



Jo & Toby Mander Jones c/o Alexander & Co

**Proposed Residence
16 Ruskin Rowe, Avalon Beach NSW**

Geotechnical Investigation

Our ref: 6406-G1
15 March 2021

Your trusted engineering professionals

Document Authorisation

Proposed Residence 16 Ruskin Rowe, Avalon Beach NSW Geotechnical Investigation

Prepared for Jo & Toby Mander Jones c/o Alexander & Co

Our ref: 6406-G1
15 March 2021

For and on behalf of

AssetGeoEnviro



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Contents

1. Introduction.....	1
1.1 General.....	1
1.2 Scope of Work.....	1
2. Site Description.....	2
3. Fieldwork	2
4. Subsurface Conditions	3
4.1 Geology.....	3
4.2 Subsurface Conditions	3
4.3 Groundwater.....	4
5. Discussions & Recommendations.....	5
5.1 Key Geotechnical Constraints.....	5
5.2 Soil Absorption Assessment	5
5.3 Earthworks	5
5.4 Temporary Shoring.....	7
5.5 Site Classification	8
5.6 Salinity & Aggressivity.....	8
5.7 Footings.....	8
5.8 Groundwater Control	8
5.9 Excavation Support	9
5.10 Potential Impacts on Adjacent Developments	10
6. Limitations	10

Figures

- 1 Site Locality
- 2 Test Locations

Appendices

- A Information Sheets
- B Field Investigation Results
- C Site Photos

1. Introduction

1.1 General

This report presents the results of a geotechnical investigation for the above project. The investigation was commissioned on 2 March 2021 by James Southern of Jo & Toby Mander Jones c/o Alexander & Co, on behalf of Jo & Toby Mander Jones. The work was carried out in accordance with the proposal by AssetGeoEnviro (Asset) dated 1 March 2021, reference 6406-P1 Rev 1. Upon client request, the scope of work was extended to include discussion of on-site stormwater disposal and was commissioned on 12 March 2021 by Madison Fay of Alexander & Co. The additional work was carried out in accordance with the email proposal by Asset dated 10 March 2021.

Drawings supplied to us for this investigation comprised:

- Survey plans (prepared by: Hill & Blume; ref: 62578001A & 62578002A; dated: 18/11/2020)
- Architectural plans (prepared by: Alexander & Co.; ref: 0505RR, Rev B)

Based on the supplied drawings, we understand that the project involves the demolition of the existing structures on site and the construction of a new two-storey dwelling with swimming pool. Excavation of up to about 1m is anticipated to be required. As part of the development, a soil infiltration system located at the front of the property is being considered. This report addresses that system as well as providing preliminary geotechnical recommendations to support a Development Application for the project

1.2 Scope of Work

The main objectives of the investigation were to assess the surface and subsurface conditions and to provide comments and recommendations relating to:

- Key likely geotechnical constraints to the development.
- Assessment of soil infiltration rate and suitability of site for a stormwater infiltration system.
- Excavation conditions and methodology.
- Subgrade preparation and earthworks.
- Site Classification to AS2870–2011 “Residential Slabs and Footings”.
- Suitable foundation options.
- Allowable bearing pressure for shallow foundation and shaft adhesion for piles (if required).
- Groundwater conditions.
- Commentary on settlement.
- Soil aggressiveness and corrosion potential.
- Excavation support methodology and design parameters.
- Maximum allowable permanent and temporary batter slopes.

The following scope of work was carried out to achieve the project objectives:

- A review of existing regional maps and reports relevant to the site held within our files.
- Clearance of underground services at proposed test locations.
- Visual observations of surface features.

- Subsurface investigation at six locations to assess the nature and consistency of subsurface soils and bedrock at accessible areas of the site.
- Engineering assessment and reporting.

This report must be read in conjunction with the attached “Important Information about your Geotechnical Report” in Appendix A. Attention is drawn to the limitations inherent in site investigations and the importance of verifying the subsurface conditions inferred herein.

2. Site Description

The site is located on the north-western side of Ruskin Rowe, as shown in Figure 1. It has a street frontage of about 8.03m wide and is about 81.11m deep along the south boundary and increasing to about 110.5m deep along the north boundary. The site has an irregular shape with an approximate total site area of 3199.2 m². It is legally registered as Lot 2 in deposited plan DP 504413. The site is bounded to the south-east by Ruskin Rowe with further residences beyond and to the north, east and west by existing residences.

Topographically, the site is located on a slightly sloping terrain, with Clareville Beach about 0.8km to the west and Avalon Beach about 1km to the east. The overall ground surface slopes in the immediate vicinity are about 5° to the north-west, becoming steeper further north-west of the site.

At the time of the investigation, the site was occupied by a single-storey, clad-built, metal-roofed residence (see Photo 1). It is in good visual condition. There were no obvious signs of instability such as cracking or ground settlement observed on the paving and stone retaining walls within the surrounding area of the house. The majority of the area is covered with short grass and scattered mature trees and an existing swimming pool located at the north-western corner at the rear (see Photo 2).

Site drainage in the area is by overland flow to the south-east. No rock outcrops were observed.

Soil Landscape type (from eSPADE) is identified as Warriewood typified by undulating swales, depressions and infilled lagoons on Quaternary sands. The geotechnical hazards associated with this soil landscape type are localised flooding and run-on, high watertables and highly permeable soil. It is important to understand that not all of them applies to this site.

3. Fieldwork

The fieldwork was undertaken on 4 March 2021 and 12 March 2021 by a Geotechnical Engineer from Asset and included invasive investigation at eight locations.

The test locations are shown in the attached Figures 2.1 & 2.2 and were set out by the client and our Geotechnical Engineer by measurements relative to existing site features. Surface levels at the test locations were estimated by interpolation from levels shown on the survey plan provided (prepared by Hill & Blume Consulting Surveyors; ref: 62578001A; dated: 18 November 2021).

Buried metallic services and utilities within the site boundaries near the test locations were cleared by referring to DBYD utility maps.

The invasive investigation included drilling of hand-drilled boreholes at eight locations and conducting Dynamic Cone Penetrometer (DCP) soundings at six locations. The boreholes were auger drilled to depths of 0.9m to 1.2m below ground level (bgl) and were discontinued at the recorded depths due to reaching target depths and practical refusal on stiff to very stiff clay. The DCP soundings were terminated at depths of 1.2m to 2.0m at 'solid' refusal & target depth.

A falling head permeability test was carried out in two borehole locations (BH7 & BH8).

The subsurface conditions encountered were logged during drilling and testing. On completion of logging, the boreholes were backfilled with the drilling spoil.

Engineering logs are provided in Appendix B together with their explanatory notes.

4. Subsurface Conditions

4.1 Geology

The 1:100,000 Sydney Map indicates the site is underlain by interbedded laminate, shale, and quartz to lithic-quartz sandstone with minor red claystone north. The site also located close to the boundary of sediments of recent geological age (Holocene) which typically comprise of silty to peaty quartz sand, silt and clay.

4.2 Subsurface Conditions

A generalised geotechnical model for the site has been developed is shown in Table 1. For a detailed description of the subsurface conditions, refer the attached engineering logs and explanatory notes. For specific design input, reference should be made to the logs and/or the specific test results, in place of the following summary.

Table 1 - Generalised Site Geotechnical Model

Unit	Origin	Description	Depth to Top of Unit ¹ (m)	Unit Thickness ¹ (m)
1	Topsoil	TOPSOIL, Sandy CLAY with some silt/ SAND with some silt, fine to medium grained sand, low to medium plasticity, grass roots, dark brown/ dark grey.	Ground surface	0.075 to 0.2
2	Fill	FILL, CLAY with some sand and silt, medium plasticity, fine to medium grained sand, yellow brown/ light grey/ dark brown/ orange, grass roots. (Only in HA6)	0.075	0.33
3	Alluvium	Sandy CLAY/ SAND with some clay and silt, fine to medium grained, medium plasticity, dark grey/ light grey to brown/ yellow brown, medium dense/ firm, becoming dense/ stiff with depth.	0.1 to 0.4	0.25 to 1.1
4	Residual	Sandy CLAY/ CLAY, medium to high plasticity, fine to medium grained sand, light grey/ yellow brown with traces of orange, brown, stiff to very stiff, becoming very stiff to hard with depth.	0.55 to 1.2	0.65 to 1.35
5	Bedrock ²	Inferred SANDSTONE, fine to medium grained, extremely weathered, extremely low strength, assessed Class V Sandstone.	1.2 to 2.0	Not proven beyond a depth of 2.0

Notes:

1. The depths and unit thicknesses are based on the information from the test locations only and do not necessarily represent the maximum and minimum values across the site.
2. Rock classification to Pells, P.J.N., Mostyn, G. & Walker, B.F., Foundations on Sandstone and Shale in the Sydney Region, Australian Geomechanics Journal, December 1998.

