NSW GOVERNMENT | Planning & Environment

Geotechnical Policy
Kosciuszko Alpine Resorts

Form 1 – Declaration and certification made by geotechnical engineer or engineering geologist in a geotechnical report.

DA Number: ____________________

To be submitted with a development application

You can use Form 1 to verify that the author of a geotechnical report is a geotechnical engineer or engineering geologist as defined by the Department of Planning & Environment (DP&E) Geotechnical Policy. Alternatively, where a geotechnical report has been prepared by a professional person not recognised by DP&E Geotechnical Policy, then Form 1 may be used as technical verification of the geotechnical report if signed by a geotechnical engineer or engineering geologist as defined by the DP&E Geotechnical Policy.

Please contact the Alpine Resorts Team in Jindabyne for further information - phone 02 6456 1733.

To complete this form, please place a cross in the appropriate boxes ☐ and complete all sections.

1. Declaration made by geotechnical engineer or engineering geologist as part of a geotechnical report

I,

Mr ☒ Ms ☐ Mrs ☐ Dr ☐ Other ____

First Name	Family Name
PAUL	ROBERTS

OF

Company/organisation

JK GEOTECHNICS PTY LTD

on this the 28 day of MAY 20 20

certify that I am a geotechnical engineer or engineering geologist as defined by the "Policy" and I (tick appropriate box)

☐ prepared the geotechnical report referenced below in accordance with the AGS 2000 and DP&E Geotechnical Policy – Kosciuszko Alpine Resorts.

☒ am willing to technically verify that the Geotechnical Report referenced below has been prepared in accordance the AGS 2000 and DP&E Geotechnical Policy – Kosciuszko Alpine Resorts.

2. Geotechnical Report Details

Report Title

GEOTECHNICAL ASSESSMENT - PROPOSED STAIR REFURBISHMENT & BIKE STORAGE CAGE

Author	Dated
ADRIAN HULSKAMP	28/5/2020

DA Site Address

13 BOBUCK LANE, THREDBO, NSW

DA Applicant

I am aware that the Geotechnical Report I have either prepared or am technically verifying, (referenced above) is to be submitted in support of a development application for the proposed development site (referenced above), and it's findings will be relied upon by the Consent Authority in determining the development application.

3. Checklist of essential requirements to be contained in a geotechnical risk assessment report to be submitted with a development application

The following checklist covers the minimum requirements to be addressed in a Geotechnical Risk Management Report. This checklist is to accompany the report.

Please tick appropriate box

- ☑ Risk assessment of all identifiable geotechnical hazards in accordance with AGS 2000, as per 6.1 (a) of the policy.
- ☑ Site plans with key hazards identified and other information as per 6.1 (b)
- ☑ Details of site investigation and inspections as per 6.1 (c)
- ☑ Photographs and/or drawings of the site as per 6.1 (d)
- ☑ Presentation of geotechnical model as per 6.1 (e)
- ☑ A specific conclusion as to whether the site is suitable for the development proposed on the above site, if applicable, subject to the following conditions;
  - ☑ Conditions to be provided to establish design parameters,
  - ☑ Conditions to be incorporated into the detailed design to be submitted for the construction certificate,
  - ☑ Conditions applying to the construction phase,
  - ☑ Conditions relating to ongoing management of the site/structure.

4. Signatures

Signature

Paul Roberts

Chartered professional status

CPEng (2307698), MIEAust

Name

PAUL ROBERTS

Date

28/5/2020

5. Contact details

Department of Planning & Environment
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REPORT TO

MUNJARRA CO-OP SKI LODGE LIMITED

ON

GEOTECHNICAL ASSESSMENT

(In Accordance with Kosciuszko Alpine Resorts Geotechnical Policy)

FOR

PROPOSED STAIR REFURBISHMENT
& BIKE STORAGE CAGE AT MUNJARRA LODGE

AT

13 BOBUCK LANE, THREDBO, NSW

Date: 28 May 2020

Ref: 32993RHrpt

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For and on behalf of
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DOCUMENT REVISION RECORD

Report Reference	Report Status	Report Date
32993RHrpt	Final Report	28 May 2020

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b) The limitations defined in the Client's brief to JKG;
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Table of Contents

1 INTRODUCTION

This report presents the results of a geotechnical assessment for the proposed stair refurbishment and bike storage cage at Munjarra Lodge, 13 Bobuck Lane, Thredbo, NSW. The location of the site is shown on Figure 1. The investigation was commissioned by Alan Kosinar by signed 'Acceptance of Proposal' form, dated 10 February 2020. The commission was on the basis of our proposal, Ref: P51183HG dated 10 February 2020, and our email dated 8 April 2020.

The supplied structural drawings prepared by Grounded Engineers (Drawing Nos. S01 to S05, Revision A, dated 20 March 2020), show that the proposed works will include demolition and reconstruction of an existing staircase and construction of a new bike storage cage below the existing lodge. The proposed bike storage cage will be partly supported by the existing structure. As part of the proposed works, two existing timber retaining walls located below the lower portion of the existing staircase will be demolished and replaced by two new steel post and concrete panel retaining walls. This will require some localised excavation and temporary battering of the subsurface profile to construct the new walls. The proposed retaining walls have been deigned to support the ground surface to a maximum height of about 1.8m, however, we expect that ground surface levels on completion of the works will be the same, or similar to, existing surface levels. A new suspended metal deck is also proposed at the entrance to the lodge. For ease of reference, the supplied structural drawings are presented in Appendix C. The design bearing pressure for the foundation piles is shown on the structural drawings as 50kPa.

The purpose of the assessment was to carry out a walkover inspection of the site and to assess the subsurface conditions at one test location, as a basis for providing comments and recommendations on excavation, retaining wall design and footing design.

This report has been prepared in accordance with the requirements of the Geotechnical Policy for Kosciuszko Alpine Resorts (2003) and the Australian Geomechanics Society (2007c) *'Practice Note Guidelines for Landslide Risk Management'*. It is understood that the report will be submitted as part of the DA documentation. Our report is preceded by the completed Form 1.

2 INVESTIGATION PROCEDURE

2.1 Walkover Inspection

A walkover survey was carried out by our Senior Associate geotechnical engineer (Adrian Hulskamp) on 11 February 2020 and 15 April 2020. The assessment was based on an inspection of the topographic, surface drainage and geological conditions of the site and its immediate environs. A summary of our site observations is presented in Section 3 below.

The attached Figure 2 presents a geotechnical site plan showing the principal geotechnical features present at the site and is based on the supplied structural 'Foundation Schedule' drawing. Additional features on Figure 2 have been measured by hand held clinometer and tape measure techniques and hence are only approximate. The geotechnical mapping symbols used are presented on Figure 3. Should any of the features be critical to the proposed development, we recommend they be located more accurately using instrument survey techniques.

2.2 Subsurface Investigation

A limited scope subsurface investigation was carried out on 15 April 2020 and included the drilling of one hand augered borehole (BH1) to a refusal depth of 0.7m and completion of one Dynamic Cone Penetration (DCP) test to a refusal depth of 1.3m below existing surface levels. The borehole and DCP test were positioned just behind the upper timber retaining wall that is to be replaced.

Following our initial walkover inspection, two test pits (TP1 and TP2) were excavated by the structural engineer along the base of the sub-floor wall along the southern side of the proposed bike cage and these were inspected during our second site visit. The test pits were excavated using portable hand held equipment to a maximum depth of 0.8m below existing surface levels.

The borehole location was set out by taped measurements from existing surface features and is shown on the attached Figure 2. The test pit locations are shown approximately in Plate 1 below. A survey plan was not provided, so the surface RLs at each test location were not established.

The compaction of the fill was assessed from the DCP blow counts. We note that the refusal of the DCP equipment often indicates the depth to the underlying bedrock. However, due to the equipment's limitations, it may also refuse on obstructions within fill, tree roots, ironstone gravel bands, 'corestones' or other 'hard' layers within the soil profile, and not necessarily on bedrock. The weathering and strength of the bedrock exposed in the sides and bases of the test pits was assessed by tactile examination augmented by hand penetrometer readings carried out in the sides of the test pits.

Groundwater observations were made in the boreholes and test pits during the fieldwork. No longer-term groundwater monitoring has been carried out.

Further details of the methods and procedures employed in the investigation are presented in the attached Report Explanation Notes.

Our Senior Associate geotechnical engineer (Adrian Hulskamp) was present on a full-time basis during the fieldwork and set out/recorded the test locations, logged the encountered subsurface profile and nominated in-situ testing and sampling. The borehole log (which includes groundwater observations) and the DCP test results sheet are attached, together with a glossary of logging terms and symbols used

Geotechnical laboratory testing was not carried out as it was deemed unnecessary. A contamination screen of site soils and groundwater was outside the agreed scope of this investigation.

3 SUMMARY OF OBSERVATIONS

Munjarra Lodge (‘the site’) is located part way down a moderately to steeply sloping hillside, which generally grades at about 26° to 27° down to the north. The site is bound by Bobuck Lane to the north. The Alpine Way is located just to the south, and upslope of the lodge, and is supported by gabion retaining walls (maximum height about 5.0m). Based on a cursory inspection, the retaining walls appeared to be in good condition. The vacant site to the west comprised the area impacted by the Thredbo landslide.

At the time of the fieldwork, the central portion of the site contained a one and two storey timber and masonry lodge with mortared granite block sub-floor walls. The rear of the lodge appeared to have been cut back into the hillside, such that a timber “Koppers log” retaining wall (about 1.0m height) was located just to the south of the lodge. The lodge surrounds comprised grass covered areas with scattered tall trees and landscaped gardens. The northern side of the lodge was supported by a mortared granite block retaining wall (maximum height about 1.1m).

Based on a cursory inspection the lodge and nearby retaining walls were generally in good condition. However, a diagonal and stepped crack (about 2mm maximum width and about 1.0m long) was recorded in the granite block sub-floor wall on the western side of the lodge, immediately adjacent to the location of the proposed bulk storage cage.

Plate 1: View looking south into the site from Bobuck Lane showing location of proposed works.

The northern (Bobuck Lane) frontage was formed by mortared granite block and timber retaining walls (maximum height about 2.2m). The granite block walls appeared to be in good condition with no obvious signs of rotation, bulging or cracking observed, however, the timber retaining walls had deteriorated and were in poor condition; we note that these timber walls will be replaced as part of the proposed stair refurbishment works. The retained surface behind the retaining walls was relatively steep; generally grading down to the north between about 20° and 32°, but with some areas sloping down at a maximum of about 60°. The staircase, which is to be replaced, zig zagged up the slope from Bobuck Lane to the entrance of the lodge. Refer to Plate 1 above. Weathered granite bedrock was locally exposed at ground surface just to the west of the timber retaining wall supporting the lower portion of the staircase.

The neighbouring three storey masonry lodge building to the east was set back about 4.0m from the eastern site boundary and appeared to be in generally good external condition, based on a cursory inspection from within the site. Ground surface levels across the eastern site boundary were similar.

4 SUBSURFACE CONDITIONS

The 1:250,000 geological map of Tallangatta (Series SJ 55-3) indicates the site is underlain by granite bedrock. Reference should be made to the attached borehole log and DCP test results for specific details at the test location. A summary of the pertinent subsurface characteristics is presented below:

Fill

Gravelly sand fill was encountered from the surface level in BH1 and extended down to the refusal depth at 0.7m. The fill was assessed to be poorly compacted. Hand augered refusal occurred on an obstruction in the fill and the refusal of DCP1 at 1.3m depth has been interpreted to be due to an obstruction in the retaining wall backfill.

In the test pits, the upper 0.2m of the subsurface profile comprised gravelly sand fill.

Residual Soils

Residual soils were not encountered in the boreholes, or the exposures in the test pits. However, based on a previous investigation completed at a downslope neighbouring lodge located opposite the site on the northern side of Bobuck Lane, residual soils, if present, may comprise silty clays of low to medium plasticity and stiff and very stiff strength and/or clayey sands and silty sands of loose to medium dense relative density.

Granite Bedrock

Weathered granite bedrock was exposed within the sides and base of the test pits below about 0.2m depth, as well as at the ground surface on the western side of the existing staircase over the lower portion of the site. Refer to Plates 2 and 3 below.

Plate 1: TP1 (Looking south).

Plate 2: TP2 (Looking south).

The granite was generally extremely weathered and of hard (soil) strength, and locally was assessed to be highly weathered and of very low strength. In TP2, some granite cobbles and boulder sized 'corestones' (less than about 0.3m size) were observed in the western side of the test pit. Hand penetrometer readings in the sides and base of the test pits were greater than 600kPa.

Extremely to highly weathered granite bedrock respectively of hard (soil) strength and very low strength was locally exposed at ground surface just to the west of the timber retaining wall supporting the lower portion of the staircase.

Groundwater

BH1 was 'dry' during and on completion of drilling. The test pits were 'dry' when we inspected them on 15 April 2020. No long term groundwater monitoring has been carried out.

Existing Lodge Footings

The test pits revealed that the mortared granite sub-floor wall of the lodge was supported by a shallow concrete strip footing at about 0.3m depth founded in extremely weathered granite bedrock.

5 GEOTECHNICAL RISK ASSESSMENT

The results of our walkover inspection and subsurface investigation have been used to prepare our geotechnical risk assessment for the proposed stair refurbishment and bike storage cage. The methodology adopted is in accordance with the Australian Geomechanics Society (2007c) 'Practice Note Guidelines for Landslide Risk Management', risk classification system.

5.1 Potential Landslide Hazards

The subsurface profile has been assessed to comprise an intermittent and limited thickness of fill and residual soils overlying weathered granite bedrock generally present at shallow depth. Areas of deeper fill represent backfill to retaining walls.

Despite the moderately to steeply sloping ground surfaces, we did not observe any obvious signs of deep seated instability, such as tension cracks, slumps, etc, at, or in the immediate vicinity of the site. We also did not observe any obvious signs of hillside creep movements, such as basal curvature of tree trunks. Apart from the timber retaining walls either side of the staircase which were in poor condition and the single crack observed in one of the sub-floor walls of the lodge, we did not observe any other obvious signs of instability at the site.

The site appeared to be well drained.

We consider that the following potential landslide hazards are associated with the site and the proposed stair refurbishment and bike storage works:

A Instability of the hillside slope (deep seated or near surface).

B Instability of the hillside slope (slow creep movement).

C Instability of existing retaining walls.

D Instability of temporary excavation batter slopes.

E Instability of proposed retaining walls.

5.2 Risk Analysis

The attached Tables A and B present the results of our assessment of risk to property and life, respectively, for the potential landslide hazards above and our assessment of factors and assumptions relevant to the risk assessments.

The attached Table A summarises our qualitative assessment of each potential landslide hazard and of the consequences to property should the potential landslide hazard occur under existing conditions and during and following construction. Based on the above, the qualitative risks to property have been determined. The terminology adopted for this qualitative assessment is in accordance with Table A1 given in Appendix A.

Table A indicates the assessed risk under existing conditions is 'Very Low', 'Low' and 'Moderate'. 'Very Low' and 'Low' risk levels would be considered to be 'Acceptable' in accordance with the Australian Geomechanics Society (2007c) risk classification system and 'Moderate' would be considered 'Tolerable'. During and following construction Table A indicates the assessed risk levels are at 'Acceptable' levels ('Very Low' and 'Low'), in accordance with the Australian Geomechanics Society (2007c) risk classification system.

We have also used the indicative probabilities associated with the assessed likelihood to calculate the risk to life for the person most at risk for each of the potential landslide hazards during and following construction, including a person present within the lodge. The results of our assessment are presented in Table B, which also includes are our assessed temporal, spatial, evacuation and vulnerability factors that have been used for the risk calculation. The resulting risk for the person most at risk is about 10^{-6} which would be considered to be 'Acceptable' in accordance with the Australian Geomechanics Society (2007c) risk classification system.

5.3 Risk Assessment

It should be recognised that, due to the many complex factors that can affect a site, the subjective nature of a risk analysis, and the imprecise nature of the science of geotechnical engineering, the risk of instability for a site and/or development cannot be completely removed. It is, however, essential that risk be reduced to at least that which could be reasonably anticipated by the community in everyday life and that landowners are made aware of reasonable and practical measures available to reduce risk as far as possible.

In preparing our recommendations, we have also assumed that no activities on surrounding land which may affect the risk on the subject site would be carried out. We have further assumed that all buried services within and surrounding the site are, and will be, regularly maintained to remain in good condition.

