



June 2012

REPORT ON

Foundation Investigation and Design Proposed Temporary Modular Bridge Petawawa River Bridge Highway 17 Site 29-196 G.W.P. 4059-01-00

Submitted to:

D.M. Wills Associates Ltd.
150 Jameson Drive
Peterborough, Ontario
K9J 0B9



REPORT



Geocres Number: 31F-175

Report Number: 09-1121-1004-4000

Distribution:

1 copy - D.M. Wills Associates Ltd.

5 copies - Ministry of Transportation, Ontario, Kingston, Ontario

1 copy - MTO Foundations Section, Downsview, Ontario

2 copies - Golder Associates Ltd.





Table of Contents

PART A - FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	2
3.0 INVESTIGATION PROCEDURES.....	3
4.0 SITE GEOLOGY AND STRATIGRAPHY.....	5
4.1 Regional Geological Conditions.....	5
4.2 Site Stratigraphy.....	5
4.2.1 Embankment Fill and Topsoil.....	6
4.2.2 Sand and Gravel, Gravelly Sand and Sand.....	6
4.2.3 Refusal and Bedrock.....	7
4.3 Groundwater Conditions.....	8
5.0 CLOSURE.....	9

PART B - FOUNDATION INVESTIGATION REPORT

6.0 ENGINEERING RECOMMENDATIONS.....	10
6.1 General.....	10
6.2 Bridge Foundations – Temporary Modular Bridge.....	10
6.2.1 Shallow Foundations.....	11
6.2.1.1 Resistance to Lateral Forces on Overburden Soils.....	12
6.2.1.2 Resistance to Lateral Forces on Bedrock.....	13
6.2.1.3 Micropiles.....	13
6.2.1.4 Rock Anchors.....	13
6.2.1.5 Frost and Scour Protection.....	15
6.2.2 Steel H-Pile Foundations.....	15
6.2.2.1 Axial Geotechnical Resistance.....	15
6.2.2.2 Resistance to Lateral Loads.....	16
6.2.2.3 Frost Protection.....	18
6.3 Site Coefficient.....	18
6.4 Lateral Earth Pressures for Design.....	18
6.5 Approach Embankment Design and Construction.....	20



FOUNDATION INVESTIGATION AND DESIGN REPORT

6.5.1	Subgrade Preparation and Embankment Construction	21
6.5.2	Approach Embankment Stability	21
6.5.3	Embankment Settlement	22
6.6	Design and Construction Considerations.....	22
6.6.1	Excavations.....	22
6.6.2	Temporary Excavation Shoring	22
6.6.3	Groundwater and Surface Water Control	23
6.6.4	Obstructions.....	24
7.0	CLOSURE.....	25

Tables 1 & 2

List of Abbreviations and Symbols

Lithological and Geotechnical Rock Description Terminology

Record of Borehole and Drillhole Sheets 11-1 to 11-6

Drawing 1

Figures 1 to 3

Appendix A

Appendix B

TABLES

Table 1 – Comparison of Foundation Alternatives, Bridge Abutments

Table 2 – Comparison of Foundation Alternatives, Bridge Piers

DRAWINGS

Drawing 1 – Petawawa River Bridge, Borehole Locations and Soil Strata

FIGURES

Figure 1 – Grain Size Distribution – Embankment Fill

Figure 2 – Grain Size Distribution – Sand and Gravel

Figure 3 – Summary of Laboratory Compressive Strength Unconfined Compression Tests

APPENDICES

APPENDIX A

Record of Boreholes – Golder 2010 Investigation

Record of Boreholes – MTO 1972 Investigation Geocres No. 31F-51

APPENDIX B

Sample Non-Standard Special Provisions



FOUNDATION INVESTIGATION AND DESIGN REPORT

PART A

FOUNDATION INVESTIGATION PROPOSED TEMPORARY MODULAR BRIDGE PETAWAWA RIVER BRIDGE HIGHWAY 17 G.W.P. 4059-01-00



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by D.M. Wills Associates Ltd. on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation for a proposed temporary modular bridge over the Petawawa River along Highway 17 in Ontario under G.W.P. 4059-01-00.

The work was carried out in general conformance with our proposal and addendum letter dated May 25 and August 30, 2011, respectively.

The work was carried out in accordance with Golder's Quality Control Plan dated October 2011.



2.0 SITE DESCRIPTION

The existing Highway 17 structure included in this assignment (G.W.P. 4059-01-00) carries Highway 17 over the Petawawa River between the County Road 37 (Murphy Road) interchange and County Road 55 (Paquette Road) interchange near Petawawa, Ontario.

Through this area, Highway 17 is a two lane undivided highway with a rural cross-section. The existing structure is aligned approximately north-south. The highway profile grade over the structures is at Elevations 148.1 m and 148.8 m at the north and south abutments, respectively. The existing structure consists of a three-span steel girder bridge supported on concrete abutments and piers. The drawing for the construction of the existing structure indicates that the south abutment is supported by spread footings on the native sandy soils and the north abutment is supported on steel piles bearing on the bedrock. The piers of the structure are indicated to be supported on spread footings on the bedrock.

The Petawawa River runs beneath the Highway 17 structure with river levels between about Elevation 136 m and 138 m during the spring and summer months.

A foundation investigation was carried out for this site in 1972 and the results of that investigation are summarized in MTO's Geocres No. 31F-51, Foundation Investigation Report W.P. 3-67-02, Structure Site 29-196, Hwy. 17, Petawawa River Bridge. It is understood that the structure was constructed between 1976 and 1977.

The original plans for the rehabilitation of the Petawawa River Bridge included the widening of the bridge to accommodate the highway traffic during the repair works on the original bridge. Therefore, a foundation investigation was carried out in 2010 for the proposed widening of the bridge at this site and the results of that investigation are summarized in Golder's Foundation Investigation Report G.W.P. 4059-01-00, Structure Site 29-196, Hwy. 17, Petawawa River Bridge. Following this investigation, the option of widening the bridge to accommodate the bypass lanes was dropped in favour of a temporary modular bridge installed about 10 metres downstream from the existing bridge.

The existing approach embankments are about 8 m to 10 m high relative to the banks of the Petawawa River and have approximately 2H:1V side slopes. No signs of embankment instability were observed.

The highway profile at the approaches does not seem to indicate that significant differential settlement of the roadway relative to the bridge has occurred, although the maintenance history at this location is not currently known.



3.0 INVESTIGATION PROCEDURES

The subsurface investigation for the abutments and approach embankments for the proposed temporary modular bridge was carried out between September 6 and 9, 2011, and on September 19 and 20, 2011, at which time six boreholes were advanced at the locations shown on Drawing 1. The borehole locations were selected as follows:

- One borehole (numbered 11-1) located at or near the proposed north abutment location, advanced using portable drilling equipment on the existing eastern side slope of the north embankment, and extending through the embankment fill and into the dense to very dense sand and gravel where casing refusal was encountered.
- One borehole (numbered 11-2) located at or near the proposed north pier location for a 76 metre span, advanced using portable drilling equipment on the north shore of the Petawawa River, extending through the embankment fill and into the dense to very dense sand and gravel where casing refusal was encountered.
- Two boreholes (numbered 11-3 and 11-4) located at or near the proposed north and south pier locations for a 60 metre span, advanced in the Petawawa River using portable drilling equipment mounted on a raft, extending through the water, sand and gravel and then cored at least 3 metres into the bedrock.
- One borehole (numbered 11-5) located at or near the proposed south pier location for a 76 metre span, advanced using portable drilling equipment on the south shore of the Petawawa River, extending through the dense to very dense sand and gravel and then cored at least 3 metres into the bedrock.
- One borehole (numbered 11-6) located about 8 metres south of the proposed south abutment, advanced using a truck mounted drill rig east of the existing south abutment, and extending through very dense sand and gravel and then cored at about 4 metres into the bedrock.

The boreholes were generally located about 10 metres east of the existing structure and highway. With the exception of the south abutment borehole 11-6, all boreholes were advanced using portable drilling equipment. The two pier boreholes for a potential 60 metre span were located near the river edge, and the portable drilling equipment was mounted on a raft. The south abutment borehole 11-6 was advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers on a truck mounted drill rig. The portable drilling equipment, the raft, and the truck mounted drill rig were supplied and operated by OGS Inc. of Almonte, Ontario. The boreholes were advanced to depths ranging from about 4.1 to 8.5 metres.

Soil samples of the overburden were obtained at intervals ranging from 0.6 m to 1.5 m of depth, using a 50 mm outer diameter split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures.

The 60 metre span north pier borehole, and both the 60 and 76 metre span south pier boreholes were advanced between about 3.3 m and 3.7 metres into the bedrock by coring using NQ-Size coring equipment. The south abutment borehole was advanced about 4.8 metres into the bedrock by coring using NQ-Size coring equipment.

The water levels in the open boreholes were observed throughout the drilling operations. Standpipe piezometers were not installed as part of this investigation.

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



FOUNDATION INVESTIGATION AND DESIGN REPORT

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

The borehole locations were determined by Golder Associates with respect to the proposed pier and abutment locations supplied by D.M. Wills Associates Ltd. These locations were subsequently surveyed and the ground surface elevations were also determined in the field by Adam Kasprzak Surveying Ltd. of Pembroke, Ontario. These elevations are understood to be reference to Geodetic datum. The boreholes and locations, including MTM NAD83 northing and easting coordinates and ground surface/water level elevations referenced to Geodetic datum, are summarized in the following table and are shown on Drawing 1.

Borehole No.	Borehole Location	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface/ Water Level Elevation (m)
11-1	North abutment	5083588.6	242074.7	144.4
11-2	North pier for 76 metre span	5083564.6	242082.9	140.5
11-3	North pier for 60 metre span	5083557.5	242086.7	*137.4
11-4	South pier for 60 metre span	5083501.6	242108.5	*137.4
11-5	South pier for 76 metre span	5083494.2	242111.3	139.4
11-6	South abutment	5083455.7	242126.3	147.7

* Note: Water level of the Petawawa River at the time of drilling, September 6 to 8, 2011.



4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geological Conditions

As delineated in *The Physiography of Southern Ontario*¹, the study area for this assignment lies within the physiographic region known as the Petawawa Sand Plain.

