



FINAL REPORT

DENDROBIUM MINE PARTICULATE MATTER CONTROL BEST PRACTICE POLLUTION REDUCTION PROGRAM

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1 INTRODUCTION

In December 2010, NSW Office of Environment and Heritage (OEH) published the draft best practice document '*NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining*' (hereafter called 'the Best Practice Report'). This document was finalised in June 2011, though no significant changes were made from the draft (**Donnelly et al., 2011**).

As an outcome of the Best Practice Report, OEH developed a Pollution Reduction Program (PRP) that requires each mine company to prepare a report on the practicability of implementing best practice measures to reduce particle emissions.

The Coal Mine Particulate Matter Control Best Practice PRP has been attached to Dendrobium Underground Coal Mine Environmental Protection Licence (EPL 3241) as varied in August 2011 to incorporate the PRP.

A copy of the PRP as attached to the OEH (EPL 3241) is included **Appendix B** and a copy of the 'Coal Mine Particulate Matter Control Best Practice – Site Specific Determination Guideline' is included in **Appendix C**.

In summary the requirements of the PRP are:

1. Identify, quantify and justify existing measures that are being used to minimise particle emissions:
 - a. Estimate baseline emissions of TSP, PM₁₀ and PM_{2.5} (tonne per year) from each mining activity using USEPA AP-42 emission estimation techniques for both uncontrolled emissions (with no particulate matter controls in place) and controlled emissions (with current particulate matter controls in place);
 - b. Rank the controlled emission estimates for TSP, PM₁₀ and PM_{2.5} emitted by each mining activity from highest to lowest.
 - c. Identify the top four mining activities that contribute the highest emissions of TSP, PM₁₀ and PM_{2.5}.
2. Identify, quantify and justify measures could be used to minimise particle emissions:
 - a. For each of the top four activities identified in Step 1(c) identify the measures that could be implemented to reduce emissions.
 - b. For each of the top four activities identified in Step 1(c) estimate emissions of TSP, PM₁₀ and PM_{2.5} from each mining activity following the application of the measures identified in Step 2 (b).

3. Evaluate the practicability of implementing these best practice measures:
 - a. For each of the best practice measures identified in Step 2(a), assess the practicability associated with their implementation, by taking into consideration:
 - i. Implementation status;
 - ii. Regulatory requirements;
 - iii. Environmental impacts;
 - iv. Safety implications; and
 - v. Compatibility with current processes and proposed future developments.
 - b. Identify those best practices that will be implemented at the premises to reduce particle emissions.
4. Propose a timeframe for implementing all practicable best practice measures:
 - a. For each of the best practice measures identified as being practicable in step 3(b), provide a timeframe for their implementation.

PAEHolmes have been commissioned by BHPBilliton Illawarra Coal to produce a report that addresses the intent of the PRP as it relates to the Dendrobium Mine, near Wollongong, NSW.

1.1 Mining activity and associated emission factors

The PRP defines mining activities as:

- Wheel generated particles on unpaved roads;
- Wind erosion of overburden;
- Blasting;
- Bulldozing coal;
- Trucks unloading overburden;
- Bulldozing overburden;
- Front-end loaders on overburden;
- Wind erosion of exposed areas;
- Wind erosion of coal stockpiles;
- Unloading from coal stockpiles;
- Dragline;
- Trucks unloading coal;
- Loading coal stockpiles;
- Graders;
- Drilling;
- Coal crushing;
- Material transfer of coal;
- Scrapers on overburden;
- Train loading;

- Screening; or
- Material transfer of overburden.

The relevant emission factors for each of these activities are presented in **Table 1.1**.

Not all of these activities occur at Dendrobium mine. **Section 2** presents the calculated emissions for the activities relevant to Dendrobium.

Table 1.1: Emission Factors

PRP activity	Units	TSP Emission Factor	PM ₁₀ Emission Factor	PM _{2.5} Emission Factor	Source
Wheel generated particulates on unpaved roads	kg/VKT	$\left(\frac{0.4536}{1.6093}\right) \times 4.9 * \left(\frac{S}{12}\right)^{0.7} \times \left(\frac{W \times 1.1203}{3}\right)^{0.45}$	$\left(\frac{0.4536}{1.6093}\right) \times 1.5 * \left(\frac{S}{12}\right)^{0.9} \times \left(\frac{W \times 1.1203}{3}\right)^{0.45}$	$\left(\frac{0.4536}{1.6093}\right) \times 0.15 * \left(\frac{S}{12}\right)^{0.9} \times \left(\frac{W \times 1.1203}{3}\right)^{0.45}$	AP-42 13.2.2
Wind erosion of overburden ^(a)	kg/ha/h	0.1	0.5 * TSP (0.5 from AP-42 13.2.5)	0.075 * TSP (0.075 from AP-42 13.2.5)	AP-42 11.9.7 Table 11.9-4
Blasting	kg/blast	$0.00022 \times A^{1.5}$	0.52 * TSP	0.03 * TSP	AP-42 11.9.7 Table 11.9-2
Bulldozing coal	kg/t	$35.6 \times \frac{S^{1.2}}{M^{1.3}}$	$6.33 \times \frac{S^{1.5}}{M^{1.4}}$	0.022 x TSP	AP-42 11.9.7 Table 11.9-2
Trucks unloading overburden	kg/t	$0.74 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$	$0.35 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$	$0.053 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$	AP-42 13.2.4
Bulldozing overburden & front-end loaders on overburden	kg/t	$2.6 \times \frac{S^{1.2}}{M^{1.3}}$	$0.3375 \times \frac{S^{1.5}}{M^{1.4}}$	0.105 * TSP	AP-42 11.9.7 Table 11.9-2
Wind erosion of exposed areas ^(a)	kg/ha/h	0.1	0.5 * TSP (0.5 from AP-42 13.2.5)	0.075 * TSP (0.075 from AP-42 13.2.5)	AP-42 11.9.7 Table 11.9-4

PRP activity	Units	TSP Emission Factor	PM ₁₀ Emission Factor	PM _{2.5} Emission Factor	Source
Wind erosion of coal stockpiles	kg/ha/h	$1.8 * u$	$0.5 * TSP$ (0.5 from AP-42 13.2.5)	$0.075 * TSP$ (0.075 from AP-42 13.2.5)	AP-42 11.9.7 Table 11.9-2
Unloading from coal stockpiles	kg/t	$\frac{0.580}{M^{1.2}}$	$\frac{0.0447}{M^{0.9}}$	$0.019 * TSP$	AP-42 11.9.7 Table 11.9-2
Dragline	kg/bcm	$0.0046 \times \frac{d^{1.1}}{M^{0.3}}$	$0.002175 \times \frac{d^{0.7}}{M^{0.3}}$	$0.017 * TSP$	AP-42 11.9.7 Table 11.9-2
Trucks unloading coal	kg/t	$\frac{0.580}{M^{1.2}}$	$\frac{0.0447}{M^{0.9}}$	$0.019 * TSP$	AP-42 11.9.7 Table 11.9-2
Loading coal stockpiles	kg/t	$0.74 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{1.4}$	$0.35 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{1.4}$	$0.053 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{1.4}$	AP-42 13.2.4 (Note: AP-42 11.9-7 Table 11.9-4 has Train loading emission factor but footnote direct user to Chapter 13 for more accurate emissions factors.)
Graders	kg/VKT	$0.0034 \times S^{2.5}$	$0.00336 \times S^{2.0}$	$0.0001054 \times S^{2.5}$	AP-42 11.9.7 Table 11.9-2
Drilling	kg/hole	0.59	$0.52 * TSP$ (PM ₁₀ ratio assumed same as blasting AP-42 11.9.7 Table 11.9-2)	$0.03 * TSP$ (PM _{2.5} ratio assumed same as blasting AP-42 11.9.7 Table 11.9-2)	AP-42 11.9.7 Table 11.9-4

PRP activity	Units	TSP Emission Factor	PM ₁₀ Emission Factor	PM _{2.5} Emission Factor	Source
Drilling	kg/hole	0.1	0.52 * TSP	0.03 * TSP	AP-42 11.9.7 Table 11.9-4
Coal crushing	kg/t	0.0027	0.0012	No data	AP-42 11.19.2 Table 11.19.2-2
Material transfer of coal (use for Loading coal to trucks)	kg/t	$\frac{0.580}{M^{1.2}}$	$\frac{0.0447}{M^{0.9}}$	0.019 * TSP	AP-42 11.9.7 Table 11.9-2
Scrapers on overburden	kg/t	0.029 ^(b)	No data	No data	AP-42 11.9.7 Table 11.9-4
Train loading	kg/t	$0.74 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{1.4}$	$0.35 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{1.4}$	$0.053 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{1.4}$	AP-42 13.2.4 (Note: AP-42 11.9-7 Table 11.9-4 has default train loading emission factor but footnote directs user to Chapter 13 for more accurate emissions factors.)
Screening	kg/t	0.025	0.0087	No data	AP-42 11.19.2 Table 11.19.2-2
Material transfer of overburden (use for Loading OB to trucks)	kg/t	$0.74 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{1.4}$	$0.35 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{1.4}$	$0.053 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{1.4}$	AP-42 13.2.4

Where:

A	=	horizontal area (m ²)
M	=	material moisture content (%)
s	=	material silt content (or surface silt content in unpaved roads) (%)
u	=	wind speed (m/s)
d	=	drop height (m)
W	=	mean vehicle weight (tonnes)
S	=	mean vehicle speed (km/h)

Notes:

- (a) An alternative method for the estimation of wind erosion from exposed areas is contained within AP-42 Chapter 13.2.5. The method takes into account site specific wind data, site-specific erodible material properties (threshold friction velocity, particle size distribution of the material eroded) and the frequency of material disturbance. Notwithstanding the data intensiveness of this approach, exercises in applying this method in to Hunter Valley mines to date (e.g. Integra Complex, Ravensworth Operations) has resulted in little or no wind initiated dust lift-off emissions being predicted from active mine sites. As such, the AP-42 Chapter 11.9.7 approach has been adopted. This is considered both conservative and applicable to the estimation of wind erosion emissions over the longer term.
- (b) The equation referenced relates to topsoil removal by scraper. No data is provided within the AP-42 relating to scraper activity on overburden. Nor is this activity identified within the activities conducted at the subject mine.

2 EXISTING MEASURES USED TO MINIMISE PARTICLE EMISSIONS

This section provides estimation of particulate matter emissions from all identified activities for the two scenarios: uncontrolled emissions (with no particulate matter controls in place) and controlled emissions (with current particulate matter controls in place)

Emissions were calculated using the relevant using USEPA AP-42 emission estimation techniques for both uncontrolled emissions and controlled emissions (See **Table 1.1**).

