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GEOTECHNICAL CONSULTANTS

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REPORT ON GEOTECHNICAL SITE INVESTIGATION

for

PROPOSED ALTERATIONS AND ADDITIONS

at

4 IRRUBEL ROAD, NEWPORT, NSW

Prepared For

Roki Mills

Project No.: 2019-028

March, 2019

Document Revision Record

Issue No	Date	Details of Revisions
0	20th March, 2019	Original issue

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1 – To be submitted with Development Application

Development Application for	____________________
	Name of Applicant
Address of site	4 Irrubel Road, Newport

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 15th August, 2018_ 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 4 Irrubel Road, Newport

Report Date: 20/03/2019 **Project No.:** 2019-028

Author: J. Yan 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 Richards & Loftus Surveying Services, Job No.: 2436, Issue: A, Dated: September 2018
Architectural Drawings by Peter Stutchbury Architecture, File Name: Rokis Light Plan, Drawing No.: 003, 005, 100, 102, 300, Dated: 14th February 2019

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 ____
Name of Applicant

Address of site __4 Irrubel Road, Newport ______________

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 4 Irrubel Road, Newport
Report Date: 20th March 2019 **Project No.:** 2019-028
Author: K. Nicholson and T. Crozier
Author's Company/Organisation: Crozier Geotechnical Consultants

Please mark appropriate box

- ■ Comprehensive site mapping conducted ___12th March 2019________ (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 12th March 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**

REGISTERED PROFESSIONAL GEOSCIENTIST
TROY CROZIER
10197

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GEOTECHNICAL REPORT FOR PROPOSED ALTERATIONS AND ADDITIONS 4 IRRUBEL ROAD, NEWPORT, NSW

1. INTRODUCTION:

This report details the results of a geotechnical investigation carried out for proposed alterations and additions at 4 Irrubel Road, Newport, NSW. The investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the request of the client Roki Mills.

The site is not located within a designated landslip hazard zone as identified with Northern Beaches Councils, Pittwater - Geotechnical Hazard Mapping (Geotechnical Risk Management Policy for Pittwater – 2009). However the proposed works trigger the action criteria of the landslip policy in regard to excavation and filling – Section 3.2 (b) (iv).

To meet the Councils Policy requirements for works which trigger the landslip policy, a detailed Geotechnical Report which meets the requirements of Paragraph 6.5 of that policy is required for submission with Development Application. Therefore, this report includes a landslide risk assessment of the site and proposed works, plans, a geological section and provides recommendations for construction and to ensure stability is maintained for a design life of 100 years. It is recommended that the client make themselves aware of the Policy and its requirements.

The investigation and reporting were undertaken as per the Tender P19-054, Dated: 18th February 2019.

The geotechnical investigation included:

a) DBYD plan review for service mains
b) Detailed geotechnical mapping of the entire site and adjacent land, with identification of all geotechnical hazards including landslip related to the existing site and proposed structures
c) Drilling of three boreholes using hand tools along with Dynamic Cone Penetrometer (DCP) testing to investigate the subsurface geology

The following plans and diagrams were supplied for this work;

- Architectural Drawings by Peter Stutchbury Architecture, File Name: Rokis Light Plan, Drawing No.: 003, 005, 100, 102, 300, Dated: 14th February 2019.
- Site Survey Plan by Richards & Loftus Surveying Services, Job No.: 2436, Issue: A, Dated: September 2018

2. PROPOSED DEVELOPMENT:

It is understood that the proposed works involve partial demolition of the existing house structure, construction of an addition to the north of the house with construction of a new retained terrace on the northern and western sides of the house. The proposed works will require excavations ≤ 1.50m depth, reducing to nil towards southeast, to achieve the proposed FFL (Finished Floor Level) at RL = 34.70m. The excavation will extend to approximately 2.0m off the west boundary and ≥ 6.0m off other boundaries. It is also potentially proposed to construct a new storage/workshop area below the house. However, the extent and FFL were not provided, as such the assessment for this work is not included in this report.

3. SITE FEATURES:

3.1. Description:

The site is a rectangular shaped block located on the high north side of Irrubel Road, at the intersection with Nullaburra Road. It has a front south boundary of 33.05m, a rear north boundary of 32.69m, a side east boundary of 33.14m, a side west boundary of 36.22m, as referenced from the provided survey plan.

An aerial photograph of the site and its surrounds is provided below, as sourced from NSW Government Six Map spatial data, as Photograph 1.

