



Final Report

Coal Mine Pollution Reduction Program Condition U3 Assessment

NSW Minerals Council / ACARP Project C22027

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Pacific Environment Operations Pty Ltd: ABN 86 127 101 642

BRISBANE

Level 1, 59 Melbourne Street, South Brisbane Qld 4101
PO Box 3306, South Brisbane Qld 4101
Ph: +61 7 3004 6400
Fax: +61 7 3844 5858

Unit 1, 22 Varley Street
Yeerongpilly, Qld 4105
Ph: +61 7 3004 6460

ADELAIDE

35 Edward Street, Norwood SA 5067
PO Box 3187, Norwood SA 5067
Ph: +61 8 8332 0960
Fax: +61 7 3844 5858

SYDNEY

Suite 1, Level 1, 146 Arthur Street
North Sydney, NSW 2060
Ph: +61 2 9870 0900
Fax: +61 2 9870 0999

MELBOURNE

Level 10, 224 Queen Street
Melbourne Vic 3000
Ph: +61 3 9036 2637
Fax: +61 2 9870 0999

PERTH

Level 1, Suite 3
34 Queen Street, Perth WA 6000
Ph: +61 8 9481 4961
Fax: +61 2 9870 0999

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1 EXECUTIVE SUMMARY

In early 2013, the NSW Environment Protection Authority (EPA) issued a variation to the Environment Protection Licences (EPLs) of all open cut coal mines in NSW which contained Pollution Reduction Program (PRP) condition U3; *Particulate Matter Control Best Practice – Trial of Best Practice Measures for Disturbing and Handling Overburden* (hereafter, PRP U3).

PRP U3 requires mines to trial best practice measures for the control of particulate matter from the use of equipment on overburden and the loading and dumping of overburden, document the investigation and trial of each best practice measure, quantify the particulate matter control effectiveness and discuss the practicability of each best practice measure.

Industry representatives were consulted through the coordination of a survey and workshop in the Hunter Valley to identify and prioritise suitable techniques/technologies, document limitations and discount unsuitable options. Operational and procedural control measures were identified as the most effective management technique for mitigating dust from loading/unloading overburden. The top three ranked technologies were selected for further assessment: foggers/sprays; water cannon and agricultural sprinklers.

Field trials were scheduled to measure the control efficiency of the following techniques for overburden handling dust control:

- Fogging a plume generated from an excavator loading trucks using fogger cannon (two separate manufacturers)
- Pre-soaking blasted overburden prior to dragline overburden handling using an agricultural sprinkler
- Irrigating the work bench and spraying the operational plume from an excavator loading trucks using a water cart mounted water cannon
- Assessing the dust generated from changes in drop heights while loading a truck

Each technique was assessed for practicability (or otherwise) in a mining environment and quantitatively evaluated, where possible, for effectiveness in terms of particulate control efficiency. Control efficiency monitoring was conducted using a vehicle mounted particulate monitoring system (T-REX) with the data subsequently being used in a plume back-calculation exercise. Bulk samples of the material that was loaded and unloaded was collected and sent to the laboratory for analysis for silt and moisture content.

Trials for two fogger cannon were scheduled on several occasions and completed twice, but due to site exclusion zone constraints, non-forecast wind conditions and throw distance limitations of the equipment, the control efficiency of this technology was not able to be quantitatively assessed. A qualitative assessment of the cannon provided for the trial has been completed. Due to a number of logistical, practicability and safety issues, wide-spread adoption of this technology appears non-viable. However, it is acknowledged that such technologies may be applicable, and regarded as Best Practice, on a mine and task specific basis.

Pre-soaking blasted overburden with an agricultural sprinkler prior to loading and unloading using a dragline was assessed and quantified. The control efficiency for this activity was calculated as ~40%. The agricultural sprinkler was observed to be most effective in terms of throw distance with a tail wind and wind dependency was identified as limitation of this technology. Other constraints for application of this technology were limited mobility, subsidence risk from applying high volumes of water and use of energy and water resources.

Irrigating the work bench and the operational plume with a water cart mounted cannon was assessed and quantified. The measured control efficiency was calculated as ~70%. During this particular field trial, the equipment had a high degree of autonomy within the work area. Such equipment is already

established at most mine sites in the Hunter Valley for other applications, namely firefighting. This technique proved an effective mitigation technique for dust control and would be a useful tool for controlling emissions on an application-specific basis when conditions require an increased focus on dust management. It is acknowledged that using water cart resources for such an application necessarily reduces the available resources for other (potentially higher priority), site-wide, applications (i.e. haul road watering).

Loading drop heights were assessed and it was concluded, through discussion with industry and observation at multiple sites in the Hunter Valley, that operators are already implementing the lowest feasible drop height for loading operations. This is due to a combination of operational efficiency, WHS and environmental outcomes. For example, minimising overburden drop heights reduces the impact on both vehicles and their operators associated with the jarring force of large rocks hitting the truck tray from height. Loading operators also work to contain dust plumes because of increased awareness of this issue and the impact of visibility. It is acknowledged that drop heights will differ between operators depending on perception and experience. Repeated training and awareness on this issue could ensure all operators are consistently operating at the lowest practical drop height. Quantification of the control efficiency of this technique was not possible, however simulations of drop height reduction at a site during the field trials resulted in significant reduction in the observed dust generation.

A summary of the field investigations and the techniques evaluated is provided in Table E1 below.

Table E1: Summary of field investigations and outcomes

Technique Evaluated	Site	Trial Date(s)	Established Control Efficiency
Fogger cannon on particulate plume	Peabody Wambo	3 April 2014, 15 May 2014	Not practicable ¹
Agricultural sprinkler to pre-soak blasted overburden	Glencore Ravensworth Open Cut	1, 4, 7 & 8 July 2014	~40% ²
Water cart irrigating work bench	Bloomfields Rix's Creek	2 July 2014	~70% ³
Drop height minimisation (truck loading)	Bloomfields Rix's Creek	2 July 2014	Not practicable ¹

Note 1: Quantification of these control techniques was not possible due to the site (principally meteorological) conditions at the time of the field trials

Note 2: Control efficiency established based on pre-watering of blasted overburden for >24 hours to achieve an 8.5% moisture content.

Note 3: Control efficiency established based on a water cart dedicated to dust control on a single excavator.

Best practice control by definition needs to consider the financial, social and environmental viability of each option, as well as local factors. It is evident from the field trials that technology for best practice dust control should be selected on a site and application specific basis to meet the local requirements and conditions of the activity in question. Further research and development may be required for some technologies to meet all requirements for implementation in a mining environment.

2 INTRODUCTION

Pacific Environment are currently completing Australian Coal Association Research Program (ACARP) project C22027, titled *Development of Australian Specific Dust Emission Factors for Coal Mines*. The emission factors developed as part of this study will be relevant to mines operating in the Hunter Valley and across NSW.

The objectives of this project are to reduce the uncertainty regarding the emission factors used in estimating dust emissions from coal mines, and deliver a set of scientifically robust, Australia-specific dust emission factors for emissions from exposed areas, hauling on unsealed roads, and equipment activity loading and unloading coal/overburden. During a meeting between Pacific Environment and NSW Minerals Council (NSWMC) it was highlighted that the methodology used to measure emissions from equipment loading and unloading coal/overburden within ACARP Project C22027 (Plume Transect) could be used to evaluate the effectiveness of identified best practice measures as part of a response to PRP U3.

Given the significant synergies between the deliverables of ACARP Project C22027 and the intent of PRP U3, with some augmentation of this project, it is possible for PRP condition U3 to be addressed in a cost-effective, industry-wide manner.

Specifically, it was suggested that if suitable best practice measures were identified and coordinated to be at the mine test sites during our C22027 monitoring campaigns, then Pacific Environment would be able to evaluate these technologies. The existing ACARP project was seen as an ideal opportunity to carry out a whole of industry response to the PRP and avoid the need for duplication by individual mines. The EPA confirmed that an industry-wide project could be used to address the PRP requirements at the time of finalising PRP U3. To this end, Pacific Environment has been commissioned by ACARP to provide a coordinated response to the requirements of PRP U3.

The process was initiated with the coordination and execution of a workshop in Singleton to evaluate suitable techniques/technologies. Trials were conducted to assess the practicability and effective of different types of dust suppression equipment, including the use of fogger cannon, agricultural sprinklers and water cart cannon.

2.1 PRP Condition U3

The following PRP condition has been included within the EPL of every open cut coal mine in NSW:

U3 *Particulate Matter Control Best Practice – Trial of Best Practice Measures for Disturbing and Handling Overburden*

U3.1 The Licensee must submit a report documenting an investigation and trial of best practice measures for the control of particulate matter from the use of equipment on overburden and the loading and dumping of overburden. Best practice measures may include, but should not be limited to, the following:

- the use of foggers;
- the use of water sprays; and
- reduction of drop heights.

The report must document the investigation and trial of each best practice measure. It must quantify the particulate matter control effectiveness and discuss the practicability of each best practice measure.

2.2 Definition of Best Practice

The definition of Best Practice, as it is applicable to the mining industry, varies across state and international jurisdictions.

For the purposes of this report, the identification of best practice measures for disturbing and handling overburden considers applicability within the context of economically and technically viable conditions, as well as local factors. This is consistent with European Union's definition of Best Available Techniques (BAT) and the United States definition of Best Demonstrated Technologies (BDT) and Western Australia's 'Best Practicable Measures' (BPM).

The development of appropriate technology to seek better financial, social and environmental outcomes, within a longer term timeframe, is consistent with the concept of 'Leading Practice' provided within the *Leading Practice in Sustainable Development Handbook: Air Contaminants, Noise and Vibration*, coordinated by the Federal Department of Resources, Energy and Tourism in 2009.

It is important to acknowledge that there are techniques and technologies that do not meet the economically and technically viable criteria required for Best Practice, but may in the future with appropriate research, development and field trialling. For this reason, this report highlights Leading Practice as being distinct from Best Practice.

2.3 Study objectives and Project Scope

The study objectives are defined by the requirements prescribed under PRP U3 (see **Section 2.1**). To achieve the objectives defined by PRP Condition U3, Pacific Environment has agreed to the following scope of work:

- Arrange for and conduct an industry-wide workshop in the Hunter Valley to identify and prioritise suitable techniques/technologies, document limitations, discount unsuitable options, etc., and document outcomes (Completed November 2013)
- Identify equipment suppliers for identified suitable techniques/technologies for trial
- Coordinate and arrange for identified suitable techniques to be available during one ACARP site monitoring event (Peabody Wambo site finalised as suitable for trial February 2014)
- Complete additional monitoring and incorporate outcomes within our ACARP Project C22027 reporting (additional Wambo, Ravensworth Operations and Rix's Creek Field Trials completed June 2014)

A preliminary report was submitted to the EPA on 14 April 2014 (**Pacific Environment, 2014**). The EPA provided feedback to all sites (example letter provided as **Appendix A**), with the following feedback:

1. The trial and a quantitative assessment of a wider range of measures (trial and quantitative assessment of a range of best practice measures, which may include foggers, sprays and reduction of drop heights)
2. Quantitative analysis of control effectiveness of all measures trialled (including additional information on the case study presented)
3. Further discussion of practicability issues (including costs of fogger establishment and operation, the use of higher capacity foggers)

These comments provided within the EPA feedback contained in **Appendix A** have been addressed in this report. Additionally, a table has been provided in **Appendix A** that summarises the individual issues raised by EPA and how these have been addressed through the reporting process with links to the relevant report section.

2.4 Report Structure

Chapter 3 of the report provides an overview of emissions associated with the loading and dumping of overburden at open cut coal mines, best practice control measures and the reported efficiency of PM-control measures.

Chapter 4 describes the process for the identification of candidate techniques / technologies, providing an overview of the industry workshop and the industry survey responses.

A summary of each field trial, as well as on-site observations relating to the potential limitations of each technique is provided in **Chapter 5**.

A summary of the findings and conclusions are presented in **Chapter 6**.

3 LOADING / UNLOADING ACTIVITIES

3.1 Mechanisms of Dust Generation

The handling of overburden is inherent to the operation of an open cut coal mine. The handling process typically involves the transfer of material from the pit to haul trucks using excavators, shovels and front-end loaders (FELs). The material is then unloaded at either the end destination (e.g. overburden emplacement area) or an intermediate area (i.e. a stockpile). Some operations are designed to move overburden with a dragline, where both the loading and dumping is conducted in a swinging motion using a bucket suspended from the boom.

When material is unloaded dust particles are entrained in the atmosphere through the transfer process or by localised wind currents. Whilst the unloading of material onto haul trucks is considered to be the most significant source, there are several other sources that are inherent in this process. These include:

- The arrival and departure of the haul truck at the loading/unloading point.
- The digging of the material to be handled.
- The lifting and swinging of the excavator, shovel, FEL bucket or dragline bucket.
- The clearing of material by bulldozers or FELs at the loading/unloading point.

The magnitude of dust emissions from material handling varies with the volume of material being handled. Field investigations within the literature have shown that there are other contributing factors, such as the moisture and silt content of the material as well as its age. The highest emissions usually occur under dry and windy conditions.

