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## REPORT ON

# FOUNDATION INVESTIGATION AND DESIGN REPORT CNR BRIDGE REHABILITATION AND WIDENING HIGHWAY 401, KINGSTON, ONTARIO G.W.P. 78-99-00

**Submitted to:**  
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REPORT



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**PART A**

**FOUNDATION INVESTIGATION REPORT  
CNR BRIDGE REHABILITATION/WIDENING  
KINGSTON, ONTARIO  
G.W.P. 78-99-00**



### 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin Corporation on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation associated with the Highway 401 expansion in Kingston, Ontario. The section of Highway 401 included in this assignment (G.W.P. 78-99-00) extends from Montreal Street to about 1.8 kilometres east of the Canadian National Railway (CNR) structure.

Foundation investigation services are required for the following components:

- CNR bridge rehabilitation/widening;
- Highway 401 embankment widening – Cataraqui wetlands;
- Montreal Street Underpass replacement;
- Overhead signs (total of 2); and,
- Noise Barrier Wall.

This report addresses the CNR bridge rehabilitation/widening component (W.P. 4015-06-01), Geocres Number 31C-202.

The terms of reference for the original scope of work are outlined in the MTO's Request for Proposal (RFP) dated April 2008. The work was carried out in accordance with Golder's Quality Control Plan dated November 2008.



## 2.0 SITE DESCRIPTION

The existing Highway 401 structure included in this assignment (G.W.P. 78-99-00) carries Highway 401 over the CNR line (Mile 171.10 of the Kingston Subdivision) and is located about 310 m east of the Montreal Street interchange in Kingston, Ontario.

Through this area, Highway 401 is a four lane divided highway with a rural cross-section. The highway profile grade over the CNR bridge structure varies from west to east from about elevation 87.8 to 86.3 m (i.e., grade declining eastward). The existing bridge, which was constructed in 1954, consists of a three span cast-in-place concrete girder structure on concrete abutments and pier. Information provided by MTO at the proposal stage indicated that the west abutment and west pier are founded on spread footings on bedrock, and that the east abutment and pier are founded on piles driven to bedrock. This information is consistent with information shown on Department of Highways Bridge Office drawings (dated April 1953, originally numbered D3349-1 though D3349-11) which were obtained by MRC and provided to Golder.

The CNR Kingston Subdivision crosses beneath the Highway 401 structure with top of rail at an elevation of about 78 m. The railway has two tracks at this crossing, with space for a third track on the west side.

No GEOCRETS information is available for this structure.

To the west, adjacent to the bridge structure, rock outcrops exist that are up to about 9 m high relative to the existing bridge deck. To the east, the existing approach embankments are up to about 10 m high relative to the surrounding natural ground surface and have approximately 1.5 horizontal to 1 vertical (1.5H:1V) side slopes. No signs of embankment instability were observed.

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



### 3.0 INVESTIGATION PROCEDURES

A subsurface investigation was carried out at the proposed CNR bridge structure and approach embankment locations between June 8 and September 16, 2009, at which time ten (10) boreholes (numbered B1 to B10, inclusive) were advanced at the locations shown on Drawings 1 and 2. The borehole locations were selected as follows:

#### Approach Embankments:

- One borehole (numbered B5) located at the west approach, about 20 m west of the existing westbound lane abutment, extending through the overburden and then cored 3.3 m into bedrock; and,
- One borehole (numbered B10) located at the east approach embankment; about 20 m east of the existing westbound lane abutment, extending through the existing rock fill embankment plus a depth equivalent to the existing embankment height (i.e., 10 m) below the base of the rock fill.

#### Abutments:

- Two boreholes (numbered B1 and B6) located at the west abutment, one on each side of the existing abutment, extending through the road base and rock fills and then cored 3 m into bedrock; and,
- Two boreholes (numbered B4 and B9) located at the east abutment, one on each side of the existing abutment, extending through the embankment rock fills, native silty clay and till, and then cored 2.6 and 3.1 m into bedrock, respectively.

#### Piers:

- Two boreholes (numbered B2 and B7) located west of the west pier, one on each side of the existing pier, extending through the overburden and then cored 3.6 and 3.1 m into bedrock, respectively; and,
- Two boreholes (numbered B3 and B8) located at the east pier location, one on each side of the existing pier, extending through the overburden and then cored 3.7 and 2.8 m into bedrock, respectively.

The boreholes were located within 5 m of the proposed bridge foundation locations, with the exception of B7 which was put down 5.7 m west of the west pier centreline.

The three boreholes advanced for the east abutment and the east approach embankment (i.e., boreholes B4, B9, and B10) were advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers on a truck-mounted drill rig (boreholes located on highway), supplied and operated by Marathon Drilling Ltd. of Ottawa, Ontario. The boreholes were advanced to depths ranging from 21.8 to 25.9 m below the existing roadway surface.

The remaining boreholes were advanced using portable/manual drilling equipment supplied and operated by OGS Drilling Services of Appleton, Ontario. The boreholes were advanced to depths ranging from 5.7 to 17.9 m below the existing ground surface.





Soil samples were obtained nearly continuously during the portable drilling, and at intervals of 0.75 m to 1.5 m of depth using the truck-mounted drill rig, using a 50 mm outer diameter (O.D.) split-spoon sampler. Where possible, the split spoon was advanced in accordance with Standard Penetration Test (SPT) ASTM D1586 procedures. At boreholes B1, B5, and B6, where access constraints did not permit use of a tripod above the hole, a one-third weight hammer was used and blow counts were adjusted accordingly to correlate with SPT values. In-situ vane testing (N vane) was carried out within the cohesive deposits where possible. Relatively undisturbed, 75 mm diameter thin-walled Shelby tube (ASTM D1587) samples of the cohesive soils were retrieved using a fixed piston sampler where possible.

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

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 samples. The soil samples were identified in the field, placed in appropriate containers, labelled, and transported to our Ottawa geotechnical laboratory where the samples underwent further detailed visual examination and laboratory testing, including grain size distribution, water content, and Atterberg limit testing. Laboratory tests were carried out to MTO and/or ASTM Standards as appropriate.

In addition, laboratory point load index and unconfined compressive strength testing was carried out on selected samples of the bedrock core, and laboratory oedometer consolidation testing (ASTM D2435) was carried out on two specimens of the Shelby tube samples of the silty clay deposit from boreholes B4 and B8 at Golder's Mississauga geotechnical laboratory.

The borehole locations and ground surface elevations were determined by Golder personnel at the site using a Trimble R8 GPS unit. The borehole locations, including MTM NAD83 northing and easting coordinates and ground surface elevations referenced to geodetic datum, are summarized in the following table and are shown on Drawing 1.

Borehole No.	Borehole Location	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)
B1	Proposed eastbound lane, west abutment	4904268.6	307188.1	87.6
B2	Proposed eastbound lane, west pier	4904273.3	307205.4	80.4
B3	Proposed eastbound lane, east pier	4904280.6	307230.6	77.3
B4	Existing eastbound lane, east abutment	4904295.2	307258.3	86.4
B5	Proposed westbound lane, west approach embankment	4904302.4	307197.7	87.8
B6	Proposed westbound lane, west abutment	4904304.2	307204.2	87.5
B7	Proposed westbound lane, west pier	4904318.2	307227.7	79.7
B8	Proposed westbound lane, east pier	4904323.6	307254.3	78.5



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Borehole No.	Borehole Location	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)
B9	Existing westbound lane, east abutment	4904324.4	307274.6	86.0
B10	Existing westbound lane, east approach embankment	4904329.3	307288.8	85.6



## 4.0 SITE GEOLOGY AND STRATIGRAPHY

### 4.1 Regional Geological Conditions

The site is located in the southern portion of the physiographic region known as the Napanee Plain, and just west of the Leeds Knobs and Flats, as delineated in *The Physiography of Southern Ontario*<sup>1</sup>.

The Napanee Plain is flat to undulating, and is characterized by relatively shallow soil deposits overlying bedrock. Geologic mapping<sup>2</sup> indicates that the bedrock within the Napanee Plain consists of grey limestone/dolostone of the Gull River Formation (of the Trenton-Black River Group), which contains some shale partings and seams. The limestone/dolostone is underlain by arkosic sandstone of the Shadow Lake Formation.

The overburden soils within the Napanee Plain generally consist of glacial till, although alluvium is present in river and stream valleys and, in the southern portion of the Plain, low-lying areas are typically covered with deposits of stratified clay. Well records indicate that the average depth to bedrock within the Napanee Plain is approximately 2 m. However, in many areas bedrock outcrops exist at ground surface, while deeper soil deposits (on the order of 10 m) are present in the northern and southern portion of the Plain, and within and adjacent to river valleys throughout the Plain.

The Leeds Knobs and Flats are characterized by knobs of Precambrian rock (i.e., Limestone Plain) surrounded by clay flats (i.e., Clay Plain). The clay is grey in colour, and very weakly calcareous.

In particular, the study area lies within the western limits of the Cataraqui River. The Cataraqui River is characterized by a number of lakes joined by the river. This river flows southerly towards Kingston.

### 4.2 Site Stratigraphy

The detailed subsurface soil, bedrock, and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil and bedrock core samples, are given on the attached Record of Borehole sheets and on Figures 1 to 11.

The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and in-situ testing 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.

The borehole locations and ground surface elevations are shown on Drawing 1.

In summary, the subsurface conditions encountered consist of up to about 13.7 m of fill material at the boreholes located at the proposed east approach embankment and east abutment locations, and up to about 7.3 m of fill material at the other borehole locations. The fill is generally underlain by up to about 10.7 m of silty clay, with the exception of boreholes B1, B5, and B6, which are located on the western portion of the site. Up to 7.1 m of limestone rock slabs were encountered beneath the silty clay in the boreholes advanced at the proposed west pier locations. The fill and/or silty clay is generally underlain by a thin silty sand matrix till deposit. Bedrock was encountered at depths of 2.4 to 3.7 m below existing ground surface at boreholes located at the proposed west

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

<sup>2</sup> Map 2544, Ministry of Northern Development and Mines, 1991.



approach embankment and west abutment locations (i.e., elevations of 83.8 to 85.4 m), and at depths of 11.8 to 23.3 m below existing ground surface at the other borehole locations (i.e., elevations of 63.1 to 66.3 m).

A more detailed description of the subsurface conditions encountered in the boreholes carried out at the site of the proposed bridge structure is provided in the following sections, and stratigraphic profiles and sections of this site are shown on Drawings 1 to 4.

### 4.2.1 Pavement Structure / Embankment and Grade Fill

The pavement structure was penetrated by borehole B4 on the south shoulder of the eastbound lanes of Highway 401 and at boreholes B9 and B10 located on the north shoulder of the westbound lanes. The pavement structure ranges from approximately 0.9 to 1.5 m in thickness and is generally comprised of 0.3 to 0.4 m of asphaltic concrete (i.e., asphalt), overlying crushed stone and sand and gravel base materials.

Beneath the pavement structure at boreholes B4, B9 and B10, and at ground surface at the other borehole locations, embankment and/or grade fill was encountered. The fill was fully penetrated at each borehole location and varies in thickness and in composition throughout the site. At the east approach embankment and east abutment locations (i.e., boreholes B4, B9, and B10), the embankment fill beneath the pavement structure ranges in thickness from 9.2 to 12.2 m. At the other borehole locations, the embankment and/or grade fill ranges in thickness from 2.4 to 5.3 m. The variable fill thickness reflects, in part, the differing native ground surface elevations at the borehole locations which vary from about elevation 96.0 m at the west approach (where the road is in cut) to about elevation 75.0 m beneath the east approach embankment fills. Portions of the fill may have been placed in association with the initial construction of the CNR tracks while the remainder was likely associated with construction of the existing Highway 401.

The embankment and grade fill material generally consists of variable amounts of rock fill, sand and gravel, silty sand, and sand fill. Layers of silty clay and silt fill were encountered at boreholes B2, B3, B4, and B7. Cobbles and boulders were also inferred to be present within the fill. Diamond drilling techniques were required to penetrate the rock fill, cobbles, boulders, and/or limestone slabs in five of the boreholes advanced using portable/manual drilling equipment.

The results of grain size distribution testing carried out on samples of the embankment and grade fill are provided on Figures 1 to 3. The results have been sorted/reported according to the fill material type in accordance with the descriptions on the Record of Borehole sheets, rather than according to the specific gradation of each sample, recognizing that there are natural variations in the material from the generalized descriptions on the borehole records. The results also do not reflect the cobble, boulder, or coarse gravel contents of the material, since the samples were retrieved using a 50 mm diameter sampler.

Standard Penetration Test 'N' values for the embankment fill ranging from 3 to greater than 50 blows per 0.3 m of penetration indicate that the material ranges in consistency from very loose to very dense, although the soil is generally loose to compact, with the higher 'N' values likely reflecting the presence of cobbles and boulders, rather than the state of packing of the soil matrix.

The measured water content of samples of predominantly granular fill ranges from approximately 3 to 13 percent. The measured water content of three samples of the more silty/clayey fill from boreholes B4 and B7 ranged from about 27 to 31 percent.



#### **4.2.2 Silty Clay to Clay**

On the east part of the site, the embankment fill at boreholes B2 to B4, and B7 to B10, is underlain by a deposit of sensitive silty clay to clay.

The silty clay was fully penetrated at each borehole location and varies in thickness from about 1.0 to 10.7 m, though the deposit is thicker to the east of the CNR tracks (i.e., 7.9 to 10.7 m thick). On the west side of the CNR tracks, where the clay was encountered only at boreholes B2 and B7, the silty clay is 2.2 and 1.0 m thick, respectively.

The results of grain size distribution testing carried out on samples of the silty clay are provided on Figure 4.

The upper portion of the silty clay at boreholes put down east of the CNR tracks and the full thickness of silty clay at boreholes put down west of the CNR tracks has been weathered to a grey brown colour. Where encountered, the thickness of the weathered crust ranges from 1.0 to 6.3 m. Standard Penetration Tests carried out within the weathered silty clay gave 'N' values ranging from 4 to 72 blows per 0.3 m of penetration, however most readings ranged from 8 to 30 blows per 0.3 m of penetration, indicating a generally stiff to very stiff consistency.

Unweathered (i.e., grey in colour) silty clay was encountered at the boreholes east of the tracks (i.e., boreholes B3, B4, and B8 to B10, inclusive) below the upper weathered silty clay. This unweathered silty clay ranges from about 1.2 to 6.3 m in thickness (i.e., extends to elevations of between 64.2 to 66.9 m) and contains occasional silty sand and sand seams. The measured SPT "N" values within this deposit ranged between 'weight of hammer' and about 5 blows per 0.3 m of penetration. In situ vane testing in this material measured undrained shear strengths ranging from about 20 to greater than 80 kilopascals. These results indicate a generally soft to stiff consistency.

The results of Atterberg limit testing carried out on fourteen samples of the silty clay are shown on Figure 5 and indicate plasticity index values generally ranging from 16 to 36 percent and liquid limit values ranging from 35 to 63 percent, reflecting intermediate to high plasticity (i.e., silty clay to clay). The measured water content of the unweathered grey silty clay ranges from approximately 31 to 58 percent, which is generally close to the measured liquid limit. The measured water content of the weathered silty clay ranges from approximately 18 to 42 percent, and is generally below the measured liquid limit. In one case, the measured water content of the weathered silty clay was at the measured liquid limit.

Oedometer consolidation testing was carried out on specimens from two thin-walled Shelby tube samples of the silty clay. The results of that testing are provided on Figures 6 and 7 and are summarized in the table below. The results indicate that the silty clay at the east pier location (borehole B8, put down at the toe of the embankment) is close to normally consolidated, having an overconsolidation ratio of about 1.1, which would be expected given its loading history and location relative to the existing embankment. Results of consolidation testing of the silty clay at the east abutment (borehole B4, put down at the top of the east approach embankment) indicate that the sample is linear elastic in its response to increased loading, with a constant void ratio (e) to load (p) rate of -0.00107/kPa for loads up to 600 kPa.



Borehole/ Sample No.	Sample Depth / Elev. (m)	Unit Weight (kN/m <sup>3</sup> )	$\sigma_p'$ (kPa)	$\sigma_{vo}'$ (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	$C_c$	$C_r$	$e_o$	OCR	$C_y$ (cm <sup>2</sup> /s)
B4 / 16 <sup>(1)</sup>	19.3 / 67.1	19.3	n/a	260	n/a	0.29	0.033	0.85	n/a	0.014
B8 / 12	10.6 / 67.9	18.4	130	117	13	0.47	0.053	1.07	1.1	0.0038

<sup>(1)</sup> Sample may have been disturbed.

## Notes:

- $\sigma_p'$  - Apparent preconsolidation pressure
- $\sigma_{vo}'$  - Computed existing vertical effective stress
- $C_c$  - Compression index
- $C_r$  - Recompression index
- $e_o$  - Initial void ratio
- OCR - Overconsolidation ratio
- $C_v$  - Coefficient of consolidation

## 4.2.3 Silty Sand Till

At boreholes located east of the CNR tracks (i.e., boreholes B3, B4, and B8 to B10, inclusive), the fill and/or silty clay are underlain by till. The till generally consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of silty sand with traces of clay.

The surface of the till varies from about elevation 64.2 to 66.9 m. The till was fully penetrated at boreholes B3, B4, B8, and B9 and varied in thickness from 0.1 to 1.4 m, extending down to elevations varying from 63.1 to 65.5 m. The till at borehole B10 was not fully penetrated, but proven for a thickness of 0.8 m (i.e., extending down to elevation 63.9 m).

Results of grain size distribution testing carried out on three samples of the till (Figure 8) confirm that the till matrix generally consists of a silty sand with variable amounts of gravel and typically trace amounts of clay. These samples were retrieved using a 50 mm diameter sampler and therefore the results do not reflect the coarse gravel, cobble and boulder content of the deposit.

Standard Penetration Test 'N' values for this material ranging from 22 to greater than 65 blows per 0.3 m of penetration indicate a compact to very dense state of packing, although the higher 'N' values could reflect the presence of coarse gravel, cobbles and boulders, rather than the state of packing of the soil matrix.

