National Environment Protection
(Ambient Air Quality) Measure

Impact Statement for $PM_{2.5}$ Variation

Setting a $PM_{2.5}$ Standard in Australia

October 2002

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1 INTRODUCTION

1.1 PURPOSE OF THE VARIATION TO THE AMBIENT AIR QUALITY NEPM

The purpose of this variation is to introduce a standard for particles (as $PM_{2.5}$) in the form of an advisory reporting standard into the National Environment Protection (Ambient Air Quality) Measure.

The current particle standard in the Ambient Air Quality NEPM relates to particles with a mean aerodynamic diameter of 10 micrometres or less (PM_{10}).

When the National Environment Protection Council made the Ambient Air Quality NEPM in 1998, the Ministers comprising the NEPC also agreed to a program of future actions, including a review (commencing by 2001) of the particle standard with a view to incorporating a standard for particles with a mean aerodynamic diameter of 2.5 micrometres or less ($PM_{2.5}$). Moreover the agreed program of future actions includes a complete review of the Ambient Air Quality NEPM scheduled to commence in 2005.

In December 2000, NEPC resolved to conduct a review to determine whether an ambient air quality standard for $PM_{2.5}$ is needed in Australia, and the feasibility of developing such a standard. The form of the $PM_{2.5}$ standard proposed in this variation takes cognisance of the future full review of the Ambient Air Quality NEPM.

1.2 THE NATIONAL ENVIRONMENT PROTECTION COUNCIL

The *National Environment Protection Council Acts* of the Commonwealth, States and Territories establish the National Environment Protection Council (NEPC), which comprises Ministers representing each of the participating governments. The NEPC is empowered by the Acts to develop and make National Environment Protection Measures (NEPMs).

The Acts provide for the development of NEPMs that relate to a specific set of environmental matters listed in Section 14 of the Acts, and require that each NEPM must comprise one or more of a standard, goal, guideline or protocol. The object of the Acts is to ensure that all Australians enjoy the benefits of equivalent protection from air, water, soil and noise pollution, and that business decisions are not distorted nor markets fragmented by variations in major environment protection measures between participating governments.

NEPMs that have already been made can be varied under Section 20 of the Acts.

Once a NEPM or its variation has been finalised, it is then formally “made” by NEPC. A decision to make a NEPM requires a two-thirds majority of members of NEPC. NEPMs are implemented by the jurisdictions that participate in the Council within their own jurisdictional legal frameworks.

1.3 PURPOSE OF THE IMPACT STATEMENT

In making or varying a NEPM, NEPC must have regard to the following matters (Section 15 of the NEPC Acts):

- consistency with the Inter-Governmental Agreement on the Environment 1992;
- environmental, economic, and social impacts;
- relevant international agreements; and
- any regional environmental differences.

Prior to making or varying a NEPM, a draft of the NEPM or the NEPM variation and an Impact Statement must be prepared. The Impact Statement must include (Section 17 of the NEPC Acts) the following:

a) the desired environmental outcomes;
b) the reason for the proposed measure and the environmental impact of not making the measure;
c) a statement of the alternative methods of achieving the desired environmental outcomes and the reasons why those alternatives have not been adopted;
d) an identification and assessment of the economic and social impact on the community (including industry) of making the proposed measure;
e) a statement of the manner in which any regional environmental differences in Australia have been addressed in the development of the proposed measure;
f) the intended date for making the proposed measure; and
g) the timetable (if any) in relation to the proposed measure.

The NEPC Acts require that both the draft NEPM (or the NEPM variation) and the Impact Statement be made available for public consultation for a period of at least two months. NEPC must have regard to the Impact Statement and submissions received during public consultation in deciding whether to make the NEPM or the NEPM variation.

An Impact Statement relating to a proposed NEPM variation should address the impacts of the proposed actions or program, demonstrate that the proposal is justified, and provide a reasonable basis for informed comment by stakeholders and the community.

The proposal under consideration in this Impact Statement is a variation to the existing Ambient Air Quality NEPM to extend its coverage to $PM_{2.5}$.

Section 20 of the NEPC Acts requires any variation to be developed in a manner similar to the development of a new NEPM. However, under Section 20, a variation is not a NEPM in its own right and, therefore, this variation is not itself a new NEPM. Consequently, the approach taken in this Impact Statement takes into account the original aims of the Ambient Air Quality NEPM and examines the potential impact of the proposed variation on the costs and benefits of initiatives related to the introduction of a $PM_{2.5}$ standard.

1.4 STAKEHOLDERS

The stakeholders who may have an interest in the proposed NEPM variation are:

- State and Territory government agencies responsible for implementation of the Ambient Air Quality NEPM;
- State and Territory government agencies responsible for the management and control of point source emissions;
- Agencies responsible for the provision of health services for people who may be affected by air pollution;
- Government and industry bodies responsible for standards for motor vehicle engine design and fuel quality;
- State and Territory government agencies and local government authorities responsible for transport and land use planning;
- State and Territory government agencies responsible for fire risk management;
- Industries which emit $PM_{2.5}$;
- Manufacturers of solid fuel heaters;
- Motor vehicle manufacturers and organisations;

- Members of the community as users of diesel and petrol fuelled motor vehicles and solid fuel heaters; and
- All members of the community that will benefit from improved air quality.

1.5 NEPM Variation Development And Consultation Strategies

1.5.1 Review Process

A team (comprising representatives from the Commonwealth, New South Wales, Victoria, Western Australia and the National Health and Medical Research Council) conducted the review.

A Jurisdictional Reference Network (JRN) was established with a government representative from each State and Territory and the Commonwealth. The JRN provided advice to the Review Team and coordinated input from their respective jurisdictions to the process. JRN members have prime carriage for jurisdictional public consultation strategies. To facilitate consultation with non-government stakeholders, a Non-Government Organisation (NGO) Advisory Group was established comprising key health, scientific, environment, community, air monitoring and industry representatives.

The first step in the review was the preparation of an Issues Paper by the Review Team. The purpose of the Issues Paper was to identify if a $PM_{2.5}$ standard was necessary and issues that would need to be addressed during development of such a standard. The NGO Advisory Group and the JRN assisted in the refinement of the Issues Paper. The Issues Paper was placed on the NEPC website and comment was sought from a broad range of stakeholders. Twenty-four written submissions were received.

The Issues Paper and a summary of submissions received by NEPC in relation to the Issues Paper are available on the NEPC website (www.ephc.gov.au).

The second step of the review comprised analysis of stakeholder comments and further consultation with the NGO Advisory Group and the JRN, followed by development of the review report. The report of the review was considered by NEPC in September 2001.

1.5.2 NEPM Variation Process

Following consideration of the report of the review in September 2001, NEPC announced the start of a formal process to vary the Ambient Air Quality NEPM to extend its coverage to $PM_{2.5}$.

A Project Team (comprising representatives from the Commonwealth (Environment Australia and the Commonwealth Department of Health and Ageing), New South Wales, Victoria, Western Australia, and South Australia) has been established to develop the draft variation and Impact Statement. An NGO Advisory Group and a JRN (see Appendix 2) have also been established, consistent with the review process undertaken previously. In addition, individuals with recognised health and air monitoring expertise have provided advice and peer review of relevant documentation.

The first step in the variation process was the preparation of a Discussion Paper *"Setting a $PM_{2.5}$ Standard in Australia"* by the Project Team. The primary purpose of the Discussion Paper was to get agreement from stakeholders on the adverse health effects and sensitive groups to be protected by a standard, and to establish a standard setting process that was acceptable to the majority of stakeholders. The NGO Advisory Group, JRN and the peer reviewers assisted in the refinement of the Discussion Paper. The Discussion Paper was placed on the NEPC website in February 2002 and comment on it was sought from a broad range of stakeholders. Fifty-two written submissions were received.

The Discussion Paper and a summary of submissions received by NEPC in relation to the Discussion Paper are available on the NEPC website (www.ephc.gov.au).

Following analysis of the comments received on the Discussion Paper, a report was developed which characterises the risks associated with a range of potential $PM_{2.5}$ standards. The inputs into this phase of the project were:

- identification of appropriate dose-response relationships; and
- collection of available $PM_{2.5}$ data and an assessment of Australian population exposure.

The NGO Advisory Group, JRN and peer reviewers assisted in the refinement of the risk modelling report, and the views of stakeholders were sought through workshops held in Adelaide, Brisbane, Melbourne, Perth and Sydney.

At its meeting on 11 October 2002, NEPC agreed to release this draft NEPM variation and Impact Statement for the statutory public consultation required by the NEPC Acts. The consultation period will commence on Thursday, 24 October 2002 and finish on Tuesday, 24 December 2002.

The views of stakeholders on these documents will be sought through meetings to be held around Australia during the consultation period, and written submissions on them are encouraged. NGO Advisory Group and JRN views will also be sought.

The NEPM variation process has involved consultation at critical stages to ensure stakeholder understanding of, input into and ultimately acceptance of the process and its outcomes.

1.5.3 Making a Submission

The NEPC encourages you to provide comment on the draft Variation and Impact Statement.

Written submissions should be sent to:
Mr Ian Newbery
Project Manager
NEPC Service Corporation
Level 5, 81 Flinders Street
ADELAIDE SA 5000
Telephone: (08) 8419 1210
Facsimile: (08) 8224 0912
Email: mgilbey@nepc.gov.au

The closing date for submissions is Tuesday, 24 December 2002.

All submissions are public documents unless clearly marked "confidential" and may be made available to other interested parties, subject to Freedom of Information Act provisions.

Form of Submission

An electronic form for lodging comments is available. The form can be emailed to you by the NEPC Service Corporation or downloaded from the NEPC website (www.ephc.gov.au). This form can be filled out and submitted electronically. Consideration of your submission will be facilitated if it is provided, if possible, in this format.

Should you wish to provide your comments in another format, submissions may be made:

- in hardcopy;
- on a 3.5 inch floppy disk; or
- emailed to mgilbey@nepc.gov.au.

To allow ease of photocopying, hardcopy submissions should be unbound. Electronic submissions should preferably be provided in Microsoft Word format.

2 PURPOSE OF THE VARIATION TO THE AMBIENT AIR QUALITY NEPM

2.1 REASONS FOR INTERVENTION

Many studies have been conducted worldwide to investigate the effects of particles on health. These studies have used mainly total suspended particles (TSP) or PM_{10} as the measure of ambient particle levels, but more recently $PM_{2.5}$ and $PM_{10-2.5}$ have also been investigated. The results of these studies have shown that particles are associated with adverse health effects, such as increases in daily mortality or hospital admissions for respiratory or cardiovascular disease. These effects are observed even at current ambient levels, which are considerably lower than those experienced during the early episodes of very high pollution levels in Belgium, the USA and London where the first reports of adverse health effects related to air pollution emerged.

While health effects have been observed for all size fractions investigated, $PM_{2.5}$ is known to penetrate deeper into the lung than either PM_{10} or $PM_{10-2.5}$ and retained preferentially to the larger size fractions. This suggests that $PM_{2.5}$ may play a more important role in the long-term effects attributable to particles than either PM_{10} or $PM_{10-2.5}$.

Accordingly, consideration has been given to the effectiveness of the current PM_{10} standard as a surrogate for $PM_{2.5}$. While the ratio of $PM_{2.5}$ to PM_{10} in Australia is generally about 0.5 based on an annual average, there are wide variations depending on season and airshed, in particular in winter when woodsmoke can become a dominant source of particles. Analysis of existing PM_{10} and $PM_{2.5}$ data obtained from co-located sources in New South Wales, Victoria and Western Australia shows that the ratio of $PM_{2.5}$ to PM_{10} varies depending on season and location, and can range from 0.3 to 0.9.

The absence of consistent $PM_{2.5}$ to PM_{10} ratios in Australia reflects the wide range of sources in urban and rural areas that emit particles. Particle sources vary greatly in terms of the particle size fractions emitted, particle composition and spatial and temporal distributions. Coarser particles tend to be produced by mechanical processes, whereas the size distribution for combustion-derived particles (eg motor vehicle exhaust, especially diesel vehicles, and woodsmoke) is generally dominated by particles smaller than $PM_{2.5}$.

These data have important implications for the management of particles, as source management strategies designed to reduce PM_{10} levels may not be adequately targeting $PM_{2.5}$ sources in areas where the coarse fraction dominates. The setting of $PM_{2.5}$ standards under the Ambient Air Quality NEPM will facilitate the collection and reporting of $PM_{2.5}$ data by jurisdictions. This may assist jurisdictions in the development of management strategies for the control of $PM_{2.5}$ while providing benchmarks against which the quality of the air can be assessed.

An associated environmental benefit from the application of health based air quality standards is improved visual amenity, often the measure of the community's perception of air quality, where the special scenic value of an area depends on a high level of air clarity.

2.2 REGULATORY OBJECTIVES

The desired environmental outcome of the NEPM variation accords with that of the original NEPM ie "… ambient air quality that allows for the adequate protection of human health and well-being".

The objective of the $PM_{2.5}$ variation is to establish national standards that will enable jurisdictions to assess air quality against benchmarks that have been set to take into account the protection of human health. The introduction of the variation will also facilitate consistent data collection and reporting of $PM_{2.5}$ data by jurisdictions.

The standards proposed in this NEPM variation are advisory reporting standards which are discussed further in Section 4.2.2. With this form of standard, the goal does not set a time line for compliance.

The proposed goal of the variation is different in type from that of the Ambient Air Quality NEPM, as the purpose of the variation is to achieve reporting against a standard which is of an 'advisory reporting' nature rather than a standard as used in the Principal Measure. The goal of the variation is therefore not framed in terms of compliance with the standard, rather it is "to gather sufficient data nationally to facilitate the review of the Principal Measure as varied, scheduled to commence in 2005".

$PM_{2.5}$ levels are to be measured at nominated performance monitoring stations located to give an 'average' representation of general exposure of the population to $PM_{2.5}$. Like the other standards set under the Ambient Air Quality NEPM, the $PM_{2.5}$ standards are not designed to be applied to monitoring peak concentrations, (eg near major industry or heavily trafficked roads), however controlling point sources may assist in managing $PM_{2.5}$ levels within an airshed.

The variation to the NEPM will require jurisdictions to report to NEPC the extent of monitoring undertaken or planned, instances where the $PM_{2.5}$ levels are above the standards, and any actions taken to reduce ambient levels of $PM_{2.5}$.

If monitoring data show that $PM_{2.5}$ levels are higher than the standards, then it is entirely at the discretion of the jurisdiction as to what action, if any, should be taken to reduce emissions of $PM_{2.5}$.

In establishing $PM_{2.5}$ standards and an associated monitoring protocol, the NEPM variation will provide a tool for:

- collecting consistent data on $PM_{2.5}$ levels in Australia;
- communicating information to the community on air quality related to $PM_{2.5}$; and
- assessing the effectiveness of air quality management programs that are designed to manage $PM_{2.5}$ emissions.

Together these outcomes should in turn facilitate more cost effective programs, better priority setting by governments at the state and national levels, improvements in infrastructure development planning, more informed choices by individuals and consequential risk reduction (particularly for those with high sensitivity to air pollution) and possibly behavioural change.

3 $PM_{2.5}$ IN AUSTRALIA

3.1 NATURE OF PARTICLES

Particulate matter consists of solid particles and liquid droplets, typically composed of elemental carbon, adsorbed organic compounds, sulfates, nitrates, metals and other trace elements. Secondary particles are formed from gases and include sulfates, nitrates, ammonium and hydrogen ions. Adsorbed organic components include toxic combustion products such as polycyclic aromatic hydrocarbons (PAHs), nitro-PAHs and oxidised PAH derivatives.

The State of Knowledge Report (EPA Victoria, 1998) notes that a complete description of particles includes density, concentration, size distribution, chemical composition, phase, morphology, diffusion, dispersion, air mass type, atmospheric transport, transformation, washout and deposition. Secondary particles formed from atmospheric processes can account for the bulk of particle mass in some situations.

There are a large number of components present in particles, including transient or short-lived components. Understanding the contributions of various sources to aerosol precursor concentrations, as well as aerosol transport and transformation processes in the atmosphere is an active area of research.

The particle size components are generally defined as:

- PM_{10} – particles with an equivalent aerodynamic diameter of 10 µm or less;
- $PM_{2.5}$ – particles with an equivalent aerodynamic diameter of 2.5 µm or less;
- ultrafine particles – particles with a diameter of 0.1.µm or less; and
- nanoparticles – particles with a diameter of 0.05 µm or less.

Gathering information on the smallest particle components (ultrafine particles and nanoparticles) is especially difficult due to the complexity of the instrumentation and measurement required, as well as difficulties in modelling, data interpretation, exposure assessment and risk quantification (Morawska, 1999).

There is still uncertainty relating to the health effects of particles with respect to whether particle size or composition is responsible for the observed effects. At present there is no clear evidence that particle composition plays a role in the observed health effects.

3.2 SOURCES OF PARTICLES

The Issues Paper noted the large contribution to particle levels made by motor vehicles and domestic wood combustion. Wood combustion is an important source in autumn and winter in the cooler southern regions of Australia, while motor vehicles (and secondary particles in some areas) are important sources in the warmer months. Some industrial emissions and natural sources such as soil and sea salt can also be significant contributors to particle mass in some areas. Bushfires and controlled burns can contribute to elevated particle levels.

Existing management strategies for PM_{10} generally assist in $PM_{2.5}$ control as well, although a greater focus on combustion sources (eg motor vehicles and wood combustion) may be required for $PM_{2.5}$. A number of strategies are already generally in place for major urban centres in Australia. Noting that diesel vehicles are the major contributor to $PM_{2.5}$ emissions from transport, in June 2001 the NEPC made the Diesel NEPM partly to manage $PM_{2.5}$ levels from this source.

Appendix 1 summarises the range of management strategies put in place by jurisdictions to address particle pollution.

3.3 CURRENT AMBIENT LEVELS

The Issues Paper discussed typical levels in urban and regional environments. Compilation of data from jurisdictions during the risk assessment phase has allowed further analysis of current levels.

Table 3-1 presents $PM_{2.5}$ monitoring data for the most recent consecutive three-year period for New South Wales, Victoria, Queensland and Western Australia. Twenty-four hour averages range from less than 5 µg/m³ to over 100 µg/m³, with higher levels generally coinciding with periods of bushfires and controlled burns. Annual averages range from less than 5 µg/m³ to 12 µg/m³ for the dataset considered. The annual average values reflect the wide daily variation in observed $PM_{2.5}$ levels.

Table 3-1: $PM_{2.5}$ Monitoring Results

		24-hour		Annual	
		Maximum	Minimum	Maximum	Minimum
	SITE	µg/m³	µg/m³	µg/m³	µg/m³
VIC	Alphington	43.9	3.1	9.8	9.2
	Brighton	31.0	2.5	9.2	6.9
	Footscray	35.7	2.3	9.1	8.6
QLD	CBD(QUT) (A)	30.6	1.4	7.6	6.7
	Rocklea	92.0	0.0	5.7	5.0
	Rocklea (A)	42.9	0.9	7.1	5.1
	Springwood	33.5	0.0	6.4	4.3
WA	Duncraig	27.0	2.6	8.6	8.0
	Caversham	31.8	1.3	7.6	7.2
	Bunbury	47.3	2.2	9.3	8.7
NSW	Liverpool	118.6	2.1	11.8	9.7
	Lidcombe	82.9	3.2	11.1	9.9
	Woolooware	81.9	2.7	11.1	8.1
	Wallsend	61.5	2.9	10.2	8.0
	Beresfield	66.4	2.8	8.8	8.8
	Wollongong	53.4	2.8	8.0	8.0
	Warrawong	32.6	2.5	9.9	8.3
	Richmond	101.3	2.4	6.7	6.7
	Westmead	91.6	2.6	9.9	9.9

These data are based on TEOM measurements, except those marked with an "A", which were recorded with an ANSTO sampler. TEOMs are known to underestimate peak particle concentrations under some circumstances, due to sample heating and loss of semi-volatile components. This effect is more pronounced in areas where the $PM_{2.5}$ has a high organic content (eg woodsmoke impacted areas), of which a proportion will be semi-volatile and prone to being volatilised and lost from the TEOM sample. No attempt has been made to account for this effect in the data presented above.