Special Note for DCP testing

Caution must be used when inferring subsurface conditions from DCP results. Refusal can be encountered on obstructions such as gravel, cemented materials, rock floaters, or other inclusions within a soil mass. DCP testing on soils with a gravel component or cementation can indicate a higher density than actual. Also, the DCP results in clay soils are significantly affected by the in-situ moisture content. It is therefore strongly recommended that an experienced Geotechnical Engineer is engaged to confirm the inferred subsurface conditions during construction and to provide advice where subsurface conditions are significantly different.

4.3 Groundwater

Groundwater was not observed in the boreholes during auger drilling to depths of 0.9m to 1.2m bgl. However, slow groundwater seepage was encountered at HA1, HA3 and HA6 borehole locations at 0.5m depth, 0.4m depth and 0.5m depth respectively. Additionally, it is worth noting that moist sandy material was encountered at all borehole locations within the depths of investigation.

Likewise, groundwater was not observed at the DCP test locations. Groundwater detection via DCP tests is indicated by wet soil materials attached on the DCP rods and conical tip. Both rods and tips extracted at the proposed test locations were moist or dry, suggesting a pervasive groundwater table within the depths of investigation was not present at during the fieldwork.

No long-term groundwater monitoring was carried out.

5. Discussions & Recommendations

5.1 Key Geotechnical Constraints

For localised excavation of up to 1.0m for the proposed new swimming pool and from the results of this investigation, it is assessed that the proposed developments will be unaffected by groundwater and would be within loose to dense sand and firm to stiff sandy clay material.

Key geotechnical constraints to the developments include non-cohesive soil excavation, temporary shoring, permanent retaining, and variable foundation conditions. Recommendations for design and construction of the development are provided in the following sections.

5.2 Soil Absorption Assessment

A falling head permeability test was carried out in two boreholes at the front of the site property with the base at 0.9m bgl. The hole was filled to the top with clean water and the time taken (in seconds) for the water to drop from a head of 0.7m to 0.68m was recorded in BH7 and from 0.7m to 0.66m in BH8. The testing was repeated until constant time intervals were recorded, namely 181 seconds for BH7 and 410 seconds for BH8.

Based on this data, the infiltration rate is calculated to be 0.0027 L/m²/sec for BH7 and 0.0024 L/m²/sec for BH8. There was no obvious difference in the subsurface profile between the two boreholes.

If an on-site stormwater absorption system is to be adopted, we recommend adopting the lower value of the two boreholes (0.002 L/m²/sec) for design. Construction of the trench should incorporate roughening of the base and sides of the trench to reduce smearing that may be caused during excavation. Roughening could be achieved by tying the base of the trench and vertical grooving the sides.

Trafficking of the base of the trench should be avoided whilst construction the absorption trench.

Trench design and construction should incorporate suitable geofabric lining to the base, sides and top of the trench.

5.3 Earthworks

5.3.1 Excavation

The excavation for the proposed development is anticipated to be fully within soils. Excavation within the soils would be achievable using conventional earthmoving equipment (i.e. hydraulic excavator bucket).

Excavation within sandstone bedrock is unlikely to be necessary. Further advice should be sought if rock excavation is required using rock hammers.

5.3.2 Subgrade Preparation

The following general recommendations are provided for subgrade preparation for earthworks, pavements, slab-on-ground construction, and minor structures:

- Strip existing fill and topsoil. Remove unsuitable materials from the site (e.g. material containing deleterious matter). Stockpile remainder for re-use as landscaping material or remove from site.
- Excavate natural soils, stockpiling for re-use as engineered fill or remove to spoil.
- Where soil is exposed in bulk excavation level, compact the upper 150mm depth to a density index (AS1289.5.6.1–1998) not less than 80%. Areas which show visible heave under compaction equipment should be over-excavated a further 0.3m and replaced with approved fill compacted to a density index not less than 80%.

Any waste soils being removed from the site must be classified in accordance with current regulatory authority requirements to enable appropriate disposal to an appropriately licensed landfill facility. Asset can provide further advice on this matter if required.

5.3.3 Filling

Where filling is required, place in horizontal layers over prepared subgrade and compact as per Table 2.

Table 2 – Compaction Specifications

Parameter	Cohesive Fill	Non Cohesive Fill
Fill layer thickness (loose measurement):		
• Within 1.5m of the rear of retaining walls	0.2m	0.2m
• Elsewhere	0.3m	0.3m
Density:		
• Beneath Pavements	≥ 95% Std	≥ 70% ID
• Beneath Structures	≥ 98% Std	≥ 80% ID
• Upper 150mm of subgrade	≥ 100% Std	≥ 80% ID
Moisture content during compaction	± 2% of optimum	Moist but not wet

Filling within 1.5m of the rear of any retaining walls should be compacted using lightweight equipment (e.g. hand-operated plate compactor or ride-on compactor not more than 3 tonnes static weight) to limit compaction-induced lateral pressures.

Any soils to be imported onto the site for backfilling and reinstatement of excavated areas should be free of contamination and deleterious material and should include appropriate validation documentation in accordance with current regulatory authority requirements which confirms its suitability for the proposed land use. Asset can provide further advice on this matter if required.

5.3.4 Batter Slopes

Recommended maximum slopes for permanent and temporary batters are presented in Table 3.

Table 3 – Recommended Maximum Dry Batter Slopes

Unit	Maximum Batter Slope (H : V)	
	Permanent	Temporary
Medium Dense Sand (or denser)	3 : 1	1.25 : 1
Residual Clay	2 : 1	1 : 1

5.4 Temporary Shoring

It is understood that permanent batter slopes may not be proposed for the development.

The pool is set back from the site boundaries at least about 2.0m. For a 1m deep excavation, a temporary batter could be adopted at the above slope angle with temporary shoring up to about 0.5m high required at the base at the batter.

Several possible shoring systems could be considered for the site. These are summarised in Table 4 together with a brief description of the advantages and disadvantages of each.

Table 4 – Summary of Shoring Options

Option	Method	Advantages	Disadvantages
1	Conventional shoring with soldier piles and steel walers, or soldier piles and shotcrete infill panels	Relatively low cost	Risk of instability and loss of ground unless adequate external dewatering is provided. Forms a poor seal against groundwater. Greater amount of dewatering required. Potential drawdown of groundwater levels outside of the site with possible adverse effects on adjacent structures.
2a or 2b	Contiguous or Secant bored piles	Can form part of the permanent structure. Minimum noise and vibration. Can maximise site building space as no temporary wall is required. Permanent waterproofing can be incorporated. Low permeability water barrier (secant piling very low permeability compared to contiguous piling)	For secant piles, ensuring complete contact of all piles over full pile length may be difficult. Additional finishing may be required following excavation if a 'smooth' internal wall is required. Relatively high cost. May require soil anchors along boundaries where high-level footings are located. Contiguous piles may require additional waterproofing where close contact not achieved.

Based on the advantages and disadvantages listed in Table 4, we recommend a contiguous (Option 2a) pile wall retention system for the basement excavation. We consider the geotechnical risks associated with Option 1 (predominantly excavation support) to be unacceptably high. The additional cost of the secant pile wall (Option 2b) compared with the contiguous pile wall is not considered justified for this site.

The founding depth of the retaining wall piles is a function of: -

- the required socket depth to achieve adequate embedment to resist overturning; and
- the required load carrying capacity if the piles are to be incorporated into the permanent works.

Design of temporary shoring for carrying vertical loading should be in accordance with Section 5.7, and for lateral pressures, it should be in accordance with Section 5.9.

Detailed construction supervision, monitoring and inspections will be required during the piling and subsequent bulk excavation to ensure an adequate standard of workmanship and to minimise potential problems.

5.5 Site Classification

Due to the presence of trees, fill, and existing site structures (causing abnormal moisture conditions), the site is classified as a Class P (Problem) Site in accordance with AS 2870–2011 “Residential Slabs and Footings”. This requires that footings be designed from first principles, rather than adopting prescriptive designs as per AS2870-2011. Where the existing fill is removed and replaced with non-reactive engineered fill, or where footings are founded on the underlying natural sandy soil, then footings may be designed and constructed in accordance with the requirements in AS2870-2011 for a Class A site.

5.6 Salinity & Aggressivity

Whilst no specific laboratory testing has been carried out to assess the aggressiveness of soil to concrete and steel, based on the subsurface profile as described above and the site conditions, we consider that the soils would likely be non-saline, mildly aggressive with respect to buried concrete and non-aggressive to buried steel structures. Further testing would be required to confirm this.

5.7 Footings

Suitable footings might comprise a slab on ground for the pool base area and pier and beam footings supporting the upper building loads. The footings should be taken down a minimum 600mm below existing ground level, below the base of any fill materials, onto medium dense sand or better, and may be designed for a maximum allowable bearing pressure of 150 kPa.

A short pile solution is recommended due to a relatively small loadings on top. If deeper piles are considered, further investigation must be carried out to verify the deeper ground conditions.

An experienced Geotechnical Engineer should review footing designs to check that the recommendations of the geotechnical report have been included and should assess footing excavations to confirm the design assumptions.

