Meadowbank Education and Employment Precinct Schools Project
Supplementary Geotechnical Investigation

SSD 18_9343
Prepared by Alliance Geotechnical
For School Infrastructure NSW
11 October 2019

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Ward Civil Pty Ltd **11 October 2019**
PO Box 1067
North Ryde BC NSW

Report Number: 9280-GR-1-1 Rev 1
Report Type: Supplementary Geotechnical Investigation Report
Project Name: Meadowbank Education and Employment Precinct Schools Project
Site Location: 2 Rhodes Street Meadowbank, NSW 2114

1. INTRODUCTION

This Supplementary Geotechnical Investigation Report has been prepared by **Alliance Geotechnical** on behalf of the NSW Department of Education and School Infrastructure NSW (the Applicant). It accompanies an Environmental Impact Statement (EIS) in support of State Significant Development Application (SSD 18_9343) for the Meadowbank Education and Employment Precinct Schools Project (hereafter referred to as MEEPSP) at 2 Rhodes Street, Meadowbank (the site).

MEEPSP will cater for 1,000 primary school students and 1,620 high school students. The proposal seeks consent for:

- A multi-level, multi-purpose, integrated school building with a primary school wing and high school wing. The school building is connected by a centralised library that is embedded into the landscape. The school building contains:
    - Collaborative general and specialist learning hubs, with a combination of enclosed and open spaces;
    - Adaptable classroom home bases;
    - Four level central library, with primary school library located on ground floor and high school library on levels 1 to 3.
    - Laboratories and workshops;
    - Staff workplaces;
    - Canteens;
    - Indoor gymnasium;
    - Multipurpose communal hall;
    - Outdoor learning, play and recreational areas (both covered and uncovered).
- Associated site landscaping and public domain improvements;
- An on-site car park for 60 parking spaces; and
- Construction of ancillary infrastructure and utilities as required.

The purpose of this supplementary geotechnical investigation is to provide geotechnical information relating to the depth of the competent bedrock, this is assumed to be predominately for structural pile design.

The objectives of this geotechnical investigation were to address the following:

- Determination of existing subsurface and groundwater conditions;
- Determine the depth to competent (class III or better) bedrock and suitable footing system;
- Confirmation of geotechnical design parameters for deep foundations.

AG's previously has undertaken environmental DSI works for this project and a previous geotechnical investigation was completed by Douglas Partners[1]. The project structural engineers requested additional geotechnical site investigation following the demolishing of the site structures to finalise foundation design for the proposed five to seven storey school building over a basement carpark.

Response to SEARs

The **supplementary geotechnical investigation report** is required by the Secretary's Environmental Assessment Requirements (SEARs) for SSD 18_9343. This table identifies the SEARs and relevant reference within this report.

Table 1 – SEARs and Relevant Reference

SEARs Item	Report Reference
Plans and Documents • Geotechnical and Structural Report	Whole Report

2. SITE LOCATION AND DESCRIPTION

The site is an irregular shape with maximum plan dimensions of approximately 285 m by 185 m covering an area of 3.329 ha. It is bounded to the north east by Rhodes Street reserve, to the northwest by a Sydney Water Monitoring Service facility, to the southwest by the Sydney Trains Main Northern Railway Line and to the south east by the existing Meadowbank TAFE.

At the time of the investigation, the previous site structures had been demolished by the client.

The 1:100,000 scale Sydney Geological Map (Geological Survey of NSW, Department of Minerals Resources, Sheet 9130, Edition 1, 1983) indicates that the site is underlain by Hawkesbury Sandstone (Rh). Hawkesbury Sandstone is described as medium to coarse-grained quartz sandstone, very minor shale and laminate lenses.

3. FIELDWORK

3.1. Methods

The geotechnical site investigation was carried out over three days on the 19th, 20th and 21st of June 2019. Selected site photographs taken during the fieldwork are presented in Attachment 1.

The investigation comprised the drilling of three cored boreholes (BH101 to BH103) and four augured boreholes (BH104 to BH107) to a maximum depth of 21m at the locations indicated by the client. Borehole BH101 was terminated at a depth of 1.7m due to refusal on a buried concrete structure and BH101a was

[1] Document MSP-DP-GT-011, Project 88443.00, May 2019.

drilled to a target depth approximately 1m away from BH101 location. The boreholes were drilled two track mounted drilling rigs and a Hanjin DB8 drilling rig all operated by Sytech Drilling.

The boreholes were advanced through soil profile using a solid flight auger fitted with a Tungsten Carbide bit (TC-bit). Coring of the bedrock was initiated in select boreholes upon encountering material suitable for coring.

The encountered profiles were logged by an experienced geotechnical engineer from AG and recovered samples were transported to AG's NATA accredited materials testing laboratory for further testing and storage.

The approximate locations of the boreholes are shown on the Borehole Location Plan (Drawing 9280-GR-1-A) presented in Attachment 2.

The borehole log sheets and core photographs are attached in Attachment 3. These log sheets should be read in conjunction with the attached Explanatory Notes, which explain the terms, abbreviations and symbols used, together with the interpretation and limitation of the logging procedure.

3.2. Results

Reference to the individual borehole log sheets attached in Attachment 2 should be made for a full description of the subsurface conditions encountered at each borehole location. Summarised descriptions of the encountered subsurface geotechnical units are provided in Table 1.

The weathered sandstone bedrock has been classified using the rock classification system developed for Sydney Sandstones and Shales as per the Australian Geomechanics publication (Pells et al., 1998).

Bedrock defects and seams are listed in the attached logs. There were a few clay seams encountered with a thickness between 30mm to 80mm. The bedrock defects have an approximate dipping angle of 5 to 65 degrees.

Table 2 - Summary of Subsurface Profile

Borehole	BH101a	BH102	BH103	BH104	BH105	BH106	BH107
Geotechnical Units	Depth below the ground surface (m)						
Asphalt Pavement & Roadbase	0.0 – 0.3	-	-	-	-	-	-
Fill Sandy clay/clayey sand/clayey gravel, appears poorly to moderately compacted	0.3 – 3.7	0.0 – 0.9	0.0 – 2.2	0.0 – 1.6	0.0 – 0.2	0.0 – 0.6	0.0 – 0.18
Alluvium / Colluvium Silty clay, medium plasticity, soft to firm	3.7 – 6.6	-	-	-	-	-	0.18 – 0.4
Residual Soil Clayey sand, very loose to medium dense/ Clay/sandy clay, soft to stiff	6.6 – 11.8	0.9 – 2.3	2.2 – 5.3	1.6 – 3.9	0.2 -0.4	0.6 – 1.6	0.4 – 1.6
Bedrock							
Sandstone with clay bands, very low strength, extremely weathered, (Class V)	11.8 - 15	2.3 – 2.8	5.3 – 6.05	3.9 – 6.8	0.4 – 0.9	1.6 – 3.2	1.6 – 7.3
Sandstone, medium to high strength, fracture spacing 30mm to 100mm, moderately to slightly weathered, (Class IV)	15 – 16.2	-	6.05 – 8.2	-	-	-	-
Sandstone, medium to high strength, fracture spacing 200 to 300mm, moderately to slightly weathered (Class III)	16.2 – 19.85 (a)	2.8 – 5.8 (b)	8.2 – 10.65 (C)	Below 6.8m*	Below 0.9m*	Below 3.2m*	Below 7.3m*
Sandstone, medium to high strength, fracture spacing > 1000mm, moderately to slightly weathered (Class II)	19.85 – 20.6	5.8 – 7.0	-	-	-	-	-
Sandstone, medium to high strength, fracture spacing 200 to 300mm, moderately to slightly weathered (Class III)	20.6 – 21.1	-	-	-	-	-	-
Termination depth	21.1	7.0	10.65	6.8	0.9	3.2	7.3
Groundwater seepage depth (m)	6.2	-	5.1	-	-	-	-