3.4 OVERSEAS STANDARDS

While PM_{10} standards have been established in a number of countries, only the USA and Canada have adopted $PM_{2.5}$ standards. This is largely because $PM_{2.5}$ air monitoring data are not as widely available and the health effects of $PM_{2.5}$ have only recently been established.

3.4.1 United States of America

$PM_{2.5}$ standards set by the US EPA are currently set at 65 $\mu g/m^3$ (24 hour average) and 15 $\mu g/m^3$ (annual average). It should be noted that the 24-hour average standard is designed to measure peak exposures rather than average exposure levels (such as those monitored under the Ambient Air Quality NEPM). These standards are based on the 98^{th} percentile of the 3-year average of the 24-hour values at all sites. The US EPA is currently reviewing their 24-hour and annual average $PM_{2.5}$ standards.

California has recently adopted an annual average $PM_{2.5}$ standard of 12 $\mu g/m^3$ (not to be exceeded). A proposal to adopt a 24-hour standard of 25 $\mu g/m^3$ is still under consideration.

3.4.2 Canada

In June 2000, all provincial (except Quebec) and territorial governments and the federal government adopted Canada-wide standards for particulate matter setting a 24-hour average standard of 30 $\mu g/m^3$ for $PM_{2.5}$ (based on the 98^{th} percentile ambient measurement annually, averaged over 3 consecutive years). This standard has been established for the interim period prior to the planned review of the standard to be completed in 2005, which will include the consideration of advancements in scientific, technical and economic information and analysis. The standard is to be achieved by 2010.

3.4.3 New Zealand

The Ministry for the Environment has recently completed a review of New Zealand's 1994 Ambient Air Quality Guidelines, publishing new guideline values for priority air pollutants including particles, to protect human health and the environment.

Due to the lack of information available on sources and levels of $PM_{2.5}$ in New Zealand, the new Ambient Air Quality Guidelines do not set a formal guideline for $PM_{2.5}$. However, through the revised Guidelines the Ministry is aiming to encourage $PM_{2.5}$ monitoring and assessment. To facilitate this, a 24-hour average "monitoring value" of 25 $\mu g/m^3$ has been included, as a value against which monitoring results should be compared. An investigation into $PM_{2.5}$ will commence in 2002 with the aim of establishing an appropriate guideline value by 2004.

3.4.4 United Kingdom

The United Kingdom has chosen not to set a $PM_{2.5}$ standard. A UK Expert Panel reaffirmed this position in 2000, acknowledging that while particle pollution is associated with a range of health effects, the PM_{10} standard provides an appropriate level of protection noting a close correlation existing in the UK between levels of PM_{10} and $PM_{2.5}$ (UK Department of the Environment, Transport and the Regions, 2000).

4 ALTERNATIVE METHODS OF ACHIEVING THE DESIRED ENVIRONMENTAL OUTCOME

Section 17(b) of the NEPC Act requires that an impact statement include:
"a statement of the alternative methods of achieving the desired environmental outcomes and the reasons why those alternatives have not been adopted".

The alternative means of achieving the desired environmental outcome can be broken down into two main types:

- alternatives approaches; and
- alternative standards for $PM_{2.5.}$

4.1 ALTERNATIVE APPROACHES

The desired environmental outcome in managing $PM_{2.5}$ is the achievement of air quality that allows for the adequate protection of human health and well being. There are several approaches that may be considered in the light of their ability to deliver the desired environmental outcome. These are:

- Commonwealth legislation;
- guidelines;
- inter-governmental agreement or memorandum of understanding;
- maintain the status quo; and
- variation of the Ambient Air Quality NEPM.

4.1.1 Commonwealth Legislation

Legal advice obtained at the time of making the Ambient Air Quality NEPM in 1998 indicated that it may not be possible for the Commonwealth, given its powers under the Constitution, to introduce legislation that could deliver the desired environmental outcomes being pursued through the variation to the NEPM. Further, the Commonwealth is unlikely to pursue unilateral action to set air quality standards, given the cooperative national approach being taken at present in relation to environmental issues, particularly through the NEPC and the Environment Protection and Heritage Council and the fact that the States have responsibility for air quality management.

4.1.2 Guidelines

NHMRC has previously determined a set of air quality guidelines for some of the major air pollutants based on their human health effects. These guidelines are employed by several jurisdictions and provide guidance in the development of air quality programs. No guidelines, however, exist for $PM_{2.5}$. Different approaches in the application of the NHMRC guidelines between jurisdictions have significantly reduced the level of certainty envisaged by the Inter-Governmental Agreement on the Environment. The NEPC was established with the ability to develop standards for ambient air quality. The clear intention at the time of making the Ambient Air Quality NEPM was that the NEPM standards would replace NHMRC guidelines for air quality.

Current NHMRC guidelines make no reference to standardising monitoring or reporting requirements between jurisdictions, making cross-jurisdictional comparisons difficult and possibly creating compliance difficulties for industries with operations in more than one jurisdiction.

4.1.3 Inter-governmental Agreement to adopt Ambient Air Quality Standards for $PM_{2.5}$.

An overarching agreement would provide for a common starting point for the development and implementation of national ambient air quality standards for $PM_{2.5}$.

The issue of how such standards should be developed and the impacts of any standards would need to be addressed. This could be achieved by agreement, either in line with the NEPC process or by each jurisdiction agreeing to manage this issue within their jurisdiction. In the latter case, several jurisdictions would need to establish mechanisms of the type currently envisaged under the draft variation. This approach would not necessarily provide a sufficient degree of uniformity or compatibility in the standards setting process or the monitoring and reporting requirements necessary to make the standards meaningful. The future actions agreed to by the NEPC when making the Ambient Air Quality NEPM called for jurisdictions to commence monitoring for $PM_{2.5}$. This occurred in four jurisdictions, providing the data on which this variation is based. It is considered that the most effective way to ensure consistency in data collection is the development of the variation to the NEPM.

As with the guidelines option discussed above, the agreed standards and monitoring and reporting requirements would not have any legislative basis. The history of implementation of such guidelines in Australia is such that uniformity would be very difficult to achieve.

This approach offers no obvious advantage over the NEPM variation as a similar process would be required, but without the likelihood of achieving uniformity in practice.

4.1.4 Maintaining the Status Quo

Arguments to maintain the *status quo* imply that the desired environmental outcomes of the variation are afforded by the PM_{10} standard in the Ambient Air Quality NEPM and that actions taken by jurisdictions to date to address particle emissions are adequate/appropriate to address $PM_{2.5}$.

The *status quo* needs to take into account systems as they evolve and does not necessarily mean that ambient air quality standards for $PM_{2.5}$ would not develop at some point. It is recognised that there are current developments in jurisdictions that will result in substantial improvements in ambient $PM_{2.5}$ levels. Some improvements are the result of national strategies, for example, the introduction of vehicle fuel quality standards. Other strategies have been developed by individual jurisdictions to improve particular aspects of air quality.

At present, for pollutants not covered by the Ambient Air Quality NEPM, air quality reporting standards differ widely between jurisdictions, reflecting their often different requirements for usage of the data collected. Costs are also incurred by some jurisdictions in developing and revising their respective air quality standards resulting in duplication of costs and effort. The different procedures and interests of each jurisdiction can also result in additional industry costs and effort in providing data and input into standard setting or revision.

At present, the level of community input to air quality standards development varies from jurisdiction to jurisdiction. It is also unclear whether the development of a standard for $PM_{2.5}$ evolving under these circumstances would provide industry and the general community with the level of access and input into standards development that occurs with the NEPC process.
It could also be expected that any evolution in air quality standards that did take place would occur at different rates among jurisdictions depending on their environmental management experience and supporting systems already in place, thus making it more difficult for industry

to plan at the national level. A national picture of air quality relating to $PM_{2.5}$ would also be less likely to emerge.

Community submissions on the Issues and Discussion Papers prepared as part of the development of the draft variation show that there is strong support for national standards for $PM_{2.5}$. The '*status quo*' option does not deliver any improved national uniformity.

4.1.5 Variation of the Ambient Air Quality NEPM

A variation to the Ambient Air Quality NEPM will facilitate a harmonised national framework for $PM_{2.5}$ monitoring and reporting in conjunction with the framework already established under the NEPM.

National air quality standards are intended to achieve the NEPC objective of providing equivalent protection, in this case from the adverse health effects associated with air pollution. NEPM standards provide a well defined objective for management of air quality, enhancing national certainty in environmental protection.

The implementation of this variation would allow for jurisdictions to flexibly implement monitoring as resources become available, as there is no timeframe set for compliance with the variation. The goal of this NEPM variation is to ensure collection of data to facilitate the full review of the Ambient Air Quality NEPM including the $PM_{2.5}$ standard, scheduled to commence in 2005.

As indicated above, other means of approaching the issue would not necessarily provide a sufficient degree of uniformity or compatibility in the standards setting process or the monitoring and reporting requirements necessary to make the standards meaningful.

Consideration of the alternatives clearly points to a variation of the Ambient Air Quality NEPM as the preferred option, which is considered to be the most effective way to achieve national consistency in the monitoring and assessment of air quality relating to $PM_{2.5}$.

4.1.6 Consequences of not making the Variation to the Measure

If the variation to the Ambient Air Quality NEPM is not made, it is likely that the current levels of monitoring and reporting delivered by the jurisdictions will continue in their current form for $PM_{2.5}$. Without national consistency, some jurisdictions may adopt standards, but these may vary between jurisdictions. This could result in differing environmental performance requirements between jurisdictions which would fail to deliver the objectives of the Inter-Governmental Agreement on the Environment, in particular the goal of the National Competition Policy, the "level playing field" and certainty for business decision-making objectives. Voluntary attempts to achieve harmonisation between jurisdictions have had mixed success. The NEPC was specifically established to overcome the problems associated with those voluntary attempts in a manner consistent with the nature of Australian governance.

Not making the variation to the NEPM would remove an essential stimulus for a harmonised national air monitoring and reporting system for $PM_{2.5}$. The current situation whereby jurisdictions collect data using different monitoring regimes, and store and report the data in varying formats is likely to continue in the absence of a national approach.

4.1.7 Summary

Consideration of the alternatives clearly points to a variation of the Ambient Air Quality NEPM as the preferred option. The variation to the Ambient Air Quality NEPM is considered to be the most effective way to achieve national consistency in the monitoring and reporting of $PM_{2.5}$ in Australia.

4.2 ALTERNATIVE STANDARDS FOR $PM_{2.5}$

A standard is a benchmark for comparison with ambient air quality data. No other mechanism is available to ensure that all jurisdictions adopt the same benchmark. In the past, guidelines such as those issued by NHMRC and ANZECC dealing with a range of issues have not delivered consistency throughout the country. In developing the ambient air quality NEPM all jurisdictions recognised that developing air quality standards through NEPC was the only way to ensure national consistency and the desired environmental outcome of equivalent protection for all Australians.

The inclusion of standards for $PM_{2.5}$ in the Ambient Air Quality NEPM is an extension of the current position.

As the variation to the NEPM introduces standards for $PM_{2.5}$ into the existing Ambient Air Quality NEPM, in deciding the form of the standard, consideration must be given to the structure of the existing NEPM. The Ambient Air Quality NEPM sets standards for six criteria pollutants, comprising a maximum concentration and an averaging period for measurement for each pollutant. The NEPM also establishes a goal that specifies the maximum number of exceedences that are to be met within a specified timeframe, ie within ten years of the making of the NEPM.

The PM_{10} standard is:

- maximum concentration – 50 micrograms / m^3
- averaging period – 1 day.

The goal of the NEPM with respect to PM_{10} is that a maximum of 5 exceedances per year of the standard is to be achieved within 10 years.

Each jurisdiction manages emissions to meet the standard and goal specified in the NEPM and reports annually against progress in meeting the goal of the NEPM. All jurisdictions have monitoring plans (approved by the Ministers comprising the NEPC) to meet the requirements of the Ambient Air Quality NEPM.

For PM_{10} there is a significant database on levels in ambient air in Australia. For $PM_{2.5}$ however data are limited and are available for Sydney, Melbourne, Brisbane and Perth. As the introduction of a standard for $PM_{2.5}$ will require jurisdictional monitoring of $PM_{2.5}$, it is important to consider the form that the standard might take and the implications for monitoring of ambient levels.

The types of standards that were considered for the variation are:

- Standard with Compliance Goal and Specified Monitoring and Reporting Protocol;
- Advisory Reporting Standard; and
- Reporting Against a Protective Health Value.

Each of these options was considered in the Discussion Paper and are summarised below.

4.2.1 Option 1: Standard with Compliance Goal and Specified Monitoring and Reporting Protocol

Consideration was given to a $PM_{2.5}$ standard that adopted a similar structure to that of the current Ambient Air Quality NEPM standards, in setting the standard as a maximum concentration, with a goal framed in terms of the achievement of the standard over a specified time frame.

As a consequence, the monitoring protocol for this option would be rigorous and parallel the protocol already in place for the Ambient Air Quality NEPM. This would require extensive monitoring of $PM_{2.5}$ at all existing sites that monitor PM_{10}.

The main advantage of this form of standard is that it would provide the most effective and widespread monitoring.

There are several disadvantages associated with this form of the standard. Nationally there are insufficient monitoring data resulting in reduced certainty in the assessment of the potential impacts arising from the potential introduction of such a standard. A standard based on such information may either not be stringent enough, or be unnecessarily stringent, could create therefore unforeseen problems for jurisdictions in implementation.

Similarly, if the goal associated with the $PM_{2.5}$ standard was not met, it would be necessary to initiate action to reduce emissions of $PM_{2.5}$. There is currently insufficient information to assess the ability of jurisdictions to achieve the goal, making the NEPM variation difficult to implement.

Finally, this option is the most resource-intensive, requiring significant resources to satisfy the requirements of the monitoring protocol and may be cost prohibitive for some jurisdictions.

Overall, the uncertainty associated with this option and the likely cost of implementation make this option unrealistic at this time.

4.2.2 Option 2: Advisory Reporting Standard

It is envisaged that this option will facilitate data collection to ensure that sufficient data are available for the setting of a $PM_{2.5}$ standard (as described in Option 1) during the review of the Ambient Air Quality NEPM, scheduled to commence in 2005.

An advisory reporting standard has the same numerical value as that under the Option 1 but without an associated goal setting a timeframe for compliance. The monitoring protocol associated with an advisory reporting standard establishes a reference method and monitoring and reporting requirements, but gives jurisdictions flexibility in relation to the timing and extent of monitoring they conduct. Any data collected can be assessed against the advisory reporting standard.

The setting of a numerical standard allows jurisdictions to compare their air quality against a health protective value. Jurisdictions can then choose to take an action as appropriate to reduce $PM_{2.5}$ levels.

Any monitors for $PM_{2.5}$ would be located in existing air monitoring stations identified in NEPM monitoring plans for PM_{10}, but the extent of monitoring would be decided by individual jurisdictions as resources become available. Jurisdictions would report to NEPC as part of their annual reporting cycle, on the monitoring undertaken or on plans to introduce monitoring into their existing network.

The major objective of the monitoring protocol under this option would be to ensure an improvement in the collection of Australia-wide $PM_{2.5}$ data and to encourage movement towards comprehensive monitoring carried out in a consistent and comparable manner. Under this option, jurisdictions not currently monitoring $PM_{2.5}$ may initially elect to only undertake limited monitoring in urban areas that are significantly impacted, while others might decide to establish comprehensive monitoring systems. This would be a decision for each jurisdiction.

This option also recognises the potentially significant investment required by jurisdictions to commence monitoring of $PM_{2.5}$, noting that only New South Wales, Victoria, Queensland and Western Australia currently collect such data on a routine basis.

The principal disadvantage of this option is that there is no mandatory requirement to achieve the standard by a given date, which may delay possible actions to reduce ambient levels of $PM_{2.5}$.

The main advantage of this option is that it allows maximum flexibility for jurisdictions in introducing monitoring of $PM_{2.5}$ as resources become available. It also allows for jurisdictions to focus resources on priority areas while providing a mechanism for the generation of a nationally consistent data set to facilitate the review of the NEPM commencing in 2005.

4.2.3 Option 3: Reporting Against a Protective Health Value

This option sets a value protective of human health, which would have the same numerical value as the standard under Option 1, and encourages the collection of sufficient Australia-wide data so as to enable the future establishment of a $PM_{2.5}$ standard (as described in Option 1) if that is considered desirable.

Under this option, jurisdictions would still be responsible for managing emissions but monitoring will be voluntary. There would be no associated compliance goal however, if monitoring is undertaken, annual reporting as to whether the protective health value is achieved would be required. If no monitoring is undertaken, this decision would be reported. Monitoring method(s) would be recommended so that consistent and comparable $PM_{2.5}$ data could be collected nationally.

The main advantage of this option is that there would be a protective health value set that would allow for assessment of ambient air monitoring data. The monitoring would be voluntary, and continuance of the existing situation, minimising costs for jurisdictions. Recommended monitoring methods may lead to an improvement in nationally consistent monitoring of $PM_{2.5}$.

The disadvantage of this option is that there are no guarantees that sufficient data will be collected to facilitate the review of the NEPM commencing in 2005. Through the consultation process there was support for both Options 1 and 2 but little support for this option.

4.2.4 Preferred Option

In developing the standard for $PM_{2.5}$ a number of scenarios assessing various numerical standards were considered through a risk assessment process. This process estimated the potential health impacts avoided by a reduction in $PM_{2.5}$ levels to the specified scenarios. These levels were further refined through the application of a cost effectiveness analysis and are discussed in detail in Sections 5 and 6.

Given the uncertainty in the current knowledge about $PM_{2.5}$ levels across Australia and the potential costs to jurisdictions for monitoring if Option 1 were pursued, it is proposed that the variation take the form of an Advisory Reporting Standard. Option 3 does not ensure the collection of sufficient $PM_{2.5}$ data to facilitate the review of the NEPM due to commence in 2005.

The draft variation includes standards (as advisory reporting standards) for $PM_{2.5}$. The standards are set to be protective of public health and provide a means of assessing air quality. The variation calls upon jurisdictions to monitor $PM_{2.5}$, report on the extent of monitoring undertaken and report instances where the $PM_{2.5}$ levels are above the standards.

4.2.5 Regional Environmental Differences

In making any NEPM or variation to an existing NEPM, the National Environment Protection Council must have regard to, *inter alia*, "any regional environmental differences in Australia" (Section 15(g) of the *National Environment Protection Council Acts*). In addition, Section 17(b)(v) of the Acts requires that the Impact Statement to be prepared with the draft variation include "a statement of the manner in which any regional environmental differences in Australia have been addressed in the development of the proposed Measure".

While the Acts do not provide any explicit definition of the term "regional environmental differences", Sections 15 and 17 provide a clear indication that the term is not intended to encompass regional economic and social differences.

