GREYWACKE GEOTECHNICS

GEOTECHNICAL REPORT

Prepared for: **Clare & Kim Manns**

Project: Proposed Alterations & Additions

Location: 20 Leinster Avenue, Killarney Heights 2087

Project No.: CLKM0643-GEO AA

2 September 2021

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1. Introduction

1.1 General

This report is prepared by Greywacke Geotechnics (Greywacke) for the proposed additions and alterations at (Lot 526 in DP218576) **20 Leinster Avenue, Killarney Heights NSW 2087.** The investigation was carried out in general accordance with Greywacke's proposal and commissioned by Clare & Kim Manns.

The architectural plans prepared by **Atelier M** (Job No.: 026, Date: September 2020) indicates that the proposed development will include addition and alterations to the existing building and construction of a swimming pool and associated decking area.

The field investigation was undertaken to provide information on the surface and subsurface soil conditions within the development site, and to deliver a factual engineering assessment, comments and design recommendations relating to the possible impacts of the excavation works within the building envelope, surrounding area and neighbouring structures. Furthermore, the location of the site is identified as **Area B** on the *Warringah Local Environmental Plan 2011 – Landslip Risk Map* and a preliminary assessment in accordance with the checklist provided in the **Section E10 Landslip Risk** of the *Warringah Development Control Plan 2011* was conducted to identify any potential slope stability issues within the site.

This geotechnical investigation report is prepared in accordance with the Australian Standards *AS 1726-2017 Geotechnical site investigations* and may be submitted to the Council to accompany a Development Application (DA) process.

1.2 Scope of work

This report entails the geotechnical investigation undertaken for the proposed project. The purpose of this report is to provide information on and discuss the following geotechnical aspects:

- Review project documents (i.e. architectural plans, structural drawings and surveys plans etc.) and develop a preliminary understanding of the earthworks related activities involving the project.
- Review of available geotechnical/geological data in the vicinity of the site;
- Identify potential geotechnical constraints for assessment and planning;
- Excavation conditions at the proposed development site;
- Groundwater conditions and foundation conditions including suitable soil/rock bearing capacity available within the site, and;
- Preliminary landslip risk assessment in accordance with the checklist provided in the Section E10 Landslip Risk of the *Warringah Development Control Plan 2011.*

This report has been prepared with reference to the project documents provided by the client and the following information, collected during our site visit(s) and from publicly available sources:

- Geological and soil landscape maps and notes;
- Archived geotechnical reports prepared for the site and/or the surrounding area;
- Aerial imagery (i.e. Google Earth, Six Maps) and;
- Design/Architectural drawings of the proposed development, and;
- Limited observations made during the geotechnical investigations across the proposed development site and the surrounding area.

2. Site Setting

2.1 Site Identification Details

The subject site (Lot 526 in DP218576) being considered for the proposed alterations and additions is located at **20 Leinster Avenue, Killarney Heights NSW 2087**, approximately 10km north of Sydney CBD. The location of the site is marked in **Figure 3** found in **Appendix B.**

The subject site is bounded by Leinster Avenue along its southern boundary line, and neighbouring residencies occupy areas immediately adjacent to its northern, eastern, and western extents. The site is currently occupied by a single storey residential dwelling with a lower ground level living area and occupies an area of approximately 705.5m^2.

2.2 Environmental Setting

2.2.1 Topography

Imagery available on the Department of Lands and Spatial Information Exchange website and the site survey plans and architectural drawings shows that the site is located at elevations varying between 65m and 76m AHD (Australian Height Datum).

The topography of the site and the adjacent areas are slight to moderately sloping down from Leinster Avenue towards the rear boundary with slopes up to 20º. The site terrain of the backyard includes benched landscape, developed naturally around exposed sandstone bedrock, and constructed with structural and non-structural retaining walls. Sandstone outcrops and boulders were also observed throughout the site (mainly within the backyard) and the surrounding area, during our site visit.

2.2.2 Regional Geology and Soil Landscapes

The 1:100,000 scale Sydney - NSW Geological Series Sheet (Geological Survey of NSW, Department of Minerals and Energy, Sheet 9130, 1983) indicates that the proposed development site is underlain by Hawkesbury Sandstone (Rh) of the Wianamatta Group. This stratum comprises of medium to coarse grained quartz, sandstone, very minor sandstone and laminate lenses. A map excerpt of the Sydney Geological map is provided below in **Figure 1** below and the red inverted 'tear drop' icon indicates the location of the site.

The *Warringah Development Control Plan 2011* indicates that the geology of the sites located within the areas identified as **Area B** generally comprises colluvial and residual soils, possibly deeper than in Class A (shallow soils), developed on Hawkesbury Sandstone. Minor detached sandstone blocks, occasional exposures of sandstone in cliffs and road cuts. Occasional fill areas associated with playing fields, roads, and some developments.

Landscape – rugged, rolling to very steep hills on Hawkesbury Sandstone. Local relief 40m–200m, slopes >25%. Rock outcrop >50%. Narrow crests and ridges, narrow incised valleys, steep sideslopes with rocky benches, broken scarps, and boulders. Mostly uncleared eucalypt open-woodland (dry sclerophyll forest) and tall open-forest (wet sclerophyll forest).

Soils – Shallow (>50 cm), discontinuous Lithosols/Siliceous Sands associated with rock outcrop; Earthy Sands, Yellow Earths and some Yellow Podzolic Soils on inside of benches and along joints and fractures; localised Yellow and Red Podzolic Soils associated with shale lenses; Siliceous Sands and secondary Yellow Earths along drainage lines.

Figure 1 Geology Map Excerpt

3. Investigation Results

3.1 Preliminaries

In accordance with Greywacke Occupational Health and Safety Policy, a site-specific Safe Work Method Statement must be prepared prior to conducting fieldwork or field investigation must be carried out in accordance with the Work Health and Safety checklist. All site staff were briefed on the requirements set out in the plan by the supervising geotechnical engineer.

Prior to the site investigation, relevant plans of buried utilities obtained from 'Dial Before You Dig' service were collated and reviewed. The plans showed no buried services or utilities were present adjacent to test locations.

3.2 Fieldwork

The Geotechnical site investigation was carried out on 19th August 2021 and comprised of a brief walkover for visual assessment of site conditions followed by two (2) Dynamic Cone Penetrometer (DCP) testing and excavation of two (2) boreholes (BH) using a mechanical hand auger at selected locations. Boreholes were excavated to auger refusal depths of 0.9m (BH2) and 1.1m (BH1) below ground level. DCP tests were carried out adjacent to each borehole, in accordance with **AS 1289.6.3.2-1997** to determine soil consistency / strength correlation.

The fieldwork was carried out by an experienced geotechnical engineer from Greywacke Geotechnics. The borehole and DCP locations are shown in **Figure 3** contained in **Appendix B,** and the borehole log sheets, test pit log sheet and DCP records are provided in **Appendix C**. These should be read in conjunction with the attached Standard Sheets in **Appendix A**.

3.3 Subsurface Profile

3.3.1 General

In general terms, subsurface conditions encountered during the excavation of the boreholes comprised of variable topsoil/fill material, then into clayey sand overlying weathered sandstone bedrock. **Table 1** below summarises the sub-surface profile encountered at each test location.

Table 1 Summary of Subsurface Conditions

Test ID	Topsoil/Fill	Colluvial Soil	Sandstone Bedrock
BH 1	0m – 0.9m	–	0.9m – 1.1m^{+R}
BH 2	0m – 0.1m	0.1m – 0.75m	0.75m – 0.9m^{+R}

Notes: 1. '+R' Refers to the depth of material extending beyond the refusal depths.
2. 'm' Refers to metres below ground level.

Reference to the individual borehole log sheets (**Appendix C**) should be made for a detailed description of the conditions encountered during the investigation.

3.3.2 Groundwater

Groundwater / seepage was not encountered in any boreholes during the short time they stayed open. However, groundwater levels may be subject to seasonal variations and following inclement weather conditions and may, therefore fluctuate, which has not been assessed.

4. Geotechnical Assessment

4.1 General

Based on the information provided, it is understood that the proposed development will include civil earthworks related activities at the site, and these activities will include, but not limited to:

- Excavation of surficial soil and weathered sandstone bedrock for the construction of the proposed inground swimming pool.

4.2 Excavation and Vibration Conditions

Architectural plans prepared by **Atelier M** (Job No.: 026, Date: September 2020) for the project, indicate that the earthworks for the proposed swimming pool and associated landscaping works may require minor to moderate excavations up to 1.8m deep (below existing ground level).

It is envisaged that excavations for the proposed works are likely to be carried out manually or with an excavator of the order of 2 to 5 tonne mass fitted with a toothed bucket through the shallow soil profile and weathered sandstone bedrock. We note that, rock strength typically increases in strength with depth, suggesting rock breakers or ripping methods may be required. Operation of rock breakers or ripping equipment may produce vibrations with the potential of undermining / de-stabilising of existing structures within the surrounding area. Where vibration sensitive structures lie within close proximity to the rock excavations or to minimise the potential of undermining / de-stabilising of existing structures, rock milling heads or rock saws will be required to limit ground vibrations.

