



**ROCGLLEN MINE
ENVIRONMENTAL
MANAGEMENT SYSTEM**

Document Owner:	Operations Manager
Last Revision Date:	06/2018
Date Printed:	6/06/2018

WHC_PLN_ROC_BLAST MANAGEMENT PLAN

BLAST MANAGEMENT PLAN



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Edition	Rev.	Comments	Author	Authorised By	Date
1	0	Initial document	T Thompson	Chris Burgess	April 2008
2	0	2011 Rocglen Extension Project Review	Chris Thomas	Danny Young	June 2013
2	1	PA 10_0015 MOD 2	Madeline Woodhead	Jill Johnson	November 2015
2	2	Review following 2016 IEA	Madeline Whitten	Jason Conomos	October 2016
2	3	Review following monitor relocation	Madeline Whitten	Jason Conomos	February 2017
2	4	Review following Annual Review	Emily Clements	Jason Conomos	May 2018
2	5	Revision following comment by DPE	Emily Clements	Jason Conomos	June 2018



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ACRONYMS USED THROUGHOUT THIS DOCUMENT

AS	-	Australian Standard
AR	-	Annual Review (incorporates former Annual Environmental Management Report)
BMP	-	Blast Management Plan
CCC	-	Community Consultative Committee
EPA	-	Environment Protection Authority
DP&E	-	Department of Planning and Environment
EPL	-	Environment Protection Licence
GSC	-	Gunnedah Shire Council
DRG	-	Department of Planning and Environment - Division of Resources and Geoscience
MIC	-	Maximum Instantaneous Charge
RCM	-	Rocglen Coal Mine

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1 **INTRODUCTION**

The Rocglen Coal Mine (RCM) is located approximately 28km north of Gunnedah and 10km east of the Canyon Coal Mine (formerly Whitehaven) (Figure 1). The mine site covers an area of approximately 460 hectares.

The mine was initially approved on the 15th April 2008 under PA 06_0198 with a minor modification granted in May 2010 to address high wall stability issues. Whitehaven submitted a Project Application, and accompanying Environmental Assessment, under Part 3A of the *Environmental Planning and Assessment Act 1979* in March 2010. PA 10_0015 was issued on the 27th September 2011 and allows for additional extraction of up to 5 million tonnes of coal at a maximum recovery rate of 1.5 million tonnes per annum (ie. increased projected life of the operation for coal extraction by up to four years).

A minor modification was approved in November 2014 relating to Coal Transport, a second modification was approved in August 2015 allowing changes to coal reject haulage to the site, and a third modification was approved in February 2017 to allow increased coal haulage during calendar year 2017.

This Blast Management Plan (BMP) has been prepared to ensure that the blasting associated with the mine's operations are in compliance with criteria stated in PA 10_0015 (as modified) for the RCM. To ensure this, the BMP has been prepared in accordance with Schedule 3, Condition 12 of the approval.

The following sub-sections identify the monitoring locations and the nature of the monitoring equipment to be used, equipment setup and post-blasting procedures as well as blast information analysis and reporting procedures. To ensure this document represents an effective on-site management tool, information on invitations for pre-blasting property inspections and investigations, blasting mitigation measures, blast notification procedures and complaint management procedures are also recorded.

The original BMP was prepared in consultation with the Environment Protection Authority (EPA) on the basis of blasting occurring within the confines of project approval limits, which specifies:

- Blasting may only take place on site between 9am and 5pm Monday to Saturday inclusive, and no blasting is allowed on Sundays, public holidays, or at any other time without the written approval of the Secretary; and
- A maximum of 1 blast a day on site, unless an additional blast is required following a blast misfire.

Information regarding blast management and performance to date is available in the site's Annual Review.

Responsibilities for blast management actions are defined in Table 1 below:



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Table 1 - Blast Management Responsibilities

Type	Responsibility	Comments
Blast Design	Blast Engineer in conjunction with site surveyor or delegate	To ensure blast design will achieve desired result and compliance requirements
Blast Notification	Site Clerk or delegate	To provide notice to nearby landholders
Blast Signs	Shot firers or delegate	To provide notice of blasts on site to passers-by and contractors/site visitors
Pre-blast checklist (including weather, safety and fume implications of the blast)	Operations Manager or delegate	To ensure all pre-task checks are complete and in order
Blast Monitors	Environmental Officer or delegate	Permanent blast monitors in place and calibration and servicing of these
Blast Monitor Review	Environmental Officer or delegate	To confirm compliance and any post notification requirements
Incident/Exceedance response	Environmental Department	Carry out notification requirements
Routine Reporting	Environmental Officer or delegate	Annual Review, CCC, monthly EPL reports

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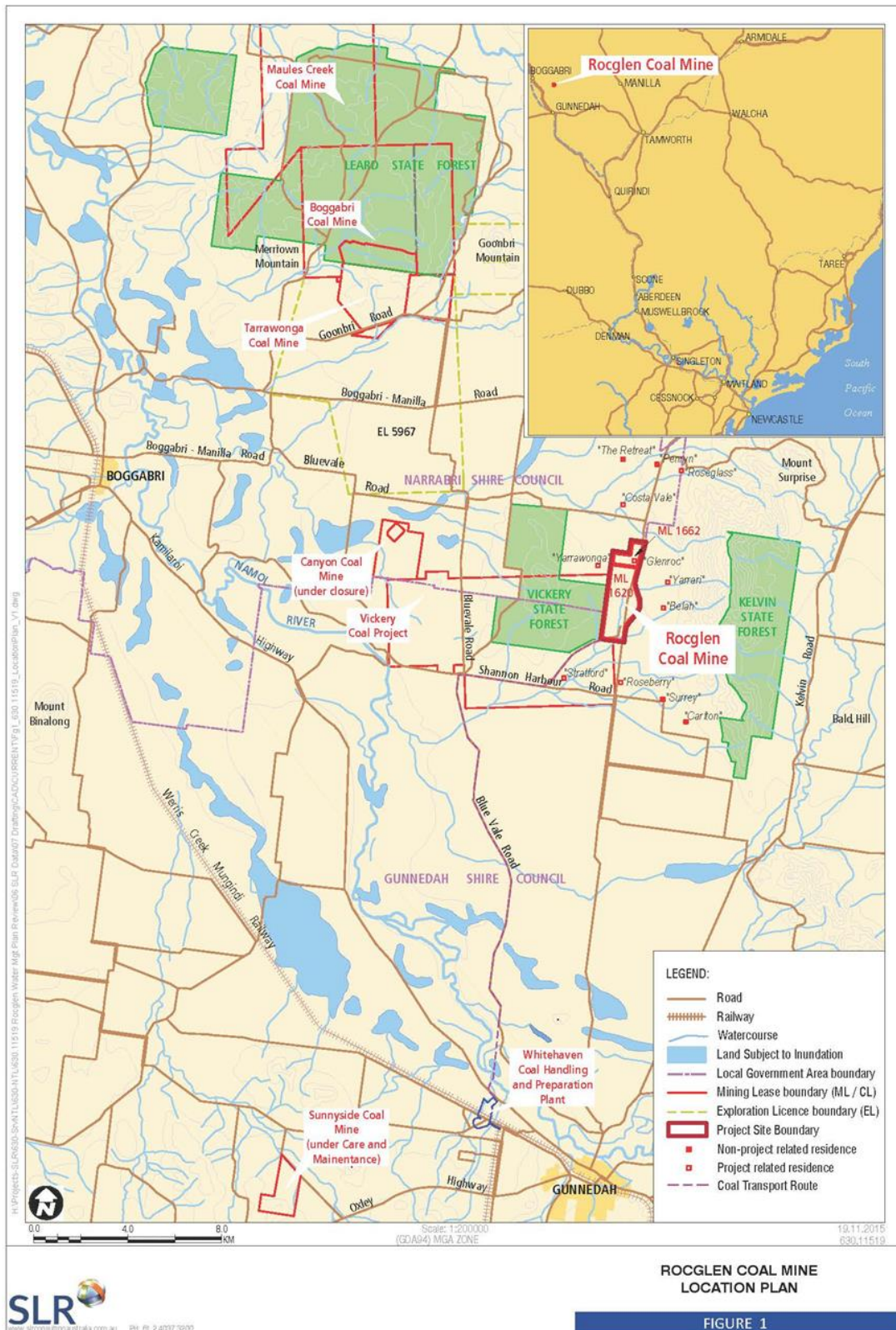


Figure 1 Rocglen Coal Mine Location

2 STATUTORY REQUIREMENTS

This Blast Management Plan (BMP) follows the management plan requirements specified in Schedule 5, Condition 2 of PA 10_0015 and complies with the requirements of Schedule 3, Condition 12, which states:

Blast Management Plan

The Proponent shall prepare and implement a Blast Management Plan for the project to the satisfaction of the Secretary. The plan must:

- (a) be prepared in consultation with EPA, and be submitted to the Secretary for approval by the end of December 2011;*
- (b) describe the measures that would be implemented to ensure compliance with the relevant conditions of this approval; and*
- (c) include a blast monitoring program to evaluate the performance of the project.*

In addition, the Project Approval includes the following conditional requirements from Schedule 3 relevant to blast management at the Rocglen site:

5. The Proponent shall ensure that the blasting on site does not cause exceedances of the criteria in Table 3.

Table 3: Blasting criteria

Location	Airblast Overpressure dB(Lin Peak)	Ground Vibration (mm/s)	Allowable Exceedance
Residence on privately owned land	115	5	5% of the total number of blasts over a period of 12 months
	120	10	0%

However, these criteria do not apply if the Proponent has a written agreement with the relevant landowner to exceed the criteria, and the Proponent has advised the Department in writing of the terms of the agreement.

