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EVT / Kosciuszko Thredbo Pty Ltd

Thredboland and Freeriders Beginner Zone Project
Friday Flat, Thredbo NSW

Geotechnical Investigation

Our ref: 6751-G1 Rev 4
12 September 2022

Your trusted engineering professionals

Document Authorization

Prepared for EVT / Kosciuszko Thredbo Pty Ltd

Our ref: 6751-G1 Rev 4
12 September 2022

For and on behalf of
AssetGeoEnviro

Mark Bartel
BE, MEngSc, GMQ, CPEng, RPEQ/NER(Civil), DEP/PRE (NSW)
Managing Director | Senior Principal Geotechnical Engineer

Document Control

Distribution Register

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1	Secure PDF	Peter Fleming / Chloe Chalk	EVT / Kosciuszko Thredbo Pty Ltd
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Document Status

Rev	Revision Details	Author	Reviewer		Approved for Issue		
			Name	Initials	Name	Initials	Date
0	Initial issue	A. To	M. Bartel	*MAB*	M. Bartel	*MAB*	6 February 2022
1	Review comments	A. To	M. Bartel	*MAB*	M. Bartel	*MAB*	9 February 2022
2	Update project descriptions	A. To / M. Bartel	M. Bartel	*MAB*	M. Bartel	*MAB*	7 June 2022
3	Updated Plans & Review comments	A. To	M. Bartel	*MAB*	M. Bartel	*MAB*	27 June 2022
4	Updated Plans & Form 4	A. To	M. Bartel		M. Bartel		12 September 2022

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ISO 9001:2015
ISO 14001:2015
ISO 45001:2018 AS/NZS 4801:2001

Contents

Department of Planning & Environment Form 4

Form 4 – Minimal Impact Certification

DA Number: _____

This form may be used where minor construction works which present minimal or no geotechnical impact on the site or related land are proposed to be erected within the "G" line area of the geotechnical maps.

A geotechnical engineer or engineering geologist must inspect the site and/or review the proposed development documentation to determine if the proposed development requires a geotechnical report to be prepared to accompany the development application. Where the geotechnical engineer determines that such a report is not required then they must complete this form and attach design recommendations where required. A copy of Form 4 with design recommendation, if required, must be submitted with the development application.

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 in relation to a nil or minimal geotechnical impact assessment and site classification

I,

Mr [x] Ms ☐ Mrs ☐ Dr ☐ Other ☐

First Name	Family Name
Mark	Bartel

OF

Company/organisation

Asset Geotechnical Engineering Pty Ltd (trading as AssetGeoEnviro)

certify that I am a geotechnical engineer /engineering geologist as defined by the "Policy" and I have inspected the site and reviewed the proposed development known as

Thredboland and Freeriders Beginner Zone Project, Friday Flat, Thredbo NSW

As a result of my site inspection and review of the following documentation

(List of documentation reviewed)

DJRD Architects Free Riders Supervisor Hut, Project No. 22 424, Drawing No. A1.101, Rev B, 2/9/2022.

Images of SureFoot Concrete Free footing system (see report)

Snowrunner Operators Hut Footings (Grounded Structural Engineering & Drafting, dwg: S01, Rev A; 7/3/2022)

Structural Design of Snowrunner - Conveyor Belt (by Bruckschlogl, dwg SKD 27, dated 3 June 2022).

Structural Design of Snowrunner - Moving Carpet (by Bruckschlogl, dwg SKD 26, 28/1/2021 & 1/2//2021)

Thredboland and Freeriders Begineer Zone - Site Layout Plan (by KT-EVT, Rev F, 6/9//2022)

I have determined that;

- ☒ the current load-bearing capacity of the existing building will not be exceeded or adversely impacted by the proposed development, and
- ☒ the proposed works are of such a minor nature that the requirement for geotechnical advice in the form of a geotechnical report, prepared in accordance with the "Policy", is considered unnecessary for the adequate and safe design of the structural elements to be incorporated into the new works, and
- ☒ in accordance with AS 2870.1 Residential Slabs and Footings, the site is to be classified as a type

(insert classification type)

Class P

- ☒ I have attached design recommendations to be incorporated in the structural design in accordance with this site classification.

I am aware that this declaration shall be used by the Department as an essential component in granting development consent for a structure to be erected within the "G" line area (as identified on the geotechnical maps) of Kosciuszko Alpine Resorts without requiring the submission of a geotechnical report in support of the development application.

2. Signatures

Signature

Mark Bartel

Chartered professional status

CPEng 35641 NER (Civil)

Name

Mark Bartel

Date

12 September 2022

3. Contact details

Alpine Resorts Team
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1. Introduction

1.1 General

This report presents the results of a geotechnical investigation for the Thredboland and Freeriders Beginner Zone Project at Friday Flat, Thredbo NSW (the Site). The investigation was commissioned on 26 November 2021 by Peter Fleming of EVT / Kosciuszko Thredbo Pty Ltd.

Drawings supplied to us for this investigation comprised:

- Architectural Plans – Supervisors Hut Plan & Elevations (prepared by: DJRD Architects; project no: 22 424; dwg: A1.101; Rev B; dated: 2 September 2022).
- Thredboland and Freeriders Beginner Zone – Site Layout Plan (prepared by: KT-EVT; Revision F; dated 6 September 2022)
- Structural Design of Snowrunner – Sunkid Conveyor Belt (prepared by: BRUCKSCHLOGL; project no: pr22-10-061; dwg: SKD 27; dated: 3 June 2022).
- Structural Design of Snowrunner – Sunkid Moving Carpet (prepared by: BRUCKSCHLOGL; EDV Nr: m21-10-101, m21-10-201_B600 and m21-10-301_12Z; dwg: SKD 26; dated: 28 January 2021 & 1 February 2021 respectively).
- Structural Details of Snowrunner Operators Hut Footings (prepared by Grounded Structural Engineering and Drafting; dwg: S01; Revision A; dated 17 March 2022)

Based on the supplied drawings, we understand that the project involves:

- Placement of a snowrunner and roof, and construction of two snowrunner operator's huts.
- Construction of Snowsports operations building.
- Trenching for installation of services including electricity and communications cable, and sewer and water pipe.
- Construction of stairway adjacent to the Mountain access road.
- Extending an existing gabion retaining wall with a rock retaining wall.

We also understand that concrete free footing system designed by SureFoot is the preferred foundation type for the proposed Snowsports operations building. No significant excavation is planned for the proposed development. The Snowrunner operators hut is to be supported by shallow concrete piers about 580mm deep by 300mm square. The Snowrunner will also have a roof/gallery over the top of it, secured with ground screws.

The objective of this investigation is to provide information on the surface and subsurface conditions at the lower slopes area in Friday Flat and to provide preliminary geotechnical recommendations to aid with the design and construction of the new Snowsports operations building.

1.2 Scope of Work

The main objectives of the investigation were to assess the surface and subsurface conditions and to provide comments and recommendations relating to:

- Site Classification to AS2870-2011 "Residential Slabs and Footings".
- Suitable foundation options and founding stratum.
- Allowable bearing pressure

The following scope of work was carried out to achieve the project objectives:

- A review of existing regional maps and reports relevant to the Site held within our files.
- Clearance of underground services at proposed test locations.
- Visual observations of surface features.
- Subsurface investigation at four locations to assess the nature and consistency of subsurface soils and bedrock at accessible areas of the Site.
- Engineering assessment and reporting.

This report must be read in conjunction with the attached "Important Information about your Geotechnical Report" and "Important Information about your Landslide Risk Assessment" in Appendix A. Attention is drawn to the limitations inherent in site investigations and the importance of verifying the subsurface conditions inferred herein. Landslide risk considerations presented in this report must be read in conjunction with the attached GeoGuides for Slope Management and Maintenance.