The Petawawa Sand Plain extends south of Pembroke and covers an estimated 210 km² and is characterized by granular overburden deposits which were deposited in the Champlain Sea by the Petawawa, Barrow, Indian and Ottawa Rivers during the Fossmill stage of Lake Algonquin.¹ The sand and gravel deposits in the area of the site range from about 1 to 9 m in thickness. The native soils are underlain by Precambrian gneiss bedrock.¹

4.2 Site Stratigraphy

For the subsurface investigation at this site for a temporary modular bridge, six boreholes were put down at foundation locations. The detailed subsurface soil, bedrock and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the in-situ and laboratory tests carried out on selected soil and rock samples, are given on the attached Record of Borehole sheets and on Figures 1 and 2. Eight borehole records from the 1972 MTO investigation and ten boreholes from the previous 2010 Golder investigation for the bridge rehabilitation are provided in Appendix A.

The borehole locations and ground surface/water level elevations from the present investigation, the 2010 Golder investigation, and MTO's 1972 subsurface investigation (Geocres No. 31F-51) are shown on Drawing 1. The soil stratigraphy section projected along the modular bridge centreline is shown on Drawings 1. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsurface conditions encountered in borehole 11-1 at the proposed north abutment of the modular bridge consist of at least 6 metres of very loose to dense gravelly sand embankment fill overlying compact to very dense sand and gravel. Although not reached in this borehole due to sampler and casing refusal, the overburden soils are believed to be underlain by gneiss bedrock in this area.

The subsurface conditions encountered in borehole 11-2 at the proposed north pier location for a 76 metre span consist of about 6 metres of compact to dense sand embankment fill overlying dense to very dense sand and gravel. Similar to borehole 11-1, bedrock was not reached in borehole 11-2, but the overburden soils in the area are known to be underlain by gneiss bedrock.

Nearby borehole 11-3 at the proposed north pier location for a 60 metre span was put down at the north edge of the Petawawa River, and at the toe of the north approach embankment. The subsurface conditions encountered in this borehole consist of about 3 metres of loose to dense native sand and gravel which is underlain by gneiss and amphibolite bedrock. The bedrock was encountered at about 3 metres depth below the water level (at about Elevations 134 metres).

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



The subsurface conditions encountered at the proposed south pier location in borehole 11-4 for a 60 metre span, and in borehole 11-5 for a 76 metre span, consist of about 1 metre of compact to dense native sand and gravel which is underlain by gneiss and amphibolite bedrock at about Elevation 136 to 138 metres.

The subsurface conditions encountered in boreholes 11-6 located about 8 metres south of the proposed south abutment for the modular bridge consist of up to about 4 metres of dense to very dense sand and gravel which is underlain by granitic to mafic gneiss bedrock at about Elevation 144 metres.

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

4.2.1 Embankment Fill and Topsoil

Topsoil was only encountered at ground surface in boreholes 11-1 and 11-2. At these locations, the topsoil ranges in thickness from about 100 to 200 millimetres, and consists of sand with some silt, trace gravel and organic matter. At borehole 11-2, the topsoil at ground surface was visibly mixed with cobbles and boulders which were likely part of the north approach embankment erosion protection system.

The embankment fill was fully penetrated in boreholes 11-1 and 11-2 where fill was encountered and varied in thickness from 1.7 to 3.7 metres. Those variable depths reflect, in part, the differing ground surface elevations at the borehole locations (e.g., borehole mid way in the embankment side slope versus borehole near the bottom of the embankment side slope). The native soil level beneath the embankment fill on the north side of the Petawawa River varies from about Elevation 138.8 to 140.7 metres.

The embankment fill material generally consists of sand with some gravel to gravelly sand with trace to some silt. Cobbles and boulders also exist within the fill, as do trace amounts of organic matter.

Fill was also encountered in borehole 11-4 which was put down outside of the south approach embankment footprint. The fill at this location was mostly comprised of gravel, cobbles and boulders, about 0.6 metres in thickness, and likely placed as part of an erosion protection system at the toe of the nearby approach embankment.

The results of grain size distribution testing carried out on samples of the embankment fill are provided on Figure 1. The results do not reflect the cobble, boulders or coarse gravel contents of the material, since the samples were retrieved using a 50 millimetre outside diameter sampler.

Standard penetration test N values ranging from 1 to 45 blows per 0.3 metre of penetration indicate that the embankment fill is very loose to dense. The higher N values could reflect the presence of cobbles and boulders, rather than the state of packing of the soil matrix.

The measured water content of the fill ranges from approximately 1 to 15 percent.

In borehole 11-2, a thin layer of buried topsoil was sandwiched between the embankment fill and the underlying sandy deposit.

4.2.2 Sand and Gravel, Gravelly Sand and Sand

Deposits of sand and gravel, gravelly sand and sand were encountered at ground surface (or beneath the river) at the boreholes for the proposed 60 metre span north pier and for the proposed south abutment. These deposits were also encountered beneath the fill at the boreholes for the proposed north abutment and for the proposed 76 metre span north pier. The sandy deposits extend down to about Elevation 138.2 metres and



144.0 metres at the proposed north and south modular bridge abutments, respectively. At the proposed north pier locations (i.e., for both proposed 60 and 76 metre spans), the sandy deposits extend down to about Elevation 134.0 to 134.4 metres. At borehole 11-5 put down for the 76 metre span south pier, only about 1.2 metres of sand was encountered at the ground surface which extends to about Elevation 138.2 metres. The sandy deposits were not encountered in borehole 11-4 put down for the proposed 60 metre south pier.

Standard penetration test N values for this material ranging from 9 to greater than 100 blows per 0.3 m of penetration indicate a loose to very dense state of packing. The higher N values could also reflect the presence of cobbles and boulders, rather than the state of packing of the soil matrix. The N values more typically range from about 25 to 65, indicating a compact to very dense state of packing. Refusal to advancement of the sampler was frequently encountered, on cobbles and boulders in the deposit.

Grain size distribution testing was carried out on 5 samples of the sandy deposits, the results of which are provided on Figure 2. These samples were however retrieved using a 50 mm diameter sampler and therefore the results do not reflect the coarse gravel cobble and boulder content of the deposits.

The measured water content of the sandy deposits ranges from approximately 3 to 16 percent.

4.2.3 Refusal and Bedrock

Sampler and casing refusal was encountered at Elevations 138.2 metres and 134.5 metres at Boreholes 11-1 and 11-2, respectively. Refusal may indicate the bedrock surface; however, it could also represent cobbles and/or boulders within the sandy deposits.

Bedrock was encountered beneath the sandy deposits and cored for 3.3 metres to 4.8 metres depth, in all of the boreholes with the exception of Boreholes 11-1 and 11-2.

The following table summarizes the bedrock surface depths and elevations as encountered at the four borehole locations where bedrock was cored.

Borehole Number	Existing Ground Surface/Water Level Elevation (m)	Depth to Bedrock (m)	Bedrock Surface Elevation (m)
11-3	*137.4	3.4	134.0
11-4	*137.4	0.6	136.8
11-5	139.4	1.2	138.2
11-6	147.7	3.7	144.0

* Note: Water level of the Petawawa River at the time of drilling, September 6 to 8, 2011.

The bedrock encountered in the boreholes typically consists of grey, black, green and pink gneiss. The bedrock is slightly weathered to fresh and typically strong to very strong. Amphibolite was also encountered at some of the borehole locations.

The Rock Quality Designation (RQD) values measured on recovered bedrock core samples ranged from about 0 to 100 percent, indicating a poor to excellent quality rock. The RQD values were generally found to be higher than 60 percent. The discontinuities observed in the rock core are typically angled, associated with the foliation



of the bedrock. Zones of the bedrock with a fracture index of greater than 10 fractures for 0.3 m of core were encountered in the bedrock at Borehole 11-6.

Laboratory unconfined compressive strength testing was carried out on two specimens of the bedrock core at the south pier locations for both the proposed 60 metre and 76 metre spans. The results are summarized on Figure 3. The two unconfined compressive strength tests for the south piers indicate values of about 118 MPa and 133 MPa.

4.3 Groundwater Conditions

Piezometers or monitoring wells were not installed in the granular soils at this site as part of the current investigation. The water level in boreholes 11-2, 11-3, 11-4, and 11-5 on the river banks are influenced by river levels. The groundwater levels in the piezometers in nearby Boreholes 10-2 and 10-8, near the north and south slopes respectively, were measured on April 23, 2010 as part of the previous 2010 Golder study. The observed groundwater levels at that time are summarized in the table below:

Borehole Number	Existing Ground Surface Elevation (m)	April 23, 2010	
		Water Level Depth (m)	Water Level Elevation (m)
10-2	145.6	7.5	138.2
10-8	145.2	4.3	140.9

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



5.0 CLOSURE

This report was prepared by Mr. Nicolas LeBlanc, P.Eng. The report was reviewed by Mr. Fintan Heffernan, P.Eng., Golder's Designated MTO Contact for this project, who conducted a technical and independent quality control review of the report.

Yours truly,

GOLDER ASSOCIATES LTD.

Nicolas R. LeBlanc, P.Eng.
Geotechnical Engineer



Fintan J. Heffernan, P.Eng.
Designated MTO Contact



NRL/FJH/bg

n:\active\2009\1121 - geotechnical\09-1121-1004 dm wills petawawa bridge\foundations\petawawa modular bridge\mto final report\09-1121-1004-4000 rpt-002 7june2012.docx

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE		III. SOIL DESCRIPTION	
AS	Auger sample	(a)	Cohesionless Soils
BS	Block sample		
CS	Chunk sample		
DO	Drive open	Density Index	N
DS	Denison type sample	(Relative Density)	<u>Blows/300 mm</u>
FS	Foil sample		<u>Or Blows/ft.</u>
RC	Rock core	Very loose	0 to 4
SC	Soil core	Loose	4 to 10
ST	Slotted tube	Compact	10 to 30
TO	Thin-walled, open	Dense	30 to 50
TP	Thin-walled, piston	Very dense	over 50
WS	Wash sample	(b)	Cohesive Soils
DT	Dual Tube sample	Consistency	C _u or S _u
II. PENETRATION RESISTANCE			
Standard Penetration Resistance (SPT), N:		<u>Kpa</u>	<u>Psf</u>
The number of blows by a 63.5 kg. (140 lb.)		Very soft	0 to 12
hammer dropped 760 mm (30 in.) required		Soft	12 to 25
to drive a 50 mm (2 in.) drive open		Firm	25 to 50
Sampler for a distance of 300 mm (12 in.)		Stiff	50 to 100
DD- Diamond Drilling		Very stiff	100 to 200
Dynamic Penetration Resistance; N_d:		Hard	Over 200
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	IV. SOIL TESTS	
PM:	Sampler advanced by manual pressure	w	water content
WH:	Sampler advanced by static weight of hammer	w _p	plastic limited
WR:	Sampler advanced by weight of sampler and rod	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 test (LV-laboratory vane test)
		γ	unit weight

Note:

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

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
F	factor of safety
V	volume
W	weight

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 stresses (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 ($D_R = p_s/p_w$) formerly (G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is p . Unit weight symbol is γ where $\gamma = pg$ (i.e. mass density \times acceleration due to gravity)

(a) Index Properties (cont'd.)

w	water content
w_L	liquid limit
w_p	plastic limit
I_p	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 (overconsolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	Overconsolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

$\tau_p \tau_r$	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

Notes: 1. $\tau = c' + \sigma' \tan \phi'$
2. Shear strength $= (\text{Compressive strength})/2$

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING 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 texture and structure are preserved.

BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very thickly bedded	>2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	<6 mm

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

O:\ Templates\Rock Description Terminology

CORE CONDITION

Total Core Recovery

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

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

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

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation 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

B -	Bedding	Ca -	Calcite
FO -	Foliation/Schistosity	P -	Polished
CL -	Cleavage	S -	Slickensided
SH -	Shear Plane/Zone	SM -	Smooth
VN -	Vein	R -	Ridged/Rough
F -	Fault	ST -	Stepped
CO -	Contact	PL -	Planar
J -	Joint	FL -	Flexured
FR -	Fracture	UE -	Uneven
MF -	Mechanical	W -	Wavy
A -	Angular	C -	Curved
BP -	Bedding Plane	H -	Hackly
BL -	Blast Induced	SL -	Sludge Coated
-	Parallel To	TCA -	To Core Axis
⊥ -	Perpendicular To	STR -	Stress Induced

PROJECT 09-1121-1004		RECORD OF BOREHOLE No 11-1				1 OF 1 METRIC									
G.W.P. 4059-01-00		LOCATION N 5083588.6 ; E 242074.7				ORIGINATED BY RI									
DIST _____ HWY 17		BOREHOLE TYPE Rotary Drill, BW Casing				COMPILED BY JM									
DATUM Geodetic		DATE Sept. 9, 2011				CHECKED BY NRL									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
144.4	GROUND SURFACE														
0.0	Sand, trace to some silt, trace gravel and organic matter (TOPSOIL)		1	SS	1										
0.2	Dark brown Moist														
143.8	Sand, trace silt and gravel (FILL)		2	SS	2										
0.6	Very loose Brown Moist														
	Gravelly sand, trace silt and organic matter, with cobbles and boulders (FILL)		3	SS	9										32 64 4 0
	Very loose to dense Brown Moist		4	SS	36										
			5	SS	13										
			6	SS	8										
140.7	SAND and GRAVEL, trace to some silt, with cobbles and boulders		7	SS	51										
3.7	Compact to very dense Red-brown to dark brown Moist to wet														
			8	SS	28										26 60 13 1
138.2	End of Borehole		9	SS	>50										
6.2															

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT <u>09-1121-1004</u>		RECORD OF BOREHOLE No 11-2		1 OF 1 METRIC	
G.W.P. <u>4059-01-00</u>		LOCATION <u>N 5083564.6 ; E 242082.9</u>		ORIGINATED BY <u>RI</u>	
DIST <u> </u> HWY <u>17</u>		BOREHOLE TYPE <u>Rotary Drill, BW Casing</u>		COMPILED BY <u>JM</u>	
DATUM <u>Geodetic</u>		DATE <u>Sept. 6, 2011</u>		CHECKED BY <u>NRL</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
							● UNCONFINED + FIELD VANE										
							● QUICK TRIAXIAL x REMOULDED										
140.5	GROUND SURFACE						20	40	60	80	100	25	50	75			
0.0	Sand, some silt, gravel and organic matter, with cobbles and boulders (TOPSOIL) Dark brown to black Moist		1	SS	45												
0.1																	
	Sand, some gravel, trace to some silt, with cobbles and boulders (FILL) Compact to dense Brown Moist to wet		2	SS	16							o				15 71 13 1	
138.8																	
1.7	Sand, some gravel, trace silt, organic matter rootlets (TOPSOIL) Dense Dark brown Wet		3	SS	30							o				23 67 9 1	
	SAND and GRAVEL, trace to some silt, with cobbles and boulders, occasional black sand, some silt seams in upper strata Dense to very dense Red-brown to dark brown Wet			4	SS	>60											
				5	SS	>50							o				
				6	SS	91											
				7	SS	82											
				8	SS	>60							o				
				9	SS	>60											
134.5																	
6.0	End of Borehole																

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT <u>09-1121-1004</u>		RECORD OF BOREHOLE No 11-3		1 OF 1 METRIC	
G.W.P. <u>4059-01-00</u>		LOCATION <u>N 5083557.5 ; E 242086.7</u>		ORIGINATED BY <u>JD</u>	
DIST <u> </u> HWY <u>17</u>		BOREHOLE TYPE <u>Portable Drill, NQ Core</u>		COMPILED BY <u>JM</u>	
DATUM <u>Geodetic</u>		DATE <u>Sept. 6-8, 2011</u>		CHECKED BY <u>NRL</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT CONTENT 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					W _p W W _L WATER CONTENT (%)						
								20 40 60 80 100											
137.4	RIVER LEVEL																		
0.0 137.2	WATER																		
0.2	SAND and GRAVEL, trace silt, with cobbles and boulders Loose to dense Red-brown to dark brown Moist to wet Note: Bedrock cored between 3.4 m and 7.1 m depth. For bedrock coring details refer to Record of Drillhole 11-3.		1	SS	9		137												
			2	SS	20			136										44 49 7 0	
			3	SS	18				135										
			4	SS	42					134									
			5	SS	33														51 38 9 2
	- Clayey silt layers below 3.1 m depth																		
134.0 3.4	End of Borehole																		

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

DATUM: Geodetic

DRILL RIG: Portable

DRILLING CONTRACTOR: OGS

[illegible]

PROJECT: 09-1121-1004

RECORD OF DRILLHOLE: 11-4

SHEET 1 OF 1

LOCATION: N 5083501.6 ; E 242108.5

DRILLING DATE: Sept. 8, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Portable

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	COLOUR % RETURN	FR/FX-FRACTURE F-FAULT CL-CLEAVAGE J-JOINT R-SMOOTH SH-SHEAR P-POLISHED R-ROUGH VN-VEIN S-SLICKENSIDED PL-PLANAR UE-UNEVEN BC-BROKEN CORE MB-MECH. BREAK B-BEDDING										DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
									RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
									TOTAL CORE %	SOLID CORE %			DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
									88888	88888			88888																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
									10	88888			88888			88888	88888	88888			88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888	88888

DEPTH SCALE

1 : 50




LOGGED: JD

CHECKED: NRL

MIS-RCK 001 0911211004-2000 (ROCK).GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT 09-1121-1004		RECORD OF BOREHOLE No 11-5		1 OF 1 METRIC	
G.W.P. 4059-01-00		LOCATION N 5083494.2 ; E 242111.3		ORIGINATED BY JD	
DIST HWY 17		BOREHOLE TYPE Portable Drill, NQ Core		COMPILED BY JM	
DATUM Geodetic		DATE Sept. 9, 2011		CHECKED BY NRL	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	w	W _L		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x REMOULDED					WATER CONTENT (%)				
139.4	GROUND SURFACE							20	40	60	80	100					
0.0	SAND and GRAVEL, trace silt, with cobbles and boulders Compact to very dense Red-brown Moist Note: Bedrock cored between 1.2 m and 4.5 m depth. For bedrock coring details refer to Record of Drillhole 11-5.		1	SS	23	139											
			2	SS	>50												
138.2	For bedrock coring details refer to Record of Drillhole 11-5.																
1.2	End of Borehole																

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: OGS

[illegible]


DEPTH SCALE

1 : 50

LOGGED: JD

CHECKED: NRL

PROJECT <u>09-1121-1004</u>		RECORD OF BOREHOLE No 11-6		1 OF 1 METRIC	
G.W.P. <u>4059-01-00</u>		LOCATION <u>N 5083455.7 ; E 242126.3</u>		ORIGINATED BY <u>DG</u>	
DIST <u> </u> HWY <u>17</u>		BOREHOLE TYPE <u>Power Auger, 200mm Diam. Hollow Stem</u>		COMPILED BY <u>JM</u>	
DATUM <u>Geodetic</u>		DATE <u>Sept. 19, 2011</u>		CHECKED BY <u>NRL</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p W W _L				
147.7	GROUND SURFACE						20	40	60	80	100						
0.0	SAND and GRAVEL, with cobbles and boulders Dense to very dense Brown Moist Note: Bedrock cored between 3.7 m and 8.5 m depth. For bedrock coring details refer to Record of Drillhole 11-6.																
			1	SS	81												
			2	SS	66												
			3	SS	44												
			4	SS	>50												
			5	NQ RC	DD												
144.0	End of Borehole																
3.7																	

PROJECT: 09-1121-1004

RECORD OF DRILLHOLE: 11-6

SHEET 1 OF 1

LOCATION: N 5083455.7 ; E 242126.3

DRILLING DATE: Sept. 20, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Rotary

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/rev)	FLUSH % RETURN	FR/FX-FRACTURE F-FAULT CL-CLEAVAGE J-JOINT SH-SHEAR P-POLISHED VN-VEIN S-SLICKENSIDED PL-PLANAR	SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR	FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED	BC-BROKEN CORE MB-MECH. BREAK B-BEDDING	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE		144.00									
4		Granitic to mafic GNEISS (BEDROCK) Fresh Fine to medium grained Thinly banded Grey-pink Medium-strong		3.70	1								
5					2								
6					3								
7					4								
8					5								
9		End of Drillhole		139.20 8.50									
10													
11													
12													
13													

