morrow

GEOTECHNICAL INVESTIGATION REPORT

638 PITTWATER ROAD, BROOKVALE NSW

Prepared for:

BROOKVALE PROPERTY INVESTMENT UNIT TRUST

Reference: P1505_ 01

17 August 2018

Morrow Geotechnics Pty Ltd | ABN 42 605 892 126
PO Box 4069, Carlton NSW 2218
P: 0405 843 933 | E: info@morrowgeo.com.au

Geotechnical Investigation Report

1 PROJECT BACKGROUND

Morrow Geotechnics Pty Ltd has undertaken a Geotechnical Investigation to provide geotechnical advice and recommendations for the proposed development at 638 Pittwater Road, Brookvale NSW (the site).

1.1 Proposed Development

Architectural drawings for the proposed development have been prepared by Barry Rush and Associates Pty Ltd for Project No. 1802 dated 20 April 2018. From the drawings provided, Morrow Geotechnics understands that the proposed development involves demolition of existing structures at the site and construction of a three-storey residential structure over a two level basement. Excavation is expected to extend to a depth of approximately 6 m below existing ground level (mBGL).

1.2 Investigation Intent

The purpose of the investigation is to provide geotechnical and hydrogeological advice and recommendations specific to the ground conditions observed at site for the proposed development. These recommendations include:

- Foundation advice along with relevant geotechnical design parameters;
- Excavation and shoring advice along with relevant geotechnical design parameters;
- Approaches to minimise the impact of the proposed development through vibration, ground movement or groundwater drawdown;
- Other relevant geotechnical issues which may impact construction; and
- Recommendations for further geotechnical input.

1.3 Published Geological Mapping

The Department of Mineral Resources Geological Map Sydney 1:100,000 Geological Series Sydney 9130 (DMR 1983) indicates the site to be underlain by the Hawkesbury Sandstone Formation, which typically comprises medium to coarse grained quartz sandstone.

1.4 Published Soil Landscapes

The Soil Conservation Service of NSW Sydney 1:100,000 Soil Landscapes Series Sheet 9130 (1st Edition) indicates that the residual landscape at the site likely comprises disturbed terrain, which generally comprises level plain to hummocky terrain, extensively disturbed by human activity, including complete disturbance, removal or burial of soil.

2 OBSERVATIONS

2.1 Investigation Methods

Fieldwork was undertaken by Morrow Geotechnics on 23 July 2018. 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 a Geotechnical Engineer to assess topographical features, condition of surrounding structures and site conditions;
- Dial Before You Dig (DBYD) services search of proposed borehole locations;
- Drilling of two boreholes in total. The boreholes (BH1 and BH2) were drilled by a track mounted drill rig using solid flight augers equipped with a tungsten-carbide bit (TC bit) to depths of 14.0 and 17.45 m below ground level (mBGL) respectively. Borehole locations are shown on **Figure 1** and borehole logs are presented in **Appendix A**;

2.2 Subsurface Conditions

The stratigraphy at the site is characterised by fill and residual soil overlying shale bedrock. Observations taken during the investigation have been used to produce a stratigraphic model of the site. The observed stratigraphy has been divided into three geotechnical units.

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	
1	**Fill**	0.0 to 0.5	0.0 to 0.5	Fine grained sand with silt and trace of medium gravel. Unit 1 is inferred to be uncontrolled and poorly compacted.
2	**Loose Sand**	0.5 to 3.0	0.5 to 1.5	Generally fine to medium grained sand with trace clay. Unit 2 was observed to be of loose consistency with SPT N values of between 3 and 10.
3	**Medium Dense Sand**	3.0 to 14.0	1.5 to 17.45	Generally fine to medium grained sand with trace clay. Unit 3 was observed to be of medium dense consistency with SPT N values of between 11 and 31. One outlying SPT value of 49 was recorded in BH2 at 14.5 mBGL.

Notes:

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

2.3 Groundwater Observations

A standpipe piezometer was installed within BH1 and bailed dry of drilling fluids on 23 July 2018. At the time of the monitoring event water within BH1 had stabilised at 3.43 mBGL.

3 RECOMMENDATIONS

3.1 Excavation Retention

Design of excavation retention systems will need to consider both the soil and groundwater conditions encountered within the investigation. Given the relatively high water level observed at site it will be necessary to design the basement shoring as a tanked system. Watertight shoring walls are usually achieved through either secant piles, cutter soil mix walls or sheet piling. If the basement shoring is designed as a watertight wall it will be necessary to design walls to withstand hydrostatic pressures and anchoring or internal bracing will be required.