2.1 Overview of Existing Operations

The Dendrobium mine is an underground operation, and has relatively few particulate emission sources relative to open cut mines. Coal from the underground mine is transported to the surface by conveyor, which exits the ground approximately 540 metres west of the stockpile. The conveyor transports the coal, via a coal sizer, to the 150,000 tonne stockpile. Trains are loaded via an enclosed gravity-feed system within the tunnel that runs under the stockpile. The coal is then transported 7 km to the Port Kembla Steelworks Coal Preparation Plant (Steelworks). Additionally, there is movement of vehicles into and out of the Nebo Portal on sealed roads.

A review of existing documents detailing dust generating activities at Dendrobium Underground Mine (**HAS 2005, BHPB 2011**) was undertaken to identify site activities that may contribute to particulate matter emissions. From an operational perspective the activities that were identified as sources of particulate matter are:

- Loading coal to the stockpile;
- Working the stockpile by bulldozer/loader;
- Wind erosion from the stockpile;
- Loading coal to trains at the Kemira Valley Coal Handling Facility (KVCHF);
- Ventilation fans; and,
- Movement of vehicles into and out of the Nebo Portal.

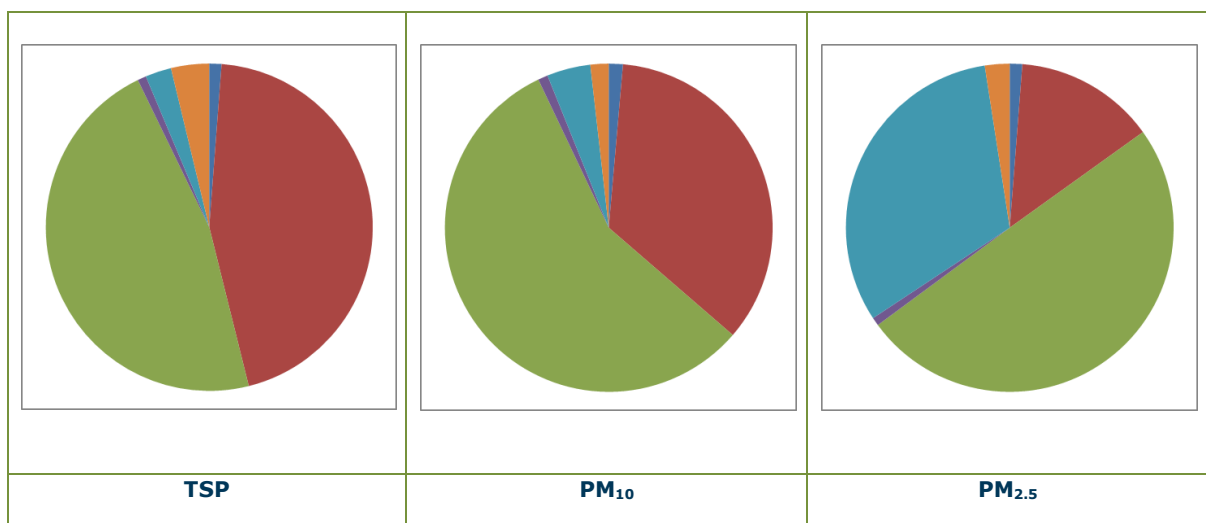
2.2 Estimated Uncontrolled Emissions

Table 2.1 provides the estimated baseline emissions of TSP, PM₁₀ and PM_{2.5} (tonnes per year) from each mining activity identified, in the absence of any air quality controls. Calculations have been made using the relevant USEPA AP-42 emission factors as listed in **Table 1.1**. A summary of the emissions calculations used for this assessment is provided within **Appendix A**.

Table 2.1: Estimated uncontrolled emissions

PRP activity	TSP (tonne/year)	PM10	PM2.5
Loading coal to the stockpile	2.1	1.0	0.15
Working the stockpile by bulldozer/loader	78.6	25.2	1.7
Wind erosion from the stockpile	81.7	40.8	6.1
Loading coal to trains	1.5	0.7	0.1
Ventilation fans	4.5	3.1	3.9
Movement of vehicles into and out of the Nebo Portal	6.6	1.3	0.3
Total	175.0	72.1	12.3

The distribution of the predicted uncontrolled emissions by activity for the TSP, PM₁₀ and PM_{2.5} size fractions by activity is shown graphically in **Figure 2.1**.



- Loading coal to the stockpile
- Working the stockpile by bulldozer/loader
- Wind erosion from the stockpile
- Loading coal to trains
- Ventilation fans
- Movement of vehicles into and out of the Nebo Portal

Figure 2.1: Annual uncontrolled emissions by activity – Current Operations

2.3 Estimated Controlled Emissions

Emissions were then recalculated taking into account various control factors for the dust controls that Dendrobium mine have in place. These controls, as well as the control factor applied, are listed in **Table 2.2**.

The control factors adopted are the default values contained within the Best Practice Report (**Donnelly et al., 2011**).

Table 2.2: Summary of current dust controls and level of control applied – Current Operations

Mining Activity	Control measure currently in place	Level of control applied
Loading coal to the stockpile	Increase in moisture content to $\geq 8\%$ ^(a)	30%
Working the stockpile by bulldozer/loader	Travel route and materials moist ^(a)	60%
Wind erosion from the stockpile	Water sprays applied ^(b)	50%
Loading coal to trains	Enclosure ^(c)	70%
Ventilation fans	N/A	N/A
Movement of vehicles into and out of the Nebo Portal	Use of vacuum sweeper, paving, water sprays ^(c)	80%

Notes:

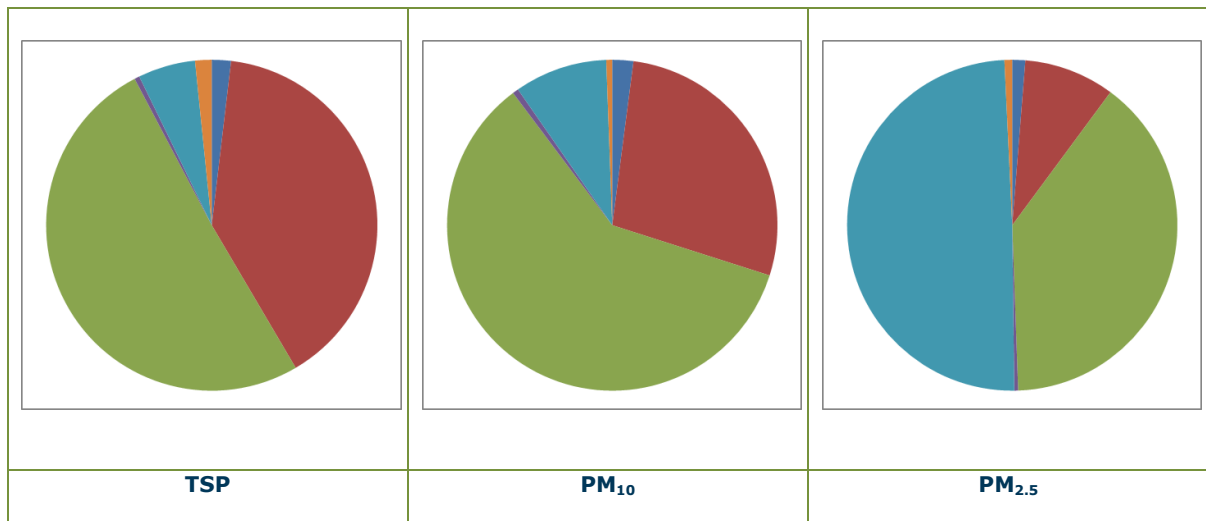
- (a) The moisture level of the coal being loaded onto the Kemira Valley stockpile is monitored via a coal scan analyser fitted to the conveyor system on the surface at Kemira Valley. Water is added via eight water sprays to maintain the moisture level at 8% or above, and water is also applied to the coal as it is loaded to the stockpile via the rill tower using two water sprays. Coal moisture levels are estimated at half hour intervals using information based on wind speed, humidity and solar radiation. The automated stockpile dust suppression system is activated to maintain coal moisture levels at 8%.
- (b) Eight ground-based sprays are used to apply water to the stockpile.
- (c) Trains are loaded via an enclosed gravity-feed system within the tunnel that runs under the stockpile.
- (d) The uncontrolled emission estimate assumes a paved road. To reflect the use of vacuum sweepers, the particulate emissions from vehicle movements on the paved, controlled, road surface, a silt loading has been taken as 2.4 g/m² has been adopted. This represents the lower end of estimates within the AP-42 literature.

A summary of the predicted annual emissions incorporating current dust controls is provided in **Table 2.3**.

Table 2.3: Estimated controlled emissions

PRP activity	TSP (tonne/year)	PM10	PM2.5
Loading coal to the stockpile	1.5	0.70	0.10
Working the stockpile by bulldozer/loader	31.9	9.5	0.7
Wind erosion from the stockpile	40.8	20.4	3.1
Loading coal to trains	0.4	0.2	0.03
Ventilation fans	4.5	3.1	3.9
Movement of vehicles into and out of the Nebo Portal	1.3	0.2	0.06
Total	80.4	34.1	7.9

The distribution of the predicted controlled emissions by activity for the TSP, PM₁₀ and PM_{2.5} size fractions by activity is shown graphically in **Figure 2.2**.



- Loading coal to the stockpile
- Working the stockpile by bulldozer/loader
- Wind erosion from the stockpile
- Loading coal to trains
- Ventilation fans
- Movement of vehicles into and out of the Nebo Portal

Figure 2.2: Annual controlled emissions by activity – Current Operations

2.4 Activities Rank

This section uses the information calculated and presented in **Section 2.2**, and ranks the activities in terms of annual mass emission.

Table 2.4 provides a rank of the mining activities according to the mass of TSP, PM₁₀ and PM_{2.5} emitted by each mining activity per year from highest to lowest.

Table 2.4: Activity rank of the estimated controlled emissions by mass

Rank	Mine activity	TSP (t/yr)	PM ₁₀	PM _{2.5}
1	Wind erosion from the stockpile	40.8	20.4	3.1
2	Working the stockpile by bulldozer/loader	31.9	9.5	0.7
3	Ventilation shaft	4.5	3.1	3.9
4	Loading coal to the stockpile	1.5	0.70	0.10
5	Movement of vehicles into and out of the Nebo Portal	1.3	0.2	0.06
6	Loading coal to trains	0.4	0.2	0.03

2.5 Top Four highest Particulate Generating Activities

Table 2.5 provides the top four mining activities that contribute the highest emissions of TSP, PM₁₀ and PM_{2.5} at Dendrobium.