DEPTH SCALE

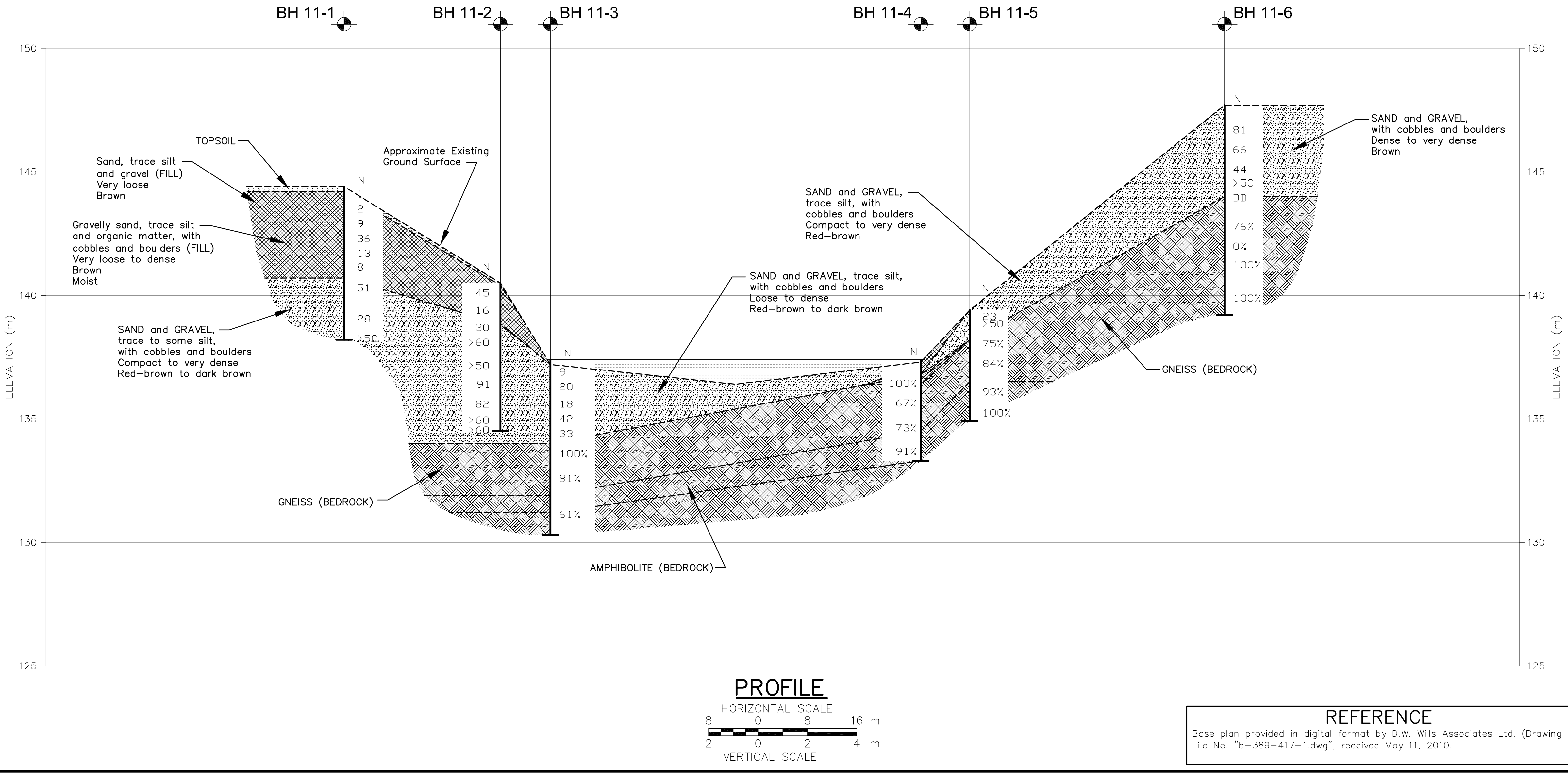
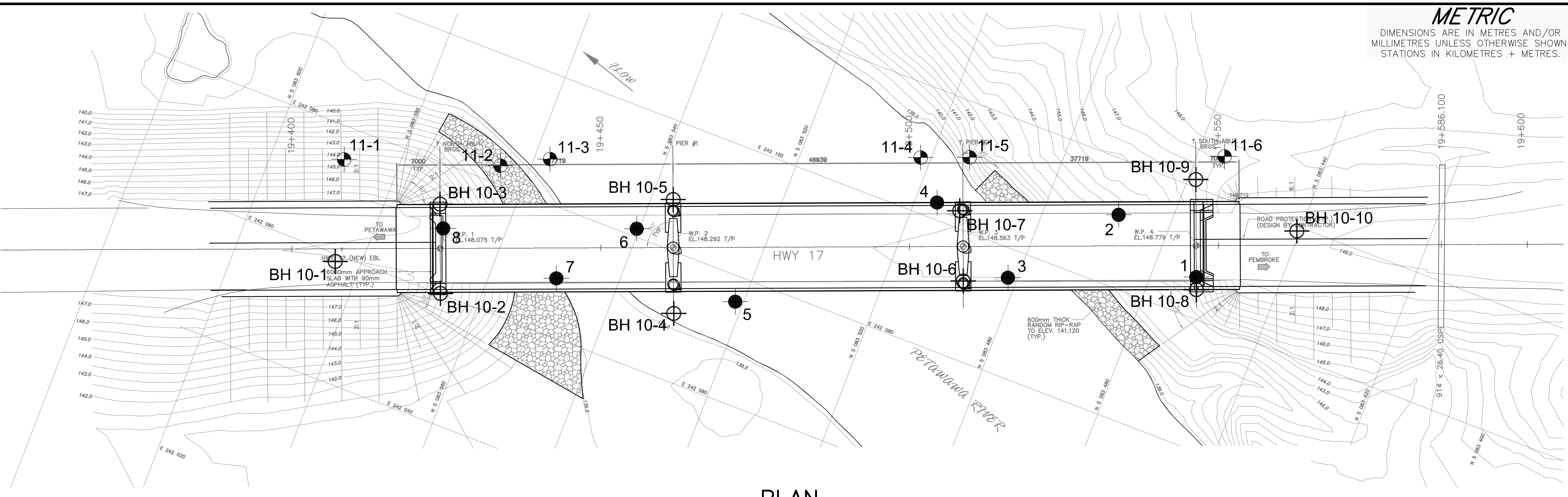
1:50



LOGGED: DG

CHECKED: NRL

MIS-RCK 001 0911211004-2000 (ROCK) GPJ GAL-MISS GDT 06/06/12 JM



CONT No.
WP No. 4059-01-00

PETAWAWA RIVER BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates Ltd.
OTTAWA, ONTARIO, CANADA

KEY PLAN
SCALE
0 4 8 km

LEGEND

- Borehole — Current Investigation
- Borehole — Previous Golder Associates Ltd. Investigation
- Borehole — Previous MTO Investigation Geocres No. 31F-51
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
11-1	144.4	5083588.6	242074.7
11-2	140.5	5083564.6	242082.9
11-3	137.4	5083557.5	242086.7
11-4	137.4	5083501.6	242108.5
11-5	139.4	5083494.2	242111.3
11-6	147.7	5083455.7	242126.3
10-1	148.0	5083584.0	242058.8
10-2	145.6	5083566.3	242060.1
10-3	145.5	5083571.5	242073.6
10-4	137.6	5083529.9	242070.6
10-5	137.6	5083536.6	242087.8
10-6	137.4	5083488.0	242092.3
10-7	137.4	5083492.6	242102.7
10-8	145.2	5083452.3	242104.6
10-9	146.9	5083458.7	242121.1
10-10	148.9	5083440.7	242119.2
1	147.2	5083453.0	242106.4
2	146.5	5083468.3	242111.3
3	138.3	5083481.4	242095.4
4	137.5	5083496.5	242102.6
5	137.6	5083521.2	242075.9
6	137.6	5083540.4	242081.2
7	139.1	5083549.6	242069.1
8	139.4	5083569.6	242070.1

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 Preliminary Design Report.

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

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

NO.	DATE	BY	REVISION

Geocres No. _____

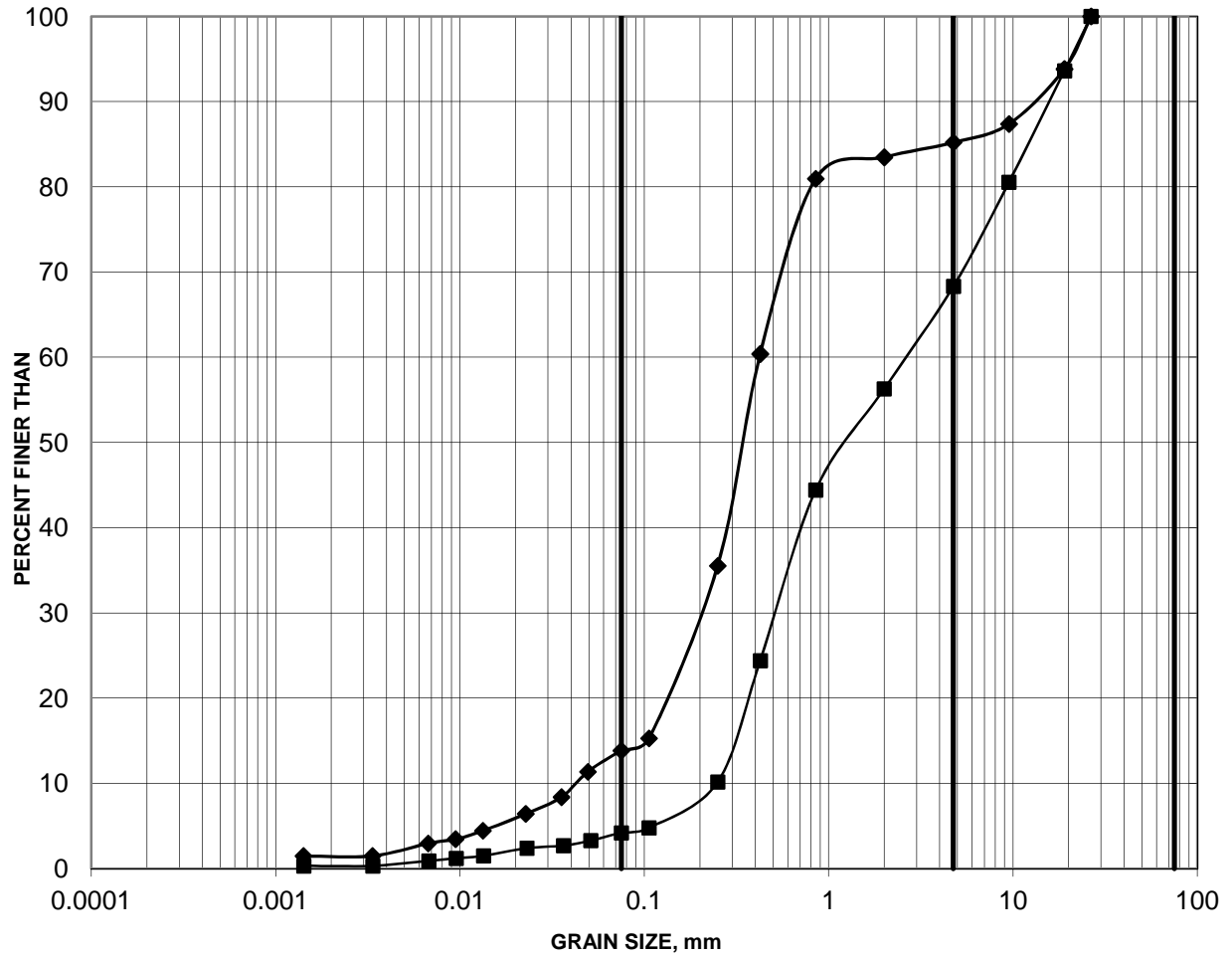
PROJECT NO. **09-1121-1004** DIST. _____