6. The Proponent shall only carry out blasting on site between 9am and 5pm Monday to Saturday inclusive. No blasting is allowed on Sundays, public holidays or at any other time without the written approval of the Secretary.

7. The Proponent shall not carry out more than one blast a day on site, unless an additional blast is required following a misfire.

Note: A blast may involve a number of explosions within a short period, typically less than 2 minutes.

8. If the Proponent receives a written request from the owner of any privately owned land within 2 kilometres of the approved open cut mining pit on site, or other landowner nominated

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by the Secretary, for a property inspection to establish the baseline condition of any buildings, and/or structures on their land, or to have a previous property inspection report updated, then within 2 months of receiving this request the Proponent shall:

(a) Commission a suitably qualified, experienced and independent person, whose appointment has been approved by the Secretary, to:

establish the baseline condition of the buildings and/or structures on the land or update the previous property inspection report; and

identify any measures that should be implemented to minimise the potential blasting impacts of the project on these buildings and/or structures; and

(b) Give the landowner a copy of the new or updated property inspection report.

9. If the owner of any privately owned land claims that the buildings and/or structures on their land have been damaged as a result of blasting on site, then within 2 months of receiving this claim the Proponent shall:

(a) Commission a suitably qualified, experienced and independent person, whose appointment has been approved by the Secretary, to investigate the claim; and

(b) Give the landowner a copy of the property investigation report.

If this independent property investigation confirms the landowner's claim, and both parties agree with these findings, then the Proponent shall repair the damages to the satisfaction of the Secretary.

If the Proponent or landowner disagrees with the findings of the independent property investigation, then either party may refer the matter to the Secretary for resolution.

10. The Proponent shall:

(a) Implement best blasting management practice on site to:

- protect the safety of people and livestock in the surrounding area;
- protect public or private property in the surrounding area; and
- minimise the dust and fume emissions of the blasting; and

(b) Operate a suitable system to enable the public to get up to date information on the proposed blasting schedule on site to the satisfaction of the Secretary.

11. The Proponent shall not carry out any blasting on site that is within 500 metres of:

(a) a public road without the approval of Council; and

(b) any land outside the site that is not owned by the Proponent, unless:

- the Proponent has a written agreement with the relevant landowner to allow blasting to be carried out closer to the land, and the Proponent has advised the Secretary, in writing of the terms of this agreement; or
- the Proponent has:
 - demonstrated to the satisfaction of the Secretary that the blasting can be carried out closer to the land, without compromising the safety of people or livestock, or damaging

the buildings and/or structures on the land; and- updated the Blast Management Plan to include the specific measures that would be implemented while blasting is being carried out within 500 metres of the land.

16. The Proponent shall:

(a) Implement best practice air quality management on site, including all reasonable and feasible measures to minimise the off-site odour, fume and dust emissions generated by the project, including those generated by any spontaneous combustion on site;

(b) Minimise any visible air pollution from the project;

(c) Minimise the surface disturbance on site; and

(d) Regularly assess the real time air quality monitoring and meteorological forecasting data and relocate, modify, and/or stop operations to ensure compliance with the relevant conditions of this approval to the satisfaction of the Secretary.

Requirements specified in ML 1620, ML 1662 and Environment Protection Licence (EPL 12870) mirror those listed in the Consent and have been referred to in the relevant sections of this Plan.

2.1 **Blasting Criteria and Limitations**

In accordance with Schedule 3, Condition 5 of PA 10_0015, the airblast overpressure and ground vibration blasting criteria is as shown in Table 2.

Table 2 - Blasting Criteria

Location	Airblast overpressure (dB(Lin Peak))	Ground vibration (mm/s)	Allowable exceedance
Residence on privately-owned land	115	5	5% of the total number of blasts over a period of 12 months
	120	10	0%

However, these criteria do not apply if RCM has a written agreement with the relevant landowner to exceed the criteria, and RCM has advised the Department in writing of the terms of this agreement.

Furthermore, PA 10_0015 restricts blasting operations to 1 blast per day, unless an additional blast is required following a blast misfire. Blasting operations are carried out between 9am and 5pm Monday to Saturday inclusive.

Blast monitors are located on the properties 'Surrey' and 'Retreat' and further information can be found in Section 5.1.2.

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3 **BLASTING CONTROLS AND MANAGEMENT PROCEDURES**

3.1 **Potential Impacts**

The Rocglen Coal Mine Extension Project Environmental Assessment assessed the potential for structural damage from blasting at surrounding company owned/private agreement, and privately owned, properties. The assessment reviewed historical blast monitoring results which show no exceedances of either the applicable ground vibration or blast overpressure criteria at the nearest residences surrounding the Project Site. On this basis, Spectrum Acoustics (2010) concluded that no significant blasting impacts were expected as a result of the Rocglen Extension Project.

All blasting at Rocglen is designed to satisfy relevant environmental and safety criteria with respect to airblast overpressure and ground vibration, initially using conservative predictive models and subsequently using site procedures developed and refined on the basis of operational experience.

3.2 **Blast Design**

The following blast design controls are used to minimise impacts:

- Blast design and implementation will continue to be undertaken by a suitably qualified blasting engineer and/or experienced and appropriately certified shot-firer.
- Blast design will continue to include the following features to ensure industry standards are met:
 - Ensuring that burden distances and stemming lengths are such that explosion gases are almost completely without energy by the time they emerge into the atmosphere; and
 - Ensuring that charges consistently detonate in carefully designed sequences.
 - Appropriate aggregates for blasthole stemming and nonel delay-type or electronic detonators will be used to initiate charges.
- Whitehaven will continue to analyse meteorological conditions (in particular, but not limited to, wind speed and direction) prior to blasting to avoid times when the potential for impact is heightened, and also endeavour to blast at around midday over the winter period to avoid temperature inversions.

Further to above, all blast design will be undertaken in accordance with internal blast planning design and record keeping procedures.

3.3 **Air Vibrations (Overpressure)**

Noise (the audible part of the air vibration spectrum) and airblast (the remaining sub-audible part of the air vibration spectrum) generation can be controlled by ensuring that all, or nearly all, of the explosion energy is consumed in fragmenting and displacing the overburden by the

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time the gases vent (via the broken burden rock and/or ejected stemming material) into the atmosphere.

This objective is met by ensuring that:

- Blast hole spacing is implemented in accordance with blast design;
- The burden distance and stemming length are carefully selected;
- Appropriate quality materials are used for stemming;
- Charges detonate in the correct sequence and with inter-row delays that provide good progressive release of burden.
- The maximum weight of explosive detonated in a given delay period (the Maximum Instantaneous Charge (MIC)) is limited to conservative and proven levels; and
- Refining these controls on the basis of the blast monitoring program.

3.4 Ground Vibrations

When a confined explosive charge detonates, a fraction of the liberated energy is manifested as seismic energy (i.e. as ground vibrations). The magnitude of ground vibrations depends upon:

- The MIC for the blast;
- The distance between the blast and a residence or sensitive structure; and
- The characteristics of the intervening material (rock, soils, geological structures, etc.) through which the ground vibration wave propagates.

Ground vibration is controlled by ensuring:

- The minimum practicable weight of explosive detonates at an instant (i.e. minimising the MIC) by using the maximum number of delay periods in each blast; and
- Most of the energy liberated by the charge(s) on a given delay number is consumed in providing good fragmentation, adequate displacement and/or a loose, highly dig-able muck-pile, rather than in creating ground vibrations (i.e. by ensuring that the burden distance and effective sub-drilling are not too large).

3.5 Fume and Other Post-Blast Emissions

Management of post blast fume is undertaken in accordance with Appendix 1.

Blast generated dust will be minimised by ensuring that stemming columns are not ejected for considerable distances into the atmosphere. Stemming column lengths would be such that their ejection velocities are low.

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3.6 Road Closures

The limit of open cut mining encroaches within 500 metres of Wean Road in its realigned position. As per the existing 2013 Road Closure Management Plan (originally approved by Gunnedah Shire Council in 2009), the safety of traffic on Wean Road is ensured via the following actions:

- For all blasts within 500 metres of Wean Road, the road will be closed with blast notice boards updated prior to each blast. Road closures will typically occur for a period of up to 10 minutes;
- Following the blast, Whitehaven will inspect the road surface and remove any rock fragments from the road surface prior to re-opening.

4 INSPECTIONS AND NOTIFICATIONS

4.1 Pre-Blasting Inspections

As a requirement of Schedule 3, Condition 19 of PA 06_0198, at the commencement of the mine RCM advised the owners of “Costa Vale”, “Surrey” and “Brolga” of their entitlement to a pre-blasting structural assessment report of their property. The “Surrey” and “Brolga” landowners accepted the offer and were subsequently provided with copies of the completed reports as carried out by Kelley Covey Pty Ltd. In addition, a structural assessment was also completed at the “Dunmohr” property located well outside the required 2km radius from blasting activities at the request of the landholder.

A further inspection of the “Brolga” residence was undertaken in 2012, following request from the landholder.

