Attachment A

A contextual review of air quality matters relating to the mining industry

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REPORT - FINAL

A CONTEXTUAL REVIEW OF AIR QUALITY MATTERS RELATING TO THE MINING INDUSTRY

Minerals Council of Australia

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1 INTRODUCTION

On 28 November 2012 the Senate referred the matter of the health impacts of air pollution to the Senate Community Affairs Committee for inquiry and report.

The Committee's terms of reference (ToR) are to examine the impacts on health on air quality in Australia, including:

(a) particulate matter, its sources and effects;
(b) those populations most at risk and the causes that put those populations at risk;
(c) the standards, monitoring and regulation of air quality at all levels of government; and
(d) any other related matters.

In developing a submission for the enquiry, the Minerals Council of Australia has requested Pacific Environment Limited to undertake a review of air quality matters as they relate to the Minerals Industry.

1.1 Purpose

The purpose of this report is to:

- Contextualise potential hazards associated with particulate matter.
- Provide an overview of Australian air quality in relation to particulates in the national and international context.
- Provide an overview of the existing status of air quality monitoring, with a focus on mining regions.
- Contextualise exposure risks from air quality issues and their intersection with the minerals industry.
- Provide key considerations for the development of an evidence based management response to air quality issues.
- Provide national and international comparison of air quality standards, regulation, and the application of the National Environmental Protection Measure.
- Provide examples of minerals industry initiatives to assess and manage risks arising from air quality issues.

1.2 Air quality issues for the minerals industry

The key air quality issue for the minerals industry is emissions of particulate matter (PM). In exploration and mining, PM is generated from various physical processes used to expose and extract material and from the operation of diesel equipment at mine sites.

Mining

Typical PM sources from mining operations include, in approximate order of volume produced[a]:

- Hauling on unsealed roads
- Wind erosion on open areas
- Material transfer of product and overburden
- Bulldozers on product and overburden
- Loading stockpiles
- Trucks unloading product and overburden
- Wind Erosion and maintenance of stockpiles
- Blasting
- Topsoil handling
- Drilling

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[a] This list is not representative of the relative toxicity hazard of particulates for each source. Accordingly, it does not represent relative risk.

- Grading
- Train loading

The more of the above activities that occur below the surface (i.e. underground operations), the lesser the potential for PM emission to air. For this reason, underground mines are generally viewed as a lesser potential PM source compared with open cut operations.

The potential exposure to PM emissions arising from mining activities is higher in areas where mining is in proximity to populated centres. For example, there is greater potential for exposure in NSW where residences and businesses are located in relatively close proximity to open cut mining operations. This is compared to Queensland and Western Australia, where mining operations are typically more remote and thus the exposure risk is lower.

Transport

The transport of material (mine to port, mine to processing plant or mine to power station) is typically via rail. Studies have demonstrated that the potential for fugitive PM emissions during transportation is low (Connell Hatch (2008), ENVIRON (2012)). The inference is, therefore, that the potential for population exposure along transport routes is low. This issue is subject to ongoing community, media and regulator attention. For example, at the time of writing, there is significant media attention surrounding the potential for PM emissions along coal train routes in and around Newcastle, NSW.

Ports

At the ports fugitive PM emissions are generated from the handling and storage of ores and coal. Exposure risk is typically higher in the vicinity of ports compared with at remote mining areas. This is due to the proximity of port facilities to populated urban areas, which has arisen as a result of both necessity (ports need a static, local workforce) and history.

There are other less significant air quality issues for the minerals industry, such as blast fume management in mining operations, however as the focus of this enquiry is on particles, we have limited our response to PM.

2 PARTICULATE MATTER, SOURCES AND EFFECTS

2.1 Particulate Matter

Suspended particulate matter (PM) can be defined by, amongst other things; size, chemical composition and source. These different aspects are discussed sequentially below.

PM Size

Particle size is an important factor influencing its dispersion and transport in the atmosphere and its potential effects on human health. Typically, the size of suspended PM ranges from approximately 0.005 to 100 micrometers (µm) and is often described by the aerodynamic diameter of the particle.

The PM size ranges are commonly described as:

- TSP – total suspended particulate matter refers to all suspended particles in the air. In practice, the upper size range is typically 30 µm – 50 µm.
- PM_{10} –refers to all particles with equivalent aerodynamic diameters of less than 10 µm, that is, all particles that behave aerodynamically in the same way as spherical particles with a unit density.
- $PM_{2.5}$ – refers to all particles with equivalent aerodynamic diameters of less than 2.5 µm diameter (a subset of PM_{10}). Often referred to as the fine fraction.
- $PM_{2.5\text{-}10}$ – defined as the difference between PM_{10} and $PM_{2.5}$ mass concentrations. Often referred to as the coarse fraction.

Evidence suggests that health effects from exposure to airborne particulate matter are predominantly related to the respiratory and cardiovascular systems. The human respiratory system has in-built defensive systems that prevent larger particles from reaching the more sensitive parts of the respiratory system. Particles larger than 10 µm, while not able to affect health, can soil materials and thus lead to nuisance impacts. For this reason air quality goals make reference to measures of the total mass of all particles suspended in the air, this is referred to as TSP. In practice particles larger than 30 to 50 µm settle out of the atmosphere too quickly to be regarded as airborne pollutants. The upper size range for TSP is usually taken to be 30 µm.

Both natural and man-made (anthropogenic) processes contribute to the atmospheric load of PM. Coarse particles ($PM_{2.5\text{-}10}$) are derived primarily from mechanical processes resulting in the suspension of dust, soil, or other crustal[b] materials from roads, farming, mining, dust storms, and so forth. Coarse PM also includes sea salts, pollen, mould, spores, and other plant parts. Given mine generated PM (excluding diesel exhaust) is mechanical in origin, it is likely to be composed of predominantly coarse PM (and larger).

Fine particles or $PM_{2.5}$ are derived primarily from combustion processes, such as vehicle emissions, wood burning, coal burning for power generation, and natural processes such as bush fires. Fine particles also consist of transformation products, including sulphate and nitrate particles, and secondary organic aerosol from volatile organic compound emissions. $PM_{2.5}$ may penetrate beyond the larynx and into the thoracic respiratory tract and evidence suggests that particles in this size range are more harmful than the coarser component of PM_{10}.

In summary, the size of particles determine their behaviour in the respiratory system, including how far the particles are able to penetrate, where they deposit, and how effective the body's clearance mechanisms are in removing them. Additionally, particle size is an important parameter in determining

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[b] Crustal dust refers to dust generated from materials derived from the earth’s crust.

the residence time and spatial distribution of particles in ambient air; key considerations in assessing exposure. With all other factors being equal, the smaller the PM, the greater the potential for health impact. PM associated with mining is generally associated with the larger (course) PM size fraction, due to its generation via mechanical (as opposed to combustion) processes.

Airborne PM Characterisation

Airborne PM is a complex mixture of particles from different sources, and the contributions of the different sources vary considerably both temporally and spatially. The different components can be categorised in a number of different ways. The components within PM are typically distinguished between the following:

- Primary natural PM
- Primary anthropogenic (man-made) PM
- Secondary natural PM
- Secondary anthropogenic PM

Primary natural PM is emitted directly into the atmosphere as a result of processes such as natural wind erosion processes (mineral dust) and the production of marine aerosols (sea salt). Primary anthropogenic PM results from processes involving either combustion (*e.g.* industrial activity, domestic wood heaters, vehicle exhaust) or mechanical abrasion (*e.g.* road vehicle tyre wear). Secondary PM is not emitted directly, but is formed by chemical reactions involving gas-phase components of the atmosphere. The main gaseous precursors of secondary PM are oxides of nitrogen (NO_X), ammonia (NH_3), sulfur oxides (SO_X) and volatile organic compounds (VOCs). Again, the origin of these may be natural or anthropogenic. Various studies have shown that secondary PM contribute significantly to $PM_{2.5}$ concentrations and, to a lesser extent, PM_{10}.