Table 2.5: Top four activities

Rank	PRP activity	TSP (t/yr)	PM ₁₀	PM _{2.5}
1	Wind erosion from the stockpile	40.8	20.4	3.1
2	Working the stockpile by bulldozer/loader	31.9	9.5	0.7
3	Ventilation shaft	4.5	3.1	3.9
4	Loading coal to the stockpile	1.5	0.70	0.10

3 BEST PRACTICE MEASURES

A summary of the best practice measures available, as well as the associated effectiveness, as documented within the Best Practice Report (**Donnelly et al., 2011**) is provided in **Section 3.1**. Where present, the existing control measure adopted by Dendrobium is shown in bold.

An estimation of the emissions through application of these measures is then provided in **Section 3.2**.

3.1 Best Practice Measures for Highest Ranking Activities

3.1.1 Wind erosion of the stockpile

Table 3.1: Best practice control measures to reduce particulate matter emissions from coal stockpiles

Control Measure		Effectiveness
Avoidance	Bypass stockpiles	100% reduction in wind erosion for coal bypassing stockpile
Surface stabilisation	Water spray	50%
	Chemical wetting agents	80-99%
	Surface crusting agent	95%
	Carry over wetting from load in	80%
Enclosure	Silo with bag house	95-100%
	Cover storage pile with a tarp during high winds	99% ^a
Wind speed reduction	Vegetative wind breaks	30%
	Reduce pile height	30%
	Wind screens/wind fences	75-80%
	Erect 3-sided enclosure around storage piles	75%
Note		
^a Estimated based on the effectiveness of chemical surface treatments		

Source: Donnelly et al, 2011

Dendrobium already utilise water sprays as an existing control and the 50% reduction effectiveness has been applied when estimated current emissions with existing controls in **Section 2**.

3.1.2 Working the stockpile by bulldozer

Table 3.2: Best practice control measures to reduce particulate matter emissions from bulldozers

Control Measure		Effectiveness
Bulldozer	Minimise travel speed and distance	Not quantified
	Keep travel routes and materials moist	50%

Source: Donnelly et al, 2011

At present, Dendrobium mine already use water sprays on the stockpile material and the 50% reduction effectiveness has been applied when estimated current emissions with existing controls in **Section 2**.

3.1.3 Ventilation shafts

No guidance is provided within the Best Practice Report (**Donnelly et al., 2011**) as to appropriate control measures to reduce particulate matter emissions from ventilation shafts.

While the ventilation shaft has been identified as one of the top four ranked emission sources from Dendrobium Mine, its source characteristics are those of an elevated point source, as opposed to a ground level fugitive emission source. Additionally, PAEHolmes are not aware of any precedent for in-stack particulate matter control being applied to underground mine ventilation shafts.

In view of the above, this source has been disregarded from further evaluation, and the fifth ranked emission source “Movement of vehicles into and out of the Nebo Portal” has additionally been evaluated.

3.1.4 Loading coal to the stockpile

Table 3.3: Best practice control measures to reduce particulate matter emissions from loading and dumping ROM coal

Control Measure		Effectiveness
Avoidance	Bypass ROM stockpiles	50% reduction in dumping emissions for coal bypassing ROM stockpile ^a Emissions associated with forming coal into stockpiles (e.g. by dozer push) would be reduced by 100% for bypassing coal
Truck or loader dumping coal	Minimise drop height	Reduce from 10 m to 5 m: 30%^b
	Water sprays on ROM pad	50%
<p>Note</p> <p>^a Reduction achieved because one dump required rather than two</p> <p>^b Reductions due to reduce drop heights have been inferred from the emission estimation equation for dropping material from a dragline.</p>		

Source: Donnelly et al, 2011

Dendrobium mine already effectively uses two off the three best practice control measures detailed above. The use of a rill tower minimises the drop height of coal onto the stockpile and water sprays are currently applied to the stockpile. **Figure 3.1** provides an image of the rill tower loading onto the stockpile.



Figure 3.1: Image of the rill tower and stockpile

3.1.5 Movement of vehicles into and out of the Nebo Portal

The estimation of uncontrolled emissions conducted for this evaluation already assumes the presence of sealed roads, as is the case for the Nebo portal access road.

As stated in **Section 2.3**, in addition to the use of a sealed road, two distinct dust control measures are applied to the portal road to reduce emissions:

- Use of a vacuum sweeper truck operated on a regular basis; and
- The use of an automatic dust suppression spray system along the portal road.

Figure 3.2 provides an image of water sprays in use on the portal road.



Figure 3.2: Image of portal road water sprays in use

While not explicit to the PRP process, a site inspection undertaken as part of this exercise indicates that, while the existing controls appear adequate, there is potential for further improvements associated with this source. To further reduce emissions from vehicle movements, there is potential to improve and upgrade the current portal road construction.

3.2 Estimated resultant emissions

For each of the top activities identified in **Section 2.5**, the emissions of TSP, PM₁₀ and PM_{2.5} from each mining activity after applying the measures identified in **Section 3.1** have been estimated.

Table 3.4 presents the annual mass emissions anticipated through application of Best Practice for current operations, as well as a summary of the percentage reduction achievable.

Table 3.4: Estimated mass emissions through application of best practice

Activity	Control measure	% reduction	TSP	PM ₁₀	PM _{2.5}
Wind erosion of stockpile	Bypass stockpiles	100%	0	0	0
	Water spray	None - Best practice already in place	40.8	20.4	3.1
	Chemical wetting agents	35% (85% - existing 50%) ^a	26.5	13.3	2.0
	Surface crusting agent	45% (95% - existing 50%) ^a	22.4	11.2	1.7
	Carry over wetting from load in	30% (80% - existing 50%) ^a	28.6	14.3	2.2
	Silo with bag house	98%	0.8	0.4	0.1
	Cover storage pile with a tarp during high winds	99%	0.4	0.2	0.0
	Vegetative wind breaks	30%	28.6	14.3	2.2
	Reduce pile height	30%	28.6	14.3	2.2
	Wind screens/wind fences	77.5%	9.2	4.6	0.7
	Erect 3-sided enclosure around storage piles	75%	10.2	5.1	0.8
Bulldozers on coal	Keep travel routes and materials moist	None - Best practice already in place	31.9	9.5	0.7
Ventilation shaft	N/A	N/A	4.5	3.1	3.9
Loading of coal to stockpile	Bypass ROM stockpiles	50%	0.8	0.4	0.1
	Minimise drop height	None - Best practice already in place	1.5	0.7	0.1
	Water sprays	None - Best practice already in place	1.5	0.7	0.1
Vehicles movements on paved road	Improve road construction	No % reduction available	1.3	0.2	0.1
<p>Note</p> <p>^a Difference between recommended BPM and 50% for water spray reduction</p>					

4 EVALUATION OF PRACTIBILITY OF BPM

4.1 Practicability of implementation of BPM

Dendrobium Mine and Kemira Valley are effectively managing their dust emissions with several best practices already in place.

Dendrobium pit top has a variety of dust control measures already in place which include:

- The use of a vacuum sweeper truck which operates on a regular basis;
- The use of an automatic dust suppression spray system along the portal road;
- The main surface travel routes and storage areas are hardstand; and
- Sections of surface travel roads are progressively being upgraded to concrete.

Kemira Valley dust control measures include:

- An automatic dust suppression system on the stockpile. Eight sprays are located around the base of the stockpile whilst a further two sprays are located at the top of the rill tower. The spray system is programmed to activate if wind velocities exceed 10m/s and/or when the coal moisture level drops below the trigger level of 8%. The sprays can also be activated by site personnel via a dial up system when required;

- A dust suppression system in the train loading chamber. This system ensures that the moisture level of the coal is adequate to minimise the potential for fugitive dust emissions whilst being transported from the Kemira Valley site to the DCPD via the Kemira Valley rail line;
- An enclosed train loading facility that enables coal to be loaded into the train while minimising any fugitive emissions;
- A dust suppression system on the Kemira Valley conveyor (including sprays at the top and bottom of the Sizer, the jib pulley, and also around the Nebo Mains transfer point) that ensures that the coal moisture content is adequate to prevent dust emissions from the conveyor; and
- Wind protection on conveyor gantries.

A matrix evaluating the top ranking activities, additional best practice control options, and the consideration of the above aspects, as developed by Dendrobium, is presented in **Table 4.1**.

Table 4.1: Review of the practicability of Best Practice Measures for Dendrobium Mine

Best practice measure	Regulatory Requirements	Environmental Impacts	Safety Implications	Compatibility with current processes and proposed future developments
WIND EROSION OF STOCKPILE				
Bypass Stockpiles (Installation of ROM product bins)	Train movements limited as per Development Consent requirements (allowable times: 6am to 11pm). All Coal extracted from Dendrobium is to be transported via rail (no road transportation permitted)	No additional environmental impacts	No additional safety implications	Installation of bin (to replace stockpile) is not feasible due to the limitations of the existing rail network and production output.
Water Sprays	Best Practice Measure already in place. Fixed Stockpile Dust Suppression System already in place.			
Chemical Wetting Agents	Not currently reflected in the site Environmental Protection Licence 2504.	Introduction of additional substances into the site water management system which is discharged into an estuarine environment.	Introduction of new chemicals to site – manual handling issues for site personnel	Minor changes required to the existing system
Surface Crusting Agents	Not currently reflected in the site Environmental Protection Licence 2504.	Introduction of additional substances into the site water management system which is discharged into an estuarine environment.	Introduction of new chemicals to site – manual handling issues for site personnel	Surface crusting of the stockpile is not feasible due to the transient nature of stockpile
Carry over wetting from load in	Best Practice Measure already in place. Coal Clearance suppression system already in place – moisture content measured and if below 8%, stockpile spray sequence triggered.			
Cover Storage pile with a tarp during high winds	No issues	No additional environmental impacts	Risk issues around engulfment during the deployment of the tarp on a full stockpile.	Tarping of the stockpile is not feasible due to the transient nature of stockpile Current configuration of stockpile with location of rill tower would impede the deployment of the tarp.

