Strata Control Technology

REPORT TO:

HANSEN BAILEY

Desktop Review of Slope Type Distribution within the Coalpac Consolidation Project - Identification of Slope at Risk and Potential Slope Hazard

HANS3825A

Mining Research and Consulting Group
SCT Operations Pty Ltd PO Box 824 Wollongong NSW 2520 Australia
sctnsw@sct.gs

Report To	Dorian Walsh Environmental Scientist Hansen Bailey Environmental Consultants PO Box 473 SINGLETON NSW 2330
Subject	Desktop Review of Slope Type Distribution within the Coalpac Consolidation Project Identification of Slope at Risk and Potential Slope Hazard
Report No	HANS3825A
Prepared By	Luc Daigle
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Luc Daigle
<u>Senior Engineering Geologist</u>

Winton J. Gale
<u>Managing Director</u>

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1. INTRODUCTION

SCT Operations was approached by environmental consultants, Hansen Bailey, to conduct a desktop study of the distribution of slope types and associated risks within proposed open cut mining areas planned by Coalpac on their Cullen Valley and Invincible Colliery mining site as part of the Coalpac Consolidation Project (the Project).

The entire area of interest is underlain by the productive Illawarra Coal Measures which is capped by the weathering resistant Narrabeen Group which forms the distinctive sandstone rock formations in the area. Extensive underground mine workings are present throughout the area and Coalpac is proposing open cut and highwall mining methods to extract additional coal from the lease.

This report identifies areas of topography that may be considered sensitive due to the presence of steep cliffs and rock formations known as escarpments and pagodas. The Narrabeen group contains thick to massive sandstone horizons which form steep cliff faces. The remnant blocks of sandstone bounded by cliff lines form classic mesa topography.

2. DESKTOP ANALYSIS

2.1 Topographic Analysis

A desktop analysis of the topography within the Project area was completed by identifying cliff faces and steep potential scree/talus slopes. Review of topographic maps and aerial photographs permitted division of the study area into three distinct zones; cliff bound hills, talus slopes and valley floors. The cliff forming rocks within the Project area are thick massive Sandstones of the Narrabeen Group which overlies the Illawarra Coal Measures.

Joint systems form the main controls on the position and orientation of cliff faces and drainage channels through the resistant sandstone. Over geological time, this weathering-resistant sandstone has formed a capping above the Illawarra Coal Measures, and resulted in the prominent sandstone Mesas common in this area and throughout the Blue Mountains. Elsewhere in the Blue Mountains (e.g. Mt Wilson, Mt Airley), Tertiary and Jurassic aged basalt flows occur on top of some of the Mesas in the region. Age dating of these volcanic rocks indicates the ancient land surface forming the top of the Mesas is 15 million to 100 million years old. The current uplifted and incised topography has formed since the last volcanic episode at the end of the Tertiary period approximately 15 million years ago.

The area examined is mainly within the Ben Bullen State Forest and is roughly centred on the village of Cullen Bullen. The landscape here rests on the north western flank of the Great Dividing Range. Close examination of the topographic map found that the top of the cliff lines is approximately the 1000 metre above sea level contour. Carefully tracing out the cliff tops identified on the 1:25,000 topographic maps and projecting the trend of these features, it was possible to precisely highlight the areas containing the cliffs and steep terrain (Figure 1). Review of colour aerial photographs enlarged to 1:10,000 scale permitted detailed identification of the cliffs, pagodas and talus slopes. These constitute the areas of greatest risk due to the steepness and potential inherent natural instability (Figure 2 and 3).

2.1.1 Identifying Sensitive Areas

Identifying sensitive areas was accomplished by analysis of the topography, cliffs and steep terrain likely to contain talus and scree deposits in repose as outlined on the 1:25,000 maps and aerial photographs. Cliff lines and rock formations locally known as pagodas are considered highly sensitive due to the steepness of the formations and weathering which has left many of these in a naturally-occurring and potentially unstable state. The zone of talus and scree is an intermediate zone between the cliff faces and the valley floor. The talus and scree slopes are composed of unconsolidated material but is in repose and forms a natural batter against the cliff faces.

2.1.2 Talus Slope and Scree Deposits

Identifying significant deposits of talus or scree is limited in this analysis; it is noted the detail in the 1:25,000 topographic maps is insufficient to readily map out these features, hence the 1:10,000 enlarged colour aerial photographs completed the desktop analysis. Previous field work in the region shows that these talus deposits are limited to the base of the steep slopes and cliff lines; the material viewed tends to be vegetated thin deposits of poorly developed soil and scree. Previous mining experience at the Cullen Valley Mine by Coalpac confirms this; the mining area adjacent to the Wallerawang–Gwabegar railway line, in the northwest of Figure 1, has shown very thin skeletal soils in the majority of final highwall positions, which are approximately 100m from the sandstone escarpments and pagodas. The absence of alluvial fans and wide scree deposits is indicative of the high energy weathering systems that operated during the formation of the topography and also demonstrates the rapid weathering of the bedrock.

