NSW GOVERNMENT

NSW Resources Regulator

INVESTIGATION REPORT

DANGEROUS BLASTING INCIDENT

Albury Quarry – 10 April 2018

NSW Resources Regulator

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Executive summary

Overview of incident

On 10 April 2018, twelve people were at risk of being struck by flyrock during an overburden blast conducted at Albury Quarry. Those at risk included members of the public, workers and a shotfirer who were at the firing location at the time of blasting. The members of the public included the partner and three friends of the quarry manager and a visiting truck driver.

At the time of the blast, four people were about 275 metres from the loaded shot that was to be fired (the blast area). The other people, including the shotfirer, were about 320 metres from the blast area.

Multiple rocks were launched into the air by the blast. Most of those present were forced to take evasive action to avoid being struck. Three light vehicles and two excavators in the immediate vicinity of these people were struck by flyrock. A piece of rock measuring approximately 400 x 200 x 200 millimetres struck the shotfirer's utility, knocked the vehicle's raised bonnet off its mounts, smashed through the front windscreen and landed on the driver's seat.

After the incident, those present were asked to delete video footage of the blast. The incident was not reported to the NSW Resources Regulator until 7 September 2018. The circumstances of the incident, including the number of people present and the amount of flyrock produced, were not made known to the Regulator until video footage of the incident was received in November 2018.

Figure 1 Flyrock on driver's seat of shotfirer's utility

Investigation findings

The investigation identified significant deficiencies in the procedures and controls of the mine operator and shotfirer, including the following:

- There was inadequate supervision of the blast:
  - The quarry manager did not possess the competence to ensure effective controls were implemented.
  - The shotfirer failed to use the judgement necessary to take control of the scene before firing the blast.
  - The mine operator did not sufficiently monitor activity at the quarry.
- Multiple procedural safety standards were not followed, including:
  - Exclusion zones were not established.
  - Non-essential personnel were present at the firing location.
  - Those present at the firing location were too close to the blast area.
  - Sentries and blast guards were not assigned.
- There was a failure to observe technical safety standards, including:
  - Inadequate blast design, including insufficient design burden.
  - The correct type of explosive was not used in all blast holes.
  - The firing location should have been located behind the blast area.
- Those present during blasting were not given enough information and training.

Recommendations

Mine operators and shotfirers must:

- ensure that a competent person determines exclusion zone boundaries using a comprehensive risk assessment process, having regard to the nature of the activity and environment
- review their blasting procedures to ensure that exclusion zone requirements are clearly prescribed and communicated to all workers

- ensure workers receive appropriate instruction and training about the risks associated with blasting
- ensure that blasting operations are adequately supervised by persons who have appropriate qualifications and experience
- ensure that only essential personnel are present at the firing location during blasting
- ensure safety observations and audit processes are undertaken on a regular basis by independent parties who are unlikely to be influenced by the normalisation of unsafe work practices
- ensure that records of the actual stemming and explosive amounts are maintained, reviewed and appropriately considered as part of the pre and post blast review process
- ensure that appropriate information and equipment is available to accurately determine the distances between blast areas and exclusion zone perimeters.

Contents

1. Purpose of the report

This report describes the mining workplace incident investigation conducted by the NSW Resources Regulator into the cause and circumstances of a dangerous blasting incident on 10 April 2018 at Albury Quarry, Ettamogah NSW.

2. Investigation overview

2.1. The Regulator

We investigate major workplace incidents in the NSW mining, petroleum and extractives industries. Our role is to carry out a detailed analysis of incidents and report its findings to enhance industry safety and to give effect to our *Compliance and enforcement approach*.

2.2. Legislative authority to investigate

Investigators are appointed as government officials under the *Work Health and Safety (Mines and Petroleum Sites) Act 2013* and are deemed to be inspectors for the purposes of the *Work Health and Safety Act 2011*. The Regulator has also delegated some additional functions to investigators, including exercising the power to obtain information and documents for the purposes of monitoring compliance with the WHS Act.

2.3. Regulator response

The incident was reported to the Regulator on 7 September 2018. We deployed inspectors to the site on 24 September 2018 to undertake an initial assessment of the incident. On 13 November 2018 an investigation was commenced.

3. Flyrock terms and risks

Key terms and the nature of the risks associated with flyrock are detailed in the following extract from Australian Standard 2187.2 – 2006 'Explosives – Storage and use - Part 2: Use of explosives.

Figure 1 - Extract 1 AS 2187.2-2006 E1 Introduction extrapolated from Standards Australia

E1 INTRODUCTION

Because the potential for severe injury or property damage exists, precautions against flyrock and fly should be foremost in the mind of any shotfirer. The closer to persons or property that blasting is carried out, the greater should be the awareness, care and degree of protection exercised in avoiding flyrock and fly incidents.

Paragraphs E1 to E3.7 mainly address the projection of rock and not debris or other material in general. However, debris that may be on, near, or around a shot may become fly and many of the principles used in the control of flyrock can be adopted to control fly. Flyrock and fly occurs when explosive energy in the form of gas expansion energy is vented violently into the atmosphere and projects rocks and/or debris outward and away from the blast area. Fly generated as such represents a serious problem for users of explosives, who must ensure the safety of persons, equipment, and property in the area surrounding the blast.

A number of incidents have been recorded where persons have been killed or injured as a direct result of fly from blasts. An even greater number of instances report property damage and near misses.