It is important to be mindful that soil slumps or retaining wall instability can occur at anytime and it would be difficult to impossible to predict when the identified potential geotechnical hazards will occur. Also, we cannot predict when an extreme or unusual event may occur (such as an earthquake or 1 in 100 year rainfall event etc) and what impact it would have on the stability of the identified potential geotechnical hazards.

6 COMMENTS AND RECOMMENDATIONS

We consider that the proposed works may proceed provided the following specific design, construction and maintenance recommendations are adopted to maintain landslide risk at 'Acceptable' levels.

The recommendations which follow address geotechnical issues only and other conditions may be required to address other aspects of the proposed development.

6.1 Conditions to be Provided to Establish the Design Parameters

6.1.1 Due to the moderately to steeply sloping site, all piles must be founded at least 0.5m into extremely weathered (or better) granite bedrock. The 0.5m embedment in rock must also be below a 45° line inclined up from the toe of any adjacent retaining walls. A deeper embedment will be required for the piles supporting the proposed new retaining walls in order to provide lateral restraint. The weathered bedrock will be suitable for the design maximum allowable bearing pressure of 50kPa. Bored piles will be feasible and will need to be formed using a rock auger attachment fitted to an excavator in order to socket into the granite bedrock.

6.1.2 The major consideration in the selection of earth pressures for the design of retaining walls supporting a soil profile is the need to limit deformations occurring outside the excavations. The following characteristic earth pressure coefficients and subsoil parameters should be used by the structural engineer to check their design.

- As the proposed cantilever retaining walls will retain garden or grassed areas where we expect minor movements can be tolerated, a triangular lateral earth pressure distribution may be adopted using an 'active' lateral earth pressure coefficient, K_a, of 0.45, for the retained profile, assuming a backfill surface inclined no steeper than about 20°.
- A bulk unit weight of $20kN/m^3$ should be adopted for the retained profile.
- Any other surcharge affecting the walls (eg. construction loads, etc) should be taken into account in the wall design using the lateral earth pressure coefficient above.
- The retaining walls should be designed as drained and measures taken to provide complete and permanent drainage of the ground behind the walls. Subsurface drains should incorporate a non-woven geotextile fabric (eg. Bidim A34) to act as a filter against subsoil erosion.
- Lateral toe restraint may be achieved by suitably embedding the piles to sufficient depth to satisfy stability considerations. An allowable lateral stress of 150kPa should be adopted for sockets within the weathered granite bedrock, but ignoring the upper 0.3m of socket to allow for tolerance effects and possible disturbance during excavation. Any localised excavations, in front of the walls such as for buried services, must also be taken into account in the embedment depth design.

6.1.3 The guidelines for Hillside Construction given in Appendix B should also be adopted.

6.2 Conditions to be Incorporated into the Detailed Design to be submitted for the CC

6.2.1 All structural drawings must be reviewed by a geotechnical engineer who should endorse that the recommendations contained within this report have been adopted in principle. This will be part of the Form 2 requirements.

6.3 Conditions Applying to the Construction Phase

6.3.1 Prior to construction of the proposed bike storage cage, we recommend that a narrow test pit be excavated on the western or eastern sides of each of the three existing columns that are to be used to support the northern side of the proposed bike cage. The purpose of the test pits is to expose the column footing details and foundation materials and to determine whether the existing footings require underpinning. However, we expect such underpinning is unlikely based on the shallow depth to granite bedrock in the test pits located immediately upslope. The test pits must be inspected by the geotechnical and structural engineers in order to confirm any underpinning and/or temporary support requirements.

6.3.2 Where the proposed replacement retaining walls are to be located, excavation through the existing retaining wall backfill (and any residual soil and weathered granite bedrock up to very low strength, if encountered) should be readily completed using a 'digging' bucket fitted to a small hydraulic excavator, where access permits, or by using hand equipment. Though unlikely, if excavation of any low or higher strength rock is required, then further geotechnical advice should be sought on suitable rock excavation equipment, controlling of vibrations and/or vibration monitoring. As an example, the use of a ripping tyne attachment to the excavator would be an appropriate non-vibration rock excavation technique.

6.3.3 Groundwater inflows into the excavation may occur as local seepage flows within the fill, at the fill/residual soil interface, the soil/rock interface, and/or through joints within the bedrock profile, particularly after heavy or prolonged rainfall. Assuming some minor seepage does occur, it is likely to be very small and satisfactorily controlled by gravity drainage down to Bobuck Lane. However, there must be appropriate 'silt' control measures in place to prevent silt and other debris entering the existing stormwater drainage system.

6.3.4 The sides of the excavation for the proposed new retaining walls may be temporarily battered to slopes no steeper than 1 Vertical (V) in 1.5 Horizontal (H) through the soil profile, provided surcharge loads are kept well clear of the crest of the temporary batters. Steeper temporary batters in residual soils and/or weathered bedrock may be possible, subject to geotechnical inspection. The new retaining walls can then be constructed along the toe of the temporary batters and subsequently backfilled.

6.3.5 Inspection of a representative number of footing excavations and retaining wall pile bases should be completed by an experienced geotechnical engineer to confirm that a satisfactory bearing stratum has been achieved. This inspection will form part of the Form 3 requirements.

6.3.6 A geotechnical engineer should inspect the subsurface drains behind the proposed replacement retaining walls, prior to backfilling.

6.4 Conditions Relating to On-Going Management of the Site/Structure

6.4.1 Any existing subsoil drainage or surface drainage measures disturbed as part of the proposed works should be reconstructed or diverted around the new staircase, so that the current site drainage is maintained. Any surface water drains around the lodge should be regularly checked and cleared of debris. We recommend this forms part of an annual maintenance plan to be carried out by the owners.

6.4.2 New and existing retaining walls must be inspected by a structural engineer at no more than ten yearly intervals; including the provision of a written report confirming scope of work completed and identifying any required remedial measures.

7 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and JK Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

Occasionally, the subsurface conditions between and below the completed test locations may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

A waste classification is required for any soil and/or bedrock excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), Excavated Natural Material (ENM), General Solid, Restricted Solid and Hazardous Waste. Analysis can take up to 7-10 working days to complete, therefore, an adequate allowance should be included in the construction program unless testing is completed prior to construction. If contamination is encountered, then further testing (and associated delays) could be expected. We strongly recommend that this requirement is addressed prior to the commencement of excavation on site.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the assessment, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

TABLE A
SUMMARY OF RISK ASSESSMENT TO PROPERTY

POTENTIAL LANDSLIDE HAZARD	EXISTING CONDITIONS					DURING CONSTRUCTION AND AFTER COMPLETION OF THE PROPOSED STAIR REFURBISHMENT WORKS AND IMPLEMENTATION OF THE RECOMMENDATIONS AS OUTLINED IN OUR REPORT				
	A: Potential instability of the hillside slope	B: Potential instability of the hillside slope (slow creep movement)	C: Potential instability of existing retaining walls			A: Potential instability of the hillside slope (shallow earth slide)	B: Potential instability of the hillside slope (slow creep movement)	C: Potential instability of existing retaining walls that will remain	D: Potential instability of temporary excavation batter slopes	E: Potential instability of proposed retaining walls
			C1: Granite retaining walls & timber retaining wall located upslope of the lodge.	C2: Timber retaining walls, adjacent to existing staircase.	C3: Gabion retaining walls supporting the Alpine Way					
Assessed Likelihood	Rare[1]	Rare[2]	C1: Unlikely[3]	C2: Likely[4]	C3: Rare[5]	Rare	~~Possible~~ Rare[2]	Unlikely[-] (C1) and Rare[5] (C3)	Unlikley[6]	Rare[7]
Assessed Consequences	Medium	Insignificant	C1: Minor to Medium	C2: Minor	C3: Medium	Medium	Insignificant	Minor to Medium	Insignificant	Minor
Risk	Low	Very Low	C1: Low	C2: Moderate	C3: Low	Low	Very Low	Low	Very Low	Very Low
Comments	1 No obvious signs of any near surface or deep seated instability observed. Where not exposed, granite bedrock is expected at shallow depths, but at moderate depth behind existing retaining walls. Drainage systems upslope and downslope of the site assumed to be operating satisfactorily and regularly maintained. 2 No obvious signs of creep movement observed. 3 These existing retaining walls were observed to be in good condition. 4 The timber walls are in poor condition. 5 The gabion retaining walls supporting the Alpine Way are in good condition and have been engineer designed. Wall drainage assumed to be operating satisfactorily and regularly maintained. 6 Assumes the recommended temporary batter slopes will be adopted in accordance with the advice in our report. 7 The proposed replacement retaining walls are engineer designed.										

TABLE B
SUMMARY OF RISK ASSESSMENT TO LIFE
DURING AND AFTER COMPLETION OF CONSTRUCTION

Landslide Hazard	A: Potential instability of the hillside slope	B: Potential instability of the hillside slope (slow creep movement)	C: Potential instability of existing retaining walls that will remain	D: Potential instability of temporary excavation batter slopes	E: Potential instability of proposed retaining walls
Assessed Likelihood	Rare	Rare	Unlikely to Rare	Unlikely	Rare
Indicative Annual Probability	10^{-5}	10^{-5}	10^{-4} to 10^{-5}	10^{-4}	10^{-5}
Persons at Risk	Person inside or outside the lodge building			Construction worker at crest or toe of batter	Person using staircase
Number of Persons Considered	1				
Duration of Use of Area Affected (Temporal Probability)	6 hours day = 0.25			8 hours per day for 2 months during construction = 0.06	0.5 hour per day = 0.02
Spatial Probability Taking Into Account Travel Distance and Travel Direction	0.2 Assume 1m wide slump over 5m wide section	1 Entire hillside	0.2 Assume 1m wide collapse over 5m wide section	0.33 Assume 1m wide slump over 3m wide section of excavation.	0.3 Assume 3m wide slump over 10m wide section of retaining wall
Probability of not Evacuating Area Affected prior to Failure	0.5 Prior warning likely	0.001 Slow creep movement	0.5 Prior warning likely	0.5 Prior warning likely. Assumes recommended batter slopes will be adopted	0.4 Prior warning likely. The proposed replacement retaining walls are engineer designed
Vulnerability to Life if Failure occurs whilst Person is Present	1 Building inundated with debris and person expected to be buried.	0.01 Unlikely to be buried	0.1 Small volume of material, unlikely to be buried	0.5 Unlikely to be buried	0.3 Unlikely to be buried
Risk for Person Most at Risk	2.5×10^{-7}	2.5×10^{-11}	2.5×10^{-7} to 2.5×10^{-8}	5.0×10^{-7}	7.2×10^{-9}
Combined Total Risk	1.0×10^{-6}				

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BOREHOLE LOG

Borehole No. 1

Client: MUNJARRA CO-OP SKI LODGE LIMITED

Project: PROPOSED STAIR REFURBISHMENT & BIKE STORAGE CAGE

Location: 13 BOBUCK LANE, THREDBO, NSW

Job No.: 32993RH **Method:** HAND AUGER **R.L. Surface:** N/A

Date: 15/4/20 **Datum:** -

Plant Type: - **Logged/Checked by:** A.J.H./P.R.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLET-ION					REFER TO DCP TEST RESULTS	0 – 0.5			FILL: Gravelly sand, fine to coarse grained, dark brown, fine to medium grained granite gravel, trace of grainte cobbles.	M			APPEARS POORLY COMPACTED
						1 – 3.5			END OF BOREHOLE AT 0.7m				HAND AUGER REFUSAL ON OBSTRUCTION IN FILL

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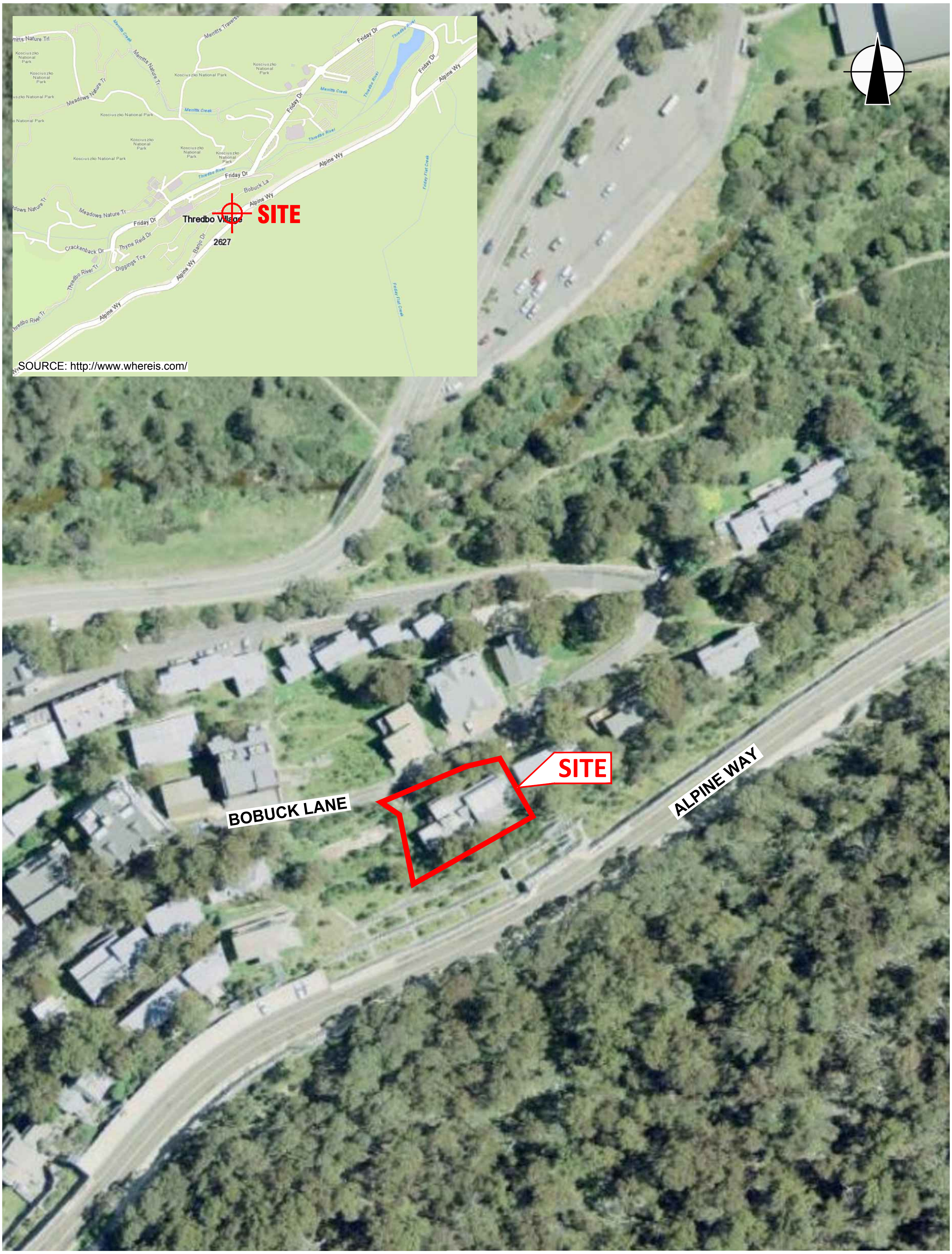
DYNAMIC CONE PENETRATION TEST RESULTS

Client:	MUNJARRA CO-OP SKI LODGE LIMITED	
Project:	PROPOSED STAIR REFURBISHMENT & BIKE STORAGE CAGE	
Location:	13 BOBUCK LANE, THREDBO, NSW	
Job No.	32993RH	Hammer Weight & Drop: 9kg/510mm
Date:	15-4-20	Rod Diameter: 16mm
Tested By:	A.J.H.	Point Diameter: 20mm

Test Location	**1**						
Surface RL	N/A						
Depth (mm)	Number of Blows per 100mm Penetration						
0 - 100	1						
100 - 200	1						
200 - 300	2						
300 - 400	2						
400 - 500	2						
500 - 600	↓						
600 - 700	2						
700 - 800	2						
800 - 900	3						
900 - 1000	2						
1000 - 1100	2						
1100 - 1200	2						
1200 - 1300	3						
1300 - 1400	REFUSAL						
1400 - 1500							
1500 - 1600							
1600 - 1700							
1700 - 1800							
1800 - 1900							
1900 - 2000							
2000 - 2100							
2100 - 2200							
2200 - 2300							
2300 - 2400							
2400 - 2500							
2500 - 2600							
2600 - 2700							
2700 - 2800							
2800 - 2900							
2900 - 3000							

Remarks:
1. The procedure used for this test is described in AS1289.6.3.2-1997 (R2013)
2. Usually 8 blows per 20mm is taken as refusal



AERIAL IMAGE SOURCE: MAPS.SIX.NSW.GOV.AU

This plan should be read in conjunction with the JK Geotechnics report.

