ACT Geotechnical Engineers Pty Ltd

Department of Planning and Environment

Issued under the Environmental Planning and Assessment Act 1979

Approved Application No 22/14835

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Signed D James

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TSA MANAGEMENT

SELWYN SNOW RESORT REDEVELOPMENT

KINGS CROSS ROAD, CABRAMURRA, NSW

GEOTECHNICAL INVESTIGATION & SLOPE STABILITY RISK ASSESSMENT

JULY 2020

ACT Geotechnical Engineers

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24 July 2020
Our ref: JM/C10872

TSA Managment
GPO Box 609
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Attention: Mr Marko Osti

Dear Sir

PROPOSED SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROPSS ROAD, CABRAMURRA, NSW

GEOTECHNICAL INVESTIGATION & SLOPE STABILITY RISK ASSESSMENT

We are pleased to forward our geotechnical investigation and slope stability risk assessment for the proposed Selwyn Snow Resort Redevelopment, in Cabramurra, NSW.

The report outlines the methods and results of field investigations, describes site subsurface conditions, and provides the site classification to AS2870, as well as geotechnical recommendations for site earthworks, structure footings and a qualitative slope instability risk assessment.

The slope instability risk assessment is based on the landslide risk management concepts and guidelines issued by the Australian Geomechanics Journal Vol 35 March 2007 "Practice Note Guidelines for Landslide Risk Management 2007". By these criteria, it was established that the level of risk to be proposed and neighbouring dwellings and to people is "Very Low to Medium", and is no higher than normally acceptable for residential development.

Should you require any further information regarding this report, please do not hesitate to contact our office.

Yours faithfully
ACT Geotechnical Engineers Pty Ltd

Jeremy Murray
Senior Geotechnical Engineer
Director
FIEAust CPEng Eng Exec NER RPEQ APEC Engineer IntPE(Aust)

TSA MANAGEMENT

PROPOSED SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROPSS ROAD, CABRAMURRA, NSW

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GEOTECHNICAL INVESTIGATION & SLOPE STABILITY RISK ASSESSMENT

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1 INTRODUCTION

1.1 Project Description

At the request of TSA Management, ACT Geotechnical Engineers Pty Ltd carried out a geotechnical investigation and a qualitative slope instability risk assessment for the proposed Selwyn Snow Resort Redevelopment, in Cabramurra, NSW.

It is understood the project involves the construction of a ~600m^2 work shop, 5 x staff pre-fabricated accommodation buildings, and a ~2500m^2 guest facilities building. The site is within “Zone G” of the Kosciusko National Parks Alpine Resorts, so under the NSW Department of Planning Geotechnical policy, a geotechnical investigation and slope instability risk assessment is required.

1.2 Scope of Investigation

The aim of the investigation was to:

- Identify subsurface conditions including extent and nature of any fill materials, soil strata, bedrock type and depth, and groundwater presence.
- Provide a site classification to AS2870 “Residential Slabs & Footings”.
- Recommend suitable footing systems for the buildings including types, founding depths and allowable bearing pressures.
- Advise on excavation batters support and earth pressures for design of retaining walls.
- Slope instability risk assessment
- Advise on excavation conditions and suitability of excavated materials for use as structural fill.
- Advise on subgrade preparation and subgrade indicative CBR values for pavement design.
- Provide the earthquake site factor.
- Advise on site drainage, and other relevant geotechnical issues.

The slope stability risk assessment required the development of a qualitative matrix risk assessment to people and property, in accordance with the guidelines of “Landslide Risk Management Concepts and Guidelines”, Australian Geomechanics Journal, 2007. In this instance, the guest and workers at the resort are considered as “people” and the proposed accommodation buildings, guest facilities building, and work shop, were considered as “property”.

The slope stability assessment is qualitative, based on the guidelines on landslide risk management published by the Australian Geomechanics Society. Risk assessment involves the following components: (i) Hazard identification, (ii) Likelihood of Hazards Occurring, (iii) Consequences of Hazards, and (iv) Significance of Risks. This uses a matrix approach to determine the risk level of each hazard based on the likelihood and consequences of each hazard occurrence.

1.3 Geotechnical Policy – Kosciuszko Alpine Resorts

Section 4 of "Geotechnical Policy – Kosciuszko Alpine Resorts" by the NSW Department of Infrastructure, Planning and National Resources details the requirements that must be included in a geotechnical report for developments within the designated "G" areas of the Kosciuszko Alpine Resorts. The table below summarises the requirements and the sections within this report that covers those requirements.

Policy Section	Policy Requirement for Inclusion in Geotechnical Report	Section in This Report Covering the Requirement
4.1 (a)	An assessment of the risk posed by all reasonably identifiable geotechnical hazards which have the potential to either individually or cumulatively impact upon people or property upon the site or related land to the proposed development in accordance with the guidelines set out in 'Landslide Risk Management Concepts and Guidelines" published in the Australian Geomechanics Journal, Volume 35 No. 1 of March 2000.	See Section 5 "Slope Instability Risk Assessment".
4.1 (b)	Plans and sections of the site and related land form from survey and field measurements with contours and key features identified, including the locations of the proposed development, buildings/structures on both the subject site and adjoining site, stormwater drainage, sub-surface drainage, water supply and sewerage pipelines, trees, and other identifiable geotechnical hazards.	See "Aerial Photographs" in Figures 2 to 4, and Figure 5 "Survey Plan".
4.1 (c)	Details of all site inspections and site investigations and any other information used in preparation of the geotechnical report. A site inspection is required in all cases. Site investigation may require sub-surface investigation; appropriate investigation may involve boreholes and/or test pit excavations or other methods to adequately assess the geotechnical/geological model for the site.	See Section 2 "Site Description & Geology" and Section 3 "Investigation Methods".
4.1 (d)	Photographs and/or drawings of the site and related land adequately illustrating all geotechnical features referred to in the geotechnical report, as well as the locations of the proposed development.	See "Aerial Photographs" in Figures 2 to 4, Figure 5 "Survey Plan", and "Site Photographs" in Figures 8 to 13.
4.1 (e)	Presentation of the geological model of the site and related land showing the proposed development, including an analysis of sub-surface conditions, taking into account thickness of the topsoil, colluvium and residual soil layers, depth to underlying bedrock, and the location and depth of groundwater.	See Section 4.1 "Subsurface Conditions", Section 4.2 "Groundwater", and Figure 4 "Subsurface Section"
4.1 (f)	A conclusion as to whether the site is suitable for the development proposed to be carried out either conditionally or unconditionally. This must be in the form of a specific statement that the site is suitable for the development to be carried out, subject to the following conditions:	See Section 5.8 "Suitability of the Proposed Development".
	(i) Conditions to be provided to establish the design parameters, including, but not limited to; footing levels and supporting rock quality, degree of earth and rock cut and fill, recommendations for excavation batters, bearing capacities for use in the design of all structural works including footings, retaining walls, and drainage, signing of Form 2 as the mechanism to check that these parameters have been used and interpreted correctly.	See Section 6 "Discussion & Recommendations".

	(ii) Conditions applying to the detailed design to be undertaken for the construction certificate, including, but not limited to; any structural design relating to the geotechnical aspects of the proposal is to be checked and certified by a suitably qualified and experienced geotechnical engineer, any other design conditions the geotechnical engineer preparing the geotechnical report believes are required in the design phase in order to ensure the design will achieve the "acceptable risk management" level as defined in the policy for potential loss of both property and life, signing of Form 2 as the mechanism to check that these parameters have been used and interpreted correctly. (iii) Conditions applying to the construction phase, including but not limited to; constructed works which require inspection and/or sign off by a suitably qualified and experienced geotechnical engineer. The report must highlight and detail the inspection regime to provide the builder with adequate notification of all necessary inspections, any other construction conditions including works methodology and temporary works that the geotechnical engineer preparing the geotechnical reportbelieves are required in the construction phase to ensure the design will achieve "acceptable risk management" level as defined by the policy for potential loss of both property and life, and signing of Form 3 as the mechanism to check that these parameters have been used and interpreted correctly. (iv) Conditions regarding ongoing management of the site/structure, including but not limited to; any conditions that may be required for the ongoing mitigation and maintenance of the site and the proposal, from a geotechnical viewpoint. (v)	See Section 6 "Discussion & Recommendations". See Section 6.9 "Hold Points for Geotechnical Inspections". See Section 6.5 "Stable Cut/Fill Battered Slopes" and Section 6.8 "Drainage".
4.1 (g)	A copy of Form 1 bearing the original signature of the geotechnical engineer as defined by this policy, who has either prepared or technically verified the geotechnical report.	See Appendix F "Form 1 – Declaration by geotechnical engineer".

2 SITE DESCRIPTION & GEOLOGY

The Selwyn Snow Resort is located on the eastern side of Kings Cross Road, about 15kn south of the Link Road intersection, near Cabramurra, NSW. Figure 1 shows the site locality.

The site was impacted by bushfires in January 2020, and the former buildings on the site have recently been demolished (although the chair lift infrastructure is still intact). The groundsurface at the proposed Staff Accommodation site dips gently south, and is grass-covered with some mature eucalyptus trees. The groundsurface at the Guest Facilities, Work Shop and Access Road is relatively flat, and the groundsurface is bare (due to the recent demolition works).

Figures 2 to 4 are a recent aerial photographs showing the site layout in January 2020 (after the bushfires but before the former buildings were demolished) and the location of the proposed development. Figure 5 is a survey plan of the site, showing the surface contours and topographical features. Figures 8 to 14 are photographs of the site, taken at the time of investigation.

The area is documented on the NSW Department of Mineral Resources Monaro 1: 500,000 Geological Map (Ref. 1), as underlain by the Jackalass Slate bedrock of Silurian age.

3 INVESTIGATION METHODS

The initial field investigation was carried out on 10 July 2020 by Jeremy Murray, a qualified senior geotechnical engineer (FIEAust CPEng EngExec NER RPEQ APEC Engineer IntPE(Aust)). The investigation comprised seventeen (17) test pits, designated 1T to 17T, dug by a 4-tonne excavator. The test pits were dug to bucket refusal in medium strong bedrock at 0.3m/1.0m depth. The test pit locations are shown on Figures 3 and 4, and the test pit logs are presented in Appendix A.

The soil profiles were visually logged in accordance with the Unified Soil Classification System (USCS). Definitions of terms used on the logs and in this report, including a copy of the USCS chart, are provided in Appendix B.

The stability assessment is a qualitative slope instability assessment, in line with the requirements of Section 4 of "Geotechnical Policy – Kosciuszko Alpine Resorts" by the NSW Department of Infrastructure, Planning and National Resources, and is based on the guidelines on the AGS "Landslide Risk Management Concepts and Guidelines 2007". (Reference 2).

4 INVESTIGATION RESULTS

4.1 Subsurface Conditions

Medium strong, moderately weathered (MW) slate bedrock was encountered in all test pits at 0.1m/0.5m depth. The bedrock was overlain either by topsoil (Staff Accommodation and Work Shop sites), or uncontrolled fill (Guest Facilities and Access Road sites).

Sections 4.1.1 to 4.1.4 detail the subsurface conditions for the Staff Accommodation building, Guest Facilities building, Work Shop, and Access Road. Figures 6 and 7 provide geotechnical models of the site, showing subsurface sections through the site, as found by the investigation test pits.

4.1.1 Staff Accommodation

Test Pits 1T to 5T found the following subsurface profile:

Geological Profile	Depth Interval	Description
TOPSOIL	0m to 0.1m/0.3m	CLAYEY SILTY SAND; fine to coarse sand, low plasticity fines, some angular slate gravels to 60mm, black, some grass roots, moist, loose.
BEDROCK	Below 0.1m/0.3m	MW SLATE; moderately weathered (MW), and medium strong rock. Grey, dark grey, some yellow-grey, thinly bedded, foliated in a N-S direction.

4.1.2 Guest Facilities

Test Pits 6T to 11T found the following subsurface profile:

Geological Profile	Depth Interval	Description
FILL	0m to 0.1m/0.3m	CLAYEY SANDY GRAVEL; angular slate gravel to 60mm size, fine to coarse sand, low plasticity clay, dark grey-brown, moist, loose. Appears to be remoulded soil/rock from demolition of the former buildings.
BEDROCK	Below 0.1m/0.3m	MW SLATE; moderately weathered (MW), and medium strong rock. Grey, dark grey, some yellow-grey, thinly bedded, foliated in a N-S direction.

