



RESIDENTIAL DEVELOPMENT
160 BROOK STREET, COOGEE NSW

Prepared for:

OROSI

Reference: P1603_01

7 January 2019

1 PROJECT BACKGROUND

This report presents the results of a Geotechnical Investigation undertaken by Morrow Geotechnics Pty Ltd to provide geotechnical advice and recommendations for the proposed development at 160 Brook Street, Coogee NSW (the site).

1.1 Proposed Development

Architectural drawings for the proposed development have been prepared by EK Design Studio dated 13 July 2018. Based on the drawings provided, Morrow Geotechnics understands that the proposed development involves construction of a five storey residential structure over a single level of basement parking. Excavation for the proposed basement is expected to extend to a depth approximately 9.5 m below existing ground level (mBGL) at the rear of the property.

1.2 Investigation Intent

The intent of the investigation is to provide geotechnical 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 during construction.

2 SITE DESCRIPTION

2.1 Published Geological Mapping

The Department of Mineral Resources Geological Map Sydney 1:100,000 Geological Series Sheet 9130 (DMR 1983) indicates the site to overlie Holocene of the Quaternary Period, which typically comprises medium to fine grained marine sand with podsols.

2.2 Published Soil Landscape Mapping

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 the Newport Landscape. This landscape type typically includes gently undulating plains to rolling rises of Holocene sands mantling other soil materials or bedrock. Soils generally comprise shallow, well sorted siliceous sands overlying moderately deep buried sands including yellow podzolic soils. These soils are noted to present a very high soil erosion hazard and localized steep slopes, and non-cohesive topsoils.

3 OBSERVATIONS

3.1 Investigation Methods

Fieldwork for the geotechnical investigation was carried out on 12 December 2018 and comprised the drilling of two boreholes (BH1 and BH2) to 4.4 mBGL. The borehole locations were measured relative to existing site features and approximate borehole locations are shown on **Figure 1**.

BH1 and BH2 were drilled using hand augers. Dynamic Cone Penetrometer (DCP) tests were carried out adjacent to borehole locations to assess soil density. On completion the boreholes were backfilled with cuttings to the ground surface.

A Senior Engineering Geologist was present throughout the drilling operations to undertake testing, record test results and log the materials encountered.

3.2 Subsurface Conditions

The ground conditions at the site are characterised by fill overlying aeolian sand. Detailed borehole logs are presented in **Appendix A**. A summary of the subsurface conditions across the site is presented in **Table 1** below.

TABLE 1 GROUND CONDITIONS

Unit	Approx. Depth Range of Unit ¹ mBGL		Generalised Description
	BH1	BH2	
1 Topsoil/Fill	0.0 to 0.4	0.0 to 0.6	Fine to medium grained sand with silt and root fibres. Unit 1 is inferred to be uncontrolled and poorly compacted.
2 Very Loose to Loose Sand	0.5 to 1.9	0.6 to 1.4	Fine to coarse grained Aeolian sand. Unit 2 is of very loose to loose consistency.
3 Medium Dense Sand	1.9 to 3.3	1.4 to 3.1	Fine to coarse grained Aeolian sand. Unit 3 is of medium dense consistency.
4 Dense to Very Dense Sand	3.3 to 9.0	3.1 to 8.0	Fine to coarse grained Aeolian sand. Unit 4 is of dense to very dense consistency.

Notes:

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

DCP results indicate that it is highly likely that ground conditions are grading towards weathered sandstone shortly beyond the DCP refusal depths of 9.0 and 8.0 m respectively. Rock levels and rock quality cannot be confirmed by hand investigations given the depth to rock at the site.

3.3 Groundwater Observations

Seepage water was not observed within the depth of excavation at the time of the investigation.

4 DISCUSSIONS AND RECOMMENDATIONS

4.1 Excavations and Shoring

4.1.1 Excavation Retention Design

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.

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 2**. 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 $0.65 \cdot K_a \cdot \gamma \cdot H$ (kPa), where 'H' is the effective vertical height of the wall in metres.