For both primary and secondary PM there is a further division between inorganic and organic components. This is especially important for secondary PM. As suggested by the gaseous precursors mentioned above, the inorganic and organic components of secondary PM typically include the following:

Inorganic:	Ammonium nitrate (with some sodium nitrate) Ammonium sulfate
Organic:	A complex mixture of compounds, commonly referred to as secondary organic aerosol (SOA)

The distinction between the composition and source of PM is important when considering particle emissions from the minerals industry.

As noted above, secondary PM comprises a significant proportion of observed ambient PM concentrations. Gaseous emissions within the mining industry that may act as precursors for seconfary PM generation are associated with diesel combustion, blasting and spontaneous combustion. Blasting and spontaneous combustion emissions can be indicated to occur infrequently and be of limited duration and therefore unlikely to contribute significantly to airborne fine particle concentrations. Diesel combustion is on-going within the mining industru with primary diesel PM emissions and precursor gaseous emissions likely to contribute to the carbon and nitrate components of airborne fine PM within mining areas.

Figure 2.1 shows the data from the NSW EPA Greater Metropolitan Region (GMR) Atmospheric Emission Inventory for 2008 and indicates that primary PM emissions from mining are dominated by the coarse, crustal derived fraction (84% compared to 16% for $PM_{2.5}$). This is compared to the percentage PM_{10} and $PM_{2.5}$ emissions for combustion sources (**Figure 2.2**) which show a much higher proportion of $PM_{2.5}$ to PM_{10} emissions.

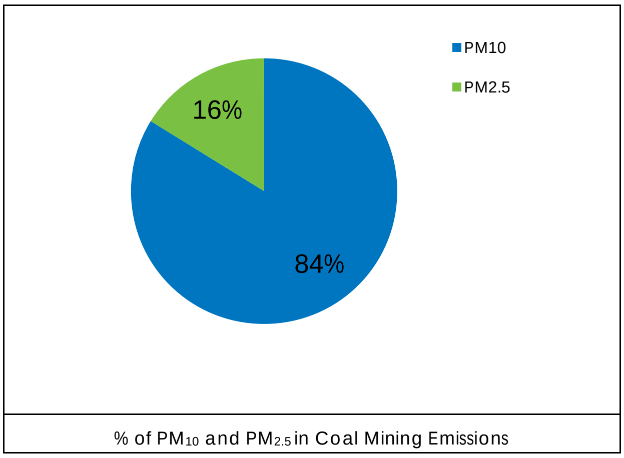

Figure 2.1: NSW EPA GMR Emissions Inventory Data for Coal Mining

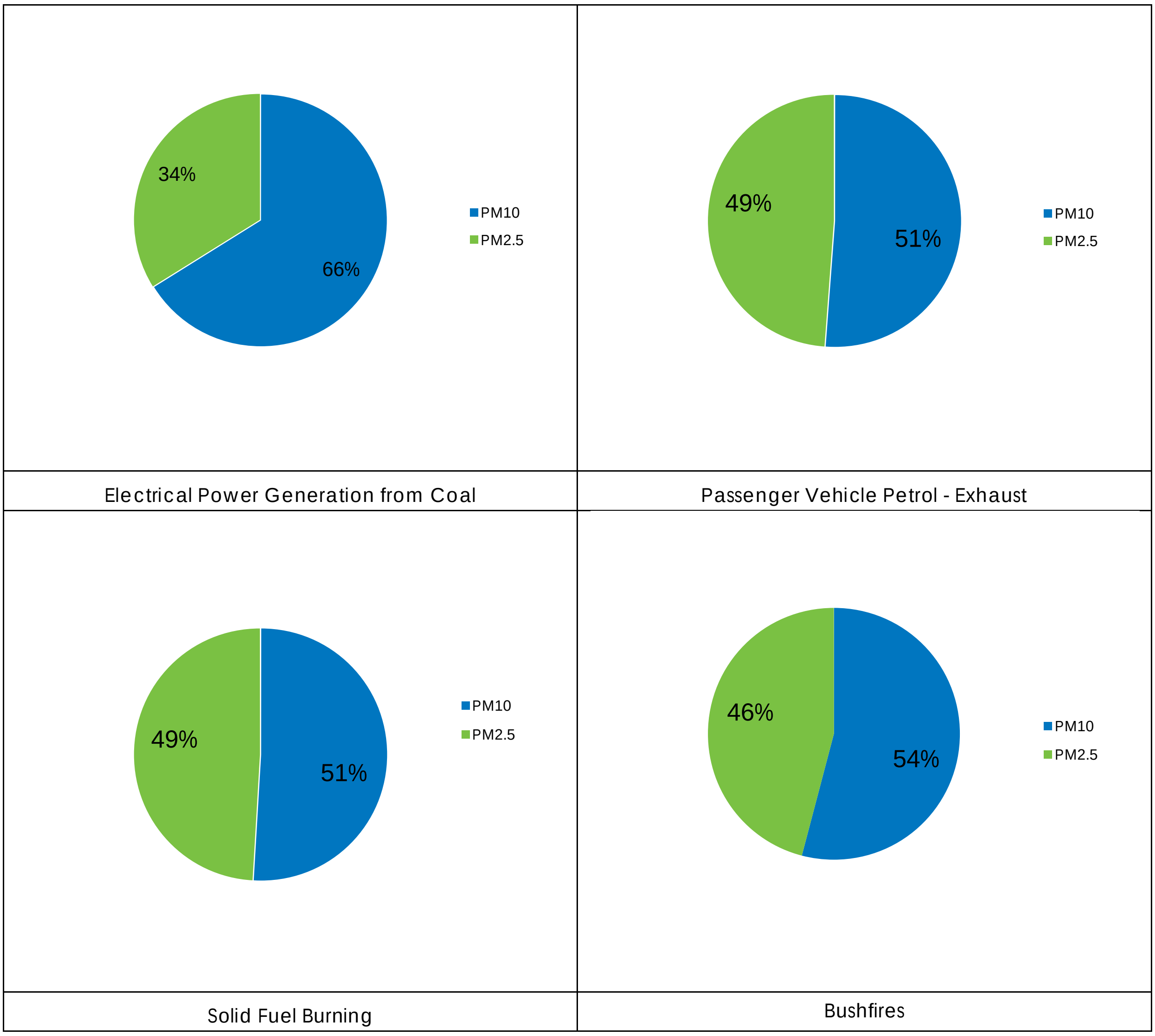

Figure 2.2: NSW EPA GMR Atmospheric Emissions Inventory Data - % PM_{10} and $PM_{2.5}$ Emissions from Combustion Sources

In summary, given their complex nature, it is necessary to categorise the components found within PM so that one can better understand, and potentially control, the key sources.

Airborne PM Composition

Whilst mining can be an important contributor to PM_{10} and $PM_{2.5}$ emissions, a very different pattern emerges when one considers the composition of the particulate matter in ambient air.

In practice, there are a number of difficulties associated with identifying and quantifying the different components in PM data (termed 'source apportionment'). For example, whilst the gaseous precursors of inorganic secondary PM are largely man-made, it is very difficult to know what fractions of secondary organic aerosol (SOA) result from anthropogenic and natural sources.

