P O Box 829
Eltham Vic 3095
Phone: (03) 9431 0033
Fax: (03) 9431 1810
URL: http://terrock.com.au
Email: terrock@terrock.com.au
ABN: 99 005 784 841

Alan B. Richards
Ph.D, F.I.E. Aust., F. Aus I.M.M., F.I.Q.

Adrian J. Moore
Dip.C.E.,B.E.(Min.), M.Eng.Sc., M.I.E.Aust.

BARRO GROUP PTY LTD

BLAST IMPACT ASSESSMENT FOR THE PROPOSED EXTENSION OF MOUNTAIN VIEW LITTLE RIVER QUARRY (WA453)

March 2023

BARRO GROUP PTY LTD

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TERROCK
CONSULTING ENGINEERS

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Eltham Vic 3095
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Fax: (03) 9431 1810
URL: http://terrock.com.au
Email: terrock@terrock.com.au
ABN: 99 005 784 841

Alan B. Richards
B.Sc.(Tech), F.I.E.Aust., F.Aust.I.M.M.,F.I.Q.

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1 INTRODUCTION

The operator of Little River Quarry, Barro Group Pty Ltd, has proposed to extend the quarry's extraction area to increase the available stone resource and prolong the life of the quarry. As part of the application for a Work Plan Variation, Terrock Consulting Engineers was requested to assess the effects, risks and impacts of blasting in the proposed extension area with respect to neighbouring land use and sensitive receptors in the surrounding area, the findings of which are contained in this report.

Attention is given to the risk and control of flyrock with regard to public land areas and private property adjacent to the quarry, and the practical application of blast clearance zones to mitigate the risk of excessive flyrock throw. Consideration is also given to the impacts of blasting to the amenity of You Yangs Regional Park, the safety of park visitors and the effects of blasting on native fauna species.

The ability of the quarry operator to maintain compliance with regulatory limits for ground vibration and airblast has also been assessed through predictive modelling and analysis of blast monitoring records from the site. The proposed extension area remains relatively remote from sensitive sites and populated areas, and the current low impacts to amenity would be maintained in the future.

The subjects of dust, air quality and audible noise from quarries (of which blasting is a contributor) are largely outside the writer's qualifications. Assessment of such topics may be undertaken by experienced consultants as needed.

2 QUARRY AND BACKGROUND

The Little River Quarry (operating within Work Authority No. 453) is located at Sandy Creek Road, Little River, Victoria. The quarry is within the local government area of City of Greater Geelong and is located approximately 22km north of Geelong and 8km northwest of the township of Little River.

A granite quarry was established on the Work Authority in 2014-15 by Barro Group. The rock is extracted by traditional drill and blast methods and processed onsite for sale to the regional and metropolitan construction industry.

3 PROPOSED EXTENSION AREA

The proposal is to expand the extraction area from the currently approved 16.3 hectares to approximately 62 hectares, primarily east and south of the current extraction limit. The proposed extraction area (as shown on site plans) includes space for stockpiles, workshops and other infrastructure that would remain in the western area of the quarry at 165m RL. A large proportion of the stone resource would be sourced from an expansion and deepening of the quarry's pit area that is centred in the eastern two-thirds of the proposed extraction area.

Staging plans (produced by BCA Consulting) show four extraction stages summarised as;

- **Stage 1** – extraction progressing northeast to the proposed extraction limit, and southwest to level and widen the floor for future plant and stockpiles (165m RL)
- **Stage 2** – extraction in all directions (excluding northeast) to the proposed extraction limit, completing upper-level blasting above 165m RL.
- **Stage 3** – widening and deepening the pit area (165m RL to approximately 90m RL) in eastern two-thirds of the extraction area.
- **Stage 4** – continued deepening of the pit to terminal floor at 60m RL.

No blasting is required in the northwest boundary area, the current workshop and dam area adjacent to the Ford Proving Grounds. A limited number of upper-level blasts would occur within 100-200m from the boundary to help widen the existing floor, but no blasting is anticipated within approximately 100m of the boundary as this area is already at the design floor level.

Design plans show up to 9-10 benches/levels from pit floor to crest with a maximum bench height of 15m. Some smaller scale blasts (5-10m depths) are likely in the upper/surface layer to assist the formation of stable terminal batters, and because a proportion of the weathered, surface material would be excavated mechanically.

The quarry currently fires a maximum of one blast per week. This frequency is expected to continue under the extension proposal, in line with other medium-large quarries that supply the Melbourne metropolitan market.

4 LOCAL GEOLOGY AND TERRAIN

Granitic sands have been sourced from WA453 and nearby Work Authorities for many years. This material overlies Late Devonian You Yangs Granite, the coarse-grained hornblende rock that is extracted at Little River Quarry. The rock exhibits some weathering in the upper layer with moderately jointed to massive structure occurring at depth. The type and classification of rock at quarries is generally unimportant for assessing blasting vibration levels because the transmission of ground vibration is mostly influenced by ground structure and conditions across the broader area.

The quarry is situated within the northern foothills of the You Yangs granite inselberg and the extraction area/pit is elevated above the surrounding plain. The pit is surrounded by hills and ridges on all sides except to the northwest where the natural surface slopes down to the Ford Proving Grounds. The quarry's elevation and surrounding hills form a natural barrier that reduces airblast levels in most directions, and may also reduce the horizontal distance rock fragments could be thrown during an excessive flyrock event.

5 SURROUNDING LAND USE

The Little River Quarry is surrounded by;

- private freehold land (to the immediate north and east)
- You Yangs Regional Park (southeast)
- Work Authority 437 (south and southwest)
- Ford Proving Grounds (to the immediate northwest).

The minimum separation distances (i.e., buffers) from the proposed extraction limit to the boundaries of neighbouring land areas are;

- private land (SSAA Eagle Park Range), north/northeast – 100m
- private land (zoned for farming), east – 550m
- You Yangs Regional Park, southeast - 200m
- Work Authority 437 (Boral Ltd), south – 380m
- Ford Proving Grounds, northwest - 25m (estimated to be 100-200m from closest potential blasts).

The closest area to the quarry with public access is the northernmost section of You Yangs Regional Park with a minimum separation distance of 200m from the proposed extraction limit. This section of the park contains numerous mountain bike tracks known as the Stockyards Mountain Bike Area. The area is accessed via Drysdale Road that terminates at the southeast corner of the Work Authority. The Stockyards Mountain Bike Area is serviced by a small carpark located 830m from the proposed extraction limit.

The Sporting Shooters Association of Australia (SSAA) Eagle Park Range is located northeast of the quarry at the western end of Gifkins Road. The site's activity areas (shooting ranges, clubhouses, etc.) are located a minimum 550m from the proposed extraction limit. The land between the SSAA facilities and quarry boundary is under ownership of SSAA and is not accessible to the public or general club members. The quarry and range are separated by a steep hill with granite outcrops and there is no line-of-sight between the two properties.

The closest section of the Ford Proving Grounds is a remote area at the southeast corner of the property. A vehicle track passes through this area at a minimum 150m from the extraction limit though it is reported to be used infrequently. The site's main facilities are located more than 2km northwest of the quarry.

The land immediately south and southwest of the quarry is Work Authority 437 under ownership of Boral Ltd. No major extractive operations are thought to have occurred on the neighbouring Work Authority and future use of the site is not known.

The Little River Quarry, proposed extension area, surrounding land areas and features, and house locations within 2km of the site are shown in the site plan **Appendix 1**.

6 SENSITIVE SITES

Blast vibration limits for Victorian quarries apply at "sensitive sites", defined by the extractive industry regulator (Earth Resources Regulation) as, "… *any land within 10 metres of a residence, hospital, school, or other premises in which people could reasonably expect to be free from undue annoyance and nuisance caused by blasting*". The closest sensitive sites to the quarry are a small number of residences on neighbouring rural properties and work authorities.

There are three sensitive sites (occupied dwellings) within 2km of the proposed extension area. The closest dwelling is located 1,000m east of the proposed extraction limit and another dwelling further east at 1,260m. The third sensitive site is shown to be ~1,400m south-southwest of the extension area and is located within Work Authority 187. The minimum separation distances between the extension and closest houses are substantial and the absence of blast-related complaints from residents (being common at most quarries) indicates ground vibration and airblast levels and impacts at sensitive sites are low.

The three sensitive sites are labelled "House 1-3" on the site plans and appendices.

7 PRESCRIBED CRITERIA FOR QUARRY BLASTING

All blasting operations at Victorian quarries must be undertaken in compliance with the following State and National regulations, standards and guidelines, and other conditions including;

- *Victorian Dangerous Goods (Explosives) Regulations 2022,*
- Earth Resources Regulation (ERR) guidelines for quarries
- *Australian Standard AS2187.2-2006 Explosives Storage and Use: Part 2 – Use of Explosives*
- *Occupational Health and Safety Act 2004*
- *Australian Explosives Code 3rd Edition*
- Work Authority conditions, as well as any site-specific blasting conditions that may apply as part of a quarry's approved Work Plan.

The conditions pertaining to blasting operations that are relevant to this assessment are outlined in the following sections.

7.1 Blast vibration limits for Sensitive Sites

Ground vibration and airblast levels from quarry blasting are regulated through Victorian State Legislation by the Department of Energy, Environment and Climate Action. The department's Earth Resources Regulation branch (ERR) provides guideline limits for ground vibration and airblast that typically become an operating condition for Work Authorities with blasting.

The limits apply at sensitive sites such as occupied dwellings and are:

Ground Vibration:	5 mm/s PPV (for 95% of blasts within a 12-month period) 10 mm/s PPV (all blasting)
Airblast:	115 dBL Linear peak (95% of all blasts within a 12-month period) 120 dBL Linear Peak (all blasting)

The upper limits (10 mm/s and 120 dBL) are provided as an allowance for the occasional, unexpected exceedance of the lower (95%) limits. However, compliance with the lower limits (5mm/s and 115 dBL) is considered by quarry operators as the target for all blasting. Compliance is assessed through the results of blast monitoring and exceedances may result in penalties for quarry operators.

The ERR limits are in consideration of human comfort and are set below levels at which blast vibration damage is known to occur to competent structures. Limits for commercial and industrial premises are not currently specified, though consideration for such premises is usually given to damage criteria at which higher limits may apply.

7.2 Blast vibration limits and conditions for infrastructure

Separate ground vibration limits may be ordered by asset owners to protect critical offsite infrastructure such as buried gas and water mains, and transmission lines, poles and towers. The limits are higher than those for sensitive sites, typically 100 mm/s for electricity transmission poles and towers, and 20-50 mm/s for buried pipelines. Such limits may only require the attention of shotfirers and blast designers where blasting occurs within 100-200m of assets and blast designs may need to be modified to reduce ground vibration levels.

The closest public utility to the quarry is a high voltage transmission line located in an easement approximately 1.2km west of the quarry. Ground vibration levels at the current or proposed blast separation distances would be low (<1 mm/s) and there is no risk of damage to the assets.

7.3 Control of flyrock

It is the responsibility of shotfirers to ensure all rock fragments thrown from blast sites are contained within the boundaries of the Work Authority at all times. Excessive flyrock throw (where rock fragments are thrown well beyond normal distances, potentially crossing quarry boundaries) is prevented by appropriate blast design, blast hole and face surveying techniques, and accurate hole loading practices and record keeping. The residual risk of flyrock is mitigated by establishing wide clearance zones around blast sites at firing times.