5.8 Groundwater Control

Limited groundwater observations made for this investigation are described in Section 4.3. The observations indicate that groundwater is unlikely to be a constraint to the proposed development. However, good practice should be followed to cater for potential groundwater, such as designing retaining walls with adequate subsoil drainage. Further geotechnical advice must be sought if significant groundwater is encountered during construction.

5.9 Excavation Support

Excavation of soil and rock results in stress changes in the remaining material and some ground movement is inevitable. The magnitude and extent of lateral and vertical ground movements will depend on the design and construction of the excavation support system. Experience and published data suggest that lateral movements of an adequately designed and installed retention system in soil and weathered rock will typically be in the range of 0.2% to 0.5% of the retained height. The extent of the horizontal movement behind the excavation face typically varies from 1.5 to 3 times the excavated height.

5.9.1 Excavation Support Design Parameters

Support system design may be based on the parameters given in Table 5. Cantilever walls or walls with only a single row of anchors/props may be designed for a triangular earth pressure distribution with the lateral pressure being determined as follows:

$$\sigma_z = K_{o,a,p} z \gamma \quad \text{where} \quad \begin{array}{ll} \sigma_z & = \text{lateral earth pressure (kPa) at depth } z \\ K_{o,a,p} & = \text{earth pressure coefficient} \\ & \quad o = \text{'at rest'}, a = \text{'active'}, p = \text{'passive'} \\ z & = \text{depth (m)} \\ \gamma & = \text{unit weight of soil / rock (kN/m}^3\text{)} \end{array}$$

Table 5 – Excavation Support Design Parameters

Material	Moist Unit Weight (γ_m) kN/m ³	'Active' Lateral Earth Pressure Coefficient ⁽¹⁾ (K_a)	'At Rest' Coefficient ⁽¹⁾ (K_o)	'Passive' Coefficient ⁽²⁾ (K_p)
Aeolian Sands	17.0	0.35	0.5	3

Notes to table:

1. These values assume that some wall movement and relaxation of horizontal stress will occur due to the excavation. Actual in-situ K_o values may be higher, particularly in the rock units.
2. Includes a reduction factor to the ultimate value of K_p to consider strain incompatibility between active and passive pressure conditions. Parameters assume horizontal backfill and no back of wall friction.
3. The values for rock assume no adversely dipping joints or other defects are present in the bedrock. All excavation rock faces should be inspected regularly by an experienced Geotechnical Engineer / Engineering Geologist as excavation proceeds.

The parameters for the 'at rest' condition (K_o) should be used for the design of lateral earth pressures where adjacent footings/structures are located within the 'zone of influence' of the wall. The 'zone of influence' may be taken as a line extending upwards and outwards at 45° above horizontal from the base of the wall. Piles for cantilever walls should be socketed below bulk excavation level by a depth at least equal to the retained height. For assessment of passive restraint embedded below excavation level, we recommend a triangular pressure distribution.

5.9.2 Surcharge

Allowance must also be made for surcharge loadings and footing loads from adjacent structures.

5.9.3 Hydrostatic Pressure

Where an adequate subsoil drainage system designed by an appropriately qualified and experienced Hydraulic / Stormwater Engineer is provided behind non-tanked retaining walls, no allowance for hydrostatic pressure would be necessary.

5.10 Potential Impacts on Adjacent Developments

Potential geotechnical risks of construction on adjoining developments could include; settlement/deflection of adjacent footings due to the pool and new footing excavation. These risks have been discussed in the relevant sections of this report. We assess that if the development is designed and constructed in accordance with the recommendations given in this report, these effects are anticipated to have negligible impact and be within acceptable limits.

6. Limitations

In addition to the limitations inherent in site investigations (refer to the attached Information Sheets), it must be pointed out that the recommendations in this report are based on assessed subsurface conditions from limited investigations. To confirm the assessed soil and rock properties in this report, further investigation would be required such as coring and strength testing of rock and should be carried out if the scale of the development warrants, or if any of the properties are critical to the design, construction or performance of the development.

It is recommended that a qualified and experienced Geotechnical Engineer be engaged to provide further input and review during the design development; including site visits during construction to verify the site conditions and provide advice where conditions vary from those assumed in this report. Development of an appropriate inspection and testing plan should be carried out in consultation with the Geotechnical Engineer.

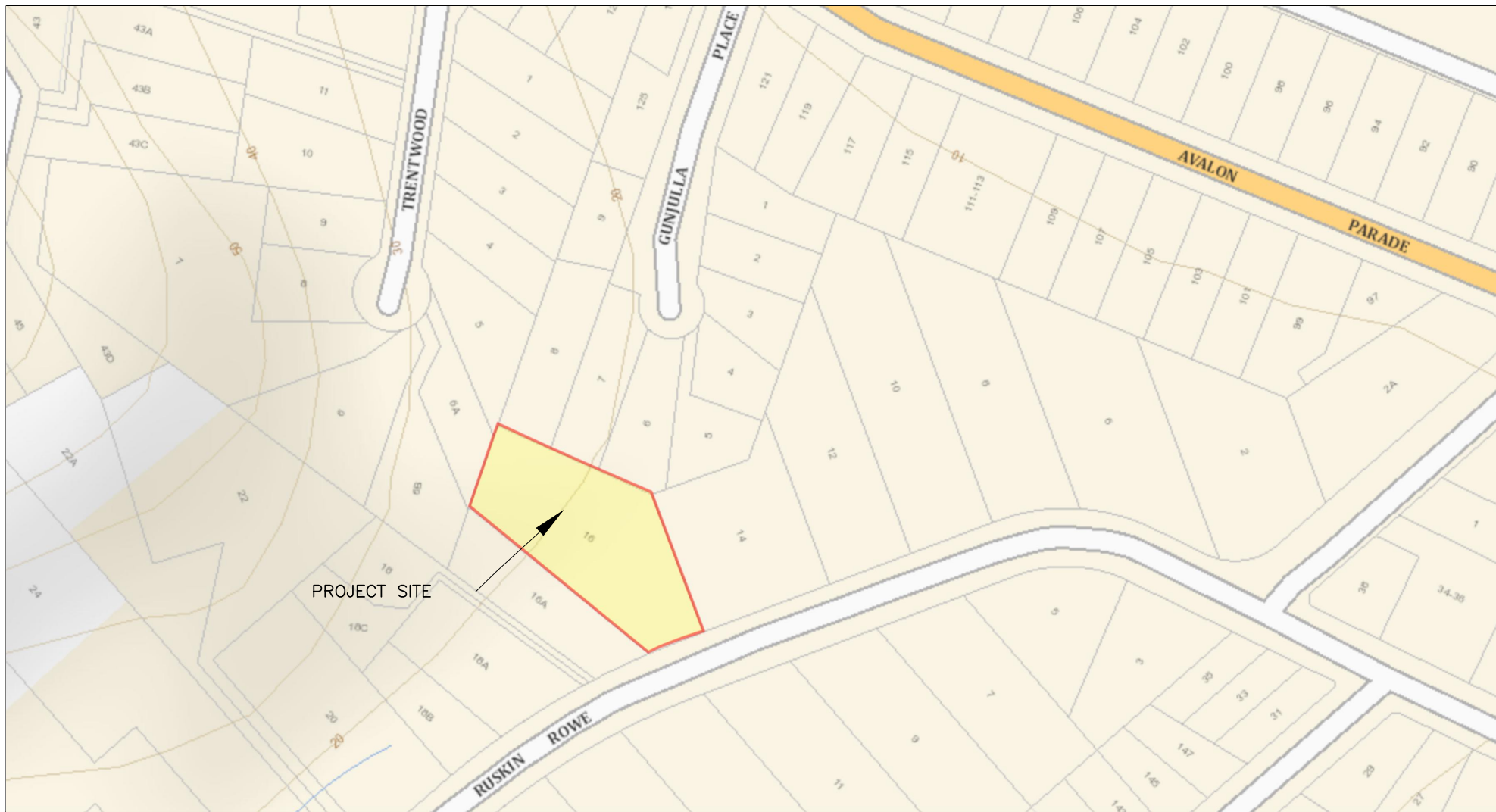
This report may have included geotechnical recommendations for design and construction of temporary works (e.g. temporary batter slopes or temporary shoring of excavations). Such temporary works are expected to perform adequately for a relatively short period only, which could range from a few days (for temporary batter slopes) up to six months (for temporary shoring). This period depends on a range of factors including but not limited to: site geology; groundwater conditions; weather conditions; design criteria; and level of care taken during construction. If there are factors which prevent temporary works from being completed and/or which require temporary works to function for periods longer than originally designed, further advice must be sought from the Geotechnical Engineer and Structural Engineer.

This report and details for the proposed development should be submitted to relevant regulatory authorities that have an interest in the property (e.g. Council) or are responsible for services that may be within or adjacent to the site (e.g. Sydney Water, Roads & Maritime Services), for their review.

Asset accepts no liability where our recommendations are not followed or are only partially followed. The document "Important Information about your Geotechnical Report" in Appendix A provides additional information about the uses and limitations of this report.