(a): Class IV Sandstone between a depth of 17.3m and 18.2m and 19.65m to 19.85m;
(b): Class IV Sandstone between a depth of 5.3m and 5.8m;
(c): Class IV Sandstone between a depth of 9.3m and 9.7m;
* Based on AG's previous experience and moderate TC bit resistance during auger drilling, the bedrock below the depth of TC bit refusal is inferred to be medium to high strength sandstone.

There is no alluvial channel shown on the geological maps but after review of the DP geological long sections, discussions with site personnel and undertaking our own borehole investigation, an alluvial channel has been identified. There is a large culvert (approx. 5m width) running roughly north-south through the site to the west of the proposed TAFE structure. It is likely that this culvert has been constructed in the location of a previous creek or tributary. The sandstone drops sharply at this point with up to 7m of poor quality (soft and wet) alluvium material overlaying the residual clayey sand layer.

3.3. Groundwater Seepage

Groundwater seepage was encountered during auguring in BH101a and BH103 at a depth of 6.2m and 5.1m, respectively. The introduction of water into the boreholes for coring precluded the field engineer's ability to identify groundwater seepage.

It should be noted that groundwater seepage depth is subject to fluctuate following prolonged rainfall season and seepage may occur at the interface of the soil and bedrock. This is particularly prevalent in geological conditions where a higher permeability residual layer (clayey sand) is overlaying sandstone bedrock, as is the case with this site.

4. RECOMMENDATIONS

4.1. Foundation

Based on the subsurface geotechnical condition encountered and the anticipated loads applied by a five to seven storey building, the building load can be supported on deep foundation (pile) founded within competent bedrock. Bored cast in place piles are recommended as the preferred pile construction method.

The bedrock quality and bearing capacity valkues present below have been assessed in accordance with the classification presented by Pells et al (1998) for Sydney Shale and Sandstone. The design parameters for the foundations are presented in Table 3.

Table 3 – Geotechnical Design Parameters for Deep Foundation

Description	Ultimate end Bearing Capacity (MPa)	Serviceability End Bearing Capacity (kPa)	Allowable Shaft Adhesion (kPa)	Elastic Modulus (MPa)
Class V Sandstone	3	1000	100	100
Class IV Sandstone	12	2500	250	400
Class III Sandstone	30	4000	400	700

The pile foundations should be designed in accordance with AS 2159-2009 Piling – Design and Installation. The pile length should be indicated by the design engineer based on the applied loads. It is recommended to found the piles into the competent bedrock with a minimum socket depth of 500mm.

Large settlements (more than 5% of minimum footing dimensions) need to occur in order to mobilise the ultimate end bearing resistance, which could be considered excessive for the building structure. As such, serviceability end bearing pressure are recommended for the design based on limiting the settlement to less than 1% of the minimum pile diameter. Pile settlement should be estimated based on the serviceability end bearing pressure and Elasticity Modulus provided.

4.2. Construction Inspections

Before pouring concrete, the exposed footing foundation base and bored pile holes, should be inspected by an experienced geotechnical engineer to confirm the adequacy of the allowable bearing capacity and piers

socket depth and also to confirm that the bases of the footing excavations/pier holes are clean and free of soft, loose, wet or disturbed soils.

5. LIMITATIONS

Alliance Geotechnical Pty Ltd (AG) has prepared this report for the site located at 2 Rhodes Street Meadowbank, NSW 2114, in accordance with AG's fee proposal and Terms of Engagement. This geotechnical report has been prepared for Ward Civil Pty Ltd for this project and for the purposes outlined in this report. This report cannot be relied on for other projects, other parties on this site or any other site. The comments and recommendations provided in this report are based on the assumption that the geotechnical recommendations contained in this report will be fully complied with during the design and construction of the proposed site development The testing results provided in this report are indicative of the subsurface conditions at the site only at the specific sampling and testing locations, and to the depths drilled at the time of the investigation. Subsurface conditions can change significantly due to geological and human processes. Where variations in conditions are encountered further geotechnical advice should be sought from AG.

Should you need any further information or to discuss this report, please contact the undersigned.

Written by

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BE(Civil), MScEng, CPEng(Civil), MIEAust, NER
Senior Geotechnical Engineer