While modern blasting techniques are highly effective to prevent and minimise the throw of rock fragments, excessive flyrock remains a possibility at all quarries and operators must ensure blasts are well designed, correctly loaded to the shotfirer's specifications and appropriate blast clearance zones are established and secured during every blast. The subject of flyrock risk and control is addressed in **Section 10.3**.

7.4 Blast firing times

Blast firing at Little River Quarry is currently permitted between 10 am and 4 pm from Monday to Friday. Blasting is prohibited on weekends and public holidays at all Victorian quarries. It is anticipated these conditions would continue to apply in the future.

7.5 Blast notifications and community engagement

Quarries are required to issue personal notifications of scheduled blast dates to subscribing residents and other stakeholders at least 48 hours prior to blast times. This is undertaken to help prevent potential startling of residents as a result of unexpected blast vibration. Notification is typically provided by email, phone call or SMS.

Notification must also be given if any part of a blast's clearance zone extends beyond the Work Authority boundary and onto private property. Affected landowners must be provided with information regarding the extent of the clearance area and the quarry's blast clearance and firing procedure at least 48 hours prior to blast time. For the proposed extension, blast clearance is only warranted at limited adjacent areas of the Ford Proving Grounds and SSAA property during the closest upper-level blasts.

8 BLAST DESIGN SPECIFICATIONS

Blasting in the proposed extension area would follow the quarry's current practice and designs with conventional drill and blast techniques. The design specifications listed in **Table 1** are observed for production blasts at Little River Quarry, noting the front row burden and stemming height are strictly minimum provisions and greater burden and stemming heights are typically used. However, because the minimum specifications would result in the highest potential airblast levels and rock throw distance, they are used for the predictive modelling in this report to provide the most conservative assessment.

There may be a need to use 102mm diameter blast holes in some areas of the quarry, as further detailed in **Section 9.4**. At some quarries with massive granite structure the use of a wider hole diameter improves fragmentation which improves the efficiency of processing the rock to aggregate. Typical design specifications for 102mm blast holes are also listed in the table.

Table 1 – Standard blast design specifications – WA453

Blast hole diameter	89 mm	102 mm
Face height	10 - 15 m	10-15m
Hole angle	5-10°	5-10°
Sub drill	1.0 m	1.0 m
Hole length	11 - 16 m	11 - 16 m
Burden x Spacing	2.3 x 2.7 m	2.7 x 3.2 m
Front row/face burden (min.)	2.8 m	3.5 m
Stemming height (min)	2.5 m	3.5 m
Explosives column length	8.5 – 13.5 m	7.5 - 12.5 m
Linear charge mass	7.5 kg/m	9.8 kg/m
Charge mass per delay	63.8 -101.3 kg/delay	73.5 – 122.5 kg/delay
Explosives/density (avg.)	1.2 g/cm^2	1.2 g/cm^2
Powder Factor	~ 0.9 kg/m^3	1.0-1.1 kg/m^3

Localised rock structure within quarries may vary and therefore design specifications may somewhat differ between individual blasts to maintain blast efficiency, performance and control. Design requirements for individual blasts are guided by review of drillers logs, blast hole surveys, hole loading records, site inspections, and the results of ground vibration, airblast overpressure and flyrock monitoring.

9 BLAST IMPACT ASSESSMENT

9.1 Ground vibration

When explosives detonate in the ground, residual energy is converted to ground vibration waves that radiate from blast sites at high velocities and reduce in magnitude with increasing distance. Beyond a few metres from each blast hole, the wave motion is elastic and the ground returns to its original position once the wavefronts have passed.

At most quarries, ground vibration can normally be felt by the occupants of buildings located within one kilometre or so of blast sites through structural and secondary responses such as a brief creak of structural members and/or movement of loose items and fixtures and the audible effects generated (i.e., rattling sounds). Blast vibration and its associated effects may occur for 2-5 seconds per blast depending on the distance from the blast site and local ground conditions.

Ground vibration from blasting is measured in terms of the Peak Particle Velocity (PPV) of the ground motion measured in units of millimetres per second (mm/s). PPV levels are commonly predicted using the following square root Site Law from Australian Standard AS2187.2-2006 Appendix J:

$$PPV = k_v \left(\frac{\sqrt{m}}{D} \right)^{-e}$$

Where:

PPV = Peak Particle Velocity (mm/s)
m = Charge mass per delay (kg)
D = Distance from blast site (m)
k_v = A site constant
e = Attenuation rate (-1.6)

The model's site constant (k_v) largely reflects localised ground conditions that influence the transmission of ground vibration waves. Because conditions vary, site constants between individual blasts and locations also vary. AS2187.2-2006 recommends a k_v value of 1,140 for predicting PPV levels in "*average field conditions*", noting the results have a 50% chance of exceeding predicted levels.

Four standard production blasts were monitored by Terrock personnel during 2020 and the data obtained is used to guide development of an appropriate, conservative PPV model for the site. The dataset of twelve PPV measurements shows k_v values ranging from 1,087 to 3,140 with an average value of 1,871. A higher value of 2,200 is adopted for this assessment to account for the normal variation of PPV between blasts and variable ground conditions in the wider area. This value is increased from a k_v of 1,600 used for previous assessments to provide a more conservative approach for assessing ground vibration levels from future blasting. The model used in this assessment is therefore;

$$PPV = 2{,}200 \left(\frac{\sqrt{101.3}}{D} \right)^{1.6}$$

The 2020 data shows PPV levels that are, relative to distance, higher than other granite quarries in the outer Melbourne region where k_v values of 1,600-1,700 are typically observed to predict maximum PPVs. The higher values are likely a reflection of the 2020 monitoring locations being in elevated areas with exposed granite and relatively close to blast sites. It is likely that PPV levels would be lower than predicted (potentially significantly lower) at more distant locations due to different ground structure and conditions across the wider surrounding area.

The 2020 blast monitoring data (PPV vs distance) is plotted on the regression analysis **Figure 1**. The attenuation line (in blue) shows the reduction of PPV levels over distance as determined with the site law model.

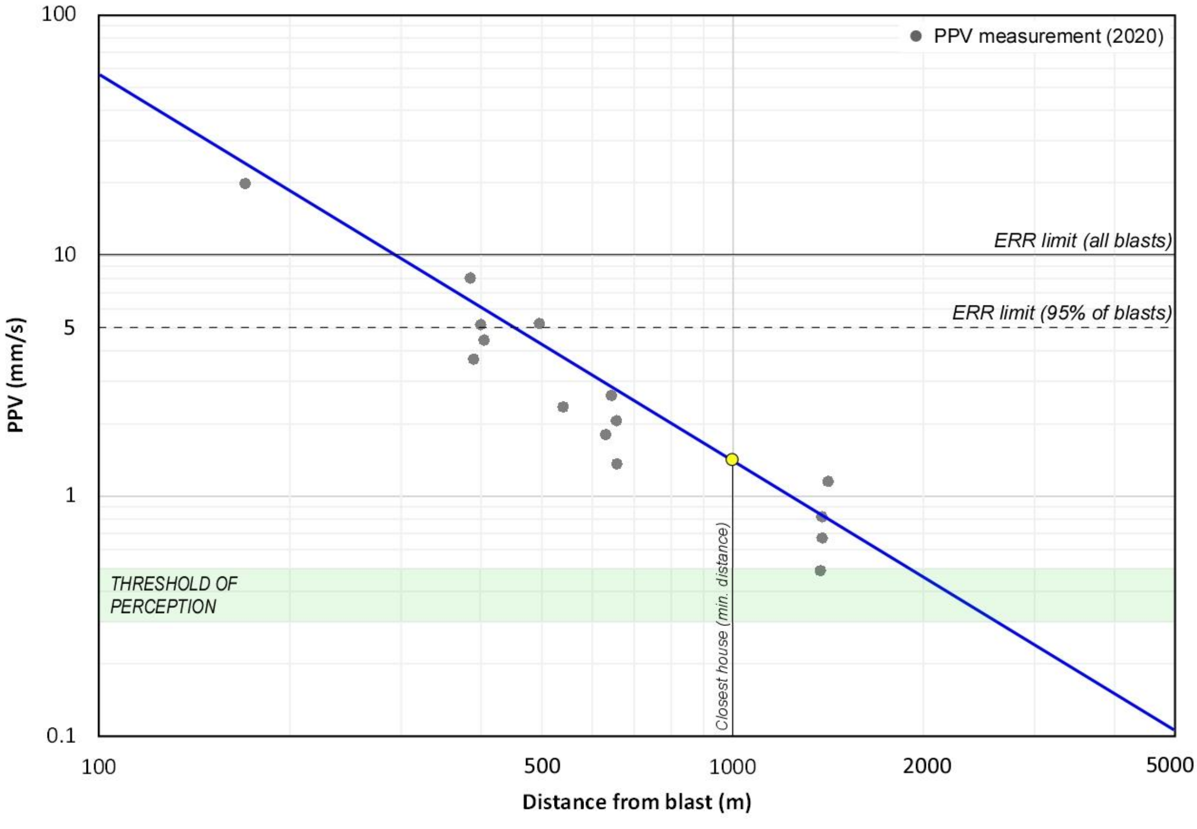


Figure 1 – Ground vibration regression analysis, k_v 2,200 (conservative)

The distances from blast sites to milestone PPV levels are shown below in **Table 2**.

Table 2 - Distance to PPV levels (MIC 101.3kg, k_v 2,200)

PPV level (mm/s)	Distance from blast (m)
20	190
10	293
5*	**452**
2	801
1	1,235
0.5	1,905

**ERR ground vibration limit (95% of blasts)*

Observing the minimum separation distance between the closest potential blasts (at the extraction limit) and Houses 1-3, the maximum PPVs at the closest sensitive sites are;

Table 3 – Maximum PPV levels at closest sensitive sites

Sensitive site	Distance from closest blast (m)	Maximum PPV (mm/s)
House 1	1,000	1.40
House 2	1,245	0.99
House 3	1,395	0.82

While ground vibration at the predicted levels may at times be perceptible to occupants of the closest dwellings, the predicted levels are well below the ERR human comfort limit of 5 mm/s and well below levels at which damage is known to occur to residential-type buildings. The threshold of perception is regarded to be 0.3-0.5 mm/s and ground vibration is unlikely to be felt at locations more than 2km of the quarry.

The ground vibration predictions (**Table 3**) are broadly conservative it is likely that actual maximum levels would be lower. The predictions also represent the closest potential blasts to houses (i.e., blasts at the extraction limit) and levels from the majority of blasts at more distant locations within the quarry would be reduced.

If required, the PPV model can be validated (or calibrated) through the results of further blast monitoring. However, compliance with the ERR ground vibration limits under the extension proposal is effectively assured and PPV levels and associated impacts at houses would remain relatively low.

9.2 Airblast Overpressure

Airblast overpressure is a brief, low frequency (<20 Hz) fluctuation of air pressure that radiates from blast sites through the surrounding atmosphere reducing at an approximate rate of 9 decibels with doubling of distance. The overpressure component of airblast (measured as dBL) is sub-audible and may only be perceived by people inside buildings at blast times through structural and secondary audible responses. The threshold of airblast perception for people inside buildings is 100-105 dBL.