Figures

- Figure 1 Site Locality
- Figure 2.1 Test Locations
- Figure 2.2 Soil Infiltration Test Locations



APPROXIMATE ONLY – SUBJECT TO DETAIL SURVEY.

SOURCE: SIX MAPS

THIS DRAWING IS USED TO ILLUSTRATE SITE LOCATION ONLY,
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issue	date	description
A	5.3.21	INITIAL ISSUE



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SITE LOCALITY

drawn: AT

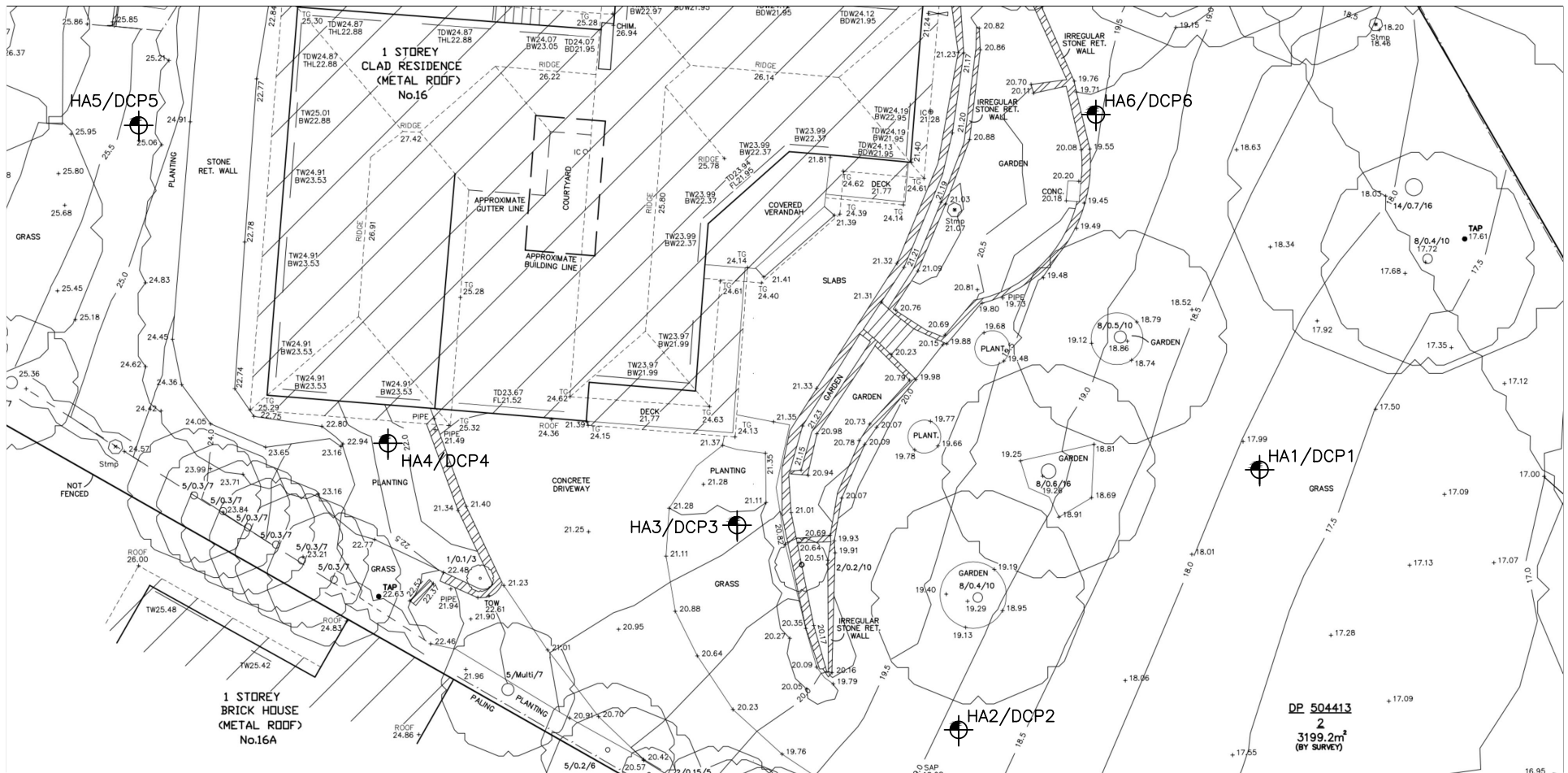
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LEGEND

HA/DCP



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A	12.3.21	INITIAL ISSUE

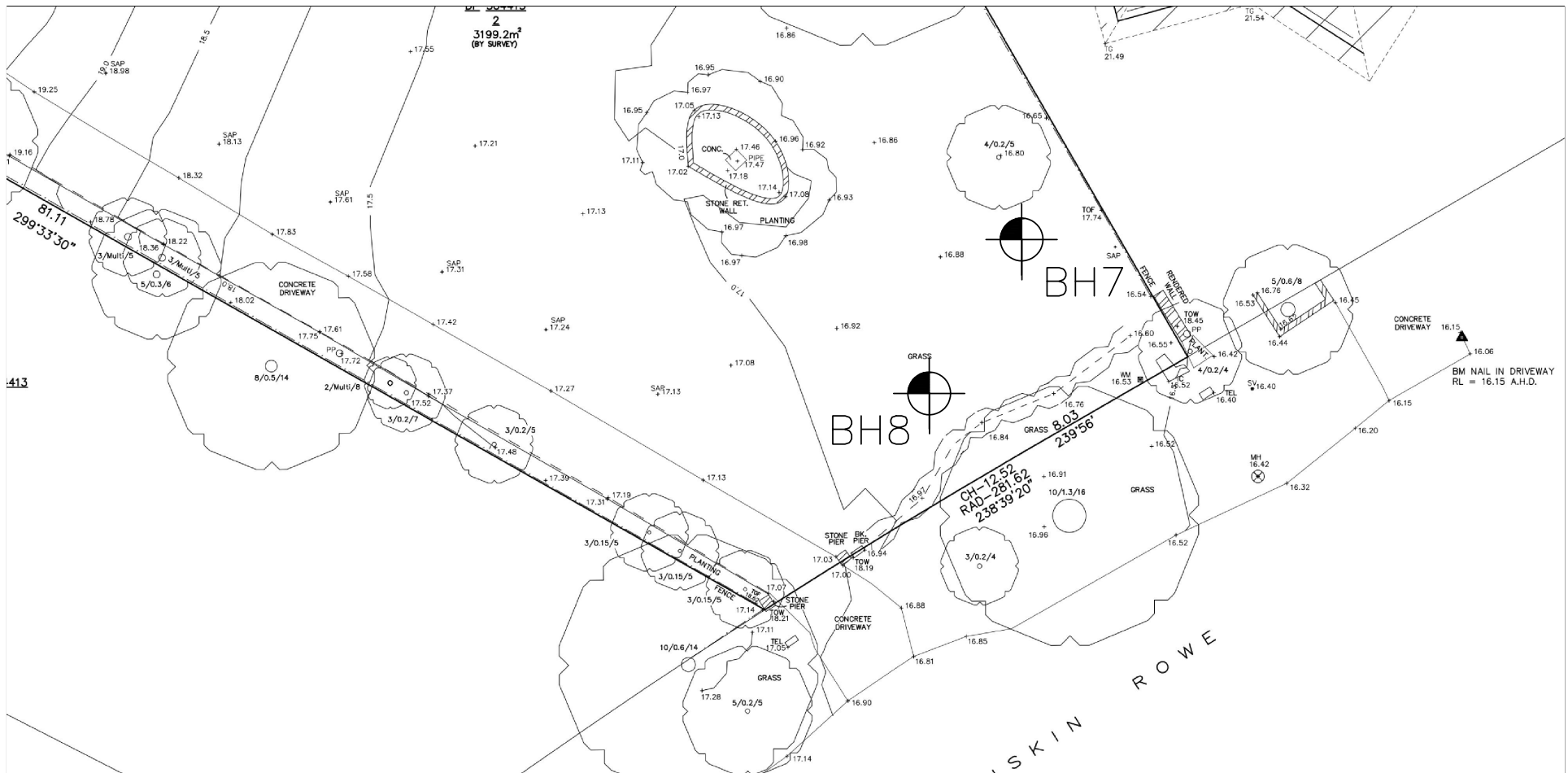

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TEST LOCATIONS

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LEGEND

 Boreholes



issue	date	description
A	12.3.21	INITIAL ISSUE



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SOIL INFILTRATION TEST LOCATIONS

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Appendix A

Important Information about your Geotechnical Report
CSIRO BTF 18

Scope of Services

The geotechnical report ("the report") has been prepared in accordance with the scope of services as set out in the contract, or as otherwise agreed, between the Client and Asset Geotechnical Engineering Pty Ltd ("Asset"), for the specific site investigated. The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

The report should not be used if there have been changes to the project, without first consulting with Asset to assess if the report's recommendations are still valid. Asset does not accept responsibility for problems that occur due to project changes if they are not consulted.