The site is located within gently southeast dipping topography from a high of approximately RL = 36.93m at the northwest corner of the property to a low of approximately RL = 31.50m at the southeast corner. It is currently occupied by a single storey timber residence with a front yard and a fibro garage adjacent to north boundary. A general view of the site is provided in Photograph 2 below.

Photograph: 1 – Aerial photo of site and surrounds.

Photograph: 2 – General view of site, facing west.

3.2. Geology:

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

Narrabeen Group rocks are dominated by shales and thin siltstone/sandstone beds and often form rounded convex ridge tops with moderate angle (<20°) side slopes. These side slopes can be either concave or convex depending on geology, internally they comprise interbedded shale and siltstone beds with close spaced bedding partings that have either close spaced vertical joints or in extreme cases large space convex joints. The shale often forms deeply weathered profiles with silty or medium to high plasticity clays and a thin silty colluvial cover.

4. FIELD WORK:

4.1. Methods:

The field investigation comprised a walk over inspection and mapping of the site and adjacent properties on the 12th March 2019 by a Geotechnical Engineer. It included a photographic record of site conditions as well as geological/geomorphological mapping of the site and adjacent land including examination of existing site structures and neighbouring buildings.

It also included the drilling of three boreholes (BH1 to BH3) to investigate sub-surface geology. A hand auger was used as access to required test locations within the site for a conventional drilling rig was unavailable.

Dynamic Cone Penetrometer (DCP) testing was carried out from ground surface adjacent to the boreholes 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.

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

4.2. Field Observations:

The site is situated on the high north side of Irrubel Road, at the intersection with Nullaburra Road, within gently southeast dipping topography. Irrubel Road contains a bitumen pavement and is gently (<-3°) east dipping where it passes the site. A sloped (up to -18°) grass reserve lies between the road and the site boundary. Nullaburra Road contains a bitumen pavement and is gently (<-2°) south dipping where it passes the site. A sloped (-16°) grass reserve and concrete footpath lies between the road and the site boundary. There were no signs of excessive cracking or deformation within the road pavement to suggest any movement or underlying geotechnical issues.

The property is accessed via a sloped (-12°) concrete driveway at the east side from Nullaburra Road. The driveway extends into the site, through the front yard and to a concrete floor carport and a fibro garage located adjacent to the north boundary. There were no signs of excessive cracking or settlement within the driveway, carport and external wall of the garage.

The site is currently occupied by a single storey timber residence situated within the rear western portion of the property. There are timber decks with steps around the house providing access from the ground floor level of the house at approximately RL = 34.50m to the northwest corner of the property at RL = 36.77m and to the southern side gate at approximately RL = 32.80m. A sandstone block paved patio is located to the northwest of the house. The patio appears to have been cut into the slope which is retained by a sandstone rock wall up to 1.10m high. There were no signs of significant cracking or deformation in the wall.

The neighbouring property to the west, No. 6 Irrubel Road, contains a two storey rendered residence located broadly at the centre of the property. The building structure appears to be in a good condition with no sign of settlement or cracking on its external walls. The property is at a similar ground level as the site along the common boundary with the remainder of the block having a similar topography to the site. The building structure is located 3.00m off the common boundary.

The neighbouring property to the north, No. 1 Nullaburra Road, contains a single storey brick residence located broadly at the centre of the property with a carport in the south. The building structure appears to be in a good condition with no sign of settlement or cracking on its external walls. The property is at a similar ground level as the site along the common boundary with the remainder of the block having a similar topography to the site. The building structure is located 4.50m off the common boundary.

No.3 and No.5 Wallumatta Road are also located to the north of the site and share a common boundary. However, due to the high timber fence along the common boundary, the neighbouring properties could not be inspected.

The neighbouring buildings and properties were only inspected from within the site or from the road reserve however the visible aspects did not show any significant signs of large scale slope instability or other major geotechnical concerns which would impact the site or the proposed development.

4.3. Field Testing:

The boreholes (BH1 and BH3) were drilled using a hand auger to the north (BH1 and BH2) and to the south (BH3) of the house with refusal encountered at a maximum depth of 0.30m (BH1) in very stiff dry silty clay.

Dynamic Cone Penetrometer (DCP) tests were carried out from the surface adjacent to the boreholes and at a separate location with refusal encountered at ≤ 1.50m depth, with the results below 0.15m to 0.45m indicating hard clay soils potentially grading to extremely low strength bedrock.