Furthermore, vibration monitoring and assessment may be included in the excavation methodology for the site works. If rock breaking equipment is used as part of the cut earthworks, then excavation methods should be adopted which limit ground vibrations at the site to no more than 6mm/sec Peak Particle Velocity (PPV).

The following recommendations can be adopted to maintain ground vibrations below 6mm/sec PPV while retaining productivity efficiency:

- Choosing alternative, lower-impact equipment (i.e. saw cut) or methods close to the adjacent structure and wherever possible.
- Routing, operating, or locating high vibration sources as far away from sensitive areas as possible.
- Sequencing operations, so that vibration causing activities do not occur simultaneously.
- Isolating the equipment causing the vibration on resilient mounts.
- Keeping equipment well maintained.

The excavation equipment must always be operated by experienced personnel in accordance with the manufacturer's instructions and in a manner consistent with minimising vibration effects. Vibration monitoring is required to measure and limit the level of vibrations produced during excavation and rock breaking.

A geotechnical engineer must be engaged for further advice if unexpected ground conditions are encountered during excavation works.

We note that unwanted material will need to be disposed of offsite in accordance with DECC (2014) Waste Classification Guidelines.

4.3 Temporary Excavation Stability

The stability and safety of excavations must be ensured during construction. The current NSW WorkCover code of practice for construction work / excavations requires that excavations in soil deeper than 1.5m must be stabilised by benching, battering or mechanical support.

Temporary batters or benching may be required during the excavation within the proposed site where sufficient space is available. For temporary cut operations (short term) through soil layers deeper than 1.5m, unsupported batter slopes should not exceed 2H:1V and no more than 1H:1V for cut operations in weathered sandstone bedrock. Vertical excavations without mechanical support may be possible in medium strength (or better) sandstone bedrock. Where this is not practicable due to site constraints, the installation / construction of an appropriate shoring system will be required.

We understand that a vertical excavation may provide the most practicable form of construction in terms of minimising the footprint of ground disturbed at the surface and, thereby, also minimising the volume of excavated material (i.e. spoil). The duration that such an excavation can be relied upon to remain self-supporting before installation of a support system is reliant on the strength/cohesion of the strata forming the excavation sides, unstable soil mass (e.g. fill materials encountered), unfavourable rock mass defect orientations and the presence of groundwater seepage may require excavation support or stabilisation to be put in place at a shallower depth.

Wherever excavations are located closer than their nominal depth to an existing structure, ground displacements resulting from the excavations could adversely affect adjacent structures. In such cases, the impact of the excavation on local structures must be considered on a case by case basis and appropriate measures undertaken to minimise potential impacts. We recommend dilapidation studies of nearby structures should also be carried out by the contractor in advance of excavation works.

The above should be reviewed by an experienced geotechnical engineer if unexpected ground conditions are encountered.

4.4 Foundations

During our site visit, it was observed that the existing building was supported on competent sandstone bedrock and appeared to be in good condition with no indication of significant cracking or deterioration on external walls.

In terms of foundation support to the proposed structure(s), we recommend all footings are supported on competent sandstone bedrock and where required, guideline for ***good hillside construction practice*** found in **Appendix D** must be implemented.

Based on the outcome of this field investigation, areas assessed for strength and consistency of the in-situ material, the bearing capacity available at the proposed development site is no more than **1000kPa** for the weathered sandstone bedrock.

An experienced geotechnical engineer should confirm the foundation conditions prior to placement of any concrete and during construction for quality and design verification purposes.

It should be noted that, there may be sandstone boulders present on across the site, and as such, these will require selective removal from the footing locations prior to commencement of footing excavations. Alternatively, the footings may be moved to an easier excavation location under the guidance of the project structural engineer.

5. Landslip Risk Assessment

As mentioned previously, the subject site is located within an area with potential slope failure hazards and found on the Warringah Landslip Risk Map. The site is located within an area identified as Area 2 and the topography of the Area 2 generally comprises flanking slopes between 5° to 25°. The **Figure 2** below is a map excerpt of the Warringah Landslip Risk Map and shows the site is located within Area 2 highlighted in orange.

Figure 2 Warringah Landslip Risk Map

A preliminary landslip risk assessment was carried out in accordance with the checklist provided in the **Section E10 Landslip Risk** of the *Warringah Development Control Plan 2011*. The checklist is completed in reference to the information provided by the client (architectural drawings and survey plans) and our field investigation records including topographic, surface drainage and geological conditions, and environmental conditions in the vicinity of the site.

Based on the review of information collected and on Council's flow chart check list – does the present site or proposed development contain:

- History of Landslip No
- Proposed Excavation/Fill >2.0m No
- Site Developed Yes
- Existing Fill >1.0m No
- Cuts / Excavation >2.0m No

It is considered that a detailed geotechnical report with Landslip Risk Assessment is **not required** for the proposed development works.

Furthermore, key indicators of slope instability were not evident across the site during the fieldwork (e.g. rock falls / topples, block slides on weak layers, wedge failures along bedrock discontinuities, mass soil / rock movement etc.). The trunks of the mature trees and power poles in the vicinity of the proposed development site are generally upright and straight, indicating a relatively well drained stable slope conditions.

6. Limitations

This report has been prepared by Greywacke Geotechnics (Greywacke) for Clare & Kim Manns (Client) and may only be used and relied on by the Client for the purpose agreed between Greywacke and the Client as set out in Section 1.2 of this report.

Greywacke otherwise disclaims responsibility to any person other than the Client arising in connection with this report. Greywacke also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by Greywacke in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. Greywacke has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

Greywacke has prepared this report based on information provided by the Client and others who provided information to Greywacke, which Greywacke has not independently verified or checked beyond the agreed scope of work. Greywacke does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by site conditions, such as the location and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions may change after the date of this report. Greywacke does not accept responsibility arising from, or in connection with, any change to the site conditions. Greywacke is also not responsible for updating this report if the site conditions change.

This report should be read in conjunction with the Standard Sheets (contained in Appendix A).

For and On Behalf of
Greywacke Geotechnics

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Geotechnical Engineer

Reviewed by:

Kadir Oncu
Senior Geotechnical Engineer

7. References

1. Geological Survey of NSW, Department of Minerals and Energy, *Sydney 1:100,000 scale Geological Series Sheet,* Sheet 9130 Edition 1, 1983;
2. Standards Australia, *AS 1726-2017 'Geotechnical site investigations', 2017*
3. Australian Geomechanics Society, "The Australian GeoGuides for Slope Management and Maintenance", Volume 42 No.1, March 2007
4. P.J.N. Pells, G. Mostyn and B.F. Walker, *Foundations on Sandstone and Shale in the Sydney Region,* Australian Geomechanics, December 1998, pp 17-29;

APPENDICES

Appendix A – Standard Sheets

GEOTECHNICAL TERMS AND SYMBOLS

The following information is intended to assist in the interpretation of terms and symbols used in geotechnical borehole logs, test pit logs and reports issued by Greywacke Geotechnical Consultants. More detailed information relating to specific test methods is available in the relevant Australian Standards AS1726-2017.

Soil Descriptions and Classification

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726:2017 'Geotechnical Site Investigations'. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Soil types are described according to the predominating particle size and behaviour as set out below:

Particle size definitions (Refer to AS1726-2017, Table 1)

Fraction	Components	Subdivision	Size[1] (mm)
Oversize	Boulders (Bo)		> 200
	Cobbles (Co)		63 - 200
Coarse grained soils	Gravel (Gr)	Coarse (cGr)	19 - 63
		Medium (mGr)	6.7 - 19
		Fine (fGr)	2.36 - 6.7
	Sand (Sa)	Coarse (cSa)	0.6 - 2.36
		Medium (mSa)	0.21 - 0.6
		Fine (fSa)	0.075 - 0.21
Fine grained soils	Silt (Si)		0.002 - 0.075
	Clay (Cly)		< 0.002

Note: 1. Corresponding (approximately) to standard sieve sizes

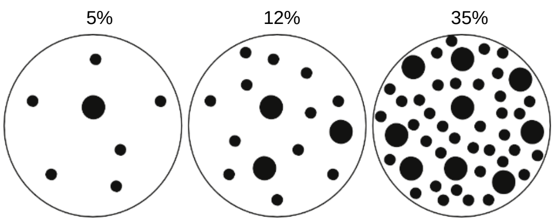
Descriptive terms for accessory (secondary and minor) soil components (Refer to AS 1726:2017, Table 2)

