GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1 – To be submitted with Development Application

Development Application for____	
	Name of Applicant
Address of site	249 Barrenjoey 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 __26 August 2025__ certify that I am a engineering geologist as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above company to issue this document and to certify that the 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 Construction of New External Staircase and Bin Storage Area

Report Date: 26 August 2025 **Project No.:** 2025-139

Author: S. Bohara and T. Crozier

Author's Company/Organisation: Crozier Geotechnical Consultants

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

Architectural: Nikki Mote Architect, Project No.: 2409, Drawing No.: AR DA 0 -00, 1-00 – 02, 2-00 – 01, 4-00 – 01, Dated: 11/02/2025
Survey: CMS Surveyors Pty Ltd, Drawing No.: 23823A, Dated: 14/01/2025

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

Signature …

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

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

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

Company… **Crozier Geotechnical Consultants**

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

Development Application for____
Name of Applicant
Address of site ___249 Barrenjoey 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 Construction of New External Staircase and Bin Storage Area

Report Date: 26 August 2025 **Project No.:** 2025-139

Author: S. Bohara and T. Crozier

Author's Company/Organisation: Crozier Geotechnical Consultants

Please mark appropriate box

- ■ Comprehensive site mapping conducted ___26.08.2025_________ (date)
- ■ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
- ■ Subsurface investigation required
  - □ No Justification …………………………………………………...
  - ■ Yes Date conducted ……Preliminary conducted 26.08.2025………………
- ■ 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**

CROZIER
GEOTECHNICAL CONSULTANTS

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

REPORT ON GEOTECHNICAL SITE INVESTIGATION

for

CONSTRUCTION OF NEW EXTERNAL STAIRCASE AND BIN STORAGE AREA

at

249 BARRENJOEY ROAD, NEWPORT, NSW

Prepared For

Strata Plan No. 20

Project No.: 2025-139
August, 2025

Document Revision Record

Issue No	**Date**	**Details of Revisions**
0	26 August 2025	Original issue

TABLE OF CONTENTS

APPENDICES

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

Date: 26th August 2025
Project No: 2025-139

GEOTECHNICAL REPORT FOR PROPOSED CONSTRUCTION OF NEW EXTERNAL STAIRCASE AND BIN STORAGE AREA 249 BARRENJOEY ROAD, NEWPORT, NSW

1. INTRODUCTION:

This report details the results of a geotechnical investigation carried out for a proposed new external staircase and bin storage area at 249 Barrenjoey Road, Newport, NSW. The investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the written request of Strata Revolution on behalf of the client Strata Plan No. 20.

The proposed works involve alterations and additions to the southeastern portion of the site which will involve construction of new external stairs and a bin storage area. The bin storage area will intersect the sloping terrain of the site requiring demolition of an existing retaining wall and bulk excavation to approximately 2.5m depth.

It is understood that a Development Application (DA2025/0860) for the proposed works have been submitted to Northern Beaches Council, with a Request For Information (RFI) provided in response, as per Section 1 of the RFI;

> ***Geotechnical Investigation***
> *Council's Development Engineer has requested the following additional information:*
> *As the proposed excavations are greater than 1.5m deep, a geotechnical report with completed forms No. 1 and No. 1(a) in accordance with Council's 'Geotechnical Risk Management Policy for Pittwater' shall be submitted to Council supporting the proposal.*

The assessment and reporting were undertaken as per the Fee Proposal No.: P25-360, Dated: 14th August 2025. The investigation comprised:

a) Before You Dig Australia (BYDA) plan review and onsite clearance of test locations by an accredited service locating sub-contractor.
b) A detailed geotechnical inspection and mapping of the site and inspection of adjacent properties, with identification of geotechnical conditions and hazards related to the existing site and proposed works by a Geotechnical Engineer.

c) Drilling of two auger boreholes to identify sub-surface geology using a restricted access drill rig employing solid flight augers and hand tools due to site access limitation.
d) Dynamic Penetrometer (DCP) testing at three locations to investigate subsurface conditions and confirm depth to bedrock.
e) Soil sample collection and logging as per "AS1726: 2017 Geotechnical Site Investigation"

The following documents, plans and drawings were supplied and were relied on for the proposal, investigation and reporting:

- Survey Drawing – CMS Surveyors Pty Ltd, Drawing No.: 23823A, Dated: 14/01/2025
- Architectural Drawings – Nikki Mote Architect, Project No.: 2409, Drawing No.: AR DA 0 -00, 1-00 – 02, 2-00 – 01, 4-00 – 01, Dated: 11/02/2025.

2. PROPOSED WORKS

The proposed works involve the construction of a new bin storage area and associated external stairs in the southeastern portion of the site. This will require bulk excavation to a maximum depth of approximately 2.50 m, necessitating demolition of the existing retaining wall in this location. It is understood that the floor finish level will be at RL38.50.

A new concrete driveway is also proposed on the north side of the proposed bin storage and external stairs with similar finish level of RL38.50.

The proposed excavation will be set back approximately 16.0 m from the northern boundary shared with No. 251 Barrenjoey Road, with the nearest structure positioned an additional 1.43 m beyond the boundary. Ground levels at No. 251 Barrenjoey Road sit approximately 2.30 m lower than the subject site in this area.

To the south, the excavation will be located approximately 12.5 m from the boundary along Beaconsfield Street, where a nature strip is positioned directly adjacent to the boundary and the road pavement lies a further 6.0 m away.

The excavation will be set back approximately 27.0 m from the western boundary shared with No. 8 Beaconsfield Street, with the closest structure situated an additional 6.0 m beyond the boundary.

On the eastern side, the excavation will be located approximately 2.0 m from the boundary with Barrenjoey Road, where a nature strip lies directly adjacent and the road pavement is positioned a further 6.0 m away.

3. SITE FEATURES:

3.1. Description:

The site (249 Barrenjoey Road, Newport, SP20) is an irregular quadrilateral shaped block situated at the corner of Barrenjoey Road and Beaconsfield Street, within gentle (≈7°) northwest dipping topography. The lot is located near the upper portion of a slope, rising further eastward towards a prominent ridgeline. The surrounding terrain to the west and northwest gradually descends toward a lower-lying basin, while to the east and southeast, the landform rises steeply toward Bungan Head, forming a well-defined hill. The survey indicates ground surface levels within the site vary from a high of RL42.48 along the southeastern corner to a low of RL37.48 at the central section of the northern boundary.

From the provided plans, the site has a west boundary of 37.575m, a north boundary of 42.645m, a south side boundary of 35.45m and a east boundary of 22.235m. An aerial photograph of the site and its surrounds is provided in Photograph 1, as sourced from NSW Government Six Maps Spatial Data.

Photograph 1: Aerial view of site and surrounds (NSW Government Six Map Spatial Data)

3.2. Geology:

Reference to the Sydney 1: 100,000 Geological Series sheet (9130) indicates that the site is underlain by weathered bedrock of the Newport Formation (Upper Narrabeen Group) rock (Rnn) which is of middle Triassic Age shown in Extract-1 below. The Newport Formation typically comprises interbedded laminite, shale and quartz to lithic quartz sandstones and pink clay pellet sandstones and tends to weather to significant depth.

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 of interbedded shale and siltstone/sandstone beds with close spaced bedding partings that have either close spaced vertical joints or in extreme cases large space convex joints.

Also, to the southeast Hawksbury Sandstone (Rh) is located.

An extract from the Sydney 1:100,000 Geological Series sheet 9130 provided below (Extract 1) indicates the geology underlying the site and surrounding area.

