ASCENT
GEOTECHNICAL CONSULTING

Geotechnical Assessment

Project: New Dwelling
37 Heath Street, Mona Vale NSW

Prepared for:
David Hellmich
37 Heath Street
Mona Vale, NSW 2103

REF: AG 20011
1 December, 2020

AG 20011
1 December 2020

Geotechnical Assessment

For **New Dwelling** at

37 Heath Street, Mona Vale NSW

Document Status			Approved for Issue	
Version	**Author**	**Reviewer**	**Signature**	**Date**
3	Ben Morgan	Karen Allan		1-Dec-20
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Version	**Copies**	**Format**	**To**	**Date**
3	1	PDF	David Hellmich – Reef Interiors Pty Ltd	1-Dec-20

Limitations

This report has been prepared for David Hellmich in accordance with Ascent Geotechnical Consulting's (Ascent) Fee Proposal dated 16 January 2020.

The report is provided for the exclusive use of the property owners, and their nominated agents, for the specific development and purpose as described in the report. This report must not be used for purposes other than those outlined in the report or applied to any other projects.

The information contained within this report is considered accurate at the time of issue with regard to the current conditions onsite as identified by Ascent and the documentation provided by others.

The report should be read in its entirety and should not be separated from its attachments or supporting notes. It should not have sections removed or included in other documents without the express approval of Ascent.

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1 Overview

1.1 Background

This report presents the findings of a limited geotechnical assessment carried out at 37 Heath Street, Mona Vale NSW (the "Site"), by Ascent Geotechnical Consulting (Ascent). This assessment has been prepared to meet Northern Beaches Council lodgement requirements for Development Application (DA).

1.2 Proposed Development

Details of the proposed development are outlined in a series of architectural plans prepared by Markham Lee Architects, Drawing No. DD02–DD05 and DD07–DD08, dated 6 November 2020.

The proposed works comprise the following:

- Demolition of existing single-storey dwelling, pool and detached secondary dwelling
- Site clearing and preparation
- Construction of new two-storey dwelling, in-ground swimming pool, and double garage.

The proposed development will take place on a 923.20m^2 residential block being Lot 31 Sec G in DP 7236.

1.3 Relevant Instruments

This geotechnical assessment has been prepared in accordance with the following relevant guidelines and standards:

- Northern Beaches Council – Pittwater Local Environment Plan (PLEP) 2014 and Pittwater Development Control Plan (WDCP) 2014
- Appendix 5 (to Pittwater P21) Geotechnical Risk Management Policy for Pittwater – 2009
- Australian Geomechanics Society's 'Landslide Risk Management Guidelines' (AGS 2007)
- Australian Standard 1726–2017 Geotechnical Site Investigations
- Australian Standard 2870–2011 Residential Slabs and Footings
- Australian Standard 1289.6.3.2–1997 Methods of Testing Soils for Engineering Purposes
- Australian Standard 3798–2007 Guidelines on Earthworks for Commercial and Residential Developments.

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2 Site Description

2.1 Summary

A summary of Site conditions identified at the time of our Assessment is provided in the table below (Table 1).

Table 1. Summary of site conditions

Parameter	Description
Site Visit	Morgan Spreadbury-Key - Ascent Geotechnical – 28/01/2020
Site Address	37 Heath Street, Mona Vale NSW – Lot 31 Sec G D.P. 7236.
Site Area m^2 (approx.)	923.20m^2 (by Title.), 929.0 m^2 (by Calc.)
Existing development	Single-storey fibro dwelling, metal roof. Detached secondary dwelling, in-ground pool and carport.
Slope Aspect	Minor fall to the west.
Average gradient & RL (AHD)	<5 degrees | Approximate average of RL ~4.6 at western boundary to RL ~4.4 at eastern boundary.
Vegetation	Large lawn areas, small shrubs and medium to large palms, trees and bamboo.
Retaining Structures	Various low treated timber walls retaining garden beds and neighbouring property level along eastern boundary of block.
Neighbouring environment	Residentially developed to the south, east and west. Heath Street to the north.

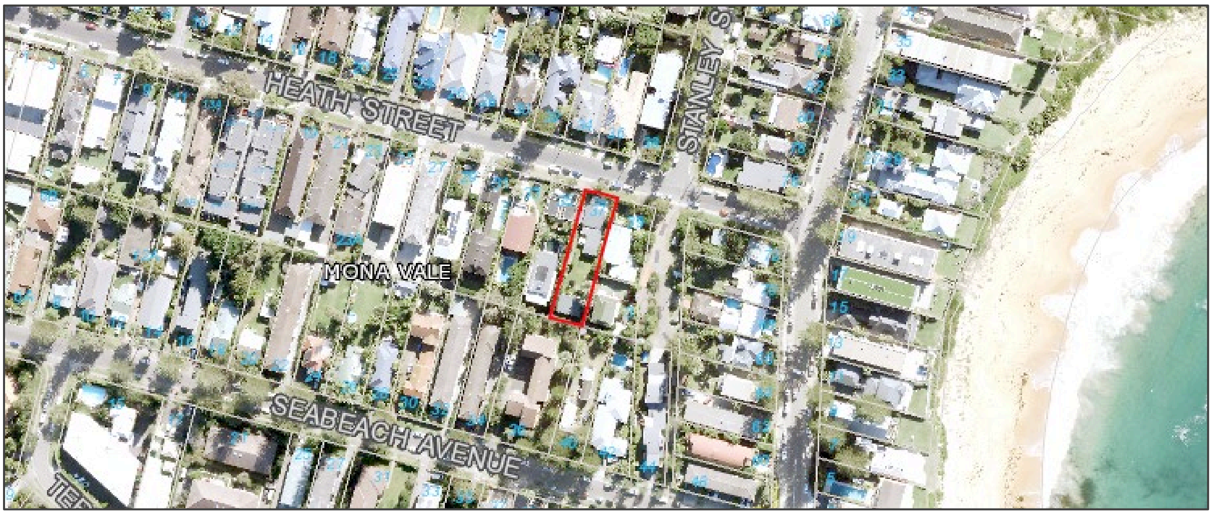

Image 1. Site location: 37 Heath Street, Mona Vale NSW (© NBC Maps)

2.2 Geology and Geological Interpretation

The Sydney 1:100,000 Geological Sheet 9130 (NSW Dept. Mineral Resources, 1983) indicates that the site is situated on the boundary between the Quaternary silty to peaty quartz sand, silt and clay (Qha), and the Narrabeen Group Newport Formation geology (Rnn), consisting of interbedded laminite, shale, and quartz to lithic-quartz sandstones. The Quaternary sediments (Qha) comprise silty to peaty quartz sand, silt and clay with ferruginous and humic cementation in places with common shell layer, and commonly overly the Narrabeen Group Newport Formation geology (Rnn).

The soil profile is interpreted to consists of shallow uncontrolled fill (O & A Horizons), sandy loam, and deep quartz sands (B Horizon) overlying weathered bedrock (C Horizon). The deep soil profile in this location is interpreted to be derived from ancient transgressive sand dunes and beach-front coastal processes.