Based on the borehole logs and DCP test results the subsurface conditions at the project site can be classified as follows:

- **TOPSOIL/FILL** – this layer was encountered at all borehole locations to 0.10m depth. It is classified as dark grey, fine to medium grained, dry silty sand.
- **Silty CLAY** – this layer was encountered at all borehole locations with hand auger refusal encountered in this layer at a maximum depth of 0.30m. It is classified as very stiff to hard, brown, low plasticity, dry silty clay, potentially grading to extremely low strength bedrock below 0.90m depth on southern side of the house (DCP3).
- **BEDROCK** – based on the DCP test results, the depth of bedrock of at least very low strength is interpreted to increase from 0.78m at the northern side of the house to > 1.50m at the southern side of the house.

There were no indications of significant seepage or a groundwater table in any of the boreholes during drilling.

5. COMMENTS:

5.1. Geotechnical Assessment:

The site investigation identified the presence of shallow topsoil/fill underlain by very stiff to hard silty clay overlying interpreted bedrock of at least very low strength with the rock surface dipping towards south from a high of approximately RL = 34.14m (DCP4) to a low of RL < 31.10m (DCP3). No groundwater table or significant seepage was encountered during the investigation.

The site investigation did not identify any signs of previous or impending shallow or deep seated landslip instability within the site.

The proposed works involve excavations ≤ 1.50m depth reducing to nil towards southeast to achieve the proposed FFL (Finished Floor Level) at RL = 34.70m. The excavation will extend to approximately 2.0m off the west boundary and ≥ 6.0m off other boundaries.

Based on the investigation results, the proposed excavation is anticipated to encounter sandy topsoil/fill to 0.10m depth and then very stiff to hard silty clay to the base of excavation. It is also possible to intersect a limited amount of very low strength to low strength bedrock at the northwest corner of the excavation. Considering the proposed depth of excavation and distance to the boundaries and existing structures the recommended safe temporary batter slopes provided in Section 5.3.2 may be implemented for all of the works.

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. 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 need to be considered in relation to the existing site and the proposed works. The hazard is:

A. Landslip (earthslide <$3m^3$) of soils from unsupported 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.

Hazard A was estimated to have a **Risk to Life** of up to **9.38×10^{-9} for a single person,** while the **Risk to Property** was considered to be 'Very Low'.

Where the recommendations of this report are followed the probability of failure becomes 'rare' in all situations and as such the risk will be 'Acceptable' when assessed against the criteria of the AGS 2007 and Councils policy. Therefore, the project is considered suitable for the site provided the recommendations of this report are implemented.

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 'S' for footings
Type of Footing	Strip/Pad or Slab at base of excavation
Sub-grade material and Maximum Allowable Bearing Capacity	- Very Stiff Clay: 200kPa - Hard Clay: 400kPa - Weathered, ELS-VLS Bedrock: 700kPa
Site sub-soil classification as per *Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia*	B_e – Rock Site
Remarks: All new footings must be inspected by an experienced geotechnical professional before concrete or steel are placed to verify the bearing capacities provided above are achieved and the in-situ nature of the founding strata. This is mandatory to allow them to be 'certified' at the end of the project. Individual structures should not be founded on materials with varying bearing and settlement characteristics unless the potential for differential movement has been allowed for in structural design.	

5.3.2. Excavation:	
Depth of Excavation	≤1.50m depth for new retained terrace
Distance of Excavation to Neighbouring Properties/structures	No.6 Irrubel Road – 2.00m to boundary, house another 3.00m, No.1, No.3, No.5 Nullaburra Road – 6.00m to boundary Irrubel Road – > 20.00m to boundary Nullaburra Road – > 16.00m to boundary
Type of Material to be Excavated	Sandy topsoil/fill ≤ 0.10m depth
	Very stiff to hard silty clay or ELS bedrock ≤ 1.50m depth

ELS = Extremely low strength (soil like), VLS = Very low strength, LS = Low strength

Guidelines for batter slopes for general information are tabulated below:

Material	Safe Batter Slope (H:V)	
	Short Term/ Temporary	Long Term/ Permanent
Fill and natural granular soils	1.5:1	2:1
Clay to Extremely low strength bedrock	1:1	1.5:1*
Very low strength bedrock	0.75:1*	1.25:1*

*Dependent on defects and assessment by engineering geologist

Remarks:

Seepage at the bedrock surface or along defects in the soil/rock can also 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.