Extract 1: Sydney (9130 Geology Series Map): 1:100,000 – Geology underlying the site

4. FIELD WORK:

4.1. Methods:

The field investigation comprised a geotechnical inspection, mapping of the site and adjacent properties on 13th August 2025 by a Geotechnical Engineer. It included a photographic record of site conditions as well as geological/geomorphological mapping of the site and adjacent land with examination of existing features and ground conditions.

The subsurface investigation included the drilling of two auger boreholes (BH1 & BH2) within the southeast grassy area of the site to investigate the sub-surface geology using a restricted access drill rig employing solid stem, spiral flight augers and hand tools due to access limitation.

Geotechnical logging of the subsurface conditions was undertaken by a Geotechnical Engineer by inspection of disturbed soil recovered from the augers. Logging was undertaken in accordance with AS1726:2017 'Geotechnical Site Investigations'.

Dynamic Cone Penetrometer (DCP) testing at two locations was carried out from the ground surface adjacent to the boreholes and an additional one 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.

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

4.2. Field Observations:

Barrenjoey Road and Beaconsfield Street are both formed with a bituminous sealed pavement that is gentle northeast dipping for Barrenjoey Road and northwest dipping for Beaconsfield Street. Barrenjoey Road is separated from the site by a concrete kerb, concrete walkway as well as a nature strip with several trees and a retaining wall on the boundary. In the nature strip is a fibre optics junction which lies in close proximity with the boundary retaining wall. Beaconsfield Street is separated from the site by a concrete kerb, concrete walkway with a bus shelter and nature strip with a tree. The Beaconsfield roadway showed some signs of cracking and deterioration but both roadways did not exhibit any obvious signs of significant cracking or excessive settlement to indicate any underlying geotechnical concerns that may impact the site.

The front east portion of the site along Barrenjoey Road consists of a concrete driveway at the north-east corner providing vehicular access to the garage at the ground floor level of the building. The driveway transitions into concrete wheel strips, with a small garden area located to the southeast (Photograph 2). South of the driveway is a concrete pedestrian ramp that previously provided access to the dwelling but is now closed off. East of the ramp is an elevated grassed area retained by a brick masonry retaining wall approximately 1.40 m high. This retaining wall exhibits notable rotation and a vertical crack of approximately 85 mm in width (Photograph 5). The retaining wall south of the concrete strips shows minor cracking but no evidence of significant structural distress or excessive settlement. East of the grassed area, a boundary retaining wall supporting the Barrenjoey Road reserve extends to a maximum height of approximately 2.50 m and displays signs of ladder cracking and rotation; it also appears to have been previously bolted and underpinned (Photograph 4). Located to the rear (south) of the grassed area is a stormwater tank and several mature trees.

Photograph 2: View of existing elevated grassy area, facing southwest

The south section of the site along Beaconsfield Street consists of a landscaped verge area behind the boundary, with gardens, lawn, and several mature trees. The boundary is generally defined by a combination of low retaining walls and garden edging. This portion of the site falls gently from the southwest towards the northeast and connects to the central paved and landscaped courtyard area within the property.

The interior portion of the site is dominated by a three-storey brick and clad apartment building with basement parking. Based on the historical imagery, it appears to be approximately 65 years old. During the site inspection, the main structure did not exhibit any obvious signs of significant cracking or excessive settlement to indicate any underlying geotechnical concerns that may impact the site.

Surrounding the structure are concrete paved areas, landscaped gardens, and retaining walls of varying heights.

Photograph 3: View of No. 249 Barrenjoey Road, facing west from Barrenjoey Road.

Photograph 4: View of the ladder cracks on the boundary wall, facing east

Photograph 5: View of the retaining wall showing signs of rotation and significant cracking, facing south

Photograph 6: View of the fibre optics junction along the east boundary, facing east

The neighbouring property to the north (No. 251 Barrenjoey Road) contains a two-storey clad residential building situated approximately 2.30 m below the finished ground level of the subject site. The main structure is positioned approximately 1.43 m from the shared boundary. The frontage of the property comprises concrete driveway leading into the property, paved area, retaining wall along the boundary, and vegetation. Ground levels along the shared boundary are noticeably lower than those of the subject site, with the transition supported by retaining structures. The visible portions of the building appeared in good condition at the time of inspection, with no observable signs of cracking, rotation, or differential settlement indicative of geotechnical instability.

The neighbouring property to the west (No. 8 Beaconsfield Street) contains a one to two storey brick masonry structure, located approximately 6.0 m from the site boundary and separated from the site by a concrete driveway of a different property. The frontage includes landscaped gardens with trees and concrete driveway leading to the structure. Ground surface levels in this area appear lower than those of the subject site. Visual inspection of the observable sections of the building and external retaining structures revealed no evidence of significant cracking or settlement that would suggest underlying geotechnical issues.

4.3. Ground Conditions:

Two boreholes (BH1 & BH2) were undertaken within the east grassed portion of the site in the envelope of proposed works. The boreholes advanced through an initial layer of topsoil/fill underlain by silty sandy clay interpreted as residual material. Drilling was terminated at a maximum depth of 1.65 m due to refusal on hard clay at BH2 and on interpreted at least low strength sandstone bedrock at BH1.

Dynamic Cone Penetrometer (DCP) tests were undertaken from the ground surface adjacent to the borehole locations and an additional one location with bounce refusal on interpreted bedrock of probable very low strength encountered at a minimum depth of 0.85m (DCP1), with the exception of DCP3, which terminated due to practical refusal in interpreted extremely weathered material.

For a description of the ground conditions encountered at the individual borehole/DCP test locations, the Borehole Log and DCP results sheets should be consulted however the subsurface conditions at the site can be summarised as follows:

- **TOPSOIL/FILL** – This layer was encountered in all boreholes from ground surface level extending to a maximum depth of 0.80m (BH2) and generally comprised a low to medium plasticity, dark grey sandy clay and consisting of trace rootlets.
- **Silty Sandy CLAY –** This stratum was encountered beneath the fill in BH2 from a depth of approximately 0.80 m and is interpreted as residual soil. It comprises firm, moist, dark orange to red clay of medium plasticity, grading to very stiff orange/red clay mottled grey from about 1.0 m depth. Below this, the material transitions to grey clay mottled orange/red with sandstone gravels, occasional rootlets, and a dry to moist moisture condition. At around 1.40 m depth, a distinct sandstone gravel band was observed. Drilling terminated upon encountering hard clay at refusal.
- **Sandy CLAY –** This unit was encountered in BH1 beneath the topsoil from approximately 0.20 m depth and is interpreted as residual soil. The upper portion comprises very soft, moist clay of low to medium plasticity, orange/red mottled grey in colour. From about 0.70 m depth, the material grades to stiff, dry to moist, crumbled **extremely weathered** material, with trace gravel and occasional rootlets noted from around 1.0 m. The consistency increases to very stiff at 0.80 m, with moisture conditions changing to moist at 1.20 m and then dry to moist at 1.30 m. This material persisted to the base of the borehole.
- **SANDSTONE**– Interpreted bedrock of at least low strength was encountered in BH1 at a depth of approximately 1.45 m. In DCP soundings, refusal indicating bedrock was recorded at depths ranging from 0.85 m (DCP1) to 2.03 m (DCP3). The presence of bedrock was inferred from refusal conditions during drilling and penetration testing.

A free-standing groundwater table or significant seepage was not encountered in any of the boreholes.