Title:	**SITE LOCATION PLAN**
Location:	13 BOBUCK LANE, THREDBO, NSW
Report No: 32993RH	Figure: 1

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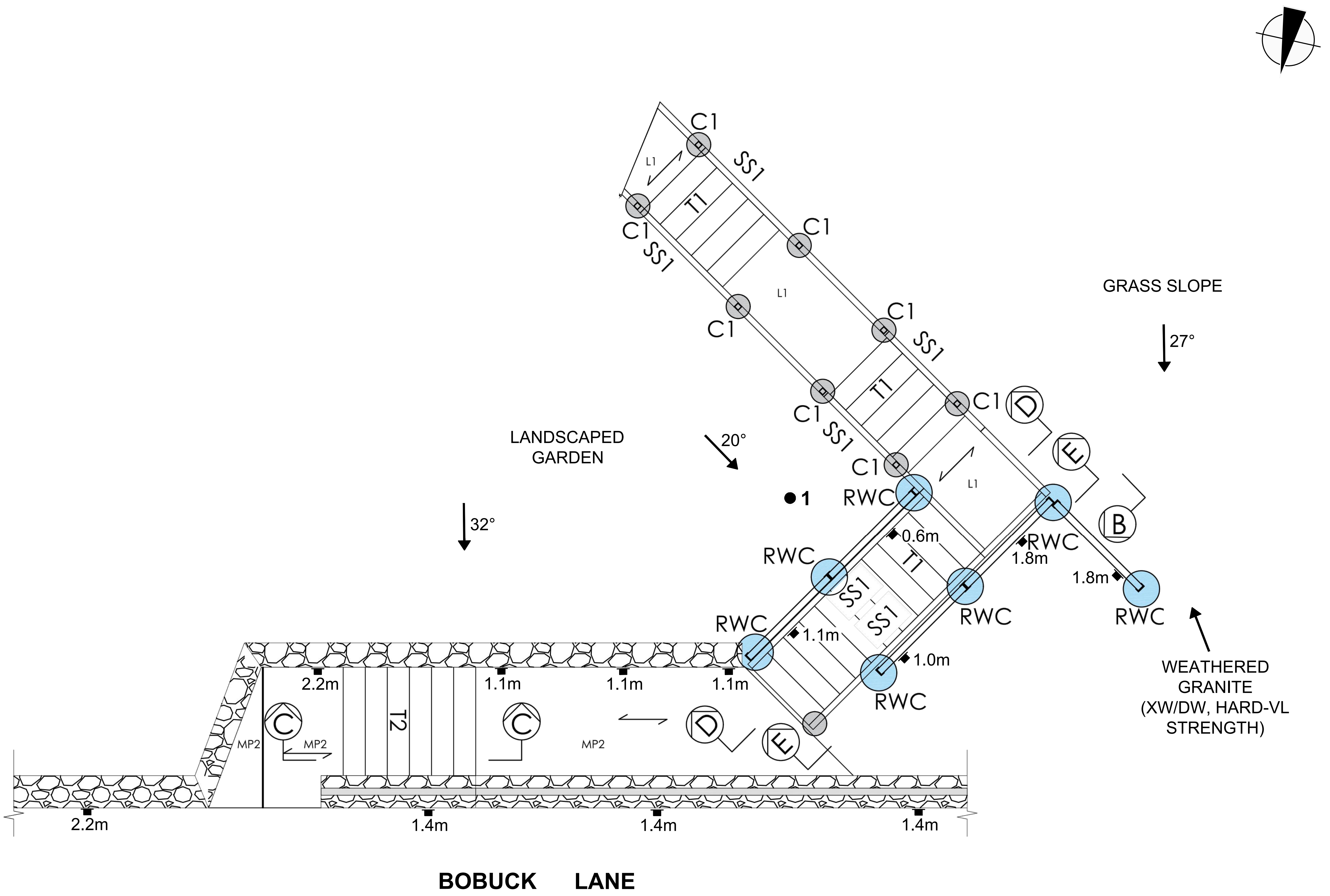
PLOT DATE: 1/05/2020 12:27:58 PM DWG FILE: Z:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\32000'S\32993RH THREDBO\CAD\32993RH.DWG



0 0.5 1 1.5 2 2.5
SCALE 1:50 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title: **GEOTECHNICAL SITE PLAN**

Location: 13 BOBUCK LANE, THREDBO, NSW

Report No: 32993RH

Figure: 2

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TOPOGRAPHY

Symbol *Ground Profile*

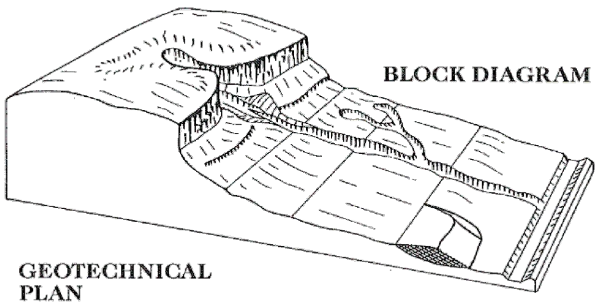
- convex / concave — well defined or angular break of slope
- convex / concave — poorly defined or smooth change of slope
- breaks of slope / changes of slope — convex and concave too close together to allow the use of separate symbols
- sharp / rounded — ridge crest
- Cliff or escarpment or sharp break 40° or more (estimated height in metres) — 3
- 15 Uniform Slope / 10 Concave Slope / 8 Convex Slope — Slope direction and angle (Degrees)
- Top / Bottom — Cut or fill slope, arrows pointing down slope
- Hummocky or irregular ground

OTHER FEATURES

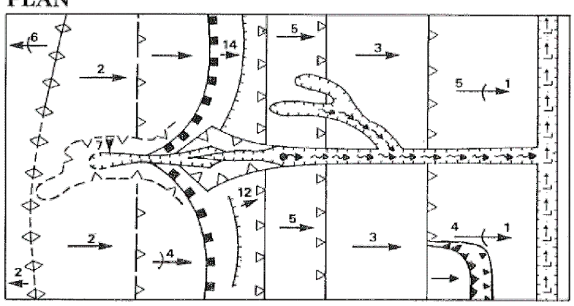
- Boulder
- Seepage/spring
- Swallow hole for runoff
- Natural water course
- Open drain, unlined
- Open drain, lined
- Fenceline
- Property boundary
- Dry Stone Wall
- J —— J 200 Major joint in rock face (opening in millimetres)
- – T – T – 10 Tension crack (opening in millimetres)
- Masonry or concrete wall
- Ponding water
- Boggy or swampy area

EXAMPLE OF USE OF TOPOGRAPHIC SYMBOLS:

BLOCK DIAGRAM



GEOTECHNICAL PLAN



(After Gardiner, V & Dackombe, R. V. (1983), Geomorphological Field Manual; George Allen & Unwin).

This plan should be read in conjunction with the JK Geotechnics report.

Title:	GEOTECHNICAL MAPPING SYMBOLS
Location:	13 BOBUCK LANE, THREDBO, NSW
Report No: 32993RH	Figure: 3

JKGeotechnics

PLOT DATE: 25/05/2020 11:27:15 AM DWG FILE: Z:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\32000'S\32993RH THREDBO\CAD\32993RH.DWG

APPENDIX A

LANDSLIDE RISK

MANAGEMENT

TERMINOLOGY

LANDSLIDE RISK MANAGEMENT

Definition of Terms and Landslide Risk

Risk Terminology	Description
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.
Annual Exceedance Probability (AEP)	The estimated probability that an event of specified magnitude will be exceeded in any year.
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.
Elements at Risk	The population, buildings and engineering works, economic activities, public services utilities, infrastructure and environmental features in the area potentially affected by landslides.
Frequency	A measure of likelihood expressed as the number of occurrences of an event in a given time. See also 'Likelihood' and 'Probability'.
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.
Individual Risk to Life	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.
Landslide Activity	The stage of development of a landslide; pre failure when the slope is strained throughout but is essentially intact; failure characterised by the formation of a continuous surface of rupture; post failure which includes movement from just after failure to when it essentially stops; and reactivation when the slope slides along one or several pre-existing surfaces of rupture. Reactivation may be occasional (eg. seasonal) or continuous (in which case the slide is 'active').
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, or kinetic energy per unit area.
Landslide Risk	The AGS Australian GeoGuide LR7 (AGS, 2007e) should be referred to for an explanation of Landslide Risk.
Landslide Susceptibility	The classification, and volume (or area) of landslides which exist or potentially may occur in an area or may travel or retrogress onto it. Susceptibility may also include a description of the velocity and intensity of the existing or potential landsliding.
Likelihood	Used as a qualitative description of probability or frequency.
Probability	A measure of the degree of certainty. This measure has a value between zero (impossibility) and 1.0 (certainty). It is an estimate of the likelihood of the magnitude of the uncertain quantity, or the likelihood of the occurrence of the uncertain future event. These are two main interpretations: (i) Statistical – frequency or fraction – The outcome of a repetitive experiment of some kind like flipping coins. It includes also the idea of population variability. Such a number is called an 'objective' or relative frequentist probability because it exists in the real world and is in principle measurable by doing the experiment.

Risk Terminology	Description
Probability *(continued)*	(ii) Subjective probability (degree of belief) – Quantified measure of belief, judgment, or confidence in the likelihood of an outcome, obtained by considering all available information honestly, fairly, and with a minimum of bias. Subjective probability is affected by the state of understanding of a process, judgment regarding an evaluation, or the quality and quantity of information. It may change over time as the state of knowledge changes.
Qualitative Risk Analysis	An analysis which uses word form, descriptive or numeric rating scales to describe the magnitude of potential consequences and the likelihood that those consequences will occur.
Quantitative Risk Analysis	An analysis based on numerical values of the probability, vulnerability and consequences and resulting in a numerical value of the risk.
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.
Risk Analysis	The use of available information to estimate the risk to individual, population, property, or the environment, from hazards. Risk analyses generally contain the following steps: scope definition, hazard identification and risk estimation.
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 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 judgments 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 Management	The complete process of risk assessment and risk control (or risk treatment).
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.
Susceptibility	See 'Landslide Susceptibility'.
Temporal Spatial Probability	The probability that the element at risk is in the area affected by the landsliding, at the time of the landslide.
Tolerable Risk	A risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.
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.

NOTE: Reference should be made to Figure A1 which shows the inter-relationship of many of these terms and the relevant portion of Landslide Risk Management.

Reference should also be made to the paper referenced below for Landslide Terminology and more detailed discussion of the above terminology.

This appendix is an extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in Australian Geomechanics, Vol 42, No 1, March 2007, which discusses the matter more fully.

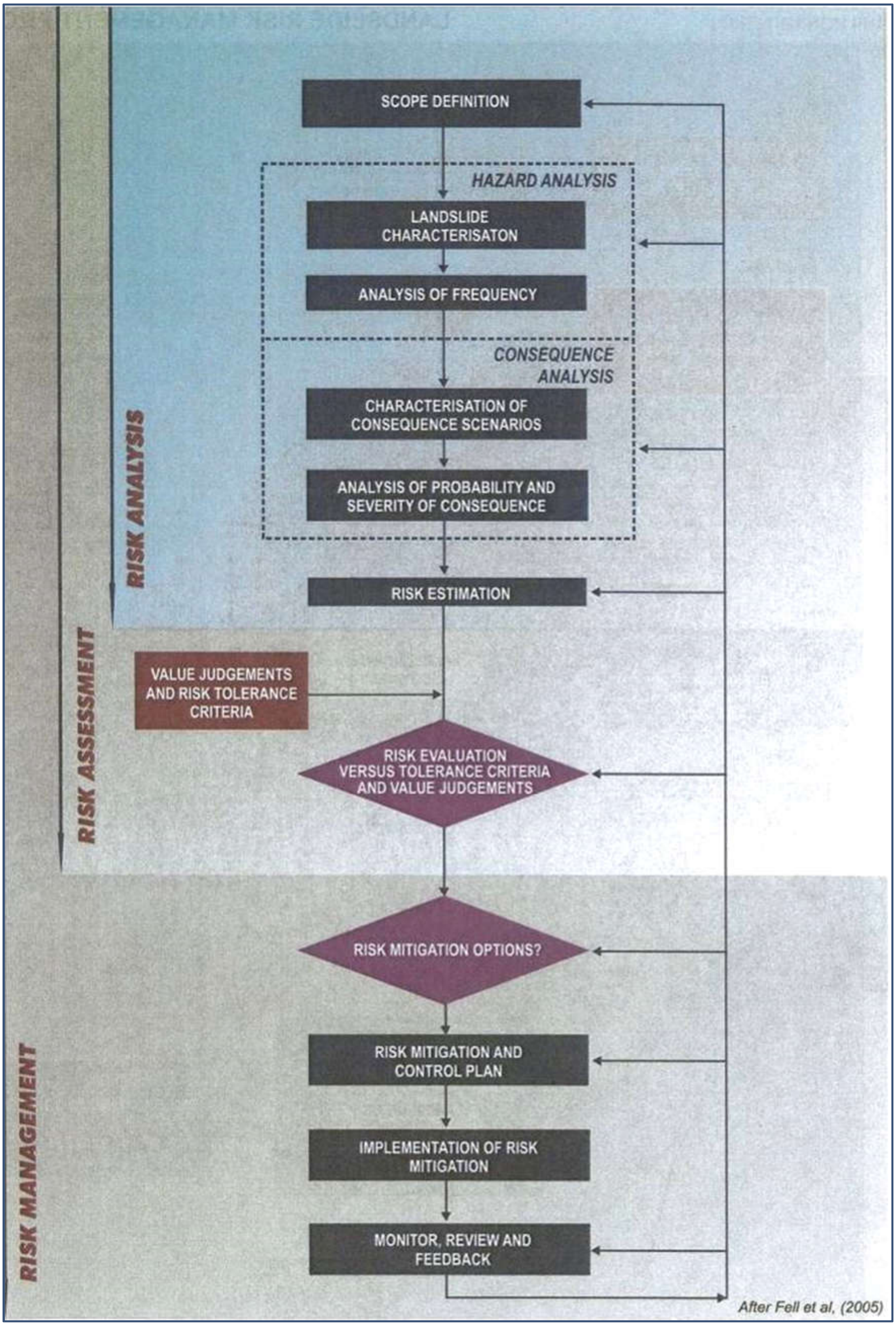


FIGURE A1: Flowchart for Landslide Risk Management.

This figure is an extract from GUIDELINE FOR LANDSLIDE SUSCEPTIBILITY, HAZARD AND RISK ZONING FOR LAND USE PLANNING, as presented in Australian Geomechanics Vol 42, No 1, March 2007, which discusses the matter more fully.

TABLE A1: LANDSLIDE RISK ASSESSMENT
QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	**Notional Boundary**					
10^{-1}	5×10^{-2}	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	5×10^{-3}	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	5×10^{-4}	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	5×10^{-5}	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	5×10^{-2}	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.

Extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in Australian Geomechanics, Vol 42, No 1, March 2007, which discusses the matter more fully.

TABLE A1: LANDSLIDE RISK ASSESSMENT
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) 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.

Extract from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in Australian Geomechanics, Vol 42, No 1, March 2007, which discusses the matter more fully.

AUSTRALIAN GEOGUIDE LR2 (LANDSLIDES)

What is a Landslide?

Any movement of a mass of rock, debris, or earth, down a slope, constitutes a "landslide". Landslides take many forms, some of which are illustrated. More information can be obtained from Geoscience Australia, or by visiting its Australian landslide Database at www.ga.gov.au/urban/factsheets/landslide.jsp. Aspects of the impact of landslides on buildings are dealt with in the book "Guideline Document Landslide Hazards" published by the Australian Building Codes Board and referenced in the Building Code of Australia. This document can be purchased over the internet at the Australian Building Codes Board's website www.abcb.gov.au.

Landslides vary in size. They can be small and localised or very large, sometimes extending for kilometres and involving millions of tonnes of soil or rock. It is important to realise that even a 1 cubic metre boulder of soil, or rock, weighs at least 2 tonnes. If it falls, or slides, it is large enough to kill a person, crush a car, or cause serious structural damage to a house. The material in a landslide may travel downhill well beyond the point where the failure first occurred, leaving destruction in its wake. It may also leave an unstable slope in the ground behind it, which has the potential to fall again, causing the landslide to extend (regress) uphill, or expand sideways. For all these reasons, both "potential" and "actual" landslides must be taken very seriously. The present a real threat to life and property and require proper management.