Note: The local underlying bedrock geology is comprised predominantly of sandstones and shale. Sandstone floaters or large detached joint blocks are sometimes found in the upper soil profile, usually at higher topographic positions. Subsequently ground conditions on site may alter significantly across short distances. This variability should be anticipated and accounted for in the design and construction of any new foundations. Based on our testing and the known geological conditions of the area, it is likely that the shale and sandstone bedrock of the Narrabeen Group Newport Formation (Rnn) deepens towards the southern boundary of the block, resulting in a deepening of the overlying and younger Quaternary sediments (Qha).

2.3 Fieldwork

A limited geotechnical site investigation was carried out by Ascent on the 28 January 2020, which included a geotechnically focused visual assessment of the property and its surrounds, geotechnical mapping, photographic record and limited subsurface investigation.

Four Dynamic Cone Penetrometer (DCP) tests were carried out to measure relative density of the shallow soils and the depth to weathered rock (if encountered). These tests were carried out in accordance with the Australian Standard for ground testing: AS 1289.6.3.2 – 1997. Possible locations of testing were constrained by existing structures, hard surfaces, and the presence of utilities. The location of these tests is shown on the site plan provided and summary of the test results is presented below in Table 2, with full details in the engineering logs presented in Appendix C.

Table 2. Summary DCP test results

TEST	DCP 1	DCP 2	DCP 3	DCP 4
Summary	End of test @ 2.05m in dense sands and/or weathered bedrock. Coarse quartz grains on moist tip.	End of test @ 3.30m in dense sands and/or weathered bedrock. Coarse quartz grains on moist tip. Rods moist from 1.80m to tip.	End of test @ 2.00m in dense sands and/or weathered bedrock. Coarse quartz grains on moist tip.	Refusal @ 2.20m Bouncing on inferred weathered bedrock or large floater. White/orange sandy clay on moist tip. Rods moist form 1.60m to tip.

Hand Auger Testing

One Hand Auger borehole (BH1) test was drilled at the approximate location shown on the site plan to visually identify the subsurface material. An engineering log of the hand auger borehole is presented in Table 3 below.

Table 3. Hand Auger test results

BH1 - Depth	Material description
0.00 to 0.25m	*FILL*. **ORGANIC SILT**. Grey to black, fine to medium grained, minor grass roots, dry and loose.
0.25 to 1.20m	**SANDY LOAM**. Brown to yellow/orange, medium grained, low cohesiveness, moist and loose.
1.20 to 1.80m	**SANDS**. Orange/yellow, coarse grained, density increasing with depth, moist and loose to medium dense.
	Borehole terminated at 1.80m in medium dense quartz sands. No standing water table or significant seepage encountered.

Note: The equipment chosen to undertake ground investigations provides the most cost-effective method for understanding the subsurface conditions. Our interpretation of the subsurface conditions is limited to the results of testing undertaken and the known geology in the area. While every care is taken to accurately identify the subsurface conditions on-site, variation between the interpreted model presented herein, and the actual conditions onsite may occur. Should actual ground conditions vary from those anticipated, we would recommend the geotechnical engineer be informed as soon as possible to advise if modifications to our recommendations are required.

3 Geotechnical Assessment

3.1 Site Classification

Due to the presence of shallow uncontrolled fill, deep unconsolidated sediments, and low bearing strength of soil materials, the Site is classified as **"P"** in accordance with AS 2870:2011.

3.2 Groundwater

Normal Groundwater seepage is expected to move downslope through the soil profile along the interface with underling bedrock, or any impervious horizons in the profile such as clays.

Minor seepage was encountered at an average depth of ~1.80m to the base of termination for DCP 2 & DCP 4 during our testing, believed to be resultant from recent rainfall percolating through the permeable soil profile to the interface of the underlying bedrock.

Based on knowledge of similar topographic locations, we would expect a standing water table to be found within the range of RL 1.0 – RL 2.0, for locations underlain by a deep sand profile. Based on the results of our DCP testing, in this location the sand profile overlies a relatively shallow weathered shale bedrock profile, dipping to the south. No significant standing water table was identified in our testing. However, it is possible that the fluctuating water table, as a result of rainfall, may influence the proposed excavation. The installation of long-term groundwater monitoring bores, by specialist contractors, may be required to confirm these assumptions.

3.3 Surface Water

Overland or surface flows entering the site from the adjoining areas were not identified at the time of our inspection, however normal overland runoff could enter the site from above during heavy or extended rainfall.

3.4 Slope Instability

A landslide hazard assessment of the existing slope has been undertaken in accordance with Australian Geomechanics Society's 'Landslide Risk Management', published March 2007.

- No evidence of significant soil creep, tension cracks or other indicators of slope instability were identified at the time of our inspection.

- The existing structure displayed no evidence of significant cracking or settlement that could be attributed to slope instability.
- The property is not located within a '**Geotechnical Hazard Area'** in Northern Beaches Council PLEP Geotechnical Hazard Map (**Image 2** below).

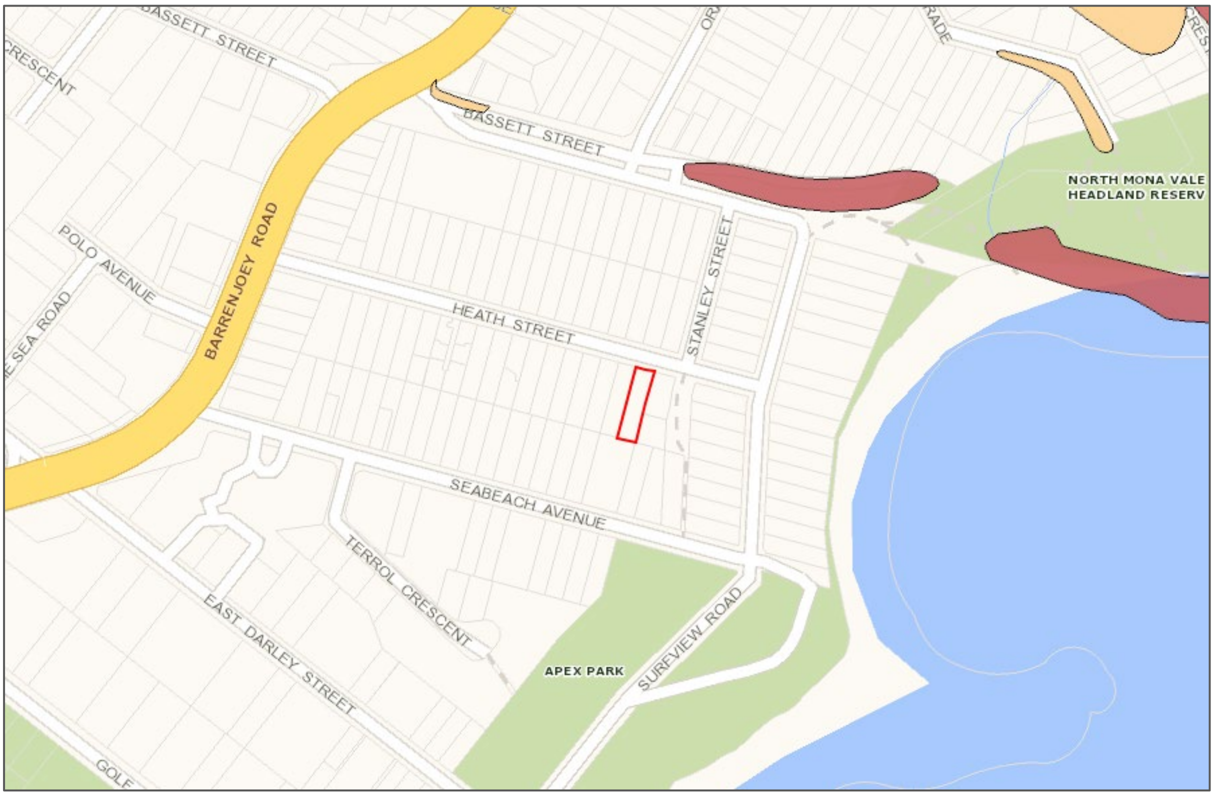

Image 2. Geotechnical Hazard Map - 37 Heath Road, Mona Vale NSW — red polygon (PLEP 2014)

