
Appendix C – Geotechnical Investigation



23 September 2011
Project No. WX16667

Dillon Consulting Limited
895 Waverley Street, Suite 200
Winnipeg, Manitoba
R3T 5P4

Attention: Mr. David Krahn, P. Eng.

**Re: Geotechnical Investigation
Proposed New Transit Garage – Brandon Avenue
Winnipeg, Manitoba**

1.0 INTRODUCTION

As requested, AMEC Environment & Infrastructure, a Division of AMEC Americas Limited (AMEC), completed a preliminary geotechnical investigation at the above noted site. The investigation included the supervision of test hole drilling and geotechnical lab testing. Geotechnical recommendations were not requested and therefore are not included herein. An environmental investigation program was completed concurrently with the geotechnical investigation and is presented under separate cover.

Based on the information provided by Dillon, it was understood that the proposed transit garage will be constructed using a design-build approach and as such, specific building information such as dimensions, location and foundation loads were not available at the time of drilling.

This report presents a summary of our findings during our field investigation and lab testing program.

2.0 SITE CONDITIONS

The site is located at the west end of Brandon Avenue, near Hethrington Avenue, in Winnipeg, Manitoba. The site was undeveloped at the time of the investigation, however construction of a Rapid Transit Corridor is occurring immediately adjacent to the site, and as such debris and construction equipment from the construction site were located on various parts of the site.

The site is bordered to the east by residential dwellings, and to the west by an operating rail yard and the recently constructed Rapid Transit Corridor. North and south of the site are undeveloped areas that will become part of the Rapid Transit Corridor. The site is generally flat lying and is partially covered by short grass.

3.0 GEOTECHNICAL FIELD INVESTIGATION

A total of twelve test holes were drilled across the site area using a SoilMec SR-30 track-mounted piling rig owned and operated by Subterranean Ltd. of West St. Paul, Manitoba. Four of the test holes were advanced to auger refusal, four test holes were drilled to a depth of 5 m, while the remaining four holes were completed at a depth of 3 m.

It should be noted that during drilling of test hole TH07, an abandoned water line was struck at approximately 0.9 m below existing ground surface. Dillon Consulting was informed. Drilling of the test hole continued until the seepage from the water line caused the test hole to fill with water. Drilling of the hole was subsequently ceased at a depth of 13.7 m. The test hole was moved to avoid the water line and drilling continued as normal. The original test hole was backfilled using 19mm down crushed gravel.

During drilling, soil stratigraphy was classified according to the Modified Unified Soil Classification System (MUSCS) by AMEC's field technician, Mr. Anthony Lospe. Disturbed grab samples were collected from the auger at regular intervals, while relatively undisturbed Shelby Tube samples were collected at select depths. Pocket penetrometers readings were taken to assess the relative consistency of cohesive samples. All samples were sealed in plastic bags to limit moisture loss and transported to AMEC's Winnipeg laboratory.

A laboratory testing program was undertaken and consisted of natural moisture content determination, unconfined compression and laboratory vane testing.

4.0 SUBSURFACE CONDITIONS

Based on the twelve test holes drilled on 8 September 2011, the soil stratigraphy at the test hole locations was as follows:

- Fill
- Organic Clay
- Silt
- Clay
- Silt Till

Fill

Clay fill materials were found at the ground surface at all test hole locations, with the exception of test hole TH11 (where no fill was observed) and at test hole TH12 (where it was found beneath a layer of surface granular fill). The clay fill was generally described as silty, low plastic, moist, stiff, brown to dark grey, and contained trace to some sand and gravel. Rubble, bricks and other debris was also found within the clay fill in several test holes. The clay fill extended to depths ranging between 0.6 m and 1.6 m.

Granular fill was found at the surface in test holes TH11 and TH12 and was described as being gravelly, sandy, poorly graded, medium to coarse grained, loose to compact, moist, brown and contained some gravel. The granular fill extended to 1.1 and 0.4 m from grade at the two

locations, respectively. A thin layer of sand fill was also noted beneath the clay fill in test holes TH08 and TH09. The sand fill at these locations was generally described as being poorly graded, medium to coarse grained, loose to compact, moist, brown and ranged between trace silt and silty. The sand extended to depths ranging between 0.9 m and 1.3 m.

Organic Clay

A layer of organic clay was found beneath the fill material in test hole TH01. The organic clay was described as being low to medium plastic, moist, firm, black and contained traces of silt, sand, and rootlets. The organic clay extended to 0.9 m.

Silt

A thin layer of silt was found in the majority of the test holes, either directly beneath the fill materials (TH02 to TH08 and TH12) or within the underlying native clay (test holes TH01, TH03, TH10 and TH11). Silt was not observed in test hole TH09.

Generally the silt was low plastic, moist to very moist, soft and light brown to tan. The silt layer was encountered at depths ranging between 0.9 m and 2.2 m, and extended to depths ranging between 1.4 m and 2.6 m.

Clay

Native clay was observed below the fill, silt and organic layers in all the test holes. The clay was silty, high plastic, moist, stiff to very stiff and brown. Generally, the clay became stiff and then firm and grey with increasing depth in the deep test holes. Sulphate inclusions were found within the clay below depths of approximately 3.1 m or greater. Traces of gravel and silt till inclusions were also noted within the clay below depths of approximately 12.2 m. The clay extended to depths ranging between 14.3 m and 15.4 m (although TH07 was terminated while still in clay at 13.7 m).

Silt Till

Glacial silt till was present below the clay in each of the deep test holes (TH01, TH06, TH07 and TH12) except test hole TH01, where refusal was met prior to reaching the till layer. The silt till was low plastic, moist, soft, grey and contained traces of sand and gravel. With depth, the till became damp dense and the till extended to the maximum depths explored in each test hole where it was found (16.0 to 16.5 m).

4.1 Sloughing and Seepage Conditions

Each test hole was left open for approximately 10 minutes after completion of drilling in order to measure short term sloughing and seepage conditions. The table below provides a summary of the sloughing and seepage conditions observed at the test holes.

Table 1: Sloughing and Seepage Conditions

Test Hole #	Drilled Depth (m)	Sloughing Below (m)	Test Hole Open To (m)	Seepage Below (m)	Water Level Prior to Backfill (m)
TH01	14.6	--	14.6	1.7 (very slight)	--
TH02	3.0	--	3.0	--	--
TH03	3.0	--	3.0	1.7 (very slight)	--
TH04	5.0	--	4.9	1.4 (slight)	4.7
TH05	5.0	1.5 (moderate)	1.7	1.5 (moderate)	1.5
TH06	16.5	--	16.5	0.9 (very slight)	--
TH07	13.7	--	13.7	0.9 (significant; from water line)	3.7
TH07-A	16.3	15.2 (slight)	16.2	15.2 (slight)	15.2
TH08	5.0	--	5.0	--	--
TH09	5.0	--	5.0	3.1 (heavy)	3.1
TH10	3.0	--	3.0	--	--
TH11	3.0	--	3.0	--	--
TH12	16.0	--	15.8	15.3 (slight) 15.8 (moderate to heavy)	13.7

"--" indicates not encountered

5.0 LABORATORY TESTING

A laboratory testing program was conducted on selected samples and consisted of natural moisture content determination, unconfined compression and laboratory vane testing. Results of all laboratory testing can be found on the test hole logs, however a summary of the unconfined compression and laboratory vane testing is presented below.

Table 2: Laboratory Testing Results

Test Hole and Sample Number	Sample Depth (m)	Unconfined Compressive Strength (kPa)	Laboratory Vane Shear Strength (kPa)	Bulk Unit Weight (kg/m ³)	Moisture Content (%)
TH06 Sample 6	3.1 – 3.7	19.9*	77.4	1701	55.0
TH06 Sample 9	6.1 – 6.7	116.2	74.0	1708	51.9
TH06 Sample 12	9.1 – 9.7	103.5	59.0	1772	47.9
TH07 Sample 7	4.6 – 5.2	80.1	82.9	1706	57.1
TH07 Sample 10	7.6 – 8.2	124.4	62.8	1734	45.0
TH07-A Sample 2	13.7 – 14.3	76.6	53.2	1770	46.6

*Low unconfined compressive strength confirmed due to presence of slickenside in sample

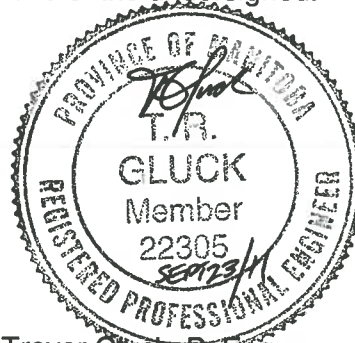
6.0 CLOSURE

Soil conditions, by their nature, can be highly variable across a construction site. The placement of fill during and prior to construction activities on a site can contribute to variable soil conditions. A contingency amount should be included in the construction budget to allow for the possibility of unexpected variations in soil conditions, which may result in modification of the design, and/or changes in construction procedures.

