GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1 – To be submitted with Development Application

Development Application for BMN Properties Pty Ltd
Name of Applicant

Address of site 4 Forest Road, Warriewood NSW 2102

Declaration made by geotechnical engineer or engineering geologist or coastal engineer (where applicable) as part of a geotechnical report

I, David Willows *on behalf of* Willows Engineering Consultants Pty Ltd
(Insert Name) (Trading or Company Name)

on this the 9 December 2022 certify that I am a geotechnical engineer or engineering geologist or coastal engineer as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above organisation/company to issue this document and to certify that the organisation/company has a current professional indemnity policy of at least $2million.
I:

Please mark appropriate box

☒ have prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's *Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009*

☐ am willing to technically verify that the detailed Geotechnical Report referenced below has been prepared in accordance with the Australian Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009

☐ have examined the site and the proposed development in detail and have carried out a risk assessment in accordance with Section 6.0 of the Geotechnical Risk Management Policy for Pittwater - 2009. I confirm that the results of the risk assessment for the proposed development are in compliance with the Geotechnical Risk Management Policy for Pittwater - 2009 and further detailed geotechnical reporting is not required for the subject site.

☐ have examined the site and the proposed development/alteration in detail and I am of the opinion that the Development Application only involves Minor Development/Alteration that does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.

☐ have examined the site and the proposed development/alteration is separate from and is not affected by a Geotechnical Hazard and does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.

☐ have provided the coastal process and coastal forces analysis for inclusion in the Geotechnical Report

Geotechnical Report Details:

Report Title: Geotechnical Report for Proposed Residential Subdivision (ref: 2021010-R1)

Report Date: 9 December 2022

Author: David Willows

Author's Company/Organisation: Willows Engineering Consultants Pty Ltd

Documentation which relate to or are relied upon in report preparation:

Subdivision drawings by ACOR Consultants (ref: NSW210416), Issue 2 dated 29/11/22.
Preliminary Geotechnical Report by Alliance Geotechnical 3/08/2016 (ref: 2406-GR-1-1)

I am aware that the above Geotechnical Report, prepared for the abovementioned site is to be submitted in support of a Development Application for this site and will be relied on by Pittwater Council as the basis for ensuring that the Geotechnical Risk Management aspects of the proposed development have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature DWillows

Name David Willows

Chartered Professional Status CPEng (civil)

Membership No. 2417109

Company Willows Engineering Consultants Pty Ltd

WILLOWS ENGINEERING
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Geotechnical Report for Proposed Residential Subdivision

4 Forest Road, Warriewood NSW 2102

BMN Properties Pty Ltd

Report No. 2122010-R1 (Rev 01)
9 December 2022

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APPENDIX

Interpreted Geotechnical Model

Willows Engineering Drawings No. 2122010-SK1 (plan), SK2 (section) and SK3 (hazards)

Boreholes, test pits, groundwater monitoring and laboratory test results

Extracts from Alliance Geotechnical report (ref: 2406-GR-1-1, 3/08/16)

Extracts from Alliance Geotechnical reports (ref: 2406-GR-1-2, 26/05/17)

Extracts from Jefferey and Katauskas report (ref: 19312VBrpt, 14/04/2005).

Landslide Risk Management

AGS 2007 risk assessment terminology and acceptance criteria (ref: AGS 2007c)

AGS GeoGuide LR8 – Hillside Construction Practice

1. INTRODUCTION

At the request of BMN Properties Pty Ltd (client), an inspection and geotechnical assessment was undertaken at 4 Forest Road, Warriewood (site) by Willows Engineering Consultants Pty Ltd (Willows Engineering).

The purpose of the assessment was to provide geotechnical input for the civil engineering design and planning for construction of the proposed residential subdivision. Previous geotechnical investigations have been undertaken at the site, including logs, groundwater and laboratory testing.

This report includes commentary on the subsurface soil and bedrock conditions, performance of the existing site drainage systems and structures, with preliminary recommendations for design and construction for the subdivision. In addition, geotechnical recommendations are provided for hillside construction risk management, drainage, earthworks, shoring, footings and retaining walls.

No additional boreholes, test pits, on-site testing or laboratory testing were undertaken. However, targeted investigations can be undertaken to confirm the inferred geotechnical model, subsurface conditions, groundwater levels and design input parameters.

Willows Engineering carried out the following scope of work:

- Walkover site inspection, review of proposed subdivision drawings and supplied documents.
- Compile existing geotechnical data (borehole logs, test pits, lab testing, groundwater, etc.).
- Prepare sketch drawings to illustrate the interpreted geotechnical model and hazards.
- Discuss the civil engineering design and construction issues with ACOR Consultants.
- Provide a preliminary risk assessment and recommendations in accordance with the *"Practice Note Guidelines for Landslide Risk Management"* (AGS 2007).

The sketches in this report are indicative only. It is envisaged that geotechnical engineering input will be provided during the civil and structural engineering design for the subdivision. Geotechnical construction inspections will be required for review and certification of earthworks, fill compaction testing, excavation support, retaining walls, footings and drainage on the sloping land.

2. SUPPLIED DOCUMENTS

Willows Engineering was supplied with the following documents from previous geotechnical investigations and subdivision planning at the site:

- Subdivision drawings by ACOR Consultants (ref: NSW210416), Issue 2 dated 29/11/22.
- *"Preliminary Geotechnical Report"* by Alliance Geotechnical 3/08/2016 (ref: 2406-GR-1-1).
- *Geotechnical and Groundwater Investigation – Factual Report"* by Alliance Geotechnical dated 26/05/2017 (ref: 2406-GR-1-2).
- *"Preliminary Geotechnical Assessment and Slope Stability Risk Assessment"* report by Jefferey & Katauskas dated 14/04/2005 (ref: 19312VBrpt).

3. REGIONAL GEOLOGY

The 1:100,000 Geological Map of Sydney (ref: Sheet 9130, 1983) indicates the bedrock underlying the site is Hawkesbury Sandstone (Rh), described as *"medium to coarse grained quartz sandstone, very minor shale and laminite lenses."* The underlying Newport Formation (Rnn) is shown close by on the map and described as *"interbedded laminite, shale and quartz to lithic-quartz sandstone."*

Groundwater seepage is commonly encountered at the interface between these geological units, together with residual clay soils from in-situ weathering of the siltstone, laminite and shale bands. Colluvium and boulders may be present in the sloping land below this interface.

An extract from the Sydney geology map is presented in Figure 1:

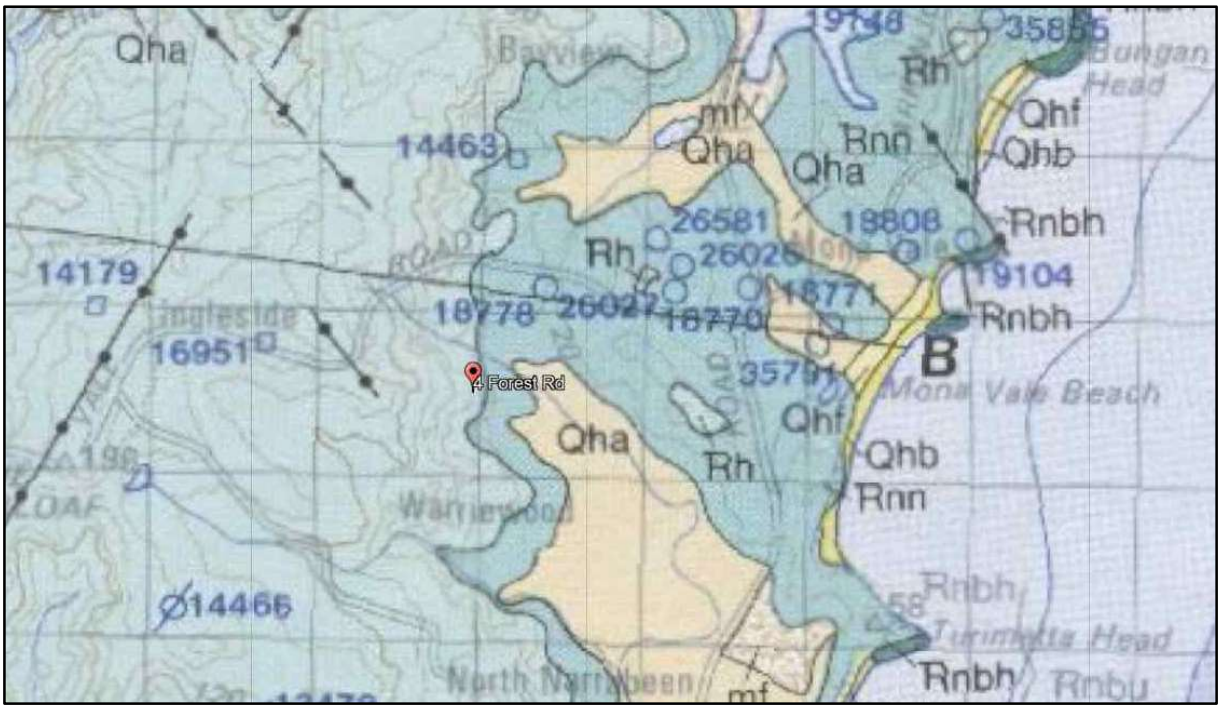


Figure 1 – Extract from Sydney Geology Map

4. SITE DESCRIPTION

A general site description was provided in Section 2.3 of the Alliance Geotechnical report as follows:

> *"The site comprises a relatively large parcel of land, located at the north-western end of Forest Road. The site is bounded on all sides by:*
>
> - *Hillview Crescent (to the north) and houses in Bert Close (to the north-east).*
> - *A row of townhouses on No. 2 Forest Road (to the east).*
> - *Undeveloped bushland to the west (understood to include a bushfire protection zone).*
> - *Mater Maria Catholic College (to the south)."*

An extract from the annotated aerial photo in Alliance Geotechnical report is presented in Figure 2:

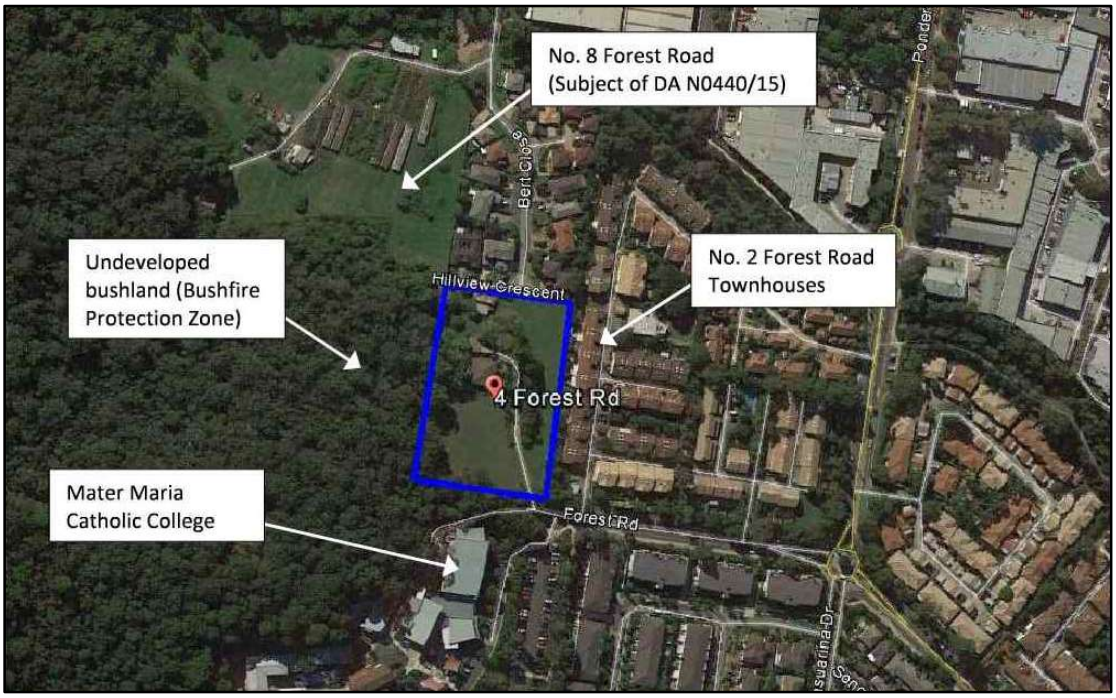


Figure 2 – Aerial Photo and surrounding properties
(Extract from Alliance Geotechnical report)