3.5 Geotechnical Hazards and Risk Analysis

No significant geotechnical hazards were identified above, beside or below the subject site.

The slope across the subject site has an average gradient of <5 degrees. The soil profile is interpreted to be comprised of shallow uncontrolled fill with sandy loam & deep quartz sands overlying weathered bedrock at depths anticipated to be between 2000mm to 3300mm from current surface levels across site. The likelihood of the slope failing is assessed as '**UNLIKELY**', the consequences of such a failure are assessed as '**MINOR**'. The risk to property is '**LOW**'.

The existing conditions and proposed development are considered to constitute an '**ACCEPTABLE**' risk to life and a '**LOW**' risk to property provided that the recommendations outlined in **Section 3.6** are adhered to.

3.6 Recommendations

The proposed development is considered to be suitable for the site. No significant geotechnical hazards should result from the completion of the proposed development provided the recommendations presented in Table 4 are adhered to.

Table 4. Geotechnical Recommendations

Recommendation	Description
Dilapidation Reporting	We would recommend that detailed dilapidation reporting, undertaken by others, be prepared for all adjacent structures before works commence on-site.
Soil Excavation	Soil excavation will be required for the construction of the proposed new sub-floor level garage, expected to be at an approximate maximum depth of ~3.3m, and as well as to establish pad levels and footings across site. It is anticipated that these excavations will encounter shallow fill, sandy loam and deep quartz sands, overlying weathered bedrock, expected to be between 2000mm to 3300mm from current surface levels. The soil materials should be readily excavated with a bucket excavator, auger attachment or using hand tools. Temporary batter slopes may be considered where setbacks from existing structures and property boundaries permits. Temporary batter slopes in quartz sands should not exceed 1 Vertical (V) in 1.5 Horizontal. If permanent batters are proposed, the unsupported batter must not be steeper in gradient than 30 degrees, and should be supported by geotextile fabric, pinned to the slope and planted with soil binding vegetation. All excavated material is to be removed from the site in accordance with current Office of Environment and Heritage (OEH) regulations
Rock Excavation	All excavation recommendations as outlined below should be read in conjunction with Safe Work Australia's *Code of Practice: Excavation Work*, published October 2018. The construction of the proposed subfloor garage level may require excavations to a maximum depth of approximately ~3.30m. We anticipate the proposed excavations will possibly encounter weathered shale bedrock between 2000mm to 3300mm from current surface levels across site. It is essential that any further excavation through rock that cannot be readily achieved with a bucket excavator or ripper should be carried out

Recommendation	Description
	initially using a rock saw to minimise the vibration impact and disturbance on the adjoining properties, and adjacent structures. Any rock breaking must be carried out only after the rock has been sawed and in short bursts (2–5 seconds) to prevent the vibration amplifying. The break in the rock from the saw must be between the rock to be broken and the closest adjoining structure. Hand operated pneumatic picks may be used without restriction. All excavated material is to be removed from the site in accordance with current Office of Environment and Heritage (OEH) regulations.
Vibrations	During excavation, it will be necessary to use appropriate methods and equipment to keep ground vibrations within acceptable limits. The level of acceptable vibration is dependent on various factors, including the type of structure (e.g. reinforced concrete, brick, etc.), its structural condition, the frequency range of vibrations produced by the construction equipment, the natural frequency of the building and the vibration transmitting medium. Ground vibration can be strongly perceptible to humans at levels above 2.5 mm/s peak particle velocity (PPV). This is generally much lower than the vibration levels required to cause structural damage to buildings. The Australian Standard AS2670.2-1990 "Evaluation of human exposure to whole-body vibrations – continuous and shock induced vibrations in buildings (1-80 Hz)" suggests a day time limit of 8 mm/s PPV for human comfort is acceptable. Based on Ascents experience, and with reference to AS2670, it is suggested that a maximum PPV of 5 mm/s (applicable at the foundation level of existing adjacent buildings) be adopted at this site for both architectural finishes and human comfort considerations, although this vibration limit may need to be reduced if there are sensitive buildings or equipment in the area. Vibrations may be generated by the installation of sheet piling or rock excavations. The parties responsible for the installation of any shoring system should be consulted regarding potential for vibrations. Depending on the type of excavation and retention methodology used, we would suggest allowable vibration limits be set at 5mm/s PPV. Vibration monitoring may be required to maintain acceptable limits.
Excavation Support	If vertical excavation is required, it will be necessary to provide temporary and permanent excavation support. This support could comprise cantilever or anchored/propped contiguous/secant bored piles, sheet piles or equivalent to be designed by the structural engineer using the earth pressure coefficients outlined herein. All permanent and temporary

Recommendation	Description
	support excavation retention systems are to be designed to comply with locations of the development indicated within Councils consent. Embedment below excavation depth will be required to maintain acceptable Factors of Safety (FOS) against wall rotation. Typical embedment depth below excavation in uniform sand is close to twice the retained height and target FOS values for temporary retaining structures range from 1.25 to 2.0 depending on wall behaviour and analysis method. Embedment below final excavation depth will reduce with the ability to socket retention systems into weathered bedrock. When considering the design of the excavation support system, it will be necessary to include surcharge loading from structures on adjoining properties, any ground surface slope and the effects of Groundwater. Where the structures in adjoining properties are within the zone of influence of the Excavation, it will be necessary to adopt at rest Ko, earth pressure coefficients when designing the temporary support system and stiffness of the wall should attempt to minimise wall movement. Cantilever walls will experience deflection during excavation and should only be adopted if the impact of calculated wall deflection can be tolerated by adjacent assets. Anchors or props can be used to provide wall restraint, reducing potential wall deflection and embedment depth. If anchors extend into an adjoining property, it will be necessary to obtain the permission of the property owners. It is not anticipated that any temporary or permanent anchors will be required under council road reserve or other council property. When props or anchors are used for support, a rectangular earth pressure distribution should be adopted on the active side of the support. Ko should also be used to design the permanent support. Retention systems, to be designed by others, should adhere to the following Geotechnical design parameters. **Earth Pressure Coefficients:** • **At rest – Ko 0.60** • **Active – Ka 0.36** • **Passive – Kp 3.00*** **Total (bulk) density for sand – 20 kN/m3** ** Ultimate design values*
Sediment and Erosion Control	Appropriate design and construction methods shall be required during site works to minimise erosion and provide sediment control. In particular, any stockpiled soil will require erosion control measures, such as siltation fencing and barriers, to be designed by others.