This memorandum has been prepared for the exclusive use of Dillon Consulting Limited and the City of Winnipeg for inclusion in the Rapid Transit Garage Design Build request for proposals. The information contained herein should be used for informational purposes only and should be verified by the successful design build team. Any use that a third party makes of this memo, or any reliance or decisions based on this memo are the sole responsibility of those parties. It has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty is made, either expressed or implied.

AMEC trusts the above information satisfies your requirements at this time. We would be pleased to provide any further information that may be needed during design. If you require additional information, please do not hesitate to contact one of the undersigned.

Sincerely,
AMEC EARTH & ENVIRONMENTAL



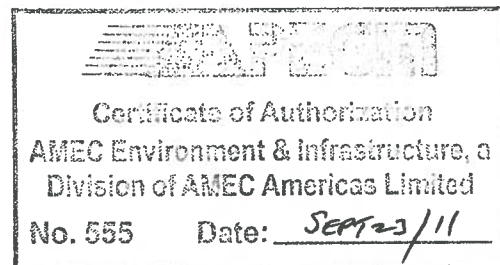
Jorden Wiwcharyk, EIT
Geotechnical Engineer-In-Training

Trevor Gluck, P. Eng.
Senior Geotechnical Engineer

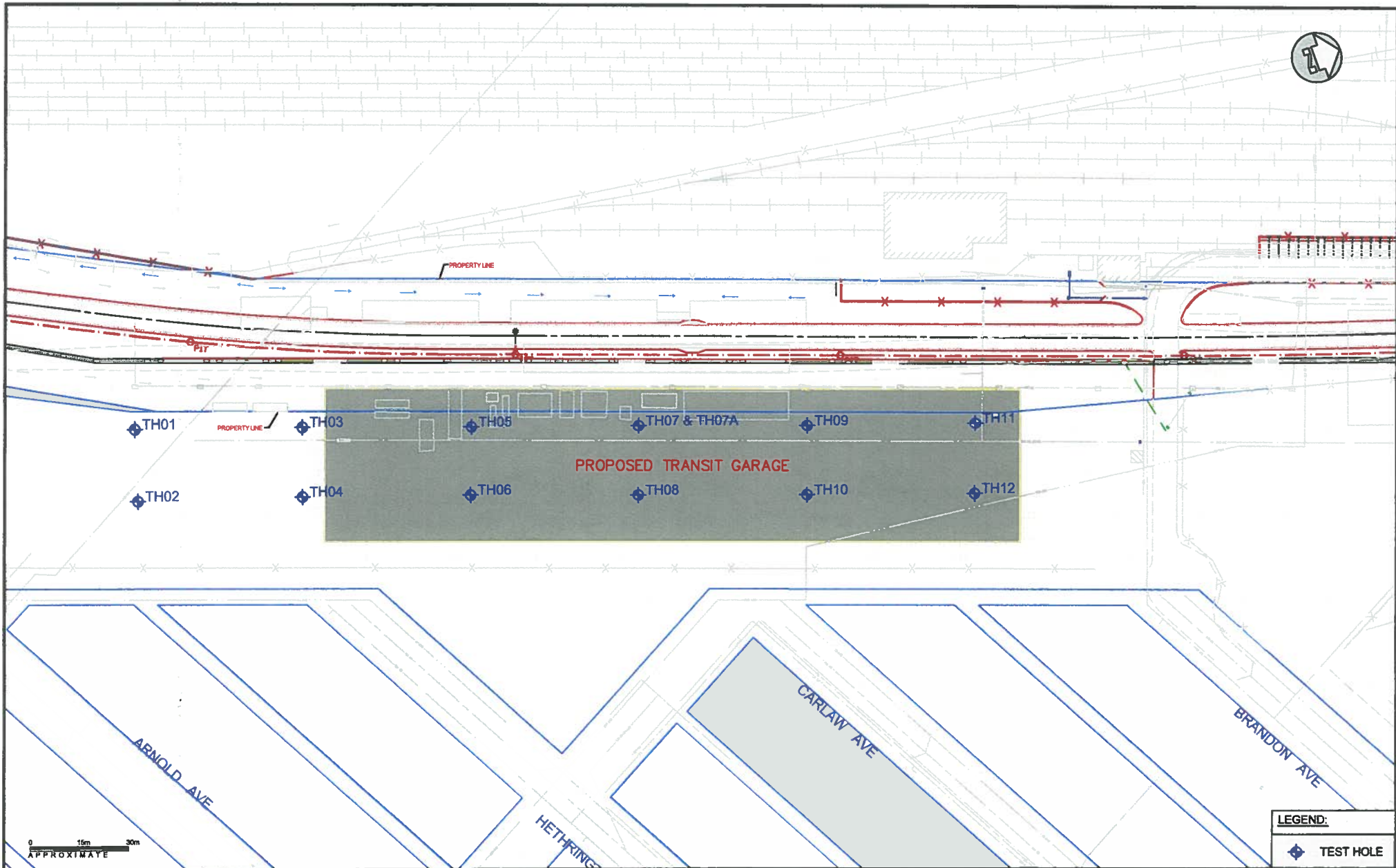
Reviewed By:



Harley Pankratz, P. Eng.
Vice President: Eastern Prairies/Northern Alberta



Attachments: Figure 1: Test Hole Location Plan
Figure 2-14: Test Hole Logs

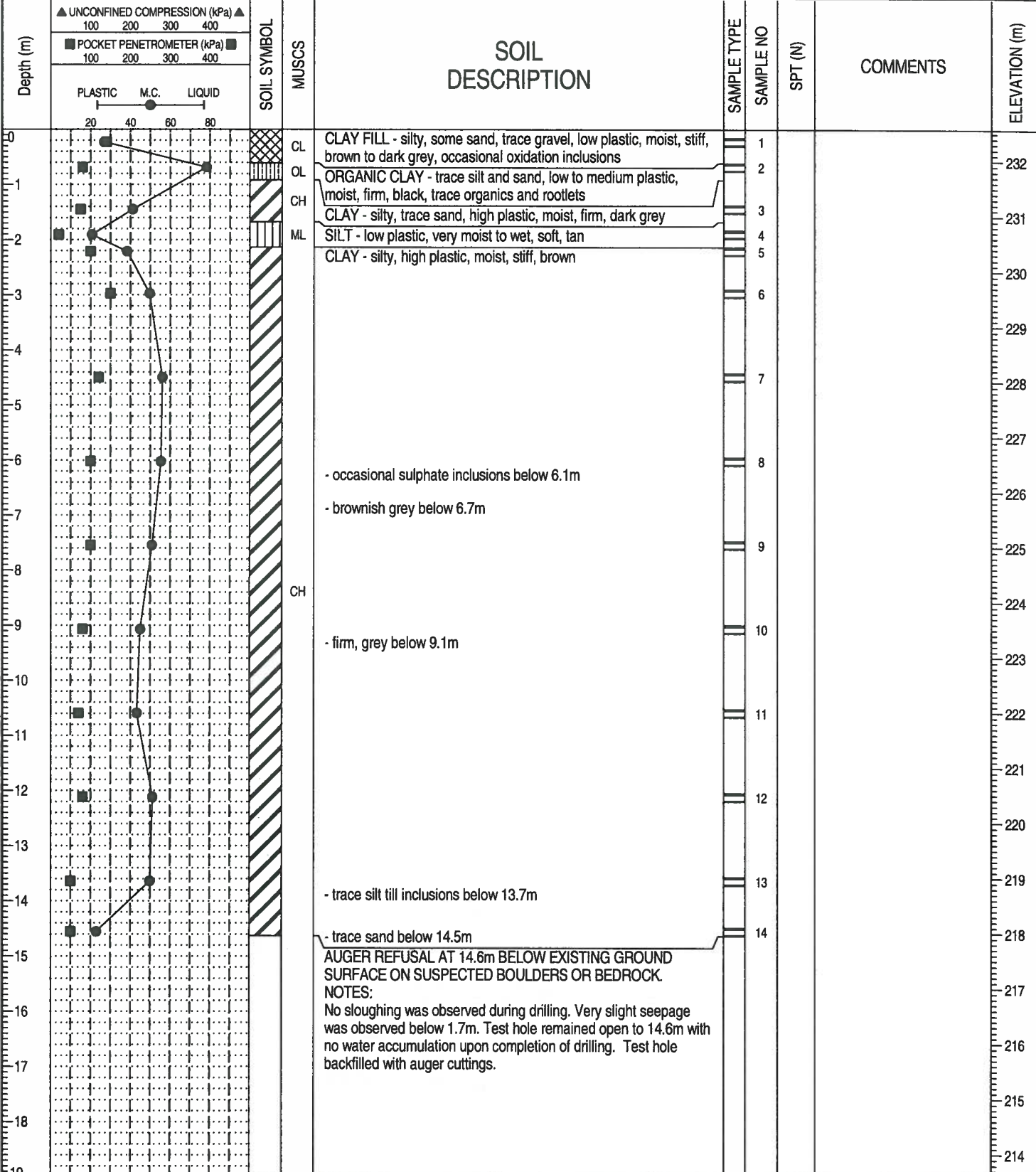


LEGEND:
TEST HOLE

CLIENT LOGO	CLIENT DILLON CONSULTING LIMITED	DWN BY: MD	PROJECT GEOTECHNICAL INVESTIGATION TRANSIT GARAGE - BRANDON AVENUE WINNIPEG, MANITOBA	REV. NO.: A
		CHK'D BY: TG		DATE: SEPTEMBER 2011
AMEC Earth & Environmental 440 DOVERCOURT DRIVE WINNIPEG, MANITOBA		DATUM: NAD99	TITLE TEST HOLE LOCATION PLAN	PROJECT NO.: WX16667
		PROJECTION: UTM Zone 0		FIGURE No.
		SCALE: AS SHOWN		FIGURE 1