Identification of landslide risk is a complex task and must be undertaken by a geotechnical practitioner (GeoGuide LR1) with specialist experience in slope stability assessment and slope stabilisation.

What Causes a Landslide?

Landslides occur as a result of local geological and groundwater conditions, but can be exacerbated by inappropriate development (GeoGuide LR8), exceptional weather, earthquakes and other factors. Some slopes and cliffs never seem to change, but are actually on the verge of failing. Others, often moderate slopes (Table 1), move continuously, but so slowly that it is not apparent to a casual observer. In both cases, small changes in conditions can trigger a landslide with series consequences. Wetting up of the ground (which may involve a rise in groundwater table) is the single most important cause of landslides (GeoGuide LR5). This is why they often occur during, or soon after, heavy rain. Inappropriate development often results in small scale landslides which are very expensive in human terms because of the proximity of housing and people.

Does a Landslide Affect You?

Any slope, cliff, cutting, or fill embankment may be a hazard which has the potential to impact on people, property, roads and services. Some tell-tale signs that might indicate that a landslide is occurring are listed below:

- Open cracks, or steps, along contours
- Groundwater seepage, or springs
- Bulging in the lower part of the slope
- Hummocky ground
- trees leaning down slope, or with exposed roots
- debris/fallen rocks at the foot of a cliff
- tilted power poles, or fences
- cracked or distorted structures

These indications of instability may be seen on almost any slope and are not necessarily confined to the steeper ones (Table 1). Advice should be sought from a geotechnical practitioner if any of them are observed. Landslides do not respect property boundaries. As mentioned above they can "run-out" from above, "regress" from below, or expand sideways, so a landslide hazard affecting your property may actually exist on someone else's land.

Local councils are usually aware of slope instability problems within their jurisdiction and often have specific development and maintenance requirements. **Your local council is the first place to make enquiries if you are responsible for any sort of development or own or occupy property on or near sloping land or a cliff.**

TABLE 1 – Slope Descriptions

Appearance	Slope Angle	Maximum Gradient	Slope Characteristics
Gentle	0° - 10°	1 on 6	Easy walking.
Moderate	10° - 18°	1 on 3	Walkable. Can drive and manoeuvre a car on driveway.
Steep	18° - 27°	1 on 2	Walkable with effort. Possible to drive straight up or down roughened concrete driveway, but cannot practically manoeuvre a car.
Very Steep	27° - 45°	1 on 1	Can only climb slope by clutching at vegetation, rocks, etc.
Extreme	45° - 64°	1 on 0.5	Need rope access to climb slope.
Cliff	64° - 84°	1 on 0.1	Appears vertical. Can abseil down.
Vertical or Overhang	84° - 90±°	Infinite	Appears to overhang. Abseiler likely to lose contact with the face.

Some typical landslides which could affect residential housing are illustrated below:

Rotational or circular slip failures (Figure 1) - can occur on moderate to very steep soil and weathered rock slopes (Table 1). The sliding surface of the moving mass tends to be deep seated. Tension cracks may open at the top of the slope and bulging may occur at the toe. The ground may move in discrete "steps" separated by long periods without movement. More rapid movement may occur after heavy rain.

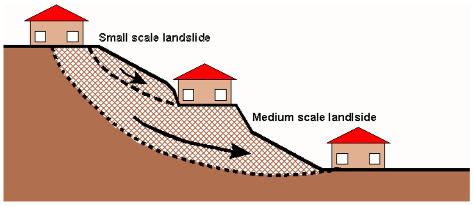


Figure 1

Translational slip failures (Figure 2) - tend to occur on moderate to very steep slopes (Table 1) where soil, or weak rock, overlies stronger strata. The sliding mass is often relatively shallow. It can move, or deform slowly (creep) over long periods of time. Extensive linear cracks and hummocks sometimes form along the contours. The sliding mass may accelerate after heavy rain.

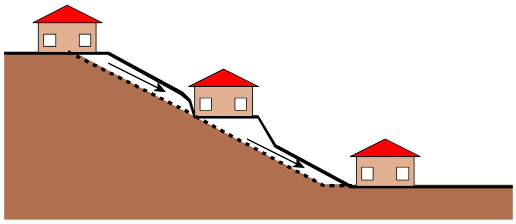


Figure 2

Wedge failures (Figure 3) - normally only occur on extreme slopes, or cliffs (Table 1), where discontinuities in the rock are inclined steeply downwards out of the face.

Rock falls (Figure 3) - tend to occur from cliffs and overhangs (Table 1).

Cliffs may remain, apparently unchanged, for hundreds of years. Collections of boulders at the foot of a cliff may indicate that rock falls are ongoing. Wedge failures and rock falls do not "creep". Familiarity with a particular local situation can instil a false sense of security since failure, when it occurs, is usually sudden and catastrophic.

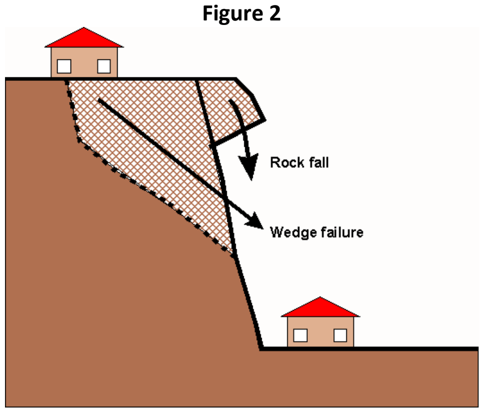


Figure 3

Debris flows and mud slides (Figure 4) - may occur in the foothills of ranges, where erosion has formed valleys which slope down to the plains below. The valley bottoms are often lined with loose eroded material (debris) which can "flow" if it becomes saturated during and after heavy rain. Debris flows are likely to occur with little warning; they travel a long way and often involve large volumes of soil. The consequences can be devastating.

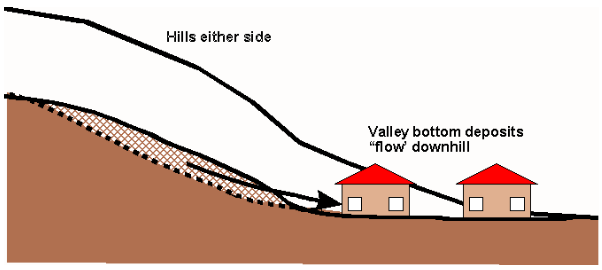


Figure 4

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR3 - Soil Slopes
- GeoGuide LR4 - Rock Slopes
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR8 - Hillside Construction
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

AUSTRALIAN GEOGUIDE LR7 (LANDSLIDE RISK)

Concept of Risk

Risk is a familiar term, but what does it really mean? It can be defined as *"a measure of the probability and severity of an adverse effect to health, property, or the environment."* This definition may seem a bit complicated. In relation to landslides, geotechnical practitioners (see GeoGuide LR1) are required to assess risk in terms of the likelihood that a particular landslide will occur and the possible consequences. This is called landslide risk assessment. The consequences of a landslide are many and varied, but our concerns normally focus on loss of, or damage to, property and loss of life.

Landslide Risk Assessment

Some local councils in Australia are aware of the potential for landslides within their jurisdiction and have responded by designating specific "landslide hazard zones". Development in these areas is normally covered by special regulations. If you are contemplating building, or buying an existing house, particularly in a hilly area, or near cliffs, then go first for information to your local council.

Landslide risk assessment must be undertaken by a geotechnical practitioner. It may involve visual inspection, geological mapping, geotechnical investigation and monitoring to identify:

- potential landslides (there may be more than one that could impact on your site);
- the likelihood that they will occur;
- the damage that could result;
- the cost of disruption and repairs; and
- the extent to which lives could be lost.

Risk assessment is a predictive exercise, but since the ground and the processes involved are complex, prediction tends to lack precision. If you commission a landslide risk assessment for a particular site you should expect to receive a report prepared in accordance with current professional guidelines and in a form that is acceptable to your local council, or planning authority.

Risk to Property

Table 1 indicates the terms used to describe risk to property. Each risk level depends on an assessment of how likely a landslide is to occur and its consequences in dollar terms. "Likelihood" is the chance of it happening in any one year, as indicated in Table 2. "Consequences" are related to the cost of the repairs and temporary loss of use if the landslide occurs. These two factors are combined by the geotechnical practitioner to determine the Qualitative Risk.

TABLE 2 – LIKELIHOOD

Likelihood	Annual Probability
Almost Certain	1:10
Likely	1:100
Possible	1:1,000
Unlikely	1:10,000
Rare	1:100,000
Barely credible	1:1,000,000

The terms "unacceptable", "may be tolerable" etc. in Table 1 indicate how most people react to an assessed risk level. However, some people will always be more prepared, or better able, to tolerate a higher risk level than others.

Some local councils and planning authorities stipulate a maximum tolerable risk level of risk to property for developments within their jurisdictions. In these situations the risk must be assessed by a geotechnical practitioner. If stabilisation works are needed to meet the stipulated requirements these will normally have to be carried out as part of the development, or consent will be withheld.

TABLE 1 – RISK TO PROPERTY

Qualitative Risk		Significance - Geotechnical engineering requirements
Very high	VH	**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 the value of the property.
High	H	**Unacceptable** without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable level. Work would cost a substantial sum in relation to the value of the property.
Moderate	M	**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 possible.
Low	L	**Usually acceptable** to regulators. Where treatment has been needed to reduce the risk to this level, ongoing maintenance is required.
Very Low	VL	**Acceptable**. Manage by normal slope maintenance procedures.

Risk to Life

Most of us have some difficulty grappling with the concept of risk and deciding whether, or not, we are prepared to accept it. However, without doing any sort of analysis, or commissioning a report from an "expert", we all take risks every day. One of them is the risk of being killed in an accident. This is worth thinking about, because it tells us a lot about ourselves and can help to put an assessed risk into a meaningful context. By identifying activities that we either are, or are not, prepared to engage in, we can get some indication of the maximum level of risk that we are prepared to take. This knowledge can help us to decide whether we really are able to accept a particular risk, or to tolerate a particular likelihood of loss, or damage, to our property (Table 2).

In Table 3, data from NSW for the years 1998 to 2002, and other sources, is presented. A risk of 1 in 100,000 means that, in any one year, 1 person is killed for every 100,000 people undertaking that particular activity. The NSW data assumes that the whole population undertakes the activity. That is, we are all at risk of being killed in a fire, or of choking on our food, but it is reasonable to assume that only people who go deep sea fishing run a risk of being killed while doing it.

It can be seen that the risks of dying as a result of falling, using a motor vehicle, or engaging in water-related activities (including bathing) are all greater than 1:100,000 and yet few people actively avoid situations where these risks are present. Some people are averse to flying and yet it represents a lower risk than choking to death on food. The data also indicate that, even when the risk of dying as a consequence of a particular event is very small, it could still happen to any one of us today. If this were not so, there would be no risk at all and clearly that is not the case.

In NSW, the planning authorities consider that 1:1,000,000 is the maximum tolerable risk for domestic housing built near an obvious hazard, such as a chemical factory. Although not specifically considered in the NSW guidelines there is little difference between the hazard presented by a neighbouring factory and a landslide: both have the capacity to destroy life and property and both are always present.

TABLE 3 – RISK TO LIFE

Risk (deaths per participant per year)	**Activity/Event Leading to Death** (NSW data unless noted)
1:1,000	Deep sea fishing (UK)
1:1,000 to 1:10,000	Motor cycling, horse riding, ultra-light flying (Canada)
1:23,000	Motor vehicle use
1:30,000	Fall
1:70,000	Drowning
1:180,000	Fire/burn
1:660,000	Choking on food
1:1,000,000	Scheduled airlines (Canada)
1:2,300,000	Train travel
1:32,000,000	Lightning strike

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR3 - Soil Slopes
- GeoGuide LR4 - Rock Slopes
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR8 - Hillside Construction
- GeoGuide LR9 - Effluent & Surface Water Disposal
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APPENDIX B

SOME GUIDELINES

FOR

HILLSIDE CONSTRUCTION

SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

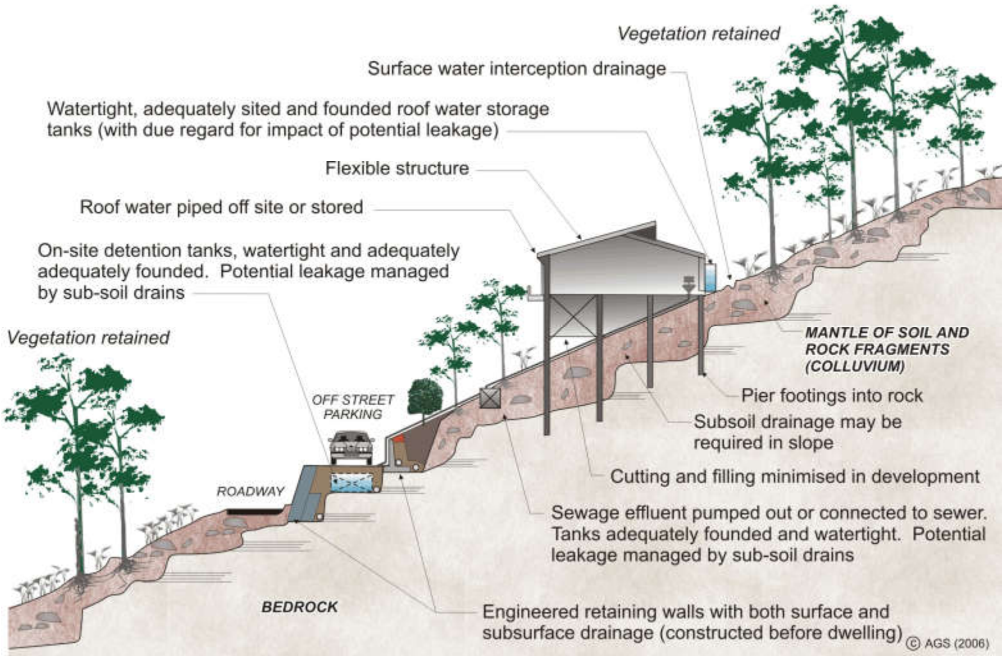
	GOOD ENGINEERING PRACTICE	POOR ENGINEERING PRACTICE
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical consultant at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having 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.	Indiscriminant 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 properties 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 bedrock 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 bedrock 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 generous 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 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 of roof run-off 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 of 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 a 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 seek advice. If seepage observed, determine cause or seek advice on consequences.	

This table is extracted from PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT as presented in *Australian Geomechanics*, Vol 42, No 1, March 2007 which discusses the matter more fully.

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.

EXAMPLES FOR GOOD HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that due to level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfill the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

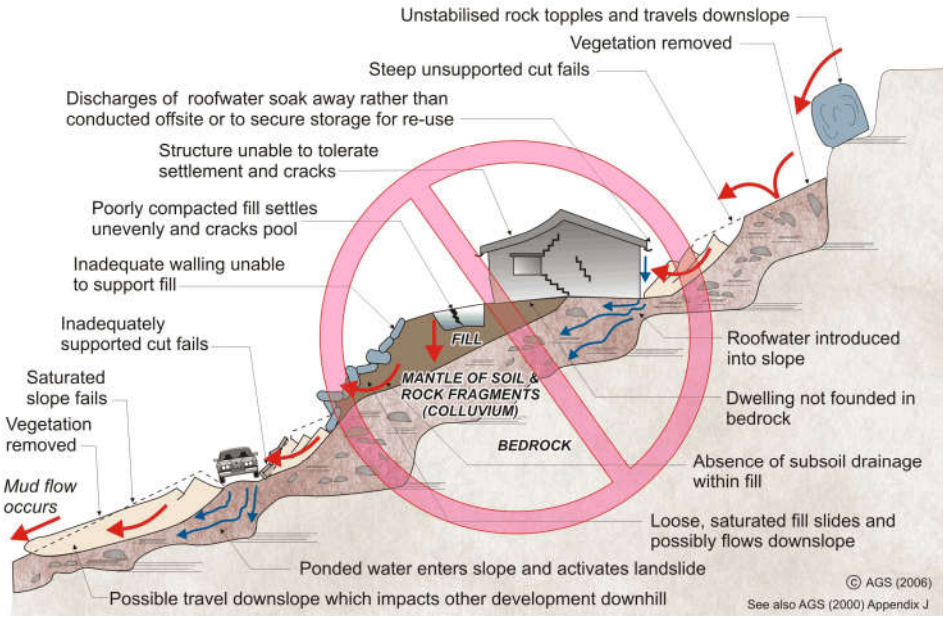
Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES

EXAMPLES FOR **POOR** HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soaks into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herringbone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

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APPENDIX C

G. GENERAL NOTES

G1. These notes shall be read in conjunction with all engineering drawings, the contract specification and other written instruction as may be issued. In case of discrepancy, precedence is given to drawings, notes, then specification.