The term "regional environmental differences" recognises that fundamental environmental characteristics of different regions may be very different, and that to apply uniform standards would not necessarily further the desired outcome of equivalent protection espoused in the legislation. For example, the issue of salinity in water bodies would provide a clear need for regional environmental differences to be taken into account in developing NEPM standards and goals for water quality.

For ambient air quality, there are no clear-cut differences in the natural state of the atmosphere that could meaningfully be reflected in different ambient air quality standards for the protection of human health. While atmospheric conditions can change rapidly and dramatically across Australia, this provides a challenge for air quality management strategies but cannot, in any practical sense, be reflected in standards. In determining appropriate standards for the protection of human health, available evidence suggests that the variation in physiological response to pollutants within any population is likely to be significantly greater than any potential variation in impact due to meteorological or other differences across Australia.

Air quality objectives have been applied uniformly in several overseas jurisdictions that have far more diversity in climate than does Australia. Primary Air Quality Standards legislated in the United States of America apply in all states of that country. They do not make allowances for regional climatic differences. Neither does the European Union in determining its air quality objectives.

Visual amenity, where the special scenic value of an area or its use for astronomical observations depends on a high level of air clarity, is an associated environmental benefit arising from application of health based air quality standards. In addition to the ambient air quality standards in the NEPM, several states also have visibility objectives in their legislation.

On the other hand it has been suggested that sub-regional differences or mesoclimates may be important. Where these are found to be significant in protecting human health, the impacts are most practically addressed through implementation programs developed by jurisdictions.

5 DERIVATION OF THE STANDARD

As part of the future actions of the Ambient Air Quality NEPM, a Risk Assessment Taskforce (RATF) was established to report to NEPC on the feasibility of using risk assessment for the development of air quality standards. The RATF Report recommends that a five stage framework including issues identification, hazard identification, identification of dose-response relationships, exposure assessment and risk characterisation could be used in the NEPC context to set air quality standards.

In deciding to develop a standard for $PM_{2.5}$, NEPC agreed to utilise the approach recommended by the RATF for the variation of the Ambient Air Quality NEPM. This process is outlined below with reference to the development of a recommendation for a standard for $PM_{2.5}$.

5.1 ISSUES IDENTIFICATION

With the release of the Issues Paper stakeholder views were sought as to whether a standard should be considered for $PM_{2.5}$. There was strong support for the development of a standard.

The issues raised through this process focussed on the health impacts of $PM_{2.5}$. It was considered that the introduction of a $PM_{2.5}$ standard would provide additional health protection beyond that provided by the PM_{10} standard. There was also strong support for the development of an annual average standard, in addition to a short-term standard, to protect against any long-term effects of exposure to $PM_{2.5}$.

5.2 HAZARD IDENTIFICATION

An increasing body of literature reports associations between particles and adverse health effects. Most information comes from epidemiological studies that have found increases in daily mortality, hospital admissions and emergency room attendances and exacerbation of asthma associated with daily changes in ambient particle levels. Much of these data come from US studies. In recent years there has been significant research conducted elsewhere, particularly Europe and the UK. These studies, while finding associations, differ from the US studies in the strength of the association and the size of the effect estimates. Recent US studies (Samet et al, 2000; Samet et al, 2001) show variability in the results across ninety US cities. Results from the Australian studies conducted to date indicate similar variability may be observed here.

Concern has been raised recently with respect to the results of epidemiological studies that have employed Generalised Additive Models (GAMs). This concern has arisen through reanalysis of the NMMAPs mortality study in the US where issues relating to the statistical modelling resulted in a reduction in the observed effects estimate from 0.5% per 10 $\mu g/m^3$ increase in PM_{10} to 0.2% per 10 $\mu g/m^3$ increase in PM_{10}. Many other studies, including Australian studies, have also used GAMs but have not observed the same problems observed in the NMMAPs mortality study. In addition, as the NMMAPs study only relates to PM_{10}, these data have not been used in the development of this variation. It should be noted that although a reduction in the effects estimate was observed in the NMMAPS work the associations observed between PM_{10} levels and mortality remained positive and statistically significant. The same level of impact in correcting for the statistical software issues did not occur in the reanalysis of the hospital admissions data in NMMAPS.

Populations that have been shown to be susceptible to the effects of particles include the elderly; people with existing respiratory disease such as asthma, chronic obstructive pulmonary disease (COPD) and bronchitis; people with cardiovascular disease; people with infections such as pneumonia; and children. Results of epidemiological studies have provided no clear evidence for the existence of a threshold value below which no adverse health effects are observed

Although there is a large body of literature linking adverse health effects with exposure to particles, most studies conducted have focussed on PM_{10} as there have been only limited air monitoring data available for $PM_{2.5}$. In some situations PM_{10} may be a good surrogate for $PM_{2.5}$ as the major component of PM_{10} is $PM_{2.5}$. For example, the results of studies conducted on the east coast of the USA are considered to be attributable to the $PM_{2.5}$ fraction as this accounts for approximately 80% of the total PM_{10} fraction. For studies conducted in other parts of the USA, for example Coachella Valley in California and Phoenix Arizona, where the contribution of $PM_{2.5}$ to total PM_{10} is lower, there is some evidence that the observed health effects cannot be attributed to $PM_{2.5}$ alone.

The US EPA in their current review of the particle standards in the USA are giving consideration to standards for both $PM_{2.5}$ and $PM_{2.5\text{-}10}$ in acknowledgment that both size fractions have associations with adverse health outcomes (US EPA, 2002).

The studies that have been conducted with $PM_{2.5}$ have shown that there are strong associations between adverse health effects and this size fraction. The results of some studies conducted with $PM_{2.5}$ have indicated that this size fraction may be more important than total PM_{10} for explaining the health effects attributed to exposure to particles. The strongest evidence for this has come from an analysis in a study conducted in six US cities (Schwartz et al, 1996), where daily mortality in these cities was strongly associated with short-term increases in $PM_{2.5}$ concentrations. The associations observed for total PM_{10} and the coarse fraction of PM_{10} ($PM_{10\text{-}2.5}$) were weaker than those observed for $PM_{2.5}$ alone. A recent re-analysis of this data (Klemm et al, 2000) confirmed the findings of the original analysis.

Australian studies have also shown adverse health effects associated with exposure to fine particles (EPA Victoria, 2001, 2000; Petroeschevsky et al, 2001; Simpson et al, 2000; Morgan et al, 1998a, 1998b; Simpson et al, 1997). All of these studies have used nephelometry data as a surrogate for $PM_{2.5}$. It should be noted that most of the studies overseas use gravimetric measures of $PM_{2.5}$.

Studies in Melbourne, Sydney and Brisbane have found that increases in daily mortality (all cause, respiratory and cardiovascular causes) are associated with increases in fine particles (EPA Victoria 2000; Simpson et al, 2000; Morgan et al, 1998a; Simpson et al, 1997). The Melbourne study shows that the results were not independent of the other pollutants except during the warm months. The Sydney and Brisbane studies found strong associations across the whole year. The strongest effects in all studies were found in the elderly.

The studies investigating the effects of fine particles on hospital admissions found strong associations in Melbourne, Sydney and Brisbane for admissions for respiratory and cardiovascular disease, asthma (especially in children <14 years) and COPD (EPA Victoria, 2001; Petroeschevsky et al, 2001; Morgan et al, 1998b). As with the studies on daily mortality, the strongest associations found in these studies were in the elderly and children.

The results discussed above have arisen from studies investigating the short-term, or acute, health effects arising from exposure to $PM_{2.5}$. There are only limited studies (Pope et al, 2002; Krewski et al, 2000; Peters et al, 1999; McConnell et al, 1999; Euler et al, 1987; Abbey et al, 1995; Pope et al, 1995; Dockery et al, 1993) that have been conducted to investigate the long-term health effects associated with exposure to $PM_{2.5}$. The long-term impact of particles on health has been an area of much uncertainty. However, a number of recent studies have established a strong basis for concern over long-term effects.

The Six Cities Study (Dockery et al, 1993), American Cancer Society Study (Pope 1995) and studies conducted in California in the Seventh Day Adventist communities (Euler et al, 1987; Abbey et al, 1995) have all indicated that long-term exposure to fine particles is associated with increases in mortality and the development of respiratory disease such as COPD and asthma. Another analysis of the California Seventh Day Adventists has shown that long-term exposure to $PM_{2.5}$ is more strongly associated with mortality than the coarse fraction $PM_{10-2.5}$ (McDonnell et al, 2000).

Recently, there has been further evidence to support the long-term impacts of $PM_{2.5}$. Krewski et al (2000) reanalysed the data from the Six Cities Study (Dockery et al, 1993) and the ACS Study (Pope et al, 1995) and confirmed the associations reported in the original analyses.

A more recent study has increased the concern about the long-term effects of $PM_{2.5}$ (Pope et al, 2002). The results of this study, which is a follow-up of the 1995 ACS Study (Pope et al, 1995), found that long-term exposure to $PM_{2.5}$ is strongly associated with increases in all cause, lung cancer and cardiopulmonary mortality. The results of this study have raised renewed concern over the importance of the long-term effects of exposure to $PM_{2.5}$.

Unlike ozone and NO_2, until recently there has been little toxicological evidence supporting the associations observed between particles and health in epidemiological studies. This situation is changing rapidly and toxicological evidence now provides some explanation of a biological mechanism for the effects of $PM_{2.5}$ observed in population-based studies, particularly those related to people with existing cardiovascular disease. However, despite this evidence, there still remains significant uncertainty around the biological mechanisms for the observed effects.

In the USA, legislation requires special consideration of children in assessing and monitoring air quality. In California, air monitoring networks must be set up to ensure that exposure of infants and children to air pollution is measured. Assessment of all air quality standards is also required to ensure protection of children's health. The following issues were identified as needing to be addressed when assessing the health impacts of air pollution:

- children have narrower airways than adults. Thus irritation or inflammation by environmental factors such as air pollution may be mild in adults but could result in a potentially significant obstruction of the airway in a young child;
- children's ventilation rates and surface area of their lungs differ from adults and make them more susceptible to the effects of air pollution;
- infant's and children's developing organs and tissues are more susceptible to damage from some environmental contaminants than are adult organs and tissues;

- exposure patterns for children may be different to adults leading to disproportionately high levels of exposure in comparison to the general population. Children spend significantly more time outdoors than adults; and
- air pollution exacerbates asthma which is particularly prevalent in children.

In developing a $PM_{2.5}$ standard for Australia the effects of $PM_{2.5}$ on all sensitive subgroups, including children, has been taken into account.

5.2.1 Health Endpoints Considered in the Setting of a $PM_{2.5}$ Standard

In setting standards for $PM_{2.5}$ a range of health endpoints have been considered that have been identified in epidemiological studies worldwide. Some of these have previously been investigated in the Australian situation, with similar effects observed. In developing a standard for $PM_{2.5}$, it is not appropriate to consider a single health endpoint as sensitive groups exist for a range of health outcomes. Therefore, the following health endpoints have been used in the development of the short-term standard for $PM_{2.5}$:

- daily mortality – all cause, respiratory and cardiovascular causes; and
- daily hospital admissions – respiratory and cardiovascular disease, asthma, COPD.

For long term health effects the following endpoints have been used:

- mortality - all cause, lung cancer and cardiopulmonary disease.

In selecting these health endpoints, consideration was given to the consistency of results from a wide range of studies (ie weight of evidence), the statistical significance of the associations observed and whether the effects had been observed in studies in Australia.

For the short-term mortality and hospital admissions categories, Australian data were used to validate the transferability of overseas data to the Australian situation. However, for the other outcomes, long-term mortality estimates, local data are not available and overseas data were adopted without validation.

The mortality outcomes relate primarily to the elderly and people with existing disease. The data on daily hospital admissions have been derived from studies conducted on people with existing disease, the elderly and children.

5.3 DOSE-RESPONSE RELATIONSHIPS

In identifying studies to be used in the development of the proposed standard it was considered that there were insufficient local studies on which to base a standard. Therefore the results of international studies have been used.

In selecting the studies a range of criteria was used. These included:

- similar climatic conditions to Australia;
- similar demographics to Australia;
- effect estimates that were statistically significant;
- $PM_{2.5}$ levels were as similar as possible to those experienced in Australia;
- similar sources of $PM_{2.5}$; and
- health effects had to have been observed in Australian studies.

The final studies selected and the dose-response relationships used in the development of the proposed standard are summarised in Table 5-1. These studies have also been identified as key studies for the review of the $PM_{2.5}$ standard in the USA.

Table 5-1: $PM_{2.5}$ Studies and Dose Response Relationships

Health Endpoint (refer to Section 5.2.1)	**Age Group**	**Dose-response % increase per 10 $\mu g/m^3$ increase in $PM_{2.5}$**	**95% Confidence Interval**	**Reference**
Short term effects (24-hour)				
<u>Mortality</u>				
All cause	All ages	2.3	1.3 – 3.3	Goldberg et al 2000
Respiratory	All ages	8.6	5.2 – 12.4	Goldberg et al 2000
Cardiovascular	All ages	1	0.15-1.9	Moolgavkar et al 2000a
<u>Hospital Admissions</u>				
Asthma	All ages	2.6	1 – 4.2	Burnett et al 1999
Cardiovascular Disease	Elderly	1.7	1 – 2.4	Moolgavkar et al 2000b
COPD	Elderly	2.6	0.4 – 4.8	Moolgavkar et al 2000c
Long term effects (annual average)				
Health Endpoint	**Age Group**	**Dose-response % increase per 10 $\mu g/m^3$ increase in annual average $PM_{2.5}$**	**95% Confidence Interval**	**Reference**
Mortality				
All Cause	All ages	6	2 - 11	Pope et al 2002
Lung Cancer		14	4 – 23	
Cardiopulmonary Disease		9	3 – 16	

5.4 EXPOSURE ASSESSMENT

In conducting the exposure assessment for the development of the draft standards for $PM_{2.5}$ the approach taken by the USEPA in their standard setting process was followed. This mirrored the approach taken to assess exposure in the epidemiological studies from which the health effects and dose response data were derived.

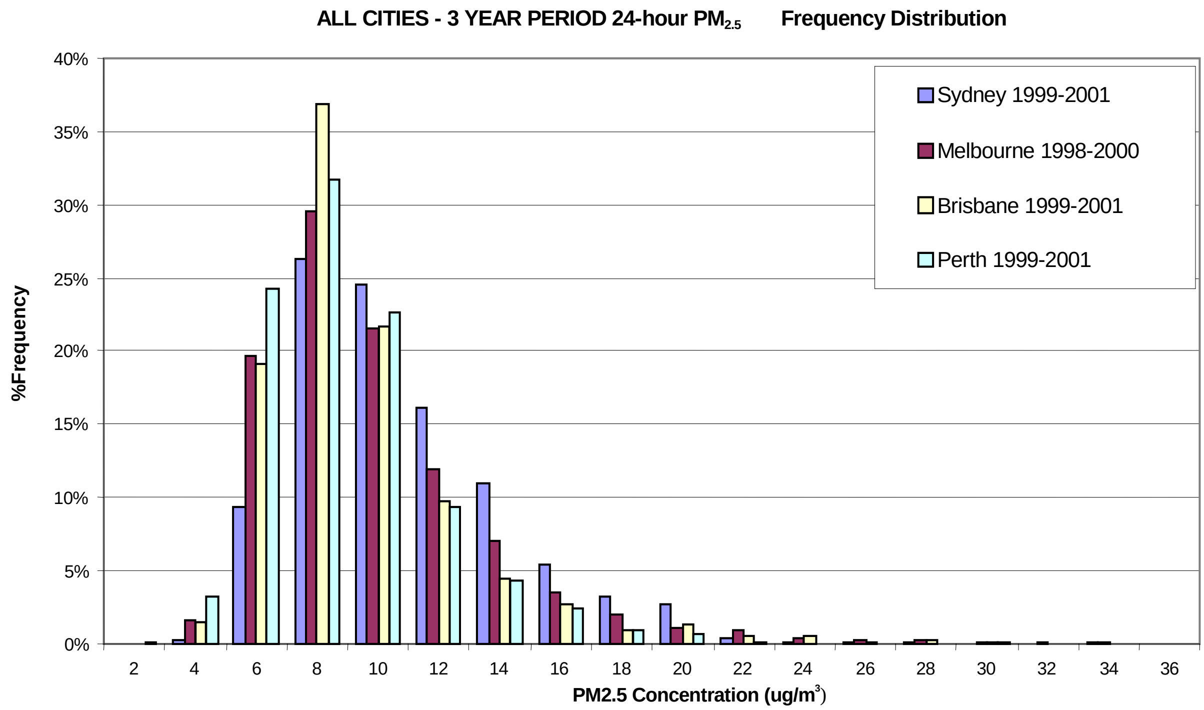
For the exposure assessment, $PM_{2.5}$ data from population oriented (rather than peak) sites were required. Data for Melbourne, Sydney, Brisbane and Perth over a three-year period were available. These data had been obtained from TEOMs operated under similar conditions with the same sample inlet heating temperature.

During the period of the assessment both Sydney and Brisbane experienced significant bushfires that led to elevated levels of $PM_{2.5}$. To obtain a representative measure of exposure the bushfire data were removed from the data sets. However, to assess the impact of the bushfires a separate analysis was also conducted with the data for those periods included.

Population data for each city were obtained from the Australian Bureau of Statistics (ABS).

Figure 5-1 shows the frequency distribution of $PM_{2.5}$ concentrations for all cities for the period of assessment. This graph shows that frequency at which levels of $PM_{2.5}$ exceed specific concentrations.

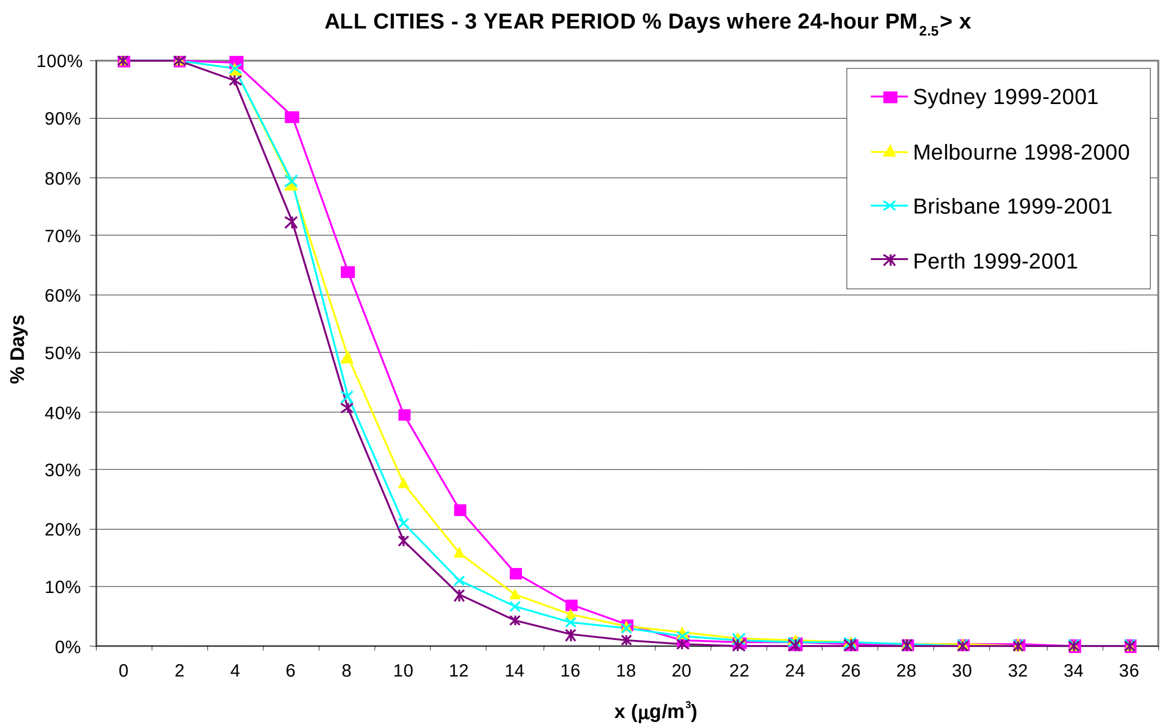
Figure 5-1: $PM_{2.5}$ Frequency Distribution



As shown in Figure 5-1, $PM_{2.5}$ levels in all four cities are similar in distribution with the majority of days ranging between 6-12 µg/m³. Generally levels are well below 25 µg/m³ although on some days higher levels can be observed.