Equipment for Excavation	Topsoil/Sandy Soils	Excavator with bucket
	Clay and ELS bedrock	Excavator with bucket
	VLS bedrock	Excavator with bucket and ripper
Recommended Vibration Limits (Maximum Peak Particle Velocity (PPV))	Not applicable unless hard rock is encountered	
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 excavated permanent batter slopes • 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 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	New retaining structures may be required as part of the proposed development
Types	Steel reinforced concrete/concrete block walls post excavation, designed in accordance with Australian Standards AS4678-2002 Earth Retaining Structures.

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 *
			Active (Ka)	At Rest (K_0)	
Sandy fill/topsoil	18	$\phi' = 28°$	0.35	0.52	N/A
Silty clay (very stiff to hard)	20	$\phi' = 35°$	0.27	0.50	N/A
ELS bedrock	22	$\phi' = 38°$	0.15	0.20	200kPa

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)
Site Location and Topography		High north side of the road, within gently south and east dipping topography
Impact of development on local hydrogeology		Negligible
Onsite Stormwater Disposal		Not recommended or required
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 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 site investigation identified the presence of a shallow layer of granular topsoil/fill (≤ 0.10m) underlain by very stiff to hard silty clay. The DCP testing identified what has been interpreted as bedrock of a minimum of very low strength between 0.78m and 1.20m depth across the northern half of the site and interpreted extremely low strength bedrock at 0.90m depth in southern side.

The proposed works involve partial demolition of the existing house structure, construction of an addition to the north of the house and construction of a new retained terrace on the northern and western sides of the house. The proposed works will require excavations ≤ 1.50m depth, which will extend to approximately 2.0m off the west boundary and ≥ 6.0m off other boundaries. Based on the proposed design, temporary batter slopes are achievable for all of the excavation perimeter.

It is expected that excavation will extend through granular topsoil/fill then very stiff to hard silty clay or extremely low strength bedrock without intersecting hard rock. Therefore, the excavation can be completed using conventional equipment (excavator with bucket/ripper) and ground vibrations should not be a hazard.

It is recommended that all new footings be founded within material of similar strength to reduce the potential differential settlement. New footings will require inspection 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.

The risks associated with the proposed development are and can be maintained within 'Acceptable' levels with negligible impact to neighbouring properties or structures provided the recommendations of this report and any future geotechnical directive are implemented. As such the site is considered suitable for the proposed construction works provided that the recommendations outlined in this report are followed.

Prepared By:	Reviewed By:
Jun Yan	Troy Crozier
Geotechnical Engineer	Principal
	MAIG, RPGeo – Geotechnical and Engineering
	Registration No.: 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

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Appendix 1

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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: -

Qc (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: -

Qc = (12 to 18) Cu

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.

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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

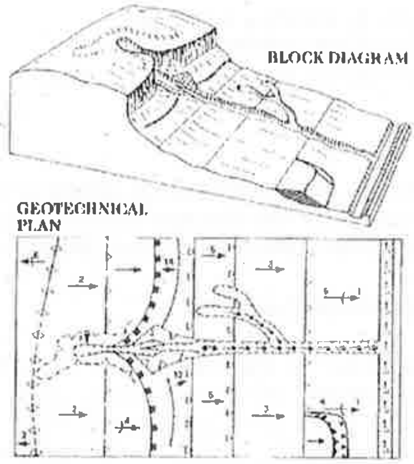
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some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

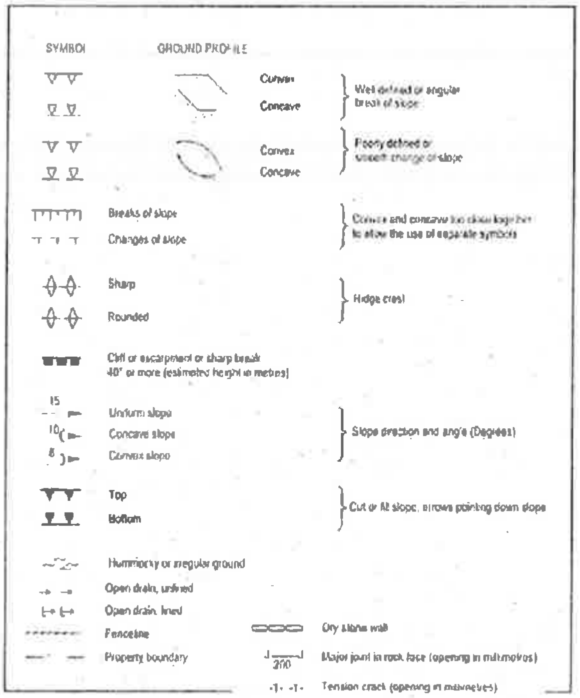
Reproduction of Information for Contractual Purposes