Moisture present in the material results in the aggregation of loose particles and the cementing of these particles to the surfaces of larger particles. The silt content defines the amount of particles that are likely to be entrained, with the higher the silt content the greater the dust emissions. Recently exposed material has a greater potential for dust emissions as there is a greater percentage of loose particles that can potentially be entrained. The silt and moisture content of a material will vary with the character of the material (e.g. overburden or topsoil) being handled.

3.2 Best Practice Control Measures and Control Efficiencies

In 2010 the EPA commissioned a review entitled *NSW Coal Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (Donnelly et al., 2011). Part of this report identifies current practices adopted by NSW coal mines to reduce dust emissions from the loading and dumping of overburden. The identified measures include:

- Water application by fixed sprays or water cart
- Automatic water sprays
- The minimisation of drop heights
- Suspension or modification of high risk activities under adverse weather conditions
- No dumping on high emplacements in strong winds

Of the above control measures, minimising drop height, water application and modifying activity during windy conditions were identified as best practice measures for the loading and dumping of overburden. With respect to quantification of these control measures, Donnelly et al. (2011) provide a quantitative control efficiency of 50% for the application of water during loading and dumping.

The *National Pollutant Inventory Emission Estimation Technique Manual for Mining Version 3.1* (DSEWPC, 2012) list a variety of particulate matter emission controls measures for various mining operations. For the loading of truck 'no control' is reported, while for the unloading of trucks and control efficiency of 70% for use of water sprays can be adopted for the unloading of trucks. Both activities do not distinguish between the type of material being handled (i.e. overburden or coal).

4 IDENTIFICATION OF TECHNOLOGIES

4.1 Overview

Part of the identification of technologies process was to consult with industry representatives. This was to enable the identification and prioritisation of suitable techniques/technologies, document limitations and discount unsuitable options.

Rather than speak with each mine representative individually, an industry-wide Workshop was held in the Hunter Valley. To complement the Workshop an online survey was also distributed for input from the mine representatives.

The following sections provide a description, results and summary of outcomes from the Workshop and Survey.

4.2 Workshop

The workshop was held at Singleton Visitors Information Centre on 7 November 2013 and facilitated by Damon Roddis and Justine Firth from Pacific Environment.

To achieve an effective response to PRP U3, the Workshop was designed to seek attendee's feedback on:

- Available dust management techniques and technologies for overburden handling
- Industry opinion and experience on:
 - Best practice technologies
 - Cost effectiveness
 - Technology suppliers.

The following personnel were targeted to attend the Workshop:

- Representatives from all NSW open cut coal mines
- Environmental and Operational personnel with an interest in practical dust management solutions
- Any other personnel interested in contributing to the outcomes of the workshop.

The workshop comprised of regular attendees to the Upper Hunter Mining Dialogue meetings, coordinated by the NSWMC. A list of the workshop attendees is provided in **Appendix B**.

4.2.1 Presentation

A short presentation was given by Damon Roddis that covered:

- Introductions
- Workshop Objectives
- Project C22027 – Australian Specific Dust Emission Factors for Coal Mines
- Pollution Reduction Program U3
- Workshop breakout sessions

4.2.2 Breakout session 1: Techniques and Lessons Learnt

Breakout session 1 was designed to identify the dust control technologies / techniques that are currently used for dust suppression during loading/unloading of overburden at coal mines. This session also allowed for input from attendees to share their onsite experience with the success and limitations of these technologies/techniques.

Table 4.1 summarises the outcomes of the breakout session, detailing the collated information on potential techniques/technologies for dust suppression from loading/unloading activities. Also provided are the lessons learnt from onsite experience using these techniques, such as effectiveness, limitations or safety issues.

Table 4.1: Summary of findings for Breakout Session 1: Techniques and Lessons Learnt

Technique	Potential Issues / Lesson learnt
Water foggers / sprays	<ul style="list-style-type: none"> - General <ul style="list-style-type: none"> o Generally ineffective o Locating fogger upwind of operation can be effective o Required infrastructure o Noise (issues) o Oscillation o Can require manual changes o Heavy (mobility issues) o Potential for stability issues on both high wall and blasted low wall - Safety <ul style="list-style-type: none"> o Safety implications o Muddy water on windscreens reduces visibility o Access - Water <ul style="list-style-type: none"> o Water quality o Evaporation of water o Overspray o Waste o Impractical due to water supply o Sprays require saturation of overburden prior to dragline operations - Meteorology <ul style="list-style-type: none"> o Wind direction o Less effective at high wind speeds o Issues with relocating fogger / spray when wind direction changes
Water carts / cannon	<ul style="list-style-type: none"> - Saturation only to certain point - Effectiveness depends on the material - Application time restrictive between loading activities - Difficulties applying this technique to <ul style="list-style-type: none"> o Active dumps o Confined / short work areas - Water restrictions may mean water is diverted from other tasks (e.g. watering haul roads)
Dump / stacker height reductions	<ul style="list-style-type: none"> - Not always effective (material dependent) - Safety considerations - Effectiveness is subject to the individual operator - Additional training / awareness required - Issues with dozer interaction at stackers when stacker heights are reduced
Weather alarms (Trigger and Response Plan; TARP)	<ul style="list-style-type: none"> - Visually effective - Subjective - OCE is the regulator - Empower all employees
Procedural/operational controls	<ul style="list-style-type: none"> - Subjective - Inconsistent - Closing haul roads - Relies on operator training - In-pit dumping - Dust and weather TARPs
On bench watering / irrigation	<ul style="list-style-type: none"> - High cost - Reduced water cart availability - Water disappears - Access - Safety
Agricultural irrigation	<ul style="list-style-type: none"> - May only cover 100 – 200m sections - Not suitable where there are water restrictions - Effectiveness lost at high wind speeds

Attendees were then asked to prioritise the techniques and technologies identified in the breakout session in order of feasibility and effectiveness at reducing dust emissions. Each attendee was asked to

rank, based on their experience, the most effective technique / technology for dust suppression from loading/unloading activities. In order of preference, three, two or one points were awarded to the individual's top three techniques / technologies. The results are presented in **Figure 4.1**.

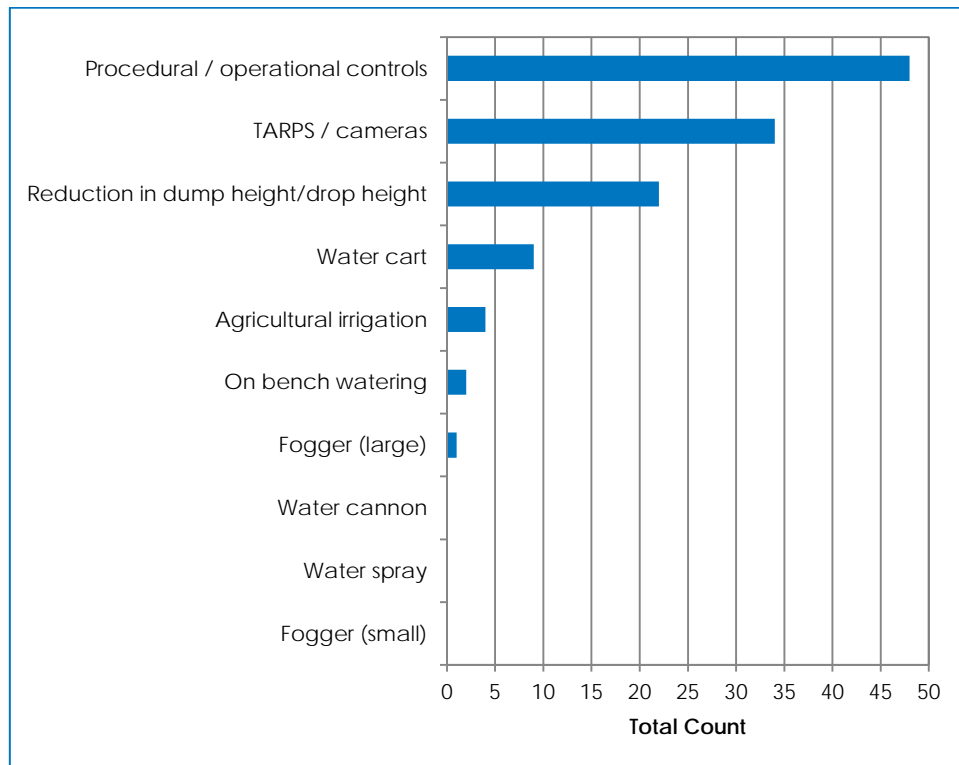


Figure 4.1: Prioritisation of Techniques and Technologies

The outcomes of the first breakout session show that operational and procedural control measures were identified as being the most effective management strategies for mitigating dust from loading/unloading overburden.

Further discussion also highlighted that some of the techniques / technologies that ranked lower in prioritisation were considered to be mine / application specific. While some attendees reported success using such techniques / technologies, others had obtained limited success.

4.2.3 Breakout Session 2: Suppliers

Breakout session 2 was designed to capture information around the suppliers of potential technologies (as opposed to techniques) for overburden handling dust suppression. The top three ranked technologies were selected:

- Fogger / spray
- Water cannon
- Agricultural irrigation.

As part of breakout session 2, attendees at the workshop were asked to identify known suppliers of the above technologies. **Table 4.2** provides a summary of the suppliers identified.

Table 4.2: Summary of findings for Breakout Session 2: Technology Suppliers

Technique	Lesson learnt
Foggers / sprays	Fanquip Wet Earth Hunter Farm and Irrigation
Water cannon	Factory specified (e.g. Caterpillar)
Agricultural irrigation	Hunter Farm and Irrigation Local suppliers

The workshop attendees provided information on potential suppliers for foggers, water sprays, water cannon and agricultural irrigation. The majority of feedback was that if such technologies were required, an internet search was typically adequate.

4.2.4 Breakout Session 3: Technologies Positives and Negatives

The majority of feedback at this point in the workshop was that there were significant issues regarding the practicability of using technologies for dust suppression of overburden handling. To capture this feedback, an additional breakout session was held to identify the positives and negatives of employing foggers, water sprays, water cannon and agricultural irrigation as mitigation strategies.

Table 4.3: Summary of findings for Breakout Session 3: Technologies Positives and Negatives

Technique	Positives	Negatives
Foggers	<ul style="list-style-type: none"> - Small mobile units good for small operations 	<ul style="list-style-type: none"> - Additional infrastructure - Availability of water - Weather (i.e. dependent on wind speed / direction) - Spray drift issues - Noise issues - Cost - Portability (significant size/weight) - Not easily mobile - Community concern regarding spray drift - Potential impact on rehabilitation areas - Water balance challenges
Sprays	<ul style="list-style-type: none"> - Can target specific operations 	<ul style="list-style-type: none"> - Saturation of work area - Infrastructure - Available water - Weather (i.e. dependent on wind speed / direction) - Cost
Water cannon		<ul style="list-style-type: none"> - Available water - Weather (i.e. dependent on wind speed / direction) - Reduces the operational capability of water cart - Safety concerns (visibility, close vicinity to operations, road conditions) - Water balance challenges - Effectiveness dependent on material properties
Agricultural irrigators	<ul style="list-style-type: none"> - Lower cost 	<ul style="list-style-type: none"> - Infrastructure - Available water - Weather (i.e. dependent on wind speed / direction)

4.3 Survey

In preparation for the workshop, the attendees were asked to take part in a pre-Workshop survey. This is short survey was designed to help identify suitable control techniques to guide the workshop preparation. The Survey was also made available after the Workshop for attendees to contribute their input if not captured during the Workshop.

4.3.1 Survey Questions and Responses

The following details the questions included in the Survey.

QUESTION 1

In your experience, please evaluate the following mitigation measures in suppressing dust emissions during loading / unloading of overburden.

Technique	Excellent	Average	Poor
Foggers			
Water sprays			
Modifications of activities during dry, windy conditions			
Reduction of drop heights			
Other			
(please specify)			

Figure 4.2 shows the frequency of response in the rating of each management technique. It should be noted that not all participants provided responses on all techniques listed.