5. COMMENTS:

5.1. Geotechnical Assessment:

The site investigation identified a topsoil/fill layer in all boreholes, extending from the surface to depths of up to 0.80 m (BH2) and generally comprising low to medium plasticity dark grey sandy clay with trace rootlets. Beneath this, residual soils were encountered, including silty sandy clay in BH2 from 0.80 m depth and sandy clay in BH1 from 0.20 m depth. These residual soils displayed variable strength, plasticity, and moisture conditions, ranging from very soft to very stiff, with localised sandstone gravel bands and trace rootlets noted. Interpreted sandstone bedrock of at least low strength was encountered in BH1 at 1.45 m depth, with DCP refusal depths indicating at least extremely weathered material/bedrock levels between 0.85 m (DCP1) and 2.03 m (DCP3).

A groundwater table was not encountered to the base investigation level; however, seepage is expected across the bedrock surface as well as along defects in the bedrock mass.

The proposed works includes construction of new external stairs and a bin storage area. The bin storage area will be cut into the sloping ground, necessitating demolition of the existing retaining wall and bulk excavation to an approximate depth of 2.50 m.

Based on investigation results and expected geological conditions safe batter slopes as per Section 5.2.2 of this report do not appear to be achievable in any parts of the excavation, therefore pre-excavation support systems will be required. These systems should comprise a soldier bored pile support wall, founded into the bedrock, with shotcrete lining applied to the pile face for excavation support. Preliminary design parameters are provided in Section 5.2.3.

The existing building is located approximately 1.70 m from the proposed excavation and therefore lies within the anticipated zone of influence. A footing inspection is recommended to assess whether underpinning will be required to maintain stability during and after excavation. In addition, caution should be exercised during demolition of the existing concrete ramp, as it is structurally connected to the building.

Along the eastern boundary, the local stormwater pit line is situated approximately 1.8 m from the proposed excavation and lies within the anticipated zone of influence. The underpinned boundary retaining wall is also located within this zone, along with a fibre optics junction positioned to the east of the boundary. These elements should be carefully considered during excavation planning to avoid damage and ensure stability and are hazards that define a requirement for pre-excavation support. It is recommended that appropriate protective measures be implemented, including physical barriers, vibration control, and monitoring of ground movements. Any excavation works in proximity to the retaining wall or fibre optics infrastructure should be carried out under close supervision, with immediate corrective action taken if signs of distress are observed.

Towards the rear (south) of the site, a retention pit and several mature trees are located within the anticipated zone of influence of the proposed works. It is recommended that these features be protected during excavation activities by establishing exclusion zones, minimising ground disturbance in their vicinity, and implementing appropriate shoring or support measures where required. Tree protection should comply with relevant guidelines to preserve root structures, while the retention pit should be monitored for any signs of movement or distress throughout the construction process.

Fill, natural soils and very low strength bedrock can be excavated using conventional earthmoving equipment (e.g. buckets and rippers) whilst low strength siltstone can be excavated by heavy ripping, however low to medium strength sandstone bedrock will require the use of the rock breaking equipment (e.g. rock hammers). The use of rock hammers can create ground vibrations which could damage the adjacent structures if unsuitable sizes and methods are used. Care will be required during the demolition and excavation, and construction works to ensure the neighbouring properties and potential structures/services are not adversely impacted by ground vibrations. However, due to the apparent strength of the bedrock and small volume required to be excavated this is not anticipated unless very large(>1000kg) rock hammers are used on this site.

Small scale equipment (i.e. rock hammer <300kg) along with rock saw and a good excavation methodology can be used to maintain low vibration levels at boundaries and avoid the need for full time vibration monitoring. As such Crozier Geotechnical Consultants (CGC) should be consulted regarding the size and type of excavation equipment proposed and excavation methodology prior to works.

Where medium strength bedrock with no poorly oriented defects is identified, it will likely be free standing and can be excavated near vertically without the need for additional support measures. Where defects are encountered additional support may be required (i.e. rock bolts) to maintain stability. While cored boreholes are not considered critical for this relatively small-scale excavation, they may be beneficial if a higher level of confidence in subsurface conditions is desired. Otherwise, excavation may proceed with an allowance for interpretation based on available data and regular geotechnical inspection.

The proposed excavation is anticipated to intersect bedrock across its majority at foundation level; therefore, its entire base should be founded to bedrock of similar strength to avoid differential settlement.

Voids adjacent to the proposed bins storage area, particularly at the existing concrete ramp area at the west of the excavation, should be backfilled with granular material, preferably clean crushed sandstone, placed in controlled layers. This material is recommended for its favourable drainage characteristics and compaction properties, which are essential for limiting long-term settlement and maintaining ground stability in the vicinity of the retaining wall and proposed structure.

To achieve uniform density and structural performance of the backfill, a plate compactor should be used during placement. Proper compaction is critical to reduce the potential for post-construction ground movement and to ensure the backfill provides sufficient lateral support to the retaining wall.

Based on the site investigation, a groundwater table is not anticipated within the proposed excavation however, minor seepage is likely to be encountered during the excavation principally at the bedrock surface and on defects in the rock. Initial investigation results indicate this can be managed as a drained excavation system with negligible impact on local hydrogeology.

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 a limited scope of investigation using auguring techniques only. This investigation provides limited data from small, isolated test points across the entire site with limited penetration into rock, therefore some minor variation to the interpreted sub-surface conditions is possible, especially between test locations. However, the results of the investigation provide a reasonable basis for the Development Application assessment and subsequent initial design of the proposed works.

5.2. Site Specific Risk Assessment:

There were no signs of existing or previous landslip instability within the site or adjacent land whilst the existing house structures show no signs of settlement or cracking. The proposed works require a deep excavation that has potential to result in instability where not properly supported.

Based on our site investigation and the proposed works, it is considered that the stability hazards associated with the proposed works are limited to:

A. Landslide (earth slide <$3m^3$) from soils at crest of the excavation
B. Landslide (rock and earth slide <$1m^3$) due to instability within the bedrock

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.

The Risk to Life from Hazard A was estimated to be up to **3.91 x 10^{-5},** whilst the Risk to Property was considered to be **up to 'Moderate'**. The Risk to Life from Hazard B was also estimated to be up to **7.81 x 10^{-7},** and the Risk to Property up to **'Low'**.

The hazards were therefore considered to be '**Unacceptable**' when assessed against the criteria of the Councils Policy. **However**, it should be noted that this assessment considers the excavations permanently unsupported, therefore actual risk levels will be significantly lower through construction of engineered pre-excavation support systems that will ensure "Acceptable" risk criteria will be achieved and maintained.

The entire site and surrounding slopes have therefore been assessed as per the Council Geotechnical Risk Management Policy 2009 and the site is considered to meet the 'Acceptable' risk management criteria for the design life of the development, taken as 100 years, provided the development is undertaken and the property is maintained as per the recommendations of this report.

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 'A' for footings founded into bedrock at base of excavation. Class 'M' for footings into reactive clay
Type of Footing	Strip, Pad, or Piers
Sub-grade material and Maximum Allowable Bearing Capacity for shallow footings	- Stiff clay: 400 kPa - Hard clay: 500 kPa - Very Low Strength Bedrock: 700kPa - Low Strength bedrock: 1000kPa
Site sub-soil classification as per *Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia*	Be – rock site The hazard factor (z) for Sydney is 0.08.
Remarks: All footings should be founded off material of similar foundation conditions to prevent differential settlement, allowance for differential settlement should be designed for if the structure is variably founded. All new footings must be inspected by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity and the in-situ nature of the founding strata. This is mandatory to allow them to be 'certified' at the end of the project.	