The higher frequency component of airblast (>20Hz) is perceived as audible blast noise and is measured in the units dBA. If required, audible noise levels from blasting can be determined by overpressure readings (dBL) by reducing peak levels by 25 decibels. For example, an airblast reading of 115 dBL would measure 90 dBA on a sound level monitor for the same event (ref. AS2187.2-2006). Audible blast noise from quarries is not subject to monitoring or noise limits but is controlled by the overpressure limits that apply at sensitive sites.

Airblast levels are influenced by many factors including face direction, weather conditions at blast times, rock structure, and blast design specifications (face burden, stemming height and charge mass). At quarries in hilly areas such as Little River Quarry, airblast levels are reduced by topographic shielding where surrounding hills and ridges form barriers to noise and overpressure in most directions.

Approximate airblast levels can be predicted using the Terrock Airblast Model (Richards and Moore). This peer-reviewed model observes blast hole confinement provisions to determine the distance to the 115 dBL level ($D115_{dBL}$). The model is broadly conservative and is used to assess airblast impacts at numerous mines and quarries around Australia and overseas. The model adopted for Little River Quarry has a site constant used for quarries with topographic shielding where reduced airblast levels occur.

The Terrock airblast model and its inputs are:

$$D_{115} = \left(\frac{ka \times d}{B \text{ or } SH}\right)^{2.5} \cdot \sqrt[3]{m}$$

Where:
- D_{115} = Distance to 115 dBL level (m)
- d = Blast Hole Diameter (mm)
- m = Max. Charge Mass/hole (kg)
- B = Front Row Burden (mm)
- SH = Stemming Height (mm)
- Ka = Site constant
  250 (front of face)
  190 (behind/side of blast)

Airblast levels are largely a function of the confinement of explosives charges (depth of burial) that is determined by stemming height and front row burden provisions. For free-face blasts at quarries, the highest dBL levels occur directly in front of the face and are controlled by front row burden. Lower emissions occur to the rear and sides of blast sites and are a function of stemming height.

Observing the airblast attenuation rate of -9 dBL with doubling of distance, the predicted distances to milestone airblast levels are;

Table 4 – Distance to airblast levels

	MIC 101.3 kg/delay	
Airblast (dBL)	**Front of Face (m)**	**Behind/side of Face (m)**
120	573	383
115*	**830**	**555**
110	1,203	804
105	1,745	1,166
100	2,530	1,691

**ERR airblast Limit (95% of blasts)*

The predicted levels and the attenuation of dBL over distance are shown on the regression analysis **Figure 2**. Separate attenuation lines are shown for higher front of face emissions, and lower behind/side of blast emissions. Because the model observes the minimum permissible hole confinement provisions and actual confinement is normally greater, the predictions are conservative for most blasts.

Actual dBL levels recorded during the 2020 blast monitoring program are also plotted on the regression analysis showing the predicted levels to be conservative. Therefore, the airblast predictions of this assessment are regarded as the maximum dBL levels that could occur from a given blast.

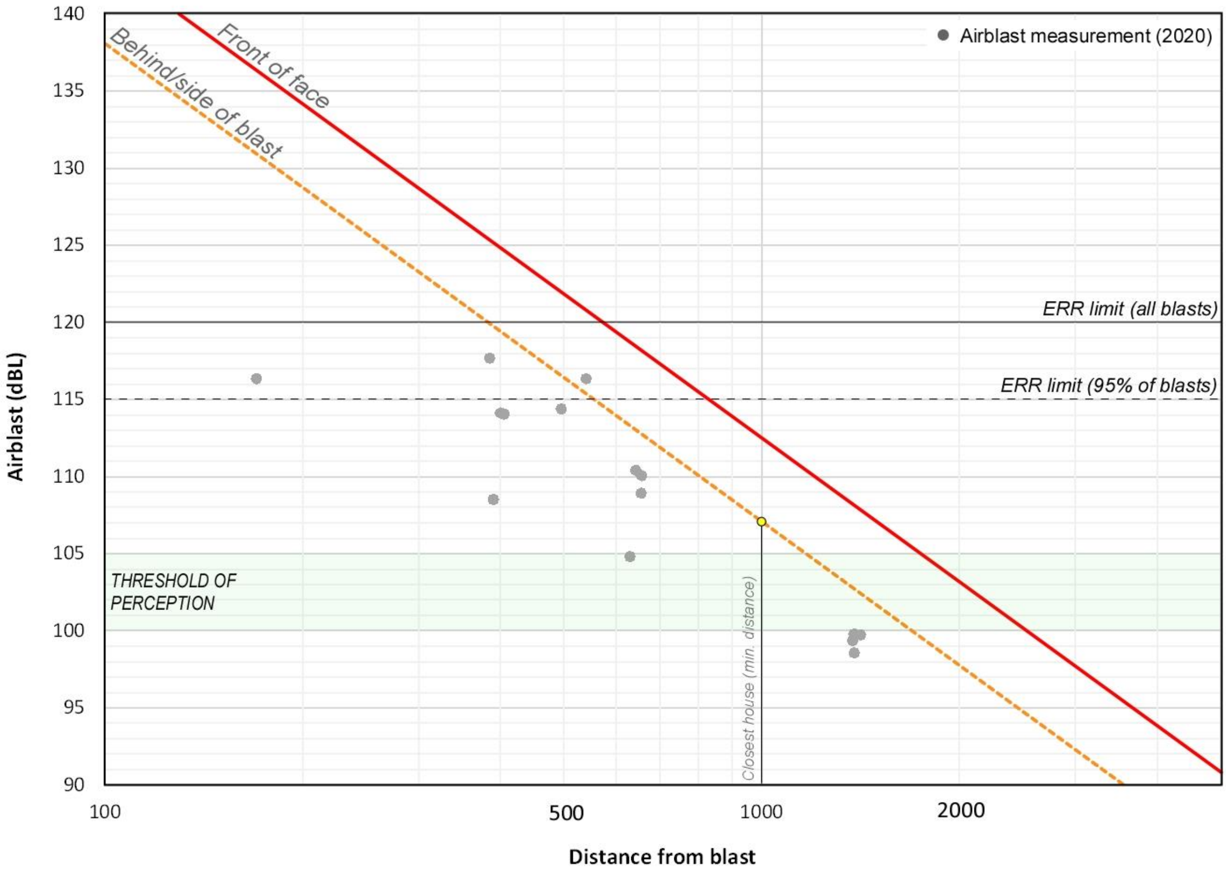


Figure 2 –Regression analysis showing maximum airblast levels and 2020 monitoring results

The airblast model shows a maximum dBL level of 107.2 dBL at House 1 to the east from the closest few blasts at the upper level of the eastern extraction limit. The maximum levels at the three closest houses are well below the ERR limit of 115 dBL regardless of face direction or the influence of topographic shielding. In terms of air pressure as measured in Pascals (Pa), 107.2 dBL (4.6 Pa) is less than half the ERR limit of 115 dBL (11.2 Pa).

Topographic shielding is a function of the incident angle and effective barrier height between a blast site and receptor location. For blasts on upper levels/benches, barrier heights and incident angles are reduced resulting in a smaller reduction of dBL levels as shown schematically in **Figure 3a.**

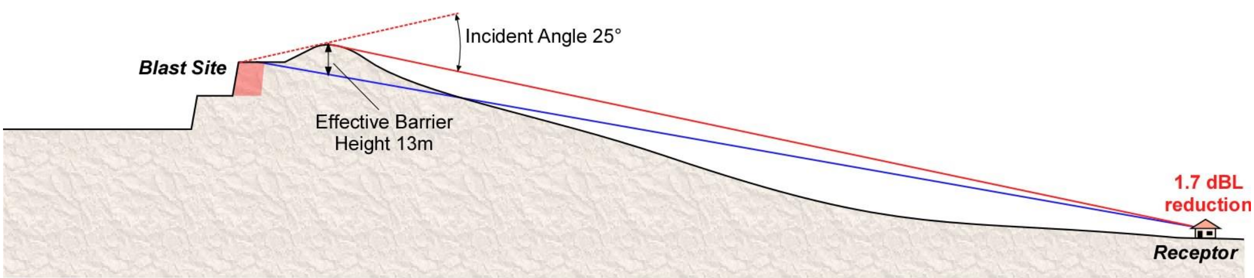


Figure 3a – Topographic shielding from blasts at upper benches/levels

For blasts on lower levels/benches deeper in a pit, barrier heights and incident angles may be greatly increased resulting in a substantial reductions of dBL levels as shown in **Figure 3b**.

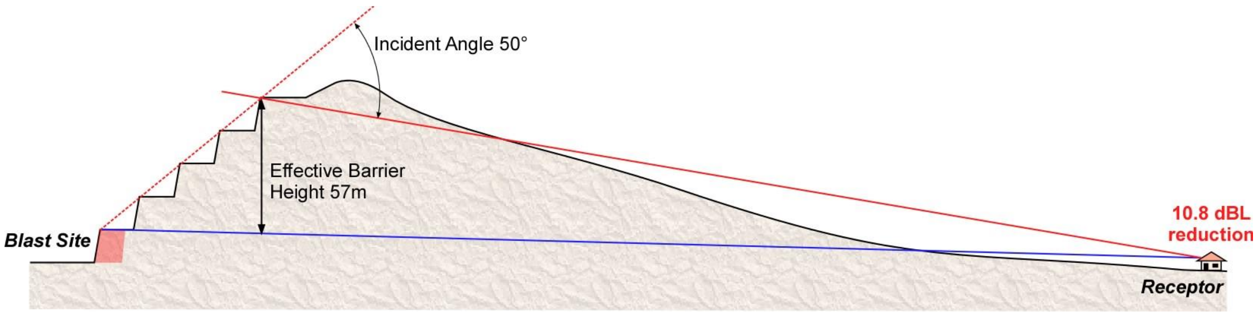


Figure 3b – Increased topographic shielding from blasts at lower benches/levels

Where distance, elevations profiles and barrier heights for individual blasts are known, decibel reductions can be approximated using the following chart.

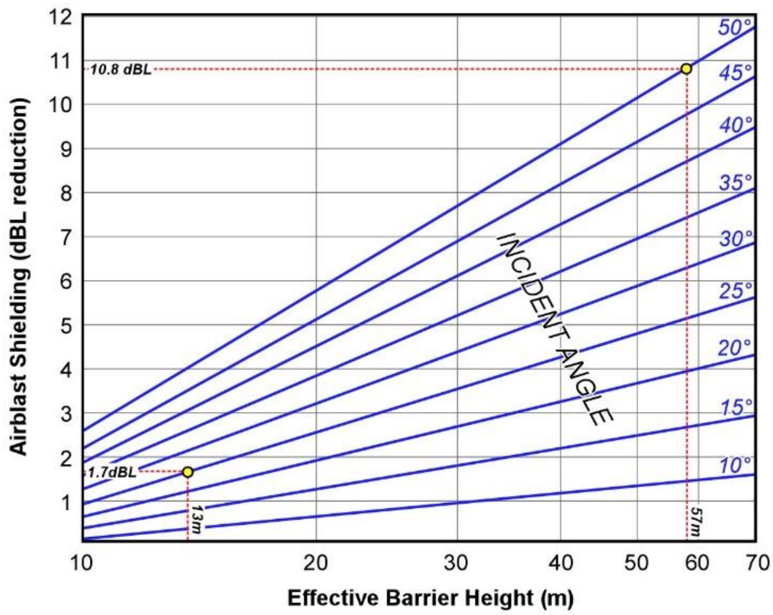


Figure 4 – Decibel reductions from topographic shielding (Figure 3a and 3b examples shown)

At Little River Quarry, the decibel reductions from topographic shielding would vary between blasts depending on blast site location and elevation with respect to sensitive site locations. Airblast levels would be generally higher from blasts on upper benches (at the highest elevations) because barrier heights and incident angles are lowest. The influence of shielding is increased for blasts at lower benches (deeper in the pit) because barrier heights and angles increase with depth.

