REPORT TO

SYNERGY CONSTRUCTION GROUP

ON

GEOTECHNICAL ASSESSMENT

FOR

PROPOSED HOUSE

AT

28 GOONDARI ROAD, ALLAMBIE HEIGHTS, NSW

Date: 31 August 2022
Ref: 34543SFrpt Rev1

JKGeotechnics

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DOCUMENT REVISION RECORD

Report Reference	Report Status	Report Date
34543SFrpt	Final Report	3 December 2021
34543SFrpt	Revision 1	31 August 2022

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1 INTRODUCTION

This report presents the results of a geotechnical assessment for the proposed house at 28 Goondari Road, Allambie Heights, NSW. The location of the site is shown in Figure 1. The assessment was commissioned by Purchase Order No. 0003 and was carried out in accordance with our fee proposal, Ref: P55313S, dated 22 October 2021

We understand from the supplied architectural drawings prepared by Micheal Fountain Architects Pty Ltd (Job No. 2129, Dwg. DA-01 to 04, DA-07, DA-10, DA-11, DA-20 to 23, various Issues, all dated 7 September 2022) that it is proposed to demolish the existing residence and construct a new three storey residence. The proposed Finished Floor Level (FFL) of the lower ground and ground floor are RL54.80m and RL57.76m, respectively, resulting in excavations to a maximum depth of about 3.6m, although generally less than 1m due to the previous earthworks for the existing residence. The upper ground level will be suspended over the upper hillside of the site.

The purpose of the assessment was to obtain geotechnical information on the likely subsurface conditions, and to use this as a basis for providing comments and recommendations on excavation conditions, retention systems, footings and subgrade preparation.

2 ASSESSMENT PROCEDURE

The assessment comprised:

- A search of the JK Geotechnics project database to identify relevant geotechnical investigations completed nearby.
- A review of aerial photography and digital street view (NearMap and Google Earth).
- A review of the regional geology maps.
- A site walkover and geotechnical mapping by our Associate Geotechnical Engineer on 1 November 2021.

No subsurface investigations were carried out as part of the assessment.

3 RESULTS OF ASSESSMENT

3.1 Site Description

The site is located on the slopes of a south-west facing hillside. The site itself slopes down to the west at roughly 20° with an elevation difference between the eastern and western boundaries of approximately 12.4m. The site has a western street frontage onto Goondari Road.

The site contains a two storey brick house positioned within the western portion of the site. The house generally appears in good condition based upon a cursory external inspection. A car port is present within the south-western corner of the site. A sloping driveway is also present at the western end of the site which has been cut into the sandstone bedrock. The site steps down the hillside via a series of sub-vertical sandstone cut faces and sandstone block retaining walls. The block retaining walls were typically less than 1m high and generally appeared in moderate condition with some disjointing and loose blocks observed. The sandstone cut faces varied in height between 0.5m and 2.1m high and the rock was assessed to be of medium to high strength. The sandstone bedrock was typically sub-horizontally bedded and contained a sub-vertical joint set with a strike direction between 0° and 30°.

The neighbouring northern property contained a two storey brick house set back approximately 1.8m from the common boundary. The house appeared in good condition with no visible defects based upon a cursory inspection from within the subject site. The site levels were relatively similar across the boundary with the some of the sandstone bedrock rock shelves observed to continue into the neighbouring property.

The neighbouring southern property similarly contained a two storey brick house set back about 1.3m from the common boundary. The house appeared in good condition with no visible defects based upon a cursory inspection from within the subject site. The site levels were relatively similar across the boundary with the some of the sandstone bedrock rock shelves observed to continue into the neighbouring property. Within a cut face along the street frontage of the property, the bedrock had been stabilised by four permanent rock bolts. Due to the presence of the adjoining stairs and retaining walls, the purpose of the rock bolts was unclear.

3.2 Inferred Subsurface Conditions

The Geological Map of Sydney (Geological Series Sheet 9130, Scale 1:100,000, 1983), published by the Department of Mineral Resources indicates the site is located within the Hawkesbury Sandstone geological unit comprising medium to very coarse grained quartz sandstone, minor laminated mudstone and siltstone lenses.

Based on our observations, we expect to encounter sandy fill/colluvium directly overlying sandstone bedrock at relatively shallow depths or sandstone bedrock exposed at the surface. Where bedrock is not exposed at surface, we expect the bedrock to be less than 1m below surface level.

Groundwater is not expected to be encountered, although some groundwater seepage is expected along the soil/rock interface, particularly during rainfall periods.

