Ref: P1784_01
6/11/2019

ABN 42 605 892 126
PO Box 4069
Carlton NSW 2218
T: 0405 843 933
E: info@morrowgeo.com.au

Slope Risk Assessment

Geotechnical Investigation and Slope Risk Assessment Report
8 Beverley Place, Curl Curl NSW

1.0 INTRODUCTION

Morrow Geotechnics Pty Ltd conducted geotechnical investigations at 8 Beverley Place, Curl Curl NSW (the site). The purpose of this investigation was to provide geotechnical advice and recommendations for proposed development at the site based on project details available at the time of the investigation.

Architectural drawings have been prepared by Action Plans and dated 20 September 2019. From the drawings provided, Morrow Geotechnics understands that the proposed development will involve alterations and additions to the existing residence requiring excavations up to a depth of approximately 2.5 meters below ground level (mBGL).

1.1 PUBLISHED GEOLOGICAL MAPPING

The Department of Mineral Resources Geological Map Sydney 1:100,000 Geological Series Sheet 9130 (DMR 1991) indicates the site to be underlain by the Hawkesbury Sandstone which comprises medium to coarse grained quartz sandstone with minor shale lenses.

1.2 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 the Lambert Landscape. This landscape type typically includes undulating to rolling rises and low hills on Hawkesbury Sandstone, broad ridges, gently to moderately inclined slopes and wide rock benches with low broken scarps. Soil generally comprise shallow (< 0.5 m) discontinuous earthy sands and yellow earths on crests. These soils are noted to present a very high soil erosion hazard, rock outcrop, seasonally perched watertables and shallow highly permeable soil.

2.0 Observations

A senior engineering geologist inspected the site on 23 October 2019. A walkover inspection to conduct geomorphological mapping of the site was undertaken. The slope grades downwards to the east towards Curl Curl Beach.

One hand augered borehole (BH1) was drilled during the investigation. The approximate borehole location is shown on the attached plan.

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

Table 1 Summary of Inferred Subsurface Conditions

Unit		Depth (mBGL) BH1	Comments
1	**Colluvium**	0.0 to 0.35	SAND with silt and fine to coarse gravel. Unit 1 is of loose consistency.
2	**Residual Soil**	0.35 to 0.73	SAND with trace silt/clay. Unit 2s of medium dense consistency.
3	**Sandstone**	0.73 +	Inferred moderately weathered, low strength sandstone grading stronger with depth.

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

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

The site generally comprises a stepped sandstone and colluvial slope. Rock out cropping is present across the slope. Minor colluvial lobes were noted, however large and developed colluvial terracing is not typical of the site conditions.

Rock outcrops typically comprise medium to coarse grained, medium to high strength Hawkesbury Sandstone. Undercuts up to 2 m depth were noted within the outcropping sandstone. Piers for the house are typically founded on exposed sandstone outcrops. One pier was noted on outcropping sandstone directly above a minor sandstone undercut (see **Figures 5** and **6**).

Cracking was noted within the northern boundary blockwork wall (see **Figure 1**). This is inferred to have resulted from differential foundation conditions between sandstone and colluvial material.

Figure 1: Crack in Northern Boundary Wall

Figure 2: View down slope

Figure 3: Upper level piers on rock outcrops

Figure 4: BH1 Location

Figure 5: Pier founded above rock overhang

Figure 6: Pier on undercut rock shelf viewed to the north

Figure 7: Sandstone overhang through boundary wall

3.0 Advice and Recommendations

3.1 Excavations

Excavations up to approximately 2.5 m depth will be required for the development. Temporary batter slopes of 1H:1V will be possible for Unit 1 and 2 material provided that surface water is diverted away from the batter faces and batter heights are kept to less than 3 m. Permanent batters of 2H:1V may be employed for Unit 1 and 2 material. Permanent batters will require surface protection or revegetation to prevent erosion and slaking. Unit 3 sandstone may be cut vertically without support provided that geotechnical inspections are undertaken during construction at no greater than 1 m depth intervals to ensure that isolated blocks and wedges are not present within the rock cutting. If blocks and wedges are present isolated spot bolting or shotcreting may be required as support.

