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Slope Risk Assessment

Geotechnical Investigation and Slope Risk Assessment Report
86 Sir Thomas Mitchell Drive, Davidson NSW

1.0 INTRODUCTION

Morrow Geotechnics Pty Ltd conducted geotechnical investigations and slope risk assessment at 86 Sir Thomas Mitchell Drive, Davidson NSW (the site). The purpose of this investigation was to provide geotechnical advice and recommendations for proposed development at the site based on project details available at the time of the investigation. Morrow Geotechnics understands that the proposed development will involve alterations and additions to the existing residence. Plans provided by the client indicate that the proposed works involve alterations and additions to the existing residence, including excavation for a proposed double garage at the south-western corner of the existing structure. Proposed excavation is expected to extend to a depth of approximately 4 m below ground level (mBGL).

2.0 OBSERVATIONS

A senior engineering geologist inspected the site on 17 September 2019. A walkover inspection to conduct geomorphological mapping of the site was undertaken. The site lies on the south-western side of a north-west trending spur line. Local topography tends downwards towards the west.

The site comprises a storey brick residence built at the base of an approximately 8 m high sandstone cliff line. The front yard is relatively level with rock outcropping and a small sandstone cliff line (approx. 3 m high) along the boundary with Sir Thomas Mitchell Drive. There is a small retaining wall on the crest of slope founded on rock, with minor filling behind to create the level front yard.

The rear yard comprises a 25 to 30° colluvial slope grading upwards to the toe of the main sandstone cliff along the rear site boundary. Several moderate size sandstone blocks and debris from previous rock falls are present across the colluvial slope at the site and in neighbouring properties.

The cliff line comprises medium strength, fine to medium grained sandstone. Bedding is present at 0 to 10° dipping to the east. Subhorizontal bedding partings were noted at approximately 500 to 1000 mm spacing. Orthogonal vertical joint sets at inferred 5 to 7 m spacing were observed during the inspection. Some vegetation and a mortared sandstone block retaining wall are present on the cliff face. Seepage from the cliff face could not be observed due to heavy rainfall at the time of the inspection.

Four hand auger boreholes (BH1 to BH4) were drilled during the investigation. Dynamic Cone Penetrometer (DCP) tests were carried out adjacent to borehole locations to assess soil consistency and density. The approximate boreholes locations are shown on the attached plan.

A summary of the subsurface conditions encountered within the boreholes is presented in **Table 1**. More detailed descriptions of subsurface conditions at the test locations are available in the borehole logs attached to this report. The details of the method of soil and rock classification, explanatory notes and abbreviations adopted in the borehole logs are also presented attached.

TABLE 1 SUMMARY OF INFERRED SUBSURFACE CONDITIONS

Unit		Depth (mBGL)				Comments
		BH1	BH2	BH3	BH4	
1	**Surficial Soil**	0.0 to 1.3	0.0 to 0.5	0.0 to 0.55	0.0 to 0.55	Mixed sand, clay and gravel. Slopewash and uncontrolled fill.
2	**Sandstone**	1.3 +	0.5 +	0.55 +	0.55 +	Inferred moderately weathered, low strength sandstone grading to medium strength with depth. Sandstone "floaters" may be present at borehole refusal level.

Notes:

1 Approximate depth below ground level at the investigation locations. More detailed descriptions of subsurface conditions are available in the borehole logs attached to this report**.** Depths may vary across the site.

Photographs of site conditions at the time of the inspection are presented in **Figures 1** to **7** below.

Figure 1: View of cliff face towards the east

Figure 2: House position at toe of colluvial slope

Figure 3: View of cliff face towards north-east

Figure 4: Sandstone boulders present in rear yard

Figure 5: Retaining wall present within cliff line

Figure 6: Sandstone outcropping near driveway

Figure 7: Sandstone outcropping at front boundary

Figure 8: Small retaining wall at crest of outcropping in front yard

Figure 9: Sandstone cliff line viewed to the north-east

3.0 ADVICE AND RECOMMENDATIONS

3.1 Excavations

Excavations up to approximately 2 m depth will be required for the development. Temporary batter slopes of 1H:1V will be possible for Unit 1 material provided that surface water is diverted away from the batter faces and batter heights are kept to less than 3 m. Permanent batters of 2H:1V may be employed for Unit 1 material. Permanent batters will require surface protection or revegetation to prevent erosion and slaking. Unit 2 Bedrock may be cut vertically without support provided that geotechnical inspections are undertaken during construction at no greater than 1 m depth intervals to ensure that isolated blocks and wedges are not present within the rock cutting. If blocks and wedges are present isolated spot bolting or shotcreting may be required as support.

Where excavations extend beneath the zone of influence of nearby structures, services or pavements, or where site constraints such as site boundaries do not allow the construction of temporary batters, excavation retention will be required. For design of cantilevered shoring systems a triangular pressure distribution may be employed using the parameters presented in **Table 2**. For design of rigid anchored or braced walls such as top-down construction, a trapezoidal earth pressure distribution should be used with a maximum pressure of $0.65.K_a.\gamma.H$ (kPa), where 'H' is the effective vertical height of the wall in metres.

