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GEOTECHNICAL REPORT

for

PROPOSED STUDIO WITH CAR PLATFORM

at

20 THE SERPENTINE, BILGOLA BEACH, NSW

Prepared For

Rob Miller

Project No.: 2023-022

February 2023

Document Revision Record

Issue No	Date	Details of Revisions
0	28 February 2023	Original issue

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 ___20 The Serpentine, Bilgola Beach, NSW

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

Geotechnical Report Details:

Report Title: Geotechnical Report for Proposed Studio and Car Platform
Report Date: 28 February 2023 **Project No.:** 2023-022
Author: Kieron Nicholson and Troy Crozier
Author's Company/Organisation: Crozier Geotechnical Consultants

Please mark appropriate box

- ■ Comprehensive site mapping conducted ____15 February 2023___________
- ■ 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 15/2/23 ....
- ■ 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 ...
- ■ 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
AUSTRALIAN INSTITUTE OF GEOSCIENTISTS
TROY CROZIER
10,197

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1 – To be submitted with Development Application

Development Application for______________________________

Name of Applicant

Address of site ___ 20 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*** *28 February* 2023 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 Studio and Car Platform

Report Date: 28 February 2023 **Project No.:** 2023-022

Author: Kieron Nicholson and Troy Crozier

Author's Company/Organisation: Crozier Geotechnical Consultants

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

Architectural Drawings – Gartner Trovato Architects, Project No.: 2236, Drawing No.: A.00 – A.06, Dated: 24/02/2023

Survey Drawing – LTS, Reference No.: 22044 005DT, Dated: 03/11/2020

I am aware that the above Geotechnical Report, prepared for the abovementioned site is to be submitted in support of a Development Application for this site and will be relied on by 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**

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GEOTECHNICAL INVESTIGATION FOR A PROPOSED NEW STUDIO WITH CAR PLATFORM AND DRIVEWAY AT 20 THE SERPENTINE, BILGOLA BEACH, NSW

1. INTRODUCTION:

This report details the results of a geotechnical investigation carried out for a proposed new studio with car platform and driveway at 20 The Serpentine, Bilgola Beach, NSW. The investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the request of the Architects Gartner Trovato on behalf of the client Rob Miller.

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 a detailed Geotechnical Report which meets the requirements of Paragraph 6.5 of that policy is required for submission with the Development Application. The report must include a landslide risk assessment of the site and proposed works, plans, geological sections and provide recommendations for construction and to ensure stability is maintained for a design life of 100 years.

Based on our understanding of the proposed development, Council and project requirements, a Fee Proposal (P21-543, Dated: 15th April 2021) was submitted and subsequently accepted by the client. The field investigation was undertaken in general accordance with the Fee Proposal and comprised:

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

This report contains the results of the nominated scope of works and includes a site description and geological setting, details of investigation methodology, detailed geotechnical/geological field observations, borehole logs, in situ test results, test location plan and a geological cross section.

This report provides recommendations for Council use in assessment of the Development Application and to assist in the preliminary structural design of the development and includes:

- Site specific AGS Risk Assessment
- Assessment of the impacts of the development
- Measures to protect adjacent properties during construction and following completion of the development
- Structural design parameters on new footings, excavations, stability, support measures and drainage
- Construction considerations including recommended plant and equipment, temporary support and excavation methods

The following documents have been supplied and relied on for the work:

- Architectural Drawings – Gartner Trovato Architects, Project No.: 2236, Drawing No.: A.00 – A.06, Dated: 24/02/2023
- Survey Drawing – LTS, Reference No.: 22044 005DT, Dated: 03/11/2020
- Pre-DA Council Meeting Notes – Northern Beaches Council, Application No.: PLM2021/0305, Dated: 09/12/2021

1.1 Proposed Development:

It is understood that the proposed works involve the construction of a new studio located near the front (west) boundary of the site that will require maximum bulk excavation depth of approximately 2.5m within the north corner of the proposed new structure. A new driveway and car platform will be constructed above the studio. It is understood that an existing sandstone retaining wall constructed on the west boundary is to remain and a second wall constructed to the east to support the additional loads.

Excavation for the studio will be approximately 3.5m and 1.0m from the north and west boundaries respectively and greater than 30.0m from the south and east boundaries.

2. SITE FEATURES:

2.1. Site Description:

The site is irregular in shape and covers an area of approximately 1977m^2 in plan as referenced from the provided survey drawing. It is located on the low east side of the road within moderately to steeply east dipping topography and the ground surface elevation varies between a high of RL39.5m within the north corner and a low of RL21.0m near the east corner of the site. It has north, east, south and west boundaries of 60.7m, 40.1m (combined), 34.1m and 50.3m (combined) respectively as determined from the survey plan provided.

The front of the site contains a steeply inclined concrete driveway accessed from The Serpentine easement to the west and a garden area supported by a series of sandstone retaining walls up to approximately 1.0m in height.

The site residence is accessed via the driveway and comprises a two-storey sandstone block and timber structure with rear timber deck, inground pool and rear manicured garden. The rear garden of the site is accessed via flagstone paths to the north and south of the residence.

An aerial view of the site and surrounding properties is provided in Photograph 1, obtained from Google Earth.

Photograph 1: Aerial view of the site (outlined red) and immediate surrounds

The site is bordered to the north, east, south and west by 20A The Serpentine, 10 Allen Avenue, 16 The Serpentine and The Serpentine carriageway and easement respectively.

No.20A is designated an Environmental Conservation area and is largely undeveloped with the exception of an access path and roadway (Allen Avenue) within the south of the property. The property is at a similar level to the site immediately adjacent to the shared boundary and shares similar east dipping topography.

No.10 Allen Avenue contains a two-storey timber dwelling with garden surrounds. The house structure is approximately 60m from the proposed development area and at the base of a cliff.