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

TABLE 2 EARTH PRESSURE PARAMETERS

Material		Unit 1 Colluvium	Unit 2 Residual Soil	Unit 3 Sandstone
Bulk Unit Weight (kN/m^3)		16	17	23
Earth Pressure Coefficients	At rest, K_o	0.55	0.44	0.25
	Passive, K_p	2.66	3.54	4.50
	Active, K_a	0.38	0.28	0.15

Notes:

1 Unit Weight is based on visual assessment only, order of accuracy is approximately ±10%.

2 Earth pressures are provided on the assumption that the ground behind the retaining wall is flat and drained.

3.2 Soil and Rock Excavatability

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

TABLE 3 SOIL AND ROCK EXCAVATABILITY

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

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

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

3.3 Excavation Vibration Considerations

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

TABLE 4 RECOMMENDED SAFE WORKING DISTANCES FOR VIBRATION INTENSIVE PLANT

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

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

- Saw cutting of the perimeter of the excavation;
- Saw cutting parallel to the perimeter of the excavation at 0.5 to 1.0 m offsets to the perimeter;
- A maximum hydraulic hammer size of 900 kg used at 50% of full operational capacity. Hammering is to be limited to 3 second bursts with a pause of at least 3 seconds between bursts;

- The orientation of rock breaking equipment in a direction away from property boundaries towards existing excavation; and
- Monitoring of vibration at the nearest residential receptor.

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

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

3.4 Foundation Design

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

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

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

TABLE 5 PAD FOOTING AND PILE DESIGN PARAMETERS

Material		Weathered Sandstone
Allowable Bearing Pressure (kPa)		500
Ultimate Vertical End Bearing Pressure (kPa)		1500
Elastic Modulus (MPa)		80
Ultimate Shaft Adhesion (kPa)	In Compression	120
	In Tension	60
Susceptibility to Liquefaction during an Earthquake		Low

Notes:

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

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

3.2 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; and
- a hazard factor (z) of 0.08 for Sydney.

3.3 Slope Risk Assessment

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

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

3.3.1 Potential Slope Hazards

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

Hazard 1: Failure of the developed sandstone overhang with pier above.

Hazard 2: Failure of northern boundary wall.

Hazard 3: Failure of small overhangs downslope of development.

Hazard 4: Global failure of slope below proposed development extending through the development.

3.3.2 Assessed Risk Level for Property Damage

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

TABLE 6 SEMI-QUANTITATIVE ASSESSMENT FOR PROPERTY DAMAGE

Hazard	Likelihood (Indicative value of annual probability)	Consequence (Indicative Value)	Assessed Risk Level
Hazard 1	Possible (1×10^{-3})	Minor (5%)	**Medium**
Hazard 2	Unlikely (1×10^{-4})	Minor (5%)	**Low**
Hazard 3	Possible (1×10^{-3})	Insignificant (0.5%)	**Very Low**
Hazard 4	Barely Credible (1×10^{-6})	Major (60%)	**Very Low**

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

3.3.3 Assessed Risk Level for Loss of Life

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

TABLE 7 QUANTITATIVE ASSESSMENT FOR LOSS OF LIFE

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

The assessed maximum risk to loss of life according to the quantitative risk assessment is 1×10^{-6}.

3.3.4 Pre Development Risk Levels

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

The annual probability of loss of life for the person most at risk as a result of slope instability impacting the site is calculated to be less than 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.