<table>
<tr><th>Recommendation</th><th>Description</th></tr>
<tr><td>Footings</td><td>
Visual inspection and our testing indicate the presence of shallow uncontrolled fill, sandy loam and quartz sands overlying weathered bedrock expected to be between 2000mm to 3300mm from current surface levels across site. All pad, strip or piered footings should be founded on and socketed a minimum of 300mm into the underlying weathered bedrock using piers as required. For fully cleaned footings, the allowable end bearing pressure is 800 kPa.
For footings taken to the overlying medium dense to dense quartz sands, pad and strip footings on this material may be designed using the allowable bearing pressures given in the table below.
<table>
<tr><td>Footing Depth (m)</td><td>0.5</td><td>1.0</td><td>1.5</td><td>2.0</td></tr>
<tr><td>Allowable Bearing Pressure (kPa)</td><td>70</td><td>120</td><td>160</td><td>180</td></tr>
</table>
The above bearing pressures assume a thoroughly clean footing and minimum 0.5m embedment below final adjoining ground surface. These bearing values are likely to result in settlement of between 10 to 20mm. Potential differential settlement can be 50% of the total values. Potential differential settlement will increase where founding depths vary across the site. Deeper footings founded on the medium dense to dense sand will settle less than similarly loaded footings founded within the upper loose sand. Consideration should be given to the footing depth of any structures to be retained, where they abut new structures.
Due to the difficulty in excavation of traditional bored piers in collapsible sands, the use of screw piles may present an appropriate solution where piles can be installed to desired torque settings dependant on depth and compaction of site soils.
</td></tr>
<tr><td>Retaining Structures</td><td>Although significant groundwater was not encountered in the tests undertaken, due to the RL of the final excavation level, and variability in groundwater level, it is recommended that the sub-level garage floor slab and any permanent retaining walls be designed to withstand temporary hydrostatic loading with waterproofing/tanking of the sub-floor level garage incorporated into the design and construction.</td></tr>
<tr><td>Fills</td><td>
Any fill that may be required is to comprise local sand, clay and weathered rock. Existing organic topsoil is to be cleared in preparation for the introduction of fill.
Any new fill material is to be placed in layers not more than 250 mm thick and compacted to not less than 95% of Standard Optimum Dry Density at plus or minus 2% of Standard Optimum Moisture Content.
</td></tr>
</table>

Recommendation	Description
	All new fill placement is to be carried out in accordance with AS 3798 – 2007 – Guidelines on earthworks for commercial and residential developments.
Stormwater Disposal	Where possible, all stormwater collected from hard surfaces is to be collected and piped to the Council stormwater network, via the curb and gutter system, or via an authorised easement, through any storage tanks or on-site detention that may be required by the regulating authorities, and in accordance with all relevant Australian Standards, and the detailed stormwater management plan by others.
Inspections	It is essential that the foundation materials of all footing excavations be visually assessed and approved by Ascent before steel reinforcement and concrete is placed.
Conditions Relating to Design and Construction Monitoring	To comply with Northern Beaches Council conditions and enable the completion of Forms 2B and 3, as required in Council's Geotechnical Risk Management Policy, it will be necessary for Ascent to: • review the geotechnical content of all structural designs prior to the issue of Construction Certificate – **Form 2B** • complete the abovementioned excavation hold point and foundation material inspections during construction to ensure compliance to design with respect to stability and geotechnical design parameters • at Occupation Certificate stage (project completion), Ascent must have inspected and certified excavations and foundation materials. A final site inspection will be required at this stage – **Form 3**.

Should you have any queries regarding this report, please do not hesitate to contact the author of this report, undersigned.

For and on behalf of, **Ascent Geotechnical Consulting Pty Ltd,**

Ben Morgan BSc Geol.
Engineering Geologist

Karen Allan CPEng MIEAust
Senior Geotechnical Engineer

4 References

Australian Geomechanics Society (March 2007), Landslide Risk Management, Australian Geomechanics 42(1).

Australian Standard 1726–2017 Geotechnical Site Investigations.

Australian Standard 2870–2011 Residential Slabs and Footings.

Australian Standard 1289.6.3.2–1997 Methods of Testing Soils for Engineering Purposes.

Australian Standard AS2670.1–2001 Evaluation of human exposure to whole-body vibration. Part 1: General requirements.

Australian Standard 3798–2007 Guidelines for Earthworks for Commercial and Residential Developments.

Herbert C., 1983, Sydney 1:100 000 Geological Sheet 9130, 1st edition. Geological Survey of New South Wales, Sydney.

NSW Department of Finance, Services and Innovation, Spatial Information Viewer, maps.six.nsw.gov.au.

Safe Work Australia (October 2018). Code of Practice: Excavation Work.

Appendix A

Information Sheets

General Notes About This Report

INTRODUCTION

These notes have been prepared by Ascent Geotechnical Consulting Pty Ltd (Ascent) to help our Clients interpret and understand the limitations of this report. Not all sections below are necessarily relevant to all reports.

SCOPE OF SERVICES

This report has been prepared in accordance with the scope of services set out in Ascent's proposal under Ascent's Terms and Conditions, or as otherwise agreed with the Client. The scope of work may have been limited by a range of factors including time, budget, access and/or site constraints.

RELIANCE ON INFORMATION PROVIDED

In preparing the report, Ascent has necessarily relied upon information provided by the Client and/or their Agents. Such data may include surveys, analyses, designs, maps and design plans. Ascent has not verified the accuracy or completeness of the data except as stated in this report.

GEOTECHNICAL AND ENVIRONMENTAL REPORTING

Geotechnical and environmental reporting relies on the interpretation of factual information, based on judgment and opinion, and is far less exact than other engineering or design disciplines.

Geotechnical and environmental reports are prepared for a specific purpose, development, and site, as described in the report, and may not contain sufficient information for other purposes, developments, or sites (including adjacent sites), other than that described in the report.

SUBSURFACE CONDITIONS

Subsurface conditions can change with time and can vary between test locations. For example, the actual interface between the materials may be far more gradual or abrupt than indicated.

Therefore, actual conditions in areas not sampled may differ from those predicted, since no subsurface investigation, no matter how comprehensive, can reveal all subsurface details and anomalies.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations can also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. Ascent should be kept informed of any such events, and should be retained to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

GROUNDWATER

Groundwater levels indicated on borehole and test pit logs are recorded at specific times. Depending on ground permeability, measured levels may or may not reflect actual levels if measured over a longer time period. Also, groundwater levels and seepage inflows may fluctuate with seasonal and environmental variations and construction activities.

INTERPRETATION OF DATA

Data obtained from nominated discrete locations, subsequent laboratory testing and empirical or external sources are interpreted by trained professionals in order to provide an opinion about overall site conditions, their likely impact with respect to the report purpose and recommended actions in accordance with any relevant industry standards, guidelines or procedures.

