



Geotechnical Investigation Report

Project

**Proposed Golf Course Subdivision
2/4 Crackenback Drive, Thredbo NSW**

Prepared for

Kosciuszko Thredbo Pty Ltd

Date

20 November 2025

Report No

14871-GR-1-1-Rev E



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1 Introduction

1.1 Background

This report presents the results of a geotechnical investigation for the proposed lot subdivision at the Thredbo Golf Course, Thredbo New South Wales (NSW) undertaken by Alliance Geotechnical Pty Ltd (Alliance). The geotechnical investigation was commissioned by Kosciuszko Thredbo Pty Ltd (the client) and was undertaken in accordance with Alliance's Estimate No. 6393, dated 15 March 2022.

The geotechnical investigation and Alliance's report have been conducted and prepared in general accordance with Australian Standards AS1726-2017 Geotechnical Site Investigations and the Geotechnical Policy, dated November 2003, issued by the Department of Infrastructure, Planning and Natural Resources.

The objective of this geotechnical investigation was to address the subsurface conditions encountered, field and laboratory testing results, and provide comments and recommendations regarding:

- The site general geology, subsoil profile, and groundwater conditions.
- Laboratory results of the following tests: shrink-swell index, Atterberg Limits, linear shrinkage, and point load index.
- Excavation conditions and vibrations.
- Temporary and permanent batter slopes.
- Earthworks construction methodology.
- Site Sub-soil Classification in accordance with AS 1170.4:2007 Structural Design Actions Part 4: Earthquake Actions in Australia.
- Site classification in accordance with AS 2870:2011 Residential Slabs and Footings.
- Suitable foundations and geotechnical design parameters.
- Slope risk assessment in accordance with AGS Guidelines (2007).

The investigation comprised drilling six boreholes and in-situ testing, followed by laboratory testing of selected samples, engineering analysis, and reporting. Details of the field and laboratory results are presented in this report, together with comments and recommendations relating to design and construction practice.

1.2 Previous Report Revisions

The geotechnical investigation was initially conducted in April 2022, with findings documented in Alliance's report, ref. 14871-GR-1-1 Rev A, dated 24 February 2023.

Following proposed design changes in July 2023, a revised assessment was provided in report Rev B, dated 3 August 2023.

In March 2025, the client advised of further design updates, which include:

- Relocation of the proposed carpark to the west and southwest of the community centre, including new pedestrian pathways to the community centre and Crackenback Drive.
- Removal of emergency access road to Cascade Close.
- Minor adjustments to the area of the previous 19 (now 18) subdivision lots.

- Inclusion of additional stormwater infrastructure and drainage works.
- Slight revisions to the layout and size of proposed golf course areas and associated minor works.
- Removal of the water tank storage.

To address these updates, Alliance issued an updated geotechnical report, 14871-GR-1-1 Rev C, dated 3 June 2025.

1.3 Current Report Revision & Compliance to DPE Requirement and Geotechnical Policy

In October 2025, the client informed Alliance of updated lot sizes. Due to conflicts between the bushfire Asset Protection Zones (APZs) and the riparian corridor along the Thredbo River, modifications were required to ensure APZs did not encroach into the inner riparian corridor. These adjustments primarily affected lots along the southern boundary and resulted in a reduction in the total number of lots from 19 to 18.

This report has been prepared at the client's request to incorporate the latest design updates and to address the Department of Planning and Environment's (the Department) requirements for an updated geotechnical report. The Department's specified requirements include:

- Review of updated plans and documentation.
- Assessment of compliance with the Geotechnical Policy, including provision of site history, geotechnical considerations, identification of hazards and risks, and a conclusion regarding site suitability subject to any recommendations.

Therefore, this report has been prepared in accordance with the Geotechnical Policy. Notably, the eastern portion of the site, is located within 'Zone G' as identified in the geotechnical maps for the Kosciuszko Alpine Resort areas as shown in Figure 1 below. Accordingly, this geotechnical investigation has been undertaken in accordance with Section 4 of the Policy. A checklist demonstrating compliance with the Policy is provided in Table 1 for reference.

Table 1 - Geotechnical Policy Compliance Check List

Geotechnical Policy – Kosciuszko Alpine Resorts Conditions		Report Section
4.1 (f) (i) Conditions to be provided to establish the design parameters, including but not limited to:	footing levels and supporting rock quality	3.2, 5.8
	degree of earth and rock cut and fill	1.4, 5.2
	recommendations for excavation batters	5.3
	recommendations for the selection of building structure systems consistent with the geotechnical assessment of risk	5.11
4. (f) (ii) Conditions applying to the detailed design to be undertaken for the construction certificate.		5.11
4. (f) (iii) Conditions applying to the construction phase.		5.11
4. (f) (iv) Conditions regarding ongoing management of the site/structure.		5.11

1.4 The Latest Proposed Development

The following updated drawings and plans were provided by the client via email dated 8 October and 5 November 2025:

- Site Plan A, prepared by djrd, ref.: 19413 A1.000, Rev D, dated 1 September 2025.
- Site Plan B, prepared by djrd, ref.: 19413 A1.001, Rev L, dated 21 August 2025.
- Client's comment annotations on 4 June, 8 September, and 8 October 2025 regarding Alliance geotechnical investigation report, ref. 14871-GR-1-1-Rev C, dated 3 June 2025.
- A set of civil plans (45 sheets), prepared by CLM Civil, ref. U-183, rev K, dated 8 September 2025 which show the cut and fill planning for the proposed development.

In addition, the following documents previously provided by the client on 17 March 2025 have been considered as part of this current report update:

- Request for additional information letter, issued by Department of Planning and Environment, ref. DA23/13081, dated 27 October 2023.

Based on the supplied documents, it is understood that the development comprises:

- The redesign of the existing nine-hole golf course.
- The construction of 18 separate lots with areas vary between 532m² (Lot 15) and 885m² (Lot 16) to house new resort accommodation facilities.
- The construction of a new concrete road off Crackenback Drive with total length of approximately 425m.
- The construction of a new carpark to the west and southwest of the community building (approximately 48 car spaces).
- The construction of municipal infrastructure such as water, sewer, gas, and telecommunication/data.

It is understood that earthworks are required for the new roads, car park area, lodge estate, and other infrastructure.

Based on the provided civil drawings, the maximum cut and fill for the proposed new roads are expected to be approximately 4m and 3m, respectively, to achieve a flat and even road surface.

Within the subdivision lots, the maximum cut and fill are proposed to be approximately 1m and 2m, respectively, in accordance with the current bulk earthworks plan.

It is noted that Alliance report 14871-GR-1-1, Revision D, issued on 7 November 2025, was prepared to address the latest design of the proposed development, incorporating associated revised comments and recommendations. This current Revision E has been prepared to address minor comments provided by the client on 18 November 2025.

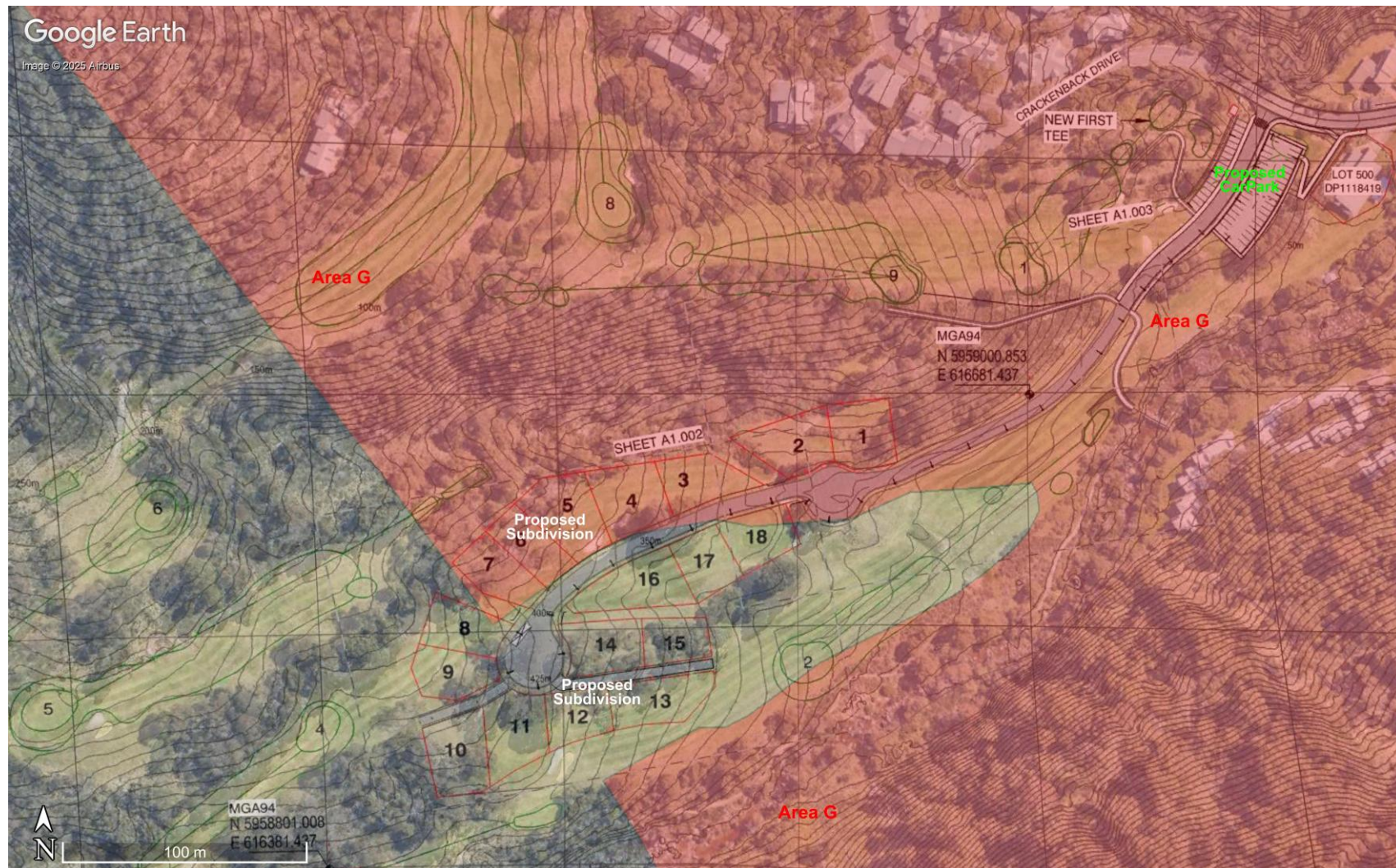


Figure 1 - The Proposed Development with the Area G (per Geotechnical Policy) Overlaid

2 Site Description & Regional Geology

The site is located at the Thredbo Golf Course, known as 2/4 Crackenback Drive within Thredbo Village, Thredbo NSW 2625 which covers an area of approximately 12ha. The Golf Course is bounded by Crackenback Drive at the northeast and surrounded by vegetation.

Along the northwest and southeast boundaries lies Thredbo River which joins Jindabyne Lake, some 30km to the northeast. Beyond the Thredbo River are the mountain ranges with a slope of approximately 20°-30°.

Figure 2 below shows the site location with its surroundings. During the site walkover as part of the investigation, granodiorite boulders were observed across the site, particularly at the northwest section.

The proposed 18 lots are situated at the middle of the golf course towards the southwestern area which the proposed road connected to Crackenback Drive with a total area of almost 15,000m².

At the time of preparing this report, the site detailed survey plan has not been provided. Based on the regional topography, the golf course compound lies within a valley, with estimated inclines of less than 15° trending toward the southeast direction. The proposed subdivision lots and carpark areas were observed to be generally flat to gently undulating, consistent with the valley floor terrain. These conditions are typical of low-lying areas adjacent to river corridors and are considered suitable for development, subject to the geotechnical recommendations outlined in this report.

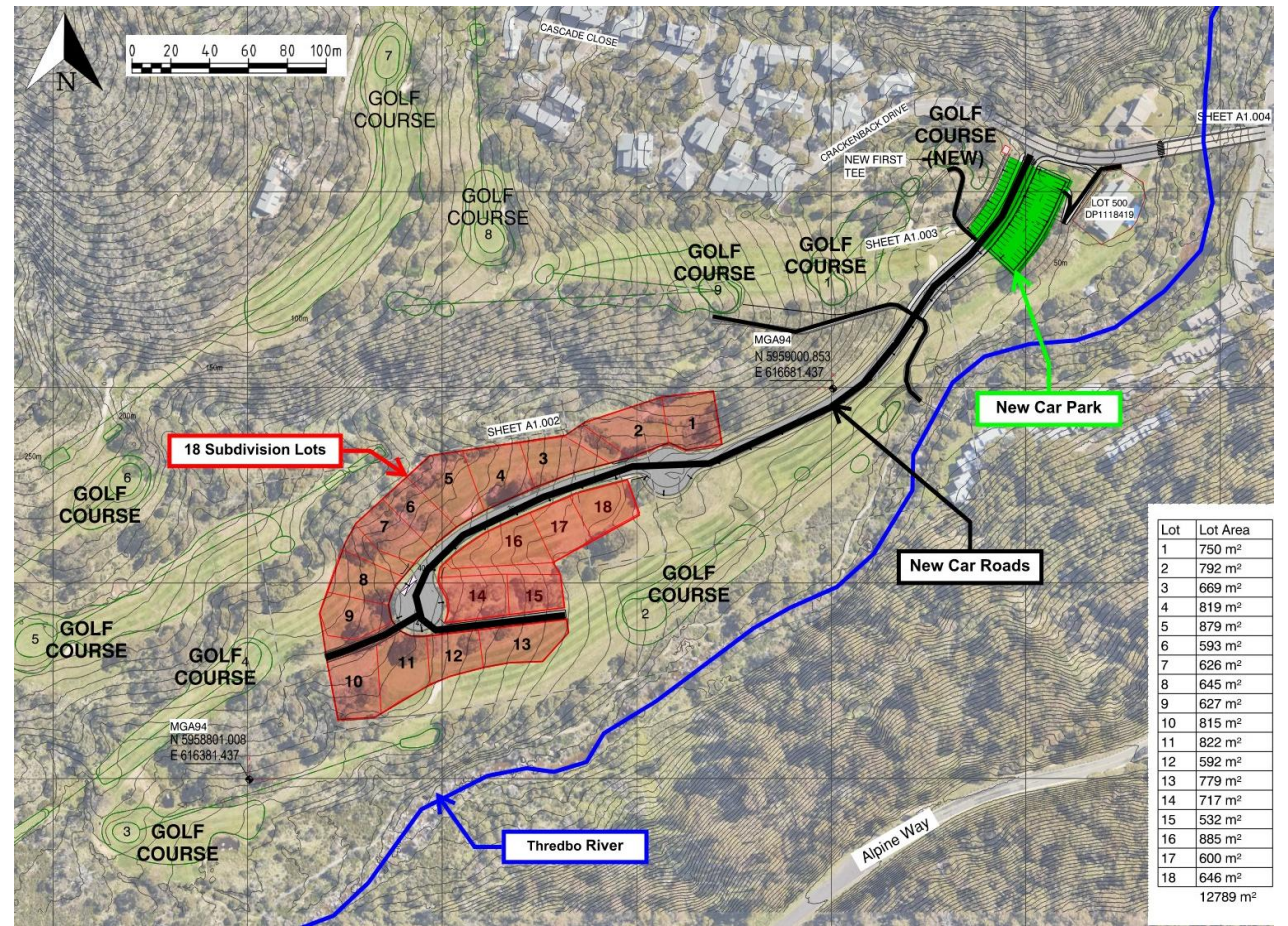


Figure 2 - The Site Location (Drawing A1.000 by djrd dated 1 September 2025 with Alliance Markups)

The NSW Seamless Geology version 2.5, published online in 2025 indicates that most of the site is underlain by Silurian aged Mowambah Granodiorite which may contain medium-grained mafic biotite-rich granodiorite,

strong foliation defined by quartz and biotite crystals plus aligned xenoliths, muscovite flakes accentuate foliation, and metasedimentary xenoliths include banded cordierite gneiss.