Designation of components	In coarse grained soils				In fine grained soils	
	% Fines	Terminology	% Accessory coarse fraction	Terminology	% Sand/ gravel	Terminology
Minor	≤ 5	Add 'trace clay/silt' to description, as applicable	≤ 15	Add 'trace sand/gravel' to description, as applicable	≤ 15	Use 'trace'
	> 5, ≤ 12	Add 'with clay/silt' to description, as applicable	> 15, ≤ 30	Add 'with sand/gravel' to description, as applicable	> 15, ≤ 30	Add 'with sand/gravel' to description, as applicable
Secondary	> 12	Prefix soil name as 'silty' or 'clayey', as applicable	> 30	Prefix soil name as 'sandy' or 'gravelly', as applicable	> 30	Prefix soil name with 'sandy' or 'gravelly', as applicable

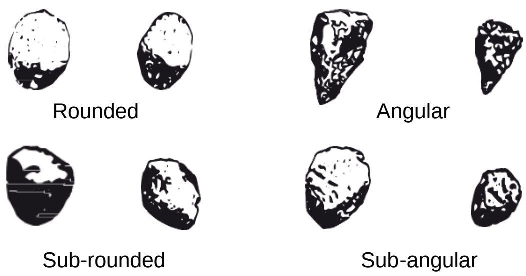
Descriptive Terms for Plasticity (Refer to AS 1726:2017, Table 6)

Descriptive term	Range of liquid limit for silt	Range of liquid limit for clay
Non-plastic	Not applicable	Not applicable
Low plasticity	≤ 50	≤ 35
Medium plasticity	Not applicable	> 35 and ≤ 50
High plasticity	> 50	> 50

Percentages of grains (after AS 1726:2017, Figure 3)



Particle shapes (Refer to AS 1726:2017, Figure 4)



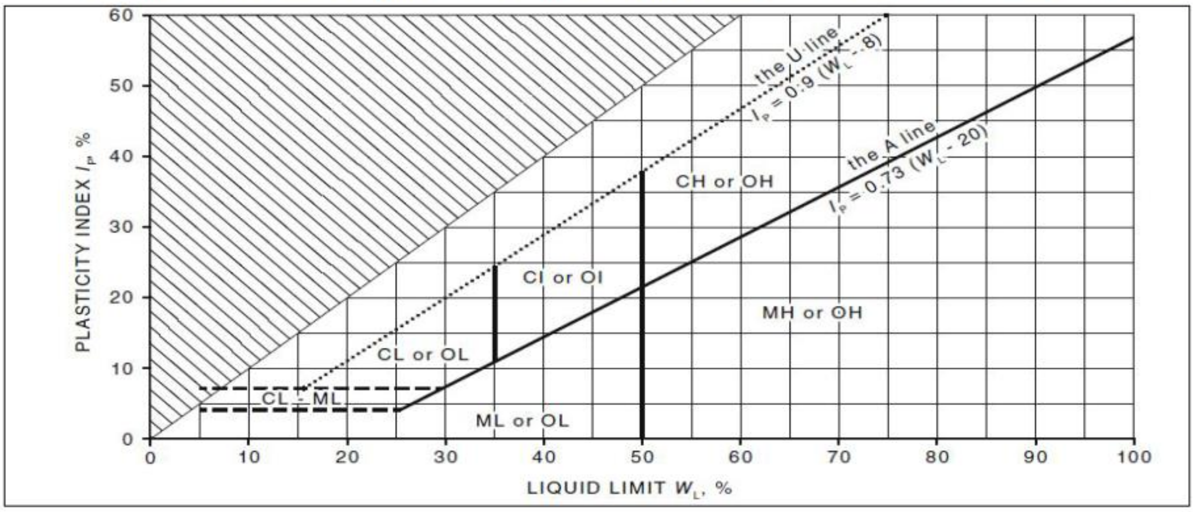
Classification of coarse grained soils (Refer to AS 1726:2017, Table 9)

Major divisions		Group symbol	Typical names	Field classification of sand and gravel	Laboratory classification	
Coarse grained soil (more than 65% of soil excluding oversize fraction is greater than 0.075mm)	GRAVEL > 50% of coarse fraction is larger than 2.36mm	GW	Gravel and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 4$ $1 < C_c < 3$
		GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		GM	Gravel-silt mixtures and gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	Fines behave as silt
		GC	Gravel-clay mixtures and gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	Fines behave as clay
	SAND > 50% of coarse fraction is smaller than 2.36mm	SW	Sand and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 6$ $1 < C_c < 3$
		SP	Sand and gravel-sand mixtures, little or no fines	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		SM	Sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	NA
		SC	Sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12%, fines are clayey	

Notes:

1. Where the grading is determined from laboratory tests, it is defined by coefficients of curvature Cc and uniformity Cu derived from the particle size distribution curve, as specified in AS1726:2017, Clause 6.1.4.11
2. For fines contents between 5% and 12%, the soil shall be given a dual classification comprising the two group symbols separated by a dash, e.g. for a gravel with between 5% and 12% silt fines, the classification is GP-GM
3. Soils that are dominated by boulders, cobbles or peat (Pt) are described separately and are not classified

Modified Casagrande chart for classifying silts and clays according to their behaviour (Refer to AS 1726:2017, Figure 5)



Note: The U line is an approximate upper bound for most natural soils. Data which plot above the U line may represent unusual / problem soil behaviour, or unreliable data and should be considered carefully.

Classification of fine grained soils (Refer to AS 1726:2017, Table 10)

Major divisions		Group symbol	Typical names	Field classification of silt and clay: Dry strength	Dilatancy	Toughness	Laboratory classification: % < 0.075mm
Fine grained soil (more than 35% of soil excluding oversize fraction is less than 0.075mm)	SILT and CLAY (low to medium plasticity)	ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity	None to low	Slow to rapid	Low	Below A line
		CL,CI	Inorganic clay of low plasticity to medium plasticity, gravelly clay and sandy clay	Medium to high	None to slow	Medium	Above A line
		OL	Organic silt	Low to medium	Slow	Low	Below A line
	SILT and CLAY (high plasticity)	MH	Inorganic silt	Low to medium	None to slow	Low to medium	Below A line
		CH	Inorganic clay of high plasticity	High to very high	None	High	Above A line
		OH	Organic clay of medium to high plasticity, organic silt	Medium to high	None to very slow	Low to medium	Below A line
	Highly organic soil	Pt	Peat, highly organic soil	–	–	–	–

Terms for coarse grained particle sizes (Refer to AS1726:2017, Claus 6.1.4.11)

Term	Description
Well Graded	Having good representation of all particle sizes from the largest to the smallest.
Poorly Graded	One or more intermediate sizes poorly represented
Gap Graded	With one or more intermediate sizes absent
Uniformly Graded	Essentially of one size

Soil and rock colour terms and abbreviations (Refer to AS 1726:2017, Clauses 6.1.5, 6.2.3.3)

Term	Abbreviation	Modifier	Abbreviation
Black	bk	Pale	pl
White	wh		
Grey	gy		
Red	rd	Dard	dk
Brown	br		
Orange	or		
Yellow	yl	Mottled	mtld
Purple	pu		
Green	gr		
Blue	bl		

Moisture condition of soil (Refer to AS 1726:2017, Claus 6.1.7)

Course Grained Soil	
Term	**Field appearance and feel**
Dry	Non-cohesive and free running
Moist	Feels cool, darkened in colour - tends to stick together
Wet	Feels cool, darkened in colour - tends to stick together, free water forms when handling
Fine Grained Soil	
Description	**Relative to the plastic limit (or liquid limit for soils with higher moisture contents)**
Moist, dry of plastic limit	Hard and friable and powdery (or ‘w < PL’)
Moist, near plastic limit	Soils can be moulded at a moisture content approximately equal to the plastic limit (or ‘w ≈ PL’)
Moist, wet of plastic limit	Soils usually weakened and free water forms on hands when handling (or ‘w > PL’)
Wet, near liquid limit	(or ‘w ≈ LL’)
Wet, wet of liquid limit	(or ‘w > LL’)

Cementation of soils (Refer to AS 1726:2017, Claus 6.1.7)

Term	Definition
Weakly cemented	Easily disaggregated by hand in air or water
Moderately cemented	Effort is required to disaggregate by hand in air or water

Consistency terms for cohesive soils (Refer to AS 1726:2017, Table 11)

Consistency[1]	Field guide to consistency	Indicative undrained shear strength s_u (kPa)[2]	Approximate range of SPT *N* values
Very Soft (VS)	Exudes between the fingers when squeezed in hand	≤ 12	0 - 2
Soft (S)	Can be moulded by light finger pressure	> 12 and ≤ 25	2 - 4
Firm (F)	Can be moulded by strong finger pressure	> 25 and ≤ 50	4 - 8
Stiff (St)	Cannot be moulded by fingers	> 50 and ≤ 100	8 - 15
Very Stiff (VSt)	Can be indented thumb nail	> 100 and ≤ 200	15 - 30
Hard (H)	Can be indented with difficulty by thumb nail	> 200	> 30
Friable (Fr)	Can be easily crumbed or broken into small pieces by hand	-	-

Notes:
1. Consistency is affected by the moisture content of the soil at the time of measurement
2. Often su = qu / 2 (where qu is the unconfined compressive strength, Foundation Analysis and Design, 5th ed., J.E. Bowles, 1997)