SUBM'D. NRL	CHKD. NRL	DATE: OCTOBER 2011	SITE:
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 1

GRAIN SIZE DISTRIBUTION

FIGURE 1

EMBANKMENT FILL



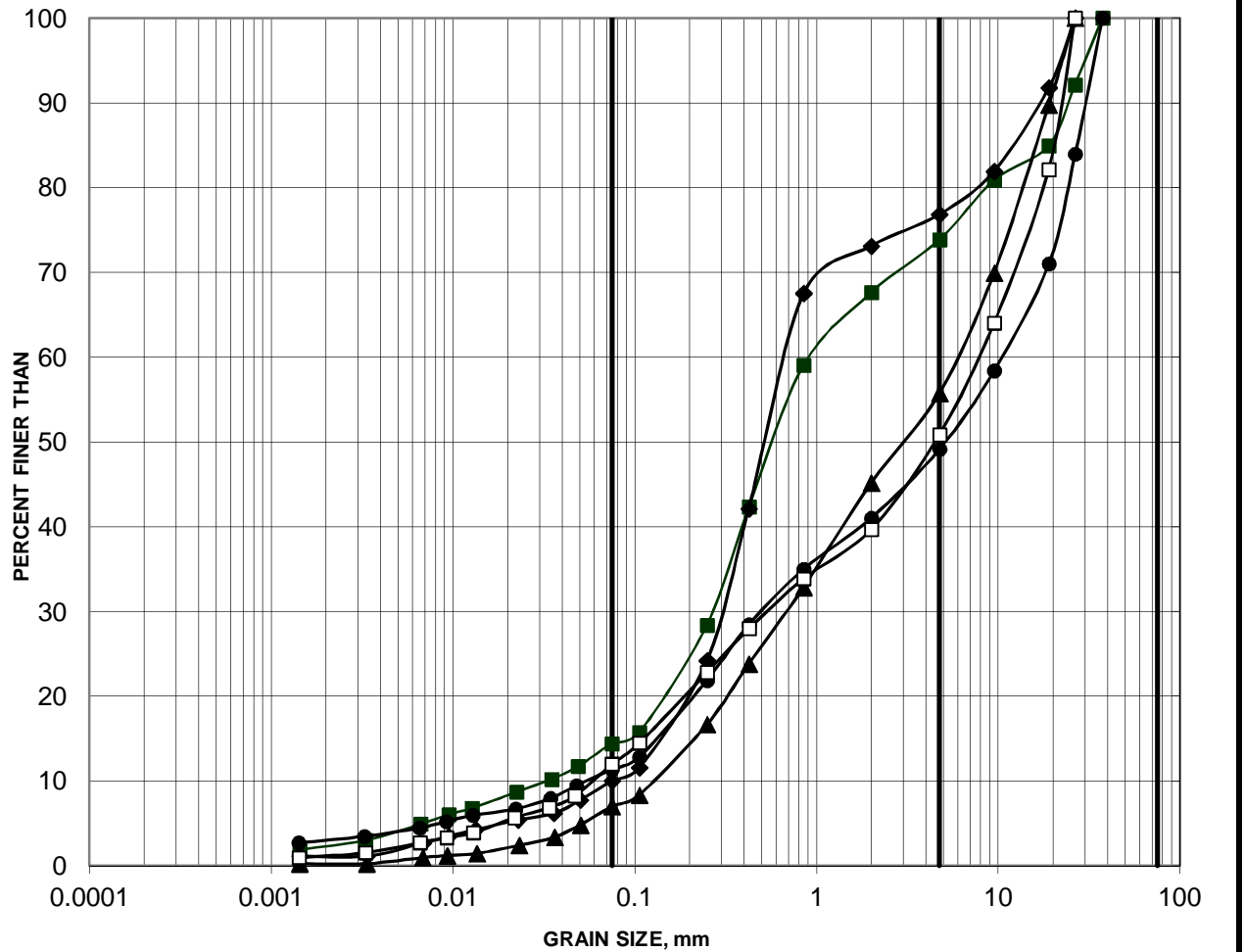
SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
—■— 11-01	3	1.22-1.83
—◆— 11-02	2	0.76-1.37

GRAIN SIZE DISTRIBUTION

FIGURE 2

SAND AND GRAVEL

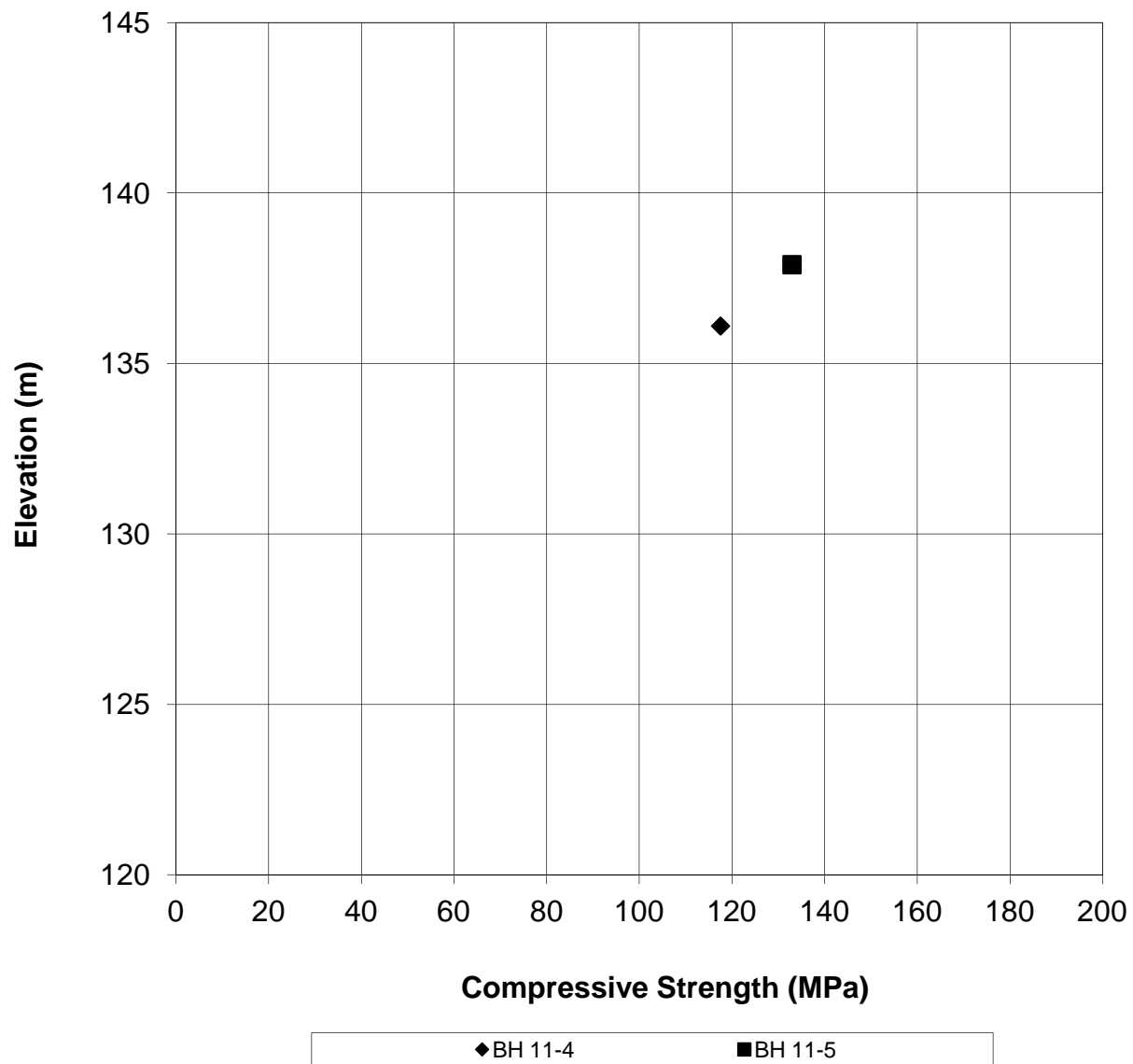


SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
11-01	8	5.13-5.56
11-02	3B	1.68-2.13
11-03	2	1.12-1.73
11-03	5	3.05-3.66
11-06	2	1.52-2.13

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

FIGURE 3





APPENDIX A

Record of Boreholes – Golder 2010 Investigation
Record of Boreholes – MTO 1972 Investigation
Geocres No. 31F-51

PROJECT 09-1121-1004			RECORD OF BOREHOLE No 10-1			1 OF 2 METRIC											
G.W.P. 4059-01-00			LOCATION N 5083584.0 ; E 242058.8			ORIGINATED BY HEC											
DIST _____ HWY 17			BOREHOLE TYPE Power Auger, 200mm Diam. Hollow Stem			COMPILED BY JM											
DATUM Geodetic			DATE April 26, 2010			CHECKED BY SAT											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m³	GR SA SI CL
							20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W _p W W _L	25 50 75						
148.0	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
0.1	Sand and gravel (BASE)																
	Brown																
147.5	Sand, some gravel (SUBBASE)																
0.5	Very dense																
	Brown																
	Moist																
146.6	Sand, some gravel, trace silt (FILL)																
1.4	Loose to dense																
	Brown																
	Moist																
			1	SS	53		147										
			2	SS	28		146										
			3	SS	23		145										
			4	SS	35		144										
			5	SS	19		143										
			6	SS	8		142										
			7	SS	19		141										
			8	SS	32		140										
140.4	Sand, with cobbles (FILL)																
7.6	Dense																
	Brown																
	Moist																
139.3	SAND and GRAVEL, trace silt, with cobbles																
8.7	Very dense																
	Red-brown																
	Moist																
			9	SS	>100		139										