5. PROPOSED SUBDIVISION

An extract from the supplied subdivision plan by ACOR Consultants is provided in Figure 3 below:

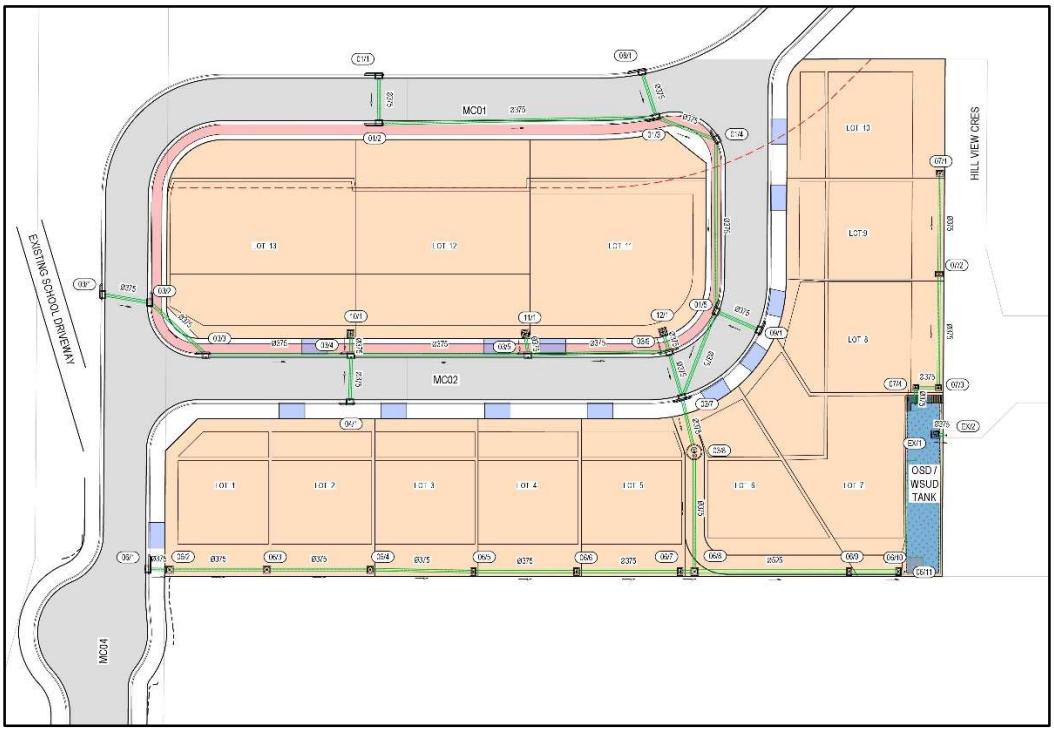


Figure 3 – Subdivision layout plan
(Extract from ACOR Consultants drawings)

6. INTERPRETED GEOTECHNICAL MODEL

A plan with mapping was included in the 2005 geotechnical report by Jefferey and Katauskas. This sketch plan has been reproduced as Drawing No. 2122010-SK1 in the Appendix. The locations of the cross section and previous fieldwork investigations are indicated on the plan.

The interpreted geotechnical model is presented on Drawing No. 2122010-SK2 in the Appendix.

The subsurface conditions and features shown are based on the walkover site observations, review of geotechnical investigation data and experience with the regional geology. The subdivision plan and other supplied documents were used to develop cross section drawings. The subsurface soil and rock profile was inferred from the boreholes and test pit logs. The drawings are 'indicative only' and provided for discussion.

7. GEOTECHNICAL INVESTIGATIONS

The previous geotechnical reports at the site (see Section 2) included results from fieldwork investigations in 2005, 2016 and 2017, including:

- Borehole and test pit logs (soil and bedrock profile).
- Dynamic Cone Penetrometer (DCP) test results.
- Laboratory test reports (moisture content, plasticity index, CBR).
- Groundwater level monitoring results.

The fieldwork results by Alliance Geotechnical in 2016-2017 and Jefferey and Katauskas in 2005 are included in the Appendix.

7.1. Subsurface Profile

A summary table of the subsurface soil and bedrock profile, from the Alliance Geotechnical report in August 2016 is presented in Figure 4:

Test Pit	Termination Depth (m)	Depth of Topsoil (m)	Depth of Colluvium (m)	Depth of Residual Soil (m)	Depth of Sandstone Class V * (m)
TP1	0.7	0.1	-	0.1 - 0.6	0. 6 - 0.7
TP2	1.9	0.2	-	0.2 - 1.5	1.5 - 1.9
TP3	1.5	0.2	0.2- 0.6	0.6 - 1.4	1.4 - 1.5
TP4	2.7	0.3	0.3 - 0.5	0.5 - 2.7	-
TP5	1.4	0.1	0.1 - 0.4	0.4 - 1.35	1.35 - 1.4
TP6	2.9	0.4	0.4 - 0.6	0.6 - 2.9	-
TP7	2.8	0.4	0.4 - 0.6	0.6 - 2.8	-
TP8	2.8	0.25	0.25 - 0.6	0.6 - 2.8	-

* The sandstone is anticipated to extend beyond the test pit.

Figure 4 – Summary of Subsurface Soil and Bedrock Profile
(Extract from Alliance Geotechnical report - 3 August 2016)

7.2. Groundwater Monitoring

The groundwater monitoring results from borehole level measurements in April to May 2017 are indicated in the extract in Figure 5:

Inspection Date	Borehole 1	Borehole 2	Borehole 3
Monday 10/04/2017	1.30m	2.80m	1.30m
Thursday 13/04/2017	1.40m	3.30m	1.10m
Thursday 28/04/2017	3.00m	5.00m	2.50m
Tuesday 02/05/2017	2.95m	4.80m	2.52m
Thursday 04/05/2017	3.48m	5.00m	2.52m
**All water level depths are measured depth below existing ground level*			

Figure 5 – Summary of Groundwater levels
(Extract from Alliance Geotechnical report - 26 May 2017)

7.3. Dynamic Cone Penetrometer (DCP) Tests

The results of the Dynamic Cone Penetrometer (DCP) tests undertaken by Alliance Geotechnical are included as an extract in the Appendix. The DCP results include a column to indicate approximate correlation of the data for typical geotechnical design parameters.

7.4. Laboratory Tests

The supplied geotechnical reports contain NATA registered laboratory results of site soil and bedrock samples. The test reports presented by Alliance Geotechnical and Jefferey and Katauskas are included as extracts in the Appendix.

8. RISK ASSESSMENT

The AGS 2007 risk assessment process involves identification of the land stability hazards and assessment of the 'likelihood' and 'consequences' of the event(s) for the 'elements at risk'.

The 'risk to property' and 'risk to life' are determined for the hazards identified on the site and surrounding land, by probability calculations and engineering judgement based on the AGS 2007 terminology and risk acceptance criteria (see attached AGS 2007 - Appendix C).

The assessment of 'risk to property' and 'risk to life' is based on compliance with the geotechnical recommendations and risk management requirements during all stages of construction. In this regard, attention is drawn to the AGS GeoGuide LR8 in the Appendix, which illustrates examples of 'good' and 'poor' hillside construction practice.

Risk management of sloping land development includes geotechnical issues associated with design and construction of drainage (surface water, groundwater, temporary and permanent), excavations, cut/fill earthworks, ground vibrations, testing of fill compaction for access roads and foundation bearing capacity to avoid differential settlement.

8.1. Geotechnical Hazards

Drawing No. 2122010-SK3 is annotated to indicate the geotechnical hazards identified on the site and considered in the landslide risk assessment for the residential subdivision development. The hazards are described as follows:

Hazard A Soil creep (fill and surface soils)

Hazard B Landslides (small scale, near surface soils)

Hazard C Landslides (large scale, deeper soil and weathered bedrock)

Hazard D Rock falls or boulder movement

8.2. Risk to Property

For the purposes of the risk assessment, it is assumed that the recommendations in this report will be followed for the subdivision design and construction. Geotechnical input is recommended for effective management of the short-term construction risks, with a civil/structural engineering design appropriate to 'good hillside construction practice' (AGS GeoGuide LR8).

The 'risk to property' assessment is presented in Table 1.

Table 1 – AGS Risk Assessment (Risk to Property)

Site Area	Geotechnical Hazards		Risk to Property					
	Hazard Type	Element(s) at Risk	Current Situation			After Risk Management		
			Likelihood	Consequence	Risk	Likelihood	Consequence	Risk
No. 4 Forest Road (Subdivision lots and access road)	Hazard A Soil creep	New lots, footings, access road, services	Likely	Minor	Moderate	Rare	Minor	Very Low
	Hazard B Landslide (shallow)	Existing structures, new lots and road	Unlikely	Medium	Low	Rare	Medium	Low
	Hazard C Landslide (deep)	Existing structures, new lots and road	Rare	Major	Low	Barely Credible	Major	Very Low
	Hazard D Rock fall or boulder roll	Structures on lots, access road and vehicles	Rare	Medium	Low	Barely Credible	Medium	Very Low

As indicated in Table 1, the 'risk to property' has been assessed as:

- 'Low to Moderate' for the current situation.
- 'Low to Very Low' after risk management as recommended in this report.

As such, the geotechnical hazards on the site and surrounding land can be managed to maintain a 'Low' or 'Very Low' level of 'risk to property' by following the recommendations in this report.

8.3. Risk to Life

The AGS 2007 guidelines provide the following equation to be used for 'risk to life' calculations:

$$R_{(LoL)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(D:T)}$$

Where:

- $R_{(LoL)}$ is the annual probability of loss of life (death) of an individual.
- $P_{(H)}$ is the annual probability of the landslide.
- $P_{(S:H)}$ is the probability of spatial impact of the landslide impacting a building (location) taking into account the travel distance and travel direction given the event.
- $P_{(T:S)}$ is the temporal spatial probability (e.g. of the building or location being occupied by the individual) given the spatial impact and allowing for the possibility of evacuation given there is warning of the landslide occurrence.
- $V_{(D:T)}$ is the vulnerability of the individual (probability of loss of life given the impact).

The risk acceptance criteria, terminology and indicative annual probability terms are set out in the AGS 2007 risk tables (attached).

The geotechnical hazards with potential to pose a risk to person/s have been considered in the calculations to assess the 'risk to life'. These are Hazard C - landslides (deep) and Hazard D - rock falls. The other hazards are assessed to only affect structures.

The 'risk to life' calculations have been considered for the current situation and during construction of stabilisation works. After completion of the drainage systems and engineered retaining walls for the proposed subdivision, the 'risk to life' will be further reduced.