4.1.3 Work Shop

Test Pits 12T and 13T found the following subsurface profile:

Geological Profile	Depth Interval	Description
TOPSOIL	0m to 0.2m/0.3m	CLAYEY SILTY SAND; fine to coarse sand, low plasticity fines, some angular slate gravels to 60mm, black, some grass roots, moist, loose.
BEDROCK	Below 0.2m/0.3m	MW SLATE; moderately weathered (MW), and medium strong rock. Grey, dark grey, some yellow-grey, thinly bedded, foliated in a N-S direction.

4.1.4 Access Road

Test Pits 14T to 17T found the following subsurface profile:

Geological Profile	Depth Interval	Description
FILL	0m to 0.05m/0.4m	CLAYEY SANDY GRAVEL; angular slate gravel to 60mm size, fine to coarse sand, low plasticity clay, dark grey-brown, moist, loose. Appears to be remoulded soil/rock from original access road construction.
BEDROCK	Below 0.05m/0.4m	MW SLATE; moderately weathered (MW), and medium strong rock. Grey, dark grey, some yellow-grey, thinly bedded, foliated in a N-S direction.

4.2 Groundwater

Permanent groundwater is not expected within at least 3m of the surface, however, temporary, perched seepages could occur at shallower depth following rainfall, particularly within the pervious topsoil and sections of fractured bedrock.

The site is mostly well-drained. The site generally sites on top of a hill, with surface slopes away from the site.

5 SLOPE INSTABILITY RISK ASSESSMENT

5.1 Method of Risk Assessment

The following sections of the report outline the slope instability risk assessment carried out for the site. The assessment is qualitative, based on the guidelines provided in the Australian Geomechanics Journal Vol 42 March 2007, and has been adopted by the NSW Department of Infrastructure, Planning and Natural Resources. This uses a matrix approach to determine the risk level of each hazard based on the likelihood and consequences of each hazard occurring.

Risk assessment involves the following components:

(i) Identification on the potential site slope hazards that may damage property and/or cause loss of life (Hazard Identification).

(ii) Estimation of the likelihood of each hazard occurring (Likelihood of Hazards Occurring).

(iii) Assessment of the potential consequences to property and people of these hazards occurring (Consequences of Hazards).

(iv) Evaluation of the significance of the assessed risks against criteria of acceptability (Significance of Risks).

Following the risk assessment, options for the treatment of the risk are provided as a guide to the owner, administrator and regulatory authorities who will need to decide whether to avoid or accept the risk, or to treat the site to reduce the likelihood and/or consequences of the hazards.

A flowchart, included in the Australian Geomechanics Journal, Vol 42, March 2007, paper on "Landslide Risk Management Concept & Guidelines" 2007 (Reference 3), which shows the processes of risk assessment/risk management is copied here in Appendix D. Appendix E provides guidelines for hillside construction.

5.2 Hazard Identification

The potential hazards to slope stability at this site were considered, and include:

- Large Scale Transitional Slide
- Small Scale Slumps in the Soil Profile
- Failure of a Retaining Wall
- Surface Erosion
- Failure of Cut Batters
- Large Rockfall from Upslope

5.3 Likelihood of Hazards Occurring

5.3.1 Large Scale Translational Slide

The Selwyn Snow Resort is located in the Kosciuszko National Park, which is an area where landslip and/or subsidence has occurred or land stability has previously occurred. In particular, there is history of severe embankment stability, rock fall, debris slide and debris flow problems in the Thredbo Valley.

To our knowledge, no landslips have been recorded in the vicinity of the Selwyn Snow Resort. Other landslides that have occurred in the Kosciuszko National Park have generally been triggered by changes in the slope (cut or fill) or changes in the drainage, combined with heavy rainfall. The combination of flattish slopes (dipping between 0° and 5°), a shallow soil profile (0.1m/0.5m) with well-established stable vegetation around and upslope of the site, and good surface drainage, reducing the possibility of a major landslip occurring. The existing trees on the slope are vertical, indicating no recent slope movement. For such a large-scale slide to happen there would need to be an extreme combination of unfavourable triggering conditions such as earthquakes, extreme rainfall, saturated soils, mass clearance of vegetation, unsupported excavations etc. Therefore, such an event is considered to be "Unlikely".

5.3.2 Small-Scale Slumps in the Soil Profile

Under adverse site conditions, such as when site soils are saturated, small slumping failures of the soils could conceivably occur. Therefore, such an event is considered to be "Possible".

5.3.3 Failure of Retaining Wall

Any excavations on the site will be supported by well-drained, properly designed and constructed engineered retaining walls. The likelihood of a properly designed, drained, and constructed retaining wall failure is judged to be "Rare".

5.3.4 Surface Erosion

There are presently no signs of surface scouring or erosion on the site, probably in part due to the thick surface vegetation and good surface drainage. The only exposed ground without vegetation cover is where the former buildings have recently been demolished. Nevertheless, the upper soils are quite silty, so if the vegetation was removed and surface water flow-paths were allowed to develop, surface erosion is "Possible".

5.3.5 Large Rockfall from Upslope

There is no evidence of large rockfalls from up the slope occurring in the past. There is some higher ground to the east and south of the proposed development, however, these slopes are relatively gentle. The bedrock on the site is also foliated and highly fractured, so the presence of large boulders is limited. Therefore, this event is "Unlikely".

5.4 Consequences of Hazards Occurring

5.4.1 Large-Scale Translational Slide

Theoretically, a large-scale slide would occur with little or no warning, and the consequences to property and people would depend on the volume of the slide material, its velocity, and whether or not people are present, or in the downslope dwelling at the time. Using the AGS table of qualitative measures of vulnerability and consequences in Appendix C, we consider the consequences of such an event to be "Medium", i.e Theoretically, there is the possibility of a fatality in the dwelling and/or the imposition of moderate damage to some of the structure in the rare even of this occurring.

5.4.2 Small-Scale Slumps in the Soil Profile

The consequence to the buildings of a small-scale slump occurring in the soil after the new footings have been founded in bedrock is believed to be "Minor". However, the slope uphill or downhill might be affected, and some material may slough onto the dwelling or downslope dwelling. The chance or temporal probability of persons being in the area during an earth slump is low, and therefore the risk of loss of life is low. The consequences for both property and persons is therefore rated as "Minor".

5.4.3 Failure of a Retaining Wall

If a retaining wall failed, damage may well result to the dwelling, depending on many factors. In general, the consequences can be rated as "Minor to Medium". The chance of persons being injured or of loss of life is low and the consequences to persons are therefore also rated as "Minor to Medium".

5.4.4 Surface Erosion

If such an event develops and occurs, small cobbles may wash out of erosion gully slides and rolled downhill. The consequential damage to a structure would be "Insignificant".

5.4.5 Large Rockfall from Upslope

The top of a small hill is approximately 300m east of the proposed Work Shop, with tree-dense bushland within the immediate vicinity of the proposed structure. Therefore, any large rockfalls that do occur will have slowed in velocity and magnitude by the time it reaches the property. Also, given that the site bedrock is highly fractured, the presence of large boulders is minor. Therefore, the consequences to people and property are considered as "Minor" to "Insignificant".

5.5 Risk Estimation

A summary of estimated risk to property and life for each of the potential hazards identified in the previous sections is provided in Table 1a. This risk assessment in Table 1a is based on the present conditions, prior to any mitigation measures being implemented. The resulting risk level was derived using the AGS risk analysis matrix presented in Appendix C.

TABLE 1a
Risk Analysis Summary – Prior to Any Mitigation Measures Being Implemented

Potential Hazard	Assessed Likelihood	Assessed Consequences	Risk Level
Large-Scale Translational Slide	Unlikely	To Dwelling - Medium	Low
		To People in/adjacent to dwelling - Medium	Low
Small-Scale Slumps in Soil	Possible	To Dwelling - Minor	Medium
		To People in/adjacent to dwelling - Minor	Medium
Failure of Retaining Wall	Rare	To Dwelling – Minor to Medium	Low
		To People in/adjacent to dwelling - Minor	Very Low
Surface Erosion	Possible	To Dwelling - Insignificant	Very Low
		To People in/adjacent to dwelling - Insignificant	Very Low
Rockfalls	Unlikely	Minor/Insignificant	Low to Very Low

5.6 Risk Treatment

To maintain and/or reduce the risk level of slope stability during the construction of the dwelling and associated structures and subsequent occupation, the following measures are recommended to be implemented:

- Ensure footings are founded into weathered bedrock.
- All retaining walls should be properly designed and constructed, and positively drained.
- Maintain adequate drainage of the site and ensure drains are free-flowing.
- Where possible, maintain the existing vegetation cover or provide erosion protection.
- Periodic inspection of the slope uphill for signs of erosion developing, and remediate as necessary.

Some useful guidelines on hillside construction, prepared by the Australian Geomechanics Society (Reference 3), are presented in Appendix E.

A summary of estimated risk to property and life for each of the potential hazards identified in the previous sections is provided in Table 1b. This risk assessment in Table 1b is based on the proposed future conditions, assuming that all recommended mitigation measures are implemented. For this risk assessment to be valid, a suitably qualified geotechnical engineer must sign Form 2 and Form 3 as the mechanism to check that these mitigation measures have been correctly incorporated into the design and constructed correctly. The resulting risk level was derived using the AGS risk analysis matrix presented in Appendix C.

TABLE 1b
Risk Analysis Summary – After Recommended Mitigation Measures Are Implemented

Potential Hazard	Assessed Likelihood	Assessed Consequences	Risk Level
Large-Scale Translational Slide	Unlikely	To Dwelling - Medium	Low
		To People in/adjacent to dwelling - Minor	Low
Small-Scale Slumps in Soil	Rare	To Dwelling - Minor	Very Low
		To People in/adjacent to dwelling - Insignificant	Low
Failure of Retaining Wall	Rare	To Dwelling – Minor to Medium	Low
		To People in/adjacent to dwelling - Minor	Very Low
Surface Erosion	Rare	To Dwelling - Insignificant	Very Low
		To People in/adjacent to dwelling - Insignificant	Low
Rockfalls	Unlikely	Minor/Insignificant	Very Low to Low

Note: This risk assessment in Table 1b is based on the assumed future conditions, assuming that all recommended mitigation measures are implemented. For this risk assessment to be valid, a suitably qualified geotechnical engineer must sign Form 2 and Form 3 as the mechanism to check that these mitigation measures have been correctly incorporated into the design and constructed correctly.

5.7 Significance of Risks (Risk Evaluation)

Risk evaluation is the process by which owners, administrators and relevant regulatory authorities can decide whether the potential risks (See Table 1a and Table 1b) are acceptable, and/or whether these can be feasibly eliminated or reduced by remedial treatment. Implications of each level of risk are described in Appendix C.

In the present conditions, the overall risk to property and people is assessed to be "Very Low" to "Medium" (See Table 1a). Provided design and construction of the units is undertaken in accordance with accepted procedures for hillside construction, and treatments and mitigation measures are carried out to reduce the potential hazards (as recommended in Section 5.6 and Section 6), the risk is assessed to be "Very Low" to "Low" (See Table 1b).

5.8 Suitability of the Proposed Development

Provided that the design and construction of the structures is undertaken in accordance with accepted procedures for hillside construction, and treatments and mitigation measures are carried out to reduce the potential hazards (as recommended in Section 5.6 and Section 6), the risk is assessed to be "Very Low" to "Low" (See Table 1b). Therefore, it is assessed that the site is suitable for the proposed snow resort redevelopment (provided all the recommendations in our report are followed).

6 DISCUSSION & RECOMMENDATIONS

Geotechnical recommendations for design and construction of the proposed development are provided in the following sections. After the structural and civil design is complete, a suitably qualified geotechnical engineer must review the design and sign Form 2 as the mechanism to check that these design recommendations and slope stability mitigation measures have been correctly incorporated into the design.

6.1 Site Classification

The upper (low plasticity) soil is moderately reactive in terms of potential shrink-swell movements that may occur due to seasonal ground moisture changes. The characteristic ground surface movement "ys", as defined by AS2870 for the range of extreme dry to extreme wet ground moisture conditions is estimated to be less than 20mm. The site is therefore a Class "S" (slightly reactive).

Deemed-to-comply footing designs provided by AS2870 are applicable specifically to residential-style one and two-storey structures, or buildings with similar loads and superstructure stiffness.

6.2 Building Footings & Ground Slabs

It is understood that the proposed structures will be founded close to existing grade or on shallow cut-to-fill platforms. Therefore, suitable footings for the structure at floor level include pads/strips founding in the weathered slate bedrock or newly placed controlled fill (Section 5.4). It is strongly recommended that all footings are founded in the bedrock, which may require piers in sections where fill is placed. All footings should be taken below any topsoil, uncontrolled fill, and/or disturbed ground.