4 PRELIMINARY COMMENTS AND RECOMMENDATIONS

The comments and recommendations provided below are based on an inferred subsurface profile as detailed above. The subsurface profile must be confirmed at the very least by inspection of the conditions encountered during construction. Alternatively, boreholes could be drilled either prior to or following demolition. If boreholes are not drilled, we recommend that test pits be excavated following demolition and prior to the start of excavation to assess the soils and the depth of the sandstone, where not exposed. Such test pits should be inspected by a geotechnical engineer. Adjustments may need to be made to the recommendations below once the subsurface conditions have been confirmed.

4.1 Excavation Conditions

Prior to any excavation commencing we recommend that reference be made to the latest version (currently January 2020 at the time of this report) of NSW Government "Code of Practice Excavation Work".

Based on the supplied information, we understand that excavations to approximately 3.6m depth for the lower ground floor will be required. Based on the results of the assessment, we expect that the excavations will encounter sandy soils and predominantly sandstone bedrock. Based on the observed sandstone outcrops, we expect the bedrock to be of good quality and of at least of low to medium strength either on first contact or shortly thereafter.

Excavation of the soils and bedrock up to very low strength may be readily excavated using a bucket of a small hydraulic excavator (5-6 tonne). However, excavation of the expected good quality sandstone is considered "hard rock" excavation conditions. "Hard rock" excavation techniques may consist of percussive or non-percussive techniques. Percussive techniques comprise the use of rock hammers while non-percussive techniques comprise rotary grinders, rock saws, ripping, rock splitting etc. In addition, rock hammers may be required for the demolition of existing concrete paved surfaces, footings and floor slabs. Where percussive excavation techniques are adopted there is the risk that transmitted vibrations may damage nearby structures.

Consequently, care must be taken when using rock breakers (both for excavation and during demolition) so that ground vibrations do not adversely affect nearby neighbouring structures. Due to the close proximity of the adjoining garage and pool our preference for this site would be not to use rock breakers and use low vibration emitting equipment, such as ripping hooks, rotary grinder or rock saws. If rock hammers are to be used, we recommend that a rock saw first be used to cut a slot along the perimeter of the excavation to help reduce the transmitted vibrations. In addition, the vibrations transmitted to the neighbouring buildings and structures to the east and west should be electronically monitored at all times while the rock breakers are being used to confirm that peak particle velocities fall within acceptable limits. We recommend that the peak particle velocities along the site boundaries do not exceed 5mm/sec. We note that this vibration limit will reduce the risk of vibration damage to the neighbouring building and structures. However, these vibrations may still result in discomfort to occupants of the neighbouring buildings. If excessive vibrations are occurring, it will be necessary to use lower energy equipment such as smaller rock breakers, grinder attachments or rock saws on hydraulic excavators. Reference should be made to the attached Vibration Emission Design Goals for further information.

If rock breakers are used, to reduce vibrations we recommend that the rock breakers be continually orientated towards the face, be operated one at a time and in short bursts only to reduce amplification of vibrations. When using the rock breakers, rock saws or rock grinders, the resulting dust should be suppressed by spraying with water.

4.2 Excavation Support

Where sandy soils are present and space allows, we recommend temporary batters are formed through the soils at no steeper than 1 Vertical (V) to 2 Horizontal (H). Given the expected limited depth of the sand, we expect temporary batters within the soils and vertical excavations within the sandstone should be feasible for the majority of the excavations.

Based on the above, the areas of potential impact may be the south-eastern and north-eastern corners of the proposed lower ground floor where the excavation will close to the boundary, If the soils are deeper than expected, then the batters will encroach into the neighbouring property. The neighbouring area only appears to be a landscaped area and therefore the impact may be minimal. Regardless, we recommend prior to excavation that a test pit is dug at these locations to confirm the bedrock level and to allow the structural and geotechnical engineers to provide further advice on the best approach to support the excavation, if required.

We expect that the sandstone will be of good quality and vertical excavation of the sandstone would then be possible. However, this must be confirmed by inspection of the sandstone by a geotechnical engineer, once encountered, and then at depth intervals of no more than 1m to check for any weak seams or inclined defects that require additional support or treatment. Any additional support recommended by the geotechnical engineer, such as rock bolts, shotcrete and mesh or dental treatment of thin seams, must be installed prior to further excavation.

Where soils need to be retained the proposed retaining walls may be designed as cantilevered walls based on a triangular earth pressure distribution using an active earth pressure coefficient, K_a, of 0.33 and a bulk unit weight of 20kN/m^3. This assumes that some resulting ground movements are acceptable. Where movements are to be kept low, or where walls are restrained from some lateral movement by other structural elements in front of the wall, such as the pool walls, an ‘at rest’ earth pressure coefficient, K_0, of 0.6 should be used.

