4.2 GROUND VIBRATION

There are several aspects to representing the ground vibration contour assessment, particularly:

- Limiting ground vibration at Residences to 5 mm/s;
- Limiting ground vibration at the SPL and Sandstone Outcrops to 100 mm/s;
- Limiting ground vibration at the Cullen Bullen General Cemetery to 20 mm/s;
- Limiting ground vibration at the Aboriginal Heritage Sites to between 20 and 100 mm/s based on the stability assessment of each location, and
- Worst case vibration from blasting is from the thickest interburden 20 – 30m thick between the Moolarben and Irondale coal seams.

The ground vibration predictions for the various interburdens, thicknesses and explosive types are shown in **Table 9(a).** The Moolarben-Irondale interburden was selected as the worst case situation at the pit shell boundary.

Ground vibration is analysed and predicted using Scaled Distance Site Law Formula in the form:

$$PPV = Kv\left(\frac{\sqrt{m}}{D}\right)^{1.6}$$

Where: *PPV =* Peak Particle Velocity (mm/s)
m = Charge mass per hole or per delay (kg)
D = Distance from blast (m)
Kv = A site constant

Table 9(a) – Predicted Milestone PPV Distances for Face Heights and 1.05 s.g. Emulsion Explosive

		Charge Mass				
Face Height (m)	**Column Height (m)**	**Charge/m (kg)**	**Mass/hole (kg)**	**5 mm/s Distance D_5 (m)**	**2 mm/s Distance D_2 (m)**	**1 mm/s Distance D_1 (m)**
30	25	34.0	850	858	1520	2350
20	15	34.0	510	665	1180	1818
14.5	9	34.0	306	515	913	1408
4.0	1.0	34.0	34	172	304	470

Note: The ground vibration could be reduced by the use of ANFO explosive (specific gravity 0.8, charge load 26.0 kg/m), which is normal Coalpac practice for dry blastholes.

Without any additional control measures, the ground vibration contours for a single blast are predicted to be as shown in **Figure 8a**.

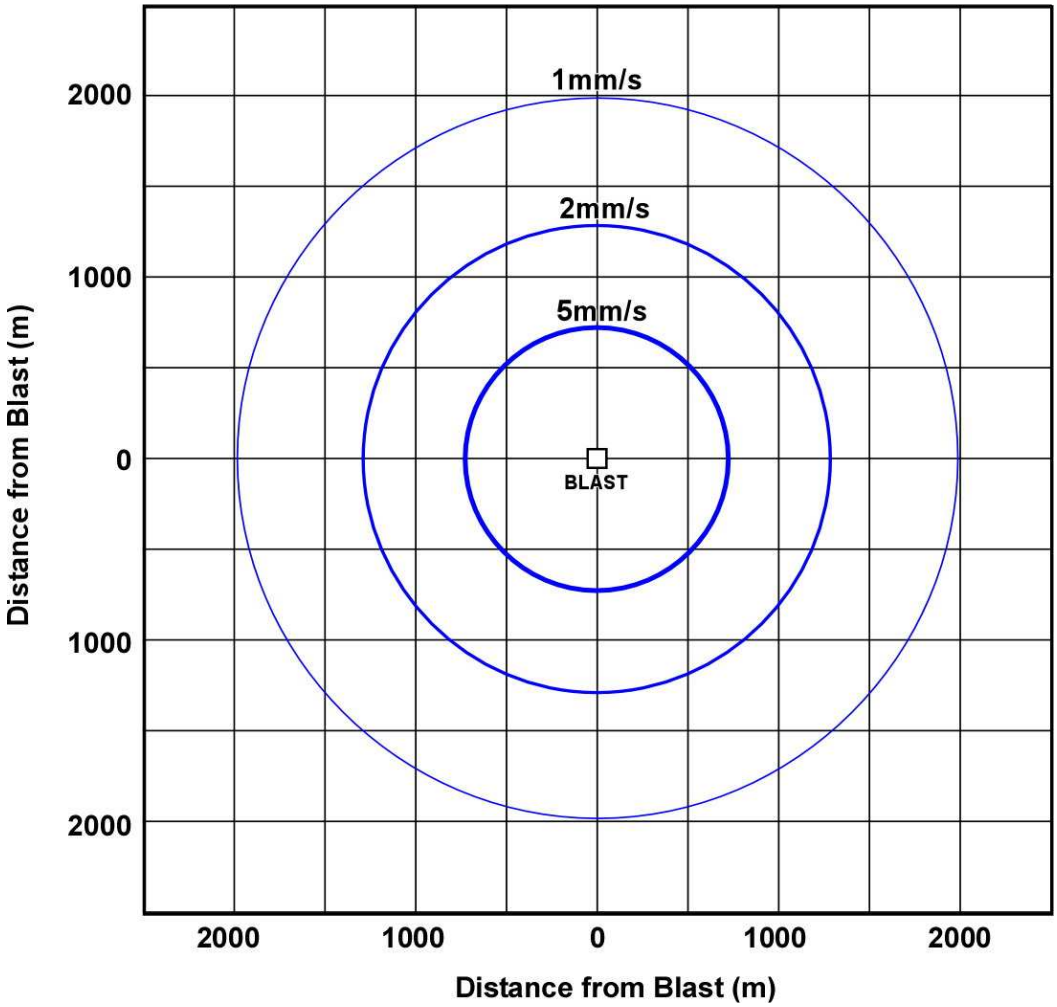

Figure 8a – Ground Vibration Contours for a 20m high face blast

To limit the PPV at the base of the SPL and Sandstone Outcrops to 100 mm/s will result in an attenuation of the ground vibration with increasing distance from the blast. This effect will mean that the bulk of the SPL and Sandstone Outcrop bodies will experience considerably lower ground vibration levels.

The resulting modelled attenuation of PPV away from the blast is represented graphically in **Figure 8b**.

The modelled results show PPV reducing by 70% within 100m away from the base of the SPL and Sandstone Outcrop travelling out from the blast centroid.

The distances shown have been used to create the contour plot shown in **Figure 8c**. Once additional control measures and blast management have been applied, these worst case levels will reduce even further.

