STS GeoEnvironmental Pty Ltd
Geotechnical and Environmental Solutions

GEOTECHNICAL INVESTIGATION

FOR

MICRO NEST PTY LIMITED

195 – 197 Sydney Road, Fairlight, New South Wales

Report No: 18/2653

Project No: 21555/0051D

August 2018

14/1 Cowpasture Place, Wetherill Park, NSW 2164, Australia
(PO Box 6989, Wetherill Park, NSW 2164, Australia)
T +61 2 9756 2166 | **F** +61 2 9756 1137
www.stsgeo.com.au | enquiries@stsgeo.com.au
ABN 61 162 976 543 | **ACN** 162 976 543

Table of Contents

1. INTRODUCTION

This report presents the results of a geotechnical investigation carried out by STS GeoEnvironmental Pty Limited (STS) for a proposed new residential development to be constructed at 195 - 197 Sydney Road, Fairlight. We have been informed the development comprises demolition of existing structures on the site prior to construction of four level residential unit development. The units are constructed over four (4) buildings with a single communal basement car park. Construction of the basement car park will require excavating up to 10.0 metres below existing ground surface levels along the southern basement wall, however due to the slope of the site the basement will be roughly at-grade with the kerb line of Sydney Road.

The purpose of the investigation was to:

- assess the subsurface conditions over the site,
- provide a site classification to AS2870,
- provide recommendations regarding the appropriate foundation system for the site including design parameters,
- provide parameters for the temporary and permanent support of the excavation, and
- provide recommendations regarding vibration control during rock excavation.

The investigation was undertaken at the request of Micro Nest Pty Limited.

Our scope of work did not include a contamination assessment.

2. FIELDWORK DETAILS

The fieldwork consisted of a detailed site inspection followed by the drilling of four (4) boreholes numbered BH1 to BH4, inclusive, at the locations shown on Drawing No. 18/2653. Restricted site access dictated the borehole locations. ***Due to restricted site access, all boreholes were drilled using a hand auger.*** In order to assess soil strengths, Dynamic Cone Penetrometer (DCP) tests were undertaken at each borehole location.

Fieldwork operations were undertaken by one of STS's Senior Engineering Geologists who also logged the subsurface conditions encountered.

The subsurface conditions observed are recorded on the borehole logs given in Appendix A. An explanation of the terms used on the logs is also given in Appendix A. Notes relating to geotechnical reports are also attached.

3. GEOLOGY AND SITE CONDITIONS

The Sydney geological series sheet, at a scale of 1:100,000 shows the site is underlain by Triassic Age Hawkesbury Sandstone. Rocks within this formation typically comprise medium to coarse grained quartz sandstone with minor shale and laminite lenses.

The site is located on the southern side of Sydney Road and comprises a roughly rectangular residential parcel of land with a combined area of approximately 1,789m^2. At the time of the inspection the site was occupied by a series of single level brick cottages with sandstone block foundations, tile and metal roofs, separate brick laundries and separate brick garages. There are several brick rendered retaining walls and sandstone block retaining walls on the site together with numerous in-situ sandstone exposures, particularly at the rear of the existing dwellings.

To the south of the site are multi-level residential units, to the east of the site is a one and two storey brick rendered house and to the west of the site is are double storey brick and rendered residential units.

The ground surface over the entire site slopes towards the north. The fall over the site is approximately 10 metres.

Site vegetation comprises grass lawns, trees, bushes and shrubs. There are trees on adjacent properties. There is sandstone bedrock outcropping on the site and there are significant vertical exposures of sandstone bedrock in the near vicinity.

The western site boundary of No.197 is demarked by a natural cliff line. The cliff increases in height to the south with a maximum height of approximately seven (7) metres. The cliff face comprises minor topsoil and fill overlying massive Hawkesbury Sandstone bedrock. The bedrock includes some vertical joints and weathered seams. Annotated photographs of the cliff are attached in Appendix A.

4. SUBSURFACE CONDITIONS

When assessing the subsurface conditions across a site from a limited number of boreholes, there is the possibility that variations may occur between test locations. The data derived from the site investigation programme are extrapolated across the site to form a geological model and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour regarding the proposed development. The actual condition at the site may differ from those inferred, since no subsurface exploration programme, no matter how comprehensive, can reveal all subsurface details and anomalies.

The subsurface conditions generally consist of topsoil and fill directly overlying sandstone bedrock. Topsoil and fill were encountered across the site in all boreholes to depths of 0.1 to 0.45 metres. Weathered sandstone directly underlies the topsoil and fill and could not be penetrated with the hand auger.

Groundwater seepage was not observed during drilling of the boreholes and no seepage was observed in the adjacent cliff face. Due to the shallow nature of the sandstone bedrock no long-term groundwater monitoring was carried out.