G2. These drawings shall not be used for committing to material orders, or construction until authorized and issued for construction.

G3. Definitions:
UNO = Unless noted otherwise
Engineer = Nominated representative of Grounded Engineering
Principal = Chris Mould

G4. Unless noted therwise:
All dimensions are given in millimetres
All co-ordinates are to map grid Australia (MGA)
All levels are given to Australian Height datum (AHD)

G5. All dimensions relevant to setting out and off site work shall be verified by the contractor before construction and fabrication is commenced.

G6. Do not obtain dimensions by scaling from drawings.

G7. Refer all discrepancies to the principal for resolution before proceeding with work.

G8. Workmanship and materials shall be in accordance with the contract specifications, Australian standards (including all amendments), codes of practice and the requirements of any other relevant statutory authorities. All of the above documents are those current (as verified by the contract documents) at the commencement of the contract.

M. STRUCTURAL STEEL NOTES

M1. All workmanship and material shall be in accordance with the contract specification, AS 5100 and AS 1554 except where verified by the contract documents.

M2. Steel components shall conform to the following table UNO

Plate	AS 3678	GRADE 350
Hot rolled sections	AS 3679	GRADE 300 PLUS
CHS >80mm diametre	AS1163	GRADE C350
Iso metric nuts and bolts	AS1111 & AS1112	
High strength steel bolts	AS1252	

M3. Provide steel members made from whole lengths wherever possible. If necessary, make lengths up of sections joined by complete penetration full strength butt welds ground flush. Where proposed, show joints on shop drawings. Ensure members are concentric at connections (gravity or guage lines to intersect)UNO.
Accurately pre form parts to avoid force and /or restraint during joining.

M4. Welds are to be full penetration butt welds where specified
Fillet Welds are to be 6mm continuous using E48XX electrodes or equivalent.

M5. Structural Steel Members must be protected against corrosion in accordance with Table 3.4.4.2 of the BCA.

BOLTING NOTES

M6. UNO connections between two structural steel members shall have a minimum of 2/M16 8.8/S Galvanised bolts in 18mm diameter holes

M7. Bolt type and tightening procedure are designated:
Number - size - strength - grade / tightening procedures
eg. 4-M24 8.8/TB = 4 of 24mm diameter metric high strength structural bolts fully tensioned in bearing mode

M8. The bolting procedure is designated as follows:

4.6/S	Commercial bolts of strength grade 4.6 to AS 1111 tightened using a standard wrench to a snug tight condition.
8.8/S	High strength bolts of strength grade 8.8 to AS 1252 tightened using a standard wrench to a snug tight condition.
8.8/TF	High strength bolts of strength grade 8.8 to AS 1252 fully tensioned to AS 4100 designed as a friction type joint.
8.8/TB	High strength bolts of strength grade 8.8 to AS 1252 fully tensioned to AS 4100 designed as a bearing type joint.

M9. Holding down bolts to be grade 4.6. UNO supply holding down bolts with two class 5 hexagonal head nuts and two extra large flat washers. Hot dip galvanize holding down bolts, nuts and washers to AS 1214. Tie holding down bolt groups rigidly together prior to installation to ensure correct bolt location.

C. CONCRETE NOTES

C1. All workmanship and materials shall be in accordance with AS 3600, AS 3610 and the contract specification.

C2. Where the meaning of abbreviations used is uncertain, refer to engineer for clarification prior to proceeding.

C3. Unless noted otherwise all cement shall comply with AS 3972:

GP	General purpose cement
GB	General purpose blended cement
SR	Sulphate resistant cement

C5. Concrete shall be nominal class concrete in accordance with AS 3600 and AS 1379 and the following requirements:

Structural element	Concrete Grade	Exposure Class	Cement Type
New entry Pavement	N40	B1	GP
Insitu slab & footings	N32	B1	GP

C11. Footings and slabs-on-ground shall have the following minimum concrete cover to all reinforcement:
- 40mm to unprotected ground and externally exposed surface
- 30mm to a membrane in contact with the ground
- 25mm to an internal surface

C12. External elements are those exposed to weather, rain and water penetration and classified B1 UNO.

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Email: paul@groundedeng.com
Mobile: 0429 071 387

Certification & Site Parameters

Design Loads in accordance with
AS1170.1 - Live loads
AS1170.2 - Wind loads
AS1170.3 - Snow loads

Wind Class: Vu = 50m/s - N3 (W41N)
Site Soil Class: S
Altitude: 1408m AHD
Ground Snow Load: 8.6 KPa

Designed: Paul Larkin
Design Checked By:

ANSARY CONSULTING ENGINEERS
Tarek El-Ansary
BE(Civil) MEngSc(Civil) MIEAust CPEng.

Signed: Date: 5 May 2020

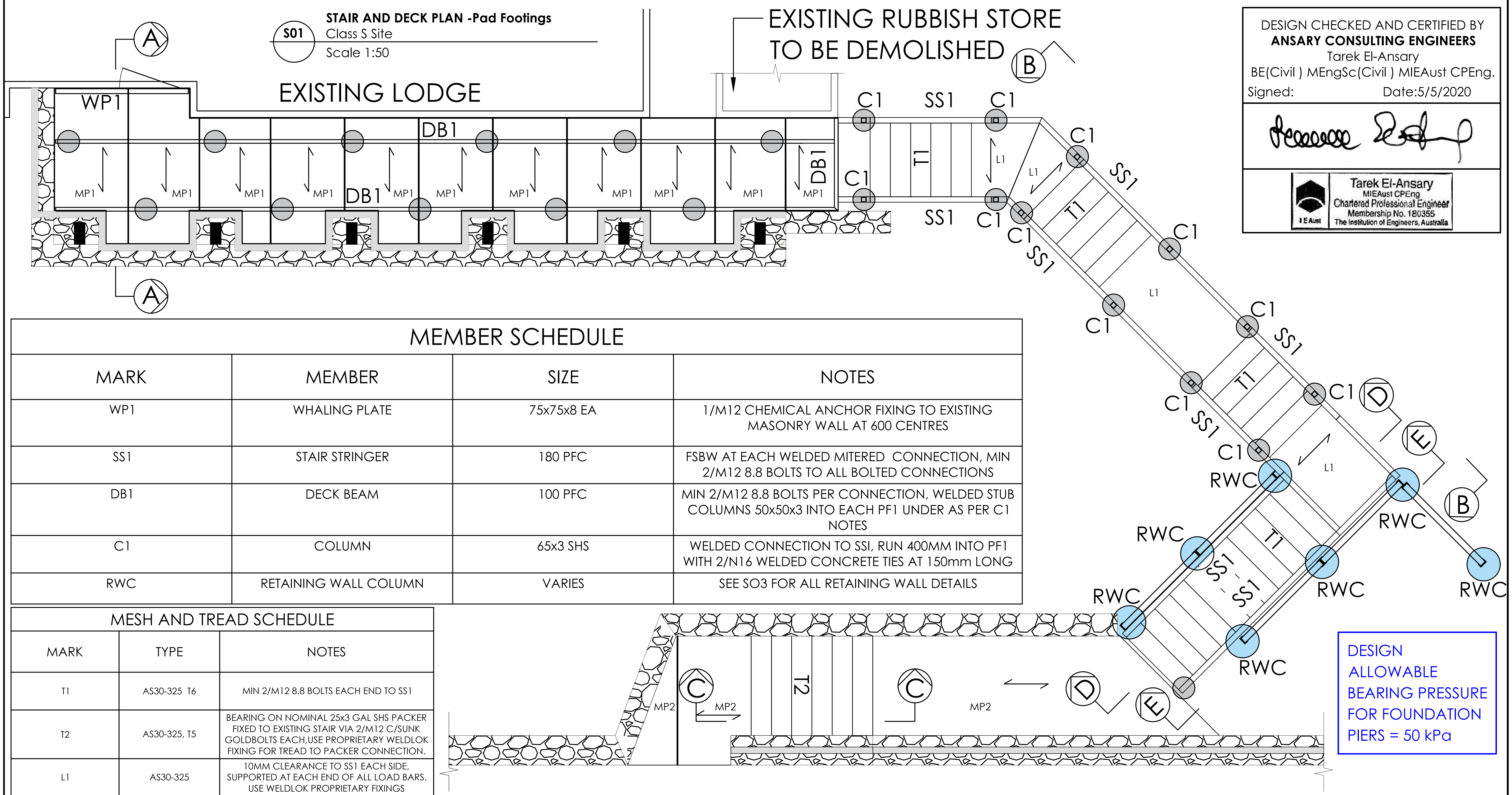
Tarek El-Ansary
MIEAust CPEng
Chartered Professional Engineer
Membership No. 180355
I E Aust
The Institution of Engineers, Australia

Project / Client:
Munjarra lodge stair replacement
lot 704 Bobuck lane Thredbo
Munjarra lodge

Drawing Title:
Cover Sheet

Drawn By:
S.Wakeford
0429 071 387

Checked :	Sheet 1 of 5
DATE: 20-3-2020	SCALE: N/A
DWG # :S00	SIZE: A3
Revision: A	AS 1100



DESIGN CHECKED AND CERTIFIED BY
ANSARY CONSULTING ENGINEERS
Tarek El-Ansary
BE(Civil) MEngSc(Civil) MIEAust CPEng.
Signed: Date:5/5/2020

Tarek El-Ansary
MIEAust CPEng
Chartered Professional Engineer
Membership No. 180355
The Institution of Engineers, Australia

MEMBER SCHEDULE

MARK	MEMBER	SIZE	NOTES
WP1	WHALING PLATE	75x75x8 EA	1/M12 CHEMICAL ANCHOR FIXING TO EXISTING MASONRY WALL AT 600 CENTRES
SS1	STAIR STRINGER	180 PFC	FSBW AT EACH WELDED MITERED CONNECTION, MIN 2/M12 8.8 BOLTS TO ALL BOLTED CONNECTIONS
DB1	DECK BEAM	100 PFC	MIN 2/M12 8.8 BOLTS PER CONNECTION, WELDED STUB COLUMNS 50x50x3 INTO EACH PF1 UNDER AS PER C1 NOTES
C1	COLUMN	65x3 SHS	WELDED CONNECTION TO SSI, RUN 400MM INTO PF1 WITH 2/N16 WELDED CONCRETE TIES AT 150mm LONG
RWC	RETAINING WALL COLUMN	VARIES	SEE SO3 FOR ALL RETAINING WALL DETAILS

MESH AND TREAD SCHEDULE

MARK	TYPE	NOTES
T1	AS30-325 T6	MIN 2/M12 8.8 BOLTS EACH END TO SS1
T2	AS30-325, T5	BEARING ON NOMINAL 25x3 GAL SHS PACKER FIXED TO EXISTING STAIR VIA 2/M12 C/SUNK GOLDBOLTS EACH,USE PROPRIETARY WELDLOK FIXING FOR TREAD TO PACKER CONNECTION.
L1	AS30-325	10MM CLEARANCE TO SS1 EACH SIDE, SUPPORTED AT EACH END OF ALL LOAD BARS. USE WELDLOK PROPRIETARY FIXINGS
MP1	AS30-325	FIX TO DB1 WITH PROPRIETARY WELDLOK FIXINGS, MAX CANTILEVER FROM BEARER 350mm IN SPAN DIRECTION
MP2	BS30-325	BEARING ON NOMINAL 25x3 SHS PACKERS RUNNING FULL LENGTH PERPENDICULAR TO MESH SPAN DIRECTION, FIX PACKERS TO CONCRETE WITH M12 C/SUNK GOLDBOLTS AT 900 CENTRES.
⟷	SPAN DIRECTION	DENOTED THE SPAN DIRECTION OF LOAD BARS IN MESH PANEL

DESIGN
ALLOWABLE
BEARING PRESSURE
FOR FOUNDATION
PIERS = 50 kPa

FOUNDATION SCHEDULE

MARK	SIZE	NOTES
● (grey)	300 DIAMETER	UNREINFORCED CONCRETE MINIMUM 25 MPa, PIERS MUST SOCKET MINIMUM 200MM INTO UNDISTURBED DECOMPOSED GRANITE
● (blue)	450 DIAMETER	UNREINFORCED CONCRETE MINIMUM 25 MPa, PIER DEPTH WILL VARY ACORDING TO HEIGHT OF WALL, SEE SO3 FOR FULL DETAIL

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LOT 704 BOBUCK LANE THREDBO
NSW 2625
Client: MUNJARRA LODGE ROB FRASER

Draftsman: S.WAKEFORD
Contact: 0429 071 387
Checked: TEA
DATE: 20-03-20

Drawing Title:
STAIR AND MESH PLAN
Drawing Number: S01
Revision: A
Sheet 2 of 5

AS 1100
SIZE: A3
SCALE: 1:50 UNO

WALL SCHEDULE		
HEIGHT (mm)	CENTRE COLUMN	END COLUMN
1500 - 1800	150 UC 23.4	150 PFC

DESIGN CHECKED AND CERTIFIED BY
ANSARY CONSULTING ENGINEERS
Tarek El-Ansary
BE(Civil) MEngSc(Civil) MIEAust CPEng.