In accordance with Schedule 4 Condition 1 of PA 10_0015 advice was issued to the “Surrey”, “Brolga” and “Roseberry” residents of their entitlement to an updated structural assessment as discussed in Section 6.1.2.2, and in 2013 property inspections were undertaken at both “Brolga” and “Surrey”, again carried out by Kelley Covey Pty Ltd. Following requests by the landholders, inspections were also undertaken by Kelley Covey Pty Ltd of the “Kahana” property in 2014, and the “Surrey” property in 2016.

In accordance with Schedule 3, Condition 8 of PA 10_0015, if RCM receives a written request from the owner of any privately owned land within 2 kilometres of the approved open cut mining pit on site, or other landholder nominated by the Secretary, for a property inspection to establish the baseline condition of any buildings and/or structures on their land, or to have a previous property inspection report updated, then within 2 months of receiving this request RCM will:

- (a) Commission a suitably qualified, experienced and independent person, whose appointment has been approved by the Secretary, to:
 - Establish the baseline condition of the buildings and/or structures on the land or update the previous property inspection report;

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- Identify any measures that should be implemented to minimise the potential blasting impacts of the project on these buildings and/or structures; and
- (b) Give the landowner a copy of the new or updated property inspection report.

4.2 Pre-Blasting Notification

As per PA 10_0015 Statement of Commitments, RCM will provide the proposed blasting schedule to all residents within a 3 kilometre radius of the blast, and any other person who registers an interest, in order to provide advance notice of the date and time of each proposed blast. The only private residents within 3 kilometres of the expanded open cut pit limit is “Roseberry” as all other residences that fall within the 3 kilometre limit are mine-owned.

Notification to the general public about proposed blasting dates and times is provided via a blast notice board near the mine entrance on Wean Road. This will notify passing motorists when the next blast is scheduled. Two additional signs are provided to the north and the south of the mine site on Wean Road to notify motorists of potential road delays between 9am to 5pm, a contact phone number is also provided. A second blast notice board is displayed on the western entrance to notify traffic entering RCM from the Whitehaven haul route of proposed blasting dates and times.

The Road Closure Management Plan, approved by Council in February 2009, and updated in 2018, will continue to be used for blasts within 500m of Wean Road.

Furthermore, RCM will not carry out any blasting within 500 metres of any land outside the site that is not owned by RCM, unless:

- RCM has written agreement with the relevant landholder to allow blasting to be carried out closer to the land, and the proponent has advised the Secretary in writing of the terms of this agreement; or
- RCM has:
 - Demonstrated to the satisfaction of the Secretary that the blasting can be carried out closer to the land, without compromising the safety of people or livestock, or damaging the buildings and/or structures on the land; and
 - Updated this plan to include the specific measures that would be implemented while blasting is being carried out within 500 metres of the land.

5 MONITORING AND REPORTING

5.1 Monitoring Program

5.1.1 Parameters Measured and Monitoring Frequency

PA10_0015 specifies the following monitoring parameters to be monitored at the locations stated in Section 5.1.2. Monitoring must be undertaken for each blast as specified in Table 3.

Table 3 - Monitoring Parameters

Parameter	Units of Measure	Frequency
Airblast Overpressure	DB(Lin Peak)	Every Blast
Ground Vibration	mm/s	Every Blast

In addition to blast monitoring at the nominated sites, RCM will also inspect the area around the blast for flyrock distribution.

5.1.2 Monitoring Locations

Monitoring is to be conducted at the residences listed in Table 4 and shown in Figure 2. These were identified in the *Noise and Vibration Impact Assessment* (Spectrum Acoustics 2010) as receivers and will be used to assess compliance and noise criteria.

Table 4 - Monitoring Locations

Description of Location	Private Property (yes/no)	Representative Receptor
"Retreat" residence	Yes	"Retreat"
"Surrey" residence	Yes	"Surrey"



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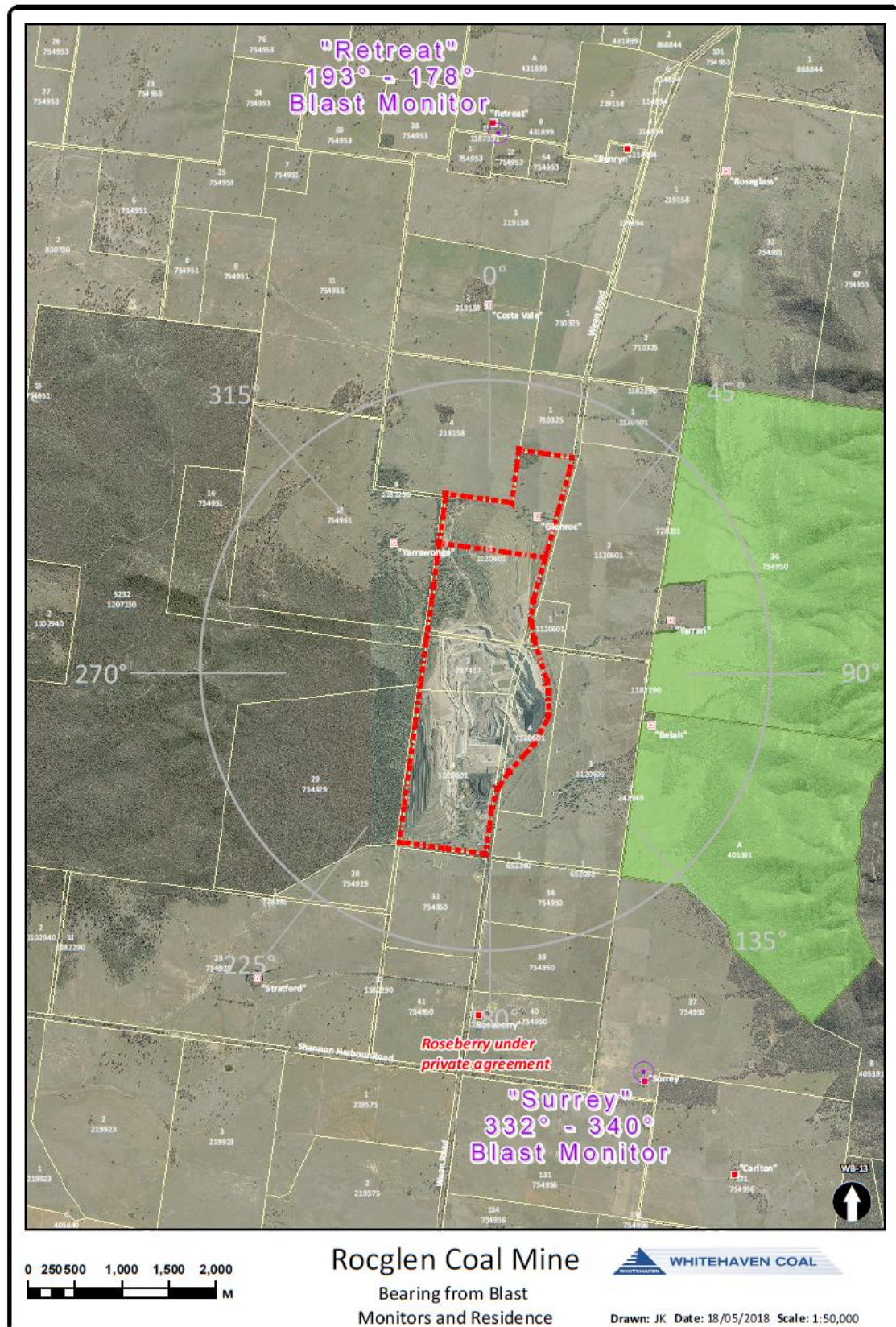


Figure 2 Blast Monitoring Locations

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5.1.3 Permanent Blast Monitors

Permanent blast monitors are established at the “Retreat” and “Surrey” properties to monitor air-blast overpressure (dBL) and peak particle velocity in a radial, vertical, and transverse direction (mm/s), i.e. ground vibration. The unit currently located at “Surrey” was relocated from the “Roseberry” property in February 2017, at the request of the DP&E and EPA. After each blast, information gathered on a blast is downloaded via the internet or wireless download. This information is then analysed by Environmental Officer to check compliance with blasting criteria. The sensors are calibrated annually and serviced according to manufacturer recommendations.

5.2 Reporting

Blast monitoring results will be reported via Community Consultative Committee (CCC) meetings and Annual Reviews.

Reporting of exceedances is discussed in Section 6.1.2.

6 MANAGEMENT OF INCIDENTS, EXCEEDANCES, NON COMPLIANCES AND COMPLAINTS

6.1.1 Blasting Related Incidents

Safety related incidents (such as misfires) will be recorded and managed via the Whitehaven incident management process. Such incidents are managed in accordance with relevant legislation and includes notification to DRG by the site’s Manager Mining Engineering. Emergencies, including notifications, will be managed in accordance with WHC processes.

Specifically in relation to blast fume, blasting design gives due thought to fume potential which is considered in product selection. Sentries are also in place during every blast to monitor fume. In the event of a fume incident all relevant agencies will be notified in accordance with Section 6.1.2.1 and any affected landholder, tenant or lessee notified about the incident and informed as to any measures that could minimise the risk of harm.

6.1.2 Blasting Criteria Exceedance

6.1.2.1 Agency Notification

In the event that the monitoring results of a blast identify an exceedance of:

- Peak vector sum velocity (ground vibration) – 5mm/s (ppv); and/or
- Peak overpressure – 115dBL,

RCM will initiate investigation as to the cause of the exceedance.