5. DISCUSSION

5.1. Site Classification to AS2870

The classification has been prepared in accordance with the guidelines set out in the "Residential Slabs and Footings" Code, AS2870 – 2011.

Provided the recommendations given below are adopted and the footings bear in the underlying weathered sandstone bedrock, the site may be classified a *stable site (A).*

5.2. Excavation Conditions and Support

Based on the conditions observed in the boreholes and our general experience in this geological environment, it is expected that excavations on this site will likely encounter medium to high strength sandstone at relatively shallow depths. Typically, the Hawkesbury Sandstone is horizontally bedded with sub- vertical joints. This type of profile can be observed in many places in Sydney where Hawkesbury Sandstone is exposed.

Excavators alone without assistance will not be able to remove any significant amount of the rock. Hydraulic breakers mounted on an excavator or jack hammers will be required to break up the majority of the rock before it can be removed using an excavator.

Particular care will be required to ensure that buildings or other developments on adjacent properties are not damaged when excavating the rock. The structures on the adjacent properties are likely to be founded directly on the sandstone. Buildings founded directly on rock can often be very susceptible to damage from vibrations.

Excavations methods should be adopted which limit ground vibrations at the adjoining developments to not more than 10 mm/sec. Vibration monitoring will be required to verify that this is achieved. However, if the contractor adopts methods and/or equipment in accordance with the recommendations in Table 5.1 for a ground vibration limit of 5 mm/sec, vibration monitoring may not be required.

The limits of 5 mm/sec and 10 mm/sec are expected to be achievable if rock breaker equipment or other excavation methods are restricted as indicated in Table 5.1.

At all times, the excavation equipment must be operated by experienced personnel, according to the manufacturer's instructions and in a manner consistent with minimising vibration effects.

Table 5.1 – Recommendations for Rock Breaking Equipment

Distance from adjoining structure (m)	Maximum Peak Particle Velocity 5 mm/sec		Maximum Peak Particle Velocity 10 mm/sec	
	Equipment	Operating Limit (% of Maximum Capacity)	Equipment	Operating Limit (% of Maximum Capacity)
1.5 to 2.5	Hand operated jackhammer only	100	300 kg rock hammer	50
2.5 to 5.0	300 kg rock hammer	50	300 kg rock hammer or 600 kg rock hammer	100 50
5.0 to 10.0	300 kg rock hammer or 600 kg rock hammer	100 50	600 kg rock hammer or 900 kg rock hammer	100 50

*Vibration monitoring is recommended for 10 mm/sec vibration limit.

Use of other techniques (e.g. grinding, rock sawing), although less productive, would reduce or possibly eliminate risks of damage to property through vibration effects transmitted via the ground. Such techniques may be considered if an alternative to rock breaking is required.

If rock sawing is carried out around excavation boundaries in not less than 1 metre deep lifts, a 900 kg rock hammer could be used at up to 100% maximum operating capacity with an assessed peak particle velocity not exceeding 5 mm/sec, subject to observation and confirmation by a geotechnical engineer at the commencement of excavation.

It should be noted that vibrations that are below threshold levels for building damage may be experienced at adjoining developments.

Saw cutting should be carried out before any rock breaking is commenced on the site. It would be appropriate before commencing excavation to undertake a dilapidation survey of any adjacent structures that may potentially be damaged. This will provide a reasonable basis for assessing any future claims of damage.

Excavations in competent sandstone should remain stable unsupported, at least in the short term. In some areas, support using rock bolts, shotcrete and/or underpinning using brick piers or infill concrete may be necessary. The latter would only normally be required if blocks fall out near to the boundary lines.

Until the excavation is commenced and the actual conditions are exposed it is not practical to be more definitive. The sandstone bedrock may include some joints. If joints are continuous they could form wedges which may need to be supported with bolts. If boulders extend beyond site boundaries then they will need to be trimmed and supported. As noted above particular care will be required when excavating close to boundaries. This work should be carried out in small sections so that the subsurface conditions can be identified and any appropriate shoring or support can be installed before too large an area is exposed.

Consideration will need to be given to the installation of temporary hording or netting along the western site boundary to ensure blocks of sandstone do not fall into the adjacent site during excavation of the cliff edge.

It is recommended that an experienced engineering geologist or geotechnical engineer observes the excavation as it progresses. At that time, they will be able to recommend any support that is required for either temporary or permanent conditions and help to finalise the design of the final cut slopes and any retaining walls that may be required.

All loosened rocks should either be stabilised or removed from the sides of the excavation as it proceeds. If floaters are encountered care will be required as they can often be sizeable in this geological environment, appearing to be part of the “solid” rock profile.