Relative density of non-cohesive soils (Refer to AS1726:2017, Table 12)

Term	Density Index %	Approximate range of SPT *N* values
Very Loose (VL)	≤ 15	0 - 4
Loose (L)	> 15 and ≤ 35	4 - 10
Medium Dense (MD)	> 35 and ≤ 65	10 - 30
Dense (D)	> 65 and ≤ 85	30 - 50
Very Dense (VD)	> 85	> 50

Note: The moisture content may influence the inferred relative density

Soil Origin

Geological and anthropogenic origins of soils (Refer to AS 1726:2017, Claus 6.1.9)

Description	Definition
FILL	Any material which has been placed by anthropogenic processes. 'FILL' should be emphasised on logs by the use of BLOCK LETTERS
TOPSOIL	Mantle of surface and/or near surface soil often defined by high levels of organic matter. 'TOPSOIL' should be emphasised on logs by the use of BLOCK LETTERS
Extremely weathered material	Formed directly from *in situ* weathering of geological formations. Although of soil strength it retains the structure and/or fabric of the parent rock material
Residual soil	Formed directly from *in situ* weathering of geological formations. No longer retaining any visual structure or fabric of the parent soil or rock material
Alluvial soil	Deposited by streams and rivers
Estuarine soil	Deposited in coastal estuaries, and including sediments carried by inflowing rivers and streams, and tidal currents
Marine soil	Deposited in a marine environment
Lacustrine soil	Deposited in freshwater lakes
Aeolian soil	Carried and deposited by wind
Colluvial soil	Soil and rock debris transported down slopes by gravity, with or without the assistance of flowing water and generally deposited in gullies or at the base of slopes. Formed from landslides.
Slopewash	Thinner and more widespread colluvial deposits that accumulate gradually over longer geological timeframes than colluvial soils from landslides

Note: Soils should be assigned to a stratigraphic unit. Where there is doubt, the terms 'possibly' or 'probably shall be used

Definitions of FILL types (Refer to AS1726:2017, Claus 6.1.11 and Appendix D)

FILL type	Definition
Controlled	Fill placed in accordance with AS 3798 or other controlled method, as demonstrated by construction documentation
Uncontrolled FILL	Fill for which no construction documentation is available

Typical characteristics and descriptive terms for FILL materials (Refer to AS 1726:2017, Table 14, and Claus 6.1.11)

Some typical characteristics of FILL
Uncontrolled / non-engineered fill may settle variably, have poor bearing capacity
Very distinct changes in soil profile, unusually variable range of colours
Presence of foreign objects such as glass, plastic, slag
Buried organic matter
'Cloddiness' of clay soil indicating previous disturbance by excavation

Generalised terms	Typical descriptions
Organic matter	Fibrous peat
	Charcoal
	Wood fragments
	Roots (greater than 2mm diameter)
	Root fibres (less than 2mm diameter)
	Night soil, putrescible waste
Artificial materials	Oil, bitumen
	Masonry, concrete rubble, fibrous plaster, plasterboard, asbestos, fibre cement
	Timber pieces, wood shavings, sawdust, leather
	Iron filings, drums, steel bars, steel scrap
	Slag, chitter, ash, tailings
	Rubber tyres, bottles, broken glass

ROCK DESCRIPTION

Refer to AS 1726-2017 for the description and classification of rock material composition, including:

(a) Rock type
(b) Grain size
(c) Texture and fabric
(d) Colour (describe as per soil).

The condition of a rock material refers to its weathering characteristics, strength characteristics and rock mass properties. Refer to AS 1726-2017.

Classification of material weathering (Refer to AS1726:2017, Table 20)

Term	Abbreviation	Definition
Residual Soil[1]	RS	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely Weathered[1]	XW	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.
Highly Weathered	HW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately Weathered	MW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable, but shows little or no change of strength from fresh rock.
Slightly Weathered	SW	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh	FR	Rock shows no sign of decomposition of individual minerals or colour changes.

Notes:
1. The term 'Extremely Weathered rock' is misleading as the material has soil properties. The word 'rock' should be replaced with the name of the original rock in lower case or the word 'material', e.g. Extremely Weathered granite or Extremely Weathered material. Residual soil and Extremely Weathered material should be described using soil descriptive terms
2. A 'specific rockmass unit (RMU)' may be defined as a significant zone (generally of > 1m length downhole in a borehole) dominated by one rock type with one dominant weathering grade, for example 'GRANITE (MW)'. RMU's may locally contain lesser zones of other materials or weathering grades, including seams, veins, dykes etc.

Rock material strength classification (Refer to AS1726:2017, Table 19)

Term	Abbreviation	Uniaxial compressive strength[2] (UCS) MPa	Guide to strength[1]	
			Point load strength index[2] ($I_{s(50)}$) MPa	Field assessment
Very Low Strength	VL	0.6 to 2	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a Triaxial sample by hand. Pieces up to 30 mm thick can be broken by finger pressure.
Low Strength	L	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable.
Medium Strength	M	6 to 20	0.3 to 1	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty
High Strength	H	20 to 60	1 to 3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High Strength	VH	60 to 200	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High Strength	EH	> 200	> 10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer

Notes:
1. Material with strength less than 'Very Low' shall be described using soil characteristics. The presence of an original rock structure, fabric or texture should be noted if relevant
2. The method for measuring the uniaxial compressive strength and shall be in accordance with AS4133.4.2.1
3. The method for measuring the point load strength index shall be in accordance with AS4133.4.1
4. Any correlation between UCS and $I_{s(50)}$ implied in the above Table shall not be relied upon for design purposes without supporting evidence

ROCK DEFECTS

Rock defect angle of incidence[1] (un-orientated drill core)

Angle of incidence (group range)[2]	Descriptor
0° - 15°	sub horizontal
15° - 30°	gentle
30° - 45°	moderate
45° - 60°	steep
60° - 75°	very steep
75° - 90°	sub vertical

Note:
1. Angle measured between defect and the normal to the core-axis (the horizontal plane for vertical boreholes).
2. For a specific rockmass unit (RMU), defects may be grouped according to the above ranges (or to more narrow ranges where appropriate).

Detailed rock defect spacing description (Refer to ISO14689:2017(E) and BS5930:1999

Defect Spacing Descriptors[1]			Rock Fabric Thickness Descriptors[2] (Stratification)	
Spacing/Width (mm)	Descriptor	Symbol	Descriptor	Spacing/Width (mm)
			Thinly Laminated	< 6
<20	Extremely Close	EC	Thickly Laminated	6 – 20
20 – 60	Very Close	VC	Very Thinly Bedded	20 – 60
60 – 200	Close	C	Thinly Bedded	60 – 200
200 – 600	Medium	M	Medium Bedded	200 – 600
600 – 2000	Wide	W	Thickly Bedded	600 – 2000
2000 – 6000	Very Wide	VW	Very Thickly Bedded	> 2000

Notes:
1. Rock defects are termed as 'discontinuities' in ISO14689:2017(E) and BS5930:1999. A distinction is drawn in BS5930:1999 between 'mechanical discontinuities', which are already open and present in the rock, and 'integral discontinuities', which are built-in potential planes of weakness. Rock fabrics are essentially integral discontinuities, either distinct or indistinct depending on the extent of their effect on intact rock strength
2. The terms 'laminated' and 'bedded' are rock fabric descriptors applicable to sedimentary rock. For igneous and metamorphic rock fabrics, use the above listed defect spacing descriptors
3. The above listed defect spacing descriptors should be used to define the frequency of defects, i.e. the spacing between successive defects, (or the mean defect spacing for zones of relatively broken rock); Alternatively, defect frequency should be measured by the 'Fracture Index', which is the number of defects per metre of core (AS1726:2017, Claus 6.2.9.3)

Rock defect surface description (Refer to AS1726:2017, Claus 6.2.5.4)

Surface Roughness	Abbreviation	Definition	Surface Shape[1]	Abbreviation	Definition
Very rough	VRo	Many large surface irregularities (amplitude generally more than 1 mm). Feels like, or coarser than very coarse sand paper.	Planar	Pln	The defect does not vary in orientation
Rough	Ro	Many small surface irregularities (amplitude generally less than 1 mm). Feels like fine to coarse sand paper.	Curved	Cvd	The defect has a gradual change in orientation
Smooth	Sm	Smooth to touch. Few or no surface irregularities.	Undulating	Und	The defect has a wavy surface
Polished	Po	Shiny smooth surface.	Stepped	Stp	The defect has one or more well defined steps
Slickensided	Sl	Grooved or striated surface, usually polished.	Irregular	Irr	The defect has many sharp changes of orientation

