STS GeoEnvironmental Pty Ltd
Geotechnical and Environmental Solutions

GEOTECHNICAL ASSESSMENT

FOR

KATOOMBA CHRISTIAN CONVENTION

119 Cliff Drive, Katoomba, New South Wales

Report No: 18/0171

Project No: 21843/9176C

January 2018

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1. INTRODUCTION

This report presents the results of a geotechnical assessment carried out by STS GeoEnvironmental Pty Limited (STS) for proposed alterations and additions to be constructed at the existing Katoomba Christian Convention Facility, located at 119 Cliff Drive, Katoomba. We understand that the proposed development is to be constructed under 3 stages and comprises the following:

- Construction of a new auditorium with adjacent plaza, breakout spaces and book shop,
- Construction of new areas of parking,
- Construction of six (6) eco lodges,
- Construction of three (3) eco chalets,
- Construction of a new dining and reception area, and
- Construction of a new café area.

We understand that the parts of the site are identified as having Slope Constraints in accordance with Clause 6.4 of the Blue Mountains City Council LEP, and as such a geotechnical report is to be provided to accompany the DA Submission.

This assessment primarily focuses on the portion of the site to the south of Violet Street. At the time of writing this report the provided architectural drawings were at concept stage, so it was not possible to ascertain cut and fill depths for the buildings. However, due to the slope of the site, the alterations and additions will likely require excavating below the existing ground surface, typically up to 2 to 3 metres.

The purpose of the assessment was to:

- Inspect the site, undertaking a detailed mapping exercise including areas denoted as having Slope Constraints,
- Provide a preliminary Site Classification to AS2870,
- provide recommendations regarding the appropriate foundation system for the site including design parameters,
- comment on safe batter slopes

- provide parameters for the temporary and permanent support of the excavations including retaining wall design parameters,

- comment on excavation conditions and provide recommendations regarding vibration control during rock excavation,

- comment on the suitability of the site for the proposed development, and

- provide recommendations for additional geotechnical investigations.

The assessment was undertaken at the request of NBRS Architecture on behalf of Katoomba Christian Convention.

Our scope of works did not include a contamination assessment of the site.

Our report is based on visual observations alone and no intrusive boreholes were undertaken on the site.

2. SITE CONDITIONS AND INSPECTION

119 Cliff Drive, Katoomba (Lot 5 in DP222736) is an irregular shaped parcel of land with an area of approximately 5.4ha. The site is bounded by Cliff Drive to the east and south, Cliff Street and residential properties to the west and Violet Street to the north.

The site is currently occupied by the Katoomba Christian Convention facility. A summary of the inspection undertaken by our Senior Engineering Geologist on the January 23, 2018 is as follows:

- The site has a general fall to the north, from the crest of a ridge line to the south of the auditorium to Violet Street. The fall is approximately 28 metres from RL1000m to RL972m.

- The southern part of the site is occupied by a large single level metal clad auditorium. The auditorium has been constructed on a level pad that has been created by cut to fill earthworks. The cut on the southern side is partially retained by a 1 metre high timber panel wall, with sub-vertical sandstone cuts exposed behind the wall. The ground surface to the south of the auditorium forms a ridge line before dropping to the south towards Cliff Drive.

- To the north west of the auditorium is a plaza which comprises of a large gravel circular structure with concrete steps and asphalt pavements.

- To the south, east and north east of the auditorium is dense bushland that slopes towards cliff drive. The slopes have angles of 5° to 15°, however there are small sections where the slope is up to 35°.

- The central-western portion of the site comprises a gently sloping camp ground area with sparse mature trees and amenities buildings. To the north and east of the camp ground is a densely vegetated slope which falls to the north and east with angles of 10° to 15°. To the north and east of the camp ground is a densely vegetated slope which falls to the north and east with angles of 10° to 15°.