No.16 The Serpentine contains a two storey brick and timber dwelling with access driveway and front and rear gardens. The house structure is approximately 2.5m from the shared boundary. The property is at a similar level to the site immediately adjacent to the shared boundary and shares similar topography.

The shared boundaries to the east and south of the site are located greater than approximately 30m from the proposed studio development works.

2.2. Geology:

Reference to the Sydney 1:100,000 Geological Series sheet indicates that the site is underlain by Newport Formation (Upper Narrabeen Group) rock 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.

Narrabeen Group rocks are dominated by shales and thin siltstone 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 silty clay soil profiles (medium to high plasticity) with thin silty colluvial cover.
An extract of the relevant geological sheet is provided as Extract 1.

Extract 1: Extract from the Sydney Series 9130 Geology Sheet with the site (outlined and circled red).

3. FIELD WORK:

3.1. Methods:

The field investigation comprised geotechnical inspection/mapping of the site and a subsurface investigation which were both undertaken/supervised by a Senior Engineering Geologist on the 15 February 2023.

The geotechnical mapping comprised a visual inspection of the site and adjacent properties to assess potential geotechnical issues relevant to the proposed development. It involved 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, vegetation and existing structures to assess the stability of the site.

The sub-surface investigation comprised the drilling of two boreholes (BH1 and BH2) using a hand auger to investigate sub-surface geology. A hand auger was used as access to the site for a conventional drilling rig was unavailable.

Soil samples were recovered from the auger for geotechnical logging purposes which was undertaken in accordance with AS1726:2017 ‘Geotechnical Site Investigations’.

DCP testing was carried out from ground surface adjacent to the boreholes and at one additional location 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 depths to bedrock.

Prior to the subsurface investigation, the test locations were cleared of services by an experienced underground service location contractor.

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.

3.2 Ground Conditions:

For a description of the subsurface conditions encountered at the borehole locations, the Borehole Log Report and Dynamic Penetrometer Test Sheet should be consulted, however a very broad description is provided below:

- **Fill/Possible Fill –** Fill/Possible fill was encountered within both boreholes to a maximum depth of 0.80m (BH1). The fill comprised a combination of very loose to loose silty sand and very soft to stiff clays. Localised cobbles were also encountered within BH1.
- **Residual Clay –** Underlying the fill/possible fill, stiff to very stiff silty clay was also encountered below depths of 0.80m (BH1) and 0.65m (BH2) which contained sandstone lithorelicts below 1.20 to 1.50m depth.
- **Bedrock –** What has been interpreted as at least very low strength bedrock was encountered in BH1 and BH2 at depths of 1.90m and 1.40m. It was noticeable that with the exception of DCP3, DCP test refusal was encountered a short distance below stiff to very stiff residual soils, suggesting a limited thickness of extremely weathered bedrock is present underlying some sections of the development. However this thickness may be greater within the vicinity of DCP3.

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.

3.3 Site Stability:

No.20 The Serpentine lies to the east of the carriageway which comprises a gently south dipping asphalt pavement and appears in good condition where it passes the site. Within an embankment located to the west of the The Serpentine and to the east of Barrenjoey Road, a previous failure of the embankment was observed which appears to be in the process of remediation. It is understood the failure occurred within the latter part of 2022 and no additional indications of instability were observed within the embankment (See Photograph 2).

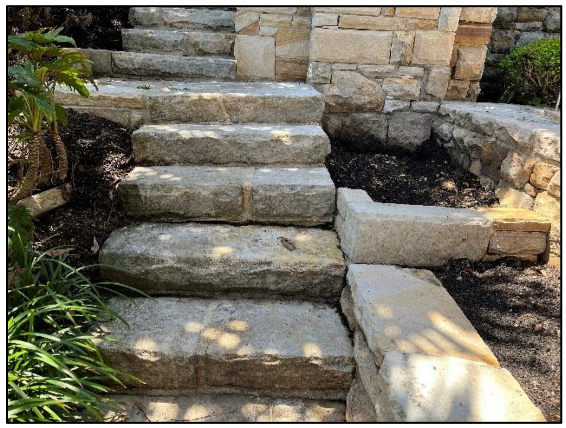
Photograph 2: View of the previous embankment failure to the west of the site

Bedrock outcrops were observed within the roadway cutting to the north of The Serpentine carriageway and comprised low to medium strength siltstone/sandstone and thought to represent deposits of the Newport Formation.

Photograph 3: View of bedrock outcrops to the west of the site

Signs of instability (significant cracking in the pavement/brickwork/render etc.) were not observed within the roadway or within the site residence which appeared to be in very good condition based on inspection of the external walls.

Some minor settlement was observed in a section of external steps and some bulging of the dry stone wall supporting the eastern boundary was observed. (See Photographs 4 and 5). Neither of these features are thought to relate to a deep-seated geotechnical issue and likely a result of settlement of near surface soils or degradation with age.



Photograph 3 and 4: View of slight bulging of the retaining wall supporting the Serpentine easement and minor settlement of steps

Signs of hummocky ground, back scars, tilting trees or any other signs of potential instability were not observed in the property.

The properties to the north and west site (No.20A and The Serpentine carriageway respectively) did not appear to be displaying any signs of distress. The properties to the south and west (No.16 The Serpentine and No.10 Allen Street) are greater than 30.0m from the development works. However, based on limited observations, no signs of instability were observed in either property.

4. COMMENTS:

4.1 Ground Model

Based on the subsurface investigation it is anticipated that the ground conditions underlying the site will comprise an upper layer of fill soils up to approximately 0.80m depth underlain by potentially stiff to very stiff residual clay soils to a maximum depth of 1.90m (BH1) underlain by interpreted very low strength bedrock. It is anticipated that the bedrock may grade to low to medium strength however this is unconfirmed.

A groundwater table is not anticipated in bulk excavation however local groundwater seepages on the competent bedrock surface are anticipated.