Temporary slopes in the shallow soil cover of 1.5:1 (Horizontal : Vertical) should remain stable. In the long term this material must be retained. Retaining walls supporting any significant depth of soil can be designed assuming an earth pressure of 0.4.

As noted above, experience has demonstrated that near vertical cuts in the competent in-situ sandstone found in this area will normally remain stable for long lengths of time. An allowance should be made at this time for the installation of some passive grouted dowels in conjunction with shotcrete, and possibly a limited number of rock bolts. Also if shaley seams are encountered they will need to be protected from long term undercutting using shotcrete and pins or infill concrete cut into the face. Even with the above support there is always the chance that some small blocks which are not identified during excavation will become dislodged later with time. If you are considering permanent unsupported vertical cuts it is essential that the excavation boundary lines are first cut using a rock saw to create a clean face. The use of hydraulic rock hammers to create final permanent cut faces is not recommended as the hammers may induce fractures in the rock that may require long term support.

An alternative to leaving the rock face exposed is to design perimeter walls to support the excavation in the long term. A nominal loading of 10 kPa on average, would be appropriate for permanent vertical sides rock cuts. The space between the rock face and the back of the walls could be filled with free draining hard igneous rock with an appropriate large agriculture drain installed at the toe. This may help to relieve the potential for damp penetrating the external walls.

A layer of geofabric would help to stop any long term clogging of the backfill. The retaining wall approach will significantly reduce the need for dowels and shotcrete.

5.3. Foundation Design

The allowable bearing pressures given below have been determined using the procedures given by Pells et al, in their paper titled "Design Loadings for Foundations on Shale and Sandstone in the Sydney Region," published in the Australian Geomechanics Journal, 1998.

The onsite sandstone is assessed to be Class IV Sandstone or better. Pad/strip footings or piles founded on this material may be proportioned using an allowable bearing pressure of 1,000 kPa. For piles an allowable adhesion of 100 kPa may be adopted for the portion of the pile shaft within the weathered sandstone.

Due to their variable nature and distribution across the site, the soils are not considered suitable for foundation support.

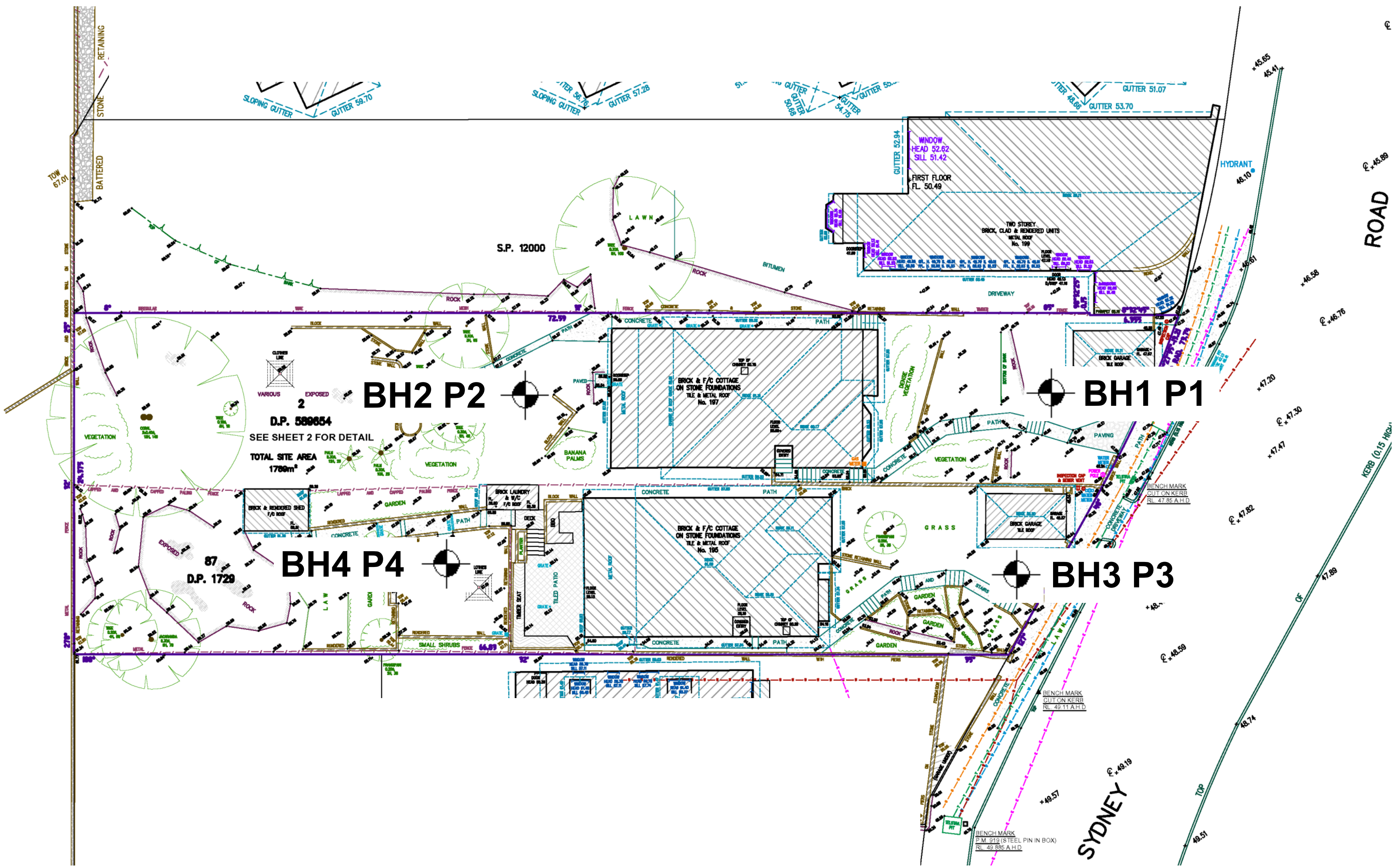
In order to ensure the bearing values given can be achieved, care should be taken to ensure that the base of excavations are free of all loose material prior to concreting. It is recommended that all footing excavations be protected with a layer of blinding concrete as soon as possible, preferably immediately after excavating, cleaning, inspection and approval. The possible presence of groundwater needs to be considered when drilling piles and pouring concrete.