2. Site Description

The Site is located close to Gunbarrel Express Bottom Station on a very gently undulating terrain and generally slopes down to the south at less than about 3° to 5° towards Friday Drive. The Site is bounded to the east by Gunbarrel Express Bottom Station and elsewhere by grass lands.

Topographically, the Site is situated at the toe of a gentle slope of about 10° to 12° up to the north west before again increasing to about 22° to 26°. Heavy populated buried services are located to the north-east of the Site.

At the time of investigation, the Site was generally grassed and used for facilities storage. Soft ground was encountered to the south of the Site which appeared to be filled / disturbed ground likely associated with recent snowmaking trenching works. No signs of granite outcrops were observed during the site walkover.

3. Fieldwork

The fieldwork was undertaken on 29 November 2021 by a Geotechnical Engineer from Asset and included invasive investigation at four locations. Reference is also made to test pits (TP3, TP4, and TP5) from a previous investigation by Asset in 2020 for a Snowmaking Pipeline.

The test locations are shown in the attached Figure 2 and were set out by our Geotechnical Engineer by measurements relative to existing site features. Surface levels at the test locations were estimated by interpolation from levels shown on Google Earth, approximate only.

Buried metallic services and utilities within the Site boundaries near the test locations were cleared by referring to local utility map provided by the client.

The invasive investigation included drilling of hand auger boreholes and conducting Dynamic Cone Penetrometer (DCP) soundings at four locations. The boreholes were auger drilled to depths of 0.2m to 0.72 below ground level (bgl) and were discontinued at the recorded depths due to reaching refusal on inferred weathered granite and or very stiff to hard clayey fill soil. The DCP soundings were terminated at depths of 0.2m to 1.3m at 'solid' refusal on inferred Granite bedrock or boulder.

The test pits were excavated to 1.4m depth, TP3 within assessed well compacted fill likely associated with the original snowmaking pipeline buried at greater depth, TP4 within hard colluvial clay with some cobbles to 200mm size, and TP5 within stiff alluvial clay with some cobbles to 500mm size overlying dense clayey sand (completely weathered granite) at 1.2m depth.

The subsurface conditions encountered were logged during drilling and testing. On completion of logging and sampling, the boreholes were backfilled with the drilling spoil.

Engineering logs are provided in Appendix B together with their explanatory notes.

4. Subsurface Conditions

4.1 Geology

The 1:250,000 Tallangatta Geological Map indicates the Site is underlain by Silurian aged intrusive granite.

The Site lies within an area designated as "G" as defined in the maps accompanying DIPNR's Geotechnical Policy – Kosciuszko Alpine Resorts", November 2003.

4.2 Subsurface Conditions

A generalised geotechnical model for the Site has been developed is shown in Table 1. For a detailed description of the subsurface conditions, refer the attached engineering logs and explanatory notes. For specific design input, reference should be made to the logs and/or the specific test results, in place of the following summary. An interpreted section A-A is shown in the attached Figure 3.

Table 1 – Generalised Site Geotechnical Model

Unit	Origin	Description	Depth to Top of Unit [1] (m)	Unit Thickness [1] (m)
1	Topsoil/ Fill	Silty, clayey SAND grading to Silty CLAY with traces of sand, fine to medium grained sand, low plasticity fines, trace of granite fragments and grass roots, dark brown to dark grey/ dark brown. Appeared to be loosely to moderately compacted.	Ground surface	0.2 to 0.72
2	Colluvium	CLAY, medium plasticity, stiff to hard, some cobbles to 200mm to 500mm size (TP4 and TP5 only).	0.1 / 0.2	1.0 to >1.3
3	Residual	Clayey SAND, medium to coarse grained, dense (TP5 only).	1.2	>0.2
4	Bedrock[2]	GRANITE, CW-XW, blocky mixed with clayey sand matrix, medium to coarse grained sand, trace of granite fragments up to 70mm in size, brown (only in BH2). DCP refusal on assessed less weathered Granite bedrock or boulders.	0.35	Not proven beyond a depth of 1.3 by DCP

Notes:

1. The depths and unit thicknesses are based on the information from the test locations only and do not necessarily represent the maximum and minimum values across the Site.

Special Note for DCP testing

Caution must be used when inferring subsurface conditions from DCP results. Refusal can be encountered on obstructions such as gravel, cemented materials, rock floaters, or other inclusions within a soil mass. DCP testing on soils with a gravel component or cementation can indicate a higher density than actual. Also, the DCP results in clay soils are significantly affected by the in-situ moisture content. It is therefore strongly recommended that an experienced Geotechnical Engineer is engaged to confirm the inferred subsurface conditions during construction and to provide advice where subsurface conditions are significantly different.

4.3 Groundwater

Groundwater was not observed in the boreholes during auger drilling to depths of 0.2m to 0.72m bgl.

In addition, groundwater was not observed in the DCP tests. Groundwater detection via DCP test is indicated by wet soil materials attached on the DCP rods and conical tip after rods extraction. For all DCP tests, the soil materials attached on the DCP rods and conical tip were dry and moist.

No groundwater was observed in the test pits during the time they remained open.

No long-term groundwater monitoring was carried out.

5. Discussions & Recommendations

No significant excavation is proposed for this development. Geotechnical constraints for the proposed buildings include variable foundation condition such as potentially softer soil or extremely weathered rock below the limited depths of investigation.

Based on from the results of this investigation, it is assessed that the proposed footings for the buildings would be fully within fill material comprising sandy, silty clay. The proposed stairs adjacent to the track and the proposed rock wall extension on the side of the track are anticipated to be within residual soils comprising sandy clays and clayey sands. Some cobbles may be encountered in footing excavations.

Recommendations for design and construction of the development are provided in the following sections.

5.1 Landslide Risk

A landslide risk assessment has been carried out for this site using the methods of AGS 2007[1].

The basis of the assessment undertaken for this site and important factors relating to slope conditions and the impacts of the development that commonly influence the risks of slope instability are discussed in the attached "Important Information about your Landslide Risk Assessment", and the attached GeoGuides.

The preliminary assessment has been carried out by:

- Consideration of the likely slope failure mechanisms and the likely initiating circumstances that could affect the elements at the site. The type and mode of landslide failure has also been classified.
- **Risk to Property.** For each case, the likely consequences with respect to future development have been considered. The current assessed probability of occurrence of each event has been estimated

[1] Landslide Risk Management, Australian Geomechanics, Vol 42, No. 1, March 2007.

on a qualitative basis. The consequences and probability of occurrence have been combined for each case to provide the risk assessment.

- **Risk to Life**. For each case, the risk for the person most at risk is assessed based on multiplying the indicative annual probability of the occurrence of the hazard, the probability of spatial impact, the temporal probability, the vulnerability, and the probability of not evacuating. The risk is then compared with acceptable and tolerable risk criteria.

The following general potential hazards/events are identified for this site and relate to slope instability:

A slump of natural slope (typical)

For the hazards / events identified, the elements that are at risk are the proposed retaining wall extension and the proposed adjacent staircase. Table A provides our preliminary risk assessment for the site with respect to risk to property, and Table B provides our preliminary risk assessment for the site with respect to risk to life.

Where development takes into consideration the possible failure mechanisms and adopts good engineering practice for hillside development, it is envisaged that the outcome of such a development would be a **Low*** risk assessed with respect to property and the risk with respect to life would be **Acceptable**.

The development should be carried out in accordance with good engineering practice that is described in the attached GeoGuides, and in accordance with the general recommendations in the following sections.

Based on the development details, and the assessed site conditions, we conclude that the development presents only minimal geotechnical impact and therefore requires only Form 4 – Minimal Impact Certification. This certification is provided on the second page of this report.