Best practice measure	Regulatory Requirements	Environmental Impacts	Safety Implications	Compatibility with current processes and proposed future developments
Silo with baghouse (Installation of ROM product bin and baghouse)	Train movements limited as per Development Consent requirements (allowable times: 6am to 11pm). All Coal extracted from Dendrobium is to be transported via rail (no road transportation permitted)	Additional electricity usage associated with the operation of the baghouse,	Spontaneous Combustion of coal within the baghouse will be one of the hazards created by this control. A baghouse was installed several years ago at the Dendrobium Washery and had three fires due to spontaneous combustion within the first three weeks of operation. The baghouse was immediately decommissioned.	Installation of bin (to replace stockpile) is not feasible due to the limitations of the existing rail network and production output
Vegetation wind breaks	No issues	No additional environmental impacts	No issues	Site roadways, buildings and water ponds are located adjacent to the stockpile area. The vegetation screen would not be as effective as the best practice calculation as because: * not all sides could be planted; * stockpile height is higher than possible vegetation screen; * Vegetation screen would need to be located away from stockpile due to the location of current infrastructure.
Reduce pile height	Train movements limited as per Development Consent requirements (allowable times: 6am to 11pm). All Coal extracted from Dendrobium is to be transported via rail (no road transportation permitted)	No issues	No issues	Reduction in stockpile height would impact production output given current restrictions on train movements
Wind Screens/Wind Fences	No issues	No issues	No issues	Site roadways, buildings and water ponds are located adjacent to the stockpile area which would impede the installation of a 'structurally sound' wind screen/fence.

Best practice measure	Regulatory Requirements	Environmental Impacts	Safety Implications	Compatibility with current processes and proposed future developments
Erect three sided enclosure around storage piles	No issues	No issues	No issues	Site roadways, buildings and water ponds are located adjacent to the stockpile area which would impede the installation of a three sided enclosure.
BULLDOZERS ON COAL				
Keep travel routes and materials moist	Best Practice Measure already in place.			
LOADING OF COAL TO STOCKPILE				
Bypass ROM stockpiles (Installation of surge capacity bin and operate existing rail operation or installation of conveyor network between the mine and washery).	Train movements limited as per Development Consent requirements (allowable times: 6am to 11pm). All Coal extracted from Dendrobium is to be transported via rail (no road transportation permitted)	No additional environmental impacts	No additional safety implications	Installation of conveyor between Dendrobium Mine and Dendrobium Washery would not be feasible due to washery location (i.e. 7km from Dendrobium mine). A storage bin to accommodate surge capacity would need to be installed.
Minimise Drop Height	Best Practice Measure already in place.			
Water Sprays on ROM pad	Best Practice Measure already in place.			

4.2 Implementation Costs

To evaluate the costs associated with the introduction of the measures summarised in **Table 4.1**, an implementation costing exercise, as undertaken by Illawarra Coal is presented in Error! Reference source not found.. This costing exercise has been conducted consistent with the requirements of Appendix A of the Site Specific Determination Guideline

Costings conducted within **Appendix D** indicate that the net cost per tonne of particulate abated as a result of such measures would either require investment of \$30,000 - \$1,000,000/tonne-PM₁₀/annum in the first year, or require ~\$7,000/tonne-PM₁₀/annum ongoing.

4.3 Justification of existing controls

In determining the value of additional best practice controls, it is also important to contextualise existing controls in terms of their ability to limit adverse air quality impacts within the local air shed.

The effectiveness of the current dust controls is reflected in the air quality monitoring data (Dust Deposition Gauges (DDG) & High Volume Air Samplers (HVAS)) and the community complaints records relating to dust.

The amenity goals for air quality assessment are all currently being met, as evidenced within **Table 4.2, Figure 4.1, Figure 4.2, Figure 4.3, Figure 4.4, Figure 4.5** and **Figure 4.6**.

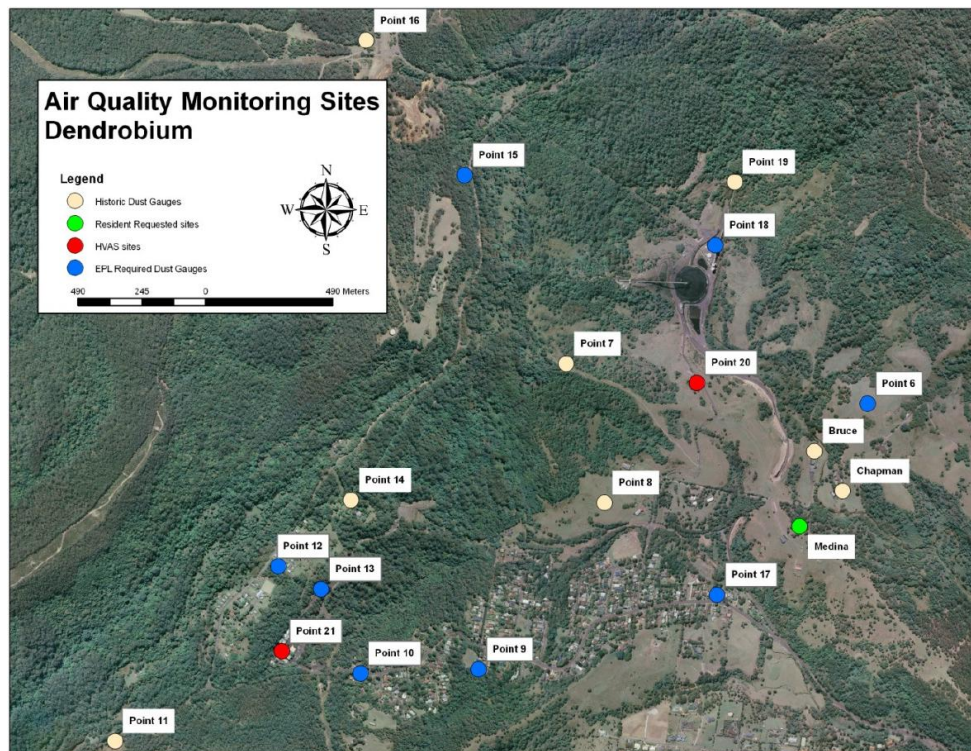


Figure 4.1: Overview of Air Quality Monitoring conducted by Dendrobium Mine

Table 4.2: Relevant Standards for Air Quality

Pollutant	Goal	Averaging period	Agency
Particulate matter < 10 µm (PM10)	50 µg/m ³	24-hour maximum	EPA
	30 µg/m ³	Annual mean	
	50 µg/m ³	(24-hour average, 5 exceedances permitted per year)	National Environment Protection Council
Total Suspended Particulates	90 µg/m ³	Annual mean	NHMRC
Dust (deposition gauges)	4g/m ² /month	Annual mean	EPA