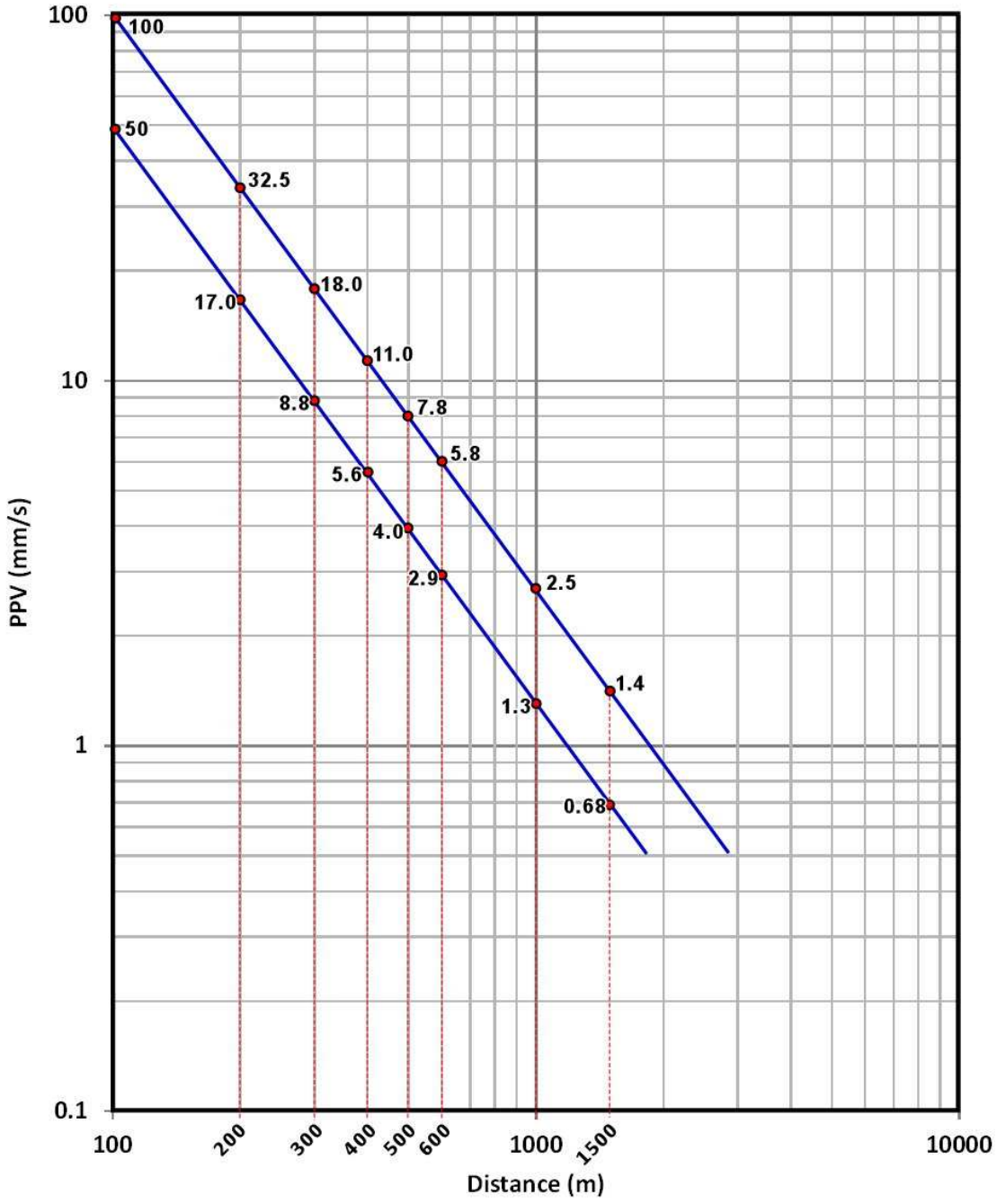

Figure 8b – Attenuation of PPV beyond SPL and Sandstone Outcrops for target limits of 50 mm/s and 100 mm/s at 100m from the blast