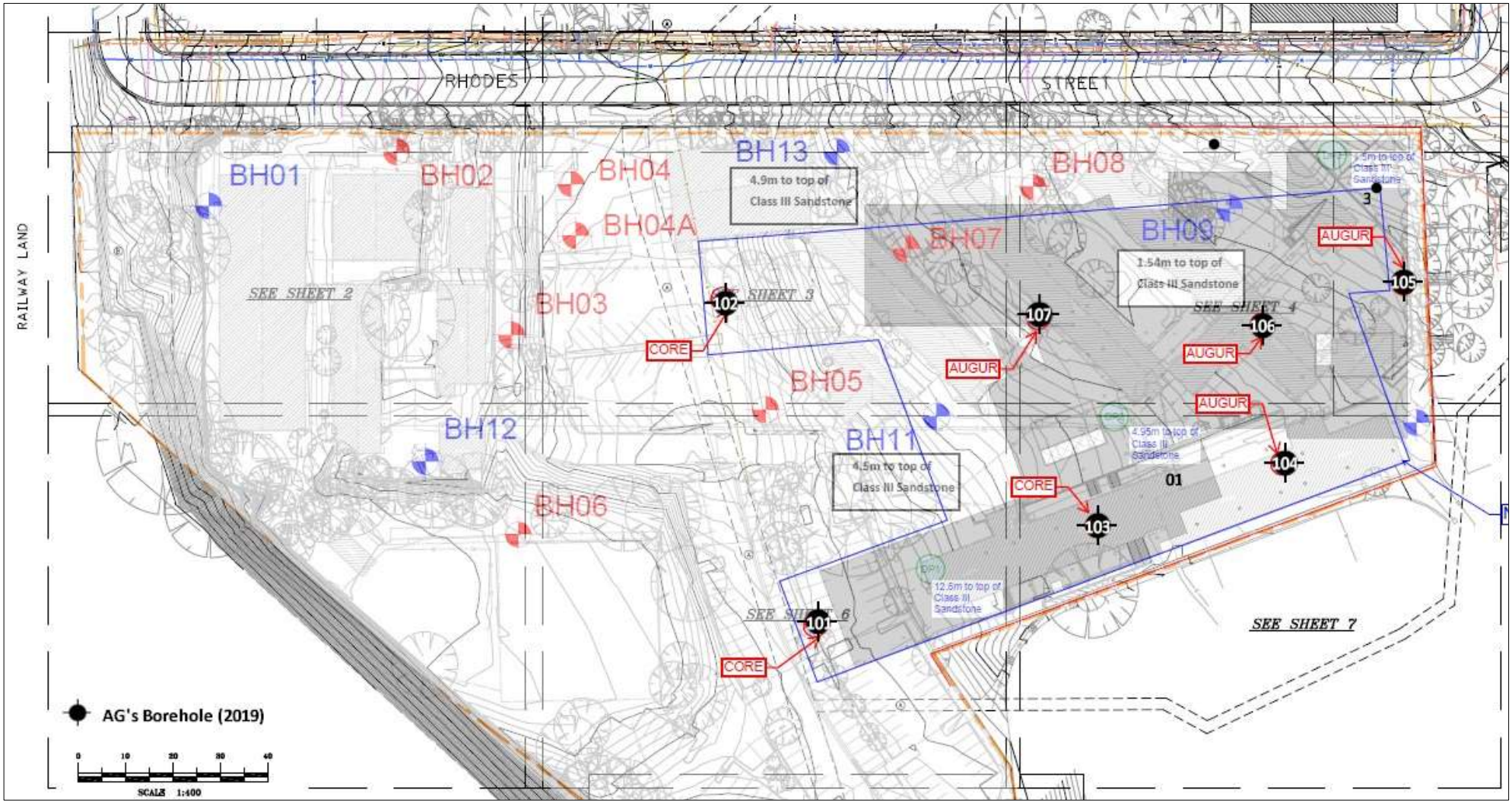
Reviewed by

Thomas Dale
BE (Civil) Hon. MIEAust
Lead Geotechnical Engineer

Attachment 1 – Site Photographs

Figure 1 – General Site Overview - AG's Site Investigatoion

Attachment 2 –Borehole Location Plan (Drawing 9280-GR-1-1)



Alliance Geotechnical ENGINEERING | ENVIRONMENTAL | TESTING Manage the earth, eliminate the risk	**Borehole Location Plan**			
	Client Name:	Ward Civil Pty Ltd	Drawing Number:	9280-GR-1-A
	Project Name:	Meadowbank Schools	Drawing Date:	27/06/2019
	Project Location:	2 Rhodes Street Meadowbank, NSW 2114	Report Number:	9280-GR-1-1

Attachment 2 –Borehole Logs (BH101 to BH107) & Core Photos

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BH No: BH 101
Sheet: 1 of 1
Job No: 9280.1

Borehole Log

Client: Ward Civil
Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 19/6/19
Finished: 19/6/19
Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** TD
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered				--	ASPHALTIC CONCRETE 50mm		--	--	PAVEMENT
					--	ROADBASE Layer (Sandy Gravel, dark grey).		--	--	
					--	FILL: Gravelly SAND, fine to medium grained, grey, medium to coarse concrete gravel. Appears moderately to well compacted.		--	--	FILL
			1		--	FILL: Silty CLAY, medium plasticity, dark grey. Appears well compacted.		--	--	
							SPT 13, >25/50mm SPT Hammer Bouncing			
						Borehole BH 101 terminated at 1.7m				TC Bit Refusal (Inferred CONCRETE Piece/Boulder)
			2							
			3							
			4							
			5							
			6							

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BH No: BH 101a
PAGE 1 OF 5
Job No: 9280.1

Borehole Log

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Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 19/6/19
Finished: 20/6/19
Borehole Size: 110mm diameter
Rig Type: Hanjin DB8
Hole Location: Refer Drawing 9280.1-GR-1-A
Driller: JC
Logged: TD/MS
RL Surface:
Contractor: BG Drilling Pty Ltd
Bearing: ---
Checked: LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT					--	ASPHALTIC CONCRETE 50mm		--	--	PAVEMENT
					--	ROADBASE Layer, Recycled Material (Sandy Gravel, brown and dark grey).		--	--	
					--	FILL: Sandy CLAY, low plasticity, grey-brown, some silt, some sandstone gravel. Appears moderately compacted.		--	--	FILL
			1							
						As above, but appears poorly compacted.	SPT 2, 3, 3 N=6			
			2							
					--	FILL: Clayey SAND, fine to medium grained, light grey-dark grey and red, some sandstone gravel, some mixture of clay and crushed sandstone.		--	--	
			3							
					--	FILL: Clayey GRAVEL, medium grained, red-yellow and light grey.	SPT 7, 8, 7 N=15	--	--	
					CI	Silty CLAY, medium plasticity, dark grey.		M - W	S - F	ALLUVIUM
			4							
							SPT 0, 1, 2 N=3			
			5			As above, but trace decomposed tree roots.				
			6							

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Rig Type: Hanjin DB8
Hole Location: Refer Drawing 9280.1-GR-1-A
Driller: JC
Logged: TD/MS
RL Surface:
Contractor: BG Drilling Pty Ltd
Bearing: ---
Checked: LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater					As above, but trace decomposed tree roots. *(continued)*	SPT 0, 0, 3 N=3			
			7		SW-SC	Clayey SAND, light grey-red.		W	VL	RESIDUAL
					CI	CLAY, medium plasticity, light brown to grey, trace fine sand and ironstone gravel.	SPT 2, 3, 4 N=7	W	F	
			8		CL	Sandy CLAY, low plasticity, red-brown, some iron indurations.		W	S - F	
			9				SPT 3, 2, 4 N=6			
			10							
			11							
			12		--	SANDSTONE, fine to medium grained, light grey and orange-brown, highly weathered, very low strength.		--	--	BEDROCK

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Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** TD/MS
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT			13		--	SANDSTONE, fine to medium grained, light grey and orange-brown, highly weathered, very low strength. *(continued)*		--	--	
			14		--	SANDSTONE, fine to medium grained, light grey and orange brown, extremely weathered, very low strength, with frequent clay bands.		--	--	
			15			Borehole BH 101a continued as cored hole				
			16							
			17							
			18							

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Cored Borehole Log

Client: Ward Civil
Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 19/6/19
Finished: 20/6/19
Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** TD/MS
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
			13								
			14								
			15		Continued from non-cored borehole						
NMLC	Full Return		16		SANDSTONE, fine to medium grained, light grey and orange-brown, highly weathered, very low strength.	MW		D 0.41 A 0.53	71		15.12, JT, 10°, Undulating, Rough, Clean 15.28, Clay SM, 50mm thickness
						HW					15.49, JT, 0-10°, Undulating, Rough, Clean 15.50, JT, 75°, Planar, Rough, Clean 15.60, EW Zone-SM, 80mm thickness
						MW		D 0.45 A 1.18			
					SANDSTONE, medium to coarse grained, orange-brown and yellow, some quartz gravel.			D 0.67 A 0.81			16.13, JT, 0°, Planar, Rough, Clean
			17					D 0.55 A 0.68			16.55, JT, 0°, Undulating, Rough, Clean
											17.04, JT, 0°, Undulating, Rough, Clean
						HW		D 0.5 A 0.73			17.34, JT, 0°, Undulating, Rough, Clean
					SANDSTONE, fine to medium grained, light grey and orange-brown.						17.45, JT, 10°, Undulating, Rough, Clean 17.50, 17.52, Clay SM, 20mm thickness
						MW		D 0.28 A 0.44			
			18								17.86, 18.00, JT, 75°, Planar, Rough, Clean