F:\ubst\16600\st16667 - Dillon Rapid Transit Garages\Drawings

PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH01
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667
LOCATION: West End of Brandon Avenue, Winnipeg, MB	DRILL METHOD: 508mm Solid Stem Auger	ELEVATION: 232.57 m
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BACKFILL TYPE	<input checked="" type="checkbox"/> Bentonite <input type="checkbox"/> Pea Gravel <input checked="" type="checkbox"/> Drill Cuttings <input type="checkbox"/> Grout <input type="checkbox"/> Slough <input type="checkbox"/> Sand	



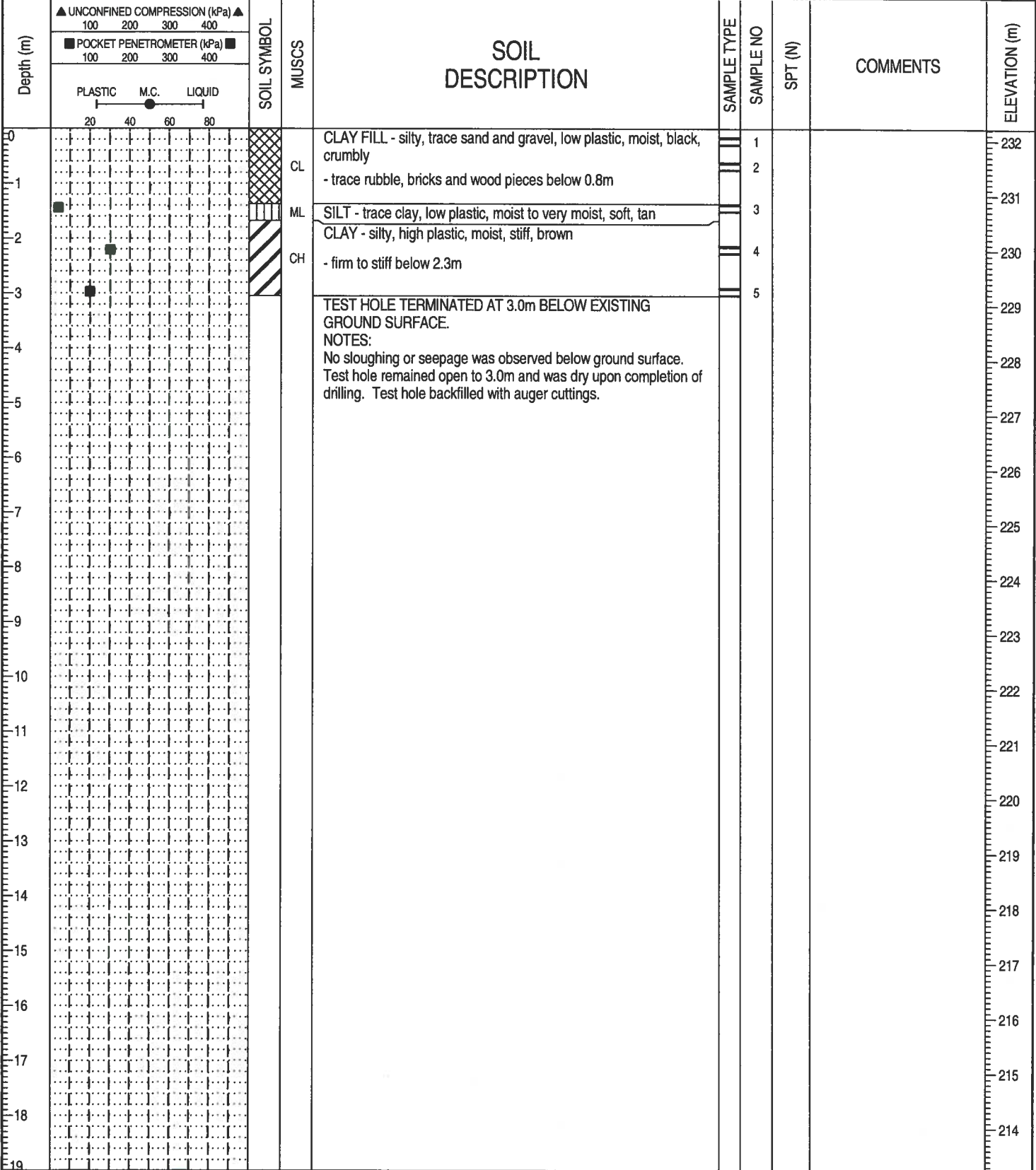
16667 - DILLON NEW TRANSIT BUS GARAGE.GPJ 11/09/23 03:30 PM (GEOTECHNICAL REVISED)



AMEC Environment & Infrastructure
Winnipeg, Manitoba

LOGGED BY: AL	COMPLETION DEPTH: 14.6 m
REVIEWED BY: TG	COMPLETION DATE: September 8, 2011
Figure No. 2	Page 1 of 1

PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH02
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667
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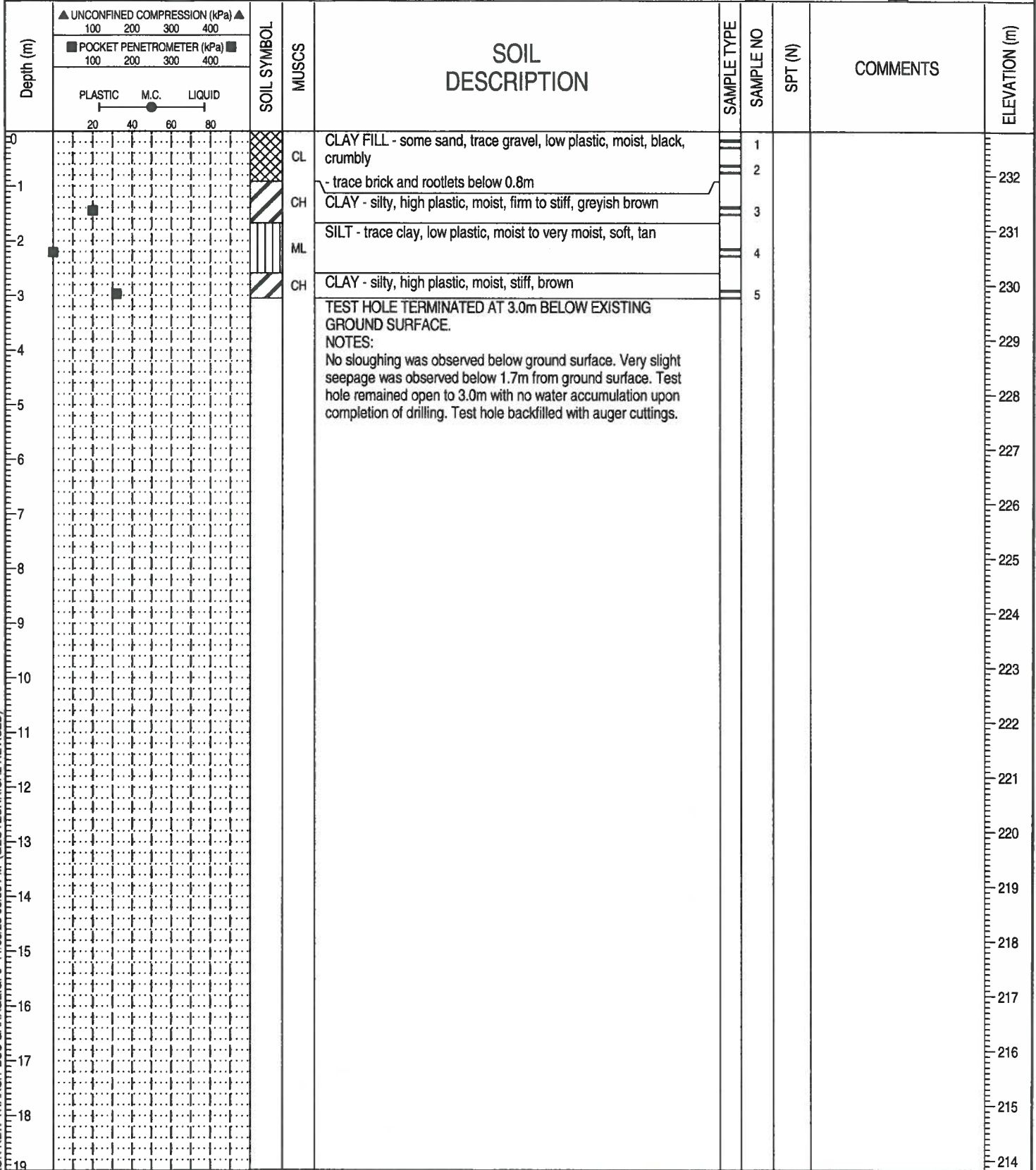