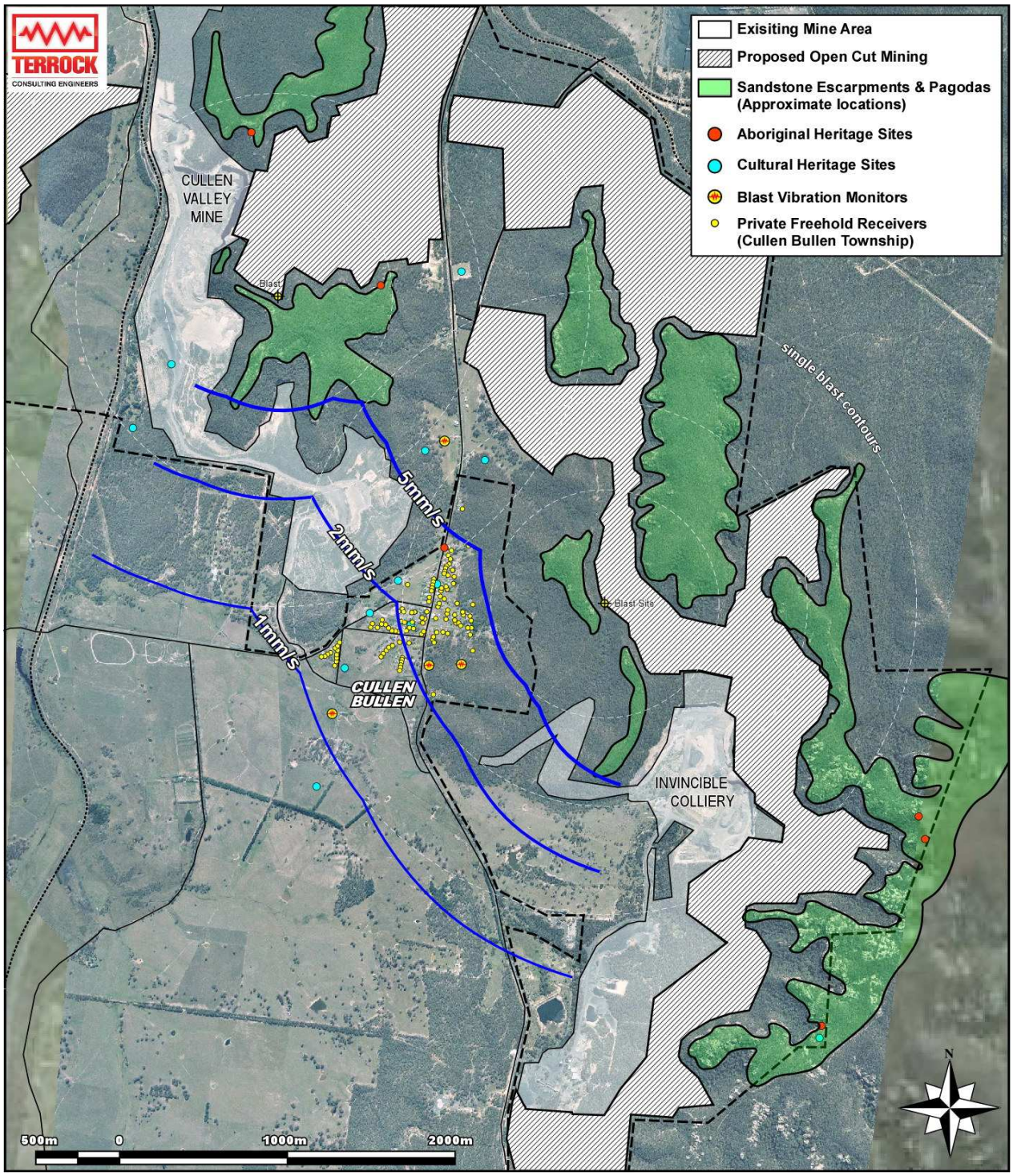

Figure 8c – Worst case ground vibration (PPV) contours from pit shell boundary with no additional control measures or blast management applied

How the 100 mm/s limit is complied with is considered to be a day to day design issue for mine staff as part of the Blast Management Plan. Blasts should be designed to incorporate a charge mass appropriate for achieving target vibration limits. Charge mass can be reduced by:

- The use of a less dense explosive such as ANFO;
- Splitting the explosive charge into two or more decks.

The initiation sequence and direction of firing can also be used to control vibration to target limits.

To achieve a 20mm/s target limit at sensitive receptors such as the Cemetery from a 20m high face may require a reduction of charge mass for blasts near the sites together with other control measures.

The remaining instrument of control over blast vibration is that it must not exceed the ANZEC guideline limits at any houses. The limits are:

≤ 5 mm/s for 95% of blasts within 12 months

≤ 10 mm/s for all blasts

Figure 8c demonstrates that the ANZEC guidelines can be complied with at the houses within the Cullen Bullen township. Blasts at different locations within the planned extraction will result in much lower vibration levels. In some mining areas it may be necessary to reduce the charge mass to achieve the 5 mm/s limits at the highway Residences, and 20 mm/s at the Aboriginal Heritage Sites and the Cemetery by controlled blasting practices. Limiting the ground vibration to regulatory limits would be part of the Blast Management Plan.

5. BLASTING AND CULTURAL HERITAGE SITES

5.1 BLASTING AND THE CULLEN BULLEN GENERAL CEMETERY

In relation to the Cullen Bullen General Cemetery, Coalpac have given the following commitments:

- (Commitment 30): Blasts required for any mining activities within 500m of the Cullen Bullen General Cemetery (the closest point being a distance of 250m) will be designed to manage vibration and overpressure levels.
    - No blasting will occur on days when formal services are scheduled at Cullen Bullen General Cemetery; and no mining or coal haulage within a 1,500m radius will occur within two hours of formal services at Cullen Bullen General Cemetery;
- (Commitment 46): To undertake a detailed archival recording and structural inspection of the Cullen Bullen General Cemetery in accordance with relevant guidelines prior to the commencement of coal extraction under this EA in consultation with LCC;
- Ground vibration at the Cemetery will be limited to 20 mm/s.

Recommendation 35 states, "*The Commission recommends no mining-induced damage is to be caused to any grave or gravestones at the Cullen Bullen cemetery. The Blast Management Plan must demonstrate how this would be achieved".*

The blast-related issues at the Cemetery can be summarised as:

- Disturbance, annoyance and amenity of visitors to the cemetery, especially during funeral services;
- Effect of ground vibration and overpressure on the stability of the gates and grave furniture (headstones, monuments etc);
- Potential for damage from flyrock to the grave furniture.

5.1.1 Annoyance

The human annoyance issue has been addressed in Commitment 30 in relation to the control of activities within two hours of any formal services.

5.1.2 Structure Response

From personal observations, the stability of grave furniture is largely a function of their physical dimensions and geometry, the foundation soil characteristics, surface drainage, weed and rabbit control. The main potential for damage is tilting or toppling of a tall monument when the centre of gravity extends beyond the outline of the base. Tilting and collapsing of short monuments is also a possibility if they are not adequately supported by the soil surrounding the actual grave excavation. This can be exacerbated if drainage, weeds and rabbits are not controlled.

Photos of the Cemetery in the Historic Heritage Assessment show that there are no tall monuments or headstones. The tallest structures appear to be the brick piers of the entrance gates. An excessive response of the cemetery structures to the vibration is therefore not expected. The detailed structural inspection will identify any structures considered vulnerable to tilt or dislodgement for special attention.