The geology map identifies a fault system, Crackenback Fault, along the site southeast boundary that follows the line of Thredbo River. Based on the provided drawing, the fault alignment is indicated to be within the extent of the proposed lots 10-12 and 14-15.

The site overlaying NSW Seamless Geology map with 10m contours are presented in Figure 3 below.

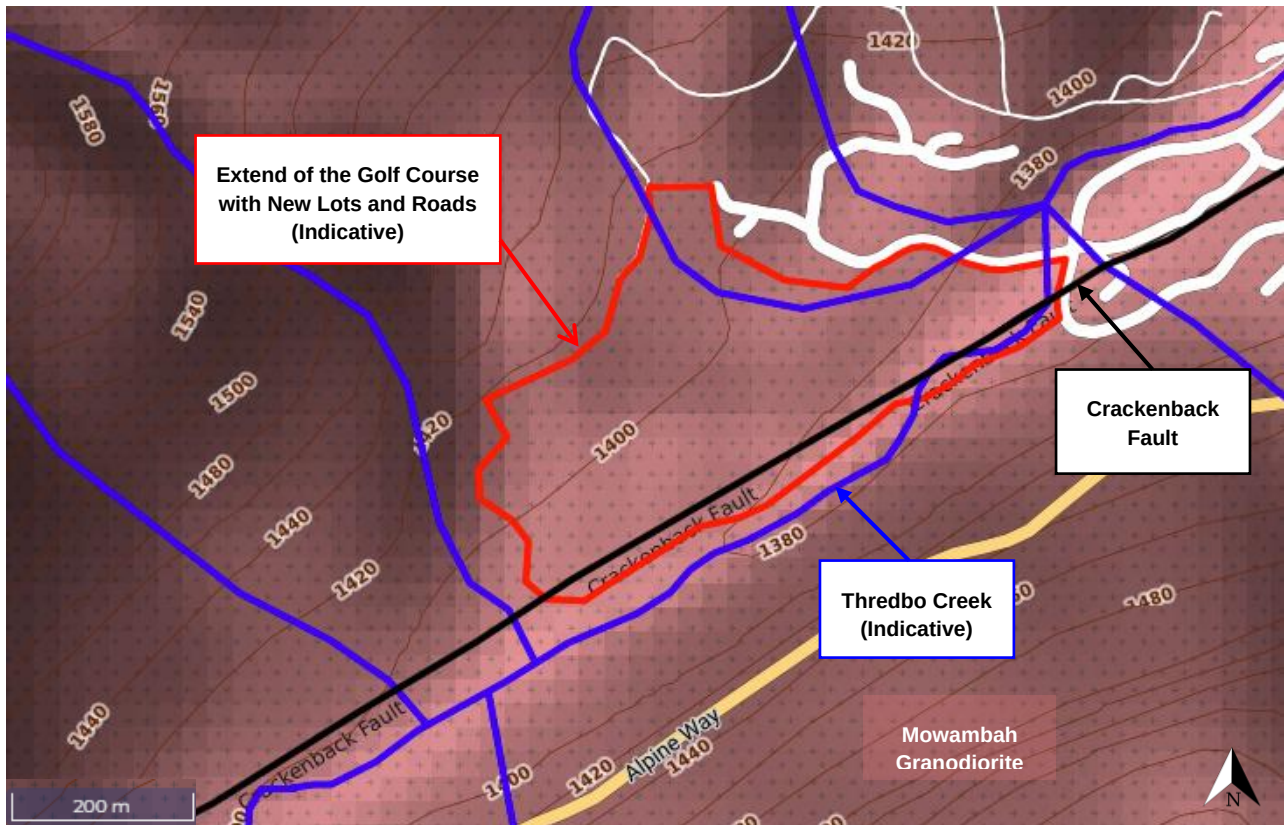


Figure 3 - The Site Location with NSW Seamless Geology and 10m Contours
(via Minview Website (Colquhoun, et al., 2025))

3 Fieldwork

3.1 Methods

The geotechnical site investigation was carried out on 27 April 2022 and commenced with a site walkover and inspection by an Alliance geotechnical engineer. During the walkover, geological and topographical features of the site were documented.

Selected photographs taken during the fieldwork are presented in Appendix A and the approximate borehole locations are shown on the Geotechnical Investigation Plan (Drawing 14871-GR-1-A) presented in Appendix B within this report.

The investigation locations were marked out on site by a client's representative prior to the fieldwork and checked against Dial Before You Dig (DBYD, now "Before You Dig Australia" - BYDA) plans before drilling commencement.

Six boreholes, BH01-BH06, were drilled with a tungsten carbide bit (TC-bit) until refusal, at depths between 1.4m and 2.4m below ground level (bgl). At boreholes BH03, BH04, and BH05, NMLC coring was initiated upon TC-bit refusal and terminated at target depths between 2.6m and 4.9m bgl. The boreholes were drilled using a trailer-mounted rig operated by an accredited subcontractor. Standard penetration tests (SPTs) were performed inside each borehole at 1.5m depth intervals except for boreholes BH01 and BH02 due to time constraints.

Dynamic Cone Penetrometer (DCP) tests were conducted adjacent to each borehole location to assess the near surface soil consistency/density. The penetrometer tests commenced at the existing surface level and terminated at refusal depths between 0.4m and 1.1m bgl on inferred granodiorite boulders.

The encountered soil profiles were documented generally in accordance with AS1726 - 2017 Geotechnical Site Investigations and recovered soil samples were transported to Alliance's NATA accredited laboratory for further testing and storage.

At completion, the boreholes were backfilled with drilling spoils and made flush with the surrounding surface. The site was reinstated to its original condition.

The borehole locations were surveyed as part of the fieldwork using a Trimble Positioning Device with GNSS and positioning ranger.

A summary of the coordinates and reduced levels (RLs) in relation to Australian Height Datum (AHD) as well as the investigation depth at each borehole location is presented in Table 2 below.

Table 2 – Summary of Boreholes Coordinates and RLs

Location	Easting	Northing	Surface RL	Termination Depth	Termination Level
Borehole ID	m MGA20 (±1.0m)	m MGA20 (±1.0m)	m AHD (±0.1m)	m bgl	m AHD
BH01	616227	5958982	1382.6	1.6	1381.0
BH02	616194	5958952	1386.1	1.4	1384.7
BH03	616133	5958932	1388.2	4.0	1384.2
BH04	616133	5958903	1388.1	1.9	1386.2
BH05	616010	5958864	1391.2	2.6	1388.6
BH06	616142	5958868	1386.3	4.9	1381.4

3.2 Results

The borehole logs, core box photos, and the DCP test results are attached in Appendix D. These log sheets should be read in conjunction with the attached Explanatory Notes, which explain the terms, abbreviations and symbols used, together with the interpretation and limitation of the logging procedure.

The summary of the encountered subsurface profile and interpreted geotechnical units are provided in Table 3 below.

Table 3 - Summary of Subsurface Profile

Ground Profile	Consistency/ Strength	Depth to top of unit	Level to top of unit	Thickness
Unit	-	m bgl	m AHD	m
Fill Clayey SILT/ Silty CLAY	Appears Moderately Compacted	0.0	1391.5 to 1381.2	0.2 to 0.6
Colluvium Interlayered of CLAY, silty CLAY, gravelly CLAY, with inclusion of low, medium, and high strength granodiorite boulders.	Firm to Stiff	0.2 to 0.6	1390.9 to 1387.6	1.8m at BH03 Not substantiated elsewhere
Colluvium Extremely weathered granodiorite (gravelly SAND, clayey SAND), with inclusion of low, medium, and high strength granodiorite boulders.	Medium Dense to Dense	0.4 to 1.8	1384.4 to 1382.2	Not substantiated

Based on the encountered materials, the site subsurface profile is interpreted to consist of apparently moderately compacted fill up to 0.6m bgl at borehole BH03, underlain by colluvium comprising interlayered firm to stiff silty clay, clay, or gravelly clay; and medium dense to dense clayey sand or gravelly sand, inferred to be extremely weathered granodiorite boulders.

Rock coring at BH03, BH05, and BH06 confirmed the presence of granodiorite boulders with varying strengths (low to high) and diameters ranging from 0.3 m to 1.6 m. Core loss between 0.3 m and 2.0 m at these boreholes suggests the boulders are underlain by colluvium soils or extremely weathered material, with no parent bedrock being encountered.

The six boreholes were terminated at depths ranging from 1.6 m to 4.9 m within the colluvial layer. Boreholes BH01, BH02, and BH04 were discontinued upon TC-bit refusal at depths of 1.4 m to 1.9 m on inferred granodiorite boulders. Rock coring at BH03, BH05, and BH06 was completed to target depths of 2.6 m to 4.9 m, terminating within colluvium. The extent of the colluvial layer was not confirmed based on the geotechnical investigation results.

3.3 Groundwater

Groundwater was not encountered during augering through the soil profiles during fieldwork. Groundwater observation during rock coring was not possible due to the introduction of water as part of the coring method. Long-term groundwater monitoring was not included the scope of this geotechnical investigation.

It should be noted that the groundwater seepage condition is subject to the soil permeability, seasonal and climatic conditions and it may vary across the site. It is expected that groundwater seepage occurs through the interface between soil and rock/rock boulders.

4 Laboratory Testing

4.1 Field Moisture Content

Five samples were selected for field moisture content testing and the tests were completed by Alliance's NATA accredited laboratory in accordance with AS1289.2.1.1:2005. The summary of the results is included in Table 4 below and the full laboratory report is provided in Appendix D.

Table 4 - Field Moisture Content Results

Samples Location	Sample Depth (m)	Material	Moisture Content (%)
BH01	1.0 – 1.5	Gravelly SAND	12.8
BH02	1.0 – 1.4	Gravelly Clayey SAND	13.5
BH03	1.5 – 1.7	Silty CLAY	25.3
BH04	0.5 – 0.7	CLAY	21.0
BH05	0.5 – 1.0	Gravelly CLAY	12.6

4.2 Shrink-Swell Index

Three relatively undisturbed samples (U50) were collected at boreholes BH03, BH04, and BH06 for shrink-swell index testing. However, due to the high presence of gravels in the sample collected from BH06 (between 1.5m bgl and 1.7m bgl), the sample was opted for Atterberg Limits with linear shrinkage testing.

The two shrink-swell index tests were completed by Alliance's NATA accredited laboratory testing facility in accordance with AS1289.7.1.1:2003. The results are presented in Table 5 below with test certificates included in Appendix D.

Table 5 – Shrink-Swell Index Results

Samples Location	Depth	Material	Shrinkage	Swell	Shrink-Swell Index
	m	-	%	%	%
BH03	1.5 – 1.7	Silty CLAY	2.4	-0.1	1.6
BH04	0.5 – 0.7	CLAY	1.8	-0.1	1.0

4.3 Atterberg Limits with Linear Shrinkage

Four Atterberg limits with linear shrinkage tests were completed on selected samples in accordance with AS1289.3.1.1, 3.2.1, 3.3.1, and 3.4.1:2008 by Alliance's NATA accredited laboratory. The results are summarised in Table 6 below with laboratory test certificates provided in Appendix D.

Table 6 - Atterberg Limits Results

Sample Location	Depth	Material	Liquid Limit	Plastic Limit	Plasticity Index	Linear Shrinkage
	m	-	%	%	%	%
BH03	2.0 – 2.5	Clayey SAND	Not obtainable	Not obtainable	Non-plastic	-
BH04	1.5 – 1.9	Gravelly CLAY	46	31	15	7.5
BH05	0.5 – 1.0	Gravelly CLAY	35	29	6	4.5
BH06	1.5 – 1.7	Gravelly CLAY	36	24	12	4.0

4.4 Point Load Testing Index

Point load strength index testing was undertaken on recovered core samples at 1m intervals in accordance with AS4133.4.1:2007. The results are presented in Table 7 below with test results indicating on the provided borehole logs within Attachment C.

Table 7 – Summary of Point Load Strength Index Testing Results $I_{s(50)}$

Sample Location	Depth	Diametral Point Load Strength Index	Axial Diametral Point Load Strength Index
	<i>m bgl</i>	<i>MPa</i>	<i>MPa</i>
BH03	2.65	0.97	2.58
BH05	1.80	0.61	1.40
BH06	2.21	1.65	3.55

5 Recommendations

5.1 Groundwater Controls

Groundwater was not encountered within the soil profile up to the investigation depth during fieldwork. Any groundwater seepage or inflow that may occur during excavation is expected to be manageable using temporary drainage measures. These may include the installation of pumps or the grading and excavation of drainage paths to divert water away from work areas, if inflows are encountered.

5.2 Excavation Conditions and Vibrations Control

Based on the subsurface conditions encountered and discussed in Section 3.2, bulk or footing excavations are expected to encounter medium dense to dense sandy soils, firm to stiff clayey soils, and granodiorite boulders of low to medium and high strength.

Excavation through the fill material and natural sandy or clayey soil is expected to be achievable using conventional earthworks equipment such as a tracked excavators with a tiger-tooth bucket. Vibrations from excavation within soil is expected to be negligible.