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Cored Borehole Log

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Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** TD/MS
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
NMLC					SANDSTONE, fine to medium grained, light grey and orange-brown. *(continued)*	MW		D 0.26 A 0.53			< 18.00, 18.05, Clay SM, 50mm thickness 18.21, 18.40, JT, Subvertical, Undulating, Rough, Clean
											18.61, 18.70, JT, 65°, Planar, Rough, Clean
			19					D 1.21 A 1.17			18.88, 18.96, JT, 65°, Planar, Rough, Clean
								D 1.15 A 0.67			19.10, 19.20, JT, 65°, Planar, Rough, Clean
											19.32, 19.34, Clay SM, 20mm thickness
									75		19.50, 19.68, JT, Subvertical, Undulating, Rough, Clean
											19.68, 19.69, Clay SM, 20mm thickness
			20					D 1.46 A 1.58 D 0.29 A 0.52 D 1.66 A 1.75			19.84, JT, 0-5°, Undulating, Rough, Clean
								D 1.38 A 1.46			20.64, 20.66, Clay SM, 20mm thickness
			21								20.90, 20.92, JT, 15°, Planar, Rough, Clean 21.03, 21.05, JT, 15°, Planar, Rough, Clean
					BH 101a terminated at 21.1m						End BH 101a
			22								
			23								
			24								

Alliance Geotechnical ENGINEERING | ENVIRONMENTAL | TESTING Manage the earth, eliminate the risk	Core Box Photo BH101a – 15m to 21.1m				
	Client Name:	Ward Civil Pty Ltd		Drawing Number:	9280-GR-1-B
	Project Name:	Meadowbank Schools		Drawing Date:	27/06/2019
	Project Location:	2 Rhodes Street Meadowbank, NSW 2114		Report Number:	9280-GR-1-1

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Borehole Log

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Finished: 20/6/19
Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** MS
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered				--	FILL: Silty CLAY, low plasticity, dark brown, with sand, trace fine grained gravel. Appears moderately compacted. MC=<PL.		--	--	FILL
					--	FILL: Sandy CLAY, medium to high plasticity, brown mottled dark grey, trace fine grained gravel. Appears well compacted. MC>PL.		--	--	
			1		CL	Sandy CLAY, low plasticity, light grey mottled orange and red, trace ironstone fragments. MC=<PL.		--	St	RESIDUAL
			2				SPT 5, 6, 6 N=12			
					--	SANDSTONE, light brown, highly weathered, low strength.		--	--	BEDROCK
			3			Borehole BH 102 continued as cored hole				
			4							
			5							
			6							

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Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** MS
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
			1								
			2		Continued from non-cored borehole						
NMLC			3		SANDSTONE, fine to medium grained, light orange-brown and light grey.	MW		D 0.48 A 0.64			
								D 0.63 A 0.5			3.16, 3.17, JT, 15°, Planar, Rough, Clean
								D 0.24 A 0.42			3.57, JT, 10°, Undulating, Rough, Clean 3.62, JT, 0°, Undulating, Rough, Clay Lined
			4					D 0.36 A 0.65			4.21, JT, 5°, Undulating, Rough, Clean
											4.52, JT, 0°, Undulating, Rough, Clean
								D 0.59 A 0.77	95		4.82, JT, 5°, Undulating, Rough, Clean
			5					D 0.57 A 0.73			4.97, BP, 10°, Planar, Rough, Clean
											5.34, JT, 0°, Planar, Rough, Clean
											5.51, JT, 50°, Planar, Rough, Clean 5.56, JT, 5°, Undulating, Rough, Clean
								D 0.54 A 0.7			5.76, 5.77, BP, 10°, Planar, Rough, Clean
			6								
								D 0.92 A 1.06			6.31, 6.32, BP, 10°, Planar, Rough, Clean

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Cored Borehole Log

Client: Ward Civil
Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 20/6/19
Finished: 20/6/19
Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** MS
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
NMLC			7		SANDSTONE, fine to medium grained, light orange-brown and light grey. *(continued)*	MW		D 0.76 A 0.82	95		
	Full Return		8		BH 102 terminated at 7m						End BH 102
			9								
			10								
			11								
			12								
			13								

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Core Box Photo BH102 – 2.8m to 7m

Client Name:	Ward Civil Pty Ltd	Drawing Number:	9280-GR-1-B
Project Name:	Meadowbank Schools	Drawing Date:	27/06/2019
Project Location:	2 Rhodes Street Meadowbank, NSW 2114	Report Number:	9280-GR-1-1

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Borehole Log

Client: Ward Civil
Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 20/6/19
Finished: 20/6/19
Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** MS
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT			0		--	FILL: Sandy CLAY, medium plasticity, grey mottled red, with silt, trace fine to medium grained gravel. Appears poorly compacted. MC>PL.		--	--	FILL
			1				SPT 2, 1, 1 N=2			
			2							
					CL-CI	Sandy CLAY, low to medium plasticity, light grey mottled red and orange, trace sandstone fragments. MC=PL.		M	St	RESIDUAL
			3				SPT 5, 5, 5 N=10			
			4							
	▼ Groundwater				CL	Sandy CLAY, low plasticity, light grey.	SPT 4, 6, 7 N=13	M	St	
			5							
					--	SANDSTONE, light grey, highly weathered, very low to low strength.		--	--	BEDROCK
			6							
						Borehole BH 103 continued as cored hole				

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Cored Borehole Log

Client: Ward Civil
Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 20/6/19
Finished: 20/6/19
Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** MS
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
			1								
			2								
			3								
			4								
			5								
			6		Continued from non-cored borehole						
NMLC					SANDSTONE, light grey and light red and yellow-brown, cross bedded 15-20°, 10-30mm spacing.	EW / HW		D 0.05 A 0.21	75		6.07, JT, 0°, Undulating, Rough, Clean 6.13, BP, 15°, Planar, Rough, Clean 6.23, BP, 15°, Planar, Rough, Clean 6.27, 6.56, JT, Subvertical 90°, UN, RF, Clean 6.37, BP, 15°, Planar, Rough, Clean