For design of flexible shoring systems a triangular pressure distribution may be employed using the parameters provided in **Table 2**. For design of rigid anchored or braced walls, a trapezoidal earth pressure distribution should be used with a maximum pressure of $0.65.K_a.\gamma.H$ (kPa), where 'H' is the effective vertical height of the wall in metres.

TABLE 2 RETENTION DESIGN PARAMETERS

Material		Unit 1 Fill	Unit 2 Loose Sand	Unit 3 Medium Dense Sand
Earth Pressure Coefficients	At rest, K_o	0.55	0.50	0.46
	Passive, K_p	2.66	3.00	3.39
	Active, K_a	0.38	0.33	0.29
Bulk Unit Weight (kN/m^3)		16	17	18

Earth pressure coefficients with **Table 2** 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 from 3 mBGL unless permanent drainage is incorporated in the wall design.

3.1.1 Soil and Rock Excavatability

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

TABLE 3 SOIL AND ROCK EXCAVATABILITY

Unit	Material	Excavatability
1	**Fill**	Easy digging by 20t Excavator
2	**Loose Sand**	Easy digging by 20t Excavator
3	**Medium Dense Sand**	Moderate digging by 20t Excavator

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

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

3.1.2 Excavation Vibration Considerations

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

TABLE 4 RECOMMENDED SAFE WORKING DISTANCES FOR VIBRATION INTENSIVE PLANT

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385:1993) [1]	Human Response (EPA Vibration Guideline)
Vibratory Roller	< 50 kN (typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (typically 2-4 tonnes)	6 m	20 m
	< 200 kN (typically 4-6 tonnes)	12 m	40 m
	< 300 kN (typically 7-13 tonnes)	15 m	100 m
	< 300 kN (typically 13-18 tonnes)	20 m	100 m
	< 300 kN (typically >18 tonnes)	25 m	100 m
Small Hydraulic Hammer	300 kg – 5 to 12 t excavator	2 m	7 m

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385:1993) [1]	Human Response (EPA Vibration Guideline)
Medium Hydraulic Hammer	900 kg – 12 to 18 t excavator	7 m	23 m
Large Hydraulic Hammer	1600 kg – 18 to 34 t excavator	22 m	73 m
Vibratory Pile Driver	Sheet Piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Notes:

1 More stringent conditions may apply to heritage buildings or other sensitive structures.

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

Where vibration intensive works such as hydraulic hammering of competent rock or driven piles are proposed contractors should make an assessment of the potential impact of their works on the basis of the borehole logs, core photographs and point load data. Monitoring of construction induced vibration should be undertaken at the commencement of such activities at the nearest vibration receptor in consultation with the project superintendent and geotechnical engineer. On the basis of trials at the commencement of works a construction methodology may be proposed to limit peak particle velocities (ppv) to acceptable levels. In the absence of ppv guidelines from affected asset owners, Morrow Geotechnics recommends the following limits be placed on vibrations:

- 20 mm/s for commercial or industrial structures;
- 10 mm/s for residential structures;
- 3 mm/s for structures which are particularly susceptible to vibration such as heritage buildings.

If vibration levels are found to be unacceptable during the trial, it may be necessary to adopt vibration mitigation measures such as:

- The use of smaller excavation plant and hydraulic hammers;
- Saw cutting of the perimeter of the excavation;
- Hammering at 50% capacity in short bursts to prevent the buildup of resonant frequencies;
- The use of low vibration techniques such as rotary grinders or chemical rock splitting.

3.2 Foundation Design

The parameters given in **Table 5** 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.

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 5 PAD FOOTING AND PILE DESIGN PARAMETERS

Material		Unit 1 Fill	Unit 2 Loose Sand	Unit 3 Medium Dense Sand
Allowable Bearing Pressure (kPa) (Values in brackets are for footings a minimum of 5 mBGL)		N/A	100	200 (500)
Ultimate Vertical End Bearing Pressure (kPa) (Values in brackets are for footings a minimum of 5 mBGL)		N/A	300	600 (1500)
Elastic Modulus (MPa)		5	20	40
Ultimate Shaft Adhesion (kPa)	In Compression	0	12	15
	In Tension	0	6	7.5
Susceptibility to Liquefaction during an Earthquake		Medium	Medium	Medium

Notes:

1. Side adhesion values given assume there is intimate contact between the pile and foundation material. Design engineer to check both 'piston' pull-out and 'cone' pull-out mechanics in accordance with AS4678-2002 Earth Retaining Structures.
2. Susceptibility to liquefaction during an earthquake is based on the following definition:
   Low - Medium to very dense sands, stiff to hard clays, and rock
   Medium - Loose to medium dense sands, soft to firm clays, or uncontrolled fill below the water table
   High - Very loose sands or very soft clays below the water table

To adopt these parameters we have assumed that the bases of all pile 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.