Figure 5-2 shows the inverse cumulative frequency distribution for all cities over the three year period of assessment. This graph shows that less than 2% of days experienced $PM_{2.5}$ levels that exceeded 25 µg/m³ in all cities investigated.

Figure 5-2: Inverse Cumulative Frequency Distribution – $PM_{2.5}$ All Cities



For the purposes of assessing potential costs and benefits associated with 24-hour standards for $PM_{2.5}$ a range of scenarios were proposed. These scenarios were:

- current air quality;
- reductions in $PM_{2.5}$ levels such that peak levels did not exceed 35 $\mu g/m^3$;
- reductions in $PM_{2.5}$ levels such that peak levels did not exceed 30 $\mu g/m^3$;
- reductions in $PM_{2.5}$ levels such that peak levels did not exceed 25 $\mu g/m^3$; and
- reductions in $PM_{2.5}$ levels such that peak levels did not exceed 20$\mu g/m^3$.

Table 5-2: Average 24-Hour $PM_{2.5}$ Results for Sydney, Melbourne, Brisbane and Perth for each Combined Three-Year Period.

Monitor	**Maximum 24-hour $PM_{2.5}$ ($\mu g/m^3$)**	**#Days >20$\mu g/m^3$**	**# Days >25 $\mu g/m^3$**	**# Days >30 $\mu g/m^3$**	**# Days >35 $\mu g/m^3$**
Sydney 1999-2001	37.6	10	4	2	1
Sydney 1999-2001 (fires included)	93.7	17	11	9	7
Melbourne 1998-2000	33.2	24	8	3	0
Brisbane 1999-2001	37.6	18	6	1	1
Brisbane 1999-2001 (fires included)	58.7	21	9	3	2
Perth 1999-2001	29.3	3	1	0	0

The information presented in Tables 5-2 and 5-3 are the combined data for the sites shown in Table 3-1.
The analysis shown here excludes the extreme fire events that occurred in Sydney and Brisbane in 2001.

Assessment of the data presented in Table 5-2 shows that although there are very few exceedances of 35 $\mu g/m^3$ as a 24-hour average, reducing $PM_{2.5}$ levels such that peak levels do not exceed 20 $\mu g/m^3$ is likely to present significant challenges to jurisdictions. This needs to be weighed against the health benefits in the recommendation of a standard for $PM_{2.5}$.

For the purposes of assessing potential annual standards for $PM_{2.5}$, a range of annual average scenarios were assessed as follows:

- current air quality;
- reductions in $PM_{2.5}$ levels such that annual averages did not exceed 10$\mu g/m^3$;
- reductions in $PM_{2.5}$ levels such that annual averages did not exceed 8 $\mu g/m^3$; and
- reductions in $PM_{2.5}$ levels such that annual averages did not exceed 5 $\mu g/m^3$.

Analysis of the $PM_{2.5}$ data provided by jurisdictions is shown in Table 5-3. Annual averages range from 7.7 $\mu g/m^3$ to 10.3 $\mu g/m^3$ (excluding bushfires). With bushfire data included, the maximum annual average is 11.4 $\mu g/m^3$.

Table 5-3: Annual Average $PM_{2.5}$ Results for Sydney, Melbourne, Brisbane and Perth

For Melbourne, Year 1 = 1998, Year 2 = 1999 and Year 3 = 2000.
For the other cities Year 1 = 1999, Year 2 = 2000 and Year 3 = 2001.

Monitor	Year 1 annual average $PM_{2.5}$ (μg/m³)	Year 2 annual average $PM_{2.5}$ (μg/m³)	Year 3 annual average $PM_{2.5}$ (μg/m³)
Sydney composite	9.1	10.1	10.4
Sydney composite (fires included)	9.1	10.1	11.4
Melbourne composite	9.4	9.0	8.0
Brisbane composite	7.8	9.2	8.3
Brisbane composite (fires included)	7.8	9.2	8.6
Perth composite	7.9	7.7	8.1

The information presented in Tables 5-2 and 5-3 are the combined data for the sites shown in Table 3-1. The analysis shown here excludes the extreme fire events that occurred in Sydney and Brisbane in 2001.

The data analysed above relates to major urban centres. It should be noted that some regional areas of Australia that are significantly impacted by woodsmoke (eg Launceston and Armidale) may experience peak levels higher and more frequently than those shown in the tables above. What this means in terms of an annual average is unclear as monitoring in those areas is generally only conducted in the cooler months. For the rest of the year these regional centres experience relatively clean air with particle levels lower than those observed in urban areas.

5.5 Risk Characterisation

To determine the risk associated with levels of $PM_{2.5}$ data on the population must be combined with the dose response data, baseline health incidence data and exposure data. This has been done for all scenarios outlined above and for all health endpoints identified in Section 5.2.1. Baseline mortality data were obtained from the Australian Bureau of Statistics and hospital admissions data from the respective State health departments.

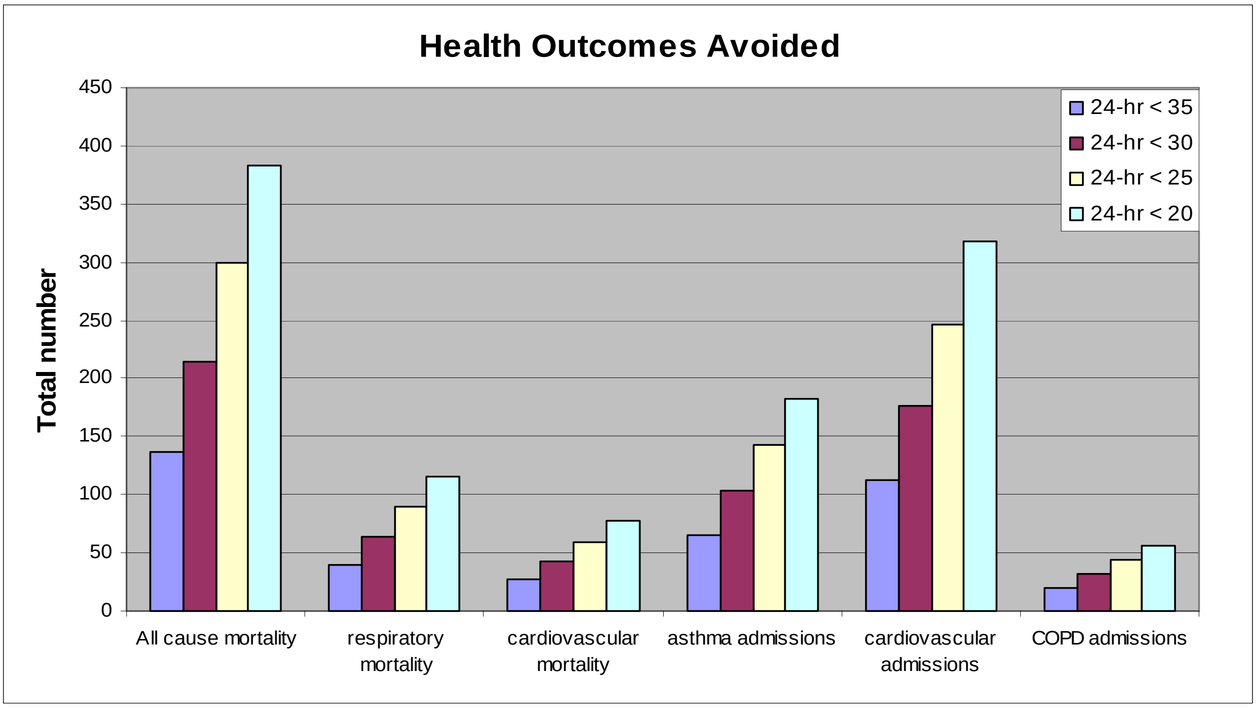
Table 5-4 summarises the outcomes of the risk characterisation process for the base case, ie the number of health outcomes attributable to current levels of $PM_{2.5}$ in each city. The data presented are the combined data for all cities and have been compiled from the results of the analysis for individual cities. It should be noted that the risk estimates quoted relate only to anthropogenic sources of $PM_{2.5}$. Background levels have been estimated as the lowest 5 percentile of the monitored levels consistent with the approach taken by the US EPA.

Table 5-4: Health Effects Attributable to Current Levels of $PM_{2.5}$ in Sydney, Melbourne, Brisbane and Perth

	Short Term Health Endpoint						Long Term Health Endpoint		
	Mortality			Hospital Admissions			Mortality		
	All cause	Respiratory	Cardio-vascular	Asthma	Cardio-vascular disease	COPD	All cause	Lung cancer	Cardio-pulmonary disease
Sydney	274	81	55	157	246	58	699	88	527
Melbourne	207	60	41	78	157	15	524	58	316
Brisbane	97	32	20	37	63	10	226	26	143
Perth	52	19	10	27	50	10	142	20	97
TOTAL	**632**	**193**	**127**	**302**	**523**	**94**	**1611**	**195**	**1096**
Including 2001 Major Bushfires									
Sydney	290	85	58	167	262	61	743	93	560
Brisbane	99	33	21	41	71	11	252	29	160

The health outcomes avoided (combined analysis) by reductions in $PM_{2.5}$ levels to meet the scenarios outlined in Section 5.4 are shown in Figure 5-3 (short term health end points) and Figure 5-4 (long term health end points). The results presented show the number of health outcomes avoided relative to the base case (ie current ambient levels of $PM_{2.5}$ experienced in the four cities).

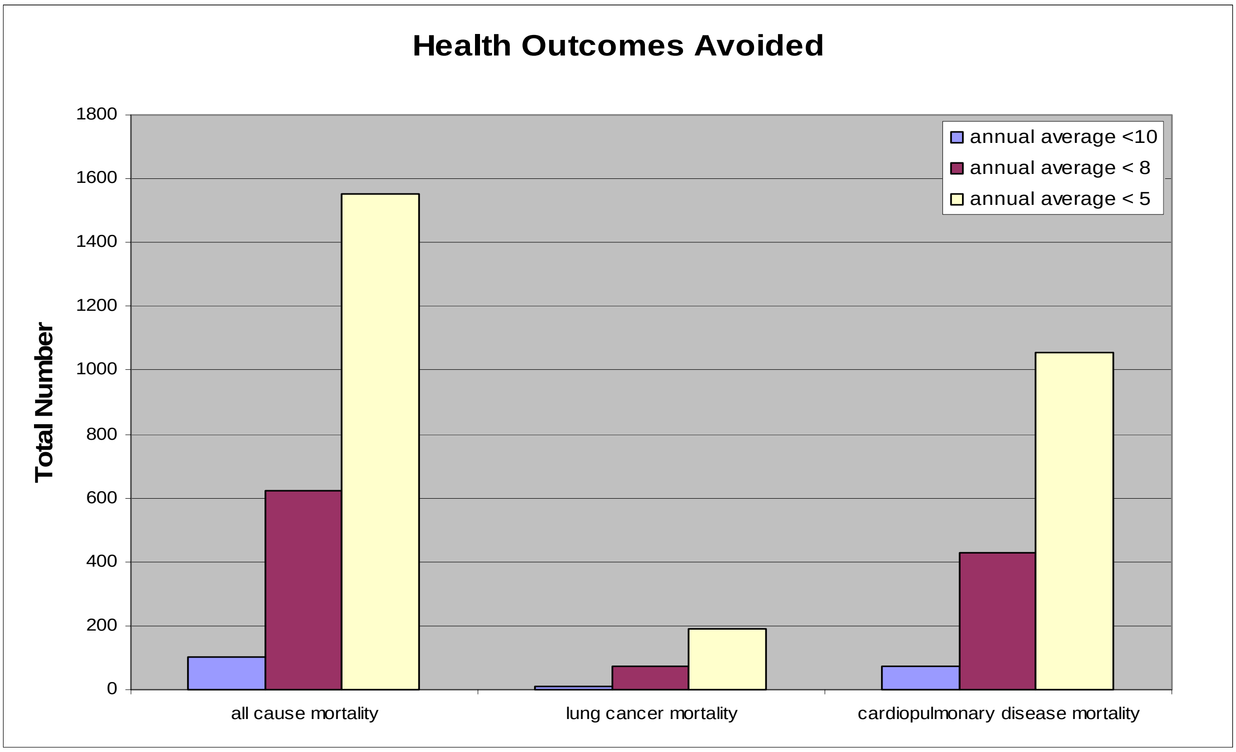
Figure 5-3: Short-Term Health Outcomes Avoided



The data in Figure 5-3 show that for each adverse health outcome, reducing $PM_{2.5}$ levels leads to significant savings in terms of adverse health effects avoided. The number of the health effects avoided is dependent on the extent of the reduction achieved, for example with 120 premature deaths avoided from all cause mortality if $PM_{2.5}$ levels were reduced such that peak levels did not exceed 35 $\mu g/m^3$. This increases to approximately 350 premature deaths avoided if peak levels were reduced to less than 20 $\mu g/m^3$.

The data presented in Figure 5-4 show for each long-term adverse health effect the impact of reducing $PM_{2.5}$ levels is greater than observed for short-term outcomes.

Figure 5-4: Long Term Health Outcomes Avoided



These data show that reductions in annual average levels of $PM_{2.5}$ are related to greater savings in adverse health outcomes than are associated with short-term exposures in both absolute and relative terms. Improving air quality such that an annual average of 10 µg/m³ is achieved does not provide significant health savings as most cities already meet this level. However, if levels were reduced to meet an annual average of 8 µg/m³, then for all cause mortality, 582 premature deaths are predicted to be avoided. As most cities are close to or already meet this level, this is not only a realistic target, but it would also provide significant health protection if attained.

An annual average of 5 µg/m³ is close to the estimated natural background levels of $PM_{2.5}$ and is unlikely to be achievable in any jurisdiction thereby making this an unrealistic target.

Any risk estimates have a significant amount of uncertainty associated with them. This uncertainty arises from a variety of sources. Some of the key uncertainties in the risk analysis include:

- the function used to model the dose-response function which may not be the best model of the true dose-response function;
- transferability of dose response functions from overseas to the Australian context;
- extrapolation of the dose response relationships beyond the concentrations used in the epidemiological study from which they were derived;
- adequacy of the air monitoring data in estimating population exposure to $PM_{2,5}$;
- no consideration of particle composition only particle mass;
- error involved in the monitoring methods used for measuring $PM_{2.5}$;

- the assumptions used in the roll-back procedure may not reflect the actual distribution if $PM_{2.5}$ levels were reduced; and
- the estimate of background concentrations may not be accurate.

The overall effect of these uncertainties in the estimate of risk is unknown. In some cases it may result in an overestimate of the predicted effects and in other cases it may result in an underestimate. However, as only a subset of health effects that have been associated with exposure to $PM_{2.5}$ in overseas studies have been assessed for the purposes of this variation, the health effects presented in this report must be considered as an underestimate of the true health effects associated with $PM_{2.5}$.

5.5.1 Potential Health Costs Avoided

The conclusion drawn for the scenarios described above relate to the populations in Brisbane, Melbourne, Perth and Sydney statistical divisions.

If the scenarios were to be projected for the total Australian population (2001 census, 19.4 million), the health incidence savings could be approximately doubled, as the population in the four cities above account for 52% of the total population and 50% of the population aged 65 and over. This is considered to be a reasonable approximation, given the expected wide range in air quality between regional areas. That is, some regional areas would have significantly better air quality than in urban areas, whereas other regional areas have relatively poor air quality (eg woodsmoke impacted).

Source documents for disease category costings and the subsequent assessment of savings in terms of health costs associated with hospitalisations are from Australian Institute of Health and Welfare (AIHW), Health and Welfare Expenditure series (Mathers C et al, 1986; 1999).

Health-related costs per case arising from hospitalisation have been assessed for asthma (ninth revision of the International Classification of Disease (ICD 9) code 493), cardiovascular disease (ICD9 codes 390-398, 401-405, 410-417, 420-429), and COPD (ICD9 codes 490-492, 494, 496).

Costs apportioned to hospital admissions for each disease classification include, average costs of hospital admission, medical costs, pharmaceutical, allied health services. For detailed cost apportionment methodology, see Mathers C et al 1998a.

To project current average costings (accounting for inflation) for health services from the data published by AIHW 1993-1994, the 'total health price index" was utilised (AIHW, 2001, Health Expenditure Bulletin No17, *Australia's Health Services Expenditure to 1999-00).*

The following averaged costs for hospital admissions were derived for:

- Asthma = $8,875;
- Cardiovascular disease = $11,709; and
- COPD = $9,610.

If the costs of these disease states are multiplied with the projected annual health incidence savings in each scenario, and summed, the total annual monetary value for avoided health costs can be calculated. These estimates are shown in Table 5-5.

Table 5-5: Estimated Short Term Health Costs Avoided (Morbidity)

24 h Scenario $PM_{2.5}$	Avoided Costs of Hospital Admissions ($) per year			Total Savings ($)
	Asthma	Cardiovascular Disease	Chronic Obstructive Pulmonary Disease	
< 35µg / m³	585,750	1,323,117	192,200	2,101,067
< 30µg / m³	914,125	2,072,493	307,520	3,294,138
< 25µg / m³	1,269,125	2,892,123	422,840	4,584,088
< 20µg / m³	1,624,125	3,711,753	547,770	5,883,648

To account for total annual health savings on top of the monetary savings for hospitalisations for the 24-hour scenarios, preventable deaths due to $PM_{2.5}$ exposure need to be included. Mortality due to respiratory and cardiovascular disease, and for all cause mortality were considered to be the appropriate indicators to be modelled. These estimates are shown in Table 5-6.

Table 5-6: Estimated Short Term Health Effects Avoided (Mortality)

24 h Scenario $PM_{2.5}$	Short Term Health Endpoint Mortality Causes		
	Respiratory	Cardiovascular	All Cause
< 35µg / m³	40	28	137
< 30µg / m³	64	43	214
< 25µg / m³	89	60	299
< 20µg / m³	115	77	383

For the long term standard, health endpoints of mortality due to lung cancer, cardio-pulmonary disease and for all causes were considered as the appropriate indicators. These were modelled for three scenarios of annual $PM_{2.5}$ levels. These estimates are shown in Table 5-7.

Table 5-7: Estimated Long Term Health Effects Avoided (Mortality)

Annual Scenario $PM_{2.5}$	Long Term Health Endpoint Mortality Causes		
	Lung Cancer	Cardiopulmonary Disease	All Cause
< 10µg / m³	12	75	100
< 8µg / m³	74	428	624
< 5µg / m³	188	1056	1552

Estimates of the lives that could be potentially saved have not been given monetary values due to difficulties in estimation and coming to a consensus on the methods for such estimations (eg number of years of life saved, the potential earning capacity of the individual during the years saved, willingness and capacity to pay to save a life).