5.2 Earthworks

5.2.1 Excavation

Negligible excavation is proposed for the development. Minor excavation is anticipated to be almost entirely within soils. Rock excavation is not anticipated to be required. If cobbles are encountered that would need removal, a hydraulic excavator would be required.

5.2.2 Subgrade Preparation

The following general recommendations are provided for subgrade preparation for earthworks, pavements, proposed SureFoot footings, and minor structures including the staircase and retaining wall extension:

- Strip existing topsoil.
- Excavate to a suitable subgrade (firm or better clays / medium dense or better sandy soils).
- Earthworks and pavement areas should be proof-rolled and areas which show visible heave under compaction equipment should be over-excavated a further 0.3m and replaced with approved fill compacted to a dry density ratio not less than 100%.

Any waste soils being removed from the Site must be classified in accordance with current regulatory authority requirements to enable appropriate disposal to an appropriately licensed landfill facility.

5.2.3 Filling

Where filing (anticipated to be minor, less than say 0.5m depth) is required, place in horizontal layers over prepared subgrade and compact as per Table 2.

Table 2 – Compaction Specifications

Parameter	Cohesive Fill	Non-Cohesive Fill
Fill layer thickness (loose measurement): • Within 1.5m of the rear of retaining walls • Elsewhere	 0.2m 0.3m	 0.2m 0.3m
Density: • Beneath Pavements • Beneath Structures • Upper 150mm of subgrade	 ≥ 95% Std ≥ 98% Std ≥ 100% Std	 ≥ 70% ID ≥ 80% ID ≥ 80% ID
Moisture content during compaction	± 2% of optimum	Moist but not wet

Any soils to be imported onto the Site for backfilling and reinstatement of excavated areas should be free of contamination and deleterious material and should include appropriate validation documentation in accordance with current regulatory authority requirements which confirms its suitability for the proposed land use. Asset can provide further advice on this matter if required.

5.2.4 Batter Slopes

Excavations for footings are anticipated to be minor, less than about 0.6m depth. Excavation for the retaining wall extension could be up to about 1m deep to be confirmed and further advice sought if greater than 1m depth. Recommended maximum slopes for temporary batters are presented in Table 3.

Table 3 – Recommended Maximum Dry Batter Slopes

Unit	Maximum Batter Slope (H : V)
	Temporary
Residual Clay & colluvium & fill	1 : 1
Completely decomposed Granite	0.75 : 1
Highly weathered Granite	0.5 : 1
Moderately weathered or better Granite	vertical *

* subject to inspection by a Geotechnical Engineer and carrying out remedial works as recommended (e.g. shotcrete, rock bolting).

5.3 Site Classification

Due to the presence of fill, the Site is classified as a Class P (Problem) Site in accordance with AS 2870–2011 "Residential Slabs and Footings". This requires that footings be designed from first principles rather than relying on standard footings in AS2870-2011.

5.4 Salinity & Aggressivity

Whilst no specific laboratory testing has been carried out to assess the aggressiveness of soil to concrete and steel, based on the subsurface profile as described above and the Site conditions, we consider that the soils would likely be non-saline, mildly aggressive with respect to buried concrete and non-aggressive to buried steel structures. Further testing would be required to confirm this.

5.5 Footings

Recommendations are provided below for footings. Inspection of footing excavations and installation must be carried out to confirm suitable foundations are achieved at each location.

5.5.1 Snowsports Operations Building

The proposed SureFoot footing system could be adopted for the site if subgrade preparation at each footing is carried out as per 5.2.2. Driving of the steel anchors into the ground should be through medium dense / firm or better soils. If these are not present throughout the driving depth, then local excavation should be carried out to found the SureFoot on suitable material.

An allowable bearing pressure of 100kPa may be adopted for the firm or better clays / medium dense or better sands below the SureFoot footings.

5.5.2 Snowrunner Operators Huts

The footings for the operators' huts comprise short concrete piers nominal 580mm deep by 300mm diameter. Due to the small size of the hut, footing loads are anticipated to be small. The proposed footings are suitable provided that the base of the piers is founded in firm or better clays or medium dense or better sands and an allowable bearing pressure of not more than 100kPa is required.

5.5.3 Staircase

We understand that the preferred foundation type for the proposed staircase modification is timber sleepers / post. Footings are anticipated to be founded at shallow depth below ground level nominal 500mm depth. Footing loads are anticipated to be relatively small, and timber shallow footings are suitable provided that the base of the posts are founded in firm or better clays or medium dense or better sands and an allowable bearing pressure of not more than 100kPa is required. Concrete pads could be considered to reduce long-term maintenance cost associated with timber footings.

5.6 Groundwater Control

Limited groundwater observations made for this investigation are described in Section 4.3. The observations indicate that groundwater is unlikely to be a constraint to the proposed development. However, good practice should be followed to cater for potential groundwater springs within the slope formation. It is anticipated that these could be controlled with suitable diversion during construction and installation of subsoil drainage to collect and divert such seepage away form critical areas. Further geotechnical advice must be sought if significant groundwater is encountered during construction.

6. Limitations

In addition to the limitations inherent in site investigations (refer to the attached Information Sheets), it must be pointed out that the recommendations in this report are based on assessed subsurface conditions from limited investigations. To confirm the assessed soil and rock properties in this report, further investigation would be required such as coring and strength testing of rock and should be carried out if the scale of the development warrants, or if any of the properties are critical to the design, construction, or performance of the development.

It is recommended that a qualified and experienced Geotechnical Engineer be engaged to provide further input and review during the design development; including site visits during construction to verify the Site conditions and provide advice where conditions vary from those assumed in this report. Development of an appropriate inspection and testing plan should be carried out in consultation with the Geotechnical Engineer.

This report may have included geotechnical recommendations for design and construction of temporary works (e.g., temporary batter slopes or temporary shoring of excavations). Such temporary works are expected to perform adequately for a relatively short period only, which could range from a few days (for temporary batter slopes) up to six months (for temporary shoring). This period depends on a range of factors including but not limited to: site geology; groundwater conditions; weather conditions; design criteria; and level of care taken during construction. If there are factors which prevent temporary works from being completed and/or which require temporary works to function for periods longer than originally designed, further advice must be sought from the Geotechnical Engineer and Structural Engineer.

This report and details for the proposed development should be submitted to relevant regulatory authorities that have an interest in the property (e.g., Council/ Event/ KT) or are responsible for services that may be within or adjacent to the Site for their review.

Asset accepts no liability where our recommendations are not followed or are only partially followed. The document “Important Information about your Geotechnical Report” in Appendix A provides additional information about the uses and limitations of this report.

Landslide Risk Assessment Tables

Table A – Risk to Life

Table B – Risk to Property

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Table A – Landslide Risk Assessment (Risk to Property)
Proposed New Snowrunner, Friday Flat, Thredbo NSW

Possible Hazards		Consequences (Note 2)	Assessed Likelihood	Risk (Note 1)	Risk Treatment and Comments
Failure Envisaged	Failure Mode				
A - Slump of natural slope (typical)	Slide	Minor	Unlikely	Low	No specific risk treatment considered necessary. Design and construction of the development to be in accordance with recommendations in Geotechnical Report 6751-G1 Rev 1 dated 7 June 2022.

Notes:

1. The risk assessment addresses only the consequences to property from potential landslide events considered relevant to the subject site. Injury to persons or potential for fatality from land sliding is not assessed in this table (refer Table B). The risk assessment is based on a preliminary appraisal only, carried out by inspection. Further assessment or quantification of the assessed geotechnical risks for the subject property would require additional data and/or investigation.
2. The consequences are for a development that is designed to accomodate the potential landslide risk or has demonstrated adequate performance over many years.
3. Refer to report and associated figures for illustration of possible hazards / slope failure mechanisms.
4. Refer to attachments for definitions and explanations of terms used in the risk assessment.