It is noted that the above criteria are able to be exceeded for up to 5% of the blasts in any 12 month period but not to exceed a:

- Peak vector sum velocity (ground vibration) - 10mm/s (ppv); and/or

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- Peak overpressure – 120dB.

As required by Schedule 5, Condition 6 of PA 10_0015, the Department and any other relevant agencies will be notified as soon as practicable after a blasting related incident occurs. Within 7 days of the incident, an incident report will be submitted to the Department and other relevant agencies.

The Department will be notified of any blast producing post blast fume that rates 3 at its highest extent and leaves the site, and any blast that rates 4 or 5. EPA will be notified, when required by the site's PIRMP.

Exceedances will also be reported in the blasting discussion in the Annual Review.

6.1.2.2 Landholder Notification

As required by Schedule 4, Condition 1 of PA 10_0015, RCM has notified in writing the owners of "Brolga", "Surrey", and "Roseberry" of their entitlement to ask for an inspection to establish the baseline condition of any buildings or structures on their land, or to have a previous property inspection report updated.

Furthermore, as required by Schedule 4 Condition 2(a) of PA 10_0015, as soon as practical after obtaining monitoring results showing an exceedance of the blasting criteria, RCM shall notify the affected landholder and/or tenants in writing of the exceedance, and provide regular monitoring results to each of these parties until the project is complying with the relevant criteria again.

6.1.3 Complaints

Any complaints received will be managed in accordance with complaints management protocol described as follows:

- A publicly advertised telephone complaints line will be in place to receive complaints during operating hours and record complaints at other times.
- Each complaint received will be recorded on a Complaints Register, which will include the following details:
 - The date and time of complaint;
 - Any personal details the complainant wishes to provide or if no such details are provided a note to that effect;
 - The nature of the incident that led to the complaint;
 - The action taken by RCM in relation to the complaint, including any follow-up contact with the complainant; and
 - If no action was taken by RCM, the reason why no action was taken.
- The Environmental Officer will be responsible for ensuring that an initial response is provided within 24 hours of receipt of a complaint (except in the event of complaints recorded when the mine is not operational).

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- Additional measures will be undertaken as required to address the complaint. This may include visiting the complainant, or inviting the complainant to the mine site.
- Once the identified measures are undertaken, the Environmental Officer will sign off on the relevant complaint within the Complaints Register.
- If necessary, follow-up monitoring will take place to confirm the source of the complaint is adequately mitigated.
- A copy of the Complaints Register will be kept by RCM and made available to the Rocglen Coal Mine Community Consultative Committee (CCC) and the complainant (on request). A summary of complaints received every 12 months will be provided in the Annual Review.

Based on the nature of individual complaints, specific contingency measures may be implemented to the (reasonable) satisfaction of the complainant. The Environmental Officer retains responsibility to ensure that complaints received are properly recorded and addressed appropriately.

6.1.4 Property Investigations

Schedule 3 Condition 9 of PA 10_0015 allows a landholder to request a property investigation if the landholder claims that blasting at RCM has damaged their property. Within 2 months of receiving a request RCM will:

- Commission a suitably qualified, experienced and independent person, whose appointment has been approved by the Secretary, to investigate the claim; and
- Give the landholder a copy of the property investigation report.

If this independent property investigation confirms the landowner's claim, and both parties agree with these findings, then RCM will repair the damages to the satisfaction of the Secretary. If RCM or the landholder disagrees with the findings of the investigation, then either party may refer the matter to the Secretary for resolution.

6.1.5 Unforeseen Impact Protocol

Unforeseen impacts in relation to blasting are generally considered to be in relation to criteria exceedances or non-compliances (e.g. failure to monitor) and complaints, which are addressed in Section 6.

7 DOCUMENT REVIEW AND CONTINUOUS IMPROVEMENT

This document will be reviewed in accordance with the requirements of Schedule 5 Condition 4 of PA 10_0015. RCM will investigate and implement ways to improve the environmental performance of the project over time. This will be achieved by keeping abreast of best practice in the industry for blast management and monitoring options and reporting on outcomes of blasting in the Annual Review.

	ROCGLLEN MINE ENVIRONMENTAL MANAGEMENT SYSTEM	Document Owner:	Operations Manager
		Last Revision Date:	10/2016
		Date Printed:	6/06/2018
WHC_PLN_ROC_BLAST MANAGEMENT PLAN			

Appendix 1 Blast Fume Management Procedure



OPEN CUT OPERATIONS

Document Owner:	Drill & Blast Manager
Revision Period:	5 Yearly
Issue:	1
Last Revision Date:	10/05/2018

WHC_PRO_OC_BLAST FUME MANAGEMENT

WHITEHAVEN COAL BLAST FUME MANAGEMENT PROCEDURE

Approval	Name	Position	Signed	Date
Document Owner:	Graham Cope	Drill & Blast Manager		18/5/18
Authorised by:	Nigel Wood	General Manager – Open Cut Operations		18-5-2018



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Document Owner:	Drill & Blast Manager
Revision Period:	5 Yearly
Issue:	1
Last Revision Date:	10/05/2018

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WHC_PRO_OC_BLAST FUME MANAGEMENT

1. SCOPE

This procedure outlines the specific blast fume management actions to be implemented at Whitehaven Coal Mines in line with the strategies outlined in the Australian Explosives Industry and Safety Group (AEISG) Code of Practice – Prevention and Management of Blast Generated NOx Gases in Surface Blasting (2011) and WHC-OC-Explosives Control Plan

The procedure applies to the Project Area and all personnel involved in the purchasing of explosives, blast design, drilling, loading and firing of explosives.

2. BACKGROUND

Blasting fumes are comprised of a group of gases known as Oxides of Nitrogen or NOx, a combination of post blast gases which are predominantly nitrogen dioxide, but may also include small amounts of nitrous oxide, nitric oxide, carbon monoxide and carbon dioxide. The two main gases, nitric oxide (NO) and nitrogen dioxide (NO₂) are found as by-products in the post-blast gases of ammonium nitrate-based explosives, and are generated in greater quantities where incomplete or low-order detonation occurs. Nitric oxide is colourless, but nitrogen dioxide ranges in colour from yellow to dark red / purple depending on the concentration and size of the gas cloud.

Fume generation can be attributed to a number of primary causes that, either singularly or combined, can be managed to minimise or mitigate the production of NOx. These causes are discussed in detail in the AEISG Code of Practice, and are listed below:-

1. Explosive formulation and quality assurance
2. Geological conditions
3. Blast design
4. Explosive product selection
5. On bench practices
6. Contamination of explosive in the blast hole

Blasting fumes can be harmful to humans if inhaled in sufficient quantities and/or over a prolonged period of time. These fumes can pose a risk to members of the blast crew and sentries in close proximity, or other mine workers exposed in the event that fumes travel outside the immediate blast clearance area without dispersing. Risks to persons outside the mining area also need to be addressed in the event that large fume clouds travel outside the mine lease on to private or public land.

3. RESPONSIBILITIES

Role accountabilities for management of the six AEISG primary causes of fume are provided in detail in Appendix 5.1 and summarised in Table 1.



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Table 1 Role Responsibilities

Primary Cause of Blast Fume		Accountable Roles for Management
Cause 1: Explosive formulation and quality assurance		- Explosives supplier - Drill and blast engineer - Shotfirer - Magazine keeper
Cause 2: Geological conditions		- Mine geologist - Drill and blast engineer - Shotfirer - Drill operators
Cause 3: Blast design		- Drill and Blast Engineer - Shotfirer
Cause 4: Explosive product selection		- Drill and Blast Engineer - Shotfirer
Cause 5: On bench practices		- Drill Supervisor(OCE) - Drill Operator - Drill and Blast Engineer - Shotfirer - MMU Operator
Cause 6: Contamination of explosives in the blast hole		- Drill operator - Drill and Blast Engineer - Shotfirer - MMU Operator

4. PROCEDURE

4.1 BLAST DESIGN AND PLANNING

Design

Blast designs will be developed to consider:

- Geological constraints such as weak or hard bands of overburden, coal bands and fault.
- Previous Blasts
- Blast performance requirements in terms of fragmentation, heave, dig rates, etc.
- Control of potential blast impacts including flyrock, fume, overpressure, vibration etc.

Blasts design mitigations may include:

- Reducing bench heights or ensuring adequate relief in deep holes.
- Selecting explosives products appropriate to the blast design and ground conditions.
- Following manufacturer's recommendations for priming, timing and sleep time of bulk explosives.
- Increasing the level of control and QA/QC checks (ie: bulled holes) on deeper shots.
- Providing appropriate separation of blast holes and explosive decks.



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- Reducing the powder factor or modifying the timing, depth or size of a blast.

Geology

Where clay or other unfavourable geological conditions are identified, explosive product selection will be modified to suit conditions. When blasting in soft ground, or areas with a history of producing blast fume, increased blast clearance may also be required to ensure the safety of personnel.

Sleep Time

All blasts will be designed and planned to be fired within 5 days of first being loaded. Approval from the Operations Manager is needed for shots requiring longer sleep times up to a maximum of 7 days. The prevailing and forecast weather conditions as well as the Fume Risk rating and manufacturers recommendations will be taken into account when planning the required blast sleep time.