The above coefficients assume horizontal backfill surfaces and where inclined backfill is proposed the coefficients would need to be increased or the inclined backfill taken as a surcharge load. All surcharge loads must be allowed for in the design, plus full hydrostatic pressures unless measures are undertaken to provide complete and permanent drainage behind the walls.

If there are to ant permanent batter slopes in soil, they may be formed at 1V:2H if they are only up to about 1m in height but should be 1V:3H if deeper soil is present as it would be difficult to maintain vegetation and prevent erosion otherwise.

4.3 Hydrogeology and Groundwater

The groundwater table is not expected to be encountered in the excavation, however seepage along the soil/rock interface and through defects in the bedrock is to be expected, particularly during and following rainfall periods. The hillside generally slopes down to the south-west and any groundwater flow would be expected to be in a similar direction. Given the proposed excavations will extend into bedrock, some groundwater seepage should be expected into the excavation.

In the event that groundwater seepage is encountered during construction conventional sump and pump or gravity drainage may be used. Over the long term the proposed provision of effective drainage of all sub-structures will allow 'through-flow' of groundwater with no build-up of uphill groundwater levels to the extent that neighbouring properties will be adversely affected.

In view of the above, the proposed development should have negligible effects on the groundwater regime above and below the site and the neighbouring buildings and structures. However, we recommend that the proposed excavations be monitored to confirm groundwater conditions. We also note that effective control of surface run-off will be required both during and after construction.

4.4 Footings

Given the assumed relatively shallow bedrock depth, we recommend all structures be supported on footings uniformly founded on the underlying sandstone bedrock. Where sandstone is exposed or is at shallow depths pad or strip footings may be used. However, where bedrock is at a depth of greater than 1.5m, then short bored piles may be necessary and prove to be more economical.

Footings founded on the sandstone bedrock of low strength or better may be designed based upon a preliminary Allowable Bearing Pressure (ABP) of 1,000kPa. Higher bearing pressures are likely to be appropriate within the sandstone, but boreholes would need to be drilled to assess the rock quality.

At least the initial stages of footing excavation should be inspected by a geotechnical engineer to confirm that a suitable founding stratum is being achieved.

4.5 Subgrade Preparation

Earthworks recommendations presented below should be complemented by reference to AS3798.

Over soil subgrade areas where on-grade slabs and/or external paved areas are to be constructed and over any areas of proposed fill, subgrade preparation should consist of the following:

- Strip any vegetation and root affected soils.
- Proof roll the subgrade with a 2 tonne deadweight smooth drum vibratory roller. The main objective of the proof rolling is to assist in detection of any soft or heaving areas and to improve the state of compaction of the near surface fill materials.
- The final pass of the proof rolling should be inspected by a geotechnical engineer to detect soft or unstable areas which should be removed and replaced with engineered fill.
- Care should also be taken when using vibrating equipment not to cause damage to adjacent existing structures. If there is any cause for concern then proof rolling should cease and further geotechnical advice sought. Alternatively, where appropriate, the static (non-vibration) mode may be used.

Engineered fill should be free from organic materials, other contaminants and deleterious substances and have a maximum particle size not exceeding 40mm. From a geotechnical perspective, we expect the excavated soils and any ripped weathered sandstone bedrock may be used as engineered fill. Engineered fill should be placed in layers of maximum 100mm loose thickness and compacted with the above mentioned roller to achieve a minimum I_D of 70% for the sandy soils. However, the I_D may be reduced to 65% in landscaped areas. For any clayey materials (including weathered sandstone bedrock) engineered fill should be compacted to at least 98% of SMDD and reduced to 95% of SMDD in landscaped areas.

Backfill to conventional retaining walls should also comprise engineered fill. The excavated sands or well graded granular materials such as crushed sandstone and demolition rubble would be suitable for this purpose. Such fill should be compacted in horizontal layers as above using a hand held plate compactor. Care will be required to ensure excessive compaction stresses are not transferred to the retaining walls.

To confirm the above specification has been achieved, density tests should be carried out at a frequency of one test per layer per 200m^2 or three tests per visit, whichever requires the most tests, for general fill and one test per 2 layers per 50m^2 for retaining wall backfill and backfill to soft or heaving areas. At least Level 2 testing of earthworks should be carried out in accordance with AS3798. Any areas of insufficient compaction will require reworking.

4.6 Further Geotechnical Input

The following is a summary of the further geotechnical input which is required and which has been detailed in the preceding sections of this report:

- Following demolition, inspection of test pits or the drilling of boreholes to confirm the subsurface profile.
- Excavation of at least two test pits to expose the subsurface conditions at the north-eastern and south-eastern corners of the proposed lower ground floor excavation and inspected by the geotechnical and structural engineers.
- Quantitative vibration monitoring once rock excavation commences.
- Inspection of footing excavations.
- Inspection of proof rolling soil subgrade.

