Crozier Geotechnical Consultants
Unit 12/ 42-46 Wattle Road
Brookvale NSW 2100
Crozier Geotechnical Consultants, a division of PJC Geo-Engineering Pty Ltd
ABN: 96 113 453 624
Phone: (02) 9939 1882
Email: info@croziergeotech.com.au

REPORT ON GEOTECHNICAL SITE INVESTIGATION

for

PROPOSED ALTERATIONS AND ADDITIONS

at

48 THE SERPENTINE, BILGOLA BEACH, NSW

Prepared For

Lucy and Ben Feek

Project No.: 2019-065

September, 2025

Document Revision Record

Issue No	Date	Details of Revisions
0	4th June, 2019	Original issue
1	16th September, 2025	Revised Issue

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1 – To be submitted with Development Application

Development Application for____________Lucy and Ben Feek ____________________________

Address of site 48 The Serpentine Bilgola Beach, NSW

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

I, ***__Troy Crozier__*** *on behalf of* ***___Crozier Geotechnical Consultants*** _on this the 16th September, 2025_ certify that I am a ~~geotechnical engineer or~~ engineering geologist ~~or coastal engineer~~ as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above ~~organisation/~~company to issue this document and to certify that the ~~organisation/~~company has a current professional indemnity policy of at least $2million. I:

- ☐ have prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009
- ■ am willing to technically verify that the detailed Geotechnical Report referenced below has been prepared in accordance with the Australian Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009
- ☐ have examined the site and the proposed development in detail and have carried out a risk assessment in accordance with Section 6.0 of the Geotechnical Risk Management Policy for Pittwater - 2009. I confirm that the results of the risk assessment for the proposed development are in compliance with the Geotechnical Risk Management Policy for Pittwater - 2009 and further detailed geotechnical reporting is not required for the subject site.
- ☐ have examined the site and the proposed development/alteration in detail and I am of the opinion that the Development Application only involves Minor Development/Alteration that does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.
- ☐ have examined the site and the proposed development/alteration is separate from and is not affected by a Geotechnical Hazard and does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.
- ☐ have provided the coastal process and coastal forces analysis for inclusion in the Geotechnical Report

Geotechnical Report Details:

Report Title: Geotechnical Report for Proposed Alterations and Additions at 48 The Serpentine, Bilgola Beach.

Report Date: 16th September 2025

Project No.: 2019-065

Author: B Taylor and T. Crozier

Author's Company/Organisation: Crozier Geotechnical Consultants

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

Site survey plan by TSS, *'Plan Showing Detail and Levels over Lot 102 in DP16393'*, Job No.: 180023, Dated: 19th January 2018
Architectural drawings by Nick Bell Architects, *48 The Serpentine, Bilgola, NSW 2107'*, Drawing No. SERP-DA-100 to SERP-DA-102, SERP-DA-200 to SERP-DA-202, SERP-DA-900 all Rev A and Dated 19th August 2025, SERP-DA-910 to SERP-DA-915, SERP-DA-920 and SERP-DA-930 all Rev A and Dated 21st August 2025

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

Signature ....

Name ...**Troy Crozier**...

Chartered Professional Status...**RPGeo (AIG)**......................

Membership No. ...**10197**...

Company... **Crozier Geotechnical Consultants**

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1(a) - Checklist of Requirements For Geotechnical Risk Management Report for Development Application

Development Application for Lucy and Ben Feeks

Address of site 48 The Serpentine, Bilgola Beach.

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 Report for Proposed Alterations and Additions at 48 The Serpentine, Bilgola Beach.
Report Date: 16th September 2025 **Project No.:** 2019-065
Author: B. Taylor and T. Crozier
Author's Company/Organisation: Crozier Geotechnical Consultants

Please mark appropriate box

- ■ Comprehensive site mapping conducted ___6th May 2019____and 15th September 2025____ (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 7th May 2019............
- ■ 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 ...**Troy Crozier**...

Chartered Professional Status...**RPGeo (AIG)** ....

Membership No. ...**10197**...

Company... **Crozier Geotechnical Consultants**

TROY CROZIER
10197

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CROZIER
GEOTECHNICAL CONSULTANTS

Crozier Geotechnical Consultants
Unit 12/ 42-46 Wattle Road
Brookvale NSW 2100
Crozier Geotechnical Consultants a division of PJC Geo-Engineering Pty Ltd
ABN: 96 113 453 624
Phone: (02) 9939 1882
Email: info@croziergeotech.com.au

GEOTECHNICAL REPORT FOR ALTERATIONS & ADDITIONS
48 THE SERPENTINE, BILGOLA BEACH, NSW

This revised report details the results of a geotechnical investigation carried out for proposed alterations and additions at 48 The Serpentine, Bilgola, NSW. An investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the request of the architect Bawtree Design on behalf of the client Lucy and Ben Feek in 2019 with an amendment provided in 2023. It is understood that the original Development Application has lapsed and that a new DA is to be submitted and that a new Geotechnical Report is therefore required.

The site is situated on the low south side of The Serpentine within moderately to steeply sloping topography. The site is currently occupied by a three-level residential house with open parking area at the front, lawn terrace and then a steep vegetated slope at the rear.

The site is located within the H1 (highest category) landslip hazard zone as identified within Northern Beaches Councils precinct (Geotechnical Risk Management Policy for Pittwater - 2009). To meet the Councils Policy requirements for land classified as H1 we will need to provide a detailed Geotechnical Report which meets the requirements of Paragraph 6.5 of that policy. This report therefore includes a landslide risk assessment of the site, plans, geological section and provides recommendations for construction ensuring stability is maintained for a design life of 100 years.

The original investigation and reporting were undertaken as per the Tender P19-118, Dated: 27th March 2019.

The investigation comprised:

a) A detailed geotechnical inspection and mapping of the site and adjacent properties by a Senior Engineering Geologist.
b) Drilling of three boreholes using hand tools along with six Dynamic Cone Penetrometer tests (DCP) to investigate the subsurface conditions

An additional site walkover was undertaken as well as preparation of this report in accordance with our Tender P25-393, Dated 25th August 2025.

The following plans and drawings were supplied for the work:

- Architectural drawings by Nick Bell Architects, *48 The Serpentine, Bilgola, NSW 2107*', Drawing No. SERP-DA-100 to SERP-DA-102, SERP-DA-200 to SERP-DA-202, SERP-DA-900 all Rev A and Dated 19th August 2025, SERP-DA-910 to SERP-DA-915, SERP-DA-920 and SERP-DA-930 all Rev A and Dated 21st August 2025.
- Site survey plan by TSS, '*Plan Showing Detail and Levels over Lot 102 in DP16393*', Job No.: 180023, Dated: 19th January 2018.

2. PROPOSED DEVELOPMENT:

It is understood that the proposed works involve alterations and additions to the existing site including a new garage to the existing car space over the existing rumpus room (which is to be retained), a swimming pool at the rear of the house, extensions to the house structure and a new roof with internal alterations.

It is understood that the new design involves relatively minor changes to the development including realignment of the proposed garage footprint to align with the existing games room below. Design modifications to the main structure involve extension to the entry level rear wall, bedroom level rear wall extension, garden level rear wall extension, as well as other minor design alterations. Moreover, changes have been proposed to the swimming pool design including its relocation towards the rear centre, as well as other minor revisions to landscaping works including retaining wall to the west of the Bedroom 4.

It appears that the proposed new garage will be constructed above the existing rumpus room footprint and that the additions to the front of the dwelling will only require excavations for new footings. It is understood the current proposal positions the pool to the west of an existing retaining wall within the rear of the property which is to be retained. The proposed pool will be constructed below RL29.49 and will require excavation up to approximately 2.0m below that level, with the exact depth and arrangement to be determined based on the sewer location however it is expected to be approximately 3.0m from the dwelling structure.

3. SITE FEATURES:

3.1. Description

The site is a trapezoidal shaped block located on the low south side of The Serpentine. It has a north front boundary and rear south boundary of approximately 14.5m with side east and west boundaries of approximately 50.0m as referenced from the provided survey plan. An aerial photograph of the site and its surrounds is provided below.

Photograph 1: Aerial photo of site and surrounds

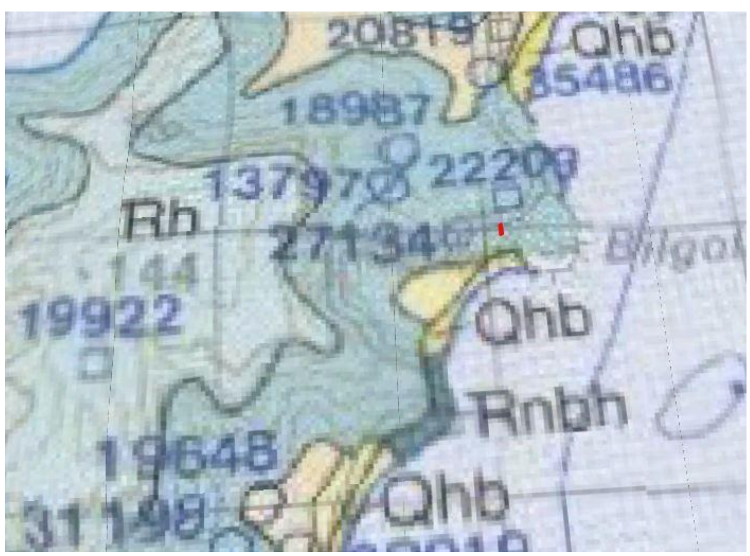
The site dwelling comprises a three-storey brick and timber residence with car parking, patio areas and a separate rumpus room (underlying the parking area) at the front of the property. Access to the residence is gained via a set of steps to the west of the rumpus room. The rear of the property contains a steeply sloping garden supported by stacked sandstone or mortared sandstone block retaining walls. Two general views of the site are shown in Photograph 2 and Photograph 3.