- The central-eastern portion of the site comprises a series of single level buildings constructed on gently sloping ground that falls to the east and north. The site is accessed via an asphalt driveway that leads to Cliff Driveway. The access driveway has been cut into the natural slope with cuts of between 1 and 2 metres. The cut faces comprise minor amounts of topsoil overlying a shallow layer of residual sandy clays, below which interbedded shale and sandstone bedrock is exposed. The bedrock is typically highly weathered, very low to low strength fine grained pale grey to yellow interbedded sandstone and shale bedrock. The cuts are near vertical.

- The north-western portion of the site comprises a large metal building, beyond which are densely vegetated slopes which fall towards Violet Street. The slopes have falls of 10-20°.

- The north-eastern portion of the site comprises a gently to moderately sloping, grassed area with mature trees that leads to the intersection of Violet Street and Cliff Drive.

- There are numerous small metal and weatherboard buildings on the site, including accommodation facilities, offices, workshops and amenities buildings.

- The existing structures on the site appeared in a reasonable condition.

- Site vegetation comprised areas of dense native bushland and cleared garden and lawn areas.

- The section of Cliff Drive to the south and east of the site has been cut to achieve a level road pavement. The cuts on the northern and western side of the road are between 1 and 2 metres in height and comprise minor amounts of topsoil overlying a shallow layer of residual sandy clays, below which sandstone bedrock is exposed. The bedrock is typically highly weathered, very low to low strength fine grained pale grey to yellow sandstone bedrock. The road cuts are near vertical.

- The exposed rock cuts have been subject to weathering and erosion which has caused fretting and undercutting of the cut faces, however there was no evidence of global instability within the cuts.

- To the south of the site, beyond Cliff Drive is an escarpment with cliff faces up to 200m in height. The bedrock exposed within the escarpment comprises fine to medium grained medium to high strength quartz sandstone.

- There was no evidence of slope instability noted during the inspection and groundwater seepage was not observed.

3. GEOLOGY AND SUBSURFACE CONDITIONS

The Katoomba Sydney geological series sheet, at a scale of 1:50,000 shows the site is underlain by the Triassic Age Banks Wall Sandstone member of the Narrabeen Group (Grose Subgroup). Bedrock within the Banks Wall Sandstone member comprises quartz sandstone, slightly lithic, with minor interbedded claystone.

Onsite there are rock outcrops consistent with the geological setting. There are other sandstone outcrops in the street and general area.

Our experience and observations suggest that there is likely to be less than a metre of soil overlying the weathered sandstone.

No groundwater seepage was observed.

4. DISCUSSION

4.1. Site Classification to AS2870

The classification has been prepared in accordance with the guidelines set out in the "Residential Slabs and Footings" Code, AS2870 – 2011.

Because there are buildings and trees present, abnormal moisture conditions (AMC) prevail at the site (Refer to Section 1.3.3 of AS2870).

Because of the AMC, and fill present, the site is classified *a problem site (P).* Provided the recommendations given below are adopted and the footings bear in the underlying natural soils below any topsoil and fill, the site may be re-classified *moderately reactive (M).* The site may be re-classified a *stable site (A)*, provided the footings are founded within the underlying bedrock.

4.2. Excavation Conditions and Support

Based on the conditions observed and general experience in this geological environment, it is expected that excavation on this site will likely encounter sandstone at relatively shallow depths. Typically, the sandstone bedrock within this region is horizontally bedded with sub- vertical joints. This type of profile can be observed within the local area where sandstone bedrock is exposed.

Excavators alone without assistance may not be capable of removing the rock. Hydraulic breakers mounted on an excavator or jack hammers may be required to break up the rock before it can be removed using an excavator.

Particular care will be required to ensure that buildings and structures on the subject site, and on adjacent properties are not damaged when excavating the rock. The existing structures are likely to be founded directly on the underlying sandstone bedrock. Buildings and structures founded directly on rock can often be very susceptible to damage from vibrations and rendered buildings will be very susceptible to cracking from ground borne vibrations.