The measured water content of the till ranges from approximately 11 to 12 percent.

## 4.2.4 Limestone Rock Slabs

Limestone rock slabs were encountered beneath weathered silty clay at the two boreholes (B2 and B7) advanced for the pier west of the CNR tracks. Diamond drilling techniques were required to penetrate the rock slabs. Numerous voids or loose soil infilled seams were encountered during the diamond drilling, as shown on the Record of Borehole sheets. Furthermore, a layer of cobbles, boulders and silty clay was encountered beneath the rock slabs at borehole B7.



The limestone rock slabs were fully penetrated at boreholes B2 and B7 and varied in thickness from 7.0 to 7.1 metres, extending down to elevation 66.2 m and 66.3 m, respectively.

#### **4.2.5 Refusal and Bedrock**

Bedrock was encountered beneath the embankment fill, silty clay, glacial till and/or limestone slabs, and cored for about 3 m depth, at boreholes B1 through B9. At borehole B10, which was advanced at the location of the east approach embankment, refusal to augering was encountered at about elevation 63.9 m. Refusal may indicate the bedrock surface; however, it could also represent cobbles and/or boulders within the glacial till.

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

<b>Location</b>	<b>Borehole Number</b>	<b>Existing Ground Surface Elevation (m)</b>	<b>Depth to Bedrock (m)</b>	<b>Bedrock Surface Elevation (m)</b>
West Approach – North	B5	87.8	2.4	85.4
West Abutment – South	B1	87.6	3.3	84.3
West Abutment – North	B6	87.5	3.7	83.8
West Pier – South	B2	80.4	14.3	66.2
West Pier – North	B7	79.7	13.4	66.3
East Pier – South	B3	77.3	11.8	65.5
East Pier – North	B8	78.5	13.6	64.9
East Abutment – South	B4	86.4	23.3	63.1
East Abutment – North	B9	86.0	21.5	64.5

At the location of the west abutment – north (westbound widening), available data suggests that the bedrock surface continues to drop towards the east from borehole B6.

The bedrock encountered in boreholes B1 to B7 consists of grey, greenish grey and reddish grey interbedded limestone and dolomitic limestone. The bedrock is fresh to weathered, medium strong and laminated to medium bedded. The Rock Quality Designation (RQD) values measured on recovered limestone and dolomitic limestone bedrock core samples were quite variable and ranged from 0 to 86 percent, indicating a very poor to excellent quality rock. However the RQD values were generally found to increase with depth. The discontinuities observed in the rock core are typically horizontal, associated with the bedding planes.

Laboratory point load index testing was carried out on nine selected specimens of limestone and dolomitic limestone core. Unconfined compressive strengths (UCS) interpreted from the point load index testing ranged widely from 14 to 199 MPa. Laboratory unconfined compressive strength testing carried out on an additional three samples of limestone indicate UCS values ranging from about 40 to 64 MPa. The results are summarized on Figure 9.





Beneath the limestone and/or dolomitic limestone at boreholes B3 and B4, and the bedrock encountered in boreholes B8 and B9 is grey, red, reddish grey, and greenish grey arkosic sandstone of the Shadow Lakes Formation. The sandstone was encountered at the boreholes east of the tracks, at elevations ranging from 62.8 to 64.9 m. The bedrock is fresh to slightly weathered, medium strong and fine to coarse grained. The Rock Quality Designation (RQD) values measured on recovered sandstone bedrock core samples were quite variable and ranged from about 47 to 100 percent, indicating a fair to excellent quality rock.

Laboratory point load index testing carried out on six selected specimens and laboratory unconfined compressive strength testing carried out on one selected specimen of the sandstone indicate that the unconfined compressive strengths range widely from 49 to 248 MPa. Results are summarized on Figure 10.

Precambrian bedrock was encountered beneath the sandstone at borehole B8. The red, grey and black rock is fresh and medium strong. The Rock Quality Designation (RQD) value measured on one recovered sample of Precambrian bedrock core sample was 38 percent, indicating a poor quality rock. Laboratory point load index testing carried out on one selected specimen from the Precambrian bedrock core indicates an interpreted compressive strength of about 197 MPa (see Figure 11).

### 4.3 Groundwater Conditions

The groundwater levels in the piezometers in boreholes B2, and B3 were measured on September 29, 2009. The observed groundwater levels are summarized in the table below:

Borehole Number	Existing Ground Surface Elevation (m)	Water Level Depth (m)	Water Level Elevation (m)
B2	80.4	4.3	76.1
B3	77.3	0.9	76.4

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





## 5.0 CLOSURE

This report was prepared by Ms. Erin O'Neill, P.Eng., under the direction of the Project Manager, Mr. Michael Snow, P.Eng., Mr. Fintan Heffernan, P.Eng., Golder's Designated MTO Contact for this project, conducted a technical and independent quality control review of the report.

### GOLDER ASSOCIATES LTD.

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Geotechnical Engineer

Michael Snow, P. Eng.  
Principal

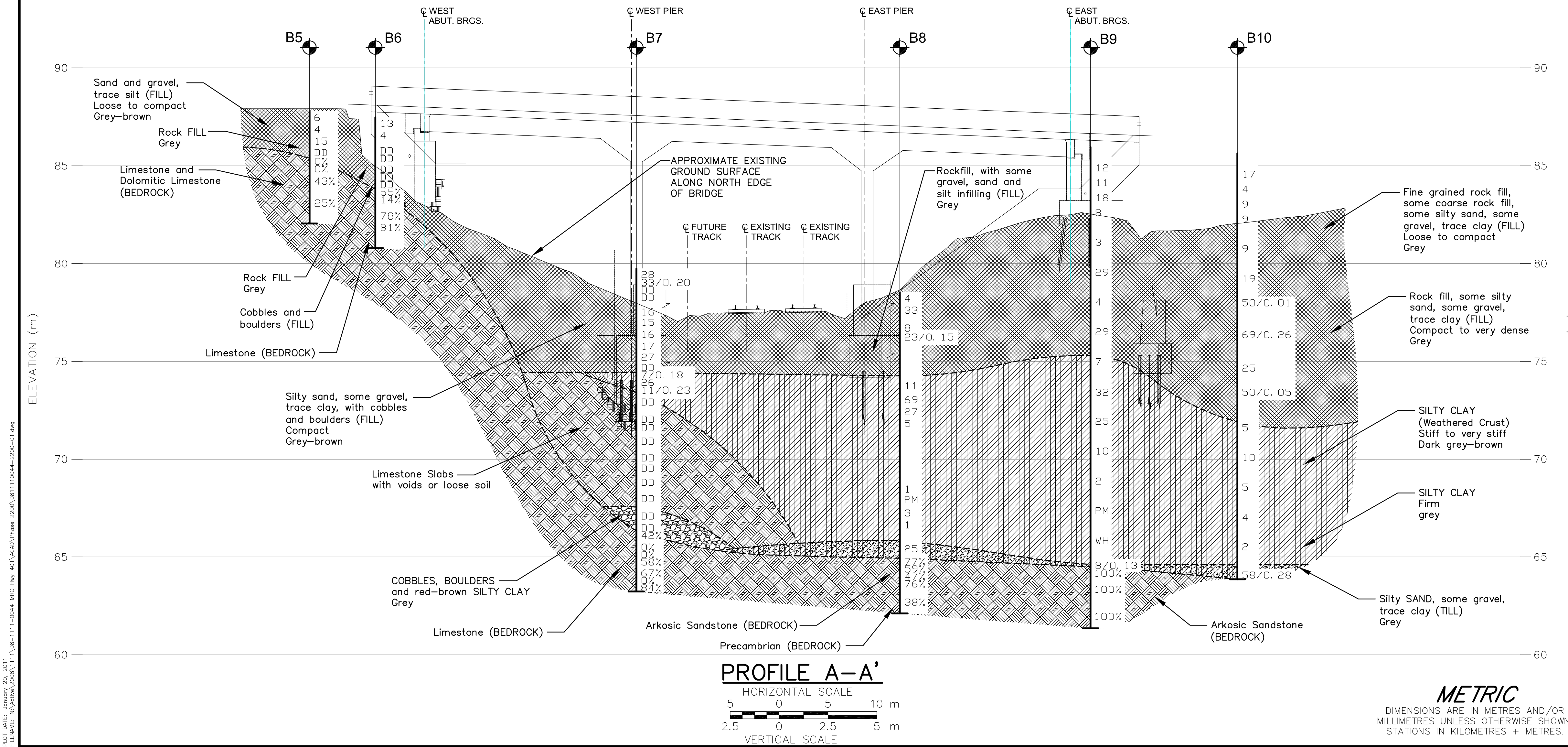
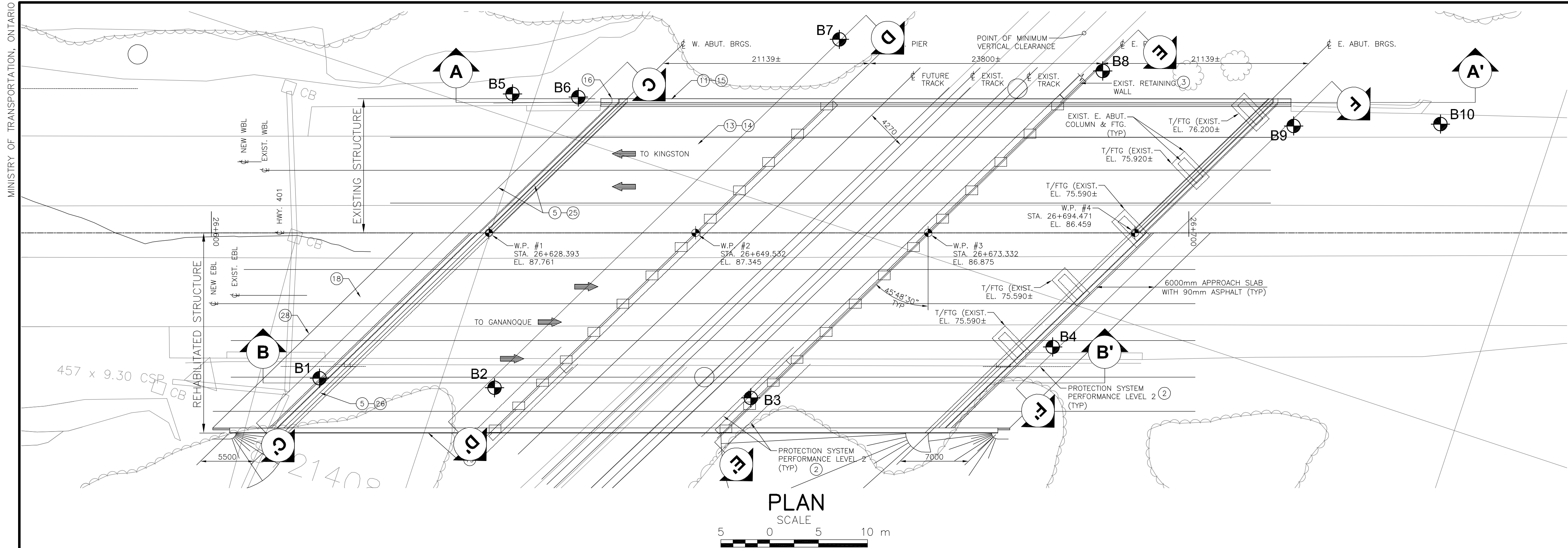
Fintan Heffernan, P.Eng.  
Designated MTO Contact



ESO/MSS/FJH/am/tm

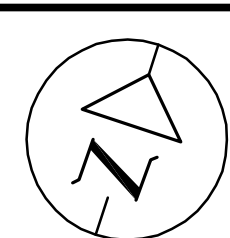
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CONT No.  
WP No. 78-99-01

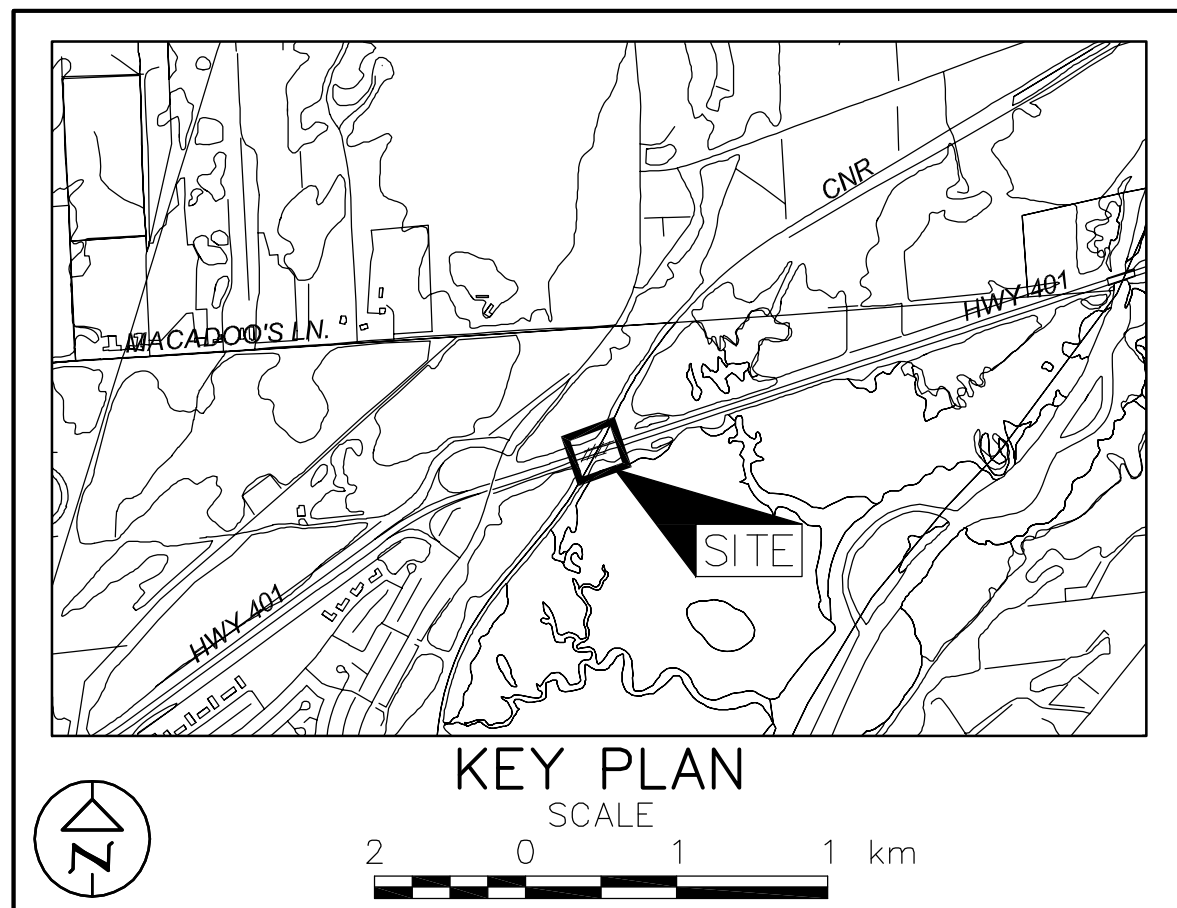
C.N.R. OVERHEAD  
HIGHWAY 401  
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



Golder Associates Ltd.  
OTTAWA, ONTARIO, CANADA



LEGEND

Borehole – Current Investigation

Standard Penetration Test Value

Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)

Rock quality designation

Seal

Piezometer

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
B1	87.6	4904268.6	307188.1
B2	80.4	4904273.3	307205.4
B3	77.3	4904280.6	307230.6
B4	86.4	4904295.2	307258.3
B5	87.8	4904302.4	307197.7
B6	87.5	4904304.2	307204.2
B7	79.7	4904318.2	307227.7
B8	78.5	4904323.6	307254.3
B9	86.0	4904324.4	307274.6
B10	85.6	4904329.3	307288.8