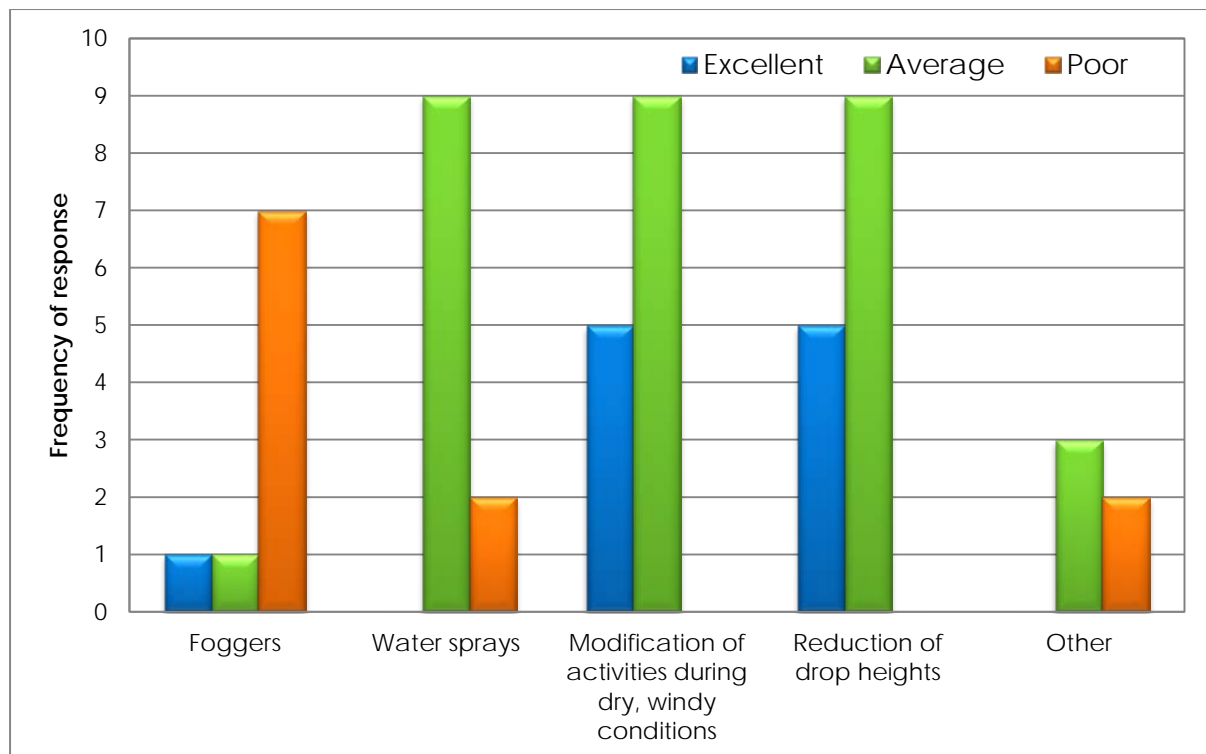


Figure 4.2: Response to Survey Question 1

The response to the survey indicates that the modification of activities during dry and windy conditions and also the reduction of drop heights rated the highest in mitigating dust from loading and unloading of overburden. The application of foggers rated most poorly amongst the respondents. Responses from the survey are therefore consistent with the feedback captured during the workshop itself.

'Other' responses included:

- Spraying the digging face with a water cart

QUESTION 2

Do you know of any companies that offer dust suppression technologies suitable for overburden handling activities?

- ☐ Yes
- ☐ No

Comments:.....

Of the 15 responses received, only two participants provided details of companies that offer dust suppression technologies suitable for overburden handling activities.

QUESTION 3

If yes, please provide contact details.

Contact details were provided for two companies.

The following comments were received:

- Most dust suppression companies will have a product that can assist with this - works similar to a flocculants in water - however I am not sure about the potential harmful effect to people or equipment
- Minetek - foggers/evap units
- We have trialled dust suppression products on active haul roads and have found them to be costly and ineffective...would not be rushing back to use them over overburden handling activities unless demonstrated otherwise

4.4 Summary

The feedback from both the workshop and survey is that altering operations / handling techniques are perceived by the industry as being both the most practicable and effective methods for controlling dust from overburden handling activities. Significant practicability issues were identified around the use of dust control technologies (i.e. the use of foggers, sprays, water cannon and agricultural irrigators).

While there were significantly more negatives than positives identified around the use of each technology, several attendees reported success using such technologies on a mine and task specific basis.

Feedback was received from the EPA during the workshop that while it was acknowledged practicability issues exist, there is regulator and community expectation that technologies are trialled as part of the PRP U3 process.

To meet the requirements of PRP U3, trials have been conducted to determine the level of control achievable from such dust suppression technologies.

Based on the outcomes of the Workshop and Survey, as well as supplier willingness to participate, the following quantifiable dust control techniques were selected for further investigation:

- Use of fogger cannon
- Water cannon / agricultural sprinklers
- On-bench watering
- Drop height minimisation

5 FIELD TRIALS

5.1 Field Trial Objectives

There are two main objectives for the completion of field trials using available dust control technologies:

- Demonstration of practicality (or otherwise) of the best practice measure in a mining environment
- Evaluate the effectiveness (quantify, in terms of % control efficiency) of the best practice measure

The outcomes and observations made during the field trial process are intended to be captured to address the first objective. A sample methodology has been developed as described below to quantify the potential control efficiencies achievable.

5.2 Sampling Methodology

In this study, PM₁₀ emissions during overburden loading and dumping activities were measured using the plume transect method, consistent with the method adopted within ACARP Project C22027. The methodology is described in greater detail in **Appendix C**, and the particulate emission rate calculation methodology is provided in **Appendix D**.

The measurement is collected using the equipment mounted to a light vehicle to reduce the WHS constraints of collecting samples on foot. The Road Emissions eXpert (REX) equipment was adapted to measure PM from an inlet mounted above the vehicle and is then run in transect mode (T-REX) (**Figure 5.1**). The vehicle is driven at a low speed (5 km/h) for each traverse downwind of the operation.

As with any empirical sampling technique employed at an active mine site, there are limitations to the method adopted. These principally relate to the inability to capture sufficient samples to ensure a robust emission estimation / control efficiency value. This is reflected in the outcomes of our field work, whereby we have only provided quantified values where site conditions have allowed sufficient sample capture.



Figure 5.1: T-REX Plume transect monitoring equipment

5.3 Trial 1 - Fogger Cannon on Loading Plume

5.3.1 Overview

A fogger is designed to atomise water to produce a mist that attracts the entrained particulate matter to form larger particles and drop out of the atmosphere. In practice, a fogger is attached to a fan system that directs the mist towards the location of the dust generation. This method uses a relatively low volume of water, and thus, results in minimal wetting of the source material being handled.

Two fogger units were selected for the field trial completed at Wambo coal mine. Both of the fogger units selected for the study were recommended by mine personnel and are already used for other industrial applications in Australia and New Zealand. The fogger models evaluated were:

- *CoolMist A-Jet 35S* supplied by CoolMist
- *SprayStream 20* supplied by BiOx International

Images of the foggers used in the field trial are shown in **Figure 5.2**.



Figure 5.2: Fogger Cannon used in field trials

The technical specifications for the *CoolMist A-Jet 35S* and *Spray Stream 20* are provided in **Appendix E** and **Appendix F** respectively.

5.3.2 Field Trials – 3 April and 15 May 2014

Two field trials were completed at Wambo mine, first on the 3 April 2014 and then on 15 May 2014. The trials were attempted on several other occasions but cancelled (often at short notice) because of forecast weather conditions and/or operational constraints.

It was intended that the plume would be monitored without foggers for 10 traverses, then with foggers for 10 traverses for as long as conditions and operations would allow.

The equipment required onsite for the completion of the trial included:

- Two foggers units; SprayStream SS20, supplied by biOx International and A-Jet 35S Turbo Fog Cannon supplied by CoolMist
- One dedicated 20,000L water cart to supply water to the fogger units
- Generator for power supply
- Tilt tray for the transportation of foggers and generator
- Light vehicles for transport of personnel
- Pacific Environment T-REX unit for sampling

On the 3 April 2014 the trial was attended by representatives from Wambo Coal Mine, CoolMist, Pacific Environment. The NSW EPA (Emma Coombs, Regional Operations Officer and Michael Howat, Regional Operations Officer) were on site to observe the field trial.

On the 15 May 2014 the second trial was attended by representatives from Wambo Coal Mine and Pacific Environment.

Both field trials were completed in the vicinity of overburden loading activities from excavator to haul truck. A sketch of the conceptual sampling configuration specific for 3 April and 15 May fogger trials are shown in **Figure 5.3** and **Figure 5.4** respectively.

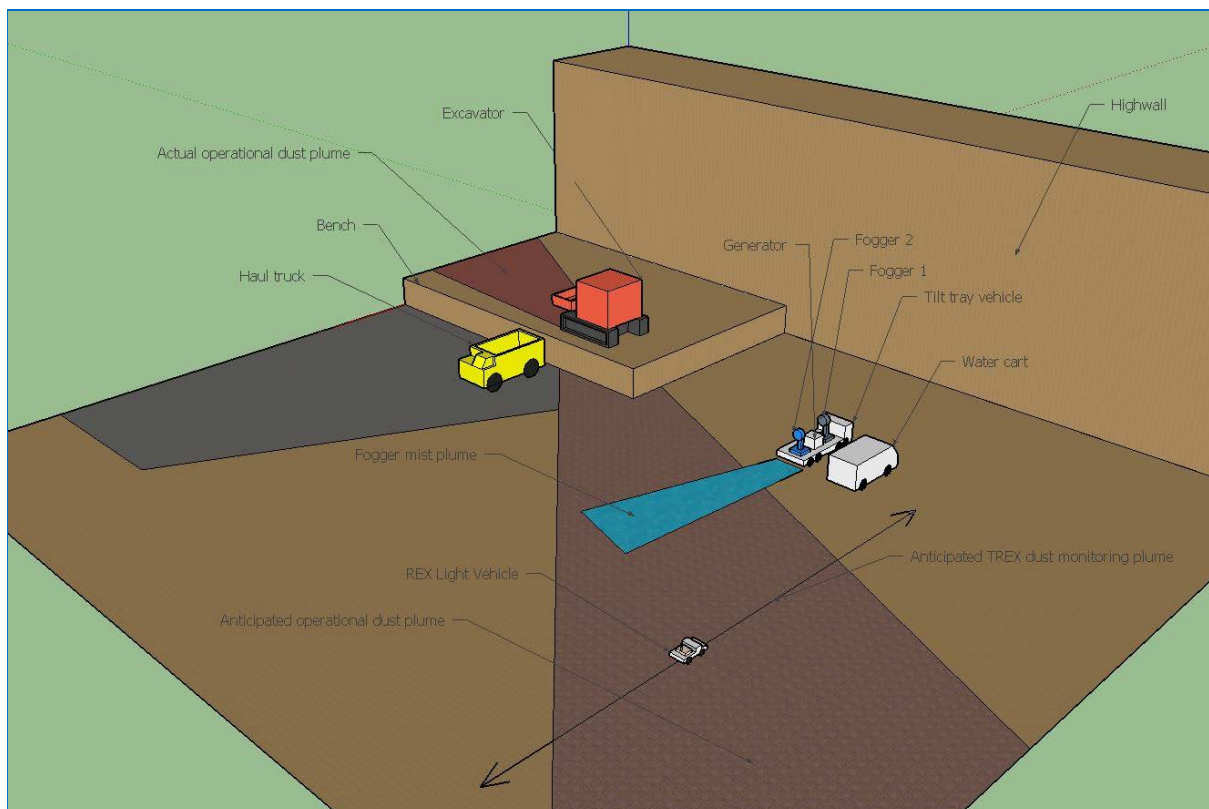


Figure 5.3: Sampling configuration for fogger cannon on loading plume (3 April 2014)

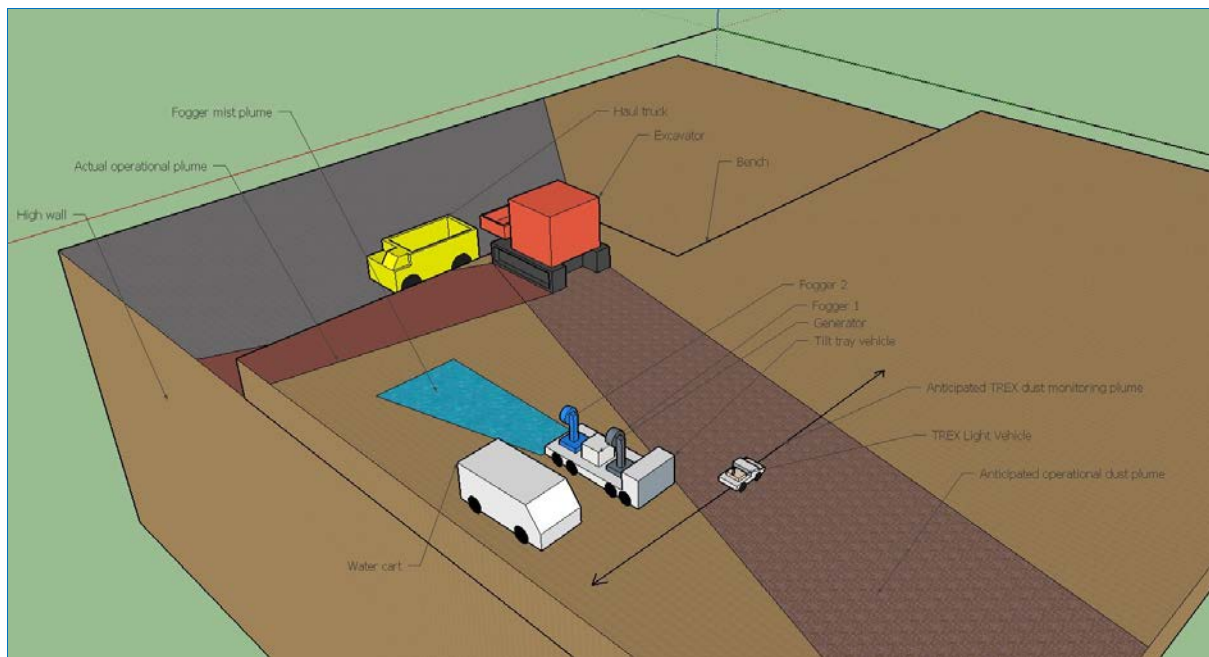


Figure 5.4: Sampling configuration for fogger cannon on loading plume (15 May 2014)

The fogger was not able to be moved into the loading plume on 15 May 2014 because the high wall and bench obstructed access. The trial site has a 30 meter exclusion zone around all operating equipment.