Figure 2 – Figure E1 extrapolated from Standards Australia

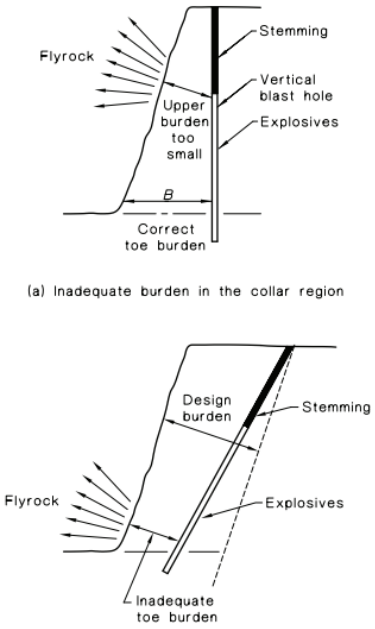


FIGURE E1 FRONT ROW BLASTHOLE BURDENS

4. The incident

4.1. The mine

Albury Quarry is located at Ettamogah, about 15 kilometres north of Albury in New South Wales, near the border of Victoria. The quarry uses a conventional drill and blast operation to extract granite-based material, which is used as aggregate, rock and road base. At the time of the incident, six workers were employed at the quarry.

4.2. Parties involved

4.2.1. Mine owner and operator

Burgess Earthmoving Pty Ltd (the mine operator) is the owner and nominated mine operator of Albury Quarry. It operates several other businesses from its Wagga Wagga base, including the Kapooka Quarry at Wagga Wagga.

4.2.2. Blasting contractor

Hamiltons Blasting Services Pty Ltd (HBS) was contracted by the mine operator to conduct blasting at its Albury Quarry and Kapooka Quarry. HBS is a Victorian based company which provides blasting services in Victoria, New South Wales and South Australia. It has extensive blasting experience.

HBS had conducted blasting at Albury Quarry on four occasions prior to 10 April 2018. All these blasts were conducted by one of its directors (the shotfirer) and were reported to be without incident.

At the time of the incident, the shotfirer had approximately 14 years' experience in the blasting industry and held a blasting explosives user licence (BEUL) in New South Wales.

4.3. Preparations in weeks prior to blast

In late February or early March 2018, a request was made by the mine operator to HBS to conduct blasting at the quarry. The mine operator required the following:

- An overburden blast along a large bench in the south-western area of the quarry (the main blast).
- Smaller 'toe' shots (secondary blasting) to break up oversize rocks on the quarry floor beneath the face of the main blast area that resulted from an earlier primary blast (the toe blast).

Figure 3- Blast area prior to blast

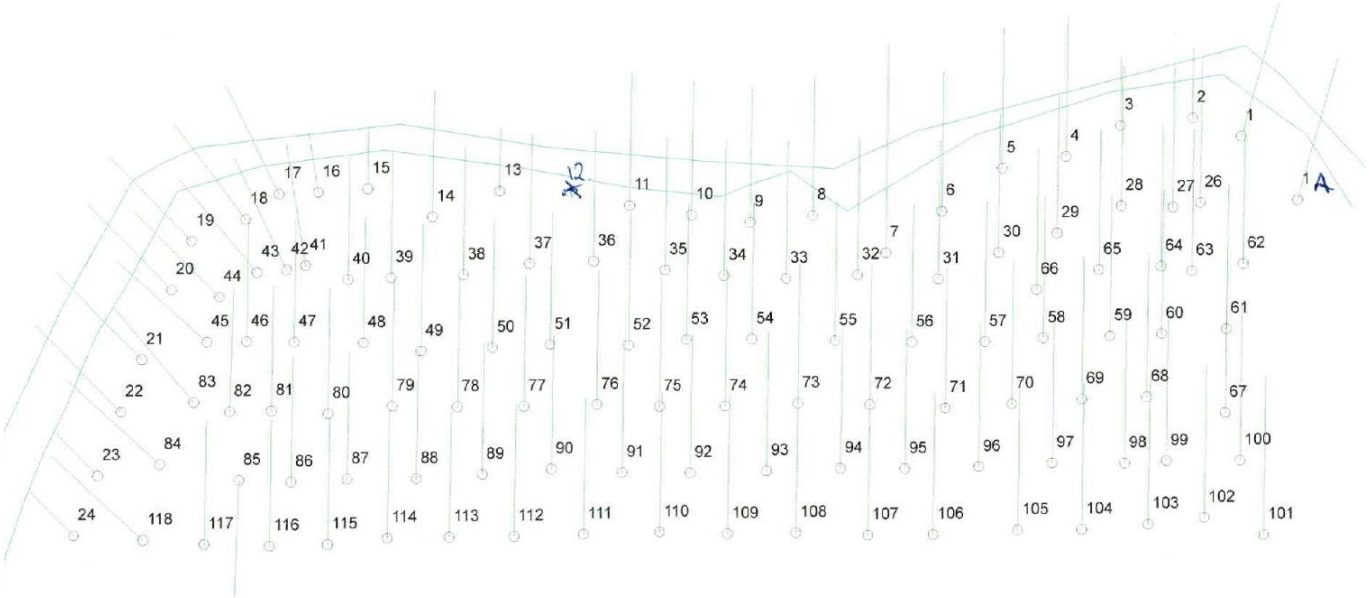
On 5 March 2018, the shotfirer attended the quarry where he marked out the blast hole locations and obtained a face profile of the blast area.

HBS followed the blast hole pattern that had been used previously by the mine operator.

A sub-contractor to the mine operator, Edge Drilling, subsequently drilled the holes in accordance with the instructions of the shotfirer (specifications detailed below at 4.5.2.1).

On 22 March 2018, the shotfirer surveyed the blast holes using a laser system designed to measure borehole deviation. He had concerns that the burden (the distance between the face and the first blast holes) was insufficient due to some deviation in several holes. As a result, he arranged for two of the holes closest to the face to be redrilled (numbers 17 and 18). The original holes were abandoned and left unstemmed (empty).