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Cored Borehole Log

Client: Ward Civil
Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 20/6/19
Finished: 20/6/19
Borehole Size: 110mm diameter
Rig Type: Hanjin DB8
Hole Location: Refer Drawing 9280.1-GR-1-A
Driller: JC
Logged: MS
RL Surface:
Contractor: BG Drilling Pty Ltd
Bearing: ---
Checked: LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	Is(50) MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
NMLC	Full Return		7		SANDSTONE, light grey and light red and yellow-brown, cross bedded 15-20°, 10-30mm spacing. *(continued)*	HW		D 0.23 A 0.37			6.49, BP, 15°, Planar, Rough, Clean
											6.74, BP, 15°, Planar, Rough, Clean
											6.82, BP, 15°, Planar, Rough, Clean
											6.95, BP, 15°, Planar, Rough, Clean
						MW					7.12, BP, 15°, Planar, Rough, Clean
								D 0.67 A 0.85			
											7.38, BP, 15°, Planar, Rough, Clean
											7.60, BP, 15°, Planar, Rough, Clean
											7.75, BP, 15°, Planar, Rough, Clean
								D 0.26 A 0.64			
			8								7.90, BP, 15°, Planar, Rough, Clean
											8.07, BP, 15°, Planar, Rough, Clean
											8.30, BP, 15°, Planar, Rough, Clean
								D 0.4 A 0.44	75		8.55, BP, 15°, Undulating, Rough, Clean
						HW					8.75, JT, 0°, Undulating, Rough, Clay Lined
											8.76, 8.82, Clay SM, 60mm thickness
											8.88, JT, 0-5°, Undulating, Rough, Clean
			9								9.00, JT, 0-5°, Undulating, Rough, Clean
						MW					9.08, 9.09, JT, 15°, Undulating, Rough, Clean
								D 0.64 A 0.64			
											9.29, 9.30, JT, 15°, Undulating, Rough, Clean
											9.31, 9.40, JT, 60°, Undulating, Rough, Clean
											9.48, JT, 10-20°, Undulating, Rough, Clean
								D 0.7 A 1.18			
											9.70, JT, 0°, Undulating, Rough, Clean
			10								9.88, BP, 0°, Planar, Rough, Clean
											10.11, 10.20, JT, 60°, Planar, Rough, Clean
								D 0.44 A 1.16			
											10.35, BP, 15°, Planar, Rough, Clean
											10.46, 10.54, JT, 45°, Planar, Rough, Clean
											10.59, BP, 15°, Planar, Rough, Clean
					BH 103 terminated at 10.65m						End BH 103
			11								
			12								
			13								

Alliance Geotechnical ENGINEERING | ENVIRONMENTAL | TESTING Manage the earth, eliminate the risk	Core Box Photo BH103 – 6.05m to 10.65m			
Client Name:	Ward Civil Pty Ltd		Drawing Number:	9280-GR-1-B
Project Name:	Meadowbank Schools		Drawing Date:	27/06/2019
Project Location:	2 Rhodes Street Meadowbank, NSW 2114		Report Number:	9280-GR-1-1

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BH No: BH 104
Sheet: 1 of 2
Job No: 9280.1

Borehole Log

Client: Ward Civil
Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 21/6/19
Finished: 21/6/19
Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** TD
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered		0		--	FILL: Clayey SAND, medium grained, brown-dark brown, some gravel. Appears moderately compacted.		--	--	FILL
					--	FILL: Silty SAND, fine to medium grianed, dark grey, trace medium to coarse grained gravel, trace brick fragments. Appears moderately compacted.		--	--	
			1							
					SP-SC	Clayey SAND, medium grained, light brown-red-light grey.	SPT 3, 4, 4 N=8	M	L - MD	RESIDUAL
			2							
			3				SPT 5, 6, 7 N=13			
			4		CL	Sandy CLAY (70%) with sandstone layers (30%), low plasticity, light grey mottled red. Sandstone fragments are very low strength, extremely weathered.		M	St	BEDROCK
										RESIDUAL
					--	SANDSTONE, light grey-yellow, very low strength. Low TC bit resistance.		--	--	BEDROCK
			5		--	SANDSTONE, light grey, very low to low strength. Low TC Bit Resistance.		--	--	
						As above, but low to medium TC bit resistance.				
					--	SANDSTONE, medium grained, brown, low strength. Moderate to high TC bit resistance.		--	--	
			6							

BOREHOLE / TEST PIT 8910 MEADOWBANK GINT LOGS.GPJ GINT STD AUSTRALIA.GDT 3/7/19

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Sheet: 2 of 2
Job No: 9280.1

Borehole Log

Client: Ward Civil
Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 21/6/19
Finished: 21/6/19
Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** TD
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT					--	SANDSTONE, medium grained, brown, low strength. Moderate to high TC bit resistance. *(continued)*		--	--	
			7			Borehole BH 104 terminated at 6.8m				TC Bit Refusal
			8							
			9							
			10							
			11							
			12							

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Job No: 9280.1

Borehole Log

Client: Ward Civil
Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 21/6/19
Finished: 21/6/19
Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** TD
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Not Encountered				--	FILL: Clayey SAND, fine to medium grained, dark brown.		--	--	FILL
					CL	Sandy CLAY, low plasticity, light brown.		M	St	RESIDUAL
					--	SANDSTONE, light grey-yellow. Moderate TC bit resistance.		--	--	BEDROCK
			1			Borehole BH 105 terminated at 0.9m				TC Bit Refusal
			2							
			3							
			4							
			5							
			6							

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Sheet: 1 of 1
Job No: 9280.1

Borehole Log

Client: Ward Civil
Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 21/6/19
Finished: 21/6/19
Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** TD
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered				--	FILL: Gravelly SAND, fine to medium grained, brown-dark grey, some steel fragments, some igneous rock gravel.		--	--	FILL
			1		CL-CI	Sandy CLAY, low to medium plasticity, light brown, trace medium grained sandstone gravel.	SPT 13, 22, 29 N=51	M	St	RESIDUAL
			2		--	SANDSTONE, medium grained, light grey-yellow, very low strength. Low to moderate TC bit resistance.		--	--	BEDROCK
						As above, but light grey-brown, with moderate TC bit resistance.				
			3			As above, but yellow, with moderate to high TC bit resistance.				
			4			Borehole BH 106 terminated at 3.2m				TC Bit Refusal
			5							
			6							

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BH No: BH 107
Sheet: 1 of 2
Job No: 9280.1

Borehole Log

Client: Ward Civil
Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 21/6/19
Finished: 21/6/19
Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** TD
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered				--	FILL: Gravelly SAND, medium grained, brown-dark grey, some rubble.		--	--	FILL
					SW-SM	Silty SAND, fine to medium grained, dark grey.		M	L	COLLUVIUM
					SP-SC	Clayey SAND, medium grained, brown.		M	MD	RESIDUAL
			1			As above, but light grey-brown.				
					SW	SAND, fine to medium grained, light grey.	SPT 21, 25+	M	D	
					--	SANDSTONE, medium grained, light grey-light brown, very low strength. Low TC bit resistance.		--	--	BEDROCK
			2			As above, but light grey and fine to medium grained.				
			3		--	SANDSTONE, light grey-red, low strength. Low to moderate TC bit resistance.		--	--	
			4		--	SANDSTONE, medium-grained, brown-light grey, low strength. Low to moderate TC bit resistance.		--	--	
			5			As above, but low TC bit resistance.				
			6			As above, but moderate TC bit resistance.				