Photograph 2: View of the rear of the existing residence

Photograph 3: View of the rumpus rooms (left) and main entrance of site property from the upper patio level.

3.2. Geology:

Reference to the Sydney 1:100,000 Geological Series sheet (9130) indicates that the site is underlain by Newport Formation (Upper Narrabeen Group) rock (Rnn) which is of middle Triassic Age. The Newport Formation typically comprises interbedded laminite, shale and quartz to lithic quartz sandstones and pink clay pellet sandstones. An extract from the Sydney 1:100, 000 Geological Series sheet is provided below.



4. FIELD WORK:

4.1. Methods:

The field investigation comprised a walk over inspection and mapping of the site and adjacent properties on the 6th May 2019 by a Senior Engineering Geologist. It included a photographic record of site conditions as well as geological/geomorphological mapping of the site and adjacent land with examination of soil slopes, bedrock outcrops, existing structures and neighbouring properties. It also included the drilling of three boreholes (BH1 to BH3) using a hand auger to investigate sub-surface geology. A hand auger was used as access to the majority of the site for a conventional drilling rig was unavailable.

DCP testing was carried out from ground surface adjacent to the boreholes and at three additional locations in accordance with AS1289.6.3.2 – 1997, "Determination of the penetration resistance of a soil – 9kg Dynamic Cone Penetrometer" to estimate near surface soil conditions and confirm depths to bedrock.

An additional site walkover was conducted by a Principal Engineering Geologist on 15th September 2025 to identify any changes to the site since the original investigation.

Explanatory notes are included in Appendix: 1. Mapping information and test locations are shown on Figure: 1, along with detailed Borehole log sheets and Dynamic Penetrometer Test Sheet in Appendix: 2. A geological model/section is provided as Figure: 2, Appendix: 2.

4.2. Field Observations:

The site is situated on the low south side of The Serpentine within moderately to steeply south dipping topography. It is currently occupied by a three-storey brick and timber residential dwelling and separate rumpus room.

The front on the property contains a single storey rumpus room, the roof of which forms the current residence parking area. To the north of the dwelling, two paved patios have been constructed at approximate RL35m and RL31m. Bedrock is exposed to the north of the lower-level patio underlying the existing rumpus room and is shown in Photograph 3. Signs of cracking were not observed within the exterior of the rumpus room, parking area or patio pavers.

The southern wall of the rumpus room can be seen extending to the top of the bedrock exposure. The exposure comprised medium strength sandstone with sub-horizontal defects and was also visible in outcrop within the neighbouring property to the east.

Photograph 4: View of the bedrock expose observed from the lower patio level.

The main site structure to the south of the bedrock outcrop appeared in good condition with no evidence of movement or distress observed.

Access to the rear of the property is gained via pathways on either side of the dwelling. Significant cracking was not observed within these pathways.

At the rear of the property a grassed area/patio with access pathway is supported by mortared/dry stone sandstone block and brickwork retaining walls. The retaining walls are typically less than 1m in height and (particularly the mortared sandstone wall), displayed signs of distress and is shown in Photograph 5.

Stormwater was observed to be functioning as intended and discharging into a network of drains prior to discharge of-site.

Photograph 5: View of the mortared sandstone retaining wall in the rear of the property.

Below the retaining walls a steep grassed slope is present which leads to an overgrown, inaccessible area at the southern end of the property. Within the slope boulders of sandstone were observed at the surface.

Within the rear of the property and based on DBYD plans obtained from Sydney Water, a sewer line is present near the existing retaining wall in the rear of the property. According to the plans it is 150mm in diameter, composed of 'Ductile Iron Cement Lined' (DICL) and has an invert level of 1.4m below the manhole cover within the neighbouring property to the east (No.50). Elevation of the manhole cover in No.50 is not known but it is estimated the sewer invert level is at a lower elevation than RL27.0m however this would require confirmation.

The neighbouring property to the east of the site, No.50, contains a two-storey rendered residence. Although the exterior of the dwelling appeared to be deteriorating, no evidence of cracking was observed. The ground surface level within No.50 is similar or slightly lower than site at the boundary with the remainder of the block having a similar topography to the site.

The neighbouring property to the west of the site, No.46, contains a two-storey rendered residence and swimming pool within the rear garden. The ground surface level with this property is at a similar level to the site at the boundary with the remainder of the block having a similar topography to the site.

The neighbouring properties and structures were inspected from the site or road reserves, however visible aspects showed no indications of geotechnical hazard that may impact the site.

4.3. Ground Conditions:

BH1 was drilled near the existing residence and refused in natural clay soils at 0.58m depth, however BH2 and BH3 refused on interpreted cobbles/boulders at 0.50m and 0.40m respectively.

DCP tests were carried out from the ground surface adjacent to the boreholes and at three additional locations to profile the bedrock surface.

Based on the borehole logs and DCP test results, the sub-surface conditions at the project site can be classified as follows:

- **TOPSOIL/FILL –** this layer was encountered in all boreholes to a maximum depth of 0.50m in BH1 (refusal). It comprised dark brown sandy clay with what has been interpreted as cobbles/ boulders. The base of the fill layer has been estimated based on the results of the DCP testing and is shown in Figure 2.
- **Silty CLAY –** This layer was only observed in BH1 and comprised stiff to hard moist, silty clay which has been interpreted as a residual soil.
- **BEDROCK –** What has been interpreted as a minimum very low strength bedrock was only encountered in the DCP test holes at depths between 1.42m and 2.80m depth. The results of the DCP testing indicate that the bedrock likely slopes gently south underlying the steep grassed slope.

A free-standing ground water table or significant water seepage were not identified within any of the boreholes. No signs of ground water were observed after the retrieval of the DCP rods.

The additional site inspection undertaken on 15th September 2025 revealed no major changes to the site or neighbouring properties since the original investigation.

5. COMMENTS:

5.1. Geotechnical Assessment:

The site investigation identified the presence of a layer of clay fill underlain by residual clay soils which grade to weathered bedrock. Based on DCP test results, the depth to the bedrock of minimum very low strength was interpreted to vary from 1.42m to 2.80m within the rear of the property. Medium strength bedrock was observed at the front of the site and likely underlies the front of the existing site dwelling at a shallow depth.

The site investigation did not identify any signs of previous or impending major, deep seated landslip instability within the site and there were no landslip hazards identified within the neighbouring properties. An existing retaining wall within the rear of the property was showing signs of distress and would be expected to continue to rotate however it is not considered a landslip hazard.

The proposed works involve limited excavation (typically for new footings only and construction of the new pool). Excavations up to 2.3m depth will be required for the swimming pool that will be approximately 4.0m from the shared boundary with No.46 (to the west), 7.0m from the shared boundary with No.50 (to the east) and greater than 10.0m from the rear boundary. The excavation will be approximately 3.0m from the existing site house.

Based on the investigation results, the proposed excavation for the new swimming pool is expected to intersect fill soils within the upper 1.0m, likely increasing in thickness towards the retaining wall. Residual soils comprising stiff to hard silty clay is anticipated under the fill to a minimum of 1.60m depth. Bedrock is anticipated slightly above or slightly below the base of the proposed pool. Based on previous experience in the area, the bedrock is likely to comprise variably weathered shale/siltstone with inter-bedded sandstone of potentially to medium strength. A ground water table is not expected to be encountered within the proposed depth of excavation however seepage through the residual soils and at the soil/rock contact could be encountered.

New footings should extend through the fill/soils and bear upon/within the bedrock encountered underlying the site unless individual structure footings are designed to accommodate differential movements.

It is envisaged that standard mechanical plant (e.g. hydraulic excavator fitted with bucket) will be sufficient to complete excavations at the site. Bedrock will likely only be encountered a short distance above the pool base therefore, if required, rock excavation will be limited. The strength of the bedrock is unconfirmed however if assessment of bedrock strength is required prior to excavation (for example to satisfy Sydney

Water requirements), additional cored boreholes would be required. Where prior assessment of rock strength is not required, it should be determined during excavation by geotechnical inspection.

Where rock excavation is required, lightweight hammers (<100kg) should be used to control potential adverse impacts to structures/services within and surrounding the site. Due to the restricted site access and space, it is envisaged that a mini excavator or hand tools (i.e. jack hammer) will be used for the excavation works. These will have a negligible potential to create vibrations of a damaging level however should heavier equipment be proposed for use it may require further assessment prior to use.

Considering the proposed depth of the excavations to be undertaken in relatively small areas along with the separation distances from the site boundaries, safe temporary batter slopes of 1.5H:1.0V (natural soils/fill) appear to be achievable around the excavation perimeter.