Notes:
1. Although the surface roughness of defects can be described at all scales of observation, the overall shape of the defect surface can usually be observed only at medium and large scale. For example, a defect which appears planar in a 50 mm diameter drill core may be described as curved, undulating or stepped when observed in outcrop where more of the defect is visible.
2. At the medium scale of observation (100mm to 1m), description of the roughness of the surface shall be enhanced by description of the shape of the defect surface using the terms in the above Table, and as illustrated in AS1726:2017, Figure 7
3. For medium scale (100mm to 1m) and large scale (1m to 10m) exposures, defect wavelength and amplitude of asperities should be measured appropriately in (mm) or (m) as per AS1726:2017, Figure 8. Surface roughness may be alternatively characterised by the joint roughness coefficient (JRC), using the profiles provided in AS1726:2017, Figure 9
4. For large scale exposures, measurements of defect waviness for may be made as per AS1726:2017, Figure 10

Rock defect aperture and infill descriptors (Refer to AS1726:2017 Claus 6.2.5.2 and Claus 6.2.5.5)

Defect Aperture			Defect Infill		
Term	Abbreviation	Definition	Term	Abbreviation	Definition
Open[1]	OP	Defects with visible aperture, with or without infill	Clean	Cn	No visible coating
Filled	FL	Open defects with infill of less than 1mm thickness	Stained	Stn	No visible coating, but surfaces are discoloured
Tight	TI	Defects with no appreciable aperture or measurable asperity	Veneer	Vr	A visible coating of soil or mineral, too thin to measure; may be patchy
Healed[2]	HD	Tight defects that have been re-cemented by minerals such as calcite and chlorite	Coating[3]	Ct	A visible, measureable coating of up to 1mm thickness

Notes:
1. Aperture of open defects shall be measured in millimetres
2. Healed defects generally possess some tensile strength across the defect surface, but the re-cemented strength is less than that of the rockmass
3. Where possible the mineralogy of the infill shall be identified. Soil material thicker than 1mm shall be described using defect terms (for example, infilled seam). Rock material thicker than 1mm shall be described as veins

Groundwater symbols

Symbol	Definition
31/01/2020 	Standing groundwater level on the date shown
	Water inflow
	Water outflow

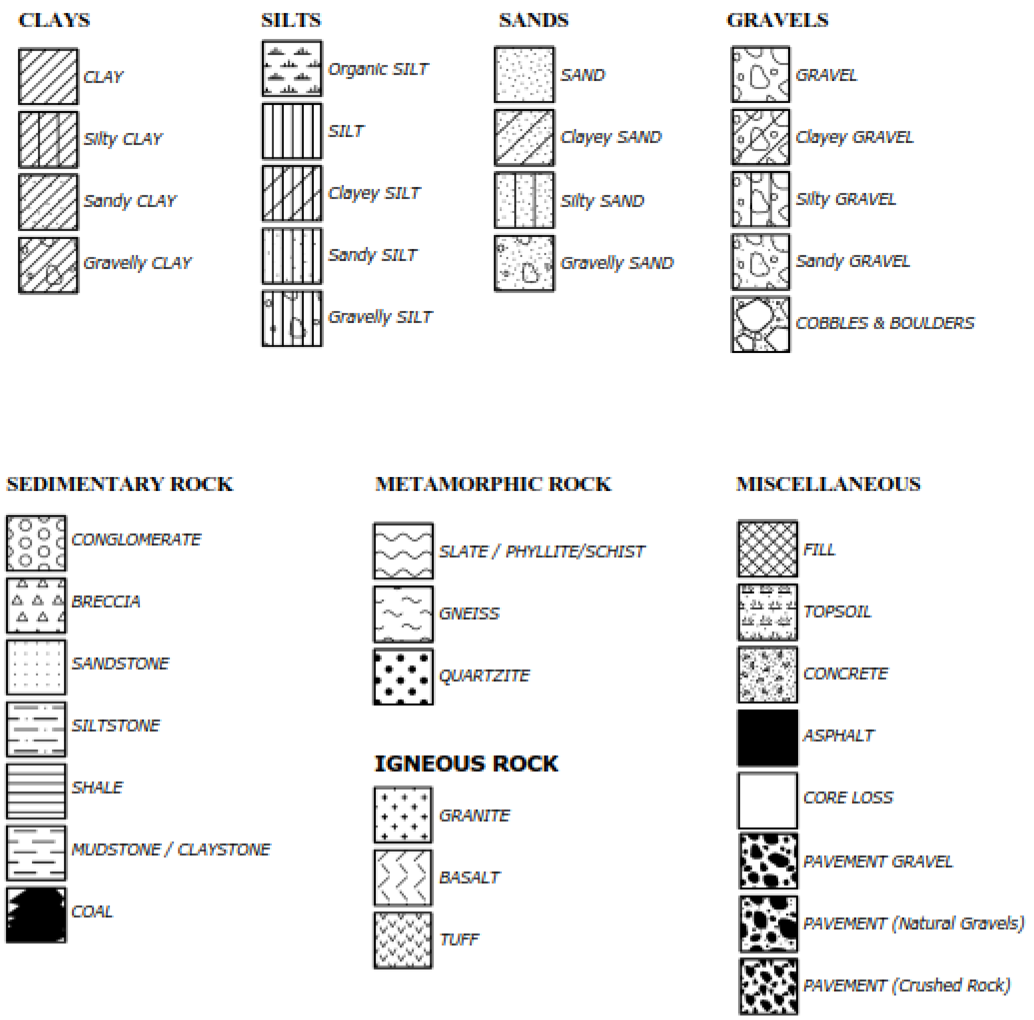
GEOLOGICAL MAPPING

Geological mapping symbols (Refer to AS1726:2017, Figure E1)

Mapping symbols for geological boundaries and structures			
———————————	Observed geological boundary, position known		
— — — — — — — — — — — — — —	Observed geological boundary, position approximate		
–?–?–?–?–?–?–?–?–?–?–?–	Geological boundary, interpreted or inferred		
~~	Fault zone or shear zone		
–U–U–U–U–U–U–U–U–U–U–U–U–U–U–U–U–	Unconformity		
25 Bedding	25 Cleavage	25 Plunge of fold[1]	Anticline, F1
25 Foliation	25 Joint	25 Plunge of lineation on plane	Syncline, F2