There have been relatively few studies of PM composition (and in particular SOA) in Australia. Source apportionment studies have been undertaken in Brisbane, and to a lesser extent in Melbourne, Sydney and Adelaide - by Griffith University **(Chan *et al.*, 1997, 1999, 2000, 2008, 2011)**. These studies have shown that secondary PM forms a significant component of PM_{10} and $PM_{2.5}$. It was observed by **Chan *et al.* (1999)** that secondary organics and secondary sulfates accounted for 21% and 14% of $PM_{2.5}$ respectively at a suburban site in Brisbane surrounded by forest. Most of the secondary products were found to be related to motor vehicle exhaust. In a study in the four cities mentioned above, **Chan *et al.* (2008)** found that, on average, secondary nitrates/sulfates contributed about 25% of the mass of the $PM_{2.5}$ samples.

Useful data on the composition of $PM_{2.5}$ are available from the Australian Nuclear Science and Technology Organisation (ANSTO). ANSTO has been sampling $PM_{2.5}$ – mainly along the east coast of Australia - since 1991. During this time fine particles have been routinely collected at selected urban, rural and industrial sites. $PM_{2.5}$ has been collected on filters every Wednesday and Sunday over a 24-hour period, with subsequent analysis using ion beam analysis techniques.

The following $PM_{2.5}$ components (as well as total mass) are reported:

- Sulfate (as '$NHSO_4$')
- 'Soil'
- Black (elemental) carbon
- 'Salt'
- Metals (K, Fe, Zn, Pb)

The contributions of these different components to monthly average $PM_{2.5}$ concentration at the ANSTO monitoring site in Muswellbrook, NSW are shown in **Figure 5**. The Muswellbrook monitoring data is presented as this is representative of a region located in the Upper Hunter Valley, with several major open cut coal mines located in the vicinity.

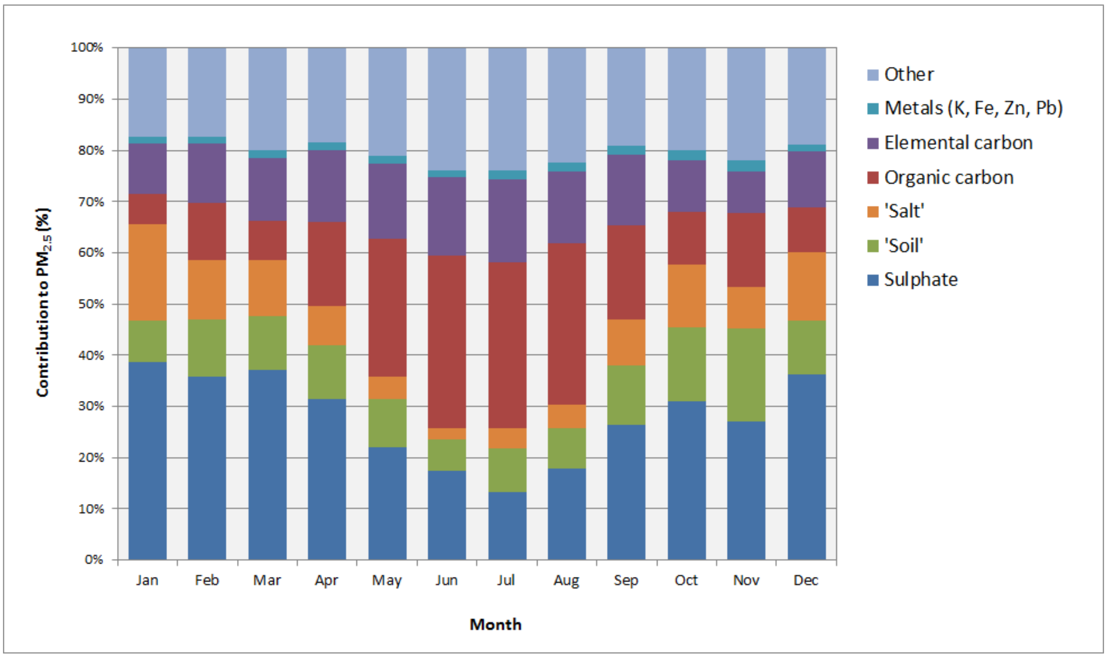

Figure 5: Components of $PM_{2.5}$ concentration at ANSTO monitoring site in Muswellbrook, NSW (averages for period 2005-2011).

A large proportion of the $PM_{2.5}$ measured in Muswellbrook is either secondary or natural in origin. For example, one of the largest components (as at all the ANSTO sties) is (ammonium) sulfate. The sulfate component has a seasonal cycle, but is responsible for around 35% of $PM_{2.5}$ in the summer months. ANSTO do not report the (secondary) nitrate component, but experience from Australia and other countries would suggest that a substantial proportion of the 'other' component in **Figure 5** is likely to be secondary nitrate. Moreover, a proportion of the organic carbon component will be SOA. The 'salt' component is likely to include a large amount of natural sea salt, and some of the 'soil' will be natural wind-blown dust. It is acknowledged that the 'soil' component is likely to include a significant anthropogenic contribution (such as dust from coal mines). However, it can be seen that the contribution of this component to the total is less than 20%.

Finally, it is noted that the $PM_{2.5}$ speciation for Muswellbrook is not substantially different from the equivalent speciation monitoring data for urban sites. These similarities in the speciation reflect the longer atmospheric residence times of fine PM and their corresponding ability to be regionally transported resulting in a more uniform signature relative to the course PM fraction.

2.2 Health Effects of Particles

There is no evidence of a threshold concentration for PM_{10} and $PM_{2.5}$ below which adverse health effects are not observed **(Pope and Dockery, 2006**; **Brook *et al*., 2010; USEPA, 2009; COMEAP, 2009)**. The evidence indicates that long-term exposure to background levels of PM is the most important effect of air quality on public health. In the absence of a health-related threshold for PM, health benefits are *directly related* to the reduction in PM exposure, and are *unrelated* to the absolute concentration. Thus, reducing the average $PM_{2.5}$ exposure from 28 µg/m³ to 27 µg/m³ across a population of 10,000 people is expected to deliver *the same health benefit* as reducing the average $PM_{2.5}$ exposure from 12 µg/m³ to 11 µg/m³ across the same population. Put another way, whilst PM_{10} concentrations in Australian cities are significantly below the standards for most of the time **(Commonwealth of Australia, 2010)**, the health impacts are actually driven by large-scale exposure to relatively low pollution levels.

Notwithstanding, both long-term and short-term exposure to high concentrations of particulate matter can lead to undesirable health impacts, predominantly related to the respiratory and cardiovascular systems. People most at risk from particle pollution include people with diseases that affect the heart or lung (including asthma), older adults, children, and people of lower socioeconomic status. Research indicates that pregnant women, newborns, and people with certain health conditions, such as obesity or diabetes, also may be at increased risk of PM-related health effects (**US EPA, 2013**).