To give an appreciation of the effect that ground vibration may have on the cemetery structures, the surface displacement can be determined from Sine Wave Theory:

$$\text{Peak Particle Displacement (PPD)} = \frac{PPV}{2 \cdot \pi \cdot f}$$

Where: PPV = Peak Particle Velocity (mm/s)
f = frequency (Hz)

The frequency of the ground motion is related to the initiation sequences during firing. At close distances the frequency of the ground motion will be 10 – 15 Hz. At 20 mm/s, the maximum surface movement in any direction therefore is:

$$\text{PPD} = \frac{PPV}{2 \cdot \pi \cdot 10 \rightarrow 15} = 0.2 - 0.3\text{mm}$$

The wavelength of the motion is the seismic velocity divided by the frequency, e.g.

$$1200 \div 10 \rightarrow 15 = 80 \rightarrow 120\text{m}$$

Assuming a 2.0m length for the grave furniture, the maximum actual displacement along the length of the grave is shown in **Figure 9.**

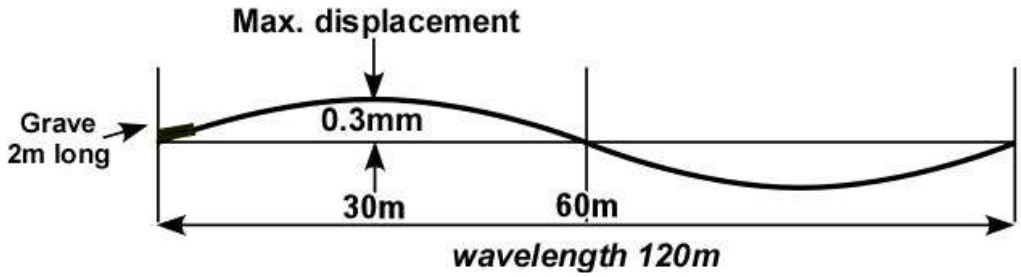

Figure 9 - Dimensions of Surface Wave Motion relative to a grave (not to scale)

The peak displacement over the length of a grave is 2.0 x 0.3 ÷ 30 = 0.02mm.

For comparison, the thickness of a human hair averages 0.1mm. The maximum surface movement of grave furniture is about one fifth of the thickness of a human hair, and the possible effect of ground motion is therefore considered to be negligible.

5.1.3 Flyrock

The risk to visitors from flyrock is addressed by the Commitment 30 and enforcement of an exclusion zone at time of blasting to ensure that no visitors are present within 500m of a blast (this is current practice).

The potential damage from flyrock is quantified in the Terrock report "*Mitigation of the Effects of Blasting in the Coalpac Consolidation Project*" (7th August, 2012). Behind face blasts, the maximum throw from standard operating practice from face blasts is 20m and for shallow parting blasts is 45m. The minimum distance to the cemetery boundary is 250m.

Based on this geometry the Factor of Safety for the grave furniture from flyrock varies from 5 → 12.

5.2 BLASTING AND ABORIGINAL HERITAGE SITES

Coalpac have given the following commitments in relation to Aboriginal Heritage Sites:

- (Commitment 43): Coalpac will conduct relevant monitoring at all rock shelters with deposit sites as shown in Figure 40 when blasting within 500m of each to achieve the criteria in Table 30 (Environmental Assessment).

  Safe access tracks will be installed to facilitate this in accordance with the Land Disturbance Protocol to the approval of relevant regulators.

- Ground vibration at the Aboriginal Heritage Sites will be limited to between 20 mm/s and 100 mm/s based on the stability assessment for each site.

- PAC Recommendation 34 states, "*The Commission recommends ground vibration criteria for Aboriginal heritage rock shelters should not be greater than the criteria set out by the Proponent, that is half the recommended ground vibration criteria and 3dB below the overpressure criteria. The Blast Management Plan should demonstrate how blasting can occur with negligible mining-induced damage of the Aboriginal rock shelter RCK2-10".*

  Regular condition and vibration compliance monitoring and blast design to achieve the target PPV limit will ensure that the PAC's Recommendations are achieved. Areas around the Aboriginal Heritage Sites with lower stability assessments may require a charge mass reduction to achieve the target PPV limit.

Blast design for ground vibration (PPV) control should be part of the Blast Management Plan and has been proven to be effective on site.

6. STAGED MONITORING AND MANAGEMENT PROCEDURE TO PROTECT THE SPL AND SANDSTONE OUTCROPS

Recommendation 38 states, *"The Commission recommends that there should be no impacts to the pagodas and cliff lines from blasting. The Commission does not accept that a 50m buffer will guarantee this outcome, but is unable to determine a satisfactory buffer distance from the available information. To accommodate this situation the Commission recommends that no blasting occur within 300m of the pagodas or cliff lines without an independent geotechnical surveyor certifying that the blasting proposed will not cause impact to the pagodas or cliff lines. In any event a minimum stand-off distance of 100m must be maintained for blasting from all pagodas, cliffs and other rocky outcrops*".

Protection of the SPL and Sandstone Outcrops from blasting, to achieve the PAC's recommendations of "*no impacts*" is a proposed series of arbitrary stand-off distances. The distances range from 50m (the Proponent) through to 100m (PAC recommendation 38 with certification from an independent geotechnical surveyor) to 300m (PAC recommendation 38).

Coalpac has shown (Section 3.2) that blasting has occurred closer than 100m to Sandstone Outcrops without detrimental impacts, but without detailed monitoring at the Sandstone Outcrop at the time.

Analysis of the records show that blasting has occurred as close as 57m to the Sandstone Outcrop in the Cullen Valley Mine. The vibration levels at the base of the Sandstone Outcrop are predicted to be in the range of 185 to 213 mm/s based on a proven site Kv factor.

There were no discernible signs of impact upon the Sandstone Outcrop from this vibration exposure. This supports the proposed vibration limit of 100 mm/s for the Sandstone Outcrops.

The SPL has been identified as requiring a higher level of protection than the Sandstone Outcrops. To provide this higher level of protection will require refinement and further confirmation of the science on which to provide a reliable basis for determination of the distance(s) and ground vibration limits for the protection of the SPL.

It is logical that a PPV limit is a preferred basis for protection of both the SPL and Sandstone Outcrops than a stand-off distance, because it is easy to routinely measure and report, and it is also the relevant controlling parameter.

The evidence to date is that ground vibration of 100 mm/s resulting from blasting will have negligible impacts on the stability of the SPL and Sandstone Outcrops, even allowing for natural weathering processes.

The Proponent has demonstrated that by using managed blast design techniques, ground vibration can be controlled to a specified limit.

The instrument of control of blast vibration for structures should be a non-damaging limit (i.e. measured as a limit of vibration), rather than an arbitrary distance (i.e. stand-off) limit. The appropriateness of the 100 mm/s non-damaging limit for SPL should be proven and demonstrated by a multi-disciplinary investigation which includes analysing the effects of controlled and closely monitored blasts.

This exercise should also look to further confirm and refine the site factor Kv for the strata close to the SPL.