A photo log of the Wambo mine field trial is provided as **Appendix I**.

5.3.3 Results and Outcomes

Neither of the two field trial days was successful in obtaining a quantitative assessment of the fogger technology. This was due to a combination of weather condition changes, operational safety constraints and equipment limitations, as described in detail in **Section 5.3.5**.

However, the field trial has been informative in terms of evaluating the practicality of using foggers to control dust from overburden handling. A qualitative comparison of the fogger units trailed is shown in **Table 5.1**. It is acknowledged that there are higher capacity foggers available from both suppliers but these were not made available by the supplier for assessment, as described in **Section 5.3.5.4**.

Table 5.1: Comparison of fogger cannon used in field trials

Component	Fogger Cannon 1	Fogger Cannon 2
Supplier	CoolMist	BiOx International
Model Number	A-Jet Turbo Fog 35S	SS20
Mobility		
Published throw distance (m)	30 - 35 m	15 – 25 m
Horizontal movement angle (°)	0 - 360° by remote	0 - 360° by hand
Adjustable angle of throw (°)	-15° - 50° by remote	-20° - 40°, by hand
Mounting method	Hydraulic tower (5.4 m), operated by remote. Mounted to a three wheeled trailer. Options for generator mounting.	Telescopic tower (5 m), vertical movement hand operated only. Options for trailer and tank mounting.
Remote control	Standard (100m range)	Optional, not tested
Operational System	Hydraulic	Electrical
Water		
Water volume range (LPM)	10 – 30 LPM	4 – 8 LPM
Operating pressure (bar)	15 - 20 bar	20 – 25 bar
Droplet size (µm)	20 - 90 µm	30 – 80 µm
Number of nozzles	64 (double crown)	15 (single crown)
Power		
Fan power (kW)	3.0 kW	2.2 kW
Pump power (kW)	2.2 kW	1.5 kW
Cost		
Capital cost (\$AUD)	AUD60k @ 0.67 EUR to AUD (unit price includes three wheel trailer and hydraulic boom)	AUD32k @ 0.67 EUR to AUD (unit only, no trailer or tank)

5.3.4 Trials Conducted Independent of the PRP Process

A similar technology has been deemed appropriate for use by another Hunter Valley mine in some locations for use under high dust generation conditions, with some success. Details of this trial were available and are included here to assess the feasibility of using foggers in mining dust control applications.

A small fogger was trialled at the mine for a short period and used intermittently during this time. This fogger was trialled specifically for use in controlling dust emissions during targeted mining activities. Operational personnel involved in the trial reported some success with the use of this fogger and on that basis, an additional trial of a project prototype for a larger fogger was granted.

The large fogger is currently in the development stage. Whilst in this development stage, available information is limited.

The small fogger was considered appropriate for small scale, targeted activities. However, due to the above challenges, the large fogger has had limited success to date, however the mine and the manufacturer are currently working together to try and overcome some of these issues.

5.3.5 Limitations and Feasibility issues

5.3.5.1 Logistics

The logistical aspects in coordinating the field trial were extensive, resulting in significant delays to the completion of the field trial and include:

- Site access restrictions with modifications required to equipment to meet plant induction requirements (Introduction to Site).
- Transport and on-site storage of equipment in a secured space.
- Training of personnel (e.g. one supplier was located interstate and one supplier was located in New Zealand) on how to use the equipment.
- Scheduling due to inclement weather

Equipment location and availability resulted in significant costs being incurred by the technology suppliers. In one case, the equipment was transported for the trial by road from Western Australia.

Logistical issues associated with trialling the technology, such as modifications to meet site induction requirements, were significant because this is the first time these units have been introduced into a mining environment. Both suppliers offer larger foggers with integrated trailer and tank options but these were not available for the trial. An understanding of the issues faced during this trial may aid future design and application of this technology.

5.3.5.2 Weather

Inherent in the nature of this study is that sampling cannot be completed during wet conditions or for at least 12 hours after rain events. Similarly, to obtain quantitative measurements, wind speeds and directions must be optimal (neither too light nor too strong and in a direction where monitoring can occur directly downwind of the overburden handling activity).

The trial was rescheduled on several occasions because of unsuitable weather conditions. On both of the final selected trial days the wind conditions were contrary to the forecast therefore no measurements could be collected. The trial was initially scheduled for the 3 April 2014 based on forecast wind directions from the north-west. However, these wind directions did not materialise throughout the day, with winds being intermittent, and when present, tending towards the south-easterly (i.e. 180 degrees out from the desired (and forecast) wind direction).

The trial was attempted a second time on 15 May, when wind directions from the north-west were forecast. The wind directions did not materialise throughout the day, with winds tending toward the north where the plume was inaccessible because of the high wall. As such, it was not possible to complete any monitoring using the T-REX unit to quantify the potential control efficiencies afforded by the technologies.

During both trials there were no alternative locations in the work area where the fogger could be relocated to access the plume. In addition to hampering quantification efforts, this illustrates the difficulty in positioning such units in an appropriate location, particularly in confined areas and where the conditions change rapidly.

It is suggested that to overcome the highly wind-affected nature of fogger use, a more localised application of fogging may prove effective. This may include the use of foggers fitted to the point of dust generation (i.e. excavator buckets). Some site experience of such trials was reported, however it was highlighted that adding additional after-market equipment (such as water reticulation to an excavator) may have issues for equipment warranties. This is highlighted as a limitation to be overcome in the future.

5.3.5.3 Safety

Site rules at Wambo regarding the interaction between personnel and mobile heavy equipment dictate that there be an exclusion of 30m between any two pieces of heavy equipment, and 50m exclusion between personnel and heavy equipment.

Given that the throw distances of the fogger units trialled was of the order of 30m, it was not possible to direct the foggers towards the activity itself, rather they had to be configured to drop out any entrained particulate downwind of the activity.

Related to the above, while one of the units (CoolMist) was able to be operated via remote control, targeted operation of the units can place the person operating the equipment where machinery is active (range of the remote control is ~100m).

These limitations are seen as significant for any ongoing adoption of the technology.

Entrained particles within the water mist landing on mobile equipment was identified during the workshop process as a safety concern, as this could result in dirty windscreens and visibility issues for operating equipment. Based on the limited observations to date during the field trial, this was not observed by the participating haul truck operators. This is an unsurprising outcome, given that due to the access restrictions described above, the fogger throw distances were less than the permissible separation distances between machinery. In some conditions such as gusty conditions where winds eddy within the pit, this presents a potential safety issue, however. This is particularly since foggers, by their nature, are highly wind affected.

5.3.5.4 Equipment Limitations

The following limitations of the fogger technologies are noted based on field trials to date:

- The technology is likely to be wind affected (i.e. performance will be significantly reduced under higher wind speeds). Given that this is often the periods when dust mitigation is most desirable, this is recognised as a limitation of the technology.
- Based on equipment availability, field trials have been limited to smaller fogger models. It is envisaged that a larger unit (i.e. CoolMist A-Jet 65S; 11.5kW fan, application rate 0.25-1.5L/s or SprayStream SS41; 7.5kW fan, application rate 0.38-1.05L/s) may be more suitable for mining applications. It is noted however that no testing of the effectiveness of examples of these larger fogger units were able to be carried out.

It was advised by the EPA that these higher capacity foggers be trialled as part of this study. Due to the logistical requirements essential to introduce this machinery to site and equipment not ready and available for trialling, these were not able to be assessed within the project timeline.

5.4 Trial 2 – Pre-soaking Blasted Overburden with an Agricultural Sprinkler

5.4.1 Overview

Ravensworth Open Cut mine use a number of Nelson Big Gun (SR200) agricultural sprinklers to irrigate material prior to loading and dumping. The principle of operation is to pre-soak blasted overburden material prior to loading for a 24 – 48 hour period. The agricultural sprinkler is currently in use at the mine, and is principally used for dust control from dragline shovel operations. A photograph of the sprinkler in use during the trial is shown in **Figure 5.5**.

The agricultural sprinkler has been configured with the unit fixed to a portable base and directed towards blast fractured overburden and dust emissions from dragline operations. The unit is supplied with water by a reticulated water supply (pipeline). The water consumption rate of the sprinkler is between 60 to 75 L/s.

The technical specifications for the *Nelson Big Gun SR200* are provided in **Appendix G**.



Figure 5.5: Agricultural sprinkler Nelson Big Gun SR200, as used in field trials

5.4.1 Field Trials – Ravensworth Open Cut, 1, 4, 7 & 8 July 2014

A schematic of the sampling configuration is shown in **Figure 5.6**. The particulate plume from the dragline bucket loading was not accessible for monitoring during the field trials because the wind direction caused this discrete particulate plume to move through the cut, at an inaccessible depth for sampling.

However, the particulate plume associated with dragline dumping was accessible and has been assessed to determine the control efficiency for this best practice control method. Typically, operators report that dumping will generate more particulate than loading during a dragline operation.

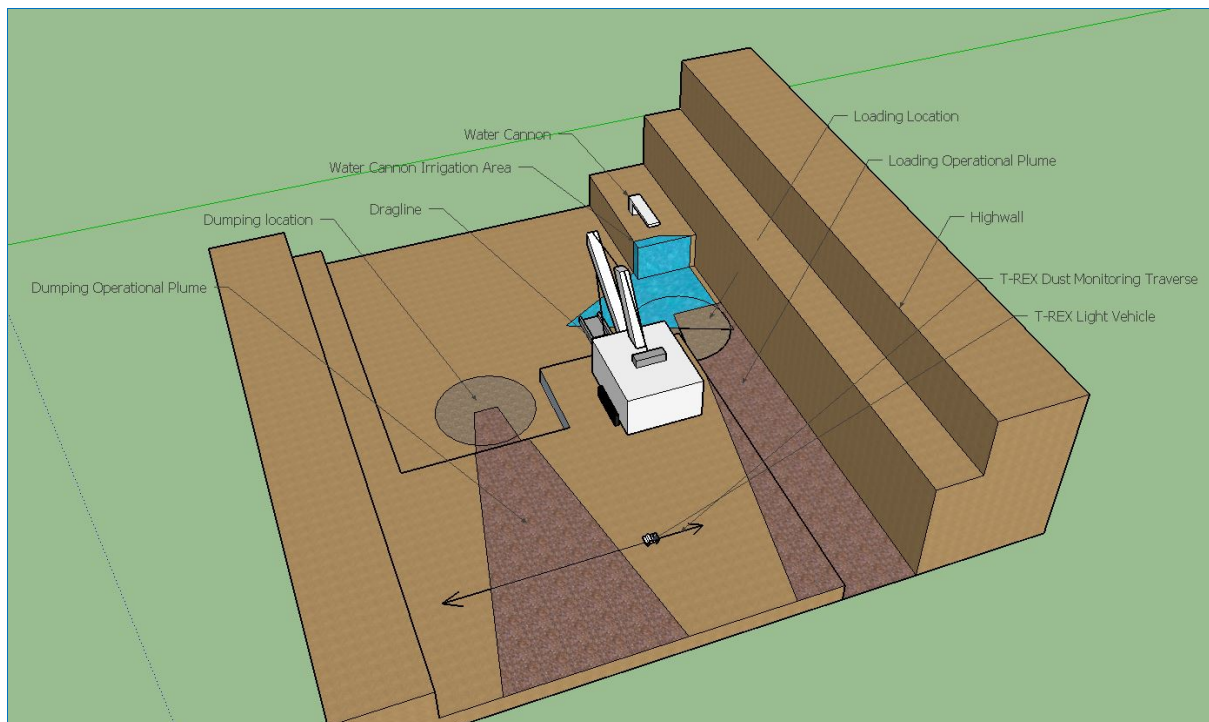


Figure 5.6: Sampling configuration for pre-soaking blasted overburden with an agricultural sprinkler (1 – 8 July 2014)

On the 1 July 2014 the morning conditions were ideal for monitoring, and a set of uncontrolled data (i.e. without pre-soaking of blasted overburden) was collected. The sprinkler had been turned off for 2 days prior to monitoring to enable monitoring of uncontrolled material. It was not possible to complete the controlled sampling on the same day because the pre-soak period typically used is 24 to 48 hours.