Recent evidence indicates that exposure to fine particles ($PM_{2.5}$) presents a higher risk to human health than exposure to larger particles (PM_{10} and TSP). The US EPA, in their recent review of the National Ambient Air Quality Standards (NAAQS) note that:

> *"An extensive body of scientific evidence indicates that breathing in $PM_{2.5}$ over the course of hours to days (short-term exposure) and months to years (long-term exposure) can cause serious public health effects that include premature death and adverse cardiovascular effects. The evidence also links PM2.5 exposure to harmful respiratory effects."*

and:

> "*Scientific evidence also indicates that breathing in larger sizes of particulate matter, coarse particles (PM_{10}), may also have public health consequences."*

The 2009 Integrated Science Assessment (ISA) (**US EPA, 2009**) which was used to inform the revisions to the NAAQS, reviewed more than 300 new epidemiological studies of PM2.5. Provisional assessment of significant new studies published since the ISA was completed in 2009 also report a wide range of health effects associated with both long- and short-term exposure to fine particles. The revisions to the NAAQS for $PM_{2.5}$ standard (discussed further in **Section 3.3**) are consistent with advice and recommendations of the independent Clean Air Scientific Advisory Committee, the body established by US Congress specifically to advise the Administrator on the NAAQS.

The World Health Organization (WHO) also used $PM_{2.5}$ as the primary indicator of health impacts (**WHO, 2006**) and note that:

> "*Although PM_{10} is the more widely reported measure, and also the indicator of relevance to the majority of the epidemiological data, for reasons that are discussed below, the WHO AQGs for PM are based on studies that use $PM_{2.5}$ as an indicator. The $PM_{2.5}$ guideline values are converted to the corresponding PM_{10} guideline values by application of a $PM_{2.5}/PM_{10}$ ratio of 0.5.*"

This is also reflected in Australia where the *Review of the National Environment Protection (Ambient Air Quality) Measure* (NEPM) conducted in 2010 (**NEPC, 2010**), indicated that PM_{10} is an important indicator in $PM_{2.5}$ impacts, as $PM_{2.5}$ monitoring data alone are too limited. This is despite that fact that '*$PM_{2.5}$ may be even more important with respect to adverse health impacts*'.

In summary, while coarse particles (PM_{10}), may have public health consequences, the focus is shifting towards greater scrutiny of $PM_{2.5}$ as a key driver of health impacts. The monitoring of larger particle size fractions (PM_{10}) will still have applicability in the near future however, as an indicator of the potential impacts of smaller sized PM (e.g. $PM_{2.5}$).

2.3 Differences in health impacts between combustion and crustal emissions

The health-based assessment criteria used in Australia have, to a large extent, been developed by reference to epidemiological studies undertaken in urban areas with large populations and where the primary pollutants are the products of combustion (**EPA**, **1998**; **National Environment Protection Council** [**NEPC**], **1998a**; **NEPC**, **1998b**).

This means that, in contrast to PM of crustal origin, the particulate matter from urban areas would be composed of smaller particles ($PM_{2.5}$). In addition, due to their origin, these smaller particles would generally contain acidic and carcinogenic substances that are associated with combustion.

The US Environmental Protection Agency has also stated that the evidence of harm from urban-type coarse particulate matter is stronger than for other types. Consequently, the EPA targeted protection in areas where urban-type coarse PM is most likely present (**US EPA, 2004**).

WHO (2004) noted that recent data had strengthened the earlier finding that '*while there was little indication that any one property of particulate matter was responsible for the adverse health effects, toxicological studies suggested that fossil fuel and biomass combustion processes may be a significant contributor to adverse health outcomes.*'

The Department of Health in Western Australia commissioned a study, completed in 2007, that concluded that in Port Hedland, where PM emissions are dominated by iron ore rich soils, health impacts are unlikely to be as severe as in other regions with higher contributions due to urban emissions (**LIWA & IOM, 2007**). However, the study recommended strongly that further monitoring and evaluation of health impacts occur in the area.

3 STANDARDS, MONITORING AND REGULATION

3.1 Introduction

In 1998 Australia adopted an Ambient Air Quality National Environment Protection Measure (AAQ NEPM) (**NEPC 1998**) that established national standards for criteria pollutants, including PM_{10}. The goal of the AAQ NEPM was to ensure compliance with the standards within 10 years of commencement, in order to attain 'ambient air quality that allows for the adequate protection of human health and wellbeing'. The AAQ NEPM was extended in 2003 to include advisory reporting standards for $PM_{2.5}$.

To meet the requirements of the NEPM, States and Territories are required to monitor and report on air quality to determine whether the standards are met within populated areas. The NEPM monitoring protocol states that some monitoring stations should be located in populated areas which are expected to experience relatively high concentrations of key air quality parameters, providing a basis for reliable statements about compliance within the region as a whole. However, it is also necessary to ensure that any NEPM monitoring network provides widespread coverage of the populated area in a region, and provides data that are indicative of the air quality experienced by most of the population in the region.

Typically, industry regulation at the state level will include both requirements under the environmental approvals process, as well as subsequent regulation of approved industry by the state's environmental protection agency.

Regulation at state level, for existing and proposed industry, often makes reference to compliance with NEPM standards. Similarly, guidance documents for air quality assessment at the state level, often refer to standards equivalent to the NEPM. Thus, the AAQ NEPM standards are often used in the regulation and compliance of industry at state level (refer **Section 3.3**). The intent of the AAQ NEPM standards is that they are applied at monitoring locations that are not influenced by a particular pollution source (e.g. heavy industry, heavily trafficked road or coal mine). In reality, the AAQ NEPM standards are typically invoked at a state level to assess compliance wherever a monitoring station may be located (e.g. adjacent to mining operations).Whilst air quality standards have an important role to play in driving down PM concentrations where exceedances are measured or predicted, localised actions are unlikely to lead to large-scale reductions in population exposure. In addition, in areas of higher population density where there are no exceedances of the standards there is currently no driver to implement measures to reduce exposure to PM.

To be able to observe the impacts associated with changing PM concentrations, epidemiological studies need, by definition, to be located in areas with relatively high populations. As a result, such populations are typically exposed to urban PM sources, principally motor vehicles. In Australia, the decision to adopt the current AAQ NEPM advisory standard for $PM_{2.5}$ (8 µg/m^3, expressed as an annual average) was largely based upon monitoring at thirteen locations in four cities over a three year period. These locations were primarily urban, with only two being described as 'semi-rural'. The study estimated the number of health outcomes avoided in urban centres at different levels of $PM_{2.5}$ concentration (5, 8, and 10 µg/m^3) (**NEPC, 2002**).

The current NEPM advisory standard for $PM_{2.5}$ was selected as it represented an improvement in air quality across most urban centres, thereby delivering significant improvement in health outcomes in those locations. Given the origin of the AAQ NEPM advisory standard for $PM_{2.5}$, its adoption for the regulation of industry in all areas (including rural and remote areas) would not achieve the same improvements in health outcomes as urban centres.

3.2 National Plan for Clean Air

In 2010 the then-Environment Protection and Heritage Council (EHPC) recommended that air quality management in Australia should take a strategic approach that integrates the setting of air quality standards with actions that reduce air pollution and the community's exposure to it. In 2011 a number of further steps were taken towards improving the regulation of air pollution in Australia, notably:

- The National Environment Protection Council (NEPC) published a review of the AAQ NEPM which recommended updating the standards for PM_{10}, $PM_{2.5}$, NO_2, O_3, and SO_2 **(NEPC, 2011a)**.
- NEPC published a methodology for the setting of air quality standards **(NEPC, 2011b)**.
- The Council of Australian Governments (COAG) identified air quality as an issue of national priority **(COAG, 2012)**, and agreed that its Standing Council on Environment and Water (SCEW) would implement a strategic approach to air quality management in the form of a National Plan for Clean Air (NPCA).

The development of an exposure-reduction framework for PM was another important recommendation of the AAQ NEPM review, and some jurisdictions are in the process of developing such a framework.