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS GDT 06/06/12 JM

Continued Next Page

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



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

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT 09-1121-1004

RECORD OF BOREHOLE No 10-2

1 OF 2 **METRIC**

G.W.P. 4059-01-00

LOCATION N 5083566.3 :E 242060.1

ORIGINATED BY PAH

DIST HWY 17

BOREHOLE TYPE Power Auger, 110mm Diam. Solid Stem, NW Casing, Wash Boring

COMPILED BY JM

DATUM Geodetic

DATE April 19-20, 2010

CHECKED BY SAT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
145.6	GROUND SURFACE							20	40	60	80	100						
0.0	Silty sand, trace to some organic matter (FILL)																	
145.3	Dark brown																	
0.3	Sand, some gravel, trace silt (FILL)		1	A.S.			145											
	Loose		2	SS	6													
	Brown		3	SS	5		144										19	78 3 0
	Moist		4	SS	5		143											
			5	SS	7		142											
141.3																		
4.3	Sand, some silt (FILL)		6	SS	22		141										0	88 12 0
	Compact		7	SS	18		140											
	Brown		8	SS	>100													
	Moist to wet																	
139.2																		
6.4	SAND and GRAVEL, trace silt						139											
	Very dense to dense																	
	Red-brown and grey-brown		9	SS	>100		138											
	Wet																	
							137											
			10	SS	46		136										47	47 4 2

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

PROJECT <u>09-1121-1004</u>		RECORD OF BOREHOLE No 10-2		2 OF 2 METRIC	
G.W.P. <u>4059-01-00</u>		LOCATION <u>N 5083566.3 ; E 242060.1</u>		ORIGINATED BY <u>PAH</u>	
DIST <u> </u> HWY <u>17</u>		BOREHOLE TYPE <u>Power Auger, 110mm Diam. Solid Stem, NW Casing, Wash Boring</u>		COMPILED BY <u>JM</u>	
DATUM <u>Geodetic</u>		DATE <u>April 19-20, 2010</u>		CHECKED BY <u>SAT</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					WATER CONTENT (%)				
								20 40 60 80 100					W _p W W _L				
— CONTINUED FROM PREVIOUS PAGE —																	
134.6	SAND and GRAVEL, trace silt Very dense to dense Red-brown and grey-brown Wet						135										
11.0 134.3 11.3	GNEISS (BEDROCK) Highly weathered Dark grey		11	SS	>100												
	GNEISS (BEDROCK) Slightly weathered Dark grey Strong to very strong		C1	NQ RC	DD		134										
133.0							133										
12.6	GNEISS (BEDROCK) Fresh Dark grey Strong to very strong		C2	NQ RC	DD		132										
131.0			C3	NQ RC	DD		131										
130.8 14.8	QUARTZ (BEDROCK) Grey-black and red-brown																
Note: Bedrock cored between 11.3 m and 14.8 m depth. For bedrock coring details refer to Record of Drillhole 10-2. End of Borehole																	
Note: Water level in piezometer at 7.5 m depth (Elev. 138.2 m) on Apr. 23, 2010.																	

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT: 09-1121-1004

RECORD OF DRILLHOLE: 10-2

SHEET 1 OF 1

LOCATION: N 5083566.3 ; E 242060.1

DRILLING DATE: April 19-20, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: D-25

DRILLING CONTRACTOR: Walker Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	PENETRATION RATE (mm/min)	FLUSH % RETURN	FR/FX-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE										DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
				DEPTH (m)	COLOUR				CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK		SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING		VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED		HYDRAULIC CONDUCTIVITY K _h cm/sec																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
									TOTAL CORE %	SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							

DEPTH SCALE

1 : 50



LOGGED: PAH

CHECKED: SAT

MIS-RCK-001 0911211004-2000 (ROCK) GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT <u>09-1121-1004</u>		RECORD OF BOREHOLE No 10-3		1 OF 2 METRIC	
G.W.P. <u>4059-01-00</u>		LOCATION <u>N 5083571.5 ; E 242073.6</u>		ORIGINATED BY <u>PAH</u>	
DIST <u> </u> HWY <u>17</u>		BOREHOLE TYPE <u>NW Casing, Wash Boring</u>		COMPILED BY <u>JM</u>	
DATUM <u>Geodetic</u>		DATE <u>April 21-22, 2010</u>		CHECKED BY <u>SAT</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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
							20 40 60 80 100		20 40 60 80 100	25 50 75				
145.5	GROUND SURFACE													
0.0	Silty sand, trace organic matter (FILL)													
145.3	Dark brown													
0.2	Sand, some gravel, trace silt (FILL)		1	A.S.										
	Loose to very loose													
	Brown		2	SS	5									
	Moist													
			3	SS	5									
			4	SS	4									
142.4														
3.1	Sand, trace to some silt (FILL)		5	SS	13									
	Compact to dense													
	Brown		6	SS	36									
	Moist													
			7	SS	24									
			8	SS	11									
139.7														
5.8	SAND and GRAVEL, some silt, trace organic matter													
139.4	Red-brown													
6.1	SAND and GRAVEL		9	SS	36									
	Dense to very dense													
	Red-brown and grey-brown													
	Wet													
			10	SS	>100									
			11	SS	63									
			12	SS	45									

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

MIS-MTO.001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT 09-1121-1004		RECORD OF BOREHOLE No 10-3				2 OF 2 METRIC							
G.W.P. 4059-01-00		LOCATION N 5083571.5 :E 242073.6				ORIGINATED BY PAH							
DIST _____ HWY 17		BOREHOLE TYPE NW Casing, Wash Boring				COMPILED BY JM							
DATUM Geodetic		DATE April 21-22, 2010				CHECKED BY SAT							
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 (%)			
	— 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;"> 25 50 75 </div>				
134.6	SAND and GRAVEL Dense to very dense Red-brown and grey-brown Wet												
10.9	GNEISS (BEDROCK) Fresh Grey Strong to very strong Note: Bedrock cored between 10.9 m and 14.0 m depth. For bedrock coring details refer to Record of Drillhole 10-3.		C1	NQ RC	DD								
			C2	NQ RC	DD								
			C3	NQ RC	DD								
131.5	End of Borehole Note: Water level in open borehole at 7.3 m depth below ground surface upon completion of drilling												
14.0													

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

DATUM: Geodetic

DRILL RIG: D-25

DRILLING CONTRACTOR: Walker Drilling

[illegible]

MIS-RCK 001 0911211004-2000 (ROCK).GPJ GAL-MISS.GDT 06/06/12 JM

DEPTH SCALE

1 : 50

LOGGED: PAH

CHECKED: SAT

PROJECT 09-1121-1004		RECORD OF BOREHOLE No 10-4		1 OF 1 METRIC	
G.W.P. 4059-01-00		LOCATION N 5083529.9 ; E 242070.6		ORIGINATED BY JD	
DIST HWY 17		BOREHOLE TYPE Rotary Drill, BW Casing		COMPILED BY JM	
DATUM Geodetic		DATE Sept. 9-10, 2010		CHECKED BY SAT	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED						
137.6	RIVER LEVEL													
0.0	WATER													
137.1														
0.5	SAND and GRAVEL, with cobbles and boulders Loose to very dense Brown Wet		1	SS	40									34 63 3 0
			2	SS	4									
			3	SS	>100									
135.3														
2.3	GNEISS (BEDROCK) Completely weathered Grey		4	SS	>100									
134.8														
2.8	AMPHIBOLITE (BEDROCK) Slightly weathered Fine grained Very strong Greenish-black		C1	NQ RC	DD									
			C2	NQ RC	DD									
133.2														
4.4	GNEISS (BEDROCK) Fresh Fine to medium grained Very strong Grey Note: Bedrock cored between 2.8 m and 9.3 m depth. For bedrock coring details refer to Record of Drillhole 10-4.		C3	NQ RC	DD									
			C4	NQ RC	DD									
			C5	NQ RC	DD									
			C6	NQ RC	DD									
			C7	NQ RC	DD									
			C8	NQ RC	DD									
			C9	NQ RC	DD									
128.3														
9.3	End of Borehole													

PROJECT: 09-1121-1004

RECORD OF DRILLHOLE: 10-4

SHEET 1 OF 1

LOCATION: N 5083529.9;E 242070.6

DRILLING DATE: Sept. 9-10, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Portable

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH % RETURN	COLOUR	FR/FX-FRACTURE F-FAULT CL-CLEAVAGE J-JOINT R-ROUGH SH-SHEAR P-POLISHED ST-STEPPED VN-VEIN S-SLICKENSIDED PL-PLANAR SM-SMOOTH FL-FLEXURED UE-UNEVEN BC-BROKEN CORE MB-MECH. BREAK B-BEDDING										HYDRAULIC CONDUCTIVITY			DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
									RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA		DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	10 ⁻⁸	10 ⁻⁷	10 ⁻⁶				
									TOTAL CORE %	SOLID CORE %													
									88888	88888													
													Continued from Record of Borehole 10-4							134.80			
3		AMPHIBOLITE (BEDROCK) Slightly weathered Fine grained Very strong Greenish-black		2.80	1		100																
4					2		100																
		GNEISS (BEDROCK) Fresh Fine to medium grained Very strong Grey		133.20 4.40	3		100																
5					4		100																
6					5		100																
7					6		100																
8					7		100																
9					8		100																
					9		100																
		End of Borehole		128.30 9.30																			
10																							
11																							
12																							

DEPTH SCALE

1:50



LOGGED: JD

CHECKED: SAT

MIS-RCK 001 0911211004-2000 (ROCK).GPJ GAL-MISS GDT 06/06/12 JM

PROJECT <u>09-1121-1004</u>		RECORD OF BOREHOLE No 10-5		1 OF 1 METRIC	
G.W.P. <u>4059-01-00</u>	LOCATION <u>N 5083536.6 ; E 242087.8</u>	ORIGINATED BY <u>JD</u>			
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Rotary Drill, BW Casing</u>	COMPILED BY <u>JM</u>			
DATUM <u>Geodetic</u>	DATE <u>Sept. 7-8, 2010</u>	CHECKED BY <u>SAT</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED										
137.6 0.0	RIVER LEVEL WATER						20	40	60	80	100							
136.7 0.9	SAND and GRAVEL, trace silt, with cobbles and boulders Dense to very dense Brown Wet																	
		1	SS	47														
		2	SS	99														
		3	SS	>100														
134.9 2.7	GNEISS (BEDROCK) Slightly weathered Fine to medium grained Strong Grey		C1	NQ RC	DD													
134.4 3.2	GNEISS (BEDROCK) Fresh Fine to medium grained Very strong Grey Note: Bedrock cored between 2.7 m and 8.9 m depth. For bedrock coring details refer to Record of Drillhole 10-5. - 0.15 m thick granite pegmatite bed at 5.3 m depth - 0.15 m thick granite pegmatite bed at 5.9 m depth		C2	NQ RC	DD													
			C3	NQ RC	DD													
				C4	NQ RC	DD												
				C5	NQ RC	DD												
				C6	NQ RC	DD												
128.7 8.9	End of Borehole																	