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Figure No. 3

COMPLETION DEPTH: 3 m
COMPLETION DATE: September 8, 2011
Page 1 of 1

PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH03
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667
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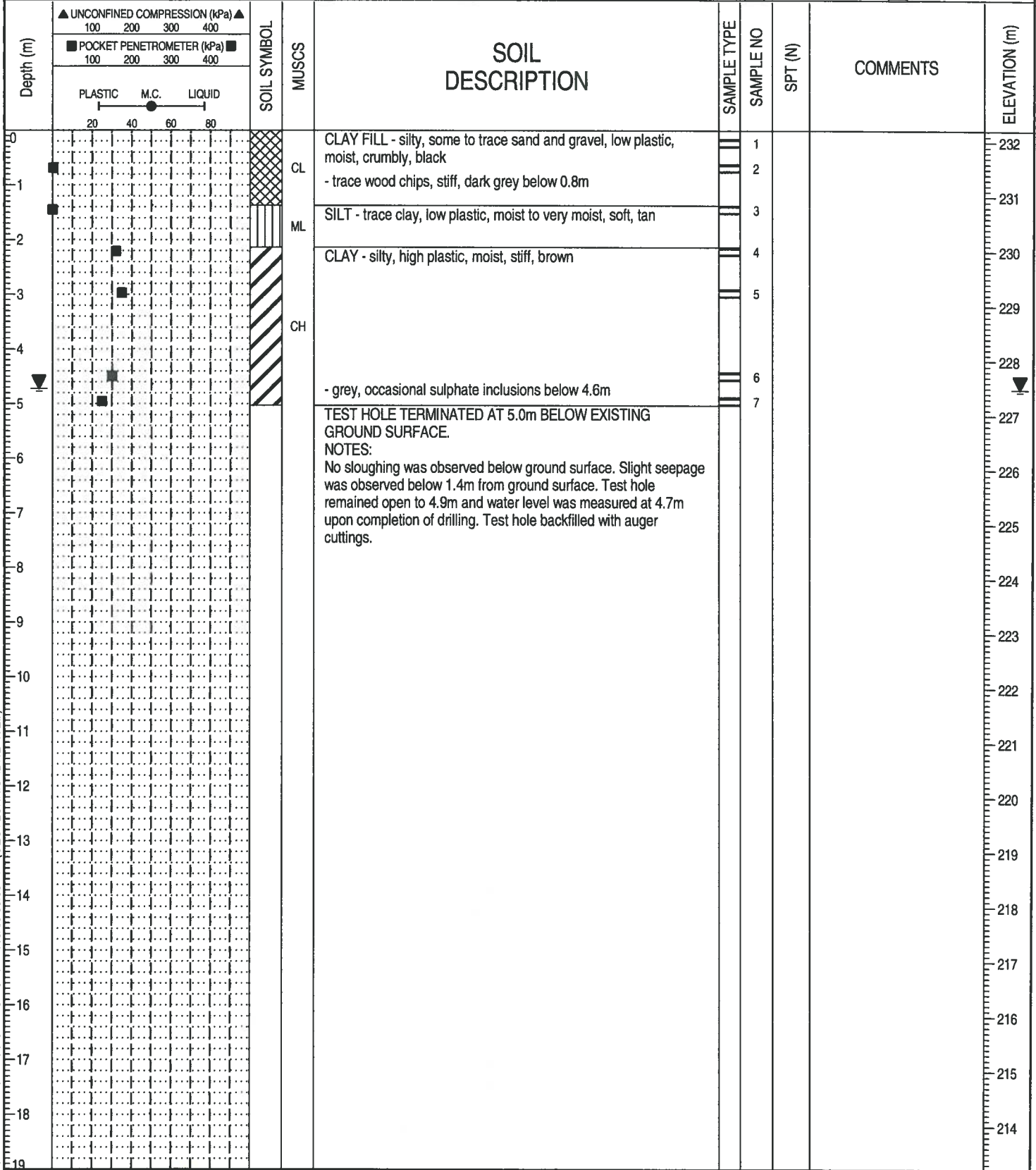


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REVIEWED BY: TG
Figure No. 4

COMPLETION DEPTH: 3 m
COMPLETION DATE: September 8, 2011

PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH04				
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667				
LOCATION: West End of Brandon Avenue, Winnipeg, MB	DRILL METHOD: 508mm Solid Stem Auger	ELEVATION: 232.21 m				
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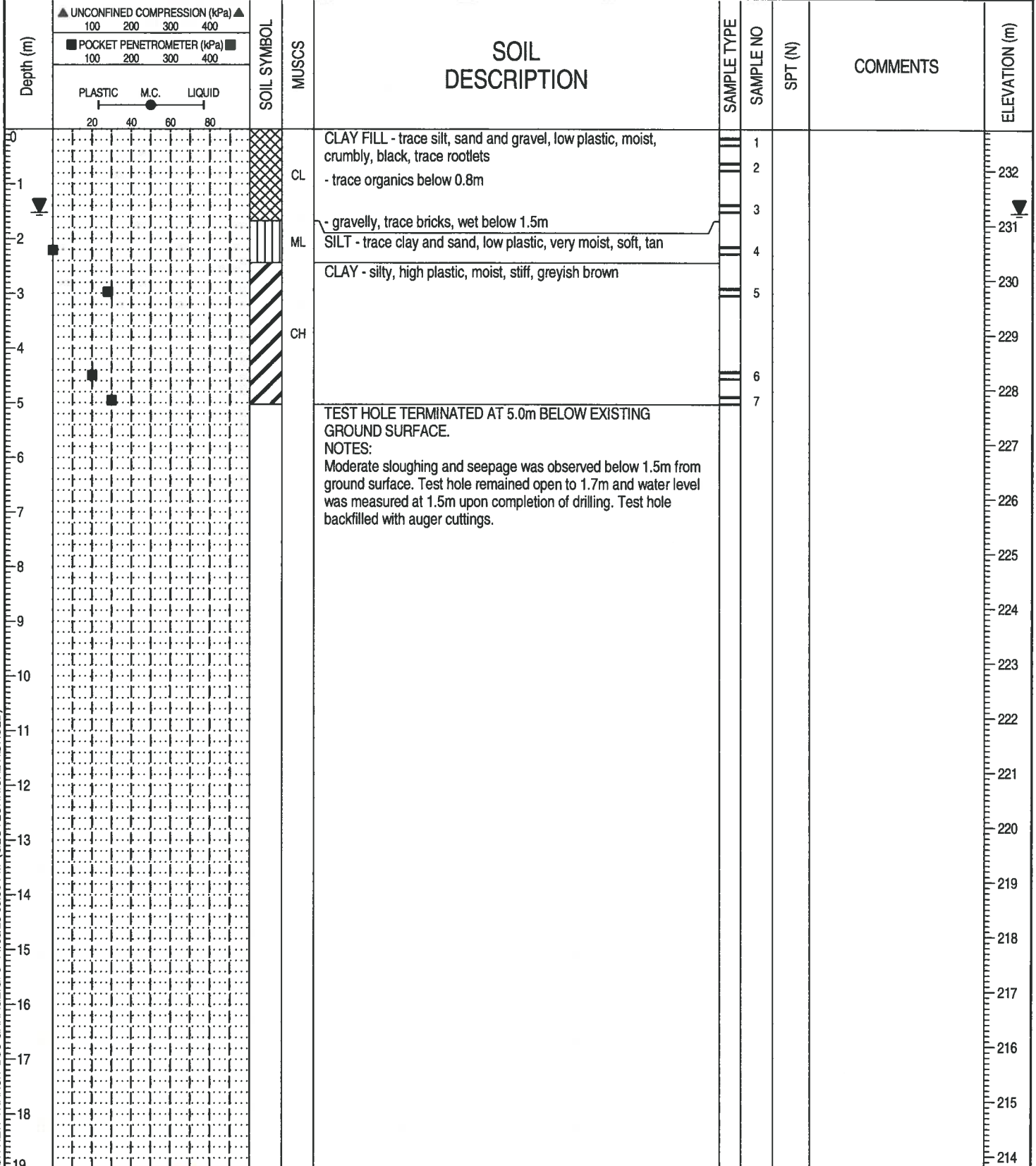
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REVIEWED BY: TG	COMPLETION DATE: September 8, 2011
Figure No. 5	Page 1 of 1

PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH05				
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667				
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BACKFILL TYPE	<input checked="" type="checkbox"/> Bentonite	<input type="checkbox"/> Pea Gravel	<input checked="" type="checkbox"/> Drill Cuttings	<input type="checkbox"/> Grout	<input type="checkbox"/> Slough	<input type="checkbox"/> Sand



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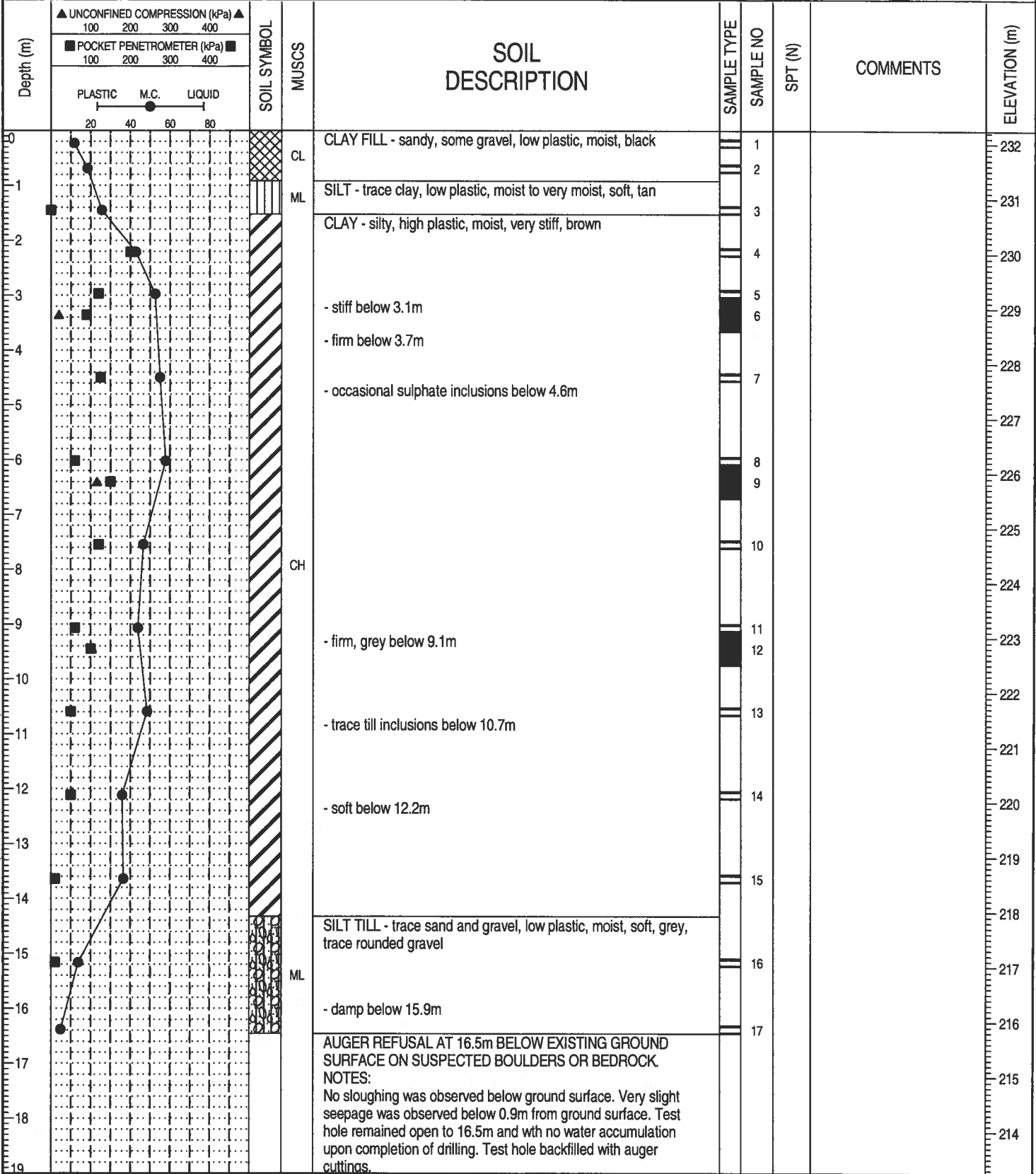


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REVIEWED BY: TG
Figure No. 6

COMPLETION DEPTH: 5 m
COMPLETION DATE: September 8, 2011

PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH06
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667
LOCATION: West End of Brandon Avenue, Winnipeg, MB	DRILL METHOD: 508mm Solid Stem Auger	ELEVATION: 232.24 m
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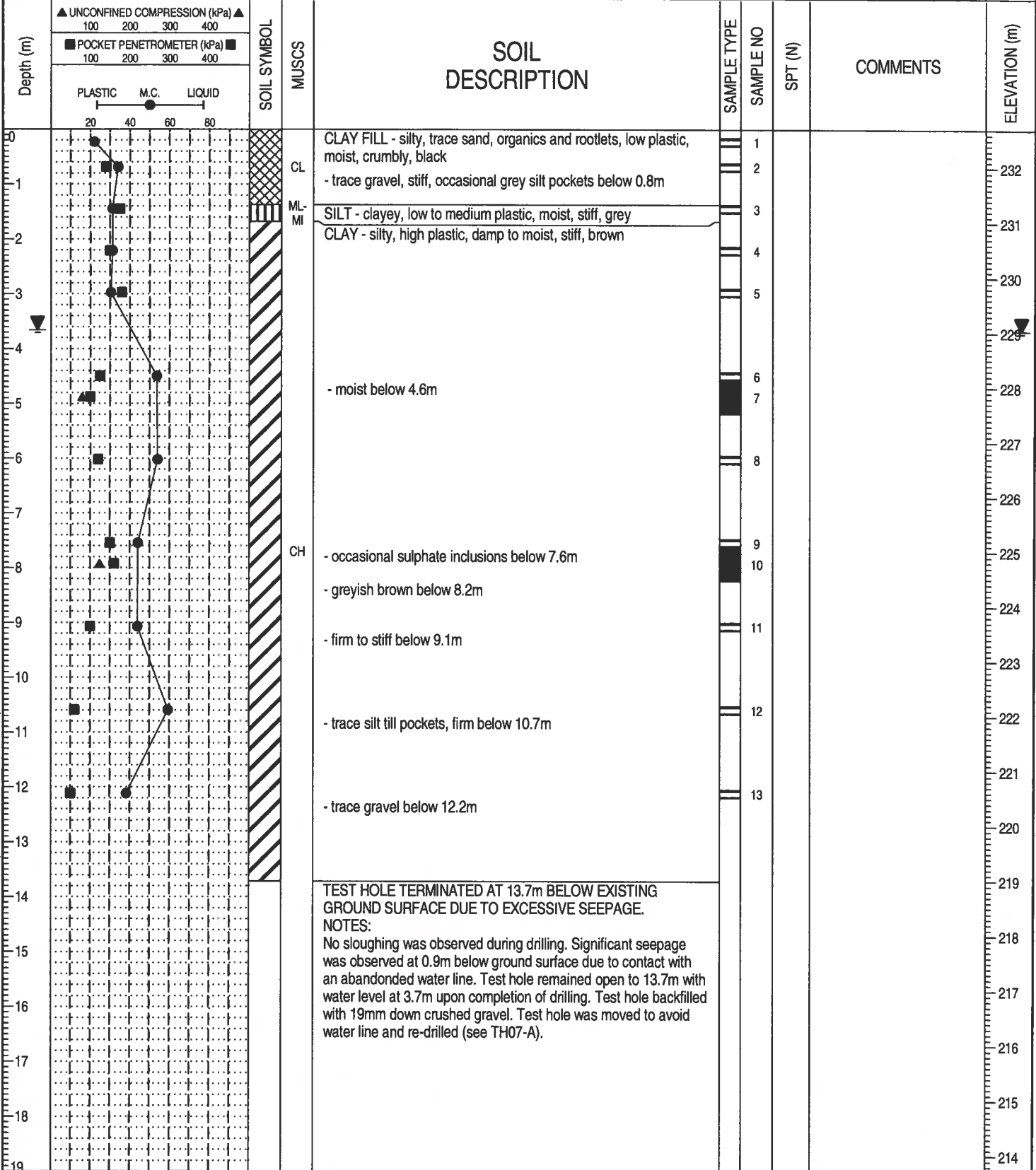