TABLE 2 EARTH PRESSURE PARAMETERS

Material		Unit 1 Surficial Soil	Unit 2 Sandstone
Bulk Unit Weight (kN/m^3)		17	23
Earth Pressure Coefficients	At rest, K_o	0.55	0.25
	Passive, K_p	2.66	4.50
	Active, K_a	0.38	0.15

Notes:

1 Unit Weight is based on visual assessment only, order of accuracy is approximately ±10%.
2 Earth pressures are provided on the assumption that the ground behind the retaining wall is flat and drained.

3.2 Soil and Rock Excavatability

The expected ability of equipment to excavate the soil and rock encountered at the site is summarised in **Table 3**. This assessment is based on available site investigation data and guidance on the assessment of excavatability of rock by Pettifer and Fookes (1994). The presence of medium to high strength bands in lower strength rock and the discontinuity spacing may influence the excavatability of the rock mass.

TABLE 3 SOIL AND ROCK EXCAVATABILITY

Unit	Material	Excavatability
1	**Surficial Soil**	Easy digging by 20t Excavator
2	**Sandstone**	Hard Ripping by 20t Excavator. Hydraulic rock hammering will be required where defect spacing precludes ripping or medium strength sandstone is encountered within the excavation.

The excavation methodology may also be affected by the following factors:

- Scale and geometry of the excavation;
- Availability of suitable construction equipment;
- Potential reuse of material on site; and
- Acceptable excavation methods, noise, ground vibration and other environmental criteria.

3.3 Excavation Vibration Considerations

As a guide, safe working distances for typical items of vibration intensive plant are listed in **Table 4**. The safe working distances are quoted for both "cosmetic" damage (refer British Standard BS 7385:1993) and human comfort (refer NSW Environmental Protection Agency Vibration Guideline).The safe working distances should be complied with at all times, unless otherwise mitigated to the satisfaction of the relevant stakeholders.

TABLE 4 RECOMMENDED SAFE WORKING DISTANCES FOR VIBRATION INTENSIVE PLANT

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385:1993) [1]	Human Response (EPA Vibration Guideline)
Vibratory Roller	< 50 kN (typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (typically 2-4 tonnes)	6 m	20 m
	< 200 kN (typically 4-6 tonnes)	12 m	40 m
	< 300 kN (typically 7-13 tonnes)	15 m	100 m
	< 300 kN (typically 13-18 tonnes)	20 m	100 m
	< 300 kN (typically >18 tonnes)	25 m	100 m
Small Hydraulic Hammer	300 kg – 5 to 12 t excavator	2 m	7 m
Medium Hydraulic Hammer	900 kg – 12 to 18 t excavator	7 m	23 m
Large Hydraulic Hammer	1600 kg – 18 to 34 t excavator	22 m	73 m
Vibratory Pile Driver	Sheet Piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

In relation to human comfort (response), the safe working distances in **Table 4** relate to continuous vibration and apply to residential receivers. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are permitted, as discussed in British Standard BS 6472-1:2008. Please note that more stringent conditions may apply to heritage buildings or other sensitive structures.

Where rock excavation will take place closer than the recommended safe working distances provided above vibration mitigation measures should be employed. Morrow Geotechnics recommends the following mitigation measures for excavation at the site:

- Saw cutting of the perimeter of the excavation;
- Saw cutting parallel to the perimeter of the excavation at 0.5 to 1.0 m offsets to the perimeter;
- A maximum hydraulic hammer size of 900 kg used at 50% of full operational capacity. Hammering is to be limited to 3 second bursts with a pause of at least 3 seconds between bursts;
- The orientation of rock breaking equipment in a direction away from property boundaries towards existing excavation; and
- Monitoring of vibration at the nearest residential receptor.

The safe working distances provided in **Table 4** are given for guidance only. Monitoring of vibration levels is recommended at the nearest receptor. This is required to ensure vibrations levels remain below threshold values during the construction period. Morrow Geotechnics recommends an upper limit for ppv of 5 mm/sec is adopted for the site. Should vibrations exceed set limits, we recommend the following:

- Cease excavation works and notify the Geotechnical Engineer immediately; and
- Develop an alternative excavation plan in conjunction with the Geotechnical Engineer.

3.4 Foundation Design

All new footings for the proposed development are to found on sandstone. Shallow footings and slabs on sandstone should be designed in accordance with AS2870:2011 based on a Site Classification of 'A.' The site classification has been provided on the basis that the performance expectations set out in Appendix B of AS2870–2011 are acceptable and that future site maintenance will be undertaken in accordance with CSIRO BTF 18.