Notes: Order and type of fold indicated with appropriate symbol

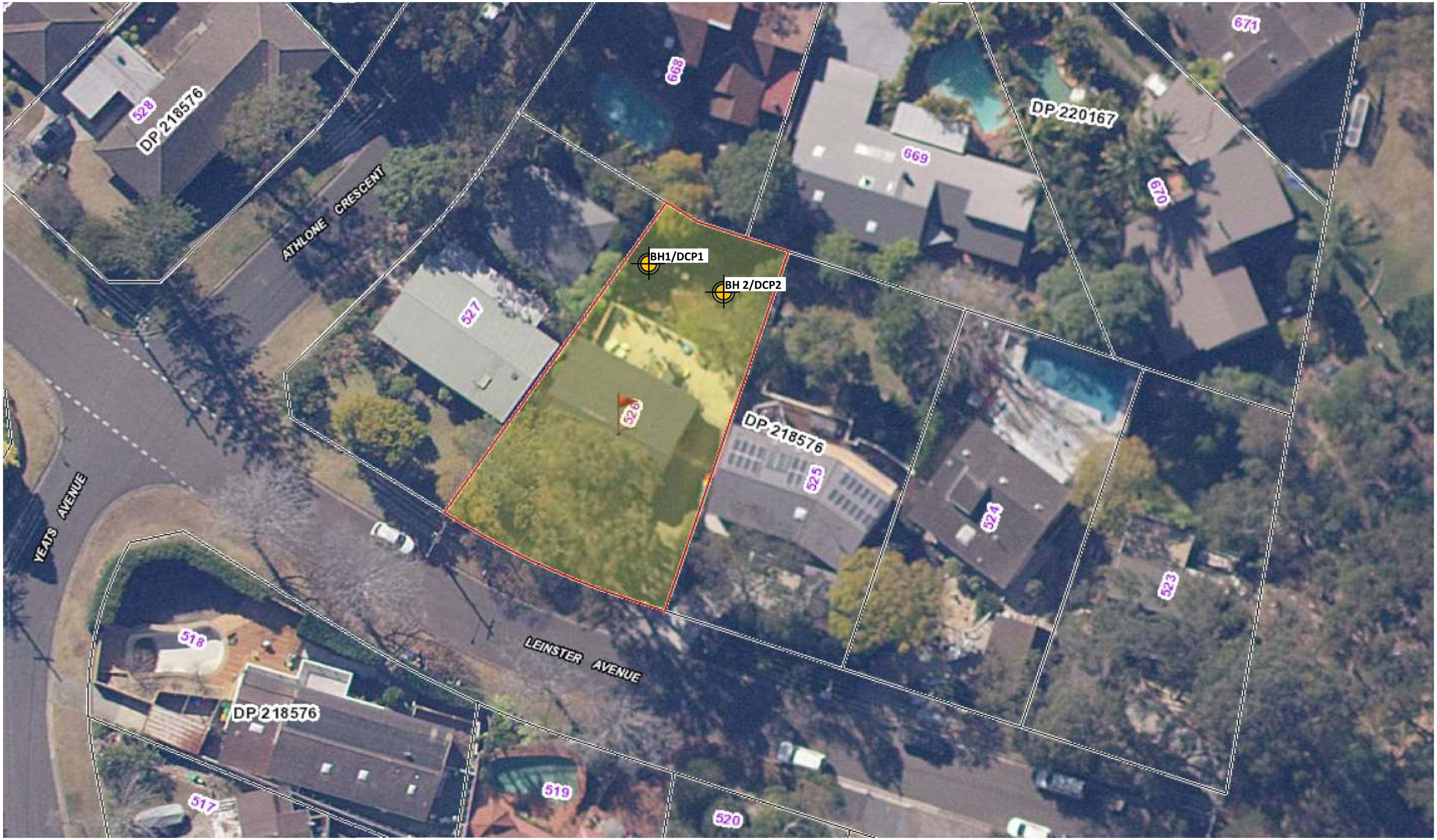
GRAPHICAL SYMBOLS



Frequently used symbols in geotechnical engineering

Symbol	Definition	Symbol	Definition
AASS	Actual acid sulfate soil	PASS	Potential acid sulfate soil
BH	Bore hole	PI or $I_{P'}$	Plasticity index
BS	Bulk distrusted sample	PL or w_p	Plastic Limit
c	Cohesion of a soil	PS	Piston sample
c'	Effective cohesion	PP	Pocket Penetrometer Test
c_v	Coefficient of consolidation	PQ	85mm diameter drill core (double tube wireline)
C_c	Coefficient of curvature	PQ3	83.1mm diameter drill core (triple tube wireline)
C_u	Coefficient of uniformity	q	Overburden pressure
CPT	Cone Penetration Test	q'	Effective overburden pressure
CPTu	Cone Penetration Test with pore pressure measurement (piezocone)	q_c	Cone resistance
D_{10}	Grain sizes for which 10% of the soil grains are smaller	q_d	VEDCP (PANDA) cone resistance
D_{30}	Grain sizes for which 30% of the soil grains are smaller	q_u	Unconfined compressive strength
D_{60}	Grain sizes for which 60% of the soil grains are smaller	Q	Wet density
DS	Disturbed sample (small)	Q_d	Dry density
DCP	Dynamic Cone Penetrometer Test	rw	Full penetration over any 150mm interval is achieved by SPT rod weight only
DMT	Flat Plate Dilatometer Test	R_D	Dry density ratio
e	Void ratio	RMU	Significant zone dominated by one rock type with one dominant weathering grade
E	Young's modulus (ratio of axial stress to axial strain)	RQD (per CR)	Rock quality designation (ratio calculated per length of core run)
E_s	Modulus of elasticity	RQD (per RMU)	Rock quality designation (ratio calculated per length of specific rock mass unit)
ES	Environmental Sample	s_u	Shear strength of a soil, (often $s_u = q_u / 2$)
ECN	Emerson Class Number	S	Degree of saturation
f_s	Cone skin friction	SPT	Standard Penetration Test
F_R	Cone friction ratio	TP	Test pit
FVS	Field Vane Shear Test	TCR	Total core recovery (%)
GSL	Ground surface level	u	Pore water pressure
hb	No measurable penetration, or the SPT hammer is bouncing for five consecutive blow	u_c	Pore water pressure measured at the tip of a piezocone (CPT*u*)
hw	Full penetration over any 150mm interval is achieved by SPT hammer and rod weight only	UCS	Uniaxial compressive strength test
HQ	63.5mm diameter drill core(double tube wireline)	U50	Undisturbed 50mm diameter tube sample
HQ3	61.1mm diameter drill core(triple tube wireline)	U75	Undisturbed 75mm diameter tube sample
I_D	Density index (cohesionless soil)	U100	Undisturbed 100mm diameter tube sample
I_{s50}	Point load strength index	VC	Vibro core
$I_{s50\ (A)}$	Axial point load strength index	VEDCP	Variable Energy Cone Penetration Test (PANDA)
$I_{s50\ (D)}$	Diametral point load strength index	w	Moisture content of a soil
$I_{s50\ (L)}$	Irregular (lump) point load strength index	w_o	Optimum moisture content (OMC)
k	Coefficient of permeability	WS	Water sample
K	Ratio of lateral to vertical stress	WLS	Weighted linear shrinkage
K_a	Active earth pressure	WPI	Weighted plasticity index
K_p	Passive earth pressure	z	Depth of interest from ground surface level (GSL)
LL or $W_{L'}$	Liquid Limit %	**Greek symbol**	**Definition**
LS	Linear Shrinkage	γ	Unit weight of material
m_v	Coefficient of volume decrease	γ'	Effective unit weight of material
MDD	Maximum dry density	ε	Strain
n	Porosity	ν	Poisson's ratio
N	SPT Penetration Resistance, (blows per final 300mm penetration)	ρ	Density
N_p	DCP Penetration Resistance, (blows per 300mm penetration, depth recorded at centre of interval)	σ	Pressure or stress
NQ	47.6mm diameter drill core (double tube wireline)	σ'	Effective pressure or stress
NQ3	45.1mm diameter drill core (triple tube wireline)	τ	Shear stress
NMLC	51.9 mm diameter drill core (triple tube wireline)	φ	Angle of internal friction
OCR	Overconsolidation ratio	φ'	Effective angle of internal friction

Appendix B – Figures



GREYWACKE GEOTECHNICS

GEOTECHNICAL SITE INVESTIGATION - TEST LOCATION PLAN

N

Paper Size A3
Scale NTS

LEGEND
Site Location
DCP/PSP Test Locations
Borehole and DCP Test Locations

Client: Clare & Kim Manns
Project: Proposed Alterations & Additions
Location: 20 Leinster Avenue, Killarney Heights NSW

Job Number: CLKM0643
Revision: A
Drawn: N/A
Date: 24-Aug-21

Figure 3

NOTE: The aerial photo view of the site is sourced from third party providers and may not be current and should not be relied upon

A: Unit 11, 6 Hume Road, Smithfield NSW 2164 T: 61 2 8798 8796 E admin@greywacke.com.au W www.greywacke.com.au

Appendix C – Borehole Logs and DCP Test Certificates

BOREHOLE LOG SHEET

Client : Clare & Kim Manns		**HOLE No. BH1**	
Project : Proposed Alteration & Additions			
Location : 20 Leinster Avenue, Killarney Heights NSW 2087		**SHEET 1 OF 1**	
Position : Refer to test location plan	**Surface RL:**	**Angle from Horiz. :** 90°	**Processed :** CB
Rig Type :	**Mounting:** Mechanical hand auger	**Driller :** KO/CB	**Checked :** KO
Date Started : 19/08/2021	**Date Completed :** 19/08/2021	**Logged by :** KO/CB	**Date:** 26/08/2021

Note: * indicates signatures on original issue of log or last revision of log

DRILLING					MATERIAL						
SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	**Description** SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index	**Comments/ Observations**
	Mechanical Hand Auger	Nil	None Encountered		0.10		SM	TOPSOIL - Silty SAND; dark brown-grey, fine to medium grained sand, with organic matter (root fibres)	D-M		
					0.90		SP	FILL - SAND; brown-grey, fine grained sand, with clay, with fine to medium ironstone gravel, traces of organic matter (root fibres)	D-M	L-MD	
1					1.10			Extremely Weathered sandstone, pale grey-pale brown, extremely low strength, with clay seams (Residual soil).			
								End of borehole at 1.1 metres. Refusal on Sandstone bedrock.			

See standard sheets for details of abbreviations & basis of descriptions

GREYWACKE GEOTECHNICS

DYNAMIC CONE PENETROMETER LOG SHEET

AS 1289.6.3.2-1997 (Cone Tip) — **510** mm drop height.