Explosive Selection

Explosives Selection for Fume Mitigation is managed by the drill and blast reconciliation process as defined in the following process model

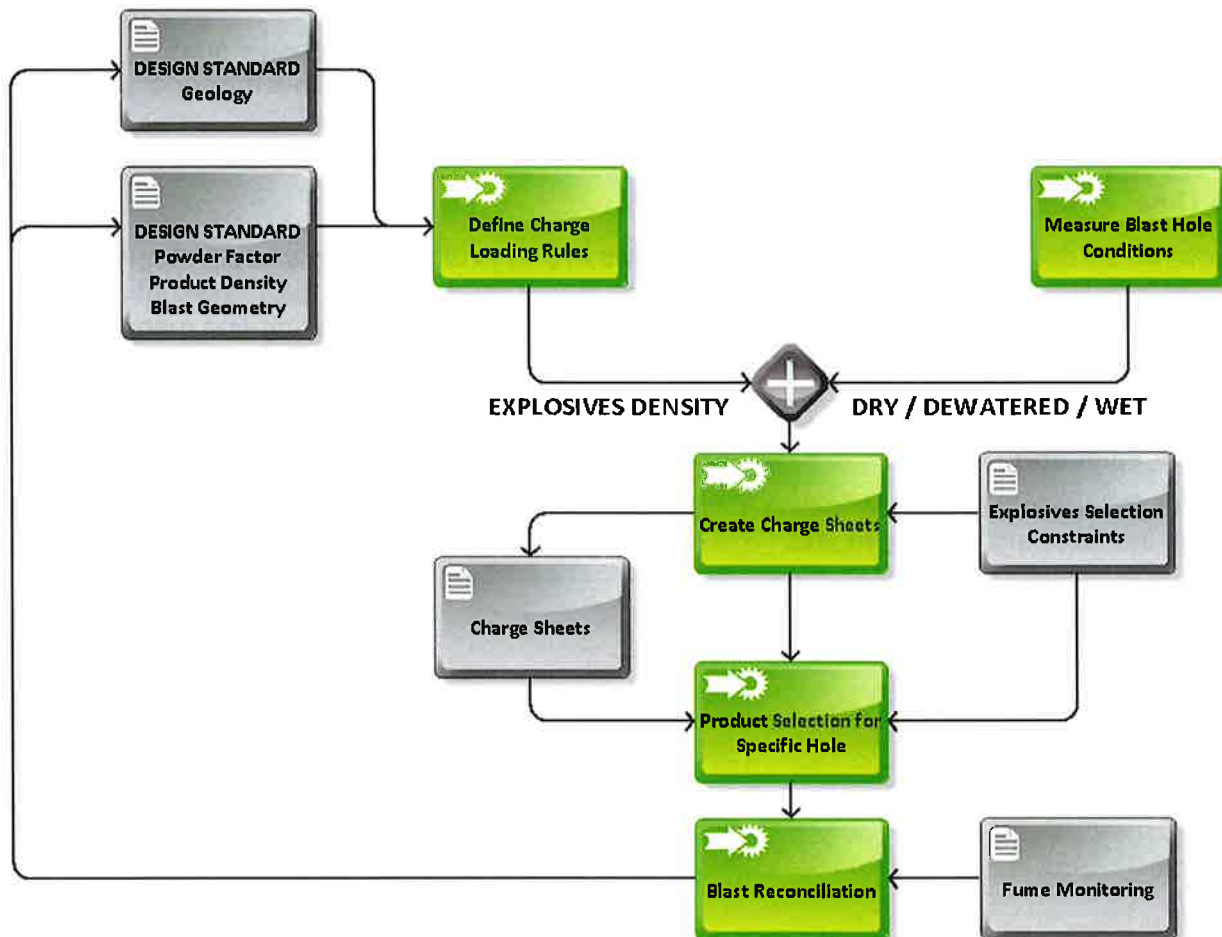


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Whitehaven Coal - Explosives Selection for Fume Management



Product selection for a specific hole is driven by three inputs:

1. The design explosives density
2. The measured water / wet walls of the hole
3. The defined explosives selection constraints

Explosives Density

Design Standards are maintained to ensure blast designs deliver acceptable blast outcomes in relation to blast performance and environmental impacts, including fume.

Design Standards:

- are specific to the defined site geological zones
- specify blast geometry and confinement through depth, face conditions and timing
- define the design targets for blast geometry
- define design powder factor and specify target explosives density.

Note that blast confinement may be defined by design powder factor, blast geometry, face condition and blast timing.



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Measured Hole Properties

Blast crews measure holes for depth, standing water and wet walls. This data is entered into the drill and blast database and, with the defined charge rules, is used to select the appropriate explosives.

Explosives Selection Constraints

Explosives selection is constrained by the measured hole properties as shown in the following table:

Hole Condition		
Standing Water	Wet Wall	Product Profile
Dry Holes		
Nil	Nil	Any product at design density to design Stem height
<1m*	Nil	Bag off toe → Any product at design density to design Stem height
Dewatered Holes		
<1m*	Wet wall no recharge	Bag off toe → Auger XL60_90/120 to wet wall+cover** → Any product at design density to design Stem height
<1m*	Wet wall low recharge rate <1m/hr	Bag off toe → Auger XL60_90/120 to wet wall+cover→ Any product at design density to design Stem height
Wet Holes		
<1m*	Wet wall high recharge rate >1m/hr	Hose XL70_120 to design Stem height
>1m*	Any	Hose EX70-120 to design Stem height

*The standing water trigger is dependent on the ground conditions and the number of wet holes in the local area.



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** Cover is the height above the measured wet wall that the water-resistant toe charge is to be loaded to

*** Actual product selected must conform to design density

Management of Explosives Selection

The ongoing management of explosives selection to mitigate fume is managed by the standard reconciliation process. Blast fume outcomes are assessed and recorded in the reconciliation process and trigger a review of both the drill and blast process and the relevant Design Standard.

EXPLOSIVES SUPPLY

Whitehaven Coal has contracted Hanwha Mining Services to supply and load down hole bulk explosive products for all open cut mines.

WHC uses hybrid explosives in addition to generic Explosives which differentiate from standard explosives as the base material used in the manufacture is Ammonium Nitrate Mineral Oil (ANMO) and includes EPS (Expanded Polystyrene balls) to lower the explosive density. XLOAD explosive product range numbering indicates the product density (i.e. XLOAD60-100 = 1.0g/cm³) while Pumped Emulsion product range numbering indicates percentage emulsion (i.e. XLOAD70-120 – 70% Emulsion).

Hanwha have self-calibrated load cells on auger explosive load trucks and implement a QA system to test and confirm the specification of the bulk explosive formulations used.

Technical and Safety Data Sheets of all products used are maintained on site.

4.2. METEOROLOGICAL CONDITIONS

- Before each blast, weather conditions will be recorded by the site Environmental Officer in accordance with the Environmental Blast Checklist. Shots will not be fired during adverse weather conditions, unless for safety reasons, or to minimise further deterioration of the product due to extended sleep time.
- Any shot that is fired during adverse weather conditions must be approved by the Operations Manager.
- Relevant parameters for consideration prior to firing a shot will be:
 - Wind speed and direction
 - The presence of a temperature inversion
 - Low continuous cloud cover
- The assessment of weather conditions will use meteorological data in the form of real-time wind speed and direction.
- When wet weather is forecast prior to or during loading of shots, product selection will be adjusted to suit as required.
- If there is a risk of blast fume, the Shotfirer must extend the blast danger zone to allow for the safety of all personnel. This is particularly important if a shot has had an extended sleep time, where water intrusion may have affected the bulk explosive, and when firing misfires.



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- The Drill and Blast Engineer in association with the Environmental Officer will carry out an Environment Blast Hazard Analysis for each Blast to evaluate the risks associated with dust, fume, vibration and Overpressure.

Where there is an identified risk of Fume the site Environmental Officer and the Mining Manager are required to assess the proposed blasting conditions and to approve the firing of the blast.

4.3 ENVIRONMENTAL BLAST HAZARD ANALYSIS

- Between the Weekly Planning Meeting and the day before the blast; the Drill and Blast Engineer/Manager should have sufficient design and information regarding the planned blast to commence the Environmental Blast Hazard Analysis checklist. The Environmental Officer (if absent delegated to Drill and Blast Engineer/Manager or their competent and authorised nominee) will complete the checklist with information about the relevant aspects of the planned blast that will allow a qualitative assessment and analysis of the hazards posed by the blast to the environment and community from the potentially adverse impacts such as dust, overpressure, vibration and fume.
- To complete the Environmental Blast Hazard Analysis checklist; the various blast design, location and weather conditions that must be rated as to whether each has a Negligible, Elevated or Substantial effect on the potential vibration, fume, dust and overpressure hazard of the particular blast being analysed. When a hazard section has been completed; an "Overall Hazard" can be qualitatively calculated for the potential vibration, fume, dust and overpressure potential of the blast by adding up the "Hazard Score" from assigning:
 - the value of 1 to each "Negligible" rating;
 - the value of 2 to each "Elevated" rating; and
 - the value of 3 to each "Substantial" rating.
- If the relevant blast hazard posed is considered "Negligible"; no additional controls are required to be implemented in the blast design or at the time of firing the shot. However, if the hazard is considered "Elevated" or "Substantial"; then additional controls will need to be implemented in the blast design, loading, tie up or at the time of firing and documented in the Environmental Blast Hazard Analysis checklist in the "Additional Controls" column. The Drill and Blast Engineer/ Manager and the Environmental Officer should sign off on the checklist for the agreed hazard rating and the Operations Manager signoff the checklist for the additional controls required for Elevated" or "Substantial" blast hazards (including sleep times greater than 7 days).