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Table A – Landslide Risk Assessment (Risk to Property)
Proposed New Snowrunner, Friday Flat, Thredbo NSW

Possible Hazard	Use of Affected Structure & Persons at Risk	Likelihood	Indicative Annual Probability P (H)	Probability of Spatial Impact P (S:H)	Temporal Probability P (T:S)	Vulner-ability V (D:T)	Probability of becoming Trapped	Risk for Person Most at Risk [Risk Evaluation]	Risk Outcome: A = Acceptable T = Tolerable NT = Not Tolerable
A3 - Slump of natural slope (typical)	Park users, maintenance workers	Unlikely	1.0E-04	1.00	0.33	0.10	0.10	3.30E-07	A

Notes:

1. The appraisal of the assessed risk relative to acceptable and tolerable risks is based on Table 1 of AGS (2007) – Reference 1, for a new development.
2. Risk mitigation will be required to ensure that the assessed risk outcome during and after the proposed development is acceptable. Referred to report for further details.
3. This table must be read in conunction with Table A.
4. Risk Outcome:
   A = Acceptable $\leq 10^{-6}$
   T = Tolerable $\leq 10^{-5}$
   NT = Not Tolerable - treatment options to be assessed and implemented
5. Temporal Probability based on per-person average assuming 8 hours per day for ski season = 8 / 24 = 0.333

Figures

APPROXIMATE ONLY – SUBJECT TO DETAIL SURVEY.
SOURCE: Kosciuszko Thredbo Pty Ltd (KT).
THIS DRAWING IS USED TO ILLUSTRATE SITE LOCATION ONLY, AND MUST NOT BE USED FOR ANY OTHER PURPOSE. COPYRIGHT OF SOURCE DRAWING REMAINS WITH KT

issue	date	description
B	7.6.22	Update base plan
A	15.12.21	Initial issue

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PROPOSED NEW SNOWRUNNER,
FRIDAY FLAT, THREDBO NSW
for
KT–EVT

SITE LOCALITY

drawn: AT / MAB
date: 7.6.2022
checked: MAB
scale: NTS

job no.: 6751
fig: 1
issue: B

APPROXIMATE ONLY – SUBJECT TO DETAIL SURVEY.

SOURCE: SITE LAYOUT prepared by Kosciuszko Thredbo Pty Ltd, Rev D, dated 22 June 2022.

0 1:600 A4 20m

LEGEND
- Borehole
- Test pit

issue	date	description
C	27.6.22	Amended base plan
B	7.6.22	Amended stairs etc, TP3 shown
A	19.1.22	Initial issue

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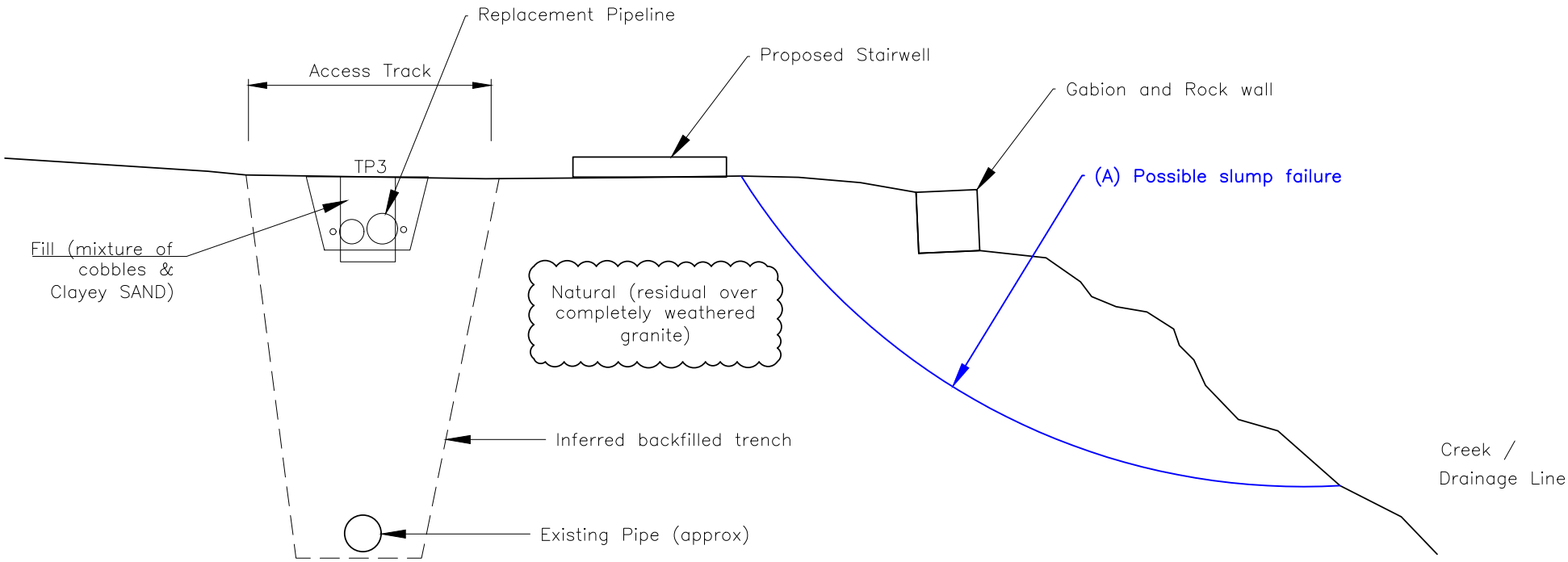
PROPOSED NEW SNOWRUNNER,
FRIDAY FLAT, THREDBO NSW
for
KT–EVT

TEST LOCATIONS

drawn: AT / MAB
date: 27.6.2022
checked: MAB
scale: 1:600 A4

job no.: 6751
fig: 2
issue: C



APPROXIMATE ONLY – SUBJECT TO DETAIL SURVEY.

issue	date	description
A	7.6.22	Initial issue

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PROPOSED NEW SNOWRUNNER,
FRIDAY FLAT, THREDBO NSW
for
KT–EVT

Interpreted Section A–A

drawn: MAB
date: 7.6.2022
checked: MAB
scale: 1:100 A4

job no.: 6751
fig: 3
issue: A

Appendix A

Important Information about your Geotechnical Report
Important Information about your Landslide Risk Assessment
CSIRO BTF 18

Important Information about your Geotechnical Report

Scope of Services

The geotechnical report ("the report") has been prepared in accordance with the scope of services as set out in the contract, or as otherwise agreed, between the Client and Asset Geotechnical Engineering Pty Ltd ("Asset"), for the specific site investigated. The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

The report should not be used if there have been changes to the project, without first consulting with Asset to assess if the report's recommendations are still valid. Asset does not accept responsibility for problems that occur due to project changes if they are not consulted.

Reliance on Data

Asset has relied on data provided by the Client and other individuals and organizations, to prepare the report. Such data may include surveys, analyses, designs, maps and plans. Asset has not verified the accuracy or completeness of the data except as stated in the report. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations ("conclusions") are based in whole or part on the data, Asset will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Asset.

Geotechnical Engineering

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared for a specific client, for a specific project and to meet specific needs, and may not be adequate for other clients or other purposes (e.g. a report prepared for a consulting civil engineer may not be adequate for a construction contractor). The report should not be used for other than its intended purpose without seeking additional geotechnical advice. Also, unless further geotechnical advice is obtained, the report cannot be used where the nature and/or details of the proposed development are changed.

Limitations of Site Investigation

The investigation program undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions. The data derived from the site investigation program and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behavior with regard to the proposed development. Despite investigation, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel. The actual interface between materials may be more gradual or abrupt than a report indicates.