Excavations methods should be adopted which limit ground vibrations at the adjoining developments to not more than 10 mm/sec. Vibration monitoring will be required to verify that this is achieved. However, if the contractor adopts methods and/or equipment in accordance with the recommendations in Table 4.1 for a ground vibration limit of 5 mm/sec, vibration monitoring may not be required.

Table 4.1 – Recommendations for Rock Breaking Equipment

Distance from adjoining structure (m)	Maximum Peak Particle Velocity 5 mm/sec		Maximum Peak Particle Velocity 10 mm/sec	
	Equipment	Operating Limit (% of Maximum Capacity)	Equipment	Operating Limit (% of Maximum Capacity)
1.5 to 2.5	Hand operated jackhammer only	100	300 kg rock hammer	50
2.5 to 5.0	300 kg rock hammer	50	300 kg rock hammer or 600 kg rock hammer	100 50
5.0 to 10.0	300 kg rock hammer or 600 kg rock hammer	100 50	600 kg rock hammer or 900 kg rock hammer	100 50

*Vibration monitoring is recommended for 10 mm/sec vibration limit.

The limits of 5 mm/sec and 10 mm/sec are expected to be achievable if rock breaker equipment or other excavation methods are restricted as indicated in Table 4.1.

At all times, the excavation equipment must be operated by experienced personnel, according to the manufacturer's instructions and in a manner consistent with minimising vibration effects.

Use of other techniques (e.g. grinding, rock sawing), although less productive, would reduce or possibly eliminate risks of damage to property through vibration effects transmitted via the ground. Such techniques may be considered if an alternative to rock breaking is required.

If rock sawing is carried out around excavation boundaries in not less than 1 metre deep lifts, a 900 kg rock hammer could be used at up to 100% maximum operating capacity with an assessed peak particle velocity not exceeding 5 mm/sec, subject to observation and confirmation by a geotechnical engineer at the commencement of excavation.

It should be noted that vibrations that are below threshold levels for building damage may be experienced at adjoining developments.

It would be appropriate before commencing excavation to undertake a dilapidation survey of any adjacent structures that may potentially be damaged. This will provide a reasonable basis for assessing any future claims of damage.

It is of course important that the onsite excavations are adequately supported at all times and do not endanger the adjacent properties.

Temporary slopes in the soils may be constructed at a maximum angle of 1 to 1. Excavations in competent sandstone should remain stable unsupported in the short term. Where there is insufficient space to temporary batter the overlying soils it will be necessary to provide temporary support. Support will probably need to be drilled and fixed into the rock below the base of the excavation.

With regards to temporary unsupported rock cuts, in some areas support using rock bolts, shotcrete and/or underpinning using brick piers or infill concrete may be necessary. The latter would only normally be required if blocks fall out near to the excavation boundary lines.

Until the excavation is commenced and the actual conditions are exposed, it is not practical to be more definitive. The sandstone bedrock may include some joints. If joints are continuous they could form wedges which may need to be supported with bolts. If boulders extend beyond excavation boundaries then they will need to be trimmed and supported. As noted above particular care will be required when excavating close to boundaries. This work should be carried out in small sections so that the subsurface conditions can be identified, and any appropriate shoring or support can be installed before too large an area is exposed.

It is recommended that an experienced engineering geologist or geotechnical engineer observes the excavations as they progress. At that time, they will be able to recommend any support that is required for either temporary or permanent conditions and help to finalise the design of the final cut slopes and any retaining walls that may be required.

All loosened rocks should either be stabilised or removed from the sides of the excavation as it proceeds. If floaters are encountered care will be required as they can often be sizeable in this geological environment, appearing to be part of the “solid” rock profile.

Bedrock within the Narrabeen Group is highly susceptible to erosion due to its chemical composition. For the reason we do not recommend adopting long term unsupported vertical cut faces. Where vertical rock cuts are created we recommend constructing perimeter walls to support the excavations in the long term.

The space between the rock face and the back of the walls could be filled with free draining hard igneous rock with an appropriate large agriculture drain installed at the toe. This may help to relieve the potential for damp penetrating the external walls.