4.2. Geotechnical Assessment:

A significant landslip hazard was not identified during the investigation and the risk assessment (see Section 4.3) indicated the risk of landslip hazards are considered ‘Acceptable’.

All new footings will need to be found in/off very low strength (or stronger) bedrock of similar strength to control potential differential movement and limit possible downslope creep movements.

With the exception of the shared boundary to the west (Serpentine easement) it appears all other excavation can be completed using the safe temporary batters provided in Section 4.4. Where the new wall is proposed to the east of the existing stone retaining wall on the west boundary, it will either need to be constructed incrementally or support prior to excavation (e.g. bored pile wall or similar) will be required to be constructed to the west of the excavation. Where incremental construction is undertaken, it is recommended that no section wider than approximately 1.0m is left unsupported below the base of the existing retaining wall.

Based on the proposed excavation and depth to bedrock, significant bedrock excavation is not envisaged however up to 0.6m depth of bedrock may require removal underlying the north end of the studio. It is recommended bedrock excavation if required is undertaken with lightweight (<250kg) rock hammers to avoid potential damage to nearby sensitive services if present.

The properties to the south and west (No.16 The Serpentine and No.10 Allen Street) are greater than 30.0m from the development works and will not be impacted by the development works within the site.
For confirmation of bedrock strength to below borehole/DCP test depths, an investigation utilizing a drill rig to drill additional boreholes should be undertaken however access for such equipment is very limited by site

conditions. As such bedrock strength through the excavation and at footing level can be confirmed by geotechnical inspection during initial excavation/construction works.

If bored pier penetration into bedrock is required for new footings system or structural footing design/surety, it should be noted that the interpreted very low strength bedrock may be significantly stronger and pier installation methods should be capable of penetrating stronger bedrock than very low strength should it be encountered or make an allowance for either doweling into the bedrock.

The recommendations and conclusions in this report are based on an investigation utilising only surface observations and isolated boreholes and DCP testing. 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 subsequent preliminary design of the proposed works.

4.3. Site Specific Risk Assessment:

The site contains a potential landslip hazard relating to the proposed excavation in the event of excavation failure and/or insufficient excavation support methods being used. The hazard is:

A. Landslip (soil slide $2m^3$) of fill/natural soils from excavation works

The hazard has been assessed in accordance with the methods of the Australian Geomechanics Society (Landslide Risk Management, AGS Subcommittee, May 2002 and March 2007), see Tables: A and B, Appendix: 3 The Australian Geomechanics Society Qualitative Risk Analysis Matrix is enclosed in Appendix: 4 along with relevant AGS notes and figures. The frequency of failure was interpreted from existing site conditions and previous experience in these geological units.

Hazard A was assessed as having a potential **Risk to Life of 1.25×10^{-7}** for people in neighbouring properties and **6.00×10^{-7}** for site occupants. The hazard was considered '**Acceptable**' for people in neighbouring properties when assessed against the AGS and Council policy. **Risk to Property** was considered to be 'Very Low'.

Through geotechnical inspections and implementation of any required support measures the assessed risks will further reduce.

4.4. Design & Construction Recommendations:

Preliminary design and construction recommendations are tabulated below:

4.4.1. New Footings:	
Site Classification as per AS2870 – 2011 for new footing design	'P' due to fill/colluvial soils and associated landslip risk.
Type of Footing	Strip/pad or Slab, piers where bedrock is 'deep' and not exposed in the base of the excavation.
Sub-grade material and Maximum Allowable Bearing Capacity	- VLS bedrock: 700kPa - LS bedrock: 1000kPa**
Site sub-soil classification as per *Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia*	B_e – rock site

** Would require additional investigation to confirm where used in design

Remarks:

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.

Individual footings should be founded within/on material of similar bearing and settlement characteristics to reduce the potential for differential settlement.

4.4.2. Excavation

Property Separation:

The table below shows the properties potentially affected by the proposed excavation, excavation depths and the separation distances to the shared property boundary/structure.

Table 1: Property Separation Distances

Boundary	**Property**	**Structure**	**Bulk Excavation Depth (m bgl)**	**Separation Distances (m)***	
				Boundary	**Structure**
North	20A The Serpentine	Studio	2.5	3.5	Not Applicable
East	10 Allen Avenue	Greater than 30.0m from shared boundary			
South	16 The Serpentine	Greater than 30.0m from shared boundary			
West	The Serpentine carriageway/easement	Studio	2.5	1.0	Possible Services
				1.0	4.5 (carriageway)

* Approximate only, subject to site set out.

Type of Material to be Excavated	Sand then clay fill to a maximum of 0.80m depth then residual clay soils to base of excavation, possibly up to 0.6m bedrock in base of north end of excavation.	
Guidelines for un-surcharged batter slopes for this site are tabulated below:		

Material	Safe Batter Slope (H:V)	
	Short Term/Temporary	**Long Term/Permanent**
Fill and natural soils*	1.5:1	2:1

*Potentially variable and dependent on defects and assessment by engineering geologist/geotechnical engineer

Remarks:

Seepage, surface flow and raindrop impacts 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 permanent support measures are installed. This should also be considered with respect to safe working conditions. Batter slopes should not be left unsupported without geotechnical inspection and approval.

Equipment for Excavation	Fill/natural soils	Bucket
VLS – very low strength, LS – low strength, MS – medium strength, HS – high strength		

Recommended Vibration Limits (Maximum Peak Particle Velocity (PPV))	Not required unless rock hammers >250kg proposed for use
Vibration Calibration Tests Required	Not required
Full time vibration Monitoring Required	Not required
Geotechnical Inspection Requirement	For unsupported batter slopes
Dilapidation Surveys Requirement	Not required

4.4.3. Retaining Structures:

Required	New retaining structures will be required as part of the proposed development.
Types	Steel reinforced concrete/concrete block wall post excavation or bored pile wall pre-excavation (west side only) designed in accordance with Australian Standard AS 4678-2002 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)**	
Fill/Natural Soils	18	φ' = 28°	0.35	0.52	N/A

Very low strength bedrock	23	φ' = 35°	0.10	0.15	300kPa

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 utilise active earth pressure coefficients (Ka).