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.

3.3 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 C_e – Shallow Soil for the site.

4 RECOMMENDATIONS FOR FURTHER GEOTECHNICAL SERVICES

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

- All excavated material transported off site should be classified in accordance with NSW EPA 2014 - Waste Classification Guideline Part 1; Classifying Waste.
- Observation of the material within pile excavations should be undertaken at the start of piling works to confirm that material across the site is in accordance with the geotechnical model presented in this report.
- 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.
- Regular inspections of battered and unsupported excavations, where proposed, to confirm geotechnical conditions and to assess the suitability of design assumptions and to provide further advice with regards to excavation retention/ support and proposed construction methodologies, if required.

5 STATEMENT OF LIMITATIONS

The adopted investigation scope was limited by site access restrictions due to presence of structures at the site at the time of our investigation and by the investigation intent. 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.

6 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 (1985) Sydney 1:100,000 Geological Series Sheet 9129 (Edition 1). Geological Survey of New South Wales, Department of Mineral Resources.

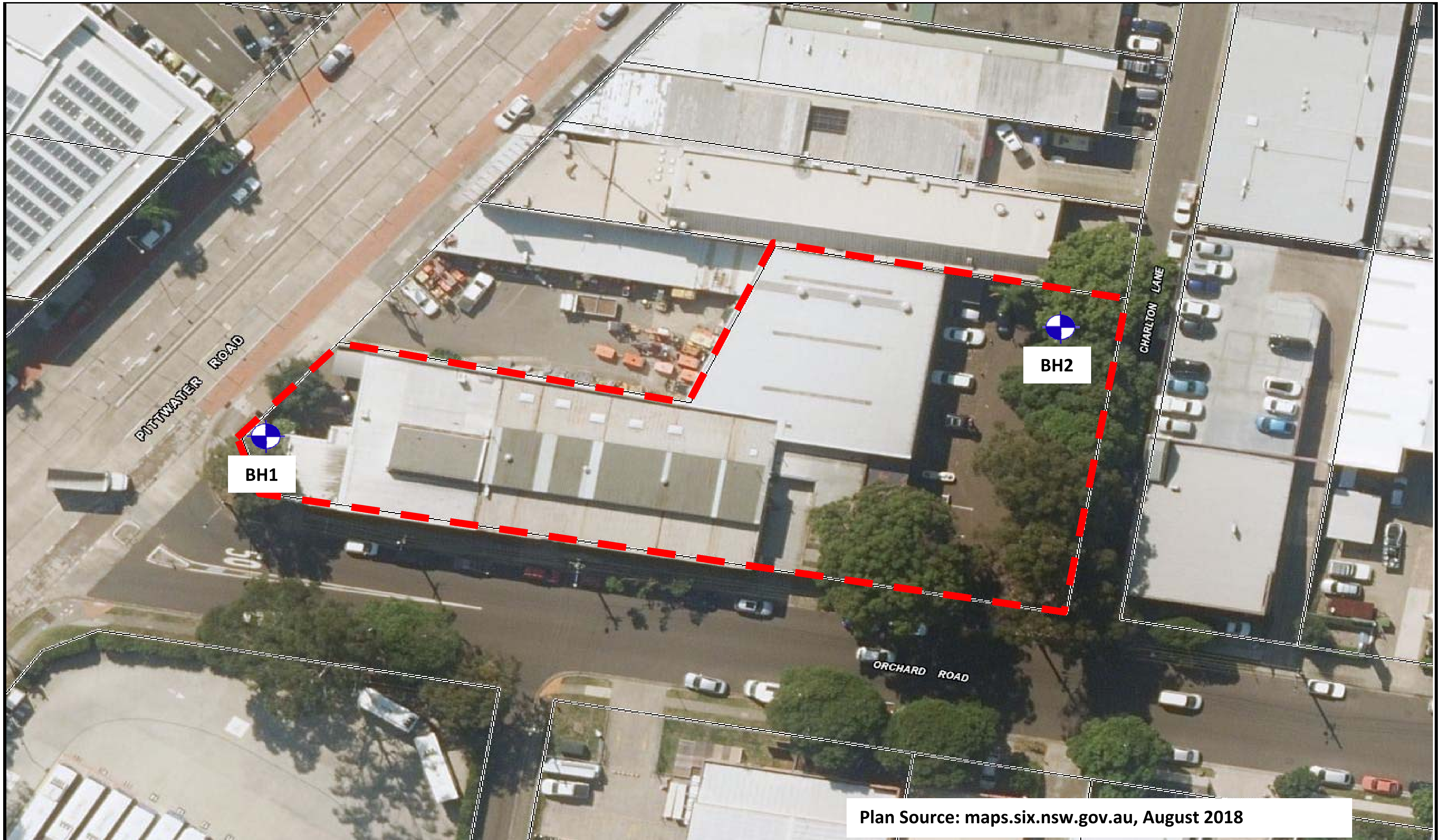
Pells (2004) Substance and Mass Properties for the Design of Engineering Structures in the Hawkesbury Sandstone, Australian Geomechanics Journal, Vol 39 No 3