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

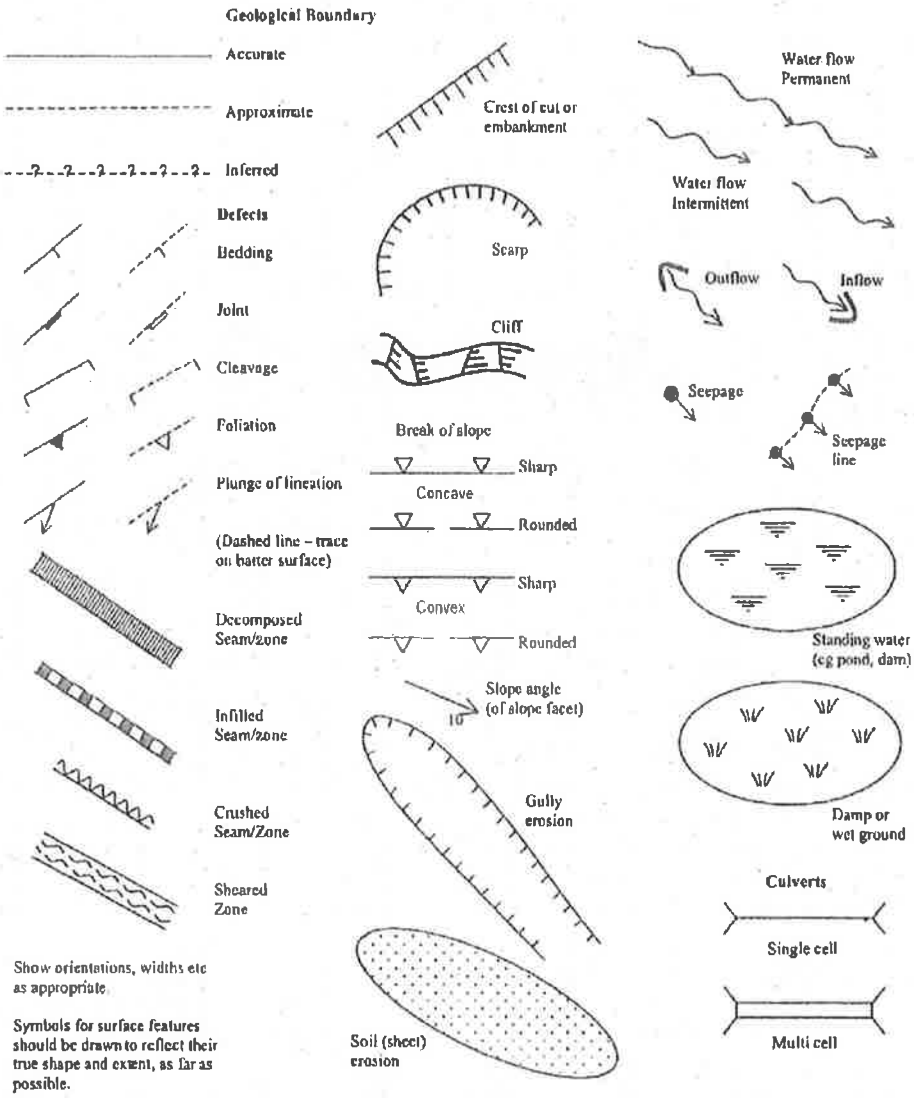
The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.





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

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).