SOIL AND ROCK DESCRIPTIONS

Soil and rock descriptions are based on AS 1726 – 1993, using visual and tactile assessment, except at discrete locations where field and / or laboratory tests have been carried out. Refer to the accompanying soil and rock terms sheet for further information.

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FURTHER ADVICE

Ascent would be pleased to further discuss how any of the above issues could affect a specific project. We would also be pleased to provide further advice or assistance including:

- Assessment of suitability of designs and construction techniques;
- Contract documentation and specification;
- Construction advice (foundation assessments, excavation support).

Abbreviations, Notes & Symbols

ASCENT GEOTECHNICAL CONSULTING

SUBSURFACE INVESTIGATION

METHOD

Borehole Logs

AS#	Auger screwing (#-bit)
AD#	Auger drilling (#-bit)
B	Blank bit
V	V-bit
T	TC-bit
HA	Hand auger
R	Roller/tricone
W	Washbore
AH	Air hammer
AT	Air track
LB	Light bore push tube
MC	Macro core push tube
DT	Dual core push tube

Excavation Logs

BH	Backhoe/excavator bucket
NE	Natural exposure
HE	Hand excavation
X	Existing excavation

Cored Borehole Logs

NMLC	NMLC core drilling
NQ/HQ	Wireline core drilling

SUPPORT

Borehole Logs

C	Casing
M	Mud

Excavation Logs

S	Shoring
B	Benched

SAMPLING

B	Bulk sample
D	Disturbed sample
U#	Thin-walled tube sample (#mmdiameter)
ES	Environmental sample
EW	Environmental water sample

FIELD TESTING

PP	Pocket penetrometer (kPa)
DCP	Dynamic cone penetrometer
PSP	Perth sand penetrometer
SPT	Standard penetration test
PBT	Plate bearing test
s_u	Vane shear strength peak/residual (kPa) and vane size (mm)
N*	SPT (blows per 300mm)
Nc	SPT with solid cone
R	Refusal

**denotes sample taken*

BOUNDARIES

________	Known
_ _ _ _ _	Probable
----------	Possible

SOIL

MOISTURE CONDITION

D	Dry
M	Moist
W	Wet
Wp	Plastic Limit
Wl	Liquid Limit
MC	Moisture Content

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

USCS SYMBOLS

GW	Well graded gravels and gravel-sand mixtures, little or no fines
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
SW	Well graded sands and gravelly sands, little or no fines
SP	Poorly graded sands and gravelly sands, little or no fines
SM	Silty sand, sand-silt mixtures
SC	Clayey sand, sand-clay mixtures
ML	Inorganic silts of low plasticity, very fine sands, rock flour, silty or clayey fine sands
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays
OL	Organic silts and organic silty clays of low plasticity
MH	Inorganic silts of high plasticity
CH	Inorganic clays of high plasticity
OH	Organic clays of medium to high plasticity
PT	Peat muck and other highly organic soils

ROCK

WEATHERING

RS	Residual Soil
XW	Extremely Weathered
HW	Highly Weathered
MW	Moderately Weathered
DW*	Distinctly Weathered
SW	Slightly Weathered
FR	Fresh

**covers both HW & MW*

STRENGTH

EL	Extremely Low
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extremely High

ROCK QUALITY DESIGNATION (%)

$$= \frac{\text{sum of intact core pieces > 100mm}}{\text{total length of section being evaluated}} \times 100$$

CORE RECOVERY (%)

$$= \frac{\text{core recovered}}{\text{core lift}} \times 100$$

NATURAL FRACTURES

Type

JT	Joint
BP	Bedding plane
SM	Seam
FZ	Fractured zone
SZ	Shear zone
VN	Vein

Infill or Coating

Cn	Clean
St	Stained
Vn	Veneer
Co	Coating
Cl	Clay
Ca	Calcite
Fe	Iron oxide
Mi	Micaceous
Qz	Quartz

Shape

pl	Planar
cu	Curved
un	Undulose
st	Stepped
ir	Irregular

Roughness

pol	Polished
slk	Slickensided
smo	Smooth
rou	Rough

Soil & Rock Terms

ASCENT GEOTECHNICAL CONSULTING

SOIL

MOISTURE CONDITION

Term	Description
Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through the hand.
Moist	Feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist, but with free water forming on hands when handled.

For cohesive soils, moisture content may also be described in relation to plastic limit (W_P) or liquid limit (W_L). [>> much greater than, > greater than, < less than, << much less than].

CONSISTENCY

Term	c_u (kPa)	Term	c_u (kPa)
Very Soft	< 12	Very Stiff	100 200
Soft	12 - 25	Hard	> 200
Firm	25 - 50	Friable	-
Stiff	50 - 100		

DENSITY INDEX

Term	I_D (%)	Term	I_D (%)
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	20 - 63
	medium	6 - 20
	fine	2.36 - 6
Sand	coarse	0.6 -2.36
	medium	0.2 - 06
	fine	0.075 0.2
Silt & Clay		< 0.075

MINOR COMPONENTS

Term	Proportion by Mass coarse grained	fine grained
Trace	≤ 5%	≤ 15%
Some	5 - 2%	15 - 30%

SOIL ZONING

Layers	Continuous exposures
Lenses	Discontinuous layers of lenticular shape
Pockets	Irregular inclusions of different material

SOIL CEMENTING

Weakly	Easily broken up by hand
Moderately	Effort is required to break up the soil by hand

SOIL STRUCTURE

Massive	Coherent, with any partings both vertically and horizontally spaced at greater than 100mm
Weak	Peds indistinct and barely observable on pit face. When disturbed approx. 30% consist of peds smaller than 100mm
Strong	Peds are quite distinct in undisturbed soil. When disturbed >60% consists of peds smaller than 100mm

ROCK

SEDIMENTARY ROCK TYPE DEFINITIONS

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

STRENGTH

Term	Is50 (MPa)	Term	Is50 (MPa)
Extremely Low	< 0.03	High	1 – 3
Very Low	0.03 – 0.1	Very High	3 – 10
Low	0.1 – 0.3	Extremely High	> 10
Medium	0.3 – 1		

WEATHERING

Term	Description
Residual Soil	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident
Extremely Weathered	Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrates or can be remoulded, in water. Fabric of original rock is still visible
Highly Weathered	Rock strength usually highly changed by weathering; rock may be highly discoloured
Moderately Weathered	Rock strength usually moderately changed by weathering; rock may be moderately discoloured
Distinctly Weathered	See 'Highly Weathered' or 'Moderately Weathered'
Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength from fresh rock
Fresh	Rock shows no signs of decomposition or staining

NATURAL FRACTURES

Type	Description
Joint	A discontinuity or crack across which the rock has little or no tensile strength. May be open or closed
Bedding plane	Arrangement in layers of mineral grains of similar sizes or composition
Seam	Seam with deposited soil (infill), extremely weathered insitu rock (XW), or disoriented usually angular fragments of the host rock (crushed)
Shear zone	Zone with roughly parallel planar boundaries, of rock material intersected by closely spaced (generally < 50mm) joints and /or microscopic fracture (cleavage) planes
Vein	Intrusion of any shape dissimilar to the adjoining rock mass. Usually igneous

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

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

Roughness	Description
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 < 1mm). Feels like fine to coarse sandpaper

Note: soil and rock descriptions are generally in accordance with AS1726-1993 Geotechnical Site Investigations

Graphic Symbols Index

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
- Coarse grained Metamorphic
- Medium grained Metamorphic
- Fine grained Metamorphic
- Coal

Other

- Asphalt
- Concrete
- Brick

Water Measurements

- Level at time of drilling
- Level after drilling
- Inflow
- Outflow

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 perpends).