3.3 Ambient Air Quality Guidelines

A summary of the air quality criteria for PM in Australian and internationally is shown in **Table 3.1**.

When compared with international values, Australia's air quality criteria are one of the most stringent. By way of example, the 24-hour PM_{10} goal adopted in the United States (US) is three times higher than that adopted within Australia's AAQ NEPM. In the European Union (EU), while the 24-hour PM_{10} goal is equal to Australia's, there is a provision for 35 exceedances annually, as opposed to five. Annual $PM_{2.5}$ goals in the US and EU are also higher (12 $\mu g/m^3$ and 25 $\mu g/m^3$ respectively, compared to 8 $\mu g/m^3$ within the AAQ NEPM). Notwithstanding the above, it is acknowledged that in the EU, air quality criteria apply at all locations where people are regularly exposed (e.g. including roadside, but not including road tunnels).

There are no state specific criteria for particles in South Australia, Western Australia, Northern Territory and the Australian Capital Territory and the NEPM standards are applied in these states. In Port Hedland, WA, an interim guideline value of 70 $\mu g/m^3$ for 24-hour average PM_{10} (with a maximum of 10 exceedances per year) is applied. This criterion was derived based on a health study to investigate the effects of inhalation exposure to PM rich in crustal material (in particular iron oxides). The study argues that the NEPM standard for 24-hour average PM_{10} is based on an urban environment is not appropriate for the Port Hedland area (**LIWA & IOM, 2007**).

The most recent revision to ambient air quality standards for PM Internationally occurred in the United States. The US EPA review of the NAAQS for PM has lowered the annual average standard for $PM_{2.5}$ from 15 $\mu g/m^3$ to 12 $\mu g/m^3$ to provide increased protection against health effects associated with long- and short-term exposures (including premature mortality, increased hospital admissions and emergency department visits, and development of chronic respiratory disease) (**US EPA, 2013**).

The revised US EPA NAAQS for annual $PM_{2.5}$ is 50% higher than the NEPM advisory reporting standard.

The US EPA NAAQS 24-hour average standards for $PM_{2.5}$ and PM_{10} remain unchanged (at 35 $\mu g/m^3$ and 150 $\mu g/m^3$, respectively). Both these standards are higher than the NEPM ambient air quality standards.

It is important to emphasise there are no national compliance standards for $PM_{2.5}$ in Australia. The advisory reporting standards were issued for $PM_{2.5}$ in 2003 primarily to support the monitoring of $PM_{2.5}$ and to inform the revision of the NEPM-AAQ. In the absence of $PM_{2.5}$ compliance standards, the advisory reporting standards for $PM_{2.5}$ have increasingly been referenced as compliance standards within Australia (for example, as adopted in Qld).

In summary, when compared with international standards Australia's air quality standards are either equivalent to, or more stringent than, those adopted within other OECD countries. Regulation at state level often makes reference to compliance with NEPM standards. It is noted that the intent of the NEPM standards were that they be applied at monitoring locations that are not influenced by a particular pollution source.

Table 3.1: Air Quality Standards/Criteria for Particulate Matter Concentrations

Pollutant	Averaging period	Standard / Criteria	Comment	Location
PM_{10}	24-hour maximum	50 µg/m^3	maximum allowable exceedances of 5 days per year	Australia (NEPC[1])
$PM_{2.5}$	24-hour maximum	25 µg/m^3	Advisory reporting standard	
	Annual mean	8 µg/m^3		
TSP	Annual mean	90 µg/m^3	-	NSW, Australia (NSW EPA[2])
PM_{10}	24-hour maximum	50 µg/m^3	-	
	Annual mean	30 µg/m^3	-	
TSP	Annual mean	90 µg/m^3	-	Queensland, Australia (DEHP[3])
PM_{10}	24-hour maximum	50 µg/m^3	maximum allowable exceedances of 5 days per year	
$PM_{2.5}$	24-hour maximum	25 µg/m^3	-	
	Annual mean	8 µg/m^3	-	
PM_{10}	24-hour maximum	50 µg/m^3	maximum allowable exceedances of 5 days per year	Victoria, Australia (EPAV[4])
PM_{10}	24-hour maximum	150 µg/m^3	-	Tasmania, Australia (EPAT[6])
PM_{10}	24-hour maximum	150 µg/m^3	not to be exceeded more than once per year on average over a three year period	US (US EPA[7])
$PM_{2.5}$	24-hour maximum	35 µg/m^3	98th percentile averaged over three years is less than or equal to 35 µg/m^3	
	Annual mean	12 µg/m^3	not to be exceeded more than once per year on average over a three year period	
PM_{10}	24-hour maximum	50 µg/m^3	35 permitted exceedances per year	Europe (EU[8])
	Annual mean	40 µg/m^3	-	
$PM_{2.5}$	Annual mean	25 µg/m^3	-	
PM_{10}	24-hour maximum	50 µg/m^3	Not to be exceeded more than 3 times per year	International (WHO[9])
	Annual mean	20 µg/m^3	-	
$PM_{2.5}$	24-hour maximum	25 µg/m^3	Not to be exceeded more than 3 times per year	
	Annual mean	10 µg/m^3	-	

Notes: $\mu g/m^3$ – micrograms per cubic metre

[1] National Environment Protection Council, "National Environment Protection Measures for Ambient Air Quality" (**NEPC, 2011**)

[2] NSW Environment Protection Authority, "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (**NSW EPA, 2005**)

[3] Department of Environment and Heritage Protection, "Environmental Protection (Air) Policy 2008" (**DEHP, 2008**)

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3.4 Ambient Air Quality Monitoring

Monitoring networks have been established by each state to monitor air quality impacts and evaluate compliance with the AAQ NEPM. In accordance with the objectives with the NEPM, monitoring locations are generally in more densely populated areas or where there are high concentrations of industry.

Various methods are used to measure PM_{10} and $PM_{2.5}$, and these vary by state. The inconsistency in instrumentation across each state and for difference size fractions, can introduce complications in the interpretation and analysis of the data. The reference method for monitoring $PM_{2.5}$ in Australia is the manual gravimetric method. The method is a non-continuous (batch), 1-day-in-3 technique that requires pre- and post-laboratory weighing. This introduces a significant time delay in data acquisition. However, the most common method for measuring and reporting PM_{10} and $PM_{2.5}$ concentrations in Australia is the Tapered-Element Oscillating Microbalance (TEOM). The main advantage of the TEOM is that concentrations are reported on a continuous basis.

Due both to historical emphasis on this size fraction, combined with the relative ease in monitoring this parameter, there are currently more sites measuring PM_{10} than $PM_{2.5}$.

Distribution of Air Quality Monitoring

The NSW EPA currently operate 37 monitoring sites for PM_{10} sites and 11 monitoring sites for $PM_{2.5}$. The monitoring stations operated by NSW EPA predominantly use TEOMs, with a number of Beta-Attenuation Monitors (BAMs) for $PM_{2.5}$ used as part of the Upper Hunter Monitoring Network. The (recently established) Upper Hunter Air Quality Monitoring Network consists of 14 monitoring sites in strategic locations, including the major population centres of Singleton and Muswellbrook.

In Queensland, monitoring networks are set up in southeast Queensland, Mackay, Townsville, Mt Isa and Gladstone. The monitoring networks consist of 21 PM_{10} monitors and 10 $PM_{2.5}$ monitors to monitor the effects of local industry (including coal mining and port services on the local community.

The Victorian EPA operate nine PM_{10} sites and two $PM_{2.5}$ sites. As in NSW, the monitoring is mostly undertaken using TEOMs. Gravimetric filter measurements - high-volume air samplers (HVAS) or Partisol samplers - are also deployed at some locations.