6.1 DEMONSTRATION AND PROVING BLASTING EXERCISES

There are over 12km of planned pit shell where the proximity to the SPL and Sandstone Outcrops may strongly influence the mining practice and extraction sequence over the life of the Contracted Project. Open cut mining will take place over 21 years.

As a result, the rock mechanics hazard mapping (Hazmap) classification of the SPL and Sandstone Outcrops prior to Contracted Project blasting does not have to be completed for the entire area in advance. The Hazmap classification (Commitment 8) needs to stay ahead of mining production and can therefore be staged to stay in advance of the planned extraction for the life of the Contracted Project. A review of these areas should also be conducted in conjunction with review of the condition of the SPL and Sandstone Outcrops post-mining.

The proposed extraction sequence is to advance the Invincible Colliery southern face to the south and mine out to the southern extraction limit. This is estimated to take 2 to 3 years. Extraction will then advance to the east towards the SPL. Concurrently with this advance, the Cullen Valley Mine face will be progressed to the East, before turning to the South towards the Sandstone Outcrops.

6.1.1. Site Factor Kv Exercises

The southern extension at Invincible Colliery is the logical place to further confirm and refine the site factor Kv for the strata close to the SPL (Site Factor Kv Exercises). The proposed area for the Site Factor Kv Exercises is highlighted in **Figure 10**.

Additional arrays of blast monitors should be located to the east of the site to measure PPV for all blasts, and conduct sufficient strain measurements to confirm the relationship between PPV and strain for blasts on the various horizons as operations progress to the south.

The data would be gathered, collated and analysed to confirm and refine a Scaled Distance Site Law to increase the confidence of initial blast design when moving to the east towards the SPL.

A similar Site Factor Kv Exercise will be conducted in the Cullen Valley Mine to determine a Scaled Distance Site Law towards the Sandstone Outcrops. This in turn will enable the advance towards the Sandstone Outcrops to be conducted with increased confidence prior to the commencement of the Non-damaging Limit Exercise.

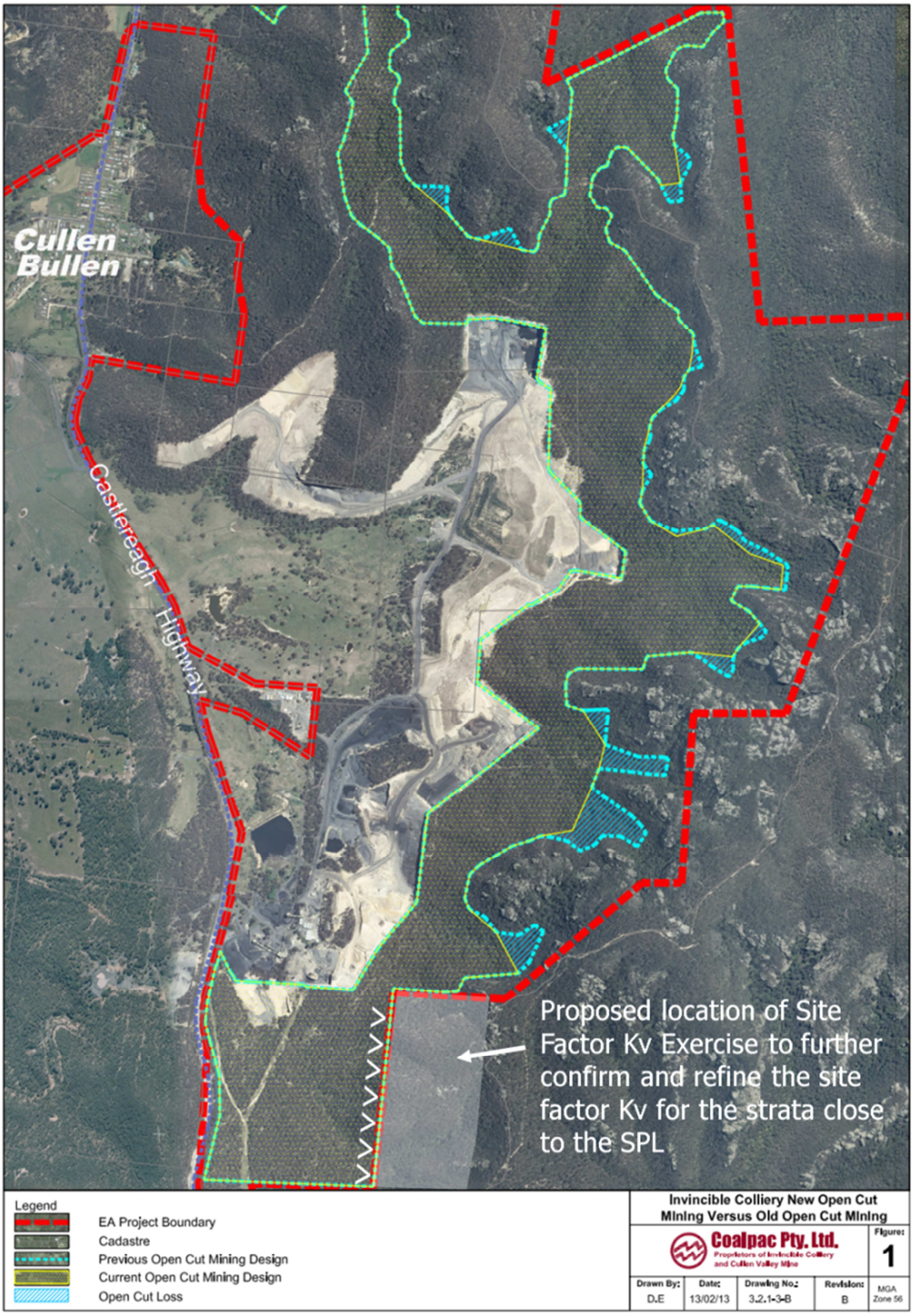

Figure 10 – Location Plan showing site of proposed Site Factor Kv Exercise

6.1.2. Non-damaging Limit Exercise

The Proponent proposes to conduct a multi-disciplinary investigation which includes analysing the effects of controlled and closely monitored blasts to prove and demonstrate the appropriateness of the 100 mm/s non-damaging limit initially for the Sandstone Outcrops in the Cullen Valley Mine. The proposed area for this exercise is highlighted in **Figure 11**.