4.4.4. Drainage and Hydrogeology

Groundwater Table or Seepage identified in Investigation		Not encountered during the investigation
Excavation likely to intersect	Water Table	No
	Seepage	Minor likely (≤0.50 L/min), on defects and at within fill and fill/natural clay interface
Site Location and Topography		Low east side of road within moderately and steeply east dipping topography.
Impact of development on local hydrogeology		Negligible
Onsite Stormwater Disposal		Unlikely unsuitable due to clay soils. Existing site stormwater system likely adequate to control additional stormwater volumes subject to assessment by Hydraulics 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 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.

4.5. Conditions Relating to Design and Construction Monitoring:

To comply with Councils conditions and to enable us to complete Forms: 2b and 3 required as part of construction, building and post-construction certificate requirements of the Councils Geotechnical Risk Management Policy 2009, it will be necessary for Crozier Geotechnical Consultants to:

1. Review the structural design drawings for compliance with the recommendations of this report prior to construction,
2. If bedrock exposed in excavation or unexpected ground conditions encountered.
3. Inspect all new footings and earthworks to confirm compliance to design assumptions with respect to allowable bearing pressure prior to the placement of steel or concrete,
4. Inspect completed works to ensure construction activity has not created any new hazards and that all retention and stormwater control systems are completed.

The client and builder should make themselves familiar with the Councils Geotechnical Policy and the requirements spelled out in this report for inspections during the construction phase. Crozier Geotechnical Consultants cannot sign Form: 3 of the Policy if it has not been called to site to undertake the required inspections.

4.6. Design Life of Structure:

We have interpreted the design life requirements specified within Council's Risk Management Policy to refer to structural elements designed to support the existing structures, 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 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.

5. CONCLUSION:

The investigation identified that the proposed excavation is expected to intersect minor fill to a maximum of 0.8m depth then stiff to very stiff residual soils a maximum of 1.9m depth. Minor (approximately 0.60m maximum thickness) of bedrock may require removal underlying the north corner of the studio. Significant groundwater is not anticipated.

Based on the results of the sub-surface investigation, safe batter slopes appear achievable for the proposed excavation for the new retaining walls under the proposed studio with the exception of the west side of the excavation where either incremental or bored pier construction of a second retaining wall will be necessary to avoid undermining the existing dry stone retaining wall on the boundary.

Excavation is unlikely to encounter significant thicknesses of competent bedrock and rock excavation or vibration monitoring requirement is not envisaged unless 'heavy' hammers proposed for use.

There were no geotechnical issues identified which are likely to result in adverse impacts on neighbouring properties provided the recommendations of this report are followed. It is considered that the site and proposed works are suitable and can meet the acceptable risk management criteria for the design life of development taken as 100 years.

The recommendations and conclusions in this report are based on a site walkover and the results of a subsurface investigation and will require confirmation during excavation. However, the results of the investigation provide a reasonable basis for the Development Application and preliminary design.

Prepared by:
Kieron Nicholson
Senior Engineering Geologist

Reviewed by:
Troy Crozier
Principal
MIEAust., MAIG, RPGeo
Registration No.: 10197

6. REFERENCES:

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3. E. Hoek & J.W. Bray 1981, "Rock Slope Engineering" By The Institution of Mining and Metallurgy, London.
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Appendix 1

CROZIER GEOTECHNICAL CONSULTANTS

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Brookvale NSW 2100 Email: info@croziergeotech.com.au
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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

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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

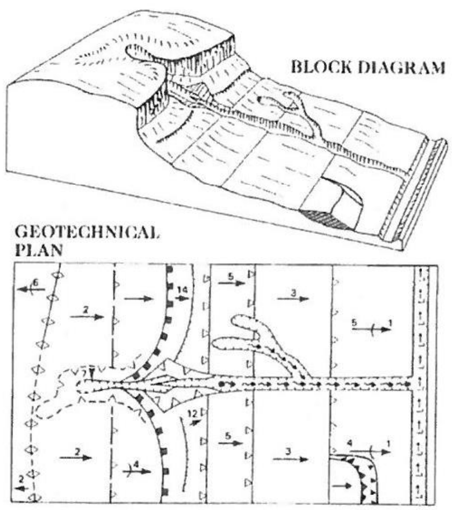
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some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

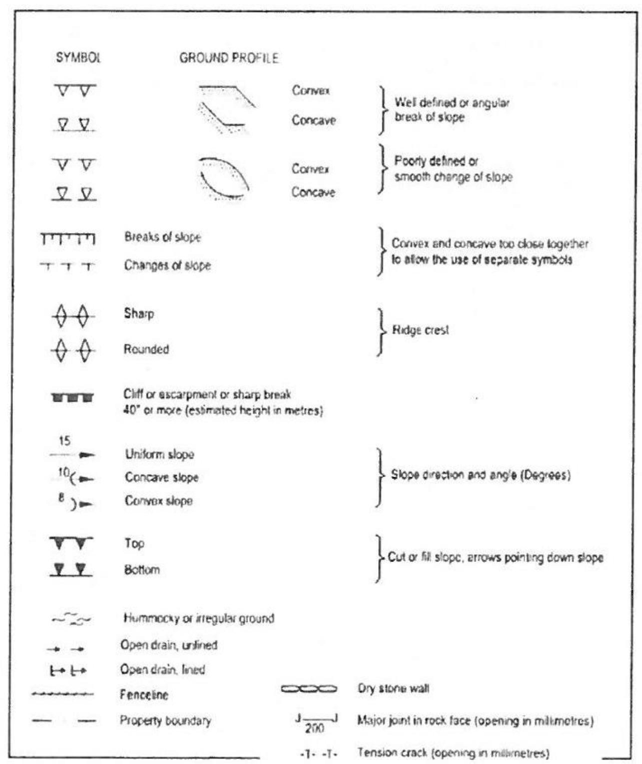
Reproduction of Information for Contractual Purposes