In WA, the Department of Environment and Conservation operate seven NEPM monitoring stations for PM_{10} and six for $PM_{2.5}$. In SA, the EPA operate five monitoring stations for PM_{10} and one for $PM_{2.5}$. In the Northern Territory, there are current three monitoring stations for PM_{10} and $PM_{2.5}$ and in the ACT there are two monitoring stations for PM_{10} and one for $PM_{2.5}$.

A summary of PM monitoring performed by jurisdictions as part of the Air NEPM is provided in **Table 3.2**.

Table 3.2: Ambient PM monitoring in Australia (under the Air NEPM)

New South Wales		
Sydney	Yes	Yes[1]
Illawarra	Yes	Yes[1]
Lower Hunter	Yes	Yes[1]
Upper Hunter	Yes	Yes[1]
Albury	Yes	No
Bathurst	Yes	No
Tamworth	Yes	No
Wagga Wagga	Yes	Yes[2]
Total number of monitors	*19*	*7*
Victoria		
Melbourne	Yes	Yes[1]
Geelong	Yes	No
Latrobe Valley	Yes	No
Total number of monitors	*10*	*2*
Queensland		
South East Qld (including Brisbane)	Yes	Yes[2]
Gladstone	Yes	Yes[2]
Mount Isa	Yes	No
Mackay	Yes	No
Townsville	Yes	No
Total number of monitors	*11*	*5*
Western Australia		
Perth	Yes	Yes[1]
Albany	Yes	No
Bunbury	Yes	Yes[1]
Busselton	Yes	Yes[1]
Collie	Yes	No
Geraldton	Yes	No
Total number of monitors	*3*	*4*
South Australia		
Adelaide	Yes	No
Whyalla	Yes	No
Port Pirie	Yes	No
Mount Gambier	Yes	Yes[2]
Total number of monitors	*7*	*1*
Tasmania		
Hobart	Yes[2]	Yes[1]
Launceston	Yes[2]	Yes[1]
Tamar Valley	Yes[2]	Yes[1]
Georgetown	Yes[2]	Yes[1]
Total number of monitors	*1*	*1*
Australian Capital Territory		
Canberra	Yes	Yes
Total number of monitors	*2*	*1*
Northern Territory		
Darwin	Yes	Yes
Total number of monitors	*N/A*	*N/A*

NOTES

For each jurisdiction, the total number of monitoring sites shown includes only those sites currently operating within urban centres >100,000 people. Where the monitoring site has more than one PM_{10} or $PM_{2.5}$ analyser, it has only been counted once.

New South Wales

1. Most monitoring sites in the NSW Greater Metropolitan Region (GMR) use TEOMs for monitoring $PM_{2.5}$ rather than the reference method in the Air NEPM
2. Most $PM_{2.5}$ data for Wagga Wagga is limited and does not use the reference method in the Air NEPM

Victoria

1. $PM_{2.5}$ monitoring is conducted using a combination of gravimetric methods and TEOMs

Queensland

1. Pollutants at selected sites are monitored using DOAS (Differential Optical Absorption Spectroscopy) (not a reference method).

Western Australia

1. $PM_{2.5}$ monitoring is conducted using a TEOM

South Australia

1. Mt Gambier has campaign monitoring so data is limited
2. $PM_{2.5}$ monitoring was conducted using an APS (airborne particle sensor) (not a reference method)

Tasmania

1. $PM_{2.5}$ monitoring is conducted using Low Volume Air Samplers
2. PM_{10} is monitored using a combination of TEOM and Low Volume Air Samplers
3. Additional particle monitoring is conducted in other locations in Tasmania however this is conducted using Dustrack monitors (not a reference method)

Australian Capital Territory

1. PM_{10} is monitored using TEOM and BAM
2. $PM_{2.5}$ is monitored using gravimetric methods

Industry Monitoring Initiatives

In additional to state regulator operated monitoring sites, extensive industry operated compliance monitoring sites exist. In additional to compliance requirements, air quality monitoring is also undertaken by industry as part of their commitment to manage and reduce PM. As an example, in the Hunter Valley, NSW extensive industry operated PM_{10} monitoring sites have been established for monitoring to meet requirements of Development Consents, as well as for operational dust management. Typically, an open cut coal mine in the Upper Hunter Valley may have three or more continuous PM monitoring devices for such purposes. In Port Hedland, the PHIC has setup a network of monitors to measure the regional air quality and manage local emissions. Similar networks have been established to manage air quality at other Australian ports, for example at the Port of Gladstone.

3.5 Examples of PM Monitoring Data

PM_{10} Monitoring Data

An overview of the measured PM_{10} concentration in NSW for the past 10 years is shown in **Table 3.3**. Data are presented as annual average concentrations (µg/m^3) and compared with the goal of 30 µg/m^3. A colour gradient is also applied to the data with the darker the colour indicating that monitoring approaches or exceeds the air quality goal. Additionally, monitoring locations deemed to be in the vicinity of mining areas (principally the Upper Hunter Air Quality Monitoring Network) are highlighted in bold.

What is immediately clear is 2009 was a consistently high year across the whole of NSW. 2009 was the warmest year on record for the state of NSW and, due to a protracted El Nino climatic event, annual average rainfall for the state was low at 484 mm. There were also a number of significant regional dust storms in 2009.

The recently extended Upper Hunter Air Quality Monitoring Network allows a comparison to be made (for the most recent year) between mining areas and the rest of the state. During 2012, of the nine sites that were greater than 20 µg/m^3, seven were in the upper hunter valley while the other two were Beresfield and Newcastle. It is important to recognise that the high density of monitoring within the Upper Hunter Valley is much greater than in any other area in Australia. Thus, when a regional exceedance is observed, this is typically recorded by multiple monitoring locations in the area, which will not be the case in other regions.

Other comparable high sites were Liverpool, in western Sydney, Earlwood, in south-western Sydney and Wagga Wagga, in western NSW. It is further highlighted that half of the monitors in the Upper Hunter Air Quality Monitoring Network (e.g. Aberdeen, Bulga, Jerrys Plain, Merriwa, Muswellbrook, Singleton South, Wybong) recorded PM_{10} concentrations at two thirds of the annual criterion or less (<20 µg/m^3).

$PM_{2.5}$ Monitoring Data

An overview of the measured $PM_{2.5}$ concentrations in NSW for the past 10 years is shown in **Table 3.4**. Data are again presented with a colour gradient applied and compared with the NEPM advisory reporting standard of 8 µg/m^3. Again, those monitoring locations deemed to be in the vicinity of mining areas are highlighted in bold.

In contrast to PM_{10} the generally dryer conditions during 2009 do not appear to have resulted in significantly higher annual $PM_{2.5}$ concentrations to the same extent as PM_{10}. This is expected given the anticipated increase in the larger sized crustal PM during dryer conditions and extreme dust events.

Sites that are greater than the NEPM advisory reporting standard during 2012 are Muswellbrook, Wagga Wagga, Liverpool, Beresfield and Singleton, suggesting factors other than mining have an influence on high $PM_{2.5}$ concentratiions. Accordingly, based on existing monitoring, it is not clearly evident that communities in mining regions are necessarily exposed to greater levels of $PM_{2.5}$ compared with communities in non-mining areas.