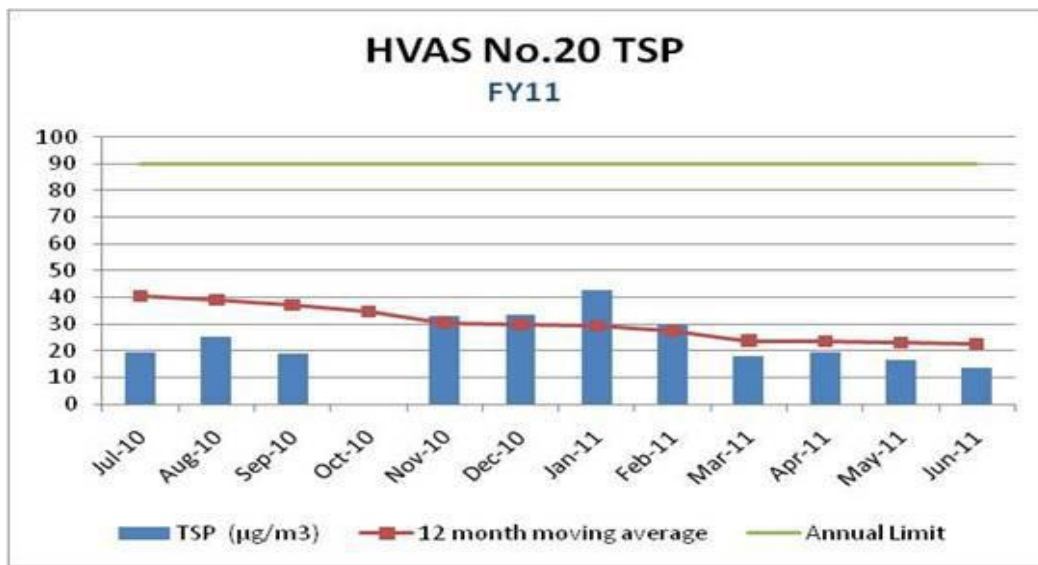


Figure 4.2: Total Suspended Particulate levels for Dendrobium HVAS No.20

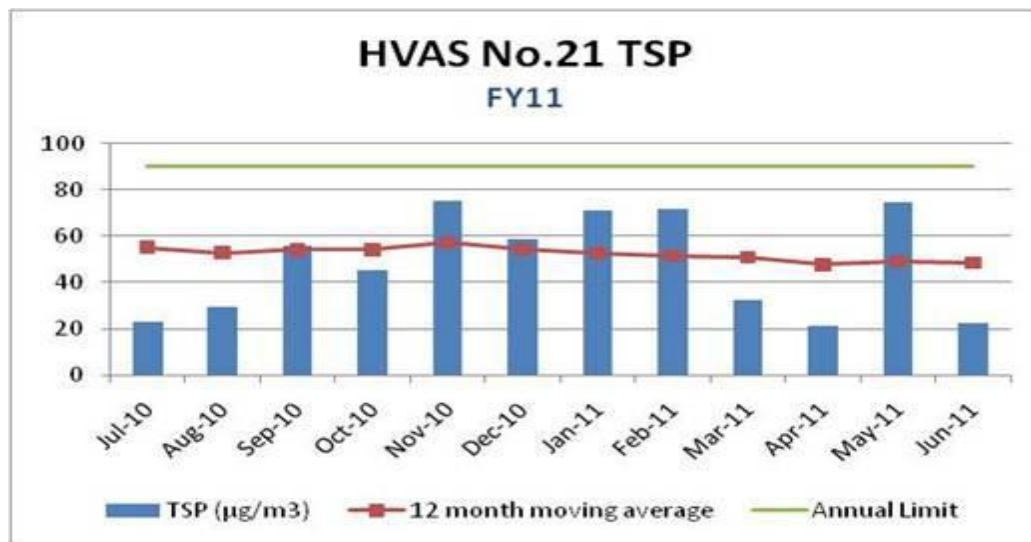


Figure 4.3: Total Suspended Particulate levels for Dendrobium HVAS No.21

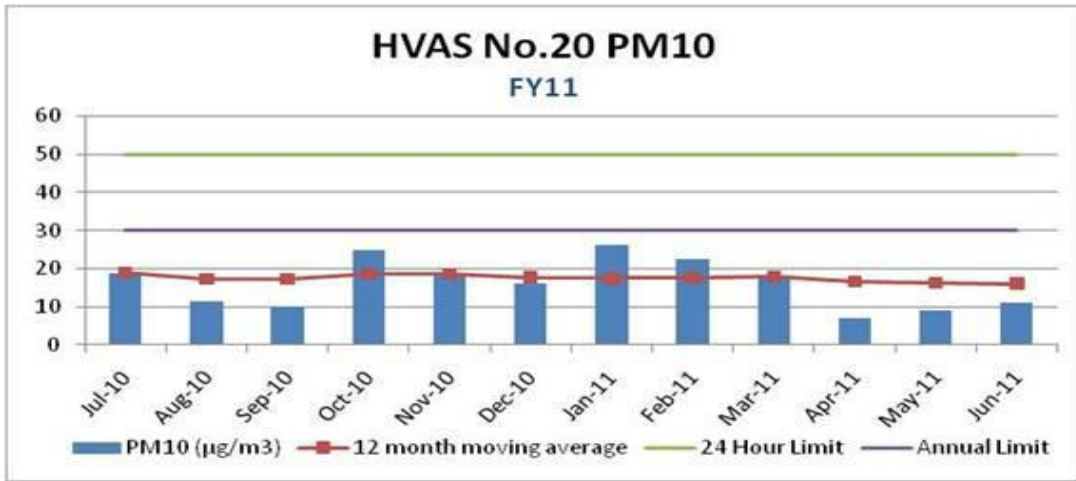


Figure 4.4: PM₁₀ (Particulate Matter <10 μm) levels for Dendrobium HVAS No.20

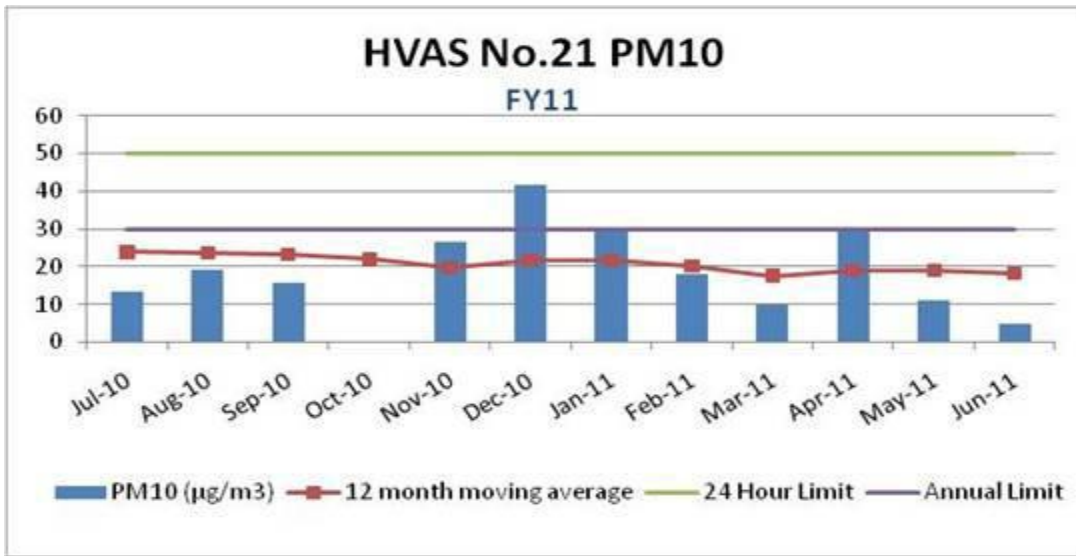


Figure 4.5: PM₁₀ (Particulate Matter <10 μm) levels for Dendrobium HVAS No.21

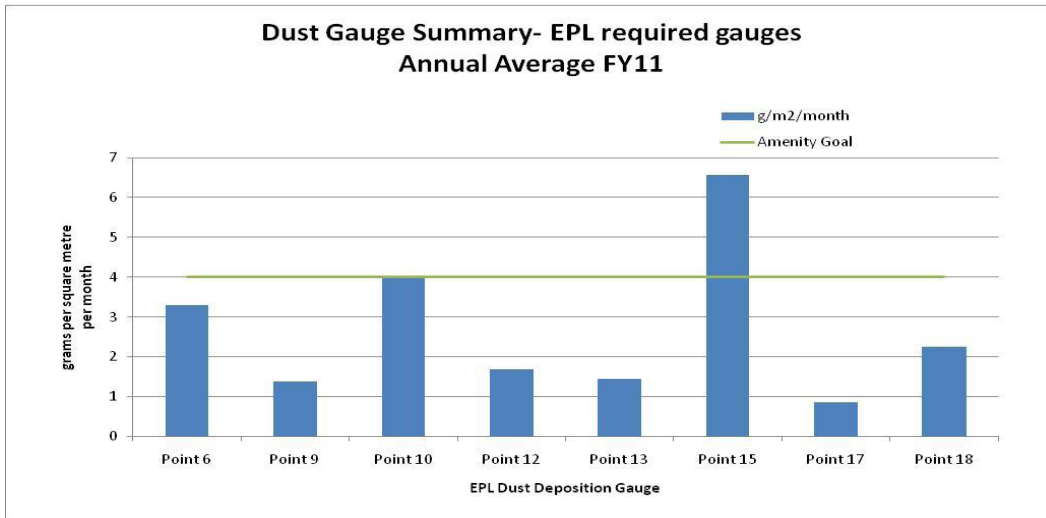


Figure 4.6: Dust deposition gauge summary

NB: Point 15 is located adjacent to a dirt bike track, and approximately 900m from the Kemira Valley stockpile and 1,500 metres from the Dendrobium Mine Pit Top. The visual dust composition for the past two years has shown high levels of dirt and vegetation, with very low levels of coal. An application was lodged with the EPA to remove Point 15 due to this contamination and Point 15 has now been removed from the licence.

The results of the dust monitoring are presented to the Dendrobium Community Consultative Committee and are also available to the general public through the BHP Billiton website (www.bhpbilliton.com). The community complaints data reflects that dust is not one of primary concerns of the local residents as Dendrobium has only received two complaints relating to dust over the past 4 years. The complaints were not aligned with dust levels found in Dust Deposition gauges.

Community Complaints January 08 - Current

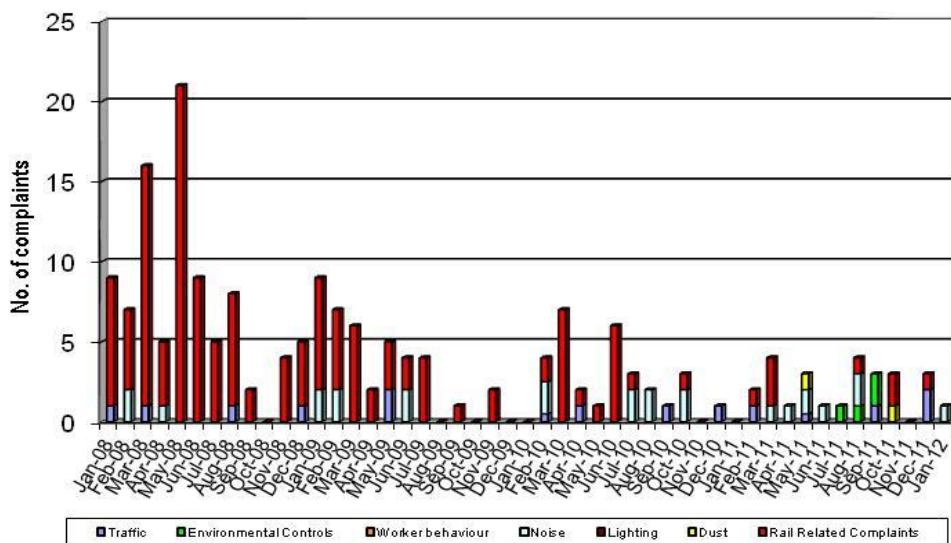


Figure 4.7: Community Complaints Summary

As dust is currently being well managed with no concerns from regulatory bodies or the local community it is hard to justify investing capital for limited reduction of dust emissions. For the best practices recommended in this PRP no options appear to be viable due to the:

- High costs (capital and / or operational) per tonne of coal particulate reduced;
- Hazards introduced by introducing the initiative (For example - fire hazard around the use of a baghouse for coal)
- Safety or conflicts with current operating procedures/processes; and
- Conflicts between current infrastructure and best practice initiatives.

4.4 Identification of Best Management Practices to be implemented

In view of the preceding discussions and evaluation, it is noted that several Best Practice Measures are already applied to the top ranking emission sources.

Under the current rill tower / train loading configuration, there is little (no) opportunity to bypass the ROM stockpile.

The only further additional area for additional Best Practice Measures would be associated with further controls to ameliorate wind erosion from stockpiles.

Wind erosion measures from the stock pile are impractical dust

Having considered the effective controls to this activity (two Best Practice Measures already applied) and their current effectiveness demonstrated by both a lack of complaints history and favourable ambient monitoring, it is difficult to justify additional control on face value.

As noted above, while not readily quantifiable under the current reporting structure, there is potential to further reduce emissions from vehicle movements, through improvement / upgrade of the current portal road construction.

5 PROPOSED TIMEFRAME FOR IMPLEMENTATION OF BEST PRACTICE MEASURES

Given that no additional best practice measures have been explicitly identified through this exercise, no timeframes for implementation are provided.

6 CLOSING/CONCLUSIONS

This study has been produced to address the requirements of the Coal Mine Particulate Matter Control Best Practice PRP as attached to the Dendrobium Underground Coal Mine Environmental Protection Licence (EPL 3241) as varied in August 2011.

The study identified that the following activities represent the highest ranking activities in terms of particulate generation, when emissions alone are evaluated:

- Wind erosion from the stockpile;
- Working the stockpile by bulldozer/loader;
- Ventilation shaft; and
- Loading coal to the stockpile.

Potential Best Practice control measures for the above activities were identified, and their practicability evaluated.

All of the recommended best practices for dust control have been evaluated, and costing exercises undertaken. Five of the best practices identified as being potentially applicable are already in place. Of the remaining best practice measures none were deemed feasible to implement at this stage.

The upgrade of the portal road is currently being progressed with asphalt being replaced with concrete on a need be basis.

7 REFERENCES

Donnelly, S.-J., Balch, A., Wiebe, A., Shaw, N., Welchman, S., Schloss, A., Castillo, E., Henville, K., Vernon, A., Planner, J. (2011).

“NSW Coal Mining Benchmarking Study□: International Best Practice Measures to Prevent and / or Minimise Emissions of Particulate Matter from Coal Mining” Prepared by Katestone Environmental Pty Ltd for Office of Environment and Heritage June 2011.

HAS (2005).