4.7 Slope Stability Risk Assessment

The site falls within 'Area B' of the Warringah Council 'Map of Geotechnical Areas – Landslips Potential Hazards'. Given that maximum excavations of 2.5m are expected, a geotechnical assessment is required to satisfy Council.

Our slope stability risk assessment is based on our walkover inspection and our experience in the local area in regard to slope instability. The attached Appendix A defines the terminology adopted for the risk assessment together with a flowchart illustrating the Risk Management Process based on the guidelines given in AGS 2007c (Reference 1).

Based on our assessment, we consider the potential slope instability hazards associated with the site and the proposed development are as follows:

A. Instability of the existing retaining walls.

B. Instability of existing sandstone cut faces.

C. Instability of the proposed cut faces, excavations and retaining walls

D. Instability of the hillside slope beneath the site.

The attached Table A summarises our qualitative assessment of each potential landslide hazard and of the consequences to property should the landslide hazard occur. The terminology adopted for this qualitative assessment is in accordance with Table A1 given in Appendix A. Table A indicates that the assessed risk to property to be "Very Low" or "Low" which would be considered 'acceptable' in accordance with the criteria given in Reference 1.

We have also used the indicative probabilities associated with the assessed likelihood of instability to calculate the risk to life. The temporal and vulnerability factors that have been adopted are given in the attached Table B together with the resulting risk calculation. Our assessed risk to life for the person most at risk is about 10^{-7}. This would be considered to be 'acceptable' in relation to the criteria given in Reference 1.

Based on our slope stability risk assessment, we consider that the risk of the proposed development poses an acceptable risk to both property and life.

5 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.

The long term successful performance of floor slabs and pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgment from an experienced engineer. Such judgment often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

This report provides advice on geotechnical aspects for the proposed civil and 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 may be 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 or Hazardous Waste. Analysis can take up to seven to ten 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 substantial 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 investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

Reference 1: Australian Geomechanics Society (2007c) *'Practice Note Guidelines for Landslide Risk Management'*, Australian Geomechanics, Vol 42, No 1, March 2007, pp63-114.

AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

Title:

SITE LOCATION PLAN

Location: 28 GOONDARI ROAD, ALLAMBIE HEIGHT, NSW

Report No: 34543SF

Figure No: 1

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

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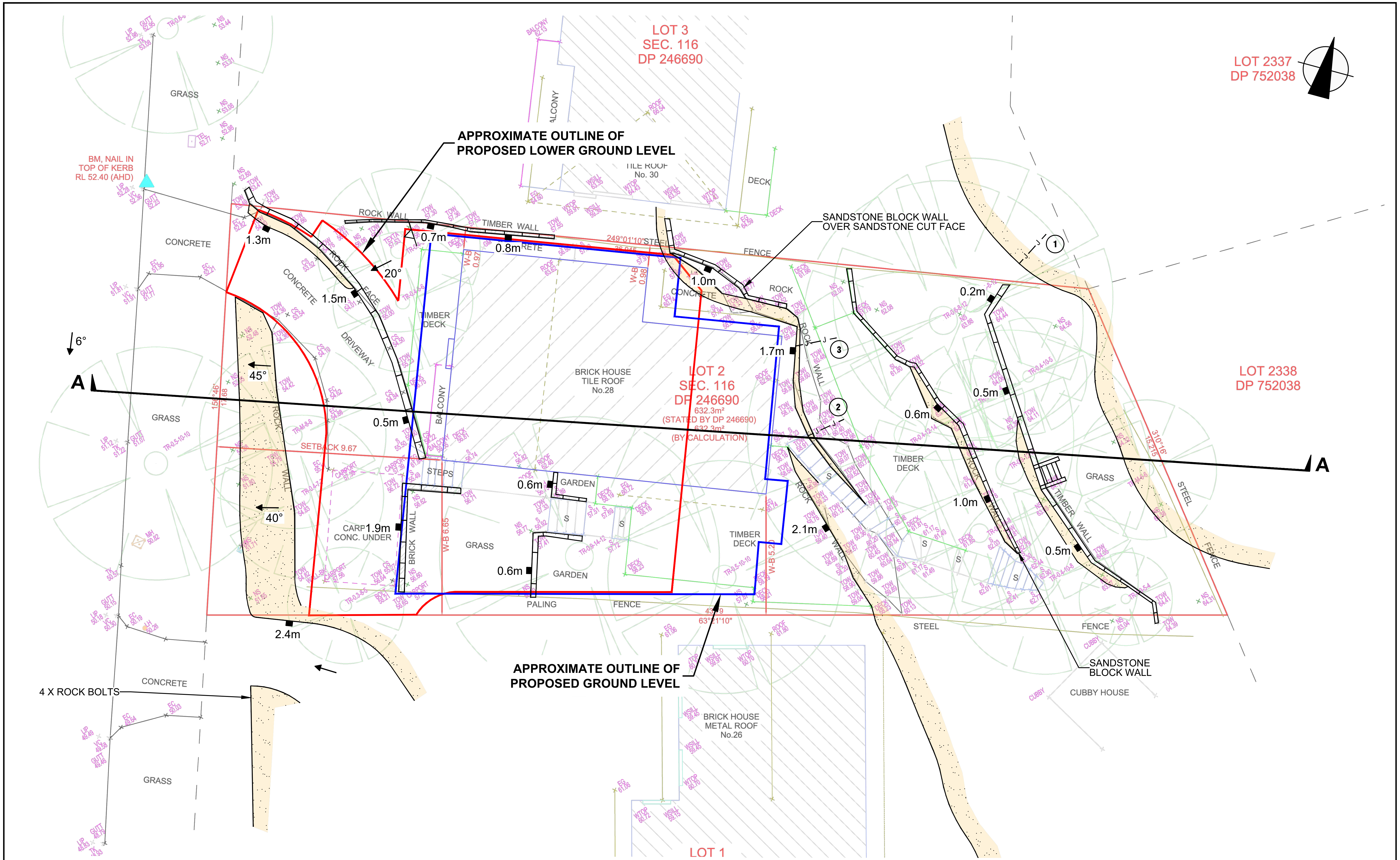
PLOT DATE: 10/11/2021 11:11:16 AM DWG FILE: J:\6F GEOTECHNICAL JOBS\34000'S\34543S ALLAMBIE HEIGHTS\CAD\34543SF.DWT