As this is a desktop study, further investigation of the talus and scree would be required as input to detailed final highwall design and position in order to ensure stability. This would require the following inputs:

- More detailed contour data from a high resolution digital terrain model which could then allow analysis using computer slope stability analysis methods,
- stereo pair air photo interpretation can also provide more detail and
- field inspections, including mapping and shallow augering.

This step of the investigation would need to be conducted as part of the risk analysis of open cut mining adjacent to the areas identified as high risk talus/scree slopes and cliffs.

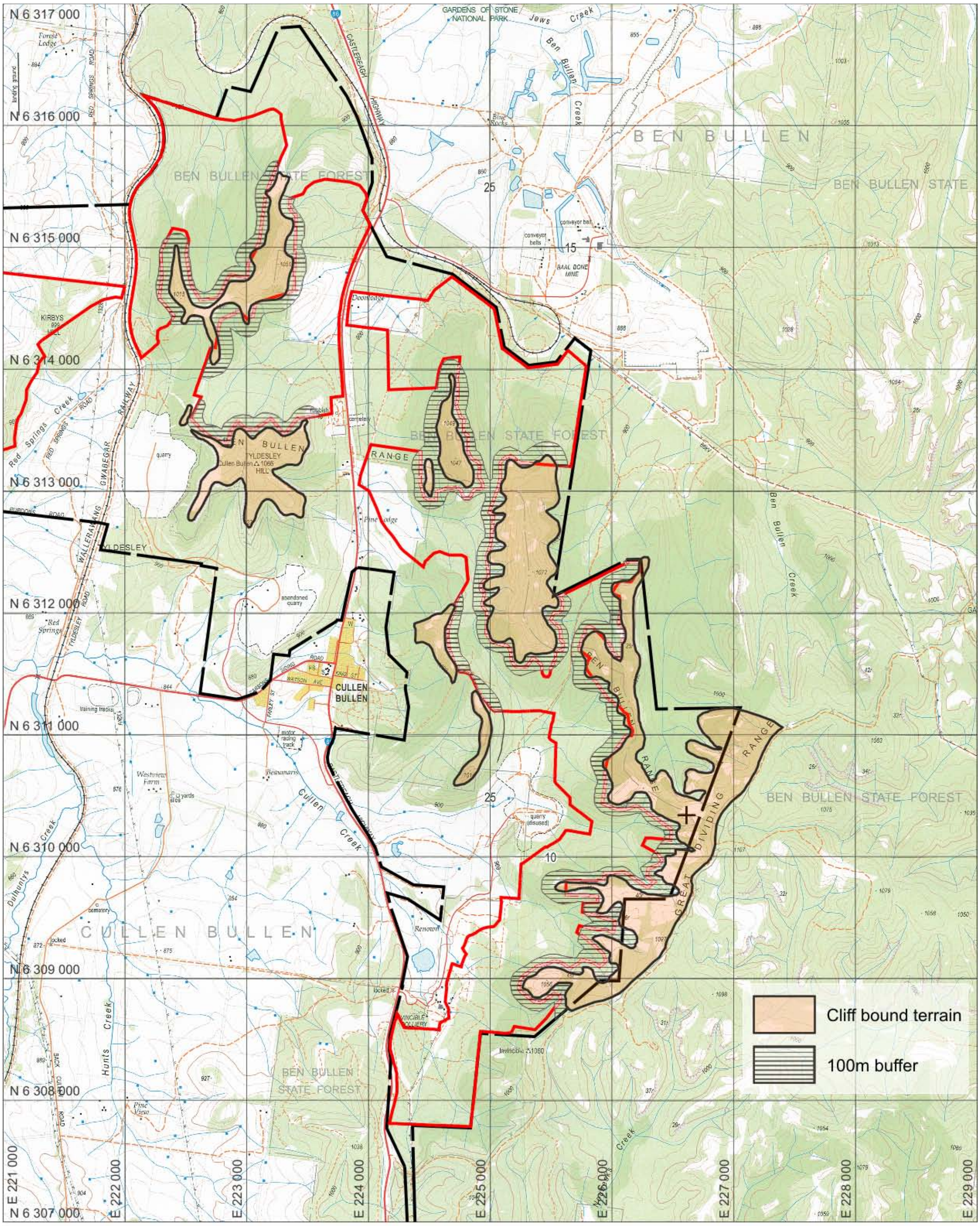

Figure 1: Coalpac slope analysis.