NOTES

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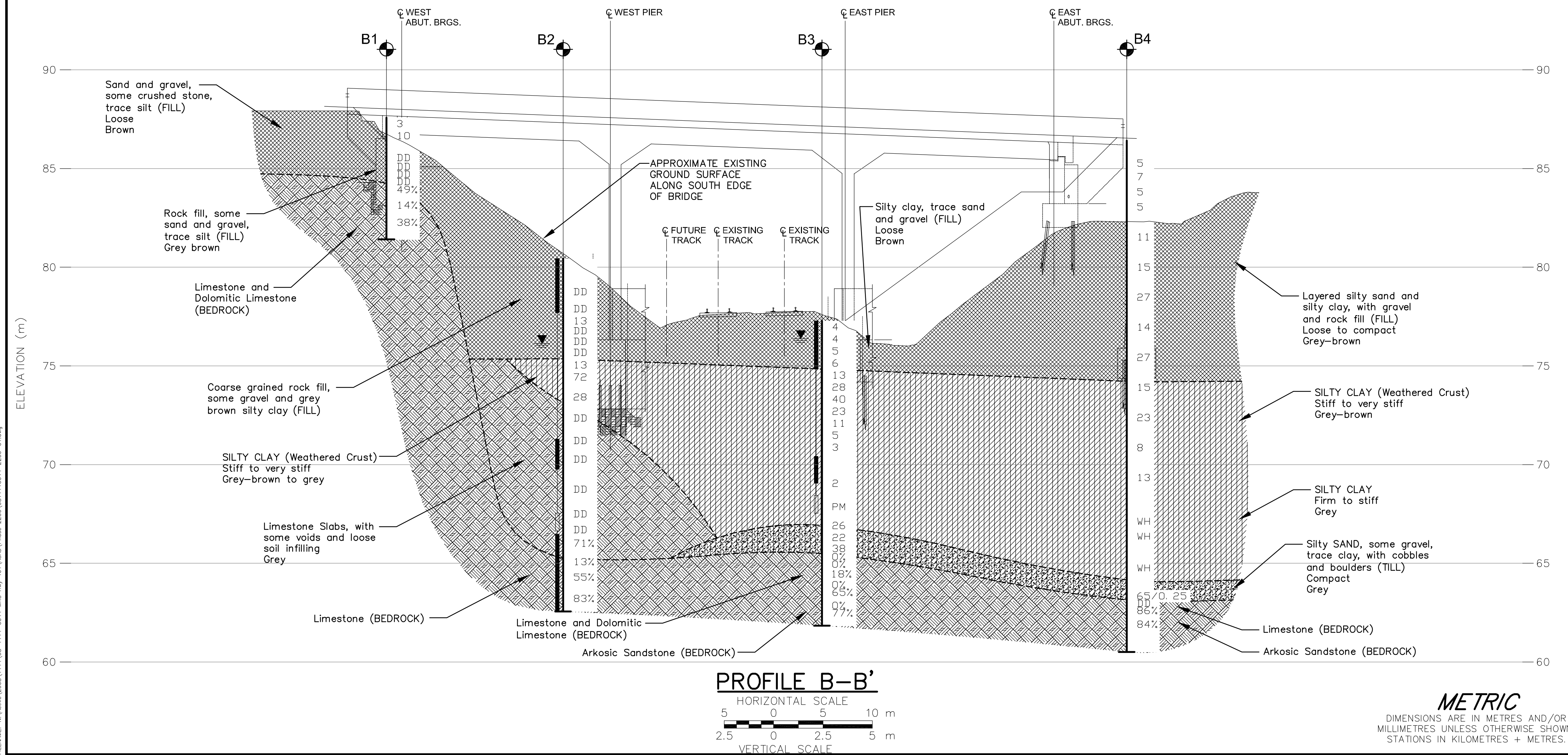
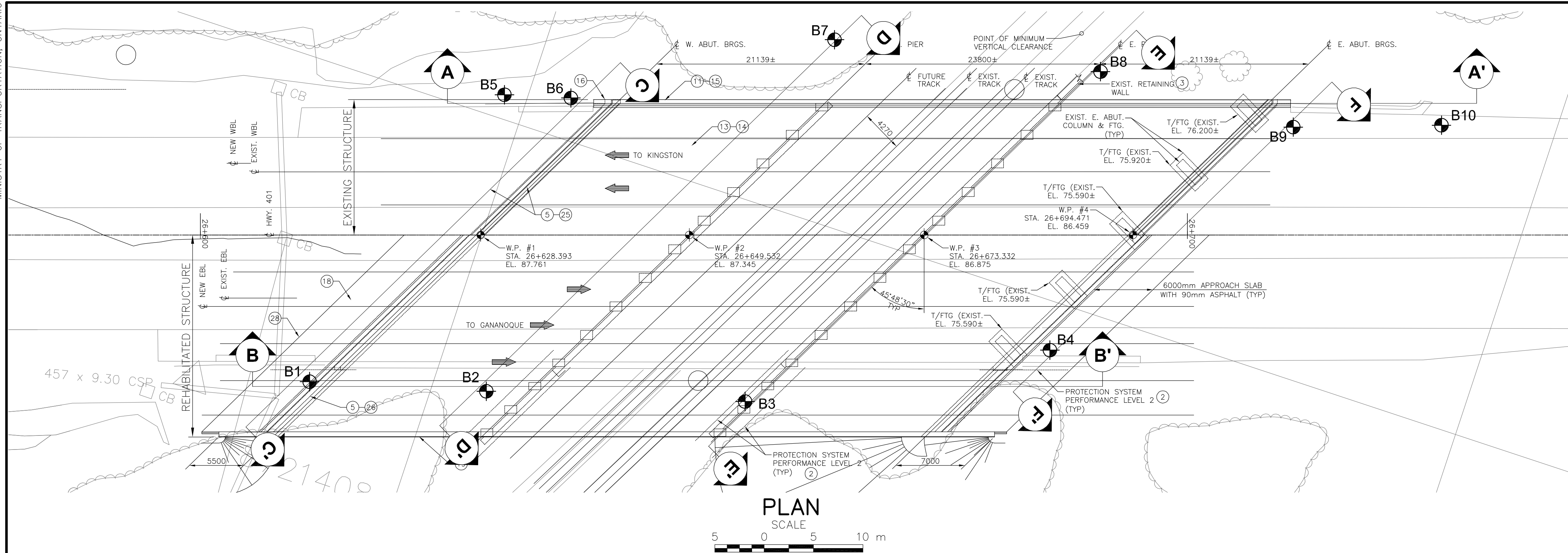
The complete Preliminary Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section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

REFERENCE

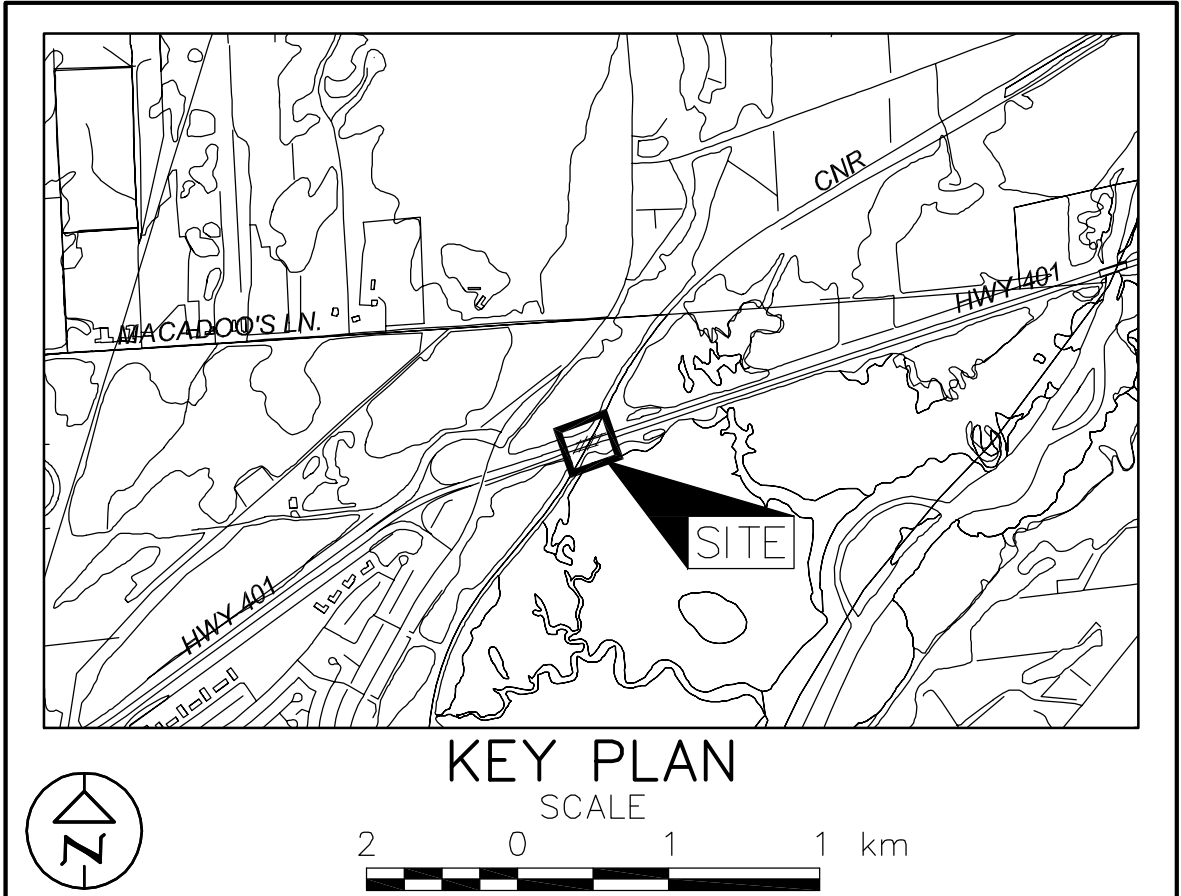
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NO.	DATE	BY	REVISION
Geocres No. 31C-202			
HWY. 401	PROJECT NO. 08-1111-0044		DIST.
SUBM'D. EO	CHKD. MSS	DATE: 1/20/2011	SITE:
DRAWN: JM	CHKD. MSS	APPD. FJH	DWG. 1



CONT No.  
WP No. 78-99-01C.N.R. OVERHEAD  
HIGHWAY 401  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates Ltd.  
OTTAWA, ONTARIO, CANADA

## LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock quality designation
- Seal
- Piezometer
- WL in piezometer on Sept. 29, 2009

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
B1	87.6	4904268.6	307188.1
B2	80.4	4904273.3	307205.4
B3	77.3	4904280.6	307230.6
B4	86.4	4904295.2	307258.3
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## REFERENCE

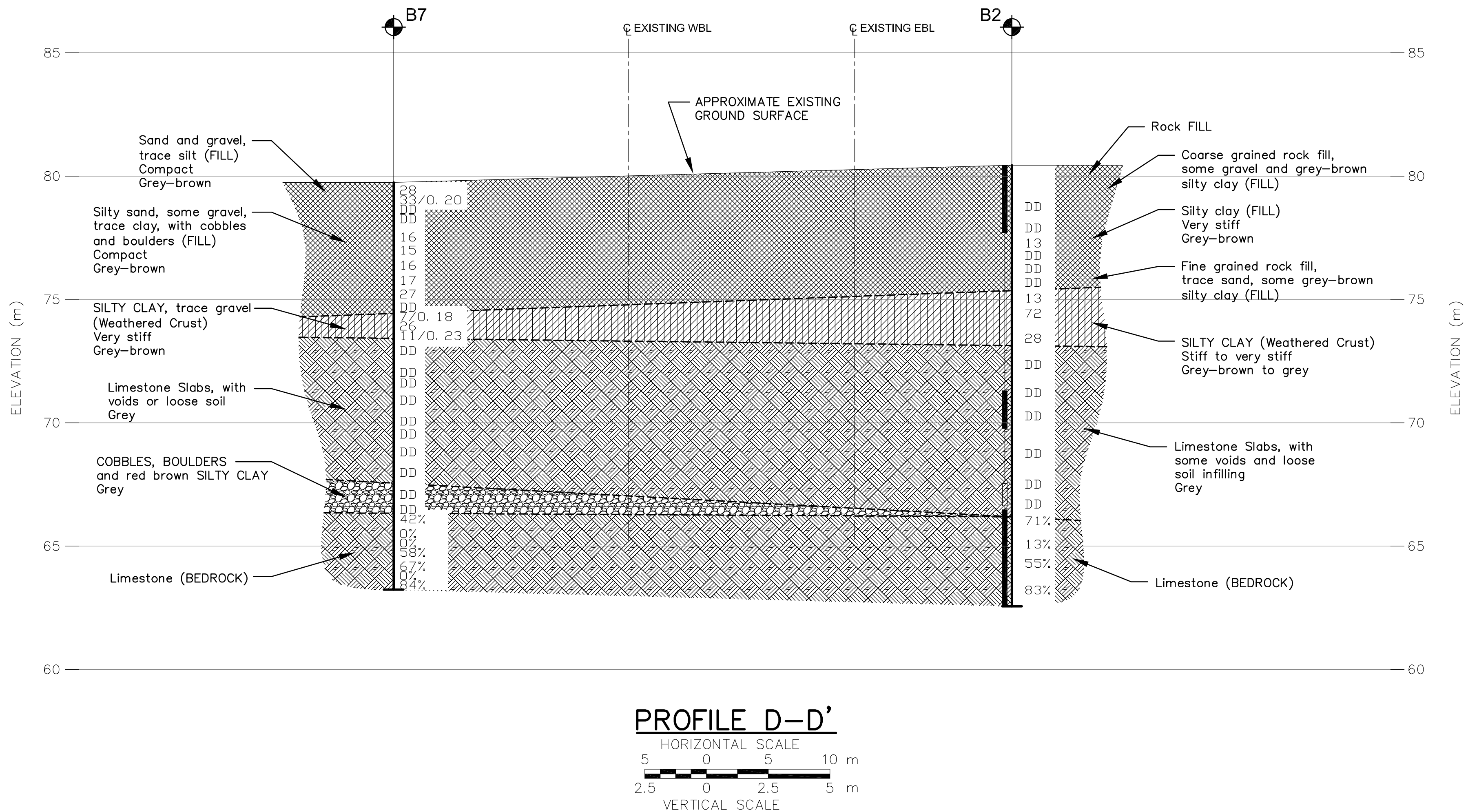
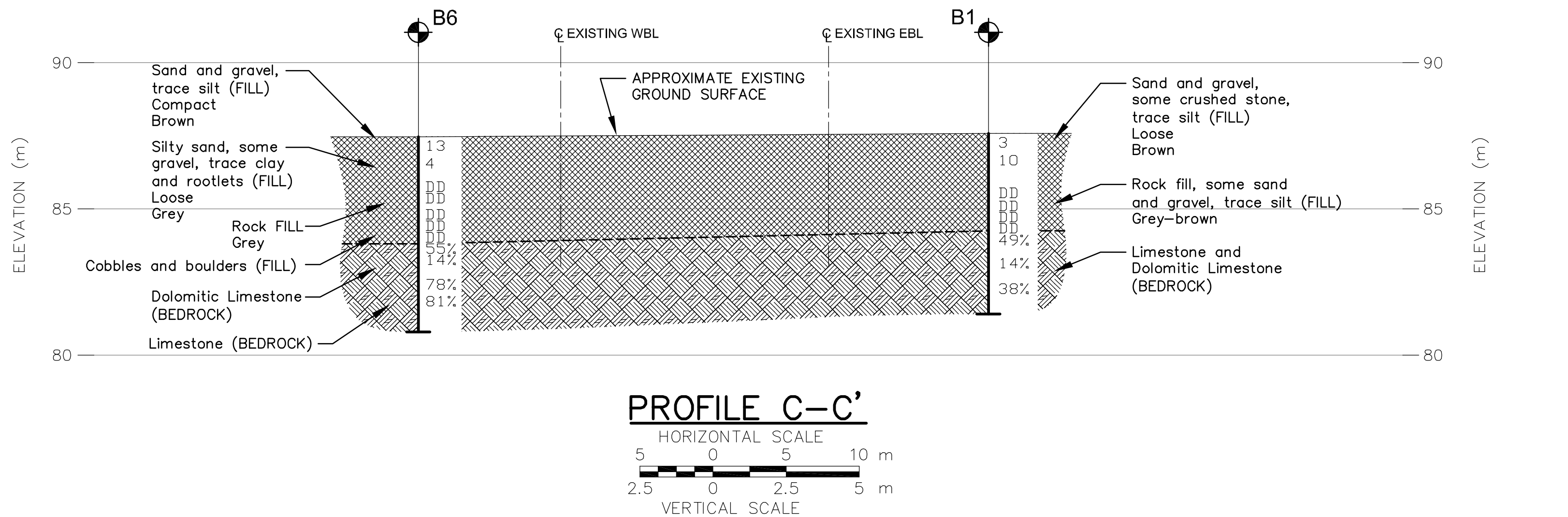
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SUBM'D. EO	CHKD. MSS	DATE: 1/20/2011	SITE:
DRAWN: JM	CHKD. MSS	APPD. FJH	DWG. 2

METRIC

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





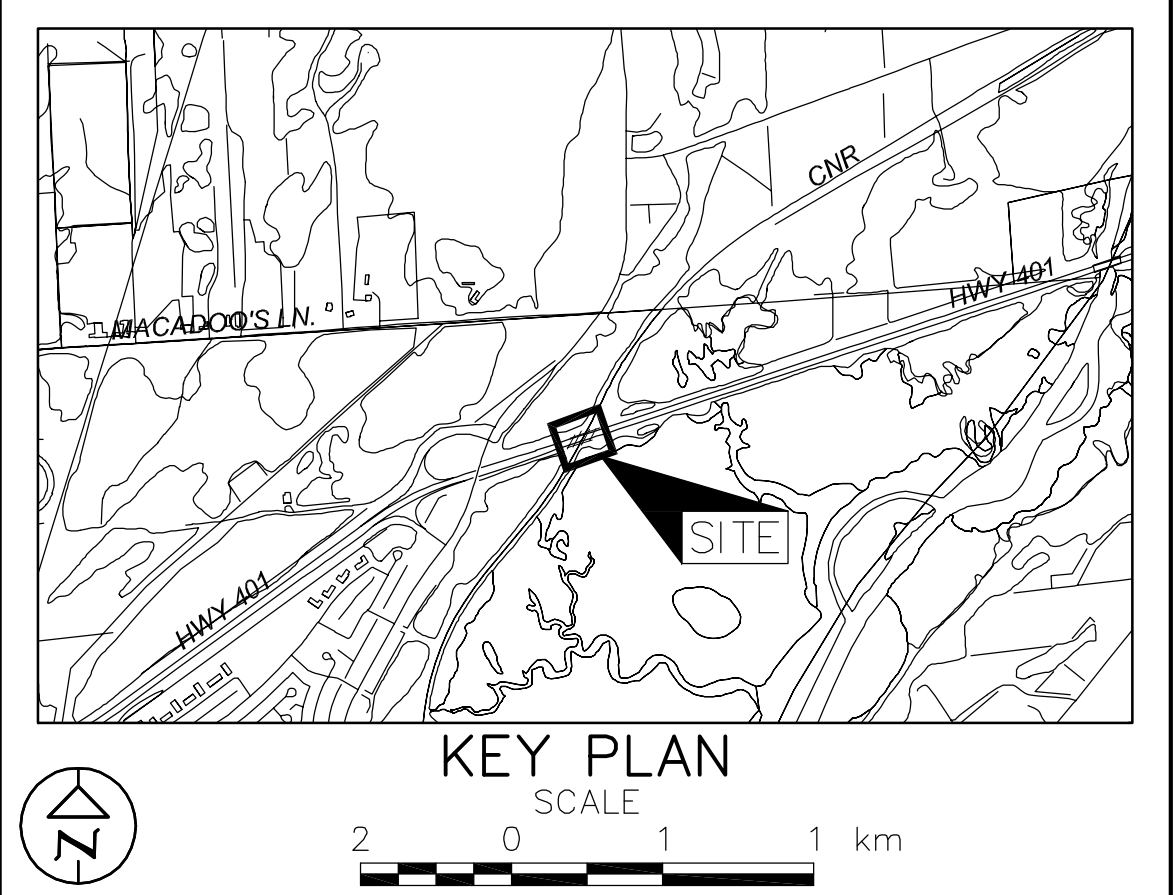
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WP No. 78-99-01