The parameters given in **Table 5** may be used for the design of pad footings and bored piles or for an assessment of the current bearing capacity of existing footings and for new footings. Morrow Geotechnics recommends that a Preliminary Geotechnical Strength Reduction Factor (GSRF) of 0.4 is used for the design of piles in accordance with AS 2159:2009 if no allowance is made for pile testing during construction. Should pile testing be nominated, the GSRF may be reviewed and a value of 0.55 to 0.6 may be expected.

No new footings are to found within Unit 1 soils. All new footings must be taken to sandstone. Given the possibility of sandstone floaters being encountered at footing level geotechnical inspections

should be undertaken to determine the stability of any encountered floaters at the time of footing construction.

To adopt these parameters we have assumed that the bases of all footing and pile excavations are cleaned of loose debris and water and inspected by a suitably qualified Geotechnical Engineer prior to footing construction to verify that ground conditions meet design assumptions. Where groundwater ingress is encountered during pile excavation, concrete is to be placed as soon as possible upon completion of pile excavation. Pile excavations should be pumped dry of water prior to pouring concrete, or alternatively a tremmie system could be used.

TABLE 5 PAD FOOTING AND PILE DESIGN PARAMETERS

Material		Weathered Sandstone
Allowable Bearing Pressure (kPa)		700
Ultimate Vertical End Bearing Pressure (kPa)		2100
Elastic Modulus (MPa)		80
Ultimate Shaft Adhesion (kPa)	In Compression	150
	In Tension	75
Susceptibility to Liquefaction during an Earthquake		Low

Notes:

1 Side adhesion values given assume there is intimate contact between the pile and foundation material. Design engineer to check both 'piston' pull-out and 'cone' pull-out mechanics in accordance with AS4678-2002 Earth Retaining Structures.

2 Susceptibility to liquefaction during an earthquake is based on the following definition:

Low	-	Medium to very dense sands, stiff to hard clays, and rock
Medium	-	Loose to medium dense sands, soft to firm clays, or uncontrolled fill below the water table
High	-	Very loose sands or very soft clays below the water table

Ultimate geotechnical strengths are provided for use in limit state design. Allowable or serviceability bearing pressures adopted in **Table 3** are intended to limit settlements to an acceptable level for conventional building structures, typically less than 1% of the minimum footing width.

3.5 AS1170 Earthquake Site Risk Classification

Assessment of the material encountered during the investigation in accordance with the guidelines provided in AS1170.4-2007 indicates:

- an earthquake subsoil class of Class B_e – Rock for the site; and
- a hazard factor (z) of 0.08 for Sydney.

3.6 Slope Risk Assessment

A Slope Risk Assessment has been carried out for the site in accordance with Australian Geomechanics Society 2007 Guidelines. This assessment is based on surface conditions observed during the inspection and subsurface conditions inferred from mapped regional geology. These guidelines allow the stability of the slope/ structure to be assessed in terms of risk to property and loss of life based on the physical features of the slope and the proposed development. Typical risk indicators of potential slope instability are:

- high slope angles;
- adverse dipping of rock joints and bedding in conjunction with dip direction of the rock joints;
- high degree of weathering; and
- signs of previous slope movements.

3.6.1 Potential Slope Hazards

Morrow Geotechnics considers that structures and people at the site may be impacted by the following potential hazards:

Hazard 1: Rear yard boulder fall from colluvium (max block dimension 1.2 m x 0.8 m x 0.8 m).

Hazard 2: Rotational slump within colluvial slope (approx. 5 m^3 of debris).

Hazard 3: Global failure of cliff line and mobilisation of large block.

Hazard 4: Collapse of retaining wall within rear boundary cliff line.

3.6.2 Assessed Risk Level for Property Damage

The risk zoning using property loss criteria in accordance with AGS 2007c is presented in **Table 6.**

TABLE 6 SEMI-QUANTITATIVE ASSESSMENT FOR PROPERTY DAMAGE

Hazard	Likelihood (Indicative value of annual probability)	Consequence (Indicative Value)	Assessed Risk Level
Hazard 1	Unlikely (1×10^{-4})	Minor (5%)	**Low**
Hazard 2	Unlikely (1×10^{-4})	Minor (5%)	**Low**
Hazard 3	Rare (1×10^{-5})	Major (60%)	**Low**
Hazard 4	Possible (1×10^{-3})	Insignificant (0.5%)	**Very Low**

The risk zoning using property loss criteria in accordance with AGS 2007c is assessed to be **Low**.

3.6.3 Assessed Risk Level for Loss of Life

The risk zoning using loss of life criteria in accordance with AGS 2007c is presented in **Table 7**

TABLE 7 QUANTITATIVE ASSESSMENT FOR LOSS OF LIFE

Hazard	Annual Probability $P_{(H)}$	Probability of Spatial Impact $P_{(IS:H)}$	Temporal Spatial Probability $P_{(IS:H)}$	Vulnerability of Individual $V_{(D:T)}$	Annual Probaility of Loss of Life $R_{(LoL)}$
Hazard 1	1×10^{-4}	0.1	0.1	0.1	**1×10^{-7}**
Hazard 2	1×10^{-4}	0.1	0.1	1×10^{-2}	**1×10^{-8}**
Hazard 3	1×10^{-5}	1.0	0.5	1.0	**5×10^{-6}**
Hazard 4	1×10^{-3}	0.1	1×10^{-2}	0.1	**1×10^{-7}**

The assessed maximum risk to loss of life according to the quantitative risk assessment is 5×10^{-6}.

