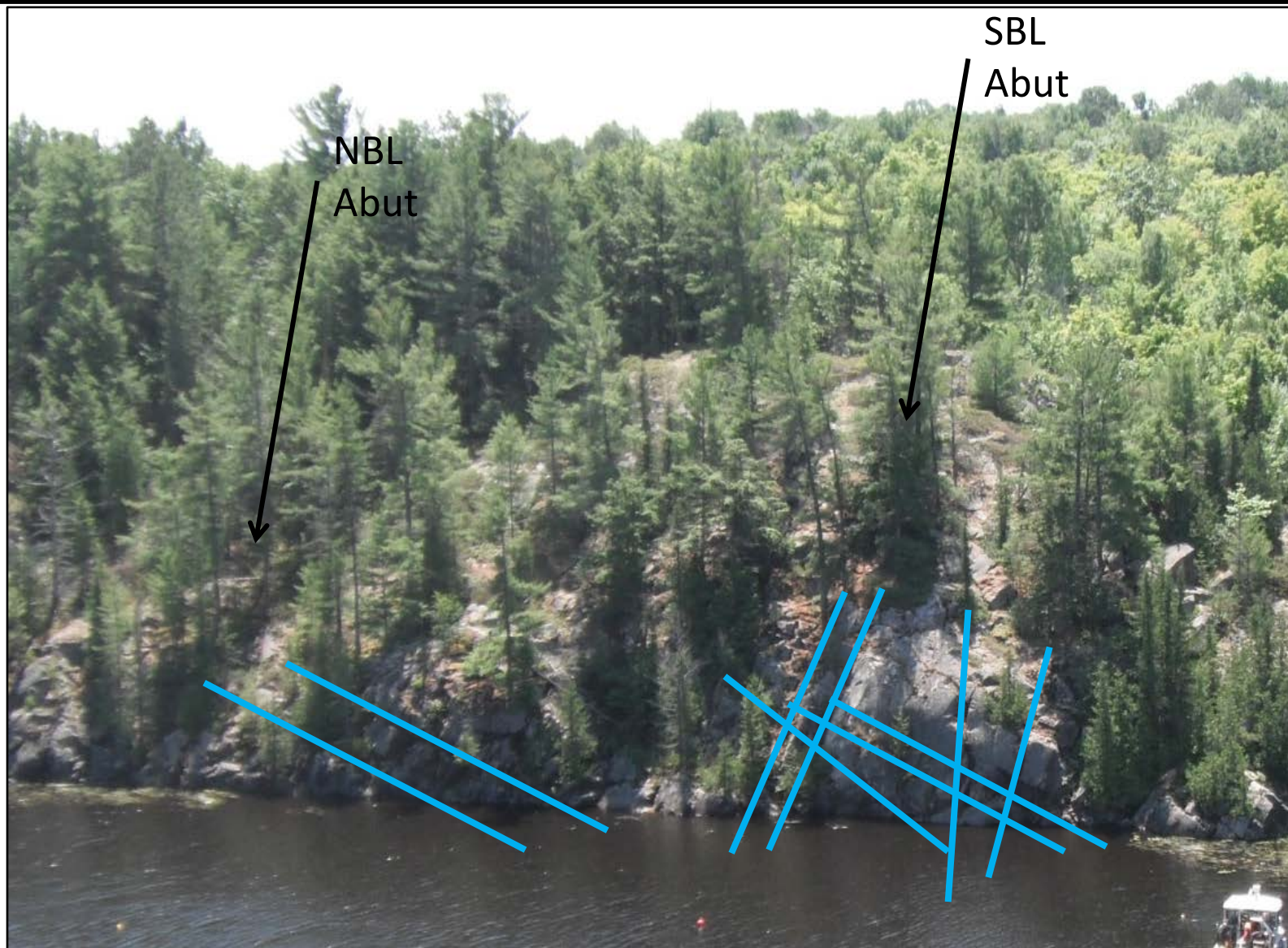
South Wall of Bedrock Outcrop at NBL and SBL Structures

TITLE

**KEY RIVER BRIDGE – ABUTMENT AREAS
JOINTS AND FEATURES
SOUTH ABUTMENTS**



PROJECT No. 09-1111-6014			FILE No. ----	
DESIGN	AB	April 2015	SCALE	AS SHOWN
CADD	--		REV.	
CHECK	MT/JPD	April 2015	FIGURE D4	
REVIEW				



South Wall of Bedrock Outcrop at NBL and SBL Structures


TITLE					
KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES SOUTH ABUTMENTS					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	AB	April 2015	SCALE	AS SHOWN	REV.
CADD	--		FIGURE D5		
CHECK	MT/JPD	April 2015			
REVIEW					