The selected values for annual probability (i.e. $P_{(H)}$ in the 'risk to life' equation) are the indicative values for the worst case 'likelihood' terms in the 'risk to property' assessment (Table 1). The remaining probability terms (i.e. $P_{(S:H)}$, $P_{(T:S)}$ and $V_{(D:T)}$) used in the calculations are determined by selecting values for the probability terms in each scenario based on experience with the geological setting, interpreted geotechnical model and engineering judgement.

The 'risk to life' assessment for the 'current situation' and 'after risk management' are in Table 2:

Table 2 – Risk to Life Calculations

Hazard	Current Situation					After Risk Management				
	$P_{(H)}$	$P_{(S:H)}$	$P_{(T:S)}$	$V_{(D:T)}$	$R_{(LoL)}$	$P_{(H)}$	$P_{(S:H)}$	$P_{(T:S)}$	$V_{(D:T)}$	$R_{(LoL)}$
Hazard C Landslides (deep)	1×10^{-5}	0.2	0.2	0.4	1.6×10^{-7}	1×10^{-6}	0.2	0.2	0.2	8×10^{-9}
Hazard D Rock falls	1×10^{-5}	0.1	0.1	0.5	5×10^{-8}	1×10^{-6}	0.1	0.3	0.2	6×10^{-9}

Note: The probability terms in Table 2 have been estimated by engineering judgement, based on experience with risk assessment calculations, hillside building developments, stabilisation works and construction risk management.

Based on the quantitative 'risk to life' calculations for the site 'after risk management' as set out in Table 2, it is noted that:

- The probability of loss of life for the individual most at risk is less than 1 x 10^{-6} per annum, which is an 'Acceptable' risk level as described in the AGS 2007 guidelines.
- The site geotechnical hazards must be managed during construction by implementing the recommendations in this report under review by geotechnical and structural engineers.
- The short-term risks associated with the construction works are expected to be the most critical for consideration in the 'risk to life' assessment.
- Construction workers are expected to be the person/s most at risk both in the current situation and during the construction of site access and building stabilisation works.
- A staged construction approach and use of a 'Safe Work Method Statement' may be required to maintain 'Low' and 'Acceptable' risk levels during the works.

8.4. Risk Management

The actions to be taken for geotechnical risk management include:

- Temporary drainage (diversion of surface water) around structures and work areas.
- Temporary construction benching and battering of earthworks, to maintain slope stability.
- Retaining walls for permanent support and temporary shoring (if required).
- Footings founded on consistent bedrock strata, verified by geotechnical engineer.
- Geotechnical inspection(s) to assess excavation stability, support systems and footings.
- Permanent drainage (both surface and subsoil drainage).

9. RECOMMENDATIONS

It is recommended that:

1. The project structural engineer and hydraulic engineer develop the engineering design drawings and draft construction specification for the proposed subdivision.
2. After approval by Council, the engineering design documentation be prepared, including calculations, drawings, construction specifications, with indications of work methods and stages, temporary works, drainage and construction access.
3. The engineering drawings and specification be provided to the project geotechnical engineer, for review prior to construction, to advise on short-term risk management and geotechnical inspection hold points.
4. Design and construction of the subdivision development be undertaken by following the geotechnical risk management actions described in this report.

10. LIMITATIONS

This preliminary geotechnical report has been prepared for the client (BMN Properties Pty Ltd), for the purposes described in the introduction. The interpreted subsurface conditions and hazards were assessed based on observations, review of the previous geotechnical investigation reports and by experience with the *"Practice Note Guidelines for Landside Risk Management"* by the Australian Geomechanics Society (AGS 2007).

It has been assumed that the engineering design and construction documentation will be prepared by qualified civil and structural engineers as per the recommendations in this report, together with construction review by the project geotechnical engineer.

It is envisaged that an updated AGS 2007 risk assessment will be undertaken when the engineering design is available, to assess the construction stages for project and provide recommendations to achieve 'Acceptable' risk levels.

If you would like to discuss this report, please contact the undersigned.

Regards

David Willows
BE(Hons), CPEng(Civil), MIEAust, NER, A.CIRCEA

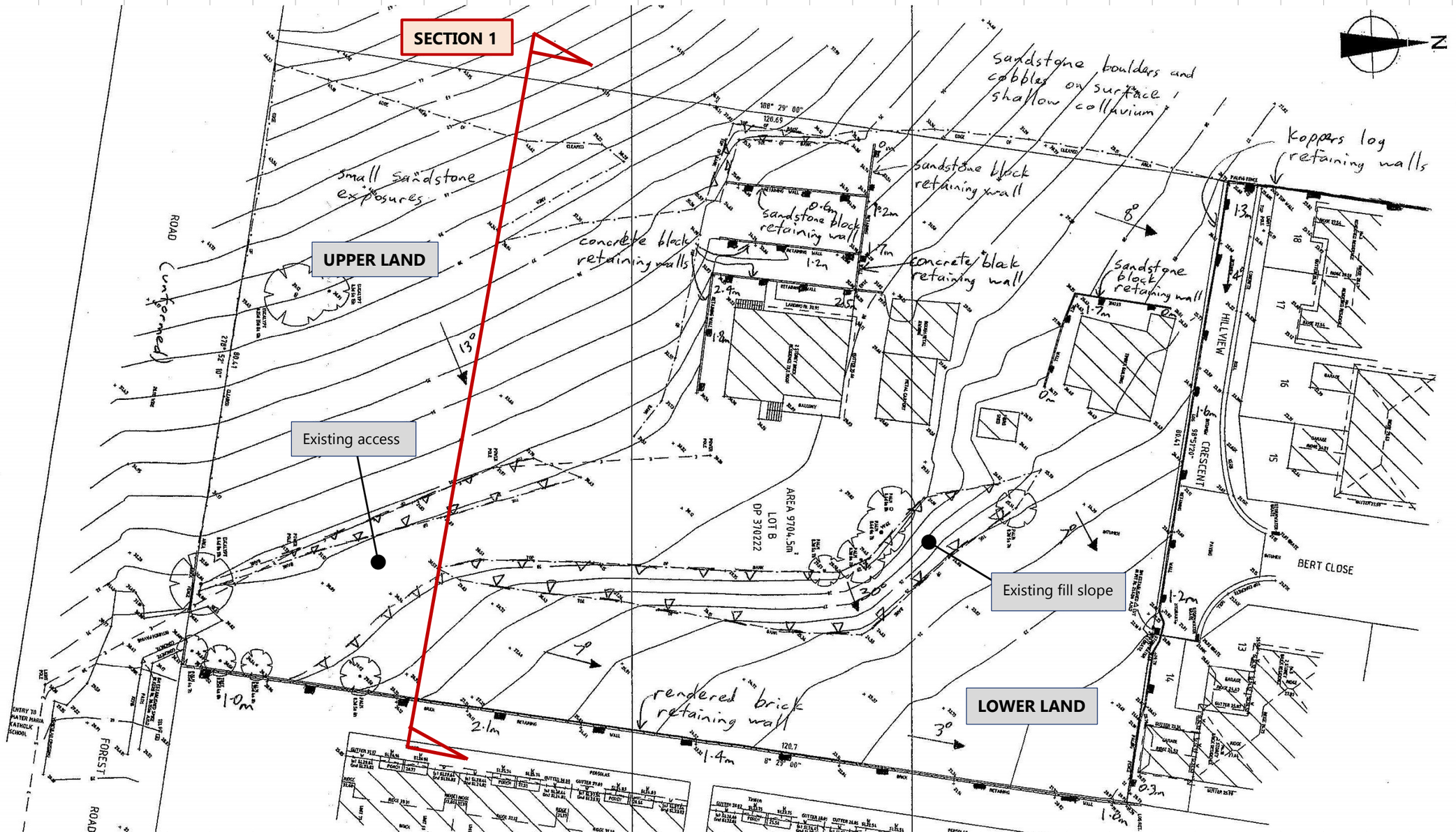
APPENDIX

Willows Engineering Drawings No. 2122010-SK1 (plan), SK2 (section) and SK3 (hazards)

Extracts from Alliance Geotechnical (2016-2017) and Jefferey and Katauskas (2005) reports: boreholes, test pits, groundwater monitoring and laboratory test results.

AGS 2007 risk assessment terminology and acceptance criteria (ref: AGS 2007c)

AGS GeoGuide LR8 – Hillside Construction Practice



Note: Base survey plan prepared by Mudge Property Services Pty Ltd (4/08/2000). Sketch mapping by Jefferey and Katauskas Pty Ltd (ref: 19312VB, 14/04/2005). Section location and annotations by Willows Engineering (refer to Drawings No. 2122010-SK2 and SK3).

INDICATIVE ONLY - FOR DISCUSSION

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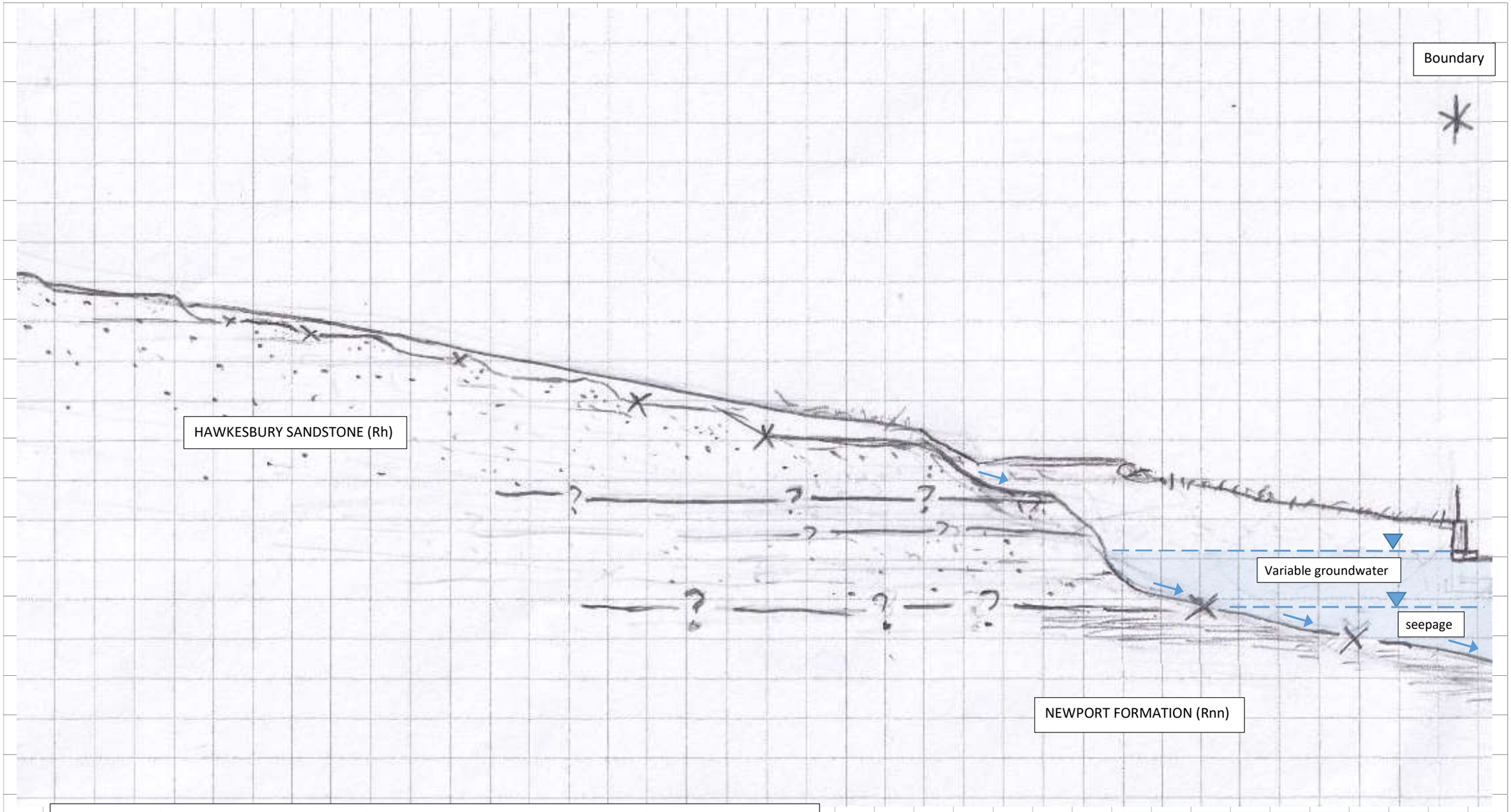
Site Plan – Section Location and Geotechnical Mapping