Therefore, the recommendations in the report can only be regarded as preliminary. Asset should be retained during the project implementation to assess if the report's recommendations are valid and whether or not changes should be considered as the project proceeds.

Subsurface Conditions are Time Dependent

Subsurface conditions can be modified by changing natural forces or man-made influences. The report is based on conditions that existed at the time of subsurface exploration. Construction operations adjacent to the site, and natural events such as floods, or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. Asset should be kept appraised of any such events, and should be consulted to determine if any additional tests are necessary.

Verification of Site Conditions

Where ground conditions encountered at the site differ significantly from those anticipated in the report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the report that Asset be notified of any variations and be provided with an opportunity to review the recommendations of this report. Recognition of change of soil and rock conditions requires experience and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly.

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This report is the subject of copyright and shall not be reproduced either totally or in part without the express permission of this Company. Where information from the accompanying report is to be included in contract documents or engineering specification for the project, the entire report should be included in order to minimize the likelihood of misinterpretation from logs.

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The report has been prepared for the benefit of the Client and no other party. Asset assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of Asset or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

Data Must Not Be Separated from The Report

The report as a whole presents the site assessment, and must not be copied in part or altered in any way.

Logs, figures, drawings, test results etc. included in our reports are developed by professionals based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These data should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Partial Use of Report

Where the recommendations of the report are only partially followed, there may be significant implications for the project and could lead to problems. Consult Asset if you are not intending to follow all of the report recommendations, to assess what the implications could be. Asset does not accept responsibility for problems that develop where the report recommendations have only been partially followed if they have not been consulted.

Other Limitations

Asset will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report.

Important Information about your Landslide Risk Assessment

Basis of The Assessment

Our assessment of landslide risk is presented in the framework of Landslide Risk Management (Australian Geomechanics Society, Vol 42, No 1, March 2007). The attached GeoGuides provide further information on landslide risk management and maintenance.

This assessment is based on a visual inspection of the property and the immediate adjoining land. Limited subsurface investigation may also have been undertaken as part of this appraisal. Slope monitoring has not been carried out within or adjacent to the property for the purpose of this appraisal. The opinions expressed in this report also consider our relevant local experience.

The property is within an area where landslip and/or subsidence have occurred, or where there is a risk of landslide. Important factors relating to slope conditions and the impact of development which commonly influence the landslide risks are discussed herein.

An owner's decision to acquire, develop or build on land within an area such as this involves the understanding and acceptance of a level of risk. It is important to recognise that soil and rock movements are an ongoing geological process, which may be affected by development and land management within the site or on ad- joining land. Soil and rock movements may cause visible damage to structures even where the risk of slope failure is considered low. This report is intended only to assess the landslide risk apparent at the time of inspection.

Our opinion is provided on the present landslide risk for the land specifically referenced in the title to this report. Foundations suitable for future building development are discussed in relation to slope stability considerations. Limited foundation advice may be provided. If so, advice is intended to guide the footing design for the proposed development. However, this report is not intended as, is not suitable for, and must not be used in lieu of a detailed foundation investigation for final design and costing of foundations, retaining walls or associated structures.

Limitations of The Assessment Procedure

The assessment procedures carried out for this appraisal are in accordance with the recommendations in Landslide Risk Management (Australian Geomechanics Society, Vol 42, No 1, March 2007), and with accepted local practice.

The following limitations must be acknowledged:

- the assessment of the stability of natural slopes requires a great degree of judgment and personal experience, even for experienced practitioners with good local knowledge;
- the assessment must be based on development of a sound geological model; slope processes and process rates influencing land sliding or landslide potential will vary according to geomorphologic influences;
- the likelihood that land sliding may occur on a given slope is generally hard to predict and is associated with significant uncertainties;
- different practitioners may produce different assessments of risk;
- actual risk of land sliding cannot be determined; risk changes with time;
- consequences of land sliding need to be considered in a rational framework of risk acceptance;
- acceptable risk in relation to damage to property from landslide activity is subjective; it remains the responsibility of the owner and/or local authority to decide whether the risk is acceptable; the geotechnical practitioner can assist with this judgment;
- the extent and methods of investigation for assessment of landslide risk will be governed by experience, by the perceived risk level, and by the degree to which the risk or consequences of land sliding are accepted for a specific project;
- the assessment may be required at several stages of the project or development; frequently (due to time or budget constraints imposed by the client) there will be no opportunity for long-term monitoring of the slope behaviour or groundwater conditions, or for on-going opportunity for the slope processes and performance of structures to be reviewed during and after development; such limitations should be recognised as relevant to the assessment.

Development on Slopes

Some landslide risk is always attached to the development of land on slopes.

Guidelines for hillside construction and examples of good practices for hillside developments are described in the attached GeoGuides.

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction
There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion
All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation
This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil
All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure
This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

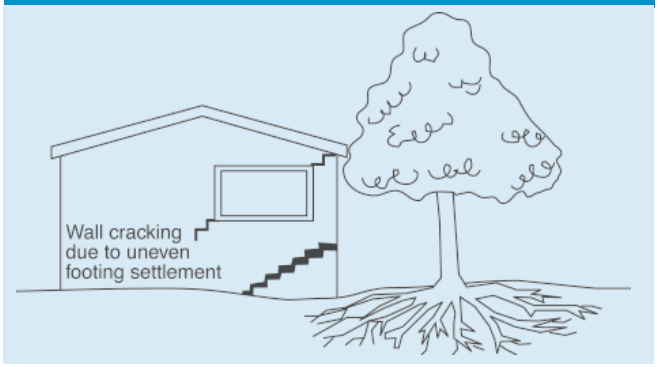
Seasonal swelling/shrinkage in clay

Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

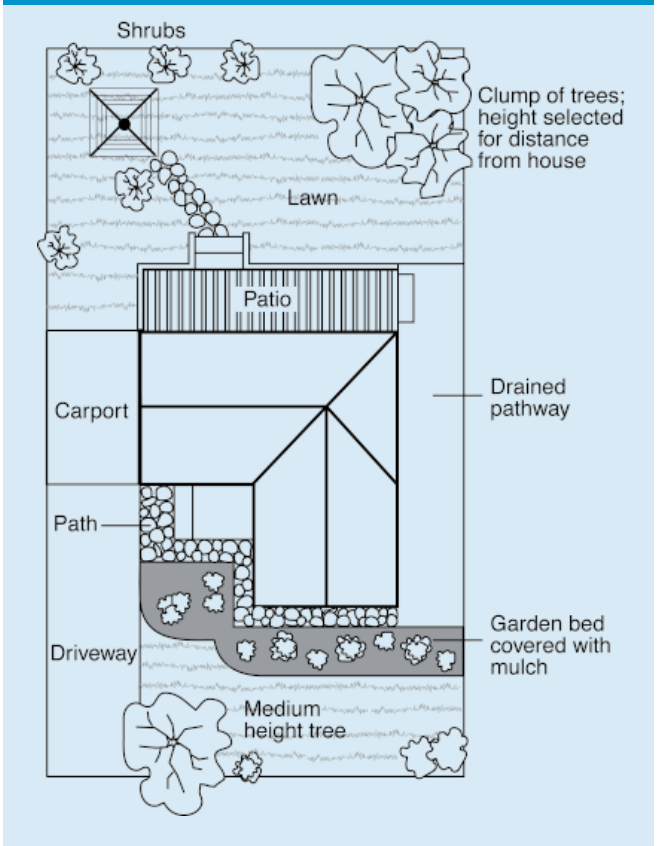
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

Distributed by

CSIRO PUBLISHING PO Box 1139, Collingwood 3066, Australia

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Appendix B

Soil & Rock Explanation Sheets
Borehole Logs
Test Pit Log
DCP Logs

Soil and Rock Explanation Sheets (1 of 2)