Excavatability through rock boulders and hard materials, if required, can be based on the method published by Pettifer and Fookes (1994) as shown in Figure 3 where the rock point load index ($I_{s(50)}$) and fracture spacing is considered. The excavatability categories range from easy to hard digging, through easy to hard ripping, to blasting.

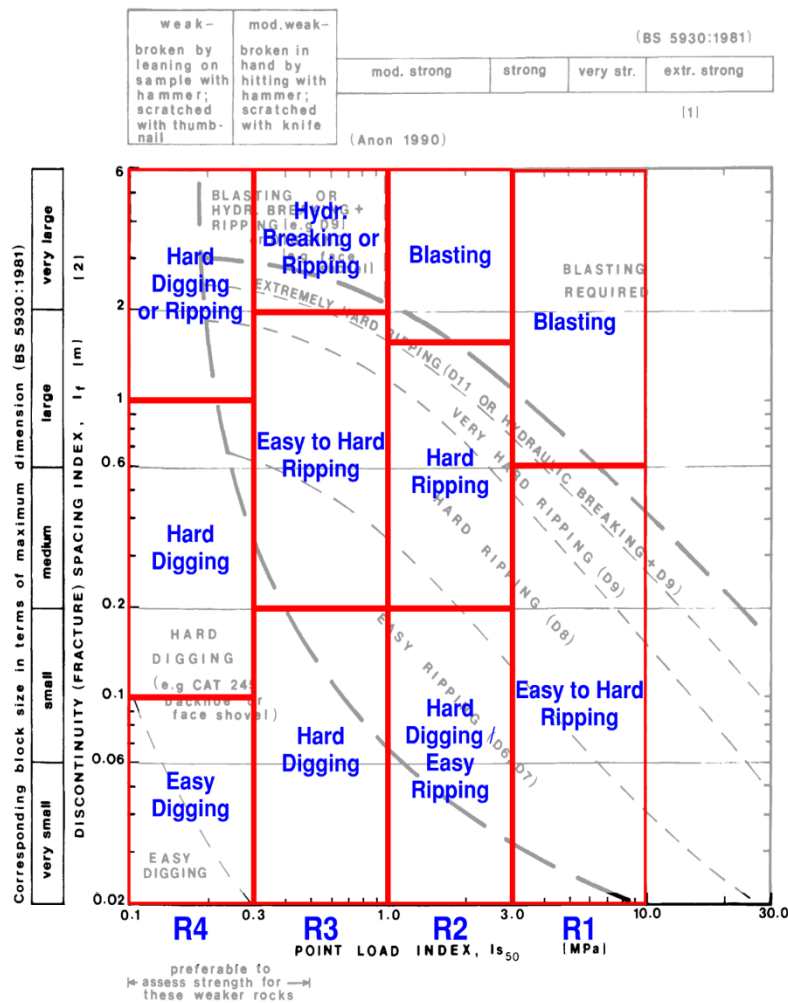


Figure 4: Excavatability Nomogram (Pettifer & Fookes, 1994)

Excavation through the medium to high strength granodiorite boulders encountered at the site may require the use of rock breaking hammers or other easy to hard ripping equipment. In areas where adjacent structures may be sensitive to vibration, low-vibration equipment is recommended to minimise impact. Where feasible, cut rock blocks may be dislodged using small rock hammers and lifted out with minimal vibration. Alternatively, blocks of cut rock mass can be dislodged using small rock hammers and lifted out without generating large vibrations.

During earthworks, large granodiorite boulders pose a potential safety risk if dislodged. Excavation through these boulders should be undertaken with care and planning. Controlled removal may be required which involves safe dislodgement followed by on-site crushing and disposal using appropriate machinery mentioned above.

Generally, the peak particle velocity during any demolition, excavation, and construction should be limited to 5mm/s. A minimum distance of 2.0m is recommended between the operation point and the adjacent structure.

If the encountered ground conditions during construction are not in line with the findings of this geotechnical investigation, the project geotechnical engineer should be informed prior to advancing the construction works.

5.3 Batter Slopes

Given the ample space available at the site relative to the proposed development, unsupported temporary batter slopes or benching may be considered feasible, provided that excavations do not extend below the 'zone of influence' of any adjacent structures, road, and other infrastructure and do not exceed the maximum recommended batter slope gradient. It is noted that the zone of influence is the area of ground affected by the load of adjacent structures or underground infrastructure, typically represented by an imaginary line projected upwards from the structure foundation at an angle of 30° for granular soils and 45° for cohesive soils.

To assess the feasibility of using batter slopes, the footing level of the adjoining structures and infrastructure, as well as surrounding services invert levels, should be assessed by the project's structural engineer.

Batter slopes within the upper soil layers or engineer fill batters are recommended to be cut at no steeper than the batter gradients presented in Table 8 below.

Table 8 - Maximum Recommended Dry Batter Slopes

Material	Safe Batter Slope (H:V)	
	Short Term / Temporary ^[1]	Long Term / Permanent ^[1]
Moderately compacted clayey FILL	1.5 : 1	2.5 : 1
Colluvial Gravelly SAND or Clayey SAND	1.5 : 1	2.5 : 1
Colluvial CLAY, silty CLAY, or Gravelly CLAY	1 : 1	2 : 1

[1] Dry batter only and without surcharge applied

As mentioned in Section 5.1, large granodiorite boulders may be present within the batter and pose a potential safety risk if dislodged. Any unstable boulders must be removed with care followed by on-site crushing for disposal using appropriate machinery.

5.4 Earthwork Construction Recommendations

It is understood that some fill placement and compaction will be required for the construction of the proposed development. However, subgrade preparation works will need to be undertaken prior to fill placement, as detailed below. It is noted that site classification may require to be re-undertaken if major filling is placed across the site.

The results of the fieldwork indicate that the natural colluvial strata underlying the site may be used for filling provided unsuitable materials containing organic or deleterious materials are removed. Provided that the materials have a plasticity index below 15%, further treatment such as lime stabilisation is not required.

Based on the geotechnical results, it is expected that unsuitable materials including topsoils and organic materials will be only within the top 600mm from the existing ground level. Should the extent of the unsuitable materials be at great depth or unexpected finds are encountered, further advice should be sought from

Alliance. Over-sized cobbles and boulders will need to be removed or pre-treatment (by means of crushing) will be required.

If it is intended to import fill material, granular material is preferred for general filling provided the fill material is of low to medium plasticity (crushed sandstone or similar). The fill must be well compacted and cannot contain any demolition waste, vegetation, organic matter or other contaminants. Plasticity index of the fill materials should be limited to 15% for the top 1000mm and 30% for filling below this depth and the maximum particles size is not to be greater than 75mm. It is recommended to place a final layer of compacted granular fill with a thickness of 250mm to finish the construction platform to protect the subgrade from soil moisture variation.

Filling material should be placed with density ratio and moisture content specified in Table 9. Placement of fill will require strict moisture control to ensure that adequate compaction is achieved. General fill (with a compaction ratio of 95%) is not recommended to be relied on as a foundation stratum for the shallow footings (without the project's structural engineer endorsement), and to support pavement and subgrades.

Table 9 - Compaction specifications

Fill Material	Loose Layer Thickness	Minimum Compaction Ratio Density Ratio / Density Index	Moisture content
General fill	250mm	95% / 70%	± 2% OMC
Engineering fill to support pavement and subgrades	250mm	100% / 85%	± 2% OMC

OMC Optimum Moisture Content. Only applicable for cohesionless material

Over-compaction should be avoided due to the potential for ground surface heave, which may cause ground slabs to crack and distortion in paving. It is recommended that a programme of density testing be implemented to ensure that the required level of compaction is being achieved in as specified AS3798:2007 to minimum Level 2 standard, but Level 1 is recommended in preference.

Methods of maintaining moisture content may include the use of plastic membranes or gravel layers over the surface of the exposed subgrade or lime blending within the upper subgrade layers. Maintaining correct moisture content within the subgrade will be assisted if there are minimal delays in construction of ground slabs and pavements after completion of earthworks. Interception and relief of subsoil seepage in all areas of significant cut is essential if subsequent softening of the subgrade below ground slabs and pavements is to be avoided.

The following procedure is provided for subgrade preparation for earthworks, pavements, and slab-on-ground construction (if required):

- Strip existing fill and topsoil. Remove unsuitable materials from the site (e.g., material containing deleterious matter). Stockpile remainder for re-use as landscaping material or remove from site.
- If natural soils need to be excavated, stockpile for re-use as fill (if suitable) or remove as spoil. Any waste soils being removed from the site must be classified in accordance with current regulatory authority requirements to enable appropriate reuse or disposal to an appropriately licensed landfill facility. Re-use of site-won materials onsite may be subject to further treatment such as lime stabilisation and environmental contamination assessments, and any controls identified by the project's environmental consultant should be addressed and discussed with Alliance.
- Areas which show visible heave under compaction equipment should be over-excavated a further 0.3m or as directed by the geotechnical engineer on site and replaced with approved fill. The replaced

select fill layers (following moisture conditioning, if required) shall be compacted with a roller until a minimum standard dry density ratio of 100% SMDD is achieved, and the in-situ moisture content of the layer is within $\pm 2\%$ of standard optimum at the time of carrying out the field density testing.

- For the pavement and slab subgrade, after excavation or filling to the design subgrade level, the exposed surface will require inspecting and test rolling in the presence of a geotechnical engineer to identify and delineate any areas of loose, soft, or unsuitable subgrade material. The test roll should be carried out using a smooth drum roller of at least 12t to pass over the entire subgrade area 4 to 6 times under low speed and in static mode. Following the inspection and test roll, areas of soft or unsuitable subgrade where the design CBR is not considered to be achievable shall be excavated to a suitable foundation level, expected not exceeding 1m below ground. The excavated areas should then be backfilled using controlled fills placed and compacted to 100% SMDD in layers not exceeding 250mm thick.

It is recommended that all compaction control testing in areas that will support structures and pavements to be completed under appropriate supervision by an approved Geotechnical Inspection and Testing Authority (GITA). Further advice should be sought where filling is required to support major structures. Any minor fill (up to 1m) which is to support pavements or lightly loaded ground slabs should be placed in a controlled manner as outlined above, and the earthworks construction and testing is to be carried out in accordance with Australian Standard AS 3798:2007 – Earthworks for residential and commercial developments). Where major filling is required (greater than 1m), then it is subject to a site-specific earthwork specification.

Any off-site disposal of excavated materials will require an assessment for re-use or classification of the soils in accordance with EPA guidelines. This includes fill soils and natural soils removed from site. Environmental assessments may need to be undertaken on excavated soils to classify spoil prior to removal from site.

5.5 Site Sub-Soil Classification

Determination of the lots' sub-soil classification has been carried out in accordance with AS1170.4:2007 Structural Design Actions Part 4: Earthquake Actions in Australia and is presented in Table 10 below.

Table 10 - Sub-Soil Classification Summary

Lot	Sub-soil Class	Hazard Factor z
1 - 18	Ce – Shallow soil	0.10

5.6 Site Classification

The site is underlain by uncontrolled fill to a maximum depth of 0.6m at borehole BH03. Hence, the site is classified as Class P in accordance with AS2870:2011 – Residential Slabs and Footings.

Given that the fill thickness varies between 0.2m and 0.6m, the lots can be reclassified given that all footings will be founded in the natural stratum beyond uncontrolled fill. However, reclassification is not applicable for slab on ground structures.

The results of shrink-swell index and plasticity testing indicate that the natural colluvium silty clay, clay, or gravelly clay and residual clayey sand are typically low to medium plasticity and have low to moderate potential for shrinkage and swelling movements due to changes in soil moisture content. The lot reclassifications have been determined and are summarised in Table 11.

Table 11 – Lot Re-Classification Summary

Lot	Lot Classification	Lot	Lot Classification	Lot	Lot Classification
1	M	7	M	13	S
2	M	8	S	14	S
3	M	9	S	15	S
4	M	10	S	16	M
5	M	11	S	17	M
6	M	12	S	18	M

S = Class S: Slightly reactive clay sites with estimated surface movement y_s less than 20mm

M = Class M: Moderately reactive clay sites with estimated surface movement y_s between 20mm and 40mm

The classification given in Table 11 is appropriate for the undeveloped lots at the time of writing this report. Revision of the lot classifications may be required once development details and proposed site works for individual lots are known.

5.7 Geotechnical Design Parameters

Where required, the lateral earth pressure parameters for retaining walls provided in Table 12 below can be used. Retaining walls should be designed in accordance with AS4678 – 2002 Earth Retaining Structures.

Where some lateral movement is acceptable, an 'active' lateral coefficient (K_a) can be used in the design. If it is critical to limit the horizontal deformation, an earth pressure coefficient 'at rest' (K_0) should be adopted.

A triangular stress distribution should be used for the design of permanent retaining walls if they are designed as a cantilever or singularly braced/anchored.

Table 12 – Geotechnical Design Parameters for Lateral Support Structures

Materials	γ (1)	C_u (2)	c' (3)	ϕ' (4)	K_a (5)	K_0 (6)	K_P (7)	E (8)	ν' (9)
	$kN.m^{-3}$	kPa	kPa	$^\circ$	–	–	–	Mpa	–
Fill Clayey SILT/ Silty CLAY	17	25	–	24	0.42	0.59	2.37	10	0.3
Colluvium Firm to stiff CLAY	18	50	5	26	0.39	0.56	2.56	15	0.3
Colluvium Dense to medium dense SAND	19	–	0	34	0.28	0.44	3.54	25	0.3

(1) Material in-situ weight, based on visual assessment ($\pm 10\%$).

(2) Undrained Cohesion/shear strength, assuming normally consolidated clay ($\pm 10\%$).

(3) Effective Cohesion, assuming normally consolidated clay ($\pm 10\%$).

(4) Effective Friction Angle ($\pm 2^\circ$) assuming drained conditions; may be dependent on defect conditions.

(5) Active earth pressure. (No friction between wall and soil, flat ground, no surcharge)

(6) Earth pressure at rest. (Assuming normal consolidated clay where applicable)

(7) Passive earth pressure. (No friction between wall and soil, flat ground, no surcharge)

(8) Elasticity (Young's) Modulus.

(9) Poisson's Ratio.

5.8 Foundations & Footings

The existing fill is not a suitable foundation material, and the proposed structures should be founded on the natural stratum only. For lightly loaded, differential settlement-insensitive structures, it may be feasible to design shallow footings founded uniformly in natural colluvium or residual soil. Parameters for shallow footing design are presented in Table 13.