3.3.5 Recommended Construction Procedures to Minimise Identified Risks

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

- Any excavations greater than 1.0 m depth opened for the installation of footings or services should be inspected by an experienced geotechnical engineer and adverse features within the rock mass, including but not limited to inclined joints, decomposed seams, wedges, blocks or highly fractured zones, should be identified and mapped. Stabilisation measures should be proposed by the geotechnical engineer and undertaken prior to the excavation proceeding.
- Surface water flow should be directed away from construction areas and the crests of retaining walls during the works.
- Drainage must be maintained behind any retaining walls and should be inspected following construction to ensure that it remains clear.
- Stormwater for the proposed extension should be connected to existing stormwater systems for disposal. New infiltration systems are not recommended for the site.
- **The undercut sandstone block currently supporting a pier (Figure 5) should be propped to sandstone material below. Propping may be achieved by construction of a strip footing on the sandstone boulder below the undercut and placement of blockwork blade walls between the boulder and the undercut block. Consultation should take place between the project structural and geotechnical engineers for design of loading on the props and placement of the props.**

3.3.6 Anticipated Risk Level Post Development

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

- Low for risk of damage to property; and
- 1×10^{-6} for risk of loss of life.

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

4.0 Closure

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

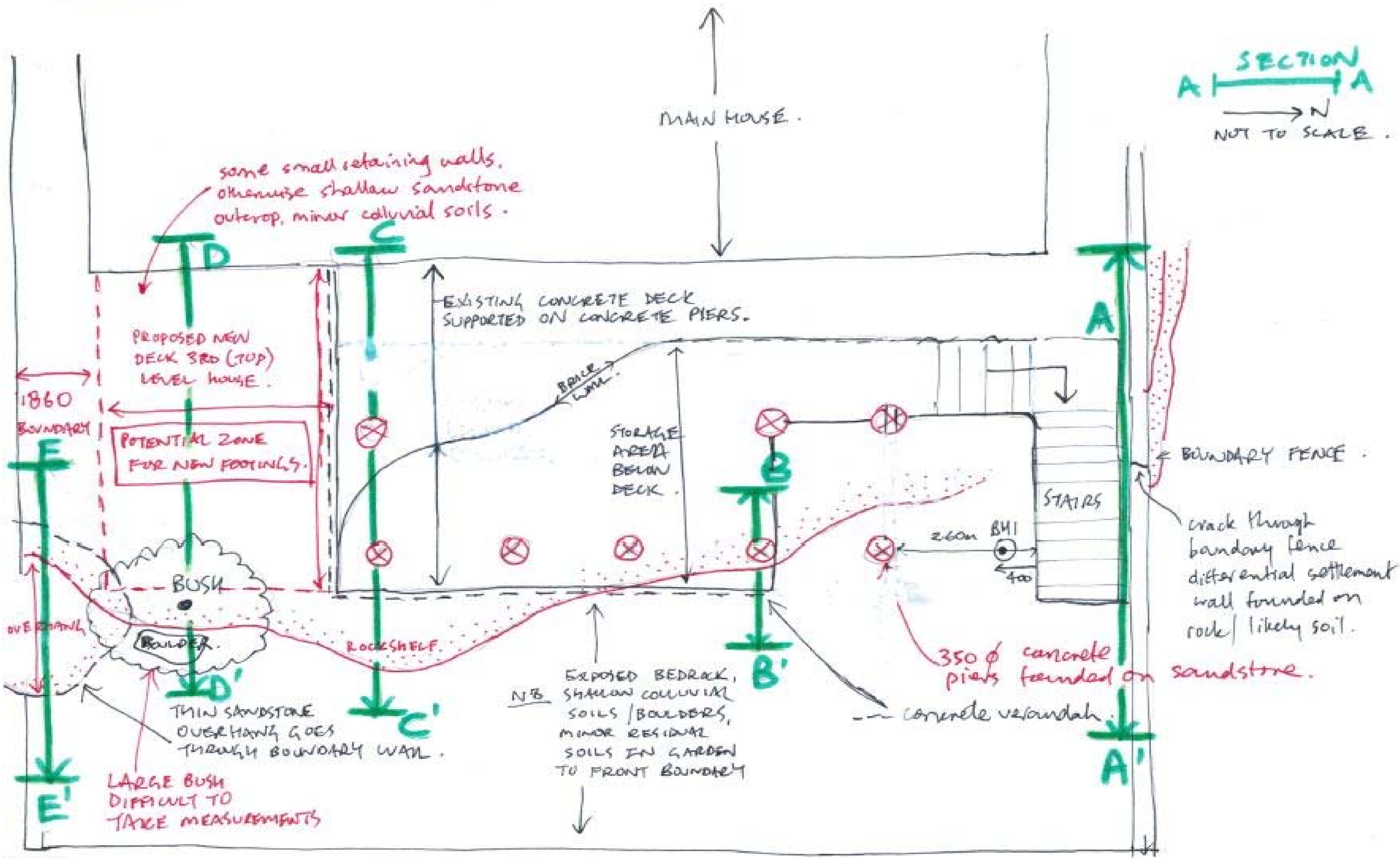
Please do not hesitate to contact Morrow Geotechnics if you have any questions about the contents of this report.