3.6.4 Pre Development Risk Levels

The qualitative risk assessment indicates the site to have a Low Risk of damage to property as a result of the potential hazards identified. AGS Landslide Risk Management Concepts and Guidelines state that a Low assessed risk to property is "usually acceptable to regulators." The AGS stipulates that the client, owner or, if appropriate, the regulator must carry out their own assessment to determine whether the low risk to property and damage is acceptable or tolerable.

The annual probability of loss of life for the person most at risk as a result of slope instability impacting the site is calculated to be less than 5×10^{-6}. The AGS Landslide Risk Management Concepts and Guidelines provide guidance on tolerable and acceptable loss of life risk for the person most at risk, indicating that a risk level of 1×10^{-4} is typically considered tolerable for existing slopes while 1×10^{-5} is typically acceptable for proposed developments. The AGS stipulates that the client, owner or, if appropriate, the regulator must carry out their own assessment to determine whether the low risk to property and damage is acceptable or tolerable.

3.6.5 Recommended Construction Procedures to Minimise Identified Risks

Morrow Geotechnics recommends the following measures are undertaken during construction in order to minimise the risks identified as part of the slope risk assessment:

- Any excavations greater than 1.0 m depth opened for the installation of footings or services should be inspected by an experienced geotechnical engineer and adverse features within the rock mass, including but not limited to inclined joints, decomposed seams, wedges, blocks or highly fractured zones, should be identified and mapped. Stabilisation measures should be proposed by the geotechnical engineer and undertaken prior to the excavation proceeding.
- Surface water flow should be directed away from construction areas and the crests of retaining walls during the works.
- Drainage must be maintained behind any retaining walls and should be inspected following construction to ensure that it remains clear.
- Stormwater for the proposed extension should be connected to existing stormwater systems

for disposal. New infiltration systems are not recommended for the site.

- Construction plant should not be placed closer than 1.5 m from the crest of the existing batters.

3.6.6 Anticipated Risk Level Post Development

Should the construction procedures outlined above be complied with, Morrow Geotechnics anticipates that the assessed risk levels will remain unchanged as a result of the proposed development. The anticipated post development risk levels are:

- Low for risk of damage to property; and
- 5×10^{-6} for risk of loss of life.

This assessment is contingent upon all advice and recommendations given by geotechnical professionals prior to and during the construction being implemented

4.0 CONCLUSION

In accordance with the findings and recommendations of this report, Morrow Geotechnics has found that the site is geotechnically suitable for the proposed development. Risk Assessment has been carried out in accordance with AGS guidelines and the development poses an acceptable risk to property and life. Further, the existing rock formations will not be impacted by the proposed loading or excavation as part of the proposed development.

