Geotechnical Investigation Report

PRELIMINARY GEOTECHNICAL INVESTIGATION AND SLOPE RISK ASSESSMENT

RESIDENTIAL DEVELOPMENT

37-43 HAY STREET COLLAROY NSW

Prepared for:

COLLAROY LIVING PTY LTD

Reference: P2828_01 rev1

13 March 2024

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1 INTRODUCTION

Morrow Geotechnics Pty Ltd has undertaken a Preliminary Geotechnical Investigation to provide geotechnical advice and recommendations for the proposed development at 37-43 Hay Street Collaroy NSW (the site). This report has been prepared to address the requirements of Northern Beaches Council which state:

> (3) Before determining a development application for development on land to which this clause applies, the consent authority must consider the following matters to decide whether or not the development takes into account all geotechnical risks—
>
> (a) site layout, including access,
>
> (b) the development's design and construction methods,
>
> (c) the amount of cut and fill that will be required for the development,
>
> (d) waste water management, stormwater and drainage across the land,
>
> (e) the geotechnical constraints of the site,
>
> (f) any appropriate measures proposed to avoid, minimise or mitigate the impacts of the development.
>
> (4) Development consent must not be granted to development on land to which this clause applies unless—
>
> (a) the consent authority is satisfied that the development will appropriately manage waste water, stormwater and drainage across the land so as not to affect the rate, volume and quality of water leaving the land, and
>
> (b) the consent authority is satisfied that—
>
> (i) the development is designed, sited and will be managed to avoid any geotechnical risk or significant adverse impact on the development and the land surrounding the development, or
>
> (ii) if that risk or impact cannot be reasonably avoided—the development is designed, sited and will be managed to minimise that risk or impact, or
>
> (iii) if that risk or impact cannot be minimised—the development will be managed to mitigate that risk or impact.

Conceptual plans for the proposed development have been prepared by PopovBass Architects, dated 29 February 2024. From the drawings provided and discussions with the client, Morrow Geotechnics understands that the proposed development of the site involves the construction of townhouses/apartments over a single level basement. Basement excavation is expected to extend to approximately 6.0 m below ground level (mBGL).

1.1 Purpose of the Investigation

The purpose of the investigation is to provide geotechnical advice and recommendations addressing:

- Expected subsurface conditions;
- Excavation and shoring design parameters;
- Allowable bearing pressure for slab and foundation design;
- Site classification for slabs and foundation design;
- Geotechnical construction considerations;
- Site classification for earthquake design; and
- Slope Risk Assessment

1.2 Investigation Methods

Fieldwork was undertaken on 01 March 2023. Work carried out as part of this investigation includes:

- Review of publicly available information from previous reports in the project area, published geological and soil mapping and government agency websites;
- Site walkover inspection by an experienced geotechnical engineer to assess topographical features, condition of surrounding structures and site conditions;
- Drilling of four boreholes (BH1 to BH4) using hand augers to depths of 0.7, 2.5, 2.1, and 1.5 mBGL respectively;
- Dynamic Cone Penetrometer tests were undertaken adjacent to the boreholes and test pits. DCP test results were used to assess soil consistency/density;
- Groundwater observations within boreholes during drilling.

Investigation locations are shown on **Figure 1** and the borehole logs are presented in Appendix A.

2 DESKTOP REVIEW OF SITE CONDITIONS

2.1 Published Geological Mapping

Information on regional sub-surface conditions, referenced from the Department of Mineral Resources Geological Map Sydney 1:100,000 (Geological Series Sheet 9130) indicates that the site is underlain by (Rnn) the Newport Formation and Garie Formation of the Narrabeen Group, which is typically comprised of interbedded laminite, shale, and quartz to lithic-quartz sandstone.