When considering the design of the supports for the overlying bedrock and overlying soils, it will be necessary to allow for the loading from structures in adjoining properties, any ground surface slope and the water table present. Where the structures in adjoining properties are within the zone of influence of the excavation, it will be necessary to adopt K_o conditions when designing the temporary support. If necessary, anchors or props can be used to provide the required support. When props or anchors are used for support, a rectangular earth pressure distribution should be adopted on the active side of the support. K_o should also be used to design the permanent support.

The following parameters are suggested for the design of the retaining wall system where there is a level ground surface:

Soil:

Active Earth Pressure Coefficient (K_a)	=	0.4
At Rest Pressure Coefficient (K_o)	=	0.55
Total (Bulk) Density	=	20 kN/m^3

Weathered Sandstone:

Earth Pressure Coefficient	=	0.2
Passive Earth Pressure Coefficient (K_p)	=	3.5 (sandstone only)
Total (Bulk) Density	=	22 kN/m^3

Excavations on the subject site are not expected to encounter the groundwater table. However, some minor perched water seepage may flow into the excavations from the soil rock interface. The inflow rates are likely to be minor and therefore a sump and a pump should be sufficient to control the anticipated seepage.

4.3. Foundation Design

Footings that bear in firm to stiff natural clayey soils at a high level may be proportioned using an allowable bearing pressure of 100 kPa. This value may be increased 150 kPa when founding in stiff natural materials.

Footings founded in weathered sandstone may be proportioned using an allowable bearing pressure of 700 kPa. For piles an allowable adhesion of 70 kPa applies to the portion of the pile shaft within the weathered rock.

In order to ensure the bearing values given can be achieved, care should be taken to ensure that the base of excavations are free of all loose material prior to concreting. It is recommended that all footing excavations be protected with a layer of blinding concrete as soon as possible, preferably immediately after excavating, cleaning, inspection and approval. The possible presence of groundwater needs to be considered when drilling piles and pouring concrete

4.4. Site Preparation

The performance of the pavements cannot be guaranteed unless the following procedures are adopted during the site earthworks:

- Remove any vegetation, topsoil and fill present. The exposed subgrade should be inspected by a geotechnical engineer who may wish to proof roll the exposed subgrade with a heavy, non-vibrating roller to detect soft or wet areas. These areas should be excavated to competent material and then filled as detailed below.

- Fill the site to the underside of slab or pavement level, in layers not exceeding 200 mm loose thickness, compacted to achieve a density ratio in the range of 98% to 102% of the Standard maximum dry density, at a moisture content within the range of -2% to +2% of the optimum for the material adopted.

The onsite soils can become un-trafficable during periods of wet weather.

4.5. Site Suitability

We understand that the parts of the site are identified as having Slope Constraints in accordance with Clause 6.4 of the Blue Mountains City Council LEP. An overlay of the Slope Constraints map in comparison to the proposed works is attached as Appendix A.

The Slope Constraint areas are primarily confined to the dense bushland on the northern and north-eastern parts of the site, where slopes are typically within the 10°-25° range. The Slope Constraint mapping extends into the proposed Ecolodge areas as well as the café and reception area.

Provided the works are undertaken in accordance with the recommendations of this report, in particular regarding safe batter slopes and temporary excavation support, we feel that this site is suitable for the development. Further, any development on the site should follow good hillside construction practices. Some examples are attached in Appendix B.

4.6. Requirement for Additional Geotechnical Investigations

This report has been prepared using our experience in this local area. Prior to commencing construction, it is essential subsurface drilling is undertaken to ensure that the design reflects the actual subsurface conditions on the site.

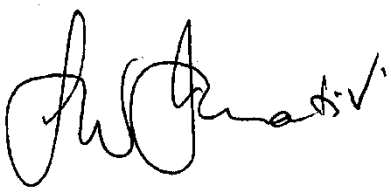
To facilitate pavement design of proposed internal roads and carparks, samples should be obtained to determine the subgrade CBR.