C.N.R. OVERHEAD  
HIGHWAY 401  
SOIL STRATA

SHEET



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



#### LEGEND

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- 100% Rock quality designation
- Seal
- Piezometer
- WL in piezometer on Sept. 29, 2009

No.	ELEVATION	CO-ORDINATES	
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#### REFERENCE

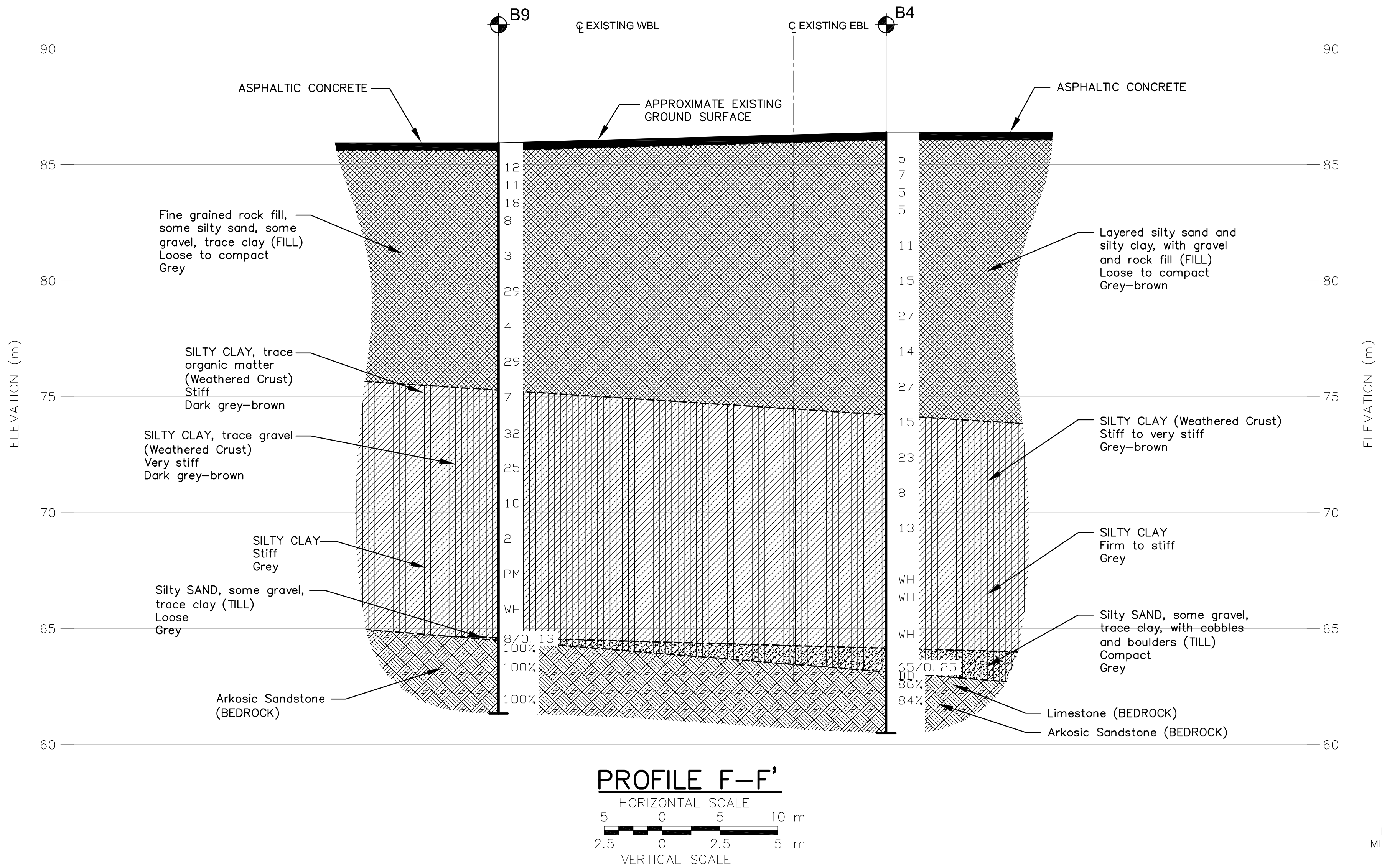
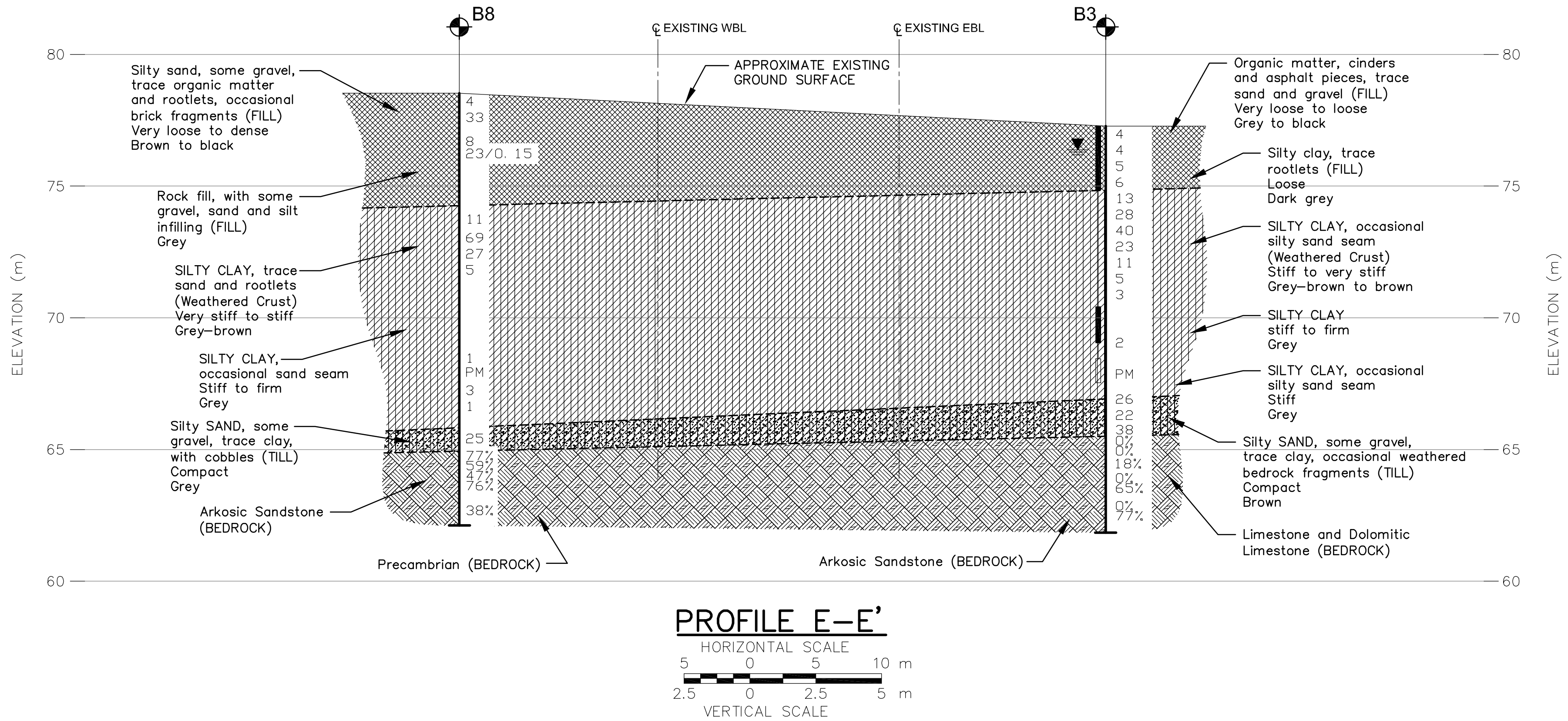
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HWY. 401	PROJECT NO. 08-1111-0044		DIST.
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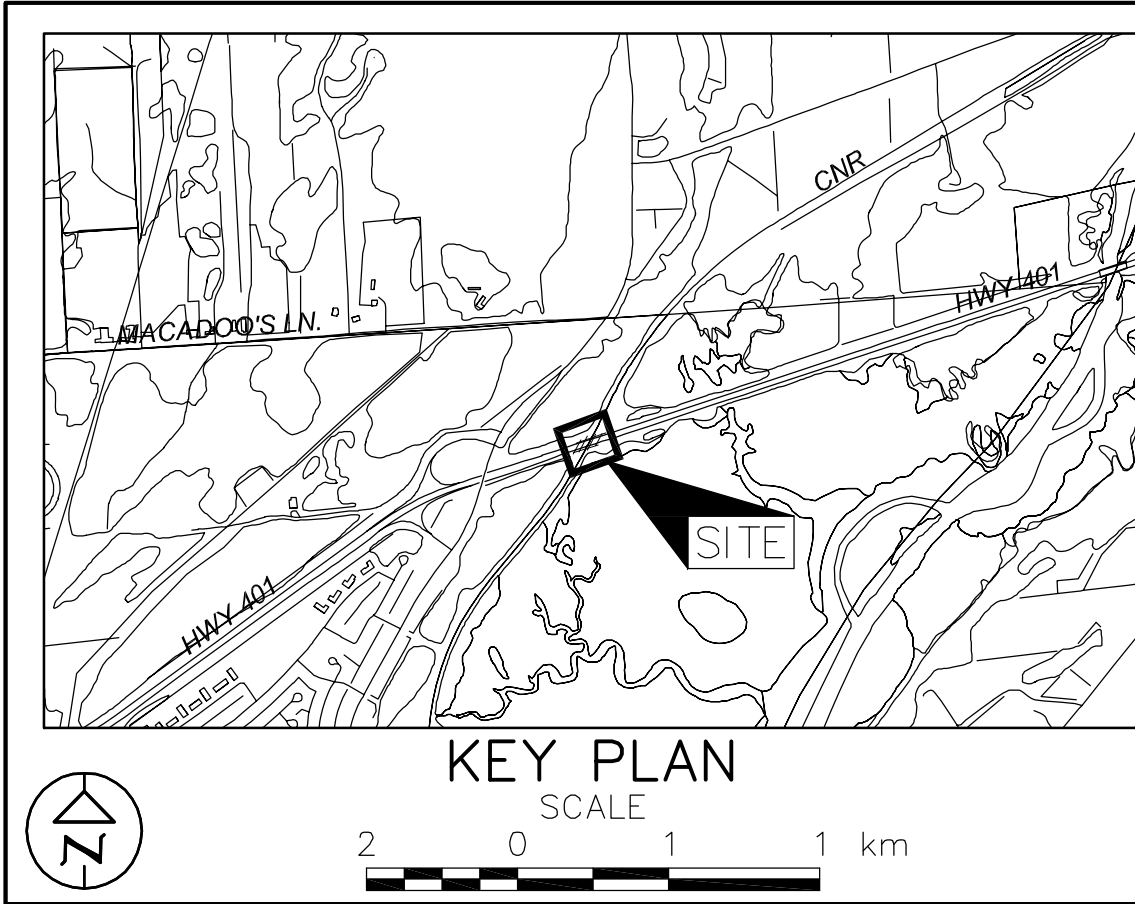
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C.N.R. OVERHEAD  
HIGHWAY 401  
SOIL STRATA

SHEET



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



LEGEND

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- Piezometer
- WL in piezometer on Sept. 29, 2009

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**METRIC**  
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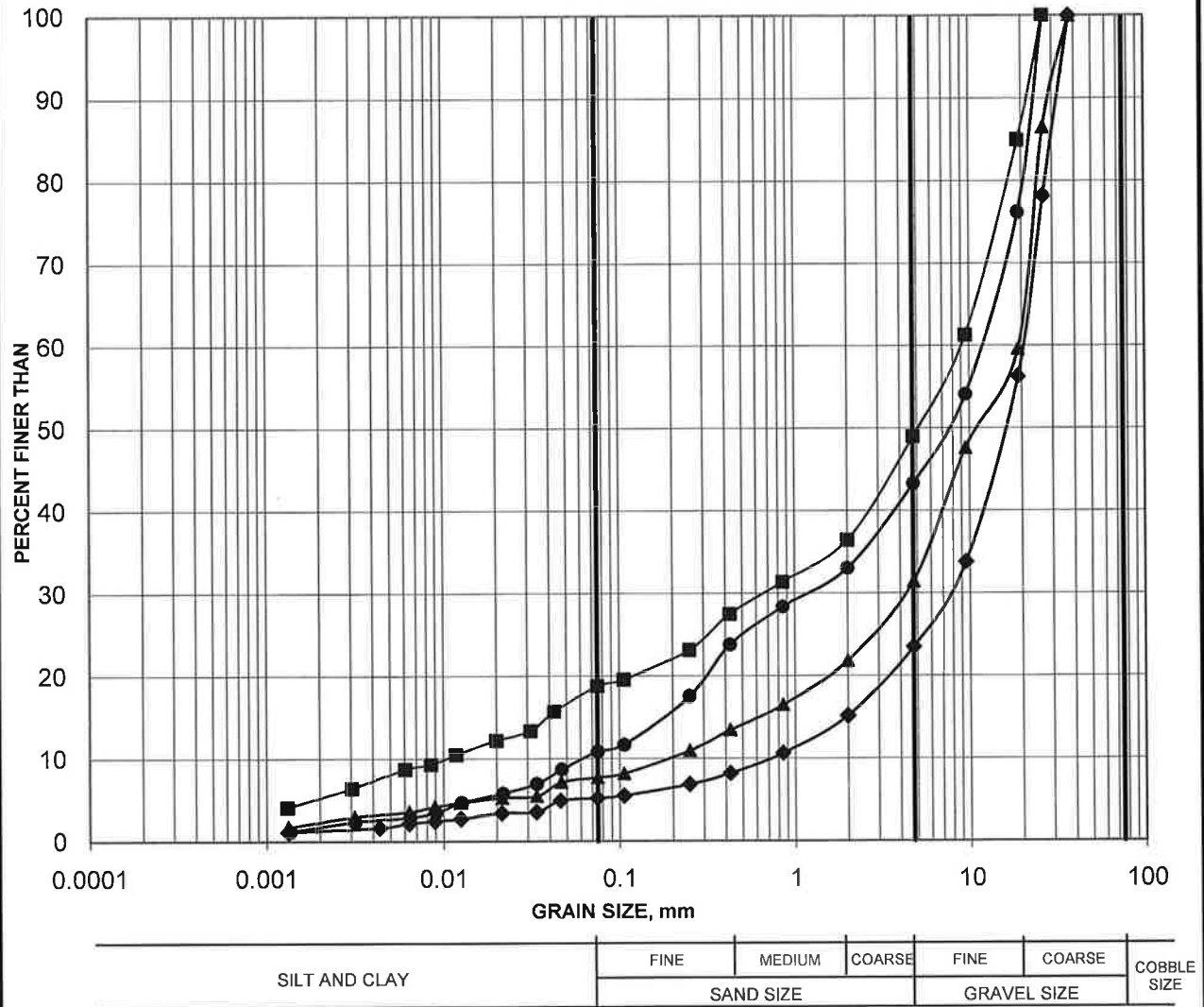
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DRAWN: JM	CHKD. MSS	APPD. FJH	DWG. 4



# GRAIN SIZE DISTRIBUTION

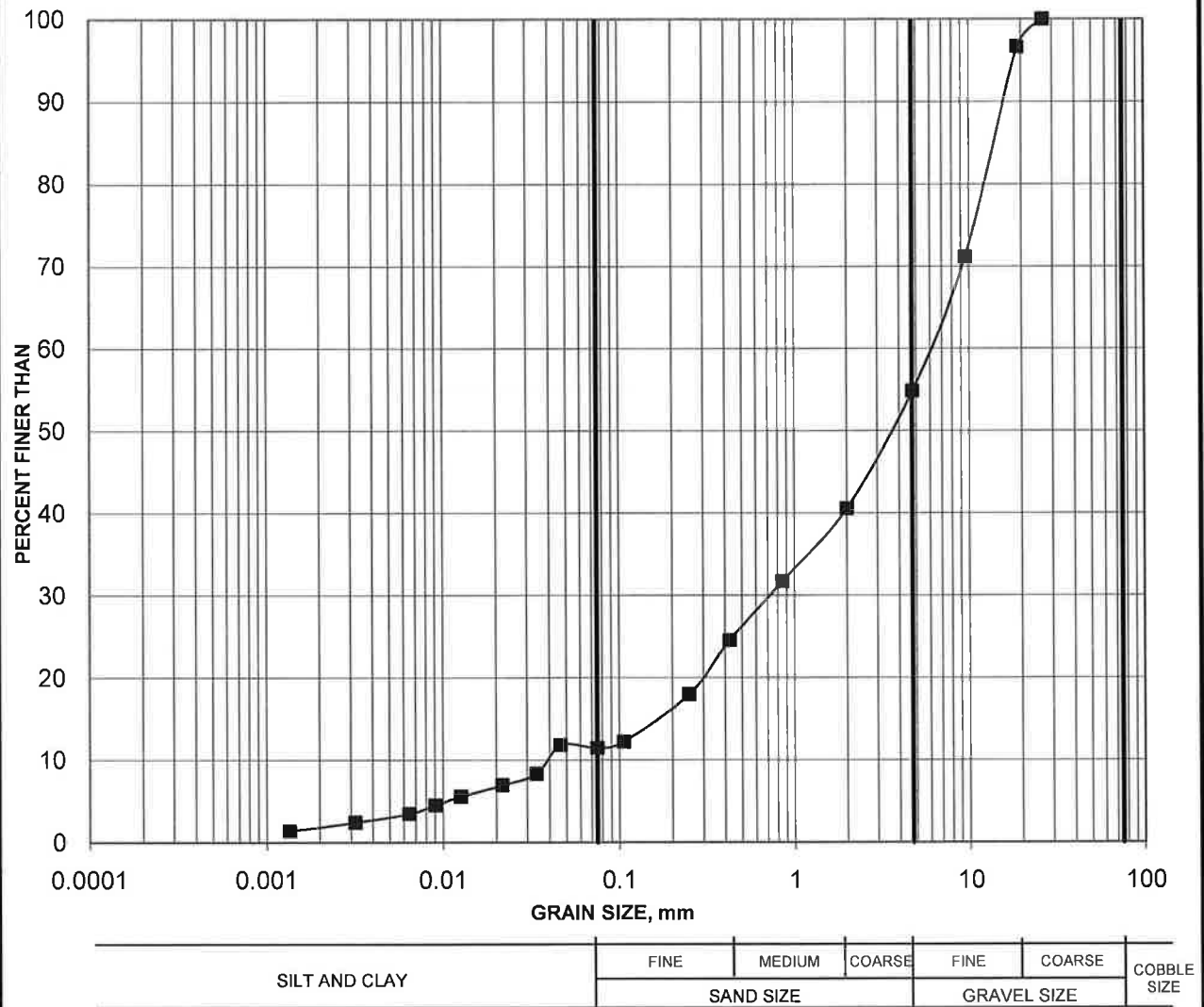
FIGURE 1

## ROCK FILL



Borehole	Sample	Depth (m)
■ B4	5	2.29-2.90
◆ B4	11	10.67-11.28
● B9	3	1.52-2.13
▲ B10	5	4.57-5.18