5.3.2. Excavation:				
Depth of Excavation		Maximum of approximately 2.50m depth for the proposed Bin storage area.		
Property Separation:				
Boundary	**Adjacent Property**	**Bulk Excavation Depth**	**Separation Distances**	
			Boundary	**Structure**
North	No. 251 Barrenjoey Road	Up to 2.50m for bin storage area.	+16.0m	Structure is +1.43m away.
South	Beaconsfield Street	Up to 2.50m for bin storage area.	+12.5m	Nature strip adjacent to the boundary, road pavement a further 6.0m away.
West	No.8 Beaconsfield Street	Up to 2.50m for bin storage area.	+27.0m	Structure is +6.0m away.
East	Barrenjoey Road	Up to 2.50m for bin storage area.	2.0m	Nature strip adjacent to the boundary, road pavement a further 6.0m away.
Type of Material to be Excavated		Fill/topsoil to 0.80m depth		
		Residual soils to extremely weathered bedrock to a maximum of 1.65m depth		
		Very low to low strength bedrock from a minimum of 1.45m depth from RL 38.80.		

Guidelines for <u>unsurcharged</u> batter slopes are tabulated below:

Material	Safe Batter Slope (H: V)	
	Short Term/Temporary	Long Term/Permanent
Fill/topsoil	1.5:1	2:1
Residual soils to EW material	1:1*	1.5:1*
VLS – LS bedrock (fractured)	0.25:1.0*	0.50:1.0*

Remarks:

*Dependent on assessment by geotechnical engineer.

Batter slopes in soils should be ≤3.0m in height without benching and where utilised will require regular geotechnical assessment and protection from saturation

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	Fill	Excavator with bucket
	VLS bedrock	Excavator with bucket and ripper
	LS-MS/HS bedrock	Rock hammer and rock saw
VLS – very low strength, LS – low strength, MS – medium strength		

Remarks:

Rock sawing of the hard rock excavation perimeters is recommended as it has several advantages. It often reduces the need for rock bolting as the cut faces generally remain more stable and require a lower level of rock support than hammer cut excavations, ground vibrations from rock saws are minimal and the saw cuts will provide a slight increase in buffer distance for use of rock hammers. It also reduces deflection across boundary of detached sections of bedrock near surface.

Based on previous testing of ground vibrations created by various rock excavation equipment within medium strength bedrock, to achieve a low level of vibration (5mm/s PPV) the below hammer weights and buffer distances are generally required:

Maximum Hammer Weight	Required Buffer Distance from Structure
300kg	3.00m
400kg	4.00m
600kg	6.00m
≥1 tonne	20.00m

Onsite calibration will provide accurate vibration levels to the site specific conditions and will generally allow for larger excavation machinery or smaller buffers to be used. Inspection of equipment and review of dilapidation surveys and excavation location is necessary to determine need for full time monitoring.

Recommended Vibration Limits (Maximum Peak Particle Velocity (PPV))	Site Structure = 5mm/s No. 251 Barrenjoey Road = 5mm/s Barrenjoey Road = 5mm/s
Vibration Calibration Tests Required	If larger scale (i.e. rock hammer >300kg) excavation equipment is proposed
Full time vibration Monitoring Required	Pending proposed excavation equipment and vibration calibration testing results, if required
Geotechnical Inspection Requirement	Yes, recommended that these inspections be undertaken as per below mentioned sequence: • At 1.50m depth intervals of excavation for assessment of batter slopes • Where temporary slope support is required • Where unexpected ground conditions are identified, or any other concerns are held. • At completion of the excavation

	• Following footing excavations to confirm founding material strength
Dilapidation Surveys Requirement	Recommended on neighbouring structures or parts thereof within 10m of the excavation perimeter prior to site work to allow assessment of the recommended vibration limit and protect the client against spurious claims of damage.
Remarks: Water ingress into exposed excavations can result in erosion and stability concerns in both soil and rock portions. 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/excavation support wall will be required as part of the proposed development to support the excavation perimeters due to the soils.
Types	Pre-excavation soldier pile shoring wall is required around the east, west and south portions of the excavation perimeter, with shotcrete lining to be applied to the pile face. Steel reinforced concrete/concrete block post excavation where batters possible. Designed in accordance with Australian Standards AS4678-2002 Earth Retaining Structures.
Parameters for calculating un-surcharged 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)	
Topsoil/Fill	18	$\phi' = 30°$	N/A	0.5	N/A
Clay (very stiff to hard)	20	$\phi' = 35°$	0.27	0.40	N/A
VLS bedrock	22	$\phi' = 38°$	0.15	0.20	200kPa
LS bedrock*	23	$\phi' = 40°$	0.10	0.15	400kPa

Remarks:
*Unconfirmed at the time of reporting.

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). For cantilever or simple anchor support walls a triangular pressure distribution can be utilised for at least initial design (pending results of further investigation).

5.3.4. Drainage and Hydrogeology		
Groundwater Table or Seepage identified in Investigation		No
Excavation likely to intersect	Water Table	No
	Seepage	Minor (<1L/min), on defects and at soil/rock interface
Site Location and Topography		Low west side of Barrenjoey Road within gentle northwest dipping topography.
Impact of development on local hydrogeology		Appears negligible
Onsite Stormwater Disposal		Unable to determine at time of reporting and will require infiltration test.
Remarks: 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 preferably discharges to the Council's stormwater system off site. Current investigation results indicate a drained basement will be suitable.		

5.4. Conditions Relating to Design and Construction Monitoring:

To allow certification at the completion of the project it will be necessary for Crozier Geotechnical Consultants to:

1. Review the structural design drawings, including the retaining structure design and construction methodology, for compliance with the recommendations of this report prior to construction,
2. Inspect soil batters during excavation and the installation of excavation support measures,
3. Inspect any medium strength bedrock and the proposed equipment prior to its excavation and at 1.50m depth intervals of excavation,
4. Inspect all new footings to confirm compliance to design assumptions with respect to allowable bearing pressure, basal cleanness and stability prior to the placement of steel or concrete,
5. Inspect completed works to confirm all slope stability, retention and stormwater systems are completed.

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:

We have interpreted the design life requirements specified within Councils Risk Management Policy to refer to structural elements designed to support 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 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 (50 years)). In order to attain an "Acceptable Risk Management Criteria" for a design life of 100 years as detailed by the Councils Risk Management Policy, it will be necessary for the property owner to adopt and implement a maintenance and inspection program. If a maintenance and inspection schedule are not implemented the "Acceptable" risk levels for the design life of the property may not 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 new development.
- There is no change to the property due to an extraordinary event external to this site, and 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). It is assumed that Pittwater 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 levels or landslide potential.

6. CONCLUSION:

The site investigation identified a topsoil/fill layer to depths of up to 0.80 m, overlying residual sandy clay and silty sandy clay soils of variable strength and plasticity. Localised sandstone gravel bands and trace rootlets were noted within the residual profile. Sandstone bedrock of at least very low to low strength was encountered at depths between 0.85 m and 2.03 m, with strength expected to increase with depth.

The proposed works comprise a new bin storage area and external stairs in the site's southeastern portion, requiring bulk excavation to approximately 2.50 m depth and demolition of the existing retaining wall. The finished level is understood to be RL38.50.

Investigation results indicate that safe batter slopes are not feasible; therefore, pre-excavation support comprising a soldier bored pile wall socketed into bedrock with shotcrete lining will be required. Preliminary design parameters are provided in Section 5.2.3.

Based on the site investigation, a groundwater table is not anticipated within the proposed excavation however, minor seepage is likely to be encountered during the excavation at the bedrock surface and on details in the rock mass. Therefore, it is unlikely to be a significant issue for this development, and tanking and large-volume dewatering are unlikely to be critical hazards.

The entire site and surrounding slopes have been assessed as per the Pittwater Council's LEP Geotechnical Risk Management Policy 2009 and can achieve the "Acceptable" risk management criteria of the policy for the design life of the development, taken as 100 years, provided the recommendations of this report are implemented in the construction phase whilst the maintenance program is implemented. As such the site is considered suitable for the proposed development.