In summary, a review of the particulate monitoring completed across Australia indicates that monitoring within mining areas is well developed and represented. For example, since the commissioning of the Upper Hunter Air Quality Network, just under half of the NSW EPA TEOM monitoring sites are located in mining regions. If the industry monitoring is added to this figure, the majority of real-time continuous particulate monitoring in NSW can be said to be conducted in mining areas.

Table 3.3: Annual Average PM_{10} ($\mu g/m^3$) 2002 - 2012 NSW

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Goal
Aberdeen	-	-	-	-	-	-	-	-	-	-	17.0	30
Albion Park South	-	-	-	-	17.2	15.5	14.8	22.1	14.0	13.6	13.6	30
Albury	19.2	30.6	16.2	16.8	22.2	20.6	17.4	19.4	12.6	12.2	14.2	30
Bargo	-	-	-	-	-	-	-	-	12.9	12.9	14.3	30
Bathurst	21.3	18.4	17.7	14.7	17.6	15.8	14.0	23.2	9.3	11.0	13.4	30
Beresfield	27.1	19.1	20.9	20.3	21.3	20.4	18.5	28.7	16.6	17.2	21.4	30
Bringelly	21.5	18.7	19.7	19.5	20.2	18.5	15.7	24.8	15.4	15.9	15.7	30
Bulga	-	-	-	-	-	-	-	-	-	-	18.6	30
Camberwell	-	-	-	-	-	-	-	-	-	-	26.5	30
Chullora	-	24.0	22.5	22.2	21.9	19.5	19.5	26.1	17.7	19.9	18.1	30
Earlwood	24.2	21.8	22.4	22.6	23.4	20.5	19.3	27.1	17.9	18.1	19.6	30
Jerrys Plains	-	-	-	-	-	-	-	-	-	-	10.8	30
Kembla Grange	-	-	-	19.3	20.9	19.4	18.5	24.2	17.8	16.8	18.4	30
Lindfield	18.7	16.9	-	-	-	-	14.4	22.0	13.6	13.2	13.9	30
Liverpool	23.8	21.7	21.6	21.5	21.6	19.0	17.6	25.9	17.0	-	19.8	30
Macarthur	-	-	-	19.6	17.2	15.9	14.5	21.3	14.0	13.2	-	30
Maison Dieu	-	-	-	-	-	-	-	-	-	-	25.7	30
Merriwa	-	-	-	-	-	-	-	-	-	-	14.2	30
Mount Thorley	-	-	-	-	-	-	-	-	-	-	24.7	30
Muswellbrook	-	-	-	-	-	-	-	-	-	19.3	21.8	30
Muswellbrook NW	-	-	-	-	-	-	-	-	-	-	19.1	30
Newcastle	-	-	-	21.6	21.1	-	20.6	31.3	18.7	19.1	20.6	30
Oakdale	-	-	-	13.4	14.0	12.8	12.4	19.5	10.7	10.7	11.7	30
Prospect	-	-	-	-	-	18.0	17.8	25.8	15.4	15.8	17.3	30
Randwick	20.5	19.7	19.9	19.3	19.3	18.2	17.3	26.2	16.0	15.9	18.0	30
Richmond	21.8	18.2	18.4	16.6	17.4	14.8	13.0	21.4	13.1	13.2	15.1	30
Rozelle	-	-	20.1	20.2	20.4	18.1	17.3	24.7	16.1	16.6	16.9	30
Singleton	-	-	-	-	-	-	-	-	-	19.8	22.3	30
Singleton Nw	-	-	-	-	-	-	-	-	-	-	25.9	30
Singleton South	-	-	-	-	-	-	-	-	-	-	19.0	30
St Marys	20.6	18.3	17.0	18.9	19.7	17.1	14.8	23.2	15.1	14.7	14.4	30
Tamworth	20.8	17.9	20.8	-	16.8	-	15.8	27.3	12.0	13.1	15.9	30
Vineyard	21.8	18.3	17.9	17.3	18.5	16.5	15.2	23.5	14.5	14.0	14.4	30
Wagga Wagga	29.2	29.6	25.6	24.7	29.1	26.1	24.7	26.8	17.2	-	-	30
Wagga Wagga North	-	-	-	-	-	-	-	-	-	-	18.8	30
Wallsend	21.3	18.1	18.7	18.2	18.5	17.3	15.4	26.7	14.9	14.2	14.9	30
Warkworth	-	-	-	-	-	-	-	-	-	-	21.1	30
Wollongong	21.6	18.8	18.6	18.6	20.1	19.8	17.8	24.2	17.8	17.0	18.0	30
Wybong	-	-	-	-	-	-	-	-	-	-	15.4	30
Gradient Key							10	15	20	25	30	

Table 3.4: Annual Average $PM_{2.5}$ ($\mu g/m^3$) 2002 - 2012 NSW

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Goal
Beresfield	10.3	6.2	7.8	6.8	6.8	6.3	6.0	8.6	6.0	5.5	8.0	8
Camberwell	-	-	-	-	-	-	-	-	-	-	7.5	8
Chullora	-	-	8.7	7.6	7.1	6.4	5.9	7.1	5.8	6.0	6.1	8
Earlwood	9.5	7.8	7.6	7.1	6.9	5.9	5.5	-	5.7	5.4	5.6	8
Liverpool	11.9	-	9.2	8.4	8.9	7.2	6.4	8.3	6.4	5.9	8.5	8
Muswellbrook	-	-	-	-	-	-	-	-	-	9.1	10.0	8
Richmond	8.3	6.5	6.5	5.7	5.8	-	7.3	5.6	4.2	4.6	5.3	8
Singleton	-	-	-	-	-	-	-	-	-	7.6	8.0	8
Wagga Wagga North	-	-	-	-	-	-	-	-	-	-	8.6	8
Wallsend	8.1	6.6	6.7	6.5	6.4	5.8	5.9	8.0	4.7	4.8	5.1	8
Wollongong	8.3	7.3	6.7	6.3	6.4	6.0	5.3	7.1	5.1	4.6	4.6	8
Gradient Key								5	8	10	12	

4 EXPOSURE RISK AND MANAGEMENT

The following case studies highlight some of the leading practice management and controls that have been implemented by the minerals industry in Australia. It is highlighted that, by its definition, leading (or 'best' practice) will be developed and implemented based on the local conditions and drivers. Thus, leading practice will be dependent on individual circumstances, with no single technique or technology universally applicable.

4.1 Australian Coal Association Research Program

The Australian Coal Association Research Program (ACARP) provides support for improvements to coal mining from mines to port including research for cleaner mining practices. Currently, ACARP has committed significant funding to a number of major research projects, aimed at better understanding dust emissions and the effectiveness of best practice control measures at coal mines.

Two such examples include ongoing studies both to understand and optimise PM control from haul roads using mobile monitoring techniques, as well as an extensive study to develop Australian-specific PM emission factors / control efficiencies.

4.2 Coal mine dust reduction strategies

In 2010, the NSW EPA commissioned a study, *NSW Coal Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (**Donnelly et al, 2010**). Following the Benchmarking study, the NSW EPA developed the Dust Stop program implemented through pollution reduction programs (PRPs) that required each mining company to prepare a report on the practicability of implementing best practice measures to reduce PM emissions.

The first phase of the PRPs has been completed, with commitments on dust minimisation measures from each coal mine. The second phase of PRPs will be implemented in 2013 and includes conditions for coal mines to demonstrate dust reduction measures and commitments made in the first phase of the PRPs.

In addition to the establishment of the Upper Hunter Air Quality Monitoring Network, the NSW EPA have commenced a study aimed at better understanding the composition and source of fine particles in the Hunter Valley. As predicated by the discussions in the previous sections, a better understanding of $PM_{2.5}$ exposure is critical owing to their potentially greater impact on health.