For and on behalf of Morrow Geotechnics Pty Ltd,

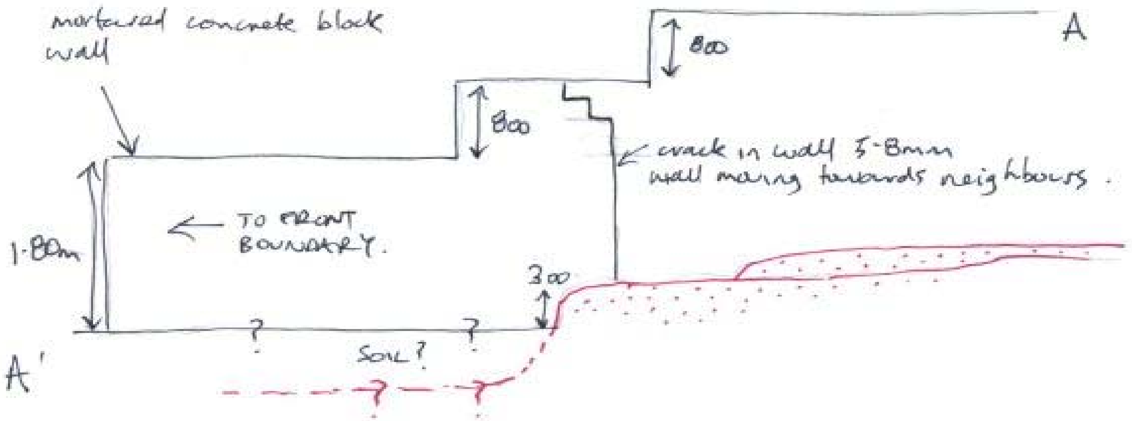
Alan Morrow
Senior Geotechnical Engineer

Attached: Important Information

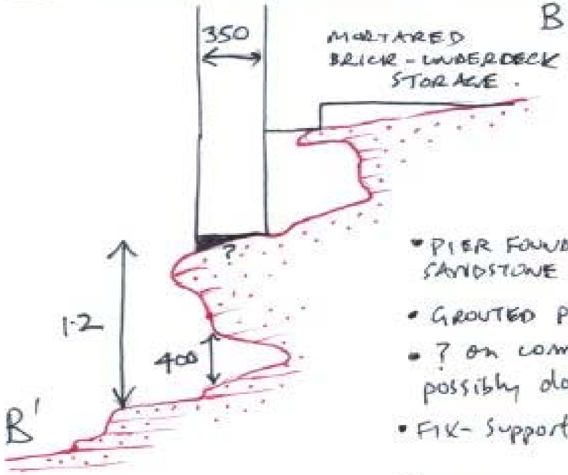
SITE PLAN: 8 BEVERLEY PLACE, CURL CURL.