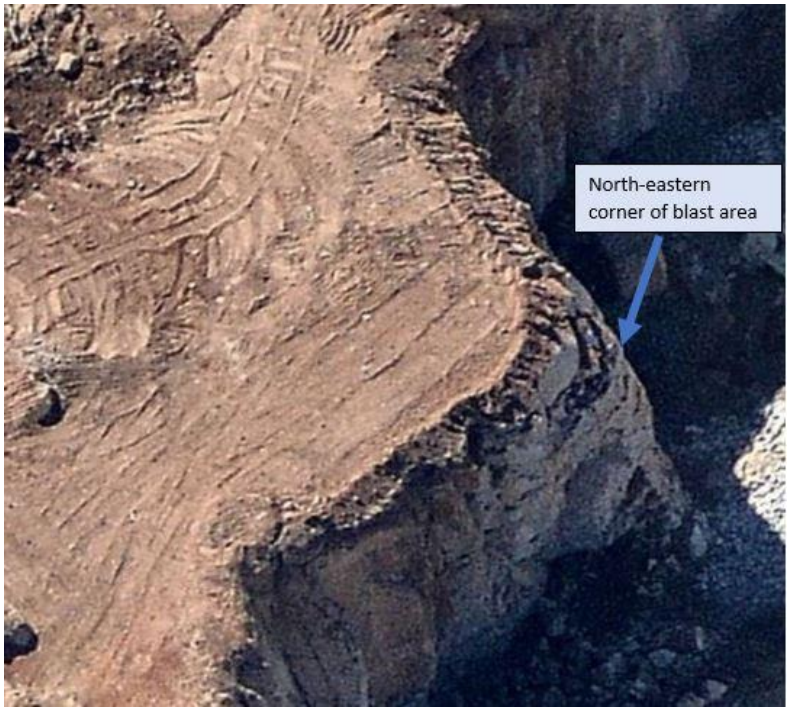
Figure 4 - Blast hole locations



4.4. Observations of blast area

The shotfirer observed some cracks midway up the face of the blast area in the north-eastern corner (refer to figure 5). He estimated the depth of the cracks to be a couple of millimetres but was unable to measure them as it was unsafe to do so.

Figure 5 - Aerial image of blast area showing conditions on 11 March 2018



The shotfirer stated that he was aware of the potential for the north-eastern corner of the blast area to fire towards a shed at the quarry. The shed was located 235 metres north-east of the blast area and about 110 metres north-west of the firing location (refer to figure 6). The shotfirer stated that this was part of the reason that he increased the amount of burden and used a lower emulsion explosive in this part of the blast area.

4.5. Day of incident

4.5.1. Morning meeting

The shotfirer attended a morning meeting conducted by the quarry manager with workers at the quarry shortly before 7 am. The purpose of the meeting was to allocate work for the day. The group discussed that blasting would occur that day, but the specific details about the blast and associated risks were not discussed. The quarry manager tasked two workers to assist the shotfirer to load and stem the holes. The remaining quarry workers were tasked to perform their usual duties.

4.5.2. Loading of holes

About 7 am, three workers from Orica Limited (Orica) arrived at the quarry to supply and load the required explosives. The Orica workers attended a preload toolbox talk conducted by the shotfirer. The talk focused on technical aspects of the blast, site access and the use of personal protective equipment.

Under the shotfirer's procedures, blast sentries, guards and workers assisting with stemming should have attended the toolbox talk, but this did not occur.

The Orica workers left the site at 12.13 pm when loading of the blastholes was completed.

4.5.2.1. The main blast

The following specifications for the main blast were obtained from information provided by HBS.

Table 1- specifications for the main blast

Element	Measurement
Number of holes	118 (24 face holes)
Hole depth	24 metres
Hole diameter	0.89 metres
Hole design angle	10 degrees
Bench height	25.8 metres
Burden	2.4 metres
Explosive	All holes except numbers 17-24: 160 kilograms Orica Centra Gold Holes 17-24 (150-160 kilograms Orica Centra Gold ES (lower density/energy product than Centra Gold).
Stemming	20-millimetre aggregate. Holes except numbers 17-24 had stemming heights of 2.5 metres. Holes 17-24 had stemming heights of 3-4 metres.

However, the claimed use of the lower energy explosive has been unable to be confirmed (see below at 8.3.3).

4.5.2.2. The toe blast

The 15 holes were each loaded with one kilogram of Centra Gold explosive.

4.5.3. Arrival of members of the public at firing location

Shortly before 2.30 pm, the quarry manager's partner arrived at the quarry in a four-wheel drive with three of her friends. The quarry manager knew that his partner would be attending the site. The partner's vehicle did not stop at the quarry entrance. She drove straight to the quarry manager's location. This position ultimately became the firing location.

All four occupants exited the vehicle and stood next to it. They weren't wearing protective clothing or footwear, and none had participated in a visitor site induction.

Around this time, a truck driver employed by a haulage contractor arrived at the quarry to have his truck loaded. One of the quarry employees told the truck driver that blasting was about to be conducted at

the quarry. The truck driver expressed his interest in watching the blast. The quarry worker allowed the truck driver to walk with him to the firing location.

Neither the shotfirer nor the quarry manager queried why members of the public were on the quarry site and allowed them to stay at the firing location during blasting.

4.5.4. Arrival of other workers at firing location

In addition to the quarry worker and quarry manager, another four quarry workers arrived at the firing location to watch the blast. The workers attended the blast for its entertainment value. None of the workers were involved in the blasting activity.

Neither the shotfirer nor the quarry manager queried why the workers were at the firing location. They were allowed to remain at the firing location during blasting.

4.5.5. Selection of firing location

The shotfirer originally selected a firing location that was later determined to be about 360 metres forward of the blast. However, the main group of people present were gathered at a point about 40 metres forward of that location ('Firing location and group 2' in figure 6) so the shotfirer decided to establish the firing location at that point where the main group was gathered (320 metres from blast area).

Figure 6 - Key locations at quarry

The shotfirer stated that he chose a firing location so that he had good visibility of the toe blast, which was to occur prior to the main blast. He estimated that the firing location was about 400 metres from the blast area but did not measure it. He considered this to be a safe location having regard to the depth of burden and the use of a lower energy explosive in some of the blastholes.