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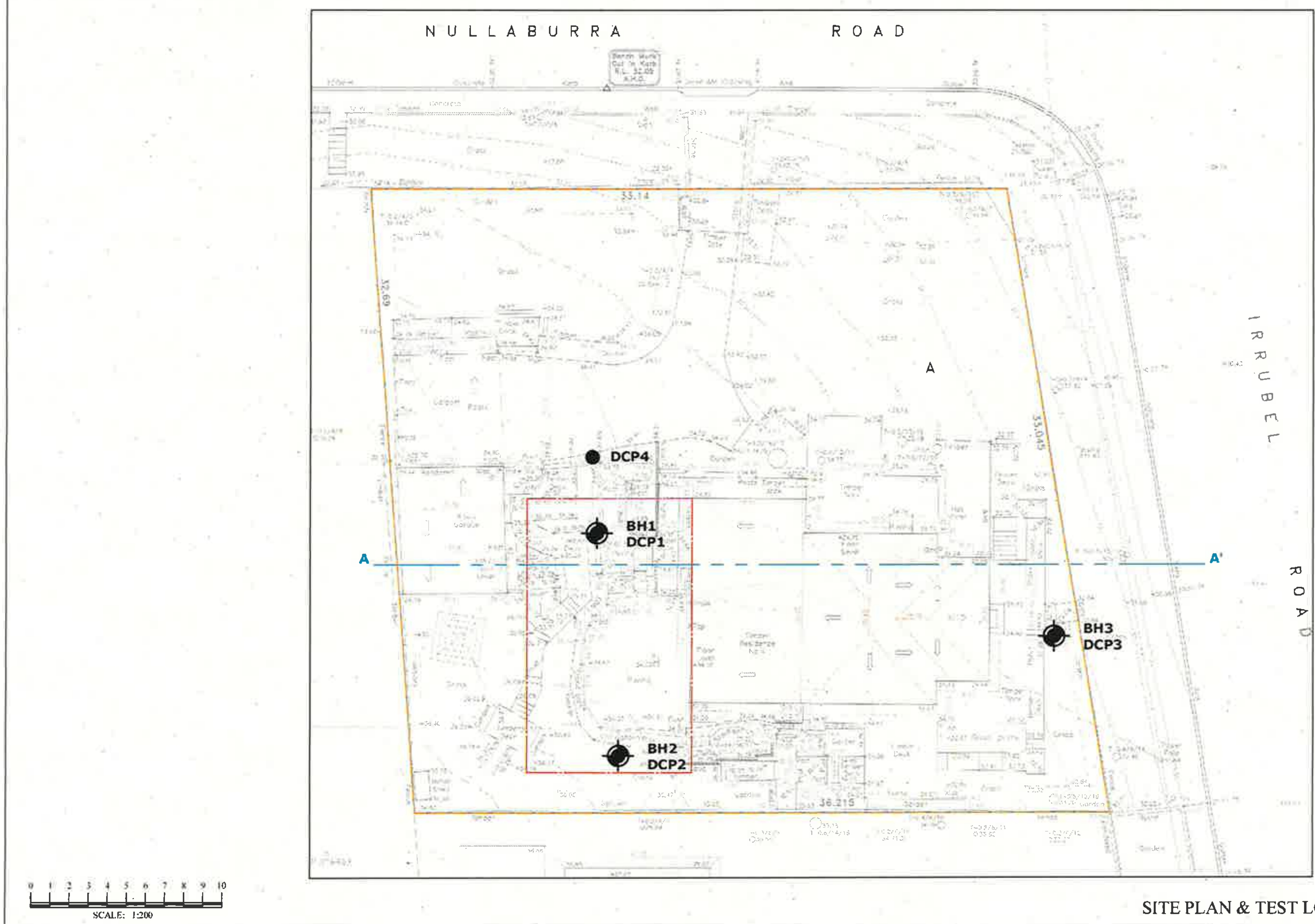
Appendix 2



SITE PLAN & TEST LOCATIONS FIGURE 1.