“Air Quality Impact Assessment: Dendrobium Underground Mine Extension, Southern Coalfields NSW” Prepared by Holmes Air Sciences.

BHPB (2011)

“Annual Environmental Management Report – Dendrobium Mine” Prepared by BHP Billiton 2011

Appendix A: Supporting Emission Estimate Calculations

A1 Loading coal to the stockpile

Each tonne of coal loaded to the stockpile will generate a quantity of particulate matter at different aerodynamic particle size ranges, depending on the wind speed and the moisture content of the coal. The emission factors (EF) for loading coal to the stockpile were derived using **Equation 1 (AP-42)**.

Equation 1

$$EF = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2} \right)^{1.3}}{\left(\frac{M}{2} \right)^{1.4}} \right) \text{ kg/t}$$

where,

$$k_{\text{TSP}} = 0.74$$

$$k_{\text{PM}_{10}} = 0.35$$

$$k_{\text{PM}_{2.5}} = 0.053$$

$$U = \text{wind speed (m/s)}$$

$$M = \text{moisture content (\%)}$$

The annual average wind speed, taken from historical dispersion meteorological data, is 3.7 m/s.

Particulate matter emissions from loading coal to the stockpile were estimated by using **Equation 2**:

Equation 2

$$E_{\text{miss}} = \frac{EF \times \text{coal per annum}}{1000} \text{ t/yr}$$

Where,

$$E_{\text{miss}} = \text{mass of emissions per year}$$

$$EF = \text{emission factor}$$

Dendrobium is approved to produce up to 5.2 million tonnes of coking coal per annum (Mtpa) and therefore, for the purpose of assessment, it has been assumed that 5.2 Mtpa of coal is passed through the KVCHF, which is the maximum annual throughput.

A1.1 Without existing controls (Loading coal to stockpile)

This section provides the estimates for annual TSP, PM₁₀ and PM_{2.5} emissions from loading coal from the conveyor to the stockpile without existing control methods.

TSP

By applying k_{TSP} , a moisture content of 6.2% and a wind speed of 3.7 m/s to Equation 1, the TSP emission factor for loading coal to the stockpile without existing controls was calculated to be 0.00041 kg/t.

Applying the above TSP emission factor to annual coal production of 5.2 Mt, the total annual TSP emissions from loading coal to the stockpile without controls are estimated to be 2.1 t/yr [$5.2 \times 10^6 \text{ t} \times 0.00041 \text{ kg/t}$].

PM₁₀

By applying $k_{\text{PM}_{10}}$, a moisture content of 6.2% and a wind speed of 3.7 m/s to Equation 1, the PM_{10} emission factor for loading coal to the stockpile without existing controls was calculated to be 0.00019 kg/t.

Applying the above PM_{10} emission factor to annual coal production of 5.2 Mt, the total annual TSP emissions from loading coal to the stockpile without controls are estimated to be 1.0 t/yr [$5.2 \times 10^6 \text{ t} \times 0.00019 \text{ kg/t}$].

PM_{2.5}

By applying $k_{\text{PM}_{2.5}}$, a moisture content of 6.2% and a wind speed of 3.7 m/s to Equation 1, the $\text{PM}_{2.5}$ emission factor for loading coal to the stockpile without existing controls was calculated to be 0.00003 kg/t.

Applying the above $\text{PM}_{2.5}$ emission factor to annual coal production of 5.2 Mt, the total annual TSP emissions from loading coal to the stockpile without controls are estimated to be 0.15 t/yr [$5.2 \times 10^6 \text{ t} \times 0.00003 \text{ kg/t}$].

A1.2 With existing controls (Loading coal to stockpile)

This section provides the calculations and estimates for annual TSP, PM_{10} and $\text{PM}_{2.5}$ emissions produced by loading coal from the conveyor to the stockpile with the existing control method.

The moisture level of the coal being loaded onto the Kemira Valley stockpile is monitored via a coal scan analyser fitted to the conveyor system on the surface at Kemira Valley. Water is added via eight water sprays to maintain the moisture level at 8% or above, and water is also applied to the coal as it is loaded to the stockpile via the rill tower using two water sprays. Coal moisture levels are estimated at half hour intervals using information based on wind speed, humidity and solar radiation. The automated stockpile dust suppression system is activated to maintain coal moisture levels at 8%.

TSP

By applying k_{TSP} , a moisture content of 8% and a wind speed of 3.7 m/s to Equation 1, the TSP emission factor for loading coal to the stockpile without existing controls was calculated to be 0.00029 kg/t.

The total annual TSP emissions from loading coal to the stockpile with existing control measures are estimated to be 1.5 t/yr [$5.2 \times 10^6 \text{ t} \times 0.00029 \text{ kg/t}$].

PM₁₀

By applying $k_{\text{PM}_{10}}$, a moisture content of 8% and a wind speed of 3.7 m/s to Equation 1, the $\text{PM}_{2.5}$ emission factor for loading coal to the stockpile without existing controls was calculated to be 0.00014 kg/t.

The total annual PM_{10} emissions from loading coal to the stockpile with existing control measures are estimated to be 0.70 t/yr [$5.2 \times 10^6 \text{ t} \times 0.00014 \text{ kg/t}$].

PM_{2.5}

By applying $k_{PM_{2.5}}$, a moisture content of 8% and a wind speed of 3.7 m/s to Equation 1, the PM_{2.5} emission factor for loading coal to the stockpile without existing controls was calculated to be 0.00002 kg/t.

The total annual PM_{2.5} emissions from loading coal to the stockpile with existing control measures are estimated to be 0.10 t/yr [$5.2 \times 10^6 \text{ t} \times 0.00002 \text{ kg/t}$].

A2 Working stockpile by bulldozer/loader

Bulldozers and front end-loaders are used to maintain the stockpile shape and to facilitate the loading of trains, which occurs from beneath the stockpile. The emission factors for bulldozers working coal have been derived using the US EPA (AP-42) emission factor equations (see **Equations 3, 4, 5**).

Equation 3 – TSP Emission Factor

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.3}} \text{ kg/hr}$$

Equation 4 - PM10 Emission Factor

$$E_{PM_{10}} = 6.33 \times \frac{s^{1.5}}{M^{1.4}} \text{ kg/hr}$$

Equation 5 – PM2.5 Emission Factor PM2.5

$$E_{PM_{2.5}} = 0.022 \times E_{TSP} \text{ kg/hr}$$

where,

s = silt content of the material in percent

M = moisture content of material in percent

The number of dozer-hours required would depend on bulldozer productivity and the way in which the stockpile is operated. In principle, if the rate at which the stockpile was loaded was able to be matched to the rate at which coal was exported by train on a daily basis it would be possible to operate the stockpile with almost no assistance from the dozer/front-end loader. If it is assumed that 25% of the 5.2 Mtpa of coal needs to be pushed and the dozer/front-end loader productivity for this activity is 1,780 tph, then it will require approximately 730 hours of work per year.

A2.1 Without existing controls (working stockpile with bulldozer)

The emission factors and total annual emissions for working the stockpile without control measures (in this case water sprays) have been derived using a moisture content of 4% (lowest of AP42 range) and silt content of 11.3% (highest of the AP42 range).

TSP

Using **Equation 3** and taking s to be 11.3% and M to be 4% the TSP emission factor is 107.8 kg/hr.

Assuming 730 hours of bulldozer operating time per year for pushing coal, the total annual TSP emission for working the stockpile by bulldozer is estimated to be 78.7 t/yr [730 h x 107.8 kg/h].

PM10

Using **Equation 4** and taking s to be 11.3% and M to be 4% the PM10 emission factor is 34.5 kg/hr.

Assuming 730 hours of bulldozer operating time per year for pushing coal, the total annual PM₁₀ emission for working the stockpile by bulldozer is estimated to be 25.2 t/yr [730 h x 34.5 kg/h].

PM2.5

Applying a scaling factor of 0.002 to the TSP emission factor (**Equation 5**) is 2.4 kg/hr.

Assuming 730 hours of bulldozer operating time per year for pushing coal, the total annual PM_{2.5} emission for working the stockpile by bulldozer is estimated to be 1.7 t/yr [730 h x 2.4 kg/h].

A2.2 With existing controls (Working stockpile with bulldozer)

The moisture level of the coal being loaded onto the Kemira Valley stockpile is monitored via a coal scan analyser fitted to the conveyor system on the surface at Kemira Valley. Water is added via eight water sprays to maintain the moisture level at 8% or above. Coal moisture levels are estimated at half hour intervals using information based on wind speed, humidity and solar radiation. The automated stockpile dust suppression system is activated to maintain coal moisture levels at 8%.

The emission factors and total annual emissions for working the stockpile with current control measures (water sprays) have been derived using a moisture content of 8% (minimum) and silt content of 11.3% (highest of the AP42 range).

TSP

Using **Equation 3** and taking s to be 11.3% and M to be 8% the TSP emission factor is 43.8 kg/hr.

Assuming 730 hours of bulldozer operating time per year for pushing coal, the total annual TSP emission for working the stockpile by bulldozer with existing control measures is estimated to be 31.9 t/yr [730 h x 43.8 kg/h].

PM10

Using **Equation 4** and taking s to be 11.3% and M to be 8% the PM10 emission factor is 13.1 kg/hr.

Assuming 730 hours of bulldozer operating time per year for pushing coal, the total annual PM₁₀ emission for working the stockpile by bulldozer with existing control measures is estimated to be 9.6 t/yr [730 h x 13.1 kg/h].

PM2.5

Using **Equation 5** and taking s to be 11.3% and M to be 8% the PM2.5 emission factor is 1.0 kg/hr.

Assuming 730 hours of bulldozer operating time per year for pushing coal, the total annual PM_{2.5} emission for working the stockpile by bulldozer with existing control measures is estimated to be 7.3 t/yr [730 h x 1.0 kg/h].

A3 Wind erosion from stockpile

This section provides estimates of the dust generated by wind erosion from the stockpile. The total annual emissions for wind erosion of the stockpile have been estimated using the AP-42 emission factors of 1.8 kg/ha/hr x u (wind speed m/s) (TSP), 0.5 x 1.8 kg/ha/hr x u (PM₁₀) and 0.075 x 1.8 kg/ha/hr x u (PM_{2.5}).

The following calculations are based on the assumption that the stockpile has a conical shape. The stockpile when full will contain 150,000 t of coal. The maximum stockpile height and base radius are estimated at 47 m and 59 m respectively. The surface area of the stockpile (excluding base surface area) will be approximately 13,968 m² or 1.4 ha. The stockpile is expected to only get to full capacity twice per year. Typically the stored coal will be 52,000 t, which will result in a stockpile height of approximately 17 m.