Where any new retaining structures are envisaged as part of the proposed works including to the west of the lower level (Bedroom 4), footings should extend through the fill and residual soils and found within very low strength bedrock (or better) to reduce the potential for differential settlement and to provide lateral support against downslope movement. Parameters for design are provided in section 5.3.3 and AGS suggestions for good hillslope construction practices are provided in Appendix 5.

Based on access limitations it is anticipated that a small machine will be used to install piers if required. Drilling difficulties using hand excavation/small equipment is envisaged if penetration (even a very short distance) into low strength bedrock is specified as part of detailed footing design. If pier penetration into bedrock is required (for surety of bedrock) appropriate equipment should be available to penetrate low (and potentially stronger) bedrock.

The proposed new pool will likely be near (and above) the existing Sydney Water (SW) sewer asset. Based on experience it is considered that SW will require plans/methodology detailing how the asset is to be protected throughout excavation/construction and following completion of works. Based on previous experience, structural design in the vicinity of SW assets can be significantly impacted and SW should be contacted as early as possible to confirm required protection measures.

The proposed works are considered suitable for the site and may be completed with negligible impact to existing nearby structures within the site or neighbouring properties provided the recommendations of this report are implemented in the design and construction phases.

The recommendations and conclusions in this report are based on an investigation utilising only surface observations and hand drilling tools due to access limitations. This test equipment provides limited data from small, isolated test points across the entire site with limited penetration into rock, therefore some minor variation to the interpreted sub-surface conditions is possible, especially between test locations. However, the results of the investigation provide a reasonable basis for the Development Application analysis and subsequent initial design of the proposed works.

5.2. Site Specific Risk Assessment:

Based on our site investigation we have identified the following geological/geotechnical landslip hazard which needs to be considered in relation to the existing site and the proposed works. This hazard is:

A. Earth slide of fill and residual soils due to pool excavation.

A qualitative assessment of risk to life and property related to this hazard is presented in Table A and B, Appendix: 3, and is based on methods outlined in Appendix: C of the Australian Geomechanics Society (AGS) Guidelines for Landslide Risk Management 2007. AGS terms and their descriptions are provided in Appendix: 4.

Due to the separation distance of the proposed works from the property boundaries and adjacent structures, along with the scale of excavation, the hazard has sensibly only a potential to impact workers in the excavation which would be controlled by NSW Health and Safety legislation. The site house may be impacted however it is likely (although not proven) that house footings extend to bedrock which would effectively mitigate Hazard A.

The Risk to Life from Hazard A was estimated to be up to **2.08×10^{-7},** whilst the Risk to Property was considered to be **'Very Low'**. The hazard was therefore considered to be 'Acceptable' when assessed against the criteria of the AGS 2007.

5.3. Design & Construction Recommendations:

Design and the construction recommendations are tabulated below:

5.3.1. New Footings:	
Site Classification as per AS2870 – 2011 for new footing design	- Class 'M' for footings extending into clay soils - Class 'A' for footings founded in bedrock within excavations.
Type of Footing	Strip/Pad or Slab at base of excavation, piers external to excavation to ensure consistent foundation.
Sub-grade material and Maximum Allowable Bearing Capacity	- Weathered, VLS Shale: 800kPa - Weathered, LS Shale: 1000kPa

Site sub-soil classification as per *Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia*	B_e – Rock site
Remarks: All permanent structure footings should be founded off bedrock of similar strength to prevent differential settlement unless designed for by the structural engineer. All new footings must be inspected by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity and the in-situ nature of the founding strata. This is mandatory to allow them to be 'certified' at the end of the project.	

5.3.2. Excavation:	
Depth of Excavation	Up to 2.30m depth for the pool
Distance of Excavation to Neighbouring Properties/structures	No. 46 – Approximately 4.0m to the shared boundary No.50 – Approximately 7.0m to the shared boundary
Type of Material to be Excavated	Clay fill up to 1.0m
	Stiff to hard silty clay (up to 1.70m depth)
	Bedrock of at least very low strength below 1.70m
Guidelines for <u>unsurcharged</u> batter slopes for general information are tabulated below:	

Material	Safe Batter Slope (H:V)	
	Short Term/ Temporary	Long Term/ Permanent
Natural soils and extremely weathered bedrock	1.5:1	2:1
Very Low to low strength bedrock	0.5:1	1.:1

Remarks:

Seepage through the sandy/clayey soils can reduce the stability of batter slopes and invoke the need to implement additional support measures. Where safe batter slopes are not implemented the stability of the excavation cannot be guaranteed until the installation of permanent support measures. This should also be considered with respect to safe working conditions.

Geotechnical inspection of batters will be required at regular intervals to assess their stability, especially for permanent batters.

Equipment for Excavation	Natural soils	Excavator with bucket
	VLS bedrock	Excavator with ripper and bucket
	LS – MS/HS bedrock	Rock excavation equipment (not anticipated)
VLS – very low strength, LS – low strength, MS – medium strength		
Recommended Vibration Limits	Not applicable unless hard rock excavation required	

(Maximum Peak Particle Velocity (PPV))	
Vibration Calibration Tests Required	Not required
Full time vibration Monitoring Required	Not required
Geotechnical Inspection Requirement	Yes, recommended that these inspections be undertaken as per below mentioned sequence: • For assessment of batter slopes • If bedrock encountered in pool excavation. • Where unexpected ground conditions are identified or any other concerns are held. • Following footing excavations to confirm founding material strength
Dilapidation Surveys Requirement	Not required
Remarks: Water ingress into exposed excavations can result in erosion and stability concerns in both sandy and clayey soils. Drainage measures will need to be in place during excavation works to divert any surface flow away from the excavation crest and any batter slope, whilst any groundwater seepage must be controlled within the excavation and prevented from ponding or saturating slopes/batters.	

5.3.3. Retaining Structures:	
Required	Low retaining structures may be required depending on final design.
Types	Steel reinforced concrete/concrete block walls post excavation, designed in accordance with Australian Standards AS4678-2002 Earth Retaining Structures. The pool shell/structure will provide the required permanent support to the pool excavation.
Parameters for calculating pressures acting on retaining walls for the materials likely to be retained:	

Material	Unit Weight (kN/m3)	Long Term (Drained)	Earth Pressure Coefficients		Passive Earth Pressure Coefficient/Lateral Pressures
			Active (Ka)	At Rest (K_0)	
Clay Fill	18	$\phi' = 29°$	0.35	0.52	N/A
Stiff to hard clay	20	$\phi' = 30°$	0.33	0.47	3.25
VLS to LS bedrock	23	$\phi' = 40°$	0.10	0.15	400 kPa

Remarks: In suggesting these parameters it is assumed that the retaining walls will be fully drained with suitable subsoil drains provided at the rear of the wall footings. If this is not done, then the walls should be designed to support full hydrostatic pressure in addition to pressures due to the soil backfill. It is suggested that the retaining walls should be back filled with free-draining granular material (preferably not recycled concrete) which is only lightly compacted in order to minimize horizontal stresses.
Retaining structures near site boundaries or existing structures should be designed with the use of at rest (K_0) earth pressure coefficients to reduce the risk of movement in the excavation support and resulting surface movement in adjoining areas. Backfilled retaining walls within the site, away from site boundaries or existing structures, that may deflect can utilize active earth pressure coefficients (Ka).

5.3.4. Drainage and Hydrogeology		
Groundwater Table or Seepage identified in Investigation		No
Excavation likely to intersect	Water Table	No
	Seepage	Minor (<0.50L/min), within sandy/clayey soils at bedrock surface or along defects in the bedrock
Site Location and Topography		Low south side of the road, within moderately to steeply south dipping topography.
Impact of development on local hydrogeology		Negligible
Onsite Stormwater Disposal		Due to the presence of highly impermeable clay soils the property is not suitable for onsite absorption disposal system. The site may be suitable for a dispersion system utilising an Onsite Detention System (OSD) and a level spreader designed by a suitably qualified Hydraulic Engineer.
Remarks: As the excavation faces are expected to encounter some seepage, an excavation trench should be installed at the base of excavation cuts to below residential floor slab levels to reduce the risk of resulting dampness issues. Trenches, as well as all new building gutters, down pipes and stormwater intercept trenches should be connected to a stormwater system designed by a Hydraulic Engineer which discharges to the Council's stormwater system off site.		

5.4. Conditions Relating to Design and Construction Monitoring:

To allow certification as part of construction, building and post-construction activity for this project, it will be necessary for Crozier Geotechnical Consultants to:

1. Review and approve the structural design drawings, including the retaining structure design and construction methodology, for compliance with the recommendations of this report prior Construction Certificate.
2. Inspect permanent excavation of filled batter slopes.
3. Inspect all new footings to confirm compliance to design assumptions with respect to allowable bearing pressure and stability prior to the placement of steel or concrete.
4. Inspect completed works to ensure no new landslip hazards have been created by site works and that all required stabilisation and drainage measures are in place.

The client and builder should make themselves familiar with the requirements spelled out in this report for inspections during the construction phase. Crozier Geotechnical Consultants cannot provide certification for the Occupation Certificate if it has not been called to site to undertake the required inspections.