It may be possible to adopt permanent un-supported vertical cut faces in competent sandstone, and attribute higher bearing pressures to the sandstone bedrock at foundation level. However, this would require drilling cored boreholes on the site to below the proposed foundation depth. A minimum of four (4) cored boreholes will be required to a depth of 3 metres below the founding depth.

5. FINAL COMMENTS

During construction, should the subsurface conditions vary from those inferred above, we would be contacted to determine if any changes should be made to our recommendations.

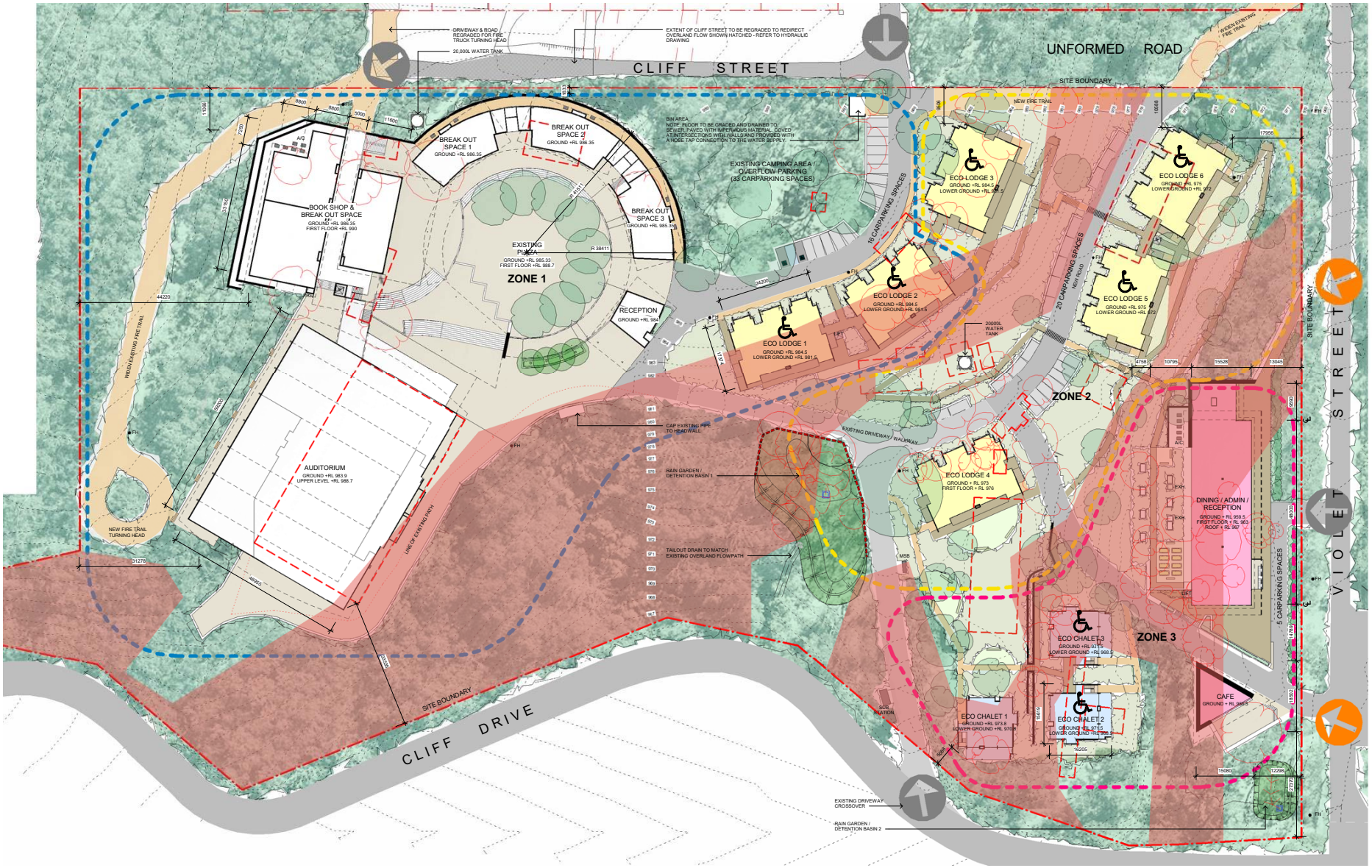
As discussed above, it is recommended that the excavation is inspected regularly as it progresses. Also, the exposed bearing surfaces for footings should be inspected by a geotechnical engineer to ensure the allowable pressure given has been achieved.