Signed: Date:5/5/2020

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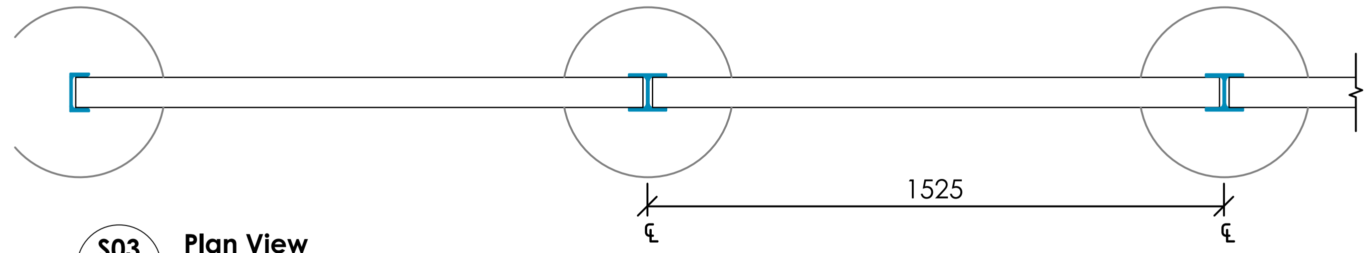
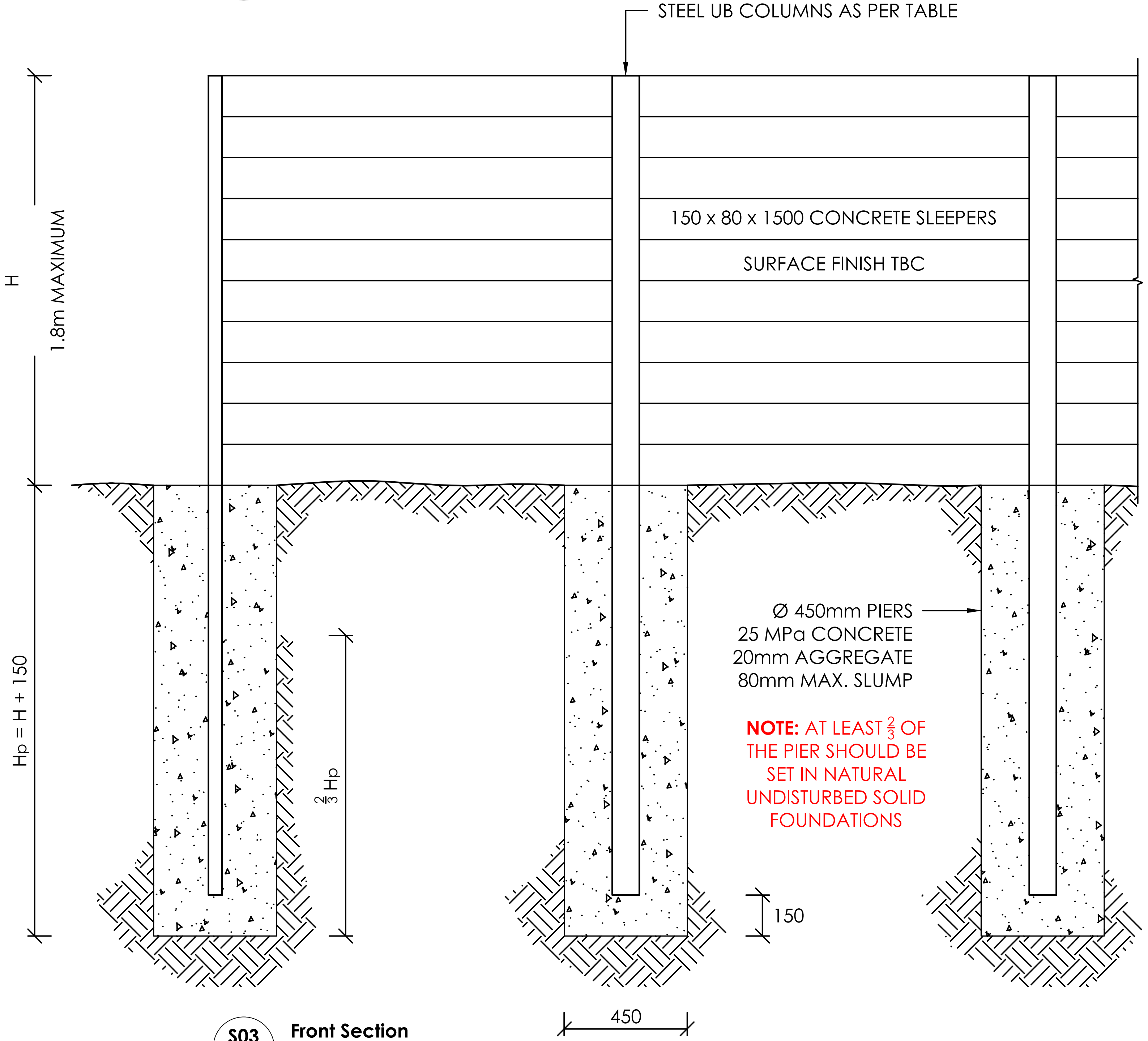
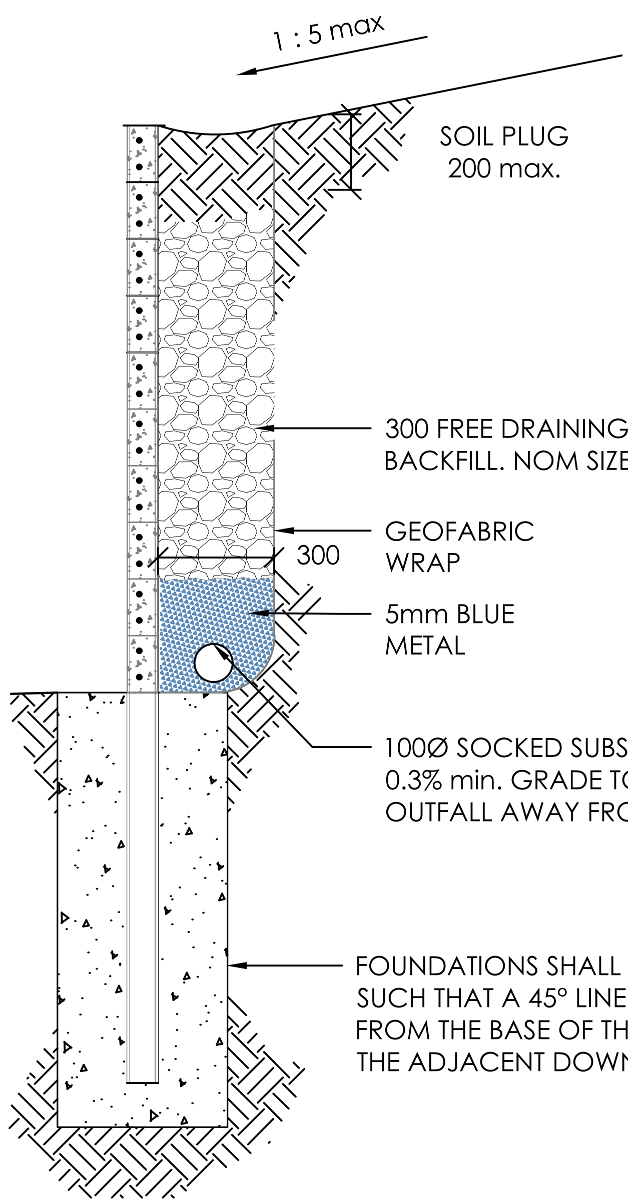


S03 **Plan View**
Scale 1:20



S03 **Front Section**
Scale 1:20



S03 **Side Section**
Scale 1:20

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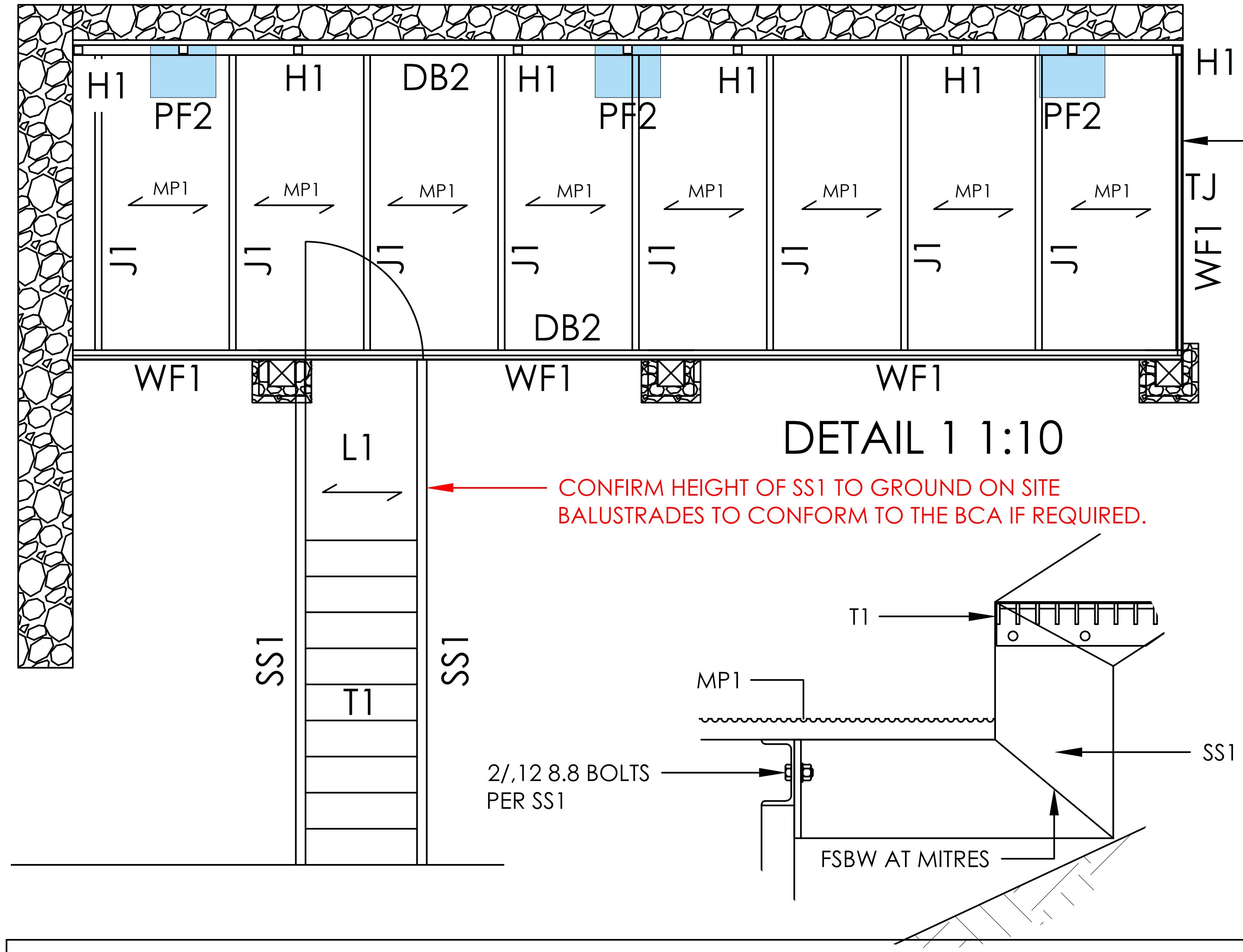
Client: MUNJARRA LODGE ROB FRASER

Draftsman: S.WAKEFORD
Contact: 0429 071 387
Checked: TEA DATE: 20-3-20

Drawing Title:
RETAINING WALL DETAILS

Drawing Number: S03 Revision: A Sheet 4 of 5

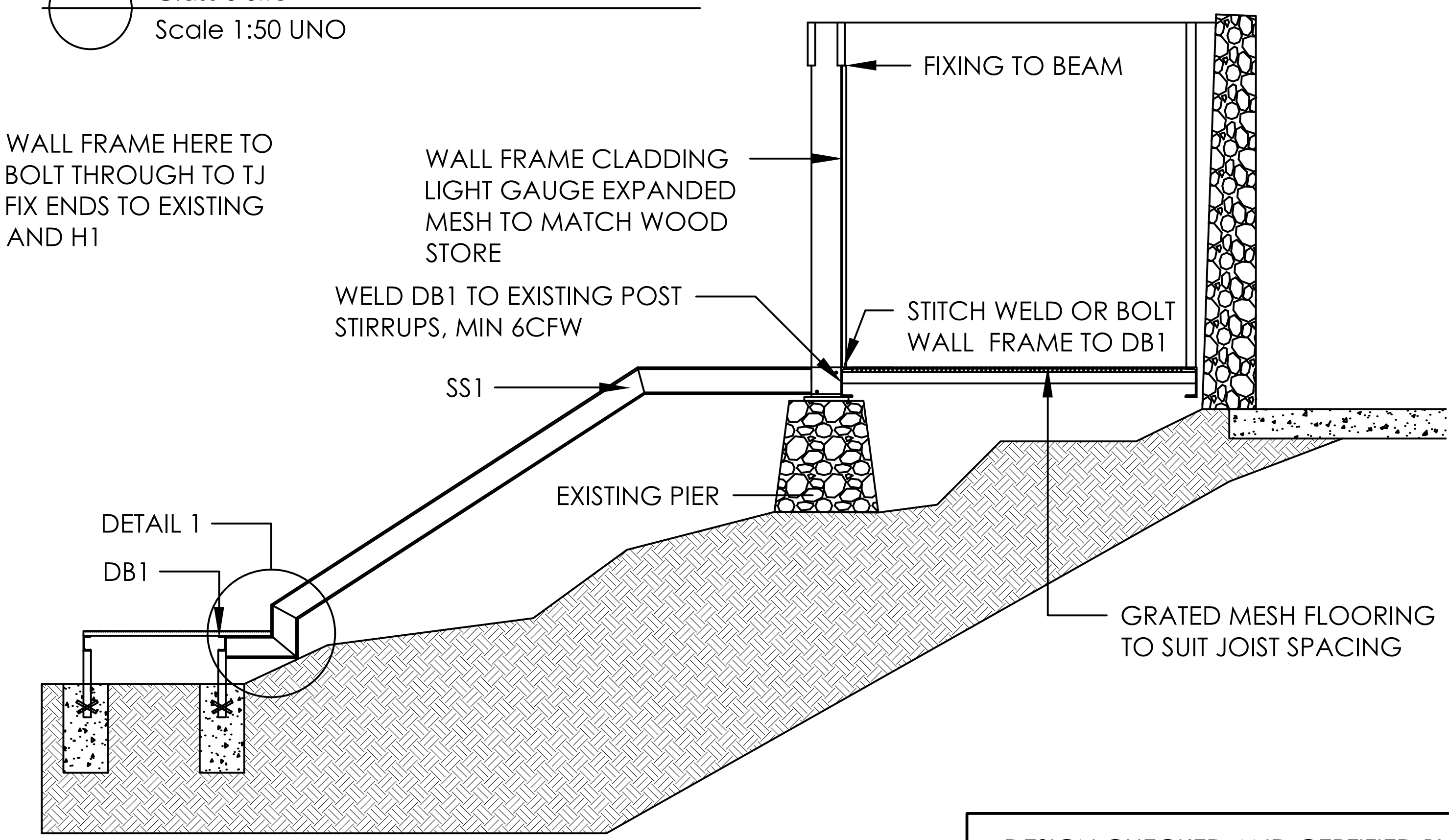
AS 1100
SIZE: A3
SCALE: VARIES



BIKE STORAGE CAGE,PLAN AND ELEVATION

S04 Class S Site

Scale 1:50 UNO



DESIGN CHECKED AND CERTIFIED BY
ANSARY CONSULTING ENGINEERS
Tarek El-Ansary
BE(Civil) MEngSc(Civil) MIEAust CPEng.
Signed: Date:5/5/2020

Tarek El-Ansary
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DESIGN
ALLOWABLE
BEARING PRESSURE
FOR FOUNDATION
PIERS = 50 kPa

MEMBER SCHEDULE

MARK	MEMBER	SIZE	NOTES
PF2	PAD FOOTING	500 x 400 x 500 DEEP (NOM)	SOCKET INTO UNDISTURBED DECOMPOSED GRANITE. 75 x 3 SHS COLUMN WITH 8mm BASE PLATE & 2 M12 CHEMSTUDS TO PF2.
SS1	STAIR STRINGER	180 PFC	FSBW AT EACH WELDED MITERED CONNECTION, MIN 2/M12 8.8 BOLTS TO ALL BOLTED CONNECTIONS
DB2	DECK BEAM	200 PFC	MIN 2/M12 8.8 BOLTS PER CONNECTION, 6CFW TO EXISTING PIERS WHERE SPECIFIED
H1	HANGER	65x2 SHS	MIN 2/M12 8.8 BOLTS PER CONNECTION, JOIST HANGERS TO HAVE MIN 6mm PLATE TO EITHER SIDE OF JOIST WITH 2/M12 BOLTS THROUGH
J1	JOIST	75x50x6 UA	MIN 2/M12 BOLTS PER CONNECTION
TJ	TRIMER JOIST	75x50x8 UA	WELDED TO DB2 MEMBERS
WF1	WALL FRAME	30X2 SHS	600mm MAXIMUM STUD CENTERS, BOTTOM PLATE TO BE FIXED TO DB2 1/M12 BOLT AT 600 CENTERS OR STITCH WELDED, TOP PLATE ATTACHED TO EXISTING TIMBER BEAM,2/T17 BATTEN SCREWS THROUGH 6MM PLATES AT 600 CENTRES

MESH AND TREAD SCHEDULE

MARK	TYPE	NOTES
T1	AS30-325 T6	MIN 2/M12 8.8 BOLTS EACH END TO SS1
L1	AS30-325	10MM CLEARANCE TO SS1 EACH SIDE, SUPPORTED AT EACH END OF ALL LOAD BARS. USE WELDLOK PROPRIETARY FIXINGS
MP1	AS30-325	FIX TO DB1 WITH PROPRIETARY WELDLOK FIXINGS, MAX CANTILEVER FROM BEARER 350mm IN SPAN DIRECTION
⟷	SPAN DIRECTION	DENOTES THE SPAN DIRECTION OF LOAD BARS IN MESH PANEL

GROUNDED
STRUCTURAL ENGINEERING AND DRAFTING SERVICES
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LOT 704 BOBUCK LANE
THREDBO NSW 2625