2.2 Published Soil Landscapes

The Soil Conservation Service of NSW Sydney 1:100,000 Soil Landscapes Series Sheet 9130 (2nd Edition) indicates that the site overlies the Newport Landscape. This landscape type typically includes gently undulating plains of Holocene sands to rolling rises over other soils or bedrock. Soils are generally shallow (< 0.5 m) siliceous sands overlaying moderately deep buried sands (< 1.5m) yellow podzolic soil with sandy topsoil on crests and deep (> 2.0m) podzols in depressions earthy sands. These soils are noted present high soil erosion hazards, localized steep slopes, very low soil fertility and non-cohesive topsoil.

3 OBSERVATIONS

3.1 Subsurface Conditions

The stratigraphy at the site is characterized by topsoil/fill and sand with residual sandy clay overlying sandstone bedrock. Observations taken during the investigation have been used to produce a stratigraphic model of the site.

A summary of the subsurface conditions across the site, interpreted from the investigation results, is presented in **Table 1**. More detailed descriptions of subsurface conditions at the test locations are available in the borehole logs presented in **Appendix A**. The details of the method of soil and rock classification, explanatory notes and abbreviations adopted in the borehole logs are also presented in **Appendix A**.

TABLE 1 SUMMARY OF INFERRED SUBSURFACE CONDITIONS

Unit	Material	Approx. Depth Range of Unit [1] mBGL				Comments
		BH1	BH2	BH3	BH4	
1	**Topsoil/ Fill**	0.0 to 0.7 (20.3 to 19.6)	0.0 to 0.2 (22.3 to 22.1)	0.0 to 0.2 (20.7 to 20.5)	0.0 to 0.4 (23.6 to 23.2)	Generally fine to medium grained sandy TOPSOIL and FILL with trace clay and fine to medium sized gravels. Fill within Unit 1 is inferred to be uncontrolled and poorly compacted.
2	**Sand**	-	0.2 to 0.8 (22.1 to 21.5)	0.2 to 1.0 (20.5 to 19.7)	0.4 to 0.8 (23.2 to 22.8)	Fine to medium grained SAND, trace clay elements grading with depth

Unit	Material	Approx. Depth Range of Unit [1] mBGL				Comments
		BH1	BH2	BH3	BH4	
3	**Residual Clay**	0.7 to 2.5 (19.6 to 17.8)	0.8 to 2.5 (21.5 to 19.8)	1.0 to 1.9 (19.7 to 18.8)	0.8 to 2.8 (22.8 to 20.8)	Generally fine to medium grained stiff sandy CLAY. Medium to high plasticity with stiffness generally grading very stiff/hard with depth. Minor ironstone gravels.
4	**Extremely Weathered Sandstone**	2.5 + (sub 17.8)	-	1.9 to 2.1 (18.8 to 18.6)	2.8 + (sub 20.8)	Extremely weathered SANDSTONE fine to medium grained with ironstone gravel bands.

Notes:

1 Depths shown are based on material observed within test locations and will vary across the site.

2 Depths to Unit 4 Extremely Weathered Sandstone are inferred from DCP refusal only and must be confirmed by further mechanical drilling and geotechnical inspections during construction.

3.2 Groundwater Observations

No groundwater seepage was observed in BH1, BH2 or BH4. Seepage was observed in BH3 at 1.6 mBGL and is inferred to be seepage at approximately the rock/soil boundary in response to surface water infiltration following recent rainfall events.

4 GEOTECHNICAL RECOMMENDATIONS FOR DESIGN

4.1 Foundation Design

It is not recommended that shallow footings or slabs found within Unit 1 or 2 material due to the potential for differential settlement caused by footings bridging between materials of varying stiffness. Shallow footings and slabs on Unit 3 or 4 material should be designed in accordance with AS2870:2011 based on a Site Classification of 'M.' 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 2** may be used for the design of pad footings and bored piles. 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 0.65 may be expected.

Selection of footing types and founding depth will need to consider the risk of adverse differential ground movements within the foundation footprint and between high level and deeper footings. Unless an

allowance for such movement is included in the design of the proposed development we recommend that all new structures found on natural materials with comparable end bearing capacities and elastic moduli.