4.4 BLAST MONITORING & FUME RATING

For each blast the following monitoring will be carried out:

1. Fixed vibration monitors – measures the peak blast overpressure (DBL) and peak ground vibration (mm/s). Portable blast monitors will be used if the fixed monitors are inoperable.
2. A video record of every blast fired will record the shot initiating, blast movement and post blast fume generation. This will then be reviewed to improve future blasting performance and to further minimise blast fumes, flyrock or vibrations. All records will be kept on site for a minimum of two years.
3. All blasts will be rated by the Shotfirer in conjunction with the Environmental Officer for fume levels on a Scale between 0-5, based on the AEISG CODE (Appendix 5.2), refer section 5.1.4 of Blast Management Plan. In the event that a blast produces fume that rates a 3 at its highest extent and leaves the mine site, or if it rated at 4 or 5, immediate notification will be



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provided in accordance with Schedule 5 Condition 8, at the earliest opportunity to the Department of Planning and Environment.

4. An Environmental Blast Checklist will be used for each blast. This includes a notification checklist; pre-blast weather conditions assessment prior to and at the time of the blast (commencing at 5 hours prior to the blast); and a post-blast assessment which includes fume rating.

4.5 BLASTING WITHIN 500M OF A PUBLIC ROAD OR PROPERTY

- If blasting is to be carried out within 500m of a public road, the road will be closed for the duration of the blast. The road will be reopened once an inspection has indicated it is free of significant fly-rock and/or dust/fumes as described in WHC-PRO-OC-Blast Clearance and Firing.
- Neighbours and Tenants who may live on a WHC owned property near the blast area will be notified of the planned blasting date and time.
- Should a fume event occur, neighbouring properties in line with the fume cloud will be notified in accordance with the site PIRMP, and if necessary evacuated.
- The date, time and location of the blast/s will be posted on appropriate signs, located on any affected road.

4.6. BLAST EXCLUSION ZONES AND TIMING

- Establishment of exclusion zones, refer example in Appendix 5.3, and the time of blasts will be conducted in accordance with the WHC-PRO-OC-Blast Clearance and Firing.
- Blasting will be carried out on the site as per Approval conditions relevant to each individual mine site.

4.7. TECHNICAL AND SAFETY DATA SHEETS

- Copies of all relevant Technical and Safety Data sheets shall be supplied to the Drill and Blast Engineer and Shotfirers by the Explosives Manufacturer. Copies will be kept on site for reference.
- The type of explosive product used for individual blasts will be selected to minimise the potential for fume generation.

4.8. INCIDENT AND HAZARD MANAGEMENT

- Blast fume incidents will be managed in accordance with the WHC-STD-Incident and Hazard Management which provides a generic process that is to be followed for all health, environment and safety incidents that may occur at WHC.
- In the event of NO_x exposure (or suspected exposure) medical assistance should be engaged, and the Medical Advice from the AEISG COP (Appendix 5.4) provided to medical personnel.
- The basic precautions are:
 - No personnel will enter the fume.
 - Personnel will move away from the path of the fume.



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- If indoors and the fume is heading towards you, close all windows and doors and stay inside.
- If in a vehicle, wind up windows, close doors, stay inside vehicle and use recirculated air conditioning if possible.
- Those exposed to NOx gases should seek immediate medical treatment and consideration should be given to placing those exposed under observation for at least 24 hours after exposure.

4.9. INVESTIGATION – POST FUME INCIDENT

- Should an excessive blast fume (level 3 or higher that is not localised) be generated from a blast, a fault tree (refer to Figure 1 below) will be used during the ICAM incident investigation to identify contributing factors that caused the excessive blast fume.
- Once the contributing factors have been identified, an appropriate action plan will be developed to mitigate and reduce the generation of fume from future blasts.

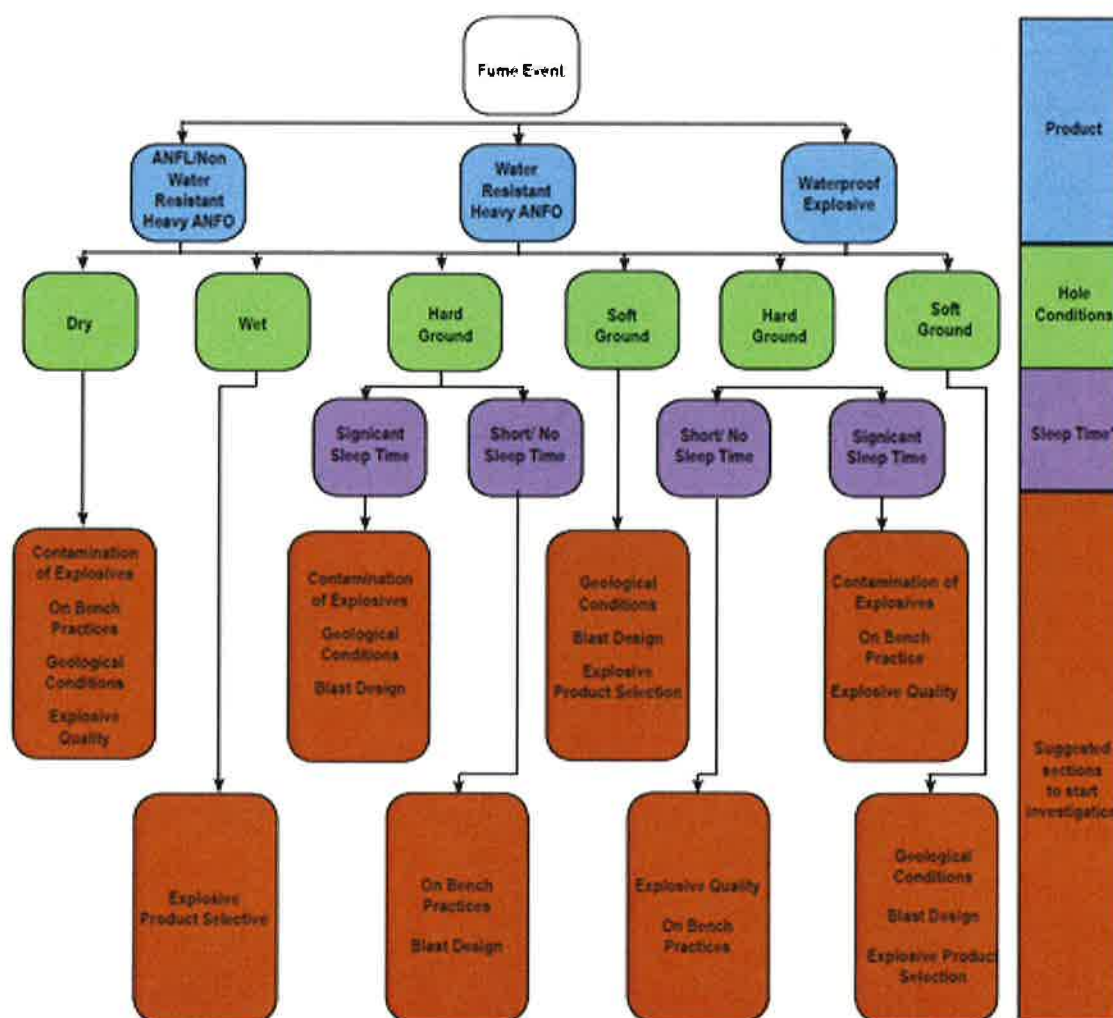


Figure 1 Fault Tree (Source: AEISG, 2011)



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4.10. REPORTING

Blast fume reporting includes:-

- All blast fume events (Level 1 and above) are reported as Environmental Incidents;
- Significant blast fume events Level 3 and above are investigated using the ICAM incident investigation method in accordance with WHC_PRO_OC_BLAST FUME MANAGEMENT;
- Blast fume events Level 3 that leave the mine site or Level 4 & 5 fume events are to be reported to DP&E Lead Compliance Officer for the Northern Region immediately.
- All blast fume events leaving the mine site boundary require consideration of the sites Pollution Incident Response Management Plan (PIRMP) regulatory/emergency and community notification protocols.

4.11. DOCUMENT REVIEWING

This document will be reviewed, and if necessary revised, every 5 years by the Drill and Blast Manager.

4.12. EDUCATION AND TRAINING

- All employees will have a general blast fume awareness session delivered through the induction program or Toolbox Talks.
- Additional education and awareness programs will be provided, on an ongoing basis, for relevant personnel working near blast areas such as sentries and drill and blast contractors. Training for relevant personnel (Drill and Blast Engineer, Shotfirers, Drillers, OCE's, drill and blast contractors) will be undertaken in accordance with WHC-OC-Training and Competency Management Plan, and covers:
 - The identification and rating of post-blast fumes.
 - The potential health impacts of fume gases.
 - Potential causes of blast fume.
 - Fume mitigating actions as detailed in this procedure.

5. APPENDICES

5.6. NOX GASES CAUSES AND CONTROL MATRIX

Cause 1: Explosive formulation and quality assurance			
Potential Cause	Likely Indicators	Possible Control Measures	Responsibilities
Explosive product incorrectly formulated	Abnormal product appearance, poor blast performance, fume generation.	Explosives formulated to an appropriate oxygen balance to minimise the likelihood of post-blast fume.	Explosive Supplier Shotfirer
	Incorrect test results.	Explosives supplier to test and provide QA reports for formulations where any change in ingredients.	