7 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,

Alan Morrow
Senior Geotechnical Engineer



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PO Box 4069, Carlton NSW 2218

P: 0405 843 933 | E: info@morrowgeo.com.au

Drawn	MHK
Approved	AM
Date	06-08-18
Scale	NTS

Brookvale Property Investment Unit Trust

638 Pittwater Road, Brookvale NSW

Geotechnical Investigation

Borehole Location Plan

Figure: **1**

Project: P1505

BOREHOLE LOGS AND EXPLANATORY NOTES

Appendix A

Borehole Log Report

Morrow Geotechnics Pty Ltd
PO Box 4069
Carlton NSW 2218
M 0405 843 933

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Hole ID.	**BH1**
Hole Depth:	**14.00 m**
Sheet:	**1 of 3**

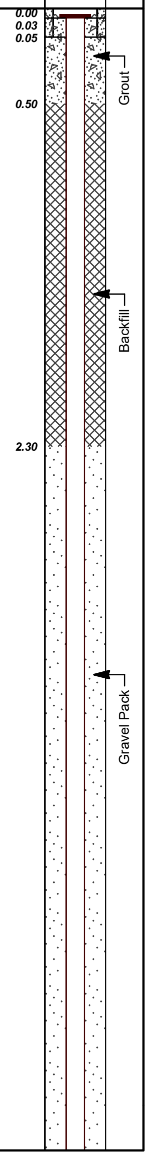
Project Name:	**Geotechnical Investigation**	Project Number:	**P1505**
Location / Site:	**638 Pittwater Road, Brookvale**	Client:	**Brookvale Property Investment Unit Trust**

Drilling Company:	**Traccess Pty Ltd**	Date Started:	**23/7/18**	Ground Level:	----------
Drill Method:	**Washboring**	Date Completed:	**23/7/18**	Easting:	----------
Equipment:	**Track mounted drilling rig**			Northing:	----------

Method	Water Level	Depth (m)	RL (m)	USCS Symbol	Material Type	Material Description	Consistency / Density	Moisture	Samples / Tests: SPT	Observations / Comments
						Surface: Garden				
Solid Flight Auger		0.0–0.5		SP		**Silty SAND**- brown, fine to medium grained, trace medium Gravel (rounded pebbles), roots.	loose	d to m		
		0.5–1.7		SP	Aeolian	**SAND**- grey, fine to medium grained.	loose	d-m	2, 1, 3, N=4	
		1.7–3.2		SP	Residual Soil	**SAND trace Clay**- grey mottled orange, fine to medium grained.	loose	m	1, 1, 2, N=3	
Washboring	3.43m well commissioned 23/7/18	3.2–6.0		SP	Residual Soil	**SAND trace Clay**- grey white, fine to coarse grained.	loose to medium dense	w	5, 5, 9, N=14; 5, 6, 6, N=12	

Depth scale: 1.0, 2.0, 3.0, 4.0, 5.0, 6.0

Well Details / Well Construction:



Moisture	
D	Dry
Dp	Damp
SM	Slightly Moist
M	Moist
VM	Very Moist
W	Wet
Sd	Saturated

Additional Comments

Logged By:	**Matthew Kilham**	Date:	**23/7/18**	Checked By:	**Alan Morrow**	Date:	**27/7/18**

Borehole Log Report

Morrow Geotechnics Pty Ltd
PO Box 4069
Carlton NSW 2218
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Hole ID.	**BH1**
Hole Depth:	**14.00 m**
Sheet:	**2 of 3**