Due to the large number of potential blast sites, elevations and incident angles (and because airblast levels at sensitive sites would be relatively low), a detailed assessment of the influence of topographic shielding has not been undertaken. However, observing the topography of the landform surrounding the proposed extension, the general directional influence of shielding on blast overpressure and noise levels is indicated in the **Figure 5**. It can be seen that the highest degrees of shielding occur in the directions of the closest private properties, public areas ad sensitive sites.

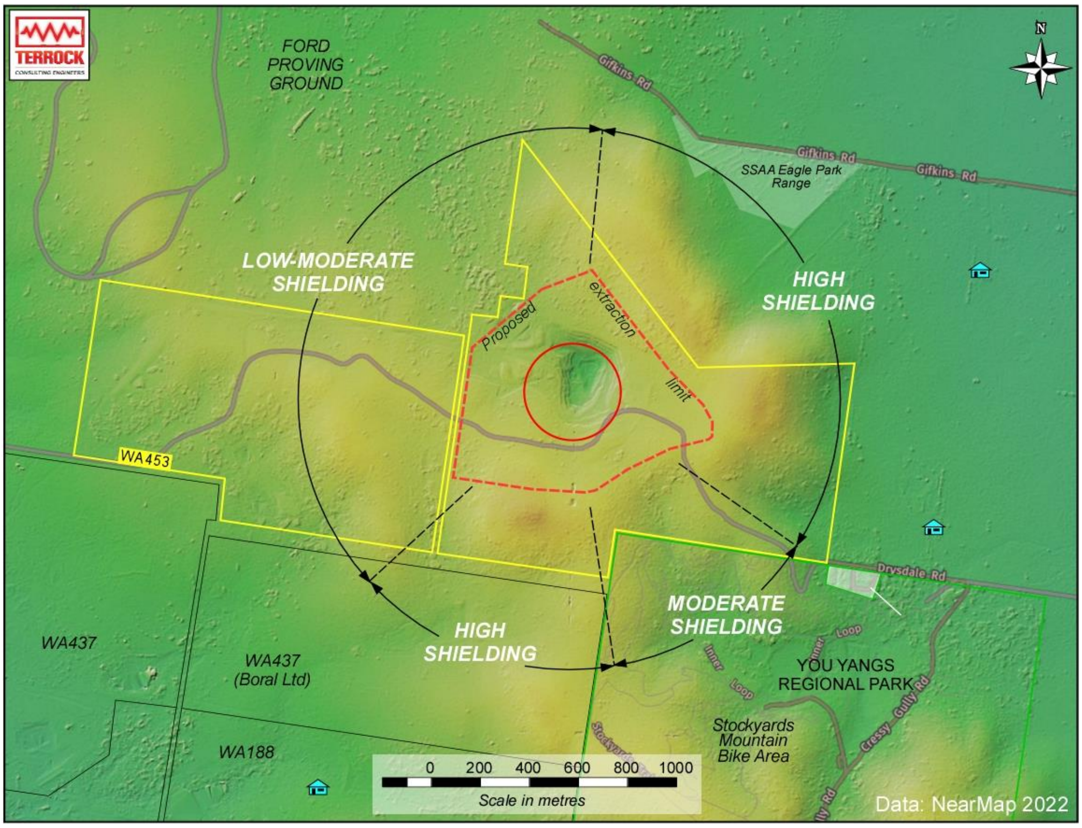


Figure 5 – General influence of topographic shielding on airblast levels around Little River Quarry

At Little River Quarry, airblast levels would be reduced by a few decibels from levels predicted with the conservative Terrock model and substantially reduced (in most directions) for blasts at lower levels/benches of the pit. However, due to the substantial separation distances from the closest houses, airblast levels would comply with the 115 dBL limit for quarries regardless of face direction or the effects of topographic shielding.

9.3 Flyrock

A model for calculating the maximum distance rock fragments may be thrown under a blast's design specifications has been developed by Terrock and refined over years of field observation and measurement. The standard, peer-reviewed model yields conservative results and is used to guide blast clearance requirements at numerous mines and quarries across Australia and overseas.

The model provides an allowance for some inconsistency of rock structure and minor inaccuracies that can occur during hole loading. The distance rock fragments may roll after landing is also factored into the model. The standard model is conservative by design and actual throw distances are typically shorter.

As with airblast, the throw distance in front of the face is controlled by face burden provisions. The furthest potential throw results from rock fragments launched at a 45° angle within a 90° arc perpendicular to the face.

The maximum throw in front of a blast is calculated with the formula:

$$Lmax_f = \frac{k^2}{G}\left(\frac{\sqrt{m}}{B}\right)^{2.6}$$

Where:

k =	Site constant (27, conservative)
G =	Gravitational constant (9.8)
$Lmax_f$ =	Max. throw - front of face (m)
m =	Linear charge mass (kg/m) (7.5 kg/m for 89mm diameter holes)
B =	Front row/face Burden (m)

For the minimum 2.8m face burden observed at Little River Quarry;

$$Lmax_f = \frac{27^2}{9.8}\left(\frac{\sqrt{7.5}}{2.8}\right)^{2.6}$$

$$Lmax_f = \mathbf{70m}$$

In the area behind and to the sides of a blast, the furthest throw occurs from smaller fragments of stemming material and loose collar rock that is launched at the hole angle (10° from vertical) and may disperse a further 10° over distance. As a result, the risk presented by flyrock behind blast sites is substantially less than in the area in front of a blast.

Flyrock throw behind and to the sides of blast sites can be calculated with the model:

$$Lmax_r = \frac{27^2}{9.8}\left(\frac{\sqrt{m}}{SH}\right)^{2.6} Sin\ 2ø$$

Where:

Lmax_r =	Max. throw - behind blast (m)
m =	Linear charge mass (kg/m)
SH =	Stemming height (m)
Ø =	Launch angle (hole angle 10° from horiz. + dispersal allowance of 10° = 70°)

For the quarry's minimum stemming height specification of 2.5m;

$$Lmax_r = \frac{27^2}{9.8}\left(\frac{\sqrt{7.5}}{2.5}\right)^{2.6} Sin\ 2\ (70°)$$

$$Lmax_r = \mathbf{61m}$$

Review of video recordings of recent blasts at Little River Quarry indicates actual throw distances from standard blasting at the quarry are shorter than the distances calculated with the flyrock model, particularly behind and to the sides of blasts. Screenshots showing recent blasts (at the moment of maximum heave) are presented as the following figures. Little (if any) throw occurs behind the blast sites from standard stemming specifications and the maximum throw prediction of 61m is indicated to be conservative.

Fig 6a-Blast fired 19/10/2022

Fig 6b – Blast fired 04/11/2022

Figure 6c – Blast fired 21/11/2022

Fig 6d – Blast fired 29/11/2022

With a minimum distance of 100m between blast sites and the closest neighbouring properties, there are adequate buffers around the proposed extraction limit to prevent rock fragments crossing the Work Authority boundary onto neighbouring land areas.

Blast clearance distances should be proportionate to the scale and design of a blast and therefore increased hole confinement (stemming height and face burden) can be used to control the risk presented by flyrock. Information on blast clearance distances and procedures around the quarry is provided in **Section 10.3.3**.

If required, the flyrock model can be calibrated to more accurately reflect the behaviour of local rock masses under blasting. This can be undertaken through a flyrock monitoring program involving field measurements of maximum throws that are used to adjust the model's default site constant of 27.

9.4 Potential use of 102mm diameter blast holes

The potential future use of wider diameter blast holes must also be considered. At many granite quarries, 102mm holes improve blast performance and efficiency in massive, unweathered granite, yielding more rock per blast and improving fragmentation. This results in fewer overall blasts being required, reduced blast vibration durations (because less holes are needed per blast) and reduced crushing and screening needs due to improved fragmentation.

Wider diameter blast holes accommodate a greater charge mass (9.8 kg per metre) but airblast and flyrock impacts are typically offset by the increased front row burden and stemming heights required to provide additional confinement. By increasing front row burden and stemming to 3.5m (considered standard design specifications for 102mm holes at granite quarries), the distances to the 115 dBL level are 712m (front of face) and 358m (behind blasts). In effect, airblast levels are reduced from the dBL levels from 89mm holes.

Under the Terrock flyrock model, the throw distance of rock fragments is also reduced for 102mm holes due to increased confinement, with maximum throws of 56m (front) and 36m (behind). While the Safety Factor 2/4 clearance distances are reduced for such blasts, it is recommended that standard clearance distances are observed for 102mm hole blasts.

Under the PPV model, 102mm blast holes with maximum instantaneous charge of 122.5 kg/hole would result in a maximum PPV level of 1.63 mm/s at House 1 from the closest blasts, a modest increase from the 1.4 mm/s from 89mm holes. However, 89mm holes would be used for upper-level blasts at or near the extraction limit.

The potential use of 102mm holes would be limited to Stage 3-4 blasts deeper in pit at elevations below 165m RL where fresh/unweathered granite occurs. For such blasts, the barriers formed by upper-level benches would help reduce airblast levels (due to increasing topographic shielding), and also limit the horizontal distance rock fragments may be thrown behind blast sites.

In summary, the potential use of 102mm holes in the pit of the quarry would not result in increased blast vibration levels or blasting risks and impacts aside from a slight increase of PPV levels. This assumes minimum stemming and front row burden for 102mm hole blasts are increased from the specifications used for 89mm holes in line with normal industry practice.

10. BLASTING RISKS AND CONTROLS

Modern blasting products and techniques have improved blast control and greatly reduced the risks presented by blasting in the past. The primary risks of blasting, and control measures required to mitigate the risks are outlined in the following sections.

10.1 Transport, handling and use of explosives

Blasting at Victorian quarries is undertaken by qualified personnel who are trained and licensed by WorkSafe Victoria to use blasting explosives.

Blasting operations at Little River Quarry are undertaken by a team consisting of personnel from Barro and an explosives supplier (currently Orica Ltd). It is a shared responsibility of both parties to conduct safe and efficient drilling and blasting operations in accordance with the requirements and objectives of quarry management, and to work to Victorian blasting regulations and standards, the procedures of the quarry's Blast Management Plan and any Work Authority conditions that may apply. It is the responsibility of quarry management to ensure all blasting operations are conducted accordance with approved site procedures, maintain site safety and security (including blast clearance areas), and give final approval for every blast design and risk assessment produced prior to blast times.