Monitoring of controlled emissions was attempted on the 4 July 2014 but the dragline had been moved to a position on a recent blast that did not allow for sufficient space upwind of the operation to collect measurements. Monitoring was again attempted on the 7 July 2014 but cancelled because of a mechanical fault on the equipment, resulting in it to not being in operation.

Monitoring of controlled operations was completed on the 8 July 2014.

A photo log of the Ravensworth Open Cut trials is provided as **Appendix I**.

5.4.2 Results and Outcomes

The control efficiency of this control method was calculated as 40% (rounded to one significant figure, to reflect the uncertainties within the method).

The projection of the water was observed to be wind dependent, with the greatest success achieved during a tail wind. This wind dependency results in some material being soaked but other areas of the digging area are not accessible without employing significant resources to periodically move the equipment.

Bulk samples of the material that was loaded and unloaded were collected and analysed at the laboratory for silt and moisture content. The methodology for analysis was consistent with the ACARP project C22027 and AP-42 (USEPA, 1993). Results from the sampling are shown in **Table 5.2**.

Table 5.2: Silt and Moisture Content (%) of Material Sampled for Pre-Soaking Water Cannon

Sample	Silt Content (%)	Moisture Content (%)
Uncontrolled overburden	3.6	3.8
Controlled overburden	1.3	8.5

5.4.3 Limitations and Feasibility issues

5.4.3.1 Wind Dependency

While less so than with foggers, agricultural spays / water cannon are affected by wind speed, with higher winds influencing performance, coverage and location selection. The effectiveness of the cannon is significantly reduced in high wind conditions, unless this is a tail wind. The saturation of material is only possible within the area that the sprinkler can access, before it needs to be moved. The sprinkler in this trial is mounted to skids and requires a dozer or grader to move it.

This limitation was noted during the field trial, and there is a photo comparison of the sprinkler operating in a head wind and tail wind within **Appendix I** to illustrate this limitation.

5.4.3.2 Water Resources

Prior to material extraction the excess water in the pit must be removed to allow material extraction. The use of an agricultural sprinkler is effectively recharging the pit with water creating the requirement for more resources to be invested into pumping the water out.

In some seasons and operations water restrictions may result in water being diverted from other tasks, such as watering of haul roads. This technique would not be appropriate during periods of water restrictions on operations where there is limited resource because of the high volume of water required to soak through the material.

It is acknowledged that significant energy and resources are assigned to the dewatering of pits.

5.4.3.1 Safety

As with all technologies where water is sprayed into the work area, there is a possible safety issue with dust adhering to windows and mirrors, causing obscuring of visibility. This was reinforced through interview with dragline operators during the trial.

When the sprinkler is used for longer applications in the same location (more than 24 hours), there is a risk of strata issues or partial collapse of the low wall or high wall caused by subsidence. For this reason sprinkler use requires significant supervision and relocation.

The technique may not be appropriate in confined work areas because of the positioning, size and weight of the equipment. This would need to be assessed on a site by site basis.

5.5 Trial 3 - Irrigating Overburden Bench with a Water Cart Cannon

5.5.1 Overview

Rix's Creek Mine operates a water cart cannon (Magnum Water Cannon RM80) to irrigate an operational bench to dampen material while it is being loaded.

The principle of the technique is to both dampen the material prior to digging and to reduce the material that is suspended in the air from the operation. The water cart is positioned near the excavator and constantly saturates worked material as the excavator is digging and loading trucks.

Rix's Creek Mine has a high ratio of water carts to haul trucks that facilitates this technique being employed when needed in operational areas where dust control should be a priority (3 large water carts to 12 trucks).

The water cannon mounted to a CAT785s water cart used for this trial is shown in **Figure 5.7**. Water cannon of a similar specification are often fitted to water carts on mine sites to aid with firefighting, wetting wind erosion sources, cleaning equipment and cooling haul truck tyres.

The cannon is mounted to the front of the water cart and operated by controls from within the operators cab. The cabin joystick is capable of 75° angle elevation and is fitted with a jet nozzle. The cannon is fed from a pipeline and actuator valve from the rear spray bay. The pipe is also used to operate a secondary sprinkler that is directed toward the ground, for use in firefighting.

The technical specifications for the *Magnum Water Cannon RM80* are provided in **Appendix H**.



Figure 5.7: Water cannon Magnum RM80 mounted to water cart, as used in field trial

5.5.1 Field Trial – Rix’s Creek Mine, 2 July 2014

A diagram of the monitoring set-up is shown in **Figure 5.8**. Initially the water cart was positioned on the bench alongside the excavator. As the excavator moved across the bench the water cart moved to the loading floor of the work area to access the loading material.

The trial was able to be completed on the scheduled day, 2 July 2014. A second set of data was planned for collection in the afternoon to support the results, but calm conditions developed in the afternoon that were not suitable for measurement.

A photo log of the Rix’s Creek Mine trials is provided as **Appendix I**.

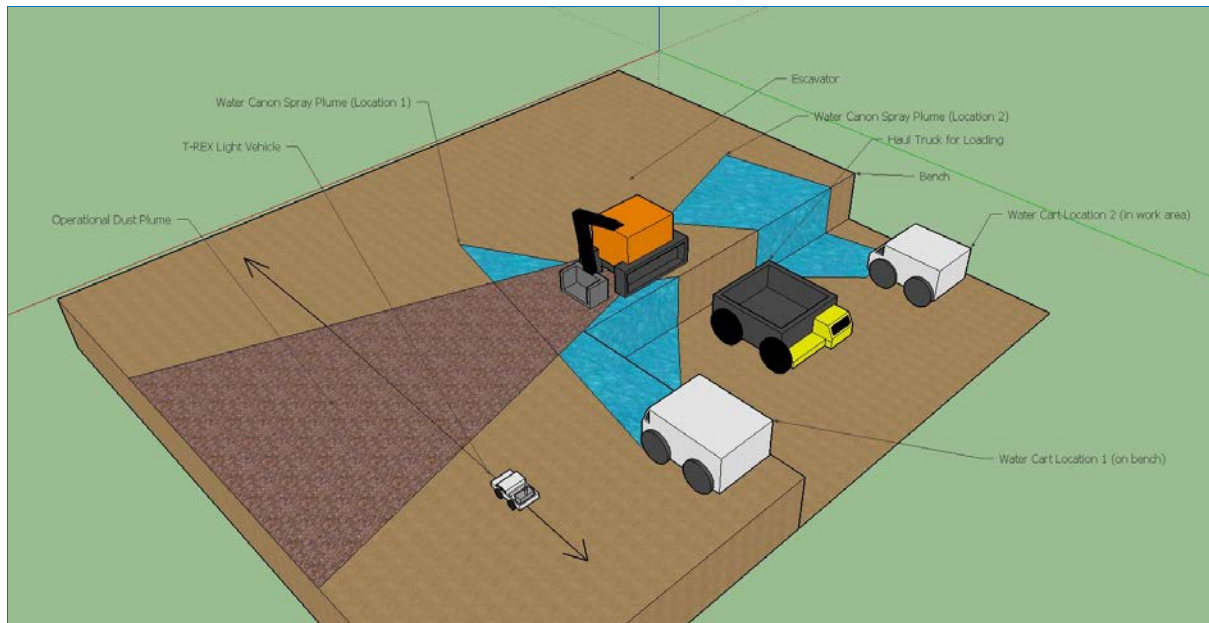


Figure 5.8: Sampling configuration of irrigating the bench with a water cart (2 July 2014)

5.5.2 Results and Outcomes

The control efficiency of this technique was calculated as 70%.

The throw distance of the water cannon was found to have sufficient range for the activity and could be directed near the operation from outside the swing radius of the excavator. The water cart and cannon has a high degree of flexibility and manoeuvrability within the operational area. This allows the water cart operator to easily adapt to changing conditions and direct the cannon to the optimal location for controlling dust. No wind dependency issues were observed during the trial because of the high volume jet nozzle on the water cannon.

The technique is able to be implemented without any capital cost for the cannon because the majority of operations already fit these cannons for other applications. If a water cart would need to be dedicated to this activity, the cost would become prohibitive as outlined in **Section 5.5.3.4**.

The cannon type tested was a jet nozzle, but there is also a fog nozzle available. A fog nozzle would reduce the volume required to apply this technique and may be more effective at wetting finer particles that have been suspended in the air. It may not be practical because it would likely be more affected by prevailing wind direction and reduce operational visibility if fine mist adheres to windscreens.

5.5.3 Limitations and Feasibility issues

5.5.3.1 Safety

In any mining operation where there is increased interaction in the work area there is an increased safety risk. Introducing a water cart into an already confined working area presents such a risk. Some operations implement an exclusion zone around operating equipment which would limit the locations the water cart could be stationed for use. At the trial mine site protocols required the water cart to remain outside the swing radius of the excavator.

As discussed for the previous techniques, throwing water near operating machinery can create a visibility hazard for the operators. Suspended material will be gathered in the mist and can adhere to windows and mirrors, limiting visibility. The process of needed to stop operations to clean these components has the potential to create an additional safety hazard.

5.5.3.2 Subsidence

In some mining operations this technique would not be practicable due to the risk of subsidence. When the bench is soaked the material can become loose and fall into the work area. This creates a hazard, where heavy equipment on the bench (water cart and/or excavator) can fall into the work area and potentially onto other machinery.

5.5.3.3 Water Resources

As described in Section 5.4.3.1, prior to material extraction the excess water in the pit must be removed to allow material extraction. The use of water carts on loading operations is effectively recharging the pit with water creating the requirement for more resources to be invested into pumping the water out.

In some seasons and operations water restrictions may result in water being diverted from other tasks, such as watering of haul roads. This technique would not be appropriate during periods of water restrictions on operations where there is limited resource because of the high volume of water required to soak through the material.

It is acknowledged that significant energy and resources are assigned to the dewatering of pits.

5.5.3.4 Cost

If the assumption is that additional water cart and personnel are required to adopt this technique, then it would require the highest resource allocation of all techniques discussed.

If existing resources are used then it needs to be recognised that using water cart resources for such an application necessarily reduces the available particulate control resources for other, site-wide, applications (i.e. haul road watering). Such competing priorities will necessarily need to be evaluated on a case-by-case basis.

The cost of labour, fuel and maintenance to run a water cart is high and it would be a significant cost to any site to assign a water cart to bench-watering. Water carts fleets are typically designed for a specific truck/shovel/water cart ratio, depending on the needs of the business. The annual cost of assigning an additional water cart is estimated as \$4 million. Finally, it is highlighted that using additional water carts could lead to noise non-compliances as it could require more equipment to be used on site then anticipated in site's environmental assessment.

5.6 Trial 4 - Minimising Loading Drop Height

5.6.1 Overview

PRP U3 suggests that drop heights should be assessed as part of this process. After discussions with mining representatives it was determined that this technique is uniformly implemented across the industry for several purposes including reducing health and safety impacts of high drop heights, operational efficiency as well as mitigation of dust generation.

5.6.1 Field Trial – Rix’s Creek Mine, 2 July 2014

The sampling configuration was the same as the sampling conducted in **Figure 5.8**.

Measurements collected on the sampling day were not able to derive a robust control efficiency for reducing loading height. However, field trial observations support that the plume generated from the high drop height was significantly larger than the plume generated from the low drop height (refer photo log in **Appendix I**).

5.6.1 Results and Outcomes

Drop height minimisation is practiced across the industry for a combination of operational efficiency, WHS and environmental outcomes. For example, minimising overburden drop heights reduces the impact on both vehicles and their operators associated with the jarring force of large rocks hitting the truck tray from height. Loading operators also work to contain dust plumes because of increased awareness of this issue and the impact of visibility.

Most sites are operating their loading operations at the lowest feasible drop height. Best practice is loading material at approximately 1.5m as was observed on the trial day. The first load into a haul truck is generally loaded at a slightly higher drop height (approximately 2 m) than subsequent loads because the excavator must contend with loading within the sides of the truck tray. This is, unless loading is possible directly from the back where the lip of the tray is less of a barrier and the slope of the tray reduces the drop height of the first load. Subsequent loads are loaded from either direction at approximately 1.5m.

5.6.2 Limitations and Feasibility issues

The effectiveness of this technique relies on the skill of the operator operating the loading unit. There can be differences between operators based on their perception of dust generation as a problem and their experience and skill for loading at a low height. Additional training and awareness would ensure that all operators are aware of the benefits of minimising the drop height whenever possible.

6 SUMMARY OF OUTCOMES

6.1 Industry Workshop and Survey

The feedback from both the workshop and survey was that altering operations / handling techniques are perceived as the most effective methods for controlling dust from overburden handling activities. Significant practicability issues were identified around the use of dust control technologies (i.e. the use of foggers, sprays, water cannon / agricultural irrigators).

The top three ranked technologies were selected for further assessment: foggers; agricultural sprinklers and water cannon for on-bench watering.

6.2 Fogger Cannon on Loading Plume

Significant project delays due to site access and unsuitable weather allowed only two field trials of two fogger technologies to be completed. It was not possible to quantify the effectiveness of the technologies because of non-forecast wind directions, site constraints and equipment limitations.