Prepared By:	Reviewed By:
Samyam Bohara	Troy Crozier
Geotechnical Engineer	Principal
	MIE Aust. CPEng (NER – Geotechnical)
	MAIG, RPGeo – Geotechnical and Engineering

7. REFERENCES:

1. Australian Standard AS1170.4 - 2007 Earthquake Actions;
2. Australian Standard AS 1289 – 2000, Method of Testing Soils for Engineering Purposes;
3. Australian Standard AS 1726: 2017, Geotechnical Site Investigations.
4. Australian Standard AS 2870: 2011, Residential Slabs and Footings.
5. Australian Standard AS3600:2009, Concrete Structures.
6. Australian Standard AS3798:2007, Guidelines on Earthworks for Commercial and Residential Developments.
7. Australian Standard AS 4678:2002, Earth-Retaining Structures.
8. Australian Standard AS1170.4 – 2007, Part 4: Earthquake actions in Australia
9. Sydney 1:100,000 Geological Series Sheet 9130 (Edition 1). Geological Survey of New South Wales, Department of Mineral Resources.
10. Spatial Information Viewer, maps.six.nsw.gov.au, NSW Department of Finance and Service.
11. 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.
12. Das., Principles of Foundation Engineering, 5th Edition, Brooks/Cole,2004.

Appendix 1

CROZIER GEOTECHNICAL CONSULTANTS

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

NOTES RELATING TO THIS REPORT

Introduction

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

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

Description and classification Methods

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

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

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

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

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

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

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

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

Sampling

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

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

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

Drilling Methods

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

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

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

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

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

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

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

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

Standard Penetration Tests

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

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

The test results are reported in the following form.

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

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

Cone Penetrometer Testing and Interpretation

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

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

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

The information provided on the plotted results comprises: -

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

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

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

$$Q_c \text{ (MPa)} = (0.4 \text{ to } 0.6)\ N \text{ blows (blows per 300mm)}$$

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

$$Q_c = (12 \text{ to } 18)\ C_u$$

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

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

Dynamic Penetrometers

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

Two relatively similar tests are used.

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

Laboratory Testing

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

Borehole Logs

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

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

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

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

Ground Water

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

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

Engineering Reports

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

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

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

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

Site Anomalies

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

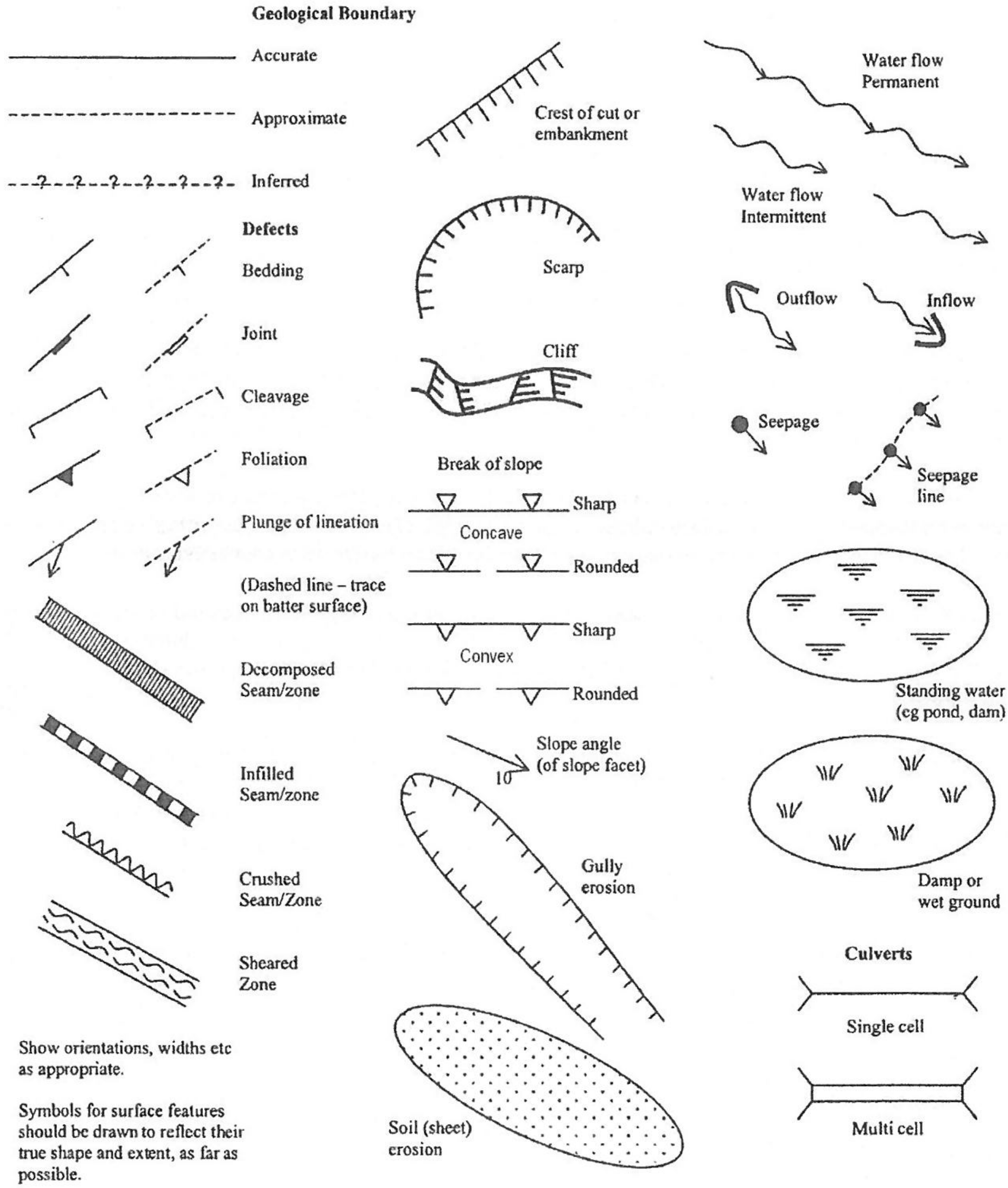
Reproduction of Information for Contractual Purposes