TABLE 2 RETENTION DESIGN PARAMETERS

Material		Unit 1 Topsoil/Fill	Unit 2 Very Loose to Loose Sand	Unit 3 Medium Dense Sand	Unit 4 Dense to Very Dense Sand
Earth Pressure Coefficients	At rest, K_o	0.55	0.55	0.47	0.43
	Passive, K_p	2.66	2.66	3.25	3.69
	Active, K_a	0.38	0.38	0.31	0.27
Bulk Unit Weight (kN/m ³)		16	17	18	19

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° 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 unless permanent drainage is incorporated in the wall design.

4.1.2 Soil Excavatability

The expected ability of equipment to excavate the soil 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).

TABLE 3 SOIL AND ROCK EXCAVATABILITY

Unit	Material	Excavatability
1	Topsoil/Fill	Easy digging by 20t Excavator
2	Very Loose to Loose Sand	Easy digging by 20t Excavator.
3	Medium Dense Sand	Easy digging by 20t Excavator.
4	Dense to Very Dense Sand	Easy digging by 20t Excavator.

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.

4.2 Foundations

All proposed footings must found below Unit 1 and 2 material to prevent differential settlement on compressible material. 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.

The parameters given in **Table 4** may be used for the design of pad footings and bored piles.

TABLE 4 FOUNDATION DESIGN PARAMETERS

Material		Unit 1 Topsoil/Fill	Unit 2 Very Loose to Loose Sand	Unit 3 Medium Dense Sand	Unit 4 Dense to Very Dense Sand
Allowable Bearing Pressure (kPa)		N/A	N/A	150	400
Ultimate Vertical End Bearing Pressure (kPa)		N/A	N/A	450	1200
Elastic Modulus (MPa)		4	12	35	70
Allowable Shaft Adhesion (kPa)	In Compression	0	8	12	15
	In Tension	0	4	6	7.5

The bases of all foundation excavations must be 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. Side adhesion values provided in **Table 4** assume there is intimate contact between the pile and foundation material as specified in Pells (2004). Design engineer to check both ‘piston’ pull-out and ‘cone’ pull-out mechanics in accordance with AS4678:2002 Earth Retaining Structures.

4.2.1 Limit State Design

For limit state design in accordance with AS2159 Morrow Geotechnics recommends that a Preliminary Geotechnical Strength Reduction Factor (GSRF) of 0.4 is used for the design of piles 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.

4.3 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.

5 ADDITIONAL GEOTECHNICAL INPUT

Further input from a geotechnical professional during design and construction is advised in order to ensure a cost-effective design which can be constructed safely and efficiently. Areas for geotechnical input should include:

- Geotechnical design input during structural design including Finite Element Analysis of ground movements for the protection of adjacent structures and properties.
- Geotechnical inspection of piling works to verify pile socket conditions and confirm the geotechnical site model.
- Geotechnical inspections of foundation of foundation material to confirm allowable bearing pressures.
- Regular inspections of battered and unsupported excavations, where proposed, to assess excavation conditions and confirm the suitability of the proposed methodology.

6 STATEMENT OF LIMITATIONS

The adopted investigation scope was limited by the investigation intent. Further geotechnical inspections should be carried out during construction to confirm the geotechnical model 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.

7 REFERENCES

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

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

Chapman, G.A. and Murphy, C.L. (1989), Soil Landscapes of the Sydney 1:100,000 sheet. Soil Conservation Services of NSW, Sydney.

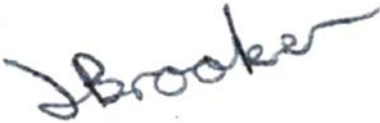
NSW Department of Mineral Resources (1985) Sydney 1:100,000 Geological Series Sheet 9130 (Edition 1). Geological Survey of New South Wales, Department of Mineral Resources.

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

8 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,

A handwritten signature in black ink that reads "J Brooker". The signature is written in a cursive, slightly slanted style.