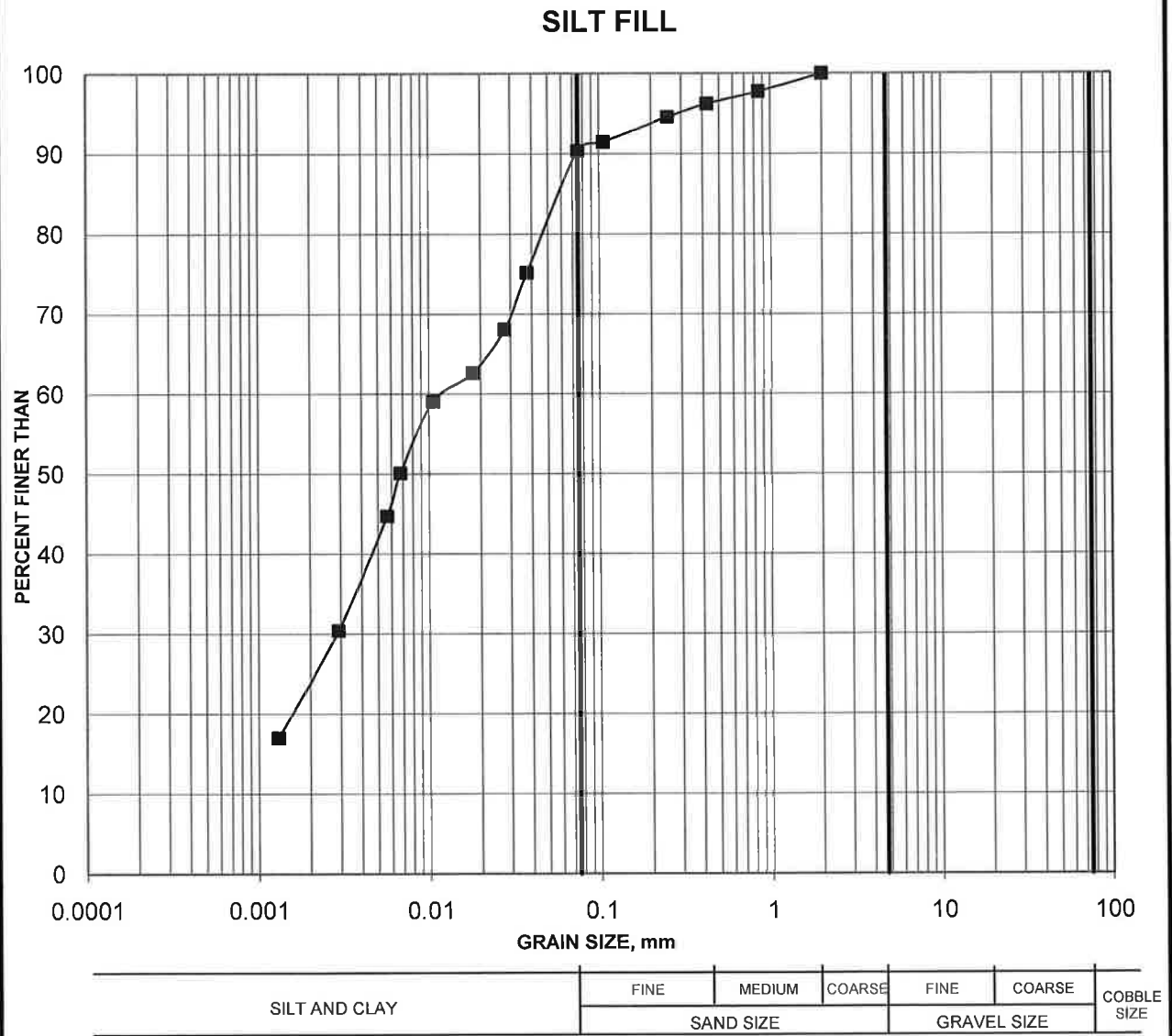
## SAND &amp; GRAVEL FILL



Borehole	Sample	Depth (m)
—■— B5	2	0.61-1.22

# GRAIN SIZE DISTRIBUTION

FIGURE 3

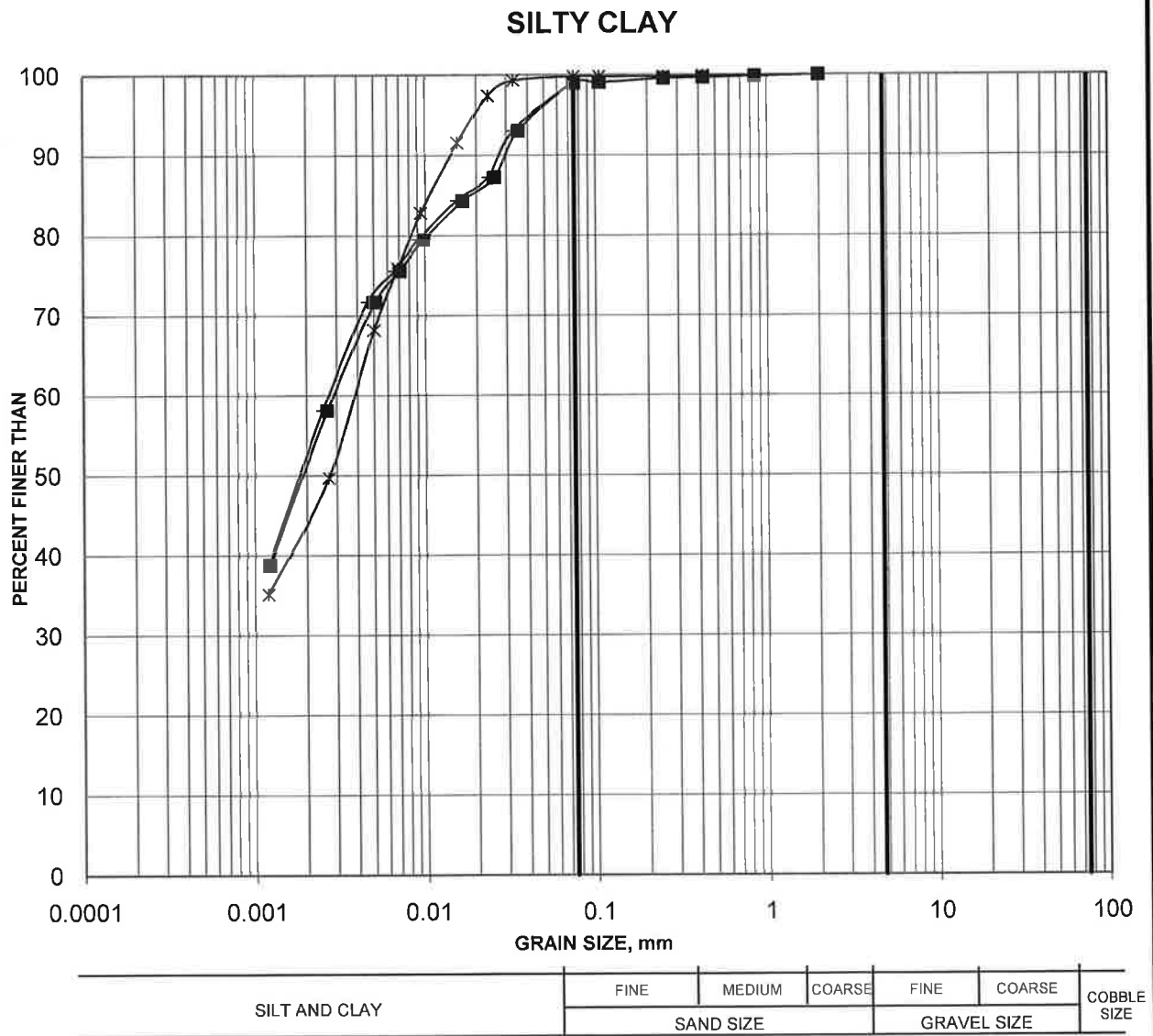


Borehole	Sample	Depth (m)
—■— B7	8B	3.81-4.27



# GRAIN SIZE DISTRIBUTION

FIGURE 4



Borehole	Sample	Depth (m)
■ B4	14	15.24-15.85
* B4	16	19.10-19.50
+ B8	12	10.40-10.80
● #REF!	14	16.77-17.38
◆ #REF!	13	16.77-17.38
▲ #REF!	15	19.82-20.43

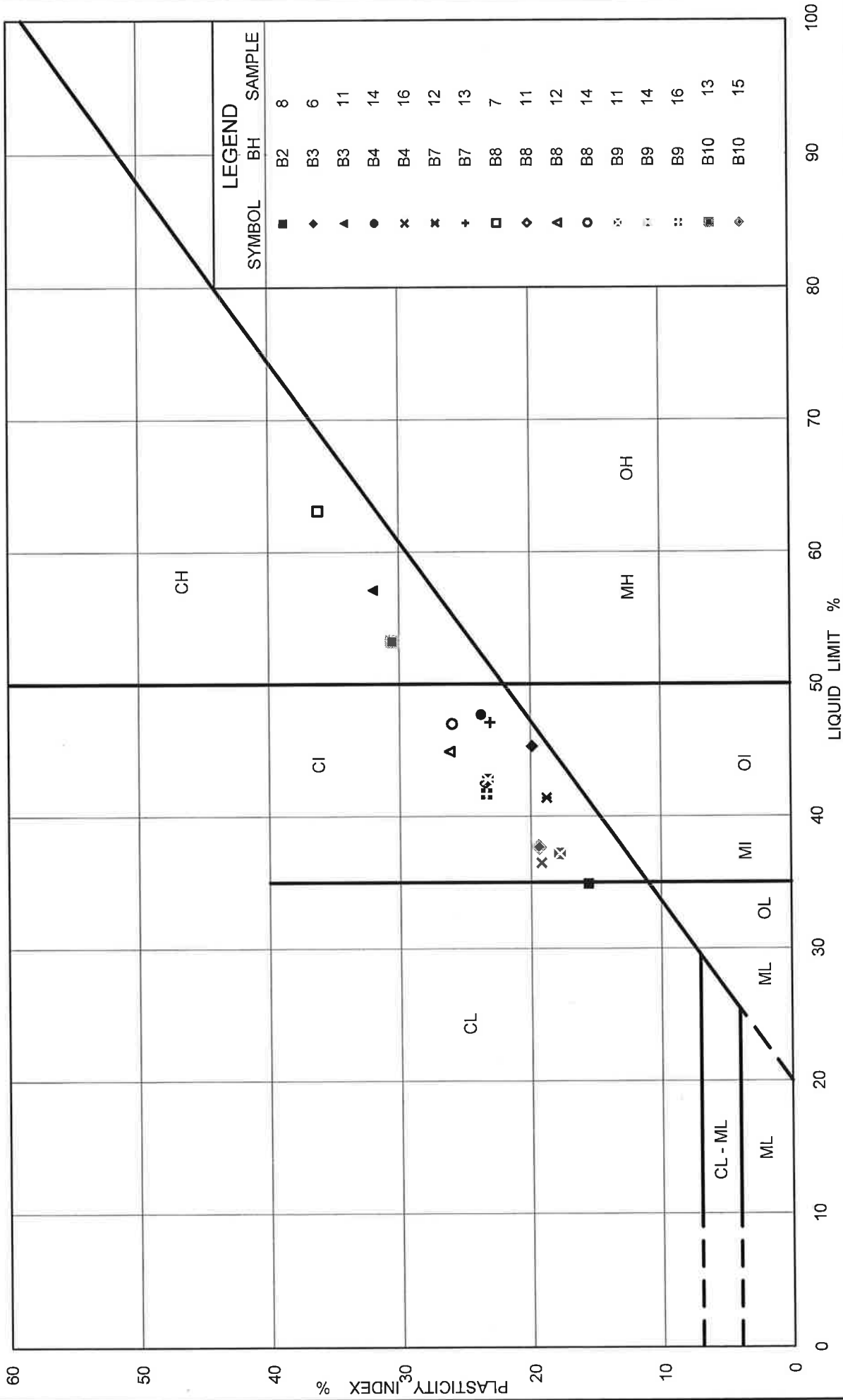


FIG No. 5

# PLASTICITY CHART

## Silty Clay to Clay

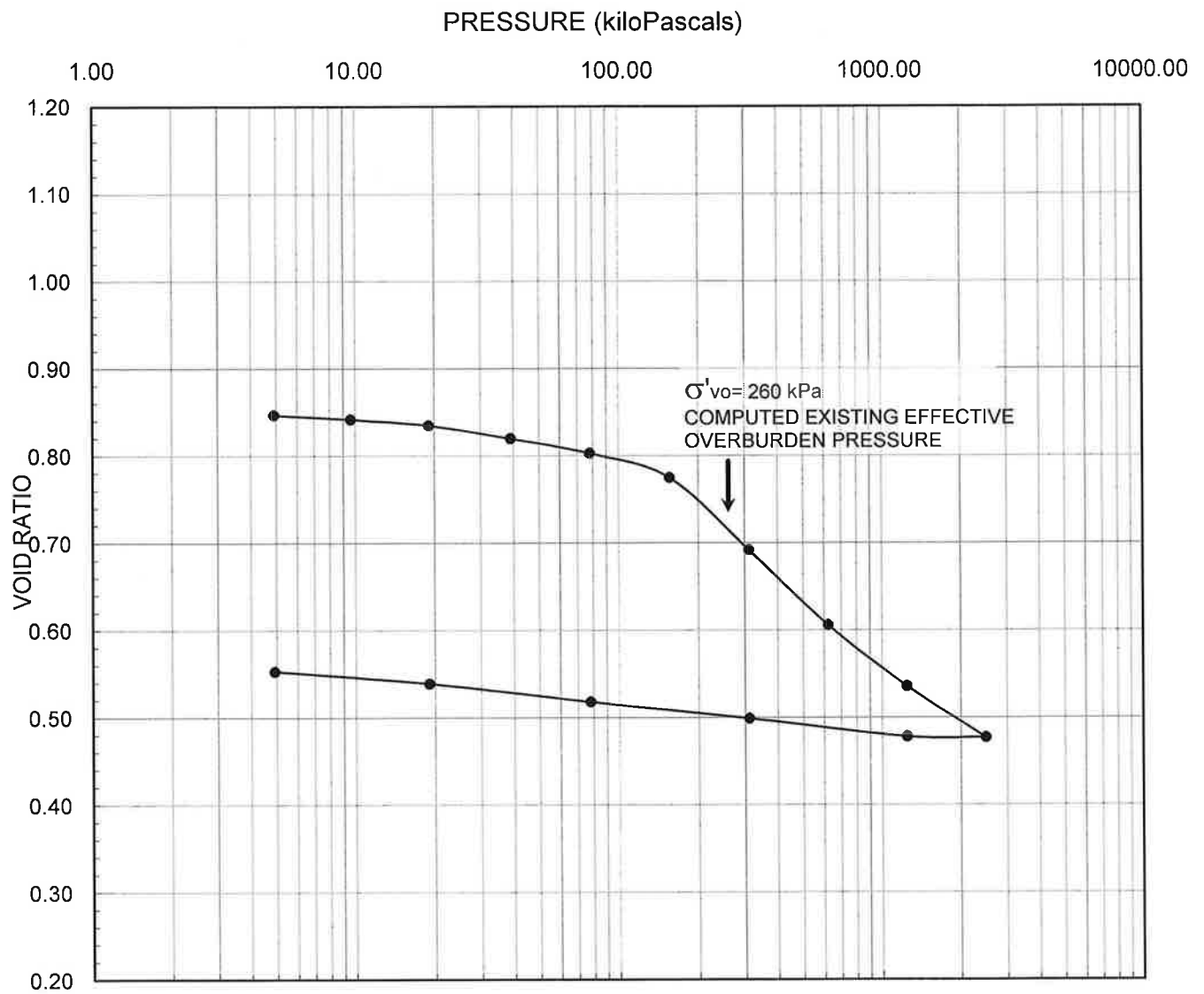
Ministry of Transportation



Ontario

Project No. 08-1111-0044

*[Signature]*



#### LEGEND

Borehole: B4	$w_i = 30.8\%$	$S_o = 101\%$
Sample: 16	$w_f = 21.4\%$	$C_c = 0.29$
Depth (m): 19.1-19.5		$C_r = 0.033$