4.5.6. Arrangements for blasting

4.5.6.1. Exclusion zones

An exclusion zone was not demarcated prior to the blast. The shotfirer anticipated that those present would remain at the firing location during blasting. The exclusion zone is the area around a blast that must be evacuated of personnel and equipment during the firing of a blast.

The exclusion zone is identified on the firing plan which will also show blast guard positions and other information relevant to the firing.

4.5.6.2. Blast guard

No person was assigned to act as a blast guard during blasting. A blast guard is a person responsible for ensuring the blast exclusion zone is evacuated prior to the firing of a blast.

4.5.6.3. Sentries

There were no sentries at the front or rear gates to the quarry. The quarry manager had asked one of the quarry workers to watch the rear gate to the quarry. The worker ignored the request and remained at the firing location. The quarry manager stated that he requested the visiting truck driver to man the front entrance to the quarry. However, having regard to other evidence obtained, this is unlikely to have occurred.

4.5.6.4. Pre-blast briefing

The shotfirer conducted a pre-blast briefing in which he warned those present that there was a risk of flyrock occurring. He advised them to take shelter behind/under nearby mobile plant if flyrock occurred. The blast management plan prepared by the shotfirer prior to the shot was not shown or referred to during the briefing. The information provided in the briefing did not contain a sufficient level of detail about the risk of serious harm or death from blasting and flyrock.

4.5.6.5. Pre-blast clearance

No steps were taken to ensure that the quarry was clear of people prior to the blast. The quarry manager and shotfirer relied on the fact that those known to be present on site were present at the

firing location. They did not consider the risk of unexpected visitors and trespassers entering the quarry between loading and firing the blast.

4.5.6.6. Location of plant, vehicles and persons

After the pre-blast briefing, but prior to the blasts, three of the workers and the visiting truck driver moved 45 metres forward of the firing location (see group 1 location in figure 6). They stood near a Volvo excavator which was located 275 metres from the blast area. The shotfirer states that he asked the members of that group to return to the firing location, but they refused. Despite this, the shotfirer continued with the blasting operation.

There were three light vehicles at the firing location, the four-wheel drive driven by the quarry manager's partner, a quarry utility and the shotfirer's dual cab utility. Immediately behind the four-wheel drive was a second excavator. The occupants of the four-wheel drive, the shotfirer and two quarry workers stood adjacent to the light vehicles. The remaining quarry worker stood on the second excavator.

4.5.7. Toe blast

Blasting began about 2.30 pm. Although the toe blast involved a much smaller quantity of explosive than the main blast, rock from the blast was ejected a considerable distance into the air (refer to figure 7). Secondary blasts of this nature are considered risky because the direction and distance of rock movement is unpredictable.

Figure 7 - Flyrock produced by toe blast

4.5.8. Main blast

The main blast occurred at 2.32 pm. When fired, the blast projected granite rocks and other material into the air towards the firing location. The majority of the flyrock landed in the dam located between the blast area and the firing location. However, multiple rocks were ejected with enough force to clear the dam and fall around the locations where groups 1 and 2 were standing.

Figure 8 - Early stages of main blast (note large flyrock)

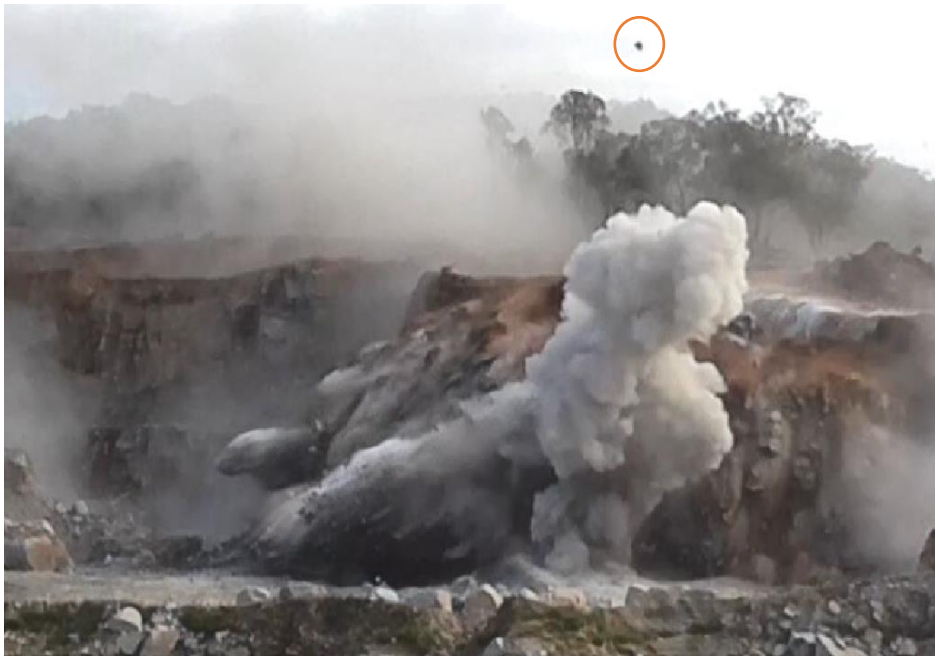


Figure 9 - Flyrock landing in dam in front of firing location

The largest piece of flyrock that was observed (refer to figure 8) struck the raised bonnet of the shotfirer's utility. The impact detached the bonnet from the vehicle. The rock smashed through the front windscreen and came to rest on the front driver's seat.

Figure 10 - Damage to shotfirer's utility

Separate rocks dented the roof of the four-wheel drive and smashed its rear driver's side window. Another rock smashed the windscreen of the quarry utility. A bolt securing a hydraulic line on the rear excavator was broken off after it was struck by rock.

The people standing immediately next to or on these vehicles were very fortunate not to be struck by the flyrock. Most were required to take some form of evasive action, including stepping, ducking and diving away from the path of the rocks and sheltering behind the front excavator.