5.0 CLOSURE

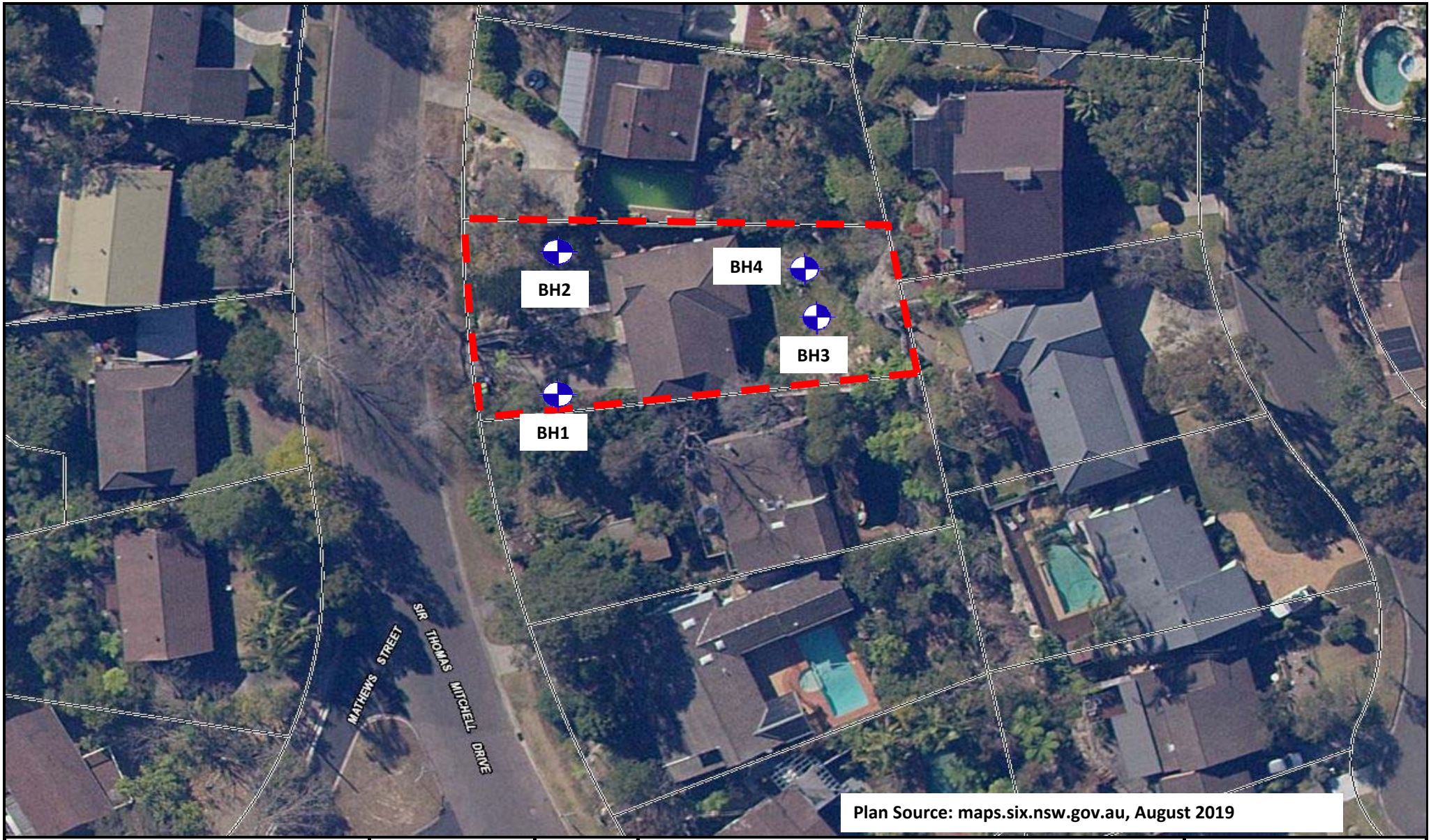
Your attention is drawn to the attached document titled "Important Information." The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Morrow Geotechnics, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

Please do not hesitate to contact Morrow Geotechnics if you have any questions about the contents of this report.

For and on behalf of Morrow Geotechnics Pty Ltd,

Alan Morrow
Senior Geotechnical Engineer

Attached: Important Information



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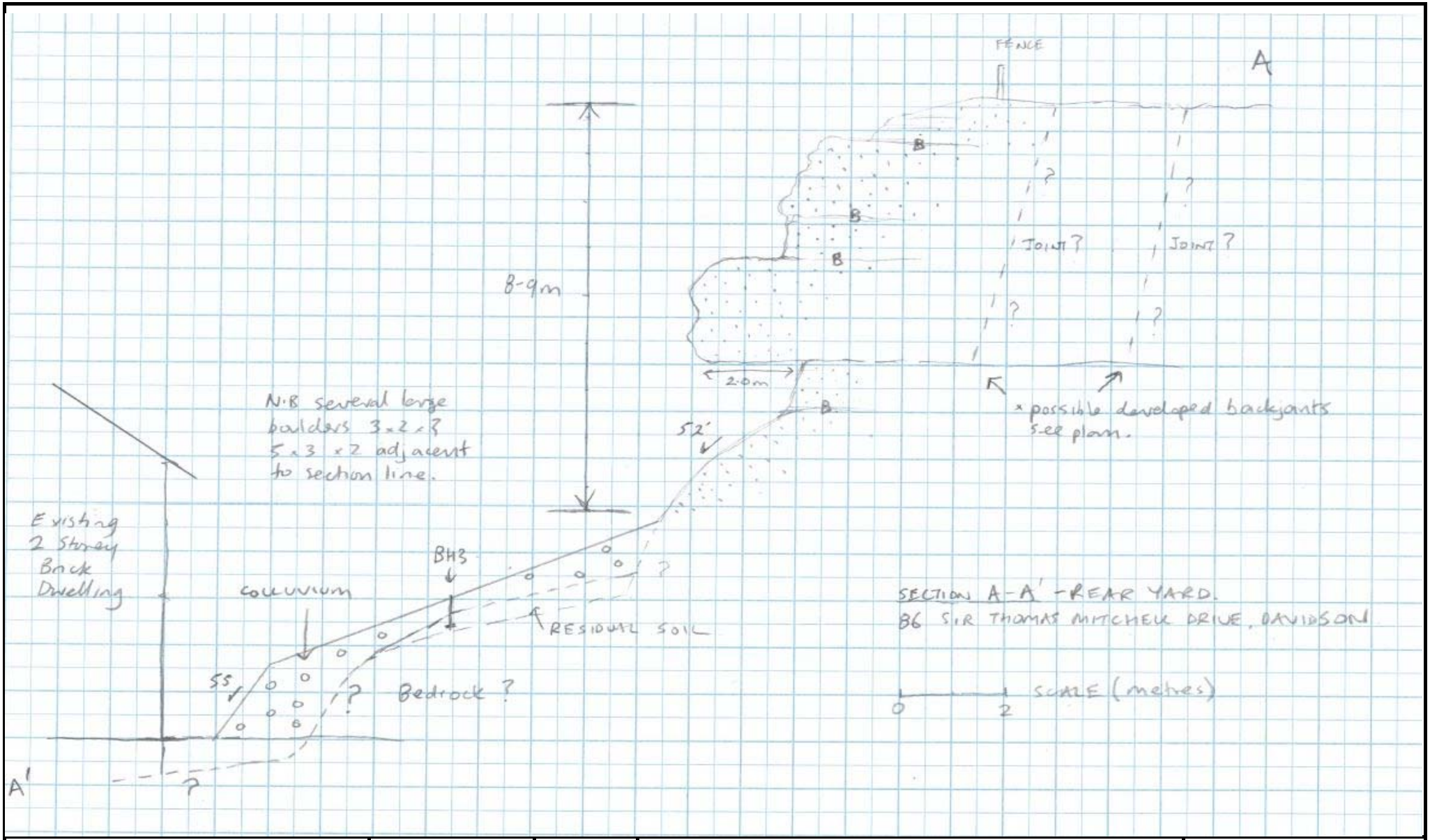
Drawn	ZS
Approved	AM
Date	12/09/2019
Scale	NTS