Client: MUNJARRA LODGE ROB FRASER

Draftsman: S.WAKEFORD
Contact: 0429 071 387
Checked: TEA DATE: 20-3-20

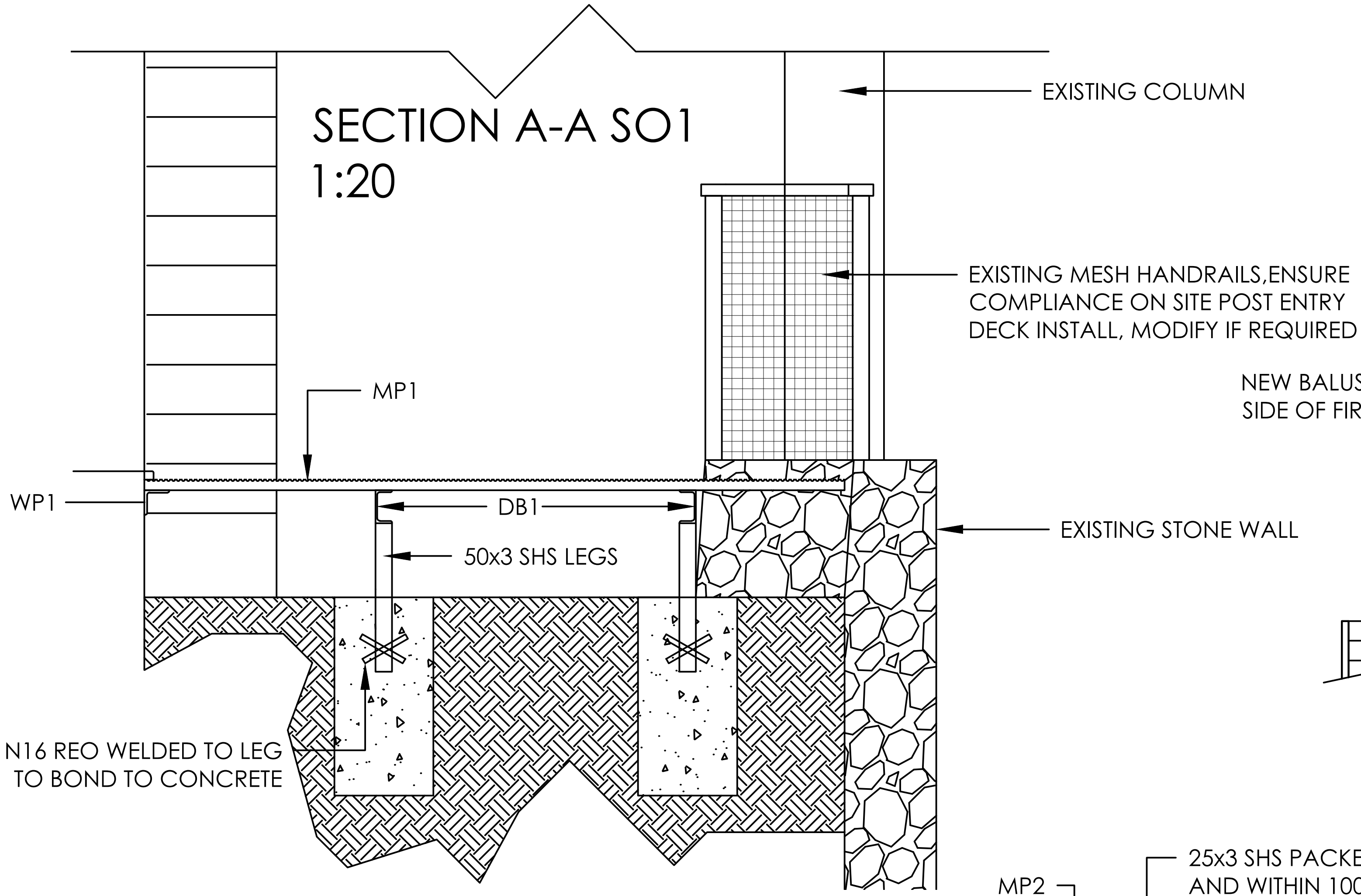
Drawing Title: BIKE STORAGE CAGE

Drawing Number: S04 Revision: A Sheet 5 of 5

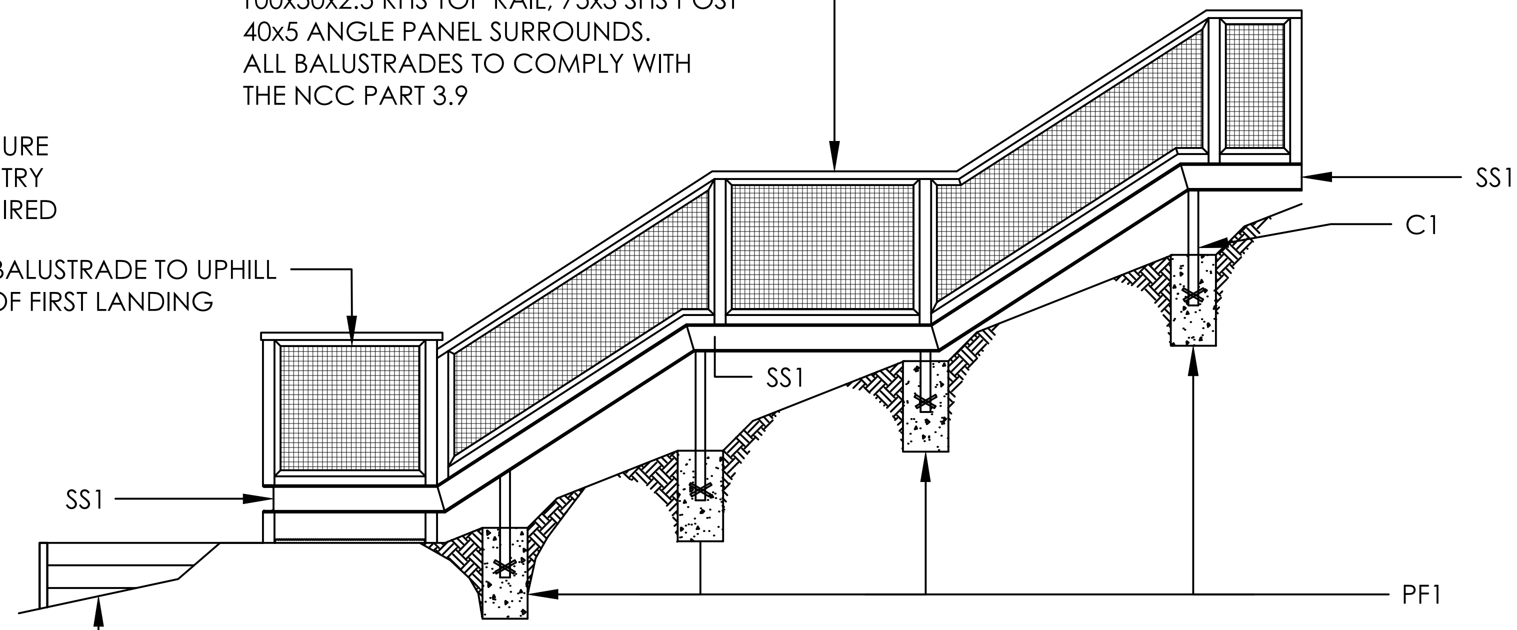
AS 1100 SIZE: A3 SCALE: VARIES

STAIR ELEVATIONS AND SECTIONS
S02
Class S Site
Scale 1:50 UNO

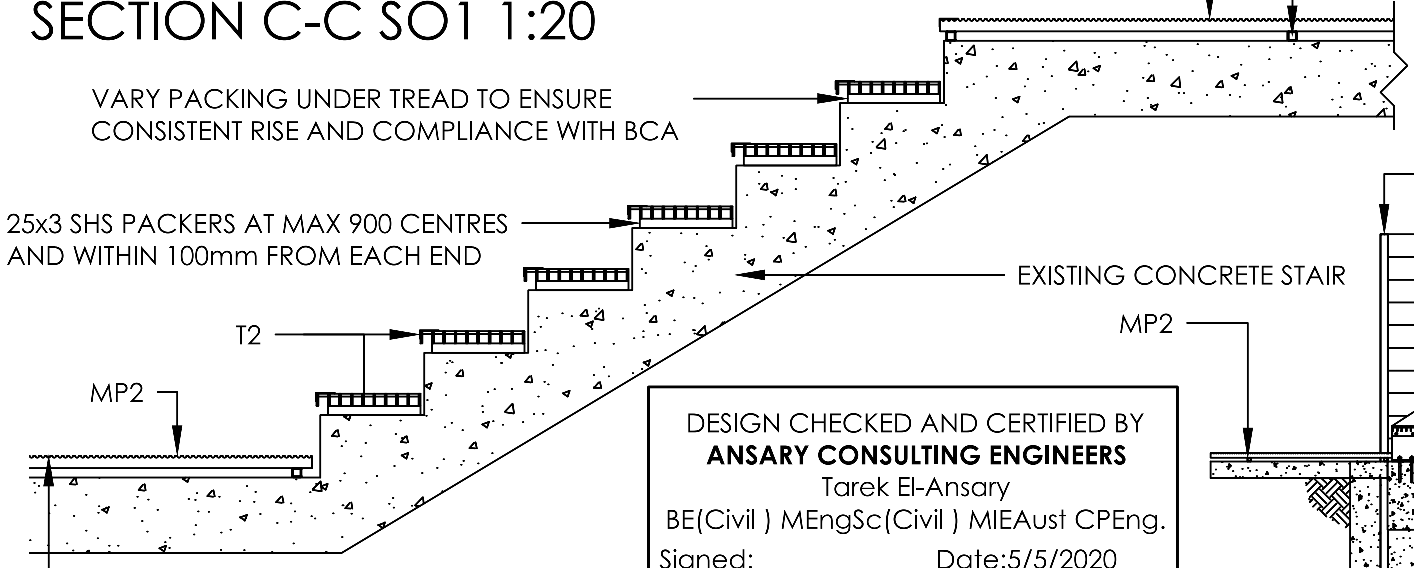
SECTION A-A SO1 1:20



ELEVATION B-B SO1 1:50



SECTION C-C SO1 1:20



NOTE: EXTERNAL STAIRS ALL HAVE SLIP RESISTANT TREADS IN ACCORDANCE WITH AS4586 AND THE NCC.
BALUSTRADES SHALL COMPLY WITH THE NCC PART 3.9.

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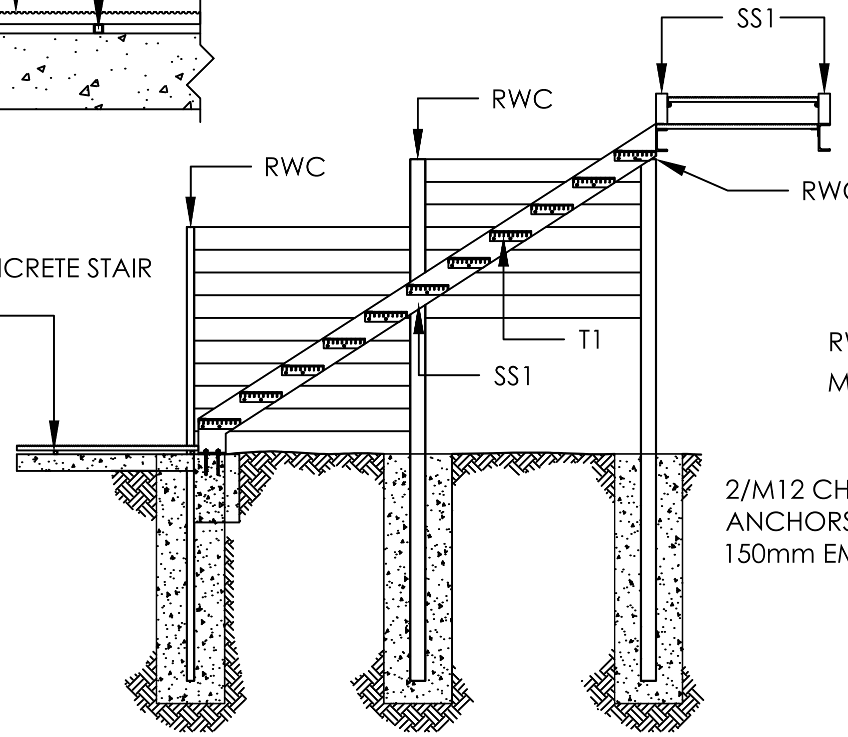
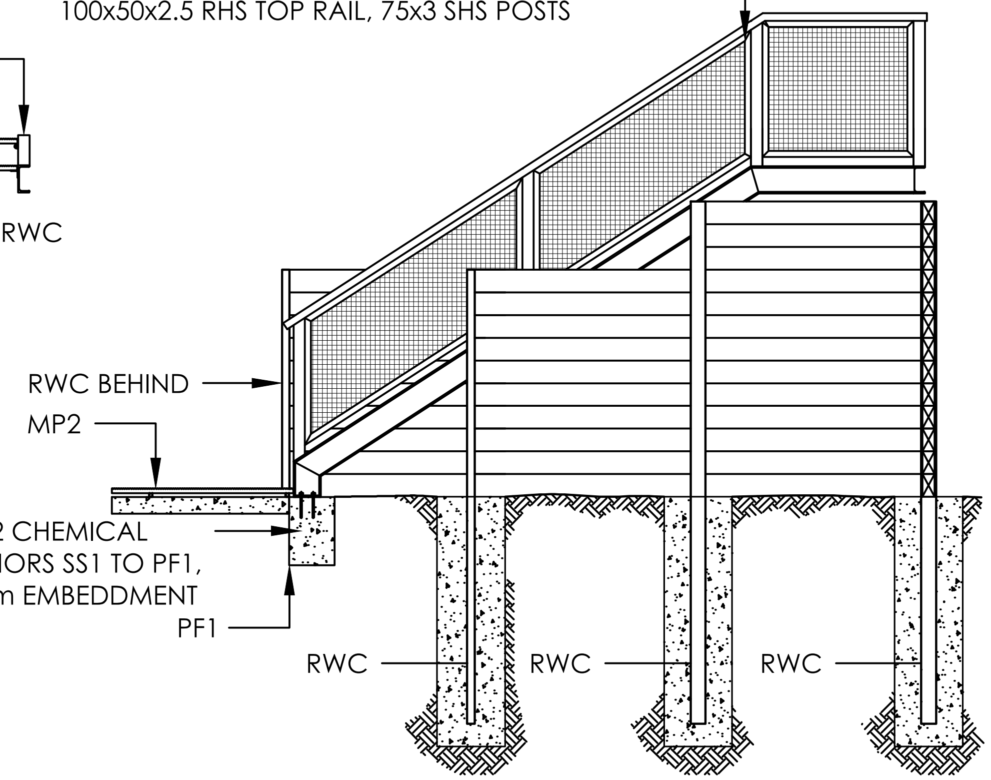
SECTION D-D SO1 1:50



ELEVATION E-E SO1 1:50



GROUNDED STRUCTURAL ENGINEERING AND DRAFTING SERVICES Director: PAUL LARKIN Email: paul@groundedeng.com Mobile: 0429 071 387 PO Box 220 Jindabyne NSW 2627	Project: MUNJARRA LODGE STAIR REFURB LOT704 BOBUCK LANE THREDBO NSW 2625 Client: MUNJARRA LODGE ROB FRASER	Draftsman: S.WAKEFORD Contact: 0429 071 387 Checked: TEA DATE: 20-3-20	Drawing Title: STAIR ELEVATIONS AD SECTIONS Drawing Number: SO2 Revision: A Sheet 3 of 5 AS 1100 SIZE: A3 SCALE: VARIES

REPORT EXPLANATION NOTES

INTRODUCTION

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

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726:2017 *'Geotechnical Site Investigations'*. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached soil classification table qualified by the grading of other particles present (eg. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	< 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 to 2.36mm
Gravel	2.36 to 63mm
Cobbles	63 to 200mm
Boulders	> 200mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose (VL)	< 4
Loose (L)	4 to 10
Medium dense (MD)	10 to 30
Dense (D)	30 to 50
Very Dense (VD)	> 50

Cohesive soils are classified on the basis of strength (consistency) either by use of a hand penetrometer, vane shear, laboratory testing and/or tactile engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength (kPa)	Indicative Undrained Shear Strength (kPa)
Very Soft (VS)	≤ 25	≤ 12
Soft (S)	> 25 and ≤ 50	> 12 and ≤ 25
Firm (F)	> 50 and ≤ 100	> 25 and ≤ 50
Stiff (St)	> 100 and ≤ 200	> 50 and ≤ 100
Very Stiff (VSt)	> 200 and ≤ 400	> 100 and ≤ 200
Hard (Hd)	> 400	> 200
Friable (Fr)	Strength not attainable – soil crumbles	

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, 'shale' is used to describe fissile mudstone, with a weakness parallel to bedding. Rocks with alternating inter-laminations of different grain size (eg. siltstone/claystone and siltstone/fine grained sandstone) is referred to as 'laminite'.

SAMPLING

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

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shrink-swell behaviour, strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All methods except test pits, hand auger drilling and portable Dynamic Cone Penetrometers require the use of a mechanical rig which is commonly mounted on a truck chassis or track base.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils and 'weaker' bedrock if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for a large excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Refusal of the hand auger can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and 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 by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of limited reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table.

Rock Augering: Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock cuttings. This method of investigation is quick and relatively inexpensive but provides only an indication of the likely rock strength and predicted values may be in error by a strength order. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is usually 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 assessed from the cuttings, together with some information from "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term 'mud' encompasses a range of products ranging from bentonite to polymers. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg. from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, NMLC or HQ triple tube core barrels, which give a core of about 50mm and 61mm diameter, respectively, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as NO CORE. The location of NO CORE recovery is determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the bottom of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils, as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289.6.3.1–2004 (R2016) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – Standard Penetration Test (SPT)'*.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63.5kg 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 blows, as

  N = 13
  4, 6, 7

- In a 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, as

  N > 30
  15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

A modification to the SPT is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as 'N_c' on the borehole logs, together with the number of blows per 150mm penetration.