Log Abbreviations & Notes

METHOD

borehole logs

AS	auger screw *
AD	auger drill *
RR	roller / tricone
W	washbore
CT	cable tool
HA	hand auger
D	diatube
B	blade / blank bit
V	V-bit
T	TC-bit

* bit shown by suffix e.g. ADV

excavation logs

NE	natural excavation
HE	hand excavation
BH	backhoe bucket
EX	excavator bucket
DZ	dozer blade
R	ripper tooth

coring

NMLC, NQ, PQ, HQ

SUPPORT

borehole logs	
N	nil
M	mud
C	casing
NQ	NQ rods

excavation logs	
N	nil
S	shoring
B	benched

CORE—LIFT

casing installed

barrel withdrawn

NOTES, SAMPLES, TESTS

D	disturbed
B	bulk disturbed
U50	thin-walled sample, 50mm diameter
HP	hand penetrometer (kPa)
SV	shear vane test (kPa)
DCP	dynamic cone penetrometer (blows per 100mm penetration)
SPT	standard penetration test
N*	SPT value (blows per 300mm) * denotes sample taken
Nc	SPT with solid cone
R	refusal of DCP or SPT

USCS SYMBOLS

GW	Gravel and gravel-sand mixtures, little or no fines.
GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels
GM	Gravel-silt mixtures and gravel-sand-silt mixtures.
GC	Gravel-clay mixtures and gravel-sand-clay mixtures.
SW	Sand and gravel-sand mixtures, little or no fines.
SP	Sand and gravel sand mixtures, little or no fines.
SM	Sand-silt mixtures.
SC	Sand-clay mixtures.
ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity.
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays.
OL	Organic silts
MH	Inorganic silts
CH	Inorganic clays of high plasticity.
OH	Organic clays of medium to high plasticity, organic silt
PT	Peat, highly organic soils.

MOISTURE CONDITION

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

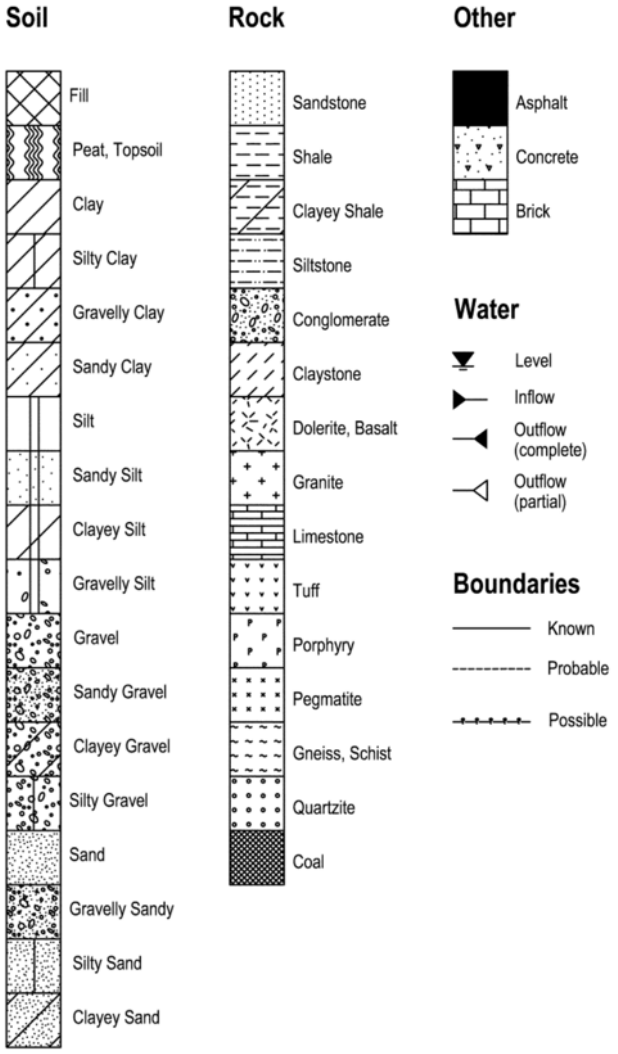
CONSISTENCY

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable

DENSITY INDEX

VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Graphic Log



WEATHERING

XW	extremely weathered
HW	highly weathered
MW	moderately weathered
SW	slightly weathered
FR	fresh

STRENGTH

VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

RQD (%)

= sum of intact core pieces > 2 x diameter x 100
total length of core run drilled

DEFECTS:

type	
JT	joint
PT	parting
SZ	shear zone
SM	seam

coating	
cl	clean
st	stained
ve	veneer
co	coating

shape	
pl	planar
cu	curved
un	undulating
st	stepped
ir	irregular

roughness	
po	polished
sl	slickensided
sm	smooth
ro	rough
vr	very rough

inclination

measured above axis and perpendicular to core

Soil and Rock Explanation Sheets (2 of 2)

AS1726-2017

Soils and rock are described in the following terms, which are broadly in accordance with AS1726-2017.

Soil

MOISTURE CONDITION

Term	Description
Dry	Looks and feels dry. Fine grained and cemented soils are hard, friable or powdery. Uncemented coarse grained soils run freely through hand.
Moist	Soil feels cool and darkened in colour. Fine grained soils can be moulded. Coarse soils tend to cohere.
Wet	As for moist, but with free water forming on hand.

Moisture content of cohesive soils may also be described in relation to plastic limit (W_P) or liquid limit (W_L) [>> much greater than, > greater than, < less than, << much less than].

CONSISTENCY OF FINE-GRAINED SOILS

Term	Su (kPa)	Term	Su (kPa)
Very soft	< 12	Very Stiff	>100 – ≤200
Soft	>12 – ≤25	Hard	> 200
Firm	>25 – ≤50	Friable	–
Stiff	>50 – ≤100		

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Term	Density Index (%)	Term	Density Index (%)
Very Loose	< 15	Dense	65 – 85
Loose	15 – 35	Very Dense	>85
Medium Dense	35 – 65		

PARTICLE SIZE

Name	Subdivision	Size (mm)
Boulders		> 200
Cobbles		63 – 200
Gravel	coarse	19 – 63
	medium	6.7 – 19
	fine	2.36 – 6.7
Sand	coarse	0.6 – 2.36
	medium	0.21 – 0.6
	fine	0.075 – 0.21
Silt & Clay		< 0.075

MINOR COMPONENTS

Term	Proportion by Mass:	
	coarse grained	*fine grained*
Trace	≤ 15%	≤ 5%
With	>15% – ≤30%	>5% – ≤12%

SOIL ZONING

Layers	Continuous across exposures or sample.
Lenses	Discontinuous, lenticular shaped zones.
Pockets	Irregular shape zones of different material.

SOIL CEMENTING

Weakly	Easily broken up by hand pressure in water or air.
Moderately	Effort is required to break up by hand in water or in air.

USCS SYMBOLS

Symbol	Description
GW	Gravel and gravel-sand mixtures, little or no fines.
GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels.
GM	Gravel-silt mixtures and gravel-sand-silt mixtures.
GC	Gravel-clay mixtures and gravel-sand-clay mixtures.
SW	Sand and gravel-sand mixtures, little or no fines.
SP	Sand and gravel sand mixtures, little or no fines.
SM	Sand-silt mixtures.
SC	Sand-clay mixtures.
ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity.
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays.
OL	Organic silts
MH	Inorganic silts
CH	Inorganic clays of high plasticity.
OH	Organic clays of medium to high plasticity, organic silt
PT	Peat, highly organic soils.