If designing footings based on engineering principles, recommended allowable end-bearing pressures for various footing systems and likely foundation materials are provided in Table 2, below.

TABLE 2

Recommended Allowable End-Bearing Pressures for Footings

Foundation Material Type	Depth Below Existing Surface	Allowable End-Bearing Pressure	
		Strips	Pads/Piers
Newly Constructed Controlled Fill	-	100kPa	125kPa
Weathered Slate Bedrock	0.1m/0.5m	1500kPa	2000kPa

All footings should be inspected and approved by an experienced geotechnical engineer to confirm the foundation material and design values, and to ensure the excavations are clean and stable.

Groundslabs can be constructed on the weathered bedrock or newly placed controlled fill, following the removal of any topsoil or uncontrolled fill material. Following excavation to required level, slab areas on soil should be proof-rolled by a pad foot roller to check for any weak, wet or deforming soils that may require replacement. Suitable replacement fill should be compacted in not thicker than 150mm layers to not less than 98%StdMDD at about OMC.

If required for design of ground slabs, a modulus of subgrade reaction of 50kPa/mm can be assumed for a controlled fill foundation, and 100kPa/mm for a cut bedrock foundation.

6.3 Excavation Conditions & Use of Excavated Material

Proposed excavation depths have not been indicated but excavations to ~1.5m depth would be through topsoil/uncontrolled fill, and into medium strong slate bedrock. The soils and weak/fractured rock are readily diggable by backhoe and medium sized excavator to ~0.5m/1m depth. Less fractured, medium strong bedrock below ~0.5m/1m depth would require ripping, and possibly rock hammering.

The weathered slate bedrock is suitable for use in controlled fill construction, although rock particles should be broken down to <75mm size. The existing uncontrolled fill can be re-used as controlled fill provided that it is free of contaminants. The silty topsoil should not be used in controlled fill construction, but could be used in non-structural applications such as landscaping.

If imported fill is required, a suitable select fill material would include a low or medium plasticity soil such as clayey sand or gravelly clayey sand, containing between 25% and 50% fines less than 0.075mm size (silt and clay), and no particles greater than 75mm size.

6.4 Controlled Fill Construction

For construction of any new fill foundation platforms and road subgrades, it is recommended that:

- Areas be fully stripped of all silty topsoil and any uncontrolled fill. A stripping depth of 0.1m/0.5m depth may be required. Stripped foundations should be proof-rolled by a vibratory pad-foot roller of not less than 9 tonne static mass to check for any weak or wet areas that would require replacement. No fill should be placed until a geotechnical engineer has confirmed the suitability of the foundation.

- Controlled fill comprising suitable site excavated or imported materials of not greater than 75mm maximum particle size (Section 5.3), be compacted in not greater than 150mm layers to not less than 98%StdMDD at about OMC.

- Fill placement and control testing be overviewed and certified by a geotechnical engineer at Level 1 or 2 involvement of AS3798 – 1996 "Guidelines on Earthworks for Commercial & Residential Developments" (Reference 3).

6.5 Pavement Subgrades

Pavement subgrades must be prepared in accordance with the advice in Section 6.4. Pavement subgrades are expected to comprise newly placed controlled fill or cut, in-situ slate bedrock. Controlled fill subgrades would have a design CBR value of 5%, whicl cut bedrock subgrades would have a CBR value of 10%. All subgrades must be inspected by a geotechnical engineer to assess suitability and to confirm or vary design CBR values.

6.6 Stable Cut/Fill Batter Slopes

Temporary site excavations to 1.5m depth can be formed at 0.25(H):1(V), although loose topsoil should be cut back at 1(H):1(V). If required and space allows, deeper temporary cuts can be formed at 1(H):1(V) or benched at 1.5m intervals in soils and at 0.5(H):1(V) in HW and less weathered bedrock. A geotechnical engineer should inspect all cut batters during construction to confirm stability. Exposed temporary batters should be protected from the weather by black plastic pinned to the face with link-wire mesh, or similar.

Permanent cut and fill soil batters should be formed at no steeper than 2(H): 1(V). All soil cut and fill surfaces should be protected against erosion by topsoiling and grassing, or other suitable means. Steeper permanent cuts should be supported by structural retaining walls. It is advisable that permanent batters are inspected during excavation by an experienced geotechnical engineer to confirm stability. To reduce the risk of future slope instability, all surface slopes around the development must be maintained to prevent erosion, and regular maintenance and inspections will be required to ensure on-going stability.

6.7 Low Retaining Walls

Retaining walls constructed in open excavation, with the gap between the excavation face and the wall backfilled later, can be designed for an earth pressure distribution given by:

$$\sigma_h = (K\gamma' h) + Kq$$

where,

σ_h is the horizontal earth pressure acting on the back of the wall, in kPa

K is the dimensionless coefficient of earth pressure; this can be assumed to be 0.4 when the top of the wall is unrestrained horizontally, and 0.6 when the top of the wall is restrained (i.e. by building slabs etc.)

γ' is the effective unit weight of the backfill, and can be assumed to be 20kN/m^3 for a lightly compacted soil backfill

h is the height of the backfill, in metres

q is any uniform distributed vertical surcharge acting on the top of the backfill, in kPa

Apart from structural restraints such as floor slabs, resistance to overturning and sliding of retaining walls is provided by frictional and adhesive resistance on the base, and by passive resistance at the toe of the wall. For a weathered bedrock foundation an ultimate base friction factor (tanδ) of 0.55, base adhesion (c) of 100kPa, and an allowable passive earth pressure coefficient Kp=3.5 can be used for calculation of sliding resistance.

Free-draining granular backfill or synthetic fabric drains should be installed behind all walls. These should connect to weep holes and/or a collector drain, and ultimately to the stormwater system. Granular backfill should be wrapped in a suitable filter fabric to minimise infiltration of silt/clay fines.

6.8 Earthquake Site Factor

Table 2.3 of AS1170.4 "Minimum Design Loads on Structures - Part 4: Earthquake Loads" (Reference 5) lists the earthquake acceleration coefficients for major centres to be considered in structural design. The Cabramurra area has an acceleration coefficient of 0.08.

Section 4 of AS1170.4 summarises the Site Subsoil Class which depends on the subsurface conditions at the site in question. A Site Subsoil Class C_e is applicable for this development.

6.9 Drainage

Suitable surface drainage should be provided to ensure rainfall run-off or other surface water cannot pond against buildings or pavements. Suitable drainage must be provided behind retaining walls.

It may be advisable to install a subsoil drain along the upslope sides of structures to intercept any subsoil seepages. The drain should extend to at least 0.5m depth and should be directed past the building and into the stormwater system. If overland flow is an issue, a swale or bund drain could be constructed upslope to divert water away from the house.

6.10 Hold Points for Geotechnical Inspections

During construction, a suitably qualified geotechnical engineer must inspect certain structural and civil elements, and sign Form 3 as the mechanism to check that these design recommendations and slope stability mitigation measures have been correctly constructed. The following is a list of hold points that require geotechnical inspection and sign off:

1) A review of all structural and civil design drawings prior to the start of construction to check that our geotechnical design recommendations and slope stability mitigation measures have been interpreted correctly and incorporated into the design correctly. This will require a suitably qualified geotechnical engineer to sign Form 2.

2) Inspect all footing excavations (footings for all structural elements, including column and wall footings, retaining wall footings, lift pits, stair wells, etc.) to check the foundation material is suitable and has the required bearing capacity, and to ensure that all loose material is removed from the base prior to pouring concrete. This will require a suitably qualified geotechnical engineer to sign Form 3.

3) Inspect all temporary and permanent cut and fill batters to check stability and advise on remediation/treatment measures.

4) Inspection and certification of all controlled fill construction (where it is specified to be controlled fill in accordance with AS3798).

5) Inspect all surface and subsurface drainage measures to check that they are adequate, and to advise for additional measures if required.