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

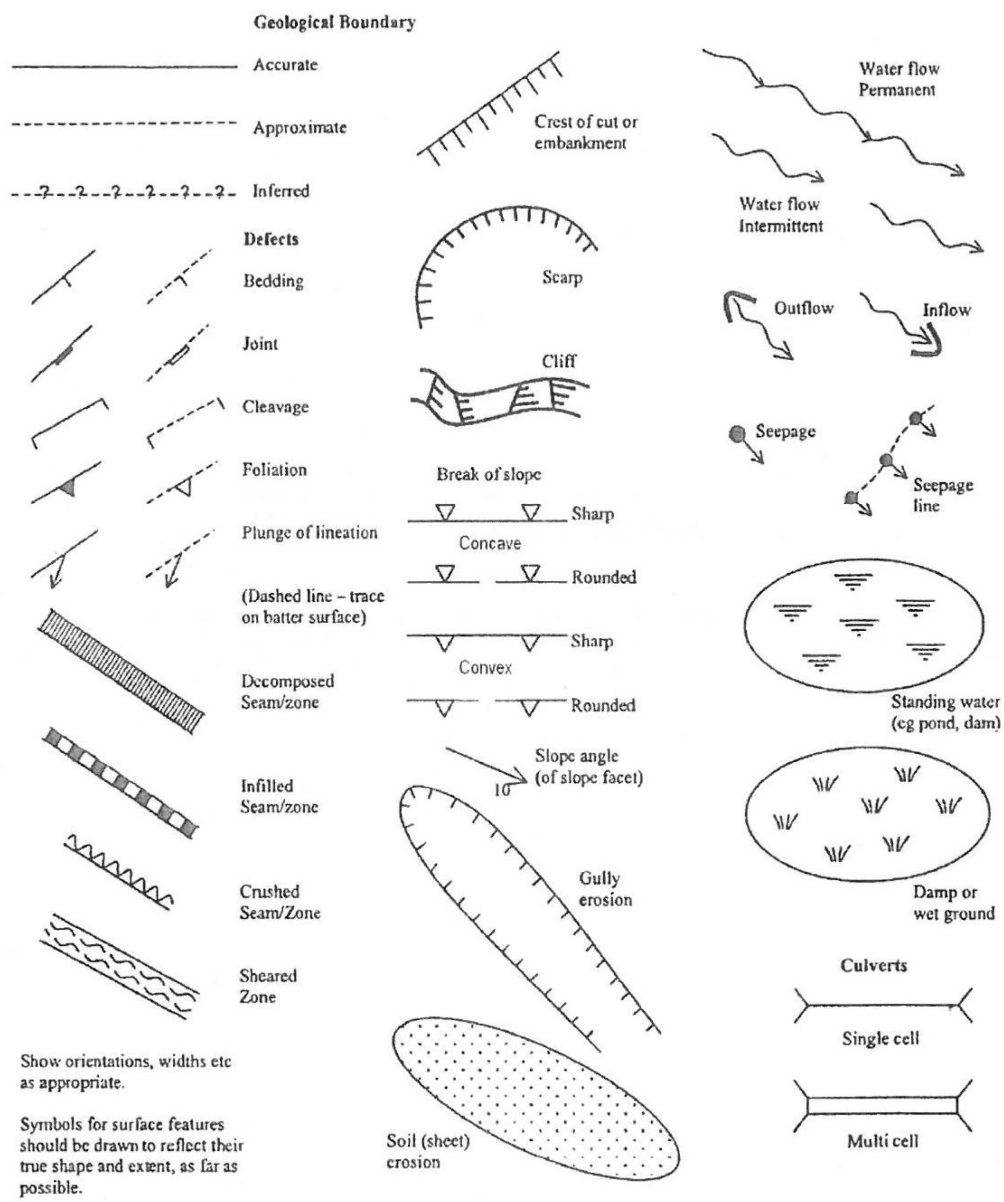
The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.