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Figure No. 7

COMPLETION DEPTH: 16.5 m
COMPLETION DATE: September 8, 2011
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PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH07
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667
LOCATION: West End of Brandon Avenue, Winnipeg, MB	DRILL METHOD: 508mm Solid Stem Auger	ELEVATION: 232.7 m
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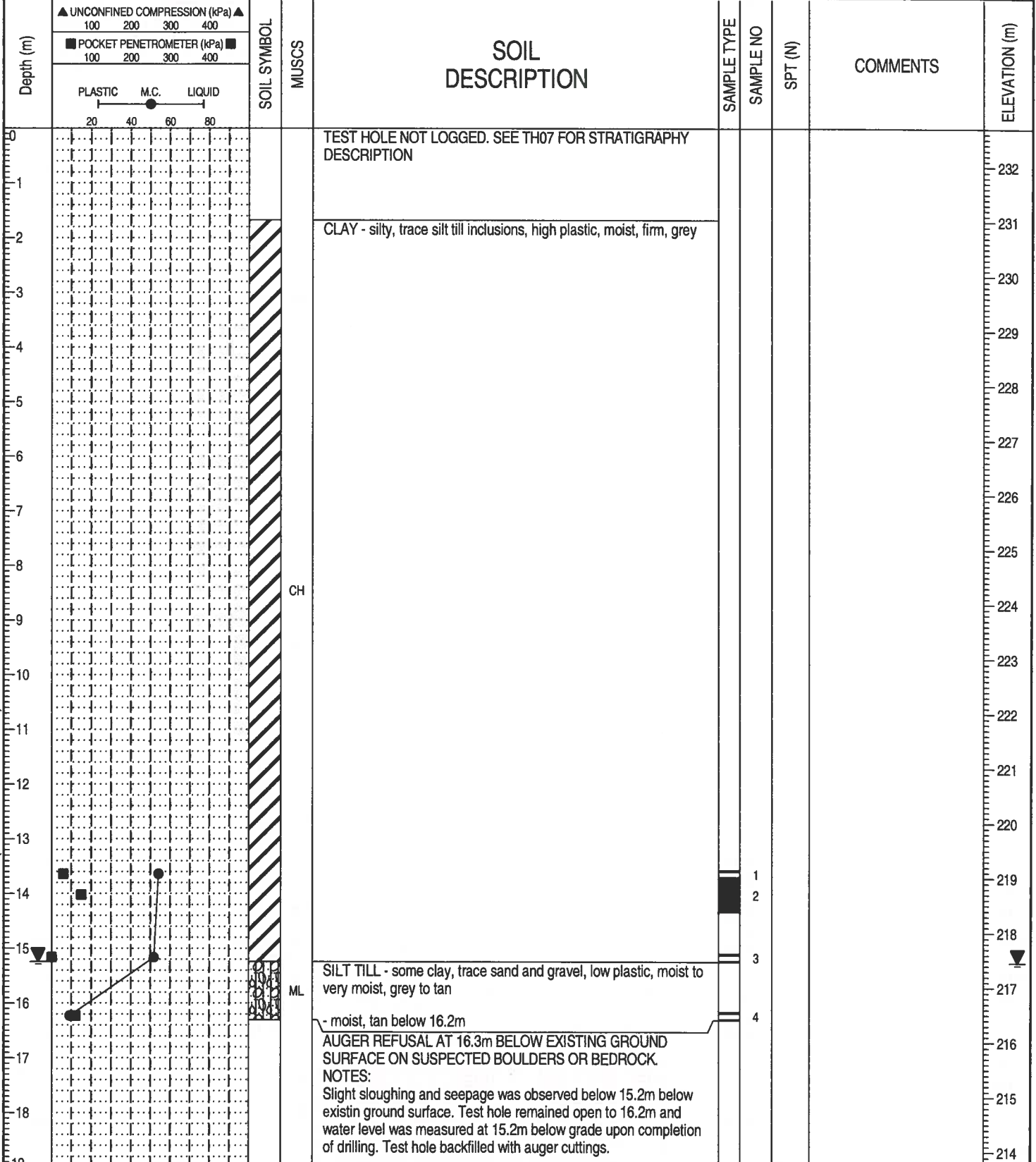
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Winnipeg, Manitoba

LOGGED BY: AL	COMPLETION DEPTH: 13.7 m
REVIEWED BY: TG	COMPLETION DATE: September 8, 2011
Figure No. 8	Page 1 of 1

PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH07-A
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667
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BACKFILL TYPE	<input checked="" type="checkbox"/> Bentonite <input type="checkbox"/> Pea Gravel <input checked="" type="checkbox"/> Drill Cuttings <input type="checkbox"/> Grout <input type="checkbox"/> Slough <input type="checkbox"/> Sand	



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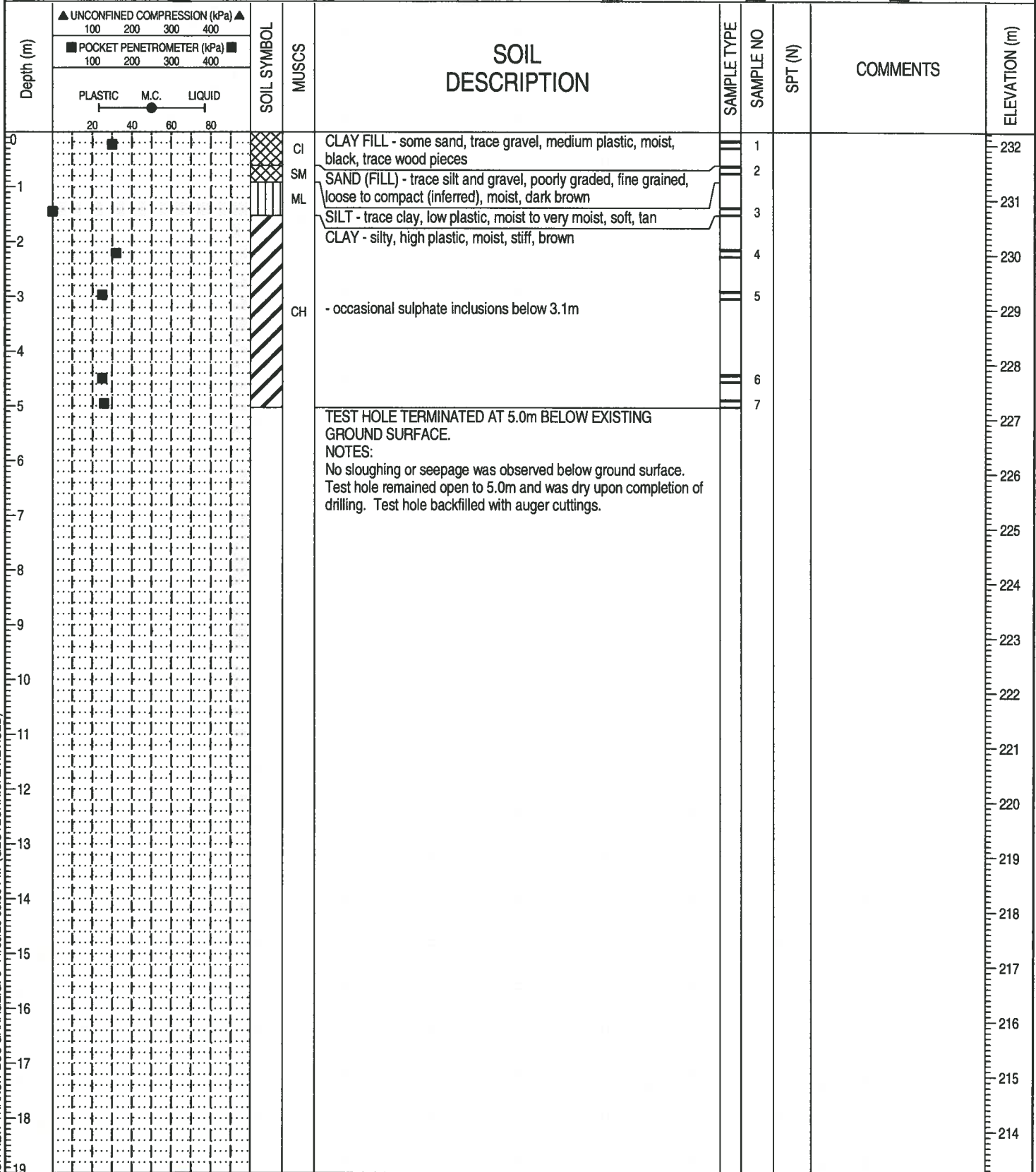