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BH No: BH 107
Sheet: 2 of 2
Job No: 9280.1

Borehole Log

Client: Ward Civil
Project: Meadowbank TAFE
Location: 57-69 Constitution Road, Meadowbank, NSW 2114
Started: 21/6/19
Finished: 21/6/19
Borehole Size: 110mm diameter

Rig Type: Hanjin DB8 **Hole Location:** Refer Drawing 9280.1-GR-1-A **Driller:** JC **Logged:** TD
RL Surface: **Contractor:** BG Drilling Pty Ltd **Bearing:** --- **Checked:** LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT			7			As above, but fine to medium grained, with high TC bit resistance.				
			8			Borehole BH 107 terminated at 7.3m				TC Bit Refusal
			9							
			10							
			11							
			12							

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EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

General

Information obtained from site investigations is recorded on log sheets. Soils and very low strength rock are commonly drilled using a combination of solid-flight augers with a Tungsten-Carbide (TC) bit. Descriptions of these materials presented on the "Borehole Log" are based on a combination of regular sampling and in-situ testing. Rock coring techniques commences once material is encountered that cannot be penetrated using a combination of solid-flight augers and Tungsten-carbide bit. The "Cored Borehole Log" presents data from drilling where a core barrel has been used to recover material - commonly rock.

The "Excavation - Geological Log" presents data and drawings from exposures of soil and rock resulting from excavation of pits or trenches.

The heading of the log sheets contains information on Project Identification, Hole or Test Pit Identification, Location and Elevation. The main section of the logs contains information on methods and conditions, material description and structure presented as a series of columns in relation to depth below the ground surface which is plotted on the left side of the log sheet. The scale is presented in the depth column as metres below ground level.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is included in the identification of material boundaries in areas of partial sampling, the location of areas of core loss, description and classification of material, estimation of strength and identification of drilling induced fractures, and geological unit. Material description and classifications are based on Australian Standard Geotechnical Site Investigations: AS 1726 - 2017 with some modifications as defined below.

These notes contain an explanation of the terms and abbreviations commonly used on the log sheets.

Drilling

Drilling, Casing and Excavating

Drilling methods deployed are abbreviated as follows

AS	Auger Screwing
ADV	Auger Drilling with V-Bit
ADT	Auger Drilling with TC Bit
BH	Backhoe
E	Excavator
HA	Hand Auger
HQ	HQ core barrel (~63.5 mm diameter core) *
HMLC	HMLC core barrel (~63.5 mm diameter core) *
NMLC	NMLC core barrel (~51.9 mm diameter core) *
NQ	NQ core barrel (~47.6 mm diameter core) *
RR	Rock Roller
WB	Wash-bore drilling

* Core diameters are approximate and vary due to the strength of material being drilled.

Drilling Fluid/Water

The drilling fluid used is identified and loss of return to the surface estimated as a percentage. It is introduced to assist with the drill process, in particular, when core drilling. The introduction of drill fluid/water does not allow for accurate identification of water seepages.

Drilling Penetration/Drill Depth

Core lifts are identified by a line and depth with core loss per run as a percentage. Ease of penetration in non-core drilling is abbreviated as follows:

VE	Very Easy
E	Easy
F	Firm
H	Hard
VH	Very Hard

Groundwater Levels

Date of measurement is shown.

Standing water level measured in completed borehole

Level taken during or immediately after drilling

Groundwater inflow water level

Samples/Tests

Samples collected and testing undertaken are abbreviated as follows

ES	Environmental Sample
DS	Disturbed Sample
BS	Bulk Sample
U50	Undisturbed (50 mm diameter)
C	Core Sample
SPT	Standard Penetration Test
N	Result of SPT (*sample taken)
VS	Vane Shear Test
IMP	Borehole Impression Device
PBT	Plate Bearing Test
PZ	Piezometer Installation
HP	Hand Penetrometer Test
HB	Hammer Bouncing

Excavation Logs

Explanatory notes are provided at the bottom of drill log sheets. Information about the origin, geology and pedology may be entered in the "Structure and other Observations" column. The depth of the base of excavation (for the logged section) at the appropriate depth in the "Material Description" column. Refusal of excavation plant is noted should it occur. A sketch of the exposure may be added.

Material Description – Soil

Material Description - In accordance with AS 1726-2017

Classification Symbol - In accordance with the Unified Classification System (AS 1726-2017).

Abbreviation	Typical Names
GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines, uniform gravels
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures.
SW	Well graded sands, gravelly sands, little or no fines.
SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands.
SM	Silty sand, sand-silt mixtures.
SC	Clayey sands, sand-clay mixtures.
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
OL	Organic silts and organic silty clays of low plasticity. *
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, clastic silts.
CH	Inorganic clays of high plasticity, fat clays
OH	Organic clays of medium to high plasticity, organic silts. *
Pt	Peat and other highly organic soils. *

* Additional details may be provided in accordance with the Von Post classification system (1922).

Organic Soils - Identification using laboratory testing:

Material	Organic Content - % of dry mass
Inorganic	<2
Organic Soil	<2 ≤ 25
Peat	> 25

Organic Soils - Descriptive terms for the degree of decomposition of peat:

Term	Decomposition	Remains	Squeeze
Fibrous	Little or none	Clearly recognizable	Only water No solid
Pseudo-fibrous	Moderate	Mixture of fibrous and amorphous	Turbid water < 50% solids
Amorphous	Full	Not recognizable	Paste > 50% solids

EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

Particle Characteristics– Definitions are as follows:

Fraction	Component (& subdivision)		Size (mm)
Oversize	Boulders		> 200
	Cobbles		> 63 ≤ 200
Coarse grained soils	Gravel	Coarse	> 19 ≤ 63
		Medium	> 6.7 ≤ 19
		Fine	> 2.36 ≤ 6.7
	Sand	Coarse	> 0.6 ≤ 2.36
		Medium	> 0.2 ≤ 0.6
		Fine	> 0.075 ≤ 0.21
Fine grained soils	Silt		0.002 ≤ 0.075
	Clay		< 0.002

Secondary and minor soil components

In coarse grained soils – The proportions of secondary and minor components are generally estimated from a visual and tactile assessment of the soils. Descriptions for secondary and minor soil components in coarse grained soils are as follows.

Designation of components	Percentage fines	Terminology (as applicable)	Percentage accessory coarse fraction	Terminology (as applicable)
Minor	≤ 5	Trace clay / silt	≤ 5	Trace sand / gravel
	> 5 ≤12	With clay / silt	> 5 ≤12	With sand / gravel
Secondary	> 12	Silty or clayey	> 30	Sandy or gravelly

Descriptions for secondary and minor soil components in fine grained soils are as follows.

Designation of components	Percentage coarse grained soils	Terminology (as applicable)
Minor	≤ 5	Trace sand / gravel / silt / clay
	> 5 ≤12	With sand / gravel / silt / clay
Secondary	> 30	Sandy / gravelly / silty / clayey

Plasticity Terms – Definitions for fine grained soils are as follows:

Descriptive Term	Range of Liquid Limit for silt	Range of Liquid Limit for clay
Low Plasticity	≤ 50	≤ 35
Medium Plasticity	N/A	> 35 ≤50
High Plasticity	> 50%	> 50

Particle Characteristics

Particle shape and angularity are estimated from a visual assessment of coarse-grained soil particle characteristics. Terminology used includes the following:

Particle shape – spherical, platy, elongated,

Particle angularity –angular, sub-angular, sub-rounded, rounded.