LEGEND

SANDSTONE OUTCROP

NOTES:
1. REFER TO FIGURE 3 FOR SECTION A-A.
2. REFER TO FIGURE 4 FOR GEOTECHNICAL MAPPING SYMBOLS.

0 1.5 3 4.5 6 7.5
SCALE 1:150 @A3 METRES

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

Title:	BOREHOLE LOCATION PLAN
Location:	28 GOONDARI ROAD, ALLAMBIE HEIGHT, NSW
Report No:	34543SF
Figure No:	2

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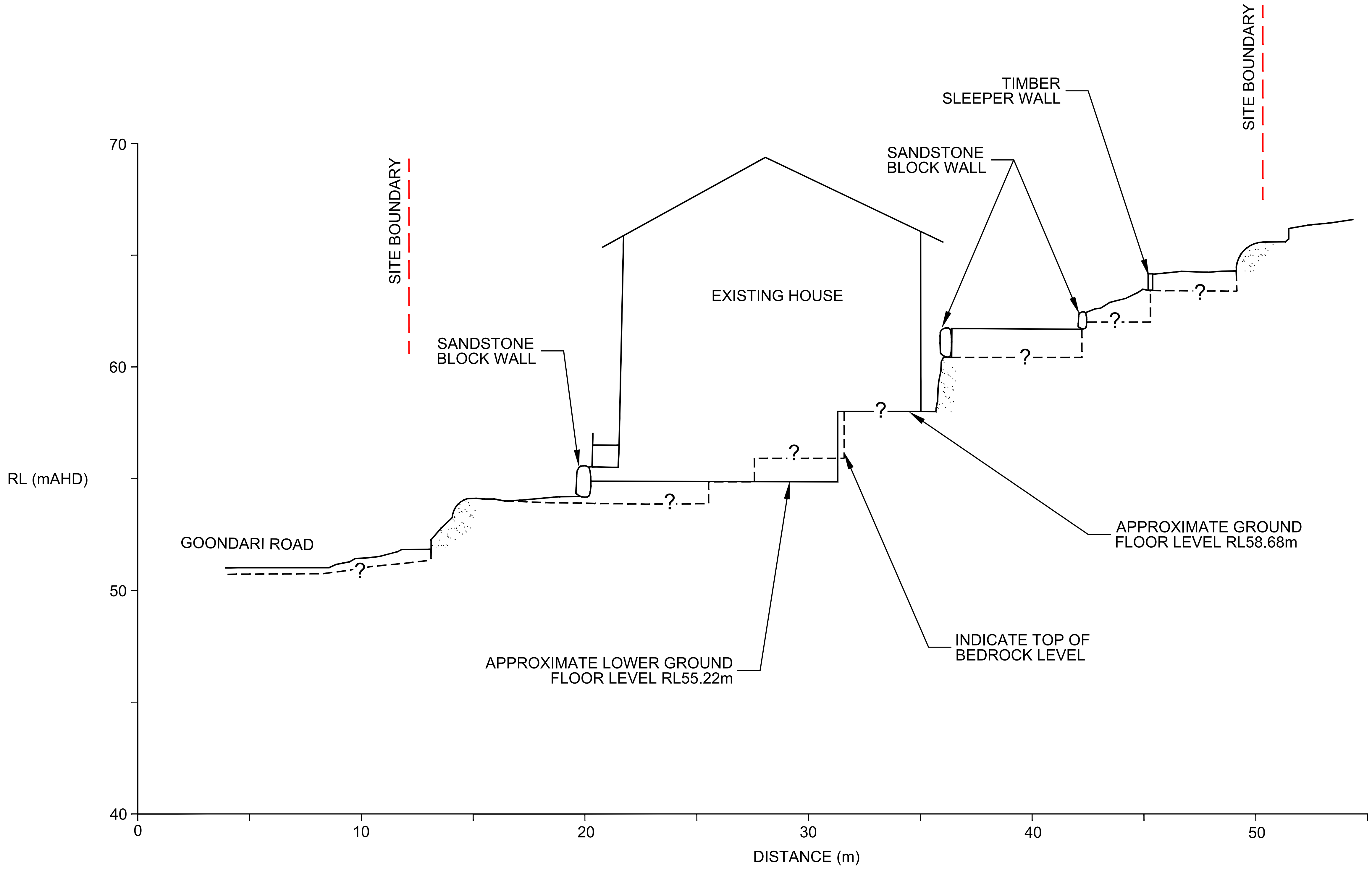
PLOT DATE: 30/08/2022 1:02:28 PM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\34000's\34543S ALLAMBIE HEIGHTS\CAD\34543SF.DWG