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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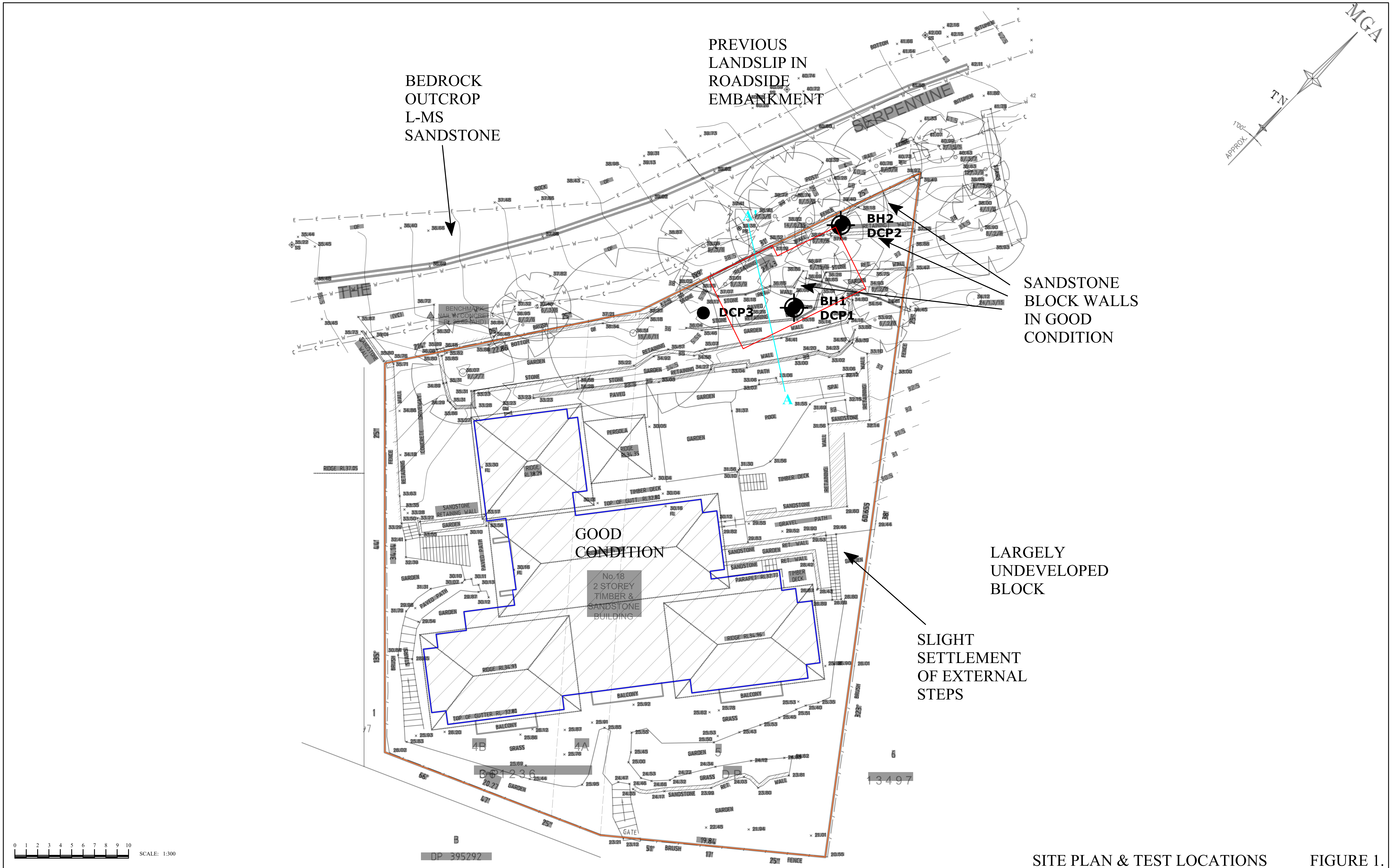
Appendix 2



SITE PLAN & TEST LOCATIONS FIGURE 1.

CROZIER GEOTECHNICAL CONSULTANTS

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

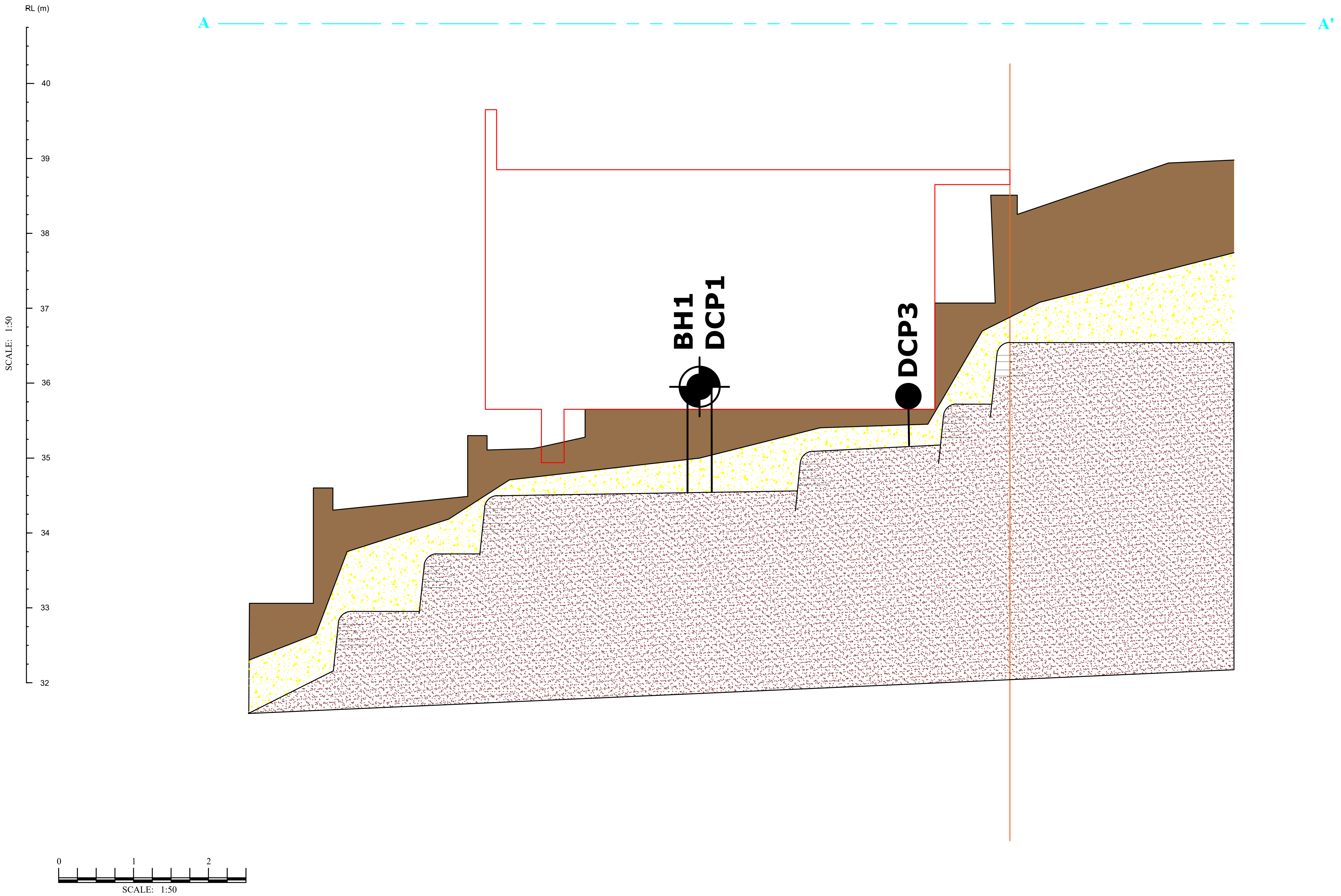
LEGEND

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

SCALE:	1:300 @ A3
DRAWING:	FIGURE 1
DATE:	02 /2023
APPROVED BY:	TMC
DRAWN BY:	JD
PROJECT:	2023-022

PREPARED FOR:
Rob Miller

ADDRESS:
20 The Serpentine, Bilgola Beach



SITE SECTION

FIGURE 2.