Rather than an arbitrary distance, a more effective control mechanism would be an interim vibration limit at the base of the Sandstone Outcrop of, say 50 mm/s while the Non-damaging Limit Exercise is conducted.

A program of reduced vibration limits and intensive monitoring program (Non-damaging Limit Exercise) would permit a regulated, measured approach as each successive blast nears the Sandstone Outcrops. For example, for a full 20m face blast using a single column of explosive charge of 510 kg, the predicted ground vibration at 300m is 17.8 mm/s. At 150m, the predicted ground vibration is 54 mm/s. At 100m, the predicted range of ground vibration 103.5 mm/s. However, at 100m, if the charge is halved by decking, the range of ground vibration becomes 42.4 mm/s to 59.4 mm/s.

Based on previous blasting experience, it would seem that the Non-damaging Limit Exercise could commence with blasts at 200m from the Sandstone Outcrop in question with an interim PPV limit of 50 mm/s.

The Non-damaging Limit Exercise would begin at 200m from a Sandstone Outcrop and move closer until vibration trigger levels (50 mm/s) show that the rock mass is remaining stable.

Rock strength characteristics for the sandstone sequence (including Unconfined Compressive Strength, tensile strength, and Young's Modulus) should be determined from physical testing as an input to assist prediction of the rock mass response to vibration.

As information is gathered over time, and the response of the rock mass is monitored through mapping and photogrammetry (as examples), blast designers can then initiate design changes progressively, keeping below trigger levels at all times and ensuring negligible impacts. Once blasting at the interim target limit of 50 mm/s has proven to have no impact, the target limit may be incrementally increased in steps to say 75 mm/s and 100 mm/s. The stability of the Sandstone Outcrop must be established before advancing to a higher level.

The experience gained at the Sandstone Outcrops in the Cullen Valley Mine will be utilised when progressing towards the SPL in the Invincible Colliery to ensure that non-damaging target limits are applied.

The target ground vibration limits, and further monitoring should then be included in the Blast Management Plan for the Contracted Project.

6.1.3. Timing of Blasting Exercises

The Site Factor Kv Exercises at the Cullen Valley Mine and the Invincible Colliery coupled with the Non-damaging Limit Exercise will be completed within the first 12 months of the Contracted Project and before the Invincible Colliery blasts approach within 200m of the SPL.

If other faces are advanced during this period, the collecting of data and developing of Site Laws at other mining locations is a routine part of a Blast Management Plan.

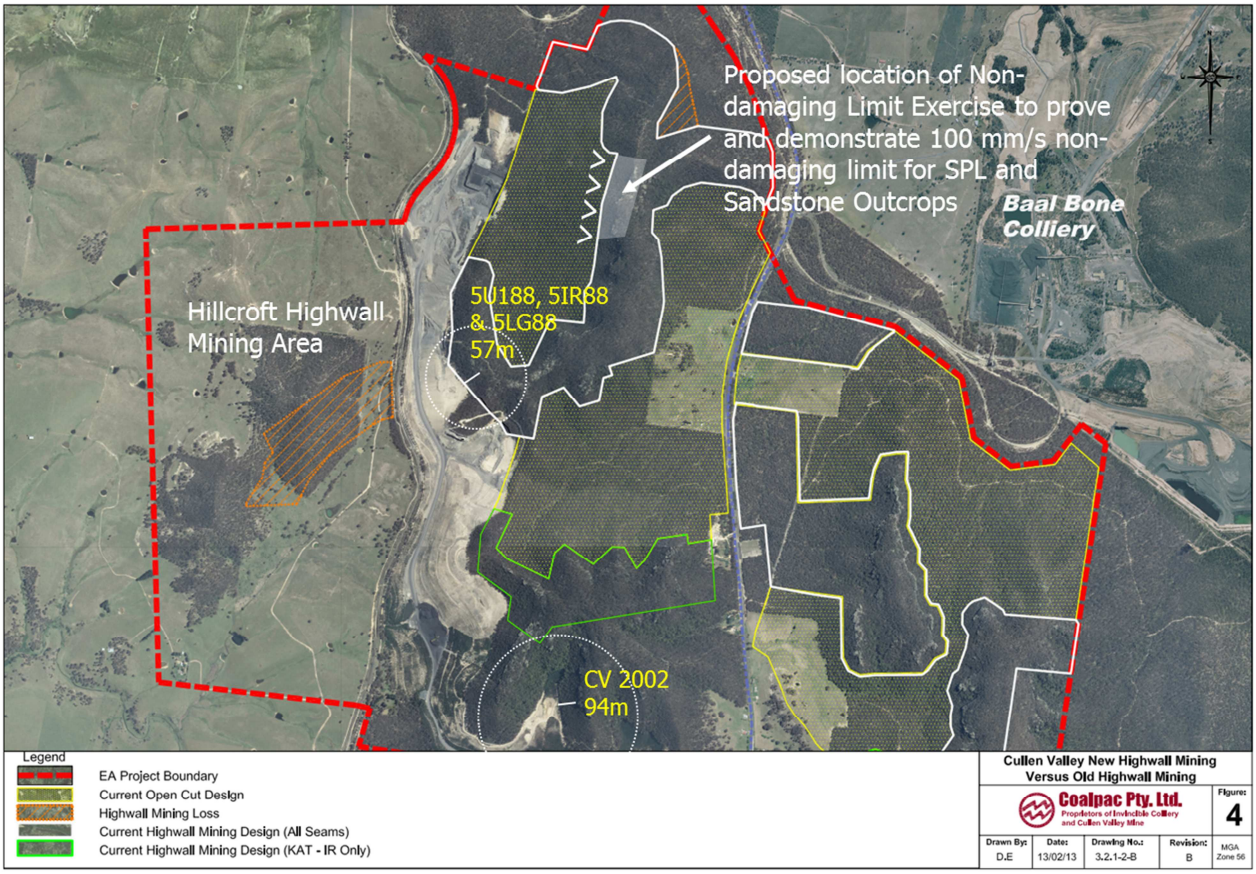

Figure 11 – Location Plan showing site of proposed Non-damaging Limit Exercise

7. SUGGESTED BLAST MANAGEMENT PROGRAM AS OPERATIONS APPROACH SPL AND SANDSTONE OUTCROPS

The data gathered in the proposed blasting exercises would be used to introduce a refined blast management program for operations adjacent to SPL and Sandstone Outcrops. The main steps of such a program are outlined below.