0 2 4 6 8 10

SCALE 1:200 @A3 METRES

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

Title: **CROSS SECTION A-A LOOKING NORTH WEST**

Location: 28 GOONDARI ROAD, ALLAMBIE HEIGHT, NSW

Report No: 34543S

Figure No: 3

JKGeotechnics

PLOT DATE: 16/11/2021 11:59:31 AM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\34000'S\34543S ALLAMBIE HEIGHTS\CAD\34543S.DWG

TOPOGRAPHY

Symbol *Ground Profile*

convex		well defined or angular break of slope
concave		
convex		poorly defined or smooth change of slope
concave		
breaks of slope		convex and concave too close together to allow the use of separate symbols
changes of slope		
sharp		ridge crest
rounded		

3 Cliff or escarpment or sharp break 40° or more (estimated height in metres)

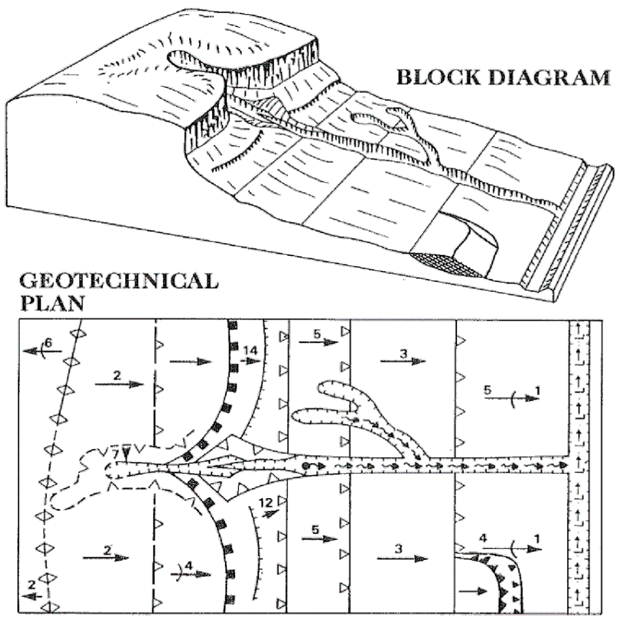
15 Uniform Slope	Slope direction and angle (Degrees)
10 Concave Slope	
8 Convex Slope	
Top	Cut or fill slope, arrows pointing down slope
Bottom	

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:



(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:	28 GOONDARI ROAD, ALLAMBIE HEIGHT, NSW
Report No: 34543S	Figure No: 4