Ultimate geotechnical strengths are provided for use in limit state design. Allowable bearing pressures are provide for serviceability checks. These values have been determined to limit settlements to an acceptable level for conventional building structures, typically less than 1% of the minimum footing dimension.

TABLE 2 PAD FOOTING AND PILE DESIGN PARAMETERS

Material		Unit 1 TS / Fill	Unit 2 Sand	Unit 3 Residual Clay	Unit 4 EW Sandstone
Allowable Bearing Pressure (kPa)		0	70	200	750
Ultimate Vertical End Bearing Pressure (kPa)		0	210	600	2250
Elastic Modulus (MPa)		5	15	20	75
Ultimate Shaft Adhesion (kPa)	In Compression	0	10	25	100
	In Tension	0	5	12.5	50
Susceptibility to Liquefaction during an Earthquake		Medium	Medium	Medium	Low

Notes:

1 Shaft 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

To adopt these parameters we have assumed that the bases of all footing excavations are cleaned of loose debris and water and inspected by a suitably qualified Geotechnical Engineer prior to pile 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.

4.2 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.

4.3 Excavation Retention

Temporary batters may be considered for retention during basement excavation only where adequate room for full batter construction is available. Temporary batter slopes of 1V:1H will be possible for all units above the water table provided that surface water is diverted away from the batter faces and batter heights

are kept to less than 4m. Where batters extend beyond 4 m height benching may be required and further advice should be sought from a qualified geotechnical engineer. Permanent batters of 2H:1V may be employed for excavation design above the water table. Permanent batters will require surface protection or revegetation to prevent erosion and slaking. Unit 3 bedrock may be cut vertically without support provided that geotechnical inspections of the excavation are carried out at no greater than 1.5 m vertical intervals.

Where excavations extend beneath the zone of influence of nearby structures, services or pavements, or where site constraints do not allow the construction of temporary batters, basement retention will be required. For design of flexible shoring systems a triangular pressure distribution may be employed using the parameters provided in **Table 3**. For design of rigid anchored or braced walls, a trapezoidal earth pressure distribution should be used with a maximum pressure over the central 50% of the supported height of 0.65.Ka.γ.H (kPa), where 'H' is the effective vertical height of the wall in metres.

TABLE 3 EARTH PRESSURE PARAMETERS

Material		Unit 1 TS / Fill	Unit 2 Residual Sand	Unit 3 Residual Clay	Unit 4 EW Sandstone
Bulk Unit Weight (kN/m^3)		17	18	18	23
Earth Pressure Coefficients	At rest, K_o	0.58	0.50	0.46	0.37
	Passive, K_p	2.46	3.00	3.39	4.40
	Active, K_a	0.41	0.33	0.29	0.23

Earth pressure coefficients with **Table 3** are provided on the assumption that the ground behind the retaining wall is flat and drained. For cases where the ground profile rises at more than 5^o behind the retaining system detailed design input should be sought from a geotechnical engineer.

Surcharge loads on retention structures may either be modelled directly through finite element inputs in programs such as Plaxis or Wallap, or they may be calculated using a rectangular stress block with an earth pressure coefficient of 0.5 applied to surcharge loads at ground surface level. The retaining walls should be designed to withstand hydrostatic pressure below the level of Unit 3 Sandstone unless permanent drainage is incorporated in the wall design.

4.4 Soil and Rock Excavatability

The expected ability of equipment to excavate the soil and rock encountered at the site is summarised in **Table 4**. 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 4 SOIL AND ROCK EXCAVATABILITY

Unit	Material	Excavatability
1	Fill	Easy digging by 20t Excavator
2	Sand	
3	Residual Soil	
4	Extremely Weathered Sandstone	Moderate to Hard ripping by 20t Excavator. Hydraulic hammering will be required for medium strength bands encountered within Unit 4.

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.

4.5 Slope Risk Assessment

A Slope Risk Assessment has been carried out for the site in general 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. 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.

4.5.1 Potential Slope Hazards

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

Hazard 1: Major failure of the slope (approx. 6 m wide by 4 m high by 2 m deep, failure would extend beyond site boundaries).