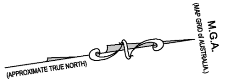
6. FINAL COMMENTS

During construction, should the subsurface conditions vary from those inferred above, we would be contacted to determine if any changes should be made to our recommendations.

As discussed above, it is recommended the excavation is inspected regularly as it progresses. Also the exposed bearing surfaces for footings should be inspected by a geotechnical engineer to ensure the allowable pressure given has been achieved.

Matt Green
Senior Engineering Geologist





STS GeoEnvironmental Pty. Ltd. | Scale: Unknown | Date: August 2018

Client: MICRO NEST PTY LIMITED

GEOTECHNICAL INVESTIGATION
195-197 SYDNEY ROAD, FAIRLIGHT
BOREHOLE AND PENETROMETER LOCATIONS

Project No.
21555/0051D

Drawing No: 18/2653

NOTES RELATING TO GEOTECHNICAL REPORTS

Introduction

These notes have been provided to outline the methodology and limitations inherent in geotechnical reporting. The issues discussed are not relevant to all reports and further advice should be sought if there are any queries regarding any advice or report.

When copies of reports are made, they should be reproduced in full.

Geotechnical Reports

Geotechnical reports are prepared by qualified personnel on the information supplied or obtained and are based on current engineering standards of interpretation and analysis.

Information may be gained from limited subsurface testing, surface observations, previous work and is supplemented by knowledge of the local geology and experience of the range of properties that may be exhibited by the materials present. For this reason, geotechnical reports should be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Where the report has been prepared for a specific purpose (eg. design of a three-storey building), the information and interpretation may not be appropriate if the design is changed (eg. a twenty storey building). In such cases, the report and the sufficiency of the existing work should be reviewed by SMEC Testing Services Pty Limited in the light of the new proposal.

Every care is taken with the report content, however, it is not always possible to anticipate or assume responsibility for the following conditions:

- Unexpected variations in ground conditions. The potential for this depends on the amount of investigative work undertaken.
- Changes in policy or interpretation by statutory authorities.
- The actions of contractors responding to commercial pressures.

If these occur, SMEC Testing Services Pty Limited would be pleased to resolve the matter through further investigation, analysis or advice.

Unforeseen Conditions

Should conditions encountered on site differ markedly from those anticipated from the information contained in the report, SMEC Testing Services Pty Limited should be notified immediately. Early identification of site anomalies generally results in any problems being more readily resolved and allows re-interpretation and assessment of the implications for future work.

Subsurface Information

Logs of a borehole, recovered core, test pit, excavated face or cone penetration test are an engineering and/or geological interpretation of the subsurface conditions. The reliability of the logged information depends on the drilling/testing method, sampling and/or observation spacings and the ground conditions. It is not always possible or economic to obtain continuous high quality data. It should also be recognised that the volume or material observed or tested is only a fraction of the total subsurface profile.

Interpretation of subsurface information and application to design and construction must take into consideration the spacing of the test locations, the frequency of observations and testing, and the possibility that geological boundaries may vary between observation points.