JKGeotechnics

PLOT DATE: 16/11/2021 9:59:36 AM DWG FILE: J:\6F GEOTECHNICAL JOBS\34000'S\34543S ALLAMBIE HEIGHTS\CAD\34543S.DWG

TABLE A

SUMMARY OF RISK ASSESSMENT TO PROPERTY

POTENTIAL LANDSLIDE HAZARD	**A**	**B**	**C**	**D**
	Instability of existing retaining walls	Instability of existing sandstone cut faces	Instability of the proposed cut faces and retaining walls	Instability of the hillside slope beneath the site
Assessed Likelihood	Unlikely	Rare	Rare	Barely Credible
Assessed Consequence	Minor	Medium	Medium	Major
Risk	Low	Low	Low	Very Low
Comments	Comments and recommendations contained in this report are adopted in full	Comments and recommendations contained in this report are adopted in full	Comments and recommendations contained in this report are adopted in full	

TABLE B

SUMMARY OF RISK ASSESSMENT TO LIFE

POTENTIAL LANDSLIDE HAZARD	A	B	C	D
	Instability of existing retaining walls	Instability of existing sandstone cut faces	Instability of the proposed cut faces and retaining walls	Instability of the hillside slope beneath the site
Assessed Likelihood	Unlikely	Rare	Rare	Barely Credible
Indicative Annual Probability	10^{-4}	10^{-5}	10^{-5}	10^{-6}
Persons at risk	Person using walkways	Person using walkways	Person using walkways, pool	Persons inside the house
Number of Persons Considered	1	1	2	4
Duration of Use of area Affected (Temporal Probability)	5 minutes/day 3.47×10^{-3}	5 minutes/day 3.47×10^{-3}	1 hour/day 0.04	14 hours/day 0.58
Probability of not Evacuating Area Affected	0.9	0.9	0.5	0.1
Spatial Probability	1.0	1.0	1.0	1.0
Vulnerability to Life if Failure Occurs Whilst Person Present	0.8	0.8	0.8	0.05
Risk for Person most at Risk	2.5×10^{-7}	2.5×10^{-8}	3.2×10^{-7}	2.9×10^{-9}
Total Risk	2.5×10^{-7}	2.5×10^{-8}	6.4×10^{-7}	1.2×10^{-8}
Combined total Risk	9.3×10^{-7}			

Note: From the summation of risk for person most at risk, the total risk for the person most at risk is 2.5×10^{-7}

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.