Hazard 2: Minor slump within soil material (approx. 1 m wide by 1 m high by 0.4 m deep).

4.5.2 Assessed Risk Level for Property Damage

The risk zoning using property loss criteria in accordance with AGS 2007c is presented in **Table 5**. Hazards have been assessed for current conditions and potential failure during excavation assuming that no control measures are implemented during construction.

TABLE 5 SEMI-QUANTITATIVE ASSESSMENT FOR PROPERTY DAMAGE

Hazard	Likelihood (Indicative value of annual probability)	Consequence (Indicative Value)	Assessed Risk Level
Hazard 1	Barely Credible (1×10^{-6})	Major (60%)	**Very Low**
Hazard 2	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 **Very Low**.

4.5.3 Assessed Risk Level for Loss of Life

The risk zoning using loss of life criteria in accordance with AGS 2007c is presented in **Table 6.** Hazards have been assessed for current conditions and potential failure during remedial works assuming that no control measures are implemented during construction.

TABLE 6 QUANTITATIVE ASSESSMENT FOR LOSS OF LIFE

Hazard	Annual Probability $P_{(H)}$	Probability of Spatial Impact $P_{(S:H)}$	Temporal Spatial Probability $P_{(S:H)}$	Vulnerability of Individual $V_{(D:T)}$	Annual Probability of Loss of Life $R_{(LoL)}$
Hazard 1	1×10^{-6}	1	1	1	**1×10^{-6}**
Hazard 2	1×10^{-3}	1	1×10^{-2}	1×10^{-2}	**1×10^{-7}**

The assessed maximum risk to loss of life according to the quantitative risk assessment is 1×10^{-6} (i.e once in every 1,000,000 years) .

4.5.4 Current Risk Levels

The qualitative risk assessment indicates the site to have a **Very Low Risk** of damage to property as a result of the potential hazards identified. AGS Landslide Risk Management Concepts and Guidelines state that a assessed risk to property of Medium or greater as a very low risk has been established, no further investigations are required at this time.

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 1×10^{-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.

5 RECOMMENDATIONS FOR FURTHER GEOTECHNICAL SERVICES

Further geotechnical inspections should be carried out during construction to confirm the geotechnical and hydrogeological model. These should include:

- Additional cored boreholes should be drilled following demolition of structures to identify ground conditions to below the proposed depth of excavation.
- All excavated material transported off site should be classified in accordance with NSW EPA 2014 - Waste Classification Guideline Part 1; Classifying Waste.
- A suitably qualified geotechnical engineer is to assess the condition of exposed material at foundation or subgrade level to assess the ability of the prepared surface to act as a foundation or as a subgrade.

6 CONCLUSION

Based on the geotechnical assessment of the site, Morrow Geotechnics can conclude that the site is geotechnically suitable for the proposed development. Furthermore, Morrow Geotechnics confirms that:

- Geotechnical risks associated with the following areas identified by Council can be appropriately managed by designing and constructing in accordance with the recommendations of this report:

  (a) site layout, including access,

  (b) the development's design and construction methods,

  (c) the amount of cut and fill that will be required for the development,

  (d) waste water management, stormwater and drainage across the land,

  (e) the geotechnical constraints of the site,

  (f) any appropriate measures proposed to avoid, minimise or mitigate the impacts of the development.

- Geotechnical risks have been appropriately identified according to the AGS 2007 Risk Assessment Guidelines and that the proposed development presents an acceptable risk level according to AGS 2007 Guidelines.

7 STATEMENT OF LIMITATIONS

The adopted investigation was limited by the agreed scope of the investigation. Further geotechnical inspections should be carried out during construction to confirm both the geotechnical model and the design parameters provided in this report.

Your attention is drawn to the document "Important Information", which is included in **Appendix B** of this report. 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.

8 REFERENCES

AS1726:1993, *Geotechnical Site Investigations*, Standards Australia.

AS2159:2009, *Piling – Design and Installation*, Standards Australia.

AS2870:2011, *Residential Slabs and Footings*, Standards Australia.