Mr Kevork Kevorkian
86 Sir Thomas Mitchell Drive, Davidson NSW
Geotechnical Investigation
Borehole Location Plan

Figure:
1

Project: P1762



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Drawn	MHK
Approved	AM
Date	23/09/2019
Scale	NTS

Mr Kevork Kevorkian
86 Sir Thomas Mitchell Drive, Davidson NSW
Geotechnical Investigation
Site Longitudinal Section

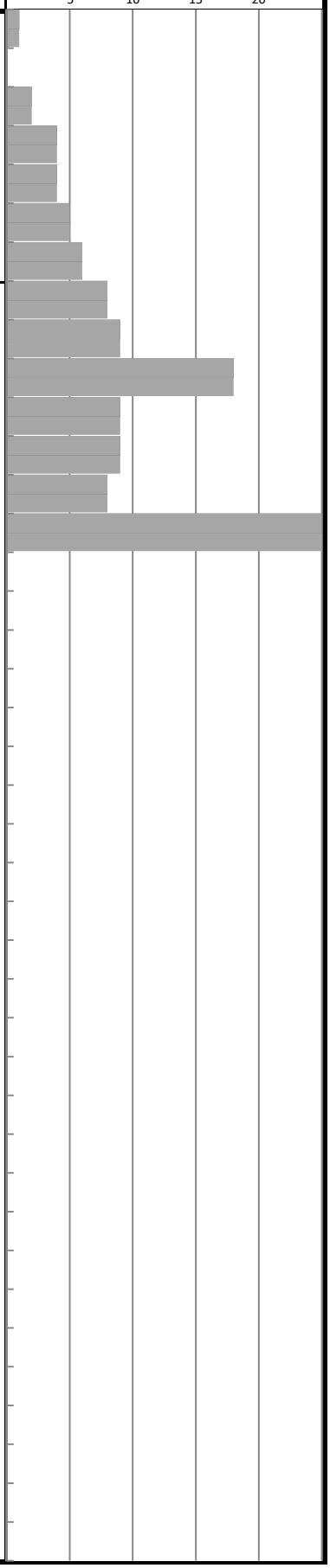
Figure: **2**

Project: P1762

Project No:	P1762	Contractor:	MG	morrow	
Client:	Mr. Kevork Kevorkian	Drill Rig:	Hand Auger		
Project:	86 Sir Thomas Mitchell Drive Davidson NSW	Sheet	1 of 1		
		Logged:	MK		
		Date:	17/09/2019		

BH1

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture	DCP (blows per 100 mm)
HA	L	GWNE		-	0.00	Silty SAND - fine to coarse grained, dark brown, with fine to medium gravel (sandstone / ironstone)	VL-L	D	
				-		Mixed FILL - comprising gravel, sand and clay, fine to coarse sand and gravel, orange / brown / white			
	M			SP	0.50	SAND, fine to medium grained, grey / white and orange, with trace silt and clay.	MD		
					0.75	End BH1 at 0.70m Practical Hand Auger Refusal			
					1.00				
					1.25				
					1.50				
					1.75				
					2.00				
					2.25				
					2.50				
					2.75				
					3.00				
					3.25				
					3.50				
					3.75				
					4.00				



Project No:	P1762	Contractor:	MG
Client:	Mr. Kevork Kevorkian	Drill Rig:	Hand Auger
Project:	86 Sir Thomas Mitchell Drive Davidson NSW	Sheet	1 of 1
		Logged:	MK
		Date:	17/09/2019