Rock

SEDIMENTARY ROCK TYPE DEFINITIONS

Rock Type	Definition (more than 50% of rock consists of …..)
Conglomerate	... gravel sized (>2mm) fragments.
Sandstone	... sand sized (0.06 to 2mm) grains.
Siltstone	... silt sized (<0.06mm) particles, rock is not laminated.
Claystone	... clay, rock is not laminated.
Shale	... silt or clay sized particles, rock is laminated.

LAYERING

Term	Description
Massive	No layering apparent.
Poorly Developed	Layering just visible. Little effect on properties.
Well Developed	Layering distinct. Rock breaks more easily parallel to layering.

STRUCTURE

Term	Spacing (mm)	Term	Spacing
Thinly laminated	<6	Medium bedded	200 – 600
Laminated	6 – 20	Thickly bedded	600 – 2,000
Very thinly bedded	20 – 60	Very thickly bedded	> 2,000
Thinly bedded	60 – 200		

STRENGTH (NOTE: Is50 = Point Load Strength Index)

Term	Is50 (MPa)	Term	Is50 (MPa)
Extremely Low	<0.03	High	1.0 – 3.0
Very low	0.03 – 0.1	Very High	3.0 – 10.0
Low	0.1 – 0.3	Extremely High	>10.0
Medium	0.3 – 1.0		

WEATHERING

Term	Description
Residual Soil	Material is weathered to an extent that it has soil properties. Rock structures are no longer visible, but the soil has not been significantly transported.
Extremely …..	Material is weathered to the extent that it has soil properties. Mass structures, material texture & fabric of original rock is still visible.
Highly …..	Rock strength is significantly changed by weathering; rock is discolored, usually by iron staining or bleaching. Some primary minerals have weathered to clay minerals.
Moderately …..	Rock strength shows little or no change of strength from fresh rock; rock may be discolored.
Slightly …..	Rock is partially discolored but shows little or no change of strength from fresh rock.
Fresh	Rock shows no signs of decomposition or staining.

DEFECT DESCRIPTION

Type	
Joint	A surface or crack across which the rock has little or no tensile strength. May be open or closed.
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub-parallel to layering/bedding. May be open or closed.
Sheared Zone	Zone of rock substance with roughly parallel, near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects.
Seam	Seam with deposited soil (infill), extremely weathered insitu rock (XW), or disoriented usually angular fragments of the host rock (crushed).
Shape	
Planar	Consistent orientation.
Curved	Gradual change in orientation.
Undulating	Wavy surface.
Stepped	One or more well defined steps.
Irregular	Many sharp changes in orientation.
Roughness	
Polished	Shiny smooth surface.
Slickensided	Grooved or striated surface, usually polished.
Smooth	Smooth to touch. Few or no surface irregularities.
Rough	Many small surface irregularities (amplitude generally <1mm). Feels like fine to coarse sandpaper.
Very Rough	Many large surface irregularities, amplitude generally >1mm. Feels like very coarse sandpaper.
Coating	
Clean	No visible coating or discolouring.
Stained	No visible coating but surfaces are discolored.
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	Visible coating =1mm thick. Thicker soil material described as seam.

Borehole Log

BH no:	**BH1**
sheet:	1 of 1
job no.:	6751

client:	Kosciuszko Thredbo Pty Ltd	**started:**	29.11.2021
principal:		**finished:**	29.11.2021
project:	Proposed new Snowrunner	**logged:**	AT
location:	Friday Flat, Thredbo NSW	**checked:**	MAB
equipment:	HA/DCP	**RL surface:**	1373 m approx.
diameter:	75mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
HA/DCP	N	None Observed					SM/MLS	TOPSOIL, Sandy Silt/ Silty SAND matrix, fine to medium grained, low plasticity fines, dark brown, grass roots.	D	VD		TOPSOIL.
					0.2			Hand Auger reached practical refusal @ 0.2m on weathered granite bedrock. DCP sounding bouncing @ 0.2m. Borehole No: BH1 terminated at 0.2m				GRANITE BEDROCK.
				1372.5	0.5							
				1372.0	1.0							
				1371.5	1.5							

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED — Borehole Log - Revision 10

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Borehole Log

BH no:	**BH2**
sheet:	1 of 1
job no.:	6751

client:	Kosciuszko Thredbo Pty Ltd	**started:**	29.11.2021
principal:		**finished:**	29.11.2021
project:	Proposed new Snowrunner	**logged:**	AT
location:	Friday Flat, Thredbo NSW	**checked:**	MAB
equipment:	HA/DCP	**RL surface:**	1373 m approx.
diameter:	75mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
HA/DCP	N	None Observed					MLC	TOPSOIL, Sandy, silty CLAY, low plasticity fines, fine to medium grained sand, brown, grass roots.	D	MD / VD		TOPSOIL.
DCP					0.35			GRANITE, CW-XW, blocky mixed with clayey sand matrix, medium to coarse sand, trace of granite fragments up to 70mm in size, brown.				GRANITE, variably weathered (CW-XW).
					0.45			Borehole No: BH2 terminated at 0.45m				
				1372.5	0.5							
				1372.0	1.0							
				1371.5	1.5							

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED

Borehole Log - Revision 10

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Borehole Log

BH no:	**BH3**
sheet:	1 of 1
job no.:	6751

client:	Kosciuszko Thredbo Pty Ltd	**started:**	29.11.2021
principal:		**finished:**	29.11.2021
project:	Proposed new Snowrunner	**logged:**	AT
location:	Friday Flat, Thredbo NSW	**checked:**	MAB
equipment:	HA/DCP	**RL surface:**	1372 m approx.
diameter:	75mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
HA/DCP	N	None Observed		1371.5	0.5		CLM	FILL, Silty CLAY with traces of sand, fine to medium grained sand, low to medium plasticity, trace of fines and grass roots, granite fragments, dark brown.	D	D / VD / L		FILL.
					0.65			Hand Auger reached practical refusal @ 0.65 on inferred weathered Granite bedrock. Borehole No: BH3 terminated at 0.65m				GRANITE BEDROCK or BOULDER.
				1371.0	1.0							
				1370.5	1.5							

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED

Borehole Log - Revision 10

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Borehole Log

BH no:	**BH4**
sheet:	1 of 1
job no.:	6751

client:	Kosciuszko Thredbo Pty Ltd	**started:**	29.11.2021
principal:		**finished:**	29.11.2021
project:	Proposed new Snowrunner	**logged:**	AT
location:	Friday Flat, Thredbo NSW	**checked:**	MAB
equipment:	HA/DCP	**RL surface:**	1372 m approx.
diameter:	75mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
HA/DCP	N	None Observed					MLC/CLM	TOPSOIL/FILL, Silty, clayey SAND grading to Silty CLAY with traces of sand, fine ot medium grained sand, low plasticity fines, trace of granite fragments and grass roots, dark brown to dark grey/dark brown.	<Wp	S/L		FILL.
										F/MD		
										St/VD		
										VSt/VD		
				1371.5	0.5					VSt/D		
										VSt		
DCP					0.72			Hand Auger reached practical refusal @ 0.72m on very stiff to hard clay.	<Wp/D?			ALLUVIUM / FILL?
				1371.0	1.0					St		
										H		
								DCP sounding bouncing @ 1.3m on inferred Granite bedrock or boulder. Borehole No: BH4 terminated at 1.3m				GRANITE BEDROCK.
				1370.5	1.5							

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED

Borehole Log - Revision 10

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Excavation Log

EX no:	**TP3**
sheet:	1 of 1
job no.:	6262

client:	EVT / Kosciuszko Thredbo Pty Ltd	**started:**	4.10.2020
principal:		**finished:**	4.10.2020
project:	Proposed Snowmaking Pipeline Replacement	**logged:**	MAB
location:	Thredbo	**checked:**	WND
equipment:	Kubota U17-3 Excavator	**RL surface:**	
dimensions:	0.9 x 0.9m **E:** **N:**	**datum:**	

excavation information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
EX	N	None observed			0.5 1.0			Mixture of cobbles and small boulders to 300mm size and Clayey SAND, medium to coarse grained, grey/brown	M	D		FILL (roadway), gravel over geofabric at top side of test pit FILL appears well compacted
					1.4 1.5 2.0			Excavation No: TP3 terminated at 1.4m				