Project:	Geotechnical Report for Proposed Residential Subdivision	Drawing No. 2122010-SK1
Location:	4 Forest Road, Warriewood NSW 2102	Date: 9/12/2022
Client:	BMN Properties Pty Ltd	Report No. 2122010-R1 (Rev 01)



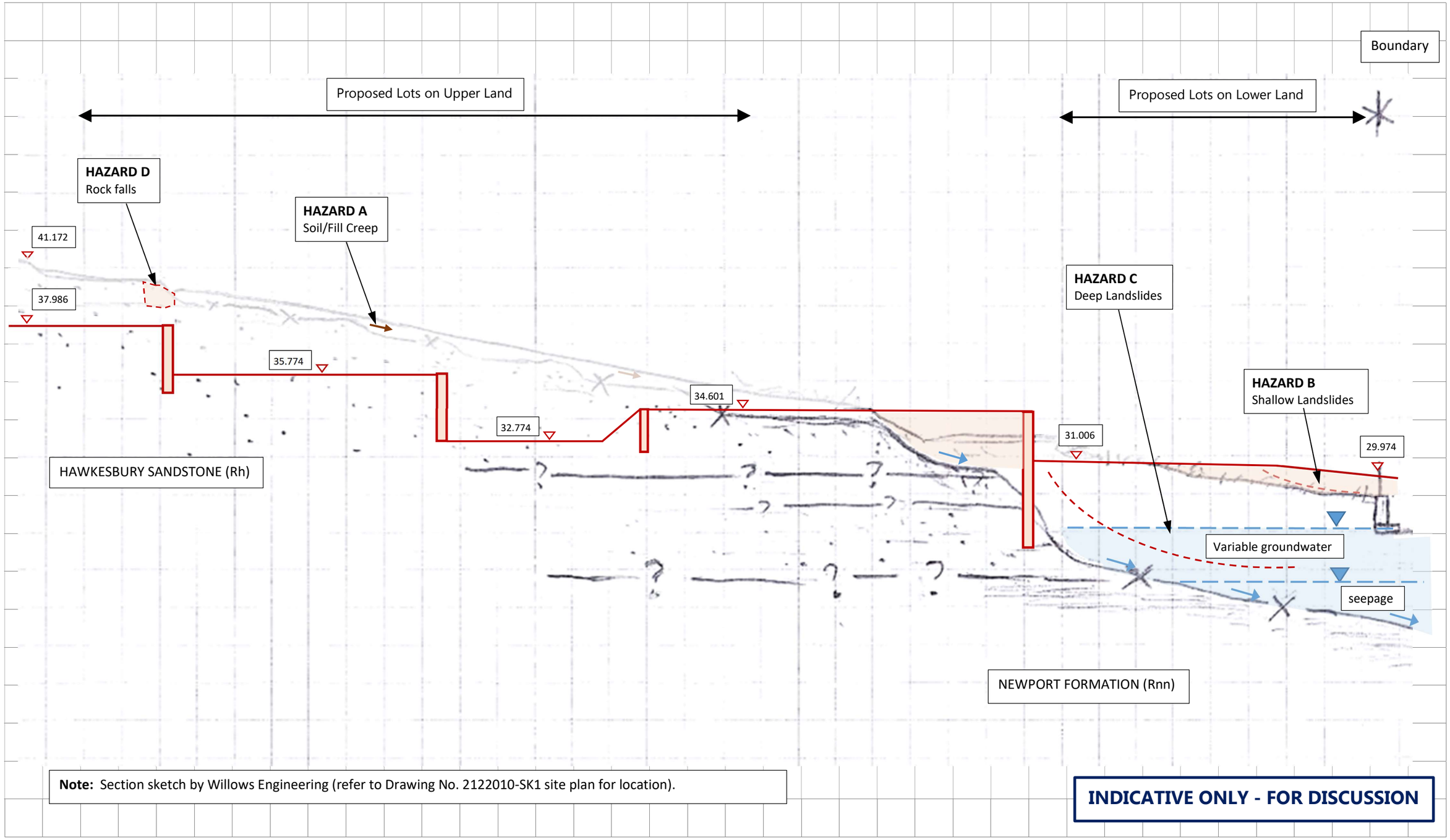
Note: Section sketch by Willows Engineering (refer to Drawing No. 2122010-SK1 site plan for location).

INDICATIVE ONLY - FOR DISCUSSION

WILLOWS ENGINEERING
FORENSIC ✦ GEOTECHNICAL ✦ REMEDIAL

Section 1 – Interpreted Geotechnical Model

Project:	Geotechnical Report for Proposed Residential Subdivision	Drawing No. 2122010-SK2
Location:	4 Forest Road, Warriewood NSW 2102	Date: 9/12/2022
Client:	BMN Properties Pty Ltd	Report No. 2122010-R1 (Rev 01)



Note: Section sketch by Willows Engineering (refer to Drawing No. 2122010-SK1 site plan for location).

INDICATIVE ONLY - FOR DISCUSSION

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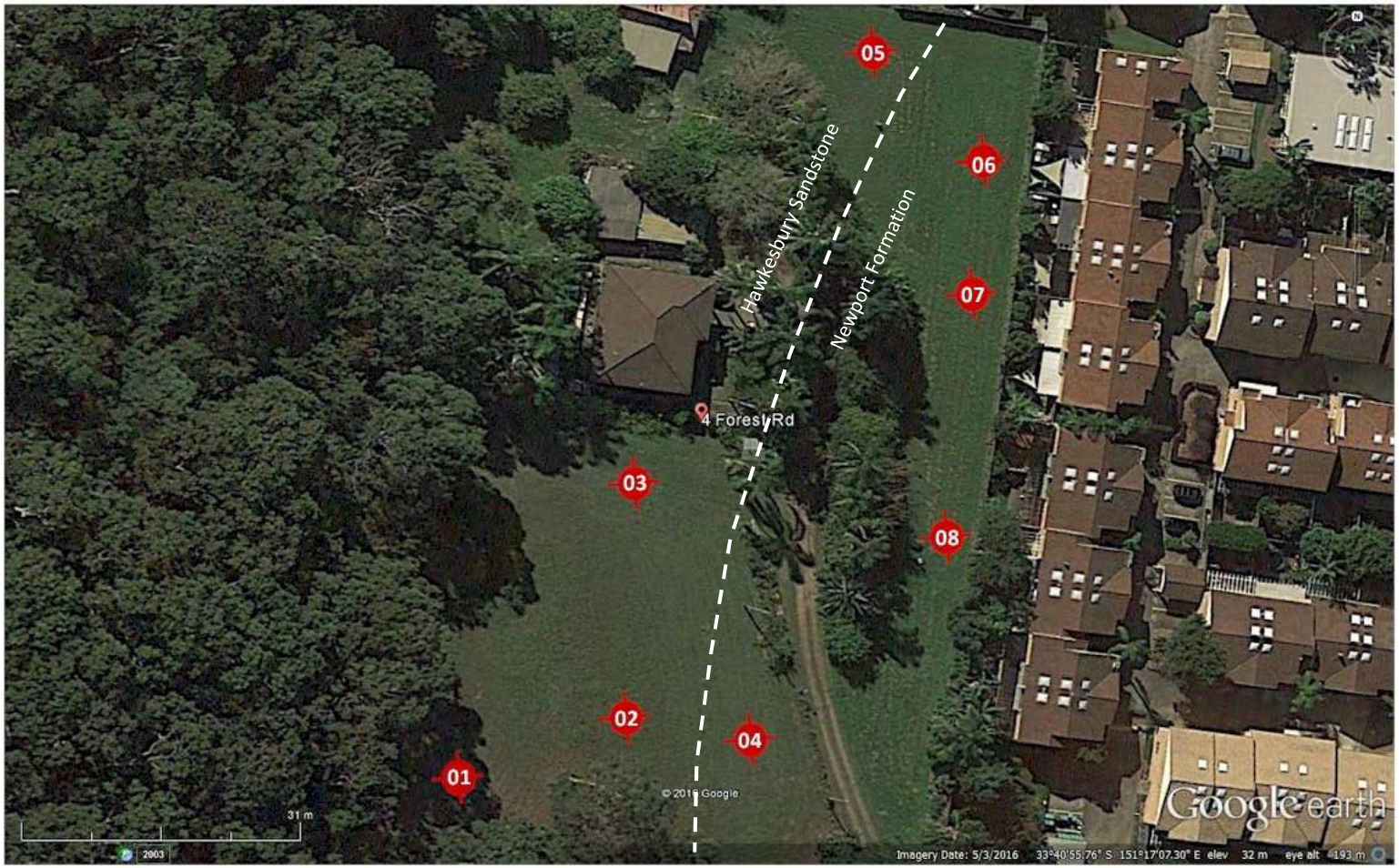
FORENSIC ✦ GEOTECHNICAL ✦ REMEDIAL

Section 1 – Geotechnical Hazards for Proposed Development

Project:	Preliminary Geotechnical Report for Residential Subdivision	Drawing No. 2122010-SK3
Location:	4 Forest Road, Warriewood NSW 2102	Date: 9/12/2022
Client:	BMN Properties Pty Ltd	Report No. 2122010-R1 (Rev 01)

Alliance Geotechnical Pty Ltd
ENGINEERING | ENVIRONMENTAL | TESTING

Drawing Number: 2406-GR-1-A
Site Plan and Test Pit Locations



N

– – · Inferred Geological Boundary

Source: Google Earth 2016

Your On-Site Geotechnical Specialists **Phone Us Today – 1800 288 188**	**Client: Messrs Gualtieri and Sacco C\- Evolution Planning Pty Ltd** **Project: Proposed Subdivision and Residential Development** **Location: 4 Forest Road, Warriewood, NSW 2072**	**Job Number: 2406** **Report Number: 2406-GR-1-1** **Report Date: 3/08/2016**

EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

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 excavtion 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

AS	Auger Screwing
AD/V	Auger Drilling with V-Bit
AD/T	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
F	Firm
H	Hard
VH	Very Hard

Groundwater Levels

Date of measurement is shown.

Standing water level measured in completed borehole

Level taken during or immediately after drilling

Samples/Tests

D	Disturbed
U	Undisturbed
C	Core Sample
SPT	Standard Penetration Test
N	Result of SPT (*sample taken)
VS	Vane Shear Test
IMP	Borehole Impression Device
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	< 25kPa
S	Soft	25 - 50kPa
F	Firm	50 - 100kPa
St	Stiff	100 - 200kPa
VSt	Very Stiff	200 - 400kPa
H	Hard	≥ 400kPa

Strength figures quoted are the approximate range of Unconfined Compressive Strength for each class.

Density Index. (%) is estimated or is based on SPT results. Approximate N Value correlation is shown in right column.