4.3 Reducing exposure risk for communities in port areas

Port Hedland is one of the largest iron ore export ports in the world and the Port Hedland Dust Management Taskforce was established to manage air quality impacts. The taskforce consists of members from industry, community and government and is chaired by the Department of State Development.

The Taskforce developed the Port Hedland Air Quality and Noise Management Plan which includes details of the monitoring network and establish roles and responsibilities for dust management and reduction. As part of the plan, individual companies will develop fence-line monitoring to determine the contribution from individual companies to the Port Hedland air shed, particularly during air quality events. The siting of fence-line particle monitors will generally be aligned with adjacent ambient air monitors, both upwind and downwind of primary PM sources.

The Port Hedland Industries Council (PHIC) was established to deliver industry cooperation and coordination of air quality monitoring and management in Port Hedland. An ambient air quality monitoring network has been developed which includes air quality monitoring stations for PM_{10} and

$PM_{2.5}$ and meteorological stations. Real-time PM_{10} monitoring is available to the public via the PHIC website.

4.4 Reducing exposure risk from fugitive dust emissions from coal transportation

Queensland Rail (QR) completed a study on fugitive dust emissions from coal trains at the Goonyella, Blackwater and Moura rail systems (**Connell Hatch, 2008**). The study identified the key sources of dust emissions from coal train transport and investigated the effectiveness of various dust mitigation measures. The dust measures considered to be practical and cost-effective include:

- Coal surface veneering using chemical dust suppressants at the mine.
- Improved coal loading techniques at the mine to reduce parasitic loads on horizontal wagon surfaces and reduced over-filling and hence spillage during transport.
- Load profiling to create a consistent surface of coal in each wagon at the mine.
- Improved unloading techniques to minimise coal ploughing and parasitic loads on wagons.

As a result of the study, QR has implemented several of the dust mitigation measures including veneering of the coal, opacity monitoring, review and modification of train loading procedures, coal type testing, sill brushes, improvements to rail load-out infrastructure and train speed indicators (**QR, 2010**). QR has installed a monitoring system to quantify dust impacts from train movements at the Goonyella, Blackwater and Moura locations. The system measures the opacity of the air across the top of moving coal trains as they pass the monitoring stations. A co-located weather station records wind direction and speed; relative humidity and rainfall to determine the influence of weather on dust incidents. The monitors will be in operation for the next few years to quantify emissions from the rail operation and to determine the effectiveness of the control measures implemented.

4.5 Continuous Improvement

Air quality management within the mining industry is subject to continual improvement, with techniques that were previously deemed leading practice becoming standard industry practice. Examples of adoption of such improvements within the industry over recent years include:

- The adoption of regional atmospheric dispersion modelling techniques to evaluate cumulative (as opposed to a single mine in isolation) PM impacts.
- The use of reactive and predictive air quality control / management systems to manage PM impacts both at mines and port facilities.
- Widespread use of chemical dust suppressants on haul roads and unstabilised exposed areas.
- Ongoing research to better understand and characterise PM size fractions, emission rates and potential control efficiencies.
- Use of (non-regulatory) PM monitoring techniques to provide real-time feedback to inform operational dust management.

5 CONCLUSIONS AND RECOMMENDATIONS

Particulate Matter, Sources and Effects

- The distinction between the composition and source of PM is important when considering PM emissions (and subsequent potential health impacts) from the minerals industry.
- There is substantial evidence to suggest that fine ($PM_{2.5}$, PM_1) and ultra fine particles ($PM_{0.1}$), and specifically 'secondary PM' related to combustion processes and conversion of organic aerosols, are more damaging to human health than coarser, thoracic particles ($PM_{2.5-10}$) derived from suspension of soil or road dust.
- PM associated with mining is generally associated with the larger (course) PM size fraction, due to its generation via mechanical (as opposed to combustion) processes.
- It is acknowledged that the minerals industry is a significant contributor to emissions of PM. However, high PM emissions do not necessarily equate to equivalent PM impacts at sensitive receptor locations, which will be a function of particle size and composition, the proximity of sources to populated areas / receptors, as well as the potential for transportation of those emissions (e.g. meteorology).
- Particle speciation studies within urban and mining areas have shown that airborne fine particle concentrations comprise 'primary PM' released directly from natural and anthropogenic sources in addition to a significant proportion of 'secondary PM' formed in the atmosphere from the chemical conversion of gaseous emissions.
- Industry emissions should be considered in relation to overall population exposure to PM from different sources, and toxicity of different PM components.

Standards, Monitoring and Regulation

- Whereas Australia has set ambient air quality standards for PM_{10}, no national air quality standard has yet been set for $PM_{2.5}$, with only an advisory reporting standard for $PM_{2.5}$ currently in place. The intention of this advisory reporting standard was to gather sufficient $PM_{2.5}$ monitoring data to facilitate the review and revision of the NEPM-AAQ.
- In the absence of national air quality standards for $PM_{2.5}$, the advisory reporting standard has been increasingly referenced as a compliance measure.
- When compared with international standards Australia's annual advisory reporting standard for $PM_{2.5}$ (8 $\mu g/m^3$) is more stringent that the recently revised US standard (12 $\mu g/m^3$), World Health Organisation (WHO) interim targets (15-35 $\mu g/m^3$) and the WHO guideline (10 $\mu g/m^3$).
- The national 24-hour PM_{10} standard is set at an equivalent concentration to the WHO guideline and EU standard (50 $\mu g/m^3$), with marginally lower restrictions on the number of exceedances compared to the WHO guideline (5 days/year compared to the WHO's 3 days/year).
- The EU permits up to 35 days/year above 24-hour PM_{10} standard. However it is acknowledged that the monitoring locations where these are assessed include major roadways, etc.
- In the recent revision of its standards the US set more stringent standards for $PM_{2.5}$ but retained its existing 24-hour PM_{10} standard of 150 $\mu g/m^3$ to address the lower health risks related to coarser PM.
- Regulation at state level, for existing and proposed industry, often makes reference to compliance with NEPM standards. However, this is inconsistent with the purpose if the NEPM. The intent of the AAQ NEPM standards is that they are applied at monitoring locations that are not influenced by a particular pollution source (e.g. heavy industry, heavily trafficked road or coal mine).

- The setting and application of air quality standards and exposure reduction targets should be based on robust scientific research and health advice, taking into account relative health impacts of particle size (PM_{10} versus $PM_{2.5}$), composition and source (crustal dust versus combustion derived PM) and context (urban versus rural).
- Ongoing monitoring and research is recommended to better understand PM (composition, size) emitted by the minerals industry, as well as further knowledge of dust control. This will facilitate more robust evaluations of the cost-effectiveness of control measures versus their respective contribution to nuisance and health outcomes.
- Measurement and monitoring techniques need to be consistent and appropriate for Australian conditions. This includes the unique Australian environment and the contemporary operation of Australian Industry.
- There are currently more sites measuring PM_{10} than $PM_{2.5}$, in spite of recent evidence which indicates that exposure to smaller particles ($PM_{2.5}$) presents a higher risk to human health than exposure to larger particles (PM_{10} and TSP).

Exposure Risk and Management

- The minerals industry has a programme of measures to reduce emissions of PM and exposure to ambient air pollution.
- Air quality management within the mining industry is subject to continual improvement, with techniques that were previously deemed leading practice becoming standard industry practice.
- There is demonstrable evidence of continual improvement in terms of PM management and control.

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