The quarry operator has proposed to store minor, quantities of supplemental blasting components such delay detonators and primers onsite in approved storage cabinets. Explosives storage is licenced by WorkSafe Victoria and subject to strict regulation and a security and management plan. Details of explosives storage at the quarry and the management thereof would be detailed in a future revision of the site's Blast Management Plan. The majority of blasting components and all bulk explosives products would be brought to site by a licenced explosives supplier on blast days with unused quantities returned to the supplier's offsite storage facility after hole loading is completed.

The risk control measures for explosives transport, and onsite handling and security procedures are referred to the quarry's Blast Management Plan, Risk Assessments and/or other procedural risk control documents for individual blasts, and Material Data Safety Sheets provided by the explosives supplier.

10.2 Damage to buildings

Buildings and other structures can be damaged if exposed to very high levels of airblast and ground vibration. While there is common belief that blast vibration, even at low levels, causes cracking in houses, the known thresholds of damage are well above the levels that occur at houses near quarries and above the ERR blast vibration limits that must be observed.

Australian Standard AS2187.2-2006 Appendix J contains frequency-dependent criteria from overseas standards and guidelines that can be used to determine minimum thresholds for blast-induced cosmetic damage (e.g. hairline cracks in plaster) for residential, commercial and industrial type buildings. The criteria are frequency-dependant because high magnitude ground vibration waves with low frequencies have a greater damage potential than vibrations with high frequencies. Ground vibration frequencies from blasting vary between sites and individual blasts, ranging from 4 to 30 Hz with a typical dominant frequency of around 10 Hz.

The criteria from the Australian Standard is sourced from British Standard BS7385.2-1993 and research from the United States Bureau of Mines (USBM RI 8507). At a dominant ground vibration frequency of 10 Hz, the threshold of cosmetic damage is 18 mm/s (from both BS7385.2-1993 and USBM criteria), above which there is an "*increasing possibility of damage"*. From the British Standard, the threshold of major/structural damage is four times the cosmetic damage values (i.e. 72mm/s). Damage criteria is conservative by design and Australian research into the effects of blasting on structures has shown PPV levels below 70 mm/s to be wholly non-damaging to brick veneer houses (ref. ACARP study C9040).

The building elements most sensitive to airblast overpressure are glass window panes. AS2187.2-2006 recommends a limit of 133 dBL to prevent damage, though the Standard notes, "*damage at levels below 140 dBL is improbable*". In terms of real air pressure measured as Pascals, 140 dBL (or 200 Pa) is eighteen times the ERR limit of 115 dBL (11.2 Pa).

The risk of blast vibration-induced damage occurring at the closest houses to current or future blasting operations at Little River Quarry is negligible. PPV and airblast levels at sensitive sites are predicted to be below the ERR human comfort limits and well below cosmetic damage thresholds from conservative criteria as indicated by blast vibration measurements, predictive modelling and the absence of blasting concerns or damage claims among residents.

10.3 Flyrock

The greatest risk of blasting to the safety of people and property is excessive flyrock, where rock fragments from a blast site are thrown well beyond anticipated distances. Such events have become increasingly uncommon at quarries due to improvements of blasting practice and no flyrock injury has been reported from a Victorian quarry for several decades. However, flyrock remains a possibility at all quarries and prevention and risk mitigation is a critical consideration for shotfirers and quarry managers for every blast.

10.3.1 The nature and causes of flyrock

When a quarry blast is fired, fragments of blasted rock heave forward and form a pile in front of the blast site from where it is loaded into haul trucks and transported for processing. Sometimes rock fragments are thrown beyond the area of the pile and the causal mechanisms and preventative measures for this are discussed in the following sections.

Flyrock in front of the face occurs due to insufficient face burden, commonly where an area of the face is undercut or front row blast holes are drilled too close to the face. Under-burdening can also occur from blast hole deviation where the bottom of a blast hole is located too close to the toe of the face. Flyrock can also be caused by structural weakness in the face such as clay seams, cavities and areas with loose, naturally fragmented rock. The causal mechanisms for flyrock in front of the face are shown as **Figure 7a**.

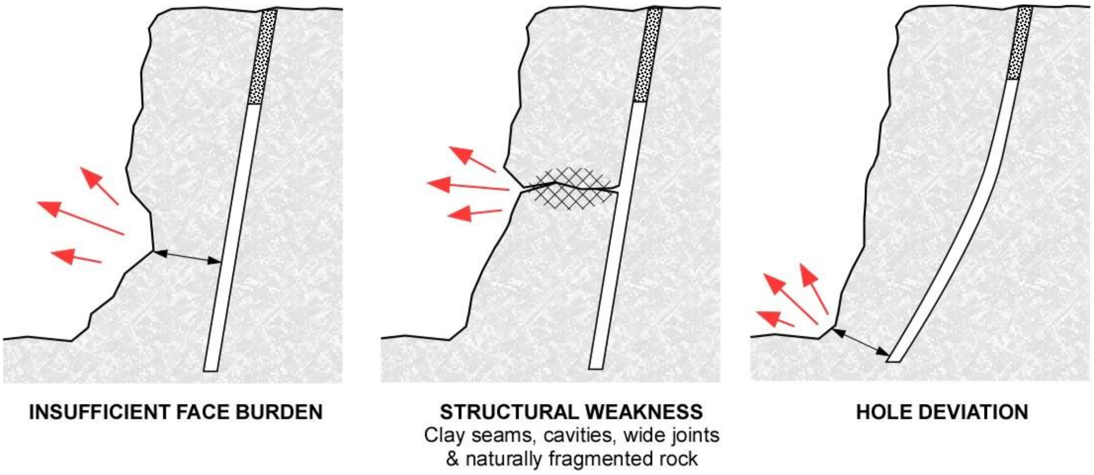


Figure 7a – Causes of flyrock in front of the face

The furthest potential throw of flyrock occurs within a 90° arc perpendicular to the face and consists of rock fragments launched at a 45° angle at high velocities. The optimum size of fragments for maximum throw is around 200mm. Smaller fragments have reduced throw distance due to wind resistance and the throw of larger fragments and boulders is limited by their mass.

Behind and to the sides of blast sites, the furthest potential throws are from smaller fragments of stemming material or loose collar rock that are launched at the blast hole angle and may disperse a further 10°. Due to the smaller size of fragments, shorter throw distance, steep launch angles and lower velocities on landing, rock thrown behind blast sites presents a lower risk of serious injury than flyrock in front of a blast.

Further throws behind the blast are possible if "cratering" occurs from significant under-stemming where rock surrounding the hole collar is launched at 45° in all directions. Cratering is prevented by ensuring the minimum length of each stemming column is at least 20x the hole diameter. For standard 89mm hole diameters, a minimum stemming height of 1.8m is required. The minimum 2.5m stemming used at Little River Quarry is sufficient to prevent cratering. Diagrams showing the causal mechanisms for flyrock behind a blast are presented as **Figure 7b**.

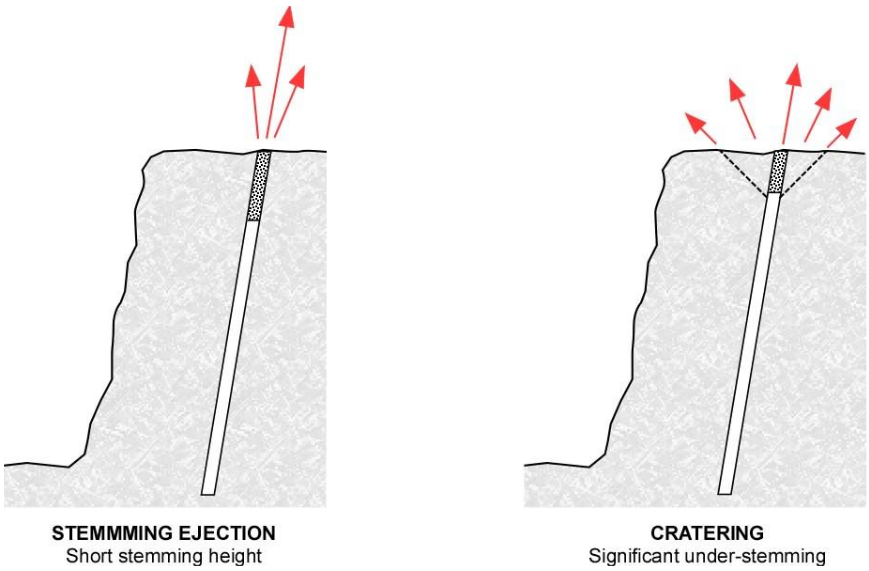


Figure 7b – Mechanisms for flyrock behind /side of blasts

10.3.2 Prevention of flyrock

Excessive flyrock throw is the result of human error, typically where under-confinement of the explosives column in a blast hole is not identified prior to firing. Under-burdening is identified by laser face profiling and Boretrak survey techniques that accurately measure the depth and deviation of front row blast holes and the true face burden. Face profiling and Boretrak is undertaken prior to every blast at Little River Quarry. Face weaknesses such clay seams or pockets of loose fragmented rock are not detected by laser profiling but are identified by thorough visual inspection of blast faces by experienced shotfirers.

Weaknesses and structural inconsistencies can also be identified during hole drilling by observing the speed and progress of the drill bit and colour of the fines produced. Such observations are recorded in a drillers log that is also reviewed by the shotfirer to help inform blast design and loading requirements. If under-confinement or face weaknesses are identified or suspected, affected holes are loaded in a manner that prevents explosives being loaded into the compromised sections. If under-confinement is widespread, blast holes may be redrilled or fully stemmed (i.e. no explosives loaded).

Flyrock thrown behind a blast site is typically an ejection of stemming material caused by under-stemming or the use of inappropriate stemming material. 10-14mm aggregate is the optimal stemming grade for 89mm diameter blast holes and is used for all blasts at Little River Quarry. Flyrock can also be caused when one or more blast holes are overcharged and the design stemming height is inadequate to confine the blast energy. Overcharging and under-stemming are identified and prevented by accurate hole loading practices and detailed record keeping.

The quarry's blast loading procedures and treatment methods for under-confined (or overcharged) blast holes are detailed in the site's Blast Management Plan. The procedures shown are in line with industry standards and effective to prevent excessive flyrock. The residual risk presented by unexpected flyrock is mitigated by establishing appropriate clearance zones around blast sites at firing times.

10.3.3 Blast clearance at Little River Quarry

Blast clearance zones at Little River Quarry are established around 30 mins prior to blast times and lifted when the shotfirer gives the "*all clear*" signal after a post-blast site inspection. The zone is secured by blast guards who are positioned at strategic access points leading to the clearance area including near the Work Authority boundary with a clear view of any neighbouring land areas. No blast may be fired until the shotfirer receives multiple guard notifications that the area remains clear of people and it is safe to fire the blast.

Control of flyrock and establishing appropriate blast clearance is the responsibility of shotfirers and quarry management, and the adequacy of standard clearance distances must be considered prior to every blast. The current clearance distances observed at the quarry are 400m (front of blast) and 300m (behind blast).