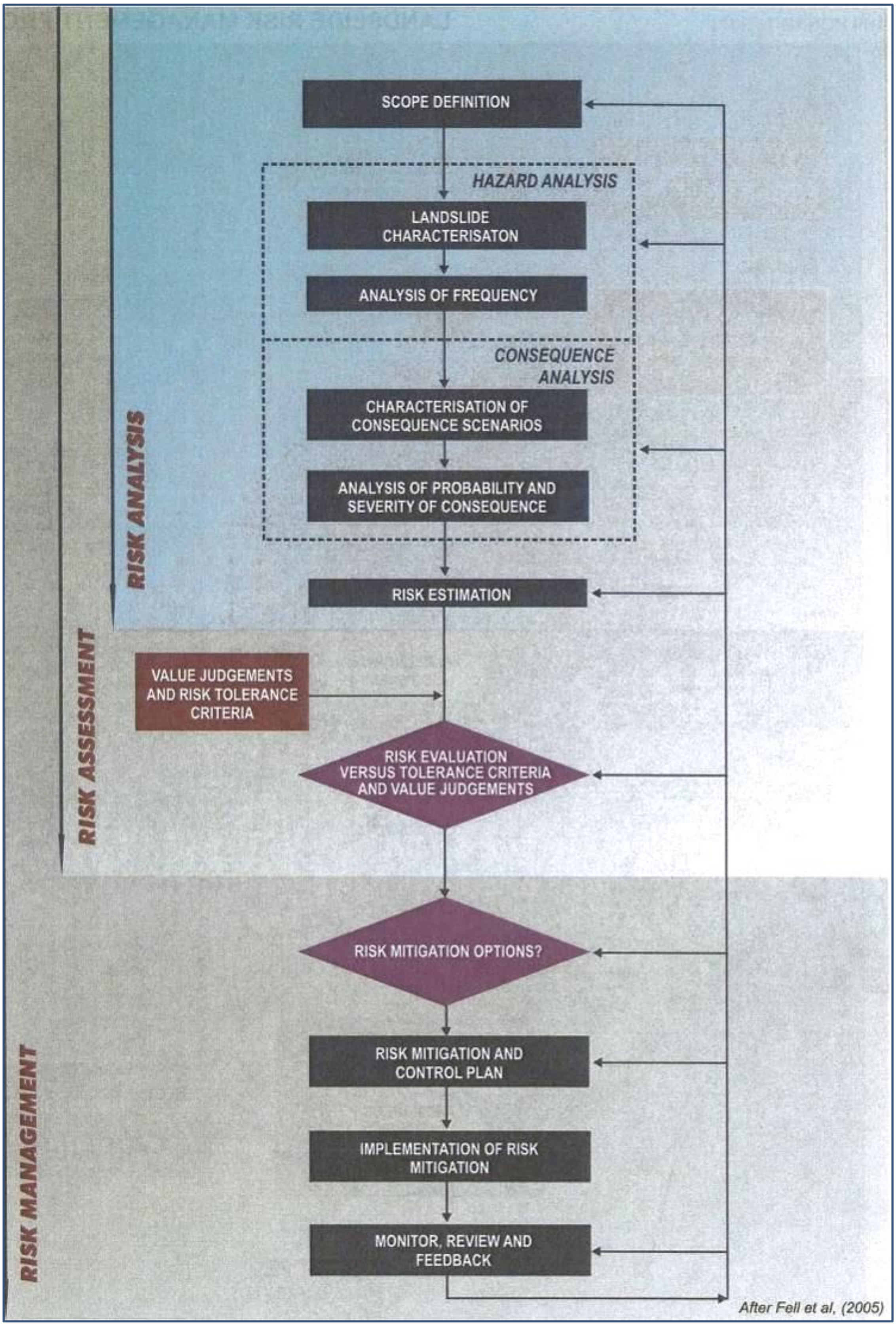


FIGURE A1: Flowchart for Landslide Risk Management.

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.

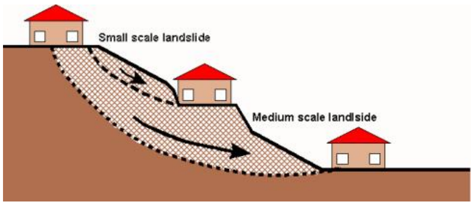


Figure 1

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.

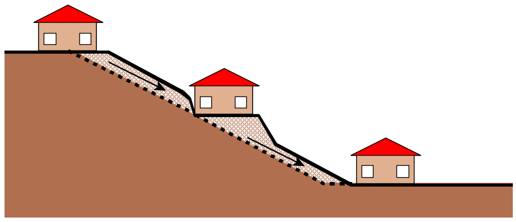


Figure 2

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.

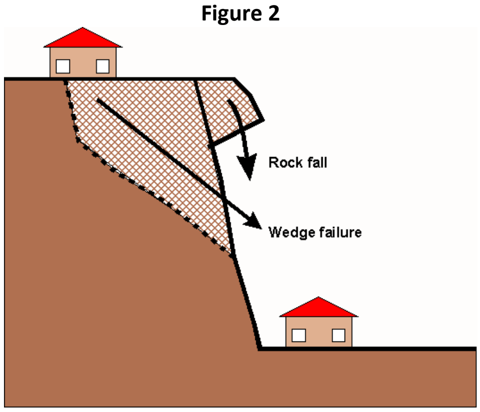


Figure 3

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.

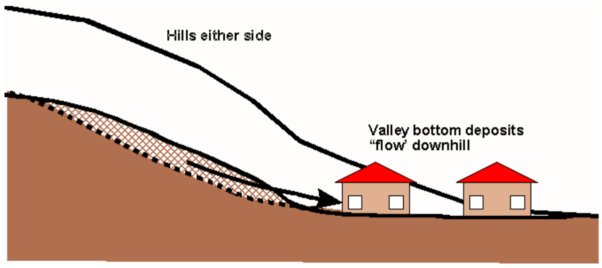


Figure 4

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:

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VIBRATION EMISSION DESIGN GOALS

German Standard DIN 4150 – Part 3: 1999 provides guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, OR, maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 1 below.

It should be noted that peak vibration velocities higher than the minimum figures in Table 1 for low frequencies may be quite 'safe', depending on the frequency content of the vibration and the actual condition of the structure.

It should also be noted that these levels are 'safe limits', up to which no damage due to vibration effects has been observed for the particular class of building. 'Damage' is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls. Should damage be observed at vibration levels lower than the 'safe limits', then it may be attributed to other causes. DIN 4150 also states that when vibration levels higher than the 'safe limits' are present, it does not necessarily follow that damage will occur. Values given are only a broad guide.

Table 1: DIN 4150 – Structural Damage – Safe Limits for Building Vibration

Group	Type of Structure	Peak Vibration Velocity in mm/s			
		At Foundation Level at a Frequency of:			Plane of Floor of Uppermost Storey
		Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design.	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use.	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 and 2 and have intrinsic value (eg. buildings that are under a preservation order).	3	3 to 8	8 to 10	8

Note: For frequencies above 100Hz, the higher values in the 50Hz to 100Hz column should be used.