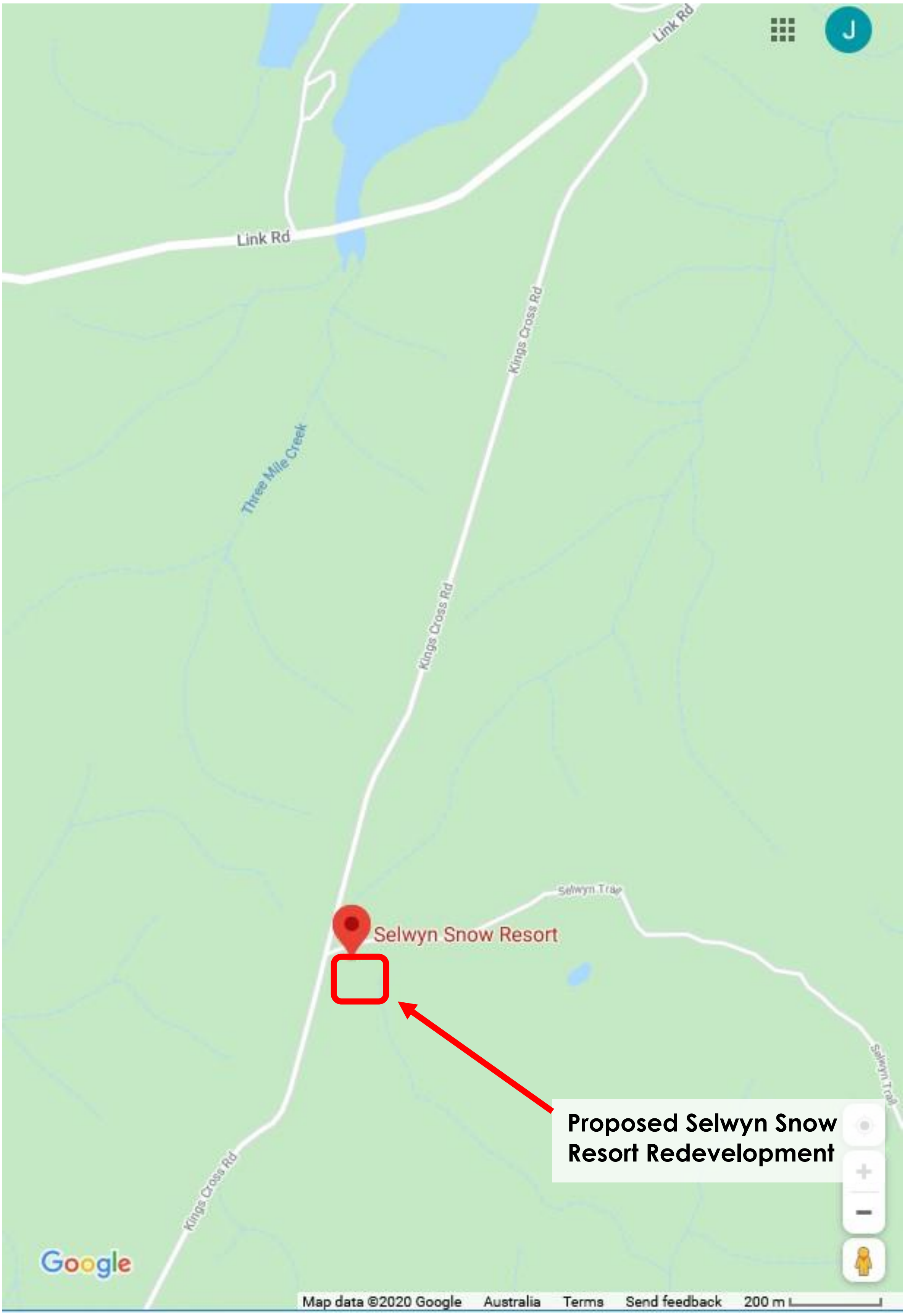
ACT Geotechnical Engineers Pty Ltd

REFERENCES

1 Bureau of Mineral Resources, Commonwealth of Australia, "Wollongong 1:250 000 Engineering Geology Series", 1985.

2 Standards Australia, "AS2870 - 1996 - Residential Slabs & Footings - Construction".

3 Standards Australia, "AS1170.4 - 1993 - Minimum Design Loads on Structures - Part 4: Earthquake Loads".



TSA MANAGEMENT
SELWYN SNOW RESORT REDEVELOPMENT
SITE LOCALITY

ACT Geotechnical Engineers Pty Ltd	**C10872**	**FIGURE 1**

TSA MANAGEMENT
SELWYN SNOW RESORT REDEVELOPMENT
AERIAL PHOTOGRAPH

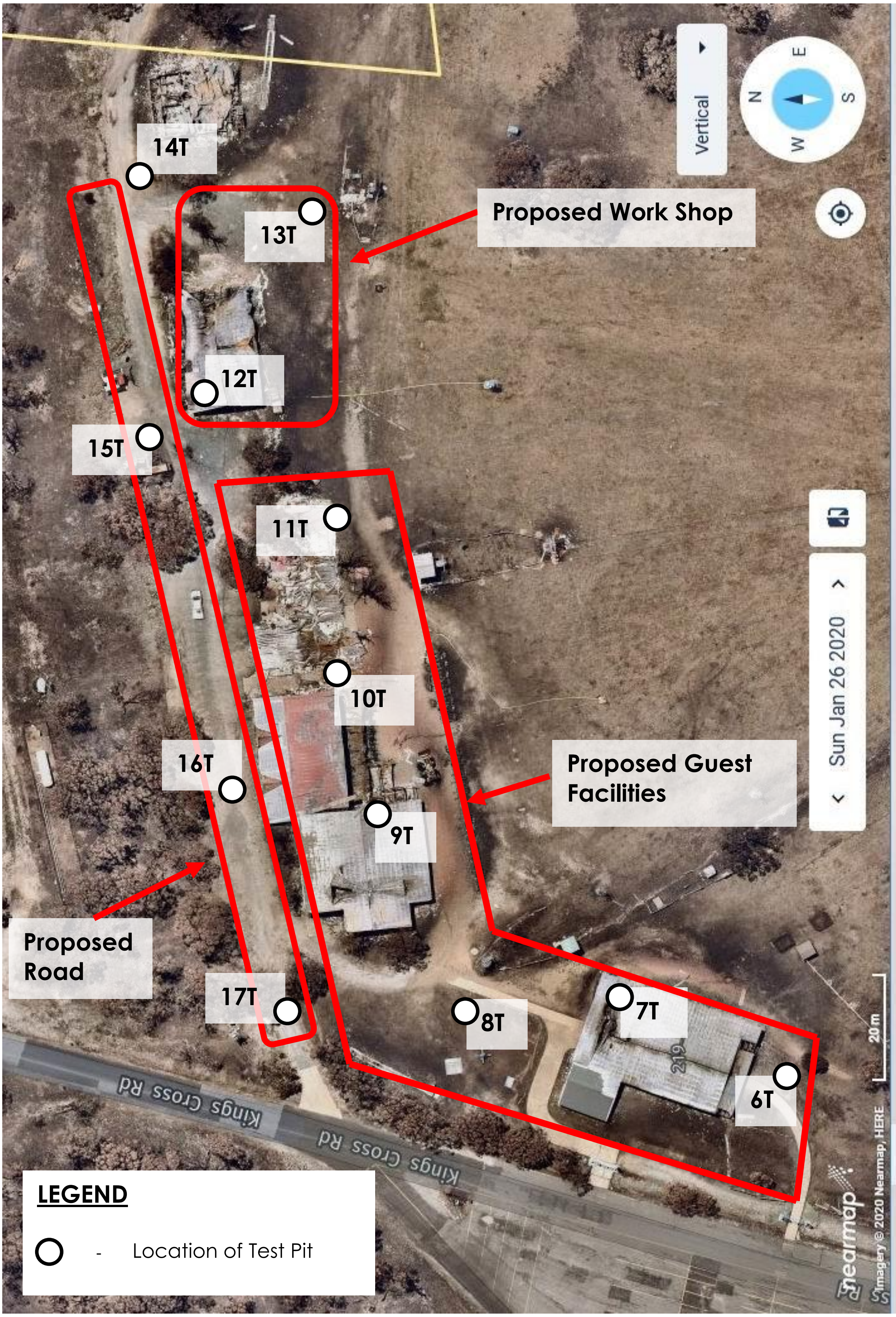
ACT Geotechnical Engineers Pty Ltd	C10872	FIGURE 2

LEGEND

○ - Location of Test Pit

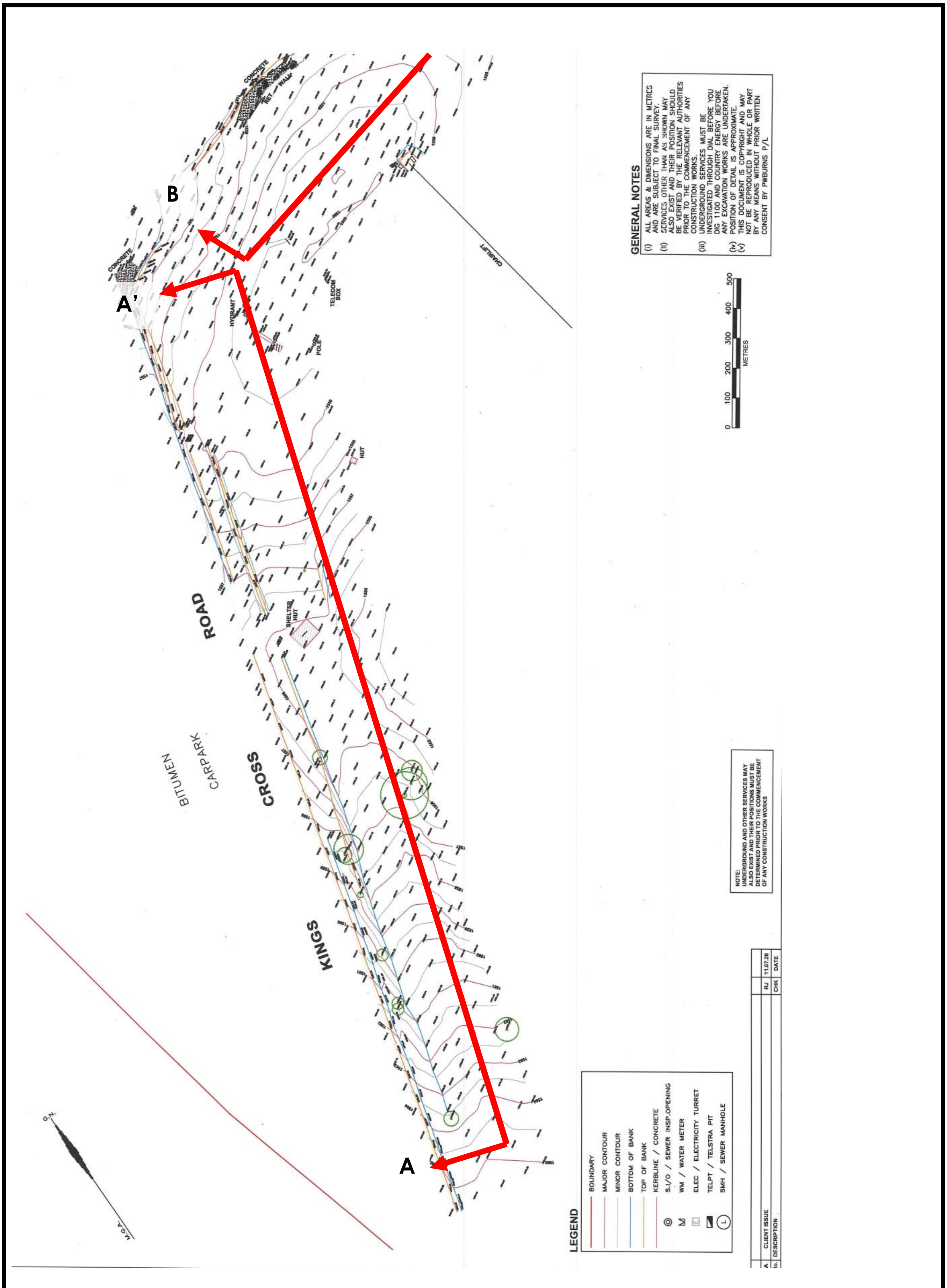
TSA MANAGEMENT
SELWYN SNOW RESORT REDEVELOPMENT
AERIAL PHOTO & LOCATION OF BOREHOLES – STAFF ACCOMM.