At some mines and quarries, minimum clearance distances are determined by applying Safety Factors to maximum throw calculations from the Terrock Flyrock Model. The minimum safety factors to have been accepted by operators and authorities are;

- Plant and Equipment - Safety Factor 2 (2 x maximum throw)
- Personnel and Public – Safety Factor 4 (4 x maximum throw)

Under this approach, the personnel/public clearance distances for standard blasts at Little River Quarry are;

Table 5 – Clearance distances for minimum face burden and stemming height specifications

	Front of face	Behind blast
Maximum throw	**70m**	**61m**
Plant & Equipment	140m	122m
Personnel & Public	280m	244m

To help reduce the need for (or extent of) clearance on neighbouring land areas it is recommended the Safety Factor 4 distance is observed behind blasts with a minimum clearance distance of 250m. The current clearance distance of 400m in front of blasts provides a minimum Safety factor of 5.7, is workable and should be maintained. This requires all blasts within 400m of the Work Authority boundary to face inwards towards the quarry, as would occur under the proposed design plans.

The front and behind clearance areas are combined to form the blast clearance zone shown as **Figure 8**.

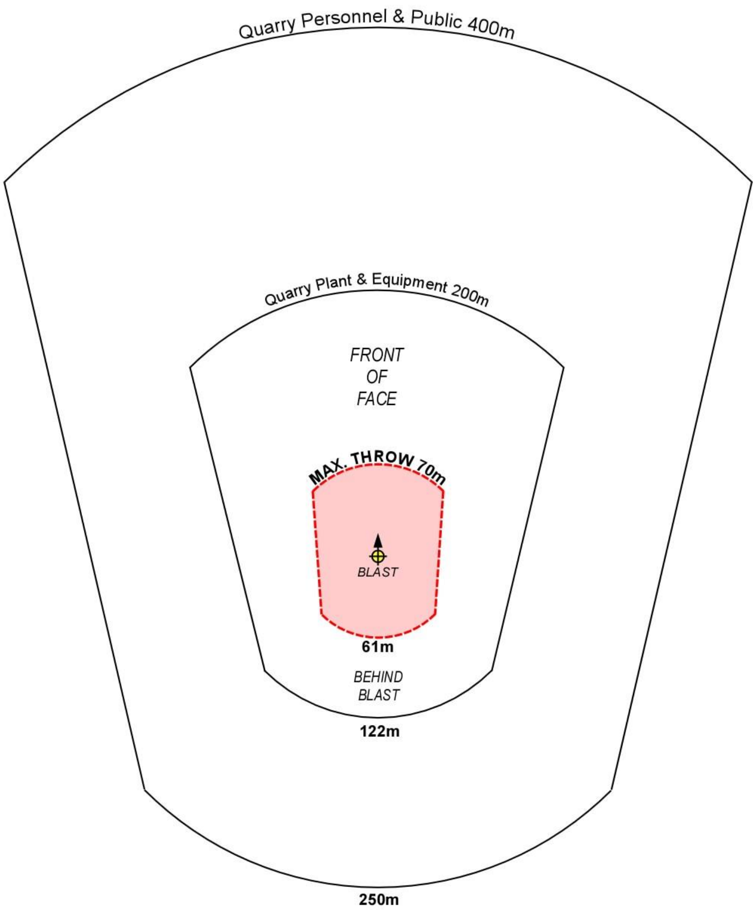


Figure 8 – Clearance zones for standard blast design specifications

Additional protection from flyrock is provided at the quarry by requiring all site personnel not directly involved with blasting to assemble at a safe location at a workshop near the weighbridge west of the pit, approximately 500-600m from recent blasting operations. Under the extension proposal, an alternative assembly area would be required for blasts in the western section of the extraction area that are located within a few hundred metres of the workshop, plant and weighbridge area (depending on face direction). A suitable location can be found within the undeveloped western section of WA453 (west of the weighbridge). Designated assembly areas for non-blast personnel should be detailed in future revisions of the quarry's Blast Management Plan.

10.3.4 Blast clearance outside the quarry

Quarry blasts at or approaching extraction limits (i.e. the closest blasts to neighbouring land areas) face inwards towards the pit with the high flyrock risk zone (the area in front of the face) located within the quarry. To reduce the need for clearance on neighbouring land areas, an extraction sequence should be observed for blasts within 400m of the Work Authority boundary to face away from the closest boundary section and inward towards the quarry so the 250m clearance area falls behind blast sites. This is indicated to occur under design plans that show the existing pit expanding to the northeast (southwest-facing blasts), southeast (northwest-facing blasts) and south (north-facing blasts).

Considerations for blast clearance with respect to neighbouring properties and land areas are discussed in the following paragraphs.

You Yangs Regional Park

For the closest few blasts to You Yangs Regional Park, the standard 250m clearance zone would overlie a small (0.5 acre) section of the Stockyards Mountain Bike Area at the northwest boundary corner. Recent aerial imagery shows the nearest bike or maintenance tracks to be at least 70m beyond the maximum clearance area (i.e., ≥270m from the extraction limit) and track closures at blast times would not be warranted.

However, to prevent the need for clearance within the park (and the need for a blast guard to be positioned in rugged terrain at the boundary), stemming height can be increased for blasts within 250m of the park boundary to reduce the maximum potential throw and Safety Factor 4 clearance distance. A modest increase of stemming from 2.5m to 2.8m reduces maximum throw from 61m to 45m, and the Safety Factor 4 distance from 244m to 180m. This measure would only be required for a few upper-level blasts (89mm holes) near the south-eastern extraction limit.

Under this approach, a 200m clearance area behind blasts with increased stemming would provide ample protection for park users and personnel with a minimum flyrock Safety Factor of 4.4 at the boundary and minimum Factor of 6 at the closest track section.

Ford Proving Grounds

The southeast corner of the Ford Proving Grounds property and its closest tracks are reported to be rarely used or visited. Blasting within ~100m of the boundary is not required and a limited number of modified and small-scale blasts is anticipated within 100-200m from the boundary. With minimum stemming height increased to 2.8m for blasts less than 250m from the Ford Proving Ground, and further modifications for a small number of potential blasts 100m-200m from the boundary as needed, the clearance zone for modified blasts can remain fully within the quarry and establishing clearance on the neighbouring property is not necessary.

Areas of the quarry in which stemming height should be increased to reduce maximum throw and prevent the need for blast clearance on neighbouring land areas are shown as "*Modified Blasting Zones*" on the following site plan (**Figure 9**). Clearance zones for modified blasts (minimum 2.8m stemming) are shown as **Figure 10**.

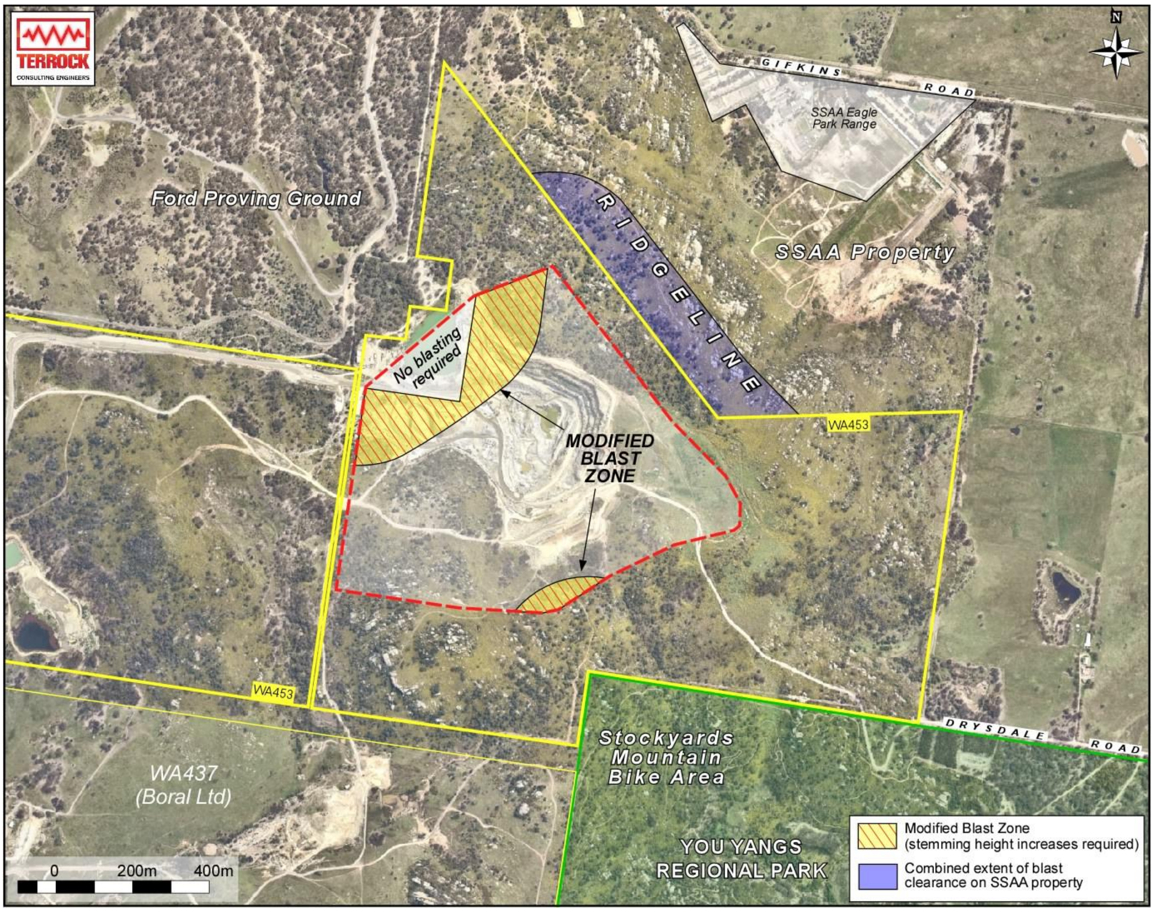


Figure 9 – Site plan showing extent of blast clearance on SSAA property and locations of Modified Blast Zones (89mm hole blasts within 250m of Ford Proving Grounds & You Yangs Regional Park)

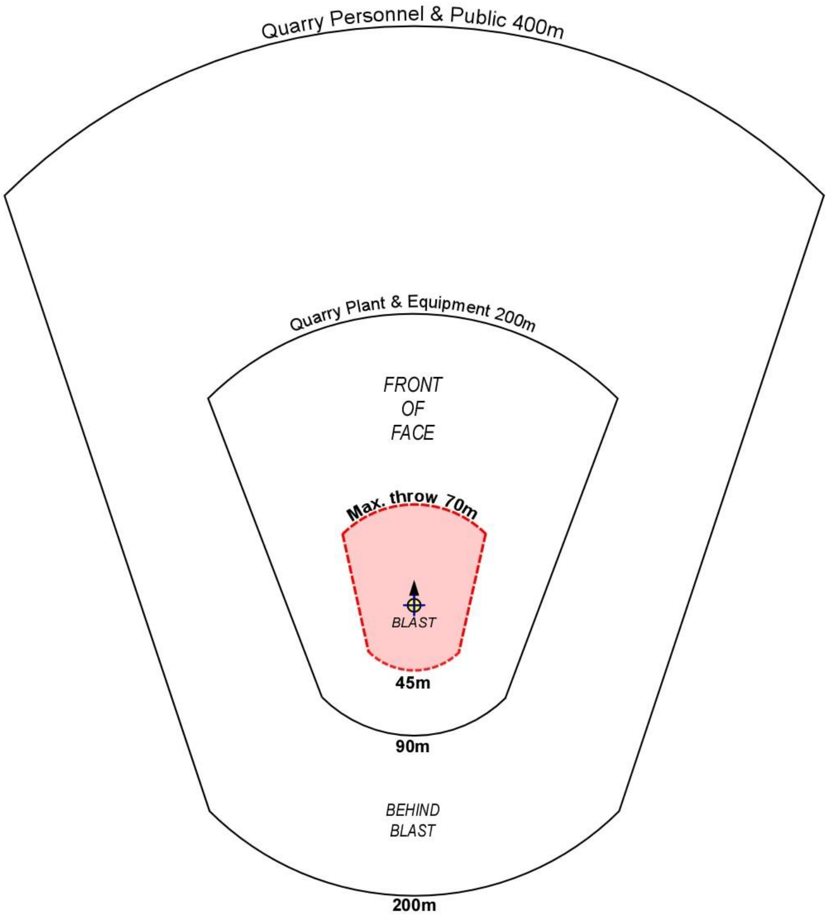


Figure 10 – Clearance zones for Modified Blasts (minimum 2.8m stemming height)

SSAA Eagle Park Range

The 250m clearance area for standard blasting is workable for the SSAA Shooting Range because the affected area is effectively inaccessible and falls well short of the club's activity areas near Gifkins Road. The maximum combined extent of standard blast clearance within the SSAA property is shown in **Figure 9**.