Matt Green
Senior Engineering Geologist

Laurie Ihnativ,
Principal Geotechnical Engineer

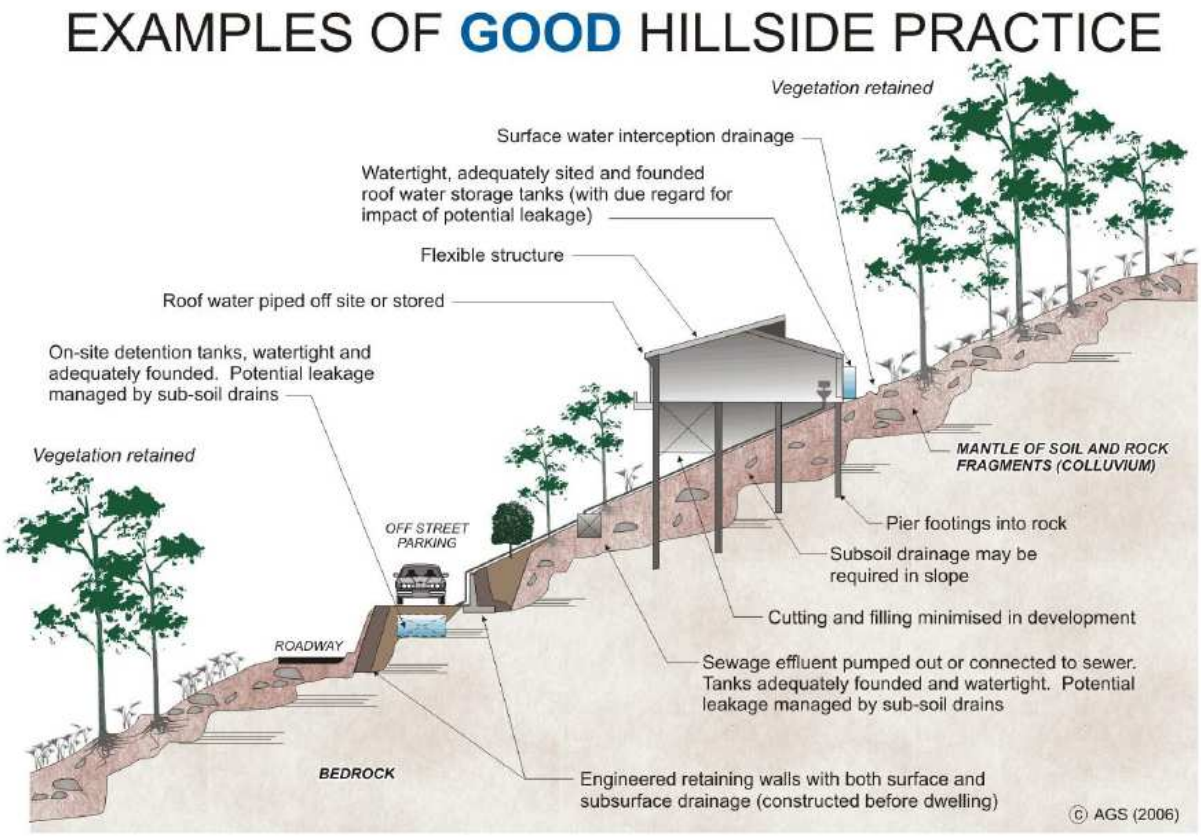
APPENDIX A – SLOPE CONSTRAINT OVERLAY

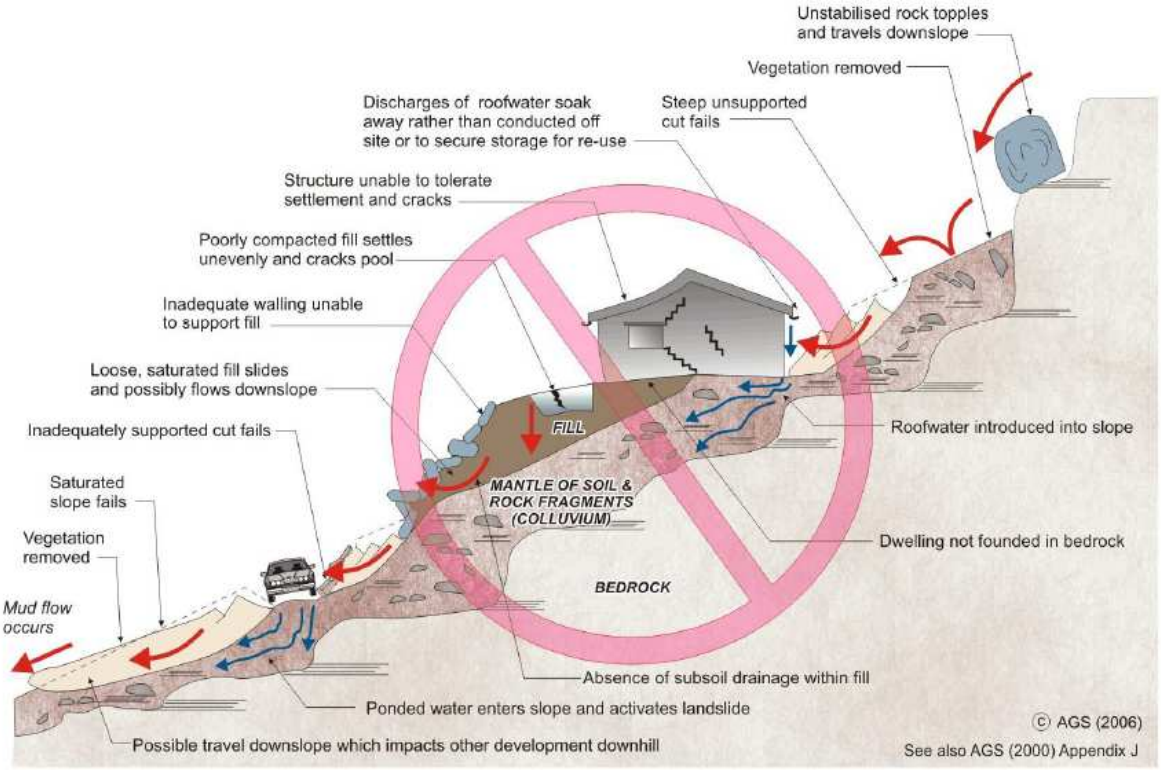


= Slope Constraint Area

STS GeoEnvironmental Pty. Ltd.	Scale: Unknown	Date: January 2018
Client: KATOOMBA CHRISTIAN CONVENTION		
GEOTECHNICAL ASSESSMENT **119 CLIFF DRIVE, KATOOMBA** **SLOPE CONSTRAINT OVERLAY**	Project No. 21843/9176C	
	Drawing No: 18/0171	

APPENDIX B – EXAMPLES OF GOOD HILLSIDE PRACTICE


EXAMPLES OF GOOD HILLSIDE PRACTICE
Vegetation retained
Surface water interception drainage
Watertight, adequately sited and founded roof water storage tanks (with due regard for impact of potential leakage)
Flexible structure
Roof water piped off site or stored
On-site detention tanks, watertight and adequately founded. Potential leakage managed by sub-soil drains
Vegetation retained
MANTLE OF SOIL AND ROCK FRAGMENTS (COLLUVIUM)
OFF STREET PARKING
Pier footings into rock
Subsoil drainage may be required in slope
Cutting and filling minimised in development
ROADWAY
Sewage effluent pumped out or connected to sewer. Tanks adequately founded and watertight. Potential leakage managed by sub-soil drains
BEDROCK
Engineered retaining walls with both surface and subsurface drainage (constructed before dwelling)
© AGS (2006)