It is however noted that there can be significant monetary savings due to avoided hospitalisations as well as lives potentially saved, from reductions in short term (24h) and annual concentrations of $PM_{2.5}$.

Estimation of costs due to restricted activity days and productivity losses have not been calculated. A recent WHO study has found that air pollution in Austria, Switzerland and France cost those countries approximately 50 million Euro per year, approximately AUD $100 million dollars. Of this total cost approximately 22% is due to restricted activity days and productivity loss. In Australia, although the absolute costs may differ, the relative costs related to air pollution are expected to be similar.

5.6 PROPOSED STANDARD

It is clear from the reviews conducted in the Issues Paper, Discussion Paper and summarised in this Impact Statement, that exposure to $PM_{2.5}$ is related to adverse health effects. Epidemiological studies conducted in Australia have confirmed that the effects observed in overseas countries are also observed here at $PM_{2.5}$ levels currently experienced in Australian cities. No threshold has been identified for the health effects of particles, and the observed health effects justify reducing $PM_{2.5}$ levels as far as practicable.

The risk assessment process has identified that reductions in $PM_{2.5}$ levels would lead to reductions in the health effects attributable to $PM_{2.5}$ such as premature mortality and hospital admissions for respiratory and cardiovascular disease. It should be noted that the health effects assessed in the risk assessment are only a subset of the adverse health effects that have been associated with exposure to $PM_{2.5}$. Therefore, the estimated health impact costs of $PM_{2.5}$ and estimated potential savings associated with reductions in $PM_{2.5}$ are considered to be an underestimate of the true health costs associated with $PM_{2.5}$ in Australia.

The proposed form of the variation is that of Advisory Reporting Standards for $PM_{2.5}$. This form of the variation will not require compliance with the standards within a set timeframe. However, reductions in $PM_{2.5}$ are likely to be achieved through a combination of management strategies already in place, and any additional measures that jurisdictions may also elect to introduce. The estimated health cost savings are not intended to indicate the result of $PM_{2.5}$ control in isolation, but recognise that jurisdictions are already acting to reduce particle levels. It is therefore possible that some of these savings would be realised without a $PM_{2.5}$ standard, however a standard will assist in assessing progress towards lowering particle levels in a nationally consistent manner and the risk posed to public health by exposure to $PM_{2.5}$ nationally.

It is considered that a $PM_{2.5}$ standard must be set that represents an improvement in the current ambient levels of $PM_{2.5}$, but is not unrealistic in the medium to long term. This approach means that, if the standards were met, the health impacts due to $PM_{2.5}$ as currently observed in Australian cities would be reduced. Accordingly, the standards proposed below are considered to represent a reasonable target for jurisdictions to aim for, although it is recognised that some areas of Australia do not currently meet these standards.

In light of the above and based on the findings of the risk analysis, the proposed advisory reporting standards for $PM_{2.5}$ are:

- 24-hour average 25 $\mu g/m^3$; and
- annual average 8 $\mu g/m^3$.

Monitoring is to be conducted at monitoring sites established for PM_{10} under the Ambient Air Quality NEPM using the preferred manual gravimetric sampling method, or continuous monitoring method, as specified in the monitoring protocol. There is no timeframe set for compliance with these standards.

6 IMPACTS OF THE VARIATION TO THE AMBIENT AIR QUALITY NEPM

It is important to recognise that the only obligations imposed by the proposed NEPM variation will be monitoring and reporting requirements placed on jurisdictions. It is further recognised that public expectations may lead to increased pressure on environment agencies to reduce $PM_{2.5}$ levels. Whilst this is not a direct consequence of the variation, it may result in a range of indirect costs.

Under the proposed NEPM variation, all governments will be expected to commence monitoring prior to the review of the Principal Measure scheduled to commence in 2005. There is no other requirement placed upon governments. All state and territory governments have active air quality management programs to improve ambient air quality and while these are expected to continue into the future, the proposed variation does not embody any extension or modification of such programs.

Each government will continue to assess the priority to be given to air quality management initiatives in the context of overall government programs. The NEPM variation will provide a sound basis for the generation of a significantly improved national dataset which will greatly improve jurisdictional ability to assess the extent of any problems in the major airsheds in relation to $PM_{2.5.}$ The variation will therefore assist governments in setting priorities for various air quality management programs.

In establishing an advisory reporting standard and an associated monitoring protocol for $PM_{2.5}$, the NEPM variation provides a tool for communicating information to the public on the state of ambient air quality in urban areas, assessing the effectiveness of air quality management programs, particularly national programs and providing a sound data base for future studies on the health impacts of $PM_{2.5}$. This in turn should lead to more cost-effective programs, better priority setting by governments, improvements in infrastructure development planning, more informed choices by individuals and consequential risk reduction (particularly for those with high sensitivity to $PM_{2.5}$) and possibly behavioural change. Overall the adoption of the NEPM variation should lead to improved protection of public health.

Because the NEPM variation deals only with the assessment of $PM_{2.5}$ by governments, the direct costs are incurred by governments. Jurisdictions will need to assess the most cost-effective means of complying with the monitoring protocol.

Programs to reduce emissions of $PM_{2.5}$ will continue and the NEPM variation will simply provide a better means of assessing the effectiveness of these programs and targeting resources. The range of actions being undertaken in relation to industry and motor vehicle emissions, in particular, are outlined in this Impact Statement and are likely to continue. They are not to be construed as constituting actions that would flow from the adoption of this proposed NEPM variation.

6.1 HEALTH IMPACTS

In addition to the direct health costs associated with these health effects there are also costs associated with lost productivity, not only for the person affected but in many circumstances, for that affected person's carer. This is especially true in the case of children who form a susceptible group for the effects of air pollution. Australia has the second highest asthma rates in the world with approximately 12% of the population suffering from this disease. In children under 5 years of age this figure increases to approximately 25-30%.

According to ABS data approximately 44% of non-accidental deaths are due to cardiovascular causes and 80% occur in people greater than 65 years of age. Data from the Victorian Department of Human Services indicates that there are approximately 7,000 admissions per year to Melbourne hospitals for asthma, 60% of which are for children less than 14 years. There are 31,000 admissions per year for cardiovascular disease, 66% of which are elderly people. For respiratory disease there are 24,000 admissions per year – 30% are children less than 14 years of age and 36% are the elderly.

Although air pollution does not cause these diseases, exposure to air pollution can aggravate these diseases and significantly impact the quality of life experienced by people in these sensitive groups. In some cases exposure to air pollution may result in premature deaths in these groups.

Data provided by the Victorian Department of Human Services indicates that these admissions alone cost Victorians and the health system of the order of $6 million per year. The costs associated with lost productivity are likely to be much greater. This estimate does not include ongoing medical costs such as medication costs and visits to general practitioners.

From the results of an exposure assessment and risk characterisation evaluation, estimates of population exposure to $PM_{2.5}$ were developed for Sydney, Melbourne, Brisbane and Perth using daily 24-hour average and annual average $PM_{2.5}$ concentrations for three consecutive years.

The health risk reductions that would result from the attainment of each of the scenario levels have been derived (for all health endpoints) by comparing the health risks associated with $PM_{2.5}$ concentrations that meet the scenario levels to the health risks associated with current $PM_{2.5}$ concentrations.

6.2 MONITORING

Any method selected for the collection of fine particle data must be able to report against the mass based $PM_{2.5}$ standards proposed in Section 5.5. Other objectives of monitoring include the collection of data that can be used for understanding contributing sources, transport and sinks of particles and their health effects across Australian jurisdictions.

The Discussion Paper raised issues relating to the monitoring of fine particles. These included discussion of monitoring techniques that have been used by regulatory agencies in Australia, overseas examples, and indicative costs and resource implications.

6.2.1 Monitoring Specialists Workshop

A jurisdictional specialists monitoring workshop was held in Sydney in April 2002, to discuss the appropriate reference methodology(s) for the NEPM variation for monitoring $PM_{2.5}$ and what equipment types could be recommended for routine monitoring of $PM_{2.5}$.

This meeting established that the preferred method for $PM_{2.5}$ monitoring should be the US EPA Federal Reference Method for the Determination of Fine Particulate Matter as $PM_{2.5}$ in the Atmosphere. However further discussions between jurisdictions have established that under this variation the $PM_{2.5}$ data reported will include that collected using both the preferred method and other continuous gravimetric methods.

In light of the need for jurisdictional flexibility in the timing of the introduction of $PM_{2.5}$ into existing Ambient Air Quality NEPM PM_{10} monitoring sites, it was agreed that that an "equivalency" program was required. The program would allow existing jurisdictional equipment to be used for $PM_{2.5}$ monitoring, and would require co-location of a preferred sampler with existing samplers at a limited number of sites nationally. The co-location data would be used to establish the relationship between different methods and whether other monitoring methods have equivalent accuracy and precision to the preferred method. This will allow jurisdictions maximum flexibility while ensuring that $PM_{2.5}$ data can be compared nationally. The equivalency program requires collection of data over a three-year period, and was considered as part of scenario development for the cost estimates presented in Section 6.2.2.

Jurisdiction monitoring representatives have been asked to nominate the sites around Australia where equivalency studies are proposed to be undertaken. These sites would be established dependant on jurisdictional funding being available.

These sites would need to be representative of the particle pollution experienced in most areas of Australia. The relationships between different sampling methods that are derived from the co-location studies will therefore be able to be applied to regions of Australia where non-preferred samplers are used. This approach will allow the generation of a nationally consistent $PM_{2.5}$ dataset that will be used in the review of the proposed standards in 2005.

An Equivalency Working Group (EWG) consisting of monitoring specialists from Victoria, Queensland and Western Australia was convened at the workshop to further develop the method to be used when assessing the equivalence between different monitoring methods. To date, the EWG has agreed on the basic concepts associated with the equivalency program. The detailed protocols for data analysis will be developed by the Equivalency Working Group (EWG) before the NEPM variation is made. These protocols will be prepared by the EWG and submitted to monitoring specialists from other jurisdictions for review.

6.2.2 Jurisdictional Costs of Monitoring

Estimates of costs to jurisdictions of monitoring (Table 6-1) are based on information provided by jurisdictional monitoring personnel. Estimates relate to equipment costs, measurement facility establishment, quality assurance document preparation, analysis costs and labour costs. Costs not included are network auditing, NATA accreditation, depreciation and motor vehicle usage. For the purposes of this assessment, a Partisol sampler has been assumed to be the approved sampler for the $PM_{2.5}$ preferred method.

Cost estimates are presented in terms of today's dollars, without discounting of future expenditures. While this approach is simplistic, it is intended to give an indication of the likely magnitude of costs associated with $PM_{2.5}$ monitoring, and of the relative differences between the monitoring options. Jurisdictions planning to introduce $PM_{2.5}$ monitoring as part of the NEPM variation would need to prepare more detailed cost scenarios.

Table 6-1: Cost Information for Partisol and TEOM Samplers

Partisol Sampler			**TEOM Sampler**		
Capital Costs	**$**		**Capital Costs**	**$**	
Sampler	25,000		Sampler	40,000	
Microbalance	25,000		Installation	1,000	
Temp / Humidity Sensor	1,000				
Weighing facility	30,000		**Consumables**		
			Filters	20	per week
Consumables			Maintenance	1,000	per year
Filters / sample storage	10	per sample	Filter change / calib.	50	per week
Static eliminator	500	per year			
Maintenance	1,000	per year	**Analysis**		
			Data analysis (2hr / week @ $50 / hr)	100	per week
Analysis					
QA docs	20,000	one off cost			
Filter prep / weighing (8hr / week @ $50 / hr)	400	per week			
Data analysis (8hr / week @ $50 / hr)	400	per week			

Information provided by jurisdictions

The project team were able to establish a basis for assessing monitoring requirements, based on that set out in requirements for the criteria pollutants in the Ambient Air Quality NEPM. This information is presented in Table 6-2 and was used in a highly conservative manner to estimate the upper bound monitoring costs that would be associated with an Option 1 (see Section 4) form of this NEPM variation. It is important to note that actual resource requirements for $PM_{2.5}$ monitoring will be less than these upper bound estimates. The proposed variation requires that jurisdictions must introduce at least one $PM_{2.5}$ monitoring station prior to the review of the Principal Measure in 2005.

Table 6-2: Number of Current $PM_{2.5}$ Monitoring Locations and Ambient Air Quality NEPM Requirements

Jurisdiction	Current Locations	NEPM requirements	Difference
VIC	6	10	4
NSW	10	17	7
QLD	2	9	7
SA	1	4	3
WA	2	5	3
TAS	0	1	1
ACT	0	1	1
NT	0	1	1

The cost estimates in Table 6-1 were used to establish monitoring costs for the three options proposed for the form of the NEPM variation. The scenarios looked at were:

- Scenario 1 - Option 1 monitoring regime using preferred samplers at existing monitoring stations where monitoring does not occur, and use of preferred samplers at planned monitoring sites, in accordance with the current Ambient Air Quality NEPM monitoring requirements for criteria pollutants. Note that all jurisdictions would need additional monitoring stations to meet such requirements.

- Scenario 2 - Option 1 monitoring regime using TEOM samplers at existing monitoring stations where $PM_{2.5}$ monitoring does not occur, and use of TEOM samplers at planned NEPM sites, in accordance with the current Ambient Air Quality NEPM requirements for criteria pollutants. Note that all jurisdictions would need additional monitoring stations to meet such requirements.
- Scenario 3 - Option 2/3 monitoring regime with the introduction of one preferred sampler into the monitoring network, as a stand alone monitor or for equivalency purposes. The costs are based on the assumption that laboratory facilities (microbalance and room setup) need to be established.

Table 6-3 to Table 6-5 present estimates of jurisdictional monitoring costs for the above scenarios. Costs are presented separately for the first year (includes equipment and facility costs) and subsequent years. Partisol sampling costs were estimated based on one sampler being operated on a daily basis, with any additional samplers operated on a 1 in 3 day cycle.

Table 6-3: Cost Estimates for Scenario 1 – Partisols

Jurisdiction	Year 1 $	Year 2+ $
VIC	211,941	91,941
NSW	388,131	137,131
Qld	388,131	137,131
SA	227,877	76,877
WA	227,877	76,877
TAS	147,750	46,750
ACT	147,750	46,750
NT	147,750	46,750
Total	**1,887,207**	**660,207**

Table 6-4: Cost Estimates for Scenario 2 – TEOMs

Jurisdiction	Year 1 $	Year 2+ $
VIC	200,360	36,360
NSW	349,880	62,880
Qld	349,880	62,880
SA	150,520	27,520
WA	150,520	27,520
TAS	50,840	9,840
ACT	50,840	9,840
NT	50,840	9,840
Total	**1,353,680**	**246,680**

Table 6-5: Cost Estimates for Scenario 3 – Single Partisol

Cost Item	Year 1	Year 2+
Sampler	25,000	
Microbalance	25,000	
Sensor	1,000	
Weighing facility	30,000	
QA documentation	20,000	
Operating (daily operation)	46,750	46,750
Operating (1 in 3 day operation)	16,564	16,564
Operating (1 in 6 day operation)	9,061	9,061
Total (daily operation)	**147,750**	**46,750**
Total (1 in 3 day operation)	**117,564**	**16,564**
Total (1 in 6 day operation)	**110,061**	**9,061**

Table 6-3 to Table 6-5 shows that the operation of preferred samplers costs substantially more than TEOM operation. The additional costs are due mainly to weighing facility establishment costs in the first year and ongoing labour costs for filter collection/handling and data analysis. Alternative arrangements for filter analysis (for example, contracting out to an external laboratory), have not been costed. Workplace efficiencies that may be associated with Partisol monitoring at a number of sites (eg job batching for filter weighing) have not been assessed.

Table 6-5 indicates that establishing one Partisol sampler in a jurisdiction has substantial capital costs in the first year associated with sampler, microbalance and laboratory setup. Operating costs in subsequent years depend on the frequency of monitoring (ie daily, 1 in 3 day or 1 in 6 day operation).

6.3 INDUSTRIAL SOURCES

Emission inventory data (AQIP/Inventory) and the results of source apportionment studies (ANSTO) have shown that industrial emissions account for approximately 15-20% of $PM_{2.5}$ levels in urban areas in Australia. These emissions arise primarily from combustion processes, but other industrial processes, such as those that use sand blasting or smelting operations, also contribute earth moving operations such mining and road construction are known to be significant emitters of dust, but these emissions are primarily in the coarse range with a small percentage in the $PM_{2.5}$ fraction.

Industry has improved its emissions performance over recent years as a result of increased environmental awareness and interaction with environmental protection agencies, which in their dealings with industry use a range of approaches. These include licensing of industrial premises, cleaner production partnerships and if required enforcement activities such as pollution abatement notices and prosecutions. Unlicensed premises, including small to medium enterprises, may still produce significant emissions that may affect local air quality. This is particularly of concern when a number of these premises are clustered together near residential areas.

The current standards specified in the Ambient Air Quality NEPM do not apply to the control of emissions from individual industries. Similarly, the introduction of a $PM_{2.5}$ standard through this variation will not apply to the direct control of industrial emissions. However, where the $PM_{2.5}$ emissions from industry impact significantly on regional air quality, jurisdictions may review licences and control practices to reduce ambient $PM_{2.5}$ concentrations.

With the introduction of a PM_{10} standard in the Ambient Air Quality NEPM, jurisdictions have put in place a range of management strategies to control emissions of PM_{10} from a range of sources including industrial sources. These strategies may also address emissions of $PM_{2.5}$ and it is unlikely that the introduction of a $PM_{2.5}$ standard will significantly change these practices. It may however lead to a greater focus on reducing emissions of the fine particles through review of licences or processes that lead to the emissions of $PM_{2.5}$. The impact on individual companies is likely to be small as these strategies are already in place.

6.4 MOTOR VEHICLES

6.4.1 Motor Vehicle Design and Fuel Standards

Motor vehicles are a significant source of particles in urban areas. Diesel vehicles are estimated to contribute between 60% and 80% of particle emissions from the vehicle fleet.