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Excavation Log

EX no:	**TP4**
sheet:	1 of 1
job no.:	6262

client:	EVT / Kosciuszko Thredbo Pty Ltd	**started:**	4.10.2020
principal:		**finished:**	4.10.2020
project:	Proposed Snowmaking Pipeline Replacement	**logged:**	MAB
location:	Thredbo	**checked:**	WND
equipment:	Kubota U17-3 Excavator	**RL surface:**	
dimensions:	0.9 x 0.9m **E:** **N:**	**datum:**	

excavation information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
EX	N	None observed					GP	GRAVEL, fine to medium grained, over geofabric	M	D		FILL
					0.1		CL	CLAY, medium plasticity, dark brown to orange-brown, some cobbles to 200mm	<Wp	H		COLLUVIUM?
					0.5							
					1.0							
					1.2		CL	CLAY, medium plasticity, orange-brown	=Wp	VSt		
					1.4			Excavation No: TP4 terminated at 1.4m				
					1.5							
					2.0							

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Excavation Log

EX no:	**TP5**
sheet:	1 of 1
job no.:	6262

client:	EVT / Kosciuszko Thredbo Pty Ltd	**started:**	4.10.2020
principal:		**finished:**	4.10.2020
project:	Proposed Snowmaking Pipeline Replacement	**logged:**	MAB
location:	Thredbo	**checked:**	WND
equipment:	Kubota U17-3 Excavator	**RL surface:**	
dimensions:	0.9 x 0.9m **E:** **N:**	**datum:**	

excavation information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
EX	N	None observed					ML	SILT, medium plasticity, dark grey, grass roots	M	F		TOPSOIL
					0.2		CL	CLAY, medium plasticity, brown, some cobbles and small boulders to 500mm size	>=Wp	St	× 100	COLLUVIUM?
					0.5							
											× 100	
					1.0							
					1.2		SC	Clayey SAND, medium to coarse grained, light grey/brown	M	D		RESIDUAL (COMPLETELY WEATHERED GRANITE)
					1.4			Excavation No: TP5 terminated at 1.4m				
					1.5							
					2.0							

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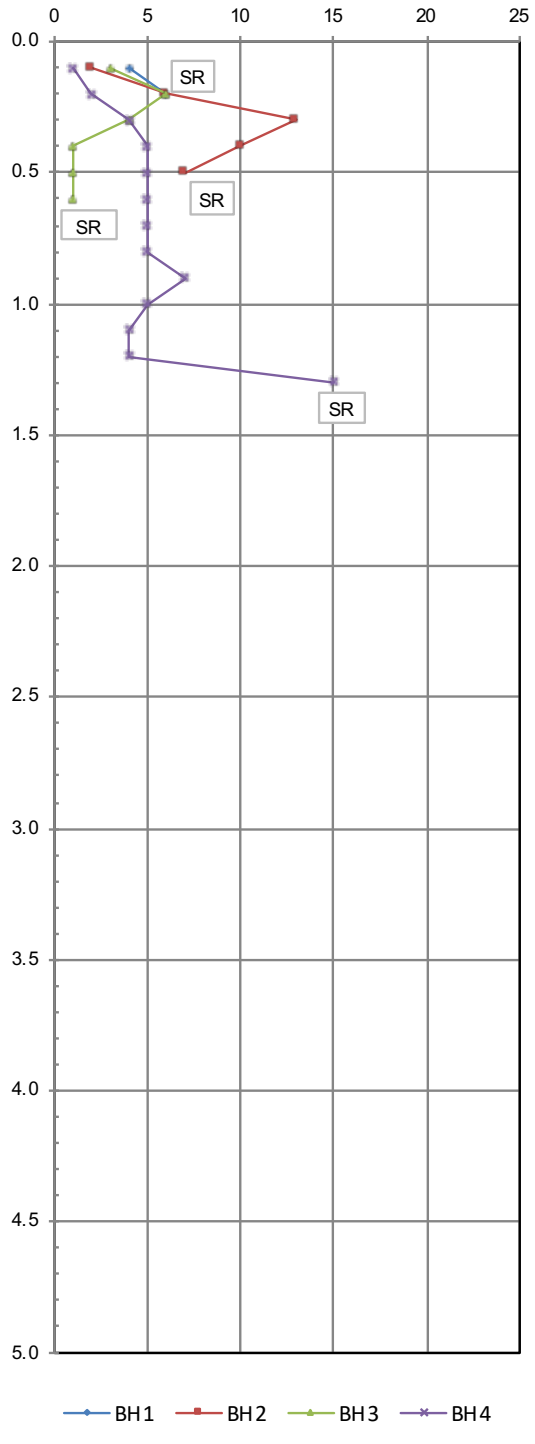
Dynamic Cone Penetrometer

Sheet:	1 of 1
Job No:	6751

client:	Kosciuszko Thredbo Pty Ltd	**started:**	29.11.2021
principal:		**finished:**	29.11.2021
project:	Proposed new Snowrunner	**logged:**	AT
location:	Friday Flat, Thredbo NSW	**checked:**	MAB
equipment:	9kg hammer, 510mm drop, cone tip		
standard:	AS1289.6.3.2-1997		

Depth (m)	Test Results (blows / 100mm)				
	BH1	BH2	BH3	BH4	BH5
0.00 – 0.10	4	2	3	1	
0.10 – 0.20	6	6	6	2	
0.20 – 0.30	SR	13	4	4	
0.30 – 0.40		10	1	5	
0.40 – 0.50		7	1	5	
0.50 – 0.60		SR	1	5	
0.60 – 0.70			SR	5	
0.70 – 0.80				5	
0.80 – 0.90				7	
0.90 – 1.00				5	
1.00 – 1.10				4	
1.10 – 1.20				4	
1.20 – 1.30				15	
1.30 – 1.40				SR	
1.40 – 1.50					
1.50 – 1.60					
1.60 – 1.70					
1.70 – 1.80					
1.80 – 1.90					
1.90 – 2.00					
2.00 – 2.10					
2.10 – 2.20					
2.20 – 2.30					
2.30 – 2.40					
2.40 – 2.50					
2.50 – 2.60					
2.60 – 2.70					
2.70 – 2.80					
2.80 – 2.90					
2.90 – 3.00					
3.00 – 3.10					
3.10 – 3.20					
3.20 – 3.30					
3.30 – 3.40					
3.40 – 3.50					
3.50 – 3.60					
3.60 – 3.70					
3.70 – 3.80					
3.80 – 3.90					
3.90 – 4.00					
4.00 – 4.10					
4.10 – 4.20					
4.20 – 4.30					
4.30 – 4.40					
4.40 – 4.50					
4.50 – 4.60					
4.60 – 4.70					
4.70 – 4.80					
4.80 – 4.90					
4.90 – 5.00					

Plot (blows / 100mm vs depth)



Notes:
RL = ground surface level (m) AHD
TD = target depth, PR = practical refusal (15+ blows per 100mm), SR = "solid" refusal (no further penetration and "solid" ringing sound from slide hammer)

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Appendix C

Site Photos & Images of Footing System

Photo 1

Overview of existing site condition

Photo 2

Continuation of Photo 1


SUREFOOT
CONCRETE FREE FOOTING SYSTEM
RESIDENTIAL


650


1200 × 730


886 × 587


316 × 248

Typical Operators Hut

Typical footing excavation for Operators Hut