Based on the limitations identified to date during both the workshop and field trials, it is unlikely that the technologies identified are practicable for adoption on an industry wide basis. This is since there are significant barriers to overcome in terms of operational logistics and practicability, safety and applicability that make wide-spread adoption effectively non-viable.

However, it is acknowledged that the commonly accepted definition of best practice requires that site specific factors are taken into consideration. On this basis, it is envisaged that such technologies may be applicable, and regarded as Best Practice, only on both a mine and task specific basis.

6.3 Pre-soaking Blasted Overburden with an Agricultural Sprinkler

Pre-soaking blasted overburden with an agricultural sprinkler prior to loading and unloading using a dragline was assessed and the measured control efficiency was calculated as 40%.

The projection of the water was observed to be wind dependent, with the greatest success achieved during a tail wind. This wind dependency means that some material is soaked but other areas of the digging area are not accessible.

Other limitations of the technique were recharging the pit with water, visibility issues when droplets adhere dust particles to machinery, limited manoeuvrability and potential to cause subsidence.

The additional water and energy resources required for this technique need to be balanced against the environmental benefit awarded from any additional particulate control.

6.4 Irrigating Work Bench with Water Cart Mounted Cannon

Irrigating the work bench and generated plume with a water cart mounted cannon was assessed and the measured control efficiency was calculated as 70%. The equipment had a high degree of autonomy and the equipment is already in use at most mining operations (albeit for other purposes).

Cost has been identified as the most prohibitive aspect of this technique if additional (hardware and personnel) resources must be dedicated only to this technique. The capital cost of a water cart and aftermarket cannon, is the highest cost of all techniques addressed. The operational cost is also high, where an operator must be employed to continuously operate the water cart and cannon.

Some sites have strict exclusion zones which may discount this technique from dust mitigation methods. The technique also presents a safety issue in terms of subsidence and visibility.

It is considered that the use of a fogger nozzle to the water cart cannon may be a useful (and as yet untried) technique in some instances where the site constraints do not mean that machinery separation distances are highly restrictive.

6.5 Minimising Drop Height

It is anticipated that the majority of operators optimise their loading operations at the lowest feasible drop height. The lowest feasible drop height was deemed from observation to be approximately 1.5m from the material or truck tray.

Drop height minimisation is practiced across the industry for a combination of operational efficiency, WHS and environmental outcomes. It is acknowledged that drop heights will differ between operators depending on perception and experience. Repeated training and awareness on this issue could ensure all operators are consistently operating at the lowest practical drop height.

6.6 Conclusion

Water carts fitted with water cannon and agricultural sprinklers for pre-soaking material prior to loading and unloading operations have proved to be a successful dust mitigation technique during the trials. Other technologies, such as fogger cannons, may be successful in some applications but there are a number of design considerations that should be considered prior to implementation. It is suggested that to overcome the highly wind-affected nature of fogger use, a more localised application of fogging (i.e. at the point of dust generation) may prove effective. It is acknowledged that attaching sprays directly to dig equipment reduces the payload of the equipment increasing cost and reducing energy efficiency.

Current control achieved on haul roads have been extensively tested in the Hunter Valley and shown that 85 % - 95 % control is achievable (**Cox & Laing, 2014**). Shutting down equipment has an effective control efficiency of 100%. A 70 % control achievable for on bench watering during loading has been derived based on a water cart dedicated solely to the control of overburden particulate from a single excavator. In view of this, any derived control efficiency should be viewed within the context of the total emission reduction across a sites particulate emission inventory. When viewed in this manner, assigning a water cart to a long linear source that traverses a site (i.e. a haul road) may result in a better environmental outcome than choosing to dedicate a water cart to a single piece of equipment.

Best practice control by definition needs to consider the financial, social and environmental viability of each option, as well as local factors. It is evident from the field trials that technology for best practice dust control should be selected on a site specific basis to meet the requirements and conditions of the operation. Further research and development may be required to get technology to meet all requirements for implementation in a mining environment.

7 REFERENCES

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8 ACKNOWLEDGEMENTS

We would like to acknowledge the participation of CoolMist and biOx International for the contributing their equipment to the study gratis.

We would like to thank Peabody Wambo Coal Mine, Bloomfield Rix's Creek Mine and Glencore Ravensworth Open Cut for their cooperation with this project, including site access, the use of equipment and site staff who helped in the field trial.

Appendix A	EPA FEEDBACK ON PRELIMINARY REPORT AND SUMMARY OF REPORT RESPONSE
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Our reference: DOC14/95741; EF13/8215
Contact: Emma Coombs; 4908 6831

11 JUN 2014

Mr Ralph Northey
Bulga Coal Management Pty Limited
PMB 8
SINGLETON NSW 2330

Dear Mr Northey

**POLLUTION REDUCTION PROGRAM (PRP) U3 – TRIAL OF BEST PRACTICE MEASURES FOR
DISTURBING AND HANDLING OVERBURDEN**

Reference is made to your Report titled *Coal Mine Pollution Program Condition U3 Assessment – Preliminary Report* (the Report) dated 11 March 2014. The Report was prepared by Pacific Environment Limited to address the requirements of Pollution Reduction Program (PRP) U3 on your Environment Protection Licence (EPL). The Environment Protection Authority (EPA) has reviewed the Report and determined that the following information is required to fulfil the requirements of the PRP:

1. The trial and a quantitative assessment of a wider range of measures

The PRP clearly requires that a range of best practice measures be trialled and quantitatively assessed, which may include, but should not be limited to foggers, sprays and reduction of drop heights

The Report presents the trial of one best practice measure, the use of foggers, for the loading of overburden at Wambo Coal Mine on 4 April 2014.

The Report also summarises an industry survey undertaken prior to the November Industry Workshop. The survey identified that respondents reported some success using technologies including foggers, sprays, water cannons, water carts spraying the digging face, and agricultural irrigators, yet no further details are provided.

A greater number of these best practice measures needs to be trialled and quantitatively studied. These trials must include best practice measures designed to reduce dust emissions during overburden dumping.

2. Quantitative analysis of control effectiveness of all measures trialled

The PRP requires quantitative assessment of the control effectiveness of each best practice measure being trialled.

The EPA understands that prevailing weather conditions prevented the collection of quantitative data on the effectiveness of the fogger at Wambo on the day of the trial. This trial needs to be rescheduled and quantitative data provided to the EPA.

PO Box 488G Newcastle NSW 2300
117 Bull Street, Newcastle West NSW 2302
Tel: (02) 4908 6800 Fax: (02) 4908 6810
ABN 43 692 285 758
www.epa.nsw.gov.au

The Report also contains a section titled: "*Case Study – Hunter Valley Mine*". The report states that three pieces of equipment were trialled and reportedly passed the introduction to site process relatively smoothly without augmentation to meet the mine site requirements. A small fogger, a large fogger and a 'SR200 Nelson Big Gun' water cannon (agricultural sprinkler) are being trialled. The water cannon is currently in use at the site, and is principally used for dust control from dragline operations. The mine is currently in discussions with the equipment manufacturer to try and overcome some of the fogger issues.

The EPA requires additional information about the trials (dates, methods, quantitative assessment of control effectiveness).

3. Further discussion of practicability issues

The PRP requires a discussion of the practicability of each best practice measure being trialled.

The Report identifies several practicability issues related to the trial of the fogger at Wambo Coal Mine:

- **Logistics:** The main logistical issues identified in the Report relate to the need for modifications to equipment to meet site induction requirements. This is considered an initial logistical issue which will not be an ongoing problem once equipment is successfully introduced to site.
- **Mobility:** The Report identifies mobility of the fogger equipment once set up as a practicability issue. The EPA understands fogger equipment needs to be mobile enough to move around mine operations to maintain a position downwind of the truck and shovel operations. During the field trial, the EPA was advised that the fogger equipment trialled could be retro-fitted to either a trailer with its own water tank or to a water cart which would address mobility issues identified in the Report.
- The EPA requires additional consideration of the feasibility of introducing mobile foggers like those already in use on other mine sites.
- **Cost:** Cost has been highlighted as a limitation to the introduction of foggers. However costing analysis has not been included in the Report to support this statement. To enable robust consideration of the practicability of implementing best practice technologies, the EPA requires information on the costs of fogger establishment and operation.
- **Fogger Capacity:** During the field trial, the EPA was advised that the fogger being trialled had the capacity to "throw" the water a distance of only 30m, limiting its effectiveness. The EPA has since been advised that higher capacity foggers are available with a 'throw' of up to 65m. The EPA requires the trials to be expanded to include these higher capacity foggers.
- **Workplace Safety:** Entrained particles within the water mist landing on the mobile equipment was identified during the workshop process as a safety concern as this could result in dirty windscreens and visibility issues for operating equipment. Given that the fogger is being placed downwind of the operations, and directed across the plume, the EPA questions whether this limits the practicability of the use of foggers.
- **Spray Drift:** Community concern regarding spray drift was identified during the workshop as an issue. Given that one of the main logistical issues highlighted throughout the Report and during the field trials was the limited capacity of the fogger to throw 30m, the EPA requests additional quantitative analysis of this issue. Information related to the use of evaporation sprays elsewhere on Wambo Coal Mine may be relevant to this issue.

You are reminded that you have an ongoing obligation to comply with the requirements of the PRP. The EPA requests that you submit the outstanding information to the EPA's Regional Manager - Hunter electronically at hunter.region@epa.nsw.gov.au by 30 July 2014.

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If you require any further information in relation to this matter please contact Emma Coombs on (02) 4908 6831.

Yours sincerely



REBECCA SCRIVENER
Acting Head Regional Operations - Hunter
Environment Protection Authority

Table A.1: Summary of EPA Comments and Report Response

EPA Issue Category	EPA Comment	Report Response
Trial and quantitative assessment of a wider range of measures	A greater number of these best practice measures needs to be trialled and quantitatively studied. These trials must include best practice measures designed to reduce dust emissions during overburden dumping	<p>The following trials have been conducted and assessed:</p> <ol style="list-style-type: none"> 1. Use of fogger units to control dust from loading plume (Section 5.3) 2. Pre-soaking blasted overburden prior to dragline overburden handling using an agricultural sprinkler (Section 5.4) 3. Irrigating the work bench and spraying the operational plume from an excavator loading trucks using a water cart mounted water cannon (Section 5.5) 4. Assessing the dust generated from changes in drop heights while loading a truck (Section 5.6)
Quantitative analysis of control effectiveness of all measures trialled	The EPA understands that prevailing weather conditions prevented the collection of quantitative data on the effectiveness of the fogger at Wambo on the day of the trial. This trial needs to be rescheduled and quantitative data provided to the EPA	Trials of fogger units were completed on 3 April 2014, and while a qualitative assessment of effectiveness was completed, the units were not able to be quantitatively assessed. Trials were again repeated at Wambo on 15 May 2014 to try to obtain control efficiency values from this measure. However, due to a combination of the inapplicability of the units and the meteorological conditions, this field trial was also unable to obtain a quantitative assessment of controls (Section 5.3.3).
	<p>The Report also contains a section titled: "Case Study- Hunter Valley Mine". The report states that three pieces of equipment were trialled and reportedly passed the introduction to site process relatively smoothly without augmentation to meet the mine site requirements. A small fogger, a large fogger and a 'SR200 Nelson Big Gun' water cannon (agricultural sprinkler) are being trialled. The water cannon is currently in use at the site, and is principally used for dust control from dragline operations. The mine is currently in discussions with the equipment manufacturer to try and overcome some of the fogger issues.</p> <p>The EPA requires additional information about the trials (dates, methods, quantitative assessment of control effectiveness).</p>	<p>This agricultural sprinkler was quantitatively assessed as part of the field trials.</p> <p>Additional detail, including results and limitations of this trial are described in Section 5.4.</p>
Further discussion of practicability issues	Logistics: The main logistical issues identified in the Report relate to the need for modifications to equipment to meet site induction requirements. This is considered an initial logistical issue which will not be an ongoing problem once equipment is successfully introduced to site	Logistical issues have been described in this report to provide a full picture of the practicability of implementing these control measures (Section 5.3.5.1).