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

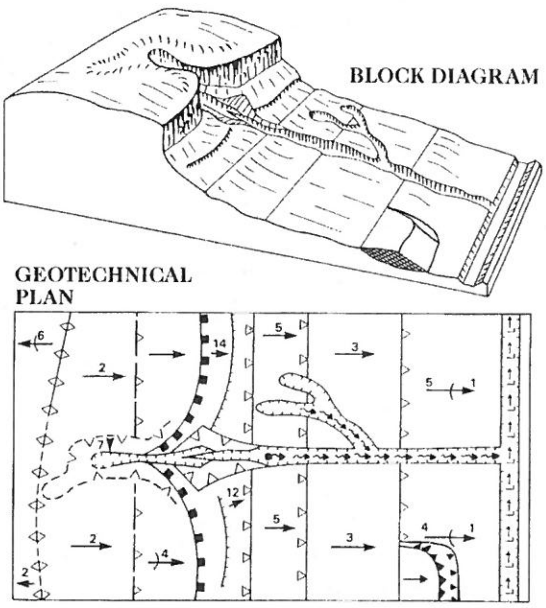
Site Inspection

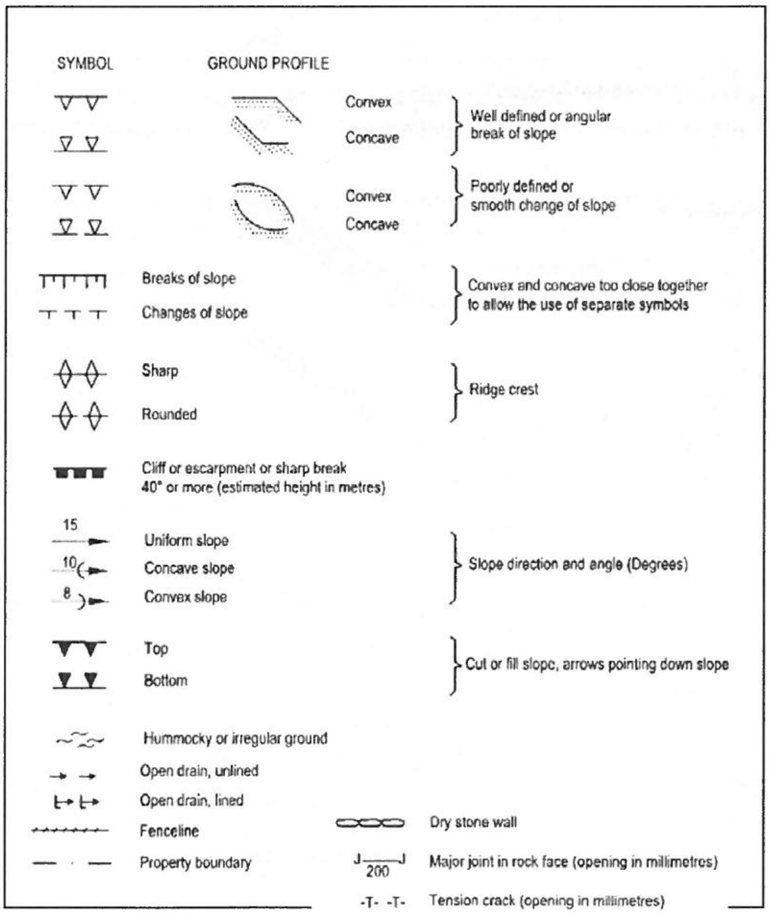
The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

APPENDIX E - GEOLOGICAL AND GEOMORPHOLOGICAL MAPPING SYMBOLS AND TERMINOLOGY



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





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

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 2

0 1 2 3 4 5 6 7 8 9 10

SCALE: 1:200

SITE PLAN & TEST LOCATIONS

FIGURE 1.

LEGEND

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

CROZIER
GEOTECHNICAL CONSULTANTS

Crozier Geotechnical
Unit 12, 42-46 Wattle Road
Brookvale NSW 2100

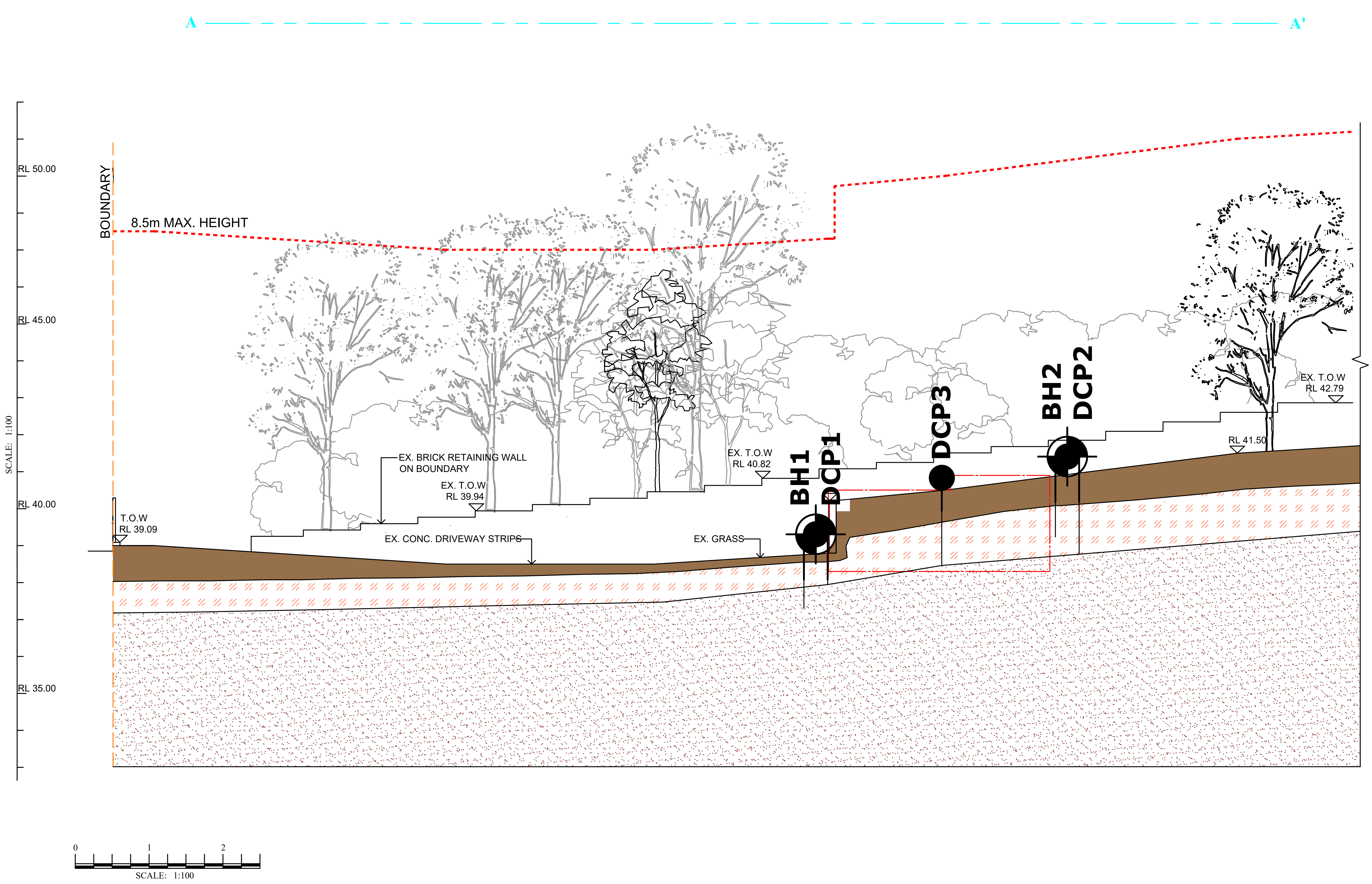
ABN: 96 113 453 624
Phone: (02) 9939 1882
Fax: (02) 9939 1883

Crozier Geotechnical is a division of PJC Geo-Engineering Pty Ltd

SCALE:	1:200 @ A3
DRAWING:	FIGURE 1
DATE:	08/2025
APPROVED BY:	TMC
DRAWN BY:	SB
PROJECT:	2025-139

PREPARED FOR:
STRATA PLAN 20

ADDRESS:
249 BARRENJOEY ROAD, NEWPORT



SECTION A: FIGURE 2

CROZIER GEOTECHNICAL CONSULTANTS

Crozier Geotechnical
Unit 12, 42-46 Wattle Road
Brookvale NSW 2100
ABN: 96 113 453 624
Phone: (02) 9939 1882
Fax: (02) 9939 1883

Crozier Geotechnical is a division of PJC Geo-Engineering Pty Ltd

LEGEND

PROPOSED WORKS | EXISTING STRUCTURES | FILL | SANDY CLAY | SANDSTONE BEDROCK | A — A' SECTION LINE

SCALE:	1:100 @ A3
DRAWING:	FIGURE 2
DATE:	08/2025
APPROVED BY:	TMC
DRAWN BY:	SB
PROJECT:	2025-139

PREPARED FOR:
STRATA PLAN 20

ADDRESS:
249 BARRENJOEY ROAD, NEWPORT

NON-CORE DRILL HOLE LOG

HOLE NO: BH1

PROJECT : Construction of new external staircase and bin storage area
LOCATION : 249 Barrenjoey, Newport
JOB NO: 2025-139
Sheet 1 of 1 FINAL DEPTH: 1.45 m