Groundwater observations and measurements outside of specially designed and constructed piezometers should be treated with care for the following reasons:

- In low permeability soils groundwater may not seep into an excavation or bore in the short time it is left open.
- A localised perched water table may not represent the true water table.
- Groundwater levels vary according to rainfall events or season.
- Some drilling and testing procedures mask or prevent groundwater inflow.

The installation of piezometers and long term monitoring of groundwater levels may be required to adequately identify groundwater conditions.

Supply of Geotechnical Information or Tendering Purposes

It is recommended tenderers are provided with as much geological and geotechnical information that is available and that where there are uncertainties regarding the ground conditions, prospective tenders should be provided with comments discussing the range of likely conditions in addition to the investigation data.

APPENDIX A – BOREHOLE LOGS, SITE PHOTOGRAPHS AND EXPLANATION SHEETS

STS GeoEnvironmental Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Micro Nest Pty Limited	Project: 21155/0051D	**BOREHOLE NO.: BH 1**
Project: 195-197 Sydney Road, Fairlight	Date : August 29, 2018	
Location: Refer to Drawing No. 18/2653	Logged: MG Checked By: LWI	Sheet 1 of 1

WATER TABLE	**SAMPLES**	**DEPTH** (m)	**DESCRIPTION OF DRILLED PRODUCT** (Soil type, colour, grain size, plasticity, minor components, observations)	**SYMBOL**	**CONSISTENCY** (cohesive soils) or **RELATIVE DENSITY** (sands and gravels)	**MOISTURE**
N/E	-		TOPSOIL: SILTY SAND: grey brown, fine grained with medium to coarse grained sandstone gravel	SM		D
			HAND AUGER REFUSAL AT 0.1 M ON WEATHERED SANDSTONE BEDROCK			
		0.5				
		1.0				
		1.5				
		2.0				
		2.5				

D - disturbed sample	U - undisturbed tube sample	B - bulk sample	Contractor: STS
WT - level of water table or free water		N - Standard Penetration Test (SPT)	Equipment: Hand Auger
S - jar sample			Hole Diameter (mm): 62
NOTES:	See explanation sheets for meaning of all descriptive terms and symbols		Angle from Vertical (^{o}): 0
			Drill Bit: V

STS GeoEnvironmental Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Micro Nest Pty Limited Project: 195-197 Sydney Road, Fairlight Location: Refer to Drawing No. 18/2653	Project: 21155/0051D Date : August 29, 2018 Logged: MG Checked By: LWI	**BOREHOLE NO.: BH 2** Sheet 1 of 1

WATER TABLE	**SAMPLES**	**DEPTH** (m)	**DESCRIPTION OF DRILLED PRODUCT** (Soil type, colour, grain size, plasticity, minor components, observations)	**SYMBOL**	**CONSISTENCY** (cohesive soils) or **RELATIVE DENSITY** (sands and gravels)	**MOISTURE**
N/E	-		TOPSOIL/FILL: SILTY SAND: orange brown, fine to medium grained with sandstone gravel, glass and brick	SM		D
			HAND AUGER REFUSAL AT 0.35 M ON WEATHERED SANDSTONE BEDROCK			
		0.5				
		1.0				
		1.5				
		2.0				
		2.5				

D - disturbed sample WT - level of water table or free water S - jar sample	U - undisturbed tube sample	B - bulk sample N - Standard Penetration Test (SPT)

Contractor: STS
Equipment: Hand Auger
Hole Diameter (mm): 62
Angle from Vertical (^{o}): 0
Drill Bit: V

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Micro Nest Pty Limited Project: 195-197 Sydney Road, Fairlight Location: Refer to Drawing No. 18/2653	Project: 21155/0051D Date : August 29, 2018 Logged: MG Checked By: LWI	**BOREHOLE NO.: BH 3** Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
N/E	-		TOPSOIL: SILTY SAND: brown, fine to medium grained with rootlets (grass cover)	SM		D
			FILL: GRAVELY SILTY SAND: orange to grey brown, fine to medium grained with sandstone gravel	SM		D
			HAND AUGER REFUSAL AT 0.4 M ON WEATHERED SANDSTONE BEDROCK			
		0.5				
		1.0				
		1.5				
		2.0				
		2.5				

D - disturbed sample WT - level of water table or free water S - jar sample	U - undisturbed tube sample	B - bulk sample N - Standard Penetration Test (SPT)

Contractor: STS
Equipment: Hand Auger
Hole Diameter (mm): 62
Angle from Vertical (^{o}): 0
Drill Bit: V