ACT Geotechnical Engineers Pty Ltd	C10872	FIGURE 3



TSA MANAGEMENT
SELWYN SNOW RESORT REDEVELOPMENT
LOCATION OF BOREHOLES – ROAD, WORK SHOP & GUEST FACILITIES

ACT Geotechnical Engineers Pty Ltd	C10872	FIGURE 4

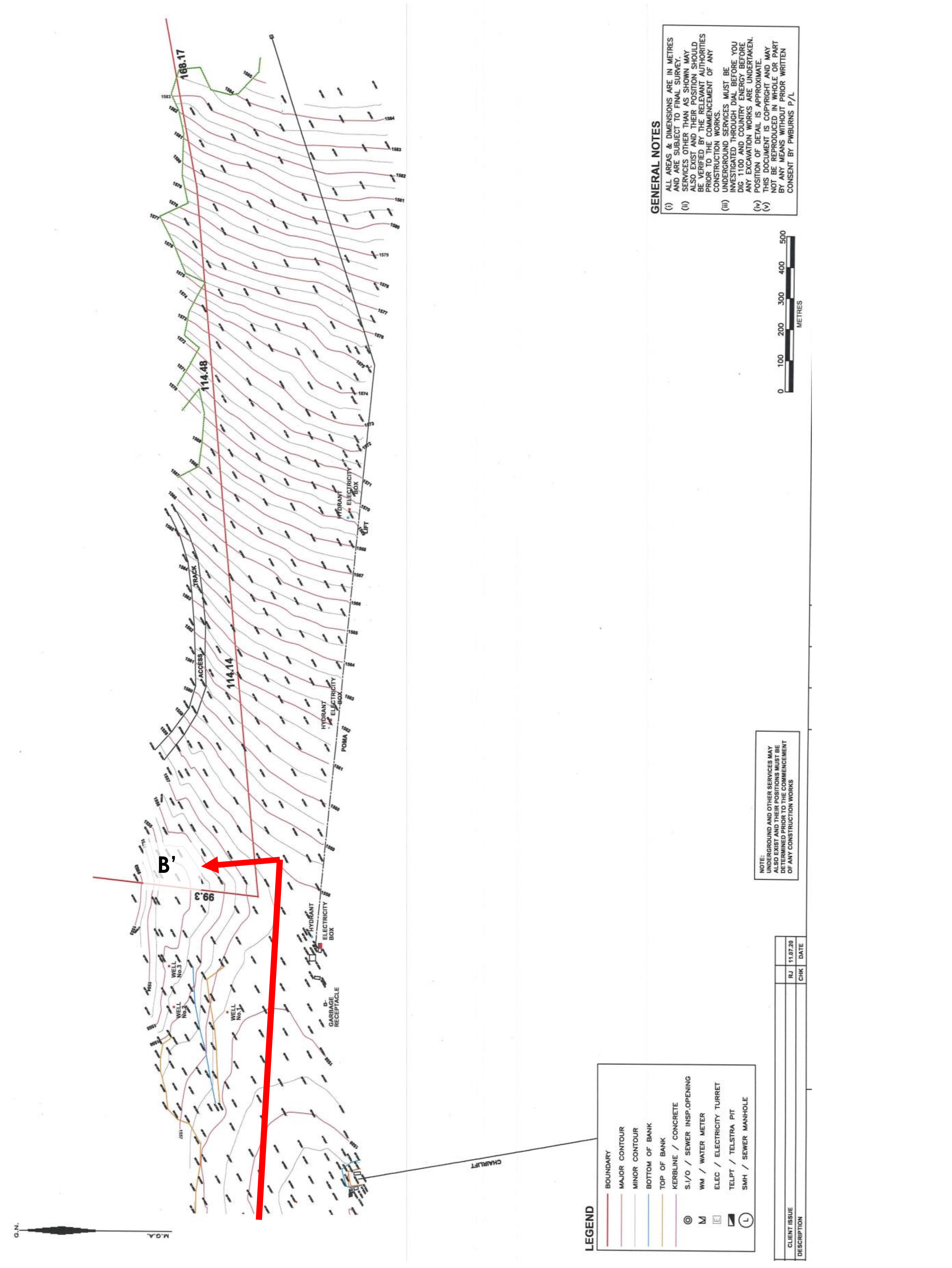


TSA MANAGEMENT

SELWYN SNOW RESORT REDEVELOPMENT

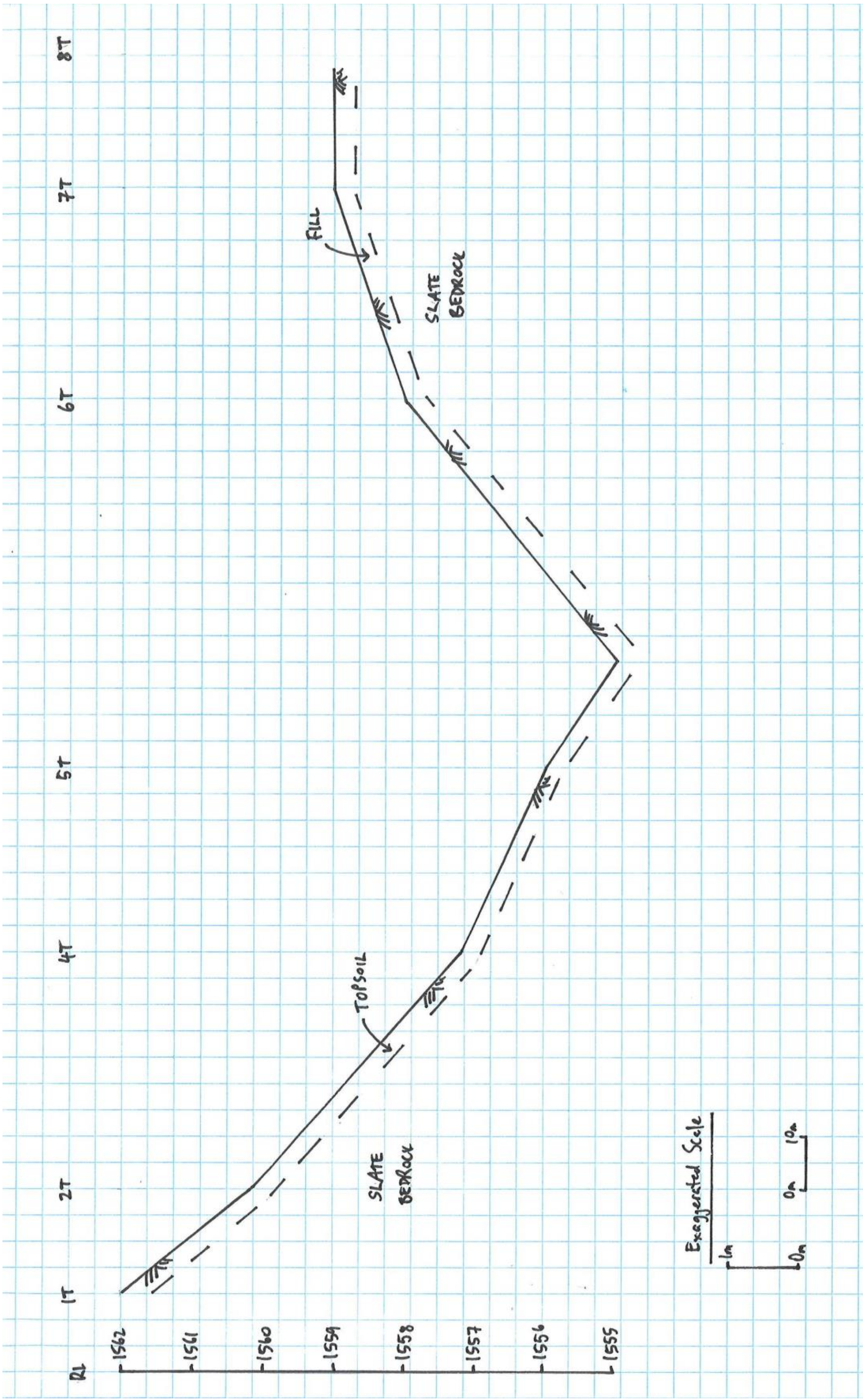
SURVEY PLAN – STAFF ACCOMMODATION & GUEST FACILITIES

ACT Geotechnical Engineers Pty Ltd	C10872	FIGURE 5A



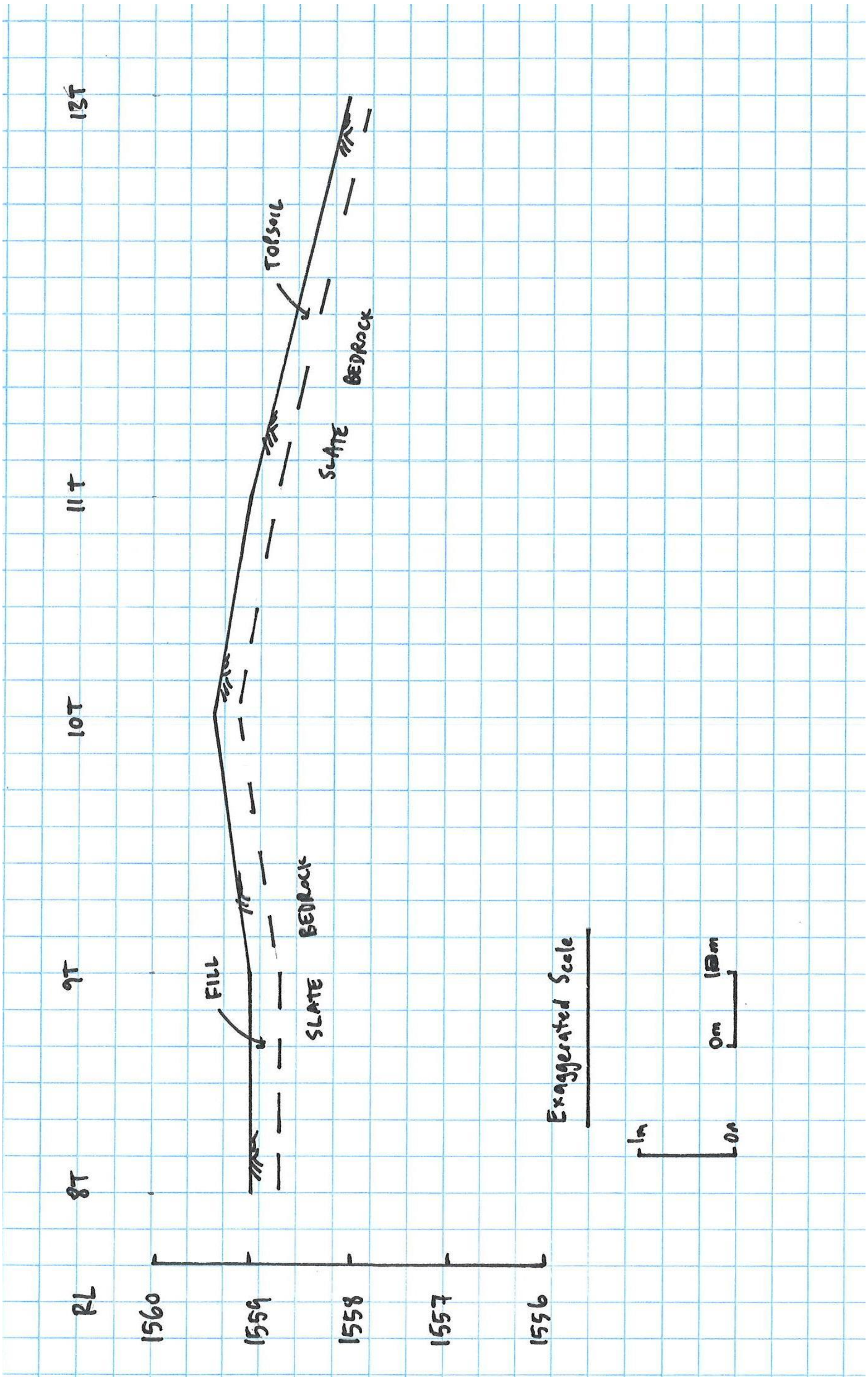
TSA MANAGEMENT
SELWYN SNOW RESORT REDEVELOPMENT
SURVEY PLAN – ACCESS ROAD & WORK SHOP

ACT Geotechnical Engineers Pty Ltd	C10872	FIGURE 5B



TSA MANAGEMENT
SELWYN SNOW RESORT REDEVELOPMENT
GEOTECHNICAL MODEL – SUBSURFACE SECTION A-A'

ACT Geotechnical Engineers Pty Ltd	C10872	FIGURE 6



TSA MANAGEMENT
SELWYN SNOW RESORT REDEVELOPMENT
GEOTECHNICAL MODEL – SUBSURFACE SECTION B-B’

ACT Geotechnical Engineers Pty Ltd	**C10872**	**FIGURE 7**

Photo 1 – 10/7/2020 – View of the proposed Staff Accommodation site, looking south from the northern end

TSA MANAGEMENT
SELWYN SNOW RESORT REDEVELOPMENT
SITE PHOTO

ACT Geotechnical Engineers Pty Ltd	**C10872**	**FIGURE 8**

Photo 2 – 10/7/2020 – View of the proposed Guest Facilities site, looking SW from the eastern end

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SELWYN SNOW RESORT REDEVELOPMENT
SITE PHOTO

ACT Geotechnical Engineers Pty Ltd	**C10872**	**FIGURE 9**

Photo 3 – 10/7/2020 – View of the proposed Guest Facilities site, looking NW from the eastern end

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SELWYN SNOW RESORT REDEVELOPMENT
SITE PHOTO

ACT Geotechnical Engineers Pty Ltd	C10872	FIGURE 10

Photo 4 – 10/7/2020 – View of the proposed Work Shop site, looking east from the western end.

TSA MANAGEMENT
SELWYN SNOW RESORT REDEVELOPMENT
SITE PHOTO

ACT Geotechnical Engineers Pty Ltd	**C10872**	**FIGURE 11**

Photo 5 – 10/7/2020 – View of the proposed Access Road site, looking east from the western end

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SELWYN SNOW RESORT REDEVELOPMENT
SITE PHOTO

ACT Geotechnical Engineers Pty Ltd	C10872	FIGURE 12

Photo 6 – 10/7/2020 – View of an existing cutting on the corner of Kings Cross Road and Selwyn Trail (near NW corner of the proposed Guest Facilities building), showing slate bedrock at shallow depth.

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SELWYN SNOW RESORT REDEVELOPMENT
SITE PHOTO

ACT Geotechnical Engineers Pty Ltd	**C10872**	**FIGURE 13**

Photo 7 – 10/7/2020 – View of test pit 3T being excavated.

TSA MANAGEMENT SELWYN SNOW RESORT REDEVELOPMENT SITE PHOTO		
ACT Geotechnical Engineers Pty Ltd	**C10872**	**FIGURE 14**

Photo 8 – 10/7/2020 – View of the subsurface profile of test pit 1T, showing topsoil, directly underlain by medium strong slate bedrock.

TSA MANAGEMENT
SELWYN SNOW RESORT REDEVELOPMENT
SITE PHOTO

ACT Geotechnical Engineers Pty Ltd	**C10872**	**FIGURE 15**

Photo 9 – 10/7/2020 – View of the subsurface profile of test pit 2T, showing shallow topsoil, directly underlain by medium strong slate bedrock.

TSA MANAGEMENT
SELWYN SNOW RESORT REDEVELOPMENT
SITE PHOTO

ACT Geotechnical Engineers Pty Ltd	C10872	FIGURE 16

Photo 10 – 10/7/2020 – View of the subsurface profile of test pit 3T, showing topsoil, directly underlain by medium strong slate bedrock.