<p>Mobility: The Report identifies mobility of the fogger equipment once set up as a practicability issue. The EPA understands fogger equipment needs to be mobile enough to move around mine operations to maintain a position downwind of the truck and shovel operations. During the field trial, the EPA was advised that the fogger equipment trialled could be retro-fitted to either a trailer with its own water tank or to a water cart which would address mobility issues identified in the Report</p> <p>The EPA requires additional consideration of the feasibility of introducing mobile foggers like those already in use on other mine sites</p>	<p>Retro-fitted fogger equipment, with a trailer and tank, was not made available for trial during this period.</p>
<p>Cost: Cost has been highlighted as a limitation to the introduction of foggers., However costing analysis has not been included in the Report to support this statement. To enable robust consideration of the practicability of implementing best practice technologies, the EPA requires information on the costs of fogger establishment and operation.</p>	<p>Costing analysis has been included in the qualitative assessment of the fogger cannon provided for trial (Section 5.3.3).</p> <p>Additional commentary on the cost of the techniques trialled is provided in Section 5.5.3.3 and Section 6.4.</p>
<p>Fogger Capacity: During the field trial, the EPA was advised that the fogger being trialled had the capacity to "throw" the water a distance of only 30m, limiting its effectiveness. The EPA has since been advised that higher capacity foggers are available with a 'throw' of up to 65m. The EPA requires the trials to be expanded to include these higher capacity foggers.</p>	<p>At the time of sourcing the fogger (loaned by the equipment suppliers) it was provided to the trial process as being a fit-for-purpose technology. The size of the units provided for the purpose of the study were consistent across equipment suppliers. It was only during the trial at Wambo that the EPA attended that one of the equipment suppliers mentioned a fogger with a throw of 65m was available as a product.</p> <p>It is not clear whether the equipment supplier would be willing to loan such a unit for the purposes of such trials, nor whether there is indeed one available in Australia for this purpose (the fogger units sourced for the Wambo trial were obtained from New Zealand and Western Australian equipment suppliers, and rely on European manufacturing).</p> <p>EPA comments related to this issue were provided after fogger trials at Wambo concluded. Given the significant issues encountered associated with introduction to site for such equipment (Section 5.3.5), it is not considered that there is a mine site (or equipment provider) that would have been able to mobilise to achieve a trial of a higher capacity fogger within the EPA's intended timeline. Our experience has been that equipment sourcing, shipping, modification and site induction alone requires scheduling of in excess of seven weeks.</p>
<p>Workplace Safety: Entrained particles within the water mist landing on the mobile equipment was identified during the workshop process as a safety concern as this could result in dirty windscreens and visibility issues for operating equipment. Given that the fogger is being placed downwind of the operations, and directed across the plume,</p>	<p>This issue has been observed in calm wind conditions where the operational plume has a tendency to eddy around the equipment. This issue has been identified by several operators as a potential hazard and so has been described in greater detail in Section 5.3.5.3.</p>

	the EPA questions whether this limits the practicability of the use of foggers	
	<p>Spray Drift: Community concern regarding spray drift was identified during the workshop as an issue. Given that one of the main logistical issues highlighted throughout the Report and during the field trials was the limited capacity of the fogger to throw 30m, the EPA requests additional quantitative analysis of this issue. Information related to the use of evaporation sprays elsewhere on Wambo Coal Mine may be relevant to this issue.</p>	<p>All considerations raised by industry representatives during the workshop were included in the assessment.</p> <p>No spray drift issues were observed during the fogger trials, however the report observes that, due to its nature, it is difficult to control where fogger spray travels.</p>

Appendix B WORKSHOP ATTENDEES

Table B.1: Workshop Attendees

Name	Company	Position
Hayley Crowther	Vale - Integra Coal Operations	Approvals and compliance superintendent
Kate Brickhill	Vale - Integra Coal Operations	Environment Advisor
Travis Warren	BHP Billiton	Advisor Environment
Michael Gale	BHP Billiton	HSE Manager
James Benson	Anglo American	Environmental Coordinator
Chloe Piggford	Mangoola Coal Operations (Glencore)	Environment and Community Coordinator
Andrew Kelly	Ravensworth Complex	Environment and Community Manager
Amy Harburg	Bengalla Mining Company	Environmental Specialist
Cal Leech	Bengalla Mining Company	Environment Advisor
Craig White	Bengalla Mining Company	Project Specialist
Summer Steward	Downer Mining	Regional Environmental Officer
Sean Piggott	Ravensworth Open Cut	Environment and Community Officer
Scott Wolfenden	Bulga Open Cut	Environment and Community Officer
Paul Amidy	Bulga Open Cut	Environment and Community Manager
Andrew Speechly	RTCA	Environmental Manager NSW
John Watson	Glencore	Environment & Climate Change Manager
John Hindmarsh	Bloomfield Group	Senior Environmental Officer
Ben de Somer	Liddell Coal Operations	Environment and Community Superintendent
James Barben	Ashton Coal	Approvals Coordinator
Pete Jaeger	Peabody	Senior Environmental Advisor
David Rankin	Peabody	Environment and Community Coordinator
Nicole Glenn	Muswellbrook Coal Company	Environmental Assistant
Rebecca Scrivner	NSW EPA	
Brad Deane	NSW Minerals Council	Policy Manager - Environment and Health
Damon Roddis (facilitator)	Pacific Environment	Principal / General Manager (NSW)
Justine Firth (facilitator)	Pacific Environment	Senior Consultant

Appendix C **FIELD TEST METHODOLOGY**

EXPERIMENTATION METHOD: PLUME TRANSECT

To measure the emissions from loading and dumping activities the plume transect technique was adopted. The principle of the method is to measure the downwind PM₁₀ plume of a source to obtain a cross-sectional profile, followed by back-calculation of the emission rate using standard Gaussian plume equation. In the past this technique has been applied by taking hand-held PM₁₀ measurements from a plume downwind of a source by walking through the plume. This method has been used successfully by **Kanalic (2012)** to estimate dust emissions from the iron ore industry in Western Australia. The plume transect method was also used by **Laing (2013)** to determine site-specific PM₁₀ emissions from the operation of bulldozers and trucks loading/unloading at an open-cut coal mine in the Upper Hunter Valley.

The methodology has recently been adapted to allow the measurement of the plume from vehicle mounted equipment to reduce the WHS constraints of collecting the samples. The Road Emissions eXpert (REX) equipment was adapted to measure PM from an inlet mounted above the vehicle and is then run in transect mode (T-REX). The vehicle is driven at a low speed (5 km/h) for each traverse downwind of the operation.

Measurements of PM₁₀ made using a system that incorporates a cyclone pre-separator and laser photometer (QALite) with an inline filter. PM concentrations are measured at 2 second intervals, along with GPS coordinates. A schematic diagram of the plume transect method is provided in **Figure B- 1**.

Background concentrations are accounted for in the plume transect calculation. During the validation testing of equipment using this methodology, it was determined that the vehicle movement and exhaust at very low speeds contributed negligible concentrations to the concentration profile. This contribution is subtracted from the output in the same way as background concentrations.

The plume traverse takes place at a sufficient distance from the dust source (10-300 m) to ensure that the centreline of the plume is captured at ground level. The traverse distance is measured using a rangefinder, and the distance noted in a sampling log.

Potential PM emissions (and the distance over which they are transported) depend on the following parameters:

- The initial release height of the PM plume; higher release heights are likely to result in further particle drift.
- The diameter of the dust particles - larger particles are likely to settle out closer to the source.
- The wind speed. Wind erosion is likely to commence above a critical wind speed and increase with higher wind speeds.
- Material moisture content. Material with a lower moisture level is more likely to result in higher dust emissions.

To obtain an accurate representation of a dust source, multiple samples are collected under various meteorological conditions (e.g. wind speed 2 m/s to 8 m/s) and material moisture contents.

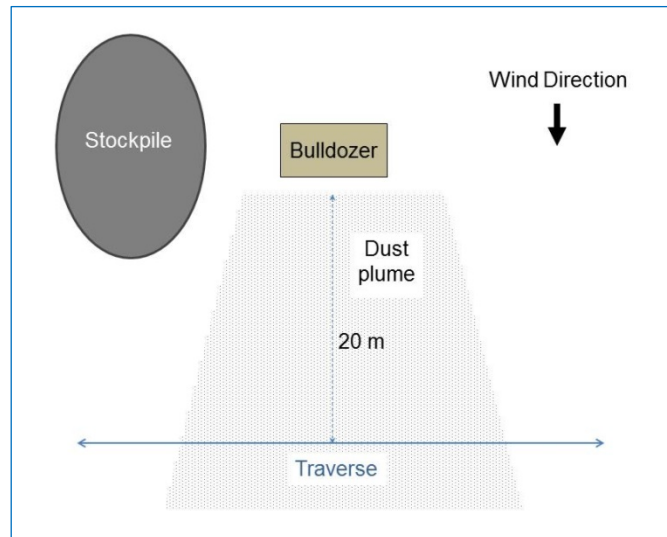


Figure B- 1: Plan view of plume transect method

MEASURED PARAMETERS

PLUME TRANSECT

The parameters measured in the plume transect method are:

- Pollutant concentration (PM10) using a cyclone pre-separator and laser photometer (QALite).
- Ambient wind speed, using a handheld anemometer (Kestrel 3500 Delta T).
- Distance from traverse to source at closest point using a laser range finder (Bushnell Yardage Pro Sport 450).
- Traverse length using an approximation from a distance measured using the laser range finder (Bushnell Yardage Pro Sport 450).

SOURCE MATERIAL PROPERTIES

Bulk samples of the overburden are also to be collected to determine moisture content (anticipated to be approximately one sample per group of 8-10 traverses) using the USEPA AP-42 sampling procedure (Appendix C.1 in AP-42) and analysis method (Appendix C.2 in AP-42).

CALCULATION OF EMISSION RATES

The calculation of emission rates from the plume transect measurements is described in **Appendix C**.

Appendix D **PLUME TRANSECT CALCULATION**

If a dust cloud is dispersed in a volume of air of rectangular shape and with dimensions Δy metres perpendicular to the wind in the horizontal plane, Δz metres in the vertical, and taking into account wind speed (U in m/s) downwind of the source, the concentration χ is given by:

$$\chi = \frac{Q}{\Delta y \Delta z U} \quad \text{Equation B1}$$

Where: Q is the emission rate in g/s

χ is the concentration in g/m³

If, instead of assuming constant concentrations in the horizontal and vertical directions, we assume a more realistic Gaussian shape (*i.e.* we replace Δy by $\sqrt{2\pi}\sigma_y$ and Δz by $\sqrt{2\pi}\sigma_z$, where σ_y and σ_z are the plume width and height standard deviations (m) respectively) we obtain the following for concentrations on the plume centreline:

$$\chi = \frac{Q}{2\pi\sigma_y\sigma_z U} \quad \text{Equation B2}$$

For ground-level concentrations from ground level sources, this becomes:

$$\chi = \frac{Q}{\pi\sigma_y\sigma_z U} \quad \text{Equation B3}$$

A factor of 2 (numerator) has been introduced to account for particle reflection at the ground, and this cancels the factor of 2 denominator in **Equation B1**.

Equation B2 will be approximately valid for sources near ground level and with relatively large initial plume spreads. The vertical plume spread standard deviation is then estimated from:

$$\sigma_z = a(x + x_0)^b \quad \text{Equation B4}$$

Where x is the downwind distance (m)

a and b are dimensionless empirical parameters (see **Table 8.1**)

x_0 is the 'virtual distance' (m).

Table 8.1: Dimensionless constants used to calculate plume spread parameters

Stability Class	a	b
A	0.180	0.945
B	0.145	0.932
C	0.110	0.915
D	0.085	0.870

Source: Zimmerman and Thompson (1975)

The virtual distance is used to simulate the effect of the initial vertical plume size (σ_{z0}) at the source. It is determined by estimating the initial 'size' of the dust cloud at the point of generation, dividing by 2.15 (**Turner, 1970**) and then inverting **Equation B3** to get:

$$x_0 = \left(\frac{\sigma_{z0}}{a} \right)^b \quad \text{Equation B5}$$

The stability class is determined using Pasquill-Gifford stability classification based on wind speed and solar radiation (**Hanna et al., 1982**).

For point sources, such as unloading of trucks, or for area sources the emission rate is determined by rearranging **Equation B2** to get:

$$Q = \pi \sigma_y \sigma_z U \quad \text{Equation B6}$$

By measuring the integrated horizontal flux of dust (χ_{int}) equal to $\int \chi dy$ or $\chi_{ave} \Delta_y$ or $\chi_{ave} \sqrt{2\pi} \Delta_y$, the emission rate can be determined by:

$$Q = \frac{\sqrt{2\pi}}{2} \sigma_z U X_{int} \quad \text{Equation B7}$$

where again σ_z is estimated as above with U taken as the mean wind speed.