Figure 11 - Damaged red four-wheel drive

4.5.9. Post incident

Following the incident, the shotfirer instructed all persons present to delete any photos or videos that they had taken of the incident. The shotfirer stated he did this because he did not want footage of the incident to appear on social media.

The quarry manager and shotfirer both spoke to the mine operator's managing director by telephone and advised him that a flyrock incident had occurred. There are varying accounts about the information that was given to the managing director about the degree of risk, number of persons present, and damage to vehicles and plant.

The incident was not reported to the Regulator until 7 September 2018.

5. The investigation

The investigation of the incident has focused on the procedural and technical deficiencies that resulted in so many people being exposed to the risk of serious harm or death. It involved:

- interviewing multiple witnesses and persons in positions of responsibility at the quarry
- using regulatory powers to obtain and analyse relevant information
- engaging a consultant to provide technical advice.

6. Risk to health and safety

Quarry workers and members of the public were exposed to the risk of death or serious injury by being struck by flyrock ejected during blasting conducted at the quarry. The risk had the potential to cause multiple deaths in a single event, meeting the definition of a principal hazard as prescribed within clause 5 of the *Work Health Safety (Mines and Petroleum Sites) Regulation 2014* (WHSMR).

7. Identification and assessment of explosives risk

7.1. Legislative requirements

Clause 9(1) of the WHSMR places a duty on mine operators to manage the risks to health and safety associated with its mining operations. Clause 9(2) of the WHSMR requires mine operators to undertake a formal risk assessment to identify the hazards and risks associated with its operations. Clause 23(1) of the WHSMR requires mine operators to identify all principal hazards associated with its operations.

In relation to each principal hazard identified, clause 23(2) requires mine operators to conduct a risk assessment that involves a comprehensive and systematic investigation and analysis of all aspects of risk to health and safety associated with the principal hazard.

7.2. Mine operator

7.2.1. Legislative requirements

Pursuant to clauses 9(2) and 23 of the WHSMR, the mine operator engaged an external consultant to facilitate and undertake a formal risk assessment of its quarrying operations in November 2017. The quarry manager and a quarry worker participated in the risk assessment process with the external consultant. Neither had specialist skills or knowledge about blasting operations. HBS was not involved in the risk assessment process, despite being the operator's sole blasting contractor.

The risk assessment identified that there was a risk of fatalities occurring as a result of flyrock being produced during blasting operations. It identified the following controls would be appropriate to manage the risk.

- Mine safety management system
- Induction, qualification and letter of competency
- Explosives control plan including contractor safety management system and service provision checklist
- Supervision of personnel working on and around a shot
- Licencing and permits
- Audits and reviews of contractors
- Health control plan – ergonomic stressors

7.2.2. Safety management system

On 1 February 2018, the mine operator implemented a new safety management system (SMS) pursuant to clause 13 of the WHSMR.

The new system replaced the quarry's safety management plan that had been in effect since 13 June 2014. The previous plan contained only basic information about drilling and blasting operations.

7.2.3. Principle control plan – explosives management

On 1 February 2018, the mine operator introduced its principle control plan for explosives management. It formed part of the SMS. The mine operator's procedures under this plan included the following:

- Albury/Wagga quarries management may be required.
- The shotfirer must make all decisions on matters relating to site safety during a blast and those decisions are final.
- Any breach of exclusion zone perimeters during a blast process must cause the process to be aborted immediately by the transmission of the words "Abort, Abort, Abort" over the UHF radio.
- Red flags and signage must be located at each end of the blast area.
- The quarry is to be cleared of personnel and plant prior to blasting.
- Site clearance and readiness for blasting must be confirmed prior to hand over of the blasting zone from the Albury/Wagga quarries production manager to the explosives contractor's shotfirer.
- Blast sentries must block their positions, confirm that they are in position and that their area is secured.

7.2.4. Contractor management plan

On 1 February 2018, the mine operator introduced its contractor management plan (CMP) which was said to detail its expectations about the systems that contractors were required to have in place in order to manage health and safety at the quarry. The quarry's production manager and supervisor were responsible for ensuring contractors met these expectations. Supervisors were required to ensure that the '… contractor's supervisor is familiar with this CMP and other relevant documentation.'

7.3. Hamiltons Blasting Services

7.3.1. Relevant safety management systems

HBS stated that it worked under the mine operator's SMS when in attendance at the quarry, and in addition, it had developed its own procedures for blasting operations at the site.

It is unclear how HBS workers were expected to follow the mine operator's SMS, as HBS had not been provided with relevant information from the SMS. It stated that, in the time that it conducted blasting at

the quarry, it had never been provided with any plans, procedures, safe work method statements or similar documents by the mine operator in relation to drilling and blasting operations.

7.3.2. HBS blast management and control plan

In December 2017, HBS developed its Blast Management and Control Plan which was said to 'assure the safety of the public, site personnel, contractors and equipment.' The plan applied across all locations where HBS provided blasting services. It was developed following a risk assessment conducted by HBS. The following controls were contained in the plan:

- All blasting to be conducted in accordance with relevant Australian Standards, applicable guidelines, statutory rules and regulations and in conjunction with site specific blasting procedures.
- Warning signs "BLASTING NO UNAUTHORISED ENTRY" shall be erected at the boundaries and entry road to the blast area.
- Only persons authorised by the shotfirer shall be permitted to enter onto the blast.
- Prior to firing the blast, all personnel (other than the shotfirer) and equipment shall be removed from the blast area. Personnel removed from the blast area are to muster at the nominated muster point.

7.3.3. HBS site specific procedures

HBS also developed a blast management plan and safe work method statements (SWMS) that were specific to blasting at Albury Quarry. The SWMS covered mark out, blasting and misfire. These documents were reviewed and approved by the (then) quarry manager in November 2016.