EXAMPLES OF POOR HILLSIDE PRACTICE
Unstabilised rock topples and travels downslope
Vegetation removed
Discharges of roofwater soak away rather than conducted off site or to secure storage for re-use
Steep unsupported cut fails
Structure unable to tolerate settlement and cracks
Poorly compacted fill settles unevenly and cracks pool
Inadequate walling unable to support fill
Loose, saturated fill slides and possibly flows downslope
Inadequately supported cut fails
FILL
Roofwater introduced into slope
Saturated slope fails
MANTLE OF SOIL & ROCK FRAGMENTS (COLLUVIUM)
Vegetation removed
Dwelling not founded in bedrock
BEDROCK
Mud flow occurs
Absence of subsoil drainage within fill
Ponded water enters slope and activates landslide
Possible travel downslope which impacts other development downhill
© AGS (2006)
See also AGS (2000) Appendix J

NOTES RELATING TO GEOTECHNICAL REPORTS

Introduction

These notes have been provided to outline the methodology and limitations inherent in geotechnical reporting. The issues discussed are not relevant to all reports and further advice should be sought if there are any queries regarding any advice or report.

When copies of reports are made, they should be reproduced in full.

Geotechnical Reports

Geotechnical reports are prepared by qualified personnel on the information supplied or obtained and are based on current engineering standards of interpretation and analysis.

Information may be gained from limited subsurface testing, surface observations, previous work and is supplemented by knowledge of the local geology and experience of the range of properties that may be exhibited by the materials present. For this reason, geotechnical reports should be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Where the report has been prepared for a specific purpose (eg. design of a three-storey building), the information and interpretation may not be appropriate if the design is changed (eg. a twenty storey building). In such cases, the report and the sufficiency of the existing work should be reviewed by SMEC Testing Services Pty Limited in the light of the new proposal.

Every care is taken with the report content, however, it is not always possible to anticipate or assume responsibility for the following conditions:

- Unexpected variations in ground conditions. The potential for this depends on the amount of investigative work undertaken.
- Changes in policy or interpretation by statutory authorities.
- The actions of contractors responding to commercial pressures.

If these occur, SMEC Testing Services Pty Limited would be pleased to resolve the matter through further investigation, analysis or advice.

Unforeseen Conditions

Should conditions encountered on site differ markedly from those anticipated from the information contained in the report, SMEC Testing Services Pty Limited should be notified immediately. Early identification of site anomalies generally results in any problems being more readily resolved and allows re-interpretation and assessment of the implications for future work.

Subsurface Information

Logs of a borehole, recovered core, test pit, excavated face or cone penetration test are an engineering and/or geological interpretation of the subsurface conditions. The reliability of the logged information depends on the drilling/testing method, sampling and/or observation spacings and the ground conditions. It is not always possible or economic to obtain continuous high quality data. It should also be recognised that the volume or material observed or tested is only a fraction of the total subsurface profile.

Interpretation of subsurface information and application to design and construction must take into consideration the spacing of the test locations, the frequency of observations and testing, and the possibility that geological boundaries may vary between observation points.

Groundwater observations and measurements outside of specially designed and constructed piezometers should be treated with care for the following reasons:

- In low permeability soils groundwater may not seep into an excavation or bore in the short time it is left open.
- A localised perched water table may not represent the true water table.
- Groundwater levels vary according to rainfall events or season.
- Some drilling and testing procedures mask or prevent groundwater inflow.

The installation of piezometers and long term monitoring of groundwater levels may be required to adequately identify groundwater conditions.

Supply of Geotechnical Information or Tendering Purposes

It is recommended tenderers are provided with as much geological and geotechnical information that is available and that where there are uncertainties regarding the ground conditions, prospective tenders should be provided with comments discussing the range of likely conditions in addition to the investigation data.