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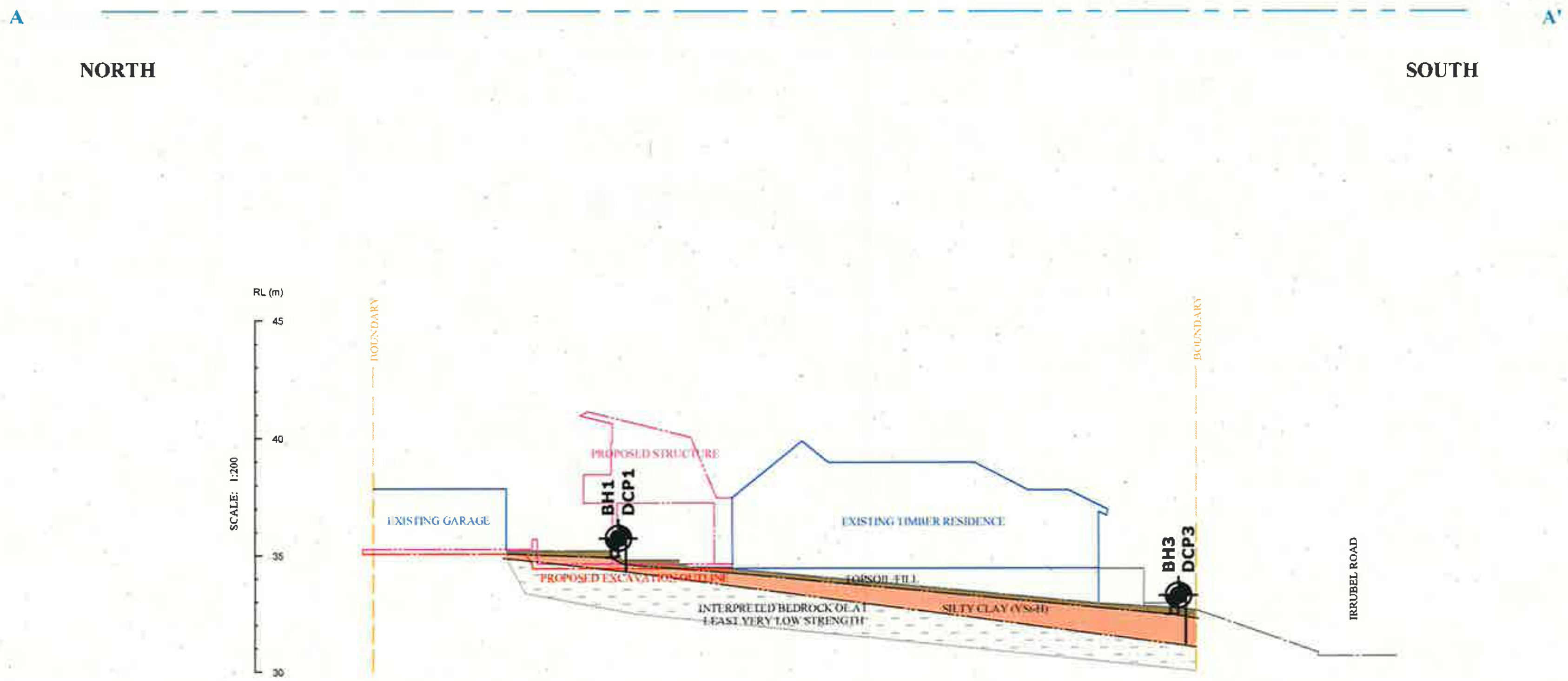
LEGEND

A — A'	CROSS-SECTION REFERENCE LINE
	PROPERTY BOUNDARY
	EXCAVATION OUTLINE
BH DCP	AUGER / DYNAMIC CONE PENETROMETER LOCATION

SCALE:	1:200 @ A3	PREPARED FOR: Roki Mills
DRAWING:	FIGURE 1	
DATE:	13/03/2019	
APPROVED BY:	TMC	ADDRESS: 4 Irrubel Road, Newport
DRAWN BY:	JY	
PROJECT:	2019-028	



0 1 2 3 4 5 6 7 8 9 10
SCALE: 1:200

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

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

GEOLOGICAL MODEL FIGURE 2.

LEGEND

- A — A' CROSS-SECTION REFERENCE LINE
- BH DCP AUGER / DYNAMIC CONE PENETROMETER LOCATION
- SILTY CLAY
- BEDROCK
- PROPERTY BOUNDARY
- TOPSOIL/FILL

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SCALE:	1:200 @ A3
DRAWING:	FIGURE 1
DATE:	13/03/2019
APPROVED BY:	TMC
DRAWN BY:	JY
PROJECT:	2019-028
PREPARED FOR:	Roki Mills
ADDRESS:	4 Irrubel Road, Newport

BOREHOLE LOG

CLIENT: Roki Mills **DATE:** 12/03/2019 **BORE No.:** 1

PROJECT: Alterations and Additions **PROJECT No.:** 2019-028 **SHEET:** 1 of 1

LOCATION: 4 Irrubel Road, Newport **SURFACE LEVEL:** RL = 35.30m

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					
0.10	TOPSOIL/FILL: Dark grey, fine to medium grained, dry silty sand				
0.30	Silty CLAY: Very stiff, brown, low plasticity, dry silty clay (Possible fill)				
	Auger refusal at 0.30m depth on very stiff silty clay				
1.00					
2.00					

RIG: NA DRILLER: AC LOGGED: JY

METHOD: Hand Auger

GROUND WATER OBSERVATIONS: No free standing ground water table found

REMARKS: CHECKED:

BOREHOLE LOG

CLIENT: Roki Mills **DATE:** 12/03/2019 **BORE No.:** 2

PROJECT: Alterations and Additions **PROJECT No.:** 2019-028 **SHEET:** 1 of 1

LOCATION: 4 Irrubel Road, Newport **SURFACE LEVEL:** RL = 35.70m

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					
0.10	TOPSOIL/FILL: Dark grey, fine to medium grained, dry silty sand				
0.20	Silty CLAY: Very stiff, brown, low plasticity, dry silty clay (Possible fill)				
	Auger refusal at 0.20m depth on very stiff silty clay				
1.00					
2.00					

RIG: NA DRILLER: AC LOGGED: JY

METHOD: Hand Auger

GROUND WATER OBSERVATIONS: No free standing ground water table found

REMARKS: CHECKED:

BOREHOLE LOG

CLIENT: Roki Mills **DATE:** 12/03/2019 **BORE No.:** 3

PROJECT: Alterations and Additions **PROJECT No.:** 2019-028 **SHEET:** 1 of 1

LOCATION: 4 Irrubel Road, Newport **SURFACE LEVEL:** RL = 32.60m

Depth (m)	Description of Strata PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Sampling		In Situ Testing	
0.00		Type	Depth (m)	Type	Results
	TOPSOIL/FILL: Dark grey, fine to medium grained, dry silty sand				
0.10	Silty CLAY: Very stiff, brown, low plasticity, dry silty clay (Possible fill)				
0.20	Auger refusal at 0.20m depth on very stiff silty clay				
1.00					
2.00					

RIG: NA DRILLER: AC LOGGED: JY

METHOD: Hand Auger

GROUND WATER OBSERVATIONS: No free standing ground water table found

REMARKS: CHECKED:

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Roki Mills **DATE:** 12/03/2019

PROJECT: Alterations and Additions **PROJECT No.:** 2019-028

LOCATION: 4 Irrubel Road, Newport **SHEET:** 1 of 1

	Test Location							
Depth (m)	DCP1	DCP2	DCP3	DCP4				
0.00 - 0.15	1	3	4	4				
0.15 - 0.30	8	8	11	12				
0.30 - 0.45	9	15	16	12				
0.45 - 0.60	16	11	12	14				
0.60 - 0.75	14	13	10	21				
0.75 - 0.90	15	10	16	5 (B) @0.78m				
0.90 - 1.05	4 (B) @0.90m	13	26					
1.05 - 1.20		14 (B) @1.20m	22					
1.20 - 1.35			31					
1.35 - 1.50			28					
1.50 - 1.65								
1.65 - 1.80								
1.80 - 1.95								
1.95 - 2.10								
2.10 - 2.25								
2.25 - 2.40								
2.40 - 2.55								
2.55 - 2.70								
2.70 - 2.85								
2.85 - 3.00								
3.00 - 3.15								
3.15 - 3.30								
3.30 - 3.45								
3.45 - 3.60								
3.60 - 3.75								
3.75 - 3.90								
3.90 - 4.05								

TEST METHOD: AS 1289. F3.2, CONE PENETROMETER

REMARKS:

(B) Test hammer bouncing upon refusal on solid object

-- No test undertaken at this level due to prior excavation of soils

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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 excavation		≤1.50m deep excavation in fill, silty clay	a) Excavation adjacent to the lawn, impact 5% of lawn b) Excavation 2.0m from the boundary, impact 5% of the boundary		a) Person in lawn 1hr/day b) Person in lawn 1hr/day	a) Possible to not evacuate b) Possible to not evacuate	a) Person in open space unlikely buried b) Person in open space unlikely buried	
			Unlikely	Prob. of Impact	Impacted				
		a) Rear lawn within the site	0.0001	0.90	0.05	0.0417	0.5	0.10	**9.38E-09**
		b) West boundary	0.0001	0.10	0.05	0.0417	0.5	0.1	**1.04E-09**

* hazards considered in current condition and/or without remedial/stabilisation measures
* likelihood of occurrence for design life of 100 years
* Spatial Impact - Probabiliy 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 <3m³) of soils from unsupported excavation	a) Rear lawn within the site	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) West boundary	Rare	The event is conceivable but only under exceptional circumstances over the design life.	Minor	Limited Damage to part of structure or site requires some stabilisation or INSIGNIFICANT damage 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%.

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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.

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.