It should be noted that the provided bearing pressures do not apply to raft footing designs. If a raft footing is proposed, an assessment of settlements needs to be made using the applied loads and geometry. Alliance can assist in the geotechnical aspects of this design if required.

Table 13 – Preliminary Geotechnical Parameters for Shallow Foundations with Vertical Centric Loads

Description	Allowable Bearing Pressure (kPa)	Youngs Modulus (MPa)
Colluvium Firm to stiff CLAY	100 ⁽¹⁾⁽²⁾	15
Colluvium Medium dense to dense SAND	200 ⁽¹⁾⁽²⁾	25

(1) Based on a 1.0m square pad footing with 0.5m embedment as a minimum. Larger and deeper footings will achieve higher allowable bearing pressures.

(2) Separate settlement assessment should be undertaken to ensure that the footing settlements are within the tolerable range.

If completely weathered granodiorite or granitic boulders are encountered, the allowable bearing capacity can be increased to 600kPa, but this is not consistent across the proposed subdivision.

Allowable bearing pressure is not a soil property, but also a function of the size of the footing, embedment depth, and load eccentricity. Larger and deeper footings have larger bearing capacities, and eccentric loads reduce the bearing capacity.

It is recommended that the footings are founded on the same strata to minimise the risk of differential settlement.

Additional geotechnical investigations may be required should highly loaded and differential settlement sensitive structures be proposed.

All footing excavations are required to be cleaned of any loose or disturbed material and any water immediately prior to placing the concrete. Geotechnical inspections should be undertaken during shallow footing excavation. An experienced geotechnical engineer or engineering geologist should be on site to confirm the design embedment depth and the assumptions made in this report regarding the subsoil conditions. Should the encountered ground conditions be different to the findings of this geotechnical investigation, the project geotechnical engineer should be informed prior to advancing the construction works.

5.9 Crackenback Fault

As mentioned in Section 2, the Crackenback Fault, identified in the NSW Geology Digital Datasets (Colquhoun, et al., 2025) as a strike-slip fault, trends northeast-southwest, running parallel to the site's southeast boundary and the Thredbo River. According to the dataset, the fault is mapped near Lots 10, 11, 12, and 13; however, it is acknowledged that the exact location may not be accurately represented, and the fault line may not intersect the proposed subdivision.

Preliminary site observations and available geotechnical investigation results indicate no evidence of current fault activity. The site is located in a flat valley area with generally undulating terrain and lacks geomorphic features such as steep slopes, sharp scarps, or offset landforms typically associated with active faulting or

instability. As such, adverse impacts from fault-related ground movement are not expected for this proposed development.

Nevertheless, should any signs of ground movement become evident, such as cracking, surface displacement, or ground rupture, even at a minor scale, or in the event of a seismic occurrence (e.g. earthquake), further geotechnical inspection is recommended, and additional advice should be sought.

5.10 AGS Slope Stability Assessment

5.10.1 Assessment Framework

The Australian Geomechanics Society (AGS) Landslide Risk Management Guidelines (2007) have been used to assess the levels of stability risks associated with the proposed subdivision development during and after completion of its construction.

The guidelines, which can be referred to in Section 7, consist of:

- A National Landslide Risk Management Framework for Australia
- AGS 2007a and AGS 2007b – Guideline for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning and commentary.
- AGS2007c and AGS 2007d – Practice note guidelines for landslide risk management and commentary.
- Australian Geoguides.

The risk assessment process involves the identification of hazards that could potentially affect the stability of the site and surrounding land, as well as identification of “elements at risk” should a landslide occur.

The risk criteria in the AGS guidelines, provided in Appendix E, is applied to assess the ‘risk to property’ for each hazard type and to determine suitable risk management requirements for the proposed site development.

5.10.2 Site History

The most recent significant landslide in the vicinity occurred at Thredbo Village on 30 July 1997, approximately 1km northeast of the current site boundary. The failure initiated within the Alpine Way fill embankment at the southwest corner of the slope above Carinya Lodge and propagated downslope in a northeast direction, impacting Carinya and Bimbadeen Lodges. The movement extended across Bobuck Lane, resulting in the complete destruction of both structures and causing 18 fatalities.

The failure mechanism was classified as a rapid earth flow, characterized by the downslope movement of saturated fill material in a semi-fluid state. The displaced mass comprised a mixture of soil, rock fragments, and water, which mobilized rapidly under gravity, producing catastrophic damage to the built environment.

Primary Trigger

The immediate trigger for the Thredbo landslide was leakage from a water supply main installed within the Alpine Way embankment. The pipeline, constructed of asbestos cement pipes with rigid joints, lacked flexibility to accommodate ground movement. Progressive soil creep and differential settlement led to joint separation, allowing water to escape and saturate the surrounding fill. This saturation reduced shear strength by increasing pore water pressures, ultimately initiating failure in the marginally stable embankment.

Slope Conditions

The Alpine Way was constructed as a temporary access road during the Snowy Mountains Hydro-Electric Scheme and was never intended for long-term use. The embankment consisted of uncompacted fill placed on

steep natural slopes without adequate benching or drainage. The fill contained organic material, boulders, and decomposed granite, resulting in a heterogeneous and weak structure. Under saturated conditions, the factor of safety approached unity, making the slope highly vulnerable to collapse. The steep slope angle (up to 28°) exceeded the effective friction angle of the fill when wet, further compromising stability.

Contributing Factors

The Alpine Way embankment was poorly constructed in the 1950s–60s using side-cast, uncompacted fill without benching or adequate drainage. Over time, blocked culverts and poor surface water control allowed infiltration, while heavy rainfall and snowmelt further increased soil moisture. Historical records show repeated instability along Alpine Way since the 1960s, yet no comprehensive geotechnical investigation was undertaken for the water main or retaining wall works. These deficiencies, combined with climatic conditions, created a highly vulnerable slope prone to failure.

Management and Oversight Deficiencies

Deficiencies in infrastructure management and planning contributed significantly to the disaster. The Alpine Way was originally built as a construction access road and was not upgraded to meet standards for permanent use adjacent to an urban settlement. Despite documented instability and multiple technical warnings, no comprehensive geotechnical investigation or systematic risk assessment was undertaken. Maintenance practices were inadequate, and responsibility for slope safety was fragmented between agencies, resulting in a failure to implement preventive measures.

Key Highlights

The Thredbo landslide was primarily caused by poorly compacted fill in the Alpine Way embankment combined with leakage from a water main, which led to saturation and loss of shear strength.

Natural slopes in the Thredbo Valley exhibited no significant evidence of instability in the recent past, and historical mobile landslides have been confined to the Alpine Way embankments.

Based on the AGS paper “Quantitative Risk Assessment of the Thredbo Landslide” (Mostyn & Sullivan, 2002), the risk associated with natural slopes is considered low, and future assessments should reflect this distinction.

5.10.3 Site Walkover Findings

As part of the geotechnical investigation undertaken on 27 April 2022, a site walkover was conducted to document geological and topographical features. Selected photographs from the walkover are provided in Appendix A.

The site was observed to be generally undulating with a gentle slope. Granodiorite boulders were noted across the site, particularly in the northwest section. Importantly, no signs of instability were observed, including:

- No soil erosion exposing boulders
- No evidence of ground movement or boulder displacement
- No tension cracks or surface distress
- No signs of tree creep or root movement
- No signs of erosion or ground movement along the riverbanks

It is noted that the mountain ranges in the southeast, beyond the Thredbo River, locate at least 100m away from the closest point of the proposed lot subdivision. As such, the risk associated with these slopes is not considered within the current slope risk assessment.

5.10.4 Identified Geotechnical Hazards

Based on observations during the site walkover and Alliance's previous experience with similar projects and subsurface conditions, the following geotechnical hazards have been identified within the proposed subdivision areas. These areas are generally located on valley floors where the terrain is predominantly flat to gently undulating, with an overall site gradient of less than 15° trending toward the southeast (toward the Thredbo River)

- Hazard A: Long-term soil flow at the Thredbo River banks along the southeast boundary of the site.
- Hazard B: Soil flow over the northwest slope.
- Hazard C: Rockfall (However, it is noted that no unstable rock boulders or wedges were observed on site during fieldwork).

These hazards can be brought about by the following trigger mechanisms:

- Uncontrolled and concentrated surface water runoff, leading to erosion of soil at surface.
- In-ground water ingress may occur due to blocked drainage systems or damaged underground services such as stormwater pits or water mains, resulting in reduced soil shear strength.
- Gradual downslope movement of soil mass is commonly observed, which may lead to long-term instability.
- Excessive vibrations, seismic activity, or undercutting by erosion or construction activities that dislodges unstable rock boulders or wedges.
- Clearing of vegetation from slope faces or riverbanks reduces root reinforcement and increases susceptibility to erosion and instability.

It is noted that other forms of hazards such as a deep rotational failure were considered not credible given the limited thickness of the colluvium, which is expected to be thicker at the location of the boreholes.

5.10.5 Risk to Property

The risk to property assessment have been presented below and refer to the geotechnical hazards identified in Section 5.10.2.

Table 14 provides Alliance's assessment of the level of "Risk to Existing Property" after appropriate risk management measures have been implemented. The AGS 2007 risk assessment tables are provided in Appendix E.

Table 14 - AGS Risk Assessment – Risk to Property

Affected Structure	Geotechnical Hazards existing on site			
	Hazard Type	Likelihood	Consequence	Risk
Proposed subdivision, car park, and other related structures	A: Long-term soil flow at riverbanks	Possible	Insignificant	Very Low
	B: Soil flow at uphill slope faces	Unlikely	Medium	Low
	C: Rock fall	Rare	Major	Low

5.10.6 Risk to Life

The AGS 2007 guidelines provide the following equation to be used for 'risk to life' calculations:

$$R_{(LoL)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(D:T)}$$

Where:

- $R_{(LoL)}$ is the risk (annual probability of loss of life (death) of an individual).
- $P_{(H)}$ is the annual probability of the landslide.
- $P_{(S:H)}$ is the probability of spatial impact of the landslide impacting a building (location) considering the travel distance and travel direction given the event.
- $P_{(T:S)}$ is the temporal-spatial probability (e.g. of the building or location being occupied by the individual) given the spatial impact and allowing for the possibility of evacuation given there is warning of the landslide occurrence.
- $V_{(D:T)}$ is the vulnerability of the individual (probability of loss of life of the individual given the impact).

The geotechnical hazards with the potential to pose a risk to person/s have been considered in the 'risk to life' calculations. The selected probability values for 'risk to life' calculations are based on the worst-case terms in the risk to property assessment in Section 7.1, in terms of their impact to persons inhabiting the property. The results of the assessment are set out in Table 15 below.

Table 15 - Summary of Risk to Life Calculations considering Risk Management Measures

Hazard	$P_{(H)}$	$P_{(S:H)}$	$P_{(T:S)}$	$V_{(D:T)}$	$R_{(LoL)}$	Risk of Injury or Loss of Life
Personal injury for people (adjacent to Thredbo River) due to long-term soil creep	1×10^{-3} (Possible)	0.1	0.01	0.05	5×10^{-8}	Acceptable
Personal injury for people (below the slope) due to soil flow	1×10^{-4} (Unlikely)	0.4	0.3	0.5	6×10^{-6}	Acceptable
Personal injury for people (below the slope) due to rock fall	1×10^{-5} (Rare)	0.1	0.3	0.7	2.1×10^{-7}	Acceptable

5.10.7 Risk Management Measures & Residual Risks

It is noted that most of the identified geotechnical issues which are pertinent to the construction of the proposed subdivision, are typical to those expected on sloping land and can be managed by established hillside construction practice (see Appendix E), in conjunction with regular construction supervision by a geotechnical engineer.

The risks associated with the hazards described in Section 5.10.2 can be maintained at acceptable levels of "Low" provided the following recommendations are implemented and maintained:

- Maintain existing deep-rooted vegetation and trees along the riverbanks to enhance slope stability and reduce erosion potential.

- Where necessary, install revetments or benching treatments along the Thredbo River riparian corridor, particularly in areas subject to high-velocity flows or visible signs of erosion.
- Preserve existing trees and vegetation on slope surfaces to provide natural protection barrier against rockfall, surface erosion, and weathering, and to act as a passive barrier against potential rockfall.
- Implement permanent surface and subsurface drainage systems to divert water runoff away from slope faces and reduce saturation-related instability.
- Periodic inspection of slope areas is recommended to identify early signs of potential geotechnical hazards, such as tension cracks, surface weathering, erosion, or unstable rock wedges. Inspections should be undertaken after heavy rainfall events ($\geq 100\text{mm/day}$ or with an intensity of $\geq 20\text{mm/hour}$). Should any such indicators be observed, a qualified geotechnical engineer must be engaged to undertake further assessment and provide appropriate remediation recommendation.
- Construction activities should follow the recommendations outlined in this report to prevent dislodgement of boulders during excavations up to 4 m deep for the proposed new roads.

By reference to the risk assessment set out in Table 14 and Table 15, it is noted that:

- The geotechnical risk to property is assessed as “Low to Very Low”.
- The quantitative risk to life calculations indicates that the probability of loss of life for the individual most at risk is Acceptable with a risk probability of less than 1×10^{-5} per annum, in accordance with the “Practice Note Guidelines for Landslide Risk Management” by the Australian Geomechanics Society (AGS 2007).

5.11 Development Approval Conditions

In accordance with the Geotechnical Policy, further geotechnical review, assessment, and inspection must be undertaken in line with Section 4 of the Policy, once detailed structural designs become available. Specifically:

- A geotechnical review of the final design must be completed when detailed structural documentation is ready. This must be accompanied by a completed Form 2: “Declaration and certification made by a structural engineer or civil engineer and geotechnical engineer or engineering geologist in relation to a geotechnical report.”
- In preparation for the Construction Certificate (CC), all structural designs involving geotechnical aspects must be reviewed and certified by a suitably qualified and experienced geotechnical engineer. Any additional design conditions deemed necessary by the geotechnical engineer must be incorporated to ensure the design achieves the “acceptable risk management” level defined in the Policy, with respect to potential loss of property and life. All CC drawings must be reviewed by a qualified geotechnical engineer and submitted with a completed Form 2.
- During construction, including all earthworks and civil works, geotechnical inspections and sign-offs must be carried out as specified in this report. All inspection records must be maintained and made available for review and completion of Form 3: “Final Geotechnical Certificate.”

Additionally, a copy of the completed Form 1: “Declaration and certification made by a geotechnical engineer or engineering geologist in a geotechnical report” has been included in Appendix F of this report, as required under the Geotechnical Policy.