VL	Very Loose	< 15%	0 - 4
L	Loose	15 - 35%	4 - 10
MD	Medium Dense	35 - 65%	10 - 30
D	Dense	65 - 85%	30 - 50
VD	Very Dense	> 85%	> 50

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

Description	Spacing (mm)
Thinly Laminated	< 6
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.

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

Orientation - angle relative to the plane normal to the core axis.

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
Roughness	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.

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TEST PIT No: TP 1
Sheet: 1 of 1
Job No: 2406

Borehole Log

Client: Messrs Gualtieri and Sacco C\- Evolution Planning Pty Ltd
Project: Proposed Subdivision and Residential Development
Location: 4 Forest Road, Warriewood, NSW 2102

Started: 15/7/16
Finished: 15/7/16
Borehole Size:

Rig Type: Yanmar excavator 5.5 t **Hole Location:** Refer to Drawing 2406-GR-1-A **Driller:**
Logged: SR

RL Surface: **Contractor:** **Bearing:** ---
Checked: SMVK

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
E	Not Encountered					TOPSOIL: Gravelly SAND, light grey, with rootlets.				TOPSOIL
			0.5		SP	Gravelly SAND, fine to coarse, poorly graded, orange-brown, trace silt and clay, estimated medium dense.		M	MD	RESIDUAL
						SANDSTONE, light orange-brown, fine to coarse grained, extremely weathered, estimated medium strength (HAWKESBURY SANDSTONE)				BEDROCK
						Borehole TP 1 terminated at 0.7m				
			1.0							
			1.5							
			2.0							
			2.5							
			3.0							
			3.5							
			4.0							
			4.5							
			5.0							

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TEST PIT No: TP 2
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Borehole Log

Client: Messrs Gualtieri and Sacco C\- Evolution Planning Pty Ltd
Project: Proposed Subdivision and Residential Development
Location: 4 Forest Road, Warriewood, NSW 2102

Started: 15/7/16
Finished: 15/7/16
Borehole Size:

Rig Type: Yanmar excavator 5.5 t **Hole Location:** Refer to Drawing 2406-GR-1-A **Driller:**
Logged: SR

RL Surface: **Contractor:** **Bearing:** ---
Checked: SMVK

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
E	Not Encountered					TOPSOIL: Silty SAND, grey-brown to dark grey, with rootlets.		M		TOPSOIL
			0.5		SC	Silty CLAY, brown-red, estimated medium to high plasticity, estimated stiff, with fine angular gravels, trace sand, friable.		M	St	RESIDUAL @Pocket penetrometer 150.33 KPa
			1.0							
			1.5			SANDSTONE, yellow-brown with red-grey , fine to coarse grained, extremely weathered, estimated low strength (HAWKESBURY SANDSTONE).				BEDROCK
			2.0			Borehole TP 2 terminated at 1.9m				
			2.5							
			3.0							
			3.5							
			4.0							
			4.5							
			5.0							

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TEST PIT No: TP 3
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Job No: 2406

Borehole Log

Client: Messrs Gualtieri and Sacco C\- Evolution Planning Pty Ltd
Project: Proposed Subdivision and Residential Development
Location: 4 Forest Road, Warriewood, NSW 2102

Started: 15/7/16
Finished: 15/7/16
Borehole Size:

Rig Type: Yanmar excavator 5.5 t **Hole Location:** Refer to Drawing 2406-GR-1-A **Driller:**
Logged: SR

RL Surface: **Contractor:** **Bearing:** ---
Checked: SMVK

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
E	Not Encountered		0.0			TOPSOIL: Silty SAND, grey-brown to dark grey, with rootlets.		M		TOPSOIL
					SC	Silty SAND, orange-grey with brown, fine to coarse grained, medium dense, with rounded to sub-rounded gravels.		W	MD	COLLUVIUM
			0.5							
					CL	Silty Sandy CLAY, brown-red, estimated low to medium plasticity, very stiff, trace fine to medium gravels, friable.		M	VSt	RESIDUAL @Pocket penetrometer 372.65 KPa
			1.0							
			1.5			SANDSTONE, yellow-brown with red-grey , fine to coarse grained, extremely weathered, estimated low strength (HAWKESBURY SANDSTONE).				BEDROCK
						Borehole TP 3 terminated at 1.5m				
			2.0							
			2.5							
			3.0							
			3.5							
			4.0							
			4.5							
			5.0							

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TEST PIT No: TP 4
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Borehole Log

Client: Messrs Gualtieri and Sacco C\- Evolution Planning Pty Ltd
Project: Proposed Subdivision and Residential Development
Location: 4 Forest Road, Warriewood, NSW 2102

Started: 15/7/16
Finished: 15/7/16
Borehole Size:

Rig Type: Yanmar excavator 5.5 t **Hole Location:** Refer to Drawing 2406-GR-1-A **Driller:**
Logged: SR

RL Surface: **Contractor:** **Bearing:** ---
Checked: SMVK

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
						TOPSOIL: Silty SAND, grey-brown to dark grey, trace clay, with rootlets.		M		TOPSOIL
			0.5		SC	Silty SAND, orange-brown, fine to coarse grained, estimated medium dense, with rounded to sub-rounded gravels.		W	MD	COLLUVIUM
	Not Encountered		1.0		CL	Silty Sandy CLAY, brown-red, estimated low to medium plasticity, estimated stiff, trace fine to medium gravels, friable.		M	St	RESIDUAL @Pocket penetrometer 166.71 KPa
			1.5							
			2.0		CL	Silty CLAY, brown-red, estimated medium to high plasticity, estimated stiff, with fine angular gravels, trace sand, friable.		M	St	
			2.5							
						Borehole TP 4 terminated at 2.7m				
			3.0							
			3.5							
			4.0							
			4.5							
			5.0							

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TEST PIT No: TP 5
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Job No: 2406

Borehole Log

Client: Messrs Gualtieri and Sacco C\- Evolution Planning Pty Ltd
Project: Proposed Subdivision and Residential Development
Location: 4 Forest Road, Warriewood, NSW 2102

Started: 15/7/16
Finished: 15/7/16
Borehole Size:

Rig Type: Yanmar excavator 5.5 t **Hole Location:** Refer to Drawing 2406-GR-1-A **Driller:**
Logged: SR

RL Surface: **Contractor:** **Bearing:** ---
Checked: SMVK

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
E						TOPSOIL: Silty SAND, dark grey, trace of clay, loose, with rootlets.		M		TOPSOIL
					SC	Silty SAND, grey-brown, fine to coarse grained, medium dense, with rounded to sub-rounded gravels.		W	MD	COLLUVIUM
	Slow seepage		0.5		CL	Gravelly CLAY, red-brown, estimated medium plasticity, estimated stiff, friable.		M	St	RESIDUAL @Pocket penetrometer 133.37 KPa
			1.0		CL	Gravelly CLAY, red-brown, estimated medium to high plasticity, estimated very stiff, with gravels and cobbles of sandstone , trace sand, friable.		M	VSt	@Pocket penetrometer 473.66 KPa
			1.5			SANDSTONE, yellow-brown with red-grey , fine to coarse grained, extremely weathered, estimated low strength (HAWKESBURY SANDSTONE). Borehole TP 5 terminated at 1.4m				BEDROCK
			2.0							
			2.5							
			3.0							
			3.5							
			4.0							
			4.5							
			5.0							

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TEST PIT No: TP 6
Sheet: 1 of 1
Job No: 2406

Borehole Log

Client: Messrs Gualtieri and Sacco C\- Evolution Planning Pty Ltd
Project: Proposed Subdivision and Residential Development
Location: 4 Forest Road, Warriewood, NSW 2102

Started: 15/7/16
Finished: 15/7/16
Borehole Size:

Rig Type: Yanmar excavator 5.5 t **Hole Location:** Refer to Drawing 2406-GR-1-A **Driller:**
Logged: SR

RL Surface: **Contractor:** **Bearing:** ---
Checked: SMVK

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
E	Not Encountered					TOPSOIL: Silty SAND, dark grey, loose, with rootlets.		M		TOPSOIL
			0.5		SC	Silty SAND, grey-brown, fine to coarse grained, estimated medium dense, with rounded to sub-rounded gravels.		W	MD	COLLUVIUM
			1.0		CL	Silty Sandy CLAY, red-brown, estimated low to medium plasticity, estimated very stiff, trace fine to medium gravels.		M	VSt	RESIDUAL @Pocket penetrometer 473.66 KPa
			1.5		CL	Silty CLAY, red-brown with grey, estimated low to medium plasticity, estimated very stiff, with conglomeratic sandstone gravels and cobbles			VSt	
			2.0							
			2.5							
			3.0			Borehole TP 6 terminated at 2.9m				
			3.5							
			4.0							
			4.5							
			5.0							

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TEST PIT No: TP 7
Sheet: 1 of 1
Job No: 2406

Borehole Log

Client: Messrs Gualtieri and Sacco C\- Evolution Planning Pty Ltd
Project: Proposed Subdivision and Residential Development
Location: 4 Forest Road, Warriewood, NSW 2102

Started: 15/7/16
Finished: 15/7/16
Borehole Size:

Rig Type: Yanmar excavator 5.5 t **Hole Location:** Refer to Drawing 2406-GR-1-A **Driller:**
Logged: SR

RL Surface: **Contractor:** **Bearing:** ---
Checked: SMVK

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
E	Not Encountered		0.0			TOPSOIL: Silty SAND, dark grey, loose, with rootlets.		M		TOPSOIL
			0.5		SC	Silty SAND, grey-brown, fine to coarse grained, estimated medium dense, trace fine to medium rounded to sub-rounded gravels.		W	MD	COLLUVIUM
					CL	Silty Sandy CLAY, red-brown, estimated low to medium plasticity, estimated very stiff, with fine to medium gravels.		M	VSt	RESIDUAL @Pocket penetrometer 228.49 KPa
			2.0		CL	Silty Sandy CLAY, red-brown, estimated low to medium plasticity, estimated very stiff, with subrounded to angular sandstone gravels.			VSt	
			2.8			Borehole TP 7 terminated at 2.8m				
			3.0							
			3.5							
			4.0							
			4.5							
			5.0							

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TEST PIT No: TP 8
Sheet: 1 of 1
Job No:2406

Borehole Log

Client: Messrs Gualtieri and Sacco C\- Evolution Planning Pty Ltd
Project: Proposed Subdivision and Residential Development
Location: 4 Forest Road, Warriewood, NSW 2102

Started: 15/7/16
Finished: 15/7/16
Borehole Size:

Rig Type: Yanmar excavator 5.5 t **Hole Location:** Refer to Drawing 2406-GR-1-A **Driller:**
Logged: SR

RL Surface: **Contractor:** **Bearing:** ---
Checked: SMVK

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
E	Not Encountered		0.5			TOPSOIL: Silty SAND, dark grey, loose, with rootlets.		M		TOPSOIL
					SC	Silty SAND, grey-brown, fine to coarse grained, estimated medium dense, fine to medium rounded to sub-rounded gravels.		W	MD	COLLUVIUM
			1.0		CL	Silty Sandy CLAY, red-brown, estimated low to medium plasticity, estimated very stiff, some fine to medium gravels.		M	VSt	RESIDUAL @Pocket penetrometer 294.2 KPa
			2.0		CL	Silty Sandy CLAY, red-brown, estimated low to medium plasticity, estimated very stiff, with subrounded to angular sandstone gravels.		M	VSt	
			3.0			Borehole TP 8 terminated at 2.8m				
			3.5							
			4.0							
			4.5							
			5.0							

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Dynamic Cone Penetrometer Test

Project No.:	2406
Project Name:	4 Forest Road, Warriewood
Date:	15/07/2016
Test Operative:	SvK