LEGEND

BH DCP AUGER / DYNAMIC CONE PENETROMETER LOCATION

PROPOSED WORKS

PROPERTY BOUNDARY

SANDSTONE BEDROCK

RESIDUAL SOILS

FILL

A —— A' SECTION LINE

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Phone: (02) 9939 1882
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SCALE:	1:50 @ A3
DRAWING:	FIGURE 2
DATE:	02/2023
APPROVED BY:	TMC
DRAWN BY:	JD
PROJECT:	2023-022

PREPARED FOR:
Rob Miller

ADDRESS:
20 The Serpentine, Bilgola Beach

BOREHOLE LOG

CLIENT: Rob Miller | **DATE:** 15/02/2023 | **BORE No.:** 1

PROJECT: New Studio with Car Platform and New Driveway | **PROJECT No.:** 2023-022 | **SHEET:** 1 of 1

LOCATION: 20 The Serpentine, Bilgola Beach | **SURFACE LEVEL:** RL 36.1m

Depth (m)	Classification	Description of Strata PRIMARY SOIL - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
0.00		FILL: Brown silty sand, fine grained, trace gravel, decaying roots/ bark, moist				
0.25		… cobbles of sandstone at 0.25m depth				
0.35		… clayey below 0.35m depth				
0.40		… brown clay, trace coarse grained sub-angular gravel of sandstone, trace fine grained sand, moist				
0.80	CI	Silty CLAY: Stiff, brown, trace fine grained sand, moist (Residual Deposit)				
1.10		… brown mottled orange				
1.20		… orange-brown				
1.50		… trace red-brown medium grained sub-angular gravel of sandstone (lithorelicts)				
1.90		Hand Auger Refusal at 1.9m depth on interpreted bedrock of very low strength or stronger				

RIG: Not Applicable

METHOD: Hand Auger

GROUND WATER OBSERVATIONS: Not Encountered

REMARKS:

DRILLER: SD

LOGGED: KN

CHECKED: KN

BOREHOLE LOG

CLIENT: Rob Miller
DATE: 15/02/2023
BORE No.: 2

PROJECT: New Studio with Car Platform and New Driveway
PROJECT No.: 2023-022
SHEET: 1 of 1

LOCATION: 20 The Serpentine, Bilgola Beach
SURFACE LEVEL: RL 38.0m

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
0.00		FILL: Brown silty sand, trace gravels, rootlets (Topsoil)				
0.20		… brown clay, trace fine grained sand (Possible Fill)				
0.65	CI	Silty CLAY: Stiff, brown, trace fine grained sand (Residual Deposit)				
1.00		… orange-brown				
1.20		… very stiff, mottled red, trace sandstone gravels (lithorelicts)				
1.40		… zones of white/grey clay				
		Hand Auger Refusal at 1.40m on interpreted very low strength bedrock or stronger				

RIG: Not Applicable
DRILLER: SD

METHOD: Hand Auger
LOGGED: KN

GROUND WATER OBSERVATIONS: Not Encountered

REMARKS:
CHECKED: KN

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Rob Miller | **DATE:** 15/02/2023

PROJECT: New Studio with Car Platform and New Driveway | **PROJECT No.:** 2023-022

LOCATION: 20 The Serpentine, Bilgola Beach | **SHEET:** 1 of 1

	Test Location									
Depth (m)	1	2	3							
0.00 - 0.10	0	0	1							
0.10 - 0.20	1	0	1							
0.20 - 0.30	1	3	1							
0.30 - 0.40	0	4	2							
0.40 - 0.50	1	4	4							
0.50 - 0.60	1	4	4							
0.60 - 0.70	1	3	3							
0.70 - 0.80	2	3	4							
0.80 - 0.90	5	4	4							
0.90 - 1.00	4	3	13							
1.00 - 1.10	4	4	22							
1.10 - 1.20	5	5	30							
1.20 - 1.30	5	8	END @ 1.2m							
1.30 - 1.40	5	7								
1.40 - 1.50	5	16 (B) @ 1.45m								
1.50 - 1.60	5									
1.60 - 1.70	4									
1.70 - 1.80	5									
1.80 - 1.90	19									
1.90 - 2.00	(B) @ 1.9m									
2.00 - 2.10										
2.10 - 2.20										
2.20 - 2.30										
2.30 - 2.40										
2.40 - 2.50										
2.50 - 2.60										
2.60 - 2.70										
2.70 - 2.80										
2.80 - 2.90										
2.90 - 3.00										
3.00 - 3.10										
3.10 - 3.20										
3.20 - 3.30										
3.30 - 3.40										
3.40 - 3.50										
3.50 - 3.60										
3.60 - 3.70										
3.70 - 3.80										
3.80 - 3.90										
3.90 - 4.00										