(1) Collation and analysis of data gathered from the Site Factor Kv and the Non-damaging Limit Exercise to provide reliable site specific parameters to support predictive modelling with confidence;

(2) Predictive modelling will be carried out initially to limit predicted levels to 100 mm/s or other agreed limit. These will be the trigger levels at which re-design or reduced design parameters will be implemented.

(3) Establish the condition of the Sandstone Outcrops near the area of close monitoring (see **Figures 10** and **11**) by enacting Commitments 7 and 8 of the Exhibited EA and produce a Hazard Map to identify and classify zones in terms of stability;

(4) Prior to advancing blasting towards the Sandstone Outcrops at the Cullen Valley Mine, install geophones on solid rock at the top and bottom of the Sandstone Outcrops at the nearest point to the blasting face. Install strain gauges at the base of the Sandstone Outcrops near the geophone, and record the rock mass response to blasting, using photogrammetric techniques.

(5) After the Non-damaging Limit Exercise at the Cullen Valley Mine to determine the relevant design criteria, a similar exercise must be conducted before advancing towards the SPL at the Invincible Colliery.

(6) It is recommended that the Proponent should present to Independent Review Committee, with suitable technical and regulatory representation, to monitor the performance of the blast management program in the proximity of the SPL and Sandstone Outcrops but also with respect to Residences, the Cemetery, Aboriginal and Non-Aboriginal Heritage Sites on a quarterly basis for the first two years. The frequency of the meetings could reduce to biannual after two years.

The above program should be used as the basis of a Blast Management Plan to safely approach to 50m from the SPL and Sandstone Outcrops, with confirmation by routine PPV measurements of all blasts coupled with observations of the rock mass.

It can be argued that both 50m and 100m extraction distances are equally arbitrary, i.e. distance is not the governing factor. The mechanisms by which the SPL and Sandstone Outcrops may be affected are ground vibration and static and dynamic instability.

In sections of the faces with no potential for instability, it could be argued that a 50m extraction limit may be appropriate if supported by the science, with ground vibration limit as the control and present no greater risk than the 100m extraction limit.

8. JUSTIFICATION FOR THE PROPOSED BLAST MANAGEMENT PROGRAM

In the past blasting has occurred to within 57m of a Sandstone Outcrop at the Cullen Valley Mine without discernible damage. The ground vibration was not measured at the time but can be reasonably estimated using a proven Kv factor and actual blast records.

Analysis has concluded that the ground vibration exposure was in the range 185 – 213mm/s.

To apply a scientific approach to predicting the response of the rock mass to blasting, a methodology has been developed at other mines which compares the tensile strain induced by vibration with the strength characteristic of the rock.

The blast management program has three phases:

(1) Collect facts and information and confirm the effectiveness of current controlled blasting practice in achieving target limits;

(2) Refine existing controlled blasting practices to achieve new target limits and outcomes, and

(3) Control the blasting process to comply with new target limits and confirm ongoing compliance.

The science behind this approach can generally be summarised as follows:

- Direct strain measurements by Terrock at Ravensworth North Mine in the Hunter Valley have shown that ground strain can be determined by Plane Wave Strain Theory whereby

$$\text{Peak Ground Strain (Tension or Compression)} = \frac{\text{PPV (Peak Particle Velocity)}}{\text{Shear Wave Velocity}}$$

- Shear wave velocity can be determined from a vibration wave trace using the speed of sound in air as a calibrator. From experience at other sites, the shear wave velocity is nominally 1200 m/s;

- The conservative range of flexural tensile strains indicated from the Tables in AusIMM Field Geologists' Manual is the range 140 με to 1000 με. Measurement of properties of the collected sandstone specimens from site will provide actual data. Blast induced stresses that do not exceed the natural strength properties of the rock will not form new cracks;

- Typical example of Strain Comparisons is as follows:

  PPV = 100 mm/s

  Ground Strain = $\frac{100}{1200 \text{ x } 10^3}$ = 83.3 με

  Compared to Flexural Tensile Strain = 140 $\rightarrow$ > 1000 με

- This approach is reinforced by on-site measurement of an overhang failure by the author at the Mangoola Mine in the Hunter Valley. The dimensions of the failed overhang were measured and analysed as a cantilever beam failure. The flexural tension of the upper surface of the failed overhang was determined to be about 2 MPa. Using a Minimum Elasticity Modulus of 10 Gpa, the failure strain indicated is about 200 με, which provides order of magnitude confirmation of the previous assumption;
- The science suggests that a PPV of 100 mm/s would not exceed the tensile flexural strength of typical sandstone and has a considerable safety factor for the weakest sandstone. New cracks would therefore not develop in the sandstone. From investigations at other sites, the articulations provided by vertical and other joints allows for considerable flexure of the rock mass before new cracks are likely to form, so this approach is also considered to be conservative;
- Also, the entire rock mass flexes as an integral unit as the waves pass with no discordant motion likely to concentrate stress and cause damage or loose blocks to fall. This may be evidenced from video recording of open cut high wall blasts. Any damage to the rock face only occurs locally just beyond the extremities of the blast pattern;

- The rock mass of the SPL and Sandstone Outcrops appears to consist of sub horizontal structures (bedding/coal seams etc) and sub-vertical structures such as joints, which control the formation of the SPL and Sandstone Outcrops, and appear to be quite structurally stable. The rock faces should be closely surveyed for the presence of steep angled structures which may affect local stability by slip or wedge failure. This approach may not anticipate the falling of loose rock 'seats' shaken from unstable seats and some minor falls of small rock seats may be expected. Savely's observations (Table 5 of the Terrock 7th August 2012 report) suggest that this occurs at about 125 mm/s. The behaviour of the representative rock mass when exposed to vibration therefore needs to be assessed;
- A greater understanding of the rock mass behaviour will be gained by the proposed Site Factor Kv and Non-damaging Limit Exercise.