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

STS GeoEnvironmental Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Micro Nest Pty Limited Project: 195-197 Sydney Road, Fairlight Location: Refer to Drawing No. 18/2653	Project: 21155/0051D Date : August 29, 2018 Logged: MG Checked By: LWI	**BOREHOLE NO.: BH 4** Sheet 1 of 1

WATER TABLE	**SAMPLES**	**DEPTH** (m)	**DESCRIPTION OF DRILLED PRODUCT** (Soil type, colour, grain size, plasticity, minor components, observations)	**SYMBOL**	**CONSISTENCY** (cohesive soils) or **RELATIVE DENSITY** (sands and gravels)	**MOISTURE**
N/E	-		TOPSOIL: SILTY SAND: brown, fine to medium grained with rootlets (grass cover)	SM		D
			FILL: GRAVELY SILTY SAND: grey brown, fine to medium grained with sandstone gravel	SM		D
		0.5	HAND AUGER REFUSAL AT 0.45 M ON WEATHERED SANDSTONE BEDROCK			
		1.0				
		1.5				
		2.0				
		2.5				

D - disturbed sample U - undisturbed tube sample B - bulk sample WT - level of water table or free water N - Standard Penetration Test (SPT) S - jar sample	Contractor: STS Equipment: Hand Auger Hole Diameter (mm): 62
NOTES: See explanation sheets for meaning of all descriptive terms and symbols	Angle from Vertical (°): 0 Drill Bit: V

SMEC Testing Services Pty Ltd
14/1 Cowpasture Place, Wetherill Park NSW 2164
Phone: (02)9756 2166 Fax: (02)9756 1137 Email: enquiries@smectesting.com.au

Dynamic Cone Penetrometer Test Report

Project: 195-197 SYDNEY ROAD, FAIRLIGHT	Project No.: 21555/0051D
Client: MICRO NEST PTY LIMITED	Report No.: 18/2653
Address: Levewl 19, 207 Kent Street, Sydney	Report Date: 30/8/2018
Test Method: AS 1289.6.3.2	Page: 1 of 1

Site No.	P1	P2	Pe	P4		
Location	Refer to Drawing No. 18/2653	Refer to Drawing No. 18/2653	Refer to Drawing No. 18/2653	Refer to Drawing No. 18/2653		
Starting Level	Surface Level	Surface Level	Surface Level	Surface Level		
Depth (m)	Penetration Resistance (blows / 150mm)					
0.00 - 0.15	1	1	1	1		
0.15 - 0.30	Bouncing	2	2	1		
0.30 - 0.45		2	3	4		
0.45 - 0.60		Bouncing	Bouncing	Bouncing		
0.60 - 0.75						
0.75 - 0.90						
0.90 - 1.05						
1.05 - 1.20						
1.20 - 1.35						
1.35 - 1.50						
1.50 - 1.65						
1.65 - 1.80						
1.80 - 1.95						
1.95 - 2.10						
2.10 - 2.25						
2.25 - 2.40						
2.40 - 2.55						
2.55 - 2.70						
2.70 - 2.85						
2.85 - 3.00						
3.00 - 3.15						
3.15 - 3.30						
3.30 - 3.45						
3.45 - 3.60						
3.60 - 3.75						

Remarks: * Pre drilled prior to testing

NATA Accredited Laboratory Number 2750
Accredited for compliance with ISO/IEC 17025
The results of tests, calibrations and / or measurements included in this document are traceable to Australian / national standards
This document may not be reproduced, except in full

Approved Signatory.... ..

Technician: MG

Laurie Ihnativ - Manager

PROJECT: 195 - 197 SYDNEY ROAD, FAIRLIGHT
PROJECT No:21555/0051D
REPORT No:18/2653
TITLE: CLIFF PRESENT ALONG WESTERN BOUNDARY

GEOENVIRONMENTAL PTY LTD
Geotechnical and Environmental Solutions

No.197 Sydney Road

Overlying bedded sandstone bedrock with sub-vertical jointing and weathered seams

Possible cliff stabilisation blocks

Underlying massive sandstone bedrock

PROJECT: 195 - 197 SYDNEY ROAD, FAIRLIGHT
PROJECT No:21555/0051D
REPORT No:18/2653
TITLE: CLIFF PRESENT ALONG WESTERN BOUNDARY

GEOENVIRONMENTAL PTY LTD
Geotechnical and Environmental Solutions

Trees and vegetation growing from the cliff face

Vertical jointing observed in the cliff face

E1. CLASSIFICATION OF SOILS

E1.1 Soil Classification and the Unified System

An assessment of the site conditions usually includes an appraisal of the data available by combining values of engineering properties obtained by the site investigation with descriptions, from visual observation of the materials present on site.