Test No.:	1	Location:	TP02		
Depth (mm)	Material type	No. Blows (n)	CBR (%)	Approx. Undrained Shear Strength, C_u (kPa) - Cohesive soils	Approx. Relative Density, (%) - granular soils
-150	Granular	1	1.5	-	11.7
-300	Cohesive	4	6.6	42	-
-450	Cohesive	3	4.8	32	-
-600	Cohesive	7	11.8	74	-
-750	Cohesive	6	10.1	64	-
-900	Cohesive	7	11.8	74	-
-1050	Cohesive	9	15.4	96	-
-1200	Weathered Rock	19	34.0	-	-
-1350	Weathered Rock	18	32.1	-	-
-1500	Weathered Rock	24	43.5	-	-
-1650		Refusal	-	-	
-1800			-	-	
-1950			-	-	
-2100			-	-	
-2250			-	-	
-2400			-	-	
-2550			-	-	

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Dynamic Cone Penetrometer Test

Project No.:	2406
Project Name:	4 Forest Road, Warriewood
Date:	15/07/2016
Test Operative:	SvK

Test No.:	2	Location:	TP03		
Depth (mm)	Material type	No. Blows (n)	CBR (%)	Approx. Undrained Shear Strength, C_u (kPa) - Cohesive soils	Approx. Relative Density, (%) - granular soils
-150	Granular	3	4.8	-	40.3
-300	Granular	11	19.1	-	74.1
-450	Granular	13	22.8	-	78.5
-600	Granular	5	8.3	-	53.6
-750	Cohesive	3	4.8	32	-
-900	Cohesive	9	15.4	96	-
-1050	Cohesive	13	22.8	138	-
-1200	Weathered Rock	22	39.7	-	-
-1350		Refusal	-	-	-
-1500				-	-
-1650			-	-	-
-1800			-	-	-
-1950			-	-	-
-2100			-	-	-
-2250			-	-	-
-2400			-	-	-
-2550			-	-	-

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Dynamic Cone Penetrometer Test

Project No.:	2406
Project Name:	4 Forest Road, Warriewood
Date:	15/07/2016
Test Operative:	SvK

Test No.:	3	Location:	TP08		
Depth (mm)	Material type	No. Blows (n)	CBR (%)	Approx. Undrained Shear Strength, C_u (kPa) - Cohesive soils	Approx. Relative Density, (%) - granular soils
-150	Granular	2	3.1	-	29.7
-300	Granular	13	22.8	-	78.5
-450	Granular	15	26.5	-	82.2
-600	Granular	12	20.9	-	76.4
-750	Granular	3	4.8	-	40.3
-900	Cohesive	10	17.3	106	-
-1050	Cohesive	19	34.0	202	-
-1200	Cohesive	12	20.9	128	-
-1350	Cohesive	13	22.8	138	-
-1500	Cohesive	12	20.9	128	-
-1650	Cohesive	15	26.5	160	-
-1800	Cohesive	16	28.4	170	-
-1950	Cohesive	22	39.7	234	-
-2100	Cohesive	18	32.1	192	-
-2250	Cohesive	18	32.1	192	-
-2400	Cohesive	17	30.2	181	-
-2550		Refusal	-	-	-

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Dynamic Cone Penetrometer Test

Project No.:	2406
Project Name:	4 Forest Road, Warriewood
Date:	15/07/2016
Test Operative:	SvK

Test No.:	4	Location:	TP06		
Depth (mm)	Material type	No. Blows (n)	CBR (%)	Approx. Undrained Shear Strength, C_u (kPa) - Cohesive soils	Approx. Relative Density, (%) - granular soils
-150	Granular	3	4.8	-	40.3
-300	Granular	9	15.4	-	68.9
-450	Granular	7	11.8	-	62.4
-600	Granular	6	10.1	-	58.3
-750	Cohesive	11	19.1	117	-
-900	Cohesive	13	22.8	138	-
-1050	Cohesive	18	32.1	192	-
-1200	Cohesive	22	39.7	-	-
-1350	Cohesive	23	41.6	-	-
-1500		Refusal	-	-	-
-1650			-	-	-
-1800			-	-	-
-1950			-	-	-
-2100			-	-	-
-2250			-	-	-
-2400			-	-	-
-2550			-	-	-

Figure 2 – Upper south-western portion of the land, looking north-east.
Note: Inferred Hawkesbury Sandstone bedrock underlying approx. 14° slope.

Figure 3 – Lower north-eastern portion of the land, looking north.
Note: Inferred Newport Formation (interbedded sandstone and siltstone bedrock) underlying approx. 10° slope. Existing houses on adjoining properties to the north and north-east.

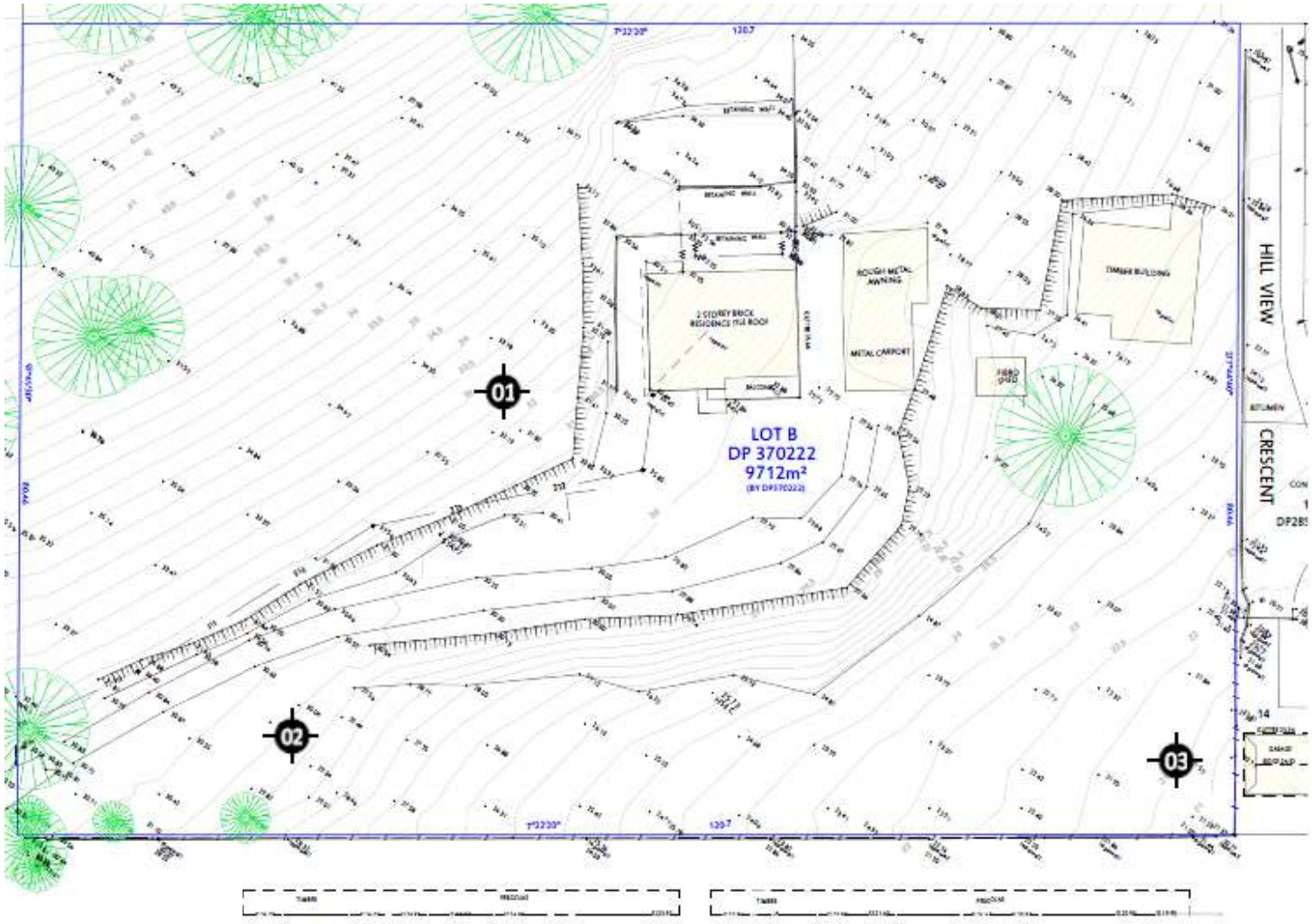
Figure 4 – Retaining walls, structures and slope behind existing house –central portion of land.
Note: Ponding of water on the ground, seepage through the wall joints, movement of wall blocks.

Figure 5 – Retaining wall and water ponding / seepage behind the existing house.
Note: Seepage through wall joints. The high volume of seepage suggests that the excavation is close to the geological interface between Hawkesbury Sandstone and Newport Formation.

Figure 6 – Fill slope below the existing house and access driveway, looking south.
Note: The slope angle of the fill varies between approx. 24° and 31°. Substantial growth of vegetation on the fill slope and green grass cover suggests groundwater seepage.

Figure 7 – Stormwater pit at the corner of Hillview Crescent and Bert Close, looking east.
Note: The development concept includes an on-site stormwater basin in the lower portion of the land for the subdivision construction, which is to be drained to this Council stormwater pit.

Drawing Number: 2406-GR-1-C
Site Plan – Borehole Locations



Source: 'Topographical Detail Survey of Property and Surrounds', issued by Pro-Position, Ref: 12146 Detail, Dated:13/07/2016

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BH No: BH 1
PAGE 1 OF 2
Job No: 2406 / 2

Borehole Log

Client: Messrs Gualtieri and Sacco C/o Evolution Planning Pty Ltd
Project: Proposed Subdivision & Residential Development
Location: 4 Forest Road, Warriewood, NSW 2072

Started: 4/4/17
Finished: 4/4/17
Borehole Size: 125mm

Rig Type: MD300 Drill Rig
Hole Location: Refer Drawing 2406-GR-1-C
Driller: HD
Logged: LM
RL Surface: 33.2 m AHD
Contractor: AG
Bearing: ---
Checked:

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT			33				TOPSOIL: Clayey Sandy Silt, dark brown and grey, with gravel, with grass roots		M	S	TOPSOIL
							Silty SAND, orange/brown and grey, fine to coarse, with gravel		VM	MD	COLLUVIUM
				1		CL-CI	Silty Sandy CLAY, low to medium plasticity, red and brown, with fine to medium ironstone gravel		M	VSt	RESIDUAL
	Seepage		32				SANDSTONE, yellow with red, fine to coarse grained, with sandy clay bands, extremely weathered, extremely low strength				BEDROCK
			31	2			Borehole BH 1 continued as cored hole				
			30	3							
			29	4							
			28	5							
			27	6							
			26	7							
			25	8							
			24	9							
				10							

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Cored Borehole Log

Client: Messrs Gualtieri and Sacco C/o Evolution Planning Pty Ltd
Project: Proposed Subdivision & Residential Development
Location: 4 Forest Road, Warriewood, NSW 2072

Started: 4/4/17
Finished: 4/4/17
Borehole Size: 125mm

Rig Type: MD300 Drill Rig
Hole Location: Refer Drawing 2406-GR-1-C
Driller: HD
Logged: LM
RL Surface: 33.2 m AHD
Contractor: AG
Bearing: ---
Checked:

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL <0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
			33	1		Continued from non-cored borehole						
			32									
NMLC			31	2		SANDSTONE, red/brown with orange bands, fine to medium grained	HW		A 0.03			1.80-2.20, Not intact/fragmented, 400mm
						SANDSTONE, light grey, fine to coarse grained	EW		A 0.04			2.43, J, 75°, Un, Ro, 70mm 2.50, J, 0°, Un, Ro
				3		SANDSTONE, light grey with red and orange bands, fine to coarse grained	MW		A 0.05	56		2.80, J, 65°, Pl, Sm, 60mm
			30						A 0.21			3.14, J, 10°, Pl, Ro 3.39, J, 5°, Pl, Ro 3.42, J, 0°, Un, Ro 3.61, J, 15°, Pl, Ro
				4		CORE LOSS 850mm						
			29									4.52, J 65°, Pl, Sm
				5		SANDSTONE, light grey, fine to medium grained, with seams containing 5mm rounded quartz gravel	EW		A 0.05			J, 65°, Pl, Sm 4.82-4.97, Not intact/fragmented, 150mm
			28			SILTSTONE, light grey, trace mica, with red indurated seam 100mm t.			A 0.09			5.41, J 0°, Pl, Ro 5.50, J, 5°, Un, Ro
				6					A 0.05	32		5.81, J, 25°,Pl, Ro
			27			SILTSTONE, red/light grey with dark red ironstone bands	HW		A 0.04			6.19, J, 5°, Un, Ro, Clay lined 6.20, J, 65°, Pl, Clay filled 6.25, J, 5°, Un, Ro, Clay lined 6.36, J, 5°, Un, Ro, Clay lined 6.41, J, 5°, Un, Ro, Clay lined 6.48, J, 5°, Un, Ro, Clay lined
				7		SILTSTONE, dark red with light grey bands, thinly laminated	MW		A 0.32			6.69, J, 5°, Un, Ro 673, J, 5°, Un, Ro 6.86, J, 5°, Un, Ro 6.91, J, 5°, Un, Ro 7.15, J, 5°, Un, Ro
			26			SANDSTONE, brown/orange and grey, fine to medium grained	SW		A 0.23			7.45, J, 5°, Un, Ro
				8					A 0.15			7.75, J, 5°, Un, Ro 7.78, J, 5°, Un, Ro 7.86, J, 5°, Un, Ro
			25						D A 0.24 0.39	62		8.05, J, 80°, Un, Ro, 100mm 8.06, J, 5°, Un, Ro 8.19, J, 5°, Un, Ro 8.31, J, 5°, Un, Ro
						SILTSTONE, grey, thinly laminated	HW					8.67, J, 5°, Un, Ro
				9		SANDSTONE, light brown and light grey, fine to medium grained	SW		A 0.1			8.91, J, 5°, Un, Ro 9.05, J, 65°, Un, Sm, 70mm
			24						D A 0.26 0.49			9.27, J, 5°, Un, Ro
				10		BH 1 terminated at 9.53m						End BH1

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BH No: BH 2
Sheet: 1 of 1
Job No: 2406 / 2

Borehole Log

Client: Messrs Gualtieri and Sacco C/o Evolution Planning Pty Ltd
Project: Proposed Subdivision & Residential Development
Location: 4 Forest Road, Warriewood, NSW 2072

Started: 4/4/17
Finished: 4/4/17
Borehole Size: 125mm

Rig Type: MD300 Drill Rig
Hole Location: Refer Drawing 2406-GR-1-C
Driller: HD
Logged: LM
RL Surface: 30.1 m AHD
Contractor: AG
Bearing: ---
Checked:

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Encountered		30				TOPSOIL/FILL: Gravelly Clayey Silt, brown, with grass roots		M	S	TOPSOIL/FILL
							FILL: Silty Sand, dark brown and grey, fine to medium grained, with fine to coarse gravel		M		FILL
			29	1		CL-CI	Silty Sandy CLAY, low to medium plasticity, red/brown, with fine to medium ironstone gravel		VM	St	RESIDUAL
			28	2							
						CI	Silty Sandy CLAY, medium plasticity, brown and red, with fine to medium gravel		M	VSt	
			27	3							
			26	4							
						CI-CH	Silty CLAY, medium to high plasticity, red and brown, with fine to coarse gravel		VM	VSt	
			25	5							
							Borehole BH 2 terminated at 5m				End of Borehole
			24	6							
			23	7							
			22	8							
			21	9							
				10							

BOREHOLE / TEST PIT 2406-BOREHOLE LOGS.GPJ GINT STD AUSTRALIA.GDT 24/5/17

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BH No: BH 3
Sheet: 1 of 1
Job No: 2406 / 2

Borehole Log

Client: Messrs Gualtieri and Sacco C/o Evolution Planning Pty Ltd
Project: Proposed Subdivision & Residential Development
Location: 4 Forest Road, Warriewood, NSW 2072

Started: 4/4/17
Finished: 4/4/17
Borehole Size: 125mm

Rig Type: MD300 Drill Rig
Hole Location: Refer Drawing 2406-GR-1-C
Driller: HD
Logged: LM
RL Surface: 21.7 m AHD
Contractor: AG
Bearing: ---
Checked:

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT							TOPSOIL: Gravelly Silty/Clayey Sand, dark grey and dark brown, with grass roots		M		TOPSOIL
						SP	Silty SAND, grey and brown, fine to coarse grained, with fine to coarse gravel		M		COLLUVIUM
			21	1		CL-CI	Silty Sandy CLAY, low to medium plasticity, brown and red, trace of fine to medium gravel		VM	St	RESIDUAL
	Strong Seepage					CL-CI	As above		W	St	
			20	2		CI	Silty CLAY, medium plasticity, red/brown and grey, with fine to coarse ironstone gravel		W	VSt	
			19	3							
						CI-CH	Silty CLAY, medium to high plasticity, red/brown, fine to coarse ironstone and sandstone gravel		VM	H	
			18	4							
			17	5			SANDSTONE, yellow and red, fine to coarse grained, with some clay bands, extremely to highly weathered, extremely to very low strength				BEDROCK
							Borehole BH 3 terminated at 5.1m				TC Bit Refusal
			16	6							
			15	7							
			14	8							
			13	9							
			12	10							

BOREHOLE / TEST PIT 2406-BOREHOLE LOGS.GPJ GINT STD AUSTRALIA.GDT 24/5/17

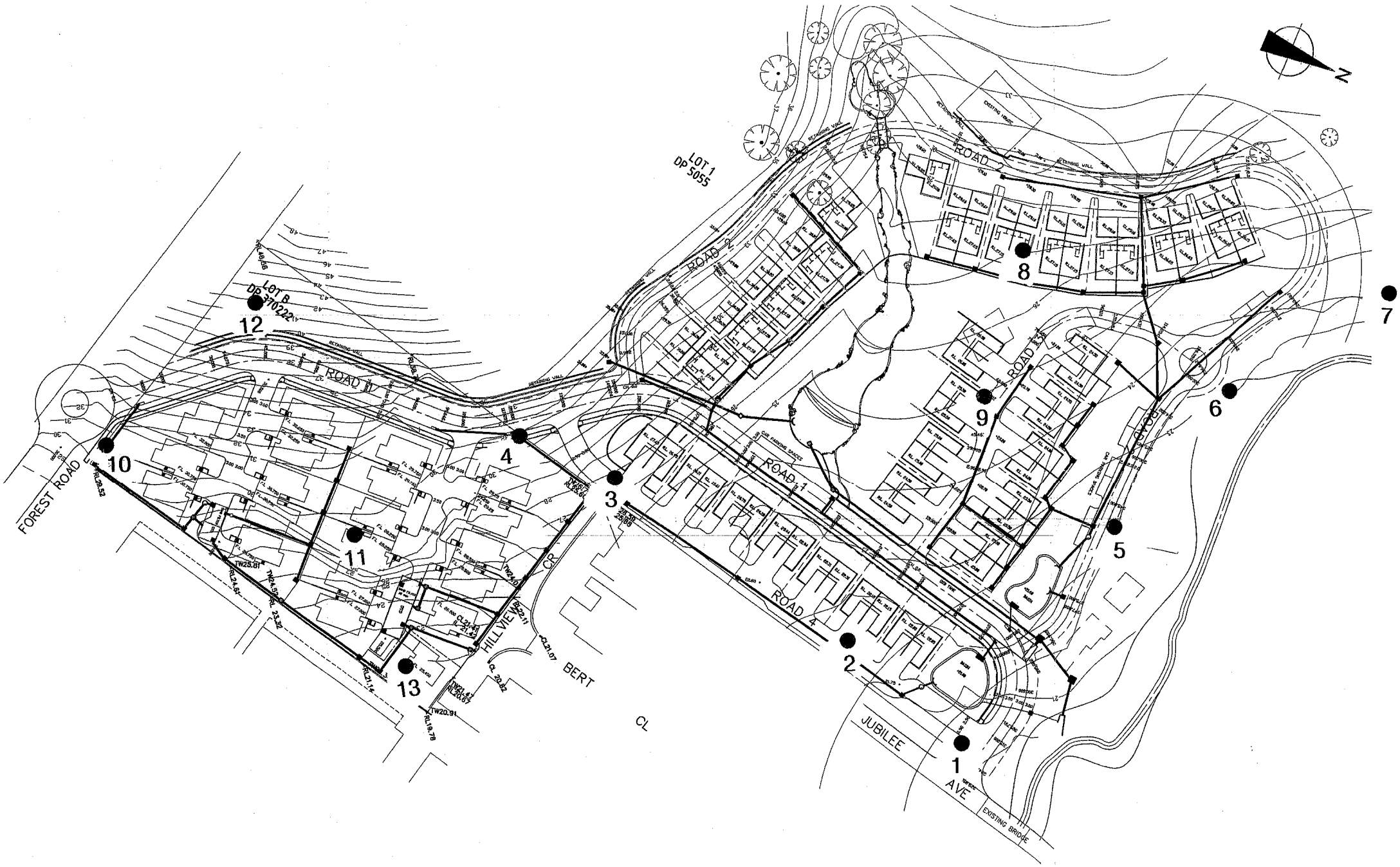
Core Photos

Figure 1 – BH1 Core Photo

Site Images

Figure 2 – BH1 drilling investigation location

Figure 3 – BH2 and BH3 drilling investigation locations in eastern portion of the site



SCALE
0 50m

BOREHOLE LOCATION PLAN

Jeffery and Katauskas Pty Ltd
Report No. 19312VB Figure No. 1

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Borehole No. 3 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 17-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S./
R.L. Surface: ≈ 27.7m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			TOPSOIL: Silty sand, fine to medium grained, dark grey, with rootlets.	D-M			GRASS COVER
DRY ON COMPLET-ION								SM	SILTY SAND: fine to medium grained, with fine to coarse grained sandstone gravel and cobbles.	D-M	(L)		COLLUVIUM
					N = 11 3,4,7			CH	SILTY CLAY: high plasticity, grey mottled orange brown.	MC>PL	H	470 580 410	
						1		SC	CLAYEY SAND: fine to medium grained, grey mottled red brown.	M	(L)		RESIDUAL
					SPT 8/0mm REFUSAL	2		-	SANDSTONE: fine to medium grained, light grey, with iron indurated bands and clay bands.	XW-DW	EL-L		VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
						3							
						4							
									END OF BOREHOLE AT 4.5m				
						5							
						6							
						7							

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Borehole No. 4 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 17-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S.
R.L. Surface: ≈ 31.8m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLET-ION						0			TOPSOIL: Silty sand, fine to medium grained, dark grey, with rootlets.	D			GRASS COVER
								SM	SILTY SAND: fine to medium grained, grey, with fine to coarse grained sandstone gravel and sandstone cobbles.	M	(L)		COLLUVIUM
					N = 25 3,8,17			CL	SANDY CLAY: medium plasticity, light grey mottled red brown, with XW sandstone gravel.	MC≈PL	H	>600 >600	RESIDUAL
						1		-	SANDSTONE: fine to medium grained, grey mottled red brown, with clay and iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
						2			SANDSTONE: fine to medium grained, light grey mottled orange brown, with a trace of iron indurated bands.	XW-DW	EL-VL		VERY LOW TO LOW RESISTANCE
						3							
						4							VERY LOW RESISTANCE
									END OF BOREHOLE AT 4.5m				
						5							
						6							
						7							