morrow PO Box 4069, Carlton NSW 2218 P: 0405 843 933 | E: info@morrowgeo.com.au	Drawn	MK/ZS	**Helen Bruen** 8 Beverley Place, Curl Curl NSW Geotechnical Investigation Borehole Location Plan	Figure: **1**
	Approved	AM		
	Date	30/10/2019		Project: P1784
	Scale	NTS		



- cracking in wall most likely poorly founded section of wall downslope from sandstone.
- low risk failure (immediate)
- will develop over time.
- underpin lower section wall to rock.



- PIER FOUNDED ON UNDERCUT SANDSTONE ROCKSHELF.
- GROUTED PAD ONTO SURFACE.
- ? on connection with pier to rock possibly dowled into rock.
- FIX - support undercut (blockwork).
- STRUCTURAL ENGINEER TO CHECK ADEQUACY OF EXISTING PIERS TO ACCEPT ADDITIONAL LOADINGS.

SECTIONS A A' B B'

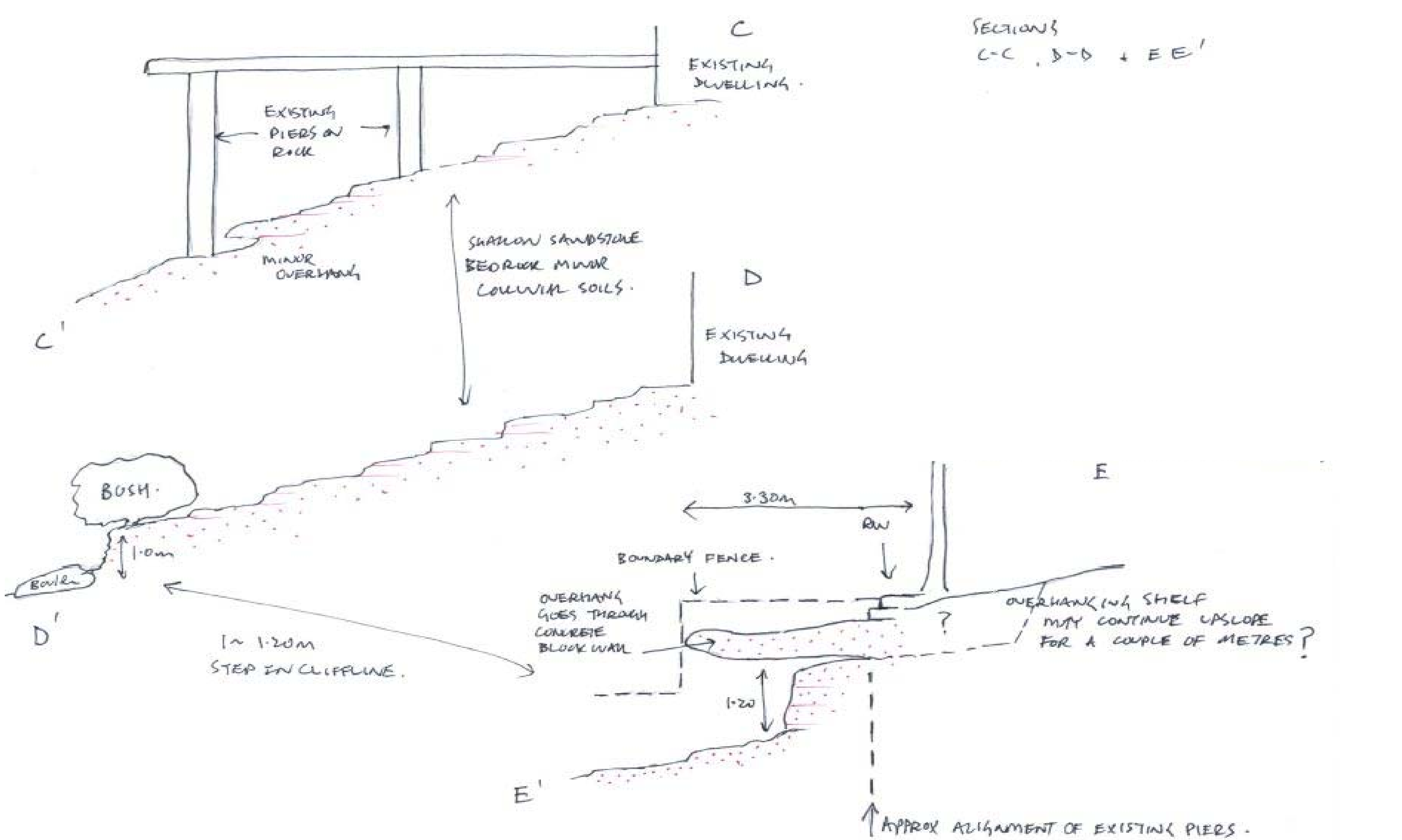
morrow
PO Box 4069, Carlton NSW 2218
P: 0405 843 933 | E: info@morrowgeo.com.au