SCALE	AS SHOWN
DATE	12/03/10
DESIGN	NA
CADD	MM
CHECK	CNM
REVIEW	ESO

TITLE

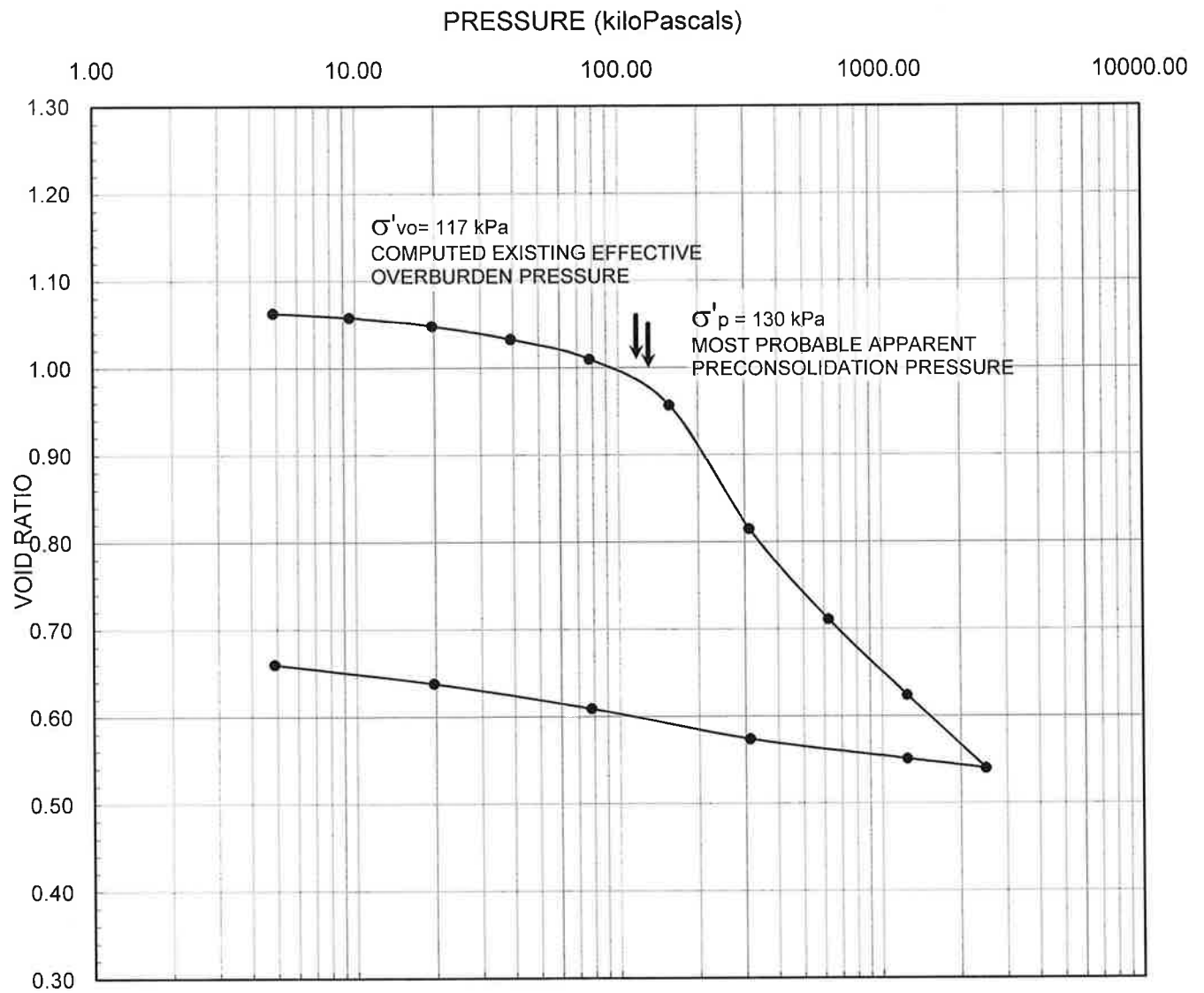
### CONSOLIDATION TEST RESULTS

FILE No. Consolidation summary

PROJECT No. 08-1111-0044 REV. 0

FIGURE

6



### LEGEND

Borehole: B8	$w_i = 37.8\%$	$S_o = 100\%$
Sample: 12	$w_f = 24.8\%$	$C_c = 0.47$
Depth (m): 10.4-10.8		$C_r = 0.053$



SCALE	AS SHOWN
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CHECK	CNM
REVIEW	ESO

TITLE

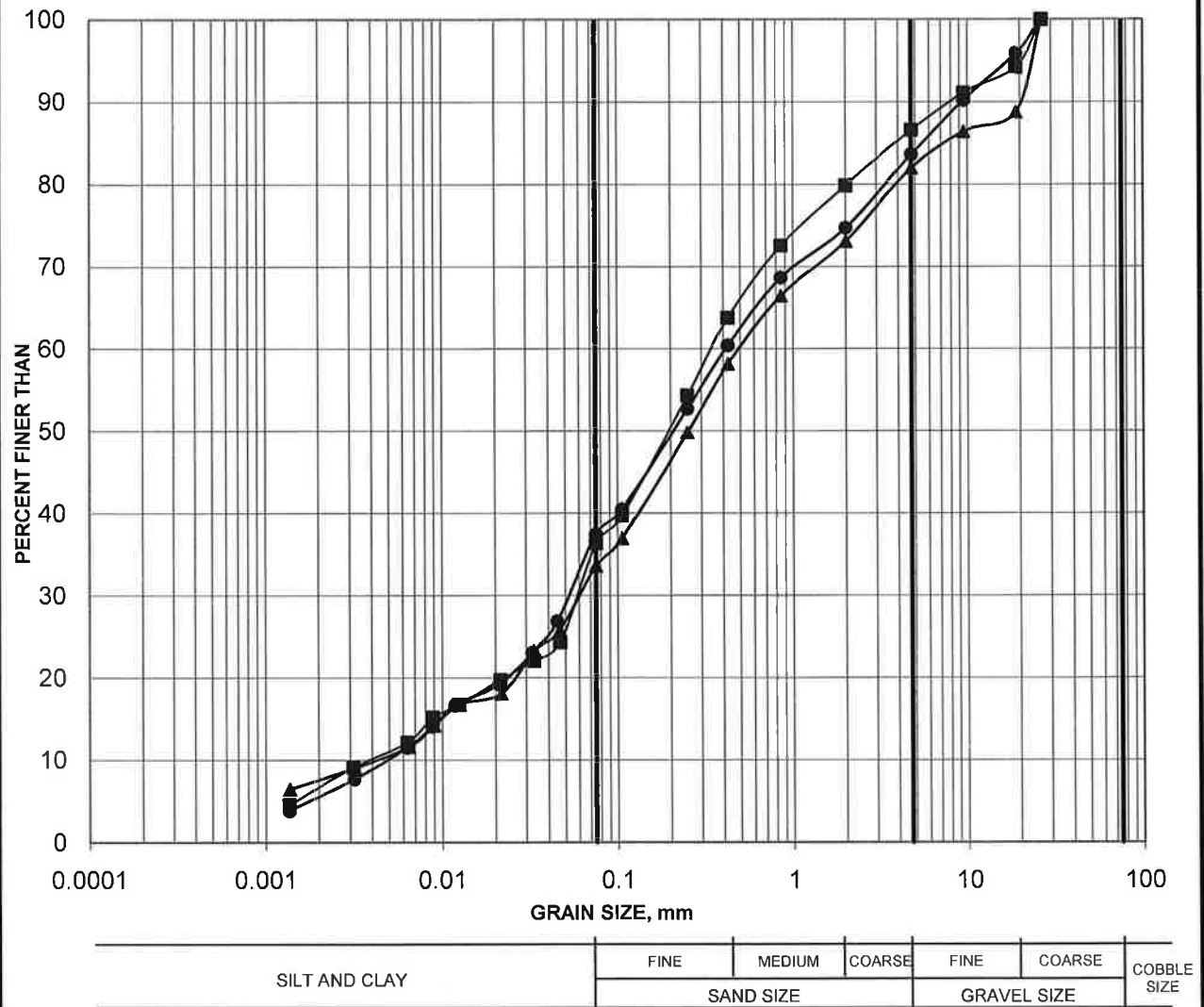
## CONSOLIDATION TEST RESULTS

FIGURE

7

FILE No. Consolidation summary  
PROJECT No. 08-1111-0044 REV. 0

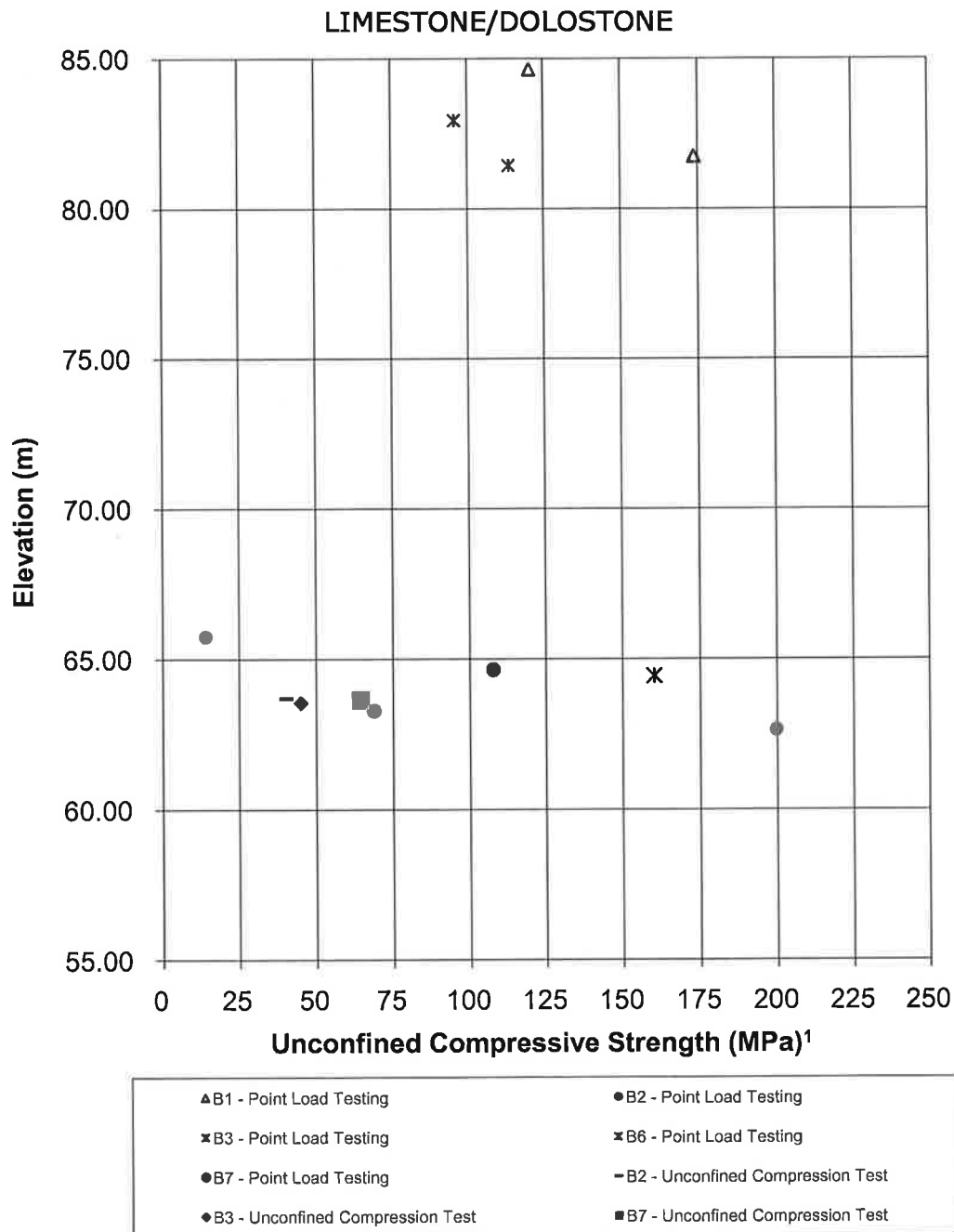
## SILTY SAND TILL



Borehole	Sample	Depth (m)
■ B4	19	22.86-23.24
▲ B8	15	12.80-13.41
● B10	16	21.34-21.77

# SUMMARY OF LABORATORY COMPRESSIVE STRENGTH MEASUREMENTS

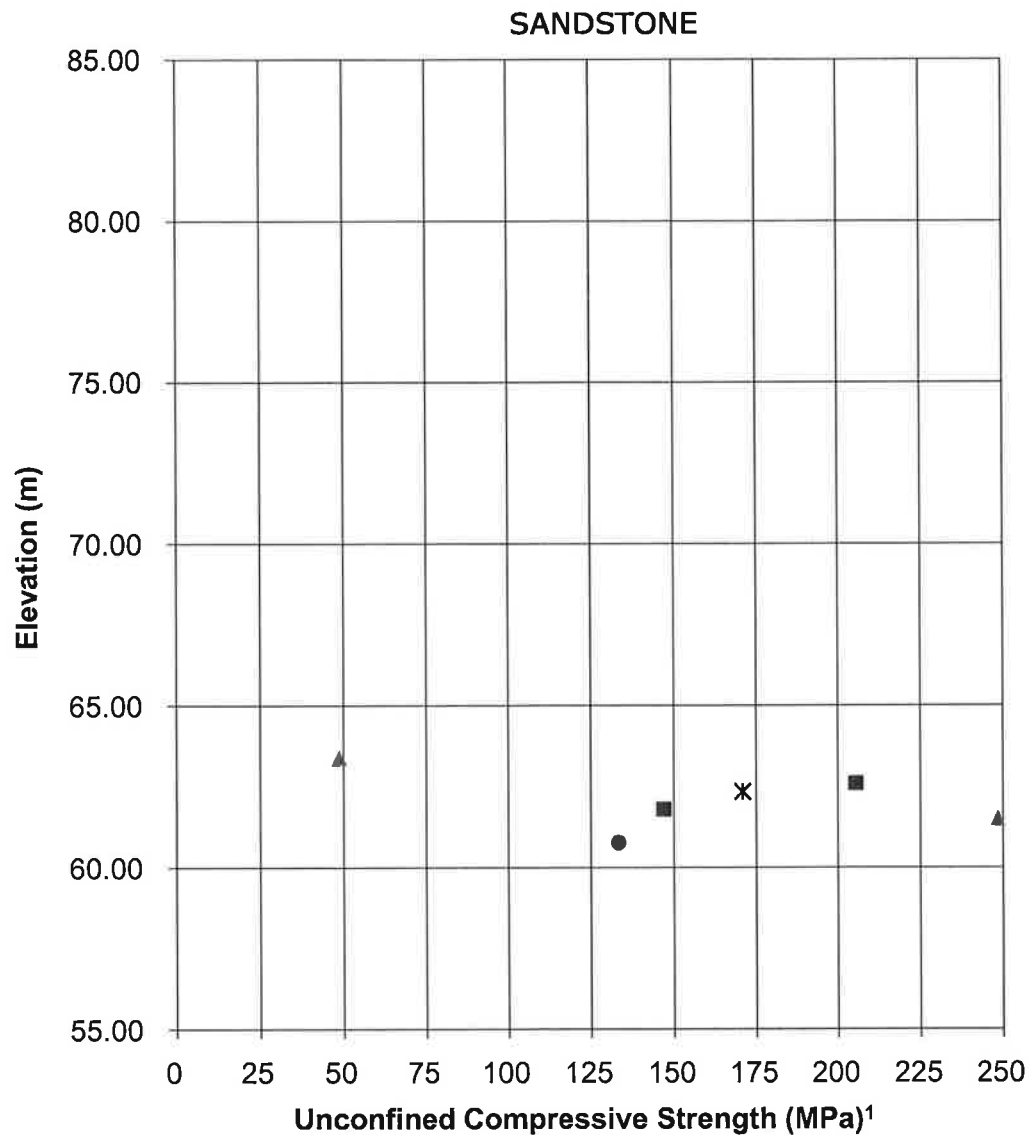
FIGURE 9



<sup>1</sup> Unconfined compressive strengths from point load testing inferred using  $Is_{60} \times C$  where  $C=21$ , from ISRM ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech. Min. Sci. and Geomechanical Abstr., Vol 22, No. 2 1985, pp. 51-60.

# SUMMARY OF LABORATORY COMPRESSIVE STRENGTH MEASUREMENTS

FIGURE 10



x B3 - Point Load Testing      ■ B4 - Point Load Testing  
 ● B8 - Point Load Testing      ▲ B9 - Point Load Testing

<sup>1</sup> Unconfined compressive strengths from point load testing inferred using  $Is_{50} \times C$  where  $C=21$ , from ISRM ("Suggested Methods for Determining Point Load Strength").

International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech. Min. Sci. and Geomechanical Abstr., Vol 22, No. 2 1985, pp. 51-60.