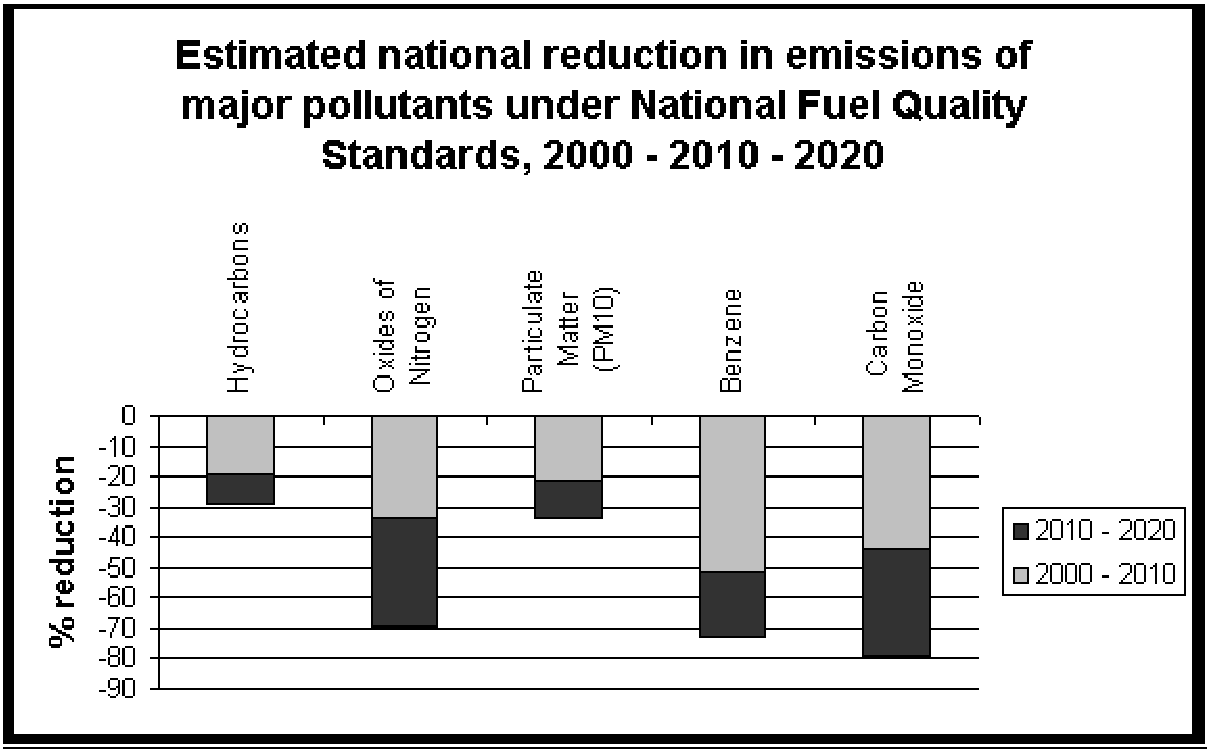
Particle emissions from the motor vehicle exhaust are generally smaller than 2.5 µm and as such will contribute to $PM_{2.5}$ levels in urban air sheds. Cadle et al (1999) reported that 91% of particle mass from petrol vehicles was smaller than 2.5 µm. The proportion for diesel vehicles was reported to be 98%. Gaseous emissions (VOC and NOx) from vehicles also contribute to the formation of secondary $PM_{2.5}$.

New vehicle emission Australian Design Rules (ADRs) have recently come into force with staged introduction of tighter emission standards for petrol and diesel vehicles. The ADRs for diesel vehicles control particle emissions as PM_{10}. To facilitate the introduction of these new vehicle emission standards, Australia has also established fuel quality standards for petrol and diesel vehicles.

Recognising the significant investment by government and industry in the development and implementation of ADRs and fuel quality standards, and the lead time required for their introduction, the $PM_{2.5}$ variation will not impact on current and planned emissions and fuel quality standards. However, the variation may act as a stimulus to specifically consider $PM_{2.5}$ while developing future ADRs and fuel quality standards (post 2006).

Combined, the new vehicle emission standards and fuel quality standards will result in a significant reduction of pollutants, including $PM_{2.5}$, from the motor vehicle fleet. These reductions are identified in Figure 6-1. While the reduction in particles is identified in terms of PM_{10}, it has been assumed in generating these data that all particle matter from motor vehicles is smaller than 10 µm and that 90% of this is smaller than 2.5 µm.

Figure 6-1: Estimated National Reduction in Emissions of Major Pollutants under National Fuel Quality Standards



Source: SETTING NATIONAL FUEL QUALITY STANDARDS - *A Review of Fuel Quality Requirements for Australian Transport* Volume 2, March 2000

The costs of these new vehicle emission and fuel quality standards have already been considered in their introduction. As their establishment was independent of the $PM_{2.5}$ standard setting process, and would have likely occurred anyway, these costs can not be considered in the context of setting the $PM_{2.5}$ standard.

However, while the precise impact of these improvements on ambient $PM_{2.5}$ levels is not clear, the predicted particle emission reductions will result in reduced $PM_{2.5}$ emissions to urban air sheds. In Sydney, for example, vehicles are estimated to produce approximately 30% of all particles. A 30% reduction in vehicle emissions (as predicted in the Commonwealth fuel study) will therefore lead to approximately a 9% reduction in total particle emissions. An indicative estimate is that 80% of those will be $PM_{2.5}$, leading to the general conclusion that the existing vehicle programs will lead to around a 7% reduction in emissions of $PM_{2.5}$ in the Sydney region. This figure is expected to be similar for other cities.

6.4.2 Motor Vehicle In-Service Performance and Usage

In addition to motor vehicle design and fuel standards, jurisdictions employ a number of other strategies to reduce emissions, including emissions of particles, from the motor vehicle fleet. There is a serious concern that the benefits achieved through setting new vehicle emission and fuel quality standards will be off-set by increased emissions from the in-service fleet, increasing number of vehicles and an increase in total vehicle kilometres travelled.

In recognition of the need to ensure that the in-service emissions performance of diesel motor vehicles is sustained, NEPC made the National Environment Protection (Diesel Vehicle

Emissions) Measure in June 2001. The purpose of this NEPM is to provide a framework for the management of emissions from the in-service diesel fleet. It is designed to facilitate compliance with in-service emissions standards developed in conjunction with the National Road Transport Commission.

To improve the emissions profile of the in-service vehicle fleet, including from petrol engine vehicles, jurisdictions are proposing the implementation of programs that encourage regular servicing and tuning of vehicles. Such programs encourage motor vehicle owners to take responsibility for managing the environmental impact of their vehicle use, and are likely to play a greater role in motor vehicle emissions management in the future. Some jurisdictions also provide incentives to purchase cleaner new vehicles.

Strategies to address motor vehicle emissions arising from in-service performance will lead to reductions in all pollutants emitted from vehicles, including particles. As such, the costs and benefits are more widely applied than solely being attributed to the introduction of a $PM_{2.5}$ standard. Further, it is up to individual jurisdictions as to what, if any, strategies need to be employed to reduce emissions from the in-service vehicle fleet.

Programs targeting smoky vehicles have been introduced in a number of jurisdictions. The programs include community reporting and vehicle spotting by authorised officers via the ‘ten second’ rule. States also regulate aspects of vehicle operation, including requirements for vertical exhaust for heavy duty vehicles, roadside inspections and enforcement provisions for poorly maintained or unroadworthy vehicles.

The continued annual growth in vehicle kilometres travelled and fuel consumption, especially by the diesel vehicle fleet, represents a significant challenge to urban air quality as motor vehicles in general, and diesel vehicles in particular, are a significant source of particles. As such, in addition to ensuring that new vehicle emission standards are tightened and the in-service performance of motor vehicles is improved, any comprehensive strategy for addressing motor vehicle emissions must also address the overall demand for travel by motor vehicle.

Initiatives to manage the demand from travel are many and varied, and include short-term and long-term options. For example, some local traffic management initiatives, such as pedestrianisation, can be implemented in a short time frame, whereas strategic transport and land use planning that encourages the integration of significant trip-generating land uses with non-motor vehicular transport modes, such as public transport, generally occurs over a longer time frame.

Initiatives to manage travel demand can be as diverse as providing infrastructure that supports alternatives to motor vehicles (such as bike paths), providing targeted information to people about their travel needs to help them make better decisions (such as the travel behaviour change programs currently being trialed in several Australian cities), and creating financial incentives that encourage the use of alternatives to the car. The overall aim is to produce an urban form and transport system that support and encourage the use of alternatives to the motor vehicle, which in turn reduces motor vehicle emissions.

To reduce vehicle usage, some jurisdictions have employed education and general awareness raising campaigns to encourage motorists to minimise private vehicle use. The success of these programs is variable and is dependent on behavioural change in the community.

The use of alternative vehicles such as hybrid, hydrogen, electric and fuel cell vehicles has the potential to deliver very significant reductions in emissions from motor vehicles in the long term.

It is considered that the introduction of a standard for PM2.5 will not change the approaches currently being taken or considered by jurisdictions to reduce emissions from the vehicle fleet. It may however, encourage jurisdictions to consider additional measures such as more enforcement actions for smoky vehicles and a greater focus on raising awareness within the community on the environmental impacts of motor vehicles. The costs of these programs will be variable across jurisdictions depending on the nature of the program.

6.5 SOLID FUEL HEATING

More than 90% of the smoke from solid fuel heating consists of $PM_{2.5}$. Solid fuel combustion emissions also include other pollutants such as carbon monoxide, nitrogen dioxide, sulfur dioxide, volatile organic compounds (VOCs), a combination of toxic air pollutants, and other chemicals known or suspected to be carcinogens such as polycyclic aromatic hydrocarbons (PAHs) and dioxins.

Annual particle emissions data mask significant seasonal variations associated with the prevalence of solid fuel burning for domestic heating. In urban areas solid fuel burning can contribute to approximately 60% of PM_{10} emissions and 68% of $PM_{2.5}$ emissions of the total particle pollution load in the cooler months. These contributions can significantly increase in rural/regional air sheds where they can be the major source of particle pollution in the absence of other air pollution sources such as transport, mining and industrial activities. An example is Launceston, where solid fuel heating accounts for as much as 85% of particle emissions.

6.5.1 Solid Fuel Woodheaters

Noting the high contribution woodheaters make to particle levels in a number of air sheds, jurisdictions are likely to consider a number of strategies to reduce their emissions where they are at levels of concern. These strategies will impact on woodheater manufacturers, fuelwood suppliers and users.

Manufacture

The Australian Standard for particle emissions from woodheaters (AS4013) has been adopted in legislation in most jurisdictions. This standard sets an emissions limit for particles (as PM_{10}) from woodheaters of 4.0 g/kg of wood burnt. The test includes all particles greater than 0.3 μm. As woodsmoke is predominantly in the fine particle fraction, $PM_{2.5}$ (particles 2.5 μm and smaller) emissions are also controlled.

The Commonwealth State of the Environment Report (2001) states that if improvement in winter air quality is to rely solely on the uptake of new woodheaters meeting tighter emission standards, it is likely that the PM_{10} standard will not be achieved in the short term. The same situation is likely to apply with regard to meeting the proposed $PM_{2.5}$ standards.

It is considered that improvements in air quality to meet the $PM_{2.5}$ standards will require additional improvements in the design performance of woodheaters. The technology exists to reduce particle emissions to levels of 1.0 g/kg and this limit applies to new woodheaters in some jurisdictions (eg Canterbury, New Zealand). The Australian Home Heating Association and Standards Australia have indicated that it is feasible to move to a 2.0 g/kg limit within five years. Notwithstanding the influence of user behaviour on woodheater emissions, improved woodheater design will lead to significant emission reductions from this source.

The $PM_{2.5}$ standard may lead to an accelerated program to further reduce the emission limit of new woodheaters, thereby leading to additional product development costs borne by heater manufacturers.

Fuel Suppliers

Some jurisdictions have introduced regulations that focus on the quality of fuelwood. For example, WA and the ACT have introduced regulations that limit the moisture content of wood sold by merchants to 20%. However, a significant amount of wood is also collected by domestic users on public and private land, and the quality of this wood cannot be controlled.

The $PM_{2.5}$ standard may lead to an accelerated program to regulate the fuelwood supply industry in jurisdictions where no regulations currently exist. This would lead to costs for government authorities for regulation development and enforcement. It is also noted that the issue of fuelwood quality is also addressed by the National Firewood Strategy (coordinated by the National Resource Management Council) and the $PM_{2.5}$ standards may lead to complementary efforts in this area.

Users

Most jurisdictions have or are considering introduction of community education programs to address woodheater emissions. These programs include:

Improving operating behaviour. Even where properly seasoned firewood and best available technology is used, poor operating conditions can result in excessive smoke production. For example, inserting a full load of wood and damping down the woodheater will increase particle emissions. Encouraging the correct operation of woodheaters is therefore an effective strategy to reduce woodheater emissions. Evidence indicates that people are more responsive to targeted education and compliance activities.

Community awareness/education campaigns are based on a number of approaches. For example, the Commonwealth's *Breathe the Benefits* campaign included television advertisements, brochures and a website promoting the correct operation of woodheaters. In Victoria, volunteers in the *Community Access to Air Monitoring* program raise awareness in their community on the impacts of wood heating.

Reducing the use of woodheaters. Jurisdictions may be able to reduce the use of woodheaters in some areas. Strategies include community requests to not use their woodheater on specific nights, eg the NSW EPA's '*Don't Light Tonight*' campaign, programs designed to replace older, more polluting woodheaters, or through to more drastic measures such as the prohibition of woodheaters.

The extreme measure of prohibiting woodheater use, whether through the banning of the installation of new woodheaters or the prohibition of woodheater use, would have significant impacts on the community, in particular lower income groups and where alternative forms of heating are more expensive, and on the woodheater manufacturing and the retailing industry itself.

Restrictions on woodheater use can be implemented by various government agencies. This would have to be weighed up in the consideration of any action to address woodheater emissions in each jurisdiction. A small number of local councils in NSW have implemented a ban on the installation of new woodheaters.

The need for community acceptance that woodheaters create pollution and that many of the actions required to reduce emissions from that source are dependent on the operation of their woodheater, is important.

6.5.2 Open Fireplaces

Particle emissions from open fireplaces can be up to four times greater than that from an AS4013 compliant woodheater. The discussion regarding woodheaters presented above is applicable to open fireplaces, for which there are no design and construction standards.

There are a number of programs currently in place to address particle emissions from solid fuel heating. It is unlikely that the introduction of a $PM_{2.5}$ standard will introduce further action than that currently planned or underway. However, the standard may be a driver for such action to occur earlier than it would otherwise.

6.6 FIRE RISK MANAGEMENT – PRESCRIBED BURNING

Prescribed burning is a management tool used by fire authorities and land managers to reduce the likelihood and impact of bushfires. The strategic use of prescribed burning for fuel reduction assists in the protection of human life, community assets, private property and habitats, and promotes biological diversity. Fire management practices in Australia have been developed in the context that fire is a natural and vital part of the landscape, and is required for the long-term survival of our unique flora and fauna.

Bushfires, in addition to their potential immediate threat to life and property, can generate substantial peak $PM_{2.5}$ and PM_{10} emissions when they occur, with potential for indiscriminate exposure to communities. Prescribed burning provides the only practical means available to modify the type and amount of fuel available for bushfires, particularly in forested areas or other areas where access is constrained. The resultant moderation of fire behaviour provides opportunities for safer and earlier control of bushfires, and therefore reduces the potential amount of smoke emissions and exposure of communities as well as reducing the direct threat to life and property. The $PM_{2.5}$ and PM_{10} emissions from strategically planned prescribed burning programs can at times be of significance. However they generally comprise only a small fraction of those produced during a single significant bushfire event. Fire also plays a significant role in the life cycle of much of the Australian biota and prescribed fire is often the only safe method of introducing fire, at the right time and under controlled conditions, to achieve desired ecological objectives.

In Australia, the community response to the destructive impacts of bushfires over the last 150 years has included the development of specific fire management laws in all jurisdictions. These laws place a clear statutory obligation on park and forest agencies, landowners and municipalities to put into place effective fire protection works. These laws also adopt regulatory frameworks for the application of fire, recognising that strategically located burning is an essential component of park, forest and other land management. Prescribed fire is a key tool, and often the only one, available to these land managers to meet their community safety obligations.

While prescribed burning is important, the impacts on air quality can be significant in the areas surrounding the burns and, occasionally, on a wider regional scale. Concerns over health and visibility impacts associated with burning of large areas for fire risk management has lead to pressure on fire management authorities to include smoke management considerations in planning and implementing prescribed burning. The challenge is to ensure adequate levels of prescribed burning, under controlled conditions, to reduce the impacts of major bushfires on life and property, while minimising the exposure of communities to smoke impacts from planned burning activities. The aim must continue to be to find the balance between the risks of smoke impacts from prescribed burning on community health, and the risk of major bushfires that threaten life and property.

Fire management authorities across Australia have increased their focus on the management of smoke impacts. Research into meteorological factors that influence the transport and dispersion of smoke plumes has lead to advanced weather forecasting systems that are used for scheduling burns to avoid or reduce smoke impacts. In Western Australia, for example, analysis of monitoring data provided by the Department of Conservation and Land Management indicate that haze events in Perth generally do not occur during the prescribed burning period (R Sneeuwjagt, WA CALM, 2002). In Victoria, smoke modelling research with the Bureau of Meteorology has enabled the Department of Natural Resources and Environment to predict smoke plume dispersion from proposed burning operations to aid decision making on burning operations near populated airsheds. Fire management and environment authorities are now working together in most jurisdictions to address air quality issues associated with prescribed burning operations.

The introduction of the PM_{10} standard in the Ambient Air Quality NEPM has in part contributed to a shift in the focus of fire authorities to focus on the management of smoke impacts. A standard for $PM_{2.5}$ is therefore unlikely to have a significant impact on fire management authorities as the current strategies in place to address PM_{10} will also address $PM_{2.5}$.

6.7 WASTE BURNING AND LAND DEVELOPMENT

Waste burning refers to the small scale combustion of domestic waste (eg paper, garden prunings) by the community. Disposal of waste in this manner is increasingly being viewed as unacceptable, and many jurisdictions have banned or severely restricted their use. Impacts of $PM_{2.5}$ emissions from small scale waste burning may be significant on a local scale (ie nuisance impacts on adjacent residents) but unless used widely would not result in widespread degradation of air quality. Accordingly, the introduction of an ambient $PM_{2.5}$ standard is not likely to impose additional costs on those undertaking or controlling waste burning.

Potential $PM_{2.5}$ impacts from land development include the clearing of vegetation and/or topsoil, bulk earthworks, trenching and road construction. Vegetation may be cleared and burnt. Impacts are generally likely be confined to the local scale, however, development of large sites may result in broader impacts. Guidelines for managing impacts of land development operations are established in most jurisdictions and appear to adequately address management of $PM_{2.5}$ emissions. There may also be specific regulations in jurisdictions that restrict the use of burning in vegetation clearance. Due to the existence of guidelines and/or regulations in jurisdictions to manage these impacts, it is expected that a $PM_{2.5}$ standard will not significantly impact land developers or regulatory authorities overseeing these activities.

6.8 AGRICULTURAL BURNING

Agricultural burning refers to the burning of crop stubble to prepare the land for re-sowing, or burning to remove pest plants or dead vegetation. Burning during fire restriction periods requires a permit, generally provided by local council officers. Burning is otherwise unregulated during non-permit periods except where local laws or other legislation come into effect.

Impacts of $PM_{2.5}$ emissions from agricultural burning would generally be localised, however, a number of burns taking place at the same time within a region may have more widespread impacts. Also burning in unsuitable conditions (eg wet stubble) increases emissions of smoke.

During permit periods, landowners have a legal obligation to advise the local fire brigade or state fire authorities of their intention to burn and assess weather conditions forecast for the burn time. Other permit conditions include the estimation of certain fire parameters (eg rate of spread) to ensure the permit holder provides sufficient resources to control the fire and prevent it from spreading beyond designated control lines. Permits may in some circumstances also require an obligation to minimise impacts such that smoke does not enter populated areas for some time after the burn, based on weather forecasts.

Some local councils and state agricultural organisations are proactive in reducing the potential for smoke impacts from agricultural burning. Activities include the promotion of alternative farming methods (eg zero tillage) and providing advice on optimum burn conditions.

It is considered that existing management systems for agricultural burning, and the commitment to further improve these systems, are an adequate basis for the management of $PM_{2.5}$ from this source. Accordingly, it is unlikely that a $PM_{2.5}$ standard will significantly impact landowners or regulatory authorities overseeing burning operations.

6.9 CULTURAL ISSUES

Traditional cultural burning practices are carried out across extensive areas of northern Australia and are usually part of land management regimes designed to provide environmental resources for communities. However, little research has been undertaken to document the characteristics of cultural burning practices in different regions.