Client: Clare & Kim Manns

Project: Proposed Alterations & Additions

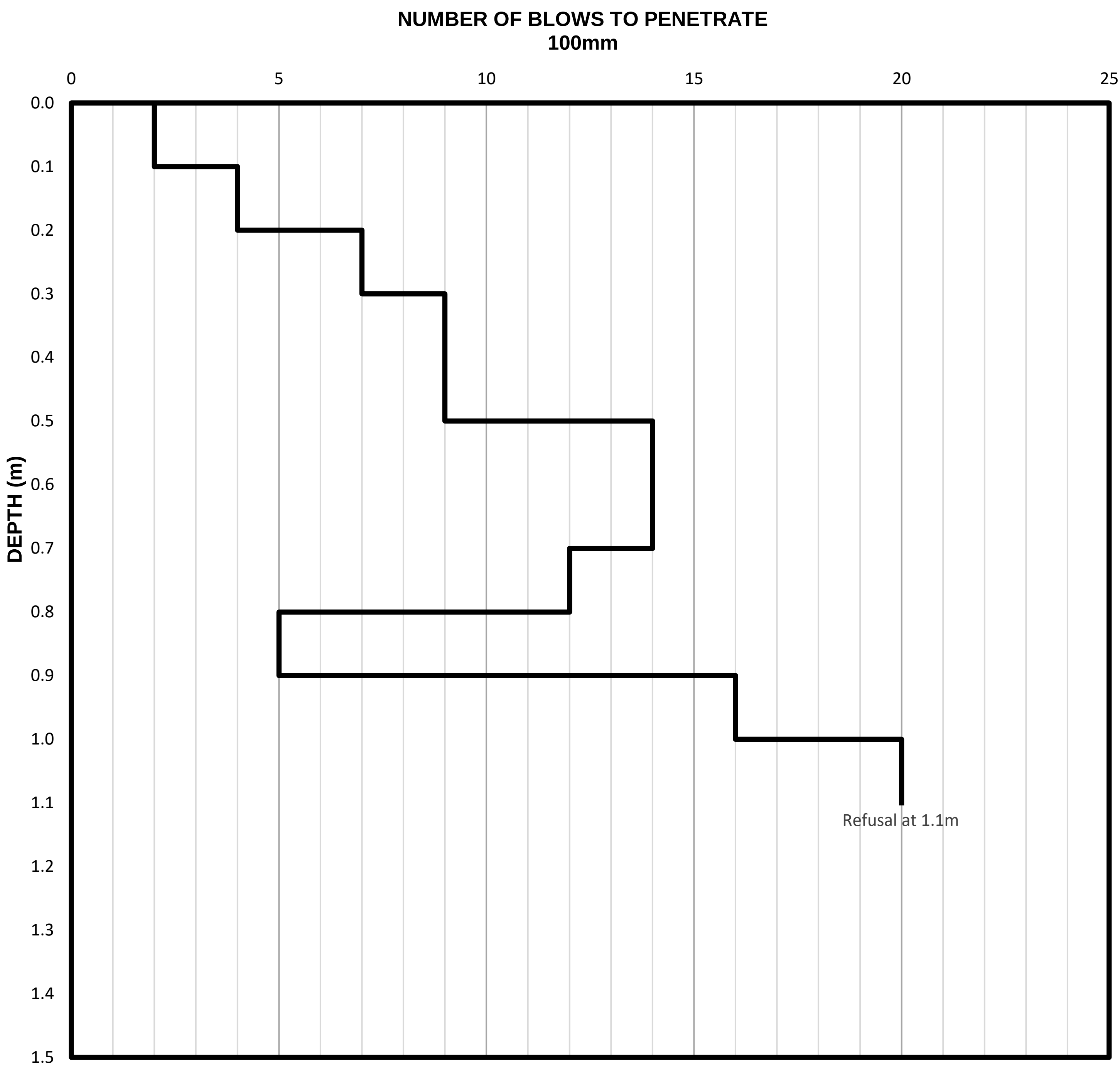
Location: 20 Leinster Avenue, Killarney Heights NSW 2087

Test No. | Adjacent BH/TP: **DCP 1 | BH 1**

Job No.: **CLKM0643 - GEO AA**

Date: 19/08/2021

Elevation: - **Chainage:** - **Site Engineer (s):** KO/CB



Notes:

BOREHOLE LOG SHEET

Client : Clare & Kim Manns			**HOLE No. BH2**
Project : Proposed Alteration & Additions			
Location : 20 Leinster Avenue, Killarney Heights NSW 2087			**SHEET 1 OF 1**
Position : Refer to test location plan	**Surface RL:**	**Angle from Horiz. :** 90°	**Processed :** CB
Rig Type :	**Mounting:** Mechanical hand auger	**Driller :** KO/CB	**Checked :** KO
Date Started : 19/08/2021	**Date Completed :** 19/08/2021	**Logged by :** KO/CB	**Date:** 26/08/2021

Note: * indicates signatures on original issue of log or last revision of log

SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth / (RL) metres	Graphic Log	USC Symbol	Description: SOIL TYPE, colour, structure, minor components (origin), and ROCK TYPE, colour, grain size, structure, weathering, strength	Moisture Condition	Consistency / Density Index	Comments/ Observations
	Hand Auger	Nil	None Encountered				SM	TOPSOIL - Silty SAND; dark brown-grey, fine to medium grained sand, with organic matter (root fibres)	D-M		
					0.10		SC	Clayey SAND; brown, fine to medium grained sand, low plasticity, traces of fine to medium ironstone gravel (Residual soil)	D-M	L MD	Residual soil
					0.75			Extremely Weathered sandstone, pale grey-brown, extremely low strength, with clay seams (Residual soil)			
					0.90			End of borehole at 0.9 metres. Refusal on Sandstone bedrock.			
1											

See standard sheets for details of abbreviations & basis of descriptions

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CONSULTING GEOTECHNICAL ENGINEERS

Job No. **CLKM0643 - GEO AA**

GREYWACKE GEOTECHNICS

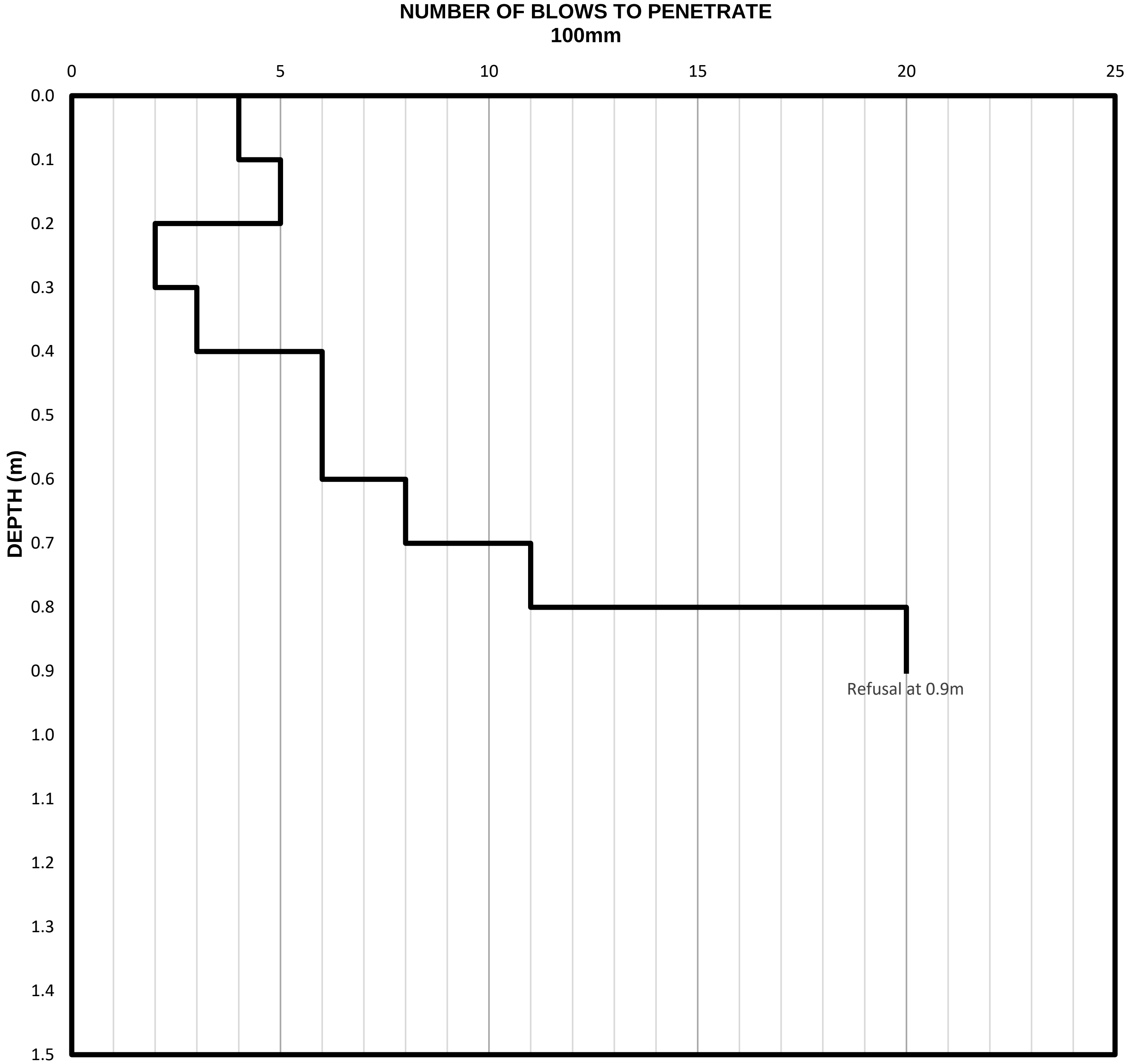
DYNAMIC CONE PENETROMETER LOG SHEET

AS 1289.6.3.2-1997 (Cone Tip) — **510** mm drop height.