7.3.3.1. HBS safe work method statement – operations blasting

The SWMS identified flyrock as a critical risk during blasting operations. It identified various controls to manage flyrock and other risks, including the following:

- Any new personnel coming onto the shot must report to the senior shotfirer, and have read, understood and signed off on the toolbox talk before commencing work.
- Clear communication with site management regarding exclusion zones.
- Site to be fully cleared. Sentries to be posted as per blasting procedure.
- Blast exclusion zones set in place and controlled before lead-in line is run out.

- Barricading, signage and guarding to prevent access.
- Shotfirer to stop the shot from taking place in the event of an unexpected risk occurrence.
- Site PPE requirements.
- Sign SWMS and conduct a Take-5 risk assessment.

8. Legislation and standards

8.1. Legislation

The effect of clause 31(2)(b) of the WHSMR and clause 65 of the Explosives Regulation 2013 is that persons using explosives on mines and quarries must comply with the requirements of Australian Standard 2187.2-2006 'Explosives – Storage and use – Part 2: Use of explosives' (AS 2187.2).

8.2. AS 2187.2

Appendix L of AS 2187.2 provides detailed information about the requirement to establish exclusion zones during blasting operation. It includes the following guidance.

- The size of the exclusion zone shall be such that all fly and associated debris is contained within the zone.
- The inner zone shall be identified by being cordoned off with flagging tape, flags, hazard blast cones, berms, signage or other suitable means visible at all times to restrict unauthorized entry.
- The requirements for an exclusion zone shall be a component of the blast management plan.
- The distance for flyrock can be difficult to predict.
- Written procedures shall be developed for the establishment and disestablishment of the exclusion zone.
- It is important that control is established and maintained at all levels of the project and the blasting should not be promoted as a public display.

9. Findings

The investigation identified that the unsafe blasting practices that led to the incident were caused by:

- inadequate supervision of blasting operations
- failure to observe safety standards - procedural
- failure to observe safety standards – technical
- failure to provide appropriate information and training.

9.1. Inadequate supervision of blasting operations

9.1.1. Situation prior to November 2017

Prior to November 2017, the quarry manager took a stronger approach to safety during blasting operations. This included a 12-month period in which HBS provided blasting services at the quarry. The previous quarry manager ensured that exclusion zones and perimeters were maintained, and that effective guarding was in place during blasting. He required workers to retreat to a nearby farmhouse or the weighbridge located at the quarry entrance prior to blasting.

The previous quarry manager held a production manager permit, which was, at that time, a prerequisite qualification to perform the role. He stopped working at the quarry in October 2017.

9.1.2. Post-November 2017

9.1.2.1. Quarry manager

On 1 November 2017, a new quarry manager started at the quarry. The quarry manager did not possess a practicing certificate, which was the necessary qualification required by legislation to fulfil the role.

An exemption that operated at the time provided that subject to certain notification requirements, quarries could operate for up to two months in a calendar year with an unqualified quarry manager (**'the maximum period'**). In accordance with the requirements of the order, the mine operator notified the regulator on 11 December 2017 that the quarry manager would be fulfilling the role.

At the time of the incident, the maximum period permitted under the exemption had been exceeded and a qualified manager had not been appointed.

The quarry manager had no previous management or blasting experience. He had worked at the quarry on a previous occasion but not in a supervisory position. He had not worked at the quarry for over 12 months before his return in November 2017. He was not given any training or induction at the quarry when he returned in the capacity of manager. He was unsure how to access information about work health and safety. Although he was involved in the risk assessment process for the development of the quarry's new SMS, he had never seen the completed system, including the explosives management plan.

The quarry manager stated that he did not feel that he possessed the necessary skills to be a quarry manager and considered himself to be a supervisor.

Workers at the quarry stated that there was a noticeable decline in safety standards at the quarry after the new quarry manager commenced. There were several workers who were at times resistant to requests made by the quarry manager. The quarry manager found it difficult to manage these workers.

The only previous blasting that had been conducted at the quarry in the period between the new quarry manager starting and the incident, occurred on 19 December 2017. There is evidence that compliance with blasting standards was relaxed during that blast and that at least one worker was present at the firing location on that occasion.

On 10 April 2018, the quarry manager did not possess the necessary skills and experience to be able to control the blasting operations. He did not feel that he had the knowledge to be able to adequately assess decisions made by the shotfirer regarding the firing location and exclusion zones. His ability to control the location of the workers during blasting was seriously undermined by his decision to allow members of the public to be present.

9.1.2.2. Shotfirer

Although the shotfirer possessed the necessary knowledge and experience to be able to make assessments about the safety of the blast, he failed to use the judgement necessary to take control of the situation. The shotfirer stated that he relied on the quarry manager to ensure that the site was safe, even though he knew that the quarry manager had no knowledge about drilling and blasting operations. The shotfirer held an important responsibility to ensure safety during blasting. He failed to manage and control the blasting process in accordance with required safety standards. It is essential that shotfirers are not influenced by others with respect to crucial safety decisions.

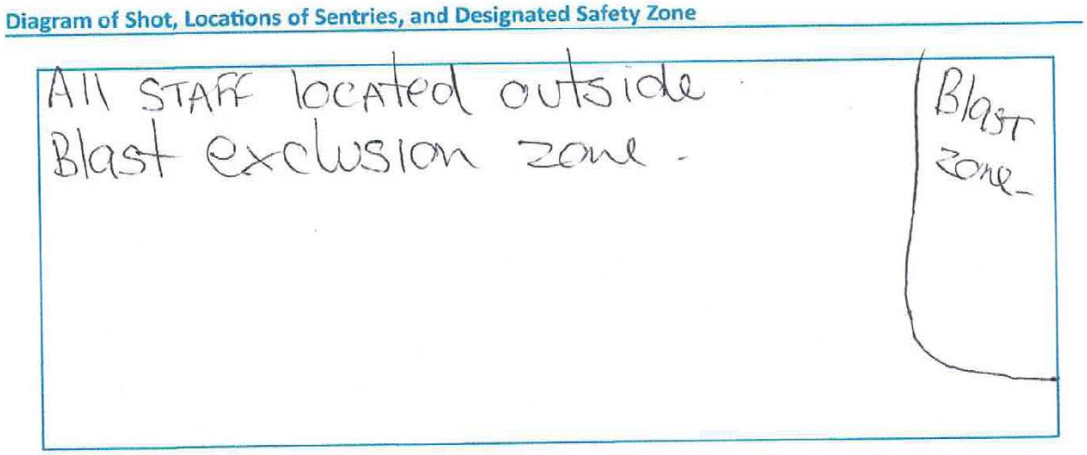
9.1.2.3. Mine operator

The mine operator did not audit blasting operations at the quarry after the new quarry manager started in the role. It also did not adequately assess the competence of the quarry manager to ensure that he understood and was able to meet health and safety requirements.