6 Limitations

Alliance Geotechnical Pty Ltd (Alliance) has prepared this report for the site, in accordance with Alliance's fee proposal and Terms of Engagement. This geotechnical report has been prepared for the client for this project and for the purposes outlined in this report. This report cannot be relied on for other projects, other parties on this site or any other site.

The comments and recommendations provided in this report are provided based on limited investigation. The borehole investigation and testing results provided in this report are indicative of the subsurface conditions at the site only at the specific sampling and testing locations, and to the depths drilled at the time of the investigation. Subsurface conditions can change significantly due to geological and human processes. Where variations in conditions are encountered further geotechnical advice should be sought from Alliance.

7 References

- Australian Geomechanics Society Landslide Taskforce, Landslide Practice Note Working Group . (2007d). Commentary on Practice Note Guidelines for Landslide Risk Management. *Australian Geomechanics Society*, 115-158.
- Australian Geomechanics Society Landslide Taskforce, Landslide Practice Note Working Group. (2007c). Practice Note Guidelines for Landslide Risk Management 2007. *Australian Geomechanics Society*, 63-114.
- Australian Geomechanics Society Landslide Taskforce, Landslide Practice Note Working Group. (2007e). The Australian GeoGuides for Slope Management and Maintenance. *Australian Geomechanics Society*, 159-182.
- Australian Geomechanics Society Landslide Zoning Working Group . (2007b). Commentary on Guideline for Landslide Susceptibility, Hazard and Risk. *Australian Geomechanics Society*, 37-62.
- Australian Geomechanics Society Landslide Zoning Working Group. (2007a). Guideline for Landslide Susceptibility, Hazard and Risk Zoning. *Australian Geomechanics Society*, 13-36.
- Australian Geomechanics Society, Sub-Committee on Landslide Risk Management. (2002). Landslide Risk Management Concepts And Guidelines. *Australian Geomechanics Journal*, 1-44.
- Australian Standards. (2007). AS1170.4 – *Structural Design Actions Part 4: Earthquake Actions in Australia*.
- Australian Standards. (2007). AS2870 – Residential Slabs and Footings.
- Australian Standards. (2007). AS3798 – Guidelines on Earthworks for Commercial and Residential Developements.
- Australian Standards. (2017). AS1726 – Geotechnical Site Investigations.
- Colquhoun, G. P., Hughes, K., Deyssing, L., Ballard, J. C., Phillips, G., Troedson, A. L., . . . Fitzherbert, J. A. (2025). New South Wales Seamless Geology dataset, version 2.5 [Digital Dataset]. Geological Survey of New South Wales, Department of Regional NSW, Maitland.
- Hand, D. (2000). Coroner Report: Report of the Inquest into the Deaths Arising from the Thredbo Landslide.
- Leventhal, A. (2007). A National Landslide Risk Management Framework for Australia. *Australian Geomechanics Society* , 1-12.
- Mostyn, G., & Sullivan, T. (2002). Quantitive Risk Assessment of the Thredbo Landslide. *Australian Geomechanics Society*, 169-181.
- NSW Department of Infrastructure, Planning and Natural Resources. (2003, 11). Geotechnical Policy Kosciuszko Alpine Resort.
- Pettifer, G. S., & Fookes, P. G. (1994). A Revision of the Graphical Method for Assessing the Excavatability of Rock. *Quarterly Journal of Engineering Geology and Hydrogeology*, 154-164.
- Sub-Committee On Landslide Risk Management. (2000). Landslide Risk Management Concepts And Guidelines. *Australian Geomechanics Society*, 49-92.
- Walker, B., Davies, W., & Wilson, G. (2007). Practice Note Guidelines for Landslide Risk Management. *Australian Geomechanics*, 63-114.

APPENDIX A – Selected Site Photographs



Photo 1 - General Site Conditions Looking Northeast with Mountain Ranges in View



**Photo 2 - General Site Conditions, Looking Southwest
Showing Gentle Gradient Toward the Southeast**



Photo 3 – Granodiorite Boulders (Assumed Backfilled) Observed at the Northwest Section of the Site



Photo 4 - Natural Granodiorite Boulders within the Site Vicinity



Photo 5 - Drilling and DCP Test Set Up at Borehole BH05 Looking Southwest



Photo 6 - SPT Split Spoon Samples at BH0, 2m-2.45m (N=32)

APPENDIX B – Geotechnical Investigation Plan



Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

alliance geotechnical & environmental solutions	Site Plan Scale 1:780 on A3					
	Client Name :	Kosciuszko Thredbo Pty Ltd		N 020 Meters	Drawing Number :	14871-GR-1-A
	Project Name :	Thredbo Golf Course Subdivision Development			Drawing Date :	12/05/2022
	Project Location	Thredbo Golf Course, 2/4 Crackenback Drive, Thredbo NSW			Report Number :	14871-GR-1-1

**APPENDIX C – Explanatory Notes, Borehole Logs with Core Box Photos,
& Dynamic Cone Penetrometer Test Report**

GENERAL

Information obtained from site investigations is recorded on log sheets. Soils and very low strength rock are commonly drilled using a combination of solid-flight augers with a Tungsten-Carbide (TC) bit. Descriptions of these materials presented on the "Borehole Log" are based on a combination of regular sampling and in-situ testing. Rock coring techniques commences once material is encountered that cannot be penetrated using a combination of solid-flight augers and Tungsten-carbide bit. The "Cored Borehole Log" presents data from drilling where a core barrel has been used to recover material - commonly rock.

The "Excavation – Geological Log" presents data and drawings from exposures of soil and rock resulting from excavation of pits or trenches.

The heading of the log sheets contains information on Project Identification, Hole or Test Pit Identification, Location and Elevation. The main section of the logs contains information on methods and conditions, material description and structure presented as a series of columns in relation to depth below the ground surface which is plotted on the left side of the log sheet. The scale is presented in the depth column as metres below ground level.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is included in the identification of material boundaries in areas of partial sampling, the location of areas of core loss, description and classification of material, estimation of strength and identification of drilling induced fractures, and geological unit. Material description and classifications are based on Australian Standard Geotechnical Site Investigations: AS 1726 - 2017 with some modifications as defined below.

These notes contain an explanation of the terms and abbreviations commonly used on the log sheets.

DRILLING

Drilling, Casing and Excavating

Drilling methods deployed are abbreviated as follows

Abbreviation	Method
AS	Auger Screwing
ADV	Auger Drilling with V-Bit
ADT	Auger Drilling with TC Bit
BH	Backhoe
E	Excavator
HA	Hand Auger
HQ	HQ core barrel (~63.5 mm diameter core) *
HMLC	HMLC core barrel (~63.5 mm diameter core) *
NMLC	NMLC core barrel (~51.9 mm diameter core) *
NQ	NQ core barrel (~47.6 mm diameter core) *
RR	Rock Roller
WB	Wash-bore drilling

* Core diameters are approximate and vary due to the strength of material being drilled.

Drilling Fluid/Water

The drilling fluid used is identified and loss of return to the surface estimated as a percentage. It is introduced to assist with the drill process, in particular, when core drilling. The introduction of drill fluid/water does not allow for accurate identification of water seepages.

Drilling Penetration/Drill Depth

Core lifts are identified by a line and depth with core loss per run as a percentage. Ease of penetration in non-core drilling is abbreviated as follows:

Abbreviation	Description
VE	Very Easy
E	Easy
F	Firm
H	Hard
VH	Very Hard

GROUNDWATER LEVELS

Date of measurement is shown.

	Standing water level measured in completed borehole
	Level taken during or immediately after drilling
	Groundwater inflow water level

SAMPLES/TESTS

Samples collected and testing undertaken are abbreviated as follows

Abbreviation	Test
ES	Environmental Sample
DS	Disturbed Sample
BS	Bulk Sample
U50	Undisturbed (50 mm diameter)
C	Core Sample
SPT	Standard Penetration Test
N	Result of SPT (*sample taken)
VS	Vane Shear Test
IMP	Borehole Impression Device
PBT	Plate Bearing Test
PZ	Piezometer Installation
HP	Hand Penetrometer Test
HB	Hammer Bouncing

EXCAVATION LOGS

Explanatory notes are provided at the bottom of drill log sheets. Information about the origin, geology and pedology may be entered in the "Structure and other Observations" column. The depth of the base of excavation (for the logged section) at the appropriate depth in the "Material Description" column. Refusal of excavation plant is noted should it occur. A sketch of the exposure may be added. Photos are recommended.

MATERIAL DESCRIPTION – SOIL

Material Description - In accordance with AS 1726-2017

Classification Symbol - In accordance with the Unified Classification System (AS 1726-2017).

Abbreviation	Typical Name
GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines, uniform gravels.
GM	Silty gravels, gravel-sand-silt mixtures.
GC	Clayey gravels, gravel-sand-clay mixtures.
SW	Well graded sands, gravelly sands, little or no fines.
SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands.
SM	Silty sand, sand-silt mixtures.
SC	Clayey sands, sand-clay mixtures.
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
OL	Organic silts and organic silty clays of low plasticity. *
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, clastic silts.
CH	Inorganic clays of high plasticity, fat clays.
OH	Organic clays of medium to high plasticity, organic silts. *
Pt	Peat and other highly organic soils. *

* Additional details may be provided in accordance with the Von Post classification system (1922).

Organic Soils – Identification using laboratory testing:

Material	Organic Content - % of dry mass
Inorganic	<2
Organic Soil	<2 ≤ 25
Peat	> 25

Organic Soils – Descriptive terms for the degree of decomposition of peat:

Term	Decomposition	Remains	Squeeze
Fibrous	Little or none	Clearly recognizable	Only water No solid
Pseudo-fibrous	Moderate	Mixture of fibrous and amorphous	Turbid water < 50% solids
Amorphous	Full	Not recognizable	Paste > 50% solids

Particle Characteristics – Definitions are as follows:

Fraction	Component (& subdivision)		Size (mm)
Oversize	Boulders		> 200
	Cobbles		> 63 ≤ 200
Coarse grained soils	Gravel	Coarse	> 19 ≤ 63
		Medium	> 6.7 ≤ 19
		Fine	> 2.36 ≤ 6.7
	Sand	Coarse	> 0.6 ≤ 2.36
		Medium	> 0.2 ≤ 0.6
		Fine	> 0.075 ≤ 0.21
Fine grained soils	Silt		0.002 ≤ 0.075
	Clay		< 0.002

Secondary and minor soil components

In coarse grained soils – The proportions of secondary and minor components are generally estimated from a visual and tactile assessment of the soils. Descriptions for secondary and minor soil components in coarse grained soils are as follows.

Designation of components	Percentage fines	Terminology (as applicable)	Percentage accessory coarse fraction	Terminology (as applicable)
Minor	≤ 5	Trace clay / silt	≤ 5	Trace sand / gravel
	> 5 ≤ 12	With clay / silt	> 5 ≤ 12	With sand / gravel
Secondary	> 12	Silty or clayey	> 30	Sandy or gravelly

Descriptions for secondary and minor soil components in fine grained soils are as follows.

Designation of components	Percentage coarse grained soils	Terminology (as applicable)
Minor	≤ 5	Trace sand / gravel / silt / clay
	> 5 ≤ 12	With sand / gravel / silt / clay
Secondary	> 30	Sandy / gravelly / silty / clayey

Plasticity Terms - Definitions for fine grained soils are as follows:

Descriptive Term	Range of Liquid Limit for silt	Range of Liquid Limit for clay
Low Plasticity	≤ 50	≤ 35
Medium Plasticity	N/A	> 35 ≤ 50
High Plasticity	> 50	> 50

Particle Characteristics

Particle shape and angularity are estimated from a visual assessment of coarse-grained soil particle characteristics. Terminology used includes the following:

Particle shape – spherical, platy, elongated,

Particle angularity – angular, sub-angular, sub-rounded, rounded.

Moisture Condition – Abbreviations are as follows:

D	Dry, looks and feels dry.
M	Moist, No free water on remoulding.
W	Wet, free water on remoulding.

Moisture content of fine-grained soils is based on judgement of the soils moisture content relative to the plastic and liquid limit as follows:

MC < PL	Moist, dry of plastic limit.
MC ≈ PL	Moist, near plastic limit.
MC > PL	Moist, wet of plastic limit.
MC ≈ LL	Wet, near liquid limit.
MC > LL	Wet of liquid limit.

Consistency - of cohesive soils in accordance with AS 1726-2017, Table 11 are abbreviated as follows:

Consistency Term	Abbreviation	Indicative Shear Strength (kPa)	Undrained Strength Range
Very Soft	VS		< 12
Soft	S		12 ≤ 25
Firm	F		25 ≤ 50
Stiff	St		50 ≤ 100
Very Stiff	VSt		100 ≤ 200
Hard	H		≥ 200
Friable	Fr		-

Density Index (%) of granular soils is estimated or is based on SPT results. Abbreviations are as follows:

Description	Abbreviation	Relative Density	SPT N
Very Loose	VL	< 15%	0 - 4
Loose	L	15 - 35%	4 - 10
Medium Dense	MD	35 - 65%	10 - 30
Dense	D	65 - 85%	30 - 50
Very Dense	VD	> 85%	> 50

Structures – Fissuring and other defects are described in accordance with AS 1726-2017 using the terminology for rock defects

Origin – Where practicable an assessment is provided of the probable origin of the soil, e.g. fill, topsoil, alluvium, colluvium, residual soil.

MATERIAL DESCRIPTION - ROCK

Material Description – In accordance with AS 1726-2017

Rock Naming – Where possible conventional geological names are used within the logs. Engineering properties cannot be inferred directly from the rock names in the table, but the use of a particular name provides an indicative range of characteristics to the reader. Lithological identification of rock is provided to appreciate the geology of an area, to correlate geological profiles seen in boreholes or to distinguish boulders from bedrock.

Grain Size – Grain size is done in accordance with AS1726-2017 as follows:

For sedimentary rock:

Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm to 0.2mm

For igneous and metamorphic rock:

Coarse grained	Mainly greater than 2 mm
Medium grained	Mainly 0.6mm to 2mm
Fine grained	Mainly less than 2mm

Colour - Rock colour is described in the moist condition.