Project Name:	**Geotechnical Investigation**	Project Number:	**P1505**
Location / Site:	**638 Pittwater Road, Brookvale**	Client:	**Brookvale Property Investment Unit Trust**

Drilling Company:	**Traccess Pty Ltd**	Date Started:	**23/7/18**	Ground Level:	----------
Drill Method:	**Washboring**	Date Completed:	**23/7/18**	Easting:	----------
Equipment:	**Track mounted drilling rig**			Northing:	----------

Method	Water Level	Depth (m)	RL (m)	Graphic Log	USCS Symbol	Material Type	Material Description	Consistency / Density	Moisture	Samples / Tests SPT	Observations / Comments	Well Details	Well Construction
Washboring		7.0			SP	Residual Soil	**SAND trace Clay**- grey white, fine to coarse grained. *(continued)*	loose to medium dense	w	6, 5, 6, N=11			
		8.0			CL		**Sandy CLAY**- grey white, low plasticity, fine to coarse grained.	stiff	w	3, 5, 6, N=11			
		9.0, 10.0, 11.0, 12.0			SC		**Clayey SAND**- grey white, low plasticity, fine to coarse grained.	medium dense	w	6, 9, 15, N=24; 5, 8, 9, N=17		10.12	Hand slotted Screen with filter sock

Moisture	
D	Dry
Dp	Damp
SM	Slightly Moist
M	Moist
VM	Very Moist
W	Wet
Sd	Saturated

Additional Comments

Logged By:	**Matthew Kilham**	Date:	**23/7/18**	Checked By:	**Alan Morrow**	Date:	**27/7/18**

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PO Box 4069
Carlton NSW 2218
M 0405 843 933

Hole ID.	**BH1**
Hole Depth:	**14.00 m**
Sheet:	**3 of 3**

Project Name:	**Geotechnical Investigation**	Project Number:	**P1505**
Location / Site:	**638 Pittwater Road, Brookvale**	Client:	**Brookvale Property Investment Unit Trust**

Drilling Company:	**Traccess Pty Ltd**	Date Started:	**23/7/18**	Ground Level:	----------
Drill Method:	**Washboring**	Date Completed:	**23/7/18**	Easting:	----------
Equipment:	**Track mounted drilling rig**			Northing:	----------

Method	Water Level	Depth (m)	RL (m)	Graphic Log	USCS Symbol	Material Type	Material Description	Consistency / Density	Moisture	Samples / Tests SPT	Observations / Comments	Well Details	Well Construction
Washboring		13.0 14.0			SC	Residual Soil	**Clayey SAND**- grey white, low plasticity, fine to coarse grained.*(continued)*	medium dense	w	5 9 7 N=16		13.12	
		15.0 16.0 17.0 18.0					**Hole Terminated at 14.00m** Borehole collapsed						

Moisture		Additional Comments
D	Dry	
Dp	Damp	
SM	Slightly Moist	
M	Moist	
VM	Very Moist	
W	Wet	
Sd	Saturated	

Logged By:	**Matthew Kilham**	Date:	**23/7/18**	Checked By:	**Alan Morrow**	Date:	**27/7/18**

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Hole ID.	**BH2**
Hole Depth:	**17.45 m**
Sheet:	**1 of 3**

Project Name:	**Geotechnical Investigation**	Project Number:	**P1505**
Location / Site:	**638 Pittwater Road, Brookvale**	Client:	**Brookvale Property Investment Unit Trust**

Drilling Company:	**Traccess Pty Ltd**	Date Started:	**23/7/18**	Ground Level:	----------
Drill Method:	**Washboring**	Date Completed:	**23/7/18**	Easting:	----------
Equipment:	**Track mounted drilling rig**			Northing:	----------

Method	Water Level	Depth (m)	RL (m)	Graphic Log	USCS Symbol	Material Type	Material Description	Consistency / Density	Moisture	Samples / Tests SPT	Observations / Comments
							Surface: Asphalt				
Solid Flight Auger		0.0					**Asphalt**.				
					SP	Aeolian	**FILL: Sandy GRAVEL**- grey, fine to coarse grained, brick.	loose	d to m	4, 5, 5 N=10	
		1.0–2.0			SP	Residual Soil	**SAND trace silt**- brown orange, fine to coarse grained.	loose	w	4, 7, 11 N=18	
Washboring (from 3.0)	3.5m 23/7/18	2.0–4.0			SP	Residual Soil	**SAND with Clay**- grey red orange, fine to coarse grained, trace gravel (hw sandstone).	medium dense	w	7, 12, 17 N=29	
		4.0–6.0			SP	Residual Soil	**SAND with Clay**- grey red orange, fine to coarse grained.			6, 12, 8 N=20	