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Figure No. 9

COMPLETION DEPTH: 16.3 m
COMPLETION DATE: September 9, 2011
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PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH08				
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667				
LOCATION: West End of Brandon Avenue, Winnipeg, MB	DRILL METHOD: 508mm Solid Stem Auger	ELEVATION: 232.23 m				
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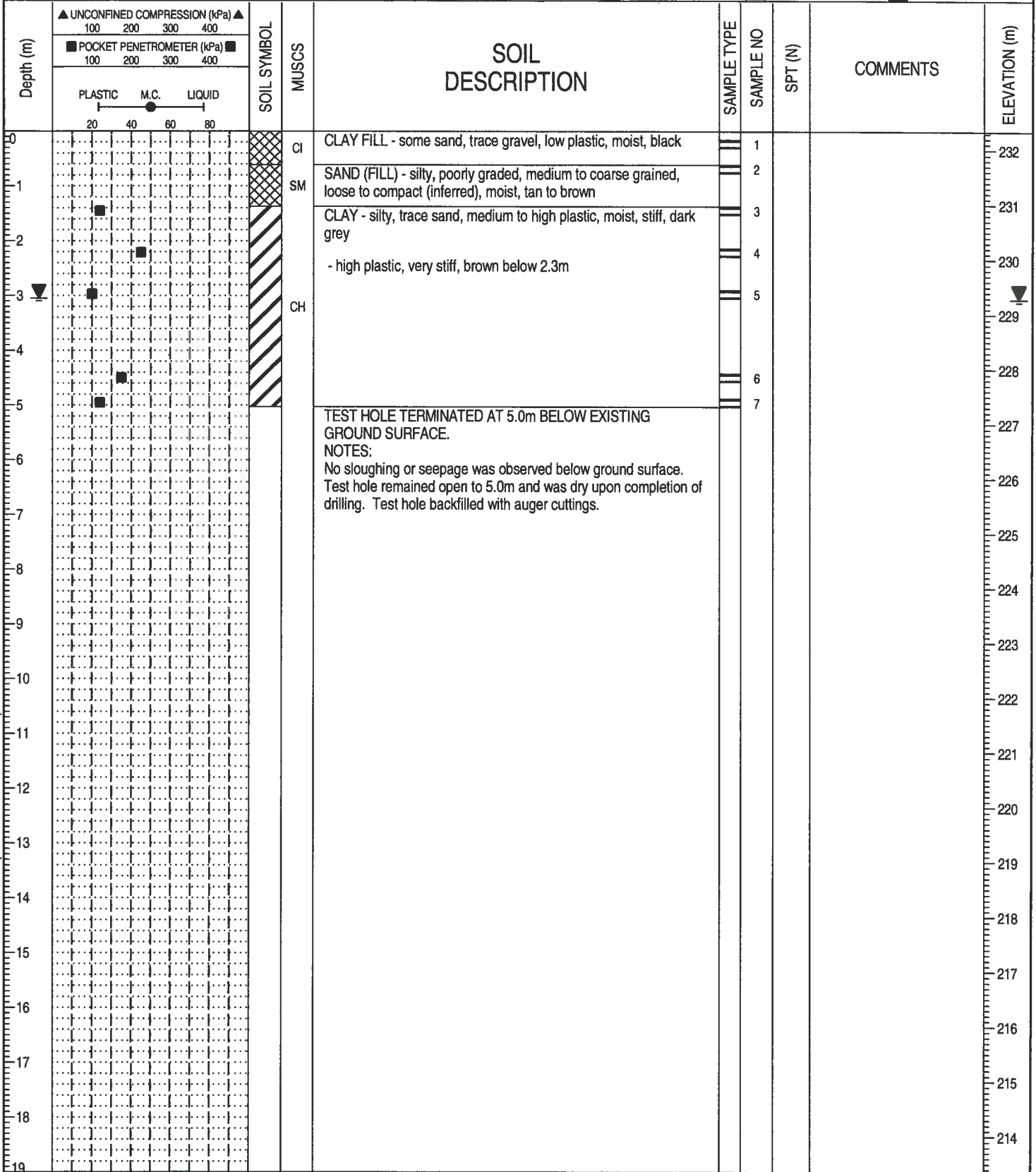
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AMEC Environment & Infrastructure
Winnipeg, Manitoba

LOGGED BY: AL	COMPLETION DEPTH: 5 m
REVIEWED BY: TG	COMPLETION DATE: September 8, 2011
Figure No. 10	Page 1 of 1

PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH09				
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667				
LOCATION: West End of Brandon Avenue, Winnipeg, MB	DRILL METHOD: 508mm Solid Stem Auger	ELEVATION: 232.34 m				
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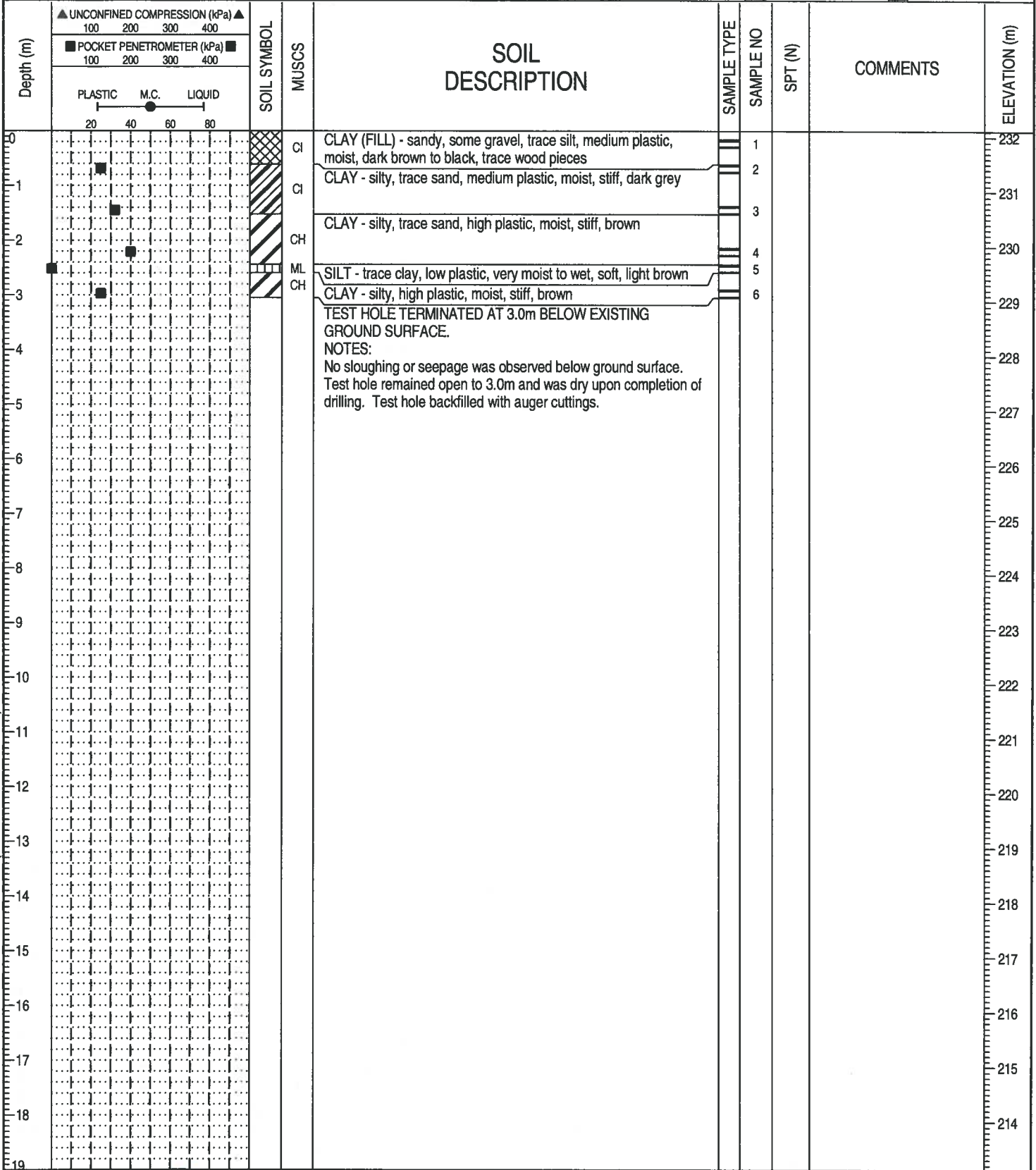
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AMEC Environment & Infrastructure
Winnipeg, Manitoba

LOGGED BY: AL	COMPLETION DEPTH: 5 m
REVIEWED BY: TG	COMPLETION DATE: September 8, 2011
Figure No. 11	Page 1 of 1

PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH10
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667
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BACKFILL TYPE	<input checked="" type="checkbox"/> Bentonite <input type="checkbox"/> Pea Gravel <input type="checkbox"/> Drill Cuttings <input type="checkbox"/> Grout <input type="checkbox"/> Slough <input type="checkbox"/> Sand	