Reliance on Data

Asset has relied on data provided by the Client and other individuals and organizations, to prepare the report. Such data may include surveys, analyses, designs, maps and plans. Asset has not verified the accuracy or completeness of the data except as stated in the report. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations ("conclusions") are based in whole or part on the data, Asset will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Asset.

Geotechnical Engineering

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Limitations of Site Investigation

The investigation program undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions. The data derived from the site investigation program and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behavior with regard to the proposed development. Despite investigation, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel. The actual interface between materials may be more gradual or abrupt than a report indicates.

Therefore, the recommendations in the report can only be regarded as preliminary. Asset should be retained during the project implementation to assess if the report's recommendations are valid and whether or not changes should be considered as the project proceeds.

Subsurface Conditions are Time Dependent

Subsurface conditions can be modified by changing natural forces or man-made influences. The report is based on conditions that existed at the time of subsurface exploration. Construction operations adjacent to the site, and natural events such as floods, or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. Asset should be kept apprised of any such

events, and should be consulted to determine if any additional tests are necessary.

Verification of Site Conditions

Where ground conditions encountered at the site differ significantly from those anticipated in the report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the report that Asset be notified of any variations and be provided with an opportunity to review the recommendations of this report. Recognition of change of soil and rock conditions requires experience and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly.

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The report as a whole presents the site assessment, and must not be copied in part or altered in any way.

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Other Limitations

Asset will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report.

Foundation Maintenance and Footing Performance: A Homeowner's Guide



CSIRO

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpend).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay

Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.

Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.

- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

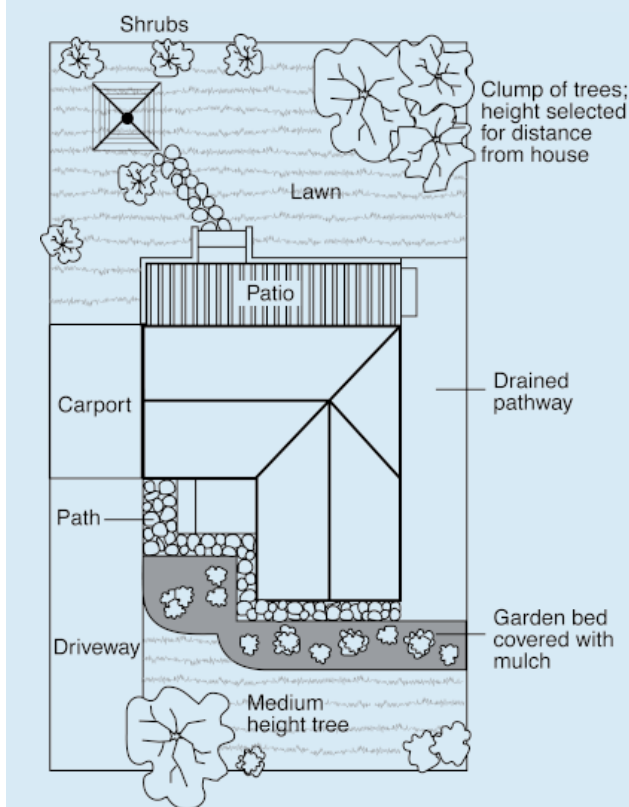
It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter

It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS		
Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4



- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

The information in this and other issues in the series was derived from various sources and was believed to be correct when published.

The information is advisory. It is provided in good faith and not claimed to be an exhaustive treatment of the relevant subject.

Further professional advice needs to be obtained before taking any action based on the information provided.

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Appendix B

Soil & Rock Explanation Sheets
Borehole Logs
DCP Logs

Log Abbreviations & Notes

METHOD

borehole logs

AS	auger screw *
AD	auger drill *
RR	roller / tricone
W	washbore
CT	cable tool
HA	hand auger
D	diatube
B	blade / blank bit
V	V-bit
T	TC-bit

* bit shown by suffix e.g. ADV

excavation logs

NE	natural excavation
HE	hand excavation
BH	backhoe bucket
EX	excavator bucket
DZ	dozer blade
R	ripper tooth

coring

NMLC, NQ, PQ, HQ

SUPPORT

borehole logs

N	nil
M	mud
C	casing
NQ	NQ rods

excavation logs

N	nil
S	shoring
B	benched

CORE-LIFT

|| casing installed

⊢ barrel withdrawn

NOTES, SAMPLES, TESTS

D	disturbed
B	bulk disturbed
U50	thin-walled sample, 50mm diameter
HP	hand penetrometer (kPa)
SV	shear vane test (kPa)
DCP	dynamic cone penetrometer (blows per 100mm penetration)
SPT	standard penetration test
N*	SPT value (blows per 300mm)
	* denotes sample taken
Nc	SPT with solid cone
R	refusal of DCP or SPT

USCS SYMBOLS

GW	Gravel and gravel-sand mixtures, little or no fines.
GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels
GM	Gravel-silt mixtures and gravel-sand-silt mixtures.
GC	Gravel-clay mixtures and gravel-sand-clay mixtures.
SW	Sand and gravel-sand mixtures, little or no fines.
SP	Sand and gravel sand mixtures, little or no fines.
SM	Sand-silt mixtures.
SC	Sand-clay mixtures.
ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity.
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays.
OL	Organic silts
MH	Inorganic silts
CH	Inorganic clays of high plasticity.
OH	Organic clays of medium to high plasticity, organic silt
PT	Peat, highly organic soils.

MOISTURE CONDITION

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

CONSISTENCY



















VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable

DENSITY INDEX
















VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Graphic Log




Soil

	Fill
	Peat, Topsoil
	Clay
	Silty Clay
	Gravelly Clay
	Sandy Clay
	Silt
	Sandy Silt
	Clayey Silt
	Gravelly Silt
	Gravel
	Sandy Gravel
	Clayey Gravel
	Silty Gravel
	Sand
	Gravelly Sand
	Silty Sand
	Clayey Sand





Rock

	Sandstone
	Shale
	Clayey Shale
	Siltstone
	Conglomerate
	Claystone
	Dolerite, Basalt
	Granite
	Limestone
	Tuff
	Porphyry
	Pegmatite
	Gneiss, Schist
	Quartzite
	Coal




Other

	Asphalt
	Concrete
	Brick

Water

	Level
	Inflow
	Outflow (complete)
	Outflow (partial)

Boundaries

	Known
	Probable
	Possible

WEATHERING

XW	extremely weathered
HW	highly weathered
MW	moderately weathered
SW	slightly weathered
FR	fresh

STRENGTH

VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

RQD (%)

$$= \frac{\text{sum of intact core pieces} > 2 \times \text{diameter}}{\text{total length of core run drilled}} \times 100$$

DEFECTS:

type		coating	
JT	joint	cl	clean
PT	parting	st	stained
SZ	shear zone	ve	vener
SM	seam	co	coating

shape

pl	planar
cu	curved
un	undulating
st	stepped
ir	irregular

roughness

po	polished
sl	slickensided
sm	smooth
ro	rough
vr	very rough

inclination

measured above axis and perpendicular to core

AS1726-2017

Soils and rock are described in the following terms, which are broadly in accordance with AS1726-2017.

Soil

MOISTURE CONDITION

Term	Description
Dry	Looks and feels dry. Fine grained and cemented soils are hard, friable or powdery. Uncemented coarse grained soils run freely through hand.
Moist	Soil feels cool and darkened in colour. Fine grained soils can be moulded. Coarse soils tend to cohere.
Wet	As for moist, but with free water forming on hand.
Moisture content of cohesive soils may also be described in relation to plastic limit (W _p) or liquid limit (W _L) [\gg much greater than, $>$ greater than, $<$ less than, $<<$ much less than].	

CONSISTENCY OF FINE-GRAINED SOILS

Term	Su (kPa)	Term	Su (kPa)
Very soft	< 12	Very Stiff	$>100 - \leq 200$
Soft	$>12 - \leq 25$	Hard	> 200
Firm	$>25 - \leq 50$	Friable	-
Stiff	$>50 - \leq 100$		

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Term	Density Index (%)	Term	Density Index (%)
Very Loose	< 15	Dense	$65 - 85$
Loose	$15 - 35$	Very Dense	>85
Medium Dense	$35 - 65$		

PARTICLE SIZE

Name	Subdivision	Size (mm)
Boulders		> 200
Cobbles		$63 - 200$
Gravel	coarse	$19 - 63$
	medium	$6.7 - 19$
	fine	$2.36 - 6.7$
Sand	coarse	$0.6 - 2.36$
	medium	$0.21 - 0.6$
	fine	$0.075 - 0.21$
Silt & Clay		< 0.075

MINOR COMPONENTS

Term	Proportion by Mass:	
	<u>coarse grained</u>	<u>fine grained</u>
Trace	$\leq 15\%$	$\leq 5\%$
With	$>15\% - \leq 30\%$	$>5\% - \leq 12\%$

SOIL ZONING

Layers	Continuous across exposures or sample.
Lenses	Discontinuous, lenticular shaped zones.
Pockets	Irregular shape zones of different material.