Texture and Fabric

Frequently used terms:

Sedimentary Rock	Metamorphic Rock	Igneous
Bedded	Banded	Amorphous
Cross-bedded	Cleaved	Crystalline
Folded	Folded	Flow banded
Graded	Foliated	Folded
Interbedded	Gneissose	Lineated
Laminated	Lineated	Massive
Massive	Schistose	Porphyritic

Bedding and fabric:

Description	Spacing
Very Thickly Bedded	> 2m
Thickly Bedded	0.6m to 2m
Medium Bedded	0.2m to 0.6m
Thinly Bedded	60mm to 200mm
Very Thinly Bedded	20mm to 60mm
Thickly Laminated	6mm to 20mm
Thinly Laminated	< 6mm

Degree of development:

Massive	No layering or fabric. Rock is homogeneous.
Indistinct	Layering or fabric just visible. There is little effect on strength properties.
Distinct	Layering or fabric obvious. The rock may break more easily parallel to the fabric.

Features, inclusions, and minor components - Features, inclusions and minor components within the rock material shall be described where those features could be significant such as gas bubbles, mineral veins, carbonaceous material, salts, swelling minerals, mineral inclusions, ironstone or carbonate bands, cross-stratification, or minerals the readily oxidise upon atmospheric exposure.

Moisture content - Where possible descriptions are made by the feel and appearance of the rock using one according to following terms:

Dry	Looks and feels dry.
Moist	Feels cool, darkened in colour, but no water is visible on the surface.
Wet	Feels cool, darkened in colour, water film or droplets visible on the surface.

The moisture content of rock cored with water may not be representative of its in-situ condition.

Durability – Descriptions of the materials durability such as tendency to develop cracks, break into smaller pieces or disintegrate upon exposure to air or in contact with water are provided where observed.

Rock Material Strength – The strength of the rock material is based on uniaxial compressive strength (UCS). The following terms are used:

Term / Abbreviation		Description	UCS (MPa)	Point Load Strength Index (MPa)
Very Low	VL	Crumbles under firm blow with sharp end of pick, can be peeled with a knife; too hard to cut a triaxial by hand; 30mm pieces can be broken by hand.	0.6 – 2	0.03 – 0.1
Low	L	Easily scored with a knife; indentations 1-3mm show with firm blows of the pick point; has dull sound under hammer. A piece of core 150mm long 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.	2 – 6	0.1 – 0.3
Medium	M	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.	6 – 20	0.3 – 1
High	H	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.	20 – 60	1 – 3
Very High	VH	Hand specimen breaks with pick after more than one blow; rock rings under hammer.	60 – 200	3 – 10
Extremely High	EH	Specimen requires many blows with geological pick to break into intact materials; rock rings under hammer.	> 200	> 10

Strengths are estimated and where possible supported by Point Load Index Testing of representative samples. Test results are plotted on the graphical logs as follows:

D	Diametral Point Load Test
A	Axial Point Load Test

Where the estimated strength log covers more than one range it indicates the rock strength varies between the limits shown. Point Load Strength Index test results are presented as $I_s(50)$ values in MPa.

Weathering – Weathering classification assists in identification but does not imply engineering properties. Descriptions are as follows:

Term / Abbreviation		Description
Residual Soil	RS	Material has soil properties. Mass structure and material texture and fabric of original rock not visible, but the soil has not been significantly transported.
Extremely Weathered	EW	Material has soil properties. Mass structure, material texture and fabric of original rock are still visible.
Highly Weathered	HW	Material is completely discoloured, significant decrease in strength from fresh rock.
Moderately Weathered	MW	Material is completely discoloured, little or no change of strength from fresh rock.
Slightly Weathered	SW	Partly stained or discoloured, little or no change to strength from fresh rock.
Fresh	FR	No signs of mineral decomposition or colour change.

Alteration – Physical and chemical changes of the rock material due to geological processes by fluids at depth at pressures and temperatures above atmospheric conditions. Unlike weathering, alteration shows no relationship to topography and may occur at any depth. When altered materials are recognized, the following terms are used:

Term / Abbreviation		Description
Extremely Altered	XA	Material has soil properties. Structure, texture, and fabric of original rock are still visible. The rock name is replaced with the name of the parent material, e.g., Extremely Altered basalt. Soil descriptive terms are used.
Highly Altered	HA	The whole of the rock material is discoloured. Rock strength is changed by alteration. Some primary minerals are altered to clay minerals. Porosity may be higher or lower due to loss of minerals or precipitation of secondary minerals in pores.
Moderately Altered	DA	The whole of the rock material is discoloured. Little or no change of strength from fresh rock. The term 'Distinctly Altered' is used where it is not practicable to distinguish between 'Highly Altered' and 'Moderately Altered'. Distinctly Altered is defined as follows:
	MA	- The rock may be highly discoloured; - Porosity may be higher due to mineral loss; or may be lower due to precipitation of secondary minerals in pores; and - Some change of rock strength.
Slightly Altered	S	Rock is slightly discoloured. Little or no change of strength from fresh rock.

Alteration is only described in the context of the project where it has relevance to the civil and structural design.

Defect Descriptions

General and Detailed Descriptions – Defect descriptions are provided to suit project requirements. Generalized descriptions are used for some projects where it is unnecessary to describe each individual defect in a rock mass, or where multiple similar defects are present which are too numerous to log individually. The part of the rock mass to which this applies is delineated.

Detailed descriptions are given of defects judged to be particularly significant in the context of the project. For example, crushed seams in an apparently unstable slope. As a minimum, general descriptions outlining the number of defect sets within the rock mass and their broad characteristics are provided where it is possible to do so.

Defect Type – Defect abbreviations are as follows:

BP	Bedding parting	SSM	Sheared seam	DB	Drilling break
JT	Joint	CS	Crushed seam	HB	Handling break
SS	Shear surface	SM	Infilled seam		
SZ	Sheared zone	EWS	Extremely weathered seam		

Sheared surfaces, sheared zones, sheared seams, and crushed seams are generally faults in geological terms.

Defect Orientation

For oriented core: The dip and dip direction are recorded as a two-digit and three-digit number separated by a slash, are collected e.g., 50°/240° and there is not core loss that could obscure core orientation. If alternative measurements are made, such as dip and strike or dip direction relative to magnetic north this shall be documented.

For non-oriented core: The dip is recorded as a two-digit number, e.g., 10°. In vertical boreholes the dip is generally measured relative to the horizontal plan. If the borehole is inclined the dip is generally measured from the core axis.

Surface Roughness – Defect surface roughness is described as follows:

VR	Very rough	Many large surface irregularities with amplitude generally more than 1 mm.
RO	Rough	Many small surface irregularities with amplitude generally less than 1 mm.
SO	Smooth	Smooth to touch. Few or no surface irregularities.
PO	Polished	Shiny smooth surface
SK	Slickensided	Grooved or striated surface, usually polished.

Surface Shape – Defect surface roughness is described as follows:

PL	Planar	The defect does not vary in orientation.
CU	Curved	The defect has a gradual change in orientation
UN	Undulating	The defect has a wavy surface.
ST	Stepped	The defect has one or more well defined steps
IR	Irregular	The defect has many sharp changes of orientation

Defect Infilling – Common abbreviation as follows:

Ca	Calcite	Fe	Iron Oxide	Qz	Quartz
Cy	Clay	MS	Secondary mineral	X	Carbonaceous

Defect Coatings and Seam Composition – Coatings are described using the following terms:

CN	Clean	No visible coating.
SN	Stained	No visible coating but surfaces are discoloured.
VN	Veneered	A visible coating of soil or mineral, too thin to measure; may be patchy.
CO	Coating	A visible coating up to 1 mm thick. Soil in-fill greater than 1 mm shall be described using defect terms (e.g., infilled seam). Defects greater than 1 mm aperture containing rock material great described as a vein.

Defect Spacing, Length, Openness and Thickness – Described directly in millimetres and metres. In general descriptions, half order of magnitude categories is used, e.g. joint spacing typically 100 mm to 300 mm, sheared zones 1m to 3m thick.

Depending on project requirements and the scale of observation, spacing may be described as the mean spacing within a set of defects, or as the spacing between all defects within the rock mass. Where spacing is measured within a specific set of defects, measurements shall be made perpendicular to the defect set.

Where significant, the nature of the defect end condition is recorded in the context of the scale of the exposure.

Block Shape – Where it is considered significant, block shape should be described using terms given in Table 23, AS 1725:2017.

Stratigraphic Unit – Geological maps related to the project are used for the designation of lithological formation name and, where possible geological unit name, e.g., Bringelly Shale, Potts Hill Sandstone Member.

Core Loss – Core loss occurs when material is lost during the drilling process. It is shown at the bottom of the run unless otherwise indicated where core loss is known.

Total Core Recovery – The percentage of rock recovered excluding core loss per core run.

Defect Spacing – The spacing of successive defects or the mean spacing for relatively broken core.

Fracture Index – Which is the number defects per metre of core.

Rock Quality Designation (RQD) – The percentage of sound core pieces of 100mm or greater per core run and is calculated using Deere et al. (1989) method.

Rock Classification System – For design purpose, Sydney Rock Mass Classification System (Pells et al. 1998, 2019) is adopted.

Borehole Log

Client: Kosciuszko Thredbo Pty Ltd						Started: 27/04/2022				
Project: Thredbo Golf Course Subdivision						Finished: 27/04/2022				
Location: 2/4 Crackenback Drive, Thredbo NSW 2625						Hole Location: Refer to Drawing 14871-GR-1-A		Borehole Size: 110 mm		
Rig Type: GEMCO 210B			Hole Coordinates 616227E, 5958982N			Driller: JB		Logged: KN		
RL Surface: 1382.6m			Contractor: GE Drilling			Bearing: ---		Checked: AS/MAG		
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/Density Index	Additional Observations
ADT	Groundwater not encountered.	1382.5			--	FILL: Clayey SILT, low plasticity, dark grey, trace fine to medium grained sand. Appears moderately to well compacted.		MC ~ PL	--	FILL
		1382.0	0.5		SP	Extremely weathered granodiorite recovered as Gravelly SAND, fine to medium grained, poorly graded, orange brown, fine to medium subangular and angular gravel, with clay.		M	MD - D	EXTREMELY WEATHERED ("FULLY DECOMPOSED") GRANODIORITE.
		1381.5	1.0				 DS: 1.0m - 1.5m			
		1381.0	1.5							
			2.0			TC-bit refusal on inferred granodiorite boulder. Borehole BH01 terminated at 1.6m				
		1380.5	2.5							
		1380.0	3.0							
		1379.5	3.5							
		1379.0	4.0							
		1378.5	4.5							
		1378.0	5.0							

Borehole Log

Client: Kosciuzko Thredbo Pty Ltd						Started: 27/04/2022					
Project: Thredbo Golf Course Subdivision						Finished: 27/04/2022					
Location: 2/4 Crackenback Drive, Thredbo NSW 2625						Hole Location: Refer to Drawing 14871-GR-1-A		Borehole Size: 110 mm			
Rig Type: GEMCO 210B			Hole Coordinates 616194E, 5958952N			Driller: JB		Logged: KN			
RL Surface: 1386.1m			Contractor: GE Drilling			Bearing: ---		Checked: AS/MAG			
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations	
ADT	Groundwater not encountered.	1386.0			--	FILL: Clayey SILT, low plasticity, dark grey, trace fine to medium grained sand. Appears moderately to well compacted.		MC	--	FILL	
			0.5								
		1385.5			SP	Extremely weathered granodiorite recovered as Gravelly SAND, fine to medium grained, poorly graded, orange brown, fine to medium subangular and angular gravel, with clay.		M	(MD - D)	EXTREMELY WEATHERED ("FULLY DECOMPOSED") GRANODIORITE.	
		1385.0	1.0				DS: 1.0m - 1.4m				
		1384.5	1.5			TC-bit refusal on inferred granodiorite boulder. Borehole BH02 terminated at 1.4m					
		1384.0	2.0								
		1383.5	2.5								
		1383.0	3.0								
		1382.5	3.5								
		1382.0	4.0								
		1381.5	4.5								
			5.0								

Borehole Log

Client: Kosciuszko Thredbo Pty Ltd						Started: 27/04/2022					
Project: Thredbo Golf Course Subdivision						Finished: 27/04/2022					
Location: 2/4 Crackenback Drive, Thredbo NSW 2625						Hole Location: Refer to Drawing 14871-GR-1-A		Borehole Size: 110 mm			
Rig Type: GEMCO 210B			Hole Coordinates 616133E, 5958932N			Driller: JB		Logged: KN			
RL Surface: 1388.2m			Contractor: GE Drilling			Bearing: ---		Checked: AS/MAG			
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations	
ADT	Groundwater not encountered.	1388.0	0.0		--	FILL: Clayey SILT, low plasticity, dark grey, trace fine to medium grained sand.		MC >= PL	--	FILL	
		1387.5	0.5		CL-CI	Silty CLAY, low to medium plasticity, orange brown, with fine subangular gravel, trace fine to medium grained sand.					
		1387.0	1.0				 SPT 2, 3, 2 N=5 *				
		1386.5	1.5				 U50: 1.5m - 1.7m				
		1386.0	2.0		SC	Clayey SAND, fine to medium grained, poorly graded, orange brown, with fine to medium angular gravel.					M
					 SPT 11, 16, 16 N=32 *						
	2.5			Borehole BH03 continued as cored hole							
	1385.5										
	3.0										
		1385.0									
		3.5									
		1384.5									
		4.0									
		1384.0									
		4.5									
		1383.5									
		5.0									

Borehole Size: 110 mm

Logged: KN

Checked: AS/MAG

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength ● - Axial ○ - Diametral	Is ₍₅₀₎ MPa D- diam- A- axial	RQD %	Defect Spacing mm	Additional Data
							EL VL JL ML HL VH EH			30 100 300 1000 3000	
		1388.0	0.5								
		1387.5	1.0								
		1387.0	1.5								
		1386.5	2.0								
		1386.0									
					Continued from non-cored borehole						
NMLC	40% - 50% water lost.	1385.5	2.5	+	GRANODIORITE, coarse grained, dark grey, brown yellow, and pale grey, crystalline, flow banded at 50°.	FR		D A 0.97 2.58			2.6m - JT, 0°, PL, VR, CN 2.62m - JT, 0°, PL, VR, CN 2.64m - JT, 90°, PL, VR, CN 2.65m - JT, 0°, PL, VR, CN 2.65m-2.80m - EWS, VR, Gravelly SAND
			3.0	+	No core, 1.15m.	EW/HW					
		1385.0	3.5								
		1384.5	4.0								
					Target Depth. BH03 terminated at 4m						End of BH03.
		1384.0	4.5								
		1383.5	5.0								

BOREHOLE # BH03

PROJECT # 14871

DEPTH 2.50 m TO 4.00 m

alliance

Engineering | Environmental | Testing
1800 288 188 allgeo.com.au

CLIENT
Kosciuszko Thredbo
Pty Ltd

DATE 27/04/22

NOTES
BOX 1/1



0m 0.1m 0.2m 0.3m 0.4m 0.5m 0.6m 0.7m 0.8m 0.9m 1m

PROJECT N. 14871
27/4/2022 BH03 CORE STARTS 2.42m

NO CORE 1.15m

3

NO CORE 1.15m (Cont.)