Moisture Condition – Abbreviations are as follows:

D	Dry, looks and feels dry
M	Moist, No free water on remoulding
W	Wet, free water on remoulding

Moisture content of fine-grained soils is based on judgement of the soils moisture content relative to the plastic and liquid limit as follows:

MC < PL	Moist, dry of plastic limit
MC ≈ PL	Moist, near plastic limit
MC > PL	Moist, wet of plastic limit
MC ≈ LL	Wet, near liquid limit
MC > LL	Wet of liquid limit

Consistency - of cohesive soils in accordance with AS 1726-2017, Table 11 are abbreviated as follows:

Consistency Term	Abbreviation	Indicative Undrained Shear Strength Range (kPa)
Very Soft	**VS**	< 12
Soft	**S**	12 ≤ 25
Firm	**F**	25 ≤ 50
Stiff	**St**	50 ≤ 100
Very Stiff	**VSt**	100 ≤ 200
Hard	**H**	≥ 200
Friable	**Fr**	-

Density Index (%) of granular soils is estimated or is based on SPT results. Abbreviations are as follows:

Description	Abbreviation	Relative Density	SPT N
Very Loose	VL	< 15%	0 - 4
Loose	L	15 - 35%	4 - 10
Medium Dense	MD	35 - 65%	10 - 30
Dense	D	65 - 85%	30 - 50
Very Dense	VD	> 85%	> 50

Structures - Fissuring and other defects are described in accordance with AS 1726-2017 using the terminology for rock defects

Origin - Where practicable an assessment is provided of the probable origin of the soil, e.g. fill, topsoil, alluvium, colluvium, residual soil.

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EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

MATERIAL DESCRIPTION - ROCK

Material Description

Descriptions of rock for geotechnics and engineering geology in civil engineering

Identification of rock type, composition and texture based on visual features in accordance with AS 1726-2017.

Rock Naming – Where possible conventional geological names are used within the logs. Engineering properties cannot be inferred directly from the rock names in the table, but the use of a particular name provides an indicative range of characteristics to the reader. Lithological identification of rock is provided to appreciate the geology of an area, to correlate geological profiles seen in boreholes or to distinguish boulders from bedrock.

Grain Size – Grain size is done in accordance with AS1726-2017 as follows:

Coarse grained	Mainly 0.6 to 2 mm
Medium grained	0.2 – 0.6 mm
Fine grained	0.06 – 0.2 mm

Colour – Rock colour is described in the moist condition.

Texture and Fabric - Frequently used terms include:

Sedimentary Rock	Metamorphic Rock	Igneous
Bedded	Cleaved	Massive
Interbedded	Foliated	Flow banded
Laminated	Schistose	Folded
Folded	Banded	Lineated
Massive	Lineated	Porphyritic
Graded	Gneissose	Crystalline
Cross-bedded	Folded	Amorphous

Bedding and Laminated – AS 1726 – 2017 bedding and laminated rock descriptions are provided below with additional detail from BS EN ISO 14689-1 as guidance.

Description	Spacing (mm)
Very Thickly Bedded	> 2000
Thickly Bedded	> 600 ≤ 2000
Medium Bedded	> 200 ≤ 600
Thinly Bedded	> 60 ≤ 200
Very Thinly Bedded	> 20 ≤ 60
Thickly Laminated	> 6 ≤ 20
Thinly Laminated	< 6

Features, inclusions and minor components – Features, inclusions and minor components within the rock material shall be described where those features could be significant such as gas bubbles, mineral veins, carbonaceous material, salts, swelling minerals, mineral inclusions, ironstone or carbonate bands, cross-stratification or minerals the readily oxidise upon atmospheric exposure.

Moisture content – Where possible descriptions are made by the feel and appearance of the rock using one according to following terms:

Dry	Looks and feels dry.
Moist	Feels cool, darkened in colour, but no water is visible on the surface
Wet	Feels cool, darkened in colour, water film or droplets visible on the surface

The moisture content of rock cored with water may not be representative of its in-situ condition.

Durability – Descriptions of the materials durability such as tendency to develop cracks, break into smaller pieces or disintegrate upon exposure to air or in contact with water are provided where observed.

Rock Material Strength – The strength of the rock material is based on uniaxial compressive strength (UCS). The following terms are used:

Rock Strength Class	Abbreviation	UCS (MPa)	Point Load Strength Index, $I_{s\,(50)}$ (MPa)
Very Low	VL	> 0.6 ≤ 2	> 0.03 ≤ 0.1
Low	L	> 2 ≤ 6	> 0.1 ≤ 0.3
Medium	M	> 6 ≤ 20	> 0.3 ≤ 1
High	H	> 20 ≤ 60	> 1 ≤ 3
Very High	VH	> 60 ≤ 200	> 3 ≤ 10
Extremely High	EH	> 200	> 10

Strengths are estimated and where possible supported by Point Load Index Testing of representative samples. Test results are plotted on the graphical logs as follows:

D	Diametral Point Load Test
A	Axial Point Load Test

Where the estimated strength log covers more than one range it indicates the rock strength varies between the limits shown. Point Load Strength Index test results are presented as $I_{s\,(50)}$ values in MPa.

Weathering - Weathering classification assists in identification but does not imply engineering properties. Descriptions are as follows:

Term (Abbreviation)	Description
Fresh (F)	No signs of mineral decomposition or colour change.
Slightly Weathered (SW)	partly stained or discoloured. Not or little change to strength from fresh rock.
Moderately Weathered (MW)	material is completely discoloured, little or no change of strength from fresh rock.
Highly Weathered (HW)	material is completely discoloured, significant decrease in strength from fresh rock.
Extremely Weathered (EW)	Material has soil properties. Mass structure, material texture and fabric of original rock are still visible.
Residual Soil (RS)	Material has soil properties. Mass structure and material texture and fabric of original rock not visible, but the soil has not been significantly transported.

Alteration – Physical and chemical changes of the rock material due to geological processes by fluids at depth at pressures and temperatures above atmospheric conditions. Unlike weathering, alteration shows no relationship to topography and may occur at any depth. When altered materials are recognized, the following terms are used:

Term		Abbreviation		Definition
Extremely Altered		XA		Material has soil properties. Structure, texture and fabric of original rock are still visible. The rock name is replaced with the name of the parent material, e.g. Extremely Altered basalt. Soil descriptive terms are used.
Highly Altered	Distinctly altered	HA	DA	The whole of the rock material is discoloured. Rock strength is changed by alteration. Some primary minerals are altered to clay minerals. Porosity may be higher or lower due to loss of minerals or precipitation of secondary minerals in pores.
Moderately Altered	Distinctly altered	MA	DA	The whole of the rock material is discoloured Little or no change of strength from fresh rock. The term 'Distinctly Altered' is used where it is not practicable to distinguish between 'Highly Altered' and 'Moderately Altered'. Distinctly Altered is defined as follows: The rock may be highly discoloured; Porosity may be higher due to mineral loss; or may be lower due to precipitation of secondary minerals in pores; and Some change of rock strength.
Slightly Altered		SA		Rock is slightly discoloured Little or no change of strength from fresh rock.