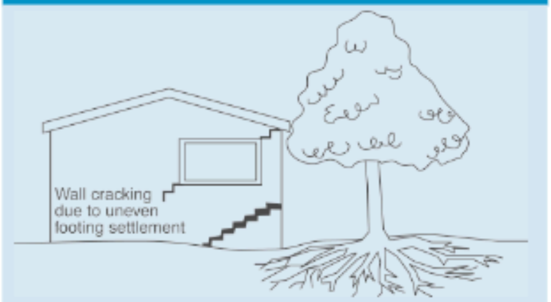
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

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

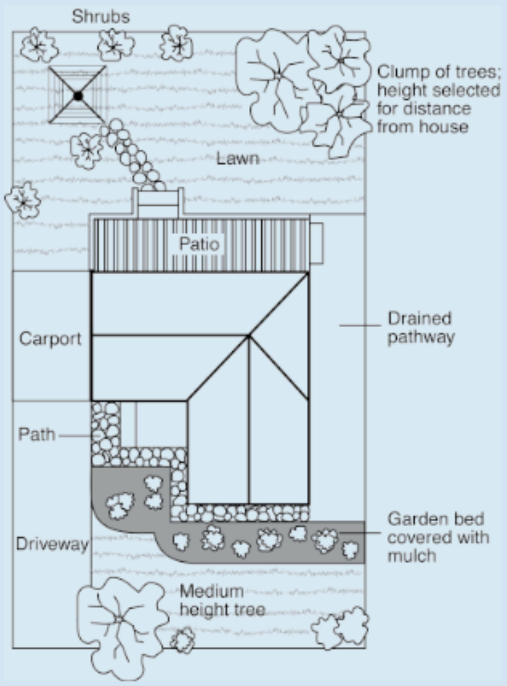
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

Gardens for a reactive site



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:

- 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.

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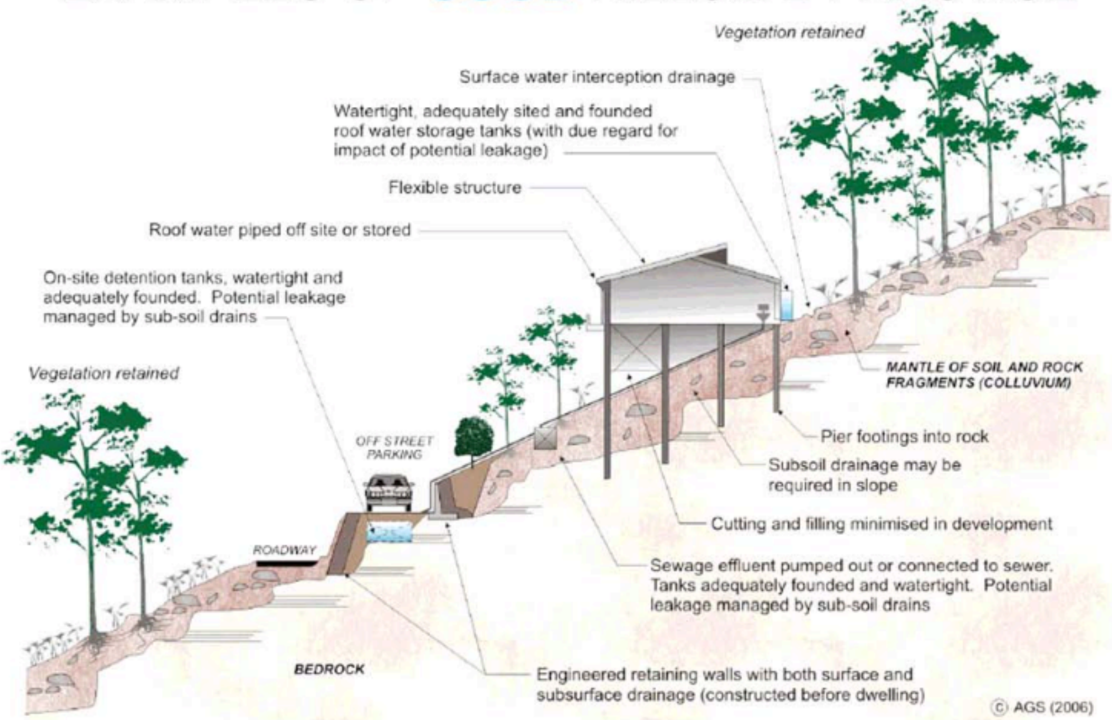
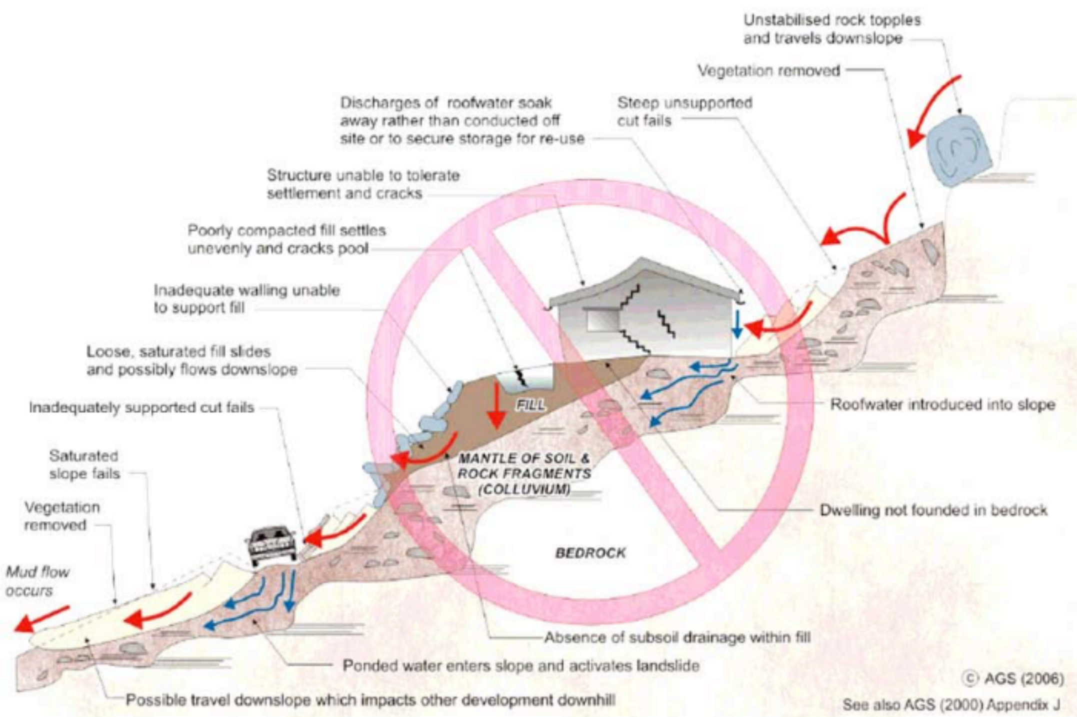
EXAMPLES OF **GOOD** HILLSIDE PRACTICE



EXAMPLES OF **POOR** HILLSIDE PRACTICE



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.