Drawn	MK/ZS
Approved	AM
Date	30/10/2019
Scale	NTS

Helen Bruen
8 Beverley Place, Curl Curl NSW
Geotechnical Investigation
Borehole Location Plan

Figure: **2-1**

Project: P1784



morrow	Drawn	MK/ZS	**Helen Bruen** 8 Beverley Place, Curl Curl NSW Geotechnical Investigation Borehole Location Plan	Figure: **2-2**
	Approved	AM		
PO Box 4069, Carlton NSW 2218	Date	30/10/2019		
P: 0405 843 933 | E: info@morrowgeo.com.au	Scale	NTS		Project: P1784

Project No:	P1784	Contractor:	MG
Client:	Helen Bruen	Drill Rig:	Hand Auger
Project:	8 Beverley Place Curl Curl NSW	Sheet	1 of 1
		Logged:	MK
		Date:	23/01/2019

morrow

BH1

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	0.25	COLLUVIAL SOIL / FILL - SAND, fine to coarse grained, brown, trace dark brown silt, trace fine to coarse grained sandstone gravel	L	M	
				SC	0.50 0.75	RESIDUAL SOIL - SAND, fine to coarse grained, orange, trace silt / clay - Becoming orange / white then white	MD	M	
					1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00	BH1 terminated at 0.73m Practical Hand Auger Refusal on fine to coarse grained sandstone (in situ bedrock or boulder)			

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

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

This Document has been prepared for the particular purpose outlined in Morrow Geotechnics' proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

The scope and the period of Morrow Geotechnics' Services are as described in Morrow Geotechnics' proposal, and are subject to restrictions and limitations. Morrow Geotechnics did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Document. The scope of services may have been limited by such factors as time, budget, site access or other site conditions. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by Morrow Geotechnics in regards to it. Any advice given within this document is limited to geotechnical considerations only. Other constraints particular to the project, including but not limited to architectural, environment, heritage and planning matters may apply and should be assessed independently of this advice.

Conditions may exist which were undetectable given the limited nature of the enquiry Morrow Geotechnics was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required. No geotechnical investigation can provide a full understanding of all possible subsurface details and anomalies at a site.

In addition, it is recognised that the passage of time affects the information and assessment provided in this Document. Morrow Geotechnics' opinions are based upon information that existed at the time of the production of the Document. It is understood that the Services provided allowed Morrow Geotechnics to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Morrow Geotechnics for incomplete or inaccurate data supplied by others.

Where ground conditions encountered at the site differ significantly from those anticipated in the report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the report that Morrow Geotechnics be notified of any variations and be provided with an opportunity to review the recommendations of this report.

This Document is provided for sole use by the Client and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Morrow Geotechnics accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Document.