5.5. Design Life of Structure:

We have interpreted the design life requirements specified within Councils Risk Management Policy to refer to structural elements designed to support the house etc, the adjacent slope, control stormwater and maintain the risk of instability within acceptable limits. Specific structures and features that may affect the maintenance and stability of the site in relation to the proposed and existing development are considered to comprise:

- stormwater and subsoil drainage systems,
- retaining walls and soil slope erosion and instability,
- maintenance of trees/vegetation on this and adjacent properties.

Man-made features should be designed and maintained for a design life consistent with surrounding structures (as per AS2870 – 2011 (100 years)). It will be necessary for the structural and geotechnical engineers to incorporate appropriate design and inspection procedures during the construction period. Additionally, the property owner should adopt and implement a maintenance and inspection program.

If this maintenance and inspection schedule are not maintained the design life of the property cannot be attained. A recommended program is given in Table: C in Appendix: 3 and should also include the following guidelines.

- The conditions on the block don’t change from those present at the time this report was prepared, except for the changes due to this development.

- There is no change to the property due to an extraordinary event external to this site
- The property is maintained in good order and in accordance with the guidelines set out in;
    a) CSIRO sheet BTF 18
    b) Australian Geomechanics "Landslide Risk Management" Volume 42, March 2007.
    c) AS 2870 – 2011, Australian Standard for Residential Slabs and Footings

Where changes to site conditions are identified during the maintenance and inspection program, reference should be made to relevant professionals (e.g. structural engineer, geotechnical engineer or Council). Where the property owner has any lack of understanding or concerns about the implementation of any component of the maintenance and inspection program the relevant engineer should be contacted for advice or to complete the component. It is assumed that Council will control development on neighbouring properties, carry out regular inspections and maintenance of the road verge, stormwater systems and large trees on public land adjacent to the site so as to ensure that stability conditions do not deteriorate with potential increase in risk level to the site. Also, individual Government Departments will maintain public utilities in the form of power lines, water and sewer mains to ensure they don't leak and increase either the local groundwater level or landslide potential.

6. CONCLUSION:

The proposed works involve construction of new rooms and a garage near the front of the site and the construction of a new pool within the rear, requiring excavation up to 2.30m depth. The other additions will not require significant excavations.

The investigation identified the presence of clay fill (potentially containing boulders) to an interpreted depth of approximately 1.0m overlying stiff to hard silty clay to a depth maximum of 2.80m. Bedrock was encountered at a shallowest depth of 1.42m and at a greatest depth of approximately 2.80m underlying the residual soils.

Indications of instability were not observed within or surrounding the site and the pool location was underlain by what is interpreted to be at least very low strength bedrock.

It appears sufficient space exists for construction of temporary batters adjacent to the side boundaries but will depend on final excavation depths and pool placement/location.

Sydney Water should be contacted to determine what requirements are needed to protect the sewer asset near the proposed pool excavation.

It is recommended that all new footings be founded within bedrock of similar strength to reduce the potential for differential settlement and provide stability within the slope.

The risk from geological/geotechnical hazard which was identified in relation to the existing site and proposed works, is limited to minor landslip failure of fill/residual clayey soils due to excavation and is considered 'Acceptable', when assessed against the criteria of the AGS 2007.

The recommendations and conclusions in this report are based on an investigation utilising only surface observations and hand auger drilling techniques. This test equipment provides limited data from small, isolated test points across the entire site with limited penetration into rock, therefore some minor variation to the interpreted sub-surface conditions is possible, especially between test locations. However, the results of the investigation provide a reasonable basis for the preliminary design and Development Application analysis.

Prepared by:

Ben Taylor
Senior Geotechnical Engineer

Reviewed by:

Troy Crozier
Principal Engineering Geologist
MAIG. RPGeo; 10197

7. REFERENCES:

1. Australian Geomechanics Society 2007, "Landslide Risk Assessment and Management", Australian Geomechanics Journal Vol. 42, No 1, March 2007.
2. Geological Society Engineering Group Working Party 1972, "The preparation of maps and plans in terms of engineering geology" Quarterly Journal Engineering Geology, Volume 5, Pages 295 - 382.
3. C. W. Fetter 1995, "Applied Hydrology" by Prentice Hall. V. Gardiner & R. Dackombe 1983, "Geomorphological Field Manual" by George Allen & Unwin
4. Australian Standard AS 3798 – 2007, Guidelines on Earthworks for Commercial and Residential Developments.
5. Australian Standard AS 2870 – 1996, Residential Slabs and Footings – Construction
6. Australian Standard AS1170.4 – 2007, Part 4: Earthquake actions in Australia

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 1

CROZIER
GEOTECHNICAL CONSULTANTS

Crozier Geotechnical Consultants ABN: 96 113 453 624
Unit 12/ 42-46 Wattle Road Phone: (02) 9939 1882
Brookvale NSW 2100 Email: info@croziergeotech.com.au
Crozier Geotechnical Consultants, a division of PJC Geo-Engineering Pty Ltd

NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, Geotechnical Site Investigation Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. Sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination.
The strength terms are defined as follows:

Classification	Undrained Shear Strength kPa
Very soft	Less than 12
Soft	12 - 25
Firm	25 – 50
Stiff	50 – 100
Very stiff	100 - 200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT "N" Value (blows/300mm)	CPT Cone Value (Qc – MPa)
Very loose	less than 5	less than 2
Loose	5 – 10	2 – 5
Medium dense	10 – 30	5 -15
Dense	30 – 50	15 – 25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling to allow information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Drilling Methods

The following is a brief summary of drilling methods currently adopted by the company and some comments on their use and application.

Test Pits – these are excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descent into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) – the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling – the hole is advanced by pushing a 100mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers – the hole is advanced using 90 – 115mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPT's or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling – similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. From SPT).

Continuous Core Drilling – a continuous core sample is obtained using a diamond-tipped core barrel, usually 50mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedures is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test 6.3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150mm of say 4, 6 and 7
  as 4, 6, 7 then N = 13
- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm then as 15, 30/40mm.

The results of the test can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50mm diameter thin wall sample tubes in clay. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch Cone – abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australia Standard 1289, Test 6.4.1.

In tests, a 35mm diameter rod with a cone-tipped end is pushed continually into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separte 130mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected buy electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) their information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: -

- Cone resistance – the actual end bearing force divided by the cross-sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio - the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0 – 5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0 – 50 MPa) is less sensitive and is shown as a full line. The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios 1% - 2% are commonly encountered in sands and very soft clays rising to 4% - 10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range: -

Q_c (MPa) = (0.4 to 0.6) N blows (blows per 300mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range: -

Q_c = (12 to 18) C_u

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculations of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Dynamic Penetrometers

Dynamic penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer – a 16mm diameter flattened rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test 6.3.3). The test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289, Test 6.3.2). The test was developed initially for pavement sub-grade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is generally carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Borehole Logs

The bore logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Details of the type and method of sampling are given in the report and the following sample codes are on the borehole logs where applicable:

D	Disturbed Sample	E	Environmental sample	DT	Diatube
B	Bulk Sample	PP	Pocket Penetrometer Test		
U50	50mm Undisturbed Tube Sample	SPT	Standard Penetration Test		
U63	63mm " " " " "	C	Core		

Ground Water

Where ground water levels are measured in boreholes there are several potential problems:

- In low permeability soils, ground water although present, may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made. More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. A three-storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty-storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions – the potential for this will depend partly on bore spacing and sampling frequency,
- changes in policy or interpretation of policy by statutory authorities,
- the actions of contractors responding to commercial pressures,