SOIL CEMENTING

Weakly	Easily broken up by hand pressure in water or air.
Moderately	Effort is required to break up by hand in water or in air.

USCS SYMBOLS

Symbol	Description
GW	Gravel and gravel-sand mixtures, little or no fines.
GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels.
GM	Gravel-silt mixtures and gravel-sand-silt mixtures.
GC	Gravel-clay mixtures and gravel-sand-clay mixtures.
SW	Sand and gravel-sand mixtures, little or no fines.
SP	Sand and gravel-sand mixtures, little or no fines.
SM	Sand-silt mixtures.
SC	Sand-clay mixtures.
ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity.
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays.
OL	Organic silts
MH	Inorganic silts
CH	Inorganic clays of high plasticity.
OH	Organic clays of medium to high plasticity, organic silt
PT	Peat, highly organic soils.

Rock

SEDIMENTARY ROCK TYPE DEFINITIONS

Rock Type	Definition (more than 50% of rock consists of)
Conglomerate	... gravel sized ($>2\text{mm}$) fragments.
Sandstone	... sand sized (0.06 to 2mm) grains.
Siltstone	... silt sized ($<0.06\text{mm}$) particles, rock is not laminated.
Claystone	... clay, rock is not laminated.
Shale	... silt or clay sized particles, rock is laminated.

LAYERING

Term	Description
Massive	No layering apparent.
Poorly Developed	Layering just visible. Little effect on properties.
Well Developed	Layering distinct. Rock breaks more easily parallel to layering.

STRUCTURE

Term	Spacing (mm)	Term	Spacing
Thinly laminated	<6	Medium bedded	$200 - 600$
Laminated	$6 - 20$	Thickly bedded	$600 - 2,000$
Very thinly bedded	$20 - 60$	Very thickly bedded	$> 2,000$
Thinly bedded	$60 - 200$		

STRENGTH (NOTE: Is50 = Point Load Strength Index)

Term	Is50 (MPa)	Term	Is50 (MPa)
Extremely Low	<0.03	High	$1.0 - 3.0$
Very low	$0.03 - 0.1$	Very High	$3.0 - 10.0$
Low	$0.1 - 0.3$	Extremely High	>10.0
Medium	$0.3 - 1.0$		

WEATHERING

Term	Description
Residual Soil	Material is weathered to an extent that it has soil properties. Rock structures are no longer visible, but the soil has not been significantly transported.
Extremely	Material is weathered to the extent that it has soil properties. Mass structures, material texture & fabric of original rock is still visible.
Highly	Rock strength is significantly changed by weathering; rock is discolored, usually by iron staining or bleaching. Some primary minerals have weathered to clay minerals.
Moderately	Rock strength shows little or no change of strength from fresh rock; rock may be discolored.
Slightly	Rock is partially discolored but shows little or no change of strength from fresh rock.
Fresh	Rock shows no signs of decomposition or staining.

DEFECT DESCRIPTION

Type	
Joint	A surface or crack across which the rock has little or no tensile strength. May be open or closed.
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub-parallel to layering/bedding. May be open or closed.
Sheared Zone	Zone of rock substance with roughly parallel, near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects.
Seam	Seam with deposited soil (infill), extremely weathered insitu rock (XW), or disoriented usually angular fragments of the host rock (crushed).

Shape

Planar	Consistent orientation.
Curved	Gradual change in orientation.
Undulating	Wavy surface.
Stepped	One or more well defined steps.
Irregular	Many sharp changes in orientation.

Roughness

Polished	Shiny smooth surface.
Slickensided	Grooved or striated surface, usually polished.
Smooth	Smooth to touch. Few or no surface irregularities.
Rough	Many small surface irregularities (amplitude generally $<1\text{mm}$). Feels like fine to coarse sandpaper.
Very Rough	Many large surface irregularities, amplitude generally $>1\text{mm}$. Feels like very coarse sandpaper.

Coating

Clean	No visible coating or discolouring.
Stained	No visible coating but surfaces are discolored.
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	Visible coating = 1mm thick. Thicker soil material described as seam.





Borehole Log

BH no: **BH1**

sheet: 1 of 1

job no.: 6406

client:	Alexander & Co	started:	4.3.2021
principal:	Jo and Toby Mander Jones	finished:	4.3.2021
project:	Proposed Residence	logged:	AT
location:	16 Ruskin Rowe, Avalon Beach NSW	checked:	MAB
equipment:	HA/DCP	RL surface:	18 m approx.
diameter:	70mm	inclination:	-90°
bearing:	---	E:	
N:		datum:	AHD

drilling information						material information							
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro- meter kPa	structure and additional observations	
HA/DCP	N	Slow seepage ▼		17.5	0.1		TOPSOIL	TOPSOIL, Sandy CLAY with some silt, fine to medium grained sand, low to medium plasticity, grass root, dark brown.	>Wp	VS		TOPSOIL.	
							SC	Sandy CLAY with some silt, fine to medium grained, low to medium plasticity, trace of grass roots, dark grey.		St		ALLUVIUM.	
					0.5			SP	SAND with traces of clay, fine to medium grained, light grey.	W	D		
					0.9			SP	SAND with some clay, fine to medium grained, light grey/ yellow brown.		MD/F		
DCP				17.0	1.0				>Wp	D/St			
					1.2			Hand Auger reached practical refusal @ 1.2m on very stiff clay.		VSt		RESIDUAL.	
				16.5	1.5					H			
				16.0	2.0			DCP terminated @ 2.0m on inferred hard clay, target depth. Borehole No: BH1 terminated at 2m					
				15.5	2.5								

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED

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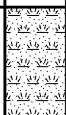




Borehole Log

BH no: **BH2**

sheet: 1 of 1

job no.: 6406

client:	Alexander & Co	started:	4.3.2021
principal:	Jo and Toby Mander Jones	finished:	4.3.2021
project:	Proposed Residence	logged:	AT
location:	16 Ruskin Rowe, Avalon Beach NSW	checked:	MAB
equipment:	HA/DCP	RL surface:	18.98 m approx.
diameter:	70mm	inclination:	-90°
bearing:	---	E:	
N:		datum:	AHD

drilling information						material information								
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	100 hand penetro- meter kPa	structure and additional observations		
HA/DCP	N						TOPSOIL	TOPSOIL, SAND with some silt, fine to medium grained, dark brown, grass roots.	M	VL		TOPSOIL.		
							L							
					0.2		SP	SAND with some silt, fine to medium grained, brown.		MD			ALLUVIUM.	
					0.3		SP	SAND, fine to medium grained, dark grey.						
					18.5	0.45		SP		SAND, fine to medium grained, light grey.	D			
						0.8		SP		SAND with trace of clay, fine to medium grained, light grey with traces of brown.	MD			
	18.0	1.0												
DCP					1.1			Hand Auger reached practical refusal @ 1.1m on inferred very stiff clay.	>Wp	VSt		RESIDUAL.		
										H				
					17.5	1.5								
						</								

Slow seepage ↓


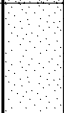
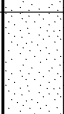
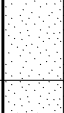
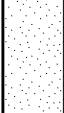
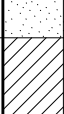
Borehole Log

BH no: **BH3**

sheet: 1 of 1

job no.: 6406

client:	Alexander & Co	started:	4.3.2021
principal:	Jo and Toby Mander Jones	finished:	4.3.2021
project:	Proposed Residence	logged:	AT
location:	16 Ruskin Rowe, Avalon Beach NSW	checked:	MAB
equipment:	HA/DCP	RL surface:	21.11 m approx.
diameter:	70mm	inclination:	-90°
	bearing:	E:	---
		N:	
		datum:	AHD

drilling information						material information						
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro- meter kPa 100 200 300 400	structure and additional observations
HA/DCP	N	Slow seepage ▼		21.0			TOPSOIL	TOPSOIL, SAND with some silt, fine to medium grained, dark grey, mixed with medium grained yellow brown sand, grass roots.	M-W	L		TOPSOIL.
				0.2			SP	SAND with some silt, fine to medium grained, dark grey.		MD	ALLUVIUM.	
				0.4			SP	SAND with some silt, fine to medium grained, dark grey/ brown.	W	D		
				0.5						MD		
				20.5			SP	SAND with some silt and traces of clay, fine to medium grained, dark brown/ light brown.		D		
				1.0	1		CL	CLAY with some sand, medium to high plasticity, fine to medium grained sand, yellow brown.	<Wp	VSt		RESIDUAL.
				20.0								
DCP					1.2			Hand Auger reached practical refusal @ 1.2m on very stiff clay.				
					1.5							
					19.5							
					2.0			DCP bouncing @ 1.7m on inferred Sandstone bedrock. Borehole No: BH3 terminated at 1.7m				BEDROCK.
					19.0							
					2.5							