AS3798:2007, *Guidelines on Earthworks for Commercial and Residential Developments*, Standards Australia.

Chapman, G.A. and Murphy, C.L. (1989), Soil Landscapes of the Sydney 1:100000 sheet. Soil Conservation Services of NSW, Sydney.

NSW Department of Finance and Service, Spatial Information Viewer, maps.six.nsw.gov.au.

NSW Department of Mineral Resources (1983) Sydney 1:100,000 Geological Series Sheet 9130 (Edition 1). Geological Survey of New South Wales, Department of Mineral Resources.

9 CLOSURE

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,

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Engineering Geologist

Alan Morrow
Principal Geotechnical Engineer

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Map description	P2828 -Borehole Location Plan		
Site location	37-43 Hay Street, Collaroy NSW		
Client	Collaroy Living Pty Ltd		
Project name	Collaroy		
Project No	P2828	**Scale**	Not to scale

Appendix A

BOREHOLE LOGS AND EXPLANATORY NOTES

Morrow Geotechnics
Bellambi, NSW
Phone: 0405 843 933

Engineering Log - Borehole

Borehole No: BH1

UTM	: 56H	Driller Rig	: Hand Auger	Job Number	: P2828
Easting	: 342686.7	Driller Supplier	: MG	Client	: Collaroy Living Pty Ltd
Northing	: 6265399.2	Logged By	: Jordan Andonoski	Project	: Collaroy
RL	: N/A	Reviewed By	: Rhiannon McKeon	Location	: 37-43 Hay Street, Collaroy NSW
Total Depth	: 0.7m	Date	: 01/03/2023		

Drilling Method	Water	DCP	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency	Moisture	Observations
Hand Auger	GW/NE	0	Fill		SM			Fill silty SAND (SM) : loose, brown, fine to medium grained, dry,	L	D	
		2									
		1									
		2									
		5									
		4				0.5					
						0.6					
		2	Fill		SM			Fill silty to gravelly SAND (SM) : medium dense to dense, brown, fine to medium grained, fine to coarse sized gravel, dry, (construction waste) .	MD-D	D	
		2						**BH1 refusal at 0.7m (Practical Auger Refusal on Fill)**			
		3									
		3									
		3				1					
		4									
		4									
		6									
		6				1.5					
		10									
		13									
		12									
		16				2					
		15									
		23									
		18									
		24				2.5					
		23 HB									
						3					
						3.5					
						4					

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Engineering Log - Borehole

Borehole No: BH2

UTM	: 56H	Driller Rig	: Hand Auger	Job Number	: P2828
Easting	: 342679.7	Driller Supplier	: MG	Client	: Collaroy Living Pty Ltd
Northing	: 6265431.2	Logged By	: Jordan Andonoski	Project	: Collaroy
RL	: N/A	Reviewed By	: Rhiannon McKeon	Location	: 37-43 Hay Street, Collaroy NSW
Total Depth	: 2.5m	Date	: 01/03/2023		

Drilling Method	Water	DCP	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency	Moisture	Observations
Hand Auger		1 1	Topsoil		SW	0.2		Topsoil SAND (SW) : very loose, brown, fine to medium grained, trace fine sized gravel, moist, (trace rootlets) .	VL	M	
		1 3 3 2 1 1	Residual		SW	0.5 0.8		Residual SAND (SW) : loose to medium dense, grey, fine to medium grained, trace low plasticity clay, moist, (low resistance) .	L-MD	M	
		1 3 3 4 4	Residual		CI-CH	1 1.3		Residual sandy CLAY (CI-CH) : firm to stiff, medium to high plasticity, orange grey, fine to medium grained sand, trace fine sized gravel, w < pl, (low resistance, minor ironstone gravels) .	F-St	w < PL	
		6 10 10	Residual		CI	1.5 1.6		AS ABOVE:(CI) : very stiff, medium plasticity, orange grey, trace fine to medium sized gravel,	VSt	w < PL	
		12 17 15 16 17 20 24 25+	Residual		CI	2		AS ABOVE:hard, orange grey red, trace fine sized gravel,	H	w < PL	
						2.5 3 3.5 4		**BH2 Terminated at 2.5m (Target Depth Reached)**			