James Brooker
Geotechnical Engineer

A handwritten signature in black ink that reads "Alan Morrow". The signature is written in a cursive, slightly slanted style.

Alan Morrow
Senior Geotechnical Engineer



<div><div><div>morrow</div><div>PO Box 4069, Carlton NSW 2218</div><div>P: 0405 843 933 E: info@morrowgeo.com.au</div></div></div>	Drawn	JB	<div><div>Orosi</div><div>160 Brook Street, Coogee NSW</div><div>Geotechnical Investigation</div><div>Borehole Location Plan</div></div>	Figure:	<div>1</div>
	Approved	AM			
	Date	20-12-18			
	Scale	NTS		Project: P1603	

BOREHOLE LOGS AND EXPLANATORY NOTES

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/Density	Moisture	DCP (blows per 100 mm)			
									5	10	15	20
HA	-	GWNE		SM		Silty SAND, fine to coarse grained, brown, with roots present, poorly graded	VL	M				
					0.5	SAND, fine to coarse grained, dark grey, poorly graded						
						SAND, fine to coarse grained, grey / white, poorly graded						
					1.0							
					1.5							
				SP			L-MD					
					2.0							
					2.5							
						SAND, fine to coarse grained, orange, poorly graded						
					3.0							
DCP				SM		Silty SAND, fine to medium grained, dark brown, grading to orange / yellow / white, weakly cemented, poorly graded	MD					
					3.5							
						SAND, fine to coarse grained, yellow-white, poorly graded						
				SP			L-MD					
					4.0							
					4.5	End BH1 at 4.4 m Reached Target Depth						
						- Start DCP from 4.4 m	L					
					5.0							
					5.5		MD					
					6.0							
					6.5		D	VD				
					7.0							
					7.5							
					8.0							

Project No:
Client:
Project:

P1603
Orosi
Residential Development
160 Brook Street
Coogee NSW

Contractor:
Drill Rig:

MHK
Hand Auger

Sheet
Logged:
Date:

2 of 2
JB
12-12-18

morrow

BH1

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/ Density	Moisture	DCP (blows per 100 mm)				
									5	10	15	20	
DCP					8.5		VD						
					9.0								
					9.5								
					10.0								
					10.5								
					11.0								
					11.5								
					12.0								
					12.5								
					13.0								
					13.5								
					14.0								
					14.5								
					15.0								
					15.5								
					16.0								

Drilling Method	Resistance	Water	Sampling	USCS	Depth	Stratigraphy (Additional Observations)	Consistency/Density	Moisture	DCP (blows per 100 mm)			
									5	10	15	20
HA	-	GWNE		SP	0.5	SAND, fine to coarse grained, grey, with trace of silt, poorly graded	-	D-M				
					1.0	SAND, fine to coarse grained, grey / white, poorly graded		M				
					1.5							
					2.0	SAND, fine to coarse grained, brown / dark brown grading to orange / orange-white, weakly cemented, poorly graded						
					2.5	SAND, fine to coarse grained, yellow / white, poorly graded						
					3.0							
					3.5							
					4.0							
					4.5	End BH2 at 4.4 m Reached Target Depth						
					5.0	- Start DCP from 4.4 m						
DCP					5.5							
					6.0							
					6.5							
					7.0							
					7.5							
					8.0							

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, $I_s(50)$ (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
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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 JT SM FZ SZ VN FL CL DL HB DB	Bedding Parting Joint Seam Fracture Zone Shear Zone Vein Foliation Cleavage Drill Lift Handling Break Drilling Break
Infilling	CN X Clay KT CA Fe Qz MS MU	Clean Carbonaceous Clay Chlorite Calcite Iron Oxide Quartz Secondary Mineral Unidentified Mineral
Shape	PR CU UN ST IR DIS	Planar Curved Undulose Stepped Irregular Discontinuous
Roughness	POL SL S RF VR	Polished Slickensided Smooth Rough 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

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

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