South Abutments Approximate Locations




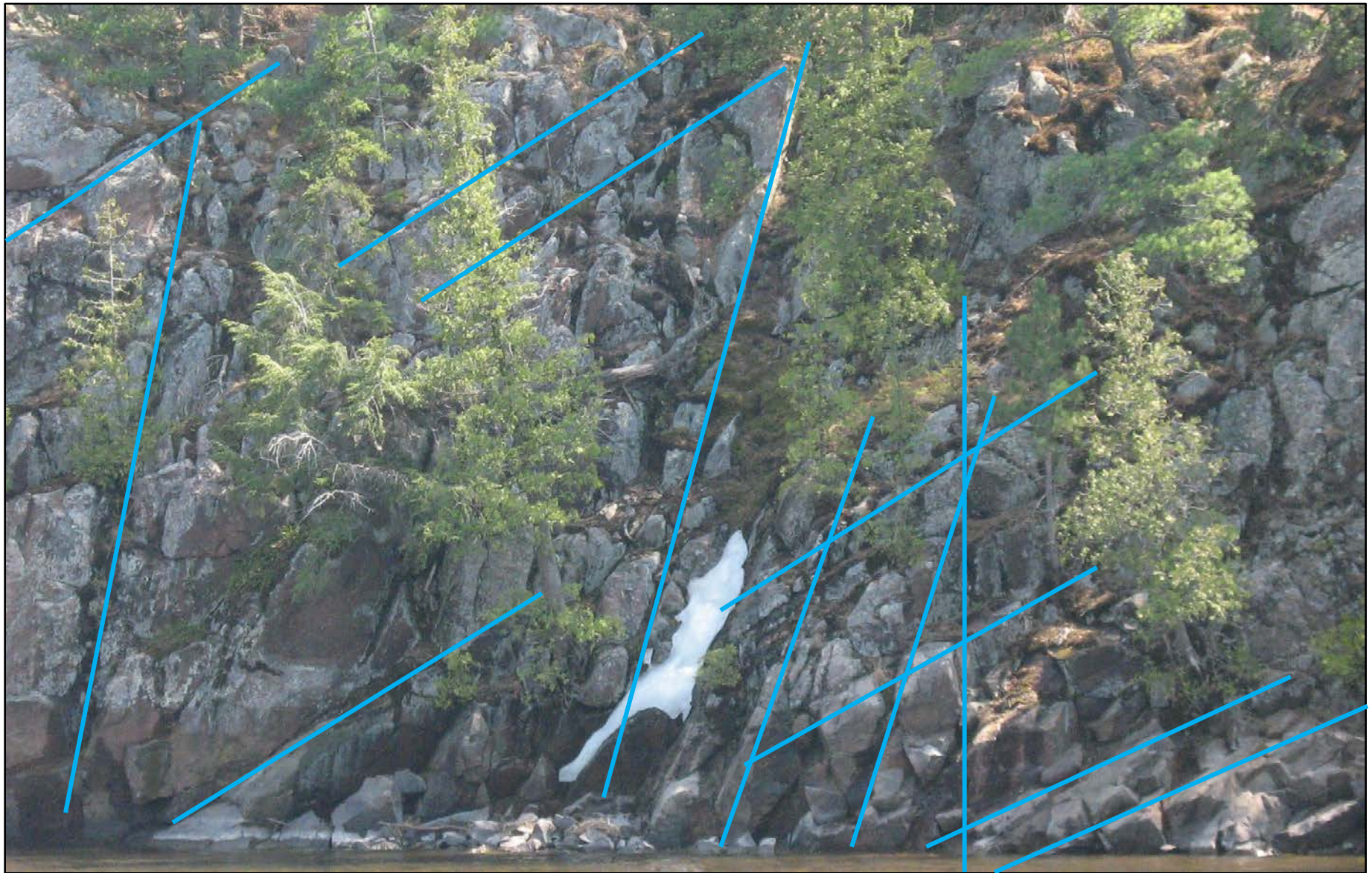
South Wall of Bedrock Outcrop at NBL and SBL Structures

TITLE					
KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES SOUTH ABUTMENTS					
	PROJECT No. 09-1111-6014			FILE No. ----	
	DESIGN	AB	April 2015	SCALE	AS SHOWN
	CADD	--			REV.
	CHECK	MT/JPD	April 2015	FIGURE D6	
	REVIEW				



South Wall of Bedrock Outcrop

<p>TITLE</p> <p>KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES SOUTH ABUTMENTS</p>					
			<p>PROJECT No. 09-1111-6014</p>		<p>FILE No. ----</p>
DESIGN	AB	April 2015	SCALE AS SHOWN		REV.
CADD	--				
CHECK	MT/JPD	April 2015	FIGURE D7		
REVIEW					



South Wall of Bedrock Outcrop

TITLE					
KEY RIVER BRIDGE – ABUTMENT AREAS JOINTS AND FEATURES SOUTH ABUTMENTS					
PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	AB	April 2015	SCALE	AS SHOWN	REV.
CADD	--		FIGURE D8		
CHECK	MT/JPD	April 2015			
REVIEW					



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South America	+ 55 21 3095 9500

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