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

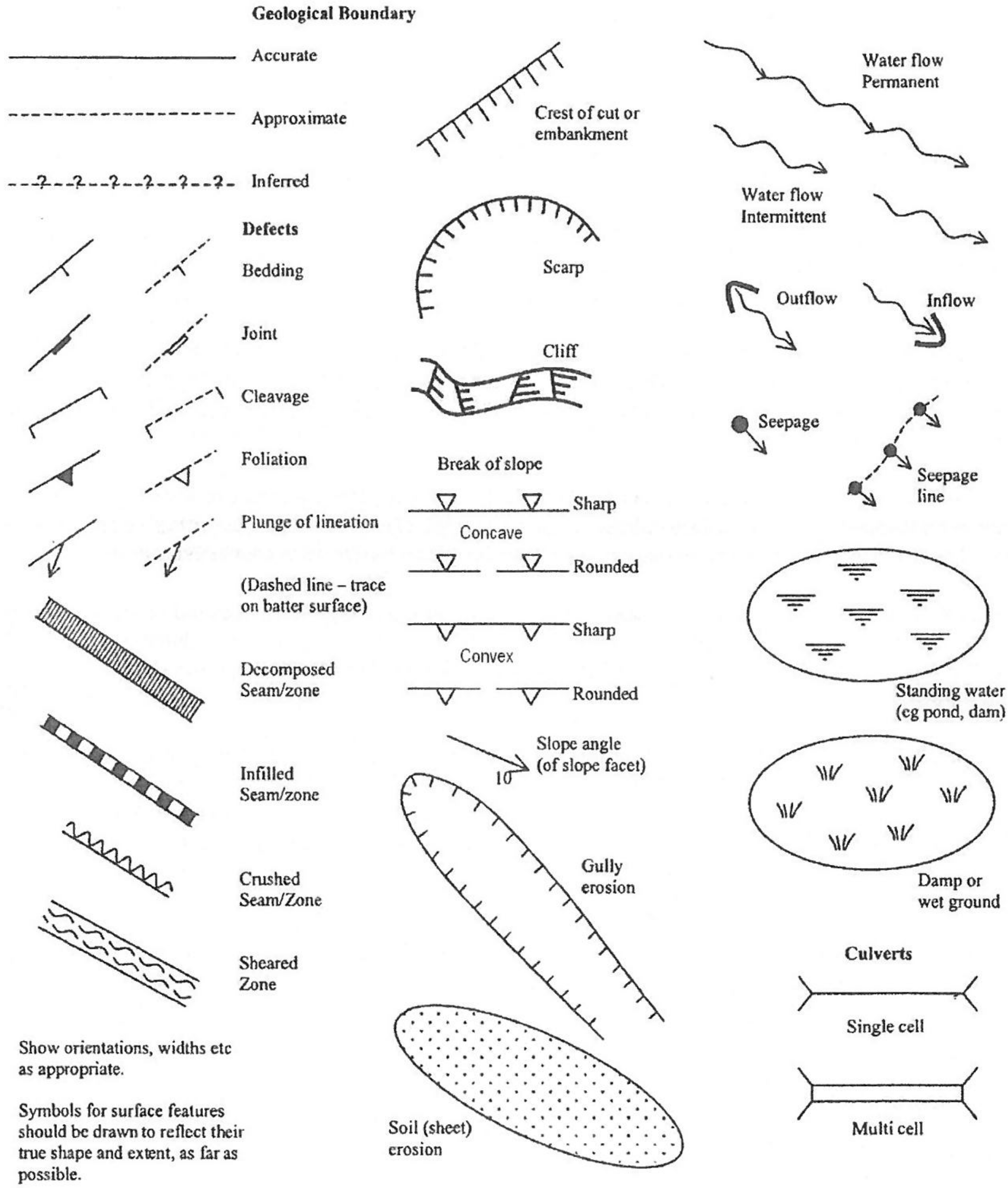
Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a special ally edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

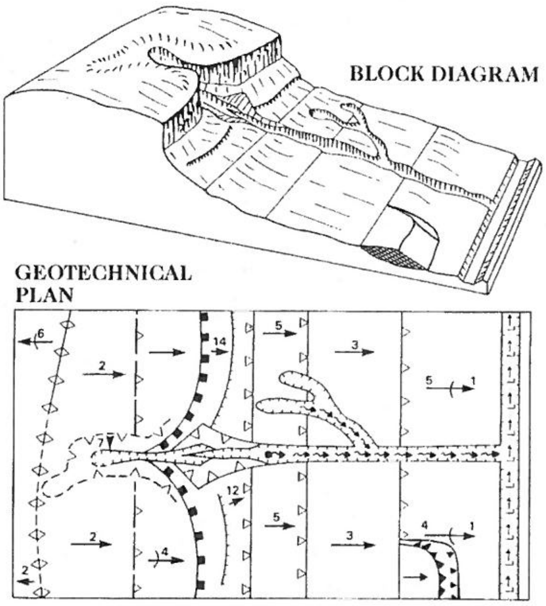
Site Inspection

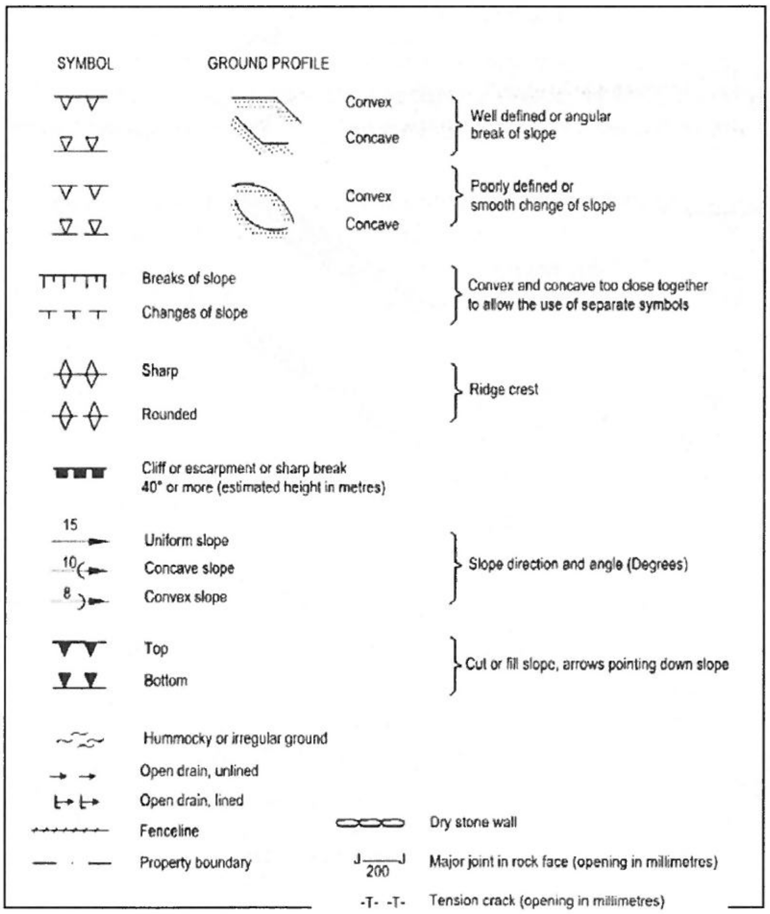
The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

APPENDIX E - GEOLOGICAL AND GEOMORPHOLOGICAL MAPPING SYMBOLS AND TERMINOLOGY



Examples of Mapping Symbols (after Guide to Slope Risk Analysis Version 3.1 November 2001, Roads and Traffic Authority of New South Wales).

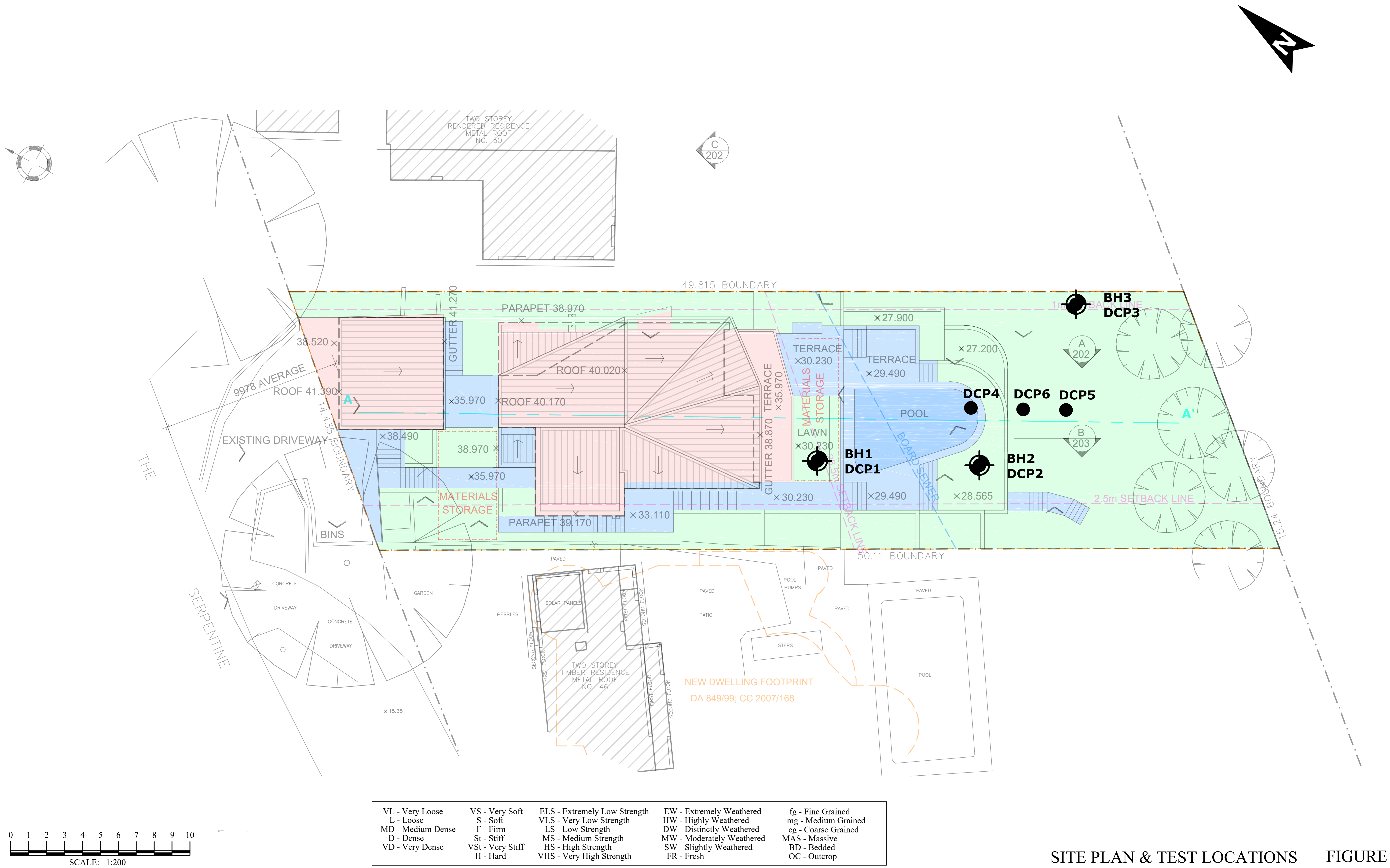




Example of Mapping Symbols

(after V Gardiner & R V Dackombe (1983).Geomorphological Field Manual. George Allen & Unwin).