For measurements which are not at the plume centreline, the reductions in concentration are determined by assuming that **Equation B7** now includes a term R where:

$$R = e^{-0.5 \left(\frac{z}{\sigma_z} \right)^2} \quad \text{Equation B8}$$

Therefore the emission rate can be determined based on the measured concentration by:

$$Q = \frac{\frac{\sqrt{2\pi}}{2} \sigma_z U X_{int}}{R} \quad \text{Equation B9}$$

Appendix E TECHNICAL SPECIFICATION FOR COOLMIST A-JET35S

A-Jet 35S Turbo Fog Cannon technical data

Vent Motor Power Installed (Kw)	3
Maximum covered area m ²	3,077
Operational system	Hydraulic
Vertical Fan Rise	Auto –15°+ 55°
Rotation angle maximum	Auto 0°-360°
Nozzle crown	2 x Stainless Steel
Nozzle number	64 (32 per crown)
Standard Nozzles	Stainless Steel
Water consumption (relative to selected nozzle rate)	6 – 110 l/ min
Standard Motor Vent Protection	IP55
Radio Remote control (100 metres)	Standard
Water Filtration Micron	100 Stainless Steel
Water Pump motor power (Kw)	2.2
Maximum water output (m ³ /h)	7 m ³ /h
Working water Output pressure	15 bar
Minimum water input pressure	3 bar
Programmable Unit	Yes
GSM multi-unit management	Yes
Multi-unit control with radio command	Yes (std)
Operation Timer	Yes
Autonomous unit (power/water)	Yes
Halogen warning lamp	Yes
Night Light (option)	Fixed light kit or Orientating kit
Warranty Period	1 Year
Machine only weight	550 kg
Machine weight on levelling jacks	770 kg
Machine weight on trailer	878 kg
Machine only Length	1465 mm
Machine only Width	800 mm
Machine only Height	2502.5 mm
Machine Length on levelling jacks	1656 mm
Machine Width on levelling jacks	1356 mm
Machine Height on levelling jacks	2832.5 mm
Machine Length on trailer including carriage	2235 mm
Machine Length on trailer including carriage tow arm	3375 mm
Machine Width on trailer including carriage	1951 mm
Machine Height on trailer including carriage	3075 mm
Wheel width on trailer model	260 mm
Wheel diameter on trailer model	Ø585 mm

Reference: CoolMist Systems Australia Brochure 2014 - A-Jet 35S Turbo Fog Cannon, Dust Suppressor.

Appendix F TECHNICAL SPECIFICATION FOR SPRAYSTREAM 20 FOG CANNON

General specifications:

Steel chassis with an aerodynamic shaped cone is made out of fibreglass composite with an integrated nozzle ring. The vertical movement is operated by hand.



- > Surface coverage up to 1500m²
- > Adjustable angle of throw -35 to +35°
- > Waterflow from 1- 500L/h (depending the application)
- > Throw 15-25m

Dimensions:

- > Length 964mm
- > Width 680mm
- > Height 700mm
- > Weight 35kg

Options:

- > Oscillation unit
- > Dosage pump
- > Medium pressure pump (22bar)
- > High pressure pump (85bar)
- > Filter/UV system
- > Remote control
- > Automatisation
- > Electrical cabinet (depending on the number of units)

Electrical specifications:

- > Fan 0,75kW; 2,2kW or 3kW
- > 3x400V or 1x220V (version 0,75 & 2,2kW)
- > Other international motors available

Additifs:





- > Spaystream Crust Agent
- > Odor control
- > Watersurfactant

Water specifications:

- > A constant press. of 0,5 bar need to be delivered to the pump
- > Stainless steel booster pump
- > Waterbox filtersystem from 500µm
- > 15 Brass nozzles (stainless steel available)
- > Droplet size spectrum vary from 20 to 80µm

Reference: SprayStream SS20 Brochure, 2014 – Dust Suppression unit, Industrial water spraying dust suppression machine.

Appendix G	TECHNICAL SPECIFICATION FOR NELSON BIG GUN SPRINKLER SR200
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75 SERIES			100 SERIES			150 SERIES			200 SERIES	
PERFORMANCE	30-160 GPM (6.8-36.3 M³/H)  25-80 PSI (1.75-6 Kg/cm²)		50-300 GPM (10-70 M³/H)  40-110 PSI (3.5-8 Kg/cm²)			100-630 GPM (23-150 M³/H)  50-120 PSI (3.5-9 Kg/cm²)			250-1200 GPM (55-275 M³/H)  60-130 PSI (4-9 Kg/cm²)	
MODEL & TRAJECTORY	Full Circle F75	Part Circle SR75	Full Circle F100	Part Circle SR100	Part Circle SRA100	Full Circle F150	Part Circle SR150	Part Circle SRA150	Full Circle F200	Part Circle SR200
	21°, 24°	18°, 21°, 24°, 43°	18°, 21°, 24°, 43°		15-45° Adjustable	21°, 24°	21°, 24°, 27°, 43°	15-45° Adjustable	21°, 24°, 27°	
NOZZLE OPTIONS	TAPERING	Not Available	TAPERING	100T (Specify Size)		TAPERING	150T (Specify Size)		TAPERING	200T (Specify Size)
	RING		TR75 (Specify Size)	100TR (Specify Size)	NA for SRNV	150TR (Specify Size)	Not Available			
	RING		Not Available	100R (Includes Set of Rings)	NA for SRNV	150R (Includes Set of Rings)	200R (Includes Set of Rings)			
SPECIAL OPTIONS	Not Available		Anodized & Powder Coated, Vaneless Range Tube*			Anodized & Powder Coated, Stainless Steel (SRA150 N/A), Vaneless Range Tube			Anodized & Powder Coated	
ADD-ON KITS	HD Lower Bearing, 12° Wedge Kit, Counterbalance Kit, Stream Straightener Vane		Low-Pressure Drive Vane Kit, Counterbalance Kit, Secondary Nozzle Kit, 12° Wedge Kit, Stream Straightener Vane			Counterbalance Kit, Secondary Nozzle Kit, Stream Straightener Vane			Secondary Nozzle Kit (standard), 12° Wedge Kit (SR200 only)	
MOUNTING DETAILS	Fits QC** & 2" 800 Series Valve		Fits QC** & 2" 800 Series Valve (QC NA for SRNV100)			Substantial thrust on riser, use 3" valve minimum			Substantial thrust on riser, use 4" valve minimum	
CONNECTION OPTIONS	1 1/2" or 2" FNPT or FBSP ANSI/DIN Nelson or Euro Flange		2" FNPT or FBSP, 2 1/2" FNPT ANSI/DIN, Nelson or Euro Flange		2" FNPT or FBSP for SRNV	Nelson, Euro or ANSI/DIN Flange Also, Nelson Flange to Female Adapters			Nelson, Euro or ANSI/DIN Flange Also, Nelson Flange to Female Adapters	

*Vaneless Range Tube option is for wastewater applications containing hair, straw, etc.

** The "Quick Coupling Valve" inlet is available in both 2" and 3" FNPT and FBSP for connection to the piping system. The "Quick Coupling Key" outlet is available in 2" FNPT, 2" FBSP, and Nelson Flange Connection for connection to the Big Gun.

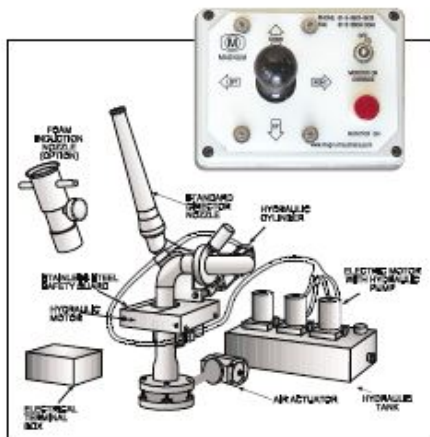
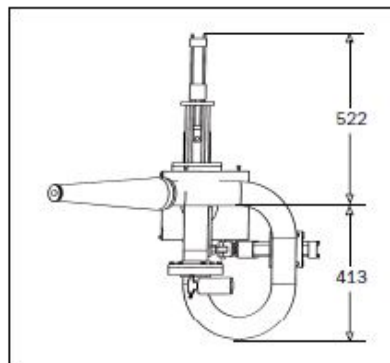
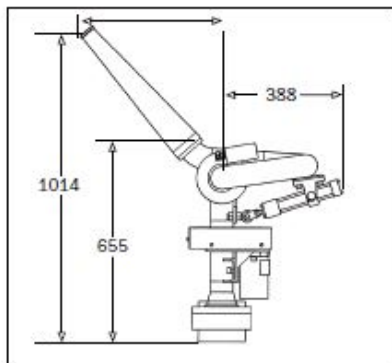
Reference: Nelson Irrigation Brochure, 2014 – The Original Big Gun Sprinkler

Appendix H **TECHNICAL SPECIFICATION FOR MAGNUM WATER CANNON RM80**



RM80 - Remote Monitor

- Easy installation
- Pressure tested to 3000 kpa
- 80mm (3") ANSI 150lb flanged inlet connection
- Hydraulic slew and elevation control
- Electric joystick cabin control supplied as standard
- Radio Frequency (R.F.) joystick control - optional
- Full automation via sequencing or PLC technology - can retro fit as optional
- Engineered balanced and compact design - see dimensions
- Direct gear drive offering up to 360° precision slew operation
- Hydraulic cylinder controlling 75° angle elevation
- Designed for mobile or fixed mounted applications
- Optional "power pack" system or can control via vehicle hydraulics
- Patented "non-flog" Magnum Australia® swivel bearings
- Automatic grease lubricators fitted
- Accepts Magnum 316 s/s fog nozzle for adjustable fan spray
- Optional 3% foam induction nozzle available for fire applications
- Director nozzle supplied -28mm (1 1/8") orifice as standard
- All s/s fasteners and protective cabinet components
- 12 month product warranty
- Spare parts readily available
- Fully serviceable



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Anaid Nominees Pty Ltd ABN 88 004 924 994
35 Parkhurst Drive, Knoxfield, Victoria, Australia 3180 Telephone: (61 3) 9801 8433 Facsimile: (61 3) 9800 3240
Email: tanks@magnumaustralia.com Web: www.magnumaustralia.com

Reference: Magnum Australia Brochure, 2014 – RM80 Remote Monitor

Appendix I FIELD TRIALS PHOTO LOG



Figure I - 1: Tilt tray test rig set up (Wambo Mine, 3 April 2014)



Figure I - 2: Manoeuvring fogger onto tilt tray (Wambo Mine, 3 April 2014)



Figure I - 3: Spray Stream 20 in action (Wambo Mine, 3 April 2014)



Figure I - 4: CoolMist fogger cannon in action (Wambo Mine, 3 April 2014)



Figure I - 5: CoolMist fogger in use at Montrose Pit (Wambo Mine, 3 April, 2014)



Figure I - 6: SprayStream fogger in use at Montrose Pit (Wambo Mine, 3 April 2014)



Figure I - 7: Nelson Big SR200 agricultural sprinkler pre-soaking overburden near the Narama Dragline (Ravensworth Open Cut, 9 July 2014)



Figure I - 8: T-REX Plume transect monitoring equipment mounted to light vehicle (Ravensworth Open Cut, 9 July 2014)



Figure I - 9: Narama Dragline digging controlled material while agricultural sprinkler soaks material (Ravensworth Open Cut, 9 July 2014)



Figure I - 10: Narama Dragline moving uncontrolled material (Ravensworth Open Cut, 9 July 2014)



Figure I - 11: Nelson Big Gun SR200 agricultural sprinkler pre-soaking overburden in direction of prevailing wind (Ravensworth Open Cut, 9 July 2014)



Figure I - 12: Nelson Big Gun SR200 agricultural sprinkler pre-soaking overburden in direction against prevailing wind (Ravensworth Open Cut, 9 July 2014)



Figure I - 13: T-REX Monitoring equipment mounted to light vehicle at the start of the monitoring traverse on the bench (Rix's Creek Mine, 2 July 2014)



Figure I - 14: 785 Water cart with after-market water cannon

on mounted to the front (Rix's Creek Mine, 2 July 2014)



Figure I - 15: Water cart irrigating the active bench during digging, while stationed on the bench (Rix's Creek Mine, 2 July 2014)



Figure I - 16: Water cart irrigating active bench during loading, while stationed in the work area (Rix's Creek Mine, 2 July 2014)



Figure I - 17: Water cart fogging plume generated from loading (Rix's Creek Mine, 2 July 2014)



Figure I - 18: Loading plume generated from drop height, approximately 4.5 m above the haul truck bucket (Rix's Creek Mine, 2 July 2014)



Figure I - 19: Loading plume generated from best practice drop height, approximately 1.5m above the haul truck bucket (Rix's Creek Mine, 2 July 2014)

Appendix J LABORATORY ANALYSIS REPORTS FOR BULK SAMPLES

AGRICULTURAL SPRINKLER LOADING - SILT AND MOISTURE SAMPLING RESULTS



Job Number : L108923
Client : Pacific Environment Limited
Reference/Order : 6961P
Project : RAVENSWORTH

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plus Cover Page

		Lab No	001	002
		Sample ID		
Analyte		DL		
NQ968 - Moisture Determination of Bulk Samples				
Total Moisture (@ 105o C)	%	0.1	3.8	8.5
NQ899 - Size Analysis of Misc.Material				
+ 31.5 mm	%	0.1	12.4	4.0
-31.5 + 16.0 mm	%	0.1	31.6	25.4
-16.0 + 8.0 mm	%	0.1	14.5	22.4
-8.0 + 4.0 mm	%	0.1	12.2	20.5
-4.0 + 0.85 mm	%	0.1	14.9	19.9
-0.85 + 0.425 mm	%	0.1	4.0	3.2
-0.425 + 0.150 mm	%	0.1	4.5	2.5
-0.150 + 0.075 mm	%	0.1	2.1	0.9
-0.075 mm	%	0.1	3.6	1.3

DL = Detection Limit	Sample Description Key (if req'd)	
LNR = Samples Listed not Received	001	1-OB UNCONTROLLED DRY
-- = Not Applicable	002	2-OB CONTROLLED WET
nd = < DL		
db = Dry basis		