BH2

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
HA	L	GWNE		SM		SAND, fine to medium grained, brown, trace silt, roots present	L	M
	M			GP	0.25	Gravelly SAND, fine to coarse sand and fine to medium gravel (sandstone), orange / brown	MD	M-W
					0.50	End BH2 at 0.50m Practical hHand Auger Refusal		
					0.75			
					1.00			
					1.25			
					1.50			
					1.75			
					2.00			
					2.25			
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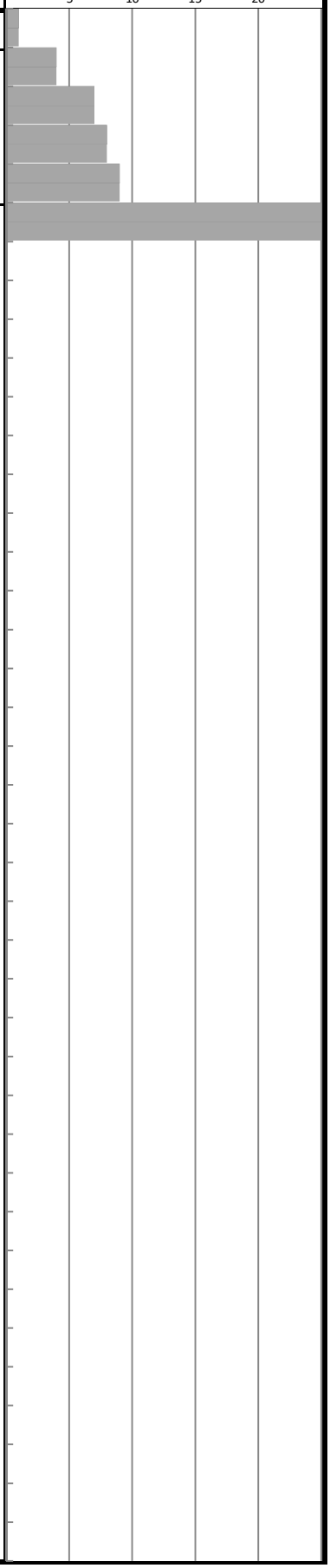
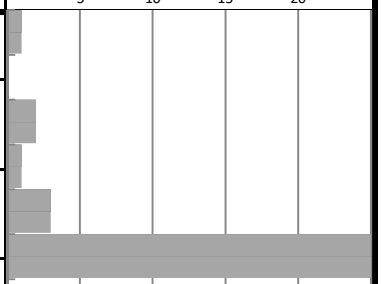


Project No:	P1762	Contractor:	MG		
Client:	Mr. Kevork Kevorkian	Drill Rig:	Hand Auger		
Project:	86 Sir Thomas Mitchell Drive Davidson NSW	Sheet	1 of 1		
		Logged:	MK		
		Date:	17/09/2019		

BH3

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture
HA	L	GWNE		SM		SAND, fine to medium grained, trace silt and clay, brown, fine to coarse grained gravel	VL	M
				CL	0.25	Sandy CLAY, low plasticity, orange / brown, fine to medium grained sand	L	M-W
				SC	0.50	Clayey SAND, fine to medium grained, grey / white, some orange, low plasticity clay		M
						End BH3 at 0.55m Practical Hand Auger Refusal		

DCP (blows per 100 mm)



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Project No:	P1762	Contractor:	MG	morrow	
Client:	Mr. Kevork Kevorkian	Drill Rig:	Hand Auger		
Project:	86 Sir Thomas Mitchell Drive Davidson NSW	Sheet	1 of 1		
		Logged:	MK		
		Date:	17/09/2019		

BH4

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture	DCP (blows per 100 mm) 5 10 15 20
HA	L	GWNE		SP	0.25	SAND, fine to coarse grained, brown, trace silt and clay, trace fine to coarse gravel and cobbles - Becoming red / brown	L	M	
					0.50			W	
					0.75	End BH4 at 0.55m Practical Hand Auger Refusal			
					1.00				
					1.25				
					1.50				
					1.75				
					2.00				
					2.25				
					2.50				
					2.75				
					3.00				
					3.25				
					3.50				
					3.75				
					4.00				

Soil and Rock Logging Explanatory Notes

GENERAL

Information obtained from site investigations is recorded on log sheets. The "Cored Drill Hole Log" presents data from an operation where a core barrel has been used to recover material - commonly rock. The "Non-Core Drill Hole - Geological Log" presents data from an operation where coring has not been used and information is based on a combination of regular sampling and insitu testing. The material penetrated in non-core drilling is commonly soil but may include rock. The "Excavation - Geological Log" presents data and drawings from exposures of soil and rock resulting from excavation of pits, trenches, etc.