Appendix 2



VL - Very Loose	VS - Very Soft	ELS - Extremely Low Strength	EW - Extremely Weathered	fg - Fine Grained
L - Loose	S - Soft	VLS - Very Low Strength	HW - Highly Weathered	mg - Medium Grained
MD - Medium Dense	F - Firm	LS - Low Strength	DW - Distinctly Weathered	cg - Coarse Grained
D - Dense	St - Stiff	MS - Medium Strength	MW - Moderately Weathered	MAS - Massive
VD - Very Dense	VSt - Very Stiff	HS - High Strength	SW - Slightly Weathered	BD - Bedded
	H - Hard	VHS - Very High Strength	FR - Fresh	OC - Outcrop

SITE PLAN & TEST LOCATIONS FIGURE 1.

CROZIER
GEOTECHNICAL CONSULTANTS

Crozier Geotechnical
Unit 12, 42-46 Wattle Road
Brookvale NSW 2100
ABN: 96 113 453 624
Phone: (02) 9939 1882
Fax: (02) 9939 1883
Crozier Geotechnical is a division of PJC Geo-Engineering Pty Ltd

LEGEND

A — A' CROSS-SECTION REFERENCE LINE

PROPERTY BOUNDARY

DCP DYNAMIC CONE PENETROMETER

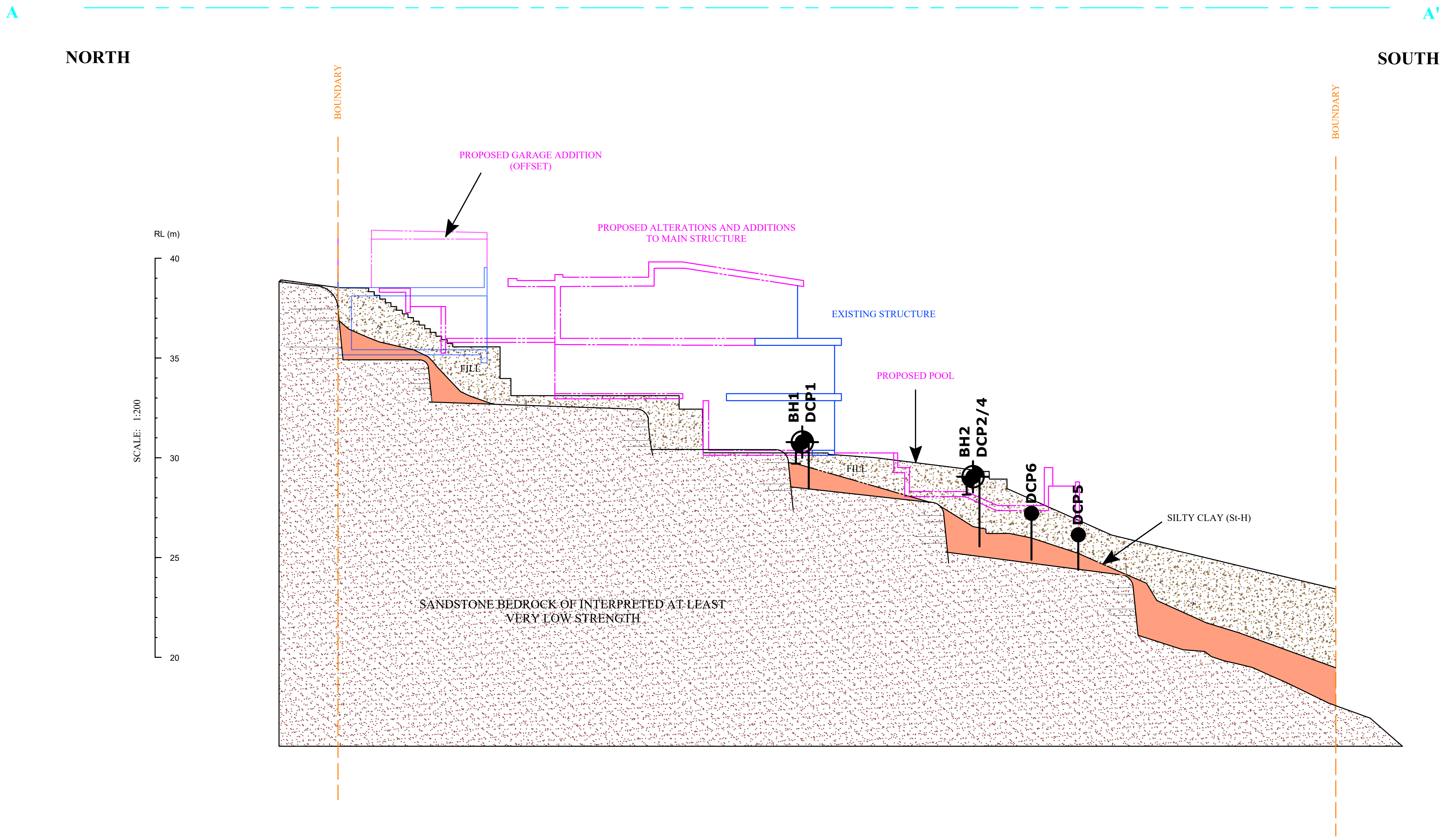
BH DCP AUGER / DYNAMIC CONE PENETROMETER LOCATION

SCALE: 1:200 @ A3
DRAWING: FIGURE 1
DATE: 09/2025

APPROVED BY: TMC
DRAWN BY: JC & JY
PROJECT: 2019-065

PREPARED FOR:
Ben and Lucy Feek

ADDRESS:
48 The Serpentine, Bilgola Beach



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VD - Very Dense	VSt - Very Stiff	HS - High Strength	SW - Slightly Weathered	BD - Bedded
	H - Hard	VHS - Very High Strength	FR - Fresh	OC - Outcrop

NB. FOR LOCATION OF SECTION A-A', PLEASE REFER TO FIGURE 1. SITE PLAN AND TEST LOCATIONS

GEOLOGICAL MODEL FIGURE 2.

CROZIER
GEOTECHNICAL CONSULTANTS

Crozier Geotechnical
Unit 12, 42-46 Wattle Road
Brookvale NSW 2100
ABN: 96 113 453 624
Phone: (02) 9939 1882
Fax: (02) 9939 1883
Crozier Geotechnical is a division of PJC Geo-Engineering Pty Ltd

LEGEND

- A — A' CROSS-SECTION REFERENCE LINE
- PROPOSED STRUCTURE
- BH DCP AUGER / DYNAMIC CONE PENETROMETER LOCATION
- SILTY CLAY
- DCP DYNAMIC CONE PENETROMETER
- PROPERTY BOUNDARY
- EXISTING STRUCTURE
- SOIL/FILL
- SANDSTONE BEDROCK

SCALE:	1:200 @ A3
DRAWING:	FIGURE 1
DATE:	09/2025
APPROVED BY:	TMC
DRAWN BY:	JC & JY
PROJECT:	2019-065

PREPARED FOR:
Ben and Lucy Feek

ADDRESS:
48 The Serpentine, Bilgola Beach

BOREHOLE LOG

CLIENT: Ben and Lucy Feek **DATE:** 7/05/2019 **BORE No.:** 1

PROJECT: Alterations and Additions **PROJECT No.:** 2019-065 **SHEET:** 1 of 1

LOCATION: 48 The Serpentine, Bilgola Beach **SURFACE LEVEL:** RL30.20m

Depth (m)	Description of Strata PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Sampling		In Situ Testing		
		Type	Depth (m)	Type	Results	
0.00	TOPSOIL/FILL: Brown, low plasticity, moist sandy clay with gravel					
0.25	Silty CLAY (CI): Stiff to very stiff, orange brown mottled grey, moist silty clay	D	0.40 0.50			
0.58	Auger refusal at 0.58m depth in hard clay					
1.00						
2.00						

RIG: NA DRILLER: AC LOGGED: JY

METHOD: Hand Auger

GROUND WATER OBSERVATIONS: No freestanding groundwater table found

REMARKS: CHECKED:

BOREHOLE LOG

CLIENT: Ben and Lucy Feek **DATE:** 7/05/2019 **BORE No.:** 2

PROJECT: Alterations and Additions **PROJECT No.:** 2019-065 **SHEET:** 1 of 1

LOCATION: 48 The Serpentine, Bilgola Beach **SURFACE LEVEL:** RL28.50m

Depth (m)	Description of Strata PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Sampling		In Situ Testing		
		Type	Depth (m)	Type	Results	
0.00						
0.25	FILL: Dark brown, moist sandy clay with gravel and cobbles					
0.50						
	Auger refusal at 0.50m depth on cobbles					
1.00						
2.00						