TSA MANAGEMENT
SELWYN SNOW RESORT REDEVELOPMENT
SITE PHOTO

ACT Geotechnical Engineers Pty Ltd	C10872	FIGURE 17

APPENDIX A

Test Pit Logs 1T to 17T

Borehole Log

Borehole No.	1T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Samples		Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
			0.3		SC-SM	Clayey Silty SAND; fine to medium grained sand, low plasticity fines, black, with grass roots, with trace angular gravel up to 60mm, moist.	LOOSE		TOPSOIL
			0.5			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
			1.0 1.2			BOREHOLE TERMINATED AT 0.5m refusal in Moderately Weathered (MW) Slate			

Logged By : JM | Date : 10/7/20 | Checked By : | Date :

Borehole Log

Borehole No.	2T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
		0.1		SC-SM	Clayey Silty SAND; fine to medium grained sand, low plasticity fines, black, with grass roots, with trace angular gravel up to 60mm, moist.	LOOSE		TOPSOIL
		0.4			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
		1.0 1.2			BOREHOLE TERMINATED AT 0.4m refusal in Moderately Weathered (MW) Slate			

Logged By : JM	Date : 10/7/20	Checked By :	Date :

Borehole Log

Borehole No.	3T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Location : SEE REPORT

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
		0.3		SC-SM	Clayey Silty SAND; fine to medium grained sand, low plasticity fines, black, with grass roots, with trace angular gravel up to 60mm, moist.	LOOSE		TOPSOIL
		0.5			Extremely Weathered (EW) SLATE; yellow-brown, moist.			BEDROCK
		0.7			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			
		1.0			BOREHOLE TERMINATED AT 0.7m refusal in Moderately Weathered (MW) Slate			
		1.2						

Logged By : JM   Date : 10/7/20   Checked By :   Date :

Borehole Log

Borehole No.	4T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
		0.1		SC-SM	Clayey Silty SAND; fine to medium grained sand, low plasticity fines, black, with grass roots, with trace angular gravel up to 60mm, moist.	LOOSE		TOPSOIL
		0.4			Extremely Weathered (EW) SLATE; red-brown, moist.			BEDROCK
		1.0			Highly Weathered (HW) SLATE; fine grained, red-brown, yellow-brown, foliated (thinly-bedded) in N-S direction, dry.			
		1.2			BOREHOLE TERMINATED AT 1m refusal in Moderately Weathered (MW) Slate			

Logged By : JM Date : 10/7/20 Checked By : Date :

Borehole Log

Borehole No.	5T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT SELWYN SNOW RESORT REDEVELOPMENT KINGS CROSS ROAD, CABRAMURRA, NSW

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Samples		Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
			0.1		SC-SM	Clayey Silty SAND; fine to medium grained sand, low plasticity fines, black, with grass roots, with trace angular gravel up to 60mm, moist.	LOOSE		TOPSOIL
			0.3			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
			1.0 1.2			BOREHOLE TERMINATED AT 0.3m refusal in Moderately Weathered (MW) Slate			

Logged By : JM Date : 10/7/20 Checked By : Date :

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Borehole Log

Borehole No.	6T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
		0.0–0.2		GP	Clayey Sandy Gravel; angular slate gravel up to 60mm, fine to medium grained sand, low plasticity clay, dark grey-brown, moist.	LOOSE		FILL
		0.2–0.3			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
		0.3			BOREHOLE TERMINATED AT 0.3m refusal in Moderately Weathered (MW) Slate			
		1.0						
		1.2						

Logged By : JM Date : 10/7/20 Checked By : Date :

Borehole Log

Borehole No.	**7T**
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
		0.0 – 0.3		GP	Clayey Sandy Gravel; angular slate gravel up to 60mm, fine to medium grained sand, low plasticity clay, dark grey-brown, moist.	LOOSE		FILL
		0.3 – 0.5			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
		0.5			BOREHOLE TERMINATED AT 0.5m refusal in Moderately Weathered (MW) Slate			
		1.0						
		1.2						

Logged By : JM   Date : 10/7/20   Checked By :   Date :

BOREHOLE/EXCAVATION LOG C10872.GPJ ACT GEO.GDT 21/7/20

Borehole Log

Borehole No.	8T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Samples		Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
			0.3		GP	Clayey Sandy Gravel; angular slate gravel up to 60mm, fine to medium grained sand, low plasticity clay, dark grey-brown, moist.	LOOSE		FILL
			0.6			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
			1.0 1.2			BOREHOLE TERMINATED AT 0.6m refusal in Moderately Weathered (MW) Slate			

BOREHOLE/EXCAVATION LOG C10872.GPJ ACT GEO.GDT 21/7/20

Logged By : JM | Date : 10/7/20 | Checked By : | Date :

Borehole Log

Borehole No.	9T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
		0.3		GP	Clayey Sandy Gravel; angular slate gravel up to 60mm, fine to medium grained sand, low plasticity clay, dark grey-brown, moist.	LOOSE		FILL
		0.5			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
		1.0 1.2			BOREHOLE TERMINATED AT 0.5m refusal in Moderately Weathered (MW) Slate			

Logged By : JM	Date : 10/7/20	Checked By :	Date :

Borehole Log

Borehole No.	10T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Location : SEE REPORT

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
		0.3		GP	Clayey Sandy Gravel; angular slate gravel up to 60mm, fine to medium grained sand, low plasticity clay, dark grey-brown, moist.	LOOSE		FILL
		0.7			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
		1.0 1.2			BOREHOLE TERMINATED AT 0.7m refusal in Moderately Weathered (MW) Slate			

Logged By : JM   Date : 10/7/20   Checked By :   Date :

Borehole Log

Borehole No.	11T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Samples		Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
			0.1		SC-SM	Clayey Silty SAND; fine to medium grained sand, low plasticity fines, black, with grass roots, with trace angular gravel up to 60mm, moist.	LOOSE		TOPSOIL
			0.6			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
			1.0 1.2			BOREHOLE TERMINATED AT 0.6m refusal in Moderately Weathered (MW) Slate			

Logged By : JM	Date : 10/7/20	Checked By :	Date :

BOREHOLE/EXCAVATION LOG C10872.GPJ ACT GEO.GDT 21/7/20

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Borehole Log

Borehole No.	12T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Samples		Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
			0.3		SC-SM	Clayey Silty SAND; fine to medium grained sand, low plasticity fines, black, with grass roots, with trace angular gravel up to 60mm, moist.	LOOSE		TOPSOIL
			0.6			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
			1.0 1.2			BOREHOLE TERMINATED AT 0.6m refusal in Moderately Weathered (MW) Slate			

Logged By : JM Date : 10/7/20 Checked By : Date :

BOREHOLE/EXCAVATION LOG C10872.GPJ ACT GEO.GDT 21/7/20

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Borehole Log

Borehole No.	13T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Samples		Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
			0.2		SC-SM	Clayey Silty SAND; fine to medium grained sand, low plasticity fines, black, with grass roots, with trace angular gravel up to 60mm, moist.	LOOSE		TOPSOIL
			0.4			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
			1.0 1.2			BOREHOLE TERMINATED AT 0.4m refusal in Moderately Weathered (MW) Slate			

Logged By : JM Date : 10/7/20 Checked By : Date :

BOREHOLE/EXCAVATION LOG C10872.GPJ ACT GEO.GDT 21/7/20

Borehole Log

Borehole No.	14T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT KINGS CROSS ROAD, CABRAMURRA, NSW

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
		0.0–0.3		GP	Clayey Sandy Gravel; angular slate gravel up to 60mm, fine to medium grained sand, low plasticity clay, cobbles up to 200mm, dark grey-brown, moist.	LOOSE		FILL
		0.3–0.5			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
		0.5			BOREHOLE TERMINATED AT 0.5m refusal in Moderately Weathered (MW) Slate			
		1.0						
		1.2						

Logged By : JM   Date : 10/7/20   Checked By :   Date :

BOREHOLE/EXCAVATION LOG C10872.GPJ ACT GEO.GDT 21/7/20

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Borehole Log

Borehole No.	15T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
		0.0–0.4		GP	Clayey Sandy Gravel; angular slate gravel up to 60mm, fine to medium grained sand, low plasticity clay, dark grey-brown, moist.	LOOSE		FILL
		0.4–0.8			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
		0.8			BOREHOLE TERMINATED AT 0.8m refusal in Moderately Weathered (MW) Slate			

Depth scale: 0.4, 0.8, 1.0, 1.2

Logged By : JM	Date : 10/7/20	Checked By :	Date :

BOREHOLE/EXCAVATION LOG C10872.GPJ ACT GEO.GDT 21/7/20

Borehole Log

Borehole No.	16T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
		0.0–0.5		GP	Clayey Sandy Gravel; angular slate gravel up to 60mm, fine to medium grained sand, low plasticity clay, dark grey-brown, moist.	LOOSE		FILL
		0.5–0.9			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
		0.9			BOREHOLE TERMINATED AT 0.9m refusal in Moderately Weathered (MW) Slate			
		1.0						
		1.2						

Logged By : JM Date : 10/7/20 Checked By : Date :

BOREHOLE/EXCAVATION LOG C10872.GPJ ACT GEO.GDT 21/7/20

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Borehole Log

Borehole No.	17T
Sheet	1 of 1
Job No.	C10872

CLIENT: TSA MANAGEMENT

PROJECT: SELWYN SNOW RESORT REDEVELOPMENT
KINGS CROSS ROAD, CABRAMURRA, NSW

Location : SEE REPORT

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : 4T EXCAVATOR
Hole Diameter : 0.5m x 2m

Samples		Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
			0.05		GP	Clayey Sandy Gravel; angular slate gravel up to 60mm, fine to medium grained sand, low plasticity clay, dark grey-brown, moist.	LOOSE		FILL
			0.3			Moderately Weathered (MW) SLATE; fine grained, grey, yellow-grey, foliated (thinly-bedded) in N-S direction, dry.			BEDROCK
			1.0			BOREHOLE TERMINATED AT 0.3m refusal in Moderately Weathered (MW) Slate			
			1.2						

Logged By : JM Date : 10/7/20 Checked By : Date :

BOREHOLE/EXCAVATION LOG C10872.GPJ ACT GEO.GDT 21/7/20

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APPENDIX B

Definitions of Geotechnical Engineering Terms

DESCRIPTION AND CLASSIFICATION OF SOILS

The methods of description and classification of soils used in this report are based on the Australian Standard 1726 – 1993, Geotechnical site investigations. In general, descriptions cover the following properties – soil type, colour, secondary grain size, structure, inclusions, strength or density and geological description.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (e.g. sandy clay) on the following basis:

Classification	Particle Size
Clay	Less than 0.002mm
Silt	0.002mm to 0.06mm
Sand	0.06mm to 2.00mm
Gravel	2.00mm to 60.00mm
Cobbles	60mm (63mm) to 200mm
Boulders	>200mm

Soils are also classified according to the Unified Soil Classifications System which is included in this Appendix. Rock types are classified by their geological names.

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

Consistency	Shear Strength su(kPa) (Representative Undrained Shear)	
Very soft	< 12	<2 (~SPT "N")
Soft	12 - 25	2-4
Firm	25 - 50	4-8
Stiff	50 – 100	8-15
Very Stiff	100 – 200	15-30
Hard	> 200	>30

Non-cohesive soils are classified on the basis of relative density, generally from the results of in-situ standard penetration tests as below:

Term	Relative Density (%)	SPT Blows/300mm 'N'
Very loose	< 15	<4
Loose	15-35	4-10
Medium dense	35-65	10-30
Dense	65-85	30-50
Very Dense	>85	>50

SAMPLING

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

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

Undisturbed samples are generally taken by one of two methods:

1. Driving or pushing a thin walled sample tube into the soil and withdrawing with a sample of soil in a relatively undisturbed state.

2. Core drilling using a retractable inner tube (R.I.T.) core barrel.

Such samples yield information on structure and strength in additions to that obtained from disturbed samples and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

PENETRATION TESTING

The relative density of non-cohesive soils is generally assessed by in-situ penetration tests, the most common of which is the standard penetration test. The test procedure is described in Australian Standard 1289 “Testing Soils for Engineering Purposes” Testing Soils for Engineering Purposes” – Test No. F3.1.

The standard penetration test is carried out by driving a 50mm diameter split tube penetrometer of standard dimensions under the impact of a 63 kg hammer having a free fall of 750mm.

The “N” value is determined as the number of blows to achieve 300mm of penetration (generally after disregarding the first 150mm penetration through possibly disturbed material). The results of these tests can be related empirically to the engineering properties of the soil.

The test is also used to provide useful information in cohesive soils under certain conditions, a good quality disturbed sample being recovered with each test. Other forms of in situ testing are used under certain conditions and where this occurs, details are given in the report.

DEFINITIONS OF ROCK, SOIL, AND DEGREES OF CHEMICAL WEATHERING

GENERAL DEFINITIONS – ROCK AND SOIL

ROCK In engineering usage, rock is a natural aggregate of minerals connected by strong and permanent cohesive forces.

Note: Since "strong" and "permanent" are subject to different interpretations, the boundary between rock and soil is necessarily an arbitrary one.

SOIL In engineering usage, soil is a natural aggregate of mineral grains which can be separated by such gentle mechanical means as agitation in water, can be remoulded and can be classified according to the Unified Soil Classification System. Three principal classes of soil recognized are:

Residual soils: soils which have been formed in-situ by the chemical weathering of parent rock. Residual soil may retain evidence of the original rock texture or fabric or, when mature, the original rock texture may be destroyed.

Transported soils: soils which have been moved from their places of origin and deposited elsewhere. The principal agents of erosion, transport and deposition are water, wind and gravity. Two important types of transported soil in engineering geology and materials investigations are:

Colluvium – a soil, often including angular rock fragments and boulders, which has been transported downslope predominantly under the action of gravity assisted by water. The principle forming process is that of soil creep in which the soil moves after it has been weakened by saturation. It may be water borne for short distances.

Alluvium – a soil which has been transported and deposited by running water. The larger particles (sand and gravel size) are water worn.

Lateritic soils: soils which have formed in situ under the effects of tropical weathering include all reddish residual and non residual soils which genetically form a chain of material ranging from decomposed rock through clay to sesqui-oxide rich crusts. The term does not necessarily imply any compositional, textural or morphological definition; all distinctions useful for engineering purposes are based on the differences in geotechnical characteristics.