Burning of vegetation through cultural burns may be an important source of $PM_{2.5}$ in rural areas and on the urban fringe. Particles from these sources can be transported over significant distances, impacting on both rural and urban areas. However, it is likely that emissions from cultural burns would not significantly impact on urban air sheds where $PM_{2.5}$ monitoring is likely to occur.

It is acknowledged that any management strategies that affect these practices may have impacts on the communities by reducing the availability of particular resources, such as bush foods. However, it should be noted that the $PM_{2.5}$ standards are not intended to be measured near source events as these are outside of the scope of the Ambient Air Quality NEPM. Further, performance monitoring stations would not normally be located near such activities that largely occur outside of metropolitan areas, and would not normally be sited within the metropolitan area to determine such an impact.

6.10 OTHER IMPACTS OF PARTICLES

6.10.1 Aesthetics/Visibility

Increases in the amount of fine particle and gases in the atmosphere are associated with reductions in the ability to see through the atmosphere or identify an object at a distance. This phenomenon, often referred to as "haze", is due to the light scattering or light absorption properties of particles and gas molecules. Fine particles ($PM_{2.5}$) and smaller are known to be the most effective particles in reducing visibility.

Decreased visual range in our urban and rural areas is a concern through decreased visual amenity. Clean, attractive and well functioning cities provide a desirable environment for living, working, investment and tourism. The public often consider visibility to be an indicator of overall air quality, which could negatively impact on the quality of life.

The potential benefits in relation to improved visibility associated with the introduction of the proposed $PM_{2.5}$ standards are likely to be an improvement in the community's aesthetics and amenity. However, while the economic cost or disbenefit of the physical effect of pollutants can be calculated with varying degrees of certainty (eg the cleaning and upkeep of soiled or damaged buildings and determining associated health costs), perceived amenity disbenefits are more difficult to estimate. The most frequently used technique to value "clean air", noting its subjectivity, is contingent valuation or "willingness to pay".

6.10.2 Tourism

Tourism is one of Australia's most important export dollar earners. The 1997 *Urban Air Pollution in Australia* report calculated that polluted cities could produce a drop in tourism income of over $0.7 billion per year. This is calculated assuming 5% of visitors are being deterred by polluted cities, which is considered conservative as over 70% of inbound tourists nominate Australia's unique flora, fauna and landscape as the main reason for their visit.

Tourism can be affected by loss of visibility (as discussed in Section 6.10.1) or by the impact of air pollution on people's health when exposed to elevated levels of $PM_{2.5}$. Rural areas significantly impacted by woodsmoke or by smoke from prescribed or agricultural burns or bushfires, can suffer losses in tourism through peak times such as Easter. This can impact significantly on tourist towns as many of these areas rely on the tourist season to support the economy of the town.

While the techniques used to derive these costs are not very reliable, they are indicative of the relative costs to the community of continued elevated particle levels.

6.11 IMPLEMENTATION OF THE VARIATION

Implementation of the Ambient Air Quality NEPM is the responsibility of each jurisdiction. This allows for local knowledge, conditions and systems to be considered in managing air quality.

The goal of this variation is different to the "compliance goal" of the original Ambient Air Quality NEPM, which is to achieve the standards within ten years. The Goal associated with this variation is to ensure that sufficient data is available for the setting of a $PM_{2.5}$ standard (as described in Option 1) following the review of the Ambient Air Quality NEPM, scheduled to commence in 2005.

The variation allows jurisdictions flexibility in relation to the timing of monitoring conducted. The proposed variation requires that jurisdictions must introduce at least one $PM_{2.5}$ monitoring station prior to the review of the Principle Measure in 2005.

A range of possible strategies may be adopted by jurisdictions to achieve the standard. These are explored in Section 6. As already stated, the Ambient Air Quality NEPM, including this variation, does not place any requirement on governments to change their programs or introduce new programs to manage ambient air quality. Each government will continue to assess the priority to be given to air quality management initiatives in the context of overall government programs.

In broader urban areas, air shed management programs already in place involve a diverse range of strategies to manage the discharge of $PM_{2.5}$, eg woodheater and diesel vehicle emissions.

6.12 PROPOSED DATE FOR MAKING THE VARIATION TO THE NEPM

The anticipated date of making the variation to the NEPM is April 2003.

APPENDIX 1 - CURRENT JURISDICTIONAL APPROACHES TO THE MANAGEMENT OF $PM_{2.5}$

COMMONWEALTH

The Commonwealth has implemented a range of initiatives in recent years to address particle pollution, and will continue to pursue national actions on PM_{10} as well as $PM_{2.5}$ emissions in urban areas, focusing on the following three key areas:

- improved understanding – undertaking investigations that improve our understanding of particles, particularly in terms of their composition, origin, distribution and health effects;
- source management – developing and implementing measures to reduce particle emissions from key sources, such as domestic solid fuel heaters and motor vehicles; and
- monitoring – supporting monitoring techniques that ensure a nationally consistent approach to measuring and reporting particles.

The above areas have been addressed by implementing a combination of research programs, and development of monitoring protocols and strategies to manage emissions from the key sources, namely motor vehicles and domestic solid fuel heaters.

<u>Motor Vehicle Emissions</u>

The Commonwealth has concentrated on improving the environmental performance of the transport sector, as it is a significant contributor to urban particle pollution, particularly $PM_{2.5}$. Four complementary strategies have been pursued:

- progressive tightening of new vehicle emission standards;
- promotion of new, low emission, vehicle technologies, such as fuel cells;
- establishment of vehicle inspection and maintenance programs; and
- regulation and improvement of fuel quality.

<u>Emissions from Domestic Solid Fuel Heaters</u>

Domestic heating (woodheaters and fireplaces) has been found in some locations to contribute to more than half the total load of particles, and to be responsible for regular exceedences of ambient air quality standards. To address the problem, the Commonwealth has:

- encouraged all States and Territories to adopt the recently tightened Australian Standard for particle emissions from woodheaters (AS 4013);
- delivered a national awareness campaign to educate households on the correct operation of woodheaters;
- implemented a financial incentive scheme in Launceston to replace older woodheaters with heaters with reduced particle emissions – this scheme has since been replicated by State and Local governments in other woodsmoke-affected regions;
- delivered a training package for local government officers to deal with nuisance woodsmoke complaints; and
- fostered complementary initiatives, such as new regulatory measures and improved monitoring facilities, from State and Local Governments to deal with woodsmoke emissions.

<u>Research and Monitoring</u>

The Commonwealth has also supported efforts by jurisdictions to reduce particle levels in Australia's urban airsheds, with Environment Australia implementing a number projects designed to improve our understanding of particles and inform the development of management strategies. This work includes:

- a pilot study into the Chemical and Physical Properties of Australian Fine Particles, and facilitating two Fine Particle Workshops;

- improving understanding of how secondary particles are formed by photochemical reaction;
- increasing understanding of the emission characteristics of domestic wood heaters (wood heaters are a major contributor to $PM_{2.5}$ levels) and reducing woodheater emissions;
- funding the development of an air quality forecasting system for Australia's major cities, which includes both PM_{10} and $PM_{2.5}$ forecasting capabilities;
- a fine particle compositional study that will determine the speciation of fine particles to ascertain origin; and
- a fine particle measurement calibration study which sought a correlation factor between the two main particle measurement methods used in Australia – the TEOM and HiVol samplers.

NEW SOUTH WALES

New South Wales programs focus on key sources:

- mobile—cars, trucks, ships and aircraft;
- industrial—power generation, steelworks, coke ovens, aluminium production, cement kilns, oil refining and waste incineration; and
- fires—controls on open burning and solid fuel heaters.

<u>Motor Vehicles</u>

Strategies that will have a direct impact on particles are:

- New vehicle emission standards and fuel quality standards will mean vehicles will have to meet tighter performance targets for a range of pollutants including particles.
- The Diesel NEPM has outlined strategies for the States to follow to reduce emissions from diesel vehicles. While particles are not explicitly targeted, diesel vehicles are known to be a significant source of many air toxics and so programs to reduce diesel emissions will lead to a commensurate reduction in particles. Regular testing of all diesel buses in the State Transit fleet has begun and those that do not meet emission standards, according to respective bus type and age, are repaired.
- The EPA smoky vehicle enforcement program is an effective way of reducing the number of smoky vehicles on the road and thus associated particle emissions. The EPA receives over 700 reports from the public each month on smoky vehicles. Since early 2002 it has been possible to report smoky vehicles via the EPA website.
- In relation to reduced vehicle use, the Government's *Action for Air* strategy contains a range of programs to address the issue of vehicle use. These include the promotion of appropriate land-use planning and infrastructure development to reduce reliance on motor vehicles and thus overall emissions. Actions agreed to at the government-sponsored Clean Air Forum in November 2001 will further enhance existing programs. Key actions include the draft State Environmental Planning Policy (SEPP) on Integrating Land Use and Transport and the improvements and enhancements to the public transport system contained in *Action for Transport 2010*.
- Vehicles using alternative fuels, such as hybrid electric vehicles and those running on compressed natural gas (CNG) and liquefied petroleum gas (LPG), will also reduce emissions. State Transit has already converted 200 of its buses to CNG in the Sydney region, with 200 more to follow by the end of 2002.
- In relation to emissions testing for cars, the Roads and Traffic Authority has established two emissions testing stations at Botany and Penrith where owners can have their cars tested on a voluntary basis. The testing provides a short diagnostic report indicating the levels of emissions from each vehicle relative to all vehicles tested to date.

Industry

Particles are usually generated as a by-product of the incomplete combustion of organic material. The EPA regulates particles by controlling the effectiveness of combustion processes, as indicated by the carbon monoxide or particle emissions they produce. By controlling these pollutants, the particles produced are also controlled. Where an industrial process is particularly associated with particle emissions, a specific monitoring program may be required to confirm that emission levels are acceptable.

A major element of the EPA's strategy to control recognised industrial emissions from existing sources has been through pollution reduction programs (PRPs) attached to environment protection licences. Standards for new developments have also been strengthened over time as technology and knowledge have improved. Together, these have substantially reduced emissions from point sources.

As an example, BHP's Port Kembla steelworks has been covered by several five-year PRPs to reduce these emissions. This has included a $93-million program to collect and reduce fugitive emissions from the coke ovens and $2 million to control emissions from gas processing. The need for further controls on gas processing will be assessed after studies of emissions monitoring data.

In a comprehensive study in 2000-01, BHP assessed the sources and contribution of emissions from its Port Kembla steelworks. The study has allowed the identification of priorities for future reduction strategies which are currently being negotiated with BHP.

Flexible Controls on Open Burning

A revised Clean Air (Control of Burning) Regulation was gazetted in September 2000 to control burning in the open and incinerators. The key features of the Regulation are:

- a focus on controlling what is burnt—councils can choose to regulate all burning or allow burning of vegetation or waste in parts of their areas;
- bans on home-unit incinerators from 1 September 2001; and
- increased penalties for burning offences.

Authorised bushfire hazard reduction burning is exempt from this Regulation.

The EPA may also issue 'no burn' notices under Section 133 of the *Protection of the Environment Operations Act 1997* to prohibit or control burning. Section 133 notices are generally issued when forecast weather conditions are likely to result in high pollution levels. The EPA liaises with the Rural Fire Service before issuing any notices and provides exemptions to allow strategically important hazard reduction burns to proceed during these no burn periods.

Solid Fuel Heaters

The EPA recently released results of a comprehensive monitoring study of a range of pollutants. This study indicated that reducing emissions from solid fuel heaters is a high priority in some higher altitude regional centres in the Great Dividing Range with topography that tends to collect air for long periods.

These emissions have already been tackled on a number of fronts. A revised Australian Standard adopted in NSW sets emission limits for particles from new solid fuel heaters. Lower particle emissions will lead to a proportional reduction in emissions of particles. This standard has been formally adopted in the Clean Air (Domestic Solid Fuel Heaters) Regulation 1997.

The NSW Government has committed $1 million to the Clean Air Fund in 2002 to reduce smoke in the regional areas identified in the study as having high levels of pollution (Armidale, Cooma, Lithgow, Orange and Tumut, plus the Blue Mountains). Under the program, home owners and businesses are offered a financial incentive to replace older, more polluting heaters with new, cleaner alternatives. The program is also supporting local council education and enforcement programs to ensure heaters are operated properly and do not emit excessive smoke.

The Government has actively promoted better use of solid fuel heaters through education campaigns, including publication of the EPA 1999 guideline, *Selecting, Installing and Operating Domestic Solid Fuel Heaters*. Other education programs include 'Don't Light Tonight, Unless Your Heater's Right' alerts when weather conditions threaten the dispersal of particle pollution in the metropolitan region; screening of information on better operation of heaters on regional television; and a comprehensive website on woodsmoke.

Under state planning legislation, local councils are able to tailor local planning instruments to prevent or restrict the installation of solid fuel heaters. Pittwater and Waverley Councils have recently amended their Development Control Plans and Local Environmental Plans to restrict the installation of new heaters in their local areas. Other councils, such as Blue Mountains, Eurobodalla, Rockdale and Wollongong have published revised local approvals policies which clearly specify their requirements for installing heaters.

Local councils are also able to prevent owners allowing their heaters to emit excessive smoke by issuing notices under the *Protection of the Environment Operations Act 1997*. In 2001, Armidale Dumaresq Council actively promoted its capacity and willingness to use these notices at times when householders ignore council requests for better operation of woodheaters. The council has reported some improvements in local air quality as a result of this program.

A review of the Clean Air (Domestic Solid Fuel Heaters) Regulation 1997 is considering giving councils additional powers to issue on-the-spot fines for poor operation of solid fuel heaters.

The effectiveness of this comprehensive program on solid fuel heaters will continue to be monitored to determine whether additional initiatives are needed to achieve the necessary reductions in woodsmoke and associated particles. The incentive scheme for the replacement of solid fuel heaters will be specifically reviewed in late 2002 to evaluate its effectiveness and consider whether to extend the program to other local government areas.

VICTORIA

In Victoria the primary legislation that guides the approach to protection of the environment and EPA Victoria's environmental systems and practices is the *Environment Protection Act (1970)*. The Act allows for the development of a range of instruments that guide the protection of Victoria's air environment. This Act established the Environment Protection Authority (EPA) and defines its powers, duties and functions. The Act's provisions include statutory powers, instruments and measures to:

- manage environmental quality;
- establish environmental standards and criteria;
- regulate emissions, discharges and wastes; and
- prevent and clean up pollution.

The important instruments for environmental management include state environment protection policies (SEPPs), industrial waste management policies, regulations, works approvals, licences and pollution abatement notices.

SEPPs establish a statutory framework for protecting the environment. SEPPs are declared by the Governor in Council, on the recommendation of EPA. These policies:

- identify the beneficial uses of the environment (including particular segments such as the air environment, or a particular water body or catchment) that are to be protected;
- establish environmental indicators and associated environmental quality objectives to establish if the environment is being protected; and
- define programs for attainment of these objectives so that identified beneficial uses are adequately protected.

Attainment programs usually specify a range of approaches, measures and instruments for policy implementation, and usually require the compliance and cooperation of government agencies, industry and the community to manage sources of pollution, reduce environmental impacts and improve environmental quality.

SEPPs provide the management approach and technical basis for the application of regulations, works approvals, licences and other statutory measures to manage the environment. The application of these instruments and measures must always be consistent with the requirements of SEPPs.

<u>SEPPs Protecting Air Quality</u>

The air environment in Victoria is currently protected by two SEPPs. These were created in February 1999 by dividing the *State Environment Protection Policy (The Air Environment)* (made in 1981 and subsequently amended several times) into two policies:

- The State Environment Protection Policy (Ambient Air Quality) or SEPP (Ambient Air Quality); and
- The State Environment Protection Policy (Air Quality Management) or SEPP (AQM).

The SEPP (Ambient Air Quality) contains the indicators, standards, goals and monitoring and reporting protocol of the Ambient Air Quality NEPM. The SEPP (Ambient Air Quality) also includes an ambient air objective for visibility reducing particles.

The SEPP (AQM) sets the framework for managing emissions to the air environment. These emissions are managed in such a way as to ensure that the air quality objectives of the SEPP (Ambient Air Quality) are met. In addition, a philosophy of continuous improvement is also pursued. The Principles of Environmental Protection contained in the *Environment Protection Act 1970* are explicitly stated in the SEPP (AQM) and guide the management of emissions to the air environment in Victoria. The focus is on the application of the waste hierarchy with avoidance being the primary aim rather than end-of pipe controls.

<u>Management Practices for $PM_{2.5}$</u>

The SEPP (AQM) classifies pollutants into Class 1, 2 and 3 indicators. Pollutants are classified according to their toxicity, odorous properties and persistence in the environment. $PM_{2.5}$ is classified as a Class 2 indicator. All generators of $PM_{2.5}$, and other Class 2 indicators, must control their emissions by the application of best practice. Design criteria have been set for $PM_{2.5}$ and all applicants for Works Approval and licences must ensure that emissions of $PM_{2.5}$

are managed in such a way that the design criteria are not exceeded at ground level. Design criteria are modelling tools to be used in the design stage of an operation.

The SEPP (AQM) also specifies an intervention level for $PM_{2.5}$. An intervention level is a local air quality objective that can be used to assess the cumulative impacts of emissions in a local area. If an intervention level is exceeded then a Neighbourhood Environment Improvement Plan may be triggered.

EPA Victoria is also currently reviewing the Motor Vehicle Regulations in Victoria with the aim of reducing pollution, including $PM_{2.5}$, from motor vehicles. This review will also be part of the implementation of the Diesel NEPM. Other initiatives to implement the Diesel NEPM include the development of a diesel eco-maintenance program to improve the skills of existing and new diesel mechanics so that they are better equipped to recognise and address diesel vehicle emission issues. EPA Victoria is also investigating opportunities to develop an in-service audit capability for diesel vehicles.

Victoria is also developing a Metropolitan Strategy, which aims to create a vision for retaining and enhancing Melbourne's livability over the next 30 years. The strategy will outline how the city can be shaped to better meet the needs of all people who live, work, visit and use services in Melbourne and the surrounding region. It will provide a framework for local and state government to implement policies and plans that are responsive to the social, economic and environmental needs and challenges facing the metropolitan region over the next two to three decades.

Growth in motor vehicle kilometres travelled and associated emissions is one of the key challenges for the region and the Metropolitan Strategy will take this into account in developing a strategic integrated transport and land use planning framework that manages the demand for motor vehicle travel.

An Industrial Waste Management Policy for Domestic Solid Fuel Heating is also being introduced that will ensure that all wood heaters manufactured and installed in Victoria will comply with Australian Standard 4013. As domestic wood heating contributes up to 70% of $PM_{2.5}$ during winter in Melbourne, introduction of this standard will assist in reducing ambient $PM_{2.5}$ levels.

EPA Victoria is also working with the Fire Protection Agencies in Victoria (DNRE, CFA) to develop an approach to reduce the impact of hazard reduction burning and agricultural burning on air quality. A Protocol for Environmental Management will be developed and incorporated under the SEPP (AQM) to address these issues.

QUEENSLAND

Management of $PM_{2.5}$ is achieved through the combined outcomes of a range of legislation, strategies and programs aimed at managing ambient air quality in general. These have been collected and prioritised for South East Queensland under a strategic plan entitled *"South East Queensland Regional Air Quality Strategy"*, 1999, but the principles, as discussed below, apply throughout Queensland.