The southern slope of the ridgeline that separates the quarry from the SSAA Range would provide some barrier to flyrock with a modest reduction of horizontal throw distance behind blasts. The maximum extent of blast clearance within the SSAA property is 150m from the Work Authority boundary and this area mostly falls across the southern (quarry) side of the ridge. A cross section of the maximum throw trajectory from a terminal blast at the northern extraction limit, the 250m clearance zone, Work Authority boundary and slope to the north is shown as **Figure 11**.

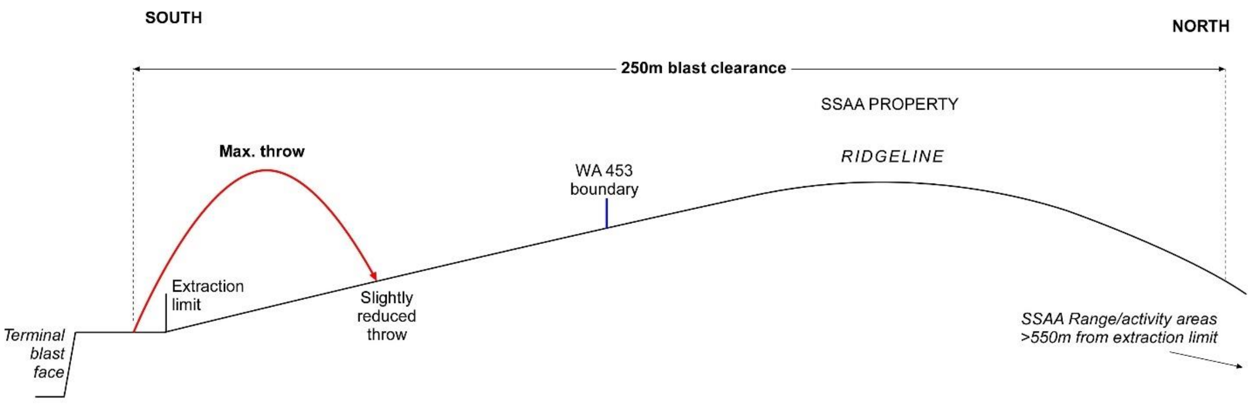


Figure 11 – Diagram showing maximum throw and maximum extent of blast clearance at the northern extraction limit (to scale)

It is highly improbable that people would be present on or near the ridgeline at blast times due to the steep, rugged terrain and the area being off limits to SSAA members. The main range, clubhouses and activity areas are located close to Gifkins Road with a minimum separation of the 550m from the proposed extraction limit and minimum Safety Factor of 9. However, the following measures can be undertaken to ensure clearance is observed and an appropriate level of safety is maintained.

Due to the terrain, it is impractical to position a blast guard on the ridgeline with a clear view of the northern approach. However, because the Work Authority boundary is located south of the ridge and has line-of-sight from the quarry, a spotter can be positioned to scan the ridgeline to help ensure no people are present at blast times.

An additional risk mitigation measure is for quarry management to contact the Range Manager to confirm that no people are present (or scheduled to be present) on the ridge at blast times. Such notification is only required for blast sites less than 250m from the Work Authority boundary where part of the clearance area falls within the SSAA property.

In summary, the risk presented by blasting to ordinary users and managers of the SSAA Range property is very low due to the significant separation distance between the closest blasts and the range's activity area, and because the clearance zone falls across the steep, rugged and largely inaccessible terrain immediately north of the quarry that is off limits to SSAA members.

10.4 IMPACT TO LOCAL AMENITY

There have been no blast-related complaints or concerns raised by residents since the Little River Quarry commenced operations. The absence of complaints is likely due to the separation distance between the quarry and sensitive sites, and local topography and ground conditions that result in blast vibration levels and impacts that are low or imperceptible. The number of residents that may be exposed to perceptible blast vibration is also low with three sensitive sites identified within 2km of the both the existing extraction area and the proposed extension area.

Under the proposal, ground vibration and airblast levels sensitive sites would somewhat increase from current levels yet would remain low with a maximum PPV of 1.4 mm/s and airblast level of 107.2 dBL at House 1 from the closest few blasts. Anecdotally, the likelihood of complaints and concerns increases where PPV levels above 2 mm/s occur, though complaints can emerge from any perceptible level of blast vibration.

While the impact of blasting to amenity is largely subjective and responses and tolerances vary among individuals, the impact to amenity of the surrounding area is considered low due to the aforementioned reasons and also because blast vibration effects are limited to a few seconds on blast days, (i.e., a maximum of 3-5 seconds of blast effects per week).

The impact of blasting to the amenity of You Yangs Regional Park for park visitors would not be significantly increased from current operations from which impacts are considered low. Visitors in the northern section of the park at blast times may hear a blast which can be equated to that of a distant boom or rumble of thunder. The influence of topographic shielding to the southeast would also help minimise noise and overpressure levels at the park and sensitive sites, especially for blasts at lower elevations within the pit.

Ground vibration is more perceptible to people inside buildings due to structural responses and is less perceptible to people outdoor at blast times, especially those engaged in physical activity. The busiest times at the Stockyards Mountain Bike Area is presumed to be on weekends when blasting is not permitted at the quarry.

There are numerous quarries in Victoria that share boundaries with public recreation preserves without reported impacts to amenity. In all cases, blast effects are considered too infrequent and too short in duration to cause adverse impacts to amenity or deter visitation to the wider area.

10.5 RISK TO LIVESTOCK AND NATIVE SPECIES

Quarries are located in rural or peri-urban settings with livestock on neighbouring properties and native fauna species residing in nearby habitat areas. The behaviour of livestock has been observed by Terrock, quarry personnel and nearby property owners for many years. The typical response of cattle, horses and sheep located within 150m from a blast is to briefly trot of walk a short distance away from the source of the disturbance. More distant animals may briefly raise their heads and look around before resuming grazing. At Little River Quarry, the closest properties with paddocks are several hundred metres from the proposed extraction limit and risk to the health and wellbeing of livestock and other domestic animals is negligible.

The effects of blasting also appear to have low or negligible impacts to native fauna residing in or near quarries. This is indicated by the ongoing presence of native fauna within quarries and adjacent areas, often close to active blasting areas. Mobs of kangaroos can be found in Oaklands Junction Quarry, and Lysterfield Quarry that neighbours Churchill National Park. Koalas can be found browsing eucalypts within an active quarry in Dromana, the animals moving between the Work Authority and neighbouring Arthurs Seat State Park. Wombats, echidnas and wallabies can be found inside an active quarry at Tynong North that borders Bunyip State Park. Snakes, goannas and other lizards are also found at quarries with suitable habitat. Some operations attract waterbirds to dams and ponds at pit floors, and raptors are a common sight at most quarries. The observed behaviour of birds close to blast sites is to take flight before settling or returning to the area shortly after when the perceived threat has gone.

A survey of native flora and fauna species was recently conducted in a bushland area adjacent to an active quarry pit at Lima South. Numerous fauna species were observed or inferred (including threatened species) and it was noted the lack of observation of transient or seasonal species does not imply such animals are not present or would not visit the area as part of their home range. In summary, the bushland habitat adjacent to the quarry pit was found to be in good condition and home to numerous regional native species. The findings suggest that nearby quarry operations including blasting have a low or minimal impact to adjacent habitat and native species.

There is potential for a brief disturbance to animals close to blasts from noise and overpressure at blast times, though blast events are seemingly too infrequent and too short in duration to cause significant disturbance to resident fauna or deter animals from inhabiting quarries or nearby areas. Airblast can be likened to noise from thunder that also has audible and subaudible overpressure components. Animals have evolved to tolerate high levels and long durations of noise and overpressure from thunderstorms, and it is reasonably concluded the impact of airblast to animals close to blast sites is similar to that of a single, brief thunderclap.

While there is currently an absence of formal, peer-reviewed studies on the effects of blasting on animals, there is no evidence that quarry-scale blasting causes harm to the health and wellbeing of native species or their habitat. It is reported that no concerns have been raised by Parks Victoria regarding the effects of blasting on wildlife within You Yangs Regional Park. While future ground vibration and airblast levels within the park would at times be above previous levels, the potential increases are not significant and blasting in the proposed extension does not present an increased risk to the habitability of the park.

11 BLAST MANAGEMENT

The control measures and onsite procedures required to mitigate blasting risks and impacts can be found in the quarry's Blast Management Plan (BMP) that accompanies the operation's Work Plan. A BMP details the procedures and controls that must be observed for all blasting to ensure blasts are well controlled, compliance with standards and thresholds set out in regulations and guidelines is achieved, and a high degree of site personnel and public safety is provided at all stages of the blasting process. The BMP's details include (but are not limited to);

- Roles and responsibilities of personnel involved with blasting operations.
- Details of relevant regulations and prescribed limits/conditions for blasting.
- Considerations that inform blast design, including the locations of sensitive sites and structures.
- Blast site access and security.
- Site communications systems and protocols.
- Blast hole loading procedures, including treatment methods for under-confined holes and weak rock structure.
- Details of the Risk Assessment procedure and other documentation to be produced for every blast.
- Blast clearance requirements, and clearance and firing procedures.
- Emergency contacts and emergency assembly areas.
- Misfire procedures.
- Blast monitoring and reporting requirements.
- Blast notification requirements and details of nearby residents.

BMPs are working documents subject to periodic review and revision to reflect any changes to blasting requirements and procedures over time. The findings of this assessment may be used to guide further development of the Little River Quarry BMP and operational procedures for blasting under the proposed extension.

12 CONCLUDING COMMENTS

This assessment demonstrates that blasting operations in the proposed extension area of Little River Quarry (WA453) can be conducted safely, in compliance with prescribed blasting criteria for Victorian quarries, and with low-level impacts to amenity at sensitive sites and adjacent land areas.

Conservative assessment shows maximum ground vibration and airblast levels that are below the ERR limits for sensitive sites, and well below levels that may cause damage to structures in accordance with Australian and international research, standards and guidelines. The potential impacts of blasting to amenity are considered low due to the separation distances between the quarry and receptors, and the moderate to high degree of topographic shielding between blasting and sensitive sites.