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) from soils within 2.5m deep studio excavation		Appears aproximately 3.0m of fill/colluvium/natural soils present near proposed retaining walls	a) May impact edge of carriageway, vehicle travelling at 50km's, 200 vehicles per day b) May impact 1% of easement c) May impact 30% of studio		a) Vehicle on road b) Person on easement 1.0 hr per/day avge. c) Person in Studio 4.0 hr per/day avge.	a) Possible to not evacuate b) Possible to not evacuate c) Possible to not evacuate	a) Person in car unlikely engulfed b) Person in open possibly engulfed c) Person in building, minor damage to building only	
			Possible	**Prob. of Impact**	**Impacted**				
		a) The Serpentine carriageway	0.001	0.05	0.01	1.0	0.5	0.5	**1.25E-07**
		b) The Serpentine easement	0.001	0.20	0.01	0.042	0.5	1.0	**4.17E-08**
		c) Person in studio	0.001	0.20	0.36	0.167	0.5	0.1	**6.00E-07**

* hazards considered in current condition and/or without remedial/stabilisation measures or poor support systems
* likelihood of occurrence for design life of 100 years
* Spatial Impact - Probaility of Impact refers to slide impacting structure/area expressed as a % (i.e. 1.00 = 100% probability of slide impacting area if slide occurs).
Impacted refers to expected % of area/structure damaged if slide impacts (i.e. small, slow earth slide will damage small portion of house structure such as 1 bedroom (5%), where as large boulder roll may damage/destroy >50%)
* neighbouring houses considered for impact of slide to bedroom unless specified, due to high occupancy and lower potential for evacuation.
* considered for person most at risk, where multiple people occupy area then increased risk levels
* for excavation induced landslip then considered for adjacent premises/buildings founded off 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 knowing 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) from soils within 2.5m deep studio excavation	a) The Serpentine carriageway	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damageor no impact to neighbouring properties, no significant stabilising required .	Very Low
		b) The Serpentine easement	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damageor no impact to neighbouring properties, no significant stabilising required .	Very Low
		c) Person in studio	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damageor no impact to neighbouring properties, no significant stabilising required .	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%.
* Cost of site development estimated at $5,000,000

TABLE: 2

Recommended Maintenance and Inspection Program

Structure	Maintenance/ Inspection Item	Frequency
Stormwater drains.	Owner to inspect to ensure that the open drains, and pipes are free of debris & sediment build-up. Clear surface grates and litter. Owner to check and flush retaining wall drainage pipes/systems	Every year or following each major rainfall event. Every 7 years or where dampness/moisture
Retaining Walls. or remedial measures	Owner to inspect walls for deveation from as constructed condition and repair/replace. Replace non engineered rock/timber walls prior to collapse	Every two years or following major rainfall event. As soon as practicable
Large Trees on or adjacent to site	Arborist to check condition of trees and remove as required. Where tree within steep slopes (>18°) or adjacent to structures requires geotechincal inspection prior to removal	Every five years
Slope Stability	Geotechnical Engineering Consultant to check on site stability and maintenance	Five years 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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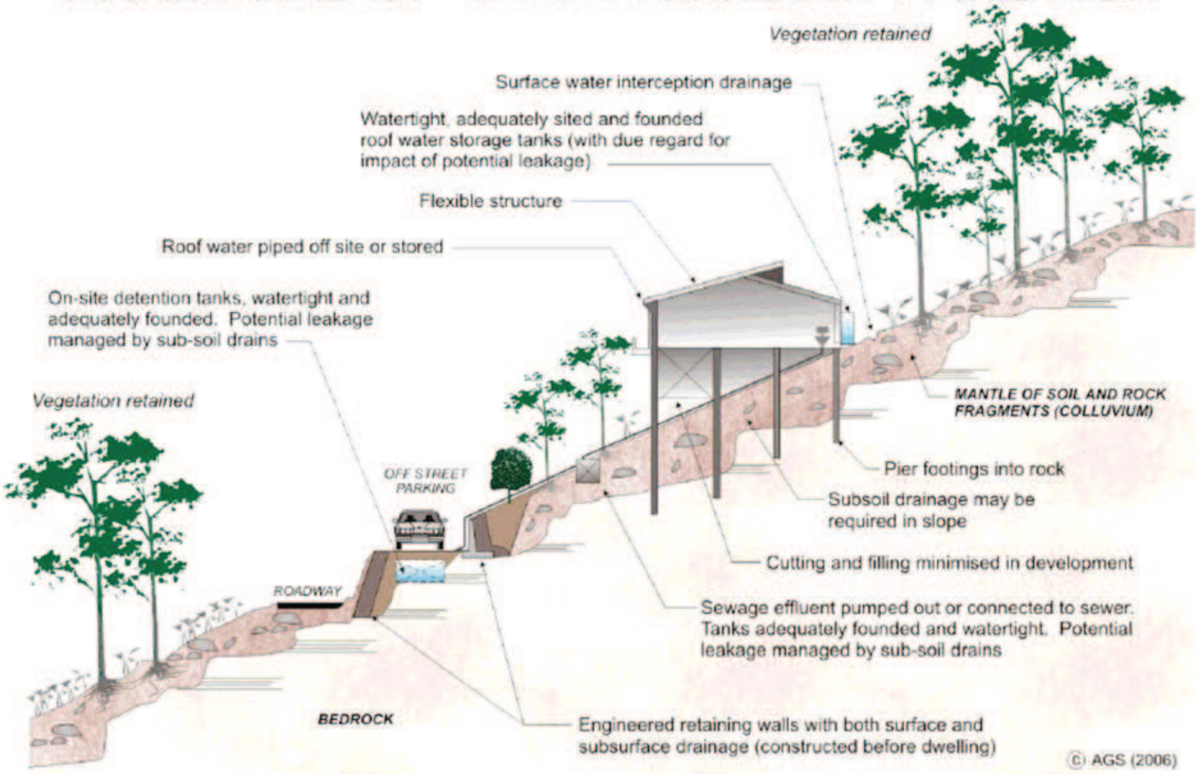
Appendix 5

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



EXAMPLES OF POOR HILLSIDE PRACTICE