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED

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








Borehole Log

BH no: **BH4**

sheet: 1 of 1

job no.: 6406

client:	Alexander & Co	started:	4.3.2021
principal:	Jo and Toby Mander Jones	finished:	4.3.2021
project:	Proposed Residence	logged:	AT
location:	16 Ruskin Rowe, Avalon Beach NSW	checked:	MAB
equipment:	HA/DCP	RL surface:	22.47 m approx.
diameter:	70mm	inclination:	-90°
	bearing: ---	E:	N:
		datum:	AHD

drilling information						material information																																						
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro- meter kPa	structure and additional observations																																
HA/DCP	N	None Observed			0.15		TOPSOIL	TOPSOIL, SAND with some silt, fine to medium grained, dark brown, grass roots.	M	L		TOPSOIL.																																
							SP	SAND with some silt, fine to medium grained, dark grey/ brown.		D		ALLUVIUM.																																
								SP		SAND, fine to medium grained, brown.	VD																																	
						0.4								Wp	VSt	St	RESIDUAL.																											
DCP					0.5			Hand Auger reached practical refusal @ 1.1m on very stiff clay.		H																																		
											0.65	SC	Sandy CLAY, medium plasticity, fine to medium grained sand, brown/ yellow brown.	VSt																														
															0.73	CL		CLAY with traces of sand, medium to high plasticity, yellow brown with tarces of orange brown.	VSt																									
					1.0						BEDROCK.																																	
												1.1																																
					1.5																																							
					2.0																																							
					2.5																																							






REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED

Borehole Log - Revision 10

Borehole Log

BH no: **BH5**
sheet: 1 of 1
job no.: 6406

client: Alexander & Co
principal: Jo and Toby Mander Jones
project: Proposed Residence
location: 16 Ruskin Rowe, Avalon Beach NSW
equipment: HA/DCP
diameter: 70mm inclination: -90° bearing: --- E: N:
started: 4.3.2021
finished: 4.3.2021
logged: AT
checked: MAB
RL surface: 25.06 m approx.
datum: AHD

drilling information							material information					
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro- meter kPa 100 200 300 400	structure and additional observations
HA/DCP	N	None Observed		25.0			TOPSOIL	TOPSOIL, SAND with some silt, fine to medium grained, dark grey, grass roots.	M-W	VL		TOPSOIL.
					0.1		SP	SAND with some silt, fine to medium grained, grey.		L		ALLUVIUM.
										MD		
					0.4		SP	SAND, fine to medium grained, dark grey/ pale brown.		D		
					0.5					MD		
				24.5	0.55		SC	Sandy CLAY, medium to high plasticity, fine to medium grained sand, pale brown to yellow brown.	<Wp	F		RESIDUAL.
					0.65		CL	CLAY, medium to high plasticity, yellow brown with traces of orange brown.		St		
					1.0							
DCP				24.0	1			Hand Auger reached practical refusal @ 1.0m on stiff clay.		VSt		
								DCP bouncing @ 1.2m on inferred Sandstone bedrock. Borehole No: BH5 terminated at 1.2m				BEDROCK.
					1.5							
				23.5								
					2.0							
				23.0								
					2.5							

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED

Borehole Log - Revision 10








Borehole Log

BH no: **BH6**

sheet: 1 of 1

job no.: 6406

client:	Alexander & Co	started:	4.3.2021
principal:	Jo and Toby Mander Jones	finished:	4.3.2021
project:	Proposed Residence	logged:	AT
location:	16 Ruskin Rowe, Avalon Beach NSW	checked:	MAB
equipment:	HA/DCP	RL surface:	19.71 m approx.
diameter:	70mm	inclination:	-90°
bearing:	---	E:	
N:		datum:	AHD

drilling information						material information						
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	100 200 300 400 hand penetrometer kPa	structure and additional observations
HA/DCP	N	Slow seepage ▼		19.5	0.075		TOPSOIL	TOPSOIL, SAND with some clay and silt, fine to medium grained sand, low to medium plasticity, light grey/ dark brown, grass roots.	Wp/M	VS		TOPSOIL
						FILL	FILL, CLAY with some sand and silt, medium plasticity, fine to medium grained sand, yellow brown/ light grey/ dark brown/ orange, grass roots.			S		FILL.
					0.4		SP	SAND, fine to medium grained, dark grey.	M-W	MD		ALLUVIUM.
					0.5		SP	SAND, fine to medium grained, light grey.	W	D		
					0.65		SC	Sandy CLAY, medium plasticity, fine to medium grained sand, light grey/ yellow brown.	<Wp	VSt		RESIDUAL.
DCP				18.5	0.8		CL	CLAY with some sand, medium to high plasticity, yellow brown with traces of orange brown.		St		
					1.1		Hand Auger reached practical refusal @ 1.1m on very stiff clay.	Wp	VSt			
								St				
				1.5					VSt			
				18.0								
				2.0								
				17.5				DCP bouncing @ 2.0m on inferred Sandstone bedrock, target depth. Borehole No: BH6 terminated at 2m				
				2.5								


REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED

Borehole Log - Revision 10

Borehole Log

BH no: BH7
sheet: 1 of 1
job no.: 6406

client: Alexander & Co
principal: Jo and Toby Mander Jones
project: Proposed Residence
location: 16 Ruskin Rowe, Avalon Beach NSW
equipment: HA
diameter: 70mm **inclination:** -90° **bearing:** --- **E:** **N:**
started: 12.3.2021
finished: 12.3.2021
logged: AT
checked: MAB
RL surface: 16.8 m approx.
datum: AHD

drilling information						material information						
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro- meter kPa	structure and additional observations
HA	N	None Observed					TOPSOIL	TOPSOIL, SAND with some silt, fine to medium grained sand, dark brown, grass roots.	M	L?	<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></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REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED

Borehole Log - Revision 10


Borehole Log

BH no: **BH8**

sheet: 1 of 1

job no.: 6406

client:	Alexander & Co	started:	12.3.2021
principal:	Jo and Toby Mander Jones	finished:	12.3.2021
project:	Proposed Residence	logged:	AT
location:	16 Ruskin Rowe, Avalon Beach NSW	checked:	MAB
equipment:	HA	RL surface:	16.76 m approx.
diameter:	70mm	inclination:	-90°
	bearing:	E:	N:
		datum:	AHD

drilling information						material information						
method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	100 hand penetro- meter kPa 300 400	structure and additional observations
HA	N	None Observed					TOPSOIL	TOPSOIL, SAND with some silt, fine to medium grained sand, dark brown, grass roots.	M	L?		TOPSOIL.
					0.1		SP	SAND with some silt and clay, fine to medium grained, medium plasticity, dark brown/ dark grey.				ALLUVIUM.
					0.15		CL	CLAY with some sand, medium plasticity, fine to medium grained sand, dark grey/ light grey.	<Wp	F-St?		
					16.5							
					0.5							
					0.55		CL	CLAY with some sand, medium plasticity, fine to medium grained sand, brown/ light grey.				
					0.6		SC	Sandy CLAY, medium plasticity, fine to medium grained sand, light grey with traces of yellow brown.				RESIDUAL.
					0.72		SC	Sandy CLAY, medium plasticity, fine to medium grained, light grey/ yellow brown.				
					0.85		SC	Sandy CLAY, medium to high plasticity, fine to medium grained sand, yellow brown.				
					0.9			Hand Auger reacted target depth @ 0.9m on inferred stiff sandy clay. Borehole No: BH8 terminated at 0.9m				
					1.0							
					15.5							
					1.5							
					15.0							
					2.0							
					14.5							
					2.5							