Project: 08-1111-0044

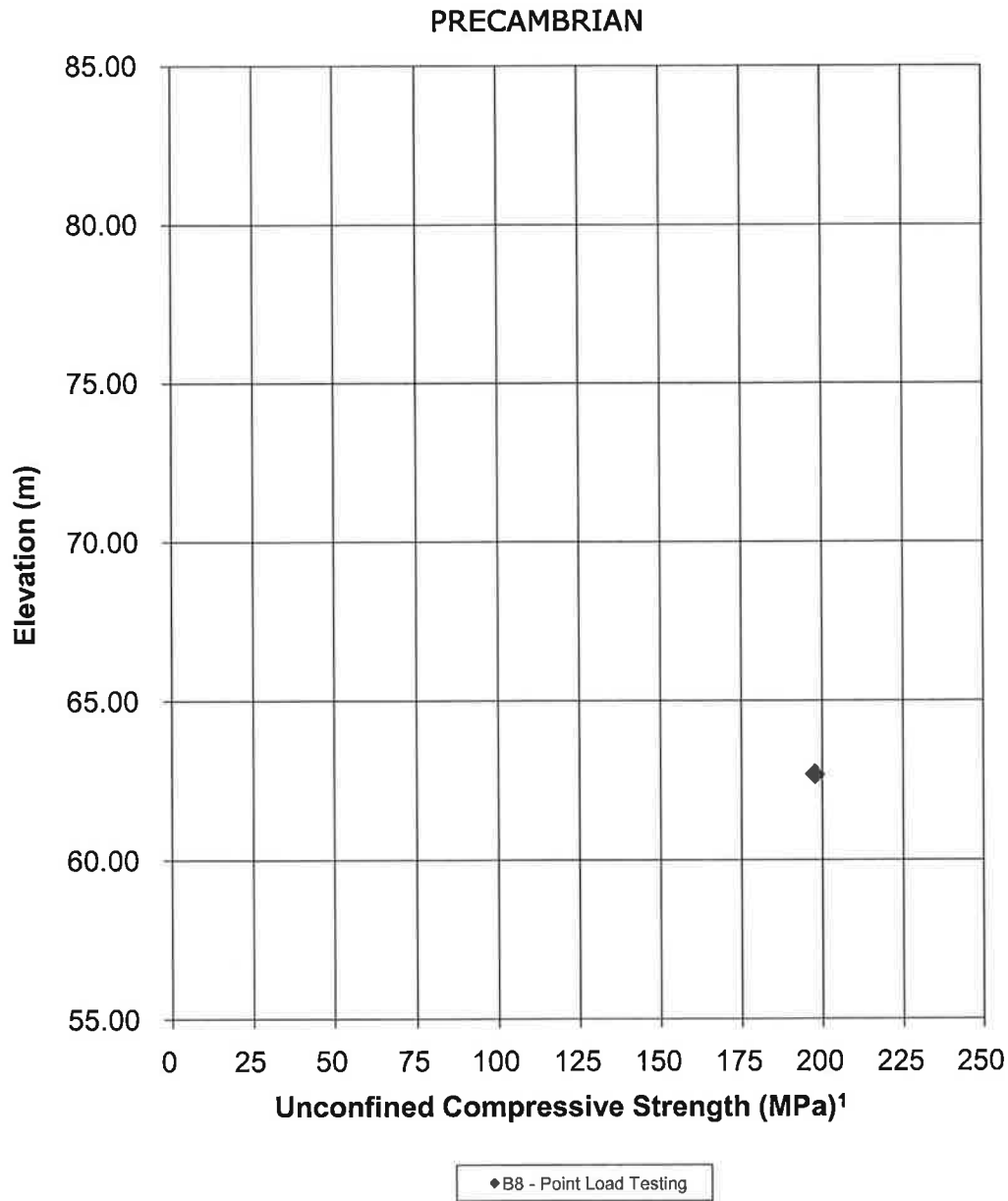
**Golder Associates**

Created by: KSL

Checked by: ESO

# SUMMARY OF LABORATORY COMPRESSIVE STRENGTH MEASUREMENTS

FIGURE 11



<sup>1</sup> Unconfined compressive strengths from point load testing inferred using  $Is_{50} \times C$  where  $C=21$ , from ISRM ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech. Min. Sci. and Geomechanical Abstr., Vol 22, No. 2 1985, pp. 51-60.





# **APPENDIX A**

**List of Abbreviations and Symbols  
Rock Description Terminology  
Record of Borehole Sheets**

## 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	Density Index	N
DO	Drive open	(Relative Density)	Blows/300 mm
DS	Denison type sample		Or Blows/ft.
FS	Foil sample	Very loose	0 to 4
RC	Rock core	Loose	4 to 10
SC	Soil core	Compact	10 to 30
ST	Slotted tube	Dense	30 to 50
TO	Thin-walled, open	Very dense	over 50
TP	Thin-walled, piston		
WS	Wash sample	(b)	Cohesive Soils
DT	Dual Tube sample	Consistency	C <sub>n</sub> or S <sub>u</sub>
II. PENETRATION RESISTANCE			
<b>Standard Penetration Resistance (SPT), N:</b>			
The number of blows by a 63.5 kg. (140 lb.)			
hammer dropped 760 mm (30 in.) required			
to drive a 50 mm (2 in.) drive open			
Sampler for a distance of 300 mm (12 in.)			
DD- Diamond Drilling			
<b>Dynamic Penetration Resistance; N<sub>d</sub>:</b>			
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.).			
<b>PH:</b>	Sampler advanced by hydraulic pressure	Very soft	Kpa 0 to 12
<b>PM:</b>	Sampler advanced by manual pressure	Soft	12 to 25
<b>WH:</b>	Sampler advanced by static weight of hammer	Firm	25 to 50
<b>WR:</b>	Sampler advanced by weight of sampler and rod	Stiff	50 to 100
		Very stiff	100 to 200
		Hard	Over 200
			Psf 0 to 250
			250 to 500
			500 to 1,000
			1,000 to 2,000
			2,000 to 4,000
			Over 4,000
<b>Peizo-Cone Penetration Test (CPT):</b>			
An electronic cone penetrometer with			
a 60° conical tip and a projected end area			
of 10 cm <sup>2</sup> pushed through ground			
at a penetration rate of 2 cm/s. Measurements			
of tip resistance (Q <sub>t</sub> ), porewater pressure			
(PWP) and friction along a sleeve are recorded			
Electronically at 25 mm penetration intervals.			
		IV. SOIL TESTS	
		w	water content
		w <sub>p</sub>	plastic limited
		w <sub>l</sub>	liquid limit
		C	consolidaiton (oedometer) test
		CHEM	chemical analysis (refer to text)
		CID	consolidated isotropically drained triaxial test <sup>1</sup>
		CIU	consolidated isotropically undrained triaxial test <sup>1</sup>
			with porewater pressure measurement <sup>1</sup>
		D <sub>R</sub>	relative density (specific gravity, G <sub>s</sub> )
		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 <sub>4</sub>	concentration of water-soluble sulphates
		UC	unconfined compression test
		UU	unconsolidated undrained triaxial test
		V	field vane test (LV-laboratory vane test)
		γ	unit weight

Note:

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

$\pi$	= 3.1416
$\ln x$ ,	natural logarithm of x
$\log_{10} x$ or $\log x$ ,	logarithm of x to base 10
$g$	Acceleration due to gravity
$t$	time
$F$	factor of safety
$V$	volume
$W$	weight

### II. STRESS AND STRAIN

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

### III. SOIL PROPERTIES

#### (a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of 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 $\gamma$ where $\gamma = pg$ (i.e. mass density x 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
$\sigma'_p$	pre-consolidation pressure
OCR	Overconsolidation ratio = $\sigma'_p/\sigma'_{vo}$

#### (d) Shear Strength

$\tau_p \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	coefficient of friction = $\tan \delta$
$c'$	effective cohesion
$c_u, s_u$	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 = (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 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		RECORD OF BOREHOLE No B1				1 OF 1 METRIC							
08-1111-0044													
G.W.P. 78-99-01		LOCATION N 4904268.6 ; E 307188.1				ORIGINATED BY DG							
DIST HWY 401		BOREHOLE TYPE Portable Equipment, Continuous Sampling, BW Casing, Wash Boring				COMPILED BY JM							
DATUM Geodetic		DATE June 17, 2009				CHECKED BY KSL							
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	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	γ	GR SA SI CL	
87.6	GROUND SURFACE												
0.0	Sand and gravel, some crushed stone, trace silt (FILL) Loose Brown Moist		1	SS	3		87						
86.4			2	SS	10								
1.2	Rock fill, some sand and gravel, trace silt (FILL) Grey brown Moist		3	AW RC	DD		86						
			4	AW RC	DD		85						
			5	AW RC	DD								
			6	AW RC	DD								
84.3	LIMESTONE and DOLOMITIC LIMESTONE (BEDROCK) Fractured Laminated Medium strong Grey		C1	BW RC	REC 100%		84						
3.3	Note: Bedrock cored between 3.3 m and 6.2 m depth. For bedrock coring details refer to Record of Drillhole B1.		C2	BW RC	REC 100%		83						
			C3	BW RC	REC 100%		82						
81.4													
6.2	End of Borehole												

PROJECT: 08-1111-0044

## RECORD OF DRILLHOLE: B1

SHEET 1 OF 1

LOCATION: N 4904268.6 ;E 307188.1

DRILLING DATE: June 17, 2009

DATUM: Geodetic

INCLINATION: -90°

AZIMUTH: ---

DRILL RIG: Portable

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	CORRELATION CHART																NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
				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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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				RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K <sub>f</sub> cm/sec			DIAMETRAL POINT LOAD INDEX (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
TOTAL CORE %		SOLID CORE %		TYPE AND SURFACE DESCRIPTION				10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>	10 <sup>-3</sup>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							

DEPTH SCALE

1 : 75



LOGGED: DG

CHECKED: KSL

MIS-ROK 001: 08-1111-0044 (ROCK) GPJ GAL-MISS GDT 12/3/10 DD

# RECORD OF BOREHOLE No B2

1 OF 2 METRIC

PROJECT 08-1111-0044

G.W.P. 78-99-01

LOCATION N 4904273.3 ; E 307205.4

ORIGINATED BY HEC

DIST HWY 401

BOREHOLE TYPE Portable Equipment, Continuous Sampling, NW, BW, AW, EW Casing, Wash Boring

COMPILED BY JM

DATUM Geodetic

DATE August 26 - September 1, 2009

CHECKED BY KSL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
80.4 0.0	GROUND SURFACE Rock FILL													
79.2 1.2	Coarse grained rock fill, some gravel and grey-brown silty clay (FILL) Moist		1	BW RC	DD									
77.5 3.4	Silty clay (FILL) Very stiff Grey-brown Moist		2	BW RC	DD									
77.1 3.4	Fine grained rock fill, trace sand, some grey-brown silty clay (FILL) Moist		3	SS	13									
75.4 5.1	SILTY CLAY (Weathered Crust) Stiff to very stiff Grey-brown to grey Moist		4	AW RC	DD									
			5	AW RC	DD									
			6	AW RC	DD									
			7	SS	13									
			8	SS	72									
			9	SS	28									
73.1 7.3	LIMESTONE SLABS, with some voids and soil infilling Grey		10	RC	DD									
			11	RC	DD									
70.4 10.3	Void or loose soil LIMESTONE SLABS, with some voids and soil infilling Grey		12	RC	DD									
69.3 11.3	Void or loose soil LIMESTONE SLABS, with some voids and soil infilling Grey		13	RC	DD									
			14	RC	DD									
			15	RC	DD									
66.2 14.3			C1	RC	REC 97%									

RQD = 71%

Continued Next Page


+ 3, × 3

Numbers refer to Sensitivity

○ 3%

STRAIN AT FAILURE

MIS-MTO 001 08-1111-0044 GPJ GAL-MISS GDT 12/3/10 DD

PROJECT 08-1111-0044		<b>RECORD OF BOREHOLE No B2</b>				2 OF 2 <b>METRIC</b>							
G.W.P. 78-99-01		LOCATION N 4904273.3 ; E 307205.4				ORIGINATED BY HEC							
DIST HWY 401		BOREHOLE TYPE Portable Equipment, Continuous Sampling, NW, BW, AW, EW Casing, Wash Boring				COMPILED BY JM							
DATUM Geodetic		DATE August 26 - September 1, 2009				CHECKED BY KSL							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
— CONTINUED FROM PREVIOUS PAGE —													
65.2 15.2	LIMESTONE (BEDROCK) Fresh Thinly bedded Weak Greenish-grey		C1	RC		65					RQD = 71%		
			C2	RC	REC 71%								
64.3 16.1	LIMESTONE (BEDROCK) Fresh to weathered Thinly bedded Weak Greenish-grey and reddish-grey		C3	RC	REC 83%								RQD = 55%
63.2 17.2	LIMESTONE (BEDROCK) Fresh Thinly bedded Weak Reddish-grey		C4	RC	REC 100%								RQD = 83%
62.6 17.9	LIMESTONE (BEDROCK) Fresh Thinly bedded Medium strong Grey  Note: Bedrock cored between 14.3 m and 17.9 m depth. For bedrock coring details refer to Record of Drillhole B2. End of Borehole  Note: Water level in well screen at 4.3 m depth (Elev. 76.1) on Sept. 29, 2009.												



PROJECT: 08-1111-0044

## RECORD OF DRILLHOLE: B2

SHEET 1 OF 1

LOCATION: N 4904273.3 ;E 307205.4

DRILLING DATE: August 26 - September 1, 2009

DATUM: Geodetic

INCLINATION: -90°

AZIMUTH: ---

DRILL RIG: Portable

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	PENETRATION RATE (mm/min)	COLOUR FLUSH RETURN	FR/FX-FRACTURE F-FAULT				SM-SMOOTH				FL-FLEXURED				BC-BROKEN CORE				DISCONTINUITY DATA	HYDRAULIC CONDUCTIVITY				DIAMETRAL POINT LOAD INDEX (MPa)				NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
				DEPTH (m)				RECOVERY		R Q D %	FRACT. INDEX PER 0.3	DIP w.r.t CORE AXIS		TYPE AND SURFACE DESCRIPTION	10 <sup>-8</sup> K <sub>s</sub> cm/sec	10 <sup>-5</sup> K <sub>s</sub> cm/sec	10 <sup>-4</sup> K <sub>s</sub> cm/sec	10 <sup>-3</sup> K <sub>s</sub> cm/sec	2	4	6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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MIS-RCK 001 08-1111-0044 (ROCK) GPJ GAL-MISS GDT 12/3/10 DD

DEPTH SCALE

1 : 75



LOGGED: HEC

CHECKED: KSL

PROJECT 08-1111-0044		<b>RECORD OF BOREHOLE No B3</b>		1 OF 2 <b>METRIC</b>	
G.W.P. 78-99-01	LOCATION N 4904280.6 ; E 307230.6	ORIGINATED BY DWM			
DIST HWY 401	BOREHOLE TYPE Portable Equipment, Continuous Sampling, EW Casing, Wash Boring	COMPILED BY JM			
DATUM Geodetic	DATE September 2-10, 2009	CHECKED BY KSL			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
77.3	GROUND SURFACE													
0.0	Organic matter, cinders and asphalt pieces, trace sand and gravel (FILL) Very loose to loose Grey to black Dry		1	SS	4									
76.1			2	SS	4									
1.2	Silty clay, trace sand and gravel (FILL) Loose Brown Moist		3	SS	5									
75.5			4	SS	6									
1.8	Silty clay, trace rootlets (FILL) Loose Dark grey Moist		5	SS	13									
74.8			6	SS	28									
2.4	SILTY CLAY, occasional silty sand seam (Weathered Crust) Stiff to very stiff Grey-brown to brown Moist		7	SS	40									
			8	SS	23									
			9	SS	11									
71.8			10	SS	5									
5.5	SILTY CLAY Stiff to firm Grey Wet		11	SS	3									
			12	SS	2									
			13	TP	PM									
68.1	SILTY CLAY, occasional silty sand seam Stiff Grey Wet		14	SS	26									
66.9			15	SS	22									
66.6	Silty SAND, trace gravel, some clay (TILL) Compact Grey-brown Wet		16	SS	38									
10.7			C1	RC	REC 69%									
65.5			C2	RC	REC 67%									
11.8	LIMESTONE and DOLOMITIC LIMESTONE (BEDROCK) Fresh to slightly weathered Thinly bedded Grey		C3	RC	REC 41%									
	Note: Occasional very thin soil seams in bedrock from about 12.8 to 14.0m depth.		C4	RC	REC 15%									
63.0			C5	RC	REC 93%									
14.3			C6	RC	REC 44%									
			C7	RC	REC 100%									

MIS-MTO 001 08-1111-0044.GPJ GAL-MISS GDT 12/3/10 DD

Continued Next Page

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

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT: 08-1111-0044

## RECORD OF DRILLHOLE: B3

SHEET 1 OF 1

LOCATION: N 4904280.6 ; E 307230.6

DRILLING DATE: September 2-10, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	PENETRATION RATE (mm/min)	FLUSH	COLOUR (mm)	% RETURN	FR/FX-FRACTURE		F-FAULT		SM-SMOOTH		FL-FLEXURED		BC-BROKEN CORE		DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION		
				DEPTH (m)	RECOVERY						TOTAL CORE %	SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K <sub>f</sub> cm/sec	MB-MECH. BREAK B-BEDDING						
															DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION			10 <sup>-6</sup>	10 <sup>-5</sup>			10 <sup>-4</sup>	10 <sup>-3</sup>
		Continued from Record of Borehole B3		65.50																				
12		LIMESTONE and DOLOMITIC LIMESTONE (BEDROCK) Fresh to slightly weathered Thinly bedded Grey		11.80	C1																			
					C2																			
13		Note: Occasional very thin soil seams in bedrock from about 12.8 to 14.0m depth.			C3																			
					C4																			
14					C5																			
		ARKOSIC SANDSTONE (BEDROCK) Fresh Fine to coarse grained Medium strong Grey		63.00 14.30	C6																			
15					C7																			
		End of Drillhole		61.90 15.40																				
16																								
17																								
18																								
19																								
20																								
21																								
22																								
23																								
24																								
25																								
26																								

DEPTH SCALE

1 : 75



LOGGED: DWM

CHECKED: KSL

MIS-PC001 08-1111-0044 (ROCK) GPJ GAL-MISS GDT 12/3/10 DD

PROJECT 08-1111-0044		<b>RECORD OF BOREHOLE No B4</b>		1 OF 2 <b>METRIC</b>	
G.W.P. 78-99-01		LOCATION N 4904295.2 ; E 307258.3		ORIGINATED BY DG	
DIST HWY 401		BOREHOLE TYPE Power Auger, 108mm Diam. Hollow Stem		COMPILED BY JM	
DATUM Geodetic		DATE June 12, 2009		CHECKED BY KSL	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	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	WATER CONTENT (%)					
86.4	GROUND SURFACE													
0.0	ASPHALTIC CONCRETE													
86.1														
0.4	Crushed stone (FILL)		1	GRAB										
85.5	Grey Moist		2	GRAB										
0.9	Sand and gravel (FILL)		3	SS	5									
	Brown Moist													
	Layered silty sand and silty clay, with gravel and rock fill (FILL)		4	SS	7									
	Loose to compact Grey-brown Moist		5	SS	5									
			6	SS	5									
			7	SS	11									
			8	SS	15									
			9	SS	27									
			10	SS	14									
			11	SS	27									
74.2	SILTY CLAY (Weathered Crust)		12	SS	15									
12.2	Stiff to very stiff Grey-brown Moist		13	SS	23									