9. SUGGESTED CONDITION TO GIVE CERTAINTY THAT BLASTING WILL NOT DAMAGE THE SPL AND SANDSTONE OUTCROPS

In Recommendation 38, *"The Commission recommends that there should be no impacts to the pagodas and cliff lines from blasting"*.

A suggested condition for insertion in the Project Approval is as follows:

Blasting operations will not visibly impact or damage the Significant Pagoda Landforms and Sandstone Outcrops adjacent to the mining areas.

Ground vibration will be measured at a series of locations for each blast. Sufficient direct strain measurements will be taken to confirm the relationship with PPV (Site Factor Kv Exercise).

Blasts will be designed to achieve incrementally increasing PPV target levels (50, 75 and 100 mm/s) at the base of the Sandstone Outcrop, with assessment of the rock mass stability at each level before progressing to demonstrate and prove trigger levels (Non-damaging Limit Exercise).

Advancing the mine faces towards the pagodas will be conducted as a TARP process, after the proving Exercises are completed, beginning 200m from the base of the SPL and Sandstone Outcrops.

Prior to the blasting approaching within 200m of SPL or Sandstone Outcrops, the stability of the rock mass will be assessed and a Hazard Map produced to identify any unstable areas.

The blasting practice to achieve the target PPV limits should be detailed in a Blast Management Plan.

Adrian J. Moore
5th March, 2013

APPENDICES

APPENDIX 1: SUMMARY OF PAC RECOMMENDATIONS APPLICABLE TO BLASTING

Recommendation 34: *The Commission recommends ground vibration criteria for Aboriginal heritage rock shelters should not be greater than the criteria set out by the Proponent, that is half the recommended ground vibration criteria and 3dB below the overpressure criteria. The Blast Management Plan should demonstrate how blasting can occur with negligible mining-induced damage of the Aboriginal rock shelter RCK2-10.*

Recommendation 35: *The Commission recommends no mining-induced damage is to be caused to any grave or gravestones at the Cullen Bullen cemetery. The Blast Management Plan must demonstrate how this would be achieved.*

Recommendation 36: *The Commission recommends no mining or coal haulage occurs within a 1.5km radius of the Cullen Bullen cemetery on any Saturday, Sunday or Public Holiday.*

Recommendation 37: *The Commission recommends that the Proponent's approach to controlling noise and vibration from blasting at residences by reducing the MIC and increasing the number of blasts to be rejected as imposing an unreasonable impact on the residents. Any exceedence of the ANZEC guideline for blasting frequency should be strictly limited, particularly when the expected noise or vibration levels are likely to be at or close to the limits.*

Recommendation 38: *The Commission recommends that there should be no impacts to the pagodas and cliff lines from blasting. The Commission does not accept that a 50m buffer will guarantee this outcome, but is unable to determine a satisfactory buffer distance from the available information. To accommodate this situation the Commission recommends that no blasting occur within 300m of the pagodas or cliff lines without an independent geotechnical surveyor certifying that the blasting proposed will not cause impact to the pagodas or cliff lines. In any event a minimum stand-off distance of 100m must be maintained for blasting from all pagodas, cliffs and other rocky outcrops.*

Recommendation 39: *The Commission recommends that strict monitoring requirements which allow detection of any blasting-induced impacts to pagodas, cliff lines or rocky outcrops be required in the event that the project proceeds.*

Recommendation 40: *The Commission recommends that the Department review the mechanism used to assess complaints of blast damage to private property with a view to providing the residents with confidence that their claims are being assessed by a qualified person who is transparently independent from the Proponent.*

APPENDIX 2: SUMMARY OF COALPAC COMMITMENTS APPLICABLE TO BLASTING

Ref	Commitment
6	No mining operations will occur within 500m of a residence located outside of Cullen Bullen without prior agreement between Coalpac and the landholder.
7	Conduct and document regular inspections associated with the highwall joint conditions, joint orientations and overall stability of the highwalls, to be undertaken by appropriately qualified geotechnical specialists. Geotechnical mapping of highwalls and regular pagoda and escarpment inspections via physical or photogrammetric methods will be carried out as design and risk assessment inputs.
8	The Project Highwall Mining Management Plan (see EA SOC Ref 8) will include at least the preparation of: • A Hazard Map (vertical elevation) of the highwall, defining and locating any significant hazards and potential zones of localised (small scale) instability. The highwall mining layout will be aligned with a surveyed baseline. This baseline will be set out and validated by the mine surveyor. Any other localised hazards or restrictions to work practices shall be included on the Hazard Map; • Highwall Mining Plan (plan view) showing the pillars and Barrier Pillars, survey baseline, toe position, crest position, surface features including pagodas and escarpments/cliffs and any other significant features; and • Risk Assessment specifically addressing the risk of instability of the highwall (large scale) that could threaten any surface cliff and pagoda features, and the risk of pillar instability and surface subsidence >20 mm (the design criteria).
22	The additional noise attenuation works for the ICPP as described in the AIA and EA will be undertaken by Year 2 of the Project.
30	Blasts required for any mining activities within 500m of the Cullen Bullen General Cemetery (the closest point being a distance of 178m) will be designed to manage vibration and overpressure levels. No blasting will occur on days when formal services are scheduled at Cullen Bullen General Cemetery; and no mining or coal haulage within a 1,500m radius will occur within two hours of formal services at Cullen Bullen General Cemetery;
43	Coalpac will conduct relevant monitoring at all rock shelters with deposit sites as shown on Figure 40 when blasting within 500m of each to achieve the criteria in Table 30. Safe access tracks will be installed to facilitate this in accordance with the Land Disturbance Protocol to the approval of relevant regulators.
46	Coalpac will undertake a detailed archival recording and structural inspection of the Cullen Bullen General Cemetery in accordance with relevant guidelines prior to the commencement of coal extraction under this EA in consultation with LCC.
71	Coalpac will continue to work with relevant individuals to minimise any inconvenience due to blasting required within a 500m radius of a residence. Any blasting event within this radius shall be planned and the landholder notified with 7 days, and any inconvenience on the day of the blast shall be limited to no more than one hour.