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED

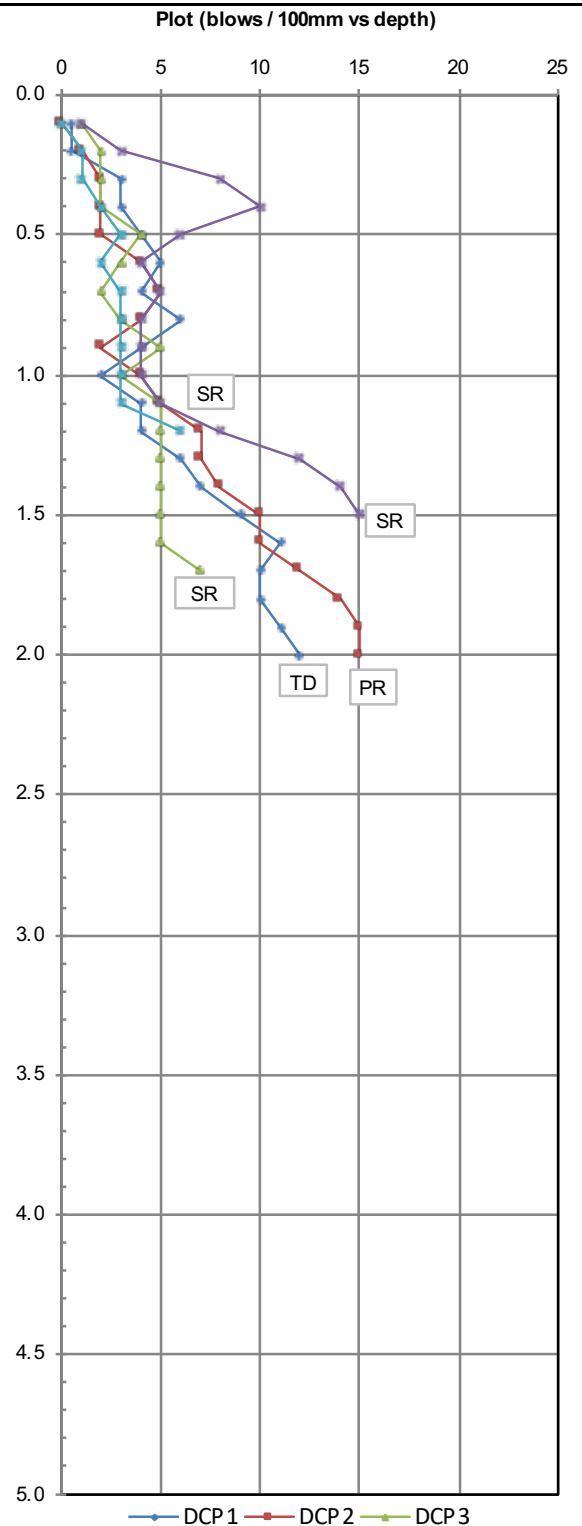
Borehole Log - Revision 10

client: Alexander & Co
principal: Jo and Toby Mander Jones
project: Proposed Residence
location: 16 Ruskin Rowe, Avalon Beach NSW

started: 04.03.2021
finished: 04.03.2021
logged: AT
checked: MAB

equipment: 9kg hammer, 510mm drop, cone tip
standard: AS1289.6.3.2-1997

Depth (m)	Test Results (blows / 100mm)				
	DCP1	DCP2	DCP3	DCP4	DCP5
0.00 – 0.10	0.5	0	1	1	0
0.10 – 0.20	0.5	1	2	3	1
0.20 – 0.30	3	2	2	8	1
0.30 – 0.40	3	2	2	10	2
0.40 – 0.50	4	2	4	6	3
0.50 – 0.60	5	4	3	4	2
0.60 – 0.70	4	5	2	5	3
0.70 – 0.80	6	4	3	4	3
0.80 – 0.90	4	2	5	4	3
0.90 – 1.00	2	4	3	4	3
1.00 – 1.10	4	5	5	5	3
1.10 – 1.20	4	7	5	8	6
1.20 – 1.30	6	7	5	12	SR
1.30 – 1.40	7	8	5	14	
1.40 – 1.50	9	10	5	15	
1.50 – 1.60	11	10	5	SR	
1.60 – 1.70	10	12	7		
1.70 – 1.80	10	14	SR		
1.80 – 1.90	11	15			
1.90 – 2.00	12	15			
2.00 – 2.10	TD	PR			
2.10 – 2.20					
2.20 – 2.30					
2.30 – 2.40					
2.40 – 2.50					
2.50 – 2.60					
2.60 – 2.70					
2.70 – 2.80					
2.80 – 2.90					
2.90 – 3.00					
3.00 – 3.10					
3.10 – 3.20					
3.20 – 3.30					
3.30 – 3.40					
3.40 – 3.50					
3.50 – 3.60					
3.60 – 3.70					
3.70 – 3.80					
3.80 – 3.90					
3.90 – 4.00					
4.00 – 4.10					
4.10 – 4.20					
4.20 – 4.30					
4.30 – 4.40					
4.40 – 4.50					
4.50 – 4.60					
4.60 – 4.70					
4.70 – 4.80					
4.80 – 4.90					
4.90 – 5.00					

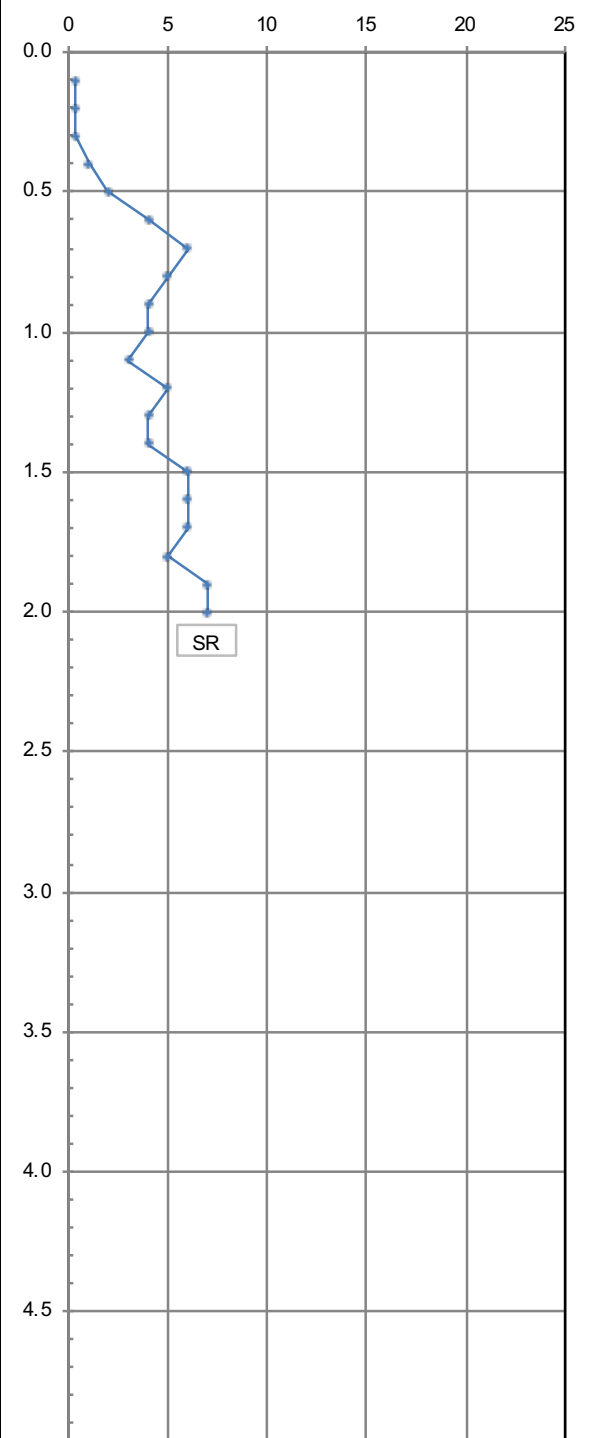


Notes:

RL = ground surface level (m) AHD
TD = target depth, PR = practical refusal (15+ blows per 100mm), SR = "solid" refusal (no further penetration and "solid" ringing sound from slide hammer)

client:	Alexander & Co	started:	04.03.2021
principal:	Jo and Toby Mander Jones	finished:	04.03.2021
project:	Proposed Residence	logged:	AT
location:	16 Ruskin Rowe, Avalon Beach NSW	checked:	MAB

equipment:	9kg hammer, 510mm drop, cone tip
standard:	AS1289.6.3.2-1997

Depth (m)	Test Results (blows / 100mm)					Plot (blows / 100mm vs depth)
	DCP6					
0.00 – 0.10	0.33					
0.10 – 0.20	0.33					
0.20 – 0.30	0.33					
0.30 – 0.40	1					
0.40 – 0.50	2					
0.50 – 0.60	4					
0.60 – 0.70	6					
0.70 – 0.80	5					
0.80 – 0.90	4					
0.90 – 1.00	4					
1.00 – 1.10	3					
1.10 – 1.20	5					
1.20 – 1.30	4					
1.30 – 1.40	4					
1.40 – 1.50	6					
1.50 – 1.60	6					
1.60 – 1.70	6					
1.70 – 1.80	5					
1.80 – 1.90	7					
1.90 – 2.00	7					
2.00 – 2.10	SR					
2.10 – 2.20						
2.20 – 2.30						
2.30 – 2.40						
2.40 – 2.50						
2.50 – 2.60						
2.60 – 2.70						
2.70 – 2.80						
2.80 – 2.90						
2.90 – 3.00						
3.00 – 3.10						
3.10 – 3.20						
3.20 – 3.30						
3.30 – 3.40						
3.40 – 3.50						
3.50 – 3.60						
3.60 – 3.70						
3.70 – 3.80						
3.80 – 3.90						
3.90 – 4.00						
4.00 – 4.10						
4.10 – 4.20						
4.20 – 4.30						
4.30 – 4.40						
4.40 – 4.50						
4.50 – 4.60						
4.60 – 4.70						
4.70 – 4.80						
4.80 – 4.90						
4.90 – 5.00						

Notes:

RL = ground surface level (m) AHD

TD = target depth, PR = practical refusal (15+ blows per 100mm), SR = "solid" refusal (no further penetration and "solid" ringing sound from slide hammer)

— DCP6

Appendix C

Site Photos



Photo 1
Overview of the
existing residence.



Photo 2
Overview of the
existing pool at the
rear