MIS-MTO 001 08-1111-0044 GPJ GAL-MISS GDT 12/3/10 DD

Continued Next Page

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

PROJECT 08-1111-0044		<b>RECORD OF BOREHOLE No B4</b>		2 OF 2 <b>METRIC</b>									
G.W.P. 78-99-01		LOCATION N 4904295.2 ; E 307258.3		ORIGINATED BY DG									
DIST HWY 401		BOREHOLE TYPE Power Auger, 108mm Diam, Hollow Stem		COMPILED BY JM									
DATUM Geodetic		DATE June 12, 2009		CHECKED BY KSL									
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100					
--- CONTINUED FROM PREVIOUS PAGE ---													
	SILTY CLAY (Weathered Crust) Stiff to very stiff Grey-brown Moist		14	SS	8								0 1 47 52
			15	SS	13								
68.1													
18.3	SILTY CLAY Firm to stiff Grey Wet		16	TP	WH		X	+					0 0 56 44
			17	TP	WH		X	+					
64.2													
22.3	Silty SAND, some gravel, trace clay, with cobbles and boulders (TILL) Compact Grey Wet		19	SS	65/0.25								13 50 30 7
63.1													
62.8	LIMESTONE (BEDROCK) Grey		20	NQ RC	DD								
23.6	ARKOSIC SANDSTONE (BEDROCK) Fresh Fine to coarse grained Medium strong Grey, red and greenish grey		C1	NQ RC	REC 100%								RQD = 86%
			C2	NQ RC	REC 100%								RQD = 84%
60.5													
25.9	End of Borehole												

MIS-MTO 001 08-1111-0044 GPJ GAL-MISS GDT 12/3/10 DD

PROJECT: 08-1111-0044

## RECORD OF DRILLHOLE: B4

SHEET 1 OF 1

LOCATION: N 4904295.2 ;E 307258.3

DRILLING DATE: June 12, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75

DRILLING CONTRACTOR: Marathon 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 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										DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY				DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
				DEPTH (m)				RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	K, cm/sec																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
								TOTAL CORE %	SOLID CORE %					10 <sup>-8</sup>	10 <sup>-7</sup>	10 <sup>-6</sup>	10 <sup>-5</sup>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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DEPTH SCALE

1 : 75



LOGGED: DG

CHECKED: KSL

MIS-RCK 001 08-1111-0044 (ROCK) GPJ GAL-MISS GDT 12/3/10 DD

PROJECT 08-1111-0044		RECORD OF BOREHOLE No B5				1 OF 1 METRIC											
G.W.P. 78-99-01		LOCATION N 4904302.4 ; E 307197.7				ORIGINATED BY DG											
DIST HWY 401		BOREHOLE TYPE Portable Equipment, Continuous Sampling, BW Casing, Wash Boring				COMPILED BY JM											
DATUM Geodetic		DATE June 18, 2009				CHECKED BY KSL											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub>	W			W <sub>L</sub>
87.8	GROUND SURFACE						20	40	60	80	100						
0.0	Sand and gravel, trace silt (FILL) Loose to compact Grey-brown Moist		1	SS	6												
			2	SS	4												
			3	SS	15												
86.0	Rock FILL		4	AW RC	DD												
1.8	Grey																
85.4	LIMESTONE and DOLOMITIC LIMESTONE (BEDROCK) Fractured Medium laminated Weak to medium strong Grey		C1	BW RC	REC 100%												
2.4	Note: Bedrock cored between 2.4 m and 5.7 m depth. For bedrock coring details refer to Record of Drillhole B5.		C2	BW RC	REC 100%												
			C3	BW RC	REC 100%												
			C4	BW RC	REC 100%												
82.0	End of Borehole																
5.7																	



PROJECT: 08-1111-0044

## RECORD OF DRILLHOLE: B5

SHEET 1 OF 1

LOCATION: N 4904302.4 ;E 307197.7

DRILLING DATE: June 18, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	PENETRATION RATE (m/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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
				DEPTH (m)	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 K, cm/sec																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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DEPTH SCALE

1 : 75



LOGGED: DG

CHECKED: KSL

MIS-ROCK001 08-1111-0044 (ROCK) GPJ GAL-MISS GDT 12/3/10 DD

PROJECT 08-1111-0044		RECORD OF BOREHOLE No B6				1 OF 1 METRIC							
G.W.P. 78-99-01		LOCATION N 4904304.2 ; E 307204.2		ORIGINATED BY DG									
DIST HWY 401		BOREHOLE TYPE Portable Equipment, Continuous Sampling, BW Casing, Wash Boring		COMPILED BY JM									
DATUM Geodetic		DATE June 17, 2009		CHECKED BY KSL									
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
87.5	GROUND SURFACE						20 40 60 80 100		25 50 75				GR SA SI CL
0.0	Sand and gravel, trace silt (FILL) Compact Brown Moist		1	SS	13								
86.9													
0.6	Silty sand, some gravel, trace clay and rootlets (FILL) Loose Grey Moist		2	SS	4								
85.9													
1.6	Rock FILL Grey		3	AW RC	DD								
			4	AW RC	DD								
84.7													
	Wood (FILL)		5	AW RC	DD								
2.9	Cobbles and boulders (FILL)		6	AW RC	DD								
			7	AW RC	DD								
83.8													
3.7	DOLOMITIC LIMESTONE (BEDROCK) Fractured Laminated Medium strong Grey		C1	BW RC	REC 100%								RQD = 55%
			C2	BW RC	REC 100%								RQD = 14%
82.6													
4.9	LIMESTONE (BEDROCK) Fresh Medium bedded Medium strong Grey		C3	BW RC	REC 100%								RQD = 78%
	Note: Bedrock cored between 3.7 m and 6.7 m depth. For bedrock coring details refer to Record of Drillhole B6.		C4	BW RC	REC 100%								RQD = 81%
80.8													
6.7	End of Borehole												

PROJECT: 08-1111-0044

## RECORD OF DRILLHOLE: B6

SHEET 1 OF 1

LOCATION: N 4904304.2 ; E 307204.2

DRILLING DATE: June 17, 2009

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 (min/m)	FLUSH	RECOVERY	R.Q.D. %	FRACT INDEX PER 0.3	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY K <sub>f</sub> cm/sec	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Record of Borehole B6		83.80 3.70										
4		DOLOMITIC LIMESTONE (BEDROCK) Fractured Laminated Medium strong Grey			C1									
					C2									
5		LIMESTONE (BEDROCK) Fresh Medium bedded Medium strong Grey		82.60 4.90										
					C3									
6					C4									
		End of Drillhole		80.80 6.70										
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														

DEPTH SCALE

1 : 75



LOGGED: DG

CHECKED: KSL


MIS-RCK 001 08-1111-0044 (ROCK) GPJ GAL-MISS GDT 12/3/10 DD

PROJECT 08-1111-0044		RECORD OF BOREHOLE No B7		1 OF 2 METRIC															
G.W.P. 78-99-01		LOCATION N 4904318.2 ; E 307227.7		ORIGINATED BY DG															
DIST HWY 401		BOREHOLE TYPE Portable Equipment, Continuous Sampling, AW, BW Casing, Wash Boring		COMPILED BY JM															
DATUM Geodetic		DATE June 19, 2009		CHECKED BY KSL															
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20						40	60	80	100	20	40
79.7	GROUND SURFACE																		
0.0	Sand and gravel, trace silt (FILL) Compact Grey-brown Moist		1	SS	28														
78.9			2	SS	33/0.20														
1.0	Rock FILL Grey		3	AW RC	DD														
	Silty sand, some gravel, trace clay, with cobbles and boulders (FILL) Compact Grey-brown Moist to wet		4	AW RC	DD														
			5	SS	16														
			6	SS	15														
			7	SS	16														
75.9																			
3.8	Silt, some clay, trace sand (FILL) Grey-brown Wet		8	SS	17														
75.2			9	SS	27														
4.6	Silty sand, with cobbles and boulders (FILL) Grey Wet		10	AW RC	DD														
74.4																			
5.3	SILTY CLAY, trace gravel (Weathered Crust) Very stiff Grey-brown		11	SS	7/0.18														
			12	SS	26														
73.4			13	SS	11/0.23														
73.1	LIMESTONE SLABS																		
72.7	VOID or loose soil		14	AW RC	DD														
72.3	LIMESTONE SLAB																		
7.4	VOID or loose soil		15	AW RC	DD														
71.7																			
71.4	LIMESTONE SLAB		16	AW RC	DD														
	VOID or loose soil																		
71.0	LIMESTONE SLABS		17	AW RC	DD														
70.6	VOID or loose soil																		
70.3	LIMESTONE SLABS		18	AW RC	DD														
	VOID or loose soil																		
69.6	LIMESTONE SLABS		19	AW RC	DD														
	VOID or loose soil																		
	VOID or loose soil																		
10.5	From 6.3m to 12.2m depth: LIMESTONE SLABS, with numerous voids and occasional inclined bedding planes Grey		20	AW RC	DD														
			21	AW RC	DD														
67.6																			
12.2	Grey COBBLES, BOULDERS and red brown SILTY CLAY		22	EW RC	DD														
66.3			23	EW RC	DD														
13.4	LIMESTONE (BEDROCK) Fractured Medium strong Grey to reddish brown		C1	EW RC	REC 84%														
65.7			C2	EW RC	REC 100%														
14.1			C3	EW RC	REC 76.3%														
			C4	EW RC	REC 100%														

MIS-MTO 001 08-1111-0044 GPJ GAL-MISS GDT 12/3/10 DD


Continued Next Page

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

PROJECT 08-1111-0044				<b>RECORD OF BOREHOLE No B7</b>				2 OF 2 <b>METRIC</b>									
G.W.P. 78-99-01				LOCATION N 4904318.2 ; E 307227.7				ORIGINATED BY DG									
DIST HWY 401				BOREHOLE TYPE Portable Equipment, Continuous Sampling, AW, BW Casing, Wash Boring				COMPILED BY JM									
DATUM Geodetic				DATE June 19, 2009				CHECKED BY KSL									
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x REMOULDED					WATER CONTENT (%) w <sub>p</sub> w w <sub>L</sub>				
-- CONTINUED FROM PREVIOUS PAGE --																	
63.2 16.5	<b>LIMESTONE (BEDROCK)</b> Fresh Thinly bedded Medium strong Grey to reddish brown  Note: Bedrock cored between 13.4 m and 16.5 m depth. For bedrock coring details refer to Record of Drillhole B7. End of Borehole		C4	EW RC	REC 100%	64											RQD = 58.1% RQD = 66.7% RQD = 0% RQD = 83.9%
			C5	EW RC	REC 100%												
			C6	EW RC	REC 100%												
			C7	EW RC	REC 100% REC 100%												



MIS-MTO 001 08-1111-0044 GPJ GAL-MISS GDT 12/3/10 DD

PROJECT 08-1111-0044				RECORD OF BOREHOLE No B8				2 OF 2 METRIC							
G.W.P. 78-99-01		LOCATION N 4904323.6 ; E 307254.3		ORIGINATED BY DWM											
DIST HWY 401		BOREHOLE TYPE Portable Equipment, Continuous Sampling, NW, AW, EW Casing, Wash Boring		COMPILED BY JM											
DATUM Geodetic		DATE September 10 - 16, 2009		CHECKED BY KSL											
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	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							
-- CONTINUED FROM PREVIOUS PAGE --															
62.8	PRECAMBRIAN (BEDROCK) Fresh Medium strong Black, grey and red		C4	RC	REC 100%	63									
15.8			C5	RC	REC 79%										
62.1	Note: Bedrock cored between 13.6 m and 16.4 m depth. For bedrock coring details refer to Record of Drillhole B8. End of Borehole														
16.4															





PROJECT 08-1111-0044

**RECORD OF BOREHOLE No B9**

1 OF 2 **METRIC**

G.W.P. 78-99-01

LOCATION N 4904324.4 ; E 307274.6

ORIGINATED BY DG

DIST HWY 401

BOREHOLE TYPE Power Auger, 108mm Diam. Hollow Stem

COMPILED BY JM

DATUM Geodetic

DATE June 9, 2009

CHECKED BY KSL


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub>	W	W <sub>L</sub>		
86.0	GROUND SURFACE							20 40 60 80 100						
0.0	ASPHALTIC CONCRETE							20 40 60 80 100						
85.6														
0.5	Crushed stone (FILL)		1	GRAB										
85.1	Grey Moist													
0.9	Sand and gravel (FILL)		2	SS	12		85							
84.4	Brown Moist													
1.5	Sand (FILL)		3	SS	11		84							57 32 9 2
	Brown Moist													
	Fine grained rock fill, some silty sand, some gravel, trace clay (FILL)													
	Loose to compact		4	SS	18		83							
	Grey Moist													
			5	SS	8		82							
			6	SS	3		81							
			7	SS	29		80							
							79							
			8	SS	4		78							
							77							
			9	SS	29		76							
75.3														
10.7	SILTY CLAY, trace organic matter (Weathered Crust)		10	SS	7		75							
74.7	Stiff													
11.3	Dark grey-brown Moist													
	SILTY CLAY (Weathered Crust)													
	Very stiff						74							
	Grey-brown Moist		11	SS	32		73							
			12	SS	25		72							

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

MIS-MTO 001 08-1111-0044 GPJ GAL-MISS GDT 12/3/10 DD

PROJECT		RECORD OF BOREHOLE		No B9		2 OF 2		METRIC										
G.W.P. 78-99-01		LOCATION		N 4904324.4 ; E 307274.6		ORIGINATED BY		DG										
DIST		HWY 401		BOREHOLE TYPE		Power Auger, 108mm Diam, Hollow Stem		COMPILED BY JM										
DATUM Geodetic		DATE		June 9, 2009		CHECKED BY		KSL										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	25
70.7	— CONTINUED FROM PREVIOUS PAGE —																	
15.2	SILTY CLAY, trace gravel (Weathered Crust) Very stiff Dark grey-brown Moist		13	SS	10													
69.2	SILTY CLAY Stiff Grey Moist to wet		14	SS	2													
16.8			15	SS	PM													
			16	SS	WH													
64.6			17	SS	8/0.13													
21.5	Silty SAND, some gravel, trace clay (TILL) Loose Grey Wet		C1	NQ RC	REC 100%													RQD = 100%
	ARKOSIC SANDSTONE (BEDROCK) Fresh Fine to medium grained Medium strong Greenish grey and reddish grey		C2	NQ RC	REC 100%													RQD = 100%
	Note: Bedrock cored between 21.5 m and 24.6 m depth. For bedrock coring details refer to Record of Drillhole B9.		C3	NQ RC	REC 100%													RQD = 100%
61.4	End of Borehole																	
24.6																		

MIS-MTO 001 08-1111-0044 GPJ GAL-MISS GDT 12/3/10 DD

PROJECT: 08-1111-0044

## RECORD OF DRILLHOLE: B9

SHEET 1 OF 1

LOCATION: N 4904324.4 ;E 307274.6

DRILLING DATE: June 9, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No	PENETRATION RATE (m/min)	FLUSH % RETURN	COLOUR % RETURN	FR/FX-FRACTURE	F-FAULT	SM-SMOOTH	FL-FLEXURED	BC-BROKEN CORE	DIAMETRAL CORE LOSS 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.O.D. %	FRACT INDEX PER 0.3	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec									
TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION											
0 5 10 15 20		0 5 10 15 20	0 5 10 15 20	0 5 10 15 20	DIP w.r.t. CORE AXIS		10 <sup>-8</sup>	10 <sup>-7</sup>	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>	10 <sup>-3</sup>	10 <sup>-2</sup>	10 <sup>-1</sup>	
22		Continued from Record of Borehole B9		64.50											
		ARKOSIC SANDSTONE (BEDROCK)		21.50											
		Fresh			C1										
		Fine to medium grained													
		Medium strong													
		Greenish grey and reddish grey													
23					C2										
24															
					C3										
				61.40											
25		End of Drillhole		24.60											
26															
27															
28															
29															
30															
31															
32															
33															
34															
35															
36															

DEPTH SCALE

1 : 75



LOGGED: DG

CHECKED: KSL

MIS-ROCK 001 08-1111-0044 (ROCK) GPJ GAL-MISS GDT 12/3/10 DD



## 1 OF 2 METRIC

ORIGINATED BY DG

COMPILED BY JM

CHECKED BY KSL

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

MIS-MTO 001 08-1111-0044 GPJ GAL-MISS GDT 12/3/10 DD

PROJECT 08-1111-0044		<b>RECORD OF BOREHOLE No B10</b>				2 OF 2 <b>METRIC</b>							
G.W.P. 78-99-01		LOCATION N 4904329.3 ; E 307288.8				ORIGINATED BY DG							
DIST HWY 401		BOREHOLE TYPE Power Auger, 200mm Diam. Hollow Stem				COMPILED BY JM							
DATUM Geodetic		DATE June 8, 2009				CHECKED BY KSL							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	γ	GR SA SI CL	
— CONTINUED FROM PREVIOUS PAGE —													
	SILTY CLAY (Weathered Crust) Stiff to very stiff Dark grey-brown Wet		12	SS	10		70						
							69						0 2 33 65
							68						
							67						
65.8							66						
19.8	SILTY CLAY Firm Grey Wet		15	SS	2		65						0 1 62 37
64.6							64						
21.0	Silty SAND, some gravel, trace clay (TILL) Grey Wet		16	SS	58/0.28		64						16 47 32 5
63.9													
21.8	End of Borehole Auger Refusal												