Moisture

D	Dry
Dp	Damp
SM	Slightly Moist
M	Moist
VM	Very Moist
W	Wet
Sd	Saturated

Additional Comments

Logged By:	**Matthew Kilham**	Date:	**23/7/18**	Checked By:	**Alan Morrow**	Date:	**27/7/18**

Borehole Log Report

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PO Box 4069
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Hole ID.	**BH2**
Hole Depth:	**17.45 m**
Sheet:	**2 of 3**

Project Name:	**Geotechnical Investigation**	Project Number:	**P1505**
Location / Site:	**638 Pittwater Road, Brookvale**	Client:	**Brookvale Property Investment Unit Trust**

Drilling Company:	**Traccess Pty Ltd**	Date Started:	**23/7/18**	Ground Level:	----------
Drill Method:	**Washboring**	Date Completed:	**23/7/18**	Easting:	----------
Equipment:	**Track mounted drilling rig**			Northing:	----------

Method	Water Level	Depth (m)	RL (m)	Graphic Log	USCS Symbol	Material Type	Material Description	Consistency / Density	Moisture	Samples / Tests SPT	Observations / Comments
Washboring					SP	Residual Soil	**SAND trace Clay**- grey some orange, fine to coarse grained.	medium dense	w	12 14 17 N=31	
		7.0			SP		**SAND with Clay**- orange mottled pink, fine to coarse grained.	loose	w	4 5 5 N=10	
		8.0									
		9.0			SP		**SAND trace Clay**- grey some pink orange, fine to coarse grained.	loose	w	5 2 5 N=7	
		10.0			CL		**Sandy CLAY**- grey mottled pink, low plasticity, fine to medium grained.	medium dense	w	5 7 8 N=15	
		11.0			SP		**SAND**- grey pink orange, fine to coarse grained, trace carbonaceous inclusions.	medium dense to dense	w		
		12.0									

Moisture		Additional Comments
D	Dry	
Dp	Damp	
SM	Slightly Moist	
M	Moist	
VM	Very Moist	
W	Wet	
Sd	Saturated	

Logged By:	**Matthew Kilham**	Date:	**23/7/18**	Checked By:	**Alan Morrow**	Date:	**27/7/18**

Borehole Log Report

Morrow Geotechnics Pty Ltd
PO Box 4069
Carlton NSW 2218
M 0405 843 933

Hole ID.	BH2
Hole Depth:	17.45 m
Sheet:	3 of 3

Project Name:	Geotechnical Investigation	Project Number:	P1505
Location / Site:	638 Pittwater Road, Brookvale	Client:	Brookvale Property Investment Unit Trust

Drilling Company:	Traccess Pty Ltd	Date Started:	23/7/18	Ground Level:	----------
Drill Method:	Washboring	Date Completed:	23/7/18	Easting:	----------
Equipment:	Track mounted drilling rig			Northing:	----------

Method	Water Level	Depth (m)	RL (m)	Graphic Log	USCS Symbol	Material Type	Material Description	Consistency / Density	Moisture	Samples / Tests SPT	Observations / Comments
Washboring					SP	Residual Soil	**SAND**- grey pink orange, fine to coarse grained, trace carbonaceous inclusions. *(continued)*	medium dense to dense	w	15 11 10 N=21	
		13.0									
		14.0									
							SAND- grey orange, fine to coarse grained.			15 24 25 N=49	
		15.0									
		16.0									
		17.0									
					CH		**Silty CLAY**- medium to high plasticty.	soft	w	5 2 5 N=7	
					SC		**SAND with Clay**- dark grey black, fine to coarse grained, with carbonaceous inclusions.	loose	w		
							Hole Terminated at 17.45m Target depth achieved				
		18.0									

Moisture		Additional Comments
D	Dry	
Dp	Damp	
SM	Slightly Moist	
M	Moist	
VM	Very Moist	
W	Wet	
Sd	Saturated	

Logged By:	Matthew Kilham	Date:	23/7/18	Checked By:	Alan Morrow	Date:	27/7/18

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-situ 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.

IMPORTANT INFORMATION

Appendix B

morrow

Important Information

This Document has been provided by Morrow Geotechnics Pty Ltd subject to the following limitations:

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