9.2. Failure to observe safety standards - procedural

The mine operator and shotfirer each failed to comply with their own safety systems and AS 2187. Some failures involved completely disregarding requirements, others involved giving token compliance. An example of the latter is shown in Figure 12. It was prepared by the shotfirer as part of its planning procedures, and purports to identify a 'Designated Safety Zone.'

Figure 2- Blast diagram included in shotfirer's blast management plan



The following procedural deficiencies were identified in the actions of the mine operator and shotfirer:

- Blast exclusion zones were not demarcated and effectively communicated to ensure the safety of those present.
- There was no signage installed at the blast area warning of dangers and no-go zones.
- Non-essential personnel, including members of the public, were present during blasting. The risks associated with blasting increases as the number of people in the vicinity of the blast increases.
- There was no protection such as shields and barriers afforded to those present at the firing location.
- There were no sentries positioned at all entry points to the quarry.
- There was no blast guard appointed to prevent unauthorised entry to exclusion areas.
- The people present during blasting and the firing location were too close to the blast area.
- The distance between the blast area and the firing location was not measured.

- An effective risk assessment of the blast, including the loading sequence, was not conducted.
- The shotfirer did not maintain a blasthole loading chart to highlight the actual loading amounts, powder factor and stemming for each blasthole and to highlight variations to the design.
- Blast documentation was completed in an ad-hoc manner and contained numerous errors and inaccuracies.
- There were no review or approval processes for the blast, including where the firing location and exclusion zones would be established.

9.3. Failure to observe safety standards – technical

9.3.1. Elimination of toe blast

There are significant risks associated with secondary blasts due to the unpredictable nature of rock movement. The operator may have eliminated these risks by using an alternate method to break up oversize rock, such as the use of hydraulic rock hammers. A risk assessment would need to be undertaken prior to any alternate method being adopted.

9.3.2. Blast design

Blast design includes factors such as the burden, spacings, charge in each hole, stemming and the delay interval. These factors determine the throw of the blast. The burden must be calculated to eliminate cratering; where rocks get thrown out from cavities or weak zones in the bench around the collar of the blast hole. There should also be adequate delay between rows of holes to allow room for the rock to swell and displace previously blasted material.

The primary causes of flyrock are face bursting, rifling and cratering.

9.3.2.1. Planning

The design of the main blast was flawed due to a failure by the shotfirer to apply important blast principles. These failures included:

- inaccuracies in the calculation of the blast sub-drill (sub-grade - distance below intended floor level)
- lack of understanding of key values in the calculation and/or presentation of powder factors
- confusion about what constitutes the maximum instantaneous charge (MIC - mass of explosive detonating in some defined time period, usually 8 milliseconds).

9.3.2.2. Insufficient face blasthole burden

The flyrock produced in the blast was primarily attributable to insufficient face blasthole burden. Increased design burdens should have been used to allow for:

- blasthole deviation (see 9.3.2.5 below)
- fragmentation from previous blasting (back break)
- confinement of the explosive's energy.

9.3.2.3. Use of driller's logs

The shotfirer failed to obtain and review the logs prepared by the contractor who conducted the blast hole drilling. Drillers' logs can include important information about the material being blasted, including rock hardness and the presence of cavities or water. This information is useful when making design decisions, particularly in relation to stemming (inert material used to confine the gasses generated during detonation) and blasthole decking.

9.3.2.4. Powder factor

The powder factor used in the blast was too high. It appears to have been calculated using the total rock volumes and the total amount of explosives. The difficulty with this method of calculation is that it fails to sufficiently consider the risks associated with rock movement from individual face blastholes. It is therefore important to determine the powder factor for face blastholes by having regard to their individual characteristics.

9.3.2.5. Blast hole deviation

As bench heights increase, it becomes more difficult to control the risks associated with blast hole deviation (the movement of the drill hole away from the intended location). Blast hole deviation towards the face results in a reduced amount of burden in face blastholes. In order to minimise blast hole deviation, quarry bench heights are typically between 15 and 18 metres high.

The 25.8 metre bench height used at the quarry decreased the driller's ability to manage hole deviation.

Although the shotfirer measured hole deviation, limited data points were collected for the lower sections of the face. His measurements would have been more accurate had he collected further points.

Additionally, the shotfirer failed to measure hole deviation in holes 17 and 18 after they had been redrilled.

It should also be noted that hole number 15 of the main blast should have been redrilled as the lower areas of that hole had less burden than the blast design. The consultant engaged by the Regulator also highlighted that hole number 15 should have been loaded using an inert deck either side of the 16-metre depth location on account of the reduced burden. This would have reduced the charge load in the hole and made the hole less prone to flyrock from face burst.

9.3.3. Explosive used

Evidence was obtained that strongly conflicts with the assertions by the shotfirer that he used a lower energy explosive (ES) in holes 17 to 24. The blast management plan sent by the shotfirer to the mine operator on 18 April 2018 made no reference to the use of ES. However, a copy of the same plan sent to the Regulator on 26 June 2019 was endorsed with the words "ES product 17 to 24".