<u>Motor Vehicles</u>

National limits are set for emissions of particulates from new vehicles under Australian Design Rules. These limits have featured a series of reductions over the last decade, and further reductions will occur over the next five years. This results in on-going reductions in emissions from the Queensland vehicle fleet as progressively less polluting vehicles gradually form greater proportions of the fleet due to vehicle write-offs after accidents and retirement of old vehicles.

Queensland Transport operates smoky vehicle and on-road vehicle emission random testing programs to encourage appropriate maintenance standards, and thus lower emissions, including particulates.

Fuel quality specifications under the *Environmental Protection Regulations 1998* include a limit of 500 parts per million on the sulfur content of diesel. Together with the national limit of 50 parts per million due to commence in 2006, this contributes to significant on-going reductions in emissions of particulates from the diesel vehicle fleet.

Commercial, Industrial and Domestic Sources

Under the *Environmental Protection Act 1994*, "a person must not carry out an activity that causes, or is likely to cause, environment harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm". A range of enforcement provisions is available including on-the-spot fines, orders to reduce or stop emissions, and prosecutions. The general provisions of the Act can be applied to sources of $PM_{2.5}$ with the aim of achieving best practice environmental management. Medium to large industrial activities are also subject to licensing requirements, which could include conditions of approval aimed at minimising emissions of $PM_{2.5}$.

Hazard Reduction and Ecological Burning

The organisations responsible for hazard reduction and ecological burning work closely with the Bureau of Meteorology and the Environmental Protection Agency to determine the most appropriate burning methods and the most suitable times for burning. The aim is ensure that all burning takes place in a way that minimises the impact of smoke, and any associated $PM_{2.5}$, on populated areas.

Domestic Woodheaters and Stoves

Under the *Environmental Protection (Air) Policy 1997*, all new domestic wood heaters and stoves sold in Queensland must comply with Australian Standard 4013, which sets limits on particle emissions. Provided these appliances are operated according to the manufacturers instructions, this has the effect of reducing all emissions, including $PM_{2.5}$. The Queensland government also supports the national voluntary code of practice for firewood merchants, which aims (among other things) to improve the quality of retail firewood and thus reduce emissions when the fuel is burnt.

WESTERN AUSTRALIA

Perth Air Quality Management Plan

The management strategies that are currently in place for particles are included in the recently released Perth Air Quality Management Plan (AQMP), available from http://aqmpweb.environ.wa.gov.au:8000/air_quality/Publications.

The principal contributing source to particle pollution during winter is smoke from domestic woodheaters. The Perth AQMP details several programs aimed at reducing smoke from woodheaters, including:

- continued education of woodheater owners on their correct operation to minimise smoke emissions;

- continued education and enforcement regarding the moisture content of firewood from wood suppliers;
- continued issuing of 'haze alerts' to warn wood heater owners when haze episodes are likely; and encourage the careful operation of their woodheaters; and
- investigating the introduction of incentives to encourage alternative heating sources.

During spring and summer, an important source of particle pollution is smoke from biomass burning (controlled burns or bush fires). The Perth AQMP includes programs to reduce the impacts from these sources, including:

- improving co-ordination to ensure that smoke from controlled burning activities does not impact on population centres; and
- studies on weather and smoke modelling to improve burn decision processes.

Diesel vehicles and poorly maintained or tuned petrol vehicles also contribute to particle pollution. The Perth AQMP (and Diesel NEPM implementation, which would be implemented in parallel with the AQMP) includes programs to reduce the contribution from vehicles, including:

- introducing a sulfur limit of 500 parts per million (ppm) from 1 January 2000 (three years prior to the Commonwealth introducing such limits);
- developing a fuel policy including the possibility of moving to 50 ppm sulfur diesel earlier than the current Commonwealth timeframe;
- encouraging the use of compressed natural gas (CNG) and liquid petroleum gas (LPG) as an alternative to diesel vehicles, particularly for the light commercial vehicle sector; and
- introducing the 'ten second smoke' rule to minimise smoke from poorly maintained or tuned petrol vehicles.

Development of State Environment Protection Policy (EPP) for Ambient Air

The EPP (under development) would refer to the NEPM standards for criteria pollutants and any future $PM_{2.5}$ standard. The EPP would allow for the development of environmental management plans for control of $PM_{2.5}$.

Anticipated Additional Strategies for Managing $PM_{2.5}$

It is expected that the strategies outlined above will be an adequate basis for managing $PM_{2.5}$ levels for domestic, mobile and fire management sources. Fine particle emissions from industry are not targeted explicitly in the Perth AQMP, although the concept of pollution prevention (eg cleaner production) will be encouraged through changes to the WA Environment Protection Act and "Green" awards.

In areas where particle impacts due to industry emissions are an issue for communities, there may additional requirements for industry to monitor and manage $PM_{2.5}$ emissions. The specific approach would be developed on a case-by-case basis.

At this stage, WA is not planning on increasing the monitoring network for $PM_{2.5}$. In some regional areas (eg Pilbara), industry may be required to assess/monitor $PM_{2.5}$, with management action required where health based standards are exceeded.

SOUTH AUSTRALIA

There is no emission limit on particles in the SA Environment Protection (Air Quality) Policy on the basis of size (PM_{10} or $PM_{2.5}$). The current limits for general process sources, incinerators and metal smelting apply to all solid particles emitted. Reduction of $PM_{2.5}$ has therefore been effected without reference to particle size, but rather by controlling smoke from industry and woodheaters.

Current management strategies for industry-related fine particles include stronger limits than are set by the Air Quality Policy, via licensing point sources of fine particles (eg metal fume, mineral dust, woodflour). Emissions from slow combustion heaters have been addressed by promoting the design of more effective heaters and education campaigns to improve user behaviour.

The other major source of fine particles is motor vehicles. South Australia has a "Smoky Vehicle" program operated by Transport SA.

<u>Anticipated Additional Strategies for Managing $PM_{2.5}$</u>

A major source of $PM_{2.5}$ is combustion particles and metal fume. The latter are managed through current emission controls, however large scale industrial sources may need to measure and report on the $PM_{2.5}$ fraction as well as their total particle emissions.

Woodheaters represent approximately 15% of total Adelaide PM_{10} according to the National Pollutant Inventory, most of which would be $PM_{2.5}$. A comprehensive strategy to address all aspects of woodheater management, including improving in-service operation in conjunction with local government, is being developed. Other strategies anticipated deal with large scale sources including burnoffs for wildfire fuel load reduction and for native forest revegetation, forest burning and stubble burning.

Motor vehicles represent a significant source of $PM_{2.5}$. The NEPM variation will add to the pressure to introduce stronger programs targeting in-service vehicle emissions from all vehicles, not just diesel vehicles. Strategies are under consideration by the transport and environment agencies.

TASMANIA

Current strategies include:

- development of an Air Quality Policy (scheduled for 2002). This will cover diffuse sources (eg domestic wood heating) and industry. A copy of the impact statement and draft policy may be found at http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/CDAT-53M4U8;
- a wood heater buy-back program in Launceston involving Environment Australia, Launceston City Council and the Department of Primary Industries, Water and Environment;
- the Airwatch Tasmania program and other community education programs on ways of reducing woodsmoke pollution;
- partnership agreements with Councils addressing local air quality issues; and
- ambient air quality monitoring and reporting of PM_{10} in Hobart and Launceston.

Additional strategies to assist in meeting the goals of the Ambient Air Quality NEPM will be considered following adoption of the Air Quality Policy.

The monitoring results available for Tasmania indicate that in winter $PM_{2.5}$ constitutes approximately 80% of PM_{10}. Consequently, management strategies aimed at reducing PM_{10} should also effectively reduce $PM_{2.5}$. Monitoring of $PM_{2.5}$ is not conducted in Tasmania at present.

AUSTRALIAN CAPITAL TERRITORY

Current Management Strategies

Whilst Canberra's overall air quality compared to other larger capital cities is excellent it does have a winter particle pollution problem due to emission from domestic solid fuel heaters. The ACT Government has implemented a number of initiatives in recent years to target emissions from wood heaters including the ACT Firewood Strategy, the licensing firewood merchants (this replaced the previous voluntary code of practice) and the introduction of an air pollution warning system.

The ACT Government introduced the ACT Firewood Strategy in 1999, the first jurisdiction in Australia to develop such a program. The strategy aims to protect native forest and habitat without adversely affecting the air quality of the ACT and surrounds. The strategy has a strong ongoing public awareness campaign focussing on the correct operation and maintenance of wood heaters to reduce smoke emissions. This includes inspectors from Environment ACT targeting excessively smoky chimneys and providing advice on ways to minimise smoke.

The strategy also comprises a code of practice for the sale of firewood and firewood heaters in the ACT. This has now been replaced by the mandatory licensing of firewood merchants.

In April 2001 amendments to the Environment Protection Act 1997 (the Act) were enacted to introduce a mandatory licensing scheme for wood merchants. Merchants must now comply with a set of authorisation conditions including only selling dry seasoned timber and providing consumers with information on how to operate their wood heater correctly. Both of these conditions relate specifically to reducing air pollution.

Under Section 4 of Schedule 2 of the Act only heaters which are certified to Australian Standard 4013 (currently 4 grams of particle emissions per kilogram of fuel burnt) can be sold in the ACT.

In June 2001 the *"Don't Burn Tonight"* campaign was launched. The campaign operates over the winter months and aims to improve air quality by calling on Canberrans who use wood fired heaters to use alternative heating sources, if possible, on nights when atmospheric conditions will prevent the dispersion of wood smoke.

Future Management Strategies

Environment ACT is investigating the suitability of a woodheater replacement program similar to that implemented by the NSW EPA and the joint program being implemented in Launceston. The aim of this program would be to replace older more polluting heaters by offering a subsidy to install cleaner forms of heating.

The ACT Government Analytical Laboratory has recently started continuous monitoring for PM_{10} as required by the Principal Measure. This monitoring will give a clearer picture as to the actual particle problem in Canberra and help guide the need for any future management strategies.

NORTHERN TERRITORY

Characteristics of Particulate Matter in the Northern Territory

The sources and patterns of particulate matter air pollution and its implications are poorly defined in the Northern Territory. Recent pilot studies of air quality in Darwin showed both seasonal and diurnal patterns for PM_{10} (CSIRO Atmospheric Research, 2001). Levels were higher and showed greater fluctuation in the dry season (June to October), reflecting the occurrence of landscape fires as the primary source and the greater nocturnal stability in the airshed. The 24 hour averaged PM_{10} mass loading exceeded 50µg/m^3 for six days during the 2000 dry season. Consistent diurnal variations show two peaks due to local transport sources and atmospheric stability in the morning and late afternoon. A study in Alice Springs indicated that local biomass burning in spring is a significant contributor to PM_{10} (CSIRO Atmospheric Research, 2002). Smoke from wood-fired heating may also be significant. There has been no assessment of the $PM_{2.5}$ fraction within PM_{10} from bushfire and other sources.

Monitoring of Particulate Matter in the Northern Territory

Campaign monitoring of PM_{10} has been carried out in Darwin and Alice Springs. Routine monitoring of $PM_{2.5}$ is not planned, nor has any campaign monitoring been undertaken.

Management Strategies for Particulate Matter

Research is needed to clarify the impacts and level of risk from particulate matter in the Northern Territory and to identify effective management strategies for both PM_{10} and $PM_{2.5}$. Such research would clarify the possible sources of PM_{10} and $PM_{2.5}$ and the processes occurring during various types of landscape burning. Factors that may affect the amount and type of combustion products and particulate matter generated include:

- seasonal timing (early, mid or late dry season);
- fuel type (grass or broadleaf); and
- fire type (controlled burning, wildfires and traditional cultural burning practices).

This will also help to define the exposure risk and health implications from dry season fires, and may provide more strategically useful information than monitoring at this stage.

Monitoring and Reporting Costs

Additional funds for monitoring and reporting of $PM_{2.5}$ are unlikely to be available.

Avoided Health Cost Benefits

An assessment was carried out in 2001 of the health risks from exposure to smoke from landscape fires around Darwin (Johnston, 2001). This study showed that hospital presentations for asthma rose significantly with mean daily PM_{10} above 30 µg/m^3. About 13% of the asthma presentations during the study period were attributed to elevated ambient PM_{10}. The health impacts of the $PM_{2.5}$ fraction have not been assessed.

Fire Risk Management/Controlled Burning

Landscape fires are likely to be the primary source of particulate matter for the Darwin region, and controlled burning is undertaken extensively in the region during the dry season. Options may be available to alter prescribed burning activities based on improving the understanding of tropical savanna fire ecology and air quality issues. Improved management of controlled burning may also allow manipulation of the proportion of the $PM_{2.5}$ fraction.

Visibility, Aesthetics and Tourism

Smoke haze is noticeable in the Darwin region at times during the dry season. The impact on visibility, aesthetics and tourism has not been assessed or quantified.

Cultural Burning Practices

Traditional cultural burning practices are carried out across extensive areas of northern Australia. However, little research has been undertaken to document the characteristics of cultural burning practices in different regions. Such research is needed to clarify the timing, frequency, extent and intensity of these fires, and their range of fuel types and likely combustion products.

Cultural burning practices are usually part of land management regimes designed to provide environmental resources for communities. Any management strategies that affect these practices may have impacts on the communities by reducing the availability of particular resources such as bushfoods.

Additional Strategies for Managing $PM_{2.5}$

The primary source of particulate matter in most areas of the Northern Territory is landscape burning including prescribed burning, traditional cultural burning and unintended bushfires. No research has been done on the composition or size distribution of particle emissions from these fires. Preliminary research is needed to clarify the size distribution of particulate matter from various types of fire sources to define the possible risks before routine monitoring of $PM_{2.5}$ can be justified. In the short term, such research may provide more useful source management outcomes than monitoring alone by indicating fire management options for minimising $PM_{2.5}$ emissions.

SUMMARY

In most jurisdictions, there are a range of initiatives to target wood stoves and wood heaters. These range from guidance on the correct operation of equipment (eg use of well-seasoned fuel, ensuring that the fire burns brightly) to subsidies for replacing wood heaters with improved technology models or alternative fuelled equipment (eg natural gas). Some of these initiatives have only recently been implemented, and an analysis of their effectiveness is not yet available.

Emission standards for new motor vehicles are specified in the Australian Design Rules (ADRs). The ADRs specify limits on exhaust and evaporative emissions for a number of vehicle categories (eg passenger vehicles, light commercial vehicles, heavy duty vehicles), and aim to harmonise Australian standards with those internationally, ie Europe and the USA. To facilitate the introduction of these new vehicle emission ADRs, the Commonwealth has introduced national fuel quality standards, through the *Fuel Quality Standards Act 2001* (Commonwealth).

Combined, these improved new vehicle and fuel standards will lead to significant improvement in the environmental performance of new vehicles. However, there is a concern that these improvements will be offset by the increasing number and use of motor vehicles and the long lag time for new technology vehicles to become established in the fleet. Further, the current and future new vehicle ADRs specify particle emission limits for diesel vehicles, but not for petrol vehicles. This is in recognition of the fact that diesel vehicles are responsible for most of the particle emissions. This means that petrol vehicles will account for a greater proportion of particle emissions from the vehicle fleet in future years. In common with other combustion sources, vehicle particle emissions are mostly $PM_{2.5}$.

Other strategies targeting motor vehicle emissions are in place in most Australian capital cities. Typical strategies include behaviour change/education actions (eg promotion of public transport, car pooling) and targeting of poorly maintained vehicles (smoky vehicle spotting). More ambitious programs are under consideration in some jurisdiction, including diesel vehicle emission testing.

The Diesel NEPM has been developed to deal specifically with diesel vehicles, which contribute disproportionately to emissions of particles and NOx. The NEPM strategies that may be implemented in jurisdictions are smoky vehicle spotting, in-service emission testing, audited maintenance programs, retrofit programs and engine rebuilding programs.

There is some evidence suggesting that new technology engines emit larger numbers of smaller particles, even though the total particle mass is reduced. Relationships between particle size/number and health effects cannot be assessed at this stage, although it is an active area of research.

APPENDIX 2 – PARTICIPANTS IN NEPM VARIATION DEVELOPMENT

PROJECT CHAIR

Victoria

Dr Brian Robinson / Mr Robert Joy (EPA Victoria)

PROJECT MANAGER

Mr Ian Newbery (NEPC Service Corporation)

PROJECT OFFICER

Ms Rebecca Collins / Ms Monina Gilbey (NEPC Service Corporation)

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Dr Lyn Denison (Environment Protection Authority Victoria)
Mr Greg Davies / Mr Roger Bluett (NSW Environment Protection Authority)
Mr Leo Heiskanen (Commonwealth Department of Health and Ageing)
Mr Sean Lane (Environment Australia)
Mr Anthony Stuart (Department of Environment, Water and Catchment Protection)

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Australian Capital Territory
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NON-GOVERNMENT ADVISORY GROUP

Dr Peter Brotherton	National Environment Consultative Forum
Mr Jeff Bazelmans	Environment Business Australia
Mr Mark Chladil	Australasian Fire Authorities Council
Ms Nadia Dimmock	Environment Business Australia
Mr Frank Fleer	Clean Air Society of Australia and New Zealand
Dr John Gras	CSIRO
Mr Richard Hoy	Electricity Supply Association of Australia
Dr Graeme Lorimer	National Environment Consultative Forum
Mr David Lang	Australian Automobile Association
Mr Stewart McDonald	Federal Chamber of Automotive Industries
Mr Ewen Macpherson	Australian Institute of Petroleum
Mr Simon Molesworth	Environment Institute of Australia
Ms Elizabeth O'Brien	National Environment Consultative Forum
Mr Peter Smith	Minerals Council of Australia
Dr Richard Strauch	Cement Industry Federation & Extractive Industries Association
Mr Peter Stephenson	Australian Industry Group
Dr Jonathan Streeton	Australian Medical Association
Mr Simon Troeth	Australian Paper Industry Council
Mrs Anne Wilson	Asthma Australia
Mr Bill Yeo	Australian Home Heating Association

PEER REVIEWERS
Professor David Bates
Dr Andrew Chan
Dr John Gras
Dr Nigel Holmes
Professor Rod Simpson
Dr Jonathan Streeton

GLOSSARY AND ACRONYMS

ANSTO	Australian Nuclear Science and Technology Organisation
Bsp	Light scattering coefficient by particles
CO	Carbon Monoxide
COPD	Chronic obstructive pulmonary disease
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EPA Victoria	Environment Protection Authority Victoria
Epidemiology	Branch of medicine that deals with the study of the distribution and determinants of disease in populations and with investigations into the source and causes of infectious diseases
Gravimetric	Manual method for sampling particles by drawing air through a filter and determining the mass by weighing the filters
Health Endpoint	An adverse health outcome to be assessed
JRN	Jurisdictional Reference Network
NEPC	National Environment Protection Council
Nephelometer	A device measuring the scattering coefficient of light caused by suspended particles in the air
NEPM	National Environment Protection Measure
NGO	Non-Government Organisation
NO_2	Nitrogen Dioxide
Partisol sampler	A manual gravimetric method for performing mass based $PM_{2.5}$ measurements
$PM_{2.5}$	Refers to particles with an equivalent aerodynamic diameter less than or equal to 2.5 micrometres
$PM_{10-2.5}$	Refers to particles with an equivalent aerodynamic diameter less than or equal to 10 micrometres and greater than 2.5 micrometres
PM_{10}	Refers to particles with an equivalent aerodynamic diameter less than or equal to a 10 micrometres
SO_2	Sulfur Dioxide
TEOM	Tapered Element Oscillating Microbalance

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