The system used by SMEC in the identification of soil is the Unified Soil Classification system (USC) which was developed by the US Army Corps of Engineers during World War II and has since gained international acceptance and has been adopted in its metricated form by the Standards Association of Australia.

The Australian Site Investigation Code (AS1726-1981, Appendix D) recommends that the description of a soil includes the USC group symbols which are an integral component of the system.

The soil description should contain the following information in order:

Soil composition

- SOIL NAME and USC classification symbol (IN BLOCK LETTERS)
- plasticity or particle characteristics
- colour
- secondary and minor constituents (name estimated proportion, plasticity or particle characteristics, colour

Soil condition

- moisture condition
- consistency or density index

Soil structure

- structure (zoning, defects, cementing)

Soil origin

interpretation based on observation eg FILL, TOPSOIL, RESIDUAL, ALLUVIUM.

E1.2 Soil Composition

(a) Soil Name and Classification Symbol

The USC system is summarised in Figure E1.2.1. The primary division separates soil types on the basis of particle size into:

- Coarse grained soils - more than 50% of the material less than 60 mm is larger than 0.06 mm (60 µm).

- Fine grained soils - more than 50% of the material less than 60 mm is smaller than 0.06 mm (60 µm).

Initial classification is by particle size as shown in Table E1.2.1. Further classification of fine grained soils is based on plasticity.

TABLE E1.2.1 - CLASSIFICATION BY PARTICLE SIZE

NAME	SUB-DIVISION	SIZE
Clay (1)		< 2 µm
Silt (2)		2 µm to 60 µm
Sand	Fine Medium Coarse	60 µm to 200 µm 200 µm to 600 µm 600 µm to 2 mm
Gravel (3)	Fine Medium Coarse	2 mm to 6 mm 6 mm to 20 mm 20 mm to 60 mm
Cobbles (3)		60 mm to 200 mm
Boulders (3)		> 200 mm

Where a soil contains an appropriate amount of secondary material, the name includes each of the secondary components (greater than 12%) in increasing order of significance, eg sandy silty clay.

Minor components of a soil are included in the description by means of the terms “some” and “trace” as defined in Table E1.2.2.

TABLE E1.2.2 - MINOR SOIL COMPONENTS

TERM	DESCRIPTION	APPROXIMATE PROPORTION (%)
Trace	presence just detectable, little or no influence on soil properties	0-5
Some	presence easily detectable, little influence on soil properties	5-12

The USC group symbols should be included with each soil description as shown in Table E1.2.3

TABLE E1.2.3 - SOIL GROUP SYMBOLS

SOIL TYPE	PREFIX
Gravel	G
Sand	S
Silt	M
Clay	C
Organic	O
Peat	Pt

The group symbols are combined with qualifiers which indicate grading, plasticity or secondary components as shown on Table E1.2.4

TABLE E1.2.4 - SOIL GROUP QUALIFIERS

SUBGROUP	SUFFIX
Well graded	W
Poorly Graded	P
Silty	M
Clayey	C
Liquid Limit <50% - low to medium plasticity	L
Liquid Limit >50% - medium to high plasticity	H

(b) Grading

"Well graded"	Good representation of all particle sizes from the largest to the smallest.
"Poorly graded"	One or more intermediate sizes poorly represented
"Gap graded"	One or more intermediate sizes absent
"Uniformly graded"	Essentially single size material.

(c) Particle shape and texture

The shape and surface texture of the coarse grained particles should be described.

Angularity may be expressed as "rounded", "sub-rounded", "sub-angular" or "angular".

Particle **form** can be "equidimensional", "flat" or elongate".

Surface texture can be "glassy", "smooth", "rough", pitted" or striated".

(d) Colour

The colour of the soil should be described in the moist condition using simple terms such as:

Black	White	Grey	Red
Brown	Orange	Yellow	Green
Blue			

These may be modified as necessary by "light" or "dark". Borderline colours may be described as a combination of two colours, eg red-brown.

For soils that contain more than one colour terms such as:

- Speckled Very small (<10 mm dia) patches
- Mottled Irregular
- Blotched Large irregular (>75 mm dia)
- Streaked Randomly oriented streaks

(e) Minor Components

Secondary and minor components should be individually described in a similar manner to the dominant component.

E1.3 Soil Condition

(a) Moisture

Soil moisture condition is described as "dry", "moist" or "wet".

The moisture categories are defined as:
Dry (D) - Little or no moisture evident. Soils are running.
Moist (M) - Darkened in colour with cool feel. Granular soil particles tend to adhere. No free water evident upon remoulding of cohesive soils.

In addition the moisture content of cohesive soils can be estimated in relation to their liquid or plastic limit.