Under the quarry's standard and modified blast designs, all rock fragments from blasting would be fully contained within the Work Authority. The risk presented by excessive flyrock is greatly reduced by the wide buffers around the extraction area, and are further mitigated by;

- developing an extraction sequence for blasts within 400m of the Work Authority boundary to face inward towards the quarry (as indicated on quarry design plans).
- observing a standard minimum clearance distance of 400m in front of all blast sites.
- observing a standard minimum clearance distance of 250m behind blast sites.
- observing a modified clearance distance of 200m behind blasts with increased stemming height where required to prevent the need to establish clearance within the Ford Proving Grounds and You Yangs Regional Park (i.e. blasts less than 250m from the boundaries)
- using blast guards and spotters to view the ridgeline area immediately north of the Work Authority boundary, and maintaining close communication with SSAA Eagle Park Range management to confirm that no people are on the ridge at blast times (i.e. blasts less than 250m from the boundaries).

The impacts of the proposed blasting to the natural environment are considered negligible and would not be notably changed from current or previous impacts. Ground vibration occurs as elastic waves that do not cause permanent deformation of the surrounding ground or surface. Where perceptible, the non-permanent displacements from blasting are very small (a fraction of a millimetre) and would occur for no longer than a few seconds per week.

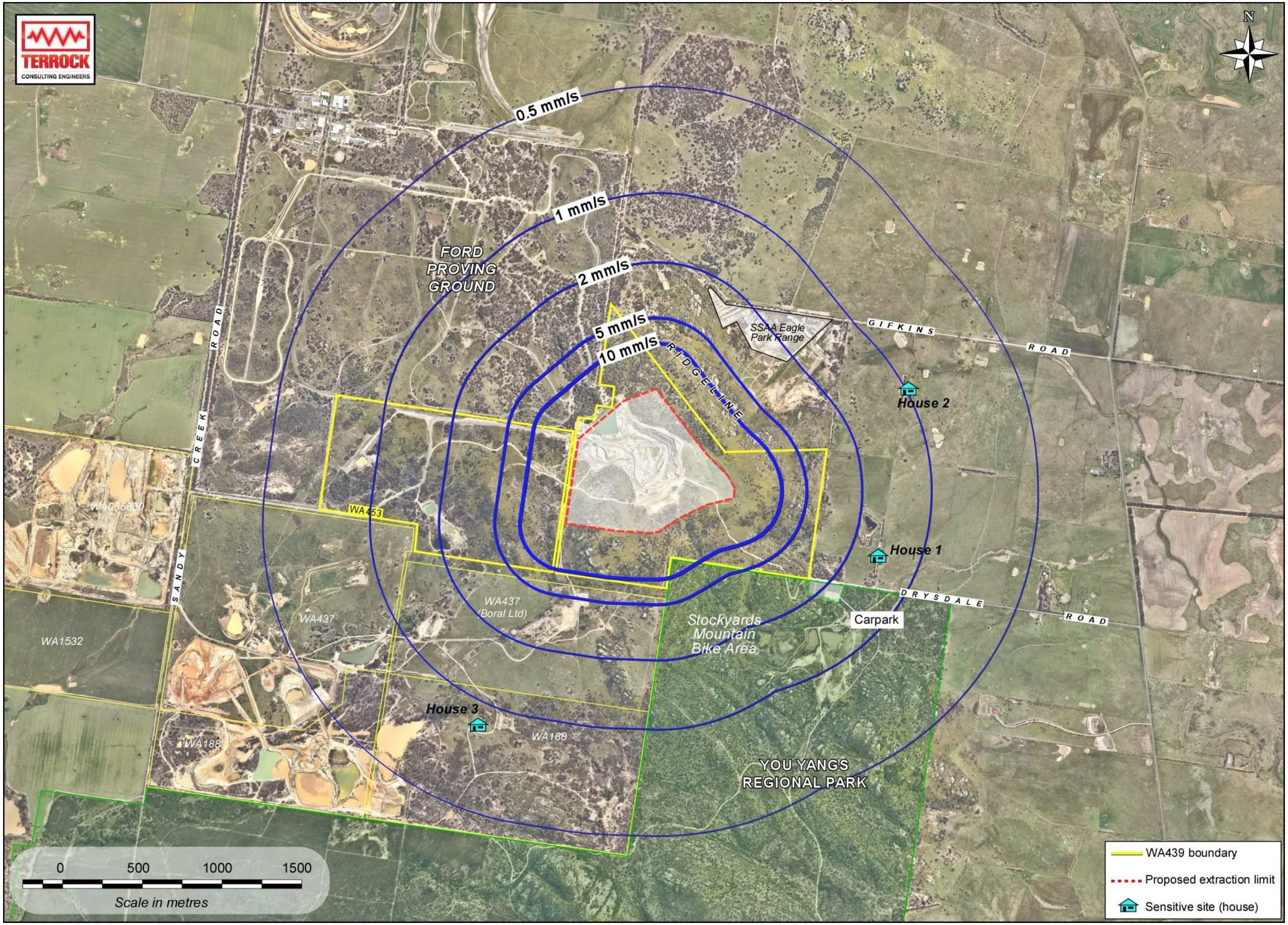
Blasting in the proposed extension area also presents a low or negligible risk to the health and wellbeing of livestock on rural properties and native fauna within nearby habitat areas. Potential noise disturbances from airblast would be infrequent, short-lived and can be likened to the effects of a distant thunderclap.

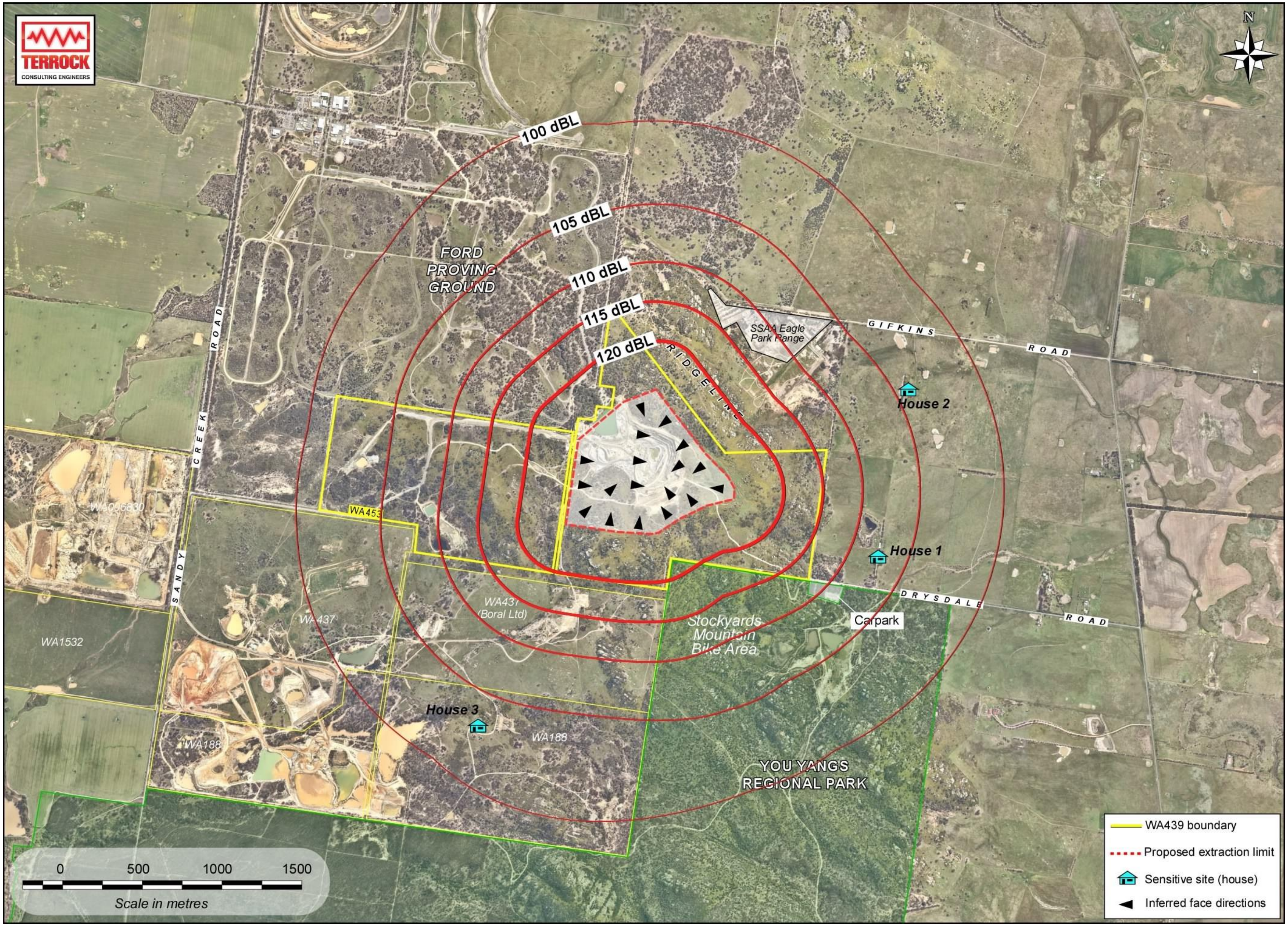
James Richards
Technical Services Manager-Terrock Pty Ltd

23 March 2023

APPENDICES


TERROCK
CONSULTING ENGINEERS
N
2,000m
1,500m
1,000m
500m
FORD PROVING GROUND
SSAA Eagle Park Range
GIFKINS ROAD
RIDGELINE
House 2
Existing Quarry Operation
SANDY CREEK ROAD
WA453
House 1
DRYSDALE ROAD
Carpark
WA437 (Boral Ltd)
WA437
WA1532
Stockyards Mountain Bike Area
House 3
WA188
WA188
YOU YANGS REGIONAL PARK
WA439 boundary
Proposed extraction limit
Sensitive site (house)
Blast monitoring location (2020)
0
500
1000
1500
Scale in metres


TERROCK
CONSULTING ENGINEERS
N
0.5 mm/s
1 mm/s
2 mm/s
5 mm/s
10 mm/s
FORD PROVING GROUND
SSAA Eagle Park Range
GIFKINS ROAD
RIDGELINE
House 2
House 1
SANDY CREEK ROAD
WA453
WA437
WA437 (Boral Ltd)
WA1532
DRYSDALE ROAD
Carpark
Stockyards Mountain Bike Area
House 3
WA188
WA188
YOU YANGS REGIONAL PARK
0 500 1000 1500
Scale in metres
WA439 boundary
Proposed extraction limit
Sensitive site (house)


TERROCK
CONSULTING ENGINEERS
N
100 dBL
105 dBL
110 dBL
115 dBL
120 dBL
FORD
PROVING
GROUND
SSAA Eagle
Park Range
GIFKINS
ROAD
RIDGELINE
House 2
House 1
SANDY
CREEK
ROAD
WA453
WA1006830
WA437
WA437
(Boral Ltd)
DRYSDALE
ROAD
Carpark
Stockyards
Mountain
Bike Area
WA1532
House 3
WA188
WA188
YOU YANGS
REGIONAL PARK
0
500
1000
1500
Scale in metres
WA439 boundary
Proposed extraction limit
Sensitive site (house)
Inferred face directions