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Borehole No. **10** 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 18-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S./
R.L. Surface: ≈ 30.5m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0		SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, medium plasticity, orange brown and red brown, with ironstone gravel bands.	M/ MC≈PL	MD/ (VSt)		DRIVEWAY GRAVEL ON SURFACE RESIDUAL
					N = 12 3,6,6	1							
					N = 25 7,9,16	2							
					N > 10 10,10/ 50mm REFUSAL	3		-	SANDSTONE: fine to medium grained, red brown, with iron indurated bands.	XW-DW	EL-VL		VERY LOW 'TC' BIT RESISTANCE
						4			END OF BOREHOLE AT 4.5m				
						5							
						6							
						7							

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Borehole No. 11 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 18-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S./
R.L. Surface: ≈ 29.6m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION					N = 14 7,7,7	0			FILL: Sandy gravel, fine to medium grained, igneous, grey, fine to medium grained sand, with a trace of clay fines.	M-W			DRIVEWAY GRAVEL ON SURFACE
									FILL: Sandy gravel, fine to medium grained, sandstone, grey, fine to medium grained sand, with a trace of clay fines.	M/ MC>PL			APPEARS MODERATELY COMPACTED
					N = 13 4,8,5	1			FILL: Clayey sand/sandy clay, fine to medium grained, medium plasticity, grey brown, with fine to coarse grained gravel.	M/ MC≈PL			
					N = 20 9,10,10	2							
						3							
					N = 42 12,17,25	4		CL/SC	SANDY CLAY/CLAYEY SAND: medium plasticity, fine to medium grained, red brown mottled light grey, with iron indurated bands.	M/ MC>PL	D/ H	>600 >600 >600	ALLUVIAL
						5			as above, but light grey mottled red brown.				
						6			END OF BOREHOLE AT 6.0m				
						7							

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Borehole No. 12 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 41.8m

Date: 18-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLET-ION						0		-	TOPSOIL: Silty sand, fine to medium grained, grey, with rootlets and fine to coarse grained sandstone gravel.	M			
									SANDSTONE: fine to coarse grained, red brown, with iron indurated bands.	DW	VL-L		LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
						1			SANDSTONE: fine to medium grained, light grey mottled red brown.		M-H		MODERATE TO HIGH RESISTANCE
						2			END OF BOREHOLE AT 2.0m				'TC' BIT REFUSAL
						3							
						4							
						5							
						6							
						7							

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Borehole No. **13** 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK250 **R.L. Surface:** ≈ 22.0m

Date: 18-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0			TOPSOIL: Silty sand, fine to medium grained, grey, with rootlets.	M			GRASS COVER
					N = 4 1,2,2	1		SC	CLAYEY SAND: fine to medium grained, orange brown.	M	VL-L		ALLUVIAL
					N = 11 3,5,6	2		SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, medium plasticity, orange brown, with ironstone gravel.	M/ MC>PL	MD/ VSt	330 220	
					N = 42 8,13,29	3			as above, but grey mottled red brown.			270 230	
					N = 50 10,24,26	4					D-VD/ H		
						5						>600 >600 >600	
						6			END OF BOREHOLE AT 6.0m				
						7							

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE A
SUMMARY OF LABORATORY TEST RESULTS

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1
BOREHOLE NUMBER	DEPTH m	MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	LINEAR SHRINKAGE %
3	0.50-0.95	30.8	70	26	44	17.0
5	0.50-0.95	9.1	np	np	np	na
6	1.50-1.95	13.7	28	12	16	4.0
10	0.50-0.95	18.4	40	14	26	9.5

Notes:
- The test sample for liquid and plastic limit was oven-dried & dry-sieved
- The linear shrinkage mould was 125mm
- np denotes non-plastic
- na denotes not applicable

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Number:1327

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Authorised Signature
(A.Tatikonda)

Date: 5/4/05

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SOIL TEST SERVICES
ABN 43 002 145 173

Ref No: 19312VB
Table B: Page 1 of 1

TABLE B
SUMMARY OF FOUR DAY SOAKED C.B.R.TEST RESULTS

BOREHOLE NUMBER		7	10
DEPTH (m)		0.20 - 1.00	0.10 - 1.00
Surcharge (kg)		4.5	4.5
Maximum Dry Density (t/m^3)		1.61 STD	1.78 STD
Optimum Moisture Content (%)		7.4	17.9
Moulded Dry Density (t/m^3)		1.58	1.75
Sample Density Ratio (%)		98	98
Sample Moisture Ratio (%)		100	100
Moisture Contents			
Insitu (%)		4.3	18.0
Moulded (%)		7.4	17.9
After soaking and			
After Test, Top 30mm(%)		18.6	19.2
Remaining Depth (%)		18.4	18.7
Material Retained on 19mm Sieve (%)		0	0
Swell (%)		0.0	0.4
C.B.R. value:	@2.5mm penetration	25	
	@5.0mm penetration		9

NOTES:

- Refer to appropriate Borehole logs for soil descriptions
- Test Methods :
  - (a) Soaked C.B.R. : AS 1289 6.1.1
  - (b) Standard Compaction : AS 1289 5.1.1
  - (c) Moisture Content : AS 1289 2.1.1

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Authorised Signature
(A.Tatikonda)

Date: 5/4/05

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or **L** (5)
B - LIKELY	10^{-2}	VH	VH	H	M	**L**
C - POSSIBLE	10^{-3}	VH	H	M	M	**VL**
D - UNLIKELY	10^{-4}	H	M	**L**	**L**	**VL**
E - RARE	10^{-5}	M	**L**	**L**	**VL**	**VL**
F - BARELY CREDIBLE	10^{-6}	**L**	**VL**	**VL**	**VL**	**VL**

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

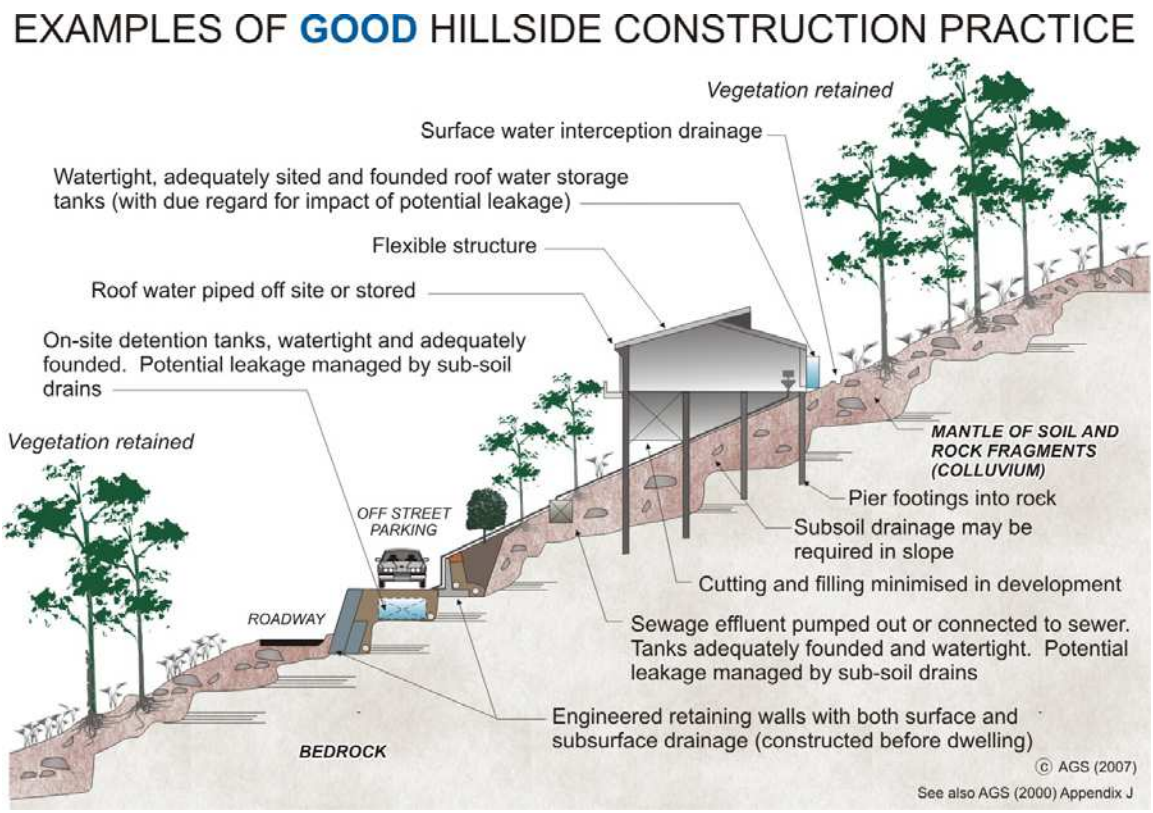
Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that in level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfil the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

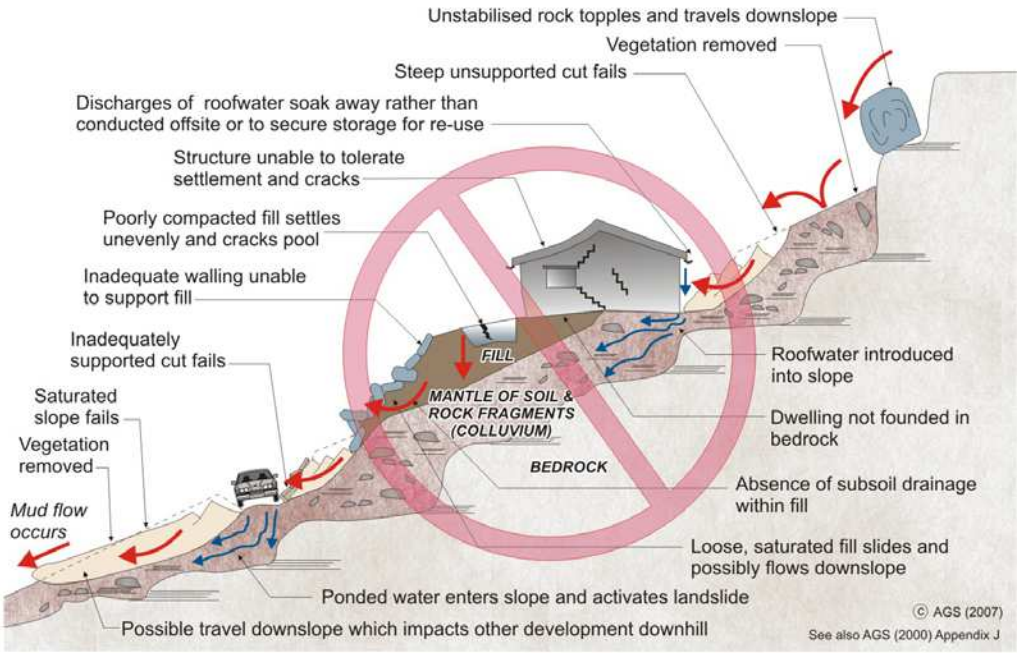
Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

EXAMPLES OF POOR HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soak into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herring bone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR9 - Effluent & Surface Water Disposal

GeoGuide LR10 - Coastal Landslides

- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.