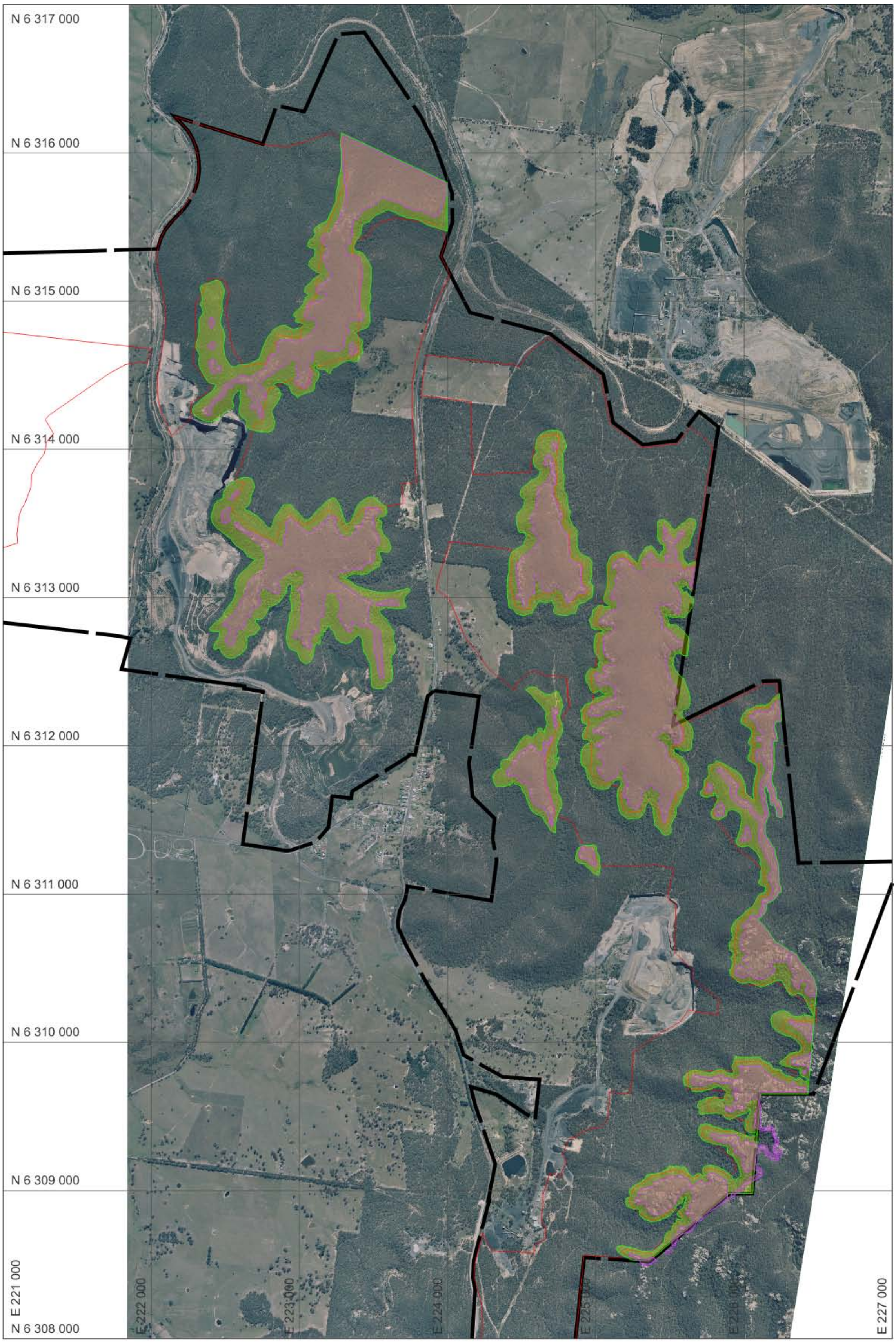

Figure 2: Identified slope types, cliff bound and talus bound from air photo analysis.

Area adjacent to the cliff and talus slopes will require a final risk review as part of the final pit design.

2.2 Previous Open Cut Mining

Coal mining has been carried out using open cut and highwall mining methods in this area since the 1950s, and show this style of extraction has operated in close proximity to the identified sensitive terrain. More recently, and described in section 2.1 above, the Cullen Valley Mine has successfully mined in topography at a distance of 100m from sandstone cliffs and pagodas, and as close as 170m from a sensitive Aboriginal heritage site with no detrimental effects.