EOH4.00

Core Box Photo – Borehole BH03 – Box 1/

alliance

Client Name	Thredbo Kosciuszko Pty Ltd
Project Name	Thredbo Golf Course Subdivision
Project Location	2/4 Crackenback Drive, Thredbo NSW

Photo Number	–
Photo Date	27 April 2021
Report Number	14871-GR-1-1

Borehole Log

Client: Kosciuszko Thredbo Pty Ltd						Started: 27/04/2022				
Project: Thredbo Golf Course Subdivision						Finished: 27/04/2022				
Location: 2/4 Crackenback Drive, Thredbo NSW 2625						Hole Location: Refer to Drawing 14871-GR-1-A		Borehole Size: 110 mm		
Rig Type: GEMCO 210B				Hole Coordinates 616133E, 5958903N			Driller: JB		Logged: KN	
RL Surface: 1388.1m				Contractor: GE Drilling			Bearing: ---		Checked: AS/MAG	
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/Density Index	Additional Observations
ADT	Groundwater not encountered.	1388.0			--	FILL: Clayey SILT, low plasticity, dark grey, trace fine to medium grained sand.		MC >= PL	--	FILL
					CL-CI	CLAY, low to medium plasticity, brown orange, trace fine to medium subangular gravel.			St	COLLUVIUM
		1387.5	0.5			At 0.5m: Becoming with fine to medium subangular gravel.	 U50: 0.5m - 0.7m			
		1387.0	1.0				 SPT 2, 4, 6 N=10 *			
		1386.5	1.5			CL-CI	Gravelly CLAY, low to medium plasticity, orange brown, fine to medium angular gravel, trace fine to medium grained sand.	 DS: 1.5m - 1.9m		
		1386.0	2.0			TC-bit refusal on inferred granodiorite boulder. Borehole BH04 terminated at 1.9m				
		1385.5	2.5							
		1385.0	3.0							
		1384.5	3.5							
		1384.0	4.0							
		1383.5	4.5							
			5.0							

Borehole Log

Client: Kosciuszko Thredbo Pty Ltd

Started: 27/04/2022

Project: Thredbo Golf Course Subdivision

Finished: 27/04/2022

Location: 2/4 Crackenback Drive, Thredbo NSW 2625

Hole Location: Refer to Drawing 14871-GR-1-A

Borehole Size: 110 mm

Rig Type: GEMCO 210B

Hole Coordinates 616010E, 5958864N

Driller: JB

Logged: KN

RL Surface: 1391.2m

Contractor: GE Drilling

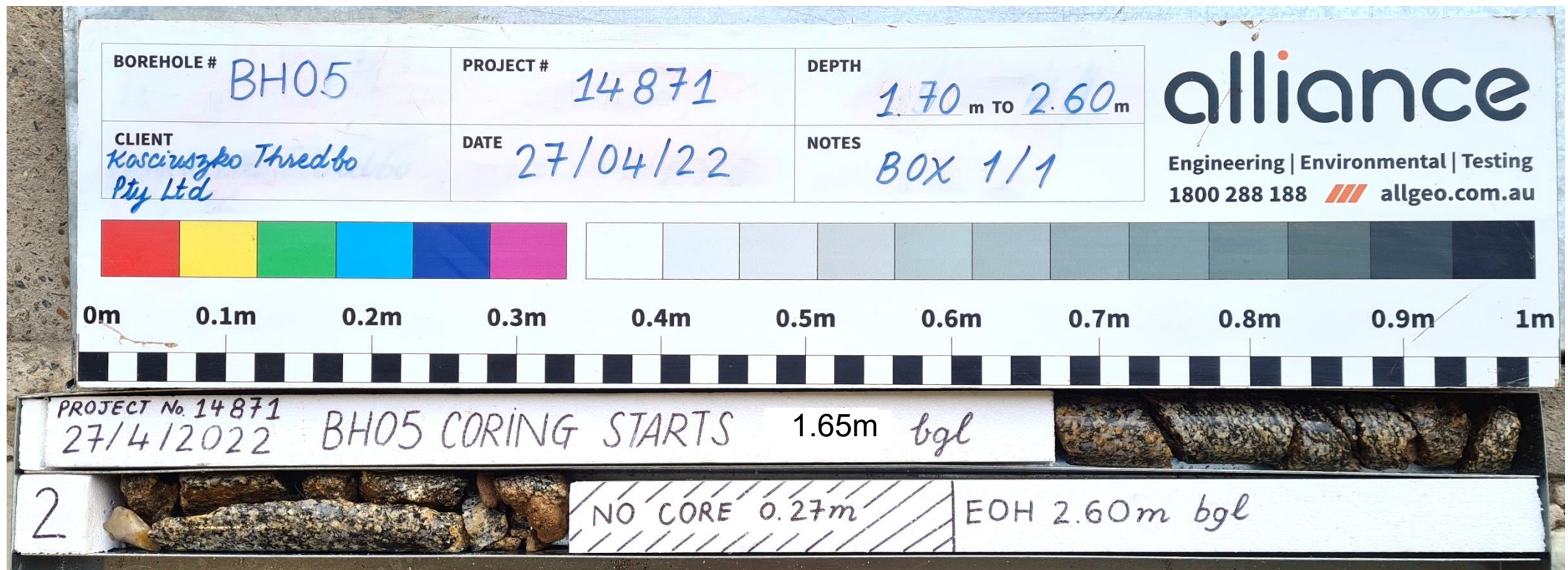
Bearing: ---

Checked: AS/MAG

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition Consistency/Density Index	Additional Observations
ADT	Groundwater not encountered.	1391.0			--	FILL: Clayey SILT, low plasticity, dark grey, trace fine to medium grained sand,		MC >= PL	FILL
			0.5		CL-CI	Silty CLAY, low to medium plasticity, dark brown, trace fine to medium grained sand.		MC > PL	COLLUVIUM
		1390.5			CI	Gravelly CLAY, low plasticity, brown mottled pale brown, fine to medium subangular gravel, trace fine to medium grained sand.	DS: 0.5m - 1.0m	MC >= PL	
		1390.0					SPT 1, 7, 8/130mm *		
		1389.5				Borehole BH05 continued as cored hole			
			2.0						
		1389.0							
			2.5						
		1388.5							
			3.0						
		1388.0							
			3.5						
		1387.5							
			4.0						
		1387.0							
			4.5						
		1386.5							
			5.0						

Cored Borehole Log

Client: Kosciuszko Thredbo Pty Ltd					Started: 27/04/2022						
Project: Thredbo Golf Course Subdivision					Finished: 27/04/2022						
Location: 2/4 Crackenback Drive, Thredbo NSW 2625					Hole Location: Refer to Drawing 14871-GR-1-A		Borehole Size: 110 mm				
Rig Type: GEMCO 210B			Hole Coordinates 616010E, 5958864N			Driller: JB		Logged: KN			
RL Surface: 1391.2m			Contractor: GE Drilling			Bearing: ---		Checked: AS/MAG			
Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength ● Axial ○ Diametral	Is ₍₅₀₎ MPa D- diam- etral A- axial	RQD %	Defect Spacing mm	Additional Data
		1391.0	0.5								
		1390.5	1.0								
		1390.0	1.5								
					Continued from non-cored borehole						
NMLC	40% - 50% water lost.	1389.5	2.0	</							



Core Box Photo – Borehole BH05 – Box 1/1

	Client Name	Thredbo Kosciuszko Pty Ltd	Photo Number	–
	Project Name	Thredbo Golf Course Subdivison	Photo Date	27 April 2021
	Project Location	2/4 Crackenback Drive, Thredbo NSW	Report Number	14871-GR-1-1

Borehole Log

Client: Kosciuszko Thredbo Pty Ltd				Started: 27/04/2022						
Project: Thredbo Golf Course Subdivision				Finished: 27/04/2022						
Location: 2/4 Crackenback Drive, Thredbo NSW 2625				Hole Location: Refer to Drawing 14871-GR-1-A		Borehole Size: 110 mm				
Rig Type: GEMCO 210B		Hole Coordinates 616142E, 5958868N		Driller: JB		Logged: KN				
RL Surface: 1386.3m		Contractor: GE Drilling		Bearing: ---		Checked: AS/MAG				
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/Density Index	Additional Observations
ADT	Not encountered	1386.0			--	FILL: Silty CLAY, low to medium plasticity, dark brown, trace fine to medium grained sand and fine subangular gravel.		MC ~ PL	--	FILL
			0.5		CI-CH	CLAY, medium plasticity, dark orange, with silt, trace medium subangular gravel and fine to medium grained sand.			St	COLLUVIUM
		1385.5								
			1.0		CL-CI	CLAY, low to medium plasticity, dark orange, with silt and fine subangular gravel, trace sand				
		1385.0					Between 1.3m and 1.4m: Trace medium to coarse subangular granodiorite fragments.	 SPT 6, 10, 4 N=14 *		
			1.5		CL-CI	Gravelly CLAY, low to medium plasticity, orange brown, fine to medium angular gravel, trace fine to medium grained sand.	U50: 1.5m - 1.7m			
		1384.5			--	GRANODIORITE, coarse grained, dark grey, grey, and pale grey, crystalline, low strength, highly weathered.		--	--	GRANODIORITE BOULDER
			2.0			Borehole BH06 continued as cored hole				
		1384.0								
			2.5							
		1383.5								
			3.0							
		1383.0								
			3.5							
		1382.5								
			4.0							
		1382.0								
			4.5							
		1381.5								
			5.0							

Cored Borehole Log

Client: Kosciuzko Thredbo Pty Ltd					Started: 27/04/2022						
Project: Thredbo Golf Course Subdivision					Finished: 27/04/2022						
Location: 2/4 Crackenback Drive, Thredbo NSW 2625					Hole Location: Refer to Drawing 14871-GR-1-A		Borehole Size: 110 mm				
Rig Type: GEMCO 210B			Hole Coordinates 616142E, 5958868N			Driller: JB		Logged: KN			
RL Surface: 1386.3m			Contractor: GE Drilling			Bearing: ---		Checked: AS/MAG			
Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength ● Axial ○ Diametral	Is ₍₅₀₎ MPa D-diam- etral A-axial	RQD %	Defect Spacing mm	Additional Data
		1386.0	0.5								
		1385.5	1.0								
		1385.0	1.5								
		1384.5			Continued from non-cored borehole						
NMLC	40% - 50% water lost.	1384.0	2.0	+	GRANODIORITE, coarse grained, dark grey, grey, and pale grey, crystalline, flow banded at 0°.	SW					2.00m - JT, 0°, PL, RO, CN
		1384.0	2.2	+	At 2.20m: Becoming dark grey, brown yellow, and pale grey, flow banded at 45°.						2.30m - Flow band parting, 45°, PL, RO, CN
		1384.0	2.4	+		MW/SW					2.35m - Flow band parting, 45°, PL, RO, CN
		1383.5	2.5	+							2.55m - JT, 0°, PL, RO, CN
		1383.5	2.6	+							2.58m - Flow band parting, 45°, PL, RO, CN
		1383.5	2.7	+							2.60m - EWS, 45°, PL, VR, Sandy GRAVEL
		1383.5	2.8	+							2.60m-2.85m - JT, 60°, UN, VR, VN, Cy
		1383.5	3.0		No core, 2.08m.						
		1383.0	3.5								
		1382.5	4.0								
		1382.0	4.5								
		1381.5									
			5.0		Target Depth. BH06 terminated at 4.9m						End of BH06.

BOREHOLE # BH06	PROJECT # 14871	DEPTH 1.90 m TO 4.90 m
CLIENT Kosciuszko Thredbo Pty Ltd	DATE 27/04/22	NOTES BOX 1/1

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0m 0.1m 0.2m 0.3m 0.4m 0.5m 0.6m 0.7m 0.8m 0.9m 1m



PROJECT No. **14871**
27/04/2022 **BH06 CORING STARTS 1.90m bgl**

2



NO CORE 2.08m

3

NO CORE 2.08m (Cont)

4

NO CORE 2.08m (Cont)

EOH4-90

Core Box Photo – Borehole BH06 – Box 1/1

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Client Name	Thredbo Kosciuszko Pty Ltd	Photo Number	–
Project Name	Thredbo Golf Course Subdivision	Photo Date	27 April 2021
Project Location	2/4 Crackenback Drive, Thredbo NSW	Report Number	14871-GR-1-1

Dynamic Cone Penetrometer (DCP) Test Report

Client	Kosciuszko Thredbo Pty Ltd	Report Number	14871-GR-1-1
Project Name	Thredbo Golf Course Subdivision	Project Number	14871
Project Location	2-4 Crackenback Drive, Thredbo NSW	Date Tested	27 April 2022
Test Method	AS 1289.6.3.2		

Test Number	DCP01	DCP02	DCP03	DCP04	DCP05	DCP06
Test Location	Refer to Drawing 14871-GR-1-A					
Surface Material	FILL: Clayey SILT	FILL: Clayey SILT	FILL: Clayey SILT	FILL: Sandy Clayey SILT	FILL: Clayey SILT	FILL: Silty CLAY
Surface Condition	MC ≥ PL	MC ≥ PL	MC > PL	MC > PL	MC ≥ PL	MC ~ PL
Approximated RL (m AHD)	1382.6	1386.1	1388.2	1388.1	1391.2	1396.3
0.00 – 0.15 m	3	6	5	8	5	4
0.15 – 0.30 m	8	9	5	12	7	9
0.30 – 0.45 m	9	9	7	10	10	9
0.45 – 0.60 m	5	25/100mm	14	10	8	8
0.60 – 0.75 m	19	Refusal	15	3	16	25/100mm
0.75 – 0.90 m	26		10/50mm	7	25/140mm	Hammer Bouncing
0.90 – 1.05 m	27		Refusal	10/20mm	Refusal	
1.05 – 1.20 m	Refusal			Refusal		
1.20 – 1.35 m						

Notes: This test report is intended to be read in conjunction with the geotechnical report by Alliance Geotechnical (ref: 14871-GR-1-1).