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT: 09-1121-1004

RECORD OF DRILLHOLE: 10-5

SHEET 1 OF 1

LOCATION: N 5083536.6 ; E 242087.8

DRILLING DATE: Sept. 7-8, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Portable

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH % RETURN	FR/FX-FRACTURE F-FAULT										SM-SMOOTH		FL-FLEXURED		BC-BROKEN CORE		DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
								CL-CLEAVAGE		J-JOINT		R-ROUGH		UE-UNEVEN		MB-MECH. BREAK		B-BEDDING							
								SH-SHEAR		P-POLISHED		ST-STEPPED		W-WAVY		C-CURVED									
								VN-VEIN		S-SLICKENSIDED		PL-PLANAR													
RECOVERY		FRACT. INDEX PER 0.3		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY																			
TOTAL CORE %	SOLID CORE %	R.Q.D. %	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	10 ⁻⁸	10 ⁻⁶	10 ⁻⁴																		
000000	000000	000000	000000																						
Continued from Record of Borehole 10-5				134.90																					
GNEISS (BEDROCK) Slightly weathered Fine to medium grained Strong Grey				2.70			0																		
GNEISS (BEDROCK) Fresh Fine to medium grained Very strong Grey				134.40	1		0																		
				3.20																					
					2		0																		
					3		0																		
- 0.15 m thick granite pegmatite bed at 5.3 m depth																									
					4		0																		
- 0.15 m thick granite pegmatite bed at 5.9 m depth																									
					5		0																		
					6		0																		
End of Borehole				128.70																					
				8.90																					

DEPTH SCALE

1 : 50



LOGGED: JD

CHECKED: SAT

MIS-RCK 001 0911211004-2000 (ROCK) GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT <u>09-1121-1004</u>		RECORD OF BOREHOLE No 10-6		1 OF 1 METRIC	
G.W.P. <u>4059-01-00</u>		LOCATION <u>N 5083488.0 ;E 242092.3</u>		ORIGINATED BY <u>DWM</u>	
DIST <u> </u> HWY <u>17</u>		BOREHOLE TYPE <u>NW Casing, Wash Boring</u>		COMPILED BY <u>JM</u>	
DATUM <u>Geodetic</u>		DATE <u>July 28, 2010</u>		CHECKED BY <u>SAT</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								<div><div></div><div>20406080100</div></div>					<div><div></div><div>W_pW</div><div>W_L</div></div>				
137.4 0.0	RIVER LEVEL WATER	<div></div>															
136.1 1.3	GNEISS (BEDROCK) Fresh Fine grained Strong to very strong Grey - Slightly weathered from 1.3 m to 1.4 m depth	<div></div>	C1	NQ RC	DD												
134.8 2.6	GNEISS (BEDROCK) Fresh Coarse grained Pink	<div></div>															
134.2 3.2	- Fractured from 2.8 m to 2.9 m depth GNEISS (BEDROCK) Fresh Fine grained Strong to very strong Grey to greenish-black - Coarse grained from 5.5 m to 5.7 m depth Note: Bedrock cored between 5.5 m and 5.7 m depth. For bedrock coring details refer to Record of Drillhole 10-6.	<div></div>	C2	NQ RC	DD												
		<div></div>	C3	NQ RC	DD												
		<div></div>	C4	NQ RC	DD												
130.1 7.3	End of Borehole																

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT: 09-1121-1004

RECORD OF DRILLHOLE: 10-6

SHEET 1 OF 1

LOCATION: N 5083488.0 ; E 242092.3

DRILLING DATE: July 28, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: D-25

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH % RETURN	COLOUR % RETURN	FR/FX-FRACTURE	F-FAULT	SM-SMOOTH	FL-FLEXURED	BC-BROKEN CORE	NOTES WATER LEVELS INSTRUMENTATION
									CL-CLEAVAGE	J-JOINT	R-ROUGH	UE-UNEVEN	MB-MECH. BREAK	
									SH-SHEAR	P-POLISHED	ST-STEPPED	W-WAVY	B-BEDDING	
									VN-VEIN	S-SLICKENSIDED	PL-PLANAR	C-CURVED		
RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY		DIAMETRAL POINT LOAD INDEX (MPa)						
TOTAL CORE %	SOLID CORE %			DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	10 ⁻⁸ K _s cm/sec	10 ⁻⁷ K _s cm/sec		10 ⁻⁶ K _s cm/sec					
		Continued from Record of Borehole 10-6		136.10										
2		GNEISS (BEDROCK) Fresh Fine grained Strong to very strong Grey - Slightly weathered from 1.3 m to 1.4 m depth		134.80 1.30	1		100							
3		GNEISS (BEDROCK) Fresh Coarse grained Pink - Fractured from 2.8 m to 2.9 m depth		134.20 2.60										
4		GNEISS (BEDROCK) Fresh Fine grained Strong to very strong Grey to greenish-black - Coarse grained from 5.5 m to 5.7 m depth		130.10 3.20	2		100							
5					3		100							
6														
7					4		100							
		End of Borehole		130.10 7.30										
8														
9														
10														
11														

DEPTH SCALE

1 : 50



LOGGED: DWM

CHECKED: SAT

MIS-RCK 001 0911211004-2000 (ROCK).GPJ GAL-MISS.GDT 06/06/12 JM

1 OF 1 **METRIC**

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM


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

[illegible]

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

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

PROJECT <u>09-1121-1004</u>			RECORD OF BOREHOLE No 10-8			2 OF 2 METRIC		
G.W.P. <u>4059-01-00</u>			LOCATION <u>N 5083452.3 ; E 242104.6</u>			ORIGINATED BY <u>PAH</u>		
DIST <u> </u> HWY <u>17</u>			BOREHOLE TYPE <u>NW Casing, Wash Boring</u>			COMPILED BY <u>JM</u>		
DATUM <u>Geodetic</u>			DATE <u>April 14-15, 2010</u>			CHECKED BY <u>SAT</u>		

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 (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x REMOULDED					W _p W W _L				
--- CONTINUED FROM PREVIOUS PAGE ---																	
	GNEISS (BEDROCK) Fresh Dark grey and pink Strong to very strong Note: Bedrock cored between 7.9 m and 12.0 m depth. For bedrock coring details refer to Record of Drillhole 10-8.						135										
			C4	NQ	RC	DD		134									
133.2																	
12.0	End of Borehole Note: Water level in piezometer at 4.3 m depth (Elev. 140.9 m) on Apr. 23, 2010.																

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT: 09-1121-1004

RECORD OF DRILLHOLE: 10-8

SHEET 1 OF 1

LOCATION: N 5083452.3 ;E 242104.6

DRILLING DATE: April 14-15, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: --

DRILL RIG: D-25

DRILLING CONTRACTOR: Walker Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	PENETRATION RATE (mm/min)	FLUSH	RECOVERY	R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA	HYDRAULIC CONDUCTIVITY K _f cm/sec	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION											
				DEPTH (m)											FR/FX-FRACTURE F-FAULT CL-CLEAVAGE J-JOINT SH-SHEAR P-POLISHED VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED	SM-SMOOTH R-ROUGH ST-STEPPED	FL-FLEXURED UE-UNEVEN W-WAVY	BC-BROKEN CORE MB-MECH. BREAK B-BEDDING							
				FLUSH											TOTAL CORE %	SOLID CORE %	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	10 ⁻⁸	10 ⁻⁶	10 ⁻⁴	10 ⁻²	2	4	8
				FLUSH											TOTAL CORE %	SOLID CORE %	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	10 ⁻⁸	10 ⁻⁶	10 ⁻⁴	10 ⁻²	2	4	8
8		GROUND SURFACE		137.30																					
		GRANITE PEGMATITE (BEDROCK) Slightly weathered Pink-grey		7.90			100																		
				136.70			100																		
9		GNEISS (BEDROCK) Fresh Dark grey and pink Strong to very strong		8.50			100																		
							100																		
10							100																		
							100																		
11							100																		
							100																		
12		End of Drillhole		133.20 12.00																					
13		Note: Water level in piezometer at 4.3 m depth (Elev. 140.9 m) on Apr. 23, 2010.																							
14																									
15																									
16																									
17																									

PROJECT 09-1121-1004

RECORD OF BOREHOLE No 10-9

1 OF 1 **METRIC**

G.W.P. 4059-01-00

LOCATION N 5083458.7 :E 242121.1

ORIGINATED BY PAH

DIST _____ HWY 17

BOREHOLE TYPE Power Auger, 110mm Diam. Solid Stem, NW Casing, Wash Boring

COMPILED BY JM

DATUM Geodetic

DATE April 12-13, 2010

CHECKED BY SAT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
146.9	GROUND SURFACE							20	40	60	80	100					
0.0	Sandy gravel, trace silt (FILL) Compact to dense Brown to grey-brown Moist		1	SS	41		146										70 26 4 0
145.5																	
1.4	Gravelly SAND, some silt, with cobbles Dense Brown to grey-brown Moist		2	SS	55		145										24 60 14 2
			3	SS	>100												
144.3																	
2.6	GNEISS (BEDROCK) Fresh to slightly weathered Grey, black and pink Strong to very strong Note: Bedrock cored between 2.6 m and 5.6 m depth. For bedrock coring details refer to Record of Drillhole 10-9.		C1	NQ RC	DD		144										
							143										
			C2	NQ RC	DD		142										
141.3																	
5.6	End of Borehole Note: Water level in open borehole at 4.3 m depth below ground surface upon completion of drilling																

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT: 09-1121-1004

RECORD OF DRILLHOLE: 10-9

SHEET 1 OF 1

LOCATION: N 5083458.7 ;E 242121.1

DRILLING DATE: April 12-13, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: D-25

DRILLING CONTRACTOR: Walker Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	COLOUR % RETURN	FR/FX-FRACTURE F-FAULT				SM-SMOOTH		FL-FLEXURED		BC-BROKEN CORE		DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
									CL-CLEAVAGE		J-JOINT		R-ROUGH		UE-UNEVEN		MB-MECH. BREAK			
									SH-SHEAR		P-POLISHED		ST-STEPPED		W-WAVY		B-BEDDING			
									VN-VEIN		S-SLICKENSIDED		PL-PLANAR		C-CURVED					
RECOVERY		R.Q.D. %		FRACT. INDEX PER 0.3		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY												
TOTAL CORE %		SOLID CORE %				DIP w.r.t. CORE AXIS		TYPE AND SURFACE DESCRIPTION		K _f cm/sec										
		GROUND SURFACE		144.30																
3		GNEISS (BEDROCK) Fresh to slightly weathered Grey, black and pink Strong to very strong		2.60																
4					1		100													
5					2		100													
6		End of Drillhole		141.30																
7		Note: Water level in open borehole at 4.3 m depth below ground surface upon completion of drilling		5.60																
8																				
9																				
10																				
11																				
12																				