(b) Consistency

Estimates of the consistency of a clay or silt soil may be made from manual examination, hand penetrometer test, SPT results or from laboratory tests to determine undrained shear or unconfined compressive strengths. The classification of consistency is defined in Table E1.3.1.

TABLE E1.3.1 - CONSISTENCY OF FINE-GRAINED SOILS

TERM	UNCONFINED STRENGTH (kPa)	FIELD IDENTIFICATION
Very Soft	<25	Easily penetrated by fist. Sample exudes between fingers when squeezed in the fist.
Soft	25 - 50	Easily moulded in fingers. Easily penetrated 50 mm by thumb.
Firm	50 - 100	Can be moulded by strong pressure in the fingers. Penetrated only with great effort.
Stiff	100 - 200	Cannot be moulded in fingers. Indented by thumb but penetrated only with great effort.
Very Stiff	200 - 400	Very tough. Difficult to cut with knife. Readily indented with thumb nail.
Hard	>400	Brittle, can just be scratched with thumb nail. Tends to break into fragments.

Unconfined compressive strength as derived by a hand penetrometer can be taken as approximately double the undrained shear strength ($q_u = 2\ c_u$).

(c) Density Index

The insitu density index of granular soils can be assessed from the results of SPT or cone penetrometer tests. Density index should not be estimated visually.

TABLE E1.3.2 - DENSITY OF GRANULAR SOILS

TERM	SPT N VALUE	STATIC CONE VALUE q_c (MPa)	DENSITY INDEX (%)
Very Loose	0 - 3	0 - 2	0 - 15
Loose	3 - 8	2 - 5	15 - 35
Medium Dense	8 - 25	5 - 15	35 - 65
Dense	25 - 42	15 - 20	65 - 85
Very Dense	>42	>20	>85

E1.4 Soil Structure

(a) Zoning

A sample may consist of several zones differing in colour, grain size or other properties. Terms to classify these zones are:

Layer - continuous across exposure or sample
Lens - discontinuous with lenticular shape
Pocket - irregular inclusion
Each zone should be described, their distinguishing features, and the nature of the interzone boundaries.

(b) Defects

Defects which are present in the sample can include:

- fissures
- roots (containing organic matter)
- tubes (hollow)
- casts (infilled)

Defects should be described giving details of dimensions and frequency. Fissure orientation, planarity, surface condition and infilling should be noted. If there is a tendency to break into blocks, block dimensions should be recorded

E1.5 Soil Origin

Information which may be interpretative but which may contribute to the usefulness of the material description should be included. The most common interpreted feature is the origin of the soil. The assessment of the probable origin is based on the soil material description, soil structure and its relationship to other soil and rock materials.

Common terms used are:

"Residual Soil" - Material which appears to have been derived by weathering from the underlying rock. There is no evidence of transport.

"Colluvium" - Material which appears to have been transported from its original location. The method of movement is usually the combination of gravity and erosion.

"Landslide Debris" - An extreme form of colluvium where the soil has been transported by mass movement. The material is obviously distributed and contains distinct defects related to the slope failure.

"Alluvium" - Material which has been transported essentially by water. usually associated with former stream activity.

"Fill" - Material which has been transported and placed by man. This can range from natural soils which have been placed in a controlled manner in engineering construction to dumped waste material. A description of the constituents should include an assessment of the method of placement.

E1.6 Fine Grained Soils

The physical properties of fine grained soils are dominated by silts and clays.

The definition of clay and silt soils is governed by their Atterberg Limits. Clay soils are characterised by the properties of cohesion and plasticity with cohesion defines as the ability to deform without rupture. Silts exhibit cohesion but have low plasticity or are non-plastic.

The field characteristics of clay soils include:

- dry lumps have appreciable dry strength and cannot be powdered
- volume changes occur with moisture content variation
- feels smooth when moist with a greasy appearance when cut.

The field characteristics of silt soils include:

- dry lumps have negligible dry strength and can be powdered easily
- dilatancy - an increase in volume due to shearing - is indicted by the presence of a shiny film of water after a hand sample is shaken. The water disappears upon remoulding. Very fine grained sands may also exhibit dilatancy.
- low plasticity index
- feels gritty to the teeth

E1.7 Organic Soils

Organic soils are distinguished from other soils by their appreciable content of vegetable matter, usually derived from plant remains.

The soil usually has a distinctive smell and low bulk density.

The USC system uses the symbol Pt for partly decomposed organic material. The O symbol is combined with suffixes "O" or "H" depending on plasticity.

Where roots or root fibres are present their frequency and the depth to which they are encountered should be recorded. The presence of roots or root fibres does not necessarily mean the material is an "organic material" by classification.

Coal and lignite should be described as such and not simply as organic matter.