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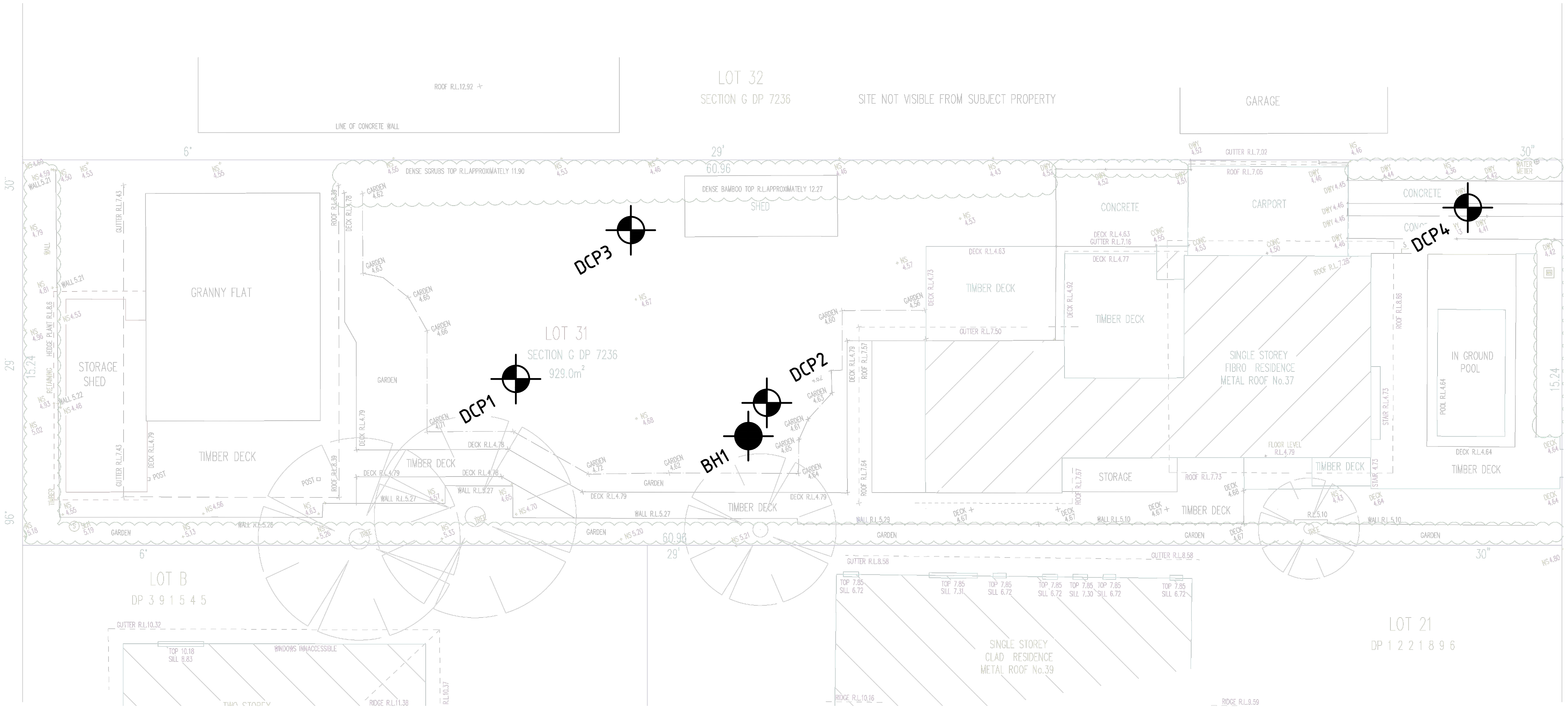
Appendix B

Site Plan | Testing Locations

LEGEND

- DCP LOCATIONS
- BOREHOLE LOCATION



SITE PLAN/GROUND TEST LOCATIONS

SCALE NTS

REV	DATE	REVISION DESCRIPTION	REV BY	CHCKD
A	31.01.20	PRELIMINARY ISSUE	VT	BM

ASCENT GEOTECHNICAL CONSULTING

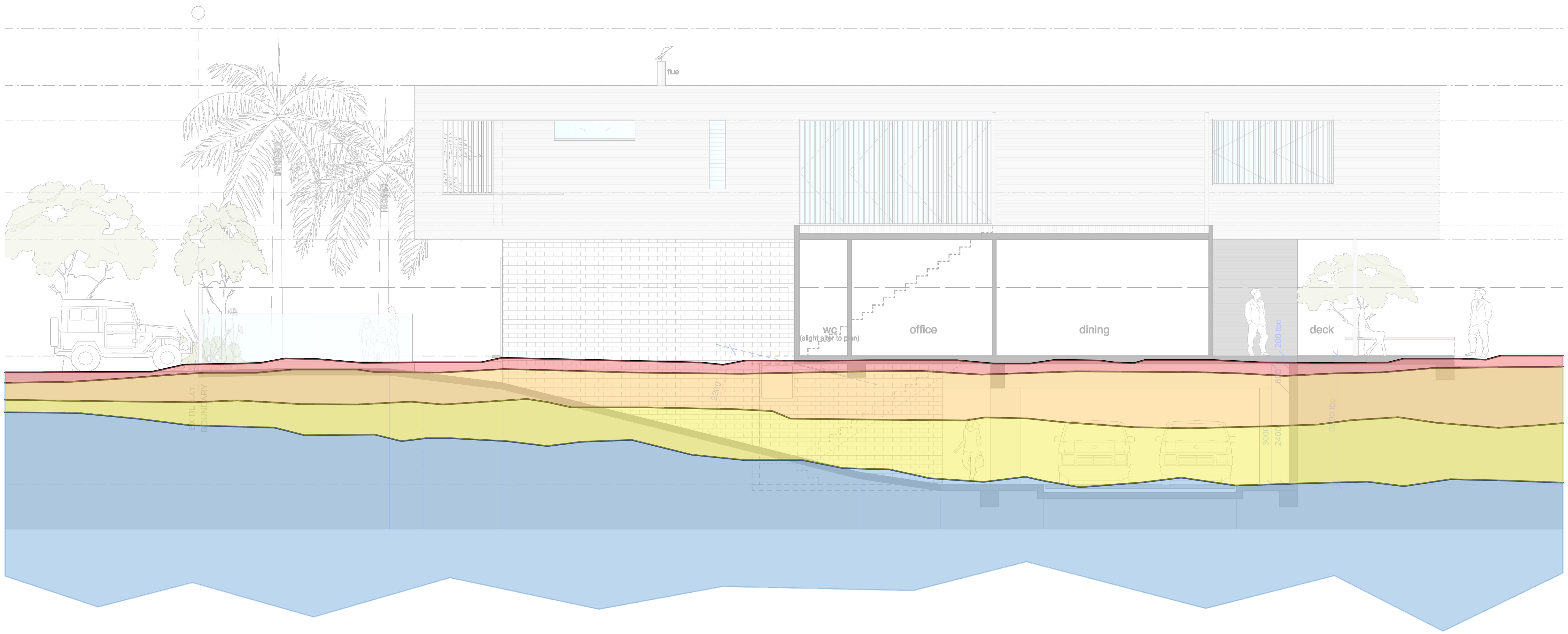
ABN: 71621428402
MIE Aust. CP Eng. NER
Ben: 0448 255 537
Ben@ascentgeo.com.au
PO BOX 37
Manly NSW 1655