APPENDIX D – Undisturbed Samples Photographs and Laboratory Test Certificates

Photo 7 - U50 Sample at BH03, 1.5m-1.7m



Photo 8 - U50 at Borehole BH04, 0.5m-0.7m



Photo 9 - U50 Sample at Borehole BH06, 1.5m-1.7m

Material Test Report

Report Number: 14871-1
Issue Number: 1
Date Issued: 30/05/2022
Client: Alliance Geotechnical
10 Welder Road, Seven Hills NSW 2147
Contact: Khue Nguyen
Project Number: 14871
Project Name: Thredbo Golf Course Subdivision
Project Location: 2/4 Crackenback Drive, Thredbo
Work Request: 18961
Sample Number: 22-18961C
Date Sampled: 27/04/2022
Dates Tested: 02/05/2022 - 06/05/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Sample Location: BH06 , Depth: 1.5 - 1.7m
Material: CLAY, medium plasticity, dark orange, with silt, trace medium sub-angular gravel and fine to medium grained sand

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Alliance Geotechnical Pty Ltd
10 Welder Road Seven Hills NSW 2147
PO Box 275, Seven Hills NSW 1730
Phone: 1800 288 188
Email: brett@allgeo.com.au



Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Brett Bellingham
Conformance Testing Manager
NATA Accredited Laboratory Number: 15100

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	36		
Plastic Limit (%)	24		
Plasticity Index (%)	12		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.1		
Linear Shrinkage (%)	4.0		
Cracking Crumbling Curling	Cracking		

Material Test Report

Report Number: 14871-1
Issue Number: 1
Date Issued: 30/05/2022
Client: Alliance Geotechnical
10 Welder Road, Seven Hills NSW 2147
Contact: Khue Nguyen
Project Number: 14871
Project Name: Thredbo Golf Course Subdivision
Project Location: 2/4 Crackenback Drive, Thredbo
Work Request: 18961
Date Sampled: 27/04/2022
Dates Tested: 02/05/2022 - 10/05/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Location: 2/4 Crackenback Drive, Thredbo

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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Brett Bellingham

Conformance Testing Manager

NATA Accredited Laboratory Number: 15100

Shrink Swell Index AS 1289 7.1.1 & 2.1.1

Sample Number	22-18961A	22-18961B			
Date Sampled	27/04/2022	27/04/2022			
Date Tested	10/05/2022	10/05/2022			
Material Source	Bore Hole	Bore Hole			
Sample Location	BH03 (1.5 - 1.7m)	BH04 (0.5 - 0.7m)			
Inert Material Estimate (%)	4	3			
Pocket Penetrometer before (kPa)	280	200			
Pocket Penetrometer after (kPa)	220	140			
Shrinkage Moisture Content (%)	25.4	20.8			
Shrinkage (%)	2.4	1.8			
Swell Moisture Content Before (%)	25.3	21.0			
Swell Moisture Content After (%)	26.3	30.5			
Swell (%)	-0.1	-0.1			
Shrink Swell Index Iss (%)	1.3	1.0			
Visual Description	CLAY	CLAY			
Cracking	SC	SC			
Crumbling	No	No			
Remarks	Nil	Nil			

Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.

Cracking Terminology: UC Uncracked, SC Slightly Cracked, MC Moderately Cracked, HC Highly Cracked, FR Fragmented.

NATA Accreditation does not cover the performance of pocket penetrometer readings.

Material Test Report

Report Number: 14871-2
Issue Number: 1
Date Issued: 30/05/2022
Client: Alliance Geotechnical
10 Welder Road, Seven Hills NSW 2147
Contact: Khue Nguyen
Project Number: 14871
Project Name: Thredbo Golf Course Subdivision
Project Location: 2/4 Crackenback Drive, Thredbo
Work Request: 19108
Sample Number: 22-19108A
Date Sampled: 27/04/2022
Dates Tested: 10/05/2022 - 13/05/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Sample Location: BH03, Depth: 2.0-2.45m
Material: Gravelly SAND, trace clay, orange brown, fine to medium sub-angular and angular gravel

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10 Welder Road Seven Hills NSW 2147

PO Box 275, Seven Hills NSW 1730

Phone: 1800 288 188

Email: brett@allgeo.com.au



Accredited for compliance with ISO/IEC 17025 - Testing

A handwritten signature in black ink, appearing to read 'B. Bellingham'.

Approved Signatory: Brett Bellingham

Conformance Testing Manager

NATA Accredited Laboratory Number: 15100

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	Not Obtainable		
Plastic Limit (%)	Not Obtainable		
Plasticity Index (%)	Non Plastic		

Material Test Report

Report Number: 14871-2
Issue Number: 1
Date Issued: 30/05/2022
Client: Alliance Geotechnical
10 Welder Road, Seven Hills NSW 2147
Contact: Khue Nguyen
Project Number: 14871
Project Name: Thredbo Golf Course Subdivision
Project Location: 2/4 Crackenback Drive, Thredbo
Work Request: 19108
Sample Number: 22-19108B
Date Sampled: 27/04/2022
Dates Tested: 10/05/2022 - 13/05/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Sample Location: BH04, Depth: 1.5-1.9m
Material: Gravelly CLAY, medium plasticity, orange brown, with fine to medium angular and subangular gravel

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Approved Signatory: Brett Bellingham
Conformance Testing Manager
NATA Accredited Laboratory Number: 15100

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	46		
Plastic Limit (%)	31		
Plasticity Index (%)	15		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.1		
Linear Shrinkage (%)	7.5		
Cracking Crumbling Curling	Cracking		

Material Test Report

Report Number: 14871-2
Issue Number: 1
Date Issued: 30/05/2022
Client: Alliance Geotechnical
10 Welder Road, Seven Hills NSW 2147
Contact: Khue Nguyen
Project Number: 14871
Project Name: Thredbo Golf Course Subdivision
Project Location: 2/4 Crackenback Drive, Thredbo
Work Request: 19108
Sample Number: 22-19108C
Date Sampled: 27/04/2022
Dates Tested: 10/05/2022 - 16/05/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Sample Location: BH05 , Depth: 0.5-1.0m
Material: Gravelly CLAY, low plasticity, brown pale brown, fine to medium subanglur granite gravel, trace fine to medium grained sand

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Approved Signatory: Brett Bellingham
Conformance Testing Manager
NATA Accredited Laboratory Number: 15100

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	35		
Plastic Limit (%)	29		
Plasticity Index (%)	6		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.1		
Linear Shrinkage (%)	4.5		
Cracking Crumbling Curling	None		

Material Test Report

Report Number: 14871-2
Issue Number: 1
Date Issued: 30/05/2022
Client: Alliance Geotechnical
10 Welder Road, Seven Hills NSW 2147
Contact: Khue Nguyen
Project Number: 14871
Project Name: Thredbo Golf Course Subdivision
Project Location: 2/4 Crackenback Drive, Thredbo
Work Request: 19108
Date Sampled: 27/04/2022
Dates Tested: 10/05/2022 - 10/05/2022
Sampling Method: Sampled by Client
The results apply to the sample as received
Location: 2/4 Crackenback Drive, Thredbo

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Accredited for compliance with ISO/IEC 17025 - Testing

B. Bellingham
Approved Signatory: Brett Bellingham
Conformance Testing Manager
NATA Accredited Laboratory Number: 15100

Moisture Content AS 1289 2.1.1

Sample Number	Sample Location	Moisture Content (%)	Material
22-19108C	BH05 , Depth: 0.5-1.0m	12.6 %	Gravelly CLAY, low plasticity, brown pale brown, fine to medium subangular granite gravel, trace fine to medium grained sand
22-19108D	BH02 , Depth: 1.0-1.4m	13.5 %	Gravelly CLAY, low to medium plasticity, orange brown, fine to medium subangular gravel, trace fine to medium grained sand
22-19108E	BH01 , Depth: 1.0-1.5m	12.8 %	Gravelly SAND, trace fine to medium grained sand, with clay

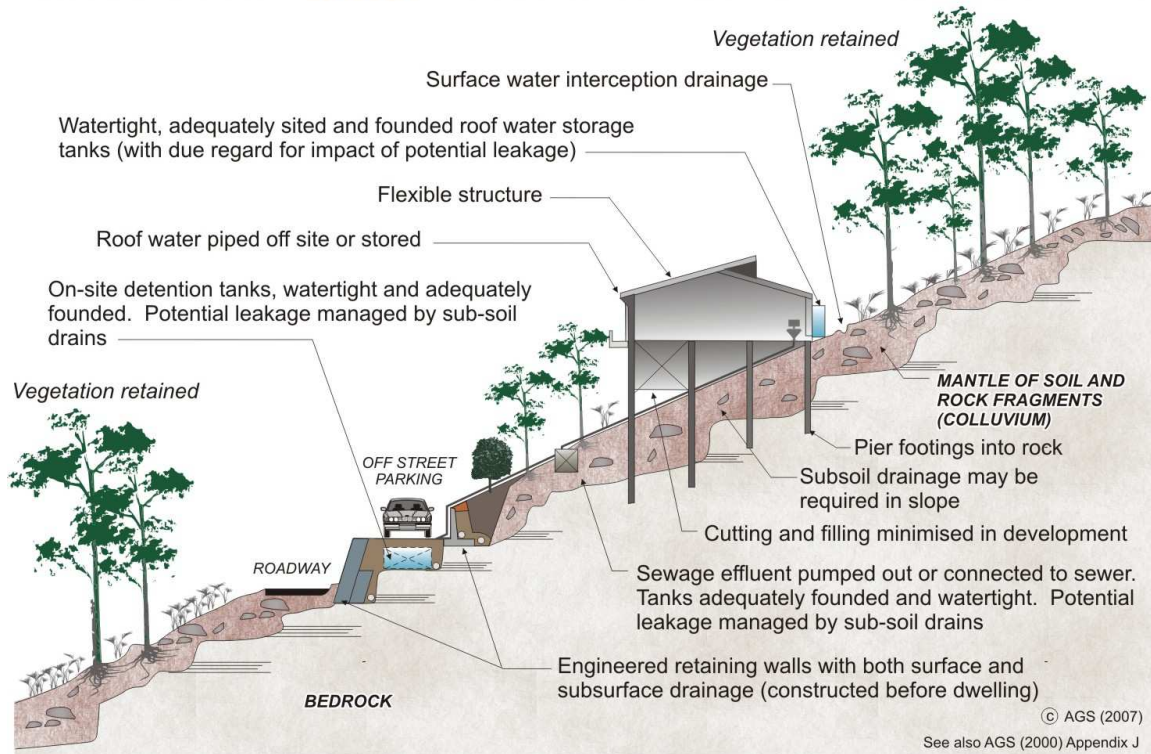
APPENDIX E – Australian Geoguide LR8 (Construction Practice) and Qualitative Terminology for Use in Assessing Risk to Property

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE 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 OF **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 in 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 fulfil 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.

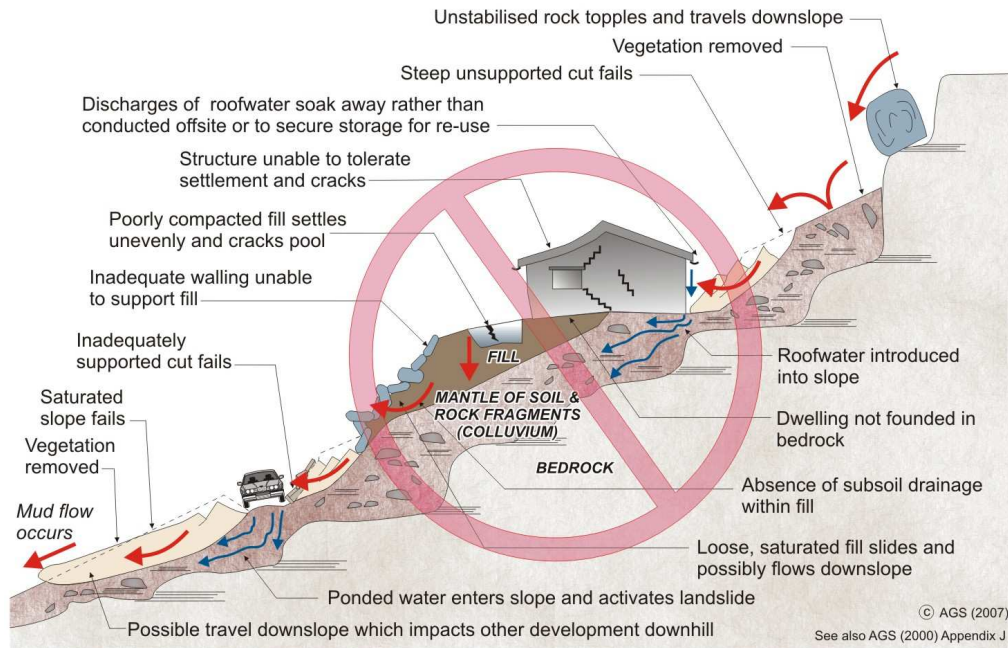
Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing 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

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

EXAMPLES OF **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 soak 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 herring bone, 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

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

- | | |
|-------------------------------------|--|
| • GeoGuide LR1 - Introduction | • GeoGuide LR6 - Retaining Walls |
| • GeoGuide LR2 - Landslides | • GeoGuide LR7 - Landslide Risk |
| • GeoGuide LR3 - Landslides in Soil | • GeoGuide LR9 - Effluent & Surface Water Disposal |
| • GeoGuide LR4 - Landslides in Rock | • GeoGuide LR10 - Coastal Landslides |
| • GeoGuide LR5 - Water & Drainage | • 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.

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10 ⁻¹	VH	VH	VH	H	M or L (5)
B – LIKELY	10 ⁻²	VH	VH	H	M	L
C – POSSIBLE	10 ⁻³	VH	H	M	M	VL
D – UNLIKELY	10 ⁻⁴	H	M	L	L	VL
E – RARE	10 ⁻⁵	M	L	L	VL	VL
F – BARELY CREDIBLE	10 ⁻⁶	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.

(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

APPENDIX F – Form 1 Geotechnical Policy

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

DA Number: DA 23/13081

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

Guillermo

Family Name

Gomez

OF

Company/organisation

Alliance Geotechnical Pty Ltd

on this the 20th day of November 2025

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~~ ^{AGS2007} 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 Investigation Report 14871-GR-1-1-RevE

Author

Khue Nguyen

Dated

20/11/2025

DA Site Address

2 Friday Drive and 1 Crackenback Drive, Thredbo
(Lot 876 DP 1243112 and Lot 500 DP 1118419)

DA Applicant

Kosciuszko Thredbo Pty Ltd (KT)

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~~ ^{AGS2007}, 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



Chartered professional status

BEng MEngSc MIEAust CPEng NER

Name

Guillermo Gomez

Date

20/11/2025

5. Contact details

Department of Planning & Environment
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