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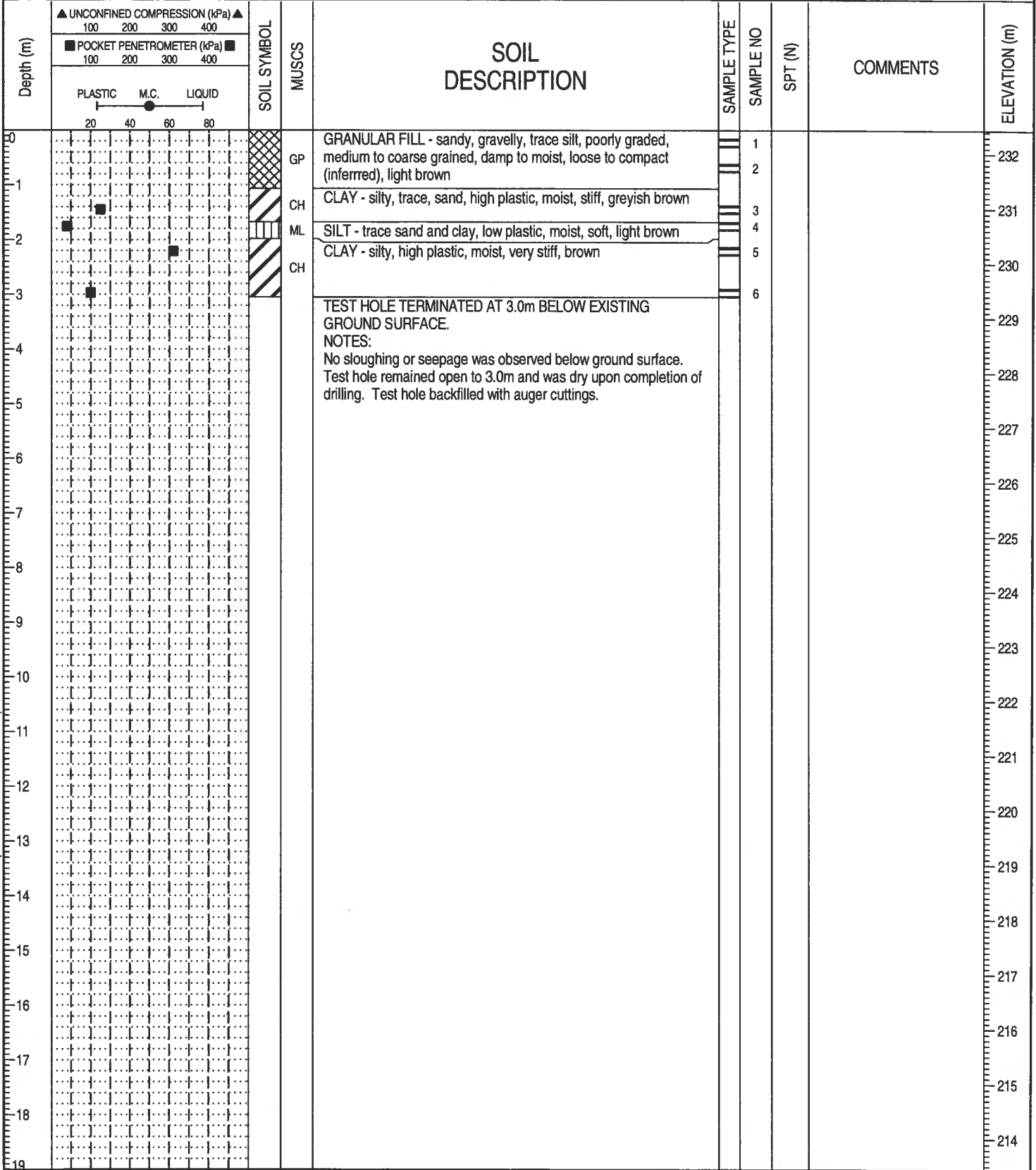


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Winnipeg, Manitoba

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REVIEWED BY: TG
Figure No. 12

COMPLETION DEPTH: 3 m
COMPLETION DATE: September 8, 2011

PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH11
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667
LOCATION: West End of Brandon Avenue, Winnipeg, MB	DRILL METHOD: 508mm Solid Stem Auger	ELEVATION: 232.43 m
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BACKFILL TYPE	<input checked="" type="checkbox"/> Bentonite <input type="checkbox"/> Pea Gravel <input checked="" type="checkbox"/> Drill Cuttings <input type="checkbox"/> Grout <input type="checkbox"/> Slough <input type="checkbox"/> Sand	



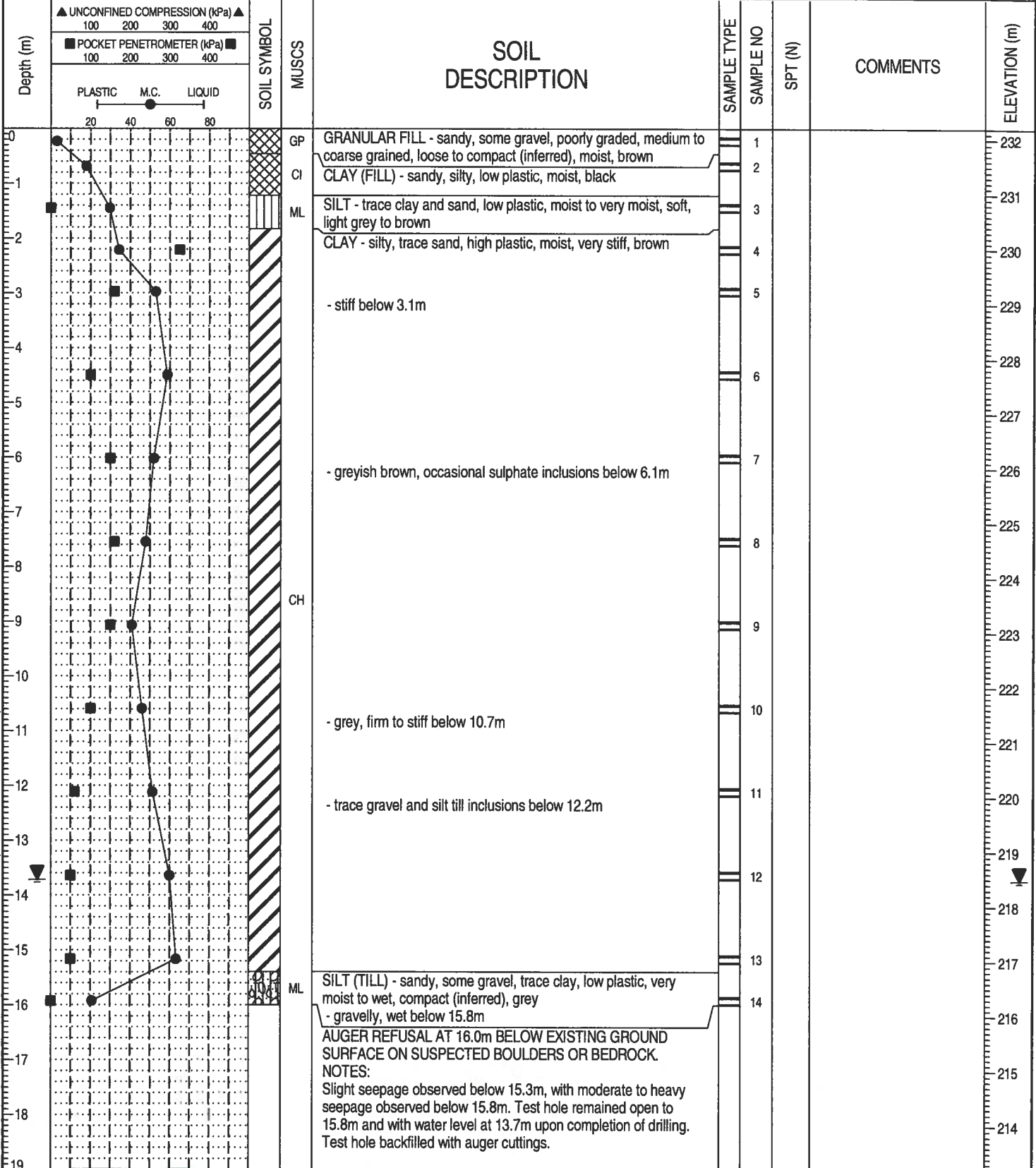
16667 - DILLON NEW TRANSIT BUS GARAGE.GPJ 11/09/23 03:30 PM (GEOTECHNICAL REVISED)



AMEC Environment & Infrastructure
Winnipeg, Manitoba

LOGGED BY: AL	COMPLETION DEPTH: 3 m
REVIEWED BY: TG	COMPLETION DATE: September 9, 2011
Figure No. 13	Page 1 of 1

PROJECT: New Transit Bus Garage	DRILLED BY: Subterranean Ltd.	BORE HOLE NO: TH12
CLIENT: Dillon Consulting Limited	DRILL TYPE: Soil Mec SR-30	PROJECT NO: WX16667
LOCATION: West End of Brandon Avenue, Winnipeg, MB	DRILL METHOD: 508mm Solid Stem Auger	ELEVATION: 232.2 m
SAMPLE TYPE	<input checked="" type="checkbox"/> Shelby Tube <input type="checkbox"/> No Recovery <input checked="" type="checkbox"/> SPT (N) <input type="checkbox"/> Grab Sample <input type="checkbox"/> Split-Pen <input type="checkbox"/> Core	
BACKFILL TYPE	<input checked="" type="checkbox"/> Bentonite <input type="checkbox"/> Pea Gravel <input checked="" type="checkbox"/> Drill Cuttings <input type="checkbox"/> Grout <input type="checkbox"/> Slough <input type="checkbox"/> Sand	



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LOGGED BY: AL	COMPLETION DEPTH: 16 m
REVIEWED BY: TG	COMPLETION DATE: September 9, 2011
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