CLIENT:
REEF INTERIORS PTY LTD

SITE PLAN/GROUND TEST LOCATIONS AT 37 HEATH STREET MONA VALE NSW

DATE: 31/01/2020
SCALE: AS SHOWN @ A3
DRAWING TITLE: SITE PLAN
DRAWING NO: AG20011- S1

INTERPRETED SUBSURFACE SECTION ONLY.
ACTUAL GROUND CONDITIONS MAY VARY.



LEGEND

- SHALLOW FILL
- SANDY LOAM
- QUARTZ SANDS
- NARRABEEN GROUP GEOLOGY

INFERRED GEOLOGICAL SECTION
SCALE NTS

REV	DATE	REVISION DESCRIPTION	REV BY	CHCKD
A	31.01.20	PRELIMINARY ISSUE	VT	BM

ASCENT
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PO BOX 37
Manly NSW 1655

CLIENT:
REEF INTERIORS PTY LTD

INFERRED GEOLOGICAL SECTION
AT 37 HEATH STREET
MONA VALE NSW

DATE: 31/01/2020
SCALE: AS SHOWN @ A3
DRAWING TITLE: ELEVATION
DRAWING NO: AG20011- S2

Appendix C

Bore Logs | DCP Test Results

GEOTECHNICAL LOG - BORE HOLE

ASCENT GEOTECHNICAL CONSULTING

Client:	Reef Interiors Pty Ltd	Job No:	AG 20011	BOREHOLE NO.: BH 1
Project:	New Dwelling	Date:	28/1/20	
Location:	37 Heath Street, Mona Vale NSW	Operator:	MSK	Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVEDENSITY (sands and gravels)	MOISTURE
		0	*FILL.* **ORGANIC SILT**. Grey to black, fine to medium grained, minor grass roots.	OL	LOOSE	D
		0.25	**SANDY LOAM.** Brown to yellow/orange, medium grained, low cohesiveness.	SM	LOOSE	M
		1.2	**SAND**. Orange/yellow, coarse grained, density increasing with depth, very minor gravel in matrix.	SM	LOOSE TO MEDIUM DENSE	M
		1.8	**Borehole terminated at 1.80m at RL ~2.8. No significant standing water table encountered.**			
		2.0				

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

See explanation sheets for meaning of all descriptive terms and symbols

Contractor: N/A
Equipment: Hand Auger
Hole width (mm):
Angle from Vertical (°):

Appendix D

Geotechnical Forms 1 & 1A

Northern Beaches Council | Pittwater LEP

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1 – To be submitted with Development Application

Development Application for DAVID HELLMICH
Name of Applicant

Address of site 37 HEATH STREET, MONA VALE NSW

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

I, KAREN ALLAN (insert name) *on behalf of* Ascent Geotechnical Consulting P/L (Trading or Company Name)

on this the 1 December 2020 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.

Please mark appropriate box

- ☐ 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
- ☒ I 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 paragraph 6.0 of the Geotechnical Risk Management Policy for Pittwater - 2009. I confirm the results of the risk assessment for the proposed development are in compliance with the Geotechnical Risk Management Policy fro 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 am of the opinion that the Development Application only involves Minor Development/Alterations that do not require a Detailed Geotechnical Risk Assessment and hence my report is in accordance with the Geotechnical Risk Management Policy for Pittwater – 2009 requirements for Minor Development/Alterations.
- ☐ Have examined the site and the proposed development/alteration is separate form and 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
- ☐ Provided the coastal process and coastal forces analysis for inclusion in the Geotechnical Report

Geotechnical Report Details:

Report Title: Geotechnical Assessment Report for New Dwelling at 37 Heath Street, Mona Vale NSW

Report Date: 12.1.2020

Author : Ben Morgan / Karen Allan

Author's Company/Organisation : Ascent Geotechnical Consulting Pty Ltd

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

Details of the proposed development are outlined in a series of architectural plans by Markham-lee Architecture, Drawing No. DD02 – DD05, DD07, DD08, dated 6 November 2020.

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 Northern Beaches 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 [signature]

Name Karen Allan

Chartered Professional Status MIE Aust CPEng NER

Membership No. 793020

Company Ascent Geotechnical Consulting Pty Ltd

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1(a) - Checklist of Requirements for Geotechnical Risk Management Report for Development Application

Development Application for **DAVID HELLMICH**
Name of Applicant

Address of site **37 HEATH STREET, MONA VALE NSW**

The following checklist covers the minimum requirements to be addressed in a Geotechnical Risk Management Geotechnical Report. This checklist is to accompany the Geotechnical Report and its certification (Form No. 1).

Geotechnical Report Details:

Report Title: Geotechnical Assessment Report for New Dwelling at 37 Heath Street, Mona Vale NSW

Report Date: 1 December 2020

Author: Ben Morgan / Karen Allan

Author’s Company/Organisation: Ascent Geotechnical Consulting PTY LTD

Please mark appropriate box

☒ Comprehensive site mapping conducted 28/01/2020
(date)

☒ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)

☒ Subsurface investigation required
- ☐ No Justification ....
- ☒ Yes Date conducted 28/01/2020

☒ Geotechnical model developed and reported as an inferred subsurface type-section

☒ Geotechnical hazards identified
- ☐ Above the site
- ☒ On the site
- ☐ Below the site
- ☐ Beside the site

☒ Geotechnical hazards described and reported

☒ Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ☒ Consequence analysis
- ☒ Frequency analysis

☒ Risk calculation

☒ Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009

☒ Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009

☒ Assessed risks have been compared to “Acceptable Risk Management” criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009

☒ Opinion has been provided that the design can achieve the “Acceptable Risk Management” criteria provided that the specified conditions are achieved.

☒ Design Life Adopted:
- ☒ 100 years
- ☐ Other ....
  specify

☒ Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater – 2009 have been specified

☒ Additional action to remove risk where reasonable and practical have been identified and included in the report.

☒ Risk Assessment within Bushfire Asset Protection Zone

I am aware that Pittwater Council will rely on the Geotechnical Report, to which this checklist applies, as the basis for ensuring that the geotechnical risk management aspects of the proposal 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

Name Karen Allan

Chartered Professional Status MIE Aust CPEng

Membership No. 793020

Company Ascent Geotechnical Consulting Pty Ltd