Cone Penetrometer Testing (CPT) and Interpretation: The cone penetrometer is sometimes referred to as a Dutch Cone. The test is described in Australian Standard 1289.6.5.1–1999 (R2013) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Static Cone Penetration Resistance of a Soil – Field Test using a Mechanical and Electrical Cone or Friction-Cone Penetrometer'*.

In the tests, a 35mm or 44mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm or 165mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck. The CPT does not provide soil sample recovery.

As penetration occurs (at a rate of approximately 20mm per second), the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa. There are two scales presented for the cone resistance. The lower scale has a range of 0 to 5MPa and the main scale has a range of 0 to 50MPa. For cone resistance values less than 5MPa, the plot will appear on both scales.
- 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 as a percentage.

  The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between CPT and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of CPT values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

There are limitations when using the CPT in that it may not penetrate obstructions within any fill, thick layers of hard clay and very dense sand, gravel and weathered bedrock. Normally a 'dummy' cone is pushed through fill to protect the equipment. No information is recorded by the 'dummy' probe.

Flat Dilatometer Test: The flat dilatometer (DMT), also known as the Marchetti Dilometer comprises a stainless steel blade having a flat, circular steel membrane mounted flush on one side.

The blade is connected to a control unit at ground surface by a pneumatic-electrical tube running through the insertion rods. A gas tank, connected to the control unit by a pneumatic cable, supplies the gas pressure required to expand the membrane. The control unit is equipped with a pressure regulator, pressure gauges, an audio-visual signal and vent valves.

The blade is advanced into the ground using our CPT rig or one of our drilling rigs, and can be driven into the ground using an SPT hammer. As soon as the blade is in place, the membrane is inflated, and the pressure required to lift the membrane (approximately 0.1mm) is recorded. The pressure then required to lift the centre of the membrane by an additional 1mm is recorded. The membrane is then deflated before pushing to the next depth increment, usually 200mm down. The pressure readings are corrected for membrane stiffness.

The DMT is used to measure material index (I_D), horizontal stress index (K_D), and dilatometer modulus (E_D). Using established correlations, the DMT results can also be used to assess the 'at rest' earth pressure coefficient (K_o), over-consolidation ratio (OCR), undrained shear strength (C_u), friction angle (ϕ), coefficient of consolidation (C_h), coefficient of permeability (K_h), unit weight (γ), and vertical drained constrained modulus (M).

The seismic dilatometer (SDMT) is the combination of the DMT with an add-on seismic module for the measurement of shear wave velocity (V_s). Using established correlations, the SDMT results can also be used to assess the small strain modulus (G_o).

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a 16mm diameter rod with a 20mm diameter cone end with a 9kg hammer dropping 510mm. The test is described in Australian Standard 1289.6.3.2–1997 (R2013) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – 9kg Dynamic Cone Penetrometer Test'*.

The results are used to assess the relative compaction of fill, the relative density of granular soils, and the strength of cohesive soils. Using established correlations, the DCP test results can also be used to assess California Bearing Ratio (CBR).

Refusal of the DCP can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, and does not necessarily indicate rock level.

Vane Shear Test: The vane shear test is used to measure the undrained shear strength (C_u) of typically very soft to firm fine grained cohesive soils. The vane shear is normally performed in the bottom of a borehole, but can be completed from surface level, the bottom and sides of test pits, and on recovered undisturbed tube samples (when using a hand vane).

The vane comprises four rectangular blades arranged in the form of a cross on the end of a thin rod, which is coupled to the bottom of a drill rod string when used in a borehole. The size of the vane is dependent on the strength of the fine grained cohesive soils; that is, larger vanes are normally used for very low strength soils. For borehole testing, the size of the vane can be limited by the size of the casing that is used.

For testing inside a borehole, a device is used at the top of the casing, which suspends the vane and rods so that they do not sink under self-weight into the 'soft' soils beyond the depth at which the test is to be carried out. A calibrated torque head is used to rotate the rods and vane and to measure the resistance of the vane to rotation.

With the vane in position, torque is applied to cause rotation of the vane at a constant rate. A rate of 6° per minute is the common rotation rate. Rotation is continued until the soil is sheared and the maximum torque has been recorded. This value is then used to calculate the undrained shear strength. The vane is then rotated rapidly a number of times and the operation repeated until a constant torque reading is obtained. This torque value is used to calculate the remoulded shear strength. Where appropriate, friction on the vane rods is measured and taken into account in the shear strength calculation.

LOGS

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

The terms and symbols used in preparation of the logs are defined in the following pages.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than 'straight line' variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

Where groundwater levels are measured in boreholes, there are several potential problems:

- Although groundwater may be present, in low permeability soils it 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 and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole or 'reverted' chemically if reliable water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after the groundwater level has stabilised at intervals ranging from several days to perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg. bricks, steel, etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably assess the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 *'Methods of Testing Soils for Engineering Purposes'* or appropriate NSW Government Roads & Maritime Services (RMS) test methods. Details of the test procedure used are given on the individual report forms.

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.

Reasonable care is taken with the report as it relates to interpretation of subsurface conditions, 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 be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.
- Details of the development that the Company could not reasonably be expected to anticipate.

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

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 rather than at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

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 specially 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.

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. Licence to use the documents may be revoked without notice if the Client is in breach of any obligation to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed <u>or</u> where only a limited investigation has been completed <u>or</u> where the geotechnical conditions/constraints are quite complex, it is prudent to have a joint design review which involves an experienced geotechnical engineer/engineering geologist.

SITE INSPECTION

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to

ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types and appropriate footing or pile founding depths, or

iii) full time engineering presence on site.

SYMBOL LEGENDS

SOIL

- FILL
- TOPSOIL
- CLAY (CL, CI, CH)
- SILT (ML, MH)
- SAND (SP, SW)
- GRAVEL (GP, GW)
- SANDY CLAY (CL, CI, CH)
- SILTY CLAY (CL, CI, CH)
- CLAYEY SAND (SC)
- SILTY SAND (SM)
- GRAVELLY CLAY (CL, CI, CH)
- CLAYEY GRAVEL (GC)
- SANDY SILT (ML, MH)
- PEAT AND HIGHLY ORGANIC SOILS (Pt)

ROCK

- CONGLOMERATE
- SANDSTONE
- SHALE/MUDSTONE
- SILTSTONE
- CLAYSTONE
- COAL
- LAMINITE
- LIMESTONE
- PHYLLITE, SCHIST
- TUFF
- GRANITE, GABBRO
- DOLERITE, DIORITE
- BASALT, ANDESITE
- QUARTZITE

OTHER MATERIALS

- BRICKS OR PAVERS
- CONCRETE
- ASPHALTIC CONCRETE

CLASSIFICATION OF COARSE AND FINE GRAINED SOILS

Major Divisions		Group Symbol	Typical Names	Field Classification of Sand and Gravel	Laboratory Classification	
Coarse grained soil (more than 65% of soil excluding oversize fraction is greater than 0.075mm)	GRAVEL (more than half of coarse fraction is larger than 2.36mm	GW	Gravel and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 4$ $1 < C_c < 3$
		GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		GM	Gravel-silt mixtures and gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	Fines behave as silt
		GC	Gravel-clay mixtures and gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	Fines behave as clay
	SAND (more than half of coarse fraction is smaller than 2.36mm)	SW	Sand and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 6$ $1 < C_c < 3$
		SP	Sand and gravel-sand mixtures, little or no fines	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		SM	Sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	N/A
		SC	Sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	

Major Divisions		Group Symbol	Typical Names	Field Classification of Silt and Clay			Laboratory Classification
				Dry Strength	Dilatancy	Toughness	% < 0.075mm
ine grained soils (more than 35% of soil excluding oversize fraction is less than 0.075mm)	SILT and CLAY (low to medium plasticity)	ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity	None to low	Slow to rapid	Low	Below A line
		CL, CI	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay	Medium to high	None to slow	Medium	Above A line
		OL	Organic silt	Low to medium	Slow	Low	Below A line
	SILT and CLAY (high plasticity)	MH	Inorganic silt	Low to medium	None to slow	Low to medium	Below A line
		CH	Inorganic clay of high plasticity	High to very high	None	High	Above A line
		OH	Organic clay of medium to high plasticity, organic silt	Medium to high	None to very slow	Low to medium	Below A line
	Highly organic soil	Pt	Peat, highly organic soil	–	–	–	–

Laboratory **Classification** Criteria

A well graded coarse grained soil is one for which the coefficient of uniformity $Cu > 4$ and the coefficient of curvature $1 < C_c < 3$. Otherwise, the soil is poorly graded. These coefficients are given by:

$$C_U = \frac{D_{60}}{D_{10}} \quad \text{and} \quad C_C = \frac{(D_{30})^2}{D_{10}\,D_{60}}$$

Where D_{10}, D_{30} and D_{60} are those grain sizes for which 10%, 30% and 60% of the soil grains, respectively, are smaller.

NOTES:

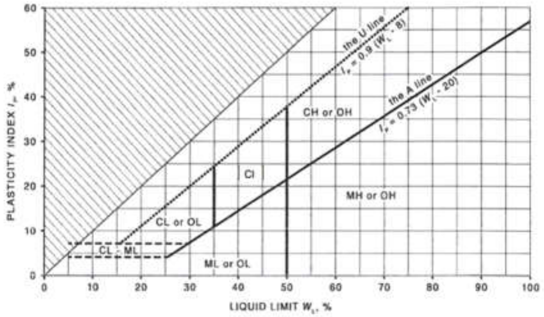
1 For a coarse grained soil with a fines content between 5% and 12%, the soil is given a dual classification comprising the two group symbols separated by a dash; for example, for a poorly graded gravel with between 5% and 12% silt fines, the classification is GP-GM.

2 Where the grading is determined from laboratory tests, it is defined by coefficients of curvature (C_c) and uniformity (C_u) derived from the particle size distribution curve.

3 Clay soils with liquid limits > 35% and ≤ 50% may be classified as being of medium plasticity.

4 The U line on the Modified Casagrande Chart is an approximate upper bound for most natural soils.

Modified Casagrande Chart for Classifying Silts and Clays according to their Behaviour



JKGeotechnics

LOG SYMBOLS

Log Column	Symbol	Definition
Groundwater Record		Standing water level. Time delay following completion of drilling/excavation may be shown.
	C	Extent of borehole/test pit collapse shortly after drilling/excavation.
		Groundwater seepage into borehole or test pit noted during drilling or excavation.
Samples	ES U50 DB DS ASB ASS SAL	Sample taken over depth indicated, for environmental analysis. Undisturbed 50mm diameter tube sample taken over depth indicated. Bulk disturbed sample taken over depth indicated. Small disturbed bag sample taken over depth indicated. Soil sample taken over depth indicated, for asbestos analysis. Soil sample taken over depth indicated, for acid sulfate soil analysis. Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'Refusal' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60° solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25 PID = 100	Vane shear reading in kPa of undrained shear strength. Photoionisation detector reading in ppm (soil sample headspace test).
Moisture Condition (Fine Grained Soils)	w > PL $w \approx$ PL w < PL $w \approx$ LL w > LL	Moisture content estimated to be greater than plastic limit. Moisture content estimated to be approximately equal to plastic limit. Moisture content estimated to be less than plastic limit. Moisture content estimated to be near liquid limit. Moisture content estimated to be wet of liquid limit.
(Coarse Grained Soils)	D M W	DRY – runs freely through fingers. MOIST – does not run freely but no free water visible on soil surface. WET – free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS S F St VSt Hd Fr ( )	VERY SOFT – unconfined compressive strength ≤ 25kPa. SOFT – unconfined compressive strength > 25kPa and ≤ 50kPa. FIRM – unconfined compressive strength > 50kPa and ≤ 100kPa. STIFF – unconfined compressive strength > 100kPa and ≤ 200kPa. VERY STIFF – unconfined compressive strength > 200kPa and ≤ 400kPa. HARD – unconfined compressive strength > 400kPa. FRIABLE – strength not attainable, soil crumbles. Bracketed symbol indicates estimated consistency based on tactile examination or other assessment.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** / **SPT 'N' Value Range (Blows/300mm)**
	VL	VERY LOOSE ≤ 15 / 0 – 4
	L	LOOSE > 15 and ≤ 35 / 4 – 10
	MD	MEDIUM DENSE > 35 and ≤ 65 / 10 – 30
	D	DENSE > 65 and ≤ 85 / 30 – 50
	VD	VERY DENSE > 85 / > 50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other assessment.
Hand Penetrometer Readings	300 250	Measures reading in kPa of unconfined compressive strength. Numbers indicate individual test results on representative undisturbed material unless noted otherwise.

Log Column	Symbol	Definition
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Twin pronged tungsten carbide bit.
	T_{60}	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.
	Soil Origin	The geological origin of the soil can generally be described as:
		RESIDUAL – soil formed directly from insitu weathering of the underlying rock. No visible structure or fabric of the parent rock.
		EXTREMELY WEATHERED – soil formed directly from insitu weathering of the underlying rock. Material is of soil strength but retains the structure and/or fabric of the parent rock.
		ALLUVIAL – soil deposited by creeks and rivers.
		ESTUARINE – soil deposited in coastal estuaries, including sediments caused by inflowing creeks and rivers, and tidal currents.
		MARINE – soil deposited in a marine environment.
		AEOLIAN – soil carried and deposited by wind.
		COLLUVIAL – soil and rock debris transported downslope by gravity, with or without the assistance of flowing water. Colluvium is usually a thick deposit formed from a landslide. The description 'slopewash' is used for thinner surficial deposits.
		LITTORAL – beach deposited soil.

Classification of Material Weathering

<table>
<tr><th colspan="2">Term</th><th colspan="2">Abbreviation</th><th>Definition</th></tr>
<tr><td colspan="2">Residual Soil</td><td colspan="2">RS</td><td>Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.</td></tr>
<tr><td colspan="2">Extremely Weathered</td><td colspan="2">XW</td><td>Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.</td></tr>
<tr><td>Highly Weathered</td><td rowspan="2">Distinctly Weathered (Note 1)</td><td>HW</td><td rowspan="2">DW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.</td></tr>
<tr><td>Moderately Weathered</td><td>MW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Slightly Weathered</td><td colspan="2">SW</td><td>Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Fresh</td><td colspan="2">FR</td><td>Rock shows no sign of decomposition of individual minerals or colour changes.</td></tr>
</table>

NOTE 1: The term 'Distinctly Weathered' is used where it is not practicable to distinguish between 'Highly Weathered' and 'Moderately Weathered' rock. 'Distinctly Weathered' is defined as follows: *'Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores'*. There is some change in rock strength.

Rock Material Strength Classification

Term	Abbreviation	Uniaxial Compressive Strength (MPa)	Guide to Strength	
			Point Load Strength Index $Is_{(50)}$ (MPa)	Field Assessment
Very Low Strength	VL	0.6 to 2	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30mm thick can be broken by finger pressure.
Low Strength	L	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium Strength	M	6 to 20	0.3 to 1	Scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High Strength	H	20 to 60	1 to 3	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High Strength	VH	60 to 200	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High Strength	EH	> 200	> 10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Abbreviations Used in Defect Description

Cored Borehole Log Column		Symbol Abbreviation	Description
Point Load Strength Index		• 0.6	Axial point load strength index test result (MPa)
		x 0.6	Diametral point load strength index test result (MPa)
Defect Details	– Type	Be	Parting – bedding or cleavage
		CS	Clay seam
		Cr	Crushed/sheared seam or zone
		J	Joint
		Jh	Healed joint
		Ji	Incipient joint
		XWS	Extremely weathered seam
	– Orientation	Degrees	Defect orientation is measured relative to normal to the core axis (ie. relative to the horizontal for a vertical borehole)
	– Shape	P	Planar
		C	Curved
		Un	Undulating
		St	Stepped
		Ir	Irregular
	– Roughness	Vr	Very rough
		R	Rough
		S	Smooth
		Po	Polished
		Sl	Slickensided
	– Infill Material	Ca	Calcite
		Cb	Carbonaceous
		Clay	Clay
		Fe	Iron
		Qz	Quartz
		Py	Pyrite
	– Coatings	Cn	Clean
		Sn	Stained – no visible coating, surface is discoloured
		Vn	Veneer – visible, too thin to measure, may be patchy
		Ct	Coating ≤ 1mm thick
		Filled	Coating > 1mm thick
	– Thickness	mm.t	Defect thickness measured in millimetres