ROCK WEATHERING DEFINITIONS

Extremely Weathered (EW)	Rock substance affected by weathering to the extent that the rock exhibits soil properties, i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly Weathered (HW)	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of the chemical or physical decomposition are evident. Porosity and strength may be increased or decreased compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original fresh rock substance is no longer recognisable.
Moderately Weathered (MW)	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Slightly Weathered (SW)	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance, usually by limonite, has taken place. The colour and texture of the fresh rock is recognisable.
Fresh (Fr)	Rock substance unaffected by weathering.

The degrees of rock weathering may be gradational. Intermediate stages are described by dual symbols with the prominent degree of weathering first (e.g. EW-HW).

The various degrees of weathering do not necessarily define strength parameters as some rocks are weak, even when fresh, to the extent that they can be broken by hand across the fabric, and some rocks may increase in strength during the weathering process.

Fresh drill cores of some rock types, such as basalt and shale may disintegrate after exposure to the atmosphere due to slaking, desiccation, expansion or contraction, stress relief or a combination of any of these factors.

AN ENGINEERING CLASSIFICATION OF SEDIMENTARY ROCKS

This classification system provides a standardised terminology for the engineering description of the sandstone and shales in the Sydney area, but the terms and definitions may be used elsewhere when applicable. Where other rock types are encountered, such as in dykes, standard geological descriptions are used for rock types and the same descriptions as below are used for strength, fracturing and weathering.

Under this system rocks are classified by Rock Type, Strength, Stratification Spacing, Degree of Fracturing and Degree of Weathering. These terms do not cover the full range of engineering properties. Descriptions of rock may also need to refer to other properties (e.g. durability, abrasiveness, etc) where these are relevant.

ROCK TYPE DEFINITIONS

ROCK TYPE	DEFINITION
Conglomerate:	More than 50% of the rock consists of gravel sized (greater than 2mm) fragments.
Sandstone:	More than 50% of the rock consists of sand sized (0.06 to 2mm) grains.
Siltstone:	More than 50% of the rock consists of silt-sized (less than 0.06mm) granular particles and the rock is not laminated.
Claystone:	More than 50% of the rock consists of silt or clay sized particles and the rock is not laminated.
Shale:	More than 50% of the rock consists of silt or clay sized particles and the rock is laminated.

Rocks possessing characteristics of two groups are described by their predominant particle size with reference also to the minor constituents, e.g. clayey sandstone, sandy shale.

STRATIFICATION SPACING

Term	Separation of Stratification Planes
Thinly Laminated	< 6mm
Laminated	6mm to 20mm
Very thinly bedded	20mm to 60mm
Thinly bedded	60mm to 0.2m
Medium bedded	0.2m to 0.6m
Thickly bedded	0.6m to 2m
Very thickly bedded	> 2m

DEGREE OF FRACTURING

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but exclude known artificial fractures such as drilling breaks.

Term	Description
Fragmented:	The core is comprised primarily of fragments of length less than 20mm, and mostly of width less than the core diameter
Highly Fractured:	Core lengths are generally less than 20mm – 40mm with occasional fragments.
Fractured:	Core lengths are mainly 30mm – 100mm with occasional shorter and longer section.
Slightly Fractured:	Core lengths are generally 300mm – 1000mm with occasional longer sections and occasional sections of 100mm – 300mm.
Unbroken:	The core does not contain any fracture.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Society of Rock Mechanics.

Term	Point Load Index Is(50) MPa	Field Guide	Approx qu MPa*
Extremely Weak:	0.03	Easily remoulded by hand to a material with soil properties.	0.7
Very Weak:	0.1	May be crumbled in the hand. Sandstone is “sugary” and friable.	2.4
Weak:	0.3	A piece of core 150mm long x 50mm dia. May be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	7
Medium Strong:	1	A piece of core 150mm long x 50mm dia. can be broken by hand with considerable difficulty. Readily scored with knife.	24
Strong: (SW)	3	A piece of core 150mm long x 50mm dia. core cannot be broken by unaided hands, can be slightly scratched or scored with knife.	70
Very Strong (SW)	10	A piece of core 150mm long x 50mm dia. may be broken readily with hand held hammer. Cannot be scratched with pen knife.	240
Extremely Strong (Fr)	>10	A piece of core 150mm long x 50mm dia. is difficult to break with hand held hammer. Rings when struck with a hammer.	>240

The approximate unconfined compressive strength (qu) shown in the table is based on an assumed ration to the point load index of 24:1. This ratio may vary widely.

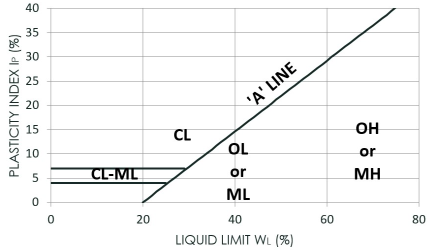
Unified Soil Classification System (Metricated)
Data for Description Indentification and Classification of Soils

MAJOR DIVISIONS		DESCRIPTION: Group Symbol	Graphic Symbol	TYPICAL NAME	DESCRIPTIVE DATA	FIELD IDENTIFICATION	GRAVELS AND SANDS: GRADATIONS		NATURE OF FINES	DRY STRENGTH	Group Symbol	LABORATORY CLASSIFICATION: % [2] < 0.06mm	PLASTICITY OF FINE FRACTION			NOTES
COARSE GRAINED SOILS — More than 50% by dry mass, less than 60mm is greater than 0.06mm.	GRAVELS — More than 50% of coarse grains are greater than 2.0mm	GW		Well graded gravels and gravel-sand mixtures, little or no fines	Give typical name, indicate approximate percentages of sand and gravel, maximum size, angularity, surface condition and hardness of the coarse grains, local or geological name and other perfinent descriptive information, symbols in parenthesis.	Determine approximate percentages of material over 60mm size, maximum size, shape, surface texture, hardness of material, geological description. Identify on estimated percentage mass of the various fractions.	GOOD	Wide range in grain size	"Clean" materials (not enough fines to band coarse grains)	None	GW	0-5	-	>4	Between 1 and 3	1. Identify Fines by the method given for fine grained soils.
		GP		Poorly graded gravels and gravel-sand mixtures, little or no fines		COARSE GRAINED SOILS — More than half of the material less than 60mm is larger than 0.06mm	POOR	Predominantly one size or range of sizes			GP	0-5	-	Fails to comply with above		2. Borderline classifications occur when the percentage of fines (fraction smaller than 0.06mm size) is greater than 5% and less than 12%.
	GRAVELLY SOILS	GM		Silty gravels, gravel-sand-silt mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics.	0.05mm is about the smallest particle visible to the naked eye	GOOD TO FAIR	"Dirty" materials (Excess of fines)	Fines are non-plastic (1)	None to medium	GM	12-50	Below 'A' line and Ip >7	-	-	Borderline classifications require the use of dual symbols eg SP-SM GW-GC
		GC		Clayey gravels gravel-sand-clay mixtures		Use the gradation curve of material passing 60mm for classification of fractions according to criteria given under "Major Division".			Fines are plastic (1)		GC	12-50	Above 'A' line and Ip > 7	-	-	
	SANDS — More than 50% of coarse grains are greater than 2.0mm	SW		Well graded sands and gravelly sands, little or no fines	EXAMPLE: Silty Sand, gravelly, about 20% hard, angular gravel particles, 10mm maximum size, rounded and sub angular sand grains coarse to fine, about 15% non-plastic fines with low dry strength, well compacted and moist in place, light brown alluvial sand, (SM)		GOOD	Wide range in grain size	"Clean" materials (not enough fines to band coarse grains)	None	SW	0-5	-	>6	between 1 and 3	
		SP		Poorly graded sands and gravelly sands, little or no fines			POOR	Predominantly one size or range of sizes			SP	0-5	-	Fails to comply with above		
	SANDY SOILS	SM		Silty sand, sand-silt mixtures			GOOD TO FAIR	"Dirty" materials (Excess of fines)	Fines are non-plastic (1)	None to medium	SM	12-50	Below 'A' line or Ip < 4	-	-	
		SC		Clayey sands, sand-clay mixtures					Fines are plastic (1)		SC	12-50	Above 'A' line and Ip > 7	-	-	

SILT AND CLAY FRACTION

Fraction smaller than 0 20mm AS sieve size

MAJOR DIVISIONS		Group Symbol	Graphic Symbol	TYPICAL NAME	DESCRIPTIVE DATA	FIELD IDENTIFICATION	DRY STRENGTH	DILATANCY	TOUGHNESS	Group Symbol	LABORATORY CLASSIFICATION	
FINE GRAINED SOILS — More than 50% by dry mass, less than 6mm is less than 0.06mm	Liquid Limit less than 50%	ML		Inorganic silts, very fine sands, rock flour, silty or clayey fine sands.	Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains, colour in wet condition, odour if any, local or geological name and r perfinent descriptive information, symbols in parenthesis.	FINE GRAINED SOILS — More than half of the material less than 50mm is less than 0.06mm	None to low	Quick to slow	None	ML	More than 50% passing 0.06mm	Below 'A' line
		CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.			Medium to high	None to very slow	Medium	CL		Above 'A' line
		OL		Organic silts and organic silty clays of low plasticity	For undisturbed soil add information on structure, stratification, consistancy in undisturbed and remoulded states, moisture and drainage conditions.		Low to medium	Slow	Low	OL		Below 'A' line
	Liquid Limit more than 50%	MH		Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts.			Low to medium	Slow to none	Low to medium	MH		Below 'A' line
		CH		Inorganic clays of high plasticity, fat clays.	EXAMPLE Clayey Silt, brown, low plasticity, small percentage of fine sand, numerous vertical root-holes, firm and dry in place, fill, (ML).		High to very high	None	High	CH		Above 'A' line
		OH		Organic clays of medium to high plasticity.			Medium to high	None to very slow	Low to medium	OH		Below 'A' line
		Pt		Peat muck and other highly organic soils.		Readily identified by colour, odour, spongy feel and generally by fibrous texture				Pt*	*Effervescence with H2O2	



PLASTICITY CHART
FOR CLASSIFICATION OF FINE GRAINED SOILS

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Limitations in the Use and Interpretation of this Geotechnical Report

Our Professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the Owner in the design of the subject development and should be made available to potential contractors and/or the Contractor for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive borehole and test pit logs, cross- sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the exploratory bore holes, test pits, and/or probes are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observed in the exploratory bore holes and test pits, or assumed to exist in the excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between conducting this investigation and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and the recommendations considering the changed conditions and time lapse.

The summary bore hole and test pit logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the test holes progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The bore hole and test pit logs and related information depict subsurface conditions only at the specific locations and at the particular time designated on the logs. Soil conditions at the other locations may differ from conditions occurring at these bore hole and test pit locations. Also, the passage of time may result in a change in the soil conditions at these test locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the boring logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples, bore holes or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. It is recommended that the Owner consider providing a contingency fund to accommodate such potential extra costs.

This firm cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report: nor can our company be responsible for any construction activity on sites other than the specific site referred to in this report.

APPENDIX C

Qualitative Terminology and Risk Management

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.

Attachment 1 – Risk Assessment Matrix

E – Extreme risk – detailed action plan required
H - High risk – needs senior management attention
M – Medium risk – specify management responsibility
L – Low risk – manage by routine procedures

High or **Extreme** risks must be reported to Senior Management and require detailed treatment plans to reduce the risk to **Low** or **Medium**.