DEPTH SCALE

1 : 50



LOGGED: PAH

CHECKED: SAT

MIS-RCK 001 0911211004-2000 (ROCK) GPJ GAL-MISS.GDT 06/06/12 JM

PROJECT 09-1121-1004		RECORD OF BOREHOLE No 10-10		1 OF 1 METRIC	
G.W.P. 4059-01-00		LOCATION N 5083440.7 ; E 242119.2		ORIGINATED BY PAH	
DIST _____ HWY 17		BOREHOLE TYPE Power Auger, 200mm Diam. Hollow Stem		COMPILED BY JM	
DATUM Geodetic		DATE April 23, 2010		CHECKED BY SAT	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)						
								20	40	60	80	100		W _P	W	W _L		
								○ UNCONFINED + FIELD VANE										
								● QUICK TRIAXIAL x REMOULDED										
148.9	GROUND SURFACE							20	40	60	80	100		25	50	75		GR SA SI CL
0.0	ASPHALTIC CONCRETE																	
0.2	ASPHALT and SAND and GRAVEL		1	A.S.														
148.4	Sand and gravel (BASE)																	
0.5	Brown																	
	SAND and GRAVEL, trace silt, with cobbles		2	SS	53		148							○				49 41 9 1
	Dense to very dense		3	SS	48		147											
	Red-brown and brown		4	SS	57		146											
	Moist		5	SS	44		145							○				60 34 6 0
			6	SS	51		144											
			7	SS	>100		143											
			8	SS	65		142											
143.0	SAND, some gravel and silt		9	SS	>100		141							○				14 73 13 0
5.9	Dense																	
	Brown																	
	Wet																	
			10	SS	52													
140.1	End of Borehole																	
8.8	Auger Refusal																	
	Note: Water level in open borehole at 7.0 m depth below ground surface upon completion of drilling																	

MIS-MTO 001 0911211004-2000.GPJ GAL-MISS.GDT 06/06/12 JM

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

JOB 72-11010

LOCATION Hwy.#17 'New' Sta. 413+20 o' 17' Rt.

ORIGINATED BY WU

W.P. 3-67-02

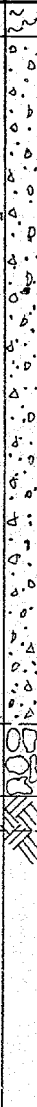

BORING DATE Jan. 18, 19 & 20, 1972

COMPILED BY RB

DATUM Geodetic

BOREHOLE TYPE Washboring-NX, BX Casing, BX Rock Core

CHECKED BY S.R.

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w				BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F.				WATER CONTENT % 10 20 30					
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE									
482.9	Ground Level															
481.9	Sandy Topsoil															
1.0	Sandy gravel to sand and gravel occ. boulders up to 5" in size below el. 472. Brown to Grey Loose to Very Dense Bouldery Zone (boulders up to 7" in size) Fractured Quartz Mica Gneiss Bedrock (Banded) (Interbeds of granite pegmatite up to 5" thick) Sound		1	SS	14	480										
			2	SS	9											
			3	SS	21	475										
			4	SS	57											
			5	SS	102	470										
			6	SS	100/4"											
			7	SS	130	465										
			8	SS	88											
			9	SS	80/5"	455										
			10	BX	40%											
28.7	Quartz Mica Gneiss Bedrock (Banded) (Interbeds of granite pegmatite up to 5" thick)		11	BX	86%	450										
			12	BX	90%		445									
442.6	Sound		13	BX	100%											
40.3	End of Borehole					440										

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 72-11010 LOCATION Hwy. 17 'New' Sta. 412 + 80 o/s 17' Lt. ORIGINATED BY WU
 W.P. 3-67-02 BORING DATE Jan. 18 & 19, 1972 COMPILED BY RB
 DATUM Geodetic BOREHOLE TYPE Washboring-NX, BX Casing-BX Rock Core CHECKED BY S.R.

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE				w_p — w — w_L WATER CONTENT % 10 20 30				
480.7	Ground Level														
0.0	Sandy Topsoil	~	1	SS	17	480									
1.0	Sand and gravel to sandy gravel	8 8													

FOUNDATION SECTION

ORIGINATED BY WU

COMPILED BY BTD

CHECKED BY _____


SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT		BULK DENSITY	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BLOWS / FOOT		WATER CONTENT %			
							SHEAR STRENGTH P.S.F.		WATER CONTENT %			
							DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT			
							BLOWS / FOOT		PLASTIC LIMIT			
							SHEAR STRENGTH P.S.F.		WATER CONTENT			
							○ UNCONFINED + FIELD VANE		W _p W W _L			
							● QUICK TRIAXIAL x LAB. VANE		WATER CONTENT %			
453.7	Ground Level		1	SS	26.7	450						P.C.F. 9875A, S.I. CI Jan. 31/72
0.0	Silly sand & gravel (occ. boulders up to 5" in size)		2	SS	50.4							
450.8	Very Dense		3	BX	74.1							
2.9	Quartz Mica Gneiss Bedrock (Banded)		4	BX	100%							
	minor thin granite interbeds.		5	BX	99%							
439.9	Sound					440						
13.8	End of Borehole					435						

FOUNDATION SECTION

ORIGINATED BY WU







COMPILED BY R14

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION		RESISTANCE		LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F. / G/CM ³ / A.S.T.M.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.				WATER CONTENT % w_p — w — w_L				
							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB. VANE							
451.0	Ground Level														
0.0	Silty sand & gravel (boulders up to 7" in size throughout)		1	BX	69%	450								Feb. 1/72	
	Compact to Very Dense		2	SS	29										
445.5	fractured		3	BX	59%	445									
5.5	Hornblende Biotite Gneiss Bedrock (Banded)		4	BX	77%										
	slightly weathered					440									
	Quartz Mica Gneiss Bedrock		5	BX	84%										
436.0	Sound														
15.0	End of Borehole					435									

FOUNDATION SECTION

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.				WATER CONTENT %				
							<div><div>○ UNCONFINED</div><div>● QUICK TRIAXIAL</div><div>+ FIELD VANE</div><div>x LAB. VANE</div></div>				<div><div>w_p</div><div>w</div><div>w_L</div></div>				
151.6	Ground Level														
0.0	Sandy Topsoil		1	SS	23	450								Feb. 2/72	
1.0	Silty sand & gravel to sand and gravel		2	SS	33										
	Brown to Grey		3	SS	10	445									
	Compact to Dense		4	SS	28										
439.2	Boundary Zone boulders to 9" in size					440									
12.4	Granite Pegmatite Bedrock		5	BX	89%										
	Sound		6	BX	100%										
	Quartz Mica Gneiss Bedrock		7	BX	100%	435									
432.2	Banded Sound														
19.4	End of Borehole					430									

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 6

FOUNDATION SECTION

JOB 72-11010

LOCATION Hwy. 17 'N' Sta. 410 + 25 o/s 10' Lt.

ORIGINATED BY ME

W.P. 3-67-02

BORING DATE Jan. 27, 1972

COMPILED BY BTD

DATUM Geodetic

BOREHOLE TYPE Washoring-BX Casing - BX Rock Core

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w				BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.				w_p ——— w ——— w_L WATER CONTENT %					
451.5	Ground Level															
0.0	Sandy Topsoil	2				450										
1.0	Silty sand & gravel to sand & gravel (boulders up to 9" in size throughout)	0.0 0.0														




















Jan. 27/72


DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 7

FOUNDATION SECTION

JOB A.O. 72-11010LOCATION Hwy. #17 "New" - Sta. 409+80, c/s 17' RT.ORIGINATED BY A.V.B.W.P. 3-67-02BORING DATE January 26, 1972.COMPILED BY R.W.B.DATUM GeodeticBOREHOLE TYPE Washboring - NX & BX Casing
EX Rock CoreCHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					w_p ——— w ——— w_L WATER CONTENT %				
456.5	Ground Elev.															
0.0	Sandy topsoil															
	Sand, with some gravel Dense		1	SS	48	455										
	Gravelly Sand to Sandy Gravel (Occasional boulders up to 4" in size throughout)		2	SS	100/2"											
																
																
																
			3	SS	60	450										
																
																
			4	SS	64											
																
						445										
443.0	Very Dense		5	SS	105											
13.5			6	BX	100%											
	Granite					440										
	Quartz Mica Gneiss Bedrock (Banded)		7	BX	100%											
																
			8	BX	100%	435										
432.8	Sound		9	BX	100%											

 Elev.
451.8
W.L.
In
Open
B.H.,
Jan. 27/72

Elev.
 451.8
 W.L.
 In
 Open
 B.H.,
 Jan. 27/72

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 8

FOUNDATION SECTION

JOB W.O. 72-11010

LOCATION Hwy. #17 'New' - Sta. 409+40, o/s 17' LT.

ORIGINATED BY B. Urle

W.P. 3-67-02

BORING DATE January 19, 1972.

COMPILED BY R.R.B.

DATUM Geodetic

BOREHOLE TYPE Washboring BX & NX Casing

CHECKED BY S.R.

BX Rock Core

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT — w_L				BULK DENSITY γ P.C.F.	REMARKS					
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BLOWS / FOOT				PLASTIC LIMIT — w_p					WATER CONTENT — w				
							SHEAR STRENGTH P.S.F.				WATER CONTENT %									
								<input type="radio"/> UNCONFINED	<input type="radio"/> + FIELD VANE											
								<input type="radio"/> QUICK TRIAXIAL	<input type="radio"/> x LAB. VANE											
457.5	Ground Level																			
0.0			1	SS	10															
			2	SS	10	1"	455												8 55 32 5	
	Bouldery Zone (Boulders up to 6" in Size)		3	BX	40%															
			4	BX	50%		450													
	Silty Sand to Sand with a trace to some gravel throughout		5	SS	23															
			6	SS	80															
	Compact to Very Dense		7	SS	76		445													
441.0			8	SS	47	1"														
16.5							440													
	Granite Pegmatite																			
	Quartz Mica Gneiss Bedrock (Banded)		9	BX	100%															
	Slightly Weathered		10	BX	50%		435													
			11	BX	100%		430													
427.7	Sound																			
29.8	End of B.H.						425													

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

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