Orica's records do not refer to any ES product being supplied at the quarry on 10 April 2018. It stated that it would be unusual for a particular type of product to be delivered without a record of it being made. The Orica workers who delivered the explosive on 10 April 2018 have no recollection of what products they actually delivered, making it difficult to resolve the conflict in the evidence in this regard.

It is unclear why the shotfirer chose to restrict the use of the ES product to holes 17 to 24. If it had been used along the entire front row of blast holes (i.e. numbers 1 to 24), it would have reduced the potential for excessive rock movement.

9.3.4. Firing location

The drilling and blasting consultant engaged by the Regulator stated:

> *"Quarry production blasting is designed to fragment rock and move it in a direction approximately perpendicular to the free face. The safest location for this type of blast is behind the last row of blastholes at the designated safe location."*

The decision to position the firing location forward of the blast increased the risk of people being struck by flyrock. It was generally known that if flyrock was produced, it would travel in the general direction toward the firing location.

The shotfirer stated that his primary reason for choosing a firing location forward of the free face was that he needed to be able to see the results of the toe blasts before proceeding with the main blast. However, the shotfirer was unable to explain why this could not have been achieved if the blasts were fired from behind the last row of blast holes. The shotfirer could have easily travelled from such a location to inspect the results of the toe blast. There was no practicable reason the main blast had to be fired so soon after the toe blast.

It was noted that on previous occasions in which the shotfirer had conducted bench blasting at the quarry, he had chosen a firing location behind the last row of blastholes.

9.4. Failure to provide appropriate information and training

9.4.1. Information

The information provided to everyone present during the pre-blast briefing was inadequate. They were told that there was a risk of flyrock occurring, and that if it was to occur that they should maintain focus of any rock flying in their direction. Despite the fact that many of those present were members of the public and had little or no previous experience with quarry blasting, the shotfirer stated that it was his expectation that they would make their own assessment about the level of risk and their own decision about whether or not they should be present during blasting. This was despite the site specific HBS blasting plan and SWMS requiring exclusion zones and that the site is to be fully cleared (refer to 7.3.3).

There was no information provided to those present about whether an exclusion zone had been established, and if so, where it was.

9.4.2. Training

Although quarry workers were regularly required to assist with loading blastholes, none could recall being given training in the risks associated with drilling and blasting operations. None of the workers present at the time of the blast had been given training in relation to the explosives management plan introduced on 1 February 2018, and most had not seen the document.

10. Failure to notify the regulator and preserve scene

Pursuant to clause 179(f) of the WHSMR, the ejection of flyrock from blasting that falls outside the blast exclusion zone, being the area from which people are excluded, becomes a notifiable incident. Section 15 of the *Work Health and Safety (Mines and Petroleum Sites) Act 2013* provides that notifiable incidents must be reported to the Regulator immediately after the operator and/or person conducting a business or undertaking (**PCBU**) at a mine site becomes aware of it (i.e. incidents arising from the operations of the mine and/or PCBU at the mine).

Persons who have a duty to notify the Regulator of notifiable incidents also have a duty under section 17 of the same act to ensure that an incident site is not disturbed until an inspector arrives.

The operator and HBS each failed in their duty to notify the Regulator of the incident and to preserve the scene of the incident.

The shotfirer also had notification requirements pursuant to clause 103(1) of the *Explosives Regulation 2013*. The shotfirer failed to comply with these requirements.

The mine operator notified the Regulator of the incident on 7 September 2018.

The mine operator stated that it was unable to make the notification earlier because it was not aware of the full circumstances of the incident. In a post-incident report given by HBS to the mine operator, the shotfirer failed to advise that there were multiple people, vehicles and plant at the firing location that were either struck by, or narrowly avoided being struck by, falling flyrock.

HBS stated that it did not notify the Regulator of the incident because it expected the operator to do it. It did not check with the operator to establish if it had made the notification.

11. Corrective action taken

11.1. Blasting contractor

HBS stated that it has implemented the following changes to improve safety for its drilling and blasting operations following the incident:

- Updated risk assessment documentation for surveying and blasting.
- Updated blast management plans requiring identification of exclusion zones and diagrams detailing sentry locations.
- No employees to be inside quarry grounds during blasting.
- Exclusion zone widened.
- Blast day analysis paperwork updated.
- Implementing GPS co-ordinates for each shot.
- Managing blast exclusion zone distances with GPS finder.
- Review of administration process and controls.

11.2. Mine operator

The mine operator stated that it has implemented the following changes to improve safety for its drilling and blasting operations following the incident:

- Replaced its quarry manager.
- Engaged a new shotfiring company to provide blasting services.
- Revised its mine safety management plan and explosives control plan.
- Rrained key personnel in the above revised plans.
- Reviews shot plans and bore tracking surveys prior to blasting.
- Obtained security clearances for key quarry personnel.
- Improved its blast management records.
- Implemented audit and review processes for blasting operations.

12. Recommendations

Mine operators and shotfirers must:

- ensure that a competent person determines exclusion zone boundaries using a comprehensive risk assessment process, having regard to the nature of the activity and environment
- review their blasting procedures to ensure that exclusion zone requirements are clearly prescribed and communicated to all workers
- ensure workers receive appropriate instruction and training about the risks associated with blasting
- ensure that blasting operations are adequately supervised by persons who have appropriate qualifications and experience
- ensure that only essential personnel are present at the firing location during blasting
- ensure safety observations and audit processes are undertaken on a regular basis by independent parties who are unlikely to be influenced by the normalisation of unsafe work practices
- ensure that records of the actual stemming and explosive amounts are maintained, reviewed and appropriately considered as part of the pre and post blast review process
- ensure that appropriate information and equipment is available to accurately determine the distances between blast areas and exclusion zone perimeters.

13. Resources

Further information regarding relevant guidance material and publications related to the incident:

- AEISG Code of Good Practice Blast Guarding in an Open Cut Mining Environment, March 2011.
- Investigation report - Dangerous shotfiring incident at the Moolarben Coal Mine on 17 May 2017