POSITION : (GDA94 / MGA zone 56) SURFACE ELEVATION : 38.80 m (AHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : CONTRACTOR : DRILLER :

DATE STARTED : 13/08/25 DATE COMPLETED : 13/08/25 DATE LOGGED : LOGGED BY : CHECKED BY : TMC

CASING DIAMETER : BARREL (Length) : BIT : BIT CONDITION :

WATER	SAMPLES & FIELD TESTS	RL (m AHD)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY
			0.0			TOPSOIL - SAND: fine to medium grained, dark grey; with gravel; topsoil.	D to M	
			0.20		CL-CI	CL-CI Sandy CLAY: low to medium plasticity, orange / red mottled grey; residual soil.	M	VL / F / St
		38.0	0.70			: crumbled; extremely weathered material.	D to M	St / VSt
			1.0 / 1.00			: trace gravel; rootlets .	D to M / M / D with M	VSt
		37.0	1.45			Terminated at 1.45 m. Refusal.		

CROZIER GEOTECHNICAL CONSULTANTS

NON-CORE DRILL HOLE LOG

HOLE NO: BH2

PROJECT : Construction of new external staircase and bin storage area
LOCATION : 249 Barrenjoey, Newport

JOB NO: 2025-139
Sheet 1 of 1 FINAL DEPTH: 1.65 m

POSITION : (GDA94 / MGA zone 56) SURFACE ELEVATION : 41.00 m (AHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : CONTRACTOR : DRILLER :

DATE STARTED : 13/08/25 DATE COMPLETED : 13/08/25 DATE LOGGED : LOGGED BY : CHECKED BY : TMC

CASING DIAMETER : BARREL (Length) : BIT : BIT CONDITION :

WATER	SAMPLES & FIELD TESTS	RL (m AHD)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY
		41.0	0.0			FILL - Sandy CLAY: low to medium plasticity, dark grey; trace rootlets ; fill.	M	
			0.80		CI	CI Silty Sandy CLAY: medium plasticity, dark orange / red; residual soil.	M	F
		40.0	1.00		CL-CI	CL-CI: orange / red mottled grey.	D to M	VSt
			1.20			: grey mottled orange / red; with sandstone gravels ; trace rootlets .	D to M	VSt / St
			1.40			: sandstone gravel band.	D to M	St / VSt / H
			1.65			Terminated at 1.65 m. Refusal.		

CROZIER GEOTECHNICAL CONSULTANTS

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Strata Revolution **DATE:** 13/08/2025

PROJECT: Construction of new external staircase and bin storage area

LOCATION: 249 Barraenjoey Road, Newport **SHEET:** 1 of 1

	Test Location									
Depth (m)	DCP1	DCP2	DCP3							
0.00 - 0.10	SW	SW	4							
0.10 - 0.20	SW	SW	1							
0.20 - 0.30	SW	2	2							
0.30 - 0.40	2	2	2							
0.40 - 0.50	2	2	1							
0.50 - 0.60	3	1	4							
0.60 - 0.70	3	3	2							
0.70 - 0.80	6	2	3							
0.80 - 0.90	6	2	2							
0.90 - 1.00	B at 0.85m	6	4							
1.00 - 1.10		4	3							
1.10 - 1.20		7	3							
1.20 - 1.30		4	4							
1.30 - 1.40		4	4							
1.40 - 1.50		4	3							
1.50 - 1.60		7	4							
1.60 - 1.70		10	5							
1.70 - 1.80		11	5							
1.80 - 1.90		13	5							
1.90 - 2.00		13	11							
2.00 - 2.10		19	6							
2.10 - 2.20		25	B at 2.03m							
2.20 - 2.30		PR at 2.2m								
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
AS 1289. F3.3, PERTH SAND PENETROMETER

REMARKS:

- **--** No test undertaken at this level due to prior excavation of soils
- **(B)** Test hammer bouncing upon refusal on a solid object
- **(PR)** Pratical Refusal: continuous 3 intervals with ≥15 Blows/100mm or a single interval with ≥25 Blows
- **(SW)** Rod settlled due to the self-weight of equipment

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	Landslide (earth slide $<3m^3$) from soils at crest of the excavation		Appears 1.45m to 2.03m of soil, no signs of existing movement, up to 2.5m deep excavation	a) dwelling 1.70m from west ofexcavation in soils, impact 25% b) dwelling is ≥17.0m from excavation in soils, negligible impact c) lawn and garden ≥17.0m from excavation, negligible impact d) footpath ≥3.0m from excavation in soils, impact 10% of pathway e) footpath ≥13.50m from excavation in soils, negligible impact f) road pavement is 8.0m from soil excavation, negligible impact g) road pavement is ≥18.50m from excavation in soils, negligible impact		a) Person in house 20hrs/day avge. b) Person in house 20hrs/day avge. c) Person in garden 1hr/day avge. d) Person in footpath 0.50hr/day avge. e) Person in footpath 0.50hr/day avge. f) Person in vehicle, 1hr/day g) Person in vehicle, 1hr/day .	a) Likely to not evacuate b) Likely to not evacuate c) Unlikely to not evacuate d) Possible to not evacuate e) Possible to not evacuate f) Likely to not evacuate g) Likely to not evacuate	a) Person in building, minor damage only b) Person in building, minor damage only c) Person in open space, buried d) Person in open space, buried e) Person in open space, buried f) Person in vehicle, damage only g) Person in vehicle, damage only	
			Likely	**Prob. of Impact**	**Impacted**				
		a) Site House (No. 249 Barrenjoey Road)	0.01	0.50	0.25	0.83	0.75	0.05	**3.91E-05**
		b) House No. 251 Barrenjoey Road	0.01	0.01	0.01	0.83	0.75	0.05	**3.13E-08**
		c) Lawn, garden, driveways - No. 251 Barrenjoey Road	0.01	0.01	0.01	0.04	0.25	0.10	**1.04E-09**
		d) Footpath - Barrenjoey Road	0.01	0.25	0.10	0.02	0.25	1.00	**1.30E-06**
		e) Footpath - Beaconsfield Street	0.01	0.05	0.01	0.02	0.25	0.50	**1.30E-08**
		f) Road Pavement - Barrenjoey Road	0.01	0.10	0.01	0.04	0.75	0.05	**1.56E-08**
		g) Road Pavement - Beaconsfield Street	0.01	0.01	0.01	0.04	0.75	0.05	**1.56E-09**
B	Landslide (rock and earth slide $<1m^3$) due to instability within the bedrock		Bedrock relatviely shallow however anticpated to be interbedded silstone/sandstone, large scale defects possible	a) dwelling 1.70m from west ofexcavation in soils, 10% impact b) dwelling is ≥17.0m from excavation in soils, negligible impact c) lawn and garden ≥17.0m from excavation, negligible impact d) footpath ≥3.0m from excavation in soils, negligible impact e) footpath ≥13.50m from excavation in soils, negligible impact f) road pavement is 8.0m from soil excavation, negligible impact g) road pavement is ≥18.50m from excavation in soils, negligible impact		a) Person in house 20hrs/day avge. b) Person in house 20hrs/day avge. c) Person in garden 1hr/day avge. d) Person in footpath 0.50hr/day avge. e) Person in footpath 0.50hr/day avge. f) Person in vehicle, 1hr/day g) Person in vehicle, 1hr/day .	a) Likely to not evacuate b) Likely to not evacuate c) Unlikely to not evacuate d) Possible to not evacuate e) Possible to not evacuate f) Likely to not evacuate g) Likely to not evacuate	a) Person in building, minor damage only b) Person in building, minor damage only c) Person in open space, buried d) Person in open space, buried e) Person in open space, buried f) Person in vehicle, damage only g) Person in vehicle, damage only	
			Possible	**Prob. of Impact**	**Impacted**				
		a) Site House (No. 249 Barrenjoey Road)	0.001	0.25	0.10	0.83	0.75	0.05	**7.81E-07**
		b) House No. 251 Barrenjoey Road	0.001	0.01	0.01	0.83	0.75	0.05	**3.13E-09**
		c) Lawn, garden, driveways - No. 251 Barrenjoey Road	0.001	0.01	0.01	0.04	0.25	0.10	**1.04E-10**
		d) Footpath - Barrenjoey Road	0.001	0.10	0.01	0.02	0.25	1.00	**5.21E-09**
		e) Footpath - Beaconsfield Street	0.001	0.01	0.01	0.02	0.25	0.50	**2.60E-10**
		f) Road Pavement - Barrenjoey Road	0.001	0.01	0.01	0.04	0.75	0.05	**1.56E-10**
		g) Road Pavement - Beaconsfield Street	0.001	0.01	0.01	0.04	0.75	0.05	**1.56E-10**