As there has been typically a 100 metre buffer zone between the cliff faces and the open cut areas with no detrimental effects on highwall stability, and therefore cliff and pagoda stability, this would appear to be an appropriate buffer to risk manage the areas of sensitive terrain.

2.2.1 Establishment of a Buffer Zone around Slope at Risk

Previous experience at this location shows a 100 metre buffer zone is effective in managing risk to the identified sensitive terrain. Figure 1 has the 100 metre buffer zone applied throughout the proposed mining area. Review of the buffer zone width is possible where slope stability risk analysis is conducted on a site specific requirement. Detailed analysis of the aerial photography and ground investigation need to form part of the risk review of the mining areas to determine the final extent of the proposed open cut highwall.

3. CONCLUSIONS

The following conclusions can be made from this desktop study:

- This desktop analysis only examines the slope stability potential, relative to the position of the sandstone escarpments and pagodas, and the proposed open cut position proposed.
- The areas containing steep topography were identified from examination of detailed 1:25,000 scale topographic maps and colour aerial photographs enlarged to 1:10,000 scale. Slope or terrain at risk is readily identified through review of topographic maps, and can be delineated as shown in Figure 1. Greater detail is discernible using enlarged colour aerial photographs (Figure 2 and 3) and digital terrain contour plots could be used to create precise surface models.
- The distribution of talus and scree slopes is restricted to the immediate base of most cliffs with only thin scree deposits noted in previous site inspections. Talus and scree deposits forming much of the steep terrain are limited in extent and more detailed

investigation is required at final highwall design stage in order to fully delineate these features and risk assess their stability.

- The distribution of the cliff faces are largely joint controlled and this is typical of sandstone dominated terrain.

- Previous open cut mining in the area demonstrates that a 100 metre buffer zone is effective in protecting slope at risk which consists of steep terrain and cliffs. The risk of slope instability to the steep terrain is from the planned open cut operations. Without adequate controls, vibrations from blasting and potential slope failures from intersecting localised structures could impact the rock formations known as cliffs and pagodas. Without adequate controls, highwall mining can potentially destabilise cliff faces if subsidence related movement is initiated.

- To reduce the risk of interfering with these sensitive sandstone features, a 100 metre risk review buffer zone from the sandstone cliffs and pagodas is recommended as a risk management measure, and planned highwall mining would have to be designed to be stable with minimal subsidence.

- Local variation in final distance of mining from high risk cliff faces and rock formations within the 100m risk review buffer zone would be accomplished by completion of a suitable risk analysis of slope stability at individual sites based on site investigation and performance of the adjoining area of mining.

- The buffer zone presented is based on site experience and has not been assessed by SCT Operations. Therefore, on the basis of the buffer zone, site experience will indicate where further analysis is required. Each site and final highwall position should be assessed on the basis of local conditions. The final open cut boundary within the 100m buffer zone may be varied where required based on more detailed slope risk analysis.

4. RECOMMENDATIONS

4.1 Further Analysis

Further investigation would be required as input to detailed final highwall design and position in order to ensure stability. This would require the following inputs:

- More detailed contour data from a high resolution digital terrain model which could then allow analysis using computer slope stability analysis methods,

- stereo pair air photo interpretation can also provide more detail and

- field inspections, including mapping and shallow augering where confirmation of scree/talus depth is required.

This investigation would need to be conducted as part of the risk analysis of open cut mining adjacent to the areas identified as high risk talus/scree slopes and cliffs.

4.2 Monitoring

Management of the mining impacts of cliffs at the Coalpac Consolidation Project should comprise the following:

1. Photo documentation of all visible cliff faces should be conducted to form a base line of the existing conditions.

2. Detailed photo documentation of the pagodas and other rock formations, preferably utilising digital 3D photography where possible.

3. Establish an adequate survey methodology, either by direct measurement if access is possible or by remote sensing tools if access is not possible on selected cliffs and pagodas as mining progresses, and resurvey on a schedule based on the advance of mining; this is to monitor any creep or tilt of the cliffs.

4. Risk assess the cliff faces and pagodas to predict the impact of mining and reassess as required to determine if any response is required to minimise or control any further impact.

5. Construct hazard management plans for any areas deemed unsafe due to natural or induced instability.

6. Active monitoring of highwall development during mining should incorporate a detailed slope monitoring system to protect the work force and equipment, especially if instability is detected e.g. a radar based system can provide constant real time monitoring in areas of high risk of instability.