RIG: NA DRILLER: AC LOGGED: JY

METHOD: Hand Auger

GROUND WATER OBSERVATIONS: No freestanding groundwater table found

REMARKS: CHECKED:

BOREHOLE LOG

CLIENT: Ben and Lucy Feek **DATE:** 7/05/2019 **BORE No.:** 3

PROJECT: Alterations and Additions **PROJECT No.:** 2019-065 **SHEET:** 1 of 1

LOCATION: 48 The Serpentine, Bilgola Beach **SURFACE LEVEL:** RL23.50m

Depth (m)	Description of Strata PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Sampling		In Situ Testing		
		Type	Depth (m)	Type	Results	
0.00						
	FILL: Dark brown, moist sandy clay with gravel					
0.30	… red brown sandy clay with gravel					
			0.35			
0.40		D	0.40			
	Auger refusal at 0.40m depth on cobbles					
1.00						
2.00						

RIG: NA DRILLER: AC LOGGED: JY

METHOD: Hand Auger

GROUND WATER OBSERVATIONS: No freestanding groundwater table found

REMARKS: CHECKED:

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Ben and Lucy Feek **DATE:** 7/05/2019

PROJECT: Alterations and Additions **PROJECT No.:** 2019-065

LOCATION: 48 The Serpentine, Bilgola Beach **SHEET:** 1 of 1

	Test Location							
Depth (m)	1	2	3	4	5	6		
0.00 - 0.15	2	1	2	1	2	1		
0.15 - 0.30	2	3	2	3	3	4		
0.30 - 0.45	4	2	8	3	13	2		
0.45 - 0.60	10	2	8	4	17	3		
0.60 - 0.75	18	3	8	2	3	3		
0.75 - 0.90	17	3	18	4	4	2		
0.90 - 1.05	13	4	18	4	10	6		
1.05 - 1.20	27	9	20	2	7	4		
1.20 - 1.35	10	3	19	6	10	6		
1.35 - 1.50	8	6	15 (B) ref at 1.42m	11	13 (B) ref at 1.42m	6		
1.50 - 1.65	23	1		1		5		
1.65 - 1.80	24 (B) ref at 1.77m	10		10		11		
1.80 - 1.95		8		10		19		
1.95 - 2.10		13		17		5 (B) ref at 1.99m		
2.10 - 2.25		10		13				
2.25 - 2.40		13		19				
2.40 - 2.55		32		24				
2.55 - 2.70		27		37 ref at 2.68m				
2.70 - 2.85		25 (B) ref at 2.80m						
2.85 - 3.00								
3.00 - 3.15								
3.15 - 3.30								
3.30 - 3.45								
3.45 - 3.60								
3.60 - 3.75								
3.75 - 3.90								
3.90 - 4.05								

TEST METHOD: AS 1289. F3.2, CONE PENETROMETER
AS 1289. F3.3, PERTH SAND PENETROMETER

REMARKS: **(B)** Test hammer bouncing upon refusal on solid object
-- No test undertaken at this level due to prior excavation of soils

Appendix 3

TABLE : A

Landslide risk assessment for Risk to life

HAZARD	Description	Impacting	Likelihood of Slide	Spatial Impact of Slide		Occupancy	Evacuation	Vulnerability	Risk to Life
A	Landslip (earth slide <3m³) of soils from unsupported pool excavation		≤1.80m deep excavation in fill, silty clay	a) Would impact narrow section of the pool excavation only. b) Excavation within 1.0m of the existing site house, impact 5% of the house.		a) Person in excavation 8hr/day b) Person in house 18 hrs/day.	a) Possible to not evacuate b) Possible to not evacuate	a) Person in open space unlikely buried b) Person in house, only house impacted	
			Possible	**Prob. of Impact**	**Impacted**				
		a) Base of pool excavation	0.001	1.00	0.05	0.0417	0.5	0.20	**2.08E-07**
		b) Rear of existing site house.	0.001	0.50	0.05	0.0417	0.5	0.05	**2.60E-08**

* hazards considered in current condition and/or without remedial/stabilisation measures
* likelihood of occurrence for design life of 100 years
* Spatial Impact - Probaility of Impact referes to slide impacting structure/area expressed as a % (1.00 = 100% probability of slide impacting area if it occurs), Imapcted refers to % of area/strucure impacted if slide occurred
* neighbouring houses considered for bedroom impact unless specified
* considered for person most at risk
* considered for adjacent premises/buildings founded via shallow footings unless indicated
* evacuation scale from Almost Certain to not evacuate (1.0), Likely (0.75), Possible (0.5), Unlikely (0.25), Rare to not evacuate (0.01). Based on likelihood of person knwoing of landslide and completely evacuating area prior to landslide impact.
* vulnerability assessed using Appendix F - AGS Practice Note Guidelines for Landslide Risk Management 2007

TABLE : B

Landslide risk assessment for Risk to Property

HAZARD	Description	Impacting	Likelihood		Consequences		Risk to Property
A	Landslip (earth slide $<3m^3$) of soils from unsupported pool excavation	a) Base of pool excavation	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring properties.	VERY LOW
		b) Rear of existing site house.	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring properties.	VERY LOW

* hazards considered in current condition, without remedial/stabilisation measures and during construction works.
* qualitative expression of likelihood incorporates both frequency analysis estimate and spatial impact probability estimate as per AGS guidelines.
* qualitative measures of consequences to property assessed per Appendix C in AGS Guidelines for Landslide Risk Management.
* Indicative cost of damage expressed as cost of site development with respect to consequence values: Catastrophic : 200%, Major: 60%, Medium: 20%, Minor: 5%, Insignificant: 0.5%.

TABLE: 2

Recommended Maintenance and Inspection Program

Structure	Maintenance/ Inspection Item	Frequency
Stormwater drains.	Owner to inspect to ensure that the drains, and pipes are free of debris & sediment build-up. Clear surface grates and litter.	Every year or following each major rainfall event.
Retaining Walls. or remedial measures	Owner to inspect walls for deveation from as constructed condition and repair/replace. Replace poorly constructed rock walls	Every two years or following major rainfall event. As soon as practicable
Large Trees on or adjacent to site	Arbourist to check condition of trees and remove as required. Where treee within steep slopes or adjacent to structures require geotechincal inspection prior to removal	Every five years
Slope Stability	Hydraulics (stormwater) & Geotechnical Consultants to check on site stability at same time and provide report.	One year after construction is completed.

N.B. Provided the above shedule is maintained the design life of the property should conform with Councils Risk Management Policy.

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Appendix 4

APPENDIX A

DEFINITION OF TERMS

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES WORKING GROUP ON LANDSLIDES, COMMITTEE ON RISK ASSESSMENT

Risk – A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability x consequences. However, a more general interpretation of risk involves a comparison of the probability and consequences in a non-product form.

Hazard – A condition with the potential for causing an undesirable consequence (*the landslide*). The description of landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides and any resultant detached material, and the likelihood of their occurrence within a given period of time.

Elements at Risk – Meaning the population, buildings and engineering works, economic activities, public services utilities, infrastructure and environmental features in the area potentially affected by landslides.

Probability – The likelihood of a specific outcome, measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between 0 and 1, with 0 indicating an impossible outcome, and 1 indicating that an outcome is certain.

Frequency – A measure of likelihood expressed as the number of occurrences of an event in a given time. See also Likelihood and Probability.

Likelihood – used as a qualitative description of probability or frequency.

Temporal Probability – The probability that the element at risk is in the area affected by the landsliding, at the time of the landslide.

Vulnerability – The degree of loss to a given element or set of elements within the area affected by the landslide hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons, it will be the probability that a particular life (the element at risk) will be lost, given the person(s) is affected by the landslide.

Consequence – The outcomes or potential outcomes arising from the occurrence of a landslide expressed qualitatively or quantitatively, in terms of loss, disadvantage or gain, damage, injury or loss of life.

Risk Analysis – The use of available information to estimate the risk to individuals or populations, property, or the environment, from hazards. Risk analyses generally contain the following steps: scope definition, hazard identification, and risk estimation.

Risk Estimation – The process used to produce a measure of the level of health, property, or environmental risks being analysed. Risk estimation contains the following steps: frequency analysis, consequence analysis, and their integration.

Risk Evaluation – The stage at which values and judgements enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental, and economic consequences, in order to identify a range of alternatives for managing the risks.

Risk Assessment – The process of risk analysis and risk evaluation.

Risk Control or Risk Treatment – The process of decision making for managing risk, and the implementation, or enforcement of risk mitigation measures and the re-evaluation of its effectiveness from time to time, using the results of risk assessment as one input.

Risk Management – The complete process of risk assessment and risk control (*or risk treatment*).

Individual Risk – The risk of fatality or injury to any identifiable (named) individual who lives within the zone impacted by the landslide; or who follows a particular pattern of life that might subject him or her to the consequences of the landslide.

Societal Risk – The risk of multiple fatalities or injuries in society as a whole: one where society would have to carry the burden of a landslide causing a number of deaths, injuries, financial, environmental, and other losses.