The annual average wind speed, taken from historical dispersion meteorological data, is 3.7 m/s and hours of operation are 8,760 hr/yr (HAS, 2000)

A3.1 Without existing controls (Wind erosion from stockpile)

TSP

Total annual TSP emission from wind erosion of the stockpile without controls was calculated to be 81.7 t/yr [1.8 kg/ha/hr x 3.7 m/s x 1.4 ha x 8,760 hr].

PM10

Total annual PM10 emission from wind erosion of the stockpile without controls was calculated to be 40.8 t/yr [0.5 x 1.8 kg/ha/hr x 3.7 m/s x 1.4 ha x 8,760 hr].

PM2.5

Total annual PM10 emission from wind erosion of the stockpile without controls was calculated to be 6.13 t/yr [0.075 x 1.8 kg/ha/hr x 3.7 m/s x 1.4 ha x 8,760 hr].

A3.2 With existing controls (Wind erosion from stockpile)

The total annual emissions for wind erosion of the stockpile have been estimated using the AP-42 emission factors of 1.8 kg/ha/hr x u (wind speed m/s) (TSP), 0.5 x 1.8 kg/ha/hr x u (PM₁₀) and 0.075 x 1.8 kg/ha/hr x u (PM_{2.5}).

Eight ground-based sprays are used to apply water to the stockpile and as such an emissions reduction factor of 50% (Donnelly *et al.*, 2011) has been applied to the calculations.

TSP

Total annual TSP emission from wind erosion of the stockpile with water spray control was calculated to be 40.8 t/yr [1.8 kg/ha/hr x 3.7 m/s x 1.4 ha x 8,760 hr x 0.5].

PM10

Total annual PM10 emission from wind erosion of the stockpile with water spray control was calculated to be 20.4 t/yr [0.5 x 1.8 kg/ha/hr x 3.7 m/s x 1.4 ha x 8,760 hr x 0.5].

PM2.5

Total annual PM10 emission from wind erosion of the stockpile with water spray control was calculated to be 3.06 t/yr [0.075 x 1.8 kg/ha/hr x 3.7 m/s x 1.4 ha x 8,760 hr x 0.5].

A4 Loading coal to trains at KVCHF

Trains are loaded via an enclosed gravity-feed system within the tunnel that runs under the stockpile. Each tonne of coal loaded to trains will generate a quantity of particulate matter at different aerodynamic particle size ranges, depending on the wind speed and the moisture content of the coal. The emission factors (EF) for loading coal to the stockpile were derived using **Equation 6 (AP-42)**.

Equation 6

$$EF = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2} \right)^{1.3}}{\left(\frac{M}{2} \right)^{1.4}} \right) \text{ kg/t}$$

where,

$$k_{\text{TSP}} = 0.74$$

$$k_{\text{PM}_{10}} = 0.35$$

$$k_{\text{PM}_{2.5}} = 0.053$$

$$U = \text{wind speed (m/s)}$$

$$M = \text{moisture content (\%)}$$

The annual average wind speed, taken from historical dispersion meteorological data, is 3.7 m/s.

Particulate matter emissions from loading coal to the stockpile were estimated by using **Equation 7**:

Equation 7

$$E_{\text{miss}} = \frac{EF \times \text{coal per annum}}{1000} \text{ t/yr}$$

Where,

$$E_{\text{miss}} = \text{mass of emissions per year}$$

$$EF = \text{emission factor}$$

Dendrobium is approved to produce up to 5.2 million tonnes of coking coal per annum (Mtpa) and therefore, for the purpose of assessment, it has been assumed that 5.2 Mtpa of coal is passed through the KVCHF, which is the maximum annual throughput.

A4.1 Without existing controls (Loading coal to trains)

The following provides the calculations and estimates for annual TSP, PM₁₀ and PM_{2.5} emissions from loading coal to trains without any existing control methods.

Emissions from loading coal to trains, without the existing control of enclosure, were estimated undertaken by using a moisture content of 8% for coal.

TSP

By applying k_{TSP} , a moisture content of 8% and a wind speed of 3.7 m/s to Equation 6, the TSP emission factor for loading coal to trains without existing controls was calculated to be 0.00029 kg/t.

The total annual TSP emissions from loading coal to trains with existing control measures are estimated to be 1.5 t/yr [$5.2 \times 10^6 \text{ t} \times 0.00029 \text{ kg/t}$].

PM₁₀

By applying $k_{PM_{10}}$, a moisture content of 8% and a wind speed of 3.7 m/s to Equation 6, the PM_{2.5} emission factor for loading coal to trains without existing controls was calculated to be 0.00014 kg/t.

The total annual PM₁₀ emissions from loading coal to trains with existing control measures are estimated to be 0.70 t/yr [5.2×10^6 t \times 0.00014 kg/t].

PM_{2.5}

By applying $k_{PM_{2.5}}$, a moisture content of 8% and a wind speed of 3.7 m/s to Equation 6, the PM_{2.5} emission factor for loading coal to trains without existing controls was calculated to be 0.00002 kg/t.

The total annual PM_{2.5} emissions from loading coal to trains with existing control measures are estimated to be 0.10 t/yr [5.2×10^6 t \times 0.00002 kg/t].

A4.2 With existing controls (Loading coal to trains)

Trains are loaded via an enclosed gravity-feed system within the tunnel that runs under the stockpile. Therefore, the operation is undertaken in an enclosure. Donnelly *et al.*, 2011 provides an emission reduction factor of 70% for enclosure. The following provides the calculations and estimates for annual TSP, PM₁₀ and PM_{2.5} emissions from loading coal from the stockpile to trains with the existing control method.

TSP

Applying a 70% reduction factor due to control measures, the total annual TSP emissions from loading coal to trains with existing control measures are estimated to be 0.45 t/yr [$1.5 \times (1 - 0.7)$].

PM₁₀

Applying a 70% reduction factor due to control measures, the total annual PM₁₀ emissions from loading coal to trains with existing control measures are estimated to be 0.21 t/yr [$0.7 \times (1 - 0.7)$].

PM_{2.5}

Applying a 70% reduction factor due to control measures, the total annual PM_{2.5} emissions from loading coal to trains with existing control measures are estimated to be 0.032 t/yr [$0.1 \times (1 - 0.7)$].

A5 Ventilation shaft

Emissions from ventilation shafts are not quantified in the USEPA AP-42. However, we have utilised emissions testing report for Dendrobium Mine for particulate matter from the report, "Dendrobium Mine Emission Testing Report – April 2005, EML Air Pty Ltd, 3 May 2005.

Dendrobium has 3 ventilation shafts, numbered 1, 2 and 3. The Number 1 and 2 ventilation shafts operate as downcast shafts (i.e. drawing fresh air into the underground workings) whilst the No.3 shaft operates as an upcast shaft.

A summary of the particulate monitoring data from existing data sources is provided in Table 4 which shows total particulate concentrations in mine ventilation air.

Table A1 Ventilation shaft emission data

Source	Pollutant	Concentration
Dendrobium Mine Vent Shaft	TSP	1.6 mg/m ³
	PM ₁₀	1.1 mg/m ³
	PM _{2.5}	1.4 mg/m ³ ^a
Note ^a PM ₁₀ and PM _{2.5} where measured in different tests.		

Volumetric flow of the ventilation shaft was measured at 89 m³/s.

Emissions from the outcast ventilation shaft were estimated using Equation 7

Equation 7

$$Vent\ Emiss = Conc \times Vol \times 3.15E07$$

where

con = concentration of ventilation air in mg/m³

Vol = volumetric flow of air m³/s

3.15E07=seconds per year

A5.1 With and without existing controls (Ventilation shaft)

The ventilation shaft does not currently have any control methods and as such, all emissions are calculated in this section.

TSP

Total annual TSP emission from the ventilation shaft was calculated to be 4.5 t/yr [1.6 mg/m³ x 89 m³/s x 3.15E07 s/yr].

PM₁₀

Total annual PM₁₀ emission from the ventilation shaft was calculated to be 3.1 t/yr [1.1 mg/m³ x 89 m³/s x 3.15E07 s/yr].

PM_{2.5}

Total annual PM_{2.5} emission from the ventilation shaft was calculated to be 3.9 t/yr [1.4 mg/m³ x 89 m³/s x 3.15E07 s/yr].

A6 Movement of vehicles into and out of the Nebo Portal

Movement of vehicles into and out of the Nebo Portal will include 36 small mine vehicles movements per day and 12 heavy vehicles movements per day over an approximate distance of 300 m (HAS, 2005). The quantity of particulate emissions from resuspension of loose material on the paved road surface due to vehicle travel on a dry paved road has been estimated using Equation 8.

Equation 8

$$EF = k(sL)^{0.91} \times (W)^{1.02}$$

Where

E	=	particle size emission factor (g/Vehicle Kilometres Travelled)
K	=	particle size multiplier for particle size range and units of interest
sL	=	road surface silt loading (g/m ²)
W	=	average weight (tons) of the vehicles travelling the road.

Equation 8 calls for the average weight of all vehicles traveling the road. Only one emission factor should be calculated to represent the "fleet" average weight of all vehicles traveling the road. Given the assumption that a small mine vehicle weighs 22.046 tons and a heavy vehicle weighs 44.092 tons, the average weight of the vehicles travelling the road is 33 tons.

Road surface silt loading has been taken as 14 g/m², which is the maximum of the range provided by the US EPA (AP-42 13.2.1 Paved Roads).

The particle size multiplier (k) above varies with aerodynamic size range. Specific particle size ranges are determined using the following (AP-42 13.2.1 Paved Roads):

k _{TSP}	=	3.23
k _{PM10}	=	0.62
k _{PM2.5}	=	0.15

Estimated annual particulate matter emissions are calculated by applying this particle size emission factors to Equation 9.

Equation 9

$$E_{Miss} = E \times VKT \times D/yr$$

where,

E	=	Particle size emission factor.
VKT	=	Vehicle Kilometres Travelled/D (14.4 km [48 x 0.3 km])
D/yr	=	Days per year (365)

$$E_{Miss} = E \times 5256 \text{ km/yr}$$

A6.1 Without existing controls (Movement of vehicles)

TSP

Using the above constants in **Equation 8**, the TSP emission factor for movements of vehicles without existing controls is 1262 g/VKT [3.23 x 11.04 x 35.4].

Using **Equation 9**, annual TSP emissions from vehicle movements without emission control are estimated to be 6.63 t/yr [(1262 x 5256)/1.0E06].

PM₁₀

Using the above constants in **Equation 8**, the PM₁₀ emission factor for movements of vehicles without existing controls is 242 g/VKT [0.62 x 11.04 x 35.4].