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		Explosives/Precursor supplier to provide relevant Technical Data Sheets and Manufacturing directions.	
Precursor delivered to mine site out of specification	Traceable to a precursor which has degraded between manufacture and use. Poor blast Performance	Investigate with supplier of explosive precursors. Precursor supplier to provide relevant Technical Data Sheets and Manufacturing directions.	Explosive Supplier
Inadequate mixing of raw materials	NOx emitted from blast holes loaded from a specific delivery system. Product appearance abnormal	Visual check. Density check. Ensure compliance with supplier's / manufacturer's instructions. Explosive supplier to provide QA reports on testing	Explosive Supplier Shotfirer
Product past use by date	Difficulty achieving final density. Separation Crystallising Fines Colour variation Poor blast performance	Once per truck to ensure the product is within the manufacturers specification i.e. pH, density, viscosity	Explosive Supplier Shotfirer Magazine Keeper
Failure to conduct quality tests	Incomplete documentation/ practices	Conduct PTO's or audits quarterly to ensure compliance with procedures. All blast crew to be trained in the potential consequences of failing to ensure the characteristics of the product loaded.	D&B Engineer
Cause 2: Geological conditions			
Potential Cause	Likely Indicators	Possible Control Measures	Responsibilities
Lack of relief in weak/soft strata. Inadequate confinement.	Recording areas of weak/soft strata. Fume generation	Understand geology of each shot and design blast (timing and explosive product) to ensure adequate relief.	Mine Geologist D&B Engineer



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	Sympathetic detonation Flyrock	Minimise blast size and depth. Appropriate explosives product selection. Change design to suit conditions.	
Dynamic water in holes	Preceded by the observation of slumped blast holes. Usually when using non water-resistant explosive products Loss of product whilst loading blast hole.	Minimise or eliminate sleep time of shot. Measure recharge rates if dewatering, and choose explosive products according to manufacturer's recommendations. Record slumped holes and use this information to build understanding of pit hydrology. Selection of appropriate explosives product	Shotfirer D&B Engineer Geologist
Explosive product seeping into cracks	Slumping Not achieving collar height during loading Poor reconciliation between design and loaded explosives volumes	Maintenance of accurate drill records which are used to map geological conditions. Record and monitor blast holes which are slumped or require excessive explosive product to reach stemming height, but where water is not present.	Drill Operators Shotfirer D&B Engineer
Moisture in clay	Fume Incorrect explosive	Consider water resistant explosive products and how this may impact sleep time.	D&B Engineer Geologist
Blast hole wall deterioration between drilling and loading e.g. cracks, voids, hole contraction	Traceable to specific geological areas Poor drill and load reconciliation	Employing different drill techniques for soft ground Minimise time between drilling and loading. Use hole savers/water while drilling. Ensure benches are unaffected by back-break from earlier blasts e.g. pre-splits.	Drill Operators D&B Engineer
Cause 3: Blast Design			
Potential Cause	Likely Indicators	Possible Control Measures	Responsibilities



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Intra-hole explosive desensitisation in decked blast holes	Fume When using decks only, inconsistent blast performance	Appropriate separation of explosive decks. Initiation timing.	D&B Engineer Shotfirer
Explosive desensitisation due to the blast hole depth	Fume Poor blast performance Poor dig rates	Reduce bench height. Ensure adequate relief in deep holes. Follow manufacturer's recommendations on explosive product selection and blast design for deep holes i.e. decking where appropriate.	D&B Engineer
Inappropriate priming and/or placement	Residue product Inconsistent blast performance Misfire	Follow manufacturer's recommendations on explosive product initiation.	D&B Engineer Shotfirer
Excessive confinement (Incorrect Timing and Pattern Design)	Fume Specific to blasts known to be confined Poor dig rates No free face present Excessive powder factor	Understand geology of each shot and design blast (timing and explosive product) to ensure adequate relief in all strata. Consider incorporation of a free face, reduction of powder factor, modified timing, depth of blast.	D&B Engineer
Desensitisation of explosive column from in-hole detonating cord initiation	Fume Inconsistent blast performance Only in areas where in-hole cord initiation is used	Follow manufacturer's recommendations on compatibility of initiating systems with explosives.	D&B Engineer Shotfirer
Primer of insufficient strength to initiate explosive column	Poor blast performance All blasts using a particular primer type/ size	Follow manufacturer's recommendations on compatibility of initiating systems with explosives.	D&B Engineer
Failure to identify potential causes of fume generation	Limited experience designers	Training	D&B Engineer



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	Inadequate analysis or records	Follow WHC_PRO_OC_BLAST PLANNING, DESIGN & RECORD KEEPING.	
Excessive energy in weak/ soft strata desensitising adjacent explosive product columns	Fume In specific areas known to contain weak/soft strata	Understand geology of each shot and design blast (timing and explosive product) to match, e.g. reduction of powder factor.	D&B Engineer Geologist
Cause 4: Explosive Product Selection			
Potential Cause	Likely Indicators	Possible Control Measures	Responsibilities
Explosives product selected not suitable for the prevailing ground conditions (water, rock mass strength)	Fume Poor blast performance	Follow manufacturer's recommendations on explosive product application. Review of the site design records/ results for previous blasts in similar strata.	D&B Engineer Shotfirer
Non water-resistant explosive products loaded into wet or dewatered holes	Fume Poor blast performance	Follow manufacturer's recommendations on explosive product selection. Regular education of shot crew on explosive product recommendations from supplier. Discipline in on-bench practices. Weather forecasts to be obtained and considered.	Shotfirer D&B Engineer
Cause 5: On Bench Practices			
Potential Cause	Likely Indicators	Possible Control Measures	Responsibilities
Inter-hole explosive desensitisation	Fume Blast holes drilled too close together. Blast hole deviation Inconsistent blast performance	Reduce bench height or ensure adequate relief in deep holes. Product selection. Initiation/timing Increased control on deeper designs/ GPS drilling assist Review product selection, adjusting for actual drilling.	Drill Operator D&B Engineer Shotfirer



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Hole condition incorrectly identified	Slumping of holes Unexpected material in drill cuttings	Dip all holes prior to loading. Record wet, dewatered and dry holes on blast plan and use this information as a basis for explosive product selection. Minimise time between drilling and loading, especially in soft and clay strata. Note: Enough time should be allowed for any dynamic water in the hole to be identified. Minimise sleep time. Training/competence of blast crew.	Shotfirer
Blast not drilled as per plan	Can be correlated with inaccurately drilled patterns	Maintenance of accurate drilling records and their review with amendment of blast design if required to compensate for inaccuracies. Record checks by engineer and Shotfirer	Drill Supervisor D&B Engineer Shotfirer
Inadequate mixing of raw materials	Frequent NOx fume in all areas associated with loading from a specific delivery system Product appearance abnormal	Visual check Density check	Shotfirer MMU Operator
Poor bench preparation not allowing for water run-off.	Pooling of water Hole collars show effects of water damage	WHC_PRO_OC_DRILL BENCH PREPARATION Ensure all loose material removed. Cut drains where required. Adequate inspection required prior to handing area over to drill team.	Drill Supervisor OCE
Dewatering of holes diverts water into holes previously loaded with dry hole explosive products	Only when using non water-resistant explosive products Fume generation	Adjust explosive product selection according to manufacturer's recommendations. Bench cleaned up for effective water run-off.	Shotfirer



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		Training/competence of blast crew. Location of dry hole explosive products considered in dewatering discharge locations	
Rainfall on a sleeping shot.	Slumping of holes Poor blast performance	Review rainfall forecasts for planned sleep time of shot and select explosive products according to manufacturer's recommendations. Maximum sleep times will be followed according to the specifications details on the Technical Data Sheets (TDS) for each explosive product. Minimise sleep time for dry blast hole explosive products if rain is predicted. Bench cleaned up for water runoff. Seal top of blast holes to prevent water ingress e.g. with gas bags. Consider removing water affected product. Consider early firing of blast.	Shotfirer Drill Supervisor
Blast not loaded as per blast plan	Not achieving collar height during loading Poor reconciliation between design and loaded explosives volumes	Training/competence of blast crew. Effective supervision. Communication of loading requirements. Record actual loadings e.g. product, quantity, height.	Shotfirer D&B Engineer
Blast hole deterioration between drilling and loading	Fume Inconsistent column rise while loading Poor drainage Traceable to specific geological areas	Minimise time between drilling and loading. Use hole savers. Optimise drilling practices to minimise hole damage though rock cracking etc. Where practicable design blast to minimise impact to next bench.	Drill Operator D&B Engineer Shotfirer



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Cause 6: Contamination of explosive in the blast hole			
Potential Cause	Likely Indicators	Possible Control Measures	Responsibilities
Explosive product mixes with mud/sediment at bottom of hole.	Water/mud identified in hole Blasts containing wet/dewatered blast holes only	Optimise drilling practices to minimise blast hole damage. Ensure appropriate loading practices are followed during charging. Ensure primer is positioned in undiluted explosive product. Insert gas bag to separate mud/sediment from explosive product. Use blast hole savers Use end of loading hose dispersers to minimise contamination. Decking to eliminate contact with known dynamic water. Verify correct hose handling practices are in place. Use suitable, safe dewatering techniques. Training/competence of blast crew.	Drill Operator Shotfirer MMU Operator
Penetration of stemming material into top of explosive column (fluid/pumpable explosive products only)	Fume Increased stemming usage Blasts charged with fluid/pumpable explosive products only	Use appropriate stemming material. Ensure explosive product is gassed to manufacture to specifications before stemming. Seal top of explosives column prior to stemming e.g. gas bag.	Shotfirer MMU Operator
Moisture in ground damaging explosive product	Wet ground occurrence Fume generation Consistent level of surrounding groundwater	Explosives product selection. Use hole liners where product not water resistant. Load wet holes first and dip remaining holes prior to loading. Adjust explosive product selection according to manufacturer's/supplier's recommendations.	Shotfirer MMU Operator D&B Engineer