Consequence →					
People	Injuries or ailments not requiring medical treatment.	Minor injury or First Aid Treatment Case.	Serious injury causing hospitalisation or multiple medical treatment cases.	Life threatening injury or multiple serious injuries causing hospitalisation.	Death or multiple life threatening injuries.
Reputation	Internal Review	Scrutiny required by internal committees or internal audit to prevent escalation.	Scrutiny required by external committees or ACT Auditor General's Office, or inquest, etc.	Intense public, political and media scrutiny. Eg: front page headlines, TV, etc.	Assembly inquiry or Commission of inquiry or adverse national media.
Business Process & Systems	Minor errors in systems or processes requiring corrective action, or minor delay without impact on overall schedule.	Policy procedural rule occasionally not met or services do not fully meet needs.	One or more key accountability requirements not met. Inconvenient but not client welfare threatening.	Strategies not consistent with Government's agenda. Trends show service is degraded.	Critical system failure, bad policy advice or ongoing non-compliance. Business severely affected.
Financial	1% of Budget or <$5K	2.5% of Budget or <$50K	> 5% of Budget or <$500K	> 10% of Budget or <$5M	>25% of Budget or >$5M
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**

Likelihood ↑ Probability:	Historical:			1	2	3	4	5
>1 in 10	Is expected to occur in most circumstances	**5**	**Almost Certain**	**M**	**H**	**H**	**E**	**E**
1 in 10 - 100	Will probably occur	**4**	**Likely**	**M**	**M**	**H**	**H**	**E**
1 in 100 – 1,000	Might occur at some time in the future	**3**	**Possible**	**L**	**M**	**M**	**H**	**E**
1 in 1,000 – 10,000	Could occur but doubtful	**2**	**Unlikely**	**L**	**M**	**M**	**H**	**H**
1 in 10,000 – 100,000	May occur but only in exceptional circumstances	**1**	**Rare**	**L**	**L**	**M**	**M**	**H**

Adapted from Standards Australia Risk Management AS/NZS 4360: 2004

APPENDIX D

Flowchart for Landslide Risk Management

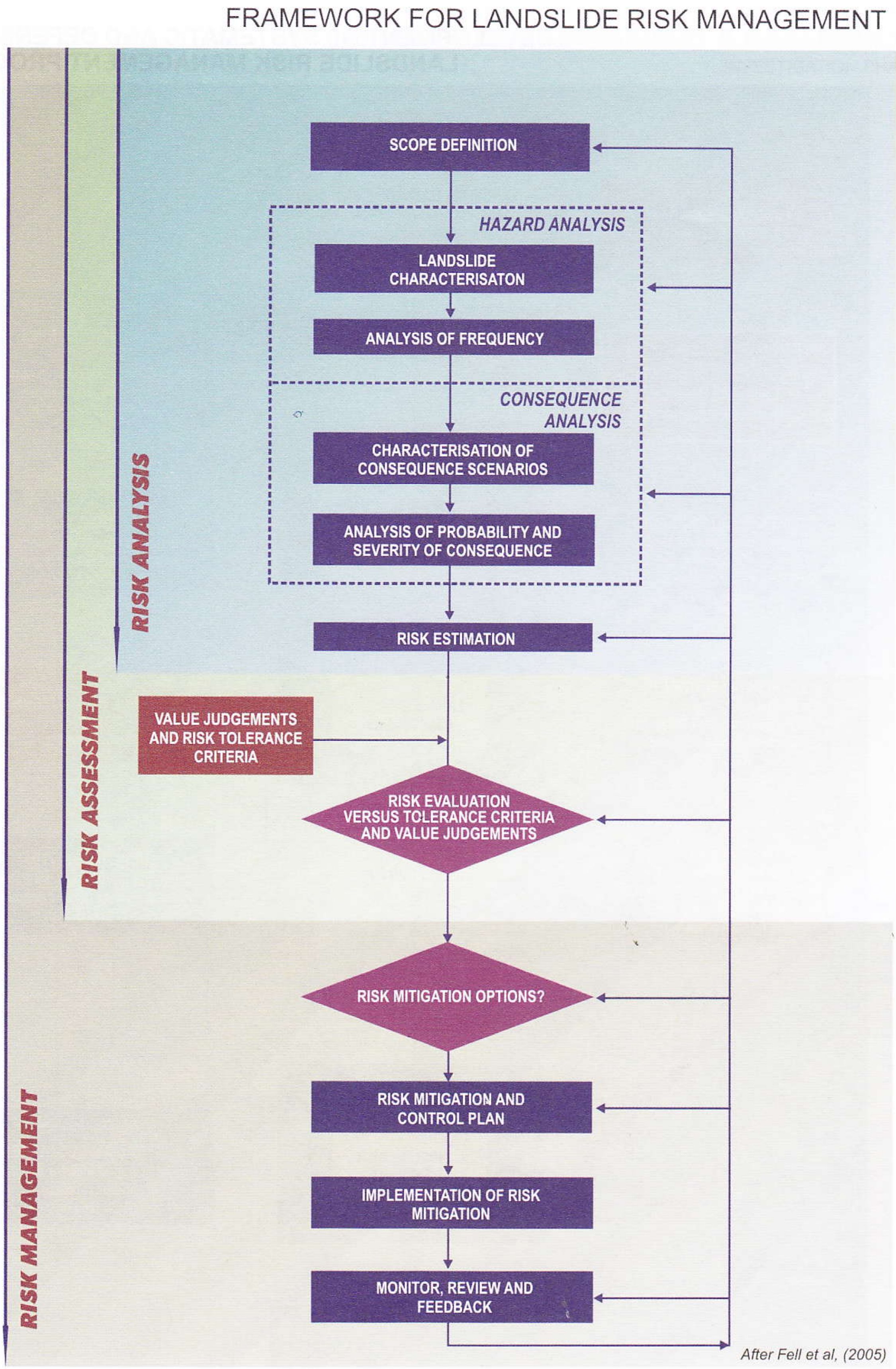


Figure 2: Abbreviated flowchart for Landslide Risk Management.
Ref: AGS (2007a, 2007c)

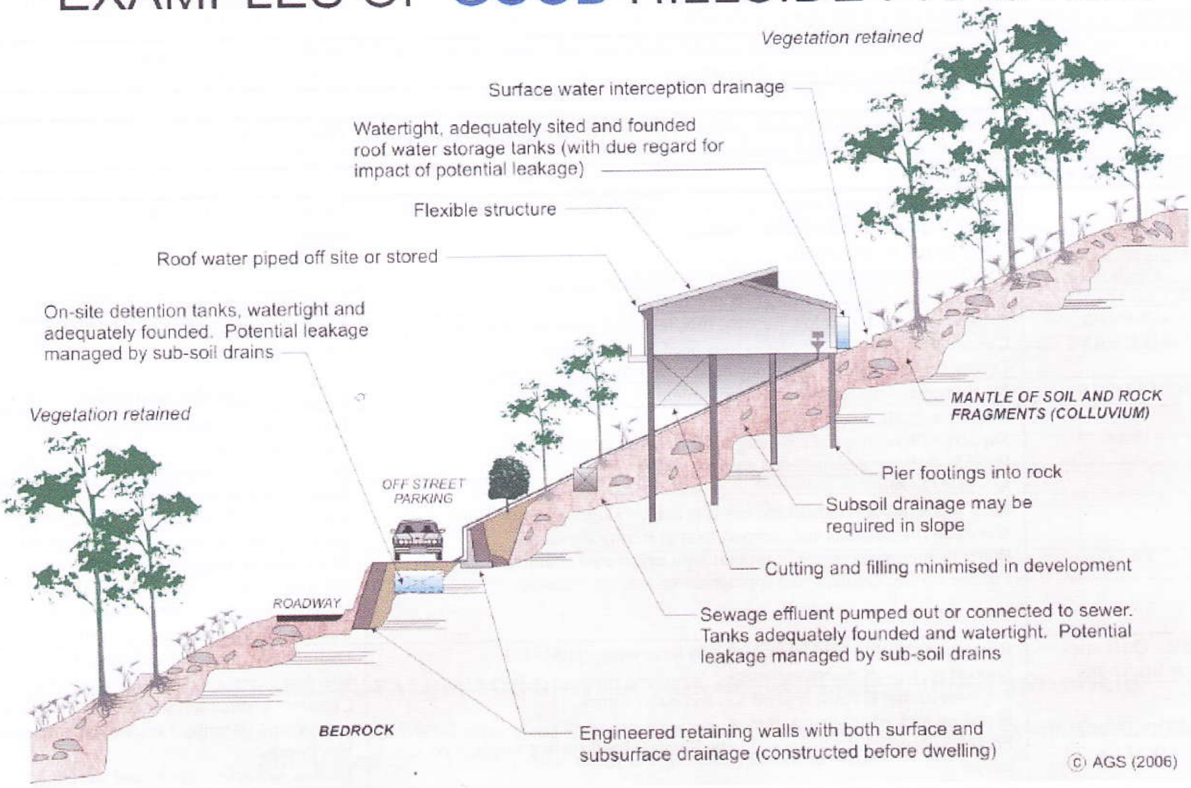
APPENDIX E

Guidelines for Hillside Construction

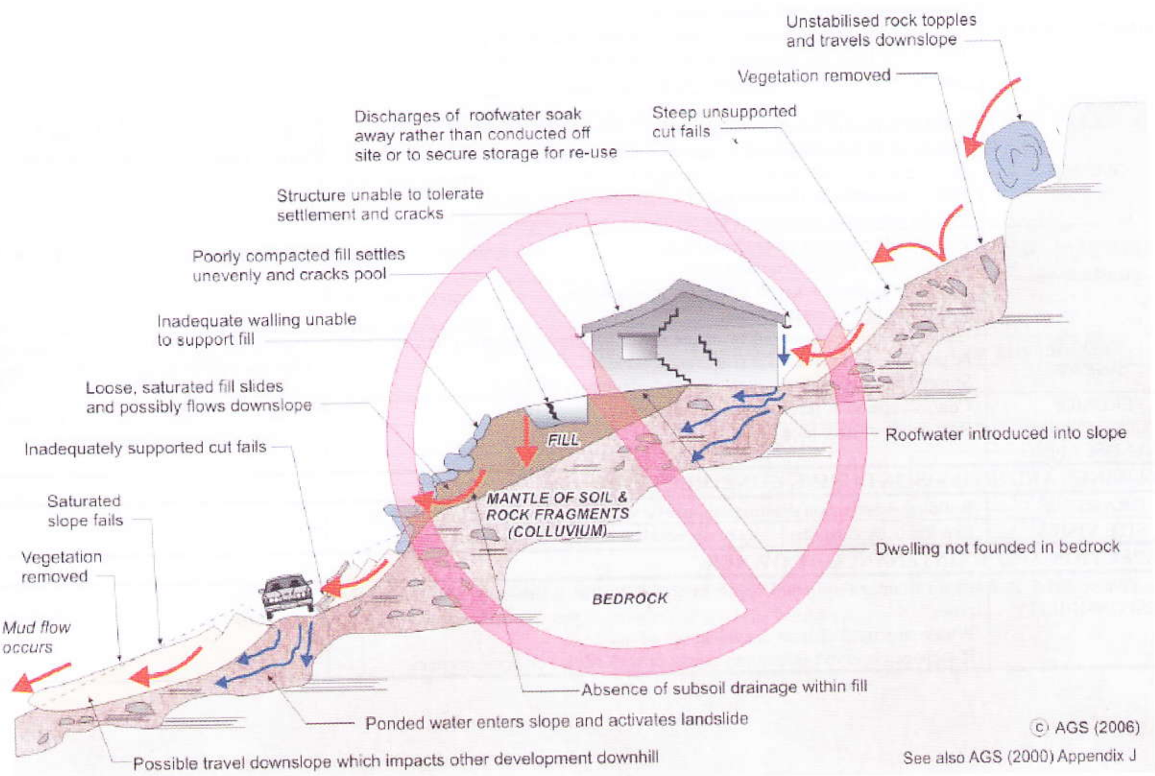
APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

ADVICE	*GOOD ENGINEERING PRACTICE*	*POOR ENGINEERING PRACTICE*
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	

EXAMPLES OF GOOD HILLSIDE PRACTICE



EXAMPLES OF POOR HILLSIDE PRACTICE



APPENDIX F

Kosciuszko Alpine Resorts – Geotechnical Policy - Form 1

NSW GOVERNMENT | Planning & Environment

Geotechnical Policy
Kosciuszko Alpine Resorts

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

DA Number: ____________________

To be submitted with a development application

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

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

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

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

I,

Mr ☑ Ms ☐ Mrs ☐ Dr ☐ Other ☐

First Name: JEREMY Family Name: MURRAY

OF

Company/organisation: ACT GEOTECHNICAL ENGINEERS

on this the 24th day of July 2020

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

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

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

2. Geotechnical Report Details

Report Title: Selwyn Snow Resort Redevelopment - Geotechnical Investigation & Slope Stability Risk Assessment

Author: Jeremy Murray

Dated: 24/7/20

DA Site Address: Kings Cross Road, Cabramurra

DA Applicant:

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

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

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

Please tick appropriate box

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

4. Signatures

Signature	Chartered professional status
[signature]	CP Eng # 2122247
Name	**Date**
JEREMY MURRAY	24/7/20

5. Contact details

Department of Planning & Environment
Alpine Resorts Team
Shop 5A, 19 Snowy River Avenue
PO Box 36, JINDABYNE 2627
Telephone: 02 6456 1733
Facsimile: 02 6456 1736
Email: alpineresorts@planning.nsw.gov.au