Using **Equation 9**, annual PM₁₀ emissions from vehicle movements without emission control are estimated to be 1.27 t/yr [(242 x 5256)/1.0E06].

PM_{2.5}

Using the above constants in **Equation 8**, the PM_{2.5} emission factor for movements of vehicles without existing controls is 58.6 g/VKT [0.15 x 11.04 x 35.4].

Using **Equation 9**, annual PM_{2.5} emissions from vehicle movements without emission control are estimated to be 0.31 t/yr [(58.6 x 5256)/1.0E06].

A6.2 With existing controls (Movement of vehicles)

At the Dendrobium Pit Top use two varieties of dust control measures on the portal road to reduce emissions:

- The use of a vacuum sweeper truck which operated on a regular basis; and
- The use of an automatic dust suppression spray system along the portal road.

As no emission reduction factor is available, in order to estimate the particulate emissions from vehicle movements on the paved, road surface silt loading has been taken as 2.4 g/m², which is the minimum of the range provided by the US EPA (AP-42 13.2.1 Paved Roads).

TSP

Using the above constants in **Equation 8**, the TSP emission factor for movements of vehicles without existing controls is 253 g/VKT [3.23 x 2.2 x 35.4].

Using **Equation 9**, annual TSP emissions from vehicle movements without emission control are estimated to be 1.3 t/yr $[(253 \times 5256)/1.0E06]$.

PM₁₀

Using the above constants in **Equation 8**, the PM₁₀ emission factor for movements of vehicles without existing controls is 48.7 g/VKT $[0.62 \times 2.2 \times 35.4]$.

Using **Equation 9**, annual PM₁₀ emissions from vehicle movements without emission control are estimated to be 0.26 t/yr $[(48.7 \times 5256)/1.0E06]$.

PM_{2.5}

Using the above constants in **Equation 8**, the PM_{2.5} emission factor for movements of vehicles without existing controls is 11.8 g/VKT $[0.15 \times 2.2 \times 35.4]$.

Using **Equation 9**, annual PM_{2.5} emissions from vehicle movements without emission control are estimated to be 0.06 t/yr $[(11.8 \times 5256)/1.0E06]$.

Appendix B: Copy of PRP as contained in Dendrobium EPL Licence

U1 Coal Mine Particulate Matter Control Best Practice

U1.1 PRP15 Coal Mine Particulate Matter Control Best Practice - Assessment and Report

U1.1 The Licensee must conduct a site specific Best Management Practice (BMP) determination to identify the most practicable means to reduce particle emissions.

U1.2 The Licensee must prepare a report which includes, but is not necessarily limited to, the following:

- Identification, quantification and justification of existing measures that are being used to minimise particle emissions;
- identification, quantification and justification of best practice measures that could be used to minimise particle emissions;
- evaluation of the practicability of implementing these best practice measures; and
- a proposed timeframe for implementing all practicable best practice measures.

In preparing the report, the Licensee must utilise the document entitled Coal Mine Particulate Matter Control Best Practice – Site Specific Determination Guideline -August 2011.

U1.3 All cost related information is to be included as Appendix 1 of the Report required by condition U1.2 above.

U1.4 The report required by condition U1.2 must be submitted by the Licensee to the Office of Environment and Heritage's Regional Manager, Illawarra at PO Box 513, WOLLONGONG NSW 2500 by 6 February 2012.

U1.5 The report required by condition U1.2 above, except for cost related information contained in Appendix 1 of the Report, must be made publicly available by the Licensee on the Licensee's website by 13 February 2012

**Appendix C: Copy of Coal Mine Particulate Matter Control Best Practice
– Site Specific Determination Guideline August 2011**

**COAL MINE PARTICULATE MATTER CONTROL BEST PRACTICE –
SITE SPECIFIC DETERMINATION GUIDELINE
AUGUST 2011**

PURPOSE OF THIS GUIDELINE

The purpose of this guideline is to provide detail of the process to be followed in conducting a site specific determination of best practice measures to reduce emissions of particulate matter from coal mining activities.

This guideline also provides the required content and format of the report required for the Pollution Reduction Program "Coal Mine Particulate Matter Best Practice".

THE SITE SPECIFIC DETERMINATION PROCESS

In preparing the Report, the following steps must be followed, as a minimum:

1. Identify, quantify and justify existing measures that are being used to minimise particle emissions

- 1.1. Estimate baseline emissions of TSP, PM₁₀ and PM_{2.5} (tonne per year) from each mining activity. This estimate must:
- utilise USEPA AP42 emission estimation techniques (or other method as approved in writing by the EPA);
 - calculate uncontrolled emissions (with no particulate matter controls in place); and
 - calculate controlled emissions (with current particulate matter controls in place).

Note: These particulate matter controls must be clearly identified, quantified and justified with supporting information).

- 1.2. Using the results of the controlled emissions estimates generated from Step 1.1, rank the mining activities according to the mass of TSP, PM₁₀ and PM_{2.5} emitted by each mining activity per year from highest to lowest.
- 1.3. Identify the top four mining activities from Step 1.2 that contribute the highest emissions of TSP, PM₁₀ and PM_{2.5}.

2. Identify, quantify and justify the measures that could be used to minimise particle emissions

- 2.1. For each of the top four activities identified in Step 1.3, identify the measures that could be implemented to reduce emissions taking into consideration:
- the findings of Katestone (June 2011), *NSW Coal Mining Benchmarking Study - International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining*, Katestone Environmental Pty Ltd, Terrace 5, 249 Coronation Drive, PO Box 2217, Milton 4064, Queensland, Australia;
 - any other relevant published information; and
 - any relevant industry experience from either Australia or overseas.

2.2. For each of the top four activities identified in Step 1.3, estimate emissions of TSP, PM₁₀ and PM_{2.5} from each mining activity following the application of the measures identified in Step 2.1.

3. Evaluate the practicability of implementing these best practice measures

3.1. For each of the best practice measures identified in Step 2.1, assess the practicability associated with their implementation, by taking into consideration:

- implementation costs;
- regulatory requirements;
- environmental impacts;
- safety implications; and
- compatibility with current processes and proposed future developments.

3.2. Identify those best practice measures that will be implemented at the premises to reduce particle emissions.

4. Propose a timeframe for implementing all practicable best practice measures

4.1. For each of the best practice measures identified as being practicable in Step 3.2, provide a timeframe for their implementation.

REPORT CONTENT

The report must clearly identify the methodologies utilised and all assumptions made.

The report must contain detailed information justifying and supporting all of the information used in each step of the process. For example, in calculating controlled emissions in Step 1, current particulate matter controls being used at the mine must be clearly identified, quantified and justified with supporting information and evidence including monitoring data, record keeping, management plans and/or operator training etc.

In evaluating practicability in Step 3, the licensee must document the following specific information:

- estimated capital, labour, materials and other costs for each best practice measure on an annual basis for a ten year period. This information must be set out in the format provided in Appendix A and included as an attachment to the report;
- The details of any restrictions on the implementation of each best practice measure due to an existing approval or licence;
- Quantification of any new or additional environmental impacts that may arise from the application of a particular best practice measure, such as increased noise or fresh water use;
- The details of safety impacts that may result from the application of a particular best practice measure;
- The details of any incompatibility with current operational practices on the premises; and
- The details of any incompatibility with future development proposals on the premises.

REPORT FORMAT

The report must be structured according to the process outlined above and submitted in both electronic format as .PDF format and hard copy format in triplicate. All emission estimates, costs and supporting calculations must be submitted in electronic format as .XLS format.

ABBREVIATIONS AND DEFINITIONS

USEPA AP42 Emission Estimation Techniques – all of the following:

- USEPA (1995), *AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources*, Technology Transfer Network - Clearinghouse for Inventories & Emissions Factors, United States Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, USA. <http://www.epa.gov/ttn/chief/ap42/index.html> ;
- USEPA (1998), *AP 42, Chapter 11.9 Western Surface Coal Mining*, Technology Transfer Network - Clearinghouse for Inventories & Emissions Factors, United States Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, USA. <http://www.epa.gov/ttn/chief/ap42/ch11/final/c11s09.pdf> ;
- USEPA (2006), *AP 42, Chapter 13.2.2 Unpaved Roads*, Technology Transfer Network - Clearinghouse for Inventories & Emissions Factors, United States Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, USA. <http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0202.pdf> ;
- USEPA (2006), *AP 42, Chapter 13.2.4 Aggregate Handling and Storage Piles*, Technology Transfer Network - Clearinghouse for Inventories & Emissions Factors, United States Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, USA. <http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0204.pdf> ; and
- USEPA (2006), *AP 42, Chapter 13.2.5 Industrial Wind Erosion*, Technology Transfer Network - Clearinghouse for Inventories & Emissions Factors, United States Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, USA. <http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0205.pdf> .

PM₁₀ – Particulate matter of 10 micrometres or less in diameter

PM_{2.5} - Particulate matter of 2.5 micrometres or less in diameter

Mining Activities – means:

- Wheel generated particulates on unpaved roads
- Wind erosion of overburden
- Loading and dumping overburden
- Blasting
- Bulldozing Coal
- Trucks unloading overburden
- Bulldozing overburden
- Front-end loaders on overburden
- Wind erosion of exposed areas
- Wind erosion of coal stockpiles
- Unloading from coal stockpiles

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- Dragline
 - Front-end loaders on overburden
 - Trucks unloading coal
 - Loading coal stockpiles
 - Graders
 - Drilling
 - Coal crushing
 - Material transfer of coal
 - Scrapers on overburden
 - Train loading
 - Screening; or
 - Material transfer of overburden

TSP - Total Suspended Particulate Matter

Appendix A: Presentation of Information on Cost of Implementation

The report should provide spreadsheets including estimates of the annual capital, labour and materials costs for each year over a ten year period for implementing each best practice measure identified in Step 2.

A template is given below for one best practice measure.

Mining Activity:	Example: Wheel-generated particulates on unpaved roads										
Specific Best practice measure:	Example: Truck replacement – larger vehicles										
Year	Yr1	Yr2	Yr3	Yr4	Yr5	Yr6	Yr7	Yr8	Yr9	Yr10	Total
Cost of specific capital items (e.g. new vehicle)*											
Total capital costs											
Labour costs including directly related on-costs											
Cost of specific materials and other items (e.g. fuel)*											
Total material and other costs											
Estimated additional cost per tonne of particulate matter suppressed for TSP, PM₁₀ and PM_{2.5}*											
Cost savings from implementing each best practice measure*											
Estimated net cost per tonne of particulate matter suppressed for TSP, PM₁₀ and PM_{2.5}*											

* each item must be specified – one item per row in spreadsheet.

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