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Contamination of explosives column by drill cuttings during loading	Hole collars not consistent size Inside of hole collars show disturbance Column rise varied from design	Verify correct hose handling practices are in place e.g. operator competence, procedures, use explosives supplier's personnel. Training/competence of blast crew. Minimise vehicle contact near blast holes. Use hole savers.	Drill Operator Shotfirer MMU Operator
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5.7. FUME RATING SYSTEM

Level	Typical Appearance
Level 0 No NOx gas	
Level 1 Slight NOx gas	
1A Localised	
1B Medium	
1C Extensive	
Level 2 Minor yellow/orange gas	
2A Localised	
2B Medium	
2C Extensive	
Level 3 Orange gas	
3A Localised	
3B Medium	
3C Extensive	
Level 4 Orange/red gas	
4A Localised	
4B Medium	
4C Extensive	
Level 5 Red/purple gas	
5A Localised	
5B Medium	
5C Extensive	

(Source: AEISG, 2011)

Assessing the amount of NOx gases produced from a blast will depend on the distance the observer is from the blast and the prevailing weather conditions. The intensity of the NOx



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gases produced in a blast should be measured on a simple scale from 0 to 5 based on the table above. The extent of the NOx gases also needs to be assessed and this should be done on a simple scale from A to C where:

A = Localised (i.e. NOx gases localised across only a few blast holes)

B = Medium (i.e. NOx gases from up to 50% of blast holes in the shot)

C = Extensive (i.e. extensive generation of NOx gases across the whole blast).

Level	Colour	Pantone Number
Level 0 No NOx gas		Warm Grey 1C (RGB 244, 222, 217)
Level 1 Slight NOx gas		Pantone 155C (RGB 244, 219, 170)
Level 2 Minor yellow/orange gas		Pantone 157C (RGB 237, 160, 79)
Level 3 Orange gas		Pantone 158C (RGB 232, 117, 17)
Level 4 Orange/red gas		Pantone 1525C (RGB 181, 84, 0)
Level 5 Red/purple gases		Pantone 161C (RGB 99, 58, 17)



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5.8. SITE PLAN AND BLAST CLEARANCE EXAMPLE





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5.9. MEDICAL ADVICE

Advice to Medical Staff

in the Treatment of Those Who Have Been Exposed to NO_x Gases.

The patient may have been exposed to NO_x. This is a gas usually produced on mines after the use of explosives. NO_x consists of multiple combinations of nitrogen and oxygen (N₂O, NO, NO₂, N₂O₄, N₂O₃, N₂O₅). Nitrogen dioxide (NO₂) is the principle hazardous nitrous gas. NO_x irritates the eyes and mucous membranes primarily by dissolving on contact with moisture and forming a mixture of nitric and nitrous acids. But this is not the only mechanism by which injury may occur. Inhalation results in both respiratory tract irritation and pulmonary oedema. High level exposure can cause methhaemoglobinaemia. Some people, particularly asthmatics, can experience significant broncospasm at very low concentrations.

The following effects are commonly encountered after NO_x exposure:

ACUTE

- Cough
- Shortness of breath
- Irritations of the mucous membranes of the eyes, nose and throat

SHORT TERM

- Pulmonary oedema which may be delayed for up to 4-12 hours

MEDIUM TERM

- R.A.D.S. (Reactive Airways Dysfunction Syndrome)
- In rare cases bronchiolitis obliterans which may take from 2-6 weeks to appear

LONG TERM

- Chronic respiratory insufficiency

High level exposure particularly associated with methhaemoglobinaemia can cause chest pain, cyanosis, and shortness of breath, tachypnea, and tachycardia. Deaths have been reported after exposure and are usually delayed. Even non irritant concentrations of NO_x may cause pulmonary oedema. Symptoms of pulmonary oedema often don't become manifest until a few hours after exposure and are aggravated by physical effort. Prior to transfer to you the patient should have been advised to rest and if any respiratory symptoms were present should have been administered oxygen. The patient will need to be treated symptomatically but as a base line it is suggested that the following investigations are required:

- Spirometry
- Chest x-ray
- Methhaemoglobin estimation

Because of the risk of delayed onset pulmonary edema it is recommended that as a precaution the patient be observed for up to 12 hours. As no specific antidote for NO_x exists, symptoms will have to be treated on their merits.



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Toxicology of NO_x (AEISG,2011)

Only one study(CSIRO Australia,2007) has been found which attempts to quantify the size , concentration and longevity of post-blast gas plumes under realistic conditions pertaining to open cut mining.

However ,the toxicology of NO_x is well understood from controlled medical studies and this knowledge is embodied in exposure limits defined by organisations such as the US Environmental Protection Agency (EPA) and US National Institute for Occupational Safety and Health (NIOSH).

The US EPA has compiled sets of Acute Exposure Guideline Levels (AEGLs) which represent threshold exposure limits for the general public and are applicable to emergency exposure periods ranging from 10 minutes to 8 hours.

The other relevant standards are known as IDLH Levels (Immediately Dangerous to Life and Health) which have been determined by NIOSH. These exposure limits are not considered relevant for public health scenarios, but are generally applied when selecting respirators in an industrial situation.

The toxicology of NO_x is summarised below, but more information including detailed definitions of AEGL's and IDLH is contained in appendix 2.

Nitric Oxide (NO)

Under normal conditions, NO is actually formed at low levels in the body and it serves as an important regulator molecule for the human cardiovascular, immune and nervous systems. NO is even used therapeutically for the treatment of several conditions(for example: adult respiratory distress syndrome and frequent pulmonary hypertension in new borns). However nitric oxide can be toxic in larger amounts because it combines with haemoglobin in the blood and prevents its normal oxygen-absorbing function. The toxicology of NO is complicated by the spontaneous formation of NO₂ which has its own adverse effects on the body. As a consequence, the toxicity of NO_x is guided by the levels set for NO₂.

Nitrogen Dioxide (NO₂)

The first toxic effects observed with NO₂ exposure are related to irritation of the airways and eyes. These effects have been studied many times with human volunteers in control environments. Because NO₂ is not very soluble in the moist airways, some gas can reach deep into the lungs, causing delayed effects, notably pulmonary oedema (fluid on the Lung), which can cause death. Normally, asthmatics or people with chronic lung conditions (eg Bronchitis) are considered to be the individuals most 'at risk 'in the general population. As with many toxic substances the observed effects depend on both the concentrations and the duration of exposure.



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Table 1. Summary of toxic effects verses NO₂ Levels.

NO ₂ (ppm)	Exposure period	Response in Healthy Adults
0.04-5		Odour threshold
0.3-0.5	2 hr	Decreased lung function, cough and dry throat and mouth.
20	30 min	IDLH level (Immediately Dangerous to Life or Health)
30	40 min	Tickling sensation in nose and throat
30	70 min	Burning sensations and cough
30	2 hr	Deep chest burning sensations , short of breath
80	3-5 min	Chest tightness
90	40min	Fluid in the lung

IDLH is defined by the US National Institute for Occupational Safety and Health (NIOSH) as the exposure that is "likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such and environment". The IDLH standard was developed to assist in selecting respirators in a work situation. It should be noted that delayed pulmonary oedema may not be accompanied by any other significant symptoms. This has been considered in the Acute Exposure Guideline Levels (AEGL). It is recommended to consult other authorities (medical) for further advice.

6. DEFINITIONS

Adverse Weather	Includes rainfall, lightening, low continuous cloud, presence of upper class inversion, wind speeds greater than 7m/s.
Dewatered hole	Wet hole removed of water with no water recharge
Dry hole	Hole identified as being dry in the bottom and no wet or damp sides
Wet hole	Hole identified as containing free water
Wet weather	>20mm rainfall



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7. REFERENCES

- AEISG Code of Practice – Prevention and Management of Blast Generated NOx Gases in Surface Blasting, 2011
- Australian Standard AS2187 Part 2-2006, Use of Explosives
- WHC-PLN-OC-EXPLOSIVE CONTROL PLAN
- WHC-PLN-OC-BLAST MANAGEMENT PLAN (Per Site)
- WHC-PRO-OC-LOADING and STEMMING BLAST HOLES
- WHC-PRO-OC-TYING UP SHOTS
- WHC-PRO-OC-WORKING IN A BLAST AREA
- WHC-PRO-OC-BLAST CLEARANCE AND FIRING
- WHC-PRO-OC-BLAST PLANNING AND RECORD KEEPING
- WHC-CHK-BLASTING
- WHC-CHK-SHOTFIRERS
- WHC-CHK-ENVIRONMENTAL BLAST HAZARD ANALYSIS

Revisions	Revision Description	Who Consulted	Date
01	New document	Drill & Blast Team Environmental Team	Feb 2014
02	Revision following DP&E comments	Drill & Blast Team Environmental Team	Feb 2015
03	Review Document	Drill & Blast Team	May 2018