The heading of the log sheets contains information on Project Identification, Hole or Pit Identification, Location and Elevation. The main section of the logs contains information on methods and conditions, material substance 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 common depth scale is 8m per drill log sheet and about 3-5m for excavation logs sheets.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is inevitable 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. Material description and classifications are based on SAA Site Investigation Code AS 1726 - 1993 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

ADV	Auger Drilling with V-Bit
ADT	Auger Drilling with TC Bit
WB	Wash-bore drilling
RR	Rock Roller
NMLC	NMLC core barrel
NQ	NQ core barrel
HMLC	HMLC core barrel
HQ	HQ core barrel

Drilling Fluid/Water

The drilling fluid used is identified and loss of return to the surface estimated as a percentage.

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
M	Medium
H	High
VH	Very High

Groundwater Levels

Date of measurement is shown.

Standing water level measured in completed borehole

Level taken during or immediately after drilling

D	Disturbed
B	Bulk
U	Undisturbed
SPT	Standard Penetration Test
N	Result of SPT (sample taken)
PBT	Plate Bearing Test
PZ	Piezometer Installation
HP	Hand Penetrometer Test

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

Classification Symbol - In accordance with the Unified Classification System (AS 1726-1993, Appendix A, Table A1)

Material Description - In accordance with AS 1726-1993, Appendix A2.3

Moisture Condition

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

Consistency - In accordance with AS 1726-1993, Appendix A2.5

VS	Very Soft	< 12.5 kPa
S	Soft	12.5 – 25 kPa
F	Firm	25 – 50 kPa
St	Stiff	50 – 100 kPa
VSt	Very Stiff	100 – 200 kPa
H	Hard	> 200 kPa

Strength figures quoted are the approximate range of undrained shear strength for each class.

Density Index. (%) is estimated or is based on SPT results.

VL	Very Loose	< 15 %
L	Loose	15 – 35 %
MD	Medium Dense	35 – 65 %
D	Dense	65 – 85 %
VD	Very Dense	> 85 %

MATERIAL DESCRIPTION -ROCK

Material Description

Identification of rock type, composition and texture based on visual features in accordance with AS 1726-1993, Appendix A3.1-A3.3 and Tables A6a, A6b and A7.

Core Loss

Is shown at the bottom of the run unless otherwise indicated.

Bedding

Thinly Laminated	< 6 mm
Laminated	6 - 20
Very Thinly Bedded	20 - 60
Thinly Bedded	60 - 200
Medium Bedded	200 – 600
Thickly Bedded	600 – 2000
Very Thickly Bedded	> 2000

Weathering - No distinction is made between weathering and alteration. Weathering classification assists in identification but does not imply engineering properties.

Fresh (F)	Rock substance unaffected by weathering
Slightly Weathered (SW)	Rock substance partly stained or discoloured. Colour and texture of fresh rock recognisable.
Moderately Weathered (MW)	Staining or discolouration extends throughout rock substance. Fresh rock colour not recognisable.
Highly Weathered (HW)	Stained or discoloured throughout. Signs of chemical or physical alteration. Rock texture retained.
Extremely Weathered (EW)	Rock texture evident but material has soil properties and can be remoulded.

Strength - The following terms are used to described rock strength:

Rock Strength Class	Abbreviation	Point Load Strength Index, Is(50) (MPa)
Extremely Low	EL	< 0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	≥ 10

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

° Diametral Point Load Test

Axial Point Load Test

Where the estimated strength log covers more than one range it indicates the rock strength varies between the limits shown.

MATERIALS STRUCTURE/FRACTURES

ROCK

Natural Fracture Spacing - A plot of average fracture spacing excluding defects known or suspected to be due to drilling, core boxing or testing. Closed or cemented joints, drilling breaks and handling breaks are not included in the Natural Fracture Spacing.

Visual Log - A diagrammatic plot of defects showing type, spacing and orientation in relation to core axis.

Defects	———	Defects open in-situu or clay sealed
	– – – – –	Defects closed in-situ
	.....	Breaks through rock substance

Additional Data - Description of individual defects by type, orientation, in-filling, shape and roughness in accordance with AS 1726-1993, Appendix A Table A10, notes and Figure A2.

Orientation - angle relative to the plane normal to the core axis.

Type	BP	Bedding Parting
	JT	Joint
	SM	Seam
	FZ	Fracture Zone
	SZ	Shear Zone
	VN	Vein
	FL	Foliation
	CL	Cleavage
	DL	Drill Lift
	HB	Handling Break
	DB	Drilling Break
Infilling	CN	Clean
	X	Carbonaceous
	Clay	Clay
	KT	Chlorite
	CA	Calcite
	Fe	Iron Oxide
	Qz	Quartz
	MS	Secondary Mineral
	MU	Unidentified Mineral
Shape	PR	Planar
	CU	Curved
	UN	Undulose
	ST	Stepped
	IR	Irregular
	DIS	Discontinuous
Rougness	POL	Polished
	SL	Slickensided
	S	Smooth
	RF	Rough
	VR	Very Rough

SOIL

Structures - Fissuring and other defects are described in accordance with AS 1726-1993, Appendix A2.6, using the terminology for rock defects.

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

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