Client: Clare & Kim Manns
Project: Proposed Alterations & Additions
Location: 20 Leinster Avenue, Killarney Heights NSW 2087

Test No. | Adjacent BH/TP: **DCP 2 | BH 2**
Job No.: **CLKM0643 - GEO AA**
Date: 19/08/2021
Site Engineer (s): KO/CB

Elevation: - **Chainage:** -



Notes:

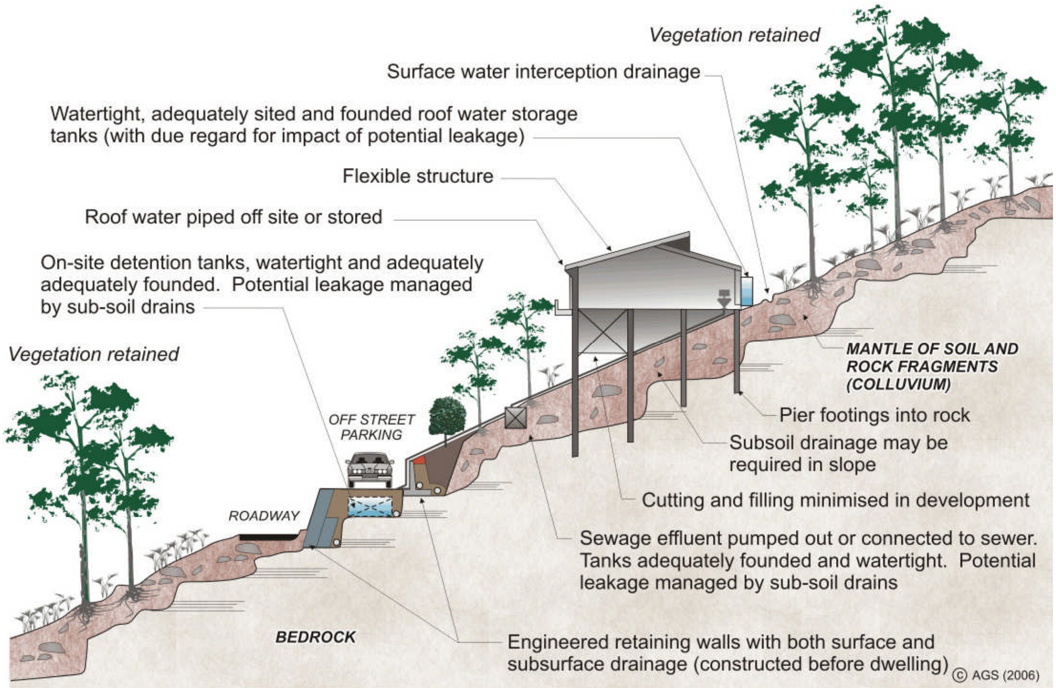
Appendix D – Extracts from the Australian Geomechanics Society Good Hillside Practice

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.

EXAMPLES FOR **GOOD** HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that due to level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfill the same purpose (GeoGuide LR5).

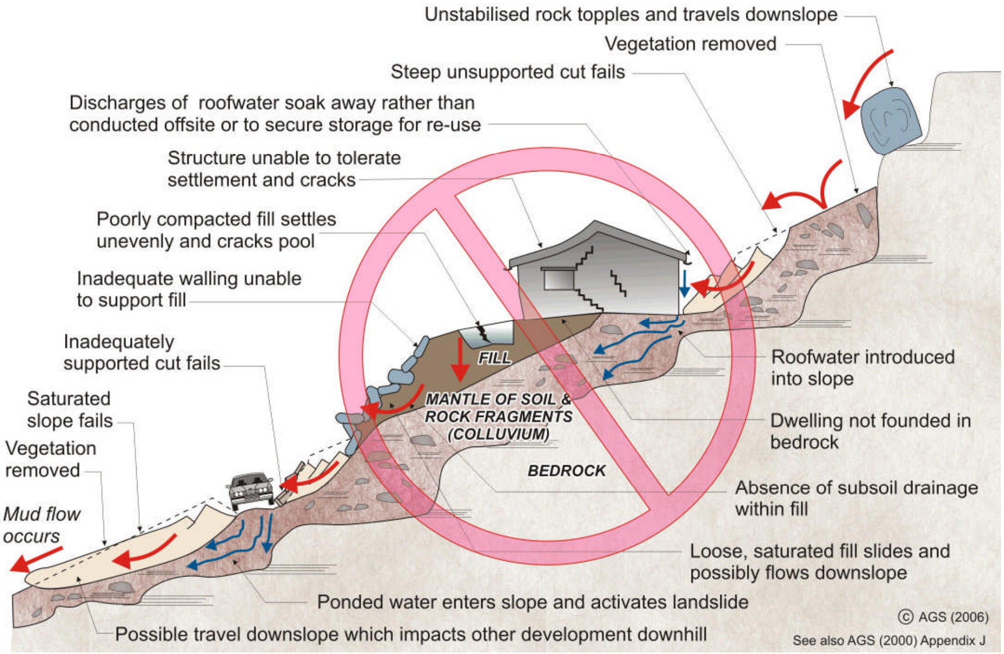
Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

EXAMPLES FOR **POOR** HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soaks into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herringbone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

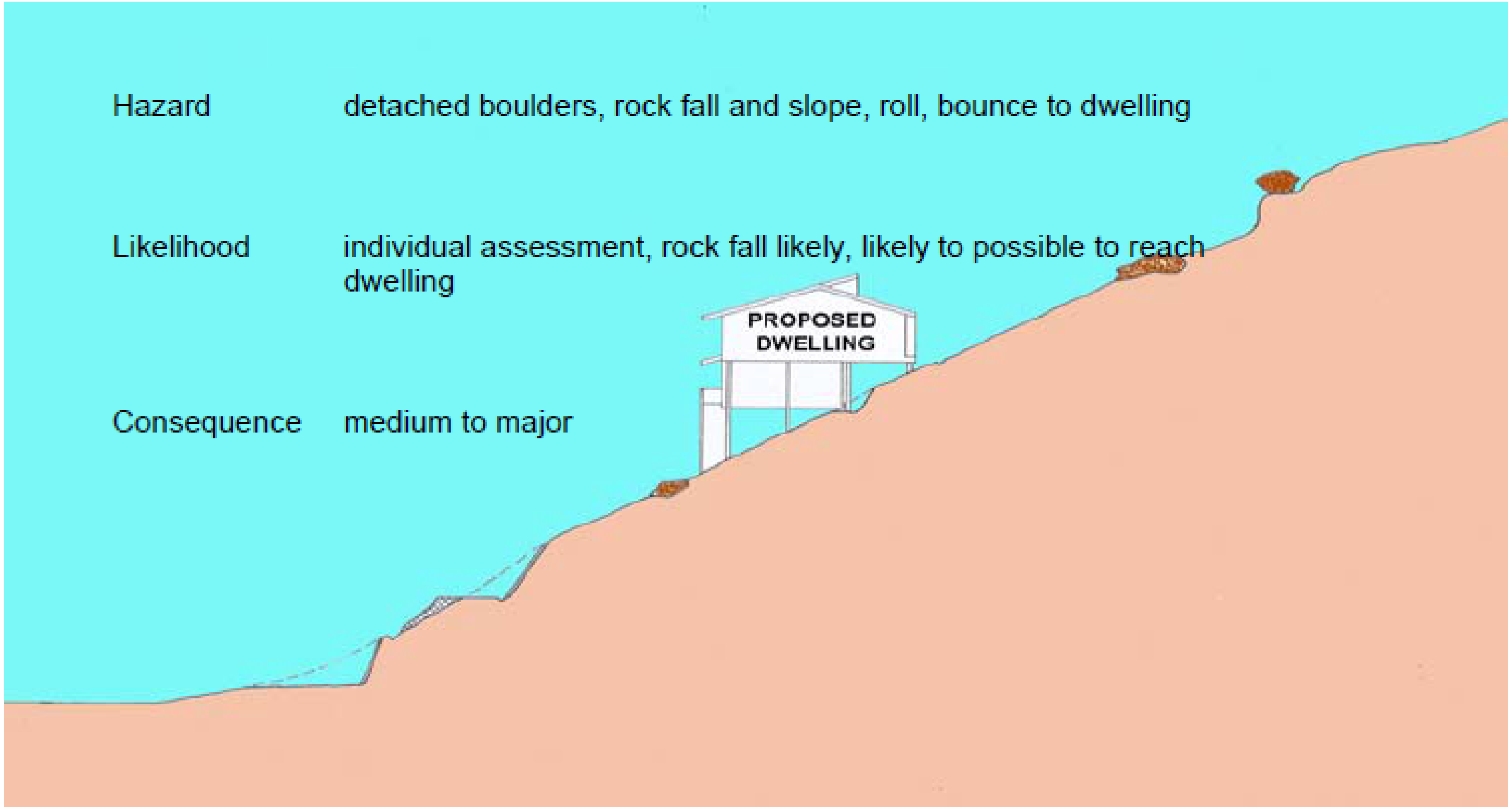
More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 Coastal Landslides
- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

Landslide Risk Assessment Process

Example - Qualitative landslide risk assessment for property (Source: Walker (2002))



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