Acceptable Risk – A risk for which, for the purposes of life or work, we are prepared to accept as it is with no regard to its management. Society does not generally consider expenditure in further reducing such risks justifiable.

Tolerable Risk – A risk that society is willing to live with so as to secure certain net benefits in the confidence that it is being properly controlled, kept under review and further reduced as and when possible.

In some situations risk may be tolerated because the individuals at risk cannot afford to reduce risk even though they recognise it is not properly controlled.

Landslide Intensity – A set of spatially distributed parameters related to the destructive power of a landslide. The parameters may be described quantitatively or qualitatively and may include maximum movement velocity, total displacement, differential displacement, depth of the moving mass, peak discharge per unit width, kinetic energy per unit area.

Note: Reference should also be made to Figure 1 which shows the inter-relationship of many of these terms and the relevant portion of Landslide Risk Management.

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}	5×10^{-2}	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	5×10^{-3}	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	5×10^{-4}	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	5×10^{-5}	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	5×10^{-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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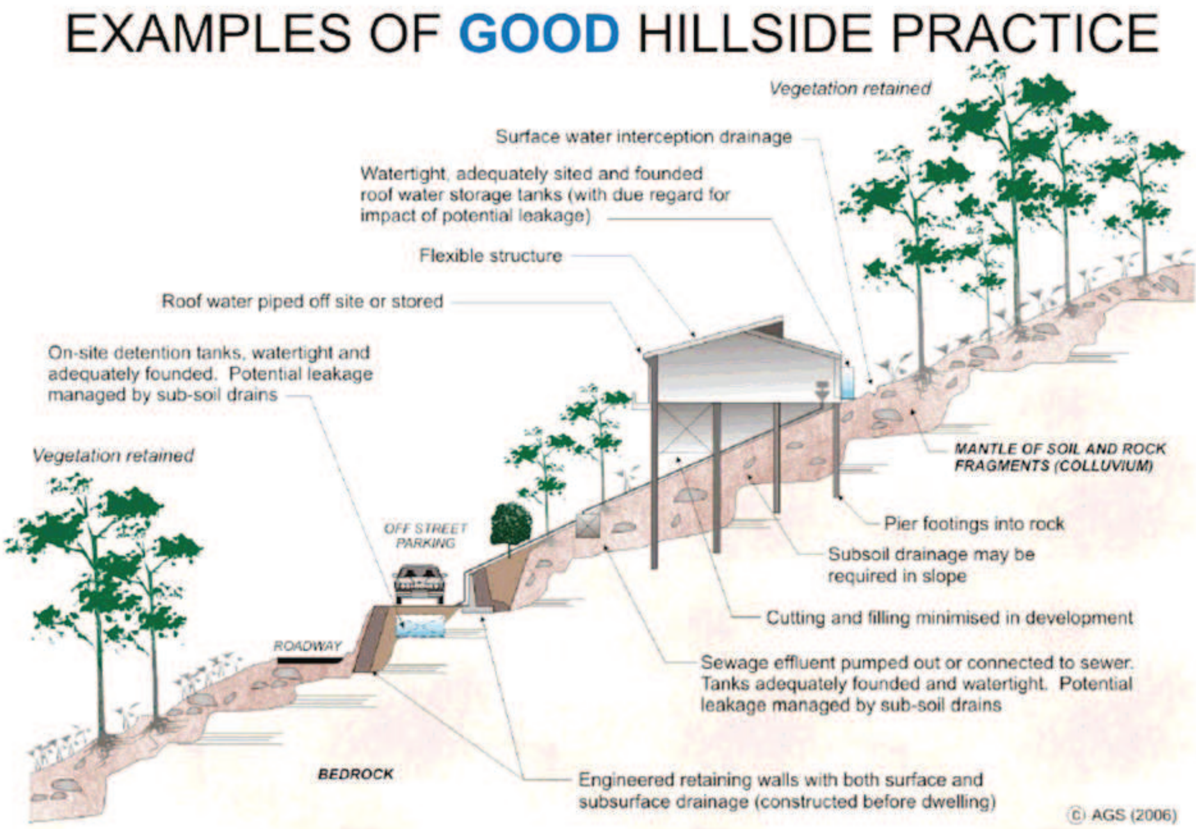
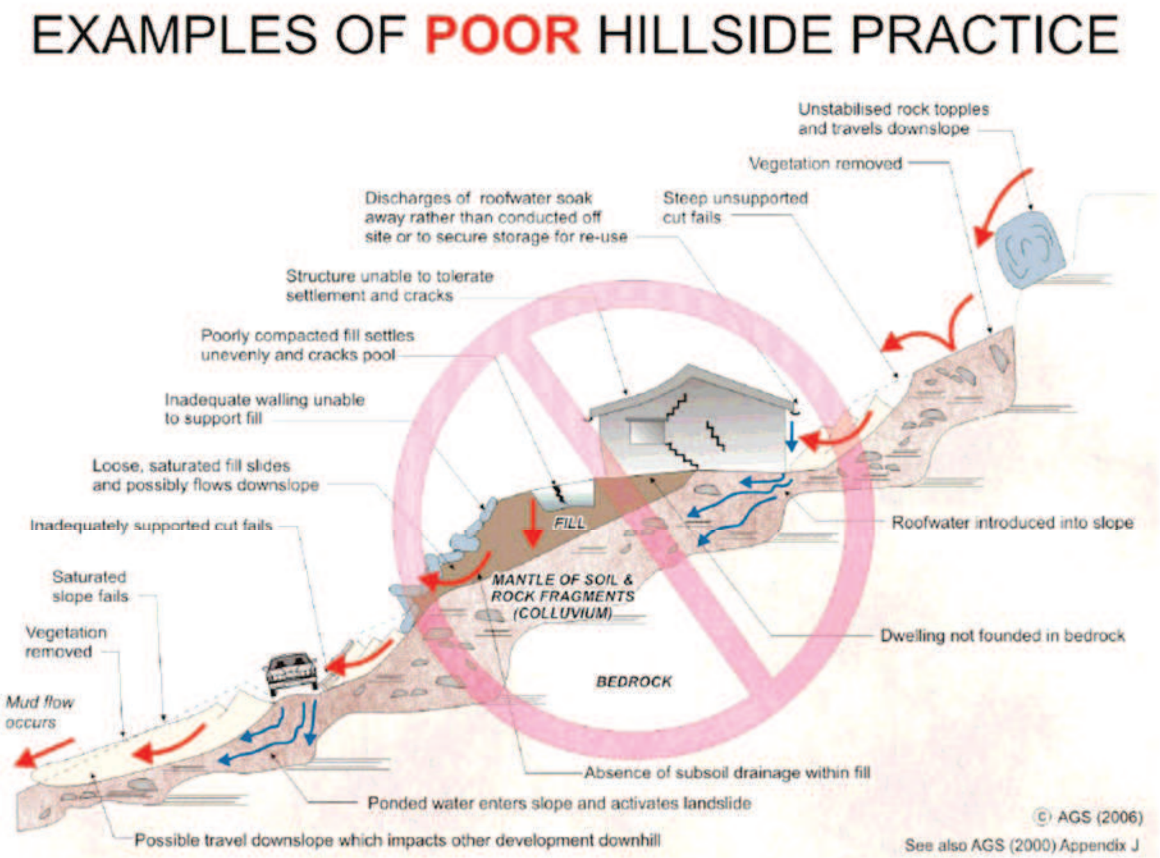
Appendix 5

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	


EXAMPLES OF GOOD HILLSIDE PRACTICE
Vegetation retained
Surface water interception drainage
Watertight, adequately sited and founded roof water storage tanks (with due regard for impact of potential leakage)
Flexible structure
Roof water piped off site or stored
On-site detention tanks, watertight and adequately founded. Potential leakage managed by sub-soil drains
Vegetation retained
MANTLE OF SOIL AND ROCK FRAGMENTS (COLLUVIUM)
OFF STREET PARKING
Pier footings into rock
Subsoil drainage may be required in slope
Cutting and filling minimised in development
ROADWAY
Sewage effluent pumped out or connected to sewer. Tanks adequately founded and watertight. Potential leakage managed by sub-soil drains
BEDROCK
Engineered retaining walls with both surface and subsurface drainage (constructed before dwelling)
© AGS (2006)


EXAMPLES OF POOR HILLSIDE PRACTICE
Unstabilised rock topples and travels downslope
Vegetation removed
Discharges of roofwater soak away rather than conducted off site or to secure storage for re-use
Steep unsupported cut fails
Structure unable to tolerate settlement and cracks
Poorly compacted fill settles unevenly and cracks pool
Inadequate walling unable to support fill
Loose, saturated fill slides and possibly flows downslope
Inadequately supported cut fails
FILL
Roofwater introduced into slope
Saturated slope fails
MANTLE OF SOIL & ROCK FRAGMENTS (COLLUVIUM)
Dwelling not founded in bedrock
Vegetation removed
BEDROCK
Mud flow occurs
Absence of subsoil drainage within fill
Ponded water enters slope and activates landslide
© AGS (2006)
Possible travel downslope which impacts other development downhill
See also AGS (2000) Appendix J