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Engineering Log - Borehole

Borehole No: BH3

UTM	: 56H	Driller Rig	: Hand Auger	Job Number	: P2828
Easting	: 342657.8	Driller Supplier	: MG	Client	: Collaroy Living Pty Ltd
Northing	: 6265419.3	Logged By	: Jordan Andonoski	Project	: Collaroy
RL	: N/A	Reviewed By	: Rhiannon McKeon	Location	: 37-43 Hay Street, Collaroy NSW
Total Depth	: 2.1m	Date	: 01/03/2023		

Drilling Method	Water	DCP	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency	Moisture	Observations
Hand Auger		1 0	Topsoil		SW	0.2		Topsoil SAND (SW) : very loose, grey brown, fine to medium grained, trace fine sized gravel, moist,	VL	M	
		1 0 1 1	Residual		SW	0.5 0.6		Residual SAND (SW) : very loose, grey, fine to medium grained, trace low plasticity clay, moist, (low resistance) .	VL	M	
		1 1 1 2	Residual		SP	1		AS ABOVE:(SP) : loose, grey orange, fine grained, wet,	L	W	
		2 4 7 7 8	Residual		Cl-CH	1.5		Residual sandy to gravelly CLAY (Cl-CH) : stiff to very stiff, medium to high plasticity, orange grey red, fine sized gravel, fine to medium grained sand, w < pl, (low to medium resistance, minor ironstone gravels) .	St-VSt	w < PL	
	▶	12 18 16 17	Residual		Cl-CH	1.9		Residual sandy to gravelly CLAY (Cl-CH) : hard, medium to high plasticity, orange grey red, fine sized gravel, fine to medium grained sand, w < pl, (medium resistance, ironstone gravels) .	H	w < PL	
		15 17	Rock		SST	2		Extremely weathered,rock sandy to gravelly CLAY (SST) : hard, low plasticity, orange red light grey, fine to medium sized gravel, fine to medium grained sand, w < pl, (high resistance, ironstone gravels) .	H	w < PL	
		20 19 25+				2.5 3 3.5 4		**BH3 refusal at 2.1m (Refusal in Sandstone)**			

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Engineering Log - Borehole

Borehole No: BH4

UTM	: 56H	Driller Rig	: Hand Auger	Job Number	: P2828
Easting	: 342654.7	Driller Supplier	: MG	Client	: Collaroy Living Pty Ltd
Northing	: 6265420.1	Logged By	: Jordan Andonoski	Project	: Collaroy
RL	: N/A	Reviewed By	: Rhiannon McKeon	Location	: 37-43 Hay Street, Collaroy NSW
Total Depth	: 1.5m	Date	: 01/03/2023		

Drilling Method	Water	DCP	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency	Moisture	Observations
Hand Auger	GWNE	1 0 1 1	Fill		SM	0.4		Fill silty SAND (SM) : loose, brown, fine to medium grained, dry,	L	D	
		1 1 1 2	Residual		SM	0.5 0.8		Residual silty SAND (SM) : loose, grey, fine to medium grained, trace low plasticity clay, moist,	L	M	
		2 2	Residual		CI	1		Residual sandy CLAY (CI) : firm to stiff, medium plasticity, grey orange, fine to medium grained sand, w ≈ pl,	F-St	w ≈ PL	
		1 1 2 2 2	Residual		CH	1.5		Residual sandy CLAY (CH) : firm to stiff, high plasticity, orange red grey, fine grained sand, trace fine sized gravel, w ≈ pl, (ironstone gravels) .	F-St	w ≈ PL	
		2 3 2 3 3 3 4 4 4 6 9 17 25+				2 2.5 3 3.5 4		**BH4 Terminated at 1.5m (Target Depth Reached)**			

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.

Appendix B

IMPORTANT INFORMATION

Important Information

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