Alteration is only described in the context of the project where it has relevance to the civil and structural design.

Defect Descriptions

General and Detailed Descriptions – Defect descriptions are provided to suit project requirements. Generalized descriptions are used for some projects where it is unnecessary to describe each individual defect in a rock mass, or where multiple similar defects are present which are too numerous to log individually. The part of the rock mass to which this applies is delineated.

Detailed descriptions are given of defects judged to be particularly significant in the context of the project. For example, crushed seams in an apparently unstable slope. As a minimum, general descriptions outlining the number of defect sets within the rock mass and their broad characteristics are provided where it is possible to do so.

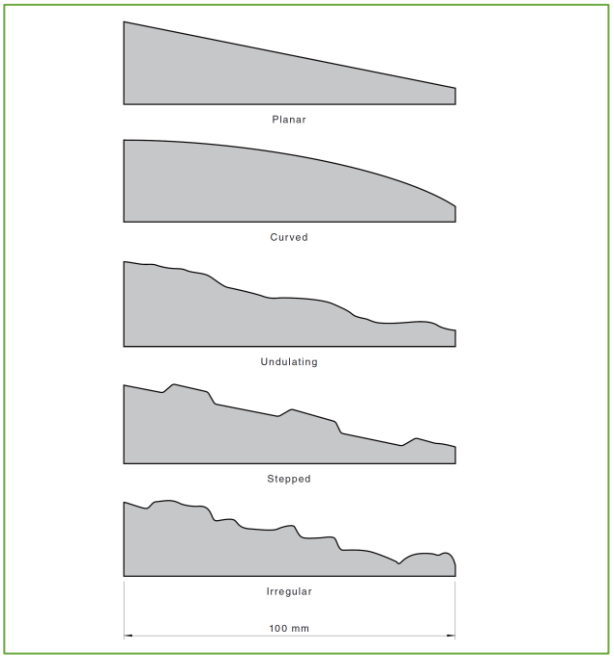
Defect Type – Defect abbreviations are as follows:

BP	Bedding Parting	FL	Foliation	SP	Shear Plane
CL	Cleavage	FZ	Fracture Zone	SZ	Shear Zone
CS	Crushed Seam	HB	Handling break	VN	Vein
DB	Drilling break	JT	Joint		
DL	Drill Lift	SM	Seam		

EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

Defect Orientation – The dip and dip direction are recorded as a two-digit and three-digit number separated by a slash, e.g. 50/240 only when orientated core are collected and there is not core loss that could obscure core orientation. If alternative measurements are made, such as dip and strike or dip direction relative to magnetic north this shall be documented.

Surface Shape –At the medium scale of observation, description of the roughness of the surface shall be enhanced by description of the shape of the defect surface using the following terms, as illustrated below:



Defect Coatings and Seam Composition – Coatings are described using the following terms:

(a) *Clean* No visible coating.
(b) *Stained* No visible coating but surfaces are discoloured.
(c) *Veneer* A visible coating of soil or mineral, too thin to measure; may be patchy.
(d) *Coating* A visible coating up to 1 mm thick. Soil in-fill greater than 1 mm shall be described using defect terms (e.g. infilled seam). Defects greater than 1 mm aperture containing rock material great described as a vein.

Defect Spacing, Length, Openness and Thickness –described directly in millimetres and metres. In general descriptions, half order of magnitude categories are used, e.g. joint spacing typically 100 mm to 300 mm, sheared zones 1 m to 3 m thick.

Depending on project requirements and the scale of observation, spacing may be described as the mean spacing within a set of defects, or as the spacing between all defects within the rock mass. Where spacing is measured within a specific set of defects, measurements shall be made perpendicular to the defect set.

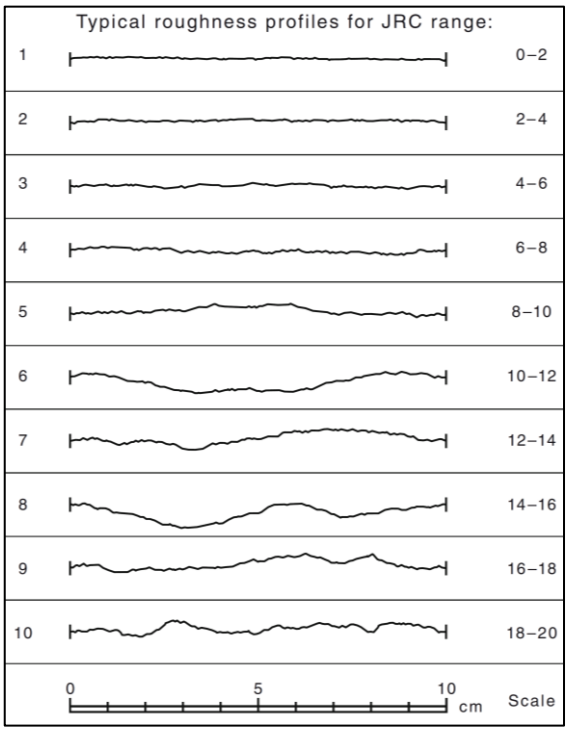
Defect spacing and length (sometimes called persistence), shall be described directly inmillimetres and metres.

Stratigraphic Unit - Geological maps related to the project are used for the designation of lithological formation name and, where possible geological unit name, e.g. Bringelly Shale, Potts Hill Sandstone Member.

Defect Roughness and Shape – Defect surface roughness is described as follows:

Very rough	Many large surface irregularities with amplitude generally more than 1 mm.
Rough	Many small surface irregularities with amplitude generally less than 1 mm.
Smooth	Smooth to touch. Few or no surface irregularities.
Polished	Shiny smooth surface
Slickensided	Grooved or striated surface, usually polished.

Where applicable Joint Roughness Range (JRC) is provided as follows:



Joint roughness profiles and corresponding JRC range based on Barton, N and Choubey, V. The Shear Strength of Rock Joints in Theory and Practice. *Rock Mechanics.* Vol. 10 (1977), pp. 1–54.

Where possible the mineralogy of the coating is identified.

Defect Infilling - abbreviated as follows:

CA	Calcite	KT	Chlorite
CN	Clean	MS	Secondary Mineral
Cy	Clay	MU	Unidentified Mineral
CS	Crushed Seam	Qz	Quartz
Fe	Iron Oxide	X	Carbonaceous

PARAMETERS RELATED TO CORE DRILLING

Total Core Recovery – T

Defect Spacing or Fracture Index – T

Rock Quality Designation – Y

Core Loss – Core loss occurs when material is lost during the drilling process It is shown at the bottom of the run unless otherwise indicated where core loss is known.