* hazards considered in current condition and/or without remedial/stabilisation measures
* likelihood of occurrence for design life of 100 years
* Spatial Impact - Probaility of Impact referes to slide impacting structure/area expressed as a % (1.00 = 100% probability of slide impacting area if it occurs), Imapcted refers to % of area/strucure impacted if slide occurred
* neighbouring houses considered for bedroom impact unless specified
* considered for person most at risk
* considered for adjacent premises/buildings founded via shallow footings unless indicated
* evacuation scale from Almost Certain to <u>not</u> 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	Landslide (earth slide <3m³) from soils at crest of the excavation	a) Site House (No. 249 Barrenjoey Road)	Possible	The event could occur under adverse conditions over the design life.	Minor	Limited Damage to part of structure or site requires some stabilisation or INSIGNIFICANT damage to neighbouring property or structure being assessed.	Moderate
		b) House No. 251 Barrenjoey Road	Rare	The event is conceivable but only under exceptional circumstances over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring property or structure being assessed.	Very Low
		c) Lawn, garden, driveways - No. 251 Barrenjoey Road	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 property or structure being assessed.	Very Low
		d) Footpath - Barrenjoey Road	Unlikely	The event might occur under very adverse circumstances over the design life.	Minor	Limited Damage to part of structure or site requires some stabilisation or INSIGNIFICANT damage to neighbouring property or structure being assessed.	Low
		e) Footpath - Beaconsfield Street	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 property or structure being assessed.	Very Low
		f) Road Pavement - Barrenjoey Road	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 property or structure being assessed.	Very Low
		g) Road Pavement - Beaconsfield Street	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 property or structure being assessed.	Very Low
B	Landslide (rock and earth slide <1m³) due to instability within the bedrock	a) Site House (No. 249 Barrenjoey Road)	Unlikely	The event might occur under very adverse circumstances over the design life.	Minor	Limited Damage to part of structure or site requires some stabilisation or INSIGNIFICANT damage to neighbouring property or structure being assessed.	Low
		b) House No. 251 Barrenjoey Road	Rare	The event is conceivable but only under exceptional circumstances over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring property or structure being assessed.	Very Low
		c) Lawn, garden, driveways - No. 251 Barrenjoey Road	Rare	The event is conceivable but only under exceptional circumstances over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring property or structure being assessed.	Very Low
		d) Footpath - Barrenjoey Road	Unlikely	The event might occur under very adverse circumstances over the design life.	Minor	Limited Damage to part of structure or site requires some stabilisation or INSIGNIFICANT damage to neighbouring property or structure being assessed.	Low
		e) Footpath - Beaconsfield Street	Rare	The event is conceivable but only under exceptional circumstances over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring property or structure being assessed.	Very Low
		f) Road Pavement - Barrenjoey Road	Unlikely	The event might occur under very adverse circumstances over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring property or structure being assessed.	Very Low
		g) Road Pavement - Beaconsfield Street	Rare	The event is conceivable but only under exceptional circumstances over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring property or structure being assessed.	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%.

CROZIER
GEOTECHNICAL CONSULTANTS

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}	$5x10^{-2}$	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.

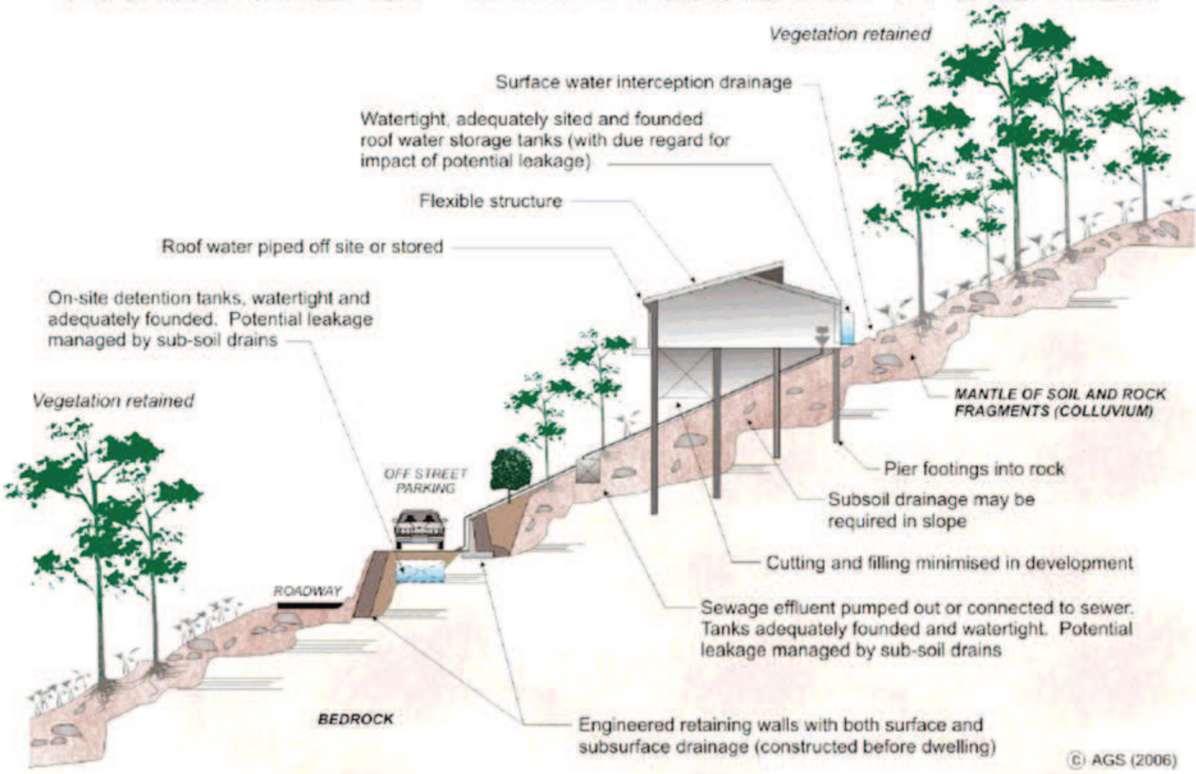
CROZIER
GEOTECHNICAL CONSULTANTS

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